

A violent end to Gondwana

The peace and tranquillity of Gondwana was disrupted 183 million years ago by intense volcanic activity, signaling an end to this supercontinent. For almost a million years a line of active volcanoes stretched across what is now Africa, through East Antarctica along the length of the Transantarctic Mountains, and on into Tasmania and New Zealand, a distance of over 4000 km.

Nearly all the volcanic rock from this massive event has eroded away, however just below the surface of Antarctica lies a telltale network of solid, vertical sheets of dykes and horizontal layers (sills). Known as the *Ferrar Dolerite's*, these features are sometimes exposed to the light of day, the dark coloured sills being particularly striking they stretch hundreds of kilometres along the steep faces of the Transantarctic Mountains.

The enormous and continuous flows that produced such sills are only possible if the lava is both super hot and plentiful. However whether the flows were the cause of the breakup of Gondwana, or caused by it, remains a mystery. Regardless of which, this prolonged volcanic event resulted in major changes in the Earth's atmosphere, climate and species.

Mount Erebus

Despite Antarctica's violent past, there are only three places where there is currently volcanic activity. The most active of these is Mount Erebus (3794 m) on Ross Island, in McMurdo Sound..



Erebus is the world's southernmost active volcano, due to rifting of the nearby crust. Its last major eruption was in 1984-85, although it has been continuously active since 1972. Erebus is one of only five volcanoes worldwide to have a permanent lake of molten magma in its summit crater and from which small fountains of lava are produced almost daily, along with an almost constant plume of water vapour and poisonous gases.

This continuous but low-level of activity (like Stromboli in Italy) means Mt Erebus can be constantly monitored from within a few hundred metres. Also, (like Mt Etna in Italy) the lower half of the volcano is a low flat shield, produced by runny basalt lavas while the top half is a steep cone (stratocone) created by a more sticky lava and volcanic debris. This unique change of shape from shield to cone can be seen in most long range photographs of Erebus.

Despite the presence of large mountain ranges, Antarctica is now relatively free of earthquakes created by rock movement. However many tremors are generated by movement within flowing ice, with only a few caused by volcanic activity.



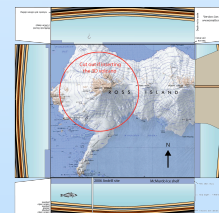
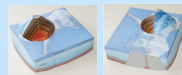
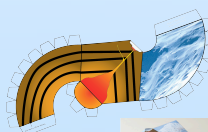
In the cliff above, each of the two dark, snow-free bands of rock is a 'sill', formed when magma flowed between layers of sedimentary rock. The thickness and extent of such sills (across Antarctica, Tasmania and southern Africa) shows how intense the volcanic activity must have been, when the Gondwana supercontinent broke apart. Image: Bryan Storey

Practical Task: Build a model of Mt Erebus

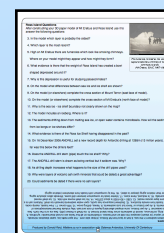
Introduction

Mount Erebus has several unique features, including a history of Antarctica's past, recorded in the sea sediments that surround it.

