THE FRANCO-GERMAN FIGURINES PROJECT (FGFP)

Regine Hunziker-Rodewald, Astrid Nunn and Thomas Graichen

Introduction (Regine Hunziker-Rodewald[1])

A comprehensive study of Transjordanian iconography and its classification, from a comparative and contextual as well as from a typological and chronological point of view, has never been conducted. The few first steps in this direction resulted in the publication of a monograph (Dornemann 1983: 30 pages on small objects and sculpture) or of some exhibition catalogues (e.g. Amiet 1986; Bienkowski 1991).

With regard to iconography, the Iron Age II BC (about 9th-6th centuries BCE) is a crucial period. Since the second half of the 8th century BCE the entire area of the Southern Levant fell subsequently under neo-Assyrian dominion. The foreign supremacy transformed the artistic production in the small kingdoms now integrated into the Assyrian Empire: the local perception shifted to an 'international' perspective with an adapted thematic scope (Beaulieu 2005; Keel 2008). This substantial change became apparent, *inter alia*, in the influences on glyptic imagery (Ornan 1993; Hunziker-Rodewald 2015a). Until the 6th century BCE the specific cultural and ideological amalgam is well attested in the area. Later it will be superimposed by the Achaemenid and the Hellenistic art style, each featuring a new scope of reference.

The Female Terracotta Figurines from the Southern Levant

In recent books on the history and culture of the kingdoms in Iron Age Transjordan (Bartlett 1989; Gass 2009; Tyson 2014) iconography has simply been treated as a companion of archaeology, its particular evidence has not been properly researched. Specific in-depth studies on topics like the *'atef* crown, the statuary of a particular site, the iconic repertoire on seals or the small objects excavated at a certain site (Horn 1973; Abou Assaf 1980; Huebner 1993; Dabrowski 2009) are *per se* thematically limited and restricted to a geographical area.

Towards the end of the 20th century, two doctoral theses - both unpublished - were dedicated to the anthropomorphic and zoomorphic representations in the plastic art from Palestine and Transjordan (Holland 1975; Amr 1980). These clay objects, as they come frequently to light in excavations, appear often in archaeological reports, as a few lines, sometimes with a photo, but these publications are mostly known only to specialists.

The females among the terracotta figurines from the Southern Levant gained in importance after the discovery of inscriptions from the 8th century BCE mentioning the Biblical God together with "his Ashera" (Naveh 1979). While trying to determine the identity of Ashera, scholars brought a long known group of iconic objects back into focus: the Judean Pillar Figurines (Pritchard 1943; Kletter 1996). The debate triggered by the Ashera inscriptions mainly centered on the known Levantine goddesses (*Athirat, Anat, Astarte*) and the "fertility cults" condemned in the Bible (Hadley 2000; Dever 2005). As the contemporaneous female figurines from Transjordan were poorly known, the main emphasis was placed on the figurines from the western side of the River Jordan (Paz 2007; Sugimoto 2008).

[1] I am grateful to Maria-Louise Sidoroff, Hobe Sound FL, for reading the manuscript of the first part of this article. Her valuable comments and suggestions are highly appreciated.

The Female Terracotta Figurines from Transjordan

The female terracotta figurines from Transjordan have many details in common with the western corpus and display at the same time various characteristics of their own (Hunziker-Rodewald 2012). In addition, the eastern figurine corpus is not homogenous, a big variety and significant regional specifics can be observed.

The assumption that the clay figurines, male as well as female, were linked to cultic activities, in the private as well as in the public sector, is supported by the discovery of shrine models, fenestrated or box-shaped with the front open, on which figurines have been attached to the façade or at the entrance (Daviau 2008). Also the accumulation of objects, primarily female figurines, and ceramic sherds in an isolated wayside shrine located on a hilltop and enclosed by a temenos wall (Daviau 2012) attests to the connection between figurines and some kind of ritual. The evidence has to be compared to other sources from the Levant in order to refine our knowledge of ritual practice performed in Transjordan during the Iron Age II. Oral or literary sources are lost or hidden behind biblical polemics (Hunziker-Rodewald 2016a) and epigraphic sources are still rare. But for example the theophoric names contain valuable information on ideological and religious practices and conceptions (Albertz 2012; Hunziker-Rodewald 2015a.2015b).

Artefacts featuring expression of ritual or cult in Iron Age II Transjordan were exposed to outside influences and may also attest reactions to these influences (Feldman 2014). The details of the corresponding shared repertoire of imagery and style, the manner of its adoption, reaction and counter-reaction still await scientific exploration.

