

Swaledale Geology and Landscape



Copy of talk for Marske website.

If you would like to use this material (or have us talk to it) please let us know. If either of us can help we will.

To contact Stephen Clark/webmaster [click here](#).

Les Knight and Stephen Clark. Keld Resource Centre.

10 May 2026. 10am to 4pm.

www.marskeswaledale.com

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Swaledale Geology

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The story of Swaledale begins

- Story starts 4.6 billion years ago
 - Difficult to tell how the first 4 billion shaped Swaledale!
- Starting in the Ordovician and Silurian
 - About 500 million years ago (500 Ma)
 - No rocks of that age in Swaledale – but important to story
- The rocks we see today only record:
 - Times when rocks were deposited
 - Places where rocks were deposited
 - Places where rocks have not then been eroded away
 - Rocks that happen to be on the surface
- So it all ends up being a bit complicated!
 - That's why geological maps are complicated to look at
 - Even in 500 million years a lot can happen

Eons	Eras	Periods / Systems	Epochs / Series	Dates
Phanerozoic	Cainozoic	Quaternary	Holocene Pleistocene	10000 2
		Neogene	Pliocene Miocene	24
			Palaeogene	Oligocene Eocene Palaeocene
	Mesozoic	Cretaceous	Upper Lower	146
			Jurassic	Upper Middle Lower
		Triassic	Upper Middle Lower	245
			Permian	Upper Lower
	Palaeozoic	Carboniferous	Stephanian Westphalian Namurian Dinantian	363
			Devonian	Upper Middle Lower
		Silurian	Prigiol Ludlow Wenlock Llandovery	439
	Ordovician		Ashgill Caradoc Llandoily Llanvirn Arenig Tremadoc	510
		Cambrian	Merioneth St David's Caerfai	544
	Precambrian (Cryptozoic)	Proterozoic	Neo	1000
			Meso	1600
		Archaean	Palaeo	2500
Late			3000	
Pre-Archaean		Early	3800	
		4600 Ma	Formation of Earth	

Image from Toghiani, P., 2000. *The Geology of Britain*. Crowood Press.

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We are on Carboniferous rocks in Swaledale

What preceded that? Older rocks near us: Silurian and Ordovician.

- Map
 - Colours denote age of rocks and/or type of rocks at surface
- Before we get to Swaledale lets look at nearby rocks that are just a little older
 - 100-200 Ma before Carboniferous
 - Ordovician/Silurian rocks of Scottish Southern Uplands – the M74 traverse
 - Ordovician rocks of Lake District volcanic areas.

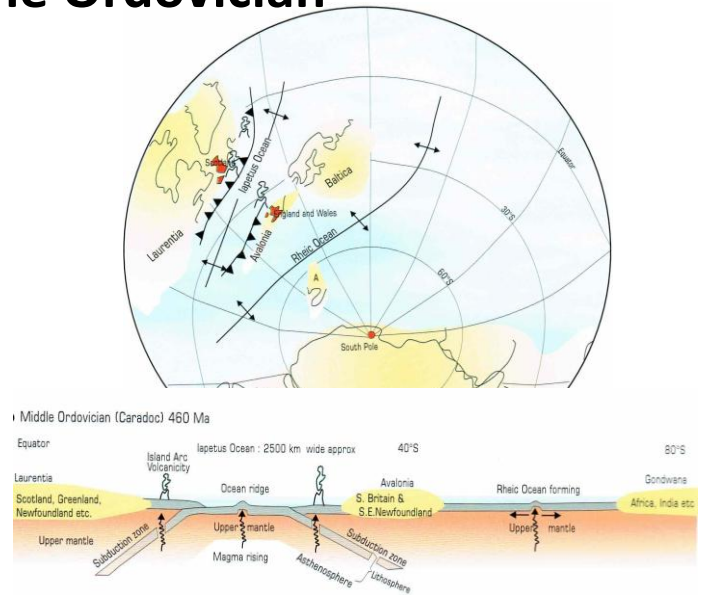


Image of 1:625000 map reproduced with the permission of the British Geological Survey © UKRI 2025. All Rights Reserved.

