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Contact: info@ukrigs.org.uk

LABORATORY DEMONSTRATION. This activity is taken from the Earth Science Education Unit (ESEU) workshop "Investigating The Changing Earth and Atmosphere". Activity 3D. Contact eseu@keele.ac.uk

INVESTIGATING EVAPORITE SEDIMENTS

1) Equipment And Preparation.

Obtain a wok or similar metal dish. Prepare artificial "seawater" as follows:
Dissolve in hot water several tablespoonfuls of calcium chloride, sodium chloride and potassium chloride in roughly equal quantities. Allow the solution to evaporate slowly from the wok, e.g. in an airing cupboard. [Real seawater contains calcium hydrogen carbonate and calcium sulphate, rather than calcium chloride. These salts are not present in sufficient concentration to give convincing brick red flame when tested.]
You will also need a Bunsen burner and gas supply; nichrome wire in a suitable handle; dilute (0.5M) hydrochloric acid; blue tinted glass.

2) The Situation.

Explain to pupils that in a hot arid climate, water readily evaporates from a shallow body of seawater (not a deep and circulating ocean), thus concentrating the soluble salts dissolved in it. Eventually these salts may crystallise and sink to form evaporite deposits, some of which are of considerable economic importance. The order in which the salts crystallise is related to their solubility, with the **least** soluble forming first, and sinking to the bottom first.

The wok represents a shallow inland, or semi enclosed basin of seawater, where progressive evaporation of "seawater" has occurred, leaving behind the dissolved salts as "evaporite deposits". As evaporation continues the area below "sea level" gradually shrinks, until only the lower, more central parts of the "sea basin" are covered by very shallow concentrated brines precipitating the most soluble of the dissolved salts.

3) The Demonstration.

Pupils should told about the preparation of the wok and what it represents. They should be asked to predict, giving their reasons, the sequence of deposition of the three dissolved salts, and their distribution in the wok. *(They are in increasing order of solubility: calcium chloride below, then sodium chloride, with potassium chloride on top, arranged concentrically at the surface, with calcium chloride round the edge, and potassium chloride in the centre, where the last parts of the brine evaporated.)*
The flame test can then be used to test for the presence of cations according to the pupils' predictions. Proceed as follows: take a small sample of the salt from the "sample site" on the nichrome wire and hold it in the Bunsen flame, whilst watching for the characteristic colour. (Sometimes this is very fleeting!) Dip the wire into the dilute hydrochloric acid between the tests to clean it.
(The characteristic colours are: SODIUM=yellow; CALCIUM = brick red; POTASSIUM = lilac).

4) The Discussion.

Pupils should be told that the wok and the "seawater" were a simplified model of the real situation, and asked to speculate on the variables involved in evaporating real seawater. (See **SE4 briefing** for guidance on homework responses)

The sequence of rocks formed by evaporating seawater can be surprisingly complex, with the sequence of layers being influenced by many variables. These include:

i) The nature of the barrier separating off a seawater basin from the open ocean and the frequency with which it is breached;
ii) seawater temperature;
iii) changes in influx of normal seawater (normal salinity is 35 parts per thousand, but can reach 40 parts per thousand in the Red Sea);
iv) salinity of the incoming seawater (which may have been partially concentrated by evaporation elsewhere);
v) water depth and re-solution of precipitated minerals;
vi) whether the precipitated layers are sealed off (e.g. by a layer of clay) from the overlying seawater preventing reactions, or re-solution of deposited salts.

HOMEWORK EXERCISE 1.

This is a description of what happens when the salts in real seawater are concentrated by evaporation. Read the description and then write out the list of the minerals in the order you would expect them to be deposited. Do this with the first one at the bottom of the list. (That's where we find the oldest layers of rock. The youngest are on top)

1) **Calcite** (calcium carbonate) is precipitated first;
2) **Dolomite** (Calcium and magnesium carbonate) is next;
3) **Gypsum** ($CaSo_4.2H_2O$) or **anhydrite**($CaSo_4$) depending on temperature;
4) after the original water had been reduced to about of 10% of the original volume, **Halite** (NaCl) is precipitated;
5) last of all, when the water has been reduced to the equivalent of 1.5% of the original volume the rare potassium chlorides, like **Sylvite** (KCl), and potassium and magnesium sulphates, like **Polyhalite**, would be formed.

Over geological time, such intense evaporation of seawater has been extremely rare.

Your list shows the order we would expect if the salinity of the seawater was continuously **increasing.** If at any time the salinity began to **decrease**, then the order of the layers will be expected to reverse.

List of minerals, oldest at the bottom.
(Youngest layer)

5

4

3

2

1

(Oldest layer)

The rocks deposited in Yorkshire about 255 million years ago formed in a sea known as the Zechstein Sea. These rocks seem to have been formed by evaporation of seawater, leaving behind some very valuable minerals, found today deep underground. Figure 1 below is a section through the rocks as if you could see them in a column. Study the section and then answer the questions.

