ITARARÉ SUBGROUP (TUBARÃO GROUP) IN THE MOCOCA—CASA BRANCA REGION — São Paulo State(*)

Por

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ABSTRACT

A newly exposed section of Itararé rocks is described from road-cuts on the Mococa-Casa Branca highway, São Paulo State. These rocks are generally coarser and more proximally located to the source area than are those of southern São Paulo. Diamictites are thinner and less numerous indicating that the effects of glaciation were less extensive in the north than in the south. Sedimentary structures indicate that paleocurrents flowed predominently toward the northwest.

INTRODUCTION

This paper describes the northernmost known section of the Itararé Subgroup exposed on the Mococa-Casa Branca road, northern São Paulo State and relates the section to the better known occurrences farther south. A second purpose of the paper is to reconstruct the paleogeography from regional facies variations and paleocurrent trends deduced from sedimentary structures. As used here, Itararé Subgroup refers to the glacial and interglacial sequence of the Tubarão Group, as in the scheme of facies relationships presented by Rocha-Campos (1967).

DESCRIPTION

The occurrences are described from the base upward, and from the eastern margin toward the center of the basin. Refecence is made throughout the description to the kilometer marks of the new Mococa-São Paulo road (Fig. 1). The rocks are located between the towns of Mococa and Casa Branca. Sections described herein are seen in deep road-cuts along the road and therefore correspond to the more resistant units of the section. The unexposed parts of the section occur along stretches of lower ground and are probably constituted of poorly cemented sandstone and mudstone.

The base of the Itararé can be seen in road-cuts at km 295½, where about 50 cm of deeply weathered pebble conglomerate rests in sharp contact on gray gneissic granite (fig. 2). Approximately 85% of clasts in the conglomerate consist of gneissic granite, probably locally derived. Brown sandstone clasts of unknown source also occur. Striated and faceted clasts were not observed, and most pebbles are subangular to sub-rounded. The arenaceous matrix of the conglomerate

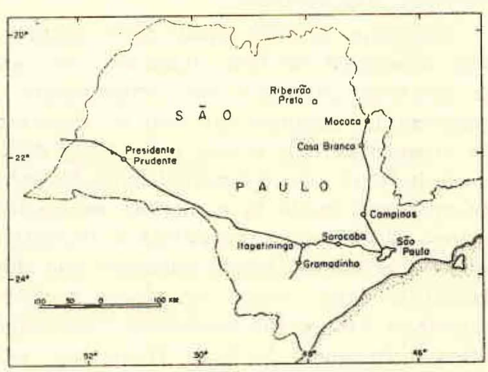

Fig. 1

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grades upward into a more poorly sorted diamictite (Flint and others, 1960), which is dark reddish brown in color and about 1.5 m thick. Locally, this diamictite overlaps the conglomerate to lie directly on granite; in places the diamictite itself pinches out against the basement rocks, and the overlying sequence of reddish brown sandstone and siltstone abuts against the floor of the basin. About 7 m of this sandy unit are exposed in the cut and it also seems to underlie most of the low country between Km 295½ and Km 284.

At Km 283.8 about 3.5 m of reddish brown fine-grained sandstone correlated with this sandy unit is overlain by approximately 4 m of reddish brown diamictite, the base of which is made up of about 20% thin siltstone beds. These beds, up to about 5 cm thick, contain soft sediment folds with axes trending roughly E-W. Asymetry of the folds suggests movement from north to south. Thinning of the diamictite in the road-cut suggests that it may be pod-shaped but the unit is tentatively correlated with a similar diamictite, 3 m thick, exposed in the road-cuts at Km 282.5. At the latter locality diamictite occurs at the base of the exposed section and is overlain by discontinuous pods and lenses of fine-grained sandstone and pebble conglomerate up to 70 cm thick. Next higher in the section is another diamictite with a maximum thickness of 4.5 m. This one differs from most lower ones in displaying fairly well developed stratification.

Extensive erosion must have occurred after deposition of this diamictite because the overlying sandstone and conglomerate is preserved in channels cut into it. However, the arenaceous unit is not extensively developed; it is, in turn, truncated irregularly by the overlying strata in a manner suggesting erosion. These strata constitute a distinctive sequence of reddish brown mudstone and thin diamictite units, which in places replaces more than 3 m of the sandstone. Maximum observed thickness is 6 m. There are two diamictites in this sequence, and they are both lenticular, having a maximum thickness of about 2.50 m and thickening northward. Clasts were not observed in the well-sorted mudstone unit.

