ePS Primary Controls on Organic Carbon Content in UK Upper Mississippian Gas Shales*

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Abstract

In recent years, substantial progress has been made in the production technology and assessment of shale gas plays, however, the primary ecological and depositional controls of the enrichment and type of organic material into gas shales are less well studied. These parameters have a major impact on the amount and quality of the associated gas.

Thick Namurian organic-rich mudstones in northern England are within the gas window. Complex palaeoecological and sedimentological processes, combined with cyclical sea level changes, influenced the type and distribution of organic matter input into the mudstones. The apparently monotonous mudrocks typically hold between 1 and 7% total organic carbon (TOC). Terrestrial plants as well as phytoplanktonic and other algae contributed to the organic carbon content of the deposits. The terrestrial material was delivered into the basin from river mouths and occurs throughout the entire mudstone succession, whereas the phytoplanktonic and other algae appear to be only associated with marine sediments.

This study investigates the biological influences on the quality of mudstones as a source and reservoir of shale gas. In detail, the objectives are to: (1) interpret different lithofacies in terms of sedimentary processes and changing local environment; (2) investigate the distribution and abundance of organic matter in relation to lithofacies and determine their potential for gas generation; (3) link palaeoenvironments to larger scale climate change and carbon cycle events; and finally (4) develop a predictive model relating biological input to shale gas prospectivity. For this, a multidisciplinary approach is used. Optical imaging of thin sections allows detailed lithofacies analyses. δ^{13}Corg data are used to delineate horizons with organic material from terrestrial versus marine sources, including the recognition of cryptic marine bands. These techniques are combined with the analysis of palynological samples to document basin-wide changes in environmental conditions.

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Website

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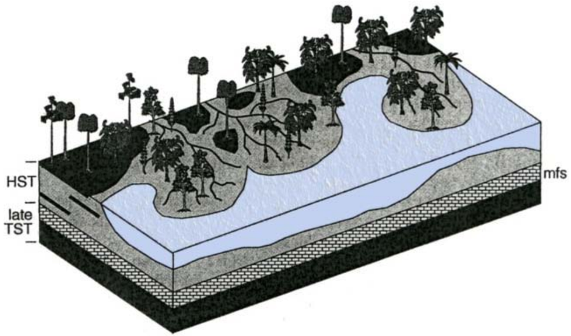

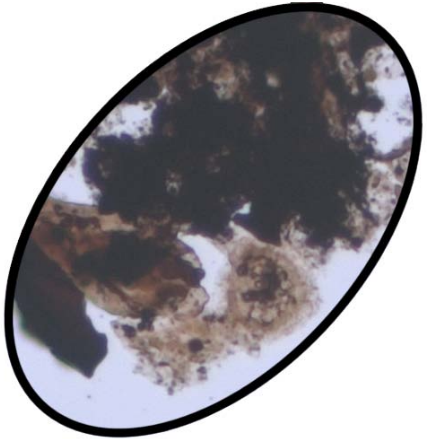

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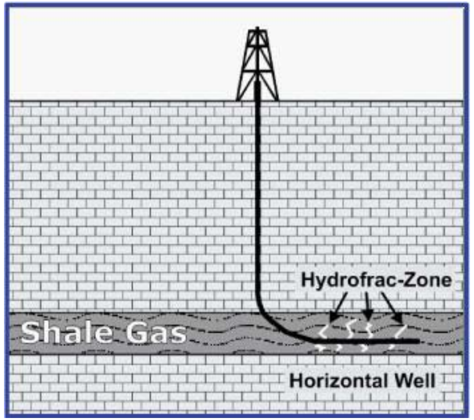
Background: Shale Gas Systems

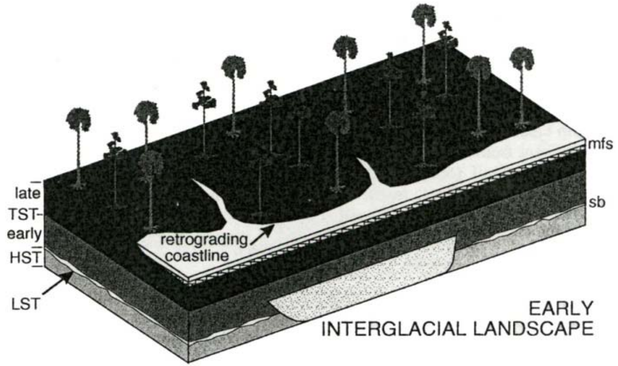
Sedimentological/Biological Parameters for Gas Generation:
Mineralogy, Fabric, TOC, Organic Matter Type

