POST-CRETACEOUS UPLIFT OF THE SIOUX QUARTZITE RIDGE IN SOUTHEASTERN SOUTH DAKOTA

By Neil C. Koch

U.S. GEOLOGICAL SURVEY

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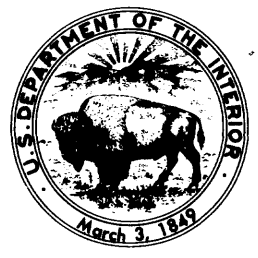

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UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric (SI) units by the following conversion factors:

Multiply inch-pound unit	By	To obtain SI unit
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer

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ABSTRACT

Evidence of a post-Cretaceous uplift of the Sioux Quartzite ridge in southeastern South Dakota consists of deformation of the Dakota Formation, Graneros Shale, Greenhorn Limestone, Carlile Shale, and Niobrara Formation of Cretaceous age. The Greenhorn is warped upward about 400 feet on the Sioux Quartzite with a formation dip ranging from 30 to 50 feet per mile. Elsewhere in eastern South Dakota the dip of the Greenhorn ranges from 3 to 8 feet per mile.

INTRODUCTION

During the Late Creataceous-early Tertiary Rocky Mountain orogeny, several isolated areas in the plains to the east were subjected to uplift. The most notable uplift is the Black Hills which included the intrusion of Tertiary igneous rocks. Deformation also resulted in the Central Kansas uplift and the Nemaha uplift in southeastern Nebraska and western Iowa (Bunker, 1981). Although there is no evidence of Tertiary intrusives in southeastern South Dakota, there is stratigraphic evidence to support the presence of a post-Cretaceous uplift.

The purpose of this report is to present evidence that a post-Cretaceous uplift occurred in southeastern South Dakota.

TECTONIC SETTING

Although the interior of North America is commonly referred to as tectonically stable, the area has actually been subjected to episodic tectonism from Precambrian to present. The most recent major tectonism occurred about 60 million years ago during early Tertiary time when the Black Hills in western South Dakota and Wyoming began rising (fig. 1). The cause of the Black Hills uplift is poorly understood; however, the contributing forces operated within or below the Precambrian crystalline rocks. The only igneous intrusives of Tertiary age in South Dakota are, in the northern Black Hills, trending in a N. 74° W. direction. Redden (U.S. Geological Survey and U.S. Bureau of Reclamation, 1975) pointed out that the Tertiary igneous rocks in the northern Black Hills are in line with the Nye-Bowler fault zone to the northwest in south-central Montana (fig. 1).

