Geo Factsheet

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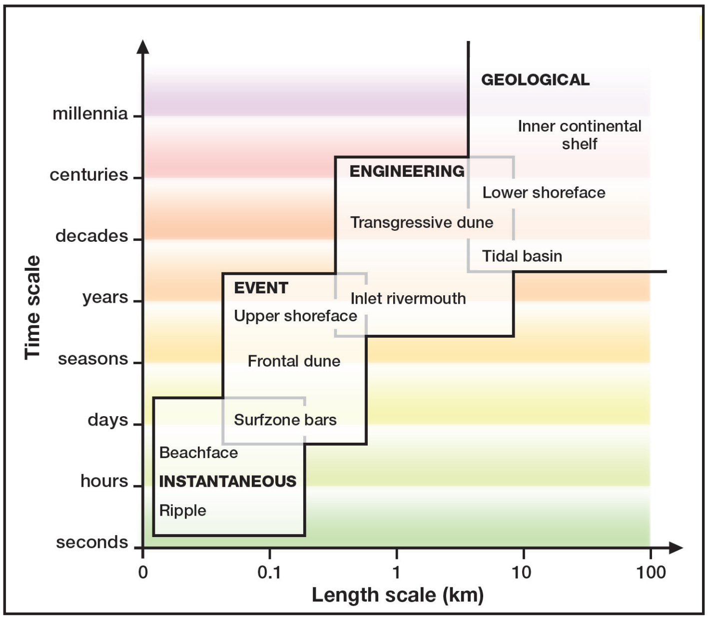
Coastal Fieldwork 1: Physical

This is the first of two Factsheets which explore a range of coastal fieldwork options that can be undertaken as part of the independent investigation for A-level Geography. Much of the discussion might also be relevant to AS students who are considering coastal fieldwork, which has a focus on physical processes and landforms.

Coastal physical surveys – why?

Physical coastal surveys can make ideal investigations because of the dynamic nature of this environment. Some of the systems that operate are instantaneous, or certainly at "event" scale (Figure 1), which means that can be measured over a number of days, weeks, or possibly months. The other advantage of physical coastal projects is that is it relatively easy to collect a large amount of data and information over a small area and in a short space of time, especially if students are working in small groups. This can then be analysed and interpreted using different statistical tools and can generate a range of individual titles. A final point to note is that there are several physical coastal models (e.g. Figure 3) that could form a topic focus and would be ideal for testing at a small scale. Other models include the micro features of a beach, and system models for beach and cliffs.

Figure 1. Spatial & temporal scales involved in coastal evolution



Investigating part of the system – process and form

A key understanding with coastal fieldwork is that is often too complex, difficult or dangerous to actually measure the processes that are operating at a particular point in time. Instead, fieldwork often aims to work out the "geography" from the evidence on the ground. That means that interpretation and conclusions are often based around incidental evidence, not actual measurements of processes operating at a particular time. The size and position of stones on a beach, for instance, is as a result of the last set of conditions (processes) that created an environment in which the sediment could be moved. This is, in effect, a relic deposit, showing the amount energy present when the stones were last mobilised.

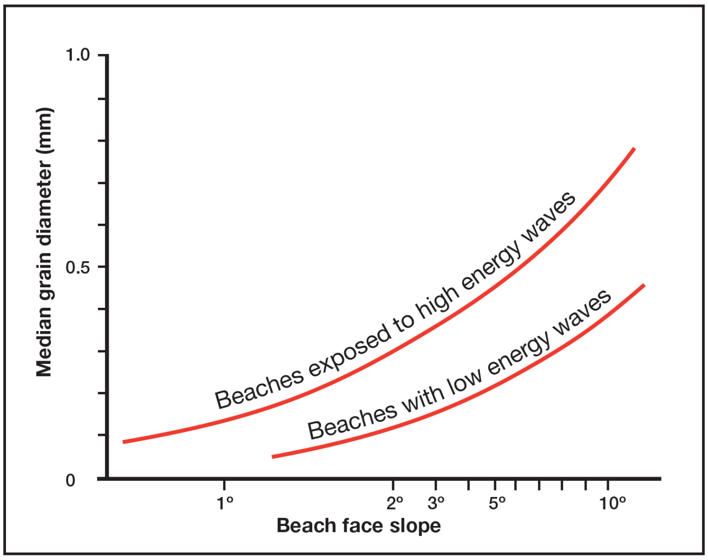
Beach profiles and beach sediments – geographical theory

Beaches and their profiles rarely remain constant. When waves arrive at an angle to a beach or coastline, wave refraction causes then to be bent so that their final approach direction is almost parallel to the beach. This can create the conditions for material to be transported along the coast (lateral movement) via the process of longshore drift. Beach profiles (cross-sections) from the interaction of waves and the size of the material involved.

