EDUQAS GCSE LEVEL GEOLOGY compared with EARTH LEARNING IDEAS – an analysis by Geopix and Earth Learning Idea.

Earth Learning Idea and Geopix wish to thank Eduqas for their kind permission to reproduce these sections of their specification.

NB With effect from May 2020, Earthlearningidea has posted a set of teaching videos and Powerpoint presentations on the website. These have been produced to help teacher educators to continue their courses online during the Covid-19 lockdown and its aftermath, but they are also of value for teachers of A Level and GCSE Geology. Many activities are demonstrated which can enliven your own teaching, either used selectively for online lessons or face-to face classes. See:
https://www.earthlearningidea.com/home/Teaching_videos_workshops.html

2021/22. For our new series on zero carbon – See Appendix

GCSE GEOLOGY and EARTH LEARNING IDEAS	
Key Idea 1: Rock exposures contain evidence of how rocks were formed and subsequently deformed	
1.1 Minerals	
a. Minerals are formed by: • crystallisation from a melt [quartz, feldspar, mica, olivine and augite] • metamorphic recrystallisation [calcite, garnet] • crystallisation from solution in evaporating water [halite] • crystallisation as cement from flowing pore waters [quartz, calcite] • crystallisation from hydrothermal fluids [in veins and faults: gangue minerals - quartz, calcite; ore minerals - haematite, galena].	Building silicates Simulating crystal size during the cooling of magma and during recrystallization in solid rock
b. Modern laboratory techniques can be used to image mineral samples on a small scale and determine their chemistry e.g. the scanning electron microscope and electron microprobe.	
Use appropriate tests of: • physical properties of minerals [observation of colour, hardness, streak, cleavage, lustre] • [reaction with 0.5 mol dm^{-3} hydrochloric acid] to identify and distinguish between the minerals on the data sheet. Interpret data from the data sheet	Identifying minerals - use your sense(s)! Mineral expert 1 Mineral expert 2 Mineral expert 3 (ELI+) Mineral expert 4 - Recycle your mobile phone Eureka! - detecting ore the Archimedes way

	Picturing Minerals -1 Visualise and draw minerals from a verbal description Picturing Minerals -2 Visualise and draw minerals from a verbal description
1.2 Igneous Rocks and Processes	
a. Igneous rocks have diagnostic properties; colour and texture [crystal size, equicrystalline, porphyritic and orientation].	Crystallisation in a pudding dish Volcano in the lab (ELI+)
b. Igneous rocks [peridotite, basalt, andesite, granite] can be classified by: • texture • mineralogy.	Unfair ‘build your own crystal’ race (ELI+) Why do igneous rocks have different crystal sizes? (ELI+)
Identify the named igneous rocks in hand specimen/rock exposures, diagrams and photomicrographs from observation of their colour, crystal size [coarse >3 mm, fine <1mm], random crystal orientation of phenocrysts/groundmass and mineralogy.	Building Stones 2 - Igneous rocks Rock grain cut out How can you tell which grains come from which rock?
c. Crystal size in igneous rocks is related to the cooling rate of magma.	A rock is a time capsule – a message from the past: Bringing to life the extraordinary stories of ordinary rocks Building silicates: Simulating crystal size during the cooling of magma and during recrystallization in solid rock
d. Magma viscosity affects the type of volcanic activity and the shape of volcanoes – the differences between relatively passive [fissure] and violent eruptions [central vent].	Collapsing volcanoes - cauldron subsidence (ELI+) Hotspots (ELI+) Partial melting - simple process, huge global impact (ELI+)
Recognise and interpret the differing shapes of volcanoes from diagrams/photographs.	Eruption through the window Blow up your own volcano! Bubble-mania Best classroom eruption? Which type of classroom eruption best shows how volcanoes erupt?
Investigate factors affecting the length of lava flows using the 'Jelly lava flow' simulation experiment or equivalent. Factors investigated to include viscosity (related to temperature) and slope angle.	See how they run
e. Igneous bodies can be distinguished by: • structure [columnar jointing, pillow lava] • form [lava flows, sills, dykes and plutons]	Volcano and dykes/jelly and cream - radial dykes (ELI+) *Opengeoscience* 1: igneous intrusions and lavas Cracking the clues:

• field relationships.	
Identify the characteristics of igneous bodies [crystal size, structures, field relationships] as seen in hand specimen/rock exposures, diagrams and photographs.	Picturing igneous rocks – 1 Visualise and draw igneous rocks from a verbal description Picturing igneous rocks – 2 Visualise and draw igneous rocks from a verbal description
Analyse simplified geological maps and cross-sections to interpret their contrasting modes of formation.	
1.3 Sedimentary Rocks and their Fossil Content	
a. Rock is disaggregated by weathering and erosion into particles of various sizes and dissolved materials that are transported and deposited to form new sediments.	Watery world of underground chemistry (ELI+) Cracking apart (ELI+) Ice power (ELI+) Karstic scenery - in 60 seconds Weathering limestone - with my own breath! (ELI+) Weathering - rocks breaking up and breaking down Will my gravestone last? Breaking up – classroom freeze-thaw weathering: Showing how freezing and thawing can break porous rocks in the classroom How many sand grains are there in a bucket – or on a beach? Planning activities to estimate the number of sand grains in a bucket – or on a beach
Distinguish between the processes of weathering and erosion and evaluate their significance in the sedimentary characteristics and the geological history of sedimentary rock.	Teacher - 'What's the difference between weathering and erosion?' How can storms affect erosion rates? Predict what will happen to a landscape if it is affected by a storm Coastal erosion: What controls the form of a coastline and the steepness of its cliffs?
b. The grain size, shape and sorting of the resultant sediment is influenced by the energy of the transporting medium and the depositional environment [screes, rivers, shallow/deep seas, wind-formed dunes].	Changing coastlines Dust bowl Grinding and gouging Mighty river in a small gutter Mighty river in a small gutter: Investigating small-scale sedimentary processes AND modelling mighty rivers

