Instructions to Students

1. You will have 10 minutes to read the paper. You must not write in your question booklet or on your multiple-choice answer sheet, or use a calculator during this reading time, but you may make notes on the scribbling paper provided.

2. This paper is in three sections:
   - **Section A: Multiple-choice Questions** (Questions 1 to 15)
     Answer this section on the separate multiple-choice answer sheet, using black or blue pen. Answer **all** questions in Section A.
   - **Section B: Short-answer Questions** (Questions 16 to 24)
     Answer this section in the spaces provided in this question booklet. Answer **all** questions in Section B.
   - **Section C: Extended-response Question** (Question 25)
     Answer this question in the space provided in this question booklet. *Include at least one field example and at least one well-labelled diagram.*

3. The allocation of marks and the suggested (approximate) allotment of time are as follows:
   - Section A: 30 marks, 30 minutes
   - Section B: 70 marks, 70 minutes
   - Section C: 20 marks, 20 minutes
   - Total: 120 marks, 120 minutes

4. The geological time-scale is on page 3. You may remove it from this booklet before the examination begins.

5. Attach your SACE registration number label to the box at the top of this page. Copy the information from your SACE registration number label into the boxes on your multiple-choice answer sheet.

6. At the end of the examination, place your multiple-choice answer sheet inside the back cover of this question booklet.
STUDENT’S DECLARATION ON THE USE OF CALCULATORS

By signing the examination attendance roll I declare that:
• my calculators have been cleared of all memory
• no external storage media are in use on these calculators.

I understand that if I do not comply with the above conditions for the use of calculators I will:
• be in breach of the rules
• have my results for the examination cancelled or amended
• be liable to such further penalty, whether by exclusion from future examinations or otherwise, as the SACE Board of South Australia determines.
### THE GEOLOGICAL TIME-SCALE

<table>
<thead>
<tr>
<th>Eon</th>
<th>Era</th>
<th>Period</th>
<th>Epoch</th>
<th>Date at boundary (million years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precambrian</td>
<td>Proterozoic</td>
<td></td>
<td></td>
<td>2500</td>
</tr>
<tr>
<td></td>
<td>Archaean</td>
<td></td>
<td></td>
<td>4600</td>
</tr>
<tr>
<td></td>
<td>Palaeozoic</td>
<td></td>
<td></td>
<td>2500</td>
</tr>
<tr>
<td></td>
<td>Cretaceous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jurassic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triassic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Palaeogene</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Eocene</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oligocene</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Neogene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Holocene</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pleistocene</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Cenozoic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quaternary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Miocene</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pliocene</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Palaeogene</td>
<td>66</td>
</tr>
</tbody>
</table>

SACE BOARD OF SOUTH AUSTRALIA
SECTION A: MULTIPLE-CHOICE QUESTIONS (Questions 1 to 15)
(30 marks)

Answer all questions in this section.

Each of the multiple-choice questions in Section A involves choosing from four alternative answers. Read each question carefully. Then indicate the one alternative that you consider best answers the question by shading the bubble by the appropriate letter alongside the question number on the multiple-choice answer sheet. Use black or blue pen. It is in your interest to give an answer to every question in this section of the paper, as no marks are deducted for incorrect answers. Each question is worth 2 marks. You should spend about 30 minutes on this section.

1. Refer to the photograph below, which shows an extrusive igneous landform:

   ![Extrusive Igneous Landform Image]

   This landform is an example of a:

   J. shield cone.
   K. cinder cone.
   L. composite cone.
   M. flood basalt.

2. A very fine texture in an igneous rock indicates:

   J. mafic composition.
   K. fast cooling.
   L. slow cooling.
   M. felsic composition.

3. The most severe extinction event in the Earth's history occurred:

   J. at the Cretaceous–Palaeogene boundary.
   K. at the end of the Permian period.
   L. during the late Cretaceous period.
   M. at the Palaeocene–Eocene boundary.
Refer to the diagram below, which shows damage that has occurred to a brick house that was constructed on clay soil. The footings* were unsuitable for use in areas of clay soil:

*footings are the parts of a building that are in direct contact with the soil or rock

Which one of the diagrams below shows the best type of footing for preventing this damage?

Source: Adapted from Selby, J 1984, Geology and the Adelaide Environment, Department of Mines and Energy, South Australia, pp 87, 89
5. Refer to the photograph below, which shows a rock containing fossilised bones:

![Photograph of fossilised bones]

During which geological period were the bones probably deposited?