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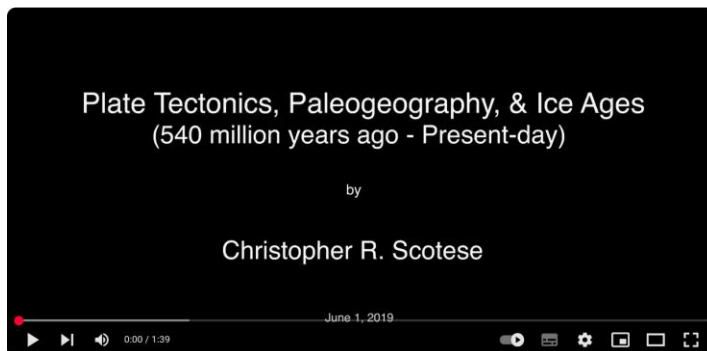
Plate tectonics of the Ordovician

- England and Scotland on separate continents
 - Separated by an ocean “Iapetus”
- Edges of Iapetus were subduction zones
 - Deposits scraped off sea-bed
 - Sediments pushed down at edge of ocean triggered volcanism
- Iapetus closed
 - Fine-grained sedimentary rocks (e.g. shales) dominate southern Scotland
 - Lake District characterised by volcanic rocks (e.g. rhyolites).
 - Harder rocks tend to produce spikier landscapes.



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Plate tectonics video



[Click here: Plate Tectonics video](#)

Your Tube Video. By Christopher Scotese.

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Subsequent collision of continents led to a period of mountain building

- The continents containing England and Scotland collided
 - Rocks were folded
 - Rocks were both compressed and/or buried and “metamorphosed”
 - Some rocks were melted, and/or molten rocks were injected into overlying rocks
- To place Swaledale’s geology in context we’re going to look more closely at these melted rocks

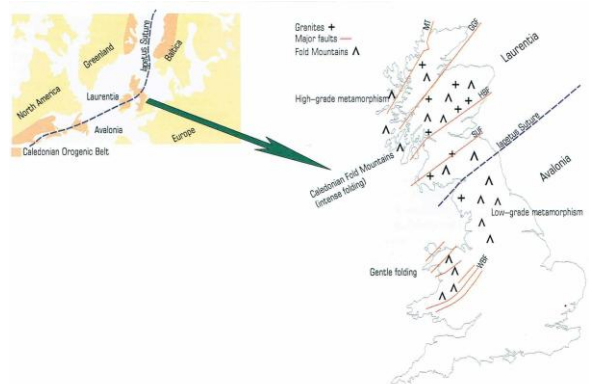


Image from Toghiani, P., 2000. *The Geology of Britain*. Crowood Press.

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Molten rocks form a spectrum

- Granite
 - Rich in silica, and typically rich in potassium and sodium
 - Relatively light weight
 - Very viscous (see [Click here for Pitch drop experiment!](#))
 - Freezes at a relatively low temperature
 - Typically light coloured
- Gabbro/basalt
 - Lower in silica, and typically rich in iron and magnesium
 - Relatively heavy
 - Much more fluid than granite
 - Freezes at a relatively high temperature
 - Typically dark coloured

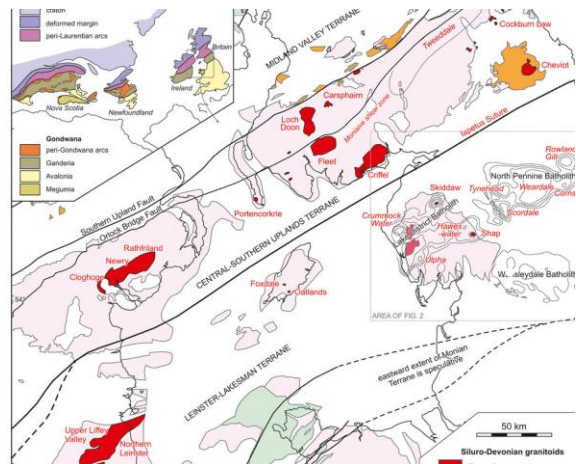


In collection of, and with permission of, White Hare Café Kirkby Stephen

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Another look at that geological map again ..

- During the mountain building phase viscous granitic melts got stuck in the overlying rocks and solidified
- Many of those granites now “outcrop” at surface
- Map shows granite blocks associated with the mountain building episodes
 - Southern Scotland and Northern Ireland
 - Lake District and Shap
 - **Hidden under Weardale and Wensleydale**
- The hidden granites play a key role in Swaledale’s geological history

