GUARATUBINHA FORMATION - PR: PETROGRAPHIC CHARACTERIZATION OF THE VOLCANICLASTIC ROCKS

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ABSTRACT The Guaratubinha Basin consits of volcanic, vulcaniclastics and sedimentary rocks formed during the later stages of the Brasiliano Cycle in the state of Paraná, southeastern Brazil. In this paper, the petrographic characteristics of different types of vulcaniclastic (pyroclastic and epiclastic) rocks of the basin are described. The abundance of primary pyroclastic features in rocks of the Guaratubinha Formation indicates that these rocks have been underestimated in the basin's lithologic sequence.

Keywords: Guaratubinha Formation, Brazil, pyroclastic rocks.

INTRODUCTION

The Guaratubinha Formation of the Guaratubinha Basin (GB) is located in the southeastern portion of the state of Paraná, in the southern portions of the Serra do Mar, about 35 km from Curitiba (Fig. 1). With an area of approximately 225 km^2, the basin contains volcanic, volcaniclastic and sedimentary rocks confined to a narrow N10-20E trending basin flanked by high-grade metamorphic rocks of the Santa Catarina Granulitic Complex (SCGC). The Guaratubinha Basin formed during the later stage of the Brasiliano Cycle (Neoproterozoic) in southeastern Brazil (Basei et al. 1992). The present tectono-morphologic structure of the basin is due to the openning of the South Atlantic Ocean during the Mesozoic.

GEOLOGIC SETING

The Guaratubinha Basin was characterized as being constituted by volcanic rocks originated in tectonic depressions with thick layers of clastic sediments. A detailed study undertaken by Fuck et al. (1967) resulted in the identification of three sequences: a) Sedimentary - constituted by an arkosic, silty and argillaceous conglomerate; b) Volcanic acid - constituted mainly by volcanic breccias, tuffs and rhyolitic lavas and c) Intermediate Volcanic – composed by andesitic lavas. Semi-detailed geological cartography carried out by undergraduate students (Castro et al. 1993, Pinheiro et al. 1995) lead to the recognition that the volcanic rocks comprise a great variety of volcaniclastic facies, which resulted in the separation of five lithologic associations, i.e., (a) a thick Clastic Association, (b) Acid Volcanic Association with associated volcaniclastic rocks, (c) Acid Volcaniclastic Association, (d) Intermediate Volcanic Association and, (e) Upper Volcaniclastic Association.

These associations consist of 90% of interbedded volcanic and volcaniclastic rocks and minor siltstone and/or argillite. The volcaniclastic rocks occur both as pyroclastics and epiclastics.

The age of the volcanic rocks is 570±10 Ma. Siga Jr. (1995) shows that this basin is associated to the development of the Brasiliano Tectonic Cycle. The rocks do not present evidence of deformation and regional metamorphism, resulting in the preservation of abundant primary features. Locally, along major faults, the volcanic rocks may occur as vertical to sub-vertical mylonites and cataclasites.

In the association study, aspects referring to the structural and textural characteristics, mineralogical composition and areas of occurrence were considered (Fig. 1). For the denomination of these rocks, the classification of Reads Bas and Sabine (1980) was used. It is based on the size and composition of the fragments. The defined associations are: a) *Clastic Association*: considered the basal association, it is constituted of polymitic orthoconglomerates with millimetric to decimetric pebbles, a sandy and lithic sandy matrix, cemented by iron oxide and calcite. The pebbles are mostly rounded (medium to low sphericity) and consist of gneisses, milky quartz, phyllite, schist, foliated calk-alkaline granitoids, quartzite, granulite (*latu sensu*) and micro-granite; b) *Acid Volcanic Association*: acid volcanic rocks, rhyolites to alkali-rhyolites prevail and, subordinately, volcaniclastic rocks. The rhyolites are pinkish-red, generally exhibiting porphyritic and seriate textures (potassium feldspar), with orthoclase phenocrysts and quartz, in a matrix made up of quartz, oligoclase, and subordinately opaque minerals, biotite, chlorite and epidote, hornblende and zircon; c) Acid *Volcaniclastic Association*: constituted predominantly of lapilli-tuffs and fine tuffs, as well as agglomerates, ignimbrites, probable hydrothermal rocks and ash tuffs, with eventual phenocryst crystals and fine rhyolitic strata; d) *Intermediate Volcanic Association*: composed of andesites with subordinate rhyodacites. The andesites are gray to dark gray and they are porphyritic (plagioclase phenocrysts). The matrix consists of andesite and/or labradorite, volcanic glass and fine opaque minerals. There are also, in smaller amounts, opaque minerals, sericite, clay minerals, probably diopside-augite, quartz and ferric chlorite. There are also amygdules with compositional zoning, filled by quartz, epidote, calcite, ferric chlorite, chalcedony and iron oxide. The textures are seriate, glomeroporphyritic, porphyritic and sporadically autoclastic. The main structure is variolitic, with associated flow structures and e) *Upper Volcaniclastic Association*: Constituted of tuffs of different grain sizes and materials and well-preserved primary structures that suggest wavy, linsen and flaser, as well as wave marks with a southeastward flow direction.