J. Cretaceous.
K. Devonian.
L. Ordovician.
M. Ediacaran.

6. A sedimentary rock with clasts ranging in size from 3 mm to 12 mm is classified as a:

J. sandstone.
K. siltstone.
L. conglomerate.
M. shale.

7. Geothermal power stations have been built in parts of New Zealand and Iceland.
The most likely source of the steam needed to generate electricity in these geothermal power stations is:

J. boiling lake water, produced when lava flows into the lake.
K. extremely hot liquid from the Earth’s outer core.
L. groundwater that has come into contact with hot rocks.
M. heat from friction during faulting.

8. Open-cut mining is used to extract coal when:

J. the water table is too high for other techniques to be used.
K. the terrain is flat.
L. underground workings through sedimentary rock are likely to collapse.
M. the deposit is shallow enough.
9. Which one of the following correctly describes the causes of load pressure and directed pressure within the Earth’s crust?

<table>
<thead>
<tr>
<th>Cause of load pressure</th>
<th>Cause of directed pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. movement of tectonic plates</td>
<td>the force of gravity</td>
</tr>
<tr>
<td>K. the weight of overlying rocks</td>
<td>movement of tectonic plates</td>
</tr>
<tr>
<td>L. movement of tectonic plates</td>
<td>the weight of overlying rocks</td>
</tr>
<tr>
<td>M. the force of gravity</td>
<td>the weight of overlying rocks</td>
</tr>
</tbody>
</table>

10. Refer to the diagram below, which shows a cross-section through the Earth. The dotted lines indicate the paths of seismic waves through the Earth and the numbers indicate three zones on the Earth’s surface:

Which one of the following correctly identifies the seismic waves recorded by seismometers in zones 1, 2, and 3?

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. P-waves and S-waves</td>
<td>No waves</td>
<td>P-waves only</td>
</tr>
<tr>
<td>K. P-waves and S-waves</td>
<td>P-waves only</td>
<td>S-waves only</td>
</tr>
<tr>
<td>L. P-waves only</td>
<td>S-waves and L-waves</td>
<td>P-waves and S-waves</td>
</tr>
<tr>
<td>M. S-waves and L-waves</td>
<td>No waves</td>
<td>S-waves only</td>
</tr>
</tbody>
</table>
11. Refer to the following graph, which is used to classify coal samples in ranks according to carbon percentage and heat-producing capacity (measured in kilojoules per kilogram, kJ/kg):

![Graph showing classification of coal samples by carbon percentage and heat-producing capacity.]


A geologist tested four different samples of coal — 1, 2, 3, and 4 — for carbon percentage and heat-producing capacity, and hence classified them according to their rank.

Which coal sample has been classified with the correct rank?

<table>
<thead>
<tr>
<th>Sample</th>
<th>Carbon %</th>
<th>Heat-producing capacity (kJ/kg)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.</td>
<td>1</td>
<td>61</td>
<td>5050</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bituminous</td>
</tr>
<tr>
<td>K.</td>
<td>2</td>
<td>65</td>
<td>5300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sub-bituminous</td>
</tr>
<tr>
<td>L.</td>
<td>3</td>
<td>67</td>
<td>5500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lignite</td>
</tr>
<tr>
<td>M.</td>
<td>4</td>
<td>82</td>
<td>7600</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Peat</td>
</tr>
</tbody>
</table>

12. Which one of the following correctly identifies the state and composition of the Earth’s inner core?

<table>
<thead>
<tr>
<th>State</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.</td>
<td>liquid iron and silica</td>
</tr>
<tr>
<td>K.</td>
<td>solid iron and nickel</td>
</tr>
<tr>
<td>L.</td>
<td>liquid iron and nickel</td>
</tr>
<tr>
<td>M.</td>
<td>solid iron and silica</td>
</tr>
</tbody>
</table>
13. The major effect of a large explosive volcanic eruption on the climate is:
   
   J. cooling, due to ash particles reducing incoming solar radiation.
   K. warming, due to heat from magma rising through the Earth’s crust.
   L. warming, due to heat from widespread lava flows entering the atmosphere.
   M. warming, due to greenhouse gases entering the atmosphere.

14. Refer to the following photograph, which shows a trilobite fossil:

   Trilobite fossils are commonly found because:
   
   J. their bodies contained only soft parts.
   K. their bodies contained hard parts.
   L. they were all very small and were quickly covered by sediment.
   M. they lived on land and were quickly covered by sediment.
15. Refer to the following diagram, which shows sediment sampling sites along creek beds, and the amount of copper present at each site (measured in parts per million, ppm):

![Diagram showing sediment sampling sites with copper levels]

The most likely direction of a copper deposit from Point A is:

J. north-west.
K. north-east.
L. south-west.
M. south-east.
SECTION B: SHORT-ANSWER QUESTIONS (Questions 16 to 24)
(70 marks)

Answer all questions in this section. Write your answers in the spaces provided under each question. The allocation of marks is shown in brackets at the end of each part of each question. You should spend about 70 minutes on this section.

