HYDROTHERMAL ALTERATION AND MINERALIZATION IN THE CLIMAX MOLYBDENUM DEPOSIT CLIMAX, COLORADO

Charles E. Sears, Jr.

A thesis submitted to the Faculty and Board of Trustees of the Colorado School of Mines in partial fulfillment of the requirements for the degree of Doctor of Science.

Signed: Charles E. Sears, Jr.

Approved: F. M. Van Tuyl

Golden, Colorado

Date:

Approved: Truman H. Kuhn

Approved: Warren R. Wagner

Gift, The Author

TABLE OF CONTENTS

Page

Page

ILLUSTRATIONS

Page

Plates

A B S T R A C T

The Climax molybdenum deposit is located high in the Front Range at Climax in northeastern Lake County, Colorado. Active operations were started by the Climax Molybdenum Company in 1918. Daily production has increased from 250 tons of 1.0 percent molybdenite to 15,000 to 20,000 tons of 0.4 percent molybdenite at the present time. Molybdenite is the principal ore mineral and, until recently, the only mineral recovered; but now wolframite, cassiterite, pyrite, monazite, topaz, and a concentrate containing titanium and rare earth bearing minerals are also recovered.

The purpose of this investigation was to study the distribution of the ore minerals and to determine the relationship of hydrothermal alteration to mineralization and ore localization.

The ore body is bounded on the west and east by normal faults: the Mosquito and Major faults, respectively. The Mosquito fault parallels the Mosquito Range and separates the Pre-Cambrian granite and schist from the Paleozoic sediments which lie to the west of the Mosquito Range. The Major fault branches from the Mosquito fault to the north of Climax and passes through the eastern side of the ore body. The relationship of the Mosquito fault to the ore body is not clear, although movement has occurred along it since deposition of molybdenite. Molybdenite mineralization does not extend west of the Mósquito fault. Tertiary dikes and sills, which intrude both the pre-Cambrian and Paleozoic rocks, have been displaced by the Mosquito fault.

The form of the ore body, as shown by development and exploration, seems to indicate a domed structure. The highly silicified, or fine grained quartz, zones are domal in form and are underlain and overlain by granite

containing large schist inclusions. The ore zone lies within the granite and laps over and under the quartz zones.

In the ore zone closely spaced quartz veinlets, which carry molybdenite as finely disseminated particles, small hexagonal plates, and leaf-like flakes, cut Early porphyry, pre-Cambrian granite, and schist. The quartz and molybdenite are believed to have been transported and deposited as colloids and immediately crystallized to quartz and molybdenite.

The accessory ore minerals, wolframite, cassiterite, and monazite, are thought to be, at least in part, older than molybdenite. Pyrite is both older and later than molybdenite, and topaz is later than molybdenite.

Hydrothermal alteration extends throughout the Climax ore body. The granite, schist, and Early porphyry show successive alteration effects of argillization, silicification, sericitization, and topazization, in the order given.

Argillization is most conspicuous in the areas of granitic rocks. Allophane is the most pervasive of the argillic minerals although montmorillonite and kaolinite are present along fractures and finely disseminated in the feldspars.

Three phases of silicification exist: (1) a high temperature phase resulting in the highly silicified zone which grades laterally into the moderately silicified zone; (2) a colloidal phase occurring as fissure filling related to the deposition of molybdenite; and (3) minor silicification, accompanying the topaz phase, which resulted in the formation of quartz-topaz veinlets. These cut earlier mineral veins.

Sericitization affects mainly the mica minerals, although the feldspars also are altered. The sericitic alteration apparently is related to the quartz-molybdenite phase of mineralization. Presumably this alteration just preceded, or was contemporaneous with, the deposition of the quartz-molybdenite veinlets. There are indications that some sericitic alteration may have taken place after the deposition of molybdenite.

Molybdenite occurs most frequently in the moderately silicified and highly fractured zones. The quantity of molybdenite present is dependent upon the degree of fracturing. Mineable ore is restricted to the highly fractured zones.

Wolframite is found most frequently in the more silicified parts of the ore body. It occurs in early quartz-pyrite veins which are cut by molybdenite veinlets and in late quartz-topaz veinlets which cut molybdenite veinlets. Some wolframite is associated with quartz veins in the schist and also as finely divided grains between biotite plates in the unaltered to slightly altered schist.

Cassiterite and monazite, which occur in the granite and schist, are abundant where there is copious sericite. The cassiterite in the granite is reddish brown in color and larger grained than that in the schist. The cassiterite in the schist occurs as small rounded bleb-like grains, usually dark straw-yellow in color. The difference between the cassiterite that occurs in the granite and that which occurs in the schist is attributed to different periods of mineralization.

The Early porphyry is composed of altered feldspars and rounded quartz eyes. The feldspars are partially albitized and altered, and only faint remnants of their original character remain. The eyes of quartz consist of several irregular quartz grains with diverse optical orientation. The Early porphyry is considered to be the product of partial assimilation and alteration of the Silver Plume granite by ascending hydrothermal solutions of Tertiary age resulting in a rock with a porphyblastic texture.

This investigation indicates the need for a more detailed X-ray, spectro-chemical, and chemical study of the Climax molybdenum deposit.

Such a detailed study would help to determine more accurately: (1) the amount and types of the several clay minerals present; (2) the relationship and importance of argillic and sericitic alteration; (3) the age relationships of wolframite, cassiterite, and monazite; (4) the relationship of Na_2O, K_2O, and CaO to alteration and mineralization; and (5) the occurrence and association of the radioactive and titanium-bearing minerals.