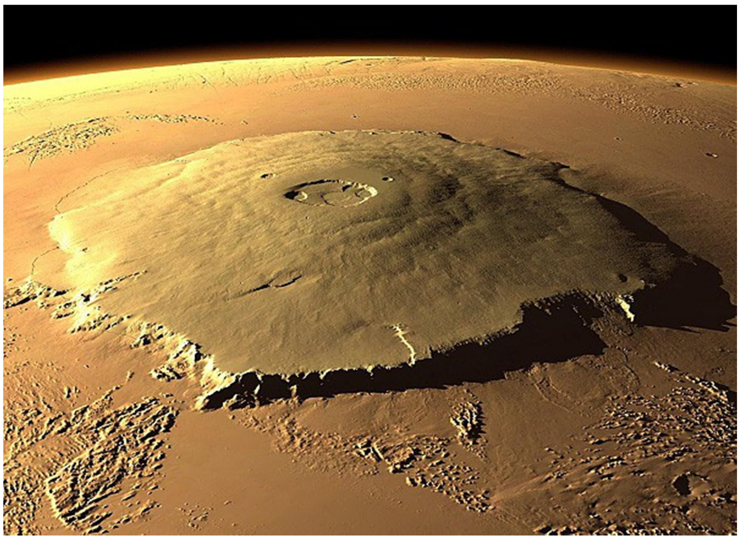
KENT GEOLOGISTS' GROUP

The Kent Group of the Geologists' Association

NEWSLETTER

No.27 – February 2021

Website: www.kgg.org.uk



Officials and Committee Members

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Supporting Committee Members:-

Alison Taylor

Doreen van Seenus

Duncan Stewart – Webmaster (Acting)

Tony Mitchell

As always we welcome and recognize the continued support given by Dr. Adrian Rundle, Dr. Ed Jarzembowski and Peter Jeens

The Kent Geologists' Group does not accept any responsibility for the views expressed by individual authors in this Newsletter. The Newsletter should not be regarded as a scientific publication for taxonomic purposes

Cover Picture: Olympus Mons. A significant volcanic feature on Mars (See inside)

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THE KENT GEOLOGISTS' GROUP IS A LOCAL GROUP OF

THE GEOLOGISTS' ASSOCIATION

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As a local group we receive details of lectures and field trips organised by the GA and other Local Groups and Affiliated Societies. Copies of the GA Magazine and the Circular with these details are on display on the Secretary's Table at Indoor Meetings.

MEMBERSHIP OF THE KENT GEOLOGISTS' GROUP

Membership is open to all who have an interest in geology, regardless of qualifications and experience. The annual subscription (which runs from January to December) is £15.00. The subscription for each Additional Member living at the same address is £2.00. There is an entrance fee of £1.00 per meeting (£3.00 for non-members) but guests and non-members are admitted free of charge for one meeting.

Membership application forms may be obtained from the General Secretary or downloaded from the Kent Geologists' Group website:- www.kgg.org.uk via the "How Do I Join" page.

Editorial

Welcome to your 2021 newsletter. As always this would not be possible without your valuable input and supporting articles. Please keep them coming thank you.

My name is Grahame Godding the new KGG Secretary (Acting). I have stepped into the shoes of John Taylor; also taking on the Editorship of this journal. This is our first opportunity to share news and articles since the dreaded Covid pandemic brought our proceedings to a halt. Sadly there were only two 2020 KGG indoor meetings. Dr. Doreen van Seenus gave us a wonderful insight into the world of 'Supervolcanoes' (see also The Long View p.47) and Dr. Geoff Turner gave us an interesting talk on 'The Human History of the San Andreas fault'.

These were followed by a memorable "Drive and Wade" field trip to sunny East Kent on 8th March 2020. Organised by Alison Taylor we discovered 'The Nailbourne in Winter' flowing from its' source along the whole length of its' course. Many thanks to Alison for a great day out.

During the spring and summer Tony Mitchell and I set a number of 'whimsies, conundrums & problems' to solve. These were emailed out to the membership to keep us all engaged with geology.

Congratulations to Tony Mitchell who provided the first complete correct answer to my puzzle 'I am a rock, but what am I?' The answer was Granite, from St.Bees beach in the Lake District. The link was to Wainwrights' Coast to Coast walk starting at St.Bees ending at Robins Hood Bay in Yorkshire. Tradition has it that a pebble taken from St.Bees by a walker is thrown into the sea at Robins Hood Bay upon completing the walk.

Thenceforth Tony set a very high standard for a number of puzzles. Kudos goes to Ann Barrett and Gary Woodall who provided the most complete answers with references to all the following:-

- Problem 2 was related to volcanism and deposition of silica and the Rhynie Chert.
- Problem 3 concerned early Man's use of materials, Flint, Obsidian and Greenstone
- Problem 4 was on the naming of a tooth, crab, fossil bird and the Dudley Trilobite. All specific names were people, but the birds's generic name was also a person.
- Problem 5 What was the order of deposition of tarmac, kerbstones and standpipes.
- Problem 6 related to deposition of volcanic ash and whether the eruption gets stronger then stops or starts big and slowly decreases, as shown by the particle sizes

Ann Barrett has organised another full and interesting programme of speakers (details at the end and on our website). In common with many other social and educational activities we have transferred from our monthly indoor meetings to a remote format using ZOOM. Thanks to hard work by Ann and Duncan the Zoom facilities were tested and available for the January talk by Dr. Chris Duffin on 'Charles Moore (1815 – 1881) A Somerset Geologist and his Collection'. This was followed by an open house 'natter'!

Take a quick trip to our website and you will now find a PowerPoint 'learning page'. Another resource that we can be proud of. Also worth a mention a date for your diary – Anthony (Tony) Brook advised that the 'Southeast England Regional Conference' has been booked for Saturday 27th November 2021 to be held at Kings Church, Lewes, Sussex. Let's hope that we will all have moved out from 'Lockdown' to a 'New Normal' by then.

Sadly I also have to report the passing of our friend and KGG colleague David Brown who died almost exactly a year ago.

Finally, I cannot close this editorial without thanking John Taylor. In addition to his admirable work in the Secretary role John has been a prolific and thought provoking author of various articles for input to the KGG Newsletter. His sterling editorship will be a very hard act to follow.

Grahame Godding (Editor)

Introduction

Hello Everyone,

I hope you are all keeping well. It's been a while since we all met at the United Reformed Church in Week Street. As it doesn't look like we will be able to meet for a while yet, we thought a Newsletter would be a good way of keeping in touch and providing some geological interest in the interim.

I hope you enjoy what we have put together and if you have any suggestions or articles for future issues please let us know.

Until we meet again, keep safe!

Anne Padfield (Chair)

Wairere Boulders NZ

Alison Taylor

In January 2017 I was fortunate enough to be able to spend two weeks in the North Island of New Zealand. I started off in Wellington where I visited my late husband's New Zealand relatives and then zigzagged across the country in a generally northerly direction until I reached the antipodean home of my cousin and her husband in the Bay of Islands.

My zigs and zags took in many wonders: the snow capped volcanoes in the Tangariro National Park, Lake Taupo, the amazing silica terraces at Orekei Korako and the beautiful and fascinating array of geothermal wonders in the Waimangu Volcanic Valley, sulphurously stately Rotorua and the bijou beauty of the Coramandel peninsular. Then through Aukland and on to the basalt columns at Whangarei, back to the west coast, and through the Kauri Forest to the monumental sand dunes at the mouth of the Hokianga Estuary. From here I had to take a road eastwards to get to Kerikeri and the Bay of Islands, but, on my way, near Taheke, I saw a signpost pointing down a side road to something called the Wairere Boulders.

I had been absolutely thrilled by all the fantastic geothermal spectacles that I had seen on my journey. Beside the fire and brimstone which, in my childhood, I had never, ever expected to see, big boulders don't seem that exciting. However, my curiosity was piqued. I had to go and see them! They were great and I thought, "I shall write about them in the next KGG Newsletter." However, when I started to write, I realised, of course, that things are never so simple, and that I would have to write a brief geological history of New Zealand as an introduction to the story of the boulders. I hope that my account is in sufficient detail for those readers who don't already have this knowledge, and succinct enough not to frustrate those who know a lot more about it than I do!

New Zealand's position on the Pacific Ring of Fire is well known, but how did it come to be stuck in the ocean 2000 odd miles out to the East-South-East of Australia, and how long has it been there?

The story begins with Gondwanaland, the supercontinent which existed in the Permian Period, the gradual break-up of which resulted in the separation of all the continents in the Southern Hemisphere. Australia, New Zealand and Antarctica originally split off as one section in late Cretaceous times, between 95 and 90 million years ago. Then, about 83 million years ago, a smaller swathe of land started to separate from the main Australian land mass. This was the birth of New Zealand, but not just New Zealand. This piece of continental crust includes New Caledonia and a sizeable area of continental shelf to the North-East and South-West of the islands. The whole area is known as Zealandia.

By 75 million years ago, Zealandia was completely separated from Australia and Antarctica, as the Tasman Sea came into existence. The separating phase continued until 53 million years ago, early Eocene, when a period of fusion occurred between the two land masses. Thus they became fixed in their current relative positions and a new plate boundary formed between them and the Pacific Plate. This left New Zealand on the meeting line between the Pacific and Australian Plates and thus is New Zealand both blessed and cursed by earthquakes and volcanic activity of all sorts which continues in the 21st Century and will continue into the foreseeable future.

Both before and during the breaking away of Zealandia from Gondwanaland, and then from Australia and Antarctica, there were repeated periods when the area was submerged and then raised again. Thus, as well as the volcanic rocks which are so much in evidence, there are also a variety of sedimentary rocks of varying ages and compositions. Greywacke is one which is quite common in both the North and South Islands. However, because of the area's violent geological history over many millions of years, the sedimentary rocks are very fractured and jumbled together, with clays, sandstones and limestones cheek by jowl with each other, frequently metamorphosed to varying degrees and interspersed with volcanic intrusions.

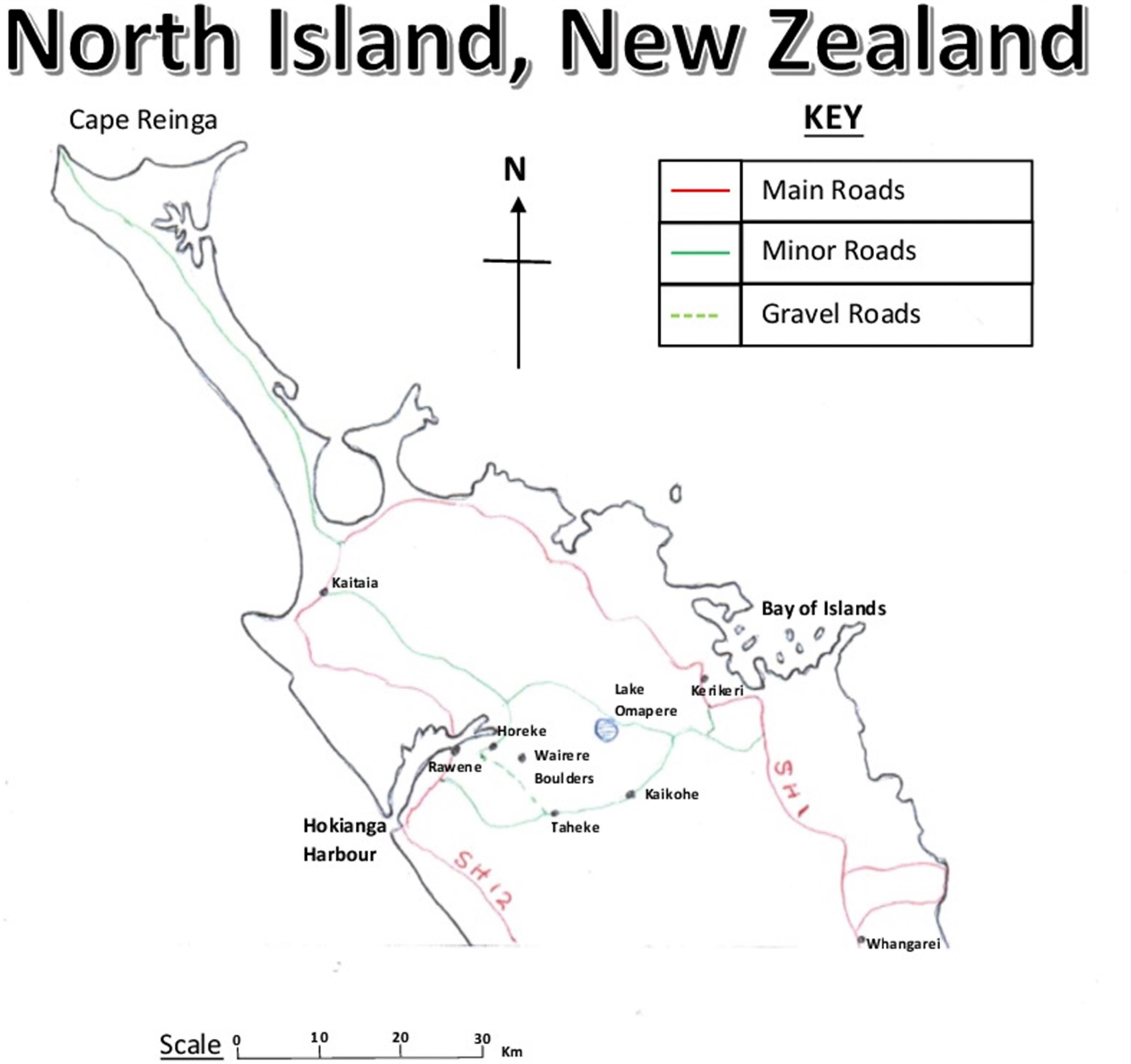
When Zealandia came to be at the plate junction, the future of the North Island area began to be determined by the subduction of the Pacific Plate beneath the Australian Plate. This started in the most northerly area during the Miocene Period and has been moving southwards ever since, so that now the main volcanic activity is along the Taupo Volcanic Zone in the centre of the North Island. Since the breakaway of Zealandia, the geological history of the South Island has been quite different, its earthquakes being the result of stress on a huge and hugely active fault line stretching from South-West to North-East, thus bisecting the whole island along its length. Since this article is primarily about the Wairere Boulders in the North Island, the more recent geological history of the South Island is not relevant.

So, back to my discovery of those Wairere Boulders. I had driven a long demanding road that day but I thought that I could just fit in one more North Island curiosity. The road indicated on the sign was quite wide for a side road, but after a couple of farm houses, the tarmac surface was replaced by a hard gravel track which quickly wound up into forested hills. It was just a timber road. I drove on and on and eventually a signpost advertising Wairere Boulders, pointed down a much smaller track leading steeply down the North side of the hill. There was pasture on both sides. On the left, (North-West), the land was quite low, but the field on my right rose steeply to the level of the forest. Dotted about on the slope were several immense squarish boulders. They looked very odd and out of place, rather as if giants had been rolling dice. My interest had already been primed because I had previously seen similar boulders on a grassy hillside adjacent to the SH4 road between Whanganui (South-West coast) and the Tangariro National Park.

After a few minutes the track ended in a small secluded car park. There was one large vehicle, (a cattle truck), in the car park and a medium sized wooden shed at the far side. The cattle truck turned out to be a vehicle converted into a motor home for a family with 4 or 5 children. The ramp was down at the back revealing beds ranged all along the sides and the family's belongings hanging on the side bars with which cattle trucks are furnished. All that was missing was the straw and the cattle!

The family were very friendly and showed me into the shed and the correct gate to take for the Boulder Walk. I started to look around at the objects and information in the shed when another car arrived and a very striking lady got out. She was in her sixties, with long dark hair and eye catching make-up. She was dressed in very colourful clothes in a style that you might expect to see at a carnival in South America. This lady turned out to be the owner, with her husband, of the Wairere Boulder enterprise. She started to tell me all about it; how they had bought the site in 1999, cleared a lot of the bush and discovered the boulders.

