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Mineralogical Analysis of Aeolian Dune Deposits, White River Badlands, South Dakota

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Abstract

The goal of this study is to test our hypothesis that sand dunes in the White River Badlands (WRB), South Dakota, northern Great Plains, formed during one or more prolonged prehistoric drought events. WRB dune fields are located on tablelands north of the White River in southwestern South Dakota. These parabolic dunes have maximum relief of 30 m and open to the northwest, consistent with the dominant wind direction for the region. Currently, dunes are stabilized by a drought-adapted, mixed grass prairie community.

Sand dunes form when 1) prolonged drought kills prairie vegetation, allowing wind to erode and transport sediment, forming sand dunes, or 2) local stream sediment supplies increase, causing dune formation in nondrought conditions. These scenarios can be distinguished based on quantitative and qualitative comparisons of dune and stream sand compositions. If mineralogical composition of WRB dune sand is equivalent to compositions of White River sand, then the origin of the dunes is related to increased sand supply, not regional drought.

In the summers of 2015 and 2016, investigators collected representative samples from the WRB dunes and the White River channel. Here investigators analyze the compositions using two methodologies. First, using a petrographic microscope, investigators identify 200 randomly chosen grains in thin section from each sample to produce a statistically valid modal composition based on quartz, feldspar, and rock fragment content.

Second, using the point counting methodology, a random grid was superimposed on the point counting methodology and how the different grains were classified. The software advanced a pointer (Figure 5) through the grid. At each selection, the investigator identified the grain composition as either 1) clear (quartz or feldspar), 2) colored (accessory minerals), or 3) opaque grains (rock fragments). After each identification, the pointer was advanced until 200 points were identified. The results are plotted in Figure 5.

Introduction

Sand dune activity is a sensitive indicator of climate change. When plant communities die during droughts wind erodes soils and creates sand dunes. During periods of greater moisture, soils are again stabilized by vegetation and dunes become inactive (Figure 3). Because dunes in our field area in the northern Great Plains are stabilized by drought tolerant plant communities, sand dunes are only active during especially severe and prolonged droughts. Alternatively, the dunes may become active during increased sand supply in local rivers, in this case the White River.

To determine the source of the sand in the dunes, we have analyzed the mineralogical composition of sands from dunes and nearby rivers. A strong northwest seasonal wind and the shape of the dunes suggest that the source of the sand may be the Cheyenne River valley north of the field area. Alternatively, the southern end of the White River borders the dune fields to the south, making it another possible source of aeolian sediment. Because the Cheyenne River and the White River drain regions with distinctly different rock types, we predicted that the composition of the sand would be an indicator of the source.

Hypothesis: If mineralogical composition of WRB dune sand is equivalent to compositions of White River sand, then the origin of the dunes is related to increased sand supply, not regional drought.

Conclusions

Results of our experiments indicate dune sand compositions are neither equivalent to White River nor Cheyenne River sand. However, it is possible that the dune sands came from the rivers but was mechanically and chemically weathered, reducing rock fragments and enriching quartz and feldspar. We expect that with wind transport of river sediment that rock fragments will decrease and the relative composition of clear grains will increase. This suggests that either the White River or the Cheyenne River sand could be a source with compositional differences between river and dune sands due to distance of transport and weathering of sand (Figure 8).

While, no definitive match was made either with the qualitative comparison or quantitative studies, the weight of evidence including the shape of the sand dunes and the modal compositions similarity to the Cheyenne River favor a drought activation of the dunes. Further research is needed to identify unique compositional differences that would uniquely determine the source of the WRB dunes.

Results

Five samples were collected from the field area (Figure 7), which included a sample from the Cheyenne River, White River, and three samples from the sand dunes. The samples were washed to remove silt or clay. Thin sections were made from these five samples. Each of the thin sections were polished to 30 microns thickness. The thin sections were scanned to produce a digital image. Digital analysis software used was to determine the mineralogical composition of each sample. For the point counting methodology, a random grid was superimposed on the image. The software advanced a pointer (Figure 5) through the grid. At each selection, the investigator identified the grain composition as either 1) clear (quartz or feldspar), 2) colored (accessory minerals), and 3) opaque grains (rock fragments). After each identification, the pointer was advanced until 200 points were identified. The results are plotted in Figure 5.

Materials and Methods

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References


