
MARE

Materials Research and Conservation of the Reverse Painted 'Spanish Map'*

• SIMONE BRETZ •

The treatment of the reverse painted 'Spanish Map' made it possible to conduct an in-depth investigation into the construction, paint technology and assembly of this *Kunstkammer* object.[1] The opportunity to examine the materials that were used shed light on the refinement of the craftsmanship, and the results of the analyses likewise testify to the status of the piece as an artistically mature work of art executed with the most valuable materials of the time.

In this article we explain the painting techniques, analyze the object layer by layer, and discuss the process of conservation and restoration in some detail.

Amelierung – A Reverse Glass Painting Technique

The map of the Iberian Peninsula is a reverse glass painting, made by a complicated technique known in German as *Hinterglasmalerei*, which involves decorating the transparent surface in reverse, from front to back. The first step was to apply gold leaf to this surface and engrave the miniature townscapes, mountain ranges, rivers, borders, coats of arms and names of towns into it with a fine etching needle. The exposed areas were then reverse painted with translucent lacquers in various colours to which, finally, a layer of tin foil was applied to achieve the multiple reflection of the lacquers and heighten the luminosity of the overall image. Blue lustre paint was used for the sea and rivers, green lacquers for the mountains and landscapes, and red and orange lacquers for the vedute and coats of arms (fig. 1).

Detail of fig. 1, p. 100

The map was executed in a special reverse glass technique known as 'amelierung'. This term is to be found only in the German-speaking regions and can be traced back to the Old German 'gamâl' (colourfully decorated, colourful) and 'gamâlen' (to draw, to paint). As far as we know, 'amelieren', 'amolieren', 'amulieren' or 'gamalieren' first appeared in 1532 in the account book kept by the Nuremberg patrician Dr Christoph Scheurl.[2] The 'Spanish Map' is an *amelierung* painting of the kind known in Southern Germany and Saxony until the end of the sixteenth century,[3]

Fig. 1
Close-up of the 'Spanish Map'.
Photo: Rijksmuseum.

which then appeared in the form of paintings, tankards and double-walled bowls made as *Kunstkammer* objects by Swiss painters until the mid-seventeenth century. Clearly there was a long tradition of *amelierung* in the production of reverse painted works – from 1532 or even earlier to around 1650. *Amelierung* painters of this period created stained glass as well as reverse painted glass works.[4] The latter involve the application of organically bound paints, while for stained glass inorganic pigments such as black metal oxide (black enamel, also called 'Schwarzlot') were fused to the glass in a kiln. The difference is revealed by the illumination: reverse glass paintings must be viewed from the front, whereas transparent glass paintings develop their luminosity when light shines through them from the back. *Amelier* artists endeavoured to endow their reverse glass paintings with the same radiance as stained glass by working with both translucent lacquers and reflective metal leaf.

The *amelierung* technique usually consists of three layers: gold or silver leaf and/or gold or silver powder, translucent lacquers, and silver or tin foil. The following combinations are found in the 'Spanish Map': pure gold leaf, red, orange, green and blue lacquers and tin foil for the land masses, and gold powder, blue lustre paint and tin foil for the sea.[5] More than half of the map's surface was gilded, and the surrounding sea was painted with silver powder to represent the waves. The vedute, landscapes and blazons were engraved into the gold leaf in miniature. The work is of outstanding artistic quality. In this context it is important to bear in mind that all this engraving, including the inscriptions, had to be done in mirror image. There are few signs of uncertainty; most of the lettering was executed with remarkable accuracy and assurance, and no more than a tiny number of letters are incorrect.[6] Upper-case letters such as OCEANVS OCCIDENTALIS were created by scraping the gilded surface off around them to the point where the letters were neatly scratched out.

Fig. 2
Putty between two segments of rock crystal. Photo: Monika Runge, Germanisches Nationalmuseum, Nuremberg.

