GEOLOGY OF THE RORAIMA GROUP AND ITS IMPLICATIONS

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ABSTRACT

The Precambrian Roraima Group in Venezuela rests on older rocks including metasediments which locally resemble the Roraima arenites in texture and composition. However, structural and mineralogical details help to differentiate between the two. The Roraimas in T.F.A., in the El Dorado-Santa Elena de Uairen road section and on the various Table Mountains (Roraima, Kukenan, Elu, Yuruari, Chimanta, Ptaritepui etc.,) consists of varying combinations of sedimentary associations or motifs which developed in the following environments: 1) low-sinuosity river channels and flood plains; 2) delta distributaries above interdeltaic lakes; 3) coastal lagoons and beach deposits; 4) intertidal mud-flats; 5) wave-dominant non-barred beach environment, etc.

Paleocurrent data suggests a northeasterly (in Guyana) to east-southeasterly source of sediments from areas now occupied by the Atlantic Ocean or beyond in the east and the Brazilian Shield in the south. The seemingly flat-topped Roraima Table Mountains could be in reality a series of shallow anticlines and synclines in which the axial region appears to have been preferentially preserved due to graben- and horst-like block faulting.

Stratigraphic and radiometric data suggest that the Roraimas may be progressively younger toward west with major but as yet unrecognizable hiatus in between. They were perhaps deposited successively in multiple basins, situated near the paleosea level and separated by basement highs. The overall homogeneity of the sediments throughout the Roraima Territory (1500 km laterally) could be due to persistence of similar tectonic and depositional environments through two to three hundred million years. Analogs of the Roraima basins could be probably found in the Vindhyans of India and the Nubian sandstone of Middle East (Gansser, 1974).

INTRODUCTION

The extensive, generally flat-lying sedimentary rocks known variously as Roraima Series (Dalton, 1912), Roraima Fm. (Martin-Kaye, 1952; Gansser, 1954; Keats, 1973) and Roraima Group (Reid, 1972; Gosh, 1977) unconformably overlie older shield rocks including lower Proterozoic sequences of the Guyana Shield. The major part of the Roraima sediments occurs in the main Roraima Range in eastern Venezuela, northern Brazil and in the westcentral part of Guyana, intruded by thick sills of basic intrusive rocks. Both to the east and west of the main Roraima Range, there are many scattered outliers of the Roraima Group. Such erosional remnants occur to the east in Tafelberg (Surinam) and Makari (Guyana) whereas to the west, in the Amazonas Federal Territory (T.F.A.) and in western part of Bolivar State, numerous Table Mountains occur, extending up to the Orinoco River (Fig. 1). The east-west lateral extent of the Roraima outcrops is about 1500 km, barring the ones which Gansser (1974) described from Colombia. The minimum area of original Roraima sedimentation could be around 250,000 sq.km. (Keats, 1973; Ghosh, 1977).

The Roraima sediments have been earlier described in some details from Guyana (Martin-Kaye, 1952; Keats, 1973), Venezuela (Gansser, 1954; Reid, 1972; Ghosh, 1977, 1978), Surinam (Priem et al., 1973; Bisschops, 1969) and Brazil (Loczy, 1973; Suszczynski 1972; Basei et al., 1975; Gansser, 1974), to name a few. The aim of this study is to emphasize certain aspects of the geology of the Roraimas with special reference to Venezuela, for example, a) the relation and distinction between the pre-Roraima metasediments and Roraima sediments, b) the various sedimentary associations or motifs observed in Roraima, c) the paleocurrent data and its implications, d) correlation and age of the Roraimas, etc.. Also the origin of the actual geomorphic form of the Roraima Table

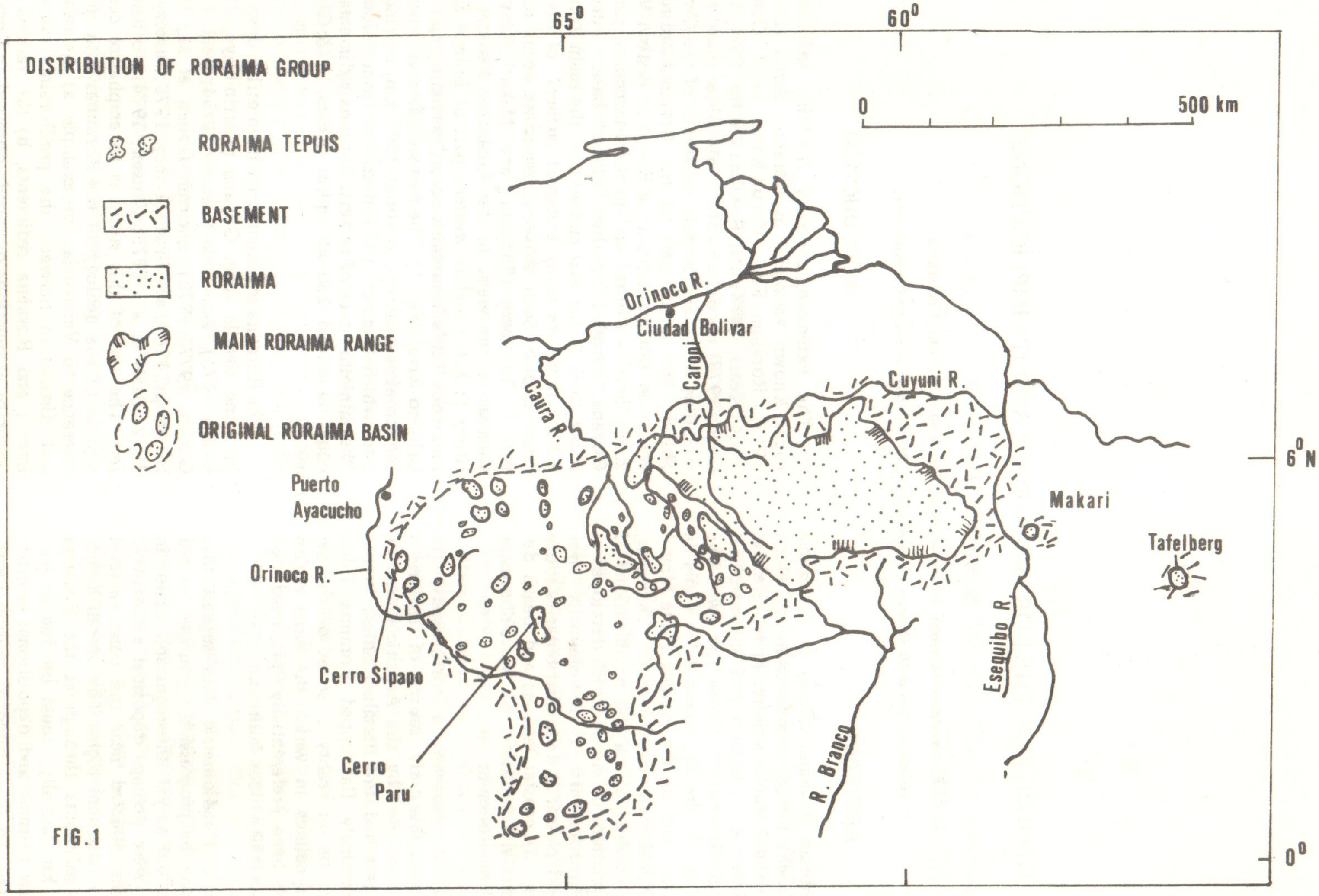

FIG. 1

Distribution of the sediments of the Roraima Gr. across Surinam, Guyana, Brazil and Venezuela (modified from Keats, 1973).

Mountains will be discussed in the light of observed tectonic framework. Finally a tentative model of sedimentation will be presented to explain the facts obtained so far.

This study is the outcome of reconnaitory traverses in the Table Mountains Cerro Sipapo, Cerro Autana, Cerro Paru, Cerro Yapacana in the Amazonas Territory during the author's tenure as a geologist of the Ministry of Energy and Mines, Venezuela. The author had the opportunity to compare these sequences with the type areas in the Gran Sabana in the eastern part of Venezuela (El Dorado - Santa Elena de Uairen road section). Also as a member of two multidisciplinary expeditions led by Dr. Charles Brewer Carias during the earlier part of 1977 and 1978, the author examined the top sequences of the various Table Mountains in the Gran Sabana area such as Roraima, Kukenan, Yuruari, Elu tepui, Auyantepui, Chimanta tepui, Aprada tepui, Ptari tepui, etc.

STRATIGRAPHIC FRAMEWORK

In the Gran Sabana the Roraimas overlie, among others, the Cuchivero acid volcanics, Supamo granite (Moreno, 1977; personal communication) and the Los Caribes Fm. (Benaim, 1972). In the Amazonas they overlie older granite gneiss and possibly associated metagabbros in San Juan de Manapiare (Supamo Complex?); elsewhere subvolcanic fine grained granite and coarser foliated granites in Paru, older metasediments in the Duida and Yapacana areas, and the Parguaza Rapakivi granite and its facies equivalents in the Autana-Cuao river areas (Mendoza, personal communication, 1977) have been observed to underlie the Roraimas.

The term 'Group' has been retained, as proposed by Reid (1972), though his classification of the Roraimas around Santa Elena de Uairen is not tenable for the Roraimas in the Amazonas Territory. The sequences here do not seem to contain any jasperiod tuffaceous rocks, though some boulders of green chert has been observed on the banks of Autana river. Also conglomerates and major arkosic sand bodies are lacking in the Amazonas Territory, so abundant elsewhere in Venezuela, Brazil and Guyana. Within the Amazonas Territory itself the Roraimas are laterally variable and thus the sequences in Cerro Paru, Cerro Sipapo and Cerro Yapacana do not match one another. Lack of marker units also makes regional correlation extremely difficult. Fig. 2 shows a tentative lateral facies distribution of the Roraimas based on published and unpublished data.

