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GEOLOGY AND ORE DEPOSITS OF THE MC DERMITT CALDERA, NEVADA-OREGON

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ABSTRACT

The McDermitt caldera is a Miocene collapse structure along the Nevada-Oregon border. The oval-shaped caldera is bounded by arcuate normal faults on the north and south and by rhyolite ring domes on the west.

Precollapse ash-flow tuffs exposed within the south caldera rim consist of three cooling units and are peralkaline in composition. Refractive indexes of nonhydrated glasses from basal vitrophyres of the units range from 1.493 to 1.503 and are typical of comendites. Post-collapse intracaldera rocks consist of tuffaceous lake sediments, rhyolite flows and domes, and ash-flow tuffs.

Within the caldera are the mercury mines of Bretz, Cordero, McDermitt, Opalite, and Ruja and the Moonlight uranium mine. The mercury mines are adjacent to ring fracture faults, and the uranium mine and other uranium occurrences are located within rhyolite ring domes. Fluid inclusions in quartz indicate a deposition temperature of 340°C for the uranium deposit and 200°C for the mercury deposits. The mercury deposits formed at shallow depth by replacement of lakebed sediments and volcanic rocks.

INTRODUCTION

The McDermitt caldera is a Miocene collapse structure along the Nevada-Oregon border approximately 200 miles (322 km) northeast of Reno, Nev. (fig. 1). It is oval shaped with a diameter of 28 miles (45 km) in a northerly direction and 22 miles (35 km) in an easterly direction.

