THE ELK RIDGE-WHITE CANYON CHANNEL SYSTEM, SAN JUAN COUNTY, UTAH: ITS EFFECT ON URANIUM DISTRIBUTION

By Henry S. Johnson, Jr., and William Thordarson

Trace Elements Investigations Report 608

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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

February 3, 1958

AEC - 298/8

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-608, "The Elk Ridge-White Canyon channel system, San Juan County, Utah: its effect on uranium distribution", by Henry S. Johnson, Jr., and William Thordarson, September 1957.

We plan to submit this report for publication in Economic Geology.

Sincerely yours,

John H. Eric
for W. H. Bradley
Chief Geologist

Geology and Mineralogy

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

THE ELK RIDGE-WHITE CANYON CHANNEL SYSTEM, SAN JUAN COUNTY, UTAH: ITS EFFECT ON URANIUM DISTRIBUTION*

By

Henry S. Johnson, Jr., and William Thordarson

September 1957

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This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

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

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THE ELK RIDGE-WHITE CANYON CHANNEL SYSTEM, SAN JUAN COUNTY, UTAH: ITS EFFECT ON URANIUM DISTRIBUTION

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ABSTRACT

Reconnaissance in the White Canyon district, San Juan County, Utah, indicates that rocks of the Shinarump member of the Chinle formation of Triassic age were deposited in that district in two different channel systems; sediments deposited in channels of one system were derived from a source to the east and sediments of the other from a source to the south. The channel system containing sediments derived from the east, the Elk Ridge-White Canyon channel system, was apparently formed by a large braided stream that flowed westward from a source in granitic and metamorphic terrane of the ancestral Uncompahgre highland.

All known uranium deposits of any consequence in the White Canyon district are confined to the Shinarump member deposited in the Elk Ridge-White Canyon system. The nature of the channels and the lithologic characteristics of the rocks filling this system of channels combine to form a much more favorable environment for the localization of uranium deposits than do the channels formed and the rocks deposited by northward-flowing streams.

Recognition of channel systems in the White Canyon district suggests that channel systems may be recognized elsewhere in the Shinarump member, and that the Shinarump member on the Colorado Plateau

may be composed of rocks deposited in many coalescing channel systems. In addition, study in the White Canyon district indicates that rocks deposited in some of these channel systems are more favorable hosts for uranium deposits than the rocks deposited in others. Recognition and delineation of these ancient channel systems may be of help in making regional appraisals of ore potential and in the search for new mining districts.

INTRODUCTION

The area described in this report is part of the White Canyon mining district, San Juan County, Utah (fig. 1). It extends from Elk Ridge on the east to the Colorado River on the west and includes the Elk Ridge, Deer Flat, White Canyon, Red Canyon, and Red Rock Plateau areas. The exposed rocks are predominantly continental deposits of mudstone, sandstone, and conglomerate and range in age from Permian to Jurassic. Over most of the area structures consist of broad gentle folds, and the beds are nearly flat lying except along the eastern edge of Elk Ridge where dips are as high as 20° to 30° to the east. The area, which lies in the Canyon Lands section of the Colorado Plateau (Fenneman, 1931, p. 306-307) is characterized by mesa and canyon topography, a semiarid climate, and sparse vegetation except on Elk Ridge where aspen and yellow pine are locally abundant. The investigation of the area was conducted by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