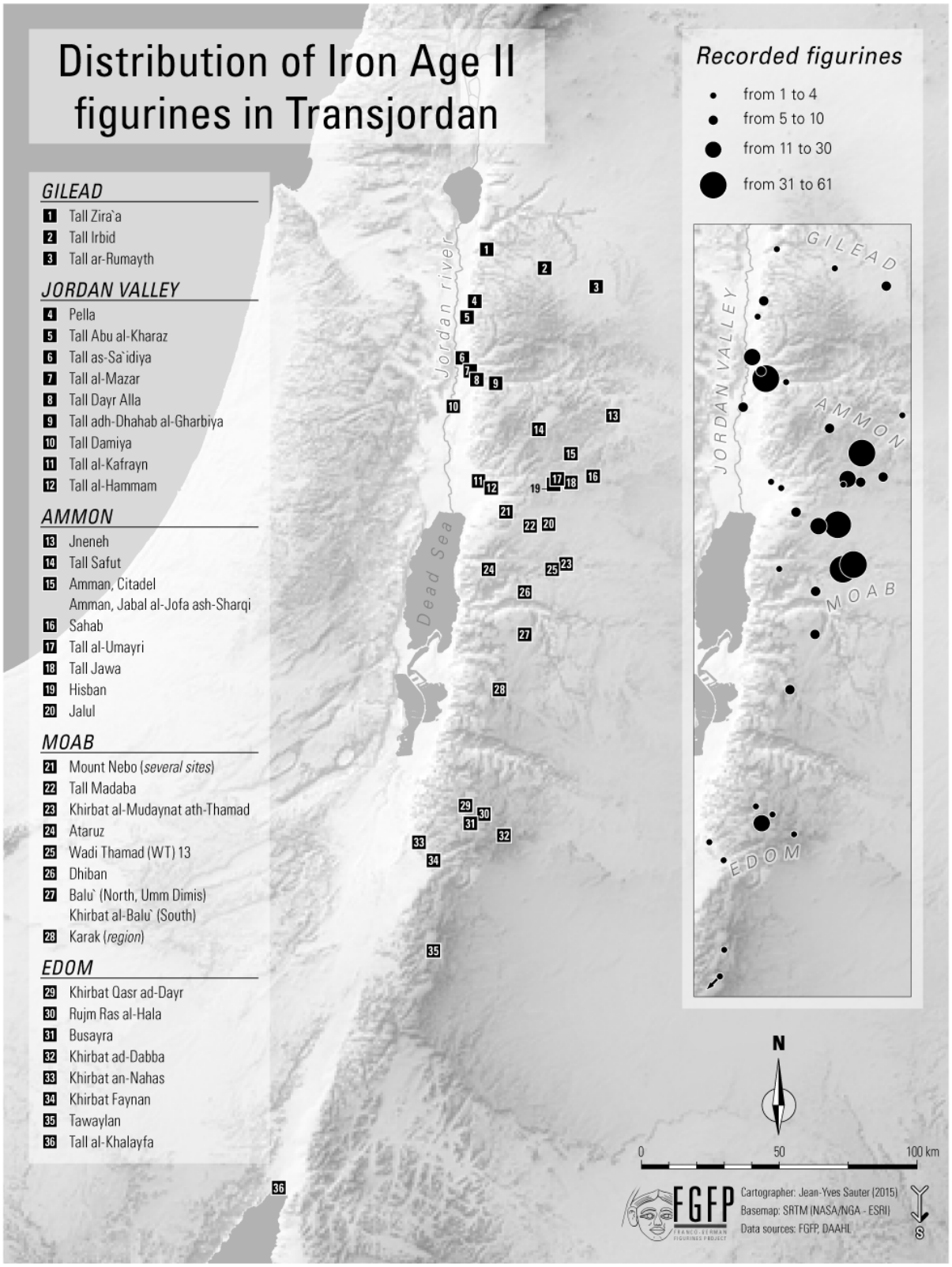
Another major challenge is the definition of the Transjordanian pantheon during the Iron Age. To date, the very few potential references to a goddess in Ammon and Moab remain highly ambiguous (Albertz 2012). Nevertheless, based on old Canaanite traditions, a link between the female figurines and the El cult is conceivable (Hunziker-Rodewald 2015a). Of major importance and definitely needed is a systematic comparative analysis of the ensemble of objects discovered together with female figurines (libation vessels, animal figurines, clay rattles, amulets, lamps etc.).

The Franco-German Figurines Project: campaigns 2012-2014

The Franco-German Figurines Project (FGFP) is financially supported by the Universities of Strasbourg (France) and Wuerzburg (Germany). Its goal is primarily to document the Iron Age female terracotta figurines found in Transjordan and to create a refined typology of these objects. Between spring 2012 and summer 2014, the project team consisting of Regine Hunziker-Rodewald, Astrid Nunn and Thomas Graichen carried out several preparative and five research sessions in France, Germany, Jordan, the United-States and Canada. The team exclusively works on material kept in museums, in storage facilities and in university collections. To date 423 female terracotta figurines, 96% of them fragments, have been registered and 229 figurines have been documented using a computational photography method (RTI, see below).

Of each figurine, the team Hunziker-Rodewald/Nunn/Graichen records the characteristics (object type, state of preservation, origin, archaeological context, current location, excavation and museum numbers, dimensions, clay quality and color, fabrication technique, painting, detailed description) in searchable files, completed by plates, photos and geographical and

archaeological maps. Concerning a preliminary evaluation of the gathered data see part II of this article presented by Astrid Nunn. Concerning the method of computational photography called Reflectance Transformation Imaging adopted by the FGFP team see part III presented by Thomas Graichen.



Map 1: The distribution of the Iron Age female terracotta figurines found in Transjordan.

The Franco-German Figurines Project: activities in 2015

This was a year of preliminary evaluation and publication, technical planning and identifying new financial resources for the continuation of the Franco-German Figurines Project (FGFP). First results were presented at international conferences in the United States, Israel, France, England and Estonia. From April 8 to May 14, 2015, over a six week period, an Experimental Archaeology Workshop, financed by the Franco-German University Saarbruecken and by the University of Strasbourg, was undertaken at the University of Strasbourg, France. Its educational and scientific goals were to achieve practical and theoretical insights into raw material processing, kiln construction, tool manufacture, master figurines and mold production as well as the molding and firing procedures. The model of the reconstructed kiln had been excavated in Mari (Beyer/Laroche-Traunecker 2006) and the originals of the reproduced figurines had come to light in Syria and on both sides of the River Jordan. The workshop was a FGFP project directed by two local potters and the ceramic technologist Maria-Louise Sidoroff who is associated to the Mudayna-Thamad Regional Survey Project in Jordan. The different sessions were documented by a videographer in a documentary film which has been registered as a candidate of the French Festival of Research Movies 2016 in Vandœuvre-lès-Nancy (https://vimeo.com/150722204).

In June 2015, an International Colloquium on nude female figurines from The Ancient Near – East, Egypt, Nubia, Mediterranean and Central Asia (Neolithic – 3rd century AD) was organized at the University of Strasbourg, France. The invited presentations focused essentially on the approaches “Figurines in context: archaeological and socio-cultural aspects” and “Interpreting nude female figurines”. The accompanying exhibition offered an additional opportunity to examine photos of Mesopotamian figurines provided by the Louvre Museum in Paris, a 3-D animation of an Old Egyptian figurine kept in the Institute of Egyptology at Strasbourg University, three RTI presentations of female terracotta figurines kept in Museums in Jordan (http://www.stephane-ostertag.fr/rti/), the film created during the Strasbourg Experimental Archaeology Workshop and some of the produced replicas. The conference volume is in preparation.

