The last 30,000 to 600,000 years ago: unravelling the timing of human settlement for the Palaeolithic site of Kozarnika.

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The last 30,000 to 600,000 years ago: unravelling the timing of human settlement for the Palaeolithic site of Kozarnika (Bulgaria)

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1 Introduction

- **Kozarnika cave** is a renowned prehistoric site in the Balkans. It contributes significantly to our understanding of the human past due to its rich assemblages associated with the Lower to Upper Palaeolithic periods. The cave was first mentioned in the prehistoric survey carried out before 1933. Years after, in 1996, the site was excavated systematically by Bulgarian-French researchers [1].
- Various chronological dating methods have been employed alongside the excavation to unravel the timing of humans' occupation in Kozarnika.
- This study presents our contribution of employing luminescence-dating methods (OSL, IRSL, pIRIR, VSL, IR-RF) to unravel the reliable timeframes for several geological units and archaeological assemblages. A vast body of techniques has been put together, enabling us to date sediment samples containing the assemblages attributed earlier to the Upper, Middle, and Lower Palaeolithic periods [2,3].
- Our results show that the inhabitants of Kozarnika occupied that region from ca 30 to 600 ka, showing general accordance with the previous dating.

2 Site location

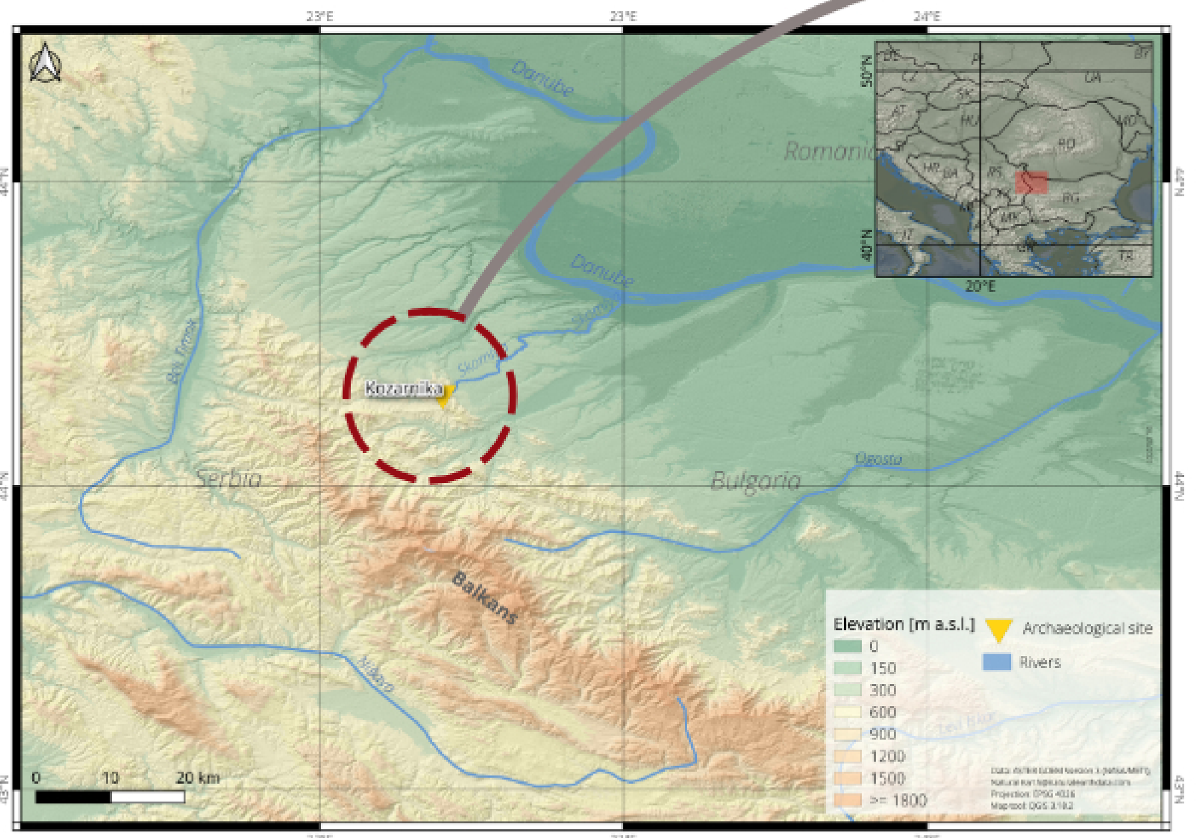
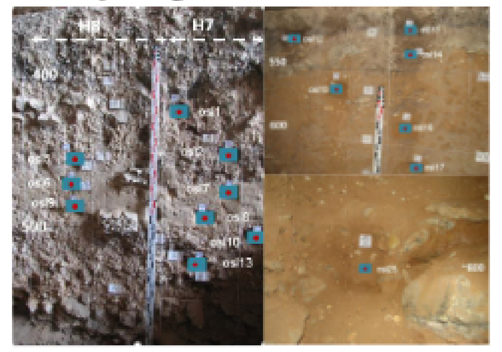


