AN INFERRED RELATIONSHIP BETWEEN SOME URANIUM DEPOSITS AND CALCIUM CARBONATE CEMENT IN THE SOUTHERN BLACK HILLS, SOUTH DAKOTA

By Garland B. Gott

Trace Elements Memorandum Report 1000

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geology and Mineralogy

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Series A

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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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AN INFERRED RELATIONSHIP BETWEEN SOME URANIUM DEPOSITS AND CALCIUM CARBONATE CEMENT IN THE SOUTHERN BLACK HILLS, SOUTH DAKOTA

By Garland B. Gott

ABSTRACT

Evidence resulting from geologic mapping in the southern Black Hills indicates that the areas marginal to some of the larger carbonate-cemented sandstones constitute favorable geochemical environments for the localization of uranium deposits. To determine whether these favorable environments are predictable a limited experimental core-drilling program was carried out. An extensive deposit was discovered in an area marginal to a sandstone well-cemented with calcium carbonate. The deposit has not yet been developed, but from the available data it appears that there is a significant quantity of mineralized rock present containing as much as 3.0 percent eU_3O_8.

INTRODUCTION

The U. S. Geological Survey is currently carrying on geological investigations in the southern Black Hills under the sponsorship of the Division of Raw Materials of the U. S. Atomic Energy Commission. Principal emphasis has been placed on determining the interrelationships among structure, lithology, and geochemical environment which favor the localization of uranium. It is the purpose of this report to set forth preliminary information on: 1) the possible relationships between carbonate cements and uranium deposits, and 2) the possible use of these relationships as a guide for prospecting for concealed deposits in the southern Black Hills. Although any conclusions based on this information must be tentative, the results to date are encouraging and, therefore, may be of interest to those engaged in the search for uranium deposits.

The results reported here are in part based on work by R. W. Schnabel, E. V. Post, Henry Bell, III, and D. A. Brobst.

PLANNING OF EXPLORATION

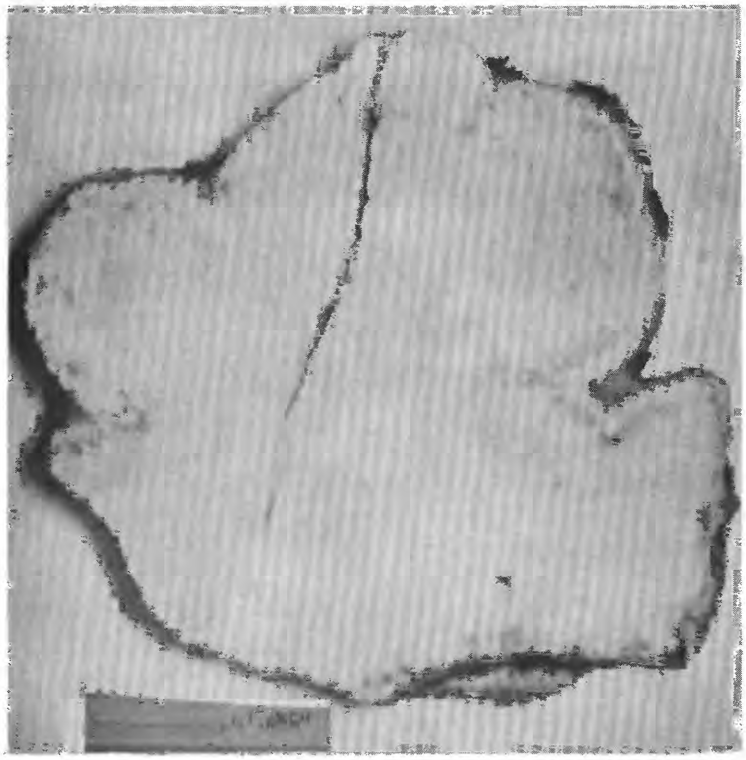
A large proportion of the uranium deposits in the southern Black Hills occurs in the areas of maximum change in chemical and physical characteristics of the sandstones of the Inyan Kara group of early Cretaceous age. The interrelationships between changes of structure, lithology, permeability, and geochemical environment appear to have been influencing or controlling factors in the localization of many of the deposits. As a result of detailed geologic mapping some inconclusive evidence has been found that suggests that one of the favorable geochemical environments is the transitional areas between carbonate-rich and carbonate-poor sandstones.

