GEOLOGIE EN MIJNBOUW VOLUME 54 (1), p. 55-60 1975

RORAIMA, TAFELBERG AND UATUMÃ FORMATIONS OF THE GUIANA SHIELD: A CORRELATION

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ABSTRACT

On the western and central parts of the Guiana Shield, South America, tabular sedimentary sequences are found, consisting of sandstones, shales and conglomerates and of tuffs, tuffites and graywackes. In Venezuela, Guyana, Roraima and Surinam they have been designated the Roraima Formation; on the southern margin of the Guiana Shield in Brazil they are called the Uatumã Formation. The writer argues that they are similar in origin and probably are roughly coeval in the several parts of the Shield. Summaries and a selection of quotations are presented, in part taken from not easily available papers, and in part translated for the benefit of students who read English but not Portuguese.

INTRODUCTION

In other papers (K l o o s t e r m a n 1973a, 1973b, and in preparation) the writer argues that three enormous ring volcanoes – with diameters of hundreds of kilometers – have been active on the Guiana Shield during the early Proterozoic, and that their calderas and ring valleys have been filled in late-volcanic and in immediately postvolcanic times with thick sedimentary sequences consisting of sandstones, shales and conglomerates and of tuffs, tuffites and graywackes. From the sediments deposited on each of the three ring volcanoes, more or less extensive tabular remnants are left – the Roraima Formation on the Roraima ring volcano, the Tafelberg Formation on the Surinam ring complex (eroded ring volcano), and the Uatumã Formation on the Amazonas ring volcano. The intercorrelation of these formations is independent of the writer's structural thesis: *if it were not true that the volcano-plutonic activity was of the central type and confined to three centers only, the correlation of the three sedimentary formations would remain valid anyhow.*

Of the sediments commonly called the Roraima Formation, the writer reckons only those situated on top of the Roraima ring volcano to belong to that formation. This excludes important patches in the southwestern part of the Guiana Shield, and the Tafelberg in Surinam, which has been correlated with the Roraima Formation – and considered part of it – since its discovery (I J z e r m a n 1931). The advantage of this division is that existing names in several parts of northern Brazil can continue to be used for those formations eventually to be correlated with the Roraima sediments, and that a general name can be chosen later.

The Uatumã Formation in northern Brazil has not been correlated before with the Roraima Formation. It is found both north and south of the Amazon river, but in this paper only the part north of the river is considered. South of the Amazon several more tabular sedimentary sequences which possibly can be correlated with the northern ones occur: the Uatumã Formation of the Tapajos river, the Cubencranquén Formation, the Gorotire Formation, the Dardanelos Formation. The writer hopes to study their interrelationships in another paper.

Summaries and a selection of quotations, in part taken from not easily available papers, and in part translated for the benefit of students who read English but not Portuguese, are presented below. They have been selected in view of those features which seem relevant for the correlation of the formations.

I am most grateful to Mr. J. McNamee, who was so kind to correct my English.

THE RORAIMA FORMATION

The main block of the Roraima Formation, with dimensions of about 300 x 400 km, occupies the central part of the western Guiana Shield, and is distributed over Venezuela, Guyana and Brazil. Its maximum thickness is 2400 meter (L o p e z e.a., 1942). Several important offshoots and minor blocks surround the main block to the west, south and east. These are commonly assumed to be erosion remnants of a once continuous cover, together with more distant patches to the southwest and with the Tafelberg Formation to the east. As the sediments are at least in part late-volcanic, they must have been deposited on a young volcanic relief, and the assumption of a continuous cover is not justified. The writer

