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**CEPHALOPOD DIVERSITY WITHIN A CONCRETIONARY INTERVAL
OF THE PIERRE SHALE (UPPER CRETACEOUS)
IN DAWES COUNTY, NORTHWESTERN NEBRASKA**

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ABSTRACT

A concretionary interval within the Pierre Shale, where it outcrops across northern Dawes County, is characterized by a diversity of cephalopod taxa. The interval falls within the ammonite zones of *Exiteloceras jenneyi* to *Baculites cuneatus* of the upper Campanian. Three or more of the following cephalopod taxa have been collected at each of the seventeen sites described herein: *Eutrephoceras dekayi* (Morton); *Baculites compressus* Say; *B. cuneatus* Cobban; *Didymoceras cheyennense* (Meek and Hayden); *Exiteloceras jenneyi* (Whitfield); *Jeletzkyites nodosus* (Owen); *Placentoceras intercalare* Meek; *P. meeki* Boehm; and *Solenoceras* cf. *S. crassum* (Whitfield). The interval that yields cephalopod diversity comprises a stratigraphic thickness of about 15 to 20 meters and appears to occur roughly 300 meters above the base of the Pierre Shale in northeastern Dawes County. The fossils are present within calcareous concretions imbedded in gray to olive-gray shale in the lower portion of the upper part of the Pierre Shale in this area. The interval seemingly correlates, at least in part, with the lower unnamed shale member of the Pierre Shale in the Red Bird area in eastern Wyoming.

† † †

The Pierre Shale outcrops across some 900 sq. km (350 sq. mi.) in northern Dawes County, northwestern Nebraska (Fig. 1). Southernmost exposures occur near the city of Chadron and Pierre Shale constitutes bedrock over most of the area northward into South Dakota. However, thick, extensive, and well-developed exposures are almost nonexistent in this region of predominantly rolling, grass-covered hills.

Very little has been published on the Pierre Shale and its macrofossil content in this area. Whitfield (1901) described an exceptionally well-preserved specimen of *Didymoceras stevensoni* Whitfield, which was

reported to have been collected at Chadron, Nebraska. Dunham (1961a, b; *because the content of these two works is essentially identical, only the 1961a report subsequently will be referred to in the body of this paper*) included a rather detailed description of the Pierre Shale in the Chadron area as well as many of the fossil localities described in this report; however, neither of his studies has been published. Tourtelot and Rye (1969) analyzed oxygen and carbon isotopes present in a number of specimens of *Baculites* collected from three localities in northern Dawes County. Cobban (1987) reported collecting a specimen of *Rhaeboceras* Meek in 1965 from northeastern Dawes County.

Several of the cephalopod taxa that occur within the concretionary interval emphasized in this paper have substantial biostratigraphic value. Thus, *Exiteloceras jenneyi*, *Didymoceras cheyennense*, *Baculites compressus*, and *B. cuneatus* define successive ammonite zones for the upper Campanian in the U. S. western interior. In northern Dawes County, the fossiliferous concretionary interval of special interest in the upper part of the Pierre Shale is sporadically exposed in a belt roughly 6 to 8 km wide that extends from near the southwestern corner of T33N, R49W in a northeasterly direction into the eastern half of T35N, R49W (Fig. 1) and then northward a few km in Shannon County, South Dakota. Across much of the western two-thirds of northern Dawes County, the fossiliferous concretionary interval is covered by stratigraphically higher portions of the upper part of the Pierre Shale. In addition to a description of cephalopod occurrence, this report includes a fairly detailed account of Pierre Shale surficial stratigraphy in this area. [In this regard, the earlier work of Dunham (1961a) has been particularly helpful.]

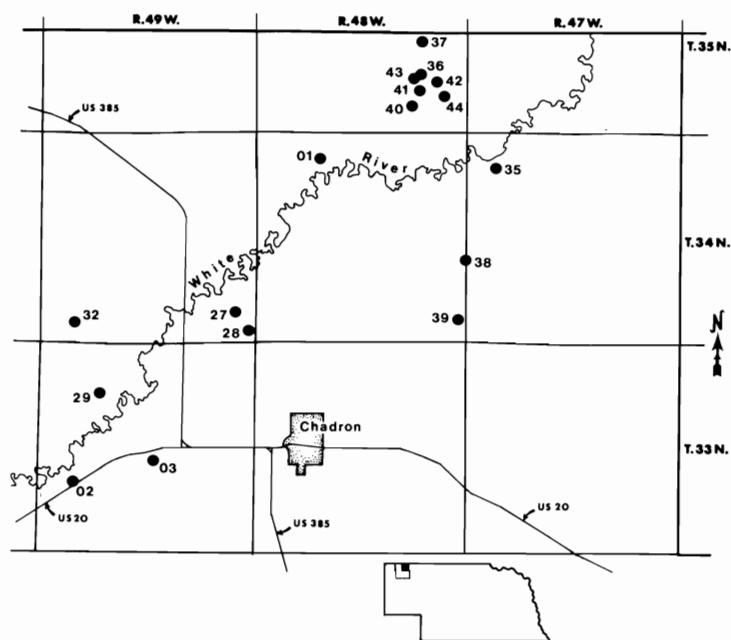


Figure 1. Map showing the locations of CSC-Kp sites described in this paper where concretions in the upper part of the Pierre Shale in northeastern Dawes County have yielded cephalopod diversity.

