

## FRONTIER-NIOBRARA CONTACT IN LARAMIE BASIN, WYOMING<sup>1</sup>

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### ABSTRACT

The Upper Cretaceous shale which has been called Carlile in the Laramie Basin, Wyoming, overlies the Frontier formation and is, in turn, overlain by the chalky beds of the Niobrara. The fauna of the upper part of the Frontier is of the same age as that of the upper type Carlile of Colorado, whereas the fauna of the "Carlile" of the Laramie Basin is of Niobrara age. It is believed, therefore, that the use of the name, Carlile, should be discontinued in the Laramie Basin and the name, Niobrara, extended downward to embrace the beds erroneously called Carlile. This basal Niobrara shale is correlated with the Sage Breaks shale member of the Niobrara of the Black Hills, and the name, Sage Breaks, is here substituted for the abandoned name, Carlile.

### INTRODUCTION<sup>3</sup>

For many years, the dark shales of Upper Cretaceous age which overlie the Cloverly formation in the Laramie Basin, Wyoming, were known simply as Benton shale, with a resistant siliceous shale in the lower part differentiated as the Mowry shale member.<sup>4</sup> The name, Niobrara, was used for the highly calcareous rocks which overlie the shales called Benton.

In 1929, in an area in the northern part of the Laramie Basin, the Benton was subdivided into Thermopolis shale at the base, Mowry shale, Frontier formation, and the Carlile shale at the top, overlain by the Niobrara.<sup>5</sup> These formations had been named previously and have their type localities in other places in Wyoming and Colorado.

<sup>1</sup> Manuscript received, June 2, 1936.

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<sup>3</sup> The writer wishes to express his thanks to J. B. Reeside, Jr., and W. W. Rubey of the United States Geological Survey, and to S. H. Knight, State geologist of Wyoming, for their valuable comments on the stratigraphy and paleontology of the formations here discussed.

<sup>4</sup> N. H. Darton, "Paleozoic and Mesozoic of Central Wyoming," *Bull. Geol. Soc. America*, Vol. 19 (1908), pp. 455-56.

N. H. Darton and C. E. Siebenthal, "Geology and Mineral Resources of the Laramie Basin, Wyoming," *U. S. Geol. Survey Bull.* 364 (1909), pp. 32-34.

N. H. Darton, Eliot Blackwelder, and C. E. Siebenthal, *ibid.*, *Plato* 173 (1910), p. 9.

<sup>5</sup> C. E. Dobbin, H. W. Hoots, C. H. Dane, and E. T. Hancock, "Geology of the Rock Creek Oil Field and Adjacent Areas, Carbon and Albany Counties, Wyoming," *U. S. Geol. Survey Bull.* 806-D (1929), p. 139. This same subdivision was used for the near-by Hanna Basin section by C. F. Bowen, in 1918, on a chart in his paper, "Stratigraphy of the Hanna Basin, Wyoming," *U. S. Geol. Survey Prof. Paper* 108-L (1918), p. 229, but the formations were not discussed.

This nomenclature has now come into general use throughout the Laramie Basin (Table 1).

The writer had noted that there is a gradation from the sandy shale of the "Carlile" into the calcareous beds of the basal Niobrara and, in addition, that the fossils which characterize the lower part of the Niobrara also occur in equal abundance in the upper part of the "Carlile." The conclusion was reached that the "Carlile" of the Laramie Basin is probably more closely related stratigraphically and faunally to the overlying Niobrara than to the subjacent Frontier. Accordingly, in 1934, specimens of the fossils which are common to both formations were sent to J. B. Reeside, Jr. He was of the opinion that the fossils indicated the "Carlile" shale to be of Niobrara rather than Carlile age.

At the writer's suggestion, the maps of parts of the Laramie Basin, completed by the Geological Survey of Wyoming during the past 2 years, show the Niobrara resting directly on the Frontier and the name, Carlile, has not been used. A brief abstract of this stratigraphic revision was published in 1935,<sup>6</sup> but the details have never been presented.

TABLE I  
EVOLUTION OF NOMENCLATURE OF COLORADO GROUP  
OF LARAMIE BASIN, WYOMING

<i>Darton (1908)</i>	<i>Dobbin, Bowen, and Hoots (1929)</i>	<i>This Paper</i>	
Niobrara	Niobrara	Niobrara	Upper chalky member
			Upper shale member
			Lower chalky member
			Sage Breaks shale member
Benton	Carlile	Frontier	
	Frontier	Frontier	
	Mowry	Mowry	
	Thermopolis	Thermopolis	

BENTON AND NIOBRARA OF GREAT PLAINS

The names, Benton and Niobrara, after localities in Montana and South Dakota, were given by Meek and Hayden<sup>7</sup> and came into gen-

<sup>6</sup> Horace D. Thomas, "Benton-Niobrara Contact in the Laramie Basin, Wyoming," *Jour. Colorado-Wyoming Acad. Sci.*, Vol. 2, No. 1 (1935), pp. 33-34.

