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Uranium in Big Sagebrush from Western U.S. and Evidence of Possible Mineralization in the Owyhee Mountains of Idaho

by

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URANIUM IN BIG SAGEBRUSH FROM WESTERN U.S. AND EVIDENCE OF POSSIBLE MINERALIZATION IN THE OWYHEE MOUNTAINS OF IDAHO

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ABSTRACT

The purpose of this report is to encourage the application of the biogeochemical approach--specifically the use of big sagebrush (*Artemisia tridentata*)--in the search for uranium occurrences in the western United States. Two regional studies of this widely distributed and dominant shrub have shown its responsiveness to known uranium mineralization in the Monument Hill and Pumpkin Buttes districts of the southern Powder River Basin, Wyoming, and the Uravan mineral belt area in southeastern Utah and southwestern Colorado. Uranium concentrations in the ash of 154 stem-and-leaf samples of sagebrush are plotted on two maps, one representing the sampling design for the Powder River Basin study, and the other representing the sampling design for the Colorado Plateaus, the Basin and Range, and the Columbia Plateaus physiographic provinces of the West. Sites having high concentrations in sagebrush correspond not only to the above uranium districts, but also reveal an area along the northeast flanks of the Owyhee Mountains in Idaho that should be further explored for its possible uranium potential.

INTRODUCTION

Sagebrush is clearly a sampling medium that geochemical explorationists should consider in western North America, for two reasons: first, its distribution; and second, its response to mineralization.

Laycock (1979, p. 207) describes its distribution as follows:

> Sagebrush is the dominant species in one of the largest range ecosystems in the western United States. The major species, big sagebrush (*Artemisia tridentata*), ranges through North and South Dakota, Nebraska, Colorado, New Mexico, and all states to the west. When other species of sagebrush are included, the range includes Oklahoma and Texas and goes far into Canada and Mexico. Total acreage estimates of the sagebrush ecosystem vary from 87 to 270 million acres, so, it is safe to say that it covers 100 million acres or more. Sagebrush generally occurs at elevations from 5,000 to 7,000 feet, but some species and subspecies grow at elevations as low as 3,000 feet; others grow up to 10,000 feet. Sagebrush grows in areas with as little as 8 or 9 inches of annual precipitation, but in some of the higher elevations, sagebrush grows in areas with as much as 25 inches of precipitation per year.

As for the response of *Artemisia* to mineralization, high levels of uranium were found in samples of big sagebrush (*A. tridentata*) that were collected from several localities during two recent regional baseline studies in the western United States. It is these case histories which form the basis of this report and point to a new area that may warrant further uranium exploration. Sagebrush should be an especially useful sampling medium in shallow valley fill over the range-front fault scarps in the Basin and Range province of the West. According to Lovering and McCarthy (1978, p. 113), blind deposits are being sought increasingly in this province.

STUDY AREAS AND SAMPLING DESIGNS

The Powder River Basin

In the fall of 1973 a geochemical reconnaissance was conducted across the Powder River Basin of Wyoming and Montana, an area underlain by rocks of Tertiary age, principally the Wasatch and Fort Union Formations. Sixty-four composite samples of stems and leaves of big sagebrush were collected, as well as samples of a soil lichen common to the high plains (Erdman and Gough, 1977). The associated soil was also sampled at three depths of the profile, and radioactivity, expressed as equivalent uranium, was included in the suite of analytical determinations.

The basin was subdivided into four sampling areas of nearly equal size. Within each area a barbell-shaped cluster of sampling sites was established which was designed to estimate the geochemical variation at a number of geographic scales, ranging from a maximum spacing of 10 km to a minimum of 10 m. A more thorough description of the sampling design may be found in Tidball and Ebens (1976).

