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The Cretaceous basal conglomerate in Kansas

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The basal Cretaceous conglomerate, consisting of material derived from the east and northeast, was deposited by westward flowing streams on an eroded surface of Paleozoic rocks. The unnamed stratigraphic unit, composed of pebble- and cobble-size material, is exposed locally along the outcrop belt from Clay County southwestward to Kiowa County.

Key Words: sub-Cretaceous unconformity, Western Interior Seaway, central Kansas, basal conglomerate

INTRODUCTION

In east-central Kansas a conglomerate occurs at the base of the Cretaceous that oversteps the old pre-Cretaceous erosional surface. The conglomerate is present locally in the lower part of the Cheyenne Sandstone, Kiowa Shale, or Dakota Sandstone, which ever unit is in contact with the underlying erosional surface. The unit is known most from exposures on outcrop and mainly from descriptions in Clay, Rice, and Kiowa counties where it is best displayed. Merriam (1957) shows no conglomerate in the Cretaceous basal beds in a series of detailed cross sections in western Kansas.

The conglomerate, because it is not conspicuous, has received little or no attention from stratigraphers or field mappers through the years, with exception of a few counties that have been mapped for groundwater studies. Because it is discontinuous and present only locally, it has not been classified stratigraphically nor named. The unit is not listed in the Lexicon (Baars and Maples, 1998), nor identified by Bayne and Ward (1974) in their study of the geology and hydrology of Rice County. It is recognized, but not designated as such, on the stratigraphic charts by Jewett (1959) and later ones. It is mentioned as a zone of pebbles and cobbles at the base of the Cretaceous in Kansas Geological Survey Bulletins 52 (Moore, Frye, and Jewett, 1944), 89 (Moore and others, 1951), and 189 (Zeller, 1968). Merriam (1963) was a little more generous in his description of the conglomerate and included two pictures of it in Rice County.

Previous Work

The conglomerate has been reported in Clay (Plummer and Romary, 1942; Walters and Bayne, 1959), Ellsworth (Bayne, Franks, and Ives, 1971), Johnson (O'Connor, 1971), Kiowa (Latta, 1946, 1948), Ottawa (Mack, 1962), and Rice (Merriam, 1963; Bayne and Ward, 1974) counties (see the Appendix). Although it occurs widely in the Midcontinent, the conglomerate is present only locally in Kansas (Fig. 1). It also is present in Nebraska (Condra and Reed, 1943), Illinois (Willman and others, 1975), and Iowa (Witzke and Ludvigson, 1996; Brenner and others, 2003).

Mack (1962, p. 15) noted that a cobble zone occurred at the base of the Cretaceous on the eroded Permian surface at most places in Ottawa County. However, none of his sections or logs describe the unit. This zone occurs at the base of the Kiowa or Dakota in Cloud County (Bayne and Walters, 1959, p. 57) where it is as much as 3 feet thick and consists of polished pebbles and cobbles of

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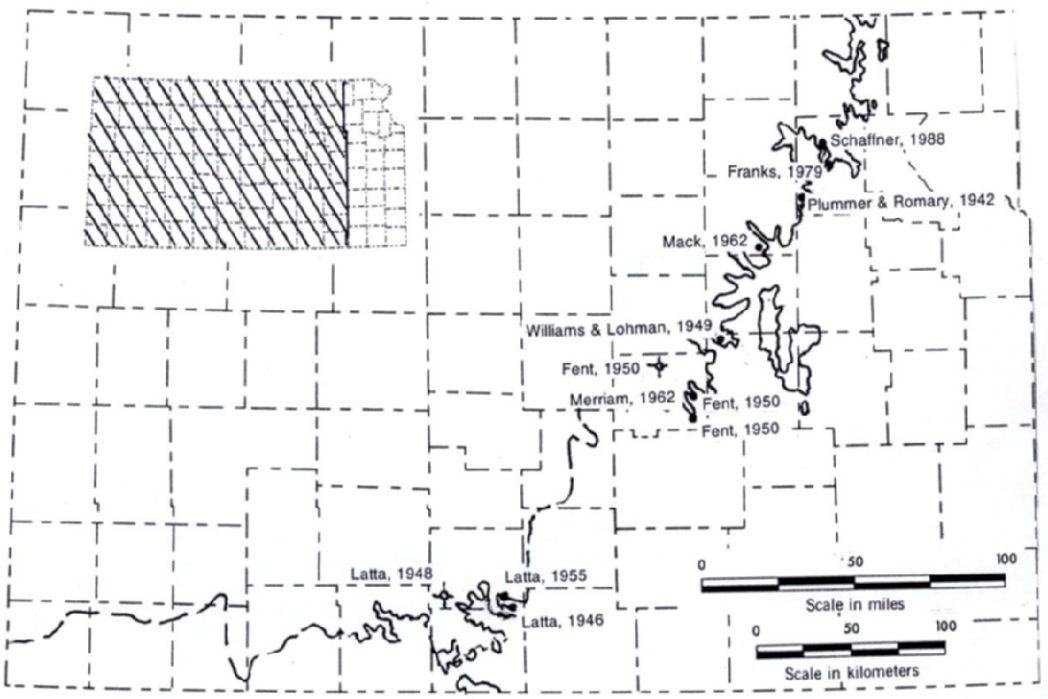