As well as making money from the people who want to walk around the Boulder Valley, they also run a very low key, environmentally friendly holiday activity centre on their land. She asked me to guess her nationality. I pondered for quite a while, not wanting to risk offending her and in the end she told me that she was Swiss. I must say, that was not among the variety of possibilities I had in my head. In the shed were some pieces of rock – basalt, photographs of people in tents on the activity holidays, photographs of the boulders in the valley with some diagrams to show how the boulders got there, and various items for sale. I would have liked to have had a better look round at all the things there, but I was very short of time and so I set off quickly to see the wonders on the trail.



The valley is very steep sided and rises rapidly with many waterfalls to a height of several hundred feet. The path leads you up one side to the level surface at the top, this being the top of the basalt lava flow. Here there is a small pool of water as shown in the bottom right hand picture. The path then leads across a little wooden bridge (picture bottom left), and down the other side. The valley sides are thickly wooded and the path is narrow and steep. You have to wind around trees and squeeze through narrow crevices in between the rocks. In some places you are in a short tunnel where the huge boulders lean on each other over your head. The stream is small but very noisy and at every turn in the path there is a new view of a great tumble of boulders, each the size of a minibus or bigger, in and around the stream bed.

As boulders they are impressive but, as an extra fillip, many of them are fluted, as if they have been gouged out by a giant potato peeler. The fluting occurred before the boulders rolled down into the valley. When the fluting occurred it was done in a vertical direction, from top to bottom, but many of the boulders are on their sides, so the fluting is visible in different directions on each boulder. Some of the flutes are a foot across and six inches deep. It took me about forty minutes to complete the circuit, including brief stops for photographs. I was going as fast as I could as my cousin was expecting me for dinner in the Bay of Islands. I would have liked to spend more time there as it was really spectacular, but it was already evening and I had at least an hour’s driving to reach my cousin’s house.

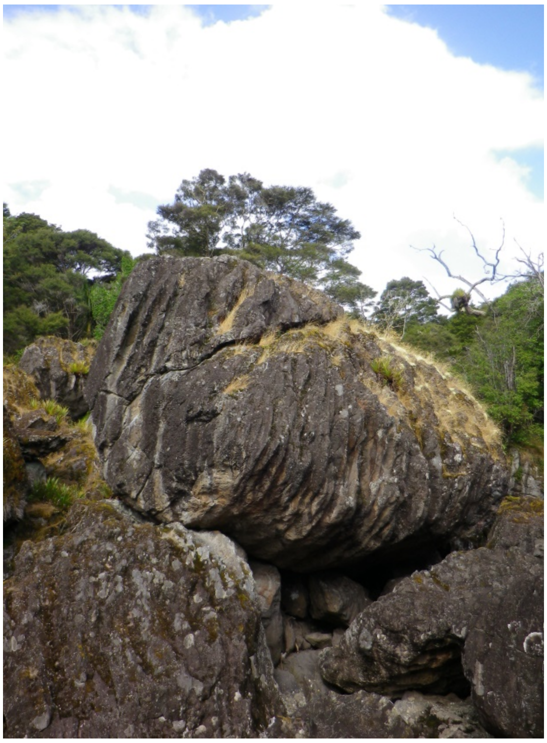
The Wairere Boulders are composed of basalt. They are the result of volcanic activity during the Upper Pliocene and Lower Pleistocene periods, (2.84 – 2.67 million years ago), when lava rose to the surface through faults in the sedimentary rocks which had been uplifted and deformed in the Kaikoura Orogeny. The cause of the uplift is the subduction of the Pacific Plate beneath the Australian one. These sedimentary rocks had been eroded to a peneplain, so the lava flowed over a sizable area with ease. There were actually four separate periods of volcanic outpourings in the northern part of the North Island, but the one from which the Wairere Boulders originated is the oldest of them.

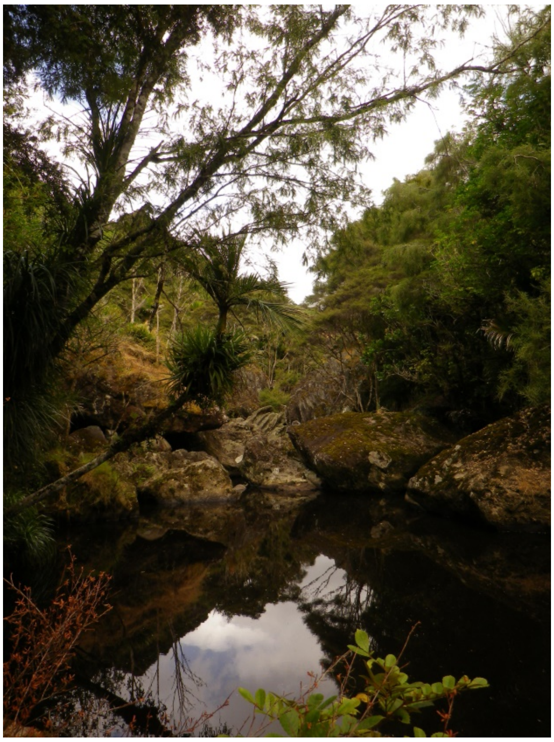
It was previously called the Horeke Basalt, but is now known as the Kerikeri Volcanic Group. Horeke is a small town in the upper reaches of the Hakianga Estuary. The lava flow originally covered an area between Kaikohe, Horeke and Lake Omapere. It was in fact the damming of a stream by the lava flow which led to the formation of the lake. The sedimentary rocks underlying the basalt are highly fractured and not very robust. They are a mixture of clays, shales, sandstones and mudstones. In fact, the height of the land in this area, (about 600 feet), is thanks to the protective covering of the basalt, and at the edges of the basalt flow, the land drops down steeply where the unprotected sedimentary rock has been eroded away. Where the basalt has been undercut, great blocks have fallen and rolled down the steep escarpment of the eroded sedimentary rock. In places, such as Wairere, where a stream has cut back, blocks from both sides of the lengthening valley have rolled downwards towards the stream bed. This steep section of the Wairere Valley is about one mile long from the high basalt plateau down through the underlying sedimentary layers to the flat plain below.

So, that’s the basalt blocks, but what about the fluting? The natural vegetation of the North Island of New Zealand is subtropical forest. The dominant species of this forest was the Kauri Pine, but there was also a rich mix of other indigenous trees and tree ferns. The view of scientists is that over thousands of years of a warm humid environment, with the leaf-mould beneath the trees being in a continuously saturated state, chemical leaching of the basalt occurred, as dilute humic acid seeped down the sides of boulders and took advantage of weakened paths caused by fissures and plant roots. The boulders are documented as a specialized type of karst formation as the flutes are assumed to have been formed by erosion from a chemical solution. However, for me, having read everything I could find about them, I am left with the puzzle of how it is that the flutes present in such a regular parallel form.

The Wairere Boulders are widely acknowledged as the premiere site for these fluted boulders, but they do occur in several other sites in the North Island of New Zealand and also in Hawaii.

There are articles and lots of photos on the internet, and if you happen to be in the North Island of New Zealand, I really recommend a visit.



Areology of Ares (The Geology of Mars) *Gordon Elder*

Introduction

All planets, by our definition, have to chart a path around a star and by accretion of the debris left over from their star's formation become self creative. The image below shows the darkened zones where protoplanets are coagulating this debris to form their identities. A very violent process taking millions of years to accomplish, this is where a planet like Mars was born.

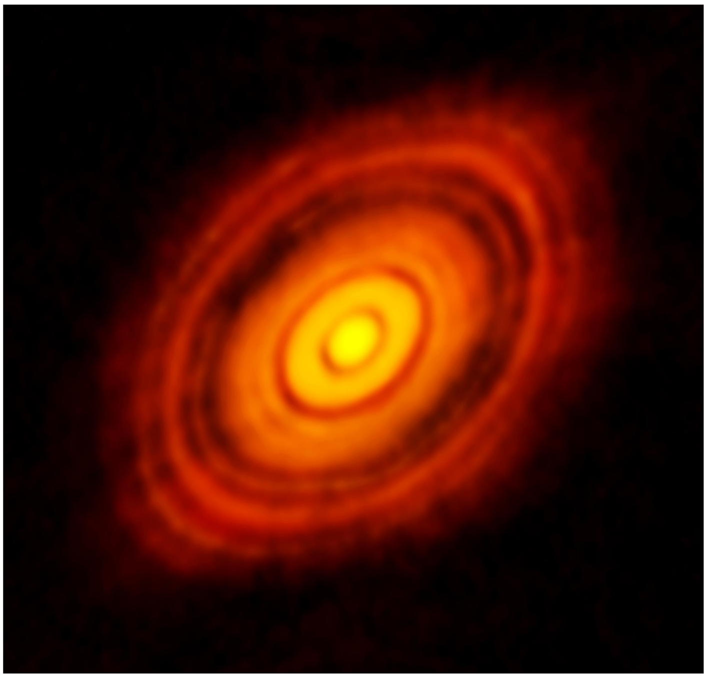


Fig. 1. *The Atacama Large Millimeter Array image of HL Tauri star's protoplanetary disk.*

Mars is the fourth planet from the Sun and the second-smallest in the Solar System. It is a terrestrial planet with a thin atmosphere and shows some beautiful cloud formations, having surface features reminiscent both of the impact craters of the Moon and the valleys, deserts and polar ice caps of Earth. The sols (days) and seasons are comparable to those of Earth because the rotational period as well as the tilt of the orbital axis relative to the ecliptic plane are very similar.

Spacecraft and Landers

There have been 56 missions to Mars, some failed and others succeeded, however, there is one that I shall concentrate on in this article simply due to space! This is the research done through NASA's Curiosity rover. Others will be mentioned. The latest, Insight and the next, Rover 2020, may be addressed in the future.

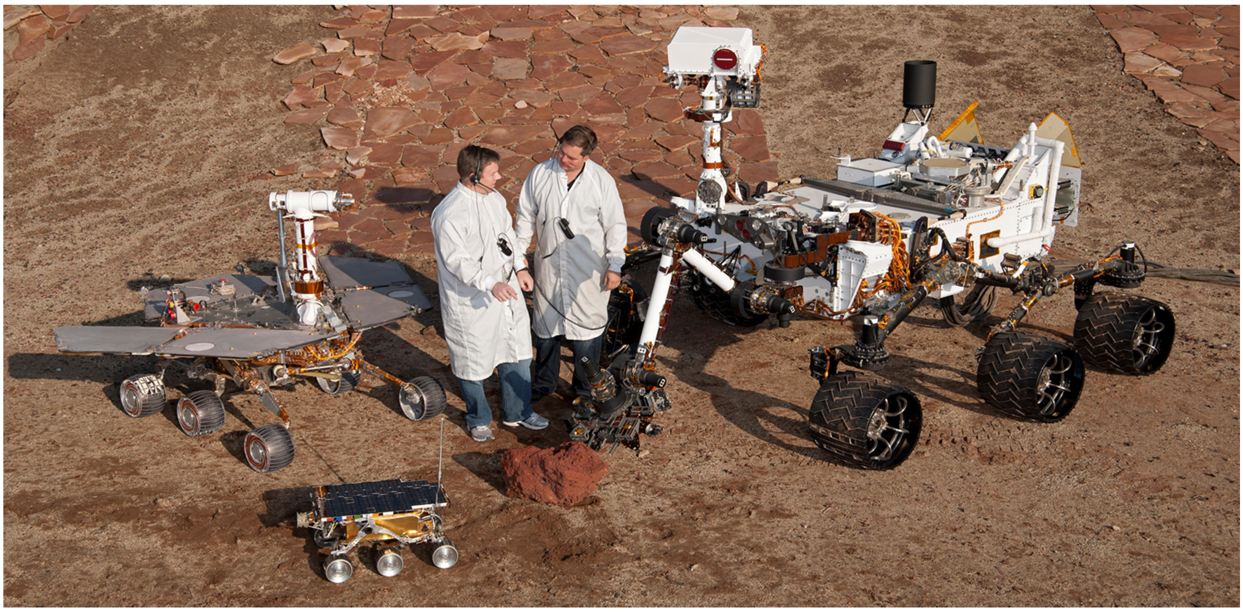


Fig. 2. *NASA's Curiosity (the larger rover on the right) and Friends (Spirit & Opportunity, twins, only one is shown, on the left) and Sojourner at the bottom of the picture.*

Areology - Mars' geology

Areology is the scientific study of the surface, crust and interior of the planet and originates from the Greek word Arēs (Mars.) Most of our current knowledge about the areology of Mars started from surveying the terrain imaged by orbiting spacecraft and some from landers and rovers.

Mars has a number of large-scale surface features that indicate the types of areological processes that have operated on the planet over time. The northern and southern hemispheres of Mars are strikingly different from each other.

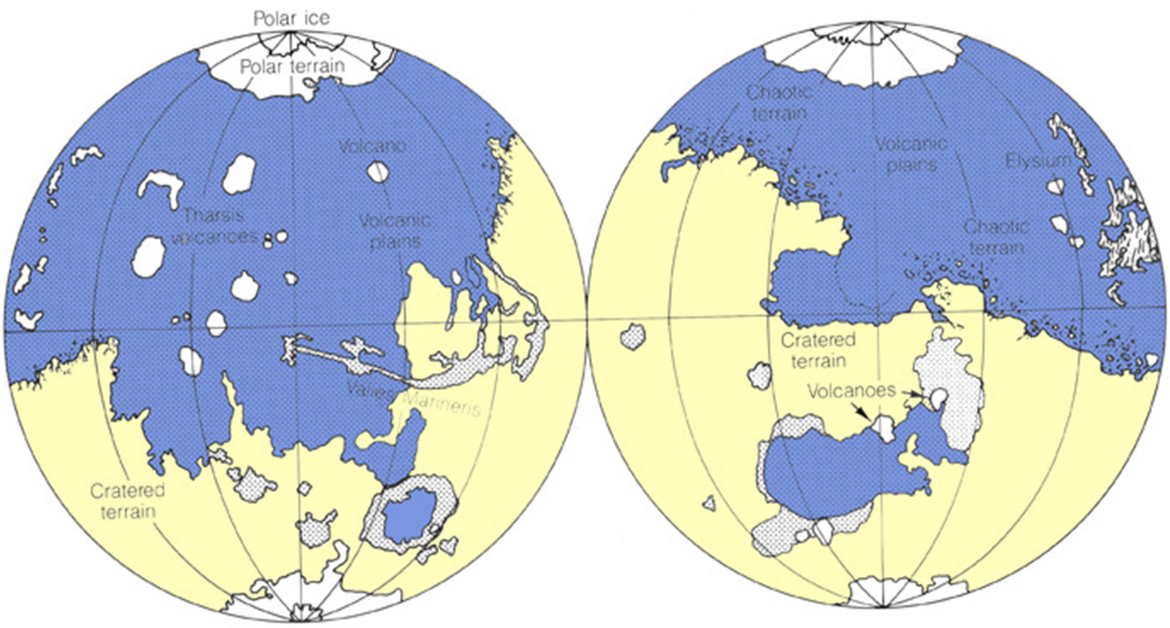


Fig. 3. *This image shows the dichotomy of Mars with, in the left-hand image, Tharsis volcanic region (Olympus Mons, and three other volcanoes,) Valies Marineris and then in the right-hand image two quasi-circular depressions.*

Laser altimetry and sonar data from orbiting spacecraft have identified a large number of basin-sized structures previously hidden in visual images. These are quasi-circular depressions (QCDs) and are features that may represent derelict impact craters from the period of heavy bombardment that are now covered by younger deposits.

The theories for the dichotomy of terrain generally fall into two categories: one, it was produced by a very large impact event or several large impacts early in the planet's history known as exogenic theories or two, it was produced by crustal thinning in the northern hemisphere by mantle convection or other chemical and thermal processes in the planet's interior described as endogenic theories. One endogenic model proposes an early episode of plate tectonics producing a thinner crust in the north, similar to what is occurring at spreading plate boundaries on Earth.

