North Eastern Geological Society

Newsletter December 2022

UPCOMING LECTURES - and other items of interest

20th January. Plate tectonics at 50 - not written in stone.

Dr Keith James, University Wales at Aberystwyth.
This lecture will be broadcast on Zoom.

(Apologies to those unable to join us in November. Why this was is a mystery as the Eventbrite link worked for some. The zoom link for this lecture will be emailed to members so there will be no need to register)

And here is a link to an interesting item:

Will the geologists of the future see that something dramatic happened on Earth starting in 1950?

https://sciencenorway.no/climate-geology/will-the-geologists-of-the-future-see-that-something-dramatic-happened-on-earth-starting-in-1950/2118181

LECTURE REPORTS

Dr Madeleine Humphreys 21 10 22

The Mushy inside of explosive volcanoes

Volcanism as we all recognise is seen at plate margins - the "ring of fire" in the Pacific is a familiar illustration of this geological association. Volcanism is especially associated with subduction zones where oceanic crust descends beneath the continental crust.

Gases in the magma

Dr Humphreys opened our eyes to the significance of water and gases taken down into the subduction zone and changes in our understanding of how these affect the nature of the magma.

The gases involved include chiefly H_2O, CO_2 but also H_2S, SO_2, Cl, F. Halogens and sulphur have a role in transporting rare earth metals into the volcanic environment. The solubility of gases in liquids is affected by pressure and temperature. At higher pressures more gas is dissolved (and we see the effect of reducing pressure when we open a bottle of champagne and the suddenly reduced pressure sees the escape of gas from solution). Conversely the amount of gas that can dissolve in an amount of liquid reduces as the temperature rises. Dissolved gas is an important ingredient in magma, affecting its physical and chemical properties including its viscosity and melting point.

Dr Humphreys name checked several volcanoes in her lecture to illustrate her points. She pointed out that the Mt St Helen's eruption of 1980 was a small affair - Krakatoa (1883) was 18 times more powerful, Tambora (1815) 150 times. The blast at St Helens was directed northwards and trees 25km distant were cut down.

Mt St Helen erupted again in 2005 and 2008 - domes and spikes of erupted material (andesite) formed and then collapsed on themselves (she showed us a time lapsed sequence illustrating this dramatic effect observed within the caldera of the 1980 eruption) - she underlined the different manifestations of lavas.

She illustrated the difference in lavas that are able to degas before emerging and appear as the relatively slowly rolling lava flows we have seen in some volcanic eruptions as opposed to the familiar eruptive appearance with splashes of molten lava appearing above a seething lake of molten rock analogous to the champagne effect.

Magmas and Mush

Dr Humphreys went on to outline new thinking about magma behaviour and plumbing - thinking about this subject is shifting to the idea of

magma *systems*. The storage of magma Is likely dominated by a crystal "mush" - ie the material is more "solid" than previously thought. The new understanding is of the magma body as a mush of crystals with only a partial liquid phase. Dr Humphreys offers us the analogy of honey where crystallisation can occur within the liquid "phase". The study of crystals has been enhanced by the development of the sensitive high resolution ion microprobe allowing examination of complex minerals in more detail. This work has shown how in some cases larger angular crystals may form and under other circumstances, smaller rounder ones, the latter being more"fluid".

Perhaps as little as 10% of the content of what is regarded as a magma chamber may be in a liquid state, while assessment of erupted material suggests that up to 40% is in a crystalline state.

Dr Humphreys outlined the conclusions of research using samples of material around the Campi Flaegri volcanic complex west of Naples which were examined with the ion microprobe. Seismic monitoring has shown that the ground has lifted up by a metre at Solfaterra ("Sulphur Earth" the clue is in the name!) in this district. The sampling study, examining the detritus of previous eruptions over several thousand years, has improved our understanding of the interpretation of changes in mineral structure in the course of the development of a magma chamber up to the time of its eruption. This study of apatite crystals (phenocrysts[1]) and glass samples and the varying content of volatile material within them has been illuminating, permitting inference of the depths and pressures at which differing crystalline forms are generated, and the development of ideas about the behaviour of the magma chamber as material ascends within it.
The work is being duplicated elsewhere, not surprisingly, and mention was made of Soufriere and Santorini.

Other opportunities for assessing the outcome of previous eruptions include research in Europe following the eruption about 13000ya that created the Laacher See in Germany (a caldera). This was a large eruption that dispersed tephra up to 10km away. Careful stratified study of the deposited tephra is also adding to an understanding of the variation of the magma content over the period of several days of the eruption.

Dr Humphrey's presentation was warmly received with perceptive questions dealt with very clearly. The audience were most appreciative of her talk and the excellent graphics used to illustrate the work.

Prof Steve McNutt University of S Florida 18.11.22

The Ha'apai and Hung Tonga eruption

Background

The islands lie on the northern edge of the Tonga archipelago - north of New Zealand and east of Australia. They are uninhabited. There was activity in 2014-15 when an island appeared between the two, joining them together. The islands define a caldera 2km by 4km, 150m deep before the eruption.

Volcanic activity recommenced in December 2021 and the island from 2015 disappeared. A cataclysmic eruption occurred on 15th January this year, the largest since Krakatoa in the 19th century. There were unfortunately no local monitoring instruments, the nearest being 750 km away in Fiji.

Estimation of the size

Monitoring included seismology, infrasound (sound waves of a frequency below 20 cycles per second) and lightning. Prof McNutt referred in passing to the Raspberry Shake "Shakenet"[2] network of low cost seismographs and infrasound sensors based on the Raspberry Pi computer enabling seismological or infrasound monitoring to be gathered from a wide distribution of monitors around the world.

