Dorset GA Group

Newsletter Summer 2020

https://dorsetgeologistsassociation.org/

Contents

Welcome to the Summer Newsletter!

It is now two years since I assumed the role of 'interim' Newsletter Editor. Who knew interim could last so long? It's been interesting and I've learned a lot, not just about the production process but also the geology! As usual, a big thank you to everyone who has contributed to the content, it is very much appreciated. If anyone has new ideas for content do please let me know - feedback is very welcome.
DGAG activities are still in abeyance until some sort of normality returns. We will keep you posted. At least it provides some time for reflection. Perhaps there's a topic you'd like to know more about, a new workshop activity or a place we could visit or re-visit to learn about the Geology. The Committee is always open to suggestions. *Kelvin*

The formation of calcareous concretions

On a recent trip to South Island New Zealand the Moeraki Boulders were on the list of places to visit. Unfortunately, the weather was poor when we were there, but the boulders were still very impressive (picture 1). The visit reinforced my interest in such geological phenomena variously called concretions, doggers or septarian nodules. On researching this topic a little further, Geological dictionaries do not recognise the term dogger in this context but the term refers to part of the Middle Jurassic. However, in sources such as the Arkell Memoir for South Dorset (H.M.S.O. 1947) and the G.A. guide to the Dorset Coast (J.C.W. Cope 2012) they both use the term dogger with particular reference to the Bencliff Grit within the Corallian sequence. Unfortunately, Jim Marshall's lecture to DGAG on carbonate concretions on the Jurassic Coast had to be postponed but hopefully it will take place in November.

1. General view of Moeraki Boulders

2. Cross -bedding and honeycomb weathering

The concretions under consideration are either calcium carbonate-rich or iron oxide-rich which helps to cement the rock together. On the Dorset coast calcium carbonate tends to dominate but iron rich concretions can be seen in for example the Coal Measures in South Wales e.g. at Broadhaven in Pembrokeshire.

The Moeraki Boulders are also calcium carbonate rich. The explanation for their formation is as follows. Sediment is deposited and in that there is calcium carbonate often in the form of aragonitic shells either whole or broken by wave action prior to burial. Other organic material is also present. Within the sediment there are shells which act as nuclei around which calcium carbonate is precipitated.

This can also incorporate the nearby sediment. This is the case with the Bencliff Grit seen on the coast between Bowleaze Cove and Redcliff Point, around Osmington Mills especially to the east towards Bran Point. In this case the original sedimentary features have been preserved and cross-bedding is clearly preserved in the doggers (picture 2 taken at Osmington Mills). This feature can also be used to determine way up and the block in picture 2 is upside down. The cross bedding can also be seen in the surrounding sediment which is soft and poorly cement allowing it to be eroded and the doggers to fall onto the beach (picture 3 taken east of Osmington Mills near Hannah's Ledge).

3. Bencliff Grit concretions weathering out

4. Septarian nodule from Oxford Clay on Fleet

The concretions form below the sediment surface over 100K years to a few million years. The presence of organic material in the sediment creates an alkaline environment due to formation of ammonia and methane as the organic material decays and this alkaline environment favours the precipitation of calcium carbonate. As the carbonate is precipitated around nuclei, it creates a lower concentration of calcium carbonate and more migrates in in the ground water to neutralise the disparity (diffusion). Concretions can be dispersed throughout a sedimentary layer when they will be rounded as seen in the Moeraki Boulders or just as one level when they will be flattened as with septarian nodules seen locally in the Oxford Clay and Kimmeridge Clay. Picture 4 is of a septarian nodule from the Oxford Clay exposed on the Fleet shore north of Tidmoor Point. Another local example is in the Bridport Sand at Burton Bradstock where continuously cemented layers occur (picture 5).

5. Bedding patterns at Burton Bradstock

6. Close up boulder with calcite veins exposed

Septarian nodules commonly have calcite rich veins or septa (wall) which are seen when the concretions are broken open or the outer layer of sediment is eroded. The veins often have an edge of less pure calcite and then central part of pure calcite as seen in picture 6. Sometimes the septarian nodules are called turtle stones or turtle backs because of the pattern of exposed calcite veins. Picture 7 is a Pacific Green Turtle seen in Hawaii. *Alan Holiday*

7. Green turtle, Hawaii

Useful reference:

Calcium carbonate cementation of sandstone. Niall Fleming. Geology Today. Vol. 9, No. 6. Nov / Dec 1993. Pp.223-6.

Shaftesbury Geology - An Outline and a Quiz

The region in a 10km radius of Shaftesbury provides a well presented set of formations and beds which show the transition from the Lower Greensand to the Chalk. The transitions are so clear, and were recognised as such by the early geologists, that many of the terms used throughout the country take their names from this small area (e.g. Zig Zag Chalk, Shaftesbury Sandstone, West Melbury Chalk). The transition from the Lower Greensand to the youngest Chalk (the undifferentiated Seaford and Newhaven of 72 to 90 Ma.) is entirely within the Cretaceous.

The oldest in this area is the Kimmeridge Clay, which outcrops to the west of the town. Above the Kimmeridge Clay there is an unconformity above which are some thin beds of the Lower Greensand (Bedchester Sands and Child Okeford Sands). The Lower Greensand is not well developed locally and is better developed to the East (on the Isle of Wight for example). The items that are missing above the unconformity (Portland Group to Wealden Group) outcrop a few kilometers away in the Vale of Wardour.

Spetisbury Chalk (0 to 25m)	
Tarrant Chalk (30 m)	
Blandford Chalk (75 to 90 m)	
Lewes Chalk (30 to 50 m)	
New Pit Chalk (10 to 20m)	
Holywell Chalk (9 to 20 m)	
Zig Zag Chalk (20 to 50 m)	
West Melbury Chalk (0 to 16 m)	
Melbury Sandstone (0 to 6 m)	Upper Greensand
Boyne Hollow Chert (0 to 15 m)	Upper Greensand
Shaftesbury Sandstone (0 to 25 m)	Upper Greensand
Cann Sand (16 to 30 m)	Upper Greensand
Gault Clay (12 to 25 m) and Fontmell Magna Sand (0 to 5 m)	Gault
Bedchester Sands and Child Okeford Sands Lower Greensand	Lower Greensand
Kimmeridge Clay	Jurassic

Generalised Vertical Section (From BGS England and Wales Sheet 313). All belong to the Cretaceous except for the Jurassic Kimmeridge Clay

Quiz: What landscape clues hint at the underlying Geology?

Look at the photograph below which is taken from Google Earth and shows the area just to the east of Shaftesbury - an area that comprised the Higher, Middle and Lower Coombes (the road at the bottom is the A30 and the group of buildings near the centre is St Mary's School).

The valleys are mainly dry and any water eventually reaches the River Nadder which heads to Salisbury.

Question 1. There is a distinct line of trees towards the top of the valleys. Might this have some connection with the underlying geology and if so which unit in the table might it occur on ?

What can roads tell us of the underlying geology?

See the photograph (right) - this is one of many examples in the area of a sunken lane. These sunken lanes are quite common in the Yeovil area and in many parts of the country. They are usually associated with a certain type of geology.

