SIGEP

Geological and Paleontological Sites of Brazil

SIGEP 035

Guaraú Striated Pavement, State of São Paulo

Marks of neopaleozoic glacier in southeastern Brazil

Annabel Pérez-Aguilar[1]
Setembrino Petri[2]
Raphael Hypólito[2]
Sibele Ezaki[1]
Paulo Alves de Souza[3]
Caetano Juliani[2]
Lena V.S. Monteiro[4]
José Maria Azevedo Sobrinho[1]
Francisco Moschini[5]

[1] Instituto Geológico/SMA, Av. Miguel Stéfano, 3.900, CEP 04301-903, São Paulo, SP, fax 50772219, annabelp@igeologico.sp.gov.br, sibezaki@igeologico.sp.gov.br; zemaria@igeologico.sp.gov.br;
[2] Universidade de São Paulo, Rua do Lago, 562, CEP 05508-080, spetri@usp.br, raphael.hypolito@br2001.com.br, cjuliani@usp.br;
[3] Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, CEP 91540-000, Porto Alegre RS, paulo.alves.souza@ufrgs.br
[4] Universidade Estadual de Campinas, Rua João Pandiá Calógeras, 51, CEP 13083-870, Campinas, SP, lena@ige.unicamp.br;
[5] Prefeitura Municipal de Salto, faleconosco@salto.sp.gov.br

Guaraú Striated Pavement, State of São Paulo

Marks of neopaleozoic glacier in southeastern Brazil

SIGEP 035

Annabel Pérez-Aguilar[1]
Setembrino Petri[2]
Raphael Hypólito[2]
Sibele Ezaki[1]
Paulo Alves de Souza[3]
Caetano Juliani[2]
Lena V.S. Monteiro[4]
José Maria Azevedo Sobrinho[1]
Francisco Moschini[5]

In the Gondwana supercontinent ice sheets advanced and retreated during the Late Paleozoic with relation to a dispersion center located in south of Africa. In Brazil, geological features from this period were preserved within the permo-carboniferous unit of the Itararé Subgroup that outcrops in the eastern border of the Paraná Basin. Near Guaraú Ceramic, southwest Salto city in São Paulo State, new aspects of this glacial event were discovered, which correspond to a striated pavement (Guaraú Striated Pavement) that developed over granite from the Itu Granitoid Complex that locally corresponds to crystalline basement rock, and a body of diamictites from the Itararé Subgroup that deposited over it. The striae correspond to sub parallel grooves with milimetric spacing and depth, about N48E, dipping 12º to 42º towards SE. Observed features and association with diamictites indicate an origin by glacial abrasion due to ice movement from southeast towards northwest in this part of the basin.

Key words: Itararé Subgrup, Itu Granitoid Complex, neopaleozoic glaciation, striated pavement; diamictite

INTRODUCTION

Two outcrops, near the Guaraú Ceramics, southwest of Salto city and *Moutonnée* Rock Park (Rocha-Campos, 2002) are here described, which correspond to A1 (Fig. 1) and A2, some meters apart each other (Figs. 2 e 3). They exhibit striated pavements covered by diamictites of the Itararé Subgroup (Pérez-Aguilar *et al*., 2009). These pavements became evident due to clay extraction for brick manufacture, mining activity common in the area. As a consequence, two big adjacent cavities were formed.

After discovering them, A2 was entirely filled up by waste of stuff material. Preserved A1 was denominated Guaraú Striated Pavement because its location near Guaraú Ceramic (Figs. 1 e 4). This is a geological site of great beauty and geological importance, constituting together with associated diamictites, new direct evidences from neopaleozoic glaciation, present in the eastern border of the Paraná Basin.

In both outcrops, the well preserved small scale glacial features and the natural distribution of different lithotypes, including crystalline basement and lateral gradation of diamictites to rhythmites, are subsides for the characterization of related sedimentation processes and depositional environment.

LOCATION

The geological site is located southwest of Salto city, near the limit with the Itu Municipality, and approximately 90 km northwest from São Paulo city (Fig. 2).

The coordinates from outcrops A1 and A2 are 23°13'8''S - 47°18'28''W and 23°13'10''S - 47°18'29''W, respectively (Fig. 3). The access from São Paulo city can be made first through the SP 075 Highway to km 35, taking then the road SLT 257 (Rocha Moutonnée Road) and, in the sequence, along the Pirambóias street.

SITE DESCRIPTION

Striated pavements

The striated pavements developed over granite bodies, locally the Itararé Subgroup basement, and belong, according to Galembeck (1997), to the Itu Granitóide Complex. Macroscopically, the granite corresponds to an inequigranular, medium to coarse grained, red-brownish rock, with crystals varying from submilimmetric up to 15 mm. Although with small compositional variations, the granite is mainly composed of potassic feldspar, quartz, plagioclase and small quantities of biotite (~5% in volume) corresponding, according to modal Streckeisen (1976) classification, to a syeno-granite. In potassic feldspar, anhedral elongated forms predominate, varying most grains between 3 and 10 mm. White plagioclase grains predominate up to 10 mm elongated crystals. Small biotite sheets are disseminated through the rock up to 2 mm in size.