Rock Crystal, Not Glass

The reverse painted map appears to be made of glass, but is actually rock crystal.[7] With the aid of the non-destructive micro x-ray fluorescence analysis method, the material was identified just as pure quartz (silicon dioxide), an indication of rock crystal.[8] Because it was found in the permanent ice of the high mountains, rock crystal was once thought to be petrified ice; its extraction was extremely difficult. Its value depends on its size, degree of flawlessness, and optical purity. There are small black inclusions in rock crystal, as well as iridescent streaks caused by tiny hollow spaces filled with liquid or gas. However, no spherical or oval gas bubbles of the kind that occur in blown glass can be found. In Europe, rock crystal is most frequently found in the French, Italian, Tyrolean, Carinthian and Swiss Alps, but it has also been extracted in Bohemia, Silesia and Saxony.[9]

Covering the surface of the 'Spanish Map' is a network of sixteen lines emerging radially from two wind roses. The map is assembled from forty-four segments altogether – triangles and rectangles of various sizes. The wind rose on the left consists of a single, perfectly round piece of rock crystal, while the one on the right is assembled from two half-moons. The individual pieces are fitted closely to one another and cemented edge to edge (fig. 2).

In the sixteenth and seventeenth centuries, crystal cutting was an important craft, which became easier with the invention of rotating grindstones driven by hand or water power. The crystal cutter treated the cut crystals with successively finer polishing and buffing materials untila high polish was achieved. The rock crystal panels that make up the map were highly polished on both sides, while the faceted edges are matt. The largest pieces, found at the centre of the object, measure a maximum of 34.2 by 7.8 cm. Consisting as they do of a natural material, the panels vary in thickness, which can be anything between 0.14 and 0.37 cm even within a single piece. In adherence to the radial line system, v-shaped grooves were cut into the surfaces of a number of the larger rock crystal pieces to create the illusion of smaller panels (fig. 3). The 'Spanish Map' consequently looks as though it was assembled from fifty individual segments.

Natural Resins and Pigments

The other materials used in the technical realization of this *amelierung* work were also subjected to scientific examination.[10] The painted layer of the map consists exclusively of resin-based lacquers. Slight variations in their composition were found in the four samples analyzed – one each in red, orange, green and blue. In all four cases, the binding medium is based on natural resins.[11] It was ascertained that, remarkably, all of the colour resins employed were extremely expensive products imported from such places as Tyrol, Greece or Asia. The main component of all the transparent lacquers is larch turpentine resin.[12]

Fig. 3
Piece of rock crystal incised (at bottom right) to give the illusion of consisting of two segments.

Fig. 4
Coloured lacquers seen from the back in reflected light.

This high-quality soft resin is a natural, clear, pale yellow balsam. It is often called Venetian resin after the city where it was once traded. Small amounts of mastic, a soft resin,[13] as well as the natural softener camphor[14] were also found. Traces of oxidized colophony (pine resin) were detected in the green and orange lacquers. Oil of turpentine or alcohol was used to liquefy this universal resin binding medium to a paintable consistency.

The resin binding medium produced in this way was transparent, the next step was to colour it by dissolving pigments in it. These were likewise imported at no small cost. In the layer of red lacquer analyzed, traces of both dragon's blood and benzoin resin were detected despite the aging process the materials have undergone. Dragon's blood[15] is an especially costly colour resin that made its way to Europe in the fifteenth century by way of Spain. Exuded by the dracaena tree, this reddish brown resin is scratched off the bark for use as a pigment.[16] Gum benzoin – an equally rare and expensive product – was added to this varnish to heighten the chromatic intensity. Benzoin resin is a pleasant-smelling reddish or yellowish resin extracted from the balsam of the red-gum tree (which grows in Java and Borneo). It lends the dragon's blood a reddish sheen.[17]

The green lustre paint proved to contain copper green pigment. The blue pigment, ultramarine, is highly unusual in *amelierung* work. Ultramarine was obtained from Afghanistan and traded primarily in Venice.[18] Its production by means of an elaborate kneading process, combined with its low yield and high import costs, made it extremely expensive – it cost as much as gold (fig. 4).

