Identification of Loess from Fluvial Deposits at Flagstaff Rim, Wyoming by Machine Learning

Mary Ann Moody[1], Xiangwei Guo[1], Yike Shen[1], Majie Fan[1]

[1] Earth and Environmetnal Scienes Department, University of Texas at Arlington

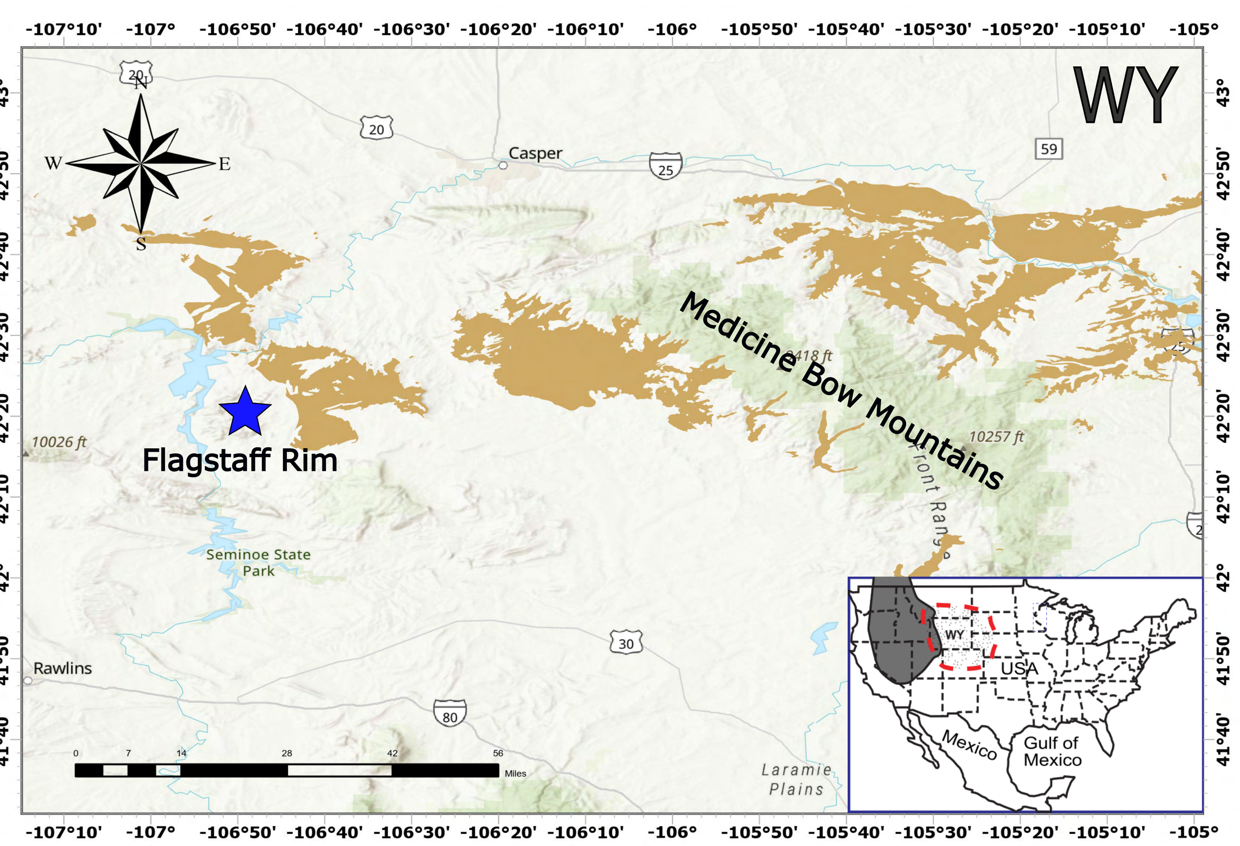
THE UNIVERSITY OF TEXAS AT ARLINGTON

Introduction

The deposition of the North American Loess Plateau during the late-Paleogene was interpreted to have initiated abruptly in response change to the surrounding climate. However, this change could have been more gradual and earlier than previously thought. (Fan et. al, 2020)

Sediment grain size distributions of wind-transported loess and river-transported sediments are different, this have been used as a tool to differentiate the two deposition environments. Such data were visually inspected to identify and group different patterns. Here we apply unsupervised machine learning algorithms to sediment grain size distributions collected from the uppermost Eocene-lower Oligocene at Flagstaff Rim Wyoming to assist identification and grouping of patterns.

