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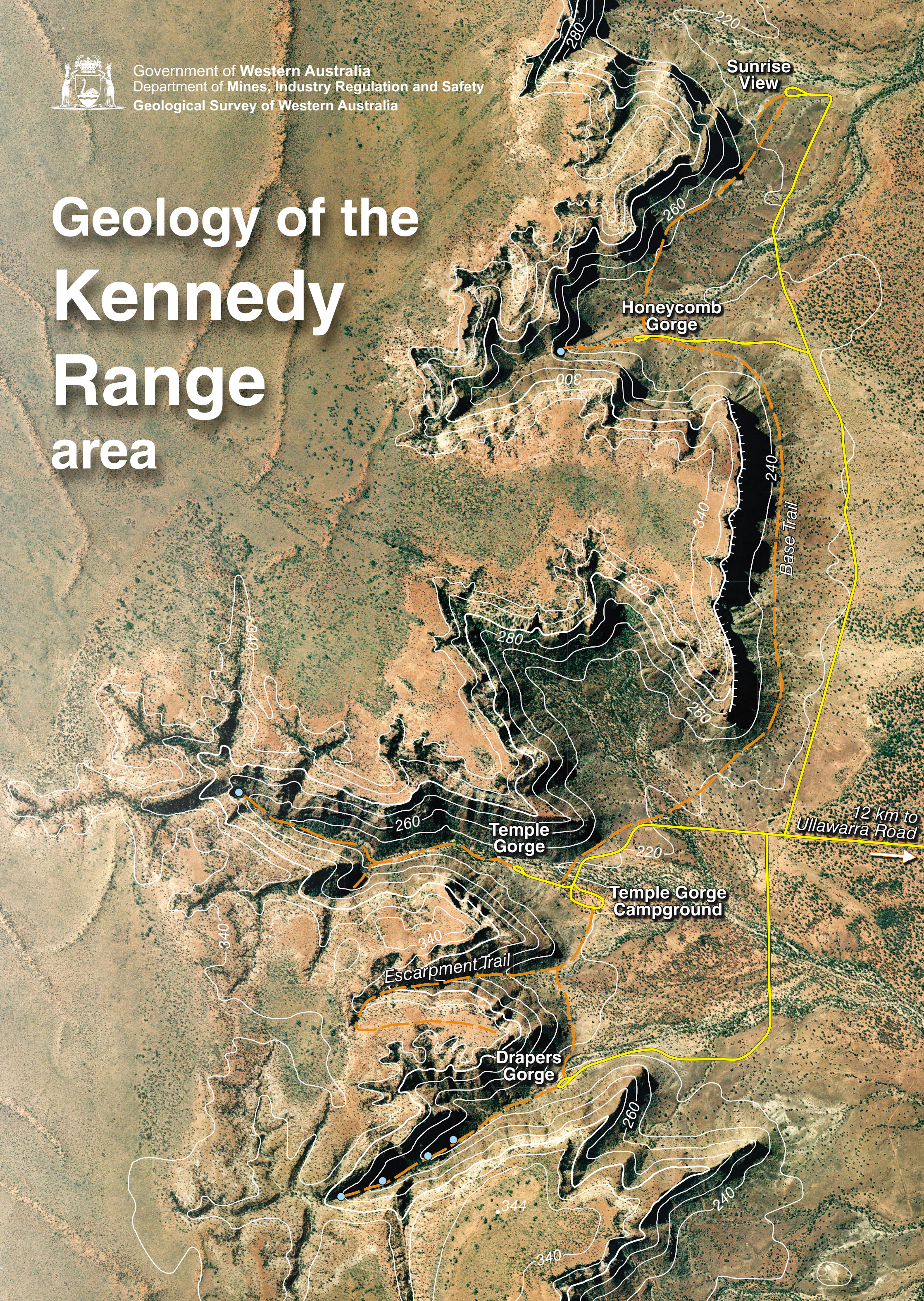
Geological Survey of Western Australia

Geology of the Kennedy Range area



MINISTER FOR MINES AND PETROLEUM
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DIRECTOR GENERAL, DEPARTMENT OF MINES, INDUSTRY REGULATION AND SAFETY
David Smith

EXECUTIVE DIRECTOR, GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Rick Rogerson

REFERENCE
The recommended reference for this publication is:
Mory, AJ and Hocking, RM 2017, Geology of the Kennedy Range area: Geological Survey of Western Australia, 12p.