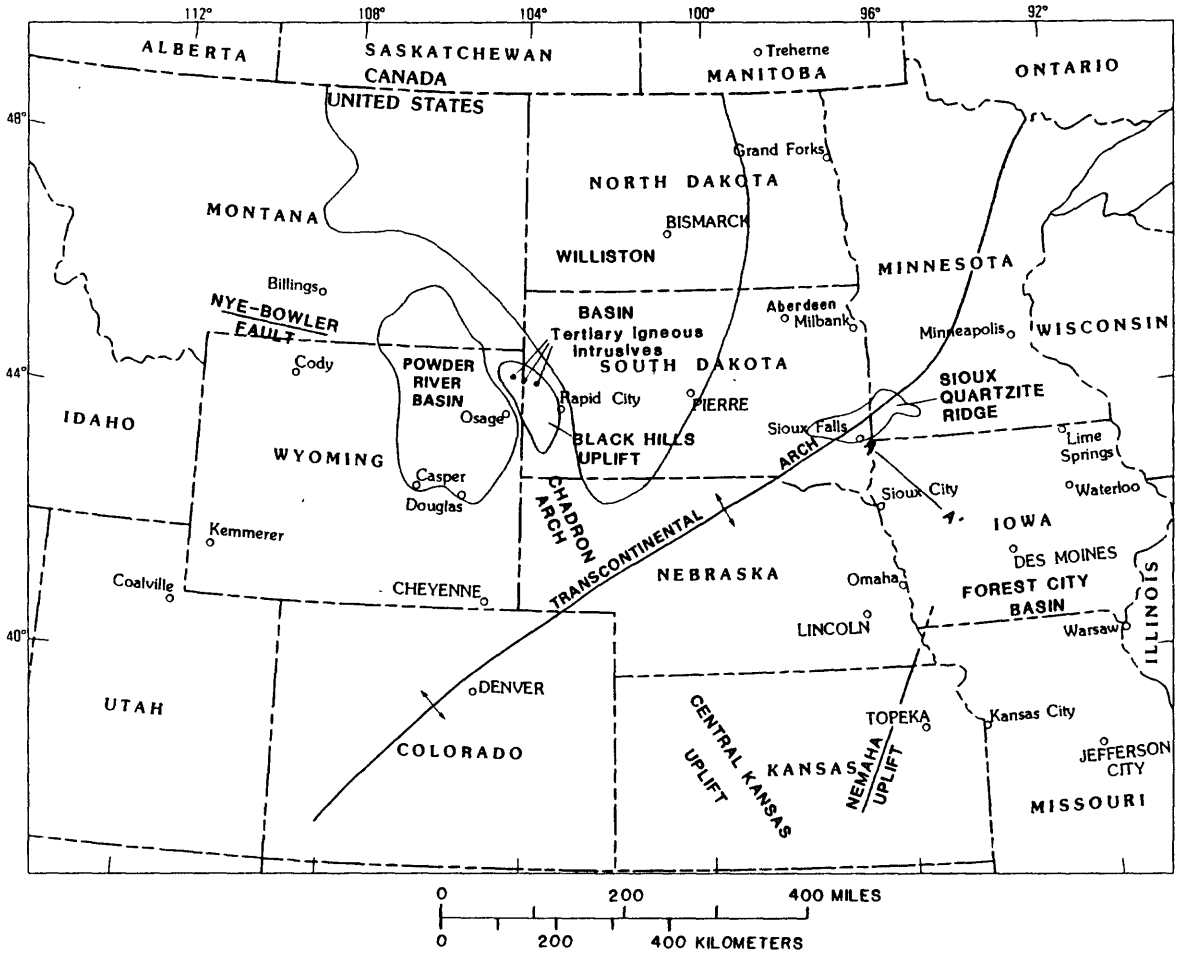

Figure 1.--Location of the Sioux Quartzite ridge, Transcontinental arch, and other structural features (modified from Merewether, 1983). Geologic section A-A' shown in figure 2.

Schoon and McGregor (1974) noted anomalous geothermal gradients in wells in the south-central part of South Dakota. These wells are approximately along the same line as the Tertiary intrusive belt in the northern Black Hills. Adolphson and LeRoux (1968) also noted a "hot water belt" in south-central South Dakota. Redden (U.S. Geological Survey and U.S. Bureau of Reclamation, 1975) suggested that the intrusive belt might continue from the Black Hills to the southeast as far as central South Dakota. If the trend line is continued further to the southeast, it coincides with the Sioux Quartzite ridge in southeastern South Dakota.

The central interior of the North American continent is divided by a major northeast-trending anticlinal feature called the Transcontinental arch (fig. 1) (Levorson, 1931, and Eardley, 1949) which crosses the Precambrian Sioux Quartzite ridge. The Sioux Quartzite ridge, which trends eastward in southeastern South Dakota and southwestern Minnesota (fig. 1), is structurally the highest part of the Transcontinental arch. The Transcontinental arch may have had its origins in the Precambrian (Warner, 1978). Evidence of a major uplift of the Sioux Quartzite in late Paleozoic or early Mesozoic time consists of the upwarped sedimentary rocks of Cambrian to Pennsylvanian age that dip steeply to the southeast in Iowa (fig. 2). Movement of the Transcontinental arch is presented by Weimer (1978) when he states that "depositional thinning or erosion within or at the top of the Niobrara across the Transcontinental arch [in Colorado] indicates recurrent tectonic movement, minor sea level fluctuations, or both."

