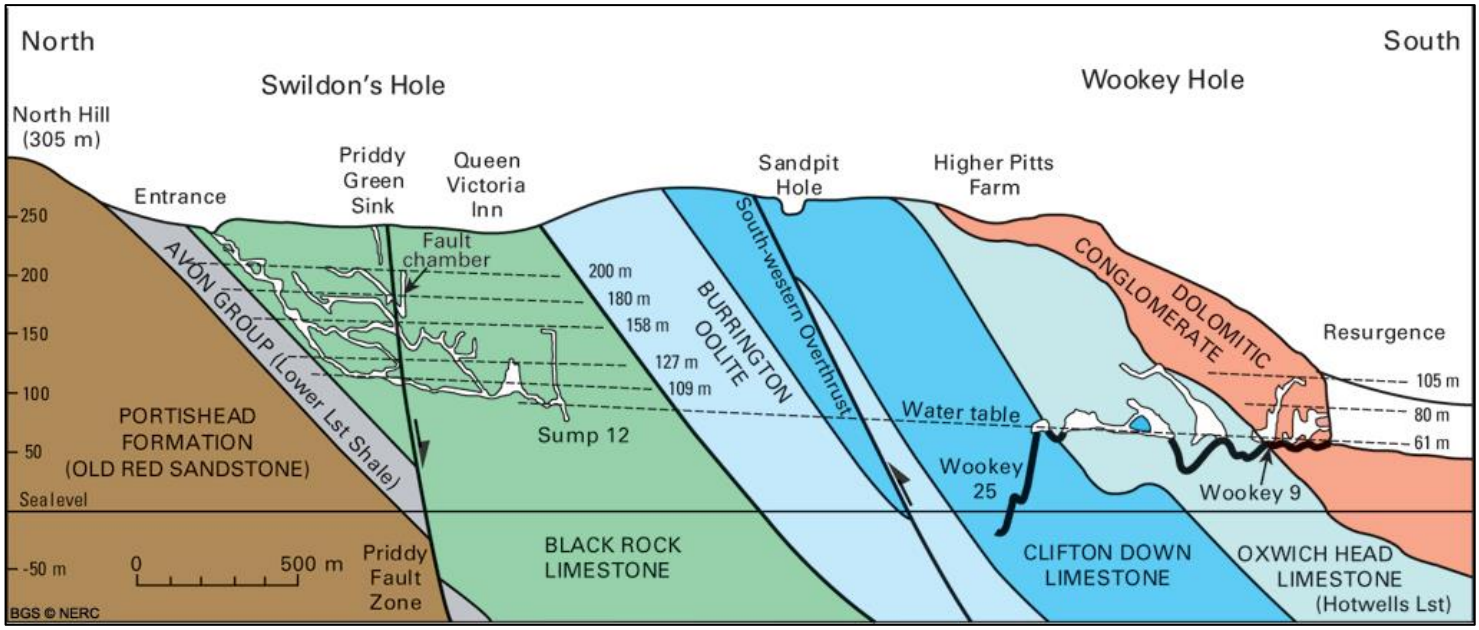
FIELD TRIP TO WOOKEY HOLE **24th February 2020**

Wookey Hole is the finest example in Britain of a cave formed by deep phreatic activity and the sequence of fossil and active caves provides evidence of a long and complex geological history.

Cross-section from Swildon's Hole to Wookey Hole

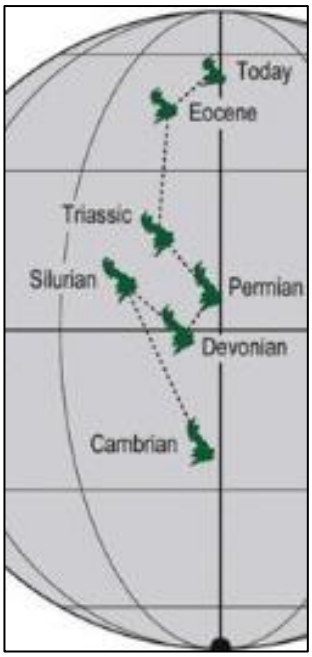


How the Mendip Hills and caves were formed.

	Eon	Era	Period	Epoch	
Younger	Phanerozoic	Cenozoic	Quaternary	Holocene	Today
				Pleistocene	11.8 Ka
			Neogene	Pliocene	
				Miocene	
			Paleogene	Oligocene	
				Eocene	
				Paleocene	66 Ma
		Mesozoic	Cretaceous	~	
			Jurassic	~	
			Triassic	~	252 Ma
		Paleozoic	Permian	~	
			Carboni-ferous: Pennsylvanian	~	
			Carboni-ferous: Mississippian	~	
			Devonian	~	
			Silurian	~	
			Ordovician	~	
			Cambrian	~	541 Ma
Older	Proterozoic	~	~	~	2.5 Ga
	Archean	~	~	~	4.0 Ga
	Hadean	~	~	~	4.54 Ga

Lower Carboniferous [370 – 327 m.y.a.]
In warm, shallow tropical seas about 20 degrees south of the equator, massive beds of limestone were laid down.