	Rock, rattle and roll Rolling, hopping, floating and invisibly moving along Earth science out-of-doors: preserving the evidence Recreating the rocks – step by step: simulating a dipping sedimentary rock sequence though a sequence of Earthlearningideas What would it feel like to wriggle your toes on an ancient bedding plane as the sediment was being deposited? Clues from the present day about the origin of sedimentary rocks ‘A world in a grain of sand’: What can a grain of sand tell us about its past?
Interpret: • the distance of transport from the shape and sorting of sediment • the energy level of the environment of deposition from sediment grain size.	Modelling for rocks: what’s hidden inside - and why? What was it like to be there - in the rocky world?
c. Porosity and permeability of sedimentary rock depends upon the characteristics of the original sediment and the degree of compaction and cementation.	Space within - the porosity of rocks Does my rock hold water and will water flow through it?
Distinguish permeable from impermeable rocks by observing the effects of dropping water on specimens and/or by immersing them in water.	
d. Sedimentary rocks [breccia, conglomerate, sandstone, shale, evaporites, limestone] have diagnostic properties [colour, texture, reaction with acid] mineralogies and other diagnostic features.	A rock is a time capsule – a message from the past: Bringing to life the extraordinary stories of ordinary rocks
Identify the named sedimentary rocks in hand specimen, rock exposures and diagrams/ photographs from observation of their colour, texture [use of sediment comparators to determine grain size, shape and sphericity], [coarse >2 mm, fine <1/16 mm], reaction with 0.5 mol dm^{-3} hydrochloric acid, mineralogy and other diagnostic features.	Under pressure (ELI+) Make your own rock Rock grain cut out How can you tell which grains come from which rock? What colour was the world in the past? Using rock evidence and ‘the present is the key to the past’ to colour the geological world
Construct and apply a classification system/key to identify the named sedimentary rocks.	
e. Sedimentary rock type is dependent upon the environment of deposition: • Shallow marine: [limestone, sandstone, conglomerate] • Deep marine: [turbidites, black shale]	Evidence from the deep freeze What was it like to be there? – clues in sediment which bring an environment to life

• Terrestrial: 1. deposited in rivers and deltas [shale, sandstone, conglomerate, coal] 2. deposited by wind and water in deserts [breccia, desert sandstone] 3. deposited by precipitation from saline water during evaporation [evaporites - halite and gypsum] 4. deposited by ice [glacial till/tillite].	Environmental detective Building Stones 3 - Sedimentary rocks Calcium carbonate question - 'I'm pure calcium carbonate' Rock around your school Rock detective - rocky clues to the past Darwin's 'big coral atoll idea' Salt of the Earth Why is the Dead Sea dead? Measuring salinity From river sediment to stripey rocks Modelling the build up of different layers of sediment as seen in sedimentary rocks Atmosphere and ocean in a lunchbox - A model for all pupils – of hot, cold and cloudy density currents Beach, river, dune, mountain, plain – what layers might be preserved here? A discussion on what evidence might be preserved in rocks from different environments How do sedimentary beds form? – and why can we see them? Demonstrating how the beds in sedimentary rocks are deposited Playground continents: A palaeogeography in your school yard. Teaching geology to students with visual impairment (VI) Modifying geological materials for students who cannot see – (also igneous and metamorphic rocks and fieldwork)
Use the characteristics of sedimentary rocks, including their distinctive sedimentary textures, structures, mineralogy and their fossil content, as seen in hand specimens, rock exposures, diagrams and photographs to interpret their environments of deposition.	
Analyse sedimentary rock formations on simple geological maps, cross-sections and graphic logs to interpret geological structure and the history of sedimentation.	
Construct a simple graphic log from bed thickness and grain size data.	
f. Distinctive sedimentary structures [lamination/bedding, cross bedding, graded bedding, ripple marks, desiccation cracks] are characteristic of their environments of deposition.	Cracking the clues Sandcastles and slopes Sand ripple marks in a tank Sand ripple marks in a washbowl Sedimentary structures - cross-bedding and ancient currents

