Department of Earth Sciences

Devon Field Course 2018

ROYAL HOLLOWAY UNIVERSITY OF LONDON

GL1900

5th - 7th October 2018

Christina J. Manning and Howard Falcon Lang

Devon Field Course 2018

Leader: Christina J Manning
Other staff: Howard Falcon-Lang, Rebecca Fisher and Martin King.

Acommodation
Colehayes Park field centre, Haytor Road, Bovey Tracey,
Devon TQ13 9LD
Telephone for emergencies only 01626 833033

Food
Breakfast & evening meal at field center.
Special diets catered for if you informed us at the start of term.
You must bring your lunch for the first day. For other days packed lunches - 'DIY' from materials provided at field center - (bring lunch box and water bottle)

First Aiders
Christina Manning
You must inform the department and field trip leader of any existing medical conditions prior to departure.

Emergency Contacts
Department of Earth Sciences, RHUL: 01784 443581/3

Money: There will be access to an ATM at Exeter services on one of the days but it charges for withdrawals so we advise you to bring some cash with you. There is a cash bar at the field centre and limited opportunities to buy ice cream and coffee.

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Summary of Fieldwork Hazard Assessment
Fieldtrip: Year One Devon Field Course

Below is a summary of the potential hazards that may be encountered on this field trip. The information here has been taken from the risk assessment that you all signed at the field work briefing. You should ensure that your behave responsibly at all times and pay attention to the saftey of yourself and others.

HAZARD	RISK	Existing controls and/or further action
Weather – usual early Autumn conditions for SW England. Commonly cold (5-16ºC). Changeable and will often range from very stormy with hail, driving rain and strong winds to calm sunny conditions.	LOW	MUST ALWAYS take suitable clothing and footwear for ALL weather conditions each day, regardless of initial weather conditions. Use a sunhat and sun cream when sunny. Always carry water in the field.
Terrain can be rough. We will be working mostly on coastal sections where the ground can be rocky, uneven and slippery.	LOW	Walking boots must be worn and care taken when moving around the field site.
Tides can change rapidly and cut off previously accessible parts of the coast. Ground uncovered by falling tides can be slippery.	LOW	Pay attention to tide times given in the field guide. Stay with the group to ensure you do not get cut off by tides. Take care when walking over wet rock and wear appropriate foot wear.
Traffic and road crossing.	LOW	Ensure you are aware of any oncoming traffic when crossing roads and getting on and off the coach. DO NOT just follow the people in front of you.
Wildlife	LOW	Do not disrupt wildlife or plants. Carry antihistamines if necessary. Avoid dogs/nettles/brambles. Avoid tick bites.
Behaviour	LOW	Irresponsible behaviour leads to accidents. Stay as a group and be punctual for departures.
Alcohol	LOW	No alcohol is permitted in the field. Students who are deemed to be suffering after effects of irresponsible drinking the night before will not be allowed into the field and will face disciplinary action on return to RHUL.

How to use this field guide

This field guide has been designed to facilitate your learning in the field through the provision of background information, maps and figures. This guide should be used in conjunction with your field notebook where you should record your observations at each outcrop. You should use the information in this book as a guide to the types of observations and measurements you should record at each outcrop and the examples included as a suggestion of how you should lay out your notebooks. The observations and measurements you take in the field are important data from which you will be able to make interpretations about the paleoenvironmental and tectonic evolution of the area. These interpretations may change as you collect more data but your data should be recorded with a level of accuracy and detail that would make it difficult to challenge. You should answer the questions for each locality in your field notebooks using the guidelines provided. It is important that you clearly distinguish between factual observations and interpretations in your notebook.

Field equipment

You will need good walking boots, waterproof clothing, a hat (for sun and/or cold weather), warm clothing including a scarf, sun cream, a day sack sized rucksack, a small 1st aid kit. Your yellow field notebook, pens, colouring pencils, compass clinometer, handlens, grain size chart, a clipboard and a hard hat. Anyone without suitable field clothing will not be permitted to come into the field.

Learning Outcomes

In order to get the most out of this trip please read the section of the field handout for each outcrop before we get to that locality, don't panic we don't expect you to understand it all but it just means you will be familiar with some of the information we tell you at the outcrop.
By the end of this trip you should be able to do the following, when you feel you have completed a learning outcome tick it off.

1	Use a compass to locate yourself on a map.	
2	Use a compass clinometer to measure a strike and dip, the orientation of a contact/boundary, the plunge and orientation of a fold and to annotate these on a map using the correct symbols.	
3	Ability to complete basic observation, description and interpretation of igneous, sedimentary and metamorphic rocks in the field.	
4	Basic ability to observe, describe and interpret fossils in the field.	
5	Ability to measure and describe basic tectonic structures in the field.	
6	Ability to complete an annotated field sketch.	
7	Ability to create a simple geological map with guidance.	
8	Ability to use field observations to make basic petrogenetic, palaeo-environmental and regional geological interpretations.	

Assessments and marks

Over the course of this trip we will be asking you to hand in work for us to mark and provide feedback on. In order to learn as much as possible from this trip, it is important that you read through the feedback provided every morning and try and focus on areas, which have been highlighted as requiring improvement.

Assessment	Deadline	weighting
Field notebook work	Friday evening	20%
Geological map	Saturday evening	20%
Granite peterogenesis	12/10/2018 by 1pm	20%
Pebble provenance	12/10/2018 by 1pm	20%
Geological history	12/10/2018 by 1pm	20%

All work to be handed in to the box outside the departmental office.
Given that the majority of the assessments require you to use information from your field notebooks we shall be checking that the information in your answers is consistent with the information written in your notebook. Failure to demonstrate your ability to make a neat record of observations in your field notebook from which you can then make interpretations will result in marks being removed from your final mark.

Day	*Arrival/start time*	*Journey time*	*Depart time*	*Location/Activity*	*Notes*
				Group 1	
Friday 5th October			08:00	Depart RH Tennis Court Bus Stop	
Weston Supermare Tides		01:30			
High tide: 03.45 8.95m	09:30		10:00	Membury Services, M4 between J14 & J15	Coffee break, shopping stop
Low Tide: 10:16 3.22m		01:30			
High tide: 16.22 9.33m	11:30		15:30	Portishead promenade & Kilkenny Bay	Split into 2 groups - Lunch and switch over 13.15 (toilets available)
		02:00			
	17:30			Arrive Colehayes Park Field Centre	
	18:30			Dinner	
	19:30			Work session	Review
Saturday 6th October	08:00			Breakfast	
Greenway Quay tides			09:00	Depart Colehayes Park	
High tide: 05.00 4.03m		00:40			
Low Tide: 10.52 1.56m High tide: 17.15 4.33m	09:40		16:00	Goodrington Sands, Paignton	Out all day so make sure you bring all your field kit and lunch. Clipboards are very important. Toilets at start and end only.
		00:40			
	16:40		17:40	Field Centre work	
	18:30			Dinner	
	19:30			Work session	Review
Sunday 7th October	08:00			Breakfast	
Greenway Quay tides			09:00	Depart Colehayes	Arrive for the coach with all belongings - we are not returning to Colehayes. Please strip bedding from beds.
High tide: 05.57 4.40m		01:00			
Low Tide: 12.01 1.18m	10:00		13:00	Burrator quarry, Dartmoor	Split into 2 groups - quarry and dam. Switch over 11.30. No toilets
High tide: 18.07 4.66m		01:00			
	14:00		17:00	Triangle Point & beach, Meadfoot Bay, Torbay	Split into 2 groups - Triangle Point and beach. Switch over 15.30. No toilets.
		04:00			
	21:00			Arrive Royal Holloway	There will be a dinner and toilet stop on the way back.

