DESCRIPTIVE MODEL OF THORIUM-RARE-EARTH VEINS

By Mortimer H. Staatz

BRIEF DESCRIPTION

SYNONYM: Rare-earth-thorium veins.

DESCRIPTION: Various thorium and rare-earth minerals in a quartz-potassium feldspar-iron-oxide gangue in veins 1 to about 1,330 m long and less than 1 cm to about 16 m thick.

TYPICAL DEPOSITS: Last Chance vein, Lemhi Pass district, Montana (Staatz, 1979); Little Johnnie vein, Powderhorn district, Colorado (Olson and Wallace, 1956); vein no. 12, southern Bear Lodge Mountains, Wyoming (Staatz, 1983); Wet Mountains area, Colorado (Armbrustmacher, 1988).

RELATIVE IMPORTANCE: A future thorium resource. Highest grade thorium resource in the United States, second largest total resource of thorium (Staatz and others, 1979). Rare earths important byproduct in some deposits; in others, the principal product.

COMMODITIES: Th, rare earths (mainly light rare earths, but at Laughlin Peak, New Mexico, the heavy rare earths most important).

OTHER COMMODITIES: None.

ASSOCIATED DEPOSIT TYPES (*suspected to be genetically related): Disseminated rare-earth minerals in both massive carbonatites and carbonatite dikes; example: one of the world's largest rare-earth deposits in a massive carbonatite at Mountain Pass, California (Olson and others, 1954).

REGIONAL GEOLOGIC ATTRIBUTES

TECTONOSTRATIGRAPHIC SETTING: Commonly associated with diverse suites of alkaline rocks and carbonatites. Thorium-rare-earth veins generally occur in an outer ring around alkaline rocks (fig. 1). May be as far as 16 km beyond outer limits of the alkaline rocks. Veins most common in the eastern part of the Cordilleran belt associated with continental crustal rocks (Staatz and Armbrustmacher, 1982).

REGIONAL DEPOSITIONAL ENVIRONMENT: Veins formed along fractures in brittle rocks. Vein fluids commonly traveled many kilometers before deposition. In a few areas, such as the Powderhorn district (Olson and Hedlund, 1981), all related igneous rocks are exposed. From the center, igneous alkaline rock complex surrounds a massive carbonatite and is bordered by fenite. Carbonatite dikes intrude outer part of alkaline rocks and neighboring country rock. Thorium-rare-earth veins intruded into an outer zone (fig. 1).

AGE RANGE: Host rock for veins: mainly Precambrian, but in several areas is Cretaceous and Tertiary. Veins: in Powderhorn and Wet Mountain districts, Colorado, formed between very late Precambrian to Ordovician (Olson and others, 1977); in Lemhi Pass district, Idaho and Montana (Staatz, 1972), Bear Lodge Mountains, Wyoming (Staatz, 1983), and Laughlin Peak area, New Mexico (Staatz, 1985), formed in Tertiary.

LOCAL GEOLOGIC ATTRIBUTES

HOST ROCKS: Hard brittle rocks. Rocks include Precambrian quartzite, hornblende schist, gneiss, granite; Upper Cretaceous Dakota Sandstone; Tertiary trachyte, phonolite, and intrusive breccia.

ASSOCIATED ROCKS: Alkalic rocks, carbonatites, fenites.

ORE MINERALOGY: principal ore minerals in most deposits: thorite±monazite. Associated minerals: ±brockite±allanite±bastnaesite. Exceptions: (1) Bear Lodge Mountains, Wyoming, no thorite, principally monazite±brockite±bastnaesite; (2) Laughlin Peak area, New Mexico, neither thorite nor monazite, principally either (a) brockite + xenotime or (b) thorium- and rare-earth-bearing crandallite.

GANGUE MINERALS: Principal minerals: quartz+iron oxides (goethite and (or) hematite)±potassium feldspar. Minor minerals: ±barite±apatite±magnetite ±rutile±anatase±zircon (Staatz, 1974).

STRUCTURE and ZONING: Veins usually fine grained and commonly heavily stained with iron oxides±manganese oxides. Mineral zoning unknown.

ORE CONTROLS: Large alkaline rock body or bodies, whose magma was source of vein fluids within about 20 km of veins (Staatz, 1974). Joints and small faults that served both as conduits for ore fluids and as sites of deposition.

ISOTOPIC SIGNATURES: Unknown.

FLUID INCLUSIONS: Unknown.

STRUCTURAL SETTING: All ore in tabular veins.

ORE DEPOSIT GEOMETRY: Veins of potential economic interest range in length from about 60 to about 1,330 m and in thickness from about 0.3 to about 16 m. Veins may strike in almost any direction. Dips of all veins steep.