Physiographic Provinces of the West

As part of a broader study of the baseline geochemistry of big sagebrush, stem-and-leaf samples of the current year's growth of big sagebrush were collected from randomly selected parts of the Colorado Plateaus province, the Basin and Range province (Fig. 1), and the Columbia Plateaus province of the western United States, using an unbalanced, nested geographic design. Only three major sampling cells, each 200 km on a side, were selected from each

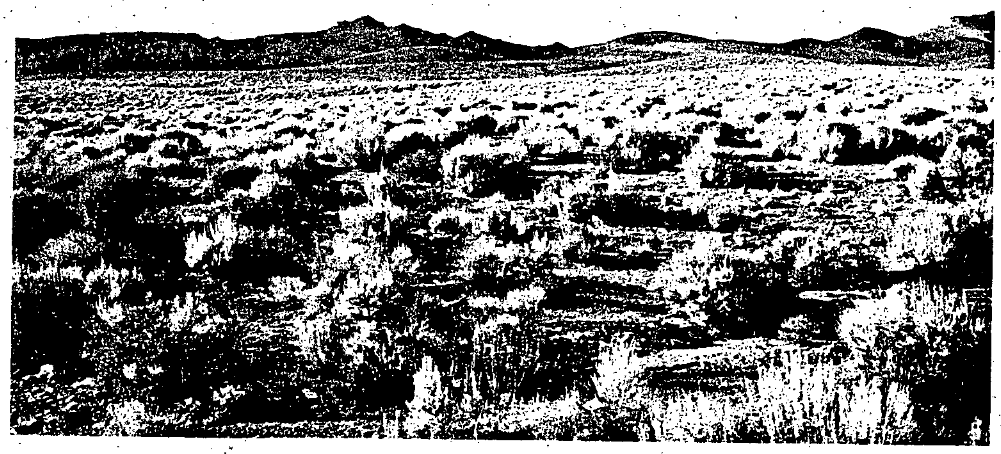

Fig. 1. Big sagebrush on Quaternary alluvium in Dry Lake Valley, southeastern Nevada. The hills in the background are in the North Pahroc Range and consist mainly of ash-flow tuffs and andesites of Tertiary age. Shrubs are about 1 meter tall.

province. The sites, then, were not uniformly distributed throughout each province. The purpose of the study was to determine whether there are important broad-scale differences in the composition of this widespread and characteristic shrub. If not, then baselines can be established quite easily over the entire range of big sagebursh occurrence. A total of 30 shrubs was sampled from each province, and samples of the top 15 cm of the associated soils were also collected. The soil samples, however, were analyzed only when the composition of the sagebrush sample from the same locality was found to be unusual.

ANALYTICAL METHOD

The combined stem-and-leaf samples were first dried and ground in a Wiley mill.[1] The resulting material was then ashed in an electric muffle furnace at about 450°C for 24 h. The uranium analyses were determined by fluorimetry (Harms and Papp, 1975, p. 77) in the plant laboratory of the U.S. Geological Survey in Denver, Colorado.

STATISTICAL METHODS

A considerable number of the plant ashes analyzed in this study contained less than 0.4 parts per million (ppm) uranium, the lower limit of analytical determination for the method used. The frequency distributions of the uranium data, therefore, are censored, and the means and standard deviations were estimated by the methods of Cohen (1959; see Miesch, 1967, for application of these methods to geochemical data).

[1]The use of a brand name in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

The frequency distributions of uranium concentration are positively skewed, and the uncensored portions correspond more closely to lognormal than to normal curves. Also, the ranges of the central 68 percent of the data are given more closely by the geometric means and geometric deviations than by the arithmetic means and standard deviations. Whereas the central range for a normal distribution is given by AM-SD to AM+SD (where AM is the arithmetic mean and SD is the standard deviation), that for a lognormal distribution is given by GM/GD to GMxGD (where GM is the geometric mean and GD is the geometric deviation). The upper limit of the central range for uranium in sagebrush from the Powder River Basin is 1.6 parts per million; the upper limit for sagebrush from the physiographic provinces study is 0.4 parts per million.

RESULTS

The Powder River Basin

Fig. 2 shows that higher than normal concentrations of uranium occur in sagebrush from two localities in the southern part of the basin that contain significant uranium occurrences. The uranium occurrences in this broad structural and topographic basin are described by Mrak (1968, p. 839) as follows:

> The uranium ore deposits occur in that part of the Wasatch Formation that is of earliest Eocene age, and they are scattered over an area of about 400 square miles. All uranium ore deposits are associated with red beds or altered sandstones within the Wasatch Formation.

However, there appears to be some question as to whether these Tertiary uranium deposits are in the Wasatch Formation of Eocene age or in the Fort Union Formation of Paleocene age (Seeland, 1976, p. 53), because of a controversy concerning the placement of the contact between these two formations.

