Home Counties North Regional Group Newsletter

Issue No. 12 - April 2021

Welcome from Newsletter Editor

WELCOME to the twelfth edition of the Newsletter of the Home Counties North Regional Group. The days are getting longer, the Covid restrictions are slowly lifting, and we are slowly getting back to some sort of normality. There are many positives to look forward to this month, and we hope you are feeling positive about the changes too! As promised, here is another newsletter issue, and we hope it finds you well. Please welcome our newest member to the committee, Adrian Marsh – you can find out more information about him in this newsletter. I have managed to compile part of this newsletter before being sent offshore again for two months, and John has agreed to complete the rest of this issue in my absence. I do hope you enjoy reading this issue!

Zuzana Lednarova - Newsletter Editor

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Report from the Chair HCNRG

Dear Home Counties North Regional members,

I hope you are all well and safe.

Our HCNRG newsletter editor and committee member Zuzana (Suzie) Lednarova, who is based in Bristol, produced part of this issue of our bimonthly newsletter before she set off in late March to the U.S.A., where she will work offshore for nine weeks; as result of that assignment, Suzie asked me to complete the rest of this newsletter, issue 12. I have, therefore, again donned the editor's hat to produce this newsletter and I will continue to wear it to produce issue 13 while Suzie is out of the country for the next two months. If you would like to have your articles published in issue 13, please send it to the HCNRG email address or to me by **Friday 28th May 2021**, I thank you for all your generous article contributions in advance.

By surnames in alphabetical order, thank you to Dr David Brook OBE CGeol. for his article **Assessment of subsidence arising from gypsum dissolution**; thank you to Zuzana Lednarova for her article **Engineering geology challenges from water level fall, case study: Dead Sea** which she wrote for a project; thank you to Dr Bryan Lovell OBE CGeol. for his article **Relying on the over-simplification that 'coal is bad' threatens COP26 success**, published with permission of The Times; last and not least, thank you to Adrian Marsh CGeol. for his article **Galapagos Islands – Never mind the flora and fauna what about the geology**, a report of his recent holiday.

Now, let me thank you all for participating in the recent voting for the candidates for the 2021 HCNRG committee; the results were most encouraging and reflected your overwhelming support and approval for the work accomplished by the 2020 committee members. We welcome a new member, Adrian Marsh, to the committee; Adrian is enthusiastic and looking forward to contributing to the HCNRG and serving the its members.

The committee and I have updated our biographies that include our voluntary contributions to the HCNRG for the benefit of the HCNRG members; it is a great satisfaction that we have been able to fulfil our obligations as elected HCNRG committee members before and during the unprecedented times of the pandemic in 2020. Due to the interruption of normal business caused by the pandemic, I introduced bimonthly newsletters and initiated a mammoth project to assist unemployed HCNRG members to obtain suitable positions in their different geoscience professions.

Before the pandemic, we have met many HCNRG members from the southern counties in our region at monthly lecture meetings, field trips, geology workshops at Burlington House and at museums, not to mention at the jolly annual December geology quiz evenings with wine prizes for all the quiz winning teams. I would stress that I have not forgotten our HCNRG members who live/work in the northern counties, in north London and in west Essex; it is one of my aims to roll out future face-to-face lectures in these areas, especially in north Bedfordshire, Northamptonshire, west Buckinghamshire, east London, north London, and the Essex area bordering east London. In 2019 and in the first quarter of 2020, I organised HCNRG lectures spread to new venues northwards to Harpenden and Husborne Crawley, westwards to High Wycombe, and eastwards to Ware; unfortunately, the latter two venues had to be cancelled and the lectures postponed because of the arrival of the pandemic.

Adrian Marsh has volunteered to take on the responsibility of organising all future lectures on Zoom and face-to-face lectures, I have asked Adrian to arrange a HCNRG face-to-face lecture in Northamptonshire and he will look for suitable new venues and inspect the facilities and feasibility of sites. The first HCNRG lecture on Zoom is proposed to roll out in May 2021, Adrian will keep you informed in due course.

Having passed on my role of organising future lectures to Adrian, I shall look forward to spending more time organising new tailor-made field trips and workshops for the benefit of HCNRG members. The field trips/ behind the scene tours will cover every HCNRG county and area as in the past (average five field trips/workshops per year) before I became Chair and took on the additional task of recruiting speakers and organising monthly lectures. I hope HCNRG outdoor activities can resume in late summer/autumn 2021 when it is safe to deliver, and also look forward to rolling out more new informal geology workshops at Burlington House as well.

As for the HCNRG career job search/assistance project, we are not going to duplicate lists of employers which are already in the public domains such as on internet websites and Linkedin, I can tell you that behind the scene we have been progressing on networking with prospective employers; many contacts were first-time two-way transparent communications and some contacts would lead to face-to-face meetings when pandemic restrictions end. When an unemployed HCNRG member asks for assistance, we will act as a go-between to introduce employers and set up meetings; there is no fee involved, just contact us. Adrian Marsh is a retired CGeol. engineer, he is the person to contact for geotechnical jobs, his email address is adrian.marsh@yahoo.co.uk , mobile 0781-891769; Karoly Pesztranszki would assist when availableand Zuzana Lednarova would assist as well. Rudy Domzalski HCNRG Secretary will respond to HCNRG members' enquiries on oil and gas industry job searches, you can contact him to the HCNRG email address homecountiesnorthregionalgroup@gmail.com , when Rudy is away, you can contact me also to the HCNRG email address homecountiesnorthregionalgroup@gmail.com , because I have a professional background in the oil and gas industry. For professional positions in geophysics, petrophysics. mining, quarrying, and museums, you can contact me as well. I will start networking with employers in the palaeontology and hydrology sectors later in the year.

I wish you all good health, stay safe. Have a successful and rewarding 2021.

Best wishes,

John Wong FGS Chair HCNRG

April 2021

Home Counties North Regional Group
2021 elected Committee Members

Officers

HCNRG Chair, Field Meeting Leader and Geology Workshop Presenter: John Wong FGS

John has a BSc in Geology (University of London) and MSc in Analysis of Geoscience Data, including computer modelling (Kingston University). He also studied master's degrees in petroleum Geology and Geophysics at Greenwich University and Sedimentology at University of London. John has worked in the oil and gas industry as Development Geologist and Consultant Geoscientist. He is the Field Officer for the Amateur Geological Society (AGS, based in Finchley, north London) since 2007 and has led 85 non-repeated monthly field trips for that group, and he was the Event's Organiser for the Bedfordshire Geology Group from 2008 to 2010. John has a passion for vertebrate palaeontology; and geoarchaeology of Hertfordshire and medieval battlefield geology are amongst his many leisure research interests in geology.

In 2019, the HCNRG committee did not have anyone specifically tasked with organising lectures and this role was undertaken by John, He organised all 7 HCNRG lectures in that year and 3 in 2020, 2 of which were later postponed/cancelled because of the lockdown restrictions. Later in 2020, John introduced bimonthly newsletters to replace annual newsletters and improve communication between members of the group; he produced 2 newsletters in 2020 when Zuzana Lednarova, the Newsletter Editor, was working abroad. John joined the committee in 2012; to date he has led 18 non-repeated field trips for the HCNRG and presented 3 HCNRG palaeontology workshops at Hitchin Museum Resources Centre as well as 3 geology workshops at Burlington House in London. In 2020, John has initiated a HCNRG committee project to assist unemployed HCNRG members to obtain suitable positions in their different geoscience professions.

HCNRG Secretary, Schools Geology Challenge Coordinator and Early Careers Geologist Award Coordinator: Rudy Domzalski FGS

Rudy started his career as an Archaeologist and Archaeological Geophysicist, surveying, mapping and excavating mostly in Great Britain. After five years as an archaeologist, he decided to study Geophysics at UCL followed by further studies at Imperial College. The Geophysics work after his studies gave him a deep understanding of seismic processing, however, he realised to build a great map you need a good knowledge of Geology. Therefore, he signed up to several Geological field trips led by John Wong. Thanks to John, Rudy was elected to join the Committee in January 2018 and it has been a great privilege for him to be responsible for communications as well as the Schools' Geology Challenge and Early Careers Award, both of which invite young Fellows to showcase their work.