	Sedimentary structures - graded bedding Sedimentary structures - imbrication Sedimentary structures - load casts Sedimentary structures - sole marks Sedimentary structures - cross-bedding, ‘way-up’ Laying down the principles What is the geological history? Sedimentary structures – make your own cross-bedding: classroom activities to make and explain how cross-bedding forms Which sedimentary structures can you make?:- Making sedimentary structures in the classroom using simple apparatus and materials Picturing puzzle structures: Visualise and draw sedimentary structures from a verbal description
g. Fossils are indicators of past environments: • reef-building corals [marine, shallow, warm] • trilobite [marine], ammonite [marine] • plants [terrestrial, indicating past climate] • trace fossils [tracks indicating terrestrial, burrows indicating shallow water]. Identify the following fossil groups on the basis of their morphology [trilobite, ammonite, coral, plants, trace fossils - burrows, footprints], as seen in hand specimens, diagrams/ photographs.	Ammonites: the ups and downs Who ate the ammonite? Fossil or not? How could I become fossilised? Running the fossilisation film backwards Trace fossils - burrows or borings Trail-making What was it like to be there? - bringing a fossil to life Curious creatures Fifty million years into the future Sea shell survival Picturing trace fossils and other strange shapes: Visualise and draw trace fossils and sedimentary structures from a verbal description Picturing Fossils -1 Visualise and draw fossils from a verbal description Picturing Fossils -2 Visualise and draw fossils from a verbal description From hard-boiled eggs to bog bodies An investigation into the effects of tannin and mild acid

1.4 Metamorphic Rocks and Processes	
a. Metamorphic rocks are the result of increased temperature and/or pressure on pre-existing rocks causing recrystallisation to form new minerals and textures.	Metamorphic aureole in a tin (ELI+) Metamorphism - that's Greek for 'change of shape' isn't it? Building Stones 4 - Metamorphic rocks Metamorphic processes: controlled by depth, temperature and pressure What factors control metamorphism? Picturing metamorphic rocks - Visualise and draw metamorphic rocks from a verbal description
Identify the named metamorphic rocks in hand specimen from observation of their crystal size [coarse, fine], crystal orientation [aligned, random]; reaction with 0.5mol dm^{-3} hydrochloric acid.	
b. Metamorphic rocks [slate, schist, marble, metaquartzite] have diagnostic textures [crystal size and orientation]: • non-foliated texture • foliated texture [slaty cleavage and schistosity].	A rock is a time capsule – a message from the past: Bringing to life the extraordinary stories of ordinary rocks
c. Metamorphic rocks [schist, marble and metaquartzite] have diagnostic mineralogy.	
Identify the characteristic features of a metamorphic aureole on diagrams and simplified geological maps and cross-sections.	
Use the characteristics of metamorphic rocks [texture, mineralogy, acid reaction] as seen in hand specimens/rock exposures, diagrams and photographs, simplified geological maps and cross-sections to interpret their contrasting modes of formation [contact and regional metamorphism].	Rock grain cut out: How can you tell which grains come from which rock?
1.5 Deformational Structures	
a. The rock record provides evidence of tectonic activity.	What catastrophic natural processes affected your region in the geological past? Use the evidence in your local region to interpret dramatic geological events
Describe safety precautions to be taken when visiting field exposures.	The 'What could hurt you here?' approach to field safety **-t**eaching how to keep safe during fieldwork and other outdoor activities
Measure strike and dip.	Do-it-yourself dip and strike model (with DIY clinometer) (ELI+) Mapping "structures" on the playing field An exercise in measuring strike and dip
Analyse strike and dip measurements to describe and interpret rock structures in 3D.	
b. Folding is caused by tectonic stress [compressional].	Margarine mountain-building

Interpret characteristic features of folding in field exposures, diagrams, photographs, simplified geological maps and cross-sections: • horizontal beds • dipping beds • folded beds [antiform, synform, axial plane trace, limb].	Squeezed out of shape Deformed Trilobites: Using fossils to estimate the distortion of rocks *Opengeoscience* 2: tilted and folded rocks Banana benders Swiss roll surgery Modelling by hand 'when the youngest rock is not on top' Right way up or upside down? - modelling anti- and synforms by hand Use your hands to show how the beds in folds can be the right way up or inverted. Valley in 30 seconds - pulling rocks apart Himalayas in 30 seconds! The sliced Jelly Babies™ approach to understanding 3D geological maps: use Jelly Babies™ cut at the dip angle to highlight structures on geological maps Mapping "structures" on the playing field: An exercise in measuring strike and dip Visualising plunging folds - with your hands and a piece of paper Using your hands and folded/torn paper to show the patterns made by plunging folds. Modelling Earth stresses with your hands - Hand modelling of compression, tension and shear in the Earth Modelling folding – by hand**: -u**sing your hands to demonstrate different fold features Modelling faulting – by hand: Using your hands to demonstrate different fault features Picturing tectonic structures – 1 faulting. Visualise and draw fault structures from a verbal description Picturing tectonic structures – 2 folding Visualise and draw fold structures from a verbal description Teaching geology to students with visual impairment (VI) Modifying block models to teach map-work to students who cannot see Teaching geology to students with visual impairment (VI) - 2 Modifying visual resources for students who cannot see
c. Faulting is caused by tectonic stress [compressional, tensional, shear].	
Interpret features of rock deformation by faulting in field exposures, diagrams, photographs, simplified geological maps and cross sections: • normal fault • reverse/thrust fault • strike-slip fault • fault displacement.	

