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TO: MR. R. D. CYPERT, JR.

FROM: KENNETH RANK

SUBJECT: "NONSANDSTONE"-TYPE RADIOACTIVE MINERAL OCCURRENCES IN UTAH

SUMMARY

The most important "nonsandstone" uranium deposits in Utah are located near Marysvale, northern Piute County. Other important occurrences are located at Temple Mountain, southern Emery County, and in the Thomas Range, central Juab County.

At Marysvale uraniferous fluorite-quartz-sulfide veins occur mainly in Tertiary quartz monzonite, but some significant mineralization occurs in volcanics of slightly younger and older ages. Economic minerals present include pitchblende, pyrite, marcasite, fluorite, and jordisite. Fluorite is closely associated with uranium mineralization along faults, shears, and breccia zones. Some uranium also occurs in altered wall rocks adjacent to the mineralized veins. The veins, while narrow, are persistent both horizontally and vertically. The best ore occurs at cross fault intersections, forming shoots. Uranium mineralization typically is only a few inches wide. Considerable alteration is associated with the mineralization. The deposits are Pliocene in age.

At North Temple Mountain uramium occurs in collapse structures (breccia pipes) cutting Mesozoic and Paleozoic(?) sedimentary rocks. The structures may be similar to those in the Grand Canyon (Orphan Lode) region. At Temple Mountain uraninite is associated with base metal sulfides, including arsenopyrite(?), realgar, and asphaltite; at the Orphan Lode uraninite, base metal sulfides, cobalt-nickel arsenides, and tennantite are present. Mineralization is confined to pipes and adjacent to them. Mineralization is Tertiary.

Uraniferous fluorite deposits in the Thomas Range occur as veins and pipes transecting Paleozoic dolomites, or as pore space fillings and coatings in tuffaceous, conglomeratic sandstone where secondary uranium minerals have precipitated without fluorite. The pipes and veins contain up to 95% fluorspar. Most deposits narrow downward. Some are up to 100 feet in diameter. Uranium up to 0.33% has been reported but most contain less than 0.10% uranium. Uranium is complexly intergrown with fluorite; secondary minerals are rare.

The remaining 47 occurrences are mostly similar to these major types. Other types include tactite skarn occurrences, pegmatites, uraniferous base metal fissure veins, rare earth minerals in igneous rocks, and uranium in faults crossing various rock types. Only those vein occurrences similar to those in the Marysvale district in southwestern Utah warrent further field evaluation.

INTRODUCTION

This brief review is intended to show the locations of "nonsandstone"-type uranium occurrences in Utah. It also attempts to illustrate the occurrences according to host rock, and mineralogic-structural types. I believe this is one of the most convenient techniques to show the types of occurrences presently known in the state, and also speculate on the regions and types of commercial deposits that may be found here in future exploration efforts.

Except for field studies in only one area this study did not include field reconnaissance. The project represents only a rapid literature search. However, based on field studies in other western states at or near similar occurrences to those found in Utah one can assume that Utah is not without merit. It has some good "hard rock" occurrences. I would place it along with Washington, Arizona and Alaska in favorability. These areas seem to be among the best areas to explore for nonsandstone-type uranium occurrences outside of the Rocky Mountain province at the present time.

I would recommend future field reconnaissance in certain areas where anomalous radioactivity has been reported in favorable environments. Perhaps the field phase of these investigations should include visits to the Thomas Range, Temple Mountain, and Marysvale districts. These visits would assist in placing into perspective those occurrences where only anomalous radioactivity is known.

GENERAL

About 140 radioactive occurrences were located in Utah as a result of this investigation. Nearly 36 percent of these occurrences and deposits are illustrated in Figure 1. The remaining 64 percent are nearly all located in the Marysvale, Thomas Range and Temple Mountain districts. Because of the scale of the map (Figure 1) these districts are represented by only a single location. The occurrences in each district are similar in most respects and it is believed they can be grouped together in this review.

