12 ICAANE

Proceedings of the 12th International Congress on the Archaeology of the Ancient Near East

Volume 1

Environmental Archaeology

Hammering the material world

Cognitive archaeology

Modeling the past

Networked archaeology

Endangered cultural heritage

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The 12th ICAANE, Bologna: Foreword and Acknowledgments

Nicolò Marchetti

The defining event of the 12th ICAANE is, of course, that it has actually taken place, if not in a way that it could actually be foreseen. When the pandemic brought to strict lockdowns all over the world in March 2020, we were less than a month away from the Congress and this forced us to steer course through uncharted waters. That the 1033 initially registered participants were still 883 (of whom 64% regular and 36% students, plus *c*. 100 Middle Eastern officials) a year later within a totally different, remote formula is something to be credited to the trust as well as the sense of community of our colleagues and their determination to serve science and keep close mutual contacts alive despite all odds. 548 papers (including 192 of them distributed in 23 workshops) and 71 posters were presented in up to 15 parallel sessions: 142 papers about the main themes are published in these two volumes.

The Congress attempted at representing a multidisciplinary environment where to pursue interconnections (geographical and chronological as well) and inclusivity at all levels: just looking at the first authors, we have an almost perfect balance of women and men from 43 countries (Europe 68%, Asia 22%, North America 8% and Oceania 2%). Eight themes were selected in an attempt at representing the current breadth and urgency of global challenges and research perspectives: 1. Field Reports. Recent excavations, surveys and research; 2. Environmental Archaeology. Changing climate and exploitation strategies: impact on ecology, anthropized landscapes and material culture; 3. Hammering the material world. Characterization of material culture, processes and technologies; 4. Cognitive archaeology. Reading symbolic and visual communication networks and structures; 5. Modeling the past. Contemporary theoretical approaches to the archaeology of economies and societies; 6. Networked archaeology. Global challenges and collaborative research in the new millennium; 7. Endangered cultural heritage. Coordinated multilateral research, conservation and development strategies; 8. Islamic archaeology. Continuities and discontinuities between a deep past and modernity.

The trust that the ICAANE International Committee showed in 2018 towards the 12th ICAANE Organizing Committee of the Alma Mater Studiorum – University of Bologna about managing such a complex event must be acknowledged at the very onset. That the University of Bologna in the first place accepted to host an ICAANE was remarkable: the then Rector Francesco Ubertini is to be credited with unlimited enthusiasm for the idea and the Head of the Department of Legal Studies Michele Caianiello followed suit in ceding for a week to the Congress his most precious commodity, the perfectly functional Belmeloro lecturing complex, without which it would not have been possible to think to such an endeavour. The then Head of our Department of History and Cultures, Paolo Capuzzo, and our Department Administration were outstanding in showing at every corner flexibility and commitment as well as allocating resources for the Congress. We greatly benefitted from the experience and creativity in handling large scientific events of the FAM-Fondazione Alma Mater (and Alessandro Vriz, in particular, has been invaluable all throughout).

The ISMEO – Associazione Internazionale di Studi sul Mediterraneo e l'Oriente and its President Adriano Rossi allotted a grant for the Congress' organization and helped us assist and manage colleagues in Iran. The publishers Harrassowitz, Brill and Ante Quem supported the prize for the best poster by gifting books to the winners (C. Sadozai and S. Moriset "Post-excavation

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treatments of earthen archaeological sites"). Iperceramica and its CEO Corrado Neri assigned a prize in cash for the best paper on ancient tiles (M.-S. Zeßin "Marks on Glazed Bricks of the Neo-Assyrian Period from Ashur"), while the cash prize offered by Carpigiani remained unassigned. To all of them we are truly grateful for their generous support.

The Directors General of antiquities from Turkey, Iran, Iraq as well as KRG, Syria, Cyprus, Lebanon, Palestinian National Authority, Jordan, Saudi Arabia, Oman and Egypt accepted to present the policies and needs of their respective Countries about cultural heritage in a plenary session: this was a great honor and we are deeply grateful to them for their enduring trust and friendship. In the Opening Session, then students Giulia Piraccini, Margherita Robecchi, Roberto Santoro, Alice Zamarchi (coordinated by Ahmad Addous) performed a poetry reading in Arabic, Turkish, Farsi and English of the "Hymn of the Rain (Unshūdat al-Matar)," by Badr Shākir Al-Sayyāb. The musician Réda Zine played a memorable performance: "Reviewing the MENA musical heritage. Gwana music from Guembri to electric guitar." We are most grateful to all of them as well as to the colleagues who accepted to e-chair sessions, to the four keynote speakers selected only on the basis of the quality of their submitted papers (here published as the opening essays of themes 2, 3 and 1), to all the participants who have been almost invariably sympathetic towards our shortcomings and many requests to them and to the legions of anonymous referees for their hard work which enormously improved the contents of these Proceedings.

Bologna Welcome and ER.GO with its Director Patrizia Mondin were ready to host colleagues and students to the best of their considerable ability: that in the end they did not have a chance to fulfill that, does not subtract from their keen availability. The online infrastructure, Ibrida.io of Search On Media Group, offered us an immersive and seamless experience of a remote conference fully functional under every aspect: not only the professionalism of Vito Esposito and his vast team was appreciated by all participants, but their subsequent acceptance of our request to grant free access to (and thus to keep online) the recordings of all sessions for almost a year after the end of the Congress added an immense value to its dissemination and tore down economic barriers in accessing state-of-the-art scientific knowledge for the global academic community.