Part of the sandstone and the full thickness of the mudstone sequence above it is also seen in road-cuts at Km 278.8. The lithologic correspondence between the two sections is good and although diamictite is lacking at 278.8, pebbly shale is developed there. Overlying the silty mudstone unit at 278.8 is a reddish brown diamictite at least 5 m thick. At the contact, load casts and convolutions of diamictite extend into the underlying mudstone and shale indicating that the mud was soft, plastic, and perhaps under water at the time the diamictite was deposited.

The top of this diamictite is not exposed at Km 278.8 but the unit is presumed to underlie at least a portion of the roadway between 278.8 and the next younger exposures at Km 278. There is some indication in small roadside exposures that sandstone also makes up part of the unseen section. At Km 278 the oldest rocks seen are fine grained, reddish brown, poorly cross-bedded sandstone and rare siltstone about 3 m thick. These are overlain by brick red diamictite with a maximum thickness of 4 m. Diamictite shows some stratification in alignment of granules and larger clasts. Striae are rare but faceted clasts are common in this unit. Load casts of overlying fine grained sandstone extend downward into the diamictite as far as 12 m. The complicated structure of the sandstone indicates that the underlying diamictite was highly plastic and probably under water at the time that the sandstone was laid down.

The sandstone exposed at the top of the section at Km 278 is the highest part of the Itararé Subgroup to be seen on the Mococa-Casa Branca road. Other exposures seen on secondary roads in the region indicate that the Itararé passes normally upward into strata of the upper Tubarão Group. Regional thinning of the Itararé to the north is here attributed to progressive butting out of the oldest units against irregularitites on the crystalline floor. Toward north of Mococa, in the State of Minas Gerais, the Botucatú and Serra Geral Formation lie directly on Precambrian rocks, with no Itararé intervening.

Granulometric analyses were run of sandstone and diamictite bodies of the Mococa-Casa Branca section and compared with size analyses of samples from sections farther south. In order to compare with the sandstone bodies, only the matrix of the diamictites was analysed. The seiving was run with ¼ ϕ interval, and the pipette with times equivalent to measure 1 Φ interval. The cumulative curves were drawn on probability paper and the parameters were calculated using the equations of Folk and Ward (1957). Table I shows the values for mean size (Mz Φ), inclusive graphic standard deviation (σ Φ), and inclusive graphic skewness (Sk Φ), of the Mococa-Casa Branca samples and for those of other areas of the eastern border of the Paraná Basin. Table 1 shows that the samples analysed had a fairly low content of clay. The maximum amount of clay in diamictite is less than 10%, and only 2 samples contained more than 7%. The water-laid deposits contain more sizeable amounts of clay.

The samples from the Mococa-Casa Branca section contain a rather uniform suite of heavy minerals. They are similar to samples analysed from other areas (Rocha Campos 1967). The following list places them in order of relative abundance: opaque minerals, tourmaline, garnet, zircon, staurolite, kyanite, and rutile. In some samples the content of garnet was considerably greater than in most.

STRATIGRAPRY

The Tubarão Group in the State of São Paulo (Barbosa and Almeida 1949; Barbosa and Gomes 1958; Rocha Campos, 1967) has been studied from surface exposures and a few long boreholes through the section. The general distribution of rock units within the Tubarão are known but these have not been verified by detailed stratigraphic work or by geologic mapping. Until this is done, it is perhaps best to keep regional correlations tentative.

Strata of the Itararé are well exposed on the Sorocaba-Itapetininga road (Frakes and Figueiredo, 1967), and they are also well developed in the rio Tietê area, where 6 diamictites have been recognized: Salto Tillite of the Itu Formation; tillite of the Elias Fausto Formation, intercalated with fluvio-glacial rocks on the Anhanguera Road; the Raffard and Mombuca Tillites of the Gramadinho Formation; the Jurumirim Tillite of the upper part of the Tietê Formation; and the Pitanga Tillite from the base of the Tupi Member of the Itapetininga Formation. It is not yet possible to make valid lithologic correlations of these dominantly continental rocks from rio Tietê to either the Sorocaba-Itapetininga of the Mococa-Casa Branca areas. Figure 2, however, shows the geologic sections exposed at the two localities, and we will make an attempt to point out the similarities and differences between them.