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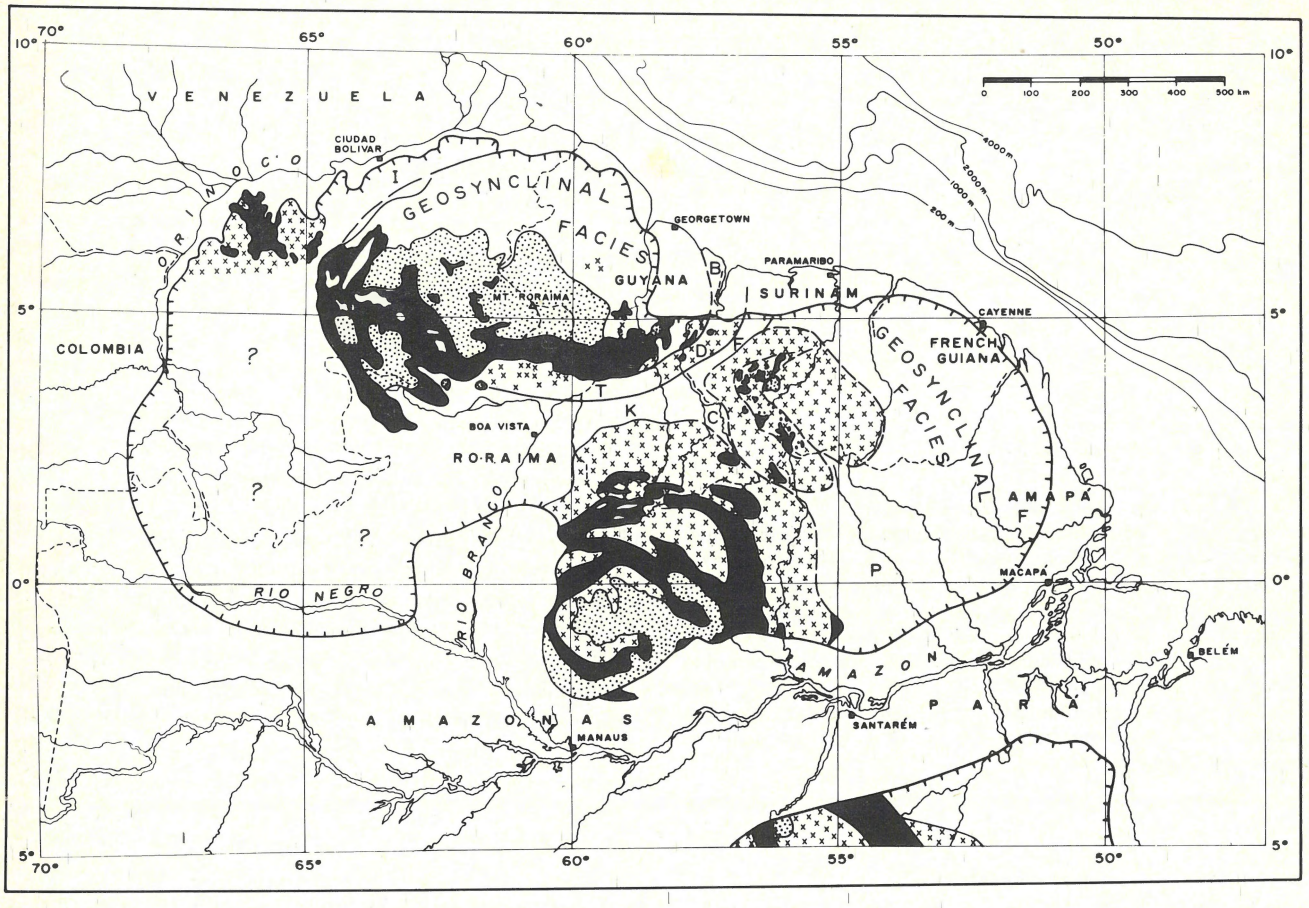

Fig. 1
Giant ring volcanoes on the Guiana Shield.
black - acid to intermediate volcanics; xxx – granitic rocks; ::::::. – tabular sediments; T – Takutu ring graben; D – Dalbana granite; B – Berbice Embayment; I – Imataca; K – Kanuku; F – Falawatra (Surinam); C – Curuni; P – Paru; F – Falsino (Amapa).

interpretes the main block as caldera-filling of the Roraima ring volcano, and the surrounding remnants as ring valley filling; this interpretation will be discussed at more length in another paper (K l o o s t e r m a n, in preparation).