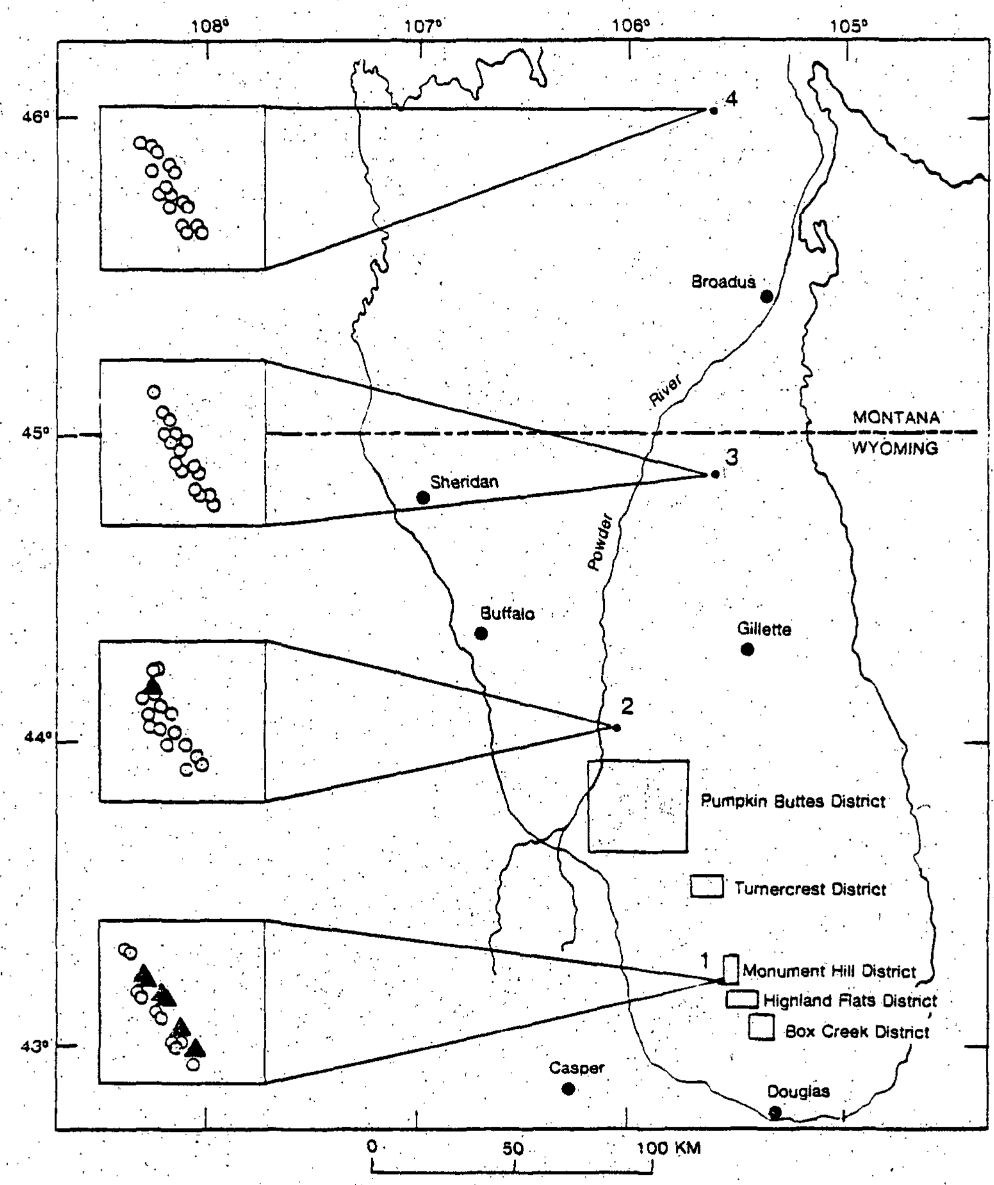

Fig. 2. Concentrations of uranium in 64 samples of big sagebrush from four areas in the Powder River Basin of Wyoming and Montana. Concentrations of 1.6 ppm or less denoted by open circles; concentrations higher than 1.6 ppm denoted by solid triangles. The distribution of uranium mining districts is taken from Mrak (1968, p. 840) and Raines et al. (1978, p. 1707).

