CYNEFIN

noun. (ker-nev-in) the place we feel we belong

Issue 1

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Introduction

Welcome to the first edition of our new geography magazine. The magazine aims to provide key information, suggestions for teaching, knowledge updates and news, as well as interesting features relating to our WJEC and Eduqas Geography qualifications.

This issue contains contributions from current teachers of our specifications, university lecturers, meteorologists and fieldwork leaders. And for any of you who are unsure of the latest thinking on the fundamentals of Plate Tectonics, two experts in the field have come together to write a definitive knowledge update for all geographers! Thanks to all those who have contributed their time generously to support this edition.

We hope you all find the variety of articles stimulating and inspiring and that they will help you develop some ideas for your classroom. We would be very grateful for any contributions that share good practice or classroom experiences for up and coming editions. If you would like to write an article, share a few top tips, or ask your students to submit a piece, please get in touch.

Best wishes,

Paul and Erin

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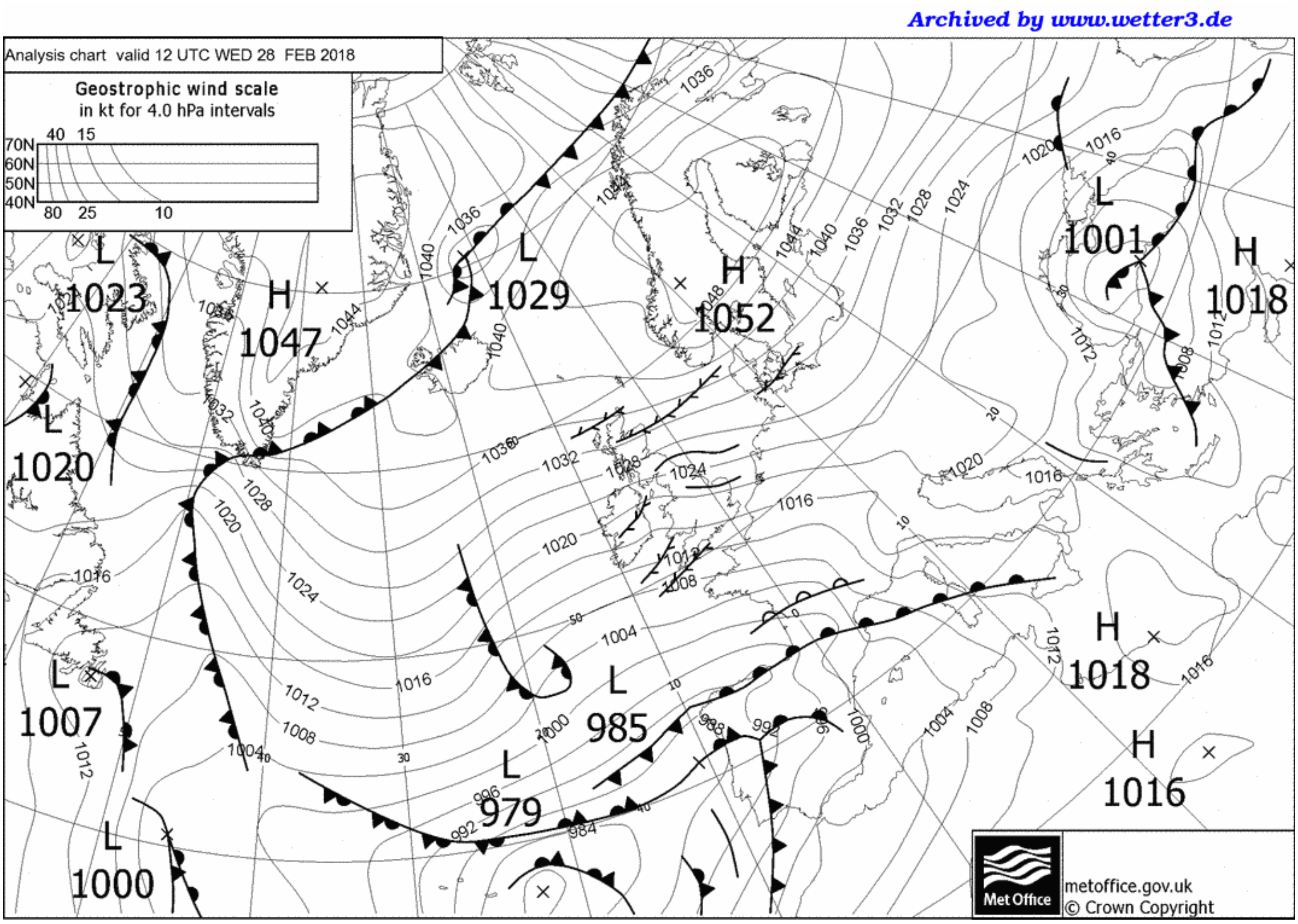
A year of extremes: The Weather of 2018

by Sylvia Knight, Head of Education, Royal Meterological Society

2018 was a year of extremes, bringing extreme cold and snow as well as heat and drought, and a fairly normal sprinkling of summer and winter storms. In this article, we'll look in detail at some of the more memorable weather events, starting with probably the most memorable – February's "Beast from the East" which brought bitterly cold weather and snow across much of the UK. This article could serve as useful case study material to support the delivery of GCSE Unit 2 in Wales, Component 1 (Specification B) and Component 2 (Specification A) in England.

As a result of the severe weather, many roads became blocked up and down the country, causing motorists to become stranded, there were disruptions and cancellations on other transportation networks, school closures, interruptions to power supplies, and some remote communities were cut off. 16 deaths were directly attributed to the weather and some studies have linked up to 2000 extra fatalities to the cold.

