Your name:

5GL505 Applied Sedimentology

Field Guide

William Smith's map of South Wales, ca.1815

Virtual Field Trip to South Wales, 2020

Abridged version of the full field guide.
Information on specific locations will be provided during the field trip.

Environmental Sciences, College of Life & Natural Sciences, University of Derby

Applied Sedimentology Field Course to South Wales, 27 - 30 April 2020

Travel

We will travel by virtual coach. We will be doing fieldwork en route on the first day**.**

- *Departure*: **09:00 a.m. on Monday 27th April** from the front door in Course Resources. This is the *departure* time – please be there at 8.45 to load the luggage and to confirm your attendance.
- **Bring a packed lunch.**
- *Return*: by 18:00 on Thursday 30th April (this is an estimate only)

Virtual accommodation:

1. Borth Youth Hostel, Morlais, Borth, Ceredigion, SY24 5JS. (1 night: 27-28 April) Google Maps
2. Manorbier Youth Hostel, Manorbier, near Tenby, Pembrokeshire, SA70 7TT. (3 nights: 28 - 30 April) Google Maps

Field Equipment (all items essential unless otherwise indicated)

- **Virtual hand lens – provided through online images**
- **Virtual field notebook, provided as a Word document**
- **Pencils (H & HB) and rubber. Coloured pencils**
- **Log and rose diagram sheets** – to be printed or downloaded
- **Ruler -** to use as a measuring device on field photos, in place of measuring tape
- **A4 scanner,** *or* **Microsoft Lens app** on your smartphone, to scan work for submission**.** This **short video** shows how it works.
- **Printer** – highly recommended. It is much easier and quicker to draw a log by hand on a printed sheet of log paper.
- **Topographic Maps** covering the areas to be visited, e.g. Ordnance Survey Wales & West Midlands, 1:250,000. If you have OS 1:50,000 sheets 135, 145, 157, 158, 159, 171, bring them with you, but do not buy them specially. Maps can be accessed in DigiMap.
- **British Geological Survey, 10 mile Bedrock map (South Sheet) and booklet** (issued in 1st year)
- **BGS maps** can also be accessed via the **iGeology app** for Android and iPhone, and on the web, the **BGS Geology of Britain viewer**
- **Books:** see the fieldwork section of the module reading list on Course Resources

Provisional Itinerary 2020

Locations and routes may change according to virtual weather, tides, traffic and time available.

	Localities	***Lithostratigraphy (Chronostratigraphy)***	***Grid reference***
Monday 27 April	*Travel from Derby to Borth*		
	Slight detour to Rubery, SW of Birmingham	Rubery Sandstone Formation (Lower Silurian, Llandovery Series) Unconformably overlies Lickey Quartzite Formation (Lower Ordovician)	SO 992 772 Google Maps
	Welshpool – virtual coffee, bara brith & supermarket break		
	New Quay (Ceredigion)	Aberystwyth Grits Group (Lower Silurian, Llandovery Series)	SN 389 602 Google Maps
	Aberystwyth sea front (north end)	Aberystwyth Grits Group (Lower Silurian, Llandovery Series)	SN 583 825 Google Maps
	Borth beach (south end)	Borth Mudstones Formation (Lower Silurian, Llandovery Series)	SN 606 888 Google Maps
Tuesday 28 April	Poppit Sands, Cardigan	Modern estuary	SN 155 488 Google Maps
	Freshwater West	Lower Old Red Sandstone Group (ORS): (Ludlow Series, Upper Silurian to Pragian Series, Lower Devonian)	SR 884 994 to SR 887 987 Google Maps
	Skrinkle Haven, Manorbier	Upper Old Red Sandstone Group, Avon Group and Pembroke Limestone Group (Famennian Stage, Upper Devonian to Tournaisian Stage, Lower Carboniferous)	SS 080 974 Google Maps
Wednesday 29 April	Caswell Bay, Gower	Pembroke Limestone Group (Tournaisian to Visean Stages, Lower Carboniferous)	SS 595 871 Google Maps
	Barry Island	Mercia Mudstone Group (Norian Stage, Upper Triassic) in contact with Pembroke Limestone Group (Tournaisian to Visean Stages, Lower Carboniferous)	ST 109 662 Google Maps
Thursday 30 April	Marros Sands to Amroth	Marros Group (Namurian Stage, Upper Carboniferous)	SN 199 076 to SN 182 073 Google Maps