Question 2. From the table on Page 3 which member of the Upper Greensand is most likely to contain sunken lanes?

What can the surface of the land tell us sometimes?

See the photo (right), which is not the clearest to show the feature in the area, but will have to suffice. Note that the ground is uneven and this is just above the Gault Clay- so the grass is growing on the Cann Sand.

Question 3. You might expect sand to give a smooth surface over time - so what is the cause of the unevenness?

What can springs tell us of the local geology?

See the photograph (right) of some springs about 2 miles east of Shaftesbury. There is a main water channel that is fed from lesser sources, indicated by a slight change in colour, which emerge from the ground at about the line of the trees.

Question 4. From the table on Page 3 in which member might you suspect the spring line is marking the base of?

Leon Sparrow

Answers to the quiz can be found on Page 16

Tarrant Rushton Church : an extract from the Dorset Building Stone website written by Jo Thomas

1. Square headed window in the south transept. Wardour Main Building Stone and Heathstone

St. Mary's Church has a wonderful mix of stones, most of them reasonably local. The river Tarrant runs through a Chalk valley lined with river gravel containing flint. To the north the valley begins near Shaftesbury, where there are quarries in Upper Greensand Shaftesbury Sandstone, not far distant from the quarries in the Vale of Wardour that could provide both the sandy limestone of the Main Building Stone and the white oolite that corresponds with the Portland Oolite of Dorset. To the south the river joins the Stour near the Tertiary London Clay heathlands that can provide Lytchett Matravers Sandstone. The Poole Formation sands and clays top the hills to the south and east. All these building stones have been used at different times in a church that was first built early in the 12th century in a cruciform style.

The church as seen today is mostly flint, with occasional blocks of Heathstone in the transept walls and banding with Heathstone in the chancel. It is occasionally possible to see that the grains in the Heathstone are rounded and coated in iron oxide, which would indicate the London Clay Lytchett Matravers Sandstone. The windows are mostly the Wardour Main Building Stone, a sandy limestone with glauconite that has weathered to a golden colour. These are all dated 14^{th} century by the Royal Commission for Historical Monuments. The exceptions are the square-headed window in the south transept, which includes Heathstone, and the south-facing window made of Upper Greensand which is heavily weathered.

2. A square-headed window in the east wall of the south transept, built of Heathstone and Wardour Main Building Stone, with two blocks of Upper Greensand either side at the top. The wall is flint, Heathstone and greensand. The top left of this window looks a different stone. As becomes evident when inside the church, considerable restoration was undertaken in the 19^{th} century.

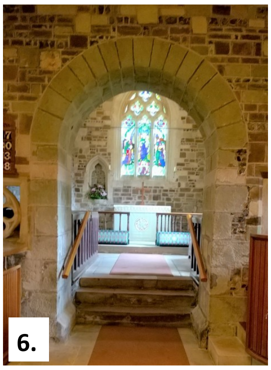
The late 12th century tower over the western extension to the nave, is built of Flint, with scattered blocks of Upper Greensand, and Heathstone. The porch was added in the 15th century and the inner porch walls are of flint and Upper Greensand chequer. The south transept walls are of flint banded with Heathstone.

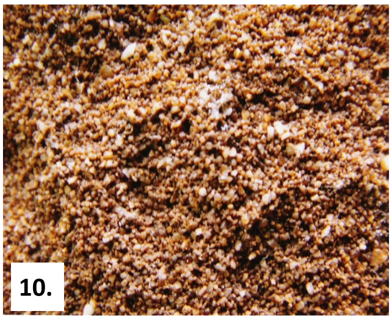
3. The late 12th century extension of the nave was built of flint with occasional blocks of Heathstone and Upper Greensand.

4. The church entrance, next to the south transept.

5. Interior of western part of nave, late 12th century extension beyond pointed arch (which is 'modern'). Closer arch early 12th century Greensand. The square doorway on left has a Purbeck Marble lintel, probably a grave slab.

Both north and south transepts were extended in the 14th century, with a window in the west wall of the north transept built of Heathstone that has 'sharp' grains, only partly covered in iron oxide, and therefore probably from the Poole Formation. On the exterior of this window are marks of hands, and it is said to be a 'lepers' window', through which the altar could be glimpsed via a squint in the corner of the north transept. This window may have been built earlier and replaced when the wall was rebuilt.





6. Interior of chancel, the early 12th century Greensand arch in the foreground and the 14th century extension by the altar. **7.** The angled squint is in the junction of east and north walls, and built of Heathstone. This suggests that the lepers' window and the squint were part of the 12th century build. The view through the lepers' window does not reach the 14th century position of the altar.

8. The lepers' window . **9.** Interior of lepers' window. **10.**Sandstone in the lepers' window.

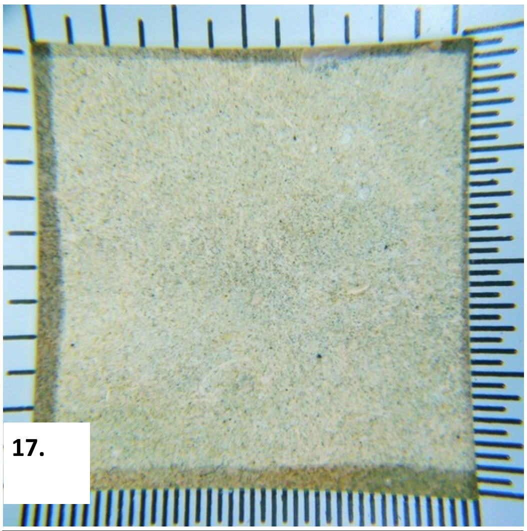
11. The chancel was also extended eastwards in the 14th century, the windows being of the Wardour Main Building Stone. The walls are of flint banded with Heathstone.

12. The banding continues in the lower part of the east wall, but becomes mixed above.

13. A closer view of the east window. **14.** Marks of hands made by persons leaning on the wall to look through the window to the altar in the 12th century.

15. A closer view of the east window frame in the north transept, of Wardour Main Building Stone .

16. A closer view of the Heathstone in the south transept window.



17. Detail of the Wardour Main Building Stone in the east window of the south transept.

Editor's Note: *This is one of many churches featured on the Dorset Building Stone website, which is full of interest. Why not use this article as your own field-guide and explore Tarrant Rushton? Take the identification key that came with Spring NL! Jo tells me someone famous is buried in the graveyard. After a visit can any member tell me who?*
https://dorsetbuildingstone.weebly.com/

Fontainebleau and the Paris Basin

Those who have looked at the short video on the formation of the Paris Basin (which is available with English subtitles at https://www.youtube.com/watch?v=LMi2_LLQ950) will recognise the similarities with our region.

Some time ago climbing in the Alps was an interest of mine. London is not well placed for rock climbing - the nearest places are the sandstone outcrops near Tunbridge Wells, such as Harrison's Rocks (where Chris Bonington started his climbing career). Similarly Paris is not well placed for good climbing rocks, but there is one outstanding nearby place and that is at Fontainebleau where the rocks are often large boulders and have similarities to sarsens. These boulders allow difficult climbing moves to be made in a subset of rock climbing that does not need the use of ropes. It is called "bouldering" and in France the people who do it are the "bleausards".