HCNRG Treasurer, Geology Quiz Organiser: Michael McCullough FGS

Michael graduated with honours in Zoology and Geology from the University of London in 1972 and got his M Phil from Camborne School of Mines in 1974-76. He has been a chartered geologist and scrutineer since 1979 and a Chartership Committee member. He has worked for Wimpey Laboratories as field and senior geophysicist, Exploration Consultants, Pentex and Marathon Oil as senior geophysicist in the oil industry and has been a consultant senior geophysicist since 1995 for both seismic interpretation and client representative of VSP and site surveys. During downturns in the oil industry, he has been an associate of M & M Geophysical for conducting geotechnical geophysics and part owner of Blue Diamond Drilling, a geotechnical drilling company and spent several years in the roles of second driller and site geologist. Michael retired from full time employment in 2018 and can be found at home in Buckinghamshire.

Ordinary Members

HCNRG Web Administrator and Publicity Coordinator: Karoly Pesztranszki FGS

Karoly has a BSc in Geology (University of London) and an MSc in Engineering Geology (University of Portsmouth). Since finishing his studies in 2018, Karoly has been working as a graduate geotechnical engineer at RSK Environmental Ltd and then as an assistant engineer at WSP from April 2021. Karoly has a passion for geology, astronomy and various engineering subjects and he is keen on attending lectures and field trips as part of his personal and professional development. He also enjoys undertaking various engineering related online courses. Karoly joined the HCNRG Committee in May 2018. Karoly maintains and updates the HCNRG webpage, and he assists with organising face-to-face and online lectures. In the past he successfully recruited RSK as a sponsor to the HCNRG.

HCNRG Newsletter Editor: Zuzana Lednarova FGS

Zuzana is currently working as a geotechnical engineer, she has a BSc in Geology (Imperial College London), and an MSc in Engineering Geology (University of Portsmouth). To date, Suzie has had the opportunity to work in numerous locations around England, familiarizing herself with the Wealden Basin, the London Basin, and also areas around Bedfordshire, Birmingham, and Leicester. Suzie is highly interested in the geological subject and enjoys attending lectures and seminars, as well as travelling around the world and visiting geologically famous landmarks/sites. In 2020, Suzie has decided to join the offshore industry and has since travelled to numerous countries to work on windfarm construction projects.

HCNRG Lecture Coordinator: Adrian Marsh FGS

Adrian has a BSc in Geology & Physics, an MSc in Engineering Geology and is a Chartered Geologist with a long working life in site investigation, geotechnical and geomaterials engineering and latterly environmental assessment and management. Now largely retired, Adrian has a keen interest in our regional geology and industrial archaeology. Geology has been a stimulating and fulfilling career for me, with the added bonus of spending a good proportion of work time outside in the field, and I hope that I can help encourage and develop further generations of geologists.

ASSESSMENT OF SUBSIDENCE ARISING FROM GYPSUM DISSOLUTION

Dr David Brook OBE

This paper is a brief summary of part of a talk I have given on a couple of occasions to local geological societies. It is based almost entirely on the results of research carried out for the Department of the Environment almost 30 years ago now by Symonds Travers Morgan and published in:

THOMPSON, A., HINE, P.D., GREIG, J.R. & D.W. PEACH, 1996. *Assessment of subsidence arising from gypsum dissolution (with particular reference to Ripon, North Yorkshire). Department of the Environment Research Contract MP0613. Summary report.* East Grinstead, West Sussex, Symonds Travers Morgan, 95pp.

One of the pleasures I derived from this research was the opportunity it gave me on completion to go into my Minister's office and open the conversation with – "Hello Minister, I've come to tell you how much of your constituency is going to fall in a hole" – as David Curry, the then local Member of Parliament, was the Minister of State at the Department.

INTRODUCTION – SUBSIDENCE IN RIPON

Gypsum in the Permian rocks of the Ripon area was originally precipitated from warm, shallow sea water. As it became buried by younger rocks, gypsum dehydrated and formed anhydrite. With the removal of overburden by erosion, anhydrite reacted with groundwater to form secondary gypsum in the near-surface zone.

With continued exposure to flowing groundwater not saturated in calcium sulphate, gypsum dissolves rapidly leading to formation of solution-widened joints and fissures with in some cases major underground cavities or cave systems. Gradual caving of weaker or thinly bedded strata and/or more abrupt failure of thickly bedded rocks causes cavities to propagate upwards to surface, leading to subsidence hollows in open fields and subsidence damage to houses.

Areas susceptible to gypsum dissolution are broadly constrained by the limits of outcrop of gypsum-bearing strata to the west and the limits beyond which gypsum beds give way to unaltered anhydrite at depth in the east.

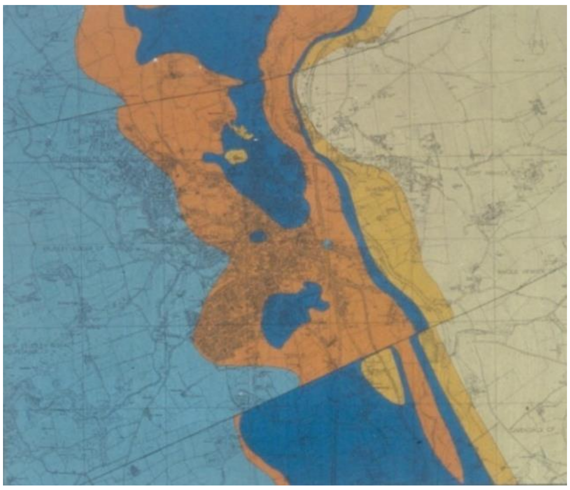
Subsidence hollow

1834 collapse hole

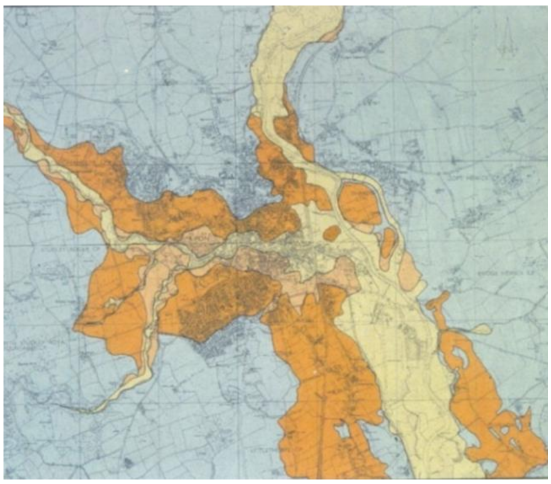
Movement along damp-proof course

Collapse of detached garage

GEOLOGY



Solid Geology



Drift Geology

The Ripon area includes the full sequence of Permian rocks overlain by variable thicknesses of superficial (drift) deposits. Solid strata have a gentle easterly dip exposing the rocks in a stratigraphical sequence from east to west:

- The **Cadeby Formation** (Lower Magnesian Limestone) lies unconformably on Carboniferous rocks. It is 40-65m thick at outcrop and thickens to 90m to the east.

- The **Edlington Formation** (Middle Permian Marl) comprises interbedded mudstones and gypsum passing down into massively bedded gypsum and anhydrite at the base. Both the formation and the gypsum beds thicken eastwards, with 20m of anhydrite overlying 13m of gypsum at Ure Bank.
- The **Brotherton Formation** (Upper Magnesian Limestone) is 10-14m thick and may thicken to 20m further east.
- The **Roxby Formation** (Upper Permian Marl) is similar to the Edlington formation with a 10m-thick basal gypsum unit. The formation is 10-18m thick, increasing to the east to 30-40m.
- Substantial thicknesses of the **Sherwood Sandstone Group** occur to the east of Ripon.

