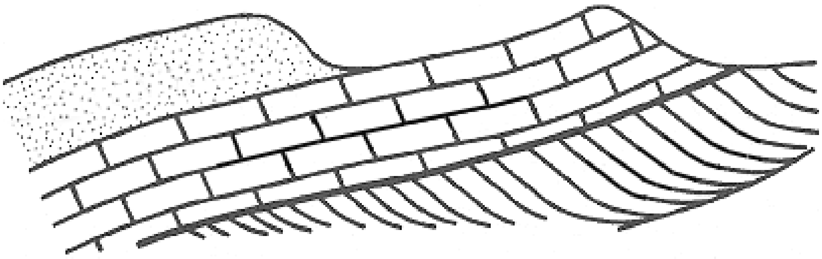
Farnham Geological Society

[www.farnhamgeosoc.org.uk]

Farnhamia farnhamensis



A local group within the GA

Vol. 21 No.2 **Newsletter** June 2018

Issue No: 99

List of contents

Editorial

I like to bring you news of the Society's activities and am usually inundated by reports from speakers or field trip attendants. I feel these reports not only provide a historical record for the Society but also enable those members, who have been unable to attend, a chance to catch up. However this time, I have had few reports from anyone.

There is so much research going on around the world in the various centres of excellence, that when I have an opportunity to bring you up to speed with some that I have noticed, I like to do so. There has been a lot of news about active volcanoes – not only because of the resultant loss of life, destruction of homes and devastation of crops, but also because there was a suggestion (apparently by some media) that the 'ring of fire' is waking up but more likely it has been a period of 'slow news days'.

The USGS website and Volcano Observatory of Hawaii have produced detailed daily reports of Kīlauea – many of these I have summarized and it gives one a 'bird's eye view' of a living, breathing monster like Kīlauea.

Liz Aston (Editor)

Memories of Alan Bromley

I was saddened to read in the last Newsletter of the death of Alan Bromley. He led two trips which I joined, one to Madeira about eight years ago and the other to Devon more recently, where he improved my knowledge of dam building at Burrator. Alan had an unaffected manner which could reduce the geology to something that was comprehensible even to a badly educated amateur such as me. More importantly, perhaps, I enjoyed his company and wish I had known him better.

Derek Jerram (FGS member)

Can animals predict earthquakes?

An article from Ask Smithsonian: August 10, 2016

Humans frequently think that animals can predict earthquakes, but they cannot. Over the centuries, people have reported seeing animals head for the hills or leave their burrows in the weeks, days or hours before a tremor hits. But is this belief grounded in science?

It's true that animals can sense a quake, usually just minutes before humans do, says Michael Blanpied, associate coordinator of the United States Geological Survey (USGS) Earthquake Hazards Program. Established in 1977, the program monitors and reports earthquakes, then assesses the earthquake impacts and hazards, and researches the causes and effects of the quakes. But that's a reaction, Blanpied adds, not a special talent for predicting when or where a quake might hit.

Some researchers have theorized that certain creatures can detect signals that humans cannot, such as subtle tilting of the ground, changes in groundwater or variations to electrical or magnetic fields. Seismologists would love to have an earthquake early-warning system, but animals don't appear to be the answer, says Blanpied.

"The most likely time to have a big earthquake is after a small quake" he says. But even that doesn't give scientists the ability to know exactly how long until or where the next one will have its epicenter. Tracking quakes is no easy feat given that the Earth experiences millions per year, many of which are barely noticed. In Greece, observations of animals fleeing were recalled in hindsight after a quake. It's hard to document, before a quake happens, that animal behavior changed, especially since quakes happen without warning, says Blanpied. The USGS sponsored a project in the late 1970s to continuously observe lab rodents in S California to see if there was a burst of activity just before a quake. Unfortunately, there were no quakes during the study's duration.

Jim Berkland, a San Francisco Bay Area geologist, made a name for himself by accurately predicting N California's 1989 Loma Prieta earthquake. His forecast relied partly on combing classified ads which he said demonstrated that more household pets were listed as missing in the week or so before the 6.9 magnitude quake than usual. He was not the only one to claim that missing pets indicated something afoot. The USGS says, however, that the missing pet theory does not hold water, pointing to a 1988 study disputing the claim.

The agency does not outright dismiss the possibility of animal activity as a predictor, says Blanpied. On its website, the agency points to a 2000 study by seismologist Joseph L. Kirschvink, which suggested that animals' instinctive 'fight or flight' response may have evolved over the millennia to also be a sort of early warning system for seismic events.

Many who believe animals can sense quakes point to work done by Friedemann T. Freund, a senior research scientist at the non-profit SETI Institute. He postulates that rapid stresses in the earth's crust cause major changes in magnetic fields, which animals can sense. Blanpied says these theories 'have been roundly questioned and criticised', because rapid stress changes would not be expected before a quake, and because such changes were never observed or recorded outside of Freund's lab. However, in 2015, he and co-researchers published a study showing that animals in Peru's Yanachaga National Park basically disappeared in the weeks leading up to a 7.0 magnitude quake in the region in 2011. Animals are able to detect the first seismic waves (P-waves) i.e. before the S-waves (shaking waves). This likely explains why some animals (elephants) can perceive low-frequency sound waves and vibrations that humans cannot detect.

Just ahead of the 5.8 magnitude quake that hit the Washington, D.C. area in 2011, some of the animals at the Smithsonian Institution's National Zoo raised a ruckus, says Kenton Kerns. Among those were the lemurs, who began loudly vocalizing about 15 minutes before keepers felt the ground shaking. Keepers recalled the activity after the quake took place - but - lemurs are prolific vocalizers when upset, and can make their grievances known multiple times a day, says Kerns. So it's not possible to know whether they sensed the impending quake, or if something else perturbed them, he says. So why do humans cling to the idea that animals are prognosticators? 'I think people feel comforted by the idea that there would be something that would make earthquakes predictable', says Blanpied.

Editor's comment – So, to my mind, it would appear that animals may or may not be able to predict an earthquake. There were reports that the elephants on the shores in Sri Lanka ran up into the hills just before the 2004 Banda Aceh tsunami hit the shores so devastatingly:

(e.g. https://news.nationalgeographic.com/news/2005/01/0104_050104_tsunami_animals_2.html).

On a different note, I once read (or heard) that a long shallow rectangular 'pond' at ?Machu Picchu (or similar ancient site in the Andes) was kept full of water by the ancient civilization as an earthquake predictor – as soon as there were any true ripples on the water, a quake was imminent. This seems more effective to me.

