GEOLOGICAL, LITHOLOGICAL, AND PETROGRAPHICAL CHARACTERISTICS OF THE ITAÚNA ALKALINE INTRUSIVE COMPLEX, SÃO GONÇALO, STATE OF RIO DE JANEIRO, BRAZIL, WITH SPECIAL ATTENTION OF ITS EMPLACE MODE

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ABSTRACT – This article presents field studies and microscopic observations of the felsic alkaline rocks of the Itaúna Intrusive Complex, São Gonçalo, State of Rio de Janeiro, Brazil. The rock body is constituted mainly by phonolitic and nepheline syenitic rocks and locally by volcanic breccia. The phonolitic main body is intruded by syenitic dykes of metric width. The volcanic breccia takes place only within a small area of 20 x 30 m. The clasts are composed entirely of massive trachytic or phonolitic rock of variable size, form 1 cm to 1 m, even within the same outcrop. The large clasts are semi-rounded and small ones are angular. Pisolite, bomb-sag structure, and vesicular clasts are not confirmed. No granulometric sorting and normal grading of the clasts are observed. The matrix shows welded structure with steeply dipped secondary flowage. The above-mentioned restricted occurrence area, steep secondary flowage planes, and variable clast size indicate that the pyroclastic rock is not tephra or pyroclastic flows, but vent-filling tuff breccia forming a subvolcanic conduit.
Keywords: Itaúna, volcano, subvolcanic conduit, trachyte, syenite, pyroclastic rock.

RESUMO – *A. Motoki, S.E. Sichel, R. Soares, J.L.P. Neves, J.R. Aires - Características geológicas, litológicas e petrográficas do Complexo Alcalino Intrusivo de Itaúna, São Gonçalo, RJ, com atenção especial no seu modo de posicionamento*. Este artigo apresenta estudos de campo e observações microscópicas das rochas alcalinas félsicas do Complexo Intrusivo do maciço Itaúna, São Gonçalo, RJ. O maciço é composto principalmente de rochas fonolítica e sieníticas e, localmente de brecha vulcânica. O corpo principal fonolítico é intrudido por diques sieníticos de largura métrica. A brecha vulcânica ocorre apenas dentro de uma pequena área de 20 x 30 m. Os clastos são compostos inteiramente de rocha maciça de composição traquítica ou fonolítica de tamanho variável, desde 1 cm até 1 m, até mesmo dentro do mesmo afloramento. Não se confirmam pisolito, estrutura de *bomb-sag* e clastos vesiculares. Não há seleção granulométrica e gradação normal dos clastos. Os clastos grandes são semi-arredondados e os pequenos, angulosos. A matriz apresenta estrutura de soldamento com fluxo secundário de alto ângulo de inclinação. A área de ocorrência limitada, os planos de fluxo secundário de alto ângulo e o tamanho dos clastos variável, acima citado, indicam que a brecha vulcânica não é formada por tephra ou fluxo piroclástico, mas sim, de natureza soldada de preenchimento de um conduto subvulcânico.
Palavras-chave: Itaúna, vulcão, conduto subvulcânico, traquito, sienito, rocha piroclástica.

INTRODUCTION

The Itaúna Alkaline Intrusive Rock Body is situated at the northeast portion of the São Gonçalo city, State of Rio de Janeiro, Brazil, occupying an elliptic area of 3.5 x 2 km elongated toward NE-SW (Figure 1). This rock body is constituted predominantly by phonolitic rock and nepheline syenitic rock, with local occurrence of pyroclastic rock.

Geology of this massif was little known and there are no article published in scientific periodic journals. However, some abstracts and unpublished technical

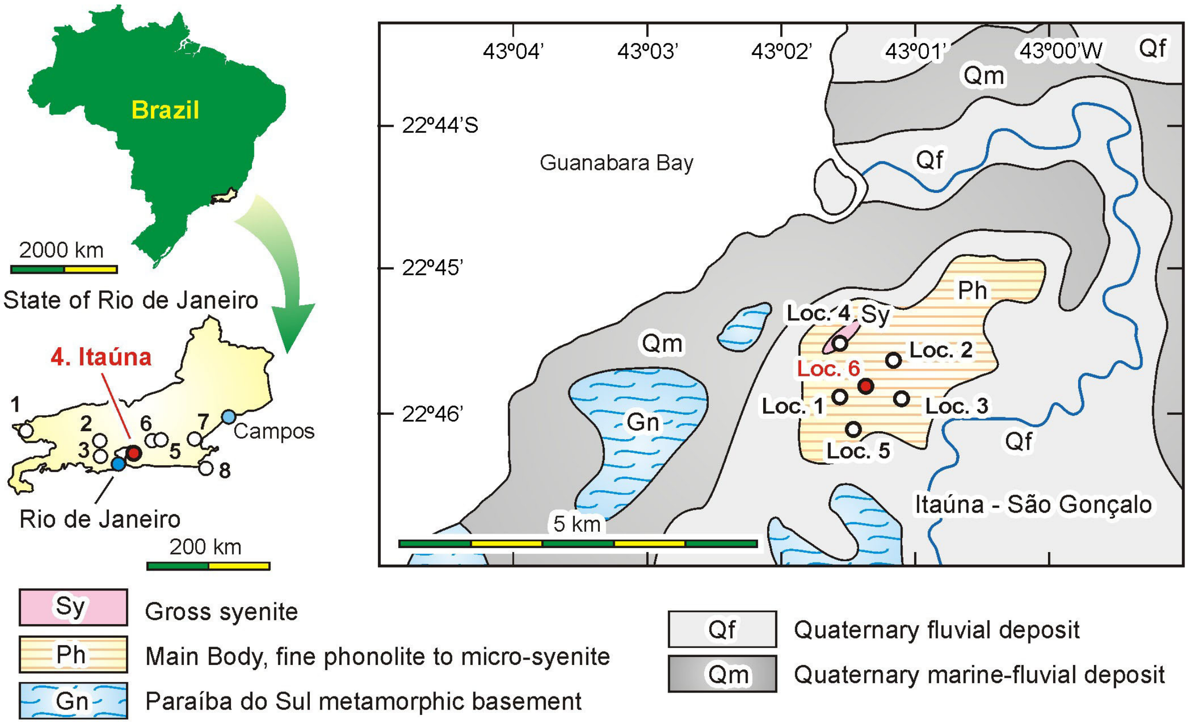

FIGURE 1. Geologic map of the Itaúna Alkaline Intrusive Complex Rock Body, modified from Silva et al. (2000). The pyroclastic rock body at Loc. 6 is not expressed because of the small distribution area. The alkaline felsic intrusive rock bodies are: 1 - Itatiaia; 2 - Tinguá; 3 - Mendanha; 4 - Itaúna; 5 - Rio Bonito; 6 - Tanguá; 7 - Morro de São João; 8 - Cabo Frio Island. The Canaã syenitic body is not included because it is Precambrian nepheline syenite gneiss.

