TEI-537

DISTRIBUTION OF ELEMENTS IN SEDIMENTARY ROCKS OF THE COLORADO PLATEAU

By W. L. Newman, E. M. Shoemaker and A. T. Miesch

Trace Elements Investigations Report 537

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

IN REPLY REFER TO:

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

September 4, 1959

AEC-438/9

Mr. Robert D. Nininger
Assistant Director for Exploration
Division of Raw Materials
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Bob:

Transmitted herewith are three copies of TEI-537, "Distribution of elements in sedimentary rocks of the Colorado Plateau," by W. L. Newman, E. M. Shoemaker and A. T. Miesch, June 1959.

This report is an abstract of a paper with the same title that is planned for publication as a Geological Survey bulletin. A copy of the entire report is in the Geological Survey files.

Sincerely yours,

John H. Eric
for Montis R. Klepper
Assistant Chief Geologist

TEI-537

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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

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ABSTRACT

Study of the distribution, volume, and lithologies of sedimentary rocks of the Colorado Plateau, and of the distribution of elements contained within these rocks, was undertaken to provide background data that might further the understanding of the genesis of uranium deposits. The study of the sedimentary rocks was made in conjunction with related studies of uranium deposits and igneous rocks of the Colorado Plateau.

The gross chemical compositions of sandstone, mudstone, and limestone from many of the formations of the Colorado Plateau were determined chiefly by spectrographic analysis; selected suites of samples were analyzed by chemical methods. Spectrographic and chemical analyses were treated by conventional mathematical methods for grouped data.

The average chemical compositions of sandstone from the principal host rocks of the Colorado Plateau--the Shinarump and Moss Back members of the Chinle formation of Late Triassic age and the Salt Wash member of the Morrison formation of Late Jurassic age--differ only moderately from the average chemical compositions of sandstones from formations of Paleozoic and Mesozoic age on the Colorado Plateau. Sandstones of the Shinarump and Moss Back members contain more aluminum, iron, titanium, zirconium, vanadium, chromium, and probably more cobalt and nickel than average sandstone of the Colorado Plateau, and less magnesium, calcium, barium, and potassium. Sandstones of the Salt Wash member contain more calcium, manganese, and copper than average Plateau sandstone, and less boron, nickel, cobalt, and yttrium. Sandstones of the Shinarump contain about twice as much titanium, zirconium, manganese, copper, chromium, and vanadium, as sandstones of the Salt Wash, about three times as much aluminum, iron, strontium, and boron, and as much as 10 times more cobalt and nickel.

Most of the uranium deposits of the Morrison formation occur in uppermost sandstone strata of the Salt Wash member. However, there is no significant chemical difference among the uppermost strata and intervening and the basal strata, except that the uppermost strata contain less potassium and calcium.

The distribution of copper and vanadium in unmineralized sandstone of the Salt Wash member corresponds favorably to the area comprising the Uravan mineral belt. There is a good possibility of defining similar large areas of potential uranium-bearing rock on the basis of variations in concentration of these two elements in unmineralized sandstone.

The distribution of elements commonly associated with igneous or crystalline rocks indicates three possible crystalline rock source areas for detrital minerals in sandstone of the Salt Wash member. These areas are: the Meeker-Craig area of Colorado, an area just south of the "Four Corners" in Arizona and New Mexico, and the San Rafael Swell area in east-central Utah.

Two areas contain abnormally high concentrations of chromium, titanium, zirconium, boron, ytterbium, vanadium, uranium, and copper in unmineralized sandstones of the Shinarump and Moss Back members, and may be possible sources for detritus in these members. One area is located in east-central Utah. The concentrations of elements in sandstone of this area may be the result of accumulation of material derived directly from the exposed Precambrian core of igneous and metamorphic rocks of the Uncompahgre highland.

The second area is located in southeastern Utah and forms an indistinct belt of ground extending northwestward from the "Four Corners" area. The source of the material containing these elements may have been the Cutler formation that was exposed over a large area adjacent to the western edge of the Uncompahgre highland during the start of Late Triassic time. High-copper uranium ores have been mined from deposits located within this belt of ground.

Studies of the variations in chemical composition of sandstone from many formations of the Colorado Plateau with regard to the occurrence of uranium deposits show that sandstones containing half a percent of potassium or less are more favorable than sandstones containing more than half a percent of potassium. Favorable host rocks, on the basis of potassium content, include sandstones of the Dakota sandstone; the Cedar Mountain formation including the Buckhorn conglomerate member; and the Burro Canyon formation, all of Cretaceous age; the Salt Wash, Westwater Canyon, and Brushy Basin members of the Morrison formation of Jurassic age; the Shinarump and Moss Back members of the Chinle formation of Triassic age; and the Coconino sandstone of Permian age.

Average chemical compositions of mudstones of Triassic age on the Colorado Plateau show that mudstone of the Shinarump and Moss Back members may contain twice as much uranium and vanadium as mudstone of the Moenkopi and other units of the Chinle. "Bleached" mudstone of the Moenkopi at or close to the Moenkopi-Chinle contact contains up to 160 ppm uranium and more gallium, lanthanum, yttrium, ytterbium, scandium, niobium, and cerium than normal reddish-brown mudstone of the Moenkopi or Chinle formation. The accumulation of these elements may indicate the presence of a fossil soil that developed on the Moenkopi surface during the mid-Triassic hiatus.

No chemical feature serves to distinguish bentonitic mudstone from non-bentonitic mudstone of the Brushy Basin member of the Morrison formation in the Yellow Cat area of Utah, or at Spring Creek Mesa, near Uravan, Colorado. Likewise, except for calcium, no chemical feature serves to distinguish "red" mudstone from "green" mudstone of the Salt Wash member of the Morrison formation in the Jo Dandy area, Colorado. Red mudstone contains about twice as much calcium as green mudstone. Red mudstone is believed to be colored by a pervasive paint of anhydrous ferric oxides, whereas green mudstone merely reflects the inherent color of the clay minerals.

Carbonate rocks of Precambrian and Paleozoic age exposed in the Grand Canyon, Arizona, show a progressive decrease in magnesium content and a progressive increase in calcium content in successively younger rocks. The greatest change in magnesium content appears to occur in the lower part of the Redwall limestone of Mississippian age where the magnesium content drops from over 10 percent to about 0.07 percent. In addition to being lean in magnesium, the Redwall contains relatively little silicon, aluminum, iron, sodium, potassium, titanium, zirconium, barium, boron, scandium, cobalt, nickel, gallium, yttrium, and ytterbium. Concentrations of manganese, vanadium, and chromium appear to be quite consistent in carbonate rocks of Precambrian and Paleozoic ages.