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Rhenium and Other Trace Elements in Molybdenite from the Christmas Mine Area, Gila County, Arizona

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INTRODUCTION

Rhenium (Re), the third-series transition metal with atomic number 75, is a rare element in the continental crust (0.0001 ppm according to Taylor, 1964), but is concentrated especially in the mineral molybdenite, MoS_2. Molybdenite from a variety of occurrences and mineral deposits in North America (for example, Fleischer, 1959; Giles and Schilling, 1972) and Australia (Riley, 1967; Morgan and others, 1968; and Ayres, 1974) has been analyzed previously and shows a wide range in Re content. Some geochemical trends are apparent: molybdenites from porphyry Cu-Mo deposits have high Re, whereas the content of Re in molybdenites from porphyry or stockwork Mo deposits is low.

Five purified molybdenite samples from the Christmas mine area, Gila County, Arizona, have been analyzed by instrumental neutron activation to determine the variation in Re content within this porphyry copper system. In addition to Re, 13 other trace elements were detected in one or more of the samples.

GEOLOGY OF THE CHRISTMAS DEPOSIT

The Christmas porphyry copper deposit (Eastlick, 1968; Perry, 1969; and Koski, 1979) is centered on a Laramide-age, composite granodioritic stock and dike complex which intrudes Paleozoic carbonate rocks and mafic breccias and flows of the Cretaceous Williamson Canyon Volcanics in the southern Dripping Spring Mountains. The Christmas stock is one of numerous calc-alkaline intrusions emplaced during Late Cretaceous and Paleocene time along regionally important east-west to northwest-southeast-trending fractures. Numerous deposits of gold and base metals occur along this zone northwest of the Christmas mine area (see Banks and Krieger, 1977).

Hydrothermal alteration and mineralization in the Christmas stock and adjacent Williamson Canyon Volcanics can be divided into: (1) early (Stage I) chalcopyrite-bornite (-molybdenite) mineralization and K-silicate (K-feldspar, biotite) alteration, and (2) younger (Stage II) pyrite-chalcopyrite mineralization and quartz-sericite-chlorite alteration (Koski, 1979). Within the contact metamorphic aureole adjacent to the Christmas stock, pure limestone beds in the Naco Limestone are thermally recrystallized to white marble; shale and siltstone are reconstituted to diopsidic hornfels. Andradite and andradite-magnetite skarn are developed along favorable beds adjacent to the central stock. The principal sulfide minerals in skarn and diopsidic hornfels are chalcopyrite, bornite, and pyrite with minor sphalerite, molybdenite and galena.

The molybdenite at Christmas is largely confined to quartz veins cross-cutting intrusive porphyry, mafic volcanic, and altered carbonate, and "paint" along fractures in diopsidic hornfels. X-ray diffraction studies show that vein molybdenite from the Christmas mine area occurs as the hexagonal ($2H_1$) polytype. Although molybdenite is widespread in the Christmas porphyry system, the overall grade of molybdenum mineralization is low, averaging 0.0001-0.002 percent Mo in the igneous rocks and 0.002-0.01 percent Mo in the skarn (D. Cook, written communication, 1978). No molybdenum has been recovered from Christmas ores.

ANALYTICAL METHOD

Molybdenite concentrates (> 99% MoS_2) were produced by handpicking after concentrating pulverized vein material by magnetic and heavy-liquid techniques. Quartz was a minor impurity adhering to molybdenite grains in all samples. Re was determined by instrumental neutron activation analysis following a 15-minute irradiation at 5×10^{13} n/cm^2/sec in the NBS reactor. Measurement of the 155 keV peak of ^{188}Re (half-life = 16.7 hr) was made with a low energy planar Ge detector. Instrumental neutron activation analysis for 21 other elements was performed with a large Ge detector after reirradiating the samples for 1 hour at 5×10^{13} n/cm^2/sec. The analytical error for Re in molybdenite by this method is 1 to 2 percent. Error limits (one sigma) for the other elements, based on counting statistics alone, generally range from 1 to 20 percent.

RESULTS

The analytical results are presented in Table 1, along with sample descriptions. The high Fe and Co in sample 2 and high Co and Zn in sample 3 appear to be anomalous and may reflect the presence of small amounts of other sulfides in the molybdenite concentrates.

Molybdenite from early (stage I) veins cutting the Christmas stock and adjacent volcanic rocks (samples 1 and 2) have the highest Re contents; molybdenite from veins cutting skarn (samples 3 and 4) have the lowest values. The molybdenite from a quartz vein in diabase from the Chilito Canyon area west of the Christmas mine area (sample 5) has an intermediate value, but the vein type is analagous to Stage I at Christmas. The Re content for molybdenites from the Christmas area (range 194-806 ppm, mean 517 ppm) are consistent with values (91-2840 ppm, 720 ppm) reported by Giles and Schilling (1972) for 16 porphyry Cu-Mo deposits in North and South America. The new data presented here support the conclusion drawn by previous workers that molybdenite from Cu-rich porphyry deposits has a relatively high Re content.

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Table 1.

Trace Element Data for 5 Samples of Molybdenite from the Christmas Mine Area, Gila County, Arizona. Results in ppm, Except for Fe, Given in Weight Percent. Analyst: J. Rowe.

Sample No.	1	2	3	4	5
Re	806	677	452	194	455
Fe (%)	0.05	1.22	0.19	0.31	0.66
Co	3.3	52.2	80.0	28.6	6.6
Cr	2.4	3.4	n.d.	4.0	2.4
Cs	0.3	n.d.	n.d.	n.d.	n.d.
Hf	4.0	n.d.	3.7	8.5	4.2
Rb	n.d.	n.d.	n.d.	n.d.	22.0
Sb	0.4	n.d.	0.2	0.6	0.2
Th	n.d.	n.d.	0.3	n.d.	0.2
Zn	8	9	140	27	7
Sc	0.27	0.19	0.14	0.13	0.33
Eu	n.d.	0.13	n.d.	0.10	0.12
Tb	1.60	1.45	n.d.	1.40	1.56
Yb	n.d.	n.d.	n.d.	1.9	n.d.

n.d. = not detected
Analyzed for, but not detected: Ba, Ta, Zr, La, Ce, Nd, Sm, and Lu.

Descriptions of samples:

1. Quartz vein with K-feldspar, molybdenite, chalcopyrite, and minor epidote and chlorite, cutting biotite granodiorite porphyry in the Christmas stock. Surface sample, Christmas open pit.
2. Quartz vein with minor molybdenite, chlorite, and epidote cutting intensely biotitized basalt near the Christmas stock. Drill-core sample, 150 m north of the Christmas open pit.
3. Quartz vein with molybdenite, pyrite, and chalcopyrite cutting a block of skarn within the Christmas stock. Surface sample from the Christmas open pit.
4. Quartz vein with minor molybdenite cutting skarn adjacent to Christmas stock. Surface sample from the Christmas open pit.
5. Quartz vein with chalcopyrite, pyrite, and molybdenite cutting a Precambrian diabase sill. Drill-core sample from Chilito Canyon area, 3.5 km west of the Christmas open pit.