Larger sized sediments require more energy to be moved. In terms of a beach profile, large stones generally mean a steeper angle of rest (this is particularly true in winter, when 'surging' storm waves construct steep beach profiles). At the lower end of the beach, 'spilling' or steep waves are associated with gentle slopes. Gently shelving sandy beaches are more likely to form in summer months due to changes in wave energy. Stones that make up a beach vary in size (calibre) but may also show changes in their shape and roundness. There is a general pattern of sorting that sees stone size getting smaller further down the beach, though the intervening surface ridges (larger size) and troughs (smaller) will show a more detailed pattern of change. The geology of the pebbles can be very helpful when trying to assess their provenance.

Figure 2. Stony beaches are relict deposits, where processes such as longshore drift can only be inferred

Figure 3. An example of a model that could be tested which shows the relationship between diferent wave types, sediment size and beach gradient



Measuring profiles and sediments

Some parts of the UK coast are well studied and known to have predictable variations in sediment sizes. Classic examples include Blakeney Point in Norfolk, Chesil beach in Dorset, and Porlock Bay in Somerset; but there are many other stretches of coast that would be equally suitable for study. It is always good practice to be able to justify fieldwork locations based on some background research including texts on longshore drift processes and position within a particular sediment cell. When considering coastal fieldwork, students must think about design (i.e. site selection, frequency of measurements, position of transects, etc.) as well as methodology related to the actual measurements at a particular point. Table 1 gives some brief details, but students will need to consider sampling frequency, for example, as well as exact positions both along and up a beach, and whether a stratified or systematic approach is appropriate.

Table 1. Examples of the fieldwork that might be used to investigate spatial changes in sediment and beach profiles

Purpose	Description
Changes in sediment size	This can either be across the beach, or up and down the beach (Figure 5). Sediment size is measured along its long-axis (a).
Changes in sediment shape	Again, this can either be across the beach, or up and down the beach. Sediment shape might be measured using the Power's scale of roundness or the Cailleux (Figure 7).
Changes in beach gradient	Usually measured up or down the beach, often with recordings being taken where there are breaks of slope. Clinometers can be used, or a simple phone app (Figure 6).

Alternative measurements: Zinggs and Phi-size

There are alternative and more technical ways available to measure both the size and shape of beach sediments. Figure 8 and Table 2 (see Page 3) give two examples – Zinggs index and the Phi-size scale. These tools can be used to make comparisons between other measurement techniques, as well as to improve both the reliability and accuracy of data collection. Phi-size might also be used to understand more about sediment sorting for instance. The terms - very poorly sorted, poorly sorted, moderately sorted, well sorted, very well sorted - have technical definitions, and describe the amount of variance seen in particle sizes. The degree of sorting depends upon how much transport the sediment has undergone, and is therefore another clue as to the processes operating in the bigger coastal system.

Figure 4. One way of measuring the long-axis of a beach pebble, using a stone calliper

Examples of possible project themes related to sediment and gradient:

- The effect of management structures, for example groynes, on the sorting of beach material. Differences in the height of material either side of the groyne can also be measured. Theories on best size and spacing of groynes can be tested.
- The origin of beach material through the study of sediment cells (linked to changes in local geology which can easily be found online).
- Comparing sediment analysis at beaches in a contrasting locations and attempt to explain similarities and differences.
- The relationship between beach sediment and other factors, for example the width and slope of the beach.