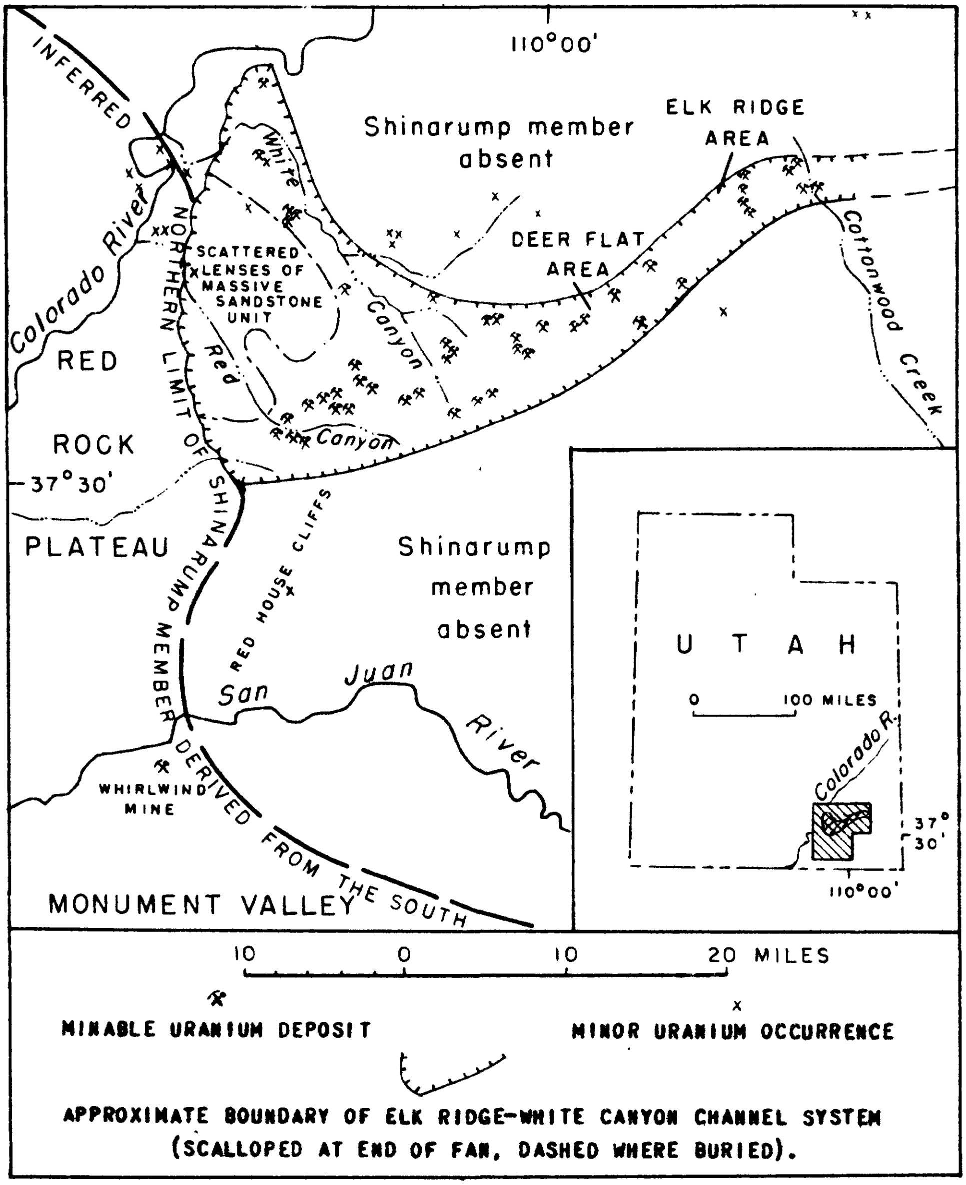

FIGURE 1.--MAP SHOWING BOUNDARIES OF THE ELK RIDGE-WHITE CANYON CHANNEL SYSTEM, WHITE CANYON DISTRICT, SAN JUAN COUNTY, UTAH.

Uranium deposits in the White Canyon district have been described by Miller (1955, p. 156-169); Trites and Chew (1955, p. 243-247); Trites, Finnell, and Thaden (1956, v. 6, p. 379-382; P.P. 300, p. 281-284); and Isachsen and Evensen (1956, v. 6, p.350-366; P.P. 300, p. 263-280). Uranium and copper minerals are associated in tabular elongate ore bodies which are for the most part oriented parallel to bedding and sedimentary trends in fluvial sediments of the Shinarump member of the Chinle formation of Late Triassic age. The ore deposits are from a few inches to 15 feet thick, as much as 300 feet wide, and as much as 3,000 feet long. Near outcrops the ores are oxidized and are characterized by secondary uranium and copper minerals and abundant iron oxides. A few tens of feet away from the outcrop the ores are commonly relatively unoxidized and are composed of uraninite, bornite, chalcopyrite, chalcocite, covellite, pyrite, and very minor amounts of sphalerite and galena. The ore minerals commonly replace carbonized plant matter--the cementing material of the sandstone host rock--and detrital grains of quartz and feldspar. The ore deposits are younger than the host rocks, but the source of the metals is unknown. Channels at the base of the Shinarump member, interbedded sandstone and mudstone, and the presence of abundant carbonaceous material have all been recognized as playing an important part in the localization of ore.

