URANIUM DEPOSITS
OF THE BLACK HILLS
SOUTH DAKOTA AND WYOMING

By C. S. Robinson and G. B. Gott

Trace Elements Investigations Report 723

UNITED STATES DEPARTMENT OF THE INTERIOR

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ABSTRACT

Uranium deposits of the Black Hills, South Dakota and Wyoming, occur in the rocks of the Inyan Kara group in four principal areas, the Edgemont, Carlile, Hulett Creek, and Elkhorn Creek areas. The ore minerals include carnotite, tyuyamunite, metatyuyamunite, corvusite, rauvite, uraninite, and coffinite; minor amounts of other uranium and vanadium minerals are also associated with the deposits.

The locations of the deposits are apparently controlled by several factors, the most important of which is the movement of significant volume of mineralizing solutions through the permeable rocks of the Inyan Kara group.

INTRODUCTION

Uranium deposits were first discovered in the Black Hills in 1951 in Craven Canyon north of Edgemont, S. Dak. (Harder, 1955). The following year many individuals and companies started prospecting the Black Hills area, and the U. S. Geological Survey began a program of geologic investigations (Bell and Bales, 1955). The geologic investigations by the Geological Survey, on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission, have continued to the present and are the basis for this summary of the geology of the uranium deposits. The writers would like to express their appreciation to the members of the Geological Survey who have worked in the Black Hills, all of whom have contributed information to this report.

Uranium ore has been produced only from the Inyan Kara group of Early Cretaceous age. Anomalous radioactivity has been reported locally in the Black Hills in the Precambrian core, in most of the Paleozoic and Mesozoic formations, and in some of the Tertiary intrusives. By far the most of the anomalous radioactivity has been found in the formations of the Inyan Kara group, and all the economic uranium deposits are on the southern, western, and northern flanks of the Black Hills in this group. Figure 1 is an index map that shows the area of outcrop of the Inyan Kara group, Morrison formation, and Unkpapa sandstone around the Black Hills, and the principal uranium mining areas.

STRATIGRAPHY

The Inyan Kara group is composed of the Lakota formation and the Fall River formation. This group overlies the Morrison formation, or its lateral equivalent in the southern Black Hills, the Unkpapa sandstone, both of Late Jurassic age, and is gradational with the overlying Skull Creek shale of Early Cretaceous age.

The Lakota formation, the basal formation of the Inyan Kara group, has the most varied lithology of any formation in the Black Hills. It consists of lenticular beds of sandstone that locally are conglomeratic and crossbedded, variegated claystone and sandy claystone, and local seams of coal and carbonaceous shale at the base. The formation ranges in thickness from about 100 to 550 feet. It is thickest at the southern end of the Black Hills; here it includes the Minnewaste limestone member, which crops out about 100 feet below the top and divides the Lakota formation into the Fuson member above and an unnamed member below. In Wyoming and northern South Dakota the Lakota formation averages about 250 feet thick.

