Examining Potential Geochemical Indicators of Fenitization in Soil Samples Collected from the Gallinas Mountains, Lincoln County, New Mexico

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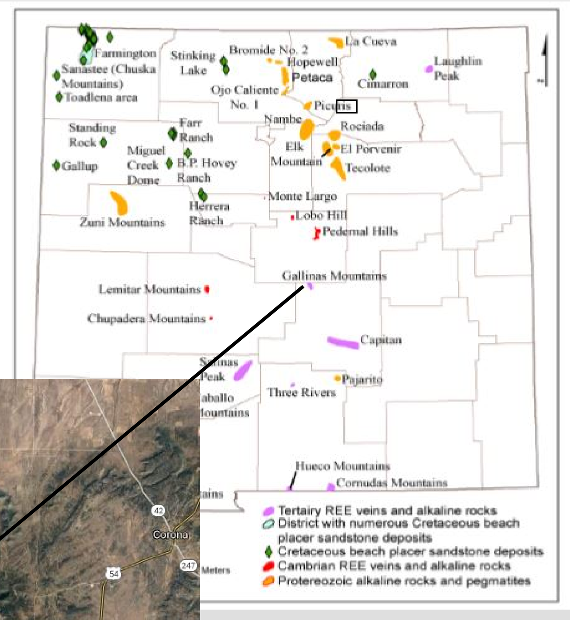
ABSTRACT

Fenitization is an alkali metasomatic alteration associated with carbonatite and alkaline intrusions. Typically, fenitization occurs with enrichments of potassium (K), sodium (Na), and rare earth elements (REE). REEs are comprised of the 15 lanthanide elements, yttrium, and scandium. REEs are increasing in demand with their use in smart phones, LED lights, solar technologies and electric vehicles. Occurrences of fenitization associated with REEs, such as at the Gallinas Mountains mining district, Lincoln County, NM, are therefore of considerable economic and strategic interest. In the 1950s, bastnaesite, a REE mineral, was produced from the Gallinas Mountains. Several companies have conducted exploration programs to identify REE potential therein. Five types of mineral deposits are found in the district: epithermal REE-F veins, Cu-REE-F veins, REE-F breccia pipe, carbonate breccias, and iron skarn deposits; all are associated with Tertiary alkaline or alkali-calcic igneous rocks, REEs, and fenitization. In 2010, 240 soil/rock chip samples were collected and analyzed with a Bruker handheld XRF instrument. Samples range in K concentrations from 0.7-3.8%, and maximum concentrations of La (2071ppm) and Ce (3547ppm), indicating zones of fenitization and mineralization that need further confirmation. Analytical precision is within +/-10%. Of the REEs, only La, Ce, Nd, and Y were detected by the instrument. Rb shows a very strong positive correlation with K, suggesting these elements are in K-feldspar, which could be related to the fenitization. As K-feldspar is a common host of Rb, this is expected. There is no apparent correlation between K and the four REEs tested (Y, La, Ce, and Nd). Subsequent fieldwork has indicated that REE anomalies are concurrent with general alteration and REE veins.



REE deposits in New Mexico

Gallinas Mountains study area.

PROCEDURE

In 2010, 240 soil samples were collected and chemical analyses were conducted by the New Mexico Bureau of Geology and Mineral Resources (NMBGMR), using a Bruker handheld XRF instrument, which is less expensive than conventional laboratory chemical analyses. Two samples were submitted for conventional laboratory analyses and results are comparable, except for REE analyses. Chemical maps were plotted using ArcGIS, with concentrations being reflected in the symbology. These data were analyzed for ratio concentrations and statistical calculations, using GCDkit geochemical modeling software. These results were used to identify areas of alteration for additional, detailed mapping and sampling. Geologic mapping is underway.

