OCR
Oxford Cambridge and RSA

Wednesday 12 June 2024 – Afternoon

A Level Geology

H414/02 Scientific literacy in geology

Time allowed: 2 hours 15 minutes

You can use:
- an HB pencil
- a protractor
- a ruler (cm/mm)
- a scientific or graphical calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

1

(a)

(i) Draw a fully labelled diagram to show the processes of saltation and traction along a river bed.

[2]

(ii) Given a constant flow velocity, explain how particles of the same grain size can be transported by saltation or suspension.

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(b) Describe the differences between sediments which are texturally mature and texturally immature. Explain how sediments become texturally mature.

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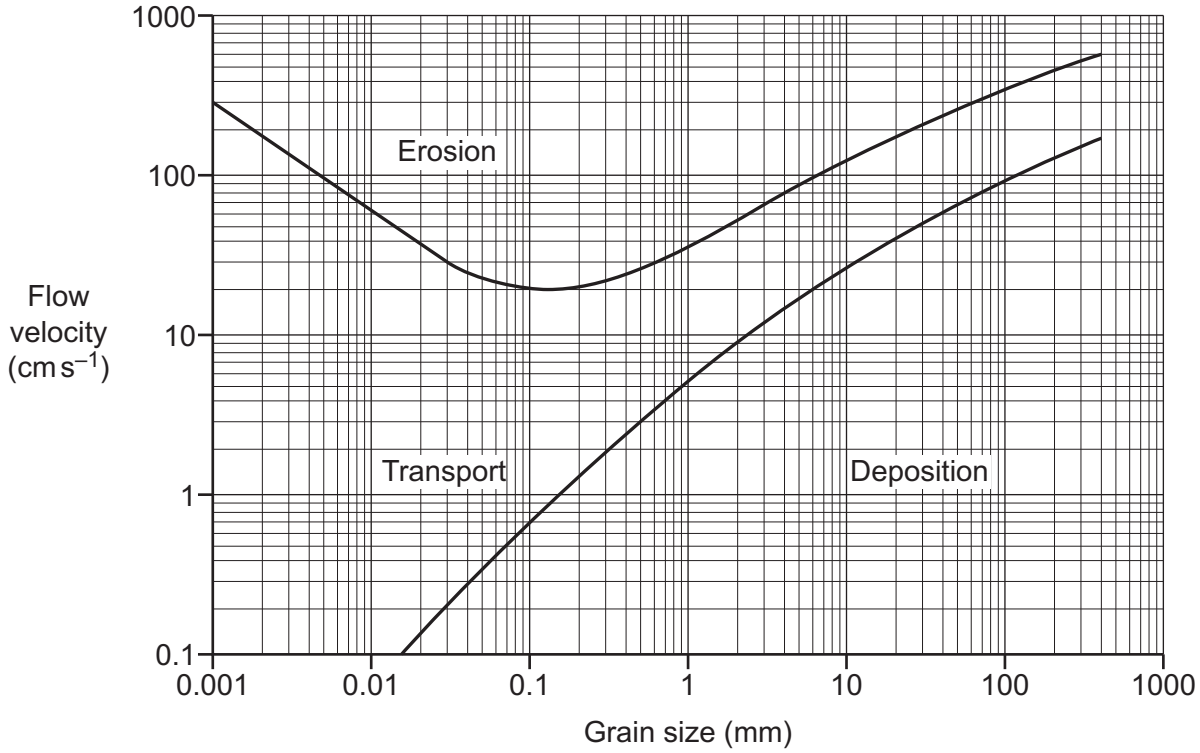
(c) The Hjulström curve graph shows the relationship between the grain size of a sediment and the flow velocity required for erosion, transportation and deposition.



(i) State the minimum flow velocity required to erode a grain size of 1 mm.

Minimum flow velocity = ... Unit = ... **[1]**

(ii) State the maximum grain size that would be deposited if the flow velocity slowed to 2 cm s^{-1}.

Maximum grain size = ... Unit = ... **[1]**

(iii) Explain why both axes of the Hjulström curve graph use logarithmic scales.