reports are present. Helmbold (1967; 1968) and Helmbold et al. (1965) notified the existence of felsic alkaline rocks at the Itaúna Massif. Lima (1974; 1976) pointed out occurrence of the volcanic breccia. Klein et al. (1999 a; b; c) interpreted that the breccia is constituent of subaerial eruptive deposits, such as tephra and pyroclastic flows. Accretionnary lapilli, that is, volcanic pisolite, and bomb-sag structure, and rheoignimbritic texture were reported with special attention. Based on this interpretation, the Secretary of Sightseeing of the São Gonçalo City Government (São Gonçalo, 2006a; b) named the Itaúna Massif as "São Gonçalo Volcano" (*Vulcão de São Gonçalo*).

The Itaúna Alkaline Intrusive Complex is a member of the felsic alkaline magmatism of this region that took place form late Cretaceous to early Tertiary, such as Itatiaia (Ribeiro Filho, 1964; Brotzu et al., 1997), Mendanha, Tanguá, Rio Bonito, Morro de São João (Lima, 1976), and Cabo Frio Island (Lima, 1976; Sichel et al., 2008). Some of them, as Itatiaia, Mendanha, and Cabo Frio Island, are accompanied by pyroclastic rocks.

Among them, those of the Mendanha Complex Intrusive Rock Body are best studied. Klein & Vieira (1980), Klein et al. (1984), Klein (1993), Silveira et al. (2005), etc. interpreted that the volcanic breccia constitutes an extinct volcano of the Cretaceous with well-preserved crater, so-called "Nova Iguaçu Volcano" (*Vulcão de Nova Iguaçu*). However, recent publications, such as Motoki & Sichel (2006) and Motoki et al. (2007 a, b, c; 2008), have revealed that they are constituent of subvolcanic conduits and fissures emplaced at a depth of 3 km, that is, vent-filling welded tuff breccia.

The emplacement mode of the Itaúna pyroclastic breccia is an interesting theme in comparison with those of the Mendanha and the Cabo Frio Island bodies. However, the Itaúna Massif is of difficult access because of social security problems. In this sense, the data acquired by restricted fieldwork are important, although they are not enough much for the complete comprehension of this felsic alkaline magmatism.

The present article shows the results of recent field observation, lithological description, and petrographical study of the felsic alkaline rocks of the Itaúna Complex Intrusive Rock Body, with special attention of the volcanic breccia, and examines the emplacement mode of this pyroclastic rock, if it is constituent of subaerial eruptive deposits of an extinct volcanic edifice or vent-filling welded tuff breccia of a subvolcanic intrusive rock body.

PHONOLITIC MAIN ROCK BODY

The felsic alkaline intrusive rock body of the Itaúna Massif is constituted mainly by phonolitic and syenitic rocks (Figure 1; 2). This body, namely "Main Body", is exposed from the flank base, 30 m above sea level, to the top, the Central Peak of 282 m. The border zone of this rock body, such as the top of the Occidental Peak (Loc. 1, Figure 1; 2), is underlain by fine-grained massive phonolitic rock of black macroscopic colour that shows obsidian-like circular fractures. This rock shows parallel cooling joints developed in three directions with interval of 10 to 20 cm. The rolling stones occur forming angular fragments with weathered surface of 0.5 to 1 cm of thickness (Plate 1A).

The thin-section observations show that this rock has aphyric texture, containing few non-altered alkaline feldspar phenocrysts of size up to 1 mm x 0.2 mm. The mafic mineral phenocrysts are altered into opaque minerals even in non-weathered rock samples. Relatively fresh amphibole phenocrysts, of 0.15 x 0.03 mm, also take place (Plate 2A). The groundmass is of microcrystalline texture, filled by well-oriented alkaline feldspar microliths of 0.05 x 0.01 mm, showing typical trachytic texture. Deuteric or hydrothermal alteration is not expressive.

To the central part of the Main Body, the rock becomes causer in grain-size, lither in macroscopic colour, and wider in joint interval. At the centre, as top of the Central Peak, Loc. 2 (Figure 1; 2), the rock turns into light grey micro-nepheline syenite. The cooling joint interval becomes 50 cm to 1 m, forming semi-rounded bowlders (Plate 1B).

The microscopic observation reveals that the rock has interstitial texture constituted by the framework of tabular alkaline feldspar of 1.5 mm x 0.2 mm (Plate 2B). They are completely altered into clay minerals. The interstitial spaces are filled by alkaline feldspar with strong effect of sericitisation and fine-grained cancrinita probably originated from nepheline. However no relitic nepheline is observed. The cancrinite sometimes show radial growth habit (Plate 2C). The mafic minerals are generally altered into opaque ones, however clinopyroxene grains with non-altered core also take place. There happen some grains of relatively fresh and idiomorphic clinopyroxene crystals, of 2 mm x 0.6 mm. These observations indicate notable effects of deuteric or hydrothermal alteration.