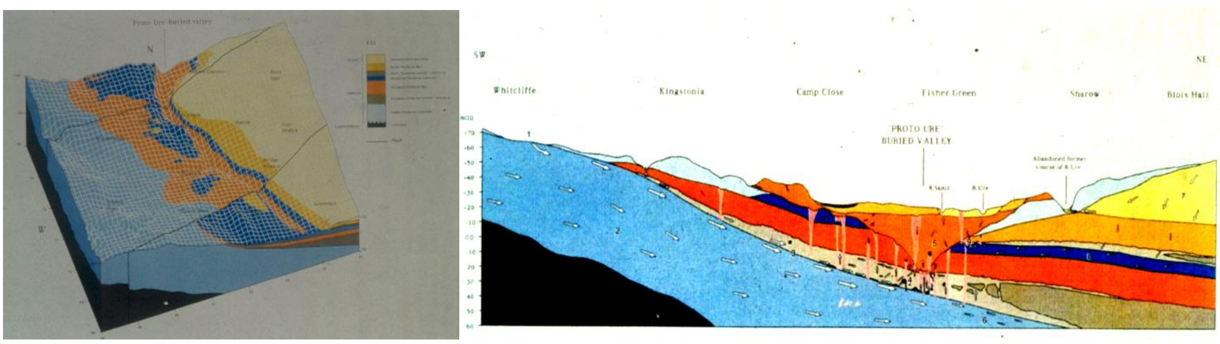
Superficial deposits comprise

- **Pre-Devensian –** a buried valley beneath the modern River Ure is infilled with coarse-grained fluvial and fluvio-glacial sediments, sandy gravels, cobbles and boulders, locally cemented by calcium carbonate precipitated from groundwater to form hard conglomerates.
- The **Devensian** is predominantly glacial till from <1 to >30m thick comprising stiff clays, with glacio-fluvial outwash sediments on sides of main valleys.
- **Post-glacial river terraces** occur along Skell and Laver valleys with isolated remnants in the Ure valley.
- **Alluvial sediments** occur beneath contemporary flood plains, typically comprising a basal sand and gravel (8m thick in Ure valley) overlain by finer-grained deposits (1-2m thick in Ure valley).
- **Holocene peat deposits** have accumulated in subsidence hollows and other areas of poor drainage, including flood plains.

GEOMORPHOLOGY

Substantial long-term foundering has occurred along the western and to a lesser extent the eastern margins of the deep buried valley beneath the modern River Ure. This is a relatively recent feature superimposed on the more general east-west thinning of gypsum since the formation of the valley.

CONCEPTUAL MODEL OF GYPSUM DISSOLUTION



The proto-Ure buried valley and influence on hydrogeology

Hydrogeological factors are fundamental to understanding the distribution of gypsum dissolution. Regional groundwater movements are predominantly east to west with base levels provided by the Vale of York. However, a local base-level is provided by the River Ure and its hydraulic connections created by the gravel-filled buried valley, which allows interception of regional groundwater flows.

On the west side of the valley, groundwater under artesian pressure in the Cadeby Formation moves upwards through the massive gypsum at the base of the Edlington Formation and into sand and gravel in the buried valley. Within a limited zone on the east side, groundwater in the Brotherton Formation is also drawn towards the buried valley and moves up through gypsum at the base of the Roxby Formation.

Together, these mechanisms are responsible for the high intensities of gypsum dissolution beneath and at the margins of the buried valley and for localised concentration of post-glacial subsidence.

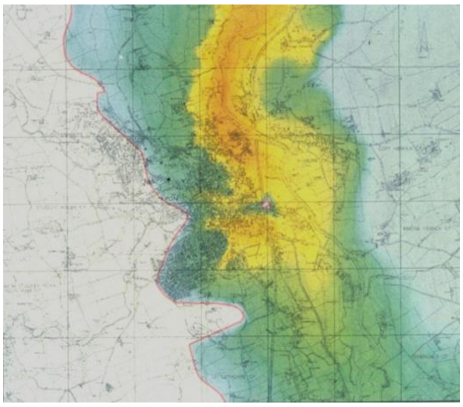
It is important to emphasise that there is only one event per year on average over an area of over 30km^2, they are largely in open countryside and cause only minor damage when they do affect buildings -- and much of that is due to compression of peat in older filled hollows. There is thus a very low property risk, much lower than that of flooding in the Ure valley.

ENGINEERING RESPONSE

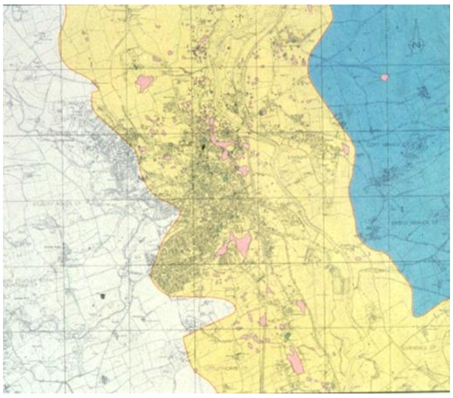
Engineering responses involve

- **investigation**, particularly to distinguish the occurrence of gypsum, which may in some instances be mistaken for limestone; and
- **mitigation**. For major structures, deep large-diameter end-bearing piles founded in the Cadeby Formation limestone below the lowest gypsum may be the only solution. For lesser structures then it is crucial that structural rigidity is provided through the use of reinforced foundations. Grouting of cavities may pose problems by changing the hydrogeological flow pattern, resulting in dissolution taking place elsewhere.

PLANNING RESPONSE



Rates of dissolution



Development Control map

Planning response is through a planning development control map subdividing the area into 3 zones based on the rates of dissolution:

- In area A, to the west, no gypsum is present, there are no constraints on local plan proposals & no planning control requirements related to gypsum. Building control measures may be needed if unexpected gypsum is encountered
- In area B, to the east, thick gypsum is present at depth but it is rarely affected by dissolution. Minor constraints may be imposed on local plan proposals and ground stability report may be required by condition on planning permissions.
- In area C, gypsum is present at shallow depth and susceptible to localised dissolution. Significant constraints may be imposed on local plan proposals and a ground condition report is normally before determination of planning applications and consents may be conditional on the implementation of approved mitigation measures.

All ground stability reports are required to be carried out by a suitably experienced geotechnical specialist, and confirmation is required that any previous ground investigation reports have been consulted, that an adequate ground investigation has been carried out and whether massive gypsum beds or cavities or foundered strata have been located and assessed for their potential effect on subsidence.

GYPSUM DISSOLUTION BEYOND THE RIPON AREA

Gypsum occurs in the Permian both northward to Darlington and Hartlepool and southward to Doncaster.

South of Darlington, at Hell's Kettles, catastrophic collapse occurred in 1179 creating 4 subsidence hollows up to 35m diameter and 6m deep. It appears to be associated with the margins of the buried valley of the River Tees. Other minor subsidence is possibly in part due to gypsum, with shallow depressions, (generally less than 1m deep) up to several hundred metres in diameter.

Subsidence hollow, Church Fenton

The Punch Bowl, Burton Salmon

The Ripon to Bedale area has widespread evidence for post-glacial subsidence but little evidence of ongoing activity and possibly not all the features are due to gypsum. In the Sherburn area, a subsidence hollow north of Church Fenton may be kettle holes. Near Knottingley, the Punchbowl at Burton Salmon and other hollows may lie along the line of a dry valley.

Engineering geology challenges from water level fall, case study: Dead Sea

by Zuzana Lednarova FGS

ABSTRACT

Sinkholes have appeared along the coast of the Dead Sea (DS) since the 1980s, which likely reflect thepresence of subsurface cavities. As the DS water-level continues to regress, a correlation has been observed with the formation of more sinkholes over time. Geological mapping, boreholes, aerial photographs, and seismic profiles have been used to deduce the subsurface conditions in close proximity to the current sinkholes. It has been observed that an area with a salt layer at approximately 20-50m depth, enveloped in clays and silts, which are interfingered with gravels and sands, are highly susceptible to subsurface cavity production. This cavity eventually results in an unstable upper surface, resulting in ground subsidence and collapse. With an increasing number of sinkholes, more touristic attractions are being shut down, and more costly repairs have to be planned, such as the repair of the road #90. With an increased availability of ground-models, site remediation projects can be planned, because sinkhole susceptible areas can be hypothesized.

The Dead Sea (DS) is located at the centre of the Dead Sea Transform (DST) zone, between eastern Israel and Jordan (Eppelbaum et al, 2008), figure 1, which is being affected by an accelerating water-level decline, figure 2, due to anthropogenic activities, and its natural evaporation rates. The DS water-level stood at 395m below the mean sea-level (bMSL) in 1960, and decreased to approximately 421m bMSL by 2008 (Closson et al, 2009), currently being the lowest place on the surface of the Earth.

