CORRESPONDENCE

The Ordovician Ice Age in South Africa

SIR,—In his recent Essay Review, entitled *The Ordovician Ice Age* (1972), Harland referred briefly to a tillite in South Africa which probably is of this age. Since much of the literature describing the occurrence is not readily available a few additional comments might be of interest.

The stratigraphy of the Table Mountain Group was the subject of a Doctor of Science thesis by I. C. Rust, presented at Stellenbosch University in 1967. The stratigraphic scheme adopted by him was outlined by Cocks, Brunton, Rowell & Rust (1970). The group is composed mainly of quartzites, but a thick band in the upper part consists of a tillite (the Pakhuis Formation) overlain by siltstones and shales (the Cedarberg Formation).

The tillite was first identified by A. W. Rogers and E. H. L. Schwarz, two of the pioneers of South African geology (Rogers & Schwarz, 1900). Further details were added by Rogers in subsequent articles (Rogers, 1902; 1904). The distinguishing features recorded by these workers are lithological; striated and facetted pebbles are scattered through an unbedded and poorly-sorted matrix of fine-grained sandy mudstone. Glaciated pavements have been described recently by Visser (Unpublished M.Sc. thesis, University of the Orange Free State, 1962; 1965) and by Rust (see above). Several of these pavements display wide, deep and irregular grooves, resembling a ploughed field; the appearance of the grooves suggests soft-sediment deformation.

Haughton, Krige & Krige (1925) and, later, Rennie (1925) described widespread penecontemporaneous folding of the strata immediately underlying the main tillite, including the lowest horizon of tillite. Haughton (1929) concluded that the folding resulted from the E to W advance of an ice-sheet, 'the folds being formed just in front of the contact line between the ice and the underlying unconsolidated water-logged sediments'. Detailed sedimentological studies by Rust (see above) indicate, however, that the regional pattern of sedimentation throughout the deposition of the Table Mountain Group in the Western Cape Province involved transport from N to S. This conclusion is based upon measurements of current-bedding orientation, till-fabric studies, studies of the orientation of striations on glaciated pavements and determinations of the provenance of distinctive clastic particles (e.g. amethyst sand grains in the tillite). Rust, accordingly, supported the view of Visser (1965) that the folds are not transverse but parallel to the direction of advance of the ice. Rust suggested that the folds are large-scale load casts. Martin (1961) described similar folds beneath an equivalent tillite in South America.

The shales of the overlying Cedarberg Formation are interpreted as outwash silt and mud from the retreating ice-sheet (Cocks *et al.*, 1970). The lowest member of this formation is varved. The formation may be traced into the Eastern Cape Province, where small, isolated pebbles may be ice-rafted erratics (D. K. Toerien & M. R. Johnson, pers. comm., 1973).

Until recently, fossils known from the Table Mountain Group consisted solely of invertebrate tracks, trails and burrows and possible branched algae. During the course of his field-work, however, Rust found an assemblage of well-preserved brachiopods, a trilobite tail, and indeterminate fragments of other invertebrate forms. These indicate a late Ashgillian or early Llandovery age, of which the former is preferred (Cocks *et al.*, 1970). The fossils are known from several localities, within the Cedarberg Formation; they indicate that the underlying tillite is of late Ordovician age. All other evidence bearing on the age of the glaciation is indirect.

The Table Mountain Group lies unconformably on the Cape Granite, which has been dated at 553 ± 8 Ma by Allsop & Kolbe (1965). These authors determined also an age for a cross-cutting mass of aplogranite within the Cape Granite complex—they obtained a figure of 500 ± 15 Ma. The Table Mountain Group is, therefore, of Late Cambrian or younger age at its base. No direct age determinations are available for

Geol. Mag. 110 (4), 1973, pp. 372–376. Printed in Great Britain.

strata within the group, but Rust made a series of estimates, based on sedimentation rates. I have been unable to locate the source of the figure of 520 Ma quoted by Harland for the Peninsula Formation (mis-printed as Penicula Formation), and suspect that this might be an error.

References

Allsop, H. L. & Kolbe, P. 1965. Isotopic age determinations on the Cape Granite and intruded Malmesbury sediments, Cape Peninsula, South Africa. *Geochim. cosmochim. Acta* **29**, 1115–30.

Cocks, L. R. M., Brunton, C. H. C., Rowell, A. J. & Rust, I. C. 1970. The first lower Palaeozoic fauna proved from South Africa. *Q. Jl geol. Soc. Lond.* **125** (for 1969), 583–603.

Harland, W. B. 1972. Essay Review: The Ordovician Ice Age. *Geol. Mag.* **109**, 451–6.

Haughton, S. H. 1929. The glacial beds in the Table Mountain Series. *Int. geol. Congr., 15th Session, South Africa* **2**, 85–90.

Haughton, S. H., Krige, L. J. & Krige, A. V. 1925. On intraformational folding connected with the glacial bed in the Table Mountain Series. *Trans. geol. Soc. S. Afr.* **28**, 19–26.

Martin, H. 1961. The hypothesis of continental drift in the light of recent advances of geological knowledge in Brazil and South West Africa. *Trans. geol. Soc. S. Afr.* **64** (Annexure).

Rennie, J. V. L. 1925. Note on the presence of a folded stratum in connection with the glacial band on Table Mountain. *Trans. geol. Soc. S. Afr.* **28**, 79–80.

Rogers, A. W. 1902. On a glacial conglomerate in the Table Mountain Series. *Trans. S. Afr. phil. Soc.* **11**, 236–42.

1904. The glacial conglomerate in the Table Mountain Series near Clanwilliam. *Trans. S. Afr. Phil. Soc.* **16**, 1–8.

Rogers, A. W. & Schwarz, E. H. L. 1900. Report on the geology of the Cedarbergen and adjoining country. *Ann. Rpt geol. Commn, Cape Good Hope*, 65–82.

Viser. 1965. Gletservloer in die Pakhuisberge, Distrik Clanwilliam. *Annals geol. Surv., S. Afr.* **4**, 43–8.

BRIAN E. LOCK

Geology Department
Rhodes University
Grahamstown
South Africa
1st February 1973

Tilloids from N.W. Pakistan

SIR,—Tillite horizons are known from several localities in the Himalayas and peninsular India. In the Himalayan region, the (presumed) Upper Carboniferous to Permian horizon is recorded from the Salt Range (Pakistan), Kashmir, Spiti, Blaini (Simla), Nepal and Sikkim, whilst Powell & Saxena (1971) have recently described an apparently Lower Carboniferous tillite, overlying phyllites, from the Chamba Himalayas of Himachal Pradesh. To the best of my knowledge, no tillite occurrence has been reported from Pakistan to the NW of the Salt Range.

Whilst in Pakistan in 1969, however, I noticed a siliceous breccia and a pebbly quartzite, suggestive of tillite, in the Warsak area (34°10′ N, 71°25′ E), some 30 km WNW of Peshawar and 200 km NNW of the Salt Range. The rocks are well exposed along the Mulagori road, approximately 1 km N of Umardin Kili (Ahmad *et al.*, 1969, map facing p. 78). Subsequent examination has shown that they are very possibly of