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GP23A-0780: Geomagnetic intensity spike recorded in high resolution slag deposit in Southern Jordan

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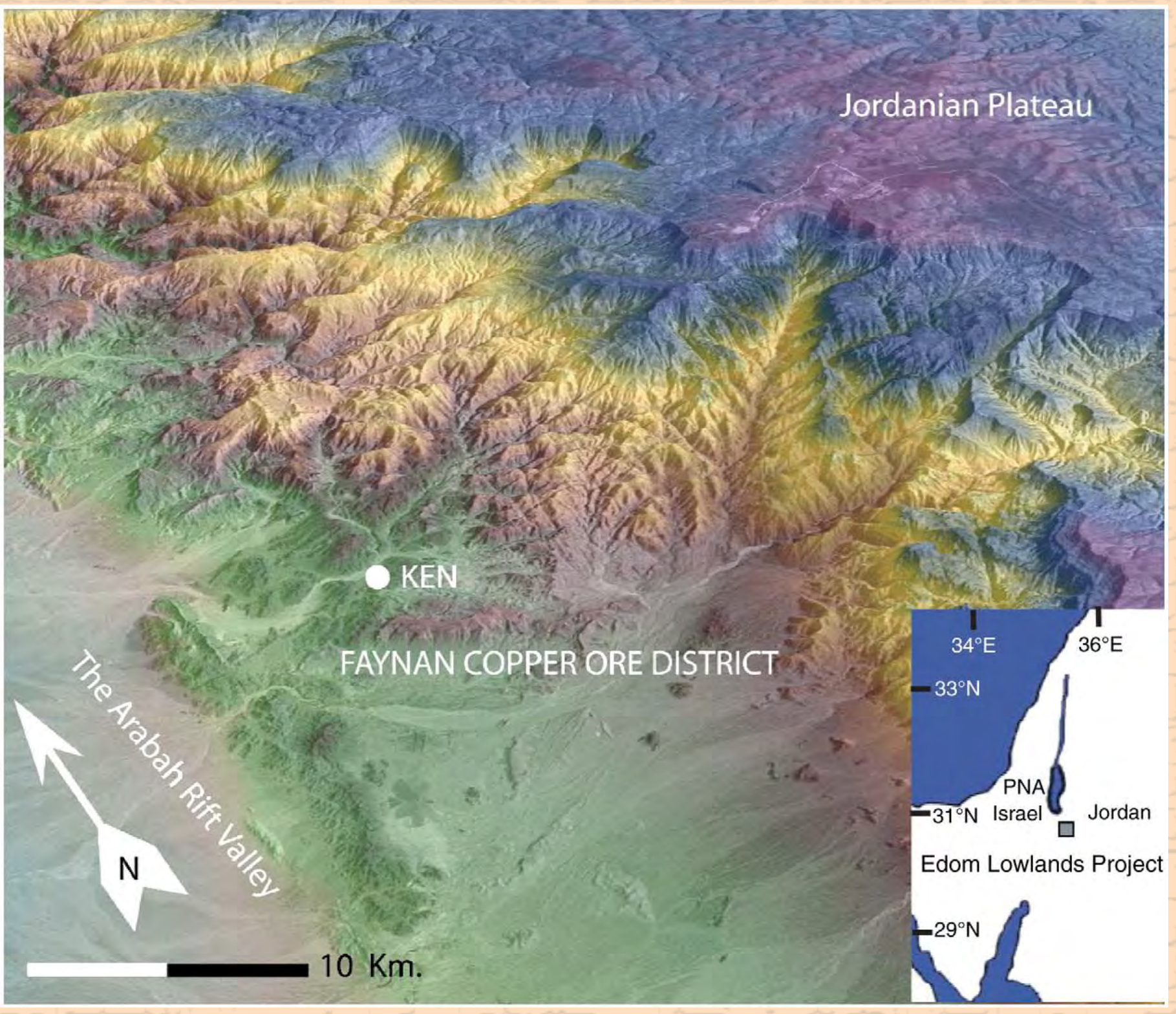
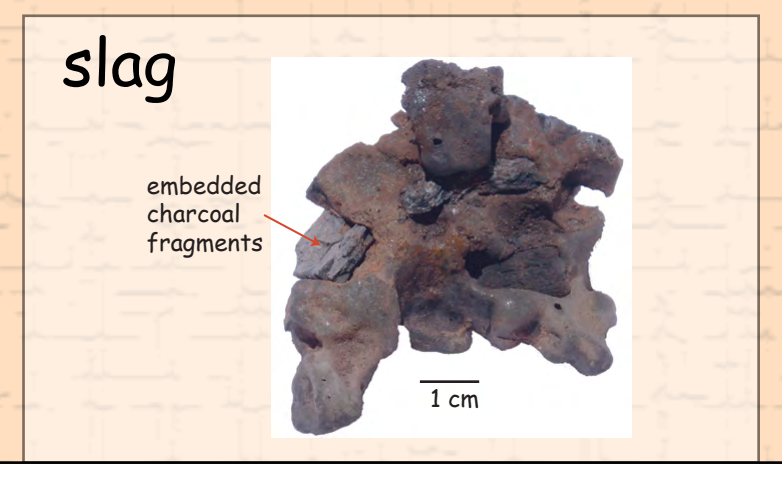
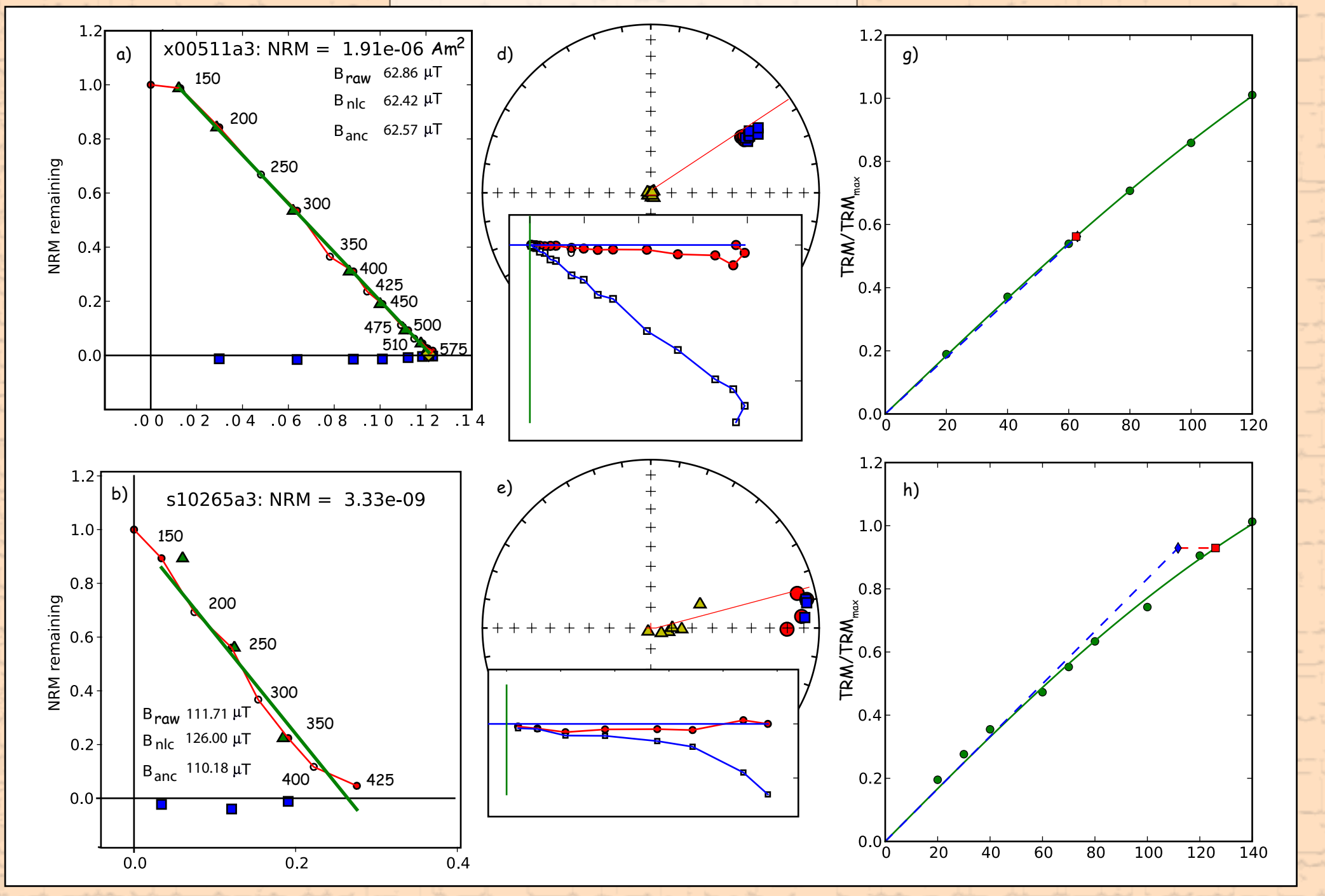
Abstract: In paleomagnetism, periods of high field intensity have been largely ignored in favor of the more spectacular directional changes associated with low field intensity periods of excursions and reversals. Hence, questions such as how strong the field can get and how fast changes occur are still open. In this paper we report on data obtained from an archaeometallurgical excavation in the Middle East, designed specifically for archaeomagnetic sampling. We measured 342 specimens from 72 samples collected from a 6.1 m mound of well stratified copper production debris at the early Iron Age (12th–9th centuries BCE) site of Khirbat en-Nahas in Southern Jordan. Seventeen samples spanning 200 yr yielded excellent archaeointensity results that demonstrate rapid changes in field intensity in a period of overall high field values. The results display a remarkable spike in field strength, with sample mean values of over 120 μT (compared to the current field strength of 44 μT). A suite of 13 radiocarbon dates intimately associated with our samples, tight control of sample location and relative stratigraphy provide tight constraints on the rate and magnitude of changes in archaeomagnetic field intensities.