Notes:
Colehayes Park Field Centre, Haytor Road , Bovey Tracey, South Devon , TQ13 9LD. 01626 836348 or 01626 833033


Overview of trip localities
N
Portishead
Colehayes field centre
Burrator reservoir
Burrator Quarry
Triangle point
Goodrington Sands
100km
Image Landsat
Google earth

Day 1

Locality 1: Portishead
Learning outcomes:
- Find a location on a map with a compass
- Basic description of an outcrop of sedimentary rock
- Basic description of a fold structure
- Completion of an annotated field sketch
- Basic description of fossils

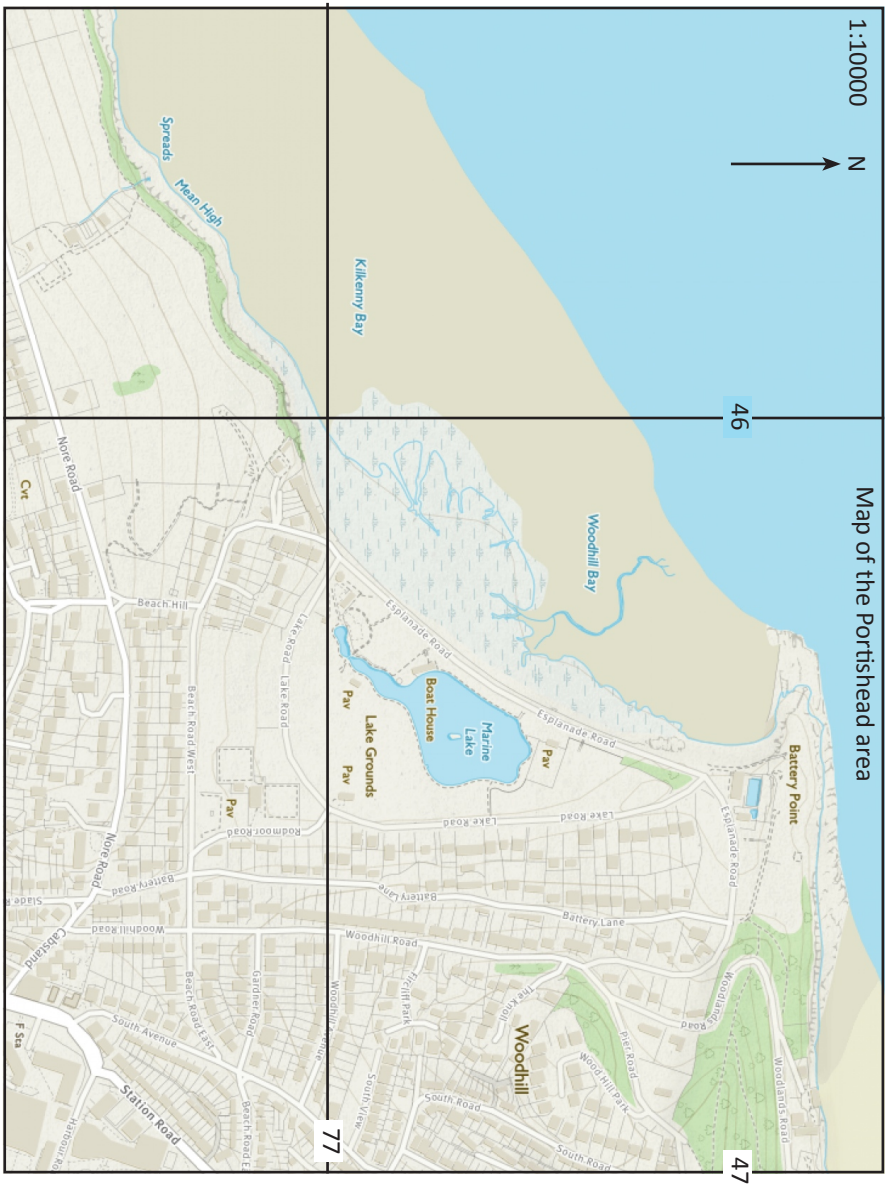
1.1 Kilkenny Bay
For each locality mark your position on the map and record the grid reference in your notebook.

1.2 Kilkenny Bay East (Devonian age)
a) The cliff here exposes rocks referred to as the 'Portishead Beds'. Describe this outcrop, following the outcrop description process in table 1.
b) Draw an annotated sketch of part of the ~2m high cliff face to show the beds and the sedimentary structures. *Make sure you use the guidelines for geological sketching to ensure you include all important information.*
c) Measure strike and dip measurements for at least one bed. Think about how many should take for a single bed.
d) **INTERPRETATION**. Using information from the description and your interpretation of the features above it should be possible to determine the probable environment of deposition of the three lithologies, both separately and together; give reasons for your answer. Include in your reasons a very brief explanation of how you have used uniformitarianism and Walther Law to guide your interpretation.

1.3 Woodhill Bay (Carboniferous age). No hammering
a) The beds contain a number of fossils. Sketch at least three examples and name the fossil group.
b) **INTERPRETATION** What can you deduce about the environment in which these organisms lived?
c) **INTERPRETATION** What happened to the organisms after they died?
d) **ASSESSED** **Draw an annotated sketch to show the structure of the beds in the low cliff and foreshore of Woodhill Bay. Make a series of strike and dip measurements of the beds and record them on your sketch.**
e) **INTERPRETATION** Were these structures produced by extension or compression? What was the orientation of these forces?