Figure 1 – Aspect of A1 outcrop, Guaraú Striated Pavement. Photo from Sibele Ezaki and Annabel Pérez-Aguilar.

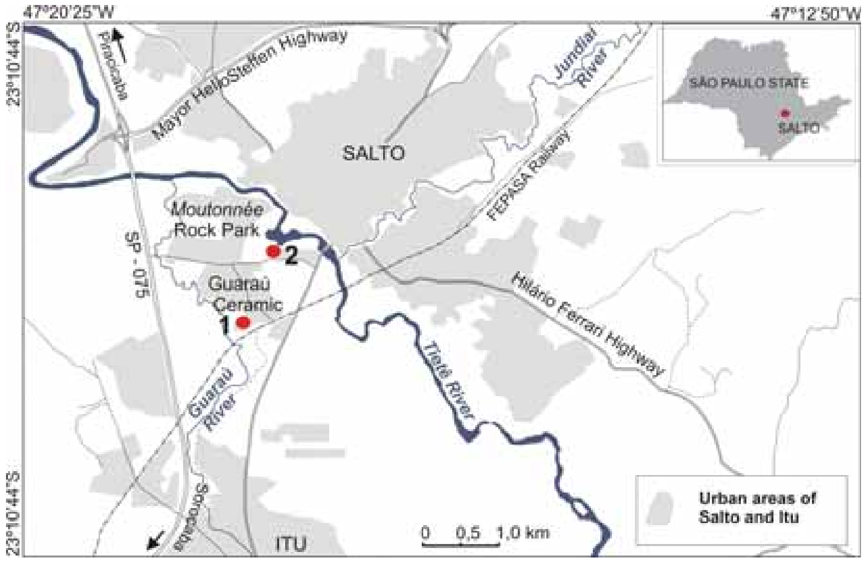


Figure 2 – Location of outcrops A1 and A2 where are present striated surfaces (1) and *Rocha Moutonnée* Park (Rocha-Campos, 2002) (2).

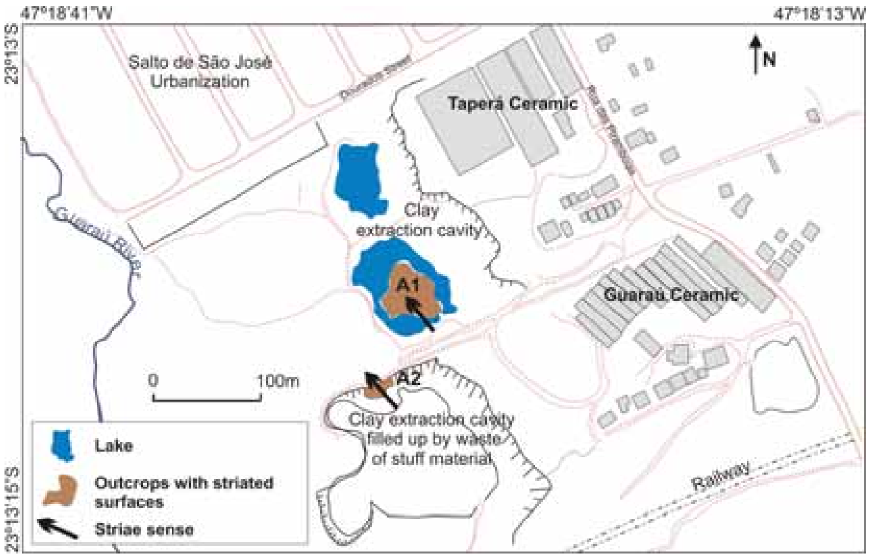


Figure 3 – Local context showing the location of the two outcrops where are present striated surfaces (A1 and A2).

In both outcrops striae are disposed as milimetric spacing sub parallel grooves, maximum one millimeter deep. Outcrop A1 is partially surrounded by a small lagoon formed by water concentration in an old abandoned clay extraction cavity. A2 is located in the margin of an adjacent clay extraction cavity filled up with staff material after the extraction was abandoned (Fig. 3). In A1, the granite body is 35 meters long, being present two striated metric surfaces (Figs. 4, 5A, and 5E). Considering both surfaces, striae directions vary between 35º and 58ºNW. Dips related to the first surface vary between 12º and 18º towards SE (Figs. 5A and 5E), whereas those related with the second one are stronger, corresponding to 42º SE. In outcrop A2 the striae orientation is N38ºW/12ºSE (Figs. 5B, 5C, and 5D). Strikes of striated surfaces are approximately orthogonal to striae directions. Present variation in striae direction is the same as that observed by Almeida (1948) in the *moutonnée* rock, which is also located near Salto city and is today part of the *Moutonnée* Rock Park (Rocha-Campos, 2002). In this outcrop directions vary between 35º and 65ºNW (Fig. 2). Thin grooves that are approximately orthogonal to striae predominantly show sub vertical dip planes, although some related planes and relative bigger fractures dip towards NW (Figs. 5D and 5E). These features correspond to crescentic fractures (crescentic fractures after Petit, 1987), indicating, dip direction, the sense of ice sheet transport. Also present are small friction marks that correspond to crescentic gouges (crescentic gouges after Slocum, 1978) with horns pointing towards SE (Figs. 5A and 5D), indicating, associated with crescentic fractures, ice sheet transport from SE toward NW.

