Initiation of Late-Paleogene Wind-Transported Loess in the Western USA

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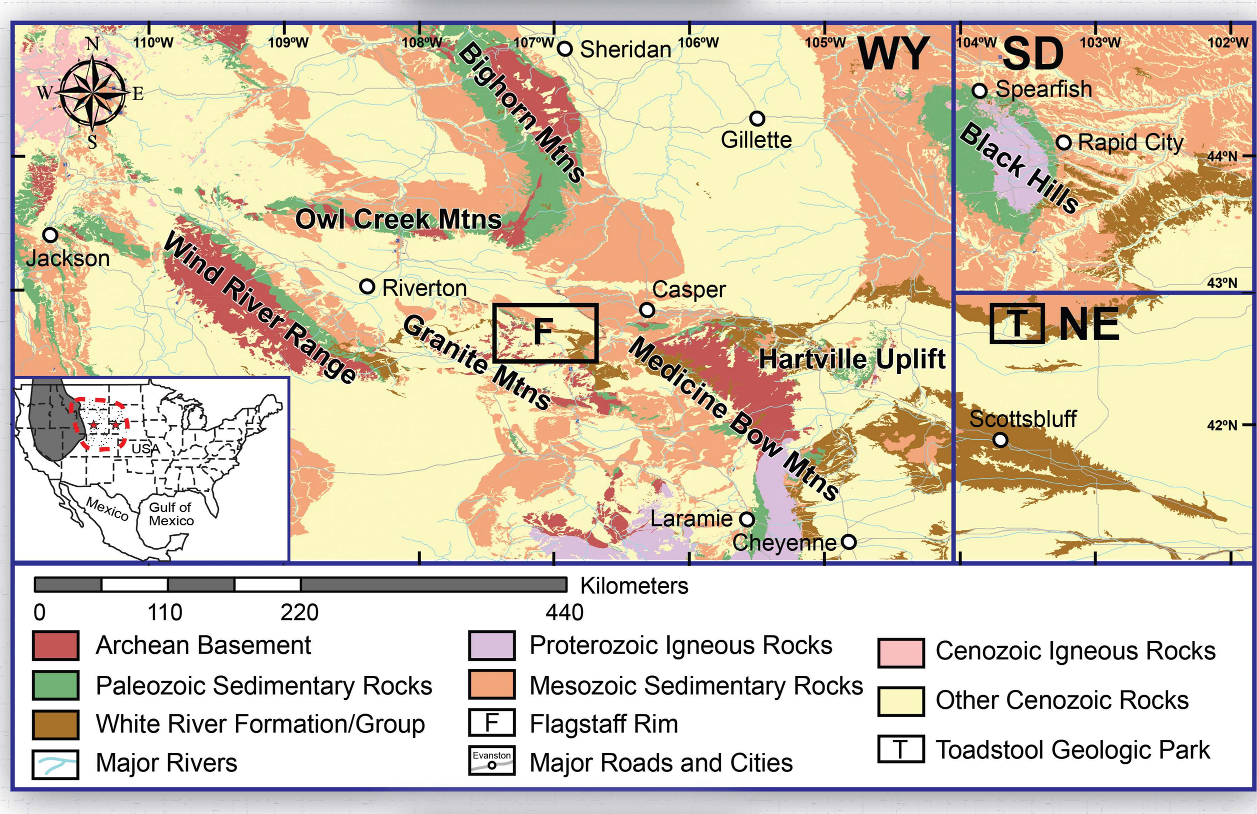
Introduction

The causes and timing of the late Paleogene loess in the western USA remain enigmatic.

❖ The causes of loess deposition are controversial, which have been previously attributed to the aridification caused by tectonic uplift (An et al., 2001), land-sea redistribution (Ramstein et al., 1997), global cooling (Dupont-Nivet et al., 2007), and/or intensified river erosion in wet climate condition (Nie et al., 2018).

❖ Late Paleogene loess have been previously reported in the western USA (e.g., Evanoff et al., 1992; Fan et al., 2020). In the four study sites examined by Fan et al. (2020), the transition from fluvial to loess deposition seems to be abrupt based on the changes of rock types (stratified to massive) and related depositional environment. However, aeolian processes may have started earlier than the change of rock types, in particular, wind-transported sediments may have been incorporated into fluvial settings or reworked by rivers.