Location of Study:

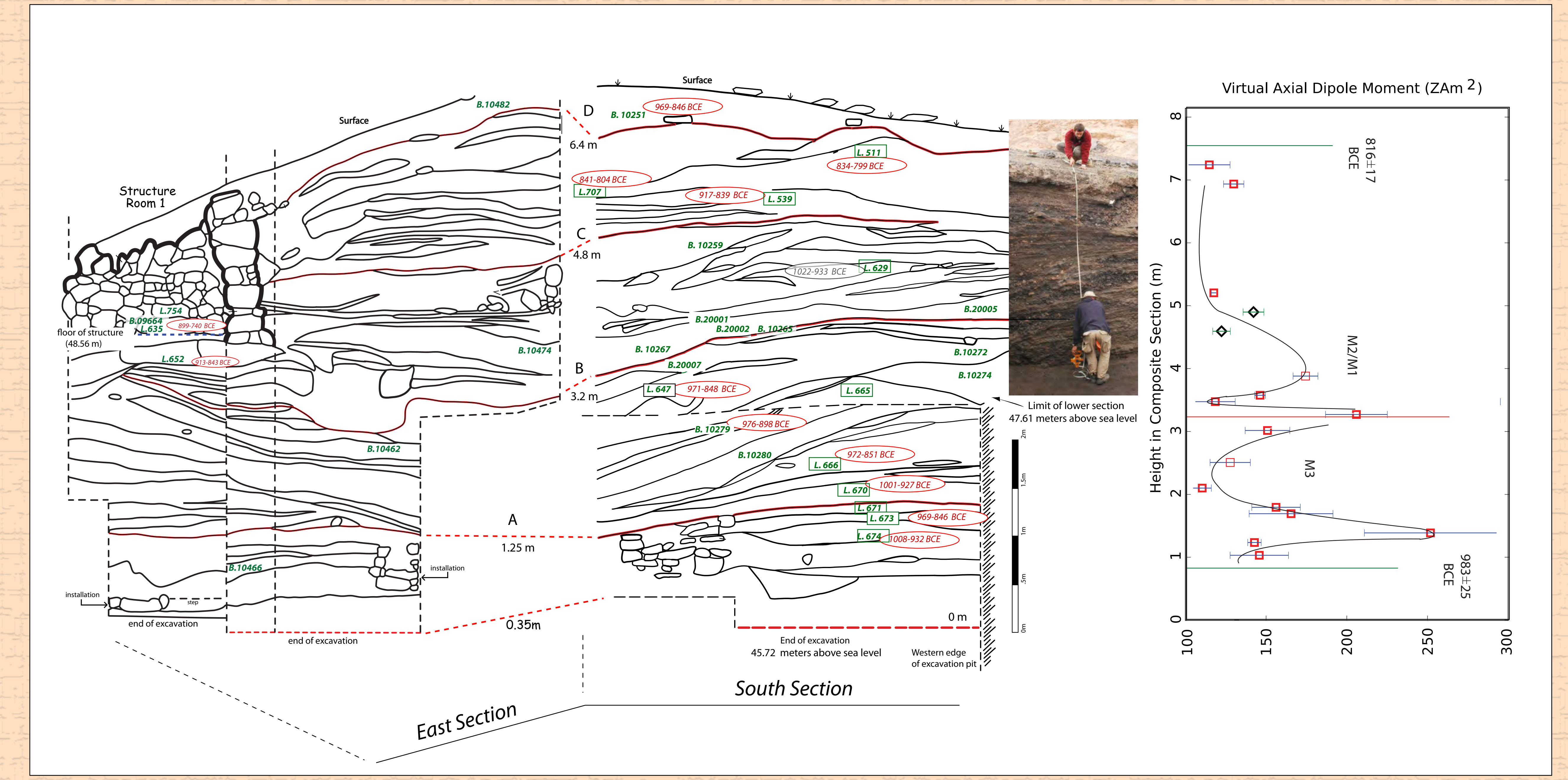
Faynan Copper Ore District in Southern Jordan, with the archaeological site of Khirbat en-Nahas (KEN), the largest Iron Age copper production center in the Southern Levant.