The 12th ICAANE Scientific Advisory Board (Pascal Butterlin, Peter Fischer, Tim Harrison, Wendy Matthews, Adelheid Otto, Glenn Schwartz, Ingolf Thuesen) proved extremely helpful in steering the Congress out of controversies and helped taking strategic decisions at all steps. The energy and dedication of the 12th ICAANE Unibo Executive Team (Michael Campeggi, Vittoria Cardini, Francesca Cavaliere, Claudia D'Orazio, Valentina Gallerani, Gabriele Giacosa, Elena Maini, Eleonora Mariani, Chiara Mattioli, Jacopo Monastero, Valentina Orrù, Giulia Roberto, Marco Valeri and Federico Zaina) have been admirable before, during and after the Congress. The volunteers Vanessa Ferrando, Noemi La Cara, Ylenia Viggiano and Elena Bandiera generously gave us their time and talents, and G. Roberto designed all the graphics. Outstanding in their roles have been C. D'Orazio as Scientific Secretary of the Congress and F. Cavaliere as Editorial Coordinator: we are all indebted to their rigorous and meticulous organizational skills.

Harrassowitz Verlag with its Director Stephan Specht was as dedicated as it can be to the Congress and accepted to publish our Proceedings in Golden Open Access, while Jens Fektenheuer has been a solid reference for all technical issues. The care and passion with which Federica Proni of Te.M.P.L.A. has typeset these two volumes cannot be praised enough. In releasing these Proceedings to the press, together with the other Editors we hope that they will represent a useful service to an international scientific community which is growing stronger and more closely knit after each ICAANE, hopefully standing up to the grave challenges lying in front of us for the protection, study, conservation and presentation of an ever more endangered cultural heritage.

Hammering the Material World

3D Model Analysis of LBA and EIA Swords from the Near East

Konstantinos Kopanias, Erato Vemou and Katerina Sidiropoulou[1]

Abstract
This research focuses on the study of 16 bronze and iron swords dating from both the Late Bronze Age and the Early Iron Age from various sites in the Near East. By using SolidWorks, three-dimensional models of various sword types, based on their physical characteristics (mainly form and alloys), have been created, in order to simulate their resistance to applied force. The results of these tests show that almost all swords were functional weapons and thus capable of being used in battle.

Introduction
This paper presents some preliminary results of a new research project at the National and Kapodistrian University of Athens:[2] it focuses on the functional capacities of 16 Near Eastern swords and their fitness as weapons during the Late Bronze Age and Early Iron Age. Using Solidworks, a mechanical program, we create 3D models of swords on which we conduct test with various forces, imitating cutting and thrusting blows, in order to define how much force they can handle before a critical level of damage is reached.

Iconography and typology
The LBA is characterized by the presence of both sickle swords and others of a considerable typological variety, influenced by the tradition of straight swords in the Eastern Mediterranean and Mesopotamia. There is an abundance of studies of swords from Anatolia (Müller-Karpe 1994; Cline 1996: 139; Yalçikli 2006: 37; Roháček 2018: 52-82) and the Levant (Maxwell-Hyslop 1946; Riis 1948; Shalev 2004; Jung 2009; Jung and Mehofer 2008; Schulz 2014; Mehofer and Jung 2017: 390) and of sickle-swords (Masetti-Rouault and Rouault 1996; Maxwell-Hyslop 2002; Shalev 2004; Massafra 2012; Vogel 2013). In Near Eastern iconographies from the LBA, sickle swords are depicted in the hands of kings as status symbols (Vogel 2013: 72), sometimes also being used by rank-and-file soldiers since the 13th century BC onwards (e.g. Heinz 2001: 307, I.18). In the Egyptian 'execution scenes', where the king ritually kills the ruler(s) of the defeated opponents, usually a mace is used and very

1 National and Kapodistrian University of Athens.
2 The project entitled "*Swords in the Eastern Mediterranean from the Late Bronze Age to the Early Iron Age*" is co-financed by Greece and the EU (ESF) through the Operational Programme "Human Resources Development, Education and Lifelong Learning 2014–2020". We would like to cordially thank Konstantinos Kalkanis (UniWA, Department of Electrical & Electronics Engineering) and Dimitris Mpelesis, Mechanical Engineer, for their advice and help in designing the 3D models, Eleni Filippaki (NCSR Demokritos, Laboratory of Archaeometry) for her supervision and advice on archaeometric aspects and Michel Roggenbucke (Laboratory Teaching Staff at the University of Athens) for providing us with information about steel. All figures are designed by the authors.

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seldomly a sickle-sword (Vogel 2013: 72-76). Sickle-swords remained the dominant type in the Levant until the 15th century BC, only afterwards did the situation change and diversify. This conservatism may have been a result of an institutional control on the production and distribution of weapons to a limited number of elite members, professional soldiers or even mercenaries (Von Dassow 2008: 289; Schulz 2014: 235; Kopanias 2017: 120-122). Whatever the case, throughout the BA the bulk of infantry in the Near Eastern armies was armed with spears, staves, maces, throwsticks and javelins (McDermott 2002: 84-244) while the elite troops consisted mainly of archers and charioteers (Spalinger 2005: 15). There is very little evidence that swords were actually used in battle. One of the earliest examples is the use of sickle-swords in the hands of two dueling soldiers in a relief at the temple of Hatshepsut at Deir el Bahri (McDermott 2002: 212, fig. 163). The Sherden warriors, who fight as part of the Egyptian army (Drews 1993: 154; Spalinger 2005: 7, 264; Schulz 2014: 237) in the battle of Kadesh, are armed with straight swords in the reliefs from the reign of Ramesses II (Heinz 2001: 282, II.1; Spalinger 2005: 209-217; Jung 2009: 132, fig. 2). The 'northern warriors', who attacked Egypt along with Libyans during the reign of Merenptah, were equipped mainly with swords, as the Egyptian texts reveal (Kopanias 2017: 121-123). This is also the case in the later attack of the Sea Peoples against Egypt during the reign of Ramesses III: in the reliefs from his mortuary temple the use of straight swords is wide-spread (Heinz 2001: 307, I.18; Yasur-Landau 2010: 182-183, fig. 5.68; Mehofer and Jung 2017: 390). In the same battle, some Egyptian soldiers are depicted as armed with sickle-swords (Heinz 2001: 307, I.18). It seems that, by that period, the Egyptian army had responded to the need to adopt new battle tactics, including the use of swords (Spalinger 2005: 6). Nevertheless, it should be noted that the depiction of swords used in actual fighting remained a very rare theme in Near Eastern iconography (e.g. in Ugarit: Gachet-Bizollon 2001: 12, fig. 6).

