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CRITICAL MINERALS IN SOUTHWEST LARAMIDE PORPHYRY SYSTEMS

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ABSTRACT

Laramide porphyry copper deposits are large, low grade (<0.8% Cu) deposits that contain disseminated copper minerals, breccias, and stockwork veinlets of copper and molybdenum sulfides associated with porphyritic intrusions in Southwestern New Mexico. Critical minerals, such as PGEs, tellurium, indium, germanium, and gallium are recovered from the anode slimes remaining after copper is refined. Detailed age dating, mineralogy, geochemistry, along with geologic mapping could refine the location of critical minerals within specific systems and could identify porphyry systems with elevated critical minerals that could become economic, in addition to the already produced copper, gold and molybdenum.

INTRODUCTION

The modern luxuries and necessities of life require many minerals, and of increased importance are minerals designated as “critical” by the United States Geological Survey (USGS). These minerals are classified as necessary in “National security, economy, renewable energy, and infrastructure” [1]. With an increased focus on “green” and renewable energy recently, many of these minerals will become even more important in the future. For the purposes of this project, the elements and minerals of focus are tellurium, germanium, indium, gallium, and the platinum group elements (PGEs), which include iridium, osmium, platinum, palladium, rhodium, and ruthenium. These elements are recovered from the anode slimes of porphyry copper deposits that are produced after the refinement process for copper [2].

The mines which produce these elements from anode slimes are porphyry copper deposits, which are large, low grade (<0.8% Cu) deposits that are enriched in copper by hydrothermal alteration processes centered around a porphyritic pluton [3]. Porphyry copper deposits produce three quarters of the world’s supply of copper, half the supply of molybdenum, and various other elements such as rhenium and other critical minerals [3]. Recently, Rio Tinto started tellurium production at their Kennecott mine, the only such operation in the United States so far [4]. The southwestern United States and northern Mexico contain many porphyry copper deposits of Laramide age (late Cretaceous to Tertiary), many of which are producing mines. Some of these plutons were dated by the K-Ar method in the 1970s and 80s, and lack high precision $^{40}Ar/^{39}Ar$ ages. Updated geochronology, along with geochemistry, mineralogy, and geologic mapping, will help refine the location and temporal evolution of critical minerals in Laramide porphyry copper systems.

GEOCHRONOLOGY OF LARAMIDE MINING DISTRICTS

The main focus of this project is the refinement of Laramide pluton ages using the $^{40}Ar/^{39}Ar$ dating method. The $^{40}Ar/^{39}Ar$ method is a derivation of the K-Ar method, which measured the naturally radioactive decay of ^{40}K to ^{40}Ar. ^{39}Ar is produced via neutron bombardment of ^{39}K in a nuclear reactor and is proportional to the original concentration of K in the sample. $^{40}Ar/^{39}Ar$ geochronology is more precise and will better constrain igneous activity and mineralization in the SW NM Laramide porphyry province. The districts selected have old K-Ar dates or unpublished $^{40}Ar/^{39}Ar$ ages. The need to update old ages and incorporate new and existing geochronology is necessary to understand the timing of pluton emplacement and mineralization. Below is a table with geochronology on selected districts in SW NM, as well as a map of surface-exposed Laramide age plutons. These districts represent porphyry Cu-Mo-Au deposits, as well as associated skarns, polymetallic veins, and carbonate replacement deposits (CRDs) [5].

Table 1. Laramide mining districts and ages of plutons. Names of districts are from McLemore (2017).

District	Age (Ma)	Method	Reference
Hillsboro	75	$^{40}Ar/^{39}Ar$	McLemore et al. (1999)
Black Hawk	75.5, 72.5	U-Pb, K-Ar	Amato et al. (2017), Hedlund (1980)
Piños Altos	74.4	K-Ar	McDowell (1971)
Eureka and Sylvanite (Little Hatchet Mtns)	71.4	$^{40}Ar/^{39}Ar$	Lawton et al. (1993)
Georgetown	71	$^{40}Ar/^{39}Ar$	McLemore (1998)
Lordsburg	58.5	$^{40}Ar/^{39}Ar$	McLemore et al. (2000)
Santa Rita (Chino mine)	58.3	$^{40}Ar/^{39}Ar$	Heizler et al. unpublished
Fierro-Hanover	57.55	$^{40}Ar/^{39}Ar$	McLemore et al. (1995)
Copper Flat (Grant County)	55.4	K-Ar	NMBGMR unpublished data
Burro Mountains (Tyrone mine)	54.5	$^{40}Ar/^{39}Ar$	Heizler et al. unpublished
Cooks Peak and Old Hadley	38.95	$^{40}Ar/^{39}Ar$	Schwenk unpublished
Camel Mountain – Eagle’s Nest	36.8, 86.3	$^{40}Ar/^{39}Ar$	McLemore et al. (2001), NMBGMR unpublished data
Tres Hermanas	34.65, 50.3	$^{40}Ar/^{39}Ar$, K-Ar	McLemore et al. (2001), Leonard (1982)
San Simon	33.2	$^{40}Ar/^{39}Ar$	McLemore et al. (1995)
McGhee Peak	32.5	K-Ar	Hoggat et al. (1977)
Apache No. 2 and Fremont	30.66	K-Ar	Deal et al. (1978)

Several of these districts (Santa Rita, Burro Mountains, Fierro-Hanover) contain operating or recently operated mines and as such have well constrained geochronology. Other districts, such as Black Hawk, Piños Altos, and Copper Flat have K-Ar or other ages, but lack high precision $^{40}Ar/^{39}Ar$ ages. These districts will be sampled and analyzed using the $^{40}Ar/^{39}Ar$ method for this project to further constrain timing of Laramide intrusion and the potential for critical minerals related to these intrusions in New Mexico.

