MINERAL DEPOSITS ASSOCIATED WITH TERTIARY ALKALINE IGNEOUS ROCKS IN NEW MEXICO

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ABSTRACT

Lindgren (1933) was one of the first geologists who noted that a belt of alkaline-igneous rocks extends from Alaska and British Columbia southward into New Mexico, Trans-Pecos Texas, and eastern Mexico and that these rocks contain relatively large quantities of gold, fluorine, zirconium, rare earth elements (REE), and other elements. Since then, the North American Cordilleran alkaline-igneous belt has been explored and exploited for numerous types of mineral deposits, especially gold. In New Mexico, the belt extends from the Sangre de Cristo Mountains near Raton, southward to the Cornudas Mountains, in the northern Trans-Pecos alkaline belt. Significant mineral production in New Mexico, especially gold, has come from deposits found within this belt. The New Mexico deposits have been referred to as Great Plains Margin deposits (GPM), Au-Ag-Te veins, Th-REE veins, alkaline-igneous related gold deposits, porphyry gold deposits, and Rocky Mountain gold province. Mid-Tertiary alkaline to subalkaline igneous rocks are found associated with mineral deposits in these districts and, in New Mexico, consist of seven deposit types: (1) polymetallic epithermal/mesothermal veins, (2) gold-bearing breccia/quartz veins (tellurium), (3) copper, gold, and silver/gold ratios, low silver/gold ratios, unlike 13 million metric tons of 0.9 g/t Au. Production from metric tons of 1.6 g/t Au and the Lukas Canyon skarn deposit is estimated for some U, Nb) epithermal veins.

TABLE 1—Alkaline-mining districts in New Mexico. Names of districts are after Fie and Northrop (1966) wherever practical, but many former districts have been combined and new districts added. The district number refers to the New Mexico Mines Database district number (McLemore et al. 2005a, b). Districts are shown in Figure 2.

TABLE 4—Summary of fluid inclusion and stable isotope data

TABLE 5—Summary of Sr isotope data

TABLE 6—Alkaline-related gold deposits in New Mexico, with reported, historic (non 43-101 compliant) resources

TABLE 7—Reported and estimated base and precious metals production by district.

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INTRODUCTION

The Rocky Mountain alkaline belt is a north-south belt of alkaline-igneous rocks and crustal thickening, roughly coinciding with the Great Plains physiographic margin with the Basin and Range (Rio Grande rift) and Rocky Mountains physiographic provinces. This belt is associated with relatively large quantities of gold, copper, rare earth elements (REE), uranium, and other elements and continues northward into Canada and southward into Mexico (Fig. 1). Mutschler et al., 1985, 1991; Bonham, 1988; Thompson, 1991a; Richards, 1995; McLemore, 1996; Kelley and Luddington, 2002). The alkaline-igneous related mineral deposits in New Mexico have been referred to as Great Plains Margin (GPM) deposits by North and McLemore (1988, 1988) and McLemore (1995, 2001). Alternative classifications by other workers include Au-Ag-Te veins (Cox and Bagby, 1986; Bliss et al., 1992; Kelley et al., 1998), alkali-gold or alkaline-igneous related gold deposits (Fulp and Woodward, 1991a; Thompson, 1991a; Bonham, 1988, Mutschler et al., 1985, 1991; Richards, 1995), porphyry gold deposits, and the North American Cordilleran belt of alkaline-igneous rocks (Woolley, 1987; Mutschler et al., 1991). The purposes of this presentation are to (1) summarize the geology, geochemistry, and mineral production of alkaline-igneous related mineral deposits in New Mexico, (2) discuss the age and formation of these deposits, (3) evaluate compiled data, and (4) comment on the future economic potential of mineral deposits in New Mexico.
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TAS and REE chondrite-normalized plots for the Orogrande rocks
(McLemore et al., 2014b).