Figure 5. Transects up and down the beach (downshore) as well as across the beach (x4) (note the identification of the mid-shore level)

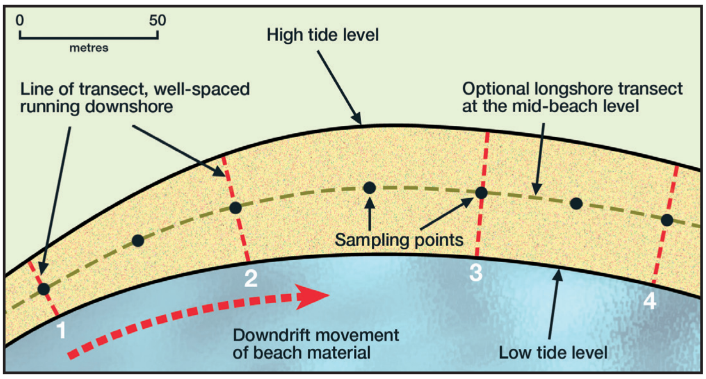
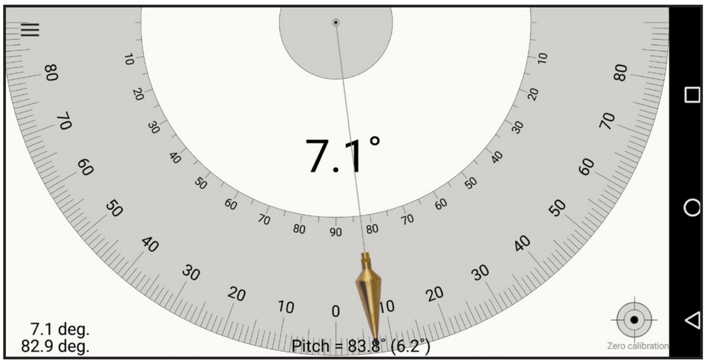


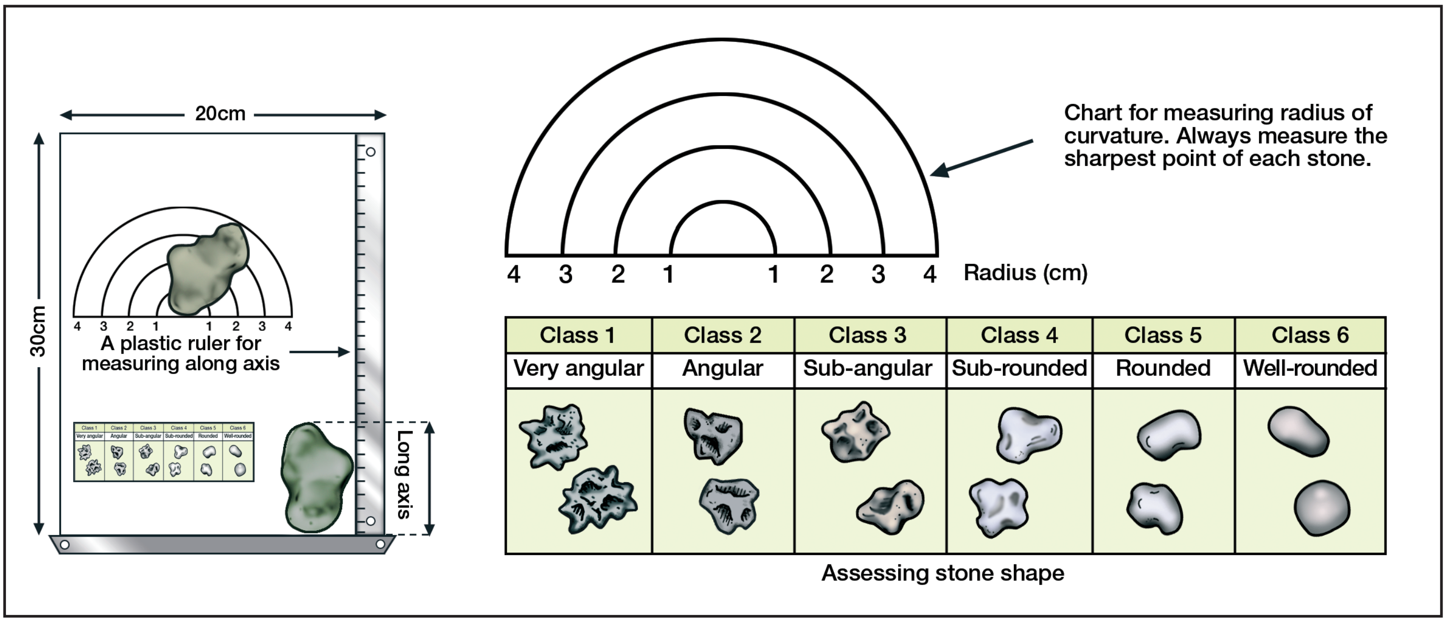
Figure 6. A free "clinometer" app that could be used to measure beach gradient on a phone



