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Technological Studies
Kunsthistorisches Museum Vienna

CONSERVATION – RESTORATION – RESEARCH – TECHNOLOGY

Special volume: Storage
Vienna, 2015

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PREFACE

Sabine Haag, Director General
Paul Frey, General Manager

Translated from the German by Emily Schwedersky

The present volume of the *Technological Studies,* as a special "Storage Facility" volume, is dedicated to the planning for and construction of our new central storage facility, as well as the relocation of the respective collection objects to this new location.

In the year 2011, we had the opportunity to build a modern and suitable storage facility in the vicinity of Vienna. The storage rented in Inzersdorf since the early 1990s had only ever been intended as an interim solution, but had nonetheless lasted nearly 20 years, although it had long since ceased to meet conservation or security requirements. In order to better conform to new scientific findings in the field of conservation, a project team worked out a new storage concept from 2008 onwards. The museum ultimately chose an ownership model, and acquired a property on the outskirts of Vienna. The budgeted costs for the project – including the purchase of land and the relocation – amounted to € 14 million. The principal part of the costs was financed by the Kunsthistorisches Museum Vienna itself. Planning of the new storage facility was undertaken in close consultation with international experts and the collection managers of our museum association. Following a year of planning, making the necessary call for bids, purchasing the property, obtaining permits, and securing funding, September 2010 finally saw the ground-breaking. After a record time of only 8 months, the storage facility was completed, and was inaugurated by Federal Minister Claudia Schmied on the 6th of July 2011.

The project constituted a tremendous logistical and practical challenge for everyone involved. Some 1 million objects of varying nature and size had to be packed, shipped, and adequately installed, under improved conservation conditions. Our special thanks at this point go out to the relocation team's project leader Alfred Bernhard-Walcher, who with his tireless dedication particularly regarding the coordination of all the collections' requirements not only made adherence to the tight schedule possible, but with his professional competence also brilliantly supervised the implementation of the best possible solutions for the relocated objects within the given financial framework. Even today, the new storage facility is already an exemplary project in the international museum field, and may be labelled an innovative contribution to the "green museum" and to a "culture of sustainability".

The seasoned editorial team, which includes Martina Griesser, head of the Conservation Science Department, Elke Oberthaler, head of the Picture Gallery's Conservation Department, and Alfons Huber, head of the Collection of Historic Musical Instruments' Conservation Department, also prepared and editorially supervised this current edition of the *Technological Studies.* Our thanks are due to these colleagues, as well as all members of staff for their important contributions to this edition, and to Brigitte Simma, who once again created an appealing graphic design for the publication.

We wish this current edition of the *Technological Studies* an interested readership.

Vienna, May 2013

INTRODUCTION

Martina Griesser
Alfons Huber
Elke Oberthaler

Translated from the German by Emily Schwedersky

If, about 30 years ago, one wanted to see or even photograph the storage facilities of one of the major Austrian museums, this was not usually possible without "good connections". The conditions were so conspicuously out of line with spatial and conservation requirements that access was habitually denied to visitors. In attics, partly humid cellars, narrow side rooms, or rented halls, the less noted testimonies of past cultural life awaited their discovery or restoration in the most confined of spaces. Pest or mould infestation would at times go unnoticed for years or had to be left untreated due to a lack of suitable alternatives.

The rental and adaptation of several storehouses in Inzersdorf, from 1992 onwards, initially constituted a marked improvement for the collections of the Kunsthistorisches Museum Vienna. Many deposited objects could be installed adequately, as well as examined and surveyed, for the first time. The setup of an anoxic nitrogen treatment facility allowed for a systematic control of insect pests, without subjecting the conservators involved to poisonous substances that put their health in danger. A part of the paintings storage and, several years later, that of the Collection of Historic Musical Instruments, were equipped with very economical and damage-preventive wall-tempering instead of the extremely insufficient air heating.

Nonetheless, as the years went by, it became clear that the rented facilities were not suitable as a repository for art works in the long term. Several instances of water ingress from the nearly 40-year-old flat roof with subsequent damage to the objects, and other structural defects, pointed towards the necessity of finding a sustainable solution. Finally, it was determined that all rented outposts had to be dissolved and a newly-built storage facility owned by the KHM should be envisaged.

The present volume of the *Technological Studies* is dedicated to the planning and building of this new central storage facility for the KHM, as well as the relocation of the objects to the new premises. The project presented an enormous logistical and practical challenge for everyone involved. Some 1 million objects, ranging from cowrie shells from the Coin Collection, serving as primitive money and weighing only a few grams, to sarcophagi from the Collection of Greek and Roman Antiquities, weighing several tons, had to be packed, shipped, and reinstalled in the appropriate place at the new location, under improved conservation conditions (mechanically secure, in acid-free wrapping, cleaned, free from active mould etc). Although conservators tend to be of a critical mindset, it has to be stressed that the project was completed within the set timeframe and budget without any significant mishaps, despite taking place under great time pressure alongside the regular commitments – such as special exhibitions and the refurbishment of the Kunstkammer. This was only possible due to the Kunsthistorisches Museum's staff's large and creative problem-solving capacity, as well as outstanding team-spirit.

Despite some inventory and documentation tasks still awaiting completion, the first few months of running the new facility have already showed its marked advantages in terms of climatic stability, a largely pest and dust free environment, and good accessibility of the objects.

During the course of the relocation, a comprehensive survey of the objects' condition, their documentation in the in-house database, and an assignment of locations via barcodes took place.

Following the positive experiences with implementing integrated pest management (IPM) at the Imperial Carriage Museum and the Weltmuseum Wien it was also installed at the new facility, and will be continued in the future.

Standardised quarantine measures are intended to prevent the introduction of pests via infested objects or other inventory; a modern anoxic nitrogen treatment facility is at the conservators' disposal in situ.

In order to implement improvements in a sustainable manner and guarantee smooth operations in the future, a working group serving all collections was established, working out an "operation manual" with conservators and on-site staff, which takes into account the diverse requirements of each collection.

The present edition is intended to give our readers an insight into the scope and complexity of the project of a "new central storage facility" and simultaneously serve as a pool of information for similar undertakings in the future. We hope to have succeeded on both counts, and that the *Technological Studies* will continue to be received favourably in its new visual appearance.

ACKNOWLEDGEMENTS

Translated from the German by Emily Schwedersky

Building the new central storage facility on behalf of the museum's management has been a great success not only for us, but for the museum as a whole. We are especially thankful to the management, Dr. Sabine Haag and Dr. Paul Frey, for the opportunity to dedicate the present volume to this topic and thereby also openly present certain problem areas, which had long remained hidden.

The implementation of a large-scale project such as the building and furnishing of a new central storage facility, as well as the relocation of the majority of the collections in storage, can only succeed through the cooperation of many. Not only the authors of this volume, but many more colleagues have contributed and thus enabled a sustainable solution to the problems of storage being reached. As a means of thanking all those involved, the following is an attempt at as comprehensive a list as possible, in the hope that we did not forget anyone.

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Dr. Alfred Bernhard-Walcher (project manager of the relocation team and collections representative), Ing. Stefan Fleck (project manager of the construction team, furnishings), Dipl.-Rest. Christina Schaaf-Fundneider (conservation representative), Univ.-Ass. Dipl.-Rest. (FH) Tanja Kimmel (conservation representative), Karl Reuter (architect), Dr. Joachim Huber (Prevart GmbH, external museum consultant), Martin Dorfmann (DP-art GmbH, external coordinator for relocations)

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Testo GmbH

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Germania GesmbH & Co. KG., Innova Solutions

Fig. 1: At first glance, the purpose of the new central storage facility for the Kunsthistorisches Museum Vienna is not recognisable, yet, it provides a stable climate for diverse objects originating from seven millennia while remaining cost-effective.

Building a Cost-Effective Art Storage Facility that maintains State-of-the-Art Requirements

Stefan Fleck

Translated from the German by Aimée Ducey-Gessner

1. INTRODUCTION

Completed in 2011, the central storage facility of the Kunsthistorisches Museum Vienna has set a new standard for the construction of museum storage facilities. After an only 20-month long planning and construction period, a functional building for the collections with a net floor area of 14,000 m² was created. The primary objectives were to build an energy-efficient structure while at the same time meeting conservation requirements along with reasonable construction and operating costs.

2. CHRONOLOGY OF THE PROJECT

The Kunsthistorisches Museum (KHM) Vienna decided in September 2009 to build a new art storage facility *(fig. 1)*. Up until that time, the collections were dispersed among nine different storage facilities of varying quality in and around Vienna. The management of the museum provided the following objectives for the project:

- All art objects should be housed in the new central storage facility according to the latest standards (climate control, fire protection, security, cleanliness, Integrated Pest Management, logistics, storage technology).
- All rented storage areas should be closed by December 31st, 2011.
- The costs should be optimised and the maximum project budget of 14 million euros should not be exceeded.
- The operating costs should also be optimised.

The museum management created two small project teams that involved the conservation departments for the implementation of the project. Direction of the construction project including technical facilities was undertaken by Stefan Fleck, who serves the KHM as structural engineer for building management; Dr. Alfred Bernhard-Walcher, director of the Collection of Greek and Roman Antiquities of the KHM, was responsible for overseeing the relocation project. Three months later in December 2009, Dr. Joachim Huber from the company Prevart GmbH was brought on as an experienced storage consultant for the entire project.

The core team of both project groups consisted of only five people: this guaranteeing a rapid decision-making process. Through an EU-wide request for proposals for the architectural design and planning, the group "B-18 Architekten ZT GmbH, Vienna/Architektenbüro Karl Reuter, Berlin" was selected because of its functional and very cost-effective project proposal. Everyone involved with the project pressed ahead with the initial planning and engineering design so that the building permit could be obtained as early as June 2010. After the detailed planning phase was completed, an EU-wide request for proposals was issued for the lead technical contractor. The construction of the building (without a basement) began in October 2010, exactly 12 months after the project was undertaken, and proceeded at a good pace, despite weather-related interruptions.

Fig. 2: Prefabricated industrial construction units contributed substantially to the short construction time.

Fig. 3: Facade construction units with gaps for the windows.

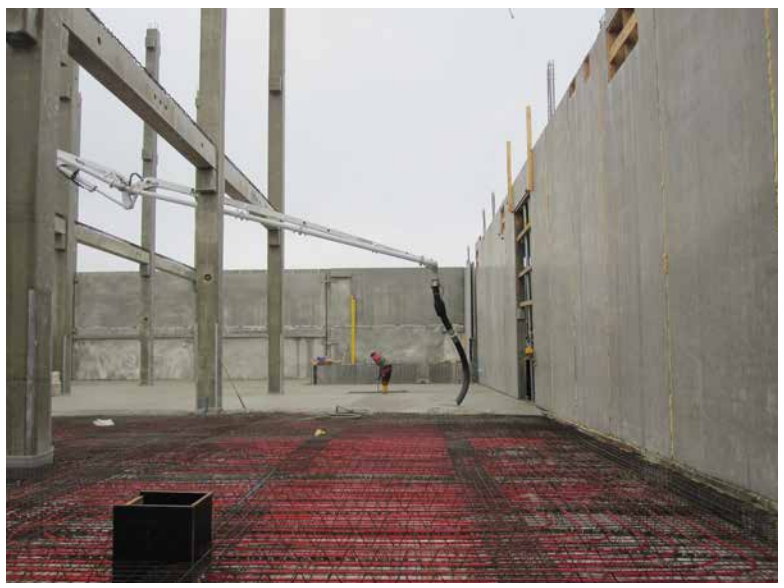


Fig. 4: Addition of concrete to the ceilings with concrete core activation and reinforcement already in place.

The companies Compactus & Bruynzeel, Kern Studer and Magista delivered and installed all furnishing for the storage facility in just six weeks, beginning in June 2011. Innovative ideas for the storage of up to 600 cm long tubes carrying rolled tapestries and columnless shelving units for the oversized costume storage boxes were implemented. The relocation of all collections in the rented storage facilities took place from August until the end of December 2011; the coordination of all practical aspects of the move was taken over by Martin Dorfmann of DP-art, who is experienced in the management of projects involving works of art.

It took only 24 months from the decision to build a new storage facility to reach this point. The total cost of the project, including real estate, personnel compensation, completed building structure, equipment and furnishings, and relocation even fell below the target budget of 14 million euros by about half a million euros.

3. CONSTRUCTION TEAM

As already mentioned, the core team consisted of only five people. The construction team was responsible for execution of the entire project from the design phase through to the final installation of equipment and furnishings. The following people were team members:

- Stefan Fleck: project manager, technical deputy KHM, liaison with city authorities, planning of equipment and furnishing.
- Alfred Bernhard-Walcher: representative for the interests of the collections
- Christina Schaaf-Fundneider: representative for the interests of the conservators
- Karl Reuter (architect): general planning and construction supervisor, liaison with city authorities
- Joachim Huber: quantity structure, planning of equipment and furnishing, advisor on scheduling of the entire project

4. THE PROPERTY

Due to budgetary constraints, the property search had to be oriented from the outset to the outskirts of Vienna. Properties within the city were considered, but their high prices prevented the possibility of constructing the new central storage facility in the immediate vicinity of the museum. According to the initial selection procedure, in which price, access to public transportation and easy vehicular access, close proximity, and building regulations were analysed, two properties were considered in Himberg, close to Vienna. The results of the geotechnical investigation of one property lead to its elimination, resulting in a clear preference for the property that has now been developed.

5. CONSTRUCTION

The new central storage facility of the KHM in Himberg close to Vienna was created with a net floor area of 14,000 m² within a net construction period of only 8 months. The short construction period and optimisation of the total construction costs were possible primarily due to the usage of prefabricated building components *(fig. 2)*. Columns, beams, stairs and the facade elements were delivered directly to the construction site from the factory as prefabricated reinforced concrete components and then installed. The high quality of the surfaces made it possible to use the components to a great extent as they were, without the necessity of further coatings or paint layers. Only the working spaces were finished to a higher standard.

The facade of the art storage unit consists of 35 cm thick double-wall panels with core insulation, which were attached to the outer supports as prefabricated facade panels with openings for windows *(fig. 3),* doors, and gates already in place. In addition to providing thermal insulation, this facade serves as a very good protection against theft. Filigree floors were built for each level and arrived as semi-precast sections. The tube system for concrete core activation was put in place on site, followed by the pouring of the concrete *(fig. 4)*. In this way, all of the ceiling slabs contribute to the heating and cooling of the building. The floors of each level were covered with a layer of a 1.5 cm thick cement-bound hard material flooring that was developed for the most demanding of environments. Further finishing of the floor, for example, by the addition of a layer of epoxy resin, was not undertaken because of budgetary constraints, but also due to pollutant emissions. The analyses of pollutants in the air carried out during operation confirm the correctness of this decision.

A similar building concept was implemented for the art transportation company Hasenkamp in Cologne by the architect Karl Reuter two years earlier. During the planning phase, therefore, one could draw on this earlier experience when designing the climate control system and selecting the building materials to be used.

6. CONCEPT OF WORKING SPACE

Several working spaces are available on the ground and 1st floors next to the storage areas. The steps undertaken upon delivery of the works of art, and the related functionality of these rooms are briefly described here.

The truck delivering art objects can drive into the building. An entry area outfitted with a vertically adjustable ramp is available where the truck can dock with the building, allowing the objects to be unloaded regardless of weather conditions. There is a room designated for the unpacking and inspection of objects where the conservator decides whether the object may be immediately delivered to the storage area, or if it must be sent temporarily to one of the two quarantine rooms while awaiting anoxic treatment. From the unpacking room, the so-called mould room can be accessed, where objects subject to mould growth can be stored. This room is equipped with a completely stand-alone ventilation system. The objects are taken from the quarantine rooms to the anoxic nitrogen treatment chamber (dimensions ca. 4.5 × 7.5 × 3 m) where, through reduction of the oxygen level, pests (clothes moths, beetles, etc.) are eliminated. After treatment in the anoxic nitrogen chamber, the objects are temporarily stored in the "post-treatment storage room" in order to maintain a strict separation between affected and non-affected objects. From there, the objects can be brought into the main collection storage areas. There are four additional multifunctional workshops available for conservation treatment. They are equipped with work tables, local air extraction units, in some cases with a jib crane, and osmosis water supply. The first floor is outfitted with an analysis room with a fume hood and its own 80 m² photography studio. A large room for the packing of objects and two shipping rooms for objects leaving the storage facility are also available.

The freight elevator allows for the best possible transportation of objects inside the building. Its inner dimensions of 3.5 m high by 2.5 m wide by 8 m deep correspond to the loading area of the largest art transportation vehicles currently in use.

7. ANOXIC NITROGEN TREATMENT CHAMBER

The newly built anoxic nitrogen treatment chamber has a volume of ca. 100 m³ and is fed by its own nitrogen generator; the system's controls are fully automatic. During treatment (exposure time typically 5 weeks) the oxygen content of the chamber at a temperature of 26 °C and 50 %rH is reduced to 0.5 %. The reduction of the oxygen content from 20.9 % (oxygen content of ambient air) to 0.5 % takes about one week. If the nitrogen generator fails, a nitrogen cylinder bundle is automatically activated that maintains the low level of oxygen content in the air during the exposure phase. Should the amount of oxygen in the chamber increase above 0.9 % during this phase, the machine is automatically restarted. The surrounding rooms are also equipped with an oxygen warning system. If a leak in the machine causes the oxygen level in these rooms to fall below 19 %, the rooms are automatically flooded with air from the outside.

In the coming months, Dr. Pascal Querner and colleagues of the KHM will investigate the duration of the exposure phase necessary for extermination of all harmful insects with the goal of optimising time expenditure.

8. SIMPLE YET EFFECTIVE CLIMATE CONTROL

The design of the climate control system had to meet the requirements of the collections. The construction team conducted a survey of all collections, and based on its results, the following values were set for 95 % of the objects: 18–22 °C, 45–55 %rH. The design was intentionally kept very simple: energy consumption by and the operating costs of the storage facility should be kept to a minimum. The thickness of the building envelope and the activated ceilings and floors *(fig. 5)* temper, i.e., cool, the building, providing a very stable climate with only slight fluctuations (target values: 20 °C and 50 %rH).

Fig. 5: The activated floors provide a stable climate. The photograph shows the installation of the tubing for the concrete core activation before the concrete has been poured.

The heating and cooling is carried out by heat pumps in combination with 32 geothermal probes that extend up to 100 m into the earth. During the winter, heat is withdrawn from the earth, while in the summer, the ground absorbs the heat drained from the building. The required rH of 50 % is maintained by commercially available, individual dehumidifiers placed throughout the building. The dehumidification of 500 m² storage space at the height of summer requires only one machine. In areas where a lower rH is necessary, for example, for bronze objects, so-called "climate boxes" were installed. The ventilation for these areas is closed-off from that of the rest of the storage facility; separately controlled dehumidifiers maintain rH of 30–40 % in these rooms.

Each storage area (with ca. 1,400 m² floor area and a spatial volume of ca. 7,000 m³) is fitted with two separate air circulation systems that are constantly functioning. The air circulation units guarantee a light circulation of air in the storage areas; this prevents the formation of microclimates within the closely-packed shelving units. Processed fresh air is admixed with the circulated air as required by law. The humidity in the spaces is increased as needed by the ultrasonic humidifier located within the air circulation units. This building concept allowed for the relocation of the collections to begin just six weeks after the building was completed, and required no additional measures: for example, no additional dehumidifiers were needed. The climate values were maintained even during the relocation phase and despite the heat emitted by personnel (sometimes 10 people were working in a single storage space) and the lighting system. The first significant measurements of climate stability without any disrupting events (relocation, etc.) were taken during the turn of the year 2011/2012. During these two weeks, the potential of the building's entire climate control system could already be adumbrated. It was demonstrated that it is possible to achieve a very good climate for objects with a less technical system and a low investment cost *(fig. 6)*.

9. FURNISHING AND OPTIMISATION OF SPACE

Both the optimal allocation of space and unrestricted access (width of walkways) to individual storage units and the objects were taken into consideration during the planning phase. The companies Compactus & Bruynzeel as well as Magista won the EU-wide call for proposals for the storage fittings. All storage furnishings are made of powder-coated steel, fulfilling conservation guidelines.

In order to best profit from the height of the rooms, thereby increasing the amount of storage space, intermediary steel platforms were built in sections of some of the storage areas *(fig. 7)*. In this way, even collections requiring diverse types of storage units could be kept together in one space.

10. FIRE PROTECTION

Weight-bearing elements of the building, such as floors, walls, facades and ceilings, are fire resistant and constructed out of cement that is at least 20 cm thick. All storage furnishings are fireproof. A fire alarm system monitors all areas of the building. After weighing the risks and due to the expense, an automatic fire-extinguishing system was not installed, despite a relatively large fire compartment of a maximum of 1,500 m². Every room is equipped with a portable fire extinguisher for fighting fires. The power supply to all storage areas (except the climate control system) is disconnected outside of opening hours in order to further minimise the danger of fire.

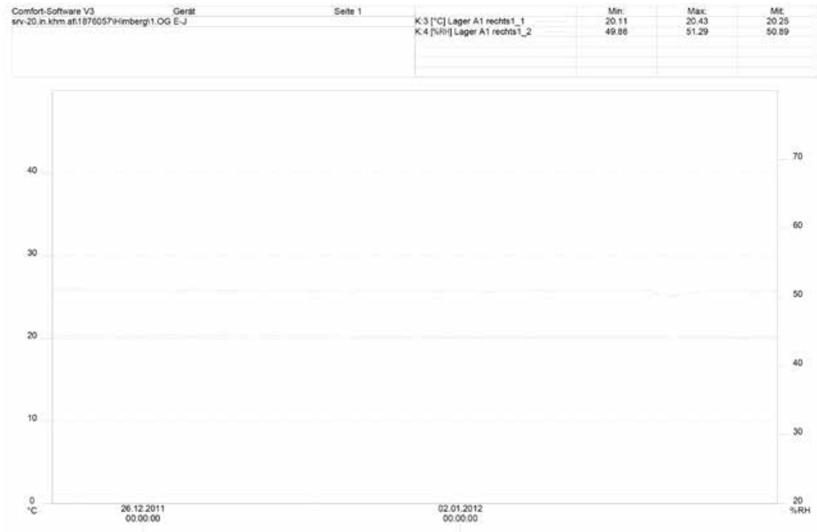


Fig. 6: The climate curve of the storage area on the first floor, Axis E–J, from December 24th, 2011 until the 8th of January, 2012. The stability of the chosen climate control design is confirmed by the constant temperature and relative humidity.

Fig. 7: The installation of intermediary steel platforms made it possible to optimise the use of the ceiling height.

11. FUTURE OPERATIONS

The energy cost for the entire building (lighting, elevator, all building services, anoxic nitrogen treatment chamber, etc.) are at the time of this writing 0.25 €/m^2 of floor space per month. This amount is low in comparison with other storage facilities. A plan for the installation of a photovoltaic system will be prepared by the end of 2012. In the future, this system will supply the base load of power, further lowering energy costs.

Through the provision of good climate conditions for the works of art while at the same time maintaining low building and operating costs, the KHM's new storage facility has already become a model of storage construction.

KEY FIGURES

- Land area: ca. 7,000 m^2
- Total floor space: ca. 14,000 m^2
- Building surface area: ca. 2,800 m^2
- Collection storage area: ca. 12,000 m^2
- Operational infrastructure including delivery area, workshops, offices, and equipment for pest management treatments: ca. 2,000 m^2
- Total cost of building without furnishings and equipment: ca. 8 million euros
- Construction time: 8 months

SUMMARY

During the construction of the new collections storage facility for the Kunsthistorisches Museum Vienna, attention was given to creating stable environmental conditions and optimal art storage while maintaining low building and operating costs and a short construction time.

This could all be realised within a planning and building phase of only 20 months in total through streamlined project structures and a largely modular construction method for the structure using premade elements. First experiences in the operational phase show that the ambitious goal could completely be achieved. The new KHM facility raises storage standards with its functional building.

ZUSAMMENFASSUNG

Beim Neubau des Zentraldepots des KHM lag das Augenmerk auf konstanten Klimawerten und optimaler Kunstlagerung, geringen Bau- und Betriebskosten sowie kurzer Bauzeit.

Das alles konnte durch schlanke Projektstrukturen sowie eine weitgehend vorgefertigte modulare Bauweise des Gebäudes in einer Planungs- und Bauphase von insgesamt nur 20 Monaten erzielt werden. Die ersten Erfahrungen in der Betriebsphase zeigen, dass die hoch gesteckten Ziele zur Gänze erreicht wurden. Dadurch setzt das neue Zentraldepot des Kunsthistorischen Museums Wien mit seinem funktionalen Bau neue Maßstäbe im Depotbereich.

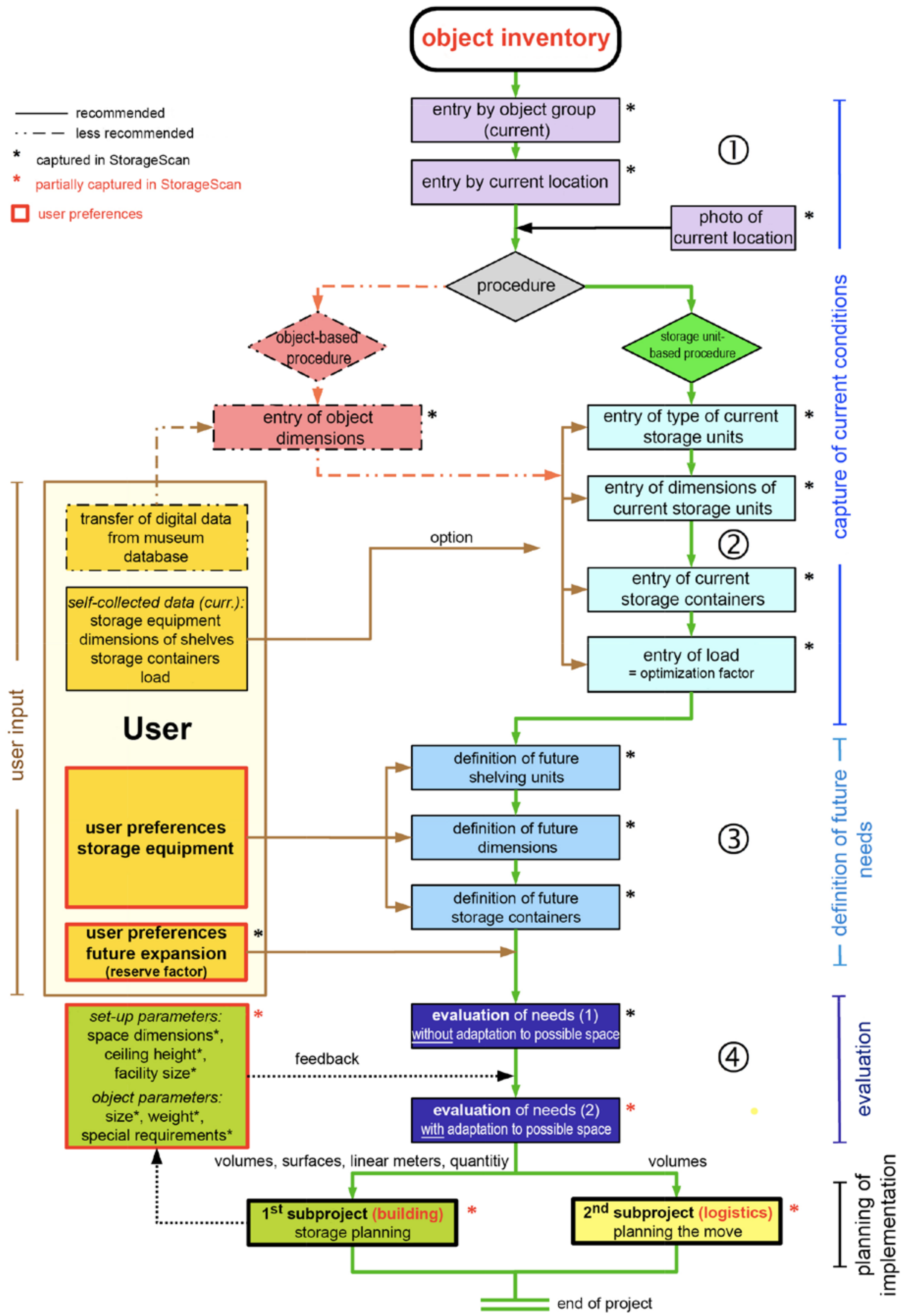


Fig. 1: Schematic representation of Prevart's quantity structure for storage planning and logistics.

Creating a Quantity Structure for Planning Storage Equipment in Museum Storage Areas

Joachim Huber

Translated from the German by Aimée Ducey-Gessner

1. INTRODUCTION

A "quantity structure" compiles data needed for the planning of storage equipment for a museum storage facility or archive. It encompasses, among other things, quantitative specifications of the storage equipment currently in use, its capacity, and the prospective storage needs of the collection. The compilation of a quantity structure is a complex task in today's world and is usually completed with the help of databases. Data contained in other systems, for example, in spreadsheets or museum databases, can be imported and analysed from diverse perspectives. The (new) compilation of data on site is, however, more efficient and effective. The space and volume required for an object is more important than its dimensions. When enough experience has already been gained, it is often easier to begin by estimating the inadequacies of the current storage equipment than to try to understand it from the frequently incomplete object data found in inventories and existing databases. It was common practice in the past, for example, to record the dimensions of a painting, but not its frame and hence the total space required for the composite object *(fig. 1)*.

The method presented here is based on ten years of experience in planning storage facilities for medium and large museums, in, for example, Zürich (Affoltern am Albis), Basel, Munich, Vienna, Berlin, Nuremberg, and Potsdam. The database has been continuously refined and adapted to increasing demands.

If from the outset, the data in a quantity structure – required primarily for the planning of the storage facility – has been acquired together with the associated storage equipment, climate, and security system data, then it serves also as an indicator (volume) for the planning and implementation of packing, transport, and storage of the collections.

2. DATA ACQUISITION

The data compiled and processed in a quantity structure encompasses many factors. The current situation and future needs are kept strictly separate; all of the steps processed during the compilation of a quantity structure are carried out in such a way that original data remains accessible: the initial situation can be reconstructed at any time.

The following case studies are based on StorageScan 15.20 (an application based on the Filemaker database that was developed over the last twelve years for the formulation of quantity structures; *fig. 2*).

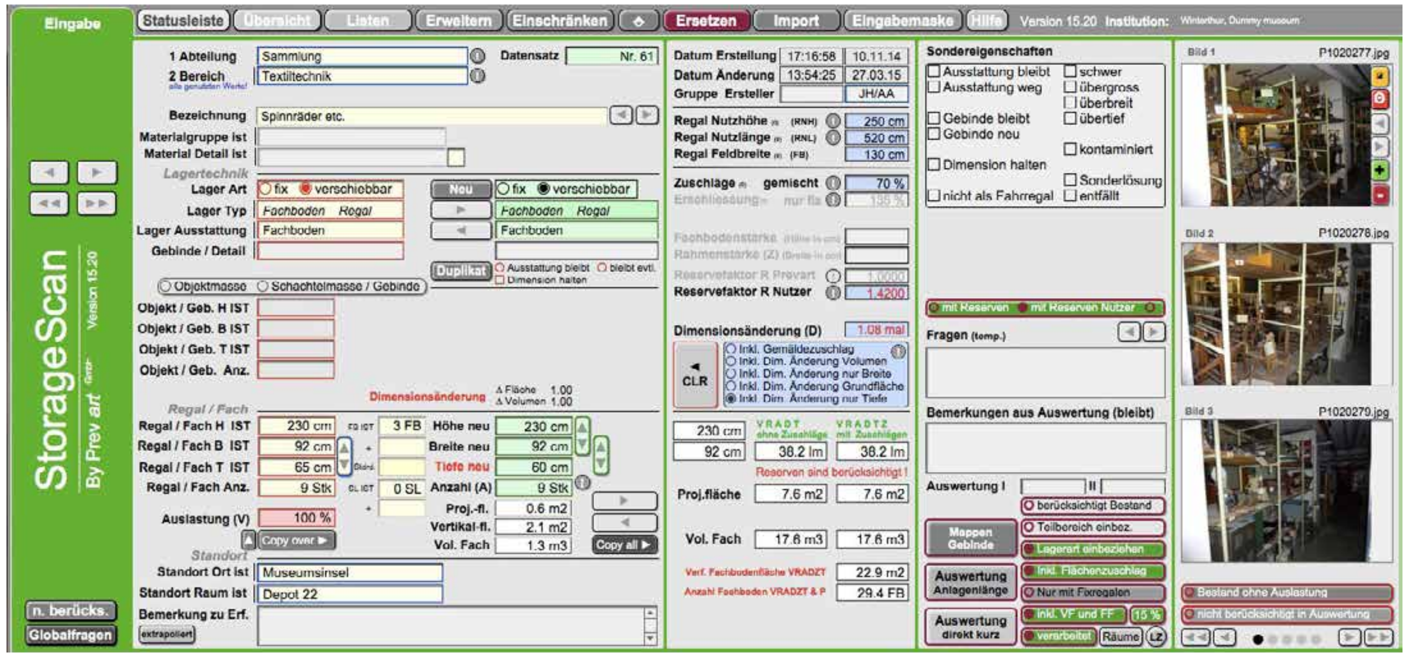


Fig. 2: Input screen in the database StorageScan 15.20.

2.1 CURRENT SITUATION (= ORIGINAL DATA)

- collections, their related subsections, and further subdivisions thereof;
- current location of existing storage equipment (possible here in two levels);
- type, model, and features of the existing storage equipment;
- type of equipment = fixed or movable units;
- equipment model: e.g., racks with standard shelves, wide span shelving units, cantilever racks, free standing units, pull-out storage panels for paintings, etc.
- variable features: fittings within the storage unit, like drawers, sliding shelves, clothes rails, etc.
- storage containers (independent of the storage equipment, e.g. stacking containers, pallets, hangers, costume boxes, folders, etc.) – this aspect is optional;
- dimensions of the existing storage equipment (e.g., shelves or pull-out panels) without any modifications; alternatively, the size of the objects can be recorded;
- currently used capacity of the existing storage equipment (E); how would the collections have to be stored in the future within the existing storage equipment such that they would be properly stored (i.e., meet accepted conservation standards) – the result is a percentage of the existing storage equipment, where a value over 100 % corresponds to the need for expansion and a value under 100 % corresponds to a possible contraction; here it must be noted that the specification of currently used capacity in this case has nothing to do with the space requirements resulting from future growth of the collection (reserve).

2.2 FUTURE SITUATION

- type, model, and features of the storage equipment required in the future (analogous to review of the existing equipment);
- size of the prospective storage equipment; here the shelf depth is particularly important because it is a primary criterion for standardisation (space requirements are usually determined by volume, by vertical surface area for paintings, by floor area for freestanding objects, movable platforms and cabinets);
- prospective storage containers (e.g., drawers, stacking containers, pallets, hangers, boxes, folders, etc.);
- prospective reserve needs (R) for accessions (reserve in % or as a coefficient; the reserve space needed is defined by estimates provided by the museum).

Further planning steps may include additional factors like weight, unusual dimensions, pest infestation, harmful substances, special climate requirements, security, etc. These factors have, however, a lower priority for the planning of the storage area. They enter into the discussions of the various collections and different departments, but do not need to be captured in detail at the level of the individual object.

3. DATA PREPARATION

The compiled raw data does not provide a systematic picture of the future storage equipment needs; current standards must be brought into the evaluation process (with respect to uniform shelving depth, for instance). Occasionally basic modifications are made to the storage of objects (one example is the switch from hanging costume storage to horizontal storage in boxes). Increased standardisation of storage is achieved with the data describing future needs, yet the original data always remains accessible. The empty space necessary surrounding an object in storage also has to be taken into consideration when collecting the objects' dimensions as basic data. The usefulness of every dataset must be assessed and if necessary adapted or corrected. In addition to a good understanding of the collections, this verification process necessitates a good understanding of the optimum storage equipment for specific groups of objects, the equipment available on the market, and possible customised solutions. About 80 – 90 % of the storage equipment needs of museums can be met by standardised solutions available on the market. For the remainder, adaptations of existing systems or specific, at times also complex, customised units are necessary.

3.1 TECHNICAL PARAMETERS

The so-called technical parameters enable, together with the collected data, the definition of concrete specifications for the type, model, features, and quantity of required storage equipment, taking into consideration site-specific conditions. These specifications (e.g., total linear meters or number of carriages for a mobile shelving unit) are also useful for architects and specialist planners during later planning phases.

Various assumptions must be considered in order to ensure that the compiled data is useful for the evaluation of a prospective construction project:

- prospective ceiling height (CH); as a rule of thumb, the maximum total height of the storage equipment equals the ceiling height minus 50 cm; free space above the storage units allows enough room for the necessary lighting and air conditioning systems;
- prospective useful height of shelving units (SUH); real useful height of storage units; for movable units, this is the height without the movable substructure (carriage); combined with the storage volume and shelving depth, the required shelving in linear meters can be determined according to the type of shelving unit;
- prospective useful length of shelving units (SUL); taking into consideration the storage volume, required shelving in linear meters, the

useful height of the shelving units and shelf depth, the number of shelving units and carriages in a movable unit can be determined depending on the shelving unit model;

- prospective width of shelves (SW); the approximate number of required individual shelves of any type (excluding the uppermost shelf, usually unused) can be deduced from the number of linear meters;
- prospective aisle width (AW) for fixed shelving units; the net storage area including aisles can be determined, taking into consideration the length of the shelving units and their access;
- supplement to the net storage area in % for aisles and transportation routes (TR); based on a standard grid (800 × 800 cm for pillars) and a standard room size, the necessary addition for aisles and transportation routes can be defined; it is directly dependent on the type and model of storage equipment.

If the modification of structural or technical prerequisites later require adjustments, these technical parameters can easily be updated in groups in the database.

3.2 ADDITIONS AND FACTORS

Specific factors are used within the database that allow non-standard data to be taken into consideration:

- M = multiplication factor (expressed as a percentage needed in excess of the actual situation); optimisation of the current storage configuration in order to achieve an acceptable conservation standard for storage in the future; this factor is captured during the inspection of the existing storage equipment;
- R = reserve for future accessions; this is usually assessed by area or in groups and delivered by museum staff;
- N = number of identical units, e.g., the same shelves, drawers, or cabinets; this simplifies data collection;
- S = supplemental information; the width of frames, shelves, and beams, if the clear dimensions of the storage equipment were recorded; this information is useful because it can improve the precision of the volume calculation, depending on how the data was captured;
- D = dimension modification; technical correction factor should the prospective storage equipment configuration's dimensions change markedly from the existing configuration, resulting in a distortion of the necessary surface area (e.g., of the individual shelves).

4. DATA EVALUATION

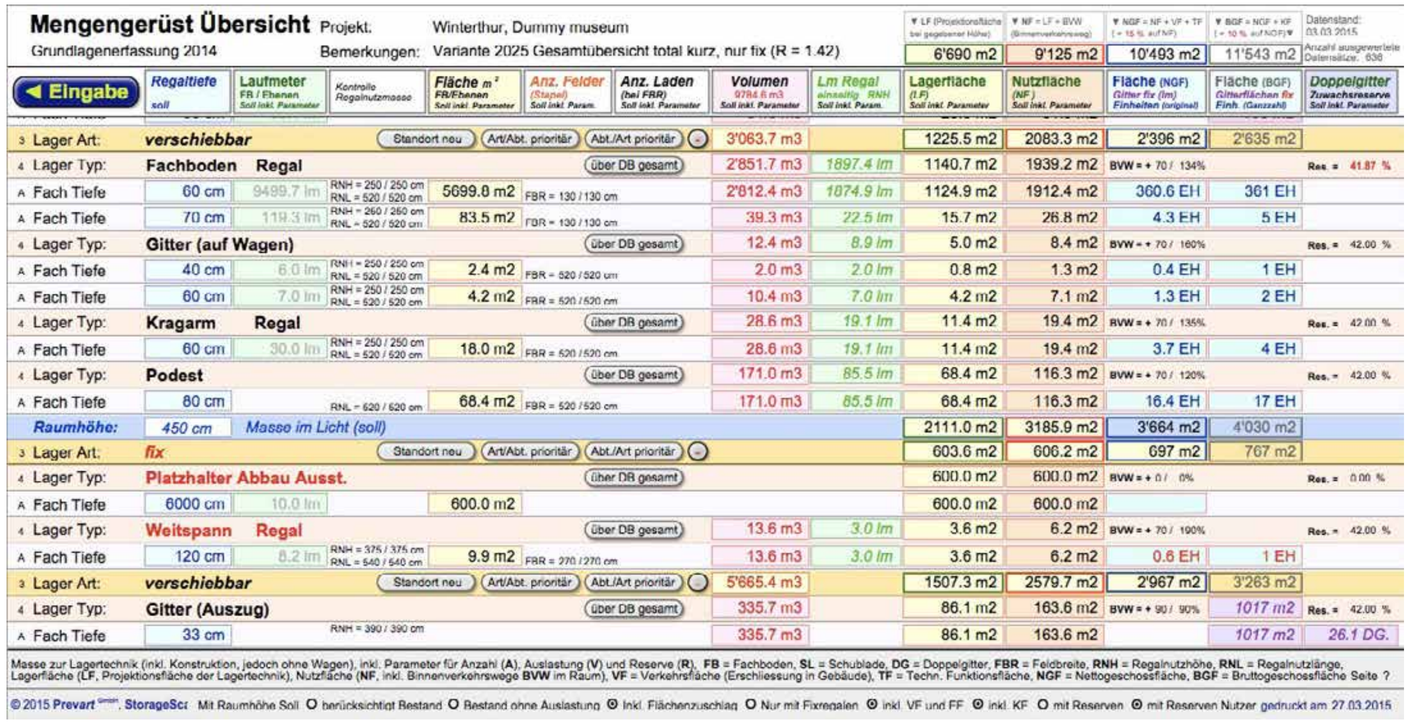
4.1 STRUCTURE OF THE EVALUATION

A default evaluation is possible that recognises department, sections, subsections, storage equipment model, features, and depth. At the least, section, storage equipment model (new) and depth (new) must be defined. Further divisions are possible that take into account the storage requirements based on a specific circumstance: climate, material (new), location (new), etc.

4.2 EXAMPLE OF EVALUATION IN THE STORAGESCAN 15.20 DATABASE *(FIG. 3)*

4.2.1 SHELF DEPTH

The depth (column: shelf or unit depth) normally designates the depth of a single shelf or shelving units, sliding metal mesh walls for paintings where the necessary distance between the axes of two walls is included.


Mengengerüst Übersicht Projekt: Winterthur, Dummy museum

Grundlagenerfassung 2014 Bemerkungen: Variante 2025 Gesamtübersicht total kurz, nur fix (R = 1.42)

▼ LF (Projektionsfläche bei gegebener Höhe): 6'690 m2 | ▼ NF = LF + BVW (Binnenverkehrsweg): 9'125 m2 | ▼ NGF = NF + VF + TF (+ 15 % auf NF): 10'493 m2 | ▼ BGF = NGF + KF (+ 10 % auf NGF): 11'543 m2 | Datenstand: 03.03.2015, Anzahl ausgewertete Datensätze: 636

◀ Eingabe	Regaltiefe soll	Laufmeter FB / Ebenen Soll inkl. Parameter	Kontrolle Regalnutzmasse	Fläche m² FB/Ebenen Soll inkl. Parameter	Anz. Felder (Stapel) Soll inkl. Param.	Anz. Laden (bei FBR) Soll inkl. Parameter	Volumen 9784.6 m3 Soll inkl. Parameter	Lm Regal einseitig RNH Soll inkl. Param.	Lagerfläche (LF) Soll inkl. Parameter	Nutzfläche (NF) Soll inkl. Parameter	Fläche (NGF) Gitter fix (lm) Einheiten (original)	Fläche (BGF) Gitterflächen fix Einh. (Ganzzahl)	Doppelgitter Zuwachsreserve Soll inkl. Parameter
3 Lager Art:	verschiebbar				Standort neu / Art/Abt. prioritär	Abt./Art prioritär	3'063.7 m3		1225.5 m2	2083.3 m2	2'396 m2	2'635 m2	
4 Lager Typ:	Fachboden Regal					über DB gesamt	2'851.7 m3	1897.4 lm	1140.7 m2	1939.2 m2	BVW = + 70 / 134%		Res. = 41.87 %
A Fach Tiefe	60 cm	9499.7 lm	RNH = 250 / 250 cm RNL = 520 / 520 cm	5699.8 m2	FBR = 130 / 130 cm		2'812.4 m3	1874.9 lm	1124.9 m2	1912.4 m2	360.6 EH	361 EH	
A Fach Tiefe	70 cm	119.3 lm	RNH = 260 / 260 cm RNL = 520 / 520 cm	83.5 m2	FBR = 130 / 130 cm		39.3 m3	22.5 lm	15.7 m2	26.8 m2	4.3 EH	5 EH	
4 Lager Typ:	Gitter (auf Wagen)					über DB gesamt	12.4 m3	8.9 lm	5.0 m2	8.4 m2	BVW = + 70 / 160%		Res. = 42.00 %
A Fach Tiefe	40 cm	6.0 lm	RNH = 250 / 250 cm RNL = 520 / 520 cm	2.4 m2	FBR = 520 / 520 cm		2.0 m3	2.0 lm	0.8 m2	1.3 m2	0.4 EH	1 EH	
A Fach Tiefe	60 cm	7.0 lm	RNH = 250 / 250 cm RNL = 520 / 520 cm	4.2 m2	FBR = 520 / 520 cm		10.4 m3	7.0 lm	4.2 m2	7.1 m2	1.3 EH	2 EH	
4 Lager Typ:	Kragarm Regal					über DB gesamt	28.6 m3	19.1 lm	11.4 m2	19.4 m2	BVW = + 70 / 135%		Res. = 42.00 %
A Fach Tiefe	60 cm	30.0 lm	RNH = 250 / 250 cm RNL = 520 / 520 cm	18.0 m2	FBR = 520 / 520 cm		28.6 m3	19.1 lm	11.4 m2	19.4 m2	3.7 EH	4 EH	
4 Lager Typ:	Podest					über DB gesamt	171.0 m3	85.5 lm	68.4 m2	116.3 m2	BVW = + 70 / 120%		Res. = 42.00 %
A Fach Tiefe	80 cm		RNL = 620 / 620 cm	68.4 m2	FBR = 520 / 520 cm		171.0 m3	85.5 lm	68.4 m2	116.3 m2	16.4 EH	17 EH	
Raumhöhe:	450 cm	Masse im Licht (soll)							2111.0 m2	3185.9 m2	3'664 m2	4'030 m2	
3 Lager Art:	fix				Standort neu / Art/Abt. prioritär	Abt./Art prioritär			603.6 m2	606.2 m2	697 m2	767 m2	
4 Lager Typ:	Platzhalter Abbau Ausst.					über DB gesamt			600.0 m2	600.0 m2	BVW = + 0 / 0%		Res. = 0.00 %
A Fach Tiefe	6000 cm	10.0 lm		600.0 m2					600.0 m2	600.0 m2			
4 Lager Typ:	Weitspann Regal					über DB gesamt	13.6 m3	3.0 lm	3.6 m2	6.2 m2	BVW = + 70 / 190%		Res. = 42.00 %
A Fach Tiefe	120 cm	8.2 lm	RNH = 375 / 375 cm RNL = 540 / 540 cm	9.9 m2	FBR = 270 / 270 cm		13.6 m3	3.0 lm	3.6 m2	6.2 m2	0.6 EH	1 EH	
3 Lager Art:	verschiebbar				Standort neu / Art/Abt. prioritär	Abt./Art prioritär	5'665.4 m3		1507.3 m2	2579.7 m2	2'967 m2	3'263 m2	
4 Lager Typ:	Gitter (Auszug)					über DB gesamt	335.7 m3		86.1 m2	163.6 m2	BVW = + 90 / 90%	1017 m2	Res. = 42.00 %
A Fach Tiefe	33 cm		RNH = 390 / 390 cm				335.7 m3		86.1 m2	163.6 m2		1017 m2	26.1 DG.

Masse zur Lagertechnik (inkl. Konstruktion, jedoch ohne Wagen), inkl. Parameter für Anzahl (**A**), Auslastung (**V**) und Reserve (**R**), **FB** = Fachboden, **SL** = Schublade, **DG** = Doppelgitter, **FBR** = Feldbreite, **RNH** = Regalnutzhöhe, **RNL** = Regalnutzlänge, Lagerfläche (**LF**, Projektionsfläche der Lagertechnik), Nutzfläche (**NF**, inkl. Binnenverkehrswege **BVW** im Raum), **VF** = Verkehrsfläche (Erschliessung in Gebäude), **TF** = Techn. Funktionsfläche, **NGF** = Nettogeschossfläche, **BGF** = Bruttogeschossfläche Seite ?

© 2015 Prevart GmbH, StorageSc: Mit Raumhöhe Soll O berücksichtigt Bestand O Bestand ohne Auslastung ⦿ Inkl. Flächenzuschlag O Nur mit Fixregalen ⦿ inkl. VF und FF ⦿ inkl. KF O mit Reserven ⦿ mit Reserven Nutzer gedruckt am 27.03.2015

Fig. 3: Example of Evaluation in the Database StorageScan 15.20.

4.2.2 LINEAR METERS OF INDIVIDUAL SHELVES

The evaluation results in the number of linear meters of shelving required of a specific type (depth).

4.2.3 CONTROL OF SHELF PARAMETERS (HEIGHT/WIDTH)

From the volume, useful height of shelving units, shelf depth, and shelf width, the number of units required can be calculated.

4.2.4 NUMBER OF DRAWERS

Drawers can also be calculated instead of shelves.

4.2.5 VOLUME

The required volume of storage equipment is revealed by the compiled data, structured according to the storage equipment model. The volume designates gross volume including frames, shelves/beams, etc. Volume is not meaningful for freestanding objects and those installed on platforms, for which floor space is the main concern.

4.2.6 LINEAR METERS OF SHELVING UNITS, ONE-SIDED

The number of linear meters of a specific type of shelving unit can be elicited from the volume by means of the stated prospective dimensions of the storage equipment and the parameter "useful shelving unit height".

4.2.7 NET AREA

Projected area used by storage equipment without access to shelves and connected transportation routes.

4.2.8 NET FLOOR AREA
Total required storage surface area within the storage (size of room including access and transportation routes).

4.2.9 GROSS FLOOR AREA
Total surface required including also access to the single rooms as well as technical areas.

4.2.10 UNITS
Application of the parameters "shelving unit depth," "useful height," and "useful length" can deduce the number of shelving units and individual carriages for movable storage shelving systems. This value provides the number of fixed shelving units.

4.2.11 METAL MESH WALLS FOR HANGING STORAGE, ONE-SIDED
The surface area of the metal mesh designates the necessary vertical surface area in m^2.

4.2.12 NUMBER OF METAL MESH WALLS (DOUBLE WALLS)
For paintings storage, the height and width of the wall determines the number of units needed based on the vertical area of the (double-sided) wall.

5. QUANTITY STRUCTURE FINDINGS: FURTHER PROCESSING

The data produced by the quantity structure enables the definition of net and gross floor space needed and preparation of the tender for the storage equipment needed. In addition, the office, workshop, technical, and other functional spaces must be accounted for when determining the spatial arrangement of the entire project.

The gross floor area associated with the definition of ceiling height and size of individual storage compartments provide the most comprehensive information to manage a storage facility project.

The database's advantage is that information can be compiled, organised, and evaluated quickly. The use of parameters enables very rapid reaction to new circumstances that arise during the course of the planning process (e.g., modified ceiling heights or column grids) and efficiently determines the resulting impact on the space needed for the storage equipment.

6. REQUIREMENTS OF THE KHM'S NEW CENTRAL STORAGE FACILITY

In the specific case of the Kunsthistorisches Museum Vienna, the quantity structure was compiled on site by two people in five storage locations during two concentrated campaigns lasting several days. The information in the museum database, and provided by the curators and conservators, could be referred to only for the paintings collection, the tapestries (at that time still folded up), and the objects from the Court Wardrobe. The detailed evaluation and standardisation of the collected data sets was carried out over several days. The different types of required storage equipment were ascertained from the evaluated quantity structure and this was aligned with construction conditions (room dimensions, climatic requirements, etc.). From this, the allocation of the rooms and the tender issued in compliance with the World Trade Organisation for storage equipment was generated. The latter was carried out in several discrete propositions, in order to find the best suited supplier for each type of storage equipment.

SUMMARY

A so-called quantity structure is a basic tool for estimating storage needs in a museum. The often highly varied collections cannot, as a rule, be evaluated through inventories in such a way as to provide reliable information on space requirements. With the method presented here for creating a quantity structure, existing storage conditions are systematically collected on-site in a database and supplemented by information on storage systems, optimisation needs, reserves, traffic patterns, room for handling, and other requisites. The analysis of the data allows an estimation of the future surface and volume requirements for the storage of the objects, and the planning of the necessary repositories with the associated storage systems. Ideally, the quantity structure can also serve as the basis for bidding on storage systems. It is sometimes also possible to use the information collected in planning the later move of the objects.

ZUSAMMENFASSUNG

Ein sogenanntes Mengengerüst ist ein grundlegendes Hilfsmittel zur Abschätzung des Lagerbedarfs in einem Museum. Die zum Teil äußerst vielfältigen Sammlungsbestände sind in der Regel nicht auf eine solche Weise über Inventare erschlossen, dass sich daraus verlässliche Angaben zu Platz- und Raumbedarf ergeben könnten. Mit der hier vorgestellten Methode der Mengengerüsterhebung wird der lagertechnische Ist-Zustand systematisch vor Ort in einer Datenbank erhoben und um Angaben zu Lagertechnik, lagertechnischem Optimierungsbedarf, Reserven, Verkehrswege, Manipulationsraum sowie weiteren Anforderungen ergänzt. Die Auswertung der Daten ermöglicht die Abschätzung des zukünftigen Platz- und Volumenbedarfs für die Lagerung der Objekte sowie die Planung der erforderlichen Depots mit der dazugehörigen Lagertechnik. Im optimalen Fall kann das Mengengerüst auch als Grundlage zur Ausschreibung der Lagertechnik dienen. Zudem ist es möglich, die erhobenen Informationen teilweise auch zur Planung der späteren Objektübersiedelung zu nutzen.

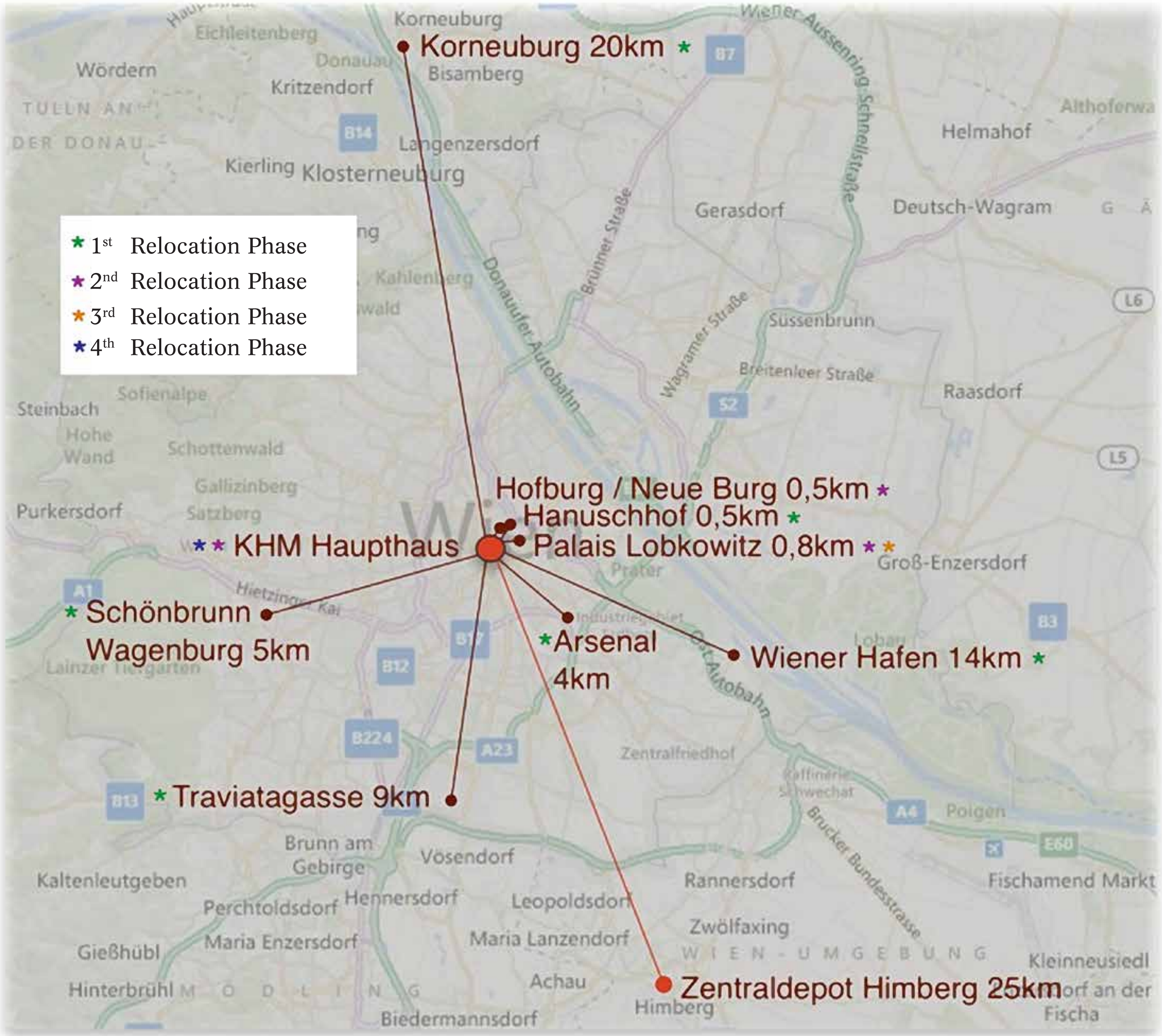


Fig. 1: Image of the old and new storage locations and their relocation phases 1 to 4, designated by colour.

Relocation of the Collections of the Kunsthistorisches Museum Vienna to the New Central Storage Facility

Preparation, Planning, and Implementation

Christina Schaaf-Fundneider and Tanja Kimmel

Translated from the German by Aimée Ducey-Gessner

1. CENTRAL STORAGE FACILITY PROJECT

The relocation of works of art requires thorough preparation. The Kunsthistorisches Museum Vienna can adamantly confirm this: around one million objects were relocated to its newly built central storage facility.

Upon his appointment as chief financial officer in 2007, Dr. Paul Frey was requested by the board of trustees of the Kunsthistorisches Museum, along with the Weltmuseum Wien and the Theatre Museum, to initiate the planning for a new storage facility. In 2008, the first collections' surveys were taken into consideration while evaluating already existing proposals for a storage facility as well as new approaches to its development. In September 2009, the decision was made to erect a new storage facility owned by the Kunsthistorisches Museum with its affiliated institutions. This meant that the objects in storage, originating from 12 collections and archives, were to be united in a newly-constructed central location. Up until that time, these objects had been stored in nine different locations in Vienna and the surrounding area *(fig. 1)*. The premises were, for the most part, outdated and in need of renovation. Obsolete technical infrastructure, poor climate conditions and high rental costs favoured relocation of the collections to a new storage facility. The combined need for improved conservation conditions along with more efficient operational and business management, yielded an urgent call for action.

Targets set by the museum's management necessitated the move of collections housed in "external" storage areas (six of the total of nine old storage locations) to the new central facility by the end of 2011. Collections stored in-house would follow in 2012 and 2013. Around one million artworks were to be deposited in their new, up-to-date, centralised storage space by the end of the first quarter of 2013, at the latest. As a result, a total of 16 months remained for the planning and preparatory phases, and 14 months for the at times simultaneously occurring relocation phase. The strict schedule along with the deadline for clearance of the old rented storage areas were primarily cost-saving measures.

The museum's management stipulated that this major project was to be executed alongside the day-to-day operation of the museum, requiring that strain on staff members be relieved by establishing some fundamental prerequisites. These included: substantial capital investment, the development and acquisition of specialised expertise, additional personnel, and the creation of an appropriate project structure. The last condition was met with the formation of two project teams "New Storage Facility: Construction and Relocation" at the beginning of 2010. Strict adherence to the specified maximum spending budget of 14 million euros[1] was a further requirement in addition to the emptying of all rented storage areas by the end of 2011.

The first essential preparations took place between the end of 2009 and the beginning of 2010. During this time, all collections' surveys were completed, which, together with the compilation of the quantitative framework by the external museum consultant Dr. Joachim Huber (Prevart GmbH), outlined the specifications for the new facility. The property search and an EU-wide call for proposals for the architectural design took place at the same time.

2. RELOCATION TEAM

A relocation team *(fig. 2)* with six permanent members was created alongside the construction team led by Stefan Fleck. Dr. Alfred Bernhard-Walcher was appointed project manager of the relocation team. The conservators Christina Schaaf-Fundneider and Tanja Kimmel represented the conservation needs of the collections. Stefan Fleck was responsible for building management and Dr. Joachim Huber (Prevart GmbH) acted as museum consultant; Martin Dorfmann (DP-art) was put in charge of operations for the relocation. Furthermore, additional staff members could be called in as needed. Each collection had a designated contact person, as well as security management, the IT department, administration of the museum database, and the registrars. At times, the relocation team consisted of up to 15 people.

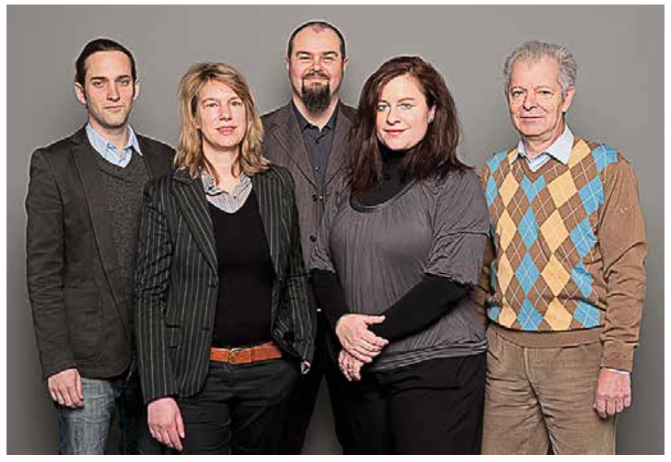


Fig. 2: Stefan Fleck, Tanja Kimmel, Martin Dorfmann, Christina Schaaf-Fundneider, Alfred Bernhard-Walcher, relocation project team.

3. PLANNING AND PREPARATION FOR RELOCATION

Four essential tools were necessary for establishing a structured approach to the relocation, its planning and preparation.