Figure 1. Location map of surface measured sections (•) of Cretaceous basal conglomerate and test wells (dry well symbol) that encountered the conglomerate in the western part of Kansas with references.

quartzite, chert, and quartz embedded in sand and clay. Two surface sections measured byBruce Latta in Kiowa County were included in the 1955 Kansas Geological Society Guidebook (p. 32 and 47). The sections show a cross-bedded conglomerate of weathered chert and quartz in a matrix of loosely cemented fine to coarse sand up to 45 feet thick.

In a paleogeomorphic study of the sub-Mesozoic and sub-Cretaceous unconformities in Kansas, Schuman (1963) noted the conglomerate consisted of igneous, metamorphic, and sedimentary rocks with chert and quartzite predominating; he also noted that chert comprised about 90% of the material in the conglomerate. Others recorded the same composition with minor amounts of limestone and added that the pebbles or cobbles up to 3 inches in diameter were polished and well rounded (Plummer and Romary, 1942). They concluded the material was a residual deposit on the Permian surface prior to the encroachment by the Cretaceous sea.

Gould reports that there is about 80 ft relief on the pre-Cretaceous surface in the Platte River Valley of east-central Nebraska, Greene (1909) noted about 100 feet of relief in northern Kansas, but Witzke and Ludvigson (1996) report up to 80 meters (285 ft) of relief in Guthrie County, Iowa. Merriam (1963, p. 67) mapped north-trending valleys on the sub-Cretaceous surface in Kansas indicating the same amount of relief as noted on the surface. As the irregular surface filled with sediments, first the Cheyenne Sandstone and then the Kiowa Shale, the irregularities in the seafloor gradually filled and the sea bottom by Dakota time became more even.

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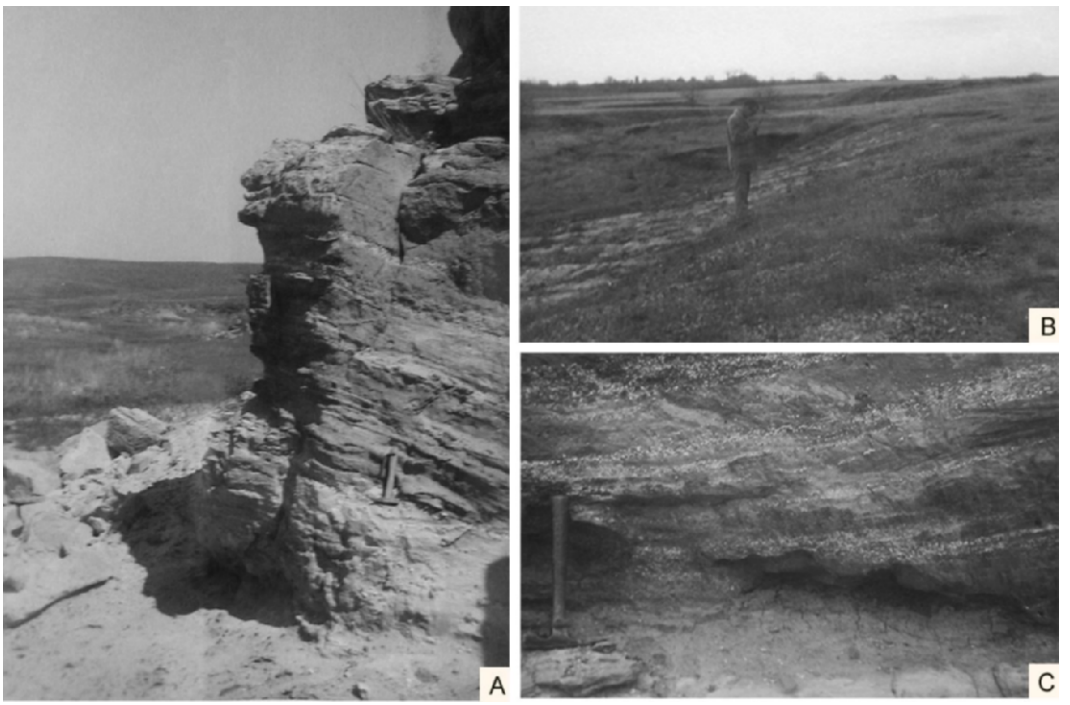

