Flinders Ranges Field Investigation

How did climate change affect Evolution in the Proterozoic and Paleozoic Eras?

Word Count: 1,466
Introduction

The Flinders Ranges is a mountain range which begins 370km North of Adelaide, South Australia and extends 430km North through the South Australia. It is part of the Island continent of Australia and was formed during the Cambro-Ordovician Orogeny 500 million years ago (mya) when sediments from the Adelaide Geosyncline were metamorphosed to form an enormous Mountain Range which was higher than the current Himalayan Mountain Range. (SA, 1994)

The Flinders Ranges were originally a basin crustal element which covered the majority of the current South Australian land mass. The rocks found in the Flinders Ranges are a mixture of Sedimentary rocks including tillite, sandstone, shale and limestone. These rocks can be used as a tool to track the climate change during the deposition of sediments in the Adelaide Geosyncline prior to the Cambro-Ordovician Orogeny 500mya. (Byrne, 2013)

The organisms being focused on throughout this investigation range from the single-celled cyanobacteria or, Stromatolites, the earliest multi-cellular life on Earth such as the Dickinsonia and the Aspiella from the Ediacaran fauna and lastly the more recent Cambrian age Archaeocyathids and Trilobites. These organisms show the evolution of the earliest life forms on Earth and their existence can be explained by the different environments which the Earth sustained.

This investigation covers the early Paleozoic and late Proterozoic Eras of the Geological Time-Scale, approximately 100 million years long, incorporating the Ediacaran and Cambrian Periods and the rise of life on Earth from the single-celled bacteria which ruled before. It will also briefly describe the time between 1200mya and the beginning of the Ediacaran 600mya.

Geological History of the Flinders Ranges

The Adelaide Geosyncline was deposited with sediments from the surrounding area which can be seen in their Sedimentary rock form today. The modern Flinders Ranges were formed when the Adelaide Geosyncline was subjected to significant metamorphism in the form of the Cambro-Ordovician Orogeny approximately 520mya. (SA, 1994) A variety of sedimentary rocks can be seen in the Flinders Ranges, showing evidence of the changing climate on the Australian continent over the last 650 million years. In the Flinders Ranges, the evolution of life can be witnessed through the Archaean up to the end of the Palaeozoic Era.

The following block diagrams on the next page show the six different rocks mentioned in this report as well as indicating when the Climate Change mentioned occurred in relation to the formation of the sedimentary layers.
Figure 2, 650mya, Block Diagram 1- Trezona Formation- Banded limestone sedimentary rock, interlaid with layers of siltstone. Low level marine environment with low energy levels. Evidence of Stromatolites found in these rocks.

Oceans were frozen over and glaciation occurred on land masses.

Figure 1- Block Diagram 2- 620mya, Elatina Formation, A tillite made up of clays, sands, pebbles and boulders. Evidence of a large scale global cooling and glaciation from scratch marks on the rocks. Angular fragment, poorly sorted. Glacial Marine environment.
Figure 3- 610mya, Nuccaleena Formation, Dolomite which indicates a period of Warming for the Earth. Low energy marine environment with a warm ocean. This marks the end of the Global ice age which occurred previously.

Figure 4, 600mya, Block Diagram 4- Brachina Formation, siltstone and shale formed from lacustrine sediments, poorly sorted with grain sizes ranging from silt to pebble. Banding of sediments indicate climate change.
Figure 6- 550mya, Block Diagram 5- Rawnsley Quartzite, a metasandstone which was well sorted quartz. Fine sand grain size, the rock is slightly metamorphosed. Shallow, low energy sea with a steady flow as depositional environment. Ediacaran Biota first appear at this time.

