RECOGNISING ACHIEVEMENT

GCE

Geology

Advanced GCE **A2 H487**

Advanced Subsidiary GCE **AS H087**

OCR Report to Centres

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Reports should be read in conjunction with the published question papers and mark schemes for the examination.

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Overview

General Comments

Overall, there was evidence of good geology on display, indicating that many candidates had been well prepared and had worked hard to understand basic principles and processes. The pattern of entry for the units was similar to the previous year though more candidates were entered for F795. All the units discriminated well and candidates achieved a wide range of marks.

There are some common issues in the reports on individual papers.

- **Command words**. If a question asks for both description and explanation, candidates should expect to be rewarded for demonstrating both skills. Many candidates answer explanatory questions poorly often describing rather than providing reasons for the explanation. A comparison needs to give a point for both of the rocks or fossils being compared. A list is not sufficient for a description but is for a question that asks to state.
- **Stem or introductory sentence of a question**. Reading all parts of a question is essential. Often a valuable clue is given in the question such as telling candidates that the answer should be from a particular group of rocks or fossils. At A2 information may be provided in the question that is new to candidates so that they apply knowledge in a different context. Not all questions have answer lines below and candidates should be encouraged to read every word of the paper so that they do not miss these questions. The sentence in italics for the long questions on F792 and F795 is designed to help candidates structure the answers by giving them additional information, but is sometimes ignored.
- **Matching the length of the answers to the space provided**. Geology papers continue to have a rationale of lines allocated per question. The general rule used is two lines per mark unless part of the answer is a diagram or a single word or phrase. Candidates run the risk of wasting time and effort on a question that does not warrant it, if they are exceeding the line allocation. Conversely they are unlikely to gain full marks for a description that is just 2 or 3 words long.
- **Diagrams** should be done in an HB pencil so that the lines are not too faint to scan. They should be clear and accurate with suitable scales. Labelling can be in pen or pencil but labels should be clearly joined to the feature drawn. If the question requires a labelled diagram then no marks may be awarded for unlabelled diagrams.
- **Technical geological terms** need to be used in their correct context and spelled correctly.
- **Quality of Written Communication** – On units F791 and F794, quality of written communication is assessed by the requirement for candidates to "use the appropriate technical terms, spelled correctly". Candidates are advised to ensure their answers to these questions are neat and legible to avoid any ambiguity in their spelling. On units F792 and F795 this is assessed particularly on the long answers where both organisation and use of correctly spelled technical terms are needed. The sentence in italics for each long question aims to help structure these answers.

Synoptic assessment – The A2 units are synoptic. The synoptic assessment is designed to test candidates' understanding of connections between different elements of the subject. It involves the explicit drawing together of knowledge, understanding and skills learned in the different parts of the GCE course. Although any synoptic question can be asked, the most obvious links are with F791 particularly geological structures and many aspects of F792 Rocks – Processes and Products unit.

Stretch and Challenge – 10% of the questions on the A2 papers are high level questions designed to "stretch and challenge" and differentiate between A* and A grade candidates. These may appear as whole questions or as individual mark(s) within a question. Stretch and challenge questions may include material in a different context and candidates are expected to make links between different areas of the specification.

F791 Global Tectonics

Candidates generally performed very well with a wide range of marks. There were many excellent scripts demonstrating a broad and consistent understanding of the module's contents. Candidates are improving in their understanding of the technical terms used in structural geology. Diagrams, although being quite detailed and annotated, were not always clearly drawn. There was no evidence of candidates running out of time.

In addition:

- Candidates showed a sound understanding of the various aspects of seismology tested including L wave characteristics and the use of shadow zones. Candidates had a good knowledge of convergent plate margins but a clear understanding of heat flow at plate margins remains difficult for many.
- Candidates showed an impressive understanding of planets which although being a relatively new topic is clearly one that captures their interest. Candidates' responses to the structural geology questions were generally impressive especially as this tends to be the least well understood section of the specification.
- Candidates' understanding of key terms such as stress, strain, competent and incompetent showed a clear improvement. The use of ooliths as strain markers was clearly something that candidates were unsure of.
- The extended prose on palaeomagnetism was well answered with the majority gaining at least half marks and 15% gaining full marks. This has proven a difficult topic in the past but it is clear that the general understanding of palaeomagnetism has improved.

Candidates with unclear writing should be encouraged to take time and care when answering questions where correct spelling is expected even to the point of spelling technical terms in capitals if necessary.

Comments on Individual Questions

Question 1

This question on seismology proved a good introduction to the paper for most candidates. It is clear that seismology in general is well understood by most candidates.

(a) **(i)** Most candidates knew the location of the P and S wave shadow zones although drawing them on the Earth cross section did prove difficult for some.

(ii) Almost every candidate knew that the outer core is liquid. Candidates should be encouraged to describe the state as *liquid* rather than *molten*.

(iii) Most candidates were aware that S waves stop at the outer core because they cannot pass through a liquid.

(iv) Few candidates were able to explain how seismologists calculate the depth of the core/mantle boundary. Explanations needed to use the size of the shadow zones and the location of the Gutenberg discontinuity.

(b) **(i)** Most candidates were aware that L waves are not body waves, but were not always sufficiently precise about their location. L waves are restricted to the surface of the Earth and not within the crust. Drawings therefore needed to show the L waves on the surface.

(ii) Many candidates were aware that L waves are surface waves and the slowest.

(iii) Many candidates were aware that L waves caused most damage as they were surface waves, but few knew that it was also linked to the way they moved the ground.

(c) **(i)** The majority of candidates knew that intensity was linked to surface damage caused by the earthquake. Precise definitions are not always evident.

(ii) A significant number of candidates made the mistake of joining the values together rather than having the isoseismal lines drawn outside the numbers and then enclosing them.

Teaching tip

Drawing isoseismal lines is a skill. These rules should help:

- the lines must not cross each other
- the lines should be roughly concentric
- the lines should be drawn outside the values and not through the numbers so that the numbers all lie between two lines for example only value intensity 4 values will be found between the 3 and 4 isoseismal lines.

(d) A minority of candidates knew the values for the average density of the Earth and the crust. Stating the exact figures of 5.5gm/cm^3 for the whole Earth and 2.7 – 2.9gm/cm^3 for the crust is the data needed for the explanation that the core must have a higher density. Few candidates could show that this data allows geologists to infer the very dense nature of the core. A logical argument is needed for a question that asks for a candidate to infer a conclusion from data.