The inference that uranium is associated with calcium carbonate cements has also been suggested by the pattern of the thermoluminescence of the cements. For a general reference on the techniques used in thermoluminescence studies see Daniels and others (1953). Although much basic work is needed before the significance of this phenomenon can be evaluated, the banded and concretionary-like patterns in the carbonate cements are suggestive. The pattern of thermoluminescence displayed by nodular-shaped masses of sandstone tightly cemented with calcium carbonate is illustrated in figure 1; photograph (a) shows a specimen of tightly carbonate-cemented sandstone, and photograph (b) shows the distribution of thermoluminescence in the same specimen. Although in photograph (a) the distribution of cementation appears uniform, the banded pattern of thermoluminescence, in photograph (b) indicates that the cementation was brought about through various stages of concretionary growth and finally by coalescing of the nodular-shaped masses.

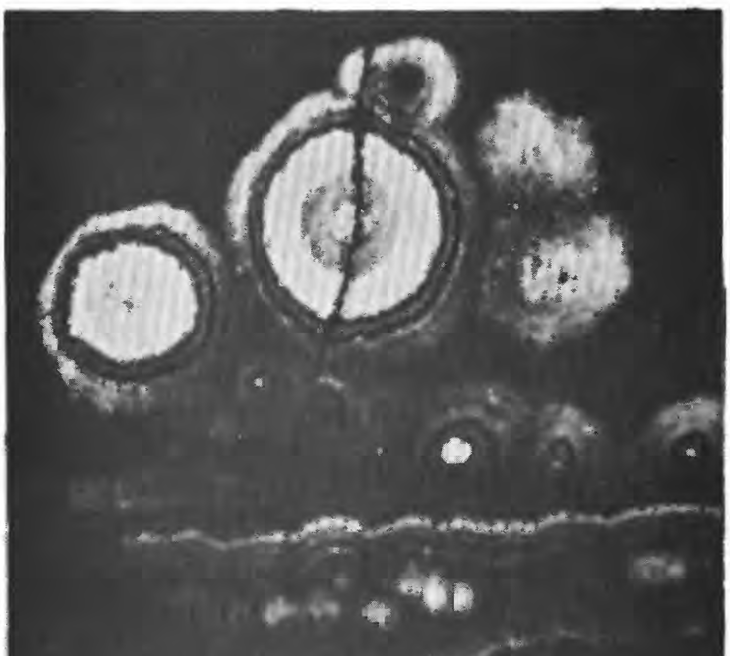
According to Leverenz (1950), thermoluminescence of crystals is proportional to radiation damage. The significance of alternating thermoluminescent and non-thermoluminescent bands, however, seems to be subject to two interpretations. First, if trace amounts of other elements are present in the calcite crystal lattice, the electron banding in the lattice may be so changed as to permit greater radiation damage for a given amount of radiation. Thus, the intensity of thermoluminescence might reflect the distribution of impurities in the calcite.

Alternatively, if the intensity of thermoluminescence is proportional only to the distribution of the radiation source--uranium and/or its decay products--the banded pattern of thermoluminescence shown in figure 1(b) could reasonably be interpreted to mean that the solution depositing the calcium carbonate cement also precipitated variable amounts of uranium and/or its decay products. Thus, calcium carbonate cement that exhibits variable or banded thermoluminescence would suggest that the original solution from which carbonate was precipitated also carried uranium, and further that such thermoluminescent calcium carbonate, whether banded or not, characterizes rocks through which uranium-bearing solutions have moved.

To test the inference that a significant concentration of uranium should be found marginal to a sandstone that is tightly cemented with calcium carbonate, limited exploration by core-drilling was done where detailed geologic mapping showed an area in which carbonate-rich sandstone graded into a carbonate-poor sandstone.



(a)



(b)

Figure 1. Photographs of (a) a specimen of calcium carbonate cemented sandstone, and (b) the thermoluminescence of the same specimen.

A sandstone-filled channel in the Inyan Kara group of rocks had been delineated by detailed surface mapping over a distance of about 25 miles from the southern part of the Flint Hill quadrangle to the southeastern part of the Harney Peak 3 SW quadrangle (fig. 2). Throughout this distance the channel has been scoured as much as 100 feet through or into a sequence of variegated impervious mudstones. The sandstone is fine- to coarse-grained, normally non-carbonaceous, poorly sorted, of extremely variable texture, and is cross-stratified. The normal type of cross-stratification consists of tabular sets of very thinly bedded cross-strata from a few inches to two or three feet thick separated by one- to two-inch thick horizontal strata. The cross-strata generally dip to the northwest. Along most of the length of this channel evidence has been found that indicates that the deepest scour was completely filled and that the stream-borne material was then spread out over a relatively wide plain, in some places several miles wide.