The sea at Fontainebleau c.30 Ma.

Below is my translation from "Le Tour de France d'un géologue (Volcanologie-Géologie-Minéralogie) (in French) 23 Aug. 2012" by François Michel:

The sands of Fontainebleau constitute a geological formation that extends from the centre of the basin of Paris to Champagne and the region round Orleans. It occurs principally to the south of the Seine between the plateau of Beauce and of Brie where it forms hills which support the large forested areas scattered with open areas and the chaos of sandstones which are very picturesque especially in the forest of Fontainebleau.

Several very celebrated sites punctuate the sands and sandstones of Fontainebleau: the massif of the 3 gables and its 25 lumps, the gorges of Franchard and Apremont, and the rocks of the Lady Jouanne, at Larchant, are areas for rock climbers known as "bleausards".

This bed of sand scattered with a chaos of sandstone also forms the subsoil of the forest of Rambouillet. Siliceous land is very acid and not propitious to agriculture, such areas are therefore always left as woods, often as royal hunting grounds. This is unlike the neighbouring Beauce and the Brie which are limestone plateaux covered with fertile silt and entirely cultivated.

The sands of Fontainebleau, which can have a thickness as much as 70m in places, are very homogeneous and very pure, with 99.9% of silica, which makes it a material much in demand by industry, in particular the glass industry. It often shows a light yellow colour due to the presence of iron oxide. The exposures at cuttings in quarries allow one to observe numerous indications of sedimentation which bear witness to the currents which lay down the sands. The fossils associated with the sands are shells of molluscs, brachiopods and gastropods, oysters, scallops, cerites, natices ...... It is similar to those of our present beaches and the coastal regions with little water depth. These fossils have allowed the deposits to be dated to about 30 Ma.

The Stratotype of Stampien

The fossiliferous sites of d'Auvers-Saint-Georges, de Morigny-Champigny and of Ormoy-la-Riviere, in the region of Etampes, belong to the geological formation of Fontainebleau, for which they have served as references, since 1852, when Alcide d'Orbigny defined the stage of Stampien (from Stampae, Etampes) which corresponded to the period of their deposition. The fossils give testimony to the last marine incursion into the Paris Basin. The stage of Stampien stretches from 34Ma to 27Ma. These sites and 3 others have, since 1989, been protected as the geological reserve of l'Essonne. The explanatory panels at the location allow the interpretation of the environment at the time. The detailed study of the fossils of d'Auvers-Saint-Georges has made it possible to define the precise context in which the animals lived: the bottom of a sea of several metres depth, containing seaweed, in calm relatively warm water, in which lived numerous molluscs. A marine mammal of sirenian type (of which the present representatives are the manatees and the dugong) lived in that environment where it fed upon vegetation analogous to that which is found today on the coasts of the Mediterranean.

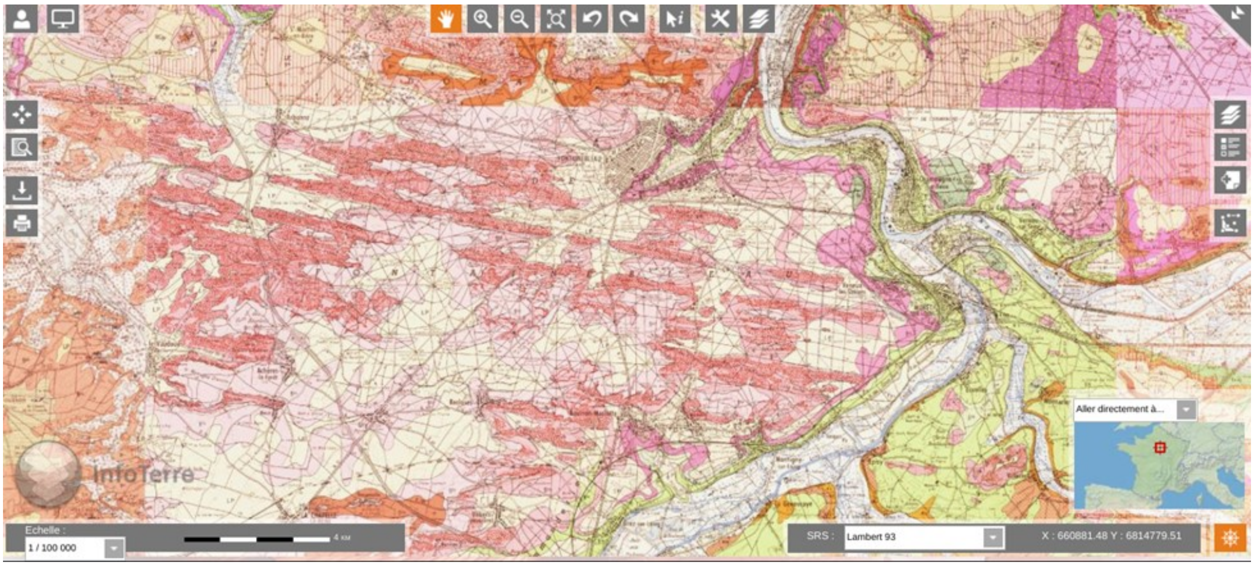
The sea at Fontainebleau

In the Stampien, the sea came from the English Channel, and invaded for the last time the centre of the Basin of Paris. This connection also opened directly to the Atlantic by an arm of the sea situated at the current position of the Loire. The rivers deposited their sediment there and the sand they carried came in particular from the alteration of granites in the Massif Central to the south. The progressive retreat of the sea at the end of the period left vast beaches which dried out to give sandy coastal plains with locally several channels and lakes, just like one is able to see on certain beaches today, in Australia for example. The sands were then rearranged by the wind into the form of dunes aligned along the fossil shores and these show themselves today in the reliefs which stretch for more than 150 km between Mantes-la-Jolie and Sezanne.

Subsequently, a part of the sands have been consolidated into doggers and tables of sandstone of several metres size. This conversion to sandstone corresponds to a cementation of the sand following a deposit of silica between the grains by circulation of water in the zone of alteration at the summit of the phreatic level (top of the level of water saturation) of the strata.

The scenery of the sandstone

Rocks called the elephant, the diplodocus, the tortoise, arse of the dog or the cup and ball game show how the sandstones often take very evocative silhouettes. How was this chaos created? At the beginning the sandstone of Fontainebleau took the form of beds several metres thick forming a sort of layer called a capstone when they are on top of sandy hills. The streaming of water, in particular during violent storms causes the erosion of the sand by sapping - undermining by forming voids in the sand - at the base of the capstone, which progressively causes an instability, it fissures and finishes by fracturing into blocks which collapse and sometimes roll on the slope giving birth to the chaos in front of the capstone. In a number of places the capstone has completely disappeared and there is only a chaos of blocks scattered in the forest. The sandstones also suffer from dissolution which makes varied aspects on their surface, like for example the wrinkled skin of an old elephant.