VOLCANIC ROCKS

The acid volcanic rocks prevail within the Acid Volcanic Association. They are rocks with aphanitic to porphyritic textures and solid structures, but locally, they have a well-developed flow structure being characterized as ignimbrites.

In the case of the ignimbrites, they present, in general, sub-horizontal flow structures, characterized by an intercalation of different colored laminae that outline the phenocrysts and some occasional clasts.

Volcanic rocks of intermediate character prevail in the Intermediate Volcanic Association. They are rocks composed predominantly of porphyritic andesites, presenting plagioclase phenocrysts in an aphanitic matrix, commonly presenting a variolitic texture.Subordinately, rhyodacitic rocks including vesicular terms, always associated with the andesites.

VOLCANICLASTIC ROCKS

The two associations that have a predominance of volcaniclastic rocks are described separately: the Acid Volcaniclastic Association has rocks described as pyroclastic (e.g. ignimbrites) and the Upper Volcaniclastic Association has rocks that are difficult to distinguish as either pyroclastic and epiclastic.

Acid Volcaniclastic Association

This association occur in the central-western portion of the studied basin, in the form of a NE-trending body, intimately associated to the larger rhyolitic body of the Acid Volcanic Association. The volcaniclastic constituents occur associated with fine rhyolite strata underlying the andesites of the Intermediate Volcanic Association.

For the effect of characterizing and describing the volcaniclastic rocks present in this association, granulometry was used as the main criterion, based on the classification of pyroclastic rocks proposed by Fisher & Schmincke (1984).

LAPILLI TUFFS OR AUTOCLASTIC BRECCIAS Composed basically of quartz clasts, opaque minerals and zeolites. Castro et al. (l993) defined this rock as a hydrothermalite, characterized by the high content of very fine quartz (films), amygdales and spherulites. The presence of the amygdales and spherulites, which are products of a high concentration of SiO_2, is an important indication that the rock is of pyroclastic origin. These characteristics show that the source area is

