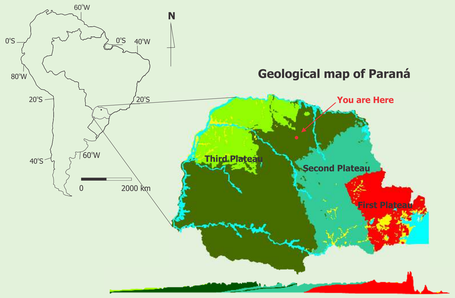
GEOLOGY OF PARANÁ



EON	ERA	PERIOD	EPOCH	Age (million years)	Features	Geology
Phanerozoic	Cenozoic	Quaternary	Holocene	Today	Mankind, Northern Hemisphere glaciation	Sediments
			Pleistocene	1,1 1,8		
		Tertiary	Pliocene	5,3		Sediments
			Miocene	23		
			Oligocene	34	Primates proliferate	
			Eocene	53		
			Paleocene	65	First horses appear	
	Mesozoic	Cretaceous		142	Dinosaurs appear; flowers	Sedimentary rocks / Magmatic rocks
		Jurassic		206	First birds and mammals appear	Paraná Basin / Sedimentary rocks
		Triassic		248	First Dinosaurs appear	
	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	Paraná Shield
		Cambrian		545	First shells; trilobites prevail	
Precambrian	Proterozoic			2500	First pluricellular organisms	
	Archean			4000	First unicellular organisms	
	Hadean			4560	Earth forms	

Formation of the basaltic rocks

The geological evolution of Paraná is followed 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 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.

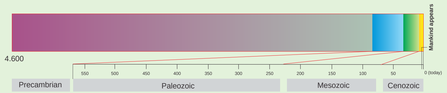
In Jurassic times, a desert named Botucatu, that spread for more than 1,500,000 km2, covered parts of southern Brazil, Paraguay, Uruguay, and Argentina.

The breakup of Gondwana, that resulted in the separation of South America and Africa and the opening of the South Atlantic Ocean, 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 km2 of the Paleozoic sedimentary rocks of the Paraná Basin. The Cambira rocks formed from one of these basalt flows. 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) spreaded over the basalt flows in northwestern Paraná as recorded by the Caiuá sandstones. 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 3 ours and 46 minutes. Dinosaurs, that lived for 100 million years, would have lived for no more than 8 days and 12 hours.



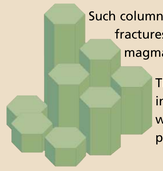
Geological Site

The Cambira Stones

The Cambira Stones

The rocks at "Cambira Stones" and other volcanic ones found in the Third Plateau of Paraná share the same origin: they are basaltic bodies formed from cooling of successive lava flows (See Rocks of Apucarana).

The "Cambira Stones", as it is fondly known with the locals, are peculiar rock columns with hexagonal bases formed by the rate of lava cooling. In Geology, such features are referred to as "hexagonal columnar disjunctions in basalt."



Such columnar disjunctions form as the basaltic lava cools and a network of polygonal fractures develops in the inner portions of the flow, which normally shapes the magma into irregular parallel columns.

The "Cambira Stones" are peculiar because they result from a very rare event in nature, the development of PERFECTLY HEXAGONAL COLUMNS. That is why these outcrops are geological monuments that must be appreciated and preserved.

Aspect of a basalt column with its hexagonal base.

Upper view of the basalt columns with their hexagonal bases.

The rocks of Apucarana

The rocks where the city of Apucarana lies were the results from the largest known basaltic lava flow on Earth. This event happened 132 million years ago in the Cretaceous Period of the Mesozoic Era.

At the time that gigantic lava flow took place, all landmasses on Earth formed a single continent named Pangea, whose southern parts, that now correspond to South America, Africa, Australia, India, and Antarctica, are referred to as Gondwana.

