Eleventh Annual

Student Showcase

Virtual

April 24, 2020

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DEPARTMENT:

Physical and Environmental Science

FACULTY SPONSOR:

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PROJECT TITLE:

40Ar/39Ar Dating of Detrital Sanidine in the Goodenough Unit, Grand Mesa, Colorado

$^{40}Ar/^{39}Ar$ Dating of Detrital Sanidine in the Goodenough Unit, Grand Mesa, Colorado

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Abstract

Radiometric dating involving $^{40}Ar/^{39}Ar$ isotopes in detrital sanidine (DS) is a relatively new and emerging method for dating non-volcanic sedimentary deposits. The technique assumes that detrital sediments contain a small percentage of volcanic air fall that is reworked into the sediment at the time of deposition. This method is being applied to the Goodenough unit, which lies stratigraphically under the Grand Mesa lava flows and above the Uinta or Green River formations. The Goodenough unit chiefly consists of unconsolidated or friable fluvial sand and floodplain or lacustrine facies. The age of the unit is poorly constrained. However, detrital sanidine data can provide the first absolute age for the Goodenough. There are currently two hypotheses for the age of the Goodenough unit: 1) Late Miocene, which suggests a major unconformity separates the Goodenough from the underlying Eocene Uinta/ Green River formations, or 2) Oligocene, which suggests a major unconformity separates the Goodenough from the overlying Grand Mesa basalt flows. The primary goal of this study is to use $^{40}Ar/^{39}Ar$ dating of sanidine to construct an accurate depositional history of when the Goodenough unit accumulated. Sample AARC-2 contained grains that dated approximately 13 Ma (Miocene). This date fits the first hypothesis best, as the Goodenough sample is closer in age to the basalts (Miocene) than to the Green River (Eocene) deposits.

Sample Locations and Goodenough Outcrops

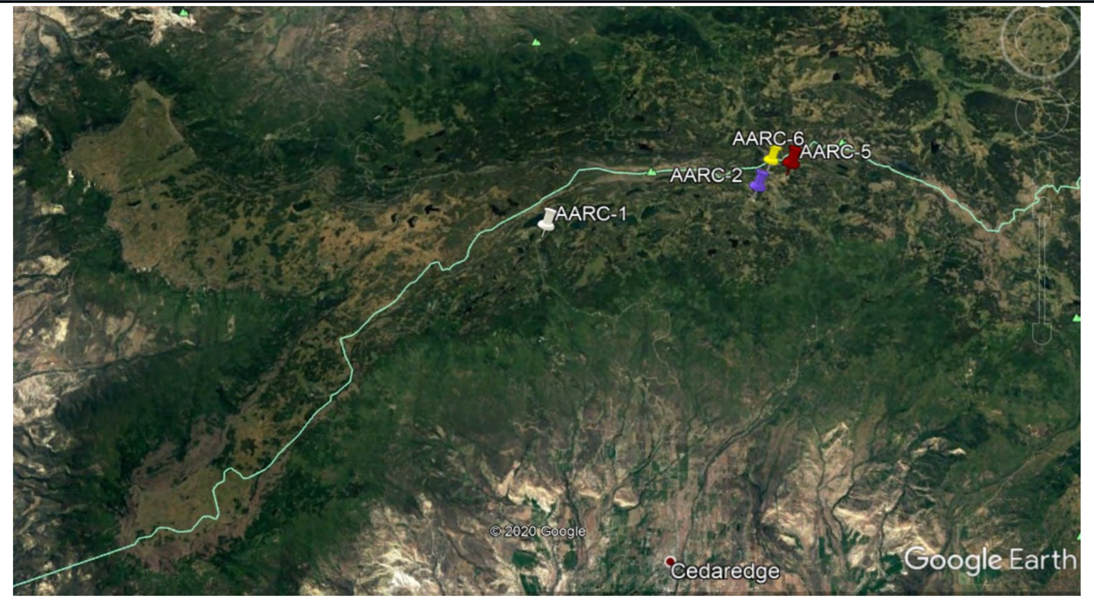

Figure 1. The different colored markers represent sample locations taken of the Goodenough unit on the Grand Mesa. Four samples in total were taken to be processed for DS (Table 1.). These locations were chosen due to their accessible outcrops . Another reason was for their potentially in-situ nature. due to the friable nature of the Goodenough unit, mass wasting is common and an in-situ outcrop can be difficult to determine and confirm.

