Farnham Geological Society

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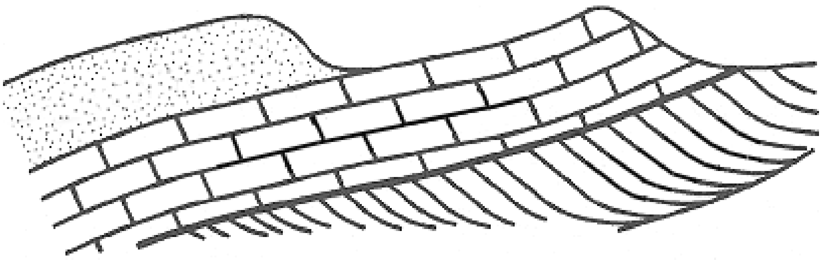

A local group within the GA

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Newsletter

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Editorial

My job is made easy by the work which Janet Catchpole and Graham Williams do in finding excellent speakers for our monthly talks and excellent leaders for the field trips. Both the talks and field trips cover a large variety of geological topics and locations and as most of our speakers are kind enough to provide good summaries it is normally possible to produce an interesting newsletter.

This edition of the Newsletter covers such divers topics as the Planet Earth, the geology of Portugal, Devonian fishes, geological hazards, a Shetland Isle conglomerate and a giant Titanosaur. I hope you enjoy it.

Liz Aston

Devonian fishes

Summary of December 2013 lecture given by Peter Forey, Natural History Museum

In popular books the Devonian Period is known as the ‘Age of Fishes’, and with good reason. Between 415Ma and 360Ma, distant relatives of modern fishes appeared alongside fishes that left no trace in our seas, lakes and rivers. The study of these fishes is intimately intertwined with the scientific development of palaeontology in the nineteenth century as well coinciding with the hey-day of private ‘collecting’ for gentlemens’ cabinets of curiosities.

The talk outlined some of the problems of interpreting fossils encountered by well-known figures such as Louis Agassiz, Thomas Henry Huxley and Hugh Miller – all of whom struggled to make sense of Devonian fishes. It has been impossible to provide a true summary of Peter’s excellent and informative talk, but I have tried to provide images from his talk of the main fish types, families and ages.

Peter Forey retired from the Natural History Museum after a life researching the evolution of fishes from the Ordovician to the Recent. His expeditions took him to many challenging places where he collected many fossil fishes as well as many wonderful memories.

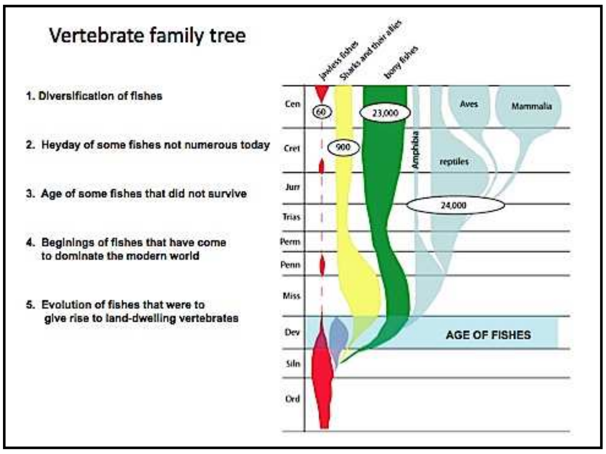


Fig. 1: Vertebrate Family Tree - Age of Fishes

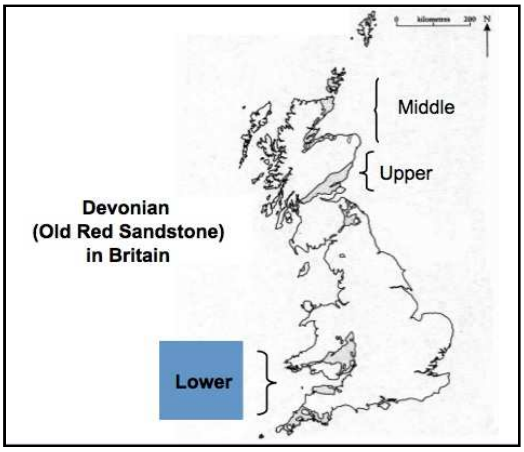


Fig. 2: Outcrops of Devonian (ORS) in Great Britain

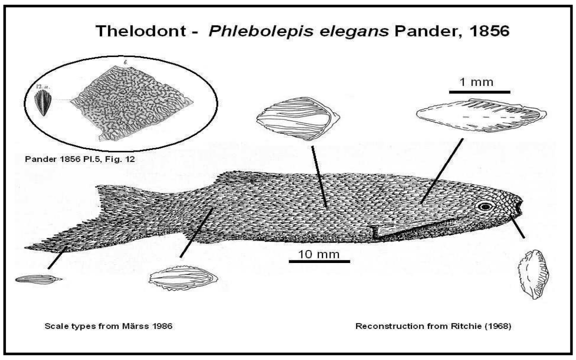


Fig. 3 (L): Cephalaspid, a Jawless fish, Lower Devonian (L. ORS)
Fig. 4 (centre): Pteraspid, a Jawless fish Lo. Devonian (L. ORS)
Fig. 5 (above R): The Thelodont – a jawless fish with distinctive small spiny scales, now extinct. Lower Devonian (L. ORS)

Fig 6: Pterichtyodes (Miller's Winged fish)