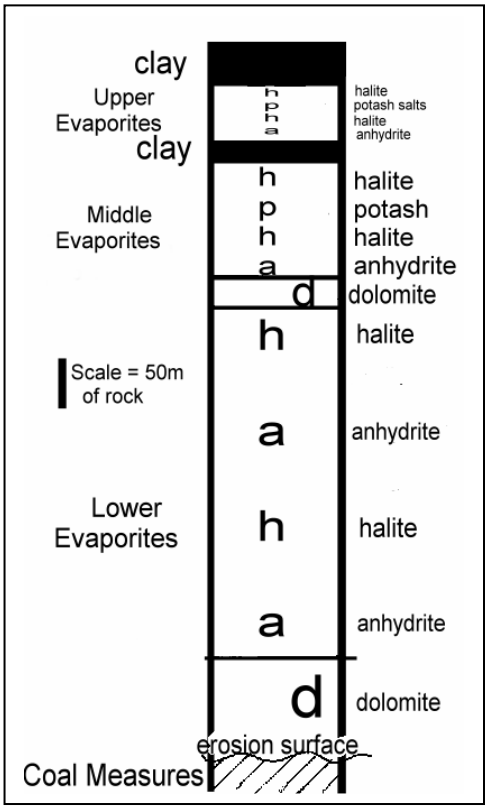

Figure 1 Geological Column

QUESTIONS:

1) Approximately what percentage of the thickness of these rocks (above the erosion surface) is made up of evaporites?
_____%

2) Shade in the parts of the column that might have been formed when the seawater was getting **more saline**. Leave blank the other parts, deposited when the seawater was getting **less saline**.

3) Can you explain why these evaporites were not re-dissolved when the sea flooded back into the area after these beds were deposited?

HOMEWORK EXERCISE 2.

Figure 2 shows the present coast of Yorkshire and the western coast of the Zechstein Sea as it was 225 million years ago. Also marked are the western edges of the areas where thick halite (NaCl) and potash (KCl) deposits are found today buried underground by younger rocks. Study the map and answer the questions below.

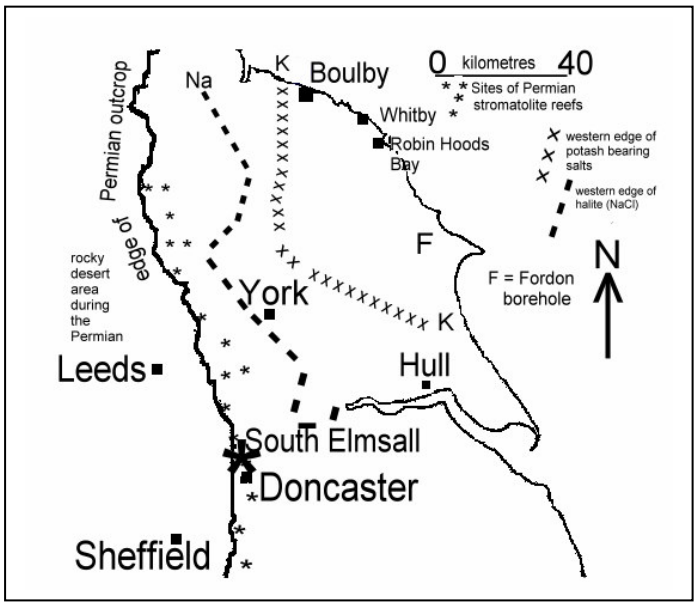

Figure 2 Map of the Zechstein Deposits in Yorkshire

1) In which direction was the centre of the Zechstein Sea in relation to Whitby?

2) Why were no evaporite salts deposited to the west of Sheffield and Leeds?

3) In which parts of the ancient Zechstein Sea did the stromatolite reefs survive?

4) Would the seawater have been deep or shallow when the potash salts were deposited? Explain your answer.

5) Why do you think very few fossils are found in evaporite rocks?

FOLLOW UP WORK

From your work at South Elmsall Quarry place the list of events below into a time sequence in the table, oldest at the bottom and building up to the youngest at the top.

Use the letter to indicate the event in the left hand column. Put the first (oldest) even next to number 1, and the last (youngest) next to number 8.

Your explanations should be based on the Earth Science principles of **Superposition** (younger beds lie on top of older beds) and **Cross Cutting Relationships** (features which cut across other features are younger) where appropriate.

A conservation of the site as an SSSI
B infilling of the quarry
C faulting uplift and tilting to the east by plate tectonic forces
D weathering and erosion revealing the dolomitic limestone at the surface
E quarrying of the rock for refractory furnace linings
F growth of bryozoan and stromatolite reefs in the shallow water
G deposition in a shallow tropical sea of dolomitic limestone in beds
H burial due to evaporite rocks being deposited on top

YOUNGEST EVENT AT THE TOP	WHICH EARTH SCIENCE PRINCIPLE DID YOU USE TO WORK OUT WHERE THIS STATEMENT GOES IN THE SEQUENCE?
8	
7	
6	
5	
4	
3	
2	
1	
OLDEST EVENT AT THE BOTTOM	