GEOLOGY AND MINERAL DEPOSITS OF THE GALLINAS MOUNTAINS (GALLINAS DISTRICT), LINCOLN COUNTY, NEW MEXICO: PRELIMINARY REPORT

Charles S. McLemore, Consultant, Grand Junction, CO 81503  knowlesconsulting@yahoo.com
Virginia T. McLemore, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM 87801  ginger@eis.nmt.edu
Malcolm Bucholtz, Strategic Resources P.O. Box 1216, Regina, Saskatchewan, Canada S4P 3B4  newmexicouranium@gmail.com

ABSTRACT

Rare earth elements (REE) are used in the electronics, automotive and metallurgical industries. Deposits containing REE are found throughout New Mexico. Minimal past production of REE in the 1950s, as bastnaesite, came from the Gallinas district, Gallinas Mountains, Lincoln County. Since then, several companies and the U.S. Bureau of Mines (USBM) have conducted various exploration programs to identify and delineate REE resource potential. Four types of deposits are found in the district: carbonatite, REE-bearing veins, REE-bearing pegmatite, and rare-alkalic igneous rocks; all are associated with Tertiary alkaline to alkalic-calcic igneous intrusions. In 1991-1992, USBM calculated an inferred resource of 0.847 million metric tons with an average grade of 2.95% total REE. Demand of REE, domestically and globally, areas such as the Gallinas district in New Mexico are being re-examined for additional REE potential; preliminary results for the Gallinas district are in this report.

INTRODUCTION

Rare earth elements (REE) are increasingly becoming more important in our technological society and are used in many of our electronic devices. REE include the 15 lanthanide elements (atomic number 57-71), yttrium (Y, atomic number 39), and scandium (Sc) and are commonly divided into two chemical groups, the light REE (La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Er, Tm, Yb, Lu) and, therefore, occur together in nature. Thorium (Th), uranium (U), niobium (Nb) and scandium (Sc) and are commonly divided into two chemical groups, the light REE (La, Ce, Pr, Nd, Sm, Gd, Tb, Dy, Er, Tm, Yb, Lu) and, therefore, occur together in nature. Thorium (Th), uranium (U), niobium (Nb), tantalum (Ta), molybdenum (Mo), zirconium (Zr), rare-earth (REE), Ti, Th, U, Nb, Ta, Mo, Zr, REE, and REE-bearing minerals are found throughout the world. REE deposits in the Gallinas district, Lincoln County, New Mexico, are associated with Tertiary alkaline to alkalic-calcic igneous intrusions. In 1991-1992, USBM calculated an inferred resource of 0.847 million metric tons with an average grade of 2.95% total REE. REE deposits have been reported from New Mexico (McLemore et al., 1995, 1996), but were not considered important exploration targets because the demand in past years has been met by other deposits in the world. However, with the projected increase in demand and potential lack of available production from the Chinese deposits, these areas in New Mexico are being re-examined for their REE potential. One of these areas in New Mexico is the Gallinas mining district, also referred to as the Red Cloud Mining district, in the Gallinas Mountains.

The Gallinas Mountains are in northern Lincoln County where a series of alkaline volcanic rocks, including porphyritic veined trachyte, andesite, and dacite, have been intruded by alkaline igneous rocks (i.e., volcanic equivalent to syenite), anatecite, and andesite, and rhyolite laccoliths, dikes and plugs, have intruded Permian sedimentary rocks belonging to the Abo, Yeso, and Glorieta Formations (Perhac, 1970; Schreiner, 1993). A small amount of bastnaesite ([Ce, La, (CO3)]F with 70-75% total REE oxide content), was recovered during processing for fluorspar. Alteration includes brecciation, silicification, chloritization, and fenitization (Griswold, 1959; Woodward and Fulp, 1991; Schreiner, 1993). Carbonatites are inferred at depth by the presence of carbonatite, brecciation, presence of REE, and similarity of the intrusive rocks and mineralization to areas with carbonatites.

PURPOSE

• Compile and interpret available published and unpublished data from the Gallinas district
• Summarize the geology, geochemistry, resource potential and origin of the mineral deposits in the Gallinas district
• Relate mineral deposits to other REE deposits in New Mexico and elsewhere

REE APPLICATIONS IN INDUSTRY

a) Oil phosphor in cathode-ray tubes (CRT), and liquid crystal displays in computer monitors and televisions
b) REE-bearing communication cables, ceramics, glass for optical filters, and lasers
c) Permanent magnets in appliances, computers, automobiles, communication systems, and nuclear power plants
(d) Urea nitrate in rocket propellants, metalurgic and nuclear medicine
(e) High-purity electrodes in cathode-ray tubes, panels for microscopes and lenses, catalytic converters
(f) Air filters, capacitors, CRT phosphors, microwave filters, glass, oxygen sensors, tubes, lasers, structural ceramics, and semiconductors
(g) High strength aluminum-cadmium alloys, electron tube beam tubes, metallurgical research, electronics, and specialty lighting (Hendricks, 2000)

