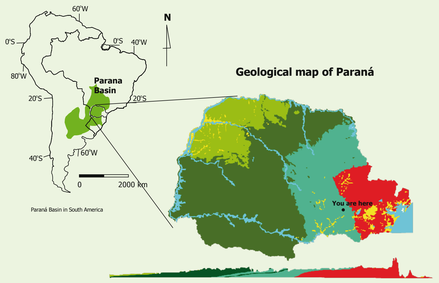
Geology of Paraná



EON	ERA	PERIOD	EPOCH	Age (million years)	Features	Geology of Paraná
Phanerozoic	Cenozoic	Quaternary	Holocen	Today	Mankind, Northern Hemisphere glaciation	Sediments
				1.1		
		Tertiary	Pleistocen	1.8		
			Pliocene	5.3		
			Miocene	23		
			Oligocene	34	Primates proliferate	
			Eocene	53		
			Paleocene	65	First horses appear	
	Mesozoic	Cretaceous		142	Dinosaurs appear; flowers	Sedimentary rocks
		Jurassic		206	First birds and mammals appear	Basalt
		Triassic		248	First Dinosaurs appear	Paraná Basin
	Paleozoic	Permian		290	Trilobites disappear	Sedimentary rocks
		Carboniferous		354	Reptiles, primitive large trees appear	
		Devonian		417	Amphibians appear	
		Silurian		443	Terrestrial plants appear	
		Ordovician		495	First fish appear	
		Cambrian		545	First shells, trilobites previal	Paranaense Shield
Precambrian	Proterozoic			2500	First pluricellular organisms	
	Archean			4000	First unicellular organisms	
	Hadean			4560	Earth forms	

Formation of the Vila Velha Sandstones

The geological structure of Paraná is recognized when the State is crossed westward. The oldest rocks, formed more than three billion years ago, are found on the coastal plain. There and all over Serra do Mar Range and the First Paraná Highland, igneous and metamorphic rocks of Archean to early Paleozoic age outcrop. The strong relief reflects their resistance to weathering, the region in which they occur being called the PARANAENSE SHIELD.

From the Serrinha scarp known as São Luiz do Purunã Range on to the west border of the State, the shield is covered by Paraná Basin, a massive sequence of sedimentary and also volcanic rocks of Silurian to Cretaceous age sustaining the state's Second and Third highlands. In the beginning of its evolution, South America and Africa were still unseparated parts of a supercontinent named Gondwana, and their geographical posit ions were quite different from today´s.

Paraná Basin evolved for more than 350 million years, in long transgression-regression cycles of an ancient ocean that surrounded Gondwana. Such cycles, immensely slow as compared to the time scale of human events, allowed generation of different marine, lacustrine, fluvial, glacial rocks in Paleozoic times.

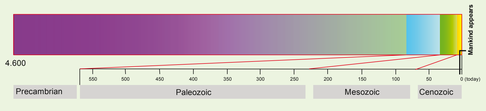
In Jurassic times, the region turned into to a desert spreading more than 1.500.000 km2 over parts of now Southern Brazil, Paraguay, Uruguay and Argentina.

Breakup of Gondwana took place in Cretaceous, when South America and Africa separated and, hence, spreading of the Southern Atlantic Ocean begun. As part of the breakup process, extensive, up to 1,500 m thick basaltic magma flows covered more than 1,200,000 km2 of the Paleozoic sedimentary rocks of Paraná Basin. It was weathering of such magma flows that generated the remarkably fertile "Terra Roxa" soils. By the end of Cretaceous, desertic terrains spread over those magma flows in Northwestern Paraná forming the so called Caiuá Sandstones. Unlike "Terra Roxa," however, soils derived from these rocks are agriculturally poor and highly susceptible to erosion.

The most recent geological units to form in Paraná are sediments of Cenozoic age. Most representative examples are those generated under arid to semi-arid conditions over part of Curitiba and Tijucas do Sul regions, those formed from weathering of crystalline rocks at Serra do Mar Range; marine sand deposits along the Eastern Coast, and also countless alluvial deposits along the rivers, streams etc. of Paraná.

Geological time

If the 4.6 billion years of geological history were scaled to one single year, Mankind would have been on Earth since 8:14 p.m. December 31 i.e., within the last 3 ours and 46 minutes. Dinosaurs, that lived for 100 million years, would have lived for no more than 8 days and 12 hours.



Geological Site

Vila Velha State Park


Photo: Gil F.Piekarz

Sandstones

The monuments of Vila Velha took shape from sandstone, a rock generated by compaction and hardening of successive sand layers. These particular layers, that correspond to a geological unit named Itararé Group, were deposited during the Carboniferous Period 300 million years ago, when South America was still unseparated from Africa, Antarctica, Oceania and India forming a vast continent named Gondwana.

At the transition between Carboniferous and Permian, during one of the most important cooling events in Earth's history, the whole Vila Velha region was closer to the South Pole, with average temperatures much lower than today's.

Late Carboniferous/Permian
Period when the sands of the Vila Velha sandstones were deposited. The whole region was close to the South Pole, covered by huge masses of ice like those in Antarctica today

Recent
Current distribution of continents and geological indicators of glacial activity 300 million years ago. Arrows mark the directions along which glaciers moved.

The shapes in which Vila Velha sandstones outcrop are not the same as when they formed 300 million years ago. At that time, different geological events led to the deposition of overlying younger sedimentary sequences. Later, tectonic movements and erosion brought the sandstones back to surface. The erosional processes that sculptured Vila Velha rocks to their current shapes, especially those related to pluvial water, took place during the Quaternary i.e., over the last 1.8 million years.

Picturesque of Vila Velha is its ruiniform relief marked by a rich association of grooves, dissolution cones, sharp-top features, towers and pillars, and especially the well-know "Wine Glass", symbol of the park and region.

