

A Note on Metallurgy at Khanak: An Indus Site in Tosham Mining Area, Haryana

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Abstract—Recent discoveries of Bronze Age artefacts, tin slag, furnaces and crucibles, together with new geological evidence on tin deposits in Tosham area of Bhiwani district in Haryana (India) provide the opportunity to survey the evidence for possible sources of tin and the use of bronze in the Harappan sites of north western India. Earlier, Afghanistan emerged as the most promising eastern source of tin utilized by Indus Civilization copper-smiths. Our excavations conducted at Khanak near Tosham mining area during 2014 and 2016 revealed ample evidence of metallurgical activities as attested by the occurrence of slag, ores and evidences of ashes and fragments of furnaces in addition to the bronze objects. We have conducted petrological, XRD, EDAX, TEM, SEM and metallography on the slag, ores, crucible fragments and bronze objects samples recovered from Khanak excavations. This has given positive indication of mining and metallurgy of poly-metallurgical Tin at the site; however, it can only be ascertained after the detailed scientific examination of the materials which is underway. In view of the importance of site, we intend to excavate the site horizontally in future so as to obtain more samples for scientific studies.

Keywords—archaeometallurgy, problem of tin, metallography, Indus civilization.

I. INTRODUCTION

THE Harappan settlement of Khanak (Lat: 28°54'26.5" N; Long: 75°52'08.9" E) is situated at a distance of 35 km north-west of the Bhiwani and 8 km north-west of Tosham, on the Tosham-Hissar road [1]. The site is extended up to foothill of Khanak hills (Aravalli hills). The site is spread over an area of about 5 hectares and leveled for occupancy activities and construction of road.

The region would have been an important resource area for many varieties of metals, minerals, stones (procured from Aravalli hills) and must have provided much needed functional trade routes facilitating the smooth flow of trade items from one place to another. The geology of this area has been well studied by Kochhar [1]. Rocks belong to the Malani igneous suite of rocks of western Rajasthan, quartzite and meta-sediments belonging to the Delhi Supergroup from the country rocks. The Tosham hill is surrounded by Khanak, Riwasa, Dulheri, Dadam and Dharan ring complexes. The occurrence of primary tin in the form of cassiterite from the Tosham area was first reported by Kochhar in 1983 [2] which was found associated with the muscovite-biotite granite.

As pointed out by Kochhar et al. [3] the Tosham is located right in the middle of the Harappan distribution zone in

Haryana. Its location may also be related to the rich copper-bearing zone of Southwest Haryana & Northeast Rajasthan. They have also mentioned that no Harappan material has yet been reported from the immediate vicinity of the hills. However, Prof. Dilip Chakrabarti, University of Cambridge has mentioned a few sites in the area in his recent publication [4]. In this context, Randall Law [5] who has been studying the mineral resources and networks spawned by the need of Indus cities like Mohenjo-daro and mentioned that

“The second most common type of grinding stone at Harappa appears to be the type of Delhi quartzite found only in the westernmost outliers of the Aravalli mountains, located in southern Haryana. Unlike the glassy highly silicified gray colored material that is typical of Delhi quartzite elsewhere in the Aravallis, the stone from these outcrops in the vicinity of Kaliaana and Makanwas villages in the Bhiwani district has a sugary texture, is red-pink to pinkish gray in color and is crisscrossed with thin haematite and quartz filled fractures. None of the other geologic formations immediately surrounding the upper Indus Basin contain material that even remotely resembles this distinctive type of quartzite. Grinding stones made of this stone at Harappa are easily identification” [6].

This extensive and important site [7] has been excavated on a small scale during the months of September, 2014 and again in February, April-May, 2016 under the direction of R.N. Singh with the assistance from Arun Kumar Pandey, Dheerendra Pratap Singh, Amit Ranjan, Sudarshan Chakradhari, Bipin Singh and Mritunjay Singh from Banaras Hindu University. In addition, Dr. Cameron A. Petrie, Department of Archaeology, University of Cambridge has visited our excavations during February, 2016 extended valuable in the assessment of cultural materials recovered from the excavations. Dr. Petrie also conducted the Total Station Survey in order to map the extension of the site. The excavations have been conducted with the financial support from the Finance Officer, Banaras Hindu University and the Archaeological Survey of India, Government of India, New Delhi [8].