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(d) Diagenesis refers to the physical and chemical processes that change unconsolidated sediments into sedimentary rock.

(i) Name and explain the physical processes that occur during diagenesis.

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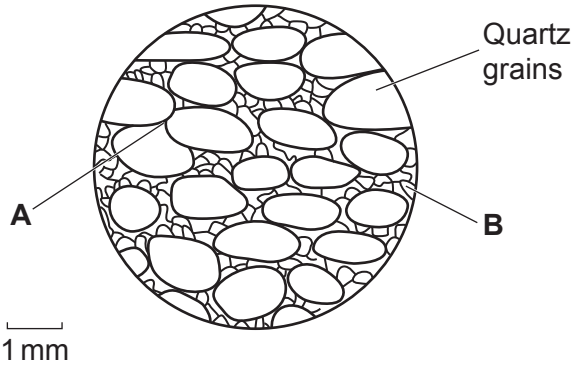
The thin section diagram shows a sandstone.



(ii) During diagenesis, cement can form in a sedimentary rock by two separate chemical processes.

Name and explain the most likely diagenetic process that will occur at point **A** shown on the diagram.

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(iii) Name and explain the most likely process by which cement will form at point **B** shown on the diagram.

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(iv) Diagenesis may continue after the sediment has been converted into a rock, causing textural changes.

Describe and explain how continued diagenesis of a sandstone may affect its ability to act as an aquifer rock.

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2

(a) The upper part of the Earth consists of the lithosphere and the asthenosphere.

(i) Describe the physical properties of the lithosphere.

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..... **[1]**

(ii) What indirect evidence has been used to locate the base of the lithosphere?

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(iii) Describe and explain the property of the asthenosphere that enables it to play a key role in plate tectonics.

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(b) Sir George Airy used gravity anomalies to explain the theory of isostasy.

(i) Explain what is meant by isostasy.

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(ii) Describe and explain how gravity anomalies can be used as indirect evidence for the theory of isostasy.

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(c)* Describe the geodynamo theory of the Earth's magnetic field **and** explain how it can provide indirect evidence for the processes operating within the Earth's core.

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Extra answer space if required.

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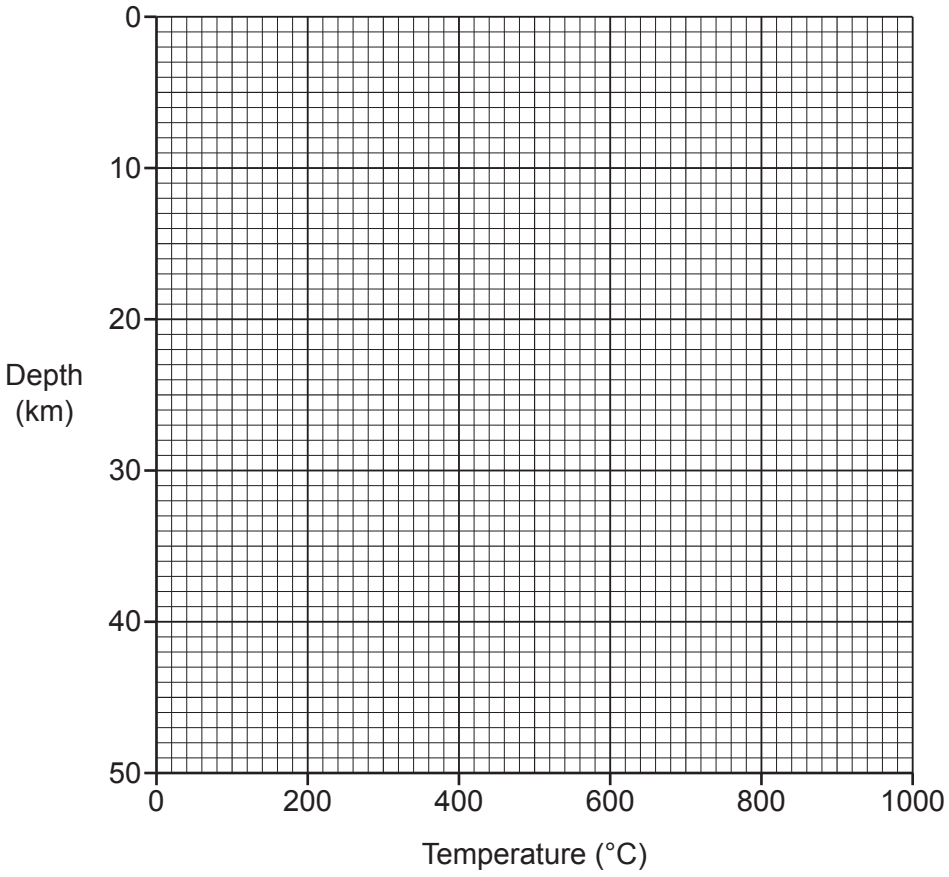
(d) The temperature change with depth (geothermal gradient) for **Region X** and **Region Y** in the Earth are shown in the table.