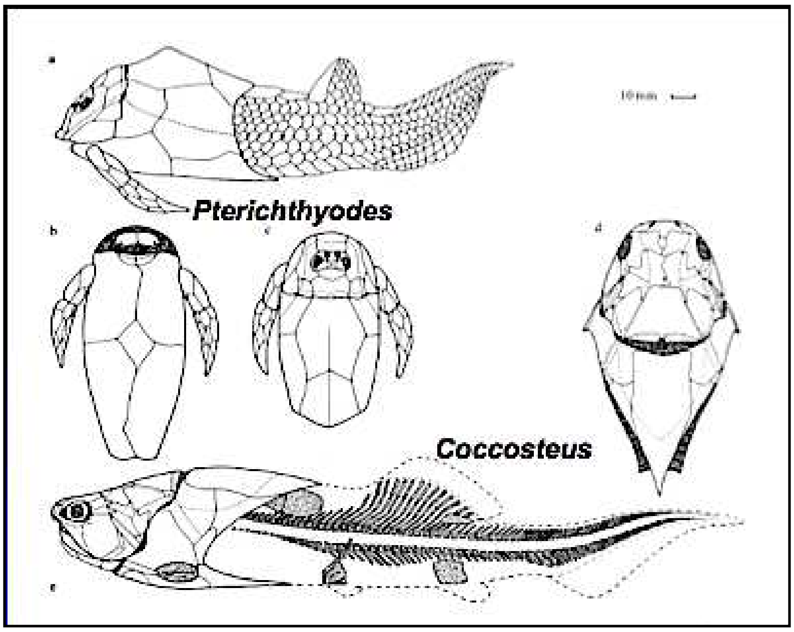


Fig. 7: Placoderm Fish

Fig. 8: Dinichthys, Upper Devonian, Cleveland Shales

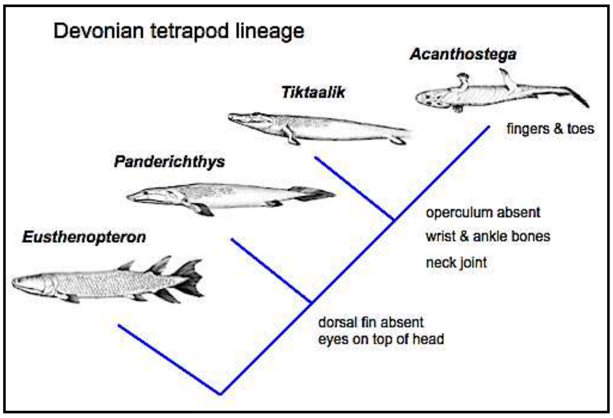


Fig. 9: Devonian Tetrapod Lineage

Summary by Liz Aston

FGS field trip to Portugal - 1 to 7 September 2013

Led by and article written by Lesley Dunlop

Portugal, together with Spain, makes up the Iberian Massif and comprises five main tectonic units that came together just over 300Ma. The tectonic map of Portugal (Figure 1) shows these and the main fault lines. Since that time there have been several other significant events that have shaped the country such as the closure of the Rheic Ocean and Variscan Orogeny followed by basin formation during the Triassic, including the Lusitanian Basin where carbonates were being deposited during the Middle Jurassic.

The central coastal part is covered by younger cover which shows evidence of the Bay of Biscay opening (125-85Ma) and then, during the Tertiary, there was significant crustal shortening, possibly about 300km.

The Iberian Massif has been said to provide the key to understanding the history of the circum-Atlantic region during the Late Proterozoic and the Palaeozoic, particularly with regard to the evolution of the northern margin of Gondwana and the Rheic Ocean. It provides exposures and structures to study deformation mechanisms in a collisional orogenic belt at different depths, particularly the large crustal thrusts and is a good reference to understand the genesis of granitoids in collision belts. It is not often that a complete section including both forelands of an old collisional orogen is found preserved.

Precambrian to Silurian Rocks of the Central Iberica and Ossa Morena Zones

The oldest rocks are the metasediments seen in the northern, central and eastern part of the country. These are shown on the tectonic map as cream and blue. The sediments here are Precambrian to Silurian marine mudstones, sandstones and limestones, which were metamorphosed during the Caledonian Orogeny to become schists, quartzites and marbles. The quartzites are probably the most obvious, often forming prominent ridges running NW to SE across the country. These ridges commonly have fortresses on them such as at Marvão and Buçaco. Granite intrusion (early granites) also occurred at approximately this time and these granites are foliated and deformed by the later Variscan Orogeny