As a consequence, the receding shoreline of the DS resulted in the evolution of new unstable coastal areas, which have experienced hectometric landslides (Closson et al, 2009), and the formation of sinkholes at a current rate of 150-200 per year, (Shirman & Rybakov, 2009). Various geological hazards have been observed such as: sinkholes, landslides, and infrastructure damage related to river erosion. This article will focus on the hazards posed by the presence of sinkholes and how they are being monitored.

Sinkholes can be defined as circular depressions (Arkin & Gilat, 2000), which form due to the collapse or subsidence of the upper-surface sediments as a result of dissolution ofsoluble rocks and deposits below the surface (Gutiérrez et al, 2007), forming dissolutioncavities. Dissolution cavities are associated with limestone, and evaporites such as gypsum and halite (Yoseph et al, 2015). It has been hypothesized that the primary cause of the sinkholes along the DS coast, is due to the dissolution of subsurface salt layers (Abelson et al, 2006), as a consequence of altered groundwater table levels (Closson, 2004).

The DS is considered to be a hyper-saline terminal lake, which gets replenished with freshwater from the northern Jordan River system, (Yechieli et al, 2016). The DS is a north-south trending pull-apart basin, which formed during the Miocene, during the sea-floor spreading of the Red Sea controlled by the DST (Garfunkel, 1981). The basin is filled with clastic and evaporitic sediments, infilling since the Miocene, and is currently structurally controlled by normal and strike- slip faults. The DST fault system is an active sinistral fault, extending 1000km from the Red Sea to the Taurus Mountain zone, Turkey (Closson, 2004) (Closson et al, 2005). The DS consists of two basins, separated by the Lisan Peninsula. The coastline of the shallower southern basin appears to be more susceptible to sinkhole formations.

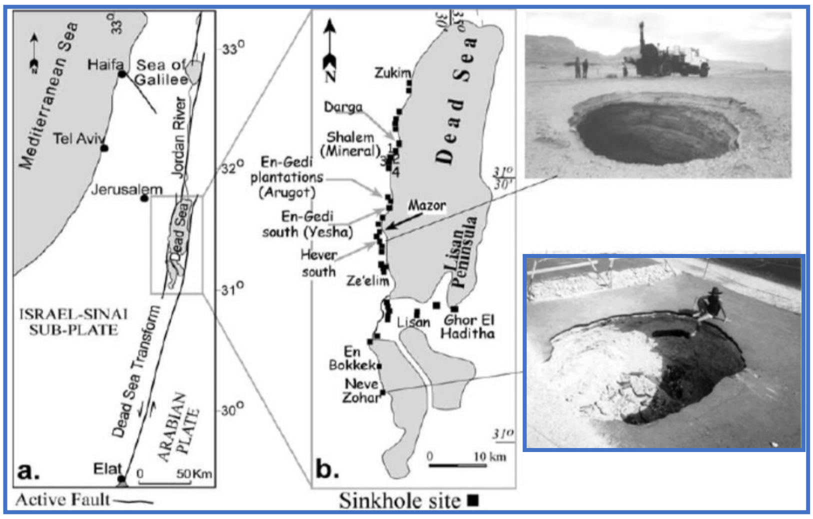


Figure 1: (a) Map of the study area showing the location of the Dead Sea, controlled by the Dead Sea Transform fault. (b) Black squares indicate thirty-six sites, which have been investigated by Abelson et al, 2006. This report focuses on two areas: Shalem (Mineral Beach), and En-Gedi.

Two photographs of sinkholes are also presented, the bottom sinkhole appeared on the road #90 in 1991(Arkin & Gilat, 2000). Top photo was taken in Hever South area, and the sinkhole has a diameter of 25m (Abelson et al, 2003) (Abelson et al, 2006).

The observed regional instability affects infrastructure, tourism development, and the ecosystems, (Qdais, 2007). Closson, 2004, has estimated that the Arab Potash Company (APC) has faced industrial damage costing more than $70-$90million as a possible consequence of the water-level decline.

In October 1992, a road in the APC complex was destroyed by a sinkhole, which was intended to be a part of a new salt evaporation pond (SEP). Following analysis, the pond was constructed further eastwards of the unstable surface, but was observed to have a leak in 1998 as a result of a sinkhole formed in 1996. To stop this leak, APC engineers decided to fill the sinkhole, which resulted in a costly construction of abridge to allow trucks the access to the SEP. However, this did not solve the problem and the SEP dried up in 2002 due to a collapse of a nearby dyke (Closson, 2004). Furthermore, other SEPs have also shown to be unsuccessful due to unstable groundconditions (Closson, 2004). Additionally, more damage has beenobserved as a result of sinkholes along the western coast of the DS. In 1991, a sinkhole appeared on road #90 at Newe Zohar, measuring at a diameter of 30m, and 5m depth (Arkin & Gilat 2000). In 2001, another sinkhole appeared on road #90, with a 30m diameter, and 20m depth. As a consequence of unstable ground conditions, buildings have collapsed into the sinkholes and the En-Gedi beachside car-park has also been closed down(Warren, 2006). Over time, further sinkholes have developed along the coast of the DS in En- Gedi, Shalem, En-Samar, Qalia, and other locations.

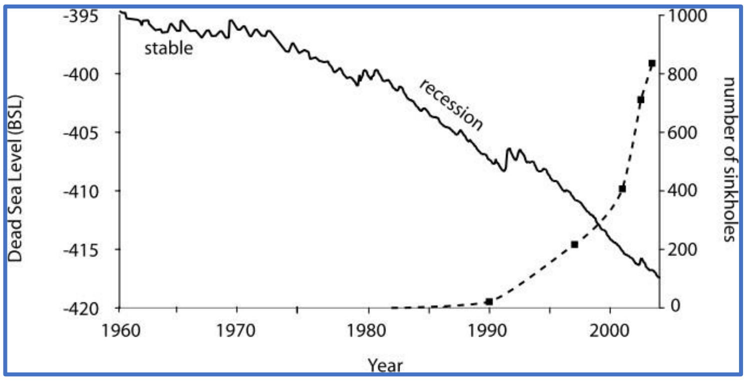


Figure 2: The decline in water level in relation with the increased number of sinkholes between 1960 and 2005, on the western coast of the Dead Sea, (Shalev et al, 2006).

The newly formed coastal areas are observed to represent two sedimentary environments: alluvial fans and mudflats. Yechieli et al, 2006 and Yechieli et al, 2016 have analysed two locations which represent the two main sedimentary environments; alluvial fan in the En-Gedi area, and mudflats at Shalem**.** Figure 5 represents the cross- sections of the two study areas, where the aim was to identify dissolution features, which are likely to be related to the formation of sinkholes. It has been observed that sinkholes in mudflats are shallower and wider, whereas gravel holes form in the frontal areas of the alluvial fans, (Arkin & Gilat, 2000), and may be up to 20m deep (Yechieli et al, 2016).

A possible explanation for the variation in sinkhole geometries with respect to the subsurface stratigraphy is due to the shear strength of the soils. Granular soils tend to have a friction angle above 36°, figure 4, whereas clays and silts have a much lower friction angle, (USCS D2487-11, 2011). This may result in a smaller diameter of the gravel holes at the surface, as observed.

