Presentation of REE Research and Anorthosite Field Course

2013 Annual Geological Society of America Meeting

Dr. Genet Ide Duke

Project Report for Professional Development Grant, ATU Geology Program

Submitted January 26, 2014

RESTATEMENT OF PROFESSIONAL ENHANCEMENT OPPORTUNITY

The purpose of this professional enhancement in October 2013 was two-fold: (1) to present research in an oral special session at the second largest annual international geology conference (Geological Society of America), and (2) to attend a field course taught by world experts on Anorthosite rocks. Secondary purposes include furthering research in the Rattlesnake Hills, Wyoming, with preparation of a paper on the geochemistry of the rocks in the area to be coauthored with Dr. Carol Frost of the University of Wyoming. The Anorthosite field course has prepared me with experience, rocks, photos, and a field guide to be able to take 2-3 Tech Geology students to this field area next summer where they will do field work in the Rattlesnake Hills and be guided (by me) through the Laramie Anorthosite complex. During the field course, I took photos and collected samples of Anorthosite other Precambrian rocks to use in my Tech Petrology classes.

BRIEF REVIEW

Research was presented orally at the Geological Society of America (GSA) Annual Meeting in Denver, CO, in a special session entitled *Evolution of REE-Enriched Carbonatite-Alkalic Rock Systems: In Honor of Daniel R. Shawe*. The title was *Rattlesnake Hills and Bear Lodge Mountains carbonatite-alkalic igneous complexes, Wyoming: REE's and other trace-element geochemistry* (Appendix). The REE (Rare-Earth Element) emphasis reflected the strategic nature of these resources and the current U.S. needs for their exploration and development. After the talk, professional connections were developed with geologists from

a company called Rare Element Resources, which might provide jobs for Tech students in the future. I plan to write a proposal for a grant to bring Tech students to the Rattlesnake Hills in the summer of 2014. In addition, because of the strong reception at my REE talk, I have had three (3) new invitations to give other talks, as well as serving as co-chair at a fourth conference. Speaking invitations include (1) at the South-Central GSA meeting in Fayetteville, AR, where I will give a 40-minute keynote talk on regional alkalic magmatism, (2) at the North-Central GSA meeting in Lincoln, NE, where I have been invited to give a broad overview of carbonatite magmatism in the U.S., (3) at the University of Missouri – Columbia, where I will give a talk on the tectono-magmatic model presented in a paper recently submitted to Earth and Planetary Science Letters. As co-convener of Rocky Mountain – Cordilleran GSA sectional meeting, I will be co-chairing the alkalic magmatism session and presenting research on Black Hills REE's and alkalic magmatism.

The second part of this professional enhancement was attendance at a field course on the Laramie Anorthosite Complex in Wyoming. The field course was taught by two world experts in Anorthosite volcanism, Dr. Ron Frost (U. Wyoming) and Dr. Robert Bauer (U. Missouri – Columbia). On the field course, I learned a considerable amount about the development of the early Earth, and I've already used a power point in my Mineralogy classes that was created by a doctoral student from the University of Wyoming. I plan to guide 2-3 Tech Geology students on a similar trip next summer to share the information and experience, en route to doing fieldwork at the Rattlesnake Hills. Professional connections were made on the field trip, including a possible research collaboration with the Geological Survey of Canada on a Precambrian carbonatite in northern Quebec. In addition, I collected rare rock samples to be used for Petrology classes at Arkansas Tech.

These are being prepared for cutting and creation of thin sections for microscopy work in classes.

SUMMARY OF EXPERIENCES

The talk I presented at the annual GSA meeting on Rare-Earth element (REE's) comparisons between the Bear Lodge Mountains and the Rattlesnake Hills, WY, generated significant interest both by academic professionals and REE mineral exploration geologists. Because of the talk and my specialization in the rocks that contain the REE's—carbonatites, kimberlites, and other alkalic igneous rocks—I have made important connections and have been invited to present talks at two regional GSA meetings (South-Central in Fayetteville, March 17-18, 2014; North-Central in Lincoln, NE, April 24-25). I have been invited to give a talk at the University of Missouri, Columbia, on April 4, 2014, and hope to make connections for graduate school for our Tech students at this venue. I also was requested to co-convene a session on early Tertiary magmatism in the entire Rocky Mountain region at the Rocky Mountain-Cordilleran GSA meeting in Bozeman, Montana, on May 18-22, 2014. The mineral exploration geologist connections include the Canadian Geological Survey and the exploration company called "Rare Earth Resources."