Figure 4– General aspect of A1. Photo from Sibele Ezaki and Annabel Pérez-Aguilar.

The direction of striae are coherent with those measured in striated pavement outcropping in the eastern border of the Paraná Basin (Riccomini & Velásquez, 1999), certifying glacial abrasion as consequence of ice sheets that advanced from southeast toward northwest.

Metric features, wider and deeper than the striae, are present at A1, forming centimetric thin channels (Figs. 1 and 5A). These features probably formed by basal gouging due to the presence of relative bigger rock fragments or debris bands at the base of the glacier.

Aqueous-glacial sediments

The striated pavements of both outcrops are in contact and covered by a pile of sedimentary rocks mainly composed of light brown silty mudstone (Figs. 5F e 6). In A1, striated granite is in contact with a pile of stratified sedimentary rocks exhibiting varying thicknesses, between two and three meters, and sixty meters long. In these rocks, centimetric to metric, smooth, non-tectonic folds are present, originated by slump and accommodation of sediments over a glacial erosion surface. Layers of mudstone with clasts (10-15% in volume) and granules randomly distributed through the rock predominate. Quartz vein, granite, and several types of sedimentary rock clasts are present (up to 30 cm x 20 cm), being some of them faceted and / or striated.

Weathered clayey-silty clasts are light purple in color, whereas those sandy-clayey are greenish and sandy ones are light brown. Faceted or flat-iron-shaped clasts are predominately sandy whereas striated clayey-silty clasts are more common. Also clayey-silty faceted and imbricated clasts were observed. These sedimentary rocks correspond to a water-glacial diamictite formed by reworking of glacial sediments.

Centimetric layers of massive, poor sorted, medium to coarse sandstones and siltstones with cross-lamination, which are interbedded within diamictite, are suggestive of water availability differences during sediment deposition. Within the pile also occurs a rock, approximately 5 cm thick, constituted by the alternation of thin dark and light layers. The dark layers are poor sorted and are made up of relative coarser grains of quartz and feldspar and fine grained biotite. In these layers are present some well preserved euhedral feldspars, up to 1 cm long. Light layers are predominantly composed of fine sand. This thin lithotype suggests the contribution of material generated by the disintegration of granite rocks near the deposition area, probably resulted from abrasive action of the glacier on the basement rock surface.