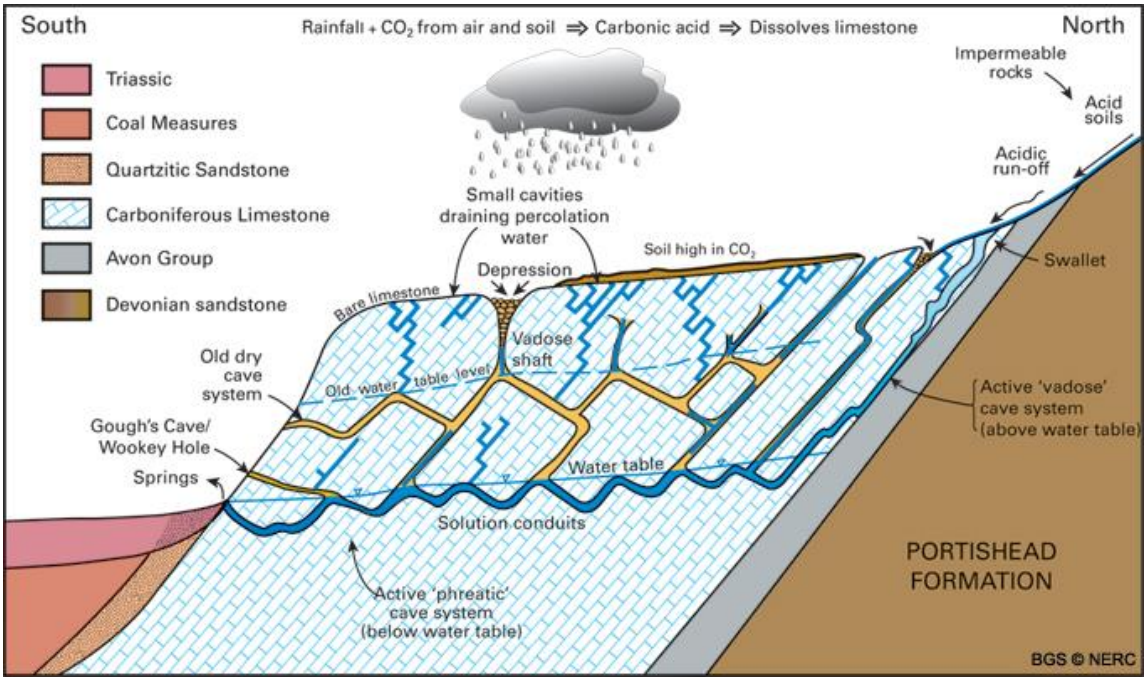
Variscan orogeny [320 – 280 m.y.a]
As Britain was crossing the equator, major tectonic forces pushed up the horizontal limestone beds into four great folds, rising to the height of 1500 metres – the Mendip mountains. Cracks on the crests of the folds were lines of weakness through which water could percolate, gradually dissolving the limestone. Unlike chalk, carboniferous limestone has low porosity. Water therefore flows along joints, fissures, bedding planes and faults. The steep dip of the beds, resulting from the orogeny, aided the flow of water and the later formation of caves.



Triassic [252 – 201 m.y.a.]
Moving northwards between 20 and 30 degrees, the mountains were being worn down, for example by the freeze- thaw effect of the extremes of temperature under desert conditions. Angular pieces of rock would have broken off, forming scree slopes. Gravity, seasonal rains and major

storms carried large quantities of the scree down towards the plains where outwash fans of the finest material spread out. In a matrix of red sand, the clasts of carboniferous limestone became lithified forming the breccias known as dolomitic conglomerates. The mountains were gradually reduced to today's height of 300 metres and the valleys filled in with Triassic rocks.

Formation of the caves.



According to the information boards, this began one million years ago. However, the process of dissolving the limestone along its joints and bedding planes would have been well under way by then. (A weak acid is formed as rainwater absorbs carbon dioxide from the air and soil.)

