A Report of the Analytical Work at the Field-side Laboratory in the Japanese Institute of Anatolian Archaeology

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1. INTRODUCTION

Owing to the discovery of X-rays in 1895, there has been technological development in the instrumental analysis, which is nowadays applied to various fields, general scientific, medical and industrial work. This new technique provides wide range of information, which is both visible and invisible, depending on the purposes. For example, radiography can show morphological details on objects, whereas compositional analytical methods such as X-ray diffraction and X-ray fluorescence spectrometry can disclose the information enclosed in the material. Invisible material characteristics, such as chemical composition and structure, have been given by these new techniques and utilized for the interpretation of complex physical phenomenon since the early stages of the X-ray study (Bothewell *et al*. 1969). Similarly, scientific approaches to ancient objects have set a new trend in archaeology toward the interpretation of the archaeological context contained in the objects. It has been gradually accepted that not only the morphological information, which has been traditionally used for the archaeological typological work, but also the invisible material property of ancient objects can provide significant information for the archaeological study. However, the circumstances surrounding this new method are still matters for consideration. Brothewell *et al*. point that there are two main reasons which cause the limitation of scientific analyses for the archaeological use; the first is the unavailability of equipment and the second is inadequate understanding of the potentiality of scientific analysis (1969: 511).


Photo 1 SEA 2010 at the analytical laboratory in the Japanese Institute of Anatolian Archaeology

In regard to the research at Kaman-Kalehöyük, scientific analyses on various kinds of samples, such as metal objects, pottery, glass, and obsidian, have been carried out since the early times of excavation in the early 1990s (Akanuma 1995; Hirao *et al*. 1992; Matsunaga *et al*. 1996; Mochizuki 1997). In 1997, an x-ray fluorescence (XRF) spectrometer (Photo 1) was equipped at a laboratory in the field-side institution, the Japanese Institute of Anatolian Archaeology, for the flexible use of on-site compositional analysis. XRF spectrometry is generally known as a typical method for the non-destructive compositional analysis. Indeed, several kinds of archaeological finds in this site have been non-destructively analyzed by scientists for the compositional characterization. However, even though this practical instrument has been used with some success for the scientific investigation, there has been few arguments in what ways on-site compositional analysis should contribute to the other areas of work at the institution. For example, although the archaeological work at the Japanese Institute of Anatolian Archaeology is composed of 3 main divisions, the excavation at Kaman-Kalehöyük, the conservation for the archaeological finds, and the academic research on the objects, the function of the XRF analysis for this institution has not been clearly defined yet. The reason for this is that there have been few attempts to illuminate the functionality of this analytical instrument for the archaeologists and conservators working at the institution and, consequently, it has been considered as a special tool only for the scientist. Therefore, most of the previous research using XRF spectrometer was conducted depending upon the particular investigative focus of each individual scientist. On the other hand, there should be another style of analysis, whose purpose is helping material identification of conservation and excavation staff working at the site.

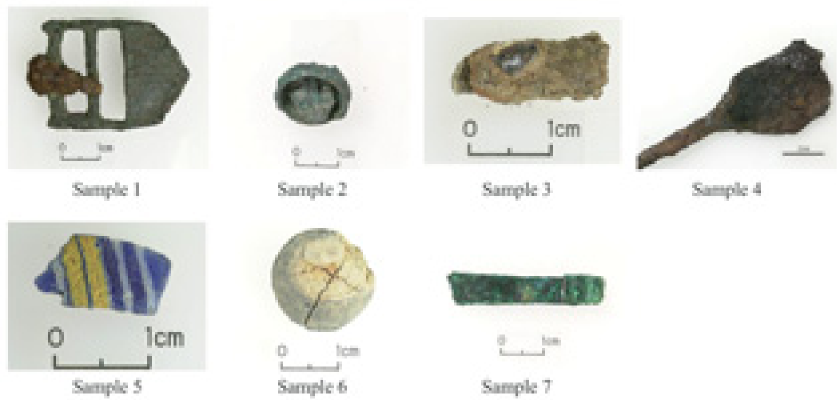

Photo 2 Sample catalogue

Appropriate information and knowledge of ancient materials are necessary to determine proper conservation treatments and to interpret the archaeological context and technological background of the archaeological finds (Caple 2000). For this reason, the chemical composition of archaeological finds should have significant meaning not only for scientists but also all other staff working at the site just like stratiglaphical or typological information. Furthermore, if such information is accumulated as a certain kind of record, it could support the construction of the precise framework for future investigative projects.

