Newsletter No. 284
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Contents:

A familiar local fossil assemblage? Don't be too sure! Read on for enlightenment!

Copy date for the next Newsletter is Saturday 1 June

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For enquiries about field and geoconservation meetings please contact the Field Secretary. To submit items for the Newsletter please contact the Newsletter Editor. **For all other business and enquiries please contact the Honorary Secretary.** For more information see our website: bcgs.info, YouTube, Twitter: @BCGeoSoc and Facebook.		

Future Programme

Indoor meetings are normally held in the Abbey Room at the Dudley Archives, Tipton Road, Dudley, DY1 4SQ, 7.30 for 8.00 o'clock start unless stated otherwise.

Visitors are welcome to attend BCGS events but there will be a charge of £1.00.

Monday 15 April *(Indoor Meeting):* 'Geology of the Chiltern Hills; new data & new interpretations'. Speaker: Dr. Haydon Bailey (Geological Adviser, The Chiltern Society). The Chiltern Hills are underlain by Chalk, predominantly lithostratigraphic units traditionally called the Lower and Middle Chalk (the latter now the lower part of the White Chalk Group) capped by the Top Rock - Chalk Rock complex. It is this series of chalk hardgrounds which effectively forms the spine of the Chiltern Escarpment. The Chalk dips gently into the London Basin, and the overlying basal Tertiary succession provides minor outliers around this northern rim of the basin. The other major geological event we have to recognise in this area is the re-routing of the Proto-Thames River during and following the Anglian glaciation, some 450,000 years ago. This created the landscape we currently see in much of the southern parts of the Chilterns. Geological mapping of the region by the BGS over the last ten years and ground investigations resulting from the ongoing construction of the HS2 High Speed rail link have greatly added to our knowledge of the regional geology. Add to this the recognition that subsurface movement of water through the chalk is far more prevalent than previously identified, then this means that we're still learning a whole load more about the geological development of the hills which form the northern margin of the London Basin.

Saturday 11 May *(Field Meeting):* Central Malverns Complexes. Led by John Moseley (Gloucestershire Conservation Trust). Meet at 10.00 in Upper Tollgate Quarry (also known as Upper Wyche Quarry) which is used as a car park GR: SO7695 4395. This is the more southerly of the Tollgate Quarries. Parking costs £5.50 for the day, but covers all the Malvern Hills car parks if we need to move. Payment is by card only. Bring a packed lunch. ►

At the Tollgate quarries we will look at the Upper Silurian and Llandovery/Malvernian unconformity. Here there is a good range of foliated rocks of igneous origins, mainly granitic and dioritic, and evidence of a sheared dyke, and an enigmatic feldspar-hornblende-biotite rock. Here we can open discussion on topics such as metasomatism, and brittle and ductile shearing. From the Tollgate quarries, we will walk through the Wyche cutting, where there is evidence of mylonites and pseudotachylites. Then there will be a short walk onto Perseverance Hill to observe granitic rocks with gneissose and schistose textures. From here there are excellent views, and a chance to put the Malvernian in its regional context.

After lunch there are various options: a section through Upper Silurian on the west side of the Malverns (quite close to Wyche Cutting) and/or Gullet Quarry for the Llandovery-Malvernian unconformity. Total walking: approx 4km. Aim to finish by 4.00.

Saturday 8 June *(Field Meeting):* BGS open Day at Keyworth. We are planning to attend this event as a BCGS outing. Details TBC. Please let the Field Secretary know ASAP, and **no later than Saturday 20 April** whether you would like to attend. Entry is free, but we need to organise tickets.

Wednesday 3 July *(Evening Field Meeting):* Glacial Boulder Trail 2 'Around Bournville and Cotteridge Park'. Led by Julie Schroder. Joint meeting with Geological Society, WMRG. Meet at 6.30 on Bournville Lane, Birmingham, outside Bournville Station, SP050811. Parking available on Bournville Lane west of the railway. Learn how Louis Barrow, Cadbury's chief engineer in the early 20th century, saved numerous glacial erratic boulders found during excavation of the factory site, and created Birmingham's finest and most comprehensive collection of erratics from the Arenig Mountains in Wales. Finish around 8.30. Possible pub social afterwards (but not in 'dry' Bournville!).

Other Societies and Events

Warwickshire Geological Conservation Group

Sunday 28 April from 11.00 to 12.30: Kenilworth Cutting Field Visit led by Ray Pratt.

Tuesday 14 May from 10.00 to 3.00: Rugby cement plant & quarry.

There is a charge of £2.00 for non-members. For more information visit: http://www.wgcg.co.uk/ or email: WarwickshireGCG@gmail.com.

Mid Wales Geology Club

Tuesday 14 May: 'A geological journey through Oman'. Speaker: James Creswell.

Further information: Tony Thorp tel. 01686 624820 and 622517 tonydolfor@gmail.com
Web: http://midwalesgeology.org.uk lectures start at 7.15 and are a hybrid of in person meetings at Plas Dolerw, Newtown, SY16 2EH and via Zoom. Those wishing to join a meeting remotely should contact the secretary, Chris Simpson, at christopher_s@btinternet.com

Shropshire Geological Society

Wednesday 8 May: 'Origin of the Earth's continental crust'. Speaker: Hugh Rollinson.

