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Some Technological Features from a Chalcolithic Site at Magaṣṣ-Aqaba

Magaṣṣ was discovered in 1967 during the construction of the Wadi 'Arabah road, while its western half was bulldozed. It is situated in the alluvial fan of Wadi al-Yutum, about 4km north of the Aqaba coastline, alongside the road to the Aqaba airport.[1]

In 1985, a team from the Department of Archaeology - University of Jordan excavated at two trenches, A.1 and B.1 (4×5m each) in the undisturbed part of the tell which measures about 75×50m. The dig revealed walls of buildings made of undressed stones. Some inner faces of the walls were covered in straw-reinforced mud mortar. Also, an installation composed of at least two pits was discovered with bottoms and sides lined with mud. A number of artefacts were retrieved from both trenches such as various types of pottery, flint tools and waste material, shell objects and detritus material, metallurgical remains in the form of raw copper ore, slag, copper pellets and corroded copper artefacts. Study of the various types of artefacts in their stratigraphic contexts indicates a late Chalcolithic date for the site.[2]

The following is a study of the industrial aspects of lithic and shell manufacture, copper metallurgy and conclusions.

Lithic and Shell Manufacture

There are four main methods of shaping stone tools: flaking, abrading and abrasion drilling, pulverizing and cutting. The appropriateness of any particular method for working the various types of stone depends mainly on two characteristics of the raw material, its hardness and fracturity.

Flint: The number of flint tools discovered during the 1985 season was 30, the waste consists of 84 items, mostly of small and medium flakes. The study of the waste material can be as helpful in understanding the flint industry as the study of tools. However, the flint collection here is so small that it is not enough either for correlation between the artefacts and waste material, or for any quantitative study.

There are two major methods of flaking flint tools, either by direct percussion with a hammer (block-on-block), or indirect percussion by applying heavy pressure at a point. The manufactured flint can be either flake-tool or core-tool. All the known forms discovered at the site are flake-tools, consisting of blades, sickle-blades, scrapers and an awl, usually on tabular flint.[3]

It is difficult to determine the method of production of flint tools without broad generalization. Of 16 blades and sickle-blades from Magaṣṣ, only the Canaanean blade shows a very small bulb, the blade is broken at the end near the striking platfrom.[4] It has been suggested that the Canaanean blades were flaked by indirect percussion using either a metal or an antler punch.[5] However, it is possible that the bulb was truncated during the manufacturing processes, e.g. a long blade can be broken into blade segments without bulb of percussion so that the bulb was truncated deliberately for hafting purposes. Examples from the Chalcolithic period showing evidence of blade hafting were discovered at Tuleilat al-Ghassul[6] and Arad.[7]

Further working to improve the shape or the function of the manufactured implements is called secondary flaking or retouch. Notching along the edge of a blade to give a saw-edge is an important modification. Only the pressure method can be applied using a bone or metal point for such denticulation. A number of the thin and wide sickle-blades

[1] T.D. Raikes, 'Notes on Neolithic and Later Sites in Wadi Arabah and Dead Sea Valley', *Levant* 12 (1980), pp. 40-60.

[2] L. Khalil, 'Preliminary Report on the 1985 Excavation at el-Maqaṣṣ - Aqaba', *Annual of the Department of Antiquities of Jordan* 31 (1987), pp. 481-483, *idem*, 'Excavation at el-Maqaṣṣ - 'Aqaba, 1985', *Dirasat* 15 N1.7 (1988), pp. 71-117.

[3] L. Khalil (1988), *op. cit.*, pp. 93-97 and Figs. 11-13.

[4] *Ibid*, Fig. 11:9.

[5] S.A. Rosen, 'The Canaanean Blade and the Early Bronze Age', *Israel Exploration Journal* 33 (1983), p. 16.

[6] J.R. Lee, *Chalcolithic Ghassul: New Aspects and Master Typology*, Unpublished Ph.D. thesis (Hebrew University, 1973), p. 251.