Figure 5- 540mya, Block Diagram 6- Parachilna Formation, composed of soft siltstones and sandstones. Marks an abrupt change from the erosion and weathering resistant Rawnsley Quartzite, subjected to renewed oceanic flooding. 1-2mm grain size quartz sands with iron oxide staining. This formation is the boundary between the Ediacaran and Cambrian Fauna.
Figure 7- 520mya, Block Diagram 7- Wirrealpa Limestone, presence of shelled creatures such as brachiopods and trilobites indicate evolution and the depositional environment of warm shallow seas with low energy indicate a fairly warm climate at the time. Marks an explosion of life on Earth.
Geological Significance of the Features

The first life on Earth appeared 3,500mya when bacterial organisms, called Stromatolites began spreading across Earth. They managed to survive in the harsh environments of Archaean Earth, using photosynthesis, these bacteria laid down the frameworks for the evolution of complex life. This caused the iron rich oceans of Archaean Earth to rust, an event called the Oxygen Catastrophe. (Holland, 2006) This laid down almost all of the iron used today. After millions of years of this process, the oceans ran out of iron through the photosynthesis of the Stromatolites. This meant that the oxygen had nowhere to go but into the Atmosphere. This led into the beginning of the Paleozoic, where Stromatolites were only life on Earth, all the while, pumping oxygen into the Earth’s Atmosphere. Despite being devoid of evolution, this time was an explosion of continental construction which formed much of the current landmass that we recognise today, including the Eastern half of Australia. (Time Travellers Guide to Australia, 2012)

Around 860mya, the Earth was subjected to a global ice-age, nicknamed the Snowball Earth. The Snowball Event of the Cyrogenian Period was most likely caused by the removal of methane from the atmosphere (Bowring, N.D), leading to the weaker sun of the time to struggle to provide heat to the Earth, causing a large freezing of oceans and landmass across the globe. Now, the first sponges and seaweeds began to evolve and survive underneath the frozen oceans. (Time Travellers Guide to Australia, 2012) The Marinoan Glaciation, which ended approximately 635mya, is evidence of the large scale glaciation which occurred. (Bowring, N.D) On the Brachina Gorge Geological Trail, the Elatina Formation (Figure 1) is a tillite formed during the Marinoan Glaciation. The presence of glacial sediments and the first sponges and seaweeds indicate that despite the surface being frozen, life was still able to sustain itself below the surface on the Ocean Floors.

610mya, a sudden warming occurred, flooding the Adelaide Geosyncline. (SA, 1994) This is supported by the presence of Dolomite as a sedimentary rock. This warming marks the beginning of the Ediacaran Period of the Geological Time Scale and the evolution of the first complex animal life on Earth, the Ediacaran Biota. The most common form of life during this period was the Dickinsonia, an invertebrate animal which

Figure 1, Elatina Formation, Brachina Gorge (Byrne, 2013)
The Elatina Formation Tillite is evidence of a glaciation event which occurred during the Marinoan Glaciation prior to 635mya. This supports the Snowball Earth Theory and indicates that there was a global ice age at the time.

Figure 2, (Byrne, 2013) Fossilisled Dome Stromatolites in the Trezona Formation Limestone, this shows that the single-celled cyanobacteria formed colonial mounds.

Figure 3, Dickinsonia at the Parachilna Hotel Ediacaran Fauna Display (Byrne, 2013). This new kind of organism showed that life was now able to exist closer to the surface of the oceans and survive in environments of warm, shallow seas exposed to the sun. This was influenced by the rise in temperature caused by the tectonic activity during this time, they lived in the shallow, warm Adelaide Geosyncline and are found fossilised in the Ediacaran Hills in the Flinders Ranges.
resembled a pancake in shape and movement (Figure 3). These fossils can also be found in the Nuccaleena and Brachina Formations of the Flinders Ranges (Gehling, n.d). The Ediacaran biota consisted of soft shelled organisms which would not normally be preserved, however, at the time the Adelaide Geosyncline was at a point where it was extremely low in energy, meaning that fine grained sand was being deposited, creating the right circumstances for fossilisation to occur. (SA, 1994) During this time, there were no predatory organisms to prey on these organisms, coupled with the fact that they lived deep enough below the sea to avoid harmful UV radiation from the sun, meant that there was no need to evolve defensive mechanisms, causing life on Earth to remain a simple form.