The geological map at a scale of 1:50000 of Fontainebleau underlines the alignment of the sandstone which runs from east to west and corresponds to ancient beach dunes formed during the retreat of the sea.

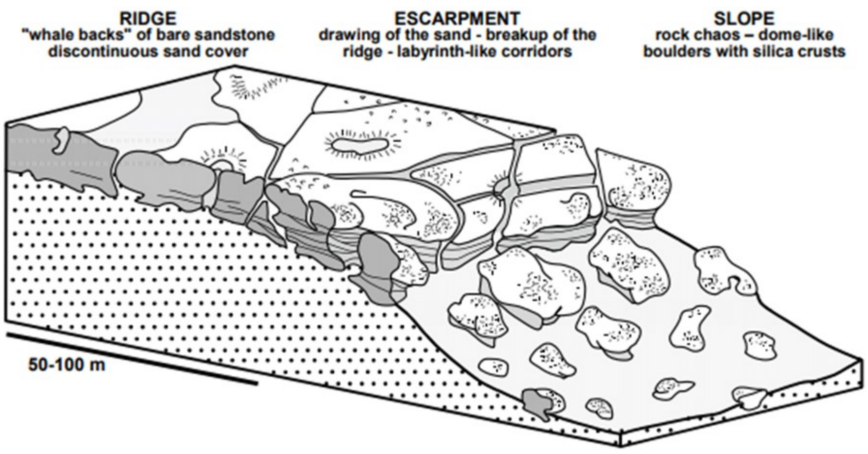
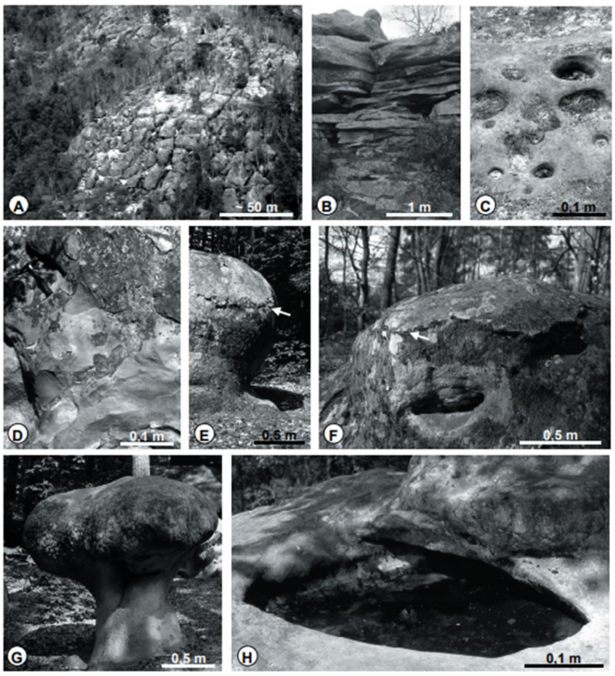


Fig. 1: Schematic sketch showing the dismantling of the Fontainebleau Sandstone ridges by vertical and horizontal fractures and development of the dome-like shaped boulders on the sand slopes.

This diagram and the photos overleaf are from M Thiry: "Weathering morphologies of the Fontainebleau Sandstone and related silica mobility"

Géoscience - École des Mines de Paris (available as English pdf at :

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.599.7232&rep=rep1&type=pdf)



If you want to see the rocks and some of the fun you can have at “Font” and learn some warm-up exercises that you could do at home at the moment there is a short video at https://www.youtube.com/watch?v=llgop3WF-7E

François Michel has made a 7 minute video (in French and with French subtitles) about the rocks at Fontainebleau. At https://www.youtube.com/watch?v=ILdTVZ63oC8

There is much more information as English PDFs etc. by Googling “Geology of Fontainebleau” such as that in The Journal of Petroleum & Environmental Biotechnology “Characterization of Fontainebleau Sandstone: Quartz Overgrowth and its Impact on Pore-Throat Framework”

Appendix

French and other geologists on the continent are not well known in this country, but they made very important contributions to our understanding of their area and hence ours. The names of the stages in the ICS geologic time scale for the Cretaceous reflect the importance of France and nearby areas and recognise the important contributions made by scientists from there (see below for a summary of the contributions to the stages of the Cretaceous).

It is noteworthy that certain names crop up many times and this reflects their influence at the time. One, Alcide d’Orbigny, travelled to South America between 1826 and 1833. When Charles Darwin heard of this he grumbled that d’Orbigny had probably collected “the cream of all good things”. Darwin recognised d’Orbigny’s visit as “a most important work” and corresponded with him. It is noteworthy that the very interesting and very well illustrated account of d’Orbigny’s “Voyage Pittoresque dans les Deux Amériques” is not available in an English translation, but current versions are available in French and Spanish and the 1853 publication is available for free in Google Play Books. *Leon Sparrow*

In the Cretaceous the stages are:

The **Maastrichtian** (1849 Andre Dumont, a Belgian geologist, in the Dutch city of Maastricht).

The **Campanian** (1847 Henri Coquand, a French geologist, after a village in Charente-Maritime about 100 km NE of Bordeaux).

The **Santonian** (1857 Henri Coquand, a French geologist, after the French town of Saintes in Charente-Maritime about 125 km N of Bordeaux).

The **Coniacian** (1857 Henri Coquand, a French geologist, after the City of Cognac 30 km E of Saintes).

The **Berriasian** (1868 Henri Coquand after a village in the Ardeche) and this is the same age as the Purbeckian.

The **Turonian** (1842 Alcide d’Orbigny, after the French city of Tours).

The **Cenomanian** (1847 Alcide d’Orbigny, after the Latin name of the French city of Le Mans).

The **Albian** (1842 Alcide d’Orbigny, after the Latin name for the French river Aube).

The **Aptian** (1840 Alcide d’Orbigny, after the French city of Apt in Provence).

The **Barremian** (1873 Henri Coquand, after the French village of Barreme in Haute Provence).

The **Hauterivian** (1873 Swiss geologist Eugene Renevier after a town on Lake Neuchatel).

The **Valanginian** (1853 Swiss geologist Edouard Desor after a town N of Neuchatel).

THE HOT ROCK SLOT

BASALTS

Having focussed on peridotites in the last issue of the Newsletter, there is a kind of logic in moving on to look at basalts because all basalts are derived (either directly or indirectly) from the partial melting of mantle peridotite. Basalts are by far the most abundant volcanic rocks on Earth (~90% by some estimates), comprising as they do a substantial proportion of the oceanic crust as well as voluminous continental flood-basalt provinces and central volcanoes. Basalt is also the rock that forms the maria of the Moon, and the crust of Mars appears also to consist mostly of basalt, but here I'm dealing only with terrestrial material.

Definition and petrographic characteristics:

Basalts are volcanic rocks of basic composition (i.e. having a bulk-rock SiO_2 content of between 45% and 55%) and are thus the fine-grained equivalents of dolerites and gabbros. Fine-grained basic rocks in minor shallow intrusions (e.g. dykes) are also commonly referred to as basalt although they are not strictly volcanic. The average density of basalt is *ca*. 3.0 g/cm^3.