REGIONAL GEOLOGIC AND TECTONIC SETTING

The North American Cordilleran belt of alkaline igneous rocks (Woodley, 1987; Mutschler et al., 1991; McLemore, 1996). Lindgren (1915, 1933) was one of the first geologists who noted that a belt of alkaline-igneous rocks extends from Alaska and British Columbia southward through New Mexico, Trans-Pecos Texas, and eastern Mexico and that these rocks contain relatively large quantities of fluoride (F), zirconium (Zr), rare-earth (REE), and other elements. Economic mineral deposits found within this belt have produced nearly 13% of the total lode gold production in the United States and Canada (Mutschler et al., 1991).

MINING AND EXPLORATION HISTORY

1881 first mining claims established
1885 early production for copper, silver, and lead
1942-1945 Fe ore produced from American Iron and Red Cliff mines
1942 fluorspar discovered in the district
1945 bastnaesite discovered with fluorspar
1951-1954 fluorspar produced from the Red Cloud and Corner mines
1950s ~142,000 lbs of bastnaesite was produced from Red Cloud mine
1954-1956 NM Copper Co. sold ore near Carrizosos, NM, produced 50,000 lbs of bastnaesite
1978 Phelps Dodge drilled a 532-ft deep hole at the Rio Timo mine
1980-1981 Molycorp, Inc. conducted geochemical survey, geophysical survey, and two drill holes on a magnetic high anomaly (Schreiner, 1993)
1989 Canyon Resources examination
1991-1992 Hecla Mining Co. examination
1992 American Copper and Nickel, Inc. and Romarross Resources
1991-1992 U.S. Bureau of Mines conducted extensive mapping and sampling of the REE deposits (Schreiner, 1993)
2009 Strategic Resources, Inc. staked claims and began exploration

MINERALS PRODUCTION FROM THE GALLINAS MOUNTAINS DISTRICT, NM

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Type</th>
<th>Grade</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bastnaesite</td>
<td>Conqueror No. 9</td>
<td>1954-1955</td>
<td>60</td>
</tr>
<tr>
<td>Bastnaesite</td>
<td>Desert No. 8</td>
<td>1954-1955</td>
<td>40</td>
</tr>
<tr>
<td>Bastnaesite</td>
<td>American Copper</td>
<td>1954-1955</td>
<td>100</td>
</tr>
<tr>
<td>Bastnaesite</td>
<td>Red Cloud</td>
<td>1954-1955</td>
<td>100</td>
</tr>
<tr>
<td>Bastnaesite</td>
<td>County No. 9</td>
<td>1954-1955</td>
<td>60</td>
</tr>
<tr>
<td>Bastnaesite</td>
<td>County No. 11</td>
<td>1954-1955</td>
<td>60</td>
</tr>
</tbody>
</table>

The Gallinas Mountains are in northern Lincoln County where a series of alkaline igneous rocks extend from the Sangre de Cristo Mountains near Raton, southward to the Cordillan Mountains east of El Paso, Texas (North and McLemore, 1986; McLemore, 1996, 2001). Significant mineral production, especially gold and silver, has come from deposits spatially associated with Tertiary alkaline igneous rocks in the New Mexico alkaline-igneous belt (McLemore, 1996, 2001). These mineral deposits in New Mexico have been referred as the Great Plains Margin (GPM) deposits by North and McLemore (1986, 1988) and McLemore (1996).
Chemical analyses are from Schreiner (1993) and this report. Geochemical plots from Schreiner (1993) confirm this hypothesis. These data suggest a crustal source for the igneous rocks. A-type granitoids (Whalen et al., 1987). A-type (anorogenic or anhydrous) granitoids and alkaline volcanic rocks (Frost et al., 2001), and have chemical compositions similar to magmatic-hydrothermal breccia pipe is a better term (Sillitoe, 1985).

The igneous rocks in the Gallinas Mountains are metaluminous to peraluminous, alkaline volcanic rocks (Frost et al., 2001), and have chemical compositions similar to A-type granitoids. Trachyte and latite are possibly related magmatically, but the trachyte could be a separate magmatic event. Detailed dating and geochemical analyses are required to confirm this hypothesis. These data suggest a crustal source for the igneous rocks.

