

**Drayton Manor High School**

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| Exam Question |
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| (a) | Study Figure 1. Analyse the pattern of the distribution of permafrost between Greenland, North America and Eurasia. *(6 marks)* |

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| (b) | Climate is one of the factors that can explain the global distribution of permafrost shown in Figure 1. Explain non-climatic factors that can influence the extent of permafrost on a local scale.  *(6 marks)* |

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| (c) | Explain the contrasting formation of drumlins and glacial moraines. *(8 marks)* |

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| (d) | Evaluate the economic and environmental value of glacial and periglacial environments. *(20 marks)* |

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| **Total:** 40 marks |

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| Source |
| **Figure 1: Distribution of present-day periglacial environments** |

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| Mark scheme |
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| (a) | 6 marks (AO1 = 3 marks, AO2 = 3 marks)Some suggested ideas are given below but you may wish to expand on these or include other relevant points. • In the Arctic Circle, most areas have continuous permafrost because of the cold temperatures all year at this latitude. South of that, there is variation. • There is no permafrost over Europe because of the warming influence of the North Atlantic Drift during the winter. • The discontinuous permafrost extends south of the Arctic Circle over North America. It extends furthest south over Siberia during the winter — it is far from the warming influence of the North Atlantic Drift, allowing freezing. During the summer, temperatures rise here allowing partial melting.**Answers to this question will be given a mark within a level bandLevel 1 (1–2 marks):** You show limited geographical knowledge and understanding of the pattern of the distribution of permafrost. You apply your knowledge and understanding of the pattern with limited effect, making limited connections between aspects of your answer and supporting your interpretations with limited evidence.**Level 2 (3–4 marks):** You show mostly relevant and accurate geographical knowledge and understanding of the pattern of the distribution of permafrost. You apply your knowledge and understanding of the pattern, making some connections between aspects of your answer as appropriate and supporting your interpretations with some evidence.**Level 3 (5–6 marks):** You show relevant and accurate geographical knowledge and understanding of the pattern of the distribution of permafrost throughout. You apply your knowledge and understanding of the pattern throughout your answer, making sound connections between aspects of your answer as appropriate and supporting your interpretations logically with evidence.**Hints and tips**Systematically break down the elements of the map to draw out the patterns. |

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| (b) | 6 marks (AO1 = 3 marks, AO2 = 3 marks)Some suggested ideas are given below but you may wish to expand on these or include other relevant points.**AO1 Demonstrating your knowledge and understanding**There are various local-scale factors that can influence permafrost development, including slope angle, rock/soil type, the presence of large bodies of water, vegetation cover and snow cover.**AO2 Applying your knowledge and understanding**These factors interact to determine localised variations in permafrost within a broader climatic context.**Answers to this question will be given a mark within a level bandLevel 1 (1–2 marks):** You show limited geographical knowledge and understanding of the non-climatic factors that can influence the extent of permafrost. You apply your knowledge and understanding of the non-climatic factors with limited effect, making limited connections between aspects of your answer and supporting your interpretations with limited evidence.**Level 2 (3–4 marks):** You show mostly relevant and accurate geographical knowledge and understanding of the non-climatic factors that can influence the extent of permafrost. You apply your knowledge and understanding of the non-climatic factors, making some connections between aspects of your answer as appropriate and supporting your interpretations with some evidence.**Level 3 (5–6 marks):** You show relevant and accurate geographical knowledge and understanding of the non-climatic factors that can influence the extent of permafrost throughout. You apply your knowledge and understanding of the non-climatic factors throughout your answer, making sound connections between aspects of your answer as appropriate and supporting your interpretations logically with evidence.**Hints and tips**Give a clear explanation of the factors at work, developing your points to show depth of understanding.  |