Exploring the time dimension: summer and winter surveys of gradient and sediment

Coastal systems are dynamic so they can change from second to second, day to day and month to month. The changes in this system could be recorded over time. One such example is to investigate changes in the beach profile between winter and summer for example. Theory suggests that during winter storms, the beach is eroded and seaward cross-shore sediment transport results in the formation of offshore bars. There are other seasonal and temporal (time) aspects that could be explored along a suitable coast. Secondary data can be downloaded and used to find wave height, direction and period (see Figures 9 & 10).

Figure 7. The Powers scale for angularity and the Cailleux roundness scale (index of curvature)



Zingg's method

Measure the a, b and c axis of each pebble.

Two ratios are calculated from these figures:

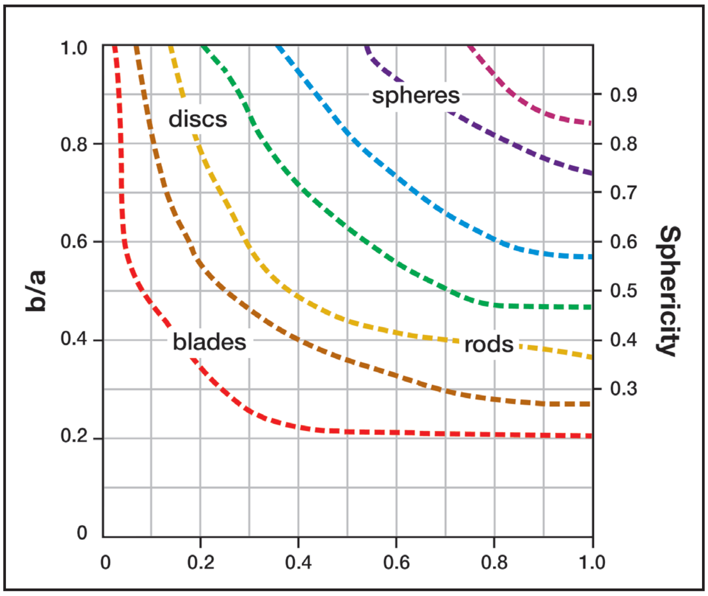
$$\frac{b}{a} \quad \text{and} \quad \frac{c}{b}$$

Zing classified particles into four groups using the following figures based on the ratios shown in the table:

Table 2. Zingg's Index

Type of particle	Axes b/a	Axes c/b
Spheres	> 0.67	> 0.67
Discs	> 0.67	< 0.67
Rods	< 0.67	> 0.67
Blades	< 0.67	< 0.67

Figure 8. Graph of results



The result for each ratio can be plotted on the graph (see Figure 8) and the type of of particle determined. The result for each ratio can be plotted on a graph (Figure 8). The type of particle can be analysed using Figure 11 (the Wentworth Scale). This method is ideal for contrasting deposits within a valley such as penglacial scree, riverine glacial or fluvioglacial. These pieces of evidence could be combined to try and begin to understand the movement of material through a study just after a storm event, for example. A focus might be to try and establish how a single storm event changes both the size and distribution of sediment along a previously observed section of beach.