The purpose of this virtual field course

The main objective of this virtual field trip is for you to gain experience of studying sections of sedimentary rocks from a variety of depositional environments, ranging from continental to deep marine. You will be trained in recording sedimentary sections, and in interpreting your observations so as to understand the processes, conditions and environments in which these rocks formed. You will draw and knowledge and skills acquired during practical classes. You will apply techniques used in mapping sedimentary formations. You will carry out exercises related to the application of sedimentology to petroleum geology and hydrogeology.

Another important aim is for you to become familiar with the Palaeozoic stratigraphy, sedimentology, geological evolution and palaeogeography of South Wales.

Geological Overview

South Wales is mainly composed of Palaeozoic rocks. Precambrian rocks crop out in small areas in Pembrokeshire, and Mesozoic rocks are limited to thin uppermost Triassic and lowest Jurassic in the Cardiff area. Rocks of Cretaceous and Tertiary age are lacking, the next succeeding deposits being the superficial glacial sequences of the Pleistocene.

During Palaeozoic times, Wales was underlain by continental crust. From the few exposures available in SW Wales and the Welsh Borderlands, it seems likely that this basement was composed of late Precambrian calc-alkaline igneous rocks.

The Lower Palaeozoic history of Wales commenced with early Cambrian volcanism and sedimentation in a major, subsiding depositional basin, probably oriented SW-NE – the *Welsh Basin* (Fig. 3). The boundaries of the basin were probably controlled by active fault zones such as the Menai Strait Line in NW Wales, and the Pontesford-Linley and Church Stretton Fault Systems along the England/Wales border. These faults defined the SE margin of the basin against the *Midland Platform*. These active fault zones exerted a strong influence over the Early Palaeozoic igneous and sedimentary history of Wales, particularly during the Ordovician.

From late Tremadoc through to late Caradoc times, Wales was the site of major volcanic activity, probably in a back-arc marginal basin setting. This may have been related to SE-directed subduction of Iapetus oceanic crust beneath a volcanic arc located in the Leinster-Lake District zone. Subsequent sedimentation during the Silurian reflects persistent instability within the Welsh Basin, with a dominance of deep-marine sedimentary environments. A major change in the style of sedimentation occurred with the infilling of the basin by largely non-marine Old Red Sandstone facies, which commenced as early as late Wenlock to early Ludlow times in SW Wales. This marks the onset of regional uplift related to later phases of the Caledonian orogeny.

Episodic phases of deformation extended at least until early-mid Devonian times. The regional structure of Wales is dominated by a pattern of upright to SE-verging major folds, with axial planar cleavage. All of the Cambrian-Silurian rocks of the Welsh Basin have been affected by low-grade metamorphism, ranging from zeolite facies in the platform region to greenschist facies in the trough area. A major period of deformation occurred during mid-Devonian times, and Upper Old Red Sandstone rocks rest with marked discordance on older Palaeozoic rocks. There is a conformable passage up into the overlying Lower Carboniferous rocks, which are dominated by marine mudstones and limestones, overlain by Upper Carboniferous sandstone-mudstone sequences of shallow marine, deltaic and fluvial origin.

Post-Caledonian sedimentary rocks of late Devonian-Carboniferous age are well represented in southern Pembrokeshire. During the late Carboniferous the region was uplifted and deformed as a result of deformation related to the Variscan (Hercynian) orogeny. As in SW England, the major structures are north-vergent folds and thrusts which reflect dominant compression from the south. A period of uplift and erosion followed the Variscan event, and In the Cardiff area, post-orogenic Triassic (continental) and Lower Jurassic (marine) sedimentary rocks rest unconformably on Upper Palaeozoic rocks.

