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Preliminary report on radioactive conglomerates of Middle Precambrian age in the Sierra Madre and Medicine Bow Mountains of southeastern Wyoming

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(Work done in cooperation with the Geology Department, University of Wyoming and Geological Survey of Wyoming)

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PRELIMINARY REPORT ON RADIOACTIVE CONGLOMERATES OF MIDDLE PRECAMBRIAN AGE IN THE SIERRA MADRE AND MEDICINE BOW MOUNTAINS OF SOUTHEASTERN WYOMING

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Abstract

Middle Precambrian miogeosynclinal metasedimentary rocks of the Sierra Madre and Medicine Bow Mountains of southeastern Wyoming contain radioactive quartz-pebble conglomerates of possible economic interest. These conglomerates do not contain ore-grade uranium in surface outcrops, but an earlier report on the geochemistry of the Arrastre Lake area of the Medicine Bow Mountains shows that ore-grade deposits may be present in the subsurface.

This report describes the stratigraphy of the host metasedimentary rocks and the stratigraphic setting of the radioactive conglomerates in both the Sierra Madre and Medicine Bow Mountains, and compares these rock units with those of the Blind River-Elliot Lake uranium district in Canada. The location of radioactive conglomerates is given so that further exploration may be undertaken by interested parties.

Introduction

A recent report (Miller, Houston, Karlstrom, Hopkins, and Ficklin, 1977) on geological and geochemical investigations of uranium occurrences in the Arrastre Lake area of the Medicine Bow Mountains of southeastern Wyoming (fig. 1), indicates that the quartz-pebble conglomerate of the Deep Lake Formation, which crops out north and west of Arrastre Lake, may contain economic concentrations of uranium in the subsurface. Studies of similar conglomerates in other parts of the Medicine Bow Mountains and in the Sierra Madre (plate 1) shows that radioactive conglomerates are present in several areas in both ranges. None of these conglomerates contain ore grade material at the surface, but most outcrops are oxidized and geochemical studies by Miller and others (1977) strongly suggest that uranium has been leached from surface outcrops. Drilling, therefore, may be the only way to prove the presence of uranium ore in this area. This report reviews the results of current geologic mapping in both the Sierra Madre and Medicine Bow Mountains, proposes a tentative stratigraphic succession for both Ranges, and indicates areas where radioactive conglomerates have been found. This information may be useful for further exploration.

The work reported here was undertaken in 1975 at the suggestion of the senior author and is a cooperative investigation of the United States Geological Survey, Geological Survey of Wyoming, and Department of Geology, University of Wyoming. The work was financed by a grant to the Geological Survey of Wyoming from the United States Geological Survey; principal investigator was Forrest K. Root of the Geological Survey of Wyoming. Mapping in the Medicine Bow Mountains has been done by Karl E. Karlstrom and in the Sierra Madre by Paul J. Graff, graduate students of the Geology Department, University of Wyoming. Detailed geologic maps for parts of the Medicine Bow Mountains should be available in 1977 and for the Sierra Madre in 1978.

Geologic background

Miogeosynclinal metasedimentary rocks were first recognized in the Medicine Bow Mountains by Hague (Hague and Emmons, 1877), who gave a relatively good description of those rocks located in the north-central Medicine Bow Mountains. They were later described in more detail by Van Hise (Van Hise and Leith, 1909) and Blackwelder (1926). Blackwelder (1926) gave the first complete description of these rocks and named various units in the upper part of the succession. Of particular interest is the fact that in a

