Issue 10
December 2025

The Silurian

The Magazine of the Mid Wales Geology Club

Contents

The Magazine of the Mid Wales Geology Club
www.midwalesgeology.org.uk

Edited by Michele Becker

Cover Photo: Sandstone cliffs on the south-east coast of Raasay
© Chris Simpson

Pitchstone. See p.13.
Image of a thin section glass slide.
© T.Thorp

Submissions

Please read this before sending in an article.

Please send articles for the magazine digitally as either plain text (.txt) or generic Word format (.doc), and keep formatting to a minimum. As text in an email is also fine. **Do not include photographs or illustrations in the document.** These should be sent as separate files saved as maximum quality JPEG files and sized to a **minimum size of 1200 pixels** on the long side. List captions for the photographs at the end of the text, or in a separate file.

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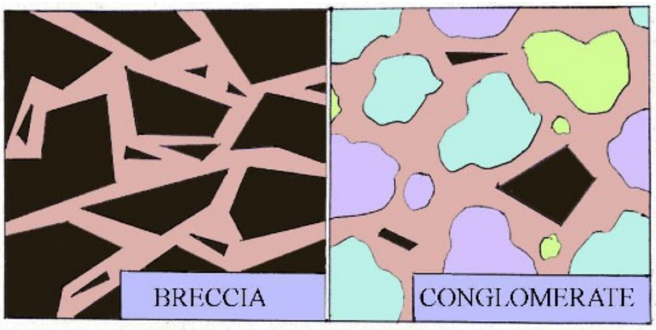
'Members Photographs' and cover photos are also wanted. Cover photos need to be in 'portrait' format and a minimum of 3000X2000 pixels.

Bill's Rocks and Minerals: Breccia

Breccia may be defined as a rock composed of angular rock fragments set in a matrix of finer grained materials. The name Breccia comes from the Italian *breccia* for rubble. The angular nature of the fragments implies that the fragments are from a local source and have not travelled very far. Most breccias are sedimentary in origin but may also be formed from the in-situ breakup of local rocks.

A word of caution. Breccia can be confused with conglomerate. Both are composed of shards of rock set in a cement matrix. Breccia however is composed entirely of shattered angular clasts, whereas conglomerate is composed mainly of rounded clasts with occasional angular clasts. The angular clasts are created locally, but rounded clasts are created by transport and friction over a long distance.



There are two main classes of breccia as far as their construction is concerned

Clast supported — Where the clasts touch each other, and the matrix fills the voids.

Matrix supported — Where the clasts are not in contact and the matrix surrounds each clast.

Illustrations by Bill Bagley

Terminology:

Breccia   Fragments of rock / minerals cemented together by a fine grained matrix.

Polymictic breccia.   Breccia which contains more than one type of rock / mineral.

Monomictic breccia.   Breccia which contains only one type of rock / mineral.

Clasts.   Clasts is the name given to pieces of rocks / minerals in the breccia.

Matrix.   The name given to the cement which bonds the clasts together. An alternative name for matrix is groundmass

Clast supported breccia.   Breccia where most of the clasts are touching each other.

Matrix supported breccia. Breccia in which the clasts do not touch each other, and are surrounded by the matrix.

Dolomite-cemented Dolostone Breccia
© James St. John, CC BY 2.0.

Sandy polymictic conglomerate
©Michael Rygel CC Attribution Share Alike 3.0

Types of Breccia

The following are the overall basic types of breccia:
Sedimentary (including Collapse),
Igneous
Hydrothermal
Tectonic
Impact.

However there are many variations of each type, very often named after the locality where they are found. There are literally dozens of breccias named after their locality, each one having it's own distinctive appearance

Sedimentary Breccia

Of all the different types of breccia, sedimentary breccia is probably the most common. There is so much erosion/weathering of surface rocks that this is hardly surprising. All types of rock, including the harder igneous rocks are subject to weathering from wind ice and rain. Just about every exposed hillside has some scree slopes. The steeper the hillside the more scree there is.

Very large accumulations of scree can occur as the result of debris flows. which are produced when a storm washes loose scree into swollen streams and rivers. The scree in the debris flow will be deposited on lower ground where the river widens, especially so in estuaries.

Upland scree slope, above Derwent in Cumbria

© Michael Graham CC Attribution-Share Alike 2.0
geograph.org.uk

Coastal rocks are especially subject to erosion, mostly by wave and storm action. Most cliffs have freshly formed scree at their bases.