The strata in the Sipapo Block adjacent to the Orinoco river is a monotonous sequence of fine to medium grained highly cross-stratified, parallel laminated and thinly graded, quartz arenite to feldspathic arenite which unconformably overlies the Parguaza granite or its cogenetic facies equivalents (Fig. 2). In general terms the sequence can be divided into three members. The lower 500 m consists of silicified, fine to medium grained, cross-stratified and interlaminated quartz arenite; the middle part (200 m thick) consists of feldspathic to argillaceous quartz arenite associated with a thin dark shale unit. The upper part which forms the prominent cliffs is about 600-700 m thick and consists of coarser quartz arenites with occasional feldspathic arenites. The famous Autana caves are located in the coarser grained, ferruginous upper member of this sequence.

The sequence in the Cerro Paru area (Fig. 2) contrasts strongly with that in the Sipapo area in that it contains thick shaly units as well as clay-rich beds containing very thin microscopic laminations of carbonate. The following is a very tentative stratigraphic sequence for the Paru area:

Upper Member 500 m.	Med. gr. ferruginous, cross-stratified quartz arenite; lenticular clay beds with thin microscopic carbonate-rich laminations.
Middle Member 100-200 m	Dark grey mud shale 20- 30 m. Med. gr. quartz arenite with abundant herringbone cross-strata and occasional thin impure sandstone 50 - 100 m. Steel grey to black clay shale 30 - 50 m.
Lower Member 300 - 400 m	Fine to coarse gr. cross-stratified and rippled quartz arenite, minor quartz wacke with occasional black sand layers (an intrusive granite affects the basal few meters of this member)

. . . . . Unconformable contact. . . . .

Coarse gr. K-rich granite and also fine gr. subvolcanic leucocratic granite.

In the Gran Sabana, the only known stratigraphic sequence other than that given by Gansser (1974), is that given by Reid (1972) from the Santa Elena de Uairen area. His four-fold classification (Fig. 2) consists of the following formations in ascending order: Uairen Fm. (fluvial conglomerate and sandstone according to Reid), Kukenan Fm. (marine shale), Uaimapue Fm. (fluvial sandstone, shale and associated tuffs) and Mataui Fm. (fluvial sandstone according to Reid). The exact relation between this section and those from the Amazonas Territory is unknown because no data from the vast intervening areas is available. However, for reasons to be discussed latter, it seems that the Amazonas sequence is younger than the Santa Elena de Uairen section.

RELATION AND DISTINCTION BETWEEN THE RORAIMAS AND OLDER METASEDIMENTS

The pre-Roraima metasedimentary rocks in Venezuela locally may resemble the Roraima arenites in texture and composition specially where the metamorphic grade in pre-Roraima metasediments is low. They occur in diverse areas in Venezuela: Galera de Cinaruco, Orinoco-Parguaza river confluence, Cerro Iguana, Picuré and Carmelita, Cerro Gavilan and Cerro

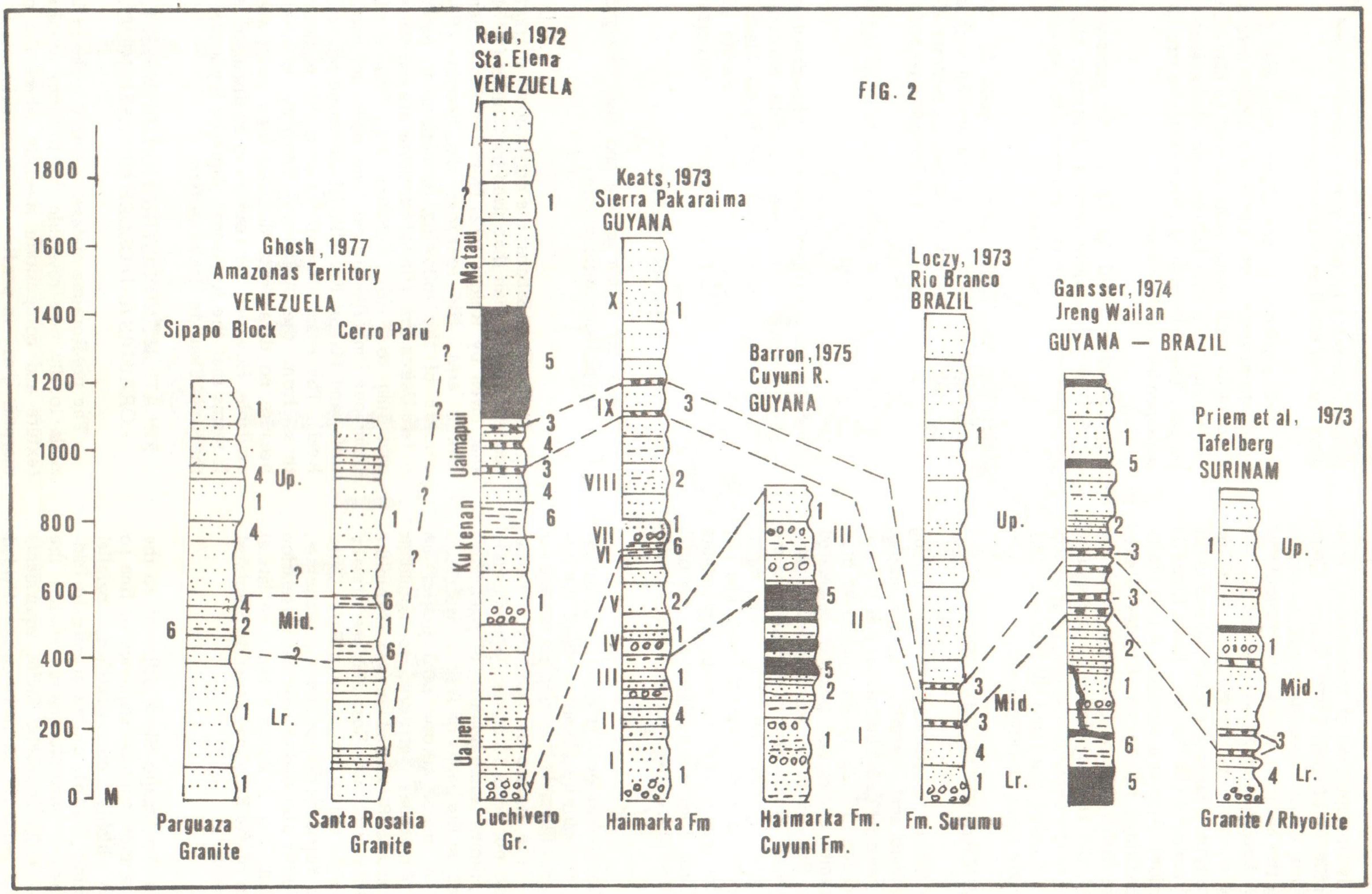

FIG. 2

Stratigraphic correlation of Roraima sections from Surinam in the east to Venezuela in the west. Lithologic successions generalized and simplified. Dashed lines indicate tentative correlation. Thickness of sills, tuff beds and some shales not in scale. The different numbers signify the following: 1 - Cong. and qtz. arenite, 2 - Thinly lam. qtz. wacke; 3 - Tuff, chert & Jasper beds; 4 - Arkose and Felds. arenite; 5 - Dolerite dykes & sills; 6 - Shale & siltstone.

Moriche - all on the Venturai river, at the foothills of Cerro Yapacana and Cerro Neblina in the T.F.A., and the areas around Alto Paragua and El Venamo among others in the Gran Sabana.

Microscopic and megascopic structural and mineralogical details help to differenciate them from the Roraimas. On the basis of structure, petrology, metamorphism and stratigraphic position these units are tentatively correlated with the Cinaruco Fm. (McCandles, 1961) and Esmeralda Fm. (Sellier de Civirieux, 1966) and the Los Caribes Fm. (Benaim, 1972) and thought to be part of the Cuchivero Group or, to a lesser extent, even older rocks. The metasedimentary units show a predominantly N 30 W to N 30 E structural trend and show metamorphism in the Green Schist facies.

Lithologically the metasedimentary assemblage consists of thick (up to 60 m) oligomictic conglomerates, occasional breccia, orthoquartzitic to subgreywake quartzites and phyllitic shales, locally associated and interbedded with metavolcanics of acidic to intermediate composition. The conglomerates, moderately to poorly sorted, consist of well rounded elliptical quartzite and vein quartz pebbles and boulders (up to 40 cm). The matrix of the conglomerate is sandy which in thin sections appears completely metamorphosed and foliated with the development of mica. Thus lithologically the metasediments are similar to the Roraima arenites and conglomerates except for metamorphism.

The metaquarzites show abundant development of metamorphic minerals, such as chlorite, muscovite, epidote, chloritoid, recrystallized sheared quartz, etc. Presence of andalusite have been observed in these rocks (near the Orinoco-Parguaza confluence) in contact with the Parguaza Rapakivi granite. The Roraimas in contrast are affected by a very low grade of metamorphism, if any. Presence of pyrophyllite (Urbani, 1977) locally reinforces the above interpretation. Also grain anisotropism and strong undulose extinction in quartz grains have been observed. However, metamorphic texture or minerals are not present everywhere in the Roraimas. For example, many samples from the Cuao river and Paru area are distinctly undeformed. Neither any pyrophyllite nor any other diagnostic metamorphic minerals are evident in thin sections or X-ray diffraction analysis. Two samples of shale from the Hacha river area when analysed by X-ray diffraction failed to show any metamorphic minerals, other than chlorite. Roraima sediments in contact with rare intrusive bodies (as in the northwest flank of the Cerro Paru) develop recrystallized blocky polygonal quartz, abundant mica and andalusite (Talukdar, 1977, personal communication; Ghosh, 1977).

The metasediments show a distinctive style of deformation; tight isoclinal and chevron folds, transposed schistosity, thrusts and extensive sheared volcanics distinguish these metasediments. The structural grain of the Roraimas seem to be unrelated to that of the older pre-Roraima metasediments and associated volcanics and granites. The Roraimas are characterized by horizontal to low dipping strata, occasional vertical to subvertical simple gravity faults, rare reverse faults, broad open folds and occasional monoclines. There are some prominent NW-SE and NE-SW trending fracture zones without major displacement. These lineaments are well observed in Side-Looking Radar Images.

