presence of accessory minerals apatite, magnetite, alkali pyroxenes and amphiboles, monazite, olivine (?) etc., the presence of Sr, Ba, Ti and P in high concentrations similar to those in carbonatites, and the presence of Ti, V and P in the accessory-magnetites, all support this conclusion. Further work on this occurrence is in progress.

Acknowledgements: The writer wishes to thank M/s. James, L. Powell, Chairman, Department of Geology, Oberlin College, Ohio, USA; A. Hatton, Project Manager of Tamil Nadu Mineral Development Project; and V. Gopal, Project Co-ordinator of the same Project; for evaluating the manuscript. He is grateful to Mr. T. S. Paramasivan, Additional State Geologist of the Tamil Nadu Geology Branch, for his timely help, encouragement and permission to take up this work. His thanks are due to his colleagues, V. Subramanian for his encouragement, and to P. V. Rajagopal, K. Shanmugam and V. Navarasam for their assistance in the field.

References

BORODIN, L. S. *et al.*, (1971) Precambrian carbonatites of Tamil Nadu, South India. *Jour. Geol. Soc. Ind.*, v. 12, no. 2, pp. 101-112.

CROHN, P. W. and GELLATELY, D. C., (1968) Probable carbonatites in Strangways Range Area, Central Australia. *Aust. J. Sci.*, v. 31, no. 9, pp. 335-336.

DEANS, T. and POWELL, J. L., (1968) Trace elements and strontium isotopes in Carbonatites, Fluorites and Limestones from India and Pakistan. *Nature*, v. 218, pp. 750-752.

GRADY, J. C., (1971) Deep main faults in South India—*Jour. Geol. Soc. Ind.*, v. 12, no. 1, pp. 56-62.

HEINRICH, E. W., (1966) *The Geology of carbonatites* Rand McNally and Co., Chicago.

A NOTE ON THE OCCURRENCE OF GLACIAL PAVEMENTS ALONG NORTHERN BOUNDARY OF NORTH KARANPURA COALFIELD HAZARIBAGH DISTRICT, BIHAR

S. K. CHAKRABORTI
Calcutta

AND

B. P. BHATTACHARYA
Patna

Although glaciation during the Talchir period (Upper Carboniferous) in India is an accepted phenomenon, and Talchir deposits of glacial origin (e.g. boulder bed) have been described from various coalfields (Pascoe, 1959) direct evidences of glacial movement are particularly scanty. The only unequivocal evidence of ice action so far recorded is the presence of glacial striae near Irai on the Pranhita-Godavari valley (Fedden, 1875). The other reported occurrence of glacial scratches from Ajoy river in Raniganj coalfield in the Damodar valley region (Smith, 1963) is generally accepted with reservation.

In the course of recent geological studies in and around North Karanpura coalfield, the westernmost of the Damodar valley group of coalfields, several occurrences of striated and polished pavements in association with Talchir glacial deposits have been observed for the first time at the northern periphery of North Karanpura coalfield between latitudes 23°52′ & 23°54′15″ and longitudes 85°14′15″ & 85°16′45″ (Fig. 1) at a distance of 20-25 km south west of Hazaribagh town.

General geology: The striated and polished pavements are made up of Precambrian porphyroblastic granite-gneiss and migmatitic gneiss around the outcrops of Talchir and post-Talchir Gondwana deposits which make up the north Karanpura basin and its outliers. The Talchir deposits are generally composed of tillite (with facetted and scratched pebbles and boulders), conglomerate, greenish siltstone, green shale and varved shale with total thickness varying from 2 m to 175 m. The sloping high ground north of the main basin is plastered with a large number of small and irregular patches of tillitic material.

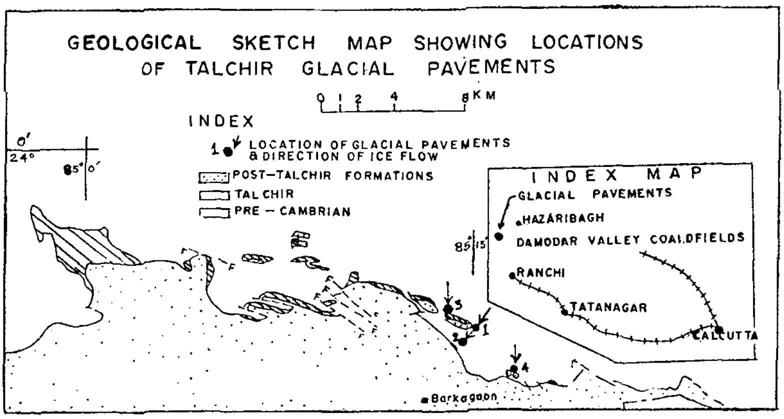

Figure 1. *Geological sketch map showing locations of glacial pavements.*

Description of striated and polished surfaces: Present finds are small areas (maximum size 6 m × 4 m) of finely striated, abraded and polished surfaces of gneiss at four separate localities (Fig. 2), the latitudes and longitudes for which are listed below.