During our limited excavations of three weeks during session 2013-2014, only five trenches were laid down viz.: A-1, A-2, A-3, A-4 & A-5 at different places and during 2014-2015 sixteen trenches were excavated viz.: AQ1 to AQ16 in the School ground in addition to a section cutting trench at the edge of Khanak hills. All trenches except A-5 were quite productive having Early & Mature Harappan cultural

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materials. A-5 was a recent filling of earth. Maximum cultural deposit was 1.50 m.

II. CULTURAL MATERIALS

Although we could reach up to the natural soil in two trenches only, an appreciable range of cultural materials were recovered belonging to Early Harappan & Mature Harappans. The most common material recovered was fragments of fired ceramic vessels of various types. Amongst the antiquities, steatite beads figured highest in number (more than 200), but there were also a range of other small finds including copper celt, TC cakes (idly shaped & triangular), beads of semi-precious stones including lapis lazuli, carnelian and others. Most important discovery of 2016 season is the recovery of several fragments of crucibles and large number of slag showing metallurgical activities at the site and its vicinity. Although we could find any complete furnaces but quite appreciable amount of ashes, furnace lining, burnt floors, etc. suggests that the site was in-habitat by the metal craftsmen during Harappan period.

III. POTTERY

The potteries were largely wheel-made, with few hand-made as well. The main ceramic assemblage includes mud applique ware, exterior incised ware, chocolate slipped ware, interior incised sherds (fabric D), bearing typical shapes such as flat topped bowl, basins, disc base of vase, beaded rim vase, perforated jar, dish on stand, goblets, handled vessels, and a handmade spouted pot (milk feeding?) vases, legged bowls goblets, handles, miniature pots, etc. Most characteristic pottery is the dull (or red washed) ware with painted decorations in two colours, a few with Pipal leaf. Incised designs include groups of parallel bands, chevrons, herring-bone pattern, criss-cross, short strokes, nail & thick wavy lines, etc. A good number of potteries contain post firing soothing mud application [9].

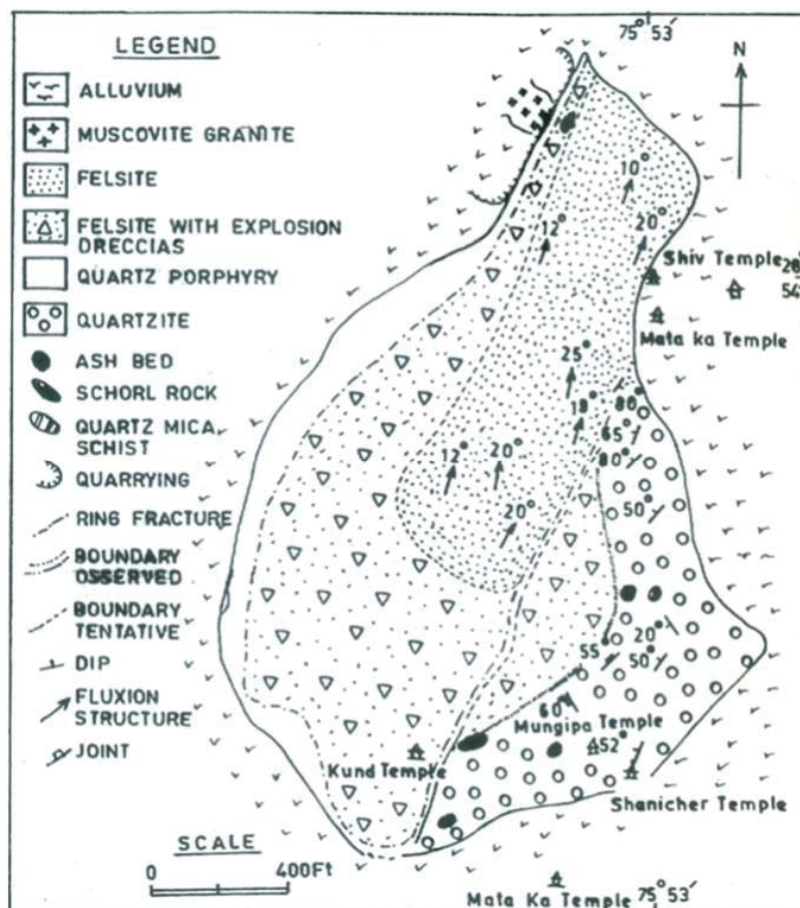


Fig. 1 Geology of Tosham area (after Kochhar)