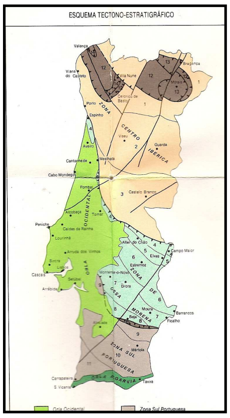


Fig. 1: The Main Tectonic Units of Portugal

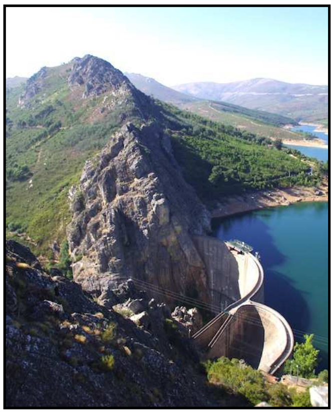


Fig. 2: Quartzite Ridge, Serra da Estrela

Fig. 3: Marble Quarry, Borba

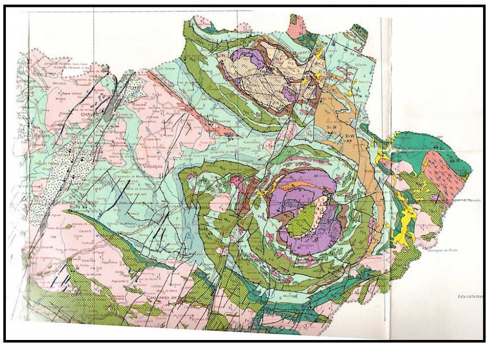


Fig. 4: Geological Map of Area around Bragança

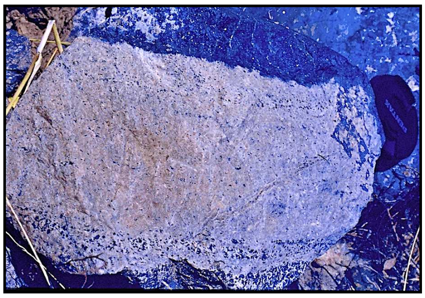


Fig.5: Chromite-bearing ultrabasic Rock, Carrazedo, Bragança

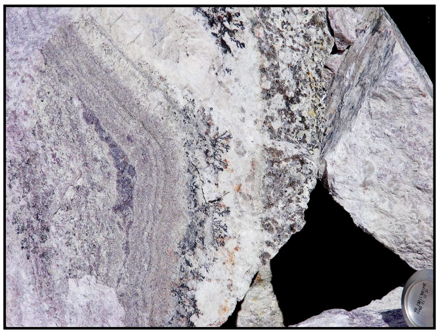


Fig. 6: Lithium pegmatite, Gonçales, near Colvilha

Near Penha Garcia, in the central eastern part of the country, trilobite tracks are found within quartzites (Figure 2), which are dated as early Ordovician.

In the SE, the marbles are worked around Borba and Estremoz for national and international use. The steeply dipping strata outcrop out in narrow bands, requiring quarries working the stone to be very deep. Lying unconformably on Precambrian schists, greywackes and quartzites are carbonates, dated as Ordovician. The sequences were folded and metamorphosed during the Hercynian Orogeny and display ductile folding of the strata. Marble has been extensively quarried in this area since Roman times for architectural decoration (Figure 3).

In NE Portugal around Bragança, there are two circular shaped outcrops shown on the geological map (Figure 4). There are similar outcrops in the adjoining parts of Spain and these are Palaeozoic ophiolite fragments and associated alkaline lavas, granulites, eclogites, gneisses and ultrabasic rocks. They were emplaced by thrusting in a WNW direction during the Early- to Mid-Devonian as part of the Variscan Orogeny. They have been interpreted as originating from ultrabasic rocks emplaced into a granulite- and eclogite-bearing island arc / continental collision complex formed during the early Ordovician.

The ultrabasic rocks are found easily by looking at vegetation changes - the areas tend to look brown and in summer dry out more quickly. Chromites (e.g. Figure 5) have been mined around Bragança and there are numerous chromite prospects and small podiform chromite mines. All these mines and prospects ceased operation in the early 1950s although there has been more recent interest as it is known that they contain some of the platinum group elements - although not in high enough concentrations to be viable presently.

Granites of the Central Iberian Zone

These granites are associated with the Variscan Orogeny and date from about 295Ma. They are typically S-type granites *(i.e. result from the partial melting of metasediments, a process called anatexis or ultrametamorphism)* and as with those of SW England are often hydrothermally altered and mineralised. These are best visited around the Serra da Estrela where the rocks are found to be coarse grained, porphyritic and to contain both biotite and muscovite (Figures 6-9). Locally there are variations such as the lithium bearing pegmatites close to Covilha, tin-tungsten mineralisation at Panasqueira and quartz, feldspar pegmatites at Mangualde.

Close to Monsanto the granite has weathered into 'mushroom shapes' (Figure 10) which are typically several metres high and locally known as 'Granite Isles'.

Fig. 7: Feldspar pegmatite, Mangualde used for porcelain

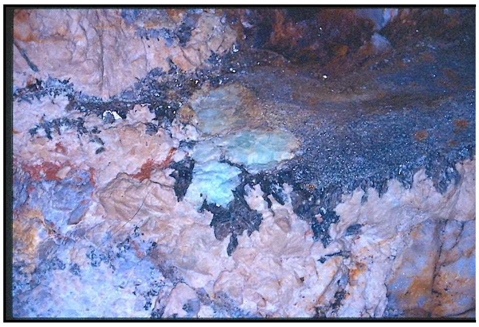


Fig. 8: Beryl & Mica: also present in the pegmatites with tourmaline

Fig 9: Quartz crystal – Mangualde (chair for scale)

Panasqueira Tin-Tungsten Mine

This is an underground mine utilising stall and pillar mining methods situated in central Portugal on the southern edge of the Sierra de Estrela mountain range (Figures 2, 11).

Tungsten (Figure 13) and tin have been mined in the Panasqueira area since the 1890s. In 1928, these workings were integrated into Beralt Tin & Wolfram Ltd, an English company, briefly listed on the London Stock Exchange. Minorco, part of Anglo-American group, acquired a controlling interest in Beralt from Charter Consolidated in 1990. A minority interest was held at that time by IPE, a Portuguese State holding company. In the mid 1980s, Panasqueira had over 1,000 employees in its underground mining and plant operations that processed 600,000 tonnes of ore p.a. to produce in excess of 2,000 tonnes of WO_3 p.a. in concentrates. Tailings were widespread (Figures 14, 15).

Fig. 10: Granite 'mushroom' Monsanto.

Fig. 11: General view of the Serra da Estrela

Fig. 12: Glaciated valley leading from the Serra to Manteigas

Minorco ceased operations and placed the mine on care and maintenance at the end of 1993. In 1994, a predecessor of Avocet Mining PLC of the U.K. acquired the Minorco interest and later acquired the IPE interest.