Assembly

Putty was used both to cement the individual pieces of rock crystal to one another and to fill the gaps and level the surface between the crystal and the slate slab upon which the entire ensemble rests. There are putties of varying hardness and varying shades in the map, dating from when the work was made and from later periods. The joints between the pieces of crystal vary in width: some of the segments are fitted edge to edge, while other joints are wider and accordingly required more putty. The grooves cut into the surface to give the illusion of separate, joined segments were filled with the same material. The outer edge of the map was like-wise sealed with it.[19]

The slate slab holding the whole piece together was initially treated with beeswax coloured white with mineral magnesium oxide and slaked lime, as well as small amounts of chalk and white lead. A second, thicker layer of wax of the same composition was then poured on to the first (fig. 5).

The finished rock crystal panels, protected with tin foil from the back, were pressed into the freshly poured beeswax compound while it was still soft. There are craters, bumps and corrugations in the formerly fluid material. The second layer of wax served the extremely important function of compensating for the varying thicknesses of the panels and ensuring that their fronts formed an even surface. To this end, however, pieces of wood veneer as well as thick paper were also inserted, either between the two wax surfaces or on top of the second (fig. 6).

The joints between the individual panels of rock crystal were formed with two different types of binder. The first to be applied was a light wax, presumably corresponding to the material poured on to the slate

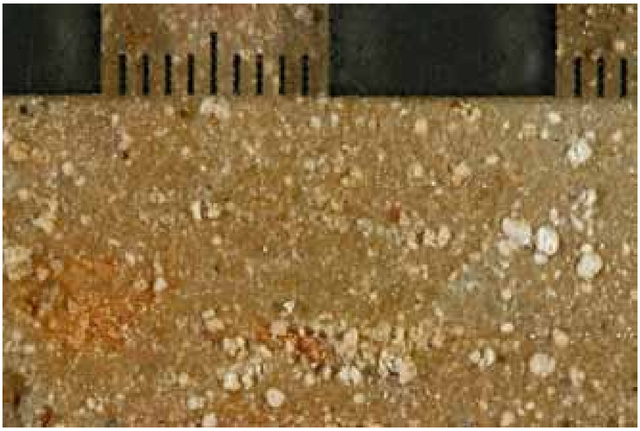


Fig. 5
White-coloured beeswax compound.

Fig. 6
Wax compound and pieces of wood veneer and paper used to create an even surface.

to provide a bed for the rock crystal segments. On top of that is a partially gilded yellow binding material. Scientific analysis established that this second layer contains pigments – for example, zinc white and chrome yellow – that did not exist in the sixteenth century; this binder must accordingly have been added during restoration measures carried out at a later date.[20] This makes it impossible to determine with certainty whether the original binder joints were gilded. It may be assumed that they were, however, and that the original gilding fell prey to the cleaning of the map over the course of time.

The analyses revealed that the seal around the edges of the object – which served to reinforce the overall stability of the ensemble – was an oil putty, also called 'glazier's putty', made of linseed oil and chalk.[21] Putties of this kind become brittle over time, making it necessary to patch with substitute compounds in later centuries.

Overall technical composition (rough outline)

0	Rock crystal (0.14 – 0.37 cm thick)
1	1.1 Gold leaf, engraved
	1.2 Silver powder, painted
2	Lustre paints in red, orange, blue and green
3	Tin foil, mounted behind lustre paints
4	Wax layer (thick)
5	Wax layer (thin)
6	Slate slab (1.72 cm thick)

The State of Preservation

The most frequent type of damage encountered in reverse paintings on glass is the delamination of the painted layer from the flat surface. In the case of the 'Spanish Map', the extent of this damage was quite considerable: some ninety per cent of the blue lacquer in the areas representing the sea had become detached from the rock crystal. Despite its former brilliance, the blue was almost unrecognizable as such, having taken on a dull greyish tone. The lacquer was badly crazed and much of it had chipped off; some of the particles were loose, while others were adhering to the wax. The condition of the gilded areas was substantially better, the detachment amounting to approximately fifteen per cent of the surface there. One of the rock crystal segments was cracked, and three other segments had been replaced with reverse painted panels made of glass.