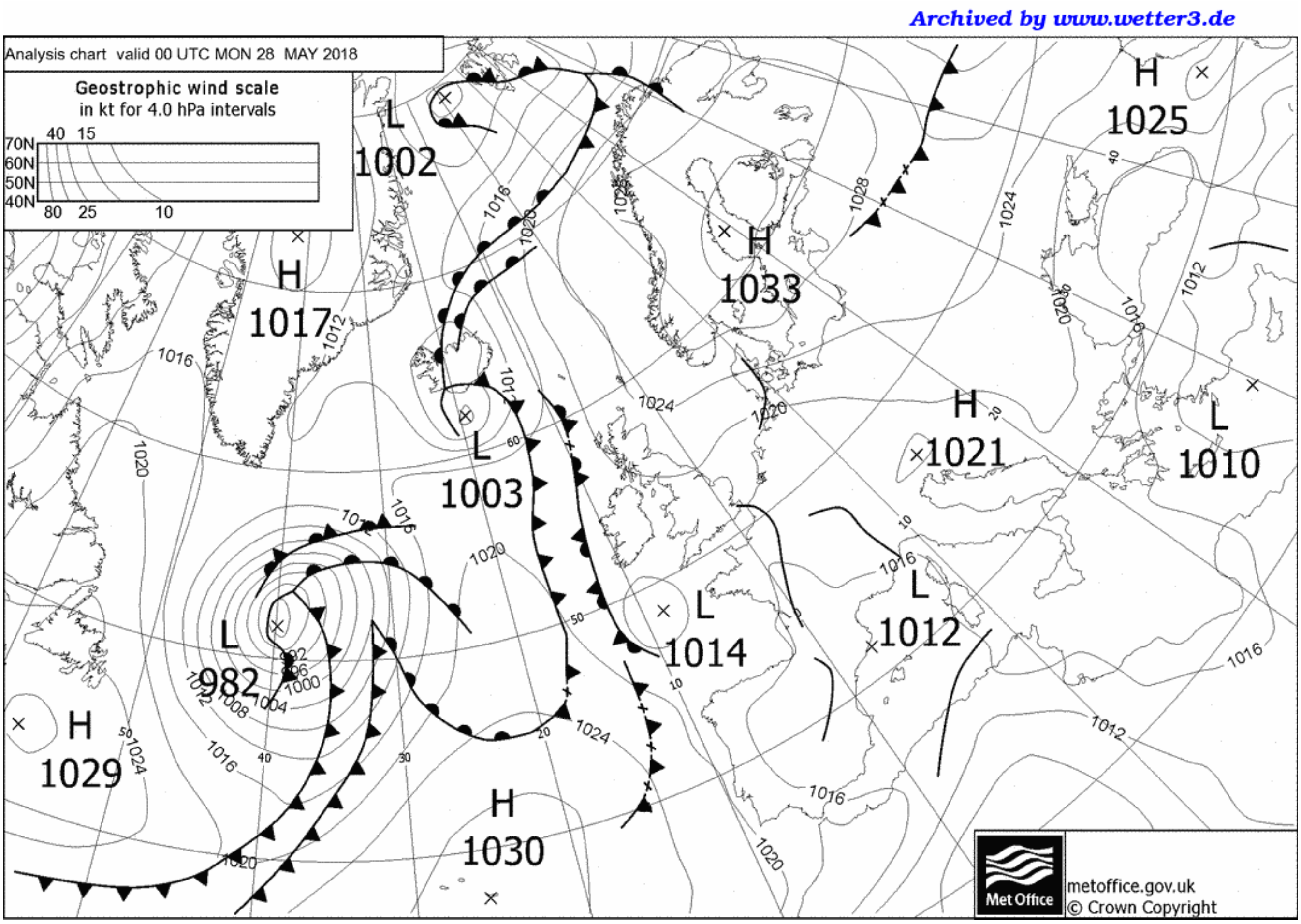


Weather chart, 28/02/2018

As a rule of thumb, the wind blows along the pressure contours (isobars) – the thinner black lines marked on this map, with the pressure values marked on them. The isobars on this day are crossing the UK in a roughly east/west direction, so the key question is whether the wind is blowing from the west (a westerly) or from the east (an easterly). To work this out, the easiest thing to do is to remember Buys Ballot's Law "If you stand with your back to the wind, then the lower pressure is on your left". On this day, the pressure is clearly lowest in the south of the UK and highest in the north of Scotland, so to have the lower pressure on your left, you need to be stood facing west – towards Ireland, indicating that the wind at your back is coming from the east. Now let's pick an isobar, say the 1024hPa contour, and follow it back to see where the air blowing along it has come from. It crosses the North Sea and then continues over continental Europe and off the map into Asia. By February, the centre of the Eurasian continent is bitterly cold, so our air started off very cold, maybe becoming slightly warmer as it approached the warmer western margin of Europe. As it warms, it becomes less stable and more inclined to rise, giving rise to clouds and potentially precipitation. As the air reaches the UK, it is still very cold, but now moisture laden having picked up moisture from the relatively warm water of the North Sea. As it hits the land, the air (which is already inclined to rise) is pushed up even more; as the air rises and cools, more cloud forms and this leads to precipitation – and in this case, that means snow. The short, herringbone type lines over the UK indicate lines of convergence where precipitation is particularly intense.

How do we know whether precipitation will fall as rain, sleet or snow? Of course, ground temperature is a useful first indicator – if it's near or below freezing then we might expect snow, but actually we need to consider the temperature of a much greater depth of the atmosphere. The key indicator usually used is the depth of the bottom half of the atmosphere. Remembering that gases expand as they get warmer, if the bottom half of the atmosphere is fairly deep, then that indicates that it is fairly warm, and if it's fairly shallow then it's cold. As a rule of thumb, if the bottom half of the atmosphere is less than 528dm (5280m) thick, then any precipitation will fall as snow. The 528 contour is shown as a red dashed line on some Met Office forecast charts and other weather maps (for more information see http://bit.ly/34CPvIU).

The weather chart from late May shows a very different situation:

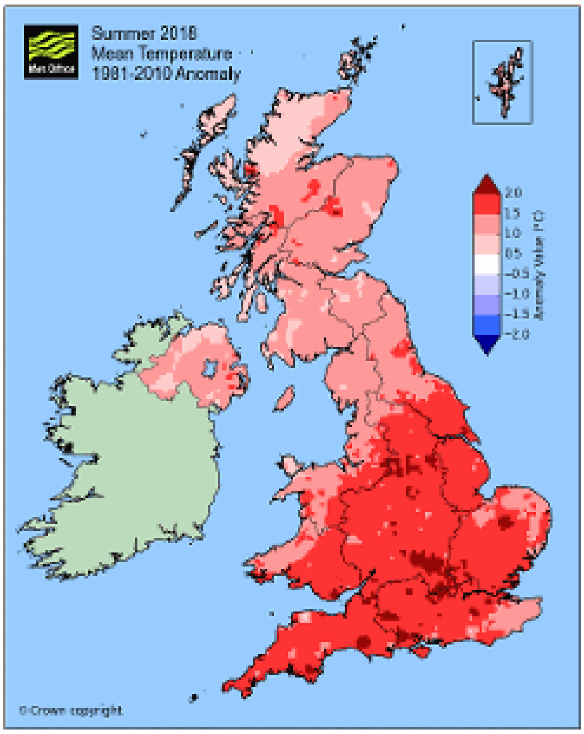


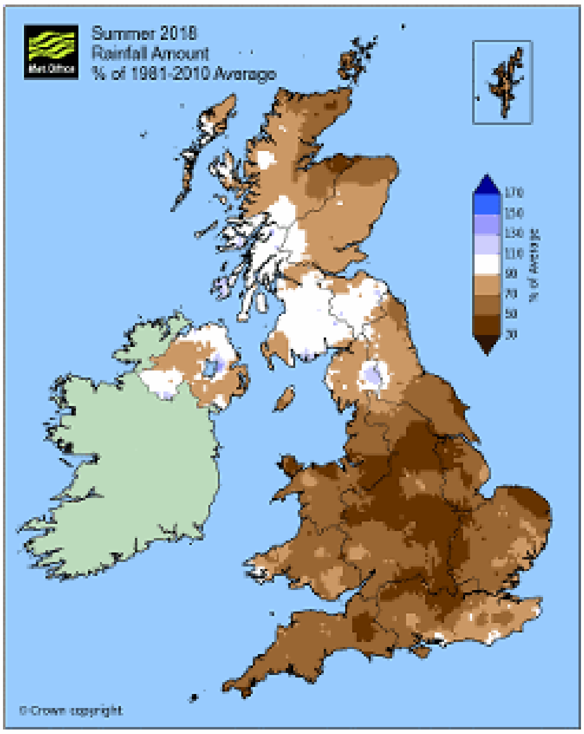
Now, there are very few pressure contours over the UK and the pressure is high – this remained typical all the way through to mid-July.

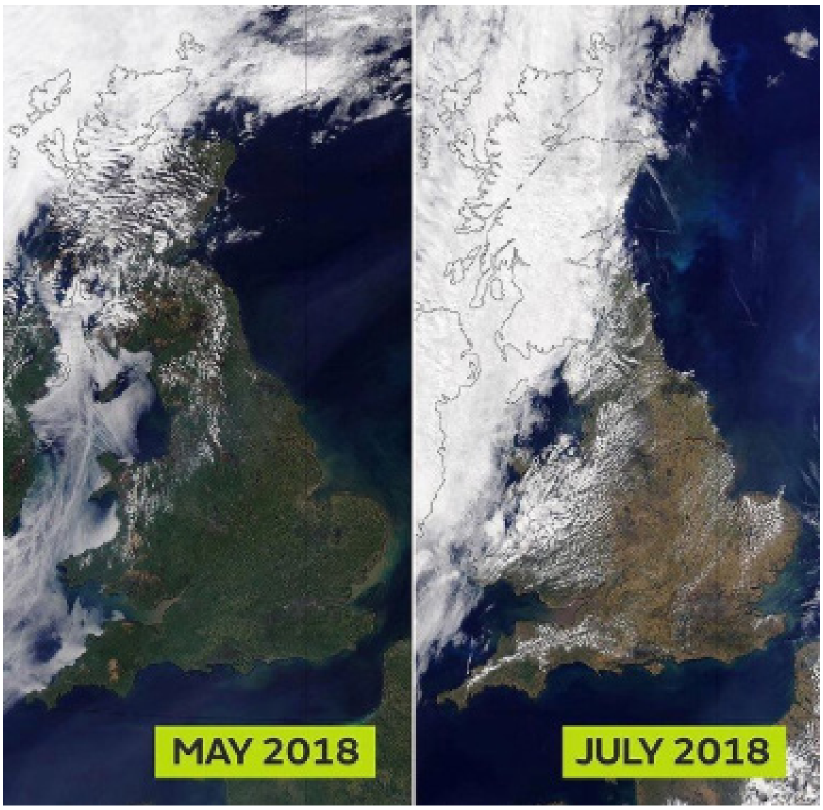
Remember that air pressure is simply a measure of how much air there is above – high pressure if there is more, low pressure if there is less. High pressure occurs where we have sinking air – air that has been forced to rise elsewhere in the atmosphere. Air converges high up in the atmosphere to take the place of the sinking air. The air sinks until it hits the ground, and then spreads out in all directions, or diverges. Because friction at the ground slows down the diverging air, but there is very little friction higher in the atmosphere to act on the converging air, we end up with air converging faster than it diverges, giving us an increasing amount of air – and the pressure rises. As air sinks through the atmosphere, it warms, meaning that where there is high surface pressure, cloud doesn't form and we tend to have clear skies. In the summer, this means the sun's light reaches the ground, warming it up and giving us gloriously hot, dry summer days.