National Library of Australia Card Number and ISBN 978-1-74168-778-1

Published 2017 by Geological Survey of Western Australia
This product is published in digital format (PDF) and is available online at <www.dmp.wa.gov.au/GSWApublications>.

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Cover image: Vertical aerial view of Kennedy Range with topographic contours in metres above sea level

Geology of the Kennedy Range area

Kennedy Range landscape today

Although Kennedy Range National Park is extensive, only a small portion along the eastern margin is readily accessible to visitors in 2WD vehicles. In the tourist area, the spectacular escarpment soars to 100 m and is dissected by gorges with walking trails to rocky pools, seasonal waterfalls and intricate textures at Honeycomb Gorge. Wind and water have sculpted the rocks into remarkable shapes, and the rocky walking trails are strewn with boulders that have broken away from the sandstone cliffs. It is a rugged and remote place.

Introduction to the rocks

Kennedy Range, about 150 km inland from Carnarvon, extends north of the Gascoyne River for nearly 100 km and is 20–30 km from east to west (Fig. 1). The eastern scarp of the range is up to 100 m high with numerous short gorges, whereas the western margin has been more dissected with creeks extending some 15 km into the range.

The range and its environs are composed of sedimentary rocks about 275 to 265 million years old (middle Permian; see time scale on Fig. 2). Successive layers of sand, silt, and mud were deposited in a narrow, north-opening seaway that extended along the western edge of ancient west Australia, perhaps as far south as the present position of Perth. Marine fossils within these layers confirm this area was once under the sea. The layers began to solidify into rock (or lithify, from 'lithos', the Greek word for 'stone') shortly after they were deposited when additional sediment settled on top and compressed the deeper layers — a process that continued for several million years. Other changes such as fluids seeping through these rocks, faulting, uplift, and erosion of the region, continued for many more millions of years afterwards. The last phase of erosion that created today's plateau began less than 25 million years ago.

Kennedy Range and its rocks are relatively young by comparison with other rocks in the region — those near Mt Narryer, 3730 million years old (inset Fig. 1), are the oldest known in Western Australia.