L o p e z e.a. (1942) describe the formation in Venezuela as essentially horizontal beds of conglomerates, sandstones, silicified sandstones, silicified arkoses, and shales, with interbedded green and red jasperized tuffs. The greatest thickness is 2400 meter at Mount Auyán-tepui. Striking features are the predominant reddish tints, frequent cross bedding and ripple marks. Locally a basal conglomerate with pebbles of porphyries and itabirite has developed. One ferruginous layer, southeast of Santa Helena, consists wholly of magnetite and yellow zircon. Late alteration of the beds appears as silicification and sericitization. "Detrital rock grains and pebbles (between Santa Helena and Luepa), consist of a very fine-grained silicified rock (probably porphyry), and vein quartz". "Well-rounded quartz-grains in many of the specimens indicate a distant source". The porphyry pebbles are most abundant in the lower part of the series, especially in the basal conglomerate, and are probably derived from a more immediate source than the later beds". Acid dikes (microgranite, hornblende-biotite-granophyre) cut both the basic intrusives and the sediments in a few places. Contact effects even of the basic sills must be ascribed to siliceous rather than basic solutions – a silicified zone is closely related to the gabbro surface. "... the majority of the quartz grains abound in microscopic, irregular cavities, and such a type of inclusion is also present in the quartz veining the grey porphyries." "During the deposition of the sediments the air would occasionally be filled with the finer materials erupted from volcanoes at a considerable distance from the basin, and a thin layer of tuff would result." "However, it is necessary to assume a slow sinking of the area to accommodate more than 2400 meters of deposits..." "The fine-grained tuffs seem to have made excellent hosts for the siliceous solutions and were changed to jaspers." The above is quoted from Lopez et al. It may be commented, that the rounded quartz grains can be derived from a distant source,

but also from a more proximate source where they existed already in this form. Furthermore, the sinking of the basin was not necessarily slow.

Martin-Kaye (1952) describes the sediments from Guyana, where they form mesas and elevated plateaus bounded by precipitous escarpments, as a more or less horizontally bedded, although partly gently-folded, succession of variably coloured but mainly pink, white, brown or grey, sometimes quartzitic, sometimes arkosic, medium and coarse grained sandstones commonly containing pebble-bearing horizons. These interfinger with finer grained rocks including shales and tuffs, commonly converted into hornfels and jaspery beds respectively. These can occur as extremely hard cherty dark green beds, or as numerous thin beds of fine red jasper, already noted in 1870 by C.B. Brown (quoted by M.K.). Grey, purplish and green tuffs are also present. "Brown on two occasions makes reference to casts of raindrops and suncracks but these have not yet been noted by subsequent workers." "Probably the only minor beds which have a wide areal extent are the tuffs...". "In some of the finer grained rocks..., the joints are close set in a predominant diamond pattern."

Snelling (1963) summarizes the Roraima sediments as stratified sandstones, quartzites, jaspers, shales, conglomerates and boulder beds. Rust (1963) mentions that "a number of small, highly weathered (acid) dykes cut the base of the Roraima formation just below Amatuk falls." "On Kanaima Mountain, two large, relatively unaltered dykes were found, which have been classified as porphyritic felsites." "..., the evidence of high temperature quartz and the absence of granophyric texture suggests a connection with granites underlying the Roraima formation." "..... some (of the granites) at least may be post-Roraima."

Of the sediments in Roraima Territory, Brazil, Paiva (1939) states: "The arkosic character on the left side of the Quinô river, and the tuffaceous or ashy aspect of some of the shales that are interbedded in the sandstones, suggest a remanescent activity of the underlying volcanics during the deposition of the first sedimentary banks."