	Folds and faults with puff pastry and chocolate: understanding folds and faults in cross section and on a geological map
d. Unconformities are gaps in the rock record. Angular unconformities are formed by a sequence of events including deformation, uplift, erosion and later deposition. Identify unconformities in the field, in diagrams, photographs, geological maps and cross-sections. Use unconformities in interpreting the geological history of exposures.	Filling the gap – picturing the unconformity *'abyss of time'?* Rocks from the big screen Modelling unconformity – by hand: using your hands to demonstrate how unconformities form
	Geological mapwork from scratch 1: a conical hill (ELI+) Geological mapwork from scratch 2: valley with simple geology (ELI+) Geological mapwork from scratch 3: valley with dipping geology (ELI+) Geological mapwork from models 1: plain with simple geology (ELI+) Geological mapwork from models 2: cuesta with simple geology (ELI+) Geological mapwork from models 3: valley with horizontal floor (ELI+) Geological mapwork from models 4: sloping ridge and valley (ELI+) Geological mapwork from models 5: folded geology on block models (ELI+) Geological mapwork from models 6: plain with faults in the direction of dip (ELI+) Geological mapwork from models 7: plain with faults parallel to the beds (ELI+) Geological mapwork from models 8: plain with different types of fault (ELI+) Geological mapwork: using surface geology to make a geological map (ELI+)
Key Idea 2: Major concepts and techniques underpin our current understanding of the Earth and its history	
2.1 The Rock Cycle	
a. Sedimentary, metamorphic and igneous processes and rocks are linked by the rock cycle [energy transfer] over geological time. Interpret rock cycle diagrams. b. Rock cycle processes take place at different rates, from seconds to millions of years [catastrophism v gradualism - e.g. meteorite impact v river erosion]. Distinguish between processes reflected in the rock record that occurred at different rates.	Rock cycle at your fingertips Rock cycle in wax Rock cycle - laying out the rock cycle: product and process Rock cycle through the window Rock cycle: Not misunderstanding the rock cycle James Hutton - or 'Mr. Rock Cycle'? (ELI+) How long does it take? William Smith - 'The Father of English Geology' (ELI+) Model the stages of the rock cycle- with your pupils

	View to the future – and the past: Using a viewpoint or overview educationally From 'Rock detective' to 'Laying out the rock cycle'..
2.2 Plate Tectonics	
a. The Earth has a concentric structure based on its: • chemical properties [crust, mantle and core] • mechanical behaviour [lithosphere, asthenosphere].	Merry waves - all year round (ELI+) Bouncing, bending, breaking (ELI+) From clay balls to the structure of the Earth (ELI+) Core activity (ELI+) Journey to the centre of the Earth - on a toilet roll Waves in the Earth 1 - the slinky simulation (ELI+) Waves in the Earth 2 - the slinky simulation (ELI+) From an orange to the whole Earth What drives the plates? The slinky seismic waves demo: Using slinkies to show how earthquakes produce P-, S- and surface waves Shadowlands Simulating the effect of the Earth's core on earthquake waves Chocolate Plates: Simulating the properties of a lithospheric plate
b. The mechanical behaviour of the outer Earth involves the lithosphere [cold, rigid outer shell composed of crust and uppermost mantle]. It is underlain by the asthenosphere [weaker layer composed of upper mantle].	
c. The lithosphere is divided into a number of rigid 'tectonic plates' which move relative to one another by mechanisms not yet completely understood.	
d. With new evidence, plate tectonic theory developed from continental drift. • Continental drift was proposed by Wegener (1915) • Evidence for sea floor spreading was discovered by Hess (1960) Vine and Matthews (1963) J. Tuzo Wilson (1965).	Plate riding (ELI+) Plate tectonics through the window (ELI+) Wegener's 'Continental drift' meets Wilson's 'Plate tectonics' (ELI+) Wandering continents What evidence enables us to reconstruct the ancient supercontinent of Pangaea?
Analyse the evidence for plate tectonics [jigsaw pattern fit, fossil distributions, heat flow, magnetic stripes, age of the ocean floor, Global Positioning System (GPS) data].	Continental jigsaw puzzle (ELI+) Earth time jigsaw puzzle