The EIA is characterized first by the continuity of the Naue II type (Matthäus 1985; Kilian-Dirlmeier 1993), which becomes predominant in the Aegean and Cyprus (Snodgrass 1964: 93; Kilian-Dirlmeier 1993: 152-160), but is less present in the Levant (Riis 1948: 97-127), and also by swords with Iranian influences (Meek 1939: 10-11). There is very scant iconographic evidence from the period and any typological variety of swords is not to be observed. The rarity and fragmentary condition of iron examples in the Levant and Anatolia compelled us to turn our attention to better-preserved iron swords from Iran, which have close typological affinities to the Levantine types. Unfortunately, most of the swords attributed to "Luristan" originate from illicit excavations (Maxwell-Hyslop 1946; Maryon *et al.* 1961; Muscarella 1988: 187), thus we selected swords recovered from regular excavations and from a secure stratigraphic context (i.e., Sangtarashan, Luristan province: Malekzadeh, Hasanpur and Hashemi 2017: 69). In the iconography of EIA North Syria, the sword is carried by either a deity or a ruler (Brown 2008), and it is rarely depicted in fighting (e.g. Brown 2008: 327, 554). In the Neo-Assyrian iconography, the depiction of swords used in battle is more frequent, since it was one of the main weapons used by the Assyrian infantry (Reade 1972: 104). The most frequent type in Anatolia and the Levant is the 'Iranian' or 'Luristan' (Riis 1948: 135; Maryon *et al.* 1961; Muscarella 1988: 112-120, 187), which remained in use in Assyria until the 9th century (Meek 1939: 10-11).

Methodology

Our methodology has been already discussed thoroughly in previous publications (Kopanias, Vemou and Sidiropoulou 2021; forthcoming). SolidWorks is a solid modeling Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) software, which is used to calculate the physical properties of objects, in our case their resistance to force. First, we designed accurate 3D models of the swords, based on their published measurements and drawings (Table 1). Due to the lack of experiments on mechanical properties of ancient alloys, we had to find the most similar ones from modern industry, matching them to the results of archaeometrical analyses on swords (Khalil 1980; Shalev 2004; Koui *et al.* 2006; Tselios 2013) and other metal objects, and then we inserted them in SolidWorks' material library. According to archaeometrical analyses, the alloy of bronze swords in the Eastern Mediterranean consists typically of 85-90% Cu, 9-11% Sn and <0.5 Pb (Tselios 2013: 91-104), thus we opted for the alloy UNS C90700, which has very similar characteristics. In the case of iron swords, we chose the alloy UNS G102500, which has a very high percentage of Fe and contains only carbon as its key alloying element (0.2-0.3% C).[3] Little is known about the ancient steeling process and the date it was first invented. Even though there is evidence of carburization in some EIA knives, daggers and swords (Waldbaum 1999: 40-41), some scholars suggest that this could be unintentional until the 10th-9th centuries BC (McConchie 2004; Eliyahu-Behar and Yahalom-Mack 2018). Therefore, we chose a medium carbon steel alloy for our 3D models, in order to be able to better simulate the characteristics of the EIA material.

We selected a sample of the main LBA and EIA sword types from the Near East (Table 1). Tests were conducted by applying forces to the 3D models, imitating sword blows, in order to determine their resistance to strength until the yield point is reached, i.e., the point when the plastic deformation of the object begins. This means that when the applied force surpasses this point, the sword will not return to its original form and it will remain permanently deformed (Miller 2017: 25-26). In all of the tests, the handle of the sword was kept stable, imitating a hand holding it. The impact was applied laterally on the percussion point (Molloy 2010: 414, n. 100) and on the tip of the sword, imitating a cutting and a thrusting attack respectively. Solidworks shows the plastic deformation of an object, and not its breaking point. In our case, plastic deformation renders a sword useless (Molloy 2011: 75). In short, Solidworks evaluates the physical properties of a great variety of archaeological artifacts in a shorter time and without the expenses of actually manufacturing them. Factors that were taken under consideration were the geometry of the blade, the balance point and the weight of the swords (Table 2, detailed description in Kopanias, Vemou and Sidiropoulou 2021; forthcoming).

