THE CENTRAL TIMNA VALLEY PROJECT (CTV) 2013

OPTICALLY STIMULATED LUMINESCENCE (OSL) AND ITS APPLICATION IN THE DATING OF ANCIENT COPPER MINES

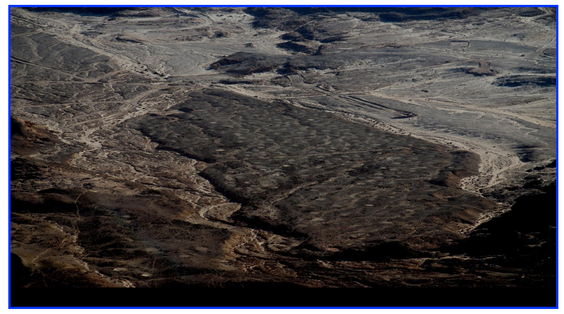
CRAIG SMITHERAM[1], EREZ BEN-YOSEF[1], NAOMI PORAT[2] AND GALINA FAERESHTEIN[2]

[1]TEL AVIV UNIVERSITY; [2]GEOLOGICAL SURVEY OF ISRAEL

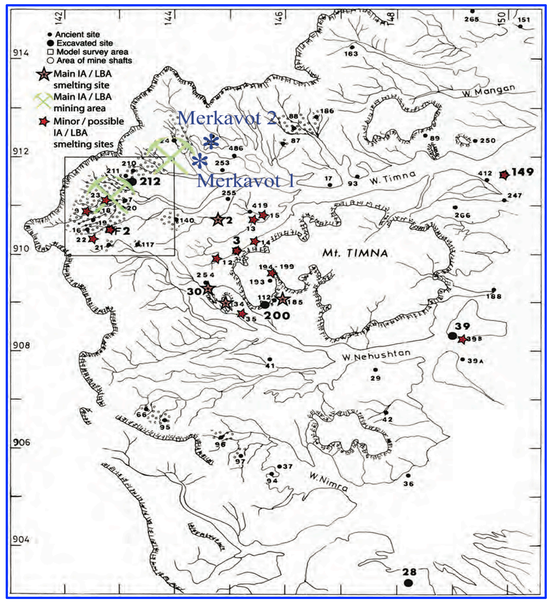
Abstract

The first season of the Central Timna Valley Project (CTV), directed by Dr. Erez Ben-Yosef, was carried out in February 2013. As part of the project we systematically investigated the two basic types of mines identified in the Timna Valley by the Arava Expedition of Beno Rothenberg: open-pit (*placer*) mines (represented by Merkavot 1 of the CTV) and the 'plate-like' shaft mines (represented by Merkavot 2 of the CTV). The results of our excavations confirm Rothenberg's typology and provide new insights regarding mining technology and post-depositional processes, including the important observation of deliberate filling of the 'plate-like' shaft mines by the miners as part of the mining process. Furthermore, to address the long standing question regarding the chronology of the mines, we applied Optically Stimulated Luminescence (OSL) dating to the fine-sand quartz grains of the mine fills and tailings. Together with preliminary results of previous research in the Faynan copper ore district (Ben-Yosef et al. 2013), we demonstrate the potential of this method to provide age constraints on ancient mining activities. As mines usually lack datable material culture or organic remains, OSL dating constitutes the best method available for dating ancient mines to date.

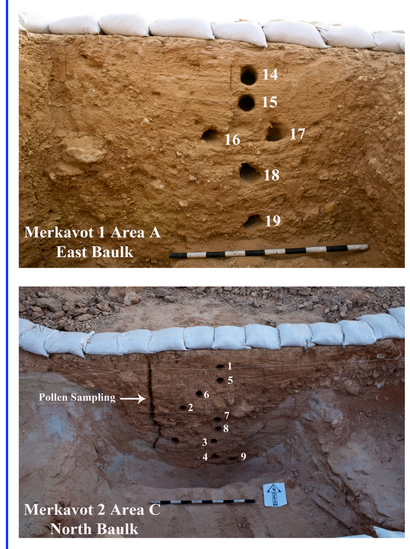
The open pit (*placer*) mines of Merkavot 1 displaying Area A and Area B from the 2013 Excavations.



Aerial photograph of "Plates" or blocked shaft mines in Timna Valley. Photo courtesy of Rita Mendes-Flohrs



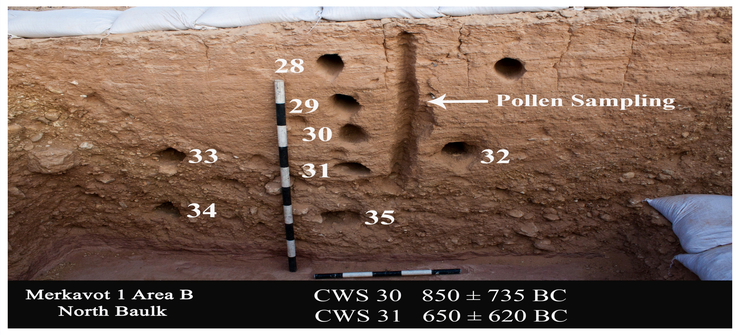
Map of archaeological sites in Timna Valley.
(Ben-Yosef 2012, based on Rothenberg 1990)



OSL sample locations from Merkavot 1 Areas A and B; Merkavot 2 Area C.