Gansser (1954) describes area from the same area (Uailã river) a layer of gently folded shales with rare intercalations of platy, argillaceous sandstones, between the Roraima sediments and the volcanic substratum. Unconformably over these shales – which resemble somewhat the Haimaraca Formation to the north – sandstones with a locally developed basal conglomerate were deposited. Two hundred meters above the base starts a succession of shaly, platy sandstones, siltstone layers, and jasper bands. Gansser specifies that by jasper he means a dense cryptocrystalline siliceous sediment: "The spotted coarser green jasper contains small quartz grains, mostly angular fragments from larger well rounded grains of which some relics are preserved. Less frequent are plagioclases of andesine composition, often presenting elongated crystals. Quite characteristic are small epidote aggregates. They are concentrated in certain areas and form the green spots visible on the hand specimen. The groundmass is very fine, mostly cryptocrystalline and altered. In places it resembles a devitrified glass mass." "No gradual change from green jasper bed into quartzite horizons has been observed. This contrasts with the red jasper intercalations. Cross bedding, noted in the coarser red jasper, was not recognized in the green variety. Conceivably, the green jasper intercalations may represent altered pyroclastics, while the red variety most likely has a predominantly sedimentary origin."

THE TAFELBERG FORMATION

The Tafelberg Formation in Surinam comprises the Tafelberg, which mountain exhibits a sequence of sediments 700 meters thick, a much smaller occurrence in the Emma range, a few minor patches in the Wilhelmina mountains and scattered remnants near the Sipaliwini savanna. The Tafelberg sediments have invariably been regarded as outliers of the Roraima Formation, a view not adopted in this paper even if their origin, lithology and age are roughly the same. The writer regards them as remnants of the caldera-filling of the Surinam volcano, and designates them the Tafelberg Formation.

Beckering Vinckers (1959) describes thin beds of indurated tuff in the steep walls of the mountain; these beds form dense reddish brown and white layers interbedded with the sandstone. In the Roraima Formation similar beds are described as being either red or green, but Tate's (1930) observation that the green Roraima jasper has surficially altered to a clear grey colour suggests that the white layers in the Tafelberg sequence represent the primary tuffs, distinguished by Gansser (1954). According to the geological map of Surinam (Groeneweg and Bosma, 1971) the sediments overlie mainly granitic rocks. Beckering writes: "It has always been understood that the granites are older than the Roraima formation. (....). Therefore discovery in the Elfriede fall area west of Kappel Savanna of a granite that is clearly intrusive into the Roraima (sediments) was a great surprise. In this area the granite cuts through the horizontally bedded Roraima sandstone. The granite and sandstone are separated by a quarter-meter wide metamorphosed zone with narrow border facies. (...). Near the contact the quartzitic sandstone is rich in sericite and relatively large muscovite leaflets may be present. Very close to the contact there is little evidence of original bedding. Macroscopically the rock has the appearance of a red jasper-like tuff."

Bisschops (1966), who apparently overlooked Beckering's information about the presence of tuff, described the Tafelberg sediments as pink colored thin to thick bedded

sandstones, with a notable development of graywackes near the base and with conglomerates in the upper part. He does not agree with Beckering's view that the granite near Kappel savanna is intrusive, and writes that several drillholes situated near the outcrop of the contact have confirmed his view that the sandstone was deposited on an eroded surface. However he does not tell us why the drillholes were placed near the outcrop, or in what way his view was confirmed. The final outcome of this controversy is of no great importance in the interpretation of the Tafelberg Formation as caldera-filling. Central plutons are common in ring volcanoes, and Rutten (1966) even explains one in Scandinavia as having been formed by slow cooling of lava in a vent, resulting in a caldera-floor of granitic rocks. Another fact mentionned by Bisschops fits very well in the writer's interpretation. Discussing the origin of the sediments, he finds detrital material supplied from west, southwest, southeast and northeast, and, assuming that such a phenomenon is impossible, he warns against rapid conclusions about the origin of sediments in general.