It is not entirely clear when the damage to the rock crystal occurred. A photograph in a set taken in 1939-40 for the creditors of Fritz Mannheimer (1891-1939) shows the object standing among various sculptures from his collection; there is no visible crack in the crystal at this point (fig. 7).[22] In 1941 the Mannheimer Collection was seized in its entirety by the German State, and in June 1945 the map turned up in the Munich Central Collecting Point set up by the Allies.[23] The notes on the index card tell us that the object was in the Nazis' stolen art repository in the Altaussee salt mines until 29 March 1946. It was then taken to Amsterdam, and in 1952 the State of the Netherlands placed it in the Rijksmuseum. The crack in the rock crystal must have happened after this, as a photograph taken in 1960 clearly reveals (fig. 8).

It is more difficult to determine when the paint layer was damaged. In the

Fig. 7
Photograph of the 'Spanish Map' taken around 1940, when the object was still in the Mannheimer Collection.
Photo: Rijksmuseum.

1939-40 photograph the surface of the seas is somewhat cloudy, which would imply that paint was already detaching in places; the putty joints of the wind roses are already visible. Taken in conjunction with the findings during the conservation of the frame, this would indicate that the reverse glass painting had been treated before, probably in the second half of the nineteenth century. Parts of the delaminated paint layer had been fixed with animal glue, presumably during this previous conservation work (fig. 9). It can be concluded from the sealant on the edges that some of the rock crystal elements were replaced with pieces of glass at that time.

With the combination of radiant blue and gold, the map must once have impressed the viewer with a striking luminosity. The quality of the colours has degraded to different degrees in different parts of the map. In the areas representing the sea, there are no more than a few spots that are still the original intense shade of blue (fig. 10).

Fig. 8
The 'Spanish Map', condition in 1960. Photo: Rijksmuseum.

Fig. 9
Animal glue used as a restoration medium in a previous treatment (before conservation). Photo: Monika Runge, Germanisches Nationalmuseum, Nuremberg.

Fig. 10
The blue lustre paint in its former splendour. Photo: Monika Runge, Germanisches Nationalmuseum, Nuremberg.

Fig. 11
Tin foil. Left side: signs of corrosion; right side: intact.

Did the materials used in the map, especially the resins and tin foil, suffer particularly badly from the poor storage conditions in the cold, damp salt mine in Altaussee? The change in shade to a dark greenish blue was undoubtedly caused by the browning of the resin binding medium. In order to achieve a blue of the optical depth and intensity once exhibited by the 'Spanish Map', it was necessary to apply quite a thick layer of lacquer. Seen from the back, the blue lustre paint has a surface resembling crocodile skin. The three remaining lustres were applied in much thinner layers (the orange layer, for example, is 20 µm thick as compared to the blue one, which measures 400 µm). Larch turpentine is notorious for its tendency to yellow with age but pine resin and mastic are also known to do this. The thicker the layer of lacquer, the greater the optical loss. The phenomenon known as 'ultramarine disease', in which the pigment is discoloured by the action of weak acids, does not seem to have occurred here.[24]

The chromatic change of the blue lacquer is related to the tin foil. Tin is subject to corrosion, causing the formerly silvery metal foil to turn grey, become brittle or holey, and lose its reflective capacity (fig. 11). Tin is highly susceptible to low temperatures, which bring about a molecular change in the composition of the metal, and to humidity, which also causes serious corrosion. Another conceivable cause of the damage is the overuse of water in cleaning the map. Moisture may well have made its way into the joints between the crystal segments and been trapped there. The slate slab would have prevented the cleaning agent from evaporating quickly.

