THE GEOLOGICAL SURVEY OF WYOMING
HORACE D. THOMAS, State Geologist

REPORT OF INVESTIGATIONS NO. 4

RADIOACTIVE FOSSIL BONES IN TETON COUNTY, WYOMING

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Kenneth G. Smith and Daniel A. Bradley

UNIVERSITY OF WYOMING
LARAMIE, WYOMING
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BY

KENNETH G. SMITH [1] AND DANIEL A. BRADLEY [2]

INTRODUCTION

Dinosaur bones are commonly found in the Upper Jurassic and Lower Cretaceous non-marine sediments of Wyoming, and in places entire skeletons have been uncovered. The specimens described in this paper were collected in Teton County, Wyoming, during the summer of 1950.

Dinosaur bone fragments occurring as float have been found in the vicinity of Lower Slide Lake, approximately fourteen miles northeast of

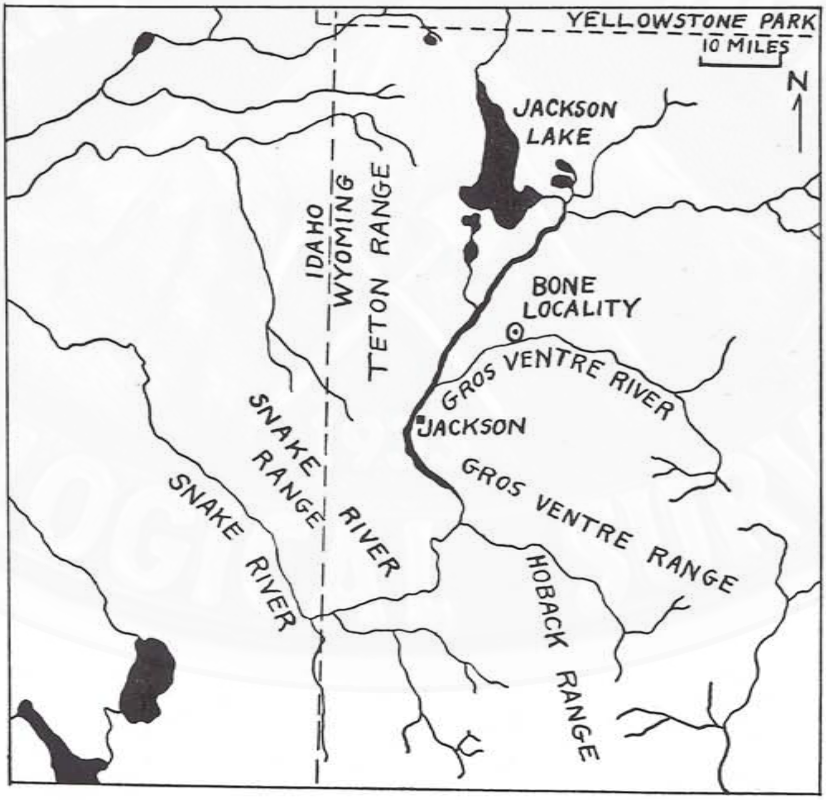

FIG. I. INDEX MAP OF THE JACKSON HOLE REGION, NORTHWESTERN WYOMING

1. Continental Oil Company, Durango, Colorado; 2. Assistant Professor of Geology, University of Missouri.

the town of Jackson (Fig. 1). They are most common near the top of a southward-facing cliff along the north side of the lake, across the valley and east of the well-known Kelly Slide. Rounded highly-polished pebbles usually identified as gastroliths, may also be found in this area. The bed from which the bone fragments and gastroliths were derived is believed to be either Upper Jurassic or Lower Cretaceous in age.

Bone specimens collected in this area were tested with a Detectron Geiger counter and were found to be radioactive. Additional field exploration led to the discovery of the bone-bearing layers, which are approximately 600 feet above the level of Lower Slide Lake.

The writers are indebted to Professors E. N. Goddard and F. S. Turneaure, of the Department of Geology, and to Professor E. Wm. Heinrich, of the Department of Mineralogy, University of Michigan, for their suggestions and constructive criticism. Professor Claude Hibbard, of the Museum of Paleontology, University of Michigan, gave valuable aid in the study and description of the fossil bones. Thanks are also due to Professor Robert M. Garrels, of Northwestern University, for his encouragement and participation in the field study.