In July 2015, the Franco-German Figurines Project has been selected as one of the three pilot projects by the team in charge of the realization of the Open Archives Initiative (Archives Ouvertes de la Connaissance [AOC]) at the University of Strasbourg, France. The project will enhance the value of the collected data with an interactive database in French, English and Arabic, with RTI files included. The project will also develop programs for RTI static images as replacement of freehand line drawings, for the virtual reconstruction of the original figurines from existing fragments and for the virtual reconstitution of the original colours from traces of paint or pigments still detectable on the surface by an appropriate equipment. All excavators of figurines as well as the Department of Antiquities in Amman, Jordan, will be officially asked for permission before the FGFP data will be posted, with their approval, on the web.

Key Issues Still to Explore

Further research includes sessions of the FGFP team in Europe and Jordan in order to complete the RTI files and the creation of an interactive data base by the team of the Open

Archives Initiative of the University of Strasbourg in collaboration with the FGFP team. Also the corpus of the female terracotta figurines, recorded and photographed since 2012, has to be explored in several archaeological, socio-cultural and religious respects. The results of these research activities will primarily be integrated into the database as pdf files which will be linked by a system of cross-references to the photos and interconnected mutually as well as to other gathered details. These documents in French and English shall be translated into Arabic by our Jordanian colleagues and collaborators. In a second phase, a lavishly illustrated monograph with high quality RTI static images is envisaged.
In the following certainly incomplete, but progressively evolving list, several concrete research procedures to be performed in the near future shall be announced:

- Comparative research on geographical distribution, regional particularities, commercial exchange and import (e.g. from Cyprus, Palestine/Israel/Juda, Phoenicia, Aram, Mesopotamia) of female terracotta figurines, in collaboration with the directors of recent excavations in Jordan; creation of geographical maps in collaboration with the AOC team.
- Identification and evaluation of the ensemble of objects and the pottery excavated in the same locus and square; creation of archaeological maps in collaboration with the directors of recent excavations in Jordan and the AOC team.
- Specification and adjustment of the dating and the relative chronology of the regional and the trans-regional types of figurines in collaboration with the directors of recent excavations in Jordan and in the adjacent regions (e.g. Araba, Jordan Valley, northern Gilead) west of the River Jordan.
- Identification of the clay texture and analysis of the specific pigments used for painting, in comparison with painted pottery from the same find spot or site; hypothetical reconstitution of the original look of the female figurines, in collaboration with experts in ancient ceramics and the AOC team; comparison with all the contemporaneous female figurines from the Southern Levant.
- Comparative studies of iconographic details: hairdo, headdress, facial features, gesture, musical instruments, jewelry, position of the hands, dress, baby; comparison with Syro-Palestinian and Egypto-Phoenician representations of females (e.g. on ivories, seals) of the Late Bronze and Iron Ages.
- Comparative ethno-archaeological, socio-cultural and anthropological studies on the ritual usage of figurines in the societies of the Ancient Near East and the Mediterranean, from the Late Bronze Age to the Hellenistic period; research on the relations woman-figurine, goddess-figurine, god-figurine and on social agency.
- Evaluation of the mold links between figurines on both sides of the River Jordan (Hunziker-Rodewald 2016b); in collaboration with the directors of recent excavations in Jordan and in the adjacent regions west of the River Jordan; identification of mold generations by enhanced measuring techniques.
- Creation of a refined typology, in discussion with the models proposed, e.g. by Holland 1975, Amr 1980, Kletter 1996.
- Iconological analysis and critical examination of the proposed identifications of the Levantine female figurines, in discussion with the existing models, e.g. by Kletter 1996, Daviau 2014, Darby 2014.

Significance

To date, the corpus of the female terracotta figurines from Transjordan has never been compiled. Kept in museums and collections in Jordan, Europe, Canada, Australia and the United States, the 423 female figurines currently known to the FGFP team are distributed over widely dispersed geographic locations. The publication of a part of these figurines is of a rather mediocre quality and some of the earlier articles and reports are not easily accessible. Since 2014, with the participation of Michèle Daviau as an associate member of the FGFP team, a Franco-German-Canadian collaboration has been established. Daviau excavated almost 25% of all known Transjordanian female figurines. This collaboration stands for a good combination of specialized knowledge and practical know how. The excellent collaboration with the directorate and the staff of the Department of Antiquities in Amman, with the directors and curators of the museums as well as with the international excavation teams for the progress of our work cannot be overestimated. We found friendly reception and strong support everywhere. In August 2013, we were, during almost three weeks, accompanied by Omar Nofal, member of staff and representative of the Department of Antiquities in Amman. Hopefully, we will be able to do our part to make certain that these figurines will soon be available for ongoing research, in Jordan and abroad. It goes without saying that the corpus of the female figurines from the Iron Age has to be enlarged by those from the Late Bronze Age and also by the male figurines. But let's take one step after the other!

Part II: Geographical Distribution and Archaeological Context (Astrid Nunn)

After the preliminary information, the geographical distribution and the archaeological context will be discussed in this section. The approach outlined here includes our latest information.

Historical and Geographical Division of the Territory

The material has been arranged according to historical provinces. Gilead is situated in the most northern part of Jordan. The "Jordan Valley" is densely settled and extends to the north of Ammon, which begins about at Wadi az-Zarqa. The border between Ammon and Moab would approximately run from the level of the northern shore of the Dead Sea to the southeast and reaches to the Wadi al-Hasa. The most southern province is Edom, which extends to the Red Sea.

Amount of Figurines and Distribution (Table 1)

This paper is based on the 415 figurines, which are currently known to us and whose provenance is secured. This number will certainly be amended: on the one hand some figures might be late Bronze Age (as in Pella) and for some others, the assignment to a gender remains unclear. Yet the current distribution reflects general tendencies, which probably correspond to a historical reality. The number of figurines varies considerably, both between regions and between different sites. The regional distribution reaches from nine figurines in Gilead to 140 in Ammon. Amongst all the sites Amman with 61 figurines is currently the

place of origin of the highest number of figurines. At the other end of the scale a few places are represented by only one figurine.