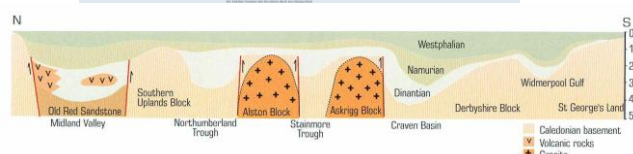
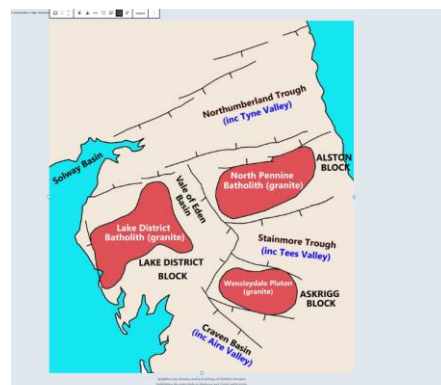


Map taken from Woodcock, N.H., et al. 2019. *Age of the Acadian deformation and Devonian granites in northern England: a review.* Proceedings of Yorkshire Geological Association, Vol 62, 2019.

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Effect of the granites on Pennines

- Simplified map
- Recall granite is relatively light
 - Crust around them has flexed upwards and broken at edges in a brittle manner
- These major faults define the Pennines today
 - Most significant faults are on the western edge of Pennines
 - Faults trending west-east have led to higher blocks of crust over the granites separated by troughs



Upper image modified from British Geological Society Memoir, 2010. *Northern England.*
Lower image from Toghiani, P., 2000. *The Geology of Britain.* Crowood Press.

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Welcome to the Carboniferous era

- Britain nestled in a continent on the edge of a small ocean
- Sediment brought down to ocean from vast continent to North including Scotland, Scandinavia and Greenland
- Shallow seas and flat coastal plains
- Equatorial climate – warm and wet
- Peaceful - no violent mountain building
 - But height of land controlled by the position of those granites and faults
 - Thicker sediments deposited in troughs; thinner sediments on top of those granites

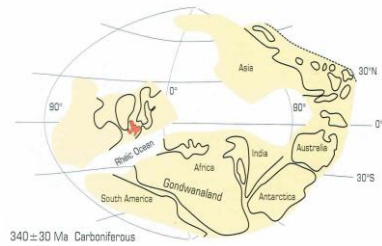
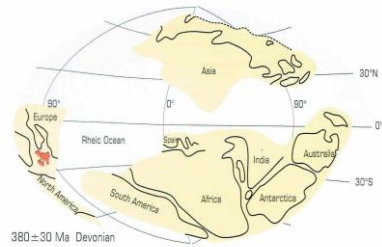
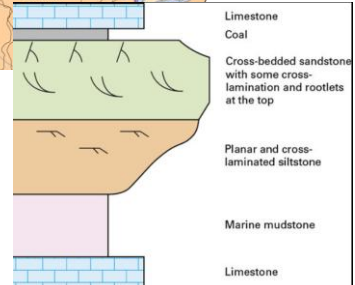
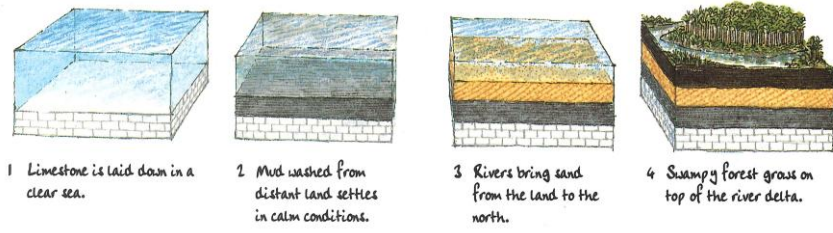
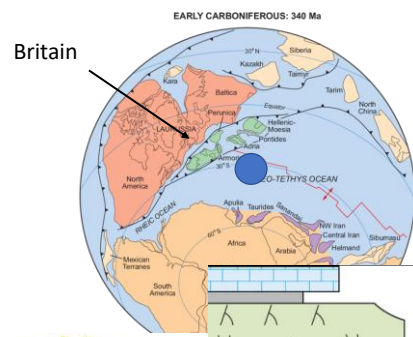
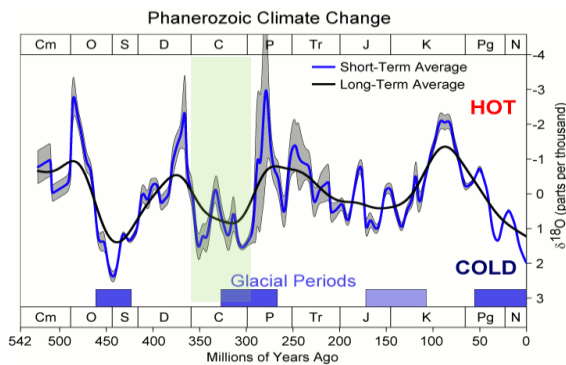


Image from Toghiani, P., 2000. *The Geology of Britain*. Crowood Press.