Study Area



Hypothesis

I hypothesize that eolian-transported grains emerged before the apparent rock-type changes in the Flagstaff Rim in Wyoming and Toadstool Geologic Park in Nebraska, and thus the transition from fluvial deposition to eolian deposition was gradual rather than abrupt.

Methods

Sedimentology/Stratigraphy

Field observation → Lithofacies analysis → Depositional environment

Minerology analysis

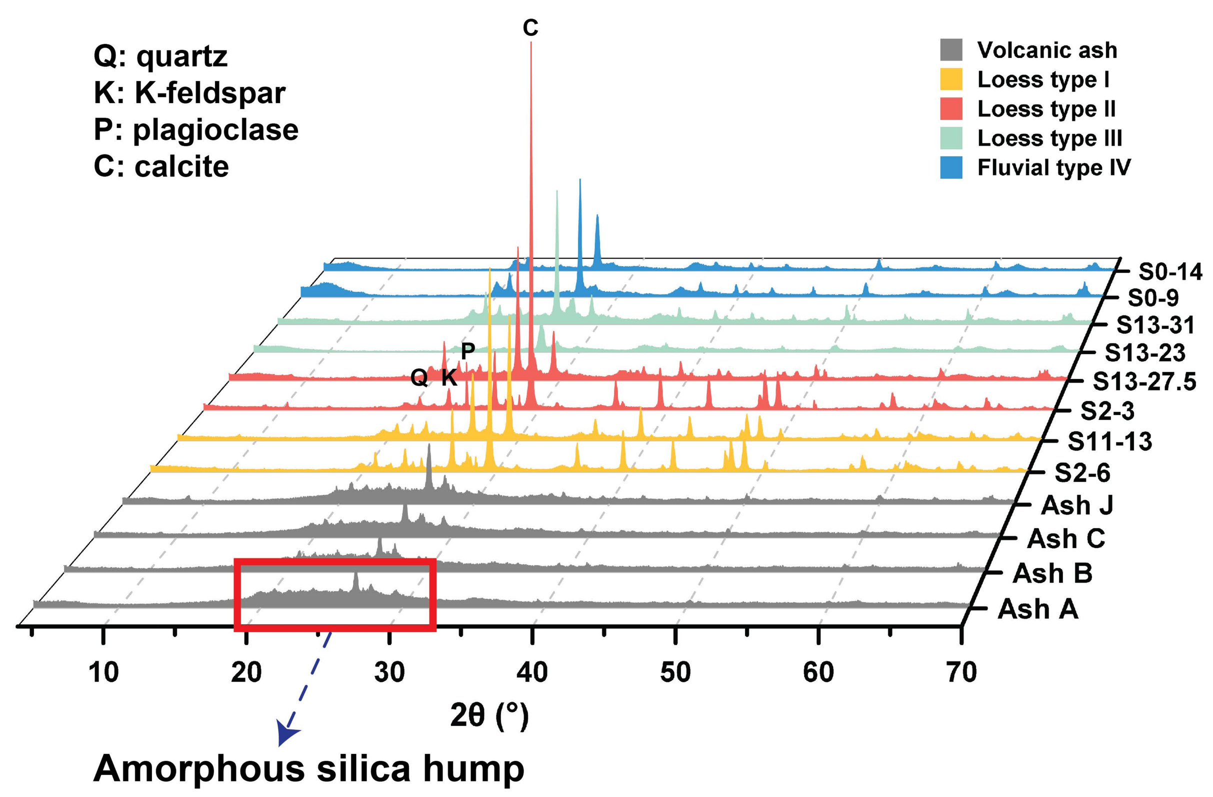
Minerology	XRD data classification
Relative abundance of Quartz, K-feldspar, Plagioclase, and Calcite	XRD pattern comparison Dimension reduction by MDS

Grain size analysis

Grain size patterns	Grain size parameters
Bimodal (Eolian) Unimodal & Multimodal (Fluvial)	Mean grain size U-ratio(16–44 μm/5.5–16 μm) Sorting (standard deviation)

