Before the talk starts, I will show a video (no audio) of old photos of the Somerset Coafield. This will emphasise that although we focus on geology, there was a huge social impact in Somerset with the coalfield.

Introduction

I am going to start with a quote from the year **1719** (way before the well-known geologists of the 19th century) from a local Somerset geologist (I can't do the Somerset accent):

"Now as Coal is here generally dug in valleys, so the hills, which interfere between the several Works….seem also to observe a regular Course in the **Strata** of Stone and Earth found in their Bowels. …. For all Coal lies shelving like the Tyle of a House, not perpendicular nor horizontal unless it be broken by a Ridge which is a parting of Clay, Stone or Rubble; as if the veins by some violent **Shock** were disjointed and broken".

This was published by Somerset man John Strachey (STRAY CHEE) in 1719 (a full 50 years before William "Strata" Smith was born) in Starchey's paper, "Account of the **Strata** in Coal Mines".

More about John Strachey, William Smith and their Somerset coal experiences later.

Good evening, I am Andy Gordon. I moved down from the Midlands to Yeovil 3 years ago to retire from working life. I then got back into Geology (I graduated from Edinburgh in 1982), got involved with the SGG and here I am today loving every minute of it again.

Hopefully, over the next 45 minutes I will entertain and inform you about the complex geology of the Somerset Coalfield …..a bit of a secret to the general public when we think about coal in the UK.

The last coal pit closed in 1973.

The content of this Talk is a summary of my observations on the geology of the Somerset coalfield over the last 300 plus years and my interpretations / story crammed into 45 minutes. I am aiming to make this talk as lively as possible (I have already presented at the OUGS symposium this year).

Agenda

- **Overview of the Geology of Somerset / the Geology of the Somerset Coalfield.**
- **The Fossils of the Somerset Coalfield**
- **The father; the birthplace and the home of English Geology?**
- **The Coalfield Geology and the Faulting – Variscan Orogeny**

SLIDE 3:

<u>Overview of the Geology of Somerset</u>

A quick overview of Somerset geology to put the Somerset Coalfield in perspective. As I said earlier, I only moved to Somerset 3 years ago and was surprised at the importance, variety and beauty of the geology in Somerset, compared to its lovely Dorset neighbour and the famous Jurassic Coast.

SLIDE 4:

Somerset is one of the most geologically diverse counties in England.

There are 220 LGS (Local Geology Sites) all reviewed in the last 5 years by the Somerset Geology Group.

There are many different building stones – Jurassic stones such as Bath Stone; Blue Lias; Doulting and Ham Hill Stone. Also, Triassic White Lias that is shown so well in the buildings of Radstock in the centre of the coalfield.

There are five geographical areas that reflect this geological diversity:

1. **South Somerset** – The overall geology of South Somerset is broadly like that on the Jurassic Coast World Heritage Site, but with the rocks mostly hidden beneath superficial deposits, soils and vegetation. Ham Hill stone (got to mention it) is a stunning building stone and unique to a very small area.
2. **Exmoor (and it's National Park**) – Devonian, Carboniferous, Permo-Triassic and Quaternary. Earlier this year, the Earth's earliest forest (390ma) from the Middle Devonian (Eifelian) Hangman Sandstone Formation was discovered at Culver Cliff on the coast (west of Minehead).
3. **Mendip Hills (and it's National Landscape)**– Devonian and Carboniferous Limestone; Triassic and Jurassic; Quaternary and Silurian and volcanics (Somerset Earth Sciences Centre). Westhay Moor (just north of Glastonbury , famous for Glastonbury Festival mud) - there is an estimated 11 million tonnes of carbon stored in Somerset's lowland peat. (Somerset releases 300,000 tonnes per year). This is part of the Somerset Levels and Moors.
4. **Vale of Taunton Dean** – Permo-Triassic riverine deposits and the Carnian Pluvial Episode (which some of you experienced last month with Garry Dawson of SGG at the Taunton Park and Ride site).
5. **Quantock Hills (and it's National Landscape)** – Devonian sandstones and slates. Somerset is also the biggest producer of aggregates in England.

Overview of the Geology of the Somerset Coalfield

SLIDE 6:

Turning now to the complex geology of the Somerset coalfield. The Somerset coalfield had 75 coal mines covering an area of 240 square miles.

There are four different coalfields in or near Somerset. For our talk today we will focus on the Somerset Coalfield – this gives the best understood example of the complex geology due to intensive mining in the past. The structure of the Upper Coal Measures is best known in the central parts of the Radstock Syncline.