SYSTEM	SERIES	LITHOSTRATIGRAPHIC UNIT		THICKNESS (m)
JURASSIC	LOWER	Blue Lias Formation (with Sutton Stone & Southerndown Beds locally developed)		140
TRIASSIC	UPPER	Penarth Group Mercia Mudstone Group (passing laterally into Dolomitic Conglomerate)		0-12 1-100
	MIDDLE			
	LOWER			
PERMIAN				
CARBONIFEROUS	WESTPHALIAN	Pennant Sandstone Formation South Wales Coal Measures Group *Gastrioceras subcrenatum* Marine Band		275-1350 900
	NAMURIAN	Marros Group	Telpyn Point Sandstone Formation ('Farewell Rock') Bishopston Mudstone Formation Twrch Sandstone Formation	20 750 190
	DINANTIAN	Carboniferous Limestone Supergroup	Pembroke Limestone Group Avon Group ('Lower Limestone Shales')	up to 1025 10-140
DEVONIAN	UPPER	Upper Old Red Sandstone Group	Skrinkle Sandstone Formation	0-350
	MIDDLE			
	LOWER	Lower Old Red Sandstone Group	Cosheston Group	up to 1800
		Lower Old Red Sandstone Group	Milford Haven Gp (inc. Ridgeway Conglomerate)	~1500
SILURIAN	PRIDOLI			
	LUDLOW	? ? ?		
	WENLOCK	Gray Sandstone Group Coralliferous Group		274-609 150
	LLANDOVERY	Skomer Volcanic Group	Aberystwyth Grits Group Borth Mudstones Formation	1200-1500

= *missing parts of stratigraphical succession, represented by unconformities*

Figure 4 ***Generalized post-Ordovician Stratigraphy in South Wales***

Reading in preparation for the field trip

Text books

Refer to the module reading list in Course Resources. The *Sedimentary Rocks in the Field* books by Tucker and Stowe are particularly useful. E-book versions of both are available.

Explore the other texts dealing with sedimentary facies and environments, e.g. James et al. (2010) and Reading (1996).

Journal articles and book chapters

I recommend you to read a selection of the following articles and extracts to prepare for the field trip. The reference list at the end of each of these articles is a good place to start exploring further.

The minimum amount of reading required is the Silurian, Devonian, Carboniferous and Triassic chapters in the following book, which is a key reference on the geology of Wales:

Howells, M.F. (2007) *Wales: British Regional Geology*. Nottingham: British Geological Survey, 230pp.

Links to extracts from this book on the BGS Earthwise site are shown below. Main page

The following references are arranged roughly in stratigraphical order.

- If the links do not work, go to the Library web site, select ***Ejournal list***, and search for the journal, volume and article from there.
- Some of these articles deal with the whole of the UK. Focus on the parts dealing with South Wales

Early Palaeozoic deep marine sedimentation

British Geological Survey (2016). Llandovery Series, Silurian, Wales. Earthwise

Schofield, D. (2009). What's in the Welsh Basin?: insights into the evolution of Central Wales and the Welsh Borderlands during the Lower Palaeozoic. *Proceedings of the Shropshire Geological Society*, **14**, 1-17.
Link to pdf

Wilson, D., Davies, J.R., Waters, R.A. and Zalasiewicz, J.A. (1992) A fault-controlled depositional model for the Aberystwyth Grits turbidite system. *Geological Magazine*, **129**, 595-607. Link to pdf [you need to be logged in to the Library site].

'Old Red Sandstone' (Late Silurian, Devonian, earliest Carboniferous

British Geological Survey (2016). Lower Old Red Sandstone, Devonian, Wales. Earthwise

British Geological Survey (2016). Upper Old Red Sandstone, Devonian, Wales. Earthwise

Marriott, S.B. and Hillier, R.D. (2014). Fluvial style in the Lower Old Red Sandstone: examples from southwest Wales, UK. Proceedings of the Geologists' Association, **125**, 534-547. Link to pdf [you need to be logged in to the Library site].

Hillier, R.D., Marriott, S.B., Williams, B.P.J. and Wright, V.P. (2007) Possible climate variability in the Lower Old Red Sandstone Conigar Pit Sandstone Member (early Devonian), South Wales, UK. *Sedimentary Geology*, **202**, 35–57. Link to pdf [you need to be logged in to the Library site].