Fig. 2 Contour Plan of Khanak showing location of Trenches

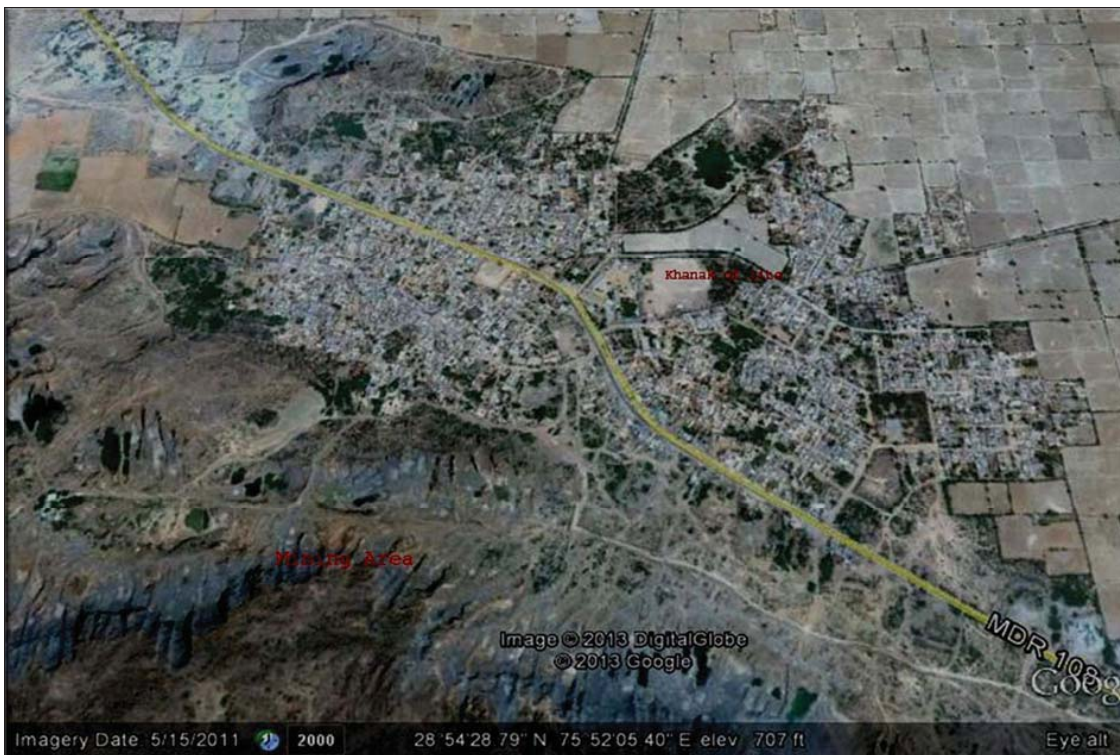


Fig. 3 Earth Image Showing Site and Mining Area



Fig. 4 Recent Mining Activities

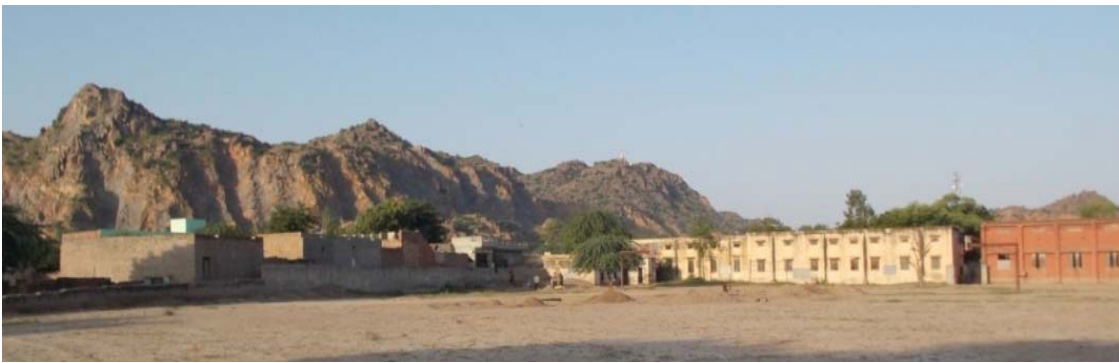


Fig. 5 Recent Mining Activities and the Site



Fig. 6 General view of the trenches showing small mud houses



Fig. 7 Circular Pit of Trench A-3



Fig. 8 Firing at lowest level in Trench A-1

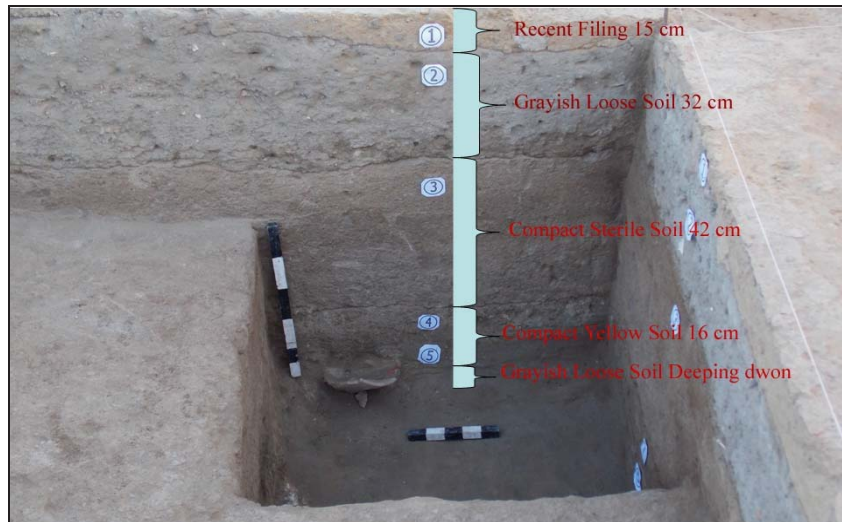


Fig. 9 Section of Trench A-4



Fig. 10 Fragments of Harappan perforated jar



Fig. 12 Few shapes of vases from Trench A-1



Fig. 11 Fragments of Dish-on-Stand and footed pots



Fig. 13 Few shapes of painted potteries



Fig. 14 Potteries with Post firing soothing



Fig. 15 Bichrome Pot sherds with Pipal leaf decorations (Similar to Kunal)

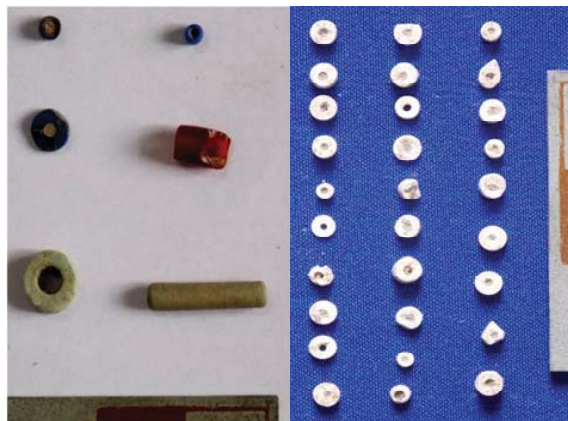


Fig. 19 Beads of Semiprecious Stones and Steatite



Fig. 16 Potteries with Graffiti Marks



Fig. 20 Copper celt



Fig. 17 Terracotta Animal Figurine



Fig. 21 Metallurgical Slag



Fig. 18 Terracotta Bangles

A. Scientific Studies of Slag and Crucible

In its endeavor to understand human behavior primarily through the materials remains of past societies, archaeology has interacted more with sciences of physics, chemistry, biology and of the Earth. In practice we often apply a range of techniques to same problems in archaeology.

B. Petrological Studies

Thin-section petrography technique has played a crucial role in the provenance studies of the ancient ceramics including Slag. First, when the non-plastic inclusions derive from distinctive igneous and metamorphic rocks, thin-section

petrography of slag provides a predictive method for identifying the source of the raw materials used in metallurgy. Very occasionally, a particular ‘key’ inclusion allows one to identify the precise source of the raw materials, ores and minerals. Considering the importance of Thin Section petrology in the study of archaeological materials 3 samples of

slag recovered from Khanak excavations have been selected for scientific examination.

C. SEM Studies

Electron microscopy have been used to study the surface and internal structure of the slag samples, the information acquired being for more detailed that which obtained from the petrological study.