A zone between the Loc. 1 and 2, such as western flank of the Central Peak, Loc. 3 (Figure 1; 2), exposes the rocks of intermediate characteristics. They have dark grey macroscopic colour and the groundmass causer than the very fine phonolitic rock of the Loc. 1. Relatively fresh idiomorphic alkaline feldspar phenocryst, of 0.3 x 0.2 mm in size, are usually observed (Plate 2D). The mafic minerals are generally altered into opaque ones or chlorite. The microlites are made up of alkaline feldspar, of 0.1 x 0.02 mm, and the

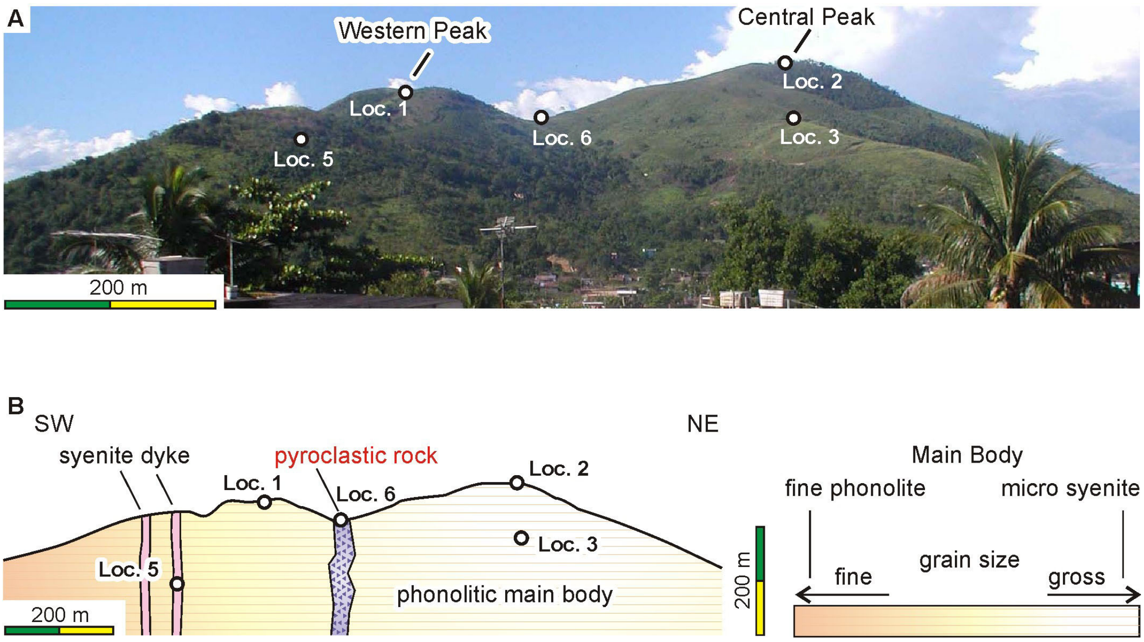

FIGURE 2. General view of the Itaúna Massif and its schematic geologic cross section, according to the present data.

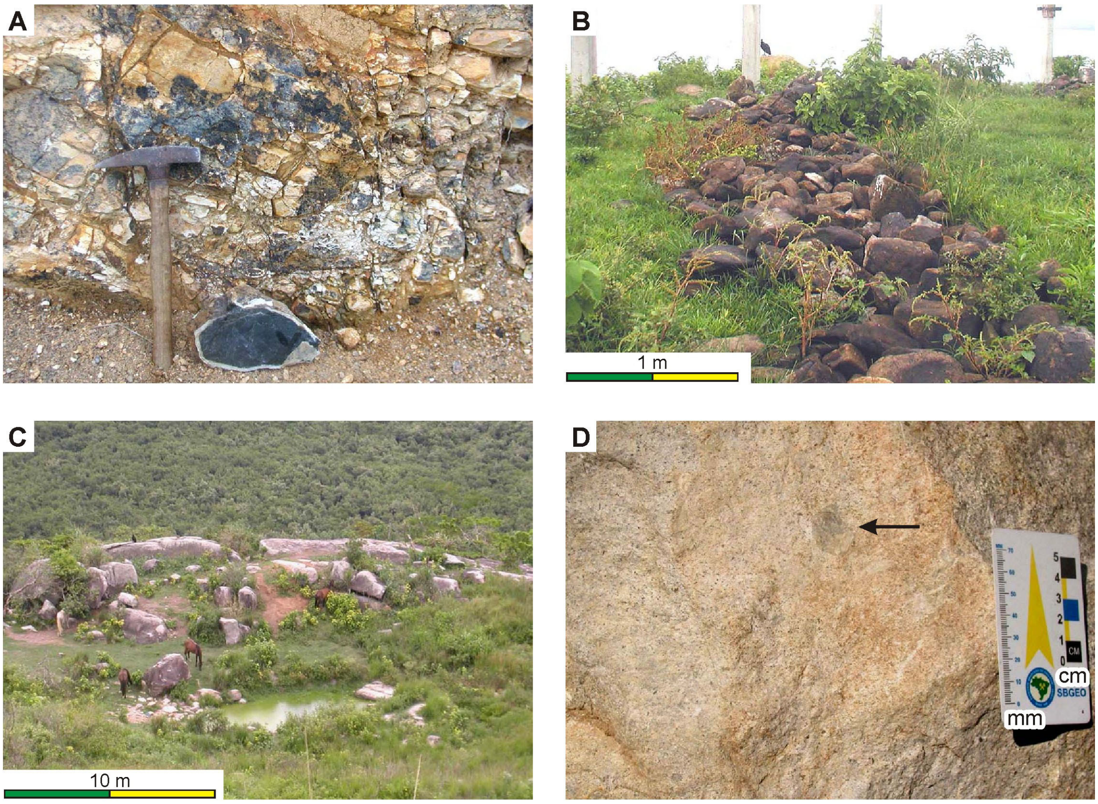

PLATE 1. Field image of the constituent rocks of the Itaúna Alkaline Intrusive Complex: A) Very fine-grained phonolite at border zone of the Main Body, at the Occidental Peak, Loc. 1; B) micro-nepheline syenite at central part of the Main Body, at the Central Peak, Loc. 2; C) syenitic body at the western border of the massif, Loc. 4; D) micro-syenite dyke with phonolitic xenolith at the south-western border of the massif, Loc. 5.