POST-CRETACEOUS UPLIFT OF THE SIOUX QUARTZITE RIDGE

Evidence of a post-Cretaceous uplift of the Sioux Quartzite ridge in southeastern South Dakota consists of deformation of the Dakota Formation, Graneros Shale, Greenhorn Limestone, Carlile Shale, and Niobrara Formation of Cretaceous age. There are no known Tertiary intrusive igneous rocks in the area of the Sioux Quartzite in southeastern South Dakota, and the cause of the post-Cretaceous uplift of the Sioux Quartzite ridge is unknown. However, based on the dipping Cretaceous formations around the Sioux Quartzite, the uplift probably was less than 400 feet in contrast to the Black Hills uplift of about 9,000 ft (Darton and Paige, 1925). During deposition of the Cretaceous formations, the ridge was a highland on which the Cretaceous sediments onlapped the quartzite. The top of the Greenhorn Limestone in eastern South Dakota is warped upward about 400 ft on the Sioux Quartzite in southeastern South Dakota (fig. 3).

The Sioux Quartzite ridge, as described by Shurr (1981), is a discrete structural block which can be distinguished from surrounding blocks. He states, "Within the Sioux Ridge block, basement rocks display a Cretaceous paleotopography which consists of steps." As the Cretaceous sea level rose, successively higher steps were flooded until the Sioux Quartzite ridge became an island. Shurr (1981) has divided the basement rocks into four blocks bounded by zones of basement weakness (fig. 4) which places the Sioux Quartzite ridge in block I. Between block I and IV near Browns Valley, the subcrop of Greenhorn Limestone and Carlile Shale dip 27°, which indicates post-Carlile tectonism (Shurr, 1980). The slight regional dip of the Greenhorn Limestone in block I indicates that there has been little tectonic activity within block I (Shurr, 1981).