Field studies by the authors in the summer of 1956 indicate that the Shinarump member in the White Canyon district was deposited by two separate systems of streams, one carrying sediments having a source to the east of Elk Ridge--this corroborates a concept first suggested by Miller (1955, p. 158)--and the other carrying sediments having a source somewhere in Arizona far to the south of the White Canyon district. The sediments deposited by the streams of these two channel systems appear to coalesce in the Red Canyon area. These studies further indicate that the minable uranium deposits of the White Canyon district are all within the boundaries of the channel system that developed from the east (hereinafter termed the Elk Ridge—White Canyon channel system), and that the nature of the channels and the lithologic characteristics of the sediments deposited in this channel system make these rocks a much more favorable host for uranium deposits than the Shinarump in the channel system that developed from the south.

The purpose of this report is to describe that part of the Shinarump member deposited in the Elk Ridge—White Canyon channel system and to discuss the effects of this channel system on the distribution of uranium deposits within the White Canyon district. The possibility of applying the channel system concept to exploration for uranium elsewhere on the Colorado Plateau is also discussed.

ELK RIDGE-WHITE CANYON CHANNEL SYSTEM

Lithology

The Shinarump member of the Chinle formation deposited in the Elk Ridge-White Canyon channel system is composed of light-gray to pale yellowish-orange fine- to very coarse-grained conglomeratic sandstone complexly interbedded with gray to greenish-gray mudstone. Carbonaceous material in the form of carbonized leaves, stems, and partially calcified logs is sparse to abundant. An interbedded sandstone-mudstone unit is commonly present in deeper scours, and a massive conglomeratic sandstone unit commonly occurs in blanketlike layers at the top of the member. Pebbles are as much as 5 inches in size and are subrounded; most of them are composed of quartz; the rest are of quartzite and chert.

Direction of sediment transport

Trends of individual channels (R. Q. Lewis, Sr., and T. L. Finnell, written communications, 1956) and the average direction of dip of crossbedding (Poole and Williams, 1956, v. 6, p. 326-330; P.P. 300, p. 227-231) indicate a westerly to southwesterly direction of transportation of the sediments in the Elk Ridge and Deer Flat areas (fig. 1). In the southern part of the thin fan-shaped alluvial deposit west of Deer Flat most channels trend westerly and southwesterly; in the central and northern part of the deposit they trend predominantly to the northwest (Trites and others, 1956, v. 6, p. 379-382; P.P. 300, p. 281-284). Trends, based on the direction of dip of crossbedding, are thought to vary less in the lower part of the Shinarump member than in the upper part. After the lower channel scours were filled with sediments the streams which deposited the upper part probably did considerable meandering.

Further indication of the general westerly direction of transportation of the sediments of the Shinarump member deposited by streams of the Elk Ridge-White Canyon channel system is a decrease in the amount of pebbles and size of the largest pebbles westward from the Elk Ridge area.

Source of sediments

The predominance of quartz pebbles and quartz and feldspar grains in the sandstone plus the general westerly direction of transport of sediments combine to indicate that the sediments deposited in the Elk Ridge-White Canyon channel system were derived from a granitic and metamorphic terrane to the east. The ancestral Uncompahgre highland, which was about 80 miles northeast (or 150 miles directly east) of the Elk Ridge area, seems to have been the most logical source area.