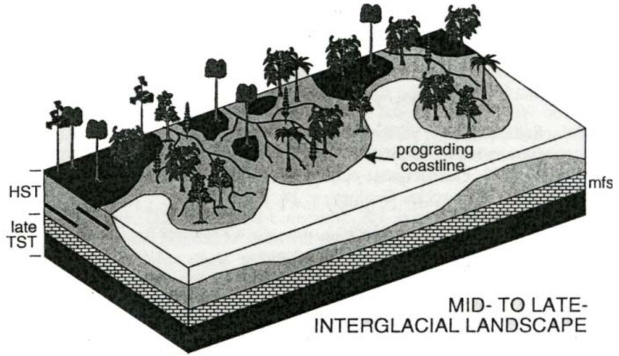


Sedimentological/Structural Parameters for Gas Production:
Mineralogy, Depth, Water Content, Reservoir Pressure, Fracture System

Biological input is dependent on...

from Falcon-Lang (2004)





High sea-level 'marine environment'

Marine algae

Some land-plant cuticles, resins and lipids

Minor woody material

OIL AND GAS-PRONE

Prospective for shale gas but oil can cause problems

Low sea-level 'low salinity environment'

Predominant woody cellular plant material

Land-plant cuticles, resins and lipids

Pollen and spores of high diversity

GAS-PRONE

Very prospective for shale gas

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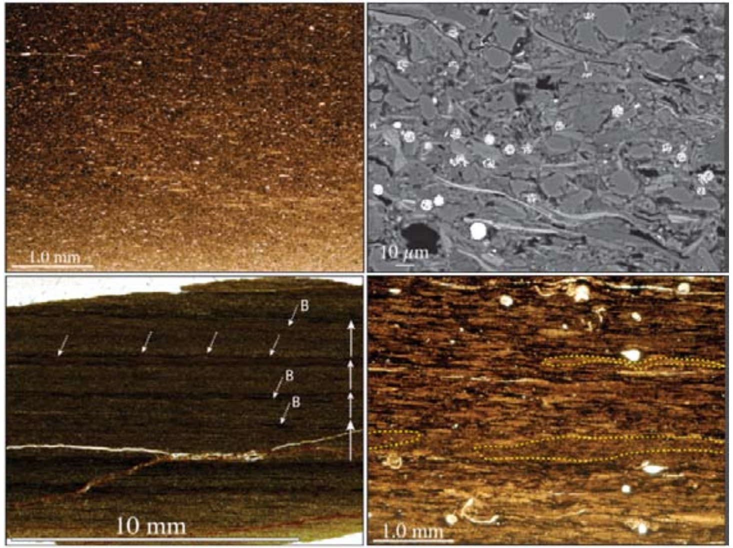
From Macro- to Microsedimentary Facies