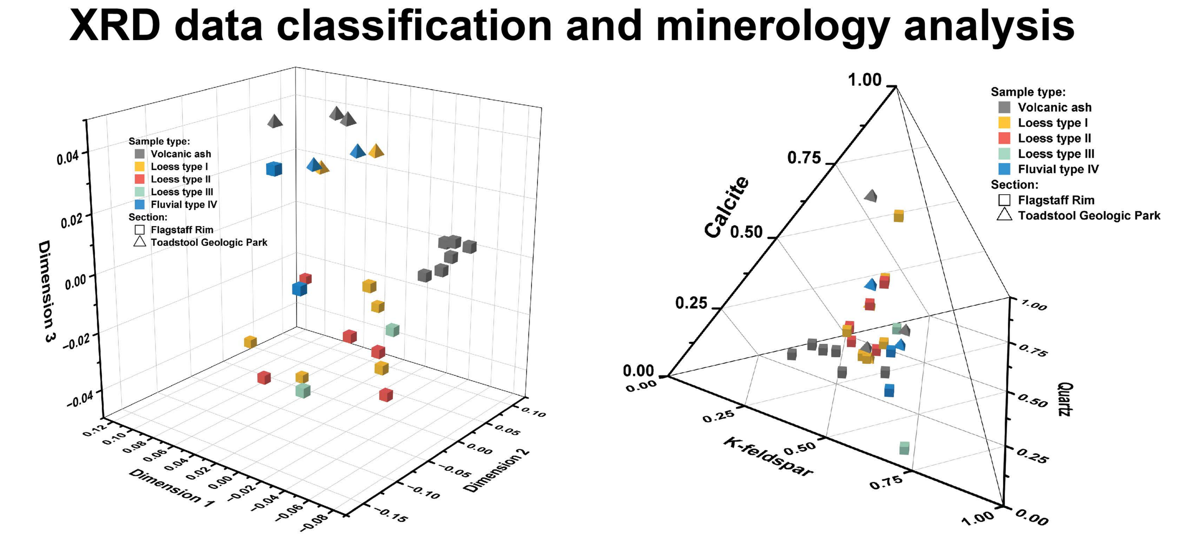
Minerology Analysis

XRD patterns

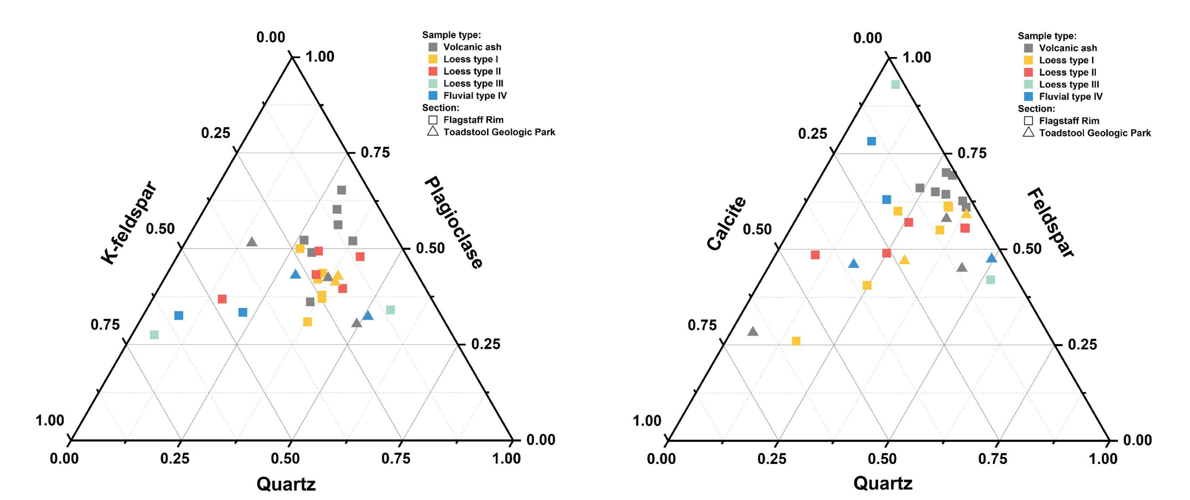


The X-ray diffraction (XRD) patterns of the four ash samples are similar to each other, but differ from the patterns of the loess and fluvial samples. The ash samples all show pronounced amorphous silica humps, reflecting abundant volcanic glass in the ashes.

