

# In the Penha Garcia Fossils Trail

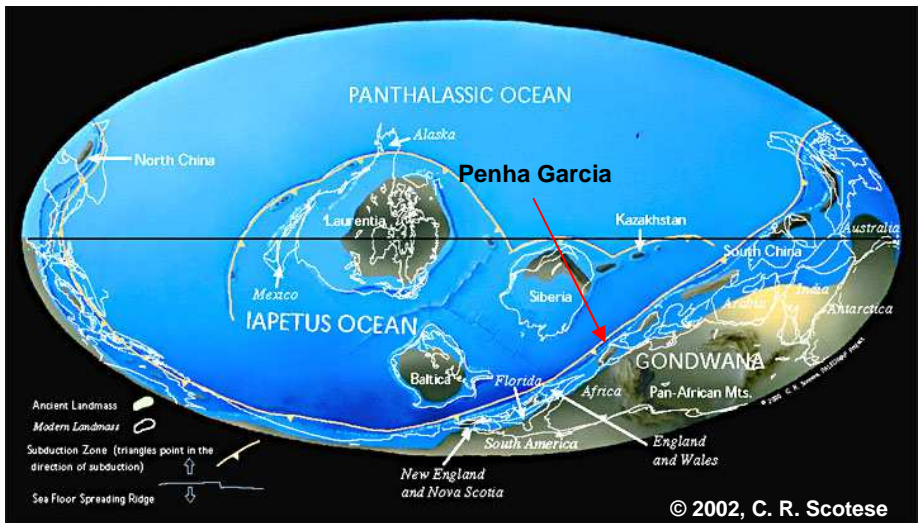
looking for traces  
from a 480 million years old sea

boiling of life...

# 12 questions that GEOtourists frequently ask while they do the PR3 (Fossils Trail) and visit Penha Garcia Ichnological Park

## 1. GEOtourist: *What?! Sea, 480 Million years (Ma) ago, here?*

**Guide:** Yes, in these rocks there are evidences for the existence of a sea. But to understand better lets go back in time and observe the distribution of continents and oceans, during the Ordovician period, in the scheme in figure 1.



**Fig. 1.** Paleogeographic reconstitution for the Ordovician times (488-443 Ma), adapted from C.R. Scotese (www.scotese.com).

## 2. GEOtourist: *What is the difference between location of continents and oceans during the Ordovician relatively to nowadays position?*

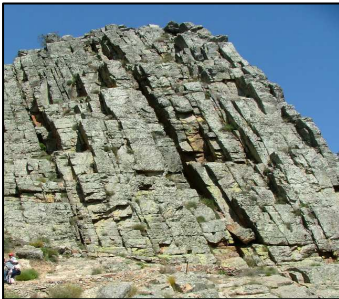
**Guide:** The majority of the continents were unified in a supercontinent, called Gondwana, located in the South Pole. In those times, the rocks that we step on now were formed in a shallow sea, located in NW of Gondwana supercontinent.

### 3. GEOTourist: What vestiges of that ancient sea can we find in the Fossils Trail?

Guide: These rocks, the sedimentary structures and the fossils of organisms that are preserved in the rocks indicate an origin in marine environment.

#### **-Rock type:**

**Quartzite** (Fig.2.)



They were sedimentary rocks, made of quartz sand that were deposited in the sea between 479 and 468 Ma.

Quartzites dominate, but there also existed thinner than sand grains, that originated schist

**Fig.2.**

#### **- Sedimentary structures with a non biogenic origin:**

**Ripple marks** (Fig. 3.)



This kind of structure has the appearance of small waves. They result from the movement of sand by the action of the currents in shallow coastal environments.

**Fig.3.**

**Synaeresis cracks** (Fig. 4.)



They are formed due to percolation of sea water from the the sediments pores.

## Tempestites (Fig. 5.)

Fig.4.



They are formed by the action of turbulent flow frequent in storm periods that reached the sea bottom and rummaged the sediments depositing them in a new arrangement.

Fig. 5.