GEOLOGY

Proterozoic Rocks
- Granite
- Granitic gneiss
- Quartz diorite

Sedimentary Rocks
- Permian Abo Formation (100 to 200 ft thick, consists of arkosic conglomerate, arkosic arenite, siltstone and shale)
- Permian Yeso Formation (tan/orange, thinly bedded sandstone, siltstone, shale, and dolomite, approximately 1500 ft thick)
- Permian Glorieta Sandstone (massive, cross-bedded quartz sandstone up to 250 ft thick)

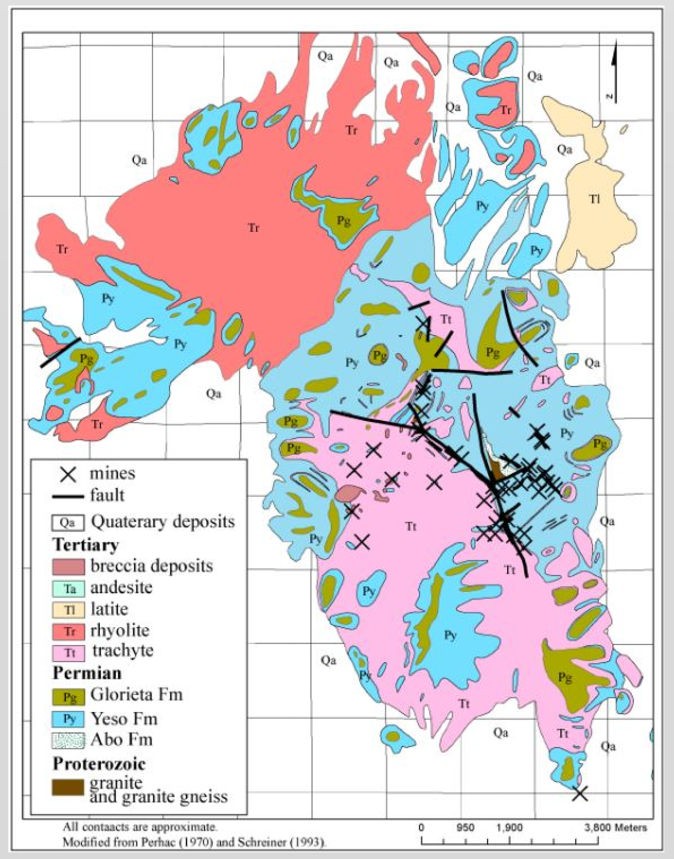
Igneous Rocks

Nomenclature of igneous rocks conforms to international classification (LeMaitre, 1989). Several types of Tertiary igneous lithologies are found: 1) trachyte to trachydacite to trachyandesite to latite, 2) syenite to microsyenite, 3) andesite, and 4) rhyolite to rhyodacite.

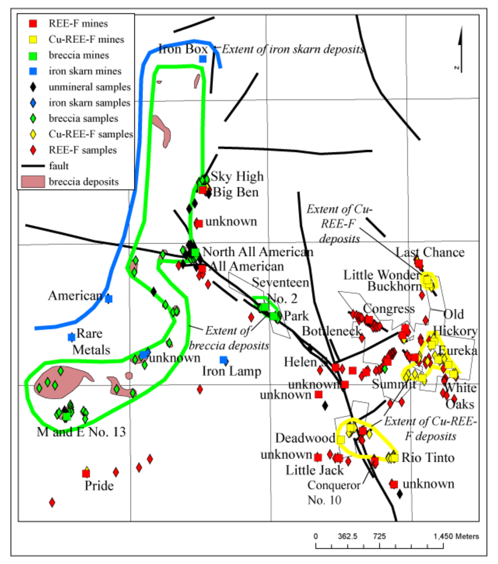
Magmatic-hydrothermal, intrusive breccia pipes intruded the trachyte/syenite and Yeso Formation. The breccia pipes consist of angular to subrounded fragments of sandstone, shale, limestone, granite, granitic gneiss, and trachyte/syenite which are up to 1m in diameter. Most pipes are matrix supported and altered.

ALTERATION

The predominant style of alteration is fenitization and is represented by K-feldspar, Na-feldspar, and alkali amphiboles and pyroxenes. Mapping, petrographic, mineralogical, and geochemical studies are underway and will be presented in future reports. The trachyte, syenite, andesite, Proterozoic rocks, and intrusive breccia pipes have been altered locally by two separate periods of fenitization; sodic (replacement of feldspars and other minerals by albite and ambiboles, pyroxenes) followed by potassic fenitization (replacement of feldspars, including older albite, and other minerals by K-feldspar and ambiboles, pyroxenes). Temperatures ranging from 400 to 700°C are estimated for fenitization (Eckerman, 1966; Kresten and Morgan, 1986; Haggerty and Mariano, 1983; Le Bas, 1987).