Please hand in your notebook into the box before dinner

Day 1


Map of the Portishead area
1:10000
N
46
47
77
Kilkenny Bay
Woodhill Bay
Mean High
Spreads
Battery Point
Esplanade Road
Lake Road
Boat House
Marine Lake
Lake Grounds
Pav
Woodhill
Battery Lane
Woodhill Road
Woodlands Road
Peer Road
Wood Hill Park
South Road
Beach Hill
Lake Road
Beach Road West
Rodmoor Road
Battery Road
Nore Road
Woodhill Road
Gardner Road
Beach Road East
South Avenue
Station Road
Cvt
F Sta

Photograph of Woodhill Bay looking E

Photograph courtsey Kevin D'Souza

Photograph of Kilkenny Bay looking E

Photograph courtsey Kevin D'Souza

Some characteristic fossils of the Carboniferous near Portishead

Trace fossil (burrow)

Crinoid ossicles

Dibunophyllum (coral)

Day 2

Learning outcomes:

- Basic description of an igneous rock
- Finding a location on a map with a compass and via topographic features
- Basic description of an outcrop of sedimentary rock
- Basic description of a fold structure
- Completion of an annotated field sketch
- Completion of a simple geological map

Locality 2. Field Study Centre

2.1 Dartmoor 'Granite': origin and mineralogy Age: about 290 Ma

a) Describe the granite taking care to describe carefully each of the minerals present. Then look to see if you can find a minerla that matches your description in Table 2. Are thhere any minerals that are not present in this table?

b) What is the average grainsize in the groundmass? Give your answer in mm

c) INTERPRETATION Which feature(s) of this rock indicate the rate of cooling, and why?

d) Sketch any structures that you observe in the rock.

e) INTERPRETATION How did these structures form?

Mineral	Hardness	Cleavage	Common properties
Orthoclase	6	2 planes at 90°	A feldspar; very common in many rock types; white to grey to red-pink; forms elongate laths with simple twinning
Plagioclase	6	2 planes at 94°	A feldspar; very common in many rock types; appears similar to orthoclase; forms elongate laths with multiple twinning
Quartz	7	none	Glassy; tyoically colourless; very resistant to weathering; chief mineral in sandstones.
Olivine	6-6 1/2	none	Olive green; glassy; rounded in shape
Pyroxene (mineral group)	5-7	2 planes and 93°	Usually green to black; stubby or equant in shape.
Amphibole (mineral group)	5-6	2 planes and 124°	Usually dark green to brown to black; distinguished from pyroxenes by cleavage and more elongate crystal shape
Muscovite	2-2 1/2	1 plane	A mica; perfect cleavage allows splitting into thin, sheets; usually light yellow to light brown
Biotite	2 1/2 - 3	1 plane	A mica; perfet cleavage allows splitting into thin sheets; usually dark green to brown to black

Table 2: Common igneous minerals and their properties in hand specimen.

Day 2

Locality 3: Goodrington Sands to Waterside Cove
ASSESSED **Your completed geological map should be handed in as you embark the coach at the end of the day. By this time you should have inked in all boundaries, symbols and annotations and included a key. **

3.1 Map and boundaries
An enlarged topographic map is used as a base map for geological mapping. This map has been enlarged to 1:5000 scale and is marked with grid lines 1 km apart. 1mm on map = 5 metres of real distance.
During the course of the day:
a) carefully outline on the map the extent of each exposure of the main lithological units. Mark with a sharp pencil in the field, but go over it in ink during the evening. Label each unit in pencil.
b) measure the strike and dip of at least 4 planar features (bedding, cleavage) as well as the orientation of contacts and faults and the orientation and plunge of fold axis'. Record this data neatly in your field notebook as well as on your map.

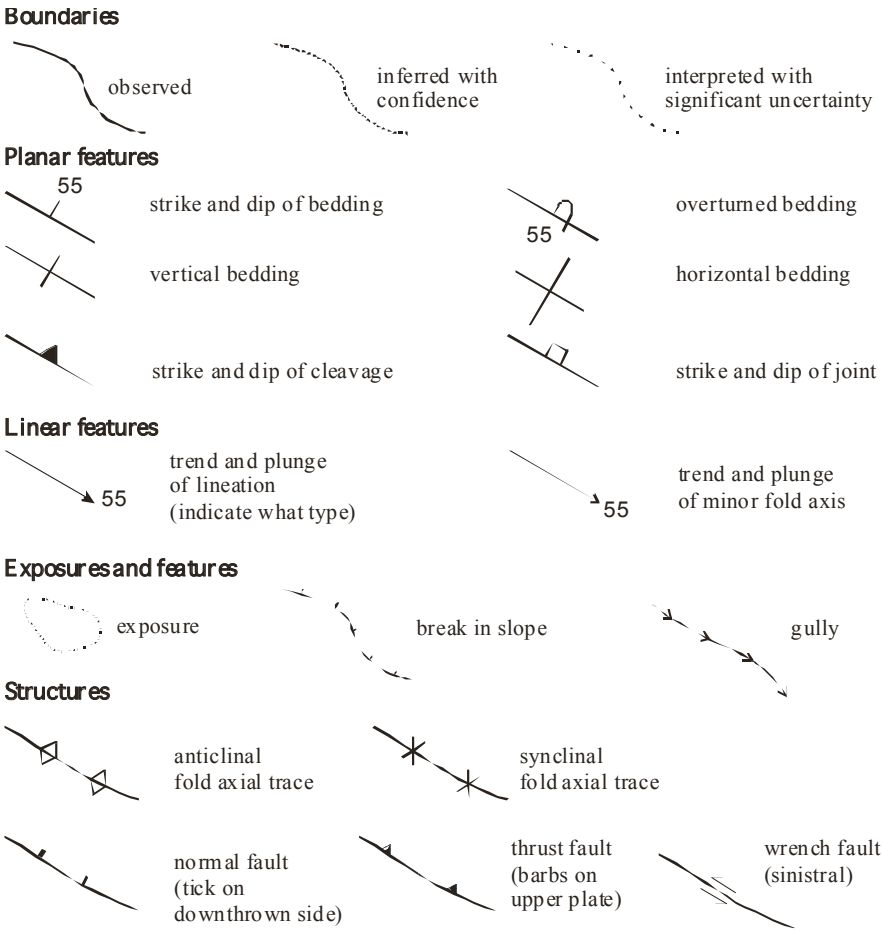
3.**2 An unconformity. (Waterside Cove)**
a) Draw a carefully annotated sketch of an unconformity. Include details of the beds below and above (bedding, faults, veins, variation of clast size etc.). Record a strike and dip measurement of the beds above AND below the unconformity.

3.3 Devonian Rocks (Meadfoot Beds). Age: about 390 Ma
a) Describe the main lithologies seen at this outcrop on the beach. Record a strike and dip measurement of the beds.
b) INTERPRETATION What kind of depositional environment might these rocks represent? Give reasons.

3.4 Permian Rocks (Watcombe Formation) Age: about 260 Ma
a) Describe the main lithology seen at this outcrop.
b) Record a strike and dip of these beds.
c) INTERPRETATION What kind of depositional environment might these rocks represent? Give reasons to support your interpretation.

3.5 Describing and measuring a fold
a) Measure the plunge and direction of plunge of the axis (hinge-line) of the fold seen between Waterside Cove and Goodrington Sands. Record it in your notebook, and on the map using the appropriate symbol.
b) Draw a sketch of the fold and annotate it with strike and dip measurements.
c) INTERPRETATION Does the fold suggest shortening in a N-S, NE-SW, E-W or SE-NW direction?