Under new management, Beralt has been successful in increasing production from the mine to an economic level and is presently benefitting from significantly higher tungsten prices. It has implemented plans to introduce new, low profile mining equipment in order to increase underground productivity and reduce mining dilution, and continues to upgrade equipment and the processing plant to improve efficiencies. The company logo of Beralt Tin and Wolfram (Figure 16) can be seen on most of the buildings. The mine is now owned by a Japanese company, Sojitz, and work has restarted underground.

The Panasqueira deposit consists of a series of stacked, sub-horizontal, hydrothermal quartz veins intruding into the Beira schists hosted within a flat, open set of joints. The flat open joint system occurs over the whole of the area surrounding the mine, but only in the vicinity of the Panasqueira granite are the tungsten mineralized veins developed. A second set of non-wolframite bearing quartz veins containing minor chalcopyrite and pyrite also exists at the Panasqueira deposit. These earlier quartz veins are aligned with the vertical foliation and cut by the later tungsten-bearing hydrothermal vein system.

The Panasqueira deposit occurs as a sequence of sub-parallel stacked quartz veins containing principally, wolframite, arsenopyrite, pyrite, chalcopyrite and cassiterite. The tungsten mineralized quartz veins have an average dip of 80°-100° SW. The mineralized zone has dimensions of approximately 2,500m in length, it varies in width from 400m to 2,200m and continues 500m in depth to date. Historic mining was from the upper levels, reserves from above Level 0 and Level 1 have been mined out.

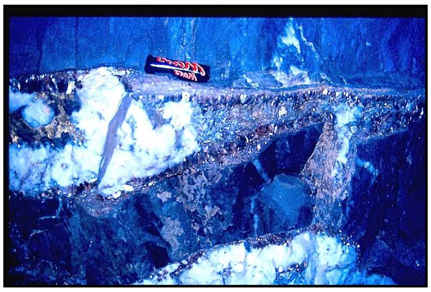


Fig. 13: Tungsten, mica, quartz

Fig. 14: Mine tailings, River Zezere.

Fig. 15: Mine Workings, Barocca

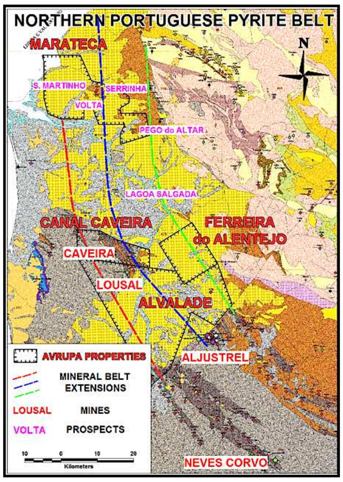
The Iberian Pyrite Belt (South Portuguese Zone)

To the south of Setubal and across into Spain there is a series of deposits known as the Iberian Pyrite Belt. These are probably better known from the Rio Tinto area of Spain but those of Portugal have been worked since pre- Roman times. There is evidence of Roman iron working at Aljustrel.

The Iberian Pyrite Belt is a vast geographical area with particular geological features and stretches along much of the south of the Iberian Peninsula, from Portugal to Spain. It is about 250km long and 30-50km wide, running NW to SE from Alcácer do Sal (Portugal) to Sevilla (Spain). The mining activity in this region goes back thousands of years.

Fig. 16: Beralt company logo.

Fig. 17: Caveira Mine Area



(Right) Fig. 18: Map of current main prospects

The Iberian Pyrite Belt was formed 350Ma in the Devonian Period, connected to active and hydrothermal volcanism that led to the formation of a volcanic-sedimentary complex. Volcanic activity in the region led to eight giant volcanogenic massive sulphide ore deposits (VMS) associated with polymetallic massive flanks of volcanic cones in the form of pyrite, and also chalcopyrite, sphalerite, galena and cassiterite. The deposits of the Iberian Pyrite Belt are notable examples of volcanic- and sediment-hosted massive sulphide (VSHMS) deposits. Over 250 deposits are known in the belt. Whilst the main gold-silver-copper mineralisation is associated with the volcanic rock, it is the enriched oxidised 'gossan' areas above these which were worked originally.

One of the largest mines in this area is still operational and is at Neves Corvo (Figures 17 to 20) where six massive sulphide lenses have been discovered. The Neves-Corvo ore bodies were discovered in 1977. The Portuguese company Somincor was established to exploit the deposit and by 1983, the Corvo, Graca, Neves and Zambujal sulphide deposits had been partially outlined, covering an area of some 1.5km x 2km. Rio Tinto Group became involved in the project in 1985, forming a joint venture with the Portuguese government (EDM). First production began from the Upper Corvo and Graca ore bodies in January 1989. The base metal grades are segregated by the strong metal zoning into copper, tin and zinc zones, as well as barren massive pyrite. The massive sulphide deposits are typically underlain by stockwork sulphide zones, which form an important part of the copper ore bodies.

Fig. 19: Processing plant, Neves Corvo

Fig. 20: Statue

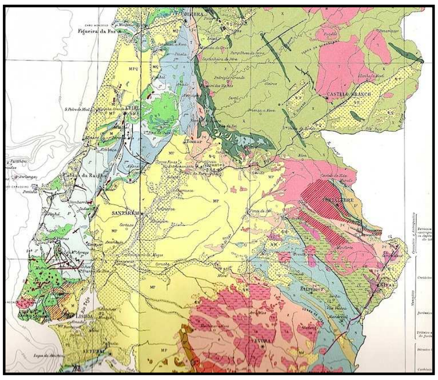


Fig. 21: Geological map, Lisbon & Setubal Area

The Western Zone – along the coast between Porto and south of Setubal

The area consists of sedimentary Jurassic and Cretaceous rocks (Figure 21) which surround an upland of igneous rocks in the Sintra area.