Region X		**Region Y**	
Depth (km)	**Temperature (°C)**	**Depth (km)**	**Temperature (°C)**
0	0	0	0
10	250	5	160
20	500	15	480
30	750	20	
40	1000	25	800

(i) Plot the data from the table for **Region X** and **Region Y** on the grid.



[3]

(ii) Determine the temperature at a depth of 20 km for **Region Y**. Write your answer in the table. **[1]**

(iii) Use the data from the table to calculate the geothermal gradient for **Region Y**.

Geothermal gradient = ... Unit = ... **[2]**

3

(a) Attenuation is an important factor to consider when compiling hazard maps used for seismic risk analysis.

(i) Define the term **attenuation** when applied to seismic waves.

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..... **[1]**

(ii) Explain why high-frequency seismic waves are more strongly attenuated than low-frequency seismic waves.

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(iii) The Mercalli Scale is used to measure earthquake intensity, rating earthquakes on the amount of damage produced in any given place.

Describe and explain why earthquake intensity depends on the nature of the underlying rock.

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(b) Seismic hazard risk analysis can be used to produce hazard maps that summarise geological data for use by government bodies (e.g. for purposes such as disaster planning and public education).

Describe **two** limitations and **two** strengths of hazard maps.

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(c) Probabilistic forecasting is a method used to determine the likelihood that an earthquake might occur in a certain area over a given period of time.

Critically analyse the statement 'the social consequences of probabilistic forecasting outweigh any benefit'.

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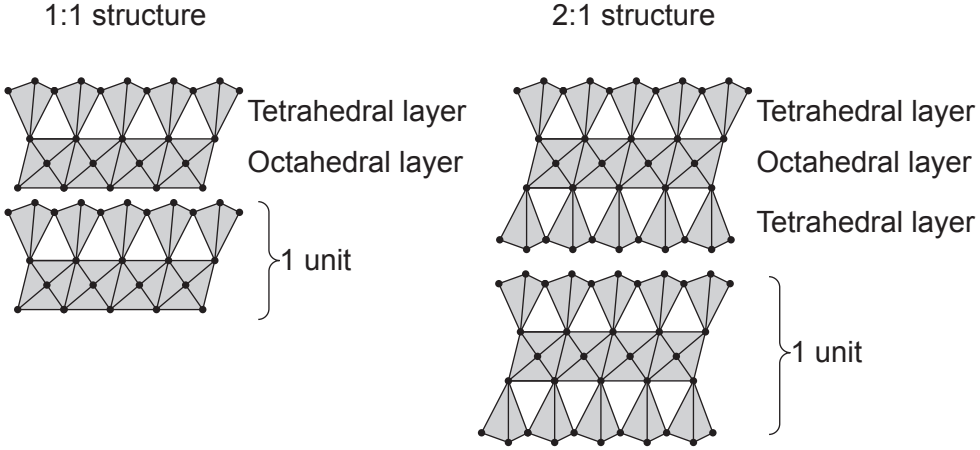
(d) Most clays can be classified as 1:1 or 2:1. These ratios refer to the proportion of tetrahedral sheets to octahedral sheets. The arrangement of layers and the method of bonding between the layers affects the properties of different clay minerals.