<sup>7</sup> F. B. Meek and F. V. Hayden, "Description of New Lower Silurian (Primordial), Jurassic, Cretaceous and Tertiary Fossils Collected in Nebraska Territory," *Philadelphia Acad. Nat. Sci. Proc.*, 1861, Vol. 13, pp. 417-42.

eral use throughout parts of Kansas, Nebraska, Colorado, and Wyoming. In 1896, Gilbert<sup>8</sup> divided the Benton of the Arkansas Valley in Colorado into Graneros shale at the base, Greenhorn limestone, and Carlile shale at the top. He pointed out in his description of the Carlile that it is about 200 feet thick; in the east it consists principally of shale, but in the west the upper quarter is sandy. Eastward the sandstone is replaced by a purplish limestone which contains the ammonite, *Prionocyclus wyomingensis*. The type Carlile is directly overlain by the Niobrara, which was divided by Gilbert into the Timpas formation at the base and the Apishapa shale at the top. The basal 50-foot limestone of the Timpas, he said, is characterized by *Inoceramus deformis* and *Ostrea congesta*; the upper part of the formation contains "abundant, very broad, flat bivalves belonging to the genus, *Inoceramus*, and usually covered with *Ostrea congesta*."

Later, in 1899, Logan carried the names, Graneros, Greenhorn, and Carlile, into Kansas,<sup>9</sup> and pointed out that *Prionocyclus wyomingensis* and *Scaphites warreni* occur along with other fossils in the upper part of the Carlile of that region. The Niobrara of Kansas had previously been divided into the Fort Hays limestone below and the Smoky Hill chalk (called "Pteranodon beds" by Logan) above.

In 1925, Rubey and Bass<sup>10</sup> summarized the Upper Cretaceous stratigraphy of central Kansas and pointed out that the Blue Hill shale, the upper member of the Carlile, is characterized by *Prionocyclus wyomingensis*, *Inoceramus fragilis*, and shark teeth, and that the upper 20-25 feet of the Blue Hill member is a gray sandstone. Rubey and Bass tentatively correlated this bed with "a sandy unit at the top of the Carlile shale in South Dakota, Colorado, and Wyoming, the 'Pugnellus' sandstone in south-central Colorado, and the 'Niobenton' sandstone of the oil geologists in north-central Colorado." It is pointed out that the Fort Hays limestone member of the Niobrara is characterized by *Inoceramus deformis*, *Ostrea congesta*, *Globigerina bulloides*, and *Textularia globulosa* (*Gümbelina globulosa*) and that the Smoky Hill chalk member is characterized by *Inoceramus grandis*, *Ostrea congesta*, *Globigerina*, and *Textularia*.

In 1926, Bass<sup>11</sup> applied the name, Codell sandstone bed, to the

<sup>8</sup> G. K. Gilbert, "The Underground Water of the Arkansas Valley in Colorado," *U. S. Geol. Survey 17th Ann. Rept.*, Pt. II (1896), pp. 565-67.

<sup>9</sup> W. N. Logan, "A Discussion of Certain Subdivisions of the Colorado Formation," *Jour. Geol.*, Vol. 7 (1899), pp. 83-91.

<sup>10</sup> W. W. Rubey and N. W. Bass, "The Geology of Russell County, Kansas," *Kansas State Geol. Survey Bull.* 10, Pt. 1 (1925), pp. 25-40.

<sup>11</sup> N. W. Bass, "Geologic Investigations in Western Kansas," *Kansas State Geol. Survey Bull.* 11 (1926), p. 28.

sandy unit at the top of the Blue Hill shale member of the Carlile in central Kansas. Since that time the name has been carried westward into western Kansas and eastern Colorado and is commonly used at the present time.

Henderson<sup>12</sup> had previously discussed the Benton of northern Colorado and had shown (1) that here it is invariably capped by a sandstone or sandy shale, (2) that the base of the Niobrara is a fine-grained limestone with *Inoceramus deformatis* and *Ostrea congesta*, and (3) that near the middle of the Niobrara "is found a lime-shale zone composed of *Ostrea congesta* attached to a large *Inoceramus* whose specific identity can not be made out."