SLIDE 7:

The Somerset coalfield is made up of the Pensford and Radstock synclines.

(The maximum preserved thickness of Coal Measures occurs in the Somerset Coalfield where it is between 2500m and 2600m in depth – the economic coal seams are a tiny part of this).

Distribution of Coal Measures (outcrop and subsurface) showing coal 'basins' - Post-Westphalian earth movements have led to the separation of the Bristol and Somerset coalfields into several structurally distinct areas previously referred to locally as basins which we now refer to as synclines.

SLIDE 8:

The Fossils of the Somerset Coalfield

So that was an overview of the Somerset coalfield in relation to the other coalfields in Somerset. I am now going to "drill down" into more details of the geology of the Somerset coalfield.

SLIDE 9:

I will remind you of the Carboniferous European and British subdivisions and how they are identified.

I will also share with you the uniqueness and abundance of the fossils in the Somerset Coalfield.

SLIDE 10:

Carboniferous European subdivisions - Most coal in the UK is Upper Carboniferous and in particular - Westphalian. The Somerset Coalfield also has Lower Stephanian coal.

(Brora, Scotland is Jurassic coal)

SLIDE 11:

Standard British Chronostratigraphical Classification of the Coal Measures - This is the Chronostratigraphical Classification of the Coal Measures after Ramsbottom et al(1973).
The spore zones are after Smith and Butterworth (1967).

Somerset Coalfields span the Westphalian through to the Lower Stephanian (the boundary is still controversial).

SLIDE 12:

Writhlington SSSI –

- 3,000 tons of spoil
- 1,400 insect fossils found – the largest collection of Carboniferous insects in Britain.
- **Meganeura (Boltonites radstockensis):** Radstock's major fossil contribution to geological science - the giant dragonfly. Wing fragments found at Writhlington indicate a wingspan of 40cm, making this the largest insect ever to fly.

At this point, I will show a short video of Meganeura.

This unique fossil in now in the care of the Sedgwick Museum of Earth Sciences in Cambridge. It is a 64mm (anterior margin measurement) wing fragment that was found.

The giant dragonfly fossil was found, in 1912, in a piece of shale on the spoil of Tyning Colliery, which is near Writhlington SSSI, Radstock.
The specimen was sent to Dr Herbert Bolton, a leading authority on fossil insects, who was at that time the director of the Bristol Museum and Art Gallery. Dr Bolton (1863-1936) recognised it as being a species unknown to science, and the largest insect fossil, flying or otherwise, to be found in the British Isles. He named it Meganeura radstockensis.
Later examination of the specimen by a German palaeontologist, Anton Handlirsch, revealed that it was different to the Meganeura in certain respects. Handlirsch renamed the dragonfly Boltonites radstockensis in honour of Dr Bolton: it is the type specimen.

These giant dragonflies probably lived on smaller insects which they may have caught in glades in swampy forests that were wide-spread during carboniferous times. IT COULD BITE YOUR FINGER OFFF!

CLICK ON MOUSE:

BOB NICHOLL'S ART mention

Other insect fossils in the 1400 plus discovered are:

- *Blattodea (cockroaches – over 1000)*
- *Chelicerates (arthropods)*
- *Araneidas (true spiders)*
- *…plus innumerable plant fossils.*

Blatodea Archimylacris and Mymarommatidae families

Protorthoptera and Palaeodictyoptera also occur. Frequent chelicerates (arthropods) include trace and body fossils of xiphosurid merostomes and arachnids, including Phalangiotarbida and Trigonotarbida and also true spiders (Araneida). Rare myriapods (millipedes) and occasional conchostracan crustaceans (clam-shrimps) also occur.

So that was an overview of the Fossils to put the Somerset coalfield in perspective.

SLIDE 14:

<u>The father; the birthplace and the home of English Geology?</u>

Somerset is historically very important in the context of geology.

However, it would be remiss of me not to mention that the evidence for William Smith's initial awareness of Earth's strata, and his indebtedness to John Strachey must be seen in the context that in 17th and 18th Century England geological knowledge of stratified rocks grew in a climate of agricultural and industrial expansion, and that its fundamental facts originated among **industrial artisans and workmen, not among academic scholars**.

