November 2017

Issue No 12

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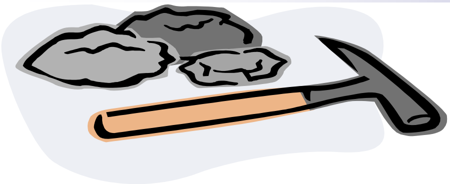
P3A Geology Newsletter



Paphos Third Age (P3A)

http://paphos3rdage.org/

Geology of the Troodos Ophiolite

During October, 30 plus members of the P3A Geology group were extremely fortunate to participate in a field trip to investigate the geology of the Troodos Ophiolite. The trip was organised and lead by Professor John Malpas, of the University of Hong Kong, Department of Earth Sciences. Professor Malpas is co-author of 'Classical Geology in Europe 7 – Cyprus'.

An ophiolite is a section of the Earth's oceanic crust and the underlying upper mantle that has been uplifted and exposed above sea level and often emplaced onto continental crustal rocks. The Troodos ophiolite has a stratigraphic completeness and ease of accessibility without equal anywhere else in the world.

Professor Malpas gave two well attended introductory classroom lectures and also produced a very detailed field guide for the trip – '***Geology of the Troodos Ophiolite, Cyprus;** P3A Geology Group, John Malpas, October 2017*'.

Classroom Lectures

The lectures provided the basis for understanding the origins of the Troodos Massif and started with 'Understanding the origin of the ocean basins, the view from Troodos'. Professor Malpas explained the various aspects of 'continental drift' and explained in particular the role played by Paleomagnatism. A record of the Earth's magnetic field is retained in igneous rocks (thermoremanent magnetization) and sediments (depositional remanent magnetization). Certain minerals in rocks lock-in a record of the direction and intensity of the magnetic field when they form. This record provides information on the past behavior of Earth's magnetic field and the past location of tectonic plates. The various investigations carried out to determine the mechanism that drives continental drift were then examined. The magnetic symmetry around oceanic ridges was explained, as they are an indication of sea floor spreading. If magma is erupting at these locations to create new lithosphere and the earth's surface is not getting bigger it must be destroyed elsewhere – subduction zones. The fluid properties of the mantle, as the driving force behind tectonic plate movement, were explained in detail. The evidence for smaller magma chambers, as the source of the Troodos ophiolite was examined, as well as the melting and crystallisation processes involved in the formation of the igneous rocks of the oceanic lithosphere. The geochemistry aspects of the lecture were at a level of detail that as a group we had not previously studied and will no doubt form the basis of future research and lectures. The presentation slides displayed many of the rocks and minerals that we expected to see on the field trip, along with an explanation of how to identify them.

Field Trip Day 1: Involved an examination of the Mantle sequence. This was the first time many of us learnt there was a 'Petrological' Moho as well as the more commonly referred to 'Seismic' Moho (Mohorovičić discontinuity). The Petrological Moho being defined by a change in the make-up of the rocks – the boundary between mafic rocks (crust) and peridotitic rocks (upper mantle). Partial melting of a fertile Lherzolitic mantle had resulted in this area being rich in Harzburgites. The hobnail-like texture of the weathered surfaces of other rocks indicated serpentinized orthopyroxene (Bastite). Traversing along the exposure there is an increase in the amount of Dunite, which contains seams of Chromite, once mined in Cyprus. Although not large or extensive, the richness of the Chromitite made the Cyprus deposits economic.

We had an overview of the Amiandos Asbestos Mine, which many of the group had visited on a previous field trip. The Chrysotile asbestos is a product of the serpentinization of the Troodos Massif mantle sequence. Chrysotile (white asbestos) is a polymorph of Serpentine.

Day 2: We were to examine the upper plutonic zone. We started off near the village of Chandria. The first surprise of the day was

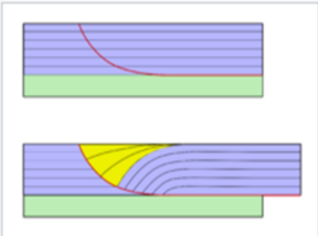
Geology of the Troodos Ophiolite—continued

to find that the orange 'blotches' on a prominent rock were not Lichen, as I and others thought, but outcrops of Wehrlites in Clinopyroxene and olivine. White veins of Plagiogranite could be seen cutting the dark Wehrlites. On the brown face of some dykes could be seen a green surface which is Epidote, which is common in metamorphic rocks rich in Calcium

East of Chandria we viewed an outcrop of gabbroic rocks situated in the middle part of a small magma chamber, cross cut by dykes. At the eastern end of the road were repeated layering of Wehrlites and Olivine Gabbronorites dipping approximately 45° – 50° westward. These were separated by inch scale layers of olivine gabbro, gabbro-norite and plagioclase rich gabbro. The thicker layers are possible indications of periodic refilling of the magma chamber, whereas the thinner layers may be the result of repeated eruptions of magma to the surface, resulting in pressure cycling.

Professor Malpas introduced the group to 'fractional crystallization', again a new concept for many of us – Rob Harris covered some aspects of this in his presentation (07/11/2017), which included an introduction to the Bowens Reaction Series.