These facts may be summarized by quoting Reeside's<sup>13</sup> observations on the Carlile and Niobrara. He says:

The Carlile and Niobrara possess a number of widespread major faunal zones . . . [which have], however, been more or less ignored in the application of lithologic formational names in a number of regions. For example, the Niobrara formation in its original locality . . . has a lower unit of limestone (mainly) and an upper unit of chalk (mainly). These contain distinctive species as well as certain long-ranging forms. The conspicuous form in the chalk is a very large, flat *Inoceramus* overgrown with *Ostrea congesta*. To this form Conrad gave the name *Haploscapa grandis*. . . *Inoceramus deformatis* Meek is a relatively small cup-shaped species and is confined to the lower, limestone, unit in the Plains. Westward the Niobrara passes into calcareous shales, the uppermost part of the chalk unit persisting farthest. At many places only this chalky remnant has been called Niobrara, though faunally the shales beneath are also Niobrara. Generally the zone of *Inoceramus deformatis* is a basal part of these shales.

Under the Niobrara in the Plains region, in the Carlile, are two very definite major zones. The upper zone has as its most conspicuous fossils *Scaphites warreni* and *Prionocyclus wyomingensis*; the lower has *Scaphites larvaeformis* and *Prionotropis woolgari*.

#### FRONTIER AND NIOBRARA OF LARAMIE BASIN

*Frontier*.—Overlying the siliceous Mowry shale of the southern part of the Laramie basin is about 700 feet of beds whose lower part consists primarily of black shale. This dark shale becomes more sandy progressively upward and culminates at the top in a tan sandstone about 20 feet thick. This succession constitutes the Frontier formation and the sandstone at the top is locally called the Wall Creek sandstone. This bed contains *Prionocyclus wyomingensis*, *Inoceramus fragilis*, and numerous shark teeth, the latter occurring most

<sup>12</sup> Junius Henderson, "Foothills Formations of North-Central Colorado," *Colorado Geol. Survey Bull.* 19 (1920), pp. 85-86.

<sup>13</sup> J. B. Reeside, Jr., personal communication, September 14, 1934.

abundantly at the base of the sandstone in association with well rounded black chert pebbles.

In the northern part of the Laramie Basin, the upper part of the Frontier is much more sandy than in the southern part and generally two or three beds of hard sandstone are present. It is believed that the uppermost bed represents the so-called Wall Creek sandstone of the southern part of the basin, although this point needs additional investigation. *Scaphites warreni*, *Prionocyclus wyomingensis*, and *Inoceramus fragilis* have been collected by the writer from one of the sandstones, but whether or not it was the uppermost one of the sequence is uncertain.

"Carlile."—The "Carlile" shale consists of 250–300 feet of finely laminated, gray sandy shales. Thin streaks of bentonite are conspicuous in good exposures (which are rare, however, because of the non-resistant nature of the rock) and one thin limestone bed, 6 inches thick, has been noted 55 feet above the base of the formation. The lower 60 feet, more or less, seems to be barren of megafossils, but the remaining upper portion contains abundant specimens of *Inoceramus (Haploscapa) grandis* covered with *Ostrea congesta*.<sup>14</sup> *Foraminifera* are abundant throughout and consist mainly of several species of *Globigerina* and several species of *Gümbelina*, but the writer has discriminated about 40 additional species, all of which have not yet been identified. The striking forms, *Lenticulina sublaevis* and *L. kansasense*, described by Morrow from the Fort Hays limestone of Kansas,<sup>15</sup> seem to be represented here and occur commonly from a horizon 55 feet above the base of the formation to one about 150 feet above the base. A species tentatively identified as *Planulina kansasensis* Morrow, another Fort Hays species, also occurs in this zone. *Spiroplectammia bentonensis* Carman, described from the "Benton" of the Laramie Basin,<sup>16</sup> occurs in this zone and the type specimens came from this horizon.

*Niobrara (old usage)*.—The Niobrara grades up from the sandy shale of the "Carlile." The basal member consists of cream-colored impure limestone containing abundant specimens of *Inoceramus grandis* and *Ostrea congesta*, and thin beds of coquina made up of shells of *Ostrea* are conspicuous. This member is 75–100 feet in thickness and is overlain by approximately 100 feet of dark fissile shale

<sup>14</sup> Identified by J. B. Reeside, Jr.

<sup>15</sup> A. L. Morrow, "Foraminifera and Ostracoda from the Upper Cretaceous of Kansas," *Jour. Paleon.*, Vol. 8 (1934), p. 189.

