EARLY DISCOVERERS
XXIII

TILL-STONE ORIENTATION
HENRY YOULE HIND (1823–1908)

By JOHN A. ELSON
(Department of Geological Sciences, McGill University, Montreal, Canada)

MILLER (1884) observed that the stones in till tended to have their long axes orientated in one direction when he examined exposures of a glaciated boulder pavement near Edinburgh. These observations of till-stone orientation are among the earliest recorded (Holmes, 1941) and may have been entirely his own, or they may have been partly those of his father, Hugh Miller the elder, who presented an unpublished paper on boulder pavements to the Royal Physical Society of Edinburgh in 1852. Hugh Miller the younger, in referring to this oral presentation, does not say whether or not till-stone orientations were mentioned in that lecture. There is no doubt that both Millers considered the till and the fabric of the stones in it to be the result of glacial action.

The personality dominating Pleistocene geology in Canada from 1855 to the end of the nineteenth century was Sir James W. Dawson, Principal of McGill University. Dawson was a prolific writer and, perhaps partly because he lived in Montreal in the midst of the Pleistocene Champlain Sea deposits, was an advocate of the theory of deposition of drift by floating ice and a staunch opponent of the glacial theory (Dawson, 1894, p. 80–148). Although his theory and authority may have retarded the progress of Pleistocene geology in Canada for several decades, Dawson's field observations were accurate and objective, and are still useful; he clearly separated fact from theory.

Henry Youle Hind, Professor of Chemistry and Geology at the University of Trinity College, Toronto (now part of the University of Toronto), was another geologist active in Pleistocene studies, which received due emphasis in his eighteen publications on geology in the years from 1853 to 1877. He was the first geologist to map some of the unexplored parts of Canada. From 1853 to 1855 he was editor of the *Canadian Journal*, which published the scientific papers and proceedings of the Canadian Institute.

Hind's interest in till-stone orientation probably began in 1855 when excavations were being made in Toronto in blue clay (a compact till) by a quarrying technique which exposed a succession of undisturbed vertical faces in which strikingly obvious alignment of cobbles and boulders was revealed. It is recorded in the *Canadian Journal* that on 8 March 1856 he presented a paper to the Canadian Institute entitled "On the blue clay of Toronto", in which he described the orientation of the stones and suggested a glacial origin for the deposit rather than deposition from floating ice or by the sea. On 3 August 1858, Hind (1859, p. 64) observed the same phenomena in cuts along the Saskatchewan River in the then wild and unsettled prairie parkland roughly 60 miles (96·5 km.) north-north-east of Saskatoon, Saskatchewan, while exploring what was at that time the Northwest Territory of Canada. He recorded this and presented the substance of his 1856 paper in the official report of the expedition (Hind, 1859, p. 119–22). In this "abstract" Hind referred to the "forced arrangement of blocks of limestone, slabs of shale, and unfossiliferous shale in the blue clay of Toronto". The blue clay is a basal till overlying shale of the Hudson River group. Its thickness

> "varies from 10 to 25 feet [3·0 to 7·6 m.]; its upper surface is irregular and undulating: upon it reposes sometimes stratified sand and yellow clay, sometimes unstratified yellow clay" (Fig. 1d).

These deposits are overlain by an upper blue clay that is stratified and forms part of the Toronto interglacial formation.

> "The lower or inferior blue clay contains quartz sand and small rolled pebbles of granitic rocks, a considerable proportion of blue shale containing fossils belonging to the Hudson River group, and frequently large fragments of the last named rock, together with more or less rolled or worn masses of granite, gneiss, &c.
>
> "The fragments from the Hudson River group frequently preserve their edges sharp and well defined, showing that they have not been water worn or removed far from the rock from which they originated. They are found not only a few inches from the surface of the parent rock, but in numerous instances as far as 15 to 20 feet [4·5 to 6·1 m.] above it, imbedded in a peculiar manner in the blue clay. Some of the larger fragments are scratched and grooved.
>
> "A cursory inspection of the artificial cliffs, as they existed during the construction of the Esplanade, was sufficient to show that a considerable number of the pebbles and imbedded masses of rock did not occupy the position they would assume if they had not been subjected to some other force besides that of gravity or water in motion. The inclination of the subjacent rock is so slight (30 feet in the mile) [5·06 m./km.] that for all purposes of the present inquiry it may be considered horizontal. And it may be further remarked, that there is no reason to suppose that any material change in position has occurred since or during the accumulation of the blue clay. A large number of the fragments of rock seen in the blue clay are symmetrically inclined at an angle of 60, 70, and 80 degrees to the horizon, and frequently lean towards the east and north-east."