The oldest rocks are Jurassic in age and were deposited into the Lusitanian basin approximately 160Ma. The Atlantic Ocean was not present at that time and the Lusitanian Basin was one of several, possibly connected, small seas. The initial deposition indicates fairly deep marine conditions becoming shallower into the Cretaceous. During the Cretaceous the basin gradually filled and lacustrine deposition became dominant. The total thickness of

Jurassic and Cretaceous rock is about 2,200m, deposited over about 60Ma. The latitude at the time was about 20°-30°N with a hot and humid climate.

Following the sedimentary deposition there were tectonic events, which lead to the opening of the Atlantic, and intrusion of the Sintra Massif during the late Cretaceous. Following the intrusion and uplift of the region the sedimentary cover was eroded and deposited in the surrounding areas. The Late Cretaceous Benfica Complex has been interpreted as part of this sequence. Miocene sediments were later deposited and on the south of the Setubal peninsula these exhibit thrusting and crustal shortening. Some sites where these features are seen are given below.

Cabo Espichel

This cape is the southern tip of the Setubal peninsula (Figure 22). It has been a place of pilgrimage since the 13th Century and in the 17th Century a sanctuary was built there with rooms for pilgrims which are now disused. To the north there is a small bay which marks the boundary between the Jurassic marine and Cretaceous terrestrial deposits.

According to ancient folklore, Our Lady stepping down from the sea would have ridden up the cliff on a mule to the platform above the cliffs named Pedra da Mua at Lagosteiros Bay. Mule’s footprints, regarded by fishermen as evidence, could be clearly seen on the cliffs. There are indeed footprints but are from dinosaurs (Figure 23) of, at the latest, Portlandian in age. This spectacular locality is rich is giant Sauropod tracks on the cliffs (Figure 22) that have seldom been found elsewhere in Europe. Following further study another locality with dinosaur footprints of Lower Cretaceous age has been found on the northern cliffs at Lagosteiros. Dinosaur tracks were made on calciclastic sands in a lagoonal environment, protected by coral reefs. A later ingression preserved the prints. Five types of tracks and footprints have been recognised:

- *Neosaurus lagosteirensis*, tracks from a giant sauropod perhaps *Camarasaurus*. Total length of animal about 15m. The only known sauropod track in the Lower Cretaceous in Europe.
- Tracks from a not so big quadruped, possibly a Sauropod. But could be from a Stegosaurus or Ankylosaurus.
- *Megalosauropus*, four therapod tracks most probably produced by megalosaurs.
- *Igaunaodon sp*., represented by some footprints and especially by a set corresponding to the feet and tail from an individual standing in a resting position
- Problematical, quite small biped.

The evidence points to a warm and moist climate where there was plenty of vegetation for the herbivores.

Fig. 22: Cliffs at Cabo Espichel.

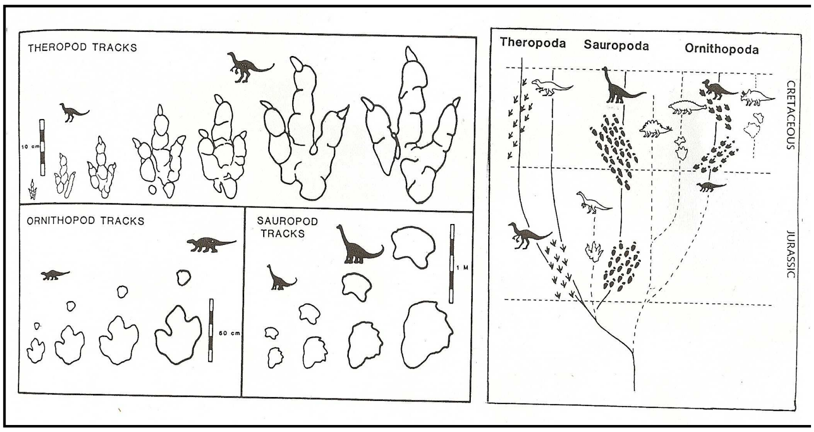


Fig. 23: Dinosaur Tracks and ‘Evolutionary Tree’.

Arrabida – between Setubal and Cabo Espichel

The Arrábida Mountain Range is the best example in Portugal of Alpine movements. During the Miocene, it acquired the present structural set up with thrusts striking ENE-WSW and N-S or NNE-SSW sinistral lateral ramps. The main tectonic phase occurred about 17-16Ma ago. The Miocene deposits are mainly biocalcarenites and date from about the same time as the latest timing for the orogeny.

There are many quarries exploiting one of the local stones for decorative use: the Arrábida Breccia (Figure 24). This breccia is composed of rock fragments of multiple colours cemented together by a reddish material; it formed about 150Ma on top of the local limestones (many of which make up the breccia) and was not affected by the faulting which is associated with the limestones. The Miocene deposits, mainly biocalcarenites, display evidence of crustal shortening with thrusts developed.

Fig. 24: Arrábida breccia, an Ornamental Stone

Fig. 25: Peniche

(Right) Fig. 26: Sintra Igneous Massif

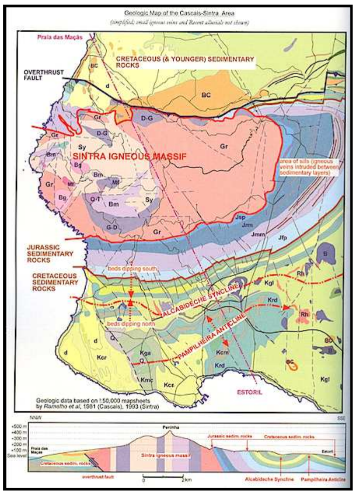


Fig. 27: View S from Peninha, on a syenitic part of the Sintra massif overlooking Cretaceous and Jurassic sediments.

