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No. 476

Page

PROGRESS REPORT ON

URANIUM IN NATURAL WATERS

Trace Elements Memorandum Report 476

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

AUG 13 1952

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AEC-172/3

Mr. T. H. Johnson, Director
Division of Research
U. S. Atomic Energy Commission
16th Street and Constitution Avenue, N. W.
Washington 25, D. C.

Dear Mr. Johnson:

Transmitted herewith for your information are copies 24 and 25 of Trace Elements Memorandum Report 476, "Progress report on uranium in natural waters," by Philip F. Fix, August 1952.

This memorandum reports on the progress of studies of uranium in natural waters since the preliminary sampling late in 1951 of waters in 15 of the states. Tentative conclusions are that the following are conducive to a significant content of uranium in natural waters; 1) a very acid or a very alkaline nature; 2) a high content of sulfate, bicarbonate, sodium, or silica; and 3) a total hardness (as $CaCO_3$) of 300 or more. Fluoride and the ratio between calcium and magnesium also have some bearing on the uranium content. These clues and others as they develop will be followed as the work continues to determine their validity as guides to uranium in natural waters.

During the first half of fiscal year 1953 an intensive investigation of natural waters is planned in parts of Colorado, Wyoming, South Dakota, Montana, and Utah where uranium mining and milling are or will be in progress, and the reconnaissance search for uraniferous waters will be continued in other areas and especially in areas where new discoveries are made.

Inasmuch as the Commission's Office of Classification has determined that this report contains Restricted Data, we are issuing the information as a separate report in order that the Trace Elements Research Quarterly Progress Report, April 1 to June 30, 1952, for which it was prepared, could be given a wide unclassified distribution. This change was discussed orally with Mr. D. R. Miller and has his approval.

Sincerely yours,

O.E. McKelvey

for W. H. Bradley
Chief Geologist

Geology - Mineralogy

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PROGRESS REPORT ON URANIUM IN NATURAL WATERS*

By

Philip F. Fix

August 1952

Trace Elements Memorandum Report 476

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*This report concerns work done on behalf of the Division of Research of the U. S. Atomic Energy Commission

2

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Division of Raw Materials, Butte	19
Division of Raw Materials, Washington	20 - 22
Dow Chemical Company, Pittsburg	23
Division of Research, Washington	24 - 25
Technical Information Service, Oak Ridge	26 - 31
U. S. Geological Survey:	
Mineral Deposits Branch, Washington	32 - 33
Geochemistry and Petrology Branch, Washington	34
Geophysics Branch, Washington	35
Alaskan Geology Branch, Washington	36
Fuels Branch, Washington	37
L. R. Page, Denver	38
R. P. Fischer, Grand Junction	39
A. E. Weissenborn, Spokane	40
J. B. Cathcart, Plant City	41
J. F. Smith, Jr., Denver	42
N. M. Denson, Denver	43
A. H. Koschmann, Denver	44
E. H. Bailey, San Francisco	45
Carl Dutton, Madison	46
R. A. Laurence, Knoxville	47
R. J. Roberts, Salt Lake City	48
TEPCO Washington (Including master)	49 - 52

PROGRESS REPORT ON URANIUM IN NATURAL WATERS

By Philip F. Fix

ABSTRACT

Preliminary sampling for uranium in natural waters during late 1951 was sufficiently promising to justify further work. Additional samples, therefore, were collected during early 1952, and sampling is continuing.

The specific objectives of the project are to: (1) search for non-saline waters containing enough uranium to be recoverable economically; (2) determine the relationship of uranium in natural waters to geologic terrane, as well as obtain information on the behavior of uranium in natural solutions; and (3) develop geochemical-prospecting techniques for uranium based upon the uranium content of natural waters.

A few tentative and generalized conclusions are made regarding the types of natural waters that may be conducive to the occurrence of significant amounts of uranium.

INTRODUCTION

The preliminary investigation of the occurrence of uranium in natural waters by the Geological Survey began with the collection of 48 samples from representative streams and ground-water sources during the first five months of fiscal-year 1952. One of the sources, for which the analysis showed a significant content of uranium, Cimarron Creek in southwestern Colorado, was resampled in February 1952 in order to ascertain the uranium content at a time of year when the ratio of ground water to surface water would differ materially from the season of the first sample taken in September 1951.

The distribution of the original 48 samples by states was as follows:

Colorado	12
Wyoming	7
Florida	6
Nevada	4
Utah	4
Tennessee	2
California	2
South Dakota	2
New Mexico	2
New Hampshire	2
Connecticut	1
Massachusetts	1
North Carolina	1
Georgia	1
Texas	1
Total	48

The distribution by geologic terranes is as follows:

Arkose and acid tuff areas	17
Thermal waters	10
Phosphatic areas	7
Sandstone in carnotite areas	5
Metalliferous mining districts	3
Glacial deposits	2
Black shales	2
Miscellaneous	2
Total	48

The results obtained from the preliminary investigation, with samples ranging as high as 690 ppb in uranium content, and with 25 percent of the 48 samples within the range from 30 to 690 ppb of uranium, were so promising

that the project entitled Uranium in Natural Waters was begun March 30, 1952.