Sample	Rock type	MΦ	$\sigma\Phi$	skΦ	sand	silt	clay
MO-1	diamictite	4.3	2.1	0.07	41.0	52.5	6.5
MO-2	siltstone	—	—	—	0.2	73.0	26.8
MO-3	diamictite	4.6	2.0	0.13	37.0	55.0	8.0
MO-4	diamictite	2.8	1.6	0.45	81.0	14.5	4.5
MO-5	sandstone	3.8	1.3	0.58	64.5	32.0	3.5
MO-6	mudstone	5.9	—	—	1.8	83.0	15.2
MO-7	sandstone	3.1	1.2	0.62	80.5	16.0	3.5
MO-10	sandstone	2.4	1.7	0.57	82.0	15.5	2.5
SP-1	sandstone	3.8	0.8	0.53	64.0	34.9	1.1
SP-2	siltstone	5.1	1.0	0.58	5.0	89.1	4.9
SP-3	siltstone	5.3	1.0	0.51	0.6	94.4	5.0
SP-4	diamictite	4.1	1.7	0.44	50.0	44.0	6.0
SP-5	diamictite	3.7	1.6	0.39	59.0	39.0	2.0
SP-6	diamictite	3.3	1.6	0.46	66.0	31.0	3.0
SP-7	diamictite	3.6	2.6	0.13	42.0	51.0	7.0
SP-8	diamictite	4.4	1.9	0.36	45.0	48.5	6.0
SP-9	diamictite	4.8	1.7	0.44	32.0	60.0	8.0

TABLE 1. Mean size (MΦ), standard deviation ($\sigma\Phi$), skewness (skΦ), and percentage in sand, silt, and clay size classes of samples from Mococa-Casa Branca section (MO) and from southern São Paulo State (SP).

Hopefully, these relationships will be of value in interpreting environments of deposition and paleogeography.

The Mococa-Casa Branca section differs from the Sorocaba-Itapetininga section in several significant aspects. First, the finer grained strata which are well developed at Sorocaba-Itapetininga are very poorly developed at Mococa-Casa Branca, except for the sequence at Km 282½. Smilarly scarce are sequences of interbedded shale and siltstone, and perhaps most significantly, pelodite. This unique rock type was not observed in the Mococa-Casa Branca section. Instead, sandstone and conglomerate bodies are much better developed in the northern section; sandstone here seems to constitute a very large parte of the Itararé. Second, diamictite bodies are considerably thinner than they are in the southern localities. In the Mococa area, diamictites average perhaps 2 m thick and range in thickness from a few em up to about 10 m, but in the south thicknesses of more than 10 m are common and the average is about 8-10 m. There are possibly slightly fewer diamictites in the north but this is determined with difficulty because of long covered intervals in both sections Third, the presence of marine intercalations such as the Capivari Formation has not yet been demonstrated for the Itararé rocks of the Mococa region. These variations are also observed in a series of wells through the Itararé, logs of which were kindly made available by Petrobrás (Petróleo Brasileiro S. A.)

Fourth, and perhaps most important, the Itararé rocks of the Mococa region do not appear to be cyclic in nature, as they may

