

## ASPECTS OF THE ATTITUDE OF MAFIC SHEETS IN THE WESTERN CORDILLERA OF COLOMBIA

– a contribution to the study of the framework of mafic sheeted complexes –

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### ABSTRACT

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Changes in the attitude of sheet-like bodies of mafic rocks ('diabase') are discussed in relation to changes in the attitude of the bedding of intercalated and otherwise associated sedimentary rocks. Examples are presented in photographs of outcrops along the main road between Buga and Buenaventura, W. Colombia.

The mafic sheets of the Colombian Western Cordillera and their mode of emplacement are compared with the sheets of the Sheeted Intrusive Complex of Cyprus, with reference to the sheet swarms of Iceland. Horizontal emplacement of sheets, never questioned in the Western Cordillera of Colombia, is considered as an alternative to vertical emplacement of sheets, previously suggested for the Sheeted Intrusive Complex of Cyprus.

The subject matter is thought to be of importance in the (geophysical) study of the framework of the ocean floors. Further field investigation of the volcanic-sedimentary complex of the Western Cordillera of Colombia should be encouraged.

### GENERAL

A large part of the Western Cordillera of Colombia is formed by the Dagua and Diabase Groups (HUBACH & ALVARADO, 1934; NELSON, 1957, 1962). Although geological field investigations have been carried out during the past ten years, by the Geology Department of the Universidad Nacional of Bogotá among others, the last available publication on geological field relations appears to be by NELSON (1962). This author concluded that the Diabase Group, presumably of Middle to Late Cretaceous to possibly Palaeocene age, overlies the possibly Triassic to Cretaceous Dagua Group. The base of the latter is not known. Reference is also made to the regional geophysical studies in eastern Panamá and western Colombia by CASE ET AL. (1971) and CASE (1974).

According to NELSON (1962) the Dagua Group consists of four schist members, showing a tendency of diminishing clastic elements towards the top of the Group, where some intercalations of diabase are mentioned in the Greenschist

Member. The Diabase Group is made up of vast masses of mafic igneous rocks, generally greenish to greenish-grey, medium- to finegrained with an ophitic to granular-ophitic texture. These rocks often form distinctly laminar sheets up to two metres thick. In addition indications are found of devitrified volcanic flows with amygdalae and some evidence of pillow structures, together with rocks of a somewhat coarser texture of the microgabbro type.

NELSON (1962) mentions several instances of siliceous schist intercalated between massive sheets of diabase, in the area west of Cali.

The two Groups have been folded into broad, broken, anticlinal and synclinal structures. The sedimentary intercalations, together with contact relations between sediments and igneous sheets elsewhere, are important in that they testify to the concordant and, most probably, horizontal emplacement of the diabase sheets.

### OUTCROPS ALONG THE BUGA-BUENAVENTURA ROAD

A large number of rather fresh outcrops can be examined along the main road from Buga to Buenaventura. Away from

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Fig. 1. Massive fine- to medium-grained diabase sheet in upper part of photograph, approximately 1.60 m thick, dipping slightly to the west; 4 km along main road west of Buga.



Fig. 2. Distinct sheets of deeply weathered mafic rocks, dipping to the west; 7 km along main road west of Buga.