e. There is a range of evidence supporting the theory of plate tectonics and the direction and rate of plate movements. Use maps to interpret the global distributions of present day earthquakes, volcanic activity and mountain belts in the context of processes at or near to plate boundaries	When did the poles 'flip'? Simulating how the Earth's Geomagnetic Polarity Time Scale was established. Did the continents move for you? (ELI+) Magnetic stripes (ELI+) What drives the plates? – the evidence. Examine the evidence for the different plate tectonic driving mechanisms. What drives the plates? in slab pull, what is it that pulls? Understanding how slab pull works through examining the data. What drives the plates? Modelling slab pull Modelling and discussing the slab pull plate-driving mechanism in the classroom Frozen magnetism (ELI+) Magnetic Earth (ELI+) Human magnets! Geobattleships Hands on magnetic stripes: Demonstrating how oceanic ridge magnetic stripes form with several pair of hands
f. The relative movements between plates produce a range of magmatic types, structures and topography identified at different types of plate boundary. • Divergent plate boundaries [basalt extrusion, sea floor spreading, the origin of basaltic magma by partial melting of the upper mantle, ocean ridges, high heat flow, rift valleys, abyssal plain] e.g. Mid-Atlantic Ridge. • Conservative plate boundaries [earthquake activity, transform faults]; San Andreas fault zone • Convergent plate boundaries: 1. oceanic-oceanic [island arc/trench systems] e.g. Java-Sumatra/Caribbean. 2. oceanic-continental [active continental margins; subduction zones, Benioff zone, partial melting producing andesitic and granitic magmas] e.g. the Andes. 3. continental-continental [mountain building, folding, thrust faulting, partial melting of the crust producing granites, associated regional metamorphism] e.g. the Himalaya.	Continental split - the opening of the Atlantic Ocean Model a spreading ocean floor offset by transform faults Continents in collision (ELI+) Partial melting - simple process, huge global impact: A "mantle plume" in a beaker – but not driving plates Mantle plumes 'yes' – but convection currents driving plates, probably 'No'. Replacement for 86. ELI+ Opening of the Atlantic Plate margins and movement by hand Faults in a Mars™ Bar Pulling apart a Mars™ Bar to model a divergent plate margin Mars™ margins – diverged, converged and transformed Modelling plate margins with a Mars™ Bar – apart, together and side by side

	Melting and boiling – the influence of pressure: how does a reduction in pressure lower melting and boiling points? The deep rock cycle explained by plate tectonics: deformation and metamorphism: A model showing how plate tectonics can explain metamorphism and rock-deformation Sounding the Pacific Ocean: An echo sounder traverse of the eastern Pacific Marie Tharp: 'The valley will be coming up soon' -. Bruce Heezen: 'What valley?' 'A woman scientist in a man's world' – what was it like? Laser Quest 1 – below the waves Seeing evidence for plate tectonics beneath the oceans - using echo sounding Laser Quest 2 – above the waves Seeing evidence for plate tectonics beneath the oceans - using satellites Mapping Magnetic Anomalies Modelling the palaeomagnetic evidence for plate tectonic boundaries on the ocean floor
Interpret the relative movement of plates from their plate boundary context shown in maps and diagrams.	Hotspots: Modelling the movement of a plate across the globe Which is the fastest spreading oceanic ridge? A map-based activity to find the most active oceanic spreading ridge
Interpret the type of plate boundaries from data [magmatic, seismic and topographic] provided in text, diagrams/photographs and maps.	
g. Plate theory is being continually re-evaluated in the light of new evidence e.g. seismic tomography and ocean drilling - RRS James Cook, Joides Resolution 360 (2016).	All models are wrong' – but some are really wrong: plate-driving mechanisms Many textbook diagrams of plate-driving forces have arrows in the wrong places. Updates: a) Follow the *Joides Resolution* research ship at sea. b) Recent research in plate tectonics.

	What do the top and bottom of a tectonic plate look like? Questions to test understanding of plate tectonic processes
2.3 Geochronological Principles	
a. Geological events are dated and interpreted using stratigraphic principles: • uniformitarianism - the present is the key to the past • the concepts of original horizontality, lateral continuity and superposition of strata • the relative dating of rocks on the basis of included fragments, cross cutting relationships.	Working out the age of the Earth - moving backwards as time moved forwards Time-line in your own backyard Toilet roll of time Sorting out the evolution of evolution headlines (ELI+) What is the geological history? Environmental detective Fieldwork: Applying 'the present is the key to the past' What happened when?: sorting out sequences using stratigraphical concepts Are the age-based stratigraphical concepts principles or laws? – and how do you use them? Now and then – spotting the difference
Investigate the link between ancient and modern processes by applying the principle of uniformitarianism. Apply the principles of relative dating to interpret the evidence in rock exposures in the field, in diagrams/photographs and simplified maps and cross-sections for the sequence of geological events that formed/deformed them.	
b. Rocks can be dated and correlated using the evolutionary change of zone fossils over time.	
c. The following zone fossil groups have morphological changes with time that are used in dating/correlation: • cephalopods [goniatites, ceratites, ammonites - suture line] • graptolites [stipes, thecae].	
Use the named fossils, as seen in specimens and diagrams/photographs to interpret the geological history of a rock sequence.	
d. The decay of radioactive materials provides a method of absolute dating for some rocks and minerals.	But how old is it? Investigating radioactive dating of rocks and minerals
Carry out a simple analysis of the age of a radioactive mineral based on the half-life concept [parent - daughter ratio, unstable parent, stable daughter].	
e. The development of the concept of *Deep Time* [Ussher (The Bible), Hutton, Kelvin, Joly and Holmes] has extended the age of the Earth back to around 4.6 billion years.	Working out the age of the Earth – moving backwards as time moved forwards Dating the Earth – before the discovery of radioactivity: Charles Lyell and Mount Etna, 1828 The origin of the Earth – at arm's length: The age of the Earth – with a good stretch of imagination