**LOCAL GEOLOGY**

The oldest rocks in the Gallinas Mountains are altered Proterozoic gneisses and granites (exposed in Red Cloud Canyon) that are overlain by Permian arkoses, quartz sandstones, siltstones, shales and limestone of the Abo, Yeso and Glorieta Formations. Tertiary igneous rocks, as stocks and laccoliths, including latite (also trachydacite to trachyanadeite, Le Maitre, 1989), trachyte/phonolite, and rhyolite have intruded the Yeso and Abo Formations. Several magmatic-hydrothermal breccia pipes are hosted in the trachyte and Yeso Formation. Most of these breccia pipes are matrix-supported and are cemented by quartz, fayalite, and hematite along with small crystals of other minerals and rock fragments. However, two breccia pipes at the M and E No. 13 prospect are clast-supported. The mineralized area of the Gallinas Mountains lies in a low magnetic anomaly surrounded by magnetic high anomalies (McLemore, 2010). The classification of breccia pipes is primarily based upon the mechanism of brecciation and the involvement of water, magma, or tectonism (Sillitoe, 1985). Sillitoe (1993) called these breccia pipes intrusive breccias. Intrusion breccias are formed directly from the subsurface movement of magma (Sillitoe, 1985). Magmatic-hydrothermal breccias are formed by the release of hydrothermal fluids from the magma chamber and can include magmatic, meteoric, connate, or ocean waters (Sillitoe, 1985). In the Gallinas breccia pipes, the breccia cement consists of hydrothermal minerals not magma, therefore, magmatic-hydrothermal breccia pipe is a better term (Sillitoe, 1985).

**PETROCHEMISTRY OF THE IGNEOUS ROCKS**

The igneous rocks in the Gallinas Mountains are metaluminous to peraluminous, alkaline volcanic rocks (Frost et al., 2001), and have chemical compositions similar to A-type granitoids (Whalen et al., 1987). A-type (anorogenic or anhydrous) granitoids typically are found along rift zones and within stable continental blocks and are characterized by high concentrations of elements such as Fe, Mg, and Ca, and low concentrations of elements such as Si, Al, and K. The igneous rocks in the Gallinas Mountains are metaluminous to peraluminous, alkaline volcanic rocks (Frost et al., 2001), and have chemical compositions similar to A-type granitoids. Trachyte and latite are possibly related magmatically, but the trachyte could be a separate magmatic event. Detailed dating and geochemical analyses are required to confirm this hypothesis. These data suggest a crustal source for the igneous rocks.

**GEOCHEMISTRY OF THE GALLINAS REE DEPOSITS**

The geochemical data for this area consists of 279 samples that were collected and analyzed for various elements by Schreiner (1993) and by the authors for this report. Geochemical anomaly plots of the Galilas district are shown above. Chondrite values are from Nakamura (1974). Geochemical anomaly maps (below) were constructed using ARCMAF and indicate that the higher concentrations of REE, Cs, Pb, and Au are found along faults filled with Cu-REE-F and F-rich veins and the M and E breccia deposits.

**DESCRIPTION OF GALLINAS DISTRICT**

**LOCAL GEOLOGY**

- Late stage deposition of quartz
- Deposition of the REE-F and Cu-REE-F veins
- Fenitization

**PRELIMINARY CONCLUSIONS**

- The igneous rocks in the Gallinas Mountains are metaluminous to peraluminous, alkaline volcanic rocks, and have chemical compositions similar to A-type granitoids.
- Trachyte and latite are possibly related magmatically, but the trachyte could be a separate magmatic event.
- Detailed dating and geochemical analyses are required to confirm this hypothesis. These data suggest a crustal source for the igneous rocks.

**RECOMMENDATIONS FOR FUTURE STUDIES**

The most important feature of activity in the volcanic rocks in the Gallinas Mountains is the presence of REE mineralization. Detailed mapping, geochemical analyses, and radiometric isotopic analyses are required to understand the source of the REE mineralization and the related magmatic-hydrothermal fluids.

**REFERENCES**


**ACKNOWLEDGEMENTS**

This work is part of ongoing research of the Department of Earth and Environmental Science at New Mexico State University at NMBGMR. Peter Tiffen and Dieter Liao provided technical assistance. This work was funded by the NMBGMR and Stantec Resources, Inc. (U.S. Geological Survey, National Cooperative Geologic Mapping Program, NCGMP, contract 33130-10-010). Steve Eyre provided technical assistance. This work was funded by the NMBGMR and Stantec Resources, Inc. (U.S. Geological Survey, National Cooperative Geologic Mapping Program, NCGMP, contract 33130-10-010). Steve Eyre provided technical assistance. This work was funded by the NMBGMR and Stantec Resources, Inc. (U.S. Geological Survey, National Cooperative Geologic Mapping Program, NCGMP, contract 33130-10-010). Steve Eyre provided technical assistance. This work was funded by the NMBGMR and Stantec Resources, Inc. (U.S. Geological Survey, National Cooperative Geologic Mapping Program, NCGMP, contract 33130-10-010). Steve Eyre provided technical assistance. This work was funded by the NMBGMR and Stantec Resources, Inc. (U.S. Geological Survey, National Cooperative Geologic Mapping Program, NCGMP, contract 33130-10-010). Steve Eyre provided technical assistance. This work was funded by the NMBGMR and Stantec Resources, Inc. (U.S. Geological Survey, National Cooperative Geologic Mapping Program, NCGMP, contract 33130-10-010). Steve Eyre provided technical assistance.