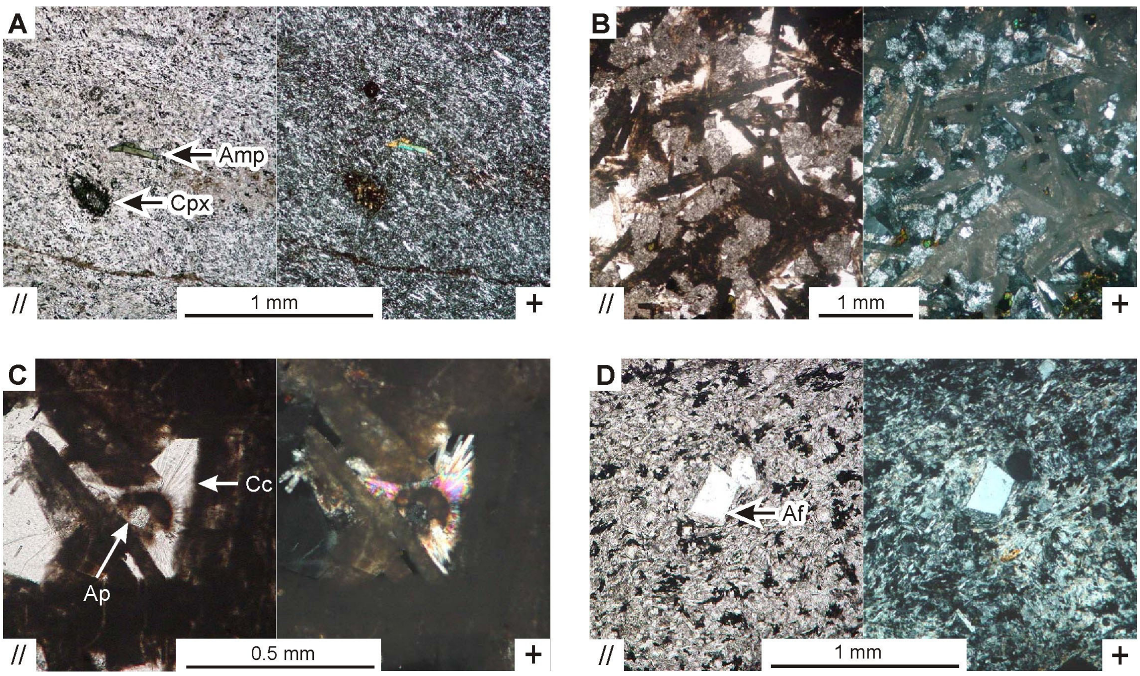

PLATE 2. Thin-section images of felsic alkaline rocks of the Itaúna Intrusive Complex: A) Very fine-grained phonolite of the Phonolitic Main Body, Loc. 1; B) interstitial texture of micro-syenite made up alkaline feldspar reticule of the Main Body, Loc. 2; C) cancrinite of the micro-syenite showing radial growth habit, Loc. 2; D) fine-grained phonolite of the Main Body, Loc 3. Symbols: Af - alkaline feldspar; Amp - amphibole; Ap - apatite; Cc - cancrinite; Cpx - altered clinopyroxene with fresh core.

orientation is not expressive. The sericitisation is heterogeneous, being strong at some points and almost nothing at other points, even within the same thin section.

The transition from the fine-grained phonolitic rock to the micro-nepheline syenite is gradual. Therefore, it is considered that these rocks were originated from the same intrusion pulse. The content of feldspathoids is not large, especially in cases of very fine-grained phonolitic rock. They are estimated to be alkaline feldspar syenite with nepheline and alkaline feldspar trachyte with nepheline, that is, the field 6' according to the IUGS classification nomenclature (Streckeisen, 1973; 1978). The detailed and more exact classification must be performed by whole-rock chemical analyses.

SYENITIC BODY

The gross-grained syenitic rock occurs in a small area, 200 x 30 m, at the north-western border of this intrusive complex, forming in-situ bowlders of metric size (Plate 1C). Because of the high security risk, this rock has not been sampled yet for thin section. On the south-west flank of this massif, two dykes of metric width composed of micro-syenite intrude into the Main Body (Loc. 5; Figure 1; 2). They are oriented approximately N25ºW and contain xenoliths of the very fine-grained phonolitic rock (Plate 1D, arrow).

PYROCLASTIC ROCK BODY

Klein et al. (1999 a; b; c) commented that the pyroclastic rock is exposed on the northwest flank of the Itaúna Massif and composed of air-fall tuff, volcanic breccia, and densely welded pyroclastic flow deposits, with special attention of accretionnary lapilli, bomb-sag structure, and vesicular clasts. They interpreted that this rock forms subaerial eruptive deposits with total thickness of 60 m. The basal part of the succession is made up of fine air-fall tuff, the median part of laminated air-fall tuff, and the upper part of alteration of volcanic breccia and welded pyroclastic flow with tephra cover. These deposits were steeply dipped to the north-east because probably of a later tectonism.

However, the field observations of the authors are highly controversial to the above-mentioned model. The pyroclastic rock is exposed at the pass between the Central Peak and Western Peak (Loc. 6, Figure 1; 2). Its distribution is extremely limited, only within an area of 20 m E-W and 30 m N-S. The matrix is generally weathered and no samples have the condition for thin section.

The rock contains relatively abundant clasts, showing clast-matrix supported texture. They are widely variable in abundance and size even within an outcrop. The clasts are constituted entirely by trachytic or phonolitic rock of the size varying from 1 cm to 1 m (Plate 3A). It is not possible to determine if nepheline is present or not in the clasts. Large clasts tend to be rounded or semi-rounded and small ones are angular. Some very large clasts show parallel fractures developed in three directions with interval of 10 to 30 cm. The fracture pattern is similar to that of the very fine-grained phonolitic rock of the Loc. 1.

Different from the previous works' descriptions, all of the clasts have massive texture. Vesicular fragments with vitric chilled margin, indicative of scoria and volcanic bomb, are not present. One observed clast has pseudovesicular structure (Plate 3B), that is, a weathering fabric often observed on surface of trachytic and phonolitic rocks (Motoki et al., 2007c).

This outcrop contains also small rounded or semi-rounded clasts of 1 to 4 cm in diameter (Plate 3A, arrows). They should correspond to the accretionary lapilli, that is, volcanic pisolite, proposed by Klein et al. (1999a; b; c).