3.1 CATALOGUE OF QUESTIONS, SITE INSPECTIONS, AND COMPILATION OF THE QUANTITATIVE FRAMEWORK

The relocation team generated a catalogue of questions at the beginning of 2010 that helped the collections compile the information necessary for the move of their artworks. Included in this was, along with the number of objects to be moved, their condition and readiness for transport, as well as their dimensions and weight. Furthermore, information about possible pest and mould infestation of the collections' objects was requested. These systematic "inventories" allowed for a comprehensive and thorough inspection of the collections, which is often not possible as part of the daily operating routine. Taking into consideration ongoing projects (planned exhibitions, research projects, etc.) and the staffing of the collections, the cost of the relocation could finally be calculated. The catalogue of questions also permitted the preparation of an approximate schedule, which was helpful for estimating the necessary preparations and allocation of external personnel *(fig. 3)*. Afterwards, the relocation team undertook numerous inspections of the various locations, together with the responsible curators and conservators, establishing the final schedule.

The catalogue of questions proved to be a fundamental tool for project management, in combination with the inspections carried out by the museum consultant Dr. Joachim Huber (Prevart GmbH). With his help, it was possible to achieve a comprehensive overview of the relocation project: from its timing, planning the necessary preparatory phases and their organisation, determining personnel costs and staff allocation, to estimating the materials needed. In addition, the catalogue of questions contributed time and again essential information for budget planning and cost control. It also served as a basis for the solicitation of bids from the art moving companies.

3.2 INTEGRATED PEST MANAGEMENT

While the catalogue of questions was being completed and the collection surveys were underway, a further important tool for preparation for the move was implemented: an integrated pest management (IPM) program realised in-house according to the latest standards in the field.

The necessity of pest monitoring was made clear by the numerous on-site inspections and control rounds in all of the storage locations, as well as countless conversations with collections personnel (curators and conservators). During inspections some dead and some living insect pests were found, along with acute mould infestation.

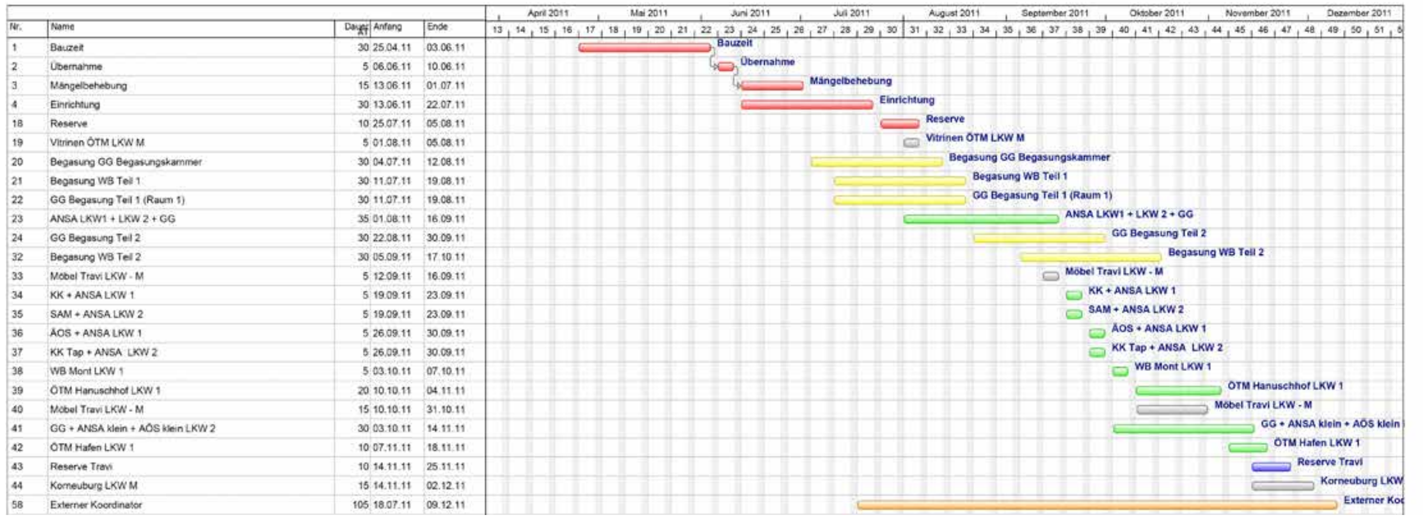


Fig. 3: Example of planning for the initial relocation schedule.

[1] The total budget of 14 million euros for the project *New Storage* was divided as follows: building: 8 million; move: 2 million; technical facilities: 1.7 million; object handling and equipment: 2.3 million.

Fig. 4: The conservator Eva Götz and an employee of the company Füreder bringing objects into the nitrogen tent in the storage facility in Inzersdorf.

Fig. 5: Nitrogen tent for anoxic nitrogen treatment of the carriages from the Imperial Carriage Museum.

IPM was established for all collections and in all of the storage locations that were to be relocated during the first quarter of 2010, and was continually in use until the last collections were moved in 2013. It was included as a measure of preventive conservation in the new central storage facility. Dr. Pascal Querner, a biologist specialising in pest management from the University of Natural Resources and Life Sciences, Vienna, was engaged to lead the IPM project. He had already been caring for individual collections, like the Imperial Carriage Museum and the Court Wardrobe, since 2000.

Identification of affected collections and all pests as well as carrying out the appropriate treatments prior to the move, were the goals of the pest monitoring program. Proper implementation of pest monitoring required first the cleaning of all storage locations. In a lecture given to the museum staff, Dr. Querner made them aware of these issues and presented the results of the monitoring program set up. The results of over three years of pest monitoring also served as a basis for budget planning and as an argument for the necessity of building additional tents for anoxic nitrogen treatment on-site with the goal of meeting the tight deadlines requested by museum management.

Pest monitoring uncovered an acute infestation of the biscuit beetles *(Stegobium paniceum)* in the storage areas of the Picture Gallery. It was initially contained through the introduction of parasitoid wasps – at the time a new method in museums. This hindered additional damage to the original paintings and glue/paste linings by the beetles.

Clothing moth infestations were apparent in various storage locations, damaging not only the costumes, but also the textile interiors of carriages. Furthermore, suspected infestation of historic exhibition mounts, furniture, and theatre props by wood-boring insects required the preventive treatment of the affected objects. Since the in-house anoxic nitrogen treatment chamber was already filled to capacity, additional non-toxic treatment remedies needed to be found.

Fig. 6: Sampling of a painting contaminated with mould.

As a result, the paintings and decorative frames from the Picture Gallery were treated with nitrogen by the company Singer in a plastic tent in the old storage area *(fig. 4);* affected objects from the Imperial Carriage Museum were also treated on-site in two nitrogen tents *(fig. 5)*.

3.3 MOULD REMEDIATION

A similar procedure was carried out for the objects and collections contaminated with mould: an external team of specialists (Dr. Katja Sterflinger, Christian Voitl, University of Natural Resources and Life Sciences, Vienna) conducted the sampling and measurement of airborne spores in the test areas during inspection *(fig. 6)*. Based on the results of the analysis, strict occupational safety requirements and handling procedures were defined and implemented for the affected groups of objects.

Since October 2011, sanitation and mould remediation of the objects from the Theatre Museum as well as the Egyptian and Near Eastern Collection have been in progress. External personnel and collection conservators are working together on this project. Thanks to an investment of almost 70,000 euros, around 6,300 objects (clay pots, omnibus volumes of potsherds, and organic objects) from the Egyptian and Near Eastern Collection could be cleaned, along with 500 theatre models, 300 marionettes, and around 300 costumes and accessories.

4. LOGISTICS

4.1 OVERVIEW OF THE COLLECTIONS AND ARCHIVES OF THE KHM SUBJECT IN PART TO RELOCATION

- Egyptian and Near Eastern Collection (ÄOS)
- Collection of Greek and Roman Antiquities (ANSA)
- Picture Gallery (GG)
- Kunstkammer (KK) and Kunstkammer-Tapestries (KK-Tap.)
- Coin Collection (MK)
- Museum Library (Bibl.)
- Collection of Historic Musical Instruments (SAM)
- Imperial Carriage Museum and Court Wardrobe (WB/MD)
- Archive
- Photo Archive (FA)
- Theatre Museum (ÖTM)
- general objects (historic/new museum showcases, room dividers, furnishings, museum shop merchandise)

4.2 OVERVIEW OF THE FIRST RELOCATION PHASE

- timeframe: August 1st to November 22nd, 2011
- closure of old storage facilities: Inzersdorf, Vienna Harbour, Arsenal, Hanuschhof, Korneuburg, Imperial Carriage Museum Schönbrunn *(see fig. 1)*
- groups of inventory objects from different collections (ANSA, ÄOS, GG, KK, KK-Tap., SAM, WB/MD, ÖTM, general objects [museum shop merchandise, historic and new showcases]) *(fig. 7)*
- 345 truck shipments in 17 weeks

Fig. 7: Employees from the company Kunsttrans preparing theatre models and costumes contaminated with mould.

4.3 OVERVIEW OF THE SECOND RELOCATION PHASE

- timeframe: April 16th to July 6th, 2012
- clearance and closure of the old storage facilities: KHM main building, Hofburg, Neue Burg, Palais Lobkowitz *(see fig. 1)*
- groups of inventory objects from four collections (ÄOS, MD, MK, ÖTM) *(fig. 8)* as well as FA, Archive and Library
- 41 truck shipments in 12 weeks

4.4 OVERVIEW OF THE THIRD RELOCATION PHASE

- timeframe: September 10th to 14th, 2012
- clearance and closure of unsuitable storage areas in the Palais Lobkowitz *(see fig. 1)*
- inventory objects from the Theatre Museum *(fig. 9)*
- 13 truck shipments in one week

4.5 OVERVIEW OF THE FOURTH RELOCATION PHASE

- planned timeframe: middle of May to end of June 2013
- clearance and closure of unsuitable storage spaces in the main building of the KHM *(see fig. 1)*
- groups of inventory objects from four collections (ÄOS, GG, KK, MK) *(fig. 10)*

4.6 NUMBER OF OBJECTS MOVED AND TIMING OF THE RELOCATION PHASES AND THEIR PREPARATION

4.6.1 EGYPTIAN AND NEAR EASTERN COLLECTION

- 115 stone objects on pallets, 30 pallets with crates (clay pots and potsherds) *(fig. 11)*
- three museum conservators and two external conservators were employed alternately and sometimes together over 11 months; the two external conservators did the mould remediation of contaminated objects *(fig. 12)* and two temporary workers helped on a weekly basis packing the objects
- 32 truck shipments in five days

Fig. 8: Library collection in the old storage location in the main building of the KHM.

Fig. 9: Theatre Museum collections in the old storage location in the Palais Lobkowitz.

Fig. 10: Objects from the Coin Collection in the old storage location in the main building of the KHM.

Fig. 11: Inzersdorf storage facility, storage area for the Egyptian and Near Eastern Collection.

Fig. 12: Freelance conservator completing mould remediation on a contaminated object.

Fig. 13: Inzersdorf storage facility, storage area for the Collection of Greek and Roman Antiquities.

4.6.2 COLLECTION OF GREEK AND ROMAN ANTIQUITIES

- 16,000 objects on 1,800 transport and storage pallets, 300 customised pallets, as well as in 50 crates and 450 pallet boxes *(fig. 13)*
- objects with a total weight of 420 metric tons
- three conservators, one registrar, and two student interns were employed alternately and sometimes together for over half a year and two temporary workers on a weekly basis for the packing of the objects
- 148 truck shipments in 14 weeks *(see fig. 29)*

4.6.3 PICTURE GALLERY

- until now 2,100 paintings and 500 decorative frames *(fig. 14)* in 67 mobile storage units for heavy loads and 70 palettes with stacking frames *(fig. 15)*
- over 10 months, four conservators, two students, and one registrar were employed along with two temporary workers on a weekly basis for the packing of the objects
- 50 truck shipments in 3.5 weeks
- two special shipments in one day

Fig. 14: External conservators preparing a decorative frame from the Picture Gallery.

Fig. 15: Loading the anoxic nitrogen tent in the old storage facility with packed Corlette storage racks and ÖBB stackable crates on Euro-pallets. (©: www.prevart.ch.)

Fig. 16: The conservator Tanja Kimmel preparing the packing of small arms from the Court Wardrobe for transport.

Fig. 17: Packed objects ready for transport in the old storage location.

Fig. 18: The conservator Ernst Gregor preparing a coach for transport.

4.6.4 COURT WARDROBE

- a total of 4,100 objects in the Inzersdorf and Hofburg storage facilities (liveries of court servants including accessories, women's gowns and accessories, mannequins, and other exhibition mounts, all robes and accessories of the Habsburg's knightly orders, historic trunks and chests)
- 48 stacked drawers on pallets *(fig. 16)*, 55 pallets with stacking frames, 56 flat textile storage boxes, 15 rolling clothes racks, trunks and chests (loose)
- Inzersdorf: two conservators were employed for half a year, in addition two temporary workers on a weekly basis; Hofburg: two conservators, one curator, six art packers, one temporary worker
- 21 truck shipments in a total of five days *(fig. 17)*

4.6.5 IMPERIAL CARRIAGE MUSEUM

- a total of 220 objects, including coaches and sleighs, caparisons, children's musical instruments, horse models, and other exhibition mounts, horse-gear furnishings, saddle stands
- one conservator was time and again occupied with the preparations over half a year *(fig. 18 and see fig. 5);* two temporary workers were additionally employed on a weekly basis
- move: three conservators, one curator, four art packers
- four truck shipments in two days

Fig. 19 a

Fig. 19 b

Inzersdorf storage facility, storage area for the Kunstkammer (left) and the Kunstkammer-Tapestries (right).

Fig. 20: Inzersdorf storage facility, objects from the Collection of Historic Musical Instruments.

Fig. 21 a

Fig. 21 b

Objects from the Theatre Museum in the old storage location.

4.6.6 KUNSTKAMMER AND KUNSTKAMMER-TAPESTRIES

- relocation of around 1,200 objects *(fig. 19)*
- 658 flat textile storage boxes (10 pcs. stacked on top of one another on customised pallets, with a total of 658 objects) as well as 52 already rolled-up tapestries
- 200 stone objects (busts, columns, tabletops, etc.)
- 20 pieces of furniture, five paintings, candelabra, etc.

4.6.7 COLLECTION OF HISTORIC MUSICAL INSTRUMENTS

- 87 historic musical instruments *(fig. 20)* as well as around 50 piano rolls, various piano components (dampers, etc.) music racks, organ stops and many other small pieces
- two conservators and two temporary workers were employed over three weeks with the preparation of the objects
- 14 truck shipments in three days

4.6.8 THEATRE MUSEUM

- relocation of 2,630 objects (1,000 theatre models, 700 costumes, 80 cases with around 400 props, stage pieces, 50 pieces of furniture, 300 paintings and framed works on paper, 300 marionettes) *(fig. 21)*

Fig. 22: Director Alram inspecting objects in the Coin Collection in the old storage location in the main building of the KHM.

- 311 linear meters of pallet-ready file boxes with bequests and the photo archive
- 317 pallet-ready boxes with duplicates of theatre documents and bequests
- four conservators, two temporary workers, occasionally together or separately on a weekly basis over the period of one year; the paintings were prepared by the paintings conservators of the KHM
- seven external conservators for mould remediation of contaminated objects over the period of two years
- 60 truck shipments in 19 days

4.6.9 COIN COLLECTION

- relocation of around 1,000 objects (antique lead seals, primitive money, collections of medals, electroplated medals, wax and plaster models, plaster sculptures, relief images, archaeological vessels) *(figs. 22 and 23)*
- preparation: three conservators, two art packers over five months
- move: one conservator, four art packers over two weeks
- until now: eight truck shipments over two weeks

Fig. 23: Objects from the Coin Collection in the old storage location in the main building of the KHM.

4.6.10 TRANSPORT VEHICLES

- 123 accounting units with two 7.5 ton trucks and a scenery truck *(fig. 24)*
- 248 object shipments
- two shipments with Art for Art scenery truck (oversized paintings)
- until the middle of October 2011: two art transport trucks, each 18 tons, with additional tandem trailer as needed
- from the middle of October until the end of January: one art transport truck, 18 tons
- from 2012: one small art transport truck, 7.5 tons
- general objects: moving company, ca. 40 shipments with showcases and exhibition mounts

4.6.11 ART HANDLING/MANPOWER

- teams of 1–4 art packers and 2–8 temporary workers *(fig. 25)*
- one driver for each truck
- total working hours: 1,900 hours packing, 3,900 hours temporary workers

Fig. 24: Scenery truck from the company Art for Art. (© Matthias Müller.)

Fig. 25: Employees from the company Kunsttrans moving objects from the Collection of Greek and Roman Antiquities with pallet trucks.

5. PACKING MATERIALS AND PREPARATION FOR TRANSPORT

Planning a move is a complex matter and the preparations must be started early. “Experience has shown that the preparatory work exceeds the time and effort capabilities of existing resources. Some aspects of the move require the recruitment and training of additional personnel or outsourcing with external employees.”[2]

Cost-effective and straightforward solutions that allow for safe handling under the given circumstances during the move of a large number of objects must be found. Planning the move of large groups of objects is to be distinguished fundamentally from the packing of individual objects for a couriered transport of loaned artworks.[3] In practice, the following procedures are essential:

Fig. 26: *PIM-our person in the museum,* Prevart GmbH, taken from J. Huber – K. von Lerber, *Handhabung und Lagerung von mobilem Kulturgut – Ein Handbuch für Museen, kirchliche Institutionen, Sammler und Archive,* Bielefeld, 2003, p. 65.

Strategy 1: Employ the use of transport containers and prepare the objects to be moved well in advance so that they can be transported with a pallet truck or forklift *(see fig. 25)*. Manoeuvring individual objects by hand, as shown in *fig. 26,* is not expedient.

Strategy 2: Develop standardised packing methods for around 95 % of the objects to be moved! The methods must not only guarantee safe transport, but also be cost-effective, efficient and appropriate for use as often as possible throughout the entire collection *(table 1)*. This takes into account the economics and ecology of the move. Appropriate packing methods and stabilisation of the objects for transport facilitate efficient handling of cargo, leading to reduced standing time for the moving vehicles.

In order to prevent exposure of the objects to harmful substances in the packing materials, all materials that were to come into direct contact with them were tested for the emission of pollutants with an Oddy-test during the planning phase.[4] With a few exceptions only the materials that caused no corrosion of the silver, lead and copper test strips during the Oddy-test were used and consequently designated for the different object types. Afterwards, the relocation team processed the orders for materials, devices and additional supplies, at the same time tracking the costs and their impact on the budget and ensuring adherence to its limits.

5.1 STANDARDISED PACKING METHODS: COMMERCIALLY AVAILABLE PRODUCTS

Commercially available packing materials were used and adapted to the transport of artworks, like wooden Euro-pallets (120 × 80 cm) and polyethylene Euro-boxes (60 × 40 cm) *(figs. 27 and 28)*. Only newly constructed pallets that had undergone a requested heat treatment by the manufacturer were used for the move in order to prevent the introduction of wood pests. Stacking frames of the Austrian Railways (ÖBB) are commercially available for the Euro-pallets *(fig. 29; see fig. 17)*. These were used individually or stacked for the transport of large stone and ceramic fragments, small-format paintings, costume accessories and mannequins.

[2] Quote from Prevart GmbH (Dr. Joachim Huber).
[3] See note 2.
[4] The Oddy-tests were carried out in the museum’s own Conservation Science Department by Sabine Stanek.

Table 1: Summary of the packing methods.

Packing Methods		**Examples**	**Collections**
Commercially available, standardised materials	**Adapted to the transport of artworks**		
standard Euro-pallets		stone reliefs, columns, furniture	ÄOS, ANSA, KK, ÖTM
standard Euro-pallet + folding box, pallet-ready	with/without lining (Ethafoam)	decorative objects, small parts, theatre models, costume accessories	ÄOS, ANSA, KK, MK, SAM, ÖTM
or + clothing boxes, pallet-ready	with/without lining (Ethafoam)	costumes mounted on mannequins, stage props	ÖTM
or + plastic boxes, pallet-ready	with/without lining (Ethafoam)	small fragments of stone and ceramic	ÄOS, ANSA
or + old store furnishings, stacked		coins, paper theatres, weapons, costume accessories	MK, MD, ÖTM
standard Euro-pallet + stacking frames of the Austrian or German Railways (ÖBB or DB), individual or stacked	with/without lining (cardboard, bubble wrap, Ethafoam) with/without cover (bubble wrap cover, pallet lid)	large fragments of stone and ceramic, small-format paintings, costume accessories, mannequins	ÄOS, ANSA, GG, MD, MK
mobile storage racks for heavy weights (Corlettes, 2 sizes), stackable + insertable shelves	with/without lining (Ethafoam)	furniture, medium format paintings	GG, KK, ÖTM
	with/without cover (bubble wrap cover, shrink wrap)	furniture, theatre models	
or + cloth rail + hanger, padded		costumes, marionettes	
mobile rack for hanging clothes + hanger, padded	with/without object covers (BW, Cellplas)	costumes	MD, ÖTM
Commercially produced custom solutions			
customised pallets		large-format stone objects, tapestries (folded in over-sized flat storage boxes)	ÄOS, ANSA, KK-Tap.
flat textile storage boxes	with/without lining (Ethafoam, cotton fabric)	costumes, accessories	MD, ÖTM
moving crates	with/without lining (Ethafoam)	stone sculptures, paintings, costumes mounted on mannequins	ANSA, GG, MD
wooden crates + insertable shelves	with/without lining (Ethafoam)	small busts, stone reliefs, musical instruments	ÄOS, ANSA, KK, SAM
Custom solutions produced in-house			
wooden structures	particle board with openings, with/without insert (polyester fleece, polypropylene fabric/Corovin)	amphorae	ANSA
wooden structures	5/8 cm wooden braces, cardboard as front and back protection	so-called “paintings on stilts”	GG
u-shaped transport boards	3-layer boards, with/without lining (Ethafoam)	musical instruments	SAM
l-shaped transport boards	formboards, with/without lining (Ethafoam)	stone reliefs, tombstones	ANSA
travel frames	formboards	fragile paintings in various sizes	GG
portable wooden rack	made out of 5/8 cm wooden braces	picture frames	GG
rack for rolled objects with standing board	archival cardboard, 3-layer boards	tapestries (already rolled)	KK-Tap.
portable rack for rolled objects	metal	rolled paintings	GG

Fig. 27: Wooden Euro-pallet for the transport of stone reliefs from the Collection of Greek and Roman Antiquities.

Fig. 28: Polyethylene Euro-boxes for the transport of ceramic fragments from the Collection of Greek and Roman Antiquities.

Fig. 29: Individual ÖBB stackable crates with pallet lids for the transport of costume accessories from the Court Wardrobe.

The stackable wooden pallet crates were either lined with bubble wrap, or the bottom and side walls were fitted with cardboard or Ethafoam to prevent damage to the objects during transport. The frames were enclosed with bubble wrap covers or palette lids, as needed.

Medium format paintings, furniture, theatre models, and marionettes were moved with the help of so-called furniture Corlettes® (mobile storage racks for heavy weights). They come in four sizes and can be stacked up to three times upon one another *(fig. 30; see fig. 15)*. They were also adapted for the move of artworks with the addition of cardboard or Ethafoam, covered with bubble wrap, or secured with shrink wrap. After use, the furniture Corlettes can be folded up and stored – a great advantage when space is limited. Various accessories are available for the Corlettes, such as insertable shelves or poles *(figs. 31 and 32)*. The Corlettes can be purchased or rented. The latter is preferable when they are needed only for a limited time.

Mobile clothes racks assisted with the efficient transfer of the costumes and marionettes to their new location. *Fig. 33* shows rented mobile clothes racks that can be stored nested together by Z-shaped based frames in order to save space. For the move, however, mobile clothes racks already in the museum’s possession were also used *(fig. 34)*. In order to keep the amount of material used to a minimum, a large part of the objects were moved in boxes, old drawers, or original storage chests already on hand. They could be fitted together, stacked on top of one another on customised or Euro-pallets, and then stabilised for transport *(figs. 35 and 36)*.

Fig. 30: Corlette storage racks for the transport of medium-format paintings from the Picture Gallery.

Fig. 31: Corlette storage rack with insertable shelves for the transport of stone panels from the Kunstkammer.

Fig. 32: Corlette storage rack outfitted with poles for the transport of marionettes from the collection of the Theatre Museum.

Fig. 33: Mobile clothes racks (rented) for the transport of court uniforms from the Court Wardrobe, which can be nested together when stored by Z-shaped frames in order to save space.

5.2 STANDARDISED PACKING SOLUTIONS PRODUCED IN-HOUSE

For groups of objects that did not fit into commercially available standard transport containers due to their size, weight, or condition, customised packing solutions were developed by the relocation team in consultation with the collections' conservators. These were for the most part made by the in-house carpenters and metalworkers. As examples, we show here the wooden mounts for the amphorae and the transport boards for the stone reliefs and tombstones from the Collection of Greek and Roman Antiquities (*figs. 37 and 38),* along with the transport boards for the pianos of the Collection of Historic Musical Instruments (Fig. 2 in the contribution by Hoheisel – Huber). Fragile paintings of various sizes were moved with the help of travel frames *(fig. 39)*. Portable metal racks simplified not only the moving of the rolled paintings, but were also used for storage in the new central facility *(fig. 40)*.

Fig. 34: Mobile clothes racks from the museum's holdings for the transport of the marionettes from the collection of the Theatre Museum. (©: Nina Zangerl.)

Fig. 35: Boxes with folded tapestries from the Kunstkammer, stacked on customised pallets for transport.

Fig. 36: Drawers containing costume accessories from the Court Wardrobe stacked on Euro-pallets for transport.

Fig. 37: Wooden mounts for the transport and storage of amphorae from the Collection of Greek and Roman Antiquities.

Fig. 38: L-shaped wooden boards for the transport and storage of stone reliefs and tombstones from the Collection of Greek and Roman Antiquities.

5.3 FILLING MATERIALS

Hollow spaces had to be filled so that the objects could not shift in their containers during transport. Commercially available filling materials were used in most cases, like tissue paper and Tyvek cushions filled with low-density polystyrene granules *(figs. 41 and 42)*. Only the Tyvek cushions and the PP sacks filled with polystyrene granules used to cushion the stone busts, sculptures and fresco fragments were custom-made in-house *(fig. 43)*.

Fig. 39: Travel frame for the move of fragile paintings from the Picture Gallery.

Fig. 40: Portable metal rack for the transport and storage of rolled paintings from the Picture Gallery. (©: Matthias Müller.)

Fig. 41: Tissue paper padding around ceramic fragments from the Egyptian and Near Eastern Collection.

Fig. 42: Low-density polyethylene air cushions used as space fillers to prevent the shifting of objects from the Court Wardrobe during transport.

Fig. 43: PP sacks filled with polystyrene granules for the transport of stone busts from the Collection of Greek and Roman Antiquities.

Fig. 44 a

Fig. 44 b

Swords with the accompanying sheathes and pendants from the Court Wardrobe, embedded into custom-made Ethafoam beds lined with Tyvek for transport and storage. View into the drawer of the old storage cabinet (left) and in detail (right).

Fig. 45: Fish storage vessel from the Collection of Greek and Roman Antiquities prepared for transport with a stabilising outer band.

Fig. 46: An employee of the company Kunsttrans unloading an over-sized painting from the Picture Gallery out of the scenery truck from the company Art for Art.

5.4 CUSTOMISED PACKING SOLUTIONS

Very fragile objects were embedded in Ethafoam sheets carved to fit their form. The melee weapons from the Imperial Carriage Museum and the Court Wardrobe are provided as examples *(fig. 44)*. Load-bearing, tension, and tie-down straps served to stabilise objects during transport. Customised solutions had to be developed for the packing and manipulation of particularly large, heavy, or fragile objects. The stabilising reinforcement of large storage vessels is one example *(fig. 45)* along with the transport of over-sized paintings in a scenery truck *(see fig. 24 and fig. 46)*. Customised solutions were also required when obstacles (e.g., a steep ascent) had to be overcome between the storage location and the moving truck *(figs. 47 and 48)*.

5.5 PLACEMENT AND LOADING OF THE OBJECTS

Space providing, objects could be packed in advance and placed in the loading area prior to transport. A space corresponding to the surface of the moving truck was marked on the ground *(fig. 49)*. Packing and pre-placement for loading was not possible in all of the old storage areas. The Theatre Museum and the Imperial Carriage Museum were packed on-site and loaded directly into the moving trucks because either there was not enough space available or the objects had undergone anoxic nitrogen treatment *(figs. 50 and 51)*.

Fig. 47: KHM, a pallet tower with formboards for moving art up a slope for the move of objects from the Egyptian and Near Eastern Collection during the second relocation phase.

Fig. 48: Theatre Museum, cellar areas. Transport board with a pulley for the transport of theatre models during the third relocation phase.

Fig. 49 a

Fig. 49 b

Inzersdorf storage facility, objects ready for transport from the Court Wardrobe (left) and the Collection of Greek and Roman Antiquities (right). Floor markings designate the size of the moving trucks.

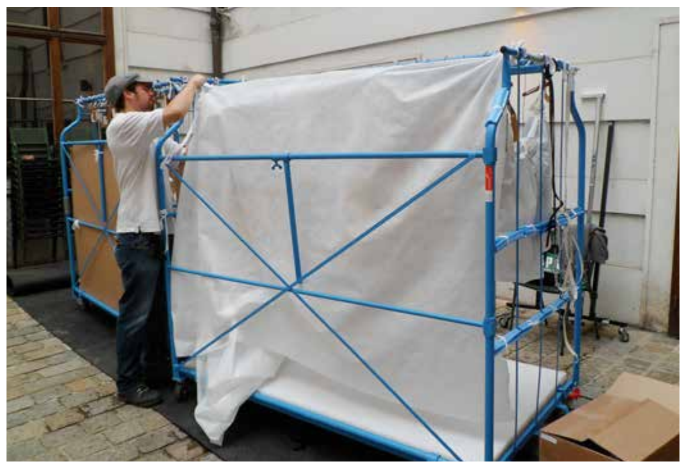


Fig. 50: Employees of the art moving company packing objects from the collection of the Theatre Museum. Due to lack of space, this took place in the courtyard.

Fig. 51: Employees of the company Kunsttrans loading a carriage from the Imperial Carriage Museum into the art-moving truck after anoxic nitrogen treatment.

6. IMPLEMENTATION OF THE MOVE

The relocation could begin as planned on August 1st, 2011, after the demanding and intense preparatory work, like surface cleaning, essential security measures, stabilisation, and careful packing of the collections with the support of external temporary workers *(see fig. 7),* had been accomplished.

First, the stone objects from the Collection of Greek and Roman Antiquities (ANSA), with a total weight of 450 metric tons, were moved to the new location *(see fig. 1)*. The objects in the largest of the old storage facilities in Inzersdorf on the outskirts of Vienna were moved next: Picture Gallery (GG), Egyptian and Near Eastern Collection (ÄOS), Kunstkammer (KK), Kunstkammer-Tapestries (KK-Tap.), Court Wardrobe (MD), Collection of Historic Musical Instruments (SAM) as well as the showcases from the general collection. Additional showcases, all furnishings, exhibition mounts, and the museum shop merchandise in the other two external storage areas were moved at the same time and housed in the general storage area of the new central storage facility. Concurrently, two of the external storage areas belonging to the Theatre Museum (ÖTM) were emptied, containing primarily costumes, theatre models, and props. The move of vehicles and riding accessories allowed for the emptying of the storage area for the Imperial Carriage Museum (WB) *(see fig. 5).* At the time of this writing, all collections' objects housed in the external storage areas are already for the most part stored in the new location *(see fig. 1)*.

Clearance of the storage facility in Inzersdorf proved to be a great challenge, requiring more time than anticipated. Showcases and exhibition mounts had accumulated over two decades, which were for the most part out-of-date or did not correspond to current tastes. The necessary dismantling of separating walls and similar architectural elements proved to be on the other hand less time-consuming. After 20 years of occupancy, the storage facility in Inzersdorf could finally be returned on time to their owners.

Leftover storage furnishings from Inzersdorf were offered for sale to interested art and cultural organisations on the homepage of the KHM under the category "Online Flea Market". For example, the former compact shelving units from the Collection of Greek and Roman Antiquities were sold to a foundation in Lower Austria. The income of around 20,000 euros flowed back into the project.

7. STORAGE EQUIPMENT AND FURNISHINGS

Storage equipment and furnishings for the objects could be optimised, thanks to construction of the new storage facility. Around 1.7 million euros were invested in new furnishings and equipment, which were protected against corrosion with a powder coating. All powder coatings that were considered during the call for proposals were tested with Oddy-tests to control for the emission of pollutants. Beginning in June 2011, the companies Compactus & Bruynzeel AG and Kern & Studer along with Magista Systems/Van Keulen Interieurbouw delivered and installed all furnishings and equipment in only six weeks.

7.1 SHELVING AND CABINET SYSTEMS

Various shelving units, such as archival, wide-span, heavy-duty, and rolling units from Compactus & Bruynzeel AG *(figs. 52 to 55)* as well as cabinets of different sizes with variable interior fittings like shelves, drawers and clothes rails (Magista Systems/Van Keulen Interieurbouw) *(figs. 56 and 57)* were installed. Openings were punched into the doors of the cabinets in order to allow for continuous air flow, thus preventing the creation of a microclimate. The cabinets housing the coin collection are outfitted with shallow, individual stainless steel trays, hindering corrosion of the sensitive metals *(figs. 58 and 59)*. Furthermore, they are located in an appropriate climate-controlled room with a reduced humidity of 40 %.

Fig. 52: Archival shelving from the company Compactus & Bruynzeel AG for the storage of library materials.

Fig. 53: Wide-span shelving units from the company Compactus & Bruynzeel AG for the storage of flat storage boxes from the Court Wardrobe.

Fig. 54: Heavy-duty shelving from the company Compactus & Bruynzeel AG for the storage of objects from the Collection of Greek and Roman Antiquities.

Fig. 55: View of the rolling shelving units from the company Compactus & Bruynzeel AG for the storage of objects from the Collection of Greek and Roman Antiquities.

Fig. 56: Powder-coated steel cabinets from the company Magista Systems/Van Keulen Interieurbouw with variable interior fittings during assembly.

Fig. 57: View of the powder-coated steel cabinet from the company Magista Systems/Van Keulen Interieurbouw with objects from the Court Wardrobe.

Fig. 58: View of the powder-coated steel cabinet from the company H. Schneider & Co.: Stainless steel trays with seals from the Coin Collection.

Fig. 59: Powder-coated steel cabinet from the company H. Schneider & Co. for the storage of objects from the Coin Collection.

Fig. 60 a

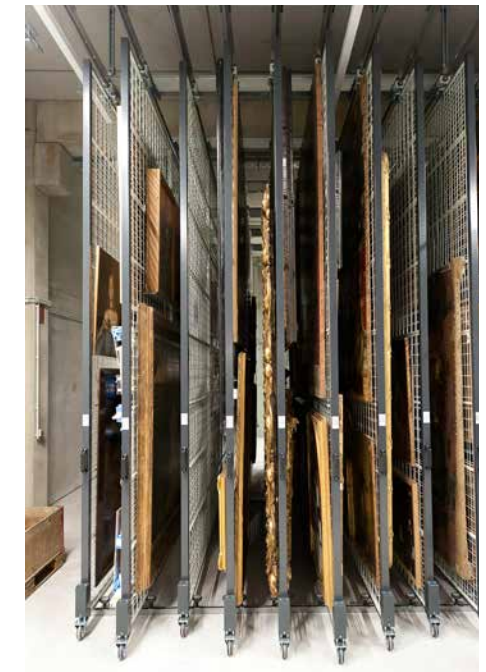


Fig. 60 b

Wire mesh storage racks (left: front view, right: side view) from the company Compactus & Bruynzeel AG for the storage of paintings from the Picture Gallery.

Fig. 61: Single and double hooks corresponding to the loop size of the wire mesh storage rack.

7.2 WIRE MESH STORAGE RACKS

An innovative model for wire mesh storage racks in two sizes (ground level: height 5 m × width 8 m, second floor: height 4 m × width 6 m) *(fig. 60)*, at the time not available on the market, was developed with the manufacturer Compactus & Bruynzeel AG for the paintings and framed works on paper from various collections. The hanging hooks, available in two sizes, were adjusted to the size of the loops in the wire mesh *(fig. 61)*. They are protected from corrosion and have a capacity load of 50 kg (single hook) or 90 kg (double hook). Additional support elements, for example, support rails, are used for large-format or particularly heavy paintings *(fig. 62)*.

7.3 CUSTOMISED STRUCTURES

7.3.1 COLUMN-FREE SHELVING UNITS

The museum team developed a new, cantilevered storage with an adjustment grid for tubes up to 6 meters in length with the company Magista Systems/Van Keulen Interieurbouw for the tapestry collection of the Kunstkammer *(fig. 63 and cover image)*. This customised structure presented a cost-effective and maintenance-free alternative to traditional circulating shelving units (paternoster) that are commonly used for the storage of large and heavy tapestries.

Fig. 62: Attachable support element for large-format or heavy paintings.

The racks are installed back-to-back in the storage area, and are accessible from one side when removing or storing a rolled tapestry. Two cantilevered arms can hold up to two rolled objects, one behind the other, and each side can carry up to eight tapestries. Going forward, the tapestries will be placed on so-called commercially available folded spiral-seam pipes made of galvanised steel sheeting reinforced with additional stiffening beads, when longer than 4.5 meters. Compared to the cardboard tubes commonly used, the spiral-form pipes have the advantage that they are lighter and do not sag. The tubes are lined with polyethylene foam (Plastazote) and polyester batting provides the necessary cushioning for the object. The rolls (core and object) have a maximum weight of 100 kg and are lifted into place with a mechanical, mobile lifting apparatus *(fig. 64)*.

Fig. 63: Inzersdorf storage facility: Assembly of a prototype for the column-free rack from the company Magista Systems/Van Keulen Interieurbouw for storage of the Kunstkammer tapestries.

Fig. 64: Custom-made mechanical, mobile lifting apparatus (Stefan Fleck/Bernard Rendl GmbH) for manipulation of the commercially available folded spiral-seam pipes made of galvanised steel sheeting for later storage of the Kunstkammer tapestries.

A column-free shelf with continuous levels was developed by Magista Systems/Van Keulen Interieurbouw for the Imperial Carriage Museum/Court Wardrobe, according to the conditions outlined in the call for proposals (see Fig. 34 a in the contribution by Kimmel, Sailer, and Kurzel-Runtscheiner) – an innovation for museum storage furnishings. As the shelf posts of the systems previously available on the market had always impaired utilisation of the full width of the shelving unit, storage of large-format textile boxes was limited.

The cantilever shelving system is comprised of vertical shelf posts to which the horizontal cantilevered arms can be attached at adjustable intervals. The shelves can be placed flush onto the arms without the use of tools. Full-extension drawers can also be assembled as needed in place of shelves; in this case, the cantilevered arm is reinforced, and extends into the transverse profile. The carrying capacity per linear meter of shelving or drawer is 40 kg. The call for proposals required that each company had to create a prototype for the customised storage equipment at the time of the granting of the contracts. This proved to be indispensable for the assessment of the quality of design and workmanship of the shelving units *(see fig. 63)*.

7.3.2 CUSTOMISED LARGE CABINET WITH SHELVING

A customised large cabinet with shelving from the company StabaArte allows for adequate storage and presentation of large-format textiles from the Imperial Carriage Museum/Court Wardrobe *(fig. 65)*. The corpus of the cabinet is exactly 180 cm high, 250 cm wide, and 350 cm deep. It is made of emission-free powder-coated steel and remains dust-tight when closed by the placement of fabric curtains on its front and back. U-shaped rails guide eight trays, which by means of slides, can be effortlessly pulled out and pushed back. Polyester fabric with a light-weight aluminium frame compose the so-called “maxi shelf,” whose maximum carrying capacity of evenly distributed weight is 10 kg. The corpus of the cabinet is placed on adjustable feet and is attached to the wall with brackets.

Fig. 65 a

Fig. 65 b

Customised large cabinet with shelving by StabaArte company for the storage and presentation of over-sized textiles. On-site assembly (left) with storage of the robes from the Order of the Garter (right).

7.4 CUSTOMISED ARCHIVAL BOXES

Over-sized textiles, such as women’s gowns or the regalia of the Habsburg dynastic orders with their splendid capes and vestments, are stored in so-called “costume boxes”. The boxes were custom-made by the company Klug-Conservation according to the specifications of the collection conservators for the Court Wardrobe because the standard acid-free cardboard boxes NOMI KS 16 did not meet the requirements of size or design. The boxes are 1.9 m long, 1 m wide, and 20 cm high: the largest possible size that can be assembled from one piece without requiring puzzle joint connection. The width of the boxes was determined by the depth of the planned shelving units for the regalia and was therefore the decisive dimension for the design.

In order to save on transport costs, the over-sized boxes were delivered flat and then assembled on site by an employee of the company Japico. When used for the storage of tapestries, the boxes were additionally outfitted inside with a tube *(fig. 66 a)*.

A total of around 3,400 boxes in various sizes (ranging from 6.5 cm × 8.5 cm to 122 cm × 110 cm) were provided by the company Schempp for the Collection of Greek and Roman Antiquities, the Egyptian and Near East Collection, and the Coin Collection. The standard acid-free cardboard boxes SB 21 (with and without lid) were most commonly used, at times with an additional insertable subdivision for the smallest objects *(fig. 66 b)*. A few custom sizes were necessary, in consultation with collection conservators.

7.5 FREE-STANDING OBJECTS

Not all objects could be housed in shelving units, cabinets, or other storage containers. Size, weight and shape sometimes demanded the placement of the corresponding artworks in open space. The tombstones and medium format sculptures from the Collection of Greek and Roman Antiquities along with the coaches and exhibition mounts from the Imperial Carriage Museum/Court Wardrobe, serve as examples here *(figs. 67 and 68)*.

Fig. 66 a

Fig. 66 b

Acid-free cardboard boxes from the company Klug-Conservation (left) and acid-free folding boxes from the company Schempp in various sizes for the new storage of metal objects from the Collection of Greek and Roman Antiquities (right).

Fig. 67 a

Fig. 67 b

Placement of tombstones (left) and stone sculptures (right) from the Collection of Greek and Roman Antiquities.

Fig. 68 a

Fig. 68 b

Himberg, storage facility for the Imperial Carriage Museum and model horses.

8. ONGOING OPERATIONS

8.1 ANOXIC NITROGEN TREATMENT SYSTEM

All artworks that return to storage after a special exhibition, and all new additions to the collections, undergo anoxic nitrogen treatment as a measure of preventive conservation in order to deter the possible introduction of insect pests to the storage areas. The anoxic nitrogen chamber is 4.5 m high, 3 m wide, and 7.5 m deep and has a volumetric capacity of ca. 100 cubic meters. It is located on the ground floor, in the vicinity of the unpacking room and immediately accessible from the delivery area *(figs. 69 and 70)*. The system is run with a nitrogen generator; control and running of the equipment is fully automatic. Should the generator fail, a back-up supply of nitrogen in canisters is activated.

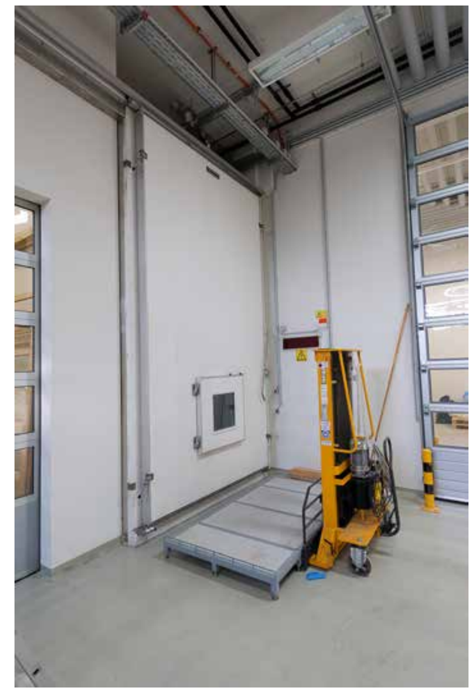


Fig. 69: Anoxic nitrogen treatment chamber in the central art storage facility of the Kunsthistorisches Museum Vienna.

8.2 BUILDING SERVICES

All building services are controlled automatically by a centralised system. Any disturbances are reported by e-mail. Should an important piece of equipment fail resulting in irregularities in the climate values, a text message is sent to the responsible person. After a year of trial operations, and curing of "childhood illnesses," the building services have become very stable. Since the fall of 2012, members of the department of facility management are responsible for the upkeep of the building service facilities, taking care of all repairs as well as the annual maintenance. The building has a five-year warranty obligation instead of the usual two-year contract.

A constant climate of 20 °C and 50 %rH guarantees the preservation of the artworks; it levelled off to the desired parameters after just three months. An example of the climate curve from the storage area for the Collection of Greek and Roman Antiquities can be seen here *(fig. 71)*. Temperature is shown in green and relative humidity is shown in red.

Fig. 70: View of the anoxic nitrogen treatment chamber of the Kunsthistorisches Museum Vienna.

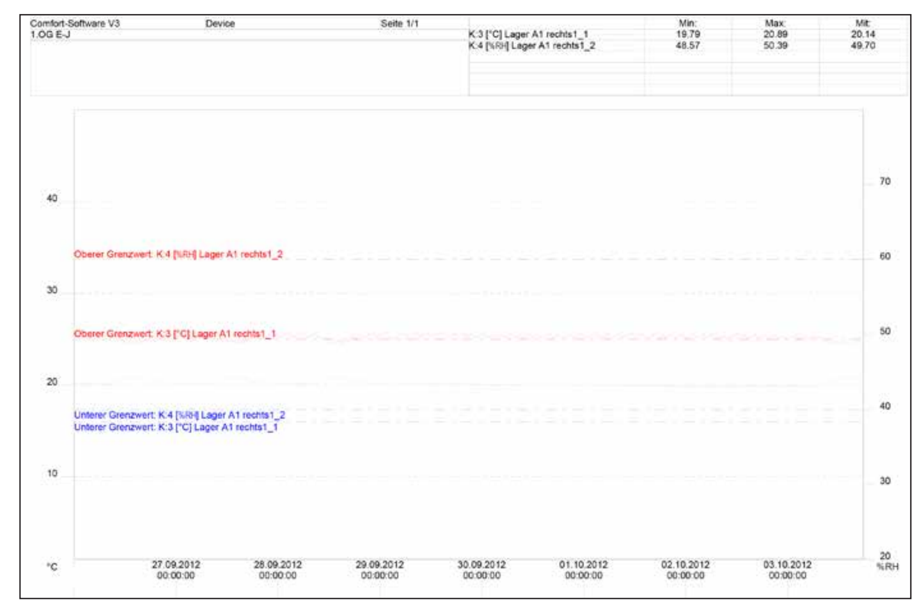


Fig. 71: Climate curve from the storage area for the Collection of Greek and Roman Antiquities. Temperature is shown in green and relative humidity is shown in red.

Fig. 72: Temperature and humidity sensors for the Testo Saveris System. (©: HLK, Heizung, Lüftung, Klima-Kältetechnik.)

Fig. 73: Storage facility manager Peter Planegger at the computer, inspecting the temperature and humidity levels in the Testo Saveris program.

Fig. 74: View of the anoxic nitrogen treatment chamber in the central storage facility filled with objects from the Kunsthistorisches Museum Vienna.

8.3 BUILDING CLIMATE

The monitoring and documentation of the building climate is carried out with Testo Saveris, a system that automatically saves temperature and humidity values *(fig. 72)*. The storage facility management looks at the program data; if current conditions exceed or fall below the stipulated values, the computer screen displays them and allows for corresponding measures to be taken to regulate the climate *(fig. 73)*. Regular evaluation and analysis of the collected data will be undertaken by Angelika Stephanides, the climate specialist for the museum.

8.4 SECURITY

The storage facility management is responsible for on-site security. They have been trained to use the building systems: in case of an incident, they can carry out inspections, repair defects, or document damages. They are also responsible for management of the anoxic nitrogen treatment procedures, which involves notifying storage administration of the current needs of the collections/museums, as well as documentation of the data tracking of incoming and outgoing

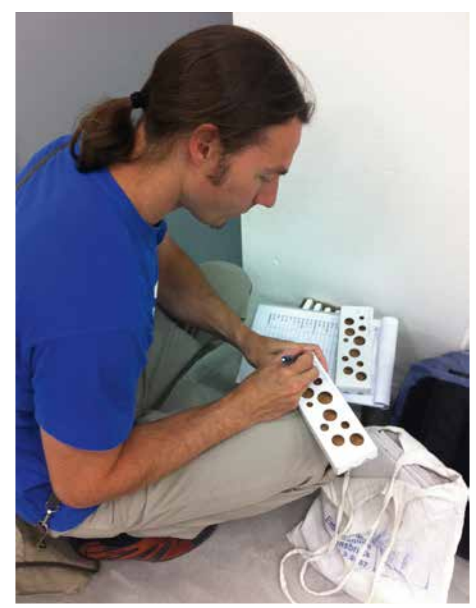


Fig. 75: The contractor of IPM, Dr. Pascal Querner, placing a pheromone trap in the central storage facility.

objects. For security reasons, only these two people have the ability to lock the door and entrance to the treatment chamber. Illuminated warning labels attached to the outside of the system indicate its operation. During the entire treatment cycle, the door to the chamber is additionally locked with padlocks.

After about five weeks, the closed anoxic nitrogen chamber is flooded with ambient air by a ventilator. A suction pipe draws the nitrogen out of the room and it is released over the roof of the building. The chamber is then only opened once the oxygen sensors in the room indicate that enough oxygen is present to enable comfortable breathing. The artworks are removed by two storage employees and brought to the rooms designated as "post anoxic nitrogen treatment" *(fig. 74)*. From there, the objects are transferred to their designated storage space by collections staff.

8.5 INTEGRATED PEST MANAGEMENT (IPM)

The IPM introduced in the old storage areas was continued in the new storage facility by Dr. Pascal Querner *(fig. 75),* assisted by Tanja Kimmel. She is the conservator responsible for all collections housed in the storage facility. The primary goal of the monitoring is to determine if the new storage facility is pest-free after the large influx of objects during the move in 2011. It also serves to identify early any presence of insect pests that may gain access to the building from outside through the gates in the delivery areas or the windows and emergency exits.

After general cleaning of the storage facility, insect traps containing species-specific pheromones and adhesives were placed in the storage areas, working rooms, and the adjacent stairwells. Three UV traps were placed in the delivery areas and general collection storage area; outside screens were added to windows that could be opened as extra protection. Light traps were installed in addition to the emergency lighting system in the storage areas of the Picture Gallery; parasitoid wasps were released there as well in an attempt to mitigate a new infestation of biscuit beetles *(Stegobium paniceum)* of the paintings.

The general collection storage area was identified as a problem area. In 2012, numerous clothing moths were captured. Along with the shop merchandise, mostly showcases, exhibition mounts, and unused furniture from various departments are stored in this area. The suspected cause of the infestation were contaminated Euro-pallets, fabric linings in some of the showcases, and filling material in upholstered furniture. A special sanitation project was carried out with external temporary workers during which the old Euro-pallets were exchanged for new ones, all extraneous materials were removed from the showcases, and suspected pieces of furniture were wrapped in plastic. Going forward, all such objects entering the storage facility will be cleaned in advance, transferred to heat-treated wooden pallets, and wrapped in plastic as needed. Shop merchandise will be stored on plastic pallets in the future.

The detailed results of the close to one-year long monitoring can be read in the report *Integrated Pest Management (IPM) During the Move of Objects to Himberg (Integriertes Schädlingsmanagement (IPM) beim Umzug der zu deponierenden Objekte nach Himberg)* by P. Querner, et. al. The results were presented to the museum staff a short while ago in a lecture. Poisonous baited traps for mice and rats were placed at the entrances and exits to the buildings and along the borders of the property and are regularly monitored by the company Michael Singer GmbH & Co. KG.

8.6 GENERAL CLEANING

The spaces of the new storage facility that were in use during the interim storage and decontamination phases of the objects were disinfected after use by Innova Solutions.[5] The patented system Fog It® is not hazardous to human health and the spaces are germ free after treatment (according to Innova Solutions, nothing remains in the air after use). The active ingredients (chlorine dioxide, quaternary ammonium compounds, among others) are distributed in the air as suspended particulates by ultra-fine atomisation. Germs, spores, and so on, are bound to the floating particulates and settle like a sediment onto the surface; at the same time a disinfection process takes place.[6] The surfaces are then cleaned as usual with warm water and cleaning agents. In February and March 2012, a two week comprehensive general cleaning of all areas, which should be repeated annually, was carried out for the first time as part of a further preventive conservation measure in the scope of "housekeeping". All storage areas, labs and general use areas are cleaned by staff from a cleaning company along with the responsible conservators and/or curators.

8.7 KHM WORKING GROUP "STORAGE"

The relocation team initiated a working group responsible for the maintenance of standards and optimal working procedures that were put in place after the implementation of the new facility. It should be understood also as an information platform for the collections and as support for the work of the storage facility management. Along with the relocation team and the storage facility management, the working group also includes conservators as representatives of their various collections. There are also contact persons for the security and facility management departments. The working group consists of 16 permanent members. Tanja Kimmel is responsible for its coordination. Additional members from other departments can be called in as needed, like for example, from the Conservation Science Department or Service Team.

The "storage circle" convenes four times a year. At this time, it is actively creating guidelines for the handling of artworks upon delivery, especially contaminated objects (pests or mould), and their identification with a uniform labelling system. This includes the preparation of a priority list for the evaluation of the urgency of and sequence in which the objects should undergo anoxic nitrogen treatment. Going forward, the completed guidelines will be available to all staff members on the museum's internal Wikipedia.

A general practice session took place on August 2nd, 2012, with the volunteer fire department of Himberg as part of the emergency planning procedures. Seven fire engines and 28 firemen participated on-site under the direction of the fire chief Michael Berger. In order to prevent possible crisis situations, familiarity with the spaces, fire protection systems, and fire routes was established, and a strategy for an emergency situation was developed. We thank Felia Brugger and Gerhard Ifkovitz, the fire prevention officer, for the organisation and implementation of these important measures.

The focus of the next exercise will be the rescue of objects from the storage area. Taking the Schloss Schönbrunn Kultur- und Betriebsges.m.b.H as a model, the forming of a "damage limitation team" should be created. This special group consisting of trained staff members from the museum should help the fire department salvage valuable artefacts in the case of a catastrophe.

[5] http://www.innovasolutions.de.
[6] See http://innovasolutions.de (03.09.2015).

Fig. 76: Conservators of the Kunstkammer preparing a tapestry for storage.

Fig. 77: Robes of the dynastic orders from the Court Wardrobe in the new storage facility undergoing scientific research by the curators and conservators. Kalpaks from the Order of the Golden Fleece before storing can be seen in the photo.

New situations always arise during the ongoing operation of the storage facility. The storage circle offers a recurring platform for the discussion and discovery of effective solutions for issues that need to be addressed.

9. STATUS QUO AND LOOKING AHEAD

With the completion of the third relocation phase, around one million artefacts were moved from the old storage locations to the new storage facility without incurring any damage. A large part of the objects is already located in their new permanent location. Nevertheless, there are parts of collections which have not yet been brought to their final location within the new storage facility. The tapestries from the Kunstkammer and the robes of the Habsburg dynastic orders from the Imperial Carriage Museum/Court Wardrobe *(figs. 76 and 77)* are two examples. Projects are also still underway that began with the first relocation phase, such as the cleaning and mould remediation of contaminated objects *(fig. 78)*. The labelling of all objects with barcodes is also still ongoing. These measures, which ensure timely capture and management of object location information, have already been successfully implemented for the Picture Gallery.

Fig. 78: Mould remediation of theatre models from the collection of the Theatre Museum.

The completing of inventories and photographic imaging of groups of objects in several collections in collaboration with scholarly research also remains to be undertaken *(figs. 79 and 80)*. This would also be the opportune moment to consolidate all data in one database, because the location capture with the barcode system can only be accomplished with TMS.

The central storage facility has already become a model for sustainable storage construction throughout Europe, due to its cost-effective construction, the high functionality of the structure, and its low operating costs. Interested developers from well-known museums have already taken advantage of on-site inspections of the facility. The project has also been presented at numerous symposia. The experiences gathered during the entire project have been disseminated to interested parties in scholarly journals and through conference presentations. The authors wish to thank on behalf of the relocation team all of the people who participated for their friendly collaboration and excellent work.

Fig. 79: Photographic documentation of the scenery and architectural models from the Theatre Museum by the photo studio after relocation to the new central storage facility.

Fig: 80: Taking the inventory of decorative frames from the Picture Gallery.

10. LECTURES, RELOCATION TEAM

S. Fleck – K. Reuter – J. Huber, *Cost-Effective Art Storage While Meeting Current Standards: The New Central Storage Facility of the Kunsthistorisches Museum Vienna,* Symposium, *Museum Storage and Storage Equipment,* ICOM Austria, Innsbruck, March 4th to 5th, 2011

J. Huber – S. Fleck – K. Reuter, *Cost-Effective Art Storage While Meeting Current Standards: The New Central Storage Facility in Vienna,* Lecture Series, *The Green Museum – Efficiency and Sustainability in Museums,* Deutsche Kongress, Vienna, April 7th, 2011

S. Fleck, *Artworks Like It Temperate – the New Storage Facility of the Kunsthistorisches Museum Vienna,* Expert Forum, *Concrete as Energy Storage: Visionary Energy Management Under Scrutiny,* Academy of Building, Salzburg, May 30th, 2012

C. Schaaf-Fundneider – T. Kimmel, *The Relocation of the Collections of the Kunsthistorisches Museum Vienna to the New Central Storage Facility: Part 1 and 2,* Lecture Series, *The Green Museum: Efficiency and Sustainability for Temporary Exhibitions and Loans,* Deutsche Kongress, Vienna, October 9th, 2012

Poster, C. Schaaf-Fundneider – M. Griesser – S. Fleck – T. Kimmel – J. Huber – K. Reuter, *The New Central Art Depository of the Kunsthistorisches Museum, Vienna,* Symposium, *Climate and Cultural Heritage: Knowledge and Ignorance,* Doerner Institute, Munich, November 7th to 9th, 2012

C. Schaaf-Fundneider – T. Kimmel, *The New Central Storage Facility of the Kunsthistorisches Museum, Vienna. Relocation of the Collections: Preparation, Planning, and Implementation,* Symposium of the Austrian Conservators Association (ÖRV) in cooperation with the Austrian Museum of Applied Arts (MAK), Vienna, November 30th to December 1st, 2012

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SUMMARY

The Kunsthistorisches Museum decided to build a new collections storage facility in September 2009. Prior to that point, the museum's art repositories had been divided among nine different locations in and around Vienna.

The complex, intensive planning and preparation for the new facility began in early 2010 with the formation of two project teams, "Construction" and "Relocation." On 1 August 2011, the move of the collections from all of the rented storage locations began. The first transport phase was successfully completed on 30 November 2011. In a second campaign from April 2012, artworks and archival materials from the in-house repositories are now being transferred. In total, 1 million objects from nine different art collections and three archives were to be moved.

Through the storage of artworks in a centralised location – in keeping with the latest standards – objects previously divided in various locations could be assembled for the first time.

The article gives insight into the execution of the project and various methods of collection assessment. Preventive conservation measures necessary in preparation, such as pest monitoring and nitrogen and mould treatments, are also described. In addition, affordable and efficient packing solutions which have enabled the safe transport of the artworks and can be reused in different collections are presented.

ZUSAMMENFASSUNG

Das Kunsthistorische Museum entschloss sich im September 2009, ein neues Zentraldepot zu bauen. Bis zu diesem Zeitpunkt waren die Kunstdepots des Museums auf neun verschiedene Standorte in Wien und Wien-Umgebung aufgeteilt.

Mit der Gründung der beiden Projektteams „Bau" und „Übersiedelung" konnte Anfang 2010 die aufwendige und intensive Planung sowie die Vorbereitung für das neue Zentraldepot beginnen. Mit 1. August 2011 startete die Übersiedelung der Sammlungsbestände aus allen angemieteten Depotstandorten. Die erste Übersiedelungsphase konnte mit 30. November 2011 erfolgreich abgeschlossen werden. In einer zweiten Kampagne erfolgte ab April 2012 die Übersiedelung von Kunstwerken und Archivalien aus hauseigenen Depots. Insgesamt galt es, ca. 1 Million Objekte aus neun verschiedenen Kunstsammlungen und drei Archiven zu verlagern.

Durch die Unterbringung der Kunstwerke an einem zentralen Standort konnten – unter Einhaltung modernster Standards – erstmalig die bis dahin auf verschiedene Standorte verteilten Sammlungsbestände zusammengeführt werden.

Der Beitrag gibt einen Einblick in die Projektabwicklung und verschiedene Methoden zur Bestandserhebung. Auch werden im Vorfeld notwendige präventive Konservierungsmaßnahmen wie Schädlingsmonitoring, Stickstoffbehandlung und Schimmelbekämpfung erläutert. Außerdem werden kostengünstige und effiziente Verpackungslösungen vorgestellt, die einen sicheren Transport der Kunstwerke gewährleisten und sammlungsübergreifend wiederverwendbar sind.

Integrated Pest Management (IPM) as Part of the Move to the New Storage in Himberg

Pascal Querner, Tanja Kimmel, Stefan Fleck, Eva Götz, Michaela Morelli and Katja Sterflinger

Translated from the German by Aimée Ducey-Gessner

1. INTRODUCTION

Protecting objects remains a great challenge for museums and collections. On occasion, pests have always been a source of considerable damage to objects. Exit holes from woodworms in wooden objects and destruction of textiles by clothes moths recur again and again. Common pests in museums are webbing clothes moths *Tineola bisselliella*, the biscuit beetle *Stegobium paniceum,* the common furniture beetle *Anobium punctatum,* various carpet beetles *Attagenus sp.* or *Anthrenus sp.*, silverfish *Lepisma saccharina,* and mice. In earlier times, insecticides like hydrogen cyanide, DDT, and lindane were regularly used against pests. Over time, however, it has become apparent that these chemicals are often damaging to the objects and the health of the museum workers who come into close contact with them. Collection conservators and storage administrators were particularly affected by an accumulation of contamination through repeated handling of the objects. The lack of attention traditionally paid to the origin of an infestation and the resulting paucity of countermeasures meant that new infestations were constantly recurring in collections inventories.