Region	**Gilead**	**Jordan Valley**	**Ammon**	**Moab**	**Edom**
Number of figurines per region	9	99	140	135	32
Sites excavated	3	9	8	7	6
Sites recorded				•Mount Nebo (*several sites*) •Karak (*region*)	•Khirbat Qasr ad-Dayr •Rujm Ras al-Hala
Sites names and figurines recorded, from North to South	•Tall Zira'a: 2 •Tall Irbid:2 •Tall ar-Rumayth: 5	•Pella: 6 + 13? •Tall Abu al-Kharaz: 1 •Tall as-Sa'idiya: 15 •Tall al-Mazar: 9 •Tall Dayr Alla: 42 •Tall adh-Dhahab al-Gharbiya: 2 •Tall Damiya: 7 •Tall al-Kafrayn: 1 •Tall al-Hammam: 3	•Jneneh: 1 •Tall Safut: 6 •Amman, Citadel and Jabal al-Jofa ash-Sharqi: 61 Sahab: 5 •Tall al-Umayri: 26 •Tall Jawa: 9 •Hisban: 1 •Jalul: 31	•Mount Nebo (*several sites*): 6 •Tall Madaba: 15 •Khirbat al-Mudaynat ath-Thamad: 42 •Ataruz: 1 •Wadi Thamad (WT) 13: 50 •Dhiban: 9 •Balu' (North, Umm Dimis) and Khirbat al-Balu' (South): 6 •Karak (*region*): 6	•Khirbat Qasr ad-Dayr: 1 •Rujm Ras al-Hala: 1 •Busayra: 21 •Khirbat ad-Dabba: 2 •Khirbat an-Nahas: 1 •Khirbat Faynan: 1 •Tawaylan: 2 •Tall al-Khalayfa: 3

Table 1: Distribution of the Iron I-II figurines according to regions and sites

Thus, the region with the largest quantity of figurines is Ammon and Moab, where 275 out of 415 were retrieved. There are as many as 374 figurines if we add the Jordan Valley. This area extending over 70 km from north to south can be regarded as the core area for this type of female figurines, though we are not yet able to determine possible places of production and distribution patterns.

The Context of Archaeological Finds

Further light can be shed on the identity of these women by the information we can gain from the archaeological context. The context refers to the stratigraphy (this still needs further study) as well as to structural features, which may lead to an interpretation of the original architectural environment of the figurines. This latter aspect is discussed here.

The context is "undetermined" for 166 Figurines. "Undetermined" comprises several possibilities: either information is missing, or the piece has no precise origin (Karak region), or it was retrieved up on the surface (Tall Dayr Alla, Amman, Khirbat al-Balua'). Moreover,

the figurines may indeed have been excavated, but either the figurines did not get to light in situ (Amman), or the original function of the excavated context is unclear.
For the remaining 249 figurines the finding places have been divided into five categories. The figures also include the pieces which we have not been able to categorise with certainty: Domestic (100 items); Domestic and/or administrative (48 items); Domestic and industrial (24 items); Cultic (62 items) and Funerary (15 items). A domestic surrounding is clearly best represented. Adding the different aspects of a pure residential domestic surrounding to the administrative and manufacturing aspects, the number increases to approximately 172 pieces (100 + 48 + 24).
Examples follow now for each category. Three significant sites have been chosen for the *domestic* context. In Busayra 19 of the 21 figurines were found in Area B. Excavations there revealed a sequence of perimeter walls and a number of rectangular structures with a possible courtyard associated with plaster floors, benches or shelves, storage and cooking, all suggesting a domestic occupation (Bienkowski 2002, 111-147). In the Iron Age II Tall Dayr Alla mostly light structures, courtyards, walls of a single layer mud-brick came to light as well as enclosing small rooms, which were annually covered with layers of reed. These were erected, destroyed, levelled and rebuilt. Therefore the "moving" of the houses is intricate and difficult to follow. Storage rooms, pits and finds hint at mainly agricultural and domestic activity (van der Kooij 2001). Among the sites Dhiban and Tall al-Mazar show an *administrative* structure with a *domestic aspect*. To date, ten figurines are known from Dhiban, six of which originate from the two adjacent rooms LII and LIIIA in the "Moabite Palace" in Area L (Routledge 2004, 161-173). The nine figurines from Tall al-Mazar were all found in Field I, where the construction phases of a large building can be followed through all strata. This building may have been an administration centre or a "Palace Fort" in the terminology of the excavator but also for private use (Yassine/van der Steen 2012). Two figurines were uncovered in the rectangular fortress on the top of the Lower Tall of Tall as-Sa'idiya (Pritchard 1985).
On Tall Jawa, all buildings have a *domestic and industrial* character and no building or architectural features of explicit religious character were found. In Building B204 (Field B) vessels and a modest number of food preparation tools hint at a domestic context. Ovens, large amounts of pottery, spindle whorls, loom weights and grinding tools are characteristic of domestic food preparation, of storage as well as of household-level textile production in the two Buildings B800, B900 and B910 (Field C). B300 (Field E) had cooking areas and food processing tools such as cooking pots, craters, bowls, lamps, store jars and pithoi, strainer vessels, basalt tools, mill stones, querns, pestles, pounders and mortars (Daviau 2002, 2003). In Khirbat al-Mudaynat ath-Thamad excavation campaigns have revealed a casemate wall with a six-chambered gate and a small shrine, where figurines were discovered. But they were even more numerous in several rather industrial buildings. As in Tall Jawa pounders, grinders and querns, stoppers, polishing stones and slingstones clarified the function of B200, B 205, B210 and B 400 for the production, the manufacture and processing of textiles. Pottery sherds, grinding tools, mortars, millstones and limestone basins all clearly hint at industrial activities, such as food processing in the buildings B300 and B303 (Daviau et al. 2006, 261, 264. Daviau, et al. 2008, 348-349).