Question 2

Candidates appear to have a sound knowledge of the main physical features of a convergent plate margin. There was a poor standard of drawing by some candidates which made it difficult to see the features to be labelled.

(a) Most candidates were familiar with the location of the main tectonic features at a convergent plate margin. The location of batholiths deep in the continental crust caused the most uncertainty. Some candidates did not make a clear distinction between the relatively thin oceanic crust and the thick continental crust and so lost a mark. In some answers the base of the plates was unclear and so crust thickness was not shown.

(b) **(i–ii)** Most candidates drew a high heat flow over the volcanoes and could explain the reason. Fewer candidates drew the low heat flow over the trench and an even smaller number realised that this was due to the cold sinking plate or cold sinking convection currents.

(c) Few candidates were aware of the violent style of eruption that occurs at this type of plate margin.

(d) The vast majority of candidates were able to link the pattern of earthquakes to the frictional resistance caused by the movement of the subducting plate. A significant number explained the pattern as being due to the Benioff zone which is the name of this pattern but not an explanation.

Question 3

Candidates showed a very sound understanding of planetary geology. Even though the topic is relatively new to the specification it is clear that the candidates are well prepared. Detailed knowledge of the characteristics of the planets could be improved.

(a) Candidates showed a very sound understanding of planetary geology. Even though the topic is relatively new to the specification it is clear that the candidates are well prepared. Detailed knowledge of the characteristics of the planets could be improved.

(b) (i) The location of the asteroid belt was well known.

(ii) Most candidates knew that the asteroid belt formed either from a planet that failed to form or that had exploded. Some candidates were too vague in their answers to gain credit.

(c) (i) Most candidates knew two characteristic features although describing them as "Earth like" is too vague. Answers tended to be lists rather than descriptions of the features.

(ii) Candidates had more difficulty with the characteristics of the gas giants. Naming the key gases was required rather than just saying *made of gas*.

(d) The vast majority of candidates knew the age of the Earth.

Question 4

This question showed a significant improvement in candidates' understanding of some key aspects of structural geology. In particular candidates are using more technical terms. Definitions need to be accurate rather than written in general terms. Insecure understanding of ooliths as strain indicators was a weakness.

(a) (i) Impressively, most candidates knew that stress related to the force applied.

(ii) Slightly fewer candidates but still a majority knew that strain linked to the change in shape or the effect of the applied stress. Better answers discussed change in shape or length as a proportion of the original shape or length.

(iii) Many candidates knew that sandstones are competent and shales incompetent and were able to link this knowledge to how they behave as shown on the graph. Some candidates knew the terms but could not apply this knowledge to explain the link between the stress and the resultant strain.

(iv) Many candidates knew that an increase in temperature would make the rocks behave in a more plastic/ductile manner although a significant number had difficulty putting this concept into words.

(b) (i) Most candidates recognised the antiform/anticline and could spell it correctly. Fewer knew that it was asymmetrical or an overfold. Descriptions should be more than just two words and candidates should be encouraged to give more detail for structural descriptions.

(ii) Almost every candidate knew that compressional forces cause folding of rocks.

(iii) Most candidates located the joints in the hinge area, but some did not restrict the joints to the competent sandstone beds. Recognition that joints only occur in competent beds is essential.

(iv) Few candidates could link the formation of the joints to tension or stretching occurring at the hinge area.

(c) There were many impressive sequences of diagrams showing the stages in the formation of cleavage. Many candidates drew randomly aligned minerals, followed by compression causing them to align. Many noted the alignment at 90^0 to the maximum compression resulting in cleavage parallel to the axial plane. The drawings

had to be labelled and it is essential that the cleavage planes are clearly labelled on the diagrams.

(d) Candidates struggled with this question. Firstly they did not know how to describe the shapes of the two ooliths and then secondly had difficulty linking this to the amount of deformation that had taken place. The use of spherical ooliths and fossils as indicators of the amount of strain within a rock is an application of strain.

(e) Most candidates knew that a normal fault would be the result of tension so drew good diagrams. Labelling the fault plane was very good. However, drawing and labelling the throw was more difficult as it needed accurate labelling between the top (or bottom) of a bed drawn on both sides of the fault. Some diagrams were unclear as the label lines did not exactly join onto the top/bottom of a bed. Drawing block diagrams is not expected or needed. Simple cross section diagrams are able to gain full marks if accurately labelled.

Question 5

Many candidates showed a thorough understanding of palaeomagnetism which is very encouraging as this topic has proved to be difficult for candidates in the past. It is particularly clear that candidates know how rocks become magnetised and many now refer to the *Curie Point* and *permanent remnant magnetism*.

In terms of the application of palaeomagnetism many candidates had a good understanding of its use as evidence for sea floor spreading such as polar reversals and the formation of “magnetic stripes” at mid ocean ridges. Although many also knew about the symmetry of these stripes about the Mid Ocean Ridge, fewer discussed that the stripes were also parallel to the ridge. The better answers included a labelled diagram that showed the parallel and symmetrical stripes.

The use of palaeomagnetism as evidence for continental drift was less successfully answered. Many candidates referred to “polar wandering curves” but did not really understand what they were. Few discussed magnetic inclination linked to palaeolatitude. The more successful answers explained this difficult concept by using diagrams showing polar wandering curves from two continents that were joined and then diverging, reflecting the behaviour of the continents.

F792 Rocks – Processes and Products

General Comments

There were some excellent scripts and the paper proved accessible to all. Few papers were incomplete suggesting that there was not a problem with lack of time. Candidates need to be aware of the command words in the question and ensure that the answers match these. Some scripts show that candidates are underlining command words to make sure that they tailor the answer to the question set which is a good idea. A few questions require responses on the diagrams such as the wind direction or the types of metamorphism and a minority of candidates miss out these questions due to not reading the questions carefully.

The stem or first sentence of a question or part question often has helpful information to guide a candidate towards the correct area of the specification for an answer, but it is clear that some candidates do not read this part of the question. This unit will always have thin section diagrams of rocks and interpretation of these is key to understanding this style of questions.