The concept of integrated pest management (IPM) with comprehensive monitoring was developed in the 1950s for the food industry and has been successfully applied in museums since the 1980s.[1] Individual strategies for IPM in

[1] See for example G.D. Albert – L.M. Albert, "Integrated Pest Management: A Program for Museum Environments," in L.A. Zycherman – J.R. Schrock (eds.), *A Guide to Museum Pest Control. The Foundation of the American Institute for Conservation of Historic and Artistic Works and Association of Systematics Collections,* Washington D.C., 1988, pp. 169–173; M.J. Linnie, "Pest Control: A Survey of Natural History Museums in Great Britain and Ireland," in *The International Journal of Museum Management and Curatorship* 6, 1987, pp. 277–290; K.O. Story, *Approaches to Pest Management in Museums,* ed. by Conservation Analytical Laboratory, Smithsonian Institute, Washington D.C., 1986, pp. 85–101.

museums were developed by Florian, Jessup, Pinniger and Winsor, Querner and Morelli, as well as Strang and Kigawa.[2] The definitive sources on IPM in museums were collected by Pinniger as well as Brokerhof, among others.[3]

The most important component of IPM is the prevention of insect infestations. This is achieved by means of a well-sealed building, control of climate conditions, frequent cleaning, implementation of quarantines, and frequent monitoring of the collections with the aid of traps. One person should be responsible for the IPM plan, coordinate its implementation, and set priorities. Should an infestation nevertheless be discovered, non-toxic treatment methods such as freezing, controlled heating, or anoxia (deoxygenation through nitrogen or carbon dioxide treatment) should be applied in order to exterminate as many pests as possible in all stages of development. Not every treatment method, however, is equally suitable for all materials and types of pests; the chosen method must be established together with the conservators. Among the large institutions there are only few museums left in Europe that regularly use pesticides (biocides) against insect pests. Small collections are also following the trend and avoiding the application of toxic substances.

At the initiative of Maria Ranacher, the Kunsthistorisches Museum Vienna was one of the first museums in Austria with an integrated pest management program and the first museum with its own stationary anoxic nitrogen treatment chamber.[4] In 1996, treatments with nitrogen were already being carried out for the Picture Gallery[5] and the construction of a walk-in anoxic nitrogen treatment chamber for the entire museum was proposed. Since the installation of the 80 m^3 chamber *(fig. 1)* in 1998 in Inzersdorf, contaminated objects from the museum's own collection, other museums, institutions, and private collections have been regularly and successfully treated with nitrogen over five week cycles.

2 M.L. Florian, *Heritage Eaters: Insects and Fungi in Heritage Collections,* James & James Publishers, 1997; W.C. Jessup, "Integrated pest management into operation," in *Collections Caretaker* 1, 1998, no. 3, pp. 1–8; D. Pinniger – P. Winsor, *Integrated pest management. A guide for museums, libraries and archives*, ed. Council for Museums, Archives and Libraries, London, 2004; P. Querner – M. Morelli, "Integrierte Schädlingsbekämpfung in Museen – Erfahrungen einer Umstellung," in *Restauro,* 2010, no. 4, pp. 234–241; P. Querner – M. Morelli, "Leitfaden für eine Einführung und Umstellung zur Integrierten Schädlingsbekämpfung (IPM)," in *Restauro,* 2010, no. 5, pp. 332–333; T.J.K. Strang – R. Kigawa, "Levels of IPM Control: Matching Conditions to Performance and Effort," in *Collection Forum* 21, 2006, nos. 1–2, pp. 96–116.

3 D.B. Pinniger, *Pest Management in Museums, Archives and Historic Houses,* ed. Archetype Publications, London, 2004; D.B. Pinniger, *Pest Management. A Practical Guide,* ed. Collection Trust, Cambridge, 2008; A.W. Brokerhof – B. van Zanen – K. van de Watering – H. Porck, *Buggy Biz: Integrated Pest Management in Collections,* ed. Netherlands Institute for Cultural Heritage (ICN), Amsterdam, 2007, p. 79.

4 M. Ranacher, "Mikroorganismen- und Schadinsektenbefall im Depot: Ursachen, Sanierung, Hygiene und Gesundheitsschutz," in Landesstelle für die nichtstaatlichen Museen (ed.), *Das Depot – der andere Teil der Sammlung, 9. Bayerischer Museumstag,* Munich, 1998, pp. 53–74; P. Querner – M. Morelli, "Nachweis von Museumsschädlingen in Schmutz," in *Restauro,* 2009, no. 2, p. 85; P. Querner – M. Morelli – E. Oberthaler – M. Strolz – K. Schmitz-von Ledebur – I. Zatschek – A. Femi-Mebarek – J. Diehl – R. Hölzl – I. Engelhardt – H. Krammer – S. Fürnkranz, "Ten Years of Integrated Pest Management (IPM) at the Kunsthistorisches Museum Wien," in *Journal of Entomological and Acarological Research* 43, 2011, no. 2, pp. 185–190.

5 Ranacher 1998 (cited note 4).

Fig. 1: First anoxic nitrogen treatment chamber in the KHM, which was continually in use from 1998 until 2011.

1.1 IPM IN THE KUNSTHISTORISCHES MUSEUM VIENNA (KHM)

Pest monitoring is frequently carried out in collections with particularly at risk objects in order to identify the emergence and spread of pests like webbing clothes moths, biscuit beetles, and woodworms. In addition to the monitoring of the Picture Gallery, which has been carried out since 1993 with different traps for biscuit beetles, woodworms, silverfish and other insects,[6] the Imperial Carriage Museum has been monitored since 2001 with pheromone traps for clothing moths. Numerous already infested objects and problem areas in the building were detected.[7] Frequent monitoring for pests has also been executed in the Weltmuseum Wien since 2003; because the objects from these collections remained in the museum's own storage space, the results are not presented here.

The management of the Kunsthistorisches Museum Vienna with the Weltmuseum Wien and the Theatre Museum decided in 2009 to plan and build a new central storage facility in order to store a large part of the collections there (with the exception of the objects from the Weltmuseum). Until that time, objects stemming from diverse collections were housed in a large storage facility south of Vienna as well as in other additional, smaller facilities. Moving to a new storage area provides a museum with the opportunity to store its entire collection free of pest infestations. Since the new storage facility contains large open areas where objects from different collections are stored together, a pest-free move was particularly important in order to prevent the potential spread of pre-existing infestations. The time period prior to the move should therefore be used to identify and treat infested objects. All of the objects in all of the collections could not be treated because of time, financial, and logistical constraints. For these reasons, all of the relevant collections were monitored as part of the IPM program during the planning and construction phases for the new facility (2010 and 2011) *(see table 1)*. The results of these investigations and the measures taken as a consequence are presented here.

6 Ranacher 1998 (cited note 4).

7 Querner et al. 2011 (cited note 4).

2. PLANNING IPM FOR THE STORAGE FACILITY

From the onset of the planning process for the new central storage facility of the Kunsthistorisches Museum Vienna, the implementation of the most effective possible pest infestation prevention system was included in the structural design. The following issues and requirements were taken into consideration when critically evaluating the first planning steps for the layout and floor plan of the building:

1. The best possible separation of delivery and storage areas;
2. An arrival area solely for delivery vehicles and an anteroom for the anoxic nitrogen treatment chamber alone;
3. Quarantine rooms for objects infested with insects or contaminated with microorganisms (mould) in close proximity to the anoxic nitrogen treatment chamber;
4. A correspondingly large anoxic nitrogen treatment chamber (100 m^3) in order to fulfil the increasing needs of the museum (the growing demand for IPM resulted from stricter guidelines for new acquisitions, loaned objects, and objects exhibited in-house, as well as increased awareness of IPM), and
5. Walls should be kept free as much as possible of shelves and objects so that monitoring with traps can be carried out and thorough cleaning can take place.

3. MONITORING OF THE COLLECTIONS IN PREPARATION FOR THE MOVE

As already mentioned, frequent monitoring was already taking place in the Imperial Carriage Museum and the Court Wardrobe, and the Picture Gallery; for the move, monitoring was introduced in the storage areas of the Theatre Museum and all areas of the storage in Inzersdorf *(table 1)*.

Table 1: Summary of the monitored collections with the number of traps and the results of the monitoring in 2010 and 2011. Traps in use: ST = sticky blunder trap, Ph = pheromone trap; identified pests: WCM = webbing clothes moth *(Tineola bisselliella)*, IMM = Indian meal moth *(Plodia interpunctella)*, SF = silverfish *(Lepisma saccharina)*, BB = biscuit beetle *(Stegobium paniceum)*, varied carpet beetle *(Anthrenus verbasci)*, black carpet beetle *(Attagenus unicolor)* and australian spider beetle *(Ptiunus tectus)*.

Collection	ST	Ph	Pests 2010	Pests 2011
Imperial Carriage Museum				
• Storage English Riding Stable	4 ST	48 Ph for WCM	56 WCM 2 SF	39 WCM 1 SF 2 Anthr. v.
• Storage Attic I	15 ST	13 Ph for WCM 16 Ph for BB	6 WCM 21 Anthr. v. 6 Attagenus u. 9 BB 1 SF	2 WCM 17 Anthr. v. 4 Attagenus u. 6 BB 4 spider beetles
Theatre Museum				
• Palais Lobkowitz	47 ST	14 Ph for WCM	11 WCM 8 Anthr. v. 1 Attagenus u. 3 SF	4 WCM 2 Anthr. v. 4 Attagenus u. 1 SF
• Hanuschhof	31 ST	10 Ph for WCM	4 WCM 10 SF	2 WCM 5 SF 1 Anthr. v.
• Vienna Harbour	14 ST	8 Ph for WCM	104 WCM 8 Anthr. v. 51 SF	38 WCM 2 Anthr. v. 39 SF 1 BB
General Storage in Inzersdorf				
• Court Wardrobe	5 ST	10 Ph for WCM	2 SF	1 SF
• Kunstkammer-Tapestries	9 ST	8 Ph for WCM	2 WCM	3 IMM 1 SF 1 Anthr. v.
• N_2-Room, Kunstkammer, Photography area, Showcases	12 ST	6 Ph for WCM	16 WCM 2 SF	13 WCM
• Collection of Historic Musical Instruments	9 ST	2 Ph for WCM	1 WCM	2 SF
• Egyptian and Near Eastern Collection	8 ST	1 Ph for WCM	10 WCM 5 SF	3 WCM 4 SF
• Hall 2	22 ST	8 Ph for WCM	3 WCM 19 BB 9 SF	5 SF
• Hall 4	10 ST	8 Ph for WCM	3 WCM 13 SF	31 IMM 12 SF 1 Anthr. v.
• Picture Gallery, Storage 1	14 ST	2 Ph for WCM 5 Ph for BB	32 BB	5 BB 3 SF
• Picture Gallery, Storage 2	21 ST	2 Ph for WCM 5 Ph for BB	5 SF	2 SF
• Picture Gallery, Storage 3	9 ST	2 Ph for WCM 5 Ph for BB	1 WCM	3 SF
Basement Storage of the Egyptian and Near Eastern Collection	21 ST	9 Ph for WCM	2 WCM 16 SF 2 Anthr. v. 1 Attagenus u.	8 WCM 24 SF

Fig. 2 a

Fig. 2 b

Objects (model horses) infested with biscuit beetles in the attic storage space for the Imperial Carriage Museum.

3.1 IMPERIAL CARRIAGE MUSEUM

The Imperial Carriage Museum is located on the grounds of the Schönbrunn palace. It contains around 180 historic vehicles, sleighs, and litters. Currently there are about 60 coaches and sleighs in the 1,300 m^2 exhibition hall; the rest of the objects are stored in three storage areas. In addition to the vehicles, the Imperial Carriage Museum possesses one of the largest collections worldwide of historic riding equipment and horse tack. The poorly insulated building – with historic doors and windows, unsealed roofs, empty shafts, and wooden floors, which serve both as a source of food and a habitat for pests – favours recurrent infestations. For many years, the webbing clothing moth *Tineola bisselliella* has been the most common pest in the collection because many of the objects are made of wool, silk, and feathers and the upholstery in the coaches and sleighs are filled with horsehair. The biscuit beetle *Stegobium paniceum* is another pest that attacks the starch paste components of the horse tack and model horses *(fig. 2)*. The varied carpet beetle *Anthrenus verbasci* and the carpet beetle *Anthrenus scrophularia* are found again and again in the collection, where they presumably primarily feed on insect remains.[8]

3.2 PICTURE GALLERY

The Kunsthistorisches Museum’s Picture Gallery collection is comprised of ca. 8,000 historic paintings, only a small selection of which are exhibited in the main museum. The portion of the collection kept in storage has suffered from a repeated infestation of biscuit beetles *Stegobium paniceum,* which has led at times to marked damage to the paintings with starch paste linings *(fig. 3)*.[9] These paintings were fumigated with methyl bromide against pest infestation in 1993 and 1994, before the relocation of some of the paintings to the old storage area

[8] P. Querner, “Museumsschädlinge und die Umsetzung der integrierten Schädlingsbekämpfung in Wiener Museen – ein erster Überblick,” in *Mitteilungen der Deutschen Gesellschaft für allgemeine und angewandte Entomologie* 17, 2009, pp. 231–233.

Fig. 3: Example of a painting infested with biscuit beetles.

Fig. 4 a

Fig. 4 b

Old mice bait boxes and poison bait eaten by biscuit beetles.

in Inzersdorf. In 1996, the first test treatments with inert gases (nitrogen) were carried out[10] as a possible substitute for treatment with methyl bromide (fumigation was discontinued in 1995), leading to the completion of the aforementioned anoxic nitrogen treatment chamber.

Pest monitoring uncovered biscuit beetles not only in the former storage area, but in the conservation studio as well, where poison bait for mice served as a source of food for the insects *(fig. 4)*. The baits had been put out by a pest controller, but were not regularly replaced. Removal of the old bait boxes improved the situation in both areas. All objects from the Picture Gallery that had been located in infested areas, however, had to be treated with nitrogen on-site in a tent before the move to the new storage facility.

[9] M. Strolz, *Die Konservierung und Restaurierung des Bildes “Theseus und die Töchter des Minos” von Benedetto Gennari, Kunsthistorisches Museum, Wien, Depot, Inv. Nr. 7126*, Diplomarbeit Hochschule für angewandte Kunst Wien 1987; Ranacher 1998 (cited note 4); A. Boruszczak, *Die Stabilisierung eines durch Brotkäfer geschädigten Gemäldes aus dem Kunsthistorischen Museum in Wien,* Diplomarbeit Universität für angewandte Kunst Wien 2013.

[10] Ranacher 1998 (cited note 4).

3.3 THEATRE MUSEUM

In 2010, systematic monitoring of the various storage areas of the Theatre Museum was introduced in preparation for the forthcoming relocation *(figs. 5 and 6)*. The conservators were already aware of an active infestation of moths; its extent, however, could first be determined only through frequent inspection, also yielding information about which of the many rooms were affected. All of the textile objects that had been stored in the severely infested storage facility (Vienna Harbour) were treated with nitrogen, either before the move in the old museum chamber or after the move in the new chamber in Himberg. The quarantine rooms in the new storage facility, designed for exactly this purpose, served as intermediate storage for the affected objects.

Fig. 5 a

Fig. 6 a

Fig. 5 b

Theatre Museum, storage cellar with marionettes (above) and theatre models (below).

Fig. 6 b

Theatre Museum, Vienna Harbour storage facility with props (above) as well as archive and stage set models (below).

3.4 ANALYSIS AND TREATMENT OF MICROBIAL INFESTATION

It was already known that objects and parts of collections were contaminated with microorganisms; during the inspection of the collections in preparation for the move to the new storage facility more contaminated objects were detected. Some of the microorganisms were inactive, but active contaminations were also discovered *(fig. 7 a)*.

All of the relevant groups of objects were examined by an external team of experts (Dr. Katja Sterflinger, Christian Voitl, University of Natural Resources and Life Sciences, Vienna) in order to prevent the transfer of microorganisms, and any potential health risks to museum employees during the move. In this case, fungal spores were the primary concern. Dust samples and samples from objects with traces of fungal contamination were taken. Measurements of the concentration of fungal spores in the air were carried out in the storage areas. The results of the analysis led to increased occupational safety requirements in the affected areas and for the handling of affected collections. These guidelines were implemented for the duration of the relocation and cleaning of the objects.

Particularly high levels of airborne mould spores (at times over 1,000 spores per m^3 of air) were measured in the storage areas containing the theatre models and textiles. This presented a health risk when handling the objects and when working in the storage room. For this reason, dust masks had to be worn at all times when working in these areas and handling the objects. Masks with filter class FFP 3 prevented the inhalation of mould spores. People with allergies or compromised immune systems were not allowed to enter these areas. The elevated fungal spore count was caused by the active fungal infestation of the theatre models in storage as well as spores present in dust.

The objects were thoroughly cleaned in order to prevent the transfer of mould into the new storage facility. Models that plainly exhibited an active mould infestation were cleaned with a 70 % ethanol solution.[11]

Wet cleaning with a 1 % solution of benzalkonium chloride (quaternary ammonium compound) in water was carried out on materials that could not be cleaned with ethanol. Objects from the Egyptian and Near Eastern Collection exhibited a clearly visible mould infestation. Laboratory tests, however, proved that it was an old, already extinct infestation and that the fungus was no longer capable of germinating. Treatment of these objects with a biocide was therefore unnecessary. Since it is possible to have an allergic reaction to extinct spores, all work that required direct contact with these objects (e.g., packing and unpacking, moving and cleaning) was carried out with gloves and a dust mask.

The introduction of fungal spores and contaminated objects into a new storage facility should always be prevented. For this reason, even the already inactive fungi were mechanically removed before packing and transport of the objects. Moreover, it must be kept in mind that fungi can penetrate with their hyphae several millimetres into porous materials, like clay and ceramics, such that a complete cleaning or decontamination of an infested object is difficult or impossible. Particularly with these objects, it is important to ensure the correct

[11] During treatment an exposure time of two minutes was maintained in order to ensure effectual disinfection of the objects.

Fig. 7 a

Fig. 7 b

Objects infested with microorganisms and mould remediation.

long-term climate conditions after cleaning.[12] Since October 2011, the cleaning and decontamination of mould-infested objects from the Theatre Museum and the Egyptian and Near Eastern Collection has been underway. The collections' conservators were working together with external colleagues. Until now about 6,300 objects (receptacles, groups of shards, and organic objects) from the Egyptian and Near Eastern Collection, 300 theatre models, 150 marionettes, and around 300 costumes and accessories from the Theatre Museum have been cleaned (fig. 7 b).

4. STRATEGIES FOR TREATING INFESTED COLLECTIONS

4.1 HOW TO DECIDE WHICH OBJECTS TO TREAT

In order to prevent the introduction of pests into the new storage facility, and in order to save on costly anoxic nitrogen treatment, the results of the monitoring in 2010 and 2011 were regularly discussed with the relocation team, and procedures were established for the abatement of infestations in affected collections or parts of collections. Pest infestations in the storage areas of the Theatre Museum (e.g., Vienna Harbour), the Picture Gallery (Inzersdorf) and the Imperial Carriage Museum (English Riding Stable), could already be detected in 2010 with the help of the IPM.

Previously detected pests were discovered again in 2011. Furthermore, additional sources of pests, and infested collections, (e.g., the textile storage area of the Theatre Museum) were located.

For the entire period of the move, anoxic nitrogen treatment in the museum's stationary chamber was planned and prepared for collections with pest infestations. The treated objects were prioritised and directly moved from the chamber to the new storage facility, or temporarily stored in a pest-free environment. For the majority of the museum's objects, however, it could be determined after close examination that anoxic nitrogen treatment was not necessary and these objects could be moved directly into the new storage facility after cleaning (cleaning is an important component of IPM and essential for the prevention of future infestations). This made it possible to keep to the very tight schedule and strict budget, although it was known that a certain amount of risk remained.

The 1,400 wooden pallets in the Collection of Greek and Roman Antiquities were, for example, only visually inspected in September of 2010 for wood-boring insects *(fig. 8)*. Spaces next to and underneath the pallets were searched for exit holes and insect frass with the help of a flashlight. The inspections did not detect any signs of an old or active infestation of the wooden pallets in the shelving units on the floor and at eye level; the storage facility management also never discovered an infested wooden pallet in the past. It could be assumed, therefore, with great probability, that the wooden pallets were not infested. A recent contamination, however, would not necessarily have been detected: the incubation period of the larvae in the wood is several years. Since no infestation with pests was discovered in the storage area with the pallets during IPM, no treatment was carried out. Instead, pallets were replaced only when they were too old and potentially unstable. New and replacement pallets were heat-treated before use in the new storage area.

All stored objects from collections with an active infestation (i.e., biscuit beetles in the Picture Gallery storage area) were treated with nitrogen. No risk was tolerated in this case, and the entire collection – including the decorative frames – was treated, although for wooden frames alone there is no risk of infestation with biscuit beetles.

[12] K. Sterflinger, "Fungi: their role in the deterioration of cultural heritage," in *Fungal Biology Reviews* 24, 2010, pp. 47–55; K. Sterflinger, "Pilze als Zerstörer – Eine Bedrohung für Kunst- und Kulturgut," in *Stapfia* 96, Pilze/Fungi, 2912, ed. by Biology Centre of the Upper Austrian State Museum Linz, pp. 347–362.

Fig. 8: Wooden pallets inspected for pest infestation in the storage area for the Collection of Greek and Roman Antiquities.

4.2 USE OF BIOLOGICAL CONTROL (PARASITOIDS) IN THE PAINTINGS STORAGE FACILITY

The containment of the biscuit beetle infestation in the Picture Gallery's storage area was aided by a relatively new method. Parasitoid wasps (they are about 0.5 mm in size) were released in controlled distances near an infestation of biscuit beetles.[13] The female wasp *(Lariophagus distinguendus)* lays its eggs on the larvae and pupae of the biscuit beetle, killing them in the process. In 2010, the wasps were released a total of three times in the three paintings storage areas (July, August, and September: *fig. 9*). This proved to be a useful, immediate measure to impede further damage until later anoxic treatment. Because the move was relatively far in the future (about 12 months after the discovery of the infestation), and due to inadequate information about the efficacy of this method in the literature,[14] this measure was not considered sufficient to exterminate the biscuit beetles. The introduction of the parasitoid wasps in 2010 against the biscuit beetle in the Inzersdorf storage facility led clearly to the reduction of the infestation *(see table 1)*, nevertheless, in 2011 a few living and dead beetles were found in the traps and on the track lighting in the ceiling. Whether these beetles originated from infested paintings or from the building could not be determined.

Fig. 9 a

Fig. 9 b

Release of parasitoid wasps *(Lariophagus distinguendus)* against biscuit beetles in the Picture Gallery storage area. (Fig. 9 b: © BiP, Biologische Beratung Ltd.)

[13] P. Querner – S. Biebl, "Using parasitoid wasps in Integrated Pest Management in museums against biscuit beetle *(Stegobium paniceum)* and webbing clothes moths *(Tineola bisselliella)*," in *Journal of Entomological and Acarological Research* 43, no. 2, 2011, pp. 169–175.

[14] Querner – Biebl 2011 (cited note 13).

Fig. 10 a

Fig. 10 b

Anoxic nitrogen treatment in the storage facility in Inzersdorf, anoxia tent from the pest company (left: inside, right: outside).

4.3 ANOXIC NITROGEN TREATMENT IN THE INZERSDORF STORAGE FACILITY, THE IMPERIAL CARRIAGE MUSEUM, AND IN THE NEW CENTRAL STORAGE FACILITY

The quantity of objects that needed to be treated from two collections was so high that three stationary tents in two locations had to be erected by an external company (Michael Singer GmbH & Co. KG). In the Inzersdorf storage facility, a ca. 1,000 m^3 tent was set up *(fig. 10)* and used for two anoxic nitrogen treatment cycles of the paintings and decorative frames. The first treatment cycle in Inzersdorf was completed without incident. The second cycle as well as the treatment on-site the Imperial Carriage Museum had to be repeated, because a technical problem led to an increase of the residual oxygen content in the tent. In order to be sure that all pests in all stages of development had been killed, the treatment was correspondingly extended, maintaining a constant residual oxygen content of 0.4 % for 5 weeks (documentation of the necessary treatment period in the literature is contradictory because few studies have investigated all relevant museum pests and all relevant factors that have an influence on the efficacy of the treatment: temperature, relative humidity, residual oxygen content, and fumigation time). In order to prevent recontamination of the treated objects by biscuit beetles that had survived in the building envelope, a contact insecticide (active ingredient: cyfluthrin) was sprayed in all mortises and corners of the paintings storage area shortly before the opening of the nitrogen tent. In addition, a fogging fumigant (active ingredient: pyrethrin piperonyl butoxide) was released in the immediate vicinity of the tent so that the area above the tent could be disinfested.

Two more large tents were built (together containing a volume of 100 m^3) *(fig. 11)* in the English riding stable, a storage area for coaches from the Imperial Carriage Museum in Schönbrunn, where vehicles, furnishings, and exhibition mounts were treated. After successful treatment, all objects were immediately moved to the new storage facility in Himberg, in order to prevent re-infestation.

Fig. 11 a

Fig. 11 b

Fig. 11 c

Fig. 11 d

Anoxic nitrogen treatment in the Imperial Carriage Museum, anoxia tent from the pest company.

4.4 MONITORING ANOXIC TREATMENT WITH TEST INSECTS

Along with constant monitoring of the residual oxygen levels during the entire treatment period, additional controls were used to confirm the efficacy of anoxic treatment with nitrogen: test insects (pests) were placed in the tent and checked after treatment *(figs. 12 and 13)*. The pests found in the collection being treated (webbing clothes moths for the coaches from the Imperial Carriage Museum and biscuit beetles for the paintings) were used. In order to exclude other external factors possibly leading to the death of the insects, living pests were also kept in closed containers outside of the tent. Only when the insects in the treatment tents are dead and those outside of the tent are still alive, can the control of the treatment be considered successful. The external company also placed longhorn beetle larvae *(Hylotrupes bajulus)* in the nitrogen tent as a further control method for the treatment. The samples were inspected after the tents were opened and it was determined that the pests in the anoxic nitrogen tent were dead and those outside the tent had survived.

Fig. 12 a

Fig 12 b

Samples with living biscuit beetles and placement of the reference set inside the tent for verifying successful treatment.

Fig. 13 a

Fig. 13 b

Samples with dead and living webbing clothing moths (inside and outside of the anoxic nitrogen tent) serving as reference test verifying successful treatment.

5. INSTALLATION OF THE MONITORING SYSTEM IN THE CENTRAL STORAGE FACILITY IN HIMBERG IN 2012

In March 2012, after moving to the central storage facility, the monitoring system was set up again in order to confirm the efficacy of the IPM. The same traps as had been previously used were employed once again and checked five times during 2012. The trap locations were marked in the facility's floor plan, which is available for reference in the storage facility management office together with general information collected in an IPM folder. Furthermore, information signs indicating the traps in use and possible pests were installed at all of the entrances to the individual storage areas *(fig. 14)*. The results of the monitoring showed that many collections are pest free and that the IPM has worked well. One area could not be included in the IPM and monitoring phase before the move because time was too limited. The emptying of the furniture storage facility in Korneuburg meant that the general storage area was relocated at very short notice. As a result, monitoring with traps and a corresponding cleaning of the furniture to be moved could not be conducted because of a lack of staffing and a shortage of time. As a consequence, numerous webbing clothes moths were caught in the general storage area in 2012 and this area had to be identified as a problem zone. Thorough cleaning of the already stored showcases and new incoming furniture in this area also solved this problem.

Fig. 14: Informational sign regarding traps in use and possible pests in the new storage facility.

Fig. 15: Insect screens on the windows of the new storage facility.

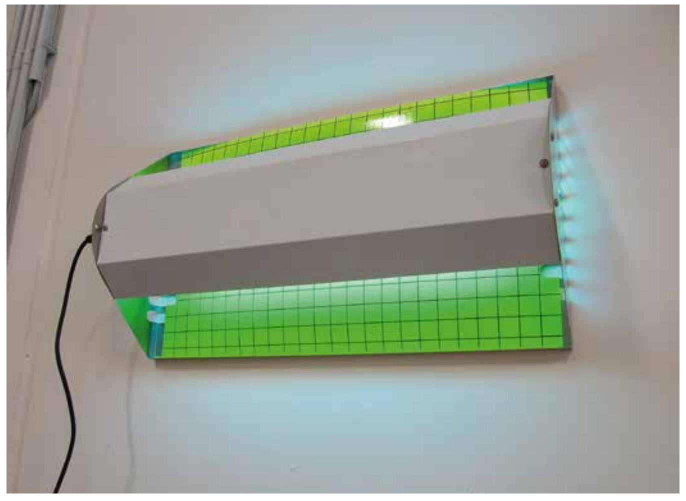

Fig. 16: UV lamp insect trap.

Over the course of the year, it was also demonstrated that bugs, lacewings, and flies (not considered pests for museum collections) are abundant in the vicinity of the central storage facility building and are drawn to it (presumably due to its white facade). They were found on the outer wall, near the entrances, and also inside in the entrance areas and in the stairwells. For this reason, insect screens were installed on all windows that can be opened *(fig. 15)*. Furthermore, three UV traps (Flytrap 80 with 2 × 40 watt bulbs; *fig. 16*) were placed in the entrance area, delivery area, and in the general storage area, in order to catch insects that gained entry to the building through open doors.

6. RESULTS OF IPM

The IPM attempted to identify pest infestations in the collections planned for relocation and to treat 100 % of the contaminated objects in the anoxic nitrogen treatment tents or in the old, and new, treatment chambers before transport to the new storage facility. Furthermore, it was possible to show that an IPM program can help to cut costs as well as protect the collections. Since not all objects had to undergo anoxic nitrogen treatment, the museum could save high costs during the move as well as logistical effort. A certain degree of risk was taken when depositing objects in the new facility that had not been treated: inspection of the storage areas for pest infestation must as a result be continued into the future. The longer a monitoring system for pests has been in place, the better and more reliable are its results. We therefore recommend that all museums as well as small and large collections set up a monitoring system as part of an IPM plan.

IPM is, however, a long-term strategy that needs to be built into regular museum operations because the possibility of a future infestation can never be excluded. New acquisitions should be inspected for infestation prior to storage or even better, as a rule, always treated in the anoxic nitrogen chamber. This way it is possible to prevent new infestations over the long term. Experience has shown that the transition to an IPM program is a process that lasts some years. Above all, old buildings are often difficult to seal and to bring up to contemporary standards for storage, leading to repeated re-infestations. At the moment, one person is responsible for IPM and monitoring in the Kunsthistorisches Museum Vienna (this is true for all of the locations except for the Weltmuseum Wien). He regularly conducts the monitoring in a large part of the collections, adjoining workshops and storage areas. This work takes place, however, in constant and very close collaboration with the conservators of the individual collections, who provide more precise knowledge and understanding of the particular building environments, as well as the history and condition of the objects. The IPM coordinator is responsible for the coordination of the different tasks and procedures, as well as the adaptation of the whole concept within the museum. Broad acceptance by all museum staff members, regular communication of the results, and training of new employees are all also of great significance to IPM.

7. MATERIALS LIST

Pheromone traps for webbing clothes moths (Finicon), for biscuit beetles and sticky blunder traps were ordered from Pestimo Services. The insects for testing the anoxic nitrogen treatment chamber were provided by BAM, Bundesanstalt für Materialforschung und -prüfung (webbing clothing moths) and by BiP, Biologische Beratung Ltd. (biscuit beetles, parasitoid wasps), both in Berlin.

8. ACKNOWLEDGEMENTS

We thank the Kunsthistorisches Museum Vienna for supporting and financing the IPM program in the various collections, the editors for their contributions, along with Ernst Gregor, Elke Oberthaler, Monika Strolz, Dr. Katja Schmitz-von Ledebur, Isabelle Zatschek, Anna Femi-Mebarek, Dr. Regina Hölzl, Irene Engelhardt and Marianne Novotny-Kargl, for their professional expertise and fruitful collaboration.

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SUMMARY

In relocating the objects housed in the various storage sites of the Kunsthistorisches Museum Vienna to a new location, the goal of a pest-free move into the new building was established. Not all objects from all collections could be preventively treated for infestation before their transfer, however; instead, during the planning and construction phases of the new storage facility in 2010 and 2011, all collections were evaluated in an Integrated Pest Management (IPM) monitoring program. Thus, and with the experience of previous years, infested objects and collections were identified. A specific problem at the KHM was a biscuit beetle infestation *(Stegobium paniceum)* in paintings with linings containing starch paste, and in horse models at the Imperial Carriage Museum (Wagenburg). Webbing clothes moths *(Tineola bisselliella)* were found at the Imperial Carriage Museum and in the storage spaces of the Theatre Museum, sometimes in large numbers. All infested objects were treated in three large nitrogen tents and in the museum's nitrogen chamber before the move in summer 2011. Two collections were affected by mould, and elaborate measures for mould treatment (cleaning) had to be implemented during packing and transport.

At the new storage facility, an enlarged nitrogen chamber, three quarantine rooms (one for mould-contaminated objects), and areas for the separate delivery of infested materials were planned and constructed. The success of the treatments was evaluated with a new monitoring program with sticky, pheromone, and UV traps first installed in 2012. As a result of the IPM, it was not necessary to treat numerous objects and collections with nitrogen, allowing substantial savings of money and time.

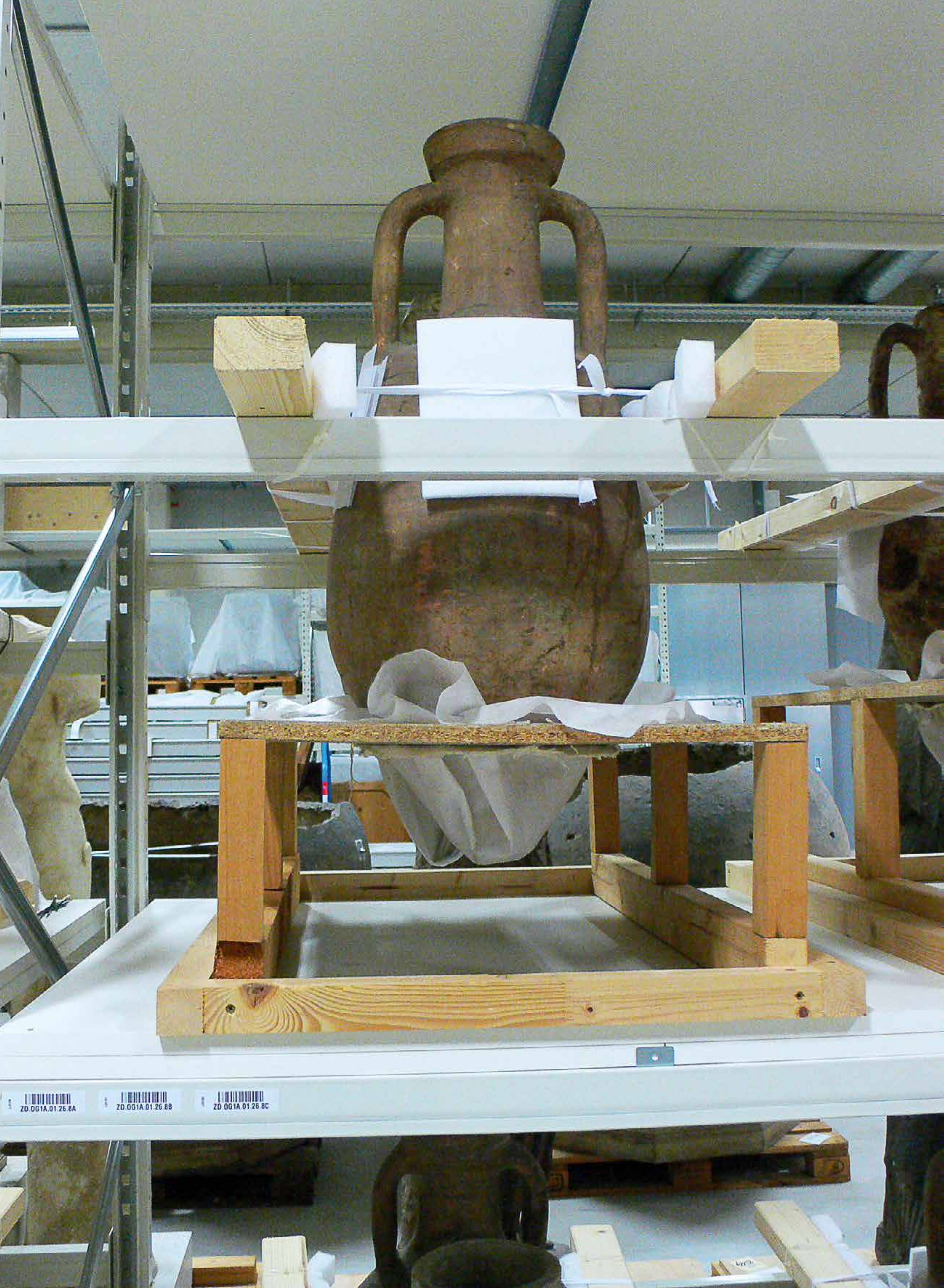
However, it is essential to continue long-term monitoring within the framework of the Integrated Pest Management program. Pests should thus be quickly discovered in the future, and infested objects recognised. As a preventive measure, all incoming objects are to be treated before entering the new storage facility to prevent a new infestation.

ZUSAMMENFASSUNG

Für die Verlegung der in unterschiedlichen Depots gelagerten Objekte des Kunsthistorischen Museums Wien in das neue Zentraldepot wurde als Ziel gesetzt, das neue Depot schädlingsfrei zu beziehen. Es konnten aber nicht alle Objekte aller Sammlungen vor dem Umzug präventiv gegen Schädlinge behandelt werden. Daher wurden während der Planungs- und Bauphase des neuen Depots 2010 und 2011 alle relevanten Sammlungen in einem IPM-Programm überwacht. Damit und mithilfe der Ergebnisse der vergangenen Jahre wurden befallene Objekte und Sammlungen identifiziert. Ein spezifisches Problem des Kunsthistorischen Museums war ein Befall mit dem Brotkäfer *(Stegobium paniceum)* von Gemälden mit stärkekleisterhaltige Doublierungen und von Pferdefigurinen in der Wagenburg. Kleidermotten *(Tineola bisselliella)* wurden in der Wagenburg und in Depots des Theatermuseums zum Teil in großer Anzahl gefunden. Befallene Bestände wurden daher vor dem Umzug im Sommer 2011 in drei großen Stickstoffzelten und in der Stickstoffkammer des Museums behandelt. Zwei Sammlungen waren von Schimmelpilzen befallen, weshalb beim Verpacken und beim Transport aufwändige Maßnahmen zum Zweck der Entschimmelung umgesetzt werden mussten.

Bei der Planung des neuen Zentraldepots wurden eine vergrößerte Stickstoffkammer, drei Quarantäneräume (einer für von Schimmelpilzen befallene Objekte) und die Schaffung räumlicher Gegebenheiten für eine separate Anlieferung von befallenen Objekten mitberücksichtigt. In Zukunft soll die Sammlung möglichst schädlingsfrei gehalten werden. Der Erfolg der Behandlungen soll mittels eines neuen Monitoringprogramms mit Klebe- und Pheromonfallen für Kleidermotten und Brotkäfer überwacht werden, welches 2012 nach dem Umzug im Zentraldepot Himberg gestartet wurde. Dabei werden auch nichtbehandelte Sammlungen überprüft, damit ein potentieller Schädlingsbefall möglichst rasch erkannt werden kann.

Infolge der Anwendung des IPM mussten zahlreiche Objekte und Sammlungen nicht mit Stickstoff behandelt werden, weshalb erhebliche Kosten und viel Zeit gespart werden konnten. Allerdings ist es notwendig, das Monitoring im Rahmen der integrierten Schädlingsprävention langfristig weiterzuführen. Auf diese Weise sollen auch in der Zukunft Schädlinge rechtzeitig entdeckt und befallene Objekte lokalisiert werden.



Implementation of a Barcode System for Museum Storage

Peter Kloser

Translated from the German by Aimée Ducey-Gessner

1. INTRODUCTION

The construction of the central storage facility in Himberg, a suburb of Vienna, and the resulting relocation of a large part of the collections, provided an opportunity to simplify the tracking of objects' locations by means of a barcode system for the affected collections. The barcode has proved to be a dependable system for computerised tracking of objects in storage since the 1970s. Furthermore, applications that link the system with the central object database TMS ("The Museum System" from Gallery Systems) have already been assessed and are available for use. With this database, all of the objects within the museum's network – the Kunsthistorisches Museum Vienna (KHM), the Weltmuseum Wien (WMW) and the Theatre Museum (TM) – can be described and managed. An essential and very important aspect of this is the commitment to a timely documentation of the current location of the collections. A barcode interface with TMS was established in order to obviate the laborious and error-prone transfer of hand-written lists. The additional time needed for the mounting of the barcode labels on the objects is more than compensated for by the considerably swifter and more reliable updating of object location during all aspects of museum operations.

The Musée des art et métiers and the Musée du quai Branly in Paris were visited in advance to examine the on-site practical application of a barcode interface with TMS and to learn from the experience of their staff.

2. REQUIREMENTS

The fundamental requirement of a barcode system is the explicit identification of an object. TMS prevents redundancies through the allocation of a unique inventory number for each object and a consecutive object identification number is created for each object entry. The latter is purely numerical and is translated into the barcode that appears on the label. Just as no duplicates may be allowed to exist in the collections, one location may not be allocated twice: consecutive location identification numbers are also assigned by the database. They serve as the basis for the location labels and are also translated into a barcode.

Access to and usage of the interface with the database must remain limited to a small number of people in order to avoid unqualified or improper manipulation of the records. This group of people can be restricted by management of the database's user's privileges.

Fig. 1: Central storage facility, Himberg: shelving units for the Collection of Greek and Roman Antiquities with the barcodes for the adjacent shelves, here storage rack No. 23, section 1, shelf B.

3. PROCEDURE

The assignment of individual locations could be undertaken after the facility management completed planning of the distribution of the collections in the space and its furnishing. It was possible to distinguish up to five levels and individual shelves could be recorded as a distinct location. The locations were subsequently created in TMS. The identification numbers for the location labels were translated into the barcode pattern and given the prefix “L” in order to preclude confusion with the object’s barcode *(fig. 1)*.

Fig. 2: Detail of a rococo tailcoat with its barcode label attached with a polypropylene security loop.

Fig. 3: Barcode label.

The inclusion of all relevant objects in the central object database TMS was an important preliminary step. The Conservation Science Department, together with the Conservation Workshops, had to find a material for the attachment of barcode labels that would not react with materials found in the collections, would not emit harmful substances, and that could not cause mechanical damage. Finally, a PE-based product was agreed upon with the dimensions 70 × 40 mm and with a pre-punched hole for attachment.

The labels were printed by means of colour ink ribbons with a thermal transfer printer (Zebra S4M) and scratch-proof ink. Attachment to the objects was carried out according to the requirements of the specific collection or type of object with either cotton string or a polypropylene security loop *(fig. 2)*. For objects to which the barcode label could not be directly attached, the corresponding adhesive label was printed (with a commercially available laser printer) and it could then be applied to the respective pallet or storage box, for example.

Moreover, the individual departments could determine any additional information that they also wanted to have included on the label. Instead of presenting merely a numerical code, the labels could serve to facilitate work in the storage areas with helpful information, such as, object title, object description, associated staff member, etc. *(fig. 3)*.

The labels were printed with the software Crystal Reports, which can generate diverse reports from TMS.

4. TWO SYSTEMS

In collaboration with the Dutch company Cit, two programs serving as interfaces between the object database and the laser scanners were adapted to the work in the storage facilities. The two systems were developed in order to best fulfil diverse needs and working situations.

The software “BarApp” was developed to facilitate working in storage areas with hand-held scanners. At the outset, the identity of the person operating the scanner and their purpose is recorded. Then, whether a temporary move of the object is taking place, or whether it is going to its permanent location, is defined. Finally, the location information and afterwards all objects associated with it are recorded with the scanner *(fig. 4)*. If a new location is encountered, it is scanned first and then the objects. At the end, the data, which are now saved in the scanner, are synchronised with the database. For this task, the database privileges are limited to staff members whose job responsibilities include registrarial duties for the collections. The software is designed such that, before synchronising the data, it can be reviewed again and any evident mistakes can be discarded *(fig. 5)*.

The name of the staff member in the storage facility as well as the person responsible for the synchronisation is now documented in the database. The log file further records whether the location was allocated with barcode system. The individual data from the scanner is stored in separate folders and can be analysed at any time when requested. TMS in turn documents the complete location history of an object, which means every change of location that occurs. Thus it should be guaranteed that the location information in the object database is at all times traceable.

Fig. 4: Scanning a barcode with the laser scanner (Motorola MC 1000 Scanner) for location logging in TMS.

“Move” is an alternative software design. In contrast to “BarApp,” however, a computer must be available in the immediate vicinity to use it because it must connect “live” to the database. The corresponding link between the computer and the server with the database must also be in place, as well as a scanner that can be connected to the computer either via cable or wirelessly. The initial data indicating the responsible staff member, the type and purpose of the move, is carried out as described above *(fig. 6)*.

Fig. 5: A barcode label is scanned for the software “BarApp” with a laser scanner.

Fig. 6: Laser scanner with USB connection for the software “Move”.

When an object is scanned with “Move,” its basic information, such as the inventory number, object description, dimensions and material, as well as any available photographs are queried in the database and displayed. The software is therefore also suitable for the verification of barcode labels and object data. It is not necessary to synchronise the software after updating information during a project; the entries are immediately visible to all database users. “Move” is suited primarily for fixed work stations where objects are temporarily located, registered, and processed, like, for example, in the photography studio or conservation department.

5. BEST PRACTICES

Ideally, when an object will be moved, the barcode is attached during packing and before transport. If the object still does not have a photograph, the opportunity can be used to create a working photo before it is packed, which can then be saved in the database. Later, identification in the storage facility may be made easier and it may also serve as documentation of the object’ s condition should it be damaged during transport. If the object arrives in the storage facility with a barcode already attached, it can be processed more quickly because the new location can be immediately documented. Thus, delays in completing an inventory of delivered works are avoided. Owing to the time-sensitive nature of the move of some external storage facilities of the KHM, however, this step could rarely be implemented.

The move of the Picture Gallery, which has a comparatively small number of objects, could be carried out quite methodically. As an additional project, objects without an image were photographed and an inventory of frames was created. Every painting and frame in the central storage facility is furnished with a barcode. Both sides of the wire mesh storage panels are identified as locations in the database so that each object has its own, clear, permanent location. If in the future paintings or frames are moved, they can be quickly returned to their original location. The permanent location can be queried in TMS.

For the attachment of barcode labels to such a large quantity of objects, an initial sorting according to inventory number in album sheets, similar to how they are used by stamp collectors, proved beneficial. Because the reports used for the production of the barcodes are sortable according to diverse sets of criteria, they can be easily adjusted to the needs of the individual collections.

6. CONCLUSION

The barcode system has proved to be a stable solution for the departments in which it is used, contributing considerably to a simplified workflow. It is also easy to document short-term and temporary changes in location. Particularly in regard to an unbroken location history of the individual objects, barcodes should be in general use. The handling of the devices and working procedures were easily learned by staff members and were quickly accepted after the first use.

SUMMARY

With the move to the new storage facility, barcode technology was introduced to simplify collections management. Two applications by the software company Cit were used for the object database TMS by Gallery Systems: a mobile system with hand scanners and later synchronisation with the database, and a stationary system with direct database access. Ideally, the placement of the barcodes on the objects and the photographic documentation for the database occurred before the transport. Due to time pressures, however, this was only possible in a few cases.

ZUSAMMENFASSUNG

Mit der Übersiedelung in das neue Zentraldepot wurde die Barcode-Technologie für eine vereinfachte Sammlungsverwaltung eingeführt. Dabei wurden zwei Applikationen der Softwarefirma Cit für die Bestandsdatenbank TMS von Gallery Systems verwendet: ein mobiles System mit Handscannern und späterer Synchronisation mit der Datenbank sowie ein stationäres System mit direktem Datenbankzugriff. Das Anbringen der Barcodes an den Objekten und die fotografische Erfassung für die Datenbank erfolgen idealer Weise vor dem Transport. Wegen des Zeitdrucks war dies jedoch nur in wenigen Fällen möglich.

Fig. 1: Old storage of portrait busts.

The Relocation of Objects from the Collection of Greek and Roman Antiquities, the Egyptian and Near Eastern Collection, and the Kunstkammer to the Central Storage Facility

Bettina Vak, Angelika Kathrein and Michael Loacker

Translated from the German by Aimée Ducey-Gessner

1. RELOCATION OF OBJECTS FROM THE COLLECTION OF GREEK AND ROMAN ANTIQUITIES: PREPARATION, IMPLEMENTATION, EXPECTATIONS

Bettina Vak and Angelika Kathrein

1.1 INTRODUCTION

The objects in storage from the Collection of Greek and Roman Antiquities range greatly in size and comprise many different materials: limestone and marble sculptures and architectural fragments *(figs. 1 to 3)*, heavy tombstones *(fig. 4)*, delicate glass ointment jars *(fig. 5)*, sundry drinking and multifunctional receptacles, and tableware out of glass and ceramic *(figs. 6 and 7)*, along with bronze statuettes, weights, and table decorations. Collections of glass, ceramic

Fig. 2: Old shelving units for the architectural fragments.

Fig. 3: Old shelving units for the busts and sculptures; in the foreground, pallets prepared for loading into the moving trucks.

Fig. 4: Old storage of tombstones.

Fig. 5: Old storage of ointment jars in a drawer.

Fig. 6: Old storage of ceramic objects.

Fig. 7: Old rolling storage unit.

Fig. 8: Old storage, glass ointment jars.

Fig. 9: Old storage, *millefiori*, fragments.

Fig. 10: Old storage, box with fragments of greaves.

Fig. 11: *Pithos* before transport.

and metal object fragments *(figs. 8 to 10)* as well as large storage jars such as amphorae and fish storage vessels *(fig. 11)* are also included. Over a period of 14 weeks, 148 truck shipments moved 16,000 objects with a total weight of 420 metric tons.

Alfred Bernhard-Walcher, director of the relocation project, scheduled the sequence of the move, planning each step in detail. First, the numerous objects stored on pallets had to be moved onto new, standardised Euro-pallets or customised pallets. This very time-consuming work was started six months before relocation; the objects in question were primarily heavy stone objects. Michael Loacker, who was responsible for the preparation and registration of the ca. 2,000 heavy objects in the Collection of Greek and Roman Antiquities, has contributed the second part of this article, which is dedicated to a detailed description of the preparation and relocation of these massive objects.

Small objects were also in need of preparation; many were stored loosely in small boxes without any additional protection. The relocation of the rolling storage units and the climate-controlled cabinet, from which the remaining 14,000 objects were taken, was carried out over six weeks by two teams, each comprised of four people, according to the method described below.

The first step took place months in advance: the collections in the rolling storage unit and the climate-controlled cabinet in the old storage facility in Inzersdorf were inspected.

1.2 PREPARATION FOR TRANSPORT: STABILISING SMALL FRAGILE OBJECTS

As already mentioned, small finds, shards, and the like were stored loosely in drawers or boxes *(fig. 12)*, at times next to or on top of one another. A month before the move was scheduled to begin, these small objects were separated and individually wrapped in tissue paper and placed in temporary transport containers *(figs. 13 and 14)*. In most cases, the old storage containers were used and reinforced as necessary, or improvised boxes constructed from cardboard or Ethafoam were prepared with basic tools (hot glue guns or packing tape; *fig. 15*).

Some of the small stone sculptures were also comprised of many fragments; small pieces were packed separately in boxes of differing sizes, reducing the amount of work immediately preceding transport *(fig. 16)*.

Fig. 12: Small finds loose in boxes.

Fig. 13 a

Fig. 13 b

Glass fragments (left), packed in tissue paper (right).

Fig. 14 a

Fig. 14 b

Fig. 14 c

Glass objects packed in tissue paper (Fig. 14 a and b) as well as in tissue paper and transport box (Fig. 14 c).

Fig. 15 a

Fig. 15 b

Metal finds separated by Ethafoam strips in an old box (left) and packed in tissue paper (right).

Fig. 16 a

Fig. 16 b

Stone objects, small objects packed for transport.

Inventory labels had been attached to a large part of the collection of vases; small, circular pieces of cardboard were attached to the objects with wire wrapped with thread. The wire was removed and the labels were placed next to the objects in the new storage system, where they proved to be very helpful for rapid identification of the objects *(fig. 17)*.

1.3 TRANSPORT OF SMALL OBJECTS

Two teams consisting of two people each – a conservator and registrar or intern (archaeology student) – worked together with two teams made up of two employees from the moving company Kunsttrans. Because there was limited space within the rolling storage unit for accessing the objects, the second team began working one day after the first, so that the same team could pack the objects one day and unpack them the next day in the new storage facility *(fig. 18)*. The division of labour was clear: the conservators took care of the handling, dry cleaning and securing of the objects for transport. Condition photographs were taken of all objects where previous treatment was apparent, corrosion was visible, or that were particularly at risk during transport. At the time of packing, the registrars prepared the packing lists, in which the photographs were also documented in three condition categories (corrosion, recent repair, fragments) *(figs. 19 to 21)*.

Fig. 17 a

Fig. 17 b

Old inventory labels placed directly on, or later next to the objects, as seen in the drawer in the new central storage facility.

Packing of the objects for transport to the new storage facility became much easier after this preparatory work had been carried out, yet, some objects still required extra measures in order to secure them for the move *(figs. 22 to 24)*. Large moving crates with up to three shelving inserts each were outfitted with PE cushions filled with styrofoam pellets. The stone objects, as well as the large amphorae, were placed in these crates and covered *(figs. 25 and 26)*.

Small objects were wrapped individually in tissue paper and were packed in transport or plastic boxes of varying sizes. Additional stabilisation was provided as needed, like for example, the addition of Ethafoam spacers or styrofoam filled cushions *(fig. 27)*.

Fig. 18: Unpacking and inspection.

Fig. 19: Basin-shaped bronze urn with very fragile walls and an old repair.

Fig. 20: Ceramic vessel from Brigetio with recent reinforcement and fragments.

Fig. 21: Column crater with fragments.

Fig. 22: Stabilising a *Pithos* for transport.

Fig. 23: Stabilisation of stone objects for transport in a pallet crate.

Fig. 25: Amphorae in a pallet crate.

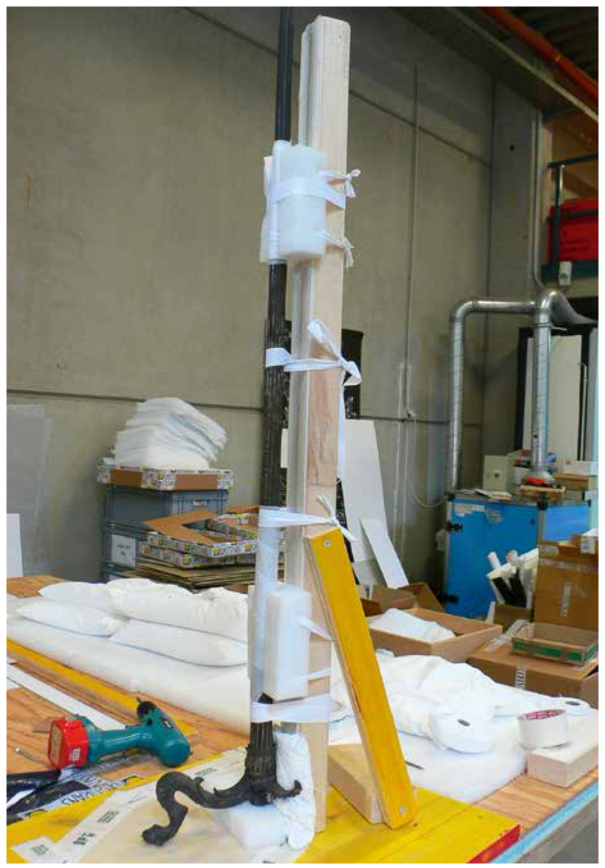


Fig. 24: Stabilisation of a metal object for transport.

Fig. 26: Moving crate with insertable shelves.

Fig. 27 a

Fig. 27 b

Fig. 27 c

Stabilisation for transport (left) and packing for transport (middle) of a fragile ceramic; in the photograph on the right, stacked in a moving crate.

If the objects previously had been placed close together in the shelving unit, as was the case for the bronze statuettes, the identical order was to be maintained in the new storage facility. The transfer of the original sequence was carried out in serpentine lines: the numbering system, beginning with one, started with the row closest to the frontmost edge of the shelf, snaking back and around until reaching the last row *(figs. 28 to 30)*. In this way, the placement of every single object could be maintained throughout the process: from shelf to packing table and inside the packed box. Placement in the moving boxes began with the last number so that when unpacked, the numbering could simply be followed from one until the end, placing the objects again in the same order in the new shelving units *(fig. 31)*.

A copy of the completed transport list was attached to the corresponding box or crate. When the objects were unpacked and brought to their new location in the new storage facility, the list was inspected and updated again, so that with it, each movement of the objects could be traced.

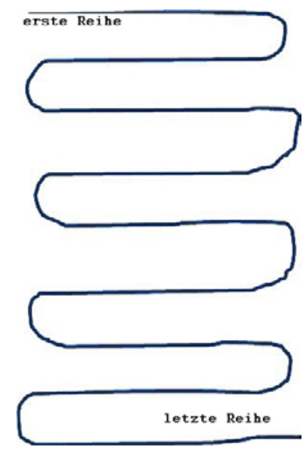


Fig. 28: Serpentine numbering system for the object location.

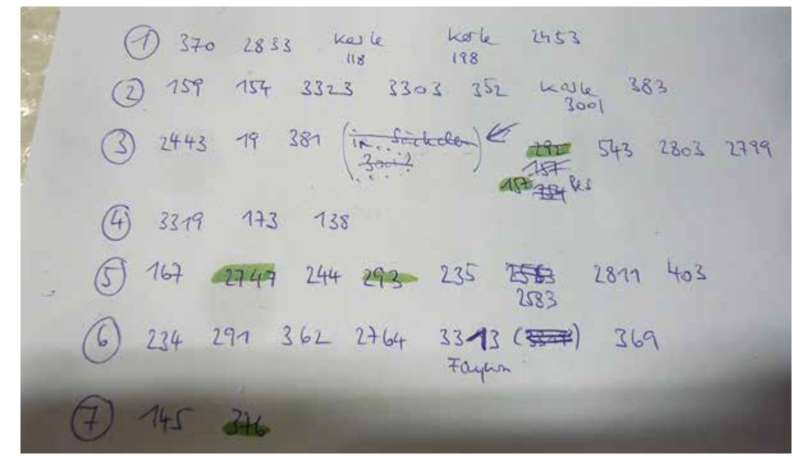


Fig. 29: Identification of the rows and placement in the packing list.

Fig. 30: After unpacking onto the trolley.

Fig. 31: Placement on the shelves.

1.4 STORAGE OF SMALL OBJECTS IN THE CENTRAL STORAGE FACILITY IN HIMBERG

The project director prepared the location plan for the 14,000 objects stored in 13 rolling shelving units and nine metal cabinets. The distribution in the drawers and on the shelves was decided, however, at the time of unpacking according to the space available. In this way, the shelves could be quickly loaded *(figs. 32 to 34)*.

The drawers in the shelving units in the new central storage facility in Himberg are lined with Ethafoam; a layer of thin polyethylene foam lines the shelves.

Glass and metal objects, when not embedded in Ethafoam, were placed on an intermediate layer of tissue paper, and particularly fragile pieces rest on an additional layer of polyester fleece. All materials in use tested negative for the emission of pollutants. Only the Oddy-tests of the thin polyethylene foam resulted in a recommended use of “non permanent” because it has a slightly corrosive effect on lead; it should not come in contact with particularly sensitive objects, like for example, heavily corroded glass and metal. The shelves in the climate-controlled space (metals) and those with glass objects were instead lined with tissue paper.

Fig. 32: Rolling shelving units with drawers.

Fig. 33: Rolling shelving units with unpacked objects.

Fig. 34 a

Fig. 34 b

Fig. 34 c

Drawers with lamps (left), ointment jars (middle) and glass fragments (right).

Fig. 35: Unstable objects with Ethafoam supports.

Fig. 36: Adjustable guard rail additionally secured with Ethafoam strips.

Fig. 37: Metal objects in the old storage boxes.

Fig. 38: Drawer with metal objects placed in archival boxes.

Unstable objects were outfitted with customised Ethafoam supports. Objects on the shelves of the rolling storage units can be additionally protected with an adjustable guard rail *(figs. 35 and 36)*.

1.5 ADDITIONAL MEASURES

During relocation, the packing materials and old storage boxes were temporarily stored on the shelves and in the drawers. The rehousing of metal objects with new, acid-free archival cardboard boxes in five standard sizes was prioritised, and eventually all of the old boxes used during the move of the small objects were replaced *(figs. 37 and 38)*.

Attachment of the barcodes could only be undertaken after the move took place and the final location of the objects had been determined; this work was completed during the following year.

2. RELOCATION OF STONE OBJECTS FROM THREE COLLECTIONS

Michael Loacker

The old storage facilities of the Kunsthistorisches Museum Vienna contained a very large number of stone objects: 2,000 belong to the Collection of Greek and Roman Antiquities (ANSA), 398 to the Egyptian and Near Eastern Collection (ÄOS) and 100 to the Kunstkammer (KK). The great variation in weight and condition of these objects presented a great challenge for the preparatory phase of the relocation project.

2.1 PREPARATORY MEASURES

The predetermined, strict time schedule for the relocation project required the creation of cost-effective, standardised packing methods that, at the same time, did not put at risk the people or the objects that they were preparing. An inventory of all stone objects in storage had to be carried out in order to make a realistic estimate of the time requirements and possible packing methods. The majority of stone objects in storage rested on wooden pallets that were in turn stored in heavy-duty shelving units.

With the help of inventory lists, the location of the entire collection and its readiness for transport could be determined. This information was updated on a case-by-case basis. Many of the Euro-pallets were in a deteriorated state due to their age (figs. 39 and 40); others were too small, making handling and transport a risk. As a result, new customised pallets were produced that were somewhat larger than the objects, reducing the danger of mechanical damage occurring during transport (fig. 41). The dimensions of every pallet were measured and documented in an Excel list. The goal was not only to calculate the number of customised pallets that needed to be ordered, but also to consider the distribution of the objects taking into account their size and weight. Since I alone had to record all of this information and enter it into the Excel list, this task required a lot of time in addition to the work of transferring the artworks to the new pallets. It provided, however, an important basis for further planning and procedures. The new, very stable customised wooden pallets were made in-house by Kurt Schopfhauser and Alfred Schodl (carpentry workshop, KHM).

Fig. 39: Covered sphinxes placed on old, deteriorated pallets.

Fig. 40: A sphinx on a damaged pallet.

The decision to make the new pallets out of wood was important: as a result, the pallets had to be heat-treated according to international standards as provided in the ISPM 15 guidelines.[1] During heat treatment, the wood is heated to a core temperature of 56 °C for at least 30 minutes, which prevents the introduction of harmful organisms.[2] Heat treatment has the additional advantage of drying out the wood, leaving only 20 % residual moisture, thereby greatly reducing the probability of the wood warping when stored under good conditions. Every delivery of pallets had to be carefully inspected because most manufacturing plants are located outside of Austria; one can never be sure that the storage conditions at the point of production or during transport were clean. Pallets made from synthetic materials were not considered because the plasticisers can damage objects during long-term storage, and adequate compressive strength for heavy objects cannot be guaranteed.

Fig. 41 a

Fig. 41 b

Transfer of a sphinx to a new custom-made pallet.