STRATIGRAPHY OF THE PIERRE SHALE

Meek and Hayden (1861: 419–424) proposed the name Fort Pierre Group for a sequence of dark shale exposed near the fur-trading post of Fort Pierre, which at that time was on the Missouri River floodplain some 6 km north of the present community of the same name. The name for the rock unit has subsequently been changed to Pierre Shale. The present thickness of the Pierre Shale in the type area is about 300 m (1,000 ft) (Crandell, 1958). Crandell (1958: 9) subdivided the Pierre Shale for the type area in central South Dakota into 8 members which are, in ascending order, the Sharon Springs, Gregory, Crow Creek, DeGrey, Verendrye, Virgin Creek, Mobridge, and Elk Butte members. He noted that all except the Sharon Springs Member crop out in the Pierre area.

At the few outcrops [e. g., in T35N, R47W, Sec. 30dc (see *description of sites collected* section for an explanation of the T-R locational format employed herein)] in northeastern Dawes County where I think I have observed the contact between the Niobrara Formation and Pierre Shale that contact appears to be gradational and conformable. However because of the generally poor quality of such exposures, misinterpretation of the boundary relationships is entirely possible. Thus it may be that the Niobrara-Pierre contact in this area actually is an unconformity as has been asserted (primarily on the basis of subsurface correlations) by, e.g.,

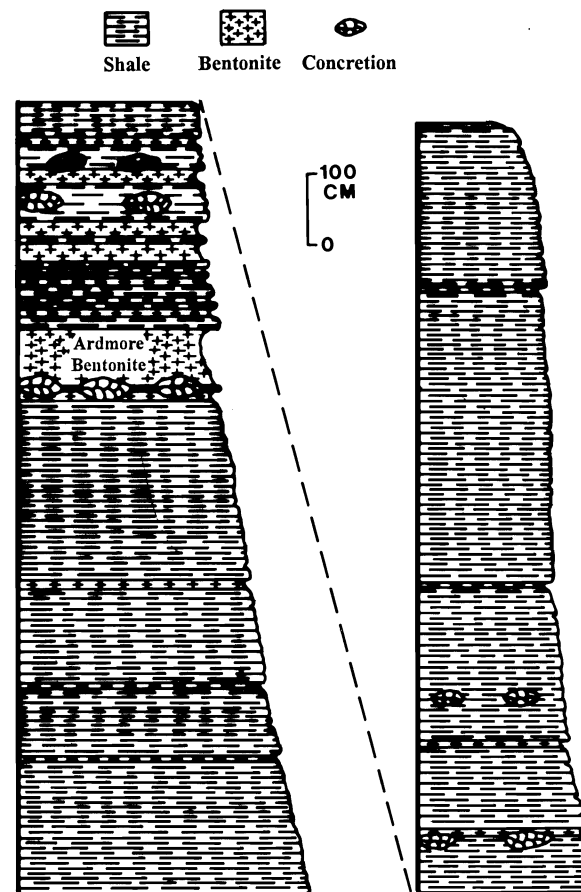
DeGraw (1975) and Shurr (1984). The regional contact between the Pierre Shale and overlying Chadron Formation (Oligocene) is a disconformity. The Pierre Shale remaining in northern Dawes County seems to be at least 400 m thick, and outcrops consist of dark shale comprising several lithologic zones characterized by the presence or absence of bentonite beds and concretions as well as variations in the nature of the shale (Fig. 2).

Sharon Springs Member

The Sharon Springs Member, whose type locality is in western Kansas (Elias, 1931), constitutes the basal Pierre Shale in northern Dawes County. It consists chiefly of relatively resistant (buttress-weathering) laminated, dark gray to black shale that includes much bituminous material as well as abundant small scales and other fish fossils. It contains several bentonite beds and concretionary layers and weathers to fissile, silvery-gray flakes. Portions of the Sharon Springs are locally exposed in extreme northeastern Dawes County on the western side of the Chadron Dome. The finest exposure of this member in the immediate area is just across the state line from Dawes County in Shannon County, South Dakota, where relatively complete sections of the unit are exposed in buttes and along gullies in T35N, R47W, Secs. 16 and 17. Moore (1954: 36) reported finding a knife-edge contact of the Sharon Springs Member and the underlying Fort Hays Limestone Member of the Niobrara Formation in Sec. 16,