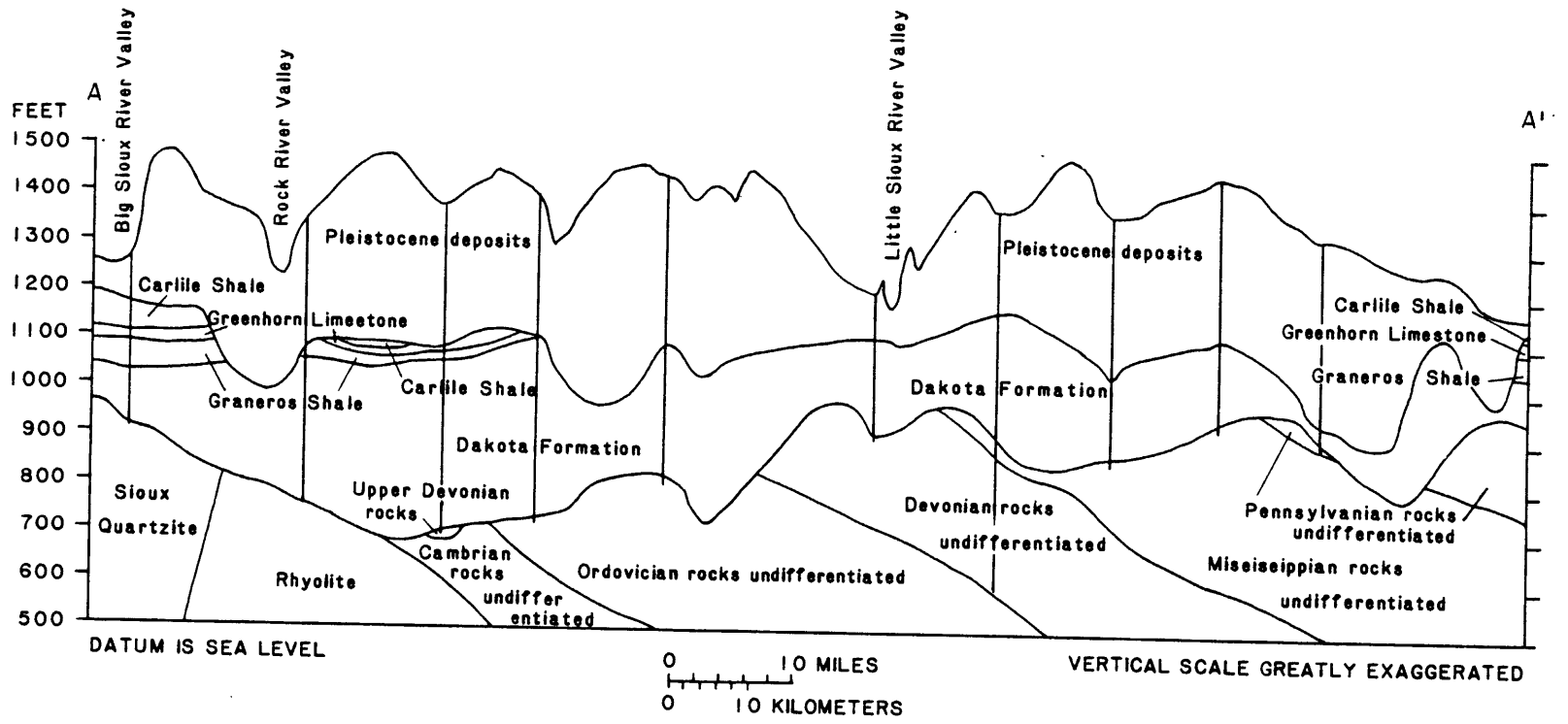

Figure 2.--Geologic section A-A' (modified from Munter and others, 1983). Location of section shown in figure 1. (Configuration of the top and bottom of the Dakota drawn on the basis of a contour map of the base of the Dakota Formation and other well data not on the cross section.)