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| (c) | 8 marks (AO1 = 8 marks)Some suggested ideas are given below but you may wish to expand on these or include other relevant points.**AO1 Demonstrating your knowledge and understanding** • Drumlins are oval-shaped small hills orientated in the direction of ice movement. Moraines come in various forms, but they are typically linear deposits of glacial debris. They can be medial, lateral, recessional and terminal. • Although these are all features of glacial deposition, they are formed in different ways: drumlins are formed as the ice advances; in contrast, the various moraines are formed by deposition as the ice retreats.**Answers to this question will be given a mark within a level band****Level 1 (1–2 marks):** You show limited geographical knowledge and a narrow understanding of the factors influencing formation of drumlins and glacial moraines. Part of your answer may be inaccurate or lack detail.**Level 2 (3–5 marks):** You show mostly relevant geographical knowledge and understanding of the factors influencing formation of drumlins and glacial moraines. Some parts of your answer are not fully developed.**Level 3 (6–8 marks):** You show accurate and relevant geographical knowledge and understanding of the factors influencing formation of drumlins and glacial moraines. Your answer is detailed and fully developed.**Hints and tips**Give a clear explanation of the formation of the two glacial features. Show understanding through the use of well-developed points in your answer.  |

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| (d) | 20 marks (AO1 = 5 marks, AO2 = 15 marks)Some suggested ideas are given below but you may wish to expand on these or include other relevant points.**AO1 Demonstrating your knowledge and understanding** • Economic value includes: farming, forestry, hydroelectric power (HEP) and tourism. • Environmental value includes: water supply (drinking water and irrigation water), the role of the tundra in biodiversity and as a carbon sink.**AO2 Applying your knowledge and understanding**You should apply your knowledge and understanding to make evaluative comparisons, e.g. how activities that can bring about economic development can also undermine the environmental value and degrade the environmental quality and resource.**Answers to this question will be given a mark within a level bandLevel 1 (1–5 marks):** You include isolated points of geographical knowledge and understanding of the economic and environmental value of glacial and periglacial environments, with some errors and inaccuracies. You have not made connections from the question to points made. Your answer is incoherent and lacks relevant evidence to support ideas. Your argument is limited, with unbalanced points. Points that you make are concluded in a general manner, if at all.**Level 2 (6–10 marks):** You make some points showing geographical knowledge and understanding of the economic and environmental value of glacial and periglacial environments, some of which may be relevant. You make some inaccurate points. You apply some of your knowledge but your ideas are not developed or may not be linked directly to the question. You use some evidence to support statements, which may answer only part of the question. You make a conclusion but this is drawn from often unbalanced ideas.**Level 3 (11–15 marks):** You make generally relevant points showing geographical knowledge and understanding of the economic and environmental value of glacial and periglacial environments. Your ideas are mostly accurate and some connections are made between ideas. You interpret the question well in general but there may be some gaps in the use of evidence to support points. You draw a conclusion that links to the arguments made but is not fully supported by evidence.**Level 4 (16–20 marks):** You show good use of geographical knowledge and understanding of the economic and environmental value of glacial and periglacial environments. You make a range of relevant points to create a coherent argument supported by appropriate evidence. You apply your knowledge well throughout. All points you make are linked to the question. You draw a good, well-balanced conclusion that links clearly to the evidence presented. **Hints and tips**Review both aspects (economic and environmental) and come to a well-justified conclusion at the end. |

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| Student Response A |
| (a) | There is a clear pattern in the distribution of permafrost in the Northern Hemisphere. The majority of areas in the Arctic Circle in Greenland, North America and Eurasia have continuous permafrost. This is because of latitude — this far north, temperatures never rise enough for the continuous permafrost to melt. South of the Arctic, some differences start to appear between the continents. In North America, there is a zone of discontinuous permafrost extending southwards — this is also found in Siberia, but it extends much further equatorwards than in North America. In contrast, there is no discontinuous permafrost in Europe. The reason for this is the warm ocean current coming up through the Atlantic Ocean (the North Atlantic Drift) which keeps the western part of Eurasia warmer during the winter. To the east over Siberia, the temperatures drop considerably over a large area of the continental interior during the winter, but they rise to quite warm during the summer, allowing the seasonal freezing and thawing to take place to create discontinuous permafrost.