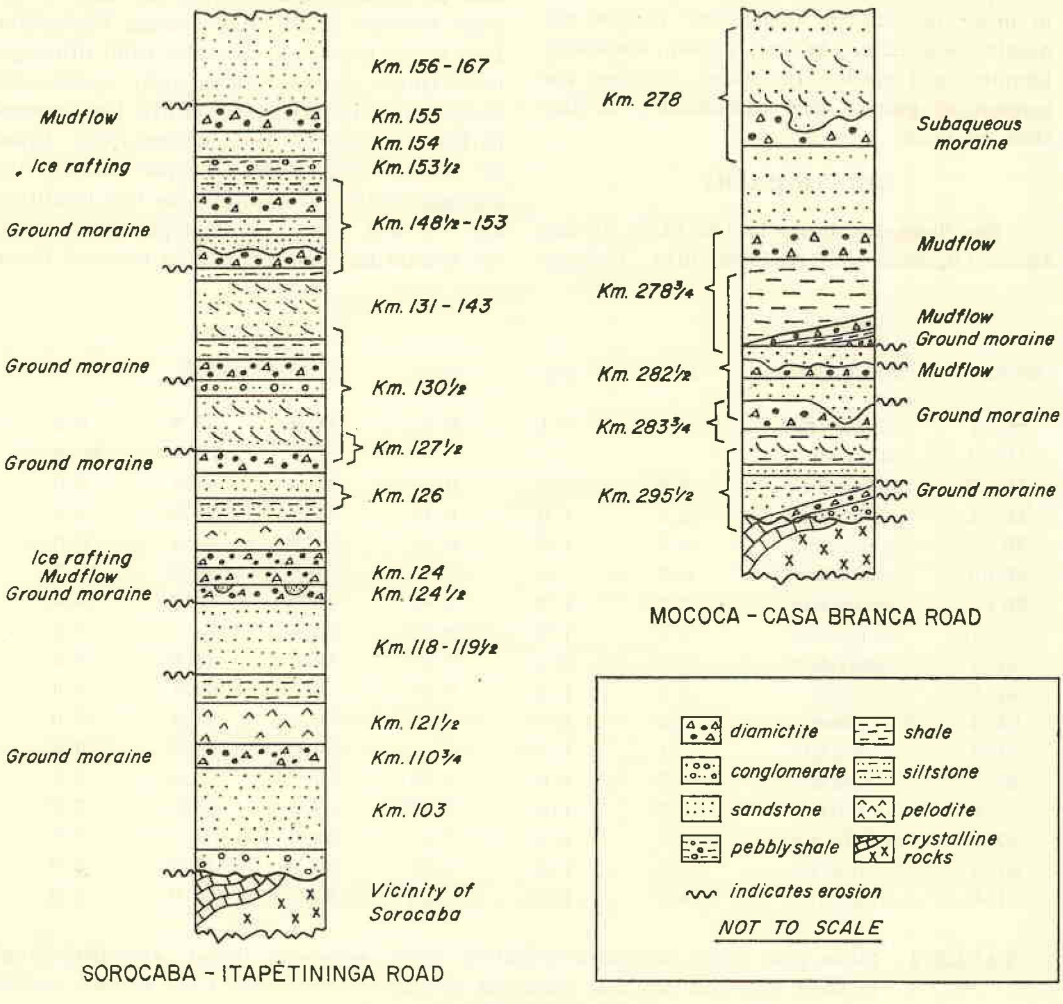

Fig. 2

be farther south in São Paulo State (Leinz, 1937; Frakes and Figueiredo, 1967). There is a general alternation of sandstone and diamictite in the Mococa section which might be interpreted as a series of cycles, but this requires more data than are currently at hand. Perhaps erosion, as indicated in figure 2, has been so extensive in the Mococa section that large portions of cycles have been removed.

These facts lead to the conclusion that the Itararé rocks are generally coarser graiined in the Mococa region, but that diamictite is less abundant. It may also be provisionally stated that there is a lack of marine strata in the Mococa section, although this conslusion is based on negative evidence and therefore highly subject to change.

PALEOGEOGRAPHY

A few interpretations may be made of the regional paleogeographic conditions, based on regional variation in facies of the Itararé and on directional sedimentary structures.

The characteristics of Itararé rocks in the Mococa section suggest that the strata were laid down near the source area and probably largely by running water in the terrestrial environment. The abundance of fine grained material in sections located farther to the southwest permits the interpretation that the basin deepened in that direction. The presence of marine intercalations in southern São Paulo State and localities farther southwest supports this conclusion.

A total of 21 directional sedimentary structures were measured in the Mococa section. They included ripple marks, cross bedding, sense of movement of slump structures, and trends of channels. Added, these data yield a vector mean of sediment transport toward 332° with a vector magnitude of 56.3%, indicating that paleocurrents flowed predominantly toward the northwest in the Mococa area.

A second point to be considered here is the possible effect of Late Paleozoic glaciation. The diamictites appear to be less well developed in this northern area than elsewhere in the Paraná Basin, in that they are both thin and less numerous. Perhaps, the depositing ice was less extensive in the north. Pebbly shale, probably formed by rafting of coarse material by floating ice into an area of normal subaqueous deposition, is almost entirely absent in the Mococa area although it is very common in the southern portions of the basin This suggests that Late Paleozoic glaciation was a major transportive force in the southern portions of the basin but that it was less important in the latitude of Mococa. In the north it appears that sedimentation took place under conditions resembling fluvial and marginal marine environments.

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