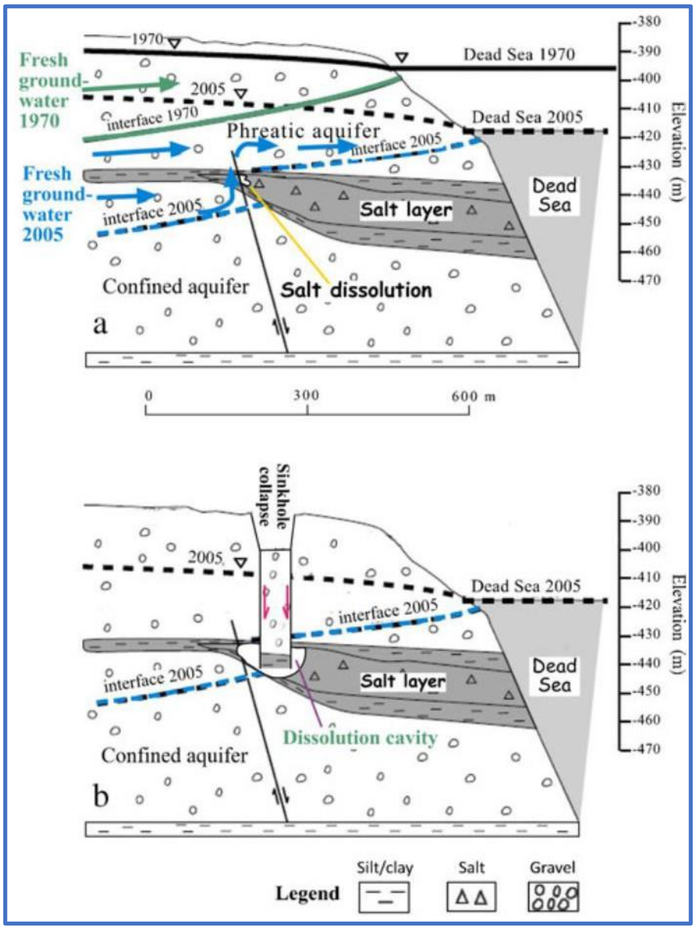


Figure 3: The deduced mechanism of sinkhole formation.

(a) The groundwater table is observed to have dropped between 1970 and 2005 as a response to the decline in the DS water level, allowing less saline water to flow through the salt layer.

(b) A dissolution cavity forms, resulting in unstable ground conditions at the surface, forming a sinkhole. (Yechieli et al, 2016).

USCS Soil-class	Description	Cohesion (kPa)	Friction angle (°)
GW	well-graded gravel, fine to coarse gravel	0	40
GP	poorly graded gravel	0	38
GM	silty gravel	0	36
GC	clayey gravel	0	34
GM-GL	silty gravel	0	35
GC-CL	clayey gravel with many fines	3	29
SW	well-graded sand, fine to coarse sand	0	38
SP	poorly graded sand	0	36
SM	silty sand	0	34
SC	clayey sand	0	32
SM-SL	silty sand with many fines	0	34
SC-CL	clayey sand with many fines	5	28
ML	silt	0	33
CL	clay of low plasticity, lean clay	20	27
CH	clay of high plasticity, fat clay	25	22
OL	organic silt, organic clay	10	25
OH	organic clay, organic silt	10	22
MH	silt of high plasticity, elastic silt	5	24

Figure 4: Relationship of different soils and their friction angle with relation to their shear strength. Silts and clays have a friction angle up to 33, whereas granular soils have a much higher friction angle, and lower cohesion. This results in steeper and narrower sinkholes formed in gravel dominated alluvial fans. (USCS D2487-11, 2011)

As well as borehole data, calibrated seismic refraction profiles have identifiedsubsurface salt layers of varying thicknesses between 2-20m, which may have changed dramatically in lateral thickness over a short distance (Shalev et al, 2006). As the DS undergoes a regression, the groundwater table also drops, and the fresh/saline water 1980, the flow of the DS brine water has been altered, figure 6, (Shalev et al, 2006)interface moves further seawards and drops (Shalev et al, 2006), figure 3a. It has been hypothesized that since 1980, the flow of the DS brine water has been altered, figure 6, (Shalev et al, 2006).

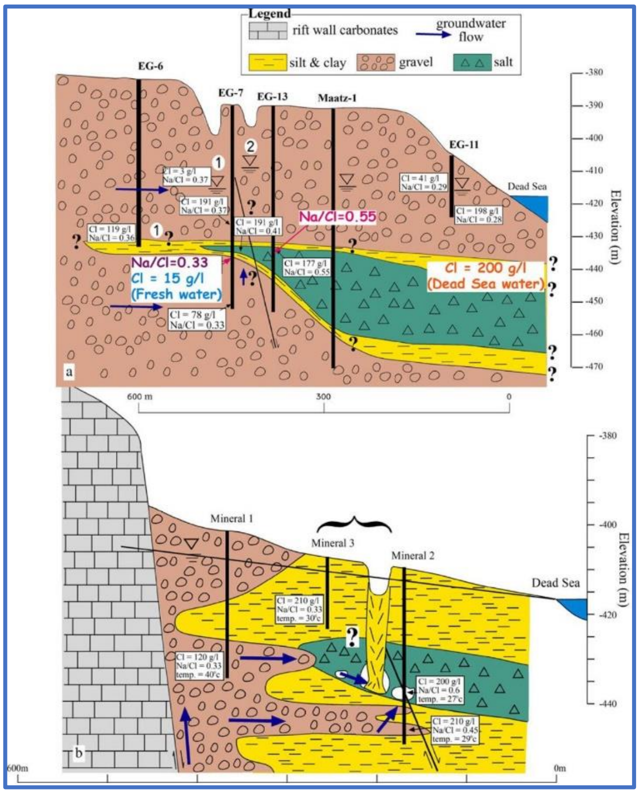


Figure 5: Hydrogeological cross sections in (a) En-Gedi (Arugot) and (b) Shalem (Mineral Beach). Subsurface interpretations have been deduced from boreholes obtained by Yechieli et al 2006. (a) Cross-section representing the sedimentary environment in alluvial fan dominated areas, where 'gravel holes' have been observed to form. (b) Cross section representing the sedimentary environment in a mud flat area, where sinkholes form in clay, and silt. Sinkholes in mud plains are shallower and wider. (Yechieli et al, 2016).

Due to a drop in the hydraulic head at the DS boundary, the brine water flows seawards towards the DS, resulting in the deeper sedimentary layers to be flushed with less saline water from the west. The fault acts as a conduit for the undersaturated water, and allows undersaturated water to migrate through the salt layer. When the salinity of the brine is less than half the salinity of the DS water, the salt is dissolved forming a dissolution cavity beneath the surface, eventually resulting in a sinkhole collapse (Shalev et al, 2006), figure 3b**.**

