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ORDOVICIAN AND SILURIAN STRATA FROM WELL CORE IN SCHOOLCRAFT COUNTY, MICHIGAN

BY

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ABSTRACT

The core recovered from a well drilled near the village of Cooks in the Northern Peninsula of Michigan reveals thicknesses of several Ordovician and Silurian formations. Several of these formations are incompletely exposed in natural outcrops. Below the glacial drift, the well penetrated 79.5 feet of Byron Dolomite of Burnt Bluff Group. Other Silurian strata encountered in the core include: Lime Island Dolomite, 27.7 feet; Moss Lake Formation, 121.2 feet; Cabot Head Shale, 87.3 feet; and Manitoulin Dolomite, 23.3 feet. Ordovician strata include: Big Hill Formation, 130.6 feet; Ogontz Member of Stonington Formation, 20.6 feet; Bay de Noc Member of Stonington Formation, 30.8 feet; Bills Creek Shale, 175.9 feet; and Collingwood Shale, 38.8 feet. The well terminated 72.1 feet into Trenton Limestone.

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INTRODUCTION

One of the difficult problems of Paleozoic stratigraphy in Michigan is accurate determination of the thickness of the stratigraphic units. Outcrops occupy a very small percentage of the area of the Upper Peninsula. Only a few exposures show the entire sequence of strata in any formation; furthermore, no exposures show all the strata in the non-

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resistant formations, such as the Cabot Head Shale, Bills Creek Shale, and Collingwood Shale. Estimates of thickness made from maps of outcrops and dips are inconclusive and may be deceptive.

Studies of Ordovician rocks (Hussey, 1950, 1952) and Silurian rocks (Ehlers and Kesling, 1957) in the Upper Peninsula of Michigan contain numerous examples of incompletely known formations.

The opportunity to study the rock core from a well in Schoolcraft County was very welcome. The well, completely cored except for a few insignificant breaks, was drilled by The Cleveland-Cliffs Iron Company. The core, clearly marked with hole depths, was presented to the Geological Survey Division of the Department of Conservation, State of Michigan, and stored in the State Office Building in Escanaba. Arthur E. Slaughter, Geologist of the Geological Survey, made preliminary notes on the core. In the summer of 1958 G. M. Ehlers and R. V. Kesling of The University of Michigan joined him at Escanaba to study the core in detail. Fossiliferous sections were extracted and brought to the Museum of Paleontology for laboratory preparation and study.

The core is remarkedly complete. Some of the softer rocks twisted off at a few depths, but scarcely any footage was lost. At one change of drilling head the well whip-stocked somewhat and repeated some coring footage; this was properly accounted in depth records.

From the records of inclination, the indicated depths were converted to vertical depths. At the well site, the strata strike N. 30° E. and dip 0° 22′ S. 60° E. (34 feet per mile). Inasmuch as the normal to the stratification is only 0° 22′ from vertical, the converted thickness of 818.8 feet is less than 0.1 foot more than the actual thickness of strata.

Examination of the fossils from the well core was nearly complete on November 12, 1965, at which time Mr. Gerald J. Anderson, Chief Geologist of The Cleveland-Cliffs Iron Company, wrote:

> There is no objection on the part of Cleveland-Cliffs to your publishing information on the drill hole northwest of Cooks, Michigan. We are pleased to know that our drill core played a part in making a significant contribution to the geology of the area.

We wish to express our sincere thanks to Mr. Anderson and to The Cleveland-Cliffs Iron Company for their generous cooperation.

WELL DATA

Location.—SW¼ sec. 19, T. 41 N., R. 17 W., Schoolcraft County, about one mile northwest of the Village of Cooks, Michigan.

Driller.—The Cleveland-Cliffs Iron Company, Ishpeming, Michigan.

Orientation.—Collar directed 67° due north. Checks of inclination show steepening and divergence to the east: 450 feet, 68½°, direction not determined; 675 feet, 70°, N. 13½° E.; 877 feet, 72°, N. 23° E.

Elevation.—Top at approximately 670 feet above mean sea level.

Depth.—877 feet along line of well; 818.8 feet corrected to vertical. Bottom of hole at about 148.8 feet below mean sea level.

Stratigraphic dip.—Dip computed for strata from base of Manitoulin Dolomite to top of Lime Island Dolomite (see Ehlers and Kesling, 1957, Map 2): 34 feet per mile, or 0° 22′ S. 60° E.