Photograph of Waterside
Cove looking N
Photograph courtsey Kevin D'Souza


Boundaries
observed
inferred with confidence
interpreted with significant uncertainty
Planar features
55
strike and dip of bedding
overturned bedding
55
vertical bedding
horizontal bedding
strike and dip of cleavage
strike and dip of joint
Linear features
55
trend and plunge of lineation (indicate what type)
55
trend and plunge of minor fold axis
Exposures and features
exposure
break in slope
gully
Structures
anticlinal fold axial trace
synclinal fold axial trace
normal fault (tick on downthrown side)
thrust fault (barbs on upper plate)
wrench fault (sinistral)

Day 3

Learning outcomes:
- Basic description of outcrops of igneous, sedimentary and metamorphic rock
- Completion of an annotated field sketch
- Basic description of fossils
- Ability to measure and describe basic tectonic structures in the field

Locality 4: Burrator Reservoir near Yelverton

4.1 Burrator reservoir old quarry

a) Describe the main rock type exposed in the old quarry face in the car park.
b) A second rock type is also found at one end of the quarry, and in some other small areas. Describe and name this rock.
c) Describe the contact between the 2 rocks.

4.2 Burrator reservoir woods

a) Describe the lithology in this small pit.
b) How does this granite compare to the one we saw at the house?
c) INTERPRETATION What geological process could explain these differences?

Locality 5. Triangle Point

5.1 Documenting an exposed fault

a) Fault plane. Measure the dip and strike of the fault surface in three different places and record them your note book.
b) Fault movement. Measure the orientation of the striae on the fault plane and record them your note book.
c) These striae or grooves in the fault surface (called slickensides) often indicate the trend of movement during faulting. What direction did the fault move in?

5.2 Devonian Fossils

The Torquay Limestone at Triangle Point contains a rich and informative fossil fauna.
a) Locate and carefully sketch (with labels and scale) an example of the following distinctive fossils:
- Stromatoporoid
- Thamnopora (tabulate coral)
- Syringopora (tabulate coral)
- Rugose coral
- Athyris (brachiopod)

b) INTERPRETATION What do the fossils tell us about the environmental conditions under which the Torquay Limestone was laid down? Be sure to explain how the fossils are evidence for the environmental conditions.

5.3 Pebble Provenance

a) Describe the lithology of a selection of pebbles on the beach. For each different rock type of pebble you find, try to name the rock type think about whether we have seen it on this trip or whether it has been sourced from somewhere further a field. Use the geological map provided to see if you can identify a potential source.

Some characteristic fossils of the Devon near Triangle Point

STROMATOPOROIDS AND CORALS IN THE DADDYHOLE LIMESTONE, TRIANGLE POINT, TORQUAY.
This photograph shows an inverted surface with stromatoporoids (larger white objects) and abundant branching coral Thamnopora.
Photograph 2007. Ian West (c) 2010.

Stromatoporoid

FOSSIL CORAL - THAMNOPORA, MIDDLE DEVONIAN, GIVETIAN, TRIANGLE POINT, TORQUAY.
These are part of the Torbay reef complex. Photograph: 12th April 2012. Photograph courtesy of
and copyright of Oleksandra Pedchenko, 2012.