Boundaries and general characteristics

Figure 1 shows the authors' concept of the approximate boundaries of the Elk Ridge-White Canyon channel system. This concept is based on the results of work by Lewis (1954, p. 30-32; 1955, p. 48-49) and Lewis and Campbell (1955, p. 54-55; 1956, p. 68-72) in the Elk Ridge area; by Finnell (1955, p. 31-34) in the Deer Flat area; by Trites (1953, p. 23-24; 1954, p. 28-29) in the White Canyon and Red Canyon areas; and on field studies by the authors throughout the White Canyon district. Sediments deposited in the Elk Ridge-White Canyon channel system have not been traced east of the Elk Ridge area because most of them are buried beneath younger sediments in that direction.

In the Elk Ridge and Deer Flat areas the subparallel boundaries of the Shinarump member suggest a sinuous alluvial valley 3 to 6 miles wide. Lewis and Campbell (1956, p. 68-72) have presented evidence of a structural trough which was subsiding in the Elk Ridge area during deposition of the lower part of the Chinle formation and which may have influenced the boundaries of deposition of the Shinarump member. North and south of the boundaries of the channel system in the Elk Ridge and Deer Flat areas, the Shinarump member has not been recognized, although a few small seemingly isolated sandstone lenses may correlate with it. West of the Deer Flat area, the boundaries of deposition of the Shinarump member and trends of the channels diverge and indicate that the Elk Ridge-White Canyon channel system debouched into an alluvial fan-shaped deposit, the apex of which is approximately at Deer Flat.

In general, the Shinarump member is thicker and individual channels are more closely spaced in the Deer Flat area than in the west-central part of the fan-shaped deposit. The diverging of distributary streams west of Deer Flat probably resulted in greater distances between the channels and caused the sediment load to be spread out in thinner deposits over wider areas.

Along the northern and northwestern boundaries of the fan-shaped deposit in the White Canyon area, the Shinarump member interfingers and grades into gray sandy mudstone and thin local beds of shaly coal. The shaly coal beds are as much as 4 feet thick and have a lateral extent of several hundred feet. Apparently the streams which deposited the Shinarump died out in muddy lakes and swamps in this area. Much of the mudstone may be the time equivalent of sandstone of the Shinarump member, but the mudstone is commonly mapped as part of the Monitor Butte member of the Chinle formation.

In the west-central part of the fan-shaped deposit in the White Canyon and Red Canyon areas the Shinarump member is characterized by scattered lenses of coarse sandstone; the base of the unit is marked by a few shallow channel scours. Between these sandstone lenses are large areas in which the Shinarump is absent or is represented by gray sandy mudstone which is probably the time equivalent of sandstone. The thinness and discontinuity of the sandstone lenses in this area are thought to be indicative of proximity to the outer margin of the fan-shaped deposit (fig. 1).

The southwestern margin of the Elk Ridge-White Canyon channel system in the Red Canyon area is very poorly defined because much of the Shinarump member in this area is buried beneath younger rocks of the Red Rock Plateau. Therefore, the boundary shown on figure 1 is largely hypothetical. Also, the rocks of the Elk Ridge-White Canyon channel system appear to coalesce in this area with sediments of the Shinarump member which were transported northward into the White Canyon district from a source to the south. The sediments of the Shinarump which were derived from the south differ from the Shinarump deposited in the Elk Ridge-White Canyon channel system in that they form a blanketlike layer consisting predominantly of light-gray fine- to coarse-grained sandstone that locally contains numerous gray mudstone pebbles and abundant interstitial gray mudstone. The layer is further characterized by very sparse amounts of carbonaceous material, scattered silicified logs, muscovite, rib- and furrow-type ripple marking (Stokes, 1954, p. 8-11) as well as crossbedding, and coarse conglomeratic sandstone found for the most part only in sparse amounts at the base of the unit. Channel trends, dips of cross-strata, and rib and furrow markings indicate that the sediments derived from the south were transported in directions ranging from east-northeast through north to west-southwest in the Red Canyon area. Along the Colorado River a few miles west-southwest of the postulated margin of the Elk Ridge-White Canyon channel system deposit, the Shinarump is as much as 60 feet thick and is apparently of the type which came from the south. Exposures of this blanketlike type Shinarump, as much as 100 feet thick, are common along the San Juan River at the extreme southern end of the White Canyon district.

