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THE SHINARUMP MEMBER OF THE CHINLE FORMATION

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GENERAL

The Shinarump member of the Chinle formation consists of sandstone, conglomerate, and rare lenses of mudstone, and is the basal member of the Chinle formation (Upper Triassic). It overlies the Moenkopi formation (Lower and Middle (?) Triassic) in most places and in other places it overlies the DeChelly sandstone (Permian). The Shinarump was deposited by a number of braided stream systems whose constant reworking caused sheets of sand and gravel to advance across a relatively flat erosional surface. The Shinarump member is resistant to erosion, when compared to the weak overlying and underlying units. This characteristic is an important factor in determining the topographic character of the areas in which it crops out. Erosion of the overlying Chinle clays, locally, forms a stripped bench back of the Shinarump cliffs but elsewhere it is entirely eroded away, leaving the top of the Shinarump member entirely bare. Many of the mesas and buttes of Monument Valley and other parts of the Colorado Plateau exhibit this common feature.

The material on the sedimentology of the Shinarump member is based to a considerable extent on Evensen (1953) and McKee, Evensen, and Grundy (1953). The section on uranium is largely from Evensen and Gray (1958).

DISTRIBUTION

The large areal extent and relatively uniform thickness of the Shinarump member is particularly remarkable in a continental sediment containing a large amount of coarse material. The unit definitely occurs in the northern third of Arizona, the southern half of Utah, and extends short distances into northwestern New Mexico and southern Nevada (Longwell, 1928 and McKee, 1951). In addition, it is considered to be equivalent in stratigraphic position and depositional history to the Dockum formation of eastern New Mexico and west Texas, the Popo Agie formation of Wyoming, and the Higham grit of southeastern Idaho (McKee, 1951 and Heaton, 1950). In many areas the Shinarump is absent locally as a result of nondeposition where the pre-existing land surface was topographically high. In these areas the advancing sheet of Shinarump sediments appears to have lapped against, and to have been deposited around, residual hills of the Moenkopi formation.

THICKNESS

The Shinarump member is generally uniform in thickness, ranging from 50 to 100 feet throughout most of the region. It is absent in some areas, however, and has a maximum thickness of more than 350 feet on the west side of Monument Valley. The primary control of the thickness was the relief of the erosion surface on which it was deposited. In addition, some variation in thickness may be due to lateral variations in lithology along the contact with the overlying Chinle member.

BASAL CONTACT

The basal contact of the Shinarump member of the Chinle formation is one of the most conspicuous unconformities on the Colorado Plateau. In many places it is extremely irregular and in some areas the underlying erosion surface has a relief measured in hundreds of feet. These are channels, cut into the underlying units and filled with Shinarump sediments. They contain almost all of the known uranium deposits in the Shinarump member. The inter-channel areas are gently undulating in general. In most of the region the Shinarump is underlain by the Moenkopi formation and a zone of bleaching in the uppermost Moenkopi makes the contact especially conspicuous. In a few areas and localities the Shinarump overlies the Permian, DeChelly sandstone.

Relief of the Basal Contact

The marked erosional unconformity at the base of the Shinarump member is significant, both in the history of the formation and because of its apparent relationship to uranium mineralization. Channels vary greatly in size; a maximum width of about 3,000 feet and a maximum depth of 275 feet has been observed in the largest-known channels on the west side of Monument Valley. The pattern of these paleochannels resembles modern streams meandering over unconsolidated sediments, with numerous slumping channel banks. It has been suggested (McKee, Evensen, and Grundy, 1953) that late Moenkopi streams carved the surface on which shinarump clastics rest and that the Moenkopi formation was unconsolidated at the time. In addition, a number of erosional features appear to have been formed by early Shinarump streams. A number of channels have been investigated both on the outcrop and by extensive drilling and these studies have revealed the following points: (1) Their cross sectional profilies vary considerably, depending at least in part on the position of the cross section along a meander. In addition, the shape and character of a channel appears to depend, at least to some extent, on the type of lithology in the underlying formation. Mudstones form moderately low-angle slopes, whereas siltstones and sandstones form steep slopes or, locally, cliffs. (2) The base of a channel may vary as much as 100 feet in altitude in a mile, indicating large scours developed locally by the eroding streams. These scours resemble those formed in modern streams and represent, topographically, the lowest areas on the basal contact. (3) Several of the channels outlined by Atomic Energy Commission drilling programs in Monument Valley appear to be discontinuous, as described by Witkind (1956). They are canoe shaped with closed ends. It is suggested that these unusual features are the result of scouring by early Shinarump streams through a thin veneer of gravels and into the underlying sediments.

