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UNITED STATES ATOMIC ENERGY COMMISSION

NOTES ON THE RELATIONSHIP OF URANIUM MINERALIZATION AND RHYOLITE IN THE MARYSVALE AREA, UTAH

By
Ray E. Gilbert

February 1957

Salt Lake Area Office
Salt Lake City, Utah

Technical Information Service Extension, Oak Ridge, Tenn.

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U. S. ATOMIC ENERGY COMMISSION
DIVISION OF RAW MATERIALS
SALT LAKE AREA OFFICE

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ABSTRACT

The Marysvale area lies in south-central Utah, 160 miles south of Salt Lake City.

Uranium deposits of the area are in volcanic and plutonic rocks of Tertiary age. The volcanics are divided into the Bullion Canyon volcanics and the younger Mount Belknap rhyolite. They are separated in time by the intrusion of quartz monzonite and related granitic phases.

The sequence of geologic events in the Marysvale Central area, following the emplacement of granitic intrusives, was apparently as follows: major displacement along east-trending faults; exposure of intrusives by erosion; then, in close sequence and probably overlapping order, extrusion of red rhyolite agglomerate, fracturing, intrusion of rhyolite dikes, minor north-northwest faulting, intense hydrothermal alteration, and finally, uranium mineralization accompanied by minor alteration.

Uranium minerals, including some ore-grade concentrations, are present in red rhyolite agglomerate and in felsitic and glassy rhyolite dikes. Mineralizing solutions were channeled into the agglomerates possibly by shears in underlying quartz monzonite. Dikes were probably mineralized by solutions from great depth that traveled within and along the dikes.

Two localities in rhyolite agglomerate have been mined for uranium ore, and additional uranium ore bodies may be present. A plan of prospecting is recommended, starting with detailed surface mapping and radiometric surveying and followed by the use of geophysical and geochemical methods in selected areas.

INTRODUCTION

The Marysvale area (Durkee mining district) in south-central Utah, 160 miles south of Salt Lake City (inset, fig. 1), lies between the Tushar Mountains to the west and the Sevier Plateau to the east, in a transverse range of hills known as Antelope Range.

Hills of Antelope Range have a maximum elevation of 7,600 feet, 1,800 feet above the valley floor of the Sevier River which skirts the western edge of the Marysvale area.

The climate is semi-arid. Sagebrush and a sprinkling of junipers and pinon pines cover the hills of the area.

Uranium deposits of Marysvale occur in veins and as disseminations in volcanic and plutonic rocks of Tertiary age.

Because of uranium ore found in rhyolite at the Potts Fraction mine and uranium minerals indicated by recent drilling in rhyolite on the Buddy and Carol claims, it is desirable that the relationship of uranium mineralization and rhyolite in the Marysvale area be reviewed.

Uranium minerals are present in rhyolite in underground workings in the Bullion Monarch mine, as well as in the Potts Fraction. Diamond drill holes indicate the presence of uranium in rhyolite on the following properties: Buddy, Bullion Monarch, Carol, Freedom, Potts, and Prospector. In most instances the uranium occurrences are spotty or low in radioactivity and have created only slight interest. The lack of interest in this type of deposit had its basis also in the knowledge that ore-bearing vein structures in quartz monzonite did not extend into rhyolite cappings on the Buddy, Freedom, or Bullion Monarch properties.

Little work has been done to test ore possibilities in the rhyolite; therefore, little is known about such occurrences. Consequently, many ideas set forth in this report are nothing more than speculations. The postulations are presented to provide a guide for checking or correcting current theories.

Acknowledgments

Geologic studies during the past year have been a continuation of previous studies by the Atomic Energy Commission in the Marysvale area. The work would have been severely handicapped without the use of the surface geology map which resulted from extensive studies in the Marysvale area by Dr. Paul F. Kerr and his assistants from Columbia University. The American Smelting & Refining Company kindly made available detailed surface maps and diamond-drill records prepared by Mr. Jack Frost.

GENERAL GEOLOGY

A good description of the general geology of Marysvale is given by Kerr, et al. (1952).

The Bullion Canyon volcanics, consisting of a great thickness of latite flows, volcanic breccias, and tuffs, represent the earliest Tertiary igneous activity in the area. These volcanics were intruded first by quartz monzonite and then by an aplitic rock which will be referred to in this report by its local designation, "granite". The intrusive sequence was followed by a period of erosion that exposed both quartz monzonite and granite. The Mount Belknap rhyolites, following the erosion interval, were extruded in later Tertiary time.

Only the igneous rocks involved in this study will be described in detail.

Mount Belknap rhyolite

Most of the Mount Belknap rhyolite lies west of the Sevier River in a lenticular mass with its greatest thickness, estimated at 4,000 feet, exposed in the high Tushar peaks west of Marysvale (Callaghan, 1939). This mass was divided by Callaghan into two distinct units, a gray and a red facies.

East of the Sevier River, in the Marysvale Central area, disconnected masses of rhyolite have been correlated with the gray and red facies, on the basis of lithologic similarity (fig. 1). A third unit, white rhyolite, of minor areal extent, was recognized and mapped by Kerr (unpublished map), and is shown in figures 1 and 2. Dikes of felsitic rhyolite and red-to-brown glass are found in the Central area, intruding the Bullion Canyon volcanics, quartz monzonite, and granite.

Red facies - The red facies of the Mount Belknap rhyolite lies west and southwest of the Central mining area. It also forms the crest of the hill in the Freedom-Potts area. The red rhyolite extends west across the Sevier River, where it appears to be unconformably overlain by flows of the gray facies (Woolard and Kerr, 1952).

A study of flow-plane attitudes indicates the probability that the greater part of the red facies in the Central area had its source in and around Barren Flat (figs. 1 and 2), instead of being an isolated erosional remnant of the thick flows of the Tushar Mountains. The rhyolite probably forced its way up through several vents and flowed in a viscous condition over an old erosion surface. The cross sections in figure 2 illustrate this hypothesis. Although most of the rhyolite seems to have had its source in the Barren Flat area, smaller sources possibly existed in the Bullion Monarch and Potts areas.

The red facies consists largely of a salmon- to brick-red, hard dense agglomerate. The matrix is fine grained to glassy. Included fragments vary in size from small bits of individual minerals to large boulders several feet in diameter. Within the Central area the inclusions consist of previously solidified red rhyolite agglomerate, Bullion Canyon latite, quartz monzonite, and granite. Individual or aggregate mineral fragments are primarily feldspar and quartz and, in lesser amounts, biotite. Flow structure is generally visible in the red facies.

Locally, especially in its basal portion, the agglomerate may be hydrothermally altered, becoming softer, losing its red color, and in extreme cases being converted almost completely to clay. The alteration may have been selective, affecting parts of the agglomerate that were primarily more susceptible to alteration than the typical dense red agglomerate. The presence of fresh red agglomerate in the Bullion Monarch area, where all other rock types are extremely altered, supports this concept.

Glass of various colors is associated with red agglomerate, appearing most commonly at or near its base.

Uranium minerals have been observed in altered agglomerate on the Bullion Monarch, Carol, and Potts properties.

White rhyolite - The white rhyolite crops out in comparatively small areas, surrounded by the red agglomerate. Because of the spatial relationship and the contorted but usually steeply dipping flow planes, the white rhyolite may represent a later surge of material and the cores of vents through which the material which formed the red agglomerate was extruded.

The white rhyolite is a felsitic rock, very light gray to white with its flow structure marked by a faint streaking of gray or lavender. The flow structures are locally highly contorted.