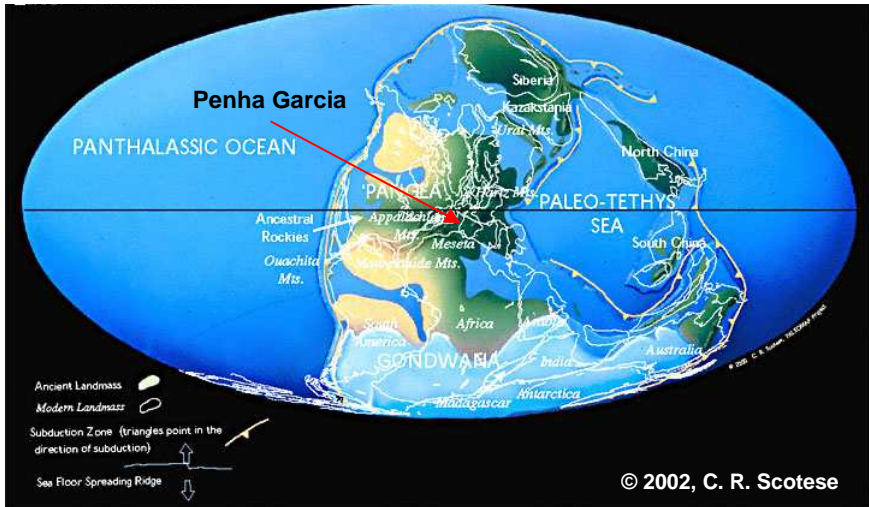
### - Activity remains of marine creatures – ichnofossils

Feeding traces; Vertical cylindrical dwelling burrows, U-shaped dwelling burrows; locomotion trails.

### 4. GEOtourist: How were the quartzites originated?

**Guide:** 480 Ma ago, erosion of nearby continental areas provided sand-size particles and with the main mineral composition of quartz. This quartz sand deposited in shallow sea bottoms, in tabular, almost horizontal layers (strata) limited by stratification surfaces. During Ordovician layers over were deposited of these sandy sedimentary rocks. Later on, those rocks suffered compaction, dehydration and even precipitation of minerals, from the captured fluids among the sediments, being transformed in cohesive sedimentary rocks, the quartzite sandstones.

Since Gondwana supercontinent formation, tectonic movements made the remaining continental plates to get closer. 300 Ma ago several continental plates collided forming Pangea supercontinent (fig. 6). This intercontinental collision promoted the increase of pressure and temperature in the rocks. In these new conditions, sandstones, sedimentary rocks as they were, were transformed in metamorphic rocks, quartzites, much more cohesive and harder.



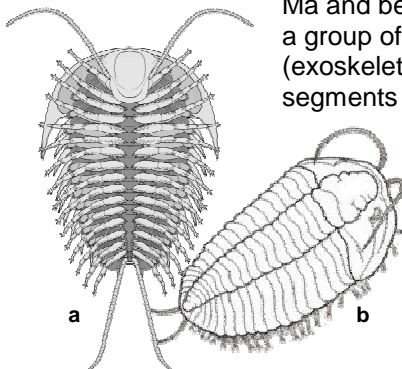
**Fig. 6.** Paleogeographic reconstitution of continents 300 Ma ago, adapted from C. R. Scotese ([www.scotese.com](http://www.scotese.com)).

## 5. GEOtourist: Why are the rock strata almost vertical and sometimes folded?

**Guide:** During intercontinental collision occurred deformation in rocks that were part of bed of the sea and his uplifting. The layers aren't anymore in their initial position, they are now inclined, almost verticals, folded and also with faults. Succeeding this geological events, in this region, it was formed a big folded structure in syncline, the Penha Garcia Syncline

## 6. GEOtourist: Which marine creatures originated the major number of fossils?

**Guide:** Trilobites – they are marine arthropods, which appeared 545 Ma and became extinct 250 Ma ago. Arthropods are a group of animals with an external skeleton (exoskeleton); the body is divided in several segments and have articulated appendages. They lived in the bottom of the sea, excavating sediments looking for organic material and/or were predators.



**Fig. 7.** Ventral (a) and dorsal (b) reconstruction of a Trilobite by Sam Gon III (<http://www.trilobites.info>).

## 7. GEOtourist: What are ichnofossils?

**Guide:** They are a kind of fossils that correspond to remains of the activity of living beings, such as feeding, reproduction and locomotion.