The rotating of the Gabbros in this area, from horizontal to its present attitude, was explained by 'Listric Faulting'. These are similar to normal faults but the fault plane curves, the dip being steeper near the surface, then shallower with increased depth. The dip may flatten until nearly horizontal, resulting in horizontal slip on a horizontal plane.

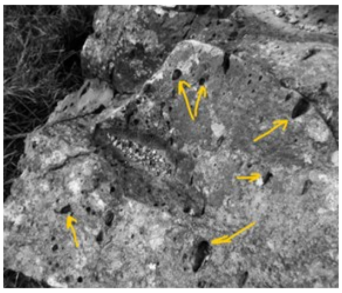


Listric fault (red line)

We viewed evidence to support the 'multiple intrusion' models in the formation of the Troodos Plutonic Sequence. Although, I think it was generally agreed by the members, that a keen trained eye was required to match the symmetrically split dykes as they progressively moved East and West away from each other. Pale Gabbros, the most abundant rock in this area, is repeatedly intruded firstly by a white Plagiogranite with poorly visible chilled margins. Later both the Gabbros and the Plagiogranite are intruded by light gray Microgabbroic dykes with clearly developed chilled margins. Distinctly different dyke compositions indicate the probability of the source being from different magma chambers – supported by detailed studies of the CY-4 borehole.

The highlights of the Klirou bridge stop were the Hyaloclastite breccia, its glassy like appearance due to the rapid cooling of erupting magma under water. The rapid cooling not allowing time for large crystal formation. The fragmentation occurs as a result of the volcanic explosion or thermal shock during rapid cooling.

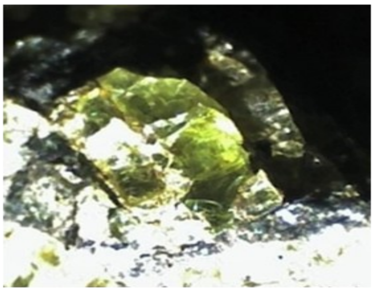
Of particular note were the vesicles – these are pits and cavities in the volcanic rock. As magma rises and the pressure reduces, dissolved gasses break out of solution forming gas bubbles. These are trapped in the cooling magma and the shape of the cavity that is formed can indicate the direction of the magma flow.



Sometimes these are filled by Zeolites (Celadonite & Quartz) which can be released by weathering and resemble melon seeds. Zeolites can form with many different crystalline structures and have large open pores (sometimes referred to as cavities), in a very regular arrangement.

The next stop was at Margi where we were able to see the basal sediments and the uppermost pillow lavas of the Troodos Massif. The boundary between the lavas and the chalk is a half-graben filled with Umber (a marine sediment associated with black smokers) and mudstone (Perapedhi Formation). At the second location, notably a pig farm, were olivine rich pillow lava. Crystal settling

Geology of the Troodos Ophiolite—
continued



from a larger body of olivine-phyric magma appears to have formed the olivine rich ultrabasic lava. Some excellent specimens of Olivine crystals were collected.

Day 3-Prior to our return to Paphos we stopped in the East-West trending Arakapas valley. Here we viewed volcanism in the transform zone of the Arakapas. The glassy pillow lavas have a dark green colour, and were formed during volcanic eruptions under water (hyaloclastite). A near vertical fault is stained red by iron oxides.

Evidence supporting the supra-subduction zone (SSZ) formation of the Troodos Massif is in the form of mafic extrusive rock, high in magnesium and silica (Boninite). Secondary melting, possibly due to water lowering the melting point, produced black pillow lavas low in trace elements. Dykes exhibiting an E-W strike suggest a clockwise rotation. (Southern Troodos Transform Fault).

Excellent examples of Boninite pillow lava formations, that have been , depleted of minerals, were examined.

The last stop of our 3 day field trip was west of Lageia. At the lowest level is coarse sedimentary breccia, blocks of lava, dolerite, gabbro and clastic sedimentary rock. Above this are alternating red mudstone and grey sandstone turbidites. This overlaid with basalt or Boninite.

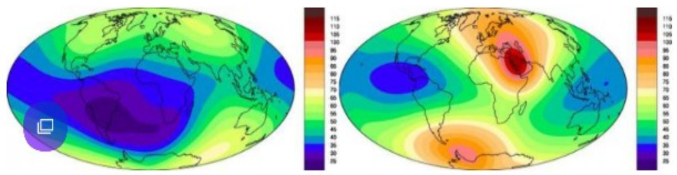
We are indebted to Professor Malpas for his time, effort and patience.

Mystery Spike in Earth's Magnetic Field 3,000 Years Ago

The Earths magnetic field is generated approximately 3000 kilometres below the Earths surface in the liquid iron core. The magnetic field generated by the iron core permeates the planet and extends out into space providing a shield which protects life and sensitive electronics from harmful radiation from the sun. The magnetic field strength varies from location to location on the Earths surface (see the South Atlantic Anomaly) and also varies with the passage of time. However, these changes in field strength tend to be relatively small and occur relatively slowly. Over the last 100 years the largest change measured is in the south Atlantic and was a 10% fall.