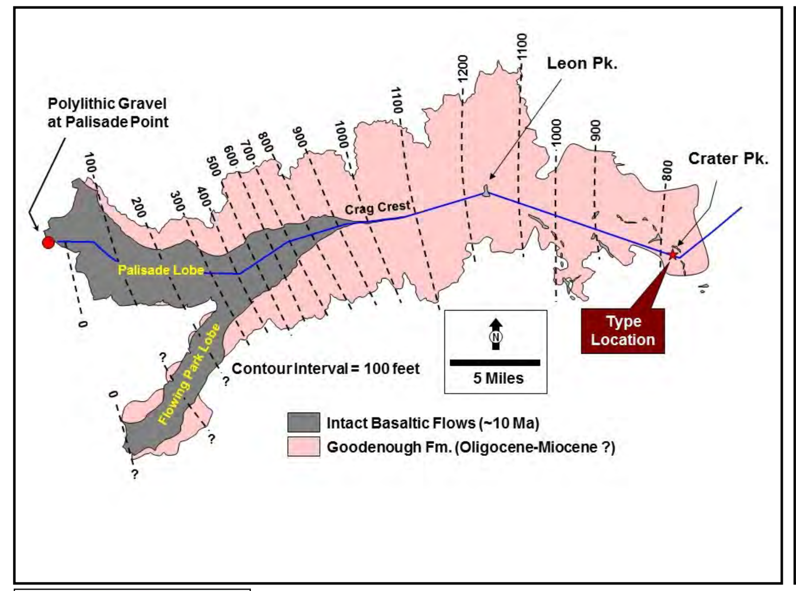

Figure 2. This diagram shows the general extent of the Goodenough unit in pink. The Type location in which the unit is informally named after is shown near crater peak with the red callout. Ancient polylithic river gravels are also shown cropping out under Lands End Lookout. These deposits are dated to be 11 Ma. These gravels are different from the Goodenough due to the composition of clasts and the ages between the two.

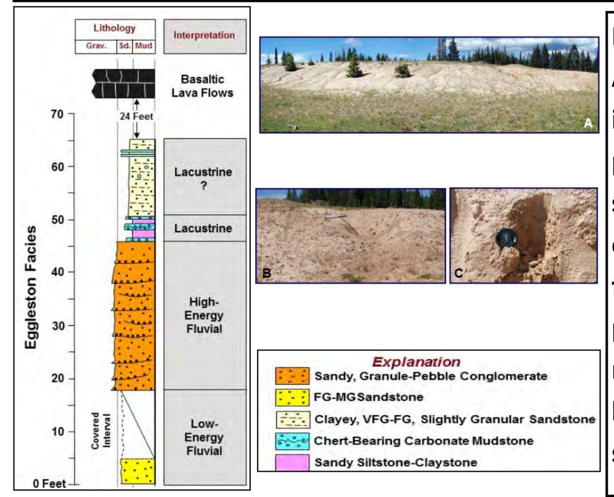

Figure 3. A stratigraphic section for the sample AARC-2. This sample location is interpreted as having both fluvial and lacustrine facies. (A). Outcrop picture for AARC-2 showing the covered interval and sandy conglomerate. (B) and (C) are outcrops of the clayey very fine grained to fine grained sand stone from which the sample was taken from. This sample location shows how diverse in facies the Goodenough unit can be in a relatively short amount of height. From high energy fluvial to carbonate mudstone, the Goodenough unit was diverse in facies.