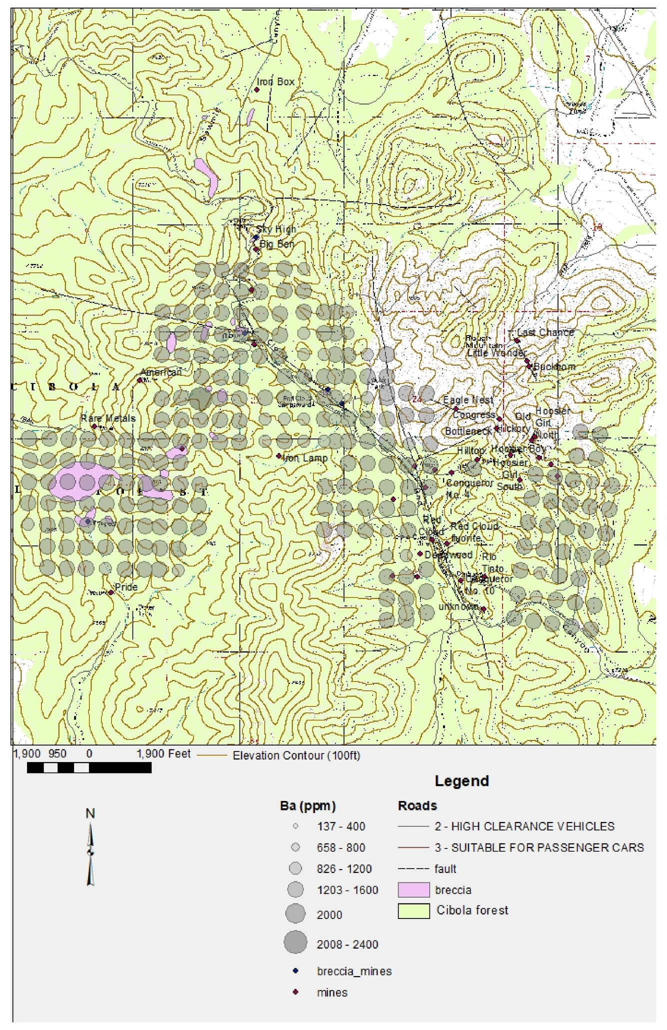
Geologic map of the Gallinas Mountains, Lincoln County, New Mexico (modified from Kelly et al.,1946; Perhac,1961,1970; Woodward and Fulp,1991; Schreiner,1993; McLemore, 2010; field reconnaissance by the authors).

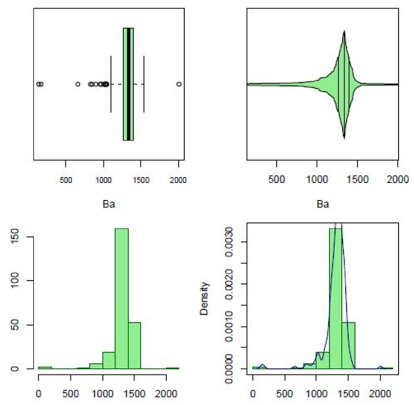


Mineral zoning in the Gallinas Mountains, based upon predominant mineralogy and chemistry of the known deposits (McLemore, 2010).

Table comparing selected chemical analyses of 2 soil samples by conventional laboratory chemical techniques (chem=analyses by USGS, using XRF and ICP methods) and Bruker handheld XRF instrument (HXRF). The variation in results may be a result of coarse-grain size of the sample split, sample not homogenized properly, or poor precision or accuracy using the HXRF of certain elements.

Sample No.	Fe %	Mn ppm	Ca %	K %	Ba ppm	Cu ppm	Rb ppm	Sr ppm	Th ppm	Y ppm	La ppm	Ce ppm	Nd ppm
A25 (chem)	2.54	465	0.86	3.2	695	33	175	108	19	48	23	52	25
A25D (HXRF)	2.2	546	0.7	3.8	1232	5	278	182	103	14	236	403	121
A27 (chem)	6.01	1317	1.74	2.5	707	25	177	168	16	89	49	120	68
A27 (HXRF)	2.7	1483	0.8	2.9	1341	23	113	514	65	27	2071	3548	898