Long fractures in the rock occurred as part of the crustal extension when the Atlantic Ocean opened up, another major tectonic event. Rainwater, and more significantly the huge volumes of summer meltwater at the end of the ice ages, found these cracks easy routes to follow, gradually widening some to form great chasms. (Chambers 7 - 9)

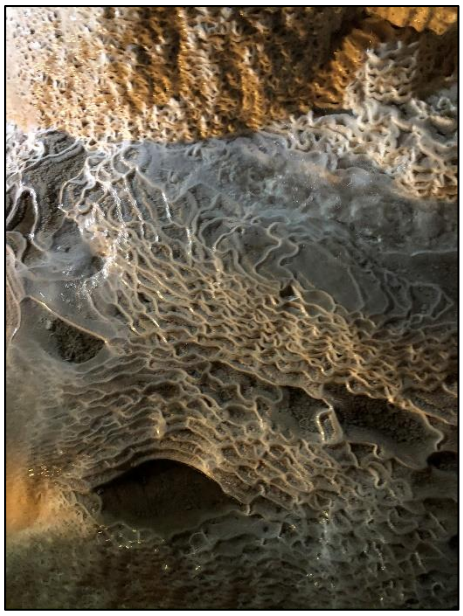
At some point, the surface streams on top of Mendip all found their way underground via swallet holes. The debris they carried would often block the way and the swirling water would enlarge a narrow passage to form a small cave and then find another route for the underground stream. Once the water table was reached, the streams moved sideways down a slight gradient. Because of the mud and stones carried in the water, particularly during heavy storms, it was common for the outlet of a chamber to be partially blocked. A whirlpool, with the abrasive effect of small stones, would then scour the sides of a cave, gradually enlarging it. (Chamber 3) This must have been an important factor in the formation of caves in the Triassic rocks as the sandstone matrix would have been less soluble than the limestone. The water table rose and fell according to the amount of rain and meltwater. All the caves at Wookey Hole were formed below the water table – i.e. phreatic. However, as the water table fell, the higher caves and passageways were left dry and air-filled, like the main show caves today. (Today, a sluice gate controls the level of the Axe, a 19th century method of maintaining the flow of water to the paper mill.)

The early show caves. [Chambers 1,2 & 3.]

These have been above the water table for a long time, as there is evidence of human habitation dating back to the Iron Age, both in the cave entrance and burial remains in chamber 4. (We were spared the guide's spell about the witch of Wookey Hole, whose 1,000 year old skeleton, now

in Wells museum, is in fact that of a man.) Divers have recently found a human jaw bone, not yet dated.

The first two chambers were large and contained several impressive stalagmites, formed as minerals precipitated out of drips of water over thousands of years. It is thought that any large stalactites are missing as they have been removed. (One story claims that the poet, Alexander Pope had the local militia shoot some down to adorn his Twickenham grotto, constructed in 1725.)



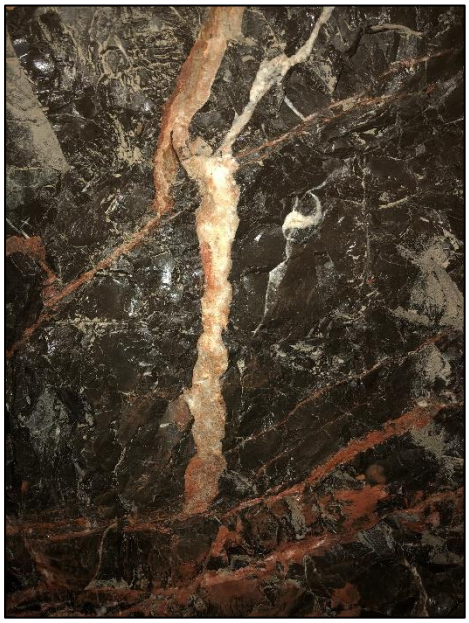
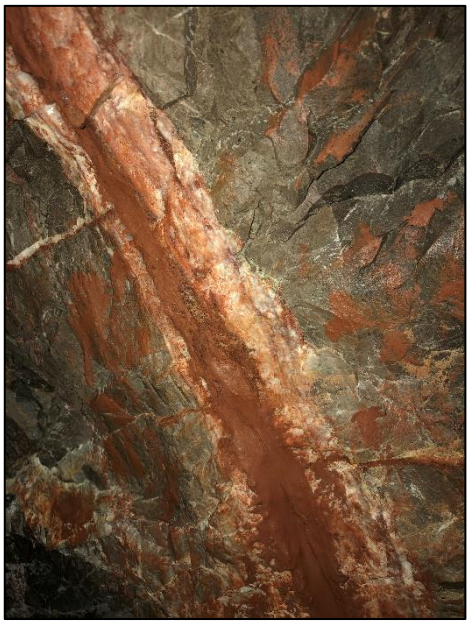
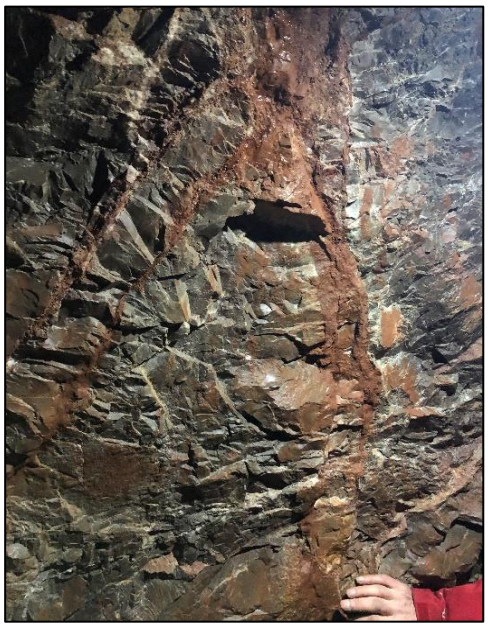
The walls of the chambers were formed of Triassic rock, with many angular fragments of varying sizes, up to a metre across. They were red from the rusting of the iron content of the desert sands, at times masking the grey of the limestone clasts.
More iron was introduced much later, dissolved in hot water issuing from deep within the earth. It found its way through cracks, some caused by crustal extension when the Atlantic Ocean was first forming. As the water cooled, metals crystallised out forming distinctive veins. In places, this occurred alongside large calcite crystals, formed when CaCO3 was dissolved from the Mendip limestone in cooler water and later deposited in the innumerable cracks throughout the cave system.