The *cultic* context of the figurines is noteworthy, in as much as the vast majority of them (49 out of 62) was retrieved in the only sanctuary of Wadi Thamad (WT) 13. The architectural remains of this isolated shrine consist of one rectangular structure, surrounded by walls of limestone. Beside the clay and limestone figurines, 20 large hollow statues of males and females, architectural models, jewellery and more than 25.000 ceramic sherds illustrate the unusual wealth of the shrine (Daviau 2012). The second most important sanctuary in relation to figurines is located in Khirbat al-Mudaynat ath-Thamad about three km to the east of Wadi Thamad (WT) 13. Seven figurines were discovered in the main room and an adjacent room (Daviau/Steiner 2000). A *funerary* context is rare. While most of the Amman figurines seem to have been originally used on the citadel, eight were found in two tombs located on the Jabal al-Jofa ash-Sharqi, 300 m east of the Roman theatre (Dornemann 1983, 47). Mount Nebo's peak rises around 800 m above sea level, some seven km west of Madaba. Of the several other peaks surrounding Mount Nebo the two historically most important ones are Jabal Siyagha on its western spur and, three km to the south east, (Khirbat) al-Mukhayyat. Two tombs dating to the Iron Age were excavated there, one of them with two figurines (Benedettucci 1998).
There may be different archaeological find contexts within one site. Buildings are domestic and industrial as well as religious in Khirbat al-Mudaynat ath-Thamad. In addition to the "Moabite Palace" in Dhiban one figurine was found in a grave (Tushingham 1972, 115).

Preliminary Conclusion
The figures presented here lead us to two conclusions, which will probably remain unchallenged by further research: the area including the Jordan Valley, Ammon and Moab must be regarded as the core area of the use of Iron Age II female figurines. This density of sites reflects not only modern archaeological activity, but also the density of ancient settlement. The second point concerns the context. Many figurines come from an everyday living and working context, be it a palace or a house. The evidence of cultic context is currently limited to a few sites, amongst them Wadi Thamad (WT) 13 is by far the most important. According to our present knowledge six sites point to a funerary context in a tomb.

Part III: The Technical Aspects of Image Acquisition in the FGFP (Thomas Graichen)
Inherent project limitations and adverse conditions were the main factors defining the requirements on the documentation method. For one, acquisition time on site would be limited due to the departments' working hours. In these short periods, a relatively large number of objects would have to be captured. Our work would be carried out in various departments, museums and storage facilities, so the dimensions of the available working space would vary. This also meant that ambient lighting conditions were likely to be unpredictable and for the most part uncontrollable. Since our destinations would probably include rural sites, reliable and constant mains power supply couldn't be guaranteed either. Considering these factors, the setup had to be simple and deploy-able in a short amount of time, allow for a time-efficient acquisition of images, and further be able to function without relying on a power grid on site. After careful consideration, the decision was made in favor of Reflectance Transformation Imaging (RTI), which produces dense surface data of captured objects, by far surpassing traditional photographs in the versatility of its output format, and requiring only a relatively

simple setup. With merely a few additions to conventional photography gear and slight adjustments to the shooting technique, a captured object's surface orientation and reflective properties can be computed per pixel and displayed in conjunction with its color value. This is achieved by examining each pixel's behavior under different known lighting angles, assuming a perfectly diffuse surface and constant lighting temperature, intensity and distance.[2]
In practice, an object view is captured from a fixed perpendicular position under varying lighting directions with two or more reflective spheres in frame (fig. 1). These pictures are then processed by the RTI-Builder (fig. 2). The resulting file can be visualized with the RTI-Viewer (fig. 3), where color, topography information and reflective properties can be processed by visualization filters to accentuate certain surface characteristics (fig. 4). This opens up many possibilities for subsequent virtual analysis of the artifacts.
This method has been used to great success in numerous heritage projects. In one of its earlier forms, it played a crucial part in the discernment of previously undetected inscribed letters on the Antikithera-Mechanism[3], and has since been adopted by a number of heritage projects[4].
The latest publicly available iteration of this technology was released by Cultural Heritage Imaging, a San Francisco based non-profit organization[5]. Developed in collaboration with Tom Malzbender from HPLabs in Palo Alto, California, the Hemispherical Harmonics Algorithm increased the portability of the acquisition setup, while simultaneously improving data accuracy[6].
In addition to meeting the requirements imposed by the above mentioned adverse circumstances of the data acquisition in our project, the files generated using RTI offer significant advantages to photographs and hand drawings. A regular photograph is limited to a representation of an object under a fixed light cadence. An RTI-file, on the other hand, allows for a seamless dynamic variation of lighting angles. Although between 24 and 60 pictures per object view are needed for reliable computation of the RTI-file[7], the shooting itself doesn't factor heavily on the total acquisition time. Since the positioning of the object and camera setting remain the same for RTI-capture and classical photography, the total difference in time between both is negligible. When confronted with objects of varying sizes, textures and reflectance properties, RTI can even be more time efficient than traditional photography, since the latter requires, depending on each objects characteristics, adjustments to lighting position, temperature and hardness; all features which can be retroactively emulated within the RTI-Viewer. Since a widely accepted standard practice has yet to be established for object photography in archeological disciplines, photographs of the same archaeological artifact can

2 See <http://culturalheritageimaging.org/Technologies/RTI/> (accessed Jan 6th 2016) for further details on theory and practice of RTI-photography.

3 See <http://www.antikythera-mechanism.gr/data/ptm/full-resolution-ptm> (accessed Jan 6th 2016) for the full resolution PTMs of the mechanism.

4 Among the most noted collaborators are the Metropolitan Museum of Art in New York, the Smithsonian Institution, the Staatliche Museen zu Berlin, as well as the The British Museum in London. For a full list, please refer to <http://culturalheritageimaging.org/About_Us/Collaborators/> (accessed Jan 6th 2016).

5 <http://culturalheritageimaging.org/> (accessed Jan 6th 2016)

6 <http://culturalheritageimaging.org/What_We_Do/Publications/vast2006/VAST2006_final.pdf> (accessed Jan 6th 2016)

7 <http://culturalheritageimaging.org/What_We_Offer/Downloads/RTI_Hlt_Capture_Guide_v2_0.pdf> p. 30. (accessed Jan 6th 2016)

differ considerably, depending on hardware, shooting technique and circumstances. Drawings can be very detailed and rich in information, especially as a complement to photographs, emphasizing surface characteristics not visible in the latter. But their use as a scientific tool is questionable at best. They are inherently interpretative, and can differ substantially between artists. RTI efficiently captures surface characteristics, which can be processed using an array of visualization filters, thus facilitating the discernment of color and topography features. This largely eliminates the need for interpretative feature accentuation via drawings. It even offers benefits compared to naked eye examination of the actual object, where many features can go unnoticed, even under magnification and varying light cadence. From a digital heritage point of view, the RTI-Builder and the produced file format comply with the standards for digital files and methods defined by nestor[8].