Utah seems to be a typical state with respect to "nonsandstone"-type uranium occurrences. Like most western states little solid information is available on "hard rock" uranium prospects where insignificant production has been recorded. Conversely, where production has been significant, vast amounts of good information is available. This is an unfortunate dilemma for the "grass roots" explorationist. If good information were available on all occurrences one could quickly and reliably judge the merits of further exploration in each area. As it stands, one can only speculate on the areas that have, as yet, been unproductive. Without further field investigation and basic research most of the minor occurrences cannot be properly evaluated. Therefore it is my opinion that many of the more prospective occurrences should warrent field evaluation in the field. This could be accomplished during the 1976 field season. During or at the end of that period we should

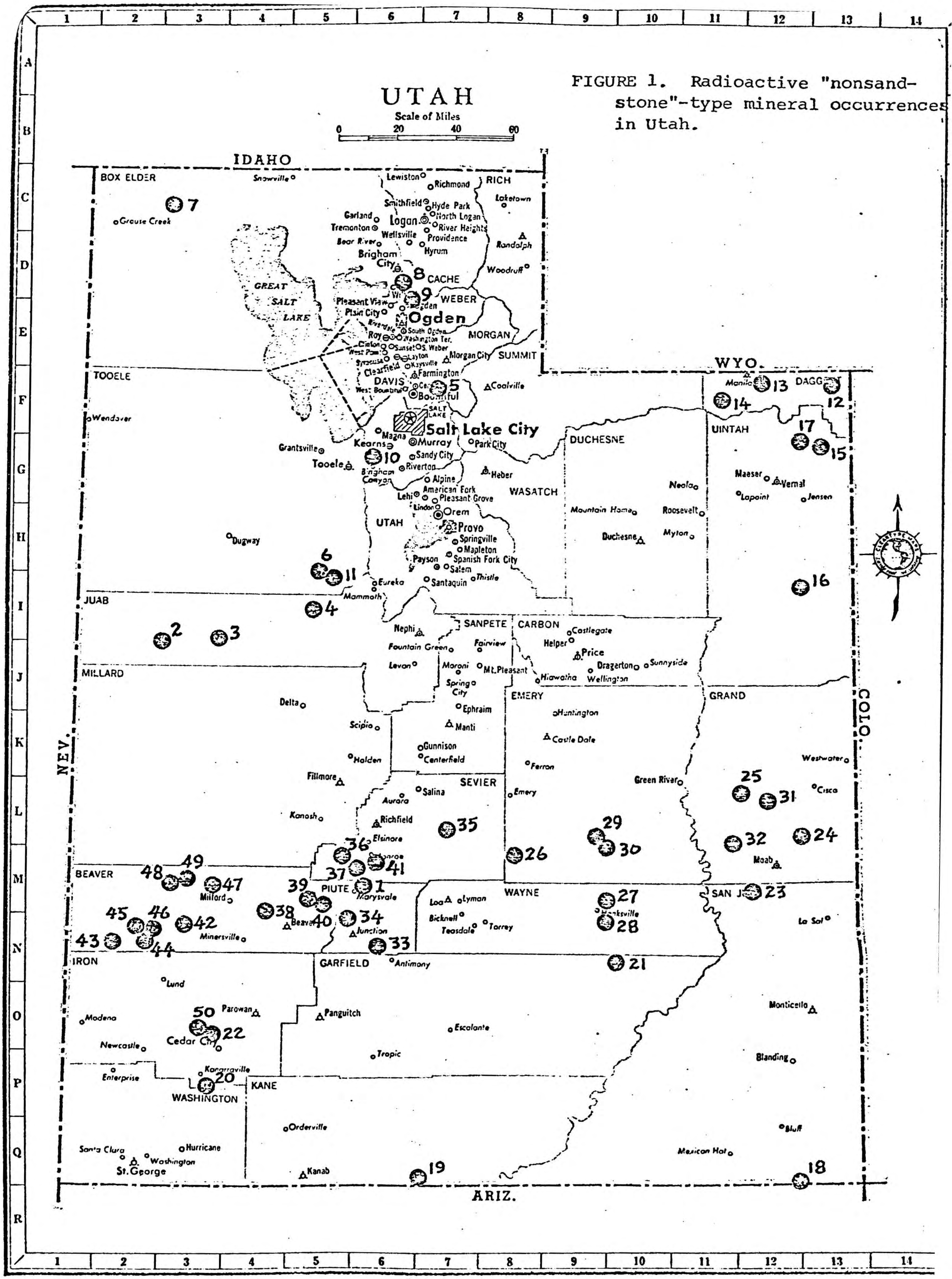

FIGURE 1. Radioactive "nonsandstone"-type mineral occurrences in Utah.

have a good idea of the exploration opportunities existing in Utah for an economic "hard rock" uranium discovery.