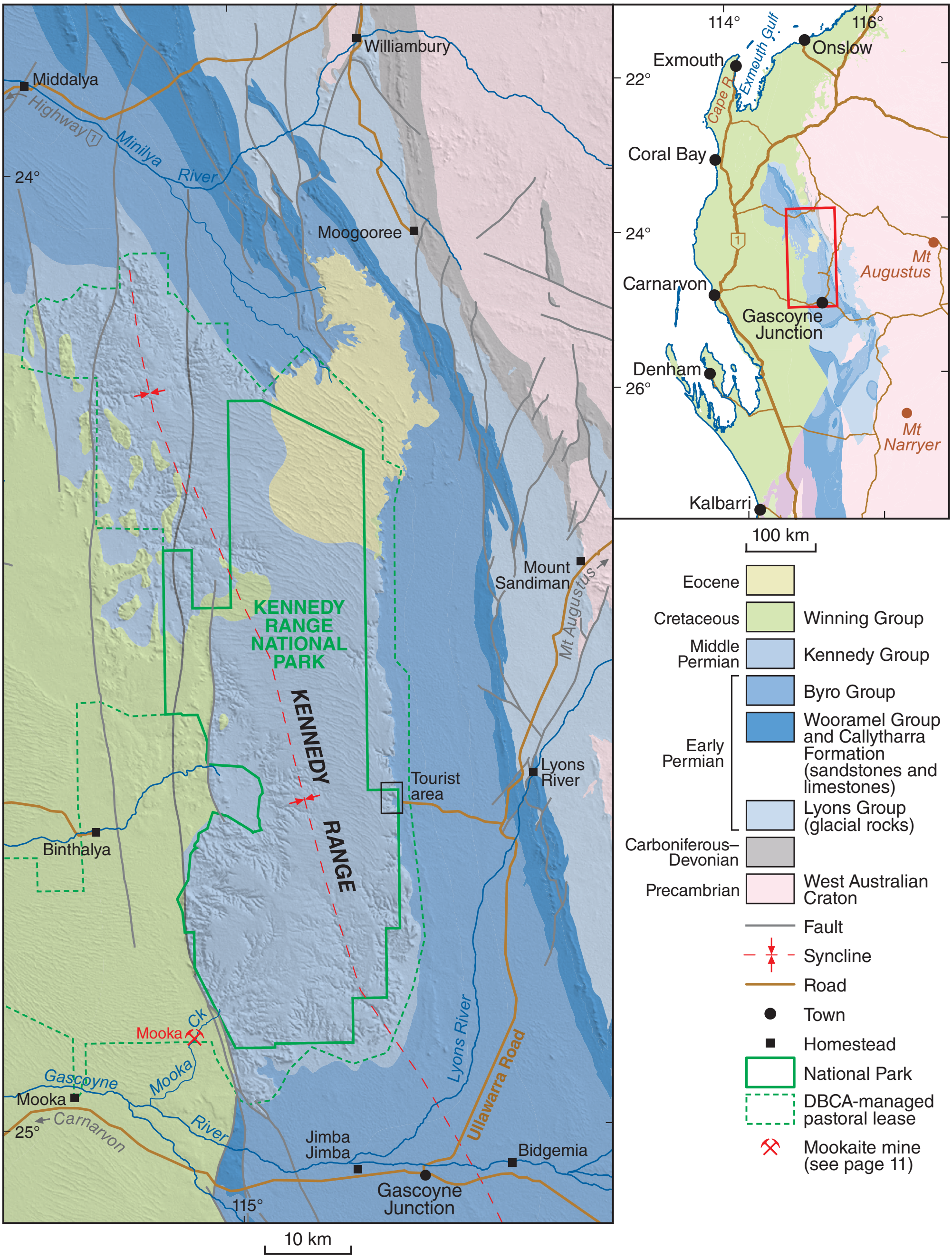

Figure 1. Geological map of Kennedy Range showing national park and pastoral lease boundaries and access roads (DBCA = Department of Biodiversity, Conservation and Attractions)

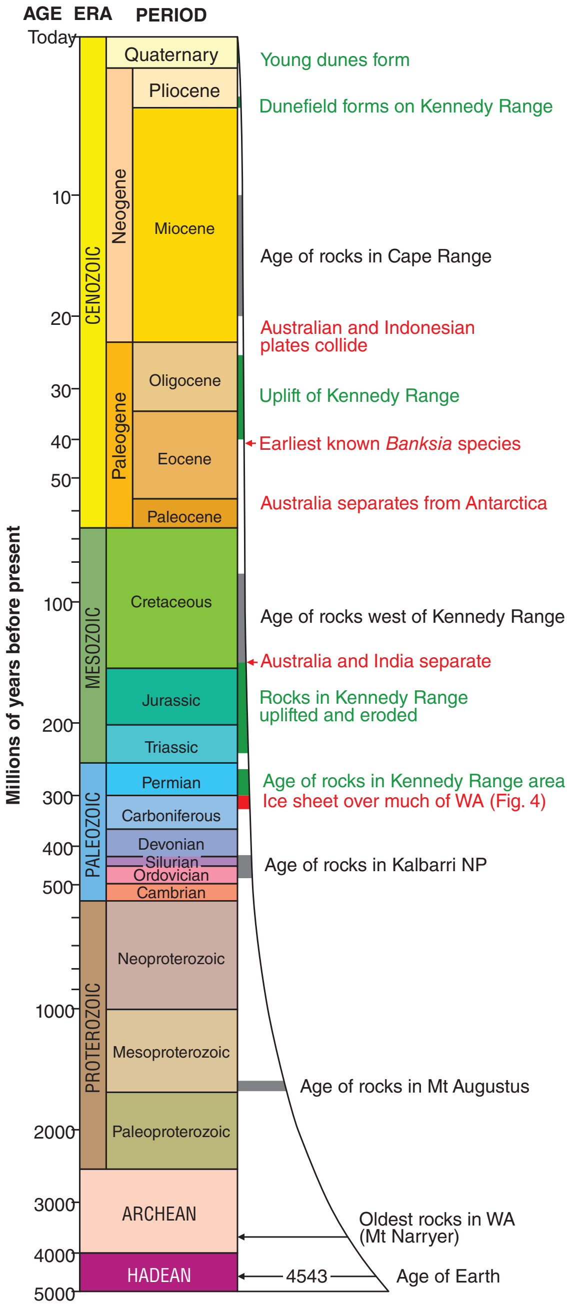

Figure 2. Geological time scale showing the main geological events in the Kennedy Range region