He mentioned that the detection of an infrasound signal more than an hour later in Miami indicated that this was a large eruption. A relative of his living in Alaska 9,500 km away heard the bang! (Obviously in the audible

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[1] A relatively large crystal embedded in a finer-grained or glassy igneous rock.

[2] https://shakenet.raspberryshake.org/

frequencies - he thought it was a moose trying to get into his garden shed - a more likely explanation in those parts apparently). Infrasound was detected in Brize Norton in the UK fifteen hours later.

Prof McNutt said that seismological information, in part as a result of the distribution of the Raspberry Pi devices mentioned above, had been gathered from over 900 sites. He touched in passing on the fact of background continuous signals from volcanic "tremor", clearly this event was very different from that.

An umbrella eruption cloud was recorded (we all saw it on the satellite image!) which reached a radius of 100km. Prof McNut mentioned his colleague Robert Constantinescu who has carried out work on the validity of assumptions made in extrapolating from observations to calculations of the mass of erupted material.

He also showed us a superposition of the recorded lightning flashes on the satellite imaging we have seen. There were 400,000 associated with the eruption. In the two hours after the eruption this accounted for more than 80% of all lightning on the planet. He distinguished between Cloud to Ground (CG) as opposed to Intercloud (IC) discharges. Later in the lecture he went into some detail about the process of electric charge acquired by water as it freezes in eruptions of a sufficient altitude (as here) which then discharges as it falls. The large number of discharges here among other things reflects the height of the eruption.

Volcanic eruptions are now graded on the Volcanic Eruption Index (VEI) which factors in such components as the height of the column of ejected material (from less than 0.1 km to more than 25km) and its estimated volume (the range of which goes from less than 10^4 cubic metres to $10^{10\text{-}11}$ cubic metres - that's a lot of cubic metres!). This eruption has been graded VEI 5-6 (different bodies have quibbled about it being 5 or 6) at the top end of the scale. Prof McNutt pointed out that the eruption was "gas rich" which means more to the members following Dr Humprey's lecture in October (see the previous lecture notes) as opposed to "gas poor" - it was undeniably explosive and many of us will have seen the extraordinary images of the eruption taken from a satellite. Vulcanologist (who know about these things) have arrived at a figure of 6.5 cubic kilometres of material discharged in the eruption, though Prof McNutt did own that there was some "pushback" (polite euphemism for disagreement I think, geologists can disagree just like everyone else!) from different quarters about this figure.

An interesting observation was the effect of air pressure changes as opposed to water pressure changes with such a large event. Tidal records in Monterey on the west coast of the USA showed a change in sea level caused by changing air pressure that preceded the arrival of the larger magnitude Tsunami wave.

How much water?

Prof McNutt described the process of assessing the volume of water taken up in the explosion. This involves assessment of the form of the eruption cloud which he illustrated as being broken down into a cylindrical core around which discs of varying diameter are centred. Satellite imagery (the CALIPSO satellite[3]) revealed that there were discs of material of differing radius around the core. The appearance is of a somewhat squat, flat umbrella.

The information on the radius and height of the cloud and data led researchers to a figure of 2,900 million tons of material ejected from the volcano. Using a calculation of 5% for the water content gives a figure of 146 thousand tons of sea water taken up into the atmosphere, contributing perhaps 90% of the visible plume.

Superlatives and future work

This has been an event for the vulcanologists to feast upon scientifically. An assessment of the caldera after the eruption has shown that it has deepened from 150m to 1000m. This is the largest eruption since Krakatoa. The eruption climbed to 58km in height. There were 400,000 lightning flashes in the first two hours.

There were some detailed questions following and in response to one about the volume

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[3] CALIPSO (Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observations) is a mission dedicated to studying how clouds and aerosols impact the Earth's climate Scientists are using this data to construct 3D models.

of water Prof McNutt went on to explain in more detail the origins of the static charges leading to the large number of lightning discharges. He pointed out that water in the plume will freeze above 40 km and that this ice may then become positively charged leading to the subsequent discharge into other negatively charged areas of the plume.

This was a fascinating exposition about this extraordinary event and Prof McNutt was warmly thanked for giving up his time to enlighten us on the current understanding of its impact.

Gordon Liddle/John McNulty

Hello NEGS members,

Thank you for supporting NEGS through the challenges of the last two years. We hope things are now settling down and we can look forward to an enjoyable 2023 programme.

There are two zoom meetings on January 20th and February 17th and the final lecture on March 17th. This will be a lecture at Durham University with Prof. Julia Knapp, all arranged for us by Prof. Gillian Foulger.

We already have our first field trip of the 2023 season, Dr Ian Kille is leading a walk in the Cheviot foothills on April 22nd. The rest of the exciting programme is being developed at the moment.
Our last meeting on December 9th. was most enjoyable with a lovely mix of Christine Telford's field based slides from Montserrat, ancient Caithness fossil fish from Ian Fulton and a great quiz from Christine Burridge. Vin Murphy organised excellent refreshments to round off the evening.

The Society continues to encourage members to help with aspects of the meetings, trips and administration. The present team has been quite outstanding in their efforts but would appreciate it if members could offer to help with specific tasks, please let me know if you would like to discuss the opportunities that are available.

I wish you all the very best for the 2022 Christmas season, you are a wonderful group of people that make it a pleasure to enjoy the programme with.

Gordon Liddle on behalf of the committee

PS any items for the newsletter - email the editor at huttonsedgewick@gmail.com - next newsletter will be at the end of February