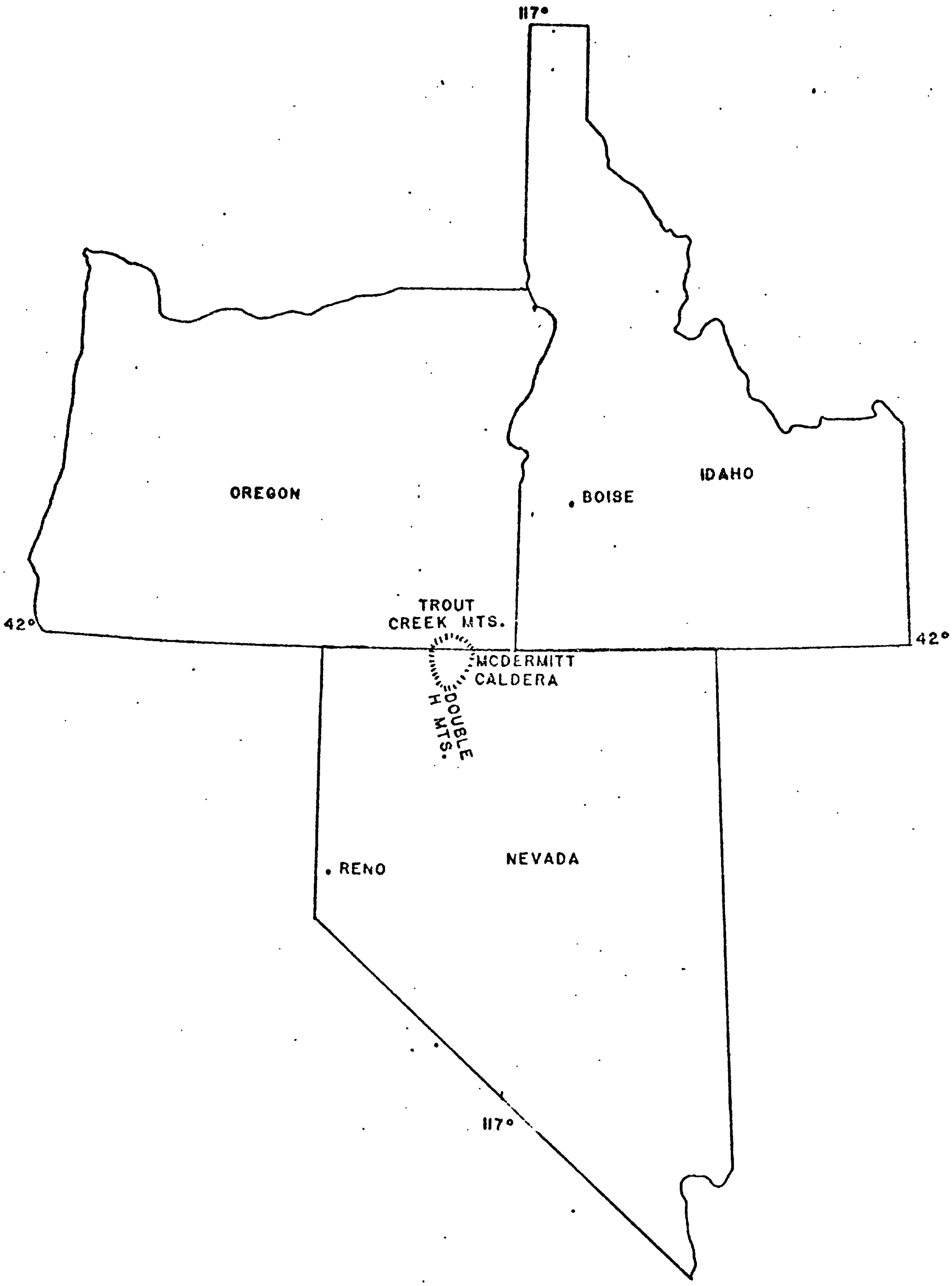

FIG.1 LOCATION OF MCDERMITT CALDERA

CALDERA STRUCTURE

The northern margin of the caldera corresponds to the southeastern scarp of the Trout Creek Mountain (fig. 2). An arcuate fault zone located along the Trout Creek scarp was initially mapped by Yates (1942), and Walker and Repenning (1965) first recognized the zone as a portion of a caldera. The southern margin of the caldera is defined by the northern, easterly-trending scarp of the Double H Mountains (fig. 2). Several arcuate, normal faults are located along the scarp and have displacements of several hundereds of feet giving a total displacement of 2,000 feet (620 m) across the fault zone. The eastern caldera margin is modified by Basin and Range faults and is projected to extend along the western side of the Quinn River Valley. The western margin of the caldera is defined by several coalescing rhyolite domes that have been emplaced along a north-striking fault zone (fig. 2).

A gravity map of the caldera (fig. 3) prepared by Donald Plouff shows a broad gravity low over the cladera, averaging 15 milligals, bordered by a gravity high on the east, south, and west. The center of the gravity gradients, shown as a dark hashed line in figure 3, corresponds closely to the mapped and inferred position of the caldera ring fracture zone. The gravity low is the result of less dense, caldera fill sediments and ash-flow tuffs, and a silicic intrusive that occupies the magma chamber from which the ash-flow tuffs were erupted.

Within the caldera are several arcuate fault zones which may define one or more smaller calderas nested within the larger McDermitt caldera. The structure and geology of the smaller collapse features are at present uncertain.