An ice sheet once covered this region

About 300 to 295 million years ago (in the earliest Permian) Australia lay much closer to the South Pole in a sub-polar storm belt, and was part of a larger landmass — the Gondwana supercontinent (Fig. 3). At this time large ice sheets and floating ice shelves covered large parts of Gondwana, including most of Western Australia (Fig. 4a). As this major ice age came to an end, melting of the ice sheet left glacially related deposits up to 3 km thick in several parts of Western Australia (Fig. 4b); in the Kennedy Range area, these are called the Lyons Group.

Figure 3. Reconstruction of the Gondwana supercontinent before 170 million years ago

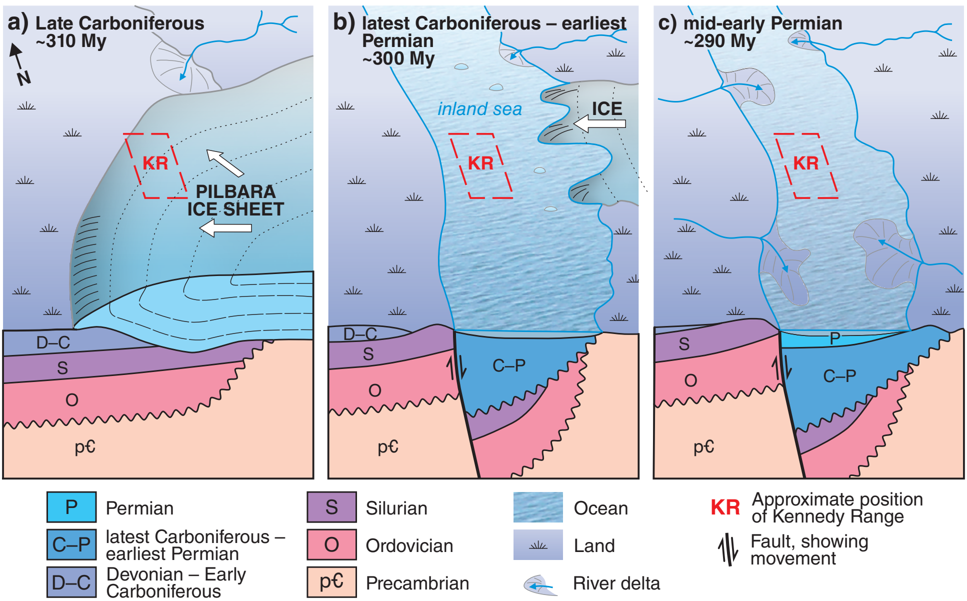

Figure 4. Cartoons of the early development of the region (looking north): a) Late Carboniferous glaciation; b) earliest Permian sediment deposition along an inland sea; c) continued infilling of the seaway in the mid-early Permian. My – millions of years before present

These glacial deposits are visible today as boulders and cobbles east of the range and south of Williambury homestead (Fig. 5). The top of the glacial deposits is marked by a fossil-rich limestone (Callytharra Formation, coloured bright blue on Fig. 1). This grey-brown limestone (Fig. 6) forms low ridges on which the Lyons River homestead is built, and over which the main road passes just south of the homestead. Please admire the fossils but don't remove them.

As the climate continued to warm and ice sheets melted and retreated to the south, rivers flushed sand, mud, and pebbles northwest into the sea. River, coastal, and nearshore deposits accumulated rapidly and built deltas (Fig. 1, the Wooramel Group; Fig. 4c). These deposits are preserved as reddish brown sandstone ridges and flat-topped hills east of the main road from Gascoyne Junction to Lyons River. Later around 295 million years ago, the sea flooded the Kennedy Range area, and sediment deposition switched from river-dominated to marine. At the same time the area steadily subsided.