Predominant sedimentary structures in the metasediments include cosets of planar cross-strata and trough cross-strata, ripple marks and subordinate graded bedding on a small scale. The lithology reflects a predominantly continental-paralic environment of deposition. The thick conglomerates are probably of fluvial origin. The presence of common overturned foresets in the associated sandstones, the clast-supported nature of the fabric along with occasional grading and imbrications within the conglomerate imply a fluvial mode of origin. (Walker, 1975). On the other hand, the locale of sedimentation for some of the sediments may have been close to shore line as inferred from the presence of ubiquitous small scale graded bedding and parallel lamination (i.e. near Pueblo Nuevo on the Parguaza River and at the foothills of the Cerro Yapacana). Such small scale graded bedding is common on sandy intertidal flats and beaches. The lateral persistence of the individual sandstone beds and their silicic composition and maturity are indicative of an environment where winnowing activity was effective. Presence of occasional herringbone cross-stratified sandstone probably implies a subtidal bar origin for some of the meta-arenites. Thus lithologically and from the point of view of environment of deposition, it seems that the Roraimas and pre-Roraima metasediments represent similar, if not identical, environment of deposition.

The pre-Roraima metasedimentary rocks are also characterized by a lithologic-tectonic association, not encountered in the Roraimas. The intimate asosociation with volcanics (often sheared) and granite gneiss, which are folded and thrusted, imparts a distinct diagnostic imprint on these rocks. They were intensely deformed and folded during the paroxysmal phase of the Trans-Amazonian orogeny. Thereafter a long period of erosion and dissection followed which left only minor remnants of the pervasive pre-Roraima suite of metasedimentary rocks, metavolcanics and granite gneiss. Erosion cut deep enough into the shield to expose older plutonic rocks in most of the places. On such a deeply eroded, largely peneplained erosion surface, the Roraima sedimentation ensued.

Thus on the basis of structure, petrology, metamorphism and stratigraphic position the metasedimentary units are distinctly older than the Roraimas and coeval with the Cinaruco Fm., Esmeralda Fm. and the Caicara Fm. and may form part of the Cuchivero Group. The metasedimentary-volcanic-granitic association at the base of the Cerro Neblina, as observed in the upper reaches of Barria river, may be time-equivalent of the Cuchivero Group or it may represent an older assemblage of rocks. The problem here is the vast horizontal distance between the known Cuchivero rocks in the north and the assemblage below the Cerro Neblina. Similar metasedimentary-acid to intermediate volcanic sequences have been described from Brazil (Lr. Roraima Subgroup of Suszczynski, 1972 and Surumu Group of Basei et al., 1975) and the Haimarka Fm. from Guyana (Keats, 1973; Barron, 1975). It is possible that the metasedimentary Rosabel Fm. of Surinam, the Los Caribes Fm. of northeastern Guyana shield (in Venezuela) and the aforementioned formations in Venezuela, Guyana and Brazil may be time equivalent (1.8 to 1.9 b.y.) and formed part of the basement of the Roraima Group.

SEDIMENTARY ASSOCIATIONS OR MOTIFS WITHIN THE RORAIMA GROUP

The Roraima formations in Venezuela consists of varying combinations of sedimentary associations or motifs which developed in the following major environments. 1) low-sinuosity river channels and secondarily in their flood-plains; 2) delta-distributaries above tranquil interdeltaic or interdistributary lakes; 3) coastal lagoons to interdeltaic bays; 4) wave-dominant non-barred beach and tidal environment; 5) intertidal mud-flat environment etc. Lateral and vertical association of these motifs depict an alluvial-deltaic complex in the vicinity of an extensive wave-dominant high-energy coast line with its abundant beaches, sandy flats and subtidal bars, occasional mud-flats and coastal lagoons. In the following pages a brief description of each of the major sedimentary motifs will be given followed by an interpretation of the same.

Motif 1:
Low sinuosity river channels and their overbank deposits

This motif is well developed in the El Dorado-Santa Elena de Uairen road section. The facies is characterized by 1) lenticular nature of the strata, 2) mineralogical and textural immaturity of the sandstones; 3) sedimentary structures indicative of fluvial origin; 4) frequent kaolin beds, etc.

The exposed strata essentially consists of medium to coarse grained, immature sandstone with occasional thin pebbly horizon at the base, immature arkosic arenites with abundant clayey matrix and occasional silty layers. Typical fluvial fining upward sequences have not been observed in great frequency. Paucity of overbank deposits like shale and siltstone coupled with the lack of classic fining-up sequences might indicate deposition in low-sinuosity river channels. Most of the beds are laterally impersistent and pinch and swell at the level of outcrops. Mineralogically the sandstones are immature with abundant feldspar in various stages of preservation. The grains are angular to subangular with little or no silica cement in between. Interstitial matter is in general clay with silts in variable proportion. Point contact and subordinate straight contact between grains is more common.

Sedimentary structures include cross-strata of various sizes and asymmetric ripple marks and parallel laminations. The cross-strata are mostly of the trough type which often show excellent rib-and-furrow structure in plan view. The foresets of the cross-strata vary between 30 cm to 1 m. Locally cosets of cross-strata have been observed where the individual sets show an erosional wavy contact. These may be due to superposition of sand waves giving rise to cosets of tabular cross-strata. The reactivation surfaces between the sets is a clue to the changes in flow conditions. The low stage may expose channel bars to wave action and cause planation of the bar margin; a rise in river stage allows the bar to resume migration and build above the former swash zone. The foresets in these strata consist of thin beds of sandstone interstratified with much thinner cm thick layers of siltstone. The overturned cross-strata in the finer sandstone occur in foresets up to 50 cm thick and show V-shaped or U-shaped overturning of the foresets. These overturned foresets are overlain by the top-set units of parallel bedded sandstone. Mckee et al. (1962) produced this structure in flume experiments. They observed that the structure is produced by strong sedimentladen currents which drag the top of the foreset laminae into recumbent folds. Such structures are abundant in modern fluvial deposits (Reineck and Singh, 1973).

Ripple marks are mostly of the asymmetrical type. They are straight crested in general, though arcuate ripple crests are not uncommon. Ripple index varies between 8-14 which suggests their current origin. The parallel laminated beds consist of lamina of alternate grain size of sands, interlaminated sandstone and siltstone, and interlaminated siltstone and clay. The last mentioned facies probably originated as vertical accretion deposits on top of levees and in flood plains.

The vertical sequence typical of this motif is shown in fig. 3. It will be observed that the lower part consists of medium to coarse grained sandstone, at times pebbly, with large scale cross-strata. The middle and the upper part of the sandy facies consist of fine grained impure sandstone with small scale cross-strata and asymmetric ripple marks. The cross-strata in the fine grained facies show abundant overturning of the foresets. The top part of the sequence consists of thin colorbanded (red and white) alternation of silty units (2 - 3 cm thick) and white clay units. Locally this last mentioned lithology shows abundant penecontemporaneous deformation structures including small scale faults.

The above sequence gives a fining upward trend and probably developed in a braided stream environment where the supply of fine silty and shaly sediments were minor. Also it should be mentioned that because of the special situation of the Precambrian time when vegetation was not present to stabilize the levees and overbank areas, perhaps the course of rivers were not as well defined as to-day and consequently the overbank deposits were often eroded away by the rivers.

The kaolin beds in the Roraimas, as exposed in the El Dorado-Santa Elena de Uairen road section in asosotiation with the arkosic sandstones, could have developed either in flood basin lakes or coastal lagoons where the clay-sized alteration product of feldspar

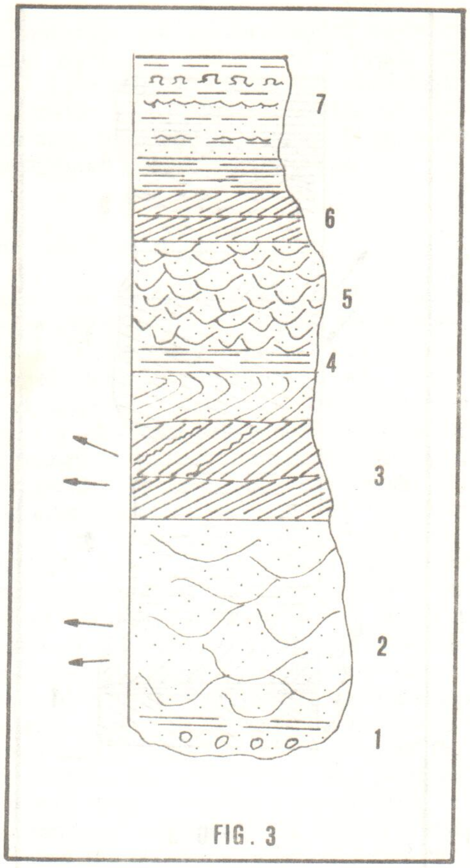

FIG. 3

Fining upward motif of a low-sinuosity river channel and its overbank deposits in Roraima. Facies 1 - Basal cong. with horizontal stratification; Facies 2 - Megaripple bedding in coarse grained sandstone; Facies 3 - T Tabular X- bed with overturned/contorned foresets; Facies 4 - Parallel lam. fine gr. sandstone; Facies 5 - Trough cross-stratified fine to med. gr. sandstone; Facies 6 - Small scale X-lam. and parallel lam. fine gr. sandstone; Facies 7 - Alternating facies of colorbanded silt and clay with minor ripples and convolute lamination. Thickness of sequence 10 - 20 m. Arrow indicate paleocurrent direction.

was flushed out. The poor outcrop conditions in most cases hinder a proper identification of the paleoenvironment. However, available evidence strongly suggests a flood basin environment of deposition for the clay beds. Close proximity to fluvial arkosic sand bodies in some cases corroborate the above interpretation.