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Carboniferous climate and sedimentary rocks



Images from Les Knight. Various sources.

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Glaciation and astronomy



[Click here for Glaciation and astronomy video](#)

Your Tube Video. By Its Just Astronomical.

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Sequences of Carboniferous rocks in Pennines

- Rhythmic patterns
 - Alternating sequences, making layers, of sandstone, limestones and mudstones/shale
- Causes of patterns
 - Periodic changes in earth's climate, dominated by cycles of glaciation
 - Meandering of rivers and deltas in coastal environments
- Thinner deposits over granites
 - 1km vs 4km of Carboniferous rocks
 - Only possible because of enormous changes in "height of land"

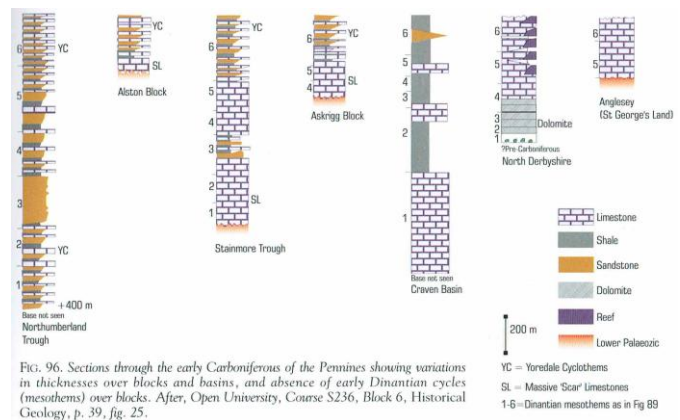


Image from Toghiani, P., 2000. *The Geology of Britain*. Crowood Press.

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Example of sequence in Swaledale

- Stylised geological section
 - Green – mainly sandstones and shales
 - Blue – mainly limestone
- Many names given to rocks by miners
- Some prominent rocks locally
 - Main Limestone – forms the cliffs between Reeth and Richmond, and Keld gorge.
 - Richmond Chert – also forms cliffs, and forms base of Richmond Castle

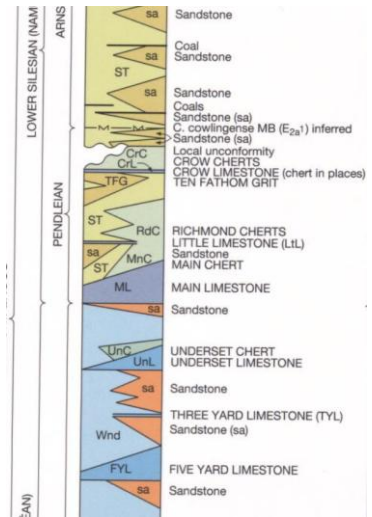


Image from 1:50000 Richmond Sheet (41). British Geological Survey © UKRI 2025. All Rights Reserved.

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Today all these layers still lie flat over Swaledale

- The Carboniferous rocks cover most of the Pennine chain
- The rocks are flat lying – no great earth movements tilting surface
- In general the sequences of rocks are quite similar across a long distance

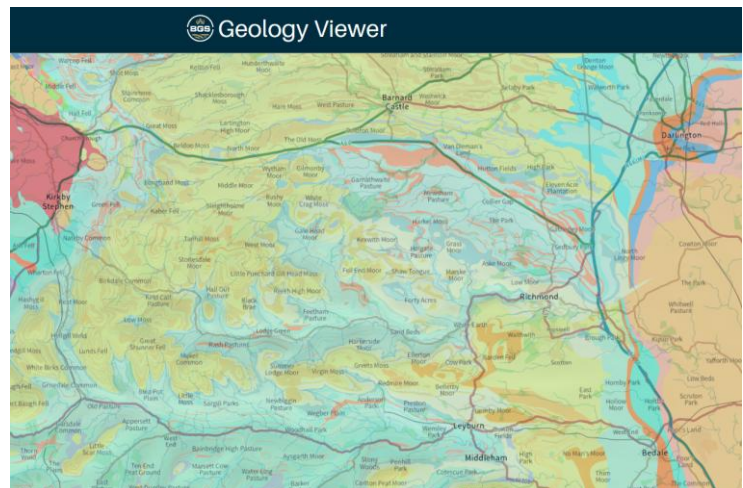


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Once solidified faults developed in the brittle rocks