False color 3D satellite image courtesy of Richard Cleave, ROHR, Nicosia, Cyprus.





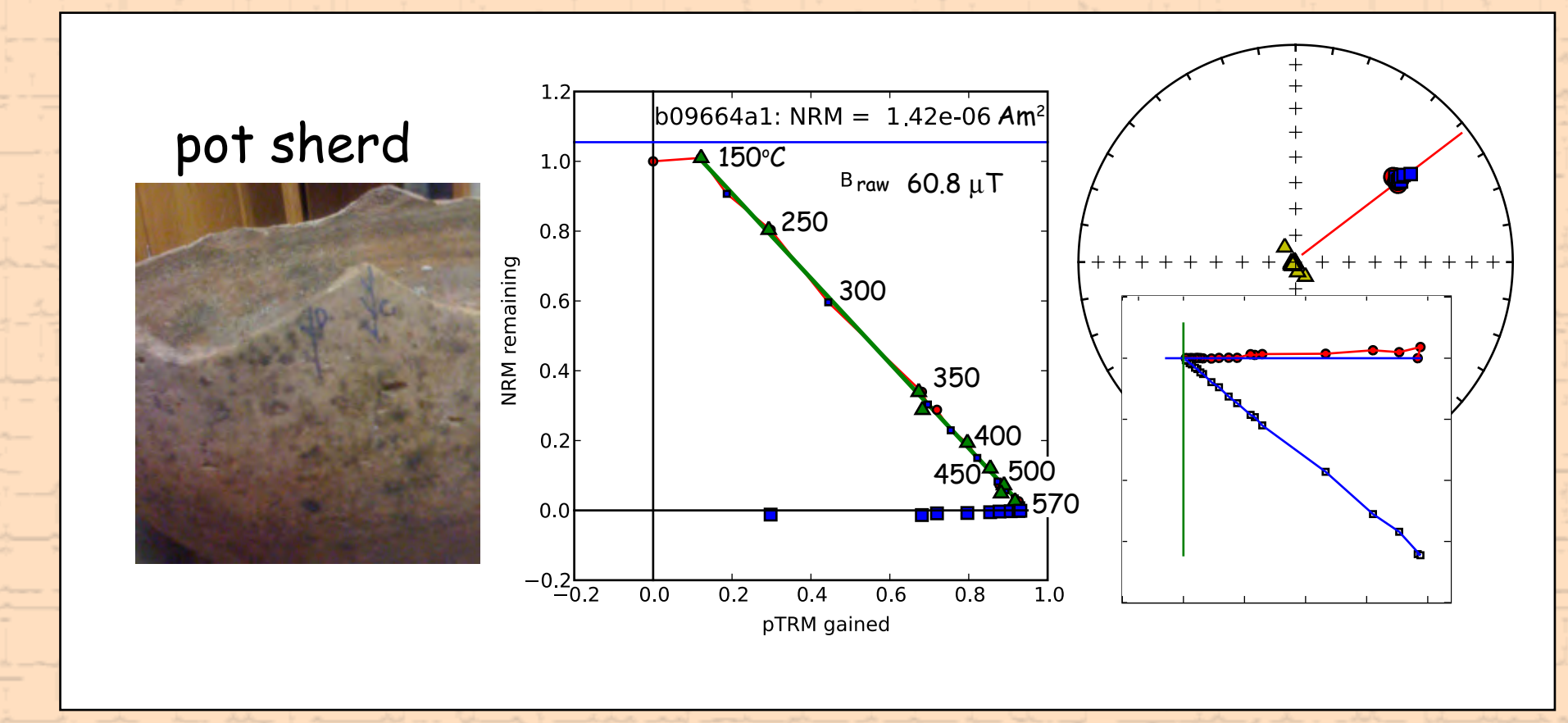
Examples of results from the archaeointensity experiments, slag (above) and burnt clay (to right) material: Diagrams to left are Arai plots, shown together with the calculated ancient field [B_{raw}: the slope of green line times laboratory field, B_{nlc}, corrected for non linear TRM acquisition and B_{anc} corrected for remanence anisotropy]. Open (closed) circles are the IZ (ZI) steps. Triangles (squares) are the pTRM (tail) check steps. NRM intensities are in Am^2.