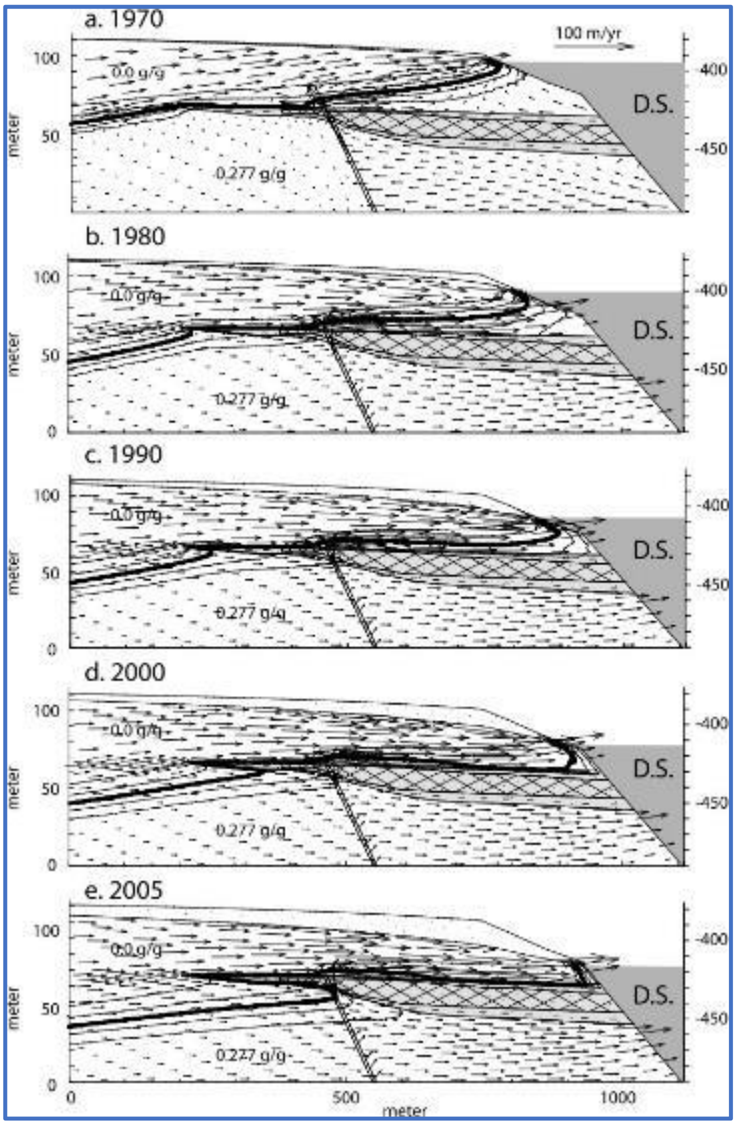


Figure 6: Evolution of the groundwater flow from 1970 to 2005 using finite element modelling and velocity vectors. Groundwater table is represented by the top solid line, and the fresh/saline water interface is the thick black line, which are observed to deepen and move seawards between 1980 and 2005. (a) Fluid velocity is estimated to be between 20-30 m yr—1 at the left edge of the cross- section, and decreases as the groundwater table falls. In 1970 the hydraulic head at the Dead Sea was at its highest, therefore the Dead Sea water entered the cross section from the right, and migrated upwards through the fault, and around the salt and clay layers. (b)-(e) Since 1908, Dead Sea brine does not enter the subsurface sedimentary layers and are returned back to the Dead Sea due to a drop in the hydraulic head at the Dead Sea boundary, as a consequence of the migration of the fresh/saline water interface, and the groundwater table. The reference velocity vector has a magnitude of 100 m yr-1. (Shalev et al, 2006).

The aim of this article is to represent a number of ground models obtained from different geophysical and field methods, to provide a greater understanding of the surface and subsurface conditions, as a response to the decline in the DS lake water- level. One issue with the presented data and the ground models could be argued that the data only focuses on the western coast. However, as the lake water declines, the shoreline retreats seawards around the lake. As a result, this affects the groundwater table in the surrounding sediments around the DS, therefore triggering the above mechanism, figures 3 and 6, resulting in subsurface salt dissolution.

Conversely, the upward propagation of brine water is controlled by the localized geology in the study area. As mentioned, faults act as conduits for groundwater, and different types of sedimentary layers may form aquifers. Previous studies have shown that coarser sediments such as gravel and sands are more susceptible to the dissolution process, and therefore sinkholes are more likely to form in alluvial sediments, interfingered with coarser sediments,(Frumkin et al, 2011). Therefore, to gain a better understanding of sinkhole susceptibility on the eastern coast, geophysical and field methods should be performed to deduce the stratigraphy.

As more damage is caused to majortouristic attractions, roads, and industrial land, a greater effort is made to identify potentially unstable ground. Current sinkholes are also being monitored for their change in shape and size, because wronglyplanned engineering solutions may prove to be costly and unsuccessful, as mentioned above with the SEP project.

Boreholes, fieldwork, geophysical profiles, and aerial photographs have allowedus to observe surface and subsurface responses to the decline in the DS water-levelthrough time. From these methods, it can be assumed that the sinkhole formation is controlled by:

1) The presence, and distribution of thesalt layer;

2) The type of sedimentary unit present, because these affect the porosity and permeability of thesedimentary bed enveloping the saltlayer;

3) The presence of faults, which act as conduits for groundwater.

These allow further models, such as figure 6, to deduce the hydraulic head, and suggest an area of an anticipated sinkhole formation, within a potential time frame.

References

Abelson, M., Yechieli, Y., Crouvi, O., Baer, G., Wachs, D., Bein, A., & Shtivelman, V. (2006). Evolution of the Dead Sea sinkholes. Geological Society of America Special Papers, 401, 241-253.

Arkin, Y., & Gilat, A. (2000). Dead Sea sinkholes–an ever-developing hazard. Environmental Geology, 39(7), 711-722.

Closson, D. (2005). Structural control of sinkholes and subsidence hazards along the Jordanian Dead Sea coast. Environmental Geology, 47(2),290-301..

Closson, D., Karaki, N. A., Klinger, Y., & Hussein, M. J. (2005). Subsidence and sinkhole hazard assessment in the southern Dead Sea area, Jordan. Pureand Applied geophysics, 162(2), 221-248..

Closson, D., Karaki, N. A., & Hallot, F.(2010). Landslides along the Jordanian Dead Sea coast triggered by the lake levellowering. Environmental Earth Sciences, 59(7), 1417-1430.

Eppelbaum, L. V., Ezersky, M., Al-Zoubi, A., Goldshmidt, V., & Legchenko, A. (2008). Study of the factors affecting the karst volume assessment in the Dead Sea sinkhole problem using microgravity field analysis and 3-D modeling. Advances in Geosciences, 19, 97.

Frumkin, A., Ezersky, M., Al-Zoubi, A., Akkawi, E., & Abueladas, A. R. (2011). The Dead Sea sinkhole hazard: Geophysical assessment of salt dissolution and collapse. Geomorphology, 134(1), 102-117.

Garfunkel, Z. (1981). Internal structure of the Dead Sea leaky transform (rift) in relation to plate kinematics. Tectonophysics, 80(1), 81 - 108.

Gutierrez, F., Cooper, A. H., & Johnson, K. S. (2008). Identification, prediction, and mitigation of sinkhole hazards in evaporite karst areas. Environmental Geology, 53(5), 1007-1022.

Shirman, B. & Rybakov, M. (2009). Sinkholes along the Dead Sea Coast and Their Development Sinkholes along the Dead Sea Coast and Their Development.

Shalev, E., Lyakhovsky, V., & Yechieli, (2006). Salt dissolution and sinkhole formation along the Dead Sea shore. Journal of Geophysical Research: Solid Earth, 111(B3).

Standard, A. S. T. M. D2487-11 (2011). Standard Practice for Classification of Soils for Engineering Purpose (Unified Soil Classification System).

Qdais, H. A. (2008). Environmental impacts of the mega desalination project: the Red–Dead Sea conveyor. Desalination, 220(1), 16-23.

Warren, J. K. (2006). Evaporites: sediments, resources and hydrocarbons. Springer Science & Business Media.

Yechieli, Y., Abelson, M., Bein, A., Crouvi, O., & Shtivelman, V. (2006). Sinkhole "swarms" along the Dead Sea coast: reflection of disturbance of lake and adjacent groundwater systems. Geological Society of America Bulletin, 118(9-10), 1075-1087.

Yechieli, Y., Abelson, M., & Baer, G.(2016). Sinkhole formation and subsidence along the Dead Sea coast, Israel. Hydrogeology Journal, 24(3), 601 - 612

RED BOX | BRYAN LOVELL

Relying on the over-simplification that 'coal is bad' threatens COP26 success

Dr Bryan Lovell OBE

Thursday February 25 2021, 12.01am, The Times

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https://www.thetimes.co.uk/article/relying-on-the-over-simplification-that-coal-is-bad-threatens-cop26-success-8tf93kdvn

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The carbon war is over: former combatants now need to raise their game accordingly. The long global conflict between environmentalists and the producers of fossil fuels involved simplification of many of the issues involved. We are now moving decisively into an era of co-operation between multinational resource companies and environmentalists. Distinctions that were previously blurred now become crucial to success in developing a low-carbon economy.

A failure to draw essential distinctions mars the current debate on the proposed new metallurgical coal mine in Cumbria. Too many influential opponents of the mine are simply saying: "If it's coal it must be bad."

Thermal coal is still burned in quantities to generate electricity. Emissions of fossil carbon from coal-burning power stations can and must be curtailed. We have other sources of electricity to which we can now turn. If we need to, we can also capture the carbon dioxide emitted by existing power stations and store it safely using proven technology.

There is another use of coal, for which we have not yet developed alternative technology at an adequate scale. For the time being, metallurgical coal remains essential for the manufacture of steel. Steel remains essential in any conceivable low-carbon economy. If we are to avoid exceeding the remaining global carbon budget, we have to control emissions from steel plants.

Leading environmentalists have recently been urging the UK government not to allow mining of metallurgical coal in Cumbria. Part of the environmentalists' case is that approval of the Cumbrian mine would hinder UK's leadership at the COP26 climate summit to be held in Glasgow this November. I disagree, for reasons that follow.

