

BIJOU FORMATION — A STREAM DEPOSIT?

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ABSTRACT

Bijou quartzite or quartzitic sandstone is present irregularly at several stratigraphic positions within the lower Ogallala Valentine and Ash Hollow formations. Although the original sediments are of Early Pliocene age, the cementing occurred probably during Late Pliocene time.

The line of quartzite-capped buttes in southern South Dakota, which extends from Wood eastward to the Bijou Hills, is not the result of channel-filling of a pre-Ogallala stream; rather, it represents the south escarpment of the valley of the post-Ogallala White River, cut into the Ogallala sediments that contain zones of Bijou quartzite facies.

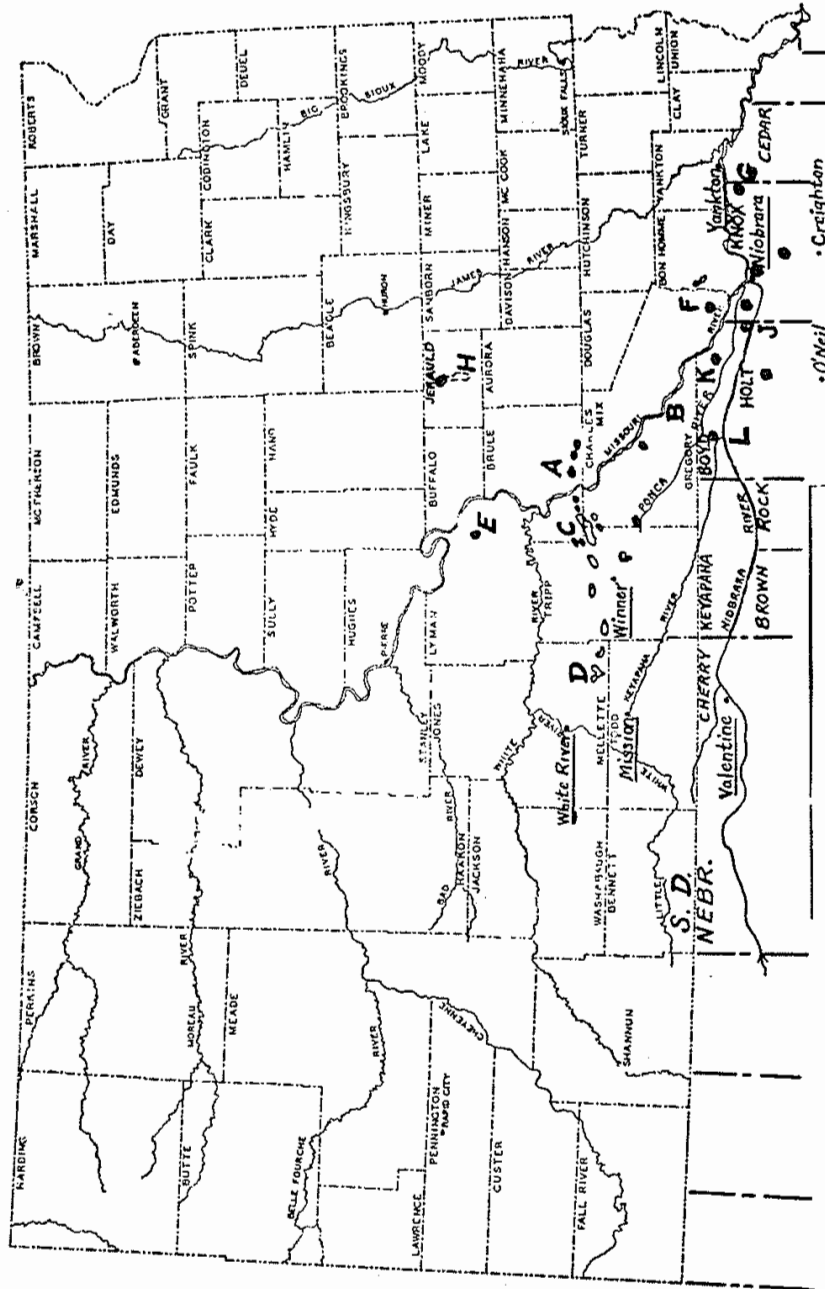
INTRODUCTION

The Bijou formation was named by Stevenson (1) from exposures in the Bijou Hills along the east side of the Missouri River, in southern Brule County, S. D. (Fig. 1, loc. A). He described a "typical section" from an exposure 35 miles to the southeast (Fig. 1, loc. B), where the formation consists of a 38-54 foot thick series of greenish and gray fine sand, silt, and clay, capped by a greenish quartzitic conglomerate (1, Fig. 1). He noted that the formation rests unconformably (with a basal conglomerate) on the Pierre dark-gray bentonitic shale, and that it is overlain unconformably in Gregory County, South Dakota, by Herrick gravels, from which however it can be distinguished lithologically only with difficulty (presumably where the capping quartzite of the Bijou formation is absent). Vertebrate fossils indicate a Barstovian-Clarendonian (Late Miocene-Early Pliocene) age for the deposit. Stevenson noted that the Bijou formation is exposed on Bijou and Iona Hills (Fig. 1, locs. A and C), on the divide between Ponca Creek and the Missouri River in Gregory County, and in several small areas near Lake Andes and Pickstown in Charles Mix County. (20 miles east of locality B., Fig. 1).

