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ON THE URANIUM POSSIBILITIES OF THE SOUTHERN INTERIOR PLAINS OF CANADA

J. A. Chamberlain

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ON THE URANIUM POSSIBILITIES OF THE SOUTHERN INTERIOR PLAINS OF CANADA

INTRODUCTION

To date, no sedimentary uranium deposits have been found in Canada comparable to those of the United States although it has been recognized since 1948 that the Interior Plains of Canada offer somewhat analogous conditions to those south of the border.

Prior to 1952, the possibility of a northward extension of the Colorado Plateau type deposits into Canada was thought to be slight, mainly because of the great distances involved. For this reason, and because the Geological Survey of Canada was concerned with projects in areas known to contain significant quantities of uranium, little reconnaissance work was done by the Survey in the Interior Plains. However, early in 1952, American authorities reported that important carnotite deposits had been found in South Dakota about 370 miles south of the Canadian border. In consequence A.H. Lang of the Geological Survey visited South Dakota that year to study the deposits, and then spent about a month testing outcrops for radioactivity in the Plains region of Manitoba. The data accumulated by Lang during the course of the investigation were summarized in a memorandum, but were not published as the results were negative. Thirty-two specimens collected from rocks ranging in age from Jurassic to Paleocene all assayed less than 0.004 per cent U_3O_8.

Later work by the United States Geological Survey and private exploration groups in the Williston basin of the western Dakotas and eastern Montana led to the discovery of economic quantities of uranium, some within 150 miles of the Canadian border. It became desirable to augment the survey of the Interior Plains, not only from the economic standpoint, but also because the presence of uranium could be of scientific value in such studies as age-dating of formations by lead-uranium ratios. As a result, the writer spent part of the 1959 field season examining many exposures in southern Saskatchewan and visiting a few specific localities in Alberta.

The present paper, like Lang's memorandum of 1952, contains data and inferences that are negative insofar as the economic uranium possibilities of the Interior Plains are concerned. This information is preceded by a brief discussion of nearby American uranium deposits occurring in rocks that are similar to those of the Plains region of Canada.

ACKNOWLEDGMENTS

B.A. Latour of the Geological Survey of Canada collected 82 specimens of coal and lignite from 13 localities in the Plains region. The uranium content of these was determined and the figures used in preparing this report. John Vogle of Swift Current, Saskatchewan, aided the writer in locating claims, and kindly sent specimens to Ottawa for examination.

SEDIMENTARY URANIUM DEPOSITS, INTERIOR PLAINS OF UNITED STATES

It is sufficient to describe here the three main types of uranium deposits occurring within a few hundred miles of the Canadian border. Persons wishing to read detailed descriptions of deposits, or to extend their studies to include all sedimentary uranium deposits of the United States, particularly those of the Colorado Plateau, are referred to a report compiled by Page, Stocking and Smith (1956)[1]. Much of the material in this section is summarized from that publication.

TYPES OF DEPOSITS

Most sedimentary uranium deposits of Wyoming, eastern Montana, and the Dakotas can be classified according to one of three types of host rock: (1) black shale, (2) sandstone, and (3) lignite. The distribution of these is indicated in Figure 1.

Black Shale

Certain marine black shales carry sufficient uranium to make them possible future sources of low-grade ore. The Heath shale (Mississippian) and shale members of the Hartville formation (Carboniferous), of Wyoming and South Dakota, are two examples in the area under consideration. The average uranium content of these shales is about 0.010 per cent U_3O_8 (Swanson, 1956); thin members contain up to 0.033 per cent. The uranium is finely disseminated through the shales and, so far, it has not been possible to isolate and identify the uranium minerals.

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[1]Dates in parentheses are those of publications listed in the Bibliography.