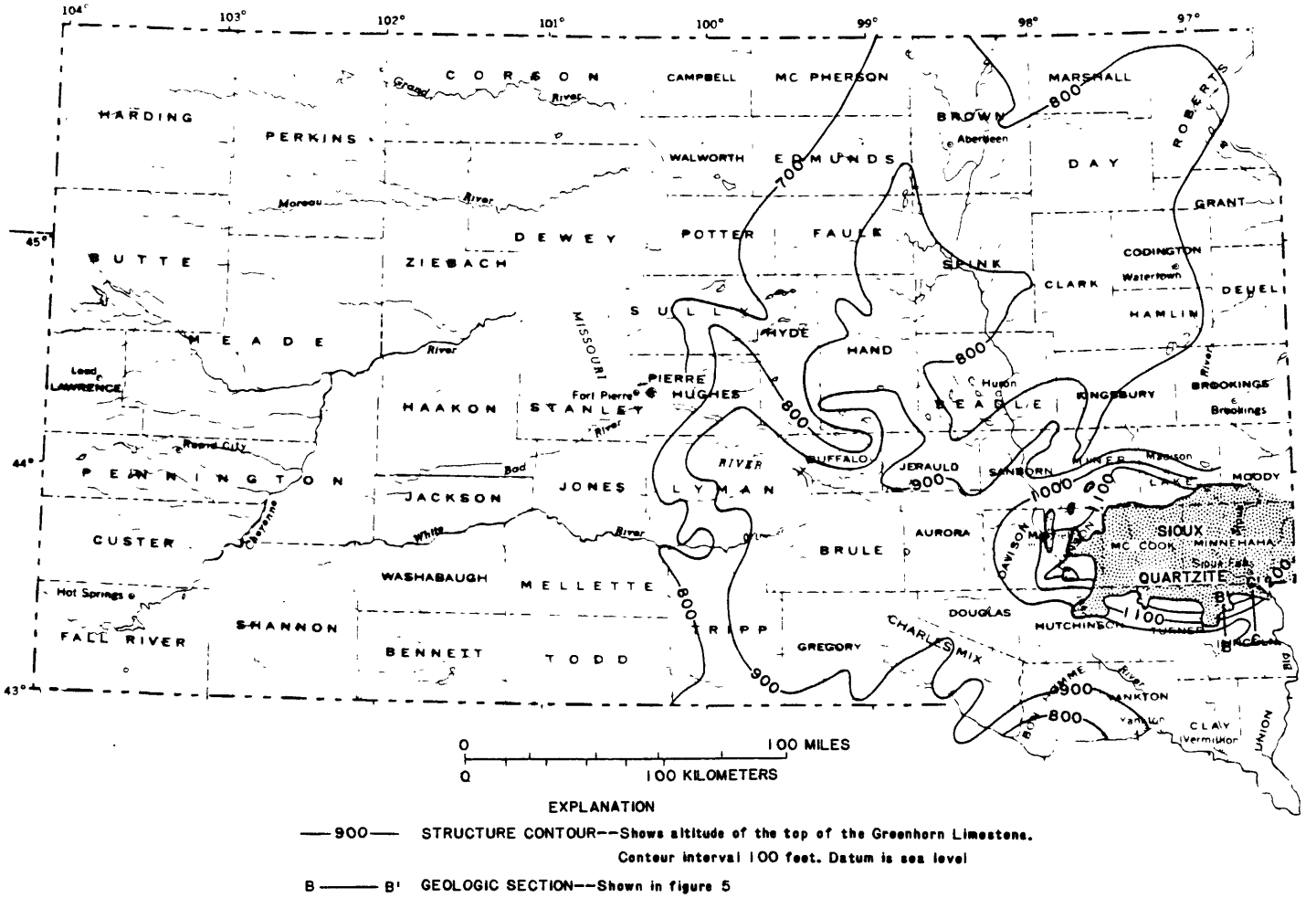

Figure 3.--Structure contours on the top of the Greenhorn Limestone in eastern South Dakota.

