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URANIUM DEPOSITS IN NORTHERN ARIZONA

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INTRODUCTION

The area encompassed by this report is arbitrarily chosen to include that portion of northern Arizona included in the Colorado Plateau province. Within the Arizona portion of this great structural and physiographic province, uranium occurs as bedded deposits in sedimentary rocks of Mesozoic age. With the exception of U. S. Highway 66, which crosses the south part of this region, the uranium mining districts of northeastern Arizona are not notably accessible. Travel incidental to the development and extraction of valuable natural resources in the Four Corners area has resulted in the improvement and expansion of the dirt road system serving this region.

Occasional references to uranium occurrences in northern Arizona are found in geologic literature extending back at least 68 years (Waring, 1890). The modern history of the uranium industry in Arizona as in other states began in 1948, with the establishment of an ore-buying schedule by the Atomic Energy Commission. Two ore-buying stations have been operated by the A. E. C. in Arizona, one near Globe and the other near Cameron. Due to insufficient deliveries of ore, the station at Globe was closed in 1957, but the buying station at Cameron, Arizona continues to operate actively, purchasing ore for the uranium processing mill at Tuba City.

Uranium now occupies a substantial position in the minerals industry of Arizona, and the state is rated as fourth in the nation in terms of measured ore. Measured uranium ore reserves in Arizona at the end of 1957 were estimated by the Atomic Energy Commission to total 2,600,000 tons, averaging 0.30% U_3O_8.

GEOLOGIC SETTING

Structure

Most of the uranium deposits in northern Arizona have been found in Jurassic and Triassic sedimentary rocks outcropping along the boundaries of major structural features. These include, principally, deposits in the Morrison formation, in the Carrizo and Lukachukai Mountains, the Defiance monocline at the northern end of the Defiance uplift, and deposits in the Shinarump and Chinle formations of Triassic age on the south flank of the Monument upwarp and along the south rim of the Black Mesa basin (fig. 1).

Rock units which outcrop in northern Arizona range in age from Precambrian to Tertiary. All of the significant uranium deposits in this area are found in rocks of Mesozoic age, namely the Morrison formation (Jurassic), the Chinle and Shinarump formations (Triassic), and with lesser occurrences at the base of the Mesaverde formation (U. Cretaceous). Because this paper is primarily economic in aspect, stratigraphic discussions which follow will be limited to those portions of the geologic column of special economic interest.