In the season of 20th excavation, XRF analysis was carried out only for the purpose of supporting material identification. This report describes the analytical results as well as the relevant issues: whether the simple qualitative analysis in present condition can provide sufficient information for conservators working at the institution and how we can improve it.

2. ANALYTICAL WORKS IN 2005

In this season, seven samples listed in Table 1 and Photo 2 with their archaeological descriptions were analyzed by an XRF spectrometer[1], at an analytical laboratory in the Japanese Institute of Anatolian

[1] SEA 2010 produced by SEIKO Instruments Co. Ltd.

Table 1 Basic archaeological description of the samples analyzed in the season of the 20th

Sample No.	Object	Year No.	Date	Trench	Sector	Grid	Provisional layer	Note
1	Buckle	05000054	07/07/2005	South	LIX-LIV Section	LVII/LVI-49/50	④	P 760
2	Fibula decoration	04000410	27/08/2004	North	XXXI	XLIV-50 (81)	㉟	R 371
3	Repairing metal	05000080 (pottery)	22/07/2005	North	XXXI	XLIV-50 (81)	㊴	P 2860 No.4
4	Dagger	90000599	28/07/1990	South	XXXVII	LXVII-61 (12)	④-ⓐ	R 40 No.3
5	Glass shard	05000091	26/07/2005	North	X	XXVI-55 (34)	⑭	P 2875 No.7
6	Born / ivory ball	05000032	04/07/2005	North	VIII	XXX-54 (44)	㊾	No.11
7	Tweezers	05000109	28/07/2005	North	XVIII	XXXIX-57 (20)	㊶	No.4

Photo 3 A scene of SEA 2010 operation in this season

Archaeology (Photo 3). Since the main purpose of these analyses was to help material determination for conservators and archaeologists working at the site, qualitative information, (the presence or absence of a particular element), was considered to be more important than quantitative information, (the amount of an element present). The measuring condition for each sample is shown in Table 2. Except for the sample 5, finds were set into the sample room under an atmospheric condition because it was highly possible that a vacuum condition would cause physical damages to these fragile samples.

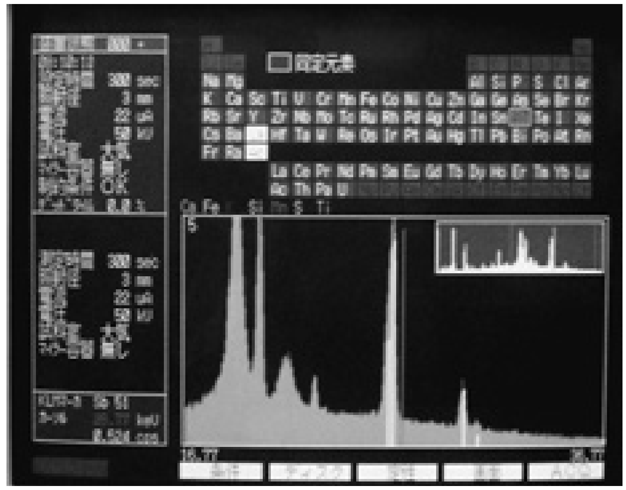

Photo 4 An x-ray fluorescence spectrum (a display of SEA 2010)

Analytical results were interactively displayed as XRF spectra on the monitor of the control unit (Photo 4). Although estimative chemical composition was calculated based on Fundamental Parameter method, in this report only the qualitative information displayed was used for the determination of the presence or absence of a particular element.