It is the accumulated scree from whichever source which will eventually, after a very long period of time become cemented to form breccia.

The rounded pebbles and pieces of rock in a conglomerate are rounded from the grinding action of long distance transportation, either by rivers or glaciers, which differentiates them from the angular pieces in a breccia.

In a karst terrain, a collapse breccia may form due to collapse of rock into a sinkhole or in cave development. Another name for collapse breccia is "solution-collapse breccia", because it is caused by dissolution of underlying soluble bedrock, such as limestone or dolomite. Once the groundwater has dissolved the soluble rock the non- soluble rocks collapse and become crushed.

In the Grotta dei Lamponi, the longest lava flow tube at Mount St. Etna, part of the roof has collapsed. The debris on the floor will eventually become cemented and transformed into a collapse breccia.

Igneous Breccia

Igneous breccia can be formed from rocks coming from two different origins, volcanic eruptions, or igneous intrusions, for this reason igneous breccia is commonly referred to as volcanic breccia. The volcanic breccias are the result of violent eruptions causing pyroclastic flows of fractured pieces of rock plucked from the wall of the magma conduit, mixed with a smaller amount of pieces of rock picked up by the lava as it flows down the volcano slopes. The resulting breccia is uniform in rock type. Volcanoes eject molten lava to the surface, whereas igneous intrusions occur when magma cools and solidifies before it reaches the surface. Igneous intrusions are often the result of more than one episode of intrusion into the same fault and when new hot magma intrudes into previously cooled magma, fracturing occurs, especially around the outer edges of the intrusion, and it is this outer fractured rock which later becomes brecciated.

Collapse breccia. Everton Formation, Middle Ordovician; Rush Creek District, Arkansas, USA.
©James St. John CC Attribution 2.0.

Sedimentary breccia (Amargosa Valley Formation) Upper Oligocene-Lower Miocene. Funeral Mountains, Inyo County, California, USA
© James St. John CC by 4.0.

Pyroclastic Flow St. Helens.
Donald A Swanson USGS public domain.

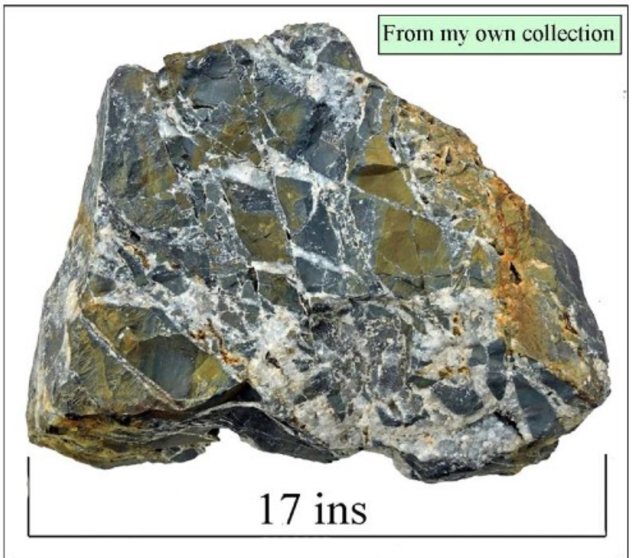
Grotta dei Lamponi
© Nunzio Santini CC Attribution-Share Alike 4.0.

Pyroclastic Breccia
© James St. John CC Attribution 2.0.

Igneous intrusion into country rock.
Note that in this intrusion the outer margins are very fractured compared with the inner core.

Hydrothermal Breccia

Hydrothermal breccias occur at relatively shallow depths in the Earth's crust, at temperatures between 150 °C and 350 °C. Fractures in the rock are home to circulating hot fluids, very often mineralised. As with any hot or boiling fluid expansion occurs, which causes extreme pressure to be exerted on the walls of the fracture by the fluid. If the extreme pressure exerted by the fluid is suddenly decreased, due to the fluid finding an escape route, the hydrofracturing process is triggered. The instantaneous decrease in pressure causes the fracture walls to shatter and implode rock fragments into the hot circulating fluid. The fluid, now carrying rock fragments will eventually cool and solidify, and a breccia is created.