(i) Complete the table by matching the correct clay mineral to its type and properties.

kaolinite **phyllite** **smectite**

Type	Clay mineral	Properties	
1:1		Non-expanding	Low shrink swell
2:1		Expanding	High shrink swell
2:1	Vermiculite	Limited expansion	Medium shrink swell
2:1	Illite	Non-expanding	Low shrink swell

[2]

(ii) A significant proportion of the UK land area is at risk of damage due to the shrinking and swelling of clays.

Describe and explain **one** chemical soil treatment that engineers can use to mitigate the problem of shrinking and swelling clays.

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4

(a) Amphibians evolved from more primitive tetrapods, the lobe-finned fish.

(i) Describe **one** similarity between a lobe-finned fish and an amphibian.

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(ii) In which geological period did amphibians first evolve as aquatic organisms?

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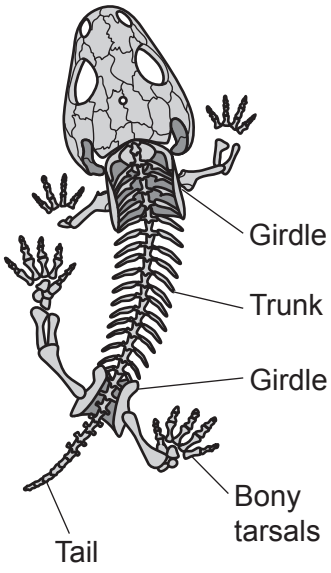
(b) The diagrams show **two** different amphibian skeletons, fossils **A** and **B**, that evolved to live in different environments.

Fossil A

Fossil B



Describe and explain the differences in the skeletons of fossils **A** and **B**. Indicate the likely environments that each of these organisms lived in.

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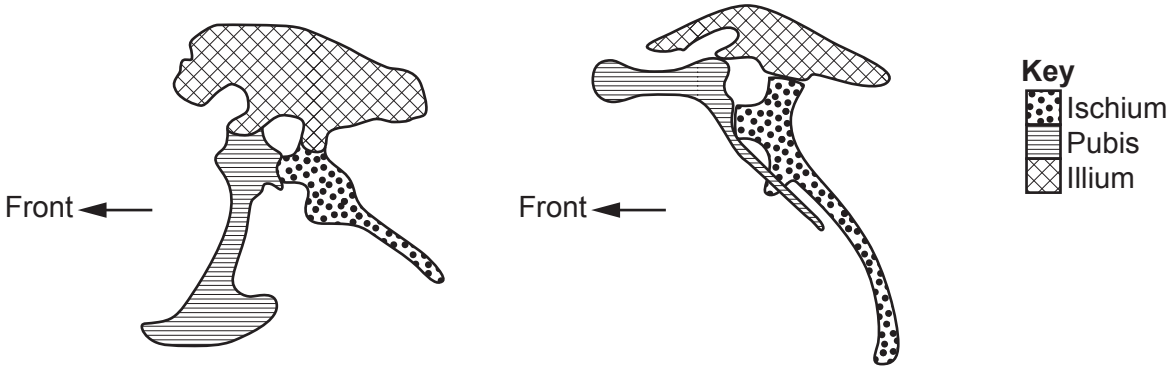
(c) The diagrams show the hip-bone arrangements in **two** dinosaurs, *Tyrannosaurus* and *Iguanodon*.



Tyrannosaurus *Iguanodon*

(i) Compare the hip bones of *Tyrannosaurus* and *Iguanodon*.

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(ii) Using information shown in the hip-bone diagrams, describe and explain to which group of dinosaurs *Iguanodon* belongs.

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(iii) Describe and explain **one** morphological adaptation that suggests *Iguanodon* was a herbivore.

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(iv) Pterosaurs and birds independently evolved wings for flight at different times.