XRD data classification and minerology analysis



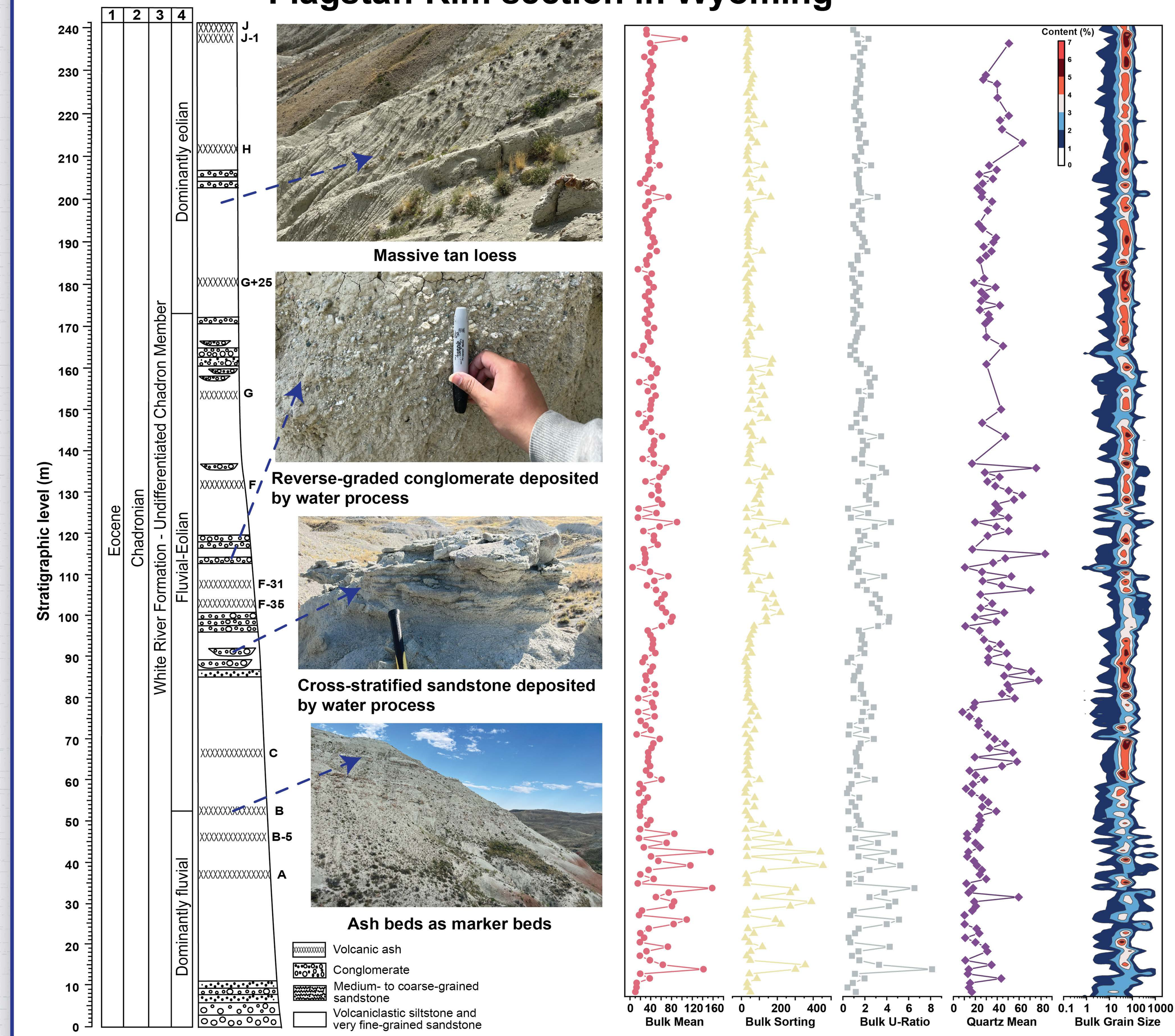
Ash samples are clustered by section and are noticeably different from loess and fluvial samples.