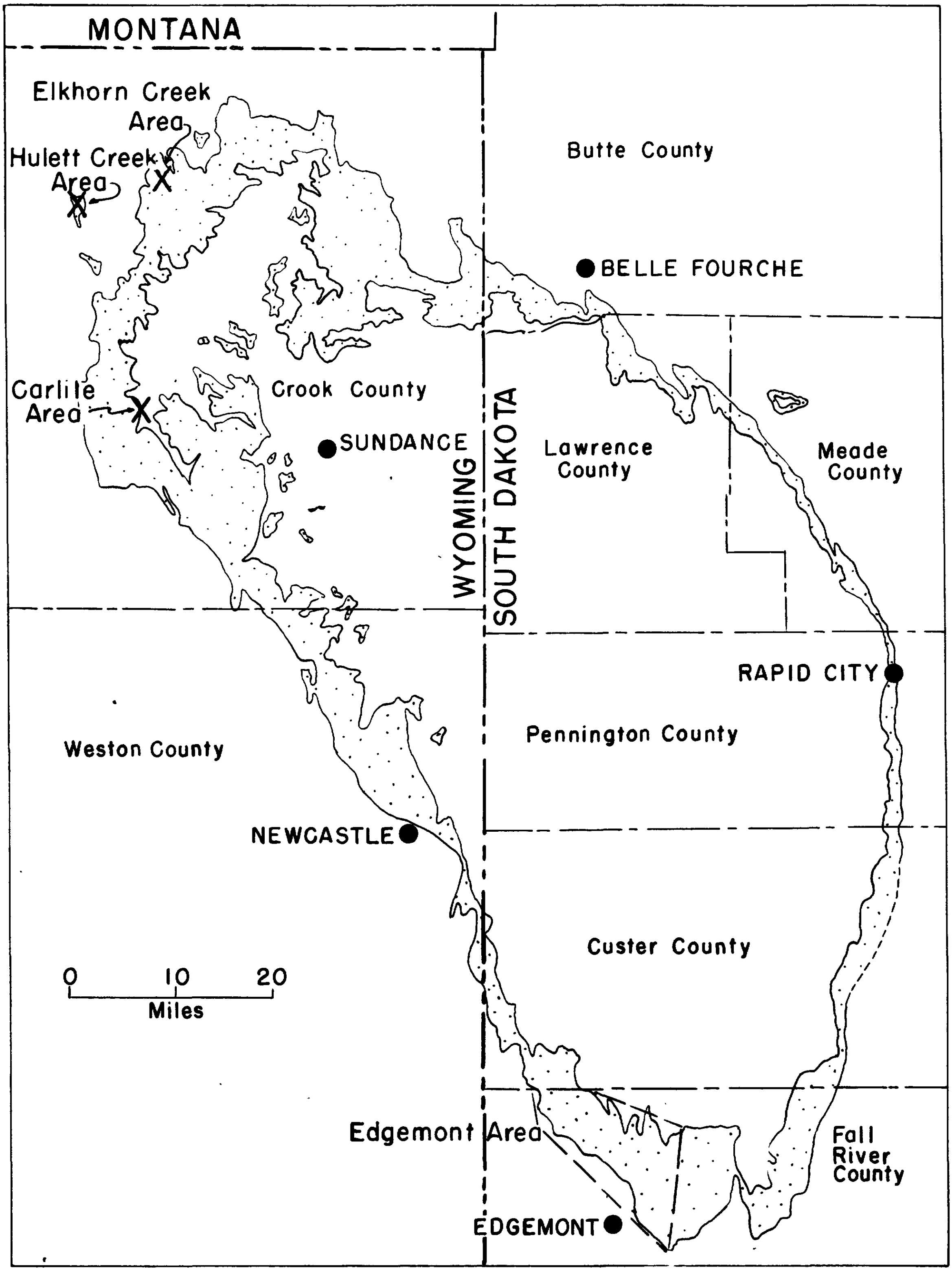

Figure 1.— INDEX MAP SHOWING OUTCROP OF THE INYAN KARA GROUP, MORRISON FORMATION, AND UNKPAPA SANDSTONE (STIPPLED), AND PRINCIPAL URANIUM MINING AREAS, BLACK HILLS

The Fall River formation, the upper unit of the Inyan Kara group, ranges from 135 to 160 feet in thickness. It consists of interbedded light-brown sandstone, light- to dark-gray siltstone, and dark-gray shale. The Fall River formation is separated from the underlying Lakota formation by a sharp lithologic break.

The Skull Creek shale, which lies gradationally above the Inyan Kara group, is about 250 feet thick and consists of dark-gray to black shale and silty shale.

STRUCTURE

The Inyan Kara group on the southern, western, and northern flanks of the Black Hills for the most part dips gently away from the core of the uplift. Superimposed on this regional structure are numerous small folds and a few large folds. Faults are rare except in the Hulett Creek area, and most of them have a vertical displacement of only a few feet. Only in the Hulett Creek area is there any apparent relationship between faults and the ore deposits.

ORE DEPOSITS

Uranium ore has been produced from four principal areas in the Black Hills: the Edgemont area, Carlile area, Hulett Creek area, and Elkhorn Creek area (fig. 1). Of these the Edgemont area has produced the most, more than all the other areas combined. The total production of the Black Hills as of October 1, 1957, has amounted to about 190,500 tons averaging 0.20 percent U_3O_8 (J. F. Foran, U. S. Atomic Energy Commission, oral communication).

Mineralogy

The first ores mined were the typical yellow oxidized ores containing the uranium vanadates carnotite, tyuyamunite, and metatyuyamunite, and the dark-gray or purplish black less oxidized ores, containing corvusite, a vanadium oxide, and rauvite, a uranium vanadate. The more recent production has been of primary ore containing uraninite and coffinite. Minor amounts of other uranium and vanadium minerals are associated with the ore deposits, including autunite, hewettite, metahewettite, hummerite, uranophane, and becquerelite (Bell, Gott, Post, and Schnabel, 1956, p. 346). Associated with the ore minerals are calcite, pyrite, marcasite, hematite, selenite, clay, and carbonaceous materials.

The ore minerals coat the sand grains and fill the interstices between sand grains and are finely disseminated in the carbonaceous material; carnotite and tyuyamunite, and other secondary minerals also fill fractures and coat joint surfaces in the vicinity of the deposits. Within a given ore body, the ore minerals occur in thin seams, irregularly shaped pods, as halos around carbonate and pyrite cemented sandstone concretions, and as coatings around carbonaceous material. The ore bodies form tabular and lenticular masses that transgress lithologic boundaries and structures in the host rock. Many of the individual lenses and pods contain only a few hundred tons, and the size of a deposit is determined by the number of lenses and pods close enough together to be mined from a single set of workings.

