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Thermal history modelling of the western margin of the Bohemian Massif using high-resolution apatite fission-track thermochronology

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The KTB deep borehole and the Naab are located on the western margin of the Bohemian Massif (BM), the largest exposure of Variscan basement in Central Europe (Figure 1). The KTB and the Naab area present contrasting fission-track signatures. The apatite ages of 50 to 70 Ma in the upper KTB section are interpreted as dating a single geological event, its Late-Cretaceous to Palaeocene exhumation (Wagner et al., 1994; Wauschkuhn et al., 2015). No older tracks survive and those formed later experienced no significant thermal effect on their fission-track ages. The track-length distributions are unimodal, with mean lengths of ~12-14 µm. The apatite fission-track ages of the Naab basement are older, ranging from 120 to 200 Ma (Vercoutere, 1994). The track length distributions range from unimodal, over skewed and mixed to bimodal, with mean lengths of ~11-13 µm. The Naab apatites contain two distinct track populations. The older, predating the Late Cretaceous to Palaeocene exhumation, experienced higher temperatures than the younger, formed after exhumation, which accounts for the higher ages and shorter lengths (Figure 2). In the Naab and the KTB, however, the confined-tracks are shorter than lab-based annealing models predict. Our methodological research suggests that the model predictions are inaccurate rather than the geological constraints (Jonckheere et al., 2017; Wauschkuhn et al., 2015).

Our project aims at a high-resolution reinvestigation of the Naab fission-track record using advanced methods. These include (a) ion irradiation to increase the number of confined tracks (Figure 3); (b) step-etching to establish the formation sequence of the tracks; (c) determining the specific zero-length for each sample by measuring induced track lengths; (d) measuring the track widths to calculate their individual effective etch times; (e) measuring the confined track lengths and orientations in reflected and transmitted light. We discuss the agreement and disagreement between the modelled thermal histories and the independent geological evidence, and the factors suspected of causing a mismatch. Figures 4 and 5 illustrate confined track data obtained after an initial etch step of 10 s in 5.5. M HNO_3.