Priem e.a. (1972) describe layers of ashflow tuffs interbedded with the mainly arenaceous sediments. "The highest pyroclastic horizon was observed at the plateau of the Tafelberg, approximately 430 meters above the base of the Roraima sequence. Its thickness could not be established, but is probably in the order of a few meters. These pyroclastics are extremely fine-grained to cryptocrystalline, banded rocks with grayish, white or reddish colours. Their chemistry corresponds to a leucorhyolitic composition. A conspicuous feature is formed by bubbles of original vesiculated glass (infilled with granular quartz or matrix material), up to several millimeters in diameter. Due to its extremely fine-grained size, only quartz, sericite, some feldspars and ore grains can be recognized under the microscope. Some bands of typical ignimbritic character (shards, flow structures, etc.) display a rhomboedric columnar jointing. Thin chert-like layers are intercalated between the tuffaceous beds."

Outside the Tafelberg, patches of similar sediments are reported by Bisschops (1966) in the Emma range, by Verhofstad (1971) in the Wilhelmina mountains and by van der Lingen (1964) near the Sipaliwini savanna.

THE UATUMÃ FORMATION

A sediment associated with acid volcanics is known in Brazil from both sides of the Amazon river – the Uatumã Formation (Derby 1877, Albuquerque 1922, Oliveira 1928, Moura 1938, Ferreira 1959). Because of its similar lithology, horizontal attitude and position in the central areas of the Amazonas and Tapajos granito-volcanic complexes, the writer equates it with the Roraima and Tafelberg formations.

Derby (1877) is the first to mention these rocks from the Rio Trombetas: "We found on the Trombetas a series very similar to a part of that of the Tapajos. It is exposed in the third cachoeira, called Quebra-potes, and also in the lower course of the river Cachorro, which empties into the Trombetas just above the cachoeira. The rock varies in color, some beds being dark red, others purplish, and like that of the Tapajos it is marked by green spots. The mass is amorphous, feldspathic, sometimes with small grains of glassy quartz, and it may be classified as felsite or eurite. The stratification is very distinct, and the lamination, wave and ripple-marks are as clearly shown as in any modern sandstone. The beds of felsite rest on those of the syenite already described, which is also marked by green spots, and dip 20° NE, the strike being N 30° W. Resting unconformably on this series are beds of sandstone containing Upper Silurian fossils." The underlying rock Derby describes as follows: "The (red) syenite consists principally of flesh-colored feldspar, with a small mixture of hornblende and small scattered spots of a green mineral in decomposition. Quartz is entirely lacking." "I could not determine, in the short time at my disposal on the Trombetas, whether the rock is stratified or not, and it is possibly of eruptive origin."

It would seem that the initial Paleozoic sedimentation in the Amazon depression has been mainly derived from the Uatumã sediments, and therefore can be very similar to them. In the following quotation Derby makes no distinction between Uatumã sediments and Silurian sandstones: "In the lower part of the second cachoeira, called Vira-Mundo, the Silurian beds rest on syenite. (...) The character of the beds is remarkably uniform. They consist almost exclusively of hard argillaceous and micaceous sandstones, generally thin-bedded, but with some massive beds of pure sandstone. The color is very variable, being white, yellow, red or purplish, but the predominant color is some shade of red, generally mottled or banded. (...). One set of beds of cherty schist, about twenty feet thick, is found at the base of the series, in contact with the syenite. This rock looks like one that had suffered some alteration, and this appearance might be taken to prove that the syenite is of igneous origin, and that it had been ejected after the deposition of these beds (...). As, however, the altered appearance is less marked in the part of the schists which is in immediate contact with the syenite, than in the upper portion of the bed, I believe that their peculiar appearance is due to some other cause." "At the foot of the cachoeira Vira-Mundo, and just above the cause." "At the just mentionned, there is a bed of fine-grained, yellowish sandstone, containing a few (Silurian) fossils."