What to do



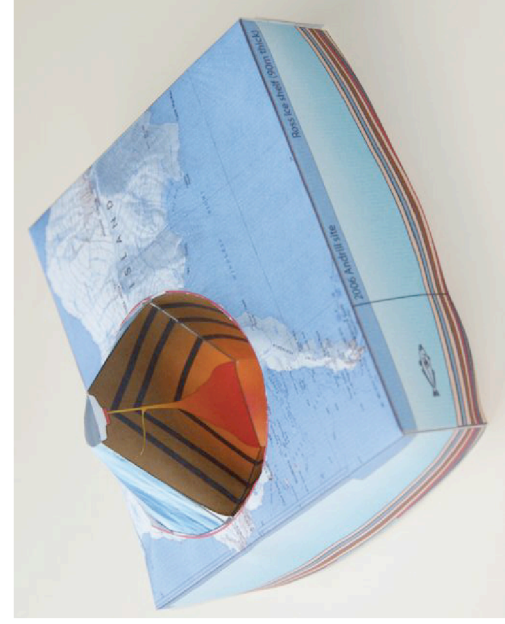
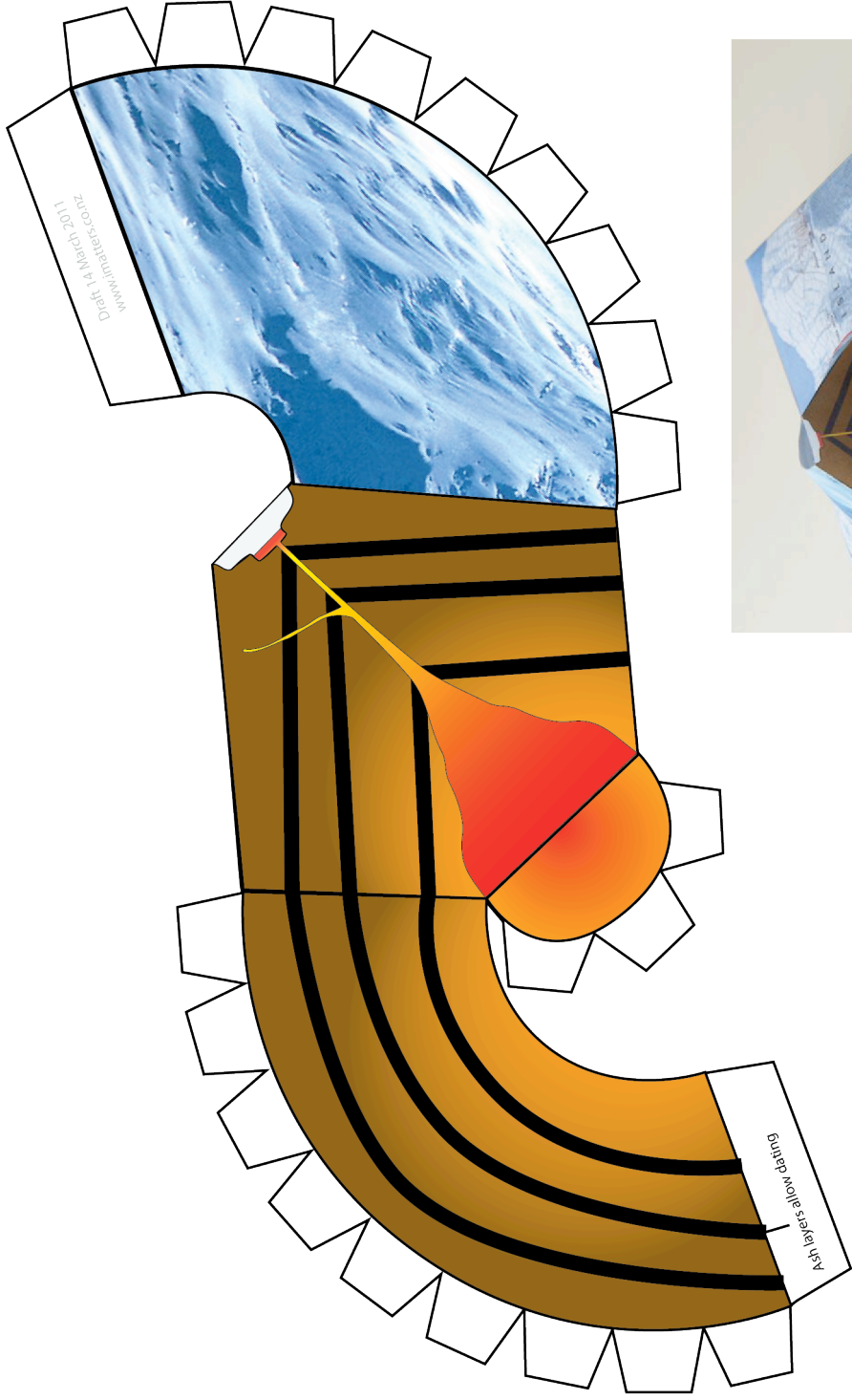
1. Assemble the 3D model of Mt Erebus using scissors and paper glue.
2. Use your model to answer the questions about Antarctica's past.