Near the north end of Red House Cliffs (fig. 1) thin discontinuous lenses of mottled purple, red, and white siltstone, sandstone, and conglomeratic sandstone have been mapped by T. E. Mullens (written communication, 1955) as the Shinarump member, largely because they occur at the base of the Chinle formation. These sandstone lenses are lithologically unlike the Shinarump in the White Canyon district which was derived from the south, and they do not correlate well with rocks deposited in the Elk Ridge-White Canyon channel system. These lenses probably were derived from a source somewhere to the east, but they are not well understood and are tentatively excluded from rocks deposited in the Elk Ridge-White Canyon channel system.

In general, the Elk Ridge-White Canyon channel system seems to have been formed by a large braided stream composed of a maze of bifurcating and intermingling waterways ranging in size from small creeks to master streams 1,000 feet or more in width (fig. 2). Gradient was probably only a few feet per mile, and the channels were choked with an overload of sediments. Alternate scouring and filling took place continuously as the water level fluctuated between flood and low-water stages. West of Deer Flat the stream emerged from its valley, the gradient became even less, and a fan-shaped deposit was formed. This "fan" was bounded on the north and northwest by muddy lakes and swamps and on the southwest by similar sediments advancing from the south.

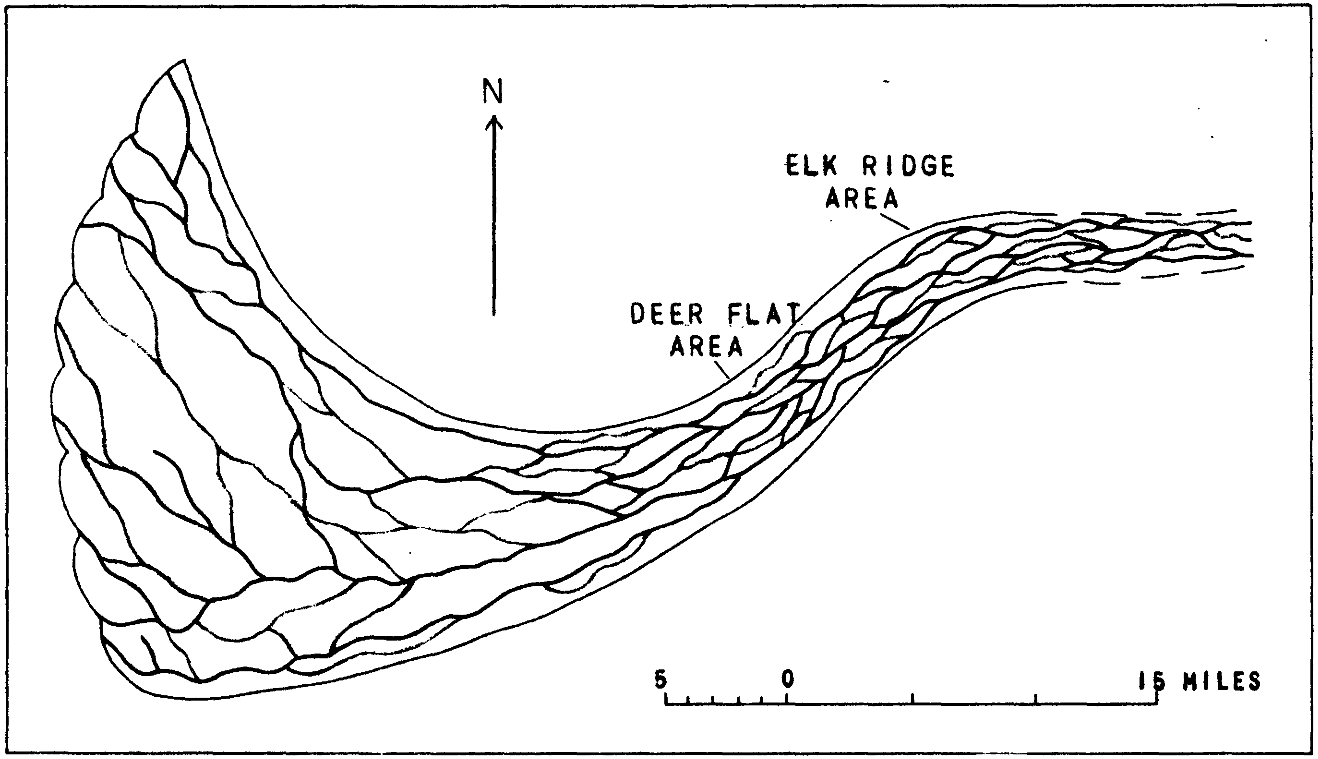

FIGURE 2.--SCHEMATIC DIAGRAM OF IDEALIZED ELK RIDGE-WHITE CANYON CHANNEL SYSTEM, WHITE CANYON DISTRICT, SAN JUAN COUNTY, UTAH.

Lithologic units

The sediments of the Shinarump member deposited in the Elk Ridge-White Canyon channel system are divided into an interbedded sandstone-mudstone unit and a blanketlike massive sandstone unit.

Sandstone-mudstone unit

This unit underlies the massive sandstone unit and commonly fills channel scours and other low areas. Sandstone and mudstone were deposited almost simultaneously in some places as interfingering lenses of sandstone and mudstone or as lenses of sandstone enclosed by mudstone. In other places alternating deposition of sand and mud formed interbedded sandstone and mudstone. Probably sand was being deposited by faster currents in the deeper parts of scours and in channel sandbars at the same time that relatively slow currents were depositing mud in slipoff slopes, flood plains, abandoned channels, and backwater areas. In general, sandstone makes up approximately 50 to 80 percent of the volume of sediments in the channel scours. The sandstone in this facies is light gray to light yellowish gray, fine-to very coarse-grained, sparsely conglomeratic and shows little cross-stratification. The mudstone is gray, massive and contains some siltstone. Carbonaceous plant debris and partially calcified logs are abundant in both the sandstone and the mudstone.