[7] R. Amiran, *Early Arad: The Chalcolithic Settlement and Early Bronze Age City*, (Jerusalem, 1978), p. 60.

of Magaṣṣ illustrate irregular notchings along their working edges.

Except for the surface end-scraper, nine tabular scrapers with flat cortical surfaces were more likely made from flint nodules. Seven scrapers have either a broken bulb of percussion or a pronounced one (FIG. 1:2), therefore, direct percussion with a hard hammer or block-on-block technique was applied in their manufacture.

The raw material of the Magaṣṣ flint collection varied in colour from dark brown, light brown, to grey brown. Only four artefacts are distinct in their colour; a Canaanean blade and two segements of blades are white in colour, and a pale brown sickle-blade is made of a very fine semi-translucent flint (FIG. 1:1).

There are no sources of flint in the Aqaba region. The nearest flint deposits are at Ras an-Naqab north of Aqaba and in the Negeb northwest of Aqaba. One cannot relate the origin of the Magaṣṣ flint artefacts to either of these deposits with any certainty. A local origin cannot be excluded, pebbles and flint nodules derived from the upland hills in the east and northeast of the site can be collected at Wadi al-Yutum. It has been suggested that the raw material for the flint industry at Horvat Beter was collected from the nearby river bed.[8]

Stone: In addition to pierced stones, querns, mullers, pestles and grinding stones were found at Magaṣṣ.[9] Of the pierced stones, two are of interest because they show evidence of the manufacturing technique. The alabaster mace-head has a cylinderical perforation (FIG. 1:3). The shaft-hole is not smoothed, therefore, it indicates three stages of working. Usually, this type of perforation only needs drilling from both sides of the object in two stages to form an "hour-glass" shaped perforation. The need for three stages of working may be due either to the hardness of the alabaster or the use of a short drill. The common method of piercing stone artefacts is by using a simple solid drill, tipped with a flint or metal head and operated by hand.[10] The final stage of working is essential to give the mace-head its fine appearance by smoothing and polishing the outside and the perforation by abrassion.

The unfinished limestone object (FIG. 1:4) was intended to be completed as a ring stone. It is another example of the manufacturing technique of pierced stone. The presence of this incomplete artefact is an indicator that manufacturing took place on the site.

Shell: Various species of shell and mollusc were used for personal ornaments in antiquity. The small shells were only drilled for suspension, and the large shells were either worked or cut to segements to be made into different shapes of ornaments.

Most of the shell consist of calcium carbonate. Therefore, apart from removing the false camaes from variegated species, the technique of manufacturing seems to be similar to working.[11] Because shell is rigid and fragile, elaborate techniques must be used for the cleaning, cutting, incising and drilling processes.

Magaṣṣ produced evidence of shell ornament manufacture. Fragments of raw material, unfinished artefacts of crescent shape, smooth segments with incising on one side and very polished curved artefacts were found (FIG. 1: 5-9). The only finished object is a broken pendant, which has a single perforation and incising decoration on the edge.

Two pendants were excavated at Horvat Beter,[12] also, three species of shells were found at the same site, whose origin is in the Red Sea.[13] A pendant of mother-of-pearl with two drilled holes was discovered at Arad.[14] Tuleilat al-Ghassul is another Chalcolithic site where fine worked shell artefacts, mostly from mother-of-pearl, were found. The origin of this type of shell is the Red Sea.[15] Timna, north of Aqaba known as a major site for copper production, also produced evidence of using shell from the Red Sea.[16]

Because the Gulf of Aqaba is rich in various types of shells, the indentification and assignation of origin will help trace the diffusion and transport routes for these artefacts. It is evident that shells from Magaṣṣ were originally from the Gulf of Aqaba. Artefacts made of various species including conch, giant clam and mother-of-pearl were found on the surface at Magaṣṣ in 1967.[17]

Copper Metallurgy

In the recovery of copper artefacts from minerals, there are five main stages of production involved, such as mining the ores, preparation of the ores, smelting the ores with fluxes to produce metallic copper, melting and casting the metal, and finally shaping the manufactured artefacts by hot or cold hammering. Each stage of manufacture is represented by metallurgical remains at ancient sites. Remains from the Magaṣṣ excavation consist of ore, slag, metallic copper in the form of pellets, lumps and artefacts.

