Hastings Cave and Thermal Springs

Teachers Fact Sheet No 2
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Geology

What is limestone?

Limestone is formed from the deposition of hard mineral remains of sea creatures or chemically precipitated calcareous mud and is mainly calcium carbonate (calcite), $CaCO_3$. It usually contains fossils and sand grains. The 'shelly' remains, including coral, get buried and are compressed and cemented together by the weight of water and other sediments. Limestone tends to form beneath warm shallow seas rich in plant and animal life. Chalk is similar, being formed from the mineral remains of tiny marine organisms in the sea. It is, chemically, relatively pure calcium carbonate and it contains microscopic fossils readily seen under a microscope.

What is dolomite?

The mineral dolomite differs from calcite, $CaCO_3$, in the addition of magnesium ions to make calcium magnesium carbonate, $CaMg(CO_3)_2$. The formation of dolomite is not clearly understood but it seems to occur where there are magnesium-rich groundwaters that have a significant amount of salinity and a warm, tropical ocean environment.

Dolomite rock is composed predominantly of the mineral dolomite. Limestone that is partially replaced by dolomite is referred to as dolomitic limestone.

Newdegate Cave in geological time

The cave we see today is extremely ancient, but the rocks it is formed in are even older, dating back to the Pre-Cambrian times, over 600 million years ago (mya).

Summary

650 mya 306 mya 160 mya 33 mya 2 mya 13mya

Approximate periods of change

650 mya. Newdegate dolomite forming 20–30° north of the equator. Gordon limestone forms when Tasmania travels south of the equator.

306 mya. Newdegate dolomite 80° south. Part of the ancient super-continent of Pangaea. Newdegate Cave begins to develop as a cavity during this period.

160 mya. The smaller continent, Gondwana, starts to break up. Mountain-building period in Tasmania. Glaciers present in Tasmania during some of this period, but predominantly warmer weather.

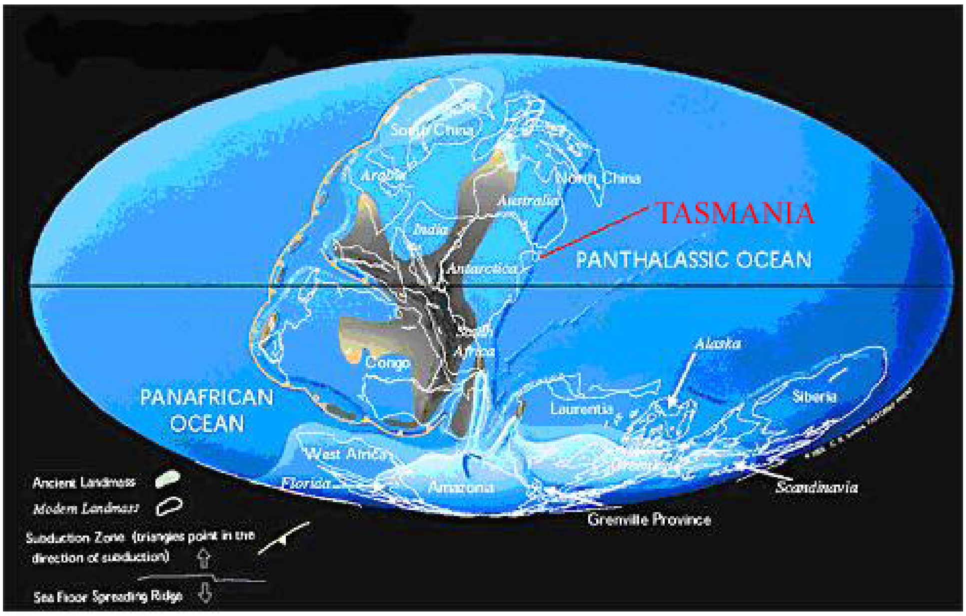
33 mya. Tasmania separates from Antarctica. This separation is believed to have formed the Antarctic Circumpolar Current, which led to late-Cenozoic Icehouse climates.