Altered felsitic dikes in the Central area are considered to be members of the white rhyolite division. The greater part of a composite and intensely altered dike zone in the Bullion Monarch area is tentatively classed as a member of the same group.

The composite dike zone in the Bullion Monarch area has been named the Bullion Monarch dike complex (fig. 3). Although it consists mostly of white felsitic rhyolite, it also contains red agglomerate and glass of the Mount Belknap. The age relationship of the different rhyolite members in the dike zone has not been determined, but it seems likely that the dike material was intruded intermittently during the Mount Belknap period. Latite, quartz monzonite, and granite have been noted in drill cores from the dike complex. Some of these earlier rocks are probably large inclusions, but others may exist as wall-like remnants of the intruded rock, separating parallel dikes of somewhat different age. Alteration of most of the rocks in the dike complex has been extreme.

The Bullion Monarch dike complex ranges in width from 100 to 300 feet. It extends south from the Bullion Monarch workings, and diamond drilling and resistivity tests indicate its existence for a distance of 700 feet to the south.

Uranium minerals have been observed in some of the felsitic dikes in the Central area and in the Bullion Monarch dike complex.

Gray facies - The gray facies is exposed in the Marysvale district east of the Central area intrusives, in several separated masses, locally crudely circular in shape. The shapes of the masses and the generally steep dips of flow planes, clearly suggest that part of the gray rhyolite in the map area lies in eroded volcanic necks (figs. 1 and 2). Diamond drilling by the American Smelting & Refining Company on Papsy's Hope property has verified this conclusion for one of the gray rhyolite occurrences.

The rock is a light gray rhyolite porphyry with numerous quartz and feldspar phenocrysts. Flow banding is notable in many places, and usually gives the rock a platy appearance in weathered outcrop. Glass of variable appearance is associated with the gray rhyolite, generally along its margins.

No uranium minerals have been observed in the gray rhyolite in the Marysvale area, though a small occurrence has been observed near Beaver, Utah.

Rhyolite glass dikes - Dikes of red-to-brown glass are present in the Central area. They are considered to be a part of a feeder system which contributed to the overlying Mount Belknap. The dikes range in width from a few inches to several feet. Banding of the glass and thin gray layers of cryptocrystalline quartz and feldspar frequently produces a distinct flow structure. The glass in places is agglomeratic, containing breccia fragments of glass and wall rock. Some of the dikes change from brown glass in depth to felsitic white rhyolite at higher elevations. The dikes commonly parallel the trend of the productive veins of the Central area, and are believed to have been intruded along fractures resulting from the same stresses that formed the vein system.

Uranium is present both within some of the dikes and in quartz monzonite bordering some of the dikes.

An excellent description of one of the mineralized dikes is given by Kerr and Hamilton (1953).

SEQUENCE OF EVENTS

The time relationship of faulting, vein fracturing, alteration, mineralization, and rhyolite activity must be established from scanty and usually indirect evidence. The possible sequence of events in the Central area, following the intrusion of quartz monzonite and granite, is proposed as follows: major displacement along at least two east-trending faults, exposure of intrusives by erosion, then in close sequence and probably overlapping order, extrusion of red agglomerate material, fracturing, intrusion of rhyolite dikes, minor north-northwest faulting, intense hydrothermal alteration, and finally, uranium mineralization accompanied by minor alteration. Reasons for proposing this sequence are discussed below.

Pre-agglomerate faulting

Two major faults that are believed to predate the red rhyolite agglomerate are known in the Central area. One of these is the Scorpion fault, which crosses the southern part of the Central area (fig. 1), the other is the Monarch fault, which is exposed in the Bullion Monarch mine (fig. 3). The south side is the downthrown block of each fault. Displacement on the Monarch fault is nearly 200 feet, as indicated by the offset of the granite-quartz monzonite contact (section C-C', fig. 4). Displacement of the Scorpion fault is probably greater but cannot be measured.

The relationship of the Scorpion fault to the red agglomerate has been indicated indirectly by a diamond drill hole that cut the southwestward extension of the fault under a capping of agglomerate. Previous evidence indicated that the contact between the agglomerate and quartz monzonite was a fault contact. No evidence of faulting was noted in the drill core where the fault was expected to be found; strong gouge, characteristic of the Scorpion fault, however, was intersected well under the rhyolite without offsetting it, and therefore, predated the rhyolite. Later study of the rhyolite contact, including some bulldozer trenching, substantiated the conclusion that it is an unfaulted flow contact.

The Monarch fault can be seen in the Bullion Monarch mine in contact with felsitic and glassy rhyolite dikes (fig. 3), and yet its relationship to the dikes cannot be certainly determined. The problem results from the extreme argillic alteration that has affected both the dikes and the fault gouge, so that it is impossible to distinguish between them.

The Bullion Monarch dike complex terminates against the Monarch fault. The contact exposed on the Bullion Monarch adit level fails to reveal whether the dike complex is cut by the fault, or whether the fault is an earlier structure that limited the northern extent of the intrusive complex. The south side of the Monarch fault moved possibly 200 feet down dip, with little lateral shift. However, the south block may have moved west with respect to the north block. In either case, if the dike complex were offset by the fault, its northward continuation should fall within the Bullion Monarch-Feeedom No. 2 area. Since the dike complex has not been found north of the Monarch fault, it is concluded that the fault was earlier.

Poor surface exposures of red agglomerate on Bullion Monarch property only suggest an unbroken rhyolite capping above the Monarch fault (section C-C' fig. 4).

Rhyolite glass, mostly altered to clay, is discontinuously intermingled with gouge along the fault in the Bullion Monarch workings, and agglomerate, felsite, and glass have been observed in the cores of several of the diamond drill holes where they have cut the fault. Rhyolite has been mapped on the north wall of the fault where it crosses the Prospector 300-level north crosscut. The rhyolite exposures are too extensive and frequent to be only drag material in later faulting. Therefore, the Monarch fault probably served as a channel for later rhyolite dike invasion. This hypothesis is illustrated in figures 3 and 4.

Fracturing

The productive veins of the Marysvale area are localized along fractures having offsets of only a few feet. Most of the veins range in strike from E. to N. 45° E. Dips vary from vertical to steeply north or south. Movement on the fractures appears to have been mostly lateral and was probably caused by east-west compressional forces, with the fractures acting as shear planes.

The Freedom No. 2 vein cuts the red agglomerate that covers the surface in that area (inset detail, section E-E', fig. 4). The "A" vein of the Bullion Monarch mine is indirectly inferred to cut the rhyolite agglomerate in the Bullion Monarch open pit (section C-C', fig. 4). The agglomerate exposed in the south wall of the lower part of the pit does not extend across to the north wall, and is, therefore, assumed to be offset by faulting.

Minor slips, containing uranium minerals, can be seen cutting quartz monzonite in the east face of the Bullion Monarch pit. These slips which have a dip of 65° to 85° S. in the monzonite, roll to 30° as they approach the contact of the agglomerate and disappear into the clay at its base. Similarly, in the Buddy mine, mineralized fractures in quartz monzonite seem to merge into the gentler dip of overlying agglomerate and to be lost in the clay at the base of the agglomerate.

In the saddle below the Potts shaft, three weakly mineralized fractures intersect and offset the quartz monzonite-rhyolite contact. However, these fractures cannot be found in a good rhyolite exposure 100 feet east of the contact along the projected strike of the fractures.

