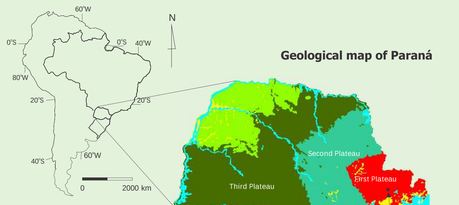
Geology of Paraná



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

Paraná Basin

Age of diabase dykes formation and South America - Africa separation

Deposition age of Capiru Formation sediments - "Capiru Sea" (1 billion of years ago)

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.

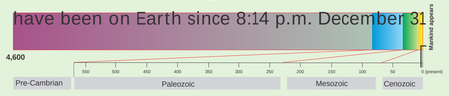
In Jurassic times, a desert named Botucatu, that spread for more than 1,500,000 km^2, covered parts of southern Brazil, Paraguay, Uruguay, and Argentina.

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 the 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



Geological Site

The Capiru Formation and the Karst

The Capiru Formation – the rocks of Almirante Tamandaré

Quaternary Alluvionars

Pleistocene Sediments

Mesozoic Diabase Dykes

Metadolomites of the **Capiru Formation (Karst)**

Quartzites and Phyllites of the **Capiru Formation**

Gneisses and Migmatites (chrystalline rocks) Embasament of Capiru Formation

Sights of the Nature Circuit

1. Sind. dos Empregados no Comércio de Curitiba e Região
2. Pesk Pag Broto
3. Estância do Lago
4. Chácara Verde Muda
5. Clube Águas de Valverde
6. Chácara Morro Alto
7. Chácara Bela Vista
8. Pesque Pague Marmeleiro
9. Moinho N. Sra. Do Carmo
10. Chácara Perussi
11. Água Minera Frescale
12. Chácara Goetzk
13. Clube 21 de Abril
14. Recanto Manós
15. Inês
16. Recanto Santo Antônio
17. Chácara Refúgio do Vale
18. Restaurante Evissima
19. Pesque Pague Colônia Gabriela
20. É no Gaspa Restaurante
21. Pesque Pague Laranjeiras
22. A Copa Prando
23. Escola de Equitação Pond Rossa

One billion years ago, when the positioning of continents was very different from the current one, the region including Almirante Tamandaré and the Nature Circuit was a **SEA FLOOR**. It is hard to figure out what was the landscape at that time, but there where surely sandy beaches, river mouths, sea floor sediments, and reefs. As time went by, the sands turned into sandstones i.e, the sediments became sedimentary rocks. Later on, forces related to crustal movements metamorphosed these sandstones into quartzites. In geology, we conventionally refer to these particular rocks as the **CAPIRU FORMATION**, a stratigraphical term that denotes their similar origin and positioning in space and time.

Now, take a look at the picture on left. It is a geological map showing the current distribution of rocks in this region. The quartzite corresponds to former sand beds. The phyllite corresponds to fine grained sediments (silt and clay) beds formerly deposited at the bottom of the sea. The metadolomite corresponds to former coral reefs in which the presence of life is evidenced by stromatolites. All these rocks are not at their original locations; they were folded, fractured and displaced as this portion of the Earths crust evolved.

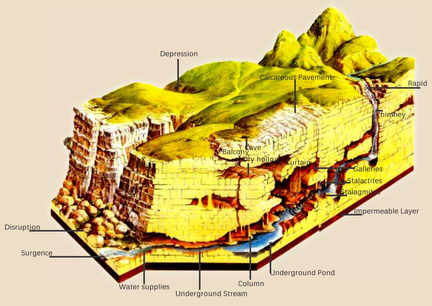
Notice how rocks control the relief. The metadolomite **(karst)** in blue forms lows in the terrain because it is less resistant to rain weathering than phyllite and quartzite (in orange). The ridges normally correspond to quartzite, the most resistant of the rocks present.

Notice also the green "lines" oriented to the Northwest. They represent diabase dykes, that consist of igneous rock generated 130 million years ago when Africa and South America separated to form the Atlantic Ocean. A massive arch appeared in this region in the early stages of continental separation, with deep fractures in the Earths crust through which magma ascended. The diabase dykes resulted from solidification of magma within such fractures.