The single largest issue is the confusion between *rock* and *mineral* which can affect answers to so many questions. Candidates need to be really clear that quartz for example is a mineral and that it is found in rocks (including quartzite). The second area of confusion was mixing terms across rock groups so porphyritic is igneous and porphyroblastic is metamorphic. However there was a general confusion, so that responses to *identify the metamorphic rock* included *granite* and *arkose*!

Teaching Tip
Coloured cards for *igneous*, *sedimentary* and *metamorphic* with all the rocks and textures in the specification could be used to revise all the terms and also to lay the rocks out in classification order.

Comments on Individual Questions

Question 1

This proved to be a good starter question and candidates demonstrated a sound knowledge of the rock cycle and the processes operating within it. Knowledge of key definitions was less secure.

This question on rock cycle processes and the differences between the rock groups showed some accurate factual answers but also some answers that were general and lacking technical terms.

(a) (i) There were no real problems with this part question with the majority of candidates able to recognise the processes and rock groups. The only common error was with Process C where a number of candidates thought it was an extension of sedimentary processes and referred to deep burial
There were many very good answers. The most difficult question was process D, which was *metamorphism*

(ii) Some clear answers referring to tectonic process that moved rocks up to the surface. As a definition the answers had to give both elements – that the rocks moved up and also by a method. Uplift does not include movement by volcanic eruptions or erosion. Very few candidates were able to describe the process of uplift. Many responses were very general and referred to movement upwards only with no indication of what caused the movement. Occasionally candidates referred to folding, faulting and tectonic processes.

(iii) Some excellent definitions particularly of weathering. Erosion caused a bit more confusion with incomplete answers that just referred to the removal of weathered material which is the process of transportation not erosion. There are still a number of candidates who describe weathering as 'a result of the weather ', or a result of 'acid rain'. Candidates were able to achieve the mark through referring to breakdown in situ or the process/es which led to the breakdown. Erosion was often confused with transport, with candidates failing to recognise breakdown with movement.

(b) (i) There were some good responses for this part question with candidates able to name and describe two methods of transporting sediment by water. The common misconception was that solution was a method, when in fact the material has dissolved and was no longer sediment. Marks were lost through candidates failing to differentiate between the sizes of particles involved in the two methods. Occasionally there were descriptions but with no names given. Good answers matched the description of the method with the grain size; so suspension can only carry fine sediment while traction moves coarse sediment. In some cases, the descriptions were incomplete but a mark could be awarded for two correct methods. *Saltation* is a method while *bouncing* is not. Solution cannot be used to transport sediment as the quartz grains and clay minerals that form the sediment are insoluble. Solution transports dissolved chemicals not sediment

(ii) *Attrition* and *abrasion* were often well described as processes, but this part question was about how the quartz grains are *affected* by these processes. i.e. becoming better rounded and smaller, rather than definitions of attrition and abrasion. The answers therefore needed to refer to grains. "Bits being knocked off" or "worn down" were not sufficient to describe the reduction is size.

(c) Rock forming minerals are generally well understood with many candidates aware that olivine is igneous and garnet metamorphic. The common error was to refer to calcite only occurring in sedimentary rocks when in fact it can occur in metamorphic rocks as a result of the metamorphism of limestone. This question was often well done, but it is of concern that a minority of candidates thought that feldspar was restricted to one group of rocks when it is actually found in igneous, sedimentary *and* metamorphic.

(d) This was a challenging question that had a very wide range of responses. The simple answers that gave the hardness and physical and chemically stability of quartz and hence its ability to survive the rock cycle tended to be the clearest. There was again confusion between the mineral quartz and rocks. Some answers were very general. Candidates had a tendency to repeat the question in their answer which led to no credit. The fact that quartz is common is not a reason. There were some good references to Bowens Reaction Series, lacking cleavage and being unchanged by metamorphism. Only a small number of candidates referred to the rock cycle and the ability of quartz to survive all the processes.

Question 2

Stronger candidates proved to have a clear understanding of xenoliths and their formation. Most candidates have a sound knowledge of igneous textures. Interpreting thin section diagrams and photographs is a key skill.

(a) (i) The majority of candidates successfully plotted the line graphs to show temperature change with distance from the intrusion. Lines were often clear and accurate.

(ii) Most candidates were able to extrapolate from the graph the widths of the metamorphic aureole. Some candidates were unable to use the scale and thus achieved the incorrect result. Most answers were correct but if wrong, they tended to

be unrelated to the graph. There was a tendency to round up answers rather than obtain accurate readings from the graph.

(iii) The identification of the larger intrusion as F was very good. Occasionally batholith was given rather than the letter of one of the two intrusions plotted. The explanation was more of a challenge; weaker candidates were able to describe but not explain. The question required an explanation of why there was a variation; both time for the process of metamorphism to occur and the area that is metamorphosed.

(b) **(i)** There were some excellent responses to this part question, with candidates able to draw and label a cross section across an intrusion to show country rock, metamorphic aureole and intrusion. Occasionally the intrusion was named but not labelled, and *baked margin* used instead of a *metamorphic aureole*. Some candidates failed to read the question effectively and drew a plan view rather than a cross section. These candidates usually had a clear understanding of the key terms. Some candidates added far more detail than asked for by labelling rock types and low to high grade contact metamorphic zones. Other candidates omitted the three labels that had been asked for in the question.

(ii) The identification of the metaquartzite was generally good with both quartzite and metaquartzite being accepted. Incorrect responses included *orthoquartzite* and a range of igneous rocks as well as regional metamorphic rocks.

(c) There were some very good answers that clearly distinguished between these two textures. Knowledge of vesicular and amygdaloidal texture is well understood with some good descriptions of the differences between them. Care should be taken not to use *air holes* when describing vesicular and *sediment infill* when describing amygdaloidal textures. Candidates often lost marks with a full description of the latter with no mention of percolating groundwater and subsequent precipitation.

(d) Identification of the xenolith was poor but the candidates that identified it correctly then went on give to excellent explanations, describing its origin and relationship to the igneous body. A very common incorrect response was *phenocryst* and *porphyritic texture.*

(e) **(i)** *Granite* was identified as the rock from the thin section drawing by the majority of candidates. They were able to correctly use both crystal grain size and mineralogy. Incorrect responses included *diorite* but also metamorphic and sedimentary rocks, even though the question stated that the rock was in an intrusion. A surprising number of candidates failed to recognise the texture as porphyritic and often named it as porphyroblastic. The textures given did not always match the rock group so that where granite was identified the texture was sometimes given as granoblastic or porphyroblastic. Phenocryst is not a texture but a descriptor within a texture.

