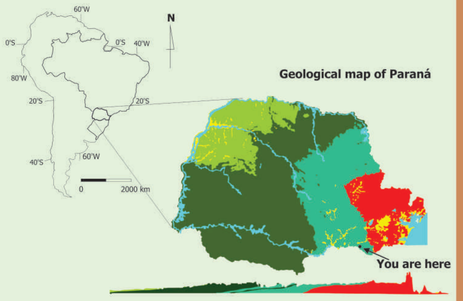
Geology of Paraná



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

The geological evolution of Paraná is followed when the state is crossed westward. The oldest rocks, formed more than 2.5 billion years ago, are found on the coastal plain. There, and all over Serra do Mar and the First Plateau, igneous and metamorphic rocks of Archean to early Paleozoic age outcrop in the region known as the PARANÁ SHIELD, whose strong relief reflects how resistant to weathering its rocks are.

From the Devonian scarp known as São Luiz do Purunã to the western border of the state, the Paraná Shield is overlain by the PARANÁ BASIN, a massive sequence of sedimentary and volcanic rocks of Silurian to Cretaceous age that sustains the state's second and third plateaus. In the early stages of the basin´s evolution, South America and Africa were still unseparated parts of a supercontinent called Gondwana, and their geographic locations were very different from today's.

The PARANÁ BASIN evolved for more than 300 million years, in long transgression-regression cycles of an ancient sea that surrounded Gondwana. These cycles, immensely slow as compared to human lifetime, resulted in different marine, lacustrine, fluvial, and glacial rocks in Paleozoic times.

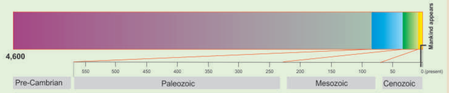
In Jurassic times, a desert named Botucatu, that spread for more than 1,500,000 km^2, covered parts of southern Brazil, Paraguay, Uruguay, and Argentina.

The breakup of Gondwana, and the consequent separation of South America and Africa as the South Atlantic Ocean spread, took place in the Cretaceous. As part of the breakup process, extensive, up to 1,500 m of superposed basalt flows covered more than 1,200,000 km^2 of the Paleozoic sedimentary rocks of the Paraná Basin. The remarkably fertile soil known as Terra Roxa derives from weathering of such basalt flows. By the end of the Cretaceous, desertic terrains (the Bauru Basin) spread over the basalt flows in northwestern Paraná as recorded by the Caiuá sandstone. Unlike the Terra Roxa, however, soils formed from these rocks are poorly fertile and highly susceptible to erosion.

The youngest geological units in Paraná are sediments of Quaternary age. Most representative examples are those generated under arid to semi-arid conditions over parts of Curitiba and Tijucas do Sul, those formed from weathering of crystalline rocks along the Serra do Mar range, marine sand deposits along the eastern coast, and also countless alluvial deposits along water streams in the state.

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 3h ours and 46 minutes. Dinosaurs, that lived for 100 million years, would have lived no more than 8 days and 12 hours. Serra do Mar as it presents itself today would have arisen within the last 5 minutes of the year.



Geological Site

Rio Negro-Mafra

The ice and the Rocks

The rocks in this region resulted from processes related to the presence of glaciers approximately 300 million years ago. In Mafra and Rio Negro, at least three cold-warm periods of the Permo-Carboniferous glaciation are evidenced in rocks of the Itararé Group.

At that time, our region was located near the South Pole. Our continent, together with Africa, Antarctica, Australia etc. still formed one single supercontinent named Gondwana.

Landscapes were quite different from the present ones. They were dominated by the presence of glaciers, water courses, and glacial lakes in fluvioglacial environments. As glaciers advanced toward lower terrains, they would aggregate sediments and rock fragments. When retracting during the warm periods when ice melted, such materials were released to form deposits known as moraines. Torrents resulting from melted ice runoff would carry such sediments, that would eventually deposit at the bottom of glacial lakes.

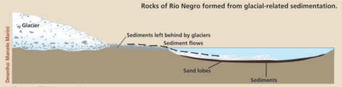

Foto: Rita Wright

An example of what the landscape would look like when the sediments that form the local rocks deposited, from a current scene of Iceland.


Foto: Antonio Liccardo

Rocks of Rio Negro formed from glacial-related sedimentation.

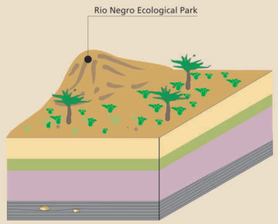
Phase 1. Glacier advance



Desenho: Marcelo Marini

Phase 2. Glacier retraction

The rocks of Mafra and Rio Negro: a glacial record



Trackway through the Ecological Park.