Tharsis and Elysium volcanic provinces

Straddling the dichotomy boundary in Mars' western hemisphere is a massive volcano-tectonic province known as the Tharsis region. This immensely elevated structure is thousands of kilometres in diameter and covers up to 25% of the planet's surface. Averaging 7–10km above datum (Martian "sea" level,) Tharsis contains the highest elevations on the planet and the largest known volcanoes in the Solar System. Three enormous volcanoes, Ascraeus Mons (NE), Pavonis Mons (middle), and Arsia Mons (SW) (collectively known as the Tharsis Montes,) sit aligned NE-SW along the crest of the bulge. The huge shield volcano Olympus Mons lies off the main bulge at the western edge of the province.

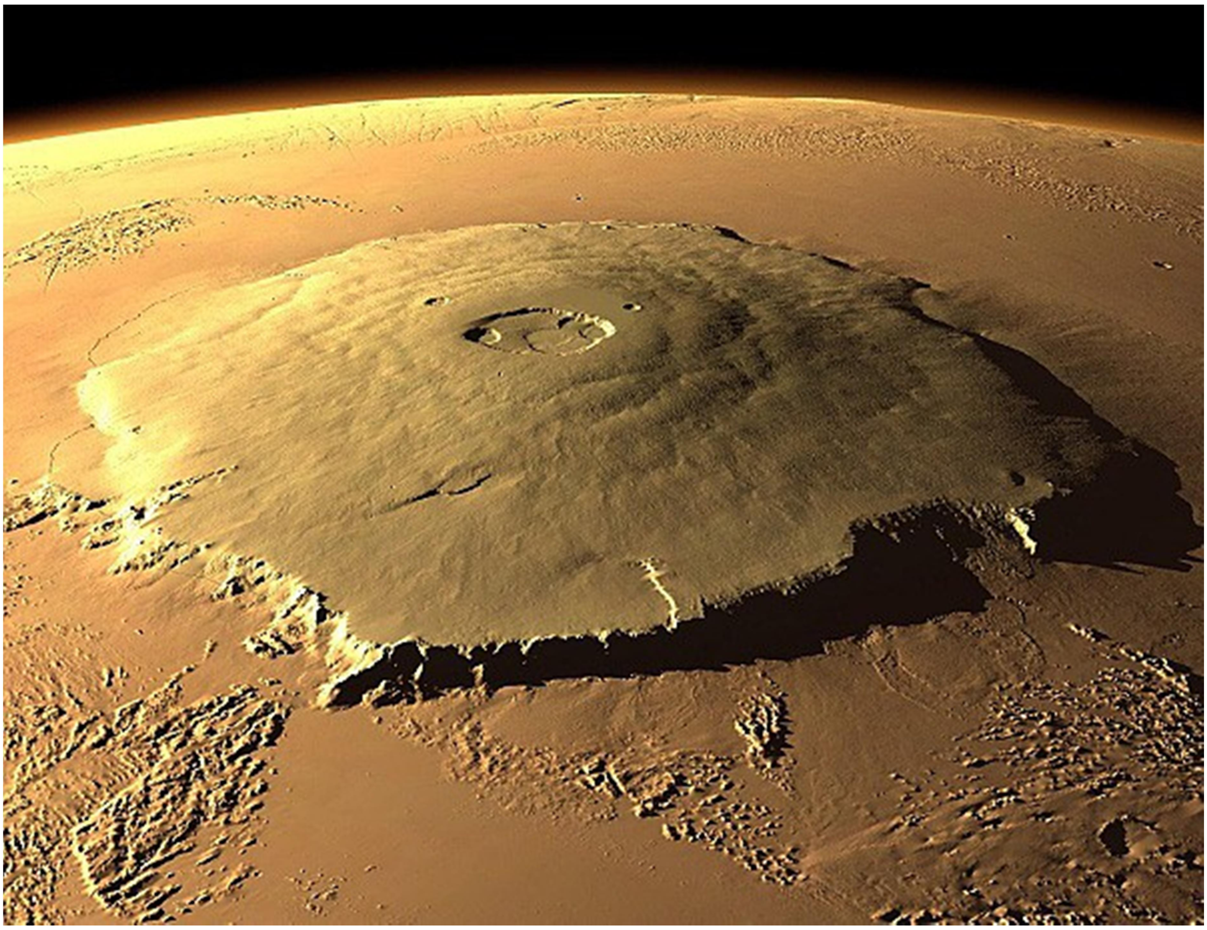


Fig. 4. *Olympus Mons.*

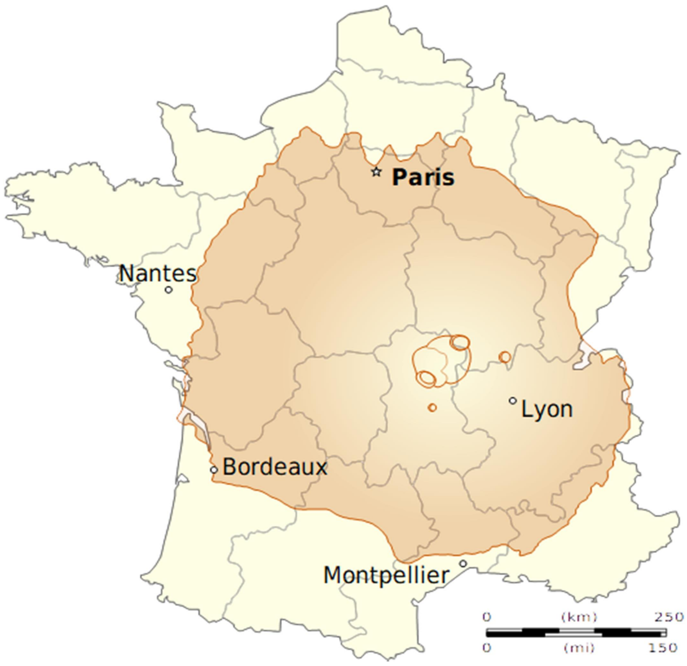


Fig. 5. *Olympus Mons in proportion to France.*

The mass of Tharsis has caused stresses on the planet's lithosphere resulting in immense extensional fractures, grabens (rift valley) and horsts radiating outward from Tharsis and extending halfway around the planet.

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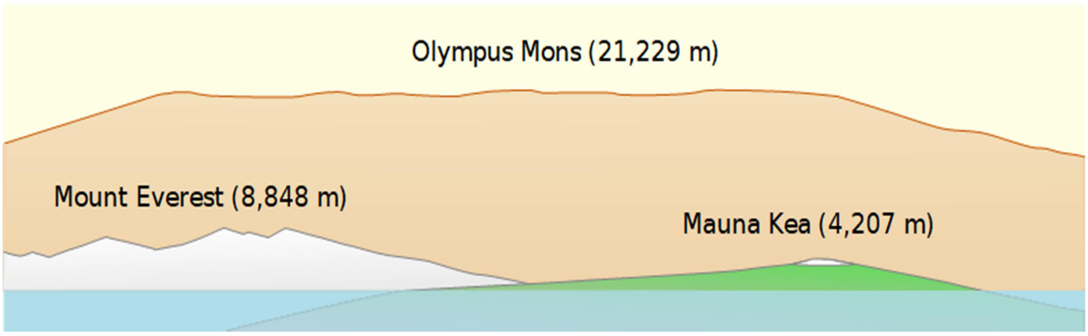


Fig. 6. *Olympus Mons as scaled to Mount Everest and Mauna Kea*

Large Graben & Horst System - Valles Marineris

Near the equator, in the western hemisphere, lies the Valles Marineris. This canyon system extends eastward from Tharsis for a length of over 4,000 km, nearly a quarter of the planet's circumference. If placed on Earth, Valles Marineris would span the length of North America. In places, the canyons are up to 300 km wide and 10 km deep. It is often compared to Earth's Grand Canyon, however, the Valles Marineris has a very different origin than its tinier, so-called counterpart on Earth. The Grand Canyon is largely a product of water erosion. The Martian equatorial canyons were of tectonic origin, faulting similar to the East African Rift valleys.

Fig. 7. *Valles Marineris from Viking orbiter images, with the USA for scale.*

Large impact basins

There are several enormous, circular impact basins on Mars and the largest one that is readily visible via an orbiter is the Hellas basin located in the southern hemisphere. The central part of the basin (Hellas Planitia) is 1,800 km in diameter and is surrounded by a broad, heavily eroded annular rim structure characterized by closely spaced rugged irregular mountains (massifs,) which probably represent uplifted, jostled blocks of old pre-basin crust. The basin floor contains thick, structurally complex sedimentary deposits. The lowest elevations on the planet are located within the Hellas basin with some areas of the basin floor lying over 8 km below datum. All these large basins on Mars are extremely old dating back to the late heavy bombardment period. They are thought to be similar in age to the Imbrium and Orientale basins on the Moon.

Impact craters

The most notable difference between Martian craters and others in the Solar System is the presence of lobate (fluidised) ejecta blankets. Many craters at equatorial and mid-latitudes on Mars have this form of ejecta morphology which is thought to arise when the impacting object melts ice in the subsurface. Liquid water in the ejected material forms a muddy slurry that flows over the surface, producing the characteristic lobe shapes. The crater Yuty has these shapes and is a good example of a rampart crater which is so called because of the rampart-like edge to its ejecta blanket

Fig. 8. *A schematic showing two craters and their depths into differentiated grounds.*

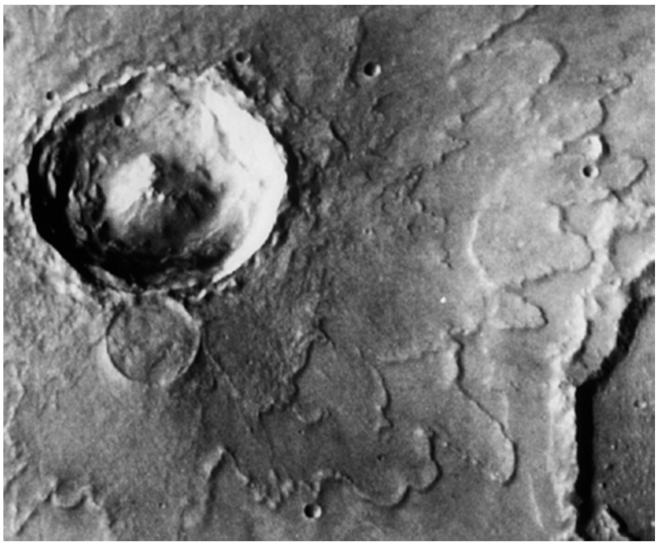


Fig. 9. *Viking Orbiter image of Yuty – a rampart crater showing lobate ejecta.*

Sedimentology

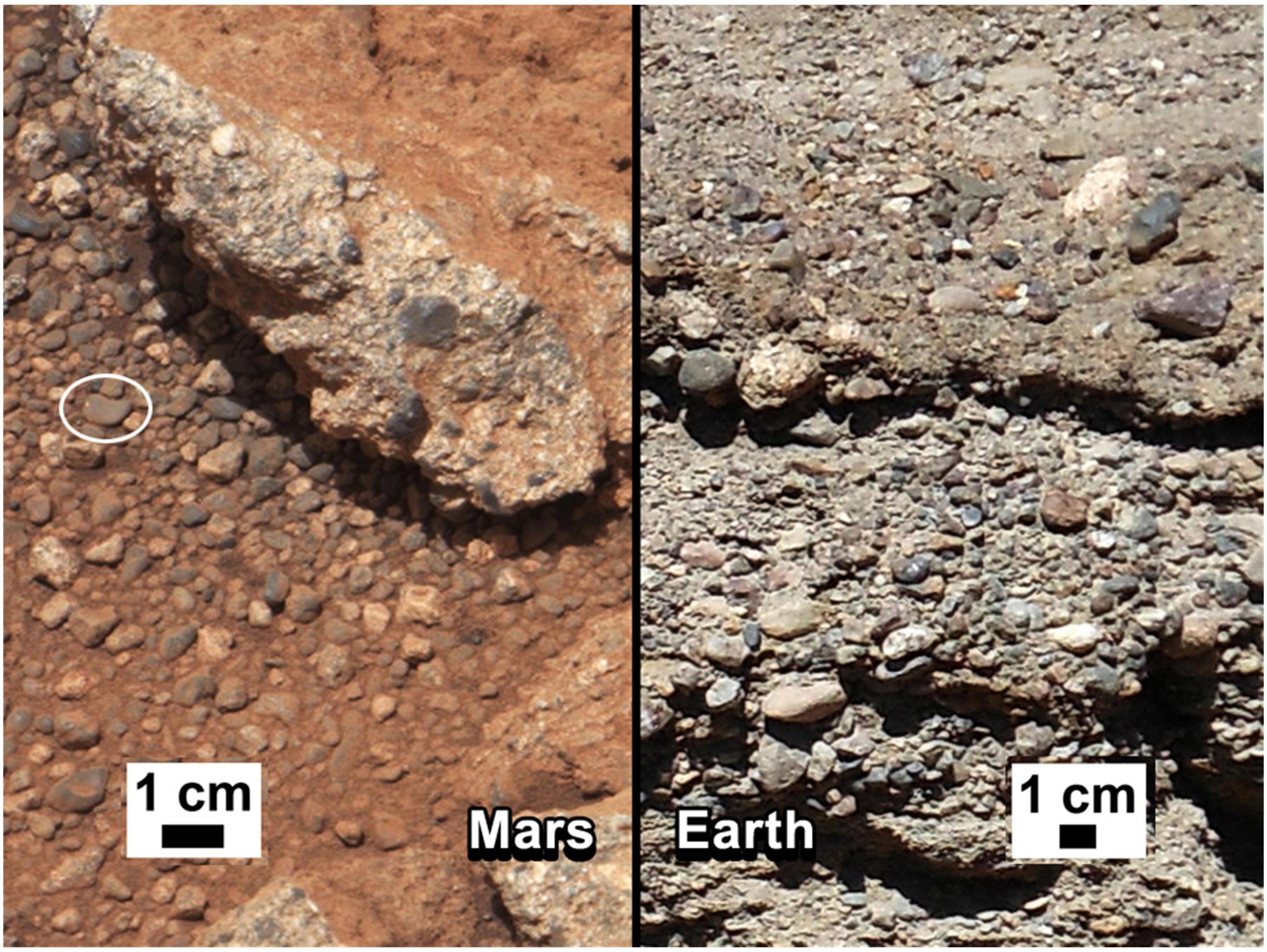


Fig. 10. *Conglomerate sediments showing signs of redeposition.*

Flowing water appears to have been common on the surface of Mars at various points in its history, especially on ancient Mars. Many of these flows formed valley networks depositing sediment. This sediment has been redeposited in a wide variety of wet environments, including alluvial fans, meandering channels, deltas, lakes and perhaps, oceans. Groundwater has been implicated in the cementation of aeolian sediments and the formation and transport of a wide variety of sedimentary minerals including clays, sulphates and haematite.