Albuquerque (1922) made a reconnaissance in the lower parts of most northern tributaries of the Amazon. On the Uatumã river, he writes: "... we observed that in the region of the porphyries there occur rocks which one at first inspection would take for a structural variety of the igneous rock, but which possibly are contact-metamorphosed sand-

stones or other rocks. For instance, a fine-grained red rock with euritic texture, looking like the porphyries and found between them, is essentially composed of quartz, fibrous radial calcedony filling vacuoles, and a powder of amorphous iron oxide, and is so rich in silica that we probably have to do with a sandstone digested by the porphyry." (Or, we may ask, with a silicified tuffaceous sediment. J.B.K.) From the sandstones which occur for 36 km downstream from the "porphyries" (read volcanics), some fossils are reported. Part of these sediments might belong to the Silurian, but from the description it would seem that the bulk of this sequence belongs to the Uatumã Formation. Albuquerque describes the ridges of rapids as formed by hard sandstone banks; locally these have divided in parallelopipedons. This seems to be a distinctive property of the Roraima, Tafelberg and Uatumã formations, as may be shown with a few quotations. M a r t i n-K a y e (1952) writes of the Roraima Formation: "In some of the finer grained rocks,..., the joints are close set in a prominent diamond pattern." T a t e (1930) noted, on Mount Roraima, the tendency of the jasper beds to break in perfect rectangles of various sizes. R i c e (1928), on the upper Uraricoera and the lower Parima rivers in Roraima, repeatedly mentions "parallelopipedon plinths" in rapids and riverbanks. From the Tafelberg, P r i e m (1972) notes that "some bands of typical ignimbritic character display rhomboedric jointing."

From the Jatapú river, Albuquerque reports subhorizontal sandstones with interbedded shales over a distance of 27 km. "Some are brittle, others are hard and resistant in the ridges which form the rapids, where the thin layers have the aspect of silex." Ripplemarks are common. From the Serra do Batata, on the bank of this stretch of the river, he mentions "very finegrained and brittle sandstones alternating with red and white finely laminated shales." About the Rio Cachorro, a tributary of the Trombetas, Albuquerque writes: "We followed this tributary seven kilometer upstream. to the Outeiro do Cachorro, a hill nearly 200 m high on the right side of the river. The rocks along this portion of the river are sandstones and porphyries. Making a trip to the Outeiro do Cachorro, we ascended a little creek with blocs of porphyry and found at its head a decomposed feldspathic rock, apparently layered and dipping to the north. Continuing the climb, we found, a few meters above the last porphyry blocs, beds of about 15 to 20 centimeters of a whitish micaceous fine-grained very hard cherty sandstone, with red stains and with many vacuoles, and interbedded with fine bands of a darker and more brittle somewhat argilaceous sandstone, locally red and occasionally finely laminated. From the presence of these sandstones we are inclined to admit that the feldspathic rocks which look like decomposed sediment, dipping to the north at the foot of the hill, belong to the same series, and were feldspathised and folded into a anticline by the intrusion of the porphyry, which did not affect sensibly the attitude of the sandstone banks that form the higher part of the hill."

An occurrence of Uatumã sediments is reported from the Rio Erepecurú, between the Cachoeira do Tronco (= Porteira) and the Cachoeira do Inferno (A l b u q u e r q u e 1922, O l i v e i r a 1928).

F e r r e i r a (1959) made a petrographic study of samples from the collection of the Mines Department (D.N.P.M.) in Rio de Janeiro, and showed that the Uatumã Formation is composed of tuffs, tuffaceous sediments and graywackes. The tuffs "are reddish, pink or greyish, with the macroscopic aspect of volcanic rocks such as quartz-porphyries or quartz-keratophyres, with occasional poorly defined phenocrysts, composed mainly of feldspar. They rather resemble either the graywackes or the igneous rocks with which they are associated: sometimes it is impossible to distinguish them macroscopically from these rocks. An intense silicification lends them great resistance and hardness." Microscopically, Ferreira describes the tuffs as mostly porphyritic, with predominant quartz phenocrysts. Some of the more sizable phenocrysts are composed of potash and more rarely of sodic feldspar. Crystals and rock fragments are embedded in a matrix of much finer material, composed either of devitrified glass or small fragments. A peculiarity of these rocks is their "chaotic texture." Epidote is a common mineral.