Mineralogically, basalts are rather uniform and, if completely crystallised (**holocrystalline**), consist essentially of pyroxene (augite and/or pigeonite) and plagioclase feldspar, with or without olivine, accompanied by minor amounts of apatite and an opaque Fe,Ti oxide (commonly titanomagnetite). A small proportion of either quartz or feldspathoid (e.g. nepheline) is also permitted. The plagioclase has a relatively calcic composition, i.e. has >50% of the anorthite end-member in solid solution. Basaltic liquid can be quenched to glass if very rapidly cooled, producing either **tachylite** (a rock consisting entirely of basaltic glass) or glassy basalt (consisting of glass plus combinations of the above minerals).

Like all natural silicate magmas, basaltic magmas crystallise over a wide temperature interval of some 100-200ºC. If erupted at a temperature above the **liquidus** (the point at which crystals first appear on cooling under equilibrium conditions, typically *ca*. 1250ºC at atmospheric pressure), a basaltic liquid crystallises to a black, fine-grained, even-textured rock, the small grain size reflecting rapid cooling on the Earth's surface.

If, on the other hand, the eruption temperature is lower than the liquidus, then some crystals will have already begun to form as the magma cooled slowly at depth (e.g. in a sub-volcanic magma chamber); in the resulting rock, these crystals, known as **phenocrysts**, have a larger grain size than the groundmass (reflecting slower cooling) and are typically **euhedral** (i.e. have well-formed crystal shapes), reflecting unhindered growth in liquid (Fig. 1); the fine-grained groundmass reflects a phase of more rapid cooling during the final eruption of the magma onto the Earth's surface. Rocks containing phenocrysts are termed **porphyritic** and an example of a porphyritic basalt is shown in Fig. 2. Phenocryst assemblages consist of combinations of augite, plagioclase and olivine, depending on the exact magma composition, the pressure and temperature during the slow-cooling stage, and the eruption temperature.

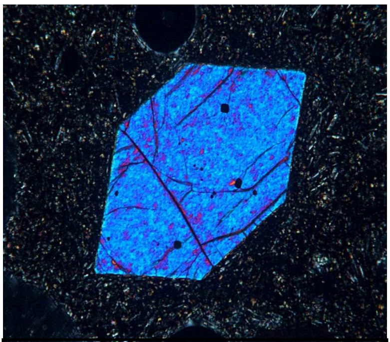


Fig.1 Photomicrograph showing a euhedral phenocryst of olivine in a glassy basalt from Réunion. Crossed polars. Width of image:1.5 mm. Photo: G. Droop.

All magmas contain dissolved gases and in basalts the most important are CO_2, H_2O and SO_2. As magmas rise through the crust these gases come out of solution to form bubbles in response to decreasing pressure, much like when a champagne bottle is uncorked.

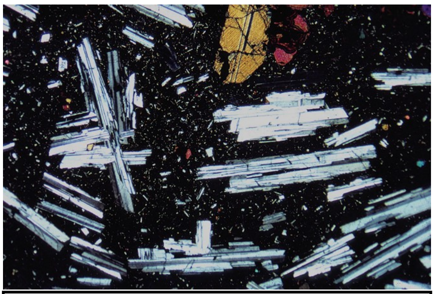


Fig.2 Photomicrograph of a porphyritic basalt. The pheno-crysts are of augite (top centre) and plagioclase feldspar. Crossed polars. Width of image: 2 mm. Photo: G. Droop.

These bubbles may be preserved in the solid rock where they are known as **vesicles** (Fig. 3). Most vesicles no longer contain the original volcanic gases but in **popping rock**, dredged from the deep ocean floor, they do. Basalts are prone to low-temperature hydrothermal alteration by hot fluids circulating in the crust (e.g. near oceanic ridges). Common alteration minerals include zeolites (e.g.natrolite), calcite, chlorite and silica. In vesicular basalts, such minerals may partially or completely fill the vesicles forming **amygdales** (Figs. 4 and 5).

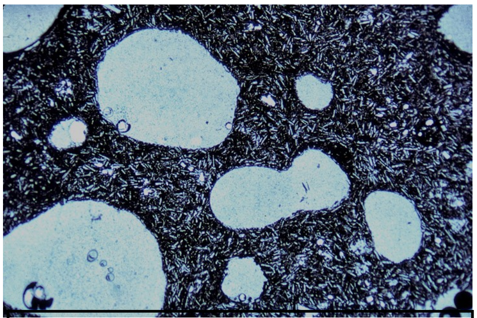


Fig.3 Photomicrograph of vesicles in a glassy basalt from Stromboli. The tiny tabular crystals are plagioclase. Plane polarised light. Width of image: 2 mm. Photo: G. Droop.

Fig.4 Filled vesicles (amygdales) concentrated at the top of a basalt lava flow on Mull. A red fossil soil (bole) separates the vesicular top from the flow above. Photo: G. Droop.

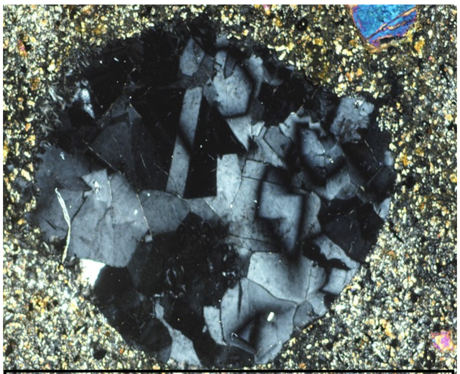


Fig.5 Photomicrograph showing crystals of chabazite (a zeolite mineral) filling an amygdale in a basalt from Réunion. Crossed polars. Width of image: 2 mm. Photo: G. Droop.

Origins of basalt:

Laboratory experiments have demonstrated that basaltic liquid can be produced by modest amounts of partial melting (*ca*. 10-20%) of 'fertile' peridotite (garnet- or spinel-lherzolite). The temperature of the fertile peridotite **solidus** (the point at which melt first appears on heating under equilibrium conditions) can be reduced by two things: (i) a decrease in pressure, caused by movement of the source rock towards the Earth's surface, and (ii) influx of H_2O. Basaltic liquids produced by these different mechanisms have slightly different chemistries (see below). There is also evidence that different compositions are produced when dry lherzolite is melted at different pressures (hence different depths and solidus temperatures).

Basaltic volcanoes:

Volcanoes that erupt basaltic magma are of two types: (i) **central volcanoes** in which magma is erupted repeatedly from one or a cluster of pipe-like conduits, resulting in the assembly of huge conical volcanoes, and (ii) **fissure volcanoes** in which magma is erupted from a linear fissure, probably fed via a dyke, with each fissure erupting only once. Most basalt eruptions in the historical past have been *via* central volcanoes. The most famous fissure eruption was the 1783 Laki fissure eruption in Iceland. Basaltic liquids have low viscosities, comparable to that of runny honey. This is because of their low SiO_2 contents which means that there is little polymerisation of SiO_4^{4-} tetrahedral units in the molecular structure of the liquid. The upshot is that basaltic magma tends to be very mobile, which has a profound influence on the mode of eruption and architecture of basalt volcanoes. Firstly, even before the magma erupts, vesicles can move and coalesce easily so that exsolved volcanic gas can escape relatively efficiently. This prevents the buildup of gas in the magma chamber, thereby suppressing explosions and promoting an effusive style of eruption characterised by '**fire fountains**' (Fig. 6).