As shown on figure 2 the channel sandstone is in places cemented with calcium carbonate, the most extensive cementation being in the southwestern part of the Edgemont NE quadrangle (fig. 3). Because of the extent of the carbonate, this area was selected for the experimental drilling. The sandstone is well cemented where exposed in the northwestern part of this area in secs. 26, 27, and 35, T. 7 S., R. 2 E., but for a distance of $3\frac{1}{2}$ miles to the southeast it is buried beneath younger rocks. Where the sandstone is again exposed in sec. 8, T. 8 S., R. 3 E., it is relatively free of carbonate cement. The immediate objective of the core-drilling, therefore, was to determine the limits of the abundant carbonate cement and the inferred presence of uranium marginal to the abundant carbonate.

RESULTS OF EXPLORATION

As a result of the limited exploration within this area, the buried portion of the channel and the extent of the carbonate-rich part of the sandstone were approximately delineated (fig. 3). Within the buried portion of the channel the sandstone was found to be carbonate-free or carbonate-poor through sec. 1, T. 8 S., R. 2 E. Drill holes GS-5, GS-16, and GS-17 penetrated the channel sandstone in the carbonate-poor segment. Of these holes GS-16 penetrated ore-grade uranium in the top part of the channel sandstone and GS-5 and GS-17 were barren. GS-10 evidently penetrated the channel sandstone near the southeast margin of the carbonate-poor segment and showed low-grade uranium of similar mineralogy to that found in GS-16. GS-11, GS-13, and GS-14 farther to the east penetrated heavy carbonate cementation and were barren. GS-18 penetrated only an insignificant amount of carbonate cement and was also barren of ore-grade material although very sparsely disseminated black uranium minerals were found in the core. The results of the drilling are summarized in Table 1.

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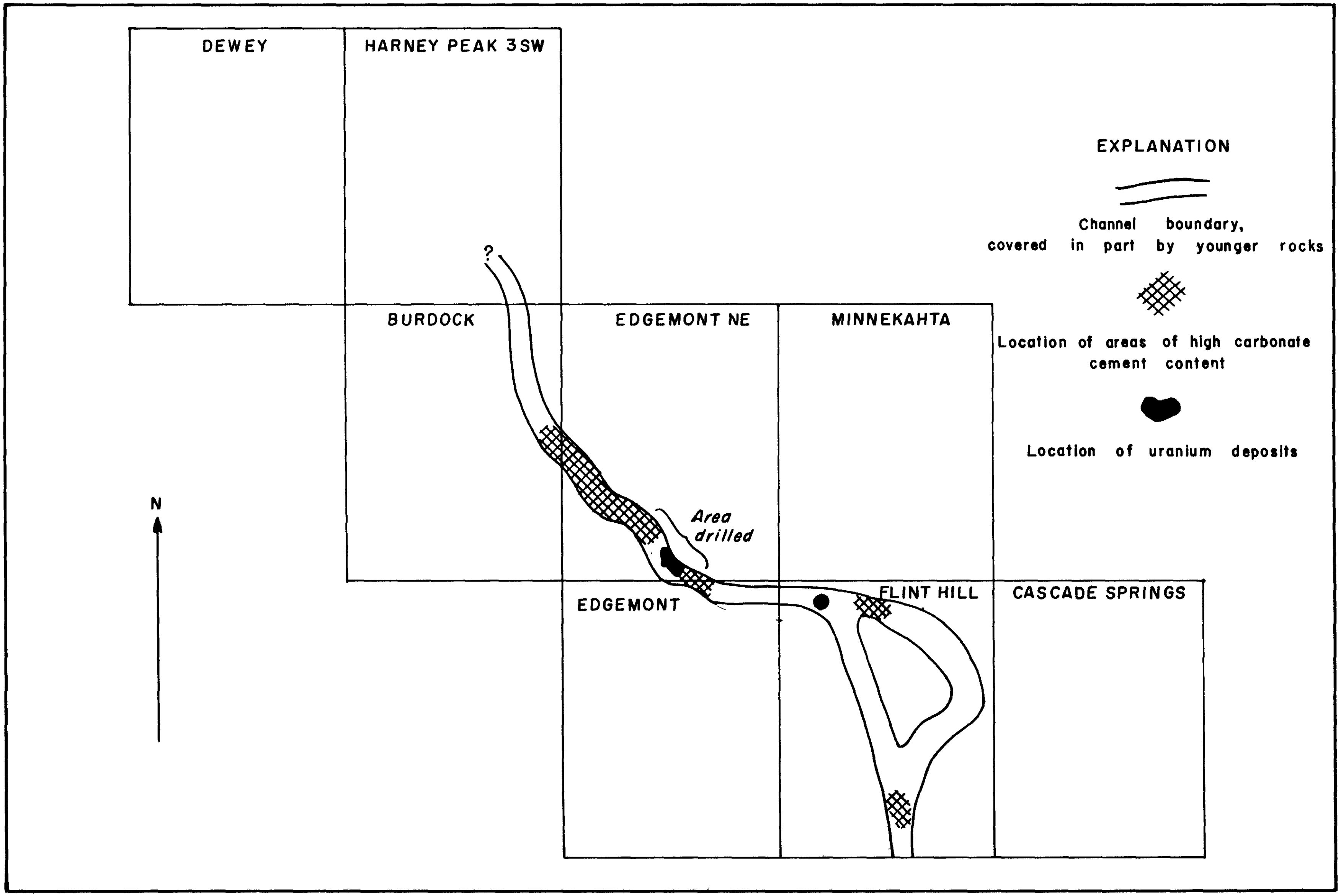