Conservation and Restoration of the Reverse Painted Rock Crystal

The differing conditions of the *amelierung* on the rock crystal panels led to the decision to conserve only those segments of the sea where there are large areas of blue lacquer, and to leave the gilded segments of the land masses untouched, even though the *amelierung* layers of the latter are gradually becoming delaminated.

Twenty-five segments were selected for conservation, and various conservation measures were considered (fig. 12). Among them – because the blue areas were densely covered with micro-cracks – was the Pettenkofer method. In this process the resin layer is exposed to alcohol vapour by means of a solvent mister; this causes the resin to swell and the craquelure to disappear, restoring the inherent luminosity of the lacquer. The complete 'reactivation' of extremely aged, oxidized resin painting is not possible, however. Once the solvent has evaporated – a process that takes several years – the areas that have been treated usually exhibit the damage again to a degree similar to – if not worse than – the state of the lacquer before the method was used.

The treatment was carried out in situ with a thin synthetic resin that has already proven effective in the consolidation of other reverse paintings on glass. The resin was introduced through small cracks and openings.

Fig. 12
The 'Spanish Map' during restoration, following the removal of twenty-five of the rock crystal panels.

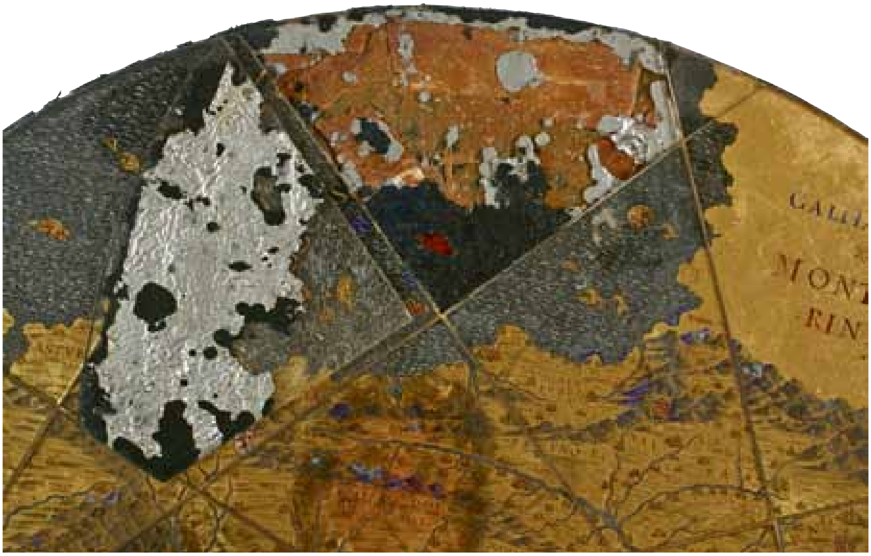


Fig. 13
A rock crystal panel which has been removed for conservation purposes.

Different concentrations of synthetic resin were used, corresponding to the differing thicknesses of the layers of lustre, to allow the consolidation of the micro-cracks.[25] This treatment ensured that the lacquers had sufficient contact with the carrier so that the crystal segments could be removed from their wax bed (fig. 13).

In the areas where fragments of the lacquer had already become detached from the crystal and were scattered and out of place on the wax ground or stuck to the tin foil, which in turn was embedded in the wax, the particles of lacquer had to be removed one by one and returned to the crystal surface in a painstaking process (fig. 14). In the best cases, the correct position of the particles was easily identified when their shape corresponded to the shape of the gap in the painted layer. For the most part it was also obvious where there were gaps in the gilded