Figure 2. A, Cretaceous basal conglomerate in Cheyenne Sandstone overlying Permian redbeds at Champion Draw south of Belvidere, Kiowa County; B, basal conglomerate exposed in Rice County (SW¼ Sec. 32, T32S, R6W); C, close up of basal conglomerate at Champion Draw.

Extent and Conditions of the Old Western Interior Seaway

There are numerous small outcrops of Cretaceous to the east of the main outcrop belt across the central part of the state (Fig. 2). Outliers of the Cretaceous tens of miles from the nearest outcrops, indicates that the Western Interior Sea and the material deposited in the seaway covered a larger area than present-day outcrops suggest. The conglomerate outlier in Johnson County is at least 130 miles east of the nearest Cretaceous outcrop gives a hint as to the amount of material that has been removed since deposition of Cretaceous sediments.

Gastroliths have been reported in the Cretaceous beds. Everhart (2005a, 2005b, p. 136) reports the occurrence of gastroliths (stomach stones) used by plesiosaurs and other sea-faring animals far from the shore to the west in the deeper part of the old Western Interior Sea; the animals must have picked them up in shallow waters. The gastroliths occur in Cretaceous beds as young as the Pierre Shale (Everhart, 2000). The pebbles and cobbles, consistent with the size that occur in river gravel, usually are composed of quartzite, quartz, or chert pebbles with some granite, basalt, or other igneous rocks included. Although most of the clasts are pea-size or smaller, they have been recorded as large as 17 cm (7 in) in length and weighing up to 1.4 kg (3 lb). Although there is some discussion of where they came from, for example, quartzite from Iowa or South Dakota or granite from the Quachita Mountains in Arkansas or Black Hills in South Dakota, they had to be scavenged from nearshore or on shore. This is the same material that makes up the basal Cretaceous conglomerate.

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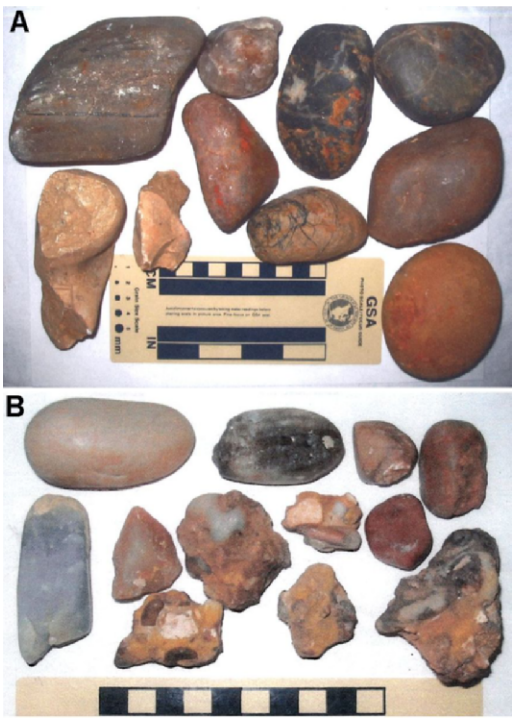

Figure 3. A, Pebbles and cobbles of quartz with exception of two pieces of local Permian chert (lower left) from the Cretaceous basal conglomerate in Clay County (SE¼ Sec. 9 and NW 15, T10S, R1E); B, basal Cretaceous pebbles and cobbles of quartz from Rice County (SW¼ Sec. 32, T19S, R6W; Fig. 2C). Some of the pebbles are cemented (lower left).

Composition of the Conglomerate

A field check was made in October of 1999 to two of the conglomerate localities described in the literature (Clay County and Rice County). The Clay County locality consists of well-rounded igneous and metamorphic pebbles and cobbles of mostly quartz with little observed chert (Fig. 3A). The Rice County conglomerate is a mixture of igneous and metamorphic pebbles with chert (Fig. 3B). This chert does not resemble the Permian chert-bearing units to the east. These clasts were not, or only loosely, cemented in a sandy, ferruginous clay matrix and weathered out covering the slope. Nothing resembling the high-level chert gravel deposits farther east were noted at either locality. It may be that these clasts were derived from elsewhere and that the Permian cherts did not travel far downslope to the west of the then outcropping units.