Processes of Deposition

Different Lithofacies

Abundance, Type and Distribution of OM



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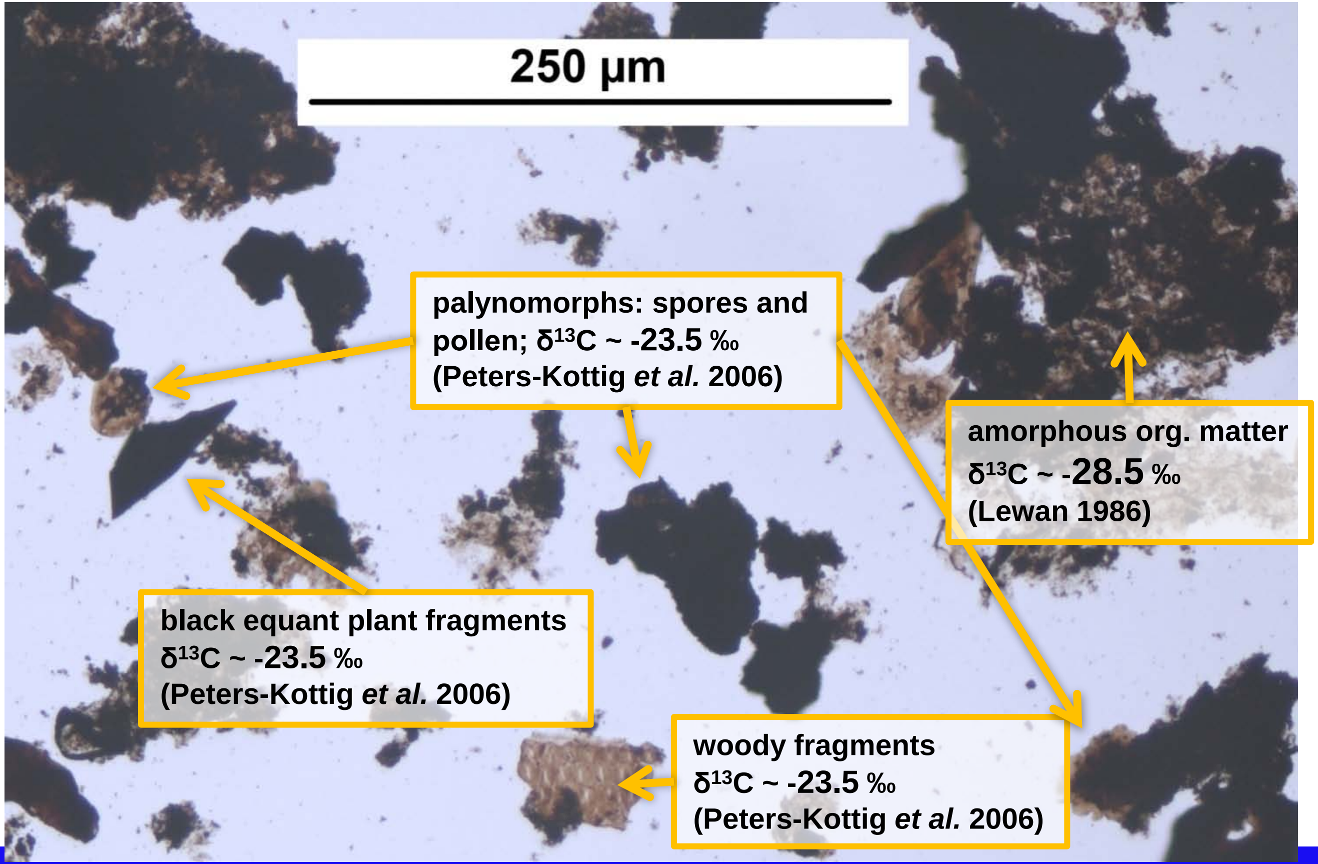
What the organic matter is made of



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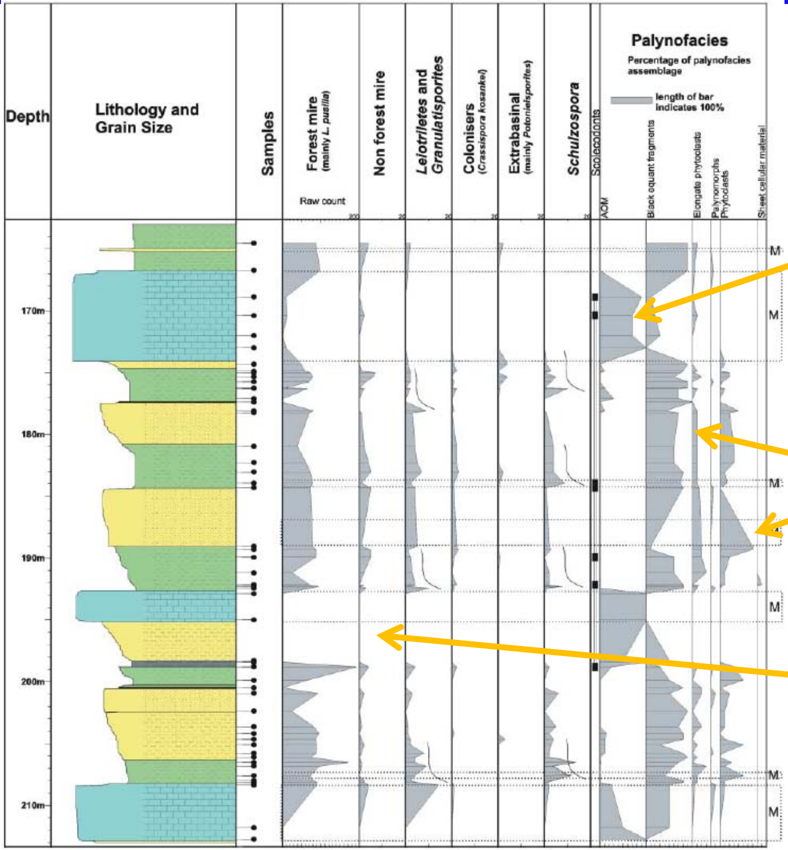
...changing depositional environments

from Stephenson *et al.* (2008)