Mining Technologies in the Timna Valley:
Two types of ancient mining technologies were studied as part of the current research: (1) *placer* mines (represented by Merkavot 1), in which eroded nodules of copper minerals were extracted from the colluvial sediments; (2) Shaft & galleries mines (represented by Merkavot 2), in which copper minerals were mined by digging vertical shafts and galleries into the ore-bearing sandstones. The difference in complexity of the two technologies led researchers to the assumption that the simpler type, the *placer* mines, is much older than the complex shaft mines. The current study aims at testing this assumption. Both excavated types of mines lacked dateable material making it difficult to determine the *terminus ante quem*; thus, OSL is the best method for applying chronological constraints on the mining technologies.

Preliminary Results:

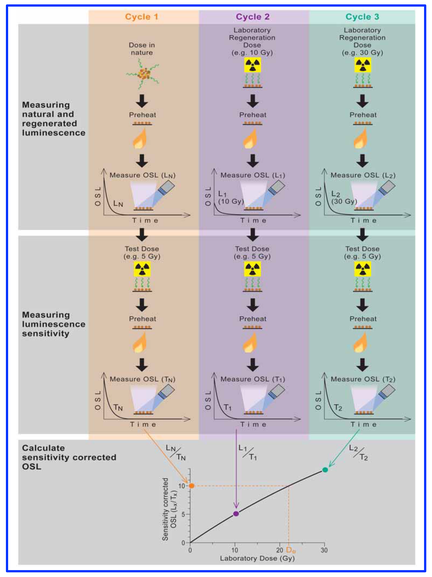


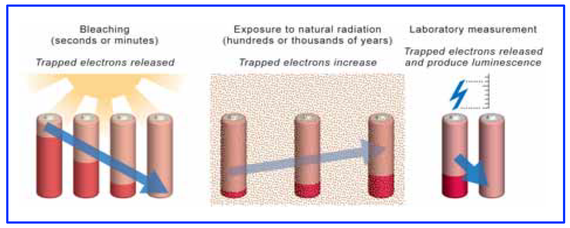
Processing of the samples was conducted in the Luminescence Laboratory at the Geological Survey of Israel, Jerusalem. The following samples CWS 30 and CWS 31, are collected from a *placer* mine located at Merkavot 1 Area B. Shown in the image *above* are the Luminescence calibrated ages of the samples based on the year processed, 2013.

The OSL Sampling Process:

A. Excavating and preparing a section within the *placer* mine for sampling.
B. Using a geological coring drill to collect the sediment covered by a blanket in order to prevent light from contaminating the sample.
C. Collecting a chemistry sample to analyze the sediment in clear bag and a separate double black bag for OSL sampling in the lab. (Note: This image is from a demonstration, hence the sample collection is not performed under the cover a blanket.)
D. After collecting the OSL sample, using a Gama spectrometer, *insitu* Gama spectrometry measurements are recorded.
E. The final product - a chemistry sample shown in the clear bag on the right and the OSL sample in a double black bag on the left. This is taken to the lab for further processing.

Acknowledgements:
We would like to thank Dua'a Abu-Salah for her work during the excavation and performing the laboratory experiments, and the CTV 2013 excavation team. The experiments were conducted at the OSL Laboratory of the Geological Survey of Israel. This research was supported by Marie Curie FP7-PEOPLE-2012-CIG grant #334274 to E.B.Y.





OSL Methodology:
After collecting the samples for OSL dating, the laboratory processes are performed to obtain an age. The image *above* uses the analogy a rechargeable battery to demonstrate how the process of luminescence dating works (Duller 2008). Fine-sand quartz grains from this study are a suitable material for luminescence dating in which the single aliquot regenerative dose (SAR) protocol is applied (*see left;* Duller 2008). Two sets of laboratory measurements need to be combined to determine the age of the sample, the D_e or Equivalent Dose which is determined using luminescence, and the dose rate. The equation for calculating the luminescence age is shown *below*.

$$\text{Age (years)} = \frac{\text{Equivalent Dose } (D_e)}{\text{Dose Rate}}$$

Conclusions:

- Preliminary results of OSL samples processed from Merkavot 1 indicate the Iron Age as the *terminus ante quem* of the *placer* mines and most probably suggest that they were operated at the turn of the 1st millennium BCE.
- OSL dating of mines in Timna Valley demonstrates the feasibility of the technique as a tool for constraining the age of mining sites world-wide. Our results complement a previous study of *placer* mines in the nearby Faynan copper ore district, conducted as part of the ELRAP project of Thomas E. Levy (UCSD).
- More OSL dating from new excavated contexts will take place as part of the Central Timna Valley Project 2014. The new data are expected to help in solving problems of technological development in the Timna Valley, as well as establishing OSL as a dating tool of ancient mines.

Selected References:

- Ben-Yosef, E. 2010. *Technology and Social Process: Oscillations in Iron Age Copper Production and Power in Southern Jordan* (PHD Dissertation, University of California, San Diego). San Diego.
- Ben-Yosef, E., Tauxe, L., Shaar, R. and Ron, H. 2012. A New Chronological Framework for Iron Age Copper Production at Timna (Israel). *BASOR 367* 31- 71.
- Conrad, H. G. and Rothenberg, B. eds. 1980. *Antikes Kupfer im Timna-Tal: 4000 Jahre Bergbau und Verhüttung in der Arabah (Israel)*. Bochum.
- Duller, G. A. T. 2008. *Luminescence Dating: Guidelines on Using Luminescence Dating in Archaeology*. Swindon.
- Rothenberg, B. 2005. Explorations and Excavations in the Mines of the Timna Valley (Israel): Paleomorphology as Key to Major Problems in Mining Research. *Journal of Serbian Archaeological Society 21* 133-148.