TEI-601

GEOLOGY OF URANIUM AND ASSOCIATED ORE DEPOSITS, CENTRAL PART OF THE FRONT RANGE MINERAL BELT, COLORADO

By P. K. Sims and others

VLS-2000

Twomal

ouc

Trace Elements Investigations Report 601

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TEI-601

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGY OF URANIUM AND ASSOCIATED ORE DEPOSITS, CENTRAL PART OF THE FRONT RANGE MINERAL BELT, COLORADO

by

P. K. Sims and others

August 1959

Trace Elements Investigations Report 601

*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

USGS - TEI-601

GEOLOGY AND MINERALOGY

Distribution	No. of copies
Division of Raw Materials, Austin	1
Division of Raw Materials, Casper	4
Division of Raw Materials, Denver	1
Division of Raw Materials, Grants	2
Division of Raw Materials, Lima, Peru	1
Division of Raw Materials, Salt Lake City	3
Division of Raw Materials, Washington	3
Grand Junction Operations Office	6
Technical Information Service Extension, Oak Ridge	6
U. S. Geological Survey:	
Alaskan Geology Branch, Menlo Park	1
Foreign Geology Branch, Washington	1
Fuels Branch, Denver	4
Geochemistry and Petrology Branch, Washington	1
Geophysics Branch, Washington	1
Mineral Deposits Branch, Washington	6
TEPCO, Denver	2
TEPCO, Washington	2
	45

GEOLOGY OF URANIUM AND ASSOCIATED ORE DEPOSITS, CENTRAL PART OF THE FRONT RANGE MINERAL BELT, COLORADO

(Includes Central City, Idaho Springs, Lawson-Dumont-Fall River, Freeland-Lamartine, and Chicago Creek mining districts)

by

P. K. Sims and others

Abstract

The Central City district and adjoining mining areas in the central part of the Front Range mineral belt have supplied small quantities of uranium ore intermittently since the discovery of pitchblende at Central City in 1871. During the early years of development the uranium production from the region was of national importance, and until 1951 the region was this country's principal domestic source of pitchblende. In recent years, however, the production has been insignificant although the search for uranium has been greater than at any previous time. The pitchblende occurs as a local minor constituent of gold- and silver-bearing base-metal sulfide veins, chiefly valuable for their gold content, which have yielded ores valued at about $200 million.

The mining districts of the central part of the Front Range mineral belt are in a terrane of complexly folded Precambrian crystalline rocks, which constitute the core of the Front Range, and are near intrusive centers of porphyritic igneous rocks of early Tertiary age. The Precambrian rocks are an interlayered and generally conformable sequence of gneissic, granitic, and pegmatitic units. The Tertiary intrusive rocks include a wide variety of rocks ranging in composition from granodiorite porphyry to alaskite porphyry. In general, the older Tertiary intrusive rocks occur as small irregular-shaped plutons, whereas the younger rocks form long narrow dikes.

Although most of the Precambrian rocks have a low natural radioactivity, a local phase of metasedimentary biotite gneiss, two varieties of pegmatite, and biotite-muscovite granite are abnormally radioactive. Except for one variety of pegmatite that contains uraninite, the radioactivity results largely from thorium and its disintegration products in the minerals monazite and xenotime.

The Tertiary igneous sequence is one of the most radioactive groups of intrusive rocks in the world. The radioactivity of quartz bostonite porphyry--the most radioactive rocks of the sequence--is 15 to 25 times as great as the average granitic rock, and results from both thorium and uranium, which according to George Phair of the Geological Survey occur largely in primary zircon.

The structural features of the region are of Precambrian and Laramide age. The Precambrian rocks are complexly folded as a result of two periods of Precambrian deformation. The dominant folds trend northeast and were formed during an early period of plastic deformation, which was accompanied by the development of migmatites and the intrusion of granodiorite. Minor folds that trend about N. 55° E. and which are particularly abundant in the southeastern part of the region were formed by a later deformation that occurred after the formation of the youngest Precambrian rocks. The younger deformation was partly plastic and partly cataclastic. Some faults may have formed late in Precambrian time, but this has not been proved.

The dominant Laramide structures are faults, and these can be divided into six sets. Faults that trend northwest and north-northeast and locally contain siliceous breccia "reefs" and low-angle faults related to the northwest-trending set are early Laramide (or older) in age; faults that trend northeast, east-northeast, and east developed after the emplacement of all the intrusive rocks except the youngest, biotite-quartz latite porphyry, and are late Laramide in age. With few exceptions the faults have a dominant horizontal relative motion of one block to the other, but displacements are small except along some of the persistent early northwest-trending faults.

The ore deposits in the mining districts of the region are gold-, silver-, copper-, lead-, zinc-, and uranium-bearing veins that formed as hydrothermal fissure fillings in the faults. The structure, mineralogy, and texture of the veins are similar to those described by Lindgren as mesothermal. The veins range from single, well-defined filled fissures to complex, branching lodes consisting of subparallel fractures, loops, and "horsetailing" fractures; in general they are 1 to 2 feet in width, the lower figure being the more common. The principal ore minerals are sulfides and sulfosalts of iron, copper, lead, and zinc; pitchblende is a local constituent. Quartz is the dominant gangue mineral, but carbonates of the calcite group, fluorite, and barite are present in some veins.