Amorphous organic matter (AOM)

Plant fragments

Spores and Spore diversity

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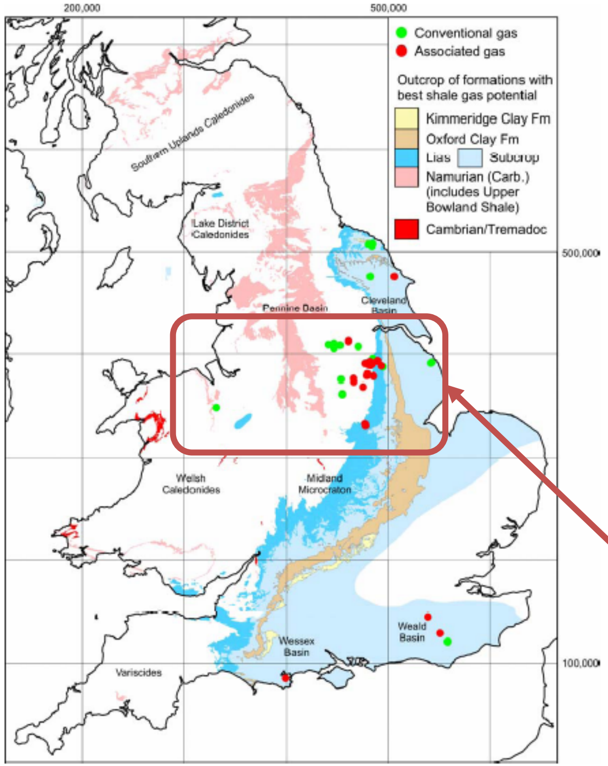
UK Prospective Shale Gas Formations

DECC (2010)



Upper Bowland Shale Formation

- Known oil and gas source rock for conventional reservoirs
- Total organic carbon (TOC) contents average 4.5% in fossil-rich marine bands and 2.5% in the mudstones between
- Deposited in an offshore basin setting → organic matter from a variety of sources