Test results

Bronze swords

The test conducted on the three bronze sickle swords from Amman, Tel Terqa and Gezer has proven that they are capable of cutting and thrusting, withstanding a great load of force in both impacts. The lower resistance of the sword from Gezer (Fig. 1a-b) is mainly due to its balance point, which is not within the body of the sword, and the existence of ridges all along

3 Fe is about 97%-99%. A lower percentage in some analyses is due to extensive corrosion. Both Cypriot (Tholander 1971; Åström *et al.* 1986) and Near Eastern objects (Stech-Wheeler *et al.* 1981) show similar results. Aegean EIA objects analyzed in NCSR Demokritos also yielded an average of 0.2-0.3% C (pers. com. M. Roggenbucke, December 2020).

the blade, which diminish its cutting capacity. In cutting attacks, the problematic areas are to be detected at the blade's base and on the point of transition from the ricasso to the outer and inner parts of the curved cutting blade. In thrusting attacks, the problematic areas are on the outer cutting curved edge. It appears from the tests that sickle swords were not used solely as stabbing weapons, as they are depicted in Near Eastern iconography, but also as cutting weapons employing their outer curved edge.

The "Ugarit"-type swords (Jung and Mehofer 2008: 122) can withstand great loads of force in thrusting attacks, but they present low resistance in cutting attacks. The examined examples from Ugarit and Tell es-Sa'idiyeh (Fig. 2a-b) were used apparently and primarily as thrusting weapons. The problematic areas here are detected at the blade's base and on both edges along the blade. In thrusting attacks, the problematic area is on the blade's tip. The position of their balance point closer to the hilt confirms also their thrusting use (Jung and Mehofer 2008: 118).

The Boğazköy sword (Cline 1996: 139) sustains only 80N during cutting, while on thrusting it handles a decent load of force. The main problem with its cutting inefficiency is the existence of side ribs, which run along the blade and diminish its cutting capacity, as has been proven by experimental works (Molloy 2010: 418). The Balıkesir sword (Roháček 2018: 53) presents a medium cutting capability, with a problematic area at the blade's base, on both cutting edges. It too is very durable in thrusting attacks. Similarly, the sword from Bodrum (Roháček 2018: 57; Yalçıklı 2006: 30) a "Siana"-type sword (Sandars 1963: 140) is competent in both cutting and thrusting attacks (Fig. 3a-b). The sword of Merenptah (Schaeffer 1956: 173) (Ugarit.b), a hybrid type influenced by Levantine and Italian swords (Jung 2009: 141, fig. 6), handles a great load of 9200N during thrusting, while on cutting attacks it sustains only 280N.

Naue II type swords usually present both good cutting and thrusting capabilities (Jung and Mehofer 2008: 123; Molloy 2010: 421). They are not common in the Near East; only a few have been found in Hama and Ugarit (Jung and Mehofer 2008: 112). However, the examined bronze sword Hama.b presents quite a low resistance to both sorts of impacts (Fig. 4a-b). Maybe this is due to its thin blade and because the current example had been repaired many times before its deposition in the urn, as seen also on the drawing (Riis 1948: nos. 322, 232). Hama.a (Fig. 5a-b) with the hollow handle (Riis 1948: nos. 522, 235) likewise sustains a low load of force in cutting attacks, probably because of its thin blade. It is worth mentioning that both swords were found intentionally bent (or 'killed') in their contexts, another fact that is likely to have affected the results.

Steel swords

The steel Naue II sword Hama.c (Riis 1948: 225, no. 57) was also found bent. In contrast to the bronze examples, it presents a great resistance in both cutting and thrusting attacks (Fig. 6a-b), displaying one of the best performances in cutting impacts. Hama.c underlines the significance of using steel and shows the greater capability a weapon of this metal has over a similar one of bronze. The rarity of Naue II swords and the fragmentary condition of steel examples (Riis and Buhl 1990: 97-127) did not permit us to examine a sufficient number of them.

The three Iranian-type steel swords, from Iran (Malekzadeh, Hasanpur and Hashemi 2017: 100-107), sustain very large loads of forces on both impacts. Regarding their cutting potential, the longest one, No. 174, has the best performance. No. 173 which is similar in form but a little shorter than the others can sustain almost half the force of No. 174, while

No. 1424 (Fig. 7a-b) sustains a similar load of force in both impacts. Nevertheless, this is still a decent load of force for a cutting blow. Regarding thrusting attacks, No. 174 has again the best performance, withstanding the incredible load of 32200N. It should be noted that it is the heaviest of the three, which makes it more stable and thus provides a better thrusting ability (Jung and Mehofer 2008: 123). Furthermore, the Gre Dimse sword from Anatolia (Karg 2001: 648-649), influenced by the Iranian types, sustains the largest load of force in cutting and thrusting attacks (Fig. 8a-b), thus making it the best example among the 16 swords of this study. At almost 70 cm, it is longer than the aforementioned three swords and it also has the narrowest blade. It is dated very early, between 1150 and 1000/950 BC and is one of the very rare examples of iron swords in the area (Kühne 2017: 327). This superiority is evident from its outline, its balance point (far away from the hilt) and its weight.

Conclusions

In conclusion, Solidworks provides a new approach for understanding the functionality of types that were mostly considered as symbols of power, such as sickle swords, which were proven capable of handling and delivering both modes of blows. It also clarified the mode of use of "Ugarit" type swords, namely as thrusting weapons. Regarding Naue II swords, Hama.c is capable of both modes, while the fragmentary condition of Hama.a and b implies their overuse, even though they show a low performance level. It is the Iranian type swords that provide excellent performances in cutting and thrusting attacks, withstanding the strongest blows.