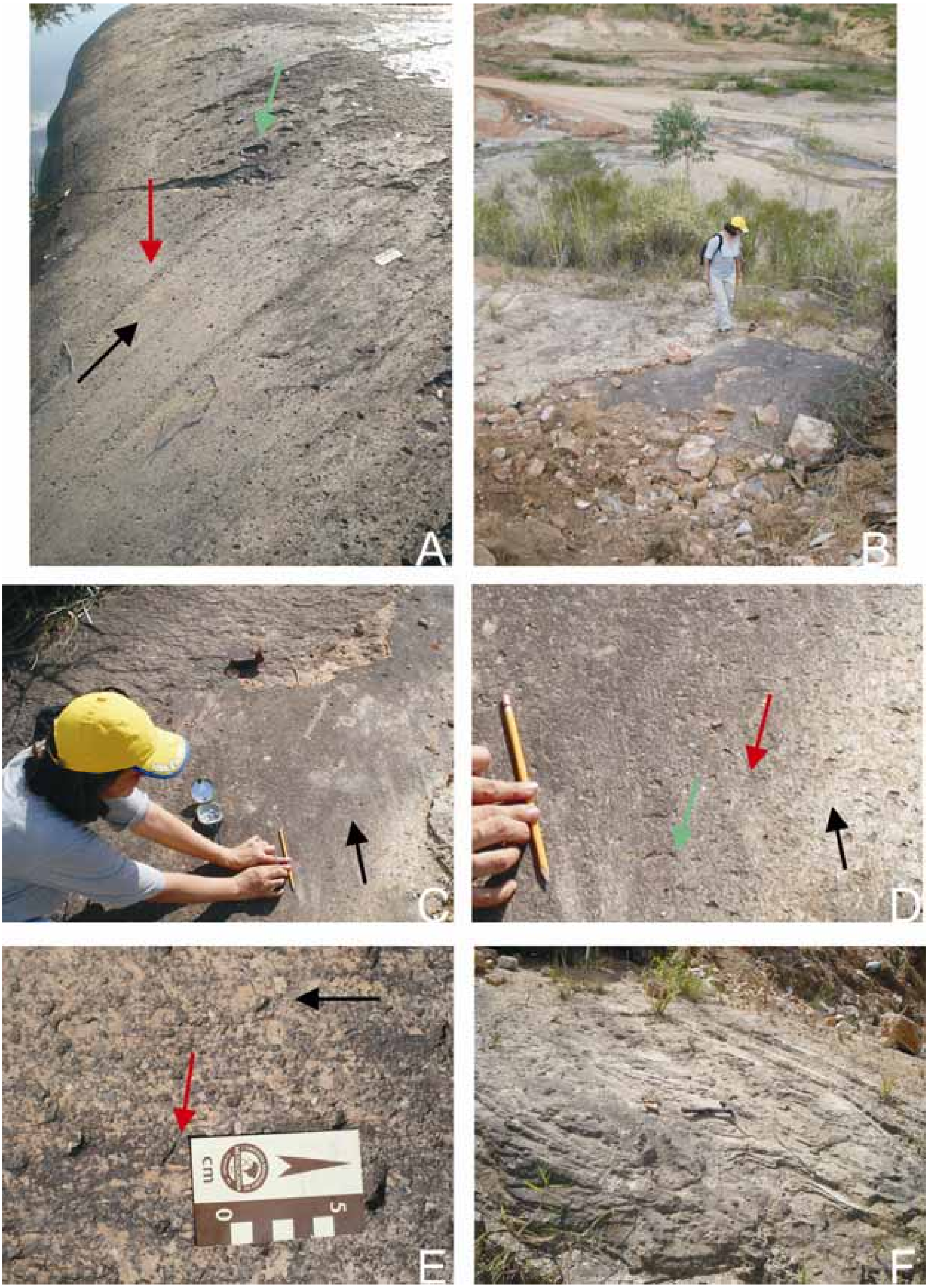


Figure 5 – Outcrops where are present striated pavements, A1 (A and E) and A2 (B, C, and D), corresponding striae mean orientation to N43ºW (parallel to black arrows), and diamictites from A2 (F); ice sheet movement from SE toward NW (black arrows) attested by the presence of NW dipping fractures (red arrows), which cut the striae, and the presence of crescentic gouges (green arrows).

Figure 6 – General aspect of A1 outcrop showing granite basement, where a striated pavement was developed, covered by diamictites from the Itararé Subgroup (A) and detail of the contact between these two units (B). Photos from Sibele Ezaki and Annabel Pérez-Aguilar

The diamictite was affected by three principal fault systems, whose surfaces correspond to N5W/84SW, N25E/32SE, and N60W/71NE. This last surface cuts others.

The locality A2 striated pavement was covered by a decimetric thick stratified silty mudstone that bears scarce clasts (up to 5% in volume), suggesting more reworked glacial sediments. Locally the relative steep granite surface acted as a ramp that allowed sediment slumping, suggested by convolute structures (Fig. 5F). The diamictites formed a small fan that grades laterally towards rhythmites.

Exposed rhythmites associated with A2 are about 20 m thick, most of them weathered, preserving only small cores of fresh green rock. These rocks are composed of couplets of milimetric dark brown clayey and cream-colored clayey/silty laminae, being clayey ones rather thicker. Granules are frequent and some dropstones are also present. Bedding plane, N55ºE/8ºSE, indicates a gently tilting of rhythmites toward SE.

Rhythmites from the area were interpreted by Stevaux *et al.* (1987) and Longhim (2003) as corresponding to basal facies of alluvial fans, from the type represented by fan deltas, or to turbitdites, being in both cases products of sediment debris flow. However, the lateral gradation of diamictites to rhythmites at locality A2 may be interpreted as a flux of silty mudstone toward a lake or lagoon, being rhythmite laminae alternation a response to seasonal decantation variations. In front of a glacier, the formation of lakes or lagoons may commonly follow a retreating glacier margin due to the presence of abundant glacial meltwater. In this environment, diamictites may be the product of reworked lodgment tills.

The occurrence of striated pavements in contact with different lithotypes attests the variety of conditions associated to deposition of sediments of the Itararé Subgroup. Faults that cut diamictite, and rhythmite bedding plane, dipping 8 grades towards SE, indicate the presences of an active tectonism after deposition of sediments and true striae dips varying between 8 e 35º.

SYNOPSIS ON THE ORIGIN, GEOLOGICAL EVOLUTION AND IMPORTANCE OF THE SITE

During the Neopaleozoic, comprising both Carboniferous and Lower Permian, between 320 and 270 million years ago, Gondwana supercontinent was affected by a glacial event of great proportion that lasted approximately 100 Ma (Martini *et al*., 2001) (Fig. 7A). During this time interval, huge ice sheets, called glaciers, advanced and retreated several times. When Gondwana supercontinent fragmented in several smaller continents, records of this glacial event were preserved in areas now geographically separated (Martini *et al*., 2001) (Fig. 7B).