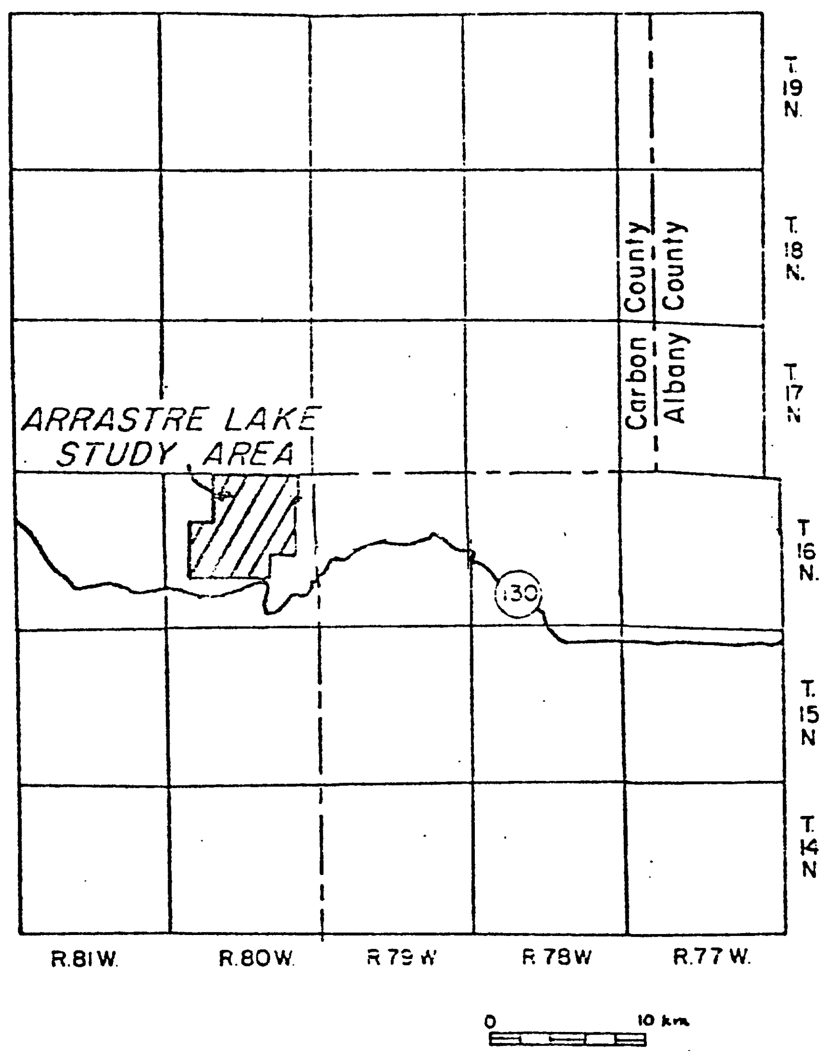

Figure 1 -- Index map showing location of the Arrastre Lake study area, Carbon and Albany Counties, Wyoming.

later paper Blackwelder (1935) noted that these miogeosynclinal rocks strongly resembled the Huronian rocks of the Great Lakes region. The first description of miogeosynclinal metasedimentary rocks in the Sierra Madre was by Spencer (1904), who made a superb reconnaissance study of almost the entire range.

In 1957, the Geological Survey of Wyoming, then under the direction of H. D. Thomas, sponsored a study of the Precambrian rocks of Wyoming, with emphasis on the Medicine Bow Mountains which were thought to have the most complete geologic record of any Precambrian-cored uplift in Wyoming. This study resulted in the publication of a report (Houston and others, 1968) that included a regional geologic map of the Medicine Bow Mountains and described for the first time the entire succession of miogeosynclinal metasedimentary rocks of the northern Medicine Bow Mountains. Like Blackwelder, Houston and others (1968) were also impressed by the lithologic resemblance of these rocks to miogeosynclinal rocks of the Great Lakes area. This lithologic correlation was supported by geochronologic studies (Hills and others, 1968) that bracketed the age of these rocks between ∿2,500 m.y. and ∿1,700 m.y. At the time this report was compiled it was known that Precambrian conglomerates of about this age contained economic concentrations of gold and uranium; several reports had been published (Joubin, 1954; Roscoe, 1957) that described uranium deposits in quartz-pebble conglomerates in the Blind River area of Canada. For this reason, Houston and others (1968, p. 159) suggested that the better sorted conglomerates of the Deep Lake Formation (the rocks in the Medicine Bow Mountains that most closely resembled ore-bearing horizons in Canada) should be examined as a possible source of gold and other heavy minerals. This suggestion received little attention by American geologists, but Canadian geologists familiar with the Huronian (Young, 1970) also suggested the correlation. As noted in the earlier report (Miller, et al., 1977), in the early 1970's Stewart Roscoe, formerly of the Canadian Geological Survey, who had done much of the detailed geologic study of the Blind River area in Canada, examined some conglomerates brought to his attention by one of the authors (Houston) and determined that they were slightly radioactive. To the writers' knowledge, Roscoe was the first person to recognize the presence of radioactive conglomerates in the region.