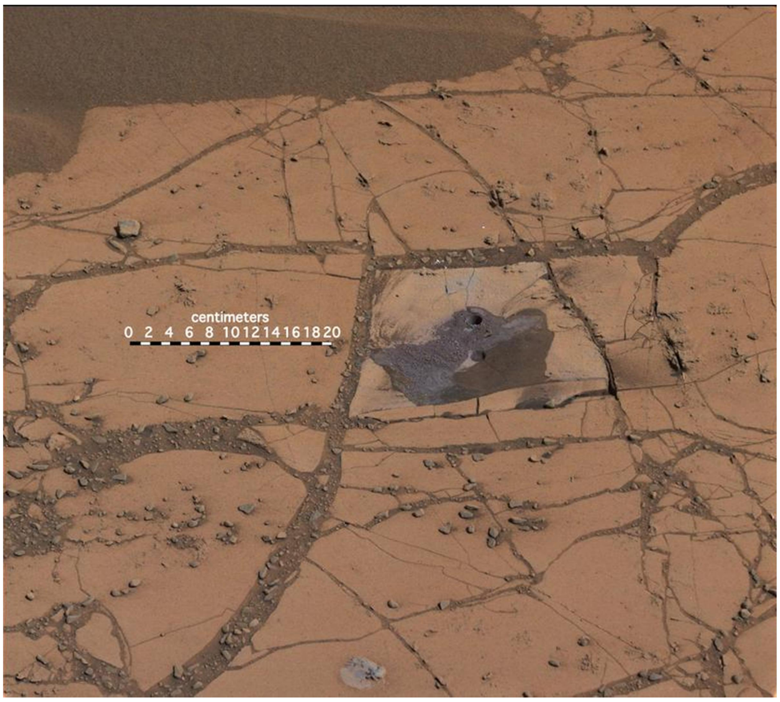


Fig. 11. *Curiosity's bore holes in sediment for analysis*

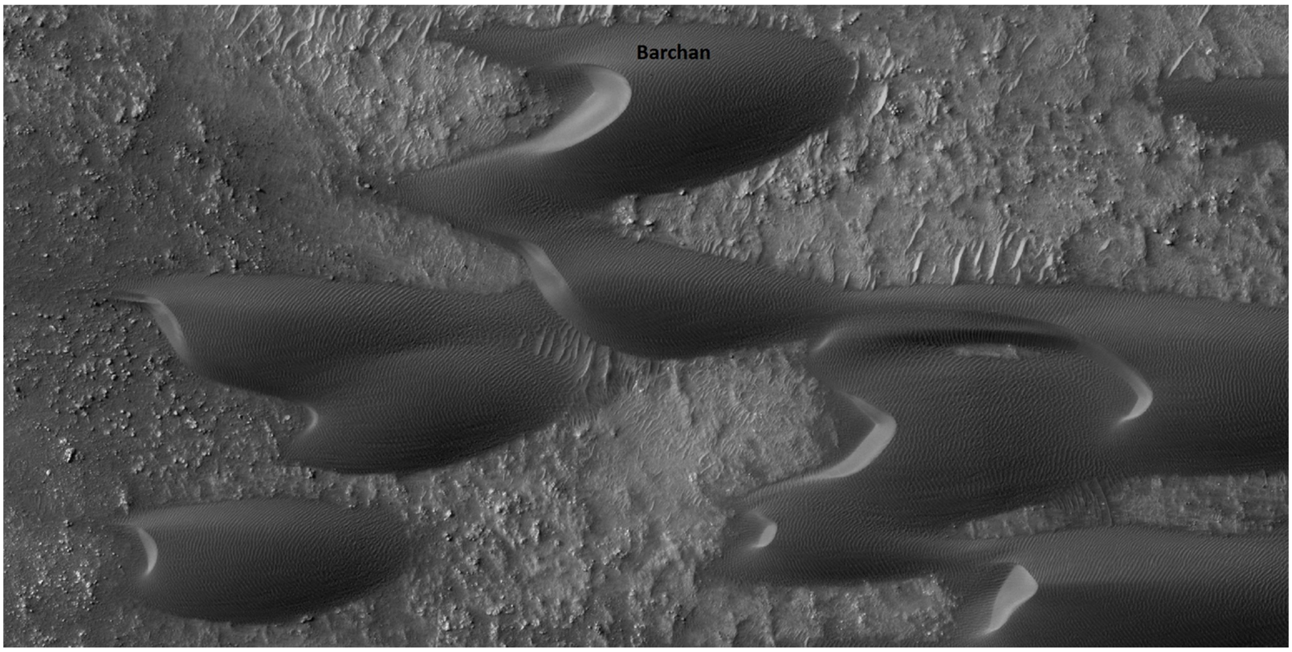


Fig. 12. *Image taken by an orbiter of barchans and smaller sand dunes.*

There is a plethora of other sedimentological facies on Mars, including glacial deposits, hot springs, dry mass movement deposits (especially landslides,) cryogenic and periglacial material, amongst many others. Evidence for ancient rivers, a lake and dune fields have all been observed in the preserved strata by rovers at Meridiani Planum and where the Curiosity rover is now in Gale crater.

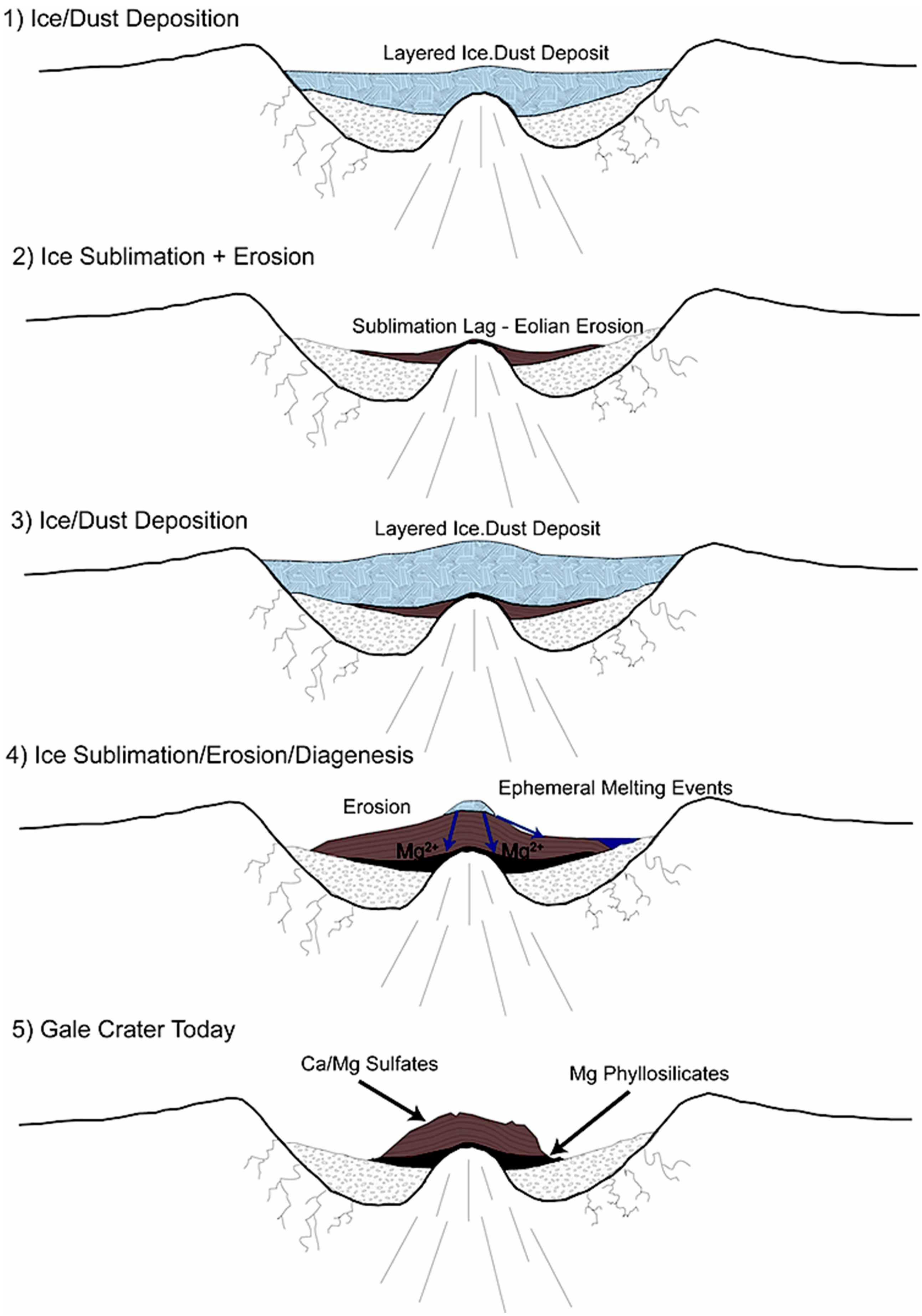


Fig. 13. *Gale Crater schematic incorporating Aeolis Mons (Mount Sharp.)*

Fig. 14. *Gale crater where Curiosity is still coursing its way towards* Aeolis Mons *(Mount Sharp) at its centre.*

Fig. 15. *Gale crater's Mount Sharp from Curiosity's point of view, seven years into its journey.*

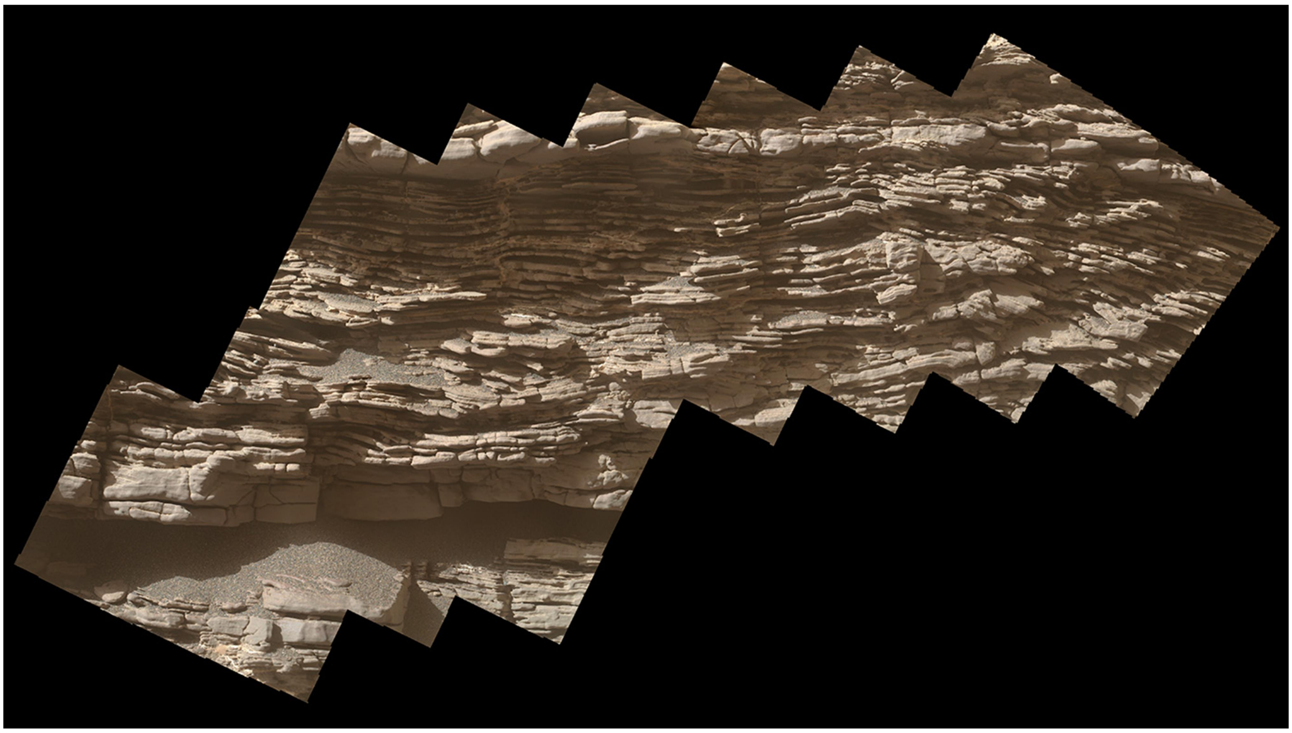


Fig. 16. *Cliffs of stratified sediment in Gale crater.*

Avalanches (Cliff falls)

On February 19th, 2008, the HiRISE camera onboard the Mars Reconnaissance Orbiter imaged a spectacular avalanche in which debris thought to be fine-grained ice, dust and large blocks fell from a 700-metre (2,300ft) high cliff.

Fig. 17. *Imaged cliff fall taken by HiRISE.*

Possible caves - Pits

Pictures from the Odyssey spacecraft have shown what might be seven caves (pits) on the flanks of the Arsia Mons volcano on Mars. The pit entrances vary from 100 to 252 metres (328 to 827 ft) wide and they are thought to be at least 73 to 96 metres (240 to 315 ft) deep. Further studies indicate that these may not necessarily be lava tube openings as seen on the Earth and the Moon.

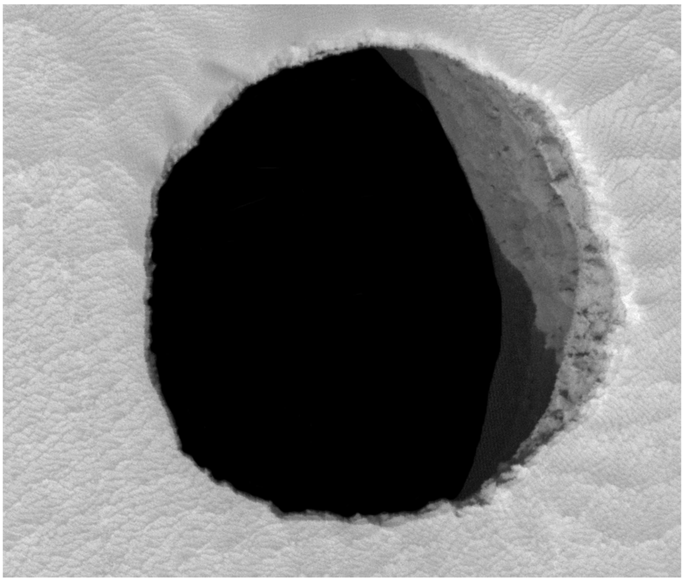


Fig. 18. *HiRISE close-up of Jeanne pit showing afternoon illumination of the east wall of the shaft.*

In Conclusion

The surface of Mars can be divided into two major regions: (a) the densely cratered, more ancient highlands in the southern hemisphere and (b) the younger, lower plains in the north. Mars probably possesses an internally differentiated structure with a metallic core, a thick mantle composed of iron-rich silicate minerals and a thin crust. This is what another lander on Mars (NASA's Insight) is to study.

Cratering has been a major process on Mars and a record of an early period of intense meteorite bombardment has been preserved. Volatiles out-gassed from the interior formed an atmosphere and a hydrological system. Later, as temperatures lowered, liquid water became locked up in the polar caps and in the pore spaces of rocks and soil, as groundwater or ice and was only occasionally released in large floods. Aeolian processes have been observed in action (dust storms and devils) on Mars and many surface features have been modified by wind erosion or deposition.

Volcanism is revealed by three types of features: (a) huge shield volcanoes, (b) volcanic patera possibly unique to Mars and (c) volcanic plains. Large crustal domes and grabens are the major tectonic features and may be produced by thermal convection in the mantle.

Mars has experienced a long and complex geological history. The size of Mars and its compositional differences may be responsible for its extended thermal evolution.

References

https://www.iau.org/ The International Astronomical Union.
https://www.nasa.gov/ The National Aeronautics and Space Administration, USA.
https://www.jpl.nasa.gov/ The Jet Propulsion Laboratory, California Institute of Technology, USA.
https://www.usgs.gov/ The United States Geological Survey (USGS.)
http://www.planetary.org/ The Planetary Society.

https://en.wikipedia.org

Should you have access to the Internet and are interested in voluntary citizen science then please try; https://www.zooniverse.org/

Observations of the Ashdown Sands / Wadhurst Clay at Pett Level

David Talbot

Pictures and text by David Talbot unless stated otherwise; 6th August 2019. An earlier version of this discussion was published in the Kent Geologists Group newsletter No.13 of August 2005.

Part 1 – Position of the Ashdown/Wadhurst junction at Cliff End

During our research and collecting for the Medway Lapidary and Mineral Society Rock Types and Geology of the Lower Cretaceous Wealden District CD-Rom, my colleagues and I used various printed material for information and sites. This variety of information came as professional papers on individual sites or beds, and as more generalised books on the area as a whole, the information being printed over a wide range of time; we specifically used the maps and memoirs from the BGS. As sites were visited, Pett Level in particular, it became apparent that some of the material was obviously out of date, for example Wes Gibbons 'The Weald'; or, in my opinion, wrong, as in the annotated photo in GA Guide No.55, page 18. My understanding is that both these books are used widely, yet give the information, again in my opinion, wrongly. The discussions outlined below draw attention to these errors, and suggest an alternative description.

