



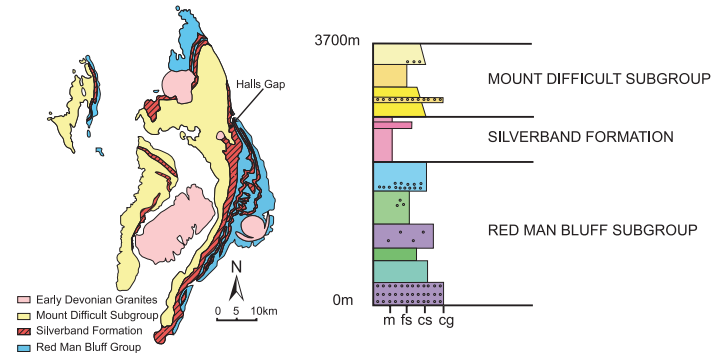
The Grampians (Gariwerd) Ranges, western Victoria—a story in stone.

Introduction

The **Grampians (Gariwerd) Ranges** rise majestically above the plains of western Victoria, forming jagged mountain chains up to 1100m above sea level. However, this has not always been the case. Aboriginal legend tells us that the Great Ancestor Spirit, Bunjil, created Gariwerd long ago. More recently, geologists have developed their own story for the formation of this region. Millions of years ago the region was not a mountain range, but was instead the ancient eastern shoreline of Australia. Massive forces, related to continental drift, uplifted, faulted and folded the sediment accumulated along this shoreline, and turned sand into stone. This pamphlet outlines a brief history of the original environment in which the Grampians sediment accumulated, and how and why those sediments were pushed up into a magnificent mountain range.

The sediments accumulate

Approximately 430 million years ago the coastline of Victoria ran north–south through the Grampians region (see **environmental diagram** opposite). To the west of the Grampians the ancient Australian continent was quite mountainous (see **1, environmental diagram**). To the east, the region that is now the rest of Victoria was a deep ocean. Over quite a few million years several thousand metres of sand and mud were laid down along this shoreline as a layer cake of flat lying sheets that eventually became converted into the rocks we now call the **Grampians Group**.



Map (left) and diagrammatic vertical column (known as a stratigraphic column; right) representing different sedimentary rocks of the **Grampians Group** in the order they were deposited. Column width refers to the grain-size of the sediment—mud, fine sand, coarse sand, gravel.

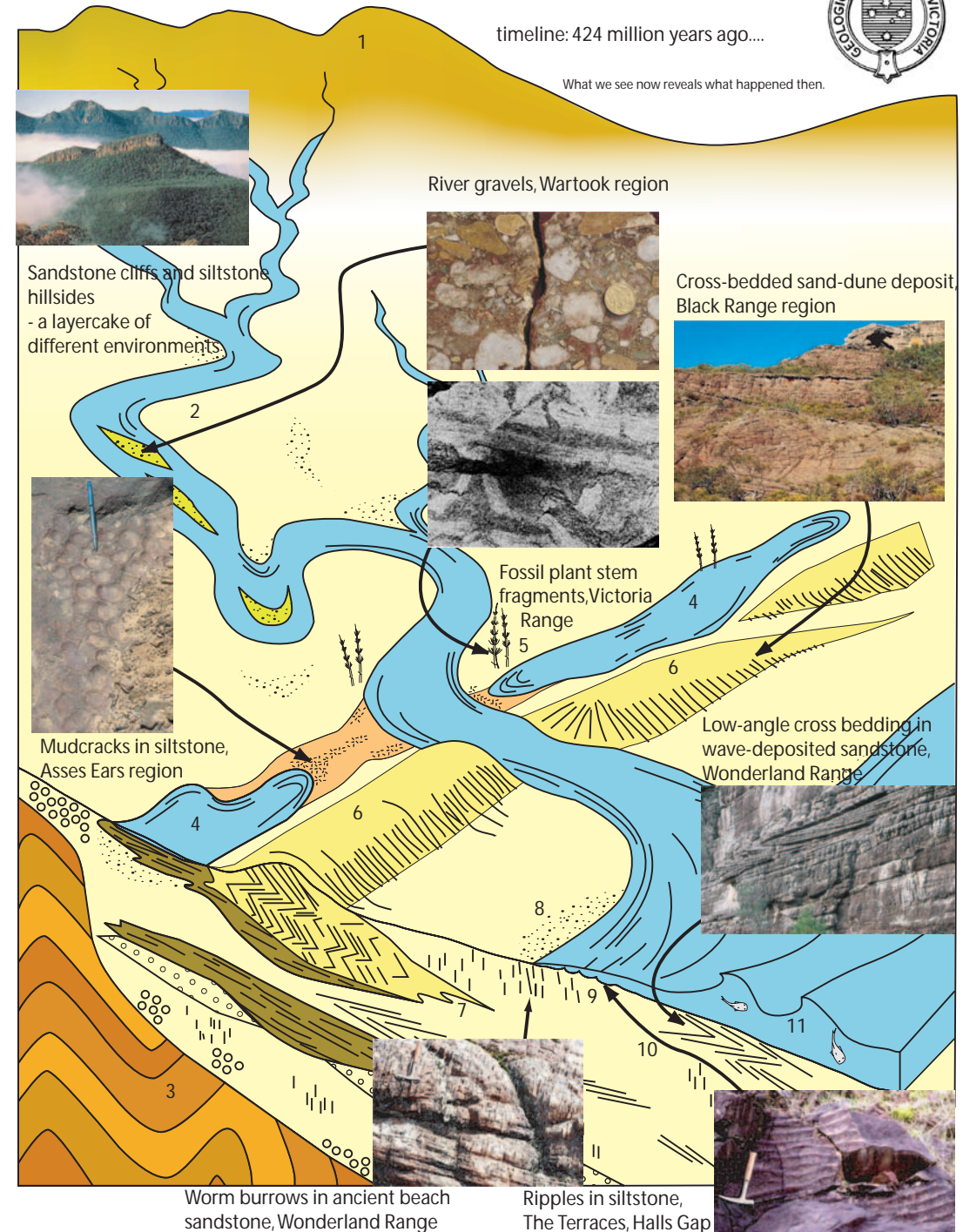
At that time the climate was probably quite wet, and land plants were small, sparse and primitive, so erosion of the ancient Australian mountains was high. Large rivers drained away from these mountains (**2**) leading to the ocean. These rivers carried sediment—sand and gravel eroded from the mountains—and some of this was deposited along extensive river flats as the Grampians Group, burying the older, folded bedrock beneath (**3**).