		Approximate Thickness (meters)	Generalized Section	Lithologic and Biostratigraphic Character
P I E R R E S H A L E	Upper Part	100+		The Upper Part is mostly light olive gray, noncalcareous shale. <i>Baculites grandis</i> occurs in the upper 40 m. Medium to large septarian concretions are present at a number of levels about 40 to 60 m above the base. Medium to large calcareous concretions that commonly contain a diversity of ammonites and other molluscs occur in an interval about 10 to 30 m above the base (this is the interval being emphasized in this report).
	Middle Part	300		The Middle Part is chiefly grayish, noncalcareous shale. Small reddish brown, sideritic concretions are common through a thickness of about 20 m just below the gumbo zone at the top of the Middle Part. Medium to large calcareous concretions—usually devoid of macrofossils and commonly septarian—occur at several horizons in the Middle Part. Abundant small, reddish, sideritic ironstone concretions—often consisting of <i>Baculites</i> casts—are abundant in the lower 25 m.
	Sharon Springs Member	25		This member is predominantly hard, fissile, carbonaceous, dark gray shale; typically containing abundant tiny, fragmental fish remains. Numerous cream to orange colored bentonite beds, ranging in thickness from mm to about 100 cm, characterize the Sharon Springs Member. Medium to large calcareous, septarian concretions occur at about five horizons.

A



B

Figure 2. A. Generalized stratigraphic section of the Pierre Shale exposed in northwestern Nebraska (vertical bar to right of upper part of the section is opposite the concretionary interval that yields cephalopod diversity) (modified from Dunham, 1961a). B. Stratigraphic section for the Sharon Springs Member of the Pierre Shale as measured by the author in T35N, R47W, Sec. 30dc, northeastern Dawes County, Nebraska.

where he assigned a thickness of 101.4 feet (30.9 m) to the member. He distinguished 58 beds in his measured stratigraphic section.

Dunham (1961a: 30) measured a section of 86 feet (26.2 m) in sections 16 and 17 and subdivided the member, from bottom to top, into the lower shale zone (26 feet thick; noncalcareous, gray to dark gray fissile shale, with 7 beds of bentonite, none thicker than 7 inches), the bentonite zone (18 feet thick; including 10 beds of bentonite that aggregate 8.8 feet, with 3.2 feet thick Ardmore bentonite bed occurring about a foot above the base; shale is similar to that in underlying zone), the concretion zone (21 feet thick; characterized by white-weathering concretions that average 6 feet in width by 1.5 feet in height and which occur at 4 levels; several thin bentonite beds; shale is similar to that in underlying zone; lower part of unit exhibits rusty boxworks measuring 2 to 4 feet on a side), and the upper shale zone (21 feet thick; 5 thin beds of bentonite; shale similar to that in underlying zone)—in order to facilitate charting the distribution of uranium within the member. Dunham (p. 31) noted that X-ray analyses of the member show that quartz is the most abundant mineral and montmorillonite is next. He also observed that crystals and small concretions of pyrite are more numerous in the Sharon Springs than in any other unit in the area. He (p. 33) reported that the bentonite in the member consists of montmorillonite and that the outstanding sedimentary structure visible in the member in the field is the evenly parallel lamination. Sections I measured in T35N, R47W, Secs. 16 and 30 generally agree in thickness and lithologic character with Dunham's description. However, these exposures reveal significant variation in thickness of some of the bentonite beds. In addition, concretions were observed to be yellowish gray-weathering and to be at one or more levels within the bentonite zone. Also, rusty boxworks may occur from the lower zone through the concretion zone.

Moore (1954: 38) referred the upper 22 feet (6.7 m) of his measured section of the Sharon Springs to bed 58, which he described as being shale, red-brown in color, with a heavy concentration of ferro-manganese nodules. Dunham (1961a: 41) assigned that general portion of the section to what he called the lower zone of the middle part of the Pierre Shale—which he described as being 75 feet (23 m) of olive gray, poorly exposed mudstone characterized by numerous siderite concretions. In their study of the Sharon Springs Member in its type area in western Kansas, where its total thickness is about 215 feet (66 m), Gill et al. (1972) defined the contact between the Sharon Springs and the overlying Weskan Member as being marked by an abrupt change upward from 10 to 13 feet (3 to 4 m) of hard slightly phosphatic, dark-brownish-black to grayish-

brown shale containing abundant organic material and numerous layers of phosphate nodules to a soft shale which contains many thin bentonite beds. Near Red Bird, in eastern Wyoming, Gill and Cobban (1966) assigned about 130 feet (40 m) of the Pierre Shale to the Sharon Springs and noted that the shales of the upper part of the Sharon Springs are conformable and gradational with the overlying Mitten Black Shale Member. They (p. A14) differentiated the two members by the upward change from silver gray papery-weathering shale to black-gray, hackly, limonite-stained shale that contains numerous siderite and grayish-orange-weathering septarian limestone concretions. They (p. A10) employed the same criteria for defining the contact between the Sharon Springs and Mitten Black Shale Members near Ardmore, South Dakota, some 65 km west-northwest of the sections measured by Moore and Dunham in sections 16 and 17.