From the preceding bits of evidence, it is concluded that the vein fractures were formed later than the red agglomerate. The stresses were possibly carried by the older rocks, and small movements were taken up along the agglomerate base rather than extending into the agglomerate. Even larger fractures that do cut the lower part of the agglomerate may die out higher in the formation.

The expansion of agglomerate vents in the Barren Flat area may have been the source of stresses causing the vein fractures, the fracturing possibly being contemporaneous with the final stages of extrusion of the agglomerate melt.

Intrusion of rhyolite dikes

Felsitic and glassy rhyolite dikes are exposed underground in the Bullion Monarch and Prospector mines. Diamond drill holes have provided additional information about dikes under and east of the Bullion Monarch workings.

Rhyolite dikes north and northeast of the Central area are parallel to the average trend of the productive veins (fig. 1). Dikes in and

and east of the Bullion Monarch workings have similar northeast trends and generally steep dips (fig. 3). A mineralized dike that was exposed by drifting on the Bullion Monarch adit level is parallel to the Freedom No. 2 vein. This relationship is verified by diamond drill holes between the two mines. The Prospector fault, striking N. 25° W. (fig. 3), may offset the structures somewhat, but the displacement is probably not great enough to invalidate the structural correlation illustrated in figure 3. The "Y" dike appears to pinch out and give way to a shear zone east along its strike. On the Prospector 200-level, a mineralized rhyolite dike was cut by a diamond drill hole 85 feet southeast of a drift on the Prospector No. 3 vein, in line with the projected strike of the vein.

The rhyolite dikes were probably emplaced, in part, in fractures or shears resulting from the same stresses that created the vein fractures. A fracture may possibly be occupied by both a dike and a vein at different points along its strike. This idea may eventually be proved by drifting southwest on the Freedom No. 2 vein, or southeast on the Prospector No. 3 vein.

Absence of rhyolite dikes immediately south of the Monarch fault and the presence of rhyolite along the fault suggest that the fault acted as a conduit for the intrusive rhyolite. Within a few hundred feet of the surface the rhyolite could have spread out into weaker fractures to form the dike swarm east of the Bullion Monarch workings, as illustrated in figures 3 and 4.

North-northwest faults

Faults which range in strike from due north to N. 35° W. and dip steeply to the west have been observed to offset the northeast veins in several of the Marysvale mines. These faults are believed to have displacements of only a few feet. Three of the faults, the Bullion, "B", and Prospector, are shown in figure 3. The Bullion fault cuts a rhyolite dike in the Bullion Monarch workings.

The "B" fault turns east and merges with the earlier Monarch fault. This characteristic implies renewed, but minor, movement on the Monarch fault. The relationships of the Monarch fault with the Bullion and Prospector faults, at their intersections, are unknown. The Prospector fault has not been recognized north of the Monarch fault; hence, it may merge with the Monarch fault in a manner similar to that the the "B" fault.

A raise was driven on the "B" fault in the Bullion Monarch mine, and some ore may have been shipped from there. No other concentrations of ore-grade material are known along the north-northwest faults, which, however, are weakly mineralized. If, as is postulated, these faults were formed prior to mineralization, the offset veins in places may be expected to show notable differences in degree of mineralization on opposite sides of the faults. Evidence from mine maps tends to support this deduction.

Alteration and mineralization

With the exception of mineralized areas in fairly fresh glass of some dikes of the Bullion Monarch area (Kerr and Hamilton, 1953), uranium minerals have been found only in rhyolite that has been strongly altered. The alteration is of a clay type similar to that occurring along veins and faults in the quartz monzonite.

The degree of alteration in quartz monzonite and granite of the Central area is apparently greater in proportion to the magnitude of the associated fault or fracture than to the intensity of uranium mineralization. Barren or weakly mineralized faults or wide sheeted zones may be marked by a wide altered halo, whereas some good-grade uranium ore is found in weak fractures which have been altered to a width of only 2 or 3 feet. The Sunnyside ore body is an outstanding example of an ore body which has been weakly altered and strongly mineralized. Both the Prospector and Freedom veins are in fractures having greater offsets than the Sunnyside vein. Alteration along these veins extends farther into the walls than it does at the Sunnyside, yet the total width of strong alteration is only a few feet, which is narrow compared with the alteration around some barren structures.

The solutions that deposited uranium in the quartz monzonite and granite appear to have affected only a moderate alteration of the wall rock, and the extreme alteration at points in the Marysvale area was caused probably by hydrothermal solutions of somewhat different age and composition.

Alteration and mineralization of the rhyolites were brought about probably by solutions similar to those producing the same effects in the quartz monzonite and granite. Uranium minerals found only in some but not in all altered rhyolite, also suggest that the strong alteration was caused by solutions different from the ore-bearing solutions. The alteration probably preceded and acted as a prerequisite for mineralization. Possible changes in the rhyolite brought about by alteration preceding mineralization may have included increased permeability and a more favorable chemical environment for uranium precipitation.

In their study of a mineralized dike in the Bullion Monarch area, Kerr and Hamilton (1953) conclude, on the basis of chemical analyses, that the uranium was introduced either coincident with the emplacement of the dike or with the first stages of alteration. However, in discussing the conclusions of their report, they also state" ... microscopic evidence points to a later emplacement of uranium". Their work, then, does not rule out the possibility that the uranium postdated most of the alteration.

A microscopic study of specimens from the Potts Fraction mine (Mathez, 1954) shows that fluorite has apparently replaced a clay-like mineral that is present in lenticular pods in the rhyolite agglomerate.

At least part of the Marysvale fluorite is considered to have been deposited more or less contemporaneously with the uranium (Dahl and Kerr, 1953), although some of the fluorite may postdate the uranium. This indirect evidence indicates that the uranium at the Potts may have replaced earlier clay materials.

Hydrothermal solutions causing the postulated barren stage of alteration may have marked the final phase of volcanic activity in the Central area. Extremely altered patches of granite, quartz monzonite, and rhyolite throughout a large block of ground in the Bullion Monarch area could have resulted from hydrothermal activity closely following intrusions of late dikes in that area. Uranium mineralization may have been a continuation of earlier hydrothermal activity or may have been a later and separate event.

URANIUM OCCURRENCES IN RHYOLITE

Mineralogy

Uraninite has been identified by X-ray analysis in rhyolite glass from a dike in the Bullion Monarch mine (Kerr and Hamilton, 1953) and in rhyolite agglomerate from the Potts Fraction mine (Mathez, 1954). In each, finely divided uraninite is closely associated with fluorite. Possibly some of the fluorite was formed contemporaneously with the uraninite, and some later (Kerr and Hamilton, 1953).

Secondary uranium minerals that have been identified in the rhyolites are autunite, meta-autunite, torbernite, and uranophane.

Potts Fraction mine

The best exposed occurrence of uranium in rhyolite is in the Potts Fraction mine. Secondary uranium minerals were first discovered at the surface in the spring of 1951. Subsequent diamond drilling cut ore-grade material in rhyolite agglomerate. Shaft sinking and crosscutting exposed ore on the 210-level, and the first ore shipment was made in early 1954.

The ore occurs in silicified and altered agglomerate that contains inclusions of latite, quartz monzonite, and granite. Introduced silica is common in veinlets transecting all original rock constituents. It also lines and fills vugs and probably acts as a replacement mineral (Mathez, 1954). Clay and sericite alteration minerals may postdate the introduced silica. In turn, fluorite and associated uraninite probably were formed later than the clay minerals. The fluorite and uranium are found in lenticular pods and bands along flow planes, apparently replacing earlier clay. Some inclusions of latite, quartz monzonite, and granite are mineralized. Fluorite has a much wider distribution than the uranium. In addition to following flow structures, barren fluorite in some places fills small fractures which cut flow planes. The uranium distribution has no discernible relationship to the fluorite-filled fractures.