0.2mya. Major glacial periods, with the last finishing around 12,000 years ago. Playing a major part in the development of Newdegate Cave.

0.13mya Time of rapid speleothem (stalactites and stalagmite) formation in Newdegate Cave. Climate rapidly warming around 12000 years ago or earlier, after another glacial period; sea levels rising again.

Precambrian period

During the late Precambrian period, around 600mya, in a shallow tropical sea approximately 10° north of the equator, natural carbonates precipitated from the sea, forming lime-rich sediments on the sea floor. These sediments and a later infusion of magnesium-enriched waters were to become the major ingredient in the formation of the Hastings dolomite.



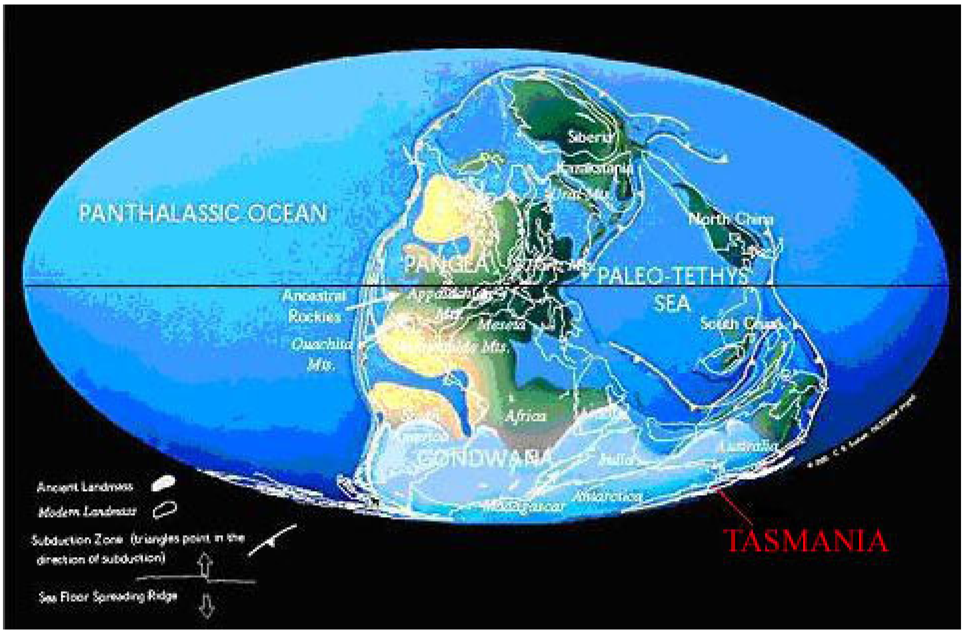
Around 600 to 650 million years ago

Life during the late-Precambrian period is characterised especially by the appearance of single-celled organisms. In the desert of Western Australia and in Canada, **stromatolites** (layered mounds built by blue-green algae) have been discovered, dating to around 3,500 million years ago.

As Precambrian life forms only have soft bodies, fossils have not been found in the Hastings dolomite, although fossilised stromatolites have been discovered in similar-aged dolomite in Tasmania.