Barclay, W.J. (2005). Chapter 1: Introduction to the Old Red Sandstone of Great Britain. *In* Barclay, W.J., Browne, M.A.E., McMillan, A.A., Pickett, E.A., Stone, P. and Wilby, P.R. (eds.) *The Old Red*

Sandstone of Great Britain. Peterborough: Geological Conservation Review Series, No. **31**, Joint Nature Conservation Committee, 393 pp. Link to pdf

Early Carboniferous marine sedimentation

British Geological Survey (2016). Dinantian, introduction, Carboniferous, Wales. Earthwise

British Geological Survey (2016). Tournaisian, Dinantian, Carboniferous, Wales. Earthwise

British Geological Survey (2016). Visean, Dinantian, Carboniferous, Wales. Earthwise

Wright, V.P. (1987). The evolution of the early Carboniferous Limestone province in southwest Britain. Geological Magazine **124**, 477-480. Link to pdf

Cossey, P.J., Adams, A.E., Purnell, M.A., Whiteley, M.J., Whyte, M.A. & Wright, V.P. (2004). British Lower Carboniferous Stratigraphy, Chapter 1. Peterborough: Geological Conservation Review Series, No. **29**, Joint Nature Conservation Committee, 617 pp. Link to pdf

Late Carboniferous fluvio-deltaic sedimentation

British Geological Survey (2016). Silesian, introduction, Carboniferous, Wales. Earthwise

British Geological Survey (2016). Namurian, Silesian, Carboniferous, Wales. Earthwise

British Geological Survey (2016). Westphalian, Silesian, Carboniferous, Wales. Earthwise

Waters, C.N. and Davies, S.J. (2006) Carboniferous: extensional basins, advancing deltas and coal swamps. *In:* Brenchley, P.J.and Rawson, P.F., (eds.) *The Geology of England and Wales*. London, England: Geological Society of London, Chapter 9, 173-223. Link to pdf

George, G.T. (2000). Characterisation and high resolution sequence stratigraphy of storm-dominated braid delta and shoreface sequences from the Basal Grit Group (Namurian) of the South Wales Variscan peripheral foreland basin. *Marine and Petroleum Geology*, **17**, 445–475. Link to pdf [you need to be logged in to the Library site]. [**Note**: the Basal Grit Group is now renamed the Twrch Sandstone Formation).

Hartley, A. J. (1993). A depositional model for the Mid-Westphalian A to late Westphalian B Coal Measures of South Wales. *Journal of the Geological Society*, **150**, 1121-1136. Link to pdf [you need to be logged in to the Library site].

Late Triassic continental sedimentation

British Geological Survey (2016). Permian—Triassic of Wales. Earthwise

Topographic maps

A general road map of Wales is useful

Ordnance Survey 1:50,000:
sheet 157 St David's & Haverfordwest area

- *sheet 158 Tenby & surrounding area*
- *sheet 159 Swansea, Gower & surrounding area*
- *sheet 171 Cardiff, Newport & surrounding area*

Geological maps

These are published by the British Geological Survey.

- Bedrock Geology of Great Britain – South Sheet
- The Rocks of Wales. 1:250,000 [covers the whole of Wales]
- 1:50,000 geological maps include sheet 209 St David's; 226/227 Milford. Bring these maps if you have them, but as we may only use them on one or two days, it is not worth buying them just for this trip.
- Access the geological maps via the iGeology App or the BGS Geology of Britain viewer

The route from Derby to Aberystwyth

Follow the itinerary on your Bedrock Geology Map of the UK (South Sheet), and make observations and notes on features of the geology and landscape, and where you see them. Use iGeology or the BGS Geology of Britain viewer, and Streetview in Google Maps.

We take the A38 south to the A5, then west on the A5 (the old Roman road, Watling Street from London to Holyhead) to Shrewsbury. We enter Wales a little further west, on the A458 to Welshpool, then follow the A483 to Newtown the A489, the A470, joining the A44 at Llangurig.

Suggested locations to note the geology are 1) around Telford (M54); the Breidden Hills north of Middletown (A458); from Llangurig to Ponterwyd (A44).

The route back to Derby

Follow the itinerary on your Bedrock Geology Map of the UK (South Sheet), and make observations and notes on features of the geology and landscape, and where you see them. Use iGeology or the BGS Geology of Britain viewer, and Streetview in Google Maps.

After leaving Pembrokeshire by the A40 and A48, we join the M4 east of Carmarthen, and leave it at Newport to take the A449, A40 and M50 northeast to the M5 and then the M42 north.

