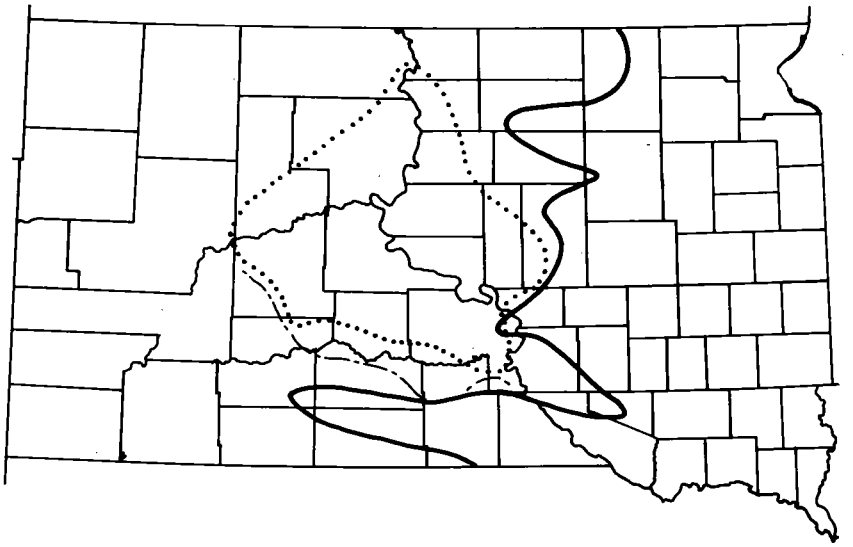
South Dakota Reprint
No. 5

THE DAKOTA FORMATION OF SOUTH DAKOTA

by Robert A. Schoon



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1965

DAKOTA FORMATION OF SOUTH DAKOTA [1]

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In 1861 Meek and Hayden applied the term Dakota Group (formerly Formation #1 of the Cretaceous) to a 400-foot sequence of yellowish, reddish, and occasionally white sandstone with local alternations of varicolored shales and lignite beds. The above sequence was described from outcrops in the hills near the town of Dakota (now Dakota City), Nebraska, and is developed extensively in Dakota County, Nebraska. Meek and Hayden also stated that this group "underlies the Fort Benton Group, of which it may be only a member."

It is interesting to note that as early as 1853, when this unit was originally described, Meek and Hayden must have possessed subsurface information because they gave the thickness as 400 feet. A century later in 1959 (p. 18-19), G. E. Condra and E. C. Reed gave the thickness of this sandshale sequence as 392 feet. In 1961 the South Dakota Geological Survey #1 Huebner Precambrian test, approximately 35 miles northwest of the Dakota type area (SW NW 25-93N-50W) penetrated exactly 400 feet of Dakota Sandstone.

The unavailability of older publications makes it difficult to ascertain when the term Dakota was first employed in the Black Hills area. In 1880 Newton (Newton and Jenney, p. 176-180) used the term Dakota to describe rocks in the Black Hills which are now known as the Inyan Kara Group. Darton (1909, p. 20) applied the term Dakota to the uppermost member of the series formerly designated "Dakota sandstone" of the Black Hills region. Later writers, notably Russell (1928) and Gries (1954, 1958, 1962), did much to disprove the misconception of earlier authors and clarify relationships between western and eastern South Dakota. To the present time, the South Dakota Geological Survey has used a dual nomenclature in correlating equivalent rock stratigraphic units across the State (Agnew and Tychsen, 1965). The nomenclature is as follows:

	Black Hills	
	"Newcastle" Sandstone	
	Skull Creek Shale	
	Fall River Sandstone	
Inyan Kara Group	Lakota Formation Central South Dakota "Newcastle" sand	
Dakota Group undifferentiated	Skull Creek Shale Dakota sands and shales	where recognizable