During the 1960's and 1970's, geologic studies of Precambrian rocks in Wyoming were continued at the University of Wyoming, with particular emphasis on the Sierra Madre. A preliminary report on the miogeosynclinal rocks of the Sierra Madre was published as a result of a study partly sponsored by the United States Geological Survey and the Geological Survey of Wyoming (Houston, Schuster, and Ebbett, 1975). This report called attention to the fact that miogeosynclinal metasedimentary rocks of the Sierra Madre strongly resemble rocks of the Deep Lake Formation of the Medicine Bow Mountains. At the time of this report it was widely accepted that uranium-bearing minerals in Precambrian pyritiferous conglomerates were preserved because of the lower oxygen pressure in the Precambrian atmosphere that existed prior to about 2,000 m.y. (Cloud, 1968; Roscoe, 1973). Houston, Schuster, and Ebbett (1975) again emphasized the lithologic resemblance of the Sierra Madre and Medicine Bow miogeosynclinal rocks to the Canadian Huronian, and suggested that a more definitive correlation might come from additional isotopic studies (a more closely bracketed age determination) or from proof that pyritic conglomerates that seem to characterize Early Middle Precambrian rocks are present in the Wyoming successions.

The current geologic studies, reported herein, were undertaken to better establish the stratigraphic succession in the Sierra Madre and Medicine Bow Mountains, to make more detailed maps of the miogeosynclinal metasedimentary rocks, and to search for radioactive, pyrite-bearing conglomerate.

General geology

The general geology of Precambrian-cored uplifts in southeast Wyoming is shown in plate 1. Miogeosynclinal metasedimentary rocks occur on the north side of a major fault system in both the Sierra Madre and Medicine Bow Mountains. This great fault system (Houston and McCallum, 1961) is thought to be a Middle Precambrian suture (Hills, Houston, and Subbarayudu, 1975), where island arcs located in Colorado were brought into contact with the Archean craton of Wyoming. The preservation of these miogeosynclinal metasedimentary rocks in southeast Wyoming some 2,000 kilometers from their possible equivalents in Canada may in some fashion be related to the development of this suture. Certainly these rocks are preserved only on the north side of the suture; rocks to the south are entirely eugeosynclinal facies.

In both the Sierra Madre and Medicine Bow Mountains miogeosynclinal metasedimentary rocks lie on a basement of Archean gneisses. Contacts between the metasedimentary rocks and basement are probably unconformable, but they are obscured by shearing at the contact and by the presence of sills of mafic igneous rocks.

The Middle Precambrian miogeosynclinal metasedimentary rocks can be divided into two parts, the Deep Lake Formation of the Medicine Bow Mountains and the metasedimentary rocks of the Sierra Madre that are thought to be its equivalent, and the rocks of the Libby Creek Group of the Medicine Bow Mountains that unconformably overlie the Deep Lake Formation. A discussion of the relationship between these two rock sequences can be found in Houston and others (1968) and Houston, Schuster, and Ebbett (1975). The following discussion concerns the Deep Lake Formation and its equivalents because of their potential for uranium.

Stratigraphy of the Deep Lake Formation of the Medicine Bow Mountains (description and correlation)

The distribution of rocks of the Deep Lake Formation of the Medicine Bow Mountains can be seen by referring to the geologic map of the Medicine Bow Mountains published by the Geological Survey of Wyoming (Houston and others, 1968). The rocks of the Deep Lake Formation crop out in the northern and northeastern Medicine Bow Mountains where they underlie an area of approximately 460 square kilometers. The Deep Lake Formation is primarily quartzite, but it includes metavolcanic rocks, slates, phyllites, arkose, marble, and both polymictic and oligomictic conglomerate. These various rock types were deposited in cycles; each cycle shows a progressive increase from base to top in the degree of sorting and proportion of quartz, undoubtedly related to some type of systematic change in depositional environment. Details of the stratigraphy and geology of these units will be given in a later report by Karlstrom, but basic characteristics of the stratigraphic succession are given in plate 2.