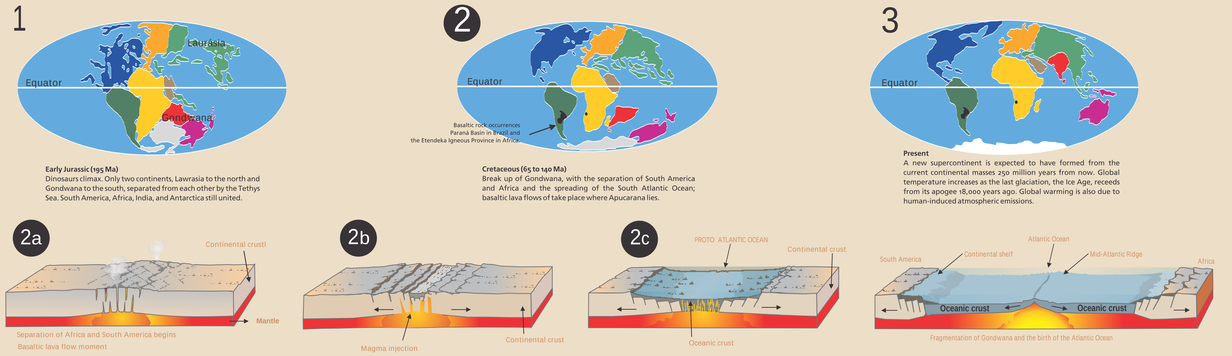
At that time, this region was part of an immense desert called the Botucatu Desert. It was in that desert scene that the breakup of Gondwana took place, which resulted in the separation of Africa and South America and in the opening of the South Atlantic Ocean.

The basaltic lava flow from which the rocks of Apucarana derive was a consequence of the breakup of Gondwana.

The basaltic lava, which resulted from the melting of the deepest parts of the Earth's crust or even below, ascended through distensional fractures before spreading over 1,200,000 km² with thickness reaching up to 1,500 m.

Many lava flow episodes were necessary for such thickness to be reached. In some places, the rock pile consists of more than fifty superimposed flows. Desert conditions remained during the whole volcanism event, as testified by the presence of intercalated aeolian sandstone bodies.

Origin of basaltic rocks



The soils of Apucarana

Weathering of basaltic rocks is responsible for the highly fertile terra roxa soils present in Apucarana and in more than fifty percent of the State of Paraná.

Soils form when basalts are gradually altered by the action of rain water, chemical agents, and temperature variations.

Deep, well developed soils identified as either red latosol or red nitosol are common in level areas of Apucarana. Shallower types bearing small rock fragments (litholic neosol) are present in steeper areas parts of the terrain.

Basaltic lava flows

Basaltic lava flows are structurally regular. When they are thicker than 15 m, they present three clearly distinguishable portions: an upper, a central, and a lower one.

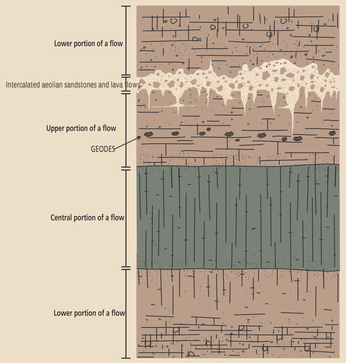
Amethyst geode in basalt

The **Upper portion** is characterized by the extensive presence of vesicles and horizontal fractures. Gases present in the lava migrate to the upper portions of the flow as lava ascends, forming empty spaces called vesicles. During and after solidification of the lava, these vesicles are filled with liquids and vaporous emanations that crystallize as mineral species such as calcite, amethyst, calcedony, agate, and zeolite. These wonderful crystal-filled spaces in the rock are known as geodes.

Being more exposed to weathering, the upper portions of a lava flow tend to assume reddish tones due to oxidation of the iron minerals present.

The **Central portions** of basaltic lava flows result in more compact rocks because of their slow cooling. Sub-vertical fracture systems form columnar disjunctions similar to those in the Cambira Stones.

The **Lower Portions** of a basaltic lava flow, being in direct contact with the ground surface, are subjet to faster cooling. This results in intense fracturing and horizontal lamination. Such fracturing and lamination can be observed where spheroidal exfoliation



Cross-section of a basalt flow
Source: Projeto Cobre em Ipatinga (CPRM, 1979).
Author: Eugênio Casamiro Seubert

Landscape showing basalt flows stacking. Each step is one basalt flow.

Realization:

GOVERNO DO PARANÁ
SECRETARIA DE ESTADO DA INDÚSTRIA, DO COMÉRCIO E ASSUNTOS DO MERCOSUL

MINEROPAR
MINERAIS DO PARANÁ SA

NATE
Núcleo de Assessoria Técnica Extensionista
Faculdade de Apucarana

Partnership:

Cultura
Secretaria de Estado

PARANÁ TURISMO
Secretaria de Estado do Turismo

Prefeitura Municipal de Apucarana

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