The pictures for RTI processing can be acquired either by a light dome (fig. 5) or a hand held light source. A dome setup offers some benefits in form of faster and less tedious acquisition, and therefore potentially more images per view, which in turn can increase data precision[9]. However, those benefits come at a cost. Since commercial solutions are not available, the development and construction of such a device can be costly and time-consuming. Spare parts are mostly unobtainable in Middle Eastern countries, especially on short notice, and ensuring a basic redundancy of all key components can be a very expensive matter. The intricate wiring of the light sources and micro-controller can require occasional on-site maintenance by a technical expert. Additionally, the dome's fixed diameter narrows the size range of objects that can be captured, and a dome's relatively large size can restrict its portability. This could be compensated by a modular setup, but assembly and dis assembly on site can be time consuming and lead to a lower structural integrity of the whole setup. Lastly, entering a near eastern country with electronic appliances of ambiguous origin and function can be difficult.

A free handed acquisition approach, on the other hand, offers many advantages to our project. The components as a whole are hardly more expensive than regular photographic equipment, consisting of a DSLR camera, a hand held external flash unit, two wireless transmitter/receiver pairs, a copystand and reflective spheres of different sizes. The setup is inconspicuous enough to raise no flags at customs, and redundancy of key components is easily achieved. It is structurally robust and can be adapted to a broad range of object sizes. As mentioned above, a manual approach means tedious and physically strenuous data acquisition[10]. In our case, this was compensated by a reduced number of shots per object view[11].

A copy stand has been chosen over a conventional tripod, since the single vertical mounting arm and the resulting top-to bottom-view allows for a better light distribution around the object (fig. 6). Furthermore, the camera's focus can be acutely adjusted by sliding the camera mounting plate down the mounting arm. Apart from the camera fixture, a firm positioning of the object is crucial, since the smallest movement can result in blurred RTI-files. After some trials with plasticine, a small box filled with chemically neutral sand was used to nest the

8 <http://www.nestor.sub.uni-goettingen.de/handbuch/index.php> (accessed Jan 6th 2016)

9 <http://vcg.isti.cnr.it/Publications/2006/DCCS06/Dellepiane_et_al_High_quality_PTM.pdf> (accessed Jan 6th 2016)

10 About 160 pictures are captured per figurine in this project.

11 However, given stationary use and nonrecurring import of the gear (i.e. an excavation project), a dome's benefits outweigh its disadvantages.

objects and the reflective spheres. In cases where our own chemically neutral sand could not be imported due to national restrictions, a self-made contraption of three pottery gauges fitted in a row has proven equally efficient (fig. 7). Concerning the camera itself, shooting with a DSLR is preferable, since it allows for precise manual control of virtually all camera settings. Even though we encountered many small figurine fragments, using a macro lens would have resulted in a much higher image distortion, as well as a very narrow depth of field. A standard kit zoom lens (18-55mm) was used initially, but we quickly observed significant image misalignment between pictures during post-processing. This was very likely caused by the shutter vibration slightly shifting the lens's zoom tube. For those reasons, the kit lens has since been swapped by a 50mm fixed focal length lens, thus eliminating image misalignment, as well as minimizing distortion. Since the focus ring still tends to shift between shots in a vertical setup, tethered shooting using the camera manufacturer's photo studio software is advised. This way, the lens's internal servo motor can be used to fix the focus for the duration of a shoot without the use of external mechanical aids. A hand-held wireless flash unit serves as the light source, enabling shorter exposure times. This way ambient lighting can be largely disregarded. Additionally, higher f-stop values can be set, thus increasing the depth of field. In addition to the figurine itself, several objects have to be placed in frame. These include at least two reflective spheres for the RTI-computation[12], grey cards for white balance correction, as well as a label containing the object's ID-number. As mentioned above, 40 pictures with different lighting angles are taken for the obverse, reverse, and side views of the object; top and bottom views are captured as photographs only. In roughly ten to fifteen minutes, a figurine can be prepared, positioned and captured accordingly. In post processing, the alignment between the images of each series is checked and, if necessary, corrected. Prior to processing in the RTI-Builder, a composite mask is applied to each image series, removing the background and adding the text formatted ID-number and dimensions of the object (fig. 8). For post-processing, roughly two and a half hours are necessary for each figurine, where most time is spent on manual background masking. However, adding this step allows for easy extraction of publication ready RTI-screenshots.

Naturally, the above mentioned work-flow leaves much room for improvement. In retrospect, an automation of the acquisition would have been favorable, given slightly different circumstances. Some of the repetitive steps in our custom post-processing could surely be further automated using high level programming languages, depending on the availability of time and financial resources. Since the RTI-method does not return real 3d-data (i. e. surface points with x, y and z values in space), a combination with photogrammetry methods could close the gap between 2,5d and 3d-data. Both methods could easily be implemented as standards in museums and excavations, regardless of the endeavor's technical sophistication or budgetary constraints. If, however, the data is not made available to the scientific community under an open data policy[13], it has little to no value to the science community. For this reason, this project aims to make its RTI-files available online in the near future.

12 See FN 6.

13 Please refer to <http://www.openoasis.org/index.php?option=com_content&view=article&id=130&Itemid=390> (accessed Jan 6th 2016) for an introduction into the subject.

Fig. 1a: The project's RTI setup, not pictured are the external flash unit and the wireless remotes.

(Photograph courtesy of Regine Hunziker-Rodewald)

Fig. 1b: RTI capture setup, from the camera's point of view. The figurine is nested in chemically neutral sand in the center, framed by two or more black reflective spheres (corners), cards for white-balance correction (right, top), and a note with the objects identification number.