ALTERATION: Iron minerals, where present, altered to goethite±lepidocrocite±hematite. Clay minerals not common; thorite often metamict, sometimes narrow zone of fenitization around vein.

EFFECT OF WEATHERING: Probably aided in forming iron-oxide minerals.

EFFECT OF METAMORPHISM: Not applicable.

GEOCHEMICAL SIGNATURES: Some enrichment of Th and rare earths in alkaline igneous rocks. Th tends to disperse rapidly in stream sediments short distances below veins (Staatz and others, 1971). Heavy metals in stream sediments not diagnostic.

GEOPHYSICAL SIGNATURES: Radiation due to thorium used to locate most veins. Generally located by hand-held geiger counter or scintillometer. Most veins too narrow and (or) poorly exposed to locate with airborne radiation counters.

OTHER EXPLORATION GUIDES: Unknown.

OVERBURDEN: Most known veins have some part exposed at surface. Veins have been traced from original exposure under as much as 10 m of overburden.

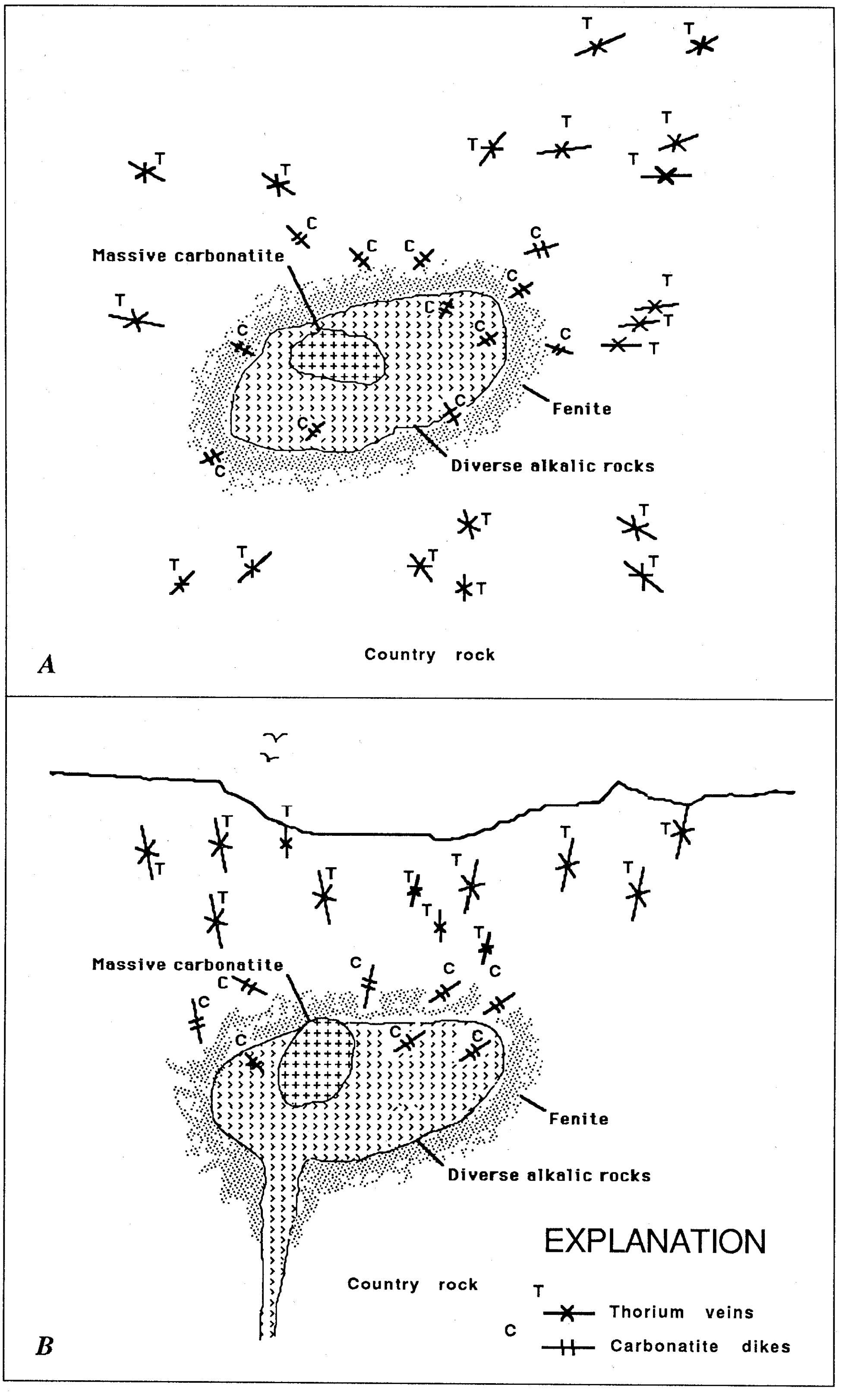

Figure 1. Idealized model showing relationship of thorium-rare-earth veins to alkalic rocks and carbonatites. *A*, Plan view. *B*, Cross-section view.