(ii) The quality of answers explaining the formation of porphyritic texture was varied. Most candidates were able to describe a two stage cooling process, although few followed this up with a detailed explanation of the phenocrysts and groundmass in terms of size, environment and rate of cooling. Even where porphyritic texture had been identified, the explanation of how it formed was often vague and lacked the technical terms of *phenocrysts* and *groundmass*. Cooling of the groundmass could not be at the surface as the crystals are all over 1mm.

Question 3

This question discriminated well with a wide range of responses. Description of sedimentary structures and rock types was good but more care was needed with explanations. More emphasis is required on interpreting diagrams accurately.

(a) (i) Many candidates had a poor understanding of the conditions required for limestone formation. Many linked the formation of limestones to anaerobic and anoxic conditions, failing to refer to water temperature, water depth or energy conditions. A large number had one correct condition but were unable to give a second. Answers that reflected deposition of clastic sediments rather than limestones were common. The most common mistake was to state that the sea was low energy while both these limestones form where there are strong currents.

(ii) A well answered part question with most candidates recognising at least one of the two limestones. Most candidates correctly identified the oolitic limestone. Care needs to be taken with the spelling of *oolitic*; there was a large variety of incorrect spellings. The reef limestone was more challenging and answers included calcareous limestone or coccolithic limestone neither of which exists. There was a range of answers that included igneous rocks and clastic sedimentary rocks

(iii) There were some excellent explanations of the formation of oolitic limestones. Many candidates could identify the need for a nucleus and the subsequent adding of concentric layers of calcium carbonate. The second mark for the explanation proved more of a challenge with evaporation and precipitation often omitted as well as the environment of the rolling, whether it was a result of current, wave or tide. There were some good clear diagrams. A minority of candidates incorrectly referred to ooliths dying and sinking to the sea bed and subsequently being cemented.

(b) (i) The majority of candidates were able to label the abyssal plain and continental shelf correctly. The continental slope, although clearly visible on the diagram, was often incorrectly placed at point J. The most able candidates labelled an area, rather than a point for each of the features.

(ii) Many candidates were unable to use the scale to get an accurate grain size. Very often general ranges were given for example 2mm – 0.0625mm rather than specific measurements for the grains in question. The terms *arenaceous* or *argillaceous* were sometimes used but were often confused. Sorting proved a challenge as many candidates incorrectly described a well sorted sediment when in fact there was a variety of grain sizes, making it poorly sorted or moderate at best. Correct terminology for sorting is essential, not just ‘good’ or ‘bad’. Grain shape was well described although it is important that candidates know the difference between roundness and sphericity.

(iii) This was not well answered. Many candidates failed to see the link between the cross section and water depth. Incorrect sedimentary responses ranged from conglomerate to sandstone, with greywacke common, but several igneous rocks were also listed.

(iv) There were some excellent answers to this part question, with clear reference to planktonic organisms (often named specifically), dying and sinking to the sea bed. This is an area of the specification that is not well understood by many candidates. Those candidates who had no idea about oozes described submarine volcanic eruptions and lava ‘oozing out’ of fissures or cracks on the sea bed, or fine sediment being deposited or turbidity currents.

(c) **(i)** Graded bedding is well understood with some good, clear, well labelled diagrams. An explanation of weight or mass linked to larger particles being deposited first was essential. Way up criteria were often explained here but was not required by the question.

(ii) Most candidates were able to label the greywacke and shale correctly, although occasionally two labels appeared on the same bed. The position of flute casts proved to more of a challenge and only the better candidates were able to correctly label the base of the coarser unit. Flute casts were often incorrectly positioned within the greywacke units. There was a need for very accurate flute cast label lines that went directly to the very base of the greywacke bed.

(iii) Two turbidity flows were recognised by most candidates but the mark was for the explanation which many candidates failed to do.

Question 4

A well answered question. Most candidates have a good understanding of desert environments. Origin of cross bedding, however, still remains a weakness, especially critical slope angles.

(a) **(i)** Most candidates were able to recognise the main features in a desert as shown in the diagram. The playa lake was best known.

(ii) The prevailing wind direction was known by the majority of candidates, although a common error was to have it in the opposite direction. Incorrect labelling indicated that candidates had failed to recognise the significance of the barchan dunes.

(b) There were some good diagrams and descriptions of wadi conglomerates. Reference to size, shape and sorting were commonly made along with a matrix or iron oxide cement. Common misconceptions were with regard to shape, with some candidates describing a breccia with angular fragments. Also the fact that grains were rounded, led to the incorrect inference that they were automatically well sorted. Some weaker candidates described a breccia or arkose, having failed to read the stem of the question which stated that the rock was a conglomerate. There is confusion between the terms *matrix* – where the grains are joined together by sand, silt or clay material and *cement* – where the grains are joined by a mineral such as quartz or hematite that precipitated out after deposition of the pebbles. In a wadi conglomerate a matrix is most likely.

(c) **(i)** Cross bedding remains a challenging topic for many candidates and the quality of answers was weak. The shape of the sand dunes was clearly understood, although occasionally windward and leeward sides were reversed. The angle of the leeward slope/internal cross stratification remains too high with some drawings showing a slope overturned or near vertical. Only a small number of candidates gave a specific angle of around 37 degrees. Internal stratification was often omitted.

(ii) The quality of rose diagrams was very high, with most candidates successfully drawing a diagram from the data given. Segments or lines were equally acceptable but all sectors needed to be completed. The interpretation of wind direction proved more of a challenge with many answers the wrong way round. The steeper leeward side is down wind thus the wind is coming from the opposite direction – in this case from the north east.

Question 5

Most candidates had a sound knowledge of metamorphic processes and products and the overall mark for this question was not much lower than other questions – an improvement on previous metamorphic questions. Emphasis on the differences between the three main types of metamorphism in terms of temperature and pressure conditions was required.

(a) **(i)** There were some good responses to this part question that required candidates to place the types of metamorphism in relation to temperature and pressure conditions. Most candidates were able to place at least one type of metamorphism correctly. The key is to know that burial metamorphism is a result primarily of pressure, contact metamorphism heat and regional both pressure and heat. Some weaker responses had regional metamorphism in the igneous field.