290–265 million years ago the region was under the sea

The rocks underneath the plain between the range and Ullawarra Road from Gascoyne Junction to Lyons River and in the range itself (called the Byro and Kennedy Groups of early and middle Permian ages respectively, Fig. 1) were all deposited in a shallow inland sea (Fig. 4b,c) comparable to the modern-day Baltic Sea. The sea opened into a broad marine shelf that deepened to the northwest beyond the present-day range. Sand, silt, and mud were brought into the seaway by rivers and longshore drift, and redistributed by waves, sea-floor currents, and storms.

Figure 5. Glacial deposits next to road south of Williambury homestead

Figure 6. Callytharra Formation (Early Permian) fossiliferous limestone formed under the sea

Most sandy sediment was deposited by waves in shallow water, probably within a few kilometres of the shore. This formed finely layered and rippled sandstone beds (see the rocks of the escarpment within the tourist area). Burrows scattered through these rocks were mostly dug for shelter by marine animals such as shellfish and worms (Fig. 7).

Some sand was carried beyond the wave zone and settled in deep, quiet water to be intensely burrowed by invertebrate marine animals. These sandstone beds, in places a few metres thick, have a 'wormy' appearance and thick, indistinct near-horizontal layering, rather than the thin, finely detailed layering or bedding seen elsewhere (Figs 8, 9). Muddy sediment, carried beyond the reach of normal, fairweather waves, forms the dark-grey to black, soft, silty rocks seen at the foot of the escarpment. Note that the white translucent crystals in some of these rocks are gypsum crystals, recently precipitated from salty groundwater.

Figure 7. Burrows and bioturbation in sandstone at Temple Gorge, approximately 450 m west of the parking area

Figure 8. Rock face showing from the base upward: 'wormy' sandstone, then about a metre of finely layered sandstone and, at the top, repeated 'wormy' burrowed sandstone, Temple Gorge

What happened later (250–2 million years ago)?

The youngest layers in the tourist area were deposited about 265 million years ago, as Australia moved north from its sub-polar location. After that, between about 240 and 130 million years ago (Triassic to early Cretaceous, Fig. 2), the rocks in the area were folded, tilted, uplifted, and eroded especially when the Gondwana supercontinent started to break up around 160 million years ago. Initial uplift was gentle with little associated folding but movements intensified when Australia and India finally separated around 130 million years ago (Fig. 3). Kennedy Range is now at the centre of a large, north–south oriented sag in the Earth's crust called a syncline (Fig. 10) with rocks east of the range tilted 10–15° down to the west. A series of major fractures, or faults, extends northwards along the western side of the range.