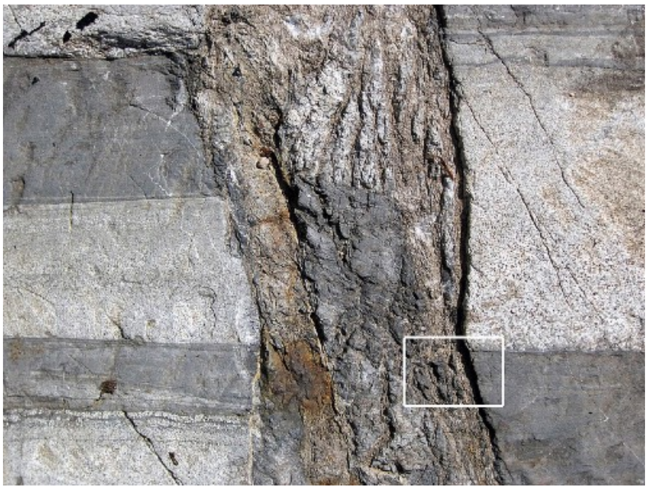


This specimen of Hydrothermal breccia was collected from Dylife mine in Powys.It is composed of silica from circulating fluid and shards of wall rock, but only very small amounts of minerals for which the mine is famous

In ore bodies the circulating fluid is usually rich in silica or calcite, but the fluid also carries other dissolved minerals, such as galena, copper, sphalerite, etc. which upon cooling crystallise, and become incorporated into the breccia.

Tectonic or Fault Breccia

Tectonic or fault breccia is formed by the action of the opposing walls of a fault grinding against each other. The cement may be the result of mineral matter introduced into ground water.



Fault with fault breccia in interbedded metagraywacke-slate (Lake Vermilion Formation, Neoarchean, Pike River Bridge outcrop, just north of Peyla, Minnesota, USA). Note that the breccia filled fault is sandwiched between beds which have moved against each other. The misalignment of the beds is obvious.

Impact Breccia

Impact breccia is not a common type of breccia because it is the product of immense heat and pressure generated by an asteroid strike, which fortunately does not happen very often.

Impact breccia is composed of shattered fragments of rock set in a crystalline matrix of melted rock, the composition of which can vary widely, dependant of the type of rock at the asteroid impact site.

Seventy-one percent of the Earth's surface is covered by water, so it is inevitable that many asteroid strikes have been in the oceans which makes them much more difficult to observe.

Odessa impact crater rim rocks - Oncolitic limestones from the Lower Cretaceous Fredericksburg Group. The Odessa meteorite crater in west Texas USA is 160m in diameter and was created by a nickel iron meteorite that fragmented in the atmosphere.

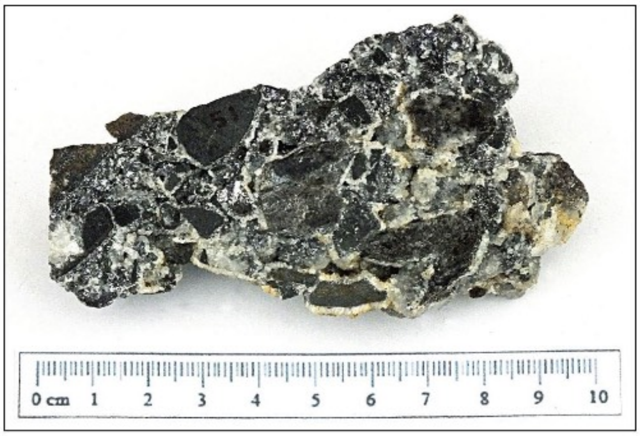
Odessa Breccia (Upper Pleistocene, 64 ka; Odessa Impact Crater, Texas, USA).

Bill Bagley

Below: Miscellaneous breccia from my collection.

Hydrothermal breccia from Bryn-y-Rafr mine, West Wales.

Rhodochrosite in Hydrothermal breccia S. Australia.



Hydrothermal breccia from Dylife mine central Wales.

Vein breccia from Cwm Rheidol mine W. Wales.

Haematite shards in hydrothermal breccia S. Wales.

A Geological Trip to Raasay

Why go to Raasay, a small island off the east coast of Skye? We all know Skye has an excellent range of geology, so why choose Raasay? Well, you won't see the gabbroic intrusions of the black Coulins, and you won't see the Moine Thrust. Otherwise everything you can see on Skye is present on Raasay, and at less than ten percent of the land area of Skye, Raasay is much easier to get around.