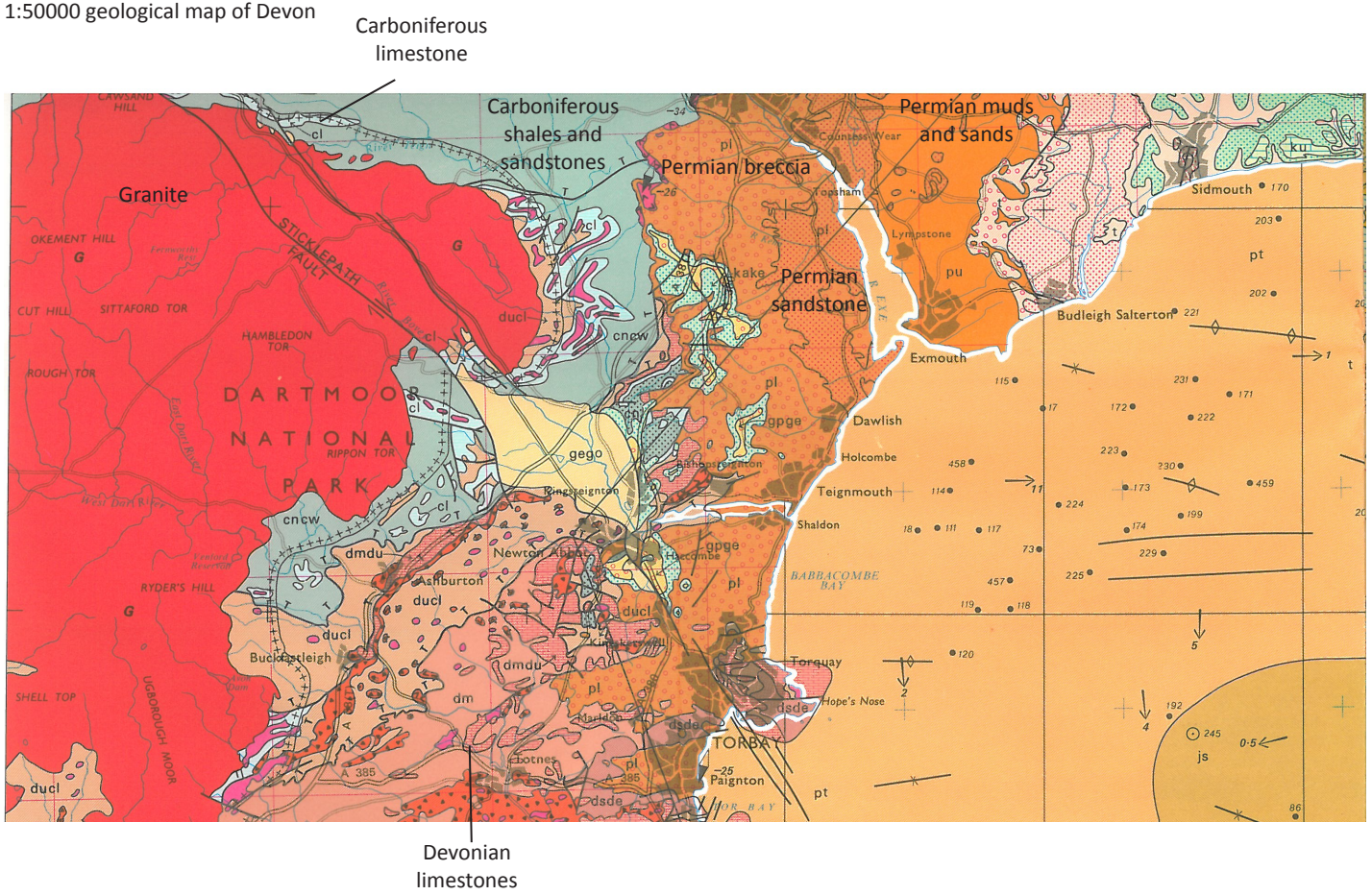
Thamnopora

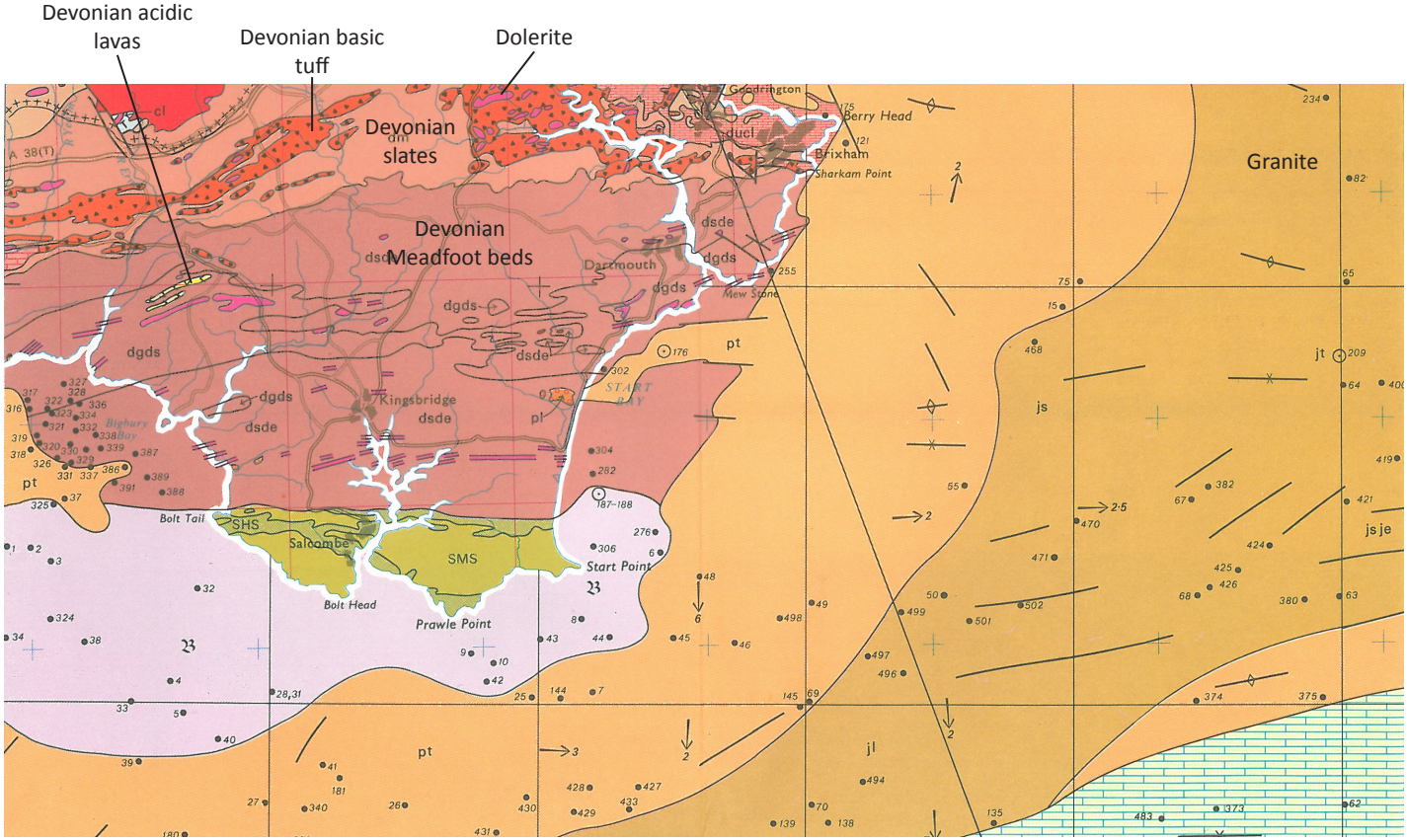
GONIATITES AND PAIRED BRACHIOPOD VALVES WITH VARIOUS AMOUNTS OF SEDIMENT FILL, DEVONIAN LIMESTONE, TORQUAY.
Very dark grey, almost black limestones in the Middle Devonian at Triangle Point, Torquay contain goniatites and brachiopods, in addition to tabulate corals and stromatoporoids. The goniatites often have a partial infill of sediment. Both empty and filled brachiopod shells can be seen. The partial sediment fills within fossils here have been used as geopetal indicators showing the original way-up. The evidence is that the strata here are inverted. The way-up direction is not obvious in the photograph because it is showing a surface that is roughly parallel to bedding. Photo: 14th April 2010. Ian West (c) 2010.

Brachiopods, Goniatites

Day 3

1:50000 geological map of Devon




Devonian acidic lavas
Devonian basic tuff
Dolerite
Devonian slates
Devonian Meadfoot beds
Granite
Goodrington
Berry Head
Brixham
Sharkam Point
Dartmouth
Mew Stone
Kingsbridge
Bigbury Bay
Bolt Tail
Bolt Head
Salcombe
Prawle Point
Start Point
START BAY
SHS
SMS
dgds
dsde
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Assessments

The following tasks should be undertaken on return from the Devon field trip only using the data you have recorded in your field notebooks during the trip. Do not be tempted to use Google we will know and your marks will be reduced accordingly. The aims of these assessments is to test your ability to accurately and comprehensively record data at each outcrop . We will be checking notebooks at the time of marking to check the information you have used is present.

Each task should be done on a separate sheet of A4 paper and should only take up 1 side. We will only mark the first side of work so if you go over the 1 page limit you will lose marks.

Assessed **Task 1: Granite peterogenesis**

Using the information from your notebooks for localities 2, 4 and 5, summarize, in a table with headings as shown below, the stages of evolution that led to the formation of the Dartmoor granitoid. The final column asks you to provide evidence for why you think it sits in this place in the chronology i.e. if you have 2 units and 1 overlies the other you could say that you know the upper unit is younger than the lower unit because it was deposited on top. There are ~6 events.

Event (oldest first)	Related feature of the rock	Reason for the order

Assessed **Task 2: Pebble Provenance**

Using the information from your notebook for locality 5.3 and the geological map provided answer the following questions.

a) Were any of the pebbles lithologies that we had already seen in outcrop? If so which?

b) Were there any rock types that we have seen in outcrop that are not present in the pebbles?

c) Were any of the pebbles lithologies which we have not seen in outcrop?

d) Use the geological map to identify potential source outcrops for these pebbles.

e) INTERPRETATION Write a brief (a few sentences only) interpretation of the pebbles in the Permian conglomerate. Hint – use the example of the pebbles on the beach to try to understand the significance of the pebbles in (and not in!) the conglmorate.