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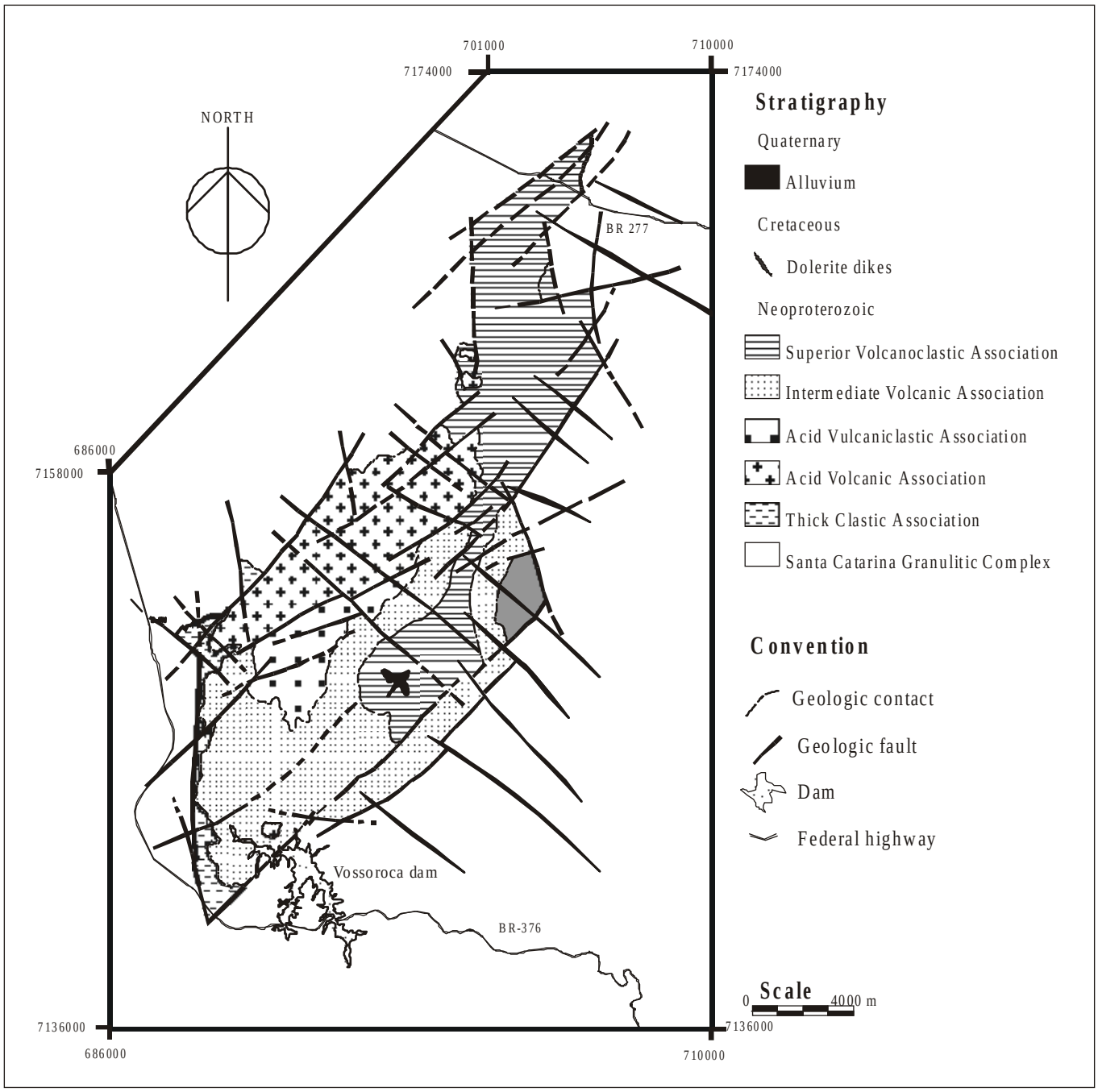

Figure 1 – Location and geologic sketch of the study area.

very probably proximal. In this case, it may be a deposit of fragments of agglutinated lava very close to the volcanic duct or, depending on the granulometry, of autoclastic breccias.

VITRIC ASH-TUFFS Castro *et al.* (1993b) describes this lithology as rocks made up of a matrix of quartz and potassium feldspar (volcanic devitrificated glass) with lithic fragments and fragments of crystals. They are rocks composed of angular clasts (crystalloclasts and lithoclasts) with corroded quartz (angular crystals) borders, lithic fragments (rhyolites and ignimbrites) and potassium feldspar (orthoclase and/or sanidine), in a main cryptocrystalline matrix made up of quartz films (devitrification?) and opaque minerals. The matrix involves the clasts and they seem to "float" in the finer material (Fig. 02).

The clasts have corrosion borders and may represent remains of bubble-wall texture Fisher (1963). However, the occurrence of elongated and oriented quartz films perhaps vitric resembling agglutinated lava (Mazzoni, 1986) and denote a fiamme texture. In this case, the quartz films represent pumice fragments with a high degree of compaction. This characteristic, associated to the clast structure supported by the matrix, indicate that this rock was generated by pyroclastic flows with a high load of fragments (dense pyroclastic flows).

IGNIMBRITES (VITRIC ASH-TUFFS) Tuffs classified as ignimbrites, with a clear orientation of the matrix (flow structure) and the presence of lithic and crystal fragments. This orientation is characterized by fine quartz films and potassium feldspar (devitrification) and opaque minerals (haematite?), and may be associated to volcaniclastic flows or compaction processes.

