Palaeosol Sedimentology and Geochemistry across Permo-Triassic Strata in NW China: Palaeoenvironment and Palaeoclimate Reconstruction through a Life Crisis

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Introduction:

The Permian-Triassic boundary (PTB) marks the largest extinction of the Phaenerozoic, yet despite this, a causal mechanism has not been firmly established. Proposed causes include: increased aridity concurrent with the consolidation of Pangaea; overturn of an anoxic ocean that resulted in rapid and catastrophic release of CO_2, CH_4, and H_2S; a bolide impact; and elevated atmospheric CO_2 and sulphate concentrations possibly associated with volcanic emissions from the Siberian Traps (see Berner, 2002). Furthermore, the demise of polar ice at the conclusion of the Late Palaeozoic Ice Age and the consolidation of Pangaea presumably altered atmospheric and oceanic circulation patterns, which likely led to increased ecosystem stress.

This project examines palaeoenvironment and palaeoclimate change across the Permian-Triassic boundary by means of a field and laboratory-based study of palaeosols from Late Permian to Early Triassic fluvio-lacustrine strata of the Turpan Basin, NW China. The Turpan Basin has been placed in the mid-latitudes in palaeogeographic reconstructions, and because few data have been presented in the literature regarding palaeoclimate for this region, temperature and precipitation reconstructions from this area will enhance our understanding of the mid-latitude response to assumed major global warming across the PTB and refine global circulation models.

Research Plan:

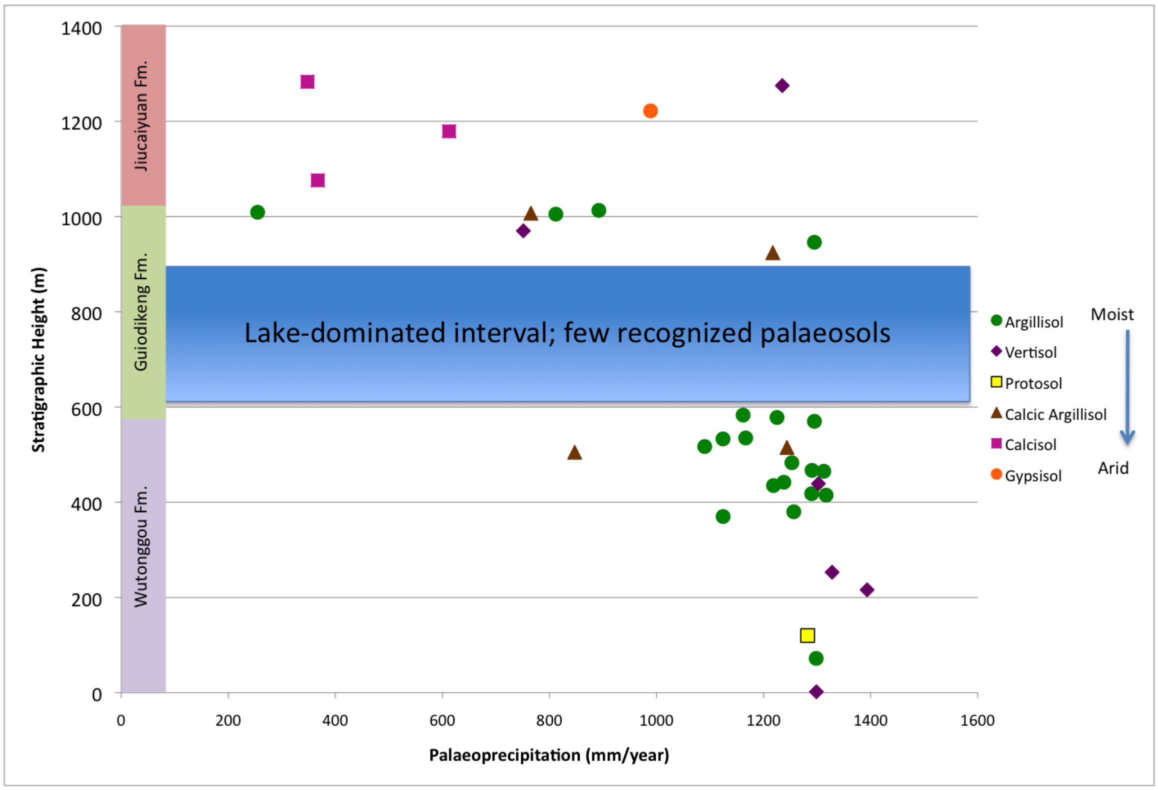
This study examines terrestrial paleoenvironmental changes and paleoclimate using palaeosols to address whether the distribution of palaeosol morphologies across the Permian-Triassic boundary (PTB) reflect changes in climate rather than catenary relationships, and to provide a quantitative estimate for precipitation during the Late Permian and Early Triassic.

Results:

Field identification of palaeosols in three formations (Wutonggou, Guiodikeng, and Jiucaiyuan Fms. has demonstrated stratigraphic variations in soil morphological features that are interpreted to reflect changes in soil moisture regime. In the Late Permian Wutonggou Fm, palaeosol features include intense redoximorphy, accumulation of vascular plant organic matter, and subsurface enrichment of layer-lattice phyllosilicates and Fe-oxides, indicative of perennially wet soil moisture regimes and slickensides, clastic dikes, and redoximorphic accumulations of Fe-oxides, indicating a humid environment, but with distinct seasonal variations in soil moisture budget. In the Guiodikeng fm, palaeosol features include accumulations of clay and carbonate and organic matter, indicative of sub-humid to sub-arid soil moisture and transitory soil moisture regimes. In the Jiucaiyuan fm, features include calcium carbonate accumulations and gypsum pseudomorphs, indicating drier environments characterized by net soil moisture deficiency. Although palaeosol morphologies varied across the palaeo-landscape, the distinct trend towards drier type palaeosols in uppermost Permian and lower Triassic strata is recognized at multiple sections and cannot be resolved by catenary position alone.

X-ray fluorescence of palaeosol material was used to obtain elemental values for palaeoprecipitation reconstruction as demonstrated by Sheldon et al. (2002). In general, palaeoprecipitation derived from CIA-K indices corroborates the observed transition from relatively wet soil moisture conditions to relatively arid conditions (Fig. 1). Data from palaeosol horizons with soil structure and/or lattice-layer clay accumulations indicate a general decrease in precipitation over >1000 m of section.

Precipitation during Wutonggou deposition appears to have been relatively stable, ranging from 1300 mm/year within the lowermost Wutonggou fm to as low as 300 mm/year in the Guiodikeng fm. Data from soil horizons bearing calcium carbonate and gypsum pseudomorphs from the Lower Triassic Jiucaiyuan fm indicate precipitation ranging from 350 to 1200 mm/yr. The observed variations in palaeo-precipitation through the section may be related to changes in soil formation: CIA-K offers a time-averaged approach, and upper Guiodikeng and Jiucaiyuan palaeosols could include palaeosols that formed over a wide range of durations relative to those found in the Wutonggou. However, this transition to precipitation instability coincides with the Permian-Triassic event, and could reflect climatic disturbances associated with the end-Permian extinction event.



REFERENCES

Berner, R.A., 2002, Examination of hypotheses for the Permo-Triassic boundary extinction by carbon cycle modeling, *PNAS* 99: 4172-4177.

Sheldon, N.D., G.J. Retallack, & S. Tanaka, 2002, Geochemical climofunctions from North American soils and application to paleosols across the Eocene-Oligocene Boundary in Oregon, J. Geol. 110: 687-696.