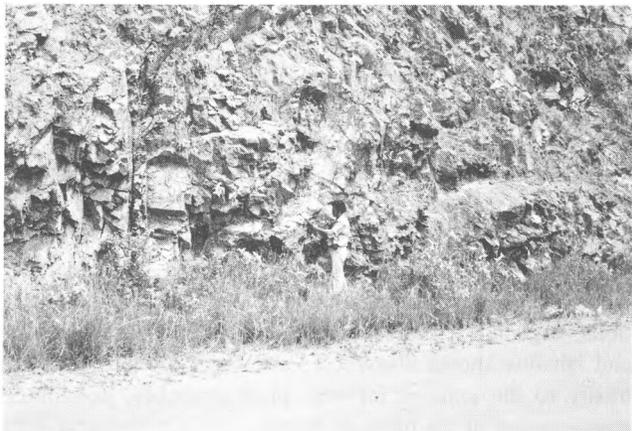
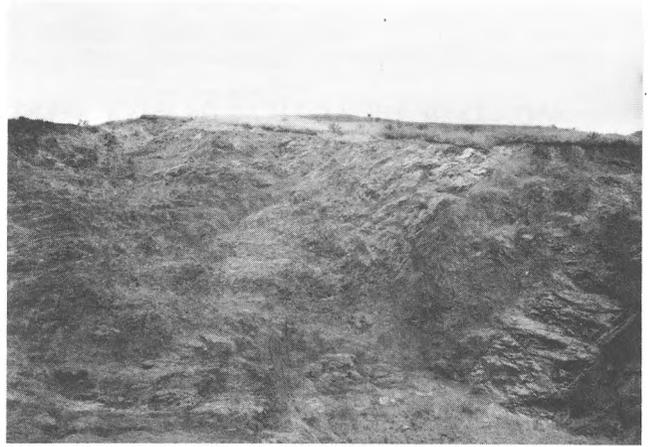


Fig. 3. Massive, fine- to medium-grained mafic rocks, in which the sheet configuration appears to have been largely obliterated by fracturing. Some evidence seems to remain just above the person holding a hammer, with a suggestion of a westerly dip. Towards the left edge of the photograph vertical planes appear to be strongly developed. It has not been possible to distinguish between original and secondary separations. The rocks have a shattered appearance; 8 km along main road west of Buga.



a



b



c

Fig. 4a. Siliceous shales in contact with a massive sheet of diabase. Bedding in shales follows the contact with the underlying diabase. In the righthand portion of the outcrop the contact dips to the west and changes gradually to horizontal to the left; 45 km along main road west of Buga. b. and c. Overlapping photographs showing details. Siliceous shales, showing micro-folding, on top of a massive sheet of diabase. Although the shales have been deformed in a different style, bedding conforms broadly to the contact with the mafic rock.



Fig. 5. Fault contact between siliceous shales, to the right, and a complex of mafic sheets. Although the igneous rocks have only been tilted and have preserved their laminar identity, the shales have been strongly contorted; 53 km west of Buga.

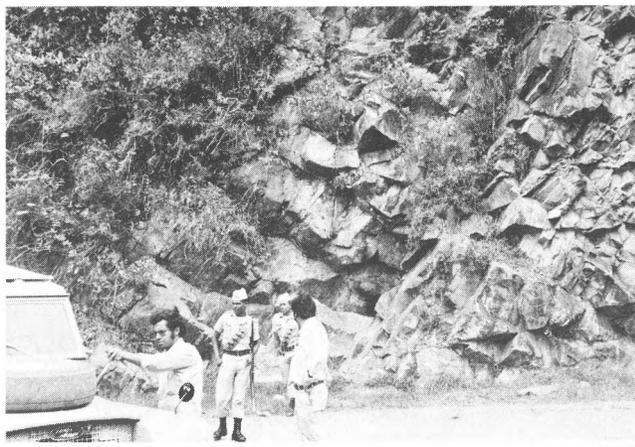


Fig. 6. Diabase sheets with easterly dip at Calima dam, between Buga and Loboguerrero, off main road.

the roads outcrops are small and scarce and generally deeply weathered.

Photographs are presented here to give an impression of relations and attitudes of massive diabase sheets, weathered lavas and sediments. For regional geological relationships reference is made to the recently published geological maps of Colombia by CEDIEL ET AL. (1976) and by BARRERO ET AL. (1976).

#### COMMENTS

Although in the area between Buga and Buenaventura a sheeted framework is often observed in the mafic rocks, this is not always obvious. It is thought that fracture folding, to various degrees, has obliterated the original sheet configuration in many cases (e.g. Fig. 3).

The lithological composition and the texture of the mafic rocks vary, recurrently, throughout the complex. Petrographic studies are in progress.

Mafic sheets show attitudes between horizontal and vertical. Gradual changes in attitude from vertical to sub-horizontal and horizontal, together with corresponding changes in the attitude of the bedding of associated (Figs. 4a, b and c) and intercalated sediments (NELSON, 1962, Photo 6) strongly suggest a horizontal emplacement of probably most mafic sheets. Intercalated mafic lava flows support this suggestion. Tectonic processes account for changes in disposition of the sheets.