Meetings commence at 7.15 for 7.30. Lectures are now being held in hybrid form, in person at the University Centre, Shrewsbury, as well as by Zoom. If you wish to attend please use their contact form. Further information: https://shropshiregeology.org.uk/events/

Teme Valley Geological Society

Monday 22 April: 'Malvern Rocks: geology in a Victorian health resort'. Speaker: Tim Carter.

Talks take place in Martley Memorial Hall at 7.30. Non-members £3. For further information email: enquire@geo-village.org or visit: https://geo-village.eu/

Geological Society, West Midlands Regional Group

Tuesday 9 April: 'Periglacial geohazards at the Colne Valley South Embankment'. Speaker: Guillermo Mondejar, Jacobs.

Tuesday 14 May: 'Mid-Pleistocene Deposits on HS2' (Title TBC). Speaker: Gerard McCardle, Systra.

Lectures are being held at Mott MacDonald, 10 Livery St, Birmingham, B3 3NU and by Zoom. They commence with refreshments from 6.00 for a 6.30 talk. For further details and registration please contact the Group Secretary at: geolsoc_wmrg@live.co.uk Click here for website.

East Midlands Geological Society

Saturday 13 April from 6.00 to 7.00: The Lower Cretaceous 'East Lindsey Group' – a jewel in the geological crown of Lincolnshire. Speaker: Paul Hildreth, General Secretary and Past President, Yorkshire Geological Society.

Tuesday 16 April from 10.30 to 4.00: Geological Walk around Sheffield's Graves Park and Botanical Gardens. Leaders: Andy Howard and Mike Allen.

Saturday 18 May from 11.00 to 3.30 approx: 'North Lincolnshire Museum and Frodingham Ironstone, Scunthorpe'. Leaders: Paul Hildreth and Mike Oates.

Non-members are welcome and should register with the secretary. Meetings will be held at 6.00 in the Geography Department of Nottingham University, which is in the Sir Clive Granger Building. Further info: www.emgs.org.uk or email: secretary@emgs.org.uk For field trip booking instructions see: https://www.emgs.org.uk/#fieldtrips

Editorial

At the AGM the subject of our Society's 50th anniversary was raised, inviting all of us to put our thinking caps on to come up with ideas for special events and activities thoughout 2025. We are also delighted that Dakota Johnson has been elected to join our Committee. She will be acting as web assistant to John, and we look forward to welcoming Dakota at our next committee meeting. We still have vacancies on the committee and need more people to be involved with running the Society. If you feel you have some time to spare and can offer skills - or just enthusiasm - please get in touch with Mark.

In this issue of the Newsletter we have Andy's annual report on our geoconservation work. Please note that Andy would love to see more volunteers at these sessions. It's important work, helping our Society, helping the park rangers and friends groups - and perhaps above all, these sessions are friendly and fun!

We have another fascinating small item from Mike Williams connecting our local geology with unfamiliar territory (for most of us!), and from Alan Clewlow a tantalising account of his recent trip to Costa Rica, with a second instalment to look forward to in the next issue. To conclude this issue, Mike Allen muses on a most extraordinary system of geological classification...

Please note that if you want to join the BCGS outing to the BGS Open Day you should register with Andy by **Saturday 20 April** *(see Future Programme p.3 above).*

As the summer approaches field visits and personal geological expeditions will be on the horizon. Please send us any items and snippets of information which you think may be of interest to our readers. We would love more of you to be involved in providing content for our two-monthly Newsletter. ■

Julie Schroder

Annual General Meeting

The 48th AGM of the Black Country Geological Society was held on 18 March 2024 at 7.30 at Dudley Archives. The meeting commenced with a greeting by the Chair, Graham Worton who then introduced the agenda.

1. Apologies
Alison Delorie, Helene Elder, Graham Hickman and Linda Tonkin.

2. Accepting of the Previous Minutes
The minutes of the 47th Annual General Meeting were produced by Mark Jeffs and made available to those in attendance. Graham asked for any objections or corrections. With no questions or corrections the acceptance of the minutes was proposed by Mike Allen and seconded by Pete Purewal.

3. Treasurer's Report
The Treasurer's report was produced by Alan Clewlow. The report was distributed to members in attendance along with the audited accounts. Alan summarised the key points in the report. ►

The audited accounts show that the Society was running at a deficit of £65.40 when comparing income with expenditure. Alan suggests that this trend is likely to continue due to speakers' expenses and room hire costs for our indoor meetings. Alan suggests looking at ways to maintain and increase membership to keep the Society sustainable in the long term. Alan suggests running a residential field trip might encourage membership after the success of the 2019 Dorset and 2022 Dingle Peninsula trips. Alan compared the membership figures and saw that the membership has been maintaining a similar level with a big increase from December 2019. Total reserves as of 31 December 2023 stand at £5304.36.

No questions followed and acceptance of the report was proposed by Mark Jeffs and seconded by Bob Fairclough.

4. Chair's Annual Report

The Chair's Annual report was produced by Graham Worton. The report was distributed to members in attendance. Graham Worton summarised the key points of the report.