In the Canyon de Chelly area, the sides of most channels are steep and in some places overhanging. This suggests that the DeChelly sandstone was well indurated in post-Moenkopi time, as it is today.

Alteration Zone

A striking feature of the basal contact of the Shinarump member is a zone of bleaching developed in the underlying Moenkopi formation. This zone is marked by the reduction and removal of ferric iron, and in the process the reddish-brown color was changed to shades of yellow, green, gray, and white. The zone resembles in many respects the alteration zones in the upper parts of other red beds on the Colorado Plateau, where they are overlain by permeable formations. The bleached zone at the top of the Moenkopi formation is much thicker and more diversely colored, however, than the usual red bed alteration. It has been suggested that there is a relationship between the thickness and color of the altered Moenkopi sediments and the quantity or composition of the mineralizing solutions which passed through the permeable Shinarump above various portions of the contact. The alteration zone ranges in thickness from less than one inch to over 15 feet, averaging about 2 feet. Studies made by the Atomic Energy Commission in Monument Valley (Evensen and Gray, 1958) indicate there is a moderately good correlation between thickness and color of alteration and intensity of mineralization.

UPPER CONTACT

The upper contact of the Shinarump member is gradational into the overlying member of the Chinle formation in most areas but is sharp in others. In some localities tongues of Shinarump sandstone and conglomerate grade laterally into typical overlying Chinle claystone. In some areas the contact appears to be indiscernible with certainty; however, minor variations in the relief of such a contact may be expected from the mode of deposition of the units.

LITHOLOGY

The lithology of the Shinarump member of the Chinle formation is extremely variable in nearly all localities, but relatively homogeneous from a regional viewpoint. Whereas all proportions of conglomerate, sandstone, and mudstone occur in the unit in any area, these same lithologic types in varying proportions are characteristic of the member throughout its extent. Although the unit has generally been known as a conglomerate, the relative percentages of each lithologic type in all areas is roughly 75 percent sandstone, 20 percent conglomerate, and 5 percent mudstone. The unit is somewhat more conglomeratic, however, nearer the source areas to the south and more argilaceous near buried Moenkopi hills. In addition, upper parts of the Shinarump member are generally better sorted and contain less mudstone and fewer pebbles.

Conglomerate

The detrital sediments in the Shinarump member which are larger than sand size consist of two types: (1) Resistant pebbles and a few cobbles, generally of siliceous composition, which appear to have been transported for long distances; and (2) fragments of varying sizes of Moenkopi and DeChelly lithology which appear to have been deposited very near the point of their origin. The first type, generally referred to in the literature as quartz-pebble conglomerate, is the predominant type and occurs in all parts of the formation. Most of the second type is restricted to channel-fill deposits. Fossil wood in the Shinarump member consists of charcoal-like carbonized wood and silicified wood, similar to that in the overlying Petrified Forest member.

Gravels collected from the Shinarump across the region fall readily into the following fourfold classification: (1) chert; (2) light-colored quartz and quartzite; (3) gray, brown, and black quartzite; and (4) red and purple quartzite. In addition, a few granite and schist pebbles were collected in several localities. Many of the chert fragments in Monument Valley consist of nodules and fragments which are poorly rounded and a few of them include soft, calcareous masses within the pebbles. These characteristics, in contrast to the well rounded and highly abraded quartzite pebbles, suggests that the chert may have been derived from a source less distant than that of the quartzite. Many of these quartzite pebbles, because of their color and lithology, resemble types that occur today among Precambrian and Paleozoic rocks of central and southern Arizona. Pebbles of igneous and metamorphic origin are noteworthy for their scarcity, perhaps because these sediments were derived from youthful mountain areas before erosion breached the sedimentary cover over a crystalline core.

A conspicuous feature of the channel-fill deposits of the Shinarump member is the quantity of subangular to rounded lumps and pellets of claystone and siltstone included in the sediments. Most of the material ranges from pea size to several inches in diameter but blocks the size of an automobile also occur. In general, the small fragments are scattered rather uniformly throughout mud-pellet conglomerate lenses, whereas most of the larger blocks are oriented parallel to the sides of the channel as if they had slid down the slopes during deposition. Much of the mudstone material appears to have been derived from erosion of the underlying Moenkopi formation. Some may have been derived from reworking of muds laid down during Shinarump deposition. A block of Moenkopi mudstone which has been compacted concordantly with undulating Shinarump sandstone units above and below it occurs on the west side of Monument Valley, indicating that it, and presumably the Moenkopi formation, had not been much lithified at the time of Shinarump deposition.