Figure 9. Worm burrows in sandstone, Drapers Gorge

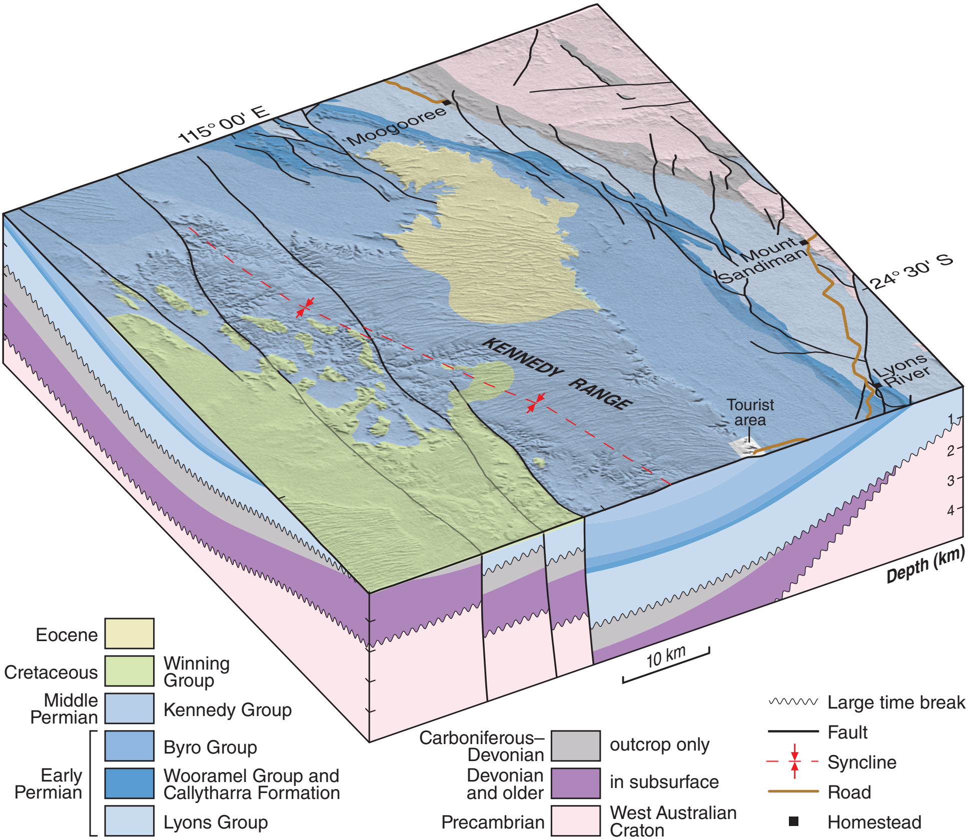

Figure 10. Block diagram showing present morphology and geology of the range

About 130 million years ago, after the breakup of Gondwana (Fig. 2), Australia's western margin subsided, allowing the sea to return to the western side of the Kennedy Range area. At first, sand was deposited directly over the Permian rock layers in a coastal setting with silt and mud deposited farther offshore. The sea retreated 100 million years ago (in the mid-Cretaceous) then advanced again about 40 million years ago (in the Eocene), when it extended onto the northeastern part of the national park. There, Eocene sandstone and siltstone lie above the modern scarp and contain a mixture of marine shells, corals, and fossil land plants including the earliest known species of *Banksia*.

Australia and Antarctica started to separate about 85 million years ago, but it was not until about 30 million years ago that these continents completely separated and Australia began to move rapidly northwards. The Australian continental plate collided with Asia about 25 million years ago, compressing both and initiating upwards warping of much of our western and northwestern margins, including the Kennedy Range area. Erosion, dominantly by water action, cut gullies and gorges into the range. The large fallen blocks at the foot of the range show that this process is still continuing today.

The dunefields (shown on the back cover) that cover the top of the range, and extend below the range to both the west and northwest probably were established about 5 million years ago during an arid climatic phase. By comparison, the smaller dunes to the east and south of the range developed during an even younger arid period about 20 000 years ago. Wind is now a minor agent of erosion in the area, forming the honeycomb texture in the sandstone at Honeycomb Gorge (Fig. 11).

Honeycomb Gorge

Honeycomb weathering develops from the action of salt and wind in coastal and semi-arid environments. Some moisture is required, as well as pore spaces, to allow the salt to soak into the rock. After many cycles of wetting and drying, crystallization of salty fluids in a wall of rock loosens the rock grains and they are swept away by wind, leaving an intricate network of small holes and tiny 'caverns' — the honeycomb or lattice texture at Honeycomb Gorge (Fig. 11).

Figure 11. Honeycomb texture in the rock give Honeycomb Gorge its name

Ironstone

The hard, black and brown sheets and nodules scattered across the floors of many gorges and gullies are ironstones created by the precipitation of iron oxide from iron-rich groundwater. These ironstones are concentrated just above the thick impervious shale near the base of the Kennedy Range escarpment, and are also scattered across the plain to the east. Hematite (ironstone, Fe_2O_3) nodules develop in sedimentary rocks through several processes, usually by the oxidation of sulfide minerals (pyrite, FeS_2, is the most common). Sheet-like ironstone layers typically originate by successive phases of iron precipitation along vertical joints or fractures in the sandstone, whereas nodules tend to develop in porous layers near such fractures (Figs 12, 13). In addition, some nodules form in anoxic (low oxygen) layers of organic mud, such as that found close to the base of the cliffs at Kennedy Range. Portions of the sediment that were originally lime or organic rich were gradually replaced by iron carried in acidic mineral-rich fluids below the water table, with the precipitated iron then producing a variety of nodule shapes. These nodules are harder than their host rocks and often litter the surface after softer sedimentary rock has been eroded away. Some nodules have distinctly black-blue coatings probably due to late precipitation of manganese oxides from groundwater. None in Kennedy Range are related to volcanic lavas.