The successful revalidation of the Black Country UNESCO Geopark was a big achievement for the area this year and some of the Society's members were directly involved in the inspection process. Julie and John were thanked. The inspectors recognised the work and passion of volunteers and local organisations within the Geopark giving the Society some international recognition for the work we do. Graham thanked all members for their support in making this happen.

Graham thanked the committee members for the work they do to help keep the Society running and thriving. Alan Clewlow was thanked for his role as Indoor Meetings Secretary and Treasurer, delivering a varied programme of interesting and engaging talks. Andy Harrison was thanked for his role as Field Meetings Secretary, delivering a varied programme of outdoor field meetings and organising geoconservation. Julie and John Schroder were thanked for their work on the newsletters and all other committee members were thanked.

Graham looked forward to our 50th Anniversary next year and mentioned that the committee already have plans underway, including the production of a journal: 'The Black Country Geologist - Volume 2' and a possible all day event. Graham invited any members with ideas for the anniversary to bring any suggestions to the committee to help make our 50th Anniversary special.

Following the report, Sue Fairclough said that Graham also deserved thanks for his leadership and passion for the Society. The membership in attendance thanked Graham. The acceptance of the Chair's annual report was proposed by Pete Purewal and seconded by Keith Elder.

5. Election of Officers

The Chair opened all committee posts for nominations. There was a nomination for Dakota Johnson as an Ordinary Committee Member to assist with the running of the website. Election of Dakota Johnson to this post was proposed by Graham Worton and seconded by John Schroder.

The Chair asked all incumbent committee members if they would stand again for another term, and they agreed. This had also been asked in an email sent out by Mark Jeffs to the committee prior to the AGM. All incumbent committee members to serve another year was proposed by Bob Fairclough and seconded by Keith Elder. ►

6. Election of Auditor

Davena Dyball to serve another year as auditor for the Society was proposed by Alan Clewlow and seconded by Julie Schroder.

7. Any other business

The Chair opened the floor to any other business. Dakota Johnson asked about the potential for engaging local colleges in the Society. There was also discussion of the revival of a 'Rock and Fossil' event that used to be very successful in engaging colleges and young people. Dakota also mentioned the use of Dudley College main hall as a venue for events.

Julie Schroder raised the issue of whether the Black Country Geological Society could run a 'Rock and Fossil' event to include the sale of fossils and rocks. Graham explained the reasons why UNESCO Global Geoparks have banned the sale of all geological materials. The reasons include the exploitation of workers collecting fossils or rocks in certain areas of the world and the damaging of internationally important sites by people in the fossil trade. Graham also expressed that he would have a conflict of interest if the Society did condone the selling of geological materials and would have to step down.

The meeting concluded at 8.00 and was followed by a talk by Rachel Burgess entitled 'Introduction to Geological Disposal of Radioactive Waste'. ■

Mark Jeffs

BCGS Geoconservation Days - Autumn 2023 and Winter 2024

With spring beginning, we say farewell to another successful geoconservation working season for 2023/2024, which has seen members return to Wren's Nest NNR, Saltwells NNR and Portway Hill, Rowley. Despite Council financial issues, we have still managed to carry out our work, once again partnered with the Birmingham and Black Country Wildlife Trust (BBC WT) at Portway Hill.

Saturday 7 October 2023 and **Saturday 24 February 2024: Wren's Nest NNR.**

We started the season at Wren's Nest on 7 October 2023, and had a spring session on 24 February 2024, each time meeting the Reserve wardens at their base on Fossil View. Both workdays were cold and sunny with some wind. Our works this season concentrated on the Reserve's southern end, once again at 'white rock' which forms the nose of the Wren's Nest pericline, and in the Lower Quarried Limestone trench, partway along the Reserve's eastern limb, known as Root Valley.

Wren's Nest - Root Valley clearance

The trench is one of two tracing their way around Wren's Nest Hill where the miners removed the Upper and Lower Quarried limestone to use as a building stone, soil sweetener and eventually iron smelting flux. Later on, the trenches were partly infilled with waste, leaving their upper parts and the rock strata either side exposed. Since the limestone mines were abandoned in 1924, thick vegetation and trees have grown, transforming the trenches into dark, uninviting tunnels unsuitable for wildlife and unappealing to the public. ►

Walking along the trench, and whilst we worked, it was plain to see how the dense ash, beech, hawthorn, holly and maple woodland blocks out the light. Beech trees with their shallow roots can be prone to sudden collapse, especially in stormy weather, as seen over this last winter. In turn, the vegetation can lead to unstable exposures and rock falls, which has occurred where the underlying Coalbrookdale Formation (also known as the Wenlock Shale) has been exposed.

Our work at Wren's Nest this season helped the wardens with clearing dense vegetation and thinning trees, particularly potentially dangerous ones from the southern end of Root Valley, to open it up and allow more light in. The result is a much more pleasant space for the general public to walk through.

Root Valley, Coalbrookdale Formation collapse

The ongoing overall aim is to open up woodland rides along the trenches, to form safe wildlife corridors connecting the Reserve's northern and southern ends. This, and letting more light in will help encourage more wildflowers such as orchids, black knapweed and wild strawberries, which in turn will attract various insects and birds. The wardens intention is also to connect the peripheral edges of Wren's Nest Hill with the central parts, where work has been ongoing to form natural enclosures and pools. This will create a diversity of habitats to improve biodiversity on the Reserve.

