PALEOSOLS AS PROXY CLIMATIC CHANGE INDICATORS IN CENTRAL NORTH DAKOTA

Deborah L. Beck*[1] and Joseph H. Hartman[2]
[1]Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, ND 58202-8358
[2]Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND 58202-9018

The utility of paleosols as paleoclimate indicators has been recognized by many studies, including those that have focused on paleosols in the central Great Plains (1) and in löess paleosol sequences of China (2). In North Dakota, paleosols of the Oahe Formation have been studied for archeological (3) and stratigraphic significance (4), but paleoclimatic interpretations have been based only on meager evidence. In contrast, the Douglas Creek Locality of McLean County, North Dakota, with its multiple stacked paleosol sequence, may permit the interpretation of subtle changes in climate during a significant portion of the Holocene.

The Douglas Creek section, exposed on the north shore of Lake Sakakawea, consists of 15 buried A horizons. Textural and biogenic differences between individual soil horizons at this locality are being used to reveal small-scale environmental changes. The combined results of textural, radiocarbon, stable carbon, palynomorph, and phytolith analyses will permit reconstruction of the environmental history of the section.

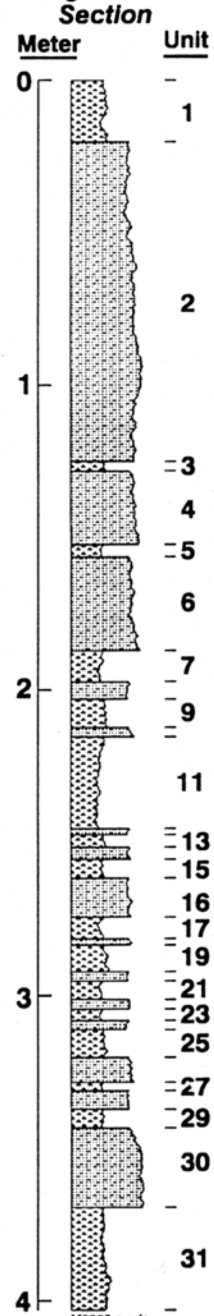
The Douglas Creek location is in a shallow valley fill that extends east–west a distance of 51.5 m. The Holocene section is up to 4 m thick. The buried soils consist of 15 sets of A and C horizons. Figure 1, a vertical section of the valley fill near its western edge, illustrates 15 sets of A and C horizons. Units 1 and 2 are modern A and C horizons, respectively. The odd-numbered units from 3 to 31 are Ab horizons. The intervening units represent Cb horizons. The average thickness of the Ab horizons is 5 cm, with a range of 2 to 34 cm. The Cb horizons are generally thicker than the Ab horizons, averaging 10 cm and ranging from 3 to 32 cm. Each Ab horizon is characterized by humus, lignite fragments, and its brown color (10YR 5/3). Cb horizons are free of organic material, olive in color (5Y 5/3), and, in many cases, have ribbons of carbonate. The grain size of the Ab horizons consists of clay ranging from 4% to 37% ($\bar{x}$ = 23.5%); silt ranging from 44% to 71% ($\bar{x}$ = 59.6%); and sand ranging from 6% to 30% ($\bar{x}$ = 17%). The ranges and means of grain size in Cb horizons are as follows: clay, 17% – 33% ($\bar{x}$ = 27%), silt from 47% to 60% ($\bar{x}$ = 54%), and sand from 8% to 26% ($\bar{x}$ = 19%). Comparison of Ab and C horizons reveals that silt is more abundant in A horizons and clay is more abundant in C horizons.

The radiocarbon dating of the paleosols conducted so far is promising. Three radiocarbon dates have been obtained. Bone samples from Units 7 and 11 were dated at 2090 ± 520 years and 3510 ± 295 years, respectively. Charcoal from Unit 17 was dated at 3800 years ± 45 years. Bone collected from Units 5, 9, and 11 as well as charcoal from Units 9, 21, 23, and 31 are expected to provide additional dates. Distinguishing between charcoal and Paleocene lignite clasts has been problematic. Fourier transform infrared analysis (FT-IR) of samples proved ineffective. Best results were obtained using luminescent petrographic analysis.

Preliminary $\delta^{13}C$ values range from −19.59 to −23.69 ($\bar{x}$ = −22.25). These values indicate that C_3 vegetation dominated the landscape during formation of most of the paleosols. Values from −19.59 to −21.94 in the uppermost buried soils suggests C_4 vegetation may have been present in the latter part of the formation of the section. Plants with C_4 metabolism (warm-season grasses) have the ability to efficiently concentrate CO_2 and thus are more productive under conditions of low atmospheric CO_2. C_3 metabolizing vegetation (trees, most shrubs, and cool-season grasses) fix O_2 at the expense of CO_2 under conditions of high temperature or low atmospheric CO_2.

Compilation of the current results leads to the hypothesis that the presence of the 15 Ab horizons is a result of long periods of stability during which pedogenesis was possible, followed by shorter periods of instability. These changes can be explained by small-scale climate changes at the site. The forthcoming results of the radiocarbon, $\delta^{13}C$, phytolith, and pollen analyses will be combined with the above results to test this hypothesis and interpret the scale of climate fluctuations.

Figure 1
Douglas Creek Section



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