Hypotheses 1 and 2

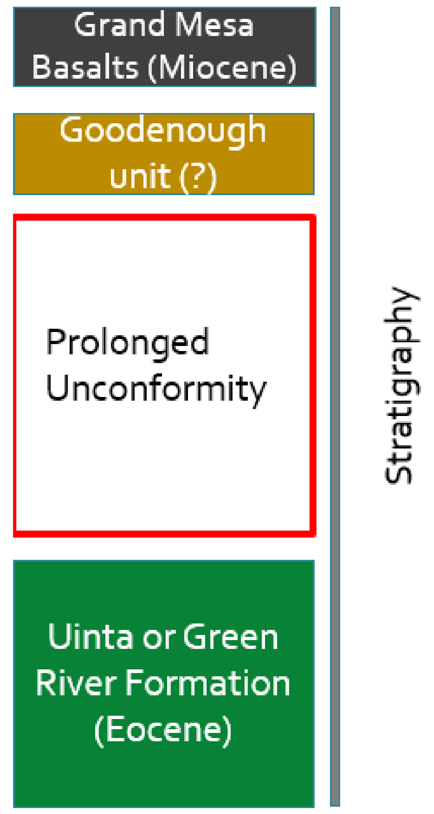

Figure 4. Hypothesis 1. Stratigraphic units located under the Grand Mesa basalts with the placement of the most lengthy conformities placed between the Goodenough unit and Uinta or Green River Formations

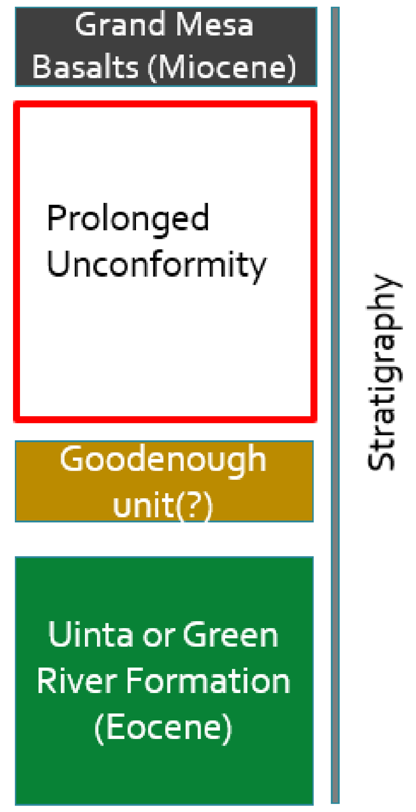

Figure 5. Hypothesis 2. Stratigraphic units located under the Grand Mesa basalts with the placement of the most lengthy of unconformities placed between the Goodenough unit and Grand Mesa basalts

Sample Processing

- Bagged sand samples were processed at New Mexico Tech in Socorro, NM.
- Sand was sieved, washed in HCL, magnetically separated, and density separated through heavy-liquid methods to isolate sanidine grains, which are used for dating.
- Individual sanidine grains were picked under a high powered microscope (Figure 6).