Before roots, shoots and leaves

Dr Paul Kenrick, Department of Earth Sciences, The Natural History Museum

Plants are highly diverse with an estimated 374,000 – 404,000 living species. We nurture and cultivate them, bring them into our homes, and many are staples of our diets. Some of their parts are used to construct buildings, whereas others are converted to fuels and still more we fashion into fabrics to make clothes. Useful and pleasing to the eye though they are, plants have a much larger scale and enduring influence on life on Earth.

As autotrophs they are the fundamental basis on which much other life depends and, less obviously, they have a major impact on the long-term habitability of our planet through their geochemical influences, especially on the carbon cycle. The work presented aims at understanding the nature of early plant based ecosystems and discovering when they first became established. For the geologist, there is much current interest in identifying potential modern analogue ecosystems to estimate the impacts of early vegetation on Earth Systems generally.

Direct fossil evidence of plant life on land first becomes abundant in terrestrial sediments of the Early Devonian (Figure 1). These are particularly well represented in the UK in the Old Red Sandstone of the Anglo-Welsh Basin and in the Midland Valley and the Orcadian Basin of Scotland. Here, the fossilized remains of plants can be found in abundance locally, and they reveal a flora of small, simple organisms that lack some of the key organ systems familiar in modern species such as flowers, seeds, roots and leaves. Although hugely informative, these fossils are mostly drifted remains captured in lake and river sediments and the preservation of anatomical scale features is patchy.

Figure 1: Fossilized land plants preserved in fluvial sediments, Early Devonian, Germany. Scale bar is 5cm.

Figure 2: The village of Rhynie, Scotland

Figure 3: Original reconstructions of two plants from the Rhynie Chert published by Robert Kidston and William Lang in 1921.

Figure 4: Cross section of stem (about 1.5mm diameter) of Rhynie Chert fossil plant showing preservation of soft tissues to cellular level

Figure 5: Crustacean, Rhynie Chert

To gain a better insight into early communities our research focuses on the Rhynie Chert, which is the World's earliest well-preserved terrestrial ecosystem[1]. It is a unique site in which plants and associated organisms are fossilized more or less in situ and where soft tissues are preserved to an unparalleled degree. The Rhynie Chert is a 407Ma-old fossilized sinter now situated on the edge of the Cairngorms National Park in Scotland (Figure 2). Discovered in 1912, a series of papers describing elements of the flora published between 1917 and 1921 caused a sensation because the plants were so astonishingly well preserved (Figures 3, 4) and clearly different to living species. The environment in which they grew was a geothermal wetland in which silica rich water emanating from hydrothermal vents periodically flooded the landscape preserving the biota. The largest plants were less than 20cm tall, and most were leafless resembling simple bifurcating twigs. Although they could not be placed in any major group of living land plants, in the simplicity of their tissue systems they seemed to bridge plants like Huperzia and Psilotum and in some respect also mosses and liverworts.

Subsequent and ongoing research is building an extraordinarily detailed picture of this early ecosystem. The fauna includes the earliest record of nematodes and seven groups of aquatic and terrestrial arthropods (Figure 5), including early relatives or ancestors of mites, centipedes and millipedes, springtails, fairy shrimps, spiders and insects. Also present are green algae, water molds (oomycetes), cyanobacteria and several major groups of fungi, including the earliest ascomycete (sac fungus). We are using new imaging techniques to research the microbiota and its interactions with the plants and animals. Recently, we documented parts of the life cycle of chytrid fungi in unprecedented detail[2]. Chytrid fungi are best known today for causing chytridiomycosis, which is a widespread infectious disease of amphibians. However, the chytrids in the Rhynie Chert (Figure 6) were doing something different. They lived in ephemeral pools where they were active in the decomposition of organic matter, recycling it back through the food web, which is a key role that their modern relatives also play in freshwater ecosystems.

Symbioses were also well established and diverse in the Rhynie Chert. Lichen-like associations between a fungus and a cyanobacterium are known. Similar associations with either a cyanobacterial or green algal photobiont (a photosynthetic partner in a lichen) have also been documented at other contemporary fossil sites indicating that lichens were an important element of early land biotas. Today, about 85% of modern plants form mycorrhizal (symbiotic association between fungi and roots of a vascular host plant) associations with fungi. The fungus typically infects the roots but it also extends outwards into the surrounding soil, where it helps the plant to scavenge macronutrients like nitrogen, phosphorous and potassium. In return, the plant rewards the fungus with sugars made by photosynthesis. Two distinctive types of mycorrhizal-like association have been documented in the Rhynie Chert plants demonstrating that this symbiosis was also operational in early terrestrial ecosystems[3]. In fact, it now seems likely that the evolution of symbiotic relations with fungi was essential to the establishment of a land-based flora.

So, are there any modern analogues to these early terrestrial communities? Considering all of the evidence to date, the biota of the Rhynie Chert most closely resembles Cryptogamic Ground Covers (seedless plants). These are important but often overlooked communities typically comprising variable proportions of mosses, lichens, fungi, cyanobacteria and arthropods[4]. They are resilient and are found encrusting plants, soils and rocks in abundance in most parts of the world, encompassing environments as diverse as boreal forests, hot rocky deserts and ice-free parts of the Antarctic Peninsula. Today, these communities of small organisms are responsible for about 7% of the net primary productivity of terrestrial vegetation and nearly 50% of biological nitrogen fixation, for which the cyanobacterial component is largely responsible.

Whereas comparisons to Cryptogamic Ground Covers (Figure 7) are strong in many respects, there are major differences. Absent from these early communities were important ecosystem engineers such as annelids and ants. Also thought to be absent were white rot and brown rot fungi in the Agaricomycetes fungi, which evolved later. These fungi are really important decomposers of cellulose and lignin, which are major structural components of plants found in variable proportions in different tissues. Therefore, one key aspect of the biological carbon cycle was different in these early communities. Also present were some organisms that have few parallels in modern systems, notably the giant ascomycete (fungus with fruiting sac) fungal fruiting body Prototaxites, which was by far the largest living organism on land at the time. Notwithstanding these differences, we conclude that, as a first approximation, in estimating their global contribution to nitrogen fixation and their impact on the weathering of calcium-magnesium silicate rocks – a key regulating factor of the geochemical carbon cycle – Cryptogamic Ground Covers are reasonable modern analogue communities[5].