Massive sandstone unit

This unit overlies the sandstone-mudstone unit and in interchannel areas may be the only part of the Shinarump member present. The sandstone is crossbedded, light gray to light yellow gray, medium- to very coarse-grained, and conglomeratic. Carbonaceous plant debris and logs are sparse. Gray massive mudstone is abundant locally but is generally absent or present in only minor amounts.

In many places the massive sandstone unit fills scours cut in the underlyi sandstone-mudstone unit. This suggests that the two different units may be due to two separate periods of deposition. On the other hand, it is conceivable that deposition of the two units was essentially simultaneous, and that the sandstone-mudstone unit was deposited in channels and low areas and the massive sandstone was deposited as a blanket once the channels were filled.

Channel scour characteristics

Channels of the Elk Ridge-White Canyon channel system cut into the Moenkopi formation range from a few feet to 1,000 feet in width. The depth of these channels generally ranges from about 15 to 25 feet, but some examined by Trites, and others (1956, v. 6, p. 397; P.P. 300, p. 283) are as deep as 50 feet or as shallow as 4 feet. The relatively shallow depths of channels in the Elk Ridge-White Canyon channel system contrast sharply with depths of 75 to 150 feet reported by Witkind (1956, v. 6, p. 368; P.P. 300, p. 235) in Monument Valley, Utah and Arizona.

Figure 3 shows schematic cross sections of types of channels present at the base of the Shinarump member in the Elk Ridge area. Figure 3a represents an asymmetrical channel with mudstone on the slipoff slope, sandstone in the deeper part of the scour, and interfingering mudstone and sandstone between. From the shape of this scour and the relative positions of mudstone and sandstone it may be inferred that the stream was bending to the left at this point. Inferences of this sort should be helpful in the attempt to trace channels behind outcrops or in front of drilling and mining operations.

Figure 3b shows a channel filled with the interbedded sandstone-mudstone unit which is overlain by the massive sandstone unit. The massive sandstone unit fills scours cut into the sandstone-mudstone unit. Figure 3c shows interfingering lenses of sandstone and mudstone of the sandstone-mudstone unit overlain by the massive sandstone unit.