All seven samples from the north of the Amazon (three from the Uatumã river, two from the Trombetas and one each from the Jatapú and Erepecurú) examined by Ferreira were classified as tuffs. This does not mean that in this area the Uatumã Formation can be simply incorporated into the volcanics of the granito-volcanic Amazonas complex: it probably reflects unsystematic sampling, with preference given to the harder beds.

Little is known of the extension of the Uatumã Formation. Possibly the flat hills visible on aerial photographs to the north, on both sides of the upper Jatapú river, are capped by these sediments, but they may also represent an old erosion surface which extends to the east beyond the Erepecurú as far as the Maecurú river, and is merely covered with eluvial deposits and laterite. To the west, the flat hills lying north of Manaus are composed of the Japurá sediments described by P a i v a (1929), who correlated them with the Uatumã Formation. Recent studies however (C.P.R.M., unpubl. rep.) indicate that they are Silurian.

CONCLUSIONS

From the descriptions of the Uatumã Formation we may conclude that it consists of shallow-water and possibly fluviatile sediments, partially graywackes derived from the erosion of volcanics and partially subaquatic pyroclastic sediments. These must be in part late, and in part immediately post-volcanic, and therefore clearly the equivalent of the Roraima and Tafelberg sediments, if we admit that the underlying granito-volcanic complex is coeval with those underlying the Roraima and Tafelberg formations . The

correlation of those complexesi is based on structural, petrographic and geochronological data, reviewed in other papers (Kloosterman 1973a, 1973b, and in preparation).

The relative importance of sandstones and conglomerates in the Roraima and Tafelberg sediments and of pyroclastics in the Uatumã series, is easily explained in the model proposed by the writer, by the provision of non-volcanic detrital material from the Guiana mountain chain on the northern rim of the Roraima and Surinam caldera lakes. That the known patches of the Uatumã Formation are concentrated near the border of the crystalline shield, can probably be ascribed to two factors: the better known geology closer to the Amazon river, and the existence of a narrow zone where the Precambrian gently disappears under the Palaeozoic of the Amazon depression, representing a pre-Silurian erosion surface upon which more post-volcanic sediment must have been left than on the actual one.

Differing presumed ages are probably responsable for the fact that the Uatumã Formation has not been previously correlated with the two other formations. The Roraima Formation in Guyana was considered as possibly Mesozoic until, in the last decade, radiometric age determinations established that it was much older, between about 2000 MY, the age of the underlying granitovolcanic complex, and about 1700 MY, the age of dolerite sills intrusive into the sediments (Snelling 1963). Priem (1972) has made direct measurements on tuffs of the Tafelberg Formation, and obtained an age of about 1600 MY. The Uatumã Formation, because of the superimposed Silurian sediments, has been recognized since its discovery as "pre-Silurian."

A difficulty encountered in mapping the Uatumã sediments is due to the fact that the basal Palaeozoic sediments of the Amazon depression seem largely derived from them. Albuquerque (1922) describes sandstones from the Urubú river that are similar to those described from the Uatumã and the Jatapú rivers, but contain some rare Palaeozoic fossils. Derby (1877) who had first found the sediments, confused Uatumã and Silurian sediments on one occasion (see above). The Japurá sediments decribed by Paiva (1929) have a lithology similar to the three formations under discussion. To the North of Manaus, where both Japurá and Uatumã sediments occur, the problem to tell them apart also arises.

REFERENCES

Albuquerque O.R. (1922) – Reconhecimentos geológicos no vale do Amazonas. DNPM/DGM, Bol. 3, Rio de Janeiro.