The uranium is present in large roll-type deposits formed within the Tertiary fluvial sandstones (Dahl and Hagmaier, 1976, p. 243). The deposits are located within five recognized districts (Raines et al., 1978, p. 1706) and are probably epigenetic in origin. Precambrian granitic rocks in the mountains flanking the basin are the probable source of the uranium (Seeland, 1976, p. 64; Raines et al., 1978, p. 1722), although other sources have been proposed.

Of 64 samples of sagebrush collected from the four localities shown in Fig. 2, only 7 had high (>1.6 ppm) concentrations of uranium. These high concentrations ranged from 2.4 to 3.2 ppm. Most of the uranium-rich samples occurred at locality 1, about a kilometer west of the Monument Hill district. One sagebrush sample from locality 2, about 15 km north of the Pumpkin Buttes district, was also high in uranium. No strong correlations were observed between equivalent uranium in soils from three horizons at each sampling site and the uranium in the associated samples of sagebrush. The radioactivity in the Powder River Basin soils appears to be uniform among the four localities sampled (Tidball and Ebens, 1976), in contrast to the differences in sagebrush shown here.

The Colorado and Columbia Plateaus Provinces

Of the 90 samples of sagebrush collected from the three provinces mentioned earlier, only 9 had high (>0.4 ppm) concentrations of uranium. These high concentrations ranged from 0.6-1.4 ppm in the ash. The 9 samples are from two regions identified in Fig. 3.

Uranium in the Uravan mineral belt area. Four of the 9 uranium-rich samples represented in Fig. 3 are from the northwestern edge of the Uravan mineral belt in the Colorado Plateaus province.