LOG OF CORE

PLEISTOCENE

Hole depth (feet)	Vertical depth (feet)	Unit	Thickness (feet)
		49. Glacial drift	11.0
12	11.0	Total thickness	11.0

SILURIAN

NIAGARAN SERIES

BURNT BLUFF GROUP

BYRON DOLOMITE

Hole depth (feet)	Vertical depth (feet)	Unit	Thickness (feet)
		48. Dolomite, very light gray to light-buff-gray, finely crystalline, earthy feel	23.9
	34.9		
		47. Dolomite, light-buff, very finely crystalline	6.4
	41.3		
		46. Dolomite, gray, medium crystalline	0.3
	41.6		
		45. Dolomite, very light gray, with some large bluish-gray areas, very minute crystals of calcite and thin veinlets of white calcite	6.2
52	47.8		
		44. Shale, gray to bluish-gray, with thin bands of buff dolomite and a few minute crystals of calcite	7.4
60	55.2		
		43. Dolomite, buff, finely crystalline, vuggy	1.9
	57.1		

		42. Dolomite, mottled buff and bluish-gray	2.1
	59.2		
		41. Dolomite, gray, with small vugs and a bluish-gray shale, 0.2-inch thick, at base	1.4
	60.6		
		40. Dolomite, mottled gray and bluish-gray, with a shale layer 0.1-inch thick at base	0.4
66	61.0		
		39. Dolomite, buff-gray to buff, very finely crystalline; some beds vuggy	25.8
94	86.8		
		38. Dolomite, light-buff to gray-buff, finely crystalline, with some chert	3.7
98	90.5	Total thickness	79.5

LIME ISLAND DOLOMITE

		37. Dolomite, buff, medium to coarsely crystalline, vuggy, with few chert nodules; *Virgiana* sp., probably *V. decussata* (Whiteaves) and *Favosites* sp.	27.7
128	118.2	Total thickness	27.7

ALEXANDRIAN SERIES

CATARACT GROUP

MOSS LAKE FORMATION

		36. Shale, bluish-gray, with thin beds of dolomite	1.8
130	120.0		
		35. Dolomite, argillaceous, steel-gray	4.6
135	124.6		
		34. Shale, bluish-gray	13.9
150	138.5		
		33. Dolomite, argillaceous, gray, fine-grained, with some vugs and shale partings	43.5
197	182.0		
		32. Dolomite, buff-gray to gray, very finely to medium crystalline, with some cherty partings	8.3
	190.3		

		31. Dolomite, buff-gray, finely crystalline, with carbonaceous partings and a few very small vugs filled with gypsum	2.8
	193.1		
		30. Dolomite, gray to bluish-gray, fine-grained, with numerous chert nodules	25.0
236	218.1		
		29. Dolomite, brownish-gray, fine-grained, with white chert nodules; fractured dolomite along some bedding planes recemented with transparent gypsum; nodules of gypsum, some thin shale layers and shale fragments also present in dolomite	10.2
247	228.3		
		28. Dolomite, argillaceous, gray to buff-gray banded with gray, fine-grained, with few nodules of gypsum	11.1
259	239.4	Total thickness	121.2

CABOT HEAD SHALE

		27. Dolomite, gray to buff-gray with dark-gray bands, very finely crystalline, with layers of gray satin spar 1/8 to 2 inches thick	6.9
	246.3		
		26. Dolomite, alternating beds of buff and gray, with a few bluish-gray shale layers 1/4 to several inches thick and a few thin partings of white gypsum; layer with external molds of *Leperditia* sp. found at 246.8 feet	12.1
279+	258.4		
		25. Shale, medium-gray to dark-gray, a few thin beds of finely crystalline buff-gray dolomite and numerous beds of gypsum occurring as alabaster, selenite, and satin spar in beds, pebbles, fracture fillings and expansion joints; white satin spar along fractures and bedding planes and in layers 1/8 to 4 inches thick; reddish gypsum (selenite and alabaster) bedded or in pebbles; gray selenite	