SLIDE 15:

- It was in the coalfield at High Littleton that William 'Strata' Smith, first put together his ideas on stratigraphy.
- He is the father of English Geology (named by Adam Sedgwick)
- He called High Littleton the Birthplace of English Geology

Adam Sedgwick *launched Smith into the role of patriarch by publicly declaring him in 1831 "Father of English Geology". Thereafter, the practical usefulness of Smith's ideas in science, agriculture, and engineering came to be widely admitted; and by mid-18th century a general belief in the utility of science, such as Smith's work, was being celebrated in two huge industrial exhibitions mounted in 1851 and 1862*.

SHOW MAP:

William 'Strata' Smith (23 March 1769 – 28 August 1839) was an English geologist, credited with creating the first detailed, nationwide geological map of any country in 1815. HE DID THIS ALL BY HIMSELF.

In 1791 – aged 21- Smith travelled to Somerset to make a valuation survey of the Sutton Court estate building on earlier work in the same area by John Strachey.[5] He stayed in the area for the next eight years, including work with the Somersetshire Coal Canal Company, living at Rugborne Farm in High Littleton. During this period, Smith inspected coal mines in the area, where he first observed and recorded the various layers of rock and coal exposed by the mining. Smith's coal mine studies, combined with his subsequent observations of the strata exposed by canal excavations, proved crucial to the formation of his theories of stratigraphy.

Smith later called High Littleton (5 miles north-west of Radstock) "The Birthplace of English Geology"

Interestingly, the specific term "German Ocean" has its earliest documented origins as "Oceanus Germäic" on printed Ptolemy maps dating back to 1477. However, during

the First World War, this appellation fell out of favor, and German cartographers eventually abandoned it in the 1920s.

SLIDE 16:

<u>Who has heard of John Strachey?</u>

- Born almost 100 years before William Smith, this Somerset (Chew Magna) man produced this drawing in 1727. He introduced a theory of "stratum".
- Strachey's stratigraphical cross-sections, of which he published several, are the earliest known in scientific literature.
- If High Littleton is the birthplace of English Geology according to Smith….I would propose that Chew Magna is actually the real Birthplace of English Geology and we could call High Littleton the "home of English geology"?

Some of you may not be aware of John Strachey FRS (10 May 1671 – 11 June 1743[1]) a geologist and topographer born in Chew Magna, Somerset, 11 miles from Radstock.

I quoted Strachey at the beginning of this talk: "Now as Coal is here generally dug in valleys, so the hills , which interfere between the several Works….seem also to observe a regular Course in the Strata of Stone and Earth found in their Bowels" - 1719 (50 years before Smith was born).

Strachey did not stray as far across England as Smith (with his mapping) – Strachey was busy fathering 19 children.

He introduced a theory of rock formations known as Stratum, based on a pictorial cross-section of the geology under his estate at Bishop Sutton and Stowey in the Chew Valley and coal seams in nearby coal works of the Somerset coalfield, projecting them according to their measured thicknesses and attitudes into unknown areas between the coal workings. The purpose was to enhance the value of his grant of a coal-lease on parts of his estate. This work was later developed by William Smith.

He was born in Chew Magna, England. He inherited estates including Sutton Court from his father at three years of age. He matriculated at Trinity College, Oxford and was admitted at Middle Temple, London, in 1688. He was elected a Fellow of the Royal Society in 1719.

In addition to his map making and geological interests he had several other publications including An Alphabetical List of the Religious Houses in Somersetshire (1731).

He died in Greenwich, London. He had married twice; firstly Elizabeth Elletson, with whom he had 18 children (see picture of 8 of them) and secondly Christina Staveley, with whom he had a further one child.

John Anstie (1873) refers to Strachey paper of 1719 – the earliest published notice of the Somerset Coalfield.

So, to summarise…it was here in Somerset that – due to the coal – Smith and Strachey can claim fame to being the father of English geology; the home of English geology and the birthplace of English geology.

So that was an overview of the History of Geology in the Somerset Coalfield.

SLIDE 18:

<u>The Coalfield Geology and the Faulting – Variscan Orogeny</u>

On this slide, I have listed the main faults locally and the type of fault.

As I mentioned earlier, "due to intensive mining in the past, the structure of the Upper Coal Measures is best known in the central parts of the Radstock Syncline, northwards from the Southern Overthrust." So… we are going to focus on the Radstock syncline, which is part of the Somerset Coalfield.

The character of the coalfield is mostly a series of east-west slide and overthrust faults caused partly by the Variscan Orogeny (with some north-south faults).

SLIDE19:

Without, I hope, insulting you…a quick overview of the Variscan Orogeny.

Post-Westphalian (Variscan) earth movements have led to the separation of the Bristol and Somerset coalfields into several structurally distinct areas (previously referred to as basins).