The horizontal emplacement of the mafic laminar components of the volcanic-sedimentary complex of the Western Córdillera has never been questioned.

In several cases the mafic sheets of this area could, in isolation, suggest that they were emplaced as dykes, on the grounds of their present steep to vertical attitude (Figs. 6 and 7).

In particular the steep to vertical attitude of similar sheets in the Sheeted Complex of Cyprus has been suggested as a major argument in favour of their vertical emplacement (GASS, 1968; GASS & MASSON-SMITH, 1963; MOORES & VINE, 1971; see also HOLMES, 1965, p. 1105; and WARREN CAREY, 1976, p. 335). Some observations on the western part of the latter complex have been put forward (DE BOORDER, 1975) to suggest that at least in the marginal portions of this complex the sheets could have been emplaced as sills, and that tectonic processes, i.e. differential uplift, could well account for much of the steep disposition in the more central parts of the complex. WALKER (1975) has compared the Sheeted Complex of Cyprus with the sheet swarms of Iceland, for which he concluded that emplacement was horizontal to sub-horizontal. Several mechanisms of emplacement have been put forward by PIPER & GIBSON (1972) and by WALKER (1975).

It is suggested that further studies on the association of the Dagua Group and the Diabase Group of the Western Cordillera of Colombia will be of help in elucidating the genesis of other sheeted mafic complexes, like those of Cyprus and Iceland.

It is also suggested that horizontal emplacement of mafic sheets, as elements of the structure of the ocean floors, should be taken into account in the interpretation of the results of geophysical investigations of the ocean floor (cf. VAN ANDEL & BOWIN, 1968, as quoted by Belousov, 1970), as well as the possibility of their vertical emplacement (e.g. VINE, 1966; GASS, 1968).

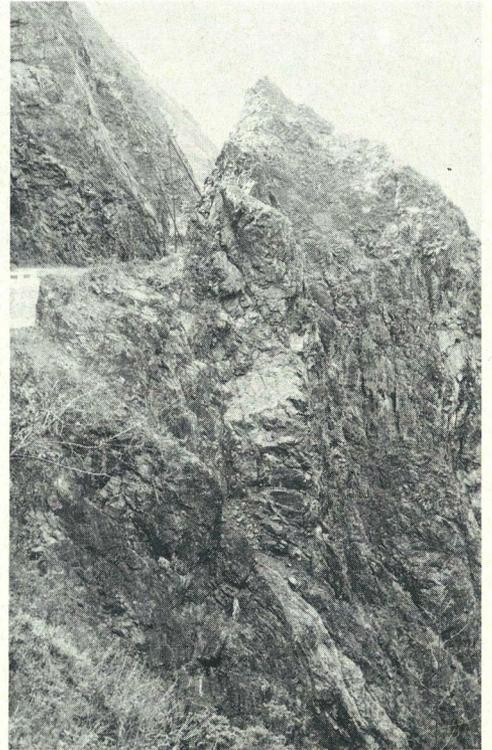
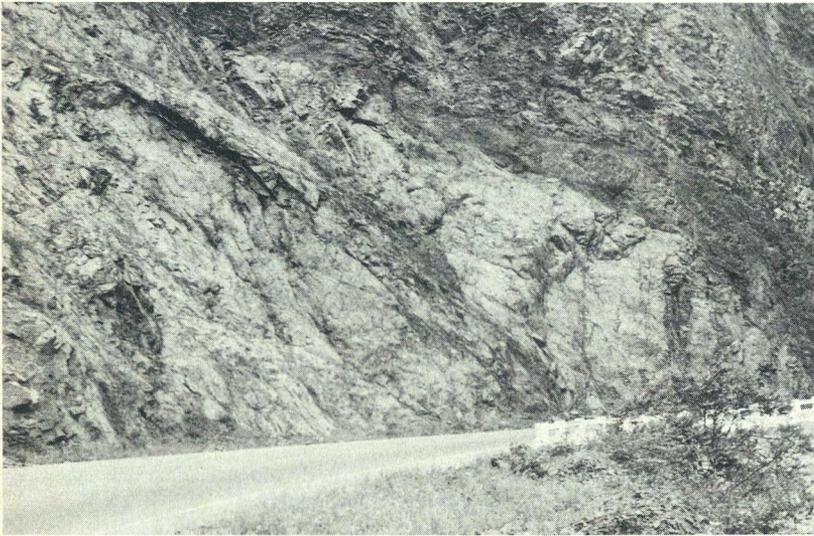