Locality 1—Lat. 23°53′45″; Long. 85°15′15″;
Locality 2—Lat. 23°53′0″ ; Long. 85°14′45″;
Locality 3—Lat. 23°54′15″; Long. 85°14′15″;
Locality 4—Lat. 23°52′0″ ; Long. 85°16′45″;

The surfaces are gently sloping towards south, smooth in appearance and bear a spectacular polish (Fig. 2). The striae are developed in discrete irregular patches and generally run across the foliation or banding of the gneiss. There are no visible step-like breaks in the striae and all the marks or polish appear to be superficial. At locality 1 considerable abrasion has taken place on the northern edge of a quartz-rich, hard and humpy band, the striae and scratches almost resembling fine chiselling action. The generally protruding large feldspar porphyroblasts and quartzo-feldspathic bands appear to have been planed off and thoroughly polished. The occurrences are parts of large gently sloping surfaces remote from any streams or possible courses of rain water.

Occurrences 1, 2 and 3 lie very close to Talchir rock outcrops, while number 4 is at a distance of 2 km from the nearest Talchir outcrop. The Talchir deposits in these places are in the main lenticular pebble-boulder units without any sorting or stratification.

Direction of ice movement: The striae are uniform in direction at individual localities. The striae directions noted are:

N35°E – S35°W at localities 1 and 2 and
North – South at localities 3 and 4.

Recorded pavement localities 1 and 2 are very close and aligned nearly in the direction of striae. Distinctly lower R.L. of locality 2 confirm glacial movement from north.

Figure 2. Photograph of striated and polished pavements of granite-gneiss at Locality 1 (indicated on Fig. 1)

Summary and conclusions: From the above evidences of ice action adjacent to the Talchir outcrops, it is concluded that during the Talchir period there has been glacial movement from north or N35°E at least up to the northern borders of north Karanpura coalfield between longitudes 85°14′ and 85°17′. With the available data it is difficult to ascertain whether the glacial marks represent the imprint of glacial lobes—one or many. It can be reasonably supposed that the area of actual glacial movement had been much wider than at present recorded. The Precambrian gneisses of this area being hard and inhomogeneous in composition are not well suited for formation of glacial striae on them. The search should, however, also continue along north marginal areas of other coalfields in the region where existence of true glacial deposits has been proved by recent studies (Ghosh and Mitra, 1967).

Acknowledgements: The authors are grateful to Sri B. Laskar and Sri K. D. Shukla, Directors, Geological Survey of India for their help and guidance in carrying out this work.

REFERENCES

FEDDEN, F., (1875) On the evidences of 'ground ice' in tropical India during Talchir period. *Rec. Geol. Surv. Ind.*, v. 8 (1), pp. 16-18.

GHOSH, P. K. and MITRA, N. D., (1967) Recent studies on Talchir glaciation in India. *Int. Symp. Gond. Strat. Palaeont.* Mar Del Plata.

PASCOE, E., (1959) *Manual of the Geology of India.* 3rd Edition (2).

SMITH, A. J., (1963) A striated pavement beneath the basal Gondwana sediments on the Ajoy river, Bihar, India. *Naiure*, v. 198, no. 4883, p. 880.

RESEARCH NOTES

PIGEONITE IN THE DECCAN TRAPS by T. Krishnamacharlu, *(Centre of Advanced Study in Geology, University of Saugar)*

Deccan basaltic lava flows containing subordinate amounts of pigeonite have been reported by Barth (1931), Naidu (1960) and Muir (1971). West (1952) after a careful examination of the pyroxenes of the basalts, concluded that the overwhelming bulk of pyroxenes in the Deccan Trap basalts are of the subcalcic augite variety and that pigeonite is rarely found in them. Sukheswala and Poldervaart (1958) and several others confirmed West's observations.

The attention of the earlier workers has been hitherto focussed on the nature of pyroxenes of the Deccan Trap flows and little consideration has been given to the Deccan Trap dykes which, since long, have been considered to be the feeders of the lava flows.

The petrographic studies of dolerite dykes of Pachmarhi, Madhya Pradesh, Dadiapada, Gujarat and Dedan, Saurashtra areas show some interesting results. The dykes of these areas consist essentially of plagioclase feldspar, monoclinic pyroxenes, iron oxide and mesostasis, with or without olivine. Subordinate amounts of pigeonite are invariably found in the slowly cooled, coarser grained dolerites. In Pachmarhi area, big plates of subcalcic augite contain pigeonitic core, as is common in the Tasmanian dolerites (Spry, 1961). Pigeonite occurs as large crystals (1×0.6 mm) and also as minute grains (0.2×0.1 mm) in the mesostasis.

In the dolerites of Dadiapada area, pigeonite occurs as small crystals generally mantled by augite, similar to pigeonites of Karroo dolerites (Walker and Poldervaart, 1949) and Tasmanian dolerites (McDougall, 1961). In many cases it occurs as columnar crystals in the core and also in the peripheral portions of augite plates. $2V_\gamma$ of augite that mantles pigeonite is generally low (30° to 37°) whereas $2V_\gamma$ of separate grains of augite is 40° to 46°. $2V_\gamma$ of pigeonite determined by the method of Turner (1940) is 7° to 12°.

The more differentiated lavas are considered to contain subcalcic augite accompanied by a subordinate amount of pigeonite (Muir, 1971; Aoki, 1967) and the ratio of pigeonite to augite seems to be related to the degree of fractionation of basaltic magma (Aoki, 1967), the ratio increasing with the progressive fractionation. In some of the thin sections of the basalts of Lonar crater, Maharashtra, and Sagar, Madhya Pradesh (kindly provided by V. K. Nayak and P.O. Alexander respectively),