UK is highlighted in yellow

The Variscan (sometimes referred to as the Hercynian or Armorican) orogeny spanned about 100 million years. The main effects on the UK took place in the late Carboniferous to early Permian (about 290 million years ago).

The event created the Variscan mountain belt, which includes the mountains of Portugal and western Spain, southwest Ireland, Cornwall, Devon, Pembrokeshire, the Gower Peninsula and the Vale of Glamorgan).

In the Somerset coalfield the Variscan Orogeny has caused North-South shortening of approximately 20 km (40%) calculated from deformed and restored strike-normal sections (Williams and Chapman, 1986).

The main trend of the fold axes is E-W, indicating the N-S collision.

The effects of the Variscan orogeny are more profound in south-west England than elsewhere in the United Kingdom.

SLIDE 20:

Just a recap from earlier in the talk - Post-Westphalian (Variscan) earth movements have led to the separation of the Somerset coalfield into two structurally distinct areas previously referred to as basins.

In the centre of the synclines are the Upper Coal Measures; whilst the “easiest” mining is to the to the west and east geographically where the Lower and Middle Coal Measures are.

Less than 10% of the coal is exposed at the surface.

The deepest shaft was 500m.

SLIDE 21:

Apologies again for keeping it simple:

A quick definition of two types of faults:

1. Radstock Slide Fault = overthrust fault
2. Southern Overthrust = reverse thrust fault

We will talk about these types of faults more in a minute.

SLIDE 22:

Now we are going to dig deeper:

Let’s look now at a couple of BGS maps of the Somerset coalfield.

Firstly, an old map from 1931 (originally surveyed in 1883)

Six inches to One Statute Mile

Amazing how accurate a map from almost 150 years ago was.

The red line is the Radstock Slide Fault (E-W orientation. Variscan)

The blue line is later faulting known as the Clandown Fault Belt.

SLIDE 23:

Here is the latest map – from 1962. BGS 1 inch to 1 mile Bristol. District. At this time, some mines were still open as you can see from the key.

The Radstock syncline itself trends NW.

The Radstock syncline is broken predominantly by E-W-ish thrusts or reverse faults. The Farmborough Fault Belt in the North and the Southern Overthrust in the south mark the boundary of the Radstock syncline.

The N-S trending faults date after the E-W-ish thrusts / faults.

Faulting normal to the axis of the syncline is widespread and appears to be arranged in three belts.

1. PINK HIGHLIGHTER:

The southern half of the syncline is characterised by numerous low-angle thrust faults dipping in a southerly direction and of which **the Radstock Slide** is the best known. Another example is the **Southern Overthrust.**

A similar, though smaller group of southerly-dipping overlap faults, with an overall northwards throw of around 200 m to 250 m, is present at the northern limit of the syncline, and is known as **the Farmborough Fault Belt.**

2. GREEN HIGHLIGHTER:

In the middle and deepest part, between Braysdown and Dunkerton, there is a swarm of east–west- to ESE–WSW- trending normal faults that dip to the north and rotate successive blocks downwards to the south, and which may possibly be related to under thrusting beneath.

3. BLUE HIGHLIGHTER:

Cross-cutting these faults, there is a later series of north-south-trending normal faults subparallel to the axis of the syncline that apparently represents a final tensional phase of earth movement. The **Clandown and Luckington** faults are the most important of these; the former has a maximum downthrow to the west of 220 m.

Radstock Slide = overthrust fault

Southern Overthrust = reverse or overthrust fault (!!)

Luckington Fault = North -> South

Farnborough Fault Belt

Vobster Klippe

G1a (grey) = white lias and blue lias

F6 (pink) = tea green marl (Triassic)

SLIDE 24:

This is section 5 of the BGS map on the previous slide

If you remember slide 20, in the centre of the synclines are the Upper Coal Measures (yellow); whilst the "easiest" mining is to the to the west and east geographically where the Lower and Middle Coal Measures (green) are.

In order of youngest first:

g = Jurassic

f= Triassic

d6b = Upper Coal Series (Upper Coal Measures) - yellow

d6a = Pennant Series (Upper Coal Measures – Westphalian C and D Stages) – mainly sandstone. USED AS PAVING IN YEOVIL!

d5 = Middle and Lower Measures - green

G1a = White lias and blue lias

F6 = tea green marl (Triassic)

CRUSHED AND DISTORTED MEASURES: The Variscan Orogeny caused the mining to be dangerous – dust; methane and water

Even today, there are many unanswered stratigraphy related questions to be answered…..which makes the history of the geology and the actual mining remarkable imho

(Ussher 1890 " The remarkable slide fault which has thrust almost horizontally the upper portion of the Radstock series over the lower half, back from the direction of the Mendips northward for a distance of from 130 to 220 feet, extending beneath Radstock from the c Old Red 5 in the north to an unknown distance southwards (but certainly past Bram hill Farm), and from Upper Writhlington Pit in the east, probably to the village of Welton in the west. The vertical displacement caused by this fault varies from 0 to 60 yards, and the amount of slide from 0 to 350 yards"*).