GRADE AND TONNAGE MODEL OF THORIUM-RARE-EARTH VEINS

By James D. Bliss

COMMENTS Definition of deposits for thorium-rare-earth veins used for this model is subject to several types of complications. Definition of vein-type deposits is never an easy task, since veins and mines exhibit various types of spatial relationships. Reports about thorium-rare-earth veins also show veins and mines using different scales. Some of the veins have been worked by small-scale mining. The majority of the veins are unmined. Production data are usually not available. Data on reserves, if known, are also not available. Production grades are not known. In some cases the distinction between carbonatite veins and thorium-rare-earth veins is unclear, and thus the model may contain carbonatite veins in error. To develop a model, several rules were established: (1) grades were estimated using the median values reported from samples taken from the veins; (2) when possible, veins were treated as a single deposit if they occurred within 1 km of each other; and (3) tonnage was estimated using median vein widths, lengths, and depths (depths estimated as 2.5 times length). Rules were applied when possible; in some cases, deposits were not used, since the rules could not be clearly applied. Thorium-rare-earth veins in the Powderhorn and Mountain Pass districts were considered, but data were found inadequate for estimation of grades and tonnages for veins using the stated rules. Some districts with closely spaced veins are treated as a single deposit. The model is probably biased in ways undefined, since none of the data are from deposits worked to exhaustion. See appendix B for locality abbreviations. See introduction for explanation of the grade and tonnage model as shown in figures 2–4.

DEPOSITS

Name	Country
Apex	USID
Beardsley	USCO
Beaverhead	USMT
Black Bear No. 2	USID
Black Bull No. 3	USID
Black Rock	USMT
Black Rock	USID
Buffalo	USID
Cage No. 12	USID
Capitan Mountain	USNM
Contact	USID
Cottonwood	USAZ
Deer Fraction 1A	USID
Elkhorn	USMT
General Ike	USCO
Haputa Ranch	USCO

DEPOSITS

Name	Country
I&L	USAK
Last Chance	USMT
Lone Star No. 2	USID
Lucky Horseshoe	USID
Nellie B	USID
Paystreak	USAK
Quartzite	USAZ
Reactor	USMT
Schwarz Ranch	USCO
Silver Queen 38A	USID
Silver Queen 52B	USID
ThO2	USID
Tuttle Ranch	USCO
Unnamed property	MXCO
Wonder	USID
Wonder No. 18-Little Dandy	USID

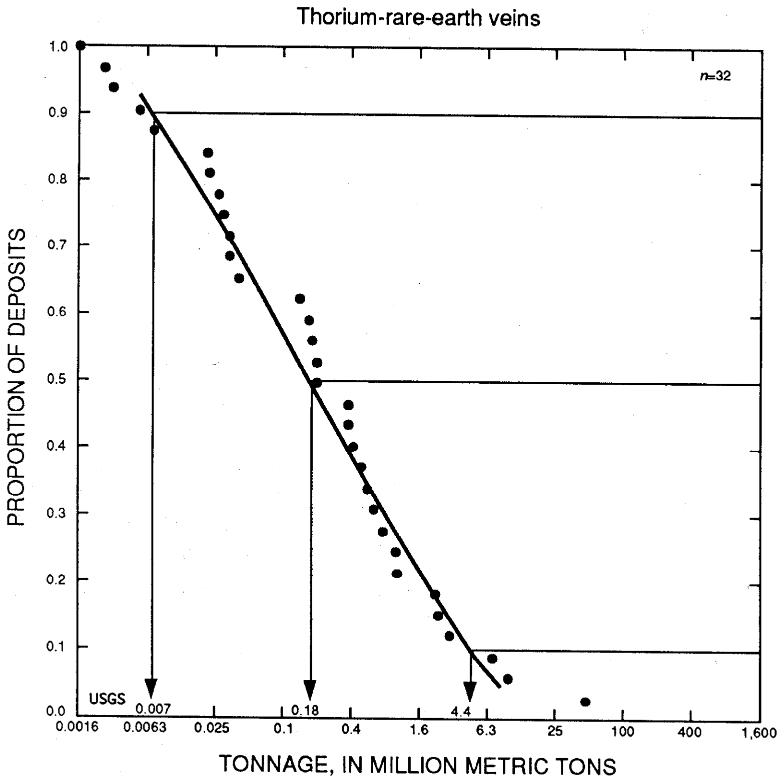

Figure 2. Tonnages of thorium-rare-earth veins.