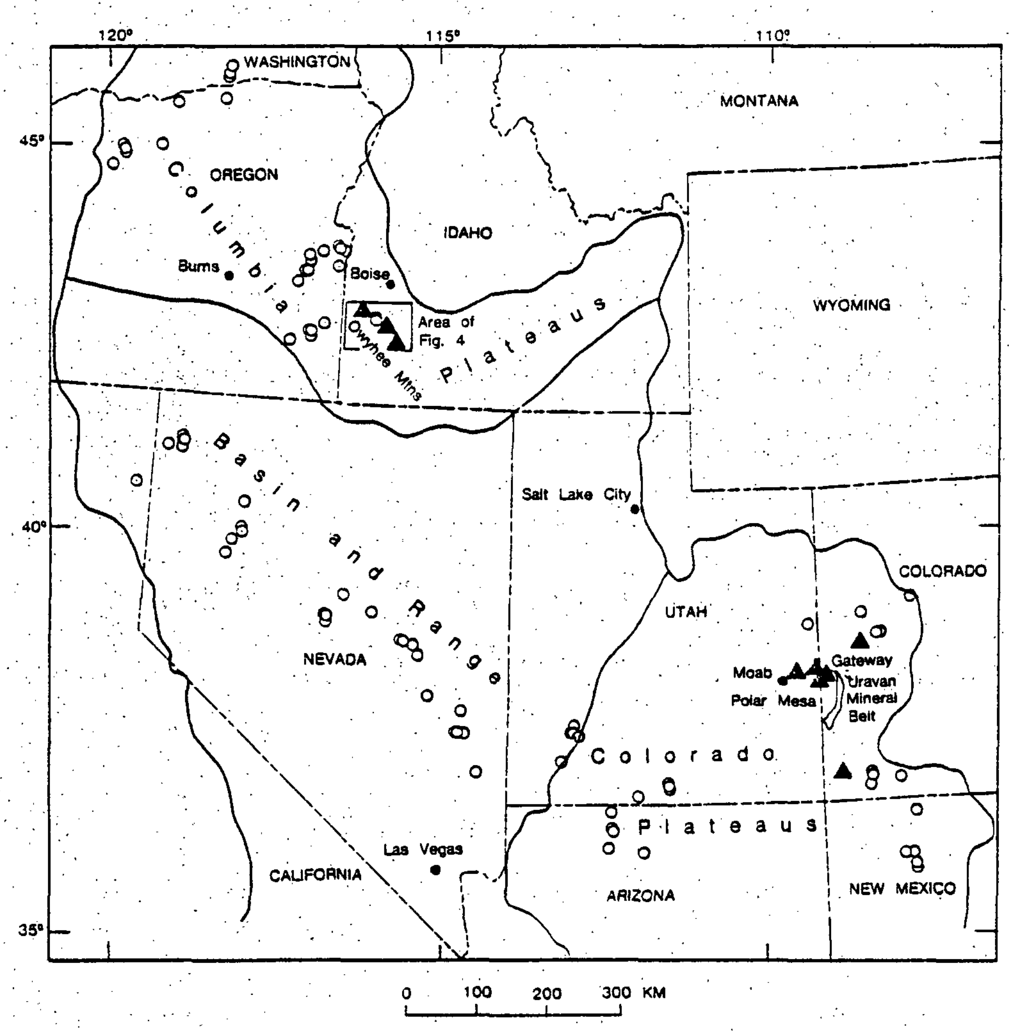

Fig. 3. Concentrations of uranium in 90 samples of big sagebrush from three physiographic provinces of the western United States. Concentrations of 0.4 ppm or less denoted by open circles; concentrations higher than 0.4 ppm denoted by solid triangles. Placement of the Uravan mineral belt is from Fischer and Hilpert (1952, plate 1).

Significant deposits of uranium and vanadium occur in the Salt Wash Member of the Morrison Formation (Late Jurassic) at many localities in this region. But "the more productive occurrences are in southwestern Colorado and adjacent portions of southeastern Utah in an area referred to as the Uravan mineral belt" (Motica, 1968, p. 806). The Uravan uranium mineral belt has an arcuate shape and extends from Colorado into Utah. It is about 42 km long and 1 to 5 km wide. As proposed by Fischer and Hilpert (1952, p. 4), "The name 'Uravan mineral belt' is applied to a narrow elongate area in southwestern Colorado in which carnotite deposits in the Morrison formation have a closer spacing, larger size, and higher grade than those in adjoining areas." The belt extends from Gateway southward.

Ores containing uranium and vanadium minerals have been mined from the Salt Wash Member from many localities in the plateau region since about 1900 when French scientists recovered radium from the ores. So the area has had a long history of exploitation.

Fischer and Hilpert (1952) did not extend the belt into Utah. But they acknowledged (p. 4) that some of the geologic relationships on Polar Mesa in Utah did support the concept of the mineral belt "so that ultimately it may be possible to extend it as far west as Polar Mesa." In point of fact, numerous deposits have been found on Polar Mesa (Finch, 1955, Kelley, 1955). One of our sampling sites was at the base of Polar Mesa (Fig. 3) but on alluvial material. Two other sampling sites were at Gateway on alluvium. One possible mechanism for the deposition of uranium on the floodplain at Gateway is ground-water transport, although contamination from mining is also possible. Another sampling site was located near Moab, some distance west of the Uravan mineral belt, where the Chinle Formation of Late Triassic age crops out. This formation is a host for major uranium deposits in the area (Ridgley et al., 1978, p. 20). Many uranium deposits occur in the Chinle Formation about 40 km southwest of the site near Moab, as shown by Williams (1964).

Because the sagebrush samples in or near the Uravan mineral belt were taken from pristine, undisturbed sites well away from obvious prospects and mines, high concentrations of uranium in the plant tissue are judged to be due to the pervasiveness of mineralization in the region.

Uranium in the Owyhee Mountains. Another cluster of uraniferous sagebrush occurs in the Owyhee Mountains of southwestern Idaho (Fig. 3), an area underlain by volcanic rocks of Tertiary age.

The Silver City district is the only mining district in the Owyhee Mountains, and the only current active mining is for silver and gold at De Lamar, west of Silver City. The ore occurs in fissure fillings, shear zones, and breccias which contain sulfides, sulfarsenides, sulfantimonides, electrum, and stibnite (Hobbs, 1968, p. 1367). The bedrock includes granodiorite of Cretaceous age, and rhyolite and basalt of Tertiary age.