Most of the ore deposits in the Black Hills have contained less than 5,000 tons of ore. Recently, however, primary ore deposits of as much as 25,000 tons have been mined.

Mining areas

In the Edgemont mining area about 75 ore deposits have been mined from thick fluviatile sandstones in the Lakota and Fall River formations, and from thin-bedded sandstone in the basal part of the Fall River formation. The sandstones of the Lakota formation, from which the ore has been produced, are the first thick sandstone above the Morrison formation in the western part of the area, and a thick channel sandstone that is present locally just below the base of the Fall River formation. The productive fluviatile sandstone in the Fall River formation is a channel sandstone that occurs in the lower half of the formation. Numerous small deposits have been mined from thin-bedded sandstone at the base of the Fall River formation. The fluviatile sandstones in both formations are channel-like in shape, 1 to 5 miles wide, and at least tens of miles long.

In the Carlile area an ore deposit of more than 5,000 tons (Harder, 1955, p. 4) has been mined from a fluviatile sandstone about 30 feet below the top of the Lakota formation. Part of this deposit was in a landslide block about 200 feet below the main deposit.

In the Hulett Creek area eight ore deposits have been mined from a northwest-trending sandstone lens, or channel type sandstone deposit, about 7,000 feet long and 2,000 feet wide at the top of the Fall River formation (Robinson and Goode, 1957). The deposits occur at the margins or in the base of the sandstone lens and in general are oriented northwest-southeast parallel to the lens. One deposit is on the downthrown side of a fault adjacent to the fault.

In the Elkhorn Creek area three deposits have been mined. Two of the deposits occur near the west end of a large east-west trending sandstone lens, about 2 miles long and 1,500 feet wide, at the top of the Fall River formation. The largest of the two was at the base of the lens at its thickest part. The third deposit is in the base of a northwest-trending sandstone lens, about 2,000 feet long and less than 1,000 feet wide, at the top of the Fall River formation.

Localization of the ore deposits

The locations of the deposits are apparently controlled by several geological and geochemical factors. Of primary importance among these is the movement, in significant volumes, of the mineralizing solutions through the permeable rocks of both the Lakota and Fall River formations. Because of their porosity, permeability, and shape the channel sandstones have evidently been the principal supply lines through which the mineralizing solutions have migrated. The movement of solutions has been further modified by structural irregularities and facies changes.

Formation of ore deposits from the mineralizing solutions is dependent on their movement into a geochemical environment that will cause the precipitation of uranium and vanadium minerals. The nature of the mineralizing solutions and the geochemical environment that causes precipitation of uranium and vanadium minerals is not yet completely understood. It is generally believed, however, that the precipitation of uranium and vanadium accompanies a reduction in the valence of the ions. The metallic ions were probably in a carbonate solution, which is indicated by the spatial relationship of ore deposits and carbonate-cemented sandstone (Gott, 1956, p. 1-8). Many ore deposits appear to have been localized as a result of the reduction of metallic ions by carbonaceous material. Pommer (1957, p. 20-27) has precipitated vanadium minerals experimentally with wood and lignite. Some of the larger deposits, however, contain no carbonaceous material, and it is evident from a study of such deposits that carbon had little or no direct influence on the precipitation of the ore minerals. These deposits, however, contain relatively high concentrations of pyrite and marcasite, and it is probable that either these minerals or hydrogen sulfide derived from them, produced a reducing environment that was responsible for the precipitation of the uranium and vanadium minerals. The unusually high density of ore deposits on structural terraces, adjacent to monoclinal axes, and at the flattening of the dip around small domes or anticlines may also be the result of the accumulation of hydrogen sulfide or other gaseous reducing agents in the structural irregularities.

The important ore minerals carnotite and tyuyamunite are formed as oxidation products of the black uranium and vanadium oxides (Garrels, 1955, p. 1004-1021). During the process of oxidation uranium is probably lost from those ores that do not contain enough vanadium to fix the uranium in stable compounds. If uranium is thus lost from low-vanadium ores, it is possible that new uranium oxide deposits form below the zone of oxidation.

SUMMARY

The mineralizing solutions probably migrated in significant quantities through the principal aquifers. Where suitable geochemical environments were encountered ore deposits were formed. During oxidation uranium may have been remobilized from low-vanadium deposits, carried down-dip below the zone of oxidation, and reprecipitated in the form of uraninite or coffinite. In searching for uranium deposits in the Black Hills, attention should be given to the channel-type sandstone bodies and sandstone lenses in the Lakota and Fall River formations, to facies changes within and at the margins of such sandstone bodies, to minor changes in the structure that would control the migration of solutions within the sandstones or where hydrogen sulfide might accumulate, and to the presence of carbonate-cemented sandstone, carbonaceous material, and pyrite.

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