UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UPPER CRETACEOUS ROCKS AT LAKE TRAVERSE IN WESTERN MINNESOTA

by

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

INTRODUCTION

A rare outcrop of rocks in the Upper Cretaceous Colorado Group has been found on the shore of Lake Traverse in Traverse County, Minnesota, near the intersection of Minnesota, South Dakota, and North Dakota. These rocks consist of limestone, shale, siltstone, and sandstone, and are herein assigned to the Greenhorn Formation and the Carlile Shale. Outcrops of Upper Cretaceous units occur along the Pembina Escarpment, 320 km (200 mi) north of Lake Traverse and along the Big Sioux River, about 320 km (200 mi) south of the lake (Cobban & Reeside, 1952). In the intervening areas outcrops are sparse and faunal control is poor. The Dakota Sandstone and Graneros Shale have been recognized at scattered localities and the Greenhorn and Carlile are suggested (Sloan, 1964) to be present in southwestern Minnesota. The Graneros, Greenhorn, and Carlile formations of the Colorado Group are well known in the subsurface of the eastern Dakotas (Schoon, 1968).

James VanAhlstine of the University of Minnesota Branch Campus in Morris, Minnesota, and Jeff Schultz provided the location of the outcrops at Lake Traverse. W. A. Cobban and E. A. Merewether of the U.S. Geological Survey visited the locality and provided helpful suggestions. Fossils obtained from the rocks were identified by W. A. Cobban. These contributions to the investigation are gratefully acknowledged.

OUTCROP DESCRIPTION

The Upper Cretaceous rocks at Lake Traverse are in the southern part of Traverse County Park, Minnesota, and are about 8 km (5 mi) north and east of the town of Browns Valley on Minn. Highway 27. They crop out near the shore of the lake along a terrace which has a thin cover of glacial till and outwash. The outcrop is about 76 m (250 ft) long, trends N. 20° E., and forms a bank which is 3.0-4.6 m (10-15 ft) high. When first examined in the late summer of 1977, exposures extended 1.5-3.0 m (5-10 ft) above the water level of the lake. Subsequent visits in the spring of 1978 revealed extensive slumping in the central part of the outcrop, within the Carlile Shale.

Cretaceous stratigraphic units dip to the north. Exposure is limited on the south by a friable silt to fine sand which has trough crossbedding and root tubes filled with limonite. Pebbles within these sands and a discontinuous gravel bed at the base suggest that this unit is more closely related to glacial sediments than to the marine Cretaceous. The northern part of the bank is largely covered by slopewash, but small exposures of noncalcareous gray shale may possibly be bedrock in place.

STRATIGRAPHIC UNITS

Two formations from the standard reference section of the Cretaceous of the Western Interior are present at Lake Traverse; they are the Greenhorn Formation and the Carlile Shale.

Rocks included in the Greenhorn are about 3 m (10 ft) thick and have been divided into two units. The basal unit consists of chalk with thin beds of siltstone and fine-grained sandstone. Terrigenous content decreases from the bottom to the top of the unit. The upper part of the Greenhorn is composed of dense limestone beds less than 30 cm (12 in.) thick, separated by chalk and calcareous shale. Two bentonite beds are found in the upper unit, and Inocermus labiatus is present in at least two beds of the limestone.

Rocks herein assigned to the Carlile Shale overlie the Greenhorn Formation and are about 30 m (100 ft) thick. The basal part of the Carlile is about 2.3 m (7.5 ft) thick and consists of gray calcareous shale which is the Fairport Member of the Carlile. Overlying the Fairport is a unit of noncalcareous gray shale that contains septarian concretions and is approximately 21.3 m (70 ft) thick. The upper third of this unit consists of interbedded shale and sandstone. Rocks in this unit are typical of the Blue Hill Member of the Carlile. The Fairport and Blue Hill, which have their type localities in Kansas, are well described by Hattin (1962).

A unit of siltstone and fine sandstone about 6 m (20 ft) thick overlies the Blue Hill. Massive sandstone comprising the lower half of the unit is dominately fine grained, has sharp lower and upper contacts, and has an increase in grain size from bottom to top. The siltstone which overlies the sandstone is noncalcareous. These rocks bear little resemblance to the massive Codell Sandstone Member of the Carlile Shale in Kansas (Hattin, 1962, 1975), although

they have a similar stratigraphic position. Near the Black Hills of South Dakota siltstone and fine sandstone in the middle of the Carlile is named the Turner Sandy Member (Rubey, 1930). The Turner in the northern Black Hills has been described by Cobban (1951). Subsurface studies (Rice, 1977), however, have shown that the Turner disappears to the east of the Black Hills. Beds of siltstone in the Carlile that crop out along the Missouri River in South Dakota and Nebraska, have been called Codell (Simpson, 1960). The name has also been used in subsurface investigations in South Dakota (Rice, 1977; Schoon, 1968). Following this local usage, the fine-grained sandstone and siltstone at Lake Traverse are herein assigned to the Codell Sandstone Member. At Lake Traverse, the Codell is overlain by an unnamed unit of noncalcareous shale which is about 6 m (20 ft) thick.

