Chapter 5

earth sciences values

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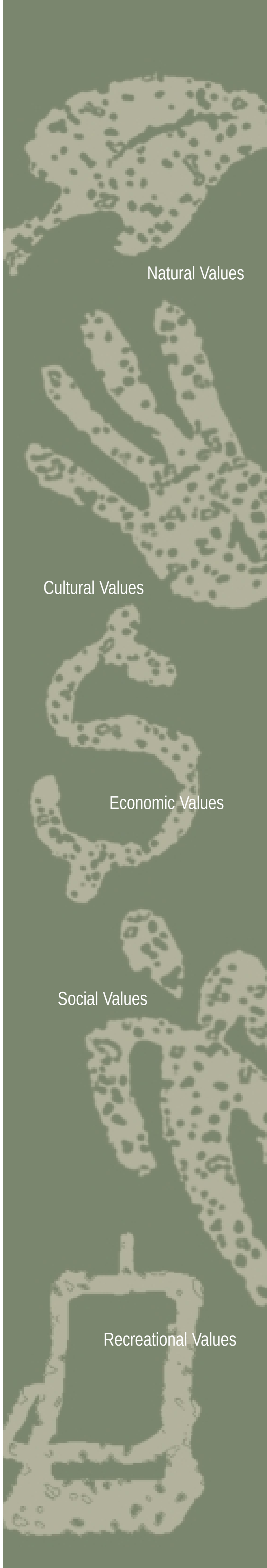

Introduction

The relevant sections of the *National Parks and Wildlife Act 1974* (NSW) stipulate that a primary object of the Kosciuszko National Park is conservation of significant landforms, geological features and earth processes. Also, management should seek to foster public appreciation and understanding of the earth science aspects of the park and sites of scientific significance. The following discussion has been written with these management aims in mind.

Geology and geomorphology are the basis of the entire Kosciuszko National Park. The geology is well displayed by a geological map at the scale of 1:250,000 (Wyborn et al 1990) and there is quite an extensive scientific literature bearing particularly on the solid geology and the effects of glacial and periglacial processes.

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Earth science features of the park can be conveniently divided into four time-based groups. Each is discussed here with comments on significance at international, national, state and park levels.

- *Ordovician to Lower Devonian* rocks (approximately 430–370 million years old), which form the bedrock of the entire area. The formation of these rocks was followed by a prolonged period of erosion that lasted to the early Tertiary.

- *Tertiary* earth movements occurred (about 2–50 million years ago) and Miocene basalt and stream sediments formed (about 20 million years ago).
- *Pleistocene* features date from (approximately the last 2 million years), with when great climatic changes, particularly over the period 70–10 ,000 years ago, that produced glacial and periglacial features.
- *Holocene* features date from (approximately the last 10 ,000 years), when the climate was roughly similar to that of today.

Ordovician to Lower Devonian

Description

The Ordovician to Lower Devonian sedimentary rocks are mainly sandstone, siltstone and shale forming greywackes deposited in deep marine environments, but including shallow-water limestone found at Cooleman in the northeast, Yarrangobilly in the centre and Indi in the extreme southwest. Some volcanic rocks occur, chiefly in the northern third of the area, including the Mount Jagungal Basalt, which is the oldest rock in the park. They were extruded mainly under marine conditions but include some subaerial occurrences. Granitic rocks were intruded at depth in Silurian and lower Devonian times, and now underlie most of the southern half of the park and the Bogong Peaks wilderness area in the northwest, plus scattered occurrences elsewhere. All these rocks have been extensively affected by folding and/or faulting Wyborn, L (Table 3 in Good 1992) lists the following areas and particularly significant geological features of this age.