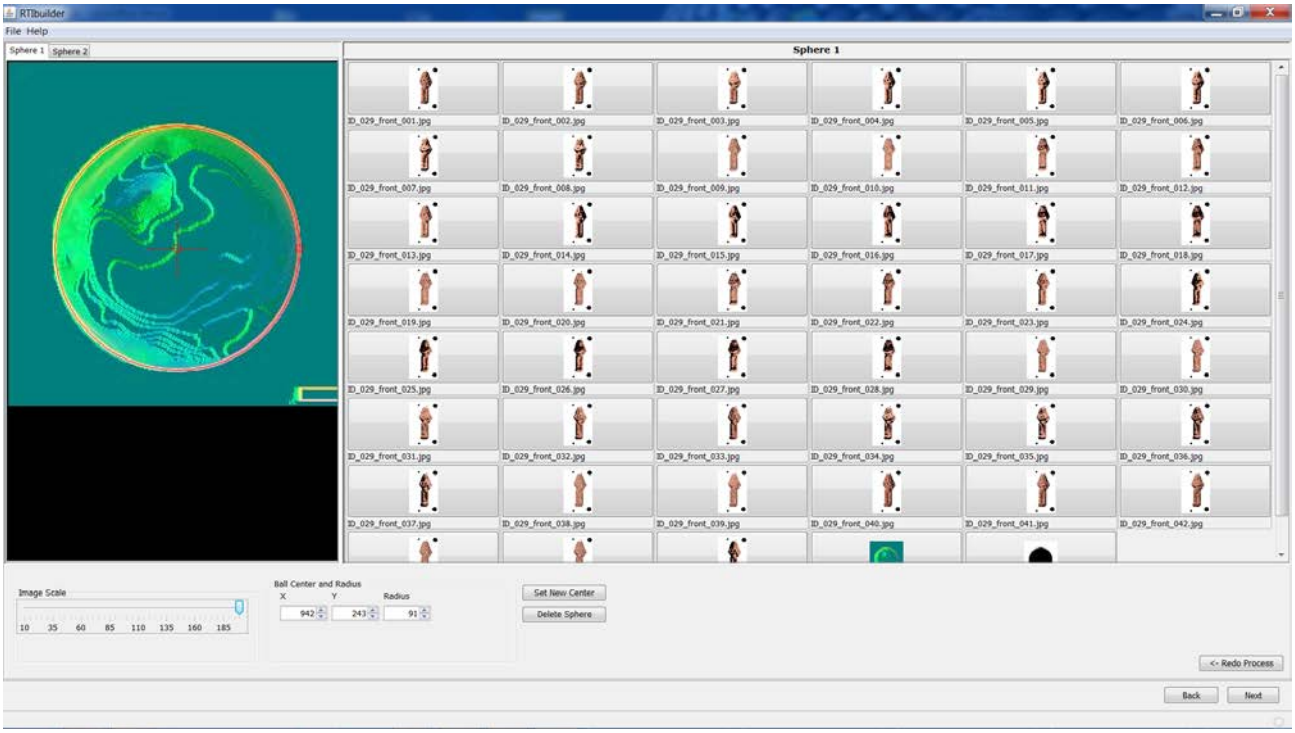


Fig. 2: A screenshot of one of the post processing steps inside the RTIBuilder.

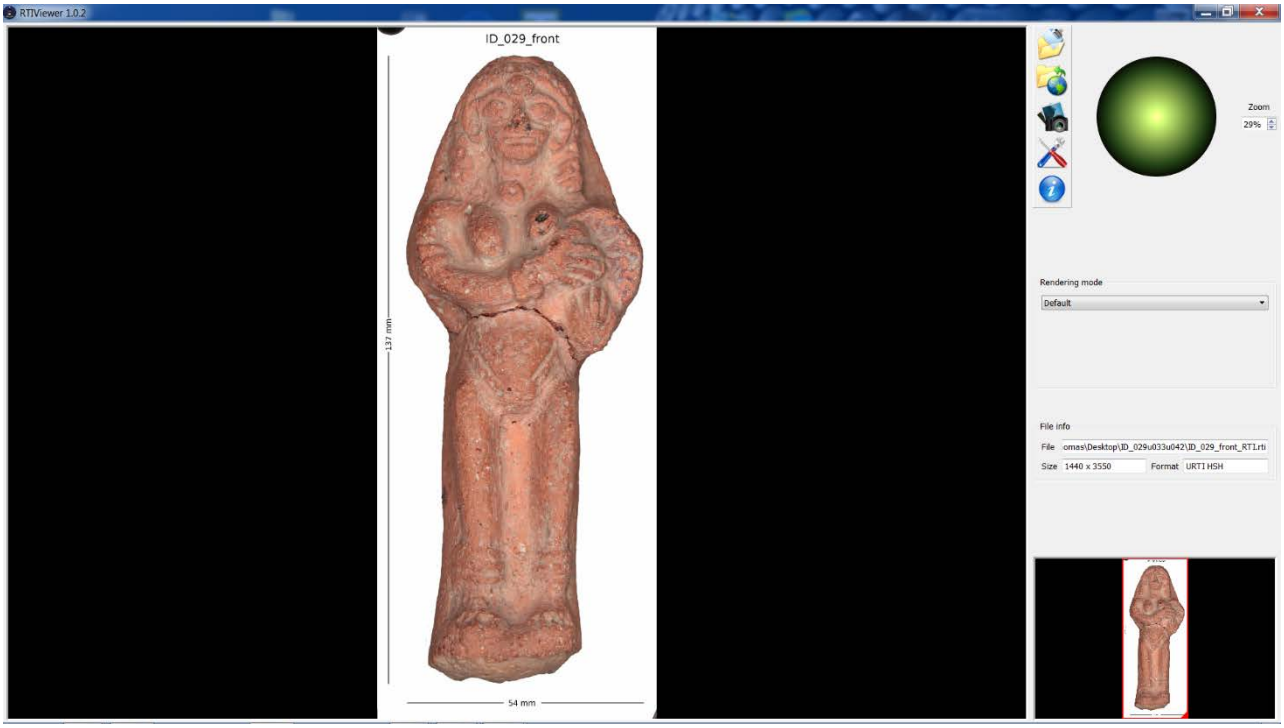


Fig. 3: The finished file loaded as displayed by the RTIViewer. The lighting angle can be manipulated using the virtual trackball (top, right), and a collection of visualization filters can be accessed via a drop-down menu (middle, right).

Fig. 4: An overview of the surface characteristics discernible through RTI-data. From top to bottom: color, surface orientation, topography (extrapolated from surface orientation) and reflectance.

Fig. 5: An RTI-dome with 64 flash units

(http://ewic.bcs.org/upload/pdf/ewic_ev11_s8paper4.pdf , accessed Jan 6th 2016).