Fig.6 *'Fire fountain' and river-like basalt lava flows, Pu'u'O'o vent, Kilauea, Hawaii, 1983. Photo: USGS.*

Basaltic volcanoes tend therefore to be dominated by lava flows rather than particulate ejecta (**pyroclasts**), although the latter can be voluminous locally (Fig. 7). Secondly, once erupted, basaltic lavas can often travel far before fully crystallising, which results in volcanoes with very shallow-sloping flanks (typically <10º) known as **shield volcanoes**, of which Mauna Kea in Hawaii is a good example (Fig. 8). In extreme cases, where very large volumes of very hot lava are erupted at a high rate from fissures (as thought to have happened during **flood basalt** eruptions in the geological past), sheet-like flows up to 50m thick can spread for huge distances (>100km) over sub-horizontal land surfaces.

Fig.8 Mauna Kea, Hawaii, showing characteristic broad, flat profile of a shield volcano. Photo: Wikipedia.

Characteristics of basalts in the field:

Because of the fluidity of basaltic lava, solidified flow surfaces are commonly smooth or ropy (‘**pahoehoe**’ type) (Fig. 9) particularly near the vent. The more distal parts of lava flows commonly develop irregular fragmented surfaces (‘**aa**’ type), as do flows with higher-than-average viscosity. Subaqueous eruptions produce a very characteristic **pillow** structure (Fig. 10). Pillows grow by bulbous budding and where they rest on pre-existing pillows, have convex-up, concave-down shapes. The outer skins of pillows are usually glassy because of rapid quenching in water.

Fig.9 Pahoehoe lava flow, Réunion. Note ropy appearance. Photo: W.J. Wadsworth.

Flood basalt flows tend to have remarkably planar surfaces (Fig. 11) and may have **columnar jointing** (Fig. 12) in which uniformly spaced joints develop on a honey-comb-like pattern perpendicular to the cooling surfaces; this forms in response to contact-parallel radial tensional forces caused by contraction during subsolidus cooling of the flow, which is pinned on its lower surface but free to contract vertically.

Fig.10 Pillow basalt, Calabria. Note reddish altered glassy rims. The convex-up concave-down shapes of the pillows indicate that the deposit is right-way-up. Photo: G. Droop.

Fig.11 Flood basalt flows near the Giant’s Causeway, N Ireland. Note columnar jointing in some flows (up to 10m thick) and red fossil soil. Photo: G. Droop.

Basalt flows commonly have vesicular (or amygdaloidal) tops (Fig. 4) produced by vesicles floating upwards while the flow is still liquid. Basalt is prone to weathering and flow tops tend to be preferentially weathered. Prolonged weathering in a tropical environment produces lateritic soils which may be preserved as red ‘**boles**’ between flows (Figs. 4 & 11).

Fig.12 Columnar jointing in basalt, Giant’s Causeway, N Ireland. Photo: G. Droop.

Distribution of basalts:

Basalts occur in almost every tectonic environment on Earth. At oceanic ridges (constructive plate margins), pillow basalts are erupted through ridge-parallel fissures, the lavas and dykes together forming Layer 2 of the oceanic crust.

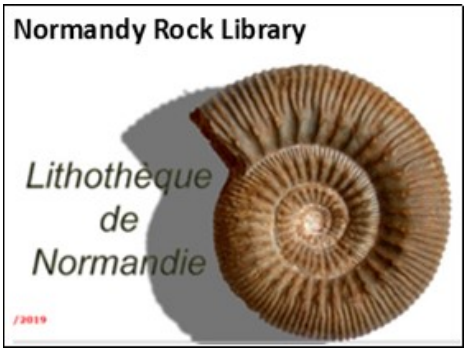
These basalts are invariably **tholeiites**, chemically characterised by silica saturation and low potassium contents, and are thought to form by relatively shallow partial melting of dry lherzolite in the ascending legs of mantle convection cells.
The basalts of island arcs and orogenic continental margins (destructive plate margins) are typically accompanied by more evolved volcanics (andesites and rhyolites) and tend to have higher K and lower Ca and Mg contents than tholeiites. They are thought to originate by wet melting of peridotite in the mantle wedges above the subduction zones, promoted by water released by dehydration of serpentinites and other hydrous rocks in subducted oceanic lithosphere.

Extensive basalt volcanism also occurs within stable plates. These basalts tend to be chemically variable and commonly include silica-undersaturated **alkali olivine basalts**. In both oceanic and continental settings, basalts build chains of shield volcanoes that develop sequentially as the lithosphere moves across hotspots (e.g. Hawaii). Also within continents, at various times in the geological past (luckily not recently!), eruption of copious flood basalts has resulted in the formation of spectacular **flood basalt provinces** (also known as **basalt plateaux**), the largest of which is the end-Permian Siberian plateau, with an original volume estimated at *ca*. 2,000,000 km^3. Others include the Karroo (S Africa), Parana (Brazil), Deccan (India), Columbia River (W USA), N Atlantic (W Scotland, E Greenland) and Ethiopian plateaux. The Cretaceous Ontong-Java – Manihiki – Hikurangi plateau of the W Pacific is probably an oceanic analogue of a continental plateau and, before becoming dismembered by later spreading, was *ca*. forty times the volume of the Siberian plateau! Some of these provinces are known to have formed within as short a time as 1-2 My. Huge amounts of CO_2 must have been added to the atmosphere at these times and may have contributed to mass extinctions. Within-plate basaltic magmatism is thought to be caused by decompression melting of deep-mantle plumes as they approach the base of the lithosphere.

Basalts in the UK:
The best places to see and sample basalts in the UK are in the British Tertiary Volcanic (BTV) province in NW Scotland and N Ireland. Here, the early phase of igneous activity was marked by voluminous outpourings of flood basalts that are now preserved in spectacular piles of lava in Mull, Skye and Antrim (Fig. 10). In Mull, the total thickness of the volcanic succession is *ca*. 2 km. Associated swarms of NW-trending basalt dykes, probably representing feeder fissures, occur across western Scotland and are well displayed along the south coast of Arran. The BTV magmatism extended from *ca*. 61 to 55 Ma. and is attributed to the proto-Iceland plume heralding the opening of the North Atlantic Ocean.
Basalts and associated alkaline volcanics of Carboniferous age are abundant in the Midland Valley of Scotland where they form the extensive Clyde volcanic plateau as well as numerous central volcanoes and plugs (e.g. Arthur's Seat and Castle Rock in Edinburgh and Elie Ness in Fife). Pillow basalts form part of the early Ordovician (Arenig) Ballantrae Ophiolite Complex and crop out near Bennane Head on the Ayrshire coast. Dismembered ophiolitic rocks of ?Cambrian age, including pillow basalts, occur in the controversial Highland Border Complex and can be seen in Glen Sannox, Arran.