Ores: A number of copper mineral nodules of varied size (0.5-4.5 cm) and weight (600 gms) were discovered, five samples (FIG. 2: 1-5) were analysed by X-Ray diffraction (XRD) using the Philips model at the Department of Geology - University of Jordan (TABLE 1).

Archaeological evidence for copper mining during the

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[8]E. Yeivin, 'The Flint Implements from Horvat Beter', *Atiqot* 11 (1959), p. 47.

[9]L. Khalil (1988), *op. cit.*, pp. 99-101 and Figs. 14-16.

[10]H. Hodges, *Artifacts: An Introduction to Early Material and Technology*, (London, 1976), p. 102.

[11]*Ibid*, p. 172.

[12]M. Dothan, 'Excavation at Horvat Beter', *Atiqot* 11 (1959), Fig. 11: 23 and 26.

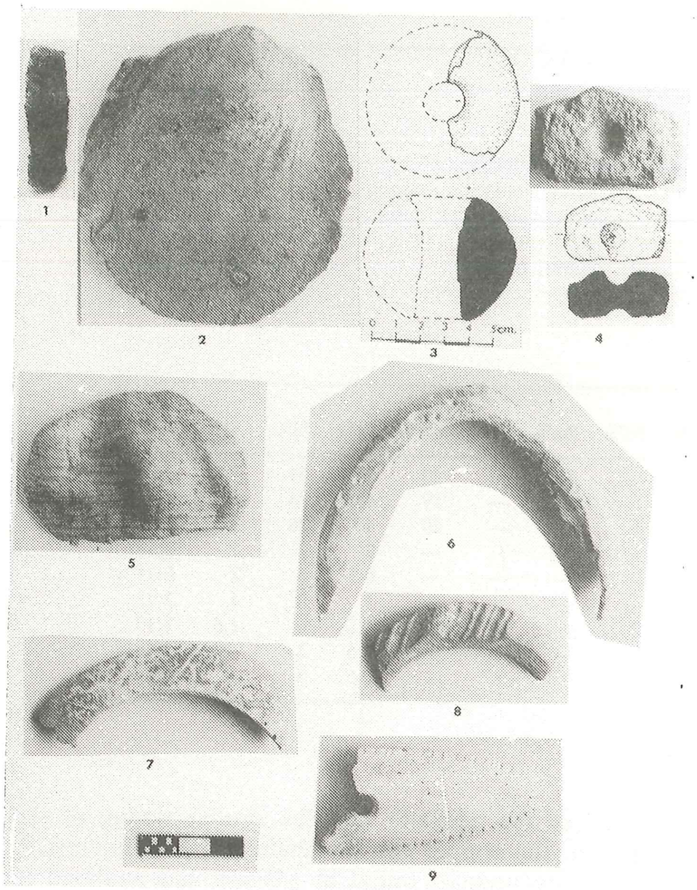
[13]*Ibid*, p. 31.

[14]Amiran, *op. cit.*, Pl. 67: 1.