Assessed **Task 3: Geological history of Devon**

Using all the information recorded in your notebook for the last three days, and applying a similar thought process to that used in Task 1, define a simplified geological history for South Devon. This should be done in a table like the one shown below. Note this table does not show the correct number of boxes for all the events.

Event (oldest first)	Related feature of the rock
Deposition of Devonian strata in rivers and the sea	
Further erosion to form the present landscape	

All assessed work should be handed in along with your field notebooks to the desk outside the departmental office by the date and time set in the table on page 5 of this guide.

Notebook layout

• You should make a considerable effort to maintain a neat record. The notebook should be clearly organised and arranged.

• Number all the pages. Put your name and contact details on the front leaf!

• Rule off a column, about 1 cm wide, at the left hand edge of each page in which you can record your locality numbers.

• Rule off a column, about 2 cm wide, at the right hand edge of each page in which information such as strikes and dips, photograph numbers or sample numbers can be recorded.

• Start each new day in the field on a new page with the day and date. Give a few sentences to indicate your targets and working area for the day.

• Record data in a systematic, neat way and keep factual data separate from interpretations.

1. Location	•Location number and name •Grid reference
2. Lithology	•Colour – of both fresh and weathered surfaces •Grain size – record the range of grain sizes present •Minerals – identify and describe main minerals present •Texture – Note the texture of the rock, interlocking grains, mineral alignment. •Rock type – identify and name the lithology.
3. Sedimentary Structures	•Record the dip and strike of the bedding plane – you may want to check this at more than 1 place on the outcrop. •Bedding – are the bedding planes evenly spaced or not, is the rock thinly or thickly bedded, are bedding surfaces regular, undulating or irregular? •Other structures – cross bedding, channels, ripples, sole markings, concretions.
4. Tectonic structures	•Faults Record dip and strike and direction and amount of movement. Sketch the fault and record any associated fault rocks, folds, and damage zone. •Folds Sketch the folding and record the trend and plunge of fold axes and the strike and dip of the fold axial surface. Describe the geometry of the fold. Remember that outcrop-scale folds give clues about the geometry and orientation of large-scale folds •Other minor structures Note the presence of any other structures such as tension gashes, slickensides, etc., and the direction of movement implied
5. Fossils	•Abundance – record abundance and distribution through the outcrop •Type of fossil - Body or trace, preliminary identification •Preservation – are they intact or fragmented. •Make sketches of individual specimens.
6. Sketches	•Title - indicate why you drew it and what you intended to show. •Location - A grid reference is necessary to indicate the site being sketched or the point from which a panorama has been drawn. •Orientation - the general direction in which you were looking while you were drawing. This can take the form of a compass bearing or a direction — 'looking SW'. On the sketch you should show the orientation e.g. by putting SE and NW at either end of the diagram. •Scale - put a scale bar showing an appropriate length in centimetres or metres. •Labelling Although your sketch should have visual impact it is essential that as much information as possible is conveyed. Label all the rocks present, give the dip and strike of planar structures and the orientation of other structures as well as depict them. Mark structural measurements directly onto the sketch to show where they were taken. Show where fossils were found and where any other points of interest were located.

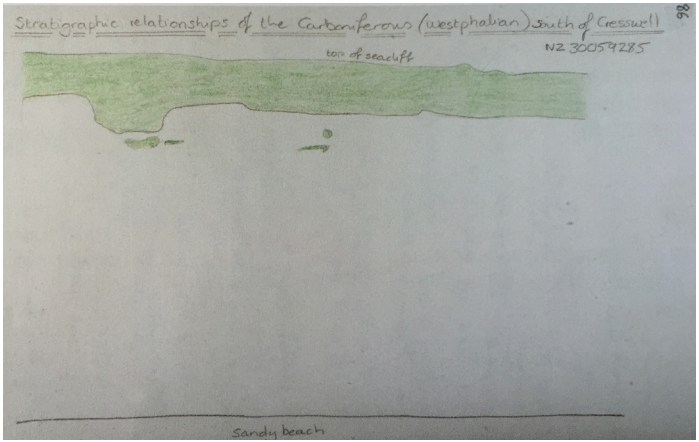
	Monday 11th Jan 2013: Day 10	
	Aim: Mapping area south of 3 peaks, following	
	contact between dacite and limestones	
	Weather: Fair, light breeze.	
Loc	(GR843699) Small bridge above stream. Mid-	Bedding:
121	grey limestones with small forams, thinly	065/25SE
	bedded. Yellowish weathering colour. Weak	067/22SE
	bedding-parallel foliation in rare pelitic layers	Foliation:
	Small-scale disharmonic folding of bedding.	064/25SE
	Folds are parallel, with overturned forelimbs	Fold hinge-
	and occur only in very thin limestone beds.	line: 22-242
	MINOR FOLDS VIEW TO N	Axial plane:
	LST, PELITE, LST, LST, cm, 0, 10 — NOTE: COMPARE TO MAJOR FAULT AT LOC. 117	072/40SE
Loc	About 50 m upstream from Loc 121. Contact	Bedding:
122	between dacite (below) and limestone (above)	055/15SE
	exposed. Obvious unconformity - with clasts of	Unconformity:
	dacite up to 1 cm across, in base of limestone.	060/20SE
	LST-DACITE U/C VIEW TO N.	(approx.)
	GRASS-COVERED SURFACE, LIMESTONE BEDS, PELITIC BEDS, DACITE CLASTS, UNCONFORMITY, WEATHERED DACITE, DACITE, APPROX 2.5 m	Photo 63

Drawing a field sketch

1. Assess the units - decide which you are going to group together and which you are going to separate

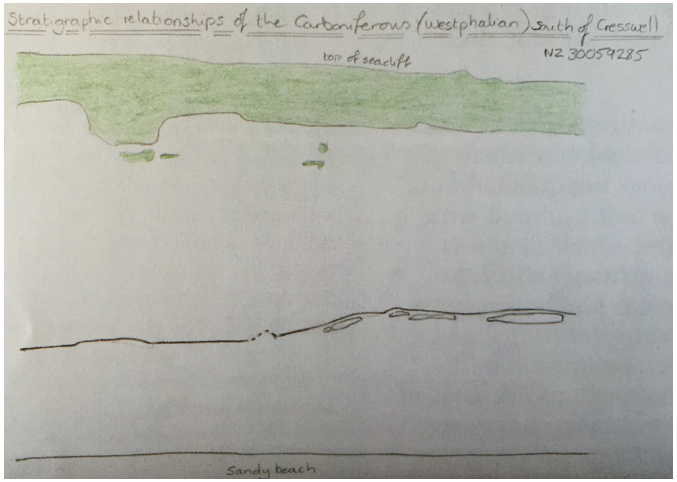
Spend time looking at the exposure and decide how many unit there are. Chose a representative part of the cliff.