The basal beds of the Deep Lake Formation are not exposed in the area studied in detail, which is the north-central Medicine Bow Mountains, Tps. 16 and 17 N., Rs. 79, 80 and 81 W. The lowermost beds consist of sheared quartzite, laminated phyllite, and talc schist which are in fault contact with the Archean basement. These basal beds are overlain by four cyclic units which are each initiated by the deposition of paraconglomerate, which probably was deposited disconformably on underlying beds. Volcanic rocks may or may not be present in association with the paraconglomerate (plate 2). Amygdaloidal basalt is the most abundant metavolcanic rock, but metatuffs, and rocks that were probably felsic lavas are also present. The paraconglomerates of the two lower cycles contain clasts of rhyolite, basalt, and mafic igneous rock, probably derived from the associated metavolcanic rocks. These paraconglomerates are open-framework conglomerates that have subangular to well-rounded clasts of different sizes in a matrix of lithic wacke, amphibolite, or arkose. The two lower paraconglomerates (cycles one and two) contain some pyrite in the matrix and are radioactive. The rocks of cycle one (plate 2) are so poorly exposed that the nature of the units that overlie the paraconglomerate are not well-understood; more than one cycle may be present or the section may be repeated by faulting.

The rocks of cycle two are better exposed and are remarkably similar to rock units of the Elliot Lake Group of the Huronian Supergroup of the North Shore of Lake Huron, Canada (plate 2). The basal unit consists of metavolcanic rock, paraconglomerate, and phyllite; this unit is similar to rocks of the Thessalon Formation of the Elliot Lake Group (plate 2). This basal unit is overlain by a feldspathic quartzite that has a feldspathic conglomerate at its base. The feldspathic conglomerate is radioactive and is green to greenish-brown in color. Pyrite can be recognized in the matrix. It is similar in character to ore-bearing conglomerates of the Matinenda Formation of the Elliot Lake Group, but it is more feldspathic and not as well-sorted as quartz-pebble conglomerates at Elliot Lake. The feldspathic quartzite is overlain by a coarse-grained quartzite marked by trough crossbeds that is generally better-sorted and less-feldspathic than underlying rocks. The primary structure in the quartzite is like that described in the Matinenda Formation by Pienaar (1963, p. 95). The upper unit of cycle two is a quartzite with interbedded phyllite. This upper quartzite-phyllite unit of cycle two is more like parts of the Matinenda Formation at Elliot Lake than the McKim Formation (plate 2). Apparently, there is no equivalent of the McKim Formation in the Medicine Bow Mountains.

Rocks of cycle three of the Deep Lake Formation are equated to the Hough Lake Group of the north shore of Lake Huron (plate 2). This correlation is not especially convincing if the individual units are compared in detail, but both sets of rocks represent cycles that could have been deposited during the same time interval.

Rocks of cycle four of the Deep Lake Formation are strikingly similar to rocks of the Quirke Lake Group of the north shore of Lake Huron (plate 2). The paraconglomerate at the base of cycle four contains clasts of various sizes, some having the snubbed edges and corners characteristic of cobbles of glacial origin; other indications of glacial origin are associated varvites and graywacke containing dropstones. These features are also found in the paraconglomerate of the Bruce Formation; the lower formation of the Quirke Lake Group (plate 2). Neither paraconglomerate can be definitely proved to be a tillite, but if they are tillites they may represent a significant Middle Precambrian time horizon. The metalimestone that overlies the paraconglomerate of cycle four (plate 2) contains numerous thin layers of quartzite that are intricately folded. This metalimestone is very similar to the Bruce limestone member of the Espanola Formation (metalimestone, plate 2) of the Quirke Lake Group. The metalimestone is overlain by a siliceous phyllite with abundant ripple marks that may equate to Espanola graywacke (graywacke, plate 2) of the Quirke Lake Group. There is no equivalent of the Espanola limestone (metadolomite, plate 2) in the Deep Lake Formation, but the upper quartzite of cycle four is very much like the Serpent Formation of the Quirke Lake Group (plate 2); both are marked by shallow water structures.

The remarkable stratigraphic similarity between the rocks of the Deep Lake Formation of the Medicine Bow Mountains and the basal three groups of the Huronian Supergroup of the north shore of Lake Huron suggest that both units were deposited in similar geological environments. However, the lithologic similarity does not prove a temporal equivalence. Nevertheless, the fact that both sequences were deposited in a sedimentary environment that is common to many lower Proterozoic sedimentary successions throughout the world (Robertson, 1974) is an indication that they are probably of lower Proterozoic age.