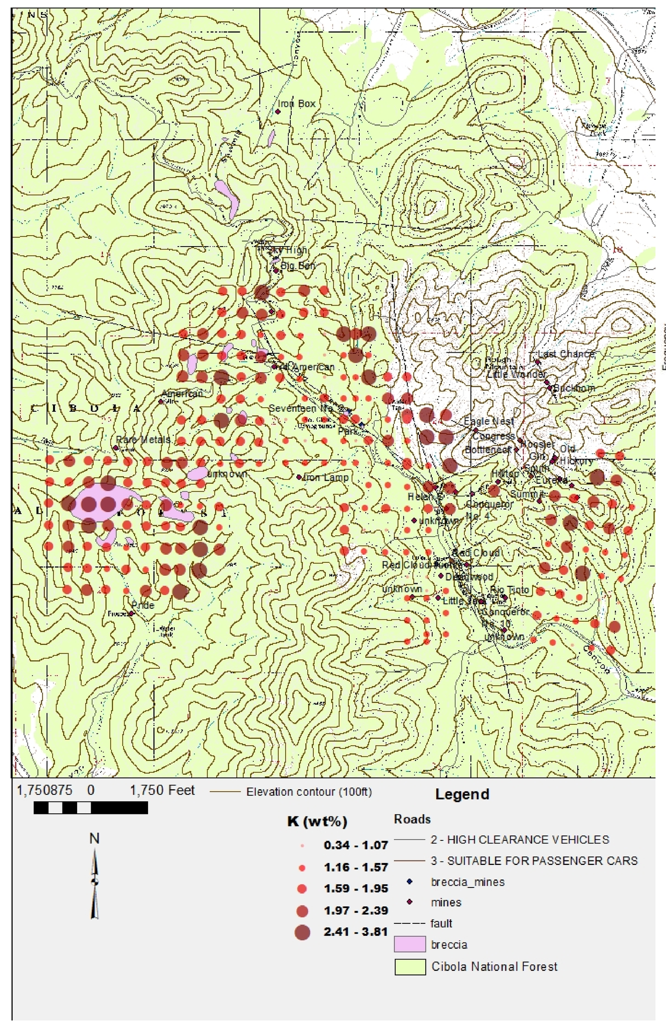


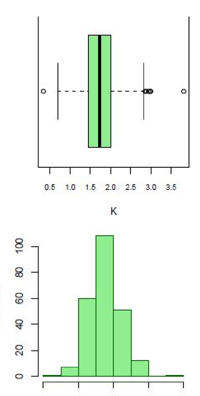


Left - a sample location map of the soil samples displaying Ba concentration. Soil sample location in T1S, 11E – 12E