STRUCTURAL GEOLOGY AND STRATIGRAPHY

Structurally the Gros Ventre Range is a broad asymmetrical anticline trending northwest, with a steep and locally faulted southwest limb and a broad, gently dipping northeast limb (Horberg, Nelson and Church, 1949). The bone-bearing stratum is on the northeastern flank of the anticline and trends parallel with the regional structure, striking N 73° W and dipping 20° NE.

The general area is underlain by formations of Pennsylvanian through Cretaceous age, which occur in almost a continuous section. The detailed regional stratigraphy was described by Helen Foster (1947). Although her sections do not indicate the presence of the Morrison formation, she notes that the upper portion of what is described as the Jurassic Stump formation may be in part Morrison. The upper part of the Stump, as described by Foster, consists of 192 feet of alternating beds of sandstones, shaly sandstones and shales of various colors; black, greenish black, gray and greenish gray.

The area in which the bones occur has recently been mapped by Love and others (1952). They point out that Foster included 250 feet of beds at the top of the Stump which they include at the base of a unit designated as "Morrison (?) and Cloverly formations, undivided," pointing out that they found no reliable basis for separating the two formations.

Although Love *et al.* have discussed the difficulties encountered in drawing a boundary between the Upper Jurassic rocks and the Lower Cretaceous rocks in this general region (1945), the writers believe that the bone-bearing conglomerate lies in strata which may be referred questionably to the Morrison formation, below beds which normally would be classed as Cloverly.

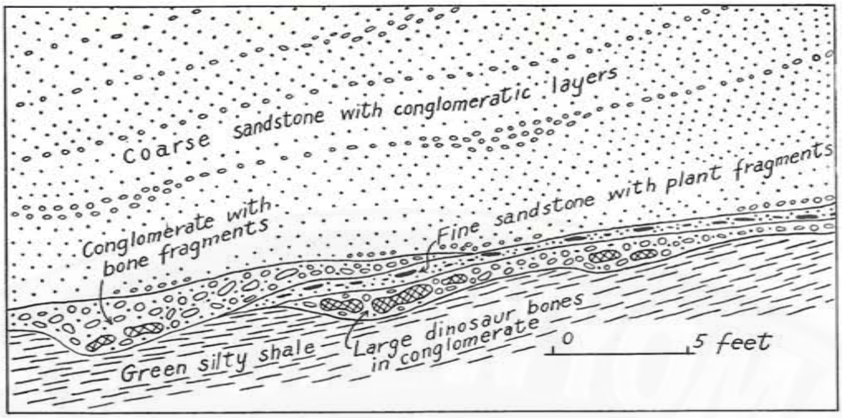

FIG. 2. FIELD SKETCH OF BONE-BEARING CONGLOMERATE ON FACE OF CLIFF; LOOKING NORTHWEST

OCCURRENCE

The bone-bearing bed is exposed for approximately thirty feet. It averages two feet in thickness and is lenticular in shape, resembling the cross-section of a buried river channel. Figure 2 is a sketch of the exposure.

The bone-bearing conglomerate is associated with alternating beds of greenish gray silty sandstones and shales. The sandstones are poorly sorted and are cemented with calcareous material. Parts of the sandstones are conglomeratic in nature, containing larger quartz and black chert pebbles. A few layers are rich in fragments of black, lustrous plant material. The general nature of the formation suggests deposition by a shifting stream that flowed across a swampy lowland area.

Bone fragments, varying in size from ¼ inch to 1½ inch in diameter, make up a large part of the conglomerate. Near the middle of the outcrop larger fragments were obtained, as much as 18 inches in length and 4 to 5 inches in diameter, with some of even greater size remaining in place. Fig. 3 shows a typical specimen of the bone conglomerate. The material appears to have been deposited in the buried stream channel, the course of which may be traced down the regional dip to the northeast.