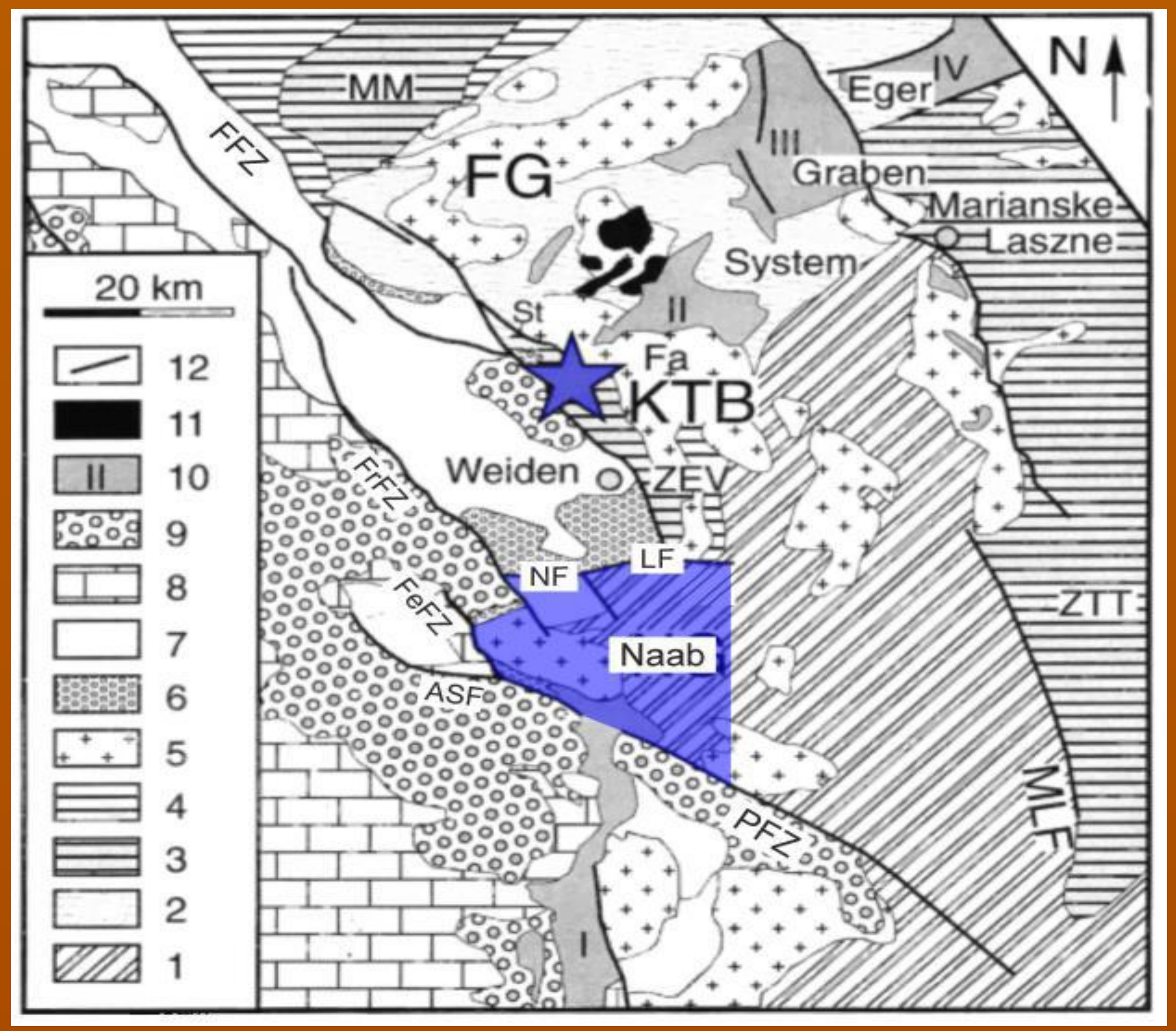


Figure 1. The western border of the Bohemian Massif with the KTB (deep continental drilling) and Naab areas. 1: Moldanubicum; 2: Saxothuringicum; 3: Zone Erbendorf Vohenstrauss (ZEV), Münchberg Massif (MM); 4: metamorphics; 5, granite; 6: Permo-Carboniferous; 7: Triassic; 8: Jurassic; 9: Upper Cretaceous; 10: Neogene sediments; 11: Neogene basalts; 12: faults. FFZ, Franconian Fault zone; LF, Luhe Fault; NF: Neudorf Fault; FrFZ: Freihung Fault zone; FeFZ: Fensterbach Fault zone; ASF: Amberg-Sulzbach Fault; PFZ: Pfahl Fault zone; MLF, Marianske Laszne Fault. After Wagner et al. (1997).