Saturday 11 November 2023 and **Saturday 13 January 2024: Blue Rock Quarry, Portway Hill**

For our two days spent at Portway Hill Nature Reserve at the former Bluestone Quarry site, we once again teamed up with members of the BBCWT. We met at the usual spot on St Brades Close for 10.30 under cold and frosty conditions during our November visit and cloud on our second visit.

Both days involved working on the newer dolerite (or microgabbro as it is now known) exposure, digging down to reveal more depth of rock face, and cleaning up the previously exposed face (Fig.1). From the spoil, we created a level platform to make accessing and viewing the exposure easier. Clearing the new face has highlighted that attention is required on the old exposure to remove soil and vegetation, which has accumulated since it was last cleared.

Figure 1: Portway Hill, discussing the local geology

Away from the rock faces, the BBCWT and the local friends group have been working hard to evolve the habitats for wildlife around their reserve. They are keeping on top of gorse and hawthorn to avoid the site returning to scrub and dense trees, whilst making meadows for wildflowers. The advantage with the underlying infill has been to provide nutrient poor grasslands loved by wildflowers, such as yarrow, hawkbit and red clover. This in turn provides a valuable food source for many insect species, including marbled white, skipper, green hairstreak and cinnabar moths and butterflies, 22-spot ladybirds and flea beetles. Likewise, the abundant insects provide a good food source for many bird species that are either permanent residents or just visiting. ►

For our second visit in January 2024, Graham led a walk across the Reserve and the former quarry. Starting at St Brades Close, we walked southwards, down through the undulating early mine workings, known as Bob's Canyon, into the BBCWT Reserve. Heading west, we continued past the dolerite exposures and along the ridge forming the Rowley Hills and stopped just before the ground started falling away towards the Portway Hill Reserve.

Along the way, Graham gave some background to the site, discussing the geology and how this has influenced the landscape and human heritage. A drovers track and dolerite stone walls forming field boundaries, hinted at the farming heritage that occurred here before quarrying the underlying dolerite commenced. The resultant void was landfilled to give the current landscape. The old quarry edges are still visible as the rock exposures we have been clearing, and as bunds forming the southern edge of the site. This landscape has given rise to the unique biodiversity that calls the BBCWT Reserve home.

We retraced our steps to St Brades Close, and as we packed up, we saw up to three foxes playing quite happily out in the open and close to the houses. They were totally unphased by people walking around and appeared quite happy to have made the Reserve into their home.

Saturday 9 December 2023 and **Saturday 9 March 2024: Saltwells NNR**

Our December and March days at Saltwells NNR saw us pretty much left to our own devices as a result of recent Council bans on overtime meaning there was no assistance from the wardens. On a rather wet December morning, a small group met at the main visitor car park and we spent the day clearing vegetation and exposures at Brewins Cutting on the Dudley No.2 Canal. The famous Carboniferous-Silurian contact at the Cutting's eastern end had particularly suffered from collapsed and accumulated soil and spoil, allowing vegetation to grow, thus creating further deterioration. This was removed to help clean up the exposure and prevent further damage. Vegetation was also cleared from the overgrown dolerite exposure at the Cutting's western end.

Saltwells NNR, Brewins Cutting Dolerite Exposure

Without a warden for the March meeting, it was decided that for instead of clearing vegetation, we would go on a walk around the reserve to take in the recent discoveries and note what future works may be required.

Starting from the visitor car park, we followed the tubline route to our first stop at Doulton's Claypit. Here, we discussed the Carboniferous geology represented, local structure, heritage and biodiversity. In the claypit we examined a fossil plant cast, recently identified by Les Drinkwater from the 'Friends of Saltwells NNR' group. Following the tubline north, we stopped to discuss the various outcrops in the Ludlow Shale and Downton Castle Sandstone and the relationship with the Carboniferous dolerite. Like the limestone trenches at Wren's Nest, the tubline had become very overgrown and dark with trees and low vegetation cover which had made it unappealing to wildlife and the general public. So, a lot of work has been undertaken to open up the tubline, making it lighter and a more pleasant route for wildlife and walkers passing through. ►

Saltwells NNR - Carboniferous fossil plant cast in Doultons Claypit

Emerging at the Dudley No. 2 Canal and Brewins Cutting, we stopped to discuss the dolerite exposures and the infamous unconformity with the new interpretation board placed beneath the Highbridge Road bridge. From Brewins Cutting, we followed the Dudley No. 2 Canal west before branching off and heading south, back into Lady Dudley's Wood, following the course of the Blackbrook. Stopping along the way, we discussed the local habitats and the industrial heritage and the impact this has had on the landscape. Passing the examples of early coal mining bell pits, we came out on to the mineral railway route that led east back towards the car park. Here, we stopped briefly to talk about the old salt spring, from which the reserve gets its name before heading back to the cars.