Figure 9. An example of a summer and winter profile model

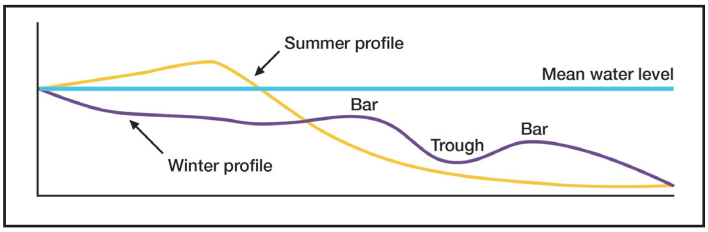
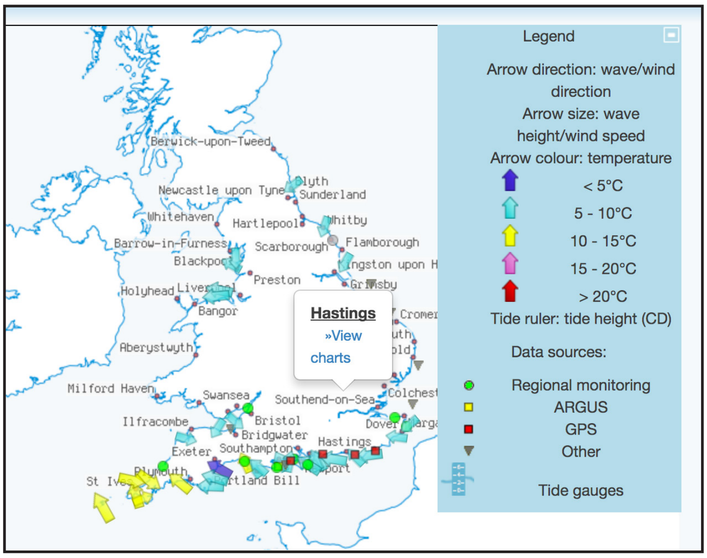
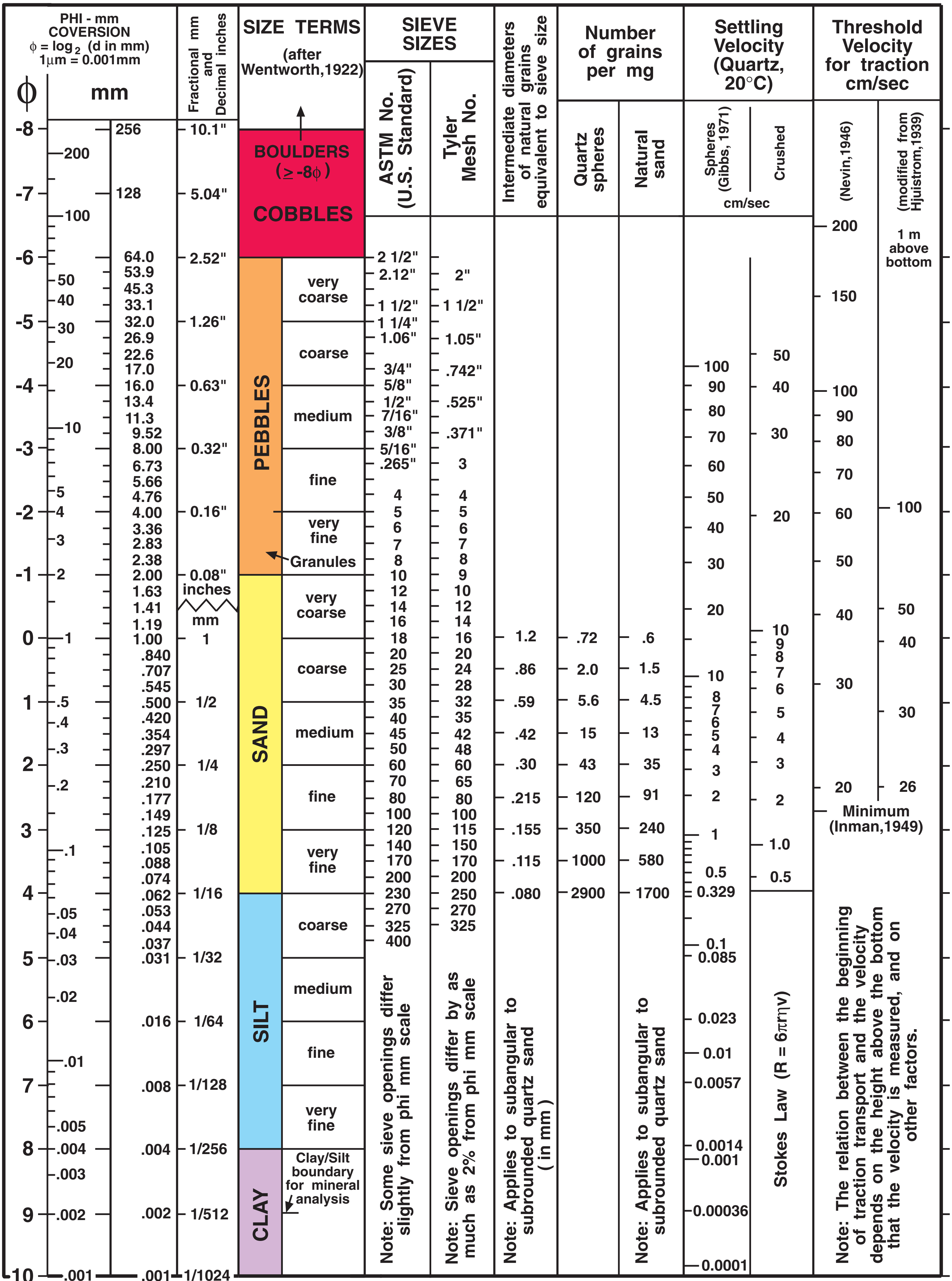