Nonetheless, the swords examined in Solidworks have to be studied in association with their context and the available iconographic evidence, in order to define any balance between their symbolic and functional roles. Generally, the program indicates the capability of a sword, but it cannot confirm that any specific one was indeed used as a weapon. Metalwear analysis (Molloy 2011; Dolfini and Crellin 2016; Hermann *et al.* 2020) in some examples could be very helpful in detecting traces of use on their surface. However, as almost all swords tested here (with the sole exception of Boğazköy) could indeed handle loads of forces, this by itself indicates them as potential serviceable and functional weapons. The functionality of every type depends on a number of factors, such as the geometry, weight and balance point, factors easily measured in Solidworks. Finally, this program offers a chance to test various swords and compare their performance in a safe and controlled environment, avoiding a lot of variables that cannot be measured (mass of the warrior, velocity of the blow etc.). For future research, it could be a useful tool, especially if combined with metal wear and contextual analysis, to better understand the performances of ancient weapons.

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Cat. No.	Material	Type	Site	Context	Chronology	Bibliography
Amman	Bronze	Sickle	Amman	Temple	1500-1400	Massafra 2012: 137.
Terqa	Bronze	Sickle	Terqa	Workshop	1550	Massafra 2012: 135.
Gezer	Bronze	Sickle	Gezer	Tomb 30	1400-1350	Massafra 2012: 149.
Ugarit.a	Bronze	Ugarit type	Ugarit	Palace	1250-1200	Shalev 2004.
Tell-es-saidiyeh	Bronze	Ugarit type	Tell-es-saidiyeh	Tomb	ca.1200	Shalev 2004.
Ugarit.b	Bronze	Hybrid type	Ugarit	Deposition in the palace area	1213-1204	Schaeffer 1956.
Boğazköy	Bronze	Mycenean Type B	Bogazkoy	Gate of Hattusa	1420	Yalçikli 2006: 32.
Balikesir	Bronze	Mycenean Type B - C	Balikesir	Unknown	1400-1300	Roháček 2018: 66; Yalçikli 2006: 56.
Bodrum	Bronze	"Siana" type	Bodrum	Unknown	1300-1200	Roháček 2018: 57; Yalçikli 2006: 56.
Hama.a	Bronze	Hollow type	Hama	Urn GVIII 322	1300-1000	Riis 1948: fig.135b, 120.
Hama.b	Bronze	Naue II	Hama	Urn GVIII 522	1300-1000	Riis 1948: fig.136b, 120.
Hama.c	Iron	Naue II	Hama	Urn Grave VIII 57	925-800	Riis 1948: fig.136A, 120.
Gre Dimse	Iron	"Iranian"	Gre Dimse	Tomb	1150-1000/950	Karg 2001: fig. 3b, 648-649, 664.
No.173	Iron	"Iranian"	Sangtarashan, Luristan	Circular structure	900-800/750	Malekzadeh, Hasanpur and Hashemi 2017: pl. 5a.173, 100, 105, 127.
No.174	Iron	"Iranian"	Sangtarashan, Luristan	Circular structure	900-800/750	Malekzadeh, Hasanpur and Hashemi 2017: pl. 5a.174, 100, 105, 127.
No.1424	Iron	"Iranian"	Sangtarashan, Luristan	Circular structure	900-800/750	Malekzadeh, Hasanpur and Hashemi 2017: pl. 34.1424, 69, 156.

Table 1: Swords and their contexts

Cat. No.	Type	**Cut (N)**	**Thrust (N)**	**Length (cm)**	**Thickness Base to Middle (cm)**	**Width (cm)**	**Weight (g)**	**Balance point**
Amman	Sickle	880	2600	55	1.6-1.5	2.9-3.4	1541	Transition between the ricasso and the blade
Terqa	Sickle	800	4600	59	1.2-1.27	3.2-3.87	1459	Transition between the ricasso and the blade
Gezer	Sickle	255	1180	58.5	1.15-1.21	2.05-2.38	975	Out of the axis
Ugarit.a	Ugarit type	550	12700	64	1.6-1.1	5.2-3.9	1164	Closer to the hilt
Tell-es-saidiyeh	Ugarit type	280	1570	50	0.81-0.71	3-2.75	944	In the handle
Ugarit.b	Hybrid type	280	9200	74	0.6-0.48	4.66-3.78	645	Further from the hilt
Boğazköy	Mycenean Type B	80	1080	78.7	1.13-0.83	5.6-2.2	744	Closer to the hilt
Balikesir	Mycenean Type B - C	335	3250	59.9	1.1-0.74	4.65-2.83	825	Closer to the hilt
Bodrum	Siana type	355	2500	53.7	1-0.65	4.75-3.06	632	Closer to the hilt
Hama.a	Hollow type	215	2480	48	0.7-0.72	2.78-3.16	600	Little further from the hilt
Hama.b	Naue II	155	860	43.2	0.64-0.42	2.86-2.7	261	Little further from the hilt
Hama.c	Naue II	870	8600	48	1.2-0.8	4.2-3.3	651.09	Closer to the hilt
Gre Dimse	“Iranian”	1200	33500	69.5	1.2	4.1	1488.58	Almost at the middle between hilt and middle of blade/ Further from the hilt
No.173	“Iranian”	500	9000	47	1.2-0.9	3.3-3	504.21	Almost at the middle between hilt and middle of blade/ Further from the hilt
No.174	“Iranian”	950	32200	54	1	3.2-4.1	883.49	Almost at the middle between hilt and middle of blade/ Further from the hilt
No.1424	“Iranian”	730	9700	52.3	1.1	2.8-3.4	731.17	Almost at the middle between hilt and middle of blade/ Further from the hilt

Table 2: Test results of cutting and thrusting attacks in Newtons and physical characteristics of the swords