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| **Examiner comment**The student clearly identifies all the main patterns in the map and offers relevant and accurate explanations for the patterns outlined. Level 3, 6 marks. |

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| (b) | While climate is the dominant factor in determining if a location has permafrost or not, there can be localised variation in the extent and nature of the permafrost due to various factors. For example, slope orientation is important. In the Northern Hemisphere, south-facing slopes receive more sunlight than north-facing and so are slightly warmer. Additionally, soil/rock type plays a part — darker coloured soils/rock absorb more solar radiation and so are warmer. Furthermore, vegetation cover is significant, as it acts as an insulating layer over the soil, protecting it from the extremes of temperature. Likewise, snow can act to insulate the soil during the winter — but it can delay the onset of thawing in the summer. Finally, if an area is close to a large body of water, this can help reduce the fall in temperatures locally, keeping the soil slightly warmer.

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| **Examiner comment**The student shows extensive knowledge and understanding of the relevant factors and has explained them clearly (AO1). |

These factors operate together to influence the development of the permafrost. For example, land on a south-facing slope, beside a large lake, with some vegetation cover will be slightly warmer than another location in the same climate zone that is north-facing, away from any lakes and with less vegetation.

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| **Examiner comment**The answer demonstrates a very clear grasp of the connections between the factors (AO2). Level 3, 6 marks. |

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| (c) | Moraines are usually linear features and come in various forms. Lateral and medial moraines form parallel to the glacier as it retreats. Lateral moraine forms at the edge of the glacier and consists of rock fragments from the side of the valley that have been dislodged by weather onto the glacier below. Medial moraine is found in the middle of a glaciated valley and is formed by the merging of two sets of lateral moraine when two tributary moraines meet. On the other hand, terminal and recessional moraines form perpendicular to the direction of glacial movement, although they too form as the glacier melts and retreats. The terminal moraine forms at the furthest end of the glacier and marks its maximum advance. This linear moraine may have since been bisected by rivers, cutting it into a linear series of mounds. Recessional moraine is similar to terminal moraine, but these mark locations where the glacier may have paused in its retreat, allowing deposition to occur.Drumlins are oval-shaped small hills and form in collections of drumlins across a previously glaciated lowland area. They come in various sizes, but an average size would be around 1 km long, 50 m high and 500 m wide. They are characterised by a steeper, more blunted end (called the stoss end) facing in the direction from which the glacier has come and a gentler, tapered end in the lee side. From their distribution, it is possible to work out the direction of glacier movement. In contrast to moraines, which form as the glacier retreats, drumlins are formed as the glacier advances. There is no clear theory for their formation, but one theory (the Boulton–Menzies theory) suggests that they are moulded around obstacles in the glacial flow (for example a section of bedrock) as the glacier passes. Hence, the up-valley stoss end is more blunted and steep, while the down-valley end is smoothed and more tapered.

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| **Examiner comment**The student demonstrates extensive knowledge and understanding of the processes at work in the formation of both moraines and drumlins (AO1). They also make relevant connections, clearly comparing and contrasting the various processes at work (AO2). Level 3, 8 marks. |