Figure 6: Flask-shaped zoosporangium of chytrid fungus reconstructued using Confocal Laser Scanning Microscopy image stack rendered to depict surface features. Scale bar 30µm.

Figure 7: Cryptogamic Ground Cover on glacial moraine, Iceland.

The Rhynie Chert provides a window into life on land 400Ma ago, but how far back do plant based communities extend? This is a question that is much debated and there are several lines of evidence to consider. In rocks older than the Devonian Period fossil evidence becomes much rarer because terrestrial sediments are rarer[6]. The rock record of the Early Palaeozoic is dominated by marine sequences. At present, our best estimates of when plants first colonized land are therefore inferred indirectly from their dispersed spores or from phylogenies of living species derived from genomic scale data and molecular clock approaches. Recently, we published a calibration that points to an interval encompassing the Late Cambrian to Early Ordovician (about 470-515Ma)[7]. This sets a new marker and an exciting challenge. To test our hypothesis and to find direct fossil evidence we need to locate terrestrial sequences in these early rocks. We don’t yet know what form the earliest plants will take, except that they are likely to be minute and even simpler than those in the floras of the Early Devonian.

References
[1] Edwards, D., Kenrick, P. & Dolan, L. 2017 History and contemporary significance of the Rhynie cherts - our earliest preserved terrestrial ecosystem. Philos. Trans. R. Soc. Lond. B Biol. Sci. 373. (doi:10.1098/rstb.2016.0489).
[2] Strullu-Derrien, C., Goral, T., Longcore, J.E., Olesen, J., Kenrick, P. & Edgecombe, G.D. 2016 A new chytridiomycete fungus intermixed with crustacean resting eggs in a 407-million-year-old continental freshwater environment. PLOS ONE 11, e0167301. (doi:10.1371/journal.pone.0167301).
[3] Strullu-Derrien, C., Selosse, M.A., Kenrick, P. & Martin, F.M. 2018 The origin and evolution of mycorrhizal symbioses: from palaeomycology to phylogenomics. New Phytol. 0. (doi:10.1111/nph.15076).
[4] Elbert, W., Weber, B., Burrows, S., Steinkamp, J., Budel, B., Andreae, M.O. & Poschl, U. 2012 Contribution of cryptogamic covers to the global cycles of carbon and nitrogen. Nature Geoscience 5, 459-462. (doi:http://www.nature.com/ngeo/journal/v5/n7/abs/ngeo1486.html#supplementary-information).
[5] Mitchell, R.L., Cuadros, J., Duckett, J.G., Pressel, S., Mavris, C., Sykes, D., Najorka, J., Edgecombe, G.D. & Kenrick, P. 2016 Mineral weathering and soil development in the earliest land plant ecosystems. Geology 44, 1007-1010. (doi:10.1130/g38449.1).
[6] Kenrick, P., Wellman, C.H., Schneider, H. & Edgecombe, G.D. 2012 A timeline for terrestrialization: consequences for the carbon cycle in the Palaeozoic. Philos. Trans. R. Soc. Lond. B Biol. Sci. 367, 519-536. (doi:10.1098/rstb.2011.0271).
[7] Morris, J.L., Puttick, M.N., Clark, J.W., Edwards, D., Kenrick, P., Pressel, S., Wellman, C.H., Yang, Z., Schneider, H. & Donoghue, P.C.J. 2018 The timescale of early land plant evolution. Proc. Natl. Acad. Sci. U. S. A. 115, E2274-E2283. (doi:10.1073/pnas.1719588115).

How does life survive then flourish after glaciations?

As a glacier or ice sheet meets the sea, the sea water freezes onto the base of the ice enclosing any creatures and sediments caught up in it, this is obviously prevalent along coastal shelf areas where there can be vast areas of shallow sea bed underlying the ice.

The thick ice of a glacier, or ice shelf, gradually evaporates from the top. Thus the 'basal' ice layer gradually rises (over many hundreds of years) to become the 'surface layer' bringing with it any debris picked up from the sea bed. At the surface, the clean ice evaporates leaving the debris behind as a layer of 'dirty ice'.

Such an area of ice with large deposits of salt and marine animal remains (sponges to shellfish) was discovered on the McMurdo Sound Ice Shelf, Antarctica, by Scott and his team at the beginning of the 20th Century. This salt and the animal remains were described by Scott's geologist Hartley Ferrar, but their origin was a mystery. Small ponds, which remain unfrozen, are found in this 'dirty ice' and in them, abundant bacteria and complex microbes are found. This life is believed to survive due to a constant flow of phosphate and trace elements through the ice.

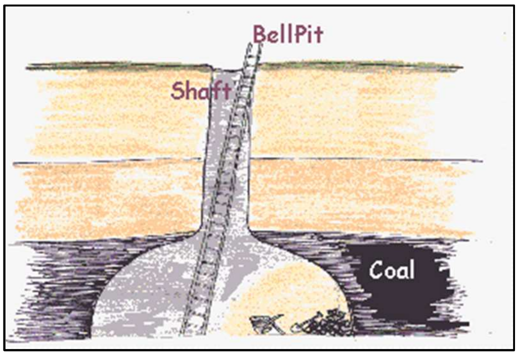
The Sturtian and Marinoan glaciations within the Cryogenian (~717-636 Ma) are believed to have been so severe at times that ice reached the Equator (creating a 'Snowball Earth'). Life as complex molecular eukaryotic structures had commenced several billion years before this time and it has been uncertain how such life could have survived such conditions to then blossom after the thaw, into the Ediocaran Biota and Cambrian 'Explosion'.

The team of scientists believe that dramatic fluctuations in biogeochemical cycling during these glaciations provided oases similar to those found in the 'dirty ice' conditions discovered by Scott. They argue that these 'dirty ice' conditions with pools of life must have been abundant during the 'Snowball Earth', allowing the major eukaryotic lineages to survive and to then evolve into the divers forms and to flourish once the ice had melted.

References
Hawes, I, Jungblut, A.D., Matys, E.D., Summons, R.E., 2018, The "Dirty Ice" of the McMurdo Ice Shelf: Analogues for biological oases during the Cryogenian.
Geobiology 16 (4), 369-377

Quarries and quarrying
January 2018 lecture to FGS given by John Williams, Member FGS

Historically, quarrying started when loose rocks were picked up from the surface and used to construct shelters, internal features and walls. Subsequently the benefits of using minerals for warmth (coal) or for moulding (copper) and larger stones (building purposes) were recognized and early man developed the ability to dig and release blocks of stone. These people usually exploited the natural splitting capabilities of the rocks – the joints and bedding planes. To release shallow underground seams, Bell Pitts were used when mining iron, coal, flint and lead (see Figure 1).