Hind illustrated the orientations of stones in four woodcuts (Figs. 1a–d) representative of a number of his field sketches. In all, 36 stones are shown in the woodcuts, although those in Figure 1d may be schematic only. It seems likely that his conclusions are based on a statistically valid sample. He emphasized that most stones are inclined steeply to the north-east at the Toronto localities. Although the azimuth of one stone is shown (Fig. 1b), he was primarily concerned with dips of tabular particles rather than directions of long axes. He argued that the granitic fragments "must have travelled at least 100 miles [160 km.] before they were lodged in the place where they are now found". Tabular particles deposited in water, either by dropping from floating ice or by strong currents, would come to rest in a position parallel to the subjacent surface (either about horizontal or at the angle of rest of the sediments in water). However, the angle of rest of the mud that forms the matrix of the blue clay, if it was deposited under water, would be much less than the 45°, which Hind said is the slope formed by sand in a subaerial environment. (From this it seems doubtful if Hind ever measured the angle of repose of dry sand, although this inaccuracy does not invalidate the ensuing argument because his till-stone dips are even steeper.) He asserted that water currents could not have been the depositing agency, because blue clay is unsorted and that it must have been "the action of *glacial* or *stranded* ice". His last comment (Hind, 1859, p. 122) obviously favoured glacial action.

> "May not the plastic and irrestible agent which picked up the materials composing the blue clay, and then melting, left them in their present position, have been largely instrumental in excavating the basin of the great Canadian Lakes?"

Hind's (1859) general report on the Assiniboine and Saskatchewan Exploring Expedition is a fascinating historical document written in a very readable style with much human interest, and it even contains touches of humour uncommon in such reports. Hind (1864) later reiterrated his theory of till-stone orientation in a paper summarizing his views on several problems of Pleistocene geology and geomorphology. In this paper he reported with satisfaction that the glacial theory "first enunciated by Professor Louis Agassiz" in 1850 (in North America) . . . "appears to be gradually gaining ground among American geologists".

Hind (1864, p. 259–60) also suggested that anchor ice played an important role as an erosional agent in rivers and lakes in cold climates. He cited examples of anchors for nets on the north shore of the Gulf of St. Lawrence being frozen to the bottom at a depth of 30 to 60 ft. (9·1 to 18·3 m.) so that when raised they bring with them frozen masses of sand. More commonly

"It forms on the beds of rivers above the head of a rapid, and frequently bursts up with a load of frozen mud or shingle, or slabs of rock, which it has torn from the bottom . . . it is best observed after a prolonged term of cold, when the thermometer indicates a temperature considerably below zero."

Hind continued to suggest that the formation of anchor ice in streams issuing from glaciers plays an important role in glacial erosion and that glaciers in "very cold climates may increase from the bottom upwards with a load of frozen mud and fragments of rock . . .". He implied that the basins of the Great Lakes formed in this way. This case for anchor ice is obviously overstated, and its formation in proglacial streams in sub-zero temperatures would be inconsistent with the existence of melt-water streams which require temperatures above freezing. However, anchor ice at the heads of rapids or falls may be geomorphologically effective enough to justify more research in this area.