Figure 10. Data is easy to find online (e.g. Channelcoast.org)



(http://www.channelcoast.org/data_management/real_time_data/charts/)

Figure 11. The Wentworth Scale



Note: Some sieve openings differ slightly from phi mm scale

Note: Sieve openings differ by as much as 2% from phi mm scale

Note: Applies to subangular to subrounded quartz sand (in mm)

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Note: The relation between the beginning of traction transport and the velocity depends on the height above the bottom that the velocity is measured, and on other factors.

(https://en.wikipedia.org/wiki/Grain_size#/media/File:_scale.png)

Figure 12. CISA (Cliff Instability Susceptibility Assessment) – this could be adapted for physical fieldwork at the coast

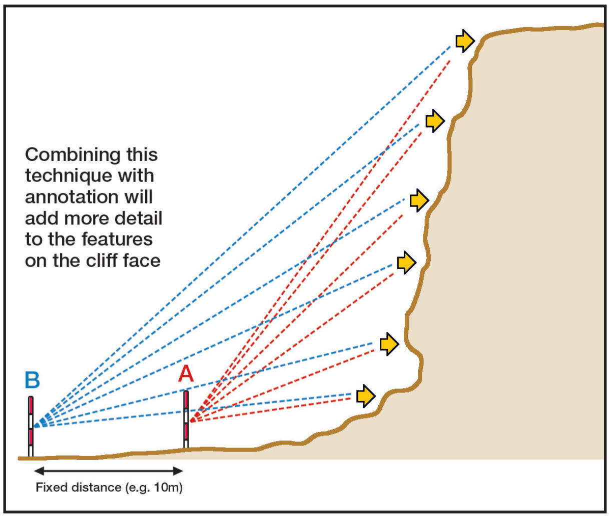
Parameters	VERY BAD 1	BAD 2	NORMAL 3	GOOD 4	VERY GOOD 5
	Geomechanical			**Joints**	
No. of joints	Crushed rock	>3	2 + random fractures	1 + random fractures	Occasional random fractures
Spacing	<0.06m	0.06–0.2m	0.3–0.6m	0.7–2.0m	>2m
Aperture	>1m	0.01–1m	0.002–0.01m	0.0005–0.002m	<0.0005 or closed
Water condition	Spring water	Wet	Very damp	Damp	Dry
Weathering	Extremely weathered	Very weathered	Weathered	Slightly weathered	Not weathered
	Morphological			**Cliffs**	
Cliff height	>30m	30–15m	14–5m	4–2m	<2m
Cliff slope	Overhanging	Steep: 75º–90º	Strong: 50º–74º	Moderate: 30º–49º	Gentle: <30º
Sea caves	Widespread	Widespread at the sea level	Widespread above the sea level	Slight	Absent
Natural breakwater	Absent	Very small	Small	Wide	Very wide
Mass movement: material and evidence	Widespread	Widespread around the sea level	Only material at the foot of the cliff	Slight	Absent
Abrasive action	Very intense	Intense	Moderate	Poor	Absent
	Meteo-marine			**Sea waves**	
Effective fetch	>250km	250–200km	201–150km	151–100km	<100km
Exposure to storm wave fronts	80º–90º	60º–79º	40º–59º	10º–39º	<10º
	Anthropogenic			**Engineering structures**	
Reinforcement	Absent	Poor	Localized	Widespread	Very widespread