(ii) The majority of candidates were able to place at least two of the rocks correctly.

(iii) Most candidates recognised that both temperature and pressure increased with depth. Some candidates failed to refer to both or had one increasing and the other decreasing. There were some very good answers on geothermal gradients.

(b) There were some good diagrams of a granoblastic texture with clear interlocking, sutured grain boundaries. For this diagram to be a marble, the mineral content had to be calcite but this was often omitted or incorrectly labelled as quartz.

(c) **(i)** Many candidates were able to recognise the schist and its texture whether that was schistose or porphyroblastic. Incorrect responses included gneiss and gneissose banding but also igneous rocks and textures or minerals even though the stem of the question asked for a metamorphic rock.

(ii) This was very well answered with most candidates getting at least one of the three minerals correct.

(d) The origin of gneissose banding proved to be a real challenge. Reference was made to light and dark bands but the mineralogy and origin was rarely known. Pressure direction was often omitted when foliation was discussed. No reference was made to crystal size or fluid movement. A few answers were igneous related describing lava flows, or sedimentary bedding.

Question 6

Deltas as a topic has been a short answer topic in the past that often gains very good marks. For this long answer question, both knowledge and understanding of deltaic environments were limited for the majority of candidates. Only a small number of candidates achieved full marks. They gave answers that described both the rocks and the environments for the three environments given. Many answers were general with reference made to rivers meeting the sea and energy being lost and subsequent deposition from high to low energy. The quality of diagrams was poor with little use of cyclothems or cross sections of the delta.

- Delta top – some candidates made reference to coal and seat earth and discussed possible environments, but only occasional reference was made to deposition of sandstones in channels, and clays on flood plains. Some answers described how peat turned into coal by diagenesis which is not part of the answer.
- Delta slope – some reference to sandstone and cross bedding but little reference to the environment, few candidates mentioned marine fossils.
- Offshore deposition – some reference to shale and or limestone in low energy conditions and occasional reference to marine fossils.

Question 7

The majority of candidates have a sound basic understanding of the classification of igneous rocks. Classification tables were used successfully to illustrate the key criteria but are not sufficient for a long answer question where description is required.

- Crystal grain size – most candidates were able to link crystal grain size with rate of cooling and where in the Earth's crust cooling took place. Occasional incorrect measurements were given for coarse, medium and fine crystals, usually following clastic sedimentary nomenclature. Some candidates did not use technical terminology and used small, medium and large. Good use of specific rock examples for each crystal grain size.
- Silica content – most candidates recognised the significance of silica content in igneous rock classification and were able to quote silicic through to ultramafic. Silica percentages were on the whole well known. Some centres are still using the terms acid and basic rather than silicic and mafic as used in the specification. A few candidates confused the silica percentage with depth.
- Mineral content – although still the weakest area, knowledge of mineral content is improving with a large number of candidates now knowing the essential mineralogy of each rock group. Care is required with feldspar content and composition so that K feldspar is restricted to silicic or intermediate rocks and plagioclase feldspar is divided into Ca-rich in mafic rocks and Na-rich in silicic. Some candidates included Bowen's Reaction Series and this could have been a good way to describe mineral composition if the first formed minerals were linked to mafic rocks and the last to silicic rocks. However the Reaction Series without the relationship could not gain marks.

F794 Environmental Geology

General Comments

This examination paper produced a good range of marks. Well-prepared candidates with secure subject knowledge scored highly. Other candidates need to ensure their answers are clearly written with good use of geological terminology. Good recall of knowledge from the AS level specification is required to ensure candidates can successfully access the synoptic elements of the paper. Questions will cover synoptic material from other units particularly F792 Rocks and Processes. The stretch and challenge questions may require information to be put into a new context and synthesised from different areas of the specification.

Candidates who read and analysed the requirements of questions carefully were able to give full and relevant responses that gained the highest marks available. There was no evidence that time was an issue as all candidates attempted the final extended question on water supply from artesian basins.

Comments on Individual Questions

Question 1

This question on slope stability was answered well by many candidates. To improve their marks some candidates need to ensure their answers include correct geological terminology relevant to the question set.

(a) **(i)** The best responses to this question included accurately drawn and labelled diagrams which clearly showed how clay slopes would fail by slumping, accompanied by a sound explanation. Some candidates lost marks as they failed to label clay on their diagrams or did not indicate the direction of movement. There was some confusion with land slipping of competent rocks.

(ii) The geological factors influencing slope stability in a well-bedded sandstone were well known but they were not always evaluated. Some candidates did not distinguish between the geological factor of the dip of the beds and the non geological factor of the angle of slope.

(b) **(i)** The reasons why heavy rain decreases rock slope stability were well known by most candidates. Some lost marks as they failed to realise that weathering was not relevant to the question as it is a long term process.

(ii) Most candidates were able to correctly suggest a human activity that could increase the likelihood of slope failure. Answers merely stating “road construction” were not specific enough to gain credit.

(c) Ground improvement strategies were well known and virtually all candidates achieved some marks on this question.

Question 2

This question on geological materials and geological factors affecting coastal erosion proved to be a good discriminator. Candidates who had a clear understanding of the connections between different areas of the specification were able to produce good answers for the synoptic content of this question.

(a) **(i)** Many candidates appreciated that the altered rock around the igneous intrusion would be metamorphosed but few took account of the large scale on the map that excluded the term *baked margin*. The correct spelling of *metamorphic aureole* was not known by all.

(ii) Less than half of the candidates knew that the rock formed when limestone is metamorphosed is marble, highlighting the need for candidates to thoroughly revise synoptic content prior to sitting A2 examinations.

(iii) As error carried forward was allowed for this question, and it was pleasing that most candidates achieved at least 2 of the 3 marks available for this question on economic uses of rocks. The best answers correctly applied general knowledge of properties of rocks to the specific rock and use they stated. It is important in these types of questions that candidates correctly distinguish between *hardness* and *strength* of rocks. Marble is a strong, competent rock, but as it consists mainly of calcite it is not hard. In addition, marble is impermeable as it consists of interlocking crystals, but is not resistant to chemical weathering.

(b) **(i)** Many candidates were familiar with dredging or open cast mining as correct methods to extract unconsolidated sands and gravels. Some candidates found it difficult to develop their answer further to give correct descriptions of the processes and machinery used. Some candidates did not appreciate that blasting is not an appropriate technique for unconsolidated material.

