have been extruded from several major centers that form an east-facing arc (Staatz and Carr, 1964, p. 117 and pl. 6). This arc does not coincide with the inferred outline of the Thomas caldera (fig. 2), but perhaps it reflects the ring-fracture zone of another caldera nested closely with the Thomas caldera. Small plugs of alkali rhyolite south of the south boundary of the Thomas caldera appear to be in part related to faults radial to the caldera.

Young flows of basalt, and some flows of alkali rhyolite, appear not to be related to the positions of the calderas. This is noticeably true for flows of rhyolite and basalt at Smelter Knoll 15 miles south of the Keg Mountains, south of the area shown in figure 1. I infer from this that the topaz-bearing alkali rhyolite and the basalt were generated by a mechanism unrelated directly to caldera formation. The caldera structures, however, provided paths of later emplacement of alkali rhyolite and basalt magmas.

ORE DEPOSITS ASSOCIATED WITH THE THOMAS CALDERA

Many ore bodies have been mined around the periphery of the Thomas caldera. Most significant production has been of manganese, fluorspar, uranium, and beryllium during three major periods of activity.

From 1925 to 1953 about 72,500 long tons of manganese ore averaging 25 percent manganese was produced from the Detroit district (Crittenden and others, 1961, p. 493) which lies in the Drum Mountains within about 2 miles south of the south boundary of the Thomas caldera (fig. 2). Manganese oxide ore was produced from weathered replacement bodies of manganese carbonate in two 20-foot beds of Cambrian dolomite. The replacement bodies formed along faults near small intrusives of quartz monzonite porphyry, and the manganese carbonate deposits are younger than the intrusive rocks. The ore bodies formed by weathering to manganese oxides within 100–200 feet of the surface (Crittenden and others, 1961). Minor amounts of copper, gold, bismuth, and silver were produced from the district prior to 1925 (Crittenden and others, 1961, p. 515; Dasch, 1964, p. 140). In recent years mining companies have prospected for disseminated copper in some of the intrusives in the district.

During 1943–52, about 75,000 short tons of fluorspar was produced from what was then called the Thomas Range fluorspar district (Staatz and Osterwald, 1959, p. 1) which lies in Spor Mountain within about 2 miles west of the west boundary of the Thomas caldera (fig. 2). Fluorspar was mined principally from oval to irregular pipes of claylike and pulverulent masses or boxworks consisting of 65–95 percent fluorite in shattered zones in dolomite or volcanics (Staatz and Osterwald, 1959, p. 1–2; 48–50) (fig. 2). Fluorspar deposits formed after most of the volcanic rocks were emplaced. At least 0.05 percent uranium was present in many of the fluorspar pipes, particularly those at the south end of Spor Mountain, but was not recovered (Staatz and Osterwald, 1959, p. 1). Mining of fluorspar has recently started again in the district.

From 1956 to 1961 the Yellow Chief uranium deposit, purported to contain in the order of 100,000 tons of ore, produced uranium ore averaging about 0.2 percent U_3O_8 (Bowyer, 1963, p. 19). The deposit is in The Dell, virtually on the ring fracture zone at the west boundary of the Thomas caldera (fig. 2). The ore, mined largely in an opencut, consisted of chiefly beta-uranophane in water-laid tuff, volcaniclastic sandstone, and conglomerate made up of fragments of mostly volcanic rocks and some carbonate rocks (Bowyer, 1963, p. 17, 19). The host rock is somewhat similar to the water-laid tuff of the youngest volcanic group in the Thomas Range. The ore was formed after most of the volcanic rocks in the district were deposited.

In 1969 opencut mining of extensive deposits of beryllium ore was started in the Spor Mountain district, which includes the area of earlier fluorspar (Thomas Range district) and uranium mining. The beryllium deposits, probably amounting to about 15 million tons of ore averaging 0.5 percent BeO (Griffitts, 1964, p. 75), lie within about 5 miles west of the west boundary of the Thomas caldera (fig. 2). The deposits are very large (the largest has a strike length of 2.5 miles), tabular, nearly concordant bodies of hydrothermally altered water-laid tuff (vitric tuff—Staatz and Carr, 1965) containing bertrandite, about 5 percent fluorite, 0.7–0.9 percent manganese oxide, about 0.014 percent uranium, and small amounts of lithium, lead, zinc, tin, and tungsten (Shawe, 1968, p. 1153–1155). The deposits are younger than the rhyolite that overlies the mineralized water-laid tuff (Williams, 1963, p. 54).

Although the known ore deposits are distributed around the southern and western periphery of the Thomas caldera and hence possibly are related to igneous rocks of the caldera cycle, the young age of all the deposits suggests instead that they are closely related to the topaz-bearing alkali rhyolites. The common association of manganese, fluorine, uranium, and beryllium, both in the ore deposits and in the topaz-bearing rhyolite, also suggests a common genesis. Staatz and Griffitts (1961, p. 948–949) proposed that the ore deposits formed by escape of mineralizing solutions from buried magma of the type that was extruded as rhyolite. Apparently the caldera provided a favorable structural environment for both intrusion of rhyolite and related mineralization. Only about a third of the periphery of the caldera is now exposed; the remainder, which is covered by late rhyolite flows or Quaternary alluvium, may well contain undiscovered deposits of manganese, fluorspar, uranium, and beryllium. The covered ring-fracture zones of the Keg and Desert calderas offer similar possibilities. Perhaps other structures near alkali rhyolite centers, but not closely related to the calderas, offer potential sites for deposits of manganese, fluorspar, uranium, and beryllium, particularly where favorable host rocks are available.

The ore deposits near the margins of the Thomas caldera are all relatively young and were formed in a near-surface environment. If the interpretation is correct that the mineralizing fluids were derived from underlying alkali rhyolite magma chambers, the fluids must have traversed rocks in deeper zones and may have mineralized them. Staatz and Griffitts (1961, p. 948–949) indicated a plausible depth-zoning relation, with the fluorspar pipes occurring in a central zone of solution flow and beryllium deposits occurring farther outward; the latter formed where solutions no longer carried fluorine sufficient to complex the beryllium. This same reasoning implies that deeper zones may also be worthy of exploring. Metals that may be present at depth are those that occur in minor amounts at the surface, such as copper, gold, silver, lead, and zinc, or those that occur in minor but abnormally high amounts in the alkali rhyolite, such as lead and tin.

The aeromagnetic data presented in figure 2 indicate possible favorable areas for exploration. Beryllium, fluorspar, and uranium mines at the west edge of the Thomas caldera are grouped on the southwest flank of a magnetic high of 2,100 gammas. Manganese deposits at the south edge of the caldera are grouped on the southeast flank of a magnetic high of 2,100 gammas and extend southeastward across a magnetic high of 2,000 gammas. Perhaps the areas of these magnetic highs warrant further exploration, as do magnetic highs of 2,200 gammas at the north edge of the Thomas caldera and of 2,300 gammas at the east edge of the caldera where no mineral deposits are known. Possibly the magnetic highs of 2,200, 2,400, and 2,500 gammas in the cores of the Thomas, Keg, and Desert calderas, respectively, where no mineral deposits are known at the surface, also justify exploration in their vicinities. Magnetic lows of 2,100 gammas each at the northwest edge of the Keg caldera and at the east edge of the Desert caldera may represent areas of sulfide alteration below the surface that are favorable targets for exploration. I emphasize that the magnetic anomalies have only relative significance, and any exploration based on them should be guided also by all available geologic information.

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