

The São Paulo's beach sands as a geotourism and geoeducation resource

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ABSTRACT: Due to the lack of geological culture of primary and secondary Brazilian students and population, some new approaches to raise the awareness about Earth's systemic functioning may be provided. One of these consists in "track" the history of sand grains since their origin through their properties. The aims of this project are to study São Paulo coast's beach sands in order to supply materials for educational and scientific activities and to produce an atlas of the beach sands of the São Paulo coastline for tourists, students and population.

KEYWORDS: Geotourism, Geosciences, Beach sand, Brazil.

1. INTRODUCTION

Brazil is internationally recognized for its natural beauty, in particularly for the biodiversity, landscapes and beaches, which are attractive for tourism, including ecotourism and adventure tourism and also for environmental education activities. Geotourism is a new segment of Brazilian tourism that focuses on the geological heritage of a region and may contribute to its preservation.

Beaches are coastal places where sand and/or gravel sediments accumulate as the result of air-water-rock interactions. These sediments are reworked by the coastal geological processes such as waves, winds, currents, and tides and also reflect, in a greater time-space scale, the weathering and eroding history of the major rocky areas close to the coast. As the result of sedimentary processes, the final product is the sand deposit, one of the steps of the rock cycle. Although all the steps of this cycle, associated with the internal and external Earth's dynamics, occur on the planet, they are not perceptible for most people. This lack of perception is due to the absence of knowledge of general population about landscape origin and evolution or about the origin and properties of geological materials. In addition, since little information is directed to landscape evolution and its geological aspects, the study of beach sands is an interesting and attractive approach for geotourism, geosciences and environmental education in the coastal area of São Paulo State.

The studied area in the coast of São Paulo State includes 15 municipalities that are distributed in three different zones: the North Coast (Ubatuba, Caraguatatuba, Ilha Bela and São Sebastião), the "Baixada Santista" or Centre Coast (Bertioga, Guarujá, Santos, São Vicente, Praia Grande, Mongaguá, Itanhaém and Peruíbe) and the South Coast (Iguape, Ilha Comprida and Cananéia). Along 427 km of coastline (latitude 23°30' to 25°S and longitude 44°30' to 48°W) there are about 292 beaches (Lamparelli, 1998). In the North Coast, only 10 % of the coastline is represented by beaches, generally confined between rocky coast portions that outcrop following the structural direction of the Pre-Cambrian basement. The extension and number of beaches in São Paulo coast grow towards south where beaches represent 65% of the coastline in the "Baixada Santista" and 87% in the South Coast (Figure 1).

Under the geological point of view, the North Coast is part of the Mantiqueira Province (Almeida et al., 1977), more specifically of the Costeiro Complex (Hasui et al., 1976) of Neoproterozoic age. High-grade metamorphic rocks such as gneisses and migmatites, as well as deformed granitic bodies, basic dykes and alkaline intrusions are the main rock types of this unit. The Reactivation Stage of the Brazilian Platform (Neojurassic to Recent age) (Almeida, 1969) explains its evolution. Since most of the events are located near the Brazilian continental margin of the South American Platform, there is a direct relationship with the Gondwana Supercontinent fragmentation and the South Atlantic Ocean opening. The genesis of the Serra do Mar Mountain Range and the shape of the Brazilian coast is also directly associated with these major events. After these tectonic events, sedimentary processes associated with Quaternary marine transgressions and regressions are responsible for the more recent evolution of the coast (Tessler and Goya, 2005).