## 8. GEOtourist: Which ichnofossils can we find along the trail and what are the producer's organisms?

**Guide:** Let's look to the Chart I and let's try to identify these kinds of ichnofossils in rocks.

Tabela I

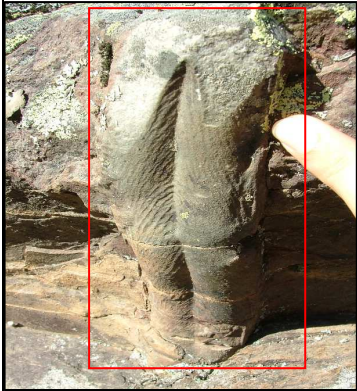
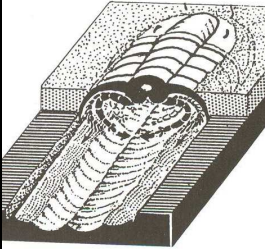

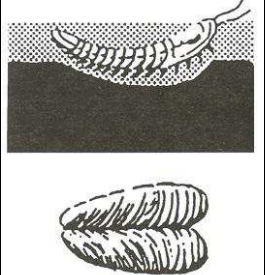
Ichnofossil (photo)	Type of ichnofossil	Scheme
<p><b>Cruziana</b></p> 	<p><b>Feeding traces that</b> present two essentially horizontal bilobated furrows, with a central ridge and may have V-shaped striations – scratch marks.</p> <p>The photo shows the epirelief preservation of the burrow and the ridge appears as a tight furrow between salient lobes.</p>	<p><b>Trilobite</b></p>  <p>Seilacher, 2007</p>
<p><b>Rusophycus</b></p> 	<p><b>Resting trace with a</b> coffee bean shape, and scratched lobes.</p> <p>The photo shows the epirelief preservation of the resting trace</p>	<p><b>Trilobite</b></p>  <p>Seilacher, 2007</p>

Table I (cont.)

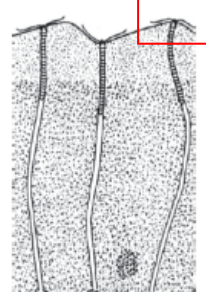
**Monocraterion**



**Dwelling vertical burrow** that opens as a cone upwards. Near the burrow entrance it is possible to observe one area where occurred the scabble of sediments.

The photo shows a transverse section of the burrow.

**Phoronid worm/ sedentary polychaetes**



Bromley, 1990

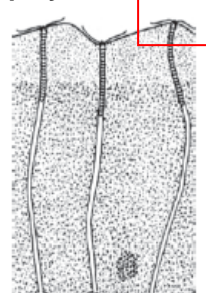
**Skolithos**



**Dwelling vertical burrow** that is thin, vertical and cylindrical, simple structure .

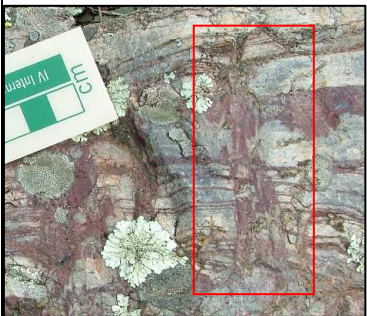
The photo shows the burrow filling.

**Phoronid worm/ sedentary polychaetes**



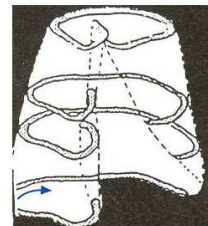
Bromley, 1990

**Daedalus**

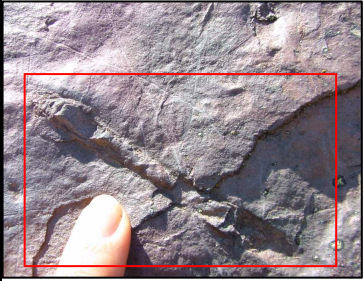
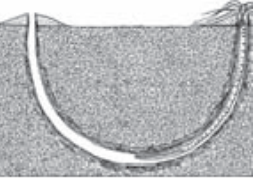
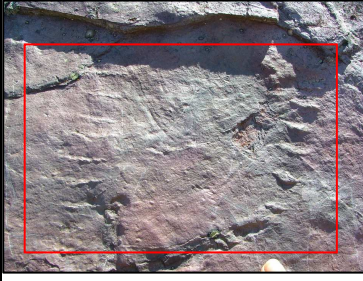
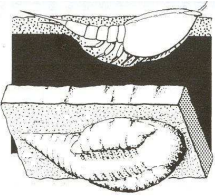