Most of the bone fragments present in the conglomerate are angular, suggesting that the material was not transported any great distance by running water. A few rounded bone pebbles were also found and these probably represent pieces that were redeposited from an area of earlier fossilization. The skeleton was apparently disrupted only to the extent of fragmenting the bones and scattering them within the localized area. As a result of this scattering effect, it is not possible to identify the original animal. Professor Claude Hibbard identified the fragments as dinosaur bones, based on the large size of some of the pieces and the environment of deposition.

FIG. 3. LARGE SPECIMEN OF BONE-BEARING CONGLOMERATE
(Scale in inches.)

The lithologic setting of the bone deposit resembles the uranium-bearing sandstones in the Morrison formation of the Colorado Plateau, as described by Fischer (1950). The Colorado Plateau deposits are lenticular bodies of sandstone interbedded with mudstone. Carnotite, the principal uranium mineral, is disseminated in the sandstone and replaces fossil plant material. Fischer believes that the deposits were formed in channels and on flood plains of streams that meandered across a surface of low relief and grade.

DESCRIPTION OF FOSSIL BONES

The bone fragments consist of a dense black outer layer, which is dusky blue on weathered surfaces, and an olive gray central porous part. Organic structure is well preserved in the central porous section, which is commonly stained with limonite. If limonite staining is not present, small, clear calcite crystals may be seen in the core. Five typical bone fragments are shown in Fig. 4. The contact between the dense outer bone and the lighter colored, porous inner bone is readily apparent on specimen number 3 of the photograph.

Thin sections of bone were examined under the polarizing microscope. The original dense bone material has been replaced by amorphous collophane. The Haversian canals are partly filled with crystalline

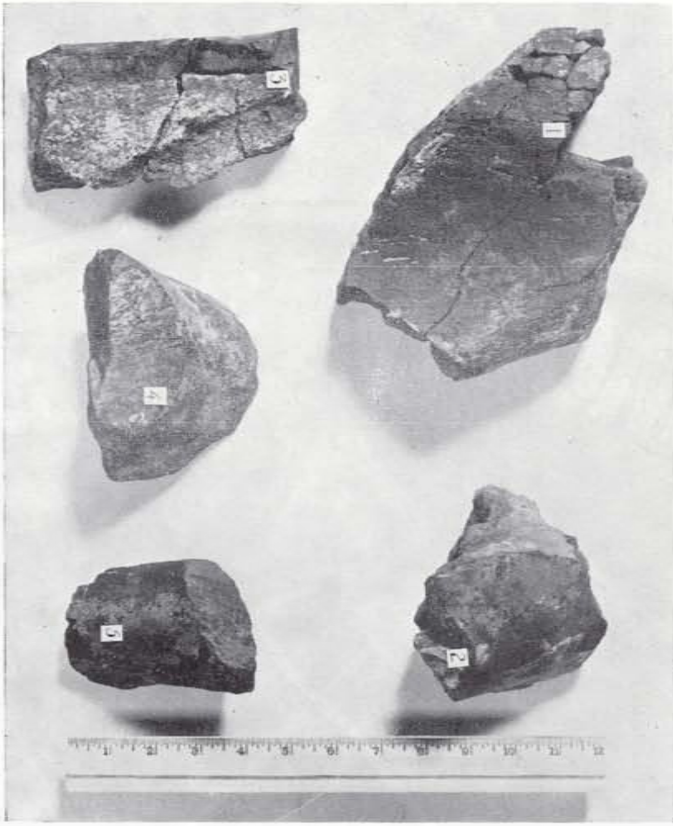

FIG. 4. TYPICAL BONE FRAGMENTS FROM THE DEPOSIT
(Scale in inches.)

calcite. The trabeculae of the porous bone have been replaced by collophane having a fibrous and pseudospherulitic structure, similar to that described by Rogers (1924). The cavities of the inner porous bone are filled either with larger calcite crystals or a paste of very fine-grained calcite.

The contact between the dense bone and the porous bone is well illustrated in a photomicrograph of a thin section cut transverse to the bone structure (Fig. 5). The contact crosses the center of the photograph horizontally and the dense bone material lies in the upper half of the illustration. The gray spherulitic areas are collophane and the white areas are calcite. Pyrite, which appears black in the photograph, fills two main fractures but can also be observed in some of the cavities formerly occupied by bone cells. Pyrite was probably introduced after fossilization of the bone had been completed.