Stratigraphy of the metasedimentary rocks of the Sierra Madre (description and correlation)

The metasedimentary rocks of the Sierra Madre are not as well understood as those of the Medicine Bow Mountains. The major difficulty in interpreting these rocks is the lack of a comprehensive structural analysis. The metasedimentary rocks of the Sierra Madre are more highly deformed and are of higher metamorphic rank than those of the central Medicine Bow Mountains, and features useful in determining tops and bottoms of beds are not well preserved. The structure has been interpreted as a faulted synclinorium (Spencer, 1904), faulted homocline (Houston, Schuster, and Ebbett, 1975), and an anticlinorium (Divis, 1976). Detailed mapping by Graff in recent years has not fully resolved the structure, but a tentative interpretation is that the major structure is the folded and faulted north limb of a west plunging syncline.

The stratigraphic succession shown in plate 2 is based on the above, tentative structural interpretation. The basal beds of the Sierra Madre succession are quartzites and metalimestone. These units are overlain by metavolcanic rocks that are primarily basalt and metatuff(?). Except for the presence of pillow lava in the Sierra Madre, which has not yet been recognized in the Medicine Bow Mountains, the metavolcanic rocks are similar to those of the Medicine Bow Mountains. The metavolcanic rocks of the Sierra Madre are overlain by three units that can be considered to represent cycles. Cycle one has a basal paraconglomerate, and is one of the most spectacular rock units in either the Sierra Madre or Medicine Bow Mountains. The clasts in this conglomerate include red, pink, and white granite and quartzite. The granite clasts vary in size (up to 1 meter in diameter) and are generally well-rounded. The coarse conglomerate grades upward into a pebble conglomerate and finally into a lithic graywacke. This paraconglomerate of cycle one of the Sierra Madre is similar to paraconglomerates of cycle one in the Medicine Bow Mountains, but it lacks clasts of metavolcanic rocks (which are present in the paraconglomerates of the Medicine Bow Mountains). In the area of the measured section (plate 2), the Medicine Bow paraconglomerate does not contain granite clasts, but such clasts are common in the same conglomerate unit in other parts of the Medicine Bow Mountains, where the conglomerate more closely resembles that of the Sierra Madre. The paraconglomerate of cycle one of the Sierra Madre is overlain by a quartzite-phyllite unit that contains rock units like those in cycle one of the Medicine Bow Mountains. The Sierra Madre quartzites are generally finer-grained, however, and contain a greater proportion of interbedded phyllite.

Cycle two of the Sierra Madre compares with cycle two of the Medicine Bow Mountains and is much like the lower cycles (plate 2). Again, quartzites are finer-grained and phyllite much more abundant in the Sierra Madre.

Probably the best correlation in cyclic lithology between the Sierra Madre and Medicine Bow Mountains is in cycle three, where paraconglomerates are overlain by metalimestone in both ranges and where overlying quartzites and quartz-pebble conglomerates are similar (plate 2).

The upper rock units of the Sierra Madre have no known equivalents in the Medicine Bow Mountains (plate 2), but the metalimestone of the Sierra Madre may correlate with metalimestones and phyllites of cycle four in the Medicine Bow Mountains.

Perhaps the most significant factor in this attempted correlation between the cyclic units of the Sierra Madre and Medicine Bow Mountains is that the Medicine Bow cycles are more like the cycles of the North Shore of Lake Huron (2,000 km distance) than the cycles of the Sierra Madre (40 km distance). It is possible that a better correlation between cycles of the two Wyoming ranges can be made after more detailed mapping is completed, especially in the Sierra Madre, but the writers suspect that the depositional environment differed between these two ranges and that the Sierra Madre rocks were deposited in deeper water. If this interpretation is correct, the exposed rocks of the Sierra Madre may not offer as good a possibility for uranium exploration as those of the Medicine Bow Mountains.

Radioactive conglomerate

The stratigraphic setting of known radioactive conglomerates of the Medicine Bow Mountains and Sierra Madre is given in plate 2, and the location of known radioactive conglomerates is given in table 1. <u>We emphasize that none of these conglomerates contains major amounts of pyrite and none of them contain sufficient uranium in surface exposures to be of economic significance</u> (table 1).