- A look near Keld – we will see later
- Flat lying strata
- Limestones lower down (blues)
- Sandstones higher up (browns)
- Black lines show faults
 - Mainly west-east
 - Or northwest – southeast
 - Driven by Africa colliding with Europe

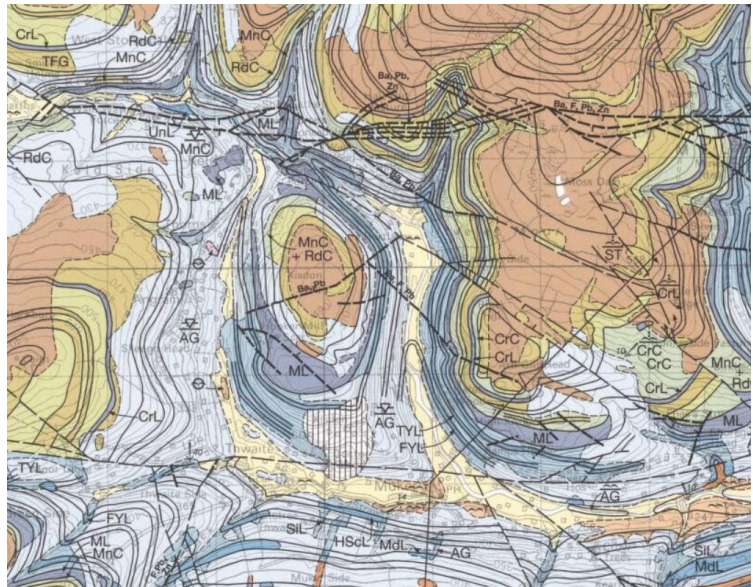
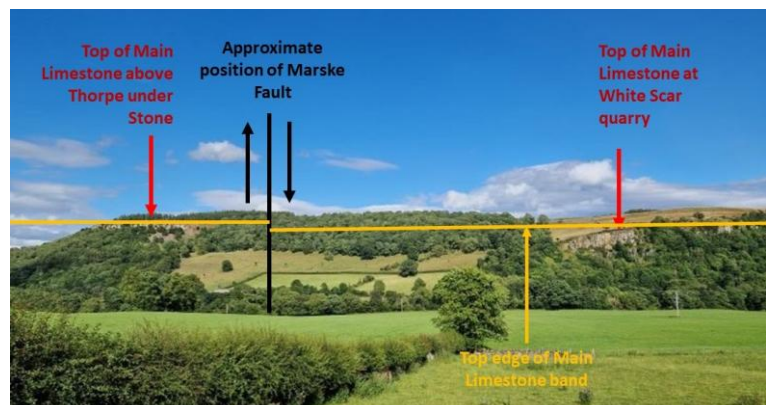


Image from 1:50000 Kirkby Stephen Sheet (40) . British Geological Survey © UKRI 2025. All Rights Reserved.

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An example of a fault at Marske “The Marske Fault”

- Runs SW-NE
- 30m displacement
- Probably “controlled” the route of Marske Beck – faults are often zones of weakness in rocks
- W-E faults between Muker and Reeth control the route of Swaledale



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Lead mineralisation subsequently took place along the faults

- Faults shown in gold (all of them on this map!) have lead ores along them
- Hot underlying granites caused fluids carrying heavy elements such as lead to rise and crystallise in the rocks above
- Most mineralisation is found in the impermeable limestones
 - Filling cracks cutting through strata in Swaledale

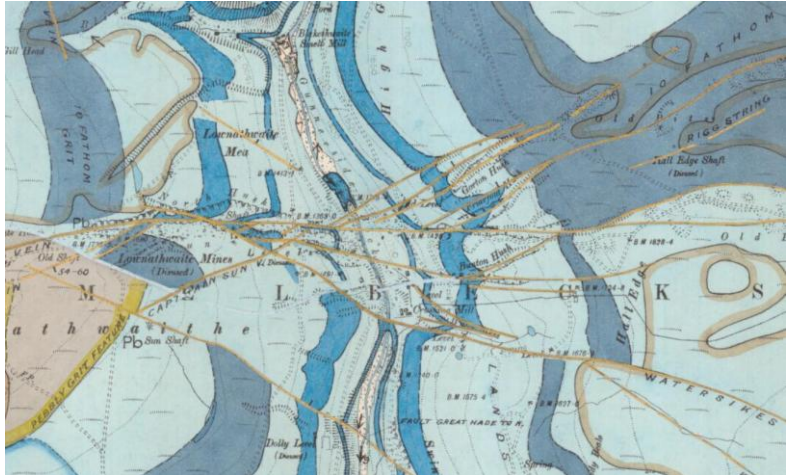


Image from 1:10650 County Series map – Yorkshire 26SE. Reproduced with the permission of the British Geological Survey © UKRI 2025. All Rights Reserved.