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| (d) | Glaciated and periglaciated environments offer tremendous economic value, not only to the population that lives in the areas themselves, but also to many millions more who live outside of them but who benefit from the resources they offer, as we will see below. First, they support farming. In more developed countries, the traditional form of Alpine agriculture is transhumance. Livestock are grazed in the Alpine meadows during the summer when they are free from snow, while the grass from the valleys is turned into hay for the winter, when the livestock are brought back down into sheds in the valleys. In Switzerland, about 35\_f the country’s farmland is made up of Alpine pastures.Second, producing hydroelectric power (HEP) is a major economic activity in many glaciated areas. Meltwater from glaciers feeds the reservoirs connected to the HEP turbines. Many glaciated regions generate significant amounts of electricity from HEP: in the case of Norway and New Zealand, over 90\_f their electricity in fact, and Switzerland as much as 70\_One of the main benefits of this is that the energy is renewable and does not contribute significantly to climate change. However, as we will see, there can be environmental concerns with HEP.Third, mining for resources can occur. For example, in the Alaskan tundra oil is extracted. The state gets 90\_f its day-to-day finances from levies on oil and gas, helping boost the economy of the region. Glacial erosion can also strip away overlying soil and help expose rock and other valuable minerals below, making it less expensive to extract the resources.Finally, tourism provides significant employment opportunities and economic growth in many glacial and periglacial areas. Tourism is growing very fast globally: in 2015, global tourism generated over US$7 trillion and made up nearly 10\_f the entire world’s GDP. Adventure and ecotourism to more exotic and environmentally sensitive regions are becoming increasingly popular. Tourism to glaciers in places like Iceland and the Rockies is growing.Clearly, this wide range of economic benefits of glacial and periglacial regions constitutes a significant economic value. However, these same regions have considerable environmental value also — and these two different values can come into conflict with each other.There are various valuable environmental resources in these regions. For example, the glaciers provide water, not only for the bottled water industries, but also irrigation water for many arid regions. The Arapaho Glacier in the USA provides irrigation water for the fruit that is grown in Colorado, which is a desert region with low rainfall totals. In addition, the tundra ecosystem has great environmental value. As well as being a unique ecosystem and so contributing to global biodiversity, the permafrost here ensures that this ecosystem acts as a significant carbon sink within the global carbon cycle. Temperatures in the Alaskan tundra have risen by 1.9°C in the past 50 years, twice the national average of the USA. As a result, there has been an increase in wildfires — there were more wildfires in the 2000s than in any decade since record-keeping began in the 1940s. This releases vast quantities of greenhouse gases such as carbon dioxide and methane into the atmosphere. A single wildfire in 2007 released more carbon dioxide than had been absorbed by the entire Alaskan tundra in the previous 25 years. To combat climate change, it might at first seem the best thing to do is to encourage renewable energy such as HEP. However, there are environmental concerns about the interference with natural systems through, for example, damming rivers and creating large reservoirs.Tourism can have a negative impact on the glacial environment. Winter tourism sports such as skiing and snowboarding need to be carefully managed so that they do not have an overly negative impact on the environment. For example, snow-making systems must be checked for their ecological consistency. Increased urban expansion in the valley floors, in large part to support the growing tourism industry, must also be carefully managed — urban sprawl not only changes the character of the villages, but eats up valuable countryside land, and air pollution from increased traffic can have negative environmental consequences. Furthermore, there has been a significant growth in tourism to glaciated polar regions. Tourism numbers for the Arctic have doubled from 1 million to 2 million per year from the early 1990s to 2014. People travel there for various activities, including outdoor sports such as husky sledging, as well as excursions onto glaciers and viewing the Northern Lights. The growth of tourism in the Antarctic has been slower, but has increased more in recent years. To protect the fragile environment here, there is a need for careful management, including via strategies such as limiting tourist numbers visiting one site at one particular time.In conclusion, it is clear that glacial and periglacial regions provide both economic and environmental value. However, these both need careful management if they are not to come into conflict with each other and end up undermining the very resources that provide the value in the first place.

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| **Examiner comment**This is a detailed and coherent answer that shows good understanding through the use of effective examples, and comes to a balanced conclusion supported by the argument. Level 4, 18 marks. |

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| Student Response B |
| (a) | In North America, the discontinuous permafrost extends southwards from the Arctic Circle. This also happens in Siberia, but it goes much further south than in North America. The reason for this is the warm ocean current coming up through the Atlantic Ocean which keeps the western part of Eurasia warmer during the winter. To the east over Siberia, the temperatures drop considerably over a large area of the continental interior during the winter, but they rise during the summer, allowing the seasonal freezing and thawing to take place, causing the discontinuous permafrost.

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| **Examiner comment**The student identifies some of the main patterns in the map, and offers relevant explanations for these. However, not all relevant patterns are identified and the answer is therefore not full and complete. Level 2, 3 marks. |

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| (b) | There are various factors that can affect permafrost character in any particular area. First, if an area is close to a large lake, this can help reduce the fall in temperatures locally, keeping the soil slightly warmer. Second, slope. South-facing slopes get more sun and so are a bit warmer. Third, snow cover. If an area is covered in snow, this can insulate it a bit during the winter — but during the summer as temperatures rise, this can delay the thawing process. Next, vegetation. Where there is some tundra vegetation, it can also help to insulate the soil from the extreme cold of winter. Finally, soil colour — dark soils absorb more of the sun’s heat and are a bit warmer as a result.