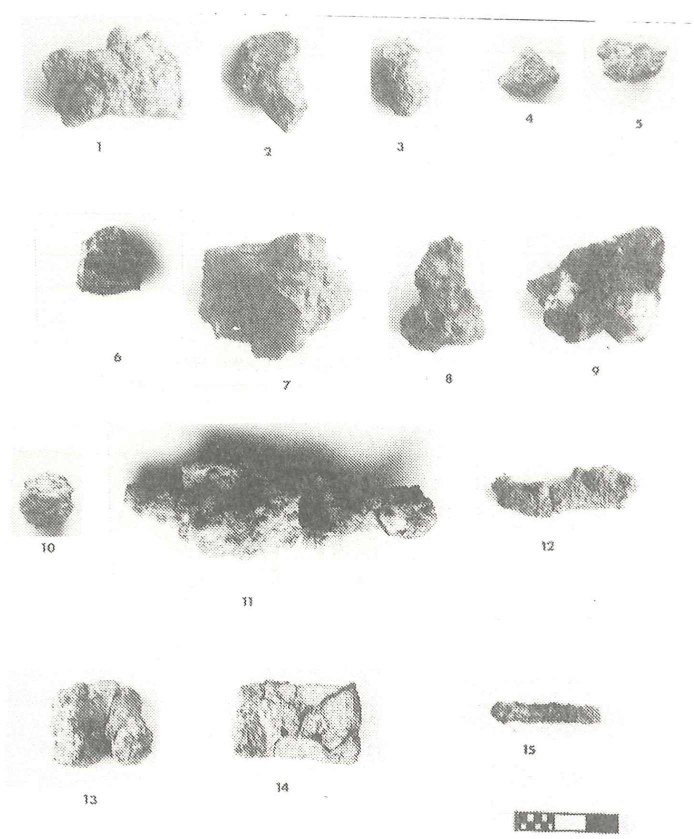
[15]Lee, *op. cit.*, pp. 308-310 and Fig. SL2.

[16]B. Rothenberg, *Timna, Valley of the Biblical Copper Mines*, (London, 1972), pp. 170, 176.

[17]T.D. Raikes, *Ancient Sites in the Wadi Araba and Nearby*, unpublished typescript (n.d.).



1. (1-4) Lithic artefacts and (5-9) shell implements.



2. (1-5) Copper ore nodules, (6) fragment of pottery crucible, (7-9) slags, and (10-15) metallic copper remains.

Chalcolithic period is reported at two areas: Feinan - Wadi Khalid and Wadi aj-Jariya on the east side of the ‘Arabah,[18] and at the Timna valley (Meneiyeh) on the western side of Wadi ‘Arabah.[19] The deposits are weathered copper sulphide ore which is associated with much iron and manganese, and copper silicate with little if any iron and manganese. Both types were not used at the same time during the early stages of copper metallurgy in the Chalcolithic period.[20]

The important type of ore as far as ancient metallurgy is concerned, is the nodular ore disseminated in the layers known as “Upper Nubian Sandstone”. In Timna, the content of this type of nodular ore is mostly chalcocite with covellite and rich in limonite, but rarely has native copper. Besides this, there is the existence of cuprite, malachite, azurite, atacamite and chrycocolla in minor quantities.[21] Also, copper mineral nodules of various sizes were reported from Feinan. The exposed nodules in the ancient mines show copper minerals mostly in the form of malachite, chrycocolla and rarely sulphide, this means that they are different from the Timna nodules.[22]

The ores from Magaṣṣ are of the nodular type, examination of lumps of ores from sites contemporary to Magaṣṣ such as Abu Maṭar,[23] and Timna[24] indicate a similar composition.

The copper rich nodules were usually crushed in granite querns and mortars to be ready for smelting, either iron oxide or silica can be added as reducing agents, various sizes of querns and pestles were discovered at Magaṣṣ.

Slag: The amount of slag found at Magaṣṣ is relatively

[18]H.D. Kind, ‘Antike Kupfergewinnung Zwishen Rotem und Totem Meer’, *Zeitschrift des Deutschen Palästina-Vereins* 81 (1956), pp. 56-73; H.G. Bachmann and A. Hauptmann, ‘Zur alten Kupfergewinnung in Fenan und Hirbet en-Nehas Im Wadi Arabah in Sudjordanien’, *Der Anschnitt* 36 (1984), pp. 110-123; A. Hauptmann *et al.*, ‘Archaometallurgische und Bergbarchaologische Untersuchungen im gebirt von Fenan, wadi Arabah (Jordanien)’, *Der Anschnitt* 37 (1985), pp. 167-195.