Motif 2:
Distributary channel facies above interdeltaic (or interdistributary) lakes

This motif is exemplified by figure 4 and occurs on the El Dorado - Santa Elena de Uairen road section

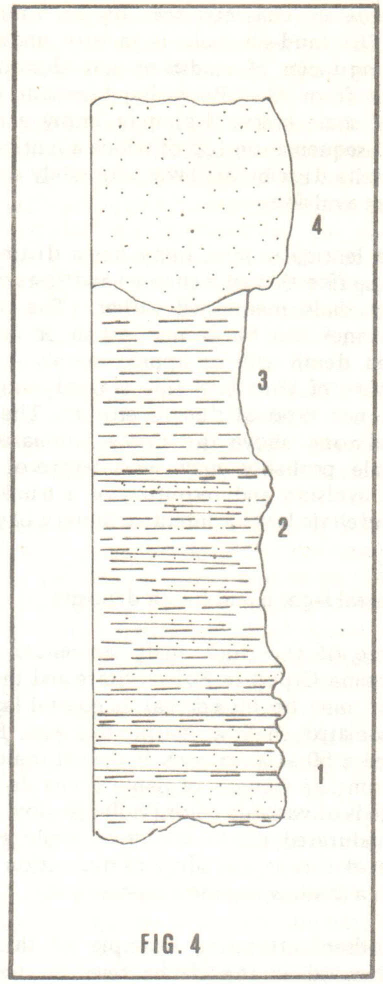

FIG. 4

Transgressive lagoonal sequence motif overlain by a delta distributary channel. Facies 1 - Interbedded sandy and muddy facies; Facies 2 - Interbedded silty and muddy facies; Facies 3 - Varvelike dark clay shale; Facies 4 - Fine gr. impure lenticular sandstone. Total thickness 30 - 40 m.

around 134 km post. Here a very finely laminated colorbanded shale is overlain by a partially exposed lenticular fine grained sandstone. The clay shale with its millimetric laminations and lateral persistence of individual lamina was probably deposited in a tranquil interdeltaic or interdistributary lake environment. The deep grey clay shale with thin white millimeter thick laminations locally resemble glacial varves in appearance. The varve-like units are interstratified with thin centimeter thick units showing micro-undulations resembling ripples in a very small scale. Apparently the clay shale developed in a quiet low energy environment of a lake. The clay shale is underlain by a sequence of silt-shale/mud-shale with thin siltstone interbeds. This coarser shale is laminated and mottled in shades of buff, grey, yellow and pale orange. Laterally individual subunits vary in thickness although they are persistent over outcrop distance.

Some beds are characterized by 3 - 5 mm wide clay dykes. The mud-silt-shale is in turn underlain by an alternating facies of sandstone and siltstone. Thus the sequence from the alternating facies at the base to the clay shale (varve-like) may imply a transgressive lagoonal sequence on top of which a lenticular channel facies (delta distributary) was ultimately deposited due to stream avulsion.

The lenticular sand body has a distinct erosional wavy base like that of a channel and rests on the varve-like clay shale mentioned earlier. The width of the paleochannel will be around 40 m or more and the preserved depth will be approximately 4 - 5 m. The upper part of this silty fine grained immature sandstone is not exposed due to erosion. The location of the sandstone above the thinly laminated varve-like clay shale probably may be interpreted as due to channel avulsion and rerouting of a trunk channel in the interdeltaic lake or interdistributary bay areas.

Motif 3:

Coastal lagoon and beach deposits

Some of the thick shaly sequences observed in the Roraima Group in Bolivar State and the Amazonas Territory may be interpreted as coastal lagoon, beach and associated shallow marine deposits. Reid (1973) described a 50 -100 m thick fissile silt shale (Cuquenan Fm.) from the vicinity of Santa Elena de Uairen. The silt shale is of variable color (violet, yellow, minor red), poorly indurated, plastic and break easily. Reid (op.cit) interpreted this as a product of deposition in an inland sea or in a shallow marine environment.

Another interesting example of this motif has been observed in the Hacha river in the vicinity of Cerro Paru in T.F.A. (Fig. 5). In the Hacha section at least two 20 -30 m thick black to grey shale have been observed which occur interstratified with clean mature quartz arenites characterized by excellent development of bimodal-bipolar cross-strata (330 ° and 140 °) and symmetrical wave ripples (ripple trend 330 ° - 150 °) and thin graded beds. The shales are mud shale, thinly laminated but many locally lack fissility. No color banding has been observed. Some thinner shale beds show ill-preserved lenticular bedding and flaser bedding. Due to fault-related deformation some of the flaser structures appear like sedimentary boudinage. In thin section the shale consists of silt and clay-sized material in distinct horizontal lamina where much secondary mica has developed along the bedding planes.

The shales might have been deposited largely in coastal lagoons and are interstratified with shallow marine sands due to oscillations of sea level. The associated sandstones, as mentioned earlier, are medium to coarse grained with well rounded grains and show excellent sorting and textural maturity. Locally a ferruginous hematitic cement occur in many quartz arenites. Low angle beach lamination characterizes many of the beds. The presence of extensive bimodal-bipolar cross-strata implies deposition probably in subtidal bars or lower sand flats in intertidal areas. Thin normally graded beds in centimeter scale in the

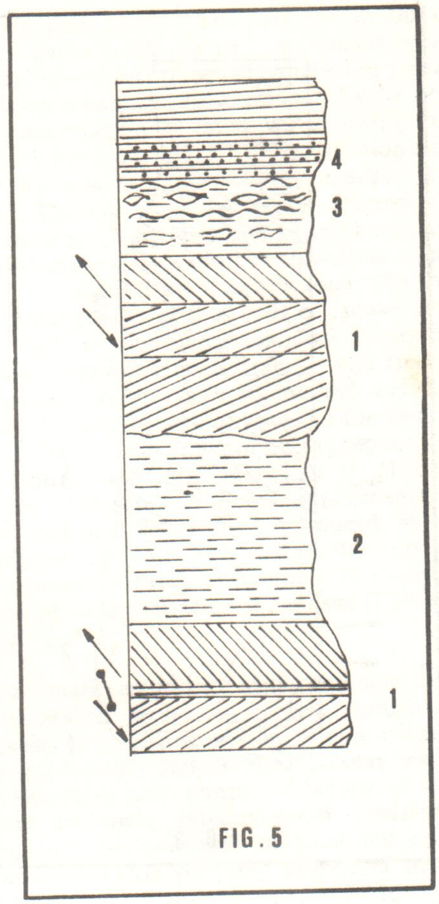

FIG. 5

Ideal sequence of a beach-coastal lagoon-tidal facies sequence from Hacha river, Amazonas Territory, Venezuela. Facies 1 - Bimodal-bipolar X-bed in mature qtz. arenite; Facies 2 - Thick dark grey mud-shale; Facies 3 - Mixed sand/mud facies with flaser/linsen bedding; Facies 4 - Black sand-rich layers with low angle beach lamination. Sequence 40 m thick approx. Arrow indicate paleocurrent direction, and bar with two dots (----) signify trend of sym. ripple crests.

sandstone could argue for an origin in shallow sandy flats or from suspension clouds generated by storms in offshore areas. Presence of both symmetrical and asymmetrical wave ripples (ripple index less than 6 - 7) indicate deposition above wave base probably in foreshore areas. Even though the sequence has been interpreted as a coastal lagoon-beach complex, no undoubted evidence of a barrier bar (prograding) sequence has been observed in this area.

Typical coarsening upward barrier bar (prograding) sequences are lacking in this area. A similar problem in interpretation might arise in relation to distinction between the coastal lagoonal muds and offshore muddy sediments in the absence of diagnostic fossils as happens in the Roraima Group. However, the presence of linsen bedding and flaser bedding in some beds might indicate their origin in lagoonal beach and tidal flat environment. Also the presence of low angle beach lamination and parallel bedded heavy mineral-rich sand layers are evidence of a beach origin of much of these sediments. Excellent mineralogical and textural maturity of the quartz arenites are additional proof of their development in areas of high energy in a shallow marine domain above wave base.

Motif 4:
Intertidal mud-falt environment

This motif has been observed only in one site on the western flank of the Cerro Paru and is represented by a lenticular claystone sequence (3m approximately) sandwiched between iron cemented higly cross-stratified (bipolar - bimodal mostly) mature quartz arenite. The claystone bed is somewhat mottled due to ferrugination and contain some silty interbeds. Microscopically the claystone beds consist of millimetric alternations of clay-rich and carbonate -rich layers and are interlaminated with clayed layers rich in silt sizes quartz grains. Some layers show a haphazard mixture of clay and calcite with tiny rhombs of dolomite crystals floating inside it. The proportion of dolomite varies from lamina to lamina. Maximum size of dolomite crystals observed are up to 0.14 mm. Most of the rhombs show a limpid external margin and a turbid dusty core. Such carbonate-clay rich rhythmites are common in modern tidal flat areas in the intertidal-supratidal zone. The presence of a mature well sorted, bipolar cross-stratified, rippled quartz arenite of lower sand flat and/or subtidal bar origin below the claystone facies reinforces the interpretation presented above (Ingle, 1975).

Motif 5:
Wave-dominant non-barred beach environment

This motif has been widely observed in the top sequences exposed in the various Table Mountains (tepuis) such as Roraima, Kukenan, Elu, Yuruani, Auyantepui, Ptari tepui, Apradatepui, Chimantatepui etc., However, the following details of this motif has been mainly documented from the top sequences in the Roraima and in the adjacent Kukenan Table Mountains. This motif has developed widely in what Reid (1973) earlier described as Mataui Fm.

A typical sequence of this motif is shown in figure 6. The lower part of the sequence (15 - 20 m) is overlain by a 20 30 m thick coarse grained cross-stratified sandstone. In the following discussion the lower part will be designated as wave-rippled facies assemblage which consists of the following three facies in order of abundance: Facies 1 - very fine grained wave-rippled sandstone; Facies 2 - fine grained parallel laminated thin sandstone units interbedded with the wave-rippled facies; Facies 3 -30 to 40 cm thick coarse grained cross-stratified (both bidirectional and unidirectional) medium grained sandstone.