- Geehi Valley: metamorphic rocks with abundant garnet, stauroliite and amphibolite;
- Ravine Basin: Devonian shallow water sediments;
- Mount Talbingo: Devonian lava flows forming cliffs;
- Cabramurra: serpentine along major faults with nickel and chromium;
- Cooleman Plain: Silurian limestone and chert;
- widespread Ordovician marine sediments forming hard quartzites and softer phyllites and schists;
- Tumut Ponds, Tantangara, Kiandra and Byadbo areas: graptolite fossils;
- The Pilot and Byadbo: Ordovician hard, green platy quartzite;
- Yarrangobilly: Silurian limestones, fossils, shales and tuffs;
- Cowombat Flat, Marble Creek and Pilot Creek: limestones and tuffs;
- Pilot Ridge and Cowombat Flat: Devonian rhyolites and breccias;
- Main Range: three types of granitoid rocks
- Nungar: folding of Bowning tectonic episode;
- Cooleman: slump bed folding; and
- Black Perry: skarn rock with garnets.

Knowledge of the solid rocks has been enhanced by the extensive and intensive studies required for the Snowy

Mountains Hydro Electric Scheme and the ski tunnel between Bullocks Flat and Blue Cow Mountain. Economic minerals, including gold, copper, tin and lead, accumulated at many places but mostly as minor occurrences.

After the Mid Devonian, the area was subject to prolonged erosion for some 250–300 million years, which exposed the granites and reduced the area to a lowland with ridges on more resistant rocks. Some features of this lowland have been partially preserved by the Miocene basalt: notably, a north-flowing valley near Kiandra. Part of the Great Divide that separates west and east flowing drainage now occurs in the park.

Condition

These rocks are obviously robust and in their natural condition.

Trend in condition

These rocks are a permanent feature of the landscape and, assuming quarrying and mining continue to be banned, no change in condition is expected. Possibly, there may be some reduction in their scenic value if additional buildings and roads are created. No special management is required to maintain their condition other than retention of the existing ban on prospecting, mining or unlicensed collection of samples.

Mining-related buildings and structures (discussed elsewhere) require continual monitoring and repair to ensure they do not deteriorate further.

Significance

These rocks form part of the Lachlan Fold Belt that occupies much of eastern Australia and they are of national and state significance. Areas of particular significance at state and park levels are the limestones with associated karst features (discussed by A Spate in Chapter 7). The landforms surviving from the later part of this period and on into the Tertiary are likewise of significance in understanding the evolution of much of southeastern Australia, including the history of the Great Divide.

Gold around Kiandra and the Grey Mare Range, copper and gold at Ravine–Lobbs Hole and tin in the southwest were economically significant and formed the basis of mining activities. The surviving associated cultural features (discussed elsewhere in this report in Chapter 13) are now of state and park significance.

Pressures

While the major rocks and landforms are immune to any conceivable pressure, large numbers of visitors can seriously detract from their scenic attractiveness by damaging the overlying soil and vegetation. This is certainly occurring around Mount Kosciuszko. It is conceivable that pressure will arise from fossickers seeking fossils in the limestones and interesting minerals such as the garnets at Black Perry Mountain. Construction of roads and buildings can greatly reduce the scenic attraction of the area.

Opportunities

There is some scope for educational signing at conveniently situated outcrops, notably the quarry on the road between Dead Horse Gap and Tom Groggin. Provision of leaflets setting out the geological story would assist leaders of educational excursions.

Knowledge gaps

There is much scope for more detailed geological mapping in most parts of the park. Research by university and state geologists will gradually meet this requirement (eg Wyborn, LAI 1977, Wyborn, D 1983). Such future research should continue to be controlled through licensing by the New South Wales (NSW) National Parks and Wildlife Service.

Indicators

In accord with the permanency of the rocks in terms of human lifespan, indicators of changing conditions are not apparent in the values themselves, but show up in such things as weed invasions that obscure outcrops, and slumping and soil erosion that cause concealment.