State the term used to describe this type of evolution.

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(d) An important evolutionary change was the development of the amniotic egg.

(i) Draw lines to match each **characteristic** with its correct **function**.

Characteristic	Function
Yolk	Membrane containing fluid
Albumen	Fatty food store for developing embryo
Amnion	Separates internal from external environment
Shell	Embryo's water supply

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(ii) Explain how the evolution of the amniotic egg enabled animals to colonise land.

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5

(a) Measuring the settling rates of different sediments can help interpret the environment of deposition in ancient sediments.

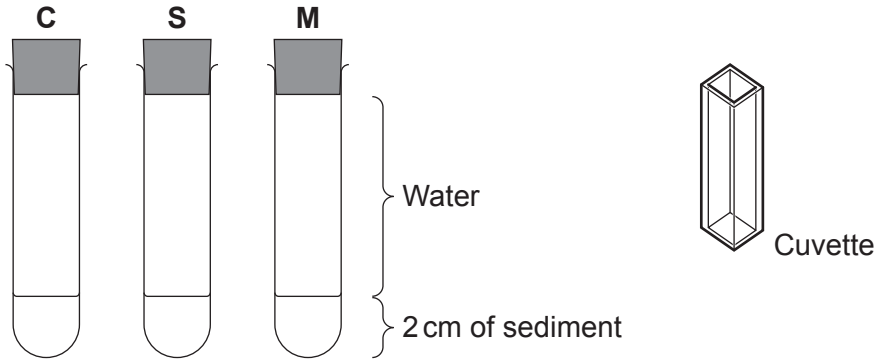
A group of students decided to investigate the effect of sediment type on the settling rate. They decided to use a colorimeter, a device which measures the amount of light that passes through a sample of liquid, where 100% transmission would be pure water with no particulates. Cuvettes are specialised tubes with a square cross section that can be inserted into a colorimeter.

Note the colorimeter must be calibrated to 100% transmission of light with a sample of pure water at the start of the experiment.

A 590 nm filter (amber) in the colorimeter was used for this experiment.

Method

- Select three types of dried sediment: clay (**C**); silt (**S**) and medium sand (**M**).
- Pour sediment up to a 2 cm line at the bottom of each boiling tube, as shown in the diagram.
- Using tube **C**, fill with water and put in a rubber bung.
- Shake the tube and place in a boiling tube rack.
- Using a pipette, remove some of the liquid from the centre of each boiling tube and transfer to a cuvette.
- Insert the cuvette into the colorimeter and record the % transmission value.
- Leave the cuvette in place and take readings every five minutes over the following twenty five minutes.
- Repeat with tubes **S** and **M** and record the % transmission values.



Boiling tubes before shaking

The results are shown in the table.

	% transmission		
Time (minutes)	**Tube C**	**Tube S**	**Tube M**
0	4.0	15.6	74.0
5	10.2	45.2	78.3
10	16.3	50.0	78.6
15	22.3	47.7	79.0
20	26.5	53.6	79.5
25	26.4	53.7	80.5

(i) Describe and explain the relationship between sediment type and % transmission.

Use the information given in the table.

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(ii) The percentage change in % transmission for tube **C** between 0 and 25 minutes has been calculated as 560%.

Calculate the percentage change in % transmission for tube **M** between 0 and 25 minutes.

Give your results to **3** significant figures.

Tube **M** = ... % **[3]**

(iii) Which experiment (**C**, **S** or **M**) would you choose to model sediment flow in a fast-flowing river? Give a reason for your answer.

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(iv) Describe **one** health and safety hazard that must be considered for this experiment.

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(v)* Analyse and evaluate the experimental procedure provided. Suggest improvements to the experiment to yield more accurate results.

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Extra answer space if required.

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(b) Describe an experiment that could be completed in the laboratory to investigate the deposition of cross-bedding in sediments.

You should include details of how you will collect data, any sampling methods that you would use and how you will process your data.

You may use an annotated diagram to illustrate your answer.

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6 Read the text below, then answer the questions that follow.