Above – geostatistical analysis of Ba concentrations

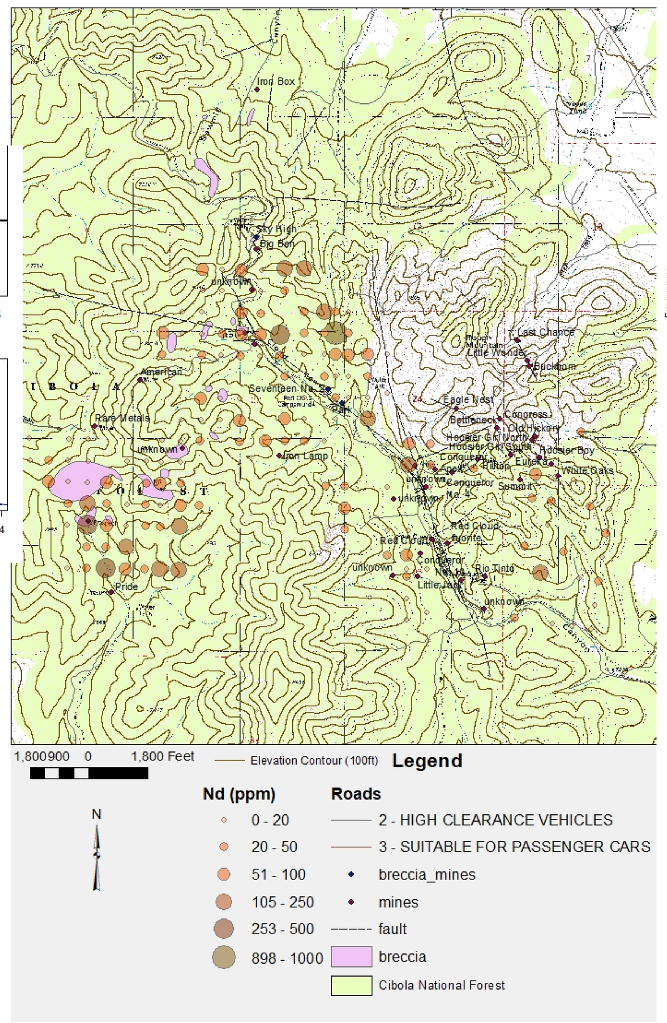
RESULTS

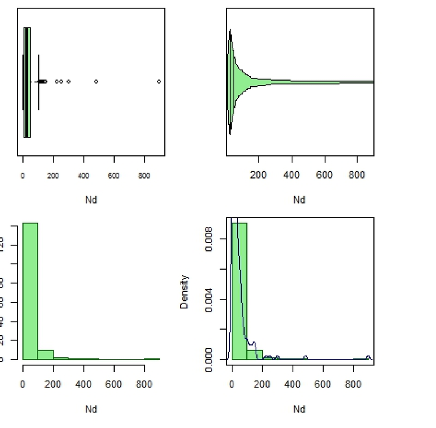




Left - a sample location map of the soil samples displaying K concentration.

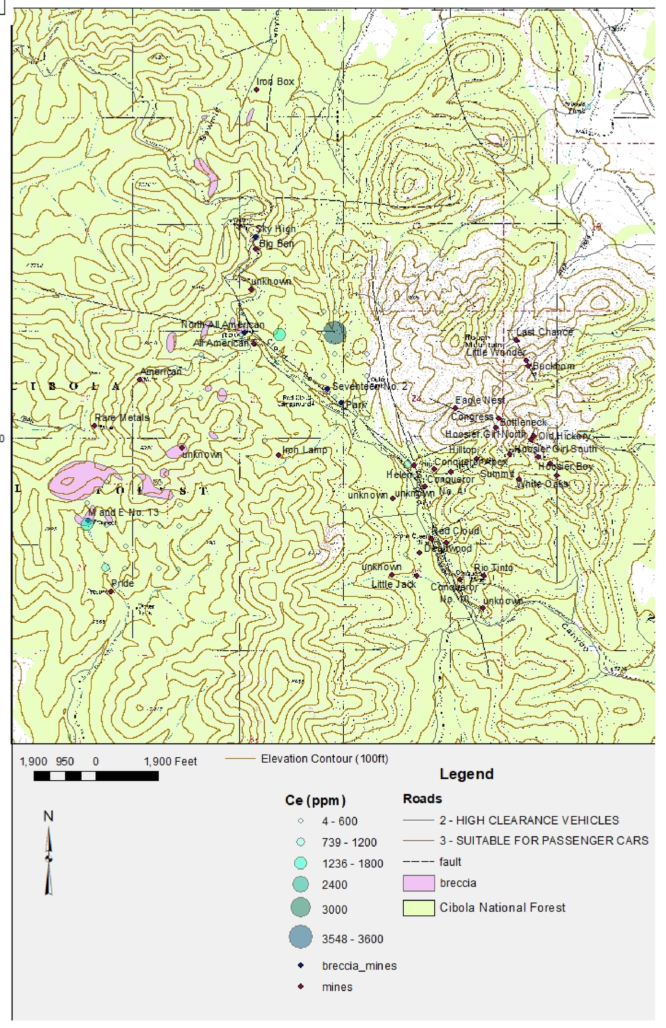
Above – geostatistical analysis of K concentrations

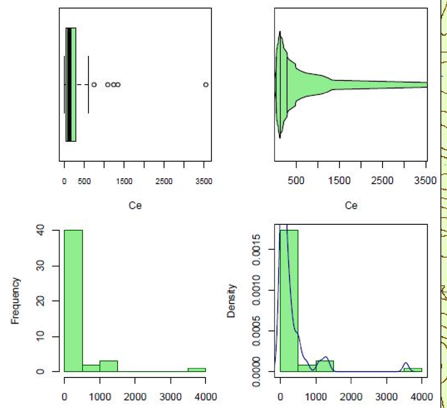




Left - a sample location map of the soil samples displaying Nd concentration.