Suggested locations include: N of Bridgend (M4); a slight diversion to Aust Cliff, looking east from the M48 Severn Bridge; area N of Bromsberrow (M50/A417 junction).

Reference Section

Description of Hand Specimens of Sedimentary Rocks

This scheme may be used for the description of sedimentary rocks in the laboratory or the field. The use of a hand lens is essential if all possible information is to be extracted from the specimen.

Colour - note *overall colour* of rock, colour of *individual components*, colour on *weathered surfaces*

Composition - describe *mineralogy* of grains, and attempt to estimate the *percentage* of each mineral. For *carbonate grains*, identify *grain type* (bioclasts, ooids, pellets/peloids, intraclasts, etc.) and estimate *percentage* of each. *Rock fragments* - give *identifying features* and *name*. *Fossils* - are they whole or fragmentary? Which *fossil groups* are present? **Matrix and cement** - *composition* and *percentage*.

Grain size and sorting - estimate both *mean grain size*, and *range of grain size*. Estimate *sorting*. Is grain size distribution *unimodal*, *bimodal*, *polymodal*?

Exact grain size of mud grade sediment is impossible to determine by eye. Try the *self-polishing test*: rub two pieces of the rock together - if clay grade, they form shiny, reflective surfaces; if silt grade, a matt powder is formed.

Grain shape - *sphericity* (are grains *equant*, *elongate* etc.); *roundness* and *range of roundness; surface features of grains* (faceting, frosting etc.) **Support** - is the rock *grain-supported* or *matrix-supported*?

Porosity - estimate percentage porosity.

Consolidation - is rock *well-consolidated*, *friable* etc.**?**

Orientation - do elongate grains have a *preferred orientation* (e.g. parallel to lamination; imbricated; shells orientated convex upwards)?

Sedimentary structures & trace fossils - describe bedding, lamination and other structures, noting *size* (thickness, amplitude etc.): use *sketches*

Other features - e.g. veins, stylolites, concretions.

Rock name - give the rock an accurate name, based on your description. Name should be based on both *compositional* and *textural* attributes. Use appropriate adjectives to *qualify* the name: e.g. glauconitic medium sandstone; crinoidal bioclastic limestone; calcareous pebbly sandstone. (N.B. do <u>not</u> attempt to apply schemes such as the Folk and Dunham limestone classifications, which can only be accurately used for thin sections).

Deposition - From your description, draw general conclusions about conditions of transport and deposition. Do not try to push this too far - there is a limit to the interpretation which can be made from a single hand specimen. Examples: *grain size* may allow estimate of energy levels; *mineralogical* and *textural maturity* may indicate length of transport and reworking; sedimentary structures may suggest particular depositional or post-depositional processes; presence of a particular *fossil group* may indicate salinity, light level, depth or age.

Diagenesis - You may be able to comment on conditions and history of diagenesis of the sedimentary rock, e.g. amount of porosity may indicate degree of burial or cementation; solution/corrosion of quartz or carbonate grains may indicate pH during diagenesis; presence of stylolites may indicate burial.

Sedimentary Logs: representing measured sedimentary sections as graphic logs.

Vertical sections through sedimentary sequences (e.g. stream sections, cliff sections, foreshore exposures, borehole logs) may be represented by graphic logs, drawn to scale, using patterns and symbols to denote lithology, structures etc.

Procedure in the field

The best procedure in the field is to record all your observations systematically in your notebook. This will be drawn on a graphic log later (there are a number of problems associated with drawing a graphic log directly in the field). The recommended procedure is:

1. ***Plan your work.*** How much section is there to measure, and how much time have you got? This will determine the scale at which you log. If you have 500m of section to log in a day, don't start off by measuring each 2cm bed, otherwise you'll never get to the top! Reconnoitre the section before starting to log, and make preliminary decisions about how to divide it up. Always start logging at the base of the sequence.

2. Decide where the ***base and top*** of the unit are. Depending on the objectives and scale of logging, a unit may be a single bed of one lithology or facies; several beds of the same lithology or facies; or a group of interbeds of two or more different lithologies or facies. Where several beds are included in one unit, you should make notes on bed thickness, and how it changes up the unit. It is useful to give each unit a letter or number for reference.