Photo: http://www.fastionline.org/data/files/webthumb_10518.jpg

Sampling

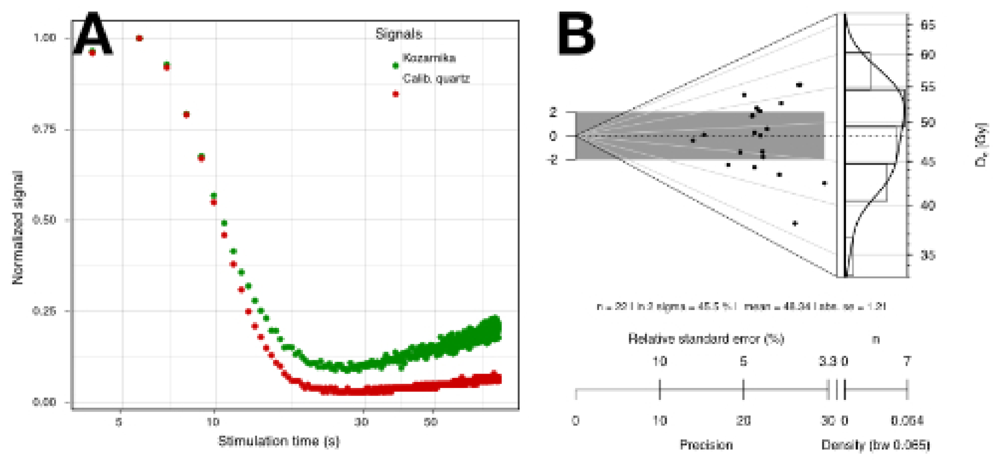


Kozarnika cave is located in the northwest of Bulgaria, 30 km away from the Serbian border. The site is situated in the northern slopes of the Balkan Mountains, merging to the Danubian Plain, which is extended to the Danube River to the north. Sediment samples were taken from the Lower, Middle and Upper Palaeolithic sequences of the cave.

3 Dating

Signal measurement

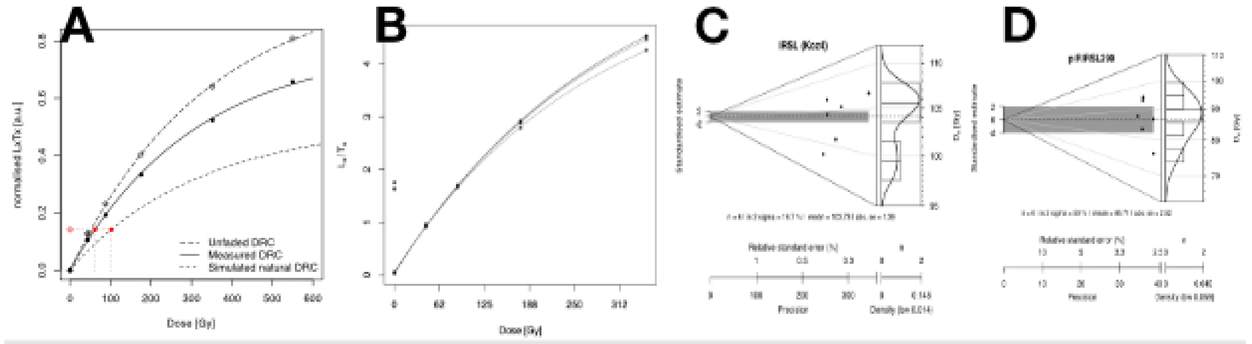
1 Optically stimulated luminescence (OSL)



A The figure illustrates the presence of a fast-decaying signal due its good match with the calibration quartz signal.