. 1: Bell Pit

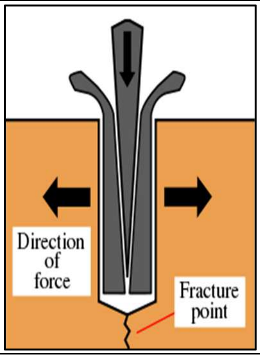
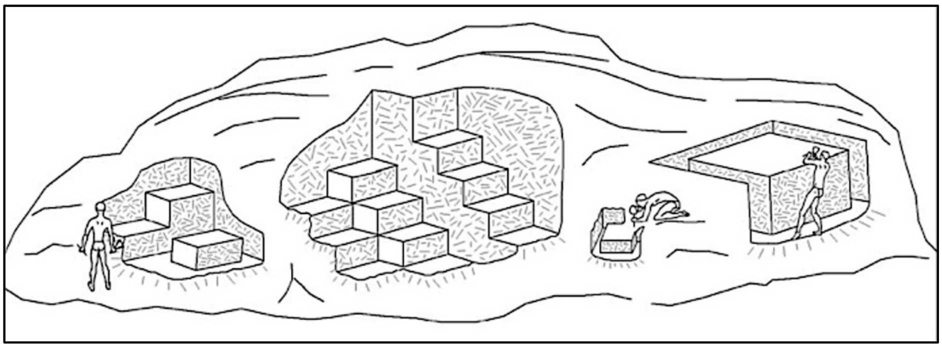
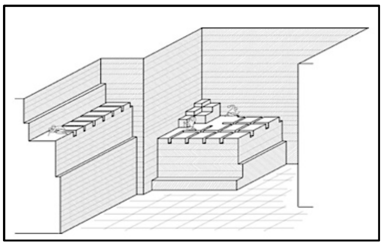


Fig. 2, 3: Plug and Feather Method – view & cross section





Large scale of adjacent Figure 4 to the left.

Figs. 4 and large scale in Fig. 5:
Multiple blocks extracted simultaneously on descending bedrock platforms using long chisels (ca. 2500 BC).

As more experience was gained there arose the need to provide stones for monumental buildings, obelisks, large statues and statues of Gods or rulers so the ability to split and remove large rocks for shaping was developed. The plug and feather method was developed (shown in Figures 2, 3). Initially using wood which was then wetted to expand it and subsequently, to this day, but using metal.

The explosive charge must be used sparingly as the percussion can mar the stone around the charge. Building stone is also known as Dimension Stone in some countries.

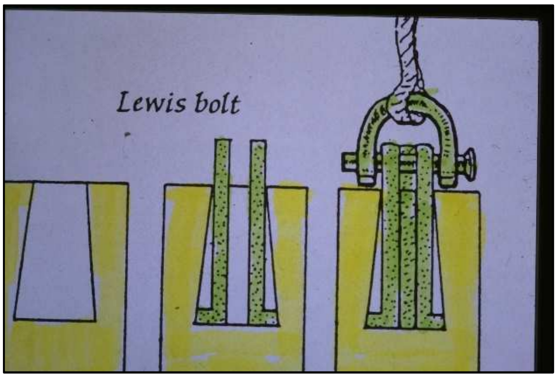


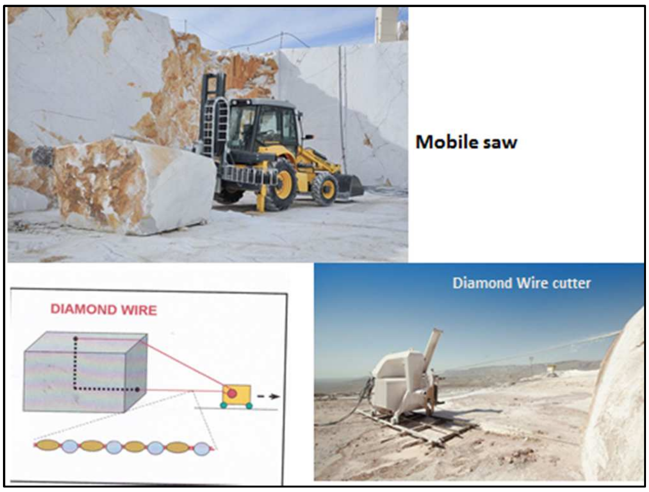
Fig. 6: Similar methods are used to this day for moving large blocks of stone

Ancient Egyptian techniques

The same methods which were used then, are still used today – see Figures 4, 5 and 6 for the methods which were used thousands of years ago and are still used today for removing large blocks of stone.

Modern methods

These days the older methods of cutting and working on rocks have been mechanized and in many cases computerized. It has been designed so that one or two persons can operate equipment that in the past would have involved a large group of quarrymen. Some examples follow of modern equipment (shown in Figures 7, 8).



Figures 7, 8: Examples of modern quarrying technicques

The Beringer fossil fraud

March 2018 lecture to FGS given by Dr Paul Taylor, Natural History Museum

There are plenty of fake fossils on the market these days. Just check e-Bay and you will find trilobites manufactured in Morocco and fossil reptiles carved in China, although rarely do the sellers admit that their merchandise is fake. These frauds are made for commercial reasons and are unlikely to fool professional scientists. Contrary to the coverage given to them by the media – and the efforts of Creationist websites – fossils faked for scientific purposes are few and far between. The best-known example in Britain is Piltdown Man, a 'missing link' discovered in 1912 in Sussex, which turned out to consist of a mixture of artificially aged bones of a human and an orangutan, planted in a gravel pit by the unscrupulous solicitor Charles Dawson. In terms of its national infamy, the Beringer fraud is the German equivalent of Piltdown Man. This was perpetrated two centuries before Piltdown in Franconia, a German province now part of Bavaria.