Tertiary

Description

Earth movements in the Tertiary uplifted the area, especially in the south and west, enabled stream erosion to cut deep linear valleys along lines of rock weakness, such as the Thredbo River, aligned along the Crackenback fault. The dissection resulting from the Tertiary uplift has produced spectacular scenery — notably the mile-high drop from the summits of the Main Range to the Geehi Valley. Miocene basalt extruded over the central part of the park covered stream valley deposits of lignite, silt and clay containing alluvial gold and fossils of rainforest trees. Later erosion has reduced the basalt to scattered remnants.

Notable areas and features of the Tertiary geology as listed by L Wyborn (in Good 1992) include:

- Round Mountain: Tertiary basalt flows;
- Kiandra, Cabramurra and Yarrangobilly: columnar basalt pinnacles; and
- New Chum Hill, Golden Crown and Round Mountain: Tertiary sediments.

The wet and warm climatic conditions favoured deep weathering. The effects are still visible in road cuttings throughout the park at medium and low levels where granite has lost its cohesion but is still in place. Over much of the park, later erosion has removed much of this unconsolidated material to leave resistant core stones exposed as tors. Detailed forms of tors relate to variations in the lithology. Some insights into the prolonged landform history can be found — for example, the sub-basalt valley at Kiandra and the mature gentle slopes of upper valleys (eg Long Plain) perched above deep lower valleys cut by later erosion.

Condition

The major landforms resulting from the geomorphic history of the Tertiary are generally robust, as is the Tertiary basalt. The surviving remnants of the Tertiary stream deposits are liable to loss by erosion. The evidence of deep weathering was clear in fresh road cuts made when the Snowy scheme was under construction, but in many places it is now obscured by rain wash, slumping and vegetation.

Most of the buildings of 19th nineteenth century Kiandra have disappeared, but the New Chum and other mine sites, storage dams and leads are still clearly visible. Informative notices at some of the sites increase their interest for the public.

Trend in condition

While the scenery will survive unchanged in terms of human lifetimes, there will probably be a gradual deterioration in the accessibility and visibility of the mining evidence as vegetation continues to encroach and explanatory notices become illegible. However, reasonable maintenance should maintain the surviving features indefinitely. Ironically, further loss of evidence of deep weathering in road cuts seems inevitable in view of soil conservation measures.

Significance

The spectacular scenery of parts of the park, notably the Geehi Valley, is certainly of Australia-wide significance. The gentler relief typical of most of the park has statewide significance. The rainforest fossils found in stream sediments under basalt at Kiandra are rare testimony of a time when Australia's climate was very different and contribute to understanding the climatic evolution of the entire continent. The alluvial gold was the focus of an important gold rush around 1860, followed by half a century of placer mining. The relics of the mining are significant at the state and park level. The deep weathering of granitic rocks seen in road cuttings is a common feature in Australia and most mid- to low-latitude countries; it is of park significance only.

Pressures

Some increase in tourist pressures on the more accessible mining sites can be expected. However, because these areas are well away from the main attractions of the ski areas and the highest country, such pressures should not be unsustainable. Any attempt to resume mining would greatly increase pressure on the area but is most unlikely to happen.

Opportunities

If any major faults are exposed in road cuttings, an information notice would be a good idea. Public knowledge of deep weathering effects could also be furthered by suitable notices. However, this would require keeping suitable road cuttings exposed, which contravenes general conservation policy. Deeply weathered granite in place is well exposed in road cuts near Island Bend and is regularly demonstrated to geology students on field trips.

Knowledge gaps

There is always scope for more research and knowledge about these rocks and the geomorphic history, and such research is best carried out by academic researchers under park licensing. Topics worth researching include finding and dating any feeder dykes for the basalt flows and comparing the landforms preserved under the basalt with the present landscape.

Indicators

As for the older rocks, a good cover of soil and native vegetation indicates good conditions, while fresh rock surfaces, slumps and gullies indicate poor, and probably deteriorating, condition.