The flow structure of the rhyolite may have had some control on the limits of uranium mineralization, but the control is not clearly defined. The ore outline follows the flow planes in some places, but in other places it cuts sharply across them (fig. 5). The exposed portion of the ore body plunges southeast at an angle that may be a few degrees steeper than the dip of the flow planes (sec. C-C', fig. 5). In detail, the ore is commonly concentrated in clay pods and bands that follow flow structures. In places where the ore boundary turns to cut across the flow planes, however, clay lenses, identical in appearance to others within the ore zone, continue along the flow bands into nearly barren rhyolite. Fluorite has replaced parts of the clay lenses in both ore and barren zones.

The difference between ore and waste cannot be judged visually, but a scintillation counter was found to be very effective in outlining the ore. The agglomerate between ore lenses generally contains less than 0.04 percent U_3O_8. Small concentrations within the ore bodies have carried as much as 1.5 percent U_3O_8, but the average mining grade is not expected to be much more than 0.20 percent.

Additional diamond drilling was done in the spring of 1954, in an effort to determine the trend and source of the Potts ore bodies. The plan and sections of figure 6 show both what is known and what is surmised about the trend of the ore bodies and the shape of the agglomerate in which they occur.

The rhyolite agglomerate originally was thought to be a surface flow, faulted down against quartz monzonite on its western edge (Gray, 1952). A good surface exposure of the rhyolite-monzonite contact west of the Potts shaft clearly indicates that no large fault is present. Possibly the agglomerate lies in the upper part of an old volcanic vent, which opened in a funnel shape about 100 feet below the present 210-level. The generally low dip of flow structures suggests that viscous agglomerate, forced up from below, mushroomed out under a roof load of quartz monzonite and previously solidified agglomerate. The Potts rhyolite is probably different from the agglomerate that covers the ridge crest above the Freedom No. 2 mine.

Investigations early in 1954 lead to the assumption that the mineralized solutions were channeled up through the old volcanic vent. Mining and diamond drilling since then indicate the source to be southeast of the present mining area. Weakly mineralized shears in quartz monzonite have been cut by two diamond drill holes south of the Potts mine. The strike of the shears is estimated to be between due east and N.70° E. Their dips are not known but are assumed to be nearly vertical. The shears may have guided mineral solutions into the basal portion of the rhyolite, and the solutions may then have followed certain flow layers in the agglomerate (sec. B-B', fig. 6).

Bullion Monarch mine

The Bullion Monarch mine is the only mine in the Marysvale area, other than the Potts Fraction, which has produced ore from the rhyolite.

Drifting was done on a rhyolite glass dike on the adit and 55-foot levels, and within the Bullion Monarch dike complex on the adit level. Some raising and stoping have been done from both levels. The shaft is in low-grade ore most of the distance between the adit level and the 55-level. Most of the work was done in 1951; little information is available concerning the grade and distribution of the ore.

Diamond-drill-hole intersections of the dike that is tentatively correlated with the Freedom No. 2 vein (fig. 3) show values ranging from 0.03 to 0.30 percent U_3O_8. Uranium minerals, as revealed by the drill holes, are both in the rhyolite glass and in sheared and altered quartz monzonite adjacent to the dike. Ore is probably present in small, irregular shoots. A small reserve of ore with an estimated grade of 0.15 percent U_3O_8 has been calculated for the mineralized rock in the dike complex around the Bullion Monarch shaft. Uranium minerals near the shaft are in an agglomeratic glass phase of the dike complex. Diamond drilling south of the shaft has cut mineralized material at various points within the Bullion Monarch dike complex, with values ranging from 0.01 to 0.28 percent U_3O_8. The uranium minerals occur in a variety of rock types—felsitic rhyolite, quartz monzonite, and granite—all altered in varying degree to clay minerals. Uranium minerals have been found at random points within the intrusive complex over a strike length of 500 feet. Resistivity measurements indicate that the dike zone continues at least 200 feet beyond the drill hole farthest south (fig. 3).

A reasonably good chance exists for finding ore bodies like those developed at the Potts mine in the Bullion Monarch dike complex. Use of a similar technique in which a radiation detection instrument is employed to outline the ore probably will be essential to a successful mining operation.

Carol property (fig. 7)

Mineralized rhyolite agglomerate on the Carol claim, west of the Bullion Monarch, is known only through diamond-drill-hole information. The drilling proved the area to be geologically complex. A block of Bullion Canyon latite has been intruded by quartz monzonite, and apparently an intrusive rhyolite (agglomerate) cuts both latite and monzonite. Flows of rhyolite agglomerate, including a black glassy flow 40 feet thick, cover an old erosion surface. The relationship of the intrusive and extrusive agglomeratic material is not known.

The drill-hole information is not sufficient to give a clear picture of possible structural control or extent of the mineralized body. Uranium was found in extremely altered agglomerate just above the base of the flows. One hole failed to intersect mineralized agglomerate but did cut mineralized quartz monzonite 15 feet below the base of the agglomerate. Neither mineralized material nor a possible solution channel was recognized in drilling deeper in the underlying latite and quartz monzonite.

The best assay of the drill cores was 0.13 percent U_3O_8, representing a 4-foot length of core. This was in altered agglomerate, only 70 feet below the surface.

The relationship between the Carol mineralized zones and those in the Bullion Monarch dike complex is not known. Their relative positions are shown in plan in figure 7.

CONCLUSIONS

There is a fairly good chance of discovery of additional ore in the rhyolite. However, the cost of discovery will probably be high compared to the uranium found. Factors that are expected to contribute to the high cost are lack of surface expression of mineralized areas, probable irregular shape and small size of ore bodies, and probability that the grade will be marginal.

Uranium minerals will be found probably in strongly altered rhyolite, which is likely to be deeply eroded and buried under a thick alluvial cover.