This study does not include radioactive spring occurrences. Actually only one was located. Samples were taken, both water and limonitic sinter, and all samples yielded less than 0.001 percent U_3O_8. The occurrence, located at the northern end of the Fish Springs Range (Wilson Hot Springs), is strongly radioactive. The lack of chemical verification suggests the anomaly is the result of radon gas. It is of no direct economic interest. Likewise, uranium occurrences in marine phosphate strata were not considered in this study. These type occurrences will be studied in detail at a later date.

Only two pegmatite occurrences were found in this study. Both appear to be of little interest. They are discontinuous(?), both vertically and horizontally, and because of their rare earth mineralogy they are probably of no economic interest.

Over 19 percent of the occurrences could not be classified with much certainty. Nearly all of these reported anomalies were taken from either Butler, et. al. (1962), and Walker and Osterwald (1963), and they made no attempt to discuss their geologic features, nor indicated available source information. Most appear to be of minor importance. These occurrences generally are associated with quartz, flourite or carbonate fissure(?) veins in shears and faults and contain minor to various amounts of base metal minerals. In this group two occurrences (numbers 47 and 50) are found in magnetite-bearing skarn(?) zones that are reminiscent of pyrometasomatic deposits such as Mary Kathleen, Queensland, Australia. The lack of information, however, suggests only radioactive anomalies at these localities. I believe these are probably of no economic potential.

It should be noted that a considerable number of occurrences of unknown types occur in sandstone environments in the Colorado Plateau province. These were tabulated here because they are strictly defined as vein-type occurrences by Butler et. al. (1963), and Walter and Osterwald (1963). In all cases mineralization is confined to shears, faults and breccia zones. These occurrences may be genetically related to epigenetic Colorado Plateau type deposits.

DEPOSITS IN PRECAMBRIAN METAMORPHICS

Only two occurrences were found that fall into this category. The Arthurs Fork occurrence (No. 5), in Morgan County, is reported to contain both monazite and xenotime associated with uraninite and molybdenite in small, local, biotite-rich pods and layers in migmatized biotite gneiss of the Farmington Canyon Complex of Precambrian age (Adams, 1963). No other information could be located concerning this occurrence. While the occurrence seems to be of minor importance it is situated in a favorable geologic environment. Perhaps some effort should be made in the future to investigate the regional geology and visit the prospect.

Mineralogic-Structural Features	HOST ROCK TYPE					
	TERTIARY		MESOZOIC-PALEOZOIC	PRECAMBRIAN	UNDIVIDED	
	Volcanics	Plutonics	Sedimentary	Metamorphics	Pegmatites	Unknown rock types
Uraninite (pitchblende) associated with quartz-fluorite-pyrite veins. Cinnabar, molybdenite, base metals may be present, Fracture controlled.	4 (39,40,45*, 46)	2 (1*,6*)	1			11 (9,21,27,28,31, 32, 34-37, 42)
Uranium minerals associated with minor amounts of introduced metallic minerals. Fracture controlled.	1 (2)		4 (20,23-25)	1 (12*)		9 (10, 13-17, 19, 33, 48)
Anomalous radioactivity reported. No secondary minerals. Possible base metals present. Fractures(?)						3 (4,18,43)
Uranium and thorium present in rare earth minerals. Usually present as disseminations.	3 (38,41,44)	1 (49)		1 (5)	2 (8*,11)	2 (7,22)
Uraninite associated with asphaltite and other minerals including: pyrite, galena, arsenopyrite. Fracture controlled.			3 (26,29,30*)			
Anomalous radioactivity associated with magnetite deposits. Skarn minerals may be present. Pyrometasomatic.						2 (47,50)

FIGURE 2. Classification of "nonsandstone"-type radioactive mineral occurrences in Utah. (Numbers in parenthesis refer to Figure 1; asterisks refer to Figure 3.)