	Counting to one million? Trying to imagine the enormity of geological time 'Looking so far into the Abyss of Time' How to visualise the immensity of geological time…with a rope!
2.4 Global Climate and Sea Level Change	
a. There is evidence for global climate change through geological time [icehouse to greenhouse conditions].	
Deposition of glacial deposits in regions close to the equator [Carboniferous tillites], deposition of limestone in areas outside the Tropics [Cretaceous limestones/chalk].	
b. Evidence for change in the climate of the British area caused by a change in its latitude.	Back in time "Alligators spotted in London" @ELI_Earth - July 1 Retrieving and communicating information
Interpret the evidence from hand specimens of rocks and fossils, maps, diagrams/ photographs for the changes in latitude of the British area from the Lower Palaeozoic to the Cenozoic. Interpret data from the data sheet.	
c. There is evidence for changes in sea level [drowned forests].	
d. The major sources of carbon dioxide in the atmosphere are volcanic emissions and the burning of fossil fuels.	
Evaluate the relative roles of volcanic emissions and fossil fuels in current rates of climate change.	
e. There is evidence for changes in atmospheric carbon dioxide levels over geological time [ice cores and sedimentary rock].	The oxygen isotope sweet simulation Interpret Earth temperatures from simulated deep-sea and ice cores. How can the ice core evidence for climate change be explained? An educational opportunity for discussing evidence, hypotheses and possible responses 'Earth's oxygen thermometers' Simulating how ocean sediment and continental ice cores record past changes in Earth's temperatures.

f. There is both positive [reduction of icecap albedo accelerating warming] and negative [carbon dioxide dissolved in sea water, absorption by organisms to form limestone] feedback on the carbon dioxide content of the atmosphere [subduction, volcanic emissions, chemical weathering and marine storage].	Ocean acidification – The other CO_2 problem: See how acidified water affects calcareous marine organisms Greenhouse effect in a bottle How to simulate the effect of increased CO2 level on Earth's temperature
g. Global warming/cooling affects continental ice sheet dimensions and global sea level.	Melting ice and sea level change 1 – sea ice: does sea level change when floating sea ice melts? Melting ice and sea level change 2 – ice caps Does sea level change when ice caps melt? Sea level in a plastic cup: eight ways to change the water level in a plastic cup – and global sea level How will rising sea level affect our coastlines? … and what can be done to adapt to rising sea levels?
Investigate the evidence from the internet, maps and aerial images for past and current fluctuations in continental ice and the effect on global sea levels.	
h. Carbon sequestration/capture is a geological strategy for reducing atmospheric carbon dioxide.	See Appendix
2.5 The Origin and Development of Life on Earth	
a. Life probably originated from the oceans or hydrothermal pools 3500 Ma [black smokers].	
b. The development of diversity in the evolution of life [through single cells, multicellular organisms, animals with hard parts, fish, amphibians, reptiles, mammals, birds and humans] is identified from the fossil record.	Sorting out the evolution of evolution headlines
Use simple evolutionary trees diagrams [cladograms] to demonstrate evolutionary trends.	
Interpret data from the data sheet.	
c. The development of life on Earth was punctuated by major extinction events [Cretaceous/Palaeogene (K/Pg) mass extinction].	
d. Major fossil finds show: • rare and exceptional preservation [Burgess shale fauna] • the links in macro fossil evolution through the morphology of modern reptiles and birds [*Archaeopteryx*]	Dinosaur death - did it die or was it killed? Dinosaur in the yard How to weigh a dinosaur Mary Anning - Mother of Palaeontology Meeting of the dinosaurs - 100 million years ago Dig up the dinosaur

• that complex fossil skeletons have to be interpreted from incomplete and disarticulated remains [dinosaurs] • features of early hominids [“Lucy”].	How could I become fossilised? Let’s weigh that dinosaur! How can a plastic model reveal the mass of an actual dinosaur?
Evaluate the significance of the incomplete nature of the fossil record.	Shell shake - survival of the toughest
Key Idea 3: Comparisons of the Earth with other planetary bodies within the Solar System provide evidence for the origin and evolution of both	
3.1 Planetary Geology	
a. There are similarities and differences between the Earth and its planetary neighbours [rocks, landscapes, atmosphere, temperature, pressure and gravity].	
b. Meteorites provide evidence for the composition of the Earth.	
c. The relationship between landforms and geological processes on Earth provides an analogue for interpreting landforms on planetary bodies within the Solar System.	
Use the principle of uniformitarianism to interpret the geological processes operating on planetary bodies within the Solar System.	
Use evidence from space imagery and other planetary exploration data [maps, diagrams/ photographs] to interpret the landforms and processes operating on planetary bodies within the Solar System e.g. Moon and Mars.	
d. Planetary landforms provide evidence for unseen Earth processes e.g. Moon impact craters.	Craters on the Moon
e. Impacts from meteorites/comets may have had a significant effect on the evolution of the Earth and its biosphere.	
Key Idea 4: Human interaction with the Earth can increase or reduce risk	
4.1 Earth Hazards and their Mitigation	
a. Geological events can be hazardous: • earthquakes [shaking triggering landslides] • volcanic eruptions [lava, ash, pyroclastic and mud flows] • landslides [and related subsidence] • tsunamis.	Merry waves - all year round (ELI+) Earthquake in your classroom Earthquake through the window - what would you see, what would you feel? Jelly/biscuit modelling of how earthquake waves amplify and devastate Krakatoa - The balloon goes up at Krakatoa See how they run: investigate why some lavas flow further and more quickly than others Tsunami alert! Run for the hills or stay by the sea?
Investigate and interpret geological data relating to the distribution, measurement and possible causes of earthquakes, volcanic eruptions, landslides and associated tsunamis.	