Bowland Shale exploration area

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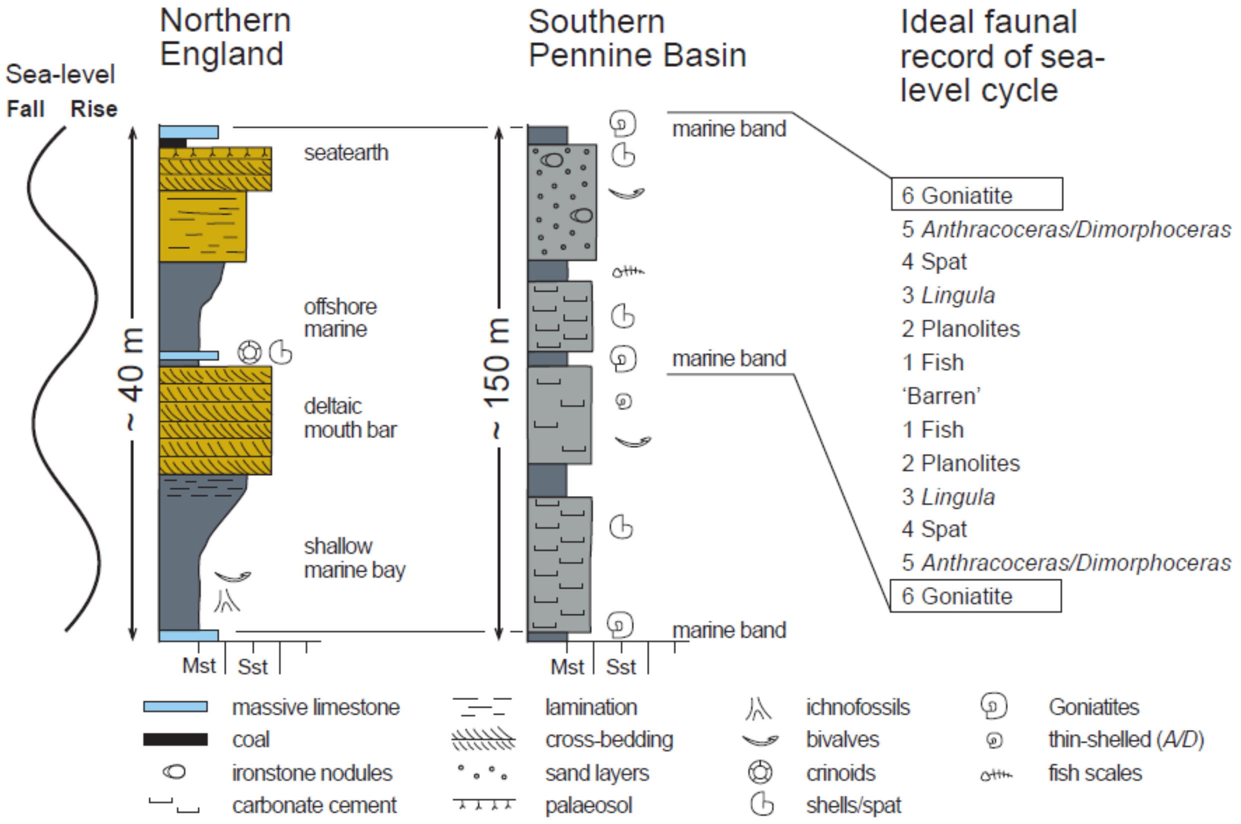
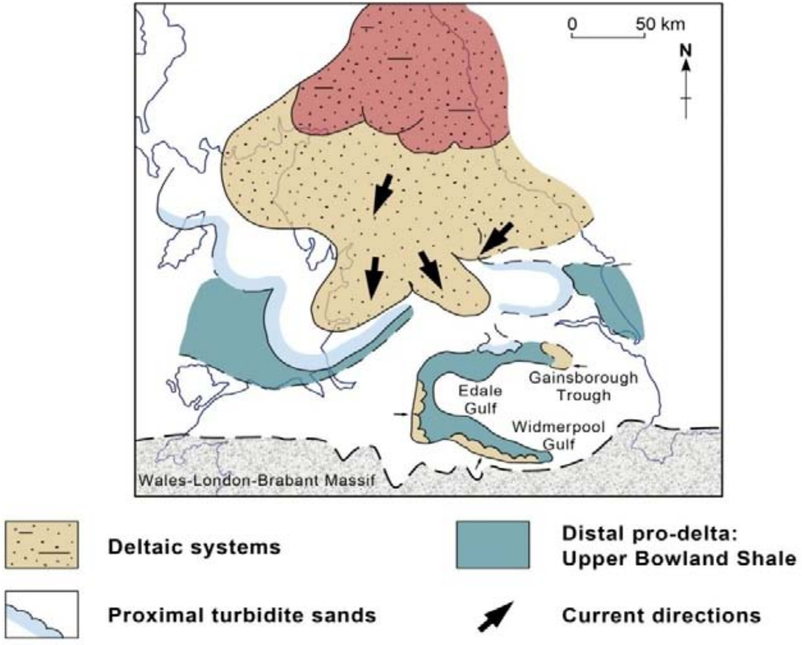
The Cyclicity of Serpukhovian Deposits

modified from Holdsworth & Collinson (1988); Davies (2008)

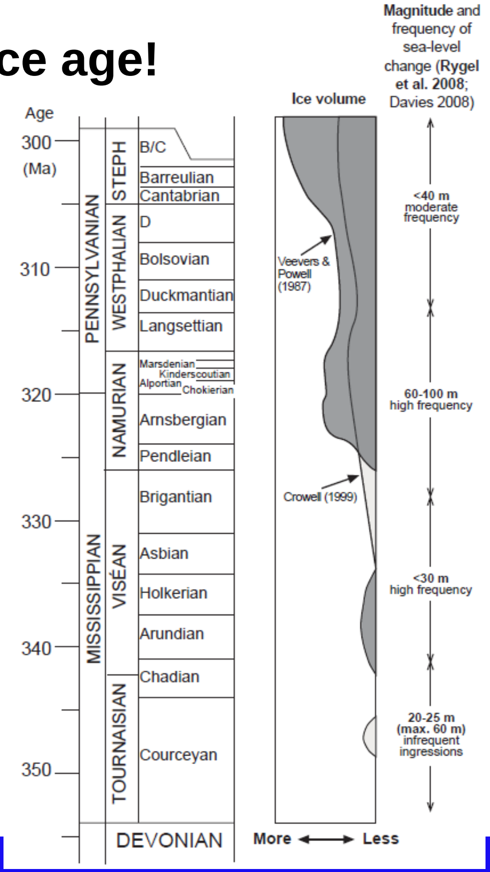


Palaeogeography

The far-field response of the late Palaeozoic ice age!