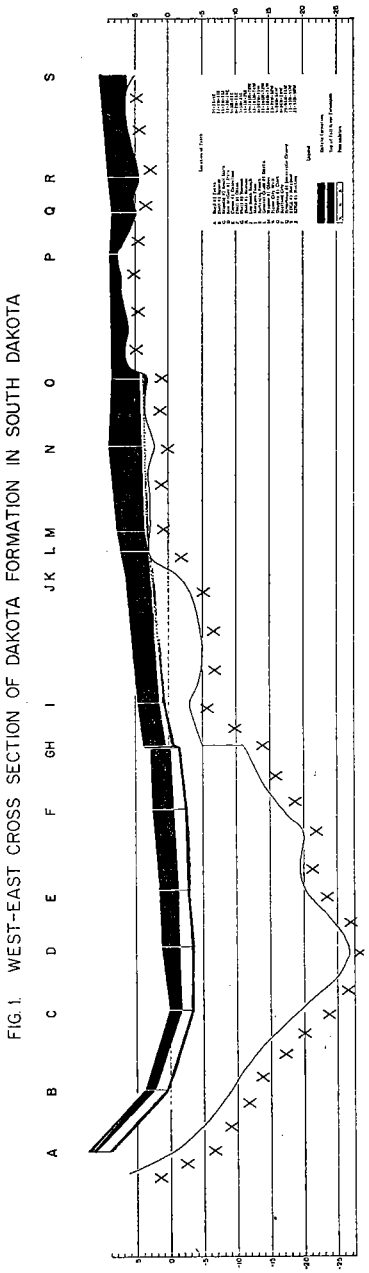

FIG. 1. WEST-EAST CROSS SECTION OF DAKOTA FORMATION IN SOUTH DAKOTA

From Figure 1 it is apparent that the Fall River-Skull Creek interval either feathered out onto the Precambrian high in the eastern part of the State, or was deposited and subsequently eroded prior to deposition of the Dakota Formation. It is believed that the former condition is the more tenable. However, if the feathering out onto the Precambrian high is not the condition in all instances, then it is logical to assume that as the sea regressed prior to deposition of the Dakota Formation, the loosely cemented sandstone and shale cover on the Precambrian highlands was exposed, rapidly eroded, and the higher elevations denuded. (See General Crude #1 Straka.) It appears, however, that at the lower elevations, remnants of Skull Creek Shale and possibly Fall River Sandstone are present. (See Wagner #1 Glaus, and Douglas #1 Clark.) Regardless of the above discussion, the Skull Creek Shale or Fall River Sandstone do not appear in tests east of the Douglas #1 Clark oil test.

Two general beliefs concerning the deposition of the Dakota sediments are: (1) the source area was to the east of South Dakota; and (2) the sediments represent a deltaic deposit. A longitudinal cross section of an ideal delta appears as a modified lens-shaped body. The maximum thickness occurs at the juncture of the subaqueous plain and the fore-set slope. However, it must be remembered this represents a delta built under static sea level conditions. During Dakota time the seas transgressed eastward and therefore the delta building processes migrated eastward also. Deltas were built upon deltas with a possible net increase in thickness eastward. In the Black Hills area the interval occupied by the Dakota Formation thickens from about 200 feet to 275 feet in Haakon County to 300 feet in Jones County and to 400 feet in Lyman County. In view of this progressive eastward thickening, it is not necessary to include the Fall River Sandstone to make up any part of the 400-foot section of sandstone at the Dakota type area.

The Newcastle Sandstone was named by Hancock (1920) for outcrops near Newcastle, and subsurface rocks in Mule Creek oil field in Wyoming. As described by Hancock, the Newcastle Sandstone undoubtedly represents the basal sand of the Dakota Formation that overlies the Skull Creek Shale in the Black Hills area. The Newcastle Sandstone becomes younger in an eastward direction, but it retains its stratigraphic relationship with the Skull Creek Shale. In central South Dakota it represents the lower part of the Dakota Formation, and the Mowry sands (recognizable farther west) are equivalent to the upper part of the Dakota. The dual nomenclature now employed by the Survey is believed untenable for the following reason. If the entire Dakota Group is represented by recognizable "Newcastle" Sandstone and Skull Creek Shale in the central part of the State, then either (1) the Mowry sands are not present in the central part of the State (which they are), or (2) the Newcastle