The crystal fragments with reaction rims may be related to the bubble-wall texture. The presence of a eutaxitic texture is incipient, compared to the texture in fiamme, that can be characterized by the high content of quartz fragments (devitrification) with an elongated

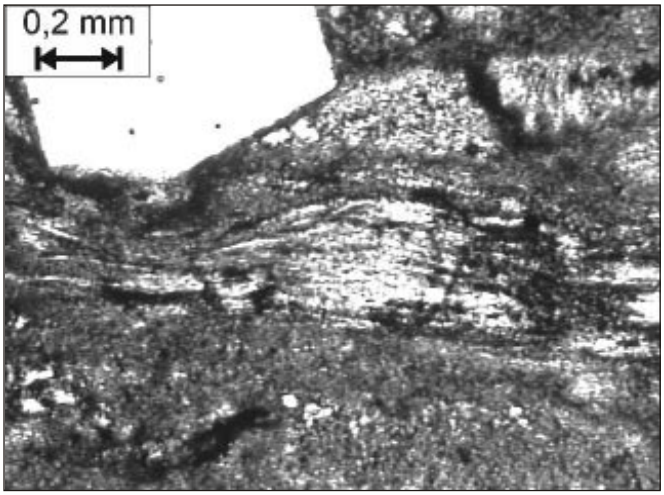

Figure 2 – Ash tuff with a fragment of euhedral potassium feldspar involved in a fine matrix (ash), probably devitrified. The crystalloclast displays dropstone-type deformation within the matrix.

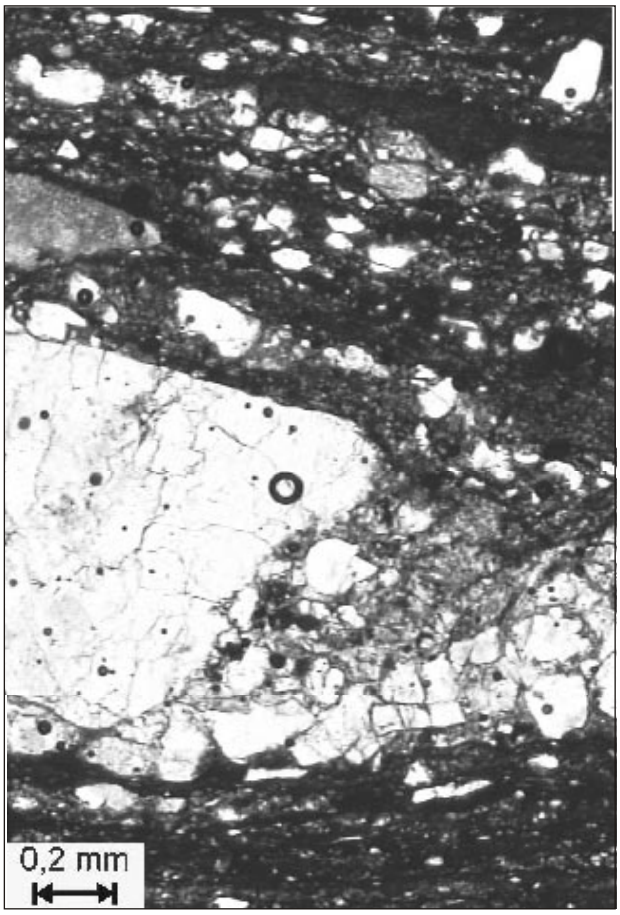

Figure 3 - "Accidental" clast of subhedral feldspar, with corroded borders in the silt matrix with smaller crystal clasts (feldspar and quartz) - this material is found in a planar parallel bedding structure.

and oriented form, similar to agglutinated lava that is common in ignimbrites (Mazzoni 1986, Ulbrich 1986).

The lithic fragments are composed basically of quartz, potassium feldspar (either orthoclase or sanidine) and mineral agglomerate. The crystal fragments are euhedral to subhedral, generally fractured, and reach a maximum size of 2 mm, with the occurrence of embayment quartz. Both the quartz crystal fragments and the feldspar fragments have seemingly corroded borders and, in some cases, seem to have been rotated.

Upper Volcaniclastic Association An association occur in the central portion of GB, at the base, deposits of relatively thick granulometry prevail (clasts of up to 2.0 mm), while at the top it become a rock with compositional banding of siltic granulometry, with plane parallel laminations, sometimes of the flaser type.

The levels of thick granulation are composed of lithic fragments (volcanic and volcaniclastic rocks) and fragments of crystals (feldspar and quartz), allowing us to characterize probable litho-crystal tuffs, always associated to irregular levels of fine material with "accidental" clasts and probable ash tuffs. The levels with predominantly siltic granulometry have a planar parallel compositional banding and they are constituted by very fine material, characterized as being lapilli-ash tuffs.