EFFECTS OF ELK RIDGE-WHITE CANYON CHANNEL SYSTEM ON DISTRIBUTION OF URANIUM DEPOSITS

Sandstone-mudstone unit

All uranium deposits of any consequence in the White Canyon district are in channel fills and are confined to the sandstone-mudstone unit of the Shinarump member. Apparently the combination of the presence of a channel and of the lithologic characteristics of the sandstone-mudstone unit provided conditions favorable to ore deposition. Probably the transmissivity of channel-fill sandstone allowed easy passage of laterally moving ore

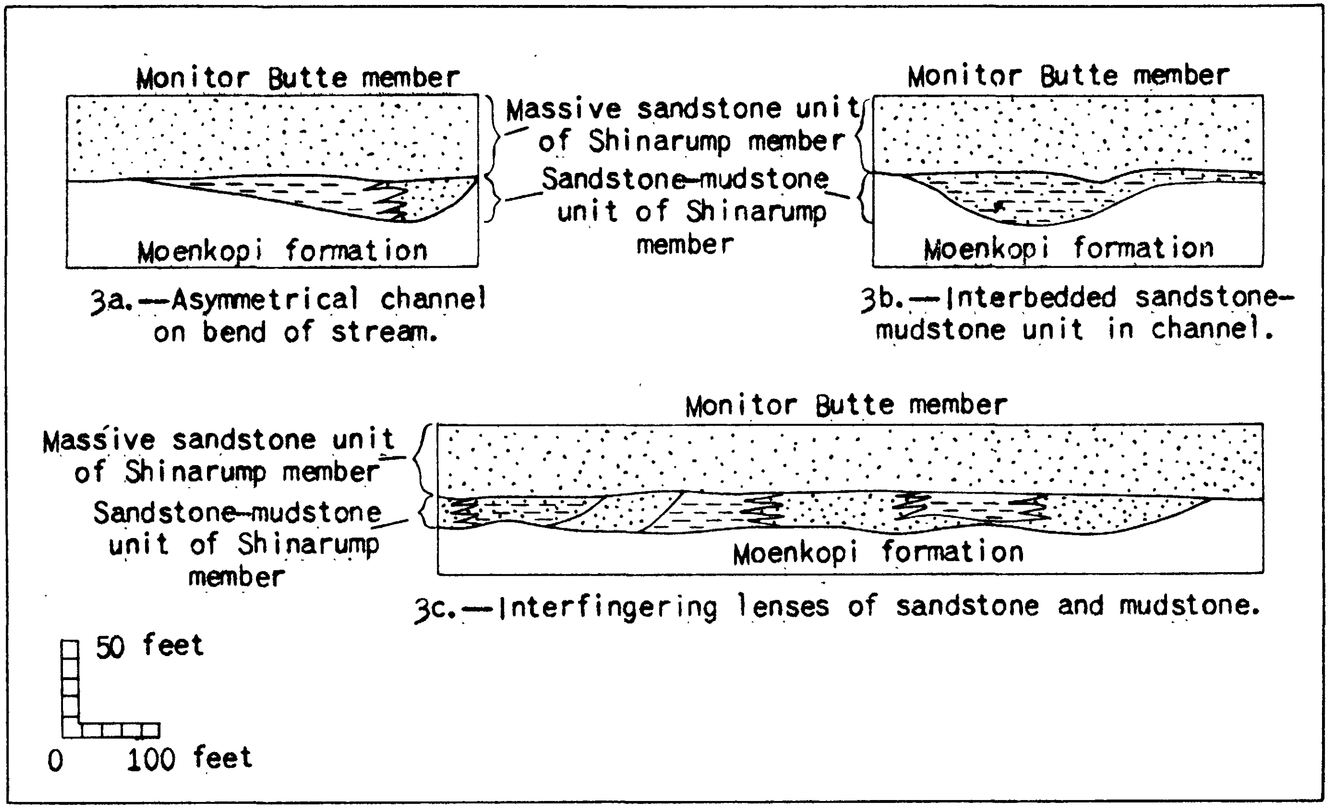

FIGURE 3.--SCHEMATIC CROSS SECTIONS OF TYPES OF CHANNELS AT THE BASE OF THE SHINARUMP MEMBER OF THE CHINLE FORMATION IN THE ELK RIDGE AREA, WHITE CANYON DISTRICT, SAN JUAN COUNTY, UTAH.