(ii) The environmental consequences of extraction of construction materials were well known. A minority of candidates gave general answers. For example, “aquatic habitats will be disrupted” is a more accurate answer than “animals in the river will be killed”.

(c) Virtually all candidates gained some credit for this applied and synoptic question on how rock types and geological structure control the shape of coastlines. As expected only the strongest candidates accessed the stretch and challenge aspects of the question by systematically assessing all the rock types and structures shown on the map and explaining why or why not they were resistant to erosion. A common error was to use the terms weathering and erosion as if they are synonymous – erosion was the key process in this situation. These ideas are synoptic on F792.

Question 3

Most candidates showed a good understanding of the requirements for the accumulation of oil and gas in traps, but were less sure of the new part of the specification covering how exploration drilling is carried out. Many found the calculation challenging. Some of the information used in the question was new to most candidates but answers are provided in the question.

(a) (i) Candidates who read this question carefully and followed the instruction to draw the paths of the seismic waves from the source to hydrophones H2 and H5 in the same way as that drawn for hydrophone H1 had no problem completing this question correctly, but they were in the minority. Knowledge of the law of reflection and the fact that seismic waves travel in straight lines was lacking. The most common errors were showing the waves zigzagging between the reflective layer and each hydrophone or showing the rays splaying out from a single point on the reflective layer to the hydrophones or not drawing direction arrows on the waves.

(ii) Candidates who followed the instructions given in the question were able to correctly state the two way times through the water and through the rock to the reflective layer shown on the cross section. Some candidates did not appreciate that because the vertical scale on the cross section was given in two way times all they had to do was read values from the scale. All the information required for this part question was provided.

(iii) As expected most candidates found this depth calculation difficult. The most successful candidates realised they had to use the formula depth (distance) = speed x time and gave a clear statement of this formula to attain one of the two marks available. The calculation itself was straightforward but, in common with calculating rates of sea floor spreading, the difficulty is converting the units – in this case from milliseconds into seconds. Some candidates did most of the calculation correctly then forgot to divide their answer by two as the time given was two way time. This was defined in the question as “the time taken for a surface generated seismic wave to reach a reflective layer and return to the surface”.

Teaching tip

For any calculations, always state the formula. Neatly show all working and make it clear what you are doing. Check the final answer to see if it is sensible. In this case 8 metres or 80 000 or even 8000 metres was unlikely to be correct

(b) (i) Candidates who were clear about the difference between exploration drilling for oil and gas and drilling production wells scored highly on this question. These candidates gave excellent descriptions which achieved the maximum 3 marks with ease. Some candidates mistakenly wrote about how geophysical exploration is carried out, while others wrote about how primary and secondary oil recovery is carried out, neither of which answered the question.

(ii) Oil and gas traps were well known and most candidates correctly drew a vertical borehole into the permeable rock below the unconformity. Only a small minority incorrectly selected the fault, which would allow the oil and gas to escape upwards through permeable rocks.

(iii) It was pleasing that most candidates were able to analyse the subsurface geology correctly to give good explanations as to their choice of site for the production well. Some candidates need to develop their use of good terminology and ensure they include terms like *cap rock* and *reservoir rock* and include full explanations.

Question 4

This question on metallic mineral deposits and heavy metal contamination of soils proved to be a good discriminator, with candidates achieving the whole range of marks available. It is pleasing that the quality of answers on metallic mineral deposits, a traditionally poorly answered part of the specification, continue to show improvement.

(a) **(i)** Most candidates had a general idea of the meaning of *concentration factor* but well-worded definitions were in the minority. Many failed to make a comparison with average crustal abundance

(ii) The technical term *cut off grade* was well known.

(iii) Most candidates were able to attain some credit for listing the ore minerals found in placer, residual and secondary enrichment deposits. It should be noted that, with the exception of gold, the use of mineral rather than metal names was required

(b) There were many excellent well drawn and annotated diagrams that fully explained how placer deposits can form at plunge pools in a river. Diagrams should be neatly drawn and labels and annotations of features full and clear. Some candidates lost marks because they did not note the command word *explain.*

(c) This high demand question proved to be a good discriminator. Most candidates were able to give reasonable descriptions of how residual and secondary enrichment deposits form, but many candidates need to further extend the skill of doing a point by point comparison of similarities and differences.

(d) **(i)** Most candidates attained at least one mark for their explanation as to why heavy metal contamination of soils is a threat to human health. When candidates did not gain marks it was because they often repeated words such as *contamination* from the question or did not give full explanations. For example, *contamination of drinking water* was insufficient – candidates had to specify what sort of drinking water, e.g. groundwater, aquifers or surface reservoirs.

(ii) This question focussed on the use of soil and stream sediment sampling surveys and how they are carried out. Very few candidates extended their answers to describe how the samples are analysed and the results interpreted. Candidates who defined the term *geochemical anomaly* were in the minority. A common error was to describe geophysical surveys.

Question 5

This question on water supply from artesian basins was answered well – all candidates gained some credit for their answers which were skewed towards the higher marks available. Weaker answers lacked precise definitions of the components of artesian basins or did not include enough detail in their answers. While there were some excellent, accurate diagrams of artesian basins complete with detailed annotations that were a credit to these candidates, others were poor. Some candidates were confused as to the source of hydrostatic pressure – it is due to the weight of the overlying column of *water* not rock.

F795 Evolution of Life, Earth and Climate

General Comments

The level was appropriate with differentiation working well across the paper and only minor sections that were answered uniformly badly or well. There is no evidence of a lack of time on this paper with many candidates going on to additional pages. A number of candidates had crossed out answers for earlier short answer questions and gave answers on the additional pages. This is much better than trying to write in the margins, however without any reference to where the additional answers are, it can be difficult to spot. A reference to "see page 17" or "see end" is needed and then the question number should be shown on page 17.

There is great variation in the quality of diagrams and this was particularly marked between the two long questions where there was a real contrast with poorly labelled and drawn graptolites and excellent cephalopods.

Command words remain an issue with questions that ask for an explanation sometimes being answered as descriptions rather than giving reasons.