Recent geologic mapping by Agnew in Mellette and Todd Counties, by Stevenson in Gregory County, and joint field reconnaissance by both in the intervening area has caused Stevenson (2) to modify and restrict the term Bijou formation to the greenish siliceous "quartzite" at the top of his original type section. Because the Bijou formation is resistant, it forms ledges and cap rocks; it is thus not only a lithologically distinct unit, but also is topographically distinctive.

AREAL EXTENT

One hundred years ago Hayden (3) examined the green "quartzite" outcrop in the Bijou Hills.



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SCALE

Figure 1. Exposures of Bijou Quartzite Included in Present Paper

Todd (4), in attempting to explain the westward limits of Pleistocene glaciation, observed that between the mouth of the White River and the mouth of the Niobrara there is no evidence of glacial drift more than 3-4 miles west of the Missouri River. "A prominent reason . . . is . . . that a high table land, more or less capped with this same 'green quartzite,' abuts upon the river through most of this distance." Todd then listed the localities where he had observed this "green quartzite," as follows:

Bijou Hills—A caprock 12-15 feet thick (Fig. 1, loc. A).

West of the Missouri River—caps similar buttes, including Medicine Butte (Fig. 1, loc. E), where 40 feet below the cap is "another thinner but similar" ledge—it is fine grained sand that is locally cross-bedded, irregularly thin-bedded, and mostly quartzitic; locally contains worn pebbles; weathers white, like mortar.

Eastern outliers:

Butte 8 miles east of Greenwood, Yankton Reservation (Fig. 1, loc. F).

Two miles southeast of Niobrara, Nebraska.

Butte in Nebraska 5-6 miles southwest of Yankton (Fig. 1, loc. G).

Quarry near Jackson's, midway between Niobrara and Creighton.

Todd noted that a sandstone resembling this quartzite is found about 100 feet below the top of the hills at Wessington Springs, South Dakota (Fig. 1, loc. H). Barometric altitudes given by Todd show a "considerable dip to the east." Todd mentioned that he had not found fossils "sufficient to identify the formation," but from stratigraphic relations there was little reason for him to doubt that it is late Tertiary. He noted that Hayden (5, p. 78) referred the strata in the Bijou Hills to the Miocene-Pliocene Loup River (Loup Fork) beds, now termed Ogallala and Arikaree (below).

Later, Todd (6, p. 124-5) again mapped the "hard splintery greenish quartzite" or "hard flinty sandstone" in the several localities. Darton (7) added that the non-quartzitic sandstone deposits on the high ridge just west of Wessington Springs are "probably of the same age as the quartzite on the Bijou Hills [as they show] the same general structure, even carrying some beds of grit between the finer layers."

In Nebraska, Hicks (8) had reported large angular boulders of quartzite on hills "along the road from Niobrara to O'Neil," which he said agree closely in lithology with boulders of "a Tertiary quartzite seen at Valentine, Nebraska." Hicks had traced the Valentine quartzite boulders to a "thick stratum *in situ* on the Minnechaduzza River, near Valentine."

In recent years the Bijou quartzite has been mapped in Brule, Charles Mix, and Gregory Counties, South Dakota by the State Geological Survey. Similarly, the quartzite has been mapped in Holt and Boyd Counties, Nebraska (9). Quartzite was mapped in South Dakota in 1956 by the writer (Fig. 1, loc. D) as far west as Wood. Thus the quartzite occurs throughout an east-west extent of at least 150 miles.

Quartzites of the Bijou type and at its stratigraphic position have been

described from the south-central Nebraska - north-central Kansas area, 175 miles to the south (10).

LITHOLOGY

The Bijou is a quartzitic facies of Pliocene Ogallala beds near the Missouri River and westward to the longitude of Valentine, Nebraska. The quartzite may occur at one or more stratigraphic positions within the lower Ogallala Valentine and Ash Hollow formations (9, 2). For example, in the southeastern corner of Boyd County, Nebraska (Fig. 1, loc. J), residual boulders of the quartzite rest directly on the Pierre shale; 15 miles to the northwest (Fig. 1, loc. K) 5 feet of quartzite is present 55 feet above the base of the Valentine formation; in western Boyd County, however, (Fig. 1, loc. L) only $\frac{1}{2}$ -1 foot of quartzite is present, and there it rests directly on the Pierre shale.