**Dwelling vertical burrow** that results from excavations that reworked the sediment in the 3 space dimensions, with a helicoidally displacement of a J- shaped burrow.

**Worm with unknown origin**



Seilacher, 2007

<p><b>Arenicolites</b></p> 	<p><b>Dwelling U-shaped burrow,</b> perpendicular to the layer</p> <p>The photo shows the epirelief preservation.</p>	<p><b>Sedentary polychaete worm</b></p>  <p>Bromley, 1990</p>
<p><b>Merostomichnites</b></p> 	<p><b>Trail and impressions</b> that represent continuous locomotion, parallel to the layer, with similar shape and dimension of appendages.</p> <p>The photo shows the epirelief preservation.</p>	<p><b>Phyllocarid crustaceans</b></p>  <p>Seilacher, 2007</p>

**Table I (cont.)**

**9. GEOtourist: When was the first written reference about these ichnofossils and who was the author?**

**Guide:** In 1885 Nery Delgado, famous Portuguese paleontologist, published a monograph entitled “Paleozoic terrains of Portugal – Study on Bilobites and other fossils in quartzites from the Silurian System base from Portugal” where he describes and presents images of Penha Garcia fossils, specially *Cruziana*.

**10. GEOtourist: Which are the most abundant ichnofossils?**

**Guide:** *Cruziana*, which are Trilobite feeding burrows, were produced while they revolved the sediments of the sea bottom, looking for organic particles to feed themselves.



## 11. GEOtourist: What is the importance of *Cruziana*?

**Guide:** The Penha Garcia *Cruziana* importance is recognized internationally, because this is one of the places in the world where it is more abundant, in a small area, they are highly diverse and show excellent preservation conditions.

They allow to study and to understand the Trilobites behaviors while they were feeding, the kind of feeding they had, life cycle and their ventral morphology.

## 12. GEOtourist: What is the interpretation of the fossils made by the village inhabitants?

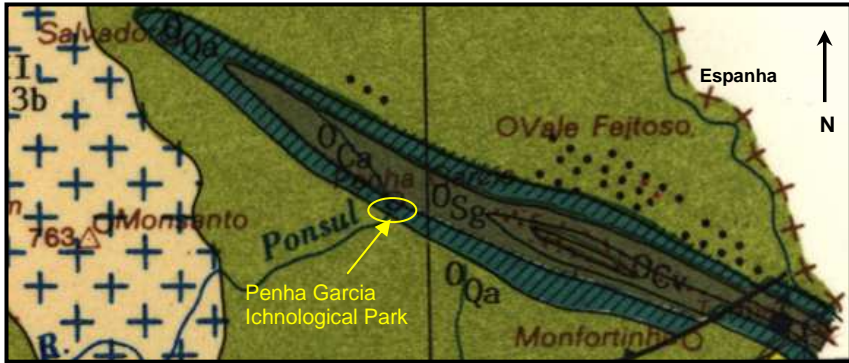
**Guide:** They call them “painted snakes” and they associate them to a legend: “Once upon a time, an enchanted Moorish girl was bewitched and transformed into a petrified snake. In the Saint John night, the Moorish girl comes back to her original form and the sorcery may be broken if someone kisses her and a treasure will be given as prize to her enchanted prince”.