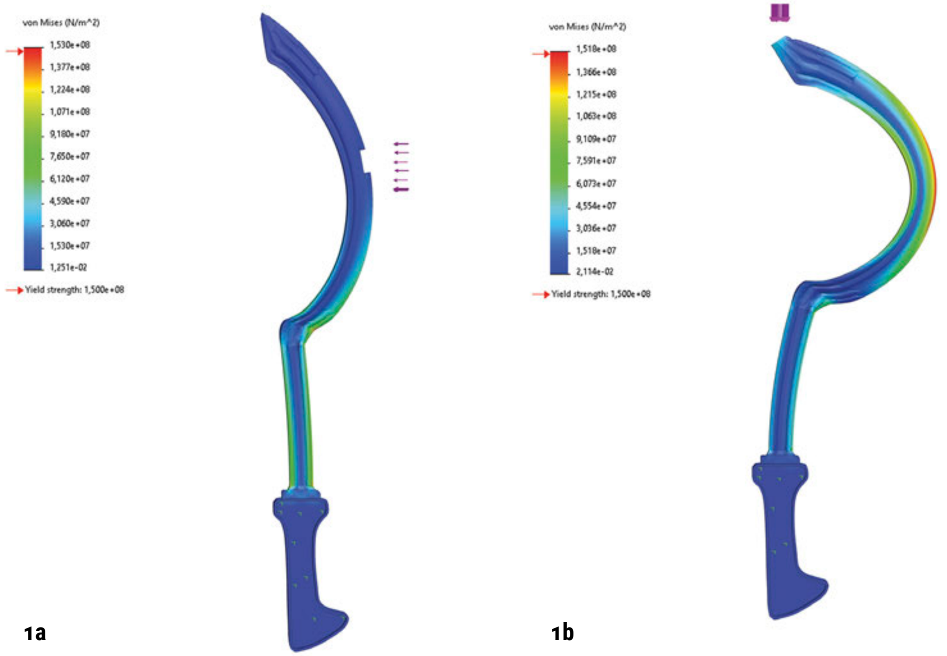

Fig. 1: Gezer a) cutting blow b) thrusting blow

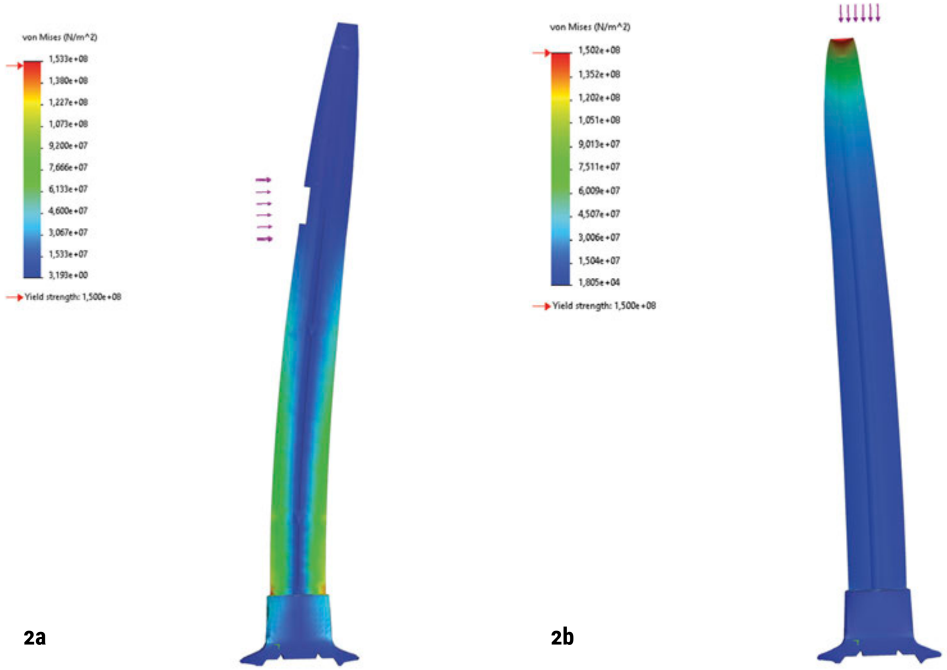

Fig. 2: Tell es-Sa’idiyeh a) cutting blow b) thrusting blow

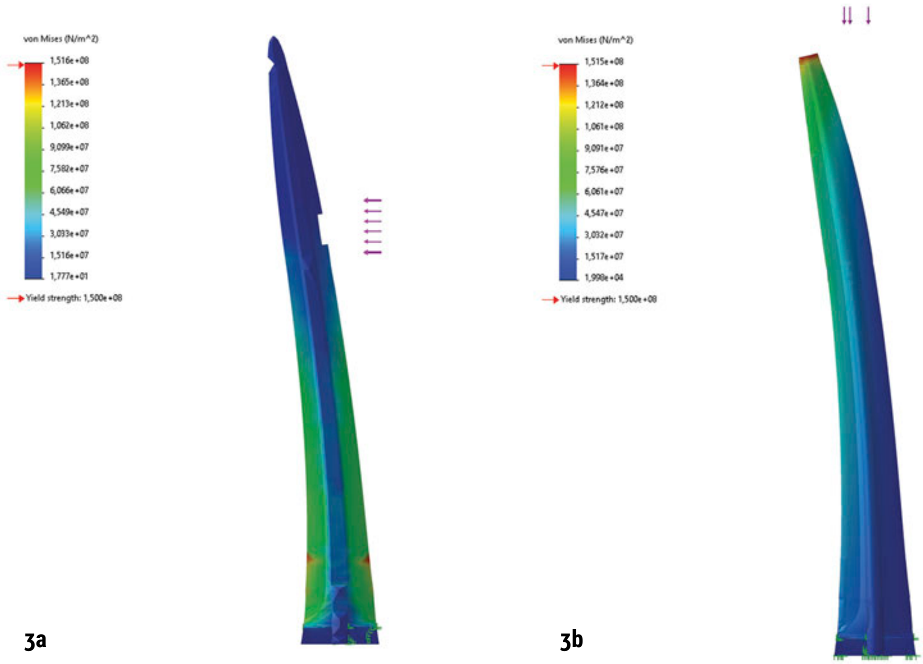

Fig. 3: Bodrum a) cutting blow b) thrusting blow

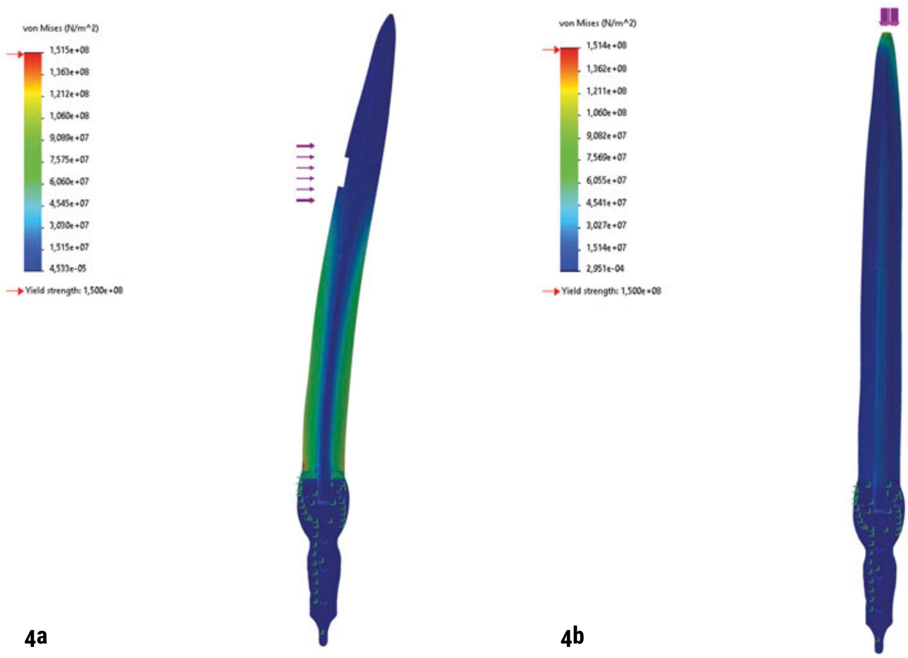

Fig. 4: Hama.b a) cutting blow b) thrusting blow (Kopanias *et al.* 2021: figs. 5c-6c)