The Plate 3 shows structural and textural differences between tephra with pisolite layers and vent-filling tuff breccia. Tephra has well-sorted mantle-bedding volcanic layering. Pisolite clasts are concentrated in determined levels. They are soft and brittle with spherical growth texture of fine volcanic ash particles (e.g. Fisher 1961; MacDonald, 1972). On the other hand, vent-filling volcanic breccia has heterogeneous texture without grain-size sorting and the clasts are hard and massive. (e.g. Motoki, 1979; Motoki & Sichel, 2006; Motoki et al., 2007a; b).

The field observations have revealed that the rounded clasts are made up of massive trachytic or phonolitic rock. No structure of spherical growth of fine volcanic ash particles is observed. They are massive and hard, and not easy to be disintegrated by a soft touch of hummer. The pyroclastic rock has very heterogeneous structure, without grain-size sorting and volcanic layering (Figure 3A). These characteristics are incompatible with tephra model, but fit well to the vent-filling tuff breccia model (Figure 3B). Therefore, it is considered that the small rounded clasts are not accretionary lapilli, that is, volcanic pisolite. The descriptions of the previous works are attributed to massive lithic fragments of trachytic and phonolitic rock.

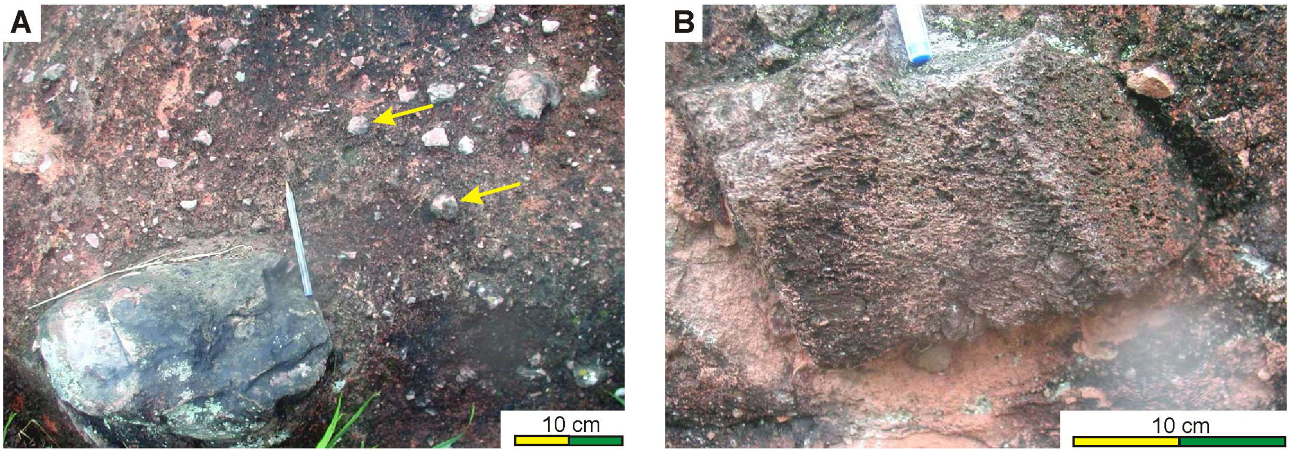

PLATE 3. Clasts of the pyroclastic rock of massive trachytic or phonolitic rock at Loc. 6: A) widely variable size and form within the same outcrop; B) pseudovesicular weathered surface of a clast. The arrows on the image A indicate small rounded clasts in question.

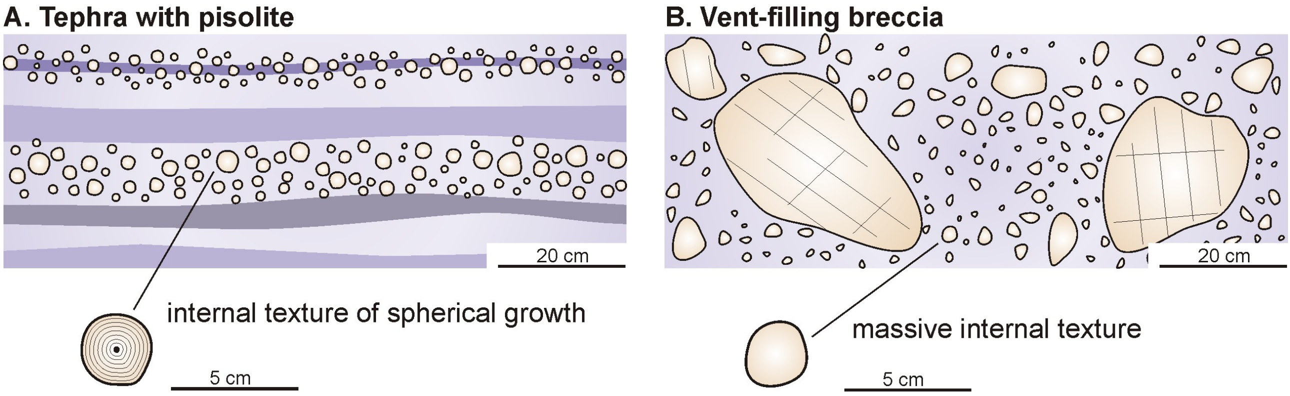

FIGURE 3. Comparative schematic illustrations of the rock structure of: A) Tephra with pisolite accumulated layers, based on the images of USGS Photo Glossary of Volcanic Terms, http://volcanoes.usgs.gov/Products/Pglossary/AccretLap.html; B) vent-filling welded tuff breccia, compiled from Motoki (1979; 1988), Motoki & Sichel (2006), Motoki et al. (2007a; b).

The matrix of the pyroclastic rock is consolidated all over the outcrop, including the levels interpreted by the previous works to be unconsolidated fall-out tuff. The alkaline rocks of the Itaúna Massif are estimated to be of early Tertiary. Therefore, the matrix consolidation cannot be attributed to diagenesis, but to high-grade welding. The high-temperature emplacement for the welding is incompatible with the previous model of fine tuff, pisolite layers, and tephra with bomb-sag structure, which require low-temperature surface emplacement. In addition, the strong plastic deformation does not permit the preservation of original depositional structures.

