

Chemical Composition of Bronze Artifacts from Tel Rekhesh

Hidemasa Hashimoto (Tenri University), Hidetoshi Tsumoto (Ancient Orient Museum, Tokyo) and Hisao Kuwabara (Tenri University)

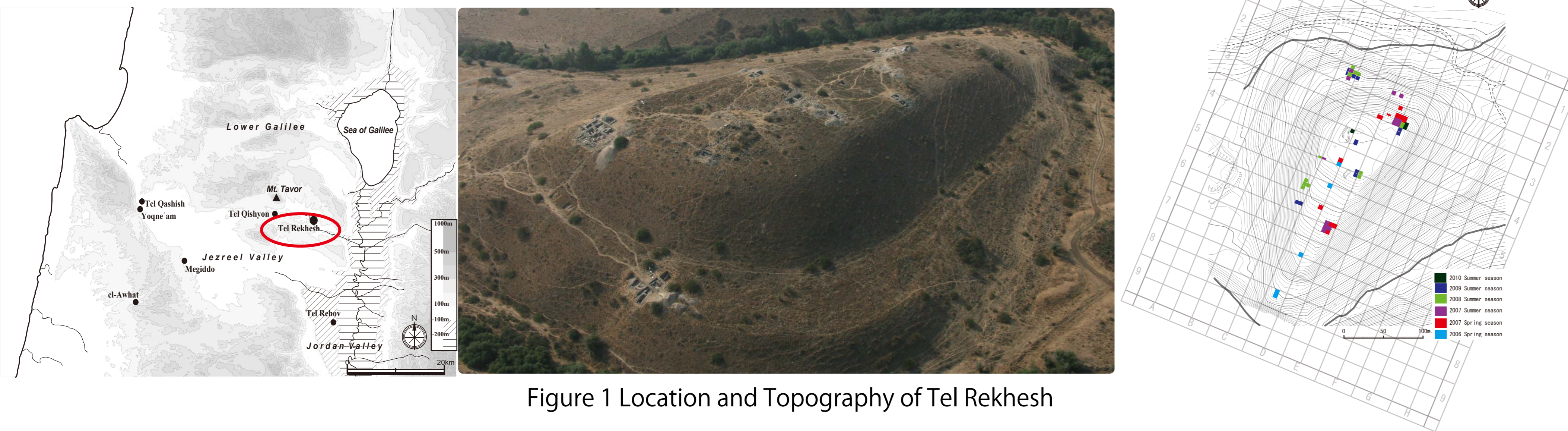


Figure 1 Location and Topography of Tel Rekhesh

1. TEL REKHESH

Tel Rekhesh is an archaeological site located in Lower Galilee, Israel (Fig. 1). Its ancient name is generally accepted to have been Anaharath, according to the provenance study of Amarna Letters. As a result of several seasons of excavations by Japanese-Israeli excavation team, it has been elucidated that settlement of the site has a long history, from EB to Roman period except Hellenistic period.