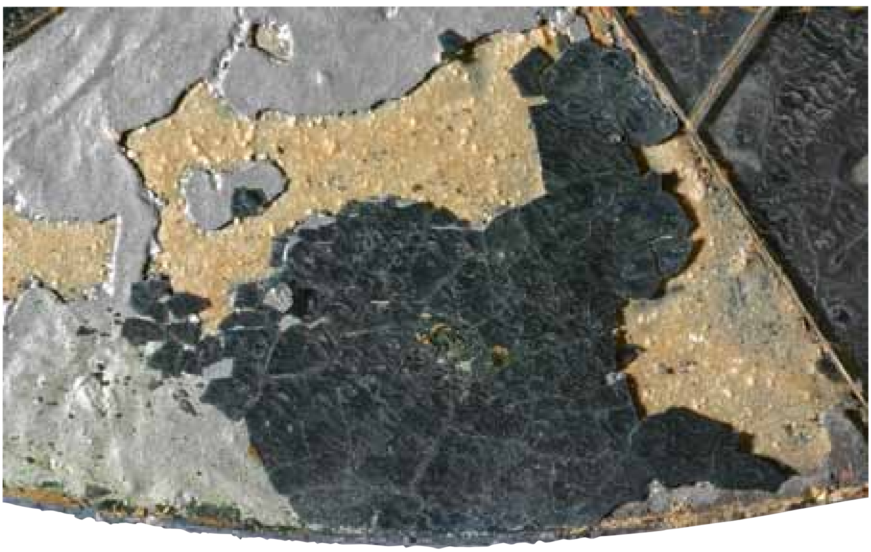


Fig. 14
Particles of lacquer stuck to the tin foil.

Fig. 15
Loose particles of lacquer which are no longer in their correct position must be rejoined in accordance with the inscription.

inscriptions, which could accordingly be filled in again (fig. 15).

A further stage of the conservation called for the treatment of the painted layer with microcrystalline wax,[26] since the evaporation of the solvent used for the synthetic resin treatment had left air bubbles. The areas that were previously blue, but now look greenish blue, proved quite difficult to consolidate. Unfortunately, owing to the extremely thick and tension-filled resin layer, the latter separated from the crystal again shortly after the treatment, albeit to a far smaller degree than before. The tin foil served as a barrier between the painted layer and the wax which had been liquefied with the aid of a heated spatula, as well as the animal glue used during a former conservation procedure. These issues meant that it was not possible to conserve the 'Spanish Map' so that the entire surface was optically satisfactory.

To compensate for gaps missing from the painting, new tin foil – coloured in keeping with the surrounding areas – was applied to the backs of the respective segments. The rock crystal panels thus treated were then re-inserted into the ensemble and the joints were closed with a coloured wax-resin compound. A non-yellowing epoxy resin was used to glue the crack and replace losses in the broken segment.

The conservation work carried out on the 'Spanish Map' generated new insights into the craftsmanship and techniques that went into its making and the valuable materials used in it, and increased our appreciation of this object as a work of art. Although the conservation did not achieve the optically satisfactory result we had hoped for or restore the intense blue of the sea, the causes of the damage are now understood and the detached areas of the painting layer were consolidated such that the map can be put on display to the public once again.

NOTES

* Also see the article by Joosje van Bennekom and Dirk Jan Biemond on pp. 100-15. All the photographs in this article were taken by the author unless otherwise indicated in the captions.

1 The reverse glass painting underwent treatment by the author, a conservator specializing in reverse paintings on glass (www.bretz-hinterglas.com). I would like to thank the following people for their extensive assistance: conservatorial supervision: Robert van Langh and Isabelle

Garachon of the Rijksmuseum; scientific analyses: Dr Patrick Dietemann and Ursula Baumer of the Doerner Institut, Munich; Dr Oliver Hahn of the BAM (Bundesanstalt für Materialforschung und -prüfung), Berlin, and Dr Luc Megens, Suzsan de Groot, Henk de Groot and Matthijs de Keijzer of the ICN (Instituut Collectie Nederland), Amsterdam.

2 K. Schwarz, *Augustin Hirschvogel: Ein deutscher Meister der Renaissance*, Berlin 1917, p. 132, document IX.

3 S. Bretz et al., 'A German House Altar from the Sixteenth Century. Conservation and Research of Reverse Paintings on Glass', *Studies in Conservation* 53 (2008), no. 4, pp. 209-24.