Name, Location, Number	Age and type of host rock	Uranium minerals present	Associated minerals	Gangue	Structural features	Alteration	Age of Mineralization
(1) Marysvale dist., Piute County	Tertiary volcanics and granitic plutons	Pitchblende, many secondary minerals	Cinnabar, pyrite, fluorite jordisite	Quartz, fluorite, adularia hematite	Pronounced faults	Argillic kaolinitic hematitic chloritic	Pliocene
(3) Thomas Range Juab County	Paleozoic dolomite	Pitchblende, fluorite	Pyrite, fluorite	Fluorite	Fissure veins and breccia zones	None	Tertiary
(30) Temple Mountain collapse, Emery County	Paleozoic-Mesozoic sediments	Uraninite, many secondary minerals	Pyrite, galena realgar asphalt	Asphaltite, carbonates	Collapse pipes	Dolomitization keolinitic silicification	Tertiary(?)
(45) Wah Wah Mtns., Beaver County	Tertiary volcanics and Paleozoic limestone	Pitchblende autunite	fluorite pyrite(?)	fluorite fouge	Faulted contact zone	Not known	Tertiary
(8) Willard dist., Box Elder County	Pegmatite in Precambrian complex	Uraninite	Biotite	Pegmatite	Pegmatic pods and layers in gneiss	None	Precambrian
(6) Silver King, Sheeprock Mtns., Tooele County	Tertiary Granite	Pitchblende	Pyrite, cobalt, copper, manganese minerals	Fluorite	Narrow fissure veins	Not appreciable	Tertiary
(12) Yellow Canary Daggett County	Precambrian metamorphics	Tyuyamunite, carnotite, volborthite	Hematite, secondary copper minerals	Hematite, quartz, carbonates	Fractures near diorite dike	Silicification sericitization hematitic	Precambrian(?)

FIGURE 3. Geologic characteristics of some representative uranium occurrences in Utah.

The Yellow Canary deposit (No. 12) in the northern Uinta Mountains, Daggett County, contains uranium mineralization in highly fractured quartzite near the top of the Precambrian Red Creek formation. The chief radioactive mineral is tyuyamunite associated with carnotite, volborthite, hematite, azurite, malachite, brochantite, and opal. The quartzite is cut by three northeast normal faults and by diorite dikes and quartz-carbonate veins (Wilmarth, 1953). Other unknown types in northern Daggett County may be of the same type (see Figure 1) but this could not be verified in the literature search. The Yellow Canary may be similar to uraniferous occurrences in the Precambrian Dripping Springs Quartzite of central Arizona. Deposits in the Dripping Springs Quartzite are believed to be of limited size and economic significance (Rank, 1975).

DEPOSITS IN MESOZOIC OR AND/OR PALEOZOIC SEDIMENTARY ROCKS

Three distinct categories of uranium occurrences were found that can be grouped under Mesozoic and/or Paleozoic sedimentary rock types. Type examples are: uraniferous massive flourite deposits in the Thomas Range, mineralized shears, faults and breccia zones in the Colorado Plateau province with minor associated base metal mineralization, and mineralized collapse structures in the San Rafael district. About one dozen specific occurrences were found to contain uranium in the Thomas Range as a result of this study. They are all represented by a single location in Figure 1 (No. 3). Actually, Heinrich (1958) reports that about 40 prospects have been located in the district and about half have yielded flourite.

The uraniferous flourite veins and pipes occur in the western part of the Thomas Range, on Spors Mountain. The deposits transect fine-grained Silurian and Ordovician dolomite and apparently terminate against underlying Middle Ordovician quartzite. These rocks are cut by Tertiary acidic dikes and stocks, and breccia zones (Staatz and Osterwald, 1956).

Most of the uraniferous flourite deposits are in pipe-like breccia zones associated with faults. The pipes are nearly vertical and their outlines are irregular to circular or ellipsoidal in plan. Surface cross sections range in diameter up to 100 feet. Most occurrences are inverted cones pinching abruptly downward (Heinrich, 1958).