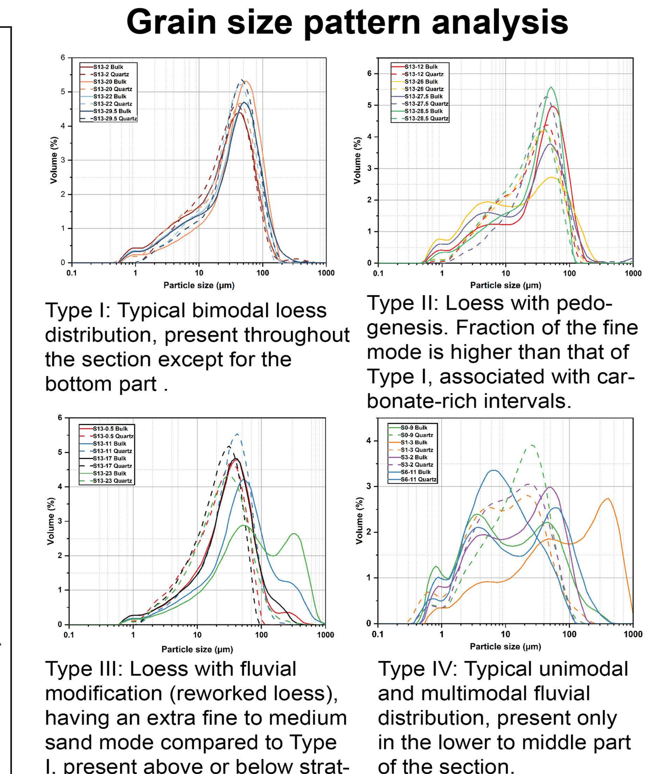
Ash samples have lower quartz and calcite content, but higher feldspar content, primarily plagioclase, than the loess and fluvial samples. Some ashes were recycled into the loess and fluvial deposits.

Grain Size Analysis

Flagstaff Rim section in Wyoming



Grain size pattern analysis



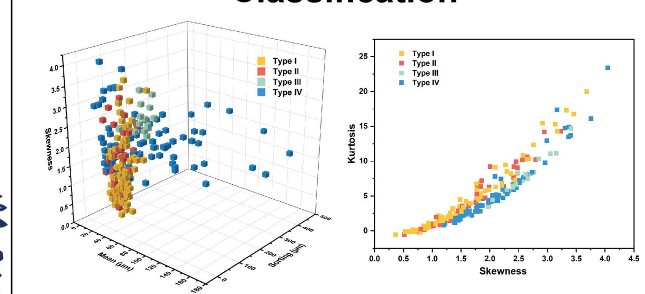
Type I: Typical bimodal loess distribution, present throughout the section except for the bottom part.

Type II: Loess with pedogenesis. Fraction of the fine mode is higher than that of Type I, associated with carbonate-rich intervals.

Type III: Loess with fluvial modification (reworked loess), having an extra fine to medium sand mode compared to Type I, present above or below stratified sandstone and conglomerate.

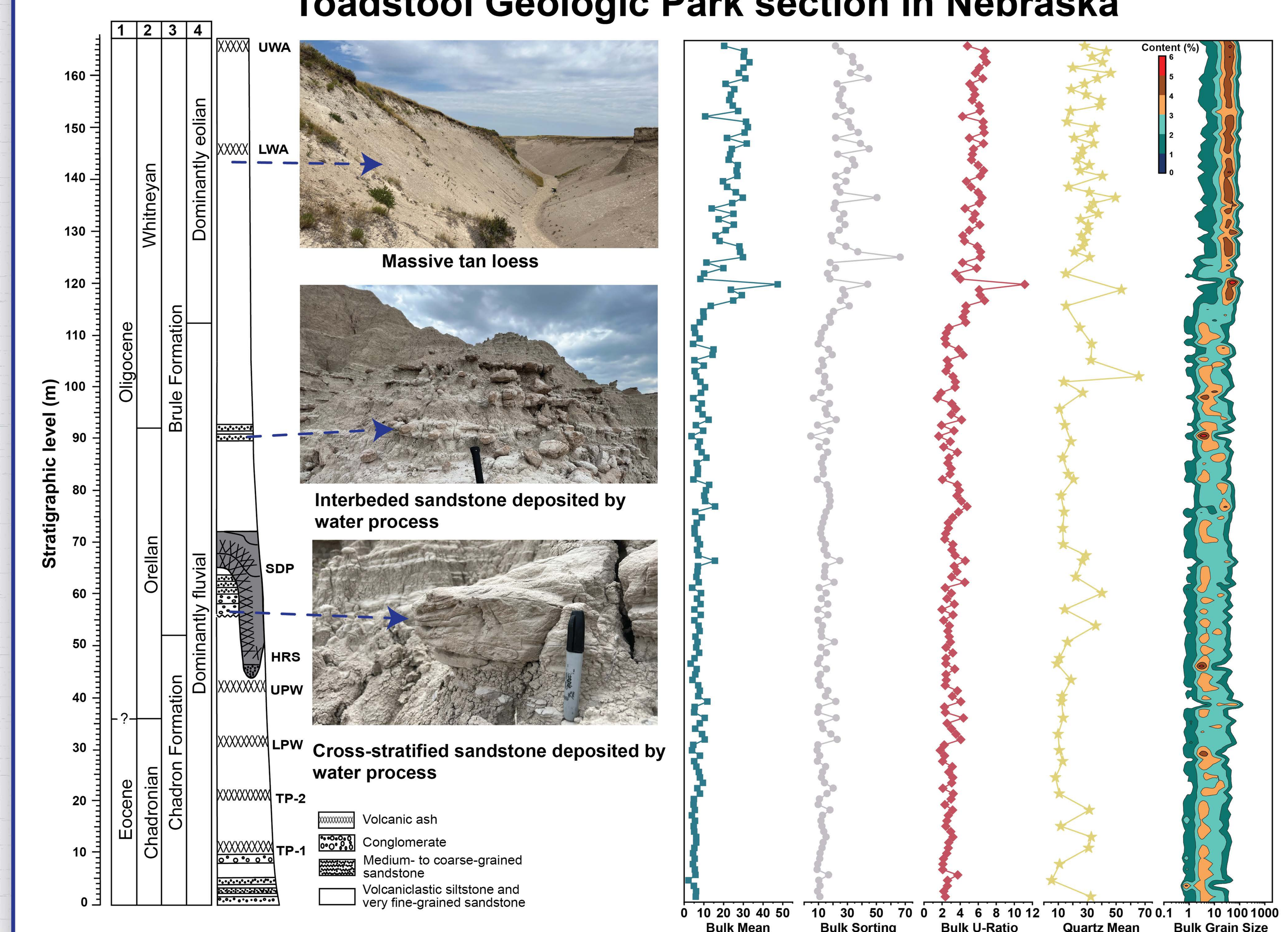
Type IV: Typical unimodal and multimodal fluvial distribution, present only in the lower to middle part of the section.