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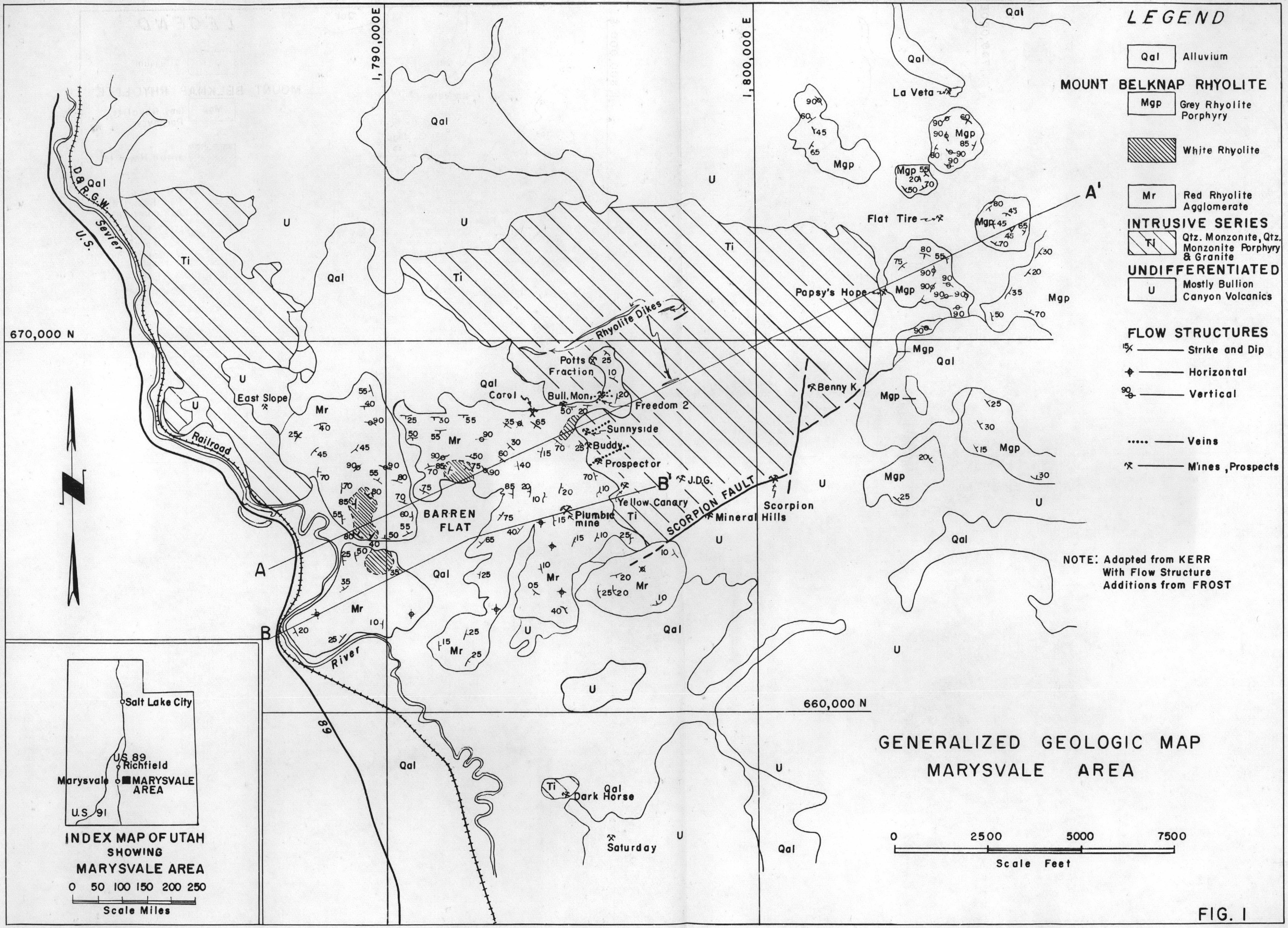
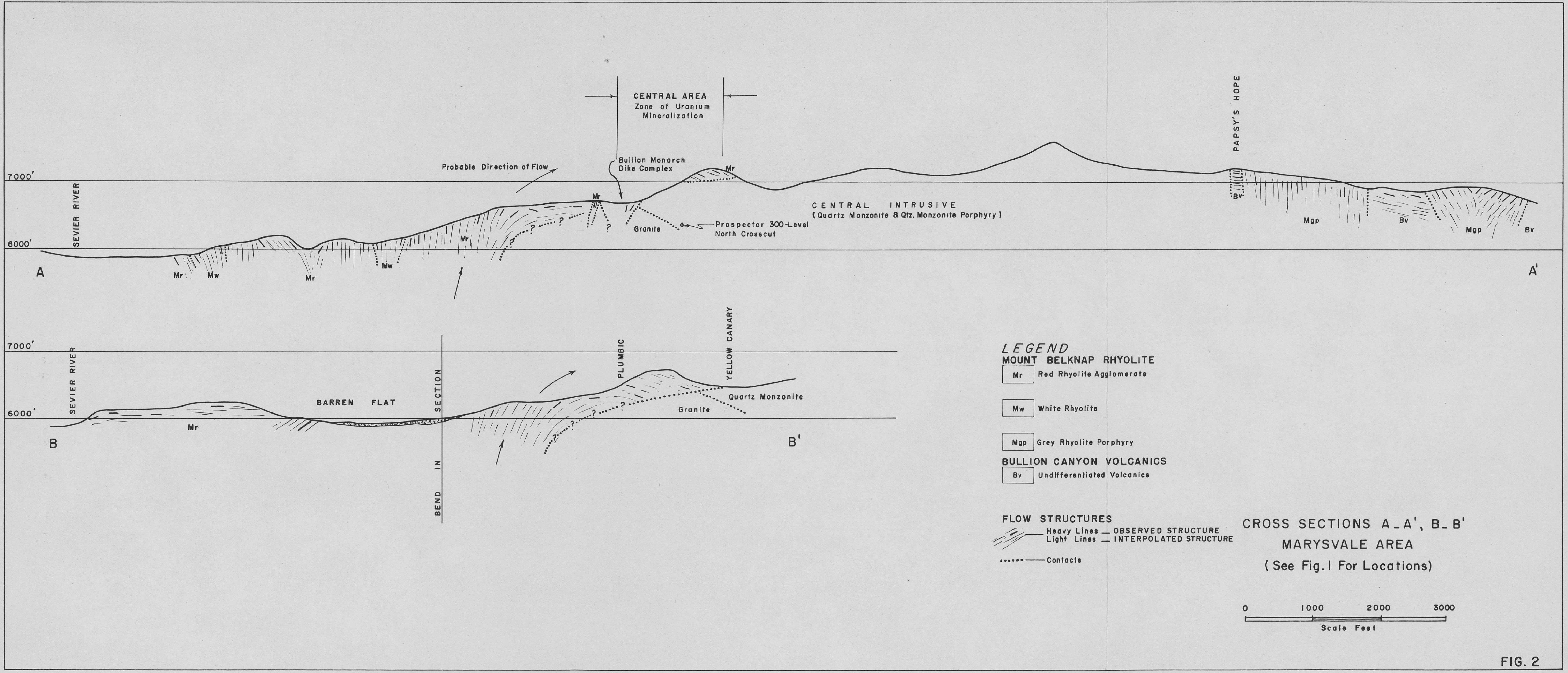