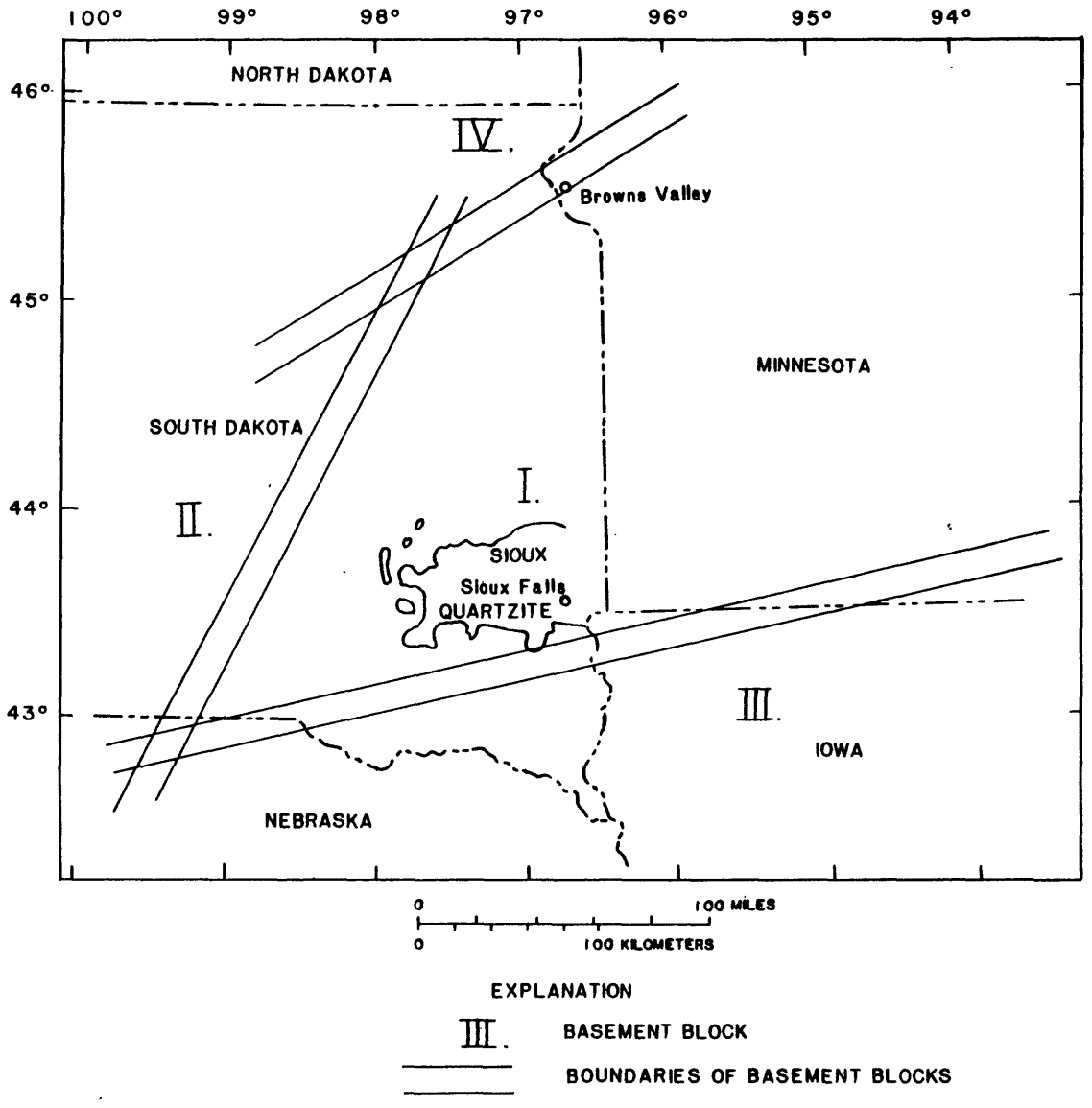

Figure 4.--Postulated geometry of structual blocks near the Sioux Quartzite ridge in eastern South Dakota and contiguous areas (modified from Shurr, 1981).

Merewether and Cobban (1981) and Merewether (1983) state that deformation during early Late Cretaceous time is indicated by the stratigraphy of the Carlile Shale. The Carlile ranges in thickness from 130 ft near the Sioux Quartzite ridge to 260 ft along the Missouri River and near Aberdeen. Mereweather and Cobban (1981) state that eastern North Dakota was subsiding more than northwestern Minnesota and that faulting in the Precambrian rocks along the Transcontinental arch in South Dakota may have caused some Cretaceous deformation. The thickening of Cretaceous units westward from Minnesota and Iowa into central North and South Dakota and Nebraska probably occurred because subsidence and sedimentation rates were greater in the western part of the Cretaceous seaway (Kauffman, 1977).

Recent test-hole data (Hansen, 1983, 1986; and Iles, in press) indicate that the dip of the Greenhorn Limestone within 20 mi of the Sioux Quartzite ridge ranges from 30 to 50 ft/mi, whereas elsewhere in eastern South Dakota the dip ranges from 3 to 8 ft/mi (fig. 3). Geologic sections (Iles, in press) show the steeply dipping Cretaceous formations near the Sioux Quartzite ridge (fig. 5). The tops of the Cretaceous Dakota, Graneros, Greenhorn, Carlile, and Niobrara Formations are warped upward about 400 ft on the Sioux Quartzite ridge to the north, west, and south.