[19]Rothenberg, *op. cit.*

[20]C. Milton *et al.*, ‘Slag from an Ancient Copper Smelter at Timna Israel’, *Journal of the Historical Metallurgical Society* 11 (1976), p. 25.

[21]B. Rothenberg *et al.*, *Chalcolithic Copper Smelting: Excavation and Experiments*, Institute for Metallurgical Studies, (London, 1978), p. 8.

[22]Bachmann and Hauptmann, *op. cit.*, p. 114.

[23]R.E. Tylecote *et al.*, ‘The Examination of Metallurgical Material from Abu Matar, Isreal’, *Journal of the Historical Metallurgical Society* 8 (1974), p. 32.

[24]A. Lupu, ‘Metallurgical Aspects of Chalcolithic Copper Working at Timna (Israel) 2’, *Bulletin of the Historical Metallurgical Group* 4 (1970), p. 21.

Table 1 Analysis of copper ores.

Sample	Area. Square	Locus: Pail	Colour of powdered sample	Mineral composition	FIG.
1	A.1	24:42	Light green	Quartz, malachite, atacamite.	2:1
2	A.1	24:42	Dark green	Quartz, atacamite, malachite, cuprite.	2:2
3	A.1	1:9	Dark green	Quartz, atacamite, malachite, cuprite.	2:3
4	A.1	11:21	Dark grey	Cuprite, quartz, tenorite.	2:4
5	B.1	18:24	Light green	Atacamite, quartz, tenorite.	2:5

Table 2: Analysis of slag and metallic copper artefacts.*

Sample	Area. Square	Locus: Pail	Description	Cu%	As%	Sn%	Ni%	Zn%	Pb%	Ca%	Fe%	Si%	Al%	FIG.
1	A.1	1:1	Slag	2.7	—	—	—	2.6	—	20	45	24	3.5	2:7
2	A.1	1:1	Slag	2	—	—	1	1	—	19	43	26	2	2:8
3	B.1	8:15	Slag	3	—	—	1	—	—	20	40	26	2.5	2:9
4	B.1	10:18	Metal pellet	92	—	T	1.2	0.2	T	—	2	3	1	2:10
5	B.1	5:21	Metal lump	80	—	—	—	—	—	—	0.5	6	2	2:11
6	B.1	9:16	Metal piece	80	—	—	—	—	T	—	1	8	4	2:12
7	B.1	4:9	Ingot-like	79	T	1	2	0.4	T	—	1.5	6	1.5	2:13
8	B.1	6:6	Awl-like	92	—	0.5	—	—	—	—	1.5	3	—	2:14
9	B.1	4:3	Awl	92	—	0.5	0.5	0.3	T	—	0.5	3	1	2:15

* In this analysis, the elements are considered as oxides. T = trace.

small (weight: 300 gms) to presume that furnace copper smelting occured at the site. It is known that a single smelting process in a small furnace will produce a relatively large heap of slag and waste material.[25] This means that either the smelting operation took place somewhere else and the copper pellets were only brought to Magaṣṣ, or crucible smelting produced the metallic copper pellets.

At al-Mrashshash, a site on top of a hill to the west of Magaṣṣ near the Gulf of Aqaba, two small heaps of slag were reported. Though no pottery was discovered, the site was dated to the Early Iron Age.[26] A Chalcolithic date has also been suggested by the comparison between the chemical analyses of slag from the site and Timna.[27] Both dates were rejected and the Middle Bronze Age I has been proposed.[28]

Crucible smelting of copper is possible, and it has been experimented by Tylecote who explains the operation as "... possible in the case of the pure oxides such as cuprite (Cu_2O), tenorite (CuO) and the basic carbonates such as malachite. When a mixture of these and a reducing agent is heated in a crucible, grains of copper are formed".[29] This fact was also proven by a simple experiment using a crucible, charcoal, crushed rich ore and a blowpipe. With the skill of the operator and the proper timing of the operation, the copper can be smelted.[30] It is interesting that the ore nodules found at Magaṣṣ and analysed in TABLE 1 are rich in copper.