CISA Value	<15	15–30	31–45	46–60	61–70
Class no.	1	2	3	4	5
Classification	Completely unstable	Unstable	Partially stable	Stable	Completely stable

Use this checklist when thinking about measuring coastal sediments and beach profile:

- Beach profiles are best undertaken at low tide when the greatest range of material is exposed.
- Recording sheets should be prepared prior to the data collection exercise, ready for immediate use in the field. Always take a pencil to write down the results as this works even if the paper gets wet.
- Always take digital camera / phone to record information such as survey details as well as close-up shots of changes in stone sizes.
- Coastal areas are potentially very dangerous, so careful forward planning is needed in terms of the state of the tides, appropriate footwear to minimise slips and trips etc. A risk assessment should always be completed prior to coastal fieldwork.

Figure 13. Fieldwork for a cliff survey



1. Sketch and visually identify key points on the profile of the cliff.
2. Mark two points (A and B) in front of the cliff a fixed distance apart and the same height on the beach face.
3. From point A record the angle to each point on the cliff, using a clinometer or clinometer app.
4. Now, from point B record the angles to the same points on the cliff.
5. Once the angles are obtained, the results can be plotted onto the graph paper to create the profile.
6. Any variations in angle, breaks of slope, and geological features should be identified and annotated.

Other surveys can use historic GIS and old maps to calculate and explore varying rates of cliff recession (see Factsheet 207 'Coastal Management').

Geology maps, cliffs and micro-features surveys

Figure 12 presents an example of a industry-standard "Cliff Instability Susceptibility Assessment". This index could be modified so that a comparison could be undertaken between two contrasting areas of coast for example.

There are a variety of other surveys that can be undertaken linked to the physical geography of the coast. Any student wishing to consider an investigation of either cliffs or coastal micro-features should start by getting hold of large scale OS and / or topographic maps of an area as well as a geology map.

These resources will be key in trying to understand some of the landscape processes, past and present, that have created the landforms which can be measured and observed. Geology maps are essential for studying the impact of structure and lithology on a particular stretch of coastline.

Cliffs are a recognisable indicator of a coastline undergoing erosion and cliff surveys may involve the measurement of a profile (Figure 13) as well as a survey in planform linked to geological factors and the intensity of wave attack. Linked to cliff surveys is research and fieldwork into the small-scale hard rock "micro" geology of a local area. Detailed feature mapping e.g. angle of dip from horizontal, (supported by close-up photographs) and mapping position of geological changes such as faults which are highlighted by a change in erosion. The GPS on a phone would allow the detailed position to be recorded. The distribution of more features, such as caves, can be mapped and then analysed using geology maps and photographs.

Risk Assessment

Working near cliffs is a potentially hazardous activity, so a hard hat always must be worn, and you should avoid areas of the cliff which look loose and liable to slippage or collapse. A risk assessment should also be completed. Seek local knowledge to identify areas that might be suitable, as well as areas which should be avoided. It is essential that impact of storm surveys are done before and after the storm and not during it.

Conclusions

Coastal projects have often been popular with students, but sometimes they have not been very successful as the work has not recognised the process-landform relationship. Success in this environment not only requires careful planning but also the focus on a small component of the coastal system. There should be a recognition that collecting evidence to infer processes operating is often complex and incomplete, leading to inconclusive results. Nevertheless, a very worthwhile and hopefully interesting piece of fieldwork and research should lead to a range of high quality NEAs. In the second article we will consider the fieldwork opportunities linked to coastal management.

References and further reading

Geography Teaching Today: http://www.geographyteachingtoday.org.uk/fieldwork/resource/fieldwork-techniques/coasts/

FSc Coastal fieldwork website can be accessed here https://www.geography-fieldwork.org/a-level/coasts/

An in-depth piece about grain shapes, etc. http://people.uncw.edu/dockal/gly312/grains/grains.htm

Acknowledgements**: This **Geo Factsheet** was researched and written by **David Holmes** and published in April 2017 by **Curriculum Press**. He works as a Geography consultant and author, and is a former Geography teacher. He has a particular interest in technology and fieldwork. He can be contacted on david@david-holmes-geography.co.uk.* ***ISSN 1351-5136