The Cambrian Explosion was the next step in the evolution of life on Earth. Occurring approximately 530mya, it marked the dawn of a new age for life on Earth and paved the way for the existence of many organisms which we recognise today such as fish, crabs, spiders and reptiles. It also set the stage for the evolutionary war which would occur millions of years in the future between amphibians and arthropods. (Walking with Monsters, 2005) Tube Worms, Archaeocyathids and shelled creatures such as Trilobites became the dominant forms of life on Earth at this time. Their appearance and methods of living indicate that climate change caused them to evolve to suit the climate of the Cambrian. Evidence of this is shown in several reasons from this period, the shells of the Trilobites and the survival techniques of the tubeworms show that evolutionary processes were enacted in order to allow their survival. The Wirealpa limestone is the sedimentary layer in which the Cambrian fauna are found. Figure 4 and 5 detail these events.

Figure 4 Tube Worm Burrows in the Parachilna Formation. (Byrne, 2013) These burrows show that the soft bodied tube worms were forced to burrow into the sands of the Adelaide Geosyncline, this can be put down to the fact that they needed a method of escaping the sun which was becoming stronger as time progressed. Climate change can be linked in with the fact that predatory animals began to evolve at this time, which helped push the need for the tube worms to burrow into the Earth.

Figure 5 Fossilised Trilobites (N.A, 2013). Trilobites were an early form of the now extinct marine arthropods of the Proterozoic. They developed a tough exoskeletal shell which protected them from the harsh sun of the Cambrian period in their shallow sea homes, this shows that climate change helped to influence the evolution of early life on Earth.
Summary

In summary, Climate Change has altered the path which life has taken over hundreds of millions of years. The question for this investigation was whether climate change affected evolution in the Paeleozoic and Proterozoic Eras of the history of the Earth. Based on the evidence that was found during the field trip to the Flinders Ranges and the further research which I conducted to further the information I gathered for this, I believe that Climate Change played an enormous role in the evolution during the first stages of life on Earth.

Evaluation

See Source Analysis attached on next page

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>suitability</th>
<th>credibility</th>
<th>accuracy</th>
<th>bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowring, S., N.D. Snowball Earth. [Online] Available at: <a href="http://www.snowballearth.org/geochron.html">http://www.snowballearth.org/geochron.html</a> [Accessed 16th June 2013].</td>
<td>Suitable, supports Snowball Earth</td>
<td>Medium Credibility-.org address, but run by expert in field</td>
<td>Accurate, uses real sources and facts for data</td>
<td>Biased, run by an advocate of snowball Earth</td>
</tr>
<tr>
<td>2013. Field Notebook.</td>
<td>Suitable, notes taken directly from the investigated location and is based on personal experience from the field</td>
<td>Medium Credibility-Student written but informatio n comes from informatio n boards</td>
<td>Medium Accuracy, could have wrong interpretatio n of information</td>
<td>Investigation Logically selects and appropriately acknowledges information about geology from different sources</td>
</tr>
<tr>
<td>Source</td>
<td>suitable</td>
<td>high credibility, supported by peer research</td>
<td>accurate, reasonably accurate</td>
<td>potential bias due to crowd sourcing</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>----------</td>
<td>---------------------------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Gehling, J., n.d. <em>Field Notes: Flinders Ranges National Park - Geological Trail</em>, Adelaide: South Australian Museum.</td>
<td>notes are taken directly from the investigated location</td>
<td>High credibility, written by an area expert who works for the South Australian Museum.</td>
<td>Reasonably accurate</td>
<td>Potential bias due to crowd sourcing</td>
</tr>
<tr>
<td>SA, D. O. M. E., 1994. <em>Information Board: Brachina Gorge Geological Trail</em>. Adelaide: South Australian Government.</td>
<td>boards were written to inform visitors</td>
<td>Written by University students under guidance from experts, highly credible</td>
<td>Highly accurate</td>
<td></td>
</tr>
<tr>
<td><em>Walking with Monsters</em>. 2005. [Film] Directed by Tim Haines. UK: BBC.</td>
<td>made to investigate evolution</td>
<td>Credible, made more to entertain than inform</td>
<td>Accurate, information supported by experts</td>
<td></td>
</tr>
</tbody>
</table>
Bibliography
Bowring, S., N.D. Snowball Earth. [Online]
Available at: http://www.snowballearth.org/geochron.html
[Accessed 16th June 2013].