Classification

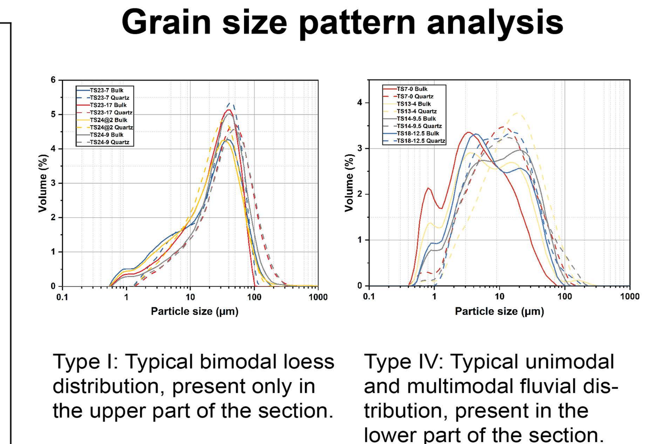


The grain size parameters of the fluvial sediments differ from those of loess or reworked loess; however, loess, reworked loess, and loess with pedogenesis have similar parameters.

Toadstool Geologic Park section in Nebraska



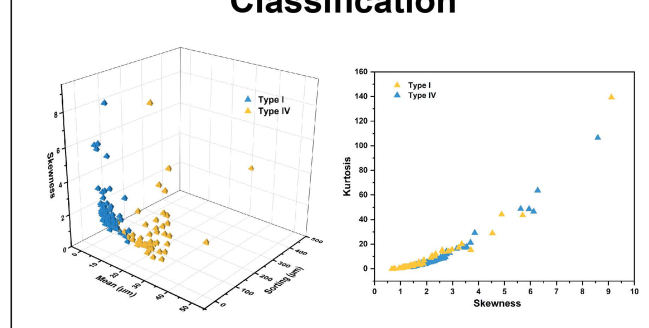
Grain size pattern analysis



Type I: Typical bimodal loess distribution, present only in the upper part of the section.

Type IV: Typical unimodal and multimodal fluvial distribution, present in the lower part of the section.

Classification



Type I and Type IV samples are clustered separately.

Conclusions

❖ Ash and loess samples differ in mineral composition, with ash being a partial source for loess and fluvial deposits.

❖ Based on the existing chronology, the eolian deposition at the Flagstaff Rim section initiated at ~36 Ma, 2 Myr earlier than previously thought. This initiation was synchronous with that in the Wagon Spring section to the west, suggesting a more extensive loess deposition in the western USA at ~36 Ma.

❖ Uplift in the western USA may have triggered aridification in the sediment source, yielding enhanced erosion and loose sediments for wind transport.

References

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