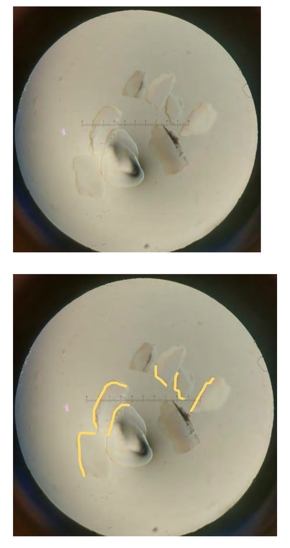

Figure 6. Cluster of sanidine grains with yellow halos

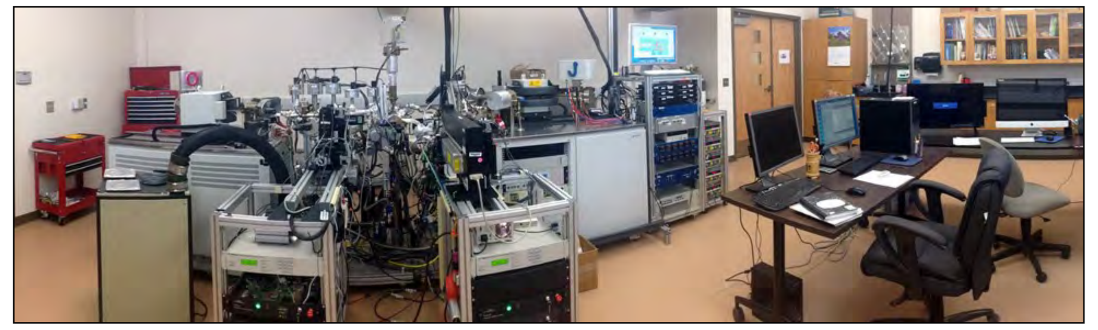

Figure 7. Mass Spectrometer at New Mexico Tech

- After a sizable amount of pure sanidine grains were isolated, the sanidine was transferred to another lab to be irradiated. The sample then returned to New Mexico Tech, to be analyzed by an $^{40}Ar/^{39}Ar$ mass spectrometer (Figure 7).
- The data gathered by this process is returned with an age.
- In figure 6, yellow halos can be seen around a cluster of sanidine grains. This is a common characteristic of sanidine grains.

$^{40}Ar/^{39}Ar$ Results for Sample AARC-2

Location	Facies	Sample #	Latitude	Longitude	Sample Elevation (ft)
Goodenough Fm					
Ward Creek Resevoir, Grand Mesa	Vela/Eggleston Facies	AARC-1	39.02842	-107.999	9971
Military Park, Grand Mesa	Eggleston Facies	AARC-2	39.05188	-107.891	10169
Vela Resevoir, Grand Mesa	Vela Facies	AARC-5	39.06377	-107.873	10095
South landslide bench, Grand Mesa	Eggleston Facies	AARC-6	39.06507	-107.883	10173

Table 1. From the four total samples (AARC-1, AARC-2, AARC-5, AARC-6) , only two (AARC-2 and AARC–5) were abundant enough in sanidine to be further analyzed. From these two samples, AARC-2 was the only one that provided a range of dates that were post-Eocene (34 Ma). The reason for the poor preservation of sanidine in these samples is most likely because of the alteration of volcanic feldspars.

Sample #	Method	Youngest Single Grain (Ma)	Mean Weighted Avg. (Ma)	n=
AARC-2	DS	13.113 ± 0.098	13.29 ± 0.06	4

Table 2. Taking the single youngest grain provides an age of 13.113 ± 0.098 Ma for the Goodenough. Another analytical method to find the maximum depositional age is to take the mean weighted average of the youngest four grains. This method gave an age of 13.29 ± 0.06 Ma. For this sample, the youngest single grain and mean weighted average can be used to confirm that the maximum age of depositional age is close to 13 Ma.

Discussion: Paleoenvironment, Sediment Source and Stratigraphic Sequences

The maximum depositional age from sample AARC-2 (13.29 ± 0.06 Ma) is much closer in age to that of the basalt flows that cap Grand Mesa. These ages being relatively close, fits the first hypothesis (Firgure 1.) best. This information matches closely with the first hypotheses. The following models were made to represent the possible environments, landscapes, and processes that the Goodenough was subject to pre– and post-deposition.

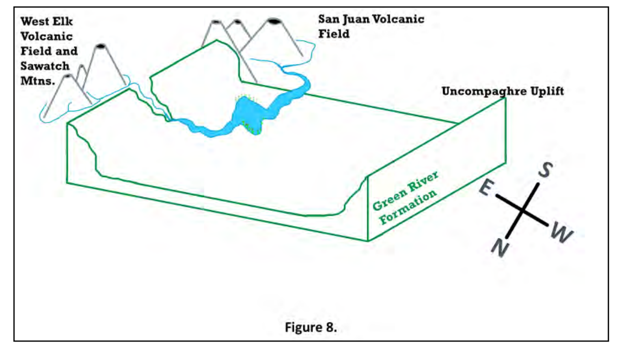

Figure 8. Paleovalley made of Green River Formation. The compass reflects the general direction of key locations like the Uncompahgre Uplift to the west and Volcanic mountains from the east/ south east.