Relevance

- The Ross Sea (which includes McMurdo Sound and Ross Island) holds a unique set of clues about Antarctica's previous past.
- Understanding previous climate changes allows us to better predict future climate change and its effects

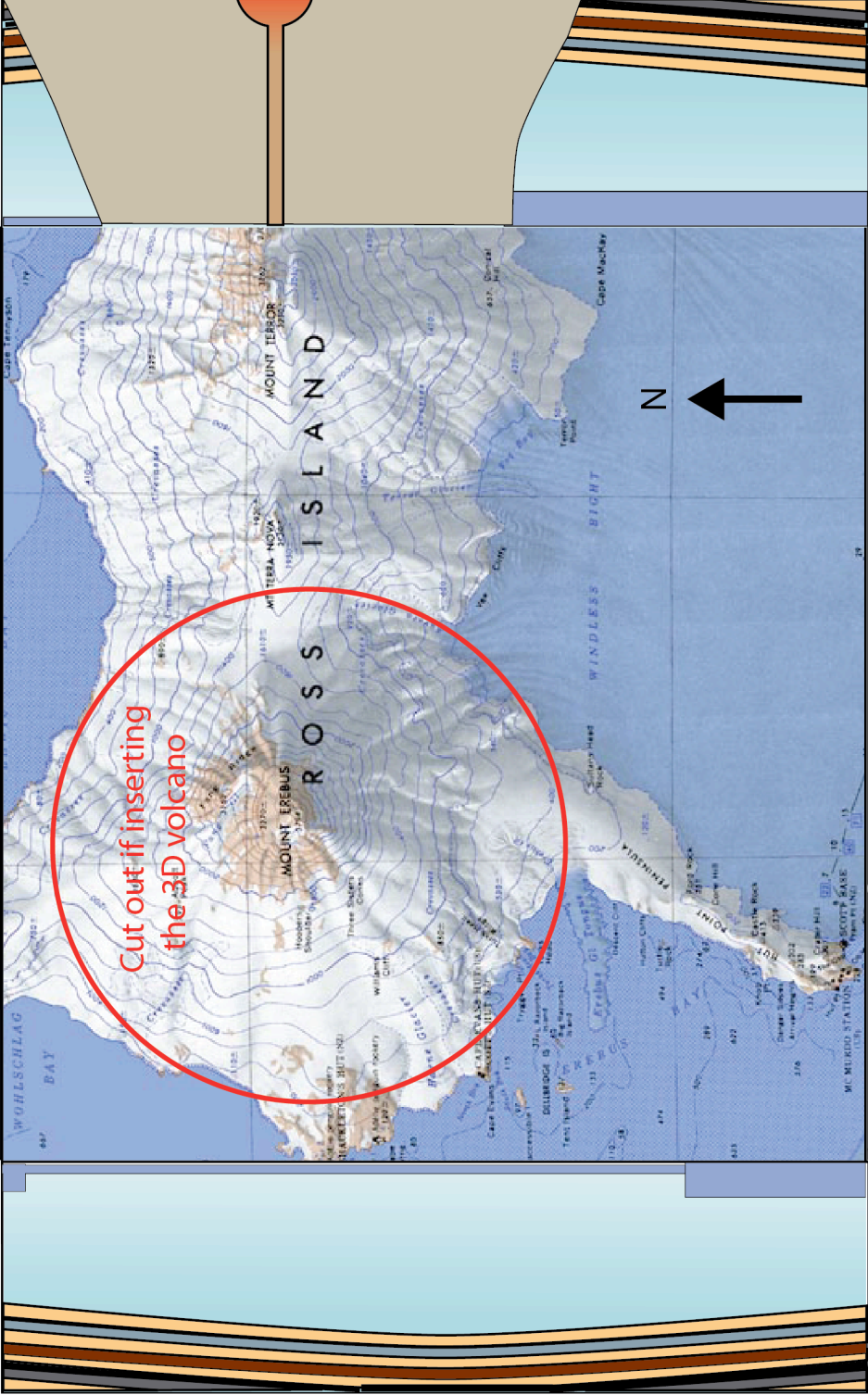
Adapted from material by *Bryan Storey, University of Canterbury* by *Donald Reid, iMatters.co.nz* in association with *Gateway Antarctica, University of Canterbury*.
Curricula: Science L4 - 8, Social Studies L3 - 4, Geography L6 - 8.