Sandstone

Sandstone comprises about 75 percent of the Shinarump member in the Navajo country; and yet they are rather inconspicuous where they occur with the more striking conglomerate and mudstone. Sand grains are composed of quartz and a little feldspar; they are subangular to subrounded and most of them range in size from medium to coarse. Most sandstone units contain less argillaceous material than the conglomerate. Zircon and tourmaline are relatively common heavy minerals with apatite, garnet, and rutile present in small amounts. Calcite is the most common cementing agent in the Shinarump member; silica cement is common and ferruginous cement is rare.

Mudstone

In addition to the mudstone pellets and lumps, a small amount occurs as beds and lenses in the Shinarump member, generally near the base. The basal mudstones resemble reworked Moenkopi material in many cases whereas the rarer upper Shinarump mudstone material generally resembles the bentonitic Chinle clays. In both cases this material probably was deposited in pools and backwash areas, protected from the rapidly moving streams which formed the coarser units.

SEDIMENTARY STRUCTURES

Although cross-stratification is the most prominent structural feature within the Shinarump member, sand concretions, ripple marks, mud cracks, current lineation, and unconsolidated rock deformation also occur in profusion in some localities. Lenses of sandstone and conglomerate are examples of large-scale, cross-sirata, after the classification of McKee and Weir (1953). The medium-scale cross-strata are either of the trough or planar type or combinations of these. Statistical studies of medium-scale cross-stratification across the Navajo country indicate the streams depositing the Shinarump member were, in general, flowing to the northwest (Grundy, 1953 and Evensen, 1953). These data were corroborated, where possible, by studies of ripple marks and current lineation.

DEPOSITIONAL HISTORY

Deposition of the Shinarump member of the Chinle formation probably resulted after uplift in areas adjacent to the margins of the present Colorado Plateau. Braided stream systems spread out the detrital material derived from these newly formed or rejuvenated mountain areas. Constant reworking caused the sheets of sand and gravel to advance across the basin toward the Triassic sea to the northwest.

The Moenkopi formation, because of the lack of sedimentary cover, did not become indurated following deposition but did become a fairly cohesive mass of mud and silt from slight compaction and cementation. The period of relative crustal inactivity in the Four Corners region came to a close, probably near the beginning of Late Triassic time, with the uplift of mountainous areas to the south and east of the margins of the present Colorado Plateau. Studies of Shinarump-like sedimens in other areas has indicated additional uplifts to the north in Utah and Colorado. To the south of the mountains in Arizona and western New Mexico, the sediments were probably contributed to the marine Upper Triassic deposits of northwestern Sonora (Cooper and Arellano, 1946). To the north of these mountains, however, extended a region the surface of which was very near base level. Sheets of sand and gravel began to advance across this region from the elevated areas. Undoubtedly the streams carrying this material modified the erosion surface over which they were flowing with the constant reworking of the moving sedimentary material destroying all but the most resistant rock types.

It has been suggested by Stokes (1950) that the Shinarump is the veneer on a pediment surface. The occurrence of Shinarump-like units, also apparently derived from the south and east, higher in the Chinle formation argues against this theory. Moreover, if the process had been one of pedimentation, the Shinarump streams would have cut down the high area between Monument Valley and White Canyon and deposited sand and gravel on the resulting surface. In addition, pedimentation would have been more effective in beveling the soft Moenkopi hills which occur in a number of areas surrounded by Shinarump sediments and overlain by Chinle clay. The end of Shinarump deposition resulted either from a change of material in the source areas or a lower topography of these areas or, very possibly, a combination of both factors.

URANIUM

The Shinarump member contains a considerable number of commercial uranium deposits, largely in the Monument Valley and White Canyon-Red Canyon areas. Almost all ore occurs in and immediately below paleostream channels cut into the Moenkopi formation and filled with Shinarump sediments. Furthermore, almost all ore occurs in areas of scouring below the normal base of the channel. These scours represent the very lowest topographic zones along the Moenkopi-Chinle contact. Paleochannel sediments in general contain greater quantities of quartz-pebble conglomerate, and carbonaceous and argillaceous material, than the normal inter-channel Shinarump. This "trashy" lithology appears to be especially favorable for uranium deposition in the Shinarump, as well as in other uranium-ore-bearing sandstones on the Colorado Plateau. Clean sandstone is relatively unfavorable as a uranium host rock and may be barren although in proximity to high-grade ore. Carbonaceous material appears to be an important precipitating agent in many localities. The physical effect of argillaceous material in forming impermeable barriers appear to be a much more important control of ore deposition than any chemical or absorption effect.

Ore deposits in the Shinarump member are a complex of uranium, vanadium, and copper minerals in varying proportions. Early "rim" discoveries were of the oxidized type with bright yellow and orange colors, whereas later discoveries under sedimentary cover are generally the black, unoxidized ores. Future discoveries will generally be of the latter type.

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