With the current season drawing to an end, I would like to thank the volunteers and wardens for their assistance and time during these work days. These days provide a great opportunity to get out and explore the local Black Country landscape and the interconnected relationship between geology, human heritage and biodiversity. So, I would like to encourage more members to get involved and come out and enjoy a day socialising as well as helping out with the all important and ongoing conservation work which is fundamentally important to the BCGS. ■

Andy Harrison

Further Adventures in SILURIA - September 2023

Looking at the picture *(right)* you could be forgiven for thinking that it is a photograph of grey Silurian rocks to be found all over the Welsh Borderlands, South Wales, or our own outcrops in the West Midlands. In fact it was taken 400m from the centre of Visby, the capital of the Swedish island of Gotland.

Murchison visited the island in 1845 to confirm his suspicions first formulated one year earlier. Between 28 July and 8 August 1844 he attended a meeting of Scandinavian Natural Scientists to explore sedimentary rocks outcropping near Christiania (today Oslo), and he had reason to believe that these strata belonged to his Silurian System. He was accompanied by Sven Lovén, and using the 'geognostic map' of Sweden produced in 1834 by Wilhelm Hisinger, along with fossils collected from Gotland on display at the Natural History Museum in Stockholm, he recognised Hisinger's 'transitional rocks' as being of lower Silurian age and equivalent to rocks well known in Britain. ►

Silurian coastal cliffs, Gotland

Today the rocks of Gotland are recognised from their abundant fossil assemblages to be of Middle Llandovery to Lower Ludlow in age *(see front cover photo).* Many excellent examples of the fossils associated with this period are to be found on display at the County Museum of Gotland located in the heart of Visby, which we were able to visit last September. The abundant exposures along the shores of the island must be a veritable treasure chest for any fossil collector - a BCGS field trip surely beckons! ■

Mike Williams

Further reading on this fascinating cousin of ours:

'Gotland: The Anatomy of a Silurian Carbonate Platform'
Sven Laufeld & Michael G Basset

'A Primitive Country of Rocks and People'. R.I. Murchison's Silurian campaign in Norway, 1844
Geir Hestmark , University of Oslo, 2008

'Murchison in Sweden: Consolidating Lower Silurian stratigraphy in the summer of 1844'
John Diemer, Geological Society of London, 2016

'Sunstones and Catskulls: Guide to the fossils and Geology of Gotland'
Sara Eliason, County Museum of Gotland

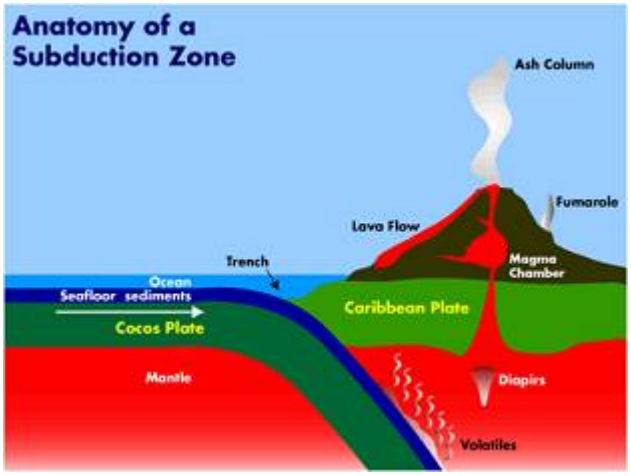
Geological Tour to Costa Rica January 2024 (part one)

In early January this year, I arranged and led a geological tour to Costa Rica. We were a group of 24, with almost everyone on the trip having been on a number of my previous trips to volcanic areas of the world. This was my fifth trip to the country, having first visited there in 2007, so it gave me the chance to observe any recent developments in the volcanoes and their features. The trip lasted 10 days, and took in five volcanoes: Irazu, Poas, Arenal, Miravalles and Rincon de la Vieja.

Geological Background

Costa Rica owes its existence to its volcanoes and its plate tectonic setting. It lies in the collision zone between two of the earth's minor tectonic plates. In this region, the small Cocos plate underlying the Pacific Ocean to the west is moving in a north-easterly direction and being subducted beneath the Caribbean Plate. Both of these plates consist of ocean crust material and so this is an example of an 'ocean-ocean' type of destructive plate margin, where one of the two ocean plates is driven down into the asthenosphere of the upper mantle at a fairly steep angle beneath the overriding plate. This produces a deep ocean trench as the leading edge of the overriding plate is pulled down in the collision zone. The trench is the Middle American Trench, and to the west of Costa Rica its depth is approximately 4 km. ►