The ideal sequential arrangement among the three aforementioned facies is: Facies 3 --› Facies 2 --› Facies 1. The Facies 1 of very fine grained wave-rippled sandstone contains occasional 1-3 cm thick beds showing normal grading and minor cross-lamination. An important characteristic of the rippled facies is that it often caps a thinning upward sequence which may range up to 4 m in thickness. The wave ripples in Facies 1 show most of the diagnostic characteristics given by De Raff et al. (1977): 1) irregular, undulating lower set boundary; 2) structural dissimilarity of adjacent beds; 3) form-discordant cross-lamination, 4) association with undulating hummocky cross-strata etc. The wave ripples are symmetrical in shape and generally have a wave length of 3-4 cm and an amplitude varying between 5 -7 mm while the ripple index varying between 5 - 7. Crest bifurcation is rather common in these beds. The wave-ripple bedding often show bedding plane truncation due to erosion. The crest trend of ripples vary from ESE-WNW to SE-NW. In the rippled facies assemblage (i.e. Facies 1,2, and 3) the lowermost beds are 3-4 cm thick (in Facies 3) whereas the top rippled beds (Facies 1) are centimeter thick.

The facies 2 of parallel laminated, occasionally graded sandstone generally occurs at the base of wave-rippled facies (Facies 1). It may also occur sandwiched between unidirectional and bidirectional cross-strata of Facies 3. This parallel laminated facies varies in thickness from 0.5 - 1 m and are composites of 5 - 30 cm beds. The facies 3 of medium to coarse grained cross-stratified impure sandstone occurs in beds up to 60 cm thick and the total thickness of this facies may reach up to 2 m or more. This facies shows cross-strata (tabular type) with azimuth toward 160 $^{\circ}$ - 180 $^{\circ}$ (southerly) and 40 $^{\circ}$ - 45 $^{\circ}$ (northeasterly) respectively. Locally a rippled unit (symmetrical wave ripples similar to those of Facies 1) may intervene between two oppositely dipping (bipolar-bimodal) strata of Facies 3. Normally Facies 3 occurs at the base of Facies 2 and thus forms the base of the fining upward and thinning upward sequence. The total exposed thickness of the lower rippled facies assemblage (Facies 1, 2,3) varies between 20 - 30 m in the Roraima Table Mountain. Qualitatively the Facies 1 and 2 dwindle in proportion toward the top whereas the Facies 3 correspondingly becomes more and more dominant as the contact with the overlying ledge-forming coarse grained sandstone (Facies 4) approaches.

The overlying Facies 4 rests on the wave-rippled facies assemblage with a sharp erosional planar contact. This facies has an exposed thickness of about 20 - 30 m and forms the highest part of many of the Roraima Table Mountains. It is characterized by 1) thick bedded nature, 2) uniformly coarse to medium grain size, 3) frequent pebbles along bedding planes or scattered haphazardly, 4) large scale unidirectional trough cross-strata with rib-and-furrow structure on plan view, 5) common soft-sediment deformation structure, 6) lenticular nature of many of the subunits etc.

A fresh unaltered sample of this facies is coarse grained feldspathic ill-sorted sandstone with a variable proportion of clayey matter due to alteration of feldspars. The cross-strata in this facies frequently occur in cosets up to 10 m in thickness and uniformly dip toward W or WNW. Individual cross-bed foreset may be up to 1 m in thickness though the average is around 50 cm. Overturned cross-strata and contorted bedding are common. Cross-strata azimuth is almost

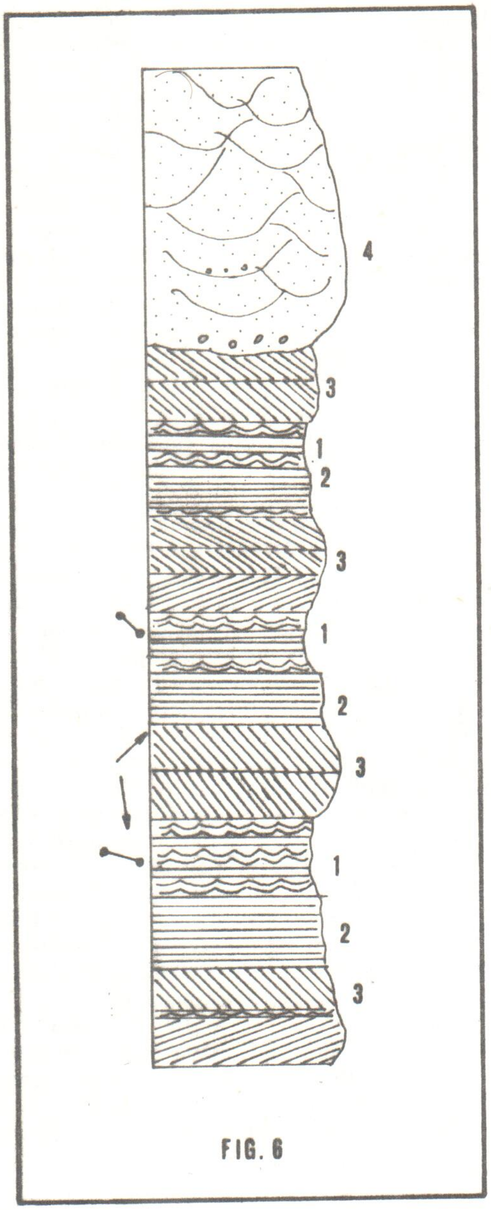

FIG 6.

Motif of a wave-dominant non-barred beach environment (Roraima Table Mountain). Facies 1 - Fine gr. wave-rippled sandstone with some graded bedding; Facies 2 - Parallel lam. fine-med. gr. sandstone; Facies 3 - Med. to c. gr. X-bedded sandstone; Facies 4 - Pebbly thickbedded, X-stratified (unimodal) sandstone. Sequence 50 m approx. Arrow shows paleocurrent trend.

always toward West. Large scale rib-and-furrow structure with wave length up to 3 m is abundant. These perhaps indicate that the megaripples were lunate or sinuous (Levell, 1980). In one outcrop one group of four form sets had an average chord length of 4-5 m. The ripple marks are typically asymmetric and dip toward NNE/N. Pebbles, mostly of vein quartz, are generally scattered haphazardly along or across bedding planes. Maximum pebble size observed is 6 cm. Some of the cross-strata show evidence of hydroplastic deformation. Such penecontemporaneous deformation structures are quite common in certain horizons and are indicative of a fluvial origin (Reineck et al., 1973). Also locally some foresets of tabular cross-strata show minor wavy and crinkled bedding due to gravity sliding in hydroplastic stage. In more extreme cases complete overturning of foresets have been observed in which the overturned strata resembles a recumbent fold. In general such overturning occurs in small scale cross-bedding (foresets up to 30 cm thick). Abundant contorted bedding has been observed near the International boundary pillar (Venezuela, Brazil and Guyana) on top of the Roraima Table Mountain.

From the evidence and discussion presented above the Facies 4 of coarse grained, thick bedded, cross-stratified arenites is of fluvial origin, probably a distributary channel. The superposition of the fluvial facies directly above the underlying mostly shoreface to foreshore facies assemblage (i.e. 1,2 and 3) implies that a major regression occurred after the deposition of the wave-rippled facies assemblage when the deltaic channel facies prograded seaward.

The Ptaritepui (2600 m high), another small Table Mountain in the vicinity of Auyantepui, shows a vertical sequence somewhat analogous to that of the Roraima Table Mountain discussed above. The sequence on top of this tepui is shown in figure 7. Here one can observe three major facies sequence from base upward. Facies 1 consists of interbedded, cross-bedded and parallel laminated sandstone which reach a thickness between 3 - 4 m. The cross-strata dip toward WNW while the symmetrical ripple crest trends N2OE. There exists an orthogonal relationship between the cross-strata azimuth and the trend of the wave ripple crests. The Facies 1 shows well developed columnar weathering phenomenon mainly in the intervening parallel bedded strata and is overlain by Facies 2. The Facies 2 has an average thickness of 2 - 3 m and consists of the following subfacies from base upward. At the base occurs a meter thick medium grained thinly laminated cross-bedded sandstone. These are composites of 0.2 to 0.5 m thick sandstone units. Here the foresets of cross-strata are smaller than those in Facies 1. The lower subfacies of Facies 2 is overlain by a fine grained cross-bedded (average thickness 0.5 to 1 m) sandstone. The foresets are 10 to 15 cm thick. This subfacies is overlain by a wave-rippled subfacies. The rippled unit is very fine grained, silty with the average thickness rarely exceeding 50 cm. It is not uncommon to observe at least three to four repetitions of Facies 2 maintaining the same sequential relationship among the subfacies. The sequence described so far is overlain by a 30 m thick medium to coarse grained pebbly sandstone of Facies 3. The sandstone consists of cosets of cross-beds many of which show rib-and-furrow marks in plan view. Some of the cross-strata have a wave length of more than 50 m and a meter or so in amplitude. The cross-strata azimuth in this facies is predominantly toward WNW/W.