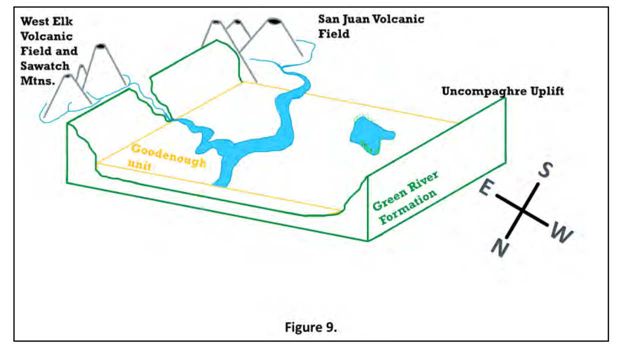

Figure 9. The paleovalley fills in with sediment from the surrounding landscape as well as detrital sediment from the volcanic highlands. The Goodenough unit fills in the valley, with conglomerate, sand, mud, and lacustrine facies. The Goodenough is interpreted to be deposited in a n internally drained environment due to the large accumulation and types of sediments.

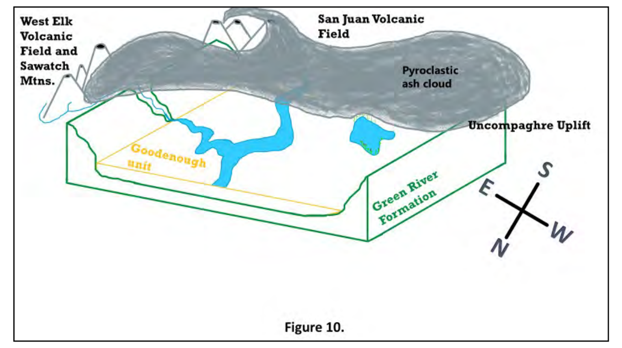

Figure 10. Pyroclastic ash clouds are ejected from the active volcanoes into the atmosphere. Within this ash, are the sanidine grains that are able to be dated to the moment they crystallized, which in theory should be close in age to the depositional age of the fluvial sediment.

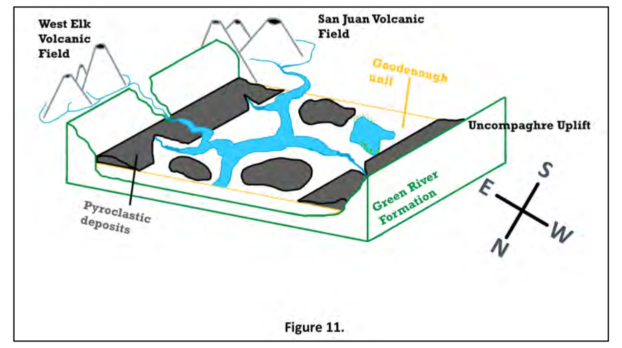

Figure 11. Ash deposits fall onto the landscape and are subsequently eroded away. Singular grains of sanidine are worked into the fluvial deposits, which are then buried and protected by overlying layers.

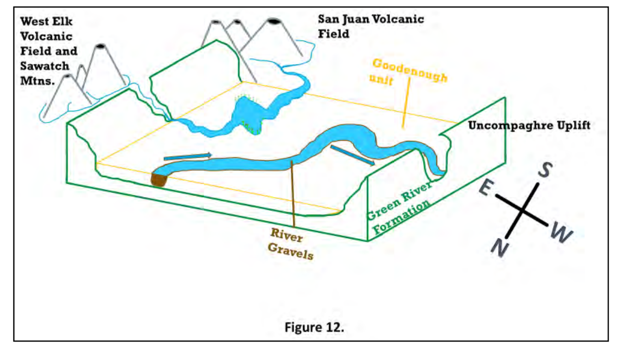

Figure 12. The River gravels that came after the Goodenough are shown as the brown outlined river and the gravel lens located in the Goodenough. This river was not being internally drained, only incising the previous deposits of the environment.