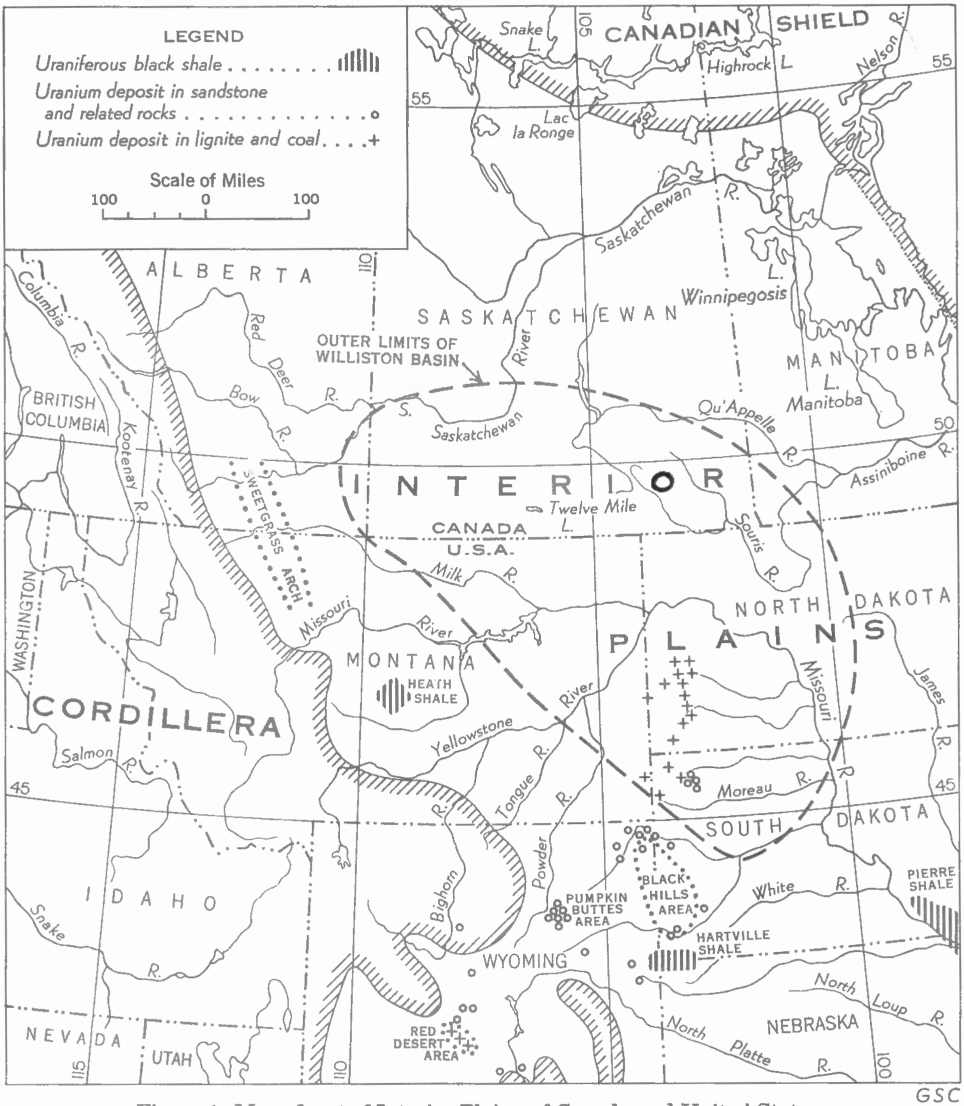

Figure 1. Map of part of Interior Plains of Canada and United States, showing distribution of uranium-bearing formations

Sandstone

Uranium deposits occur in non-marine sandstones through a wide belt extending southwest from the Dakotas to Nevada and California. In the northeast part of this belt--relative to the region under consideration--some uranium is produced from Cretaceous sandstones bordering the Black Hills in Wyoming and South Dakota, and from Tertiary basin deposits in Wyoming (Butler and Schnabel, 1956).

The uranium deposits of the Black Hills region are characterized by the presence of carnotite and tyuyamunite occurring as "coatings on sand grains, interstitial fillings, and as coatings on joint surfaces" (Bell, et al., 1956). Other uranium minerals, corvusite and rauvite, are locally important. These deposits generally occur in non-calcareous sandstones, especially where these rocks form structural terraces. Steeply dipping beds are unfavourable.

The basin deposits of Wyoming occur in flatly dipping clastic rocks of Tertiary age. Various primary and secondary uranium minerals exist over a wide region, generally in sandstone, but the greatest concentration is near Pumpkin Buttes where more than 250 occurrences of uranium-bearing material have been examined (Sharp, et al., 1955). Deposits of up to 2,000 tons commonly contain 0.3 per cent U_3O_8.

Lignite

Uraniferous lignites of economic grade were discovered in the southern part of the Williston basin in 1954. The search for these deposits was aided by a preliminary ground-water survey (Denson, et al., 1956b) and by later investigations in which the ratio of sodium to calcium and magnesium was plotted and contoured, the belief being that uranium leached from overlying leucocratic volcanic rocks in the region would be reflected by a high sodium content in the ground water (Towse, 1957). Most of the subsequent discoveries and developments have been in western Stark and eastern Billings counties, North Dakota, where the highest sodium ratios were outlined.

The uranium occurs in flat-lying lignite seams up to 6 feet thick in the Paleocene Fort Union formation. Ore-grade material in the lignite is generally less than 2 feet thick. Proved and probable reserves total more than 200,000 tons averaging 0.10 per cent U_3O_8.

ORIGIN

Geologists appear to be in general agreement on the origin of uranium in black shales. The uranium is believed to be derived from sea-water at or near the time of deposition of sediments, i.e. the deposits are syngenetic. McKelvey, et al. (1956) suggested that uranium in phosphate-rich shales and in hydrocarbons in black shales is enriched by circulating solutions after the sediments are deposited.

