Origin of Late Cretaceous, continental interior, volcanism in the Rocky Mountain region

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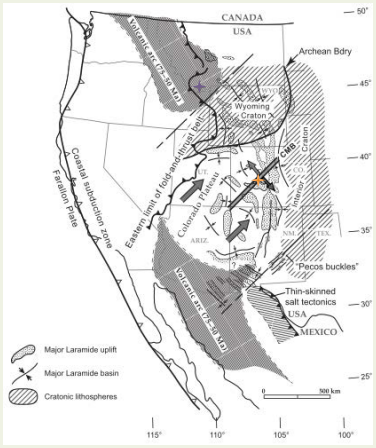
Above: Graduate Student Aaron H. and Intern Belinda G. listen as research mentor Dr. G. Lang Farmer shares info on the rocks they were trying to find for future samples at the Windy Member Gap of the Middle Park Formation. (Photographer: Aisha Morris)



Above: Areas in western U.S. where magmatism is present from 65-80 Ma. (Image: Chapin 2012)
Map locations:
Purple: Sliderock Mountain, MT – Orange: Colorado Mineral Belt (COMB)

Background

During the Late Cretaceous parts of the western U.S. were intruded by small-volume continental volcanism ~1500km inward from the Pacific margin. These intrusions include the Colorado Mineral Belt (COMB) and Sliderock Mountain, Montana. The continental lithosphere in these areas is quite thick, and the mechanisms by which these volcanic rocks were generated and erupted through this lithosphere are not well understood.

We compared the chemistries of several volcanic centers to better understand the roll of the lithosphere in magma generation . Slide Rock Mountain erupted through Archean (~2.6 Ga) lithosphere, whereas, the Windy Gap Member erupted through Proterozoic (~1.7 Ga) lithosphere. If pre-existing continental lithosphere was involved in magma generation, the difference in age and composition of the lithosphere in these regions should be apparent in the chemistries of these volcanic rocks because it was imparted from their parental magmas.

Thermal Ionization Mass Spectrometry

In order for our Sliderock Mountain volcanic clasts to reach the state that can be analyzed by the spectrometer, they must first be chemically purified by performing standard column separation methods.

Figure 1: These volcanicclastic samples from Sliderock, Montana will undergo column separation for Pb, Rb, Sr, Sm, and Nd.

Figure 2: Initial rock crushing and powdering to a sand size grain.

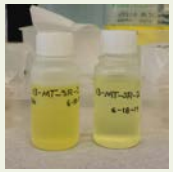


Figure 3: Beginning with the rock dissolution process, Samples 13MTSR-1 and -2 are shown after being powered and then added to hydrofluoric (HF) acid to dissolve organic material.

Figure 4: Several "drying" steps in between adding acids are necessary after collecting for specific isotopes.

Figure 5: RESESS Intern Belinda Gonzalez is shown adding hydrobromic acid (HBr) to columns. This process will separate the lead (Pb) from the original un-spiked samples.

Figure 6: The fret and Pb resin inside the columns act as a filter through which the samples drip through.

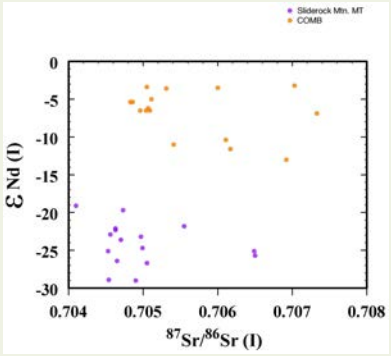
Figure 7: After the column separation process is complete, our sample is now ~1mm. It can now be combined with another acid and loaded in to the spectrometer.

Figure 8: Emily Verplanck, manager of the TIMS lab in the University of Colorado Boulder, is shown running the mass spectrometer.

TIMS - Geochemical Results

We analyzed mafic basalt samples that show negative ε_{Nd} values and likely came out of the continental mantle lithosphere (chrondrite reservoirs). Modern asthenospheric values of εNd are positive, the εNd values of these basalts are too low for them to have been derived from melting of the asthenosphere. If you have lower a 147Sm/143Nd ratio it will plot as a negative ε_{Nd} value, as time goes by, because partial melts of the mantle are rich in LREE.

In regard to the origin of the magmas, since the decay of 147Sm/143Nd is always happening the isotopic compositions of the Windy Gap Member plot less negatively in comparison to those of Sliderock Mountain. The longer the magma has been separated from its source means it will develop increasingly negative ε_{Nd} values.



Above: The εNd value was calculated by normalizing the 143Sm / 144Nd ratio to the 143Sm / 144Nd ratio of the Chondritic Uniform Reservoir (CHUR). εNd values vary with the age of extraction from CHUR, with more negative values suggesting longer isolation.

Conclusion

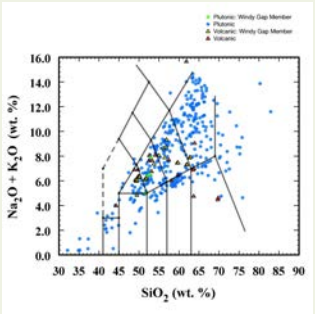
The extrusive igneous activity in both volcanic suites have similar bulk compositions.

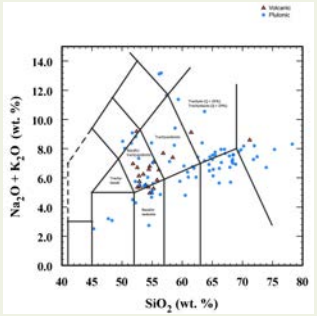
The magmas could not have originated in the asthenosphere or else they would be expected to have high positive ε_{Nd} values.

These magmas are too mafic to have been generated by crustal melting. Therefore, the negative ε_{Nd} values in these mafic magmas suggest the magma at both locations were derived from light rare element enriched continental mantle lithosphere, and that the ε_{Nd} differences reflect differences in mantle lithosphere age.

NAVDAT Results

NAVDAT compilation of intrusive and extrusive igneous activity present in the **Colorado Mineral Belt (left)** and **Sliderock Mountain, MT (right)** during the Late Cretaceous. Time range: 60-80 Ma.

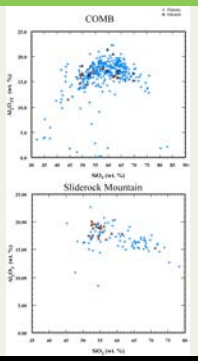




Space-time-composition plots were generated to better understand the relationship between petrology and magmatism.

By plotting SiO_2 against major oxides and trace elements and comparing them to Bailey's (2007) results, we have deducted that activity in Sliderock Mountain and in the COMB is very similar. The volcanic activity within these 2 suites of rocks plot mainly in the trachyandesite and basaltic trachyandesite regions of a TAS Diagram, after LeMaitre et al. (1989), depicting they have similar bulk compositions.

In general, the major oxides and trace elements of the extrusive rocks are fundamentally alike in SiO_2 & Al_2O_3 suggesting they originated from a compositionally similar source.



Acknowledgements

UNAVCO / Research Experiences in Solid Earth Science for Students (RESESS), Joshua Villalobos, Dr. Jose M. Hurtado, ExxonMobil Foundation, NSF Opportunities for Enhancing Diversity in the Geosciences (OEDG) Grant No. 0914704 GEO-OEDG.

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