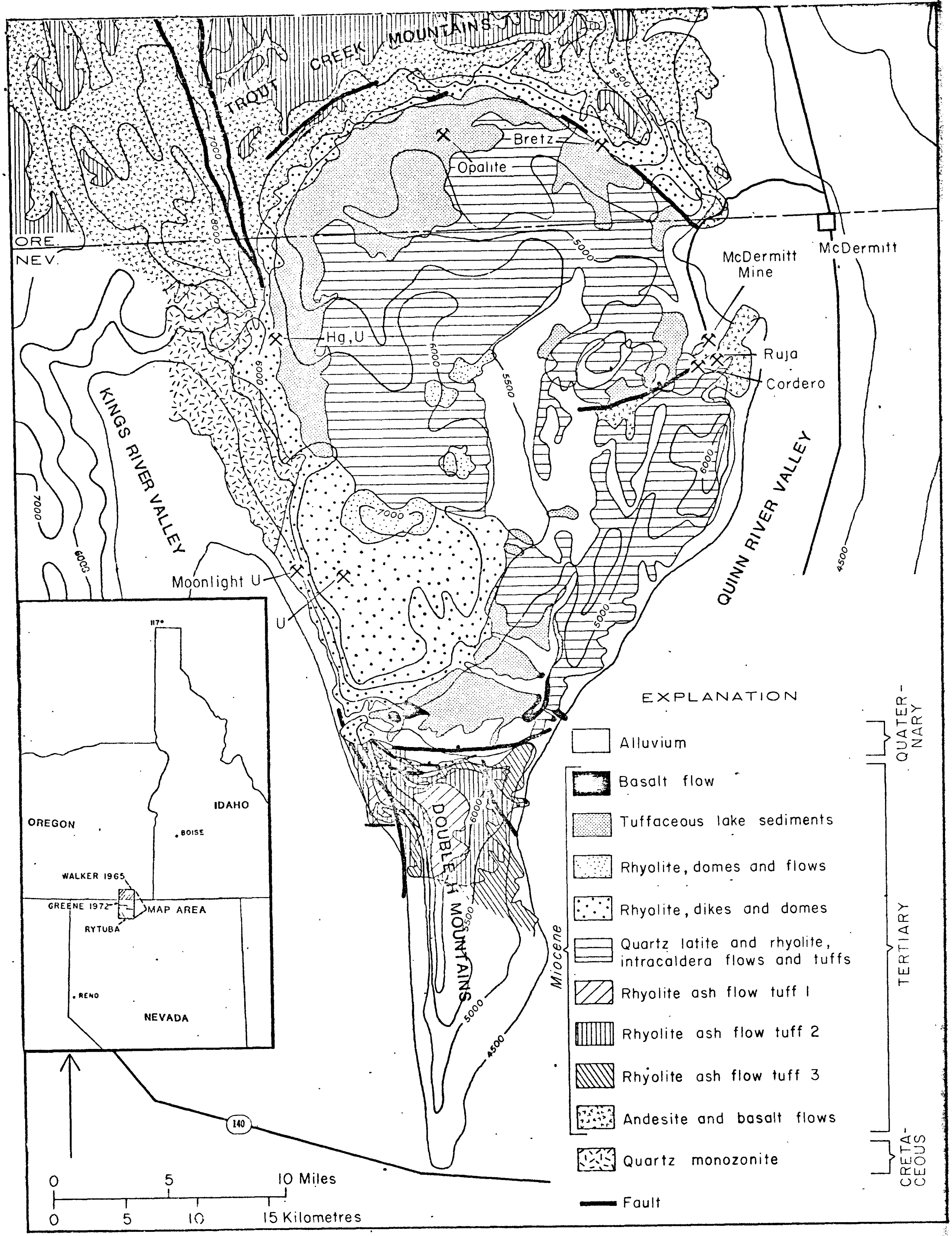

FIG. 2 GEOLOGIC MAP OF MCDERMITT CALDERA

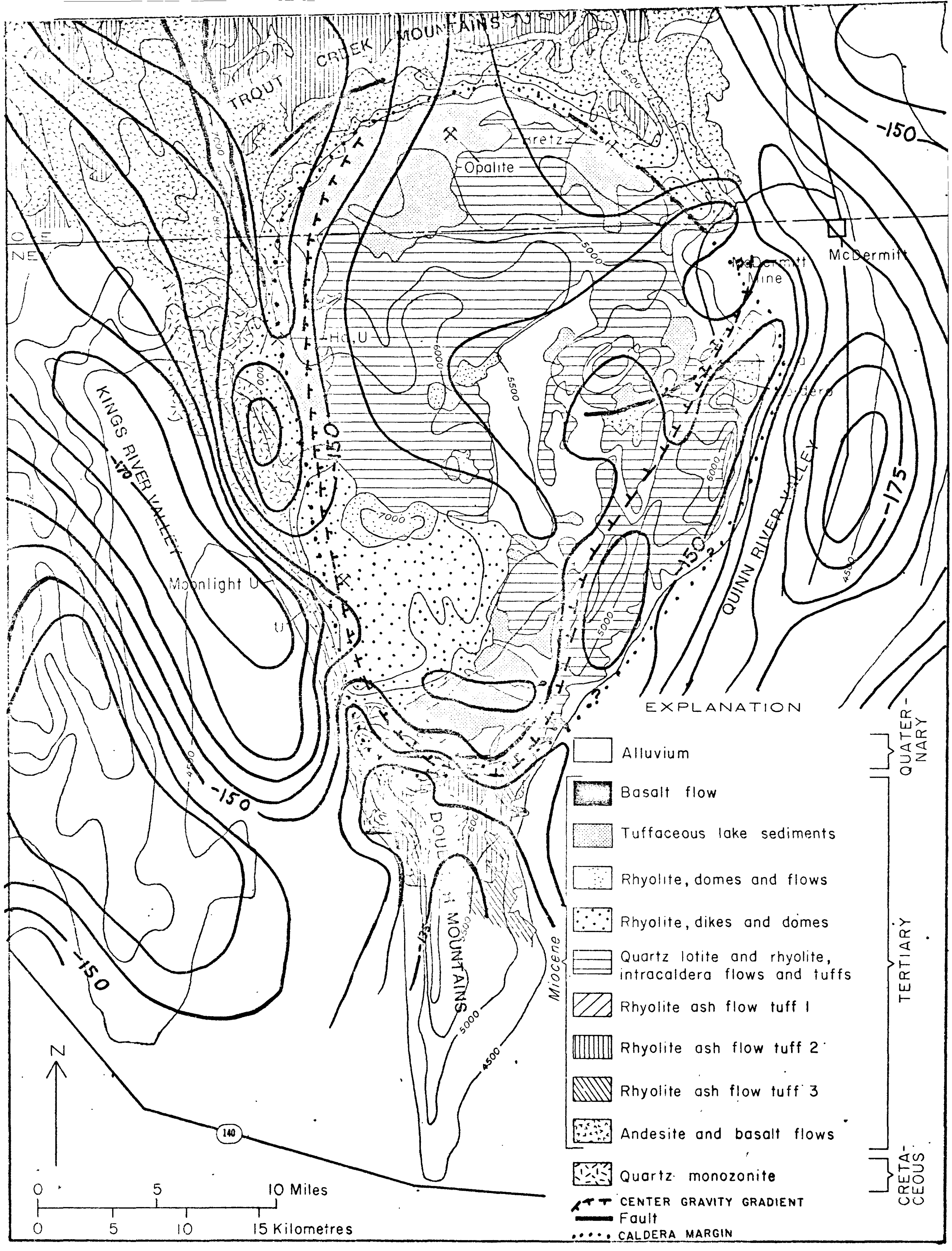

FIG.3 GRAVITY AND GEOLOGIC MAP OF MCDERMITT CALDERA

VOLCANIC HISTORY

The Tertiary volcanic rocks in the McDermitt area consist of early Miocene basalt and andesite flows and late Miocene rhyolite ash-flow tuffs associated with the McDermitt caldera. The volcanic rocks have been described by Yates (1942), Curry (1960), Fisk (1968), Walker (1973), and Greene (1972), and dated by McKee and others (1975) and McKee (1976). Volcanic activity in the McDermitt area began in the early Miocene with the eruption of andesite and basalt flows from fissure vents. The flows rest unconformably on granitic rocks of Cretaceous age and range in age from 24 to 18 m.y. At about 18 m.y., volcanic activity became dominantly felsic and explosive with the eruption of large volume ash-flow tuffs. Ash-flow tuffs that erupted during the earliest stage of felsic volcanism are exposed within the south and north rims of the caldera (fig. 3) and consist of three cooling units. Eruption of each unit likely caused collapse of the magma-chamber roof and resulted in the formation of the McDermitt caldera. The oldest rhyolite ash-flow tuff (unit 3) is a simple cooling unit with a minimum thickness of 750 feet (230 m). The lower half