The diabase dykes form ridges where they cut metadolomite bodies, and valleys where they cut phyllite and quartzite. This is due to the different resistance that each one of these rock types opposes to weathering: the less resistant the rock, the lower the relief, while more resistant types tend to be preserved as highs.

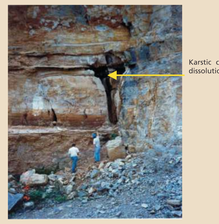
The Karst

A karst is a landscape whose bedrock is soluble in acidic water, like the limestones and dolomites of Almirante Tamandaré and neighbor municipalities. The name karst is taken from the Serbian-Croatian word meaning "calcareous field". The karst presents a peculiar relief originated from the slow (thousands of years) dissolution of such rocks, resulting in dolines, abrupt end of drainage systems, surgences, caves, and complex underground water flow.



How does the karst form?

All begins with rain water, that becomes acidic by adsorbing some of the carbon dioxide (CO_2) in the atmosphere. In the soil, rain water becomes even more acidic by adsorbing some of the carbon dioxide released by organic matter, and carbonic acid forms as (H_2CO_3) - $H_2O + CO_2 = H_2CO_3$. This acidified water dissolves the calcareous rock as it percolates its fractures. Spaces are thus enlarged to form galleries and caves.



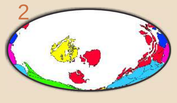
Karstic conduits formed by dissolution along fractures.

The origin of the Capiru Formation – a time travel

f the whole history of Earth (4.6 ba) and life could be condensed to a few minutes, we would be able to watch continents to collide and separate, mountain chains to arise, oceans to spread and close, and volcanic eruptions and earthquakes to take place at different parts of the globe at different times. We would witness abrupt environmental and climatic changes, and meteors and comets to fall from space, sometimes changing the course of evolution of species. The following is a brief sequence of changes from the **"Capiru Sea"** days until now.

DEPOSITION OF THE CAPIRU FORMATION SEDIMENTS

The age of Earth accounts to about 4.6 billion years. The Oldest rocks are known to be approximately 3.9 billion years old. Microfossils were found in 3.5 billion years old rocks. In the beginning, the surface of our planet consisted of hundreds of microcontinental masses. The first important continental collision event took place 3.0 billion years ago. Later, after a separation stage, continents collided again at about 1.0 to 1.2 billion years ago to form a megacontinent named RHODINIA. It was in the Rhodinia days that the sediments of the Capiru Formation deposited. Rhodinia occupied mainly the equatorial portions of the globe, extending from pole to pole. This megacontinent existed for approximately 400 million years before it broke apart. .



METAMORPHISM OF THE CAPIRU FORMATION

At about 650 to 550 million years ago, the continents in the southern hemisphere underwent a new grouping cycle, the South Pole being the center of the "stage. " That resulted in important continental collision events during which tectonic movements buried the Capiru Formation sediments to deeper levels in the Earths crust. Subject to high pressure and temperature conditions, the sediments evolved to sedimentary rocks that eventually transformed into intensely deformed metamorphic types.

THE CONTINENTAL DANCE GOES ON

The Paleozoic Era begins, and the continental drift goes on. Again continental masses are separated. They would group again 300 million years later, in the beginning of the Mesozoic Era, to form Pangea, a continent extending from one pole another and surrounded by the Pantalassa Ocean. Life flourishes to plenitude in the equatorial zone of the globe; the age of dinosaurs begins. In its evolutionary saga, Pangea would break into three large blocks 200 million years later: Laurasia to the North, Gondwana to the South comprising what now represents South America and Africa, and another block to the Southeast comprising what now represents India, Australia and Antarctica.