<sup>16</sup> Katherine Carman, "Some Foraminifera from the Niobrara and Benton Formations of Wyoming," *Jour. Paleon.*, Vol. 3 (1929), p. 311.

which is apparently almost barren of megafossils. The upper member is platy, impure cream-colored limestone several hundred feet thick. The upper two members are strikingly less fossiliferous than the lower calcareous member. In all three of the members the *Foraminifera* are not nearly as diversified as in the "Carlile" and are represented mainly by *Globigerina* and *Gümbelina*.

CORRELATIONS BETWEEN LARAMIE BASIN, GREAT  
PLAINS, AND BLACK HILLS

The fauna of the Wall Creek sandstone at the top of the Frontier of the Laramie Basin, and its stratigraphic position, make it apparent that this horizon represents the top of the Carlile of the Great Plains. The so-called Wall Creek sandstone is probably identical with the Codell sandstone of Kansas and Colorado. The fauna of the "Carlile" shale of the Laramie Basin is undoubtedly a Niobrara fauna and indicates that the "Carlile" is younger than the Carlile of the type region (Fig. 1).

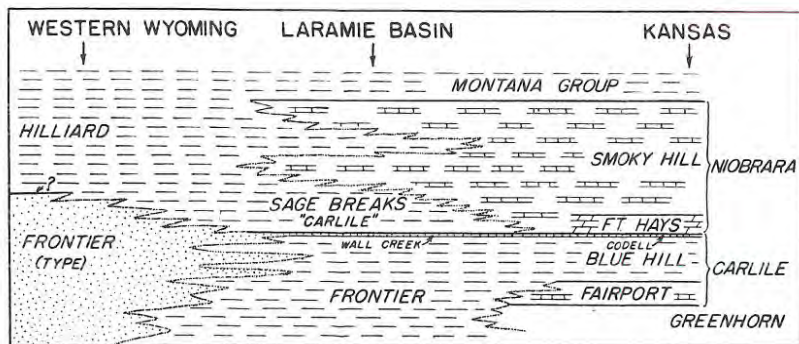


FIG. 1.—Diagrammatic restored section showing relationship of beds of Carlile and Niobrara age between Kansas, Laramie Basin, and western Wyoming. Horizon of Frontier-Hilliard contact is uncertain in respect to Laramie Basin section and is only diagrammatically represented here.

It is believed, therefore, that the use of the name, Carlile, in the Laramie Basin should be discontinued and the name, Niobrara, extended downward to embrace the beds previously called Carlile. This procedure imparts a quadripartite nature to the Niobrara, as follows: (1) a basal sandy shale member, (2) a lower creamy, chalky member, (3) an upper dark shale member, and (4) an upper platy, creamy, chalky member.

Although no attempt has been made to determine the details of the areal extent of the four lithologic units, it is known at this time

that they may be distinguished throughout most of the Laramie Basin, in north-central Colorado along the headwaters of the Big Laramie River, and as far west as the Sage Creek Basin, south of Rawlins, Wyoming. Over an area of at least 4,000 square miles, then, outcrops of the Niobrara show this quadripartite nature and it is believed that the members may be recognized over a still greater area.

*Sage Breaks shale member of Niobrara (first application in south-eastern Wyoming).*—The name, Sage Breaks, was applied by Rubey to the basal shale member of the Niobrara in the Black Hills of northeastern Wyoming.<sup>17</sup> This shale overlies the Turner sandy member of the Carlile and had been included in the Carlile in earlier reports. It is overlain by the Beaver Creek chalky member of the Niobrara.

The writer believes that the beds in the Laramie Basin between the Wall Creek sandstone and the lowermost chalky member of the Niobrara—that is, those previously called Carlile—are essentially equivalent to the Sage Breaks shale member of the Niobrara of the Black Hills. Therefore, as a substitute for the abandoned name, Carlile, the name, Sage Breaks, is applied here to this shale in the Laramie Basin, in spite of the fact that the shale has not yet been traced between the Black Hills and the Laramie Basin. This procedure is thought to be much more satisfactory than applying a new name to the shale and perhaps subsequently finding it to be synonymous with the name, Sage Breaks.

It is believed that the Sage Breaks shale of the Laramie Basin is equivalent to the Fort Hays and the lower Smoky Hill of the Great Plains. However, no specimen of *Inoceramus* which even closely approaches *Inoceramus deformis* has been found in the lower part of the Sage Breaks shale in the Laramie Basin by the writer. It may be that the zone characterized by this fossil is not present in the Laramie Basin, for there is a suggestion of a disconformity between the Frontier and the Niobrara, or that the environment was not suitable for the flourishing of the species.