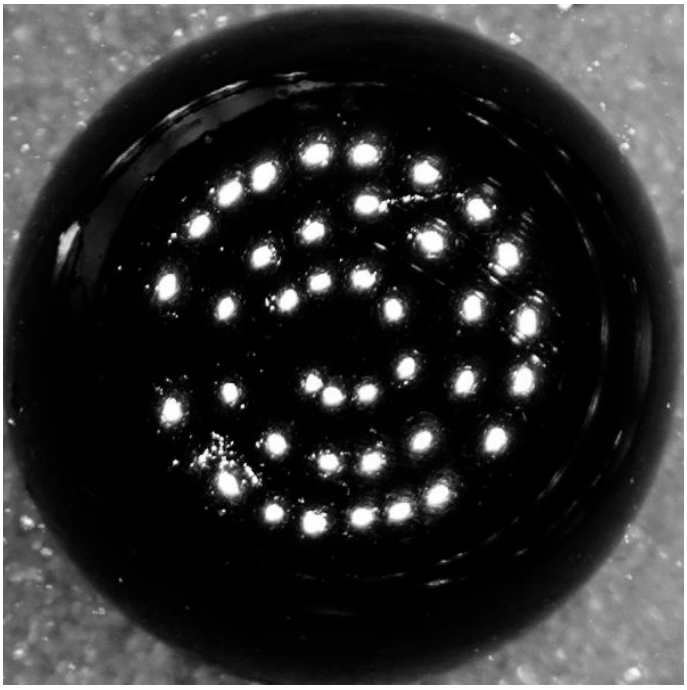


Fig. 6: Light distribution using a copy stand. The stand's arm prevents lighting from its direction, leaving a slight gap (horizontal, left).

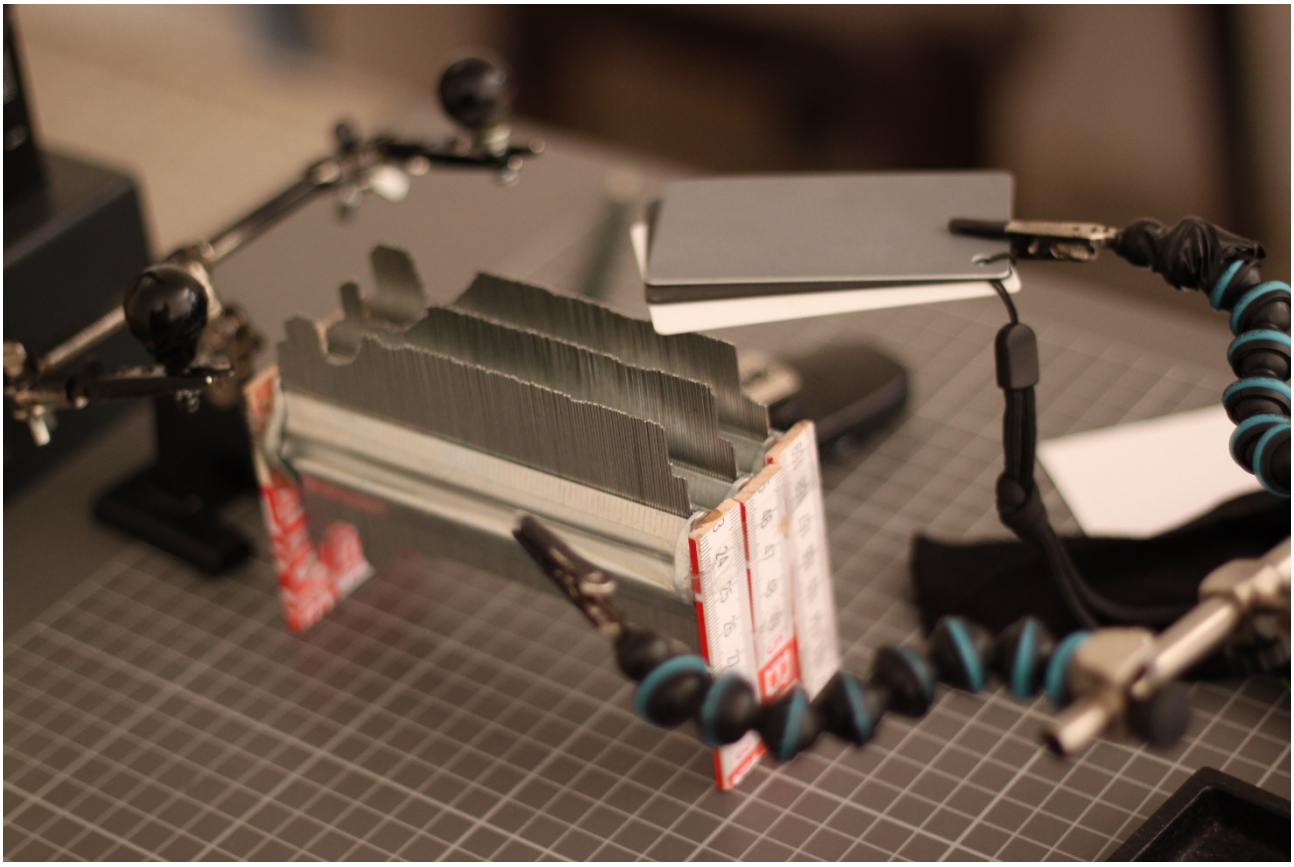


Fig. 7: A contraption made of aligned pottery gauges used as a fixture for the figurines.

Fig. 8: A composite mask is applied to all photographs before further processing, discarding the background and adding the figurine's identification number and measurements.

Regine Hunziker-Rodewald
Old Testament studies and History of the Near East
Faculty of Protestant Theology
University of Strasbourg
9 place de l'Université
67084 Strasbourg (France)
rhunziker@unistra.fr

Astrid Nunn
Near Eastern Archaeology
Julius-Maximilians-Universität Würzburg
Residenzplatz 2A
97070 Würzburg (Germany)
astrid.nunn@uni-wuerzburg.de

Thomas Graichen
Near Eastern Archeology and Computational Archaeology
i3mainz - Institute for Spatial Information and Surveying Technology
University of Applied Sciences
Lucy-Hillebrand-Str. 2
55128 Mainz (Germany)
tgraichen@web.de

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