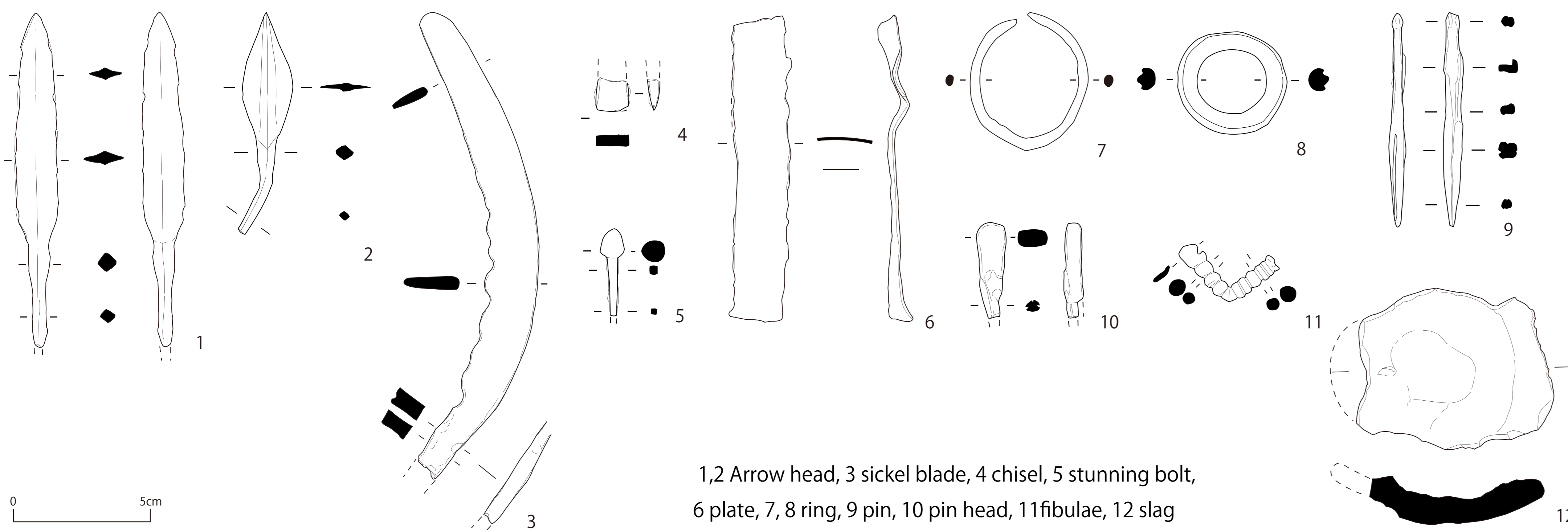


Figure 2 Bronze or Copper Artifacts from Tel Rekhesh 2006-2010

2. METAL ARTIFACTS from TEL REKHESH (2006-2010)

28 metal objects dating from the Late Bronze Age to Roman period were uncovered at Tel Rekhesh between 2006 and 2010. 15 of the objects are made of iron while the other 13 are made of either bronze or copper (Fig.2). Tools and weapons are made of both bronze and iron, while the 'jewellery' and the 'make up implements' are mostly made of bronze and copper but not of iron. The objects are arranged according to the following categories:

1. Weapons: Arrowheads, spearhead
2. Work tools, such as, chisel, nail, knives and sickles
3. Jewellery and self-adornment objects, such as rings, bracelet, pins and fibulae
4. Objects related to metallurgical activity, such as slag

The authors conducted XRF analysis on 12 Bronze or copper artifacts in order to understand relationships among manufacturing techniques, chemical composition and function of each object.

3. INSTRUMENT and CONDITIONS

Instrument used for the analysis is a hand-held X-ray fluorescence (XRF) spectrometer, Innov-X *a* 4000 (Innov-X Systems, Inc., USA). The analysis was conducted under the following conditions of the measurement:

- Tube max voltage: 35Kv
- Tube electric current: 5 μ A
- Tantalum target; size of collimator: ca.10mm in diameter
- Time for measurement: 15 seconds

Composition of the objects is given below both in XRF spectra and table format (Fig.3, Tab.1).