ORIGIN

The areal distribution of the exposures of Bijou quartzite in South Dakota shows a pattern like that of stream drainage. Flint (11, p. 25-6) suggests that this represents the filling of an eastward-trending, pre-Ogallala valley. The regional stratigraphy of the exposures of the quartzite suggests, rather, that the quartzite is a facies of lower Ogallala deposits and thus Flint's suggestion cannot be accepted. If we wish to retain the stream origin, however, the silica cement may presumably have been introduced by streams flowing across the Pliocene Ogallala beds, cementing by underflow the previously unconsolidated sands and silts.

On the other hand, the distribution of exposures of the quartzite in northern Nebraska does not bear out this hypothesis of stream origin. Furthermore, the more-extensive deposits along the Nebraska-Kansas border likewise do not corroborate this hypothesis. Rather, Frye and Swineford (10, p. 56-60) conclude that, during the deposition of Ogallala sediments the regional water table must have stood relatively near the surface. Volcanic ash was deposited during later stages of the Ogallala, and shortly after the accumulation of the ash, hydration and leaching below the water table caused the precipitation of silica as opaline cement; the green color is due to ferrous iron (thus below the water table), which is readily adsorbed by silica gel.

The quartzite occurs only in the lower part of the Ogallala both in the South Dakota-Nebraska area and in the Nebraska-Kansas area (upper Ogallala formations are not present in the South Dakota-Nebraska area). Furthermore, in a Kansas locality unsilicified limestone rests on quartzite; this suggests that the silicification occurred before the end of Ogallala deposition, although it is admitted as a possibility that moving, silica-bearing, post-Ogallala ground waters may have cemented selectively the more permeable zones of the Ogallala.

But back to the apparent stream pattern of the quartzite in South Dakota (Fig. 1). The string of quartzite-capped buttes lies parallel with the White River and about 20 miles south of it. The course of the Missouri River

was determined by a late stage of Pleistocene ice advance, after Pliocene Ogallala time. Thus, although the present mouth of the White River is at the Missouri River, in late Pliocene and early Pleistocene time the White River continued eastward beyond the present James River (11, p. 7). Therefore the Bijou Hills probably represent the eastward extension of this south escarpment of the White River Valley during late Pliocene or early Pleistocene time. The quartzite at Medicine Butte (Fig. 1, loc. E) represents an outlier or remnant of its former wide extent.

CONCLUSION

The Bijou quartzite is a widespread silica-cemented facies of lower Ogallala sediments, which originated by ground water action during late Ogallala (Pliocene) time. The eastward-trending line of quartzite-capped buttes in southern South Dakota south of the White River represents the south escarpment of the post-Ogallala, preglacial White River Valley that was cut in Ogallala sediments, and is not the result of channel-filling of a pre-Ogallala valley in that position by Ogallala sediments.

BIBLIOGRAPHY

1. Stevenson R. E., The Bijou Formation in South-central South Dakota, Proc. S. D. Acad. Sci., **32**, 86-90 (1953).
2. Stevenson, R. E., Revision and Interpretation of the Bijou Formation, Proc. S. D. Acad. Sci., **37**, 34-38 (1957).
3. Hayden, F. V., Geologic Structure of the Country Bordering on the Missouri River from the Mouth of the Platte River to Ft. Benton in latitude 47°30'N, longitude 110°30'W, Acad. Nat. Sci. Phila. Proc. **1857**, 109-16 (1857).
4. Todd, J. E., Further Notes on "A Green Quartzite from Nebraska," Am. Geol., **3**, No. 1, 59-60 (1889).
5. Hayden, F. V., Catalogue of the collections, in Warren, G. K., Preliminary account of explorations in Nebraska and Dakota in the years 1855-56-57: U. S. War Dept., An. Rept. 1858 (U. S. 35th Cong., 2d Sess., H. Ex. Doc. 2), p. 673-705, 1859; Reprint, p. 59-125 (1875).
6. Todd, J. E., The Exploration of the White River Bad Lands, in 1896, S. Dak. Geol. Survey Bull. **2**, 117-35 (1898).
7. Darton, N. H., Geology and Underground Waters of South Dakota: U. S. Geol. Survey, Water Supply Paper **227**, 58 (1909).
8. Hicks, L. E. (Quartzite Boulders in Nebraska), Am. Geol., v. **2**, No. 5, 351-2 (1888).
9. Mendenhall, G. V., "The Bedrock Geology of Boyd and Northern Holt Counties, Nebraska," Unpubl. M. S. Thesis, Univ. Nebraska, 107 p., 15 figs., 1 pl. (1953).
10. Frye, J. C., and Swineford, Ada, Silicified Rock in the Ogallala formation: Kansas Geological Survey Bull. **64**, (pt. 2), 33-76 (1946).
11. Flint, R. F., Pleistocene Geology of Eastern South Dakota, U. S. Geol. Survey Prof. Paper **262**, 168 p., 7 pls., 36 figs. (1955).