16. Refer to the article and image and answer the questions that follow:

Tsunami warning issued after magnitude-7.3 quake in Indonesia

This text cannot be reproduced here for copyright reasons. It can be found at: http://www.abc.net.au/news/2014-11-15/tsunami-warning-issued-after-strong-quake-in-indonesia/5893878


(a) Name the scale used to measure the magnitude of this earthquake.

_____________________________________________________________________________________________ (1 mark)

(b) Suggest what the diameters of the circles in the image represent.

_____________________________________________________________________________________________ (1 mark)
(c) Describe the exact location of the focus of this earthquake.

_______________________________________________________________________________________________________

(1 mark)

(d) Suggest a reason why so many earthquakes occur in Indonesia.

_______________________________________________________________________________________________________

_______________________________________________________________________________________________________

(1 mark)

(e) Suggest one possible cause of a tsunami, other than an earthquake.

_______________________________________________________________________________________________________

(1 mark)
17. Scientists have often applied geological principles to interpret photographs from other planets, particularly in the search for evidence of water and life.

Refer to photograph A and photograph B and answer the questions that follow:

Photograph A: Earth

Photograph B: Mars


(a) (i) Name the rock shown in photograph A.

________________________________________________________________________________________ (1 mark)

(ii) Suggest the most likely transporting agent of the clasts in this rock.

________________________________________________________________________________________ (1 mark)

(iii) Describe the evidence in this photograph that supports your answer to part (a)(ii).

______________________________________________________________________________

______________________________________________________________________________ (2 marks)

(b) (i) Suggest the most likely transporting agent of the clasts in the rock shown in photograph B, and give a reason for your answer.

________________________________________________________________________________________

________________________________________________________________________________________ (2 marks)

(ii) Name the geological principle that you used when answering part (b)(i).

________________________________________________________________________________________ (1 mark)
(iii) Describe one limitation of applying this geological principle in this case.

__________________________________________________________________________________________________

_______________________________________________________________________________________

(2 marks)

(c) State one reason why the search for life on Mars has been closely associated with a search for evidence of water on Mars.

__________________________________________________________________________________________________

(1 mark)
18. Earthquakes regularly occur at the boundary between the Nazca Plate and the South American Plate, which is shown in the diagram below:

![Diagram showing the boundary between the Nazca Plate and the South American Plate.]

[This diagram is not drawn to scale.]

Source: Based on Clark, IF & Cook, BJ 1983, Perspectives of the Earth, Australian Academy of Science, Canberra, p 463

Data from eight earthquakes that have occurred at the boundary are shown in the table below:

<table>
<thead>
<tr>
<th>Distance of epicentre from coast of South America (km)</th>
<th>Depth of focus (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.5</td>
<td>17</td>
</tr>
<tr>
<td>70.0</td>
<td>62</td>
</tr>
<tr>
<td>69.0</td>
<td>101</td>
</tr>
<tr>
<td>68.5</td>
<td>134</td>
</tr>
<tr>
<td>68.0</td>
<td>147</td>
</tr>
<tr>
<td>67.0</td>
<td>218</td>
</tr>
<tr>
<td>66.5</td>
<td>225</td>
</tr>
<tr>
<td>66.0</td>
<td>256</td>
</tr>
</tbody>
</table>

Source: Data from Rapid Earthquake Viewer (REV), viewed 4 August 2016, http://rev.seis.sc.edu/stations.html
Refer to the diagram and table on page 16 to answer the following questions.

(a) On the grid below, complete the scale on the depth axis, plot the data from the table, and draw an appropriate line graph.

```
<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>70</td>
<td>69</td>
<td>68</td>
<td>67</td>
<td>66</td>
<td>65</td>
</tr>
</tbody>
</table>
```

(b) The completed graph in part (a) represents a cross-section of the plate boundary.

On the cross-section, mark:

(i) the locations of the Nazca Plate and the South American Plate. (1 mark)

(ii) an arrow to indicate the direction in which the Nazca Plate is moving. (1 mark)

(c) (i) State the type of plate boundary represented by this cross-section.

________________________________________________________________________________________ (1 mark)

(ii) Use evidence from the cross-section to explain your answer to part (c)(i).

__________________________________________________________________________________________________
__________________________________________________________________________________________________
_________________________________________________________________________________________ (2 marks)
(d) Consider a section of the crust on the ocean floor at the plate boundary.