Fig. 22 Fragments of Metallurgical Crucibles

TABLE I
PETROLOGICAL STUDY OF SLAG: CONTEXT 103

Khanak, Bhiwani, Haryana/ Trench No.-A1, Context - 103, Slag



Texture: Unimodel
Mineral Phases:
 Mica: Muscovite
 K-Feldspar: Plagioclase
 Silica: Quartz
 Ground Mass: Iron Oxide
 Containing into various Quartz & Muscovite minerals due to weathering at its boundary

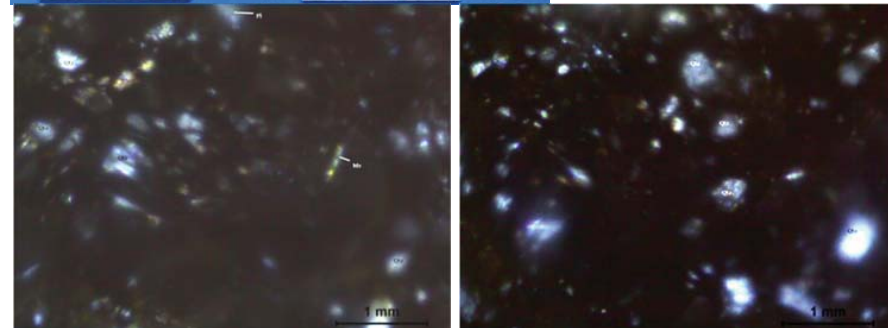
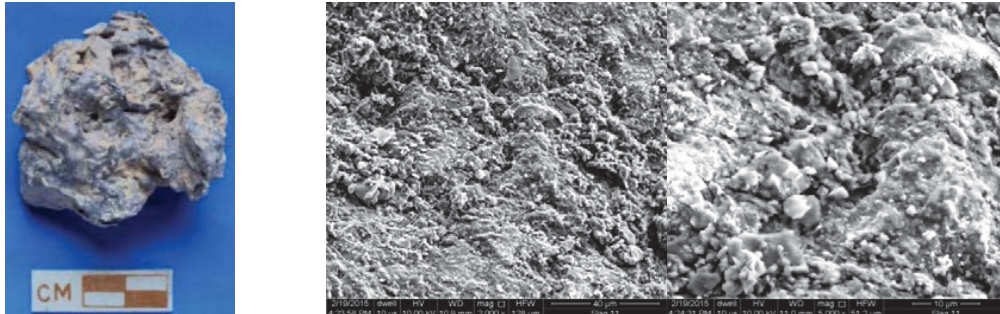


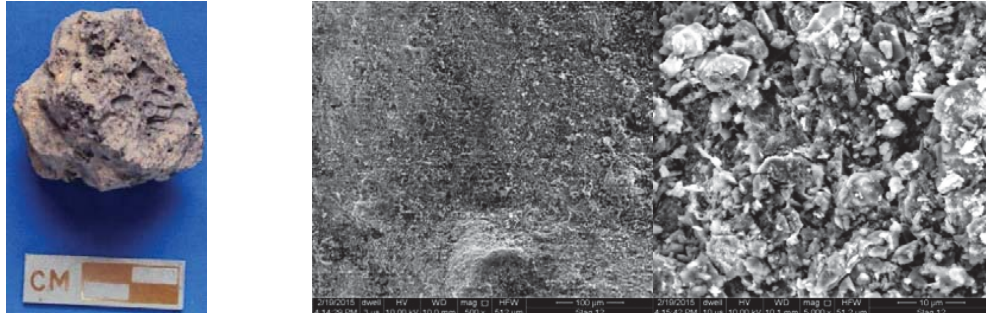
TABLE II
PETROLOGICAL STUDY OF SLAG: CONTEXTS 402 & 105

	<p>Khanak, Bhiwani, Haryana/ Trench No.-A4, Context - 402, Slag Texture: Unimodel Mineral Phases: Mica: Muscovite K-Feldspar: Plagioclase Silica: Quartz Ground Mass: Iron Oxide Containing into various Quartz & Muscovite minerals due to weathering at its boundary</p>	
	<p>Khanak, Bhiwani, Haryana/ Trench No.-A1, Context - 105, Slag Texture: Unimodel Mineral Phases: Mica:- Muscovite K-Feldspar:- Plagioclase Silica:- Quartz Ground Mass:- Iron Oxide Containing into various Quartz & Muscovite minerals due to weathering at its boundary</p>	

Sample No. – KNKDP6, Site Name - Khanak, Bhiwani, Trench No. & Context – A1, 103, Type of Ware – Slag



Sample No. – KNKDP7, Site Name - Khanak, Bhiwani, Trench No. & Depth/Context – A4, 402, Type of Ware – Slag



Sample No. – KNKDP10, Site Name - Khanak, Bhiwani, Trench No. & Depth/Context – A1, 105, Type of Ware – Slag