Depth not to scale

Sea ice
(3m thick)

volcanic ash allows dating
McMurdo Sound
(deep 1000m)



Cut out if inserting
the 3D volcano

RIS, 90m thick

Sea depth = 1000m

volcanic ash allows dating

McMurdo Ice shelf

2006 Andrill site



iceshelf
open ocean
glacier
iceshelf
open ocean
iceshelf

Ross island Questions

After constructing your 3D paper model of Mt Erebus and Ross Island use it to answer the following questions



*This fumarole, formed as hot volcanic vapours become a chimney of ice, still continues to grow.
(Mt Erebus. B.A.E. 1907- 09)*

1. In the model which layer is probably the oldest?
2. Which layer is the most recent?
3. High on Mt Erebus there are fumaroles which look like smoking chimneys.
Where on your model might they appear and how might they form?
4. What evidence is there that the weight of Ross Island has created a bowl shaped depression around it?
5. Why is this depression useful for studying palaeoclimates?
6. On the model what differences between sea ice and ice shelf are shown?
7. On the model (or elsewhere) complete the cross section of Mount Terror (east face of model).
8. On the model (or elsewhere) complete the cross section of Mt Erebus's (north face of model)?
9. Why is the sea ice - ice shelf boundary not clearly shown on the map?
10. The model includes an iceberg. Where is it?
11. The sediments drifting down from melting sea ice, or open water contains microfossils. How will the sediments from ice bergs or ice shelves differ?
12. What evidence is there of the Ross Ice Shelf having disappeared in the past?
13. On 16 December 2006 ANDRILL set a new record depth for Antarctic drilling at 1285m (13 million years). How far was this below the drillers feet?
14. Does the ANDRILL drill stem (pipe) touch the ice shelf? Why?
15. The ANDRILL drill stem is drawn as being vertical but it seldom was. Why?
16. As drilling depth increases what happens to the size of the drill pipes used?
17. Why were layers of volcanic ash (with minerals that could be dated) a great advantage?
18. Could sediments be dated if there were no ash layers?

Answers
1. Bottom sediment in the sea. 2. Ash or lava from Mt Erebus. 3. Near side vent. Hot spot melts ice, water dissolves minerals, water vapour (or steam) escapes into cold air and freezes. 4. Sediments on all four faces are curved downwards / synclines. 5. Has long, continuous, record of sediments since Ross Island formed. 6. Ice Shelf is thicker (x30). Sea ice is to the north. Sea ice is seasonal. 7. As per Erebus, cone shaped alternating layers of rock and ash. May include thermal metamorphosis of sediments. 8. As per Erebus or Terror but cuts sediments. 9. Varies, drifting snow. 10. NW corner. 11. Few fossils, mainly rocks. Any fossils from remote locations. 12. Sediment sequence has cyclic, open water sediments beneath ice shelf. Volcanic ash is a uniform layer across model. 13. 1285 + 90+1000 is about 2370m. 14. No ice shelf moves with tide. 15. Ice shelf moved horizontally. 16. Is reduced, three sizes. 17. Marker beds for comparison between drill cores. Minerals allow absolute aging, rather than relative aging (deeper is older). 18. Yes by comparison with fossils from elsewhere (relative aging)