Figure 12. Ironstone nodule in porous sandstone showing the friable centre has weathered away

Figure 13. Sheet-like ironstone layers formed along vertical fractures, about 250 m north of the campground

Gemstones

There are no precious or semiprecious gemstones or minerals known in the immediate area but the ornamental stones mookaite and petrified wood found west of Kennedy Range are popular lapidary material. Mookaite (named after the former station on Mooka Creek, about 32 km northwest of Gascoyne Junction) forms when groundwater rich in silica and iron oxide (which give these stones their vibrant colours) percolated into porous, silica-rich Cretaceous siltstone to produce a hard, impermeable opaline or porcellaneous rock with strongly variegated colouring (Fig. 14). Petrified wood is created in much the same way: dead tree trunks and branches floated out to sea, became waterlogged, and sank, with the organic material and any cavities later being replaced by silica. The 'peanut wood' texture seen in some examples represents borings made in the tree trunks by marine worms and shellfish, with these borings later being filled by silt on the sea floor. The original growth rings of the tree are still visible in the rock (Fig. 15).

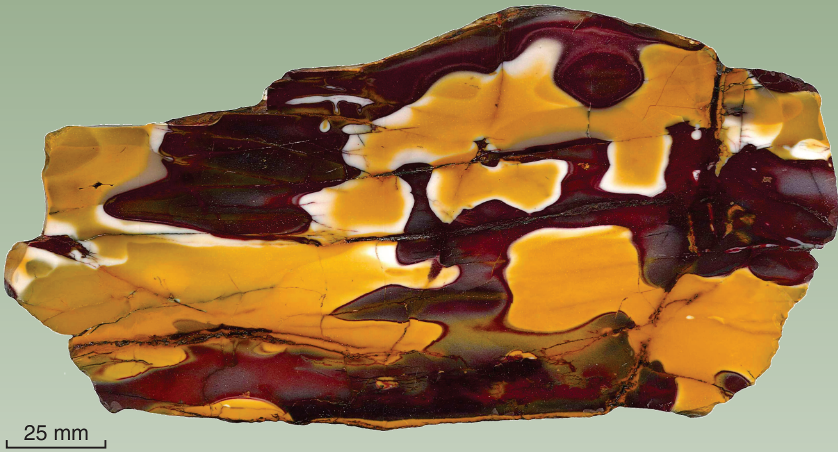

Figure 14. Cut and polished mookaite from Mooka Creek on the southwestern edge of the range

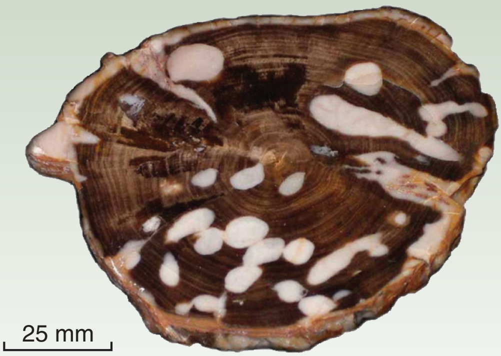

Figure 15. 'Peanut wood' from west side of the range (courtesy Glenn Archer, © Australian Outback Mining Pty Ltd www.outbackmining.com)

What we see today

Today the range shows evidence of many phases of climatic change — from the 300 million year-old glaciation to recent warmer and wetter climates when much of the ironstone and the mookaite formed. The range began to develop as a response to uplift and erosion more than 130 million years ago. Weathering and erosion by wind and water continue to slowly modify its shape.

Figure 16. Unusual rock shaped by wind and erosion, south side of Temple Gorge

Further reading

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About this pamphlet

Some 300 million years ago the Kennedy Range area was covered by an ice sheet, and was later inundated by the sea. In the last 20 million years, the region has experienced significant changes in climate. See the evidence for these events in the rocks at Kennedy Range.

Road

Walk trail

240 Contour, 20 m interval

Seasonal waterhole

500 m

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