The term environment is common on this paper and candidates need to be clear that it refers to a specific area such as coral living in a warm, clear, high energy, shallow sea or plant fossils most common in a delta swamp where low energy, shallow waters allow burial in fine sediment in anaerobic conditions. The term climate or palaeoclimate refers to the temperature and precipitation and is normally described as equatorial, wet tropical, arid tropical, temperate and Arctic or glacial.

Questions will cover synoptic material from other units particularly F792 sedimentary rocks and processes and in this paper, unconformities from F791. The stretch and challenge questions may require information to be put in a new context and synthesised from different areas of the specification.

Comments on Individual Questions

Question 1

Most candidates showed a good understanding of the identification and detail of these fossils and elements of classification, with many candidates gaining nearly full marks. Where the initial identification was incorrect then error carried forward was used where possible so that candidates were not disadvantaged in other parts of the question.

(a) **(i)** The identification of these fossils was generally well done although a number of candidates were unable to recognise the enrolled trilobite and identified it as a bivalve or cephalopod. Unusual views or parts of fossils are a useful identification skill as in the field it can be rare to find whole fossils. The conodont was the next least well known.

(ii) The identification of the morphological features was often excellent. The function of the dissepiment was generally well understood. The septa and dissepiments were mixed in a few cases and the term columella confused with corallite or corallum.

(iii) This was generally well known with the description of strength well known. There was some confusion regarding the fact that the dissepiments join the septa together and not the septa to the tabula.

(iv) The composition of a conodont was known by most candidates but a large minority stated that it was calcium carbonate rather than apatite or calcium phosphate. The

identification of teeth was excellent and some went on to state that they were similar to the teeth of a hagfish.

(v) Gastropod labels were exceptionally well known and a much wider range of morphological features were used than are listed in the specification.

(vi) Knowledge of the mode of life of this *Turritella* gastropod was very mixed, ranging from candidates who knew that it lived buried in sediment spire down to those who made no attempt at description and just wrote 'low energy'. The environment needs to be a specific area – in this case shallow seas – and conditions can be either high or low energy. This gastropod generally lives in soft sediment though a few are buried in coarse sediment.

(vii) Some excellent responses that showed a really good understanding of how to observe and then use evidence to infer the mode of life. The compound eyes are both large and positioned on the top or side of the cephalon so allowing trilobites to see above them in order to catch prey or avoid predation and this positioning shows that they lived on the sea floor. The possession of eyes does not identify where the trilobite lived as nektonic trilobites may also have eyes. It is the link between the evidence and the mode of life that gains the mark rather than a statement of the mode of life. The answer required a mode of life AND the evidence for it (based on what could be seen in the diagram). General statements on trilobite lifestyles are not enough. Some candidates only provided one piece of evidence and conclusion.

(b) **(i)** There were many very good drawings that clearly showed the brachiopod attached to a rock by a pedicle. A few candidates confused the larger pedicle valve with the smaller brachial valve. Spelling of the labels was poor in a number of answers. A few drawings were so small – at less than 1 cm – that it was very difficult to see which features were being labelled.

(ii) Detailed knowledge of the cilia on the lophophore was often well known. Explaining how the cilia trap the food particles and pass them along the lophophore to the mouth was more challenging. A few candidates used only the information given in the question i.e. describing filter feeding.

Question 2

Some excellent responses showing good knowledge of preservation of fossils. Understanding of trace fossils was more limited particularly where the information needed to be applied synoptically for the unconformity.

(a) The definitions of methods of preservation were very well known.

(b) Some answers showed a series of well annotated drawings that made a clear distinction between moulds and casts and internal and external structures. However some drawings had few labels that did not have enough detail to explain the formation. Label lines need to end in exactly the right place as the line between internal and external cast or moulds is very small. Many answers did not distinguish between internal and external structures. The idea of the shells being dissolved by percolating groundwaters was sometimes confused with erosion.

(c) The effect on fossil preservation of transport and particle size was well known but understanding the effect of diagenesis, the synoptic topic, was weaker. There were some candidates who assumed that 'quick' was the same as 'early diagenesis' and failed to demonstrate a complete understanding of the mechanisms involved. A few candidates stated each of the factors without explanation, which meant it was not possible to gain marks. Most answers described high preservation potential with the detail available from fine sediment. There were some answers that described the reverse argument of the damaging effects of coarse sediment.

(d) **(i)** Fossils E and F are actually worm burrows but answers that referred to burrows formed by bivalves or other organisms were accepted. The best answers included reference to *Diplocraterion* and *Skolithos* which goes beyond the expected level of detail. The burrows can only form in soft sediment that the organisms can excavate. This answer needs full use of the two lines provided for the mark.

(ii) Answers were often about way up structures rather than unconformities. The bed immediately below an unconformity may have been the sea floor for a long period of time in the time gap before a new bed is laid down unconformably.

(iii) Many good answers with full descriptions of at least two points to describe the conditions that allowed the burrows to be preserved. Where a single condition such as low energy was stated it does not give the detail needed for a description. Some answers just stated the general conditions for good preservation of anoxic and low energy without applying their knowledge to this specific question.

(e) **(i)** Good precise answers show an excellent understanding of zone fossils. Most candidates recognised C as the best zone fossil and included good explanations with technical terms such as short stratigraphic range.

(ii) Generally excellent, but some general answers. Good answers were based on first appearances and extinctions and most correctly pointed out that Bed 3 contained 5 of the 6 species.

(iii) Most answers accurately listed the ammonites contained in Bed 2. Answers needed the identification of the species or the first appearances and extinctions of named species.

(f) Many answers referred to fossils being destroyed but the explanation needs to say how the fossils are destroyed by a specific method. There is a wide range of possible answers but some candidates only wrote about one factor. There were some answers that lacked the explanation asked for in the question.

Question 3

Knowledge of amphibians and lobe fin fish was very good but palaeoclimate is poorly understood and answers often lacked detail. There was a greater diversity of answer quality than in most questions.

(a) **(i)** Describing the environment of deposition for plants means giving all the details needed for fossilisation to take place and it will not occur unless there are is a low energy swamp with fine sediment being deposited rapidly in anaerobic bottom conditions. Many answers lacked sufficient detail for full marks although some candidates spent time explaining why each condition was important. Some answers were entirely on carbonisation which is a diagenetic process that takes place after fossilisation.

(ii) There were some good answers giving the morphological similarities between lobe finned fish and early amphibians. The position of the fins and limbs was the most common feature described.