Sandstone can be differentiated from the Mowry sands in the central part of the State (which at present are not differentiated). In effect, it would then be permissable to call the Mowry sands farther west the "Newcastle" Sandstone. However, this would violate the original description of the Newcastle Sandstone. Hancock defined the Newcastle Sandstone as overlying 175 feet of shale (now called Skull Creek Shale) and underlying about 50 feet of shale that merges upward into the typical Mowry Shale.

From Figure 1 it appears that the sandstone interval called Dakota at the type area in northeastern Nebraska can be correlated with sandstones in central South Dakota that would be called "Newcastle" sand if the present dual nomenclature were used. Therefore, it is desirable to refer to the sandstone sequence in the central part of the State as the Dakota Formation for the following reasons.

(1) In Meek and Hayden's original description, the Dakota Formation was not restricted in the sense that it underlies the Mowry Shale or overlies the Skull Creek Shale. Hancock (1920, p. 39 and 96) defined the Newcastle as underlying the Mowry Shale and separated from what is now known as the Fall River Sandstone by 175 feet of shale (Skull Creek Shale).

(2) If the term "Newcastle" sand is employed to describe sediments in the central part of the State that are equivalent to the sandstone sequence of the Dakota type area, then the term Newcastle replaces the term Dakota. However, for one term of a given unit to have preference over another term for the same unit, according to the Code of Stratigraphic Nomenclature, Article 11, Remark (a), and Article 13, Remark (g), the original or first term should be given priority.

(3) Article 11, Remark (b) of the Code states, "A name that has become well established should not be displaced, merely on account of priority by one not well known." In this case the term Dakota would be displaced by a term which does not have priority although they are both well known and established in the literature.

In view of the foregoing, it is suggested that (1) the term Dakota Group as described by Meek and Hayden be lowered to rank of formation and include the entire sequence of sand overlying the Skull Creek Shale, and underlying and interfingering with the Mowry Shale in western and central South Dakota, and interfingering with the Mowry and/or younger sediments in eastern South Dakota (Fig. 2); and (2) the term Newcastle Sandstone be retained and recognized as the lowest sandstone tongue of the Dakota Formation, and be lowered to the rank of member until additional information and study permit all units of the Dakota to be formally named.