The contact definition employed at Red Bird and Ardmore, which is more or less coincident with that used by Dunham for the Chadron area, appears to be reasonable and, therefore, is being used herein for northern Dawes County. Relatively good outcrops of the Sharon Springs Member occur in T35N, R47W, Secs. 19 and 30, in extreme northern Dawes County, where a thickness of about 15 to 25 m may be observed, and where the member is distinguished, as usual, by various bentonite beds and concretion layers as well as the general character of the shale. I have not yet found any invertebrate macrofossils in northern Dawes County in the Sharon Springs Member; however, Dunham (1961a: 36) reported finding scarce *Baculites haresi* Reeside and *Baculites* aff. *B. asper* from about 30 feet (9.1 m) below the top of the member approximately 10 km to the northeast in Shannon County, South Dakota at USGS Mesozoic locality D207 in T35N, R46W, Sec. 5ad.

Middle and upper Pierre Shale.

Dunham (1961a: 29) was unable (and I have been unable), in the Chadron area, to formally subdivide Pierre Shale overlying the Sharon Springs Member. Thus, he eventually subdivided that part of the formation into two mapped informal units—the middle part and the upper part. He (pp. 39 and 40) attempted to construct a stratigraphic section for his middle and upper parts of the Pierre by piecing together outcrops scattered roughly east to west across some 8 km, mostly in extreme southern Shannon County, South Dakota. He (p. 39) noted that the thicknesses recorded for some intervals were little better than estimates. He assigned a thickness of 900 feet (271 m) to the middle part and 300+ feet (90+ m) to the upper part.

Middle part of Pierre Shale. Dunham (1961a: 41, 42) observed that lamination is scarce or absent in

the Pierre above the Sharon Springs Member in the Chadron area—perhaps because postdepositional reworking resulted in an intimate mixing of montmorillonite, silt, and other material—and that the contact between the Sharon Springs and overlying zone of sideritic concretions is gradational through an interval of several feet. He (p. 42) described the siderite concretions which occur in the lower 75 feet (23 m) of the middle part as being about a foot wide and dark brown where fresh but which, upon weathering, disintegrate to a debris of ¼ inch to 1 inch angular fragments of metallic reddish brown limonite. He reported collecting numerous limonitic internal casts (“molds”) of *Baculites* aff. *B. asperformis* Meek from the weathered concretions. I have collected a few dozen partial internal limonitic casts of what appear to be *Baculites maclearni* Landes from roughly a 5 m-thick zone of concretions exposed about 10 to 15 m above the top of the Sharon Springs Member in a south-trending ridge in T35N, R47W, Sec. 19cc as well as a few from near the top of a hill approximately 2 km due south in Sec. 30dc (plus a few from additional localized outcrops in the same general area) in extreme northeastern Dawes County.

Dunham (1961a: 42) described the middle 700 feet (213 m) of the **middle part** of the Pierre Shale as comprising light olive gray noncalcareous shale characterized by white-weathering lime concretions. He (pp. 42, 43) noted that white-weathering concretions in the lower few tens of feet are associated with calcareous concretions that weather brown or red, presumably from contained siderite, and that one zone of sideritic limestone concretions occurs in the middle of the unit. He (p. 43) described the upper 125 feet (38 m) of the middle part as forming a banded landscape, barren of vegetation and consisting of massive beds (10 to 20 feet thick) of swelling clay which becomes very sticky and plastic when wet (popcorn beds or gumbo). Near the middle of the upper 125 feet (38 m) of the middle part of the Pierre he (p. 44) found a 1 foot (30 cm) thick zone rich in heavy black pellets and small concretions which contained about 10 percent of manganese as well as iron plus some silicates.

During the 1992 field season I measured a section using a modified Jacob's staff, from T35N, R47W, Sec. 19ca west-northwestward to T35N, R48W, Sec. 23ac in extreme northeastern Dawes County near the Nebraska-South Dakota boundary. I began the section at the top of the Sharon Springs Member and ended it at the top of the interval that displays cephalopod diversity. At this time and in this area the only places where the attitude of the formation could be estimated were below the base of the measured section in outcrops of the Sharon Springs Member and, less reliably, in the upper 38 m (125 feet) of the middle part. Between these two

points, no adequate outcrops were observed. Along most of the section measured, the Pierre Shale is covered by soil, alluvium, and low vegetation. No concretions were observed near the traverse line through the middle 213 m (700 feet) portion of the middle part. However, yellowish gray- to dark yellowish orange-weathering unfossiliferous septaria outcrop with some frequency in parts of this interval within a few km to the south of the traverse line. The upper 35 to 40 m of the middle part forms a banded landscape of gumbo that is largely barren of vegetation, and unfossiliferous, reddish brown sideritic concretions occur in a number of beds in its lower portion.