Pleistocene

Description

During the Pleistocene, comprising about the last two million years, the world experienced remarkable climatic events, including the repeated growth and decay of immense icesheets in North America and Europe, while glaciers developed on mountain ranges throughout the world. In Tasmania there were several extensive glacial events but, on present evidence, in mainland Australia only the very highest land in the Kosciuszko National Park had small glaciers during the last part of the Pleistocene. Cold-climate periglacial processes beyond the ice produced distinctive landforms and deposits.

Glacial features of the park include cirques, moraines, lakes, erratics and ice-scratched surfaces. The cirques formed mainly in the lee of north-northeast–south-southwest ridges where accumulation of snow was maximal and melting minimal. Some 13 cirques have been identified (Galloway 1963, Barrows et al 2001).

Both terminal and lateral moraines occur. They usually form bouldery ridges but one case of hummocky moraine exists in Mawsons cirque. Radiometric dating of boulders in the moraines has shown that there were several successive ice advances and retreats during the last glaciation (sens lat) (Barrows et al 2002).

There are five glacial lakes. Only one (Blue Lake) is at least partly formed by glacial erosion of the bedrock; the others are shallower features formed by morainic dams. Sediments in at least two of the lakes have provided valuable records of vegetation and climatic changes since the ice disappeared some 15 ,000 years ago.

Glacial erratics range in size from small stones to large boulders. Their use as evidence for former ice extent requires considerable care because boulders can creep down slopes from one lithology to another. Identification of erratics is particularly difficult on some of the granitic rocks that contain inclusions resembling the Ordovician sedimentary rocks as well as various varieties of granite within a single batholith. Further confusion can be caused by anomalous rock material imported to make roads and tracks. Ice-striated surfaces that occur on lower slopes overlooking Lake Albina demonstrate the former direction of ice movement. Ice-smoothed rock surfaces are well developed in Blue Lake cirque.

The periglacial evidence, while less immediately striking, is more widespread and can be found in most areas above the 1000 m contour and possibly as far down as 600 m. Features of interest include frost-shattered bedrock, boulder fields, solifluction deposits, stone streams, stone-banked lobes, non-sorted steps and nivation features.

Frost-shattered Ordovician sedimentary rock — evidence of former permafrost — is exposed in a roadside quarry one kilometre east of Mount Kosciuszko, and permafrost probably affected all these rather brittle rocks at high altitude. This is perhaps almost the only evidence for past permafrost in mainland Australia. Angular rock debris around tors at high altitudes is the product of former intense frost-wedging.

In many parts of the park, solifluction (the downslope movement of unconsolidated rock debris aided by freeze–thaw, interstitial ice and snow melt) has produced smooth slopes. The northwest facing slope of the Kangaroo Ridge is a good example. Where the debris included boulders, the fine fraction and interstitial ice may be subsequently washed out to leave boulder fields and stone streams (Caine and Jennings 1968), which are a favoured habitat for the Mountain Pygmy-possum. Striking block streams, dated to about 20,000 years ago, occur at about 1100 m altitude near Ravine. In detail, solifluction can result in irregular low steps formed by the fronts of solifluction lobes and terraces. Sometimes these fronts are barely discernible through soil and vegetation (eg on the Kerries Range). In road cuttings, solifluction deposits can be seen to fill valleys and gullies cut in the weathered granite.

Nivation is a complex of land-forming processes found in and around long-lasting snow patches, particularly where the ground surface is bare of vegetation. It includes splitting of rocks by freeze–thaw and mass movement of wet soil and rock debris. In the long term it produces shallow hollows that form incipient cirques; there are many such nivation hollows in the highest areas of the park.

Condition

The glacial features are generally clearly visible, although the older ones have naturally lost much of their pristine form. The periglacial deposits are best exposed in road cuttings and quarries where they gradually become less identifiable because of rain wash and growth of vegetation. Soil conservation measures have also obscured this evidence. A road has cut through the block streams at Ravine.