after Fraser & Gawthorpe (2003)



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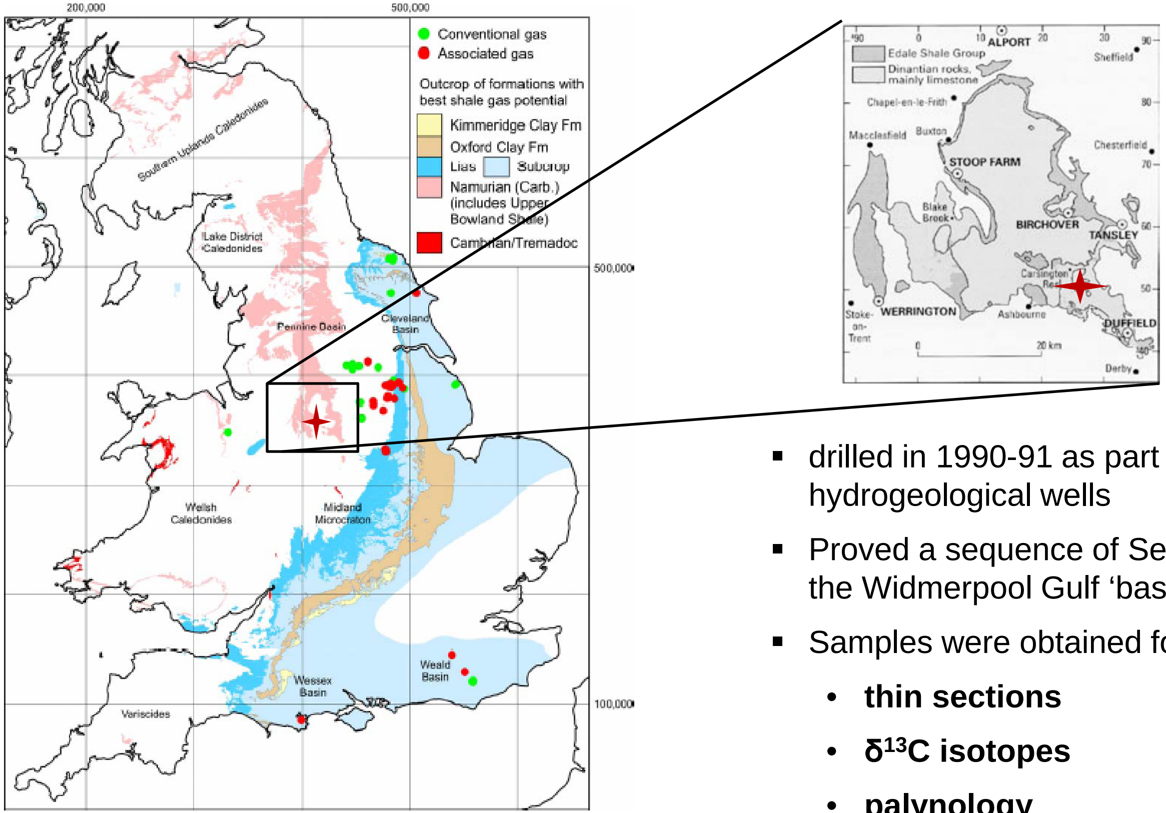
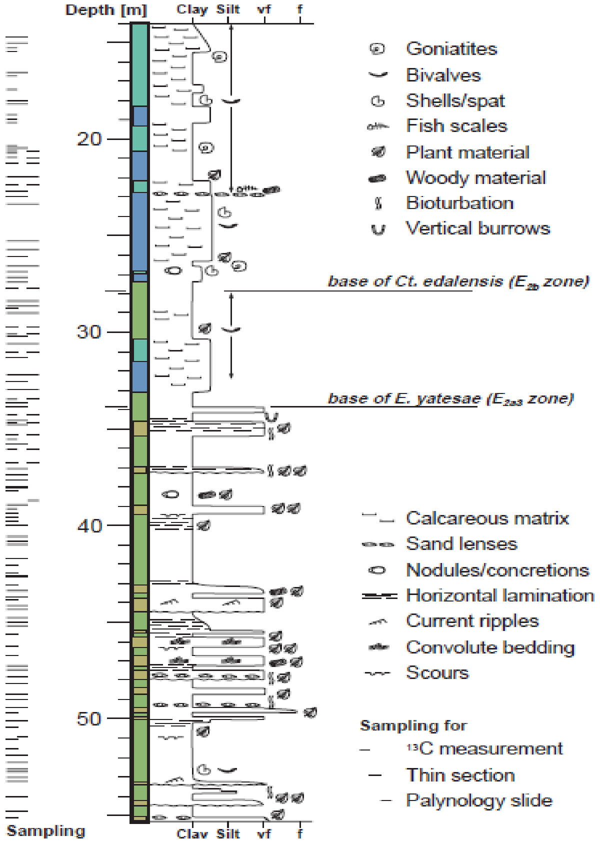
The Carsington C4 Borehole