Correlation of Geochronology with Arc Magmatism

There are at least two pulses of magmatism that have produced plutons: 75-71 Ma and 60-54 Ma. The initial pulse at 75-71 Ma is likely to have been the beginning of arc magmatism in the southwest [6]. The next pulse is at 60-54 Ma, as evidenced by ages for Santa Rita, Burro Mountains, Fierro-Hanover, Lordsburg, and Copper Flat. This latter pulse of plutonic activity is associated with some of the most economic mineralization, and some of the largest mines in the state, such as Freeport-McMoRan’s Chino (including the Continental/Cobre mine) and Tyrone mines. There may be further pulses of magmatism in New Mexico, but the geochronology needs to be further constrained. Some districts (e.g., Cookes Peak, San Simon, Apache No. 2) are younger and could either be associated with Laramide activity or younger Tertiary activity. There may also be younger plutons that overprint Laramide plutons, such as in the Tres Hermanas district with a K-Ar age of 50.3 Ma [7] and a $^{40}Ar/^{39}Ar$ age of 34.65 Ma [8]. Additionally, some districts lack any known geochronology entirely.

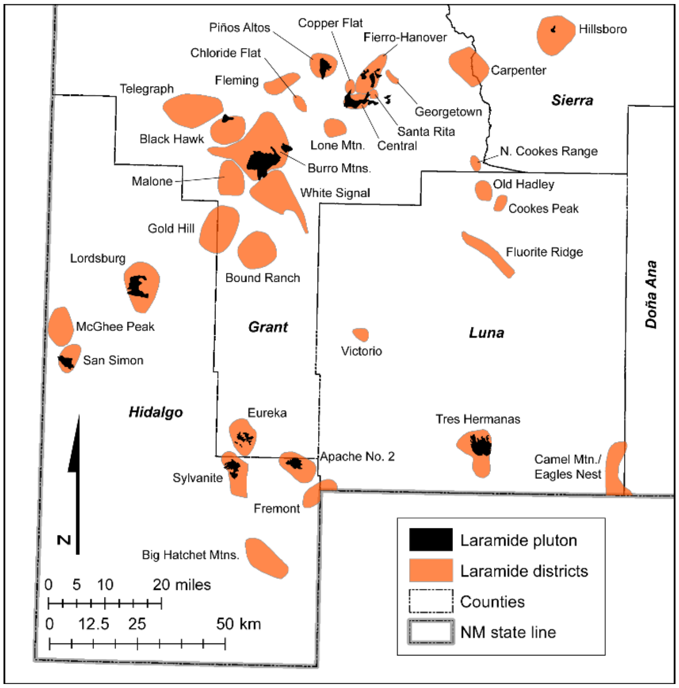

Figure 1. Map of Laramide districts in New Mexico and associated plutons. Districts are from McLemore (2017).

PRELIMINARY CONCLUSIONS

An overview of geochronology data in literature suggests that there are at least two pulses of Laramide magmatism associated with economic mineralization in New Mexico. The initial pulse at about 75 to 71 Ma produced plutons associated with economic mineralization at the Hillsboro, Black Hawk, Piños Altos, Eureka, Sylvanite, and Georgetown districts. A subsequent pulse at 60 to 54 Ma produced plutons at the Santa Rita, Burro Mountains, Fierro-Hanover, Lordsburg, and Copper Flat districts. Other districts have plutons of younger age, and further work needs to be done to constrain the ages of plutons.

FUTURE WORK

The first step to further constraining the ages of Laramide plutons is performing $^{40}Ar/^{39}Ar$ geochronology. Districts to be sampled include any of those listed above, but the Black Hawk, Tres Hermanas, Piños Altos, Georgetown, and the Camel Mountain-Eagles Nest districts will be sampled first due to unique mineralogy (Ag-Co-Ni-As-U veins in the case of Black Hawk [9]), lack of recent $^{40}Ar/^{39}Ar$ dates, or inconsistent results (86.3 Ma for Camel Mountain-Eagles Nest (NMBGMR unpublished data)). Samples collected will have minerals separated and analyzed at the New Mexico Geochronology Research Laboratory (NMGRL) to determine the emplacement age of the plutons, as well as the timing of mineralization types in relation to critical minerals. Additionally, characterization of samples from mineralization in these districts will be performed using petrography, geochemical analyses, and electron microprobe analysis to try and identify the phases which could bear critical minerals. These phases include pyrite, chalcopyrite, pyrrhotite, and magnetite [2]. These analyses will be used to correlate which, if any, critical minerals are associated with which pulses of Laramide magmatism and their associated deposit types and mineralization styles.

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