The average summer temperatures in 2018 were tied with those of 1976, 2003 and 2006 for being the highest since records began in 1910. The weather had a significant impact on some crops and saw record numbers attending A&E. Wildfires burned in Ceredigion, Greater

Manchester, Lancashire and N. Ireland. Elsewhere in Europe the high pressure led to drought and forest fires – notably in Greece and Sweden, an increase in elderly mortality, severe decline in crop yields, the biggest algae blooming in the Baltic sea for decades, poisoning water for both human and animal use, and the shutting down of nuclear power plants as the water in the rivers used for cooling the reactors was too warm, leading to electricity grids crashing.







It's worth noting that although projections of UK climate through the 21st century have long suggested hotter, drier summers, the exact pattern which gave rise to this heat wave, with high pressure over Scandinavia, is not the weather pattern projected to dominate in the future. This was 'weather', not 'climate'.

Further Links

https://www.metoffice.gov.uk/research/collaboration/ukcp Climate projections for the UK

www.MetLink.org Resources for teachers, include worksheets looking at further case studies of weather systems and air masses in the UK.

Beyond Burgess: Using models and concepts to enhance fieldwork enquiry

By Janine Maddison, Education Development Officer, Field Studies Council

Geographical models have always played a pivotal role in school Geography, helping to simplify and explain complex geography. Countless cohorts have used the Burgess model to inform their investigations into urban settlements, comparing land-use of their local town to the model. Yet Burgess is decades old, and Geography in its very nature is current and constantly changing, and so the models and concepts used in fieldwork enquiry should reflect this.

At GCSE, students need to be able to engage with fieldwork enquiries that are underpinned by a conceptual framework, utilise secondary data, pose geographical questions and engage with the design of fieldwork methodologies.

With the demands of A Level Geography and the Independent Investigation, never has it been more important for students to engage with, utilise and critique a range of models and concepts at their disposal.

This article aims to explore ways in which current models and concepts can be used to enhance fieldwork enquiry at all stages of the enquiry process at A Level. It shares examples of how four models and concepts can be utilised at the different stages of place-based fieldwork enquiry, as well as highlight four other useful models.

Using models and concepts in planning

When planning investigations students will often use census data to help build up a picture of the area in question. Whilst this information is both reliable and accurate, a population statistic that a student does not then subsequently apply to their investigation or infer information from does little to inform how that place feels or behaves. How can students begin to investigate communities and neighbourhoods and not just census defined areas? Comments from the 2018 Eduqas/WJEC examiner reports reflect this.

"It was good to see many including links to appropriate theory but sometimes this was broached but not followed through, perhaps showing a lack of understanding of its relevance to the investigation."

"Support from literature was often patchy and often not well applied with many just listing sources in their appendix. Candidates had some secure locational context, which was often well justified, although at times this was lengthy, historical and not well linked to the investigation."

(A Level Examiners' Reports Geography Summer 2018)

The Health Map - Barton, H. and Grant, M. (2006)[1]

This model provides a visual tool for communicating and analysing the relationship between health and settlement (Figure 1). This model aims to show the complex interactions between the built, natural and social environment, and how these can influence neighbourhoods.

By finding and utilising both quantitative and qualitative data which can exemplify the categories in this model, a more holistic assessment of a location can be built. Subsequently, this may open up interesting dimensions to an enquiry, as the enquiry area is interrogated.

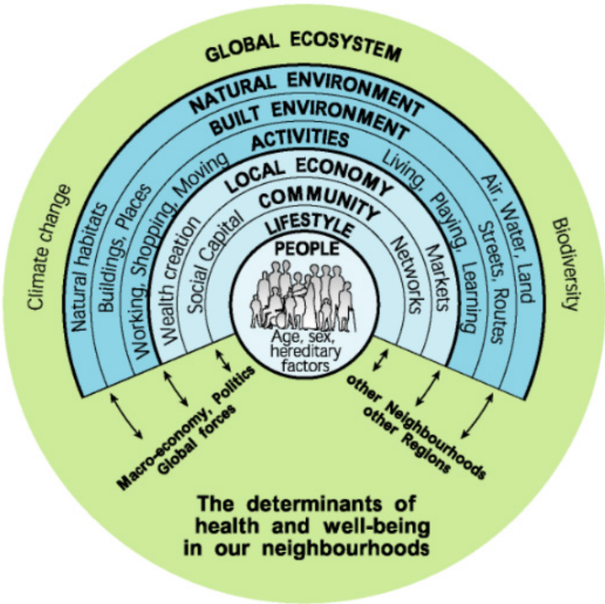


Figure 1: The Health Map

An example of this model being applied to a location in the planning stage, to refine and focus an investigation can be seen in Figure 2.

Initial enquiry title ideas:

Impact of the recent regeneration of Stockton High Street on local people.

Impact of inequality in contrasting areas of Stockton.

Category & Source	Findings
People ONS, 2013	Average age - 41 years 77.3% of people report good or very good health.
Lifestyle Newspaper article - Teesside Live (Nov, 2018) The £35m a year bill for Stockton's couch-potato lifestyle	Study into physical activity in the borough found that "lack of physical activity" was costing the LA £35.6 million a year on its public health and care services.
Community Stockton Borough Council - Family Hub Info	Stockton-on-Tees' council-run Family Hubs have received praise for tackling inactivity in the Borough. Services include: health visitor sessions, activity sessions, workshops for ages 0-19, café serving healthy and affordable food, access to extra support services.
Built Environment Stockton Borough Council - Regeneration Schemes Info	Regeneration schemes are transforming Stockton Borough to make it a "wonderful place to live, work, visit and play." Pedestrianisation of High Street - Attractive, safe, family friendly environment with minimal vehicle movement.
Natural Environment Stockton Borough Council - Green Infrastructure Info	Stockton-on-Tees Green Infrastructure Strategy Vision: diverse, rich, local distinctive, high quality environment; promoting enjoyment, health and well-being; contribute to regeneration and sustainability of area.

How has this information focused and refined initial area of enquiry?

To what extent has the investment and focus on the green infrastructure in Stockton centre had an impact on the access and uptake of healthy lifestyle indicators.

This area faces stark contrasts in the health and economic security of its residents. Investment in this area has aimed to promote healthy lifestyles, enhance the green economy, whilst growing the economic resilience of this area.

Figure 2. Utilising a selection of the components of the Health Map to interrogate a location and refine an enquiry title.

Using models and concepts in data collection

In fieldwork design, students often fall back on the tried and tested data collection methods, using Environmental Quality Assessments (EQAs) and questionnaires, regardless of their enquiry title or aim of their investigation. An off the shelf generic EQA or questionnaire is rarely going to gather the specific information required for students' own focused investigations, but the use of models and concepts to inform the design of data collection methods can increase the usefulness of data collection.

Home Zones: Department for Transport (2005)[2]

The Home Zones concept is one which considers how roads and streets can be re-designed to promote social use, and create streets where cars are the guest. Design of streets using this Home Zone concept invariably evolves along a continuum from regular traffic calming measures to unique landscaping and shared spaces.

The UK Department of Transport issued guidelines for the use of the Home Zone concept:

- designing for people
- gateways
- movement
- delineation
- accommodating play
- parking
- lighting.

Figure 3. Assessing Home Zone of a housing estate in Telford, Shropshire

The guidelines of the Home Zone concept could be incredibly useful for studies into meaning and representation of places, connections and relationships, economic change and social inequalities, rebranding process and urban management.

It is these 6 guidelines which have been taken and transferred into the categories of a bi-polar assessment, an example of which is shown in Figure 4 for the area shown in the photograph in Figure 3.

Bi-polar Assessment- Home Zone									
Criteria	Negative Evaluation	-3	-2	-1	0	1	2	3	Positive Evaluation
Gateways	This area is indistinct from the other surrounding areas.						x		A strong feature identifies that the area is different.
Movement	Vehicles' movement is unrestricted.					x			Vehicles and pedestrians share movement at a comparable speed.
Delineation	Vehicles control this space.							x	Vehicles and people effectively share this space.
Accommodating Play	Nothing in the environment encourages children to play.		x						Formal and informal play spaces for children.
Parking	Parked cards are limiting movement of pedestrians in the area.							x	Flexible approach. People can park without causing an obstruction.
Lighting	Level and quality of lighting is poor. Promotes negative feelings.						x		Level and quality of lighting encourages feelings of safety and security.
Total	**+9**								

Figure 4. Example Bi-polar Assessment - Home Zone based on Figure 3.