DECC (2010)



- drilled in 1990-91 as part of a series of shallow hydrogeological wells
- Proved a sequence of Serpukhovian mudstones in the Widmerpool Gulf ‘basinal’ facies
- Samples were obtained for
  - **thin sections**
  - **$\delta^{13}C$ isotopes**
  - **palynology**

The Carsington Borehole: Sedimentology



The following lithofacies could be observed:

A. Calcareous fossil-bearing mudstones

B. Silt-bearing clay-rich mudstones

C. Clay-dominated mudstones

D. Silt-rich plant debris-bearing sandstones

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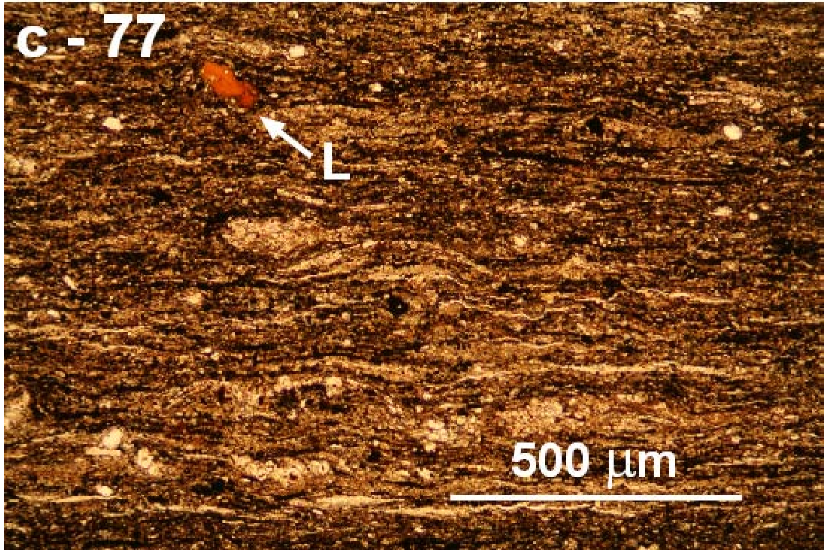
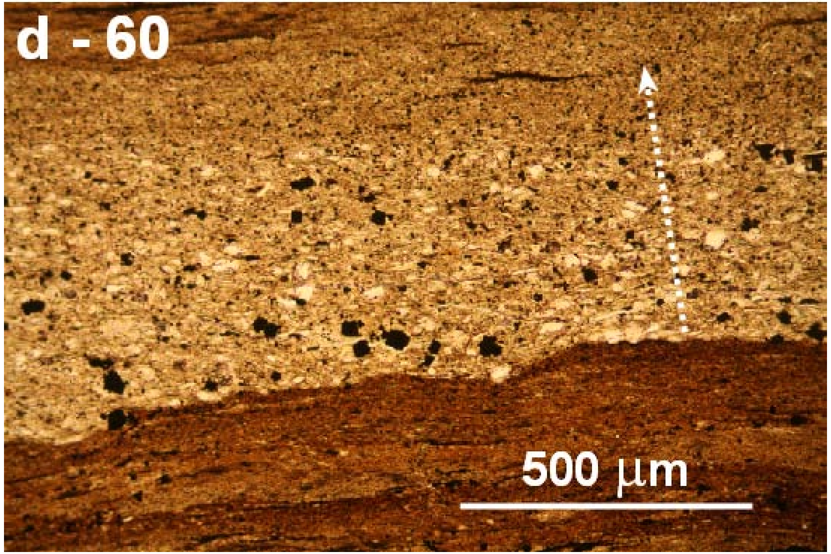
Lithofacies in Thin Section