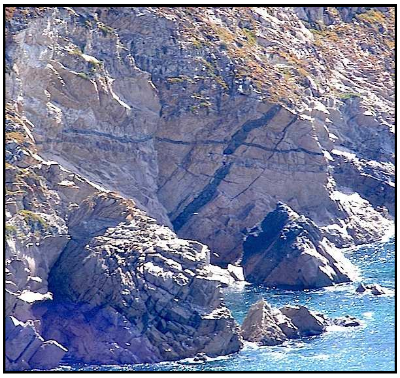


Fig. 28: Veining near Cabo da Roca

Peniche

These carbonates have been dolomitised, form a karstic topography with a flat pavement with rough surfaced blocks separated by crevices. This is also known as a lapiés or karren-field. This can be seen at Peniche (Figure 25) where the lower Jurassic displays excellent karst formation. Here, there is carbonate and clastic deposition into a basin adjacent to the Berlingas horst. The Berlingas Islands which can be seen in the distance of the image are granitic. Interbedded with the carbonates around Peniche are volcanic rocks and elsewhere volcanic bombs can be seen indicating a nearby source of material associated with extension of the Lusitanian Basin.

Sintra Igneous Massif

Following the sedimentary deposition there were tectonic events which lead to the opening of the Atlantic, and intrusion of the Sintra Massif (Figure 26) during the late Cretaceous. This is an elliptical body about 10km long and 5km north to south. The great proportion of the rocks are *alkaline* rocks and felsic and include five large quartz syenite intrusions (Figure 27) and trachyandesite, trachyte and alkali rhyolite lavas and dykes, most of which are oversaturated. Mafic rocks are uncommon, but vary widely from alkaline and highly undersaturated types containing high K_2O, TiO_2 and Ba, similar to the contemporaneous Lisbon lavas, to hypersthene normative trachybasalts and one hypersthene normative basalt. The various magma types are intimately associated and a well-developed net veined complex of alkali gabbro, monzonite and syenite is recognised at Cabo da Roca (Figure 28).

Editor's Note: For further information regarding the classification of granites, go to the following link which downloads as a pdf document: *www.nsm.buffalo.edu/courses/gly206/L08B_SIAMClassy.pdf*

An examination of material from the Funzie conglomerate of Fetlar

An exposure of this conglomerate, up to about the 60 m contour, can be seen on the south-east coast of the island of Fetlar, one of the Shetland Islands, and a characteristic pebble with some still attached matrix has been subjected to microscopical examination .

Fig 1: Funzie cliffs, conglomerate

Fig2: Quartzite pebble with matrix still attached

Fig 3: Longitudinal section through pebble showing matrix porosity

Fig.l shows that this particular cliff face exhibited a well defined geometric pattern. The conglomerate consisted of deformed quartzite pebbles loosely embedded in a complex matrix of igneous and metamorphic material, and the extensive permanent deformation of what, at normal temperature would be brittle material, indicates this flow must have happened under elevated temperature-low strain rate conditions.

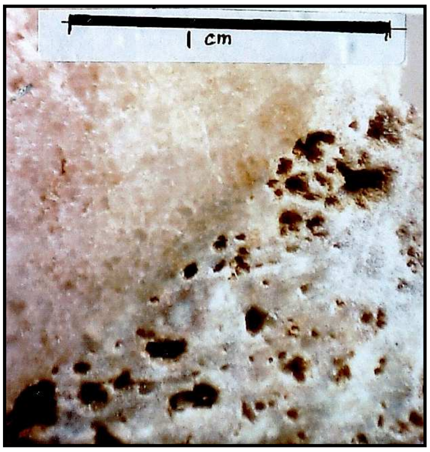


Fig 4: Cross section showing porosity

Fig.2 is an illustration of a typical pebble with adhering matrix material, and Figs.3 and 4 show sections taken through that specimen revealing that the quartzite had, at some stage in its history, bonded well to the matrix, and that bond had been partially retained in the specimen, even after extensive plastic flow of the pebble's surroundings .

It is noticeable that pores and even enlarged voids had formed in the matrix, particularly in the elastically constrained zone near the quartzite/matrix interface. With extended deformation these pores had become 'pipe-like', and with extreme reduction of the load carrying area, rupture had occurred. Even the quartzite, which would be stiffer than the matrix material, had suffered a change of shape and exhibited limited grain boundary porosity.

This conglomerate had behaved as would be expected for a composite material. The softer matrix being reinforced by stiffer, that is higher elastic modulus pebbles, that had, by supporting part of the externally applied load, helped to shield their surroundings from deformation. The appearance of considerable porosity might indicate that during that time the conglomerate experienced less than the complete hydrostatic stress conditions that would have promoted the healing of such voids.

Referring now to the pronounced 'V shaped' way that the rock face had weathered. This pattern reveals the direction of the long range shear/tensile stresses, now resulting from gravitational pull, that is causing rock falls.

Most rocks are composites, not necessarily where the reinforcement is provided by a 'foreign' body as with a conglomerate but where more intimate mixtures of particles or phases with different elastic properties exist as part of the constitution of the rock forming material. It is this elastic and plastic heterogeneity, as demonstrated by the past behaviour of the Funzie conglomerate, that produced an extensive non-uniform distribution of fissures in that formation .

In this example longitudinal strength reduction would have been by loss of section but the reducing cross section of each ligament would also cause lateral (transverse) tensile stresses and so induce longitudinal splits between pebbles. Such features would become particularly damaging by joining up to form the extensive cracks that have grown into the cliff facets so prominent in Fig.1.