There are excellent online guides to Raasay geology, including a comprehensive review of the geology of Skye and Raasay by Brian Bell. The rocks range from Lewisian gneiss at approximately three billion years old to tertiary volcanics and evidence of recent glaciations.

What follows is a summary of some of the excellent exposures present on Raasay. Many of them can be visited within a day's walking trip, but having a car is helpful to get to the various start points and reduce the walking required. I'll start off in the north, and end up at the southern end of the island.

Photo 1. *The view of Raasay from the ferry terminal on Skye. It has a very distinctive skyline due to the flat-topped peak of Dun Caan, the highest point on the island.*

Photo 3. *Closer view of the gneiss, smooth-surfaced because of glacial erosion.*

Photo 4. *Low tide showing the tombolo linking Raasay with the small island of Eilean Fladday.*

Photo 5. *A closer view of the tombolo. The raised ridge of rocks crossing between the two islands is a dolerite dyke, resisting erosion more than the surrounding country rock. The dyke is seen going vertically up the hill in the centre of the picture and can be followed right to the top near the right hand side.*

Photo 2. *The view looking over the north of the island. Typical Lewisian gneiss appearance.*

Photo 6.

Brochel Castle perched on an outcrop of breccia within late Torridonian mudstones.

Photo 7. *A closer view of the breccia at beach level below the castle. (The bracken fronds at the bottom of the photo give a scale).*

Photo 8. *The walk up to Dun Caan starts from a road and proceeds in a SSE direction over a wide expanse of flat rocks for over a mile.*

Photo 9. *The surface of the rock is largely covered in lichen – but occasionally, the true nature of this rock is revealed in a stream bed. It is an extensive granite sill, dipping gently NNW.*

Photo 10. *This photo shows the top of Dun Caan at the left, with another igneous feature towards the right of the picture – two adjacent igneous rock exposures with columnar jointing, but with totally different origins.*

Photo 11. *The top of Dun Caan. This is an extrusive lava flow.*

Photo 12. *An intrusive dolerite sill below the summit.*

Photo 13. *The view from SE Raasay looking up at Dun Caan. The irregular nature of the land seen here and in the previous photo is due to extensive landslips.*

Photo 14. *More evidence of the unstable nature of the rocks with incipient separation of a large sandstone block.*

***Photo 15.** Further evidence of past landslips of sedimentary sandstones with large blocks containing multiple beds, all arranged in a haphazard fashion, having fallen from the cliff face above into the sea.*

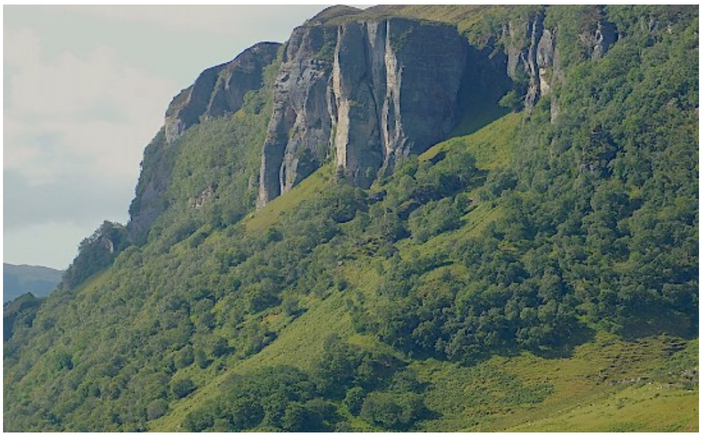


***Photo 16.** A marvellous display of the cliffs seen over much of the eastern coast of Raasay. This is the Druim an Fhuarain Sandstone Member from the middle Jurassic period.*

***Photo 17.** The Oskaig sill on the west side of the island.*

***Photo 18.** A closer view of the sill with clear evidence of columnar jointing. This sill is part of the Paleocene Little Minch Sill Complex, which is more widely exposed on Trotterhish in north Skye.*

Iron was mined at the southern end of Raasay during the 1st World War. Some of the mining and processing plant still remains. There are plenty of interesting exposures just above the old mine and along the coast towards Inverarish.