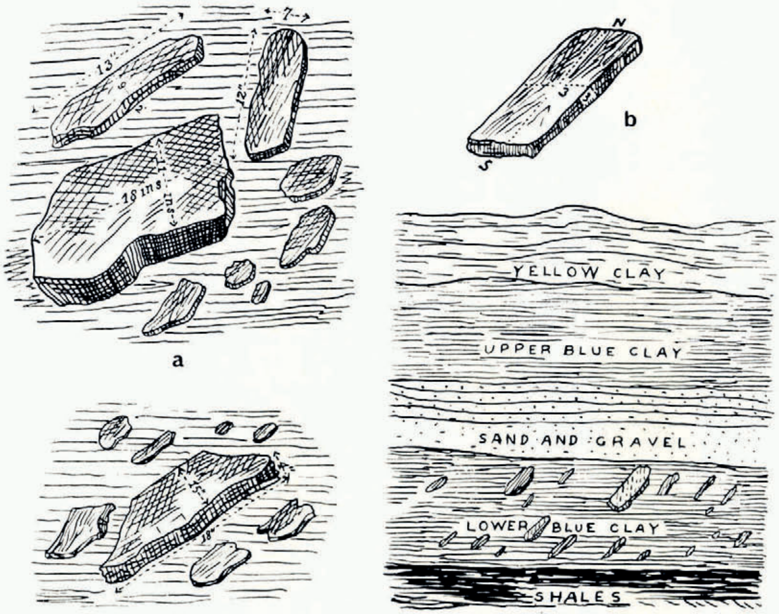

Fig. 1. Sketches showing till-stone orientation redrawn from woodcuts in Hind (1859, p. 120–21). Outlines and lettering traced; shading modified to facilitate reproduction

(*a*) *Stones inclined at an angle of about 50° towards the north-east. Near the Waterworks, Toronto*

(*b*) *General inclinations of shale fragments 60° east and a few hundred yards from* (*a*) [*sic*]

(*c*) *Slab of Hudson River formation 7 ft.* (*2·1 m.*) *from the top of the blue clay and 10 ft.* (*3·0 m.*) *above the rock inclined at a high angle toward the north-east. A boulder of gneiss is slightly inclined in the same direction. Around the slab numerous smaller fragments of rock present the same inclination* [*sic*]

(*d*) *Section showing the stratigraphy of the Pleistocene deposits at Toronto and the position of the lower blue clay*

In recognition of Hind's contribution to glacial geology studies, a glacial lake in south-western Manitoba, part of the region he explored, has been named after him (Elson, 1957, 1958). Extinct Glacial Lake Hind occupied part of the Souris River basin and had an area of about 1,000 miles² (2,590 km.²). It discharged into early Glacial Lake Agassiz through the Pembina valley. Its three sucessive levels (altitudes 1,470, 1,460 and 1,435 ft. (448, 445 and 437 m.)) are marked by deltas deposited by the Souris River at Melita, Napinka and Lauder, and by terraces in the Pembina valley.

MS. received 25 May 1965

REFERENCES

Dawson, *Sir* J. W. 1894. *The Canadian Ice Age*. Montreal, Wm. V. Dawson; New York and London, The Scientific Publishing Co.

Elson, J. A. 1957. Souris basin glacial lakes, southwestern Manitoba, Canada. *Bulletin of the Geological Society of America*, Vol. 68, No. 12, p. 1722. [Abstract.]

Elson, J. A. 1958. Pleistocene history of southwestern Manitoba. *North Dakota Geological Survey. Miscellaneous Series*, No. 10, p. 62–73. [Lake Hind is shown in Fig. 6.]

Hind, H. Y. 1859. A preliminary and general report on the Assiniboine and Saskatchewan exploring expedition. *Canada. Legislative Assembly Journal*, Vol. 19, Appendix 36.

Hind, H. Y. 1864. Observations on supposed glacial drift in the Labrador Peninsula, western Canada, and on the south branch of the Saskatchewan. *Quarterly Journal of the Geological Society of London*, Vol. 20, Pt. 1, p. 122–30; *Canadian Journal. New Ser.*, Vol. 9, p. 253–62.

Holmes, C. D. 1941. Till fabric. *Bulletin of the Geological Society of America*, Vol. 52, No. 9, p. 1299–1354.

Miller, H. 1884. On boulder-glaciation. *Proceedings of the Royal Physical Society of Edinburgh*, Vol. 8, No. 16, p. 156–89.