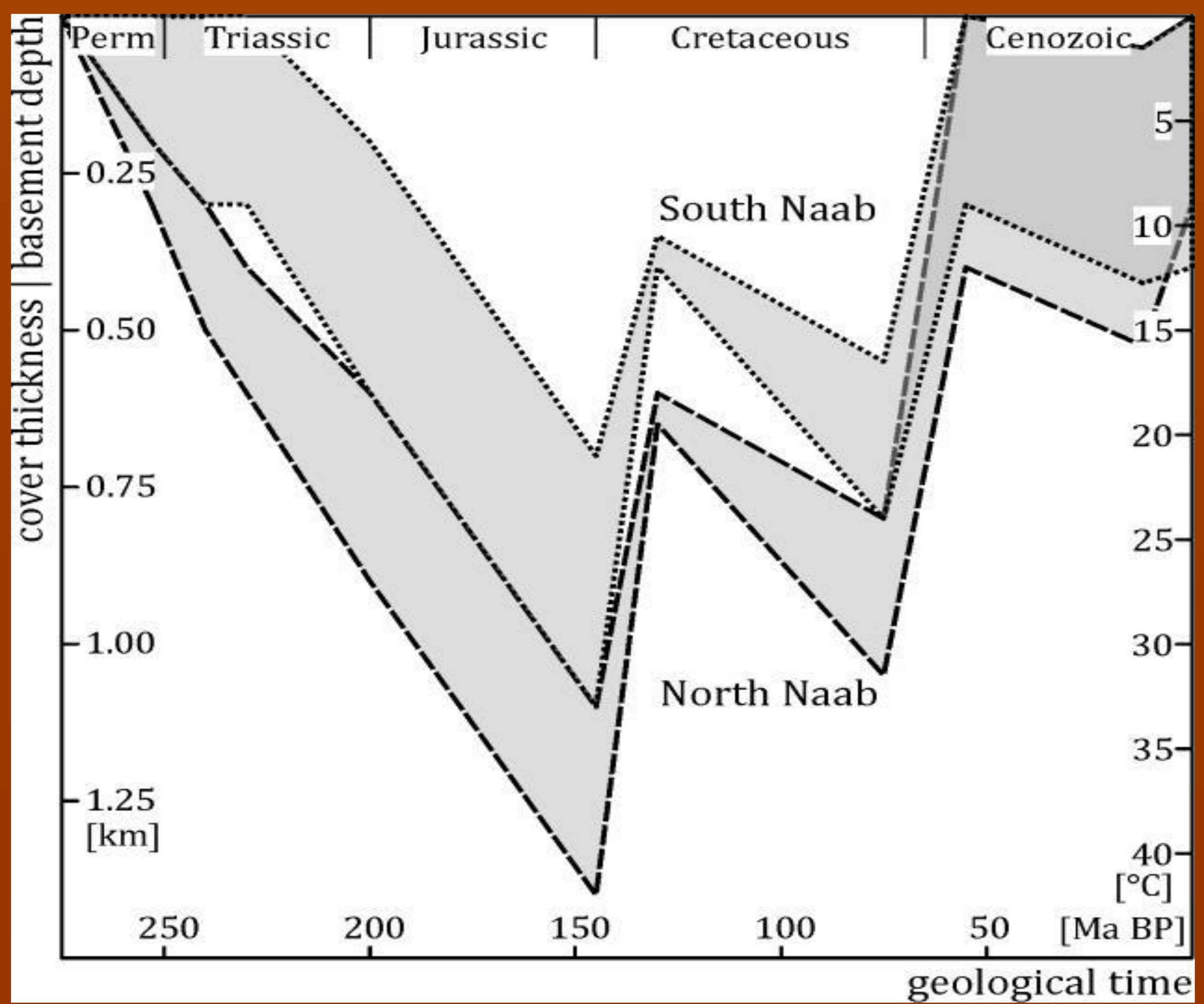


Figure 2. Sediment thickness above the north and south Naab basement from the middle Permian to the present. Assuming a constant geothermal gradient of 30°/km, no part of the post-Variscan erosion surface seems to have experienced temperatures above ~40 °C. Data from Vercoutere (1994).