The nearest basalt outcrops to Dorset are those of Devonian age in the vicinity of Totnes in S Devon; these are part of a belt of scattered outcrops that extends westwards to Rumps Point on the Cornish coast. The Ordovician arc-related volcanics of N Wales include basalts e.g. at Rhobell Fawr. The Carboniferous basalt of Calton Hill (Derbyshire) is notable for its xenoliths of mantle peridotite. *Giles Droop*

An excellent site for browsing the Geology of Normandy
http://geologie.discip.ac-caen.fr/index



A brief comparison of the Middle Jurassic of Southern England and Northwest France

Middle Jurassic overview

The Middle Jurassic spans 174 to 163 million years ago, some eleven million years.

Stage	Time	Derivation
Callovian	3 my	Kellaways, Wilts
Bathonian	2 my	Bath, Wilts
Bajocian	2 my	Bayeux, Normandy
Aalenian	4 my	Aalen, Germany

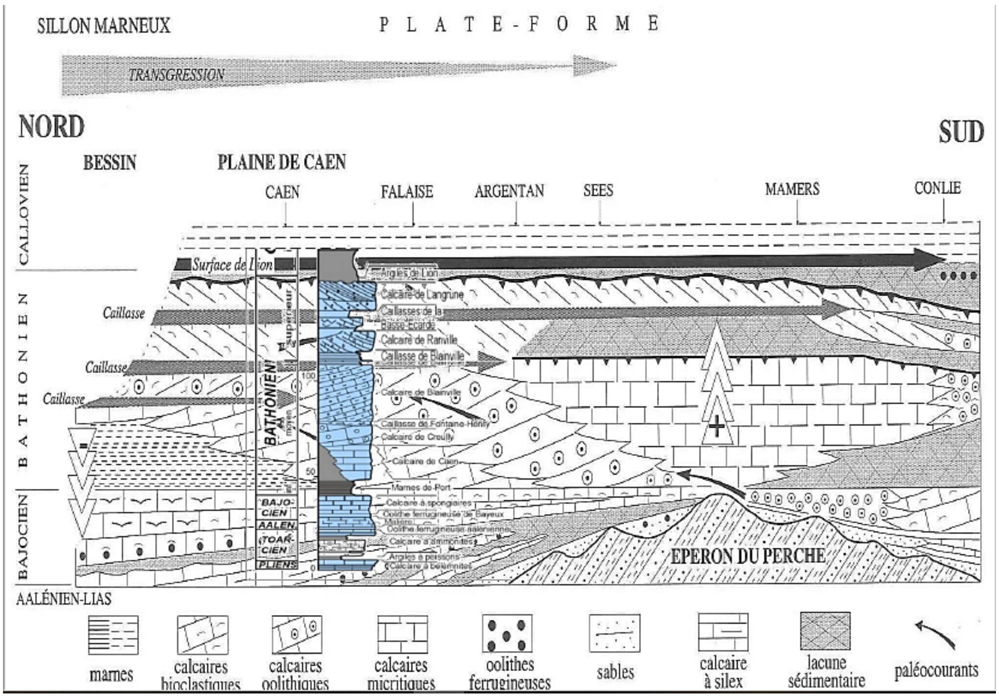
Southern England

In Dorset, the Middle Jurassic sequence is different from that in the Wiltshire-Weald (subsurface) area and in the southern and eastern Midlands. On the Dorset coast the Aalenian strata comprises the upper part of the Bridport Sands and the Inferior Oolite limestone; the Bathonian comprises Fullers Earth, Frome Clay, Forest Marble and Cornbrash. Move to the greater Bath area, however, and the Dorset coast clays are represented by shallow marine bioclastic and oolitic limestones of Bath Building Stone fame *[https://dorsetbuildingstone.weebly.com/bath-stone---somerset--wilts.html*]. In the subsurface of West Sussex and Hampshire, similar limestones are producing oil and gas.

North west France

The Middle Jurassic sequence seen on the Normandy coast and quarries inland is similar to the Wiltshire area but with an even greater variety of marine invertebrates. Again, there is lateral variation, this time from south to north. The Middle Jurassic succession is summarised here: https://dorsetbuildingstone.weebly.com/normandy.html and here: http://geologie.discip.ac-caen.fr/mesozoi/bathoni/portenbessin/milieu.html

How to explore the website



You can see how, say, the Mesozoic succession compares with ours.
If you dig into *Jurassique* then *Bathonien* you can see outcrops, hand specimens and thin sections. Flashing arrows means there is more left and right!

If you actually want to see for yourself bear in mind that you might come across a…

Site à protéger - marteau interdit !

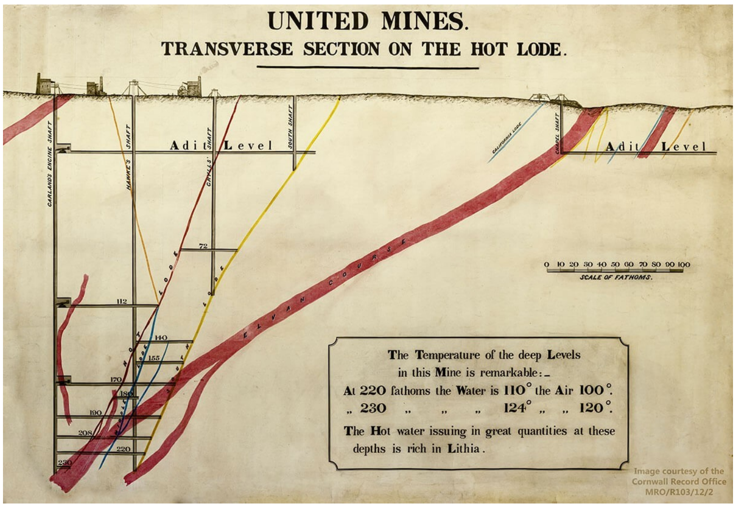
Geoff Townson

Some observations on the geology of Lithium, the 21st century's most important raw material?

Lithium is element 3 on the periodic table next to hydrogen, helium and beryllium and boron. As a 'light' element, lithium is often left over as the granitic igneous melt cools and that is why minerals containing lithium often occur in aplite and pegmatite veins that cut the granite intrusion and the surrounding country rocks. I remember finding a small example of the mineral lepidolite, a potassium, lithium alumino-silicate on one of my first field trips to south west England during the degree course at Kingston when we visited Meldon Quarry near Okehampton. Another important lithium mineral is the pyroxene mineral spodumene, also a lithium aluminium silicate.