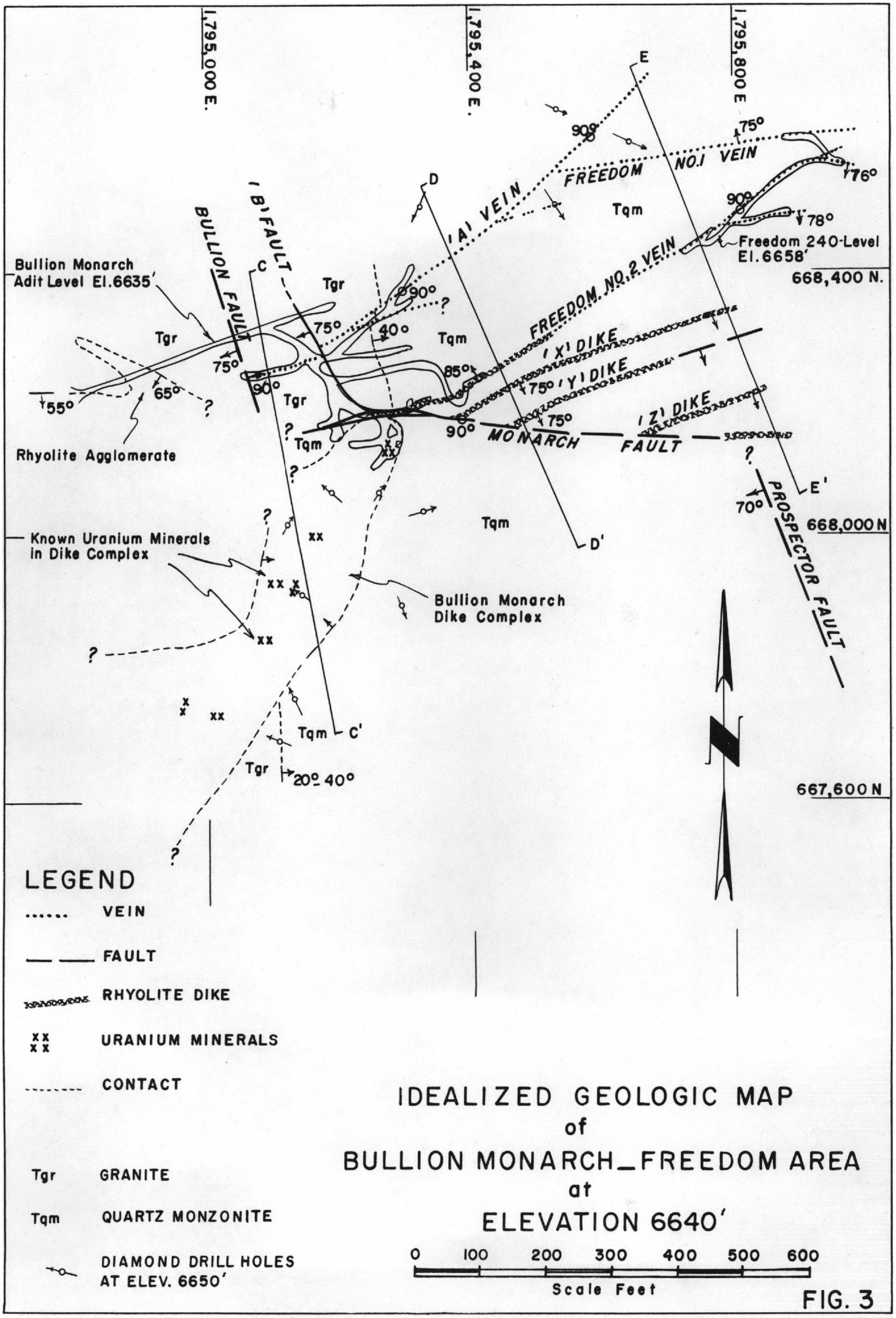
GENERALIZED GEOLOGIC MAP
MARYSVALE AREA

FIG. 1



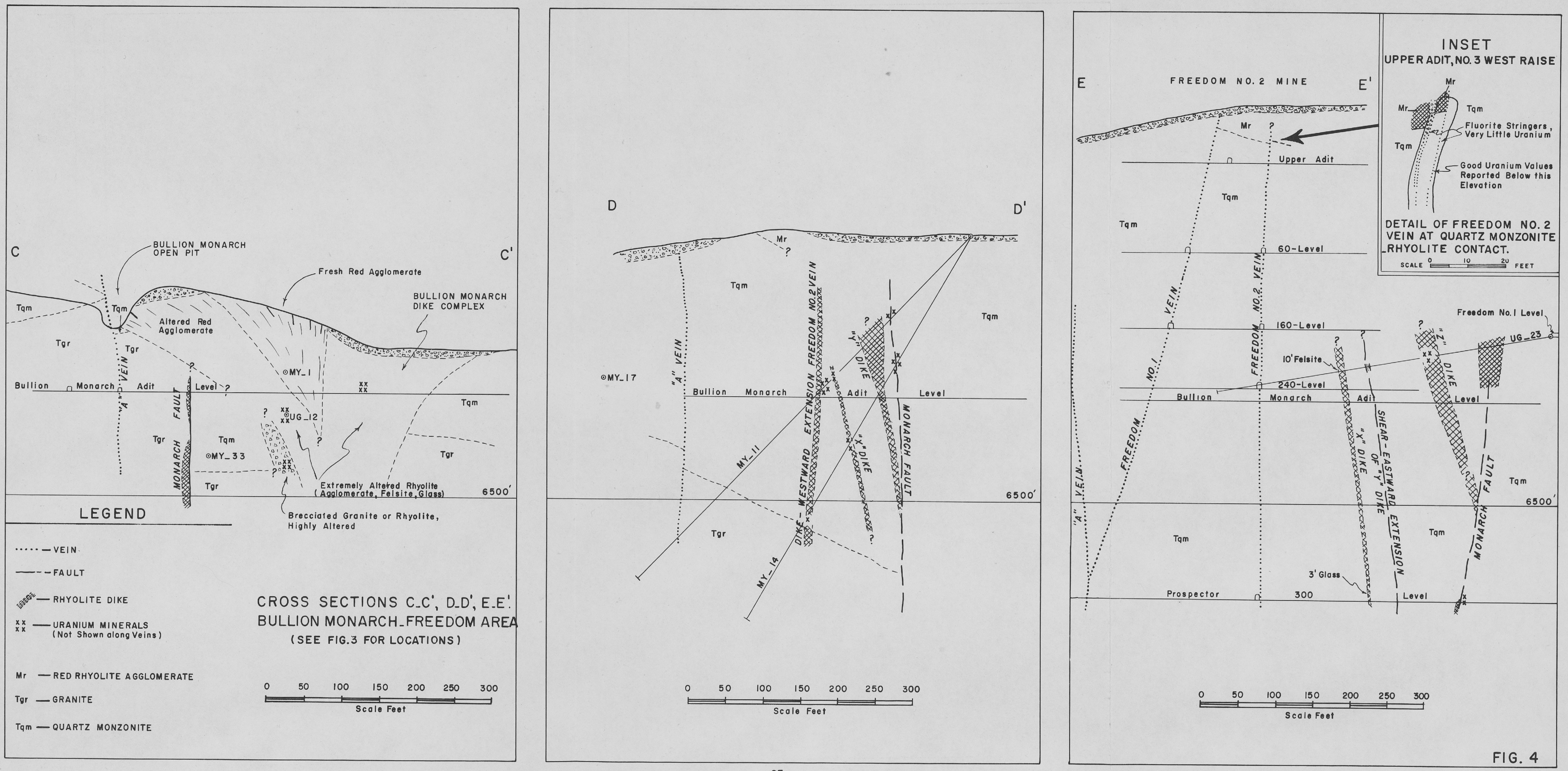
CROSS SECTIONS A–A', B–B'
MARYSVALE AREA
(See Fig. 1 For Locations)