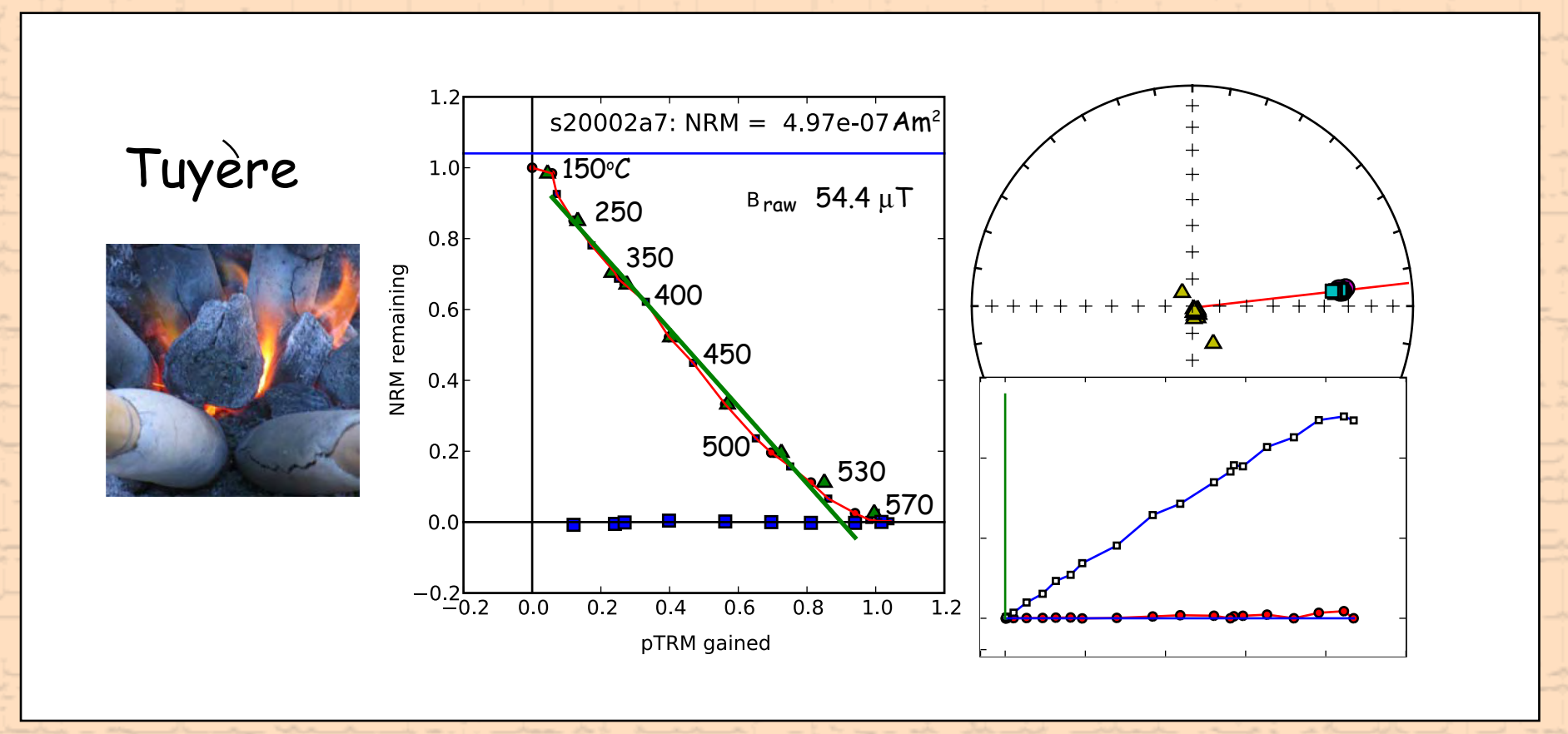
Directional results are also plotted as equal area projections with vector end-point diagrams shown as insets. The solid line from the center to the edge of the equal area projections is the direction of the NRM, which serves as the X axis direction in the vector end-point diagrams. The triangles in the equal area projections are upper hemisphere projections of the directions of the pTRM gained at in-field temperature step. The applied field was at the center of the diagram (in the up direction). Offset from the applied field direction implies significant anisotropy of remanence; require anisotropy correction. Circles (squares) are ZI (IZ) steps and closed (open) symbols are lower (upper) hemisphere projections. To the right in the diagram above are results from our TRM acquisition experiments. Specimens are given a total TRM by heating to 600°C and cooled in varying applied fields (dots). The data are fit with the best-fit hyperbolic tangent (solid line). Braw (diamond) is found using the linear acquisition assumption. The actual field required to produce the same TRM (square) is B_{nlt}.