In Idaho the uranium occurrence nearest to the Owyhee Mountains appears to be a placer deposit at the edge of the Salmon River Mountains east of Boise (Weiss, 1958, p. 9). Mathews (1955, 1956) reported several uranium occurrences in northern Malheur County, Oregon, about 90 km northwest of the central Owyhee Mountains. Recently, a significant uranium deposit was discovered in the Opalite (mercury) mining district (Fisk, 1968) in the McDermitt caldera complex (Rytuba and Glanzman, 1979), which straddles the Oregon-Nevada boundary and lies about 100 km southwest of the Owyhee Mountains. The orebody at the new Aurora Mine is estimated to contain 15 million tons of grade 0.05% U_3O_8 (Nevada Mining Assoc., 1979). Within the last few years there has been some interest in the uranium potential of the Reynolds Creek basin in the Owyhee Mountains as evidenced by radiometric surveys, water-chemistry studies, track-etch sampling, and requests to study gamma logs of wells sampled by the Department of Agriculture's Northwest Watershed Research Center at Boise (G. R. Stephenson, personal communication, 1979).

Four sagebrush sites sampled in or near the Owyhee Mountains are shown in Fig. 4. Sites 1 and 2 are on Quaternary alluvium near localities with extensive artesian springs or wells. Although the rooting depths of sagebrush are unknown under these conditions, the large size of the shrubs indicates that the roots are probably close to the water table. Site 1 is on Shoofly Creek about 18 km south of Grand View. Plants associated with the sagebrush are the halophytes, greasewood (Sarcobatus vermiculatus), and fourwing saltbush (Atriplex canescens). Greasewood is one of the most reliable ground-water indicators in the West (Meinzer, 1927, p. 39). Site 2 is on Castle Creek just northeast of Foremans Reservoir; it, too, is characterized by halophytic vegetation. The predominant geological units adjacent to these sites, as given by Ekren et al. (1978), are Quaternary fan alluvium and fanglomerates and the Pliocene and Pleistocene(?) Glenns Ferry Formation, which consists of lake and stream deposits characterized by abrupt lateral changes in facies. Site 3 is in coarse basalt colluvium below the western scarp of Fossil Butte; the sagebrush sampled here was not anomalous (uranium <0.4 ppm).

The most interesting target is site 4, about 13 km west of Murphy (Fig. 4), an upland site with dark residual soils derived from olivine basalt flows and tuffs of Miocene age (Ekren et al., 1978, p. 11). The soil appears to belong to the Reywat Series, described by Stephenson (1977, p. 52) as "soils formed principally in residuum weathered from basalt or other similar extrusives." The site is about 2 km east of lake sediments in the Reynolds Basin that appear to be a favorable environment for uranium deposition.