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| **Examiner comment**The student shows good knowledge and understanding of the relevant factors and has explained them (AO1). However, the answer does not show how they interact with each other and so the connection necessary for AO2 is not made. Level 2, 3 marks. |

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| (c) | Drumlins are collections of small hills found in previously glaciated lowland areas. They are oval-shaped with steeper, more blunted ends facing up-valley and gentler, tapered ends facing down-valley. Drumlins are formed as the glacier advances. There are various theories on how they are formed. According to the Boulton–Menzies theory, they are moulded around obstacles in the glacial flow (for example a section of bedrock) as the glacier passes. Another theory (the Shaw theory) suggests that they were formed by deposition in sub-glacial streams that was then moulded by the advancing ice. This makes the up-valley stoss end more blunted and steep, and the down-valley end smooth and more tapered.Moraines are linear landforms. Lateral and medial moraines form as the glacier retreats. Lateral moraine forms at the edge of the glacier. It consists of rock fragments from the valley sides dislodged by weather onto the glacier below. In the middle of a glaciated valley, medial moraine forms as two sets of lateral moraine merge when two tributary moraines meet. At the furthest end of the glacier, terminal moraine forms, marking the glacier’s maximum advance. This linear moraine may have since been bisected by rivers, cutting it into a linear series of mounds. Recessional moraine marks locations where the glacier may have paused in its retreat, allowing deposition to occur.

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| **Examiner comment**The student shows good knowledge and understanding of the processes at work in the formation of the both moraines and drumlins. The answer could be improved by drawing out the contrasts between the processes of formation clearly and explicitly, e.g. drumlins form as the ice advances, whereas moraines form as it retreats; terminal and recessional moraines form perpendicular to the direction of ice movement, whereas lateral and medial moraines form parallel to the direction of movement. Level 2, 4 marks. |

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| (d) | There are various economic activities that go on in glaciated areas. Farming in Alpine areas is mostly transhumance. Livestock are grazed in the Alpine meadows during the summer when they are free from snow, while the grass from the valleys is turned into hay for the winter, when the livestock are brought back down into sheds in the valleys. Hydroelectric power (HEP) is also common in glaciated regions, and countries can generate significant amounts of their energy from this source. For example, Norway and New Zealand generate over 90\_f their electricity from HEP. Mining and mineral extraction is an important economic activity here too, including oil mining in Alaska. Tourism provides many jobs in glacial areas as tourists want to visit exotic locations with glaciers. Tourists are not only going to traditional glacial regions such as the Alps and the Rockies, but they are travelling further to go to places such as the Arctic (Greenland) and the Antarctic. They often visit in ships. The Antarctic receives around 40,000 visitors a year.These areas also have environmental benefits and value too. Tundra areas act as a carbon sink. As global warming occurs and the permafrost melts, methane is released, further adding to global warming (feedback loop). Rising temperatures here have also contributed to a rise in the number of wildfires. These fires damage the plants in the short term, but they also give off carbon dioxide, adding to climate change. Glaciers also provide water for drinking and for irrigation. Tourism is bad for these regions. Tourists visiting remote glaciated regions can have the following effects: disturbing wildlife, litter and waste, trampling of sensitive ecosystems.In conclusion, both glacial and periglacial locations have economic and environmental value.

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| **Examiner comment**The student refers to both main aspects of the question — economic and environmental value — but the answer requires various other elements to reach a higher level. The answer would be improved with a more detailed and coherent conclusion that is informed by the points made. The answer lacks coherence. The student almost contradicts themselves about tourism (is it a good or a bad thing?) To address this, the student should explicitly point out that there are two sides to the impacts of tourism — economic benefits alongside environmental challenges — and that both can be true at the same time. Level 3, 11 marks. |

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