ASH-CRYSTAL TUFFS Constitute irregular layers of coarse-grained tuffs (around 0.5 to 2.0 mm), composed predominantly of quartz, feldspar, lithic and opaque fragments, intercalated with layers of fine granulometry (less than to 0.05 mm), composed mainly of quartz, feldspar, phyllosilicate (white mica), clay-minerals and opaque minerals. These levels have slightly asymmetric wave marks, with decimetric wavelength, a flow direction indication to the SE quadrant, besides having wavy, linsen and flaser structures.

The lithic fragments occur sub-rounded with an approximate size of 2.0 cm and they are formed mainly of fragments of polycrystalline quartz, andesite and rhyolite. The crystal fragments prevail on the lithic fragments: in general they possess corroded borders and a granulometry less than 1.5 mm, with the significant presence of plagioclase crystals, feldspar potassium and quartz (Fig. 03).

The origin of the rocks of this association is debatable. They may be volcaniclastic rocks of either the pyroclastic or the epiclastic type. Suggestive of a pyroclastic origin, is the presence of lithic fragments with an approximate size of 2.0 cm. This fragment type is in generally associated to pyroclastic phenomena referring to fragments of ballistic trajectory (Ulbrich, 1986). The epiclastic hypothesis is plausible, considering the existence of normal, upward-fining gradation of the fragments, displaying abrupt and irregular upper and basal limits. This lithological type, when analyzed under Scanning Electron Microscopy - SEM shows the morphology of the fragments and their relationship with the matrix, where a structure sustained by clasts is evident, indicating the immaturity of the material.

ASH TUFFS This type is constituted of silt and clay-grain-size layers, with countless clasts of coarse sands, intercalated with layers of fine sands. The levels silty to clay grainsize would be layers of ash tuffs, while the sand-grainsize layers, crystal-tuff layers.

The layers of gray-tuffs are formed predominantly by ash, besides the clasts of crystal fragments (quartz and secondarily feldspar) and "accidental" lithic fragments. The lithic fragments are constituted by polycrystalline quartz, in some cases with internal structuring, similar to the fragments of volcanic devitrified glass that occur in the Acid Volcaniclastic Association. The presence of fragments of the fine material of the matrix also occurs, as well as probable intraformational clasts, and/or altered vitric clasts (Fig. 04).

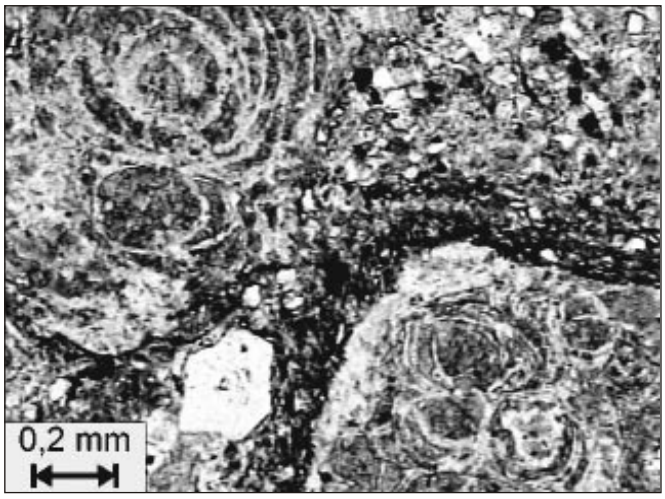

Figure 4 - Vitric fragments of incompatible granulometry, with a high degree of devitrification. The matrix is a probable crystal tuff.