At GCSE this approach could easily be constructed using Egan's wheel when investigating sustainability in a community.

Using models and concepts in data analysis

Students often only think of statistical tests as their only method for analysing data, and so when it comes to collecting qualitative data from questionnaires, observation data or interviews, students can struggle to present and analyse this type of data, and therefore often de-value the rich, qualitative data that can be obtained from these methods as they are unsure of what exactly to do with it.

Coding is an example of qualitative data analysis which can help students to analyse this type of data. There are many different forms of qualitative coding, as there are different forms of statistical analysis. Models and concepts can be used to inform and enhance the qualitative coding method used.

The Great Places Model, Project for Public Spaces[3]

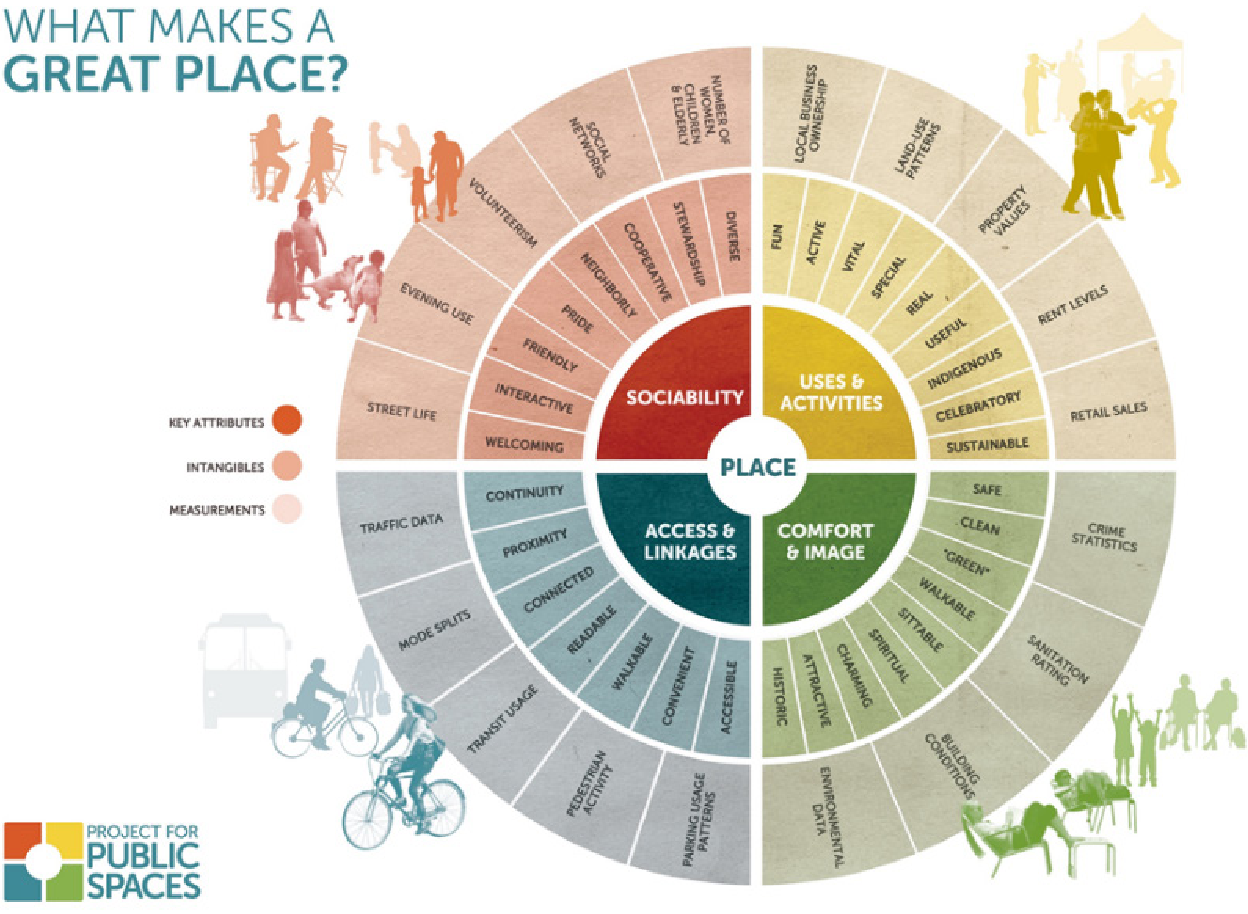


Figure 5. The Great Places Model
Source: Project for Public Spaces

This model identifies four key attributes of what makes a great place. (Figure 5)

- Sociability
- Uses and activities
- Comfort and Image
- Access and Linkages

This model then defines the measurements that can be an indicator of that attribute alongside the softer, more intangible feelings that a place may exhibit in each of these categories. It can be used as a tool to help people and planners judge how successful a place is.

These four key attributes can be utilised as categories in the method of *Categorising Qualitative Coding*. An example of this is shown on some qualitative, non-participant observation data from Morecambe seafront in Figure 6. The text from the observation data has been coded for whether observations agree or disagree with the 4 key attributes of the Great Places Model.

Sociability		Uses & Activities		Comfort & Image		Access & Linkages	
Agree	Disagree	Agree	Disagree	Agree	Disagree	Agree	Disagree
4	5	10	2	8	2	1	3

Figure 6. Non-participant observation, Morecambe Sea front

What to record?		Notes
Facts	Date and time, location and weather	Saturday 5th August 2017; 11:30-13:00; Sunny, warm and dry Eric Morecambe statue, Marine Road Central, Morecambe seafront
Physical environment	What is the layout?	Views over Morecambe Bay Stairs up to statue of Eric Morecambe. Benches with back to statue face out to sea. Landscaped beds with colourful flowers. Access to the promenade and the beach. Views over to the hills and mountains. Circular area bounded by railings. Concrete stars on the ground. Smaller seagull statues in the flower beds. RNLI Lifeguard hut on beach.
	How is the environment being used by people?	People sitting on benches looking out to sea.

What to record?		Notes		
Social environment	How many people?	32 sat on bench	34 queueing for selfie with statue	52 on promenade
	Social characteristics Demographics	Families with children under 10: 17 Older than 60: 15 Gender: 20F, 12 M	18-60 year olds: 34 Gender: 20F, 14 M	Families with children under 10: 23 18-60 year olds: 17 Older than 60: 12 Gender: 18F, 34 M
	How are people arranged in this environment?	Sat facing the sea. In family/friend groups. Few solo sitters.	In ordered line.	Spaced out family/friends groups. Solo runners and dog walkers.
	What are people doing?	Eating picnics. Eating fish and chips. Looking at views over Morecambe Bay and the hills and mountains of the South Lakes.	Focused activity of taking a selfie. Different family/friend groups are talking to one another in the queue.	Leisure activities (dog walking, cycling, running, walking). No interaction between different family/friend groups.

What to record?	Notes
Feelings, hunches and impressions	Very distinct activities e.g. no one who took a selfie also walked along the promenade. This was not what I expected. Those that queued for a selfie with Eric Morecambe came from the road, sole purpose of visit. More likely to be tourists, who are en-route somewhere else. Minimal time spent in Morecambe. Those walking on promenade, likely to be more local. Familiar with the area as didn't tend to pause and look at the view over the Bay and up the hills. Very activity organised e.g. dog walking, running, cycling. The running and cycling were all individual, perhaps area would benefit from an organised walking and cycling group. Those picnicking and sitting on bench did so for on average~35 minutes. Lingered longer due to nice weather, and demand for limited seating along the promenade. Had staked their claim. No picnic benches present were suitable for people who use wheelchairs. Proximity, noise and busyness of road to the picnic benches could impact length of time spent here. Convivial interaction from people in the 'selfie queue' shared purpose, meant they had something to talk about together. Some groups even took photos of other groups vice versa. Little to no interaction with the 'What's on Morecambe' board nor the 'History of Morecambe' board. Limited interaction between groups on benches, sometimes a "Do you mind if I sit here?" "Could you take a photo of us?" Some solo sitters passed the time by checking their phone, "body glossing". No interaction between groups of people on promenade. Very few instances of face engagement. Very few looked at the geographical and biological interpretation boards (5 instances). People don't value the importance of Morecambe Bay as landscape.

Using models and concepts in drawing conclusions

Drawing conclusions based on fieldwork data can be a challenge. Anomalies in the data and limitations in the data collection methods can mean that pulling together conclusions and assessing the reliability of those conclusions can seem a little bit like "subjective guesswork".