1 ISPM stands for the International Standards for Phytosanitary Measures, which is summarised in 15 points. The material used for wooden transport materials is often made from inexpensive raw materials, leading to the possibility of infestation with pests, like larvae, which as "hidden passengers" can be transported around the world. Through globalisation and diverse trade routes, the pests reach every continent in a very short time.
The ISPM define the necessary measures for treating the raw wood before its application as a packing material, so that no undesirable pests come along on the journey. Wood that has been treated according to the ISPM guidelines must always be indicated. The label contains a country code, region code, as well as a registration number. In addition, information about the treatment carried out is provided. Permission to use the fumigant methyl bromide was discontinued on August 31st, 2006.

2 More detailed information can be found under *Bundesamt für Wald* http://bfw.ac.at/400//pdf/fsaktuell_34.pdf> (07.09.2015) and <http://de.wikipedia.org/wiki/Internationaler_Standard_f%C3%BCr_Pflanzenschutzma%C3%9Fnahmen (07.09.2015).

A test run of the transfer of artworks onto the new pallets was carried out in order to obtain a realistic estimate of the time requirements. We began with the carved stone reliefs from Trysa in the Collection of Greek and Roman Antiquities. With the help of Johannes Cermak, Zoltan Feher and Rudolf Kreuz (KHM, service team), the reliefs were moved onto their new pallets in about 50 hours. During the first pallet transfer phase, around 36 relief blocks could be transferred in one work week, corresponding to ca. seven objects a day.

I carried out the following pallet transfers with assistance from the company Gerald Füreder, amounting to ca. 293 hours. In order to estimate the weight of the objects with their pallets for transport as well as for distribution later in the shelving units of the new storage facility, each object was weighed with its pallet. A very essential part of the planning at this point was determining the future weight distribution in the heavy-duty shelving units in the new storage facility in order to ensure sufficient carrying capacity and free space. The weighing of all objects with their pallets provided important information for future transport (e.g., loans) as well. Unfortunately, for unknown reasons some of the newly delivered cross beams for the heavy-duty shelving units were too weak, and cross beams with greater capacity load had to be reordered.

2.2 APPLIED METHODS OF TRANSFER AND STABILISATION

As already mentioned above, reusable, variable yet standardised packing methods were sought whose versatility allowed for their use throughout the collection. The following list provides insight into the different areas and variety of objects in the affected collections:

- carved stone relief blocks from the Heroon of Trysa
- tombstones
- historic marble columns
- portrait heads and busts
- fish storage vessels
- stone sculptures
- stone architecture and stone pedestals
- stone fragments and broken pieces
- milestones and sarcophagi

Fig. 42 a

Fig. 42 b

Fig. 42 c

Removal of a stone relief block from an old pallet and transfer to a new, customised pallet.

2.2.1 CARVED STONE RELIEFS FROM THE HEROON OF TRYSA

Up until this time, many of the stone relief blocks were stored directly on thin, mostly unplanned wooden planks with insufficient distance between the stone and the wooden pallets. Going forward, five cm thick wooden boards placed on the pallet provide adequate air circulation and enable easier placement of the Ethafoam lined hoisting sling; the Ethafoam provides extra protection of the object's surface. Before lifting, each object had to be inspected for capillary cracks, which determined the placement of the sling. The objects could not be approached from the side with the forklift because the pallet supports run longitudinally to the ground. As a result, each pallet had to be propped up on wooden blocks *(fig. 42)*.

Acrylic fleece cut to size was adhered to the upper surface of the new boards on the pallets, protecting the surface of the object during long-term storage. The advantage of the white acrylic fleece is that it cannot absorb ambient humidity and will not cause discoloration of the object's surface even when permanently in contact with it.

Fig. 43: Wooden blocks with attached acrylic fleece.

The acrylic fleece had to be cut to size because no ready-made strips in the desired width were available. This was carried out by hand from a roll of bulk material with a box cutter and straightedge. A very sharp blade is necessary for cutting the fleece, which is made out of spun acrylic fibres and will immediately distort when cut with a dull blade *(fig. 43)*.

For the temporary stabilisation of the objects on the pallets during transport, load-binding straps of varying tensile strength were used, securing the most stable position for the object. After placement in the new storage facility, the stabilisation measures used for transport, including Ethafoam padding, could be quickly removed.

2.2.2 TOMBSTONES

A particularly safe and fast method had to be developed for the handling and transport of the ca. 23 tombstones attached to the wall in the old storage area, in part due to their great weight. In collaboration with Martin Dorfmann (DP-art), the idea to build a kind of "wooden shoe" construction (l-shaped transport board) was developed that served not only as a temporary container for transport, but also simplified placement on the wall in the new storage facility. Stones with continuous, dispersed horizontal crack formations had to be supported from the back with an attached wooden panel, guaranteeing stability when the object was lifted with a forklift. During transfer to the pallet, the very heavy objects were tied to the "wooden shoe" and wooden back panel with straps, and electric lifting devices were necessary to carefully lower the entire construction at a tilt slowly onto the Euro-pallet. The less heavy objects could be transferred by hand by four to six men.

Detailed workflow: loosening of the wall mount and placement of the lower, narrow side on wooden blocks the same height as the Euro-pallet *(fig. 44)*. Very heavy or deteriorated stones had to be lifted with a lifting device and straps.

Fig. 44: Removal of tombstones from the wall.

Fig. 45 a

Fig. 45 b

Sliding the tombstones onto the "wooden shoe" construction by means of soaped boards.

Fig. 46: Removal of the soaped boards.

Fig. 47: Positioning and lowering of the tombstone into the "wooden shoe" construction.

Fig. 48: Lowering of the tombstone with a lifting device.

Fig. 49: Transfer of the tombstone by hand.

Fig. 50: Tombstones on Euro-pallets prepared for transport to the new storage facility.

Fig. 51: A two-piece tombstone in the old storage facility of the Kunsthistorisches Museum Vienna.

Fig. 52 a

Fig. 52 b

Lower and upper part of a two-piece tombstone in the new central storage unit.

Fig. 53: Placement of a two-piece tombstone with wooden storage container mounted on the concrete wall in the new central storage facility.

Placement of soaped boards and sliding of the stone onto an awaiting pallet. Thin, planed hardwood boards were coated on one side with soap. In order to slide the stone, the coated sides had to lie on top of one another. In this way, even very heavy objects could be moved without a problem *(figs. 45 and 46)*.

Positioning of the "wooden shoe" construction along the back side of the stone and sliding it into the "wooden shoe". With the help of lifting devices, the stones could be directly placed into the "wooden shoe" *(fig. 47)*.

Stabilisation with load-binding straps and lifting straps. Transfer of the stone with a lifting device or by hand *(figs. 48 to 50)*.

"Wooden shoe" constructions made from formboards were prepared for the two-piece tombstones *(figs. 51 to 53)*.

Fig. 54: Transfer of historic marble columns with soaped boards.

Fig. 55: Placement of marble columns in the old storage facility of the KHM.

Fig 56 a

Fig. 57: Raising a stabilised stone column with a continuous crack formation with the help of a lifting device.

Fig 56 b

Upper and lower sections of a stone column with continuous dispersed crack formations.

2.2.3 HISTORIC MARBLE COLUMNS

Whenever possible during the relocation of large, heavy objects, soaped boards were used as a safe and quick method to move, or slide, them onto the new pallets, proving to be very helpful for the entire project *(fig. 54)*.

The historic marble columns with vertical crack formations, however, had to be additionally secured (Ethafoam and load-binding straps) and could not be moved with the help of the soaped boards because the danger that they could fall apart was too great *(figs. 55 to 57)*. In this case, the stabilisation methods used for transport were also suitable for later, long-term storage in the new storage facility *(fig. 58)*. The use of Euro-pallets and stackable wooden crates, which could be stabilised on the inside with wooden braces, worked well in this case and proved reliable over continued use. Rectangular metal plates or wooden boards were screwed onto the crates from the outside, preventing the detachment during transport *(fig. 59)*.

Fig. 58 a

Fig. 58 b

Lower and upper sections of a stone column with stabilisation for transport to the new storage facility.

Fig. 59: Marble columns in the new storage facility on Euro-pallets with stackable wooden crates.

2.2.4 PORTRAIT HEADS AND BUSTS *(FIG. 60)*

The historic stone pedestals that had been custom-made for the busts of Roman Emperors were built somewhat small, making them problematic for use during transport or for long-term storage. In an upright position, the weight of the objects became concentrated on a limited area due to the relatively small, and in some cases damaged pedestals. This less than optimal distribution of weight during transport would have been too dangerous, as the vibrations could have caused the rupturing of localised, capillary cracks already present in the pedestals, leading to their possible collapse. In addition, the preparation of a support construction for all of the busts would have been very time-consuming and was not possible within the constraints of the project's schedule. As a result, it was decided to move the objects in a horizontal position, which was successfully executed with the placement of the busts on cushions filled with styrofoam pellets. Portrait busts with statically problematic crack formations were designated with a white band around the neck before transport and also placed on cushions, but not stored in an upright position in the new storage facility *(figs. 61 to 65)*.

Fig. 60: Roman portrait busts in the old storage area of the KHM.

Fig. 61: Portrait busts in the old storage area that have been inspected and designated with cloth bands.

Fig. 62 a

Fig. 62 b

Fig. 62 c

Moving and transfer of portrait busts onto cushions filled with styrofoam pellets.

Fig. 63: Stabilisation of portrait busts with adjustable straps.

Fig. 64: Portrait busts awaiting transport to the new storage facility.

Fig. 65: Long-term storage of the Roman portrait busts in the new central storage facility.

Fig. 66: Fish storage vessel without new stabilisation in the old storage facility.

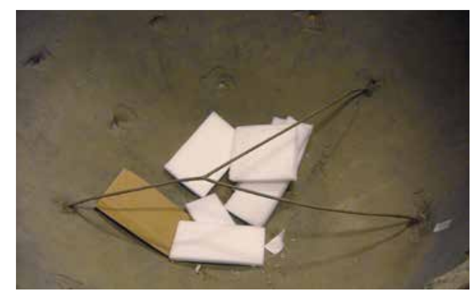


Fig. 67: Inside bottom of a fish storage vessel with old metal stabilisation.

2.2.5 FISH STORAGE VESSELS *(FIGS. 66 TO 68)*

Viktor Freiberger carried out another special stabilisation method for the transport of two damaged fish storage vessels. The vessels had been previously stabilised with a metal band encircling the outer wall of the container, preventing the vertical crack formations from causing it to break apart. This method alone, however, was not stable enough. Additional supporting threaded rods were fixed to the inside of the container and secured with screw nuts to additional curved metal bands placed on the exterior of the vessel.

2.2.6 STONE SCULPTURES *(FIG. 69)*

The freestanding, in part life-size stone sculptures were transported in existing crates. Wooden braces, felt and Ethafoam fittings on the inside of the crates served to stabilise the sculptures during transport. In some cases, the crate fittings had to be improved with additional supports. Opportunely, some of the crates could be reused for the transport of additional sculptures *(figs. 70 and 71)*.

Fig. 68 a

Fig. 68 b

Outside and inside of a fish storage vessel with new stabilisation for transport.

Fig. 69: Stone sculptures in the old storage facility of the KHM.

Fig. 70: Moving a stone sculpture with wooden studs and soaped boards.

Fig. 71: Long-term storage of freestanding stone sculptures in the new central storage facility.

Wooden pallets provided with uniform, stackable wooden crates were another standardised solution. U-shaped mounting rails made by Markus Lenhart (KHM metalworking shop) were attached to the top edges of the wooden crates. Wooden braces stabilised with metal U-shaped clamps held the stone objects in place and were in turn secured to the rails with screws; internal screw threads built into the mounting rails allowed for easy loosening of the screws during unpacking in the new central storage facility *(see fig. 23)*.

2.2.7 STONE ARCHITECTURE AND STONE PEDESTALS *(FIG. 72)*

The numerous architectural fragments, which primarily belong to the Greek and Roman Antiquities Collection, were stored next to and on top of each other on pallets on the floor in the old storage facility in several groups of differing sizes. Lighter weight pieces were stored on pallets or without pallets in a scaffolded shelving unit. Since the weight during transport of each pallet had to be limited, many of the stone blocks and heavy ornamental fragments had to be distributed over more pallets. The transport weight of all architectural pieces and stone pedestals including pallets came to ca. 32,260 kg.

2.2.8 STONE FRAGMENTS AND BROKEN PIECES

A simple, easy to execute solution for transport had to be found for the many small stone fragments and broken pieces stored in part without a pallet directly on the shelves. The solution – Euro-pallets with standardised wooden crates and Ethafoam-lined insertable shelves – should have been at the same time useful for long-term storage in the new central storage facility. Numerous fragments and pieces were packed in about 35 hours by two to three people *(figs. 73 and 74)*.

Fig. 72 a

Fig. 72 b

Fig. 72 c

Pieces of stone architectural elements reorganised and partially packed in scaffolded shelving units in the old storage facility.

In order to determine the number of pallets necessary and the amount of packing material needed for the fragments, the three most commonly occurring maximum heights of the fragments were taken as the average size and the objects were then accordingly sorted *(fig. 75)*.

Fig. 73 a

Fig. 73 b

Numerous stone fragments and pieces in the heavy-duty shelving units in the old storage facility.

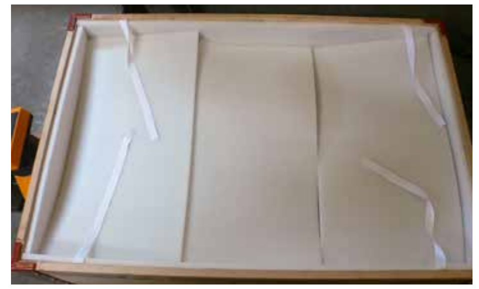


Fig. 74 a

Fig. 74 b

Fig. 74 c

First and second layer of packed fragments with enclosing Ethafoam cover.

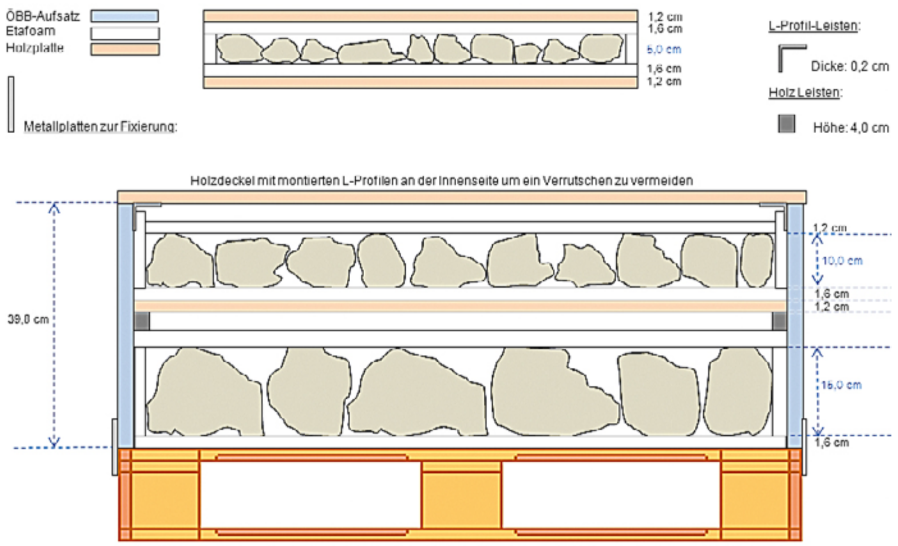


Fig. 75: Plan drawing for the multitude of stone fragments and pieces.

Fig. 76 a

Fig. 76 b

Transfer of milestones with a gantry crane and forklift.

2.2.9 MILESTONES AND SARCOPHAGI

The extremely heavy objects from the Greek and Roman Antiquities Collection, the Egyptian and Near Eastern Collection, and the Kunstkammer had to be moved and transported using a variety of methods. These freestanding objects, which were stored in part without a pallet, also had to be transferred to new pallets in preparation for the move. Some of the milestones from the Greek and Roman Antiquities Collection were secured in the old storage facility with massive iron fittings attached to concrete support pillars. In this case, movement with a gantry crane proved to be appropriate *(fig. 76 a)*. The heaviest milestone weighing ca. 1,250 kg had to be lifted with a hoisting sling and a drawbar forklift because the maximum height of the gantry crane was insufficient *(fig. 76 b)*. As a measure of extra protection, the objects on the customised pallets were further stabilised with wooden braces *(fig. 77)*. The heaviest object in storage from the Egyptian and Near Eastern Collection is a stone sarcophagus made out of rose granite with a total weight of ca. 3,208 kg without the lid (lid: 1,302 kg). It had to be lifted and moved with special hoisting machines. Because of the low ceiling height in this part of the storage area, movement with a forklift was unfortunately not possible. It was finally removed from the storage area with the aid of special hoisting machines and industrial casters, followed by loading with an electric forklift. A “pallet tower” was built to support the loading platform of the moving truck so that it could bear the weight of the 3.2 metric tons during loading. The sarcophagus was supported from both sides in the moving truck by horizontally placed pallets, protecting it during transport *(figs 78 to 83)*.

Fig. 77: Packed milestones awaiting transport to the new central storage facility.

Fig. 78: Storage of the stone sarcophagus in the old storage room of the KHM.

Fig. 79 a

Fig. 79 b

Lifting and placement of casters with lifting machines.

Fig. 80: Conveyance of the sarcophagus to the loading area.

Fig. 81: Transfer of the sarcophagus with forklifts onto a transport pallet made of formboards and wooden beams.

Fig. 82: The sarcophagus awaits loading in the loading area.

Fig. 83 a

Fig. 83 b

Loading of the sarcophagus with forklifts.

Fig. 84: Vacuuming the objects with vacuum cleaners and brush.

2.3 THE MOVES

In order to save the new central storage facility from an inundation of dust-covered objects, the surfaces of all stone objects were cleaned with a brush and vacuum cleaner prior to transport *(fig. 84)*.

The art moving company Kunsttrans completed the entire move, also collaborating on the preparation and movement of the heaviest objects. In order to load the moving trucks as quickly as possible, their dimensions were drawn on the floor of the loading area; within these two designated areas, the objects – packed and ready for transport on their pallets along with any additional packing materials to be used during transport – could be prepared, avoiding delays due to "down time" during loading *(fig. 85)*. The good planning, preparatory work, and excellent collaboration of all people involved allowed for 53 truck shipments with a total of 250 metric tons to be brought to the new central storage facility in one work week, beginning with the first transport of stone objects. The move of all stone objects that were stored in the old storage facility of the Kunsthistorisches Museum Vienna was carried out between August 1^{st} and September 29^{th}, 2011, and constituted a total weight of approximately 450 metric tons. During a second relocation phase between May 2^{nd} and May 11^{th}, 2012, additional stone objects were moved that had been located in the cellar and mummy storage area of the Egyptian and Near Eastern Collection of the Kunsthistorisches Museum Vienna.

Fig. 85 a

Fig. 85 b

Fig. 85 c

Packed objects in loading area.

2.4 CONCLUSION

In summary, it should be noted that it is particularly important that all preparatory work for the move of heavy objects be carried out well in advance in order to achieve a successful and timely completion of the project. Although the schedule was strict and little time buffer was available, there were no significant mishaps during the entire relocation project. The required training period of the staff went smoothly because of the cooperative nature and adeptness of our colleagues as well their manual dexterity. An important component of such projects going forward, however, is the availability of experienced personnel, which in this case were not always on hand during the preparatory phase. In the future, some projects could proceed even more quickly and more efficiently with experienced staff.

In the end, we are extremely grateful to everyone who participated in this project for their outstanding work.

SUMMARY

The move of 16,000 objects from the Collection of Greek and Roman Antiquities with a combined weight of 420 tonnes presented a particular challenge in the coordination of operations and handling of the objects.

For the ca. 2,000 heavy stone objects, documentation and rationalised transfer were paramount. The confirmation of inventory numbers, placement on new Euro-palettes, and weighing of these objects preceded their actual packing and securing. In a few cases, customised palettes for oversized objects had to be constructed. The firm DP-art and particularly its technical director Martin Dorfmann assisted the Kunsthistorisches Museum as external coordinator and designer of transport materials. Thanks to his help, sacks and crates were developed that enabled the quick and easy packing of all object groups. The move of tombstones mounted to the wall was effected with specially made “wooden shoes”; the movement of very heavy objects was performed primarily on palettes with load-binding straps. Electrical lifting machines, various lifting belts, load-binding straps and a crane were all used.

The securing of small fragile objects (glass, ceramic, metal) necessarily took place before the move. Small parts had to be individually wrapped in tissue paper and organised in small boxes. Through precise inventories and location control, the deadline of six weeks allotted to move the 14,000 small objects could be met. Larger objects were individually packed in tissue paper and organised in transport boxes, which were stacked onto palettes fit with shelving. To facilitate the loading of the trucks, floor markings were established with the dimensions of their loading surfaces. The placement of the already packed and secured object palettes and other packing units was thus prearranged in two fields.

This large move could be implemented in a safe and timely fashion thanks to the exemplary collaboration of all involved.

ZUSAMMENFASSUNG

Die Übersiedelung von 16.000 Objekten der Antikensammlung mit einem Gesamtgewicht von 420 Tonnen stellte in Hinblick auf die Koordination der Vorgänge und die Handhabung der Objekte eine besondere Herausforderung dar.

Für die ca. 2.000 schweren Steinobjekte standen vorerst die Erfassung sowie die rationelle Umlagerung im Vordergrund. Die Inventarnummernkontrolle, das Umschichten auf neue Euro-Paletten und das Abwiegen der ca. 2.000 schweren Steinobjekte gingen der tatsächlichen Verpackung und Sicherung voraus. Vereinzelt mussten für übergroße Objekte Paletten mit Sondermaßen angefertigt werden. Als externer Koordinator und Entwickler von Transporthilfen stand dem Kunsthistorischen Museum Wien die Firma DP-art mit ihrem technischen Leiter Martin Dorfmann zur Seite. Dank seiner Hilfe wurden Transportsäcke und -kisten entwickelt, die für alle Objektgruppen ein schnelles und einfaches Einpacken ermöglichten.

Der Transport aller an der Wand aufgestellten Grabsteine ging mit eigens angefertigten „Holzschuhen“ vonstatten, die Bewegung der Schwerlastobjekte erfolgte vorwiegend auf Paletten mit Zurrgurtfixierung. Es kamen elektrische Hebegeräte, diverse Hebeschlaufen, Zurrgurte und ein Balkenkran zum Einsatz.

Die Sicherung gefährdeter Kleinobjekte (Glas, Keramik, Metall) musste vor dem Transport geschehen, Kleinteile waren separiert mit Seidenpapier zu umhüllen und in Schächtelchen einzuordnen. Mit einer exakten Listenführung und Standortvergabe konnte für die 14.000 Kleinobjekte die vorgegebene Zeit von 6 Wochen für die Übersiedelung eingehalten werden. Die Objekte wurden einzeln in Seidenpapier verpackt und in Transportkartons geschlichtet, die wiederum in Paletten mit Aufsatzrahmen eingepasst wurden. Damit beim Transport das Beladen der LKWs möglichst zügig vorgenommen werden konnte, wurden Bodenmarkierungen in der Größe der Beladungsgrundfläche des LKWs (Beladungszone) festgelegt. Somit war die Platzierung der fertig gepackten und gesicherten Objektpaletten sowie aller anderen Verpackungseinheiten auf jeweils zwei Feldern bereits vorbereitet.

Dieses große Übersiedelungsprojekt konnte aufgrund der hervorragenden Zusammenarbeit aller Beteiligten termingerecht und sicher umgesetzt werden.

Relocation of Small Objects from the Egyptian and Near Eastern Collection to the Central Storage Facility in Himberg

Irene Engelhardt

Translated from the German by Aimée Ducey-Gessner

1. NUMBER OF OBJECTS MOVED

In 2010, the planning and preparation began for the relocation of objects in the Egyptian and Near Eastern Collection from the Inzersdorf storage facility to the new central storage facility in Himberg. Unlike the move to Inzersdorf in 2000–2001, this time the objects were to undergo a long-awaited cleaning as well as pest management measures. This was necessary because during the previous move in 2001 from the cellar spaces in the Weltmuseum Wien, the extent of the problems associated with a mould infestation became clear, caused by improper environmental conditions: approximately two-thirds of the objects were infested with spots of mould and their surfaces were dusty and soiled. These infested objects had been packed in tissue paper at the time (in order to prevent further spread of the spores) and – clearly indicated – in the environmentally more stable storage spaces in Inzersdorf (in the rolling shelving units reconstructed there) *(figs. 1 to 4)*. In total, 6,366 inventoried objects from the Egyptian and Near Eastern Collection were cleaned (including large quantities of diverse groups of objects) and moved to the new storage facility.

Fig. 1: Storage facility in Inzersdorf: large, compact storage unit with objects that have been wrapped in tissue paper since January, 2001 due to mould infestation; large objects are wrapped in bubble wrap; cardboard boxes with various groups of objects.

Fig. 2: Densely-packed shelves holding cylindrical and other similarly shaped vessels.

Fig. 3: Various shards of vessels: in the foreground, a large fragment from a coffin. Condition: restored, adhered with plaster fills, large sections inpainted (or overpainted), in fragments.

Fig. 4: Generally dirty storage shelves and objects; in the foreground a fragment of an ostrich egg in a can, bone fragments to the right.

Fig. 5: Orange-coloured vessel fragment with red mouth and stamped pattern in the centre.

Fig. 6: Orange-coloured vessel fragment, the exterior is painted with linear ornamentation and birds.

Fig. 7: Detail, potter's mark on a large, thin vessel.

Fig. 8: Amphora, exterior with shallow ribs, in fragments.

Fig. 9 a: Ribbed vessel fragments with mathe beige slip, painted pale red (photograph of the initial state).

Fig. 9 b: Cleaned shards with pale red vine pattern; they are laid out to give an impression of the complete vessel.

Fig. 10 a

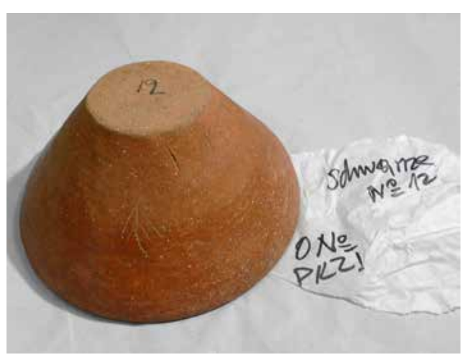


Fig. 10 b

Intact clay vessel. Fig. 10 a: The surface is lightly abraded, with dark spots of mould throughout (top). Fig. 10 b: Black number painted on the bottom and two notches; a "floral" potter's mark scratched into the exterior.

Fig. 11: A very large, ball-shaped vessel, the lower half of the exterior is textured.

Fig. 12: Various transparent green glass fragments, decorated, a dried flower, a bone fragment, a hook-like piece of metal with green patina (contents of a fish can with "47" inscribed in black), cleaned.

Fig. 13: Two large, curved, seal fragments from the remains of an amphora, rectangular seal surface is coloured red; cleaned.

Fig. 14: Flint fragments of different colours; cleaned.

Fig. 15: Mosaic made of white, green and red stone, in mortar bed, 4 pieces (photograph of the initial state) *(see fig. 64).*

The objects are made from many different materials. For the most part, they comprise inorganic materials like ceramics, but organic materials and composite materials are also present, often existing only as fragments. Here are some examples:

- ceramics – vessels (some with a potter's mark), ring stands; oil lamps, statuettes; low and high fired; decorative elements: with fluting, painted, unpainted, glazed, polished, incised, stamped, encrusted *(figs. 5 to 11);* sometimes with traces of substances inside *(see fig. 48);*
- faience – amulets, circular and cylindrical beads *(see fig. 16);* small statuettes*;* glass vessel shards, coloured, sometimes transparent, sometimes iridescent *(fig. 12);* oriental ceramics – sometimes with pale turquoise or matte green glazing, incised, with relief;
- oriental glass – coloured (iridescent);
- clay seals, sometimes with remains of string (ancient finger prints); with red seal surface; many without coloured accentuation *(fig. 13),* clay figurines;
- stone – colourful flints (and slivers) *(fig. 14),* colourful muller; alabaster (calcite); fragments of stele and statues, large green slate plates*;*
- mosaic fragments – parts of mosaics made out of stone (limestone, porphyry, serpentine – in mortar bed) *(fig. 15, see fig. 64);*
- fragments of wall paintings – loose;
- jewellery (bracelets, hair rings, pendants, hair pins) – made from various crustaceans, shells, mother of pearl, bone *(fig. 16);*
- ostrich eggs (shells) *(see fig. 4);*
- bronze – fragments of statues, vessels (e.g., large dish-shaped objects, very fragmented);
- fragments of gold leaf; a few particles *(see fig. 71 a);*
- Asian coins (2 objects);
- leather, fur – fragments of bags (?), partially coloured red (painted?), clothing *(fig. 17);* shoes (pairs); with seams, decorative seams, knots, strings; leather fringe bracelets with fastener (2 objects) *(fig. 18);*
- single animal hairs;
- animal bones; small devices made out of bone;
- human bones, fragments of cranial skin sometimes with hair (short hair, curly hair, braids, loose), remains of skin and/or sinew, finger nails (often attached to textile fragments) *(fig. 19);*

Fig. 16: Group of objects, box with bracelets made from snail shells, hair rings, colourful circular beads, small mother-of-pearl and stone amulets, small fragments of cloth and yarn, muller (photograph of the initial state).

Fig. 17: Fragment(s) of fur: folded together, broken; with twisted leather thread and grommets (photograph of the initial state).

Fig. 18: Open leather bracelet with fringe; for tying together.

Fig. 19 a

Fig. 19 b

Cranial skin with short, curly hair (front and back views, photograph of the initial state).

Fig. 20 a: Fragment of pants with button, partially decorated with an embroidered design (diamond pattern); cleaned.

Fig. 20 b: View of the fastener.

Fig 20 c: Detail, pearl-shaped button, formed from linen fabric.

- textiles – linen fabric with various weaving techniques and densities, in various colours, with patterns, markings, fringe, strings, knots *(figs. 20 and 21);*
- fabric – macramé-like technique (from black yarn?) *(fig. 22);*
- wood – fragments of coffins, containers, or furnishings, small utensils, statues (sometimes with a layer of wax [paraffin] as stabiliser) *(fig. 23);*
- papyrus – small individual fragments with writing;
- braided objects (from plant materials) – fragments of mats; burial basket *(fig. 24, see fig. 78),* sandal soles *(fig. 25),* excavation worker's basket (2 objects); remains of straps (e.g., on clay seals, ceramic vessels) *(fig. 26);*
- plant parts – dried leaves, blossoms (1 object); fruit, seeds, pits, skins *(fig. 27);*
- resin, wax;
- excrement, animal, human (?), dried;
- forgeries – various.

Fig. 21: Pieces of a loin cloth patterned with light and dark brown yarn, cord sewed onto the edges; remnants of human remains present (light, on the right side); cleaned.

Fig. 22: "Macramé"-like knotted textile; cleaned.

Fig. 23: Brown cardboard box with various wood fragments, some bent (angular forms) or with long slits.

Fig. 24: Bottom of a basket-like object with bone fragments, one of countless fragments belonging to this object number; cleaned.

Fig. 25: Sole of a sandal made from plant material, straps are missing (photograph of the initial state).

Fig. 26: Small, round clay vessel with knotted string under the mouth; cleaned.

Fig. 27: Plant sections, seeds, dates, palm fronds, various broken fragments; cleaned.

2. CONDITION/KINDS OF DAMAGE

Along with the mould infestation already mentioned, various kinds of damage and old restorations were found. The objects had either already been glued together or discovered in fragments, sometimes with unstable or freshly broken previously repaired joins (particularly among the stone and ceramic vessels), sometimes with inpainted plaster fills; the occasional piece of adhesive tape was found still in place; scuff marks; in rare cases advanced salt efflorescence and/or the related flaking and powdering of the material layers *(figs. 28 to 32)*.

Fig. 28: Flaking clay surface, caused by moisture and salt (photograph of the initial state).

Fig. 29: Large clay vessel with matte, pale yellow slip; large areas of the surface are falling away, handle is missing.

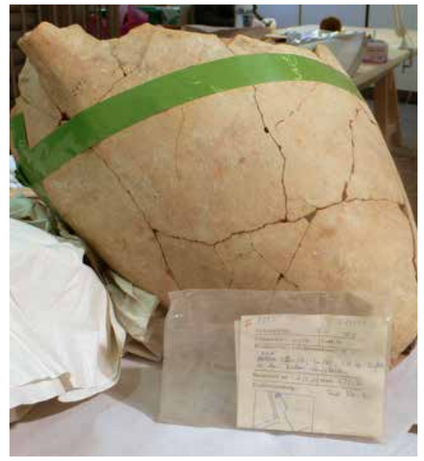


Fig. 30: Vessel shards held together with a green, insulating tape (photograph of the initial state).

Fig. 31: Large clay plate. Many fragments glued together; cleaned.

Fig. 32 a

Fig. 32 b

Inpainted plaster fills in a small bowl (top and bottom); cleaned.

Fig. 33 a: Group of leather fragments and bones in a cigar box (photograph of the initial state).

Fig. 33 b: Leather fragment from the cigar box with traces of frass from an insect pest; cleaned.

In addition, pest infestation on leather and textile fragments occurred: feeding holes, tunnelling *(figs. 33 and 34);* broken and falling away hairs, fur (short or long-haired); tears, creases *(see fig. 17),* etc.; damage to crustaceans: cracking; glass: occasional corrosion *(fig. 35);* metal objects were very fragmented and corroded *(fig. 36);* mould growth was discovered on inorganic and organic materials (sampling of ceramic objects: *fig. 37*).

Fig. 34: Detail: loin cloth with a pattern formed from light and dark brown yarn, edge with sewed on cord; a few mummified human remains (pale – on the right side), *see fig. 21.* All fragments have been cleaned; evidence of damage: eaten away by insect pests, holes.

Fig. 35: *Millefiori* glass fragments, broken, glass corrosion (iridescent).

Fig. 36: Fragments of a metal plate and limestone fragments in a cigar box (photograph of the initial state).

Fig. 37: Vessel shards, an example of taking samples of ceramics by drilling.

3. SEQUENCE OF THE RELOCATION

3.1 PREPARATION

The following steps were taken in advance:

- ascertainment of the number of objects and the space requirements as well as the object specific storage needs; further, the definition of appropriate climatic conditions (to prevent any microbial infestation) by the collection director – in agreement with the conservators from the Egyptian and Near Eastern Collection. It was also important to consider increasing the number of rolling storage units early on; often only after one had sorted out the jumbled contents of a group of objects stored together could its full range be revealed.
- the appointment of the conservators responsible for the relocation project.[1]

3.2 ASSESSING THE HEALTH RISKS OF MOULD

The introduction of mould spores and infested objects in a new storage facility should be prevented at all costs. In order to identify the species of mould present, assess the degree of associated health risks, and determine the necessary procedures, Dr. Katja Sterflinger, professor of geomicrobiology at the University of Natural Resources and Life Sciences, Vienna,[2] was commissioned in

1 Irene Engelhardt was responsible for the objects in the rolling shelving units; Michael Loacker was responsible for the large objects from the Egyptian and Near Eastern Collection. See the contribution by Vak – Kathrein – Loacker.

2 IAM, Dr. Guadalupe Pinar, Christian Voitl, Muthgasse 18, 1190 Vienna; see also the contribution by Querner et al.

Fig. 38: Small, round clay bowl, inside black, polished – light spots of mould throughout.

Fig. 39: Leather fragment from a shoe – light, furry mould spots on the exterior.

Fig. 40: Large vessel with light, linear mould growth pattern.

Fig. 41: Large clay dish with stain-like growth.

Fig. 42: Oil lamp with spots of light, furry, mould growth.

Fig. 43: Large bowl with scattered, dark areas of mould growth.

September 2010 to carry out mould analysis. The following phenomenological investigations were carried out on the objects (mummies, sarcophagi, clay, and ceramics) and photographically documented:

- measurement of mould infestation in the room's air and in the shelving units (with Sartorius MD 8, gelatine filter, 1001 by 50 l/min) – mediums: MEA, DG18; incubation: 22 °C, 5 days;
- morphological identification according to production of pure cultures;
- surface contact sampling of selected objects for detection of the growth and germination capacity of the existing visible mould.

3.2.1 FINDINGS

Naked eye observation could clearly identify a mould infestation comprised of white, spot- or cross-shaped colonies with a granular to powdery surface. The mould had not only formed cell threads (hyphae) and groups of cell threads (mycelium), but also the spores that form a layer of mould on the mycelium were also observed. Sampling of the surface proved that the mould possessed a limited capacity for germination, and in the majority of cases, was no longer capable of germination, eliminating the need for treatment with a biocide. The allergenic potential of the mould, however, had to be considered, as it can be stimulated by dead spores as well. It is caused by protein in and on the cells *(see fig. 36 and figs. 38 to 43; also see figs. 48, 50, and 51)*.

3.3 ESTABLISHING A CLEANING METHOD

The following procedures for cleaning were established based on the results of the mould analysis while taking into consideration the need for equipment and material:

- dry surface cleaning (with vacuum cleaners equipped with HEPA and ULPA filters);
- protective measures for worker's health – protective mask with the corresponding quality class (FFP3), protective glasses, single-use protective suit, single-use gloves, noise protection;[3] table magnifier lamps, head magnifier loupe;
- determination of packaging materials: pollutant-free PE zip lock bags, PE sheeting, acid-free cardboard trays, boxes (agreement on a few, designated sizes); the packaging should simplify and accelerate the packing process and the chosen packing solutions should be functional for a variety of groups of different objects composed of diverse materials, and at the same time be appropriate for long-term storage (e.g., acid-free boxes).

Complete cleaning or decontamination of an object infested with mould is only possible to a limited extent because spores can penetrate deep into porous materials. Control of environmental humidity is essential for safe storage of such items – not only in the open spaces but in the shelving units as well – and proper ventilation in order to prevent microclimates in recessed spaces.

Before the conservators began their work, the curator of the Egyptian and Near Eastern Collection, Michaela Hüttner, in collaboration with a registrar (Barbara Poropatich, later, Doris Bauer) carried out a review of the inventoried objects, existing photographs, ancillary photographs, and assigned temporary numbers to "unnumbered objects".

Fig. 44: Cleaning a fragile fragment of mud jar stopper with pale mould growth: vacuuming with a small brush nozzle (pale left corner not yet cleaned).

Fig. 45: Cleaning test on a large clay vessel with incised star-shaped forms; the left side has been cleaned (vacuumed) *(see fig. 44)*, followed by cleaning with Wishab sponges and a TeraTex cloth.

3.4 CLEANING AND DOCUMENTATION

Cleaning the objects, all with differing degrees of soiling and mould infestation, was carried out as outlined above in two to three different dry surface cleaning phases. The following measures were established:

- primary cleaning with specialised vacuum cleaners (vacuum level control, mini-brush attachments, adapter hoses, diverse bristle brushes; tulle net nozzle protection) *(fig. 44);*
- secondary cleaning with Wishab® sponges (hard), Wallmaster sponges, TeraTex cleaning cloths *(figs. 45 to 50 and fig. 52)* and soft erasers (for writing on paper);
- textile fragments were vacuumed through three layers of tulle netting, smaller fragments of various materials were vacuumed (depending on fragility) in two-layer tulle pouches or sandwiched between layers of tulle netting *(fig. 51)*. Remains of mixed materials found in the containers were sifted through fabric, sorted, and placed in labelled PE zipper lock bags;
- worker safety measures: exchange of personal hygiene equipment according to contamination and dirt level: masks, every 1 – 3 days; protective overalls, every 3 – 4 weeks.
- each object was photographed during cleaning (often collections of shards):
- before and after treatment photographs (as many sides as possible, with any special features);
- photographs of any supplemental information sources like numbers, printed or hand-written notes, sketches, etc.;

[3] See the contribution by Schaaf-Fundneider – Kimmel.

Fig. 46 a Fig. 46 b

Small, bulbous vessel with dark red, freely painted decoration; left: before cleaning (photograph of the initial state); right: after cleaning.

Fig. 47: Large bowl with dark mould growth after cleaning *(see fig. 43)*.

Fig. 48 a Fig. 48 b

Amphora fragments containing dark, resin-like deposits, ribbed exterior *(see fig. 8);* left: exterior/interior before cleaning; right: interior after cleaning.

Fig. 49 a Fig. 49 b

Leather shoe with mould growth overall: left before, and right after, vacuum cleaning with a small brush nozzle and a soft brush, followed by cleaning with a Wallmaster sponge.

Fig. 50 a Fig. 50 b Fig. 50 c

Diverse bone fragments with pale mould infestation. Fig. 50 a: Photograph of the initial state. Fig. 50 b: Individual bone fragments before cleaning. Fig. 50 c: A few bones after removal of mould.

Fig. 51 a Fig. 51 b

Compact, mould infested textile with negative imprint resembling a spinal column, encased in linen fabric; soiled and infested with pale mould growth. Fig. 51 a: Photograph of the initial state. Fig. 51 b: After cleaning.

Fig. 52: Flint fragments (photograph of the initial state) and two cigarette boxes with small slivers. All were cleaned with TeraTex cloths (microfiber cloth, *see fig. 14:* Flints after cleaning.)

In addition, the following measures were carried out:

- short descriptions and condition reports;
- sifting and classification of shards and/or mixed materials (especially in groups of objects stored together in one container) – when possible, determining which pieces belonged together and then packing them separately with the appropriate identification within the larger group of objects *(fig. 52 and see figs. 55 to 57);*
- the opportunity was also taken to sample as many materials as possible that were found most often in vessels;
- some dead insect pests or fragments of insects were also discovered and documented *(figs. 53 and 54)*.

A large number of objects were housed in very dirty, occasionally stained and/ or deformed brown and grey cardboard trays (sometimes with a lid) or black coin trays – all containers originated from the middle of the twentieth century *(fig. 55)*. Other artefacts, often those made out of organic materials, were still in the sealed, individual plastic bags originating from the excavation site (some of these were still closed or had already been opened, most had three diagonally

Fig. 53: Newly identified insect pests: carpet beetle and larvae *(Attagenus sp.)*, they eat animal and human organic material as well as fur, feathers, and dead insects.

Fig. 54: Loin cloth from a grave, countless fly pupae found in the folds of the textile.

Fig. 55: Various cardboard storage containers. Boxes with and without lids, cigarette boxes, black coin trays, and original containers from the burial site.

Fig. 56 a: Cigarette carton SAMUM.

Fig. 56 b: Tin tobacco can.

Fig. 57: Container for a group of objects: *Confiserie Otto Lehrenkrauss Le Caire*.

Fig. 58: Tin can with grave number by Hermann Junker (15j1) on the upper edge of the cut-open lid. Contents: fragment of cranial skin with curled hair, leather fragments, fragments of a string with yellow and turquoise faience beads, fragments of stucco.

Fig. 59: Tin canister without a bottom, resting on its sharp edge, stamped, painted. Container for the remains of a fragmented, "encrusted" shroud with grey fleece as intermediate layer.

cut corners in order to prevent the formation of an unfavourable microclimate) *(see fig. 79 a)*. Occasionally, objects were found in original receptacles – in easy to hold, typical storage containers for everyday use on the excavation site at that time: for example, many different brands of cigarette cartons, wooden cigar boxes, elegant candy boxes, tin cans, canned fish containers, a tin canister without a bottom with Arabic stamps, etc. The excavation number is often hand written on the containers. A few selected examples of historic excavation receptacles were dry surface cleaned and added separately to the collection inventory *(figs. 56 to 59; see also figs. 4, 12, 33 a and 36)*. The documents and torn slips of paper found with the objects (aged, in some cases already torn or brittle), some of which included sketches, were also treated. These documents, sometimes up to four pieces, were placed into suitable PE zip lock bags and packed with the object.

3.4.1 SOME EXAMPLES OF PACKING METHODS AND SUGGESTIONS FOR IMPLEMENTATION

When many shards belonging to one object number were stored together, strips of paper were placed between the individual pieces lying next to each other in order to prevent further abrasion *(fig. 60)*. Shards that obviously belonged together were photographed together and packed separately within the larger group of objects. Collections of mixed materials were sorted in this way and separately packed *(fig. 61)*. If fragments of an object whose number had already been assigned were discovered in containers with different object numbers (for unknown reasons), a reference to the situation was provided in a short condition report whenever possible *(figs. 62 to 72)*. Fragile, flat objects were laid between pieces of tissue paper and then (if the object allowed) stabilised in a sandwich of acid-free cardboard *(figs. 73 and 74)*.

Fig. 60: Fragment of a vessel wrapped protectively in tissue paper (to prevent abrasion); then placed in a PE zipper lock bag.

Small vessels with round bottoms and very convex shards were placed in paper bundles or on rotated circular stands made of tissue paper; larger, heavier vessels were placed on a circular stand made of diagonally rolled bubble wrap, whose ends were held together with packing tape, with tissue paper placed between it and the object *(fig. 75)*. This is a temporary solution; at that moment the need for and acquisition of pollutant-free materials for long-term storage was delayed *(figs. 76 and 77)*.

Fig. 61 a: Flints – with and without identification, grey stone palette fragment in the cardboard box (photograph of the initial state). They were cleaned with TeraTex cloths (microfiber cloths).

Fig. 61 b: Photograph of all identified and unidentified flints. They were individually photographed and individually wrapped for storage in a cardboard tray.

Fig. 61 c: Group of identified flints.

Fig. 61 d: Separate packaging of both groups of flints and the corner fragment of the stone palette stored temporarily in the lid from a copier-paper box.

Fig. 62 a

Fig. 62 b

Fig. 62 c

Fig. 62 d

The assembly of clay fragments from, for example, large plates could be matched many times from memory to object fragments throughout the shelving system due to their different colouring, for example, the bottom fragments compared to the edge pieces, and also their shape (including that of the missing pieces). The fragments were placed together in order to document the degree of completeness. Fig. 62 a shows a large plate (inv. no. A4165) with the wrong bottom fragment. In Fig. 62 b the bottom piece has been removed. Fig. 62 c shows another large plate (inv. no. A4174) without the bottom fragment.
In Fig. 62 d the additional bottom piece can be seen.

Fig. 63 a

Fig. 63 b

Fig. 63 c

A complete incense burner, assembled from pieces found on many different shelves, which had previously already been assembled with adhesive. The thick piece of broken-off glue fits in the broken join. Fig. 63 a: Bottom piece. Fig. 63 b: Upper piece. Fig. 63 c: Both pieces complete each other, except for a few small losses, forming the complete incense burner.

Fig. 64 a: Group of objects (photograph of the initial state), various clay vessel fragments of differing colour and condition; a pale imprint; two small stone slabs of porphyry with white inclusions, mortar remains on the edges and underside (left edge).

Fig. 64 b: The stone slabs depict two grapes, which could be matched to the missing areas in the stone mosaic with the grapevine pattern (*see fig. 15:* photograph of the initial state).

Fig. 64 c: Box with two fragments, including a vine leaf, which also matches the stone mosaic.

Fig. 64 d: Vine leaf from *fig. 64 c,* after cleaning.

Fig. 65: Coin drawer with fragments of bone, stone, metal, gold leaf, faience beads, plant sections, snail shells, cone-shaped stones, wood; condition: very soiled.

Fig. 66 a: Various stone fragments from drawer in *fig. 65*.

Fig. 66 b: Stone fragments, sorted and packed.

Fig. 67 a: All snail shells and fragments from the drawer in *fig. 65*.

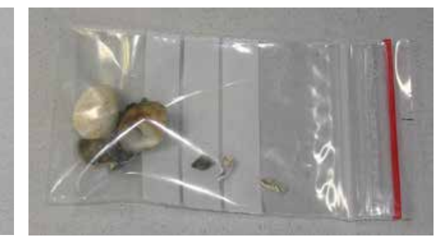


Fig. 67 b: Packed snail shells.

Fig. 68 a: Plant sections – seeds, hulls – from the drawer in *fig. 65*.

Fig. 68 b: Plant sections, sorted and packed.

Fig. 69 a: Fragments of bone from bracelets from the drawer in *fig. 65;* categorised, cleaned.

Fig. 69 b: Sorted fragments belonging to a bracelet.

Fig. 70: Remaining fragments and slivers of bone, metal, and wood, from the drawer in *fig. 65;* which were collected in a PE zip lock bag.


Fig. 71 a


Fig. 71 b


Fig. 71 c

More fragments from the drawer in *fig. 65*. Fig. 71 a: Gold leaf fragment.
Fig. 71 b: Thin slab of wood with hole, fragment with red writing (?).
Fig. 71 c: Fragment of wood, semi-circular, partially in the shape of a trough.


Fig. 72: Storage of all fragments found in the drawer in *fig. 65* in bags in a cardboard tray, which in turn was enclosed in a large PE zip lock bag.

Fig. 73 a

Fig. 73 b

Cardboard strips, cut out, painted, with writing. Fig. 73 a: Before treatment.
Fig. 73 b: Packed.


Fig. 74: Plant sections from *fig. 27,* packed; before placement in a cardboard tray.


Fig. 75: Small vessels and other diverse objects closely packed in many rows.


Fig. 76: Temporary circular supports made of bubble wrap for large vessels; stabilisation of loose or not completely broken off fragments and glued joins with a band made from tissue paper folded several times and packing tape; the dark remains of the adhesive tape can be seen on the vessel in the middle, left.


Fig. 77: Temporary circular supports made of packing paper for smaller vessels and for bulbous shards stacked on top of one another.

For the aforementioned reasons, only intact historic storage containers of an appropriate size that were dusty, but free of mould contamination, were used again, after being cleaned and wrapped in tissue paper. Each object was placed into an appropriate PE bag, facilitating safer handling of the objects and later simplifying packing for transport.

We collected copier-paper boxes (DIN A4, A3; *fig. 78*) because they proved to have an extremely beneficial format for our purposes, as well as large, intact shoe boxes; occasional, unusual object formats required production of customised boxes from acid-free cardboard *(fig. 79)*.

Large ceramic vessels, whose instability stems from partial breaks, or fragmented, previously repaired (glued) receptacles, whose adhesive has deteriorated over time, were supported with a band of tissue paper folded several times, which was then wrapped tightly around the vessel and closed with packing tape (one could have also used an adhesive bandage). They showed damage from previous, temporary stabilisation with adhesive tape used to hold together the shards; examples of these usually low-fired ceramic surfaces demonstrate the resulting tearing away of surface particles and sometimes embedded remains of adhesive *(see fig. 76)*.


Fig. 78: Photograph during packing *(see fig. 24)*, detail: (ca. one third) of the countless braided fragments; after cleaning.


Fig. 79 a: A storage box made on site in the storage facility in Himberg from pollutant-free corrugated cardboard for a combination of fur and textile fragments with coloured, felted, remains and two-colour twine fragments and a bone and hair from a burial. The objects are enclosed in two sealed plastic bags, each with three diagonally cut corners. The bags originate from the excavation site. The three cut corners should prevent the formation of an unfavourable microclimate inside the bag.


Fig. 79 c: New packing of the contents shown in *fig. 79 b* in acid-free tissue paper and placed on a cardboard support with cotton twill tape to lift the entire assembly.


Fig. 79 b: Contents of one of the plastic bags.


Fig. 79 d: Completed packing of the objects.

Fig. 80: Inzersdorf storage facility: above: temporary storage of cleaned objects. Some have been placed in PE zip lock bags or without additional packing materials under a thin PE cover sheet folded one time (*see fig. 2:* storage of cylinders, vessels without additional materials). Below: objects not yet cleaned.

3.5 TEMPORARY STORAGE OF CLEANED OBJECTS PRECEDING THE MOVE TO HIMBERG

A clean area was established in the rolling shelving units in Inzersdorf for the cleaned objects until they could be moved because there was no other possibility for them: the 30 cm deep shelves were lined with a thin, PE sheeting folded one time (the depth and height was determined by the tallest object on the shelf), so that the objects and fragments in their PE zip lock bags along with their documentation and sketches (and their subgroups) could be placed between the layers of protective PE sheets. Most of the air had been pressed out of the PE bags *(fig. 80)*. Similar objects (e.g., cylindrical glass or stone vessels) were placed standing on the shelves in compact rows (two to three deep) with no additional cover; the protruding material from the zip lock bags would have reduced their standing stability and the available storage space in the shelves. Large vessels were individually wrapped in thin sheeting *(see figs. 2, 76, 77, 80 and fig. 81)*.

The reordering of materials and contact with suppliers when technical devices wore out was coordinated by one person, which proved very helpful.[4] She also ensured regular cleaning of the microfiber cloths.

3.6 PACKING – TRANSPORT – UNPACKING IN THE CENTRAL STORAGE FACILITY IN HIMBERG

Further packing of the small objects in typical cardboard moving boxes could be quickly accomplished because of the implemented packing methods. Some of the boxes originating from the move of the Collection of Greek and Roman Antiquities were already lined with foam rubber, or were outfitted with tissue paper bundles air cushions, and/or Ethafoam sheets serving as stabilising packing materials. Grey plastic containers in three different sizes (14/24/34 cm high, 60 × 39.5 cm square), used for transport of objects within the collection, were also used *(fig. 82)*. Several very large vessels were packed in a large wooden

Fig. 81: Small objects remained with their accompanying documentation in PE zip lock bags fitted to the documents.

Fig. 82: Grey plastic containers in three sizes with an additional Ethafoam lining and/or cardboard trays were one solution used during the move.

4 Christina Schaaf-Fundneider (Conservation Science Department) and Tanja Kimmel (Imperial Carriage Museum), respectively.

crate (with two levels): stabilised with styrofoam pellet-filled bags and wrapped in tissue paper, they could be moved without risk (see fig. 26 in the contribution by Vak – Kathrein – Loacker).

The work was always carried out in teams: the archaeologist and the conservator each with an art packer from the art transportation company Kunsttrans at their side. The originally planned schedule for the two teams *(table 1)* had to be changed in practice because unpacking the objects in the central storage facility took longer than expected due to the height and depth of the shelving units. The difference in time required for packing and unpacking also led to shortages of transport containers. The temporary container number and name of the person who packed it were written on the transport containers. Inspection of the list of objects was carried out by the curators during unloading. Objects that were not transported because they had not yet been cleaned were indicated with slips of paper as place holders.

3.7 SUBSEQUENT WORK IN THE CENTRAL STORAGE FACILITY IN HIMBERG

Every object made of an organic material – mostly textiles, burial clothes and human remains like skin, bones, hair and fingernails –, which were already deposited in numerous boxes and plastic excavation bags, but that could not be cleaned before the move due to lack of time, were temporarily stored on Euro-pallets with stacking frames. A storage room in the new facility was temporarily made into a quarantine location.[5] Cleaning of the objects from the rolling shelving units was completed at the end of 2012.

Along with the collection's daily management and special exhibitions, further time-consuming measures must be undertaken in the future:

- significant rearrangement due to, among others, the integration of objects cleaned later (from the pallets with stacking frames);
- completion of the location map for the storage space;
- processing the hand-written condition reports, labelling the accompanying digital images, processing the sampled materials.

Two further relocations (including cleaning of the objects) of a few very large ceramic vessels, animal mummies, and textiles were still pending.

In the future, it would be possible to reconstruct large vessels that at the moment exist as towers of shards next to the "flatware" during the course of a project. The differing heights of objects, like vessels or statues, require extra space for movement, so that an object in the back row can be removed from the shelf. Since these manipulations become more difficult the higher the objects are stored in the shelving unit, it is necessary to create a device that could serve as a ladder but with an additional, shelf-like surface area, where objects could be placed when accessing other objects towards the rear of the shelf.

Table 1: Planned and modified relocation procedures.

Originally planned daily procedures	**Modified daily procedures**
Day 1: • Team 1, pack	Day 1: • Team 1 and 2, pack
Day 2: • Team 1, load moving truck, move, unpack • Team 2, pack	Day 2: • Team 1 and 2, load moving truck, move, unpack

5 See the description of "black and white areas" in the contribution by Fleck.

It should not be too heavy and provide a stable support for several objects at a time. In order to be able to use a double shelf (ca. 120 cm) for large textiles (pollutant-free boxes and materials have already been procured for this purpose), the distance between two rolling shelving units would need to be increased, so that the large, flat boxes for textiles can remain in a horizontal position during removal from the shelf.

Other important tasks remain: replacement of the temporary circular stands, folding the pollutant-free cardboard boxes and removal of the temporary boxes, installation of metal security barriers wrapped in PE foam where needed. The space required for unsorted groups of objects was difficult to estimate before the move. As a result, the compact shelving units needed urgently to be expanded, especially the heavy duty shelving unit, which has already reached its load capacity. In December of 2012, the expansion was implemented: additional shelving units were added to the existing rolling system (H. 314 cm, 6 shelves with an inner dimension of ca. 48 cm, double rolling units with a depth of 60 cm each).

3.8 PERSONNEL REQUIREMENTS AND TIME EXPENDITURE/DIVISION OF RESPONSIBILITY *(TABLE 2)*

The pre-set schedule had to be maintained despite the small staff size of the Egyptian and Near Eastern Collection, such that two short-term temporary positions could be created. The new employees were trained over three days in the handling of the objects and materials: first ceramics, followed by unpainted stone and simple wooden objects. Special attention was given to faded numbers, inscriptions, and symbols, as well as instruction in a form of shorthand for documentation. The treatment of organic materials, which took longer in general to clean and document, was undertaken only by the collection's conservators. The short condition reports were transferred to the collection computer at the end.

Table 2: Key data for the relocation of small objects in the Egyptian and Near Eastern Collection.

Total timeframe for preparation and relocation of the small objects	December 13th, 2010 – November 4th, 2011
Packing and relocation	October 10th – November 4th, 2011
Number of truck shipments	7
Cleaning the central storage facility	January 16th – February 23rd, 2012 and April 3rd – August 20th, 2012
Personnel requirements – people	1 curator, 1 secretary, 2 conservators, 2 external temporary workers, 2 packers/drivers
Personnel requirements conservation – weeks	56 weeks, conservators KHM 39 weeks, external temporary workers
Relocated and cleaned small objects	6,366 inventoried objects from the Egyptian and Near Eastern Collection

SUMMARY

The years from 2010 to 2012 were dominated by the move of objects from the Egyptian and Near Eastern Collection from Inzersdorf to the newly built storage facility in Himberg. This time, the works – they are largely made from inorganic materials e.g. ceramic, stone, metal, etc., but also from a variety of very different organic substances including leather, fur, textile, and plant material – were to be subject to cleaning and infestation treatments that were already long deemed necessary. During the previous move from the basement of the Weltmuseum Wien (WMW) in 2000/2001, a severe mould problem resulting from improper environmental conditions had become acutely evident. These contaminated objects had remained packed and correspondingly labelled in Inzersdorf. Further damage was observed in reassembled objects, which at times had broken apart (especially stone and ceramic vessels); there were also several cases of salt efflorescence and/or resulting scaling, crumbling material layers; pest infestation in leather fragments (holes, tunnelling) and fur, in addition to cracking, etc.

From the results of the mould analyses, a dry cleaning program with protective measures for the safety of the workers was developed, and clean provisional storage made available on rolling shelving. Not only was quick handling thus possible, but transport packaging was also created, which was of particular importance due the large number of units containing objects made of different materials.

In the course of the cleanings, photo-documentation was made of each individual object as well as any additional informational material, and temporary numbers were systematically assigned to "numberless" objects. Short condition reports were produced, and inspection and sorting e.g. of shards and/or mixed materials (especially of grouped items) was performed. A number of samples of possible contents were also taken, primarily from vessels.

Outstanding projects include the production of a location map for the storage space, the assignment of barcodes, the processing of handwritten condition reports and the final placement of objects. Two additional moves of a few very large ceramic vessels, animal mummies, and textiles are also pending.

ZUSAMMENFASSUNG

In den Jahren 2010 bis 2012 beschäftigte sich die Restauratorin der Ägyptisch-Orientalischen Sammlung vor allem mit der Übersiedelung aus Inzersdorf in das neu erbaute Zentraldepot in Himberg. Diesmal sollten die Werke – sie bestehen zum großen Teil aus anorganischen Materialien wie z. B. Keramik, Stein, Metall usw., aber auch aus einer Vielzahl unterschiedlichster organischer Substanzen, etwa Leder, Fell, Textil und Pflanzenteile – einer bereits länger als notwendig erkannten Reinigung und Schädlingsbekämpfung zugeführt werden. Bei der vorangegangenen Verlagerung aus den Kellerräumen des WMW 2000/2001 war nämlich das Ausmaß der Problematik eines aufgrund von ungünstigen Klimabedingungen entstandenen Schimmelbefalls akut sichtbar geworden. Solcherart kontaminierte Objekte verblieben dann bis dato eingepackt und entsprechend gekennzeichnet in Inzersdorf. Weitere Schäden wurden an geklebten, teils wieder auseinandergebrochenen Objekten (besonders Stein- und Keramikgefäßen) festgestellt; hinzu kamen in einigen Fällen Salzausblühungen und/oder dadurch abblätternde, absandende Materialschichten, Schädlingsbefall an Lederfragmenten (Löcher, Fraßgänge) und Pelz, ferner Risse u. a.

Aufgrund der Ergebnisse der Schimmelpilzanalysen wurde eine Trockenreinigung mit Schutzmaßnahmen für die Gesundheit der Bearbeiter konzipiert und die Möglichkeit einer sauberen Zwischenlagerung in den Rollschränken geschaffen. Dadurch wurde nicht nur ein rascheres Handling möglich, sondern es entstand gleichzeitig auch eine Transportverpackung, die aufgrund der Vielzahl an Konvoluten mit einem Inhalt an Objekten aus unterschiedlichen Materialien von besonderer Wichtigkeit war.

Im Zuge der Reinigung erfolgten die fotodokumentarische Aufnahme jedes einzelnen Objektes, die Aufnahme jeglicher Art von Beilagen zur Information sowie die systematische Vergabe von temporären Nummern bei Objekten „ohne Nr.". Kurze Zustandsprotokolle wurden angefertigt, und es wurde das Sichten und Zuordnen etwa von Scherben und/oder gemischten Materialien (besonders bei Konvoluten) vorgenommen. Ebenso wurde eine Vielzahl an Probenahmen von möglichen Inhaltsstoffen – meist von Gefäßen – durchgeführt. Noch zu verrichtende Nacharbeiten umfassen u. a. die Erstellung des Lageplans, die Barcode-Vergabe, das Aufarbeiten der handschriftlichen Zustandsprotokolle und die endgültige Einlagerung von Objekten. Ebenso stehen noch zwei weitere Übersiedelungen von wenigen sehr großen Keramikgefäßen, Tiermumien und Textilien an.

A Storage Facility for the Kunsthistorisches Museum's Tapestry Collection

Katja Schmitz-von Ledebur

Translated from the German by Emily Schwedersky

1. INTRODUCTION

Despite their in most cases monumental dimensions, tapestries are exceedingly fragile works of art. Like other textiles, they react acutely to a multitude of external influences. Dust for example, which often contains oily or other aggressive substances, can cause long-term damage to the organic material. The impact of light on any type of textile is also well-established. It causes structural damage and promotes the disintegration of the fibres. They become brittle and exhibit changes in colour. Mechanical stress, too, contributes to the destruction of the textile structure.