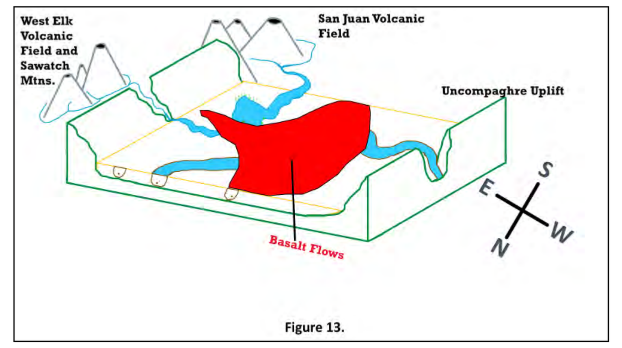

Figure 13. Flows of basalt fill the valley, encasing sediments, both Goodenough and river gravels.

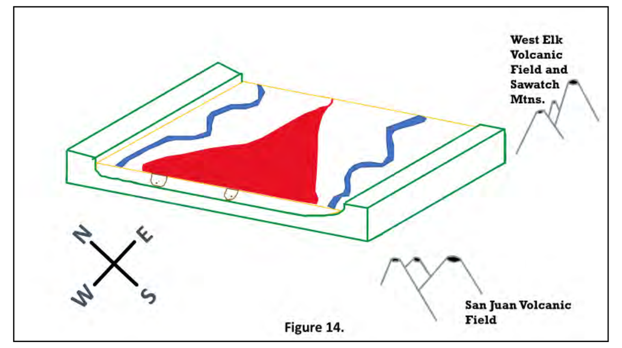

Figure 14. The orientation has been rotated to looking eastward. Subsequent erosion of valley walls, and rerouting of large rivers around the resistant basalt.

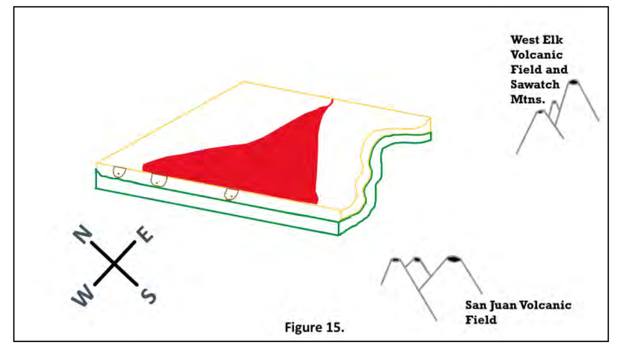

Figure 15. Erosion of flanks of Grand Mesa. The basalt acts as a protective barrier against erosion.

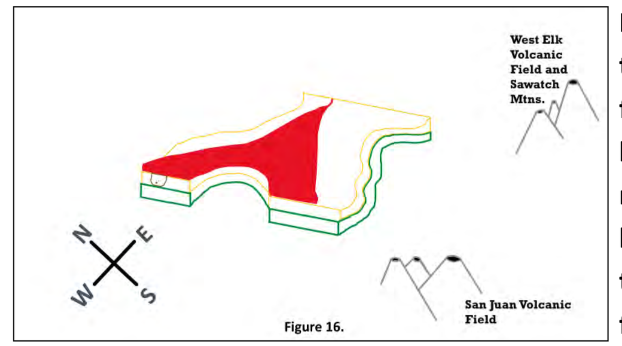

Figure 16. Further erosion of flanks, leaving behind a flat mountain. The basalt cap turns the valley into a flat mountain.

Conclusions

- Maximum depositional age of Goodenough unit is 13.29 ± 0.06 , This places the Goodenough within the time of The Miocene Epoch.
- The Miocene Epoch had both the deposition of Goodenough unit sediments (13 Ma) and flows of basalt (10 Ma)
- The hypothesis which fits the DS data best is the first hypothesis, where a lengthier unconformity exists between the Goodenough unit and Green River Formation
- The Goodenough unit was an internally drained basin where fluvial systems flowed to, but did not flow out of. This is because of the large aggradation of sediments. If the basalt had not formed a resistant cap, the preservation of sediments from an ancient valley would not have been preserved.