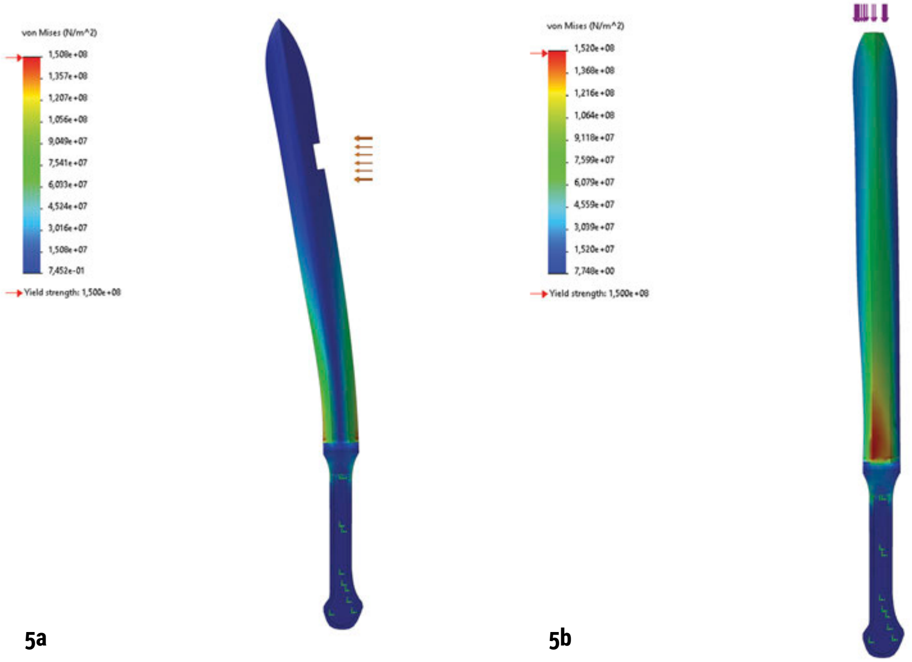

Fig. 5: Hama.a a) cutting blow b) thrusting blow

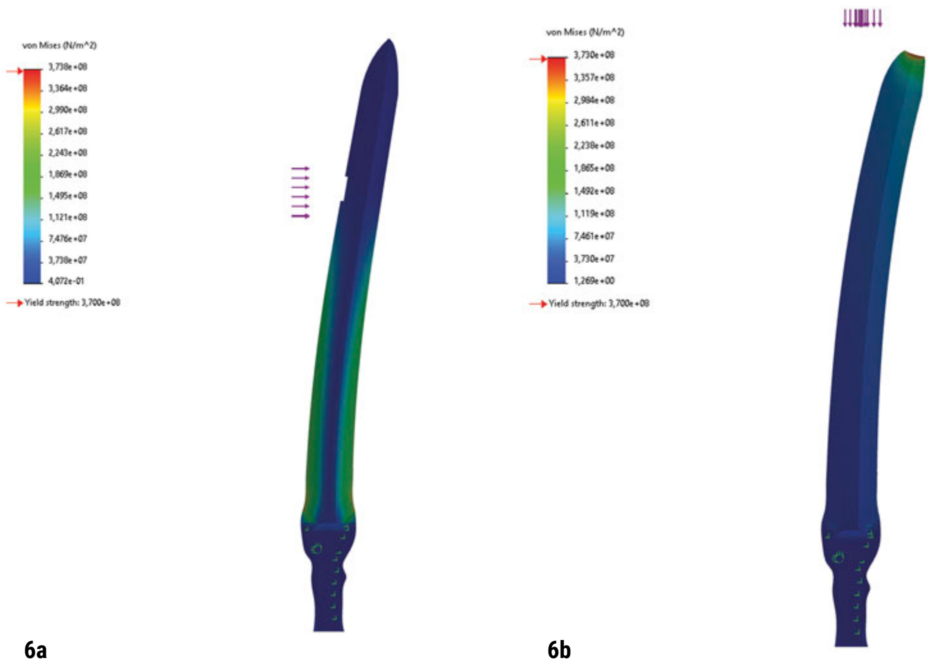

Fig. 6: Hama.c a) cutting blow b) thrusting blow (Kopanias *et al.* 2021: figs. 7b-8b)