***Photo 19.** Lower Jurassic Ardnish Formation strata above the mine. Same scale on this photo and the next one.*

***Photo 19.** A closer view of the thick limestone beds with intervening beds rich in siliclastic sediment.*

***Photo 20.** Plentiful fossils – almost all of which are the oyster Gryphaea arcuate (scale is a car key fob, 4cm in width).*

Photo 21. *The granite sill seen on the slopes of Dun Caan outcrops on the beach at the SW of the island.*

Photo 22. *The granitic nature of the outcrop is clear.*

Photo 23. *Further west, the sill overlies the darker Pabay Shale Formation strata.*

Photo 24.

A closer view of the contact.

Photo 25. *The Pabay shales are also displayed in a nearby turning.*

Photo 26. *A closer view of the shales. Calcareous bands are a later mineral infill within these loose shales.*

Chris Simpson

Geology in Art

Coal seam at Wern Ddu © Alan Hughes.
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"A Nod to the Carboniferous Period" A Photomontage.

Thanks to attending the Geology Club, I came across an interesting book, ***'Coal Measure Plants', by R. Crookall***, of the Geological Survey of Great Britain; this title was put on my Christmas list, and I received a second-hand copy. It inspired me to create some artwork in response to it, but where it would lead me, I did not know at the time. After three years developing my project, and finishing it at the beginning of this month, it lead me up the lane where I live in Dernol to a forest at the end of the valley, where I hung it as a temporary textile installation.

Although I was initially inspired by Crookall's book and fossils of coal measure plants, after I did some research and saw photographs of coal seams, I became fascinated by how coal was made through heat, pressure and time, and my artwork developed into something completely different to what I had initially envisaged.

To start with, in my mind, I wanted to replicate these processes in my artwork, although of course on a minuscule level compared to how coal was made millions of years ago! So in my workroom I used lengths of cotton fabric, immersed them in water, twisted them, applied pressure and heat to see what happened. Surprisingly, knots and useful wrinkles appeared that I was able to hand paint and sparsely embellish with embroidery techniques. My finished piece became a photomontage. I made a huge leap in my abstract way of thinking, and here are the results:

"A Nod to the Carboniferous Period" *my finished photomontage.*

Although I had not initially thought of using this technique, I combined two photos to add some context, one of the artwork and, as a background, one of the moss-draped trees adjacent to where it was hung. To be able to do this, I first needed to photograph the installation in the forest, so I hung the cotton lengths between two trees, and draped various textured threads around the edges of the main piece as it hung in the landscape. So it's a bit of a stretch to connect it literally to how coal was made, but I felt that my response was produced by travelling back in time to connect with, and appreciate, the beauty of the 'swampy forests', from which coal was derived; I did not want it to be twee, or about the controversy of burning coal, as some artists have done. The photograph (by Les Wilkins) of my artwork shows it amongst a backdrop of a group of trees that we had visited and photographed a few years ago, and I had kept the photo as I knew I wanted to incorporate it into my artwork one day.

Plants of the Carboniferous age. *This page comes from Book 15 of the 4th edition of [Meyers Konversationslexikon] (1885–90). Image in the public domain.*

Coal measures*: coal-bearing rocks formed in the upper Carboniferous period.*

Carboniferous: *formed in the fifth period of the Paleozoic era, between the Devonian and the Permian periods, which lasted for 80 million years, and during which coal measures were formed.*

'Pitchstone' a free-standing drawing

More thanks are due to the Geology Club for inspiring my artwork, this time to member Tony Thorp, who introduced me to thin sections of rock mounted on a glass slide (see P.1), which showed me the beauty of patterns in nature. He kindly shared images of nine of these via email, and for this project I chose to use the pitchstone slide. This one became a starting point for the drawing whilst I was an artist in residence at the Wyeside Arts Centre in Builth Wells, where I had a solo show called 'Outside In' in 2017. I had a large enough space to create and experiment with pencil & paper, and the drawing turned into a cylindrical free standing piece.

Pitchstone: *a volcanic lustrous glass that forms when lava or magma cools quickly.*

Work in progress, artist in residence Wyeside Arts centre.

"Pitchstone" *finished piece in a corner 2017. Diameter: 20 x 120 cm.*

Sue Purcell.
suepurcellart.com
Instagram: @sue.purcell2023

A Local Rock Collapse

A small collapse has occurred on the rough car park close to the entrance to the Clywedog dam viewing point. The location (**SN 911 866**) is between the Aberdaunant and Bryntail mines each of which are about 300-400m away. The collapse exposed a bed of hydrothermal origin; which is the light coloured rock in the middle of **Fig 1**.