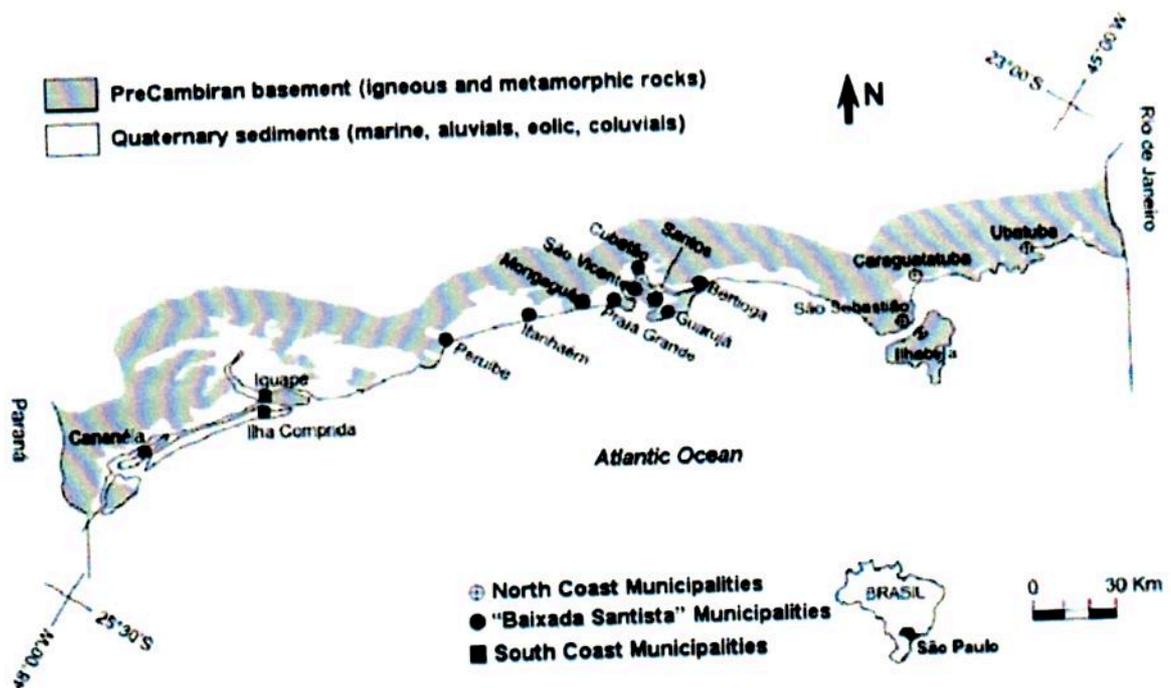


Figure 1. São Paulo State coastline (modified from Souza and Suguio, 1996).

2. PROPOSALS AND ACTIVITIES

In order to contribute to create a sand beach atlas of São Paulo coastline for tourists, students and general population, a first study of the diversity of beach sands has been initiated in the North Coast beaches, specially in Ubatuba and Caraguatatuba municipalities. The first results showed a diversity of sands, particularly in what concerns granulometry, color and mineralogical composition, as shown in Table 1. In addition, the morphodynamic profile of beaches shows some differences that may have a relation with sand granulometry.

Table 1. Sediment size distribution of beaches of the North Coast of the State of São Paulo.