Upper part of Pierre Shale. Dunham (1961a: 46) reported that the upper part of the Pierre Shale remaining in the Chadron area is about 300 feet (91 m) thick and that it is characterized by concretions different from those in other parts of the formation. He observed that the shale of the upper part of the Pierre is light olive gray and noncalcareous and is unlike the lower parts of the Pierre in containing feldspar and in lacking kaolinite. Dunham (p. 46) reported that concretions peculiarly rich in ammonites and other fossils characterize a 40-foot (12 m) interval about 55 feet (17 m) above the base of the upper part of the Pierre. This is the concretionary interval that yields the cephalopod diversity described in this paper. According to ammonite zonation employed for the Cretaceous in the U.S. western interior this concretionary interval lies within the zones of *Exiteloceras jenneyi* to *Baculites cuneatus* of the upper Campanian. The approximate median age for this portion of the upper Campanian appears to be 73.2 ± 0.7 Ma (Kennedy and Cobban, 1993). In northeastern Dawes County I have found that the base of this concretionary zone usually occurs between 12 and 15 m above the base of the upper part of the Pierre and that the thickness of the zone ranges up to about 20 m; however, the most fossiliferous concretions seem to be in the lower part. Dunham (p. 46) described the concretions as being spaced about 30 feet (9 m) apart laterally, concentrated at several levels, about a foot or two in diameter, almost spherical, variably septarian, white-weathering, and comprising dark silty lime matrix. My observations indicate that the concretions occur at several levels and are commonly spaced from 5 to 10 m apart laterally. Individual concretions generally have the shape of an oblate spheroid and a maximum dimension between 30 and 75 cm. Relatively fossiliferous concretions were found to be nonseptate, dominantly whitish-weathering, and imbedded in pale olive or grayish shale. Larger (to more than 2 m across and/or high), variably septate, only sparsely fossiliferous concretions tend to characterize the higher concretionary levels. Thus, in general, there appears to be an inverse relation between the size of the concretions and the abundance of contained macrofossils. Dunham (p. 47)

Table I. Occurrence and apparent relative abundance of cephalopod taxa at sites collected and described in this report. The numbers shown after each taxon for the various sites refer to the apparent relative abundance and the meaning is as follows: 33 (abundant; 10s to 100s of specimens normally may be collected each site visit); 22 (moderately abundant; about 5 to 15 specimens usually found each site visit); 11 (rare; generally find fewer than 5 specimens per site visit); and 00 (I have not yet found any specimens at the site).

Cephalopod Taxa	C S C Kp Collecting Site Numbers																
	01	02	03	27	28	29	32	35	36	37	38	39	40	41	42	43	44
<i>Eutrephoceras dekayi</i>	11	11	11	11	11	00	00	11	11	11	00	00	11	11	11	11	11
<i>Baculites compressus</i>	33	22	33	33	22	33	22	33	33	33	33	22	33	33	33	33	33
<i>B. cuneatus</i>	00	00	11	00	00	00	00	11	11	11	00	00	11	11	11	11	11
<i>Didymoceras cheyennense</i>	11	11	00	00	00	11	11	22	11	11	11	11	11	11	11	00	11
<i>Exiteloceras jenneyi</i>	00	00	11	00	00	00	00	11	00	00	00	11	00	00	00	00	00
<i>Jeletzkyites nodosus</i>	22	11	22	11	11	11	11	22	22	22	11	11	22	22	22	22	22
<i>Placentoceras intercalare</i>	11	00	00	00	11	00	00	11	11	11	00	00	00	00	11	11	11
<i>P. meeki</i>	11	11	11	11	00	11	11	11	11	11	11	00	11	11	11	11	11
<i>Solenoceras cf. S. crassum</i>	11	11	11	00	00	11	11	22	11	11	11	00	11	00	11	00	11

reported that *Baculites* in these concretions differ from those found elsewhere in the Pierre in the Chadron area in often retaining their aragonite shell with its inherent pearly luster. He (p. 47) was puzzled by the arrangement of the fossils within the concretions because they do not occur in layers nor do they lie parallel to bedding, but instead appear to be jumbled all together. He (p. 47) had the impression that the macrofossils tend to be more concentrated in the marginal part of concretions than in the interior. The macrofossils indeed appear to be jumbled together; however, I have not detected any obvious concentration in the marginal portion. He (p. 47) observed also that the shells show few or no signs of breakage or toothmarks nor have they been bored by perforating algae or other borers. The living cavities were found to be filled or partly filled with silty fine limestone, not with the sparry calcite that is precipitated chemically in voids (p. 47). In general, I concur with the above observations; however, sparry calcite does occur locally in some cephalopod chambers. The most abundant macrofossils in the concretions typically are representatives of bivalves such as *Inoceramus* and high-spined gastropods.