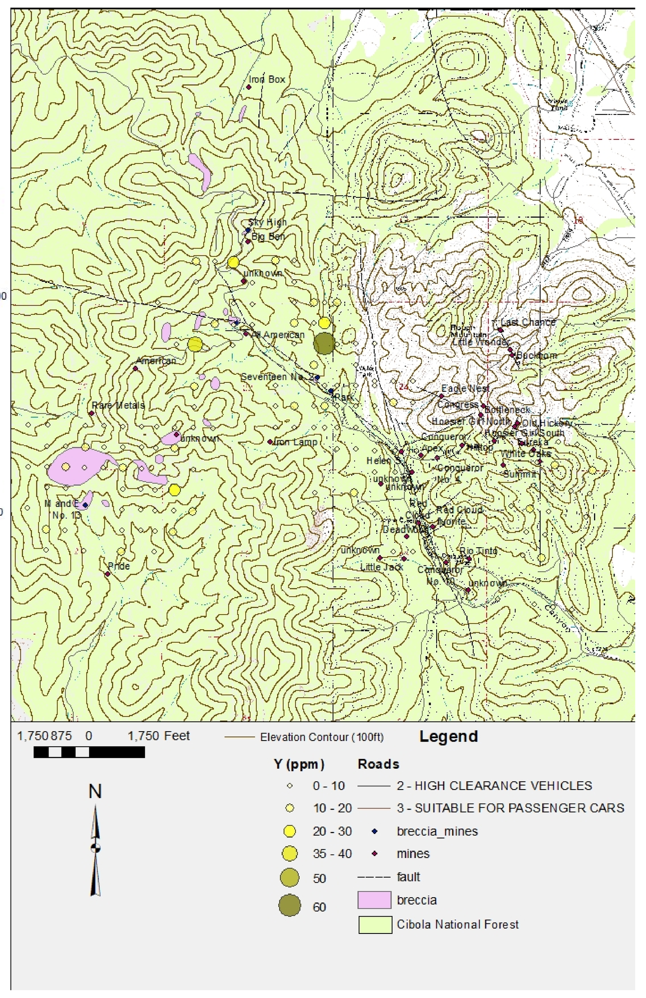
Above – geostatistical analysis of Nd concentrations

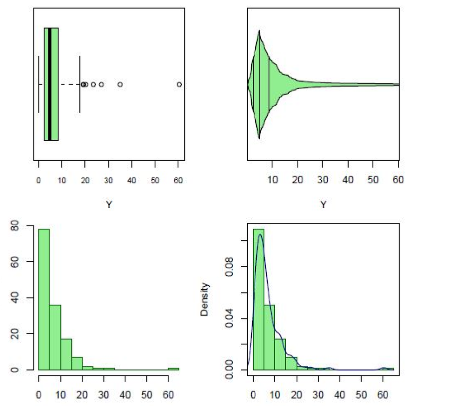




Left - a sample location map of the soil samples displaying Ce concentration.