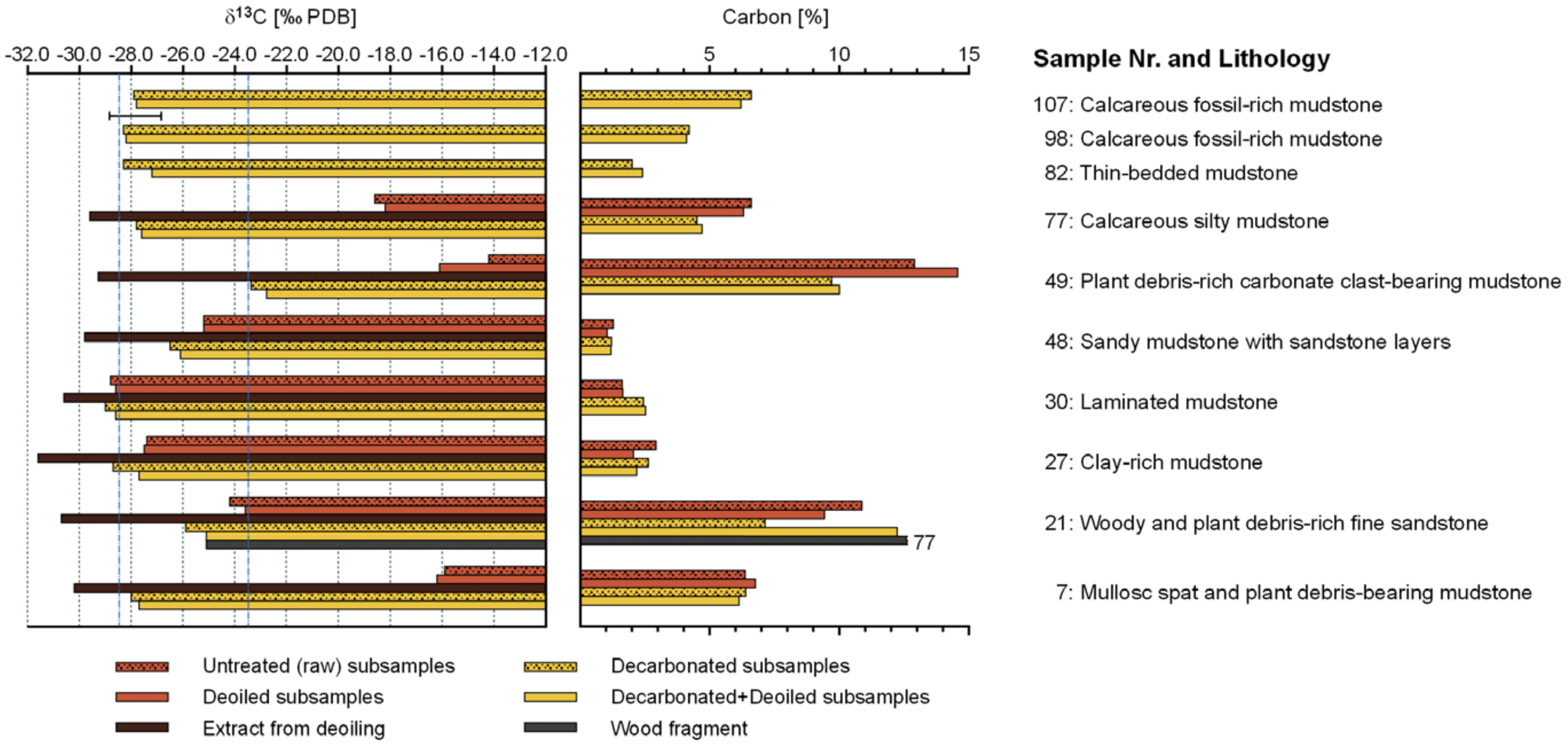


Sample 77: calcareous mudstone containing shell material and carbonate clasts (liptinite particle [L]



Sample 60: clay-rich pelleted mudstone at bottom, truncated by normal graded silty quartz-bearing mudstone

Preliminary carbon isotope data



Conclusions

Conclusions

- small-scale changes of mineralogy and sedimentary structures
- observation of the Carsington C4 core indicates relationship between organic carbon content and main lithofacies
- first isotope tests reveal relatively light isotopic material
- decarbonating as best preparation method to run routine carbon isotope analysis

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Please do come and see my poster in Location 3A in the Exhibition Hall!

or e-mail me: sven.koenitzer@le.ac.uk

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