Trend in condition

Continued obscuring of relevant exposures through natural processes and soil conservation measures is to be expected. A particular problem is the deeply frost-shattered sedimentary rock near Mount Kosciuszko. This strong evidence of former permafrost will be grassed over and concealed for conservation and scenic preservation.

Significance

The glacial features are of very high scientific and educational significance for Australia and the entire southern hemisphere. They are an outstanding example of a glaciation that developed under extremely marginal conditions (Galloway 1989) and are the only occurrences on the Australian mainland. They contribute to understanding the nature of climates during the Pleistocene. The Helms moraine near Blue Lake is a particularly clear example of glacial transport of one kind of rock onto another. The so-called 'Railway Embankment' moraine near Muellers Pass is another interesting example; it is the site of an early estimate for the date of glaciation (David et al 1901) and is consequently significant for the history of geology in Australia. The periglacial phenomena are amongst the most striking in Australia and demonstrate the widespread effects of cold climate in the Quaternary and in the recent past.

Pressures

The glacial features are well outside the ski resort concessions and consequently should not experience greatly increased pressure, although there will be some increase in foot traffic along and near access tracks. The more widespread periglacial features may suffer some loss through building and road construction. On the other hand, such work can expose new examples of solifluction deposits. A more immediate pressure is the smoothing of ski runs by bulldozing and removal of boulders.

During early stages of construction of the Snowy Mountains Hydro Electric Scheme it was proposed to dam Spencers Creek. This would have seriously affected the integrity of the landforms, especially the ridge known as the David Moraine (whose morainic origin is very dubious). However, the proposal was abandoned and is no longer a problem, although traces of disturbance by exploratory trenches still exist.

Opportunities

There is considerable public interest in the glacial history in the park but the periglacial story is less well known. Opportunities exist for informing the public with signs at appropriate locations. Existing signs may need to be updated in the light of recent research. There is a case for permanently recording features temporarily exposed during construction of roads and buildings, as is sometimes done with archaeological sites. It may be feasible to show the development of a small glacier by means of a kaolin model, which could be an item in an educational video on the park.

Knowledge gaps

There is scope for further radiometric dating (Barrows et al 2002) to increase understanding of both glacial and periglacial history. Current work in progress is successfully dating block streams. More detailed mapping of the granites and included xenoliths should assist in resolving the question of exactly how far the ice extended. There are probably many evidences of past vegetation such as described by Caine and Jennings (1968) still to be discovered under solifluction layers. Probably many more periglacial features remain to be identified. All such research will need to be done carefully in view of the need to avoid damaging the environment and geology of the park.

Knowledge gaps more directly related to the conservation aims of the *NSW Act* include studying the distribution of periglacial features in relation to proposed ski developments. Also of potential importance is the location of old gullies cut in soft weathered rock and then later filled by soliflucted material. The presence of one such gully may have contributed to the Thredbo landslip disaster. It could be of interest to study the alluvial fans on valley floors (notably at Thredbo) to assess the likelihood of damaging floods in future, especially since run-off may be higher as a result of clearing for ski runs and also, perhaps, as a result of climate change.

Indicators

Indications of changing condition include fresh boulder surfaces exposed by stripped off lichens, clearing of boulders from ski runs and slumping of the steep fronts of solifluction terraces.

Holocene

Description

By 15,000 years ago, the last glaciers had melted as the climate warmed with the close of the ice age.

The tree line, which had been lowered by as much as 1000 m, gradually rose to about its present level at around 1800 m. By 10,000 years ago the climate was broadly similar to that of today.