O'Connor (1971, p. 27) reported gravel of possible Cretaceous age in central Johnson County in the northeastern part of the state. (The Johnson County locality could not be located in 2002.) He noted the conglomerate consisted of scattered rounded pebbles and cobbles of quartz, quartzite, and subrounded chert which is lithologically similar to similar deposits in north-central Kansas. In addition there are subangular pebbles and cobbles of ferruginous conglomeratic sandstone similar to those in Saline County but distinctively different from Pennsylvanian sandstone in eastern Kansas (O'Connor, 1971, p. 28).

From these brief descriptions of the conglomerate, it would seem that the chert in the conglomerate was derived from the Permian chert-bearing limestones exposed now in the Flint Hills of central Kansas. In early Cretaceous time, the chert-bearing limestones must have been exposed farther east making them a good source of material until they were eroded westward and down dip to their present condition and location. It would seem logical to assume that these limestones must have been a source of chert since the Permian right up until now.

Aber (1994) in mapping Butler County, which is located just to the west of the Flint Hills, noted many deposits of the residual chert in the southern part of the county. Merriam and Harbaugh (2004) described similar deposits to the east of the Flint Hills that are Plio-Pleistocene in age. Moore, Jewett, and O'Connor (1951) mapped Quaternary and Tertiary gravel units in Chase County west of the Flint Hills, no doubt the chert deposits had been transported downslope from the

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higher part of the hills located to the east. Lag gravels similar to these on the old erosional surface must have been reworked by the advancing Cretaceous sea and locally incorporated into the basal Cretaceous.

Origin of Material

Frank's work (1979) in Clay County did not give any hint as to the origin or emplacement of the conglomerate in the Longford Member of the Kiowa Formation, which is the basal Cretaceous unit in north-central Kansas. The conglomerate seems to be located at the eastern margin of the Western Interior Sea along the old shoreline. O'Connor (1971) suggested, based on the work of Frye and Leonard (1952), the source of material was from the north and east. Moore and others (1951, p. 28) also suggested, based on composition of the material, the source was from the northeast.

Paul Franks and others (1959) made a study of the cross-stratified Dakota sandstone in Ottawa County in north-central Kansas. Dip bearings in these water-laid deposits in general indicate the transportation of the material was from northeast to southwest. This would put the source of the material to the northeast as surmised by other workers including Howard O'Connor, John Frye and Bryon Leonard, and R.C. Moore and coworkers.

Gould (1901, p. 147) in his description of the Dakota of Nebraska notes gravel beds at the base of the Dakota along the Platte River at Cedar Creek and Springfield. The gravel beds are composed of '...an extremely hard conglomerate, arranged in layers, which are usually cross-bedded and interspersed between ledges of pebbles of quartz, feldspar, granite, etc., varying in size from fine sand to the size of a walnut. These pebbles are cemented together by silicon into a rock which is so hard as to be broken with great difficulty.' Gould interpreted these beds as part of an ancient Dakota river system with the cross-bedding usually inclined toward the southwest indicating a northeast source for the material.

A conglomerate supposedly of Cretaceous age occurs in southwestern Iowa (Hershey and others, 1960). A similar conglomerate at the base of Cretaceous rocks has been reported in Guthrie County, Iowa (Witzke and Ludvigson, 1996, p. 42-48). The clasts are dominated by chert and quartz pebbles up to 2 cm in diameter but include cobbles up to 10 cm in diameter. The pebbles and cobbles with southeast-dipping cross-stratification are comprised of Paleozoic material as determined from the fossil content of the clasts. It is obvious from all these occurrences that the advancing Cretaceous sea incorporated the weathered and eroded material on the old Paleozoic surface into the lower part of the section.

Summary

The origin of the basal conglomerate was through a complex river system that drained the area east and northeast of the old Cretaceous inland seaway. Most of the material, as noted by its composition and size, must have been transported a considerable distance, maybe tens or hundreds of kilometers. This coarse material on the old erosion surface was incorporated into the advancing sea along with the finer material along the shoreline. Because of the irregular nature of the surface on which the gravel was deposited, it was incorporated into the lowest sediments and preserved only locally. This scenario was well presented verbally and graphically by Brenner and others (2003).

Acknowledgements

I would like to thank Pieter Berendsen for identifying and verifying my designations of the pebble/cobble conglomerate material; James Aber and Mike Everhart provided thoughtful reviews; and Janice Sorensen, as

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usual, located and provided information on relevant publications.