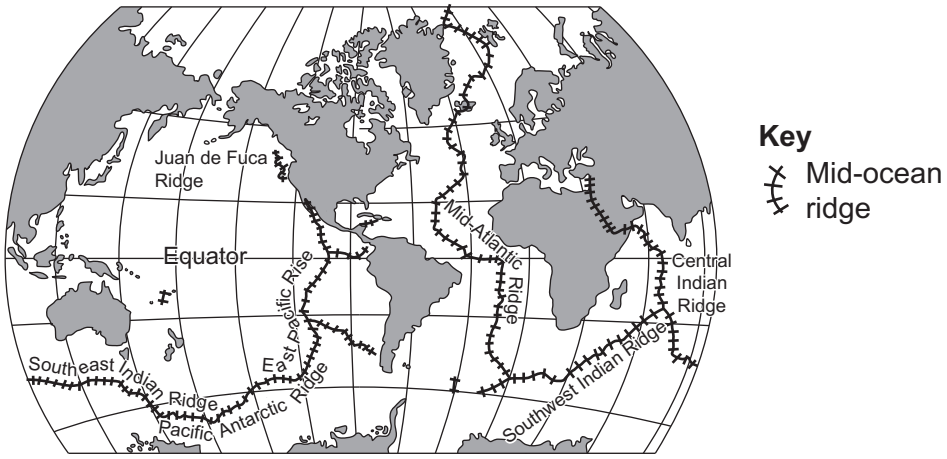
The Origins of the Plate Tectonics Paradigm?

The plate tectonic paradigm developed over a period of time, as new ideas, observations and models arose. The earliest model was called the geosynclinal model. This model used contraction theory to explain mountain building events, known as orogeny, to explain the existence of the Appalachian and Caledonian mountain ranges. This was followed by continental drift theory, proposed by Alfred Wegener in 1915. He proposed no mechanism, but noted that continents fitted together, rather like a jigsaw.

Mechanisms for the movement of plates evolved over time to explain earlier observations. In 1929 British geologist Arthur Holmes proposed that the Earth produces heat by radioactive decay. He also suggested that the Earth was losing heat through volcanic activity. He suggested that there could be mantle convection to enable dispersion of heat and linked this to continental drift with mantle convection driving this process. Holmes' textbook 'Principles of Physical Geology' became widely used and respected by academics.

Alex du Toit was a South African geologist who compared stratigraphy from different parts of the world – Africa, South America, Australia, India, Antarctica and Arabia. In 1937 he suggested the idea that these were all once joined in a supercontinent called Gondwanaland.

In 1962 the American geologist Harry Hess proposed the theory of seafloor spreading, based on ocean basin research during WWII and evidence from the global seismic network which was set up to monitor nuclear tests during the Cold War. He described new crust development at oceanic ridges.



Simplified map showing the positions of mid-ocean ridges, identified during and after WWII.

In 1954 the American geologist Hugo Benioff studied deep-focus earthquakes, up to around 700 km depth, and was the first to plot these earthquakes to identify island arcs as a narrow band. He linked this to the idea of subduction of the Earth's crust.

In 1965 J Tuzo Wilson wrote a paper entitled 'A New Class of Faults and Their Bearing on Continental Drift' where the offset nature of transform faults was noted.

In 1966 Lynn Sykes then noted that 95% of earthquakes occur in belts and identified about 12 major plates and described their relative motion.

In 2021 a group of researchers from Toronto, using supercomputer modelling, showed that the plates on which Earth's oceans sit are being torn apart by massive tectonic forces occurring away from plate boundaries. There may be a need to modify current ideas based on this evidence.

(a)

(i) Describe evidence for the geosynclinal model, which attempted to explain the presence of mountain ranges.

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(ii) Using evidence from the text and your own knowledge, evaluate the statement 'the plate tectonics paradigm has now been solved'.

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(iii) Harry Hess was the first person to describe hot spots. Describe **one** piece of evidence for the formation of hot spots.

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(b) Describe how uniformitarianism and the rock cycle models developed over time.

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END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.