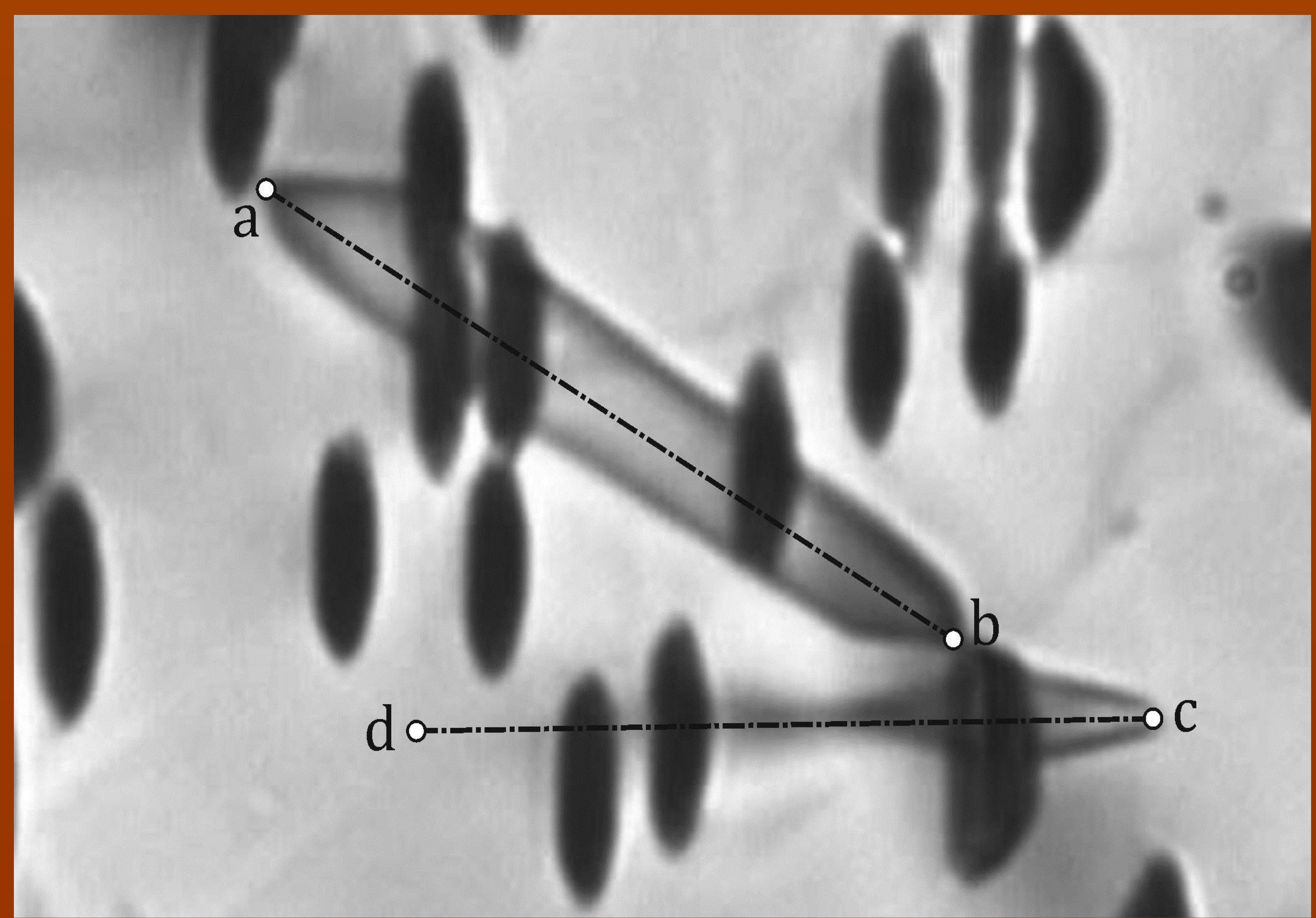
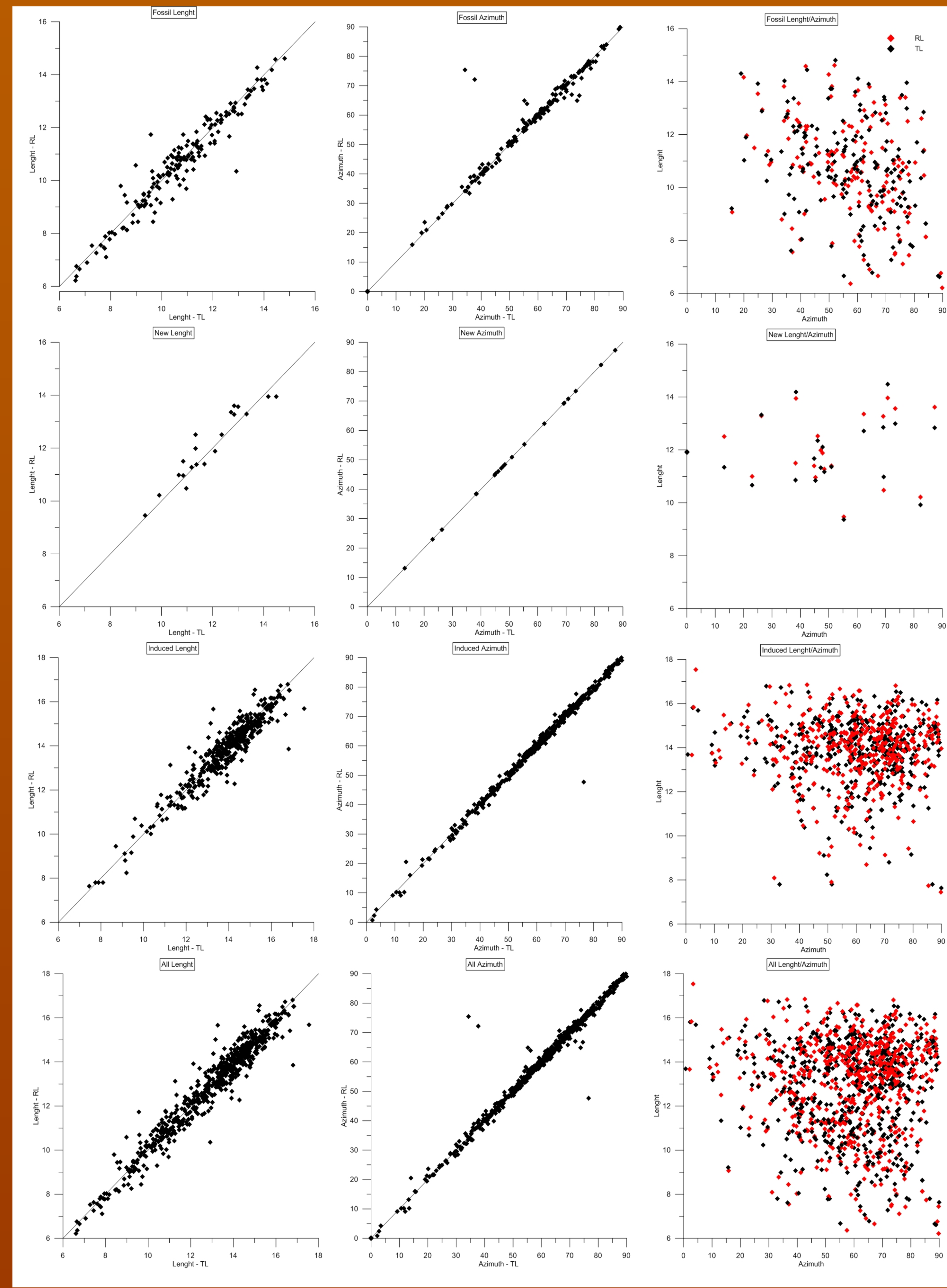