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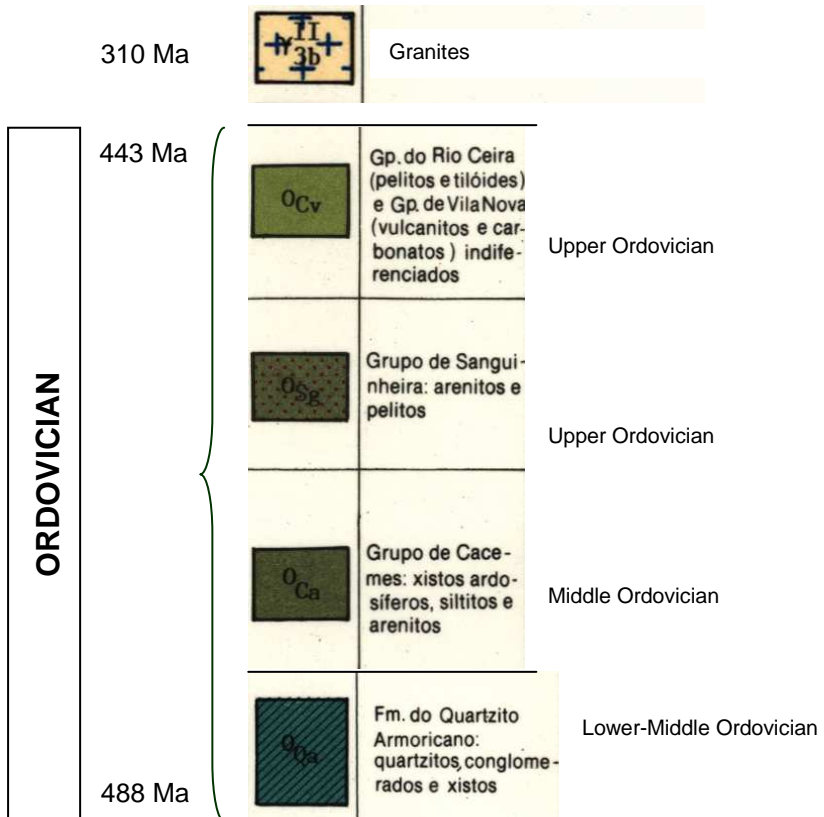
### Penha Garcia

*The stone dip carries the weight  
of the wind. In a cleavage of millennia,  
counted by the fossils, the eyes meet the skylight  
by which they look at the beginning:  
an ocean soup where life  
ferment. But in the village coffee shop,  
I turn the flute to see  
how it plays; and the blow  
vanishes inside the worked cane,  
where fingers cover and uncover the holes,  
trying to release the music.  
Maybe this flute is another fossil,  
And my blow only release a memory  
of old cane-plantations, where the birds  
still sing. Then, a river flows again inside the canes;  
and their music fills the coffee shop,  
making the employee to turn the tap off,  
as though it were from there the water sound.*

Nuno Júdice, in *As Pedras dos Templários Nos 800 Anos de Idanha-a-Nova*



**Fig.8.** Adapted extract from Geological Map of Portugal, scale 1:500 000 (Oliveira *et al.*, 1992, edited by IGM). It is possible to observe the rocks which compose Penha Garcia Syncline. The Quartzitic Formation is represented with OQa and corresponds to the relief visible in figure 9.