These wonderfully sculptured monuments derive from the action of pluvial water, solar energy, and changes in temperature and organic activity on natural weakness zones such as fractures and faults, sedimentary structures, and also differential texturing and cementation.

Formation of the Sandstones


Photo: Paul Wright
Simulated landscape at the time when Vila Velha Sandstone were deposited. Image from Greenland.

Phase 1 - glaciers progress

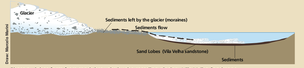


Photo: Nicolini Roberto
Phase 2 - lobes form from sands brought by the receding glacier - Vila Velha Sandstone

The sands from which the Vila Velha Sandstones formed are of Carboniferous age i.e., 300 million years ago, when the local landforms were quite different from today´s. At that time, the local landscape was dominated by glaciers, rivers and lakes that corresponded to a fluvioglacial environment.

As glaciers progressed toward the lower parts of the terrain, they would aggregate local sediments and rock fragments. As glaciers receded by melting, such materials (called moraines) would be carried by rivers and torrents to form sedimentary, sometimes lacustrine deposits. Vila Velha sandstones were generated from sediments that were deposited in such glacial lakes.

In Vila Velha, these sediments are mostly sandy, and in several places over the Campos Gerais region, elongate scratches (striae) on the ground evidence glacial activity. A good example of such features can be seen on the way to Curitiba, at a geological site in Witmarsun Settlement.

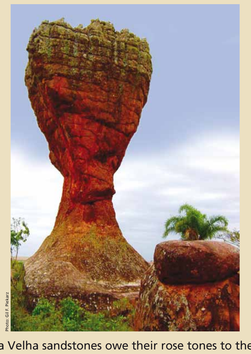


Photo: Gil F.Piekarz
The Vila Velha sandstones owe their rose tones to the iron-rich material that cements their grains. This material is also responsible for horizontal layers more resistent to erosion, which contribute to the richness of forms observed.

Natural Pits

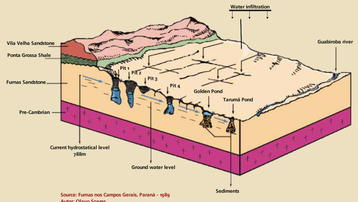

Photo: Jean Claude Prance de Souza
Pit 1


Photo: Silvia Sargut de Melo
Golden Pond

Among the great attractions of Vila Velha State Park are the deep natural pits ("furnas"). These features correspond to erosional features that appear as vertical crater-like cylindrical depressions into the ground. These pits did not develop into Vila Velha sandstones, but into an underlying whitish sandstone unit named Furnas Formation (see geological map of the Park).

Fourteen natural pits are known to occur in the region of Campos Gerais, six of which at the Vila Velha State Park. Two of the pits in the park, Lagoa Dourada (Golden Pond) and Lagoa Tarumã (Tarumã Pond), are considered to be in their terminal stage i.e., almost completely filled with sediments.

Except for number 3, that has not already reached its base level, all other pits are interconnected below their current hydrostatical level (788 m relative to the sea). That means there is intense circulation of ground water between the pits and Lagoa Dourada due to fractures and discontinuities in the sandstone.



Source: Furnas nos Campos Gerais, Paraná - 1989
Autor: Olavo Soares

The natural pits at Vila Velha State Park formed from circulation of pluvial water where acidified by organic activity. The acid water slowly affected the structures that keep the rock coherent, especially where faults and fractures intersect. The erosional structures appeared as rock-forming grains were mechanically removed by the ground water flow.

The following sequence of photographs shows how these forms developed, especially those related to the action of pluvial water:


Photo 1. Sandstones as seen from above, with weakness lines (faults, fractures) marked

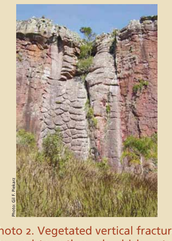


Photo 2. Vegetated vertical fractures in sandstone through which water percolates.


Photo 3. Blocks separated by the combined action of pluvial erosion, vegetation and solar energy

Geology of the Park

Source: UEPG - 2002

Quaternary Sediments
These are muddy-sandy sediments with subordinate gravel, deposited at the alluvial plains of Guabiroba and Quebra Perna rivers.

Diabase Dykes
Two NW-SE oriented diabase dykes outcrop at Vila Velha State Park. The region was strongly affected by Ponta Grossa Arch, an upward warping 130 million years ago (in the Mesozoic) when the continent of Gondwana broke up and the Atlantic Ocean begun to spread. Deep fractures caused by that warping allowed a huge amount of basaltic magma to ascend and consolidate as diabase dykes.

Vila Velha Sandstones
This is the unit of Itararé Group that outcrops at the Vila Velha State Park, being its greatest attraction. See detailed description in "Sandstones."

Undifferentiated Itararé Group
This is the basal unit of Itararé Group at the Vila Velha State Park. Its rocks are of most varied nature, which reflects the many different glacial environments from which it formed. Rock types include diamictite, mudstone, shale and sandstone.

Ponta Grossa Formation
This Devonian unit ranges in age between 400 and 375 million years. It comprises dark fossil-rich marine shale and mudstone. Its typically marine, well known fossil content, that includes gastropods, trilobites, brachiopods, and crinoids constitutes the Malvinokaffric fauna. Exquisite exposures of this unit can be observed near the park at Rivadávia Farm.

Furnas Formation
This early Devonian unit aged 400 million years comprises medium- to coarse- grained sandstone terms. The whitish color of its rocks is given by restricted kaolinic conglomerate levels. These rocks, that formed from interacting marine and fluvial environments, show remarkable sedimentary structures such as plane-parallel and planar cross-bedded stratification.

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