Chamber 3 (left) had a lower roof than the first two and was a clear example of a cave formed by a whirlpool effect. What appeared to be a lake was in fact the River Axe, its entrance being larger than its outlet.

First blast tunnel.
In 1973, former miners from the Radstock area were employed to blast a 180 metre tunnel through the dolomitic conglomerate to several more chambers. (One section is being used to store maturing Cheddar cheeses. The constant temperature of 11 degrees C is ideal for this.)

Chambers 7, 8 &9.
A bridge crosses the first two of these dramatic caves, impressive chasms through which huge volumes of water must have passed, particularly at the end of the ice ages. Chamber 9, the largest of the three at 30 metres high, had walls covered in a shining flowstone stalactite formation. Red iron staining and lichen growth made it difficult to determine whether two lower beds, each about two metres wide, were of carboniferous limestone.

Second blast tunnel.

Above are fractures cutting the Carboniferous Limestone infilled with calcite and iron oxides.

This was opened in 2015 to give access to further chambers. In the tunnel roof we saw a clear junction between the Dolomitic conglomerate and the earlier Oxwich Head carboniferous limestone. This unconformity represented a time gap of some 100 million years.


Chamber 20.

A huge, extremely impressive space, very different from the previous caves. [Dimensions: 22m x 60m x15m.] Its most striking feature and the best example in the UK was the spectacular fluting on a 5metre high sloping surface, known as rillenkaren. (German for cart grooves.) Over thousands of years, small rivulets carved grooves in the limestone, aided by condensation of the humid air in the caves which formed slightly corrosive acid. The cave was discovered in 1970 and divers called this feature King Arthur's beard. (photos above)

In the centre of the cavern were some large boulders (right) and in the NW corner a long, distinctive bed, dipping south, perhaps the Ebbor Thrust. If so, it was evidence of tectonic shift during the Variscan.

The origin of the name Wookey Hole.

Wokyhole and its mill is mentioned in Domesday in 1086. Ogo is Celtic for cave. Hole means the same in Anglo Saxon, so the phrase Wookey Hole caves is emphatically tautological. The photos below show the river Axe flowing out of the caves with the sluice gate controlling the level of the river.This is a 19th century method of maintaining the flow of water to the paper mill.

And finally - a *stately* pleasure - dome? Was Coleridge prescient?

Whilst living in Somerset, the poet Coleridge visited Wookey Hole. The caves must have haunted his dreams when he wrote: "In Xanadu did Kubla Khan

A stately pleasure- dome decree:
Where Alph, the sacred river, ran
Through caverns measureless to man
Down to a sunless sea."

Once again, thank you Susan and Doug for arranging the trip and checking this account. It is difficult to express how much we appreciate having our eyes opened. Thank you, Doug, for moving to Wookey Hole and making us aware of how it was formed. A big thank you to Wookey Hole Caves for making us so welcome.

References

Diagrams 1&4 Farrant, A R. 2008. A walkers' guide to the geology and landscape of western Mendip. Book and map at 1:25 000 scale. (Keyworth, Nottingham: British Geological Survey.)

Diagram 2 Scientists' Warning Learn & Act Wiki

Diagram 3 Trond H. Torsvik, Pavel V. Doubrovine and Mathew Domeier Continental Drift (Palaeomagnetism) 2014 uploaded by Doubrovine