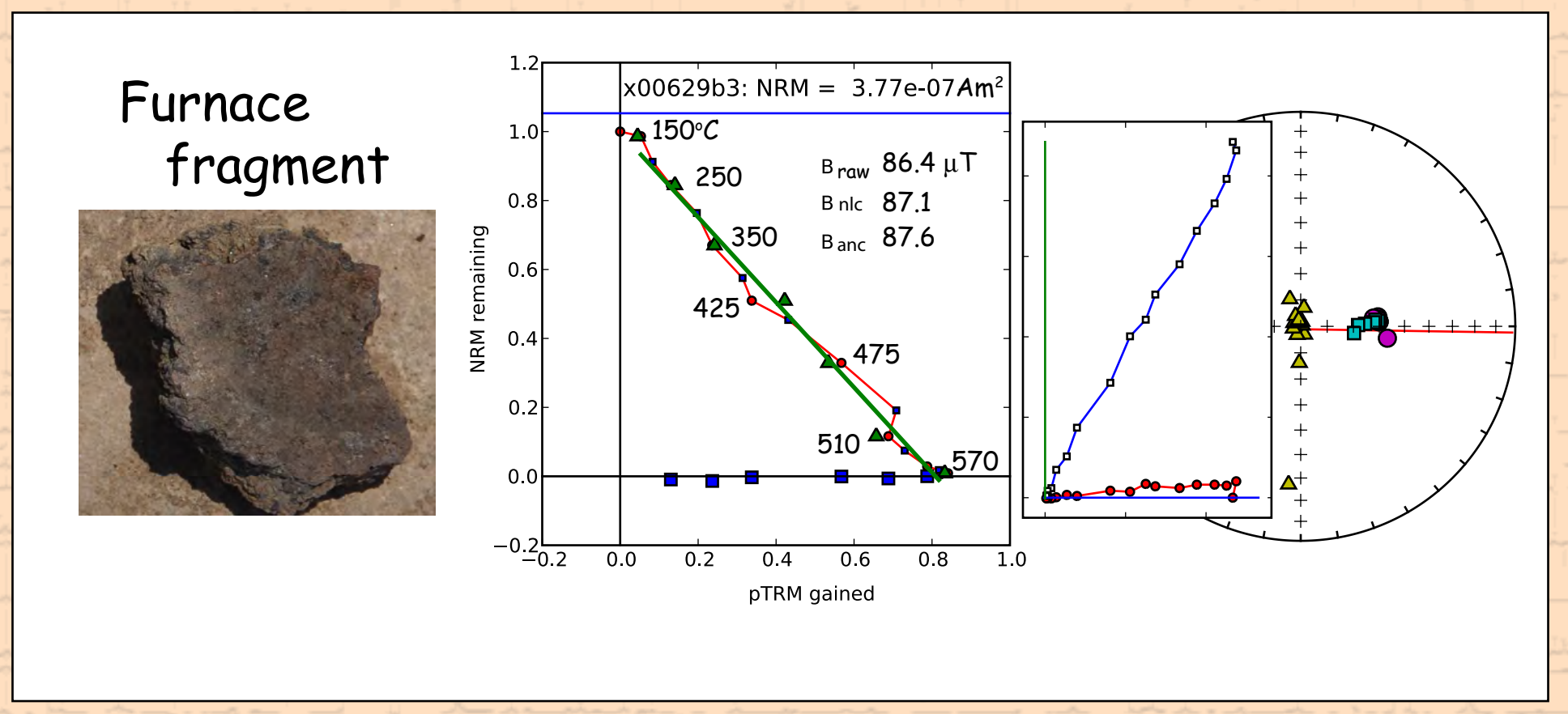


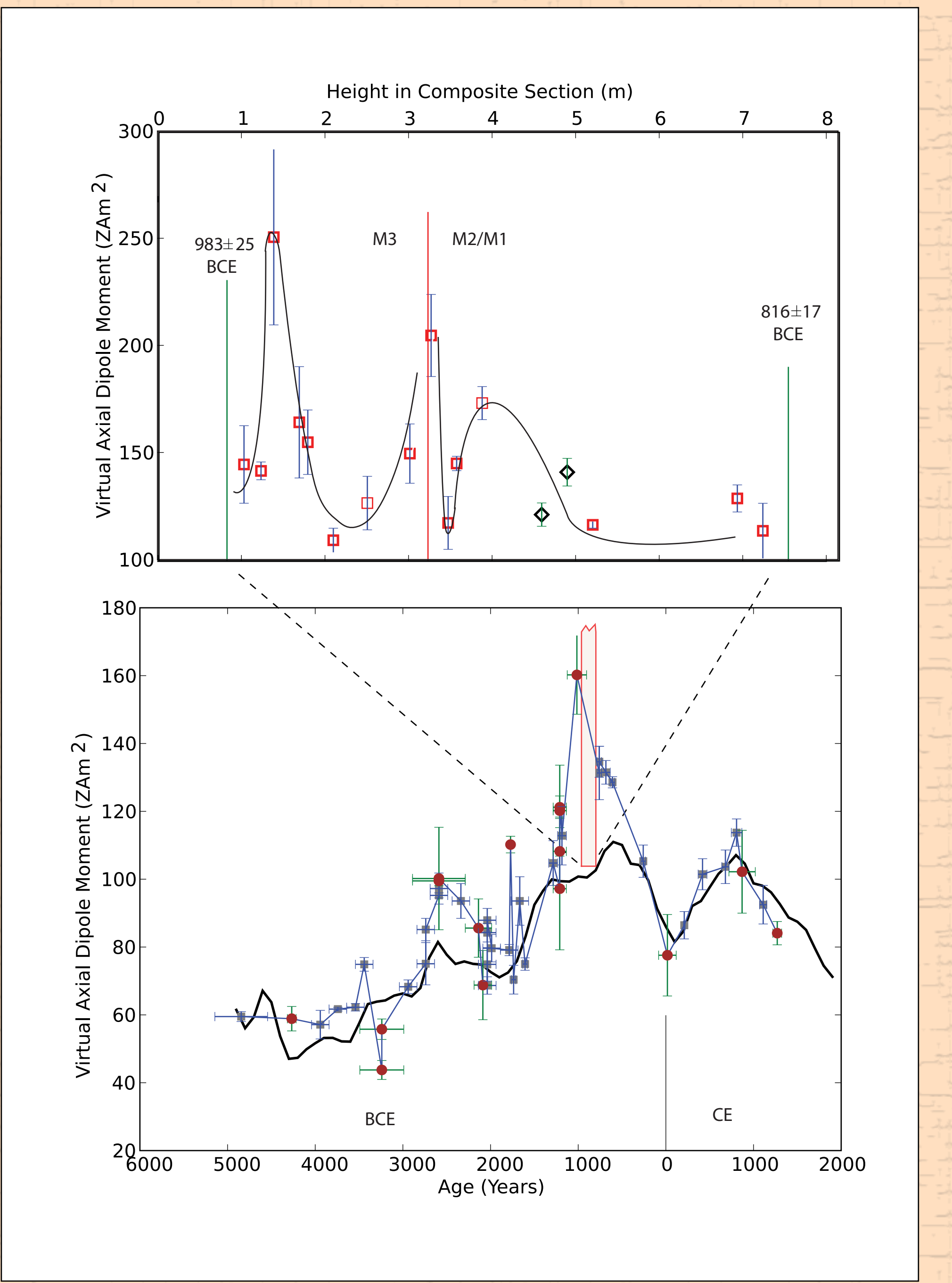
Details of section:

Khirbat en-Nahas, area M (Faynan Copper Ore District, Jordan): drawing of the eastern (left) and southern (right) walls of excavation pit in a 'slag mound' depicting multi-layer sequence of copper production debris and location of all samples with 'successful' archaeointensity specimens obtained directly from these walls ('B' numbers for Baskets) or from the associated excavation ('L' numbers for Loci). Results from radiocarbon samples of Levy et al. (2008) are marked by circles. Also indicated as heavy lines are the reference stratigraphic horizons for composite stratigraphic height measurements.