#### CORRELATIONS BETWEEN LARAMIE BASIN AND WESTERN WYOMING

It is generally believed that the top of the Mowry shale of central and southern Wyoming is a horizon synchronous with the top of the

<sup>17</sup> W. W. Rubey, "Lithologic Studies of Fine-Grained Upper Cretaceous Sedimentary Rocks of the Black Hills Region," *U. S. Geol. Survey Prof. Paper 165-A* (1930), p. 4.

siliceous Aspen shale of western Wyoming.<sup>18</sup> The type Frontier overlies this horizon and comprises about 3,000 feet of marine shales and sandstones, and continental coal-bearing beds. It is almost certain, according to Reeside,<sup>19</sup> that the upper part of the Frontier is of Niobrara age, and according to Rubey, *Inoceramus deformis* ranges through a great thickness of Frontier in the Wyoming Range in western Wyoming.<sup>20</sup> In spite of this fact, it is at present much more convenient to carry the name, Frontier, eastward into the Laramie Basin and limit its scope, rather than to apply the name, Carlile, to the upper part of the Frontier of the Laramie Basin. It has been impossible thus far, because of lack of paleontologic evidence, to correlate the Thermopolis, the Mowry, and the Frontier of the Laramie Basin with the Graneros, the Greenhorn, and the Carlile. Therefore, the name, Frontier, is used in the Laramie Basin in a restricted sense and probably does not embrace as great a length of time as does the name, Frontier, in the type locality.

#### SUMMARY

A widespread sandy horizon at the top of the Carlile shale of the Great Plains is characterized by *Prionocyclus wyomingensis*, *Scaphites warreni*, and *Inoceramus fragilis*. This fauna is found in the Laramie Basin in the so-called Wall Creek sandstone at the top of the Frontier formation. The Niobrara formation of the Great Plains contains a distinctive fauna, characterized mainly by *Inoceramus grandis*, which occurs in the Laramie Basin in the shale which has been called Carlile as well as in the Niobrara. Therefore, the upper part of the Frontier in the Laramie Basin is of Carlile age and the "Carlile" shale of this region is of Niobrara age. The scope of the name, Niobrara, is expanded in the Laramie Basin so as to include the shale previously called Carlile, and the name, Sage Breaks shale member of the Niobrara, is substituted in place of the abandoned name, Carlile.

#### DISCUSSION

A. E. BRAINERD, Denver, Colorado (discussion received June 2, 1936): The term Sage Breaks, as defined by Professor Thomas, was applied in the Black Hills district, and is being used by him for the lower part of the Niobrara section in the Laramie Basin. I am not just sure if it is wise to use the term over this rather widespread area without tracing it through. In our drilling wells [Continental Oil Company] in eastern Colorado we have found

<sup>18</sup> W. W. Rubey, "Origin of the Siliceous Mowry Shale of the Black Hills Region," *U. S. Geol. Survey Prof. Paper 154-D* (1929), pp. 169-70.

<sup>19</sup> J. B. Reeside, Jr., *op. cit.*

<sup>20</sup> W. W. Rubey, personal communication (March, 1936).



the Timpas (Fort Hays) limestone, basal Niobrara, resting on the Codell, which I believe now to be Frontier (Wall Creek), as is indicated by Professor Thomas.

In other places we have found a shale interval between the Codell sandstone or Wall Creek sandstone and the Timpas limestone. It is evident that there is an unconformity at the base of the Timpas limestone (Fort Hays limestone) in eastern Colorado. Just what is the age of the shale which lies between the Timpas and the Codell, would be open to question.

HORACE D. THOMAS: A suggestion relative to the age of the shale which lies between the Codell sandstone and the Timpas limestone in places in Colorado to which Mr. Brainerd has called attention is as follows.

Beneath the Great Plains, between the Laramie Basin and Kansas, there should be localities at which the lower shale member of the Niobrara is thin. Such a condition is shown in Figure 1 midway between the Laramie Basin and the Kansas sections. The shale in question may simply represent the attenuated southeastward extension of the Sage Breaks shale member. The localities in Colorado at which the shale is not present possibly were sites of deposition seaward from the early Niobrara "mud-line," and there the shale has graded into, and is represented by, the basal Timpas limestone. If this suggested relation is correct, the *Foraminifera* in the shale should be species which also occur in the Fort Hays limestone of Kansas.