Study Area



White River Formation

Study Area

Methods

Dimension Reduction: The process of taking a high dimensional dataset and reducing the components and complexity so the dataset may be more easily analyzed and visualized.

PCA: Principle Component Analysis is a method for reducing the dimensions of linear data

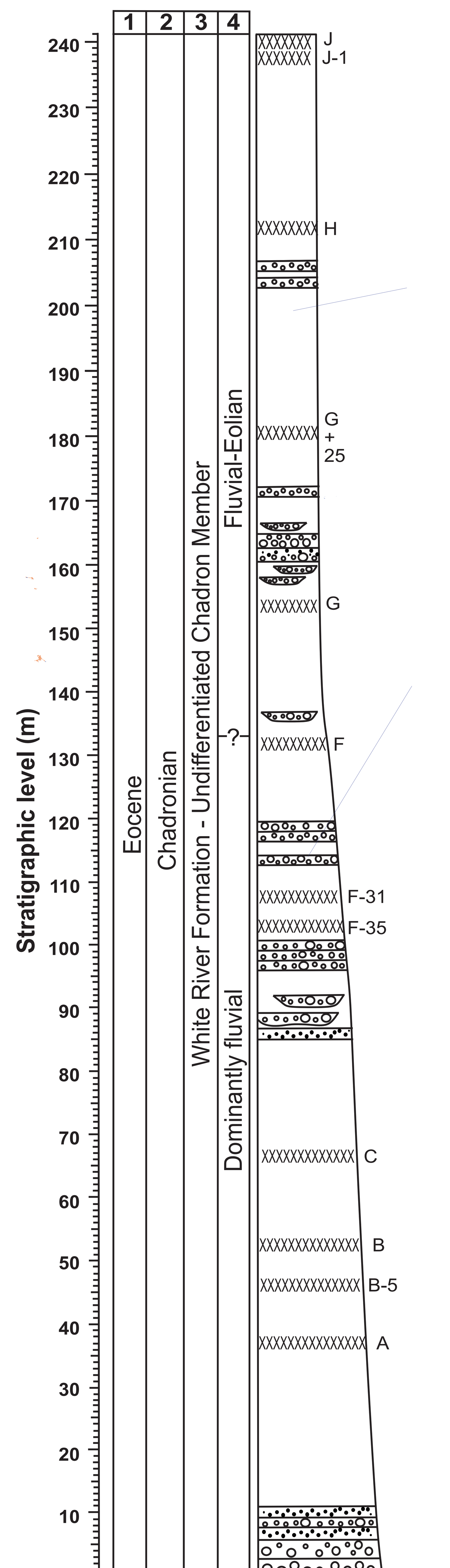
T-SNE: T-distributed Stochastic Neighbor Embedding reduces the dimensionality of the data while preserving groupings of similar points and seperating those that are not.

Clustering Analysis: Determination of naturally occuring similar groups that occur within the data.

K-Means Clustering: A clustering method that attempts to group similar items togeher by minimizing their euclidian distances.

Spectral Clustering: A clustering based on the relationships of the different features in high dimensional space.