FIG. 2



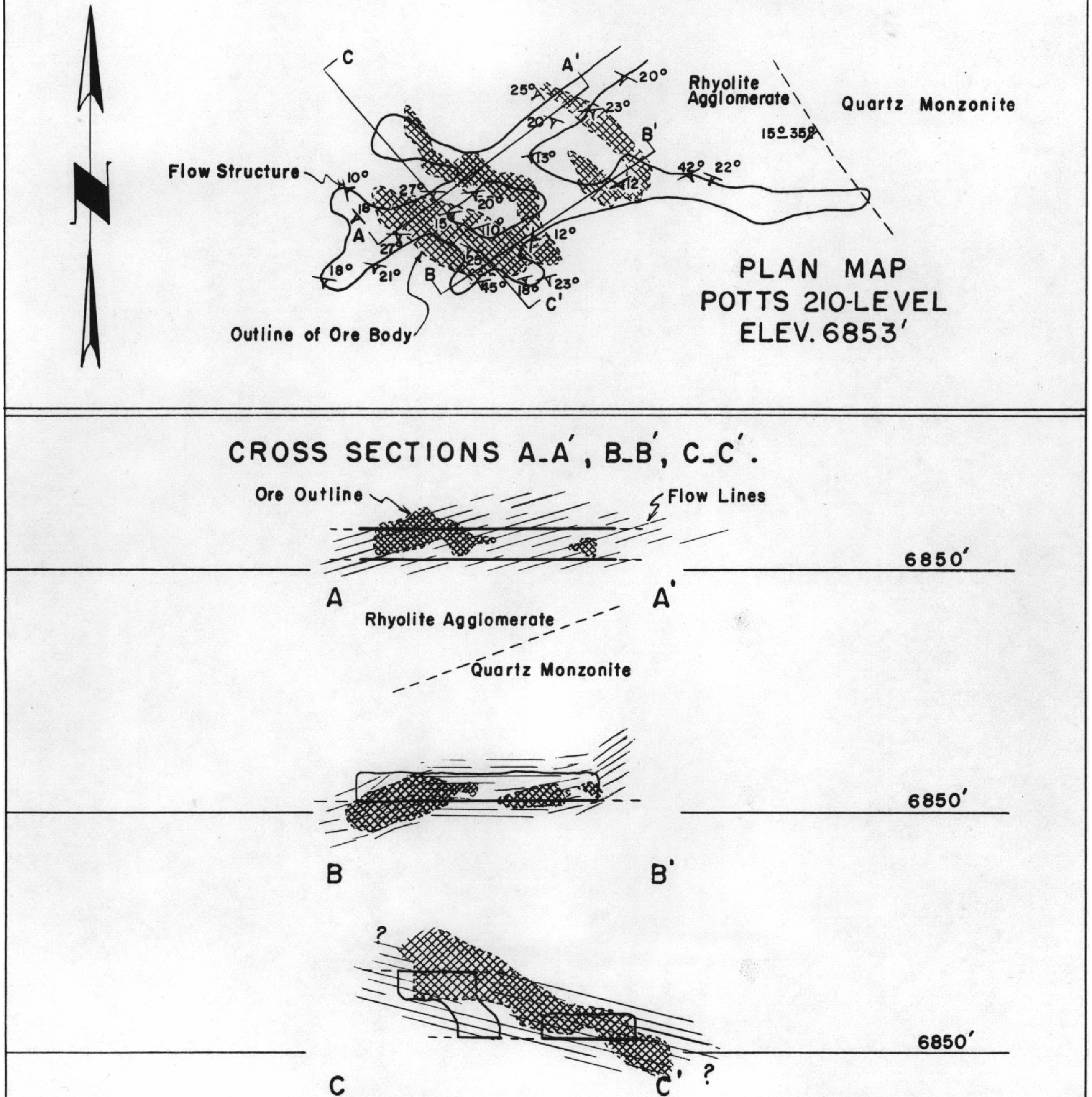
IDEALIZED GEOLOGIC MAP
of
BULLION MONARCH—FREEDOM AREA
at
ELEVATION 6640'

FIG. 3



C
C'
BULLION MONARCH OPEN PIT
Fresh Red Agglomerate
BULLION MONARCH DIKE COMPLEX
Tqm
Altered Red Agglomerate
Tgr
"A" VEIN
Bullion Monarch Adit Level
MY_1
UG_12
MY_33
MONARCH FAULT
Extremely Altered Rhyolite (Agglomerate, Felsite, Glass)
Brecciated Granite or Rhyolite, Highly Altered
6500'
LEGEND
VEIN
FAULT
RHYOLITE DIKE
URANIUM MINERALS (Not Shown along Veins)
Mr — RED RHYOLITE AGGLOMERATE
Tgr — GRANITE
Tqm — QUARTZ MONZONITE
CROSS SECTIONS C_C', D_D', E_E'.
BULLION MONARCH_FREEDOM AREA
(SEE FIG.3 FOR LOCATIONS)
0 50 100 150 200 250 300
Scale Feet
D
D'
Mr
MY_17
"A" VEIN
DIKE - WESTWARD EXTENSION FREEDOM NO.2 VEIN
"Y" DIKE
"X" DIKE
MONARCH FAULT
Bullion Monarch Adit Level
MY_11
MY_14
6500'
0 50 100 150 200 250 300
Scale Feet
E
E'
FREEDOM NO. 2 MINE
Upper Adit
60-Level
160-Level
240-Level
FREEDOM NO. 1 VEIN
FREEDOM NO. 2 VEIN
10' Felsite
"Z" DIKE
Freedom No. 1 Level
UG_23
Bullion Monarch Adit Level
SHEAR-EASTWARD EXTENSION OF "Y" DIKE
"X" DIKE
"A" VEIN
MONARCH FAULT
3' Glass
Prospector 300 Level
6500'
INSET
UPPER ADIT, NO. 3 WEST RAISE
Fluorite Stringers, Very Little Uranium
Good Uranium Values Reported Below this Elevation
DETAIL OF FREEDOM NO. 2 VEIN AT QUARTZ MONZONITE _RHYOLITE CONTACT.
SCALE 0 10 20 FEET
0 50 100 150 200 250 300
Scale Feet