In the eastern border of the Paraná Basin, Neopaleozoic glaciation records are found, both through sedimentary rocks of the Itararé Subgroup and erosion textures preserved in the basement rocks. This subgroup exhibits a large variety of continental and marine sediments deposited under glacial, interglacial, and periglacial conditions. In addition, after sediment deposition, an active tectonism caused tiltings, upliftings and subsidences. Today this scenario resulted in a large horizontal and vertical variety of lithotypes, due to the deposition of sediments associated to glacial, fluvial, lacustrine, aeolian, deltaic and marine systems (Barbosa & Almeida, 1949; Bjornberg *et al*., 1965, Rocha-Campos, 1967; Saad, 1977; Stevaux *et al*., 1987; Zalán *et al*., 1990; Petri & Pires, 1992; Eyles e*t al*., 1993; Santos *et al*., 1996; Rosada, 2003; Salveti, 2005).

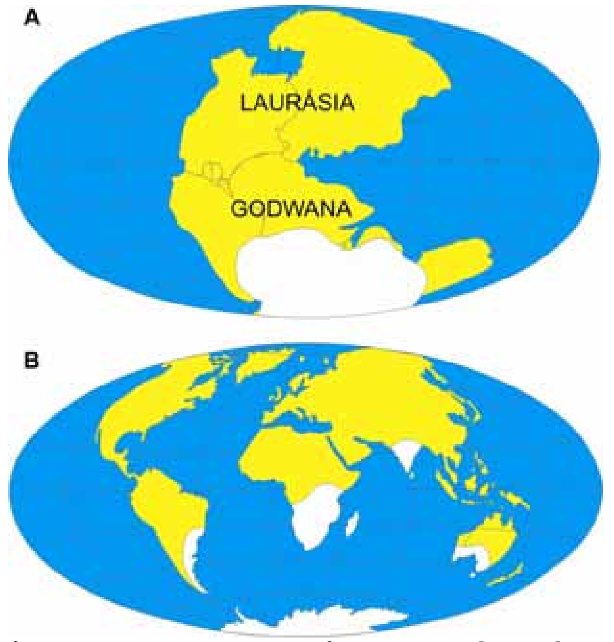


Figure 7 – Reconstitution of Laurasia and Gondwana supercontinents (A) and actual distribution of continents (B), corresponding white color to areas covered by the Neopaleozoic glaciation (Tarbuck & Lutgens, 2000).

In the Itu Municipality Marger Gutmans discovered, in 1946, the first *moutonnée* rock with presence of striated surfaces (*in* Almeida, 1948). This occurrence was latter described by Almeida (1948), having this author correctly deduced ice movement sense by interpreting features present in the rock, a topic that had promoted many discussions (Leinz, 1937). The importance of this record motivated the establishment of the *Moutonnée* Rock Park (Rocha-Campos, 2002) (Fig. 2).

Roche moutonnée is a french term used to describe a rock morphology after reworked by glaciers, which acquires a sheepback-like shape. *Roches moutonnées* are stream-lined landforms with a smooth, gentle, upflow slope and an irregular, steeper, downflow side produced by rock fragmentation due to plucking. They are 1 to 50 m high, a few meters to kilometers long, and tens of hundreds of meters wide. (Martini *et al*., 2001).

Amaral (1965) described a new *moutonnée* rock 340 meters SE from the above mentioned *moutonnée*, which was probably later buried due to landfill activities commonly carried out in the area. Viviani & Rocha-Campos (2002) related the existence, also in the area of Salto, of several glacial morphologies and striated surfaces present in granite bodies outcropping in the margin and in the Tietê river bed, through at least 1.2 km long. In 2006 striae present in A1 called the attention of Renato Antônio Cruz, whom showed them to Francisco Moschini, co-author of this paper. The pool that partially surrounds A1 has been used since several years ago as a place for bathing and a diving of the local people.

Striated pavements and glacial morphologies outcropping at the area nearby Salto city, associated with several other striated surfaces discovered in the eastern border of the Paraná Bacin, referred by Riccomini & Velásquez (1999), have served to infer ice paleo-directions and to reconstitute glacier dispersion centers coming from south of Africa during the existence of the Gondwana supercontinent. In this scenario, Guaraú Striated Pavement constitutes new evidence that corroborates transport of ice sheets from southeast toward northwest during the Neopaleozoic, in this part of the basin (Frakes & Crowell, 1969; Santos *et al*., 1996).