(i) Estimate the distance, in kilometres, that this section of the crust is likely to have moved after 3 million years. Show your calculation.

(2 marks)

(ii) Suggest one way in which this section of the crust is likely to have changed as a result of this movement.

________________________________________________________________________________________

(1 mark)
19. One phase of exploration for metallic ores is an airborne survey that measures the physical properties of the Earth’s crust.

(a) Name two physical properties that are likely to be measured, and explain why each property indicates the possible presence of a metallic ore.

(i) Property 1.

(1) Name: ___________________________________________ (1 mark)

(2) Explanation: __________________________________________________________

__________________________________________________________________________ (2 marks)

(ii) Property 2.

(1) Name: ___________________________________________ (1 mark)

(2) Explanation: __________________________________________________________

__________________________________________________________________________ (2 marks)

(b) Suggest the next phase of exploration that may be undertaken if the results of the airborne survey are encouraging.

__________________________________________________________________________ (1 mark)
20. Refer to the diagram below, which shows a cross-section of rock structures in an artesian basin:

(a) State two properties that a rock must have in order to act as an aquifer.

(i) ___________________________________________________________ (1 mark)

(ii) ___________________________________________________________ (1 mark)

(b) State the function of rocks that form aquicludes.

__________________________________________________________________________________________ (1 mark)

(c) On the diagram above, label the following:

(i) the recharge zone. (1 mark)

(ii) the position of the water table. (1 mark)

(d) Wells have been drilled into the aquifer at locations 1 and 2. Identify the aquifer from which it would be more expensive to extract water, and explain your answer.

__________________________________________________________________________________________ (3 marks)
(e) Describe how the extraction of water from an artesian basin should be managed, in order to provide a sustainable resource.
21. Refer to the photographs below, which show fossils of two extinct organisms:

![Fossil A](image1.jpg) ![Fossil B](image2.jpg)

(a) Name these two fossils.

(i) Fossil A:  
(ii) Fossil B:  

(b) Name one of the geological periods in which each fossil could have formed.

(i) Fossil A: 
(ii) Fossil B: 

(c) State one contribution that both fossils have made to our knowledge of the Earth’s history.


22. Refer to the photograph below, which shows an impact crater in central Australia:


State two examples of evidence resulting from impact that might be found at this site, and explain how this evidence would have appeared.

(a) Example 1: __________________________________________________________

Explanation: __________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________ (2 marks)

(b) Example 2: __________________________________________________________

Explanation: __________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________ (2 marks)
23. Open-cut mines are often used to extract metallic resources.

(a) Haematite is a metallic ore mineral that is commonly extracted from open-cut mines.

(i) Name the mineral group to which haematite belongs.

________________________________________________________________________________________ (1 mark)

(ii) Name the metal produced from haematite.

________________________________________________________________________________________ (1 mark)

(b) In the space below, draw a cross-section of an open-cut mine, indicating the location of the resource.

(3 marks)

(c) Open-cut mines can produce excessive amounts of dust.

Describe one method of reducing the impact of excessive dust on nearby townships.

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________

________________________________________________________________________________________ (2 marks)

(d) State two requirements of the *Aboriginal Heritage Act 1988* (or its Northern Territory equivalent) that must be met before an open-cut mine is constructed.

(i) ________________________________________________________________________________ (1 mark)

(ii) ________________________________________________________________________________ (1 mark)
24. Refer to the following block diagram of a fault. The sequence has not been overturned:

(a) Complete the top face of the block diagram.  

(b) State the type of fault shown in the block diagram.  

(c) On the block diagram, label the:

(i) hanging wall and foot wall.  

(ii) directions in which pressure has acted.  

(d) (i) State how the sea level changed after the sandstone was deposited.  

(ii) Using evidence from the block diagram, explain your answer to part (d)(i).  

(e) Describe evidence in the block diagram that indicates that one other process has occurred within this rock sequence.  

SECTION C: EXTENDED-RESPONSE QUESTION (Question 25)

(20 marks)

Answer this question in the space provided on pages 26 to 30. You should spend about 20 minutes on this question.

You should present a clear, logical, and well-illustrated response to this question. Include at least one field example and at least one well-labelled diagram.

25. Fossil evidence provides information about the evolution of life throughout the history of the Earth. Discuss the:
   • rock types in which fossils are most likely to be found
   • relationship between the fossil record and the eras of the geological time-scale
   • significance of the formation of stromatolites in the early history of the Earth
   • reasons why the fossil record provides only an incomplete history of life on Earth.