The structure of strong welding and secondary flowage is observed on an intensely weathered surface of the outcrop, in forms of orange and white colour bands (Plate 4A). There occurs eutaxitic structure characterised by plastic deformation of matrix layer around lithic fragments (Plate 4A, arrow). The secondary flowage planes are steeply dipped, with local attitude of N30ºW45E (Plate 4B). In spite of notable layering of the matrix, no expressive granulometric sorting and normal grading of the clasts are observed.

The bomb-sag structure, originated from impact of a large block on fine-grained soft tephra layers, also is not found. The descriptions of the previous works could be attributed to above-mentioned eutaxitic texture.

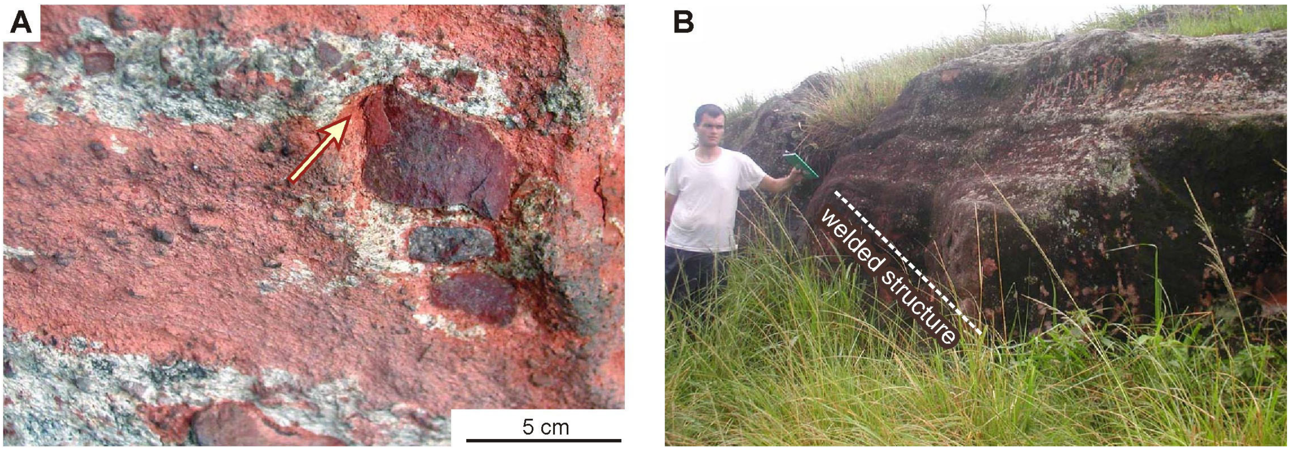

PLATE 4. Highly developed structure of welding and secondary flowage of the pyroclastic rock at Loc. 6: A) Eutaxitic texture around lithic clast, arrow; B) welded plane dipped about 45º to the north-east. The volcanic layering apparently sub-horizontal is due to outcrop cut-angle effect.

SUBAERIAL DEPOSIT MODEL

As mentioned before, the previous works interpreted that the pyroclastic rock of the Itaúna Massif forms a volcanic sequence with total thickness of 60 m (Klein et al., 1999a; b; c), made up of soft air-fall deposit and welded pyroclastic flow deposits (Figure 4A).

However, the field observations by the authors are widely different from the above-mentioned interpretation in the following viewpoints: 1) extremely restricted distribution area of the pyroclastic rock; 2) very heterogeneous structure of the pyroclastic rock; 3) regional tectonic history without strong deformation events in the Tertiary and the Quartanery; 4) intrusive emplacement of the phonolitic main body; 5) denudation history of this region elaborated from the fission track datings for apatite extracted from the metamorphic basement of this region (Hackspacher et al., 2004; Motoki et al., 2006).

The previous interpretation was based only on the lithologic observations and the volcanic breccia was directly attributed to pyroclastic flow and fall-out deposits. However, such an attribution is inaccurate in

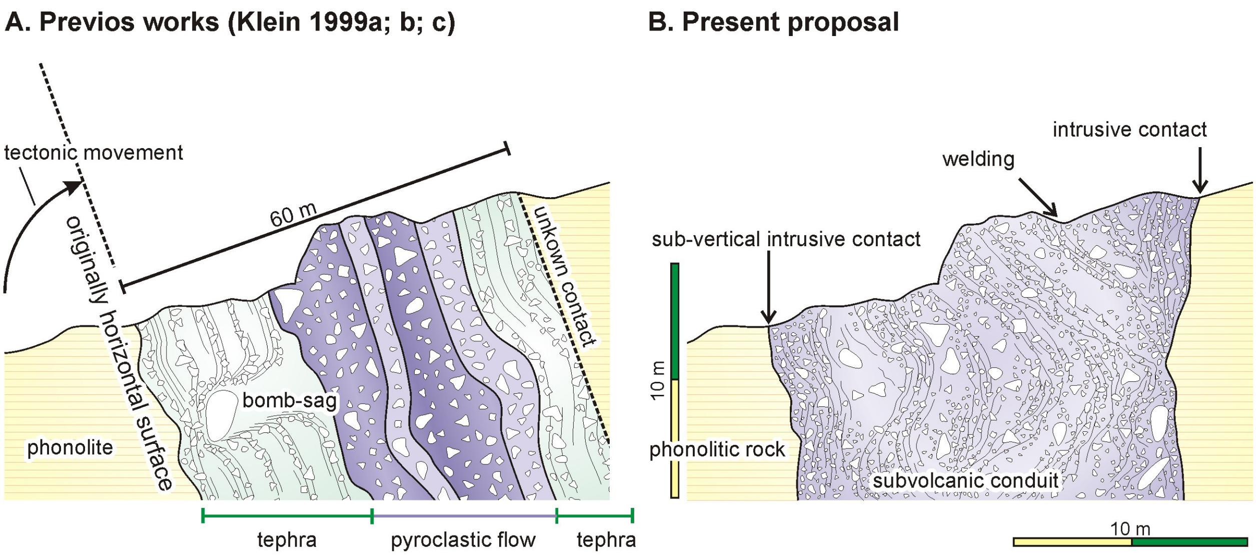

FIGURE 4. Comparative diagrams for the geologic emplacement models of pyroclastic rock of the Itaúna Alkaline Intrusive Complex: A) steeply dipped tephra and pyroclastic flow deposits after Klein et al. (1999a; b; c); B) vent-filling welded tuff breccia forming a pyroclastic subvolcanic conduit proposed by the present article and Motoki et al. (2007d; e). The illustration A contains scale discrepancy problem.