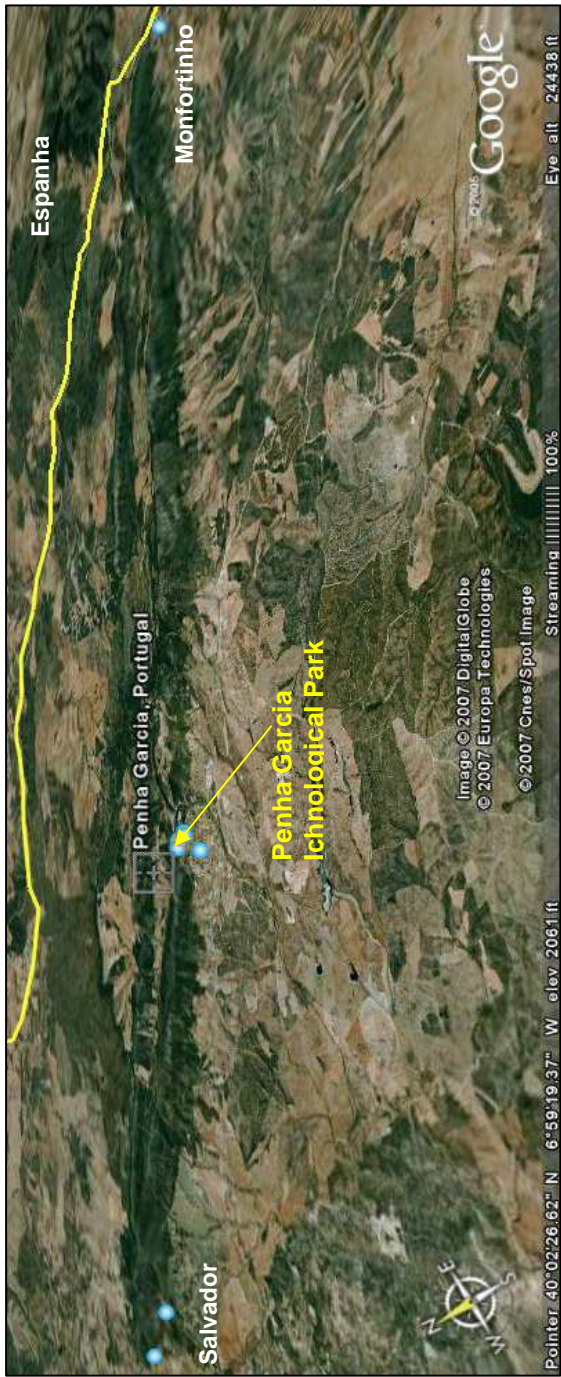
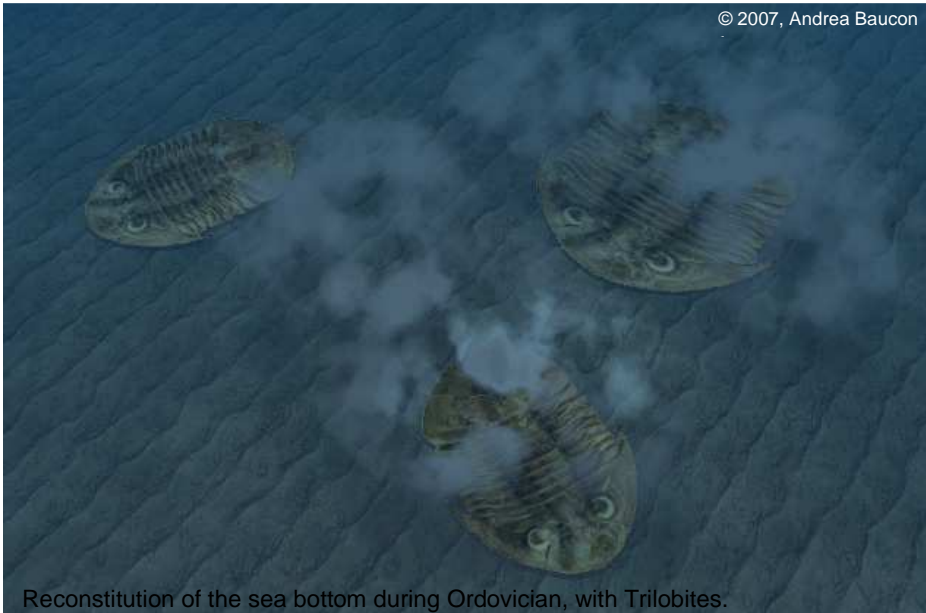


Fig. 9. Penha Garcia Syncline (satellite image from Google Earth).



Reconstitution of the sea bottom during Ordovician, with Trilobites.

When you come down to the Ponsul river valley get dress the diving suite and put on the fins to start the adventure of backing 480 Ma in time and diving in the shallow sea that bathed this area. Fill yourself swimming side by side with primitive beings that constituted marine communities in former times, such as Trilobites, spying them to know their secrets and survival strategies, many times disturbed by ferocious storms and sometimes by small earthquakes ... Here stays the invitation to your imagination. ...

**ORGANIZATION:**

Maria Manuela Catana (Coord.)

M. Isabel Caetano Alves, Carlos Neto de Carvalho and Andrea Baucon

**TRANSLATION:**

Joana Rodrigues & Carlos Neto de Carvalho