Stratigraphy



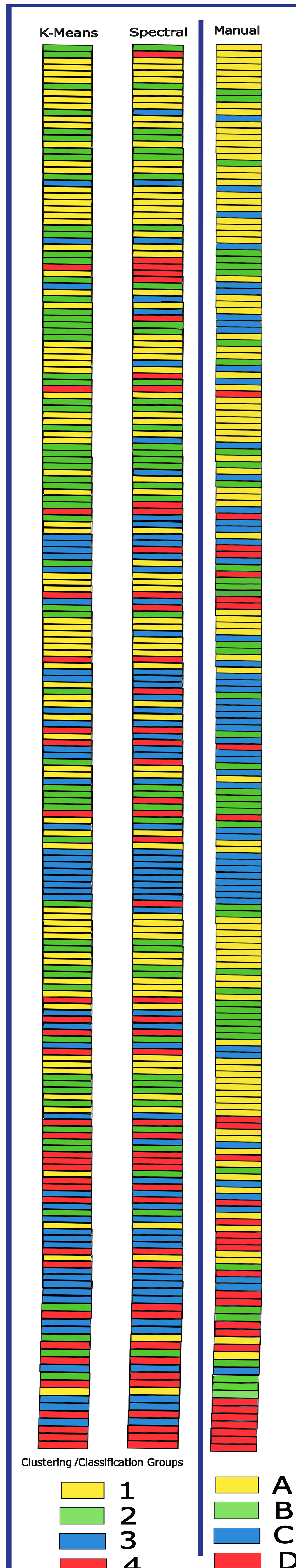
Volcanic ash

Conglomerate

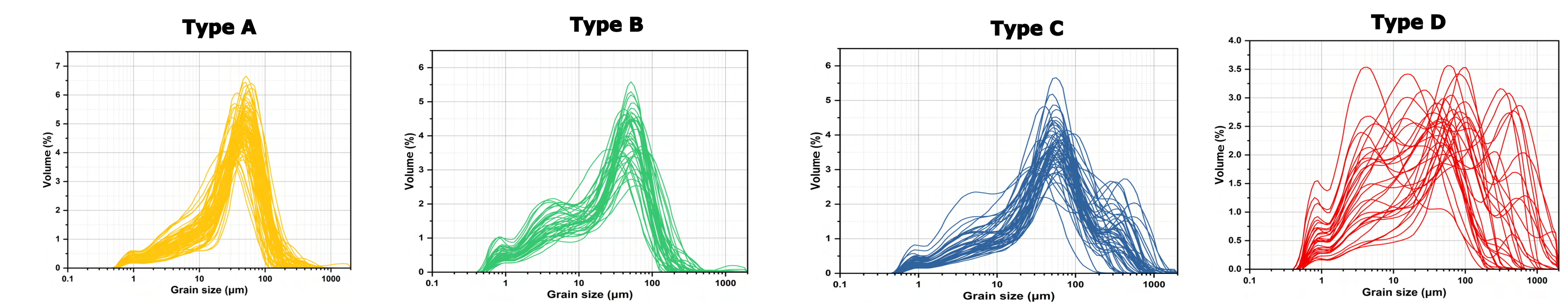
Medium- to coarse-grained sandstone

Volcaniclastic siltstone and very fine-grained sandstone

Results

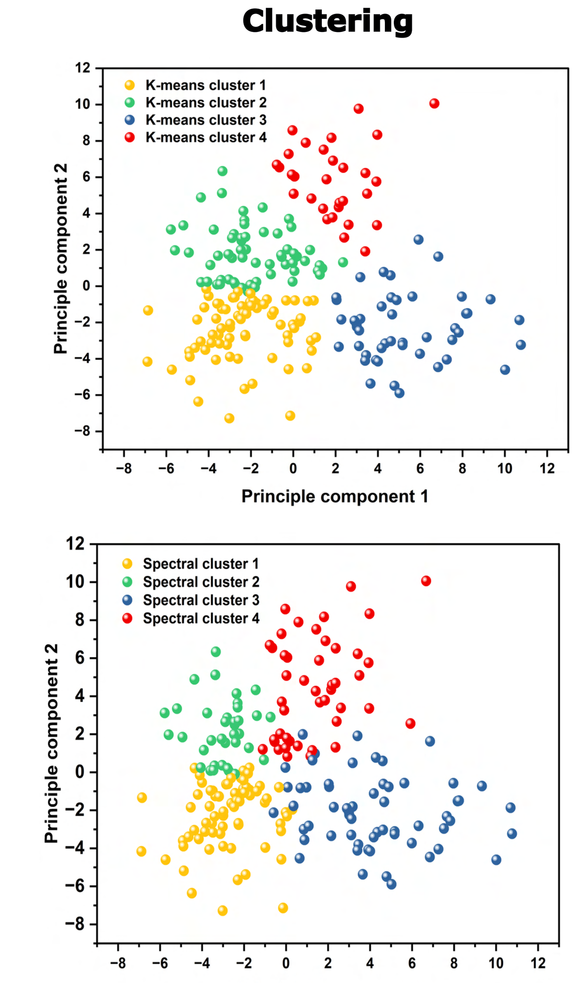


Manual Classification Results

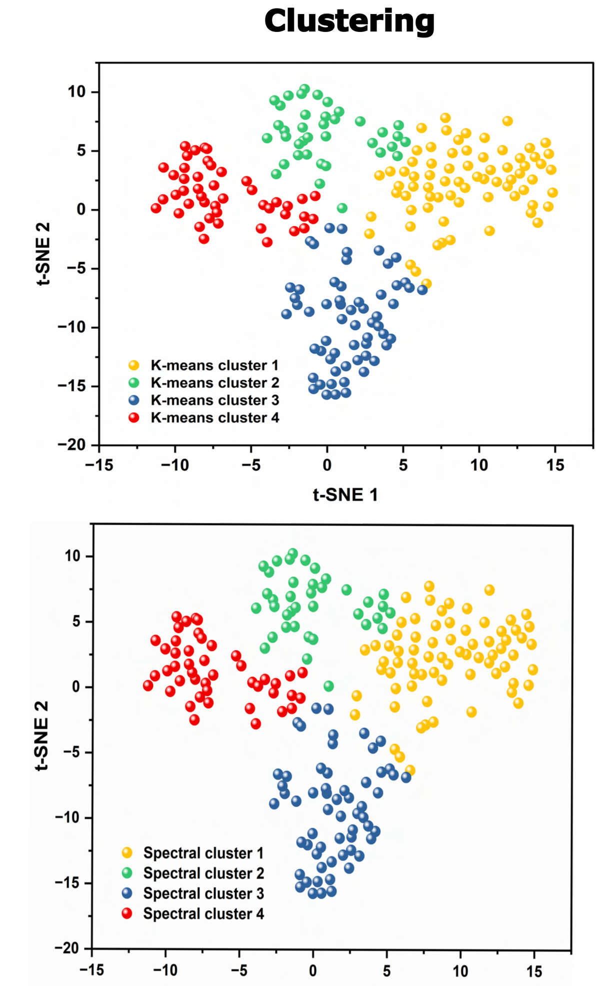


Clustering Groups with Dimension Reduction

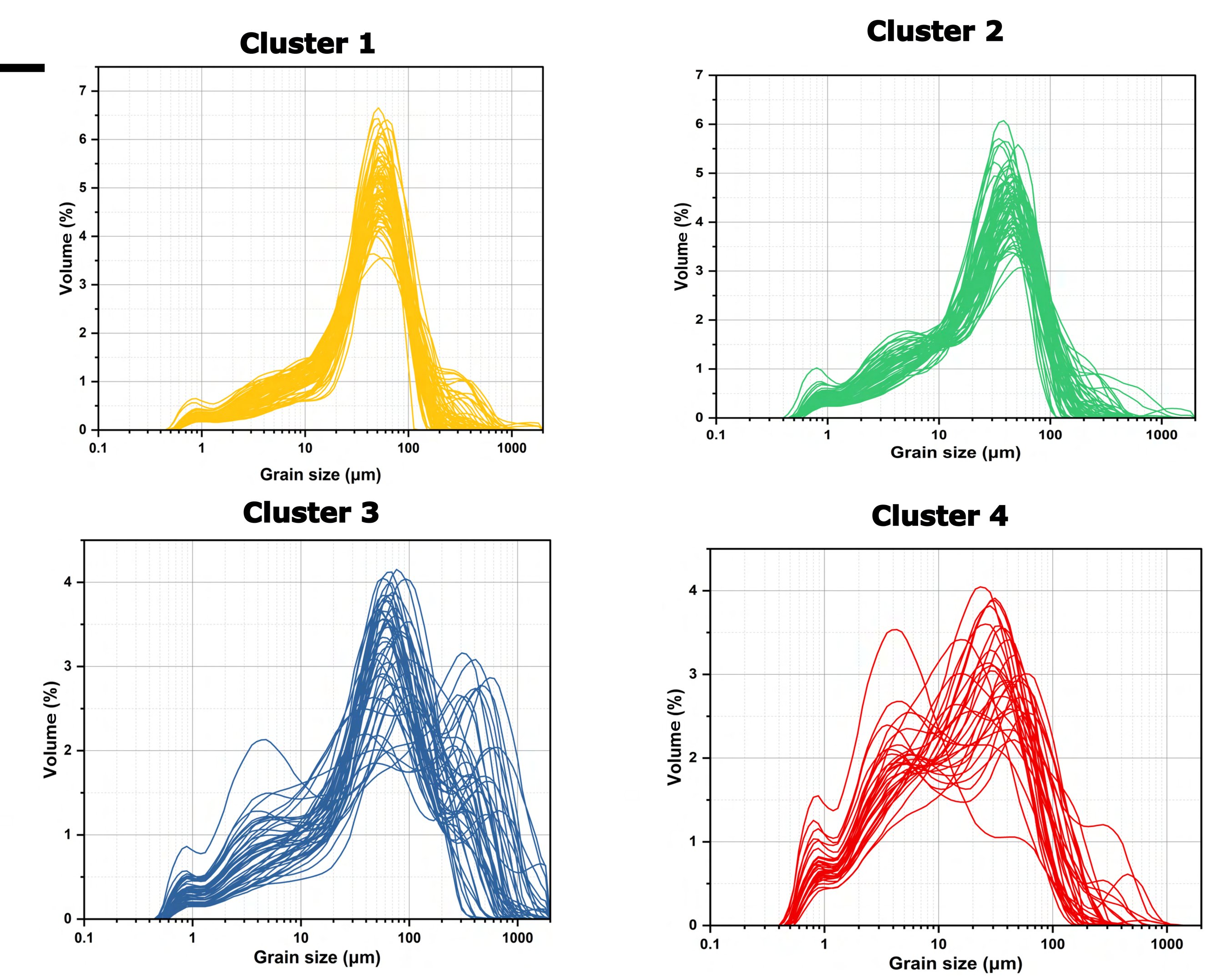
PCA Dimension Reduction Clustering