4 S. Bretz et al., 'Allerhand Loth zu machen. Das Schwarzlot in der Hinterglasmalerei', *Restauro*, no. 8 (December 2011), pp. 27-39.

5 Report of analysis by Dr Oliver Hahn, BAM, 16 July 2007.

6 For example the letter N appearing as И.

7 The refractive index of rock crystal, between 1.544 and 1.553, is close to that of glass.

8 Report of analysis by Dr Oliver Hahn, BAM, 16 July 2007.

9 G. Irmscher, *Der Breisgauer Bergkristallschliff der frühen Neuzeit*, Munich 1997, p. 21. Reverse glass paintings made with the *amelierung* technique in Lombardy at the end of the sixteenth century are also made of rock crystal. There, gold and silver powder as well as gold leaf and colourful lustres backed by tin foil were used to depict complex miniature scenes. For examples, see F. Ryser, *Verzauberte Bilder. Die Kunst der Malerei hinter Glas von der Antike bis zum 18. Jahrhundert*, Munich 1991, figs. 99, 100.

10 The following non-destructive methods were used for the material analyses: VIS spectrophotometry, micro XRF, X-ray fluorescence (XRF) and Fourier transform infrared spectrometry (FTIR). Loose particles were used to analyze the binding medium with the aid of gas chromatography/mass spectrometry (GC/MS), a destructive method.

11 Report of analysis by Ursula Baumer and Dr Patrick Dietemann, Doerner Institut, 20 August 2007.

12 *Larix decidua* Mill., native to Europe, e.g. Tyrol.

13 *Pistacia lentiscus*, native to the Greek island of Chios.

14 Resin of the camphor tree, *Cinnamomum camphora*, native to Asia.

15 Dragon's blood from the *Dracaena draco* species.

16 U. Baumer and P. Dietemann, 'Identification and Differentiation of Dragon's Blood in Works of Art Using Gas Chromatography/Mass Spectrometry', *Analytical & Bioanalytical Chemistry* 397 (2010), no. 3, pp. 1371, 1373, fig. 4.

17 T. Brachert, *Lexikon der historischen Maltechniken*, Munich 2001, p. 37.

18 Latin: *ultramarinus*, 'from beyond the sea'.

19 Report of analysis by Dr Oliver Hahn, BAM, 16 July 2007, and by Ursula Baumer and Dr Patrick Dietemann, Doerner Institut, 20 August 2007.

20 Report of analysis by Dr Luc Megens and Suzsan de Groot as well as Matthijs de Keijzer, ICN, 25 November 2009, and second report by Dr Luc Megens, Suzsan de Groot and Henk de Groot as well as Matthijs de Keijzer, ICN, 15 October 2010.

21 This type of glazier's putty usually consists of fifteen per cent linseed oil or linseed oil varnish and eighty-five per cent chalk.