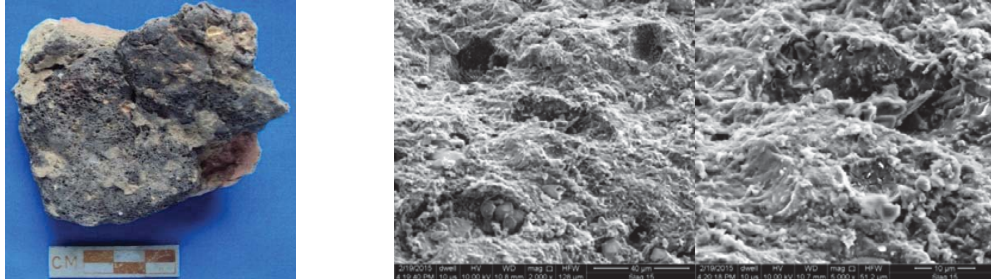


Fig. 23 SEM Studies of the Samples

D. EDAX Analysis

Prepared samples of slag for Scanning Electron Microscopy (SEM) has been use for micro analysis utilizing EDAX facilities available in Banaras Hindu University.

Sample details for EDAX Analysis:

- No. – KNKDP6- Slag
- Trench No. & Depth/Context – A1, 103

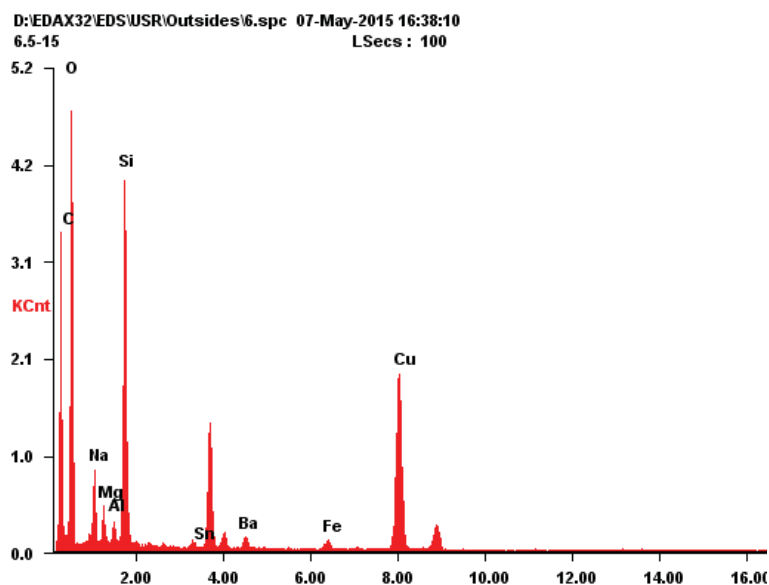


Fig. 24 EDAX Peaks of the Samples

TABLE III
EDAX STUDIES OF METALLURGICAL SLAG

Elem	Weight %	Atomic %
C K	27.80	44.10
O K	30.00	35.80
NaK	02.90	02.40
MgK	01.50	01.20
AlK	00.90	00.60
SiK	13.90	09.40
SnL	00.20	00.10
BaL	03.30	00.50
FeK	00.80	00.30
CuK	18.70	05.60

IV. OBSERVATION & FUTURE WORK

The excavations at Khanak focused on recovering well stratified cultural material, carbonized organic remains for new radiocarbon assay, samples for phytolith and soil micromorphological analysis, and samples for flotation to collect macro-botanical remains. Archaeozoological remains will be analysed by Prof. P.P. Joglekar at the Deccan College. Our preliminary observation suggests the site is occupied at least since Early Harappans. Recovery of Kunal type bichrome potteries along with other material is important in this part of the country. Earlier it was presumed that there was no Harappan site in the Aravalli Range but with the discovery of Khanak has proved that the exploitation of the area for exploitation of mineral resources has a long history. Evidences suggest that its antiquity may go back even earlier than Early Harappan- Sothi-Siswal periods since we have not reached up to the natural soil.

There is ample evidence of metallurgical activities as attested by the occurrence of crucibles, slag, ores and evidences of ashes and fragments of furnaces. In order to understand provenance of raw materials, petrological, SEM and EDAX studies have been conducted by the second author on the slag, ores and crucibles samples recovered from Khanak excavation have given the indication of mining and metallurgy of poly-metallurgical Tin at the site. The data emerged so far for the analysis and subsequent petrological, SEM and EDAX studies revealed that the Harappan settlers at Khanak utilized locally ores from nearby areas and were well acquainted with metallurgical process particularly of copper-bronze. However, it can only be ascertained after the detailed scientific examination of the crucible lining, copper celt and other materials which is still in progress.

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