FIGURE 2—MAP SHOWING DISTRIBUTION OF CARBONATE CEMENT AND URANIUM DEPOSITS IN CHANNEL SANDSTONE, FALL RIVER CO., S. DAKOTA

0 5 10 Miles

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Table 1.--GAMMA-RAY LOG INTERPRETATION

Hole No.	Depth Drilled (feet)	Depth Logged From - To (feet below surface)	Anomaly Detected From - To (feet below surface)	Anomaly Thickness (feet)	Counts per minute	Grade % eU_3O_8
GS-2	--	11.0 - 75.0	Barren			
GS-4	--	11.0 - 157.3	Barren			
GS-5	--	10.0 - 246.1	Barren			
GS-6	--	10.1 - 180.0	Barren			
GS-10	--	8.4 - 141.3	118.3 - 121.5	3.2	300	<0.005
			124.5 - 125.2	0.7	300	<0.010
			128.1 - 129.0	0.9	200	<0.005
			129.0 - 133.3	4.3	1,300	0.026
GS-15	--	10.4 - 183.0	Barren			
GS-16	201.0	9.4 - 196.5	110.0 - 111.0	1.0	1,600	0.040
			114.6 - 115.4	0.8	800	0.029
			116.0 - 117.5	1.5	2,400	0.058
			117.5 - 120.7	3.2	540	0.011
			120.7 - 121.9	1.2	1,300	0.030
			123.3 - 124.3	1.0	7,900	0.35
			124.3 - 125.5	1.2	1,000	0.023
			125.5 - 128.2	2.7	300	<0.010
			169.1 - 170.4	1.3	800	0.022
GS-17	--	11.0 - 130.0	Barren			

Note: No casing used.

Polished thin sections of the mineralized core from GS-16 contain fine-grained uraninite in aggregates 1 to 2 mm in length associated with pyrite, iron oxides, calcite, and clay minerals. The aggregates of uraninite are concentrated around pods of green pyritic clay in a quartzose sandstone. The pyrite near the margins of the pods is euhedral in contrast to the more massive grains within. The relations of the minerals suggest that the pods of pyritic clay were formed in place before the uraninite. The occurrence of massive and euhedral pyrite suggests two generations of pyrite, the euhedral type originating perhaps at the time of deposition of the uraninite. The relative ages of the pyrite and calcite are not clear. The iron oxides were deposited after the pyrite. The close association of all of these minerals interstitial to the quartz suggests that they are essentially contemporaneous.

In addition to the minerals listed above, black prismatic crystals of a uranium mineral were found in rotary cuttings from a privately drilled hole located near GS-16. The crystals are less than 1 mm in length and yield a positive reaction in the flux test for uranium. Under the microscope, the crystals are dark red and have high birefringence, an index of refraction greater than 1.80, parallel extinction, and are combustible. The crystals also are insoluble in acid. The X-ray diffraction pattern is not similar to the well known dark uranium minerals. Quantitative spectrographic analyses show that the material contains 3 percent uranium and 44 percent vanadium. In view of the combustibility of this mineral it is most probably one of the organo-metallic compounds.

After completion of government exploration, private drilling in the vicinity of core hole GS-16 (fig. 3) extended the deposit found by the Geological Survey, and discovered two additional deposits, one of which contains a significant amount of mineralized rock with as much as 3.0 percent eU_3O_8.

CONCLUSIONS

A possible relationship between the relative abundance of calcium carbonate as a cementing material and the concentration of uranium seems to have been confirmed by the results of limited exploration. As inferred, uranium is concentrated in carbonate-poor sandstone marginal to sandstone tightly cemented by calcium carbonate.

If this relationship has a general validity, it should be possible to locate similar deposits by selecting areas for prospecting where poorly cemented and friable sandstone grades into hard, tightly cemented calcareous sandstone.

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