A quartz-pebble conglomerate from the core of a wildcat oil well drilled west of the Sierra Madre is of particular interest for this study, for it is radioactive and pyritiferous and closely resembles classical Early Proterozoic ore conglomerates, such as those at the Blind River and Witwatersrand districts. The well is Battle Mountain-State Number One drilled by Kirby Royalties, Incorporated, in Carbon County, Wyoming, sec. 36, T. 13 N., R. 88 W. The well is located west of the Sierra Madre, where metasedimentary rocks should be present in the subsurface. The pyritic conglomerate was encountered at a depth of 7,788 feet, and gave a distinct anomaly on the gamma-ray log. This conglomerate was overlain by dolomite of the Phosphoria Formation and underlain by Precambrian greenstone and amphibolite. It is considered Precambrian, but this age is equivocal. The conglomerate contains clasts of quartzite, sericite schist, chert, microcline, and muscovite that range in size from 1 to 20 mm diameter. The clasts are in a matrix of pyrite and silica. The pyrite cement is older paragenetically than the silica cement. Studies of polished sections and thin sections failed to reveal rounded grains of pyrite, but chalcopyrite was recognized in local areas of the matrix. The thickness of the conglomerate is not known, but it is probably in excess of four and one-half feet.

Table 1.--Location of radioactive conglomerate in metasedimentary rocks of the Medicine Bow Mountains and Sierra Madre, southeastern Wyoming [n.d., not detected]

Type of conglomerate	Pyrite	PPM U	PPM Th	Location
Arkosic quartz-pebble conglomerate	Present	9 samples range = 2.8-8.4	9 samples range = <2Ø-38	Medicine Bow NW sec. 1Ø, T. 16 N., R. 8Ø W.
Heavy mineral separate from above conglomerate	Present	89	n.d.	
Arkosic quartz-pebble conglomerate	Present	5 samples range = Ø.5-11.2	n.d.	Medicine Bow sec. 22, T. 17 N.,R. 79 W.
Paraconglomerate (arkosic matrix)	Present	n.d.	n.d.	Medicine Bow sec. 23, T. 16 N., R. 81 W.
Paraconglomerate (amphibolite matrix)	Not Present	n.d.	n.d.	Medicine Bow NE sec. 21, T. 16 N., R. 8Ø W.
Coarse grained Arkosic quartz-pebble conglomerate	Present	3.2	n.d.	Medicine Bow SW sec. 1Ø, T. 18 N., R. 79 W.
Quartz-pebble conglomerate	Present	3.Ø	n.d.	Sierra Madre SE 1/4, sec. 13, T. 14 N., R. 85 W.
Quartz-pebble conglomerate	Not Detected	4.3	n.d.	Sierra Madre NE 1/4, sec. 8, T. 14 N., R. 86 W.
Quartz-pebble conglomerate	Casts	n.d.	n.d.	Sierra Madre NE 1/4, sec. 25, T. 14 N., R. 86 W. (Whalen, 1954)
Quartzite	n.d.	n.d.	n.d.	Sierra Madre NW 1/4, sec. 31, NE 1/4, sec. 3Ø, T. 14 N., R. 86 W. (Whalen, 1954)
Mine dump (quartzite and phyllite)	n.d.	n.d.	n.d.	Sierra Madre NW 1/4, sec. 16, T. 14 N., R. 86 W.

The conglomerate was analyzed for uranium and thorium in the Denver Laboratories of the United States Geological Survey. The analyses were made by H. T. Millard and D. A. Bickford, using the delayed neutron activation method. The results are, as follows:

Same Number	WT.(GMS.)	PPM Th	CV(%)	PPM U	CV(%)
SM-75-2	10.6	178.4	2.6	14	3.0

The thorium/uranium ratio of 12.7 is high, indicating that most of the radioactivity is the result of thorium. The uranium content is below ore grade. This sample is interesting, however, in that it proves that pyritic conglomerates are present in the subsurface, and suggests that drilling should be done in favorable areas of the Sierra Madre.

Conclusions

Results of recent geological and geochemical studies in the Medicine Bow Mountains and Sierra Madre suggest that miogeosynclinal rocks of the Deep Lake Formation of the Medicine Bow Mountains and their possible equivalents in the Sierra Madre may contain heavy metal-bearing, pyritic, quartz-pebble conglomerate. Ore grade pyritic, quartz-pebble conglomerates have not been found on the surface, but one pyritic conglomerate thought to be of Precambrian age from a wildcat oil well contained 178 ppm thorium and 14 ppm uranium. The writers suggest that drilling should be done in favorable areas of both ranges to determine if ore-bearing pyritic conglomerate is present in the subsurface.

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