<u>From 'The Weald', Wes Gibbons</u>

As stated, one of the more general publications we used was the small soft-back book, written by Wes Gibbons, called simply 'The Weald', and published in 1981. This gives a geological background to the Weald in the first part of the book, covering the Purbeck through to the Recent; with a series of eleven field excursions described in the second part. It is this second part, and excursion 10, Pett Level to Haddocks Steps that I wish to draw your attention to. Observe closely the diagram below, from 'The Weald'.

Fig. 1
Diagram from Wes Gibbons, The Weald, 1981.

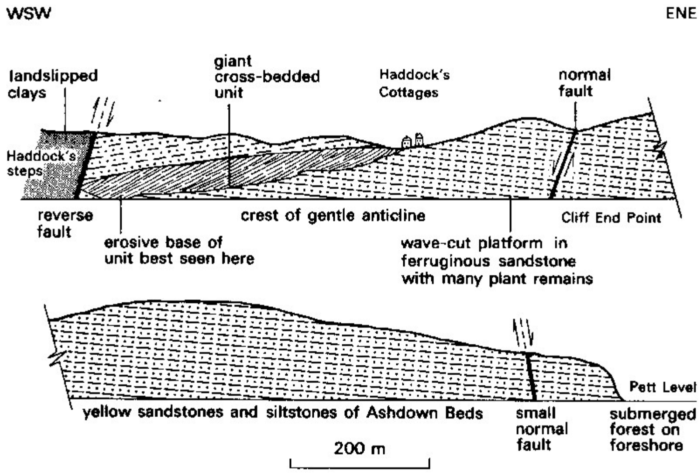


Figure 33 Geological cliff section between Pett Level and Haddocks Steps (Excursion 10).

Below is a list of errors which I believe to be in the diagram, fig 1 above:-

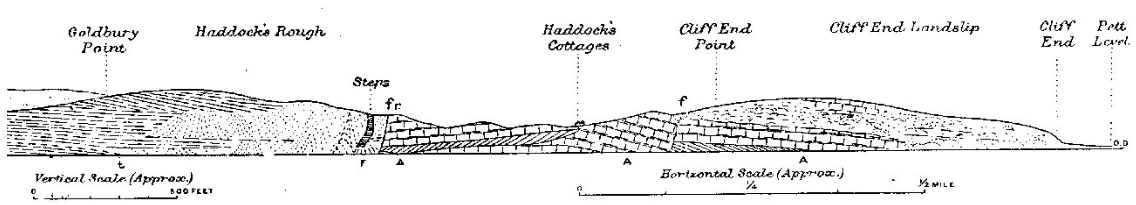
1. The Ashdown/Wadhurst junction is not shown.
2. The Wadhurst Clay is not shown.
3. The fault to the right of Haddocks Cottages is shown as normal, not reversed.
4. The bone-bed is not shown.

This latter point is not so relevant. However, the first three, to me, are major omissions. If Gibbons' diagram is so wrong, why was that? I wondered at first if he had visited the site, or whether he was relying on printed material only? But, assuming he did visit, and there I'm sure he did but probably only the Cliff End area, he could still have only gone by that same printed material available to him at the time. So what was it?

During our investigations and collecting for the CD-ROM we had access to memoirs of the Wealden area, with their associated maps, from the BGS. Several of these memoirs were out of date, and out of print, though we were issued photocopies of them. Others were in print and quite obviously more recent. One of the more recent ones was the Hastings and Dungeness memoir. This is dated 1987. In that case, Gibbons who was published much earlier, in 1981, so, a full 6 years before had never had access to the revised one; it had not been published.

This led me to think further. What about the earlier BGS Hastings memoir? Did our Mr. Gibbons have this to hand? I think that maybe he did. This earlier edition was published in 1928, over 50 years before, a copy of which was loaned to me by Peter Golding. On page 33 of that edition is a diagram of the whole of the cliff section from Hastings to Pett Level. This of course is very similar to the sketch in the latest edition, 1987. However, the earlier sketch is somewhat different to the later one with respect to the Pett Level end. See diagram below from 1928 edition.

Fig 2
From BGS diagram of Fairlight Cove to Pett Level, 1928.



The older memoir shows a normal fault adjacent to Cliff End Point, fig 2 and none at all at Cliff End, only landslips. In Gibbons', the group of small faults are shown. Here is proof that he probably did visit the site, he was able to add them to his representation of the cliff, but he still only had the information given in the old text, for the bulk of his interpretation.

This actually poses another question, if the old surveyors couldn't see the normal faults at Cliff End, covered by landslip, yet Gibbons could, what had happened to change that situation? It would appear that there has been more cliff-face erosion over those intervening years, 1928 to 1981, such that the landslips have been removed and cliff base erosion has caused cliff-face collapse - maybe the latter half of the 20th century was stormier? Gibbons could only report what he had seen and only had the old text and drawings to go by.

Fig 3,
Cliff End fault, downthrow about 4 metres.

The current position at Cliff End is one of continuing erosion by the sea especially in the last few years, since 2015, with numerous falls around the normal fault area, including in the last few weeks (2019) the destruction of the 'cave' in the top of the Cliff End Sandstone.

Prior to 1928 the base of the cliff must have had something of a protective barrier in place, or the weather was kinder in those days compared to today. But something occurred to remove it sufficiently to cause cliff erosion, causing slipped material to be removed and uncovering fresh faces. Around about 1900 Hastings harbour had been extended and some believe this may have caused a reduction in shingle being moved, by longshore drift, to under the cliff sections. It would mean a gradual removal of existing material without recharge, or not enough recharge. With this reduction in protection, came an increase in erosion. Maybe by the time Gibbons got to see the section, that erosion had uncovered and removed it. (Discussion with P Golding).

In conclusion, I am certain that Gibbons did have use of the earlier Hastings memoir, and, like me with the later one, used it to his best ability. He must also have visited the site; otherwise he would not have drawn the Cliff End faults at Pett Level, as they were covered up by landslip in the earlier memoir. There were though several other workers in the area at the time especially the late Perce Allen who published many papers on the area.

From GA Guide No.55 Early Cretaceous Environments of the Weald

One of the other guides we used in our work on the Weald was the GA Guide of 1996 on 'Early Cretaceous Environments of the Weald', No.55. In the photograph on page 18 the annotated picture 'shows' the Ashdown/Wadhurst ‘junction’. This also is wrong in my humble opinion. The position of the Wadhurst Clay is too low down and for that reason, the Cliff End Sandstone is shown as too much of the cliff. The WC should be in line with the bed in line with the 'C' of CES. In this area the Ashdowns are ten metres thick, which is the same as the thickness for the CES. For clarity I have scanned the photo from the GA publication and added my own lettering, in black, to it, fig 4. The GA also contradicts themselves in the discussion of the basal clay ironstone in the text on page 19 following this picture.

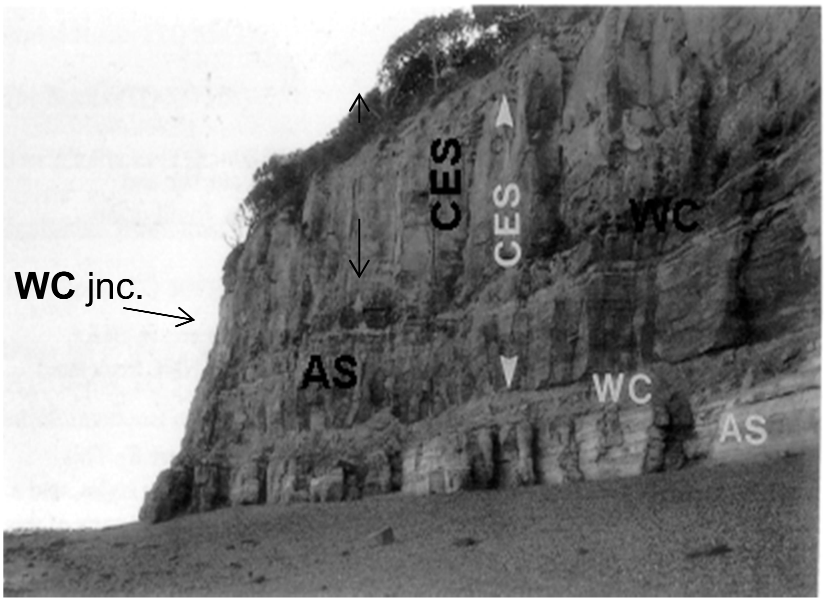


Fig 4,
My lettering in black;
GA lettering in white.

They state…’ The grey clays form a notch….’ and…’Beneath this marker are 15 m of Ashdown sands and silts….’ If that is so then their marker for the WC should be where mine is surely as both formations at this point are approximately half and half of the whole cliff. Finally, in the text on page19 of the guide, Iguanodon is called a sauropod; this too is wrong, as it is an ornithopod.

As stated above with our use of the BGS maps and memoirs we had a great deal of information at hand for our research. For me with my constant visits to Pett they gave me somewhat more than the publications alluded to above. It’s all in the detail.

The Cliff Formation As I See It

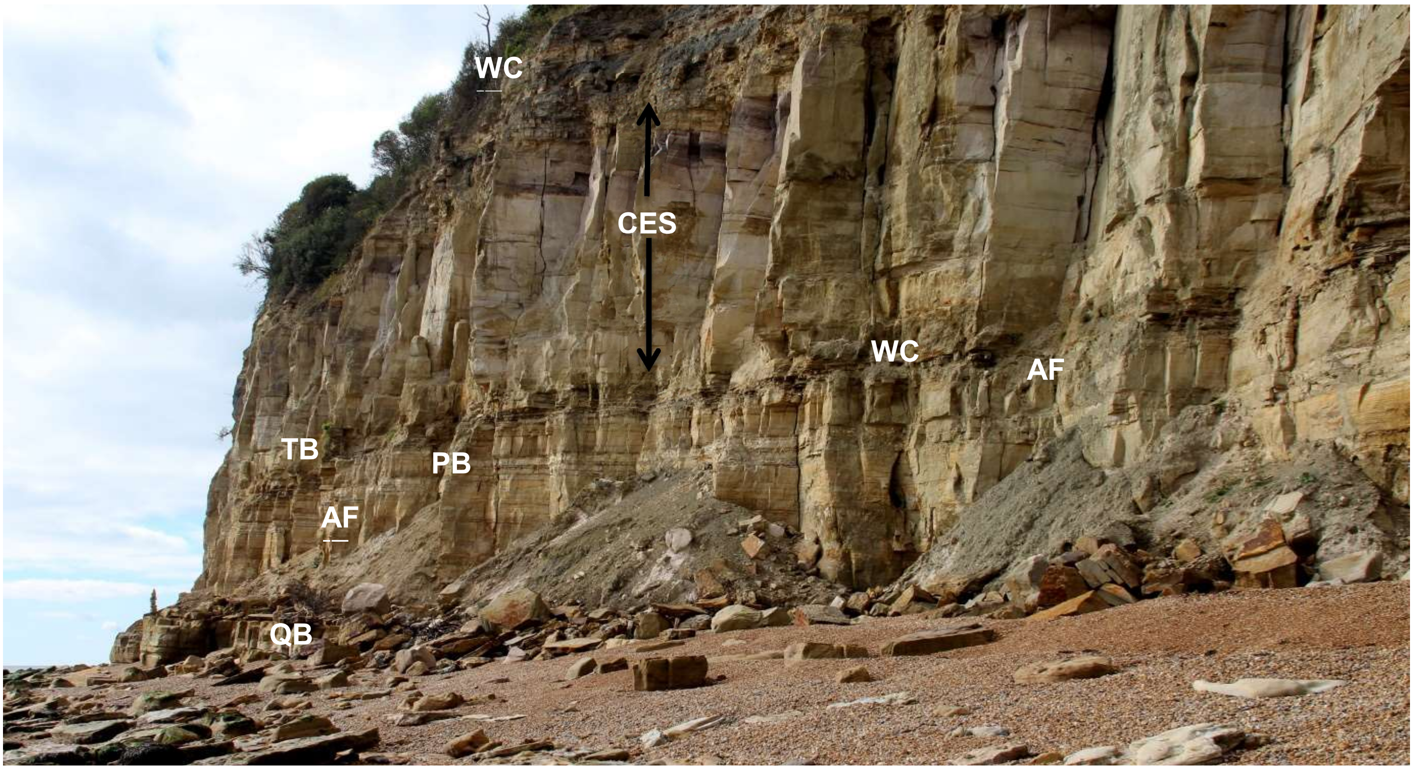


Fig 5, I have used initials for section titles as follows; formation names are AF (Ashdown Formation), WC (Wadhurst Clay Formation); member name CES (Cliff End Sandstone); others PB (Pale Band), QB (Quillwort Bed), TB (Transition Bed).

The plan now is to explain these beds as described and measured in BGS 320 for Hastings. It has been known for many years there are two formations in the cliffs at Pett Level, initially the early surveyors had believed the whole cliff was in the Ashdown, however, workers during the latter part of the 20th century had realised in various findings, this was not so. This has a lot to do with Anderson's research on ostracod zones within the Wealden. It was found that a particular ostracod of the Wadhurst Clay above the CES could also be found in the clays and shales below it, in the TB. This then being realised the new boundary between the Ashdown and Wadhurst Clay could be formalised. It also placed the Wadhurst Clay below the CES. Thus my first two points against Gibbon's diagram and description being erroneous are resolved. But there's more to it than that!

As geologists, both amateur and non-amateur, we have to start somewhere when investigating the rocks of an area, this is usually with that area's BGS map; the memoir also if one wants to know the finer details of a place, is a must. On pages 68 and 69 of the Hastings book the BGS gives a thorough explanation to the beds within the Cliff sequence at Pett. Page 68 describes the Wadhurst Clay beds above the CES with thicknesses as measured at the time, there are ten of these beds. Page 69 gives the bed sequence from the top of the CES to beach level a few tens of metres from the Cliff End faults. (All measurements pre-1987). There is also a first class sketch of the cliff line between Haddock's and the Cliff End faults by Mr. A. R. Tingley.

Yes, the measurements, we must first understand the dynamics of basin fill. In a terrestrial environment these must differ considerably from a marine setting due to local climate, the size of rivers and lakes, tectonics and rock structure in the uplands, as well as locally sediments being reworked and flora and fauna in and above these sediments. (There are of course a great many more aspects to fluvial and lacustrine environments that I will not go into here). All this means is that over a period of time and relatively short distances any amount of conditions can be met controlling deposition or erosion of sediment in and around the basin; of course this is what we find, multiple beds of silt, sand, clay and calcareous material and all of varying thicknesses and facies.

In places around the Hastings area a Top Cliff End Sandstone Pebble Bed has been found, but neither this or the Top Ashdown PB is particularly prominent in the Pett cliffs. What has been noted is a quartz-rich coarse sand of 30 mm with a few scattered pebbles. Allen, 1976, in his various accounts of these beds gives another name to the top of the sandstone, the Fairlight Soil Bed. There certainly is erosion to the top CES with the sand becoming purplish due to ‘finely divided organic matter’. Not too sure about this being soil, but this material has been described as ‘forest fire ash’ to me previously and it certainly gives that impression when examining it on the tops of fallen blocks. The CES is approximately ten metres thick, give or take half a metre and is no different here being a little over. The BGS makes this up with three major beds and six minor ones between those. I must say that in many visits here I have never seen the cliffs quite like this which verifies my statement above on how varied in thickness these beds can be due to conditions when deposited. This is of no real consequence as the general layout and beds remains the same with only subtle differences in thickness and condition. Just below the CES a bed of calcareous sandstone partly de-calcified and about 700 mm thick is particularly prominent due to recent falls (2019). The de-calcified section erodes quickly and forms a notch further along the cliff to assist with locating the base of the CES and its position in the cliffs.