2. Give your sketch a title and draw an outline of the units



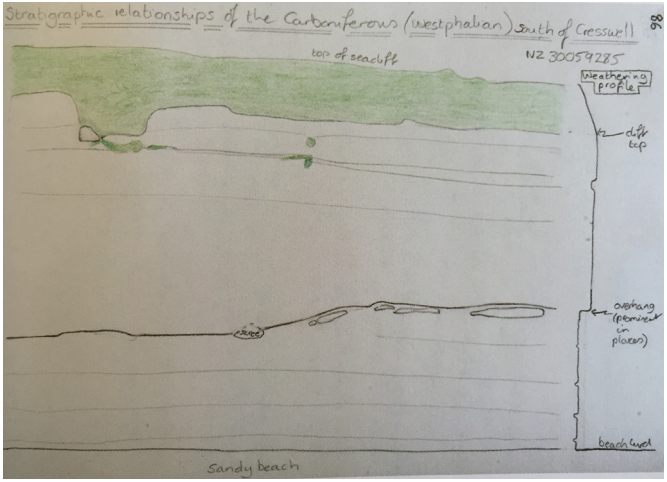
Make sure your notebook is orientated in the best direction for the sketch. Put a descriptive title at the top. Draw the outline first and you can highlight areas of vegetation as a reference but just as a green area not drawn in detail.

3. Draw the major geological boundaries



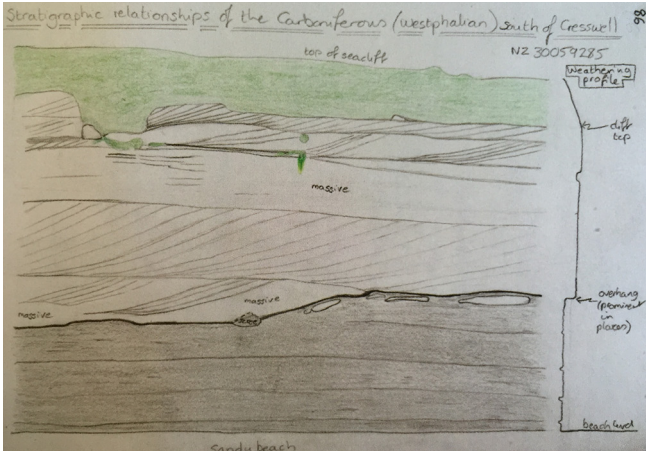
Draw the major geological boundaries between units. Distinguish between gradational and sharp boundaries using thick dark lines for sharp boundaries and a medium thick less dark line for gradational boundaries. Use your compass-clino to estimate angles. Follow the boundary along carefully to check whether it is continuous.

4. Draw the boundaries of any sub units



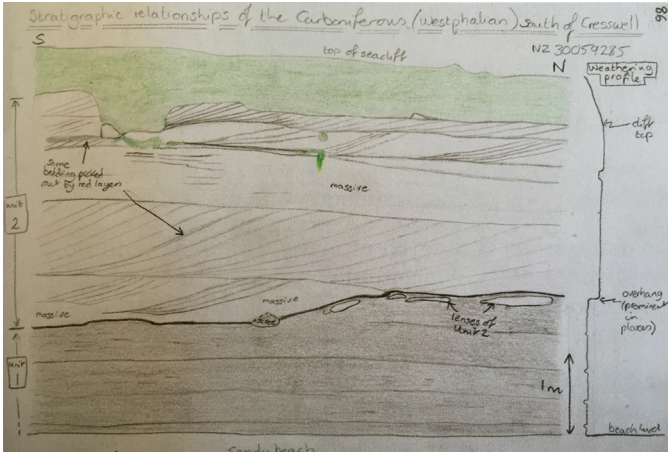
Draw in the boundareis of sub units using appropriate thickness and weight of line.

5. Draw in the detail within each of the units



Make detailed observations of each unit in turn and add these observations on to the sketch. Represent the colour of units using shading as appropriate. Add lines to show details within the units i.e. folds, thinner beds, sedimetary structures. Where details are too small to add or there is insufficient time use annotations. Make sure that the main geological boundaries remain clear.

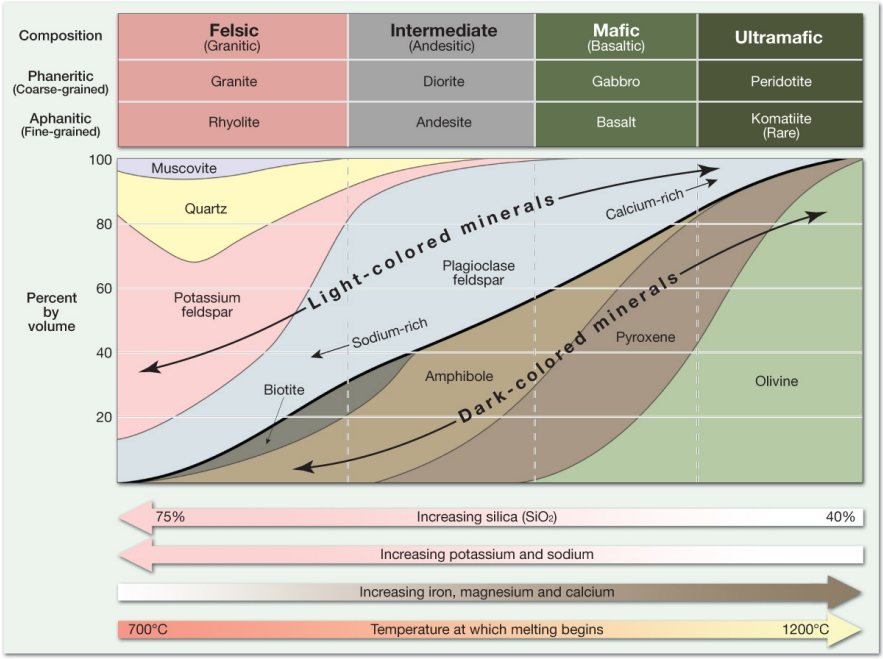
6. Add the finishing touches



Add a scale, orientation and number/name the units so that you can refer to them in your text.