SLIDE 25:

THIS IS THE SECOND LAST SLIDE

Coal Seams: Radstock (yellow) and Farrington Series (yellow) are the most profitable seams. There are 17 seams – 12 cycles of sedimentation and 5 cycles of regression

Pennants – intertidal dark green sandstones sometimes oxidised. These separate the Upper Coal Series from the Lower Coal Series

OD = ordnance datum i.e. height reference to sea-level.

Supra Pennant Measures include:

1. Radstock Group - thin seams rarely greater than 0.7m
2. Barren Red Group – 90m thick....no workable seams.
3. Farrington Group - thin seams, 2 of the seams are less than 0.6m

The coal type is essentially bituminous and was used by the gas industry. The lack of fire damp meant that most mines could work using a naked flame for light.

SLIDE 26:

THIS IS THE LAST DETAILED SLIDE ON THE FAULTING

Strongly incompetent nature of the Lower and Middle Coal Measures (green) allowed the Pennant Measures to the north to fold regularly and independently; to the south are steeply dipping carboniferous limestone.

Faults shown here are:

1. **Farmborough Fault Belt** – southerly-dipping overlap faults with a northwards throw of up to 250m
2. **Southern Overthrust (red)** – reverse fault that has an estimated overthrow to the north of at least 750m
3. **Vobster Klippe** - (German for cliff or crag) is a geological feature of thrust fault terrains. The klippe is the remnant portion of a nappe after erosion has removed connecting portions of the nappe. This process results in an outlier of exotic, often nearly horizontally translated strata overlying autochthonous strata.

As a result of the faulting, the 3 x different coal measures (Lower, Middle and Upper) have been affected as follows:

1. **Lower and Middle Coal Measures (green)**
    1. Only been worked in the South (e.g. Vobster) i.e. at the edge of the "Easter Egg" basin. The seams vary between 0.75-1.9m thickness (including 2 in the Pennant Measures).
    2. 580m thick (the top 150m are placed in the Pennant Measures).
2. **Upper Coal Measures (yellow)**
    1. Pennant Measures - twice as thick as the Lower and Upper Coal Measures – 1100m. Mostly sandstone.
    2. YELLOW: Supra-Pennant Measures - 900m thick and occupy the central part of the Radstock Syncline.

On average, the vein size is 24" (vein was the word that originated from lead mining)

autochthonous = native to the soil

*nappe or thrust sheet = **a large sheetlike body of rock that has been moved more than 2 km (1.2 mi) or 5 km (3.1 mi) above a thrust fault from its original position.** Nappes form in compressional tectonic settings like continental collision zones or on the overriding plate in active subduction zones.*

Sibly (1912) successfully interpreted the Vobster 'inlier' as a klippe due to large scale overthrusting of Lower Carboniferous above Upper Carboniferous rocks.

When a thrust sheet such as the Belt rocks above the Lewis Thrust is subject to erosion, sometimes it gets sufficiently chewed away so that only small remnants are left, like "islands" surrounded by the footwall rocks below the thrust. This situation results in a feature called a klippe. If you have more than one, they are klippen, plural.

- *Pericline –*
    - *An elongated dome that forms during sediment deposition.*
    - *The strata within a pericline slope upward from the crest.*
    - *It is characterized by convex-upward folding.*
    - *The oldest rock layers are found at the core of the pericline.*

Page 72 of "Bristol and Gloucester Region" has more data

The structure at depth remains unproved because no workings penetrate to the Pennant Measures north of the Southern Overthrust. (P948972).

THANKYOU

If anyone asks you about what you have discovered today about the complex geology of the Somerset coalfield, I will prompt you by saying the following three things:

1. Complex Faulting of the Somerset Coalfield – one of 4 coalfields in the area.

2. William Smith and John Strachey – the father; the home and the birthplace of English Geology.

3. The largest collection of Carboniferous insects in Britain; Radstock's major fossil contribution to geological science - the giant dragonfly.

There is a final slide of my references.

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