		bedded and in disseminated crystals in the dolomite	39.9
322+	298.3		
		24. Dolomite, light-buff to buff-gray, very fine-grained with dark gray argillaceous bands	2.8
325+	301.1		
		23. Shale, dolomitic, dark-gray, with a few thin satin spar deposits along bedding planes; fossiliferous, brachiopods and algal (?) debris	10.7
337	311.8		
		22. Dolomite, grayish-buff, very finely crystalline with dark-gray to brown-gray shale bands very numerous, thin satin spar layers ⅛ to ¾ inches thick; four-inch bed of brown selenite near the base	8.4
	320.2		
		21. Dolomite, buff-gray, very fine crystalline, with bluish-gray mottling	1.4
	321.6		
		20. Dolomite, buff-gray, very finely crystalline, with many dark-blue-gray argillaceous bands; a few thin satin spar fillings in fissures and along bedding planes	5.1
		Total thickness	87.3
	MANITOULIN DOLOMITE		
		19. Dolomite, buff-gray, very finely crystalline, with bluish-gray local mottling, banded with argillaceous beds; a few bryozoa (?)	11.2
	337.9		
		18. Highly argillaceous dolomite, dark-gray to medium-gray, finely to medium crystalline; some fossils, mostly brachiopods and bryozoa	12.1
378	350.0	Total thickness	23.3

ORDOVICIAN

CINCINNATIAN SERIES

RICHMOND GROUP

		BIG HILL FORMATION	
		17. Dolomite, buff-gray, medium to finely crystalline, very fossiliferous; *Palaeophyllum stokesi* (Edwards and Haime) and some *Halysites* sp.; *Palaeophyllum* found at 353.7, 355.6, 361.1, 362.1 (very large corallum), 365.8, 366.7, and 367.7; *Halysites* sp. cf. *H. gracilis* (Hall) at 353.7 and 365.8	17.7
397	367.7		
		16. Dolomite, buff-gray to greenish-gray and gray, medium crystalline; contorted shale laminae, locally mottled with light gray; argillaceous dolomite and shale partings or layers occur at 383.5, 391.8, 402.1, 414.1, 421.7–424.5, 428.2–429.2, and 438.4; cup corals occur at 369.5, 375.1, and 408.8; large lobate to digitate bryozoa filled with dolomite crystals at 370.5, 400.3, 409.8, 415.3–416.3, 426.4, and 431.0; gypsum nodule at 377.0; limestone layer from 463.6 to 472.9; greenish color occurs in top 10 feet of unit and throughout in the argillaceous layers..	107.3
512	475.0		
		15. Dolomite, gray, very finely crystalline; very large trepostomatous bryozoa at the base of the unit	5.6
518	480.6	Total thickness	130.6
		STONINGTON FORMATION—OGONTZ MEMBER	
		14. Argillaceous limestone, gray to brownish-gray or dark-buff-gray, very finely crystalline; alternating bands of light-buff-gray argillaceous limestone and dark-gray limy shales; somewhat fossiliferous at the base, sparsely fossiliferous at the top	15.0
534	495.6		

		13. Limestone, buff to brownish-gray, medium to coarsely crystalline, shaly partings, very fossiliferous; bryozoa numerous	5.6
540	501.2	Total thickness	20.6

STONINGTON FORMATION—BAY DE NOC MEMBER

		12. Calcareous shale, gray to steel-gray, quite crystalline in sections due to organic calcite; brachiopods abundant in some layers, but unit not very fossiliferous as a whole	14.0
555	512.2		
		11. Shale, non-calcareous, brownish-gray, barren in the upper part, more fossiliferous near the base	1.9
	517.1		
		10. Shale, with dolomitic layers that are replacement of organic calcite; trepostomatus bryozoa abundant, but structure completely destroyed by dolomitization	1.8
559	518.9		
		9. Shale, dark-brown to brownish-gray; a few thin layers of dolomite replacing organic limestone; some trepostomatous bryozoa as in unit 40, but not as abundant	2.8
	521.7		
		8. Same as unit 10	2.8
565			
	524.5		
		7. Same as unit 9; bryozoa common at 529.1, occurring as a small layer 3 to 4 inches thick; the pelecypod *Cleidophorus* sp. abundant at 529.1, occurring with bryozoa	7.5
573	532.0	Total thickness	30.8

BILLS CREEK SHALE

		6. Shale, gray to brownish-gray, alternating with greenish-gray layers; badly fractured in upper 14 feet; dense shale with conchoidal fracture from top to 628.8 feet; closely	

		spaced ("poker chip") partings in zones from 626.8 to 668.1 feet; dense shale, alternating gray and brownish-gray layers from 668.1 to base of unit	175.9
760	707.9	Total thickness	175.9
		MOHAWKIAN SERIES	
	COLLINGWOOD SHALE		
		5. Shale, brownish-gray with a few dark-gray partings; *Leptobolus* sp. at 731.5 feet	27.4
789	735.3		
		4. Limestone, dark-brownish-gray to buff-gray; very finely crystalline limestone interbedded with coarsely crystalline organic limestone; fossils numerous in some layers	9.0
	744.3		
		3. Shale, calcareous, dark-brown, interbedded with thin light-brownish-gray layers	1.0
	745.3		
		2. Conglomerate, 1½ inches thick, at base, overlain by dolomite	1.4
801	746.7	Total thickness	38.8
	TRENTON LIMESTONE		
		1. Limestone, buff-gray mottled with brownish-gray, medium to coarsely crystalline; fossiliferous	72.1
877	818.8		