Edited from Geological Field Techniques. Angel Coe. Wiley Blackwell 2010

Naming igneous rocks in the field

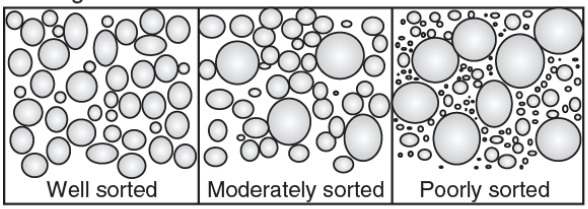


Naming metamorphic rocks in the field

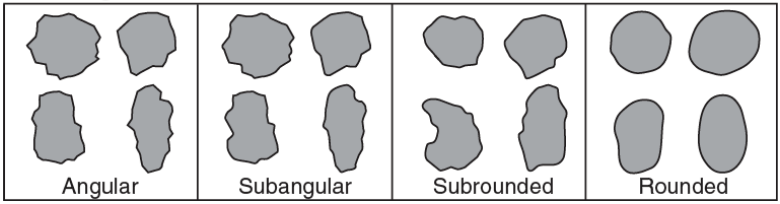
Texture		Grain Size	Composition	Type of Metamorphism	Comments	Rock Name
Foliated	Mineral alignment	Fine	Mica, Quartz, Feldspar, Amphibole, Garnet, Pyroxene	Regional	Low-grade metamorphism of shale	Slate
		Fine to medium		Heat and pressure increase with depth	Foliation surfaces shiny from microscopic mica crystals	Phyllite
					Platy mica crystals are visible from metamorphism of feldspar or clay minerals	Schist
	Banding	Medium to coarse			High grade metamorphism. Separation of minerals into bands	Gneiss
Non foliated		Fine	Variable	Contact (heat)	Various rocks changed by heat from nearby intrusion	Hornfels
		Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	Quartzite
			Calcite or Dolomite		Metamorphism of limestone or dolostone	Marble
		Coarse	Variable minerals in clasts and matrix		Metamorphism of conglomerate	Metaconglomerate

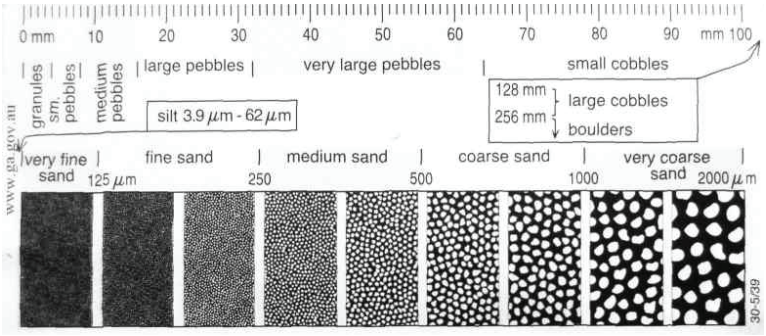
Naming of sedimentary rocks

Sorting:



Rounding:





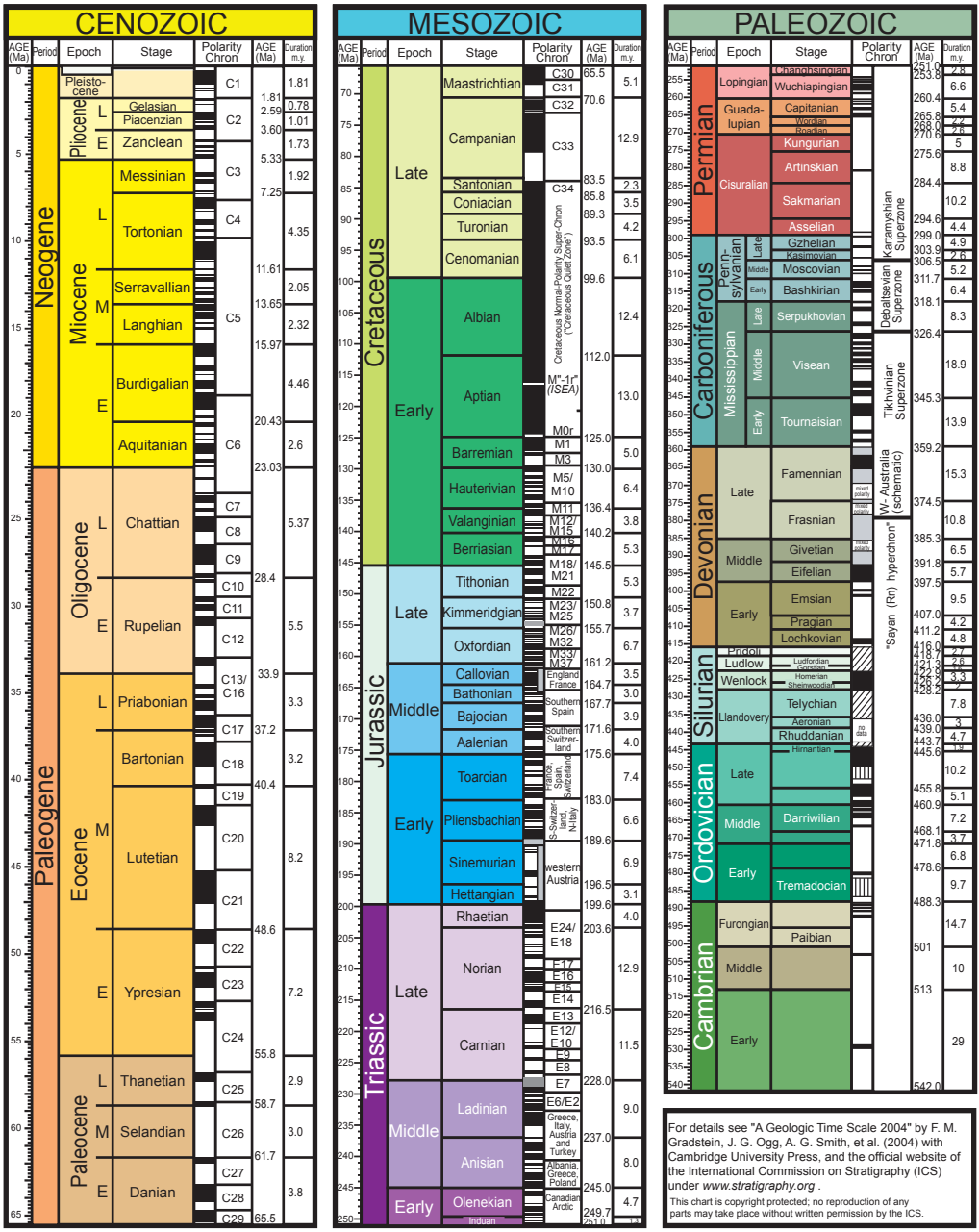
Textural Classification of Carbonate Sediments[1]

Percent Allochems	Over 2/3 Micrite Matrix				Subequal Spar & Micrite	Over 2/3 Spar Cement		
	0-1%	1-10%	10-50%	Over 50%		Sorting Poor	Sorting Good	Rounded & Abraded
	Quiet water deposition ⟵					⟶ *Wave/current activity*		
	⟵ *Matrix Supported Allochems*					*Grain Supported Allochems* ⟶		
Rock Name	*Micrite*	*Fossiliferous Biomicrite*	*Sparce Biomicrite*	*Packed Biomicrite*	*Poorly Washed Biosparite*	*Unsorted Biosparite*	*Sorted Biosparite*	*Rounded Biosparite*

Micrite (lime mud) Matrix Sparry Calcite Cement

GEOLOGIC TIME SCALE

PHANEROZOIC



For details see "A Geologic Time Scale 2004" by F. M. Gradstein, J. G. Ogg, A. G. Smith, et al. (2004) with Cambridge University Press, and the official website of the International Commission on Stratigraphy (ICS) under *www.stratigraphy.org* .