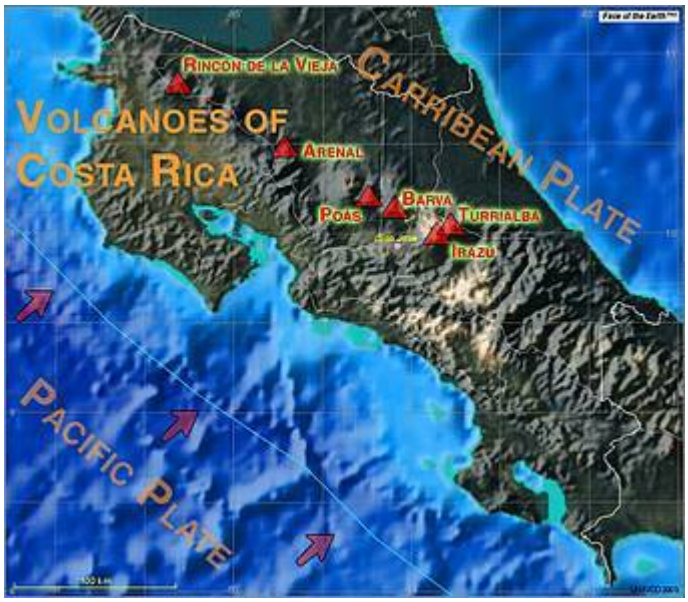
Friction between the two plates generates extra heat in the subduction zone and partial melting (those minerals with lower melting points are the ones which melt, while others, eg. olivine remain as denser crystals are returned to the asthenosphere). The magma created is 'intermediate' in character, with a higher silica content and less iron and magnesium than the crustal material it formed from. It has relatively low density and so rises towards the surface.



Originally, this would have formed a chain of island-arc volcanoes, but over many years, so much material has been produced that these have merged to create the land-bridge that today links North and South America.

The situation in reality is rather more complex than that explained above. One of the main complications is that the angle of subduction varies. In the north-west, it is steeper, at about 65°, whereas further to the south-east the angle is only 35°. The change occurs in a zone called the Quesada Sharp Contortion, and results in two different types of volcano in the country.

North of the Quesada Sharp Contortion, the downgoing crust is older and magma generation occurs at greater depth. It produces the ***Guancaste Range*** of volcanoes, which are generally smaller and richer in silica.



To the south-east, the low angle of subduction means that magmas are generated at shallower depths. The volcanoes which have formed here in the ***Central Range*** are larger in area, of lower angle and magmas more basaltic in character. There has been less time for the contamination and assimilation of overlying material as they rise to the surface.

There are also some rare outcrops of ultrabasic ophiolites in the far west of the country. These are called the Nicoya complex and formed from deep ocean crust, as deep ocean sediments and submarine volcanoes in the Jurassic and Cretaceous periods.

As might be expected from an area lying at a plate boundary, the country is subject to frequent earthquakes. The general pattern is that earthquake foci become deeper moving north-east, further away from the Pacific coast and the ocean trench, but in reality, powerful shallow-focus earthquakes are likely to occur anywhere in the country, such as the event on 8 January 2014, when an earthquake of magnitude 6.2 hit the country. Its epicentre was located on the slopes of Poas volcano, about 30 km north of the capital, San José. Up to 60 people may have been killed, mainly due to burial by landslides triggered off by the earthquake. ►

Volcan Irazu - main crater with lake in 2009

The first volcano we visited was **Volcan Irazu**. This is one of the main tourist attractions in the country, being the closest to the capital city, San José. It is also the highest active volcano in the country, at 3432 metres. From its summit, if the visibility is good, it is possible to see both the Pacific Ocean and the Caribbean Sea. The volcano is a classic composite cone volcano, with steep sides and alternating layers of lava and ash deposits. The chemistry of the erupted material is variable, and lavas tend to be mainly either basaltic or andesitic in character. Near the summit, there is a series of vents and craters.

Although there is plenty of evidence of eruptions dating back thousands of years, no-one knew it was an active volcano until 1723, when the volcano erupted for the first time following settlement of the country by the Spanish.

Most visitors come to view the main crater, which on all my previous visits was filled with a bright green crater lake, which I am reliably informed was highly acidic, with a pH close to zero. However, on this visit, the lake was not to be seen, having disappeared due to a lowering of the local water table (a victim of climate change?).

In recent times Irazu has seen frequent eruptions. In the last century, the two main ones were from 1917 to 1920, and then again from 1962 to 1965. That eruption started with a few minor explosions of ash in August 1962, but it really burst into action in March 1963, coinciding with the arrival of President Kennedy to the country on a state visit. It produced a huge ash-column, which left a covering of ash over San José. In the following months, the volcano also produced lava-bombs and showers of small pellets of lava (lapilli), though these fell only in the area close to the volcano. People were killed by the eruption, but these were all located entirely in river valleys, caused by a number of lahars (mudflows), triggered by intense rainfall mixing with volcanic ash.

The next volcano on our visit was **Poas**. This volcano is easily accessible from San José by main road, and so is a major tourist attraction, despite (or perhaps because of) a history of frequent eruptions. It sits surrounded by rainforest in the country's most visited national park. The volcano itself is 2,700m in height and is more than one million years old.