of the unit is a densely welded tuff, and the upper half is a vapor-phase altered tuff composed of alkali feldspar, cristobalite, and soda amphibole. Undevitrified glass from the basal vitrophyre has a refractive index of 1.495, indicating a silica content of 72 percent. Erosion of unit 3 occurred during a hiatus in volcanic activity and, locally, up to a meter of tuffaceous siltstones were deposited.

Rhyolite ash-flow sheets 1 and 2 were erupted in close succession. Unit 2 is a simple cooling unit having a thickness of 680 feet (210 m). The ash-flow tuff has a densely welded base which grades upward into a 50-foot-thick (15-m-thick) vitrophyre having a refractive index of 1.503 and a silica content of 69 percent. The upper part of the unit is vapor-phase altered tuff.

Ash-flow tuff 1 is exposed both on the north and south rims of the caldera. The unit has been partially eroded and a minimum thickness of 210 feet (65 m) is present. At its base, the unit consists of a distinctive crystal-rich welded tuff which grades upward into a crystal-rich vitrophyre 50 feet (16 m) thick. The upper portion of the unit is a vapor-phase crystallized tuff consisting of alkali feldspar, cristobalite, and soda amphibole. Undevitrified glass from the vitrophyre has a refractive index of 1.493, indicating a silica content of 72 percent.