A small furnace filled with charcoal with a crucible was supported about halfway up, air induced from underneath by means of bellows would be essential to reach a temparture about the 1083°C necessary for the reduction process.[31]

A very small fragment of a "pottery vessel rim" (FIG. 2: 6) with black-brown vetrified material was found from (B.1, 6:5). Pottery crucibles were also reported from the site.[32] Many layers of ash-charcoal were discovered at a corner and inside of the possible building in square A.1. Between these layers, a number of copper pellets, small mud-bricks and burnt clay fragment were found. More excavation is necessary to determine if the area was a furnace complex.

Three slag fragments (FIG. 2: 7-9), varied in size between 2-5cm, were submitted to a semi-quantative analysis using Wavelength Dispersive X-Ray Flourescence (XRF), type PW 1404 Philips at the Royal Scientific Society.

The chemical composition of the slag is similar (TABLE 2:

[25]H.G. Bachmann, *The Indentification of Slags from Archaeological Sites*, Institute of Archaeology Occasional Publication No. 2, (London, 1982), p. 5.

[26]N. Glueck, *Exploration in Eastern Palestine II, Annual of the American Schools of Oriental Research* 15 (1935), p. 48.

[27]M.W. Several, 'Dating the Mrashshash Slag' *Israel Exploration Journal* 23 (1973), pp. 103-104.

[28]B. Rothenberg, 'Ancient Copper Industries in Western Arabah', *Palestine Exploration Quarterly* 94 (1962), p. 61; *idem*, 'More on Dating the Mrashshash Slage Heap', *Israel Exploration Journal* 25 (1975), pp. 23-41.

[29]R.F. Tylecote 'Can Copper be Smelted in a Crucible?', *Journal of the Historical Metallurgical Society* 8 (1974), p. 54.

[30]L. Khalil and H.G. Bachmann, 'Evidence of Copper Smelting in Bronze Age Jericho', *Journal of the Historical Metallurgical Society* 15 (1981), pp. 105-106.

[31]Tylecote *et al.*, *op. cit.*, p. 34.

[32]Raikes, *op. cit.*, p. 2.

1-3). Two specimens (2-3) show weathered drops of metallic copper 0.2-0.5mm in diameter. When they were thin sectioned and examined by normal microscopy at the Department of Geology, green copper droplets were identified in the slag texture.

The silica/iron ratio is an important factor in the analysis of slag. Though the Chalcolithic slags from Timna (site 39), are very inhomogenous in their composition, it has been established that the silica content is higher than that of iron oxide. Meanwhile, the slags of the Early Iron Age have higher silica than iron in their composition.[33] However, the number of the analysed slag here are small and two of them were found in (Locus 1) which is the top soil layer.

Metallic Copper: The relative amount of metallic copper from the Magaṣṣ excavation is large, and can be classified in the following groups:

1) Metal pellets or drops: They vary in size between 0.5-2.0cm diameter (FIG. 2: 10), the total weight is 320 gms. They are globular in shape and badly weathered. These metallic drops are the first to be recovered from any smelting process. Their analyses in TABLE 2 show almost pure copper with low iron content.

A number of these metal pellets can be smelted or melted in a crucible to produce a lump copper ready for further working.

2) Lumps of copper - ingot like: Various lumps of copper were discovered during the excavation, their total weight was 490 gm. They are shapeless (FIG. 2:11-13) or in the shape of an ingot (FIG. 2:14). The lump can be cold or hot hammered to any required shape.

Their chemical analysis indicated that they are almost pure copper with either low percentages or traces of other elements including arsenic, nickle, zinc and lead. They contain iron in the range between 0.5-1.5%. The presence of 2% nickle in sample number 7 is unusual. It is important that the presence of silicate and aluminum in the composition of all the metallic copper is meaningless, because it is possible that this was caused by the mixture of the corrosion with sand and soil at the site. Besides, the analysed samples were not taken from the core of the metal because of the severely weathered condition of the artefacts.