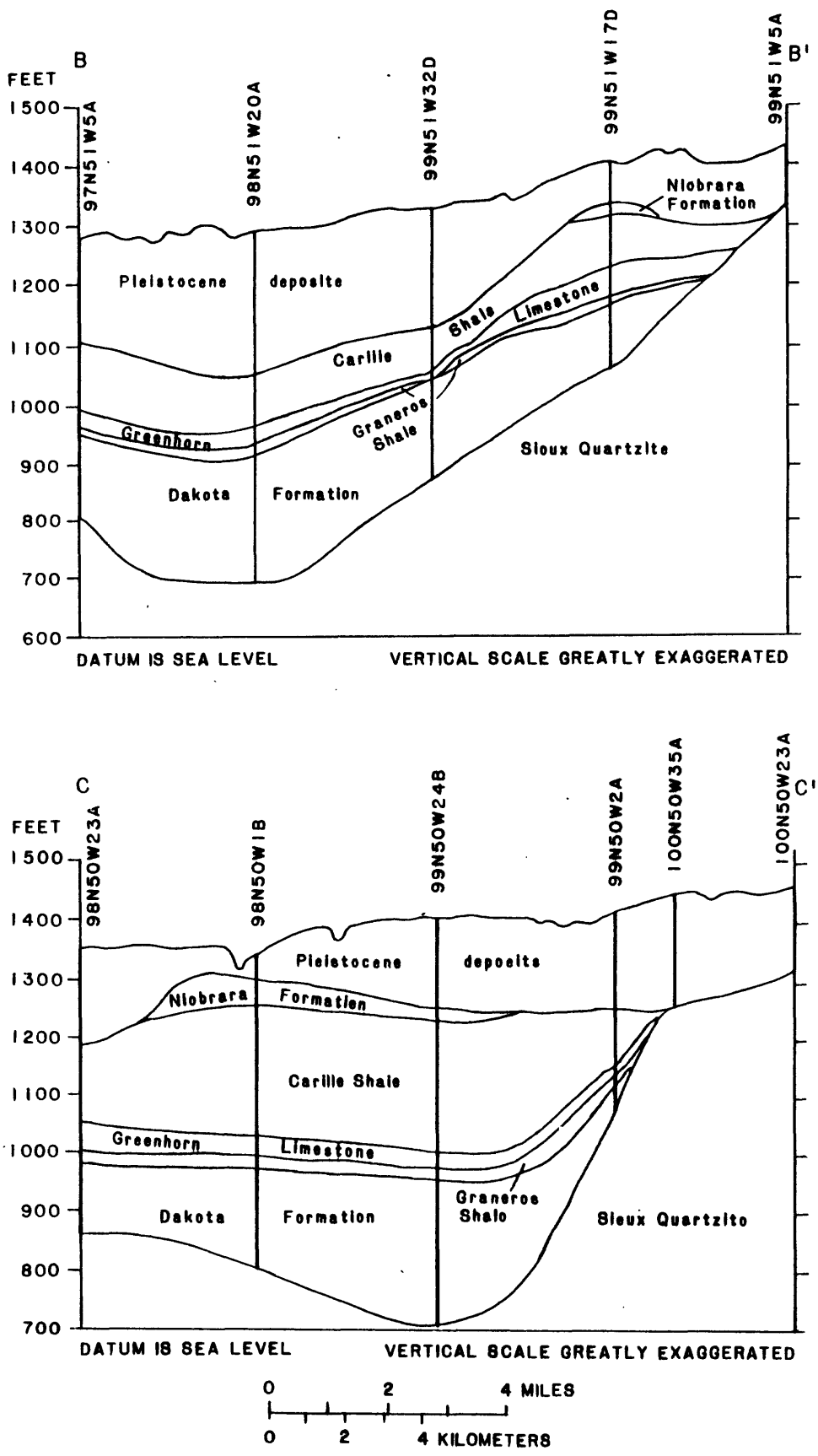

Figure 5.--Geologic sections B-B' and C-C' (modified from Iles, D. L., in press). Locations of sections are shown in figure 3.

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