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APPENDIX

Clay County

The pebbles at base of Cretaceous (SE ¼ Sec. 9, T10S, R1E) are well rounded and in some places polished pebbles and cobbles up to 3 inches in diameter. Consist of quartzite, chert, and rarely limestone. May be residual on Permian surface prior to invasion of Cretaceous sea (Plummer and Romary, 1942). Cobble zone at base of Dakota Formation consists of quartzite, chert, igneous rocks and many types of metamorphic rocks resting on the Permian Wellington Formation (Walters and Bayne, 1959). Franks (1979, p. 8) notes that pebbles and granules of chert, silica-cemented sandstone, quartzite, and "vein" or pegmatitic quartz are concentrated in the basal parts of the Cretaceous units above the [Permian] unconformity in many places (e.g. NW ¼ Sec. 27, T8S, R2E). Schaffner (1938) describes finely polished pebbles of quartz, chert, and sandstone up to 3 inches in diameter in Clay County (SE ¼ Sec. 19, T7S, R2E and 20 same township). He attributes them to be gastroliths.

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My collection of material from Clay County (SE ¼ Sec. 9 and NW ¼ Sec. 15, T10S, R1E) consisted mostly of rounded and polished quartzite and quartz with as much as one-third of the material chert. The largest quartzite was 5 inches in length. Pieter Berendsen suggested the source for this material was probably in Nebraska and/or South Dakota. No easily identifiable Sioux Quartzite from the South Dakota area was in the samples.

Dickinson County
Mike Everhart (pers. comm., 2007) collected pebbles and cobbles at base of Dakota along with fossil wood at an outcrop in the NE ¼ Sec. 25, T16S, R1E. This outcrop was described by Walter Schoewe in Kansas Geological Survey Bull. 96, pt. 2 (1962), but made no mention of a basal conglomerate.

Ellsworth County
The Permian/Cretaceous surface has as much as 50 feet of topographic relief in central Kansas. The unconformity is marked by a conglomerate of chert and quartzite pebbles measuring up to 3 inches at the base of the Kiowa Shale (Bayne, Franks, and Ives, 1971, p. 7).

Johnson County
An outlier of Cretaceous conglomerate was described by Howard O'Connor in his study of the county (NW¼ SE¼ Sec. 30, T14S, R23E) at an elevation of 1040 ft in a new roadcut along Interstate 35. He determined the scattered pebbles and cobbles of dark quartz, quartzite, and subrounded chert (similar to conglomerate in north-central Kansas) in a ferruginous matrix developed on the Pennsylvanian Weston Shale is not of glacial origin and can not be attributed to Tertiary or Pleistocene stream deposits (O'Connor, 1971).

Kiowa County
Lenses of pebble conglomerate at or near the base of the Cheyenne Sandstone of red, gray, and clear quartz and weathered white to gray chert in a matrix of fine to coarse quartz sand (Latta, 1946, 1948). Chert pebbles are subangular to subrounded and quartz pebbles are subround to well rounded. Pebble range from about 2mm to 10 mm in diameter. Thickness ranges from a few inches to a foot; thickest section in SW¼ Sec. 26, T30S, R16W. Conglomerate occurs in the Champion Draw section (SE¼ Sec. 9, T30S, R16W).

McPherson County
Conglomerate 1 to 2 feet thick at base of Cretaceous with pebbles and cobbles of chert or resistant igneous rock 1 to 3 inches in diameter. On Ninnescah Shale (SW¼ Sec. 2, T17S, R5W) (Williams and Lohman, 1949, p. 51-52).

Ottawa County
A course conglomerate and sandstone 5 feet thick at the base of the Dakota Formation overlies an uneven surface on the Kiowa Shale (NE¼ NE¼ NW¼ Sec.19, T12S, R2W) (Mack, 1962, p. 26).

Rice County
Pebble and cobbles of conglomerate consisting of igneous and metamorphic rocks and chert (SW¼ Sec. 32, T19S, R6W) (Merriam 1963, p. 65). This locality also was Stop 1 on a Dakota field trip (Feldman, 1994). Cobbles are also present on weathered slopes (Sec. 27, 28, 34, and 35, T20S, R6W) on Permian (Fent, 1950). My collection from Rice County consisted of about one-fourth angular chert and three-fourths rounded, smooth quartz and quartzite. Much of the quartz is milky. Some of the material is cemented. Overall the material is smaller in size than that from Clay County.

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