	Tsunami through the window - what would you see, what would you feel? Tsunami! Earthquakes in art - developing a scientific report based on evidence in historic paintings. If a sedimentary bed were laid down outside now – what would it be like? A discussion of beds and catastrophic processes Which natural hazards could damage the area where you live? How safe is your home area? Making waves: a storm in a teacup? Three ways to make waves in a container of water: wind, earthquake and impact Landslide danger – and climate change: Case studies of how landslides work and the likely effects of climate change Picturing Landforms – 5: Mass Movement B Visualise and draw landforms from a verbal description
b. The level of risk of a hazard is associated with life and property and relates to: • population density • technology [buildings] • development [economic situation, education, communication].	Surviving an earthquake
Use examples to contrast the risk of naturally occurring hazards in areas of contrasting development - LEDC and MEDC.	Danger - quicksands! Failing slopes Landslide through the window - what would you see, what would you feel? Sink hole! Testing rocks 2 - ‘Splat!’ Testing rocks 3 - that shrinking feeling
c. The level of accuracy of hazard prediction is limited.	
d. The methods of reducing risk include: • building design and regulation • prediction	Quake shake - will my home collapse? Shaken but not stirred? Earthquake prediction - when will the earthquake strike?

1. hazard interval patterns [seismic gaps] 2. ground deformation [tiltmeters] 3. groundwater changes 4. gas emissions • warning schemes and evacuation	Party time for volcanoes! (ELI+) Take a 'Chance' on the volcano erupting (ELI+) When will it blow? - predicting eruptions Fluids, friction and failure Slip-sliding away How does monitoring fault creep help to forecast earthquakes?
4.2 Earth Resources and Engineering	
a. There is a distinction between Earth's: • resources - naturally occurring useful substances • reserves of a resource - the calculated amount that is economic to extract.	Gold prospectors Hydrothermal mineralisation - interactive (ELI+) Riches in the river
b. Mineral resources are important in construction, industrial manufacturing and energy generation.	Building Stones 1 - a resource for several ELI activities Building Stones 2 - Igneous rocks Building Stones 3 - Sedimentary rocks Building Stones 4 - Metamorphic rocks Roadstone - which rock? Testing rocks 1 - bouncing back Essential Minerals for the Green Revolution – 1 Lithium An element which is pulling more than its weight in the world Essential Minerals for the Green Revolution – 2 Copper An element for which the demand is increasing rapidly Essential Minerals for the Green Revolution – 3 Rare Earth Elements Vital components in modern technology Essential Minerals for the Green Revolution – 4 Graphite From a pencil to the electric car! Essential Minerals for the Green Revolution – 5 Cobalt Mined by children Essential Minerals for the Green Revolution – 6 "The Three Ts" Tin, Tungsten and Tantalum Essential Minerals for the Green Revolution – 7

	Gold An essential mineral – or is it? Essential Minerals for the Green Revolution – 8 Critical Minerals Essential mineral – critical mineral: what is the difference? Essential Minerals for the Green Revolution – 9. Critical Minerals for the USA Why are certain minerals of such importance to the USA? Rock around your school: Investigating the building materials Urban fieldwork – the stories from materials, colours, lines and shapes: find out the stories told by materials used in building and for decoration
Investigate the uses of the following minerals • Limestone for aggregate in construction • Haematite in the steel industry • Uranium in energy generation.	Smelter on a stick (ELI+) What is it made of? Relate each mineral or rock to the everyday object containing it. Mineral or not? Discussion about what is a mineral and what is not
c. Geologists prospecting for new reserves use a variety of techniques: • geological mapping • borehole correlation [using microfossils] • geophysical [seismic, magnetic and ground penetrating radar] • geochemical [soil and river sediment analysis].	Modelling remote sensing geophysics (ELI+) Electrical ground probing Where shall we drill for oil? Boring chocolate!
Interpret prospecting data [geological mapping, geophysical, geochemical] to identify possible valuable mineral resources.	
d. There are characteristic structures and rock properties associated with the migration and accumulation of oil and gas in potential onshore and off-shore gas/oilfield resources: • source rock • contrasting porosity and permeability of reservoir and cap rocks • the main types of trap for oil and gas [anticline, fault, unconformity, salt dome].	Make your own oil and gas reservoir Trapped! Why can't oil and gas escape from their underground prison? Fracking: Recipe for the perfect fracking fluid Where does offshore oil come from? Blue Hydrogen – the fuel of the future? Could "blue" hydrogen be produced and used here?
Interpret data from maps, cross-sections and seismic surveys to identify possible gas/oilfields.	
e. There are technological difficulties and environmental issues involved in exploring for and extracting oil and natural gas [including fracking].	What is/are the least bad option(s) for plugging the future global energy gap?
f. Factors affecting the extraction of underground water from aquifers include:	From rain to spring: water from the ground