The contact between the two types of bone can also be recognized in the longitudinal thin section shown in Fig. 6. The black areas in the

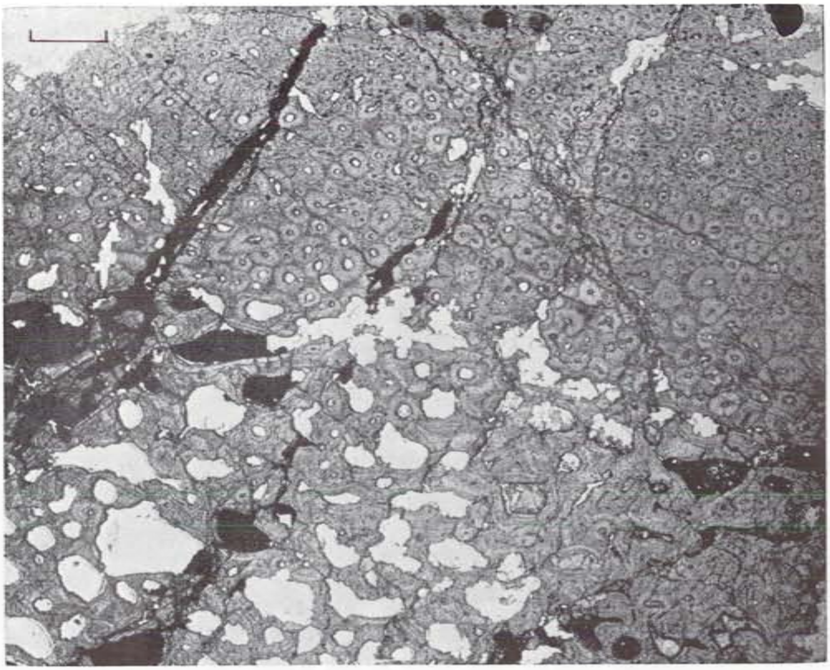

FIG. 5. PHOTOMICROGRAPH OF TRANSVERSE THIN SECTION OF BONE SPECIMEN SHOWING CONTACT BETWEEN DENSE OUTER BONE AND POROUS INNER BONE
(Scale in upper left-hand corner represents one millimeter.)

lower half of the photomicrograph are cavities of the porous bone which have been filled with a fine-grained calcite paste. The white angular particles in some of the cavities are clastic mineral grains. Evidently there were continuous channels available through which the clastic material moved into the bone. Minerals identified among the clastic grains are quartz, plagioclase feldspar, orthoclase, microcline, muscovite, amphibole, and zircon.

The Haversian canals of the bone served as circulatory pathways for blood. After death and subsequent burial these pathways were evidently utilized for the circulation of mineralizing solutions. During fossilization the sequence of changes is believed to have occurred in the following order:

1) Solutions effected a collophane fossilization.
2) A very fine-grained calcite paste flowed into the cavities of the porous bone and hardened, forming crystalline calcite locally.
3) A stream of clastic fragments penetrated the open and available cavities and a few transverse fractures, filling them with an arkosic mixture.
4) Iron sulphide bearing solutions were introduced into the fossil bone, replacing some of the calcite in the main cavities with