During 60 years as a geologist, I have maintained an interest in applying academic research to finding and producing natural resources essential to our global economy. That has been the case whether I was being employed by a university or an oil company. Earlier this century I wanted to write a book about the oil industry and climate change. I warned my prospective editor that my proposed approach would be greeted with hostility from both sides in the then binary carbon war: not a great sales pitch.

The essence of my approach was trust in the geological record, with which it is unwise to argue. The evidence from rocks and ice provides powerful independent support for the deep concern about human-induced climate change long expressed by climate scientists. So why would I have qualms now about the environmentalists' opposition to the Cumbrian mine? As we approach the Glasgow summit, do we not need the simple message that coal is bad?

Emphatically not: such simplification threatens success at COP26 in November. Emissions from steel manufacture will be on the agenda in Glasgow. We need international agreement on coping with the emissions from the essential continuing use of metallurgical coal. The proposed Cumbrian mine can be a natural starting point in the debate: is this mine a commercially and environmentally sensible project when viewed from an international perspective? What role could be played by the application of proven expertise in carbon capture and storage (CCS), expertise that the UK has in abundance?

Myles Allen and Nathalie Seddon, of the University of Oxford, have considered CCS and Cumbrian metallurgical coal in a recent article in The Conversation UK. Local production of fossil carbon, followed by local safe burial of that carbon once we've had the use of it, is an attractive idea worth testing thoroughly. That testing won't happen if we remain trapped in the simple exchanges of the recent carbon war. We must take advantage of the peace on the road from Cumbria to Glasgow.

Bryan Lovell is at the University of Cambridge. He was adviser on climate change to BHP from 2013-2020 and is the author of Challenged by Carbon: the Oil Industry and Climate Change.

Galapagos Islands – Never mind the flora and fauna what about the geology

by Adrian Marsh

Ever since Gwyn (now my wife) and I met at Durham University in the early 1970s we have wanted to visit the Galapagos. We finally made it in January 2020. During her career Gwyn has taught environmental science at primary through to tertiary level including working for the Charles Darwin Trust delivering courses for school children at Down House. She had a good idea what to expect in terms of the unusual plants and creatures. But what about the geology, where she was relying upon me to be the guide. Not a comfortable position for a semi-retired engineering geologist who has spent much of his career working in southern England where active volcanoes are vanishing rare. My preparations and our experiences island hopping revealed a fascinating story.

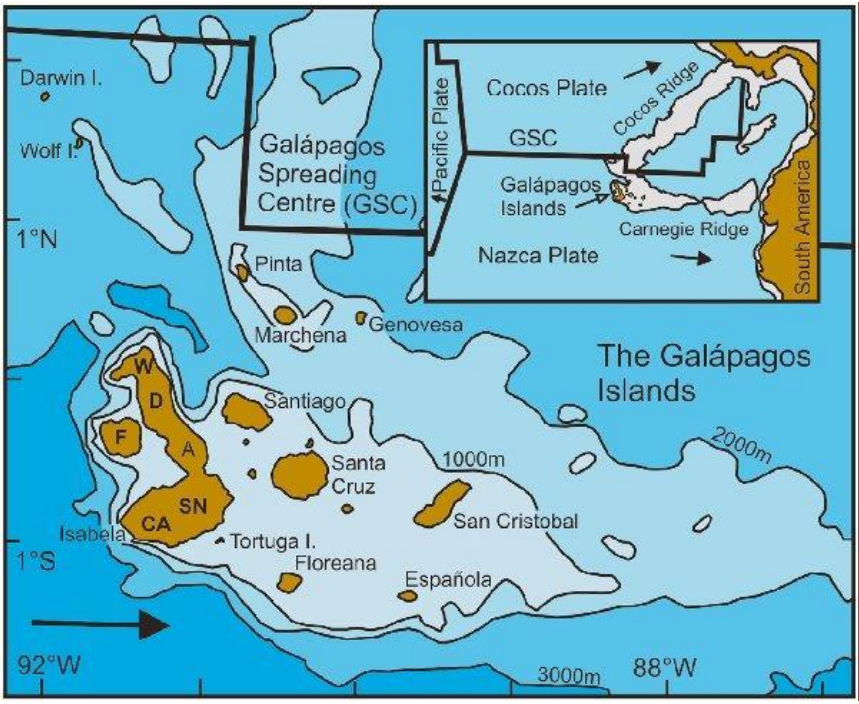

Figure 1: Map of Galapagos Islands with tectonic setting insert

My first misconception before the trip was that the Galapagos Islands, Figure 1, have been formed by one main process; oceanic crust, the Nazca Plate, passing from west to east over a hotspot in the mantle with a resulting series of volcanoes, similar to for instance the Hawaiian Islands, as illustrated in Figure 2. In fact, two processes are at work, with the hotspot responsible for the main archipelago but uniquely this hotspot is adjacent to a mid-oceanic ridge, Galapagos Spreading Centre (GSC), associated with the formation of the northern islands, including Darwin and Wolf, as shown in Figure 1. The Nazca Plate moves eastwards at a rate of 6-8 cm per year across the eastern Pacific eventually colliding with the South American plate. The lighter South American plate, comprised of continental crust, rides up over the denser Nazca plate. In this process of *subduction*, the Nazca plate's oceanic crust is forced into the mantle, where it melts and eventually rises up as volcanoes. This same process results in crumpled up crust and raised land which forms the Andes mountain chain, over 1000km to the east of the Galapagos.

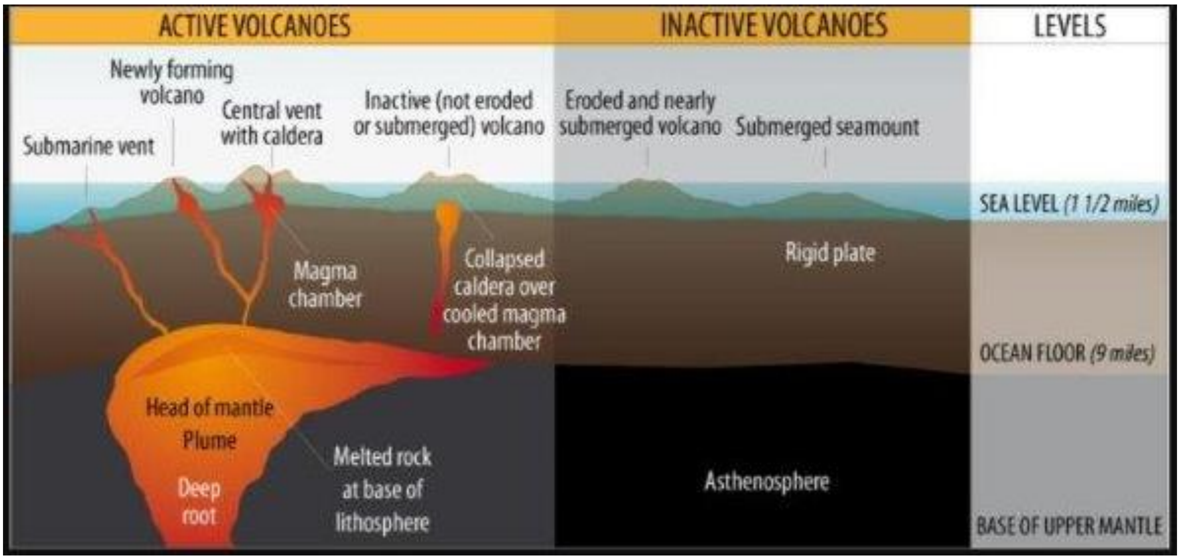

Figure 2: Schematic of the formation of hotspot volcanoes

Most of the volcanoes found throughout the Galapagos are rounded shield volcanoes rather than cone-shaped. The younger, western islands, e.g. Fernandina and Isabela, retain the shallow-sloping shape of shield volcanoes whilst the older volcanoes to the east are progressively more eroded, eventually becoming submerged seamounts after millions of years. Many of the Galápagos volcanoes are capped with the large cavity of a caldera. The largest caldera throughout the islands is Siera Negra on Isabela, an oval-shaped caldera that measures 9 km east-west and 7 km north-south. It has produced at least 10 eruptions in historical times, with an average resting period of only 15 years between each eruptive period. The last two eruptions occurred in 1979 and 2005. The youngest caldera is on Fernandina, located to the west of Isabela, which collapsed in 1968—resulting in a 300m drop in the caldera floor. The last major eruption in the region was on Fernandina in 2009.