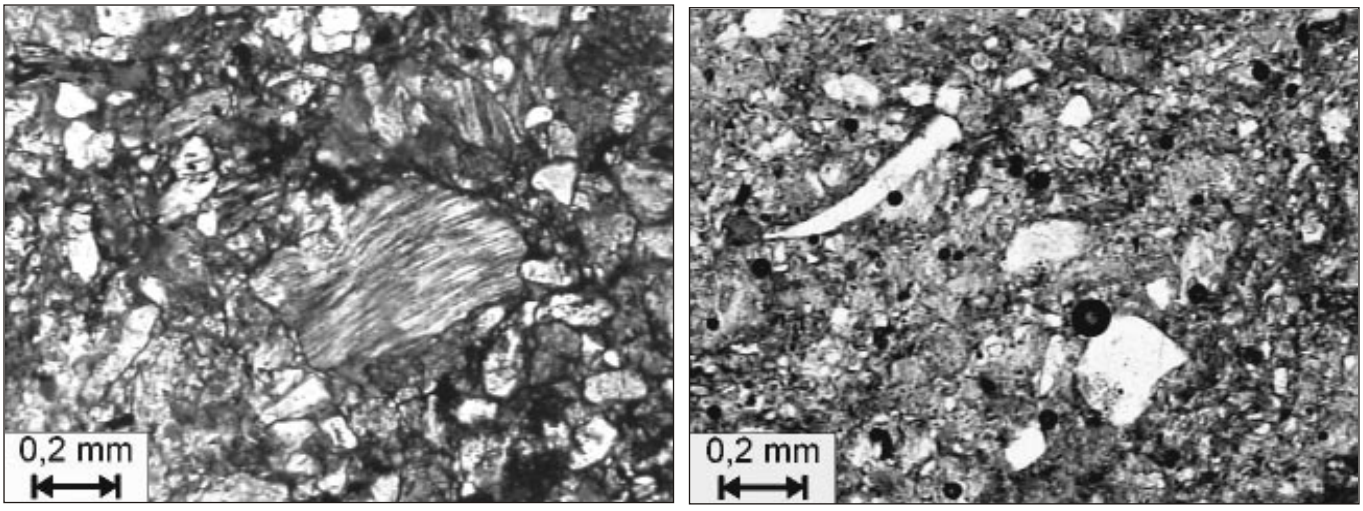

Figure 5 – (A) - Devitrified glass fragments with eutaxitic internal structures. (B) - Shard fragments with curvilinear forms, substituted by quartz. Probable evidence of ash fall deposits.

In the layers of crystal tuffs of sand grainsize, fragments of crystals prevail, and the finer material of the rock is described as probable volcanic ash. According to Castro et al. (1993a) this material is constituted of fine opaque minerals, chlorite, sericite and clay minerals. This information is reinforced by the preliminary results of X-ray diffraction, which indicated the presence of quartz, feldspars, probable illite and, in some cases, phyllosilicates, possibly sericite or chlorite.

In general, the relationship between these levels shows a normal gradation between the layers of coarse fragments and these of fine grainsize, being the abrupt upper and lower limits of each set.

A pyroclastic origin or contribution allows us to understand the presence of fragments of incompatible granulometry with the surrounding environment, denominated "accidental clasts." Specifically, the presence of lithic clasts, is possibly of ballistic origin. The structures commonly described in these sets are deformation below the base of the clast (i.e. dropstone-type deformation) and deformation of the actual clast.

VITRIC ASH-TUFFS Partially altered rock of a whitish-yellow color composed basically of fragments with a size smaller than 2 mm, of feldspar, quartz, pumice, shards, in general devitrified. This devitrified material is characterized by the presence of microcrystalline quartz, white mica and clay-minerals.

These tuffs present planar parallel structures, defined by banding with fragments of differentiated grainsize, the thickness of the laminae being less than 1.5 mm. There is also incipient gradation at each layer, with diffuse and gradational limits. The presence of fragments of devitrified volcanic material: pumice, shards and crystal fragments with vitric margins, named mixed pyroclast by Mazzoni (1986), sufficient to define this rock as having a of pyroclastic origin (Fig. 05).

LAPILLI TUFFS These are gray-to brown rocks of silt grain-size, with a high clast concentration. The clasts are constituted of lithic fragments of andesitic composition and crystal fragments of quartz, epidote, potassium feldspar, plagioclase, sericite, clay minerals and mafic minerals. There are also fragments with forms similar to the shards and pumices, which exhibit internal structures similar to the axiolites, as well as cryptocrystalline material with a size inferior to 0.1 mm, possibly devitrified glass fragments.

Structurally, this lithology is supported by clasts and a matrix composed of cryptocrystalline material. In outcrop, they occur in the form of centimetric packages interlayered within bodies of andesitic composition.

CONCLUSIONS

The Guaratubinha Formation, besides presenting volcanic rocks, also has lithological associations constituted essentially of rocks of volcaniclastic origin. The existence of ignimbrites brings evidence to the presence of pyroclastic material, while different types of tuffs make it difficult to distinguish between a pyroclastic or an epiclastic origin, in the latter case, with a high degree of immaturity.

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