Varvite: This type of rock forms from sediments deposited in lakes. Its paler layers, that are constituted of silt or very fine sand, deposited durig warm periods when sediments were brought by water courses. The dark layers consist of clay deposited during cold periods when the surface of the lake would freeze. When ice displaced from surrounding elevations by gravity reached lakes, it would break into drifting icebergs. When icebergs melted, the rock fragments would drop to the bottom of the water bodies. Such events, that repeated for millions of years when our region was very near the South Pole, and the whole Earth was under glacial conditions, are recorded in this rock wall.

Diamictite. This type of rock consists of fragments of varying size involved in a clay matrix. In this particular case, they formed from sediments deposited directly from glaciers. The presence of debris flow represent a glacial climax.

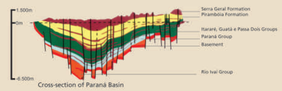
Fossiliferous Siltite. This type of rock results from sedimentation of silt-size particles. Here, they represent an interglacial period during which the ice mostly melted and the sea level rose. The sedimentary basin was then connected to the ocean (maximum flood), which brought about a large variety of fish, mollusk, worms, etc.

Sandstone. This rock forms from deposited sands. In our region, it represents a period when the relative sea level started to lower and sediments were consequently carried to the basin by water courses.

Paraná Basin

The Paraná Basin represents an immense, 1,400,000 km2 elongated depression filled with sediments that reach thickness of up to six kilometers in some places. In the State of Paraná, it corresponds to the second and third plateaus. In the beginning of its evolution, the distribution of continents was very different from today. South America and Africa were still part of the Gondwana supercontinent. Its long evolution was relatively calm, which allowed a variety of marine, deltaic, lacustrine, fluvial, glacial, and desert sedimentary environments to develop. When these continents started to separate, a large portion of Paraná Basin was covered by lava flows. Erosion of its borders reveals a succession of sedimentary layers that tells us, especially in Paraná's Second Plateau, the history of this part of the Earth over the last 350 million years.

Location of Paraná Basin in Brazil



Cross-section of Paraná Basin

Fossils


A paleoniscid fossil found in the surroundings of Mafra (CENPÁLEO collection)

Fossils are precious records of ancient ages. Their preservation requires a well defined set of conditions without which dead animals and plants would otherwise have been completely decomposed. Dead organisms are buried by mud at the bottom of water bodies or by sediments carried to the sea. Although the soft parts of their bodies soon disappear, bones, teeth, shields, shells and wooden fragments may take longer to decompose. When buried under low oxigen conditions, they can be preserved in sedimentary rocks for millions of years. Another type of fossil record is that left by footprints or burrowing worm. The regions of Mafra and Rio Negro bear a large amount of fossils of fish, shelves, and even worm holes, the latter being known as ichnofossils.

The Pedra Caída (Dropped Stone) monument


Foto: Antonio Liccardo


Foto: Antonio Liccardo

On the rock wall known as Pirambeira, on the bank of rio Negro river, a massive, rounded block of quartzite lies embedded in varvite. The scene from Iceland on the left gives us an idea of what the local climate and landscape looked like 300 million years ago. The quartzite block, originally aggregated and transported by a glacier, dropped to the clayish bottom of a lake when the ice melted. The varvite shows signs of the sediment deformation caused by the dropping block. The block is one meter high, and its apparent thickness of of 1.5 meter.

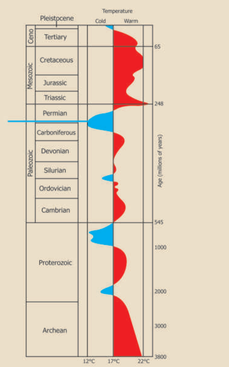
Cobbles are commonly found in this varvite wall and at the quarries near it. The one on the left has a diameter of 12 cm.

Glaciations: the ages of ice

Climate changes during the evolution of our region were determinant in the formation of the rock we observe here. The presence of glaciers, their advancing and retracting movements, and other processes related to ice melting are among the most important factors that led to the geological changes recorded in these rocks.

Upper Carboniferous-Permian
Sedimentation of the material from which the rocks of Rio Negro and Mafra formed. Our region remained near the South Pole, and it was covered by massive ice sheets like those in Antarctica. The distribution of continents was different from the current one.

Present
Current distribution of continents and geological evidences of glaciers 300 million year ago. Arrows indicate glacier movement.



Cold (glacial) and warm (interglacial) periods in Earth's history.

Realization:
GOVERNO DO PARANÁ – SECRETARIA DE ESTADO DA INDÚSTRIA, DO COMÉRCIO E ASSUNTOS DO MERCOSUL
MINEROPAR – MINERAIS DO PARANÁ SA

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