The veins in the region differ in quantitative mineralogy, and they can be classified into two main types, one characterized by dominant pyrite and the other by dominant galena and sphalerite. The distribution of veins of the two contrasting types indicates a regional concentric zonal arrangement of the ores around a major center of mineralization. A large irregular core area (central zone) of pyrite type veins, a few of which contain substantial amounts of copper minerals, is surrounded by a broad outer area (peripheral zone) of galena-sphalerite type veins; transitional veins are pyrite type veins that contain galena and sphalerite as well as copper minerals and occur within an intermediate zone.

Uranium occurs locally in veins of different mineralogic types throughout much of the region, but it is abundant in only a few veins. Of a total of 141 localities known to contain concentrations of uranium, 53 mines including 16 that have produced uranium ore contain selected material that assays .10 percent uranium or better. The remainder of the localities are not known to contain material of ore grade. Although uranium-bearing veins are widely scattered, a large proportion of the occurrences and most of the minable deposits are in an area of less than a square mile in the Central City district.

Pitchblende, a black oxide of uranium, is the primary uranium mineral in the veins. Oxidation of the pitchblende has yielded a limited variety of hexavalent uranium minerals, which are hydrous uranium phosphates, silicates, sulfates, and carbonates. The most abundant secondary minerals are torbernite, autunite, and kasolite.

The pitchblende varies from hard black dense material with a pitchy luster to soft porous sooty material with a dull luster. And all gradations between these extreme types exist. The hard pitchblende appears massive, but characteristically has a colloform texture and occurs in spheroidal forms, vein forms, pellets, and rarely "cellular" or dendritic forms. The sooty pitchblende is loosely aggregated, and little is known of its texture. The change from a hard dense mineral to a sooty material is the result of oxidation, and is accompanied by a decrease in the unit cell dimension of pitchblende and a loss of definition of X-ray diffraction powder patterns.

The pitchblende contains a distinctive suite of minor elements which can reasonably be inferred to occur in the mineral structure. Spectrographic analyses indicate that pitchblende from the Central City district and the Lawson area is relatively rich in zirconium, and probably in molybdenum and tungsten; all pitchblende concentrates contain yttrium, and many also contain other rare earth elements. Pitchblende concentrates from Fall River are nearly devoid of zirconium but contain substantial nickel and some cobalt. The nickel and cobalt occur in inclusions of foreign minerals in the pitchblende.

The pitchblende was deposited early in the sequence of vein filling, essentially contemporaneous with quartz and sparse early pyrite, but before the deposition of base-metal sulfides and sulfosalts. In the Central City district pitchblende was deposited during the first of three distinct stages of mineralization, and preceded a pyrite stage and base-metal stage mineralization; but at Fall River it appears to have been an early local variant of pyrite stage mineralization.

The pitchblende occurs locally in all fracture sets as small lenses, pods, or stringers, or rarely as larger ore shoots. The margins of the ore bodies are sharp, and the intervening vein material commonly is nearly devoid of uranium. Most ore bodies contain only a few tens to a few hundred pounds of ore, but some of the larger shoots contain as much as 50 tons of ore. The bodies commonly are high in grade but much narrower than mining widths, and accordingly the grade of the shipping ore depends upon the care taken in mining and sorting.

As the pitchblende was deposited as fillings of open spaces, it was localized largely by structural features that produced openings along the fissures; but other factors of importance were proximity of the openings to the source of the ore-forming fluids and, perhaps locally, the presence of mafic wall rocks along the vein-fissures.

In contrast to the gold- and silver-bearing sulfide ores, the pitchblende deposits do not appear to extend over long vertical distances, and they rarely can be mined profitably over a vertical range of more than 500 feet. At Central City all the known valuable deposits are within 500 feet of the surface.

The upper parts of pitchblende-bearing veins have been altered by surficial waters and atmospheric gases. Uranium was leached from pyrite type veins; but an assemblage of hexavalent secondary uranium minerals was formed by the oxidation and solution of uranium in the primary pitchblende from galena-sphalerite type veins. The secondary uranium minerals occur in the original vein with limonite and as disseminations and fracture coatings in wall rock adjacent to the originating vein. Sooty pitchblende occurs at the interface between the unoxidized and the oxidized parts of veins. At most localities secondary uranium minerals do not extend below a depth of 150 feet.

Because of the close spatial and temporal association of the ore deposits and Tertiary igenous rocks and substantiating mineralogical and chemical data, we infer that the uranium as well as the associated sulfide ore deposits were derived from the magmas that yielded the Tertiary igneous rocks. Uranium generally was a sparse constituent in the ore-forming fluids, but in certain environments, as at Central City, substantial quantities probably were derived from local, shallow crystallizing quartz bostonite porphyry dikes. These fluids mingled with the ore-forming fluids from the main deep-seated source to yield deposits of economic value. These deposits generally were formed near the separate dike sources and many are within 500 feet of a presumed source.

The uranium-bearing ore bodies that have been found in the region are small but generally high in grade. There is little reason to expect the discovery of bodies that are larger than those previously mined, and accordingly, future production of uranium from this region can be expected to come from scattered small pods and ore shoots distributed through the uranium-bearing veins. These bodies can be recovered most economically during the mining of precious- and base-metal ores.