Derby was the first geologist to report to glacial sediments in the Itararé Subgroup, then called Serie, around 1850 (*in* Leinz, 1937). A great quantity of sediments was produced, especially during ice sheet advances, which acted as huge sandpapers that scratched bedrocks. These sediments were afterward reworked, especially during periods of glacier retreats (Milani & Ramos, 1998). Their thickness exhibit different values, more complete records displaying some thousands of meters thick (Milani & Zalán, 1999). In a general way, absolute ages are scarce for the permo-carboniferous interval of the Paraná Basin. In addition, there is an almost totally absence of guide fossils for correlations with the international geocronological column, based essentially in conodonts and amonoids. In spite of the fossil diversity (Rocha-Campos, 1967; Rocha-Campos & Rösler, 1978; Petri & Souza, 2003), facts are not different for the Itararé Subgroup. As consequence, ages pointed out for the glacial event are relative, mainly based in palynomorphs, whose abundance and wide distribution in the basin permit its use for establishing long distance correlations (Souza, 2006). Palynological data have attribute to rocks from this unit a Permo-Carboniferous age, more precisely between the Bashkirian/Moscovian (Pennsylvanian) and the Sakmarian (Cisuralian), comprising an interval of approximately 25 to 30 Ma (Souza & Marques-Toigo, 2003; Souza, 2006).

The diamictite that cover Guaraú Striated Pavement probably are reworked lodgment tills formed during glacier retreat. Lateral gradation of diamictite towards rhythmite suggests a lacustrine or lagoonal environment for the deposition of these lithotypes.

SITE PROTECTION

Actually no protection actions have been taken in relation to the Gauraú Striated Pavement. Although, discussions between the Instituto Geológico/SMA and Salto Municipality began in order to take the necessary steps to preserve this geological patrimony. A representation of the local Municipality, in this paper, constitutes an initial signal of bilateral efforts for its protection.

The risk for loosing this site is that the clay extraction cavity, the place of Guaraú Striated Pavement, also turns a zone of filling up activities with waste of stuff material, as happened with the neighboring pavement.

It would be of great scientific and cultural interest if a park could be installed comprising the geological site and its surrounding green area.

ACKNOWLEDMETS

This work is a product of projects associated with Fapesp 2006/51699, CNPq 473081/2006-7, and SMA Nº30 019/2007 processes.

REFERENCES

Almeida,F.F.M. de. 1948. A ‘roche moutonnée” de Salto, Estado de São Paulo. *Geologia e Metalurgia*, **5**: 112-118.

Amaral, S.E. do 1965. Nova ocorrência de rocha moutonnée em Salto, SP. *Boletim da Sociedade Brasileira de Geologia*, **14**(1/2): 71-82.

Barbosa, O. & Almeida, F.F.M.A. 1949. A Série Tubarão na Bacia do Rio Tietê, Estado de São Paulo. *Notas Preliminares e Estudos*, Departamento Nacional da Produção Mineral/Divisão de Geologia e Mineralogia, **48**, 16 p.

Bjornberg, A.J.S.; Landim, P.M.B.; Gandolfi, N. 1965. Indícios de contribuição eólica nos sedimentos do Grupo Tubarão em Limeira e Casa Branca, São Paulo. *Geologia*, Publicação da Escola de Engenharia de São Carlos –USP, **135**: 1-16.

Eyles, C.H.; Eyles, N.; França, A.B. 1993. Glaciation and tectonics in an active intracratonic basin: the Paleozoic Itararé Group, Paraná Basin, Brazil. *Sedimentology*, **40**: 1-25.

Frakes, L.A. & Crowell, J.C. 1969. Late Paleozoic glaciation: I, South America. *Bulletin of the Geological Society of Amererica*, **80**: 1007-1042.

Galembeck, T.M.B., 1997. O complexo múltiplo, centrado e plurisserial Itu – SP. Tese de Doutorado, Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista, Rio Claro, 374 p., 2 anexos.

Leinz, V. 1937. Estudos sobre a glaciação permo-carbonífera do sul do Brasil. Rio de Janeiro, Departamento Nacional da Produção Mineral/Serviço de Fomento da Produção Mineral, *Boletim*, **21**: 47 p.

Longhim, M.E. 2003. *Palinologia do Grupo Itararé em Salto, Estado de São Paulo (Bacia do Paraná, Carbonífero Superior)*. Dissertação de Mestrado, Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista, Rio Claro, 126 p., 1 anexo.

Martini, I.P.; Brookfield, M.E.; Sadura, S. 2001. *Principles of glacial geomorphology and geology*. Upper Saddle River, New Jersey, Prentice Hall, 381 p.

Milani, E.J. & Ramos, V.A. 1998. Orogenias paleozóicas no domínio sul-ocidental do Gondwana e os ciclos de subsidência da Bacia do Paraná. *Revista Brasileira de Geociências*, **28**(4): 473-484.

Milani, E.J., Zalán, P.V. 1999. An outline of the geology and petroleum systems of the Paleozoic interior basins of South America. *Episodes*, **22**: 199-205.

Pérez-Aguilar, A.; Petri, S.; Hypólito, R. Ezaki, S.; Souza, P.A.; Juliani, C.; Monteiro, L.V.S.; Moschini, F. 2009. Superfícies estriadas no embasamento granítico e vestígio de pavimento de clastos neopaleozóicos na região de Salto, SP. *Revista da Escola de Minas*, **62**(1): 17-22.