Peter Forsyth

Geological Hazards

Summary of February 2014 lecture given and summarised by John Williams, Member FGS

Geological Hazards can encompass a range of natural events including volcanoes, earthquakes, mass movements, floods and various types of mining. In this talk we will mainly cover the first two and then look at the major ones that have occurred during 2013. Inevitably these will be selective. The impact of the hazards can be both human and monetary, e.g.:

- Nevado Del Ruiz eruption, Colombia, 25,000 deaths;
- Kobe earthquake; Japan, 1995, 5000 deaths and $1 trillion property damage;
- California earthquake, 1994, over $30 billion property lost.

The risk can be quantified as the hazard multiplied by the vulnerability of the location.

Volcanic Hazards

Heat from the eruption can melt ice and snow causing fast moving mudflows (lahars). Explosive eruptions can produce clouds of very hot fast moving dust and ash (pyroclastic flows). Poisonous gas can roll down the side of the volcano. Rivers of very hot lava can destroy everything in their path. One Montserrat eruption covered the whole countryside with ash whilst Pinatubo's ash went up into the stratosphere and around the world causing a half degree drop in temperature for a year.

It is of great advantage if eruptions could be predicted so volcanologists map past volcanic deposits and use satellites to look at volcanic features, ash clouds, and gas emissions. They also monitor seismic activity, ground deformation, and geomagnetic, gravimetric, and geoelectrical and thermal changes at a volcano. They study and monitor the volcanic gases produced, together with temperature and rates of flows, also sediment transport, and water levels of streams and lakes near the volcano.

Lava hazard maps can be prepared such as the one below of Big Island in the Hawaiian chain (Figure 1) so allowing inhabitants to be aware of the risk around the island.

Earthquakes

Earthquakes occur as a result of the release of stress that has occurred in the crust as plates move against each other. Friction causes energy to be stored up. The amount of energy stored up is the magnitude of the earthquake which is released as the fault finally ruptures. The focus is the point where rupture happens, waves spread out from this point. The epicentre is point on the earth's surface directly above the focus.

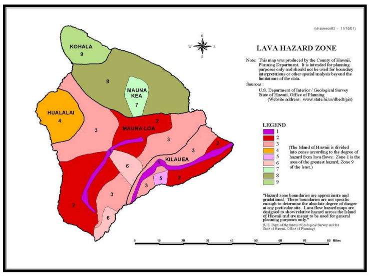


Fig. 1: Lava Hazard Map of Big Island, Hawaiian Chain

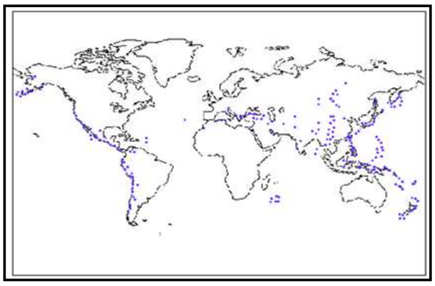


Fig. 2: The Distribution of Earthquakes: Compare with the Plate Margins shown in Figure 3.

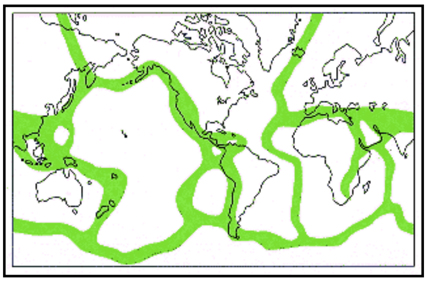


Fig. 3: Plate Boundaries

Earthquakes are usually measured on two scales: Richter or Mercalli. The former is a logarithmic scale and is a measure of the amplitude of ground motion corrected for distance from the epicentre whilst the latter is a twelve point scale which measures the earthquake quake intensity related to the effects felt.

Size, focus depth and distance from the focus will determine the intensity of the quake but local ground conditions and building standards will affect the amount of destruction. Solid bedrock will provide a strong foundation whilst loose waterlogged soils liquefy and buildings sink into the soil. Poor quality buildings stand no chance and fall over or collapse.

Where the ocean or sea is involved a tsunami can occur as a result of the sudden displacement Usually thrusting) of the sea floor. Water rushes into the depression and over corrects by raising the sea level. The sea oscillates before coming to rest and long low waves spread over the ocean or sea surface. As these waves approach the coast, they get bigger and shorter as they interact with the sea bed. It takes about twelve hours for a tsunami to reach the coast of Japan from an earthquake in mid Chile.

Fig. 4: Trail from the Meteor which Landed in Chelyabinsk

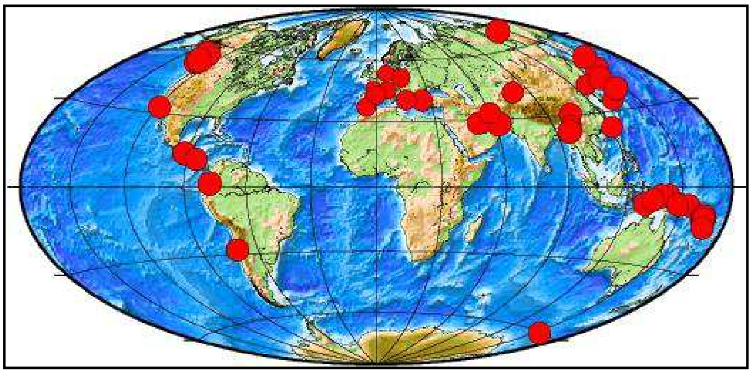


Fig. 5: Distribution of earthquakes around the world from July 2013-February 2014.

In earthquake prone areas various changes are monitored as a means of prediction. Seismic activity; seismic gaps; groundwater levels and pressure; tilting and ground elevation; radon gas emissions; electromagnetic signals; presence of ‘earthquake lights’*; electrical resistivity; and animal behaviour. Earthquake drills are practised and advice on what to do is publicised. A tsunami warning system is in operation for the Pacific and another being introduced for the Indian Ocean.