The origin of uranium in sandstone is still a controversial topic although most workers agree that the uranium is epigenetic, i.e. introduced after deposition of the enclosing rocks. McKelvey, et al. (1956) believed that uranium in the Colorado Plateau was transported by deep-seated solutions of igneous origin which rose along fractures to mingle with circulating ground water in permeable beds. Garrels and Richter (1955) suggested that carbon dioxide rather than hydrothermal solutions, may have been the transporting agent for uranium in sandstone deposits. Gruner (1956) and many earlier workers believed that uranium, present in trace amounts in all rocks, was concentrated by circulating ground water. Gruner further suggested that repeating cycles of solution and deposition gave rise to increasingly high concentrations of uranium.

Denson, et al. (1956 a, b) and Pipiringos (1956) indicated that tuffaceous rocks, widely distributed through Wyoming and adjacent regions, may be the source of uranium in both lignite and sandstone. The uranium content of the tuffs varies greatly from place to place but shows a maximum of 0.003 per cent U_3O_8 and averages 0.0015 per cent. There is good evidence to show that these weakly radioactive tuffs supplied much of the uranium now present in the underlying rocks.

So much has been written on ore controls that it is difficult, and perhaps misleading, to generalize on the subject. It seems clear, however, that few of the United States sedimentary uranium deposits are directly related to features caused by regional deformation. Control of uranium deposition by faults and folds appears to be important in only rare instances. Many mineralized zones occur in or at the margins of regional structural basins or uplifted areas, but their relationship to such features is uncertain.

Perhaps 95 per cent of the economic uranium deposits in the United States occur in sandstone or lignite. This can hardly be fortuitous and argues for some kind of lithological control on localization of uranium. The widely differing physical and chemical properties of the two host rocks further suggest that ore controls are somewhat different in each case. Existing evidence points to permeability or transmissivity as a key control in the case of sandstone deposits (Jobin, 1956), whereas the presence of uranium in lignite deposits may be controlled by transmissivity of enclosing rocks (Vine, 1956) working in conjunction with chemical factors.

URANIUM OCCURRENCES OF THE INTERIOR PLAINS OF CANADA

The Interior Plains region of Canada is a major geological province separating the folded and faulted Cordillera on the west from the Canadian Shield on the east. It extends southward as an arcuate belt from Banks Island in the Arctic Ocean through Great Bear Lake, and widens to include most of Alberta, all of southern Saskatchewan, and the southwest part of Manitoba. Exclusive of the Northwest Territories, the region has an area of about 500, 000 square miles. It is underlain by flatly dipping sedimentary rocks ranging in age from Cambrian to Oligocene. These rocks form a thin cover over crystalline basement rocks of the Canadian Shield in the east, and thicken westward to 10, 000 feet or more near the foothills of the Rocky Mountains.

The rocks exposed over the southern part of the Interior Plains are principally of Cretaceous age. Tertiary remnants are preserved along the western margin, and in southern Saskatchewan and Manitoba. The Cretaceous rocks generally comprise grey and green shales, which grade upward into siliceous shales and sandstones. The Tertiary strata are mainly sandstones with interbedded shales and related rocks, containing abundant seams of lignite and coal. Tertiary volcanic rocks are virtually absent throughout the Interior Plains.

The abundance of structural basins and domes in the western part of the Plains region of the United States testifies to a moderately active tectonic history during upper Mesozoic and Tertiary time (Shoemaker, 1956). This tectonism decreased in activity northward so that the Interior Plains of Canada remained tectonically quiescent during the same period of time.

One of the few structural features of any prominence in Cretaceous and younger rocks of the Interior Plains of Canada is the Sweetgrass arch. This is a gentle swell of great amplitude, the axis of which trends northwest from Montana through south-central Alberta.

No occurrences containing 0.05 per cent[1] or more of uranium are known in the Interior Plains of Canada. Samples from two localities in Saskatchewan showed high radioactivity, but investigations, in one case by the Geological Survey and in the other by Saskatchewan authorities, indicated that the samples came from boulders. As boulders derived from the Canadian Shield are common in the Interior Plains, as a result of glaciation, these occurrences are of no significance in the present discussion.

Many rocks of the Plains region are known to contain slightly higher than average quantities of uranium. These are described in the sections that follow.

BLACK SHALE

According to Lang, et al. (in press), specimens from outcrops of the Exshaw formation and other black shales of this type show that "the highest assays obtained by fluorimetric analyses were 0.0070 per cent U_3O_8 for a sample of the Banff formation and 0.0047 per cent for a sample of the Exshaw."

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[1]This figure serves as a convenient, though not particularly meaningful cut-off when discussing uranium occurrences that are presently of marginal grade.