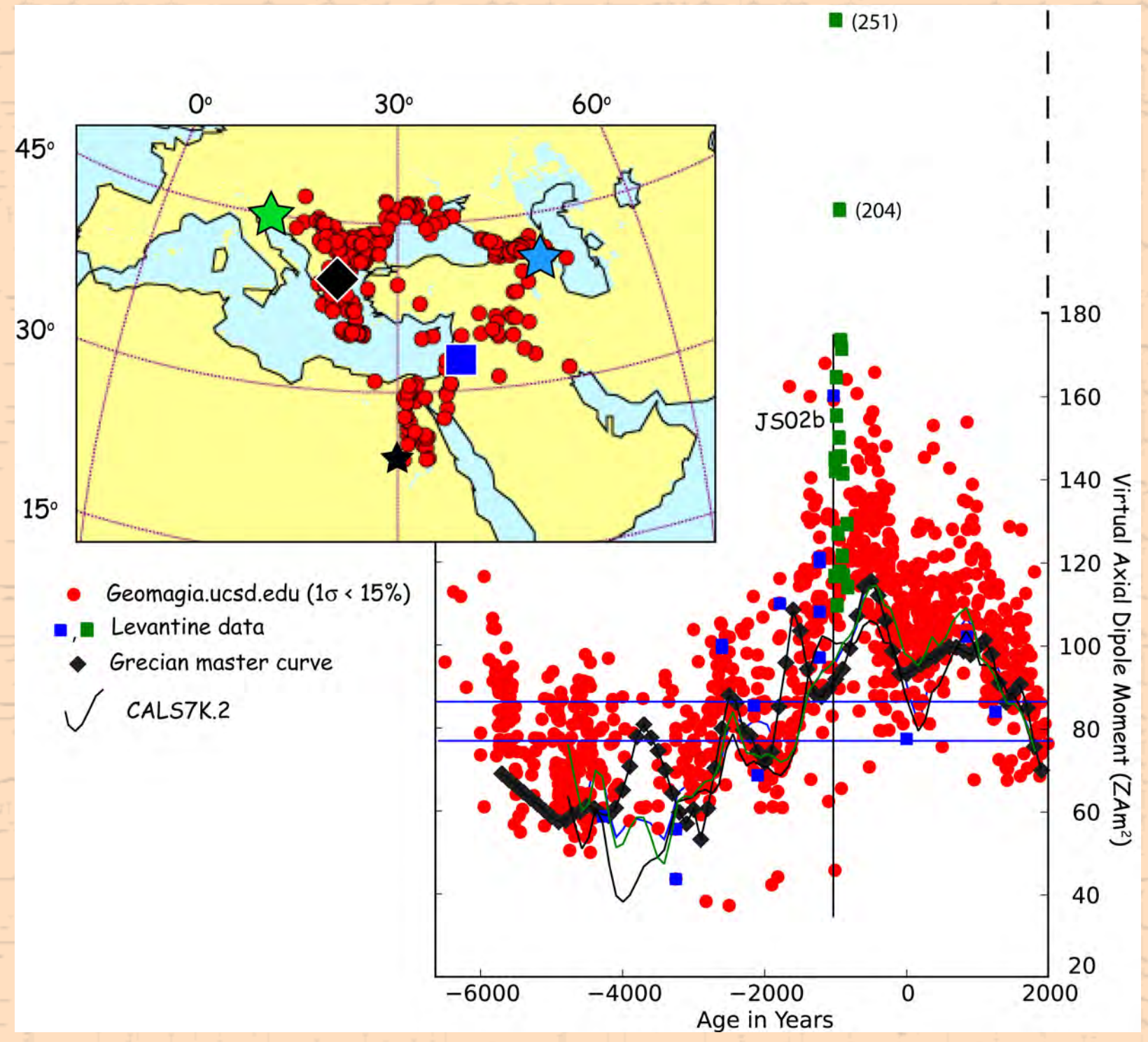






The Levantine Master Intensity curve and the Khirbat en Nahas geomagnetic field spike:

Virtual axial dipole moments (VADMs) of the geomagnetic field for the last seven millennia and the spike recorded in this study (note that 'Z' stands for 10^21). Southern Levantine data are from Ben-Yosef et al. (2008a,b) (red circles), northern Levantine data are from Genevey et al. (2003) and Gallet et al. (2006) (grey squares), and the CALS7k.2 model is of Korte and Constable 2005) (black curve). Inset shows data from this study; a line is sketched through the data points as a visual aid, emphasizing trends and possible major hiatus. Note changes of scale, and the boundary line of Strata M3/M2 (see figure to left.)



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