

## **Miocene Clarkia Lake Deposit: Archive of Annual Climate Variability at 16 Ma**

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Laminated sediments from the Miocene Clarkia Lake deposit [1] offer an exceptional, high-resolution paleoenvironmental record from the middle Miocene Climate Optimum – the warmest phase of the entire Neogene. Absolute age and sedimentation rate of the deposit are demanding tasks, yet critical for paleoclimate interpretations.

Here we report the first absolute age of the Miocene Clarkia Lake deposit ( $15.85 \pm 0.03$  Ma, zircon U-Pb TIMS), using volcanic ash preserved in the lake sediment. This is in general agreement with previous tephrochronological works that correlated Clarkia Lake deposit with other volcanic activities in the area (15.85–15.5 Ma, [2], [3]), but with much improved precision. This result confirmed a middle Miocene age of the Clarkia Lake previously inferred from paleontological evidence, placing this deposit into the peak warming of the Miocene.

Laminated successions of organic-rich, dark, very fine-grained, and quartz-rich, light, coarse-grained layers usually represent annual deposition. Micro X-ray Fluorescence ( $\mu$ XRF) scanning of units from the varve sequence provided signatures of the elemental ratio distribution in the Clarkia Lake deposit. Spectral analysis of elemental ratios (Ti/Al, Zr/Rb) shows strong cyclicity between ca. 5 and 11 mm throughout the deposit. These cycles correlate with grain-size distributions and color changes. Since the exceptionally well-preserved leaf fossils found in the deposit require rapid sedimentation, we interpret these cycles as representing annual changes. Therefore, the total sedimentation of the Clarkia Lake deposit (~7.5 m) at the classic P-33 site amounts to approximately one thousand years.

[1] Smiley, Gray, & Huggins, *J. Paleontol.*, 1975, 833–844  
[2] Nash & Perkins, *PLoS One*, 2012, 1–13. [3] Ladderud et al., *Northwest Sci.*, 2015, 309-323.