In general the sequence in this motif can be explained as shallow marine sands overlain by a dis-

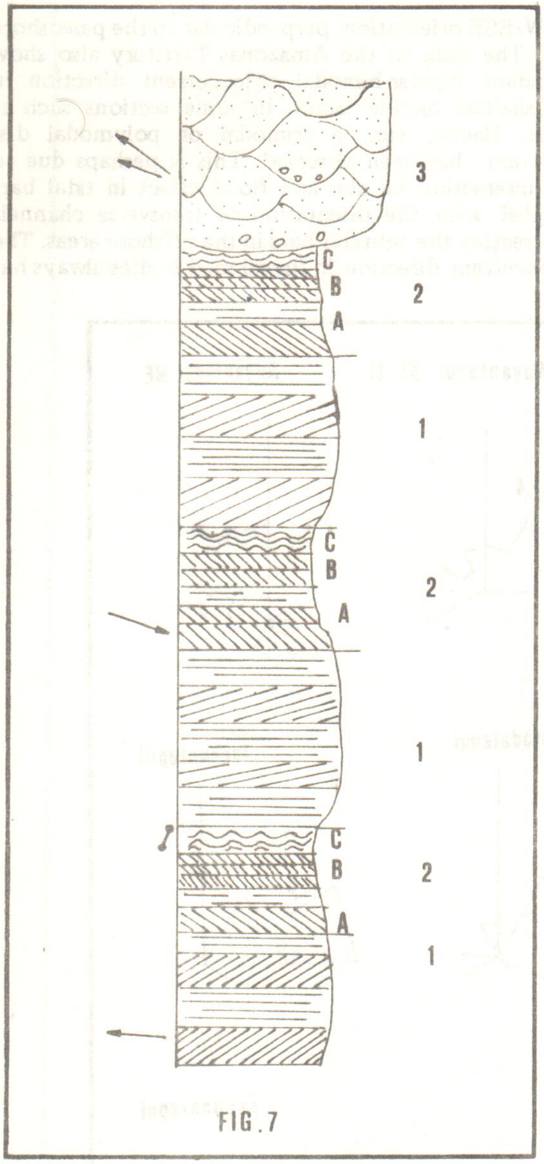

FIG. 7

Sedimentary association of a wave-dominant beach sequence (Ptaritepui). Facies 1 - Interbedded, X-bedded, parallel lam., occasionally graded sandstone; Facies 2 - Thinly bedded, X-lam. sandstone (Subfacies A), fine gr. X-bedded sandstone (Subfacies B), very f. gr. wave-rippled sandstone (Subfacies C); Facies 3 - Pebbly, impure X-bedded (unimodal) sandstone. Sequence 30 m thick. Arrow indicates paleocurrent direction.

tributary channel facies. The lower part of the motif is thought to be a shallow marine sequence because of the following: 1) textural and mineralogical maturity; 2) lateral persistence of sedimentary units; 3) abundant wave ripples; 4) absence of channeling; 5) tabular geometry and sheet-like non-erosive form; 6) vertical and lateral uniformity of facies; 7) lack of a pebbly facies; 8) low feldspar content; 9) lack of soft-sediment deformation structure etc., Some of the above evidences are not conclusive by themselves of a fluvial origin (for example No. 7 and 8 mentioned above); however, taken together with other evidence they reinforce the above interpretation. The data suggest that the Facies 1 of medium to coarse grained, interbedded sequence of parallel laminated, cross-stratified and minor wave rippled facies probably was deposited in the offshore (subtidal shelf) environment. The presence of occasional graded bedding could be due to deposition from storm suspension clouds. The evenly bedded units were also produced by suspension clouds triggered by storm generated waves and/or tidal currents (Reineck et al. 1973).

The Facies 2, a fining upward sequence (from base upward) medium grained graded/parallel laminated/cross-bedded sandstone, fine grained cross-laminated sandstone, and wave-rippled very fine grained (rarely silty) sandstone, was deposited in the near shore (subtidal shelf) to beach/subbeach areas respectively. The vertical repetition of Facies 1 and 2 probably implies sea level oscillation due to transgressive-regressive phases. The occurrence of a 30 m thick sequence of Facies 4 i.e. medium to coarse grained, pebbly, trough cross-bedded sandstone with common soft-sediment deformation structures and a persistent unidirectional paleocurrent direction implies a fluvial origin for Facies 3. The occurrence on top of a shallow marine fining upward regressive sequence implies the culmination of the regressive phase when the fluvial facies prograded toward the marine areas.

PALEOCURRENT ANALYSIS

Paleocurrent direction in the field was estimated through the study of azimuth of trough and tabular cross-strata and lee-side orientation of asymmetric ripples and crest trends in symmetrical ripples. In case of trough cross-strata the trough axis dip direction was determined while in case of tabular cross-strata the foreset dip direction was measured. The trend of ripple crests in the symmetrical ripples in the majority of cases are parallel to the paleoshore line. The rippled facies often show an orthogonal relationship with the cross-strata dip, thus suggesting perhaps that they are genetically related. The data in this study have been grouped on the basis of geographic entity such as the individual Table Mountains and also on the basis of facies variation. Data have been gathered from measurement along river sections like Autana, Paru, Asisa, Hacha, etc. , in the Amazonas Territory, the El Dorado - Santa Elena de Uairen road section, and from the top hundred meter or so of Roraima sequence of the Table Mountains in Gran Sabana i.e. Roraima, Kukenan, Elu, Yuruari, Auyantepui, Chimanta tepui, Apradatepui, Ptaritepui, etc., Clearly a much more close spacing of paleocurrent data will be necessary in order to observe the temporal and spatial variation in the paleocurrent direction throughout the Roraima Territory. Nevertheless, available data (more than 1200 paleocurrent measurements) coupled with the published data from Guyana (Keats, 1973) do show a clear paleocurrent trend within the Roraimas.

Figures 8, 9 and 10 show the rose diagrams of paleocurrent data in various locations. In the top fluvial sandstones of Auyantepui, Toronotepui, Apradatepui and the upper fluvial facies of the Ptaritepui a very strong W/WNW current direction has been observed suggesting a southeasterly source of sediment, probably from the Brazilian shield area. The bimodal-bipolar data in the various Table Mountains (not apparent in rose diagrams in some cases) perhaps are related to the tidal sand-flat and subtidal bars with WNW/ESE orientation, perpendicular to the paleoshore line. The data in the Amazonas Territory also show abundant bipolar-bimodal paleocurrent direction in the shallow marine facies. In some sections such as Asisa, Hacha, etc., a trimodal or polymodal distribution has been observed. This is perhaps due to the interaction of ebb and flood effect in tidal bars coupled with the orientation of transverse channels intersecting the subtidal bars in the offshore areas. The paleocurrent direction in fluvial sand bodies always has

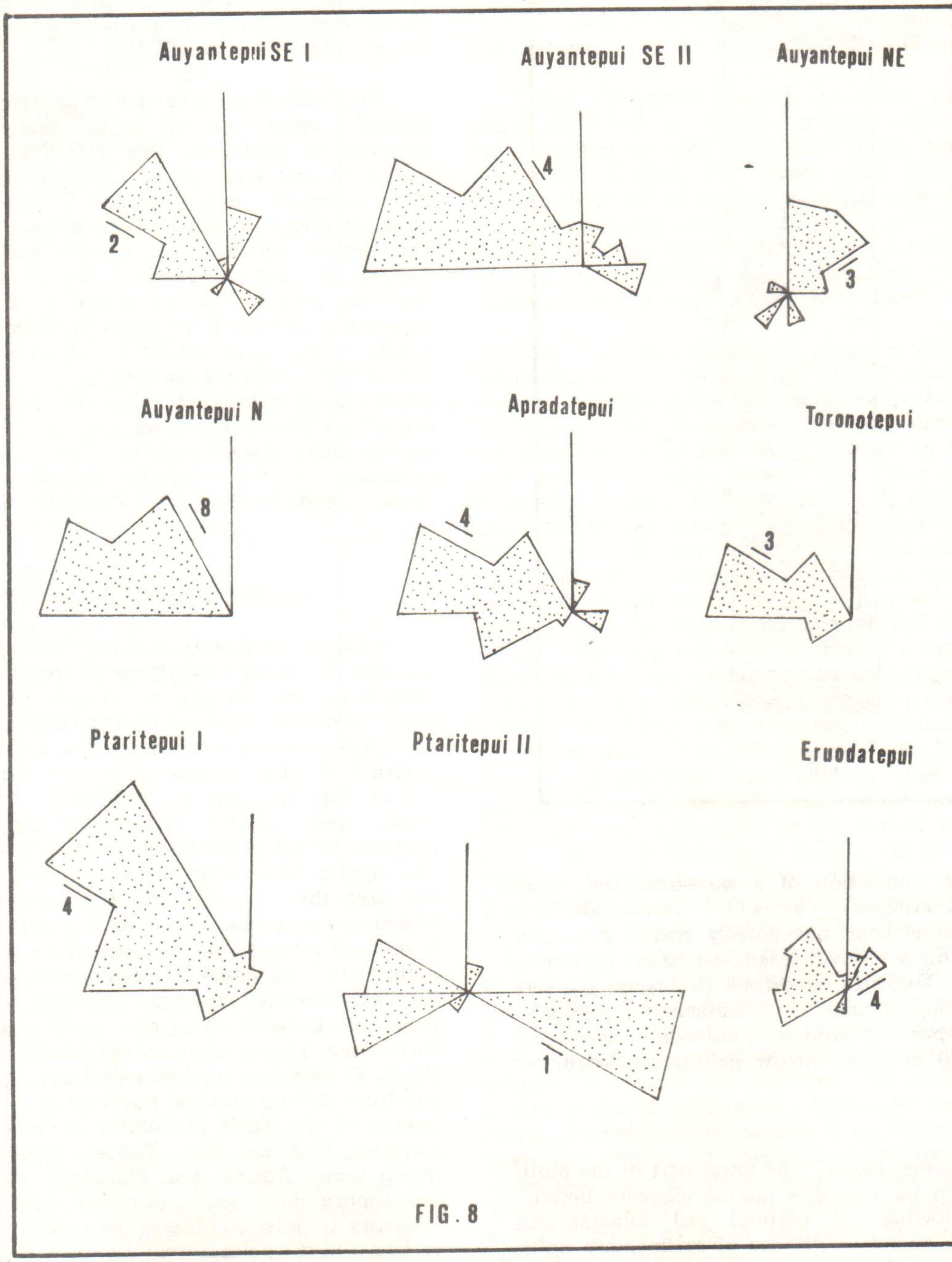

FIG. 8
Paleocurrent rose diagrams in the different Table Mountains in and around Auyantepui. Data in diagrams of Ptaritepui I and II represent data from the upper fluvial and lower beach facies respectively. Bar length represent number of measurements.