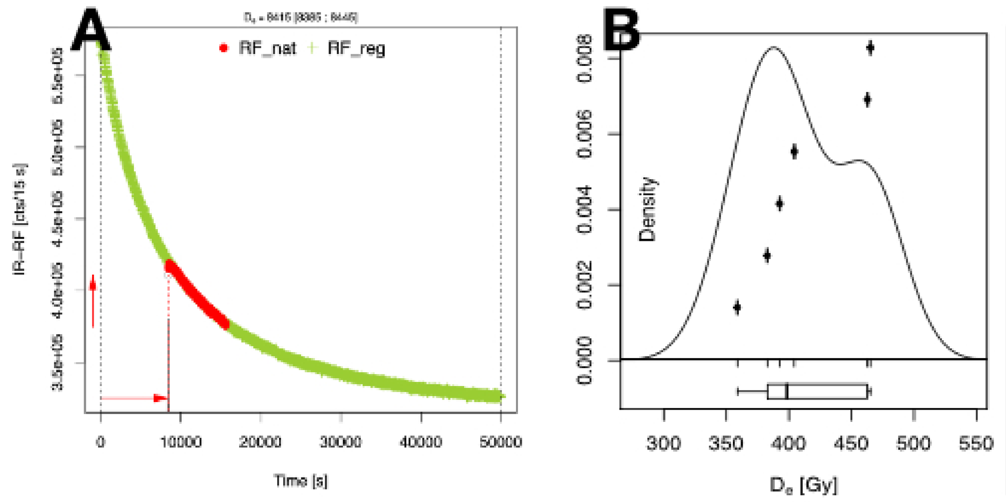
B Quartz OSL equivalent dose distribution using multi-grain approach for Koz4 as an example.

2 $IRSL_{50}/pIR_{50}IRSL_{290}$



A&B: Dose-response curves obtained for sample Koz4 as an example using $IRSL_{50}$ (A) and $pIR_{50}IRSL_{290}$ (B) signals. Equivalent dose distributions obtained $IRSL_{50}$ (B) and $pIR_{50}IRSL_{290}$ (D) signals.

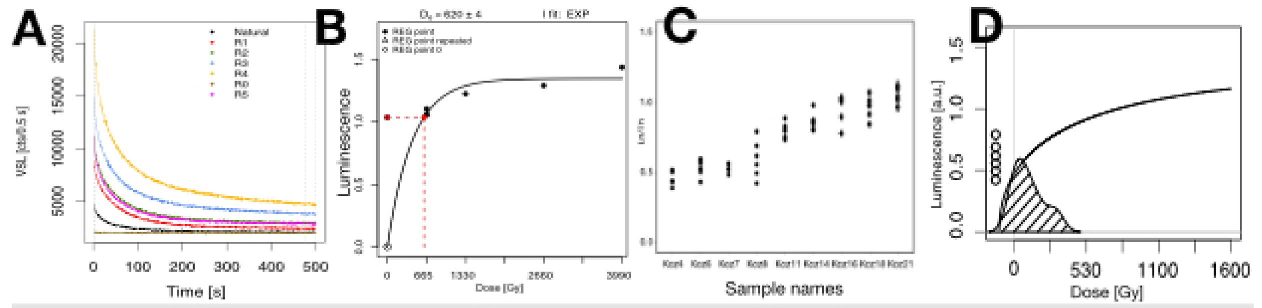
3 Infrared radiofluorescence (IR-RF)



A The IR-RF curve was obtained for one sample (Koz11) using the RF70 protocol [4].

B The kernel density estimate (KDE) plot illustrates the dose distribution for the same sample.

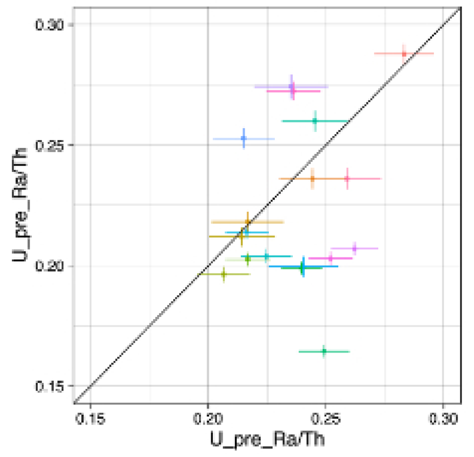
4 Violet OSL (VSL)



A Typical shine-down curves of VSL after blue-stimulation. **B** a dose-response curve for Koz21. **C** A smooth increase in the obtained L_n/T_n values as samples' depths along with the profile. **D** Equivalent dose distribution obtained for sample Koz4. These values were projected onto DRC constructed using the MAAD protocol [5] to estimate the dose response.