Not all the Grampians Group was deposited by rivers. As the rivers neared the sea, they sometimes turned into tidal inlets, or overflowed into large brackish lagoons (**4**), where great thicknesses of fine red mud and silt accumulated—the Silverband Formation. Sometimes these lagoons dried up, and mud-cracks developed. There were also small primitive plants (**5**). In places the lagoons were separated from the ocean by wind-blown sand dunes (**6**). Grampians rocks deposited in such sand dunes still display the distinctive large-scale high-angle cross-beds visible in modern day sand dunes (**7**). Indeed, this whole system of ancient environments would have been very similar to some modern day coastlines—for example, the present-day Gippland Lakes coastline around Lakes Entrance. Here rivers drain off the Australian Alps, pass through wide river flats as they approach the coast, and enter a series of lagoons and barrier sand dunes before reaching the open ocean.

Along the old Grampians coastline much sediment was also deposited on the shore face (**8**). These marine rocks often have distinctive fossil vertical worm burrows (called *Skolithos*; **9**), ripples caused by waves in very shallow water, and low-angle cross bedding caused by bigger surf wave-generated ripples (**10**). Further evidence of marine deposition of Grampians Group sediments comes from small fragments of primitive jawless fish (**11**), small shelly organisms called brachiopods, and curious elongate blobs which may have been algal mats. Geologists have used these fossils to estimate the age of this part of the Grampians Group (Silurian, or about 420 million years old).

In the high-energy shore face environment of crashing waves and tidal channels the grains of sediment

Diagrammatic cartoon, looking approximately northwest



The Grampians Ranges Western Victoria:

timeline: 424 million years ago...

What we see now reveals what happened then.



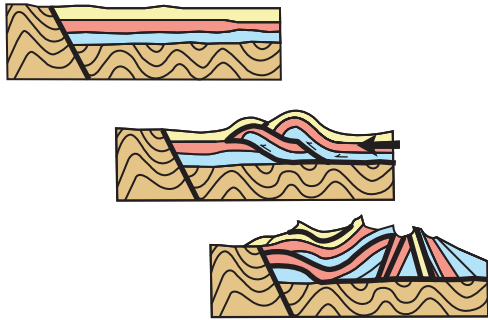
Worm burrows in ancient beach sandstone, Wonderland Range

Ripples in siltstone, The Terraces, Halls Gap

were jostled and constantly reworked. This action winnowed out the weaker minerals and the mud to leave a deposit of tough, resistant quartz grains. The hard durable rocks that were formed from this material (called quartz-arenite) cap many of the rugged peaks and are the backbone of the Grampians Ranges. Their uplift testifies to the massive geological forces that can turn ancient beaches into mountain tops.

Turning sand into stone

Once a few kilometres of Grampians Group sediment had accumulated the sheer weight of the overlying material caused an increase in pressure and temperature. This squeezed much of the water out of the sediments and altered the mineral grains into an interlocking network that turned the sediment into stone.



Shortly after the Grampians Group had been deposited, huge compressive forces began to be exerted on the rocks. These forces resulted from plate motions and continental drift and can be seen today forming mountain ranges such as the Himalayas. The ocean to the east of the Grampians Group began to close, and the sediments beneath the ocean were buckled into folds and uplifted and converted into a new part of the Australian continent—an important part that includes the goldfields of central Victoria and the Alps of eastern Australia. Suddenly, the Grampians Group rocks weren't on the edge of an ocean any more, they were right in the middle of a newly emerging continent!