The use of an appropriate model at this stage of an enquiry can enable the data collected to be assessed against known criteria, which can reduce the subjectivity of conclusions drawn.

4Es model- DEFRA (2008)[4]

This model was created within DEFRA's Framework for Sustainable Lifestyles, it aimed to set out an approach to support and influence behaviour change centred around the 4 Es; Enable, Encourage, Engage and Exemplify. (Figure 7).

These 4 notions can, however, be applied to a variety of different contexts not just behaviour change. This model could be used in a range of enquiry topics including: to assess the success of a community-led placemaking strategy, the impact of an economic investment to gentrify an area or the ability of an area to cope with change.

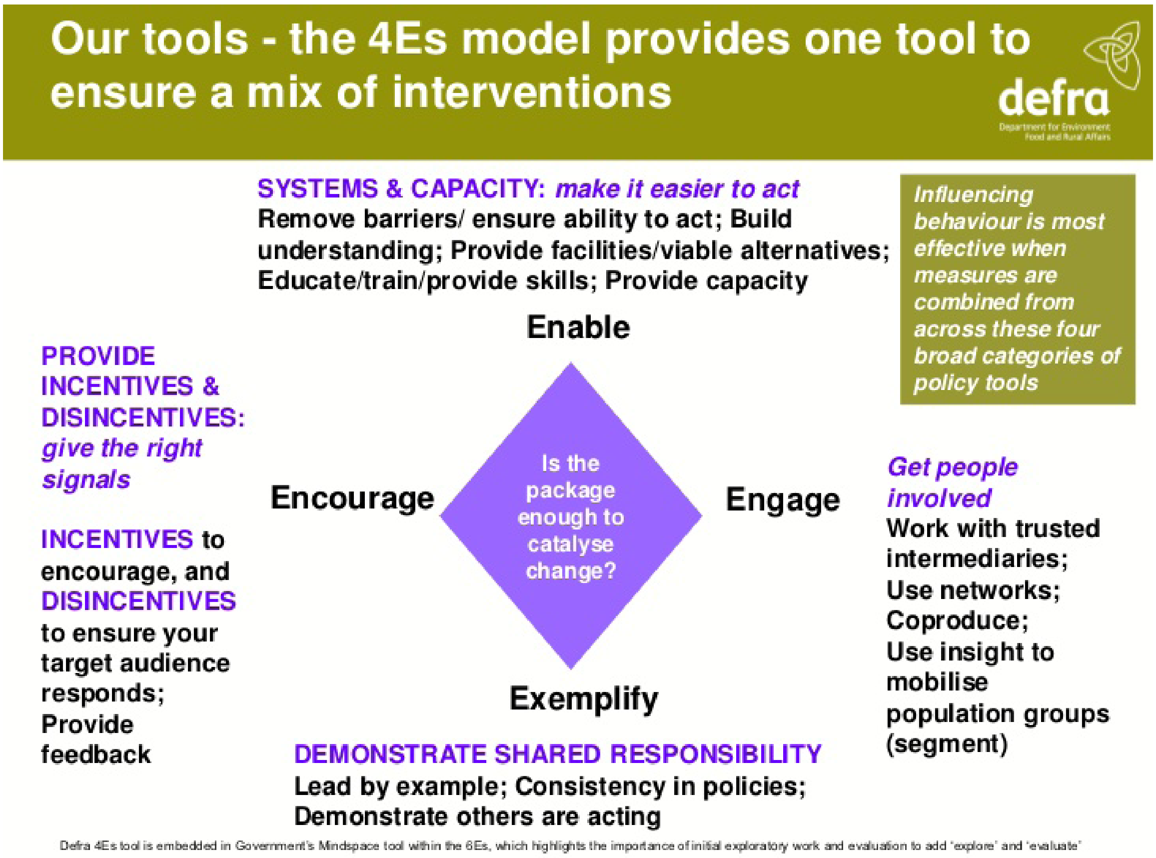


Figure 7. 4Es model

References

[1] Barton, H. and Grant, M. (2006) A health map for the local human habitat, The Journal for the Royal Society for the Promotion of Health, 126 (6). pp 252-253

[2]Department for Transport (2005) Home Zones: Challenging the Future of Our Streets

[3]Project for Public Spaces, The Great Places Model, www.pps.org

[4]DEFRA (2008) A Framework for Pro-Environmental Behaviours, Report http://bit.ly/2qOuPPG

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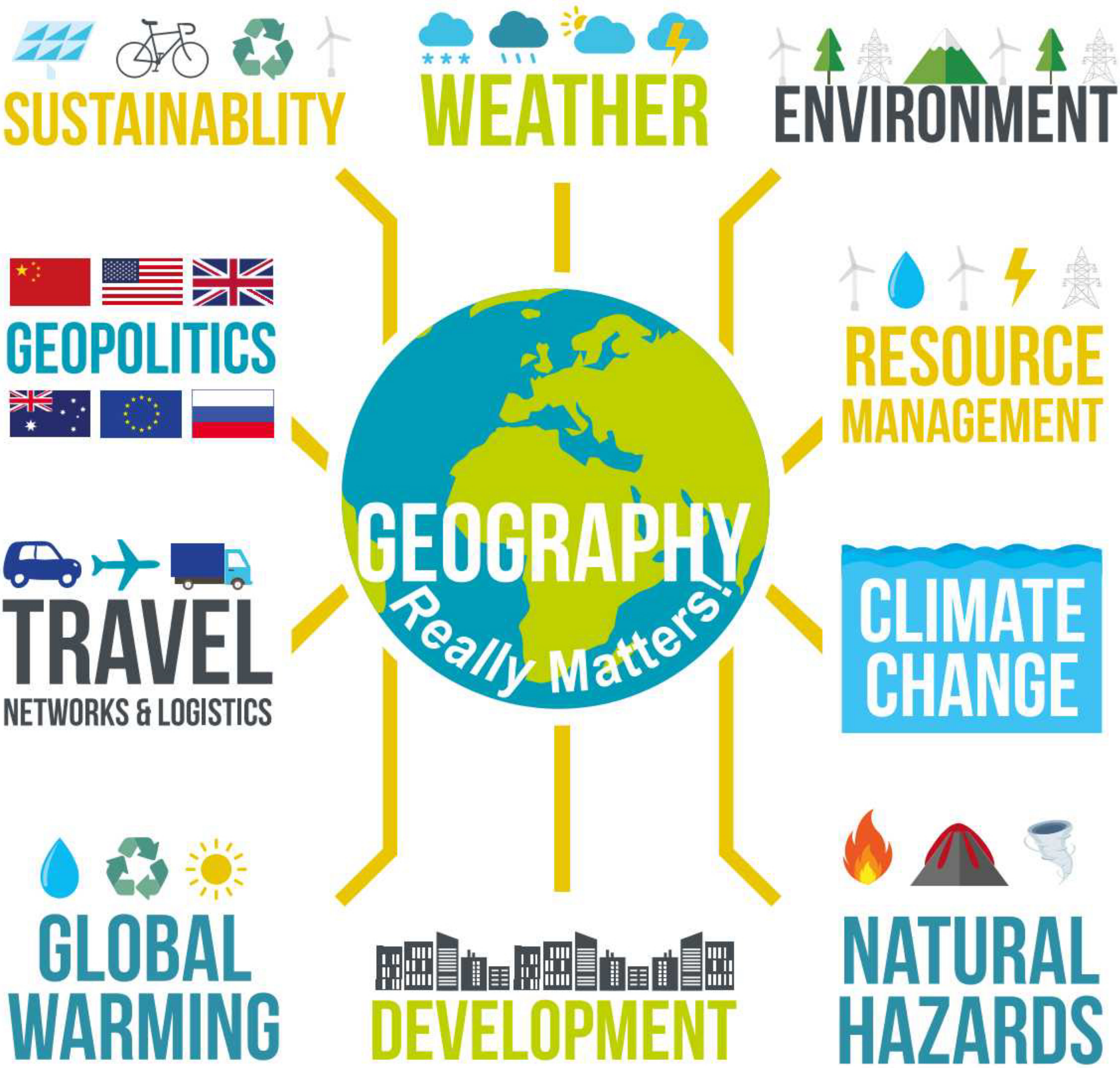

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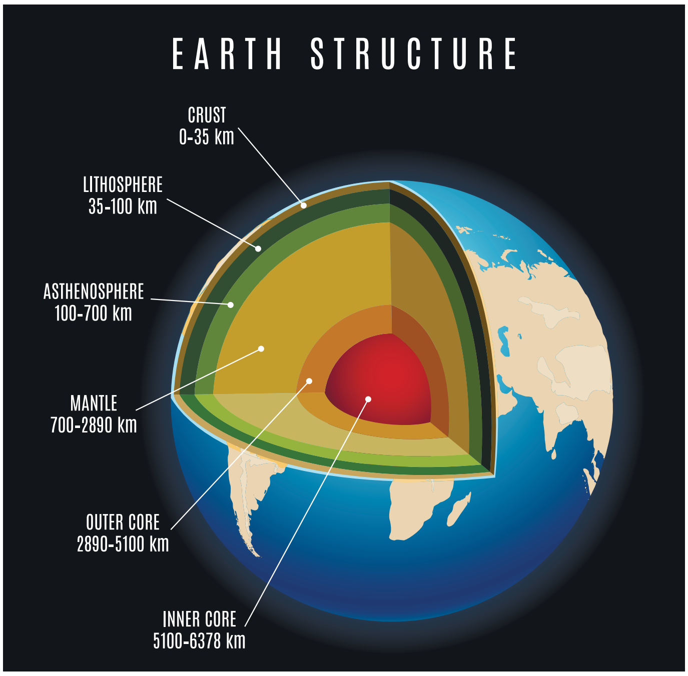
INSIDE THE EARTH: How and why do tectonic plates move?