solutions, interfingering sandstone and mudstone lenses provided local traps to slow and guide the ore solutions, and the presence of carbonaceous material caused a chemical environment conducive to ore precipitation.

Relation of ore deposits to the margin of the channel system

Trites, and others (1956, v. 6 p. 397; P.P. 300, p. 283) have stated that all known high-grade ore deposits in the White Canyon area (fig. 1) are within 3,000 to 15,000 feet of the margin of deposition of the Shinarump member. A possible control such as the damming up of laterally moving ore solutions by pinchout of the Shinarump is suggested. On the other hand, it seems more likely that certain features of the Elk Ridge-White Canyon channel system may have caused this apparent grouping of ore deposits. Upon divergence of the streams to form the fan-shaped deposit, major drainage apparently tended to follow courses near the northern and southern margins of deposition. This left large areas in the central and west-central portions of the fan to be covered only by sandy mudstone or thin scattered lenses of sandstone, both of which are relatively unfavorable for the formation of uranium deposits.

Regional relationships

All known uranium deposits of any consequence in the White Canyon district are confined to that part of the Shinarump member deposited in the Elk Ridge-White Canyon channel system. Apparently the channels and lithologic characteristics of the Shinarump deposited in this channel system make it a much more favorable host for uranium ore bodies than the blanketlike Shinarump deposited by streams flowing into the

White Canyon district from the south. The unfavorableness of the sediments of the Shinarump derived from the south as a host for ore deposits is probably due largely to the relative uniformity of its gross lithology (ore solutions would tend to be dispersed through the blanketlike unit rather than guided or trapped in certain parts of it) and the sparseness of interbedded mudstone and carbonaceous material in it. It may be argued that this part of the Shinarump is favorable for large uranium deposits in Monument Valley (fig. 1) and, therefore, should also be favorable beneath the Red Rock Plateau where it is essentially the same lithologically. There seems to be no completely satisfactory explanation for this apparent lessening of favorableness northwestward; but prospecting of the extensive outcrops of the Shinarump member in the western part of the Monument Valley district and along the San Juan River (and there are some very large channels in these areas) strongly indicates that--with the lone exception of the rather small Whirlwind mine--the Shinarump contains no significant uranium deposits in these areas. Consequently, estimates of potential ore reserves within the whole White Canyon district must take into consideration the likelihood that the boundaries of the Elk Ridge-White Canyon channel system essentially delineate ground relatively favorable for minable uranium deposits within the district.

APPLICATION OF THE CHANNEL SYSTEM CONCEPT TO THE SEARCH FOR URANIUM

Study of rocks of the Shinarump member of the Chinle formation deposited in the Elk Ridge-White Canyon channel system suggests that the Shinarump member on the Colorado Plateau was deposited in a wide shallow basin of deposition by many coalescing streams of channel systems. It further indicates that sediments deposited by streams of certain of these channel systems are more favorable as hosts for uranium deposits than the sediments deposited by others. Geologic studies leading to the recognition, delineation, and understanding of these ancient channel systems may, then, be of great help in making regional appraisals of ore potential and in the search for new mining districts. Information on pebble assemblages from outcrops in Arizona and southwest Utah suggests that several different channel systems were present along the southern margin of the Colorado Plateau during deposition of the Shinarump.

ACKNOWLEDGMENTS

Thanks are due many geologists of the U. S. Geological Survey and the U. S. Atomic Energy Commission with whom the concept of the Elk Ridge-White Canyon channel system has been discussed. In particular, recognition should be given Miller (1955, p. 156-169) for his contribution to the understanding of the Elk Ridge-White Canyon channel system.

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