Petit, J.P. 1987. Criteria for the sense of movement on fault surfaces in brittle rocks. *Jounal of Structural Geology*, 9(5/6): 597-608.

Petri, S. & Pires, F.A. 1992. O Subgrupo Itararé (Permocarbonífero) na região do médio Tietê, Estado de São Paulo. *Revista Brasileira de Geociências*, **22**(3): 301-310.

Petri, S. & Souza, P.A. 1993. Síntese dos conhecimentos e novas concepções sobre a bioestratigrafia do Subgrupo Itararé, Bacia do Paraná, Brasil. *Revista do Instituto Geologico*, 14(2): 7-18.

Riccomini, C. & Velásquez, V.F. 1999. Superfícies estriadas por geleira neopaleozóica no Paraguai Oriental. *Revista Braileira de Geociências*, **29**(2): 233-236.

Rocha-Campos, A.C. 1967. The Tubarão Group in the Brazilian portion of the Paraná Brasil. *In*: Bigarella, J.J.; Becker, R.D.; Pinto, I.D. (eds.) *Problems in Brazilian Gondwana Geology*. Mar del Plata, IUGS, International Symposium on Gondwana Stratigraphy and Paleontology, 1, p. 27-102.

Rocha-Campos, A.C. 2002. Rocha moutonnée de Salto, SP – Típico registro de abrasão glacial do Neopaleozóico. 2002. *In*: Schobbenhauss, C.; Campos, D.A.; Queiroz, E.T.; Winge, M.; Berbert-Born, M. (eds.) *Sítios geológicos e paleontológicos do Brasil*. 1ª ed. Brasília, DNPM/CPRM - Comissão Brasileira de Sítios Geológicos e Paleobiológicos, **1**: 155-159. Disponível em: http://www.unb.br/ig/sigep/sitio021/sitio021.pdf. Consulted in: 07/10/2008.

Rocha-Campos, A.C. & Rösler, O. 1978. Late Paleozoic faunal and floral sucessions in the Paraná Basin, Southeastern Brazil. *Boletim do IG-USP*, **9**: 1-15.

Rosada Jr, J. *Análise faciológica e rochas – reservatório do Grupo Itararé (Permocarbnífero) no sudeste do Estado de*

São Paulo. 2003. Dissertação de Mestrado, Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista, Rio Claro, 74 p., 2 anexos.

Saad, A.R. 1977. *Estratigrafia do Subgrupo Itararé no centro e sul do Estado de São Paulo*. Tese de Doutorado, Instituto de Geociências, Universidade de São Paulo, São Paulo, 107 p.

Salveti, R.A.P. 2005. *Sistemas deposicionais e paleogeográficos do Subgrupo Itararé (Neopaleozóico da Bacia do Paraná), na região de Itu e Indaiatuba, SP.* Dissertação de Mestrado, Instituto de Geociências, Universidade de São Paulo, São Paulo, 110 p., 1 anexo.

Santos, P.R. dos; Rocha-Campos, A.C.; Canuto, J.R. 1996. Patterns of late Palaeozoic deglaciation in the Paraná Basin, Brazil. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **125**: 165-184.

Slocum, R. 1978. Friction cracks as directional indicators of glacial flow on Mt. Desert Island, Maine. *Ohio Journal of Science*, **78**(1), 11-17.

Souza, P.A. 2006. Late Carboniferous palynostratigraphy of the Itararé Subgroup, northeastern Paraná Basin, Brazil. *Review of Palaeobotany and Palynoogy*, **138**:.9-29.

Souza, P.A. & Marques-Toigo, M. 2003. An overview on the palynostratigraphy of the Upper Paleozoic strata of the Brazilian Paraná Basin. *Revista del Museo Argentino de Ciencias Naturales, Nueva Serie*, **5**: 205-214.

Stevaux, J.C.; Souza Filho, E.E. de; Teixeira, J.A.; Landim, P.M.B. 1987. Sistemas deposicionais do Subgrupo Itararé (P-C) na Bacia Hidrográfica do Baixo Rio Capivari (SP): um modelo para prospecção de água subterrânea. *In*: SBG-NSP, Simp. Reg. Geol., 6, *Atas*, **1**, p. 355-374.

Streckeisen, A. 1976. To each plutonic rock its proper name. *Earth Science Reviews. International Magazine for Geo-scientists*, **12**: 1-33.

Tarbuck, E.J. & Lutgens, I.C. *Ciencias de la Tierra, una introducción a al geología física*. Madrid, Prentice Hall Ibéria, S.R.L., 540p, two appendix and one CD. (spanish translation by Ana Maria Rubio)

Viviani, J.B. & Rocha-Campos, A. C. 2002. Late paleozoic exhumed glacial erosive landscape in Salto, SP. *Anais da Academia Braileira de Ciências*, **72**(4): 549-550.