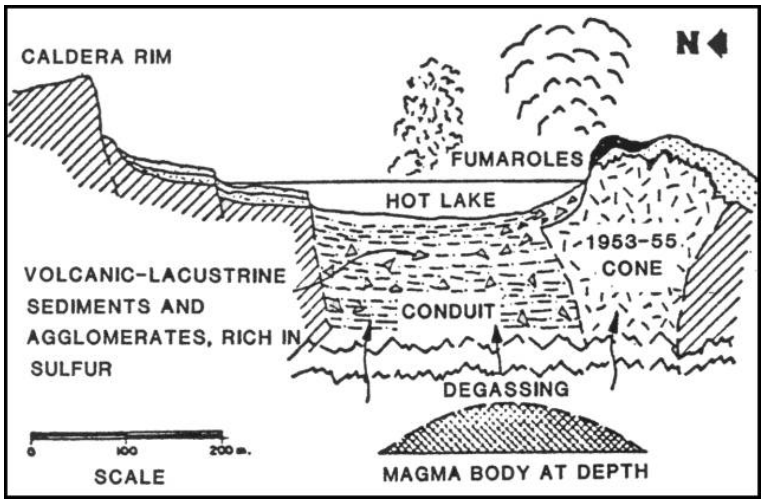
Volcan Poas - main crater, January 2024

Like other major volcanoes in the country, it is a fairly steep-sided composite cone volcano. The volcano has built up over an underlying basement of siliceous ignimbrites and lava flows which date back to the Pliocene and Pleistocene. There are also the remains of two calderas, the youngest of which was formed 40,000 years ago. The total area covered by the volcano is around 300 sq. kms. ►

At its summit area, the landscape flattens out. There are three main craters at the summit. In the centre is the current active crater. The active crater is 1.5 km in diameter. At its base is a crater lake of pale turquoise-blue colour. From the lake, fumaroles create clouds of sulphurous steam. Chemical analysis of the lake-water has revealed it to be highly acidic - its sulphuric acid content is 4 parts per 1000, and the pH is below 1.

The first recorded eruption of the volcano in its recent history dates back to 1828, when there were reports of blocks being hurled into the air which burned with blue flames (probably from burning sulphur). Throughout the period since, there have been numerous eruptions. Many of these are 'phreatic' eruptions (steam explosions which may blast out blocks and smaller fragments of volcanic rock formed at earlier times). There have also been some spectacular eruptions of ash clouds - one in 1910 rose to a height of 8,000 metres which deposited material throughout the Central Valley.

There was a period of intense activity in the period 1987 to 1989. It started with phreatic explosions, but gradually by 1989 the crater lake disappeared to reveal pools of liquid sulphur on the crater floor and red flames within the fumaroles as the sulphur ignited.



Sketch of Poas Volcano crater, courtesy of Global Volcanism Program, Smithsonian Institution

The first large eruption of Poas in the 21st century was in the spring of 2006. There were a number of phreatic explosions, which ejected steam, ash and blocks up to half a metre in diameter. All this was contained around the active crater summit area, but caused the National Park to be closed to visitors for some time. Since then, there were eruptions in 2010, 2011, 2013, 2014, 2016 and 2017. The most recent eruption was a phreatic eruption which took place last year in August 2023, again closing the National Park to visitors. It must have been quite a violent event, as our guide pointed out various indentations in the concrete path, where ejected rock-fragments from the eruption had landed. The authorities have now put in place an early warning system, indicating the level of activity, (based on a number of different types of sensor), using red, amber and green lights. If the lights turn red, visitors are ordered to leave immediately. The lights varied between amber and green during the period of our visit, and from the noise and variations in gas emissions that we witnessed, it really felt that this is very much an active volcano.

On our arrival, the view down from the caldera rim into the main crater was partly obscured by swirling mist and steam, but within minutes, this had cleared to reveal the crater lake and features around it. On leaving the viewpoint for Poas main crater, we then followed a trail with a steady climb for about a kilometre to the south-east to view the Botos Crater. This is now extinct, having last been active in pre-historic times. Its appearance of dark waters surrounded by thick, luxuriant vegetation presented a sharp contrast to the active crater. ■

Alan Clewlow

Part two of this account, with descriptions of the volcanoes: Arenal, Miravalles and Rincon de La Vieja will follow in the June issue of the Newsletter.

Mike's Musings No. 50

The 'End-Member' concept and a novel Classification System of Sedimentary Rocks

The end-member concept is a familiar one in many geological contexts, not least in rock classification. In some cases two principal end-members are involved, requiring a simple 'x' versus 'y' construct to be used e.g. the 'Folk classification system of limestones' (and it's various derivatives) that I mentioned in my last piece (Newsletter 283, Feb 2024).

Despite today's increased awareness in society for the need to serve everyone equally, it remains the case that current systems cater only for those equipped with the senses of sight, taste and touch, and consequently fail to meet the needs of all. Moreover, they are in danger of becoming stale, hackneyed and over-used or at least being taken too much for granted.

A new system of classification proposed for sedimentary rocks has been brought to my attention, and I am happy to have this opportunity to bring it to the attention of a wider audience through my regular column in this Newsletter. This system seeks to embrace the senses of olfaction and hearing, which the authors predict will be welcomed and widely embraced by the smellier and noisier members of the geological fraternity.

They assert that sedimentary rocks may be considered as mixtures of two end members: odoriferous and sonorous types. These end members may be combined in all proportions, dependent on how impressed one might be with one quality as compared with the other. A possible weakness lies in the extent to which this balance will be seen as a matter of personal opinion, but effort has been made to minimise the degree of subjectivity involved.

1 - End members based on odour:

Rocks to be tested for smell should be contained within a closed, transparent, odourless vessel of 1 litre capacity, (ideally 10cm x 10cm x 10cm), with a removable 'nose-piece' on the lid that, with hygiene in mind, may be changed between users. It may be beneficial to warm the container slightly, but gently, to facilitate the release of odours which are most often created by volatile constituents held within a specimen.