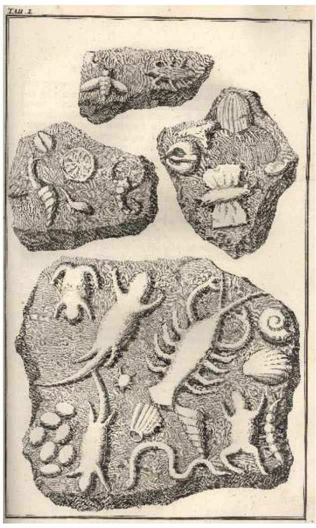


Fig. 1: Plate 1, LW, showing some unlikely 'fossil' assemblages

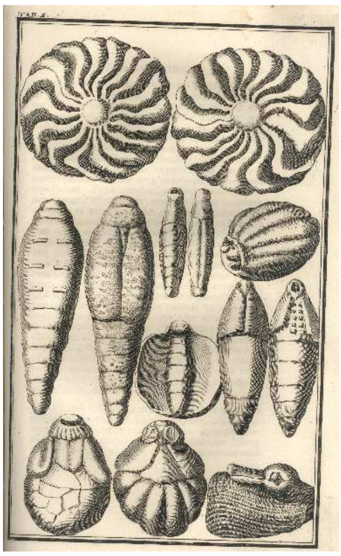


Fig. 2: Plate 2, LW. The top object was interpreted as the sun while most of the others resemble insect pupae, apart from the apparent duck in the lower R.

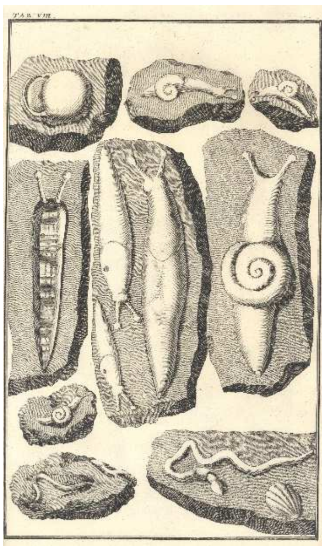


Fig. 3: Plate 8, LW, dominated by slugs and snails.

Johann Beringer (1667–1740) was a *großer Käse* (big cheese) in the city of Würzburg during the early 18th century. Not only was he the Dean of the Faculty of Medicine at Würzburg University, but he was also Chief Physician to the Price Bishop of Franconia, Christoph Franz von Hutten. Like other learned men of the time, Beringer kept a cabinet of natural curiosities that included Triassic fossils from the Muschelkalk limestone found in this part of southern Germany. These fossils, it seems, did not interest him greatly. However, in 1725 a large number of truly remarkable 'fossils' from nearby Eibelstadt came into his hands. These were quite unlike those previously known from Franconia, or indeed anywhere else in the world. Beringer believed he had been blessed by Divine Providence and set to work on a monograph entitled *Lithographiae Wirceburgenis* (LW in figures), which was published in 1726. This volume, written in Latin but translated into English by Jahn & Woolf (1963), contains a series of plates illustrating 204 of 'fossils' later to be dubbed 'Lügensteine' (lying stones).

The plates from Lithographiae Wirceburgenis, four of which are reproduced here (Figures 1 to 4), depict an astonishing range of objects. To our modern eyes, very few of these are passable as fossils: some specimens do resemble ceratitid ammonites or bivalves but the majority are, quite frankly, ludicrous. They range from mating frogs, to spiders astride their webs, birds next to clutches of eggs, and tiny mermaid-like creatures. As if these were not enough, there are also examples of Hebrew-style lettering and miniature celestial objects – the sun, the moon and comets. More than 400 'Lügensteine' survive today, most in museums in Germany, and it is believed that as many as 1000 may have been made. Some examples of those that survive are shown in Figures 5–10. The limestone in which they are carved is a hard micrite and each would have taken several hours to manufacture. Most are bas-reliefs but a few are in the round. The 'fossils' are perfectly preserved, not crushed, distorted or incomplete, in ideal anatomical orientation and exactly fit the size and shape of the rock. Sometimes unlikely assemblages adorn the surface of a single slab, combining terrestrial plants with marine shells, fishes and the like.

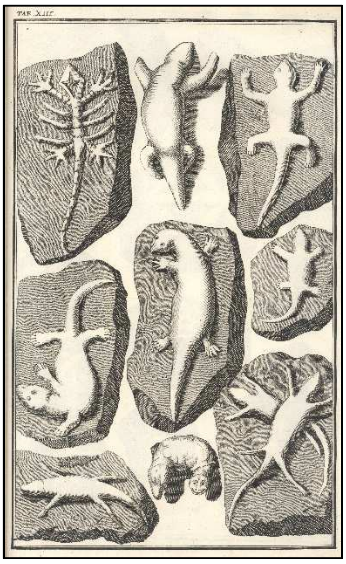


Fig. 4: Plate 13, LW. Most of the lizards or salamanders show soft part preservation except for the one, top L, which is a skeleton (of sorts).

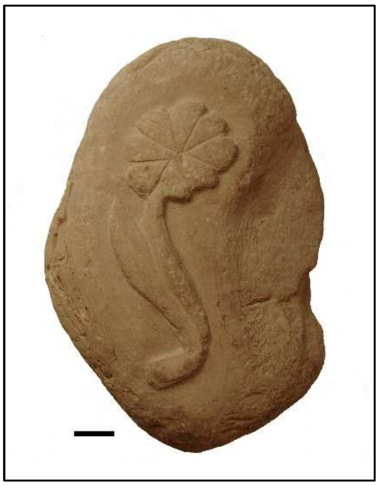


Fig. 5: One of Beringer's 'fossils' from the collection of Würzburg University, a plant with flower. This & the following scale bars are 1 cm.

Fig. 6: Beringer 'lying stone' in the form of script.

Fig. 7: One of the many examples of a frog 'fossil'.

Fig. 8: Fine example of an insect. Note the close fit to stone.

Above - Fig. 9: Strange animal with pincers and a tortoise-like carapace.

The text of *Lithographiae Wirceburgenis* does not give descriptions of the 'fossils' depicted in the plates. Rather, it focuses on how these exceptional 'fossils' could have been formed in the context of the ideas prevailing at the time about the origin of fossils. While the notion expounded by Steno and others that fossils were the remains of once living animals and plants was accepted by many naturalists, some still had their doubts. Alternative theories included vis-plastica, that fossils grew inorganically inside the rock like minerals, and the Spermatick Principle that at least some developed fossils from the 'seeds' of marine animals that went astray and became lodged in cracks in the rocks, there to develop as stony replicas of the animals.