Dunham (1961a: 47) encountered concretions also in the upper 100 feet (30.5 m) of the upper part of the Pierre Shale. However, these were found to be quite different from the aforementioned in that each one consisted of the lithified filling of the interior of a single large *Baculites grandis* from which the shell is gone; the casts consisting of calcareous clay that weathers

pink, presumably because the clay is sideritic (p. 48). I have not been successful in finding *B. grandis* in place near the lower zone of fossiliferous concretions. The only *B. grandis* specimens I have discovered in place occur in north-central Dawes County (e.g., near the hilltop in T34N, R49W, Sec. 6c and Sec. 7b), apparently 50+ m stratigraphically above the interval of cephalopod diversity, where they occur as isolated internal casts or as one or two specimens within relatively small, subcylindrical concretions. Some of these specimens do retain altered portions of shell material.

MATERIALS AND METHODS

All the fossils collected and described in this report currently are deposited in the Department of Earth Science invertebrate fossil collections at Chadron State College. Although the Pierre Shale outcrops across most of northern Dawes County, there are few places where the fossiliferous concretionary zone is well exposed at any given time. Since the fall of 1975, but especially during 1984, 1990, 1991 and 1992, I have attempted to visit every outcrop of the Pierre Shale in northern Dawes County which looked promising for the collecting of macrofossils. Thus far, only 17 sites have been found where the interval containing the fossiliferous concretions is relatively well exposed (Fig. 1).

DESCRIPTION OF SITES COLLECTED

For each of the Chadron State College Pierre Shale (CSC-Kp) localities described below from which I have

thus far collected a diversity of cephalopods from the fossiliferous concretionary interval, I have included the township-range location [T-R locational data presented in this paper are typically listed in the following order—township, range, $\frac{1}{4}$ section, and $\frac{1}{4}$ $\frac{1}{4}$ section (section subdivisions are indicated by—*a* for NE $\frac{1}{4}$, or NE $\frac{1}{4}$ of NE $\frac{1}{4}$; *b* for NW $\frac{1}{4}$ or NW $\frac{1}{4}$ of NW $\frac{1}{4}$; *c* for SW $\frac{1}{4}$ or SW $\frac{1}{4}$ of SW $\frac{1}{4}$; and *d* for SE $\frac{1}{4}$ or SE $\frac{1}{4}$ of SE $\frac{1}{4}$, e.g., a location given as Sec. 7db means that the site is located in the NW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 7)], name of pertinent U.S.G.S. 7.5' topographic map, approximate average (mean) elevation of the fossiliferous concretions (in feet above mean sea level), general description of outcrop and concretions (unless otherwise noted, individual exposed concretions are embedded in fissile gray shale), and additional items of interest. Table I shows the apparent relative abundance of the various cephalopod taxa at the sites collected.

CSC-Kp 01: T34N, R48W, Sec. 5dd; Isinglass Buttes Quadrangle; average elevation c. 3180 ft. The primary outcrop consists of moderately steep to vertical, nearly vegetation-free shale bluffs along the north side of Madden Creek. Moderately to highly fossiliferous concretions are exposed at several levels through a stratigraphic thickness of about 20 m and along an outcrop width of roughly 200 m. A number of similar concretions occur at various places along the sides of several nearby draws, especially to the east in Sec. 4c. Specimens of *Baculites compressus* and *Jeletzkyites nodosus* are relatively abundant and well preserved at this locality and range in diameter from a fraction of a mm [for two *B. compressus* embryonic shells (ammonitellas)] to in excess of 55 mm for a few *B. compressus* specimens and 65 mm for a single *J. nodosus* specimen. This locality is the same as USGS Mesozoic locality D212 (Dunham, 1961a; Tourtelot and Rye, 1969). Dunham (p. 49) reported collecting *Baculites corrugatus* Elias (*B. corrugatus* Elias and *B. compressus* Say may be synonyms) and *Acanthoscaphites brevis* (Meek) (referred herein to *Jeletzkyites nodosus*) from this site.

CSC-Kp 02: T33N, R49W, Sec. 29bb; Chadron West Quadrangle; average elevation c. 3380 ft. Outcrop constitutes a partly grassed (the amount of grass cover has increased appreciably in recent years), gently sloping shale bank along the north side of U.S. highway 20 where the highway cuts through a ridge that trends northwest-southeast. Sparsely fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of up to about 8 m and along an outcrop width of some 75 m. Individual exposed concretions are imbedded in fissile, predominantly pale olive shale. Macrofossils are neither abundant nor especially well preserved at this locality.