certain cases. Some papers have mentioned that welded pyroclastic rocks also form subvolcanic conduits and fissures and they crop out as pyroclastic necks and dykes in denudated volcanic regions (e.g. Motoki, 1979; 1988; Maeda et al., 1983; Miura, 1999; 2005; Bryan, et al., 2000; Torres-Hernández, et al., 2006; Motoki & Sichel, 2006; Motoki et al., 2007a; b; c).

A pyroclastic flow extends generally along tens and hundreds of kilometers of distance, covering a wide area, up to hundreds of square kilometers (e.g. Smith, 1960; MacDonald, 1972). A tephra can cover an area much wider. If the breccia of the Itaúna Massif were pyroclastic flows or air-fall deposits, the distribution area cannot be limited within an outcrop, but it should cover extensively the lowland of São Gonçalo urban zone. Densely welded pyroclastic flows are robustly resistant against weathering. In addition, the erosion effect on the Itaúna Massif is much stronger than the São Gonçalo lowland. Therefore, the welded pyroclastic deposits on the São Gonçalo lowland could be easily found by fieldwork and photo-interpretation, if they were present. However, no pyroclastic rock takes place on the urban lowland. This fact makes unviable the model of surface eruptive deposit proposed by the previous works (Figure 5A).

The previous works suggested that the total thickness of the pyroclastic succession would be 60 m. However, considering the outcrop size, 30 x 20 x 5 m, and the dip angle of supposed volcanic lamination, the total thickness must be less than 20 m (Figure 4A). It is impossible to put so many volcanic layers of different origins within such a small thickness. In addition, upper contact of the pyroclastic layers with the country phonolitic rock cannot be explained by the previous model.

Klein et al. (1999a; b; c) attempted to justify the steep dip of the welded tuff body by means of possible existence of Tertiary tectonism (Figure 5A). However, such a tectonism is not known in this region.

The previous works emphasized pisolite and bomb-sag structure as important evidences of the tephra model. However, as mentioned before, the recent fieldworks have revealed that they are, in fact, small rounded massive clasts (Figure 3) and eutaxitic texture (Plate 4A).

The Main Body has massive general structure, without fabrics indicative of surface volcanic eruption of lava flow or lava dome, such as well-developed vertical columnar joints called “colonnade” of metric interval, gently curved sub-horizontal fractures of close interval, “entablature”, and rock blocks formed by rapid cooling on the surface of lava flows, “clinker”. This observation suggests that the Main Body is not originated from lava flows or lava dome, but to an intrusive body. The absence of columnar joints points out that the emplacement depth of this body is not very shallow. The granulometric variation between the border zone and the centre of the Main Body can be attributed to the magma cooling from intrusive contact or fluid concentration in the central part.

Summary, the new fieldwork makes unviable the surface eruptive deposit model proposed by the previous works.

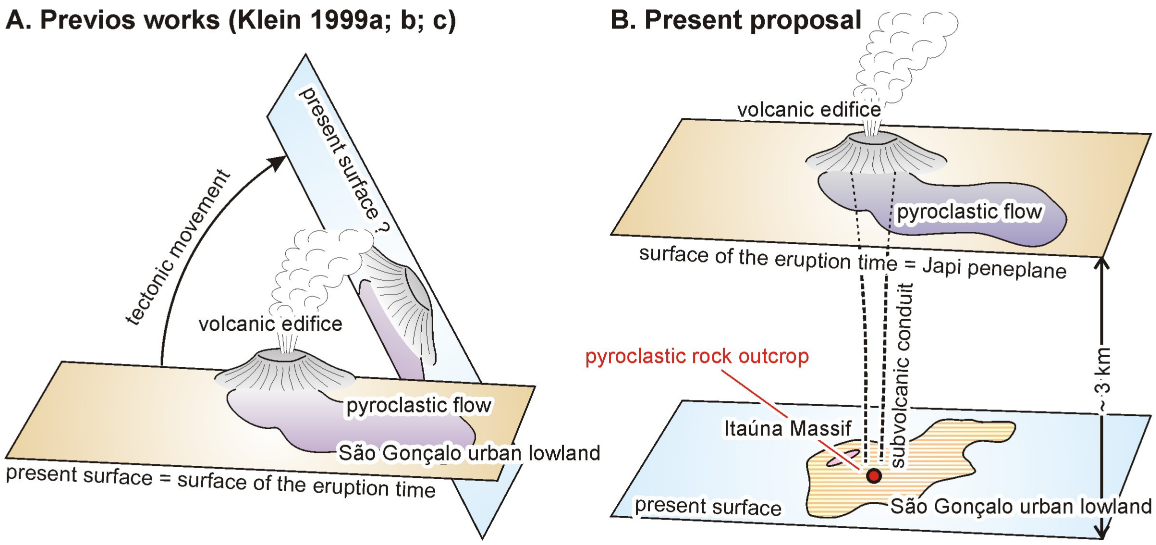

FIGURE 5. Schematic illustrations for geologic setting of the Itaúna Alkaline Intrusive Complex after: A) Klein et al. (1999a; b; c); B) present paper and Motoki et al. (2007d; e). The illustration A contains problems in the present surface identification and the inexistence of pyroclastic flow deposit on the São Gonçalo urban lowland.

SUBVOLCANIC CONDUIT MODEL

To solve the above-mentioned contradictions, the authors propose an alternative volcanological model for geologic emplacement mode of this pyroclastic rock. The new idea is based on subvolcanic conduit model, that is, of vent-filling welded tuff breccia, which has been introduced by Motoki et al. (2007d; e) in scientific events (Figure 5B).