Beringer also considered an idea called 'light fabrication', whereby images of objects in the landscape were somehow projected into the rocks in the manner of a camera obscura. He was attracted to this possibility because close to Eibelstadt where the 'fossils' were found was an old Jewish cemetery with gravestones bearing Hebrew inscriptions that might have been the source for the writing seen on some of his specimens. While not coming to any firm conclusion, there were two theories he discounted for the origin of his 'fossils'. The first was the Biblical Flood. He reasoned that the torrent of the flood would not have permitted preservation of spiders on their delicate webs. In addition, the 'fossil acorns' among his specimens would not have been around at the time of the Biblical Flood as this was widely thought to have happened in the springtime, possibly during May. The second theory that did not appeal to him was that the specimens were of human manufacture. Despite observing what seemed to be gouge marks caused by an instrument, and being shown by a colleague how it was possible to carve a 'fossil' using a Jewish circumcision knife, Beringer held firmly to his belief that his specimens were natural and not man-made.

Shrouded in the mists of human history, the events responsible for the about-turn by Beringer that happened very soon after the publication of *Lithographiae Wirceburgenis* are unclear. Beringer realized that he had been tricked and initiated a court hearing. Two of his colleagues at Würzburg University, J. Ignatz Roderick and Georg von Eckart, were accused of employing three youths from Eibelstadt to carve the fake fossils and plant them on the outcrop for Beringer to discover, or take them directly to Beringer and offer them for sale. The two men apparently believed Beringer to be arrogant and wanted to take him down a peg or two. Unfortunately, the court papers describing the conclusion of the hearing are lost and the final outcome is unknown. Whatever, Beringer returned to his life as a physician and wisely took no further interest in fossils.

Perhaps the most remarkable aspect of the Beringer fraud is its sheer scale. Over a short period of a few months perhaps a thousand Lügensteine carved in hard limestone appeared. Roderick and von Eckart were seemingly responsible for a short-lived cottage industry in Eibelstadt manufacturing fake fossils. Was Beringer a gullible fool to be taken in by this fraud? Possibly yes, but he has to be judged in the context of his time when there was still debate about the true origin of fossils.

Volcanoes in the News

May-June 2018 appears to have been a very active period of volcanic activity – with (on the one hand) in Hawaii an attractive lava fountain giving rise to a relatively slow, but continuous flow of molten lava spreading down the slopes of Kīlauea, destroying homes, crops and and villages, more and more each day, and then boiling away Hawaii's largest freshwater lake in just a matter of hours. Then (about one month later) in Guatemala, the Fuego Volcano's massive explosive eruptions causing multiple injuries when a pyroclastic flow consumed villages, coffee farms, even a golf resort within minutes.

Both these events make great news items because they are visually spectacular but the devastation to the populations affected must have been extreme. Lives and livelihoods ruined. The types of volcano responsible are very different geologically but that is irrelevant if it is you, your family, your livelihood, your friends and their livelihoods, which are affected or destroyed. And I sympathise and send condolences to each and every one of those people affected.

So are the volcanoes getting excited, as some of the media think; they have also reported eruptions and earthquakes in Japan, Alaska, Bali, and the Philippines being active. Or was it just a time of 'slow news'? But, it made me investigate those two volcanic events, and I have attempted to summarise some of my findings below. Needless to say, the scientific reports re Kīlauea are more numerous and scientific as the volcano is continually monitored by the United States Geological Survey (USGS) and, in particular, the Hawaiian Volcano Observatory (HVO).

I have concentrated on the two volcanic eruptions from Kīlauea and Fuego as they are totally different types of volcano – the former is a broad, gently sloping, 'shield volcano'. The latter, Fuego, is a steep-sided, classical volcanic cone or 'stratovolcano'. In the following summaries, the italicised text is taken from USGS and HVO web pages.

The Hawaiian Volcano, Kīlauea, has gently sloping sides, it is a low-volatile, low-explosive volcano, made from low viscosity magma which can flow for miles, forming a shield volcano. These volcanoes are still dangerous but have far less explosive power. They normally produce lava fountains rather than high, explosive plumes of ash etc. Hawaii is used to volcanoes, lava flows and fountains (see Figure 1).

The recent flows of lava started on May 3rd but suddenly increased in number and size. Most of the eruptions and flows have come from the lower E rift zone (Figure 2). Later developments included fresher, hotter magma gushing out of fissures on the SE flank of the mountain. '*A braid of channelized lava poured down the flank of*

Kīlauea … attributed … to the arrival of fresher, hotter magma that moved down from the summit area'. Activity from several fissures increased with four flows merging into a continuous line of lava, some flows have achieved 0.3kph.

Fissure 8 (in lower E rift zone) has been very active, feeding lava continually; its lava stream has flowed downhill and finally entering the ocean at Kapoho. These eruptions have been associated with very high volcanic gas emissions which form VOG (atmospheric pollution caused by SO_2 and other gases and particles reacting with oxygen (O_2) and moisture). Also, Pele's hair *(*fine threads of volcanic glass, formed when a spray of lava droplets cools rapidly in the air*)* which drifts downwind of the lava fountain with other lightweight volcanic glass fragments. Whilst the other active fissure (Fissure 16) has quietly oozed lava daily (HVO).

Comments from media sources reporting information given by HVO and Hawaii County Civil Defence Agency include: '*two fast-moving, channelized lava flows, which joined and separated as they moved toward the ocean, eventually plunging into the water in two locations'…'Steam generated when lava enters the ocean, creates lava haze, or 'laze', a cloud containing hydrochloric acid gas mixed with volcanic glass particles that can cause skin and eye irritation as well as breathing difficulty ... which can extend for ~24 km downwind'*. On June 2nd, the USGS reported that one lava flow entered and boiled away the water of Green Lake, sending a white plume of steam into the sky. By June 16th lava from these eruptions had covered ~24 km^2 in a period of several weeks.

There were significant explosions from the summit – an unusual style from this type of shield volcano, but these shifts in Kīlauea's eruption style had been predicted by the scientists monitoring the volcano. One report notes: explosive eruptions of ash and steam have begun from Kīlauea summit, with one ash plume extending >9km. *'Although Kīlauea is known as an effusive volcano, producing runny lava that fountains up from vents or oozes out of fissures, it does have a history of explosive activity, last observed in 1924, according to scientists with HVO … Satellite observations … showed that the summit's crater vent had nearly tripled in size'* (from ~0.05 to ~0.14km^2). *'In addition, an indentation (*~0.06km^2*) had developed on the E rim of the crater, reflecting a slumping of the rim toward the growing pit'*.