CSC-Kp 03: T33N, R49W, Sec. 22bc; Chadron West Quadrangle; average elevation c. 3390 ft. Outcrop comprises a gently sloping north-trending, west-facing shale bank on the east side of Deadhorse Road, where that road cuts through a ridge that trends northwest-southeast, approximately 0.3 km south of its intersection with U. S. Highway 20. Sparsely to moderately fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of about 5 m and along an outcrop width of roughly 50 m. Individual exposed concretions are imbedded in fissile, pale olive shale. *Baculites compressus* and *Jeletzkyites nodosus* are moderately abundant at this locality, but the preservation commonly is only fair. This locality coincides with USGS Mesozoic locality D4930 (Tourtelot and Rye, 1969).

CSC-Kp 27: T34N, R49W, Sec. 36ba; Bohemian Creek Quadrangle; average elevation c. 3250 ft. This outcrop consists of a nearly bare, moderately steep, east-facing shale slope exposed a few meters west of a north-south fence. Sparsely to moderately fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of about 5 to 7 m and along an outcrop width of some 50 m. Individual exposed concretions are imbedded in fissile, pale olive shale. Cephalopods are neither abundant nor especially well preserved. However, one *Baculites compressus* embryonic shell was found.

CSC-Kp 28: T34N, R49W, Sec. 36da; Bohemian Creek Quadrangle; average elevation c. 3270 ft. This outcrop constitutes a gently sloping, sparsely grassed, south-facing shale bank. A small number of moderately fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of up to about 5 m and along the outcrop for only some 30 m. Individual exposed concretions are embedded in fissile, pale olive shale. I found a relatively well-preserved partial crown of a crinoid (cf. *Monachocrinus*) within a living chamber of a *Baculites compressus* at this site—the only significantly complete crinoid I have found thus far in northwestern Nebraska. This locality would seem to correspond to USGS Mesozoic locality D234. Dunham (p. 49) reported collecting *Eutrephoceras* sp., *Baculites compressus*, *B. corrugatus*, *B. n. sp.*, and *Acanthoscaphites* sp. from this locality. In addition, he reported collecting *Baculites* cf. *B. corrugatus* and *Placentoceras* cf. *P. meeki* from USGS Mesozoic locality D235, which he described as being approximately 50 feet above D234. Apparently D235 is now too grassed over for concretions or macrofossils to be observed.

CSC-Kp 29: T33N, R49W, Sec. 8 (chiefly north half); Chadron West Quadrangle; average elevation c. 3360 ft. Numerous intermittent outcrops of sparsely to moderately fossiliferous concretions occur at a several levels through a stratigraphic thickness of about 5 to 15

m along several low shale breaks on either side of hills that trend northwest-southeast.

CSC-Kp 32: T34N, R49W, chiefly Sec. 31da; Way-side Quadrangle; average elevation c. 3270 ft. This is about as far west in Dawes County as I have been able to find exposures of the fossiliferous concretionary interval. The principal outcrop comprises a sparsely grassed, gentle to moderately steep west-facing shale bluff a few 10s of meters east of Willow Creek. Sparsely to moderately fossiliferous concretions are exposed at several levels through a stratigraphic thickness of about 10 m and along an outcrop width of more than 100 m. Minor exposures of the fossiliferous zone occur at a few places between 1 and 2 km east of this outcrop.

CSC-Kp 35: T34N, R47W, Sec. 6dd to 7ab; Isinglass Buttes Quadrangle; average elevation c. 3170 ft. This outcrop consists of sparsely grassed, moderately steep, north- and west-facing bluffs a few hundred meters south of the present course of the White River. Sparsely to abundantly fossiliferous concretions are exposed at several levels through a stratigraphic thickness varying from about 10 to 20 m and along an outcrop width of several 100 m. *Didymoceras cheyennense* and *Solenoceras* cf. *S. crassum* are remarkably abundant and well preserved at this locality. This locality is the same as USGS Mesozoic localities D221 and D 222. Dunham (p. 49) reported collecting *Eutrephoceras montanense* (Meek) [*E. montanense* (Meek) and *E. dekeyi* (Morton) may be synonyms], *Baculites corrugatus*, *B. n. sp.*, *Solenoceras meekianum* (Whitfield), *Didymoceras ? cheyennense*, *Acanthoscaphites brevis*, *A. cf. A. quadrangularis* (Meek and Hayden), and *Placentoceras intercalare* Meek from this locality.

CSC-Kp 36: T35N, R48W, Sec. 26 ac to ba; Isinglass Buttes Quadrangle; average elevation c. 3270 ft. This sequence of outcrops comprises, for the most part, shale breaks along the northwestern to northeastern sides of a spur that trends north-northwest and is located a few 100 m south of Alkali Creek. Sparsely to abundantly fossiliferous concretions are exposed at several levels through a stratigraphic thickness of about 10 to 15 m along an outcrop width of a few 100 m. *Baculites compressus* and *Jeletzkyites nodosus* are relatively abundant and often well preserved at this locality. One *B. compressus* embryonic shell was discovered here.