Holocene land-forming processes in the park include solifluction (less intense than during the Pleistocene), soil erosion, fluvial erosion, nivation, frost heaving of soils (Costin and Wimbush 1973), stone movement by snow pressure (Costin et al 1973) and the formation of string bogs (narrow turf contour ridges separating narrow ponds). At high altitudes, solifluction of frost-shattered debris and soil on the Ordovician sedimentary rocks has produced non-sorted steps, lobes and terraces on slopes with frontal risers up to a metre. They are now inactive but a slight decrease of mean temperatures would reactivate them (Costin et al 1967). Water erosion is generally insignificant except in limestone areas and alluvial flats. However, surface wash of soils and other fine-textured surface materials can be significant, especially if the vegetation cover is sparse; at least 7 m of sediment has been washed into Blue Lake since the ice disappeared some 15,000 years ago. Wave action on the shoreline of Blue Lake is damaging lake sediments. Nivation is most active today on the upper lip of the glacial cirques, where thick snow patches accumulate every winter, and around long-lasting snow patches in south- and east-facing hollows. Frost heaving of soils is common on bare ground and, by hindering vegetation establishment, it tends to perpetuate bare areas.

In the last 170 years, stock grazing, road construction, mining and hydroelectric works have had major impacts on the park. They have caused accelerated soil erosion and changed the behaviour of streams. Climate changes induced by the putative greenhouse effect may affect future snow cover, although so far no significant change is apparent despite the occurrence of some warming (Osborne et al 1998).

Condition

Over most of the park, Holocene processes and deposits are generally in reasonably good condition but there are limited areas of concern such as the heavily impacted summit of Mount Kosciuszko and much of the area covered by the ski concessions. It has been feared that ‘snow farming’ in ski concessions could lead to unwanted surface changes. While this may be true for vegetation and soil compaction, the depths of snow involved are substantially less than would be required for full nivation to occur (Galloway et al 1998). Active stream bank erosion below Blue Lake is cutting away sediments with potential value in dating.

Trend in condition

Soil conservation works, walkway construction and attention to areas of accelerated erosion have helped to re-establish natural, more gradual, Holocene processes. Trend in Holocene processes is closely linked to conservation of soils and vegetation. Frost heaving on bare soil hinders vegetation reestablishment.

Significance

In the park, surface processes such as soil wash, frost heaving and nivation can be observed under the present climate in a great variety of situations. The park can thus serve as a benchmark for processes in more heavily impacted regions elsewhere in south-eastern Australia, giving it state or possibly national significance. In particular, it offers comparison with alpine areas in Victoria that are subject to more stock grazing, although the advent of horses in the alpine zone is now tending to reduce this contrast. Pollen in the sediments in Blue Lake and Club Lake, and peat in the Twynam Cirque, have given valuable information on vegetation changes associated with post-glacial warming. Again, they are of state or even national significance.

Pressures

Changes in Holocene processes are inevitably linked to changes in park usage, with pressures concentrated in heavily used areas like Charlotte Pass, the Kosciuszko summit and ski concessions.

Opportunities

The evolution of alluvial flats in both disturbed and undisturbed country could be studied using successive generations of air photographs, the oldest going back almost 60 years. This air photo record could provide a useful post-1939 reference condition for some soil and vegetation aspects of the park.

Re-establishment of the Spencers Creek climate station at the same site as in the 1950s and 1960s might be possible using solar-powered unstaffed equipment, recording temperature only; this would enable climate change over half a century to be assessed. It is important that the Snowy Mountains Hydro-Electric Authority snow courses, particularly the course at Spencers Creek, be maintained; their value as records of snow history increases year by year.

Knowledge gaps

What is the rate of soil formation versus the rate of soil erosion on different rocks and in different climatic environments in the park? What effect will the ever-increasing use of artificial snow making have on stream processes? How much erosion or other effects might occur in a 100-year flood? Will significant climatic change occur?

Indicators

Monitoring at 10 year intervals of sediment accumulation in lakes and dams throughout the park could provide useful information on rates of soil erosion. A good cover of native vegetation indicates good condition, while bare earth and erosion gullies indicate bad, and probably deteriorating, condition.

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