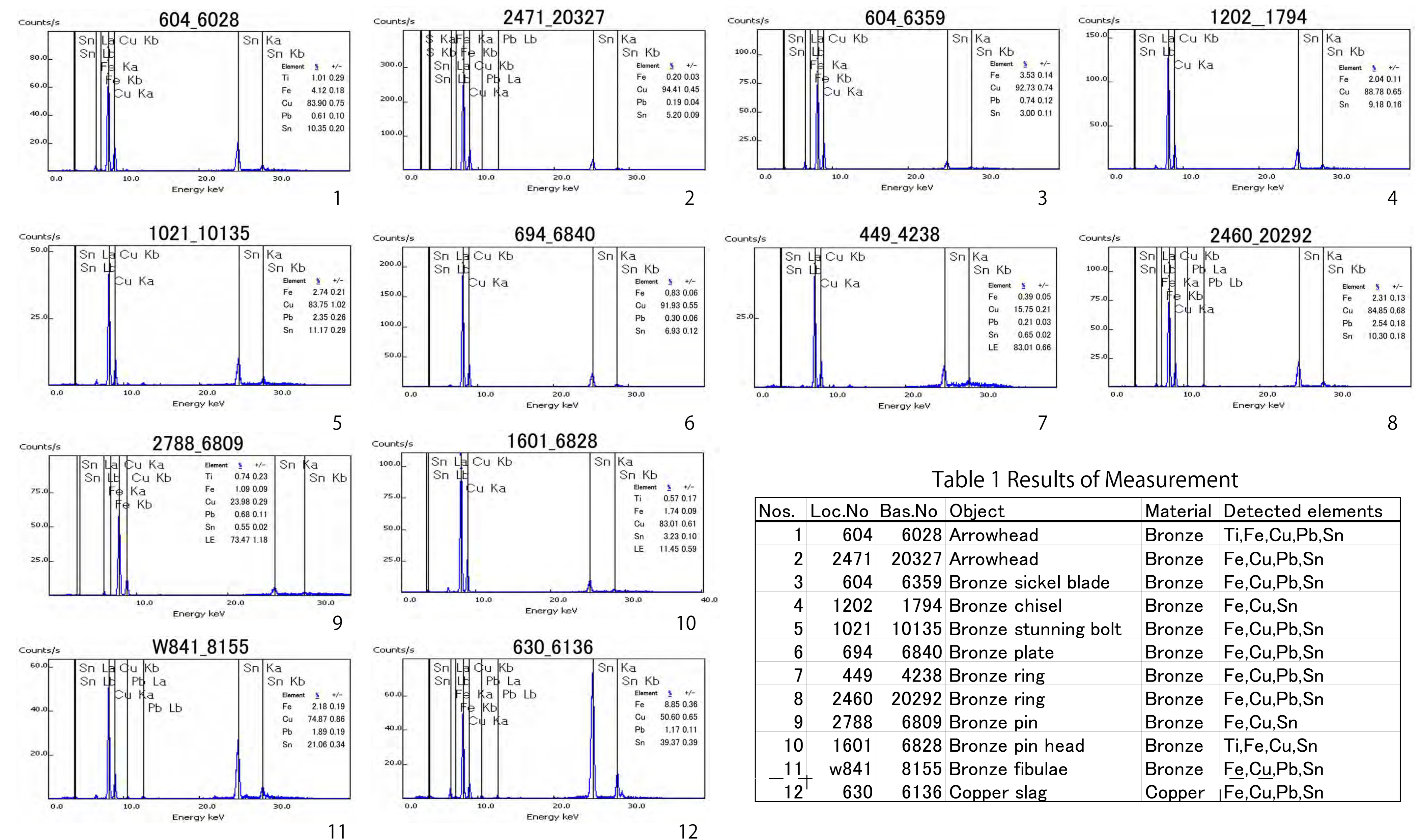


Figure 3 XRF Spectra of Artifacts

Nos.	Loc.No	Bas.No	Object	Material	Detected elements
1	604	6028	Arrowhead	Bronze	Ti, Fe, Cu, Pb, Sn
2	2471	20327	Arrowhead	Bronze	Fe, Cu, Pb, Sn
3	604	6359	Bronze sickle blade	Bronze	Fe, Cu, Pb, Sn
4	1202	1794	Bronze chisel	Bronze	Fe, Cu, Sn
5	1021	10135	Bronze stunning bolt	Bronze	Fe, Cu, Pb, Sn
6	694	6840	Bronze plate	Bronze	Fe, Cu, Pb, Sn
7	449	4238	Bronze ring	Bronze	Fe, Cu, Pb, Sn
8	2460	20292	Bronze ring	Bronze	Fe, Cu, Pb, Sn
9	2788	6809	Bronze pin	Bronze	Fe, Cu, Sn
10	1601	6828	Bronze pin head	Bronze	Ti, Fe, Cu, Sn
11	w841	8155	Bronze fibulae	Bronze	Fe, Cu, Pb, Sn
12	630	6136	Copper slag	Copper	Fe, Cu, Pb, Sn

4. RESULTS and DISCUSSION

The result of XRF analysis of bronze objects revealed that some items, such as chisel (2.4, 3.4), stunning bolt (2.5, 3.5), bronze pin (2.9, 3.9) and bronze pin head (2.10, 3.10) do not include lead (Pb) as its components. As for a chisel, absence of lead could be understood from the necessity of hardness as a metal tool used for engraving or cutting tool. The absence of lead in stunning bolt is difficult to explain, though the necessity of hardness might be one reason.

At the start of our examination, the possibility to be working tools was excluded about both bronze pin (2.9, 3.9) and bronze pin head (2.10, 3.10) from the macroscopic examination. However, composition of them seems to leave us slight possibility of its use as metal working tools like chisel, drill or awl.

REFERENCES

- Paz, Y. and Kuwabara, H. 2007. The First Season of Excavations at Tel Rekhesh: The Preliminary Stage (15-27 March, 2006) – Excavation Results. *Orient Express: Notes et Nouvelles d' Archéologie Orientale* 2007-1/2: 17-25.
- Paz, Y., Okita, M., Tsukimoto, A., Hasegawa, S., Lim, S.-G., Sugimoto, D.T., Onozuka, T., Tatsumi, Y., and Yamafuji, M. 2010. Excavations at Tel Rekhesh. *Israel Exploration Journal* 60: 22-40.
- Tsukimoto, A., Kuwabara, H., Paz, Y. and Hasegawa, S. 2011. Tel Rekhesh 2009: Preliminary Report. *Hadashot Arkheologiyot: Excavations and Surveys in Israel* 123
- Tsukimoto, A., Kuwabara, H., Paz, Y. and Hasegawa, S. 2013. Tel Rekhesh 2010: Preliminary Report. *Hadashot Arkheologiyot: Excavations and Surveys in Israel* 125

Acknowledgement

This work was supported by JSPS KAKENHI Grant Numbers JP19H01349, JP17H04527