The veins range from a few inches in width and a few feet in length to a width of 14 feet and a length of 250 feet. Most of the mineralized fissure veins are in dolomite but a few occur along faults in rhyolite porphyry dikes. Some flourite deposits have been found as disseminations in volcanic rocks in clayey layers in tuff, and in cavities and fractures in rhyolite and latite (Staatz and Osterwald, 1956).

The ore consists of 65 to 95 percent flourite. Carnotite is rare and occurs only at two occurrences. Generally radioactive uranium minerals cannot be seen although nearly all flourite occurrences are abnormally radioactive. Uranium can run as high as 0.33 percent but in only four deposits have uranium values exceeded more than 0.10% U.

The Thomas Range uraniferous fluorite deposits are not commercial because of the complex nature of the uranium in the fluorite lattice structure, generally low grade, and discontinuous nature of the mineralized structures.

Uranium occurrences in the Colorado Plateau province (Figure 2, Nos. 20, 23-25) occur as fissure veins(?) in faults, shears, and breccia zones. These occurrences are associated with base metal minerals. Butler, et. al. (1962), and Walker and Osterwald (1963) give locations for these occurrences but no published references. This suggests their small size and indicates that they have had only limited or no previous production. The occurrences are probably all located in Mesozoic sedimentary rocks. No other information was located concerning their geologic characteristics. They are low priority occurrences based on this present (lack of) information.

Uranium occurrences in collapse pipes at Temple Mountain, San Rafael Swell, southern Emery County (Figure 1, Nos. 29, 30) may be similar to the Orphan Lode, Grand Canyon Arizona. These deposits are closely related to breccia pipes. Within the pipes surrounding Mesozoic and Paleozoic sediments have slumped downward within the pipe chamber. In both localities a number of breccia pipes (collapse structures) are known and most are radioactively anomalous although few have made commercial deposits. The origin of the pipes are believed to have a similar origin.

The mineralogy at Temple Mountain is somewhat different from the Orphan Lode. At Temple Mountain uraninite is associated with pyrite, galena, sphalerite, arsenopyrite(?) realgar and asphaltite. Mineralogy at the Orphan Lode consists of pyrite, uraninite, chalcopyrite, tennantite, minor galena, sphalerite, and nickel-cobalt arsenides. At both areas mineralization occurs adjacent to pipe rims and within the collapse structures. Mineralization in both localities is believed to be Tertiary. Alteration associated with the mineralization includes dolomitization, silicification and kaolinitization. Hematitization and chloritization is present in the Orphan Lode but may not be present at Temple Mountain.

Uranium exploration in the San Rafael Swell has probably been intense in the past 20 years. As a result of previous and present(?) exploration efforts land ownership there is probably very complicated.

A similar occurrence has been reported by Walker and Osterwald (1963) in southwestern Emery County (Figure 1, No. 26). No information on this reported occurrence is available.

DEPOSITS IN TERTIARY IGNEOUS ROCKS

Clearly the most important "hard rock" uranium occurrences in Utah are those near Marysvale, Utah (Figure 1, No. 1). These uraniferous fluorite-quartz-sulfide vein deposits are among the most productive known in the United States. They lie in a zone along the edge of a Tertiary quartz monzonite intrusive body. Tertiary volcanics consisting of alkalic latites and andesites (flows, tuffs, and agglomerates) have been intruded by latite porphyry, quartz monzonite, and granite. Later, Tertiary rhyolitic volcanics were deposited over the previous igneous rocks (Kerr, 1968).

Most of the veins are in quartz monzonite. The fault controlled veins have a northeasterly or northwesterly strike. These fault zones have dips from 40 to 60 degrees. Each zone consists of one or more veins of chalcedony or coarse-grained quartz with considerable fluorite, adularia, and some hematite. Pitchblende, pyrite, marcasite, and jordisite also are present. Metacinnabar is present in the deposits and is unique among uranium deposits (Heinrich, 1958). Fluorite is dark purple and is closely associated with uranium minerals and jordisite both veins and hydrothermally altered wall rock adjacent to the faults. The wall rocks typically contain magnetite, pyrite and ilsemannite. The pitchblende forms fine-grained veinlets, vein stockworks, irregular masses, and breccia cement, and in altered wall rocks also appears as grains, pods, fracture coatings, and vesicle fillings. In veins, pitchblende concentrations are confined to a maximum width of a few inches in any zone (Kerr, 1968).