STRUCTURAL AND ECONOMIC SIGNIFICANCE

The outcrop at Lake Traverse is situated within a zone of faulted basement rocks which separates two Precambrian terranes (Morey and Sims, 1976). This fault zone is a fundamental tectonic feature and was the locus of minor earthquake (G. B. Morey, Minnesota Geological Survey, oral commun., 1977). E. A. Merewether and W. A. Cobban, of the U.S. Geological Survey, and the author have recently used the elevations of Cretaceous biostratigraphic zones to propose Late Cretaceous or Cenozoic tectonism in Minnesota. One fossil locality is north of the faulted zone and another is south of the zone.

The relatively uniform dips of the strata at Lake Traverse may be further evidence of Late Cretaceous or Cenozoic tectonism. Unit 2 dips 27° to the northeast and strikes N. 110° E.; unit 10 dips 27° to the northeast and strikes N. 115° E.. The observed dip may have been caused by glacial activity or a landslide; this, however, would probably have produced more variability in the dip and strike directions.

The Cretaceous rocks exposed at Lake Traverse are locally important aquifers in western Minnesota (Rodis, 1963). The same units in nearby eastern North Dakota have recently been included in a drilling program investigating the possibilities of uranium concentrations (Walter Moore, North Dakota Geological Survey, oral commun., 1977). Oil and gas are known to occur in Cretaceous rocks in western Minnesota (Thiel, 1937). Similar lithologies in a similar stratigraphic position have been described as reservoirs for shallow biogenic gas in eastern Montana and the western Dakotas (Rice and Shurr, 1978).

LAKE TRAVERSE SECTION

Traverse County Park, Minnesota

NE, SE, 2, T. 125 N., R. 49 W.

Carlile Shale (part):	METERS (FEET)	
Unnamed member:		
12. Shale, gray, noncalcareous, and slightly silty; weathered; yellow melerite on bedding and joint surfaces.	1.5 (5)	
11. Covered interval.	4.0 (13)	
Thickness of unnamed member		5.5 (18)
Codell Sandstone Member:		
10. Siltstone, light-gray, noncalcareous; interbedded with fine-grained sandstone near base; beds are 1-2 cm (0.4-0.8 in.) thick; yellow melerite on bedding and joint surfaces.	3.4 (11)	
9. Sandstone, grayish orange, fine-grained; grades to interbedded siltstone and sandstone at base; contains brown clay parting 46 cm (18 in.) below top; upper 90 cm (35 in.) is well indurated with iron oxide cement; base and top are sharp.	2.9 (9.5)	
Thickness of Codell Sandstone Member		6.3 (20.5)

Blue Hill Shale Member:

8. Shale, gray, noncalcareous; includes thin discontinuous stringers of fine-grained white sandstone; contains single septarian concretion, possibly not in place. .6 (2)
7. Covered interval. Approximate thickness. 3.1 (10)
6. Shale, gray, noncalcareous; contains a few fish scales; yellow melerite and selenite crystals on bedding and joint surfaces; contains two beds of septarian concretions, at 3.4 m (11 ft) and 1.5 m (5 ft) below top of unit; concretions are 0.6-1.0 m (2-3 ft) long and 15-20 cm (6-8 in.) thick. 5.6 (18.5)
5. Covered interval. Generally covered by till and colluvium; scattered small outcrops of gray, noncalcareous shale interbedded with grayish orange, slightly silty, noncalcareous shale; silty shale is in beds 5-8 cm (2-3 in.) thick. 12.2 (40)

Thickness of Blue Hill Member 21.5 (70.5)

Fairport Member:

4. Shale, gray, calcareous; weathers grayish orange. 1.2 (4)

3. Shale, gray, calcareous; weathers grayish orange; very thin limestone interbeds less than 2.5 cm (1 in.) thick; contains abundant Inoceramid fragments, possible Ostrea, and rare fish vertebrae. 1.1 (3.5)

Thickness of Fairport Member 2.3 (7.5)

Partial thickness of Carlile Shale 35.6 (116.5)

Greenhorn Formation (part):

2. Limestone, gray, weathers grayish orange; slabby and dense beds, less than 30 cm (12 in.) thick; abundant Inoceramid fragments towards top; grades to interbedded limestone and chalk towards base; base is marked by 5-8 cm (2-3 in.) bed of earthy limonite concretions which have a yellow core and a hard brown to orange rind; 2.5 cm (1 in.) bentonite beds at 1 m (3 ft) and 2 m (6 ft) above base; collections of Inoceramus labiatus from 50 cm (6 in.) below top and 60 cm (24 in.) above base of unit (U.S.G.S. Mesozoic locality D10372). 2.0 (6.5)

1. Chalk, gray; weathers grayish orange; beds are 15-20 cm (6-8 in.) thick with sharp base; siltstone to fine sandstone at base of each bed grades upward to chalk; base of unit marked by discontinuous bed of fine sandstone less than 30 cm (12 in.) thick. 1.2 (4)

Partial thickness of Greenhorn Formation 3.2 (10.5)

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