Now, the really interesting bit!
The ‘Basal Beds of the Wadhurst Clay’, these are also known as

- The Passage Beds – Allen.
- The *Endogenites* Beds – older authors.
- The Transition Beds – Talbot.

However, wherever one comes across the Ashdown/Wadhurst junction in the Weald, some form of these beds can be seen.

Continuing down from the previous bed is a mixture of various sediments:-

- Clay-ironstone, tabular, variably blue, black and brown between 100 – 150 mm.
- Shales, siltstones, grey-black, pale yellow, shelly debris, basal silt up to 900 mm.
- TAPB, sandstone, buff, irregular top, some quartz/chert pebbles at base, 200 mm.

Due to the variability of these beds they are often measured together at 1000 mm and as stated previously the TAPB cannot be proven here. In that case where is the actual base of the Wadhurst Clay? On page 25 of the memoir a passage states thus; ‘…sections where this is absent a rippled surface without pebbles caps a massive sandstone,,,’ **<u>this is the base of the Wadhurst Clay at Pett Level!</u>**
The photograph below shows a good clean section of the Transition Beds and Wadhurst Clay base position <u>as I understand it</u>, fig 6 below, July 2019.

Wadhurst Clay Fm

De-calcified sandstone which can form notch in cliff, above:-

Multi-bedded calcareous sandstone or Tilgate Stone

Sideritic clay-ironstone 100 to 150

Grey, black and pale yellow clay, shale and siltstone with shelly de-calcified *Neomiodon sp* fossils and ostracods.

Medium grained sandstone, rippled, irregular top.

Base of Wadhurst Clay here when evidence of quartz and chert

Very fine-grained ferruginous, silty-sandstone rippled; basal ripple top of next bed is chosen as the base of the Wadhurst Clay in this instance when there is no physical evidence of a TAPB.

BASE OF WADHURST CLAY
TOP OF ASHDOWN FORMATION

Ashdown Formation

Massive, coarse-grained sandstone with siltier ferruginous base (not shown here).

Fig 6, Photo shows section of Transition Beds at Cliff End about one metre wide by one and a half metres this view. Information on these beds taken from BGS 320, Hastings. Photo 2019.

In Conclusion

As far as it is possible to see along the cliff face from here a number of things assist in ‘seeing’ where the junction is in the cliff at the quillwort bed area. As well as the Cliff End Sandstone there are two other beds to help get your ‘eye in’. The CES is the easiest as it’s around ten metres thick and it’s above the clay-ironstone, which itself is fairly easy to see as it’s a dark strip which climbs upward with the CES as you look along, these are both in the Wadhurst Clay. The third help is the ‘Pale Band’, this is in the Ashdown which the BGS named and is about two metres below the Transition Bed and the clay-ironstone; it is what it says it is a light coloured silty rock which can look like a pale stripe running the full length of the cliff face. These beds show how the junction of the Ashdown/Wadhurst Formations climbs up the cliff to roughly the halfway point about halfway along the face.
By using the memoir with photos and a measuring tape I believe I have located the junction of these two formations here at Pett Level.

In a future Part 2 of this report we shall discuss the cliff line in general; the Quillwort Bed and its surrounding area; and Haddock’s reverse Fault.

References: -

Geology of the country around Hastings and Dungeness, RD Lake and ER Shephard-Thorn, 1987, BGS.
Early Cretaceous Environments of the Weald, A Ruffell, A Ross and K Taylor, 1996, GA Guide No.55, The Geologists Association.
The Weald, W Gibbons, 1981, Unwin Paperbacks.
The Geology of the Country near Hastings and Dungeness, HJ Osborne White, 1928, HMSO.
Sedimentary Geology, M E Tucker, 1999, Blackwell Science.
Petrology of the Sedimentary Rocks, J T Greensmith, 1989, Unwin Hyman Ltd.
Principles of Stratigraphy, M E Brookfield, 2004, Blackwell Science.

From our correspondent in China

Ed Jarzembowski

Those of you who have been on our Wealden field trips will have met Ed Jarzembowski – an expert on both fossil insects and the Wealden. For the past eight years he has been Visiting Professor at the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences. In that time Ed has published more than 100 scientific papers, and in 2015 the Jiangsu Provincial Government awarded him the 'Jiangsu Friendship Award', the Government's highest award for foreign experts, in recognition of his outstanding contributions to the economic and social development of the province. Below is a selection of photos from Ed's travels in China over the past year. The first six photos were taken in October 2019 during the International Geological Correlation Programme (IGCP 679) Conference on 'Cretaceous Earth Dynamics and Climate in Asia' in the city of Qingdao, Shandong Province, China, and the last two during an earlier visit to China in June, when he was able to visit sites in Inner Mongolia.

Fig. 1. Upper Cretaceous bone bed containing the remains of several dinosaurs, together with illuminated pictorial descriptions, inside the Zhucheng Pavilion at the Zhucheng Dinosaur National Geopark, Shandong Province (see https://www.myhuangdao.com/zhucheng-dinosaur-park/ for more information on the Geopark).

Fig. 3. Skeleton of the dinosaur *Tsintaosaurus* in the Geopark Museum, first discovered in the region in the 1950s and named after the city of Qingdao (often transliterated as "Tsingtao" or "Tsintao") where the IGCP Conference was being held.

Fig. 2. During one of the Conference field trips to Laiyang a nest of Upper Cretaceous dinosaur eggs was discovered. They have been identified as being *Tsintaosaurus* eggs and will be excavated by the Geopark Museum.

Fig. 4. Tsingtao is the best- known Chinese beer. It is brewed in Qingdao and, like the dinosaur *Tsintaosaurus*, was also named after the city (see caption to figure 3). Like all Chinese beers it has a low alcohol content of around 3% so is ideal for recovering after a long day in the field!

Fig. 5. Lower Cretaceous desert dunes in Jinan Shandong Province.

Fig. 6. A water beetle larva of the genus *Coptoclava* found in Lower Cretaceous lake sediments in Laiyang, Shandong Province.

Fig. 7. Mammoths outside the railway station in the Inner Mongolian city of Manzhouli. Manzhouli lies on the border with Russia and was the traditional last stop and end of the line before exploring Siberia.

Fig. 8. A massive coal seam in a Lower Cretaceous (Wealden age) opencast mine in Inner Mongolia. Raman spectroscopy on some yellow droplets found in the coal deposits confirmed that they were amber, some coating the fossil plants.

A walk along the Medway Valey in the Burham area 17/02/18

Article by Dave Talbot, led by Dr. Anne Padfield

The Church of St.Mary at Burham

Photo 4279: A small group of KGG members met at a crossroad at the end of a short tarmac road where the ancient church of St. Mary at Burham stands. This 12th Century Norman church has been variously modified over the years, but its position near to the Medway became somewhat tenuous in later years when the population moved to higher ground and nearer to new brick making and cement factories. Due to its abandonment the church has more recently been adopted by The Churches Conservation Trust and others. At the crossroad a track continued to the river at the rear of some cottages to the left and to some farm buildings to the right beyond the church. The road to the left passes the front of the cottages and continues on passing fields on either side to a fenced off area on the right, this, a Southern Water site. A track back at the junction goes off on the right to some more farm buildings; we are to look at the old church first.

We will be examining the building stones of the church later, but first is a look at the inside and various aspects of the architecture. It is rarely, if ever, used now but is open to the public due to its history. We entered by the south facing porch, through a wooden framed gate with chicken wire mesh; you could not call this a door! A notice asked us to close this before opening the main door; a bulky, wooden one of medieval age, to prevent the ingress of our feathered friends, (they can be quite messy and should they get locked in, will probably die, which would encourage other vermin). Having done this, we entered. It seemed to be a large building, but I think this was to do as much with there being no ceiling and the white emulsioned walls. Wooden pews, some painted white, others just varnished filled a part of the floor space, about sixteen of these. At the far end of the church a wooden framed altar stood partly covered by a white shroud with a wooden cross on the table top. Unfortunately, in 2013, thieves broke in stole the brass crucifix and a pair of candle holders. The upper two thirds of the walls are still plastered, the lower third has obviously suffered from rising damp as this is plaster free and the stone remaining is powdery and flakey.

Photos 4283 / 4282:

Photo 4283: Another item inside the church was a wooden wheel, mounted on the north wall of the tower, which was about six feet across; it had been mounted there after a previous theft, in 1982, when a medieval bell had been stolen from the upper tower. There is no age given for this wheel so I would assume a medieval age again. Entry to the tower through a door is barred; this does however have an age given as fifteenth century.
Two Norman fonts, the first just inside the door is circular of unknown origin, the second is a larger square one and has been in the church a long time. The font may be twelfth century; however, the pedestal it stands on is of a modern material and design.

Photo 4282: The north and south sides have variously been altered over time as can be seen by the changes of blockwork. Aisles were added in the thirteenth century but only lasted 100 years or so, when they were again removed and re-blocked with small windows being added. The removal of plaster through rising damp has given us the opportunity to look at the types of rock used in the church's design. Much of it is ragstone from quarries at Ditton, but other rock seen is chalk, flint, tufa, very local and brick and tile as added extras to the fabric of the building, most likely from Roman villas, the ruins of which have been found local to the church. One piece could be rotten *Paludina* limestone.
Quarry tiling finishes off the floor of the building with a natural ferruginous colour, unsure of the age of this. The altar window at the east end of the building was last re-modelled in the fifteenth century. Low down in the north wall the blockwork of a stairway is seen; this led to the loft atop the Rood Screen which would have divided the church into a nave and a chancel. The loft, I can only assume, may have been the area for pilgrims to sleep and rest on their way to Canterbury, as this church is on that route.



Photos 4287 / 4292:

Photo 4287: We had not quite finished yet with the church and Anne led us outside; this was a welcome respite from the chilly feel to the inside as todays weather was uncommonly warm for February outside. Weathering to the church's outer walls has had some time to work, this being, originally, a twelfth century building, so that any limey or calcareous rock types are showing the results of that aging, being friable and crumbly. These would be the rag, chalk and tufa, others, like the flint and sandstone not quite so bad. With the river so close there may also be exotics from ballast used in holds of the different ships trading up and down it.

Editor's Note: *Buried in the grounds of nearby All Saints Church at Wouldham (Parish of Burham and Wouldham) is a famous seaman HMS Victory's Purser Walter Burke. It was he pictured supporting Nelson's pillow in the famous painting 'The Death of Nelson, 21st October 1805'. Walter Burke was thought to be the oldest sailor serving at Trafalgar. He retired to Wouldham and survived for another 10 years until he passed in 1815 at the age of 79*.

From the porch we proceeded clockwise around the building taking in the tower, on the west, to the northern long wall. Here looking at the construction, we could see why the interior suffered from rising damp, as the ground came directly up to the walls, with no drainage ditch or the like; the eastern end was the same. On getting to the south facing wall however, a ditch had been dug, lined with cement with a brick wall to hold back the bank, this came right up to the porch. This has obviously been carried out in the last few years, so maybe the intention is to continue around the entire building, at some time later, given enough funds.

Photo 4292: The church has been built on Head looking at the areas geological map. On the OS map for Maidstone and the Medway Towns it sits just above the five metre contour which isn't really that much above the river, certainly not when high. In more recent years river flood defences have been improved, not when the church was built though, so it is understandable that rising damp should affect it; as well as from natural groundwater from rivers and springs out of the Downs. As industry grew along the river, the brick making and cement works especially, with their attendant quarries, the local populace were gradually moved to higher up the valley. This was probably a twofold affair, in that they were moved away from flooding and closer to the works area. That was in the 19th century; they even had a new church built, which didn't last anywhere near as long as it was demolished in 1981.

NB: Even today streams still run out from the Downs in a myriad of places, flowing toward the river. Some of these are directed into culverts and ditches around the lower fields to help keep them drained and suitable as grazing land for sheep and cattle. This is also a way to keep a freshwater barrier between the tidal section of the river and habitat for wildlife in the ditches.


Photo 4290 / 4294:

Photo 4290: Talking of the river's water movements we have now come up to the flood wall where we are opposite a tight meander in it. The tide is on its way in so the river is running fast, easy to see with flotsam on the surface racing along. I wonder how salty or brackish it might be, but that would be down to several conditions including the amount of fresh water coming from upstream; by how much it has mixed in; the strength of the tide and these days, the amount of weirs the Environment Agency have positioned up river (for holding it back) and the extraction points Southern Water might have (for extraction to reservoirs). The material on the river includes clumps of dead reeds, straw and wood moving swiftly past our position on the bank as the river squeezes itself around the bends, (remember, faster on the outside, slower on the inside). And there are thousands of reeds in the banks of the river standing tall and straight, and dead, it being winter. With the sun streaming down on us into our eyes, makes for a quite surreal scene.

Photo 4294: As we proceed downstream Anne points out several things to us including a line of plinths in the distance – we shall get to these a little later on – she tells us they are to do with the cement works built there in the 1850's. A certain Thomas Cubitt built the brickworks in 1852, at the time one of the most modern in the country. To reduce labour costs a network of tramways were built, though by 1859, 600 to 700 boys and men were employed, producing 25 to 30 million bricks a year. Drain pipes, ornamental flower and chimney pots and tiles were also made. A huge engine house driving a 520 foot lineshaft, drove the machines for brickmaking, with heat produced being used for drying sheds, where bricks were laid out prior to firing in the kilns.


Photos 4299 / 4310:

Photo 4299: We have continued along the bank following a straight section of the river and are heading towards another bend. To our left, on the opposite bank, Townsend-Hook papermill has just started letting off steam. As the steam rises it covers the sun which is just perfect for me to get a few shots with the camera; I am told I shouldn't look into the sun, but with steam covering it, it's what I call, 'perfict'. To the right, the tower of Snodland church rises above the trees surrounding it. It is said that the two churches both stood on the Pilgrims Way and gave succour to those travelling to Canterbury and the shrine of St. Thomas Becket. And here, where we have stopped in-line with the churches, is a memorial stone that tells of a crossing here by Roman soldiers in AD43; they defeated the army of King Caratacus in the Battle of the Medway.

We had been walking away from the Downs up to here, but we turn again as we follow the path and the Downs are now to our right, rising up to the sky with several cliff faces cut in them; these are the faces of the old quarries. As noted above, there had been a cement works built also, this had started up in 1855, just a few years before the death of Cubitt; this substantially expanded over the next 30 years, hence the chalk quarries. Clay was also required and this came from another quarry dug a little below the chalk ones, probably in the Gault Clay. Bottle and beehive kilns were made of brick and were used to burn the slurry of clay and chalk for clinker, which then had to be ground into a powder, the cement, for packing and distribution. Most of this went to London so was loaded onto barges on the river from a quite substantial wharf, with cranes and derricks alongside for that purpose. Cubitt had the river dredged here and walls built for wharf stability and strength.

Photo 4310: We take another turn now, on our journey toward the Downs and the path now takes us alongside of those plinths we had seen from distance earlier. This site is off limits due to the height of the wharf above the river and its condition; however, a gap in the hedge and between the plinths does allow some entry to it. On the floor of the wharf the old buildings footings are still visible, so there is a possibility of twisting ones ankle or tripping over. The plinths about sixteen or so, not sure, never counted them, are of an early concrete mixture, quite stable looking on the undamaged sides, but where they have been broken, poorly mixed rubble interior does not seem at all strong enough. However, these carried an overhead truck system for moving chalk from Margetts Pit below the Downs, to the wharfside cement works. The plinths are about a metre square and several metres high.

Photos 4312 / 4322:

Photos 4312 / 4322: We have now arrived at a new road, built in the last few years for southerly access to a new housing estate called Peters Village, the name of one of the old quarries that has lately been infilled. From the other end of the development a four way roundabout takes you left across a new bridge over the river to the A228 and the M20 or M2, left or right respectively. We had seen this bridge earlier whilst passing the plinths, I had asked if it was just a footbridge, well, there's the answer. On the roundabout flat, steel plates have been cut into a collage of designs and left to rust; the designs have been mounted on a tubular steel arch depicting the natural and industrial history of the area.