It is composed of quartz and in places appears to be layered, see **Fig 2**. The bed is sandwiched between beds of sandstone; those below are very thin whilst those above are massive see **Fig 3**. One of the beds below is completely exposed, and is covered with ripple marks shown in **Fig 4**. Sole marks are visible on the surface of the quartz as in the specimen shown in **Fig 5.**

I could not resist the temptation to pick up several specimens, one of which is about twice the size of the featured specimen.

Bill Bagley

Fig. 1. *Exposed Hydrothermal bed.*

Fig. 2. *Layers in the Hydrothermal bed.*

Fig. 3. *Looking up the rock face.*

Fig. 4. *Showing ripple marks on the exposed bedding.*

Fig. 5. *Sole marks on the surface of the quartz.*

The Variability of Volcanic Ash

Most people when asked what they know about volcanic ash will mention the 2010 eruption of Eyjafjallajökull in Iceland which paralysed European air transport for six days. But there is a lot more to volcanic ash than this, which this article will examine.

Volcanic Ejecta

When molten magma erupts on the earth's surface through a volcano, it can take a variety of physical forms. Most volcanoes will combine more than one of these components, often with a marked variation in composition as the volcano works through its life cycle.

Gas: water vapour, carbon dioxide, sulphur dioxide and hydrogen sulphide are the main gases emitted by volcanoes, but there are many other compounds which can be emitted.

Liquid: lava flows vary greatly in composition from viscous, high-silica lavas to runny, low-silica lavas.

Solid: tephra is a generic term for solid ejected material which includes ash (particles <2mm), cinder (particles 2–64mm) and blocks (particles >64mm).

Ash

As magma rises in the volcano, if there is a high content of gases, this will cause fragmentation of the magma on eruption with rapid cooling of the liquid to form a cloud of small solid ash fragments. Once formed, ash is often thrown high into the atmosphere where it can spread thousands of miles before coming back down to the ground.

Volcanic ash deposits which are subsequently lithified are known as tuff. To be classified as tuff, a rock needs to be >75% ash. Rock which is 25–75% ash is known as tuffaceous. Tuff is relatively soft rock, so it has been utilised for building for thousands of years.

Ash in the Geological Record

Thick ash beds will often be seen in the areas around old volcanoes. Thin ash beds can also be seen for hundreds, or even thousands, of miles round an old volcano. These thin beds are very useful marker bands which help geologists correlate and date the geology across different countries. Nineteenth century geologists only had the physical appearance of these bands to work with; but nowadays, we have geochemistry, which usually yields a distinctive chemical and trace element profile for any particular marker band.

Chris Simpson

Photo. 1.
A road cutting in the Greek Island of Kimolos showing a fairly typical mixture of tephra types. In this example, they are all creamy white.

Photo. 2.
A closer view of the above showing mainly ash and cinders with an occasional block.

Photo 3.
Another road cutting in Kimolos with successive layers of volcanic ash. In this instance, most of the layers are coloured. The different colours represent different composition of the remaining magma in the magma chamber following each eruption.

Photo 5.
A surface ash deposit on the Greek Island of Milos. Erosion by wind and rain has created fantastic shapes.

Photo 6.
The same deposit as 5. showing the texture with mainly ash and some cinder. The scale is a rucksack.

Photo 4.
A closer view of this series of ash deposits in Photo. 3. Each one is clearly demarcated, often with a marked colour change. Some layers are mainly ash while others are mainly cinder.

Photo 7.
Milos again. The tuff layer composed of fine ash is just above present sea level. Because the rock is so soft, boat owners have excavated into it to create boat houses.

***Photo 8*.**
A view of a road cutting in El Hierro largely composed of successive layers of volcanic ash. There is a small vertical fault evident near the left side.

Photo 9.
Clearly demarcated layers of ash with different colours. The circumscribed dark layer near the centre appears to be a deposit within a pre-existing rain water channel.

Photo 10.
A closer view of the channel deposit with two blocks within the light-coloured ash layer between the two darker layers. The vertical marks were made during the road construction.

Photo 11.
The Timanfaya National Park in Lanzarote. We see a reddish ash layer lying over a lava flow. The park contains the areas of the 1720, 1736 and 1824 eruptions – all of which were witnessed with written records.

Photo 12.
Iceland. An excavation for a house extension reveals successive ash layers from the 9th to the 19th centuries.