FIG. 4



POTTS FRACTION MINE
PLAN & SECTIONS
Showing
DETAILS OF ORE BODIES

0 20 40 60 80 100 120
Scale Feet

FIG. 5

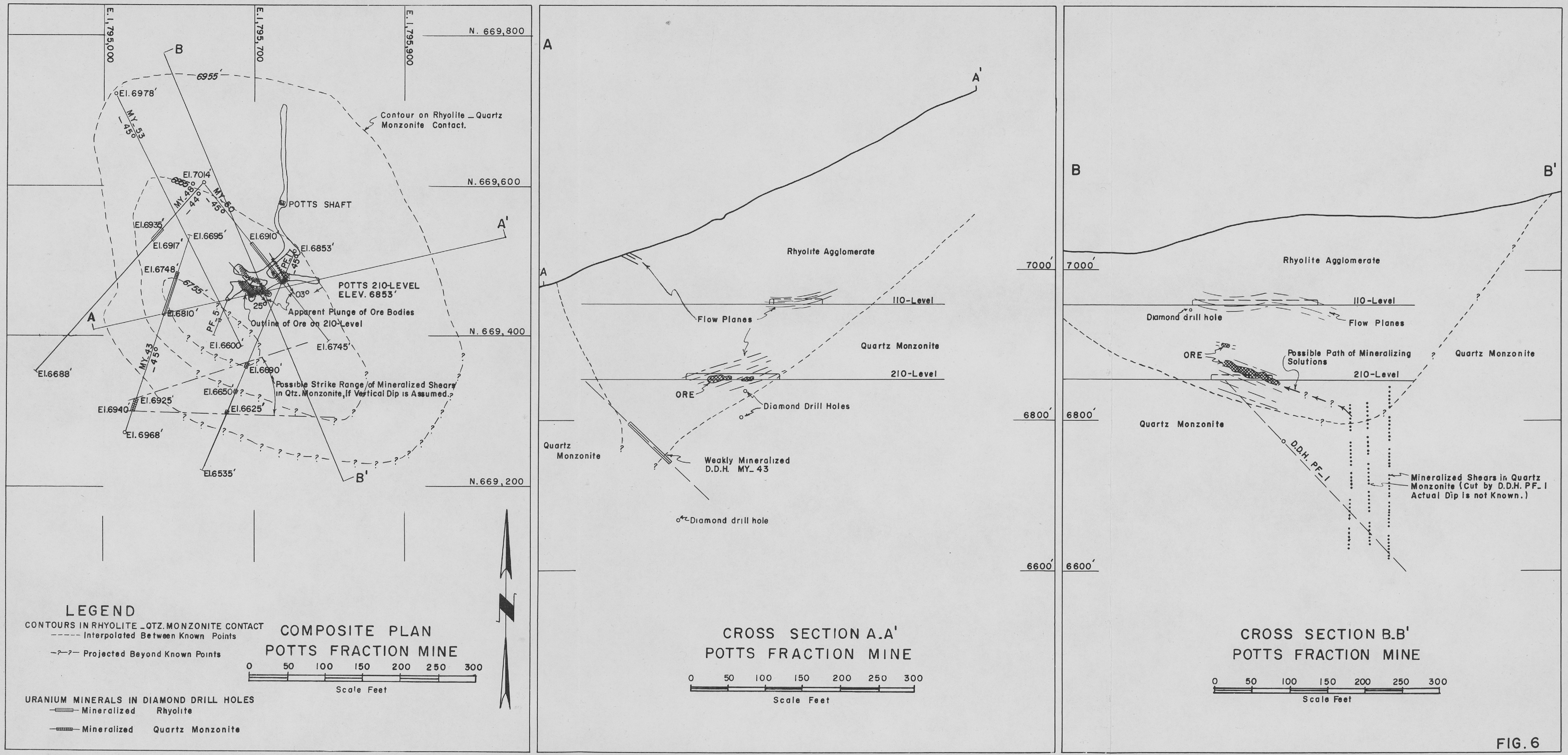
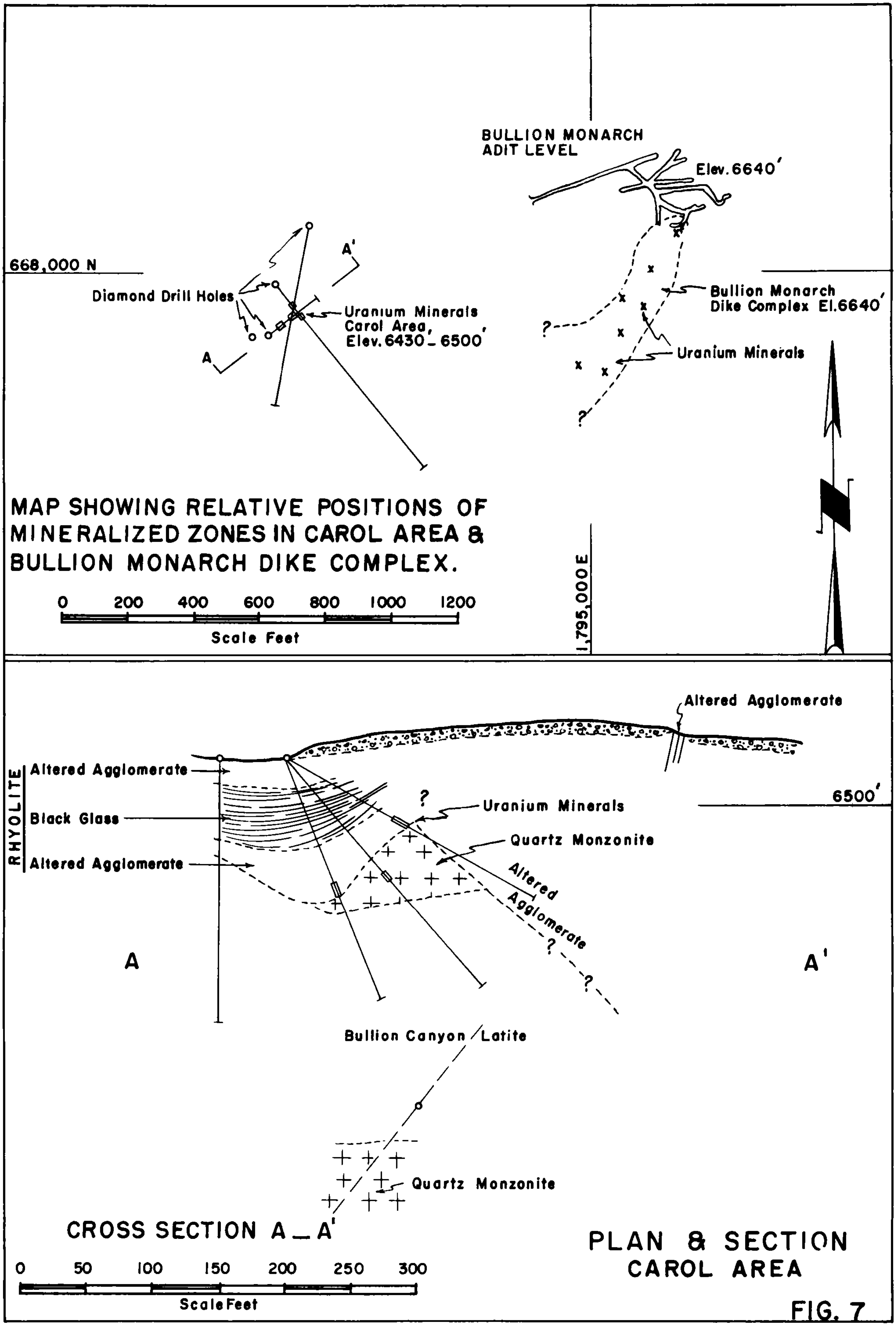

E.1,795,000
E.1,795,700
E.1,795,900
N. 669,800
N. 669,600
N. 669,400
N. 669,200
6955'
6755'
El. 6978'
MY-53 -45°
Contour on Rhyolite _ Quartz Monzonite Contact.
El. 7014'
MY-48 -44°
MY-60 -45°
POTTS SHAFT
El. 6935'
El. 6917'
El. 6695'
El. 6910
El. 6853'
PF-1 -45°
El. 6748'
POTTS 210-LEVEL ELEV. 6853'
03°
25°
Apparent Plunge of Ore Bodies
El. 6810'
PF-5
Outline of Ore on 210-Level
El. 6600'
El. 6745'
El. 6690'
El. 6688'
MY-43 -45°
El. 6650
Possible Strike Range of Mineralized Shears in Qtz. Monzonite, If Vertical Dip is Assumed.
El. 6940
El. 6925'
El. 6625'
El. 6968'
El. 6535'
A
A'
B
B'
LEGEND
CONTOURS IN RHYOLITE _ QTZ. MONZONITE CONTACT
Interpolated Between Known Points
Projected Beyond Known Points
URANIUM MINERALS IN DIAMOND DRILL HOLES
Mineralized Rhyolite
Mineralized Quartz Monzonite
COMPOSITE PLAN
POTTS FRACTION MINE
0 50 100 150 200 250 300
Scale Feet
Rhyolite Agglomerate
110-Level
Flow Planes
Quartz Monzonite
210-Level
ORE
Diamond Drill Holes
Quartz Monzonite
Weakly Mineralized D.D.H. MY_43
Diamond drill hole
CROSS SECTION A-A'
POTTS FRACTION MINE
0 50 100 150 200 250 300
Scale Feet
7000'
6800'
6600'
Rhyolite Agglomerate
110-Level
Diamond drill hole
Flow Planes
ORE
Possible Path of Mineralizing Solutions
Quartz Monzonite
210-Level
Quartz Monzonite
D.D.H. PF-1
Mineralized Shears in Quartz Monzonite (Cut by D.D.H. PF-1 Actual Dip is not Known.)
CROSS SECTION B-B'
POTTS FRACTION MINE
0 50 100 150 200 250 300
Scale Feet

FIG. 6



PLAN & SECTION
CAROL AREA

FIG. 7