The three ash-flow tuffs have refractive indices typical of commendites, and chemical analyses of the rocks (Noble and others, 1969) confirm that they are peralkaline. All the tuffs have undergone post-depositional flowage and have well-developed lineation; features typical of peralkaline ash-flow tuffs.

After eruption of the ash-flow tuffs and formation of the caldera, resurgence of the central portion occurred so that at present the maximum elevation of the resurgent dome is slightly greater than the caldera rim. Rhyolite domes were emplaced along the western and northern ring fracture zones, and tuffaceous lake sediments and rhyolite flows and tuffs were deposited within the caldera. Near the caldera margins, coarse conglomerate and talus deposits derived from the cladera walls interfinger with the fine-grained lake sediments. The sediments have a Miocene fossil assemblage (Yates, 1942), and an andesite flow interbedded with the sediments has an age of 16.4 m.y. (McKee and others, 1975). The last stage of volcanic activity resulted in the intrusion of rhyolite domes within the central resurgent dome of the caldera.

ORE DEPOSITS

Ore deposits withinthe caldera consist of the Bretz, Cordero, McDermitt, Opalite, and Ruja mercury mines and the Moonlight uranium mine (fig. 2). Several unnamed mercury and uranium prospects also occur within the caldera. The recently discovered McDermitt mine is the largest operating mercury mine in North America and has reported reserves of 400,000 flasks of mercury.

The mercury mines are in the northern part of the caldera. The Opalite and Bretz mines are adjacent to the northern ring fracture zone and the Cordero, McDermitt, and Ruja mines are adjacent to a normal fault that may define a smaller collapse structure nested within the larger McDermitt caldera. The Bretz, McDermitt, and Opalite ore bodies occur in lake-bed sediments, whereas those of Cordero and Ruja occur in volcanic rocks. Ore bodies in volcanic rocks occur along faults, and ore bodies in lake beds are generally conformable to the strata. Cinnabar is the dominant ore mineral at all mines, but at McDermitt corderoite, $Hg_3S_2Cl_2$, comprises about a third of the ore (Foord and others, 1974; Roper, 1976). Native mercury and mercury oxychlorides occur but are uncommon. Marcasite and pyrite are present in ore bodies within volcanic rocks, whereas iron oxides predominate in the lake-bed ore bodies. Silicic and argillic alteration is associated with all ore bodies. Nearly complete silicification of the lake beds and volcanic rocks has locally occurred to form a rock termed "opalite" (Yates, 1942; Bailey and Phoenix, 1944). Opalite is commonly developed along and adjacent to faults, along certain lake-bed strata, and within conglomerate and talus deposits near the caldera margins. It is the host for the mercury ore bodies at Opalite and for some of the ore bodies at Cordero. At the Bretz and McDermitt mines, opalite is present near the ore bodies, but the ore primarily occurs in the unsilicified, argillically altered sediments.

The temperature of deposition of the mercury ore bodies occurring in lake-bed sediments has been determined from fluid inclusions in quartz associated with cinnabar. Two-phase fluid inclusions are abundant in fine-grained quartz occurring in veinlets and lining cavities within opalite. Homogenization temperatures indicate a deposition temperature of 195°C$\pm$5° at Opalite, 200°C$\pm$5° at McDermitt, and 205°C$\pm$5° at Bretz. The inclusions all homogenize over a small temperature interval and indicate that boiling did not occur during deposition of the quartz. A minimum depth of formation of 500 feet (150 m) is necessary to prevent boiling and is compatible with the the probable thickness of the lake beds within the caldera at the time of mineralization.

The Moonlight uranium deposit and several uranium occurrences are in rhyolite domes intruded along the southwestern ring fracture zone of the caldera. The dome in which the Moonlight deposit occurs is faulted on the west by range faults bounding the Quinn River valley, and the uranium ore is localized along a breccia zone that strikes northerly and dips 60° to the east and parallels the flow foliation planes within the dome. The ore minerals are autunite and pitchblende, and the gangue minerals are quartz, fluorite, and pyrite. Fluid inclusions in quartz associated with the pitchblende are two-phase inclusions which homogenize at 340°C$\pm$7. A sample of unaltered rhyolite from the dome contains anomalously high uranium, 0.02 percent Ur (Taylor and Powers, 1955) and indicates along with the high temperature of deposition that the deposit is genetically related to the rhyolite intrusive.

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