Table 2 Measuring conditions of the samples

Sample No.	**Type of object**	**Measured point**	**Location**	**Voltage /kV**	**Currency /mA**	**Measuring time /sec.**	**Beam aperture /mmf**	**Sample room**
1	Buckle	1-1	Green corrosion (body)	50	1	300	10	Air
		1-2	Brown spot (body)	50	1	300	3	Air
		1-3	Reddish corrosion (pin)	50	1	300	3	Air
2	Fibula decoration	2-1	Adhering material	50	10	300	3	Air
		2-2	Hemispherical head	50	1	300	10	Air
3	Repairing metal	3-1	Surface	50	12	300	3	Air
		3-2	Back-side	50	12	300	3	Air
4	Dagger	4-1	Black corrosion	50	30	300	3	Air
5	Glass shard	5-1	Blue glass	50	6	300	3	Vacuum
		5-2	Yellow glass	50	6	300	3	Vacuum
		5-3	White glass	50	20	300	3	Vacuum
6	Born / ivory ball	6-1	Surface	15	100	100	3	Air
		6-2	Surface	15	150	500	3	Air
7	Tweezers	7-1	Around adhering material	15	100	300	3	Air

Table 3 The aim and the result of each qualitative analysis

Sample No.	Object	Aim	Element expected	Result ○ detected × not detected
1	Buckle	The compositional difference between the buckle body and the pin	Copper (body) / Iron(pin)	○ (brass) / ○
2	Fibula decoration	The identification of the sticking material around the pin	Lead & Tin	○
3	Repairing metal	The identification of the bulk material	Lead	○
4	Dagger	The identification of the black corrosion (the presence of tin)	Tin	×
5	Glass shard	The compositional characteristics especially of the yellow glass	Lead	○
6	Born / ivory ball	The material identification (stone or organic material)	Silicon	×
7	Tweezers	The identification of adhering material on the object (hair or not)	Sulphur	×

3. RESULTS AND DISCUSSIONS

Table 3 shows the aim and result of each qualitative analysis. According to the results, it can be said that XRF analysis achieved most of the information required. For example, metal determination (sample 1 to 4) succeeded in revealing the curious ancient metalwork technique: combined use of iron and brass (sample 1), use of lead/tin solder for a fibula (sample 2), and use of lead for fixing a cracked pottery (sample 3). In addition, based both on the compositional characteristics and the technological evidence obtained by the visual observation of sample 5, it was suggested that this object should be classified into the core-formed glass, which is an important material for typological studies (Hatje 1994). On account of wide availability of the XRF instrument, it can be stated that even a simple qualitative analysis provided important material and technological information of archaeological finds.

There are still some technical problems to be considered. Firstly, the determination of organic material, bone, ivory, human remains and so on, was difficult only with XRF analysis. For instance, it may be clear that sample 6, in which no silicon was detected, was not made of stone, but it is still uncertain what the material is. According only to the chemical composition, there is no decisive information whether it is bone, ivory or another material with similar composition. In such a situation, it is necessary to use another analytical method to make a decision. Indeed, microscopic examination of the tissue structure of sample 6 suggested that it was ivory rather than bone. Thus, collaborative analysis with visual examination, and occasional use of wet chemistry, is required to confirm the material. Furthermore, it might be important to understand the accuracy or detectability of the analytical instrument. In the case of sample 7, although we expected that the fine thread-like remain on the sample surface might be hair, sulpher, which should be contained in hair, was not detected. However, it still cannot be denied that the object, a fine thread-like remain, was comparatively too small to detect sulphur but we have not justified it yet. It is, therefore, important to realize that the XRF analysis is not suitable for all-purpose use in terms of type and size of the sample and we need to adopt some other approaches, which make up and check the flaws of XRF analysis.

Another more abstract problem exists: how to record and deal with these analytical results. In this season, some results were shown to conservation and excavation staff only by oral presentation in the evening meeting during the excavation season. However, these analyses, not based on official research projects, may tend to be forgotten unless they are kept as a certain kind of documentation or publication work. Therefore, it may be helpful if there is a database, on which these basic material characteristics are accumulated, just like the small finds database, which is already in use to record archaeological information of all finds excavated in this site.

4. CONCLUSION

This report reviwed the analytical work at the Japanese Institute of Anatolian Archaeology in 2005. In this season, 7 samples were qualitatively analyzed by the XRF spectrometer, and most of the results provided sufficient answers to the question of conservators and excavators. However, there were some technical problems regarding the availability of the XRF instrument and the absence of formula for the documentation of analytical results. In order to fully utilize our analytical equipment, it may be required both to arrange a more suitable condition for the general analysis and to show a clear instruction about the possibility and a limitation of the instrument.

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