2013. Field Notebook.


Available at: http://en.wikipedia.org/wiki/Trilobite
[Accessed 18th June 2013].


WORK SKILLS ASSESSMENT SHEET

Completion of the following tables will provide evidence for assessment of specific feature A3; demonstration of skills in individual and collaborative work.

Teacher Checklist

<table>
<thead>
<tr>
<th>Skill</th>
<th>very good</th>
<th>good</th>
<th>satisfactory</th>
<th>poor</th>
<th>limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration with others when making observations</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adherence to safe practices (appropriate clothing, shoes, bushwalking safety advice)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consideration of other people and the environment (following conservation guidelines)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual initiative and focus during investigation</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadership demonstrated throughout investigation</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Peer Review

Briefly review the effectiveness with which you worked with others in making your observations. I effectively worked with others in the following ways:
- I shared equipment with my classmates e.g. hand lens, geology pick and dilute HCl acid.
- I took turns to look at, draw and take photos of fossils and important rocks.
- I helped my classmates to read maps.

Self-Reflection

Describe how you implemented safe and ethical investigation procedures.
Explain why it was important to do so. I implemented safe investigation procedures by:
- Staying on the paths, where possible, so that I didn't trip and hurt myself.
- Being careful when using the geology pick so I didn't hit myself or another person.
- Being cautious when using dilute HCl so that I didn't get any on myself or another person.
I implemented ethical investigation procedures by:
- Putting rock specimens back where I found them after I looked at them so that other organisms using them wouldn't be disturbed too much.
- Not removing rock or fossil specimens from the National Park are of the Flinders Rangers to preserve the specimens that are there for future people to see and investigate.
- Trying, as much as possible, to walk on the paths and not of the grasses or other vegetation, to try and keep the area as protected from disruption as much as possible.
- Not littering so that the area was free from visual pollution and kept the way I found it.
**Additional Comments**
This response is illustrative of a B grade.

**Investigation**
Greater depth in the discussion of bias, credibility and accuracy would provide evidence of critical and logical selection of information.