Above – geostatistical analysis of Ce concentrations



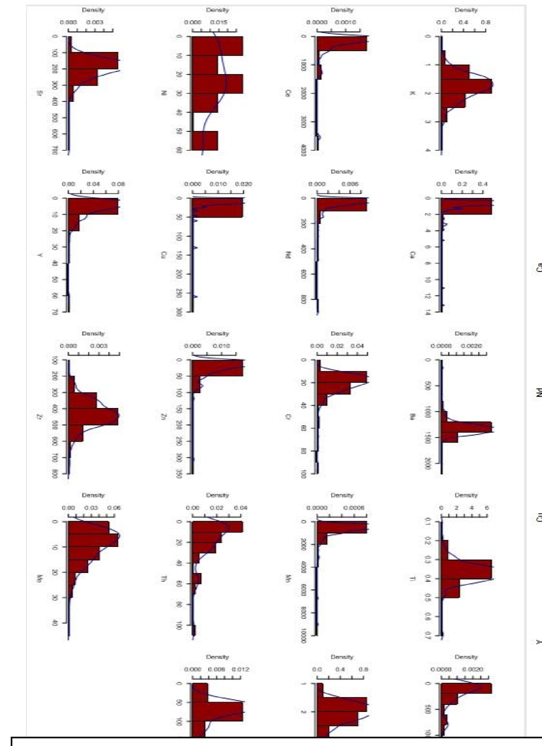


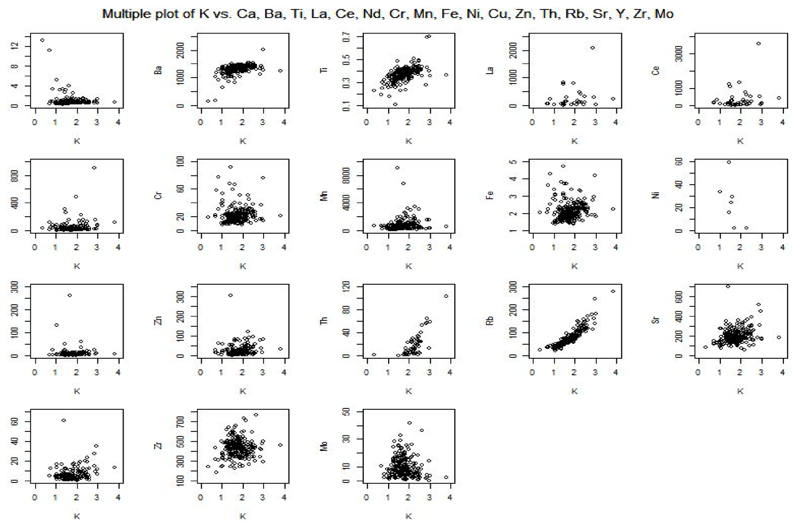
Left - a sample location map of the soil samples displaying Y concentration.

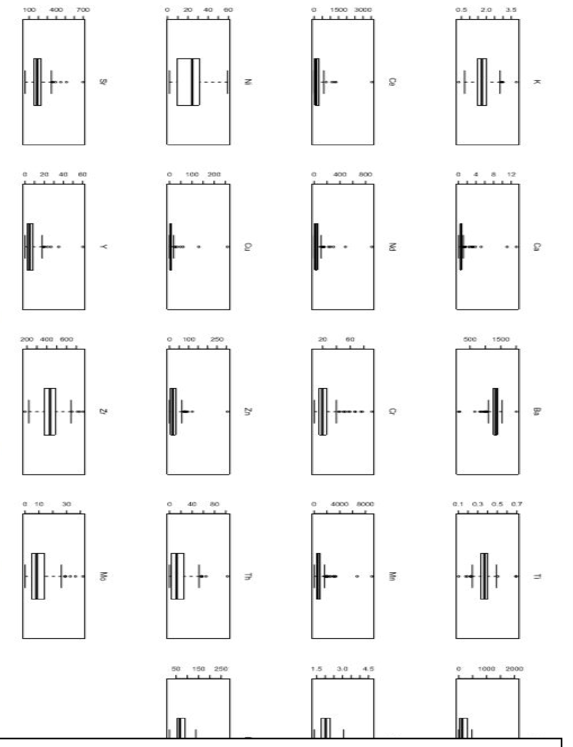
Above – geostatistical analysis of Y concentrations

Cumulative Statistics

Right - Box and Whisker plots of the elements analyzed. Left – Density distributions of elements analyzed. Below - Scatterplots of all elements analyzed plotted against K. Note the strong positive correlation seen in Th and Rb.







Acknowledgements

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FUTURE WORK

Additional fieldwork with both handheld XRF and laboratory geochemical analysis should be conducted to determine the feasibility of the Bruker handheld XRF instrument. Reanalysis of the data using ratios may resolve analytical problems. The extent of fenitization needs to be mapped in detail and characterized to determine extent, mineralogy, and geochemistry of the alteration.

CONCLUSIONS

The Bruker handheld XRF instrument has potential for rapid, field reconnaissance of soil samples. However, additional analyses are required to determine the differences between HXRF and convectional laboratory results. High concentrations of K, Rb, and Ba are indicative of fenitization. Rb shows a very strong positive correlation with K, suggesting these elements are in K-feldspar, a characteristic of fenitization. There is no apparent correlation between K and the four REE (Y, La, Ce, and Nd). Subsequent mapping and geochemical analyses have indicated that REE anomalies are concurrent with alteration and veining.

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