The Galapagos Islands and their coastal waters were declared a National Park and Marine Reserve by the government of Ecuador in 1959. In 1978 the Galapagos Islands were also named a UNESCO World Heritage Site. As a result, access for visitors is restricted and in the more sensitive areas limited in numbers at any one time. We were impressed by how the approved guides and associated tour operatives do carefully control the intrusion of visitors into the natural habitats and 'personal space' of the multitude of land and marine animals present. Many islands are only accessible by boat, with landing at a designated beach then following a proscribed footpath.

My second misconception was that being on the equator the Galapagos Islands would be covered by thick tropical jungle. In fact, there are two weather seasons; Jan-May – Sunny and warm with occasional short downpours; and Jun-Dec – Cool, dry and windy due to the dominance of Humboldt current flowing northwards from Antarctica. These combine to create a water shortage, with potable water now having to be imported from the mainland to support the resident population and tourist trade. Rainfall patterns on each island are largely controlled by the topography with most rain falling on the southern flanks of the volcanoes and dry rain-shadow areas being present on the northern side of many islands. Where the rain falls, the lava rapidly weathers to fertile soils and farming is possible, whilst conversely in the rain-shadow belts soils are thin or absent and the vegetation scrubby. This means that much of the volcanic geology is on full show, as illustrated in Plate 1.

Plate 1: Recent lava flow from a side vent on Santiago in the background, an eroded chimney vent in the middle ground, with smooth and twisted 'pahoehoe' lava in the foreground on Bartolome.

With so much lava exposed and essentially unweathered, differences in its form and texture become apparent. A'a' lava is the most common appearance type of lava flows that cool down forming fragmented, rough, sometimes spiny, or blocky surfaces, as illustrated in Plates 2 and 3. A'a' lava forms when the viscosity of the lava, e.g. because of high gas bubbles content and relatively low temperatures, and/or the strain rate of the flow, related mainly to eruption rate and steepness of the ground, are high. When these factors change, the same original lava can sometimes produce the other end-member known as pahoehoe lava, which has a smooth, often twisted surface, as illustrated in Plates 1 and 4. With a spectrum of transitional types of lava between both a'a and pahoehoe lava inevitably found.

Plate 2: a’a’ lava field on the Tintoria islands off Villamil, Isabela

Plate 3: slightly less inhospitable a’a’ lava with resident marine iguana

Plate 4: pahoehoe lava on the shoreline at Villamil, Isabela

Not only do you get to see the surface of lava fields but access is also possible at a number of locations to enter voided lava vents, referred to as lava tunnels, see Plate 5, where still flowing lava discharged as the surrounding material solidified, leaving a striated tunnel surface. On the present-day coast line of Isabela, this process has also created a series of marine tunnel bridges, shown in Plate 6.

Plate 5: Lava tunnel on Santa Cruz

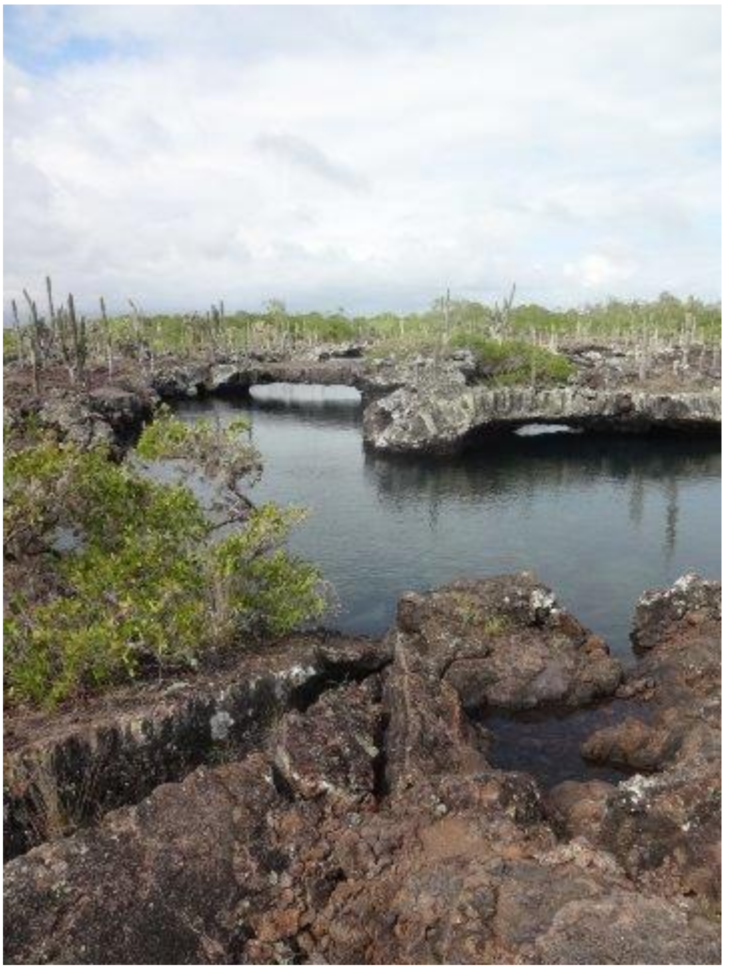

Plate 6: Los Tuneles, Isabela

Of course not all of the volcanic eruptions in the Galapagos result in relatively placid lava flows and evidence of large quantitites of pyroclasitc material is exposed in cliffs on Rabida, see in Plate 7.

Plate 7: Bedded pyroclastic material exposed in the sea cliffs of Rabida

My third and possibly greatest misconception was that an inquiring mind and desire to learn more about our natural world would be the driver for mass tourism to the Galapagos Islands and hence that we would meet up with like-minded people on our travels. Sadly, such fellow visitors were the exception not the rule, with a majority appearing to struggle to recognise the difference between a Theme Park and the real thing! (So much for science education.) For instance, we were the only couple out and about on many days who had packed essential kit such as a pair of binoculas and guide books. However, there were occasions on which the remoteness of the islands and associated lack of modern infrastructure and sophistication was evident, as illustrated in Plate 8.

Plate 8: Construction on Isabela requires an ancient approach to plant delivery!

Note from the Editor - Future meetings of HCNRG 2021

As the UK is looking at easing the restrictions, and we are hoping to get back to some normality in the near future where we can hold face to face lectures. In the meantime, we have been working together as a committee to try to arrange virtual evening Zoom lectures for the current year. We have also welcomed Adrian Marsh during the AGM into the committee who has become our lecture coordinator, who has brought in many great ideas into the HCNRG committee. We look forward to announcing some virtual events with you in the near future.

In the meantime, please visit the Events page of the Geological Society website to keep up with virtual lectures led by other regional groups, and the Society itself. We encourage our members to attend all of the lectures advertised. Please continue to check out the HCNRG events page for the most up to date Programme of Meetings for 2021, and also what we are doing to become more involved with our members.

If you wish to hold a meeting about a project or a topic which you are or have been involved in, please get in touch with us and we can discuss this with you. Given the current restrictions on social gatherings, any future meetings will be held virtually until we can return to some normality in the future.

We are pleased to offer you this newsletter, mainly to update you on our future plans. We are continuously working on improving what we can deliver, and how we can aid our members to become more involved. I hope you have enjoyed reading the article about Galapagos Islands, I surely enjoyed reading it! If you do wish to write an article to be included in the next issue, please don't hesitate to contact us or to send us an article. We love reading them and helping our members!

Should you wish to have your report included in the next newsletter, issue 13, please inform the Chair, John Wong, of your intentions, and forward your article to me on my personal email (z.lednarova@gmail.com), or when I am not in the U.K. and working offshore, please send it to John at homecountiesnorthregionalgroup@gmail.com and copy me in.

The closing date for the next article submission is Friday 28th May 2021.

As a closing note, thank you for taking the time to read the newsletter, and I hope to hear from you all in the future, keeping me updated with future meetings.

Wishing you all stay healthy and safe, and we look forward to welcoming you in future meetings.

Zuzana Lednarova