Some Hazards of 2013

- The super typhoon in the Philippines, November 2013
- The landslip on the Northern Normandy coast of July 15th seen on the recent Field trip.
- The eruptions of Mount Etna in Sicily between July and November
- The obsidian flow at Puyehue Cordon Caulle, Chile, flowing since June 2011
- The Chelyabinsk meteor of 15th February
- Two major wildfires: Australia 18–25th October; California 17–24th August, which threatened Yellowstone Park.
- A landslide in Aspen, Colorado, in mid September.
- The strike slip earthquake in Pakistan of September 24th which created a new island in Paddi Zirr, near Gwadar.

The talk finished with a graphic of the worldwide Earthquakes of the last 200 days from the BGS website (Figure 5). * For more information about ‘Earthquake Lights’ go to:
http://news.nationalgeographic.com/news/2014/01/140106-earthquake-lights-earthquake-prediction-geology-science/

Lucky Planet

Summary of March 2014 lecture given by Dr David Waltham, Royal Holloway College

Fig. 1: Earth – also known as ‘The Blue Planet
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Fig. 2: Greenland ice cap, blue waters of the Atlantic Ocean and white gaseous clouds.

Fig. 3: The Earth, the Moon and the Sun

The Earth is a very unusual planet: the chances of intelligent life arising on any given world are tiny but, despite this, it happened here anyway. Why was the Earth so lucky?

Everything about our world is just right for life to begin, prosper and diversify but this makes it a very odd place. Most planets are too hot or too cold; too wet or too dry; too small or too big; or just wrong for life in any one of a hundred other ways. In particular, the Earth is a rare jewel in the Universe, a planet which is able to support complex life because, purely by chance, it has had an exceptionally stable climate.

Global climate is controlled by just three things: the brightness of the Sun; the fraction of sunlight the Earth reflects rather than absorbs; and the concentration of greenhouse gases in the atmosphere. This has been known for over a century but we have only recently realized that astronomical, geological and biological processes have massively altered all three factors over the 4Ga that life has existed on our world.

Our Sun has warmed 40% as it has aged, the Earth's reflectivity has altered as cloud and ice-cover have repeatedly changed, and our atmosphere now has an utterly different composition to that of even 2Ga ago. These changes should have produced surface temperatures varying by hundreds of degrees centigrade - thus making complex life impossible - but, somehow, the multifarious influences on climate have always cancelled each other out to give weather perfect for life. I find that odd – and intriguing.

The probability of such a long period of climatic stability occurring purely by chance is extremely low and many people, from religious fundamentalists to James Lovelock with his Gaia theory, have offered complex explanations for our apparent good fortune. However, I think there is a much simpler interpretation - we really were just very, very lucky. That said, the huge number of planets in the Universe (at least ten billion trillion) makes it virtually certain that the climatic consequences of many complex events will fortuitously cancel each other out to give relatively constant temperatures on a few lucky worlds - and we must live on one of these since complex life, and hence intelligent observers, can only thrive in such places.

At least some of the factors giving our planet a long-term stable climate are astonishingly improbable. In recent years I have published papers in international, peer-reviewed science journals describing complex computer models of the interactions between the Earth, the Moon and the planets of our solar system. It has been known for 150 years that these very subtle interactions affect our climate and, for example, are the fundamental drivers of the Earth's Ice Ages. My own recent developments of these well established ideas have led to breath-taking conclusions.

First, had our Moon been just 20km larger, the Earth's climate would have been so unstable that human life could not possibly have emerged. We therefore avoided climatic disaster by a spectacularly small margin.

Second, small changes in the arrangement of planets almost always lead to more unstable climates than that we have actually enjoyed. Our solar system therefore seems to be fine-tuned to give us good weather.

These two observations, fine tuning of the moon's size and fine tuning of planetary arrangements, are the most convincing evidence yet produced to support the contention that everything about our planet is just right to give us climate stability.

The general idea behind all this, that preconditions necessary for human existence bias the view we have of the Universe, is not a new one. In the technical literature it goes by the name of anthropic selection and its gradual acceptance can be thought of as a long overdue correction to the prevailing 'Copernican' dogma that the Earth is a typical planet in a typical solar system occupying a typical location in a very typical galaxy.

In fact, the Earth may be very atypical in many ways. I believe that the Earth is a rare, beautiful and very special place - it is one of the luckiest planets in the Universe.

Editor's Note*: Images of our Lucky Planet added by the Editor, and David Waltham's Book is: Lucky Planet - Why Earth is Exceptional And What That Means for Life in the Universe*

Giant Titanosaur found in Argentina - newspaper snippet

Fossils discovered by an Argentinian farm worker in 2011 have been fully excavated by the Museum of Paleontology Egidio Feruglio led by Dr. Jose Luis Carballido and Dr. Diego Pol. The fossils, were from seven different titanosaurs and were described as being in 'remarkable condition'. These dinosaur fossils were enormous and are believed to be from the largest dinosaur on record. This titanosaur is thought to have measured circa. 40m x 20m and to have weighed circa. 70 tonnes (some 10-fold the weight of a *Tyrannosaurus Rex*). It had a long neck and tail, but a relatively small skull, was probably a herbivore, and lived in Cretaceous forsest, ca. 100Ma. The 150 fossils were found in close proximity to other species, including carnivores, suggesting that they died in a drought or became stuck in mud.

They told the BBC '*… these bones … surpass any of the previously known giant animals … (making it) the largest animal known that walked on Earth ... It's like two semi-trucks, one after another, and the equivalent of more than 14 African elephants together in weight. Such dimensions put the focus on the extent to which these animals may have grown. It's a real paleontological treasure'.*