According to this model, the present exposure of the Itaúna Alkaline Intrusive Complex corresponds to subvolcanic structure of magma chamber level. In the eruptive time, extensive pyroclastic flow deposit and tephra could be formed. However, they have been eliminated completely by regional uplift and consequent denudation. The present surface exposes only underground section of a volcanic conduit. The contact with the wall rock body is intrusive and sub-vertical. This geologic setting is similar to that of the felsic alkaline intrusive complex of Mendanha, Cabo Frio Island, and Poços de Caldas (e.g. Motoki et al., 2007 a, b; 2008; Sichel et al., 2008.

This three-dimensional form of the pyroclastic body and geologic emplacement mode justify all of the above-mentioned geologic, lithologic, and structural characteristics of the volcanic breccia of the Itaúna Massif. The model explains reasonably the very small distribution area of the pyroclastic rock and the inexistence of welded pyroclastic flow deposit on São Gonçalo urban lowland. The absence of pisolite and bomb-sag structure also is consistent.

Developed layered structure of pyroclastic rocks is observed commonly in the basal part of densely welded pyroclastic flow deposits. When the pyroclastic materials are emplaced in a high temperature and deposition surface is inclined, gravitational viscous flowage of welded matrix takes place during or just after the welding, the phenomenon called "secondary flowage" (Smith, 1960). Such a rock body is eventually called "rhyoignimbrite". A good example in Brazil is observed in rhyolitic and dacitic rocks of the Palmas Formation, Serra Gaúcha, State of Rio Grande do Sul (Motoki et al., 2003).

However, not all of the welded and secondary-flowed pyroclastic rocks are originated from surface pyroclastic flows. Subvolcanic conduit have large thickness, virtually infinite, steep wall plane, being sub-vertical, and of slow cooling. These conditions are optimal for secondary flowage development. The examples were observed at the Sumiyoshigawa Acidic Rock Body, Kobe, Japan (Motoki, 1979), the Poços de Caldas Alkaline Intrusive Rock Body, State of Minas Gerais (Motoki, 1988), and the Mendanha Alkaline Intrusive Complex, State of Rio de Janeiro (Motoki & Sichel, 2006; Motoki et al., 2007a; b). The volcanic breccia of the Cabo Frio Island also show similar emplacement mode (Sichel et al., 2008).

The model of vent-filling secondary-flowed welded tuff breccia fits well to the high-angle layering structure of the Itaúna pyroclastic rock body. The steep angle is attributed to originally sub-vertical secondary flowage in the subvolcanic conduit. Later tectonic movement, which was proposed by the previous works, is not necessary. The heterogeneous size, very poor granulometric sorting, and relatively rounded form of the clasts are characteristics in subvolcanic conduit (Motoki, 1979; 1988 Motoki & Sichel, 2006).

The neighbor alkaline felsic rock bodies, such as the Mendanha massif and the Cabo Frio Island, expose basal level of magma chamber. The fact points out that a deep regional denudation took place from the time of the magmatism up to the present. Motoki et al. (2006) estimated the intrusion depth of the syenitic rock bodies of the State of Rio de Janeiro to be about 3 km, based on the fission track datings for apatite. This estimation confirmed the previous considerations, such as Fonseca & Pupeau (1984), Zimbres et al. (1990), Netto et al. (2000; 2001), and Hackspacher et al. (2004). In this sense, it is impossible that the surface eruptive materials of the early Tertiary could be preserved up to the present. The volcanic edifice and eruptive deposits have been eliminated completely by regional denudation. The present outcrops expose the subvolcanic structure of 3 km from the surface of eruptive time (Figure 5B).

The terms "volcano" and "volcanic edifice" are defined scientifically as a morphologic elevation formed directly by volcanic eruptions and consequent accumulation of eruptive materials on the Earth's surface (e.g. MacDonald, 1972; Motoki & Sichel, 2006). As mentioned before, no eruptive materials of surface emplacement does take place at the Itaúna Massif. The present morphologic elevation may be originated from differential erosion.

At the early Tertiary, an explosive volcanic eruption surely took place in this locality. However, according to the above-mentioned definition, the Itaúna Massif does not correspond to an extinct volcano.

CONCLUSION

The fieldwork and microscopic observations of the rocks of the Itaúna Alkaline Intrusive Rock Body, São Gonçalo, State of Rio de Janeiro, present the following results:

1. The felsic alkaline complex intrusive rock body of the Itaúna Massif is exposed in an area of 3.5 x 2 km. It is constituted mainly by fine-grained phonolitic and micro-syenitic rocks, secondary by gross-grained syenitic rocks, and locally by volcanic breccia.
2. The main intrusive body is composed of fine-grained phonolitic rock and micro-syenite. The central part of the Main Body is made up of relatively gross rock, micro-syenite, with strong deuteric or hydrothermal alteration. The border zone is made up of fine-grained phonolitic rock, almost without deuteric alteration.
3. The gross syenite takes place at the west margin of the intrusive complex. The syenitic dykes of metric width are intrusive into the Main body.
4. The pyroclastic rock takes place only at a locality, within an area of 20 x 30 m. The clasts are constituted entirely by trachytic or phonolitic rock, and widely variable in size, from 1 cm up to 1 m, and in form, angular to semi-rounded. No expressive granulometric sorting is observed. Vesicular essential fragments, such as volcanic bomb, are not present.
5. This rock presents strongly welded structure and developed secondary flowage. The layered structure of the matrix is steeply dipped.
6. The extremely limited distribution area, steep matrix layering, well-developed welding and secondary flowage, widely heterogeneous clast size, absence of pisolite and bomb-sag structure, etc. indicate that the pyroclastic rock is not of surface eruptive deposit, but subvolcanic vent-filling welded tuff breccia.
7. The subvolcanic conduit model fits well the regional denudation history of 3 km based on fission track datings for apatite. The volcanic edifice and eruptive deposits have been eliminated completely eliminated by regional denudation. In this sense, the Itaúna Massif, São Gonçalo, State of Rio de Janeiro, Brazil, does not an extinct volcano.

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