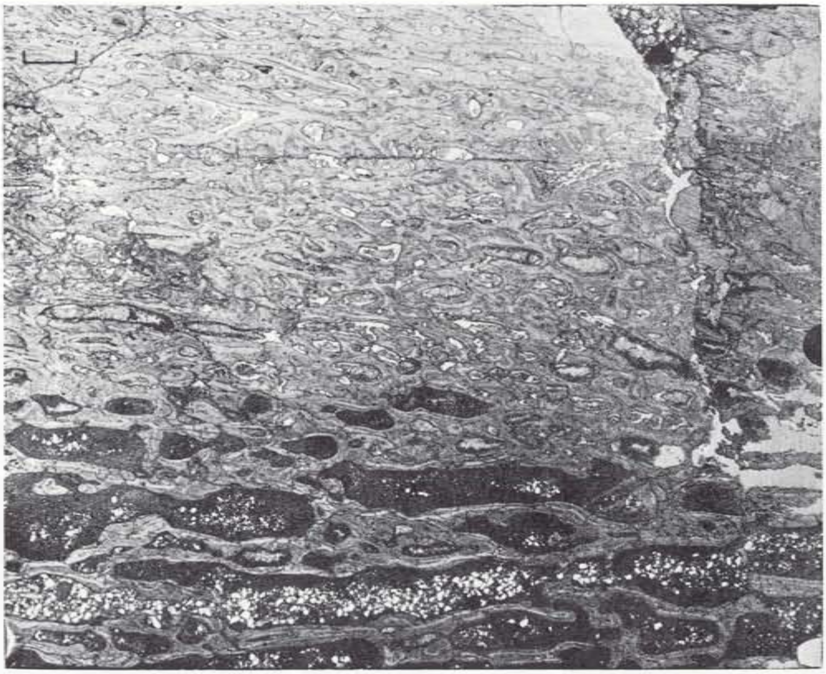

FIG. 6. PHOTOMICROGRAPH OF LONGITUDINAL THIN SECTION OF BONE SHOWING PRESENCE OF CLASTIC FRAGMENTS IN THE LARGER CAVITIES
(Scale in upper left-hand corner represents one millimeter.)

pyrite. There was some expansion of pyrite-filled chambers with delicate extensions of pyrite into minute radial and concentric fractures.

RADIOACTIVITY AND URANIUM CONTENT

Bone fragments were first tested for radioactivity in August, 1950. The average background count on the day the bones were examined was 48 radiations per minute. Nine bone fragments showed radiation counts ranging from 129 to 314 per minute. Six specimens of associated sedimentary rocks averaged 60 radiations per minute. The result of tests are given in Table I.

The five bone fragments shown in Fig. 4 were also tested with the Detectron Geiger counter. The average background count was 45 radiations per minute. Results are given below:

Specimen Number	Radiation Count
1	360
2	312
3	390
4	312
5	324

The bone from which thin sections were made had an average radiation count of 234 per minute as opposed to a background count of 43 radiations per minute.

The fifteen specimens examined were submitted to the Geochemical Branch of the United States Geological Survey for analysis,, where it was determined that all specimens contained small amounts of uranium, with a larger concentration in the fossil bones. The geochemical results correlate with the radioactive counts recorded for the bone fragments. Both tests show the bones to be considerably more radioactive than the associated sediments.

A tabulation of the uranium content (Table I) permits a comparison to be made of the values for the bone fragments and the values for the sediments in which they are found. The percentage of uranium in each specimen, with possibly two or three exceptions, correlates rather well with the approximate radioactive counts, a fact which may be useful as an aid for further field investigations in this area.

TABLE I

Uranium content of samples; from analysis by the Geochemical Branch, United States Geological Survey.

Sample number	Description	Radiation Count	%U
1	Medium-grained quartz sandstone with a carbonate cement; green clay nodules and chert; also woody black fragments.	67	.005
2	Mineralized fossil bone material with a small amount of carbonate and some Fe stains.	194	.135 .11
3	Fossil bone material with Fe stains.	247	.12
4	Fossil bone material.	314	.095
5	Fine-grained sandstone with a few chert nodules and Fe stains; carbonate cement.	70	.005
6	Fossil bone material.	208	.12
7	Fossil bone material.	235	.085 .080
8	Fossil bone material.	213	.12
9	Fossil bone material.	241	.12 .12
10	Fossil bone material.	129	.040
11	Fossil bone material with quartz and Fe stains.	234	.12
12	Cherty conglomerate with carbonate cement and some black, woody material, also clay and Fe stains. Red and green chert pebbles visible.	63	.002
13	Fine-grained, well sorted quartz sandstone with carbonate cement. Some black, lustrous plant material with replaced veinlet of calcite on surface.	48	.001
14	Fine-grained quartz sandstone with Fe stains and clay carbonate cement.	52	.001
15	Very fine-grained quartz sandstone with green clay and carbonate cement.	60	.001