Beckering Vinckers H. (1959) – New data on the Table Mountain area. Vth Guiana Geol. Conf., Georgetown: 75-79.

Bisschops J. (1966) – The Roraima formation in Suriname. VIIth Guiana Geol. Conf., Paramaribo. Verh. K.N.G.M.G., 1969 (27): 109-118.

Derby O.A. (1877) – Contribuição para a geologia do Baixo Amazonas. Arqu. Museu Nac., Rio de Janeiro, 2: 77-104.

—— (1879) – A contribution to the geology of the Lower Amazon. Amer. Phil. Soc. Philadelphia, Proc. 18: 155-178.

Ferreira E.O. (1959) – Contribuição a litologia da Série Uatumã. DNPM/DGM, Bol. 185, Rio de Janeiro.

Gansser A. (1954) – Geological observations on the Guiana Shield. Ecl. Geol. Helv. 47(1): 77-112.

Groeneweg W., W. Bosma (1971) – Simplified geological map of Suriname, 1:1.000.000. Geol. Mijnb. Dienst Sur., Med. 21, encl. 5, Paramaribo.

Kloosterman J.B. (1973a) – Vulcões gigantes to tipo anelar no Escudo das Guianas. Miner. Metal. 341(5): 52-58. Rio de Janeiro.

—— (1973b) – Giant ring volcanoes on the Guiana Shield. II Congr. Latinoameric. Geol., Caracas.

– The giant ring volcanoes of the Guiana Shield. In preparation.

Lingen G.J. van der. (1964) – Geological map of the Sipaliwini region, southern Surinam. Geol. Mijnb. Dienst Sur., Paramaribo.

Lopez V.M., E. Mencher, I.H. Brineman (1942) – Geology of southeastern Venezuela. Geol. Soc. Amer., Bull. 53(6): 849-872.

Martin-Kaye P. (1952) – The Roraima formation in British Guiana. Geol. Survey Dept., Bull. 22, Georgetown.

Moura P. (1938) – Geologia do Baixo Amazonas. DNPM/DGM, Bol. 91, Rio de Janeiro.

Oliveira A.I. (1928) – Através da Guayana Brasileira pelo Rio Erepecurú. DNPM/DGM, Bol. 31. Rio de Janeiro.

Paiva G. de (1929) – Fisiografia e geologia do vale do Rio Negro. DNPM/DGM, Bol. 40, Rio de Janeiro.

—— (1939) – Alto Rio Branco. DNPM/DGM, Bol. 99, Rio de Janeiro.

Priem H.N.A., N.A.I.M. Boelrijk, E.H. Hebeda, E.A.Th. Verdurmen, R.H. Verschure (1972) – Age of the Precambrian Roraima Formation in northeastern South America. Lab. Isot.-Geol., Amsterdam, Progr. Rep. '70-'72: 7-16.

Rice A.H. (1928) – The Rio Branco, Uraricuera and Parima. Geogr. Journ. 71(2): 113-143; (3): 209-223; (4): 345-357.

Rust B.R. (1963) – Some investigations of the Roraima formation intrusives in British Guiana. Geol. Mag. 100: 24-32.

Rutten M.G. (1966) – The Siljan ring of paleozoics, central Sweden: a posthumous ringcomplex of a late Precambrian Dale porphyries caldera. Geol. Mijnb. 45(5): 125-136.

Snelling N.J. (1963) – Age of the Roraima formation, British Guiana. Nature 198: 1079-1080.

Tate G.H.H. (1930) – Notes on the Mount Roraima region. Geogr. Rev., N.Y. 20(1): 53-68.

Verhofstad J. (1971) – The geology of the Wilhelmina Mountains in Suriname. Geol. Mijnb. Dienst Sur., Med. 21: 9-97. Paramaribo.

IJzerman R. (1931) – Outline of the geology and petrology of Surinam (Dutch Guiana). Thesis, Utrecht.