By Stephen Davies and Peter Loader

Discussing the inside of the earth is difficult because we cannot see it for ourselves and because there are two different but related schemes for describing it. Until the theory of plate tectonics was developed, the Earth was divided into crust, mantle and core.

This straightforward division is based on the chemical composition of the layers:

- crust - lightest silicate minerals, exemplified by granite and sandstone
- mantle - heaviest silicate iron-magnesium minerals, exemplified by peridotite
- core – high density metallic elements, principally iron and nickel.



There are a few points that are worth remembering when discussing these layers:

- The crust is solid and very thin – like sticking a postage stamp on a football.
- The mantle makes up the greatest proportion of the Earth and is entirely solid. However, it is a solid which can flow, technically called a rheid. Common rheid materials include glacier ice, tar/bitumen and modelling clay.
- The core has liquid/molten outer core with a solid inner core.

What we know today about the internal structure of the Earth has been principally deduced through the study of seismic waves. These waves propagate from strong earthquakes and travel through the Earth where they reflect and refract off internal boundaries (in the same way as light).

It may be useful for geographers to try to remember some of the most important properties of these seismic waves:

- P (pressure, push, primary) and S (shear, secondary) waves both travel through the body of the earth.

- P and S waves travel through solid and liquid rock but S waves cannot travel through liquid.

As these waves encounter different surfaces inside the earth, their velocity changes and boundaries between surfaces which have different physical properties emerge. In geology, these boundaries are called discontinuities. Major boundaries or discontinuities within the earth identified in this way include the Mohorovičić Discontinuity (Moho for short), the transition zone which lies between the crust and upper mantle; the Gutenberg Discontinuity between the mantle and outer core and the Lehmann Discontinuity which lies between the outer and inner core. Studying these waves has therefore shown both geologists and geographers that the inner core is solid, the outer core is liquid and the whole of the mantle is solid.

Plate Tectonics

The plate tectonic theory divides the Earth into layers based on physical properties, particularly rigidity. It is best for most plate tectonic purposes to ignore the crust, which is not actively involved in the processes. Plate tectonics happen in the upper mantle, which can be divided into three layers, lithosphere, asthenosphere and the rest of the upper mantle, as seen in the diagram below.

Depth, km	Compositional (chemical) layering	Mechanical (physical) layering
0	Crust	Lithosphere
mean of 15	Mantle	Lithosphere
about 100	Mantle	Asthenosphere
about 250	Mantle	The rest of the mantle

Mohorovičić Discontinuity

- The outer lithosphere (meaning rock sphere) is rigid and includes the uppermost mantle and crust.
- Beneath the lithosphere, the mantle warms up to about 1300°C and begins to lose its strength. This is the asthenosphere (meaning *sphere without strength*). The asthenosphere is identified by seismic waves which slow down here because of the lower rigidity.

- Beneath the asthenosphere, the increasing pressure (from the rocks above) makes the upper mantle more rigid and seismic velocities increase again.

The Earth's 20 or so rigid lithospheric plates move very slowly at about the same rate as your fingernails grow. There are various ideas about the cause of this movement, but ultimately it depends on heat from the core and mantle (due to heat given out by the decay of radioactive elements).

Early ideas were based on convection currents. Hot mantle rises towards the surface where it spreads apart. As the currents spread sideways, they drag the overlying lithospheric plates with them. Where the plates diverge, there is intense volcanic activity which builds up the mid-ocean ridge.

One of the main problems with this encouragingly simple mechanism is the presence of the weak asthenosphere which effectively separates the moving mantle from the lithospheric plate which it is meant to be carrying. Evidence now shows that far from being mere passengers on a moving mantle, the plates are an integral part of the convection system.

The mid-oceanic ridges are very high mountain chains which increase in size because of the ascending magma beneath. This gives rise to the idea of 'ridge push', that plate movement is caused by the plate sliding off downhill away from the hot ridge. As the plate moves away, it cools, contracts and gets denser, helping this movement.

The spreading plate eventually meets a plate coming from the opposite direction. The denser of the two plates subducts into the mantle, causing earthquakes and volcanic activity of a different type than at the ridge. This cold, dense descending plate may pull the rest of the plate with it, leading to the idea of 'slab pull' as a cause for plate movement. Slab-pull is thought to drive convection patterns, and ultimately it is now accepted that plates and the mantle are a coupled system. This theory of 'slab pull' is currently thought to be the most important mechanism for plate movement.

Further details may be obtained on the Geological Society website
https://www.geolsoc.org.uk/Plate-Tectonics

Carbon, water and Upland Wales

By Hywel Griffiths, Senior Lecturer, Department of Geography and Earth Sciences, Aberystwyth University

For decades, scientists have understood that there is a relationship between carbon in the atmosphere and the earth's temperature. That fact is at the heart of current climate change discussions, with pressure on the leaders of the largest economies in the world to commit to reducing carbon emissions, although many argue that it is too late to prevent the most severe effects of the warming. At the same time, and closely tied to these environmental changes, the world is facing water crises due to a wide range of constantly developing factors, including overpopulation, domestic and industrial overconsumption (including agriculture), pollution, over-reliance on the construction of large dams, hydro-politics, privatisation and commercialisation, terrorism, and of course, climate change itself. Understanding the circulations of carbon and water, which are so important for feeding the planet through biological productivity, heating the planet through water vapour and the great circulations of the atmosphere and the oceans and powering the world through various forms of energy, is vital for planning for our future.

But where on earth is there carbon and water? As shown in Table 1, the main carbon stores are the oceans, rocks, the atmosphere, vegetation, soils and sediments. The atmosphere contains a small enough volume when compared with the rest, but of course, because of its importance as a greenhouse gas its influence is great. In the oceans, there is a difference between the volume of carbon in the surficial layers (the top ~ 100 m) and the deep ocean (which stores 50 times more than the atmosphere; Dessler, 2012). The upper layer, the mixed layer, which is mixed by winds, exchanges carbon with the atmosphere and with the deep oceans. In the Earth's rocks, such as limestone, the vast majority of the carbon is on the planet and there is a growing recognition of the importance of soils and sediments as carbon stores as well. Peatlands and bogs (for example the Migneint, the Berwyn Mountains peat bogs, Cors Fochno or Cors Caron - figure 1) are particularly important stores and the influence of biological crusts on soils is also receiving increasing attention. The carbon from one store to another is cycled through the processes of respiration and photosynthesis, diffusion, oxidation, rock weathering, volcanic activity and of course, increasingly through the combustion of fossil fuels.