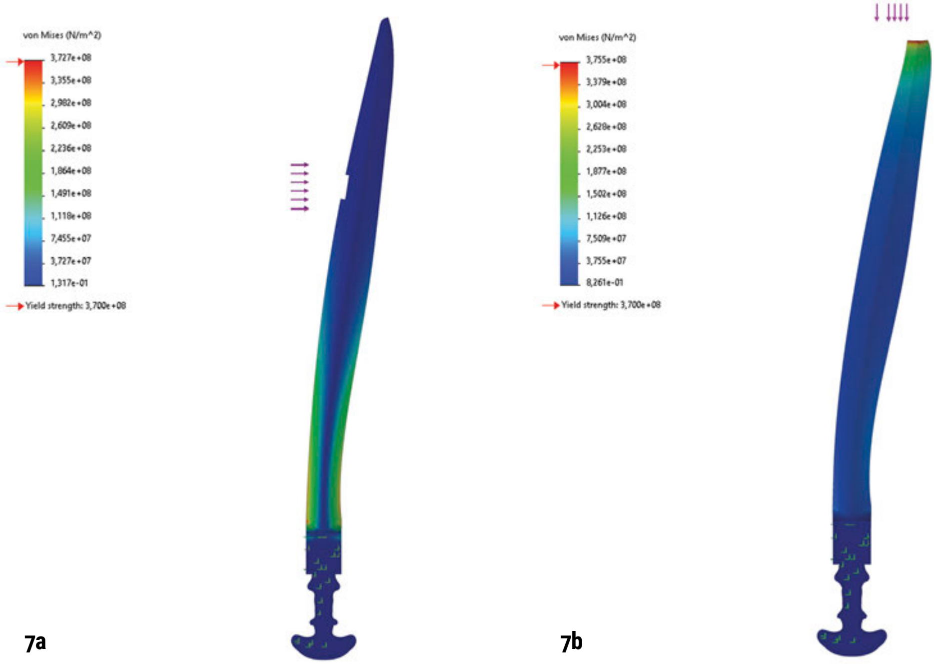

Fig. 7: No.1424 a) cutting blow b) thrusting blow

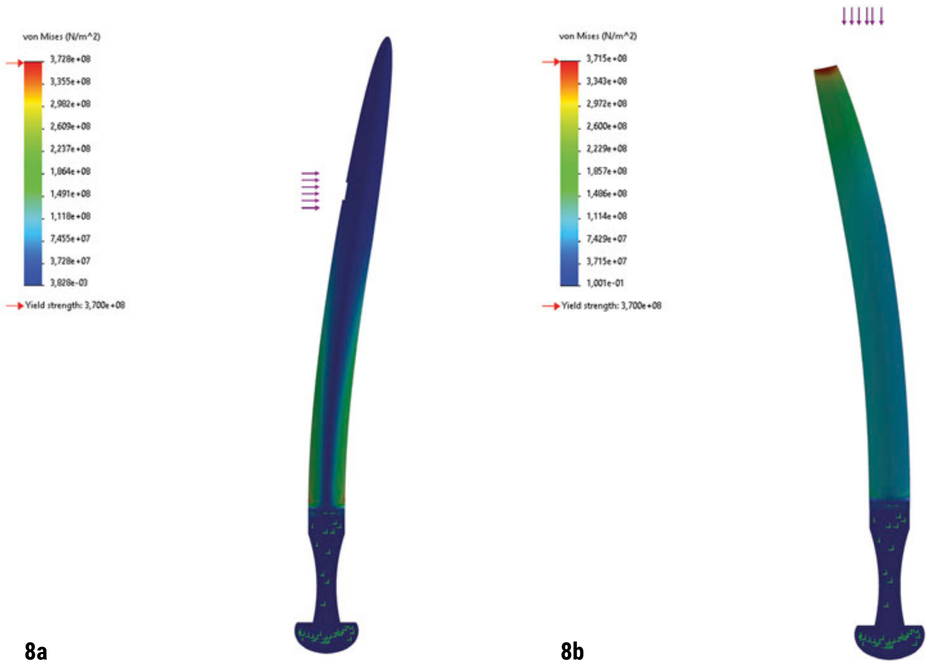

Fig. 8: Gre Dimse a) cutting blow b) thrusting blow (Kopanias *et al.* 2021: figs. 9b-10b)