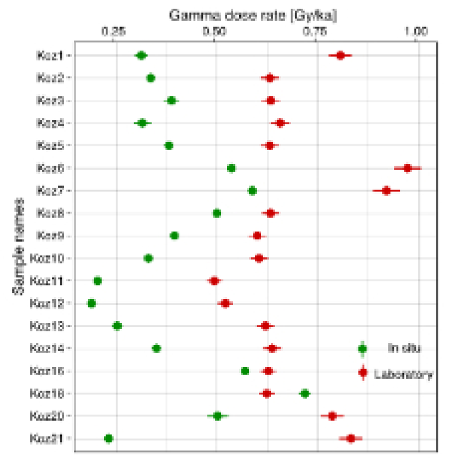
Dose rate

1 Gamma-ray spectrometry



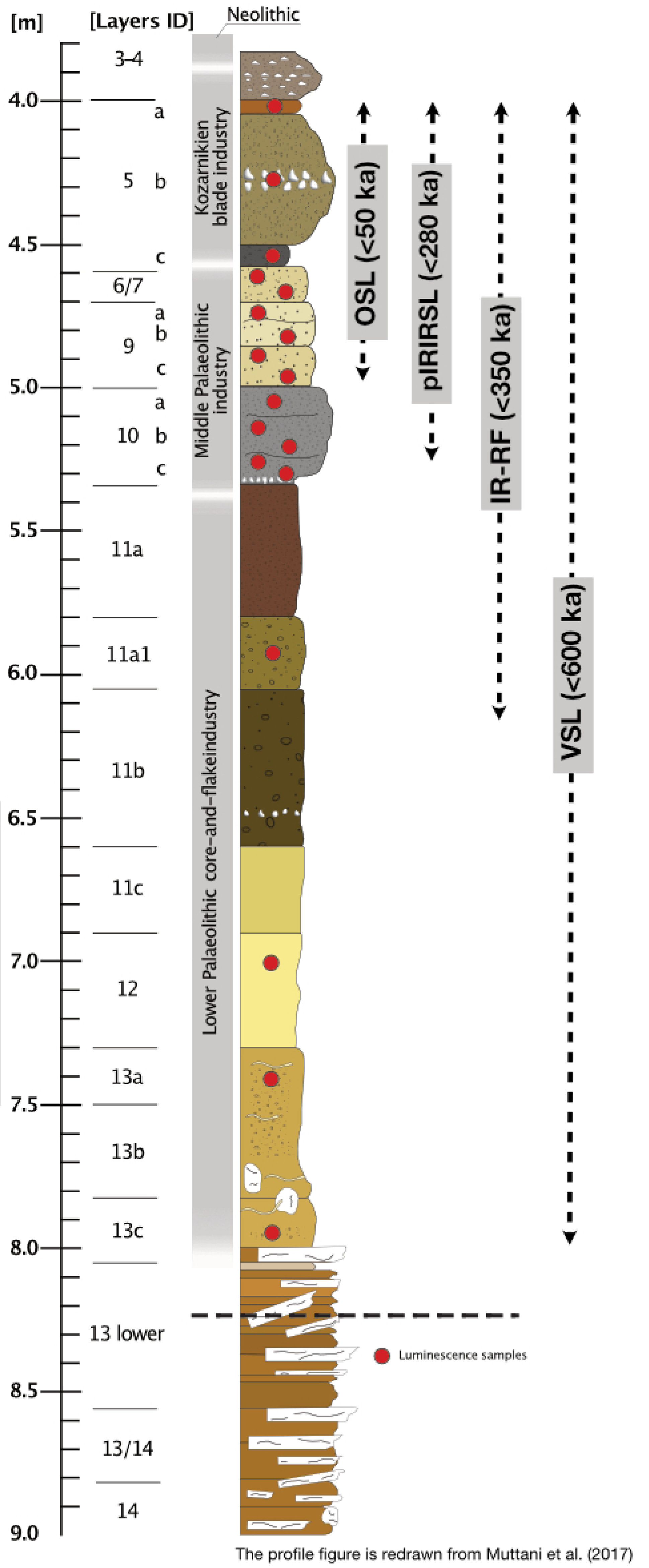
The equivalent ^{238}U concentration was determined from the top (pre-^{226}Ra) and the bottom of the chain U decay chain (post-^{226}Ra).
This allows us checking for potential disequilibria in the U chain for our samples.

2 *In-situ* gamma-dose rate



The *in situ* gamma-dose rate results are significantly lower compared to results obtained in the laboratory, due to the heterogeneous environment observed in the sediment layers. Hence, only the *in situ* results were used to estimate the ages.

4 Chronology



The profile figure is redrawn from Muttani et al. (2017)

5 Summary

- The luminescence-based chronology at Kozarnika's cave covers 30 to 600 ka
- The overall accordance between the OSL with the $pIR_{50}IRSL_{290}$ ages for the upper part of the sequence makes it likely that both signals were completely bleached before mineral deposition.
- Muttoni et al. (2017) [6] assigned the Brunhes–Matuyama reversal (780 ka) to the layer beneath 13c using Palaeomagnetic dating. VSL in combination with MAAD protocol resulted in ages consistent with the Brunhes–Matuyama reversal.
- The independent age available for layer 13a-c (with the range of 600-750 ka) also might indicate that the IR-RF ages represent the minimum age for the layers.

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