Photos 4313 / 4319

Photo 4313: When we had first got to the river from the church, the tide was coming in with the river running fast upstream. Due to various stops and discussions on what we were seeing, high tide had passed, with the river now ebbing and water flowing to the estuary. We were now standing at the entrance to the new village, where a path led down to a new esplanade, built along the riverside below blocks of flats and houses. A launch was making its way upstream and leaving large ripples, chevrons, from its stern, as it ploughed through the water. These appeared to ride up and down as the ebbing river forced them downstream. The confusion of the two forces formed a myriad of ripples as they gradually collapsed away from the launch. But they were also breaking and reforming as longer, thinner ones as they also spread across the width of the river. It had a quite mesmerising effect - isn't nature grand?

Photo 4319: These low level, river level walks may not always have spectacular geology, certainly not at this end of the country – our soft rocks of clay and chalk tend to get rounded, with slumps, nothing grand like mountains and canyons. We have fields of green with trees and bushes, grass covers everything not cultivated, sheep and cattle graze; being close to a river adds towns and villages, farms and orchards.

However, by taking a look at the geological map for this area – BGS 272, Chatham – we can see a whole new dimension. The Medway rises near Turners Hill, West Sussex, running 70 miles to its estuary between the Isle of Grain and Sheppey, one of the longest rivers in the southeast. Its tidal limit is Allington Lock, a few miles short of Maidstone. On its way it flows around the southern edge of East Grinstead; through Forest Row; across the northern side of Ashdown Forest, which are all in Sussex; then, Ashurst to Penshurst, Kent, coming off the high Weald to Tonbridge; across the Low Weald to Maidstone and on to Rochester. We would need the use of BGS maps 288 Maidstone; 287 Sevenoaks; 303, Tunbridge Wells; and 302 Horsham, to follow its full extent.
I digress. Here at the lower levels of our river we can see, by the different colours the BGS use, where it has carved a way to the sea. A series of meanders across a floodplain, here 750 to 1500 metres across, leaves river alluvium and deposits of *Head* beyond that. Head is a poorly-sorted material of angular rock debris which can cover hill-slopes, being deposited by *gelifluction*; this being the term for the flow of saturated rocks over frozen ground. From the BGS map it would seem this head material covered a fair width of the river valley once. Higher up, on the chalk downs, a material known as 'Clay with Flints', covers an expanse of the Upper Chalk from its erosion over the eons of time. Chalk breaks down to clay by the efforts of weathering and biodegradation, leaving a veneer of stone and soil, which itself gets further refinement – and so it goes.
Where this has eroded away from weathering and *solifluxion*, (this being the movement of soil and small particles downhill by continually freezing and thawing), the three formations of the chalk are found, Lower, Middle and Upper, as one walks up the slope of the Downs. Lower down the Cretaceous System outcrops of the Gault Clay and Folkestone Sands occur towards Maidstone. Towards the estuary, Thanet Sand and London Clay, rocks of Tertiary age, are seen. What I find quite striking is the gap in the chalk Downs at Rochester, where the Medway flows through. Rivers will flow where it is easier to run and I wonder if there was a fault of some size here to allow it to do so, maybe a result of Alpine movement after the London Clay was deposited, as that formation is also either side of the gap.

Photos 4317 / 4321

From the new housing we crossed the road and took a bridleway up the lower slopes of the Downs where we followed a muddy track through an avenue of trees. We exited here into a much sunnier and warmer area and continued onto a stone track between fields. We stopped at a five-bar-gate where a notice asked us not to enter without permission. This had been Peters Pit, hence the name of the new village, and had also been an important chalk fossil collecting area. It is also one of those pits recently filled with waste from the local papermill and water treatment works at Aylesford. Another stop before the church was a little further on at a pond, newly positioned for the local wildlife, in a liner of plastic on top of a shallow defile especially formed for the purpose. At various points around it, and at other points on this walk, were what appeared to be steel tubes protruding from the ground with metal covers; I thought they might be dipping points to check groundwater levels. However, I was reliably informed by our leader they are checking points, but not for that purpose. They are there for checking for the possibility of contamination of the groundwater should the liners under the waste get breached.

For my part, I have found our visit today to have been a thoroughly informative one along the flood defences and around the church, it has certainly given me 'food for thought' and, on behalf of the group, I would like to thank Anne once again for showing us this area's intriguing history and geology.

References

(1) Small booklet on St. Mary's Church, Burham; (2) BGS Maps BGS 272 Chatham; BGS 288 Maidstone; BGS 287 Sevenoaks; BGS 303 Tunbridge Wells and BGS 302 Horsham and (3) OS Explorer Maps 163 Gravesend; OSE 148 Maidstone; OSE 147 Sevenoaks; OSE 136 High weald and OSE 135 Ashdown Forest

‘Dutchsinse’ and the Theory of Earthquake Prediction

Dr. Anne Padfield

Whilst in lockdown, I came across a YouTube site that I have since avidly watched and found extremely interesting, with many novel and very convincing theories. I urge you to take a look, if you can access YouTube, or visit the other social media sites. This is where this fascinating scientific mind, posts his work to, on an almost daily basis.

Dutch, as he calls himself, uses various public sites, such as the USGS Earthquake 3D Livestream. He has annotated the diagrams to suit his own ideas. For example, on the USGS rotating Earth map, showing the latest earthquakes, he has marked many red arrows, crosses and letter ‘D’s. Over a period of ten years he has observed many earthquakes and come to several conclusions, leading him to annotate the globe in this way. For example, there are earthquakes that circumnavigate the Pacific plate, ‘The ring of fire’, as one might expect. However, Dutch has observed that they propagate in the same clockwise direction, around the North Pacific, each time, so has shown this with red directional arrows.

Additionally. Dutch has noticed that earthquakes travel in a chain like fashion, along plate boundaries and large active faults. From the West Pacific, they travel Westwards towards Indonesia, the Middle East and Europe. He has marked these other directional routes with more red arrows.
The letter ‘D’ marks the site of deep-seated earthquakes, with a seismic focus of several kilometres of depth. Time and again, deep earthquakes have struck at these sites. Many red ‘X’s are sited at the mid ocean ridges, where energy is also released as earthquakes on fracture zones.
When an earthquake occurs, it appears as a circle on the USGS Earth map, with its given magnitude annotated. The larger the earthquake, the bigger the circle that denotes it. The next earthquake will then occur along the route of the red directional arrows. As the shock waves that cause the ‘quake’ are of similar intensity as they travel away, the next earthquake will be of a similar size and a chain of near equal magnitude earthquakes will result. The intensity will eventually diminish as they move a greater distance away from the start.

However, all the pent-up energy is rarely released and at a central point between two earthquakes, where their rings overlap, called the ‘Fulcrum Point’, another smaller earthquake usually occurs. The earthquakes travelling away from a deep ‘quake’ are mostly larger, shallower focused earthquakes. If you can imagine the shock waves coming up in the pattern of an upside-down cone, towards the surface of the crust, it is easier to understand why you would get an earthquake occurring between two ‘quakes’, where the energy is doubled.

All of this means, that the site of most earthquakes, originating from a deep-seated earthquake, can be predicted, along with their magnitudes. The observed timeframe between earthquakes, is between 7 and 10 days, (sometimes a little longer), depending on the distance from the original earthquake that started off the chain.

Dutch has also noticed that, if a large volcano is present on the plate boundary, where the earthquakes are propagating, then this often erupts, instead of the energy being released as an earthquake.

Dutch lives in the USA and has observed many earthquakes propagating around the edge of the North American craton, towards the East coast of the USA. Earthquakes are apt to occur at any point of weakness in the crust, at the San Andreas fault for example, or at very old, as well as more active, volcanic centres. Earthquakes have even been observed to occur at Man Made perforations in the Earth’s crust and at the antipodes of bigger deep earthquakes, on the opposite side of the Earth. Some of this sounds pretty controversial of course, but Dutch has so much more to tell you than I can recount here; about ‘waves, electricity, hotspots, giant fires, tsunami, hurricanes, volcanoes’ etc. You will just have to watch him and make up your own mind, but I guarantee, you will be thoroughly fascinated!

- Ref: Dutchsinse…. M.YouTube,Com>dutchsinse>videos
- Dutchsinse is also on; Twitter, Pinterest, Twitch and Facebook
- He uses and recommends; Earthquake 3D Livestream

Fracking – *Dr. Anne Padfield*

Fracking is attacking
Our geology and our lives.
The land that is taken
Leaves our rural world forsaken.
Concrete and infrastructure
For an oily rupture.
It's conjecture,
Whether the fracture
Will fulfil
The desire to drill.

Drinking water is wasted,
Never ever to be tasted.
Extracted from reservoirs,
Already stretched to the limit,
Our water resources are not infinite.
The rock for roads and foundation slab,
Quarried somewhere, leaving the landscape sad.
CO^2 from cement,
Expelled to the air,
Along with methane from wells,
Whilst the earth is stripped bare.

The metals for headgear,
Another resource,
Exploited for fossil fuels,
With high pressure force.
In crustal rocks
Faults and fissures abound
And tectonic deformation
Has disturbed underground.
The oil may not be so easily won,
As it is in the States,
Where it’s all on one level,
In the hot desert sun.

Drilling through the groundwater bed,
Requires casing to protect the water’s head.
The casing needs to be grouted in,
The grout injected not too thin,
Resistant to sulphate and chloride attack
And the mix so strong
That it doesn’t crack,
At the same time fluid, enough to flow
And fill all voids to keep permeability low.

It is a very well-known fact,
That with the addition of water,
The strength of cement, is known to falter.
A plasticising agent is therefore needed,
But normal setting with this mix
Is often impeded.
Disturbing too soon
Is to be avoided,
Effectiveness otherwise null and voided.

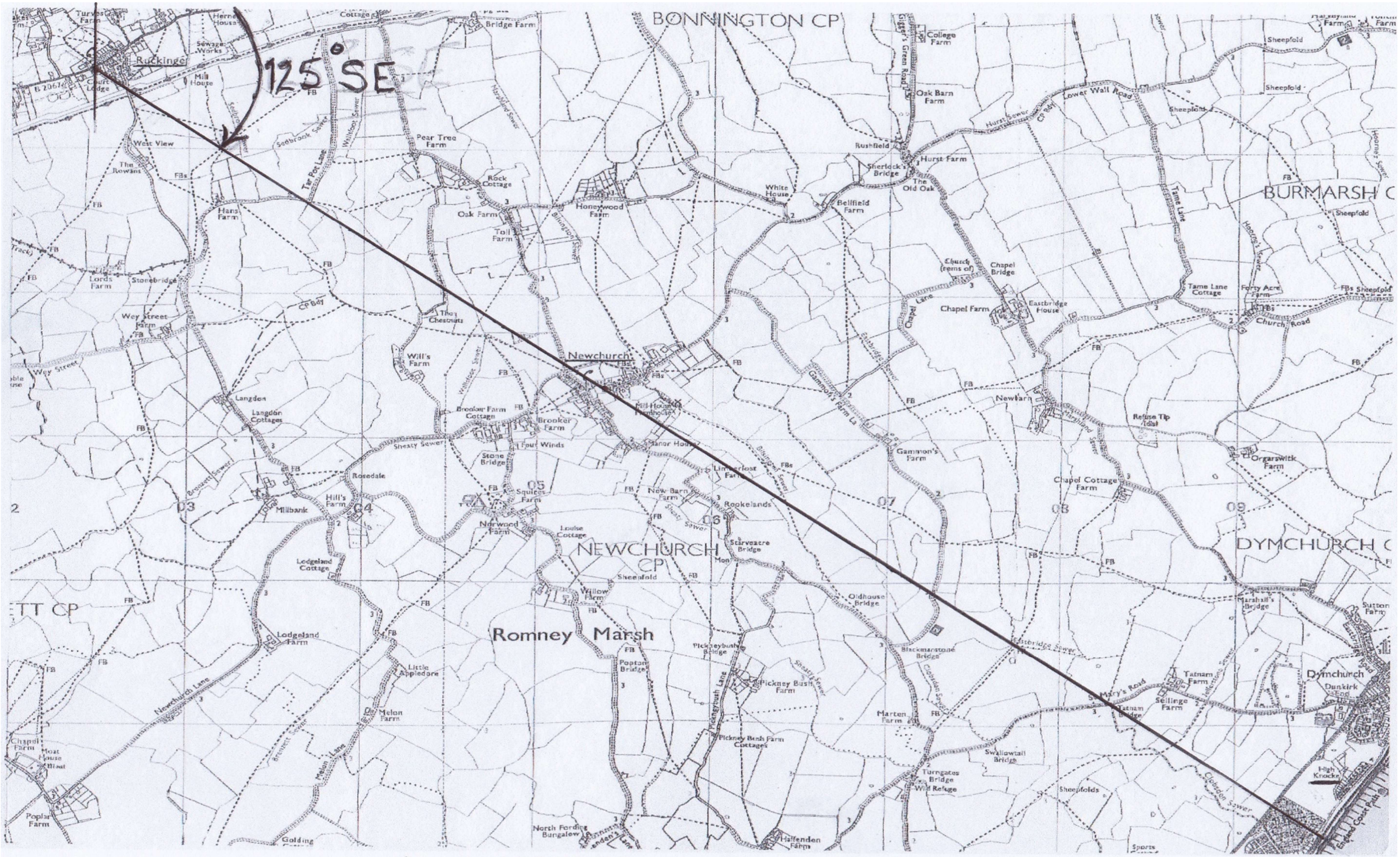
A chemical cocktail,
Containing sand suspended,
Is supposed to keep the fissure open
Whilst the soup being forced
Through beds upended,
Along existing faults unseen,
Could lead to movements created by men,
The practice of fracking is hardly green.
Unsustainable, unfathomable
Practically unimaginable.
Our society has a predilection to dispose,
But we must refrain, endeavour to re-use,
Else, whilst our World we pillage and plunder,
Our descendants lives we will tear asunder.

Ruckinge and the Early Ordnance Survey

Anthony Brook

N.B. First published in the Hastings and District Geological Society Journal, 26, December 2020, 18-20

'Baseline of Verification' surveyed from Ruckinge, Kent to the English Channel, in the late Autumn, 1787



from the 1:25000 O.S. map, reduced to fit landscape page

Ruckinge and the Early Ordnance Survey

Anthony Brook

In the summer of 2019 Roger Cordiner and I continued our surveying of the building stones in the Parish Churches of the county of Kent. On 28 June, accompanied by our Kent colleague, Geoff Downer, we visited the Parish Church in the village of Ruckinge, on the northern side of Romney Marsh. Ruckinge is one of a series of settlements strung out at intervals along the high ground of the old shoreline of what was, in Medieval times, extensive marshland all the way to the sea. As we preparing to leave the church, after surveying the building stones inside and out, I noticed an unusual plaque by the church gates, which was erected as the Ruckinge Millennium Sign (Fig.1). After noting the nearby Royal Military Canal, which circumscribed Romney Marsh in 1806-08 'as a defence against Napoleon', and 'the illegal activity of smuggling carried on throughout the centuries in the locality', it tells us about Ruckinge's role in a great national enterprise: *'The Ordnance Survey, founded in 1791, celebrated its bicentenary at Ruckinge. A time-capsule was buried southeast of the church at the point where General Roy created the first baseline of verification, for the purpose of triangulation, between Dymchurch and Ruckinge in 1787.'*

That was intriguing and required some investigation. It would seem that there are only 4 publications that cover the origins and early decades of the Ordnance Survey: Close (1926); Brown (1949); Seymour (1980) and, most recently, Hewitt, in 2010. Although they agree on the generalities of measuring the 'baseline of verification' across Romney Marsh, they beg to differ on some of the specifics (see the Appendix): for instance, Close, in 1926, states that 'Lieutenant Fiddes, of the Engineers, was in charge, with Lieutenant Bryce, of the Artillery, subsequently transferred to the Engineers, as his assistant': Brown, in 1946, and Seymour, in 1980, both state that Lieutenant Bryce was in charge; and Hewitt in 2010, implies the presence of 'General Roy and his assistants' In the following description of events in Romney Marsh in the autumn of 1787, I shall make use of the most probable description, particularly those described by several, most or all of these historians.