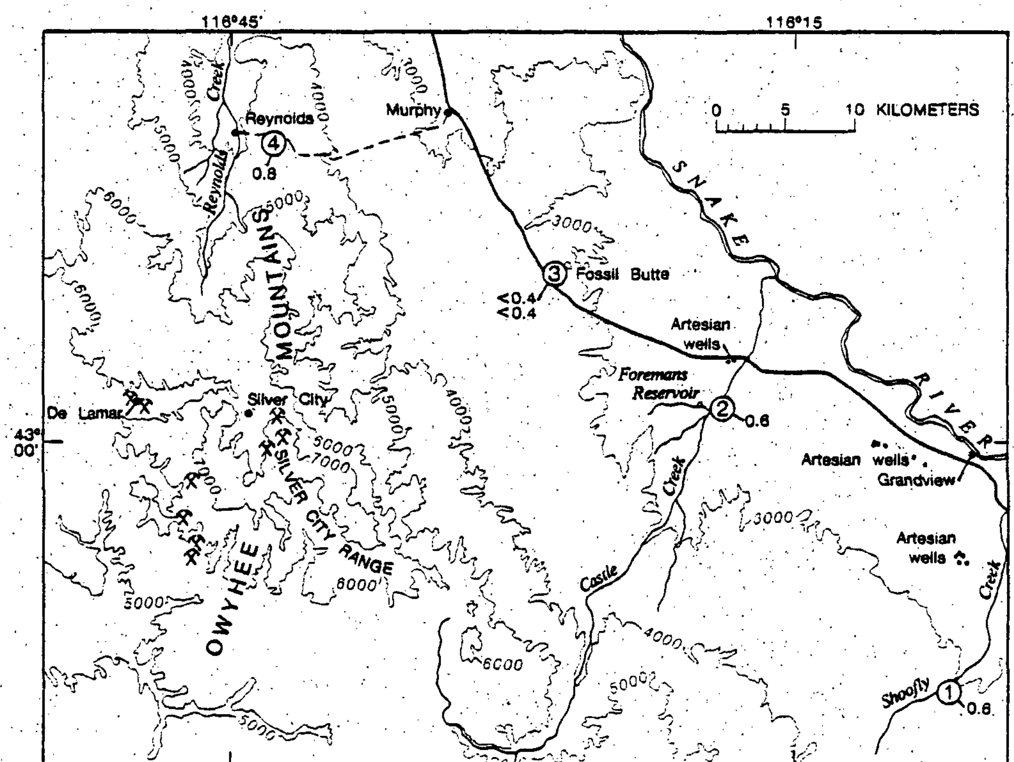

Fig. 4. Locations (sites 1-4) of big sagebrush sampled in the Owyhee Mountain area of southwestern Idaho. Uranium concentrations in ppm are given for each site. Also shown are active and abandoned mines of the Silver City district.

According to McIntyre (1972) and Ekren et al. (1978), the Reynolds Basin is underlain chiefly by Miocene volcanic and sedimentary rocks that rest on a substrate of Cretaceous granitic rocks. Exposures of basalt and granitic rock are prominent along the east margin of the basin. Exposed in the center of the basin are sediments containing fine vitric tuff, diatomite, pumice breccia, and lignite that locally are overlain by a unit containing arkosic sand and gravel. The thin lignite beds and the arkosic sand and gravel (when silicified wood is present) may have provided the reducing environment needed for uranium deposition. High gamma readings were observed in logs from wells drilled in the sediments in the northeastern part of the basin (G. R. Stephenson, personal communication, 1979).

Sample site 4 is located on basalt high on the east-central rim of the basin. It is unclear how the high uranium value in sagebrush at this site can be related to possible uranium anomalies in sediments several kilometers distant and several hundred meters lower in elevation within the basin.

Ground water might have served as a conduit to sagebrush sites 1 and 2. This speculation is supported from the following information provided by F. N. Ward of the U.S. Geological Survey (personal communication, 1979). First, the halophytic vegetation indicates alkaline conditions, which would tend to mobilize uranium in the ground water. And, second, Ward's analysis of the soil samples collected at all 4 sites showed normal levels (<1 ppm) of uranium.

DISCUSSION

We are convinced that biogeochemical prospecting as an exploration technique has more potential than most published literature indicates. H. W. Lakin, in his keynote address at the 7th International Geochemical Exploration Symposium (Lakin, 1979), strongly encouraged the use of this approach when, throughout his paper, he underscored the role of biogeochemistry in exploration geochemistry. Because of the increased need to locate buried ore deposits, he stressed that we must be alert to every possible exploration technique, one of which should involve the biological activity in deeply weathered areas. Lakin (p. 4) called the plant kingdom "a mining corporation of unbelievable dimensions," and the individual plants, "pioneer miners." A. A. Kovalevskii, perhaps the Soviet Union's foremost proponent of the use of plants in mineral exploration, likened plants with deep rooting systems to "living drill cores" (personal communication, 1978). Plants of the genus Artemisia (sagebrush, wormwood) have been used with considerable success in certain regions of U.S.S.R. where allochthonous deposits (loess, etc.) are common (Kovalevskii, 1979, p. 84-85). In central and southern Kazakhstan, for example, anomalies of Pb, Zn, and Ba were observed particularly in shrubs of Artemisia where they grew above polymetallic orebodies concealed by 10-30 m of transported surficial materials.

CONCLUSIONS

Results from two independent regional studies of big sagebrush in the western United States show higher than normal concentrations of uranium in samples collected from two major uranium districts--the southern Powder River

Basin district of Wyoming and the Uravan mineral belt area of the Colorado Plateau. The responsiveness of this widely distributed shrub to uranium suggests that it can be used as a prospecting tool in the search for new occurrences. Unusually high concentrations of uranium in sagebrush sampled from the northeast flanks of the Owyhee Mountains in Idaho may indicate a new source of uranium in an area where commercial deposits are presently unknown.

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