Figure 3. Etched horizontal (ab) and dipping (cd) confined fission tracks in an ion-irradiated apatite prism face. The etchant penetrates via the perpendicular ion tracks (dark elliptical features) into the confined fission tracks. The ***c***-axis runs from top to bottom.



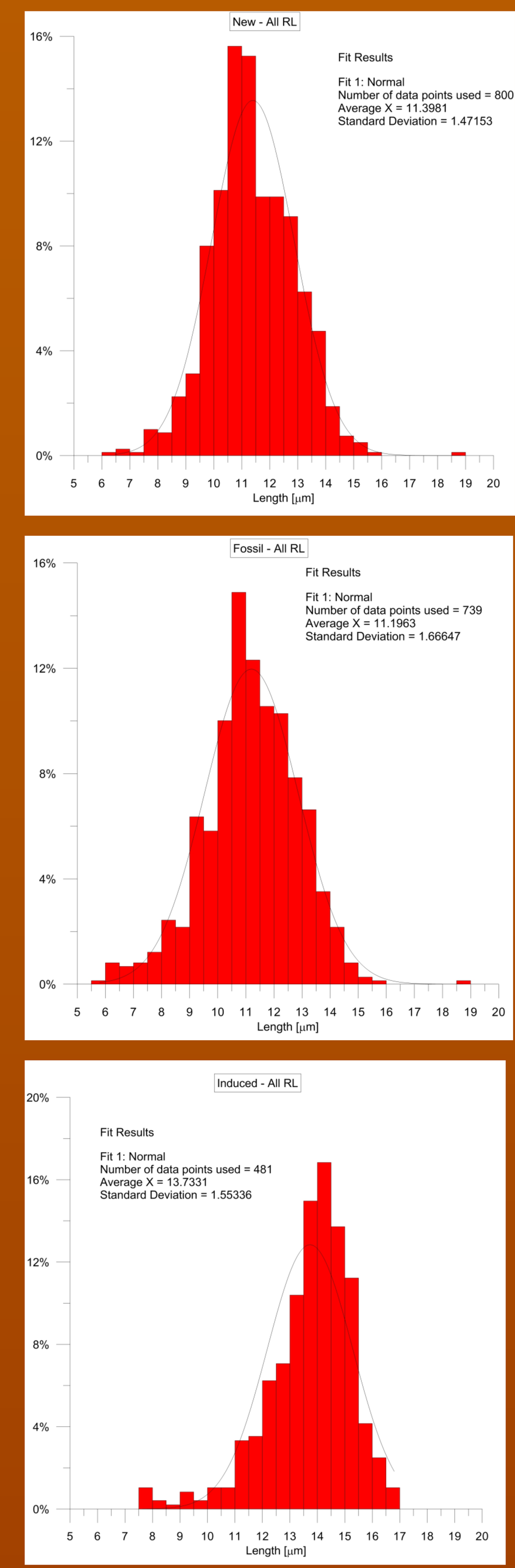


Figure 4. Confined track length distributions of fossil and induced fission tracks.

Figure 5. Length and angle to the ***c***-axis of fossil and induced confined tracks measured in reflected (RL) and transmitted (TL) light.

REFERENCES
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