Although the summit is >30km from the E rift zone, these summit explosions and the multiple fissure flows associated with the E rift zone are linked by the internal pluming system. The lava which has been erupting continually from the rift zone fissures has withdrawn lava from the magma chamber below the summit, causing the volcano summit to drop and collapse inward. But this has also brought the magma level below the ground water table, causing the magma to vapourize (Figure 3), become more 'gassy' and when pressure is released from a gassy magma, there are powerful explosions, particularly, if the vent has been blocked. Such numerous large plumes of steam and ash are rare in this type of volcano, but here they have lasted intermittently for days with ash and rocks up to 0.5m falling. The rim has continued to slump in as the fissure eruptions of the E rift zone have continued, heralded by multiple earthquakes at the summit.

On June 21st they reported *'Magma continues to be supplied to the Lower East Rift Zone. Seismicity remains relatively low in the area with numerous small magnitude earthquakes and low amplitude background tremor. Higher amplitude tremor is occasionally being recorded on seismic stations close to the ocean entry. Seismicity at the summit increased throughout the day following the abrupt drop after the … gas and ash emission this morning. Inward slumping of the rim and walls of Halema'uma'u crater … continues in response to ongoing subsidence at the summit* … The following day HOV reported *after elevated seismicity, a collapse explosion occurred at the summit producing an ash-poor steam plume that rose 150m …. The energy released by the event was equivalent to a magnitude 5.3 earthquake. Seismicity dropped abruptly from 40 earthquakes/hr (~3 magnitude) leading up to the collapse explosion* … with earthquakes at <10 /hr. *Then, seismicity gradually increased, reaching ~30/hr and inward slumping of the rim and walls of Halema'uma'u continues in response to ongoing subsidence at the summit'*.

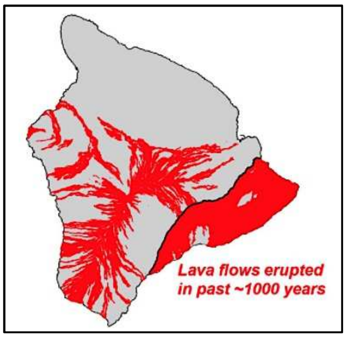


Fig. 1: Lava flows from past ~1000a

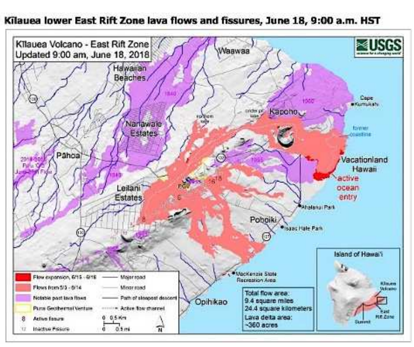


Fig 2: Fissures & Flows from current period of activity

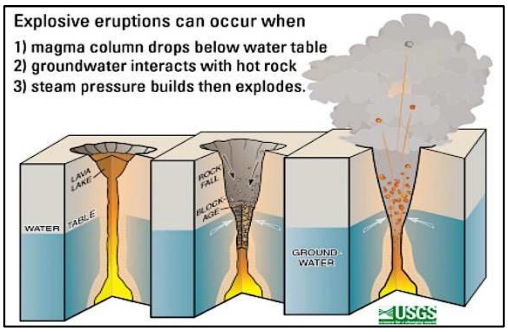


Fig. 3: Diagram showing result of magma chamber with a column of magma encountering the water table.

Images in Figures 1-3 have been taken from UGS website and relate to images produced by USGS or HVO.

The Kīlauea magma has changed with time – initially, the lava exuding from the lower E rift zone fissures was old, probably emerging from dykes, where it had resided for decades or longer. *'Having cooled with age, the lava emerged viscous and sticky - more sluggish than fresh, fast-flowing lava … once the old lava was pushed out, a fresher batch could follow'*. More recent lava samples have been found to be *'younger and hotter. This fresh Kīlauea lava tends to be runnier, therefore producing more voluminous, faster-moving flows'*. See Figure 4 for thermal images of the lava flows.

A further interesting development in the rift zone is a large hole which has opened below one of the recent lava channels. *'The hole opened up [across] the entire width of the channel, and all the lava that was flowing E is pouring down into the hole … we still aren't sure why and how the openings form and where the lava goes, but similar activity was seen in a 2011 Kīlauea eruption. The lava that poured into the ground never reappeared at the surface'*.

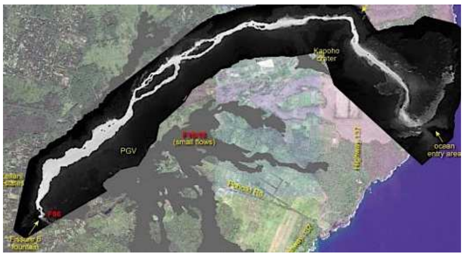


Fig. 4: Thermal image of lava from Fissure 18 in the SE Rift zone flowing down the valley & into the ocean. Image modified from one provided by USGS / HVO

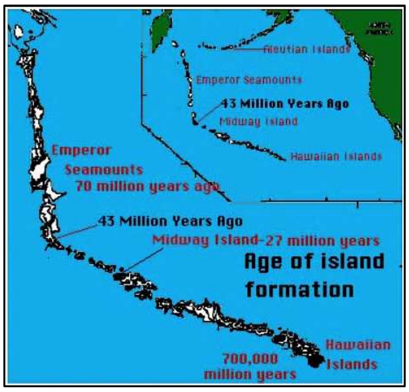


Fig. 5: Image of Hawaiian Chain with trends & ages. Image from: http://volcano.oregonstate.edu/hot-spot-volcanoes-hawaii-and-yellowstone-lesson-9

To put Kīlauea into a tectonic setting, it is at the SE end of the Hawaiian Chain of islands (Figure 5). This chain of islands are interpreted to have formed as they passed over a 'hot spot' at the top of a plume of magma which has risen from deep within the mantle, probably from the core-mantle-boundary at ~2700km.

They lie within a Pacific Ocean plate which has gradually drifted NW over this 'hot spot' during the last >75Ma – the older volcanoes (which now lie to the NW of Hawaii) are extinct, often subsiding below sea level as sea mounts.

Mauna Loa Volcano which is ~30km to NW of Kīlauea but appears to be unaffected by Kīlauea's activity. '*Mauna Loa is the largest active volcano on Earth producing voluminous, fast-moving lava flows, sometimes reaching the S and W coasts. Eruptions typically start at the summit but soon migrate to either the NE or SW Rift Zones. Since 1843, the volcano has erupted 33 times with intervals between eruptions ranging from months to decades. Mauna Loa last erupted 34 years ago, in 1984'*.