Radioactive logs of wells drilled for oil and gas indicate that the Exshaw is the most radioactive formation yet intersected in the Interior Plains. Examination of several such logs reveals that the gamma count characteristically rises to a peak of 2 1/2 to 3 times average in the Exshaw formation, resulting in an impressive curve. However, logs of this type are made using extremely sensitive instruments, so that radioactive substances present in excess of about 0.003 per cent register as peaks on the charts.

The writer also examined the type section of the Exshaw formation in Alberta. Along an exposed strike-length of about 1,500 feet, a Geiger counter registered little or no increase over normal background.

According to Adams, et al. (1959), the average uranium content for black shales is about 3.7 parts per million, or 0.00037 per cent. This figure results from 75 determinations on 4,847 specimens of black shale from many parts of the world and means that the Exshaw shale has a uranium content somewhat higher than would ordinarily be expected in a rock of this type.

Under present market conditions, the Exshaw would have to be enriched in uranium by a factor of about 20 times in order to be of economic interest.

SANDSTONE

Sandstones predominate in the southern part of the Interior Plains. They have so far proved to be low in uranium content despite their textural similarities to mineralized sandstones of Wyoming and South Dakota.

John Vogle of Swift Current, Saskatchewan, holds seven claims in the vicinity of Wood Mountain, south of Twelve Mile Lake. The property is underlain by Paleocene rocks of the Ravenscrag formation, consisting of interbedded sandstones and clays, with numerous seams of lignite. The writer found no zones on the property or in surrounding areas that registered radioactivity above normal background. Eight samples from one of the claims, sent by Mr. Vogle to the Geological Survey and assayed there, showed no radioactive constituents above 0.002 per cent. Four out of five other samples sent by Mr. Vogle to the Saskatchewan Research Council showed less than 0.005 per cent U_3O_8, but one showed 0.41 per cent. The single high assay seems anomalous and requires clarification.

Only scanty data are available on the average uranium content of the world's sandstone deposits (Adams, et al.. 1959). The few available figures suggest that there is only about one tenth as much contained uranium as there is in black shales, i.e. about 0.4 parts per million or 0.00004 per cent.

Thus, the Ravenscrag sandstone, while apparently carrying considerably more uranium than average for this type of rock, contains only about as much uranium as the weakly radioactive black shale described in the preceding section.

COAL AND LIGNITE

Upper Cretaceous and Paleocene formations in the southern part of the Interior Plains contain abundant coal and lignite. The writer examined a number of seams in southern Saskatchewan, and Lang made similar examinations in southern Manitoba. No radioactive anomalies were detected.

Fluorimetric analyses of 5 ashed samples from seams in Alberta and Saskatchewan gave the following results (Lang, et al., in press):

Per cent U_3O_8	Ash percentage of sample
0.008	18.4
0.006	18.8
0.004	35.4
0.001	25.3
0.001	40.4

The average uranium content in the ash of the above samples is 0.004 per cent. The uranium content of the original samples is about 0.001 per cent, which is less than the average uranium content of many of the world's coal deposits (Masursky, 1956; Pipiringos, 1956).

CONCLUSIONS

There is no evidence of the occurrence of economic uranium deposits in the Interior Plains of Canada, nor of conditions particularly favourable for such occurrences. The one propitious factor is the similarity and proximity of certain Canadian sedimentary rocks to those containing uranium in the United States. This, however, seems outweighed by negative factors, as follows:

Reconnaissance work by government agencies, exploration groups, and others has not resulted in the discovery of any deposits that are close to economic grade. However, the area under consideration is very large, relative to the limited amount of work done so far.

Thousands of radioactive logs of wells drilled for oil and gas throughout the Interior Plains indicate that the low-grade Exshaw shale is the most radioactive formation yet intersected.

Although structural features do not appear to be essential to ore localization in many United States sedimentary deposits, their near-absence in Canada can hardly be considered favourable.

Tertiary volcanic rocks, considered by many authorities to be the source of much of the uranium in sedimentary deposits of the United States, are virtually absent in the Interior Plains of Canada.

It is interesting to speculate on the nature of ground-water movements as related to ore deposition. The general slope of the water table in the southern plains region of Canada is to the south-east. Palaeogeographic maps (Schuchert, 1955) indicate that a similar slope could have persisted throughout upper Cretaceous and Tertiary time. If circulating ground water was responsible for solution, transport, and deposition of uranium in adjacent regions of the United States, then such ore-bearing solutions would tend to move eastward or southward from their source-areas, not northward to the Interior Plains of Canada.

It is likely that deposits of uranium and other metals occur in the Interior Plains in the underlying basement rocks, but these would be of interest only where the sedimentary cover is thin, i.e. along the eastern margin of the region. Even where basement rocks are overlain by only a few hundred feet of younger strata, exploration costs would be high, relative to the chances of locating orebodies.

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