(iii) There were some excellent and thoughtful answers on this topic. The idea of a girdle (shoulder or pelvic) to connect the limb bones to the spine was the key concept as this allows the amphibian to move on land supporting its own weight. Many answers focussed solely on soft tissue changes rather than the bones.

(b) **(i)** The idea of equatorial climates being non seasonal is poorly understood. The lack of tree rings shows that there was no change in temperature and humidity throughout the year. There is some confusion about deciduous trees which did not exist in the Carboniferous as they first appeared in the Triassic.

The rate of growth is influenced by water and temperature not specifically carbon dioxide/oxygen levels or sunlight. Warmth alone does not make trees grow taller e.g. in a desert where plant growth is severely restricted – abundant plant growth requires water as well.

(ii) Many answers just gave *tropical* which was not allowed as deserts occur in tropical climates where there is little precipitation, hence the need for *wet* tropical, although the best answer is *equatorial*. Candidates need to appreciate the distinction between these two climates.

(c) There were some excellent answers to this stretching question including confident assertions based on isotope ratios and detailed UK Carboniferous geology examples. This question was on the evidence for the palaeoclimate of the Carboniferous so evidence had to be from that period. Broad leaved plants, elephants and tigers did not exist in the Carboniferous! The only limestone that is climate specific is reef limestone due to the corals that it contains. Many answers were very general, lacking specific evidence. The confusion between environment and climate meant that some candidates described the environment and not the climate.

Question 4

Mass extinction is a topic that is well known but applying new data is more challenging. Correlation is a topic that is less popular with a lack of understanding of the processes and problems.

(a) **(i)** The graph plotting was generally accessible but many had trouble drawing the curve.

(ii) The line to show mass extinction needed to be drawn at the maximum level of iridium as the iridium spread around the Earth rapidly. The line was acceptable drawn either vertically or horizontally.

(iii) There were many good answers that described the iridium coming from outer space and some good explanations of the meteorite impact causing the iridium to be spread through the atmosphere as dust and then forming a thin layer in the clay around the world. Iridium must come from space not volcanoes.

(b) This question was well answered although it was difficult for some candidates to condense the evidence into a limited space. This topic has been set previously as an essay question and answers often continued onto the additional pages. Answers showed a good understanding of mass extinction caused by volcanic activity and the best answers made the link to the Siberian Traps. The question required an explanation for each point made and some candidates knew the facts but not the reasons. Detail such as the names of the volcanic gases was expected.

(c) There were many very good descriptions and explanations were given, particularly using the laws of cross cutting relationships and included fragments. There was some confusion between the terms *older* and *younger* particularly with included fragments. Way up structures were well described but were not always linked to younger/older which is essential for relative dating. Radiometric dating and correlation are not methods of relative dating. A few answers were very general and did not refer to specific methods.

(d) **(i)** There were many good answers but also some made up words like stratography. Learning the precise technical terms is essential.

(ii) The definition of *diachronous* is not well known and has been confused with diagenesis. The concept of the same rock being laid down across time was confused with lateral variation where a bed changes lithology while being laid down at the same time.

Question 5

Bivalves as a topic are well known and knowledge is good. Matching the answers precisely to the question set is essential.

(a) **(i)** This true/false question was generally very well done.
(ii) Generally excellent with many very accurately labelled. The most likely label to be wrong is pallial sinus.

(b) **(i–ii)** Some very good answers with a good range of adaptations. Diagrams without labels are a problem as they cannot show specific adaptations to gain marks. Some drawings were poor, making it impossible to see the adaptations. Technical terms are key – full marks cannot be given to general points. Some adaptations were a mix from different examples of bivalves so referred to strong ribs and a byssus. There were three marks for each section which required description, drawings and explanations for each adaptation. Clear spelling is important and the spelling of muscle as in adductor muscle and *Mytilus* the mussel was often confused.

(c) This question on Uniformitarianism was a challenge for many candidates and explanations were often very general. Some candidates knew why it was useful to study present day bivalves but few could express this clearly. Some candidates repeated the question or described assemblages and so did not make the link to geological time. Statements about bivalves having no evolutionary change are not part of the answer.

Question 6

This is a straightforward descriptive question that needs evolutionary changes of specific morphology during the Lower Palaeozoic. This question proved challenging for many, not due to a lack of knowledge but more that it was poorly structured and muddled. Candidates should use the appropriate time periods of Ordovician and Silurian to show how the graptolites change over time. A minority of candidates were confused between oldest and youngest for the Ordovician and Silurian periods. A few candidates have the evolutionary sequence the wrong way round so starting with *Monograptus* forms. It is possible in this case to gain some marks for labelled diagrams. The most common labels are theca, stipe and sicula. The graptolite drawings were very varied from simplistic stick drawings to excellent diagrams that clearly showed theca. The question asked for labelled diagrams and those that were not labelled could not gain any marks. The use of technical terms is essential so that the term *stipe* should be used rather than arm or stem and similarly *theca* rather than cup.

Some answers including information about mode of life or preservation which was not part of the question asked.

The mark scheme allowed for detailed statements of specific forms and although genus names are not essential, a majority of candidates knew them. General evolutionary statements were also allowed, so that there were two different approaches possible: either working through time from oldest to youngest or the main trends using examples to describe each.

It was not possible to gain full marks for the whole question without including all parts in the answers i.e. labelled diagrams and morphological adaptations. However as this is a long answer that requires prose, it was not possible to gain full marks from a table or list of diagrams. A few well drawn and labelled diagrams were better than many poor and unlabelled diagrams.

Question 7

Most candidates showed an excellent appreciation of the features of the cephalopods. There was appropriate and accurate use of technical terms – it appeared that this topic was popular and very well understood. The answers on cephalopod similarities and differences were usually very well structured with excellent diagrams showing both internal and external features of both nautiloids and ammonoids. Diagrams tended to be well labelled but a few were the wrong way round or did not state which drawings belonged to each group. It was very impressive that so many candidates had done a clear comparison for both cephalopod groups for each morphological feature. A few candidates confused nautiloids and ammonoids. Others described the mode of life in some detail and a few included the classification of cephalopods.

This question had sections in the mark scheme with maximum marks so that it was not possible to gain full marks without including in the answers all parts i.e. similarities, differences and labelled diagrams.

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