The effects of fluctuations in climate also have to be pointed out, as they put a particular strain on the hygroscopic material. In a dry atmosphere, the fibres release moisture, while in a moist atmosphere, they absorb it. The mechanical friction process of the fibres (during expansion and contraction) can lead to lasting damage.[1]

Keeping these damaging factors at bay as much as possible is among the most important tasks of museum institutions. Aware of this responsibility, the Kunsthistorisches Museum Vienna set up a literally "exemplary" repository for its extensive collection of liturgical vestments in the area of the Viennese Treasury as early as 1986.[2] With the construction of a central storage facility for the Kunsthistorisches Museum's objects, Vienna's tapestry collection, which, comprising 700 objects, is one of the world's largest and most important, can now also be adequately stored.[3]

1 Constant relative humidity and in this context, a constant room temperature therefore serve to protect the objects. Changes in temperature indirectly affect relative humidity, as warmer air can absorb larger amounts of water. Lowering the room temperature additionally slows down the natural ageing process of the materials. See M. Flury-Lemberg, *Textilkonservierung im Dienste der Forschung. Ein Dokumentarbericht der Textilabteilung zum zwanzigjährigen Bestehen der Abegg-Stiftung,* Bern, 1988, p. 57.

2 See K. Schmitz-von Ledebur – S. Svec, "Deponierung und Ausstellung von Paramenten in der Schatzkammer des Kunsthistorischen Museums, Wien. Deposition and Presentation of Liturgical Vestments in the Secular and Ecclesiastical Treasury of the Kunsthistorisches Museum, Vienna," in *Restauratorenblätter* 27, 2007/2008, pp. 137–142.

3 Regarding the collection see K. Schmitz-von Ledebur, "Ein Schatz im Verborgenen – die Tapisseriensammlung des Kunsthistorischen Museums in Wien," in *Museum aktuell* 159, 2009, pp. 19–21; and by the same author, "Mit Glanz von Gold und Seide – die Tapisseriensammlung des Kunsthistorischen Museums in Wien," in exhibition catalogue S. Haag – A. Wieczorek (eds.), *Sammeln! Die Kunstkammer des Kaisers in Wien,* Mannheim (Reiss-Engelhorn-Museen, Museum Zeughaus), 2012, pp. 40–55.

2. HISTORIC STORAGE OF THE TAPESTRIES

The majority of the Viennese tapestry holdings were assembled by members of the House of Habsburg, who like the dukes of Burgundy before them, were among the greatest patrons and enthusiasts of these textile wall decorations. The costly medium was highly appreciated due to its representativeness and political character amongst other things. It was employed mainly on ceremonial occasions as a sign of dignity and as an ennobling element, to impart an appropriate appearance to interiors but also to public spheres. The majority of the existence of these fragile objects was however spent in the so-called *garde-meuble,* for their own protection.

Even today they are not permanently accessible to the public, but only displayed temporarily. Some objects are presented in special exhibitions, in the Kunstkammer, the Collection of Arms and Armour, and the Collection of Historic Musical Instruments in the Neue Burg. In the permanent exhibitions they are exchanged at regular intervals of about two years. After such a period of installation the textile material should receive the period of rest it requires, in storage facilities free from any harmful influences.

The search for suitable storage premises for the singular Viennese tapestry holdings, which were bestowed on the Kunsthistorisches Museum Vienna after the fall of the monarchy and henceforth to be deployed in a museum context, proved to be particularly difficult. Efforts concerning this matter can be traced back to the 1950s, and became more concrete in the 1960s. As early as 1958, Dr. Hermann Fillitz, then-director of the Collection of Sculpture and Applied Arts (today's Kunstkammer), responsible for the care of the tapestries, pointed out "[…] anew the very unsatisfactory storage of the tapestries, unjustifiable by conservation standards […]". "In consequence to the lack of room available to this collection, the tapestries have to be stored folded up and on top of one another."[4]

In 1961, the Kunsthistorisches Museum informed the Federal Ministry of Trade and Reconstruction that the "appropriate storage and care" of the holdings was impossible within their current accommodation and that "irreparable damage was occurring to these objects, which are of inestimable value in a material as well as a non-material sense".[5]

In a report of the same year, Fillitz notes: "The alarming state of emergency is still ongoing, but the articles in the press and the minister's inquiry to parliament in the last weeks of this year have led to certain prospects for improvement regarding the shortage of space. It is impossible to say at this point whether this will lead to any actual results."[6]

Notwithstanding the unresolved issue of finding a suitable space, a new storage system was being developed at this time for the collection; estimates were gathered for the furnishing of a new tapestry repository. The Technische Hochschule Wien developed plans for racks to store the holdings. The system provided for a number of tapestries to be stored in a spread-out state, resting on metal plates. The tapestries thereby stacked in racks on separate metal plates, could only have been moved by crane. Despite the system having been fully thought-out, it was never put into practice. Its implementation may have been prevented by the vast amount of space required, combined with the difficulties of handling the objects in their spread-out state.

[4] Akt Zl. 1/PL/1959, Jahresbericht 1958, Kunstkammer, Kunsthistorisches Museum.
[5] Akt Zl. 28.559 – 6/61, Kunstkammer, Kunsthistorisches Museum.
[6] Akt Zl. 1/PL/1962, Jahresbericht 1961, Kunstkammer, Kunsthistorisches Museum.

Nobody could have guessed at that time that the search for suitable accommodation for the tapestry collection would develop into an enduring problem. Over the course of the following years, different Viennese locations were brought into the discussion, such as the Palais Liechtenstein (contemplated as a tapestry museum in 1984), the Messepalast, the Belvedere, or the Semperdepot (1990, former repository for the stately theatres' scenery). In 1994, the provisional removal of the entire collection to the former sugar factory in Siegendorf was under discussion. Dr. Wilfried Seipel, then director-general of the Kunsthistorisches Museum Vienna, and Dr. Rudolf Distelberger, curator of the Kunstkammer, voiced their displeasure at this proposal in a letter to the Federal Ministry of Science and Research Dept. III/2c. At the same time, the possibility of basement storage under the Maria-Theresien square was being considered, which was to provide sufficient space for the storage of the tapestries, as well as exhibition rooms for their temporary display, amongst other things. The plan was never carried out. Even after 1994, the tapestries remained in two rooms of the so-called Corps de Logis in the Neue Burg for the time being, where they had been brought for "temporary" storage already in the 1960s. Here they remained stored in a folded-up state and piled on top of one another, covered with fabric *(fig. 1)*.

Hopes among professional circles, after years of discussion about the appropriate storage of the holdings, rested upon their transfer to a specially furnished storage space in Inzersdorf in 1997/98. So it came as a great surprise when it became known that the tapestries continued to be stored folded-up, albeit with every object in a separate box, which could be slid into a shelving unit *(fig. 2)*. After a change in curators for the textile domain, the unfolding and unrolling of a part of the collection was begun in 2003, but the space available for their storage in the current Viennese repository was soon exhausted.

By the time the tapestry collection was moved to the newly built repository in September 2011, 65 of the tapestries were already put on rolls *(fig. 3)*. The stated objective, long before the construction of the new storage facility, was the future storage of all tapestries on rolls, each on its own roll and with a specific location in the shelving system. For small-scale objects such as seat covers, flat storage solutions were devised. Enabling easy access to the tapestries, and the development of a system for the gentle and simple handling of the objects was also a priority. The use of archival storage materials was a pre-condition from the conservator's point of view.

Fig. 1: Storage facility in the Neue Burg, with the folded-up tapestries piled on top of one another.

Fig. 2: Storage facility in Inzersdorf, with folded-up tapestries stored in boxes.

Fig. 3: The first rolled-up tapestries in the repository in the 23rd district (after 2003).

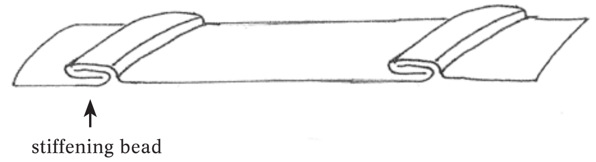


Fig. 4: Schematic diagram of the folded spiral-seam pipe with stiffening beads.

3. STORAGE AT THE NEW CENTRAL STORAGE FACILITY

3.1 TUBES/PIPES FOR THE STORAGE OF TAPESTRIES

In a first step, requirements were defined for tubes that would be suitable for the storage of the objects. The use of tubes made of acid-free cardboard, which had previously been in practice, had to be dismissed for various reasons. For example, they had proven not to be dimensionally stable under prolonged strain from a tapestry's weight. Additional stabilising measures such as fixing a wooden core to the centre of the tube, would have been necessary. However, this would have drastically increased the weight of the tube, which in turn would have made the handling more difficult and thus more dangerous for the object in question. Additionally, wood was generally rejected as a raw material due to its potential of introducing various harmful substances into the ambient air.

Thanks to friendly pointers from the royal manufacture de Wit in Belgium, namely by Yvan Maes de Wit, a series of tests were carried out with pipes made of galvanised steel with and without powder-coating. Eventually, commercially available folded spiral-seam pipes made of galvanised steel sheeting with a thickness of 0.6 mm were chosen. With reference to the average weight of a lined tapestry made with metal threads, dimensional stability of the pipes without sagging could be guaranteed up to a length of 4.50 m. All longer pipes required additional stiffening beads *(fig. 4)*. The minimum length of the pipes was determined by the object's size.[7]

20 cm width were added to these measurements on either side to facilitate handling of the pipes and their resting on the shelf *(fig. 5)*. Following in-depth study of all the tapestries, the holdings could be categorised and distributed onto six lengths of pipes with measurements of 600, 550, 500, 450, 400 and . With regards to the diameter of the rolls, two variants of 25 and 35 cm were chosen, with the addition of c. 5 cm for the build-up and the wrapping elaborated below.

7 The Viennese tapestries were rolled in the direction of the warp thread, as is common practice, so that the height of the tapestry usually determined the length of the roll used for its storage.

Fig. 5: Handling surface of the folded spiral-seam pipe.

Fig. 6: Wrapping of the folded spiral-seam pipes with Plastazote (PE foam) cut into narrow strips (first step).

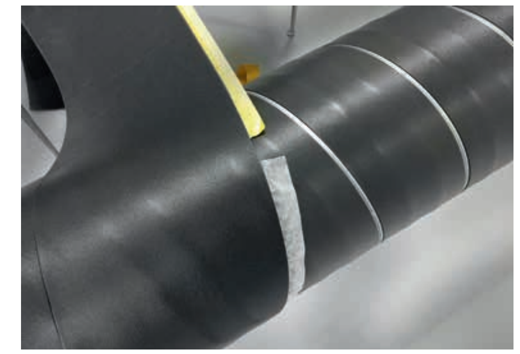


Fig. 7: Wrapping of the folded spiral-seam pipes with another layer of Plastazote (second step).

Due to the spiral fold of the pipes, it was imperative that they should be adapted to their new use. The stated objective consisted in providing a homogenous surface suitable to accommodating the rolling-up of the tapestries. After a test phase with various materials, Plastazote (PE foam material on reels) was chosen for wrapping around the pipes. The wrapping procedure was divided into three steps. Narrow strips of cut Plastazote with a thickness of 2.5 mm (corresponding to the thickness of the folds on the pipes) were used to fill the space between the folds *(fig. 6)*. The pipe was then wrapped with a second layer of Plastazote of 5 mm thickness to achieve an even surface *(fig. 7)*.

The fact that the tapestries had been folded up for decades proved to be problematic, as the folds were clearly distinguishable in the fabric. To prevent breaking of the fibres, the rolls were therefore wrapped with polyester fleece in a third step, as it gives way to the tapestry's movements *(fig. 8)*. The three-layered wrapping does not however cover the whole length of the pipes. Areas of 20 cm were left bare on both sides of the pipes, without Plastazote and polyester fleece, to facilitate their handling and resting on the shelf. The visual division of object and handling areas serves, amongst other things, to protect the objects. To secure and simultaneously stabilise the sharp-edged ends of the pipes, they were riveted with lids *(fig. 9)*.

Fig. 8: Wrapping of the folded spiral-seam pipes with polyester fleece (third step).

Fig. 9: Riveted lids of the folded spiral-seam pipes.

During the rolling-up process, the surface of the tapestries mounted onto the pipes was protected by Cellplas,[8] which was rolled on with the tapestries. The same material served as an intermediary layer between the tapestry and the fleece. Externally, the rolled objects are protected from dust by a thin cotton fabric. Loosely knotted cotton ribbons were used to hold the fabric in place *(fig. 10)*.[9]

Fig. 10: Dust protection of the rolled-up tapestries by an outer layer of thin cotton fabric.

8 Cellplas is fleece made of polypropylene fibres. It is manufactured in a process solely using heat and pressure, without the use of adhesives.

9 As rolling-up the tapestries requires great sensitivity for the textile material as well as a lot of time, it will take another few months for all the objects from the Viennese holdings to be rolled-up and installed in their designated spot in the storage facility.

Fig. 11: Shelves for storage of the tapestries rolled onto folded spiral-seam pipes.

All materials used in the storage facility were previously examined by the Conservation Science Department of the Kunsthistorisches Museum Vienna by means of Oddy-tests, to determine their suitability for use in the field of object storage.[10]

3.2 SHELVES FOR THE STORAGE OF TAPESTRY ROLLS

The space available for the storage of the tapestries was limited to c. 1,420 m² and the room height to 3 m. A powder-coated shelving system with lateral posts (2.20 m high) and cantilever arms projecting freely into the room was chosen for the storage of the tapestries mounted on pipes (tapestry rolls) *(fig. 11)*. The width of the shelves corresponds to the length of the tapestries stored on them. The ends of the tapestry rolls rest on the cantilevers, with a so-called half-shell especially developed for the purpose *(fig. 12)*.[11] The 4 cm wide, nearly semi-circular support surface of this construct prevents the tapestry from moving on the cantilevers, and helps to ideally distribute the weight of the roll (c. 1/5 of its circumference has a corresponding support surface) so that it is not absorbed by a single spot on the pipe.

Fig. 12: Half-shell for the folded spiral-seam pipes to rest in.

The shelves, which are bolted to the floor, are arranged in rows placed close together (in threes or fours) and back-to-back in the storage room. Corridors of c. 1.60 m width are placed in between, allowing access to the shelves in their full width from the front. Within the storage room, two of these blocks of shelves were arranged in such a way that they are accessible from a wide main corridor at the centre of the room, as well as via sideways routes.

10 Simple material test used in the museum field, named after Andrew Oddy, British Museum. On the performance of the test, see L. R. Lee – D. Thickett, *Selection of Materials for the Storage or Display of Museum Objects* (British Museum Occasional Paper 111), London, 1996.

11 My special thanks at this point go out to Stefan Fleck of the Kunsthistorisches Museum's facility management for his creative input.

Fig. 13: Shelf with eight folded spiral-seam pipes.

The horizontal pairs of cantilever arms support two tapestry rolls each, one behind the other, in order to make optimum use of the limited space available. Each shelf fits four superimposed pairs of cantilevers, so that one shelf provides space for eight tapestries in total *(fig. 13)*. The distance between the cantilever arms as well as between the half-shells attached to them – thus between the tapestries – is flexible and based upon the size of the rolled objects; the cantilevers are height-adjustable via adjustment steps in units of 50 mm. The half-shells sitting on these arms can be fixed into any desired position with a system of screws.

Prior to purchasing the 97 shelves for the storage facility with the corresponding number of pipes, the functionality of this storage concept was tested on one shelf as a prototype.

3.3 HANDLING OF THE TAPESTRY ROLLS

A mechanical, mobile lifting apparatus was developed for the handling of the tapestry rolls arranged in four superimposed rows *(fig. 14)*. It has variable lateral extension arms at its disposal, which can be adjusted to the width of the shelf in question, and regulated to any desired height with a crank handle. To each end of the extension arms, one half-shell sitting on a cantilever arm is fixed at a 90 degree angle (with short cantilevers for rolls at the front of the shelf, and longer ones for those in the second row). The extension arms with laterally affixed half-shells on the lifting apparatus standing in front of the shelf, are regulated to such a height that they are positioned between two cantilevers or underneath the lowest cantilever of any shelf respectively; this positioning depends on the tapestry to be displaced. Through targeted movement of the lifting apparatus in the direction of the shelf, the half-shell can be positioned directly below the tapestry roll in the 20 cm wide handling area, and the extension arms lifted by the slow turning of the crank. Through a backwards movement of the apparatus, it is possible to remove the tapestry from the shelf *(fig. 15)*.

Fig. 14: Lifting apparatus.

Fig. 15: Lifting apparatus in action.

Fig. 16: Dolly with half-shells for handling the tapestries rolled-up onto folded spiral-seam pipes.

The rows of shelves offer sufficient space for this backwards movement of the lifting apparatus. Even in front of the shelf, it is possible to gently lower the tapestry to be manipulated by turning the crank, and rest its ends on the specially designed dolly which has also been equipped with half-shells *(fig. 16)*. On this dolly it is possible to move the tapestry to any given location.

Next to these rows of shelves, the storage space has two sufficiently large floor areas for manipulation, finished with a special, easy-to-clean surface (their size is about 7 × 8 m). The tapestry roll can be brought here using the dolly, and rested on slats. It can then be unrolled for examination. The process of depositing a tapestry in its designated location on one of the shelves takes place in reverse order to its removal.

In distributing the museum objects on their respective shelves, care was taken to place tapestries belonging to a series in spatial context. Every tapestry was assigned a specific location in the shelving system prior to the relocation of the collections. With bar codes on the objects themselves and on their respective positions on the shelves, the objects can be located and are easily trackable.

Fig. 17: Support-free shelving with acid-free cardboard boxes.

3.4 SHELVING SYSTEMS FOR SMALL-SCALE OBJECTS

Small-scale objects from the collection, such as portraits or seat covers, are stored in acid-free cardboard boxes, placed on powder-coated support-free shelving units with continuous levels *(fig. 17)*.

4. SUMMARY

Apart from the creation of appropriate storage solutions for the objects, as well as the establishment of premises for their professional handling, several other criteria played a major part in planning the new storage facility. Among those were a stable indoor climate, facilities for the nitrogen treatment of objects to be returned into storage after being displayed, a quarantine and a packing room, suitable rooms for photographing the objects, studio spaces, rooms for monitoring etc. These topics are elaborated on in the respective articles in this publication.

With the construction of a new storage building in 2010/11, the Kunsthistorisches Museum Vienna has finally brought the discussion about an appropriate space and adequate storage system for one of the most important tapestry holdings worldwide, which had lasted several decades, to a satisfactory conclusion.

SUMMARY

The outstanding Vienna tapestry holdings were assembled by members of the House of Habsburg, who like the dukes of Burgundy before them were among the greatest sponsors and enthusiasts of these textile wall decorations. The fragile objects, which since the end of the monarchy have been in the care of the Kunsthistorisches Museum Vienna, can for conservation reasons not be permanently displayed to the public, but rather can only be shown temporarily. The storage of these holdings must thus be given particular care.

With the construction of a new collections storage facility, the Kunsthistorisches Museum Vienna was not only able to create a repository in keeping with modern standards of preservation – it also developed a special storage system for the tapestries. After a long testing phase, rolls made of galvanised steel sheeting wrapped with polyethylene and polyester fleece were chosen. The tapestries will be stored on these rolls in the future. Each tapestry received its own roll and a specific location in a shelving system that is appropriate to the needs of the collection. The accessibility of the tapestries and the development of a system for the careful and easy handling of the rolled objects were additionally considered.

ZUSAMMENFASSUNG

Der einzigartige Wiener Tapisserienbestand wurde von den Mitgliedern des Hauses Habsburg zusammengetragen, die wie vor ihnen bereits die Herzöge von Burgund zu den wichtigsten Förderern und Liebhabern des textilen Wanddekors gehörten. Die fragilen Objekte, die seit dem Zusammenbruch der Monarchie vom Kunsthistorischen Museum Wien betreut werden, können aus konservatorischen Gründen der Öffentlichkeit nicht dauerhaft zugänglich gemacht, sondern nur temporär gezeigt werden. Der Deponierung dieses Bestandes muss daher besondere Aufmerksamkeit geschenkt werden.

Mit dem Bau eines Zentraldepots konnte das Kunsthistorische Museum Wien nicht nur neuesten konservatorischen Standards gerecht werdende Depoträume schaffen, sondern auch ein spezielles Lagersystem für die Tapisserien entwickeln. Die Wahl fiel nach einer langen Testphase auf Rollen aus verzinktem Stahlblech, die mit Polyethylen und Polyestervlies ummantelt wurden. Auf ihnen werden die Tapisserien zukünftig aufgerollt deponiert. Jeder Tapisserie wurde eine eigene Rolle sowie ein eigener Standort in einem den Bedürfnissen der Sammlung gerecht werdenden Regalsystem zugewiesen. Berücksichtigt wurden zudem eine leichte Zugänglichkeit der Tapisserien sowie die Entwicklung eines Systems für das schonende und einfache Handling der aufgerollten Objekte.

Fig. 1 a: At the former storage facility in Inzersdorf, large-format paintings had to be stacked leaning against the walls. Owing to steady increase in the number of objects stored there as well as displacements due to water ingress, smaller paintings came to be stored in front of them.

Fig. 1 b: At the new centralised storage facility, there is room even for the largest formats on the wire mesh walls of the pull-out picture racks. Picture of a large format wrapped in PE foil, taken during the relocation campaign.

The Relocation of the Picture Gallery's Collection from Inzersdorf to the Central Storage Facility in Himberg

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Translated from the German by Emily Schwedersky

1. PRELIMINARY REMARKS

"An archive is a depository for the future, a starting point, not an end point …"[1]

The repository to be relocated contained some 2,000 paintings and 800 picture frames, which had been housed in three halls of a rented property in Inzersdorf. These holdings naturally do not constitute a fixed selection of paintings that have been designated for storage once and for all. Instead, they consist of a more or less fluctuating "mass," which, much like the public collection, reflects the institution's activities, constantly changing appraisal and time-conditioned points of view.

Paintings are frequently taken out of storage for the short term for special exhibitions, or used to furnish state rooms for various administrative bodies. Conversely, they are often deposited when they make room for special exhibitions in the exhibition rooms or have to be removed to a safe place during rebuilding works. Longer-term displacements are attributable to re-evaluation due to a continuous engagement with the collection and current research findings. A long list of artworks that were kept in storage, often unrecognised or misjudged due to their ambiguous state of preservation, serve to illustrate this point and would merit a separate survey.[2] Numerous paintings which today are an integral part of the public display, spent long periods of time in storage.[3]

The property in Inzersdorf was arranged as a provisional solution prior to the beginning of the Kunsthistorisches Museum's general renovation. The collection of paintings stored in three halls of the building was brought together from different locations. In 1989, several in-house repositories had to be vacated to allow for the building works and rededication of the rooms. These were storage rooms on the ground floor of the museum's main building (Burgring 5), which were adjacent to the Picture Gallery's conservation studios, as well as rooms in the Neue Burg and in various cellars.[4]

1 From: C. Meran (ed.), *an/sammlung an/denken. Ein Haus und seine Sammlung im Dialog mit zeitgenössischer Kunst* (Österreichisches Museum für Volkskunde, vol. 86), Vienna, 2005, p. 18.

2 On this topic see also: V. Oberhammer, *Neuerworben 1955–1966 Neugewonnen. Zuwachskatalog der Gemäldegalerie des Kunsthistorischen Museums*, Vienna, 1966, pp. 10–11.

3 For example, in the course of the revision undertaken in 1772 with regards to refurnishing the Upper Belvedere's Picture Gallery, Titian's *Nymph and Shepherd* and Giorgione's *Three Philosophers* were found on the lists of paintings of the so-called "Gallerieböden" (repository rooms).

4 A large paintings repository was until 1989 situated in parts of today's Picture Gallery conservation studios, facing the courtyard, as can still be seen in the inscription "GALERIEDEPÔT" over one of the portals.

Fig. 2: The frames were for the most part accommodated on shelves, which were similarly difficult to access.

The storage facility in Inzersdorf initially constituted a marked improvement in comparison with the previous storage situation, due to an increase in space and superior control of climatic conditions. However, the building's structural defects, such as the aged flat roof especially, increased over the years and seriously put the paintings at risk, finally leading to the artworks being concentrated in several areas of the repository, making a proper order difficult to maintain *(figs. 1 a and 2)*.

The Picture Gallery's most important desideratum for the new storage facility to be built, aside from a solid building structure with the appropriate climatic conditions, was the creation of hanging space for all paintings, including the large-format ones, and to thereby enable access and regular inspection of all the holdings, without having to manipulate them. A part of the wire mesh walls therefore had to be designed to be suitably large. The specifications of spatial requirements were based on a calculation which included the accommodation of all paintings used to furnish state rooms, paintings on rolls in a stretched state, further repository holdings in the "Sekundärgalerie" (a former exhibition space currently used for storage), as well as possible additions to the collection.[5] The spatial requirements were expressed in square metres of hanging space (for paintings) and linear metres of shelving (for smaller frames). In accordance with this space requirement projection, the furnishings for the new storage facility were developed in close cooperation with the building and relocation teams.[6]

The challenge that this repository presented in terms of relocation, was however not only due to its large scale but above all its overwhelming abundance and variety of unsolved and postponed conservation problems, resulting not least from overly cramped and inadequate storage situations.

2. PLANNING PHASE – INSPECTION, COMPILATION OF A CATALOGUE OF MEASURES, CALCULATION OF THE WORKING TIME

As has been elaborated elsewhere in this publication, very tight cost calculations underlay the entire project. It was apparent that the team of collection conservators had to be added to, on the grounds of the collection's large scale and very poor condition of some of the works alone. In any case a larger number of people would be involved in the project. As a basis for decision-making, a catalogue of measures was compiled, intended to aid a coordinated approach to coping with the considerable quantitative and qualitative workload.

Such intense work in a repository should in fact also be seen as an opportunity to deepen the level of knowledge of the collection. It was therefore important to structure the preliminary work in such a way that the acquired know-how would remain within the institution and that the collection's conservators could build on this knowledge for future maintenance of the storage facility.

5 The projections regarding the holdings and the required hanging spaces were carried out in 2009 by Elisabeth Wolfik. The decision to provide for the accommodation of all paintings furnishing state rooms was crucially influenced not least by the recommendation of the Austrian Court of Audit to withdraw all these paintings from the offices.

6 According to the particular needs of the Picture Gallery, pull-out picture racks were devised in two different sizes (Kern Studer AG; Art Storage Systems, Art Storage System Type L–40; ceiling-running systems with linear guide; size of the wire mesh walls: 500 × 805 cm or 400 × 605 cm) *(figs. 1 b, 3 to 5)*. The size of the rack system was guided by the format of the largest painting, which is still rolled up at present. When unrolled, the painting will occupy the entire span of a wire mesh wall of the large pull-out picture rack. Shelves were chosen for storage of the frames, and a flat file cabinet for the storage of particularly fragile paintings which therefore had to be stored flat. Both these systems are also in use in other collections at the storage facility. Shelves: Compactus & Bruynzeel AG; Flat file cabinet: Magista Systems/Van Keulen Interieurbouw *(fig. 6)*.

Fig. 3: Installation of the 500 × 805 cm wire mesh walls of the pull-out picture racks by the Kern Studer company.

Fig. 4: The installation should be monitored very closely. At the new storage facility, the fact that the wire mesh panels had not been assembled so that they fit perfectly in some places was only noticed relatively late. The resulting slight misalignment is especially bothersome when using the additional support elements to be hooked in individually. Unfortunately this could not be rectified, as a very large number of paintings had already been hung on the racks at that point.

Fig. 5 a

Fig. 5 b

A ceiling-running system with linear guide and an additional floor roller was chosen for the new storage building. The individual wire mesh walls are easy to pull out, with hardly any vibration. Some smaller issues unfortunately only became apparent during use. For example, when pulling out two adjoining wire mesh walls, there is a danger that they run in slightly different directions. This can lead to the distance between the individual walls being significantly reduced, as can be seen in Fig. 5 a. In order to guarantee a fixed trajectory of the wire mesh walls, all the wheels were very precisely adjusted, and a second guide rail subsequently put in place. This can be seen in Fig. 5 b. The picture was taken during the annual general cleaning campaign. Moreover, it was discovered that the floor rollers have a tendency to become flat, so that it is advisable to slightly shift the positions of the walls at regular intervals.

Fig. 6: A number of particularly fragile paintings that require flat storage are housed in a flat file cabinet, such as the two portraits at the bottom right for example, which are "painted" using tree bark and leaves.

The following solutions were found: the continuity and consistency of the work was warranted by the presence of an in-house conservator who constantly oversaw the project, coordinating all activities in situ and consulting with the head of the Picture Gallery's conservation studio day-to-day. As additional support, at least one of the collection's conservators would join her (all the staff members taking it in turns, each on a one- or two-week schedule), so that all in-house conservators were involved in this work, and at the same time, on-going tasks at the main building could be negotiated.

In order to apply for the budgeting of supplementary personnel on the one hand, and be able to begin the work on time on the other hand, it was firstly necessary to estimate the entire working time required for securing and documenting the paintings before transport. These measures were also essential to account for any potential damages incurred during transport. For this calculation, inspections of the entire collection were carried out, including, next to the paintings hanging on wire mesh walls, stacked large-format paintings, paintings without stretchers, which were stored on rolls or between sheets of cardboard, as well as frames.

The majority of the paintings were located on the wire mesh walls. Based on ca. 15 % of these walls, all the necessary working steps and measures on the paintings were calculated, in order to obtain a representative picture of the problems to be anticipated, and an average value of the amount of work resulting from them. The established average values were verified in situ several times, on separate days, and finally extrapolated to the total number of wire mesh walls. With regards to the stacked large-format paintings, it was only possible to make an approximate calculation, as they had been stored in this manner for a very long time and neither enough space nor manpower were available to examine them in more detail *(see fig. 1 a)*. In the case of the paintings stored on rolls (78 paintings on 18 rolls), several of the fixtures and poles had become unstable or broken down[7] *(fig. 7)*. It was therefore necessary to stabilise them sufficiently, not only for transport, but also for future storage. The establishment of a satisfactory substitute for the storage on rolls, which is problematic in the long term, can only be tackled after completion of the relocation project.

Another "inherited burden" was represented by 36 paintings on canvas, which formerly had been stored flat, without stretchers, in the Neue Burg and finally in the repository for display cases in Inzersdorf. Stretching the paintings, some of which are badly damaged, had so far not been possible due to time constraints. But since those areas of the repository had to be vacated at short notice, it had to be managed with the following interim solution: the paintings were placed between two pieces of cardboard that were secured together with wooden poles *(fig. 8)*. By this means, it was possible to quickly bring the individual paintings in an upright position and transport them. This treatment was temporarily left in place for the relocation, as the paintings could be transported safely and with minimum strain. Here too, however, a different solution will have to be arrived at in the longer term.

A collection of about 800 picture frames was for the most part stored on shelves, and in small part hung on wire mesh walls. A further repository housed large, very fragile frames and frame elements, as well as boxes with miscellaneous found pieces of ornaments *(see figs. 47 and 48 a)*.

[7] Some of these are ceiling paintings from the former gallery in the Stallburg, others large versions of Jan van der Hoecke's tapestry modelli. The rolls have already been in existence for a very long time.

Fig. 7: A total of 78 paintings were stored on 18 rolls, which differed greatly in construction and had become unstable in places. Note the fractured head of one of the rolls at the bottom right (marked by the arrow).

Fig. 8: Some paintings without stretchers had already been stored upright since 2003. The unstretched canvases are pressed between sheets of cardboard and held by wooden braces, which are bolted together. These makeshift structures were left in place for the relocation, however the long-term plan is to consolidate and restretch them. This picture shows the current form of storage at the new central facility, with the paintings tied to the wire mesh wall and resting on individually mounted support elements. The distance between the walls is slightly larger here than in other areas of the building.

2.1 THE PROBLEM OF PEST INSECTS – BISCUIT BEETLES, SILVERFISH

Another important aspect in planning for the relocation was the issue of pest insects. Owing to the traditional use of glue-paste in the lining of canvas paintings, they form attractive breeding grounds for the larvae of the biscuit beetle *(Stegobium paniceum)*. Having said this, the infestation seems to be a specific characteristic of the Viennese gallery, as other painting galleries seldom report on similar problems.[8] It is remarkable that a certain type of lining is being favoured and evidently infested repeatedly, resulting in severe damage to the paintings in question *(fig. 9)*. While it is known that these linings were carried out around 1900, the exact link with the lining material has not yet been resolved.[9]

[8] The authors are only aware of this report: *affaire-stegobium, Portefeuille pédagogique,* Octobre 2006, CICRP, Marseille. http://www1.montpellier.inra.fr/CBGP/insectes-du-patrimoine/sites/default/files/textes_divers/affaire-stegobium.pdf (11.10.2015).

[9] Labels bearing the name of Hermann Ritschl, restorer of the "k. k. Gemäldegalerie" (Imperial Picture Gallery) from 1892 to 1921, can in many cases be found on the stretchers of the paintings in question. On this topic, see also: Monika Strolz, *Die Konservierung und Restaurierung des Bildes "Theseus und die Töchter des Minos" von Benedetto Gennari (1633–1715) entstanden in Bologna 1702, Öl auf Leinwand. Format: 121,5 cm × 100,5 cm. Standort: Kunsthistorisches Museum, Wien, Depot, Inv. Nr. 7126,* diploma thesis, University of Applied Arts Vienna, Vienna, 1987, and Agathe Boruszczak, *Die Stabilisierung eines durch Brotkäfer geschädigten Gemäldes aus dem Kunsthistorischen Museum in Wie*n, diploma thesis, University of Applied Arts Vienna, Vienna, 2013.

Fig. 9 a

Fig. 9 b

Fig. 9 c

The biscuit beetle favours paintings with starch paste linings as a habitat. A few typical damages are shown here: Fig. 9 a shows the verso of a painting with the typical exit holes. Fig. 9 b and 9 c illustrate the fact that especially areas of the painting which are usually hidden by the frame rebate are often damaged, making an infestation difficult to recognise during the early stages. If it is not noticed in time, the damage to the support can be so significant that large areas of the original may be lost.

Comprehensive pest monitoring had hence been conducted in all the different storage locations during the summer before the relocation. In the course of this examination, a massive biscuit beetle infestation had again been detected in one of the three facilities.[10] Due to the mobility and lifestyle habits of the beetles (egg deposition and feeding activity of the larvae preferentially in protected areas, for example under the stretcher bars), it was difficult to determine the exact location of the infestation, let alone contain it reliably. This circumstance meant that the entire collection had to be treated, so as not to introduce the pest into the new storage building. The treatment should moreover take place as close in time to the relocation as possible, to avoid another infestation, and was thus to be undertaken after completion of all other preparatory work.

Following intensive consultations and several site inspections (with museum personnel and external experts), the decision was finally made in favour of in-situ treatment directly in one of the three painting repositories in Inzersdorf. An external pest control company[11] was charged with building an anoxic nitrogen tent with a volume of about 1,000 m³ around the entire pull-out picture rack system *(see figs. 32 and 33)*.[12]

Numerous paintings additionally exhibit paper facings of varying age. Some of these facings are likewise breeding grounds for pests, as can be seen from the increased number of exit holes (infestation with biscuit beetles) or feeding damage in the paper from silverfish. In consequence, it will be necessary to remove the facings in the long term.

[10] An acute biscuit beetle infestation was first discovered in 1985, when the storage rooms still adjoined the Picture Gallery's conservation studio and a part of the holdings (the portraits) were transferred to a newly adapted cellar room. Thus upon furnishing the new facility in Inzersdorf, about two-thirds of the collection had been fumigated with toxic methyl bromide by the Breymesser company. Following the construction of an in-house nitrogen chamber in 1998, anoxic treatment had been continued with nitrogen.

[11] Company: Michael Singer GmbH & Co. KG.

[12] See the contribution by Querner et al. The construction of the tent's roof allowed for it to be covered with plastic sheeting, which also provided protection against future water leakages while the work was ongoing at the Inzersdorf repository (roof construction: Füreder company). The roof was covered with fleece and two continuous layers of plastic sheeting by the Singer company. The fact that the entire pull-out picture rack system was filled with paintings proved to be particularly problematic during implementation of these measures.

Summing up, the following sets of problems could be identified:
- loose paint layers and frame surface coatings;
- unstable painting supports (tears/holes in the canvas, panel paintings with cracks or under strain);
- canvas paintings without stretchers (paintings stored between sheets of cardboard or on rolls);
- pest insects: acute biscuit beetle infestation, indications of silverfish infestation.

The catalogue of conservation measures with regards to the relocation included the following tasks for all paintings, according to necessity and available time:
- condition checking;
- checking for pest infestation (acute?), especially the areas around the edges;
- * unframing/removal, and if required replacement, of edge protection battens;
- surface cleaning;
- removal of dirt particles between the stretcher and the canvas;
- * consolidation of paint;
- * stabilisation of painting supports;
- ** removal of infested facings (breeding ground for further infestation);
- * consolidation of frames;
- secure mounting in the frame;
- examination of the hanging fixtures, or their application/replacement;
- * protective measures for transport
  (backboards and insert linings against vibration);
- brief documentation (filling out a form, possibly photographs);
- arrangement in packing units, or rehanging;
- documentation of the logistics.

Frame collection:
- dusting;
- * securing surface coatings

* where necessary
** where possible within the time constraints

Assuming the continuous involvement of 4 to 5 conservators, a period of at least 6 months was to be anticipated for these activities. In consideration of the on-going work related to exhibitions that was to be managed in addition, an application was made for two external conservators for the duration of the preparatory work, and a part-time employee for the entire year 2011. Additional support was organised through a series of interns.

As was mentioned at the outset, the problematic state of repair of the building in Inzersdorf over the last several years, had required repeated relocation of the paintings, which had also been insufficiently documented. For this reason, a revision of the inventory proved to be indispensable, not least as a premise for planning a sensible organisation of the collection in the new storage facility.

It was generally necessary to continuously accompany the conservators' work logistically, to ensure that the location of each painting was traceable at all times. Conservation and logistical work (revision of the inventory, planning of the new storage facility's organisation) therefore had to be carried out side-by-side, as well as intertwined with each other. During anoxic nitrogen treatment or moving, it would also not be possible to remove individual paintings from their packing units or from the anoxic nitrogen tent, so that the storage facility had to be considered closed from a certain point onwards. This, in turn, was to be taken into account in due time when planning activities for the main building.

The gathering of logistical data was to be in the hands of one single person. For the duration of the project therefore, a registrar who was to deal solely with the relocation was to be appointed, with responsibility for all logistical questions – object location tracking, revision, new storage organisation – and function as the go-to person for curators and conservators.

In summary, the following parameters were determined for the relocation work during the planning phase: the move of all the objects had to be finalised by the end of November 2011, to meet the end-of-year deadline for the handover of the Inzersdorf building. Due to climatic conditions in the only partly air-conditioned facility in Inzersdorf, the aim was to complete the relocation by the end of October. As the nitrogen-based anoxic treatment (acute biscuit beetle infestation) had to be carried out immediately preceding transport, all conservation treatment accordingly had to be concluded prior to this. The work preparing the objects for transport thus had to begin as early as February and be finished by July.[13]

3. PRACTICAL IMPLEMENTATION

By reference to selected examples, the most commonly implemented measures will be outlined below, and a few special cases with exceptional requirements singled out. Moreover, the logistical challenges of transport and rehanging of the objects will be elaborated.

As described above, the whole project was based on very tight calculations. Two freelance and two in-house paintings conservators, as well as one registrar worked at the storage facility on average. The tasks assigned to the conservator and registrar who worked exclusively on the relocation project, comprised time management, calculating material requirements, as well as coordinating the collaboration with other departments, the relocation team and the art handling company, amongst other things. The freelance conservators and one conservator from the collection at a time, changing on a weekly basis, on the other hand, worked solely on the objects themselves.

The greatest challenge was presented not by the individual objects, but rather by the sheer number of items to be tackled in a minimum of time. In this context, the weekly in-situ meetings between the responsible conservators and the head of the Picture Gallery's Conservation Department during the initial stages of the project, proved vitally important for evaluating the course of action and adjusting it where appropriate. The work was thereby usually discussed in a practice-oriented manner with the help of individual exemplary objects. Especially due to the time constraints, clear priorities had to be established, but above all, many compromises had to be made. The focus lay on the transportability of the paintings and hence their safe and sparing transfer to the new location. Beyond that, the aim was to achieve sustainable and durable improvement in the storage situation. The principle followed was "as much as necessary and as little as possible".

[13] It should be mentioned at this point that it is very important to factor in a time buffer, especially when dealing with such extensive treatments. There was in fact a delay of a few weeks because of a technical defect that occurred during the second anoxic nitrogen treatment cycle, which thus had to be prolonged.

Fig. 10 a

Fig. 10 b

A view of the former storage facility in Inzersdorf in 2011, during preparatory work for the relocation. New condition and treatment reports were made for all paintings. Unfortunately, it was not possible to feed them directly into the Access database for logistical reasons. The data is however continuously being transferred to the database. At the moment, about 90 % of the information is accessible digitally.

3.1 INSPECTION AND DOCUMENTATION

The condition check that was systematically carried out on all paintings was combined with the necessary stocktaking (storage and location revision).

In contrast to some of the Museum's other collections, the Picture Gallery's repository holdings were at least generally documented and had last been inspected, as well as basic measures implemented, about ten years previously in the course of a digitalisation campaign. Almost all the paintings were recorded in the in-house museum database with a photograph and their respective location.[14] The condition and treatment reports written at that time formed the basis for the set-up of an Access database, in which condition, measures implemented and preparations for transport were recorded in a standardised fashion for each object *(fig. 10)*, and which could be linked to the museum database. In addition, certain damages and measures were captured in photographs.

The revision, location documentation and new organisation were in the hands of a registrar dealing solely with the Picture Gallery's relocation. Aside from the incompletely documented rehanging of paintings, there were also external objects that were not or inadequately recorded.

Thanks to this revision, all displaced objects could be retrieved and several previously unrecorded paintings could be included in the database with their current locations. Moreover, all movements of objects before and during the relocation could be planned and tracked transparently at all times.

[14] A digitalisation campaign took place in 2003, during which all the paintings were inspected and succinctly documented, as well as much-needed measures implemented, with the support of two temporarily hired external conservators (federal digitalisation project, set-up of the object database TMS).

Fig. 11: Dr. Katja Sterflinger, professor for geomicrobiology at the University of Natural Resources and Life Sciences, Vienna – IAM, taking a specimen in order to test for possible microbial contamination of the objects.

Fig. 12: Old, inactive mould spores were cleaned away using vacuum cleaners equipped with HEPA-filters.

Since the paintings were again to be hung according to subject, i.e. portraits or other subjects, and within those categories chronologically and by regions/schools of painting in the new central storage facility, meticulous preparation was of the essence. Matters were complicated further by the fact that the picture racks were of a different size and the hanging did not fully correspond to that in the old facility. For this reason, all paintings and their respective frame measurements were previously entered into the database by the registrar, and the individual new walls planned in cooperation with the collection curators using the *GalleryCreator* program *(see fig. 36 a)*.[15]

The Picture Gallery was the only collection to already fully implement the newly introduced registration/logging of all objects via barcode labels during the relocation *(see fig. 28 b)*.

3.2 PREPARATORY CONSERVATION MEASURES ON THE OBJECTS

3.2.1 SURFACE CLEANING

No evidence of active mould growth was detected in the paintings repository upon investigation for mould spores, however individual paintings did exhibit clear evidence of old, now inactive mould[16] *(figs. 11 and 12)*. Rather than the paintings themselves, it was the accretions of dust and dirt that had collected on them over time that proved critical, as they constitute an ideal breeding ground for mould spores. In order to minimise the danger of contaminating the new storage facility, all objects were superficially dusted using cloths, vacuum cleaners and brushes. Objects with old mould growth were cleaned using a vacuum cleaner equipped with a HEPA filter. As even dead spores have allergenic potential, gloves and particulate removing facemasks (filter grade FFP3) were worn while carrying out these tasks *(fig. 12)*. On the basis of the survey, it was not deemed necessary to subject the objects to further biocide treatment.

3.2.2 CONSOLIDATION OF PAINT AND APPLICATION OF FACINGS

Numerous paintings exhibited areas of flaking paint, which were consolidated using mostly sturgeon glue, and sporadically acrylic dispersions.[17] In one special case, cyclododecane was employed to temporarily stabilise very underbound, matte, flaking paint that had been loosened by an old water damage *(fig. 13)*.

As has been previously mentioned, many paintings had paper facings that had been applied to the paint layer years before, some large and some even covering the entire painting. These were applied as a temporary measure, to prevent paint losses. The presumption that these paintings would receive conservation treatment in the medium term however proved to be unrealistic. Various types of paper were used as facing materials over the years, the most common being

[15] This working step was very time-consuming. The *GalleryCreator* program was developed at Bern University and is usually used by the Picture Gallery to visualise the hanging of paintings. In practice, it became clear that the relocation of such a large collection in such a short time was only possible due to this pre-planning of every last detail and visualisation of each and every wall. Although some small changes were still made where measurements had been slightly incorrect, or different priorities were to be set with regards to content, on the whole this plan was adhered to. Without these diagrams, the rehanging would have been significantly more time-consuming.

[16] Examination carried out by Dr. Katja Sterflinger and Christian Voitl, University of Natural Resources and Life Sciences, Vienna.

[17] Medium for consolidation by Lascaux, or a diluted acrylic dispersion of 1 part Plextol D498 + 1 part K360 dispersion + 2 parts water.

Fig. 13 a

Fig. 13 b

Fig. 13 c

Parts of the very matte, underbound and partly flaking paint layer of this painting were temporarily consolidated for transport using cyclododecane. Fig. 13 b shows a preliminary test, Fig. 13 c a detail with a lifting, but secured flake of paint after transport.

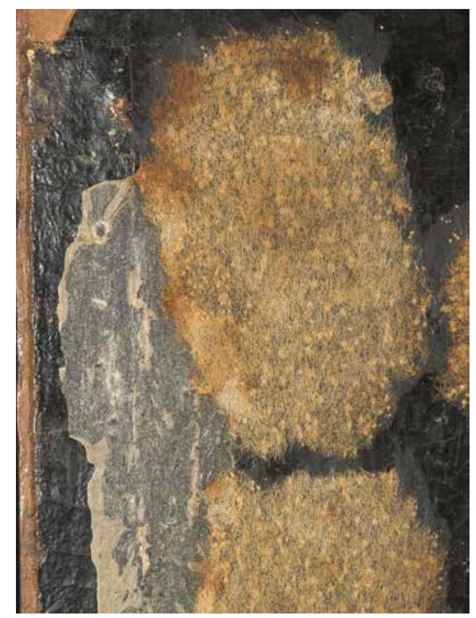

Fig. 14: Several types of paper were used as facing materials over the years. Some of the facings with Japanese tissue paper are noticeably discoloured. Analysis of the binding medium of these protective papers, which had only been applied in the 1980s, has revealed that the browning and crystallisation phenomena stem from the use of honey in the consolidating material.

Japanese tissue paper. The facings covering the whole surface of paintings were usually executed using newsprint. Mixtures of starch paste and glue as well as methylcellulose were probably used as adhesives, most of the facings are still water soluble even today. Some facings however are very difficult to remove at this point, the adhesion being stronger between facing and paint layer than between support and paint layer in some areas. In addition, the papers exhibit partial, sometimes severe discolouration *(fig. 14)*[18] or feeding traces from silverfish.

Due to time constraints, most of these old facings had to be left on the paintings, they were only removed if they seemed to endanger the original or if adhesion was very poor *(figs. 15 and 16)*. The paint layer was then partly consolidated according to need. Mechanical wear had also caused some of the facings to detach along the edges, with parts of the original occasionally adhering to the paper. Since the latter could not be removed without loss to the original material, they were often secured with new facings *(fig. 17)*.

New facings were only applied in exceptional cases, where consolidation of the paint was not possible, if for example the support was too badly damaged or the paint layer extremely embrittled. In those cases, Japanese paper was locally affixed with methylcellulose *(fig. 18)*.

[18] A diploma thesis examined paper facings from the 1980s found on a painting in the Kunsthistorisches Museum's collection. It established that the browning and crystallisation phenomena could be ascribed to the use of honey in the adhesive. (U. Heinisch, *Aus dem Bestand marouflierter Gemälde des Kunsthistorischen Museums Wien: Restauriergeschichte und Behandlungsmöglichkeiten, exemplarisch anhand des Gemäldes* Damenportrait, *Leinwand auf Holz, 53 × 44 cm, nach 1600*, diploma thesis, Academy of Fine Arts Vienna, Vienna, 2007.)

Fig. 15: In some cases, the facings have caused new damages, for example to this painting. Tension in the consolidating adhesive, which has been applied beyond the paper, is pulling up the paint layer and causing cupping (note the arrow).

Fig. 16: Some facings had become almost entirely detached over the years. They were removed completely where possible, and the paint layer partly consolidated.

Fig. 17: Old, strongly bonded facings, which, together with parts of the paint layer, had become detached due to mechanical strains, were re-adhered using new Japanese paper facings.

Fig. 18 a

Fig. 18 b

Detail of a newly applied facing. In order to keep the use of temporary facings to a minimum, where possible, it was not the loose paint flakes themselves that were secured, but merely the areas around them, so that the paper could be removed after transport without causing further damage. If worst came to worst, a detached paint flake would not be lost, but would remain in the paper.

3.2.3 STABILISATION OF THE PAINTING SUPPORT FOR TRANSPORT

A stable or stabilised support is a fundamental prerequisite for damage-free transport. With regards to panel paintings, it was primarily their mounting in the frame which was checked and improved where necessary *(fig. 19)*. Occasionally, individual frame rebates were adapted to the warp of the panel using blocks of Ethafoam that were cut to shape in-situ, as a provisional measure *(fig. 20)*. A few of them received new protective wooden frames, custom-made by the Museum's carpenters and frame makers. Seven particularly fragile panels, which were extremely warped, weakened by former pest infestation, or had been thinned significantly, were brought to the Picture Gallery's conservation studio for the time being, to receive conservation framing which would guarantee solid mounting in the long term.

Many canvas paintings exhibited insufficient tension. In some cases this could be remedied by simple keying out of the stretcher or by replacing missing nails. In some places however, the textile fabrics had ripped – especially at the

Fig. 19 a

Fig. 19 b

The strongly warped panel was mounted in the frame with nails, a stiff attachment that was replaced with flexible fixing plates.

corners and along the tacking edges – or been eaten away by biscuit beetles. Due to time constraints, it was usually not possible to avoid provisional measures: the loose parts of the canvas were sometimes affixed with drawing pins; occasionally areas with large damages were reinforced with strips of Beva-coated canvas *(fig. 21)*, and tears in the canvas stabilised with Beva-coated strips of Holytex applied to the verso *(fig. 22)*.

3.2.4 INSERT LINING AND BACKING BOARDS

Numerous canvas paintings showed inadequate tension despite stabilising measures – for example because of tears, missing tacking margins or unstable frames – and thus insufficient stability for the upcoming transport. In such cases, mounting a backboard and/or insert lining often brought significant improvement. In addition, such measures have a demonstrably positive impact on long-term storage. Kapaplast foamboards were screwed onto the stretchers as backing boards; paintings that were especially at risk additionally received an insert lining made of polyester fleece. The latter was cut and placed between the members of the stretcher, matching their thickness *(see fig. 22)*. Only occasionally was a finer fleece thinned at the sides and pulled through under the stretcher's crossmembers, primarily if those were unbevelled and sharp-edged, and exhibited pronounced splits in the wood. In some cases, the spaces between the stretcher bars were additionally padded with a thicker fleece.

Fig. 20 a

Fig. 20 b

Fig. 20 c

Fig. 20 d

Wooden protective frame with Ethafoam profile that was adapted in situ. The panel has multiple splits, and is under extreme tension from a wooden structure glued to its verso. The eyebolts for hanging were screwed directly into this wooden structure. A wooden protective frame made by the in-house carpenters was fitted with a provisional Ethafoam profile in situ. Following the application of a backing board and flexible mounting with fixing plates, the painting is once again sufficiently stable for transport and storage.


Fig. 21 a

Fig. 21 b

Stabilisation of the painting support using strips of Beva-lined canvas applied to the reverse of a torn area at the edge of the painting, enabling its reattachment using drawing pins.

Fig. 22: Example of a provisional tear-mending with Beva-coated strips of Holytex. By inserting fleece material in the thickness of the stretcher, and mounting Kapaplast foamboard to the painting's verso to prevent vibration, the stability of fragile canvas paintings is further improved.

Fig. 23: Fragile edges were enveloped in tissue paper and protected by polyethylene U-profiles.

Many paintings already possessed insert linings and backing boards as protection against vibration, made of corrugated cardboard inserted into the space between the stretcher members *(see fig. 38 c)*.[19] These were usually left in place, for time and cost reasons, and only replaced in a few instances, if they exerted pressure on the canvas for example.

[19] These preventive measures, like many others, date back to Maria Ranacher's efforts. On this topic, see Maria Ranacher, "Mikroorganismen und Schadinsekten im Depot: Ursachen, Sanierung, Hygiene und Gesundheitsschutz," in *Nicht ausgestellt! Das Depot – der andere Teil der Sammlung. Tagungsbericht vom 9. Bayerischen Museumstag Schweinfurt 9.–11. Juli 1997, Landesstelle für die nichtstaatlichen Museen beim Bayerischen Landesamt für Denkmalpflege*, Munich, 1998, pp. 53–74.

3.2.5 EDGE PROTECTION, PACKING FRAGILE PAINTINGS

Particularly fragile painting edges were enveloped in strips of tissue paper for transport, and fitted with polyethylene U-profiles *(fig. 23)*.[20] Paintings which exhibited a fragile surface overall were wrapped in full *(see fig. 29)*. The wrapping consisted of an inner layer of tissue paper and an outer layer of non-woven fabric made of polypropylene,[21] and was removed upon arrival at the central storage facility.

3.2.6 HANGING FIXTURES AND MOUNTING IN THE FRAME

As standard practice, the manner in which the painting was mounted in its frame was examined and improved where necessary. For example, cork spacers had to be added to two thirds of the framed paintings. To ensure speedy execution of transport and rehanging, the hanging fixtures were already inspected during condition checking, and adapted or replaced where necessary.

4. PACKING

Due to the large number of items as well as the very tight deadline for the relocation, it was not possible to treat the paintings as single objects during packing and transport. It was nonetheless important to make sure they were well secured in their frames, and to safeguard them from mechanical damage and direct environmental influences. As the relocation took place in summer, it was possible to greatly reduce the use of packing materials.[22] Moreover, it was essential that the packing units were prepared before the start of the actual relocation phase, in order to minimise the danger of recontamination of the objects by biscuit beetles.

In order to work in a cost-efficient, resource saving and environmentally sound manner, the aim was also to reuse packing materials several times – they were intended for use during the relocation of paintings as well as other collections. In addition, standardised and commercially available materials were to be employed.

Following several preliminary tests, three standard packing systems were chosen, which could easily be combined for transport:

- Euro-pallets with stacking frames, covered in PE foil;
- Corlette storage racks in two different sizes *(see fig. 31)*, covered in PE foil;
- Individual wrapping (PE foil) of paintings of dimensions surpassing 200 × 260 cm.

[20] Tulip-shaped Nomapak U-profiles by the Moderne Verpackung C. B. Hoffmann company were used, in five different sizes with inner measurements of 15–80 mm.

[21] Heat-spun non-woven polypropylene fabric by the Kreykamp GmbH Technische Vliesstoffe company.

[22] The objects were for the most part just wrapped in PE foil, a more insulating wrapping such as bubble-wrap being unnecessary. The PE foil was mainly intended to provide a physical barrier and a certain mechanical protection, for example against dirt or precipitation, and therefore did not need to be fully sealed. Wrapping was completely dispensed with where possible, including paintings that were stored between sheets of cardboard and were sufficiently protected as well as less fragile frames.

Fig. 24: View of a pallet from above. All intermediate spaces have to be padded, which is very time-consuming, to prevent shifting of the objects during transport.

4.1 STANDARDISED PACKING SOLUTIONS

About half of the objects – and thus, about 1,000 paintings – are in fact small enough to be accommodated in the pallets with their stacking frames (inner measurements of the Euro-pallets: 74 × 114 cm). However, this option was quickly discarded during preliminary tests, as only a comparatively small number of paintings can be accommodated in the pallets, whereas padding them for transport takes a disproportionately long time *(fig. 24)*. Moreover, the filled pallets can only be moved using lifting equipment, which would have impeded handling them in some very narrow storage rooms in Inzersdorf.[23]

The use of Corlette storage racks[24] proved to be much more practical and efficient. Two different sizes were deployed in the relocation: the depth measured 110 cm and the height 160 cm, respectively, and the width – depending on the model – 191 or 261 cm (internal measurements).[25] The smooth wooden flooring is stabilised by a metal frame on three sides, the front side is open. Among the Corlettes' advantages are their great stability, the presence of wheels which significantly facilitate handling, and the fact that they are stackable, which proved to be very important for optimum filling of the anoxic nitrogen tent *(see fig. 31)*.

Polyethylene sheets of 2 cm thickness were used to pad the bottom of the pallets and Corlettes,[26] while the metal frames were covered in polyethylene O-profiles.[27] This provided sufficient padding for the majority of the paintings. Tulip U-profiles (also made of PE) were put on where necessary during packing *(figs. 25 to 27)*. The side walls of the Corlettes were fitted with corrugated cardboard, and the paintings were likewise divided by sheets of cardboard. Size and quantity were calculated in advance, and the cardboard was ordered cut-to-size.[28]

It was possible to fix the paintings very easily and flexibly in the Corlettes, simply by pulling cotton ribbons through one of the hanging fixtures and tying them to the metal frame. However, it was important to ensure that the paintings were in a fully vertical position and closely spaced. Afterwards, the entire stack was tightly secured to the frame using hemp roller-blind belts. Nearly all paintings with a size up to 260 × 200 cm could be transported in this manner. All larger paintings – 157 in total – were individually wrapped in PE foil.

23 Some pallets were used nonetheless, in order to use the space available in the anoxic nitrogen tent to maximum capacity *(see fig. 31)*.
24 Corlette storage racks are usually deployed in furniture storehouses, and were already used in the 2010/11 relocation of the Münchner Stadtmuseum's collections to the new museum storage facility of the regional capital Munich.
25 Corlette® storage rack 2000: external measurements H. 1,800 mm, W. 2,000 mm, D. 1,150 mm; internal measurements: H. 1,610 mm, W. 1,912 mm, D. 1,108 mm. Corlette® storage rack 2700: external measurements H. 1,800 mm, W. 2,700 mm, D. 1,150 mm; internal measurements: H. 1,600 mm, W. 2,612 mm, D. 1,108 mm.
26 The polyethylene-cell/skin-sheets by the Eurofoam company, Kremsmünster, were pre-cut and were inserted with the relatively smooth side facing up.
27 Moderne Verpackung Carl Bernhard Hoffmann GmbH, Jeging.
28 Cutting such a large number of sheets in situ would have been extremely time-consuming and therefore very expensive. It is important to note, however, that a minimum quantity of 300 m² was necessary for some orders of pre-cut cardboard of a certain size.

Fig. 25: Frames were padded with U-profiles in such a way that the fragile ornaments at the corners for example would not be under strain during transport.

Fig. 26: This matte, powdery paint was protected by spacers, so that it would not be abraded during transport.

Fig. 27: In the end only 19 paintings required travel frames for relocation; almost all others were fit for transport in "standard" packing following appropriate preparation. For example with the help of PE wedges, U-profiles and cotton ribbons, round or oval formats too could be accommodated in the standard packing units.

Fig. 28 a

Fig. 28 b
This very warped and unstable painting had to be mounted separately in the travel frame. To this end, Temart T-hooks were screwed into the travel frame, on which the painting was hung by its eyebolts, fixed in place solely with the locknuts, which usually serve as an anti-theft-device. The barcode label affixed to the eyebolt is also visible.

4.2 INDIVIDUAL SOLUTIONS

For about 5 % of paintings, individual solutions had to be found, as relocating them using one of the above-mentioned options would have been too risky or inefficient.

This concerned the following objects:

- two paintings which had been folded down the middle[29] and a winged altarpiece;
- 36 paintings without stretchers, stored between sheets of cardboard;
- 78 paintings on 18 rolls;
- 18 fragile paintings, which had to be stored flat;
- parts and pieces of frames.

Moreover, a few particularly fragile objects were separately mounted into travel frames. This was the case for instance for paintings with very matte, powdery surfaces without frames, or paintings with particularly warped and fragile stretchers or strainers as well as for very elaborately ornamented and delicate frames *(see figs. 25 to 27)*. The manner in which objects were mounted into their travel frames was adapted individually to the work in question. For the most part, Ozclips, Hasenkamp hanging systems, as well as various angle brackets, metal springs and fixing plates, wood and cotton ribbons etc. were used.[30] For lightweight paintings with eyebolts, a system with Temart T-hooks was very convincing.[31] It meant that the painting in question could be hooked into the T-hooks and fixed in place with a locknut, without having to drill any more holes into the object *(fig. 28)*.

29 These were two paintings that have been furnished with hinges in the middle and can be folded for transport and storage. For both of these examples, this seems to be an original feature, and they continue to be stored in this manner.
30 The Kunsttrans company staff improvised very skilfully.
31 This system was suggested by Martin Dorfmann, DP-art company, who was called in as an external coordinator for the relocation.

Fig. 29: All paintings hung on the wire mesh walls were prepared and ready for transport.

Fig. 30: As the next step, the large formats had to be secured standing nearly vertically to the inner walls of the pull-out picture racks for anoxic nitrogen treatment. The back wall and side walls of the tent had already been closed off.

4.3 PACKING MATERIALS

The selection of packing materials was subject to similar requirements as the transportation devices. Here too, safe and smooth transport had to be ensured using resource saving and inexpensive methods. Furthermore, several materials were employed which are less commonly used in a museum context. For example, a polypropylene spunbonded fleece was substituted for the considerably more expensive Tyvek material. A width of 230 instead of 150 cm was also a clear advantage for wrapping especially large-format paintings. Possible disadvantages stemming from the slightly rougher surface were countered by using tissue paper as an intermediary layer. Tyvek was thus only used in exceptional cases. This was the case for the foldable paintings *(see figs. 38 a and 38 b)*, for which the use of tissue paper would not have been sensible, since it would have probably slipped or torn, and the wrapping was to be left in place for future storage.[32]

5. IN SITU ANOXIC NITROGEN TREATMENT AT THE PAINTINGS REPOSITORY

As mentioned above, all objects had to be disinfested directly preceding transport, to minimise the danger of recontamination as far as possible – an immense undertaking for nearly 3,000 objects. The first treatment cycle included about 1,500 paintings and 500 frames and was to start in mid-June, in order to ensure the start of the relocation as planned. This entailed that between February and mid-June, an average of 20 paintings had to be treated and prepared for transport per day.