Beach	Mean diameter	Standard deviation	Skewness	Kurtosis	GRAVEL				SAND				FINES	
					Pebbles	Granules	Very coarse	Coarse	Medium	Fine	Very fine	Clay		
Camburi P1	1,73	0,82	-0,68	3,67	0,00	0,57	2,18	14,96	43,79	35,16	3,34	0,00		
Camburi P2	1,58	0,83	-0,41	2,32	0,00	0,00	2,58	24,69	36,62	34,95	1,16	0,00		
Camburi P3	2,24	0,74	-1,16	5,31	0,00	0,32	0,87	5,22	24,51	57,86	11,22	0,00		
Praia Brava P1	1,80	0,50	-0,27	4,09	0,00	0,02	0,11	5,84	63,46	29,90	0,67	0,00		
Praia Brava P2	1,62	0,57	-1,26	7,30	0,00	0,78	0,34	10,85	66,69	21,27	0,08	0,00		
Praia Brava P3	2,69	0,36	-0,09	3,00	0,00	0,00	0,00	0,00	2,13	80,01	17,87	0,00		
Picinguaba	1,82	0,70	-0,17	3,15	0,00	0,02	0,84	12,57	42,76	39,86	3,94	0,00		
Fazenda P1	3,24	0,24	-0,57	6,60	0,00	0,00	0,00	0,00	0,06	11,31	88,63	0,00		
Fazenda P2	3,24	0,24	-0,68	7,44	0,00	0,00	0,00	0,00	0,12	10,48	89,40	0,00		
Almada	2,05	0,71	-0,31	2,87	0,00	0,02	0,20	8,34	37,04	47,08	7,33	0,00		
Estaleiro do Padre P1	2,96	0,53	-0,89	3,59	0,00	0,00	0,00	0,13	5,96	35,56	58,35	0,00		
Estaleiro do Padre P2	2,93	0,56	-0,81	3,24	0,00	0,00	0,01	0,14	7,96	34,80	57,09	0,00		
Ubatimirim	2,93	0,51	-1,16	5,03	0,00	0,01	0,01	0,28	4,76	40,46	54,48	0,00		
Promirim P1	0,33	0,69	-0,39	2,82	0,00	5,24	22,75	55,73	16,25	0,03	0,00	0,00		
Promirim P2	0,16	0,69	-0,09	2,71	0,00	6,05	32,33	50,55	11,00	0,07	0,00	0,00		
Félix P1	1,52	0,44	-1,08	6,39	0,00	0,20	0,14	11,83	80,81	6,99	0,03	0,00		
Itanambuca	1,07	0,70	-0,48	3,39	0,00	1,03	4,73	37,75	50,96	5,46	0,08	0,00		
Tenório	2,53	0,33	0,39	3,07	0,00	0,00	0,00	0,00	1,86	91,62	6,53	0,00		
Bonetinho	1,68	0,89	0,00	2,07	0,00	0,00	1,05	25,86	30,72	34,54	7,83	0,00		
Praia do Perez	2,32	0,91	-0,66	3,27	0,00	0,07	1,61	6,88	22,98	41,42	27,04	0,00		
Lagoinha (Ubatuba)	3,14	0,33	-1,84	14,18	0,00	0,03	0,00	0,00	0,36	21,39	78,22	0,00		
Lagoa P1	0,57	0,52	-0,34	4,06	0,00	1,05	9,08	71,40	18,28	0,19	0,00	0,00		
Lagoa P3	0,00	0,77	-0,33	2,04	0,00	17,72	23,28	52,66	6,34	0,01	0,00	0,00		
Lagoa P2	0,88	0,54	-0,06	3,86	0,00	0,23	3,78	56,68	37,66	1,62	0,02	0,00		
Ponta Aguda P1	2,09	0,62	-0,56	3,52	0,00	0,00	0,24	6,17	32,12	56,55	4,92	0,00		
Ponta Aguda P2	1,89	0,77	-0,62	3,36	0,00	0,06	0,92	12,64	35,69	45,10	5,59	0,00		
Ponta Aguda P3	1,95	0,73	-0,94	4,20	0,00	0,13	0,99	10,39	30,55	53,28	4,66	0,00		
Tabatinga P1	2,17	0,87	-0,38	3,38	0,00	0,26	1,14	6,48	39,22	31,33	21,57	0,00		
Tabatinga P2	1,82	0,55	0,29	3,73	0,00	0,00	0,03	6,07	63,00	28,28	2,61	0,00		
Tabatinga P3	1,10	0,66	-0,22	2,82	0,00	0,12	4,18	38,62	51,77	5,19	0,12	0,00		
Martins de Sá P1	2,24	0,60	-0,33	3,89	0,00	0,04	0,17	2,04	33,65	54,74	9,36	0,00		

Beach sediment size ranges from very fine sand to coarse sand, with medium and coarse sand most common on reflexive beaches and very fine and fine sand on dissipative beaches. Granules may be present in sediments of some beaches such as "Promirim" or "Lagoa" and represent a few portion of the bulk sediment (5 to 18%). As an example, two beaches may be representing the main morphodynamic profiles observed on the studied portion of the North coast: the "Lagoa" beach is reflexive and sediments consist mainly of coarse sand (70%) and the dissipative beach "Estaleiro do Padre" beach with sediments that consist mainly of very fine sand (58%). Composition of beach sands is also studied. A variation of composition may be deduced macroscopically and mainly consist of quartz; micas, heavy minerals, lithic fragments and some shell fragments have been also identified but further analysis must be done since the study has been recently initiated.

In order to supply educational and scientific material that focuses Geosciences and Geotourism themes and in the meantime ecotourism guides and science teachers' training (an other aspect of the purpose), a geosciences educational activity about sand material has been developed with school students in the Juréia Ecological Station-EEJI (South Coast of the São Paulo State, Peruíbe Municipality). The EEJI is a UNESCO World Heritage Site and the most preserved remains of Atlantic Forest in São Paulo State. Its objective was to raise the students' interest and curiosity through sand observation and associating their observations with weathering, erosion and sedimentation processes. In fact, despite the children population lives inside the EEJI they don't realize the Earth process at their side. The common sense prevails over geoscientific knowledge.

3. FINAL REMARKS

Geotourism is a new approach for Brazilian researchers and just a few studies about this theme are present in the intentional bibliography.

São Paulo State coast is a frequent touristic destination and has potentiality for geosciences education activities. The geological knowledge of this region can be transformed in educational activities that can improve touristic, integrating both activities. But, the Earth Science context is not available in the tutorial speeches that rather highlight the biodiversity aspects. However, the first practical action in the field with students has already reached the aim to raise the interest in geoscientific themes and in natural materials as sand.

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