STRATIGRAPHIC NOTES

Byron Dolomite.—The bedrock first encountered in the well lies in the upper half of the Byron Dolomite of the Burnt Bluff Group. At Burnt Bluff, on the west side of Big Bay de Noc about 9 and one-half miles southwest of Garden and about 20 miles south-southwest of the well, nearly the full sequence of the Byron Dolomite is exposed. At that place, the formation is 117 feet thick (Ehlers and Kesling, 1957, pp. 13, 15). Comparison of the well log with the measured section at Burnt Bluff indicates that the talus-covered interval noted by Ehlers and Kesling in outcrop is probably represented in part by unit 44 of this paper, a gray to bluish-gray shale with thin bands of buff dolomite.

Lime Island Dolomite.—This unit is readily identified in the core by the presence of *Virgiana* and by the typical lithology of buff crystalline dolomite.

Moss Lake Formation.—The general lithology of this formation is similar to that of the underlying Cabot Head Shale, consisting of dolomite and shale layers. The base of the Moss Lake Formation is placed above the main occurrence of gypsum, which appears to climax a sedimentary cycle in the Cabot Head Shale. Most, if not all, of the gypsum in the Moss Lake occurs as nodules in the lower units; probably, this material was reworked from evaporites in the Cabot Head. The core also shows that the dolomites of the Moss Lake Formation contain numerous nodules of chert, whereas the Cabot Head is chert-free. The dolomitic units within the Moss Lake Formation are so nearly alike that we cannot determine which are represented in the type section of the formation at Moss Lake (see Ehlers and Kesling, 1957, pp. 6–7); we can only suggest that the strata exposed there are in the lower or middle part of the formation.

Cabot Head Shale.—The distorted argillaceous dolomites containing *Leperditia* and the brown gypsum exposed in the small quarry on the north side of Mormon Creek Truck Trail, about 8 and one-half miles west of the well, probably belong in our units 25 and 26 (see Ehlers and Kesling, 1957, p. 6). At most, 19 feet of the formation can be seen in the quarry. Although various kinds of gypsum are present throughout the formation, the percentage of these evaporites increases toward the top of the sequence, apparently culminating an episode of evaporation.

Manitoulin Dolomite.—The lithology of the well core is strongly similar to that of rocks exposed in the small abandoned quarry about one mile north of Manistique Lake in Luce County (see Ehlers and Kesling, 1957, p. 5). The fossils in the core are not easily removed from matrix. It would appear that the Manitoulin Dolomite must be weathered to yield good fossils.

Big Hill Formation.—The entire 130.6 feet of this Ordovician formation contains abundant corals (*Palaeophyllum* and *Halysites*) as well as numerous bryozoa. The limited exposures known of the formation, at Hinkin's Hill (Big Hill) in sec. 11, T. 39 N., R. 21 W., on Stonington Peninsula, give no indication of the shale laminae noted in our unit 16.

Ogontz Member of Stonington Formation.—The fossils in the core are not silicified, as are those in the outcrops on Stonington Peninsula to the southwest.

Bay de Noc Member of Stonington Formation.—As in the type exposure (Hussey, 1950, pp. 16–17), this member is argillaceous, in contrast to the overlying Ogontz Member.

Bills Creek Shale.—The type section along Bills Creek, in sec. 7, T. 41 N., R. 20 W., and sec. 12, T. 41 N., R. 21 W., consists of alternating thin beds of "shale" and "argillaceous limestone" (Hussey, 1952, p. 45). Evidently, weathering is necessary to develop the contrasts between beds, for the core shows no significant lithologic changes throughout the extent of the Bills Creek Shale. The shale tends to fracture conchoidally rather than to part along bedding planes. Several breaks through the core failed to uncover any fossils.

Collingwood Shale.—Distinctly brown shales and limestones between the Trenton Limestone and the Bills Creek Shale are here called the Collingwood Shale. This formation is not known to be exposed at all in areas near the well. The base is a thin conglomerate.

Trenton Limestone.—The core did not yield fossils sufficiently well preserved to determine which parts of the Trenton are represented. Presumably, the unit includes strata of the Groos Quarry Member.

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