I. **Inodorates**
   - A. Strongly inodorate
   - B. Weakly inodorate

II. **Odorates**
   - A. Argillaceous ('clayey')
   - B. Bituminous ('coaly')
   - C. Irony ('ferruginous')
   - D. Phosphatic ('coprolitic)

III. **Malodorates**
   - A. Organic ('farmyard-like')
   - B. Sulphurous ('bad-egg-like')
   - C. Arsenical ('garlicky')
   - D. Fetid ('anoxic')

2 - End members based on sonority:

Rocks to be tested for sound should be dropped from a standard height of 2 metres on to a slab of 'standard-mix' concrete, 20 centimetres thick.

I. **Polyphons**

These are rocks which are broken either before or on the first drop

For sub-types and adjectives see II.

II. **Monophons**

These are rocks which remain intact after the first drop:

A. Non-Resonates (non resonant types)

These generally create sounds of low frequency (or lower pitch)

Sub-types include:
- i. Thudiferous
- ii. Whopiferous
- iii. Thumpaceous
- iv. Crumpaceous
- v. Clunkaceous
- vi. Plunkitic

B. Resonates (resonant types)

These generally produce sounds of higher frequency (or higher pitch)

Sub-types include:
- i. Klangaceous
- ii. Klinkaceous
- iii. Chinkaceous
- iv. Chickitic
- v. Tickitic
- vi. Ringiferous

All proportions between the two main end-members, **1** and **2**, are possible (in theory at least), thus we may have the following crumpaceous (A-iv) rock types in order of increasing smell:

1) Weakly inodorate, crumpaceous, non-resonant, monophon
2) Bituminous irony, crumpaceous, non-resonant, monophon
3) Ironic phosphatic, crumpaceous, non-resonant, monophon
4) Organic, sulphury, crumpaceous, non-resonant, monophon
5) Highly fetid, crumpaceous, non-resonant, monophon

Since all these terms are new to the geological literature there is little risk of confusion arising, and the system is expected to bed in (particularly appropriate for the sedimentary world) without major problems arising.

The accompanying table (Fig.1) is provided to illustrate the relationships between this new classification scheme and examples from the more established classical schemes of classification based on the remaining senses. ►

EXAMPLES OF RELATIONSHIP BETWEEN NEW "SMELL & SOUND" CLASSIFICATION SYSTEM AND OLD "CLASSICAL" NOMENCLATURE OF SEDIMENTARY ROCKS

musing50

1) ODOR / 2) SOUND	I. Inodorates	II. Odorates				III. Malodorates			
		A. Argillaceous	B. Bituminous	C. Irony	D. Phosphatic	A. Organic	B. Sulphurous	C. Arsenical	D. Fetid
I. Polyphons	Gravel Sand some Oolites	Silt Clay	Peat	poorly cemented Ironstone	weakly cemented Phosphorite	fresh Peat Manure	Sulphur	none known	some Muds / Sands
II. Monophons A. Non-Resonates	some Limestones Molasse	Loess	Lignite Bituminous Coal	ferruginous Sandstone	Phosphorite	Biomicrite	Pyritic mudstones	Arsenopyritic mudstones	Oomicrite
II. Monophons B. Resonates	Arkose Greywacke Sandstone	Shales impure Sandstones	Anthracite (Graphite)	Ironstone "Cank"	Coprolite	Biosparite	Pyritic sandstones	Arsenopyritic sandstones	Oosparite

Figure 1

Thus, an ironic monophon would approximate to a ferruginous flint or chert or a well-cemented ironstone such as the concretions termed 'cank knackers' in some Midland coal mines. Most limestones fall into the malodorate resonate monophon category.

Polyphons largely include poorly-consolidated or unconsolidated rocks accounting for 90% of all so-called 'drift' deposits. Incidentally, the size of particles composing various polyphons may be estimated by listening for the number of phons in a single drop (or 'unit toss').

Possible wider application:
It has not gone unnoticed by the authors that such a system of nomenclature could be extended to both the igneous and metamorphic world, but these generally offer less variety in terms of descriptive discrimination.

Advantages:
One obvious advantage of this new system will readily be appreciated in no longer having to try and distinguish between such abstruse and archaic lithologies as greywacke, molasse, arkose and the like. Furthermore, it does away with the compound terminology of tongue-twisting varieties of limestone such as biopelsparite, oosparrudite, pelletiferous micrite and the like, which will bring much relief to stressed-out undergraduates struggling to cope with the present-day rigours of funding their way through university.

Conclusions:
In conclusion, this classification system will be of great advantage to those geologists who have lost the senses of sight, taste and touch, or indeed, those potential geologists who never possessed much sense in the first place and were therefore disadvantaged by a heavily skewed system of preferment, being generally denied admittance to establishments of higher education in the first place: a parlous state of affairs affecting egregious losses to the geological fraternity and, arguably, ultimately, to society at large. *(...Yes Minister!)* ■

Mike Allen

Please note that your Editor is assembling this item for the Newsletter on the morning of Monday 1 April...