DESCRIPTION OF DEPOSITS

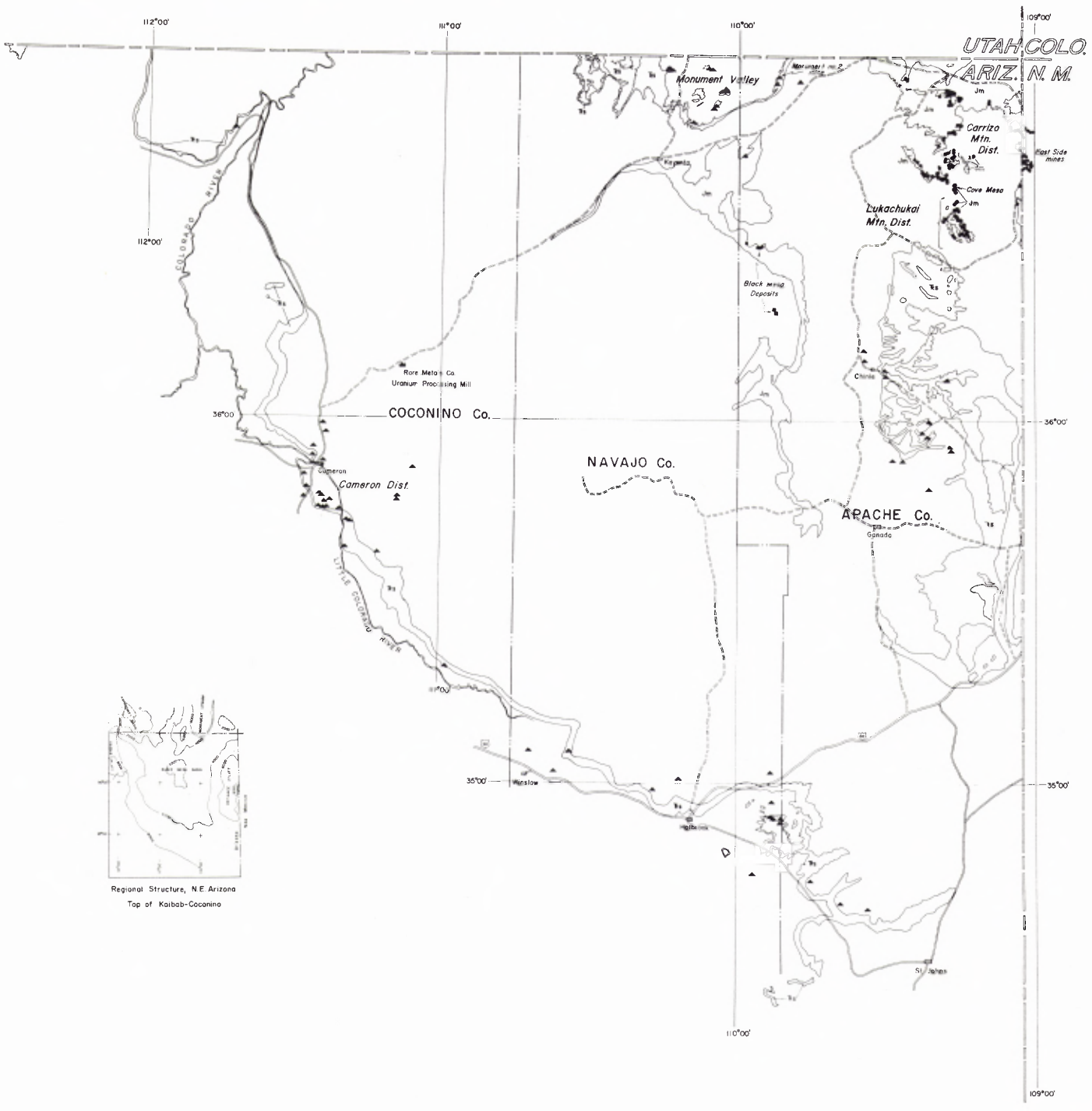
Morrison formation

Lukachukai (Chuska) Mountains — Ore is found in the fluviatile Salt Wash sandstone member of the Morrison formation in a belt of deposits across the Lukachukai Mountains. According to Masters (1955), "The ore belt conforms to a facies of lenticular sandstone and mudstone that apparently provided sufficient permeable sandstone for the passage of ore solutions, and sufficient impermeable mudstone to ristrict movement of solutions to particular sandstone beds. An unusual concentration of carbon appears to have served as a precipitation agent. Lateral changes in permeability of the sandstone beds, related to the old stream systems, influenced the movement of mineralizing solutions. The solutions apparently bleached red sandstones to gray or to limonitic brown. Mapping of drill-core data shows that ore-bodies (1) are elongate parallel to sedimentation, (2) tend to occur along the flanks of sandstone channels that are bounded laterally by zones of 'flood-plain' lithology, (3) commonly occur in groups, (4) tend to 'build up' against permeability barriers. The degree of mineralization in an area is related to the initial quantity and quality of: (1) ore solutions, (2) carbon, and (3) permeability variations. Permeability changes probably do not directly cause precipitation, but are effective in the formation of large deposits."

Carrizo Mountains — Commercial deposits of carnotite (potassium uranyl vanadate) occur in the Salt Wash sandstone member of the Morrison formation on the flanks of the Carrizo Mountains, in a uranium district encompassing about 950 square miles in the northeastern corner of Arizona and an adjoining narrow strip in northwestern New Mexico. The main mountain mass is composed of intrusive igneous rocks, and Mesozoic sedimentary rocks are exposed around the flanks. As early as 1918, carnotite was discovered in the area, and claims were located because of interest in the vanadium content of the ores. During World War II, more than 20,000 tons of ore was mined for its vanadium, which averaged 2.25% V_2O_5. Mining activity in the Carrizo area was revived in 1948, and continues to this date. Stokes (1951) states: "The ore deposits consist of sandstone impregnated with carnotite and a vanadium-bearing mica. The ore contains from 0.1 to about 0.5% U_3O_8, and 1.0 to 5.0% V_2O_5, and much of the ore contains more lime as cementing material than does typical ore from Colorado and Utah. Most of the ore bodies are roughly tabular masses which are also irregular in plan, but some are elongate, podlike masses, less common and less well-developed than those in Colorado and Utah. In general the deposits tend to form clusters in ill-defined areas. The deposits are believed to have formed from ground-water solutions shortly after the accumulation of the enclosing sands, and localization of the deposits does not appear to have been influenced by regional deformation, or igneous activity." As in most areas of sandstone-type deposits, the Carrizo Mountains district typically finds the ore bodies in the Salt Wash sandstone in intimate association with carbonized vegetal debris. Although there are localities where organic matter in the sandstone is barren of mineralization, nearly all of the commercial uranium deposits are associated with an abundance of carbonaceous detritus.