3. Measure the ***thickness*** of the unit and record its ***geometry*** (e.g. does it show lateral thickness changes? is it parallel-sided or lenticular? does it die out laterally?). Sketch the geometry. Ensure that you are measuring the true thickness of the bed, by measuring perpendicular to the dip. Also record the thickness of any gaps in the section.

4. Record the nature of the ***basal contact*** of the bed. Is it sharp or gradational? Is it planar, erosive, bioturbated, or deformed by soft-sediment deformation? If erosive, what are the depth and steepness of the erosion surface? Is the base faulted? Or unseen?

5. Give a detailed description of the ***lithology*** and ***texture***, using a standard hand specimen description scheme. Record composition, grain size and sorting carefully. Name the lithology. Does the lithology change up the unit, or laterally? If several lithologies occur within the unit, describe each in detail. If the same lithology is repeated through the sequence, it need only be described in detail the first time it is encountered.

6. Record any ***sedimentary structures*** present, describing them in as much detail as possible, with the aid of diagrams. For example, it is not sufficient to record just that cross bedding is present. You must record the type (planar tabular, trough etc.), the height of the sets, the angle of the foresets, any grainsize changes within the foresets, etc. Record depositional and erosional structures, biogenic structures (e.g. burrows, borings, root traces), and chemical/diagenetic structures (e.g. concretions, stylolites, mottling).

7. Record details of any ***fossils*** present, using sketches where appropriate. Identify the major groups present. Note the state of preservation (e.g. whole, articulated, broken, abraded), distribution, and orientation (life position, current stable etc.). Comment on the diversity of the fossil assemblage.

8. Measure and record ***palaeocurrent directions***. Ensure that you note the type of structure you are measuring (e.g. trough cross-bedding azimuth; flute direction; wave ripple crest trend). Where dip is

>20 degrees, you will also need to record the dip and strike of the bed, and the plunge of fold hinges, in order to perform stereographic re-orientation.

9. Before you move onto the next unit, attempt a brief ***interpretation*** of the ***processes and conditions*** involved. Don't be afraid of recording the obvious. Think about, for example, energy levels, mode of transport and deposition (bedload traction, settling from suspension etc.), types of bedforms, salinity, water depth, oxygenation of the bottom. You should be thinking how to interpret the units whilst you are logging, and are still able to test your hypothesis.

10. Only ***after*** thinking about processes and conditions should you attempt a brief ***environmental interpretation***. General interpretations such as fluvial, shallow marine are unhelpful: be more specific, e.g. high energy, low sinuosity fluvial channel; low energy fluvial overbank with well-drained soils; moderate energy shallow marine bioclastic sand shoal, above fair-weather wavebase. State the ***evidence*** for each of your conclusions. Do not try to interpret the ***overall*** environment until you have logged the whole section, or at least several units.

Drawing the graphic log

The following attributes of sedimentary rocks can be represented diagrammatically on a graphic log:
lithology, grain size, sedimentary structures, fossils, palaeocurrents. Additional observations and interpretations are added as notes opposite the appropriate unit.

Accurately complete the details at the top of the logging form.

Decide on an appropriate scale (this will depend on the length of the section, and the degree of detail you wish to show). In the left-hand columns of the log, show a regularly spaced scale, in metres, and record stratigraphical names and ages.

Now record the following information for each unit:

Lithology is represented as patterns in a column on the left, and grain-size is represented on the right as a profile of varying width (wide for coarse, narrow for fine). If a unit contains more than one lithology, the column may be divided horizontally or vertically to include two or more patterns.