CSC-Kp 37: T35N, R48W, Sec. 23ac; Isinglass Buttes Quadrangle; average elevation c. 3250 ft. This sequence of outcrops consists chiefly of the moderately steep, rather sparsely grassed shale flanks of two southeast-trending spurs a few 100 m north of Alkali Creek. Sparsely to abundantly fossiliferous concretions are

exposed at several levels through a stratigraphic thickness of 10 to 20 m and along an outcrop width of a few 100 m. This is the northernmost occurrence of the fossiliferous horizon in Dawes County. This locality is the same as USGS Mesozoic localities D223 and D224. Dunham (p. 49) reported collecting *Baculites compressus*, *B. corrugatus*, *B. n. sp.*, and *Acanthoscaphites brevis*, *A. cf. A. quadrangularis*, *Eutrephoceras montanense*, *Solenoceras meekianum*, and *Didymoceras ? cheyennense* from D223 and D224. Apparently both microconchs and macroconchs of *Jeletzkyites nodosus* occur at this locality because mature conchs range in diameter from about 60 to 100 mm.

CSC-Kp 38: T34N, R48W, Sec. 24da; Isinglass Buttes Quadrangle; average elevation c. 3240 ft. This outcrop comprises a moderately steep, southwest-facing shale slope northeast of a small intermittent creek. Sparsely to moderately fossiliferous concretions are exposed at several levels through a stratigraphic thickness of 10 to 15 m and along the outcrop for more than 100 m. This locality presumably is the same as USGS Mesozoic locality D217. Dunham (p. 50) reported collecting *Baculites* sp. and *Acanthoscaphites* sp. from this general location.

CSC-Kp 39: T34N, R48W, Sec. 36ad; Isinglass Buttes Quadrangle; average elevation c. 3310 ft. This is a relatively restricted outcrop located just east of a fairly large stock reservoir. Sparsely to moderately fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of less than 5 m and along the outcrop for less than 50 m. Individual exposed concretions typically are much less than 1 m thick and/or across. The locality likely is the same as USGS Mesozoic locality D216. Dunham (p. 50) recorded collecting *Baculites* sp. and *Didymoceras ? sp.* at D216.

CSC-Kp 40: T35N, R48W, Sec. 35aa; Isinglass Buttes Quadrangle; average elevation c. 3230 ft. The principal portion of this outcrop constitutes gentle, moderately grassed shale slopes on the northeastern to southwestern flanks of a small, southeast-trending spur a few hundred meters south-southeast of a stock reservoir. Sparsely to moderately fossiliferous concretions are exposed at a several levels through a stratigraphic thickness of 5 to 15 m and along an outcrop width of a few 100 m. This locality is the same as USGS Mesozoic locality D218, from which Dunham (p. 49) reported collecting *Baculites corrugatus* and *Placentoceras meeki*.

CSC-Kp 41: T35N, R48W, Sec. 26dd; Isinglass Buttes Quadrangle; average elevation c. 3250 ft. This outcrop comprises gentle, moderately grassed shale slopes along the western flank of a south-southwest-trending spur a few 100 m north and across a stream

valley from locality CSC-Kp 40. Sparsely to moderately fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of 10 to 15 m and along an outcrop width of about 300 m.

CSC-Kp 42: T35N, R48W, Sec. 26ad; Isinglass Buttes Quadrangle; average elevation c. 3260 ft. The outcrop comprises gentle, moderately grassed shale slopes that extend around especially the northern flanks of a northwest-trending spur along the south side of Alkali Creek. Sparsely to abundantly fossiliferous concretions are intermittently exposed at several levels through a stratigraphic thickness of 10 to 20 m and sporadically along an outcrop width of nearly a km. One well-preserved *Jeletzkyites nodosus* macroconch from this site has a diameter of nearly 100 mm.

CSC-Kp 43: T35N, R48W, Sec. 26ac; Isinglass Buttes Quadrangle; average elevation c. 3250 ft. This outcrop consists of gentle, moderately grassed shale slopes around the northwestern periphery of a relatively small northwest-trending spur that lies between CSC-Kp 36 and CSC-Kp 42. Sparsely to abundantly fossiliferous concretions are exposed at several levels through a stratigraphic thickness of 10 to 20 m and along an outcrop width of about 300 m.

CSC-Kp 44: T35N, R48 W., Sec. 25cd; Isinglass Buttes Quadrangle; average elevation c. 3230 ft. This outcrop constitutes moderately steep, partly grassed shale slopes primarily along the northeast flank of a southeast-trending spur (the southeastern extension of CSC-Kp 42). Sparsely to moderately fossiliferous concretions are exposed at a few levels through a stratigraphic thickness of 10 to 15 m and along an outcrop width of nearly 400 m.

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