22 Haarlem, Noord-Hollands Archief, Rijksmuseum Archives, inv. no. 2142, Inventory of the Mannheimer Collection.

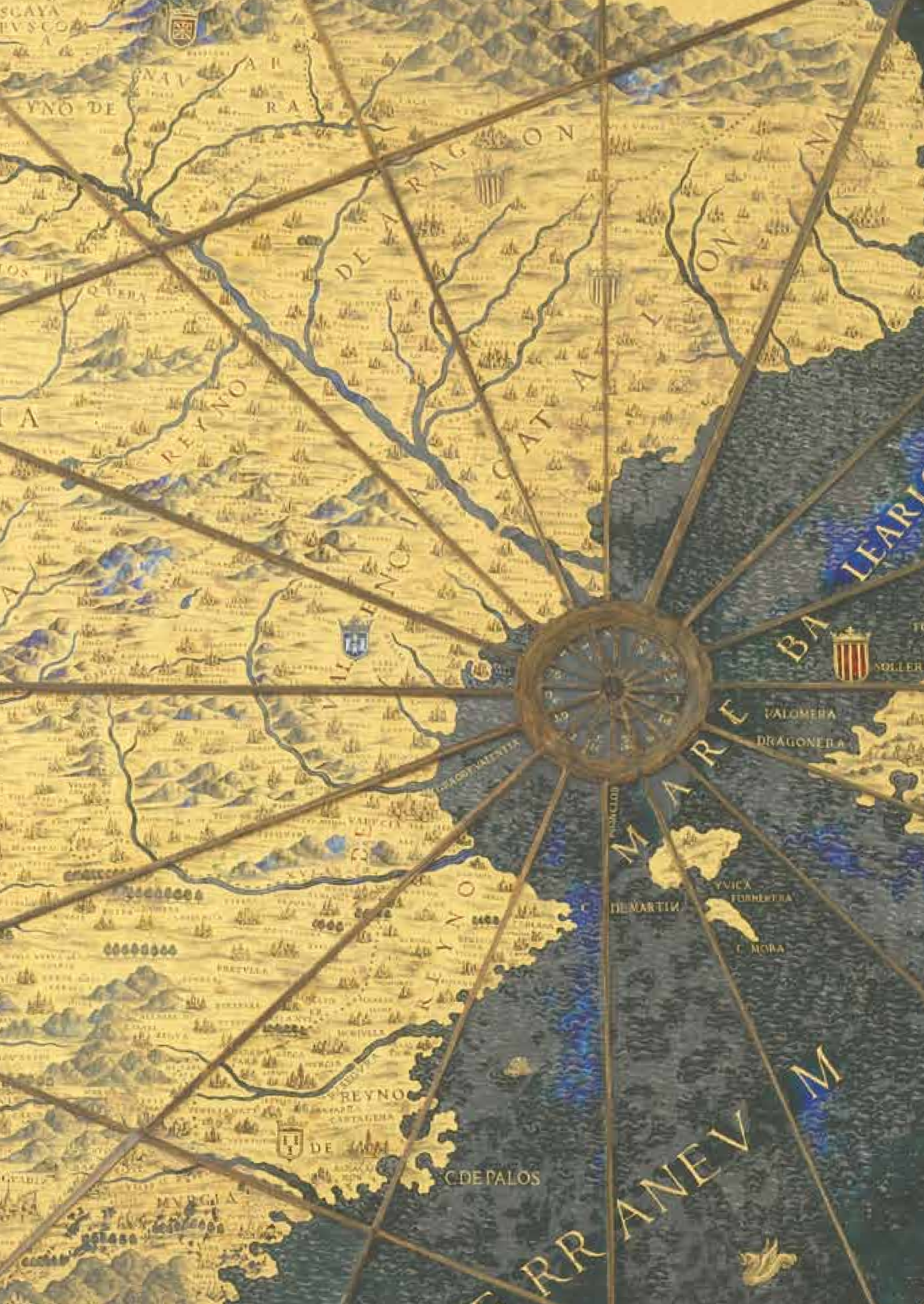
23 The accompanying photograph must have been taken when the object was brought in in 1945. The crack in the lower right segment was not visible at this point. The records have been digitalized and can be accessed through the website of the Deutsches Historisches Museum; see restitution card Mü.-Nr. 1682/1, http://www.dhm.de/datenbank/ccp/dhm_ccp.php?seite=9 (access 20 December 2011).

24 My sincere thanks to Dr Jörg Klaas and Mark Richter, Technische Universität München (Munich University of Applied Sciences), Department of Restoration, Art Technology and Conservation Science, for their valuable information on the subject of 'ultramarine disease'.

25 Hydrocarbon resin *Regalrez 1094* dissolved in white spirit in concentrations of ten to thirty per cent.

26 Microcrystalline wax *TeCero 30445*.

Detail of fig. 1



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