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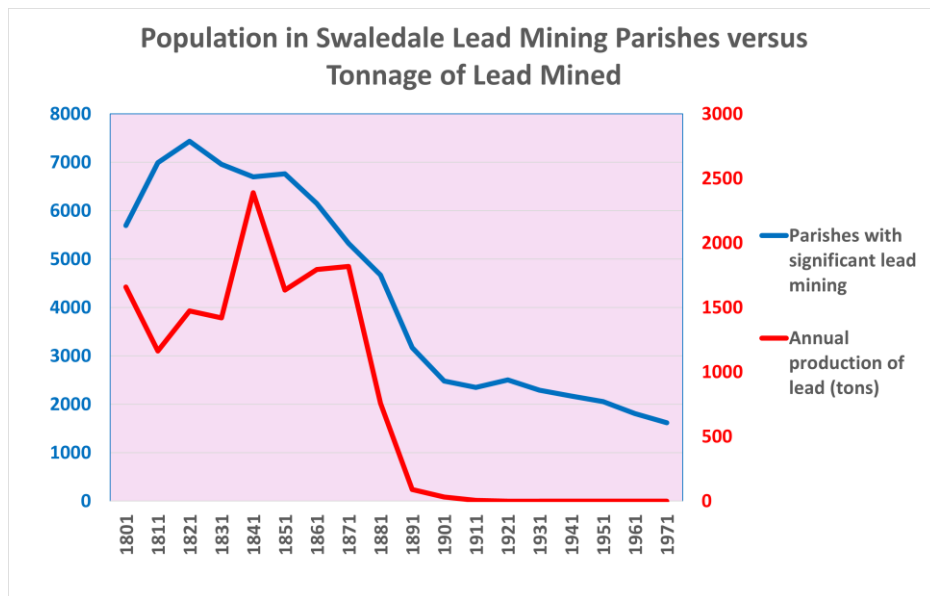
Lead smelting

- Main lead ore is Galena (PbS)
- Process is smelting (not melting)
 - Perhaps 10 smelt mills in C19
- Recipe for making lead metal on a wood fire
 1. Heat Galena in a hot fire in the air
 - $2\text{PbS} + 3\text{O}_2 \rightarrow 2\text{PbO} + 2\text{SO}_2$
 2. Liquid Lead Oxide (PbO) will sink to base of fire where there is less oxygen and maybe charcoal
 - $\text{PbO} + \text{C} \rightarrow \text{Pb} + \text{CO}$
 - $\text{PbO} + \text{CO} \rightarrow \text{Pb} + \text{CO}_2$
- Btw SO_2 (Sulphur dioxide) isn't good for your health or your children's health
- It isn't quite this simple – and quite a lot of lead ends up left in the ashes.
 - Where it is still killing plants and sheep



Image from Richardson, R. 1759. *A Plan of the Clints Estate*. Reproduced with the permission of North Yorkshire County Archives – ZAZ files.

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Sources: www.markseswaledale.com.
 Historical Population Report website. *Censuses of England and Wales, 1801-1931*.
 University of Portsmouth Great Britain Historical GIS Project (2003-23). [Vision of Britain Through Time Website](http://www.visionofbritain.org.uk).
 Fieldhouse, R. and Jennings, B. 1978. *A History of Richmond and Swaledale*.

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That gets us to 300 million years ago

- Very little then happened .. zzzzz
- Swaledale got buried by more rocks from the later Permian period (perhaps 1-2km thick)
 - All that has now been eroded away in Swaledale
 - Everything has been slowly eroded down to a flat plateau dissected by rivers.
- Further afield:
 - The Atlantic formed (c50-60 Ma) – Arctic Ocean fringed by continents
 - Antarctic continent settled over South Pole (c30 Ma)
 - Both these events led to Earth becoming cooler
 - Leading to glaciation – 2 Ma (and finally 20000 years ago).

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Cordilleras Lane, Marske. Painting reproduced with the permission of David Morgan Rees, and Richmondshire Museum.