• height of the water table • porosity/permeability of the aquifer • the presence of natural springs • the distribution of wells.	Water pressure - underground (ELI+) Water – a matter of taste or a taste of matter? Does my rock hold water and will water flow through it? Limestone springs – the wells of Wells: Modelling the underground flow of water through limestone passages to springs Make your own aquifer – 1 with sponges A clean way to demonstrate water in pores in rocks Make your own aquifer – 2 The London Basin Model the aquifers in the London Basin with sponges
Analyse different rock types for their suitability as an aquifer.	
g. The impact of domestic and hazardous waste disposal on vulnerable aquifers depends on: • geological factors [permeability] • engineering factors [geomembranes] • monitoring of potentially polluted water • restoration of contaminated ground.	
Use data from descriptions, diagrams/photographs, maps and cross-sections to: • investigate the suitability of a potential landfill site for the disposal of domestic waste. • investigate the suitability of a potential site for the long term storage of hazardous waste.	Energy from buried waste: Landfill gas Nuclear waste disposal: Investigating geological disposal facilities (GDFs)
h. Geological factors affect the siting of engineering projects e.g. reservoirs, dams, tunnels and cuttings [permeability, stability of bedrock, dip of strata, the presence of faults and joints].	Dam burst danger Harnessing the power of waves: investigating the development of wave power Storing gas underground: What can we store? How can we do it? How will it help? Matching supply and demand using stored water: Pumped storage hydroelectric schemes – just-in-time power
Use data from descriptions, diagrams/ photographs, maps and cross-sections to investigate the geological factors affecting the siting of major engineering projects.	Correlation between boreholes Illustrating uncertainty in ground investigations using LegoTM

Appendix

“Net-zero” carbon emissions

In preparation for the COP26 U.N. Climate Change Conference in November 2021, Earthlearningidea prepared a series of 28 activities, covering mitigation and adaptation measures which might be implemented in order to achieve zero carbon emissions by 2050. They are being revised as necessary and published on a fortnightly basis as usual, but teachers may wish to use the 28 drafts before then, and they are all shown on the webpage https://www.earthlearningidea.com/home/Net_zero.html
Some of the activities impinge on a number of existing topics in the Specification, but they will be listed fully here, rather than in the table above:

3.5.2021 How will the 'net-zero' target affect your local area? Assessing the local impact of the government's 'net-zero' targets for carbon emissions
17.5.2021 Capturing carbon? Can we capture and store carbon from burning fuel, cement- and steel-making? Should we?
14.6.2021 Blue Hydrogen – the fuel of the future? Could "blue" hydrogen be produced and used here?
28.6.2021 Harnessing the power of the Sun. Could solar farms be used in your area?
26.7.2021 Tidal energy Can the tides be harnessed to produce green energy?
9.8.2021 How will rising sea level affect our coastlines? … and what can be done to adapt to rising sea levels?
6.9.2021 Heat from the Earth: Investigating ground source heat pumps
20.9.2021 Green hydrogen used to even out renewable energy supplies? Could 'green hydrogen' be the solution to the efficient use of renewable energy?
18.10.2021 Energy from burning waste Where does all my non-recyclable waste go?
1.11.2021 Hydrogen of many colours: The situation regarding hydrogen in the UK, October 2021
15.11.2021 Energy from buried waste: Landfill gas
29.11.2021 Small-scale hydroelectric power schemes Investigating opportunities for micro-hydro
13.12.2021 A new use for old coal mines A potential source of energy from beneath our feet
27.12.2021 Let's plant some trees Investigating the importance of trees to our planet
7.2.2022 Nuclear waste disposal Investigating geological disposal facilities (GDFs)
21.2.2022 Deep geothermal power from 'hot dry rocks': an option in your area? A discussion of potential for extracting 'hot dry rocks' geothermal energy locally
21.3.2022 Harnessing the power of waves: investigating the development of wave power
4.4.2022 Storing gas underground: What can we store? How can we do it? How will it help?
2.5.2022 The future for global agriculture: The adaptation of agriculture to climate change
16.5.2022 Nuclear batteries - the future? Investigating advances in battery technology
13.6.2022 Farming the wind – through onshore and offshore windfarms: A discussion on the local and national potential of developing wind energy sources

11.7.2022 Liquid biofuels - keeping our wheels turning into the future: Investigating fuels produced from biomass
8.8.2022 Inland flooding: a Sheffield case study. How should we respond to the increased risk of inland flooding as temperatures rise?
5.9.2022 Matching supply and demand using stored water Pumped storage hydroelectric schemes – just-in-time power
19.9.2022 How do I choose the best insulation? Investigating enhanced insulation for buildings
17.10.2022 Electric vehicles - the way to go? Investigating the advantages and disadvantage of EVs
31.10.2022 Speeding up nature to trap carbon dioxide The potential role of enhanced weathering and carbonation in mitigating climate change
28.11.2022 Nuclear power - harnessing the energy of the atom: Investigating the use of nuclear power now and in the future
12.12.2022 Landslide danger – and climate change: Case studies of how landslides work and the likely effects of climate change