Shinarump formation

Monument Valley — Important ore deposits occur in the Shinarump conglomerate on the south flank of the Monument upwarp, the dominant structural element in this area, whose southern extremity reaches the vicinity of



URANIUM DEPOSITS of NORTHERN ARIZONA

Showing Principal Ore-bearing Formations & Mining Districts

10 0 10 20 30
Scale (miles)

FIGURE 1.

EXPLANATION:

Jm = Morrison Fm.
Ts = Shinarump cgl.
▲ = Uranium Mill
• = Deposit in Morrison Fm.
▲ = Deposit in Chinle or Shinarump
• = Deposit in Toreva Fm. of Kmv

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Kayenta, Arizona. In the Monument Valley area, the eastern flank of the Monument upwarp dips steeply and is well-defined by Comb Ridge, a conspicuous monocline which is probably the surface expression of a great deep-seated fault. Northward-trending asymmetrical anticlines are commonly superimposed on the south portion of the upwarp.

I. J. Witkind (1956) summarizes the uranium occurrences as follows: "The uranium ore bodies are localized in conglomeratic sandstone of the Upper Triassic Shinarump conglomerate that fills stream channels scoured in the underlying Lower and Middle Triassic Moenkopi formation. These channels range from narrow and shallow, 15 feet wide and 10 feet deep, to broad and deep, 2,300 feet wide and 70 feet deep. Two types of channels can be distinguished — a short type, less than two miles long, and a long type, traceable for distances greater than two miles. Plant matter in the form of trees, branches, and twigs was deposited with Shinarump sediments in the channels. It is probable that when the Shinarump conglomerate was invaded by mineralizing solutions the uranium ore was deposited primarily in localities formerly occupied by the plant material. Also, it is thought that the short channels are more likely to have ore accumulations than long channels."

The most notable ore body in the Monument Valley district is at the Monument No. 2 mine of Vanadium Corporation of America. Probably this deposit, whose ore is shipped to the uranium processing mill at Durango, Colorado, has accounted for more than any other single deposit in Arizona. The mine of second greatest economic significance in the Monument Valley district is probably the Moonlight mine of Industrial Uranium Company, 22 miles west of the Monument No. 2 mine. Numerous other mineralized paleochannels in this district have contributed important quantities of ore to the State's economy.

A large proportion of the Shinarump paleochannel deposits are found to contain copper minerals in association with uranium minerals. Typical examples of copper-uranium occurrences are at Hunt's Mesa, Copper Canyon, Holiday Mesa, and Hoskininni Mesa. Carbonized vegetal debris in the host sandstone is known to have an affinity for dissolved copper as it does for uranium ions.

Chinle formation

Cameron-Holbrook-St. Johns-Ganado Area — Uranium occurrences of commercial significance exist in the extensive arcuate outcrop of the Chinle formation along the south rim of the Black Mesa basin. In this belt of deposits, the mineralization is in the "Petrified Forest" member of the Chinle; better known as Gregory's "C" member (Gregory, 1917). In the Cameron district, the mineralization is found in the lower part of the "C" member; in the Holbrook district, it is in the lower and middle parts of the "C" member; and in the St. Johns, Ganado, and Monument Valley districts it is in the middle of the "C" member (Gregg, 1955). The best uranium deposits thus far found in the Arizona province of the Chinle formation are in the Cameron district.

Altered and bleached rocks typically surround all known uranium occurrences in the area. Uranium normally is concentrated in the rather sandy and silty mudstone lenses which occupy ancient scours. Ore bodies may occupy a number of different positions within scours (Isachsen, 1955), which range in width from 100 to 200 feet, in length from 300 to 1,000 feet, and are usually less than 10 feet deep. Altered zones surrounding the depressions are generally elongate, and may be as much as a quarter mile in area. Concentrations of carbonaceous material at the base of scours are the loci for the highest grade ore deposits.

Miscellaneous mineralized formations

Toreva Formation — On Black Mesa uranium occurs in the Toreva formation of the lower part of the Mesaverde group. All known deposits are in quartzose lenses at the top of the thick arkosic sandstone which is the basal unit of the Toreva formation. The better deposits are on the steep northeast flank of the asymmetrical Black Mountain anticline, a superimposed flexure on the northeast flank of the Black Mesa basin. Only secondary uranium minerals have been revealed in this area, where the occurences appear to be restricted to carbonaceous siltstone and mudstone in paleostream-type scours. No deposits of commercial magnitude in the Black Mesa area are known to this writer.

Todilto Formation — One or two specimens of ore-grade Todilto limestone have been turned in by prospectors, but Federal and State authorities have failed to locate the source outcrops, which may be in the Defiance uplift area.

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