3) Artefacts: Only simple types of metal artefacts like awls (FIG. 2:15) were found. They were very corroded. The analysis of the awl (TABLE 2:9) showed almost pure copper and only traces of impurities in the composition. Therefore, it was easily worked to shape from a lump of copper by either hot hammering or cold hammering and annealing.

Conclusion

The settlement at Magaṣṣ was a small but major site, one component of which is clearly workshops to manufacture lithic, shell and copper artefacts.

The derived pebbles and flint nodules from the eastern hills usually accumulated in yearly alluvial deposits. The ancient people could acquire these raw materials for flint and stone industry. Flint can be percussed immediately, the final flaking and the secondary retouch can be done on site. Only a sickle-blade (FIG. 1:1) is of different raw material from the other flint implements, it is made of semi-translucent flint with advanced lithic technique. Therefore, it may be assumed that it was imported.

Stone pebbles can be obtained in the same way as flint nodules. As mentioned before, the presence of the unfinished object which was intended to be completed as a ring stone is a good indicator that it was worked on site.

It seems that the lithic industry was local and sufficient for the residents' requirements. It is difficult, however, to locate the place of this industry in the development of lithic technique in Jordan and Palestine.

The Gulf of Aqaba is very rich in different species of shells. Evidence for shell ornament manufacture was found, and it is logical that shells from the Red Sea were discovered at sites contemporary to Magaṣṣ such as Ghassul, Horvat Beter and Timna. This indicates that there was trade between Aqaba and these sites.

Timna, located 30kms north of Aqaba, is considered as one of the earliest centres for copper metallurgy during the Chalcolithic period. It was also a main source of copper ores. This may suggest that the copper nodular ores from Magaṣṣ were exchanged with either raw material or manufactured shells that were found at Timna.

From the study of the metallurgical remains from Magaṣṣ, it may be concluded that they are debris from a metal workshop. The amount of the discovered metallic copper is relatively large in relation to the size of the settlement. A small, rectangular piece of metal in the shape of an ingot was found. Copper ingots of various shapes dated to periods later than the Chalcolithic were reported from Palestine, e.g. Early Bronze Age from Jericho[34] and Middle Bronze Age I from Har Yerham south of Beersheba and the Hebron Hills.[35] Ingots from the Bronze Age were historically and scientifically studied to develop an understanding of trade in the Mediterranean during the Bronze Age.[36] Nevertheless, the capacity of the metal workshop at Magaṣṣ seems more than the need of the settlement. Therefore, it may suggest extra production used to fulfill the requirements in the neighbourhood. It is

[33] Lupu, *op. cit.*, p. 21.

[34] L. Khalil, *The Composition and Technology of Copper Artefacts from Jericho and some Related Sites.* Unpublished Ph.D. thesis, University of London (1980), p. 51.

[35] R. Maddin and T.S. Wheeler, 'Metallurgical Study of Seven Bar Ingots', *Israel Exploration Journal* 26 (1976), pp. 170-173.

[36] T.S. Wheeler *et al.*, 'Ingots and Bronze Age Copper Trade in the Mediterranean: A Progress Report', *Expedition* 17 (1975), 31-38.

as yet difficult to draw a map for copper trade during this era. However, an unexcavated tell, Ḥujeirat al-Ghuzlan, twice the size of Magaṣṣ at about 1.5km to the east, could have provided a market for the Magaṣṣ metal production. The pottery sherds and other artefacts from the surface collected by the author indicate a contemporary date with Magaṣṣ.

In summary, remains from Magaṣṣ demonstrate a level of skill common during the second half of the fourth millennium BC in manufacturing pottery, flint, stone, bone and shell artefacts. Besides, metallurgical relics were another element not only important in illustrating the technological level in the production of metallic copper, but also in presenting evidence for communication with other sites in the area. If the lustre on the working edges of most discovered sickle-blades is interpretated as evidence for harvesting cereals, it means that the site was self-sufficient from an economic point of view. Aletrnatively, the site could have been especially devoted to industry.

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