FORMATION OF THE DIABASE DYKES

Between 180 and 120 million years ago, immense hot spots resulting from mantle activity underneath Gondwana caused the continent to break into Africa and South America, with the consequent opening of the South Atlantic Ocean. Massive basaltic lava flows associated to this process covered more than 1.500.000 km2 of the states of Paraná, Santa Catarina, São Paulo in Brazil, and also important portions of Argentina, Paraguay and Uruguay. A considerable amount of lava ascended from the mantle through large fractures that would eventually become sealed with diabase as the magma cooled. The diabase dykes you see in the Nature Circuit were formed that way.

THE PRESENT

By the end of the Mesozoic Era 65 Ma ago, the impact of a huge meteor with a diameter of 17 km in the region that now corresponds to Mexico caused dramatic climate changes over the whole Earth. That marked the end of the Age of Dinosaurs and many other species, and the beginning of the Age of Mammals.

THE FUTURE

In 50 million years, the Atlantic Ocean will be much wider and the Pacific Ocean will be much narrower than now. Africa and Europe will collide to form new mountain chains which will bear fossilized remnants of the life forms found in the Mediterranean Sea, that will have disappeared. The continental dance will relentlessly go on centimeter by centimeter for millions of years as long as the Earths internal forces remain.

The rocks of the Capiru Formation

Stromatolites: The STROMATOLITES (structures formed by the activity of cyanobacteria and algae) in the Capiru Sea sediments are among the oldest records of life on Earth. The presence of such organisms for millions of years, the chemical precipitation of carbonate and the deposition of sediments in the shallow waters of the Capiru Sea resulted in the stripe of metadolomites in this region (carbonates with Calcium and Magnesium) – the whitish rock from which the calcium oxide is extracted for calcimine and soil correction agent.

Phyllites: fine to very fine grained and easily exfoliating metamorphic rocks composed mainly of quartz and mica, with a typical foliation. They formed from finer sediments such as silt and clay deposited in deep parts of the Capiru Sea or in shallower waters under low energy (movement) conditions.

Quartzites: these are metamorphic rocks composed mainly of quartz. They resulted form metamorphism of the sandstones formerly represented by sand beaches at the Capiru Sea.

Diabase: igneous rock composed mainly of feldspar and pyroxene, formed 130 million years ago during the separation of Africa and South America, when the Atlantic Ocean started to spread. See detailed information above in "The Capiru Formation - the rocks of Almirante Tamandaré."

Speleothems

Speleothems originate during the long period it takes for a cave to be carved. They consist of ornaments of crystallized minerals, especially calcite. Water becomes enriched in calcium bicarbonate after it infiltrates and dissolves the calcareous rock. This enriched water drops from the caves roof. Speleothems such as stalactites, stalagmites, columns, curtains etc. grow as calcium bicarbonate precipitates from salt-saturated droplets at the roof of the cave.

Stalactites, stalagmites and small curtains in a cave

The importance of the karst: risks and preservation

Three factors account for the importance of preserving the karst

WATER SUPPLIES: the cavities in the karst are perfect reservoirs of quality drinking water. Therefore, extreme care must be exerted so that pollutants are not incorporated to these ecosystems through ponds, streams, rivers, quarries, dolines etc., because the cavities are interconnected among themselves and to the surface.

OCCUPATION: occupation can both harm and be harmed when inappropriately conducted. The main problems are related to karstic collapse caused by:

1. occupation (buildings, heavy traffic);
2. mining (explosives can cause cave roofs to collapse);
3. water drilling without proper technical control cause abrupt water table oscillations.

NATURAL PATRIMONY: the main caves of Paraná are in the karst. Given their geological, biological, historical and cultural importance, these caves are a federal natural patrimony stated in the Brazilian Constitution. Inappropriate occupation can irrecoverably destroy this patrimony that belongs to mankind.

Doline in the city of Almirante Tamandaré, the underground water supply being polluted by solid waste and sewage.

Karstic collapse: holes and cracks in buildings

Speleothems: columnar stalactite and stalagmite.

Realization:

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

MINEROPAR
MINERAIS DO PARANÁ SA

Partners:

SECRETARIA DE ESTADO DO TURISMO
PARANÁ TURISMO

Cultura
Secretaria de Estado

ECOPARANÁ

SEMA

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