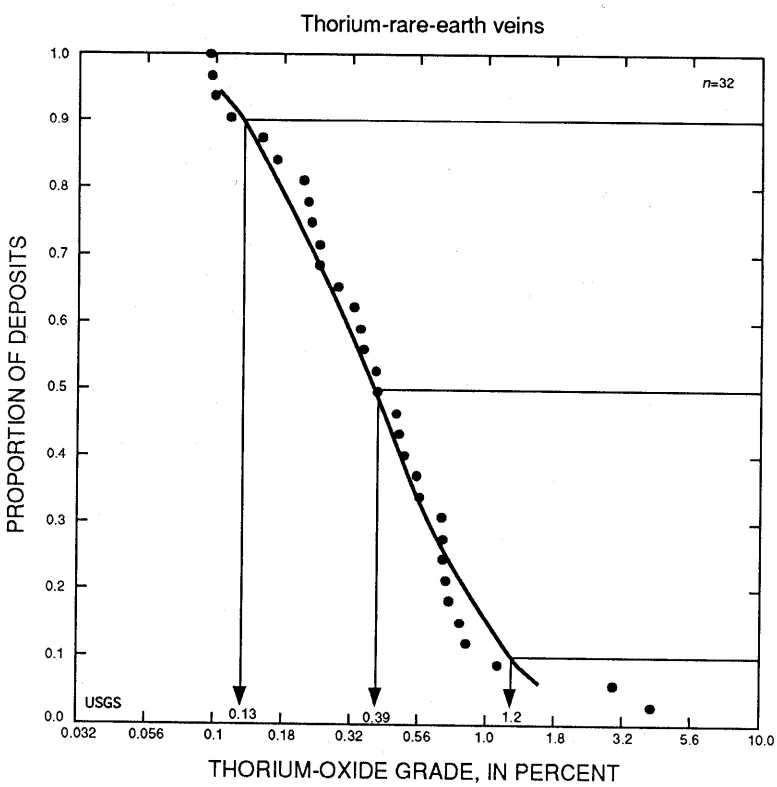

Figure 3. Thorium-oxide grades of thorium-rare-earth veins.

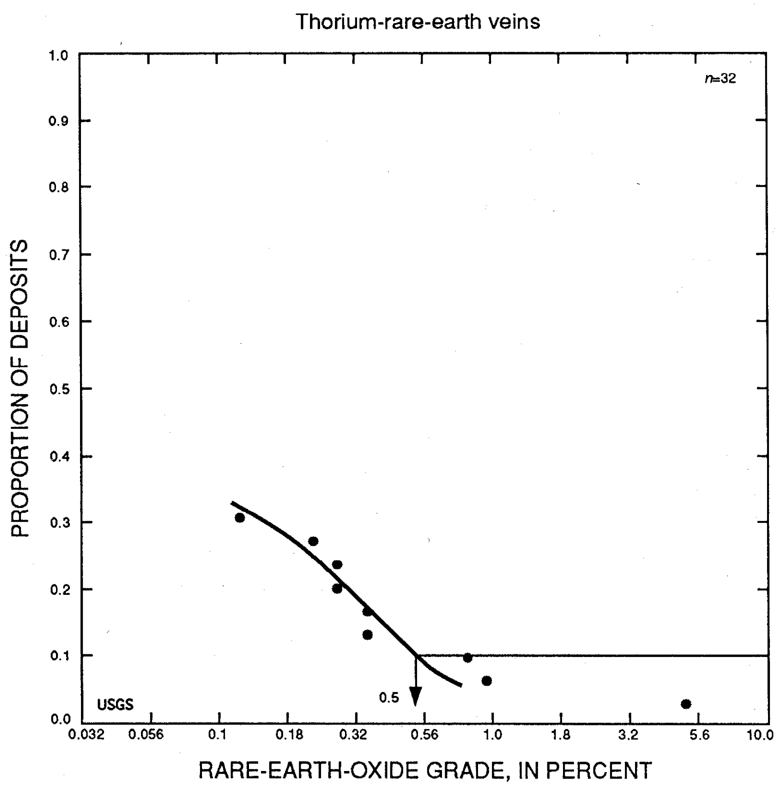

Figure 4. Rare-earth-oxide grades of thorium-rare-earth veins.