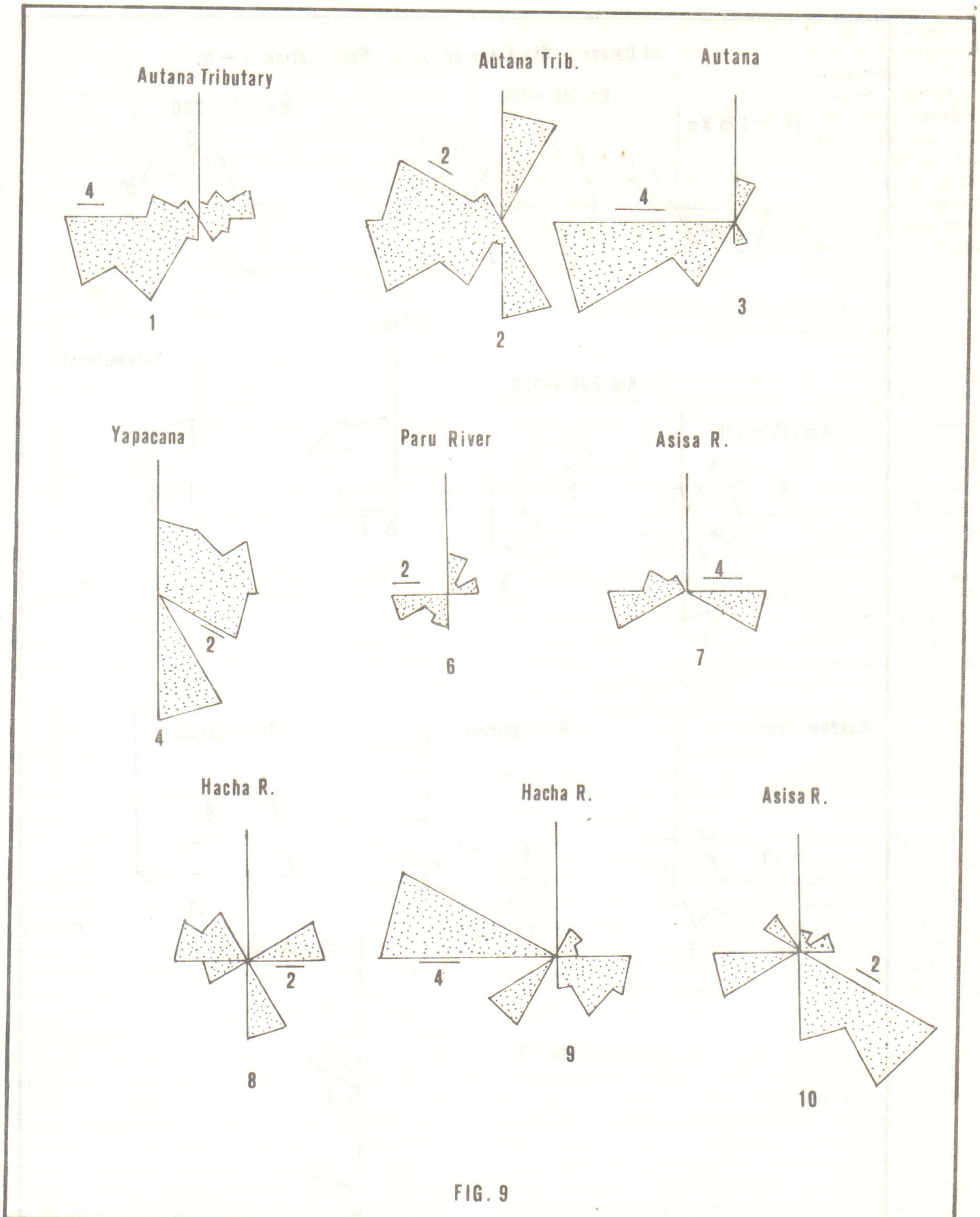

FIG. 9
Paleocurrent rose diagrams of data from Yapacana Hills and various river sections in Amazonas Territory. Diagram 7 and 10 represent data from Lr. and Up. Roraima in Asisa river; similarly diagrams 8 and 9 represent data from Mid. and Up. Roraima in Hacha river.

a strongly unimodal westerly/northwesterly/southwesterly component which clearly indicates a northeasterly, easterly and southerly source of sediments.

However, it is difficult to explain the paleocurrent direction in the Cerro Yapacana where data show divergent paleocurrent trend; here a wide scatter from

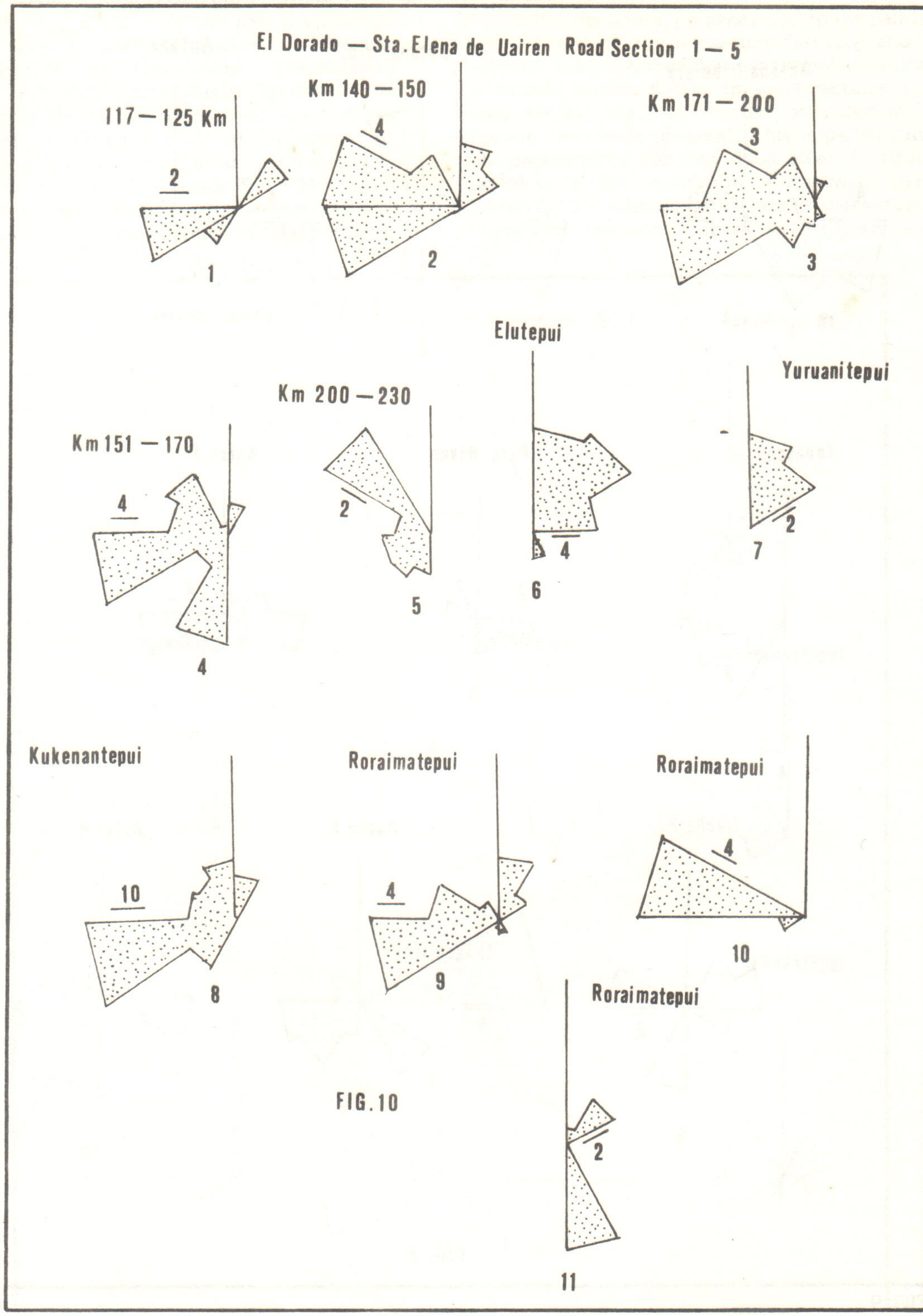

FIG. 10

Paleocurrent data from the Gran Sabana area. Data from the El Dorado-Santa Elena de Uairen road section divided into five sectors. Diagrams 9 and 10 represent data from the upper fluvial facies whereas diagram 11 represents data from the lower rippled facies assemblage in the Roraima Mountain.

north to east to south has been recorded. This may be due to the fact that sedimentation took place in the shallow marine sandy shelf where various agencies shaped the sand bodies: a) meteorological currents such as unidirectional storm currents; b) wave and wave-generated currents; 3) bimodal-bipolar tidal currents, and 4) semipermanent ocean currents (Johnson, 1977). If the effect of some of them are equally dominant the resulting distribution may show wide scatter and in extreme cases an isotropic distribution of paleocurrent data. Speaking in general terms, however, tidal effect seems to be more dominant in the case of Roraima sedimentation. Abundance of bipolar cross-stratification in the mature quartz arenites reinforces the above interpretation.

The paleocurrent data from neighbouring Guyana (Keats, 1973) tends to corroborate the results of this study. The fluvial facies of Keats all show a north-easterly, easterly and southeasterly source of sediments. Thus tentatively it seems that the source of Roraima sediments was from the east from areas now probably occupied by the Atlantic ocean or further beyond and from the south probably from the Brazilian shield areas. In the shallow marine domain the Roraima sediments were shaped mainly by tidal currents but secondarily by meteorological currents (storm and wave generated currents). The long crests of wave ripples were perhaps oriented parallel to the paleoshore line.

ORIGIN OF THE GEOMORPHIC FORM OF THE RORAIMA TABLE MOUNTAINS

It is interesting to discuss the morphology of the 'flat-topped' Table Mountains in relation to tectonics. Contrary to popular belief that the Table Mountains are always flat-topped, it has been found that many of the Table Mountains in the Gran Sabana and in the Amazonas Territory have a saucer shaped configuration (Ghosh, 1977) in which the marginal rims show a basin-ward centripetal and convergent dip. This feature is well observed in Cerro Paru, Cerro Duida in the Amazonas Territory and the Auyantepui (Gansser, 1974) and the Table Mountains in the vicinity of Caura river in Bolivar State. The Cerro Yapacana in the T.F.A., on the other hand, shows the reverse phenomenon, that is, the easterly and westerly rims dip outwardly from the central table land. Field checking in the Cerro Paru area confirmed a basin-ward dip of the basal Roraima sandstones varying between 20 ^{o} - 45 ^{o} . Earlier Van de Putte (1973) observed that most of the pseudo-mesas are located on the axis of synclines and represent examples of inverted topography. Gansser (1974) referring to the structure of the Auyantepui and Table Mountain much further to the southeast (probably the Chimantatepui) observed that "the picture convincingly gives the impression as if the large block mountain was gently depressed (isostatically?) or that some kind of weak undulation affected the sandstone plateau and that only the sediments in the basin-like depressions are now preserved". Often the hinge zones between the marginal rims (cuestas) and the central mesetas are marked by faults as observed in Cerro Paru (Ghosh, 1977) and also in Cerro Yapacana.