'Over the last few years, seismic stations have recorded elevated rates of shallow, small-magnitude earthquakes beneath Mauna Loa's summit, upper SW Rift Zone, and W flank together with ground deformation consistent with input of magma into the volcano's shallow magma storage system and indicating that the volcano was above background levels of activity. This episode of unrest lasted several years without progressing to an eruption, similar to an earlier period of unrest. Since then, earthquake and ground motion activity related to inflation of shallow magma reservoirs have slowed to near background levels. Recent recorded motions on Mauna Loa are due to the M6.9 Kīlauea S flank earthquake on May 4, 2018 and subsidence at the summit of Kīlauea Volcano but none of the activity on Kīlauea has had a detectable effect on Mauna Loa's magmatic system'.

- There are plenty of images and videos of volcanoes on: https://www.independent.co.uk/topic/Volcanoes
- There is a live webcam at: https://www.express.co.uk/news/world/976311/Hawaii-volcano-live-webcam-Kilauea-watch-USGS-video-update
- **References:**

- Reports from various scientists from USGS and HVO. And Ilima Loomis (email: ilima@ilimaloomis.com), Freelance Journalist.
- See also: https://volcanoes.usgs.gov/volcanoes/kilauea/geo_hist_summary.html and http://volcano.oregonstate.edu/hot-spot-volcanoes-hawaii-and-yellowstone-lesson-9

In the case of the **Volcán del Fuego**, Figure 6, there were a series of explosions on June 3rd, comprising plumes of ash and tephra ejected ~10 km into the air, which then rained down in a mixture of ash, pumice fragments, bombs of hard rock and molten lava. Also incandescent flows of rock, ash, gas and glassy shards cascaded down the slopes as pyroclastic flows. Fire fighters were quoted to record temperatures of 400-700°C in some places from the layers of ash in the pyroclastic flows. One eye witness is quoted as saying *'In a matter of 3 or 4 minutes the village disappeared … It was smothered in a 'sea' of muck that came crashing into homes, inundating people, pets and* *wildlife"*. More than 100 people were confirmed to have died (National Institute of Forensic Science), hundreds injured and some 200 people still missing and more than one million people affected (reported by UPI).

This type of volcano is characterized by extremely explosive eruptions – Fuego's magma is mainly a basaltic-andesitic lava but sometimes with more acidic dacite and rhyolite affinities and with ignimbrites (pyroclastic flows of incandescent gas and ash particles which produce welded tuffs). It has been erupting for >50 years, often characterized by '*vulcanian explosions with minor ash emission, punctuated by Strombolian episodes with extrusions of lava flows and rare larger eruptions with pyroclastic flows, most recently in September 2012'*.

Fig. 6: Close-up aerial view of actively fuming crater of Fuego. View is directly from S, with Acatenango in the background
Photo by Bill Rose, 1980. Image

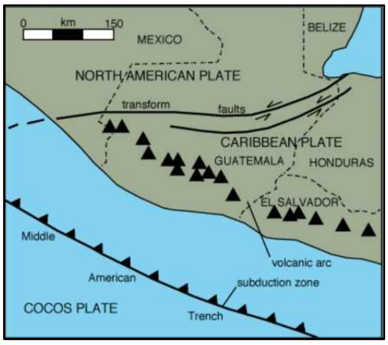


Fig. 7: Tectonic setting of the Fuego Volcano, Guatemala. Modified from Duffield and others (1989).
Image From: http://volcano.oregonstate.edu/fuego

Fig. 8: Steaming hot mudflow materials in Barranca Honda, east of Fuego's summit.
Photo: Sam Bonis, October 1974.

This volcano is a classic stratovolcano, the result of the Cocos Plate (one of the Pacific Ocean Plates) subducting below the thin string of mountains connecting the North and South American continents (Figure 7). As the dense oceanic plate subducts, it starts to melt, releases water, chemicals and volatiles which mix with asthenosphere peridotite to form a magma which drives upward into an area of lower pressure. The presence of water and volatiles increases the viscosity of the magma, the gases within the magma expand continually and the magma ends in a very gassy (and massive) explosion. This volcano is part of the 'Ring of Fire' around the Pacific which contains >450 volcanoes and ~50 or more of these volcanoes erupt every year (according to the USGS).

This particular volcano is very active, one of the most active in Central America. Fuego has erupted >60 times since 1524 and this latest eruption is the largest for >100 years. Three of these earlier eruptions caused fatalities. As if that weren't enough, the rescue efforts have been hampered by torrential equatorial rainstorms. The tropical rains increase the potential for major steaming mud flows (Figure 8) of ash and volcanic material (lahars) which can move at >150 kph.

Volcán Fuego is one of three large stratovolcanoes overlooking Guatemala's former capital, Antigua. The scarp of an older edifice, Meseta, lies between the 3,763m high Fuego and its twin volcano, Acatenango, to the N. Collapse of the ancestral Meseta volcano about 8,500 years ago produced the massive Escuintla debris-avalanche deposit, which extends about 50 km onto the Pacific coastal plain. Growth of the modern Fuego volcano followed, continuing the southward migration of volcanism that began at Acatenango. In contrast to the mostly andesitic Acatenango volcano, eruptions at Fuego have become more mafic with time, and most historical activity has produced basaltic rocks. Frequent vigorous historical eruptions have been recorded at Fuego since the onset of the Spanish era in 1524, and have produced major ash falls, along with occasional pyroclastic flows and lava flows.

Typically, violent vulcanian eruptions last a few hours to several days and produce pyroclastic flows. Figure 5 shows Fuego (foreground) and Acatenango (background). The most recent large eruptions at Fuego were in October of 1974. Over a ten day period there were four distinct pulses in vulcanian activity, each lasting 4-17hrs. An ash cloud shot >7km above the volcano. Glowing avalanches moved down the slopes of Fuego at 60 kph. Atmospheric effects were reported for months following the eruption. There are active fumaroles in the crater at the summit.

References
https://www.smithsonianmag.com/smart-news/five-things-know-about-eruption-guatemala-180969233/
http://volcano.oregonstate.edu/fuego
Image Sources: Michigan Technological University Volcanoes Page
Whittington, A. G.; Magaldi, T.; Calderas, A.; Chigna, G.; Escobar-Wolf, R. P.; Lyons, J. J.; Mathias, O.; Robert, G.; Seaman, S. J.; Magma rheology and eruption style at Volcán Fuego, Guatemala.
http://adsabs.harvard.edu/abs/2013AGUFM.V43C..08W

Liz Aston, Member FGS