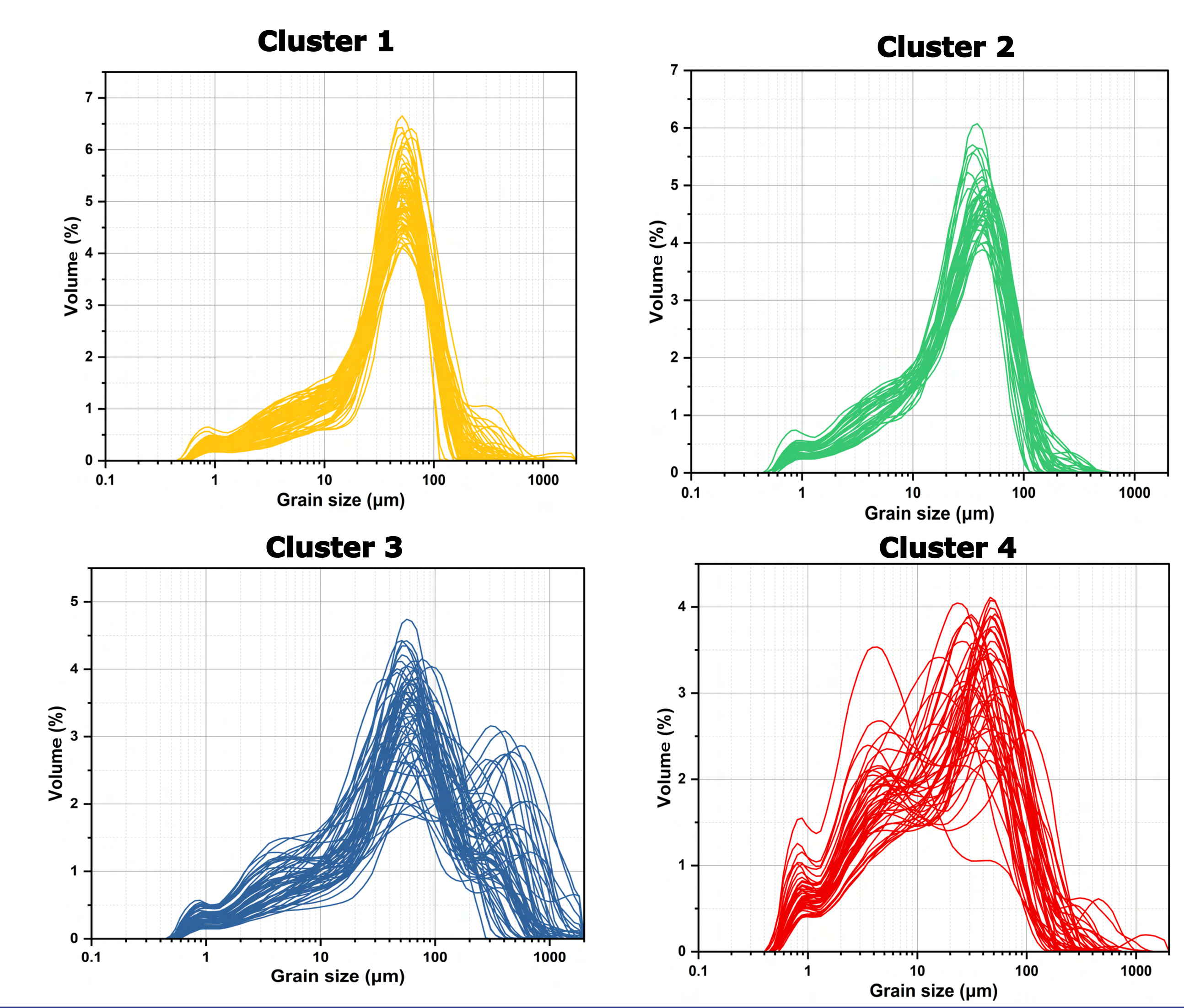
T-SNE Dimension Reduction Clustering



K-Means Clustering Grain Size Distributions



Spectral Clustering Grain Size Distributions



Conclusion

1. Analysis of the 2D representations of the clustering features showed that spectral clustering methods paired with T-SNE dimension reduction methods showed the clearest groupings with the most tightly clustered/similar groups.
2. When placed side by side in a catagorical representation of clustering groups K-Means shows more similar results compared to the manual determination of the classification results.
3. While the T-SNE graphs show similar results, the clustering groups did not as easily differentiate between two variations of loess deposition making it more difficcult to observe the temporal pattern.

References

Fan, Majie, et al. "Late Paleogene emergence of a North American loess plateau." Geology 48.3 (2020): 273-277.

Muhs, Daniel R. "Loess and its geomorphic, stratigraphic, and paleoclimatic significance in the Quaternary." (2013).

Sun, Donghuai, et al. "Bimodal grain-size distribution of Chinese loess, and its palaeoclimatic implications." Catena 55.3 (2004): 325-340

Újvári, Gábor, et al. "The physics of wind-blown loess: Implications for grain size proxy interpretations in Quaternary paleoclimate studies." Earth-Science Reviews 154 (2016): 247-278.