Some faults are mineralized over strike lengths of 800 feet and vertical distances of 700 feet. Some ore shoots occur at junctions of intersecting fault zones or where faults abruptly change strike. Values as high as several per cent U_3O_8 have been recorded but typically the ore material averages between 0.20 to 0.25 percent U_3O_8 (Kerr, 1968). Pitchblende is known to have a vertical range of at least 2,000 feet (Walker and Osterwald, 1956).

Vein zones are separated by gouge from argillized wall rock in which biotite has been altered to chlorite and/or illite, feldspar to sericite, and magnetite to pyrite. Montmorillonite and kaolinite are also present in the alteration zone (Kerr, 1968). Quartz and hematite also are present locally. Alunite deposits present in the district are generally not radioactive (Heinrich, 1958).

Some uranium mineralization occurs in the volcanics which also contain both argillic alteration and pyrite and fluorite. The mineralization is thought to be Pliocene in age (Kerr, 1968).

The assemblage of oxidized uranium minerals includes autunite, torbernite, metatorbernite, phosphuranylite, uranophane, beta-uranophane, schroeckingerite, johannite, uranopilite, zippeite, tyuyamunite, and rauvite (Walker and Osterwald, 1956; Kerr, 1968). Umohoite and sooty pitchblende probably also are secondary. Concentrations of these species occur in near-surface, oxidized extensions of flourite-pitchblende veins (Heinrich, 1958). Uranophane and beta-uranophane are the most abundant and occur only in quartz monzonite, granite, and rhyolite as fracture coatings and veinlets. Other minerals of the oxidized zone include ilsemannite, goethite, manganese oxides, carbonates, and gypsum. Oxidation is deep extending to as much as 400 feet (Heinrich, 1958).

Butler, et. al. (1962), and Walker and Osterwald (1963) indicate about 20 individual occurrences in the district. About half of these have had some production many of which have yielded greater than 1,000 tons of ore grade material. Total production from the district is in excess of 275,000 tons yielding about 1.1 MM pounds of U_3O_8. The district is presently being explored by several(?) companies. Western Nuclear Corporation probably has the greatest holdings in the district and rumor has it that they have staked about 1,000 new lode mining claims in the district this year.

Several small deposits (Figure 1, Nos. 39, 40) occur northeast of Beaver, Utah, on the west slope of the Tushar Mountains. The host rocks are Tertiary volcanics identified as being the same as those present in the Marysvale district. The mineralization, which occurs along dikes related to volcanism, consist almost entirely of secondary uranium minerals, fluorite, pyrite, quartz, chlorite, sericite and iron oxides along fractures, faults, and shear zones (Heinrich, 1958). Hilpert (1969) reports the presence of erratically distributed uraninite as also being present.

The southern part of the Wah Wah Mountains, western Beaver County (Figure 1, Nos. 45, 46), uraninite and some autunite are present in rhyolite porphyry in association with fluorite pods adjacent to the faulted contact with Paleozoic carbonate rocks and in fragmental rhyolitic tuff that, in places, directly overlies carbonate rocks (Hilpert, 1969). These occurrences are the subject of a recent submittal and will be investigated in the field in 1976. Similar occurrences have been mentioned by Hilpert (1969), Butler, et. al. (1962), and Walker and Osterwald (1963) at several other locations in western and southwestern Utah (Figure 1, Nos. 2, 38, 41 and 44). These occurrences are typically small but could indicate larger deposits at depth similar to those found in the Marysvale district.

Narrow fluorite veins with minor pitchblende, pyrite, silver minerals, and oxidized cobalt, copper and manganese minerals occur in Tertiary granite in the Erickson district, Sheeprock Mountains, Juab County (Figure 1, No. 6). They appear to be only of scientific interest; no production has been indicated nor are they expected to yield uranium ores in the future.