**DESCRIPTION OF DEPOSITS IN NEW MEXICO**

**Queretaro district**
- Caldera volcanism 22-28.5 Ma and intrusions 19-32.5 Ma (Zimmerman and McIntosh, 2012)
- Calc-alkali to slightly alkaline, metaluminous to peraluminous intrusions
- WPG (within-plate granites) to VAG (volcanic arc granites), active continental margins to within plate volcanic zones (Pearce et al., 1984; Schandl and Gordon, 2002)
- Low TREE, light REE-enriched patterns with no Eu anomaly
- Calc-alkalic to slightly alkaline, metaluminous to peraluminous

**Lincoln County Porphyry Belt (LCPB)**
- Two pulses of igneous activity, older 30-38 Ma and younger pulse 26-30 Ma (Allen and Ford, 1991)

**Gallinas Mountains district (early pulse at 29.2 Ma)**
- Metasomatic to peraluminous, alkaline rocks
- A-type, WPG (Pearce et al., 1984; Whalen et al., 1987)
- Light REE-enriched chondrite-normalized REE patterns
- Zoned mineralization, REE-Cu-F veins and breccias, REE-bearing Fe hydroxides (McLemore, 2010)
- Fenites contain light REE enriched chondrite-normalized REE patterns (Schandl, 1993)
- Highest Au (1707 ppb) found in breccias (Schandl, 1993; McLemore, 2014)

**Jicarilla district (older pulse at 39.45-40.72 Ma)**
- Alkaline to calc-alkaline, metaluminous to peraluminous
- I or S type granites, VAG, active continental margin (Pearce et al., 1984; Whalen et al., 1987; Schandl and Gordon, 2002)
- Slightly enriched-light REE chondrite-normalized patterns, with no Eu anomaly
- Slightly enriched-light REE chondrite-normalized patterns, with no Eu anomaly

**Negro-Bonito district (26.33 Ma)**
- Alkaline to slightly calc-alkaline, metaluminous to slightly peraluminous to peralkaline
- A-type (some I and S), WPA to VAG, active continental margins to within plate volcanic zones (Pearce et al., 1984; Whalen et al., 1987; Schandl and Gordon, 2002)
- Light REE-enriched patterns with no Eu anomaly
- Lower crust source
- Change from Laramide northeast compression to Tertiary east-west extension
- Th-REE veins derived from magmatic-hydrothermal fluids, low Au

**CONCLUSIONS**
- Generally early calc-alkali followed by younger alkaline volcanism
- Small to medium-sized volcanic fields or porphyry systems, ages 22 to 46 Ma (Table 1)
- Typically emplaced as multiple, compositionally diverse magmas, with periods of varying volumes and wall rock assimilation
- Low Sr isopes, low La/Nb, Zr/Nb suggests primitive mantle magma sources (Table 5)
- Volcanic systems formed during the transition at the end of Laramide subduction (continental arc) and beginning of extension (Rio Grande rift) (Sauer, 1993; McLemore, 1996; Kelley and Liddington, 2002)
- Waning of Laramide compression +3-37 Ma and rifting/extension began at +33-36 Ma (McMillan et al., 2000; Chapin, 2012)
- Different melt regimes exist for Laramide compression and younger rifting/extension: Laramide magmas are derived from the mantle to lower crust, and shifts to intracrustal melting of heterogeneous sources (McMillan et al., 2000; Anthony, 2005)
- Complex, generally older magmatic-hydrothermal breccia pipes and porphyry deposits to generally younger, hydrothermal veins and skarns, involving mixing and cooling of magmatic metawaters and leaching from host rocks (Table 4)
- Structural control
- Generally early base-metal veins followed by gold veins or Th-REE veins. Veins and replacements found in most districts, with high concentrations of gold and/or REE
- Style of mineralization in New Mexico differs from Colorado: Te is found in most of the Colorado districts, but most New Mexico districts have low silver/gold ratios than other districts (North and McLemore, 1988; McLemore, 1996)
- Note that Te could be found in specific zones within New Mexico deposits
- Gold values in alkaline-igneous deposits are generally higher than other deposits in New Mexico and have high gold/base-metal ratios and low silver/gold ratios than other districts (North and McLemore, 1988; McLemore, 1996)
- Deposits of REE are found in several districts, but typically not with gold deposits (Table 1)
- Mineralization potential
  - See Table 2 for known Au historic resources
  - Mo resources remain at Questa and Nogal-Bonito districts
  - REE potential in the Laughlin Peak, Gallinas Mountains, and Comudas Mountains districts
  - Te potential in the Organ Mountains district
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