Let us start at the beginning: What was a 'Baseline of Verification', and why was it needed?
Any large-scale topographic survey requires a very-accurately-measured Baseline, from the ends of which all subsequent bearings and distances are measured, in a series of triangles: it is the fundamental base, upon which the whole survey is constructed. The Baseline for the Ordnance Survey was measured across Hounslow Heath in the summer of 1784, but to check its accuracy required another Baseline to be measured in a similar way before surveying could be extended far and wide. There were 3 criteria: the land had to be as flat and level as possible, with the fewest landscape obstacles along the line of survey; surveying should be on a constant compass bearing; and carried out over a minimum of 5 miles. Romney Marsh met all these specifications.

Romney Marsh was a 'flat stretch of wetland just inland from the south coast of Kent and Sussex, sheltered by the shingle beach of Dungeness: General Roy explained that from its levelness, as well as other advantageous circumstances attending its situation, Romney Marsh seemed to afford the best base[line] of verification' (Hewitt, 2010) Surveying of this baseline took place in the autumn of 1787, between 15 October and 4 December, to be precise, between Ruckinge and 'High Nook' (High Knocke), on the coast, southwest of Dymchurch, on a constant bearing of 125 degrees Southeast from Ruckinge church to that at Newchurch, clearly visible 3 miles away across the reclaimed marshland and drainage ditches, locally called sewers; and continued in that direction all the way to the sea (Fig. 2). 'It was extremely hard work in dirty weather' (Brown, 1949); the soggy ground was 'so much intersected with ditches full of water that the laying of bridges for the tripod stands was a very troublesome and tedious operation' (Hewitt, 2010). Glass rods were dispensed with and preference given to Ramsden's 100-foot steel chain; temporary scaffolding had to be erected en route to make good use of Ramsden's new, 3-foot tall and heavy Theodolite, finally delivered in July 1787 (Seymour, 1949).

'Despite these hazards, the Romney Marsh measurement was a success' (Hewitt, 2010). The linear distance from Ruckinge to the coast was measured as 28,532.92 feet (Seymour, 1980; Hewitt, 2010). As deduced from the primary baseline across Hounslow Heath it should measure 28,535.67 feet (Seymour, 1980), a discrepancy of only 2.75 feet in 5.4 miles, which was well within the tolerance limitations of contemporary methods of surveying. General Roy thought the accordance even closer; based on deductions from the baseline on Hounslow Heath, it agrees with measurement within less than a foot' (Close, 1926). 'It showed that Roy's triangulations were extraordinarily accurate' (Hewitt, 2010).

This, then, was the claim to fame of the small village of Ruckinge, on the northern elevations of Romney Marsh: it was the origin of an important confirmation of the methods under- pinning the whole basis of the Ordnance Survey.

Appendix of published sources

Charles Close Early Years of the Ordnance Survey 1926 (reprinted 1969) p. 22

Base in Romney Marsh The base[line] of verification was measured with Ramsden's 100-feet steel chain in the autumn of 1787. Lieut. Fiddes, of the Engineers, was in charge of the work, with Lieut. Bryce, of the Artillery, subsequently transferred to the Engineers, as his assistant. The base, as then measured, was 28,535.7 feet long; as deduced from the Hounslow Heath base, the value came out as 28,533.3 feet, a difference of 2.4 feet, or about 1 in 12,000. These values are given by Mudge, but [General] Roy thought the accordance was even closer; in a letter of the 7 February 1788, he wrote 'our trigonometrical operation answers to a wonderful degree of exactness. The base in Romney Marsh, between 28-29,000 feet, deduced from that on Hounslow Heath, agrees with the measurement within less than a foot'.

The actual discrepancy between the measured and calculated lengths of the baseline in Romney Marsh appears to be due, almost entirely, to errors in the measurement of this base: there are reasons to suppose that it was not measured as accurately as the Hounslow Heath base. The latter, when tested by the definitive 19th century triangulation, has an error of 2 inches in 5 miles. Moreover, Roy's triangles, as tested by the triangular errors of the 16 fully-observed triangles, are wonderfully good, the mean triangular error, independent of sign, being just over one second.

Lloyd Brown The Story of Maps 1949, p. 260

The baseline of verification on Romney Marsh, between Ruckinge and [coastal] High Nook, was measured between October and December [1787] under Lieutenant Bryce, of the Royal Artillery; it was extremely hard work in dirty weather. The glass rods were dispensed with and only Ramsden's steel chain was used, because, during the survey on Hounslow Heath, it was found that the difference in error between the two had amounted to no more than an 1/2 inch for the 24,404.7 feet, not enough to make an appreciable in the final calculations. The decision was further justified when it was discovered that the 2 base lines 'measure each other reciprocally within a few inches of the truth'.

W. A. Seymour (Editor) A History of the Ordnance Survey 1980, pp. 16-17, 34

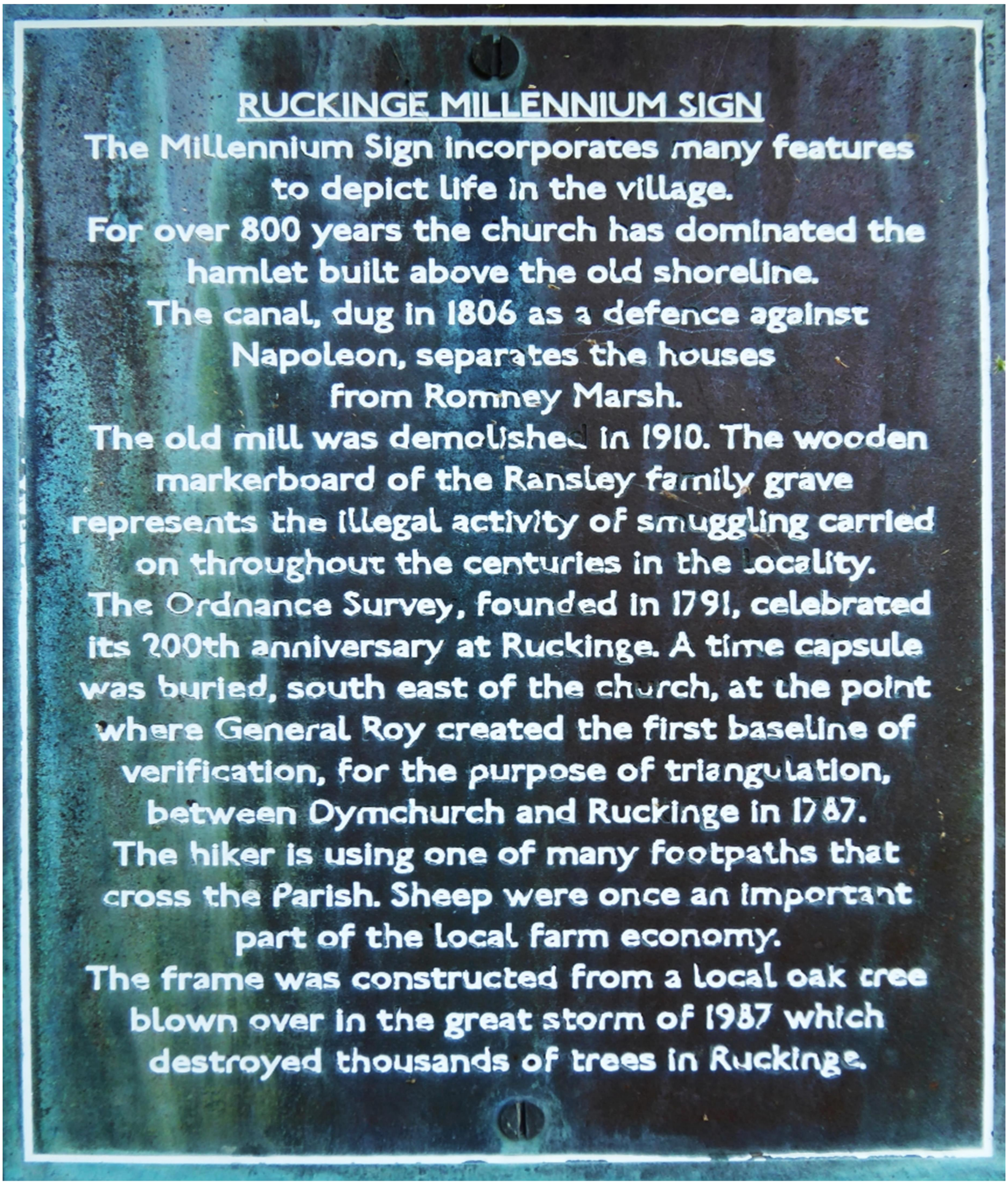
16-17 Lieut. Fiddes worked on the measurement of the baseline of verification in Romney Marsh [in the autumn of 1787]; 'an officer and a detachment of artillery-men' were sent to give labouring and semi-skilled assistance'; the laboratory at Woolwich [Arsenal] was instructed 'to supply whatever fireworks might be wanted for signals'; and, on Ordnance Survey property at Greenwich Observatory, Shooter's Hill and Dover Castle', temporary scaffolds were erected for the reception of the instrument [Ramsden's Theodolite, finally delivered in July 1787].

34 It was decided to use the [100-foot steel] chain, laid in coffers and strained with a 28lb weight, for the check baseline in Romney Marsh. This base was measured between 15 October and 4 December 1787, and gave a length of 28,532.92 feet, corrected to mean sea level. Mudge calculated the length as 28,535.67 feet, which must be assumed to be the correct value, due to erroneous corrections by [General] Roy. {a difference of 2.75 feet in 5.4 miles}

Rachel Hewitt Map of a Nation 2010, pp. 87 & 89

87, 89 But first he [General Roy] decided to measure a second baseline, known as a 'baseline of verification'. The actual measurement of this second base on the ground could be compared with the length provided by trigonometrical equations to test the accuracy of the triangulation so far and expose any errors. In August 1787 Roy and his assistants headed to Romney Marsh, a flat stretch of wetland just inland from the south coast of Kent and East Sussex., sheltered by the shingle beach of Dungeness. He explained that 'from its levelness, as well as other advantageous circumstances attending its situation', Romney Marsh 'seemed to afford the best base of verification for the last triangle'. But the soggy ground was 'so much intersected with ditches full of water' that 'the laying of bridges for the tripod stands' (for the glass rods) was 'a very troublesome and tedious operation'. Despite these hazards, the Romney Marsh measurement was a success. It gave a distance of 28,532.92 feet, and showed that Roy's triangulation was extraordinarily accurate. An impressed journalist reported, 'the *line of verification,* measured for that purpose on *Romney Marsh'* showed that 'there was only and error of *4 inches and a half'* between the actual measurement of the base and that calculated by trigonometric equations from the theodolite's angular observations.

Ruckinge Millennium Sign



Fossil Specimen

Lynne and Charles Hugkulstone

Specimen: *Teredolites ? longissimus (Photo's next page)*
Location: Isle of Sheppey
Formation: London Clay
Epoch: Eocene (Ypresian; ~56 - 49 Ma)
Comment:
A trace fossil of borings in wood, probably produced by the bivalve *Teredina personata* and formed as a feeding trace. It is usually restricted to shallow marine, intertidal or shallow shelf zones (relating to the occurrence of the required substrate) and is not indicative of depth. A modern equivalent would be *Teredo spp*, the ship-worm.
This was found on an OUGS trip to Warden Point by Lynne but was carried home by Charles because it is rather heavy!

References:

- British Caenozoic Fossils. HMSO 1975.
- Introduction to Paleobiology and the Fossil Record. Benton MJ, Harper DAT. Wiley-Blackwell 2009.
- Ichnology. Organism-substrate interactions in space and time. Buatois L, Gabriela Mángano G. Cambridge University Press 2011.

N.B. First published in the November 2020 issue of Soft Rock; the OUGS South East Branch newsletter (4/20; Page 19)

The long view

Doreen van Seenus

This year we have all been myopically focussed on the Covid-19 pandemic and all its possible consequences, and for good reasons. If for most of us this came completely out of the blue in January 2020, not so for virologists.

At the time of writing, this current pandemic has resulted in around 100,000 deaths in the UK and 1.5 million deaths word wide. Of course pandemics have happened regularly in the past. To put things in perspective, the “Spanish” flu in 1918, at the end of the First World War, has been estimated to have caused around 50 million deaths. It had not originated in Spain, but in a poultry farm in the USA. At that time the world population was around 2 billion. Then there were various epidemics of plague; the Great Plague of London in 1665 was estimated to have caused 100,000 deaths just in London, one quarter of the population.

To broaden the view a bit, there are existential threats to humanity caused by natural events that fall more in the realm of geology. The two major categories are eruptions of super volcanoes and asteroid impacts. These are rare events, but they do happen and will happen again.

A super volcano is defined as a volcano capable of an eruption with a Volcanic Explosivity Index of 8. The VEI rating is exponential and based on the amount of material that is erupted. The volume of magma erupted from a super volcano is $>10^{12}$ m^3, which is >1000 km^3; it hard to imagine a volume like that. A lot of the erupted ash will end up in the stratosphere, causing a volcanic winter and stopping or significantly reducing photosynthesis. And of course a large surface of the Earth will be covered in ash fall.

There has been just one super volcanic eruption during the time that Homo sapiens have walked the Earth; the eruption of Toba in Indonesia, 74,000 years ago when an estimated 2800 km^3 of ash was erupted. The resulting global environmental catastrophe is thought to have been responsible for a bottle neck of the human population. There may have been just a few thousand people left!

Compare that to the VEI 6 eruption of Krakatau in 1883 which spewed out an estimated 45 km^3 of pyroclastic material. Those Europeans living in that area who were lucky enough to survive, described the event as “judgement day”. Fatalities, mostly due to tsunamis, were a round 36,000.

We live on a dynamic planet!

CLOSE

I hope you enjoyed your read. If you did and you’ve got something you would like us to include next issue, please get in touch.

I hope to see you all soon.

Until then, keep on geologising, folks!

All the best,

Anne

PROGRAMMES

KENT GEOLOGISTS' GROUP PROGRAMME FOR 2021

CURRENT ZOOM MEETINGS These are held on the third Tuesday of the month. 6.45 for 7pm start.
Contact Indoor Programme Secretary: Ann Barrett.
Tel. 07746 783398 e-mail annbarrettgeo@gmail.com

INDOOR MEETINGS As Above

19th January	**Dr Chris Duffin** Charles Moore (1815-1881): A Somerset Geologist and his Collection
16th February	**Tony Mitchell** Classification - the Basics
16th March	**Annual General Meeting Followed by:** **Ken Brooks** Ecclesbourne Glen
20th April	**Prof Karen Hudson-Edwards** Mine Waste: Environmental Problem or Untapped Resource?
18th May	**Dr Haydon Bailey** Stratigraphy and Sedimentology of European Chalks
15th June	**Geoff Downer** The Geology of Herne Bay
20th July	**Dr Eric Buffetaut** Tertiary Dinosaurs in Southern France? The Late Cretaceous Vertebrates of the Saint-Chinian Area and their Discovery
17th August	**Anthony Brook and Roger Cordiner** A Building-Stone Transect of the Weald This meeting may be a local outdoor activity such as a building stones walk or church visit.
21st September	**John Henry** George Bellos Greenough's Maps
19th October	**Dr Geoff Turner** William Smith and the Somerset Coalfield
16th November	**Anne Beecham** Wolf by the Hearth, Aurochs at the Gate. How the Domestication of Animals Changed our Lives
14th December NB not 21st	**Christmas Evening**

PROGRAMME OUGS

Diary dates for 2021 – OUGS meetings

- To register please contact Marilyn Besford (malbesford@hotmail.com) registration FREE

Saturday 27th February – ZOOM @ 2pm: Landscape Geology with Ken Brooks

Saturday 24th April – ZOOM @ 2pm: The cloud under the sea with Dr.Michael Clare