The Hacha river and partly the Paru and Asisa rivers are controlled by hinge zone faults or lineaments. The exact origin of the faults, the central depressions and the marginal cuestas are not yet definitely known. However, vertical faults around the central part of the meseta, in which the basement below the central table land acts like a graben and the outlying rims like tilted horsts could possibly give rise to this structure. In Brazil, Suszczynski (1972) also observed that the Roraimas are characterized by folding with the limbs dipping up to 25 ^{o} - 30 ^{o}. Erosion has dissected these folded sequences and only the core of the folds are now preserved and appear as horizontal mesas. The monoclines within the Roraimas, as observed in the Sipapo block may also be due to vertical basement tectonics in which the overlying sedimentary blanket is not ruptured but adjusts simply by buckling (Ghosh, 1971).

CORRELATION, AGE AND SEDIMENTARY FRAMEWORK OF THE RORAIMAS

The sediments of the Roraima formations occur over an area extending from Surinam in the east to the Cerro Sipapo in the west over a distance of about 1500 km. Understandably the sequence in all the scattered areas are not identical and they overlie discordantly basement rocks of various ages. Table I gives the age of the Roraima sediments on the basis of samples of Roraima and its basement rocks from areas occurring in Surinam, Guyana, Brazil and eastern Venezuela. It will be observed that many of the dates are from the dolerite sills and dykes intruding into the middle and upper Roraimas; the dates mostly cluster around 1700 - 1800 m.y. (Snelling et al., 1969). Therefore the Roraimas in these areas may be at least as old as 1800 m.y. Similarly the tuffaceous rocks from the Roraimas of Surinam have been dated and give an age betwwen 1600 - 1800 m.y. (Priem et al., 1973). Further Keats (1973) assigned an age of 1700 - 1800 m.y. to the Roraimas in Guyana. Similar data from Brazil gives an age for the dolerite intrusives around 1690 ± 100 m.y. and 1610 ± 60 m.y. for the tuffaceous rocks. Basei et al. (1975) assigned a 1800 - 1890 m.y. for the Brazilian Roraimas. From the above data it will be perhaps logical to assume that the Roraimas in the main Roraima Range and further to the east will be about 1800 m.y. old. In contrast the Roraimas in the Amazonas Territory in Venezuela unconformably overlies the Parguaza Rapakivi granite which has been dated to be about 1500 m.y. old (Gaudette et al., 1978).

It should be made clear here that the exact contact between the Roraimas and the typical Parguaza Rapakivi granite has not been observed. Mendoza (1977, personal communication) observed an erosional unconformable contact between a pink feldspathic porphyritic granite and the overlying Roraimas in the Cuao river area and suggested that this granite could be a lateral facies equivalent of the Parguaza granite. However, indirect evidence such as lack of contact metamorphic effect and the absence of xenoliths of Roraima sandstones within the granite argues for an unconformable contact. Also at various places at the base of Cerro Autana and Cerro Sipapo along the Autana river, even though no contact has been observed, the vertical distance between the last Parguaza granite exposure and the first of the basal strata of the Roraima is minimum. This suggests that in case of an intrusive body the exposed basal section of the Roraimas would have been definitely affected by the heat of an intrusive batholith of the size of the Parguaza granite.

On the other hand, where the Parguaza granite has intruded into the pre-Roraima meta-sedimentary rocks (Cinaruco Fm.) as observed near the confluence of Parguaza and Orinoco rivers, extensive development of andalusite has been observed over a distance of more than half a kilometer from the intrusive contact. Such contact metamorphic minerals are conspicuous by their absence in the Roraimas overlying the Parguaza Rapakivi granite. Thus the Roraimas above the Parguaza granite (or its facies equivalents) may be considered as old as or, more probably, younger than 1500 m.y. (Gaudette et al., 1978) in the Sipapo Block at the westernmost outcrop of the Roraima Group, as opposed to the much older age of the same in the areas further south and east in Venezuela, Brazil, Guyana and Surinam (Table 1).

A general conclusion of the above discussion will be that the Roraimas could be of multiple ages. Stainforth (1964) earlier made a similar suggestion. The overall similarity of composition and other characters throughout the area may be simply due to the persistence of similar tectonic and depositional environment over a span of hundreds of millions of years. It is likely, as Gansser (1974) observed, that the Roraimas are not coeval everywhere and that they may be progressively younger toward west with prominent but unrecognizable hiatus in between. Gansser (op. cit.) is inclined to extend the stratigraphic range of the Rŏraima sediments from 1800 m.y. to 80 m.y., on the basis of his work on the Macarena Mountains in Colombia where Cretaceous and Tertiary sandstone sequences form spectacular Table Mountains, identical in form to those in the principal Roraima Territory further east. However, pending further studies the author is hesitant to accept Gansser's correlation of the Roraimas up to the Macarenas in Colombia.

If the Roraimas are of multiple ages, as discussed above, it is possible that they were deposited in more than one discrete basins. More work is necessary, specially detailed paleocurrent data, to be specific about this point. Available evidence on the sedimentology and the tectonic set-up suggests that the Roraima basins should be shallow water cratonic ones tucked well inside the craton but connected to open oceans. The Roraima basins could have been separated from one another by Precambrian basement highs (like the Cincinati Arch; Findlay Arch etc., of N. America). The pre-Roraima erosion surface may be thought of as lying close to the then existing sea level.

TABLE I

Age of the Roraima Group and its basement rocks

1.	Snelling, 1963	1.500 - 1.700 m.y.; dolerite sills in Roraima, Guyana
2.	----------- & McConnell, 1969	1.700 - 1.800 m.y.; dolerite dykes & sills in Up. & Mid. Roraima & Mid. Roraima, Guyana.
3.	McConnell et al., 1964	1.700 m.y.
4.	Hargraves, 1968 (Unpub. M.E.M. Report)	1.497 - 2.073 m.y.; dolerite sills in Roraima, Venezuela
5.	Priem et al., 1973	1.600 - 1.800 m.y. Roraima tuff & basement granite, Surinam.
6.	Keats, 1973	a) 1.700 - 1.800 m.y.; Roraima Fm., Guyana b) 1.880 ± 80 m.y.; volcanics of Iwokrama Fm. (basement of Roraima), Guyana. c) 1.825 ± 125 m.y.; rocks of Akawaian orogeny, Guyana.
7.	Gansser, 1974	a) 1.690 ± 100 m.y.; dolerite dykes, Tafelberg. b) 1.610 ± 60 m.y.; Roraima tuff, Surinam. c) 1.600 - 1.700 m.y.; intrusive dykes & sills in Lr. & Mid. Roraima of Ireng-Wailan area, (border region of Guyana-Brazil).
8.	Amaral et al., 1975	Less than 1.580 m.y.; Roraima basement, Brazil.
9.	Bassei et al., 1975	1.800 - 1.890 m.y.; Brazil.
10.	Gaudette et al., 1978	1.550 m.y.; Parguaza granite (Roraima basement), Amazonas Territory, Venezuela.

Extensive winnowing in such areas could eliminate the finer fraction and the labile constituents from the shallow marine domain. Tidal influence is inferred from the evidence presented in the foregoing pages. A gradual fluctuation of the sea level over a span of geological time could produce the Roraima type sediments in intracratonic basins spread in space and time, having striking resemblance with one another because of the steady and stable provenance and tectonic environment.

The foregoing analysis is specially appropriate for the Amazonas sections. It is likely that the sequences exposed in the Santa Elena de Uairen road section, consisting of relatively immature conglomerates and arkose may represent facies proximal to the source area in an essentially piedmont-valley flat-delta plain environment. Data from neighbouring Guyana reinforces the above interpretation (Keats, 1973). However, the sequences on top of the various Table Mountains may represent depositional environments similar to those of the Amazonas sequences. The maturity of the sediments, both textural and mineralogical, sedimentary structures and the tabular persistent nature of the individual units of the scarp forming sequences in the Table Mountains imply a shallow water marine origin.

Fig. 2 illustrates the lateral correlation of the Roraimas across the International boundary on the basis of the meager data that is available. With more study of the vast intervening unexplored areas and more radioactive age-dating, the picture might change drastically. However, the figure shows convincingly that the basins evolved toward west. For example, only the top three members of the nine-member stratigraphic sequence, established by Keats in Guyana, continue in Venezuela and outcrop as the basal Roraima sequence in the Gran Sabana area.

The jasperoid volcanic tuffaceous rocks occuring in the Roraimas in various parts of the Guyana shield (Fig. 2) could be an excellent marker unit for regional correlation, assuming that there was only one such restricted period of volcanism. In Venezuela they occur in such widely separated areas as the Quebrada de Jaspe near Santa Elena de Uairen, Auyantepui and as far west as the upper reaches of the Paragua river (Moreno, 1977; personal communication). Presence of these units and subsequent age-dating of these rocks could yield valuable information leading to reliable regional correlation. Similarly the shaly facies within Roraimas occurring in areas like Santa Elena de Uairen - El Dorado road section (around 134 km post), and in the Amazonas Territory in the Hacha river section could be good candidates for dating and therefore future stratigraphic correlation in the Guyana shield.

Analogs of the Roraima basins could be probably found in the intracratonic Illinois Interior Basin in the U.S.A., Athabasca Fm. in Canada and the Vindhyan Basin in India. In the Vindhyans the paralic and shallow water marine sediments range in age from 900 to 1400 m.y. and were deposited in craton margin (Indian shield) set-up (Ghosh, 1971). The Nubian sandstone of Middle East and Africa could also represent similar tectonic and depositional setting as the Roraimas where similar sandstones were deposited over a time span ranging from Cambrian to Cretaceous (Gansser, 1974).

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