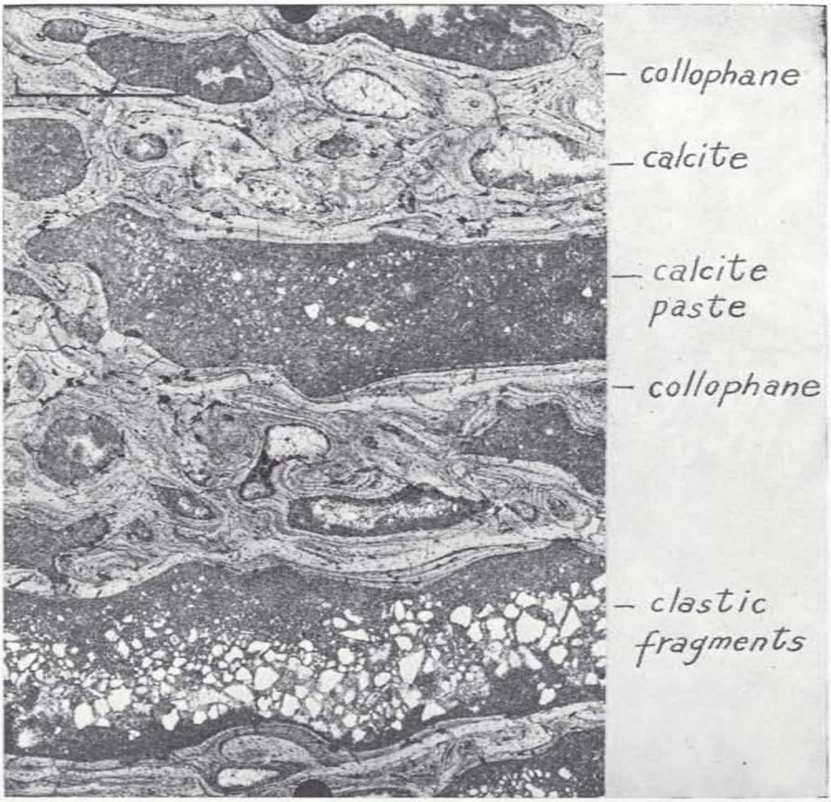

FIG. 7. ENLARGED PHOTOMICROGRAPH OF LONGITUDINAL THIN SECTION SHOWING AREAS OF CALCITE AND COLLOPHANE MINERALIZATION
(Scale in upper left-hand corner represents one millimeter.)

No uranium minerals could be identified with the microscope due to the very small amounts present in the bone as compared with the balance of the mineral matter contained. The uranium-bearing substance is evidently distributed throughout the organic bone material, probably associated with the collophane. Bain (1950, p. 280) states that the diversion of uranium into some secondary deposits may have resulted from a depression of the hydrogen ion concentration in the mineralizing solution due to an oxygen deficiency in the presence of hydrocarbons, thus causing precipitation of the uranium minerals. This explanation may account for the higher uranium concentration found in the dinosaur bone fragments. Fischer (1950) reports that fossil plant material is richly mineralized in places in the Colorado Plateau uranium deposits, and fossil wood is commonly replaced by carnotite.

CONCLUSIONS

It is suggested by the authors that the uranium was precipitated from ground water solutions percolating through the old river channel at the time of fossilization of the bone fragments. Bone material was partially converted to collophane, which served as a possible host to uranium. Fisher (1950) concludes that the ore minerals of the Colorado Plateau uranium deposits were deposited from percolating ground waters shortly after deposition of the river sands. Similar conditions may have existed in this section of Wyoming in later Jurassic time, but the source of uranium is unknown.

Further conclusions concerning the origin and extent of the uranium-bearing beds described cannot be drawn until additional field investigations are carried on in the area. The presence of uranium may be merely a local phenomenon, or there may be several such occurrences in the vicinity of Lower Slide Lake. Other uranium-bearing deposits might be found by tracing the Morrison (?) formation along strike, or deposits might be found at other horizons. All regional structures should be examined for possible Morrison (?) outcrop areas. Furthermore, as the Morrison (?) formation crops out extensively throughout western Wyoming, every extensive outcrop might be worth investigating for the possible occurence of buried river channels and radioactive dinosaur bones.

The authors feel that further exploration in the Slide Lake area may lead to the discovery of sandstone or conglomerate layers in which the uranium has been concentrated in greater quantity.

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