The Anorthosite (light-colored, reflective rocks of the Moon) field course allowed me to become updated on a hot topic currently debated by geologists. The course is currently benefiting my ATU students in the classroom with new rock samples to examine, thin sections to be made for microscopic examination, new photos and accompanying power point presentations, as well as a field excursion planned for students in the summer of 2014.

CONCLUSIONS AND RECOMMENDATIONS

The professional enhancement opportunity this past October 2013 allowed me to present research on an important topic of interest both academically and economically. It allowed me to make numerous connections with 4 requests for invited talks, contacts for new collaborations and potential employment/graduate schools for students. The GSA presentation will expand in the next year or two to a publishable manuscript after further study involving microscope work and geochemistry, as well as mass spectrometry analyses of radiogenic isotopes. Publication will be in either the journal Mountain Geologist or Rocky Mountain Geology.

The Anorthosite field course information and photos are being disseminated to students in power-point presentations, lectures, lab studies, and future field work. I intend to bring 2-3 students to the Rattlesnake Hills for fieldwork in July or August 2014, and en route, I plan to provide a one- or two-day field trip through the Laramie Anorthosite Complex.

The professional enhancement opportunity was an outstanding investment both for the Geology students at Tech (classes, field work, employment, graduate school potential), as well as for me in terms of expanding research. The invited talks at four (4) new localities will be a good future advertisement for the Arkansas Tech Geology Program.

Appendix

Rattlesnake Hills and Bear Lodge Mountains carbonatite-alkalic igneous complexes, Wyoming: REEs and other trace-element geochemistry

Duke, G. Ide, and Frost, C.D.

The Rattlesnake Hills (RH) alkalic igneous complex (44-45 Ma) consists of a central alkalic group with carbonatite, phonolite, trachyte, trachyandesite, and trachydacite, flanked on the east and west by more silica-rich intrusive rocks including rhyolite. The Black Hills (BH) alkalic belt (including Bear Lodge Mountains (BLM)) (<46-58 Ma) includes these and additional tephrite, basaltic trachyandesite, shoshonite, various lamprophyres, as well as alkali and subalkalic rhyolite. Both complexes contain gold, but only the BLM contains significant REE deposits.

REE, Th, and Nb concentrations in rocks of the Rattlesnake Hills (RH) are lower than those of carbonatites and other rocks in the BLM. In a BLM drill-core sample of carbonatite, Ce is >10,000 ppm and La is 8000 ppm, whereas in two RH drill-core samples of carbonatite, concentrations of Ce are 845 and 952 ppm, and those of La are 696 and 960 ppm. The RH REE patterns are less LREE-enriched: Ce/Yb of phonolites, trachytes, and trachyandesites in the RH is <50, whereas in the BH, this ratio is 100-200. Black Hills thorium concentrations are high—775 ppm Th in BLM carbonatite, 104 ppm Th in phonolite in the central BH, and 83 ppm Th in the Missouri Buttes phonolite (westernmost BH intrusions). In the RH, 20 ppm Th is the highest value in carbonatite from drill core, whereas 49 ppm Th is found in phonolite from a surface sample. Nb content is lower in RH samples (<40 ppm) than in BH samples (mostly <100 ppm, with some phonolites and trachytes between 120-220 ppm).

Barium concentrations are greater in the RH (65-1079 ppm in surface samples of trachyte-phonolite). In central RH drill-core, phonolite contains 23,000 ppm Ba, and carbonatite contains 51,000 ppm Ba. In the BH, Ba concentrations are 1750 ppm in phonolite outcrop, and one BLM carbonatite outcrop contains 30,000 ppm Ba. Higher Ba concentrations in RH rocks appear to be related to assimilation of high-Ba mantle of the Wyoming Archean craton (similar to the Crazy, Highwood, and Bearpaw Mtns., Montana).

Initial ε_{Nd} and $^{87}Sr/^{86}Sr$ isotopic values from the RH are lower than those in most BH samples. Isotope and trace-element contrasts between the RH and BH/BLM reflect differences between the two complexes in (1) age and composition of crust and mantle lithosphere, (2) evolution of magmas, and (3) depth of sampling (*i.e.* emplacement depth).

TOPICAL SESSION:
97. Evolution of REE-Enriched Carbonatite-Alkalic Rock Systems: In Honor of Daniel R. Shawe Ed DeWitt, Central Mineral Resources Team, US Geological Survey, MS 973, Denver Federal Center, Lakewood, CO 80225, Phone: 303-236-5636, edewitt@usgs.gov