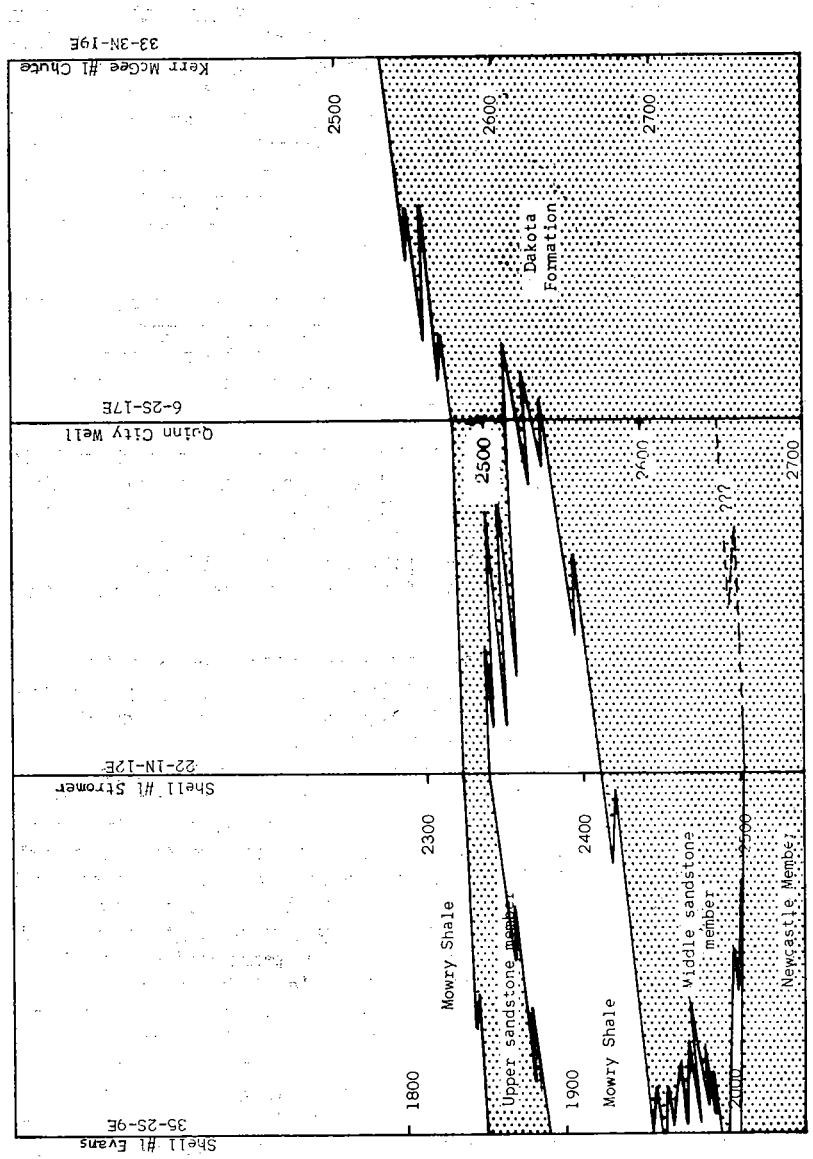

Figure 2. Stratigraphic relationships in Dakota Formation of western South Dakota
Datum Base of Dakota Formation

It is agreed that the Newcastle Sandstone is a mappable unit in the western part of South Dakota. Although all members of a formation may be locally mappable, it does not follow that they should be raised to formational rank. Multiplicity of formation names may obscure rather than clarify relationships with other areas (Code of Stratigraphic Nomenclature, Article 7, Remark [b]). In central South Dakota it is believed that to apply the terms "Newcastle" sand and Skull Creek Shale (where both units are recognizable) to constitute the Dakota Group is an unnecessary complication of relationship that exist within the Dakota Formation.

It is also apparent that the Dakota Formation contains at least two unnamed units in western South Dakota, and perhaps three unnamed units in the eastern part of the State. For the present, therefore, the Dakota should remain of formational rank, because a group unit may contain no unnamed formations.

Defined in this manner the Dakota Formation would include the Newcastle Sandstone, a middle and an upper sandstone member which, as suggested by Roadifer (1962), may be equivalent to the Gurley or the "D" and "G" sandstones of Nebraska. However, before the units are formally named, the equivalents should be established, and thus preclude the possibility of cluttering the literature with unneeded names.

Previous authors (Wing, 1938; Erickson, 1954; Gries, 1958, 1962, and possibly others) have discussed the occurrence of gas in the Dakota Formation in central South Dakota. Preliminary studies of water temperature variations in this formation give interesting though possibly not pertinent correlations. Figure 3 (after Gries, 1962) shows that the southern boundary of the gas area passes through Jackson, Jones, Lyman, and Tripp Counties. A line constructed to connect maximum water temperatures passes through Jackson, Washabaugh, Mellette, Tripp, and Lyman Counties, and has a configuration similar to that of the southern boundary of the gas area. The significance of this similarity is not fully understood, but may be related to several factors. The temperature gradient does not appear to be entirely governed by depth because the temperatures in Jackson and southern Haakon Counties are higher than those for the Dakota water farther north where the formation occurs at greater depth. This condition may be a result of gas being evolved within the Dakota Formation. If so, one would expect higher temperatures in all parts of the gas area. This is not the case. This phenomenon may also be related to structural adjustments occurring in west-central South Dakota, or it may be possible that gas migrates under the Skull Creek Shale, or older rocks, escapes to, and is dissolved in the Dakota waters, thus giving off heat in the process. Because temperature measurements are scarce, any conclusions drawn at this time are at best hypothetical. If, for example,