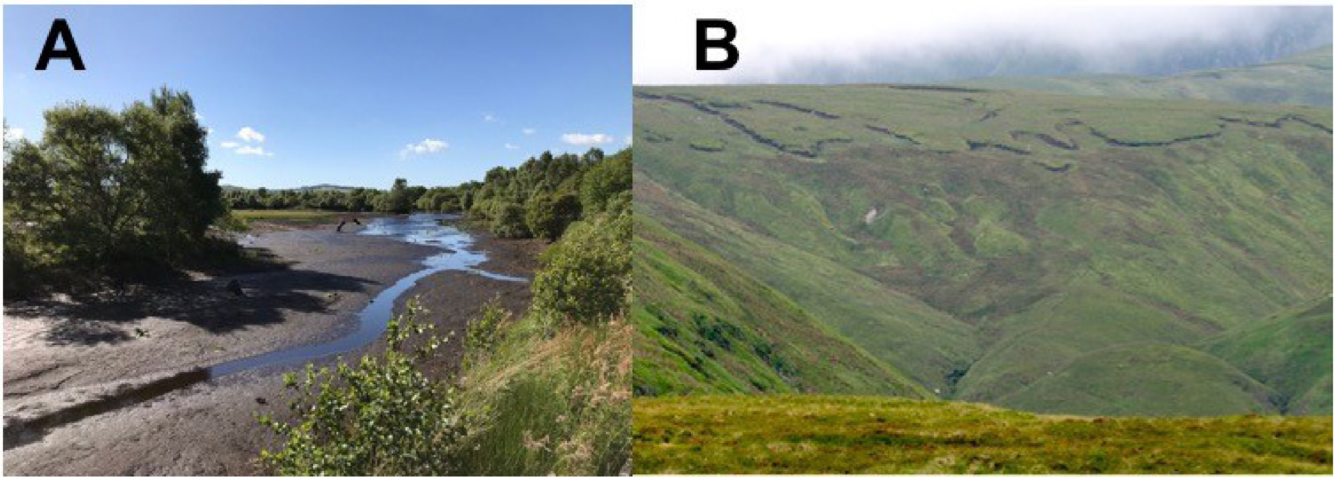


Figure 1: a) Part of Cors Caron during the dry summer of 2018 (photo Hywel Griffiths); b) Peat bogs near Bwlch y Groes in the Upper Dyfi Valley (photo Stephen Tooth).

Store	Volume (gigatonne)
Atmosphere	740
Terrestrial biosphere	2700
Oceans (top 100 m)	1000
Oceans (deep)	38500
Rocks	>1,000,000
Soils and Sediments	2700

Table 1: Carbon volume contained in various stores (after Dessler, 2012).

The storage of the hydrological cycle, or the hydrosphere, includes the oceans, frozen water in the cryosphere (ice curtains, polar and mountainous glaciers, permanent ice, seasonal ice and snow), groundwater, water in the atmosphere, water in 'terrestrial' stores (rivers, lakes, inland seas, water in soils, including water in irrigated soils, reservoirs, etc.) and water in biota (including our bodies of course!). The largest of these by far is the oceans, which store 97.4% of all the earth's water (Table 2). Of course, from the point of view of humanity's use of water, the fact that this water is salty makes it very difficult to use it unless it's desalinated. The cryosphere contains about 1.98% of the Earth's water, but 85.9% of the Earth's freshwater, the vast majority of which are polar ice sheets (the Greenland ice sheet and the Antartica ice sheet). Other large volumes are in the mountainous glaciers of the middle and lower latitudes (e.g. the Himalayas and the Andes), in the great plains of North America and Russia and in the permafrost.

Store	Volume ($10^3 km^3$)	Percentage	Turnover rate (years)
Oceans	1,350,000	97.4	3000
Ice sheets/glaciers	27,500	1.98	8000-15000
Terrestrial waters	8477.8	0.61	
Groundwater	8200	0.59	>5000 (deep) <330 (active)
Inland seas	105	0.008	
Lakes	100	0.007	10
Soil moisture	70	0.005	0.038-0.96
Rivers	1.7	0.0001	0.038
Biota	1.1	0.0001	0.077
Atmosphere	13	0.001	0.027
Reservoirs	5	0.0004	
Irrigated soils	2	0.0001	

Table 2: Water stores, volume, percentage of all water on the earth, and turnover rate (after Jones, 1997).

Yet, the majority of the cryosphere's water sources are very difficult to use as they are far from the large population centres who need them, the cost of exploiting them would be high, and of course they are among the most sensitive environments of the Earth, which are currently experiencing urgent and sudden changes. Having said this, it must be remembered that these sources, in particular the glaciers of the middle latitudes (e.g. the Himalayas and the Andes), feed some of the world's largest rivers (e.g. the Ganges River and the Brahmaputra River), and very large populations depend on them for drinking water, water for agriculture and hydro power. Although groundwater is considered as one of the major shores of water, there is considerable uncertainty about the exact amount of water to be found in it. Water exists in the atmosphere as water vapour and of course in the terrestrial sources as noted above (Figure 2). Water cycles through these stores through evaporation, evapotranspiration, various precipitation processes, overland flow, subsurface flow in soils, groundwater flow and through river flow. Although the last source is the smallest, rivers are the source on which we rely most, because water turnover through them occurs quickly, and therefore supply can be regarded as renewable and reliable, and rivers are particularly good for cleaning themselves as their constant flow washes out any pollution. Riverbanks, therefore, have attracted human societies and civilizations along the millennia.

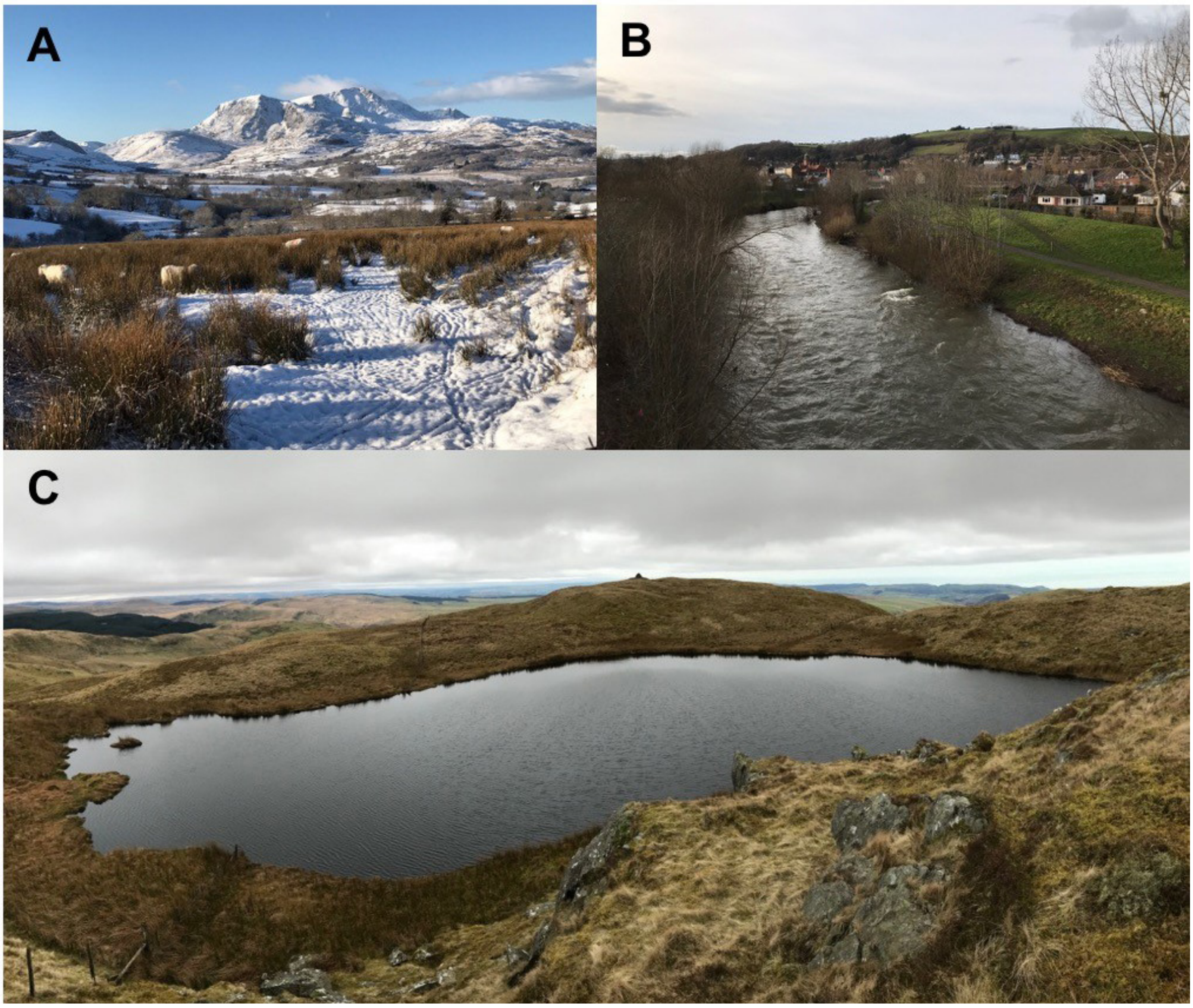


*Figure 2: Example of a water storage as **A)** seasonal ice on Cader Idris; **B)** The river Hafren in Newtown; **C)** Natural Lakes - Moel Llyn, Elenydd Mountains, Ceredigion.*

Although it is possible to differentiate between systems for closer study, in reality there is a need to consider how systems interact with each other in order to fully understand them. Carbon and water circulations are good examples of this as they often overlap. The importance of peatlands is already mentioned as carbon stores but also as stores that can hold back water during periods of heavy rainfall. Similarly the oceans are a store of carbon, and if there are changes in sea level then there will be implications to this. Rivers are able to transport carbon as soluble organic carbon out of their catchments to the sea and this may change over time as a result of population growth and change in land use (Nocacco et al., 2019). Climate change, which, of course, is a side effect of carbon emissions from humanity, has enormous implications on the hydrological cycle, particularly on such components as the cryosphere store, stores in rivers and lakes, evaporation rates and evapotranspiration, and the amount and frequency of storms can cause flooding. Following this to the end, it could be argued that these more frequent storms and floods will lead to higher rates of erosion on the shores of the coasts and in river catchments and thus affect carbon storage in rocks and soils. The interactions in ecosystems can also be seen when considering the vital role of water in terms of the distribution of plants that will then respire and photosynthesise.