Making the Grampians Ranges

The compressive forces squashed the Grampians Group into a thickened pile by folding and faulting, a process called deformation. In the Grampians some of the stronger sandstone beds responded to the deformation by sliding and stacking up over layers of weaker mudstone along faults. Thus the Grampians Group sequence became even thicker than it was originally.



Fault-rock exposed in Cool Chamber, Wonderland Range

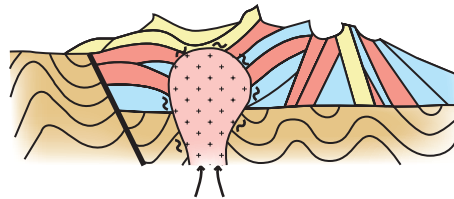
Eventually, about 410 million years ago, the



*Up-ended bedding in **The Terraces**, viewed from Boronia Peak, just east of Halls Gap. These steeply dipping beds are separated by a steep fault from more the gently-dipping beds of the **Mount Difficult Range** in the background. This particular fault lies buried beneath the town of Halls Gap, but many others are well exposed.*

whole sequence became faulted and folded into its present configuration. During the deformation some beds were upthrown onto their edge, as seen in **The Terraces** and at **Golton Gorge**. Other beds dip more shallowly such as the **Elephants Hide** near Halls Gap, whilst some were folded into domes and basins, such as the horseshoe-shaped **Mount Difficult Range**. Large faults developed, in places separating the Grampians Group from the older bedrock beneath.

Shortly after the deformation the Grampians Ranges were intruded by hot molten rock (magma) which cooled and crystallised to form the granite and dyke rocks in the **Victoria Valley** and at **Mafeking** and **Wartook**. Careful measurement of the products of radioactive decay of certain elements in these granites tells geologists that they were intruded around 400 million years ago. These very different rocks are less resistant to erosion, and now form less rugged areas. There is a small amount of gold in the granite, and this was liberated by erosion to form small goldfields that were briefly mined in the 1900s.



Slowly, over millions of years, most of the large mountains of eastern Australia have eroded away. The Grampians Ranges, with a tough skeleton of sandstone layers protecting weaker mudstone layers, have been more resistant, and have remained to form the backbone of the magnificent **Grampians National Park** we enjoy today.

For further information contact the Geological Survey of Victoria, Department of Natural Resources and Environment.

Prepared by R.A. Cayley, D.H. Taylor, P.J. O'Shea, and K. Sherry.

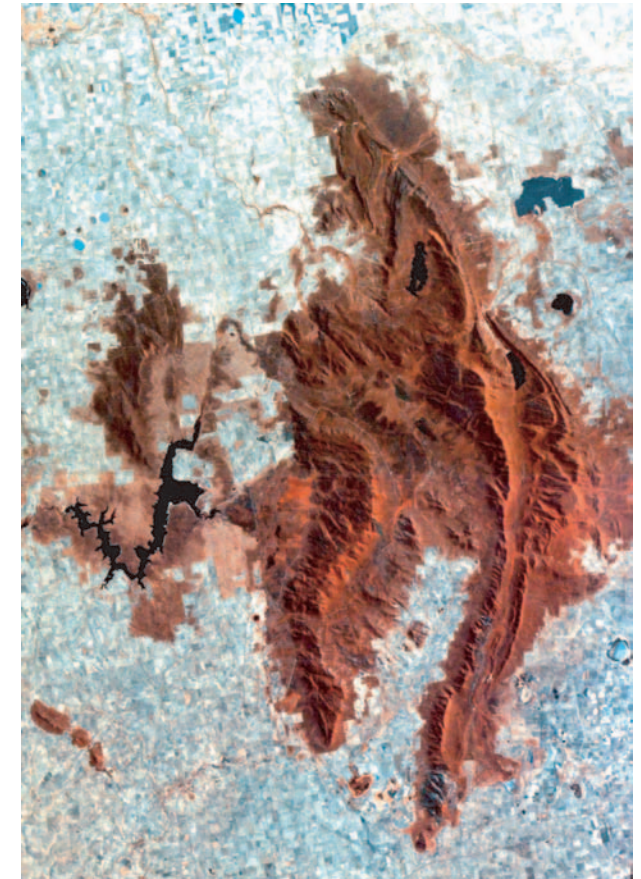
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Satellite image of the Grampians Ranges (Landsat), with pseudocolour Infra-red spectral range. The image shows the shape of the ranges, including the Black Range and Dundas Range. The image also shows large structures such as the open fold at Wartook, and granite intrusions such as the circular granite at Mafeking.

Image: Australian Centre for Remote Sensing, Canberra



Department of Natural Resources and Environment