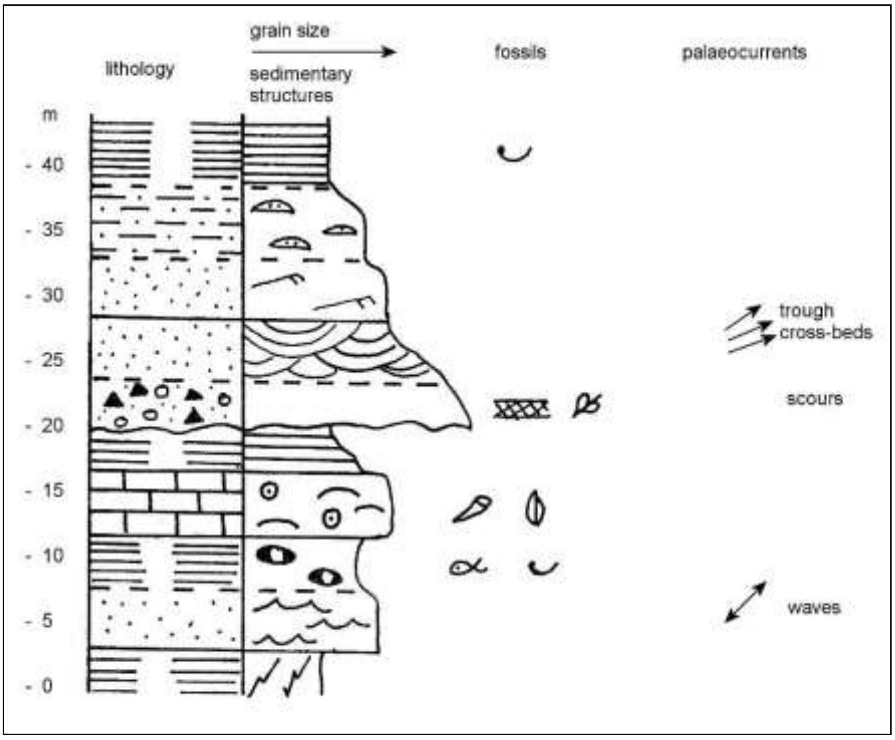
Sedimentary structures are shown as symbols within the right-hand profile. Fossils, trace fossils and palaeocurrents (correctly orientated line or arrow) are usually shown to the right of this. An example of a graphic log is shown below.

For commonly occurring lithologies, structures and fossils, standard patterns and symbols are used, as shown on the following pages. It is impossible to design a scheme which will represent all the variations in sedimentary rocks. Thus, for more unusual features, you may invent your own patterns and symbols. The most useful are those which bear a resemblance to the item being depicted, so that they convey an immediate visual impression to the observer. Different sedimentologists have different styles of drawing logs, but the best advice is to make your logs look as much like the actual sequence as possible. ***Whichever symbols and patterns are used, they must all be shown in a* KEY *accompanying the log.***

As you draw your log, you should write an interpretation of the processes, conditions and local environments for each unit in the right-hand column of the log. You may also use this column to record additional descriptive information which is sufficiently important to show on the log. Do not use this column to repeat in words information which is already shown as symbols on the log.

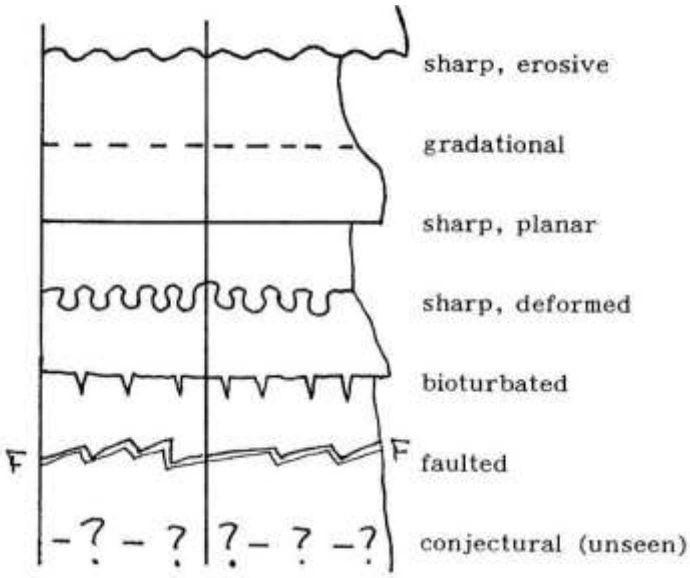
Finally, once your log has been completed, you should attempt a brief interpretation of the overall environment(s), and of any changes in process, conditions and environment through the sequence.

EXAMPLE OF VERTICAL PROFILE



CONTACT TYPES

The type of contact at the base of each sedimentary unit is often of great significance, and should always be recorded. The various line styles for the different types of contact are represented in both columns.



LITHOLOGIES

These are represented in the left-hand column only. Use mixed patterns for mixed lithologies. Use the blank cells to create new lithology patterns.
[several pages of suggested symbols follow]