Fig. 7 Photographs, with a small gap, of a sheeted complex of mafic igneous rocks of slightly different lithologies, reflected by different weathering, represented by different tones and morphology. The steep dip of the sheets on the right changes upward to a less inclined attitude. The light unit in the centre wedges upward between adjacent units. The darker smooth unit above is thought to be a lava flow. The blocky unit towards the top is a fine- to medium-grained hard greenish-grey diabase; 63 km along main road west of Buga.

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#### REFERENCES

- Barrero, D., H. Duque, J. L. Arango, T. Kassem & F. Zambrano 1976 Mapa geológico de Colombia, escala 1:1,500,000-Inst. Nacional Invest. Geol.-Min., Apartado Aereo 4865, Bogotá.
- Belousov, V. V. 1970 Against the hypothesis of ocean floor spreading-Tectonophysics 9: 489-511.
- Case, J. E. 1974 Ocean crust forms basement of Eastern Panamá-Geol. Soc. Amer. Bull. 85: 645-652.
- Case, J. E., L. G. Duran, A. Lopez & W. R. Moore 1971 Tectonic investigations in Western Colombia and Eastern Panamá-Geol. Soc. Amer. Bull. 82: 2685-2712.
- Cediel, F., G. Ujueta & C. Caceres 1976 Mapa geológico de Colombia, escala 1:1,000,000-Geotec Ltda, Apartado Aereo 51846, Bogotá.
- De Boorder, H. 1975 The Sheeted Intrusive Complex of Troodos, Cyprus-Geol. Mijnbouw 54: 199-204.
- Gass, I. G. 1968 Is the Troodos Massif of Cyprus a fragment of Mesozoic oceanic crust? - Nature 220: 39-42.
- Gass, I. G. & D. Masson-Smith 1963 The geology and gravity anomalies of the Troodos Massif, Cyprus-Phil. Trans. Roy. Soc. London, Ser. A 255: 417-467.
- Holmes, A. 1965 Principles of Physical Geology - Thomas Nelson and Sons, Ltd. (London): 1288 p.
- Hubach, E. & B. Alvarado 1934 Geología de los Departamentos del Valle y del Cauca, en especial del carbón - Informe 87 Archivo Inst. Geol. Nacional, Bogotá.
- Moore, E. M. & F. J. Vine 1971 The Troodos Massif, Cyprus, and other ophiolites as oceanic crust; evaluations and implications - Phil. Trans. Roy. Soc. London, Ser. A 268: 443-466.
- Nelson, H. W. 1957 Contribution to the geology of the Central and Western Cordilleras of Colombia in the sector between Ibagué and Cali - Leidse Geol. Meded. 22: 75 pp.
- 1962 Contribución al conocimiento de la Cordillera Occidental. Sección carretera Cali-Buenaventura - Bol. Geol. Serv. Geol. Nacional, Repúbl. Colombia 10: 81-108.
- Piper, J. D. A. & I. L. Gibson 1972 Stress control of processes at extensional plate margins - Nature, Phys. Sci. 238: 83-86.
- Van Andel, T. H. & C. O. Bowin 1968 Mid-Atlantic Ridge between 22° and 23° N latitude and the tectonics of Mid-Ocean Rises - J. Geophys. Res. 73: 1279-1304.
- Vine, F. J. 1966 Spreading of the ocean floor; new evidence - Science 154 (3755): 1405-1415.
- Walker, G. P. L. 1975 Intrusive sheet swarms and the identity of Crustal Layer 3 in Iceland - J. Geol. Soc. London 131: 143-161.
- Warren Carey, S. 1976 The expanding Earth - Devel. Geotect. 10, Elsevier Sci. Publ. Co. (Amsterdam): 488 p.