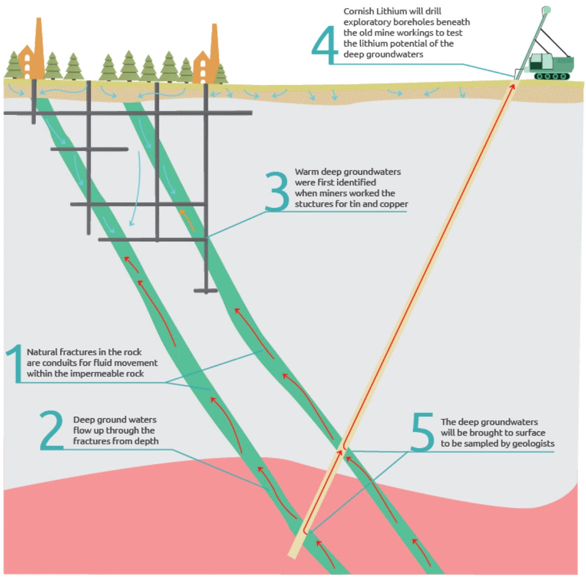
Recently there has been increased interest in lithium because of its use in batteries and the move towards electric cars. A company called Cornish Lithium is actively working in the county to establish an economic method of extracting lithium from geothermal brines circulating within granite intrusions. Cornish Lithium has the rights to survey 300 km 2 area for metal brines. The importance of this development is shown by the government financial support for the initiative.

The presence of lithium in Cornish rocks has been known about since 1864 when an academic from Kings College London studied brines associated with mining activity. Working in the United Downs area (between Penryn and Redruth) the geoscientist Miller found fluids at a temperature of 51^{o}C at a depth of 240 metres. The fluids were often hotter than the surrounding rock because they originated from a greater depth. If you remember that a typical geothermal gradient is 10-20^{o}C / km, if we extrapolate, the data from Miller we get 200^{o}C at 1 km (although I am not sure that this is directly applicable!). The high temperature is the result of heat generated by the decay of radioactive minerals also present in the igneous rocks. In GCR No 5 Igneous Rocks in S.W. England, chemical analysis of granites shows up to 1000 ppm of Rubidium. It also gives data of 1% lithium and 6-9% lithium micas in Cligga Head and Godolphin granites.



At the time there was no commercial interest in lithium but in the 1980's work at South Crofty Mine found lithium at concentrations that are now considered to be economic, hence the work being carried out by Cornish Lithium. Their website says they have 10 geoscientists working on the project. Extraction of lithium from the brines can be achieved quickly and with a high degree of purity (99.9% lithium). At present exploration drilling is taking place to measure the levels of lithium. This is a timely development as it has been suggested that demand for lithium will triple in the next 5 years and it will be beneficial not to be dependent of foreign sources. Currently the main producers are Argentina, Australia, Brazil, Chile, China, Portugal and Zimbabwe.

Alan Holiday ***(refs. on next page)***



Cornish Lithium | 2D schematic illustrating the presence of hot ground waters deep beneath Cornwall

References for Lithium article

https://www.cornishlithium.com/

https://www.theguardian.com/business/2020/apr/22/cornish-copper-find-metal-mining-industry?CMP=share_btn_link (a related story)

Book Review

Great Geologists by M.D.Simmons

Have you ever wanted to know a little about geologists whose names keep coming up in the literature or conversations? Who were/are they? Or what did they do and are known for? (preferably without having to read through a lengthy biography or autobiography, if there is one easily available).
Most people who are interested in Geology can name a few and sometimes what they are well known for, but can you list 35 ranging from 1666 to the present day?
If you are interested in the history and development of the science of Geology, at least as a starting point, then this is the book for you.
The book is a collection of essays written for Neftex Exploration Insights magazine between 20015 and 2018 by Prof. Mike Simmons, Halliburton Technology Fellow. Halliburton is probably the largest oil field cementing company in the world - a lot of cement is used in the drilling of oil wells!
The book comprises a very brief summary of the history of Geology before the main part comprising entries on the 35 geologists. Many names will already be known e.g.: James Hutton, William Smith, Mary Anning, but some only slightly. One or two were unknown to me (e.g. Maureen Raymo) Some I knew the name but couldn't tell you what they were known for.
The book is not at all technical and has the clearest, simplest description of Milankovitch cyclicity that I've read. It is a good book, easily read and very informative, and best of all it's free - yes FREE!!

A limited number were printed, and to see if any are still available you need to e-mail Mike.Simmons@halliburton.com

E-books are available From Insights magazine at: https://view.joomag.com/exploration-insights-great-geos-ebook/0172709001539012700?short
You will be asked to subscribe to the magazine, if you don't want to just click on the X at top left of the subscription box.
John Scott

Quiz Answers

Question 1 The line of trees corresponds with the Shaftesbury Sandstone - it is possible to see many places where there are the remains of small quarries. This area is not suitable for grazing or arable crops.

Question 2 2 Roads passing down slopes of unconsolidated sand often form these “hollow ways” caused by the passage of traffic and rainwater runoff. The Cann Sand is the case here and is so in most of the sunken lanes. Cann is adjacent to Shaftesbury - the previous name for the Cann Sand was the “Glauconitic and Micaceous Sands Of The Zone of *Mortoniceras Inflatum*”

Question 3 The reason for the unevenness is because of landslipping. The landslides are most readily seen to the south and west of Shaftesbury.

Question 4 Water leaves a permeable rock when it meets an impermeable layer. The line of trees is thus likely to be close to the junction of the Gault Clay and the Cann Sand. If you want something more to think about - can you think why it emerges at certain points rather than oozing out along the line of the junction?

DGAG Field Trips and allied events 2020

Please note that events have been postponed until further notice owing to Coronavirus restrictions.

To book a place on our field-trips, contact Val Fogarty using the details below. £2.00 day trip fee.

Saturday 5th September:
Hampshire Fossil and Mineral Fair, Lyndhurst.

Friday 11th – Monday 14th September:
Black Country Residential Fieldtrip

Saturday 24th - Sunday 25th October:
Lyme Regis Fossil Festival

Saturday 24th October:
Holiday Rocks, Broadmayne.

Saturday 28th November:
DGAG Annual Dinner, Weymouth

Saturday 12th December:
Winter Workshop, Broadmayne.

Websites:

https://dorsetgeologistsassociation.org/
https://dorsetbuildingstone.weebly.com/
https://dorsetrigs.org/
https://ougs.org/wessex/
https://jurassiccoast.org/

DIGS (Dorset's Important Geological Sites)

The group welcomes anyone wishing to help with conservation work on Local Geological Sites. Please contact Alan Holiday if you are interested. Working parties go out on both weekdays and weekends.
alanholiday@btinternet.com

Wessex OUGS events

Please contact Jeremy Cranmer on: wessexdaytrips@ougs.org or telephone 01305 267133 to book a place. £2.50 day trip charge.

September 6th (Sunday) Horn Park and area. Leader: Bob Chandler

September 20th (Sunday) Geology and Fossils, Lyme Regis. Leaders: Sam Scriven and Chris Readman

October 11th (Sunday) Conservation on a Dorset LGS. Alan Holiday

November 1st (Sunday) Bowleaze Cove. Leader: Alan Holiday

Reminders: Contributors' deadline for the Autumn Newsletter is: **Monday, September 28th, 2020.**

Committee news:

We **still** need an Events Officer!
Kelvin

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