[32] The following materials were used as standard: fleece for insert lining Thermoelastic Synth. (Belousek company, AT Vienna), backing boards made from Kapaplast foamboards (Kohlschein company, DE Viersen), tissue paper on rolls (Japico company, AT Vienna), Tyvek (Deffner & Johann GmbH, DE Röthlein), polypropylene spunbonded fleece (Kreykamp GmbH, DE Nettetal), tulip U-profiles made from PE, O-profiles made from PE (Moderne Verpackung Carl Bernhard Hoffmann GmbH, AT Jeging), pre-cut corrugated cardboard (Moderne Verpackung Carl Bernhard Hoffmann GmbH, AT Jeging), stretch-foil (Rajapack Austria GmbH, AT Wiener Neudorf), cotton ribbons (Belousek company, AT Vienna).

Fig. 31: A view of the fully loaded pull-out picture racks in room 1 of the former storage facility in Inzersdorf prior to anoxic nitrogen treatment. The storage system was filled with paintings ready for transport *(see fig. 29)*. In the middle aisle of the pull-out picture racks, the large formats were tied to the wire mesh walls standing in a nearly vertical position, the space in between was filled with Corlettes stacked one on top of the other. There was also space for a few stacked Euro-pallets with stacking frames in front of the storage racks.

Fig. 32: View of the painting storage 1 at the old Inzersdorf facility shortly before the beginning of anoxic nitrogen treatment. The left hand side of the picture shows how the special foil, which at the back and sides has already been heat-sealed and adhered to the floor, is now being closed at the front as well for anoxic nitrogen treatment.

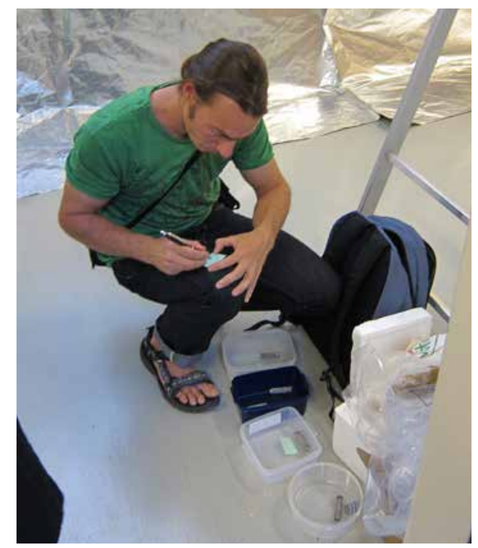

Fig. 33 a

In order to fit as many paintings as possible into the nitrogen tent and to make sure the relocation that was to follow could be implemented in a time-saving manner, all paintings on the large pull-out picture rack system in room 1 were firstly prepared for transport, including edge protection and wrapping where necessary, and then rehung *(fig. 29)*. The empty spaces between them on the wire mesh walls were also filled and the racks lashed to one another, so that they could no longer be moved. The next step was tying the paintings that were stored between sheets of cardboard and wooden poles, as well as some of the large frames, to the exterior of the rack system, while the large-format paintings were leaned sideways against the wire mesh walls and likewise fixed in place in its middle aisle *(fig. 30)*. The stacked-up Corlettes were then moved into the empty space in between. Finally, pallets with stacking frames were stacked on top of each other in front of the pull-out picture rack system, and the measuring instruments, connected to air humidifier, radiator and ventilator by the Singer company, as well as reference blocks with insects, to verify the anoxic nitrogen treatment's effectiveness, were accommodated in the tent. The tent having been filled to optimum capacity, the special foil, which had already been sealed at the back and the sides, was now adhered together at the front as well *(figs. 31 to 33)*.

Fig. 33 b

Following the placement by Pascal Querner of test insects inside the tent to verify its effectiveness, the tent was closed off and flooded with nitrogen.

6. RELOCATION, REHANGING AT THE CENTRAL STORAGE FACILITY

The anoxic nitrogen tent was only opened on the 16th of August 2011, when the relocation began. Firstly, the 18 pallets and 28 Corlettes were cleared out. Having been checked briefly and the lashings tightened where necessary, they could be relocated without needing any further work except covering in PE foil, and, in some cases, securing with shrink wrap *(fig. 34)*.[33] Paintings stored between sheets of cardboard and large frames were transported without additional wrapping, while large-format paintings were wrapped in PE foil as mentioned before *(fig. 35)*. Within just a few days, the pull-out picture rack system was freely accessible once again. This marked the beginning of the logistically much more complex and time-consuming part of the relocation, as the paintings hanging on the racks were to be pre-sorted before transport.

As has been explained before, all wire mesh walls were perfectly prepared before the relocation began, and had been visualised as wall-diagrams with the accompanying lists and location tracking *(fig. 36 a)*.

For the relocation, the paintings were packed in groups according to these new diagrams, and brought to the new storage facility. Having arrived there, it was possible to hang them very rapidly, despite the extraordinarily large size of the pull-out picture racks, measuring 500 × 800 cm *(fig. 36 b)*. In the old as well as in the new storage location, the paintings were moved in cooperation with Kunsttrans company staff under the paintings conservators' guidance.

Fig. 34: Unloading of the Corlettes filled with paintings at the central storage facility.

Fig. 35: The individually wrapped large-format paintings in PE foil were directly hung on their respective wire mesh walls after unpacking at the central storage facility.

[33] Only especially fragile objects or particularly bad weather conditions necessitated the PE foil to be fixed in place and sealed by shrink wrap. The latter has the advantage of being self-adhesive and thus easy to apply, and the PE foil can be reused afterwards.

Fig. 36 a: With the help of the *GalleryCreator* programme, each wall was meticulously planned and visualised in its respective wall scheme prior to the relocation.

Fig. 36 b: Implementation of the planned new hanging scheme on the respective wire mesh walls at the central storage facility.

Fig. 37: This very fragile yet heavy winged altarpiece received a custom-made wooden frame structure. The altar was fitted in the case with Ethafoam board, elaborately wrapped in Tyvek and tissue paper.

6.1 SPECIAL FORMATS

For a total of three objects, customised wooden structures were built, which would be retained for improved future storage of the object. This concerned a winged altarpiece, which was extremely fragile due to its size, with the original hinges still in place, and had been weakened by wood worm infestation in the past, but, at approximately 100 kg, was also extremely heavy and unwieldy. The custom-made transport crate was padded accordingly, and equipped with handles for transport *(fig. 37)*. At the storage facility, a polypropylene spunbonded fabric was added as additional protection against dust.

The second custom-made wooden structure was manufactured for a painting measuring 665 cm length and 195 cm in height, with a semi-oval top, which was originally folded in the middle. Since the painting and auxiliary support had obviously become deformed, it was no longer possible to fully unfold it and thus to hang it on one of the wire mesh walls *(figs. 38 a and 38 b)*. A stable wooden construction, again equipped with handles, served to protect the painting during transport and continues to stabilise it in storage *(fig. 38 c)*, where it now rests on special metal support elements on the pull-out picture racks.

A massive panel painting by Garofalo, measuring 325 × 190 cm, was likewise too unstable for transport. The wooden panel was under strain and weakened by former wood worm infestation. In addition, it had to be tilted onto its long side for transport, which – especially due to its size and weight – would not have been possible without further stabilisation of the existing, rather thin and insufficiently sturdy frame. The panel thus received an additional wooden frame and was fitted with screwed-on wooden panels[34] *(fig. 39)*.

[34] Following the anoxic nitrogen treatment the panel was brought directly to the KHM, where it has undergone extensive conservation treatment by Ingrid Hopfner.

Fig. 38 a

Fig. 38 b

Fig. 38 c

This semi-oval painting with a total length of 665 cm, originally folded in the middle, could no longer be fully unfolded, and was therefore fitted in a custom-made wooden structure for transport and subsequent storage. It was wrapped in Tyvek to protect the paint layer. The vibration protection and backing made from corrugated cardboard fitted in between the stretcher members was left in place.

Fig. 39 a

Fig. 39 b

This large and very heavy panel painting by Garofalo also had to be fitted into a frame structure reinforced by wooden boards.

6.2 LARGE-FORMAT PAINTINGS

The large-format paintings presented a special challenge. The 25 largest paintings had been stacked against the walls since the collection had moved to the Inzersdorf facility, and had thus not been condition checked for quite some time *(see fig. 1)*. In preparation for the imminent relocation, they were placed in the more spacious storage area of the Collection of Greek and Roman Antiquities in three stages, and promptly treated *(fig. 40)*. Unconventional solutions had to be found for transport of the very largest formats, as the trucks have a maximum loading height of 275 cm, the jumbo trailers a height of 310 cm, and even the particularly high tandem trailer, with a recess inserted between the wheel base, only has maximum diagonal dimensions of 386 cm *(fig. 41)*. For the eight largest formats, the relocation team leased a scenery truck with a height of 325 cm from the Art for Art company, which works for the Bühnen Wien amongst others. The largest formats of 4 m however still only fit in diagonally, so that they had to be secured with loading straps and padded wooden boards, which were bolted to the floor, for safe transport *(fig. 42)*.

Fig. 40 a

Fig. 40 b

All large-format paintings were condition checked and treated in the storage area of the Collection of Greek and Roman Antiquities. The largest painting with a height of nearly four metres only fit through the door of the painting repository when tilted diagonally.

Fig. 41: This special tandem trailer from the Kunsttrans company has a maximum diagonal of 386 cm, due to a lowered loading space inserted between the wheel base.

Fig. 42: In spite of this, an Art for Art scenery truck had to be leased in order to relocate the eight largest paintings, measuring up to 400 cm in height.

Fig. 43: The heads of all painting rolls were replaced. To this end, the rolls were rested on PP sacks filled with polystyrene granules. Custom-made metal stands were produced for storage at the new facility.

Fig. 44: Crossbars were fitted in the truck for the shipment of the very fragile painting rolls, which were strapped to them individually and at a distance from one another. Polystyrene-filled PP sacks were placed immediately below the rolls for additional protection.

Fig. 45: One of the rolls did in fact break during transport. Thanks to the foresightful manner of transport however no further damage was incurred.

Fig. 46: The painting roll could nonetheless not be repaired and was unrolled at the central storage facility's workshops. A total of 15 mostly small-format paintings was stored on it, which are currently accommodated in their unrolled state in a flat file cabinet of the Collection of Historic Musical Instruments. Two to four paintings respectively are stored on top of one another, protected by sheets of tissue paper.

6.3 PAINTINGS WITHOUT STRETCHERS

The paintings without stretchers, which were stored between sheets of cardboard, were lashed to the board wall of the truck for transport, much like the other large formats. With the wooden poles mounted to both sides, these paintings have a total depth of 20 cm. In order to be able to hang them on the new storage facility's wire mesh walls, extra wide intermediate spaces were planned between some of the racks. The paintings were placed on individually mounted metal support elements and strapped to the wire mesh wall *(see figs. 3 and 8)*.

6.4 PAINTINGS ON ROLLS

Another special case was presented by the paintings stored on 18 rolls, which exhibited very diverse types of construction. They included massive tree trunks, tubes made from wooden planks nailed together, and cardboard tubes. Diameter and weight of the rolls also differed considerably. While some of them still appeared stable, others were already broken at the ends *(see fig. 7)*.

"Unrolling" the 78, mostly large-sized paintings would have entailed elaborate conservation measures. As had been the case during previous relocations, wholesale treatment was unfortunately not possible due to time constraints. A decision was therefore made only to improve the stability of the rolls as well as their future storage at the new centralised facility. To this end, all rolls were inspected by the in-house carpenters and metalworkers, and modified in such a way that could be hooked into three custom-made metal stands at the new storage facility. All the rolls' heads were fitted with stable, newly glued-on and bolted wooden disks with round metal bars. These were selected in such a way that two uniform lengths were achieved *(fig. 43)*. The largest roll with a length of 600 cm was treated separately and now rests on a custom-made wooden structure.

Since only the heads rather than the entire rolls could be renewed however, transporting them directly on their metal rack was deemed too risky. It was feared that the rolls might break in other places. As a compromise, they were fixed separately to crossbars which were secured in the truck for transport. The crossbars were mounted as far down as possible, and the underside of the rolls additionally padded with PP sacks filled with polystyrene granules *(fig. 44)*.

Despite all precautionary measures, one of the painting rolls broke during the last roll-shipment. The paintings incurred no further damage however, due to the preparatory work. The roll in question was not remounted, but opened in

Fig. 47 a: Former frame repository in the Neue Burg (repository of the Weltmuseum Wien) with very dirty, partly loosely stored frame parts.

Fig. 47 b: Storage at the repository for display cases in Inzersdorf.

Fig. 48 a

Fig. 48 b

Numerous fragments and pieces of picture frames stored in several boxes. These were also cleaned, photographed and packed in groups.

the new central storage facility's workshops *(fig. 45)*. It was revealed that a total of 15 rather small-scale paintings had been rolled up on top of each other. They were temporarily stored flat in a flat file cabinet of the Collection of Historic Musical Instruments *(fig. 46)*. Two paintings from the broken roll were brought to the KHM's painting conservation studio for further treatment.

7. FRAME STORAGE

Unlike the paintings, the picture frames in storage were not inventoried and documented. The largest part, mostly "gallery frames"[35] or simple wooden frames, were stored on shelves. More elaborate, i.e. more valuable frames were hung on wire mesh walls. About 170 to 200 picture frames had only been brought to the Inzersdorf facility in 2009, including some very large and heavy parts of frames, which were disassembled and stored in no particular order *(fig. 47)*. Finally, there were numerous cardboard boxes with miscellaneous individual parts and frame fragments as well as several old stretchers and strainers *(fig. 48)*.

The condition of the frames varied greatly. Some were in very good condition and well looked-after, while others were unstable, often the surface coating was loose or pieces were missing. Especially the frames and fragments which had been brought in in 2009 were extremely dirty.

[35] The term "gallery frame" denotes a uniform Josephinian frame profile, with which the entire collection was framed for the refurnishing of the Upper Belvedere's Picture Gallery.

All frames were cleaned using vacuum cleaners, brushes and cloths *(fig. 49)*, occasionally they were stabilised by screwing on wooden boards, metal strips and angle brackets as well as by applying cotton ribbons. In some cases, the surface had to be consolidated and secured. Two very large and elaborately ornamented frames required extensive consolidation before they could be cleaned, as the surface coating was held together primarily by the accretions of dirt and mould growth *(fig. 50)*.

The individual frame members were sorted into groups and secured in the three respective pallets, custom-made by the in-house carpentry workshop, for transport and storage *(fig. 51)*. The fragments, too, were cleaned and sorted. Related groups were assigned numbers, photographed and wrapped individually, before being accommodated in two pallets with stacking frames, stacked one on top of the other *(see fig. 48 b)*.

At the new central storage facility, it was finally possible to accommodate about 600 frames, in particular the ornamented and fragile specimens, on the wire mesh pull-out picture racks. The remaining 230 frames with smooth edges – including numerous gallery frames – were arranged vertically on shelves. In addition, all picture frames were inventoried and provided with barcode labels. They were measured in detail; information about technique and condition was fed into an Access database. All labels and inscriptions, found mostly on the verso, were also recorded. In the meantime, all the data and photographs have been transferred to the museum's own database.

Altogether, it took just four weeks to move more than 2,000 of the Picture Gallery's objects, including the very time-consuming large formats, from Inzersdorf to the new centralised facility in c. 70 shipments, and hang them. The logistics of the relocation were coordinated by an external supervisor from the DP-art company, Martin Dorfmann, in close cooperation with the relocation team, as holdings from other collections of the KHM (for example those of the Collection of Greek and Roman Antiquities) were moved parallel to the painting shipments. The Picture Gallery's remaining objects were relocated in just three days at the end of November, so that the old repository could be handed over according to schedule by the end of 2011.[36]

Fig. 49: All picture frames were cleaned.

Fig. 50 a

Fig. 50 b

Fig. 50 c

Two large frames had to be extensively consolidated, as large parts of the surface coating were severely loosened and only held together by former mould growth and dirt accretions. Cleaning without prior consolidation was not feasible.

Fig. 51: The individual frame members were sorted and securely fastened onto specially custom-made pallets for transport and subsequent storage.

36 Due to the seasonal poor weather conditions, the last shipment was carried out using only small trucks, which could be driven into the by now largely empty storage facility for loading.

8. OUTLOOK

The accommodation of objects at the central storage facility ensures adequate conservation standards – also for those holdings which are not displayed to the public – for the first time. By building the facility outside of Vienna, a more generous spatial solution was possible, albeit also resulting in an increase in transport volume.[37] Building a system of transportation that is compatible with conservation standards is therefore of central importance.

Monitoring pest insects is deemed to be especially important. A more detailed pest infestation survey is being developed, which is intended to enable the precise localisation of problem cases and more frequent monitoring of the situation. In addition, all canvas paintings stored on rolls or between sheets of cardboard are to be surveyed, conserved and individually stretched, so that they too shall be safe and accessible for the long term.

Upholding the high standard of the new system will present a great challenge in general. This will require good collaboration first and foremost between all the collections housed at the central storage facility as well as continued and collegial support for the storage facility management working in situ.

Due to the new arrangement, all paintings are freely accessible and visible for the first time. This provides a basis for the preservation, for further varied necessary conservation work and for the art historical analysis of this large collection. Many possibilities have arisen, since, to return to the beginning of this article: a storage facility is not a "final destination," but a fund for the future.

[37] In 2012 for example, 28 paintings had to be transported to and 41 paintings from the storage facility.

SUMMARY

Mid-2011 saw the completion of a new building at the edge of Vienna to group the substantial storage holdings of the KHM and the Theatre Museum in a centralised facility. The dissolution of one of the Kunsthistorisches Museum's former external repositories affected around 2,000 paintings and 800 frames from the Picture Gallery. These had to be transferred within a few weeks to the new facility. The move was complicated by an acute insect infestation that necessitated the nitrogen treatment of all of the objects. For this, all of the paintings storage racks were wrapped and the contents fumigated in a nearly 1,000 m³ anoxic nitrogen tent.

To facilitate the move, the objects were documented, remedially treated, and prepared for transport over a six month period by a team including restorers from the department and external collaborators. The most commonly executed interventions are presented here on the basis of selected examples. Conservation treatments required for the transport are discussed, as are provisional preventive measures, but also methods for the lasting improvement of the storage situation. Handling, logistics, and transport are discussed, as are innovative and resource-saving packing solutions. Additionally, individual solutions for objects with special requirements are singled out, for example the move of large-format works with dimensions of up to 4 × 6 m, or a group of rolled paintings.

Concurrent with the move, a new location tracking system using barcode labels was introduced. All of the frames were also documented, photographed, and their locations recorded for the first time; they are now likewise digitally documented.

ZUSAMMENFASSUNG

Mitte 2011 konnte ein Neubau am Stadtrand Wiens bezogen werden, welcher die umfangreichen Depotbestände des KHM und TM in einem Zentraldepot zusammenfasst. Die Auflösung eines der ehemaligen Außendepots des Kunsthistorischen Museums betraf unter anderem ca. 2.000 Gemälde und rund 800 Zierrahmen der Gemäldegalerie. Diese mussten innerhalb weniger Wochen in das neue Zentraldepot überführt werden. Erschwerend kam ein akuter Schädlingsbefall hinzu, welcher eine Stickstoffbehandlung sämtlicher Objekte notwendig machte. Hierfür wurde die gesamte Gemäldezuganlage eingehaust und in einem fast 1.000 m³ umfassenden Stickstoffzelt behandelt.

Für einen reibungslosen Ablauf der Übersiedelung wurden die Objekte ein halbes Jahr lang mit einem Team von Sammlungsrestauratoren und externen Mitarbeitern dokumentiert, gepflegt und für den Transport vorbereitet. Anhand ausgewählter Beispiele werden die am häufigsten durchgeführten Maßnahmen exemplarisch dargestellt. Für den Transport zwingend notwendige konservatorische Maßnahmen werden ebenso angesprochen wie provisorische Sicherungsmaßnahmen, aber auch Methoden zur dauerhaften Verbesserung der Depotsituation. Neben innovativen und ressourcenschonenden Verpackungslösungen werden Handling, Logistik und Transport thematisiert. Darüber hinaus sollen Einzellösungen für Objekte mit außergewöhnlichen Ansprüchen herausgegriffen werden, wie beispielsweise die Übersiedelung von Großformaten mit Dimensionen von bis zu 4 × 6 m oder eines Konvoluts aufgerollter Gemälde.

Zeitgleich mit der Übersiedelung konnte zudem ein neues Standorterfassungssystem mittels Barcode-Etiketten eingeführt werden. Auch wurden alle Zierrahmen erstmalig dokumentiert, fotografiert und verstandortet; sie sind nun ebenfalls digital erfasst.

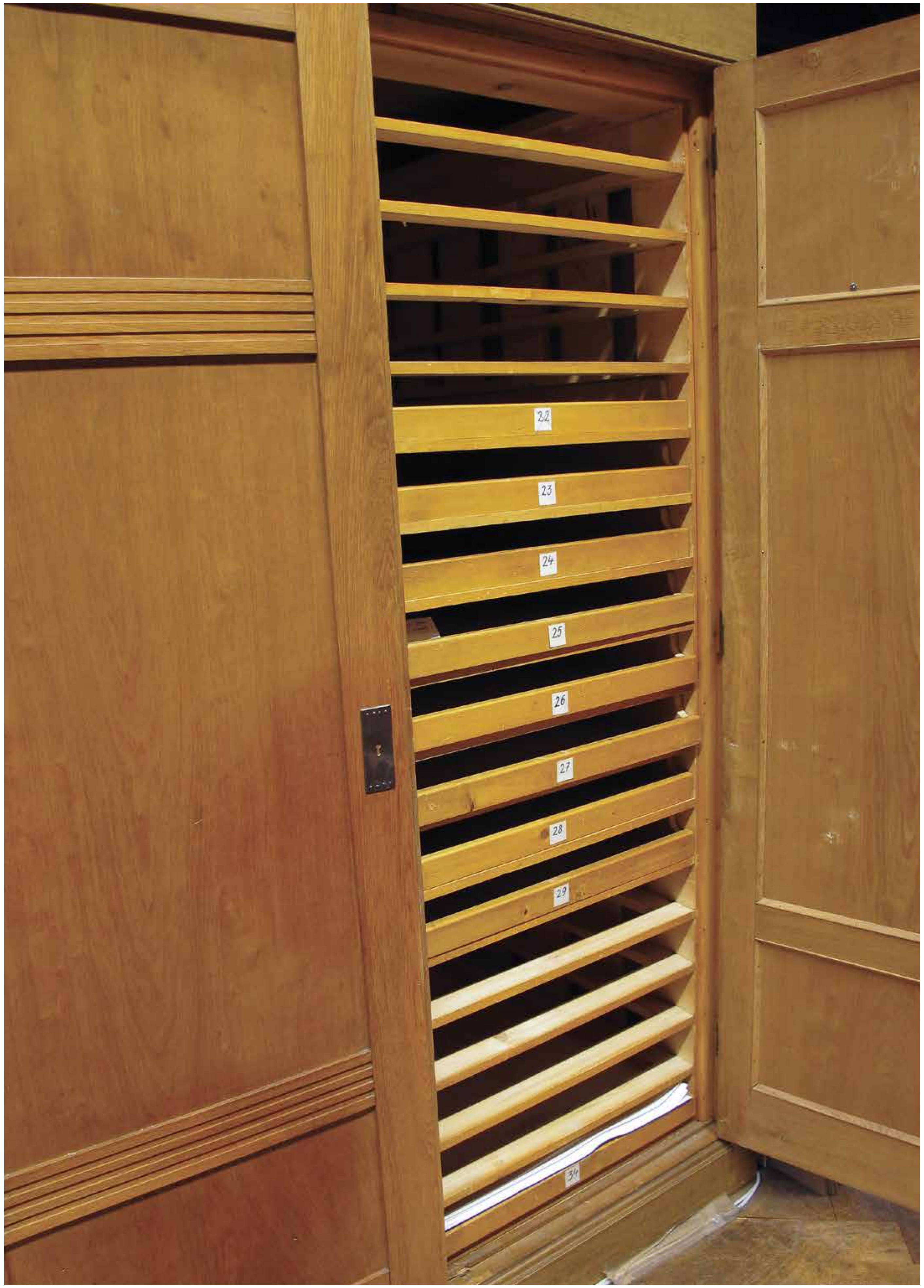

Fig. 1: Oak cabinet with drawers.

Relocation of Selected Category Groups from the Coin Collection to the New Central Storage Facility in Himberg, in particular, the Collection of Primitive Money

Nora Gasser, Sabine Imp and René Traum

Translated from the German by Aimée Ducey-Gessner

1. INTRODUCTION

René Traum

The Coin Collection of the Kunsthistorisches Museum Vienna possesses a significant and substantial collection of orders and seals. These highly sensitive objects, composed of many diverse materials (enamel, gemstones, textiles, wood, stone, horn, etc.), were housed until now in the rooms of the Coin Collection. They were selected for storage in the new central storage facility in Himberg where the climate conditions are much better. The wax models made by the well-known medallist Anton Scharff constitute another significant collection that was also prepared for storage in the new facility, but whose relocation took place at a later date.

During a two-year period, the Coin Collection, in collaboration with the company Schneider, designed coin cabinets made out of materials that had been tested by the Conservation Science Department for pollutants and approved for use. These cabinets had already been successfully installed in the Coin Collection and could be adapted for storage of the sensitive objects in the Himberg storage facility.

At first, nitrogen cabinets were selected for the storage of the wax models that were threatened by corrosion processes, however, the purchase had to be delayed for budgetary reasons to a later date. A dedicated climate box, in which the required climate parameters of max. 40 %rH and max. 20 °C can be permanently maintained, was installed inside the storage facility for the selected objects from the Coin Collection.

It was possible for the relocation team and the staff of the Coin Collection to move the orders, seals, and primitive money in only ten days with the help of two external conservators and a four person team from the art transport company Kunsttrans.

At this time we wish to express our sincere gratitude to the museum's management for their commitment and support, along with all persons who collaborated on this project.

2. PROCESSING AND RELOCATION OF THE COLLECTION

Sabine Imp and Nora Gasser

2.1 SELECTION OF THE GROUPS OF OBJECTS FOR RELOCATION

Orders, seals, medals, models and primitive money, balances with coin weights and coin vessels were classified and stored in wooden cabinets on the second floor of the Kunsthistorisches Museum Vienna. A few balances and large plaster figures from the 18th century were in part stored on top of the cabinets due to lack of space; some of the plaster reliefs were hung on the walls. Space was found in the "Austrian Mint" for another group of large plaster objects.

2.2 AVAILABLE SPACE FOR STORAGE, CLIMATE, DUST, AND THE IMPACT OF POLLUTANTS

Along with space issues, which an abundance of stored collections creates over time, other complex situations subsequently came to light that required the move of the selected groups of objects and materials to the controlled atmosphere of the storage facility. Appropriate storage is crucial for the preservation of art and cultural heritage. Damage can be reduced and prevented at the outset through adjustment of the environment to fit object specific needs and by eliminating potentially damaging conditions.

The climate is an essential aspect of preservation. The structural conditions of the rooms on the top floor of the KHM and the double windows, whose wooden frames had been sealed only one year earlier, cause considerable climatic fluctuations. Especially during the summer months, the rooms, without air conditioning, heat up unchecked, impacting the storage cabinets and their contents. These temperature and humidity fluctuations can effect changes in materials that damage the substance of the objects. The sensitive wax models and the multiplicity of different materials found in orders, badges of honour and seals, are particularly complex. These objects, which consist primarily of copper alloys or iron (which alone require low atmospheric humidity), often comprise minerals or organic materials as well. It should also be remembered that enamel, which often forms a part of orders and badges of honour, is extremely sensitive to climatic fluctuations.

Dimensional changes caused by climatic conditions can have dire effects because of the differing expansion behaviour of diverse materials. Damage to the enamelled orders and wax models had already occurred due to this phenomenon.

The old oak cabinets and drawers are very problematic for the condition of the objects stored inside of them because they release compounds that are damaging to materials *(fig. 1)*. Wood[1] is in general a problematic material for the storage of objects because it releases acidic degradation products for many years. Oak is especially acidic,[2] strongly attacking stored materials and damaging them: its use should be scrutinised particularly critically.

Dust contamination inside the cabinet is also aggravated by climate-induced deformation of the wood and its constant dimensional response (expansion and contraction). The objects frequently lay in open boxes in the drawers, where they were exposed to the dust and degradation products of the wood.

1 H. Weber, *Bestandserhaltung in Archiven und Bibliotheken,* Stuttgart, 1992.
2 J. Tétreault, *Guidelines for Selecting Materials for Exhibit, Storage and Transportation (CCI-Publications),* Ottawa, Ontario, 1993.

Fig. 2 a: Wooden drawer with black trays.

Fig. 2 b: Modern electrotypes stored in the black trays.

Some of the storage materials and boxes already in use that served as dust protection or for the separation and classification of individual objects had to be tested for their archival suitability. Damaging degradation products can split off of the diverse kinds of paper, cardboard, synthetic packing materials, and various adhesive materials and tapes, which have often already aged, posing a hazard directly on or next to the objects. Cardboard trays lined with shiny black paper in the drawers were of particular concern, in which the majority of delicate objects like orders, medals, seals, electrotypes, and primitive money were stored. Many of these objects were packed individually *(fig. 2)*.

The Conservation Science Department subjected the cardboard trays to an Oddy-test to check for the release of degradation products that were incompatible with the objects. The test confirmed the damaging effects of the "black trays". They had to be removed as quickly as possible from the objects' surroundings.

2.3 NEW STORAGE SETTING IN HIMBERG

A design concept was created for the storage of the selected objects from the Coin Collection in the new central storage facility, with the following essential prerequisites:

- climate regulation;
- replacement of wooden cabinets with metal cabinets;
- removal of inappropriate storage materials and replacement with archival materials.

Fig. 3: The new metal cabinets in the Himberg storage facility.

A compromise solution was required for establishing the new climate parameters that had to meet the demands of different groups of objects. The diversity of materials requires first and foremost constant climate values. The large number of metal objects and components composed of copper alloys and iron, both very sensitive to humidity, necessitated a maximum relative humidity of 40 %rH with a maximum room temperature of 20 °C.

2.3.1 CONSTANT CLIMATE VALUES IN A "CLIMATE BOX"

A separately installed room in a spacious storage facility, the so-called "climate box," provides an area segregated from the rest of the stored objects originating from other collections of the KHM that require higher atmospheric humidity during long-term storage due to their often purely organic combination of materials.

The limited spatial volume of the "climate box" and its low ceiling height of barely 2 meters allow it to maintain constant low levels of relative humidity in an energy-efficient way.

2.3.2 PREVENTION OF DUST CONTAMINATION

Separated from the main storage areas and equipped with its own air filtration system, the "climate box" has additional, increased protection from dust and the influx of pollutants. Despite, or exactly because of this closed air system, monitoring for potentially hazardous conditions should occur.

Special archival steel cabinets were made for the housing of the objects. The solid, welded construction from pure stainless steel dispensed with materials that could release degradation products. Neither lubricants nor rubber joins were used. The exterior walls are powder coated in order to avoid the solvent evaporation associated with common paints *(fig. 3)*.

Fig. 4 a

Fig. 4 b

Examples of the collection of primitive money.

2.3.3 PREVENTION OF POLLUTANTS

Storage materials and supports for the objects were reduced to the absolutely necessary. Only acid-free and adhesive-free archival materials were to be used;[3] folding paper trays without adhesive, customised folding storage boxes made of fine flute corrugated cardboard and three sizes of paper trays for the drawers are available for the storage of the small, individual objects and their classification; they also protect them from mechanical stress during movement of the drawer. In individual cases, Ethafoam supports and tissue paper interlayers provide increased protection of the objects.

2.4 PREPARATION OF THE PRIMITIVE MONEY FOR THE MOVE TO THE NEW STORAGE FACILITY

The collection of primitive money in the Coin Collection comprises more than 400 individual objects made of organic and inorganic materials *(fig. 4)*. One-third of the primitive money is composed of organic materials like wood, textiles, plant fibres, shells, beads, and animal-based products (bones, teeth, skin). There are occasionally instances of chains of human phalanges and teeth. There are a lot of mixed media objects made of organic and inorganic materials, like objects comprised of iron with plant fibres. The remaining two-thirds of the collection consists of metal objects, electrotyped reproductions and plaster casts. The size of the objects varies greatly and extends from lead balls only 5 mm in diameter to spears 1.5 meters long.

All objects were stored for many years in the unsuitable old oak cabinets. Not a single object possessed appropriate storage materials and in some cases, dedicated storage materials were completely absent. Often, the objects lay loose in black cardboard trays made of strongly acidic materials.

3 From the supply companies Schneider and Schempp.

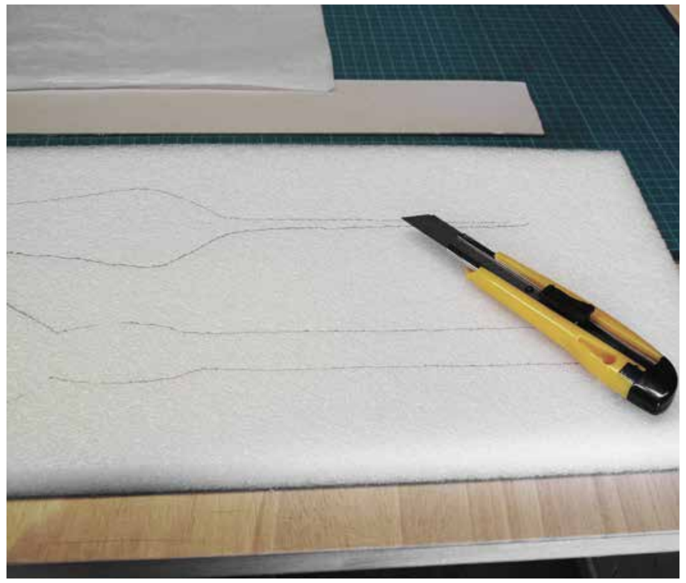

Fig. 5 a

Fig. 5 b

Preparation of the custom-fit blocks of Ethafoam for the packing of two spears, carved to the shape of the objects and lined with tissue paper.

During the relocation to the new storage facility in Himberg, it was absolutely essential to inspect the collection and to check the objects for any existing pest infestations and conservation needs. As it turned out, some organic and mixed media objects suffered from an acute pest infestation and had to be urgently treated separately in order to avoid bringing it into the new storage facility and to prevent as a consequence the infestation of other objects.

2.4.1 CONSERVATION TREATMENT

Since the majority of objects were very soiled due to many years of storage in unsuitable circumstances, a preliminary cleaning was carried out first. Dry cleaning of the surface of all objects was undertaken with latex sponges, microfiber cloths, and soft brushes. A more thorough surface cleaning at a later time is urgently recommended.

Next transport boxes made of acid-free fine flute corrugated cardboard of differing sizes were prepared. Ethafoam and tissue paper were used to pack the small objects in the boxes, some of which were very fragile, so that they could be moved and transported without danger. Nevertheless, in such cases, it is important to ensure that mechanical stresses, like impacts or uneven packing of delicate objects, are minimised or avoided altogether *(fig. 5)*. In addition, it was possible to store the objects in the new storage facility in their new packing materials.

Special emphasis was placed on the procurement of age resistant materials in archival quality (they had to be free of acid-forming components, buffered, with neutral glue). The objects were stored lying flat in order to prevent further mechanical damage. Additional space was built into the new storage packaging, taking into account the possible change in size of the objects due to climatic fluctuations.

Organic objects and objects with acute pest infestation were sealed additionally in plastic film bags that were subsequently filled with nitrogen gas. Care was taken to treat objects with iron and organic materials at 45 %rH and purely organic objects at 50 – 55 %rH. Oxygen absorbers were also used in order to keep the remaining oxygen content at a minimum and at the same time to

Fig. 6 a

Fig. 6 b

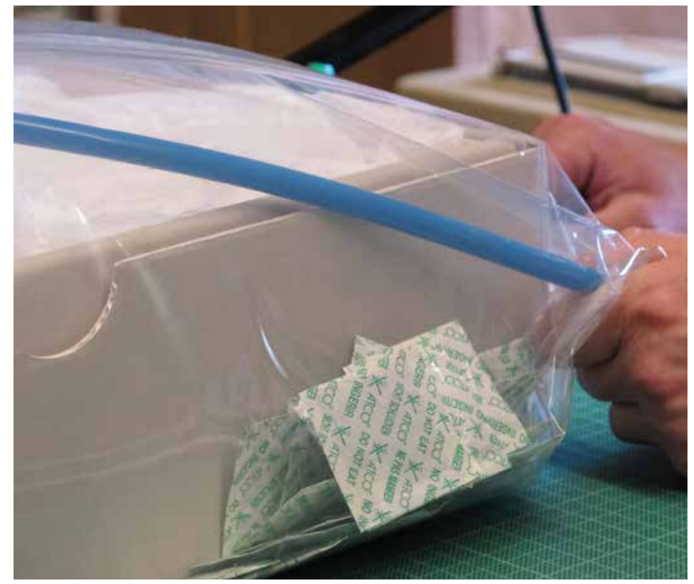

Fig. 6 c

Fig. 6 d

The procedures for sealing storage containers and treating objects with nitrogen gas with the addition of oxygen absorbers and indicators.

deter corrosion processes in iron and to asphyxiate aerobic microorganisms. Inclusion of oxygen indicators enabled quick assessment of the practically oxygen-free environment inside of the boxes *(fig. 6)*. The objects remained enclosed in the plastic wrapping during the move and for at least another 6 months afterwards in order to ensure that all pests had been exterminated. For the long-term preservation of the collection, it is imperative to conduct regular inspections and monitoring for new pest infestations.

Since this group of objects is comprised of a multiplicity of different materials, a compromise had to be found for the execution of preventive conservation measures, storage, and for handling and monitoring, which would take into consideration optimal storage conditions for each individual material.

Identification of the newly packed units and documentation of the treated objects was achieved by classification into the following material groups/subsections. Sections 1, 2, 3, 6 and 7 comprise organic objects:

- Section 1: primitive money;
- Section 2: primitive money: textiles;
- Section 3: primitive money: shells, beads;
- Section 4: primitive money: metals;
- Section 5: silver bars, modern electrotyped reproductions and plaster casts;
- Section 6: wood;
- Section 7: sundry objects.

Detailed summary lists were also compiled *(table 1)*.

The following information is captured in the summary lists: the designation corresponding to the 7 subsections/object groups, the total count of objects in the box and their inventory numbers, the number of boxes and the count of objects contained in each one along with further information about packing materials, conservation measures (treatment for pest infestation) and storage. Each of the larger packed units/boxes has a detailed list of the objects in it, including subsection, inventory number, etc.

2.5 GENERAL PACKING PROCEDURES

The existing arrangement of the majority of small objects that were stored in wooden drawers had one advantage: the drawers could be removed from the cabinets with the objects in place and serve as stable transport boxes for the move.

For the most part, the individual objects had each been placed in a cardboard tray and identified by an underlying inventory card. Larger sized objects were sometimes in two cardboard trays. These trays were placed next to one another in the drawers in rows. This pre-existing separation of the individual objects saved a substantial amount of time and materials during packing. A piece of Tyvek was used to cover and protect the objects' surfaces in the open drawers. Finally, stabilisation against sliding and impact during transport was secured with air cushions and pieces of Ethafoam cut to fit exactly into the empty spaces in the drawers *(fig. 7)*. Up to 7 drawers could be stacked on a transport pallet *(fig. 8)*.

The pre-existing organisation of the drawers spared time-consuming individual wrapping of the objects and additional labelling for the transport phase. The original locations in each drawer could be transferred and used during unpacking and for the new storage location, allowing for rapid location of the objects after completion of the move.

Table 1: Tabular summary list of the packed collection of primitive money.

Subsection	Total objects	No. of boxes	Box no.	Objects per box	Sealed/ nitrogen treatment	Relative humidity	Object nos., inventory nos.
Section 1: Primitive money	11	2	Box 1	4	yes	50–55 %	1, 7, N247, obj. w/o no.
			Box 2	7	yes	50–55 %	2, 3, 4, 5, 9, 10, N247
Section 2: Primitive money – textiles	9	2	Box 1	6	yes	50–55 %	2, 3, 4, 5, 7, 8
			Box 2	3	yes	50–55 %	1, 6, N3

Fig. 7: The drawers were stabilised with Tyvek and Ethafoam padding to prevent sliding of the objects during transport.

Fig. 8: Packing the drawers for transport on a pallet with stacking frame.

The drawers containing orders and badges of honour, seals and models; the archival boxes with the collection of primitive money; and the large objects (plaster casts, balances, and sculptures) individually packed with tissue paper and air cushions, were placed on pallets with staking frames that were additionally stabilised with pieces of foam and air cushions to prevent sliding during transport. Care was taken to minimise the amount of packing material used. Packing materials could be used repeatedly when carefully handled during packing and unpacking. Labels on the sides of the crates and packing lists helped to keep track of the objects until the move took place.

2.6 UNPACKING IN THE STORAGE FACILITY

The selected category groups were relocated into a total of 20 double door cabinets and 2 flat file cabinets with 10 drawers each. 11 of the double door cabinets were needed for the coin carrying drawers and 9 contained shelves. Individual groups of objects were assigned their own cabinet. In order to delay future space issues, more space was allocated than needed at the time of the move. A metal mesh wall was also installed that served as a room divider and for the hanging of 7 plaster casts *(fig. 9)*.

About 20 large plaster reliefs had been stored hanging on the wall, where they were not protected from mechanical damage or dust. The dust layer was removed with vacuum cleaners and brushes and the reliefs were subsequently hung on the metal mesh wall with S hooks and karabiners. The remaining reliefs, that were not too large for the double door cabinets, were placed horizontally on Ethafoam supports. Around 10 coin vessels and 20 balances with coin weights were first cleaned of dust and then stored in the cabinets with shelves *(fig. 10)*.

Fig. 9: Wire mesh wall with reliefs.

Fig. 10 a Fig. 10 b
Example of a shelf with figures and coin find containers, and one with balances.

Around 500 models for coins and medals, as well as electrotypes, mostly made from copper alloys, were sorted into the drawers of the flat file cabinets. The many small objects – ca. 1,200 seals and 1,700 orders and badges of honour sometimes with separately stored ribbons, cases and boxes – were moved in the numbered wooden drawers (as already mentioned above).

After removal of the transport packing materials from the drawers, the objects and their inventory cards were cleaned of surface dust with brushes and latex sponges prior to placement in the new storage units. Then they were provided with new, archival, folding paper trays and arranged in the metal drawers *(fig. 11)*.

Fig. 11 a

Fig. 11 b

Fig. 11 c
Drawers filled with seals, orders and badges of honour, sorted into archival paper trays.

In order to ensure that the new location could be easily captured later, the order of the trays in the old storage space was maintained as much as possible and the contents kept in their original arrangement. Since the available space in the new metal drawers is almost double that of the old wooden drawers, the contents of consecutive drawers were kept together whenever possible and the original drawer identification was indicated on the outside.

Around 1,700 orders and badges of honour were placed in individual folded paper trays and stored in the shallow metal drawers planned for this purpose. Some cases and *etuis* that were taller than the 5 cm high drawers were carefully labelled and placed in a custom drawer 10 cm high *(fig. 12)*. These higher drawers were filled with objects from consecutive drawers as needed. In order to maintain the chronological organisation system, the occasional higher drawer was also labelled on the outside with the locations of the related object drawers. In this way, use of the available storage space and cabinet height was optimised by inserting as many drawers as possible.

Fig. 12 a

Fig. 12 b

The contents determined the different drawer heights – temporary labelling with post-it notes provides an overview of the object locations.

Fig. 13: Archival boxes containing primitive money sealed in plastic wrapping in a metal cabinet.

The collection of primitive money, comprising approximately 425 pieces, had to be handled separately due to a pest infestation and packed appropriately, as already explained above. The continued use of the boxes sealed in plastic wrapping and filled with nitrogen gas for the organic and in some cases infested objects, lead to a reduction in the time, space, and effort required to move them. After placement in the storage facility, the necessary quarantine period of at least 6 months for the extermination of the pests could be fulfilled without a problem *(fig. 13)*. The archival and transport boxes, some of them sealed in plastic, were deposited in the intended metal cabinets; they were unpacked after the quarantine period had ended during a second phase.

2.7 OUTLOOK FOR THE SECOND PHASE

The Coin Collection's substantial collection of wax models (figures and decorative images) could not be moved during the first phase of the relocation at the beginning of July 2012 because of the high summer temperatures. The sharp decrease in temperature in the acclimatised storage facility would have inflicted disastrous damage on the sensitive material. The complex packing and transport of the wax models was carried out in a second phase using acclimatised crates that also reduce vibrations. And as mentioned above, the primitive money collection was unpacked and stored in its final location after the quarantine period has passed.

After all relocation tasks have been completed, entry of the new object location in the collection database can be finished.

SUMMARY

The Coin Collection possesses a substantial collection of medals and seals, coin models, and primitive money in a wide variety of materials (copper alloys, iron, enamel, gemstones, textiles, wood, shells, horn, etc.) and material combinations. The often sensitive objects were previously kept in the rooms of the Coin Collection at the KHM. For the rehousing and long-term archival storage at the new collections facility in Himberg, a plan for adaptation to object-specific needs with the elimination of harmful influences was developed and implemented. This entailed the removal of inappropriate packing materials and their substitution with archival materials, the replacement of the unsuitable oak cabinets with customised, pollutant-free metal cabinets, and the optimisation of environmental conditions.

During the move, particular attention was given to the collection of primitive money, where several objects suffered acute insect infestation. These had to be treated separately in order to prevent the introduction of pests into the new repository and the resulting contamination of other collection materials. After an initial cleaning of the objects, acid-free transport packaging was produced. Organic and/or infested objects were additionally sealed in plastic film and the resulting packages were filled with nitrogen, with oxygen absorbers and indicators added. The objects remained in their envelopes not only during the transport, but also for about six months in the new storage facility, to insure that all pests had been eradicated. Within the storage complex, a climate controlled room was created for all of the Coin Collection's objects, in which the required environmental parameters can be permanently maintained.

Furthermore, through the separation of this "climate chamber" from the large storage area and the installation of separate air filtration, additional protection from dust and pollutants could be achieved.

ZUSAMMENFASSUNG

Das Münzkabinett besitzt eine umfangreiche Sammlung an Orden und Siegeln, Münzmodellen und Naturalgeld aus den unterschiedlichsten Materialgruppen (Kupferlegierungen, Eisen, Email, Edelsteine, Textilien, Holz, Muscheln, Horn etc.) und Materialkombinationen. Diese oft sehr sensiblen Objekte waren bisher im KHM in den Räumlichkeiten des Münzkabinetts untergebracht. Für die Neulagerung und Langzeitarchivierung im neuen Zentraldepot Himberg wurde ein Konzept zur Anpassung an die objektspezifischen Bedürfnisse unter Ausgrenzung objektschädigender Einflüsse erarbeitet und umgesetzt. Dies beinhaltet die Entfernung objektunverträglicher Verpackungsmaterialien und ihren Ersatz durch archivsicheres Material sowie den Ersatz der unverträglichen Eichenschränke durch eigens angefertigte schadstofffreie Metallschränke und eine Optimierung der klimatischen Verhältnisse.

Besonderes Augenmerk wurde bei der Übersiedelung auf die Naturalgeldsammlung gelegt, bei welcher einige Objekte von akutem Schädlingsbefall betroffen waren. Sie mussten separat behandelt werden, um ein Einschleppen in das neue Depot und eine damit einhergehende Kontamination anderer Sammlungsgüter zu verhindern. Nach einer ersten Vorreinigung der Objekte wurden säurefreie Transportverpackungen angefertigt. Organische Objekte bzw. Objekte mit Schädlingsbefall wurden zusätzlich in Kunststofffolie eingeschweißt und die so entstandenen Verpackungen wurden unter Beigabe von Sauerstoffabsorbern und -indikatoren mit Stickstoff befüllt. Die Objekte verblieben nicht nur während des Transports, sondern auch noch im neuen Depot für ca. ein halbes Jahr in den Hüllen, um sicherzustellen, dass sämtliche Schädlinge abgetötet werden konnten.

Innerhalb des Depotkomplexes wurde für alle Objekte des Münzkabinetts eine eigene „Klimabox" geschaffen, in welcher die erforderlichen Klimaparameter dauerhaft eingehalten werden können. Zudem konnte durch die Separierung der „Klimabox" von der großen Depothalle und die Installation einer eigenen Luftfiltrierung zusätzlich ein erhöhter Schutz vor Staub und Schadstoff-Einträgen erreicht werden.

Relocation of the Collection of Historic Musical Instruments in Storage

Ina Hoheisel and Alfons Huber

Translated from the German by Aimée Ducey-Gessner

1. PRELIMINARY CONSIDERATIONS

With around 90 objects, the Collection of Historic Musical Instruments – in comparison with other collections[1] – definitely does not have the largest number of works in storage. When you take into consideration, however, that it is made up of primarily keyboard instruments from the late 18th through the early 20th century, which can be characterised as predominantly unwieldy, the need for a differentiated approach and a thoroughly thought-out plan is evident. Some of the instruments are on the one hand very heavy, weighing up to 600 kg, and on the other hand, possess elaborately designed and fragile decorative elements, such as mouldings, painted surfaces, metal appliqués, as well as sensitive lacquered surfaces. In addition, organs often are comprised of many separate and in part very damaged individual pieces (pipes, mechanical parts, revolving cylinders with raised pins, etc.). Last but not least, some of the instruments in storage are still in a playable condition, which must not be endangered during a move.

The preparatory work for the relocation was undertaken by the senior conservator for the Collection of Historic Musical Instruments (Dr. Alfons Huber) and a freelance colleague (Ina Hoheisel) as well as 2 to 4 external workers from the company Füreder. The curator of the Collection of Historic Musical Instruments (SAM) (Dr. Beatrix Darmstädter) undertook for the most part the logistical planning.

2. CLIMATIC AND CONSERVATION ASPECTS

The date of the move was planned for the middle of September 2011. The packing of the instruments had been, however, intentionally already carried out between February and April 2011 – in the cold, dry season – in order to prepare them for transport in a "winter climate" with lower temperatures and lesser atmospheric humidity in comparison with the summertime. A general enclosure in bubble wrap (which although not completely airtight nevertheless prevents constant air exchange) was chosen seeing that the water vapour content of the air under the plastic was not becoming higher than that of the environment to avoid the danger of mould growth. When the objects are packed during the wintertime, this potential risk is mitigated. A data logger (Testo Saveris H3D) was packed under the lid of a fortepiano made by Daniel Dörr (SAM 428) in order to monitor the climate inside the packed instrument; a reference measurement with a second data logger was carried out outside of the packaging.[2]

1 Somewhat more than 2,000 works of art and ca. 850 ornamental frames were relocated for the Picture Gallery.

2 The data loggers were delivered at the beginning of June from the IT department. From the end of June until the beginning of July, an unexplainable interruption of measurement for almost three weeks occurred due to a software error that the Testo manufacturer was unable to explain. The measurement data from July and August, however, prove the correctness of the working hypothesis.

The following charts confirm the correctness of the described assumption: on the one hand, the packaging as expected served as a climatic buffer, and on the other hand, the value of the relative humidity inside of the instrument remained below that of the surrounding atmospheric environment as hoped, which in August in the old storage space increases above of 60 %rH *(fig. 1)*. Since the packing materials were not vapour proof and came into equilibrium with the environmental humidity during the summer months, the packaging had to be opened again at the end of September, before the heating systems were activated for the colder months. Otherwise, the sinking temperatures outside of the wrapped objects would have led to the increase of relative humidity within the wrapping, which was to be avoided.

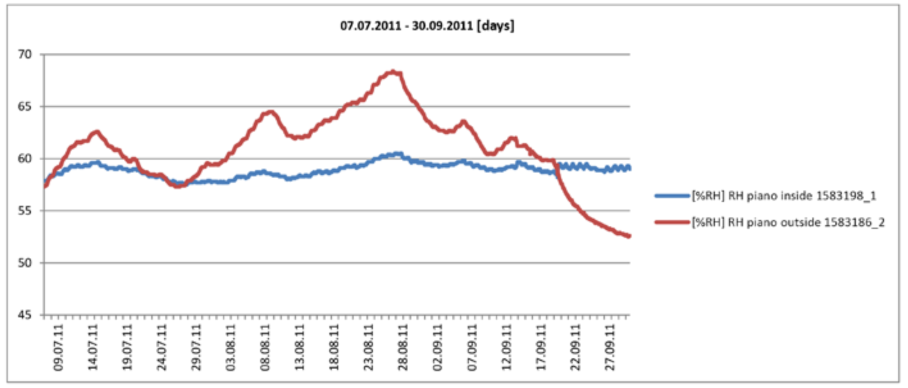

Fig. 1 a: The relative humidity inside the packed instrument is lower than the environmental humidity. (Chart: Angelika Stephanides.)

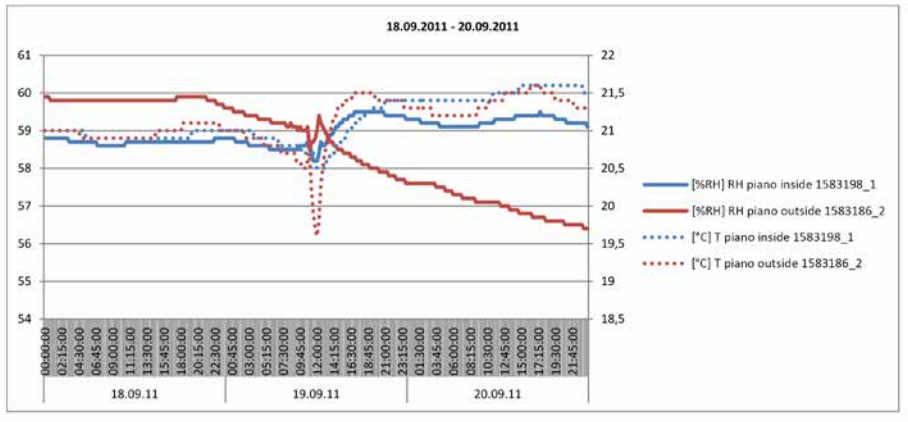

Fig. 1 b: The climatic buffering action of the packing materials during relocation is clearly visible. (Chart: Angelika Stephanides.)

3 Because of its fragmentary condition, a custom-made crate had already been made for the glass harmonica.

4 A piano moving company was commissioned for the transport of the Bösendorfer Imperial Piano SAM 434 because, weighing around 600 kilograms, it can only be correctly manipulated by trained handlers.

3. PACKING MATERIALS FOR TRANSPORT

The selection of suitable packing materials required some further considerations: as mentioned at the outset, among the instruments kept in storage are several very heavy pianofortes (with a weight of up to 600 kilograms) as well as cumbersome objects made up of many individual parts like, for example, organs or the glass harmonica (SAM 1001).[3] For this reason, all of the packed objects were to be moved with a forklift or a pallet truck.[4] Furthermore, a time slot of only three days was allotted for the relocation of all objects, such that they had to be quickly moved from one place to the other and with an economic use of space. For the pianos, therefore, it seemed to make sense, that they should rest on their long, back side and the legs should be unscrewed and removed for transport. To this end it was very helpful that many of the pianos in the old storage space were stored on trestles with the legs sometimes separately enclosed in storage boxes.

Colleagues from the museum's carpentry workshop made an individual u-shaped transport board for each piano from a 25 mm thick 3-layer wooden panel: the length and width of each board was determined by the length and height of the long back side (including the lid) of each piano. On one long side of the board, a strip projecting 50 mm (for the lid to lean against) was attached with screws; the underside of the board was furnished with three to four wooden blocks (100 × 60 mm), so that it could be easily raised by the forklift. A 40 mm thick Ethafoam panel was attached to the transport board with hot glue, leaving a gap of about 30 mm between it and the wood panel. (The gap is necessary so that in the case of a turned up lid, no pressure is exerted on the protruding lid or its hinges.) To protect the lid, the strip attached to the board was also covered with a thin layer of foamed plastic *(fig. 2)*. The instrument was placed on the transport board so that the long back side of the piano rested on the foam while the protruding lid and its hinges fit into the gap.

Before the piano was placed on its transport board, its legs were individually packed in tissue paper and bubble wrap and the inventory number was written by hand on the package. The same steps were carried out for the music stand, and when appropriate, for the lyre and pedal rods. The entire piano body was next wrapped in Mollino-Nessel fabric (inexpensive, coarse, unbleached cotton fabric) *(fig. 3)*, so that contact between the surface, which was in most cases

Fig. 2: Custom-made transport board ready for use.

Fig. 3: In order to protect the surface, the pianos were first wrapped in Mollino fabric.

Fig. 4: The second layer of bubble wrap served as protection against mechanical damage and as a climatic buffer.

lacquered, and the different synthetic materials could be avoided. This was followed by a generous envelopment with bubble wrap *(fig. 4)* that was closed here and there with adhesive tape in order to guarantee a certain degree of air transfer. In this condition, the piano was lifted onto its transport board *(fig. 5)* and labelled with its name and inventory number.

For the earlier – and therefore more delicately constructed – keyboard instruments it was possible to place the legs and music stand on the curved side, thereby packing all elements together. The later instruments required stable cardboard boxes for these elements because of their larger volume and weight. In order to ensure that the instrument was securely bound to its transport board, a "final packing" took place: both elements were wrapped together with PE sheeting *(fig. 6)*. The encased objects were stored this way in the old storage area until relocation *(fig. 7)*.

The harps had already been stored in upright, lockable rolling crates made of 6 mm thick birch plywood and were therefore already prepared for transport. For additional security on the inside, pieces of Ethafoam wrapped in tissue paper were fitted between the crate's wall and the body of the harp as spacers. In this way, the harps could be transported without any further effort.

Fig. 5: The encased piano is lifted onto its transport board.

Fig. 6: The encased piano and its transport board are wrapped together in PE sheeting.

Fig. 7: Completely packed objects before the move.

The collection's curator requested climate-controlled crates for 18 particularly sensitive objects (fragments of organs, two pyramid pianos, and the aforementioned glass harmonica) which, initially consented to, in the end could not be ordered because of budgetary constraints. As a consequence, these objects were packed on Euro-pallets with stackable frames or cardboard boxes. Both of the pyramid pianos were outfitted on site with provisional transport containers constructed for each from a Euro-pallet with walls constructed out of stable 3-layer wooden panels.

4. RELOCATION

The relocation was carried out by the company Kunsttrans, who safely moved and loaded the instruments into the waiting moving trucks with forklifts or pallet trucks *(fig. 8)*. Upon arrival at the central storage facility in Himberg, the objects were not immediately unpacked due to climatic considerations and exposure to construction-related dust.

The organisation of the objects in the TMS barcode system was carried out according to storage area of the Collection of Historic Musical Instruments. Keyboard instruments and heavy objects were placed chronologically according to their time of origin on the ground; lighter objects and individual pieces were stored as necessary in shelving units on the intermediary level. The accessibility of the intermediary steel platform is still problematic, however, because there is no lift, which could be used to handle objects at this level; a forklift is always necessary for accessing the instruments and parts of instruments on the shelves.

Fig. 8 a

Fig. 8 b

The instruments could be safely moved and loaded into the waiting moving trucks with forklifts or pallet trucks.

5. CONCLUSION

In general, the relocation went smoothly, except for minimal damages (detached veneer or loose parts). This can be to a great extent ascribed to the outstanding logistical preparations organised by the curator, but also to the productive collaboration with the relocation team and the external contractors.

The relocation to the new central storage facility represents generally and qualitatively an improvement for the objects in the Collection of Historic Musical Instruments. The weak points should be, however, mentioned: the spatial and climatic proximity to the neighbouring collections as well as the serious disadvantage of the difficult access to the intermediary level, which can only be loaded and unloaded with a forklift. Whether the continuing virulent dust exposure is due to the remaining construction work or abrasion of the floor, still requires clarification.[5] The observed accumulation of dust in the new storage facility is currently subject to investigation by the museum's Conservation Science Department.

[5] 2015 – after several cleaning campaigns and fine-tuning of the ventilation system – the problem seems to be solved.

SUMMARY

The primary task was the packing of ca. 70 pianos, objects characterised both by their great weight and by their delicacy, with sensitive surfaces, structural components, and decorative elements, and at times by fragile states of preservation. Through shrewd and timely logistical planning and the development of a climatically buffering and economic packing on easy-to-manoeuvre transport planks or adapted Euro-palettes, a safe and efficient progression was possible within the narrow allotted time.

ZUSAMMENFASSUNG

Die Hauptaufgabe bestand in der Verpackung von ca. 70 Klavieren, die einerseits durch ihr großes Gewicht, andererseits durch empfindliche Oberflächen, Bauteile und Dekorelemente und z. T. fragile Erhaltungszustände charakterisiert waren. Durch eine zeitgerechte und gute logistische Vorplanung und die Entwicklung einer klimapuffernden und kostengünstigen Verpackung auf leicht handhabbaren Transportbrettern bzw. adaptierten Euro-Paletten war ein effizienter, sicherer Ablauf innerhalb des engen vorgegebenen Zeitrahmens möglich.

Fig. 1: Storage facility Inzersdorf, the Monturdepot's storage area.

The Emperor's New "Clothes-Chamber"

The Relocation of Objects of the Wagenburg (Imperial Carriage Museum) and Monturdepot (Court Wardrobe) to the KHM's New Central Storage Facility

Tanja Kimmel, Daniela Sailer and Monica Kurzel-Runtscheiner

Translated from the German by Emily Schwedersky

1. INTRODUCTION

The "Wagenburg" (Imperial Carriage Museum) in Schönbrunn is the best-preserved vehicle fleet of a European dynasty. It possesses some 200 historic vehicles, 1,500 riding and carriage harnesses including their related components, as well as over 2,000 paintings and works of art on paper on the topics of courtly life, representation and vehicle culture. Due to the vast size of the collection however, only a tiny percentage of the objects can be displayed publicly, while the considerably larger part is kept in storage. The affiliated "Monturdepot" (Court Wardrobe) is a collection of historic textiles, which for conservation reasons cannot be permanently displayed. It comprises some 6,000 historic garments and accessories, among them the world's largest collection of civilian uniforms, the entire wardrobe of the Habsburg dynastic orders (Golden Fleece, Order of St Steven, Order of St Leopold, Order of the Iron Crown), a considerable number of liveries of the Viennese court and its nobility, in addition to an exquisite selection of personal garments of the Austrian dynasty, first and foremost those of Empress Elisabeth.

The objects had so far been stored in three different locations, provided that they were not displayed in the exhibition halls in Schönbrunn or Vienna's Imperial Treasury:

1. in the Kunsthistorisches Museum's storage facility in Inzersdorf (liveries of the Viennese court and historic gowns; *figs. 1 to 4*);
2. in the Monturdepot in Vienna's Hofburg (imperial family household, civilian uniforms, robes of the dynastic orders, liveries of the nobility; *figs. 5 to 8*);

Fig. 2: Storage facility Inzersdorf, storage of rococo tailcoats in oversized drawers.