**Application**
Block diagrams should include a key and appropriate symbols.

**Knowledge and Understanding**
Use of a broader range of formats (e.g. maps and sketches of rock types an fossils in addition to text, diagrams and photographs) would provide evidence of highly effective communication of Knowledge and Understanding.
## Performance Standards for Stage 2 Geology – Field Investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Analysis and Evaluation</th>
<th>Application</th>
<th>Knowledge and Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> Designs logical, coherent, and detailed geological investigations. Critical and logically selects and consistently and appropriately acknowledges information about geology and issues in geology from a range of sources. Manipulates apparatus, equipment, and technological tools carefully and highly effectively to implement well-organised safe and ethical investigation procedures. Obtains, records, and displays findings of investigations using appropriate conventions and formats accurately and highly effectively.</td>
<td>Critically and systematically analyses data and their connections with concepts to formulate logical and perceptive conclusions and make relevant predictions. Critically and logically evaluates procedures and suggests a range of appropriate improvements.</td>
<td>Applies geological concepts and evidence from investigations to suggest solutions to complex problems in new and familiar contexts. Uses appropriate geological terms, conventions, and diagrammatic representations highly effectively. <strong>Consistently demonstrates a deep and broad knowledge and understanding of a range of geological concepts. Uses knowledge of geology perceptively and logically to understand and explain social, economic, or environmental issues. Uses a variety of formats to communicate knowledge and understanding of geology coherently and highly effectively.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>B</strong> Designs well-considered and clear geological investigations. Logically selects and appropriately acknowledges information about geology and issues in geology from different sources. Manipulates apparatus, equipment, and technological tools generally carefully and effectively to implement organised safe and ethical investigation procedures. Obtains, records, and displays findings of investigations using appropriate conventions and formats mostly accurately and effectively.</td>
<td>Clearly and logically analyses data and their connections with concepts to formulate consistent conclusions and make mostly relevant predictions. Logically evaluates procedures and suggests some appropriate improvements.</td>
<td>Applies geological concepts and evidence from investigations to suggest solutions to complex problems in new and familiar contexts. Uses appropriate geological terms, conventions, and diagrammatic representations effectively. Applies mostly constructive and focused individual and collaborative work skills. <strong>Demonstrates some depth and breadth of knowledge and understanding of a range of geological concepts. Uses knowledge of geology logically to understand and explain social, economic, or environmental issues. Uses a variety of formats to communicate knowledge and understanding of geology coherently and effectively.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>C</strong> Designs considered and generally clear geological investigations. Selects with some focus, and mostly appropriately acknowledges, information about geology and issues in geology from different sources. Manipulates apparatus, equipment, and technological tools generally carefully and effectively to implement safe and ethical investigation procedures. Obtains, records, and displays findings of investigations using generally appropriate conventions and formats with some errors but generally accurately and effectively.</td>
<td>Analyses data and their connections with concepts to formulate generally appropriate conclusions and make simple predictions with some relevance. Evaluates some procedures in geology and suggests some improvements that are generally appropriate.</td>
<td>Applies geological concepts and evidence from investigations to suggest some solutions to basic problems in new or familiar contexts. Uses generally appropriate geological terms, conventions, and diagrammatic representations with some general effectiveness. Applies generally constructive individual and collaborative work skills. <strong>Demonstrates knowledge and understanding of a general range of geological concepts. Uses knowledge of geology with some logic to understand and explain one or more social, economic, or environmental issues. Uses different formats to communicate knowledge and understanding of geology with some general effectiveness.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>D</strong> Prepares the outline of one or more geological investigations. Selects and may partly acknowledge one or more sources of information about geology or an issue in geology. Uses apparatus, equipment, and technological tools with inconsistent care and effectiveness and attempts to implement safe and ethical investigation procedures. Obtains, records, and displays findings of investigations using conventions and formats inconsistently, with occasional accuracy and effectiveness.</td>
<td>Describes basic connections between some data and concepts and attempts to formulate a conclusion and make a simple prediction that may be relevant. For some procedures, identifies improvements that may be made.</td>
<td>Applies some evidence to describe some basic problems and identify one or more simple solutions, in familiar contexts. Attempts to use some geological terms, conventions, and diagrammatic representations that may be appropriate. Attempts individual work inconsistently, and contributes superficially to aspects of collaborative work. <strong>Demonstrates some basic knowledge and partial understanding of geological concepts. Identifies and explains some geological information that is relevant to one or more social, economic, or environmental issues. Communicates basic information to others using one or more formats.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>E</strong> Identifies a simple procedure for a geological investigation. Identifies a source of information about geology or an issue in geology. Attempts to use apparatus, equipment, and technological tools with limited effectiveness or attention to safe or ethical investigation procedures. Attempts to record and display some descriptive information about an investigation, with limited accuracy or effectiveness.</td>
<td>Attempts to connect data with concepts, formulate a conclusion and make a prediction. Acknowledges the need for improvements in one or more procedures.</td>
<td>Identifies a basic problem and attempts to identify a solution in a familiar context. Uses some geological terms or diagrammatic representations. Shows emerging skills in individual and collaborative work. <strong>Demonstrates some limited recognition and awareness of geological concepts. Shows an emerging understanding that some geological information is relevant to social, economic, or environmental issues. Attempts to communicate information about geology.</strong></td>
<td></td>
</tr>
</tbody>
</table>