Zalán, P.V.; Wolf, S.; Conceição, J.C. de J., Marques, A.; Astolfi, M. A. M.;Vieira, I.S.; Appi, V.T.; Zanotto, O.A. 1990. Bacia do Paraná. *In*: Raja Gabaglia, G.P. & Milani, E.J. (eds.) *Origem e Evolução de Bacias Sedimentares*. Rio de Janeiro, PETROBRÁS, p. 135-168.

[1] Instituto Geológico/SMA, Av. Miguel Stéfano, 3.900, CEP 04301-903, São Paulo, SP, fax 50772219, annabelp@igeologico.sp.gov.br, sibezaki@igeologico.sp.gov.br; zemaria@igeologico.sp.gov.br;

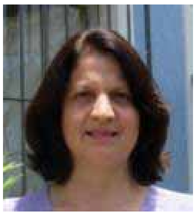
[2] Universidade de São Paulo, Rua do Lago, 562, CEP 05508-080, spetri@usp.br, raphael.hypolito@br2001.com.br, cjuliani@usp.br;

[3] Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, CEP 91540-000, Porto Alegre RS, paulo.alves.souza@ufrgs.br

[4] Universidade Estadual de Campinas, Rua João Pandiá Calógeras, 51, CEP 13083-870, Campinas, SP, lena@ige.unicamp.br;

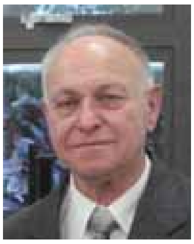
[5] Prefeitura Municipal de Salto, faleconosco@salto.sp.gov.br

AUTHORS SYNOPTIC CURRICULUM



Annabel Pérez-Aguilar – Master and PhD in Geology by the Universidade de São Paulo (USP). From 2004 on she is a scientific investigator from the Instituto Geológico, Secretaria do Meio Ambiente from São Paulo State. Performance areas: geological mapping, metamorphic petrology, volcano-sedimentary sequences, fluid-rock interaction, and stable isotopes.

Setembrino Petri – PhD in Natural History by the Universidade de São Paulo (USP). Actually he is Titular Professor from the Permissionnary Board at the Instituto de Geociências from the USP. Performance areas: Paraná Basin and sedimentary rock stratigraphy.



Raphael Hypólito – PhD in Geosciences by the Universidade de São Paulo (USP). Actually he is Titular Professor from the Permissionnary Board at the Instituto de Geociências from the USP. Performance areas: environmental geochemistry and hydrogeochemistry, mechanisms for availability of pollutant agents in environment and development of techniques in able to recuperate refuse.

Sibele Ezaki – Master in Mineral Resources and Hydrogeology by the Universidade de São Paulo. From 2004 on she is a scientific investigator at the Instituto Geológico, Secretaria do Meio Ambiente from São Paulo State. Performance areas: hydrogeology and geochemistry, hydrogeochemistry, heavy metals, soil and sanitary landfill.

Paulo Alves de Souza – PhD in Paleontology and biostratigraphy by the Universidade de São Paulo. Between 1992 and 2002 he was a scientific investigator at the Instituto Geológico, Secretaria do Meio Ambiente from São Paulo State. From 2002 on, he is an Adjunct Professor at the Instituto de Geociências from the Universidade Federal do Rio Grande do Sul (UFRGS). Performance areas: palynology and stratigraphic paleontology, Paraná Basin (Carboniferous and Permian) and Pelotas Basin (Cretaceous and Quaterary).

Caetano Juliani – PhD in Mineralogy and Petrology by the Universidade de São Paulo (USP). Actually he is an Associated Professor at the Instituto de Geociências from the USP. Performance areas: petrology crustal evolution and metalogenese, hydrothermal alteration, metamorphism, geothermobarometry, Serra do Itaberaba Group and Tapajós.

Lena V.S. Monteiro – PhD in Mineral Resources by the Universidade de São Paulo and Post-PhD in Crustal Evolution and metalogenese by the Universidade Estadual de Campinas (UNICAMP). Actually she is Assistant Professor at the Instituto de Geociências from the Universidade Estadual de Campinas (UNICAMP). Performance areas: iron-cupper-gold oxide deposits, gold and base metal deposits, evolution of mineralized fluids, and fluid rock interaction and hydrothermal alteration.

José Maria Azevedo Sobrinho – Master in Mineralogy and Petrologyy by the Universidade de São Paulo. Actually he is a scientific investigator at the Instituto Geológico, Secretaria do Meio Ambiente from São Paulo State. Performance areas: geological mapping, mineralogy and petrology, charnockites and granulites.

Francisco Antônio Moschini – Licensed in Physic Sciences, Biology and Pedagogy. He is a Fundamental and High School Pensioned Teacher. Actually he is a Member of the Hydrographic Committee of the Piracicaba, Capivari, and Jundiaí Rivers, Hydrographic Committee of the Middle Tietê River, from the Administration Council of the Environmental Protected Areas of Cabreúva, Cajamar, and Jundiaí (APAs), and from the Salto city Environmental Municipal Council.