On a slightly smaller scale, and more locally, cutting peat for incineration as fuel remains a traditional practice in rural Ireland, and historically this was happening much more widely, including in the uplands of Wales. Yet, despite recognition of the importance of restoring peat, the practice persists for both traditional and economic reasons. In the United Kingdom, including areas of the uplands of Wales such as the Migneint, a number of peat bog restoration projects have been established (New LIFE for Welsh Raised Bogs, 2019) to ensure carbon is continued to be stored in them. Such projects often also bring ecological benefits and flood-prevention benefits as the peat behaves like a sponge that absorbs water and discharges it slowly. However, there is considerable uncertainty about the future of the uplands of Wales. In the wake of Brexit, a number of fundamental questions arise about the funding of projects such as this, and how land cover will change in the uplands if commercial forestry becomes more profitable than farming following changes to European agricultural subsidies, creating landscapes such as those shown in Figure 3. Landscapes such as this that are the result of rapid, industrial forestation create routes for faster water flow, faster soil erosion and carbon loss from those soils, and it is possible that the role of peatlands and wetlands on the uplands with regards to water purification will be lost. The circulation of carbon and water, therefore, is not just a physical issue. Political, economic and cultural factors are also key, and the understanding of geographers, who can appreciate the interactions between them, is going to be instrumental when facing the challenges of the future.

Figure 3: The impact of commercial forestry in the uplands of the Elenydd Mountains, Ceredigion

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New LIFE for Welsh Raised Bogs, 2019 http://bit.ly/2KTnt4j

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Developing better geographers: Using questioning in the classroom

by Tom Miller, Deputy Headteacher and Senior Examiner

One of the great advantages our students have compared to those of twenty years ago is the number of online resources they have easy access to. Many of these resources are excellent; they fill gaps in knowledge, they test and mark for instant feedback and they offer colourful, stimulating support for learning out of the classroom.

However, all these wonderful opportunities have one common flaw – they often don't deal with application very well.

One of the reasons for this is that application is challenging. Indeed, our examiners' reports are littered with phrases such as "weaker responses did not achieve higher than Band 2 as they lacked evaluation", "candidates need to be more aware of the need to achieve balance in their responses and discuss both points of view" and "Evaluation includes the weighing up ... of information to come to conclusion". It is worth highlighting at this point that application is a very good differentiator. Eduqas data shows that students of all abilities can access at least some of the marks – the challenge with application is to achieve more of them.

Another reason for the perception of challenge in application is that all the command stems ask for higher order thinking: Suggest how; decide whether you agree; discuss the impact. All these present our students with challenges because they can seem indistinct, and a little opaque, to some candidates when compared to other lower order commands such as list, state and describe. Finally, application requires a sophisticated, mature student to consider an issue holistically – not all our students are as sophisticated or as mature as we might like....

But application isn't an issue we can ignore. It is 35% of the GCSE total exam marks and 37% of the A Level of the Eduqas/WJEC papers. The examiners' reports are clear that achievement in application is varied, with the best students able to demonstrate the ability to apply their knowledge to different locations and concepts. So, with something so complicated, a one-off task won't work. It has to be something that permeates every lesson and geographical interaction, and therefore the questions you pose to your classes during discussion and group work and in your marking are the best place to raise the standards of your students' application.

Application is officially defined as "Apply knowledge and understanding to interpret, analyse and evaluate geographical information and issues and to make judgements" and seems a good place to start because four words or phrases stand out for consideration:

INTERPRET ANALYSE EVALUATE MAKE JUDGEMENTS

Interpret could easily be transformed into the more student friendly "what is happening here?" and we can use it all the time in geography lessons. "Suggest what might happen next?" and "If we do this what will that mean?" will be standard practice in your classroom but this piece proposes that your classroom dialogues could be more effective with planning, practice and preparation. For instance, our students' abilities to interpret can be improved to include an element of time with enquiries about what might happen next. Students could have their understanding of the location of MNC factories extended with a question from you such as "What happens to the host country once the positive multiplier has worked and wages in the host country rise?"

Analysis as an element of this assessment objective requires students to deconstruct information and/or issues to find connections and provide logical chain(s) of reasoning. It is much easier for students to process if you can consistently phrase it as a consequence, as something that happens because of the issue, idea or decision. Your classes will benefit from a mantra of "this leads to this leads to this" whenever writing extended answers. And if you can access a visualiser to demonstrate how extended answers form, then you'll see the benefits as they show analysis with a variety of connectives and conjunctives such as "so", "because" and "therefore", or if balance is required "however", "on the contrary" and "on the other hand". I have seen great classroom displays that make these words prominent on several walls and windows, and great practice with exam mats and revision stimuli.

Analysis can be extended easily too. During class discussion students can be challenged with statements such as "When (or where) might this not be true?" and "For whom might that not be true?" Analysis can also be a great staging post for developing linkages. As the students' knowledge of the curriculum builds, questions such as "How does this link to…?" will increase depth and understanding and meet several mark scheme criteria for high marks too.

The new specifications feature more question stems that ask students to evaluate, and these can be supported with a rich variety of dialogue between you and your class from basics such as "Do you agree?" and "Why do you say that?" through to emotive questions such as "What do you feel is right?" and "What does that mean to you?" right up to stretch and challenge with "How are you sure that this is the right answer?", "How might others see this?" and a personal favourite of mine: "Is this your best answer or your first answer?" Too often the hurly burly of school or the pressure of exams offers obstacles to the real-world process of considering more than one threat through an idea. There is a strong case that classwork has a duty to prepare students for post-16 and post-18 study and for being effective in the real world, and so we must consider that our students should be pushed by our questioning to form complex and sophisticated responses.

"What do you feel is right?" can be focused and deepened with qualifiers such as "for the people involved?" or "for the environment?". "Is this your best or final answer?" can be made more effective with follow-up questions with a fieldwork focus by asking what other information you would need and what could you collect. Our need to build the Enquiry Cycle into our teaching and into our students' learning means that these simple extensions, whether spoken or projected, can extend all of our students' understanding. And as questions like this become second nature, the development of application grows and grows.

The final phrase in the application statement (for GCSE) is to make judgements and it is, arguably, the area your classroom is already very adept at. Natural questions to new issues such as "What does this mean?", "Why do you say that?" and "What is your solution to this?" come easily to geographers but that doesn't make them any less valuable. Good classroom dialogue can further extend the balance with evolutionary questions such as "Do you agree?" and "Why do you say that?" and with contradictory statements such as "What is your response to that solution?", "What if the opposite was true?" and "Could the opposite be true?". In a confident, safe, aspirational classroom you might even feel bold enough to try "I disagree with your opinion, persuade me."

The questions posed throughout this piece are framed as teacher to student but not to the exclusion of any other forum. You could use them as whole class discussion points or as the beginning of think, pair, share activities. My department has had a lot of success using them as 7+ (A grade +) challenge tasks; your department could plan for them in schemes of work or in banks to dip into or on an exam or revision mat.

These activities and questions are at the heart of what it means to be a geographer – to investigate with an open mind; to consider all sides of an issue; to decide how complex issues should be mitigated; to propose solutions that hold key principles dear; to empathise across a spectrum of views. Skills and qualities that aren't just geographical but that are key to being well-rounded citizens too. As geographers ourselves we know this importance is real but if we don't plan our opportunities to deliver them or don't formally recognise these high-level attributes as positives, in several senses, for geography and beyond then we are missing a huge opportunity.

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