The Yellow Chief mine in the Thomas Range (Figure 1, No. 3) is in a valley that separates Spor Mountain from the main part of the Thomas Range. It is a fairly large deposit (Hilpert, 1969). Upper Tertiary lava flows and tuffs in the valley are interbedded with clastic sediments derived from nearby ranges. The host rock for the uranium ore is a massive, tuffaceous, conglomeratic sandstone. It was deposited in a fluvial environment and is probably late Miocene or early Pliocene in age. The ore mineral is beta-uranophane. It fills pore spaces and coats the sandstone particles. The deposits appear to be stratigraphically controlled. This uranium deposit differs from others in fluvial strata in that carbonaceous matter and iron sulfides are sparse or lacking. Bowyer (1963) suggests the uranium may have been emplaced by circulating ground water following erosion of the uranium-bearing fluorspar bodies of Spor Mountain, or it may have been altered from primary uranium minerals originally contained in magmatic fluids. It has been included here because it indicates that several types of deposits may exist in districts where numerous vein-type deposits are known but are uneconomic for other reasons. This deposit shall be visited during the 1976 field season.

Several locations (Figure 1, Nos. 38, 41, 44 and 49) have been indicated by various workers (Butler, et. al., 1963; Walker and Osterwald, 1963; Hilpert, 1969; Adams, 1969) to contain anomalous radioactivity due mainly to thorium and rare earth minerals. These anomalies are of no interest because they are confined to erratic shear zones in igneous rocks, or as disseminations, and do not contain appreciable uranium. They can, with no question, be considered of little or no practical economic value.

CONCLUSIONS AND RECOMMENDATIONS

About 140 individual radioactive mineral occurrences were found in this brief literature search. General locations and districts are represented by 50 localities in Figure 1. These occurrences range in geologic age from Precambrian to Tertiary. The most important and largest number are of Tertiary age. These include deposits in the Marysvale, Thomas Range and Temple Mountain districts, although uranium occurrences are located in rocks of Mesozoic-Paleozoic(?) age at Temple Mountain, mineralization is probably Tertiary. Precambrian(?) occurrences are located in the Rocky Mountain province and are represented by pegmatitic pods in metamorphic environments or as occurrences in quartzite. They appear to have little economic significance.

Placer uranium occurrences found in Phanerozoic rocks were not considered in this study. Radioactive occurrences found in the Permian Phosphoria Formation were also not studied. Nor were occurrences(?) in black shales, lignites, or coals considered. Spring deposits and trace amounts of uranium in porphyry copper deposits were excluded from this study. These types appear to be of minor exploration importance at the present time.

Based on this investigation the best environments to search for undiscovered uranium deposits in Utah appear to be those of the Marysvale type. Reported fluorite-quartz-pyrite-uranium prospects in Tertiary volcanics or shear zones in Tertiary plutonics related to volcanism appear to offer some "grass roots" exploration guide-lines. I think these types should be visited during the 1976 field season. After those investigations we would be in a better position to judge the uranium possibilities of Utah.

K. Rauch

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APPENDIX

(Numbers refer to Figures 1 and 2)

NAMES OF "NONSANDSTONE" URANIUM OCCURRENCES IN UTAH

1. Marysvale district; refers to 20 individual occurrences.
2. Bell group; refers to 4 individual occurrences
3. Thomas Range fluorspar district; refers to 12 individual occurrences.
4. Orin Porter Rockwell
5. Arthur's Fork district
6. Sheeprock Mountains
7. Century mine
8. Willard district
9. Kathy Ann
10. North Bingham
11. Pegmatite
12. Yellow Canary
13. Unknown
14. Unknown
15. Jensen Draw
16. Blanca 1
17. Unknown
18. Red Mesa Copper Pit
19. Radiant Claims
20. Epsolon
21. Unknown
22. Unknown
23. Atomic King
24. Red Head Group
25. Cobalt 1
26. Helm Claims
27. Copper Queen
28. Kay Hunt
29. Little Joe
30. Fumerole and Lopez; represents eight collapse structures in area.
31. Parco 23
32. You-All group
33. Nucular Sniffer
34. Deer Trail, Great Western, Shamrock
35. Mt. Terrel Group
36. Tiger Eye 1
37. Better Be
38. Rare earth
39. Beehive group
40. Canary group
41. Monroe
42. Surprize claims
43. Commissary
44. Unnamed
45. Unnamed
46. Unnamed
47. Old Hickery
48. Horn Silver - King David
49. Unnamed
50. Smith Iron Mine

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