Fig. 3: Storage facility Inzersdorf, storage of court uniforms including accessories in hanging cabinets and drawers.

Fig. 4: Storage facility Inzersdorf, storage of mannequins and exhibition equipment.

Fig. 5: Storage at the Hofburg, due to lack of space, some of the accessories have to be piled on top of one another and stowed on top of the cabinet.

Fig. 6: Storage at the Hofburg, also due to lack of space, miscellaneous historic trunks and chests are piled up in a recess.

3. in the storage areas of the Wagenburg in Schönbrunn (carriages, harnesses with their different components, collection of paintings and works of art on paper; *figs. 9 and 10*)

The construction of a new central storage facility and the related closure of the storage in Inzersdorf brought vast improvements to this state of affairs: on the one hand, the new storage facility fulfils all conservation requirements, and on the other hand, it provides much-needed space for growth, so that the repositories in the Hofburg and in Schönbrunn, which had long reached the limits of their capacity, could be relieved. Planning a new central repository thus constituted a major opportunity, but also an extraordinary challenge.

Fig. 7: Storage at the Hofburg, inadequate accommodation of capes and vestments of the dynastic orders. The textiles are folded several times, enveloped in linen cloths and stowed on extensible trays in the cabinet.

Fig. 8: Storage at the Hofburg, inadequate accommodation of accessories of the robes of the dynastic orders. Original boxes and metal cassettes are piled on top of one another in the cabinet.

Fig. 9: Storage at the Wagenburg, so-called English Riding Stable, due to lack of space, some of the carriages are parked in the aisle area.

Fig. 10: Storage space in the Wagenburg's attic.

The collection's conservators were able to actively contribute to the planning process: in collaboration with the relocation project team, they developed strategies for the adequate storage of objects according to conservation standards, as well as for best possible use of the space available. Other main objectives were a clear arrangement of and easy access to the objects, a stable climate with low energy expenditure, the provision of optimum security for the collections and employees, the implementation of IPM for pest control, and location management via a barcode system with direct link to the museum's database.

Within the collections, it was necessary first of all to establish a precise quantity structure, to determine the specific spatial needs in the new facility, as well as the requirements for cautious and rapid transportation of the objects, and, last but not least, their optimum storage in the new location. In the course of this procedure, "inherited liabilities" were and still are being processed, including for example the inventory of specific object groups that had previously been insufficiently documented (such as the robes of the Habsburg dynastic orders).

Other internal tasks included planning for the preventive anoxic nitrogen treatment of the objects that were to be moved (carriages, furniture and exhibition equipment) in custom-made anoxic tents, developing individualised packing solutions for large-scale objects, and implementing conservation treatments of fragile objects, which otherwise would not have been able to travel.

2. PRELIMINARY WORK TOWARDS THE RELOCATION OF OBJECTS FROM THE WAGENBURG/ MONTURDEPOT COLLECTION

Following some two years of intense preparation by the collection's staff, the objects of the Monturdepot, which had to date been housed in Inzersdorf, could finally be relocated to the new central storage facility in September 2011. Subsequently, several carriages, sleighs and historic textiles were transferred from the overcrowded repositories of the Wagenburg to the new storage space. They were all cleaned before undergoing anoxic nitrogen treatment by the Singer company on site in Schönbrunn.

Finally, in May 2012, the next large transfer took place: the entire collection of robes of the dynastic orders was transferred from the Monturdepot in the Hofburg to Himberg. Due to lack of space, this enormous collection of several hundred large-scale regalia had been stored under untenable conditions *(see figs. 7 and 8)*. Relocation to the new central storage facility also provided the first opportunity to closely inspect and scientifically analyse the entire valuable collection as well as to store it appropriately according to conservation criteria.

Thanks to the forward-looking planning of the relocation project team, good collaboration with the Kunsttrans company, and the outstanding coordination by Martin Dorfmann (DP-art company), it was possible to carry out the relocation of the 4,100 objects of the Monturdepot and 220 objects of the Wagenburg damage-free in only 6 working days *(table 1)*.

2.1 STORAGE IN INZERSDORF

Over a period of four months, all objects from the Monturdepot stored in Inzersdorf were packed for transport by two of the collection's conservators. The space required for manipulation was gained by selling discarded storage furniture. By the time the move began, all the objects were ready to be loaded using the vehicles' space to maximum capacity. By keeping standing time of the trucks short, it was ultimately possible to ensure surprisingly low transport costs.

Table 1: The relocation of the Wagenburg's and Monturdepot's collections in numbers.

Inzersdorf storage facility c. 1,700 objects
• liveries of court servants including accessories
• women's gowns and accessories
• mannequins and other exhibition equipment
distance to Himberg: c. 11.5 km relocation: 2 days, 8th and 9th September 2011 totalling 15 truck shipments, 2 trucks with two teams comprising 4 people each (1 driver/3 packers) staff from the collection: 1 curator, 2 conservators
Wagenburg c. 220 objects
• carriages and sleighs
• caparisons
• children's musical instruments
• model horses and exhibition equipment
• harness cabinets, saddle stands
distance to Himberg: c. 18 km relocation: 2 days, 23rd and 27th September 2011 totalling 4 truck shipments, 1 truck with a team comprising 4 people (1 driver/3 packers) staff from the collection: 1 curator, 3 conservators
Hofburg c. 2,400 objects
• entire collection of robes of the dynastic orders
• historic trunks and chests
distance to Himberg: c. 18 km relocation: 3 days, 10th to 14th May 2012 totalling 6 truck shipments, 1 truck with a team comprising 4 people (1 driver/3 packers) external personnel: Vienna Art Handling company (2 packers) staff from the collection: 1 curator, 2 conservators additional KHM-staff: 1 inventory administrator

Fig. 11: Storage facility Inzersdorf, pre-packed objects of the Monturdepot.

Fig. 12: Storage facility Inzersdorf, pre-placement of the packed objects for transport by the art moving company. The demarcations on the floor indicate the size of the truck.

2.1.1 PACKING SOLUTIONS FOR TRANSPORT

In order to keep material costs as low as possible, most objects were moved in the drawers of the discarded cabinets. These were stacked on top one another on Euro-pallets and secured for transport with finger-jointed 5/8er wooden braces[1] by employees of the Füreder company *(figs. 11, 13 and 14)*.

[1] Squared timber with a 5 × 8 cm side length.

Fig. 13: Rococo tailcoats, packed in the drawers of the disused old cabinets.

Fig. 14: Füreder company employees stacking the drawers.

Fig. 15: Mobile clothes racks with Z-shaped base frames can be nested into one another to save space.

Fig. 16: Fixing individual hangers to the crossbar of the mobile clothes rack with cable ties.

By leasing mobile clothes racks and Z-shaped base frames, hanging objects could be moved to the new location in an efficient and space-saving manner *(see figs. 11 and 15)*. The liveries of court servants were left on their padded hangers, which were affixed to the crossbars of the mobile clothes racks with cable ties *(fig. 16)*. Every other garment received a Cellplas[2]-slipcover for protection, particularly richly decorated liveries were covered with cotton fabric casings. The mobile clothes racks were additionally covered with bubble wrap for transport.

The collection of women's gowns was transported in the flat textile storage boxes that they had been stored in: for this purpose, several Euro-pallets were connected and furnished with a wooden board to increase the bearing surface,

[2] Microporous fleece made of polypropylene fibres, for in-depth information see http://www.art-handling.com/images/dokumente/cellplas.pdf (05.09.2015).

Fig. 17: ÖBB stacking frames fitted with Ethafoam, for the relocation of costume-accessories. Padding of any existing voids with LDPE-air cushions.

Fig. 18: ÖBB stacking frames stacked on top of one another and lined with bubble wrap, for transporting exhibition equipment such as mannequins and hat-stands.

so that it was possible to stack several of the boxes on top of each other according to size and weight *(see fig. 12)*. Wooden braces mounted to the sides and lashing straps served to secure them. Particularly fragile gowns, permanently mounted on Kyoto-mannequins (Kyoto Costume Institute), were moved in their existing transport boxes *(figs. 12 and 37 b)*.

Some groups of objects (such as historic hat boxes) and pieces of exhibition equipment were relocated using stacking frames of the Austrian Railways (ÖBB), which were used individually or stacked according to need *(see figs. 11, 17 and 18)*. They were either lined with bubble wrap *(see fig. 18)*, or with Ethafoam at the bottom and sides *(see fig. 17)*. In some cases the stacking frames were closed by bubble-wrap covers or pallet lids, if required.

In order to prevent the objects from shifting, any void was filled with customary filling materials such as tissue paper and LDPE air cushions *(see fig. 17)*. Only the Tyvek cushions filled with styrofoam granules, used for example to cushion the pommels of historic porter's canes during transport, were custom-made. Very fragile objects were embedded in specially cut blocks of Ethafoam *(figs. 19 to 22)*. The melee weapons from the Monturdepot's collection serve as examples for this treatment.

2.2 WAGENBURG

Objects to be relocated from the Wagenburg first underwent laborious dry surface cleaning by conservators from the collection, followed by anoxic nitrogen treatment carried out by the Singer company in the repository in Schönbrunn. After opening the purpose-built anoxic tents, they were immediately loaded

Fig. 19: Storage of hunting daggers with the accompanying sheaths and pendants in the old storage location. Danger of the objects shifting upon the drawer being pulled out.

Fig. 20: Preparation of custom-fit blocks of Ethafoam, carved to the shape of the object and lined with Tyvek, for securing the objects within the drawers.

Fig. 21: Hunting daggers with the accompanying sheaths and pendants, embedded in Ethafoam for transport (old storage cabinet Inzersdorf).

Fig. 22: Adapting the custom-made Ethafoam beds for subsequent use in the drawers of the central storage facility's new cabinets.

Fig. 23: Tents for the anoxic nitrogen treatment of carriages from the Wagenburg. Left hand side: closed. Right hand side: opened to load the objects.

Fig. 24: Loading one of the carriages from the Wagenburg onto the art moving company's truck.

Fig. 25: Storage at the Hofburg, packing of rapiers and swords by employees of the Vienna Art Handling company.

Fig. 26: Storage at the Hofburg, bringing objects from the first floor to the ground floor for packing by employees of the Kunsttrans company.

onto the truck and transported to Himberg *(figs. 23 and 24)*. This helped to eliminate the danger of pest infestation.[5] Due to their special size, their weight and their shape, objects from the Wagenburg were not wrapped for transport *(see fig. 24)*, and could therefore only be moved in fair weather.

2.3 HOFBURG

Due to the crowded conditions in the historic Monturdepot within the Hofburg, it was not possible to pack the several thousand objects comprising the collection of the dynastic orders prior to transport. The regalia and their accessories instead had to be set aside and packed piece by piece on the days of their transport *(fig. 25)*. This was aggravated by the fact that the bulk of the objects was housed on the first floor, meaning that they first had to be brought down a spiral staircase to the ground floor one by one *(fig. 26)*. The Office of the President of the Republic, which houses the repository, supported the move in several ways: by providing a room adjoining the storage area, in which the packed objects for the next truckload could be placed, and by opening access to the inner courtyard for the evacuation of the boxes, safeguarded by police.

3. WORK AT THE NEW SITE IN HIMBERG

While the Wagenburg's objects could be placed in their designated locations directly following the unloading of the respective truckload, this approach was not workable for the Monturdepot's more than 4,000 objects (Inzersdorf and Hofburg). The latter were therefore temporarily placed in the new storage building in their packaging, until they could be successively unpacked and stored in their final location following the relocation campaigns *(figs. 27 and 28)*.

[5] See also the article by Querner et al. in this publication.

Fig. 27: Successive unpacking of the Monturdepot's objects in the central storage facility upon completion of the relocation campaign.

Fig. 28: Successive storage of the Monturdepot's objects in the central storage facility upon completion of the relocation campaign.

Fig. 29: Powder-coated steel cabinets by the Magista Systems/Van Keulen Interieurbouw company for storage of the Monturdepot's objects.

3.1 FURNISHINGS/STORAGE TECHNIQUE

The storage of textiles knows many forms – with objects hanging, lying flat or stored on rolls. The type of storage selected is determined by the shape, size and above all the condition of the objects. The storage technique finally employed depends on the amount of space available, the structure of the rooms, and ambient conditions. The budget available is naturally a decisive factor, but the status that the respective collection enjoys within the museum also plays a considerable part in reaching a decision regarding the investment to be made. Owing to the carefully planned, newly manufactured furnishings and the stable room climate in the new location, storage of the almost 4,100 objects of the Monturdepot could be improved significantly.

3.1.1 STANDARD FEATURES OF THE CABINET SYSTEM

Powder-coated steel cabinets with variable interior furnishings such as clothes rails, shelving and drawers by the Magista Systems/Van Keulen Interieurbouw company allow for flexible storage of the costumes collection. They thereby meet the complex requirements for accommodating the manifold textiles *(figs. 29 to 31)*.

Fig. 30 a

Fig. 30 b

Examples of the interior fittings of the steel cabinets, with clothes rails, shelving and drawers in different sizes.

Fig. 31 a

Fig. 31 b

Examples of the various types of storage of costumes and accessories in drawers.

The cabinets are arranged back-to-back in blocks of five units, with a distance of 280 cm to the outside wall. An aisle width of 200 cm between the blocks not only leaves enough space for handling, but also allows for the use of mobile worktables in front of the cabinets. The aisle also constitutes an area which can serve as a reserve for putting up additional mobile shelving at a later date.

With a width of 125 cm, a usable shelf depth of 80 cm, and a height of 220 cm, the cabinets are consistent with common standard measurements, and clothes rails, shelving levels and drawers can be hooked into a grid variably and without using tools, at intervals of 35 mm. The maximum load per linear meter is 20 kg for the drawers, for the clothes rails and shelves it is twice that amount. Vent holes were stamped into the double doors, providing for air circulation within *(see fig. 29)*. The cabinets are labelled using magnet boards.

Fig. 32 a

Fig. 32 b

Wide-span shelving units by the Compactus & Bruynzeel AG. On the left with deposited trunks and chests from the Monturdepot. On the right with caparisons, foil sealed, from the collection of the Wagenburg.

3.1.2 STANDARD FEATURES OF THE SHELVING SYSTEM

The Monturdepot owns a multitude of historic trunks and chests, in which the valuable attire was once safely stored, as well as transported while travelling. Due to the overcrowded conditions in the Hofburg's repository, it could not accommodate these artefacts adequately *(see fig. 6)*. The relocation to the central storage facility was intended to ensure better storage conditions by taking into account the varying dimensions and the high deadweight of some of the objects.

A space-saving alternative to free-standing trunks and chests was found in the wide-span shelving units from the Compactus & Bruynzeel Storage Systems company, which will ensure the clearly laid out storage of these objects in future *(fig. 32 a)*. The measurements of the shelving system are 200 × 270 × 80 cm (H × W × D); it has a load-bearing capacity of 800 kg per linear meter of shelving.

A comparable shelving system is also deployed in the storage area of the Wagenburg, primarily for the storage of caparisons and children's musical instruments *(fig. 32 b)*.

3.1.3 CUSTOMISED ARCHIVAL BOXES

Oversized textiles such as gowns with long trains, or the regalia of the Habsburg dynastic orders with their grand capes and vestments, are stored in flat textile storage boxes *(see fig. 33 b and 34 b)*. These were manufactured especially for the Monturdepot by the Klug Conservation company, to the specifications of the collection's conservators, since the standard range of products available on the market (NOMI KS 16 acid-free cardboard box) did not correspond to the desired requirements in format or execution.

As is customary, the boxes are manufactured from 3 mm corrugated board, with a double wall thickness on two opposing sides. However, they are equipped with additional cotton ribbons on two sides to serve as carrying straps and thus facilitate their handling. To prevent these from shearing under strain, they are riveted to the bottom of the box twice, and covered by a further base insert. Polyester envelopes by the Monochrom company, common in the archiving of photographs, serve to label the boxes and are affixed using double-sided Secol-tape.

Fig. 33 a

Fig. 33 b

Acid-free cardboard boxes by the Klug-Conservation company for the storage of oversized textiles. On the left, during assembly by an employee of the Japico company. On the right, with stored regalia of the English Order of the Garter.

Fig. 34 a

Fig. 34 b

Support-free shelving units with continuous levels by the Magista Systems/Van Keulen Interieurbouw company, with acid-free cardboard boxes by the Klug-Conservation company for the storage of oversized textiles.

The boxes are 20 cm high, 190 cm long and 100 cm wide, and thus have the largest format that can be assembled from one piece without puzzle joint connections; the width of the boxes was predetermined by the depth of the shelving system.

In order to reduce transport costs, the boxes were delivered in a flat state and only assembled in situ by an employee of the Japico company *(fig. 33 a)*.

3.1.4 CUSTOMISED CANTILEVER SHELVING SYSTEM

A support-free shelf with continuous levels was developed by the museum adviser Dr. Joachim Huber in collaboration with the Magista Systems/Van Keulen Interieurbouw company for the storage of the large-format textile boxes *(fig. 34)*. This constitutes an innovation in the field of museum storage furnishings, as the shelf posts of the systems previously available on the market had always impaired utilisation of their full width.

The cantilever shelving system is made from steel, powder-coated on all sides. It consists of vertical shelf posts with an adjustment grid (frame size: 230 cm, adjustment grid: 5 cm), to which cantilever arms are affixed horizontally. Shelving (width: 95/120 cm, usable depth: 100 cm) can be hooked onto these flush

Fig. 35: Assembly of the prototype for the support-free shelving at the storage facility Inzersdorf.

Fig. 36 a

Fig. 36 b

Large cabinet with shelving by the StabaArte company for the storage and display of oversized textiles. On the left, during assembly. On the right, with deposited regalia of the Order of the Holy Spirit.

and without using tools, up to a total length of 14 metres! Alternatively, full-extension drawers can be mounted instead of the shelving, in which case the shelf support is reinforced and extends into the light cross profile. The load-bearing capacity per linear meter shelving is 40 kg, that of the drawers is 20 kg.

Like the above-mentioned steel cabinets, the shelving racks are also arranged back-to-back, and in theory constructed in such a way that the depth of both shelves can be used in full. The boxes can thus be stored not only by length but also by width. In practice however, the double depth can only be made full use of in panels without additional cross-bracing.

According to the call for bids, the respective companies were required to produce a prototype for each part of the furnishings *(fig. 35)* before procurement, so that quality and functionality could be verified in advance.

3.1.5 CUSTOMISED LARGE CABINET WITH SHELVING

The Monturdepot is not accessible to the public; only selected highlights of the collection are exhibited at the Wagenburg and the Treasury. However, given substantial interest from peers, objects from the collection can be studied at the storage facility. Showing large-format objects, such as regalia of the dynastic orders, previously required preparation by at least two of the collection's conservators. In the new storage facility, exemplary objects from these object groups are now housed in a large cabinet with shelving from the StabaArte company *(fig. 36)*. Thanks to the easy handling of the cabinet, which has been placed near the entrance, the objects can be presented effortlessly by a single collection employee. In this manner, the objects are not put under the unnecessary strain of handling and mounting, while valuable working time is being saved simultaneously.

The corpus of the cabinet is 180 cm high, 275 cm wide and 340 cm deep. It consists of sheet steel with emission-free powder-coating, and can be sealed dust-tight by fabric blinds to the front and reverse respectively.

3.1.6 CUSTOMISED MANNEQUIN BOXES

To date, the gowns mounted onto the so-called Kyoto-mannequins were stored in the wooden crates built for their transport when going on loan *(fig. 37)*. These were also intended to protect the objects from mechanical damage during storage, as well as light and dust. The cut trains, up to 4 m in length, were folded and draped over wooden poles, which were padded with foam material and bolted to the crate's side walls *(fig. 37 b)*.

For conservation reasons, the large-sized and partly fragile dresses were to be left on the custom-fit mannequins. However, it was necessary to replace the acidic and unwieldy wooden crates, which could only be moved by forklift due to their high deadweight. The new storage method was also intended to facilitate handling of the dresses: the objects had thus far been difficult to access, and dismantling the bolted wooden poles had always been time-consuming.

Mannequins will therefore be stored in custom-built, mobile "profiled pipe containers" (h 180 cm, l 110 cm, w 110 cm) *(fig. 37 c)*, guided by the container-system developed by Martijn de Ruijter for the Tropenmuseum Amsterdam. Their bottom panels consist of PVC rigid foam board (Celuka), which is often used in the construction of display cases and is non-hazardous according to the Oddy-test. A frame of powder-coated profiled pipes is mounted onto the bottom panels, into which detachable crossbars can be hooked to accommodate the trains. The walls of the boxes are lined with Tyvek and are opened and closed using Velcro. Steering castors with locking brakes allow for easy displacement of the racks.

Fig. 37 a

Fig. 37 b

Fig. 37 c

Empress Elisabeth's large mourning robe on a custom-fit Kyoto-mannequin. Bottom left, in a crate from the art moving company. Bottom right, new accommodation in a container custom-made by the Museom company.

3.1.7 FREE-STANDING INSTALLATION AND GRID SYSTEM

Not all objects can be accommodated in cabinets, shelving systems or other constructions. Their size, weight and shape sometimes necessitate a free-standing placement of the objects. The carriages, historic cabinets and exhibition equipment of the Wagenburg may be named as examples *(fig. 38)*.

Fig. 38 a

Fig. 38 b

Central storage facility Himberg, storage area of the Wagenburg with carriages (left) and model horses (right).

Fig. 39 a

Fig. 39 b

Coordinate system for the storage of the collection of mannequins. Adhering the tape to the floor (left), and the complete grid with self-adhesive letters and numbers for determining locations (right).

As the coordinate system conceived for the storage of the Monturdepot's mannequins in the old location had proved successful in practice, it was to be expanded and applied to the new storage facilities *(fig. 40)*. To this end, black adhesive tape was used to form a grid on the cleaned floor, leaving fields of 50 × 50 cm size as positions for the mannequins *(fig. 39)*. In accordance with the previous model, the columns and rows of the grid were labelled continuously with self-adhesive letters and numbers *(see fig. 39 b)*. The assignment of positions is carried out using the corresponding coordinates (e.g. B2), which are recorded next to the respective object in the collection inventory and facilitate locating the appropriate exhibition equipment effortlessly when needed. In addition, a layout plan is available onsite, to provide the required overview in case of computer failure. To determine the locations for the carriages and sleighs in the Wagenburg's storage area, parking spaces were delineated using a grid of black fabric tape. In addition, the empty corridors between the vehicles were labelled "space for manoeuvring" in order to keep these areas free.

Fig. 40: Central storage facility Himberg, the completed coordinate system for storage of the collection of mannequins.

Fig. 41: Barcode labels to be affixed with polypropylene safety thread, printed in advance by the TMS-department, and sorted numerically by collection staff.

Fig. 42: Detail of a pair of breeches from the Monturdepot, with its barcode label affixed to the buttonhole. Next to it, the old, manually written inventory label.

3.2 STORAGE SLOT STATUS REPORT

Storage of the objects at the new location took place with the help of a storage slot status report.[4] In a previously prepared layout plan, all storage systems were recorded with their respective "location IDs," and details of the location and manner in which the objects should be stored. Reserve areas were also factored in, so that later additions can be integrated into the collection in thematically appropriate locations. Although the intended order could not always be adhered to, the storage slot status report still proved to be a useful tool ensuring systematic accommodation of the objects in the new location.

4 The expression storage slot status report (Lagerspiegel in German) is a logistical term and denotes a comprehensive report on a storage facility's holdings. According to logipedia.com, it specifies which of a storage facility's storage bins are occupied or barred. In some applications, the type and quantities of the articles per storage bin are also stated. From: http://www.still.de/408+M50a3420b95a.0.0.html (24.01.2013), http://www.logipedia.de/lexikon/Lagerspiegel (24.01.2013).

3.3 BARCODES FOR OBJECT AND LOCATIONS MANAGEMENT

An innovation which significantly enhanced the efficiency of storage was the introduction of barcodes: by means of electronically readable barcodes, any change in an object's location can be automatically registered using a reading device (Motorola MC 1000 Scanner) *(see fig. 45)* and electronically processed. In addition to barcodes for the objects, there are barcode labels on shelves, drawers or shelving (so-called "location-IDs"). Due to these barcodes, any change in location, including specifications of the date and the person in charge, will be electronically recorded.[5]

The barcodes were laser-printed onto archival hangtags made of polyethylene foil (TTR TAG PE-Foil Polyart S2), which contain the barcode, inventory number and object identification *(figs. 41 to 43)*. These tags are carefully affixed to the objects using 12 cm polypropylene safety thread with "one time"-fastening (in white or black) *(see figs. 42 and 45)*. For reasons of clarity, within groups of similar objects, the tags are always affixed to the same spot (for uniforms e.g. to the uppermost buttonhole). For objects to which no tags can be attached (such as original hat boxes), the object information is adhered to a transparent polyethylene strip, which is placed around the object as a banderole, without interfering with the original material *(fig. 44)*.

4. STATUS QUO AND OUTLOOK

All the objects previously stored in Inzersdorf and the Wagenburg have already been documented photographically, stored in the new location and recorded in the museum's central database (TMS) *(fig. 46)*.

The robes of the Habsburg dynastic orders previously housed in the Hofburg however can only be moved to their final location bit by bit: for decades they were stored under overcrowded conditions in inadequate containers and are now being transferred to new, custom-made textile boxes *(fig. 47)* and cabinets.

Fig. 43: Employee of the Wagenburg/Monturdepot collection printing out barcode labels at the central storage facility.

Fig. 44: Tagging of an original wig-box from the Monturdepot with a banderole made of a strip of polyethylene with a barcode label adhered to it.

5 See also the article by Kloser in this publication.

Fig. 45: Reading of object data using a barcode scanner.

Fig. 46: Photographic documentation of children's musical instruments from the Wagenburg at the new central storage facility.

Fig. 47: Vestments of the Order of the Golden Fleece, lined up at the central storage facility for scientific examination. In front of them, the flat textile storage boxes custom-made for this collection.

This has served as an opportunity to scientifically examine, museologically record and photographically document the unique collection of several thousand, partly large-format objects for the first time.

Historic trunks and chests, also relocated from the Hofburg, have been preventively treated in the in-house anoxic nitrogen chamber. They have been moved to their permanent location at the new storage facility, where they are easily accessible for future surface cleaning and inventory.

The historic gowns mounted onto Kyoto-mannequins are at present stored in transport boxes and are going to be permanently deposited in the new "profiled pipe containers". For the Monturdepot's numerous, very diverse accessories (hats, wigs, plumes, etc.), shape-giving support and storage devices will gradually be produced by conservators from the collection over the coming years in accordance with time resources.

5. ACKNOWLEDGEMENTS

The staff of the Wagenburg/Monturdepot collection would like to thank all those who contributed to the successful outcome of the project, for their great dedication and support.

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SUMMARY

The construction of the new central art depository provides the Imperial Carriage Museum (Wagenburg) and the associated Court Wardrobe (Monturdepot) with optimal, conservation-appropriate storage conditions, and offers long-needed room for expansion. Through the move, which took place from late 2011 until early 2012, the cramped storage facilities of the two collections at their respective locations could be relieved; due to the space available in the new facility, a sizeable group of large-format objects could be investigated by scholars, recorded according to museological standards, and photographically documented for the first time.

The article first considers the two-year preparations and the subsequent move of the objects from three different locations: the storage facility in Inzersdorf, which was emptied; the storage space of the Court Wardrobe in the Hofburg; and the repositories of the Imperial Carriage Museum in Schönbrunn palace. The development of various packing solutions for the transport, and other preparations such as the cleaning and nitrogen fumigation of objects, are also discussed.

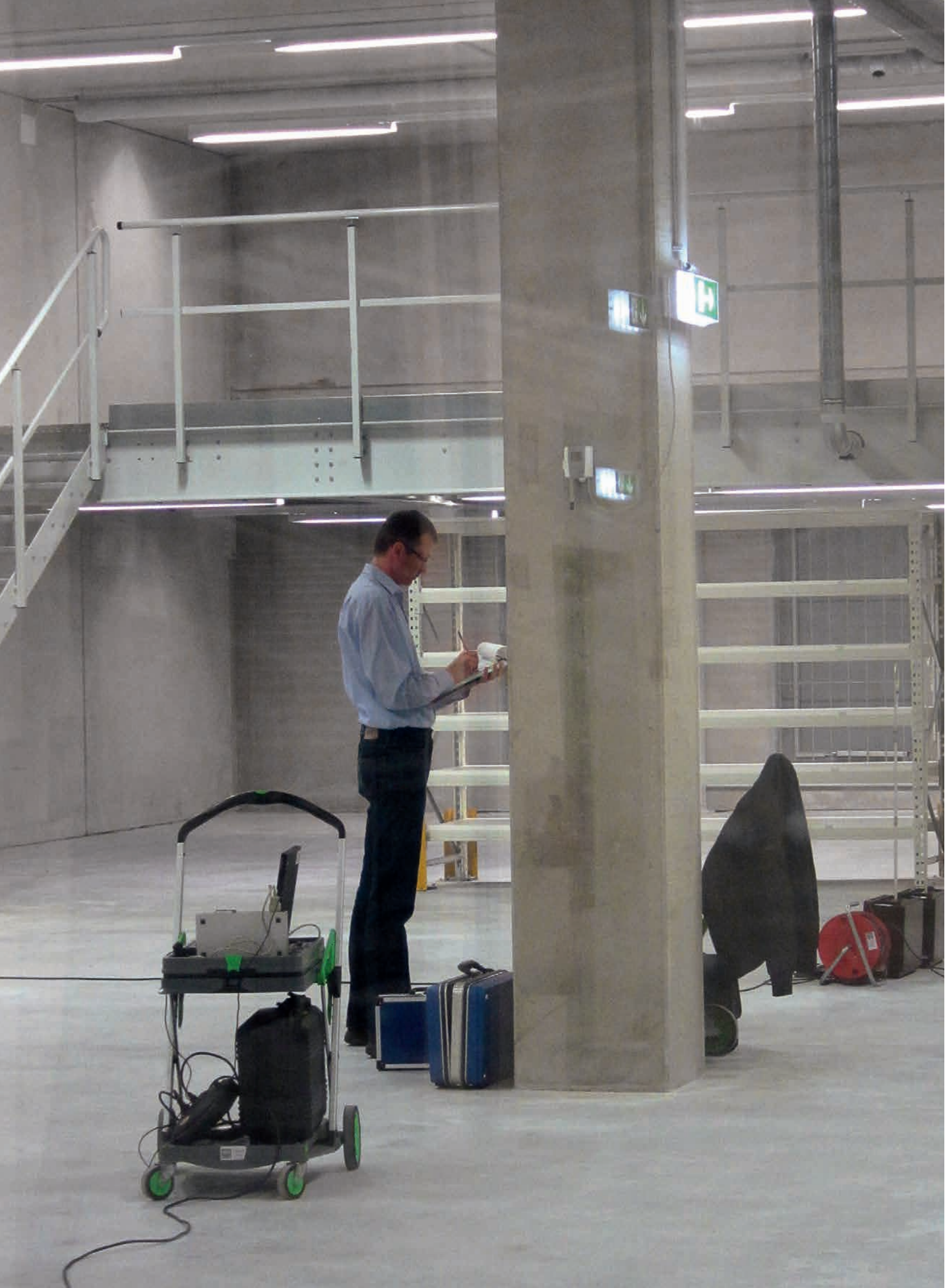
Additionally, new storage systems and the facilities for different object groups are presented. Specially developed features such as cantilever storage racks, a large cabinet with shelving, portable boxes for mannequins, and a standardised cabinet system with variable internal configurations are described in greater detail.

ZUSAMMENFASSUNG

Der Bau des neuen Zentraldepots ermöglicht für die Kaiserliche Wagenburg Wien und das ihr angeschlossene Monturdepot optimale Lagerbedingungen unter konservatorisch einwandfreien Voraussetzungen und bietet den lange benötigten Raum für Zuwachs. Durch die Ende 2011 und Anfang 2012 durchgeführten Übersiedelungskampagnen konnten die überfüllten Depots der beiden Sammlungen an ihren Standorten entlastet werden. Die neu entstandenen Depotflächen ermöglichen erstmals auch die Sichtung, Erfassung und Dokumentation von großformatigen Objekten.

Der Beitrag befasst sich zunächst mit der zweijährigen Vorbereitung und der darauffolgenden Durchführung der Übersiedelung der Objekte von drei unterschiedlichen Standorten: dem aufgelösten Depot in Inzersdorf, dem Monturdepot in der Hofburg sowie der Wagenburg in Schönbrunn. Aufgezeigt werden auch verschiedene Verpackungslösungen für den Transport und es werden notwendige Vorarbeiten wie die Reinigung und Stickstoffbehandlung der Objekte beschrieben.

Weiters werden die neue Lagertechnik sowie die Einrichtung für die unterschiedlichen Objektgruppen vorgestellt. Speziell konzipierte Ausführungen wie ein stützenfreies Kragarmregal, ein Großtablarschrank, fahrbare Figurinenboxen und ein Standard-Ausstattungs-Schranksystem mit variabler Innenausstattung werden näher vorgestellt.



Monitoring Air Pollution Levels as a Preventive Conservation Measure

Introduction and Initial Experiences in the Central Storage Facility

Christina Schaaf-Fundneider and Martina Griesser

Translated from the German by Aimée Ducey-Gessner

1. INTRODUCTION

Upon completion of the newly constructed central storage facility, the Conservation Science Department of the Kunsthistorisches Museum Vienna had the opportunity to observe the evolution of the concentration of selected air pollutants and groups of pollutants from the outset. While preparing the air pollution monitoring system, the authors had to access for the most part English-language literature and sometimes even unpublished manuscripts in order to gain an overview of the common pollutants in the museum environment and their threshold values. The current state of research into pollutants will be discussed first, drawing upon a quotation from Andreas Burmester, followed by presentation of the detailed results of the measurements carried out in the storage facility up until this time.

Andreas Burmester defined preventive conservation as follows: "Preventive conservation gathers a multitude of indirect interventions for the long-term preservation of cultural heritage, endeavouring to attain a holistic, interdisciplinary perspective on the complex of problems surrounding the preservation of cultural heritage. The creation of a suitable building envelope, improved climate, lighting, and air conditioning conditions, or the optimisation of transport processes contribute to the preservation of an entire collection or groups of collections in a sustainable manner. Careful analysis, assessment, and minimisation of all risk factors remain in the foreground. Preventive conservation is an effective and in the long term economical method that reduces direct intervention measures to a minimum. Preventive conservation endows everyone working with cultural heritage with a certain responsibility."[1]

Preventive conservation also encompasses risk management[2] and risk assessment,[3] which include the parameters specified in the quotation, but also grappling with additional possible risk factors that could present a danger to art and cultural heritage (for example, the building environment, impermeability of the building envelope, insect pests/IPM, mould, storage and presentation conditions, etc.), which, however, will not be addressed in this text. In summary, the

1 A. Burmester, *Es sind also alle die Gefahren: Vom Museumsbau, fauler Luft und Staub,* lecture in Osnaburg 14.03.2005, citation from the unpublished lecture manuscript defining the term preventive conservation, 4, http://www.doernerinstitut.de/de/mitarbeiter/publikationen_burmester.html (04.10.2015).

2 Risk management includes all activities that systematically identify, analyse, assess, monitor, and control risks. Source: http://de.wikipedia.org/wiki/Risikomanagement (04.10.2015).

3 "Risk assessment is a step in a risk management procedure. Risk assessment is the determination of the quantitative or qualitative value of risk related to a concrete situation and a recognised threat (also called hazard). Quantitative risk assessment requires calculations of two components of risk (R): the magnitude of the potential loss (L), and the probability (p) that the loss will occur." Source: http://en.wikipedia.org/wiki/Risk_assessment (04.10.2015).

parameters mentioned here are of daily concern for museums and collections and in the ideal situation are integrated into survey and analysis: the only way to a clear understanding of the whole. Capturing the complexity of this topic is complicated by numerous physical and chemical relationships and processes that are not easy to understand and whose vocabularies are often daunting.

"The complexity of this topic requires sound analysis and often external expertise – it is rare that a museum is able to deal with it on its own. The introduction of guidelines and threshold values is often discussed.[4] Taking into consideration the conservation, restoration, and financial criteria also is a fundamental requirement. The possibilities represented by metrological inspection are also questioned: the costs associated with it are often difficult to implement because the prevention of pollutants within the frame of preventive conservation is primarily an abstract problem, which is seldom clearly ascertainable or able to be perceived. To date no clear action plan has been developed for approaching the problems created by pollutants." [5]

This article provides a summary of the most well-known English and German technical publications dealing with air pollutants in museums whose collective knowledge is the result of over 27 years of research. The development of pollutant control and monitoring in the Kunsthistorisches Museum Vienna will also be presented with an emphasis on the first results from the new central storage facility. This text does not, however, presume to offer a complete summary of the results nor all of the relevant citations from the literature; the topic of air pollutants in museums is simply too extensive. Rather, a basic idea should be communicated and it should serve for colleagues as an introductory guide to daily museum operations.

2. POLLUTANT MONITORING IN MUSEUMS

As early as the mid-19th century, museum professionals were aware of the damaging effects on artworks caused by urban air pollution from industry and traffic.[6] In 1850, the adverse effects of soot and sulphur dioxide on paintings in the National Gallery in London were observed, resulting in the addition of glazing to the frames in order to protect the artworks.[7] The inclusion of these observations of the museum environment (including air quality) in their daily work routine and their documentation by restorers and conservators first emerges in the mid-20th century. Independent of this, several international organisations were founded, like IIC,[8] ICOM[9] and ICCROM.[10] From that time on, the question of air pollutants was introduced and discussed during congresses bringing together international groups of experts, leading to the internationalisation of local problems and issues.[11]

4 Guidelines are understood as a recommendation; threshold values on the other hand are generally understood as mandatory rules.
5 A. Schieweck, "Materialemissionen und Luftqualität in Museumsvitrinen – Schadstoffprävention im musealen Umfeld," in *Restauro,* 2011, no. 5, pp. 21–29.
6 See C. L. Eastlake – M. Faraday – W. Russell, *Report on the subject of the protection of the pictures in the National Gallery by glass, House of Commons, 24. May 1850,* pub. by: G. Thompson, *The Museum Environment,* 2nd ed. 1986, p. 130.
7 P. Hatchfield, *Pollutants in the Museum Environment. Practical Strategies for Problem Solving in Design, Exhibition and Storage* (Archetype Publications), London, 2002, p. 1.
8 International Institute for Conservation of Historic and Artistic Works (IIC), founded in 1950, http://www.iiconservation.org/.
9 International Council of Museums (ICOM), founded in 1946 in collaboration with UNESCO, http://icom.museum/.
10 International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), founded in 1959, http://www.iccrom.org/.
11 Thompson 1986 (cited note 6), Series Editor's Preface.

The maintenance of adequate climate control in museums, exhibition spaces, and storage areas has become a predominant concern of restorers and conservators over the last two decades. Alongside this trend, the detection of air pollutants and their effects on art and cultural heritage has also gained prominence in recent years as a central concern of restorers in German-speaking countries. Anglo-American and Scandinavian countries, however, have a clear lead in this area in terms of research and publications.[12] Scientists from many different disciplines (physicists, chemists, specialised conservators, i.a.) exchange information about the latest research on a regular basis during conferences.[13] In German-speaking regions, the staff of the Fraunhofer Institute for Wood Research – Wilhelm-Klauditz Institute WKI in Braunschweig should be featured (in particular Alexandra Schieweck and Tunga Salthammer) who, with their German-language publication *Schadstoffe in Museen, Bibliotheken und Archiven,* have made a highly valuable contribution to the literature.[14]

3. THE MOST SIGNIFICANT POLLUTANTS, THEIR SOURCES, EFFECTS ON ART AND CULTURAL HERITAGE, ALONG WITH THE RECOMMENDED REFERENCE VALUES

3.1 SOURCES OF POLLUTANTS

Outside air entering a building (through air ventilation systems and/or open windows) and its treatment for galleries and storage areas carries pollutants into the building – depending on the filtration system in use. Even construction and furnishing materials in the building itself (paint, varnish, sealants, floor coverings, etc.) and cleaning products emit pollutants. Human activities, it must be remembered, can also act as a source of pollutants in buildings (CO_2 and H_2S production during breathing, humidity, particles of dirt …).[15] Finally, pollutants are present within the material components of the artworks themselves, or can be generated by chemical reactions on the surface or in its structure through the interaction of the different substances – the latter is also referred to as "secondary pollutant formation".[16] The formation of secondary pollutants is slow: it can persist throughout the entire life cycle of a material.[17]

The pollutants and groups of pollutants introduced effect a change on the optical appearance of the materials and/or material compositions and lead to a weakening of their structure: corrosion, loss of stability, disintegration, and in extreme cases destruction of the object are the consequences.

12 C. Waller, *Reduzierung von Luftschadstoffen in Museen und Archiven*, http://www.cwaller.de/teil4.htm (04.10.2015).
13 The *Indoor Air Quality Meeting,* a conference addressing pollutants in museums and archives that takes place every two years (last meeting: 2014 in Prague).
14 A. Schieweck – T. Salthammer, *Schadstoffe in Museen, Bibliotheken und Archiven,* pub. by the Fraunhofer-Institut für Holzforschung – Wilhelm-Klauditz-Institut WKI, Brunswick, 2006.
15 Waller, *Reduzierung* (cited note 12).
16 J. Tétreault, *Agent of Deterioration: Pollutants*, http://www.cci-icc.gc.ca/resources-ressources/agentsofdeterioration-agentsdedeterioration/chap07-eng.aspx (04.10.2015).
17 P. Wolkoff – P. A. Nielsen, "How to evaluate VOC emissions from building products? A perspective," in *Proceedings of Healthy Buildings/IAQ 97*, Washington DC/USA, vol. 3, 1997, pp. 491–496; E. Uhde – T. Salthammer, "Impact of reaction products from building materials and furnishings on indoor air quality – A review of recent advances in indoor chemistry," in *Atmospheric Environment* 41, 2007, pp. 3111–3128.

The introduction of air pollutants can be divided into the following categories:[18]

- environmental factors (outside air, soil);
- human activities (breathing, sweating, physical activity);
- construction materials and furnishings;
- collection objects (inherent materials, conservation/restoration products) – the pollutant exists already as a part of the object or is formed on its surface or in its material structure by chemical reactions;
- pollutant exchange during contact between two materials.

Dry air consists mostly of nitrogen (N_2, 78.1 % vol.) and oxygen (O_2, 21 % vol.). A small fraction of inert gases[19] and carbon dioxide (CO_2) are also found. Depending on temperature and relative humidity, differing levels of water vapour are also present[20].

Pollutants can exist as gases, aerosols, liquids or particles (fine dust). The fine particles resting on an object can be strongly bound to the surface.[21] Gaseous substances (volatile organic compounds, VOCs) are adsorbed by the dust.[22] Along with the optically disruptive layer of dirt, the dust layers, which can also hold moisture, promote additional corrosion and degradation processes. Dust also serves as a nutrition source for insect pests and mould growth.

The most significant air pollutants in outside air (natural and human-produced sources) are:[23]

- sulphur dioxide (SO_2);
- carbonyl sulphide (COS);
- nitrogen dioxide (NO_2) and nitrogen oxides (NO_x);
- ozone (O_3);
- hydrogen sulphide (H_2S; also found in indoor air).

The most significant air pollutants in indoor air originate for the most part from construction materials: wall panelling, floor and cabinet materials, as well as cleaning products and are the following:[24]

- organic acids, for example, acetic acid or formic acid;
- formaldehyde (HCHO);
- ammonia (NH_3);
- solvent vapours, for example, different benzines, aromatics, alcohols, esters;
- hydrogen sulphide (H_2S; also present in outside air).

[18] Schieweck – Salthammer 2006 (cited note 14), 21; Tétreault, *Agent of Deterioration: Pollutants* (cited note 16).
[19] Inert gases, as their name says, normally do not react with other materials, and they can only participate in very few chemical reactions. Nitrogen and all of the noble gases (helium, neon, argon, krypton, xenon, and radon) are inert gases. Source: http://de.wikipedia.org/wiki/Inertgas (04.10.2015).
[20] Hatchfield 2002 (cited note 7), p. 6; Burmester 2005 (cited note 1).
[21] Tétreault, *Agent of Deterioration: Pollutants* (cited note 16).
[22] M. Eibl, "Die Reinigung musealer Räume als Maßnahme der Präventiven Konservierung, Teil 1 – Grundlagen der Verschmutzung und Reinigung," in *Zeitschrift für Konservierung und Kunsttechnologie,* 2009, p. 81.
[23] M. Grießer, lecture: *Aufbewahrungsbedingungen und Depotmaterialien,* Summer Academy for Collections Survey and Care, organised by the University of Applied Arts Vienna, Institute for Conservation and Restoration, Vienna, 15.–23.09.2007.
[24] Cited note 23.

3.2 UNITS

The specification of the concentration of air pollutants is usually given in parts per million [ppm], parts per billion [ppb], or in microgram/cubic meter [µg/m³].[25] The conversion from ppb into µg/m³ is dependent on temperature and air pressure.[26]

3.3 THE "KEY AIRBORNE POLLUTANTS"[27]

The "key" airborne pollutants associated with the preservation of art and cultural heritage are the organic acids (like acetic and formic acid), formaldehyde, ammonia, hydrogen sulphide and carbonyl sulphide, nitrogen oxides – above all nitrogen dioxide –, sulphur dioxide, and ozone. Furthermore, fine particles from various sources are an important consideration, primarily due to the fact that they can bind air pollutants and moisture to surfaces, just as water vapour plays an important role in preventive conservation. Water vapour can contribute to the deterioration of an object physically – through repeated uptake and release of water – as well as chemically by hydrolysis or by aiding degradation of the material, like corrosion. This will, however, only be discussed briefly.

3.3.1 ACETIC ACID (CH_3COOH), FORMIC ACID (HCOOH) AND FORMALDEHYDE (HCHO)

Organic acids, like acetic acid and formic acid, as the end product of the decay of organic substances as well as aldehydes are found to varying degrees in many showcases and storage cabinets, and especially in air-tight enclosures. They are released most often in indoor spaces when inappropriate products are used during installation (floor coverings, showcase construction, etc.).[28]

Wooden composite materials of all kinds and ages are damaging for sensitive museum objects. They release acetic acid, formic acid, and formaldehyde. Some tree species less (spruce, poplar), others more (chestnut, beech, birch, and in particular oak); fresh wood more than aged. Oak has been shown to have the highest emission rate of acetic acid. The amount of emitted volatile acids is related to the pH value of each type of wood. Wood with a pH value < 5 should not be used. The climate also plays a role in this context: higher relative humidity and temperature cause much more acid to be released.

Furthermore, products containing wood, like paper, paperboard, and cardboard, release acids and are therefore inappropriate for the storage of materials sensitive to acids. PVAc adhesives, acetic acid separating silicone resins, cellulose acetate (film, foil, etc.), varnishes, oil-based paints, household cleaners, and many other materials are further sources of organic acids. Formic acid is also

[25] Units: ppm; significance: number of molecules in a million (10^6) molecules of air (application: compounds in a gaseous state), conversion: 1 ppm = 10^3 ppb. Units: ppb; significance: number of molecules in a billion (10^9) molecules of air (application: compounds in a gaseous state), conversion: 1 ppb = 10^{-3} ppm. Units: µg/m³; significance: mass per unit volume (application: matter suspended in the atmosphere, aerosols, particulates/dust), conversion: µg/m³ = ppm × 40,9 (MW) = ppb × 0,0409 (MW). MW = molecular weight of the compound. See Schieweck – Salthammer 2006 (cited note 14), p. 2.
[26] Burmester 2005 (cited note 1).
[27] *Key Airborne Pollutants*, from Tétreault, *Agent of Deterioration: Pollutants* (cited note 16), and J. Tétreault, *Airborne Pollutants in Museums, Galleries and Archives: Risk Assessment, Control Strategies and Preservation Management,* published by the Canadian Conservation Institute, 2003; Waller, *Reduzierung* (cited note 12); Schieweck – Salthammer 2006 (cited note 14).
[28] Composite wood materials, adhesives, paint/varnish (especially oil-based), sealants/silicone, etc.

additionally produced by the oxidation of formaldehyde (see below) in the air or on surfaces. Along with organic materials, lead and other base metals react the most sensitively to organic acids. The corrosion of lead containing objects can be observed *en masse* where acetic acid containing wood or sealants for the construction of showcases or storage cabinets were used.

Formaldehyde is one of the most well-known air pollutants. Solid timber has been shown to contain small amounts of formaldehyde. It is released to a much greater degree by chipboard and medium-density fiberboard (MDF), which are bound with urea-formaldehyde resins. Today all engineered wood products (plywood, chipboard, and fiberboard) correspond to category E1 and are low in formaldehyde content. As a result, the average pollution in interior spaces is decreasing. As a rule, however, a residual content of the extremely reactive formaldehyde remains, which can form – in particular in well-sealed showcases – considerable concentrations of pollutants, constituting a risk for sensitive objects.

Other sources of formaldehyde include the finishing products used on textiles for different purposes or not completely hardened stoved enamel coatings. Formaldehyde is a strong reducing agent and reacts with cellulose and many other materials. It hardens, for example, organic binders and leather. Formaldehyde can, when catalysed by acids, bases, or metals, be oxidised into formic acid and as a result lead to acid-induced damage of lead and other metals. The concentration of formaldehyde can fluctuate with the season.[29]

3.3.2 AMMONIA (NH_3)

Compounds containing ammonia, the most significant alkaline component of indoor air, come primarily from the ingredients in cleaning products, but are also emitted during biological decay. They can also form in cooling systems (air-conditioning units), sewage systems, and metal polish, but only in small amounts.[30]

3.3.3 HYDROGEN SULPHIDE (H_2S) AND CARBONYL SULPHIDE (COS)

Hydrogen sulphide is a reduced sulphur gas with the associated typical smell of "rotten eggs". It can originate from natural organic decay or from industrial processes, the main sources of H_2S being the paper and petroleum industries. Beyond urban areas, hydrogen sulphide is emitted by the oceans, volcanoes, geothermal activity, marshlands, and vegetation. Inside buildings, perspiration and in particular, exhalation, of visitors and workers are often the primary sources of hydrogen sulphide. Furthermore, objects and interior materials emit sulphuric gases: wool, vulcanised and natural rubber, and polysulfide-based adhesives should be mentioned.[31]

H_2S is the main air pollutant that blackens silver and copper in a short period of time, even outside of urban areas. The darkening of lead white and lead white containing pigments in paintings is also caused by the presence of reduced sulphuric gases.

[29] Waller, *Reduzierung* (cited note 12).
[30] Schieweck – Salthammer 2006 (cited note 14), p. 28.
[31] Waller, *Reduzierung* (cited note 12); Schieweck – Salthammer 2006 (cited note 14).

Another sulphuric compound found in the atmosphere that should not be neglected is carbonyl sulphide (COS), a product of combustion processes. This is a highly stable gas that plays a significant role in corrosion. Carbonyl sulphide is equally present in the air in urban and rural areas. The concentrations in indoor and outside air are practically the same; they remain, however, as a rule clearly higher than that of H_2S. Furthermore, COS can become hydrogen sulphide in the presence of water.[32]

3.3.4 NITROGEN OXIDES (NO_X), NITROGEN DIOXIDE (NO_2)

Nitrogen oxides (NO_x) are the gaseous oxides of nitrogen, the principal forms being nitrogen monoxide (NO) and nitrogen dioxide (NO_2). Nitrogen oxides form at high temperatures, for example, in combustion motors or during dielectric breakdown. Indoors, gas stoves can function as a source of pollutants. Nitrogen oxides also evaporate during the decay of cellulose nitrate that was used in film and is also sometimes found in contemporary objects, which in turn can then serve as a primary source of pollutants.[33]

Nitrogen dioxide represents the greatest danger to objects because it is very difficult to remove it from outside air (e.g., with filtration), it degrades very slowly once inside a building, and forms nitric acid (HNO_3; a strong acid) in the presence of moisture.[34]

3.3.5 SULPHUR DIOXIDE (SO_2)[35]

Sulphur dioxide (SO_2) is formed primarily by the combustion of fossil fuels like coal and heating oil. The concentration of SO_2 in closed interiors is noticeably lower than in outside air because it is quickly absorbed by many surfaces, especially fresh plaster, and can be effectively removed with the corresponding filtration system. SO_2 itself is weakly acidic, however, it oxidises further into sulphur trioxide (SO_3) and then reacts with humidity to become sulphuric acid (H_2SO_4; also a strong acid).[36] Protein-based substances, rubber vulcanised with sulphur, and the oxidising sulphides found in geological materials and individual colourants serve also as sources of sulphuric compounds. Sulphur dioxide causes the corrosion of copper, the fading of certain colourants, and the deterioration of vegetable-tanned leather. Together with the nitrogen oxides, it is also responsible for the acidification of paper.

[32] Schieweck – Salthammer 2006 (cited note 14).
[33] Waller, *Reduzierung* (cited note 12); Schieweck – Salthammer 2006 (cited note 14); M. Ryhl-Svendsen, "Luftschadstoffe in Museen – Eine Einführung in Wirkungsweise, Monitoring und Kontrolle," in *Restauro,* 2001, no. 8, pp. 613–619.
[34] Waller, *Reduzierung* (cited note 12).
[35] Tétreault, *Agent of Deterioration: Pollutants* (cited note 16).
[36] S. Hackney, "The distribution of gaseous air pollution within museums," in *Studies in Conservation,* vol. 29, no. 3, 1984, pp. 105–116; Schieweck – Salthammer 2006 (cited note 14); Waller, *Reduzierung* (cited note 12).

3.3.6 OZONE (O_3)

Ozone (O_3) is found not only in the upper atmosphere; it is also a photochemical reaction product of nitrogen oxides from motor vehicle exhaust and hydrocarbons (summer smog). Furthermore, it can be emitted by electric devices like photocopiers and some lamps, which however, are generally outfitted with ozone absorbers. The concentration of ozone is usually much lower in indoor spaces than it is in outside air because ozone reacts quickly with organic materials; it is quickly broken down, primarily through reaction with unsaturated hydrocarbons. The resulting reaction products, like organic acids, aldehydes, and ketones, are in turn also air pollutants.[37]

The primary damages incurred by ozone are the degradation of natural vulcanised rubber and colour changes in some pigments.

3.3.7 OTHER VOLATILE ORGANIC COMPOUNDS AND SEMI-VOLATILE ORGANIC COMPOUNDS (VOC AND SVOC)

"Volatile organic compounds (VOC) comprise the most important component of indoor air pollution and are the primary object when inspecting interior spaces for pollution. The World Health Organisation (WHO) classifies organic air pollutants according to the boiling point range of the individual compounds"[38] *(table 1)*.

Table 1: Classification of volatile organic compounds according to boiling range.[39]

Abbreviation	Name	Boiling Range [ºC]
VVOC	Very Volatile Organic Compound	0 – 50/100
VOC	Volatile Organic Compound	50/100 – 240/260
SVOC	Semi-Volatile Organic Compound	240/260 – 380/400
POM	Particulate Organic Matter	>380

The VOCs most commonly detected in interior spaces are solvents that originate primarily from construction materials and furnishings. They span typical industrial chemicals *(table 2)* that are used in paints, finishes, floor coverings, and cleaning maintenance products *(table 3)*. After renovation and sanitation projects, a higher proportion of these substances is often found in the air. There are in addition secondary products from incomplete combustion processes. Furthermore, museum interiors may also contain emissions from the materials of the art objects themselves as well as from the conservation treatment of those objects.[40]

The solvents and additives in paints, coatings, and sealants contain VOCs that are also released in new showcases, which under some conditions – for example, in essentially air-tight showcases – can react, thereby also possibly leading to the production of secondary compounds. One example of this phenomenon is the splitting of acetic acid esters from coatings causing the release of acetic acid.[41]

[37] Schieweck – Salthammer 2006 (cited note 14); Waller, *Reduzierung* (cited note 12).
[38] Schieweck – Salthammer 2006 (cited note 14), p. 30.
[39] Eibl 2009 (cited note 22), p. 81.
[40] Schieweck – Salthammer 2006 (cited note 14), p. 30.
[41] Waller, *Reduzierung* (cited note 12).

Table 2: Sources of volatile organic compounds (VOC). (Translated from Salthammer 2000.[42])

typical industrial chemicals	aliphatic hydrocarbons aromatic hydrocarbons alcohols ketones esters glycols/glycol ethers
"reactive" volatile organic compounds and "reaction products"	unsaturated hydrocarbons terpenes aldehydes organic acids acrylic monomers diisocyanate monomers

Table 3: Compounds in indoor air and their sources. (Translated from Salthammer 1994; Moriske – Beuermann 2004.[43])

Compound	Source
acrylates	paints, finishes
aliphatic aldehydes (C1 – C4)	alkyd resins
alkanes, mineral spirits	carpeting, wallpaper
alkaline aerosols	concrete, mortar, plaster
alkyd resins, unsaturated fatty acids	linoleum
alkylated benzene	paints, adhesives, finishes
amines	finishes, carpeting
asbestos	construction materials, outside air
benzaldehyde derivatives	fission products from photo-initiators
benzene	gasoline, combustion exhaust
diisocyanates	finishes, PUR foams
formaldehyde	timber products, finishes
halogenated hydrocarbons	paint stripper
carbon dioxide (CO_2)	open flames, human metabolism
carbon monoxide (CO)	outside air, tobacco smoke, combustion processes
man-made mineral fibres	construction materials
synthetics: plasticisers, flame retardants, etc.	wall, ceiling, and floor coverings
microbial contamination	moisture damage, human activities, air humidifiers, air-conditioning units, outside air
organic solvents	paints, adhesives, finishes, and cleaning products
organic acids	timber products
PAHs (polycyclic aromatic hydrocarbons)	combustion processes, tar-containing products (carbolineum)
pentachlorophenol (PCP), lindane	wood preservatives
pesticides	cleaning and sealant products, pest control products
phenols	adhesives, cork products
polychlorinated biphenyls (PCB)	fluorescent tubes, transformers
phthalic acid esters (plasticisers)	carpeting, PVC materials
airborne particles	outside air, construction activity, tobacco smoke, combustion processes
dust deposits	combustion processes, construction activity, outside air, human activities
heavy metals	paints, finishes, outside air, tobacco smoke
sulphur dioxide (SO_2)	outside air, textile decolourants, combustion processes
nitrogen dioxide (NO_2)	outside air, combustion processes
styrene	finishes, carpeting, insulation material
terpenes	wood, cleaning products, fragrances
vinyl acetate	floor coverings
vinyl chloride	PVC materials
"other contaminants" (electric smog)	cell phone towers, electric installations, electric and electronic devices

[42] Schieweck – Salthammer 2006 (cited note 14), p. 21. From: T. Salthammer, "Verunreinigung der Innenraumluft durch reaktive Substanzen. Nachweis und Bedeutung von Sekundärprodukten," in H.-J. Moriske – E. Turowski (eds.), *Handbuch für Bioklima und Lufthygiene,* Landsberg, 2000, Chapter III 6.4.2, pp. 1–16.
[43] Schieweck – Salthammer 2006 (cited note 14), p. 23. From: T. Salthammer, "Luftverunreinigende organische Substanzen in Innenräumen," in *Chemie in unserer Zeit* 28, 1994, pp. 280–290; H.-J. Moriske – R. Beuermann, *Schadstoffe in Wohnungen: Hygienische Bedeutung und rechtliche Konsequenzen (Das Grundeigentum),* Berlin-Reinickendorf, 2004.

Plasticisers, whose addition increase the elasticity of brittle synthetic materials or finishes, and which are often used in textile finishing products, are considered a semi-volatile compound. These so-called phthalates are contained in products and art objects made from soft PVC (polyvinyl chloride). The plasticisers travel to the surface over time, evaporate, or are transferred to other objects should they come into contact. Various pesticides and biocides, for example, wood preservatives, which were often used in the 20th century to terminate insect pests in wooden objects, are semi-volatile organic compounds. Although it is intended that these products remain in the objects, they can with time be released into the environment from the object's surface.[44]

3.3.8 DUST

Dust is the accumulation of particles in a visible layer on surfaces that are normally always present in the air. The particle size can vary greatly, from coarse (particle size > 10 µm), fine (particle size < 10 µm), and ultrafine (particle size < 0.1 µm), as well as the composition. Particles in outside air originate primarily from industrial processes and during the combustion of fossil fuels, penetrating to differing degrees into buildings' interiors: depending on how well the building is sealed and its air filtration system. Visitors to museums and collections are an additional source of dust in the form of dirt from the street, fibres, flakes of skin, and hairs, also causing the dust to move around in the rooms. During construction projects, dust containing limestone, plaster, brick dust, wood and metal is released.[45]

4. EFFECTS OF POLLUTANTS ON ART AND CULTURAL HERITAGE

Christoph Waller's website[46] provides a good overview of the effects of pollutants in the museum setting. Among the most sensitive groups of materials are:

- organic materials (paper, textiles, leather, etc.);
- materials containing limestone;
- glass and enamel;
- metals (above all base metals like lead, zinc, and iron along with copper and copper alloys; silver above all for H_2S and COS); as well as
- some pigments and colourants.

Table 4 provides an overview of the air pollutants described in section 3.3 and their damage to sensitive groups of materials.

Table 4: Known effects on artworks caused by air pollutants. (Translation based on Bear – Banks 1985; Brimblecome 1990; Pietsch 1994.[47])

Pollutant	Material	Damage
ozone (O_3)	rubber metals textile colourants photographic materials paper, textiles	embrittlement corrosion fading degradation loss of stability
nitrogen oxides (NO_x)	rubber photographic materials, plastic, metals	embrittlement degradation
sulphuric dioxide (SO_2)	metals colourants, dyes, photographic materials, leather, paper, textiles inorganic materials (e.g., glass, stone, lime plaster, frescos) organic materials (e.g., cellulose, proteins, plant fibres)	tarnishing degradation, embrittlement corrosion colour shift
hydrogen sulphide (H_2S)	metals colourants lead pigments photographic materials	tarnishing deterioration blackening degradation
formaldehyde (HCHO)	paper, metal oxide pigments, leather, parchment, wool, silk	deterioration, discolouration, embrittlement
formic acid (HCOOH)	metals, calciferous materials, paper, textiles	corrosion
acetic acid (CH_3COOH)	proteinaceous materials	corrosion
hydrogen peroxide (H_2O_2)	iron photographic materials	corrosion colour shift
ammonia (NH_3)	metals	corrosion, tarnishing

4.1 RECOMMENDED REFERENCE VALUES FOR GASEOUS POLLUTANTS[48]

Despite many attempts in the museum sector to set international guidelines for the concentration of pollutants, the complexity of atmospheric chemistry and the multiple possible interactions of pollutants with each other and reactive surfaces has led to several large museums establishing their own standards.