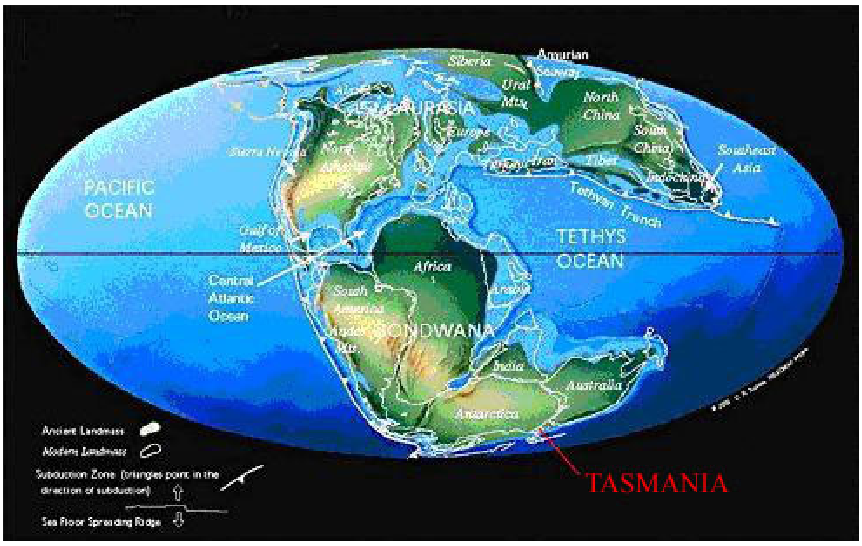
Permian period

Due to the movements of plate tectonics, the Hastings dolomite, now a part of the great landmass of Pangaea, was pushed from north of the equator, where it was during the Precambrian, to around 80° south of equator during the late-Carboniferous and Permian period (300mya). During the early Permian period, a large ice sheet moved from the west to the east over most of southern Pangea. As the melting ice sheet drifted eastward over the top of the Hastings dolomite, unconsolidated sediments ('till') were deposited over the top of the dolomite and lithified (turned into rock under intense pressure) into the hardened cap rock known today as Permian tillite. Marine sediments and terrestrial sandstone later covered these. Due to the resistance of the tillite and other cap rock to erosion, it became a protective mantle over the dolomite during later glacial periods, only allowing erosion by solution.



Around 306 million years ago

Triassic – Jurassic period



Around 154 million years ago

Over the next 150 million years the super-continent Pangaea separated under tectonic (earth-moving) pressures into two large landmasses, Laurasia and Gondwana.

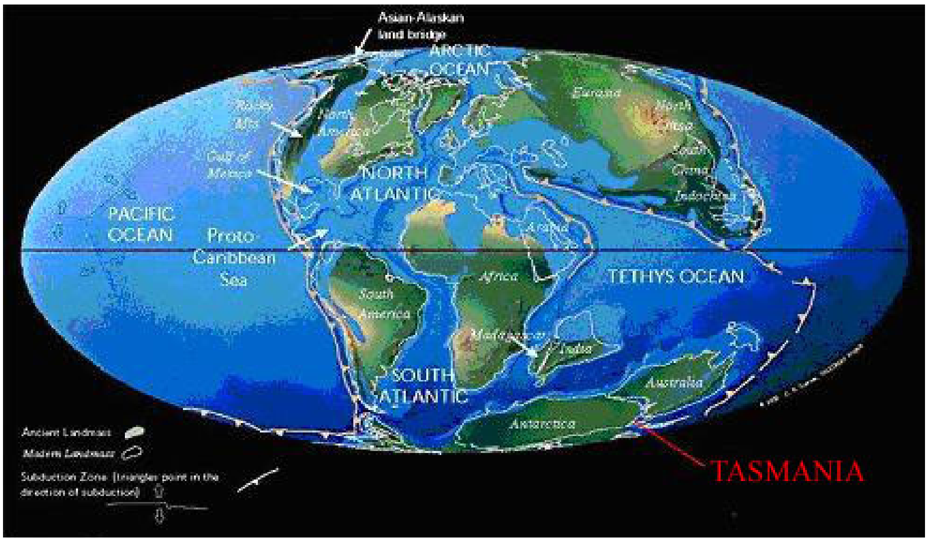
Across southern Gondwana during the early Jurassic period there were large intrusions of dolerite from South Africa across lower Antarctica, ending their eastward flow in Tasmania. Mount Wellington and Adamson's peak, to the west of Hastings, are examples of the many remnant mountain ranges in Tasmania that originated when cap rocks were eroded from this intrusion.

As Gondwana slowly drifted north, continental plates began separating, India first at approximately 125mya. Some 40 million years later what we know now as the great Australian Bight is believed to have started separating from Antarctica, with Tasmania reluctantly following approximately 45mya. This separation from Antarctica caused major uplifting across Tasmania with sediments such as dolomite being raised above sea level.