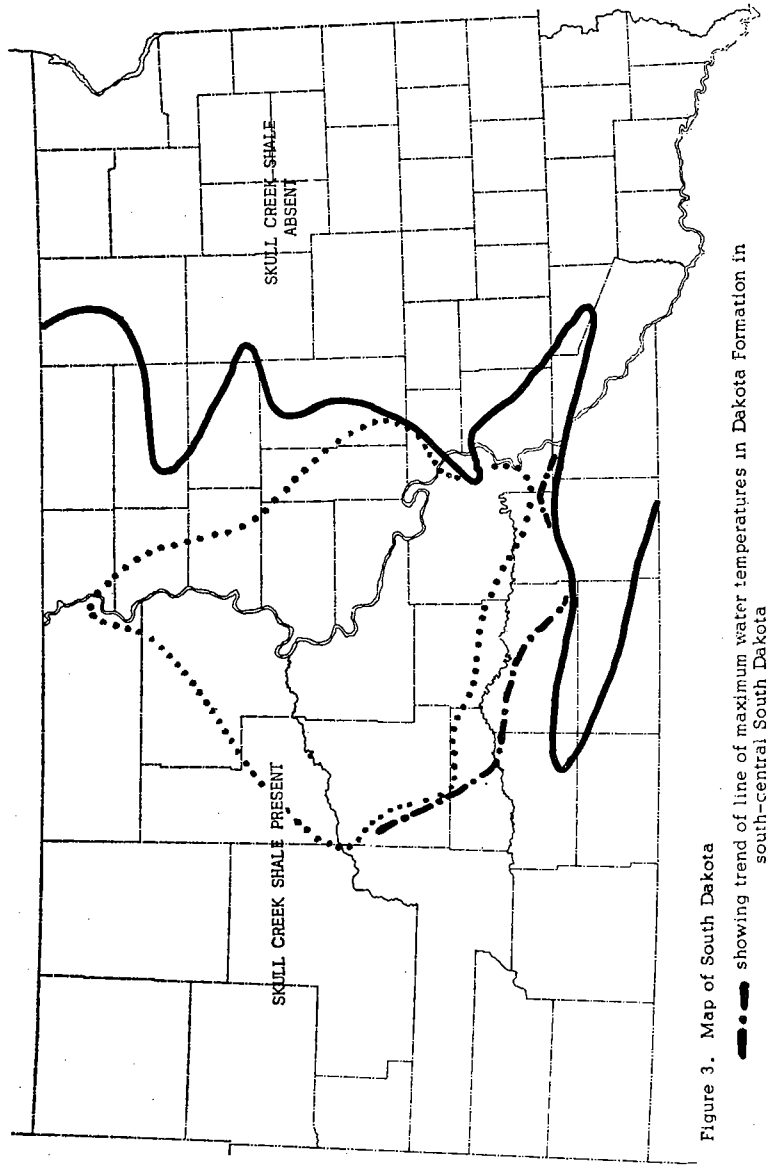

Figure 3. Map of South Dakota

either of the last two systems is at work, then a number of interesting possibilities follows. (1) The Skull Creek Shale feathers out from north to south at a point near the line of maximum temperatures. (2) The line of maximum temperatures represents an area of structural adjustment of sufficient magnitude to allow gas or warmer water to escape through fractures in the Skull Creek into the Dakota Formation. Or (3) a combination of the two. Certainly the possibility of stratigraphic traps to the west and structural traps in the Dakota Formation of south-central South Dakota should not be overlooked. If the Skull Creek does feather out from north to south as suggested above, then the eastern limit of the Skull Creek Shale in the south-central part of the State is much farther west than heretofore believed, and appears as drawn in **Figure 3.**

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