By examining copper slag scientists were able to determine that in a localised area, the magnetic field strength rose then fell by 100% in only 30 years.

These high field strengths were found in Turkey, China and Georgia but not in India, Egypt and Cyprus. This indicates that the 'spike' was possibly only 2,000km wide.



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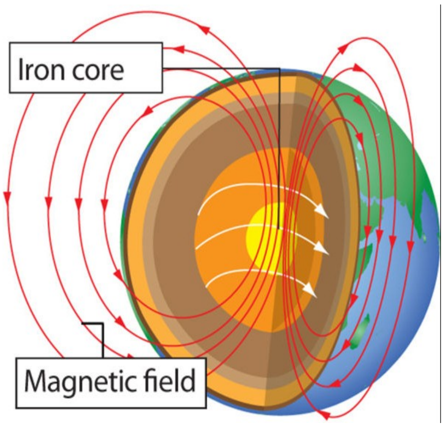
The strength of Earth's magnetic field in 2010 (left) and 1000BC (right). Courtesy of Christopher Davies

The exact process that caused this spike is not fully understood but is thought to be related to the flow of iron in the core which causes the magnetic field to be moved around.. It is possible that the magnetic spike was drawn toward the Earth's surface by a jet of molten iron moving upward. The iron core is heated from below and cooled from above resulting in turbulent motion.



This evidence that localised flows can occur over a short period of time is challenging our present understanding of the dynamics of the Earths molten core.

Acknowledgments:

- Geology of the Troodos Ophiolite, Cyprus: Professor John Malpas
- Wikipedia (online)
- Encyclopaedia Britannica (online)
- geograph (online)
- Mail Online.
- Yahoo News
- The Guardian online
- Rionagh Walker
- The Conversation
- The British Geological Survey

'Unlucky' dinosaurs: no extinction if asteroid had hit almost any other part of Earth

A group of scientists claim that the 9 km wide asteroid, which struck Mexico's Yucatan peninsular 66 million years ago, could have struck almost anywhere else on Earth and would not have resulted in the extinction of the dinosaurs.

The 180km wide and 20km deep impact crater is in an area particularly rich in hydrocarbons. The impact resulted in soot and sulphate aerosols being sent into the sky resulting in global cooling and drought. Calculations indicate that only around 13% of the Earths surface held sufficient hydrocarbons to have resulted in a mass extinction from such an impact. It is estimated that the amount of material blasted into the air cooled the planet by as much as 10 deg C.

theguardian.com

Glossary: *To continue in the next issue*

P

P wave — The first and faster of the body waves which moves by a series of compressions and dilatations, similar to a sound wave. They can travel through both solid and liquid.

Palaeobiogeography — The study of the global, regional and local distribution patterns of fossil plants and animals.

Palaeoecology — The study of the relationship between fossil plants and animals, and the environment in which they lived in the geological past.

Palaeogene — The period of time between 24 and 65 million years ago.

Peat — A thickness of partially decayed vegetation, formed in wet anaerobic ground.

Permafrost — Permanently frozen ground in polar regions. It forms in regions close to, but not under, ice caps, ice fields and glaciers. The frozen conditions may be several tens of metres thick, but the top layer may thaw in the summer months before freezing again in the winter. During the last Ice Age, much of southern Britain was affected by permafrost.

Permeability — The ability of a fluid, like water or oil, to pass from one pore space to another. Substances that allow water to pass through them are called 'permeable'.

Permian — The period of time between 252 and 298 million years ago.

Phreatic — (adjective) describes a cave, passage or cave system that formed below the water table and was consequently permanently flooded. The phreatic zone (or phreas) is the zone permanently saturated by water below the water table.

Plate — The Earth's crust is made out of a number of huge rafts of rock. Some have continents on them and others are covered by oceans. These huge slabs are called 'plates'. The plates are continuously moving relative to each other.

Plate boundary — The place where two or more plates in the Earth's crust meet.

Plateau — Flat-topped area of high ground.

Plate tectonics — The Earth's surface (crust) is divided into huge fragments called tectonic plates which carry the continents on top of them. They move very slowly over the globe, past each other, away from each other or colliding and taking the continents with them.

Pleistocene — The main epoch of the last Ice Ages, between 10 000 years and 1.8 million ago, during which continental glaciers periodically expanded to cover sub-polar regions in both hemispheres.

Pleistocene (Quaternary) glacial episodes — The period from 2 500 000 to 10 000 years ago, during which continental glaciers periodically expanded to cover sub-polar regions in both hemispheres.

Pore space — Spaces or voids between grains in the rocks in which air, water, other fluids or fine-grained mineral cements can be present.

Porosity — The proportion of a rock that comprises spaces, voids and cracks (known as pores) between the grains.

Precambrian — The period of time before animals with skeletons and shells had evolved. It stretched from the formation of the Earth about 4600 million years ago to 545 million years ago.

Precession — The slow circular movement, or 'wobble', of the Earth's axis of rotation around another axis.

Precipitation — When salts or minerals, such as calcite, come out of solution and are deposited on a rock surface. (The word also has another sense, meaning rain or snow, but that is not used here.)