Another major factor resulting from the separation of Tasmania from Antarctica was a total climate change due to the creation of the Great Oscillating Current mixing waters from the Southern Ocean and the Pacific Ocean and circling the Antarctic continent, creating a wet, warm climate, ideal for cave formation, which rapidly eroded away the newly formed escarpments.

Cretaceous period ~95mya to present

Due to escarpment erosion, dolomite was exposed, allowing carbon dioxide and humic acid enriched water to enter through fault lines. This then followed the bedding plains, which at Hastings slope in a south-eastern direction, slowly dissolving the dolomite and continuing the formation of Hastings Caves.



Around 94 million years ago

From approximately 2 mya to around 15,000 years ago the Hastings area was subjected to fluctuating glaciation. Tasmania is believed to be the only state in Australia where glaciers travelled from the mountains to the ocean. The Lune Valley, with Hastings on the northern escarpment, is one of the glacial valleys formed in this process.

Around 750,000 years ago glaciers were eroding and deepening valleys to sea level. As the climate slowly warmed the glaciers retreated and moraines and gravels were deposited, filling the valleys. Due to continuing climate warming, sediments became stabilised as new vegetation became established and rivers began cutting into the valley floors. Around 130,000 years ago in the 'Last Interglacial' period, stalagmite growth in the cave was at its fastest, a time of warm climatic conditions and high precipitation on land, possibly similar to today.

Between around 30–15,000 years ago or perhaps earlier, Tasmania entered another glacial period, although not as severe as the previous one. Glaciation still took place on the higher slopes of Adamsons Peak, and later outwashes filled the valleys that had been eroded away during the previous interglacial period, the caves filling up with gravels.

Over the past 10,000 years rivers and streams have been gradually eroding away glacial sediments both inside and outside the caves and all Australian glaciers have melted.

Evidence of the rising and falling of the water table can be observed where gravels and remnant sections of floating floor still remain attached to the cave walls and ceilings.

Alpine herb fields may have surrounded the Hastings area around 20,000 years ago. Small glaciers formed in the upper reaches of the valleys and the average temperature was around 8–9°C. The sea level was approximatley120m lower than at present but, at around 12,000 years ago, with the climate warming, the polar icecaps were slowly melting. The sea levels began rising, flooding the Bass Basin savannah and creating Bass Strait, separating the mainland of Australia from Tasmania again.

Hastings Thermal Springs

The temperature of thermal springs may be due to three different causes: underground water (either meteoric or juvenile) coming in contact with hot underground intrusive rock of recent origin; volcanic activity, where the water is hot rather than warm; or simply the geothermal gradient of water coming from great depths, which is the most likely cause of heating at Hastings.

This geothermal gradient is the rate at which the Earth's temperature increases with depth, indicating heat flowing from the Earth's warm interior to its cooler surface. Away from tectonic plate boundaries, it is 25–30°C per kilometre of depth.

It is considered that the heating of water at the Hastings thermal area is due to the depth from which the water comes. The water probably enters the dolomite in the caves area at a higher elevation than the springs area, descends to 1000m in a continuous stream in the synclinal dolomite beds, passes beneath the quartzite beds and has sufficient hydraulic gradient to be forced up to the surface. It is contained in dolomite beds, ascends the major fault zone and then seeps through the alluvial cover.

The springs occur in several spots coinciding with an intersection between major faults and bedrock fractures over an area of about 25 hectares in the vicinity of the pool. The temperature of the water is 30°C and remains remarkably constant from day to day.

For further information on the geological periods and the Geological Column see:

http://en.wikipedia.org/wiki/Geologic_time_scale

http://earthsci.org/education/teacher/basicgeol/geotim/geotim.html#TheGeologicColumn

http://www.ucmp.berkeley.edu/help/timeform.html

http://www.ucmp.berkeley.edu/geology/tectonics.html

PALEOMAP Project (http://www.scotese.com)

Acknowledgement: Christopher R Scotese, PALEOMAP Project

http://www.scotese.com/late1.htm