Jean Tétreault developed an assessment model that is relatively widespread primarily in the Anglo-American community: the hazardousness of an air pollutant for different groups of materials is determined according to the values in NOAEL (no observed adverse effect level), LOAEL (lowest observed adverse effect level), or LOAED (lowest observed adverse effect dose) *(table 5)*.[49] Since the stated values are based on observations that were determined under differing conditions and with differing methods, comparison among them proves difficult. The connection with real – complex – situations is also not necessarily simple to derive because normally only the mechanism of single components or simple mixtures of substances were investigated.[50] The values provided in the different publications can therefore only be understood as indicative and not as fixed guidelines.[51]

44 Waller, *Reduzierung* (cited note 12).
45 Hatchfield 2002 (cited note 7); Schieweck – Salthammer 2006 (cited note 14); Waller, *Reduzierung* (cited note 12).
46 Waller, *Reduzierung* (cited note 12).
47 A. Schieweck, *Airborne Pollutants in Museum Showcases – material emissions, influences, impact on artworks*, diss. Hochschule für Bildende Künste Dresden, 2009, p. 9. From: N. S. Bears – P. N. Banks, "Indoor air pollution: effects on cultural and historical materials," in *The International Journal of Museum Management and Curatorship* 4, 1985, pp. 9–20; P. Brimblecombe, "The composition of museum atmospheres," in: *Atmospheric Environment* 24B (1), 1990, pp. 1–8; A. Pietsch, "Vitrinenwerkstoffe und ihre Gefahren für Museumsobjekte," in A. W. Biermann (ed.), *Der Ausstellungsraum im Ausstellungsraum – Moderne Vitrinentechnik für Museen* (Schriftenreihe des Rheinischen Museumsamtes, no. 59), Landschaftsverband Rheinland, Rheinisches Museumsamt/Bildungsstätte für Museumspersonal, Cologne, 1994.
48 Waller, *Reduzierung* (cited note 12); J. Tétreault, *Guidelines for Pollutant Concentrations in Museums*, in *CCI Newsletter* 31, 2003, pp. 3–5; A. Schieweck, "Schadstoffe in musealen Einrichtungen – Historie und aktueller Forschungsstand," in *Preventive Conservation – Beiträge des Workshops Preventive Conservation on March 1st 2007 at the Fachhochschule für Technik und Wirtschaft Berlin,* Munich, 2007, pp. 45–52.
49 Tétreault 2003 (cited note 27); Tétreault, *Guidelines* (cited note 48).
50 Schieweck – Salthammer 2006 (cited note 14).
51 Tétreault, *Guidelines* (cited note 48); C. M. Grzywacz, *Monitoring for Gaseous Pollutants in Museum Environments,* The Getty Conservation Institute, Los Angeles, 2006.

Table 5: Guidelines for air pollutants. (From Tétreault 2003, Table 2.[52])

Key air pollutants	Maximum average concentration for indicated preservation targets, µg/m³ (ppb)[a]			Reference average concentration range, µg/m³	
	1 year	10 years	100 years	clean low troposphere	urban area
acetic acid	1,000 (400)	100	100	0.3–5	0.5–20[b]
hydrogen sulphide	1 (0.71)	0.1	0.01	0.01–1	0.02–1
nitrogen dioxide	10 (5.2)	1	0.1	0.2–20	3–200
ozone	10 (5.0)	1	0.1	2–200	20–300
sulphur dioxide	10 (3.8)	1	0.1	0.1–30	6–100
fine particles ($PM_{2.5}$)	10	1	0.1	1–30	1–100
water vapour	keep below 60 %RH[c]			N/A	

notes :
[a] Preservation target is the length of time (in years) for which the objects can be exposed to the indicated level of pollutants with minimal risk of deterioration. These targets are based on the LOAED of most objects (exclude high risk objects) and assume that average RH is kept between 50 and 60 %, temperature ranges between 20 and 30 °C, and the collection is kept clean (if not, the maximum levels of key airborne pollutants for each class of targets may need to be readjusted). These values are not applicable to high risk materials – ppb means parts per billion.
[b] Acetic acid levels can be emitted to levels as high as 10,000 µg/m³ in enclosures made with inappropriate materials, such as fresh acid-cured silicone.
[c] For permanent collections where the RH has not been kept between 50 and 60 %, maintain the historical conditions.

5. CONTROLLING AIR POLLUTANTS IN THE KUNSTHISTORISCHES MUSEUM VIENNA

5.1 DEVELOPING AN APPROACH TO POLLUTANTS IN THE KHM

Before the establishment of the Conservation Science Department in the Kunsthistorisches Museum Vienna in 1996, hardly any data about pollutants in the collections' environment had been collected. Only in exceptional cases, for example, in the context of an EU initiative at the end of the 1990s,[53] were individual areas in the museum investigated with respect to selected pollutants. This study revealed that parts of the Picture Gallery that were equipped with an air-conditioning system lacking sufficient filters for pollutants contained a higher concentration of NO_2 originating from outside air than in museum areas with natural ventilation. In 2005–2006 the concentration of the outdoor air pollutants NO_2, NO_x, SO_2, and Ozone were investigated one more time in two paintings' galleries during an attempt to improve climate control. While SO_2 can be almost completely removed from air intake by air washers, in the best case it is only possible to reduce the load of NO_2 and NO_x by about one half.[54]

[52] Tétreault, *Agent of Deterioration: Pollutants* (cited note 16).
[53] D. Camuffo – R. Van Grieken – H.-J. Busse – G. Sturaro – A. Valentino – A. Bernardi – N. Blades – D. Shooter – K. Gysels – F. Deutsch – M. Wieser – O. Kim – U. Ulrych, "Environmental monitoring in four European museums," in *Atmospheric Environment* 35, Supplement no. 1, 2001, pp. 127–140.
[54] The investigations were carried out in collaboration with Franco Desantis and Francesca Vichi from CNR – Istituto sull'Inquinamento Atmosferico, Rome.

At the end of the 1990s the first attempt to explain corrosion phenomena on coins in the Coin Collection was undertaken. In collaboration with the Getty Conservation Institute, A–D strips (acid detection strips) were used to investigate the acidic atmosphere inside the historic storage cabinets made out of oak.[55] Along with the wooden cabinets, slips of paper (already yellowed) stored under the objects, photographs, and plaster casts could be identified as further sources of pollutants that had led to corrosion of sensitive objects. In the following 10 to 15 years, several projects were carried out by the Coin Collection in collaboration with the Conservation Science Department to investigate the appearance of corrosion and to improve storage conditions. Additional investigations of the acidic atmosphere in the cabinets were performed with glass sensors from the Fraunhofer Institute for Silicate Research.[56] The partial replacement of wooden storage cabinets with metal ones, as the budget allowed, was one of the most comprehensive measures taken. A nitrogen purged storage cabinet could even be acquired for particularly sensitive objects.[57]

In order to prevent the introduction of pollutants in exhibition showcases by their own materials, such as panelling, finishes, sealants, textiles, etc., the Oddy-test, developed by Andrew Oddy in the British Museum as a simple material test for museums, was implemented in 1999 by the Conservation Science Department.[58] With moderate success at the beginning, and later with increasing benefits, as many materials as possible used in the special exhibitions and most of the permanent exhibitions have been tested and replaced as needed

[55] These investigations were carried out in collaboration with Alberto de Tagle and Cecily Grzywacz from the Getty Conservation Institute and Manfred Schreiner from the Academy of Fine Arts Vienna. A–D strips were developed by the Image Permanence Institute in order to track the deterioration of acetate films ("vinegar syndrome") in film archives. They are dye-coated paper strips that change colour in an acidic environment, and are useful as a quick test for acidic conditions in showcases or storage cabinets. A–D strips can be ordered from Long Life for Art, Christoph Waller, Hauptstr. 47, D–79356 Eichstetten, www.cwaller.de, e-mail: info@llfa.de (04.10.2015).
[56] The original glass sensors designed at the Fraunhofer Institute for Silicate Research, Bronnbach, are today referred to as glass dosimeters. They test the corrosion potential of the atmosphere in different locations and are often used in the art and cultural heritage sector. They can be obtained from the Fraunhofer Institute for Silicate Research ISC, Außenstelle Bronnbach, Frau Gabriele Maas, Bronnbach 28, D–97877 Wertheim/Bronnbach, www.isc.fraunhofer.de/vertrieb, e-mail: gabriele.maas@isc.fraunhofer.de (04.10.2015).
[57] M. Griesser – R. Traum – K. E. Mayerhofer – K. Piplits – R. Denk – H. Winter, "Brown spot corrosion on historic gold coins and medals," in *Proceedings of the 18th International Conference on Surface Modification Technologies (SMT 18), Dijon, France, 15th–17th November 2004. Surface Engineering*, vol. 21, nos. 5–6, 2005, pp. 385–392; R. Traum – M. Grießer, "Naturwissenschaftliche Untersuchungen und restauratorische Behandlung korrosionsbefallener Goldmünzen und -medaillen," in *Technologische Studien Kunsthistorisches Museum. Korrosion an Goldmünzen und Medaillen. Sonderband Numismatik*, vol. 3, 2006, pp. 106–153; M. Griesser – R. Traum – K. Vondrovec – P. Vontobel – E. H. Lehmann, *Application of X-Ray and Neutron Tomography to Study Antique Greek Bronze Coins with a High Lead Content. IOP Conference Series: Materials Science and Engineering*, vol. 37, 2012, 012011, online: doi:10.1088/1757-899X/37/1/012011; M. Griesser – R. Traum – K. Vondrovec, "Korrosionserscheinungen an antiken Bronzemünzen," in M. Alram – H. Emmerig – R. Harreiter (eds.), *Akten des 5. Österreichischen Numismatikertages, Enns, 21. – 22. Juni 2012. Forschungen in Lauriacum*, vol. 15, Linz, 2014, pp. 55–66.
[58] For execution of the test see L. R. Lee – D. Thickett, *Selection of Materials for the Storage or Display of Museum Objects (British Museum Occasional Paper 111)*, London, 1996. For materials in the museum environment see S. Kalabis, "Schadstofffreie Materialien für Ausstellung, Deponierung und Transport von Kunstwerken," in *Restaurierung und Konservierung – Ein Praxisleitfaden*, published by Verbund Oberösterreichischer Museen, Leonding, 2011, pp. 12–16.

with more appropriate materials. Over time, the material tests have also been applied to materials found in the storage areas and finally for furnishing the new central storage facility, including the tools and materials used during relocation of the objects.

In collaboration with external analytical laboratories, usually at the Vienna University of Technology,[59] isolated pollutants in showcases were investigated after the turn of the millennium. The old furnishings of the Collection of Sculpture and Decorative Arts (Kunstkammer) before its closing in 2002, the Imperial Treasury in 2008, and storage cabinets, like those of the Imperial Carriage Museum, in Schönbrunn, were tested. Unsurprisingly, old wooden showcases and wooden composite panels showed increased levels of acetic acid and formic acid – sometimes at very high levels. Proof of sulphur-containing contaminants in the lacquered metal storage cabinets in the Imperial Carriage Museum, which in a related test led to the rapid tarnishing of silver, could, however, not be produced.

The problem of pollutants in showcases was comprehensively addressed for the first time in the context of the new installation of the Kunstkammer, which consists of a series of sealed showcases. Since pollutants enclosed in sealed showcases can have catastrophic effects on the preservation of objects due to the lack of air circulation, the newly-constructed showcases were spot checked for pollutants by BAM (Bundesanstalt für Materialforschung, Berlin).

The plan for the new central storage facility in Himberg provided the KHM for the first time with the opportunity to test the structure for pollutants from the outset and to establish a pollutant monitoring system from the beginning.

5.2 IMPLEMENTATION OF POLLUTANT MONITORING IN THE NEW CENTRAL STORAGE FACILITY IN HIMBERG

The construction of the KHM's new storage facility provided the unique opportunity to track pollutant emission trends in an empty building envelope up until its furnishing with the latest products and equipment. The necessity and feasibility of a pollutant monitoring system was discussed right from the start during the planning phase of the storage facility for the KHM, the Weltmuseum Wien and the Theatre Museum. Discussions with internal and external colleagues confirmed the need for a system that should begin as soon as possible after the sealing of the building envelope.

The procedure originally planned for the initial pollutant assessment in the still empty storage facility and the repetition of air sampling after it had been equipped with storage furnishings could not be carried out exactly in this way because completion of the spaces overlapped with their furnishing. It was still possible, however, to test the spaces with a mezzanine (intermediary steel platform) and furnishings already in place before bringing in the first objects. This served to establish comparison values for later measurements *(fig. 1)* and to evaluate the Oddy-tests carried out beforehand on all materials used for coating the storage

[59] The pollutant measurements were carried out by the working groups of Dr. Anne Kasper-Giebl and Dr. Erwin Rosenberg, Vienna University of Technology, Institute of Chemical Technologies and Analytics, Getreidemarkt 9, 1060 Vienna.

Fig. 1: First air pollutant measurement carried out by IBO Innenraumanalytik OG in August 2011; view of the storage area on F1, Imperial Carriage Museum/Court Wardrobe with mezzanine (intermediary steel platform) during indoor air sampling.

Fig. 2: Regular monitoring of VOCs with the handheld VOC measurement device ppbRAE 3000, here in the storage area for the Collection of Greek and Roman Antiquities.

equipment, for permanent storage systems, and the packing materials used during the move. With the exception of the wooden Euro-pallets, all materials in use should have withstood the test with the result "appropriate for permanent storage;" materials that emit corrosive pollutants should have been immediately excluded.

Pollutants inside the storage space (without objects) could originate either from the coated particle board (class E1, i.e., low formaldehyde content) used in the mezzanine and/or unknown additives in the construction materials, or from the ventilation unit bringing in outside air. In August 2011, about a month after inauguration of the building, the Conservation Science Department was able to begin assessment of air pollutants using various measurement methods.

5.2.1 CONTINUOUS MONITORING OF VOLATILE ORGANIC COMPOUNDS (VOCS)

The first step began at the end of August 2011. A handheld measurement device[60] for VOCs, which the Conservation Science Department was gratefully able to borrow from Dr. Matija Strlic[61] at the Centre for Sustainable Heritage, University College London, was used to track the concentration of VOCs inside the new building. Pollutant monitoring was undertaken at 35 measuring points on every floor of the building *(table 6)* in two to four week intervals. From the outset until January 2012 the loaned device was used; subsequently until April 2012 (at this time most artworks were already stored in the new facility) a device belonging to the museum of the same manufacture (ppbRAE 3000) was used *(figs. 2 and 3)*.

[60] ppbRAE 3000, RAE Systems, Inc.
[61] Senior Lecturer in Sustainable Heritage, University College London, The Bartlett School of Graduate Studies, Centre for Sustainable Heritage.

Table 6: List of measuring points for the pollutant monitoring system in the storage areas (handheld VOC device ppbRAE 3000). MF … main floor, ME … mezzanine.

Measuring point number	Storage area
1	Ground Floor (GF), vestibule of truck unloading dock
2	GF, multifunction room
3	GF, unpacking zone
4	GF, anoxic nitrogen treatment chamber
5	GF, Picture Gallery
6	GF, Collection of Greek and Roman Antiquities
7	GF, vestibule of stairway 2
8	GF, elevator entrance area
9	GF, packing room
10	GF, post-nitrogen treatment area
11	First Floor (F1), laboratory
12	F1, workshop 3
13	F1, workshop 2
14	F1, workshop 1
15	F1, entrance area to workshops
16	F1, photography studio
17	F1, Imperial Carriage Museum/Court Wardrobe
18	F1, Collection of Greek and Roman Antiquities (MF)
19	F1, Collection of Greek and Roman Antiquities (MF), climate box
20	F1, Theatre Museum (MF)
21	F1, Theatre Museum (ME)
22	F1, stairwell
23	inside elevator
24	Second Floor (F2), Picture Gallery (MF)
25	F2, Coin Collection (MF), climate box
26	F2, Collection of Historic Musical Instruments (ME)
27	F2, general storage (MF)
28	F2, (ME)
29	F2, stairwell 2
30	Third Floor (F3), Near Eastern and Egyptian Collection (MF)
31	F3, Kunstkammer (MF)
32	F3, Theatre Museum (ME)
33	F3, Kunstkammer-Tapestries
34	F3, Imperial Carriage Museum/Court Wardrobe (ME)
35	F3, stairwell 2

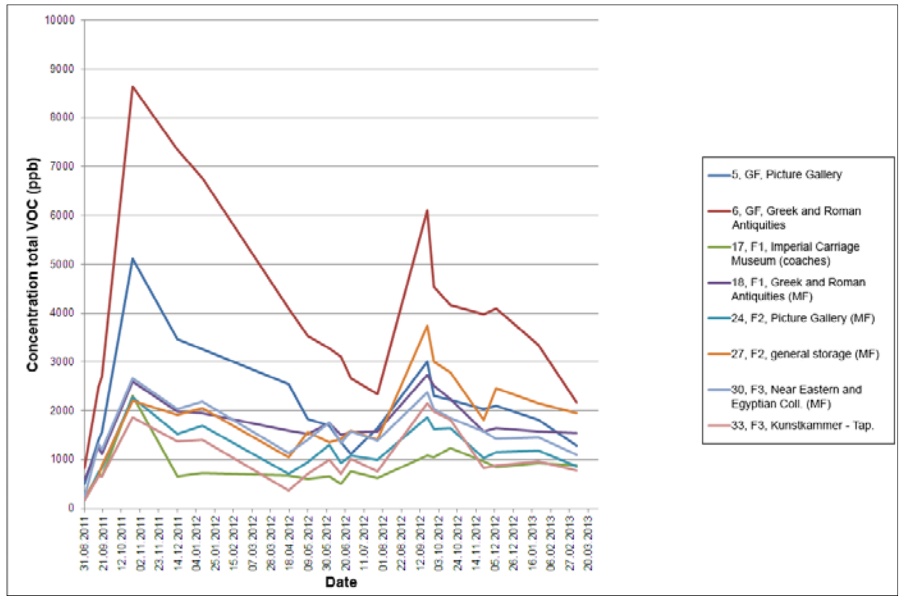


Fig. 3: Development of the total concentration of VOCs in the storage facility measured between August 31st, 2011 and March 7th, 2013: the increase of VOC concentrations is clearly recognisable while the collections (and their packing materials) were being moved into the storage areas shown here, followed by decreasing levels.

Very low background levels of VOCs in the magnitude of ca. 150 – 200 ppb *(table 7)* were measured in the completed but still empty spaces. The publication by Cecily Grzywacz, *Monitoring for Gaseous Pollutants in Museum Environments,*[62] can be used as a reference for the comparison of assessments of air quality. This book states that, in general, values under 100 ppb of pollutant concentration in museum collections are desirable. Although this level was slightly exceeded in the areas that contained only storage furnishings and equipment, it still remained at the lower end of the section following the one stated "ideal range" in the above cited reference publication, titled "action limits," which specified 700 ppb as a high VOC concentration value.

Table 7: Overview of the VOC background levels (ppb) measured with the ppbRAE 3000 on August 31st, 2011 in the newly-completed areas of the storage facility. MF … main floor, ME … mezzanine.

Storage Area	VOC Concentration (ppb)
First Floor, Imperial Carriage Museum/Court Wardrobe	190
Second Floor, Picture Gallery (MF)	155
Second Floor, general storage (MF)	220
Second Floor, (ME)	280
Third Floor, Near Eastern and Egyptian Collection (MF)	230
Third Floor, Kunstkammer (MF)	230
Third Floor, Theatre Museum (ME)	250
Third Floor, Kunstkammer-Tapestries	155
Third Floor, Imperial Carriage Museum/Court Wardrobe (ME)	200

Continuation of measurements in the areas already filled with collection objects exhibited a clear increase in the level of VOCs *(see fig. 3)*. Immediately during the moving in of objects (and all storage materials) and shortly thereafter, values of ca. 1,000 up to a maximum of 8,000 ppb were measured with the handheld device. The highest values were detected in sections of the Collection of Greek and Roman Antiquities that contained Euro-pallets for the storage of stone objects. It was known prior the move that these wooden pallets emit pollutants, above all terpenes. This compromise was deliberately made because of the load-carrying capacity needed for these heavy objects, their lack of sensitivity to the emitted pollutants, and finally for financial reasons (metal pallets would have been too expensive).

During the monitoring phase underway over the first ca. 1.5 years, the amount of VOCs in the individual storage areas has constantly been decreasing and at the beginning of 2013 reached values of ca. 300 up to a maximum of 2,000 ppb *(see fig. 3)*. Unless otherwise noted, the measurements were taken at approximately every four weeks in order to observe the stability of pollutant concentration conditions and to be able to react promptly in case of unusual developments.

[62] Grzywacz 2006 (cited note 51).

Fig. 4 a

Fig. 4 b

A colleague from IBO Innenraumanalytik OG testing the air on F3, Kunstkammer-Tapestries for aldehydes in August 2011.

5.2.2 QUANTITATIVE ANALYSIS OF AIR POLLUTANTS

A company specialising in the analysis of air pollution, IBO Innenraumanalytik OG, carried out supplementary measurements at three locations *(fig. 4)*. Along with a qualitative and quantitative survey of VOCs in the different areas, the indoor air was sampled for carboxylic acids (organic acids), aldehydes and ketones.[63]

The first of these tests took place at the end of August 2011 in storage spaces containing only storage furnishings and equipment – no objects – and tested for the concentration of nitrogen oxides, sulphur dioxide, and ozone in the outside and inside air as well as particulate matter analysis *(fig. 5)*. As already mentioned above, the purpose was to rule out the possibility of the introduction of air pollutants or dust from the outside by the ventilation system: a circulation system using minimal amounts of fresh air. After approximately one operating year of the storage facility (September 2012), analysis of typical indoor air pollutants – VOCs, carboxylic acids, aldehydes, and ketones – was completed in the storage area now filled with objects and storage materials.

Considering the detection of outdoor air pollutants, it could be determined that their concentration was consistently lower, and sometimes significantly lower, inside the storage facility. The fine particulate matter fraction indoors was also proven to be minimally detectable. Consequently, it was concluded that the air circulation system was not contributing to an enrichment of outdoor air pollutants or fine particulates in the storage facility and sampling was discontinued in September 2012.

63 All of the following measurement values are extracted from the analysis report from IBO Innenraumanalytik OG/Innenraum Mess- & Beratungsservice for both measurement campaigns: F. Twrdik – P. Tappler, *Schadstoff-Untersuchungen – Messung 1 – Nach Fertigstellung des Gebäudes – Zentrales Depot KHM, Befund und Gutachten*, Innenraum Mess- & Beratungsservice, Österreichisches Institut für Bauen und Ökologie GmbH, 20.10.2011; F. Twrdik – P. Tappler, *Schadstoff-Untersuchungen – Messung 2 – Nach Bezug und bei Nutzung des Gebäudes – Zentraldepot KHM, Befund und Gutachten*, Innenraum Mess- & Beratungsservice, Österreichisches Institut für Bauen und Ökologie GmbH, 06.11.2012.

Fig. 5 a

Fig. 5 b

Fig. 5 c

Testing the concentration of typical pollutants and particulates found in outside air in August 2011. Fig. 5 a: Preparation for testing for NO_x and SO_2 by employees of a company contracted by IBO Innenraumanalytik OG. Fig. 5 b and c: Measuring particulate matter in outside air – as a comparison with that found in indoor air – in F3, Kunstkammer-Tapestries.

The first measurements of VOCs taken in August 2011 before the move of the collections showed primarily solvent residues with a total concentration of ca. 600 µg/m³. This corresponds to ca. 180 ppb when converted with hexane as the base value (corresponding to the information in the publication from the Getty Conservation Institute mentioned above), and coincides well with the values measured with the handheld device. Testing for aldehydes and ketones detected the expected increase in formaldehyde levels in the space with a mezzanine constructed from particle board. Formaldehyde could be documented in this room only; it was not detected in the comparison space without the mezzanine. With 8 µg/m³, approximately ca. 6.5 ppb, the concentration of formaldehyde was at the border of the recommended concentration for sensitive collections of below 5 ppb, and for collections in the general, for which the desired range is 5 – 20 ppb (again as stated in the Getty reference publication).

Along with formaldehyde, acetaldehyde (29 µg/m³ ≈ 16 ppb) and benzaldehyde (36 µg/m³) could be detected in an acceptable amount (under 20 ppb) for sensitive collections. Unfortunately, it could not be clarified with the manufacturer if benzaldehyde can be emitted by the particle board used. In the space without a mezzanine, on the other hand, 330 µg/m³ (ca. 132 ppb) of acetic acid was detected, possibly originating from floor coverings recently installed in some sections of the space, which, however, fell within the desired range for collections in general (40 – 280 ppb).

Fortunately, the storage facility proved to be minimally contaminated with pollutants in its empty state, i.e., without objects. About one month after the completion of the construction and furnishing phases, no objectionable concentrations of pollutants could be detected.

During the repetition of the air sampling in September 2012, the most contaminated storage area – that containing heavy stone objects from the Collection of Greek and Roman Antiquities placed on wooden pallets – was chosen, along with one of the earlier investigated areas, in order to compare the qualitative and quantitative identification of air pollutants *(figs. 6 and 7)*. As expected, primarily terpene derivatives from the wood used in the pallets and solvent

Fig. 6: Second air pollutant measurement by IBO Innenraumanalytik OG in September 2012; view of GF, Collection of Greek and Roman Antiquities during indoor air sampling. The shelves are already filled with objects on Euro-pallets.

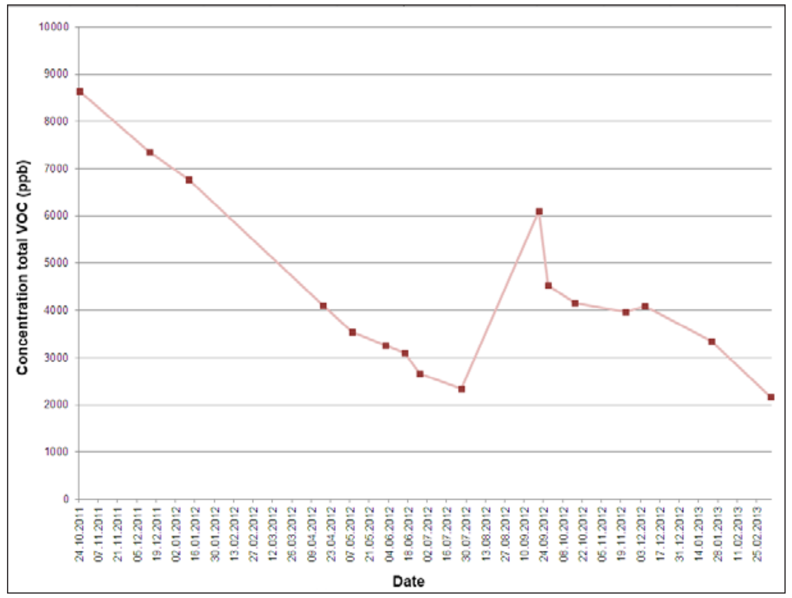


Fig. 7: Evolution of the total concentration of VOCs in GF, Collection of Greek and Roman Antiquities from October 24th, 2011 onwards: the use of wooden pallets leads to an increase in the total concentration of VOCs in comparison with other storage areas, which – as the measurements taken by IBO revealed – can be ascribed to terpenes from the wood.

residues were detected in the storage area for the Collection of Greek and Roman Antiquities. The VOC concentration remained altogether at 1,600 µg/m³, of which 1,263 µg/m³ was terpene. In the comparison space (with mezzanine), the total VOC concentration remained at 590 µg/m³, of which ca. one-third was terpene and the rest accounted for by solvent residues. Formaldehyde in a concentration of 24 to 52 µg/m³, and acetaldehyde with 90 to 159 µg/m³, could be detected in clearly higher concentrations than in the empty storage space. Acetic acid was detected in both sampled spaces with a concentration of ca. 25 – 30 µg/m³.

The most significant results of both measurement campaigns are collected in the table in *fig. 8.* It is taken from the analysis report from IBO Innenraumanalytik OG dated November 6, 2012.[64]

5.2.3 MONITORING THE CORROSIVE POTENTIAL OF THE ATMOSPHERE

As part of the EU support MUSECORR project "Real time monitoring of air corrosivity using AirCorr Loggers," corrosion sensors were developed under the leadership of the *Institut de la Corrosion* (French Corrosion Institute; ICO) that can provide an indication of the corrosive potential of the atmosphere for certain objects and groups of objects.[65] The sensors are based on the measurement of the change in the electric resistance of a thin metal strip placed upon an isolating substrate brought about by the corrosion of the metal by pollutants found in the surrounding air. During an advanced stage of the project a trial was carried out in the first half of 2012 with selected end users, who were to test the newly developed sensors for their suitability for daily use, user friendliness, etc. The Conservation Science Department was selected to be one of the end users with the task of testing the air quality in the newly constructed storage facility.

64 Twrdik – Tappler 2012 (cited note 63), p. 27.
65 For further details see www.musecorr.eu.

Sum or average values in each measurement period (rounded)[a]	Sampling series 2 after occupation and during use of the building (Sept. 18, 2012)		Sampling series 1 after completion of the building (Aug. 31, 2011)	
	Collection of Greek and Roman Antiquities, stone collection (Ground Floor – A01)	Imperial Carriage Museum (First Floor – A02)	Imperial Carriage Museum (First Floor – A02)	Kunstkammer-Tapestries (Third Floor – A01)
	[µg/m³]	[µg/m³]	[µg/m³]	[µg/m³]
alkanes (sum)	43	44	34	18
alkenes (sum)	–	–	–	–
aromatics (sum)	53	61	56	47
chlornapthaline (sum)	–	–	–	–
chlorinated hydrocarbons (sum)	2	–	–	–
terpenes (sum)	1,260	200	85	22
monovalent alcohols (sum)	61	110	260	330
esters of monovalent alcohols (sum)	6	3	5	22
cyclic ethers (sum)	7	4	4	1
glycols, glycol ethers, glycol esters (sum)	13	11	38	120
fatty acid esters, dicarboxylic acid esters (sum)	–	–	–	–
heterocycles (sum)	7	4	3	3
plasticisers (sum)	–	–	–	–
phenols (aromatic alcohols) (sum)	–	–	–	–
other unsaturated compounds (sum)	–	–	–	–
other VOC compounds (sum)	–	–	1	–
formaldehyde	52	24	8	–
aldehydes and ketones (without formaldehyde) (sum)	560	480	230	120
acetic acid	24	30	–	330
formic acid	–	–	–	–
total quantifiable organic compounds (rounded)	**2,100**	**970**	**730**	**1,000**

– not detected analytically (below detection limit)
[a] values are rounded to a maximum of three significant digits

Fig. 8: Summary of the most significant findings of air pollutants detected by IBO Innenraumanalytik OG during their measurement campaigns (translated from the findings report dated November 6, 2012).

The readings were carried out from January 27th to June 15th, 2012 with a prototype of the AirCorr I Logger with lead (Pb – 400 nm), silver (Ag – 50 nm) and bronze sensors (CuSn – 400 nm) in three pre-selected measurement locations in the storage areas for the Coin Collection, the Collection of Greek and Roman Antiquities, and the Imperial Carriage Museum (for the lead sensor only) *(figs. 9 and 10)*. Since the AirCorr I logger can only contain one sensor at a time, and all three sensors were to be tested in all possible storage areas, the prescribed exposure time – normally at least one month – was reduced to 2 – 3 weeks for each measurement location, after consultation with the responsible project administrator at MUSECORR.

A corrosion depth of 0.2 nm was measured upon evaluation of the bronze sensor exposed for 21 days in the Coin Collection, with the resulting corrosion rate calculated to be 4.3 nm/year *(figs. 11 and 12)*. At the time of our tests, the categorisation of corrosion into classes was not yet available; the MUSECORR project organisers informed us, however, that this indicates an extremely low rate of corrosion: a potentially non-corrosive environment. This was also confirmed by the comparison measurement carried out with the lead sensor, which showed a corrosion rate of 15.6 nm/year (0.8 nm in 23 days), a situation that is also considered potentially non-corrosive. The pollutant monitoring that we carried out in the same location and timeframe as the bronze sensor measured

Fig. 9 a: Use of the AirCorr I logger with lead sensor (below, left) in a drawer already filled with artefacts in F3, Imperial Carriage Museum/ Court Wardrobe.

Fig. 9 b: Collecting the corrosion data from the lead sensor, which was in place as shown in *fig. 9 a* for 20 days.

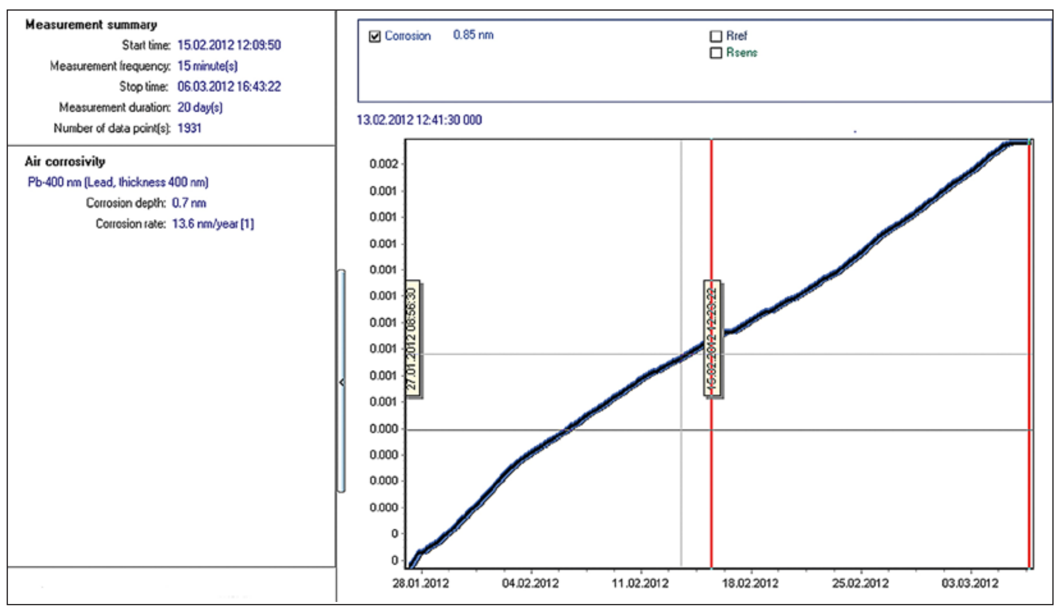


Fig. 10: Results of the evaluation of the lead sensor placed in F3, Imperial Carriage Museum/Court Wardrobe, gained by using the associated software. Like with all sensors in the MUSECORR system, the lead sensor can also be used more than once in different locations for testing the corrosive potential of the surrounding atmosphere. In the evaluation shown here, the measurement period in F3, Imperial Carriage Museum/Court Wardrobe is delimited by the two red lines (from February 15th, 2012 to March 6th, 2012). The evaluation of this section of the corrosion curve shows a corrosion depth of 0.7 nm and a corrosion rate of 13.6 nm per year. According to the project leaders at MUSECORR, this corresponds to a potentially non-corrosive environment for objects.

Fig. 11 a: Use of the AirCorr I logger with a bronze sensor in the still empty F2, Coin Collection, climate box.

Fig. 11 b: Collecting the corrosion data from the bronze sensor, which was in place as shown in *fig. 11* a for 21 days.

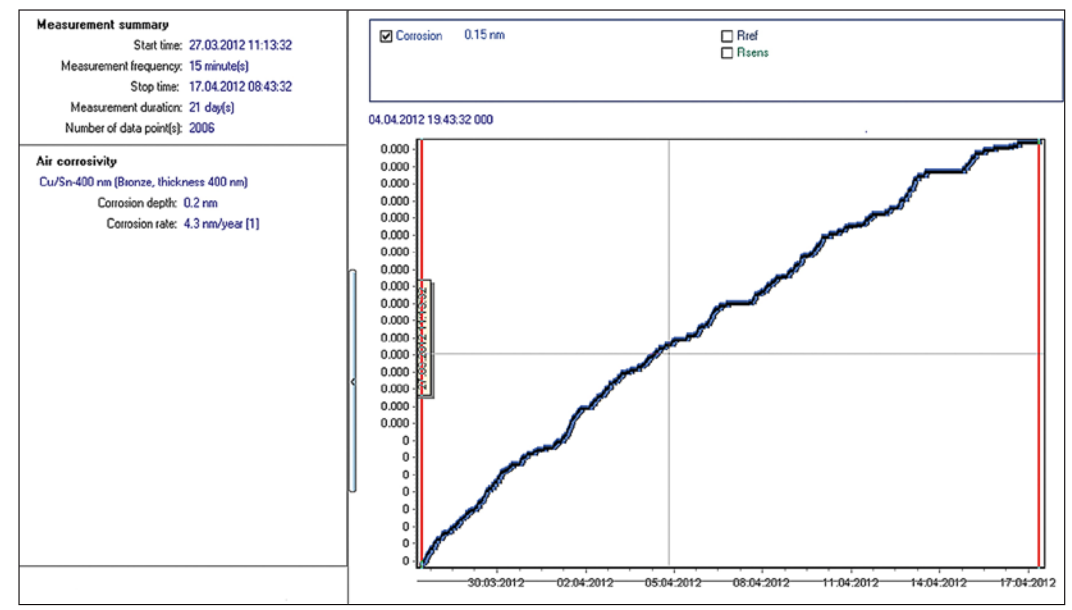


Fig. 12: Results of the evaluation of the bronze sensor in F2, Coin Collection, climate box, which also demonstrate that a potentially non-corrosive environment for objects could be established.

ca. 2,250 ppb total VOCs. A following measurement in the Coin Collection storage area with the silver sensor with an exposure time of 24 days recorded a corrosion depth of 0.3 nm and a resulting corrosion rate of 4.9 nm/year (*fig. 13;* see also Fig. 59 in the contribution by Schaaf-Fundneider – Kimmel). The corrosion classification already available in the evaluation software led to the ranking of the surrounding atmosphere as class "IC 1 very low". The environment was, according to this classification for silver, unpolluted and potentially non-corrosive. The total VOC levels measured with the handheld device remained at 1,200 – 2,350 ppb during the exposure period.

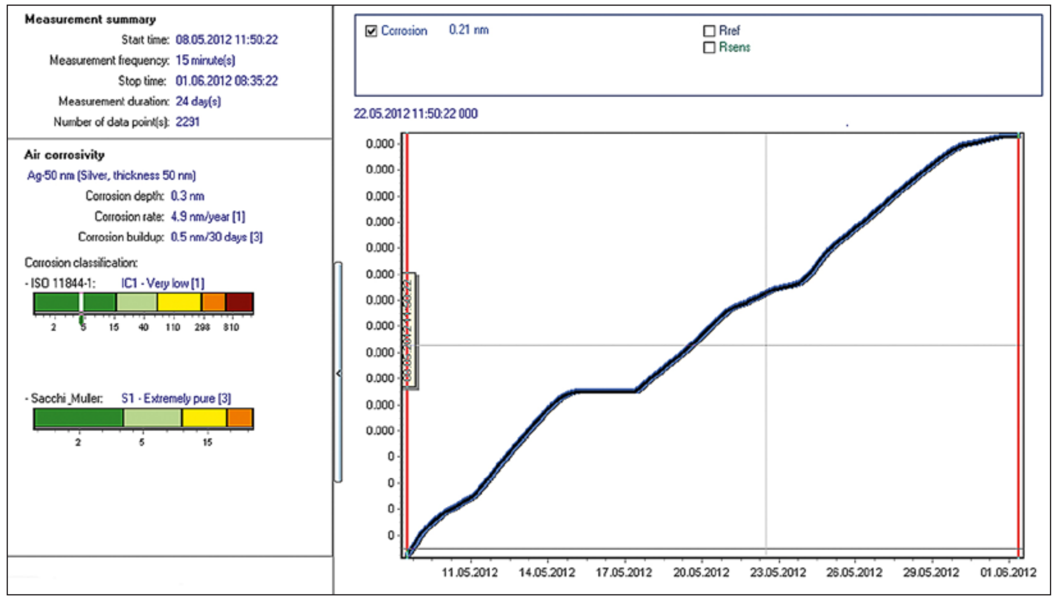


Fig. 13: Results of the evaluation of the silver sensor in F2, Coin Collection, climate box, which now contains the full extent of evaluation options for all sensors used in the MUSECORR project. The corrosion classification of the atmosphere is also graphically represented by the calculated corrosion rates: here, for example, the silver sensor shows a potentially non-corrosive environment (highlighted in the dark green section of the corrosion classification).

In summary, the results of the trial run of the corrosion sensor AirCorr I in the new storage facility were very positive. In particular, due to the very minimal corrosion rate and potentially non-corrosive environmental conditions that could be documented in the Imperial Carriage Museum storage area and in the more heavily contaminated storage area of the Collection of Greek and Roman Antiquities (during the exposure period of the metal sensors the total concentration of VOCs was around 3,000 ppb) *(figs. 14 and 15)*.

At this point it should be mentioned that the AirCorr corrosion sensors are now commercially available. The battery-run loggers can be used autonomously over many years and in changing locations. Interim data results can be collected and evaluated at any time as needed.[66]

[66] For information and ordering the loggers and/or sensors, contact Frédéric Ledan from the Institut de la Corrosion, e-mail: frederic.ledan@institut-corrosion.fr, Tel.: +33 (0) 2 98 05 89 02. The first non-binding price offer that was provided to us by the MUSECORR project leader, listed the Logger AirCorr I without sensor at € 1,250.00; for the data pencil and communication interface € 350.00; and a recommended price for most sensors between € 95.00 and € 215.00; the WinAirCorr Software for data evaluation was free of charge.

Fig. 14 a

Fig. 14 b

Use of the AirCorr I logger with a silver sensor in GF, Collection of Greek and Roman Antiquities, with objects already moved in.

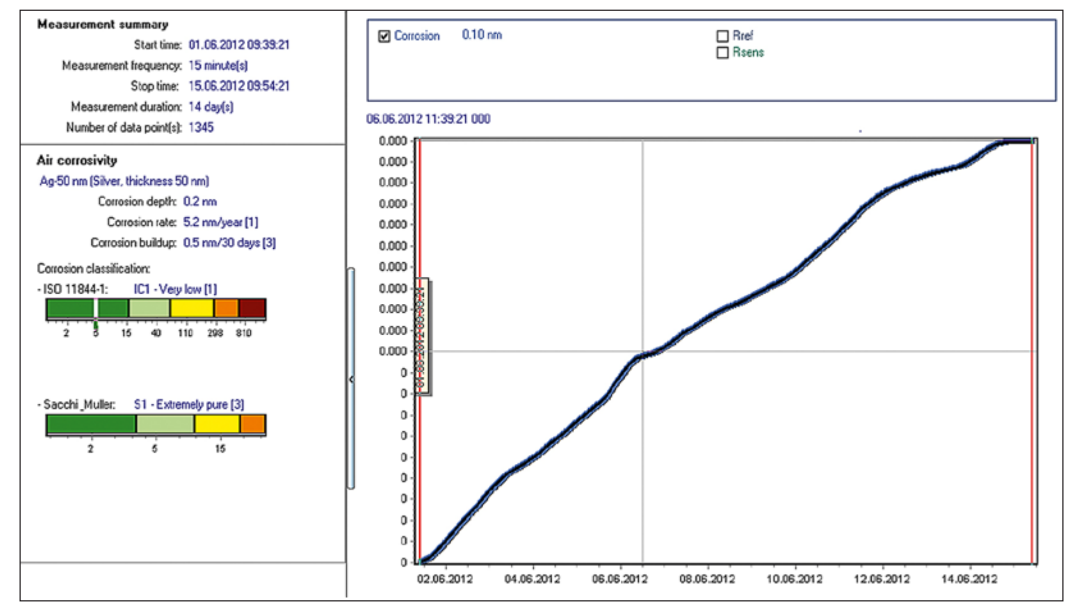


Fig. 15: Results of the evaluation of the silver sensor in GF, Collection of Greek and Roman Antiquities, also with a corrosion classification indicating an unpolluted environment. The lead and bronze sensors also produced good results in this area, i.e., little potential for corrosion in the atmosphere, although contamination by VOCs inside this storage area was the highest.

5.2.4 SUMMARY AND OUTLOOK

The investigation of air quality and pollutants relevant to collections' objects carried out from the outset in the new central storage facility of the Kunsthistorisches Museum Vienna has resulted in the successful creation of good storage conditions for the long-term preservation of the art objects. The concentration of pollutants present in the environment, like the terpenes discovered emitting from the wooden storage pallets, has also been proven to pose no health risks to people using the storage area.

This positive result could be achieved first and foremost through the conscious selection of materials, which – despite financial restrictions – was aimed at avoiding as much as possible the use of materials that emit pollutants and as far as possible not applying special surface treatments to the walls and floors of the concrete prefabricated structure. The air circulation system, which was chosen to increase climate stability, uses as little outside air as possible, also proving its value: enrichment of the air inside the storage facility with pollutants and dust from outside air has not been observed. The constantly decreasing VOC values regularly measured over the first ca. 1.5 years also seems to show (tentatively) that the inside air is not being saturated with pollutants introduced by the objects (and wooden pallets). Pollutant monitoring of the total amount of VOCs along with analysis for quantitative detection of pollutants present in the air (the latter at longer intervals) will be continued in order to be able to react as quickly as possible to potentially negative developments.

SUMMARY

As an aspect of preventive conservation in museum environments, atmospheric pollutants and their effects on art and cultural property have received increased attention in recent years, in Austria and elsewhere. In this article, the most significant atmospheric pollutants, their most common sources, and their effects on artworks are first presented; considering the German and English literature, it seeks to offer an "introductory guide" for colleagues in everyday museum praxis.

With the completion of the newly constructed collections storage facility in Himberg, the Conservation Science Department of the Kunsthistorisches Museum Vienna was given the chance to observe from the start the concentration development of a selected number of atmospheric pollutants and/or pollutant groups in the building, and to introduce pollutant monitoring. During the construction and furnishing of the storage facility and in preparing the objects for the move, an attempt was already made to keep the entry of pollutants as low as possible. All materials used were additionally subjected to the so-called Oddy-test and – with the exception of wooden Euro-palettes for heavy stone objects – only those without demonstrable damage potential for objects were used.

The investigation of atmospheric pollutants by the Conservation Science Department using various methods of measurement could finally be started in August 2011. The most likely pollutants and/or classes of pollutants – volatile organic compounds (VOCs), organic acids, aldehydes and ketones, nitrogen oxides, sulphur dioxide, and ozone – from the external air, the construction materials, the (new) storage systems, and finally also the objects gradually brought into the repository were analysed, and the VOCs in particular were subject to regular monitoring at 35 measurement points over a period of 1.5 years to date.

In the framework of the EU Project MUSECORR, the corrosive potential of the atmosphere in the storage facility for (art) objects could further be evaluated at three selected measurement points using a newly developed measurement technology.

The data collected thus far indicates that the attempts to keep the concentration of pollutants in the building low, i.e. to provide slightly to non-corrosive environmental conditions for the long-term storage of the artworks, have been successful.

ZUSAMMENFASSUNG

In den letzten Jahren wurde als Teil der Präventiven Konservierung im musealen Ambiente den Luftschadstoffen und ihren Auswirkungen auf Kunst- und Kulturgut auch in Österreich verstärkte Aufmerksamkeit gewidmet. In diesem Beitrag werden daher zunächst einführend die wichtigsten Luftschadstoffe, ihre häufigsten Quellen und ihre Auswirkungen auf Kunstwerke vorgestellt, womit – unter Berücksichtigung von deutsch- und englischsprachiger Literatur – ein „Einstiegsleitfaden" für KollegInnen im Museumsalltag geboten werden soll.

Mit der Fertigstellung des neu errichteten Zentraldepots in Himberg bot sich dem Naturwissenschaftlichen Labor des Kunsthistorischen Museums Wien die Chance, von Beginn an die Entwicklung der Konzentration einiger ausgewählter Luftschadstoffe bzw. Schadstoffgruppen im Gebäude zu beobachten und ein Schadstoffmonitoring einzuführen. Bereits während der Errichtung und Einrichtung des Depots und zur Vorbereitung der Objekte für die Übersiedelung dorthin wurde versucht, den Schadstoffeintrag so gering wie möglich zu halten. Alle verwendeten Materialien wurden dazu dem so genannten Oddy-Test unterzogen und es wurden – mit Ausnahme von Euro-Paletten aus Holz für schwere Steinobjekte – nur solche ohne nachweisbares Schädigungspotential für Objekte eingesetzt.

Schließlich konnte im August 2011 durch das Naturwissenschaftliche Labor die Untersuchung von Luftschadstoffen unter Einsatz verschiedener Messmethoden aufgenommen werden. Dabei wurden die aus der Außenluft, den Baumaterialien, den (neuen) Einrichtungsgegenständen (Lagertechnik) und letztlich auch den nach und nach in das Depot eingebrachten Objekten am ehesten zu erwartenden Schadstoffe bzw. Schadstoffklassen – flüchtige organische Verbindungen (VOCs), organische Säuren, Aldehyde und Ketone, Stickstoffoxide, Schwefeldioxid und Ozon – analysiert und es wurden v. a. die VOCs an 35 Messpunkten über einen Zeitraum von bisher ca. 1,5 Jahren einem regelmäßigen Monitoring unterzogen.

Im Rahmen des EU-Projekts MUSECORR konnte weiters an drei ausgewählten Messpunkten mittels einer neu entwickelten Messtechnologie das korrosive Potential der Depotatmosphäre für (Kunst-)Objekte erfasst werden.

Aus den bisher erhobenen Daten zeigt sich, dass es gelungen ist, die Schadstoffkonzentrationen im Gebäude niedrig zu halten und somit gute, d. h. nicht bis wenig korrosive, Umgebungsbedingungen für die dauerhafte Aufbewahrung von Kunstwerken zu schaffen.

Authors

Translated from the German by Emily Schwedersky

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1972–1976 Polytechnic of Applied Arts (painting and graphic), Innsbruck, qualification: apprenticeship certification exam. Specialised holiday work: wall painting; internship at a conservation studio in Innsbruck; 1976/77 freelance work in Wilma Wechner-Griesser's conservation studio in Innsbruck's old town (in the fields of polychrome sculpture, oil painting, gilding). From 1977 studies at the Academy of Fine Arts Vienna, masterclass of conservation and technology with Prof. Dr. Helmut Kortan, specialisations: polychrome sculpture, gilding, painting, ceramics, glass, paper/graphic arts; 1982 diploma, award from the Gesellschaft der Akademiefreunde. 1982–1986 freelance work; since 1986 member of the conservation studio of the KHM's Egyptian and Near Eastern Collection; supervision of numerous exhibitions, international collaborations on practical scientific topics.

Stefan Fleck
Training in structural engineering at the Camillo Sitte Institute, structural engineer since 2005, until 2004 site engineer in a Viennese architecture firm, since 2004 employed in the facility management at the Kunsthistorisches Museum Vienna as project manager for building alterations and new buildings, from 2009 project management Building – New Storage Facility.

Nora Gasser
Studies at the Institute for Conservation-Restoration of the Academy of Fine Arts Vienna, specialisations: paper, graphic arts, books, archival/modern and contemporary materials, diploma 2010. 2009–2013 participation in the Vienna Technical Museum's storage inventory project as a conservator; since 2012 freelance conservator as part of the Kollektiv papier&moderne – Atelier für Konservierung-Restaurierung.

Eva Götz
Following the completion of studies at the Cologne University of Applied Sciences (diploma in conservation, specialisation in paintings/sculpture) in 2003, work as a freelance conservator. 2004–2005 employed at ICN, Netherlands Institute for Cultural Heritage in Amsterdam, focussing on microscopy and painting research. 2006–2007 freelance work. Since 2007 paintings conservator at the Kunsthistorisches Museum Vienna and assistant lecturer at the University of Applied Arts Vienna, Institute for Conservation and Restoration.

Martina Griesser
Studies of chemistry, specialisation in analytical chemistry, at the Vienna University of Technology as well as doctoral thesis 1993–1995 at the same university in the field of analytical characterisation of chemically isolated diamond layers. Since 1996 setup and management of the Kunsthistorisches Museum's Vienna Conservation Science Department; additionally assistant lecturer at the University of Applied Arts Vienna, Institute for Conservation and Restoration, since 1999. Author and co-author of various publications.

Ina Hoheisel
2003–2008 studies of conservation and restoration at the University of Applied Sciences Erfurt; diploma thesis about a harp by J.H. Nadermann, Paris 1785, from the KHM's Collection of Historic Musical Instruments (SAM 727), supervised by Alfons Huber. 2009–2011 correspondence course *Schutz europäischer Kulturgüter* (protection of European cultural assets) for a master's degree *(Methodischer Leitfaden für die Besaitung historischer Tasteninstrumente*/methodical guidelines for the stringing of historic keyboard instruments*)* at the European University "Viadrina" in Frankfurt/Oder. Since 2009 freelance work at the SAM.

Alfons Huber
Following the completion of studies at the Academy of Fine Arts Vienna (1981) freelance work; since 1983 conservator at the KHM's Collection of Historic Musical Instruments. 1996 habilitation at the Academy of Fine Arts Vienna. Numerous publications on conservation/restoration of musical instruments, historic organology and matters of preventive conservation and climate stabilisation in museums. Simultaneously expanding on practical experience by making replicas of historic string pianos. 2012 doctoral thesis *(Ökosystem Museum*/Eco system museum*)* at the Academy of Fine Arts Vienna.

Joachim Huber
1985–1990 Art History studies at the Universities of Bern and Zurich. 1994 thesis on silversmith's art of the High Middle Ages. Since 1997 co-managing director of Prevart GmbH, Winterthur, a company which deals with aspects of preventive conservation in museums. The focus of his work is on advising building contractors as well as planning storage facilities and collection relocations. Numerous publications and lectures on matters of long-term collection preservation and sustainability in museums.

Sabine Imp
Studies at the Institute for Conservation-Restoration of the Academy of Fine Arts Vienna, in the fields of paper, graphic arts, books, archival/modern and contemporary materials. After graduating with a diploma 2010, work as freelance conservator, for example at the KHM's Coin Collection since October 2010, in connection with the conservation and new storage of objects from the paper-holdings (stocks, shares and paper money); since 2012 member of the Kollektiv papier&moderne – Atelier für Konservierung-Restaurierung.

Angelika Kathrein
Studies at the Academy of Fine Arts Vienna, Department of Conservation and Technology, graduating in 1982. 1983 University of Applied Arts, Department for Artistic Lettering and Book Design. Internship at the Graphic Collection of the Academy of Fine Arts and at the Theatre Museum. Freelance work since 1984: wall painting, sculptures, paintings, paper, modern art. From 1992 onwards participation in projects of the KHM's Egyptian and Near Eastern Collection and Collection of Greek and Roman Antiquities. Since 2002 conservator at the Collection of Greek and Roman Antiquities.

Tanja Kimmel
Studies of Restoration and Conservation of Art and Cultural Property – specialisation in textiles and leather objects at the Cologne University of Applied Sciences. Since 2004 textile conservator at the Kunsthistorisches Museum Vienna, initially at the Imperial Carriage Museum and Court Wardrobe, since July 2012 at the Kunstkammer and Treasury. In the course of building the central storage facility, the range of professional tasks was expanded. Member of the relocation team and responsible for the relocation and storage of art objects from the collection of the Imperial Carriage Museum and Court Wardrobe as project manager. Coordinator of the depot circle and co-supervisor of integrated pest management at the centralised storage facility. Since 2010 additionally university assistant and lecturer at the Institute for Conservation and Restoration at the University of Applied Arts Vienna.

Peter Kloser
Art History studies in Vienna and Berlin. 1995–2000 freelance work in wood conservation in the studio of Stefan Kainz. Since 1996 freelance work at the Institute for Foreign Cultural Relations, ifa Stuttgart. 2000–2005 art historical reappraisal of the Viennese archdiocese's collection. From 2002 onwards freelance art historian and managing director of the Kunstverwaltung OG company. 2004 and 2005 freelance work at the Federal Monuments Office. 2005–2009 collection supervision and TMS-administration at the Landesmuseum Niederösterreich. Since 2010 at the KHM as TMS-administrator.

Monica Kurzel-Runtscheiner
Studies of Art History and History in Vienna and Rome. Member of the Austrian Institute of Historical Research and lecturer for women's history at the University of Vienna. Since 1993 scientific contributor at the Kunsthistorisches Museum Vienna, initially as curator, and since 2001 as director of the Imperial Carriage Museum and the Court Wardrobe.

Michael Loacker
1992–1996 professional training as gilder, decorator and sign manufacturer in Tyrol, Fachschule für Kunsthandwerk (professional school for handicraft), Elbigenalp. 1996/97 internship in the field of restoration and conservation of timber framed buildings and historic facades in Vorarlberg. 1997–2002 studies in paintings conservation at the University of Applied Arts Vienna. 2000–2002 work experience in the studio for paintings conservation Manfred Siems, Vienna. 2002–2003 work at the Federal Monuments Office, Vienna, focusing on the conservation of altarpieces, metal-coating and polychromy on sculptures (St. Stephen's Cathedral, Church of the Augustinian Friars). 2003–2004 work for Gebr. Zingerle OHG, Innsbruck, with projects in North and South Tyrol, focusing on interior decoration of churches, stone conservation, and historic facades. 2004–2006 freelance conservator and working partnership in Vorarlberg with commissions from the Federal Monuments Office for the Feldkirch diocese. Since 2006 conservator at the KHM's Egyptian and Near Eastern Collection (since 2010 additionally at the Collection of Greek and Roman Antiquities).

Michaela Morelli
Studies of Restoration and Conservation of Art and Cultural Property – specialisation in textiles and leather objects – at Cologne University of Applied Sciences. Internships at the Austrian Museum of Applied Arts/Contemporary Art and the Weltmuseum Wien. Practical semester at the Musée des Tissus et des Arts Décoratifs de Lyon. From 1999 onwards freelance work, amongst others for the Five Continents Museum in Munich (formerly State Museum of Ethnology), Weltmuseum Wien, Federal Monuments Office Vienna, Department of Textiles and Archaeology and the Papyrus Collection of the Austrian National Library, Vienna. Since 2000 conservator at the KHM, Imperial Carriage Museum and Court Wardrobe.

Elke Oberthaler
1981–1986 studies of Conservation and Restoration at the University of Applied Arts Vienna. Since 1984 employed in the Department for Painting Conservation of the KHM's Picture Gallery, head of the department since 1997. 1990–1992 A.W. Mellon Fellow at the Metropolitan Museum of Art in New York. 2006 Visiting Conservator at the Courtauld Institute of Art, London. Since 1997 lecturer at the University of Applied Arts Vienna, since 2005 additionally at the Academy of Fine Arts Vienna.

Pascal Querner
1996–2002 studies of Biology at the University of Vienna, followed by a doctorate at the University of Natural Resources and Life Sciences, Vienna (BOKU, graduating in 2008). Since 2002 work in the field of integrated pest management in museums in Vienna and other provinces of Austria, specialising in monitoring, consulting, prevention and IPM-concepts. One year's work in IPM at the Rathgen Research Laboratory in Berlin. Supervision of various storage relocations for museums in Austria and Georgia. At present working as freelance consultant for several of the KHM's collections, as research assistant at the BOKU, and as lecturer at the University of Applied Arts Vienna. Author of various publications on IPM in museums.

Daniela Sailer
Kolleg für Mode und Bekleidungstechnik (professional school of fashion and clothing technology) at the Modeschule Herbststraße/Vienna. 1995–1998 studies and diploma in textile conservation at the Textile Conservation Centre, University of London, England; parallel to the studies internship at the National Museum of Scotland, Edinburgh. Various exhibition projects at the Norsk Folkemuseum, Oslo, Norway. 2000–2002 work as a textile conservator in England, at the Conservation Services, The Textile Conservation Centre, Winchester amongst others. Subsequently private conservation projects and freelance work at the Vienna Technical Museum. Since 2003 conservator at the Kunsthistorisches Museum's Imperial Carriage Museum and Court Wardrobe.

Christina Schaaf-Fundneider
2003 graduation in diploma studies of Restoration-Conservation, Art Technology and Conservation Science at the Technische Universität München, with a specialisation in researching painting techniques. 2003–2005 collaboration on the FWF research project on Titian's painting technique at the Kunsthistorisches Museum Vienna. 2006 until early 2011 freelance work as conservator for paintings, polychrome surfaces and preventive conservation at the Atelier Kunstgenuss founded with Eva Hottenroth in Vienna. In this context, since 2007 focus on storage and collections care, risk management und measures of preventive conservation. Since 2009 supervision of the HIROX 3D-microscope at the KHM's Conservation Science Department, and from 2010 till 2012, as representative of the conservators, part of the planning and relocation teams for the new storage facility of the KHM. Since 2013 head of the department of conservation, restoration and object preservation at the Collections Centre for Art of the state government of Lower Austria in St. Pölten (maternity leave replacement).

Katja Schmitz-von Ledebur
Studies of Art History, Classical Archaeology and German Philology in Bonn and Munich. Doctor's thesis on Flemish tapestries of the sixteenth century. Work at the Bayerisches Nationalmuseum Munich, and the German Historical Museum Berlin. Since 2003 curator of the Kunsthistorisches Museum's Kunstkammer and the Imperial Treasury (Collections of the Secular und Ecclesiastical Treasury). Exhibitions and supervision as well as scientific research of its tapestry collections, coronation and liturgical vestments. Research projects on the display of tapestries in historic rooms, the development of a system for the storage of tapestries and of installation walls with variable inclination angles for the display of tapestries. Since 2011 member of the Direction Council of the Centre International d'Étude des Textiles Anciens.

Katja Sterflinger
1993 diploma in Biology and 1995 doctorate in Microbiology at the Carl von Ossietzky University of Oldenburg, at present associate professor of Geomicrobiology at the BOKU, being in charge of the Austrian Centre of Biological Resources and Applied Mycology at the Department of Biotechnology. Since 2009 deputy head of the Department for Biotechnology. Lecturer at the Academy of Fine Arts Vienna and the University of Applied Arts Vienna. Specialisation in microbial infestation and damage of art objects and monuments, ecophysiology of fungi and molecular taxonomy of fungi and black yeasts. Member of various scientific committees and co-editor of professional journals.

René Traum
Trained gold- and silversmith. 1983–1987 and since 1998 work in the Coin Collection's conservation studio at the KHM. Additional training in the techniques of enamelling and historic gold- and silversmithing. Numerous publications on coining technique and cleaning and conservation of coins from archaeological finds. Since 2001 collaboration on two research projects on corrosion phenomena on gold coins and ancient bronze coins, funded by the Jubiläumsfonds der Oesterreichischen Nationalbank (Anniversary Fund).

Bettina Vak
Studies in Object Conservation (metal) at the University of Applied Arts Vienna. Engagement in ancient goldsmithing techniques. Since graduation (1986) freelance work. Lengthy work stays in New York (private antique restorer), Istanbul (collaboration on the conservation treatment of the Constantine mosaic), St. Petersburg, Hermitage. Conservation of Roman mosaics, wall paintings, pottery and Egyptian material (Baden, Graz, Frankfurt): sarcophagi, cartonnage objects, gold masks. 1996 participation in the ICCROM course in Rome on Scientific Principles of Conservation. Since 1995 conservator for the KHM's Collection of Greek and Roman Antiquities.

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