The specific objectives of the project are to: (1) search for nonsaline waters containing enough uranium to be recoverable economically; (2) determine the relationship of uranium in natural waters to geologic terrane, as well as obtain information on the behavior of uranium in natural solutions; and (3) develop geochemical-prospecting techniques for uranium based upon the uranium content of natural waters.

The work in the first quarter of the project, ending June 30, 1952, consisted largely of an intensive review of results obtained in the preliminary investigation; obtaining necessary equipment, maps, and supplies; determining the general sequence and timing of investigations in the project to the extent permitted by available information; determining the specific timing and sequence of field work for the second quarter of the project ending Sept. 30, with due allowance for modifications that may result from discovery of new uranium-bearing areas, weather, delivery dates of supplies, and related factors; and coordinating the project with related existing projects, particularly with the Radioactivity of Natural Waters project of the Water Resources Division of the Geological Survey. It is hoped that all equipment and supplies, some of which were received late in the first quarter, may be in hand before the end of the second quarter. In the meantime, field work is being carried out with the aid of equipment and supplies borrowed from the Water Resources Division.

During the latter part of the quarter, samples of water were collected from 12 sources in Montana, Wyoming, and Utah; a sample from each source was shipped to the Geological Survey Trace Elements Section Washington Laboratory for uranium determination, and a second sample from each source

was delivered to the Salt Lake City regional laboratory of the Water Resources Division for concurrent chemical analysis. Samples from 8 other sources were delivered to the Salt Lake City laboratory for partial chemical analyses to determine the content of key constituents for correlation with content later in the year when regular samples are taken. Two samples also were shipped to the Quality of Water Branch in Washington for radioactivity determinations. Uranium determinations already have been received from 2 of the 14 samples.

The number of samples collected during the latter part of the first quarter was considerably less than had been planned, inasmuch as uncommonly high water levels and surface dilution from heavy rains in the areas investigated made it undesirable and impracticable to collect samples from many sources that had been scheduled for sampling. Some of these sources were sampled for partial chemical analyses that will permit seasonal correlations to be made in comparison with samples to be collected later when conditions are suitable. Some of the sources were so badly diluted by hard rains during field work that no samples were taken.

HYPOTHETIC GEOCHEMICAL CLUES TO URANIUM

Although only general and very hypothetic conclusions may be drawn from the results of the 51 determinations of uranium made to date, these provide what appear to be very useful indications of the types of natural waters which may be conducive to occurrence of significant amounts of uranium, and therefore serve to guide field work within certain limits. Such conclusions, outlined below, must be treated with great circumspection, inasmuch as the additional weight of a few more data may radically alter the conclusions. The extraordinarily effective results of the preliminary investigation,

based upon geologic knowledge, in finding relatively large amounts of uranium in 25 percent of the samples, and significant amounts of uranium in many other samples of the total 48, suggests that these conclusions may be fairly accurate even at this early stage of investigation.

Natural waters of very acid or very alkaline nature seem far more conducive to the occurrence of significant amounts of uranium than do those of nearly neutral nature.

A high content of sulfate, especially of sodium sulfate, seems very favorable.

A high content of bicarbonate, especially of sodium bicarbonate, seems very favorable.

A high content of sodium seems very favorable, although high content of uranium may occur in the presence of little sodium.

The greatest content of uranium found was in a water very high in iron sulfate.

A total hardness (as $CaCO_3$) of 300 or more, other factors being equal, seems highly favorable. Six of the eight water samples analyzed to date that show the highest uranium content are in the range from 312 to 483, another shows 992, and the remaining one a total hardness of 104.

The silica content of water seems to be definitely related to uranium content. The most favorable range in waters analyzed to date seems to be 10 to 30 ppm, with a content of less than 5 ppm definitely unfavorable. Information on high-silica waters is too inadequate to permit their evaluation.

The fluoride content seems definitely related to that of uranium.

The ratio between calcium and magnesium seems to have some bearing on the uranium content.

PLANS FOR FURTHER INVESTIGATIONS

Work planned for the first half of fiscal-year 1953 (second and third quarters of the first project-year) is as follows:

1. Begin intensive investigations in parts of Colorado, Wyoming, South Dakota, Montana, and Utah, where uranium mining and milling either are in progress or in prospect.
2. Advance status of the reconnaissance search for uraniferous waters in states west of the Continental Divide, in remaining postions of Colorado, Wyoming, and Montana, in the Black Hills region, and perhaps in the black-shale region of Tennessee, Kentucky, Ohio, and Indiana.
3. Continuing coordination of the project with related projects, and especially with new discoveries of uranium as they are made.
4. Continuing evaluation of results of the investigations in order that work may be more and more sharply focused upon the most significant factors in the search as these become established.

In the quarter ending Sept. 30, as much of the foregoing will be accomplished as conditions may permit. It is presently intended, subject to change, that intensive investigations will begin in the San Juan region of Colorado and the Pumpkin Buttes-Black Hills region of Wyoming and adjacent states; and that the reconnaissance investigations will be in parts of Utah, Nevada, California, Idaho, Montana, Wyoming, and perhaps the Ohio Valley States mentioned above.