Geology and Geomorphology of Victoria's Grassland Regions

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This paper outlines the geology, land forms and some of the past and present land-forming processes of Victorian landscapes now dominated by grassland vegetation. The most extensive grasslands of the State occur on plains such as the Western District Volcanic Plains, the Wimmera, Riverine and Mallee plains and coastal plains in south Gippsland and western Victoria. Patchy (discontinuous) grasslands occur on coastal dunes and on small plains in the Highlands. Grasslands mainly occur on relatively young geological materials such as Pleistocene and Holocene alluvial and aeolian sediments and on Tertiary volcanic rocks, although in the highland areas they are developed on Palaeozoic geology as well. After a brief overview the paper concentrates on the geomorphology of the volcanic plains and the northern alluvial and aeolian plains.

Origin of Victorian Plains

Some plains have a simple geological history — for example, the undulating plain around Port Campbell is a result of the uplift of a Tertiary marine limestone deposit with only mild tectonic deformation. Stream dissection and karst (solution) processes have shaped a surface of modest relief. Although a complex of processes produces and shapes most plains, two broad, overlapping causes are predominant — erosion and deposition. Long periods of weathering under stable tectonic conditions result in the gradual lowering of the land and the development of extensive planar surfaces over areas of diverse geology. These are known as planation surfaces or erosion surfaces and are an obvious feature of much of the Australian continent (Ollier, 1991).

The surface may be regolith and soils derived from the underlying geology or may be blanketed by younger materials of sedimentary (including glacial) or volcanic origin. If these plains are uplifted they become plateaus that may be dissected leaving isolated remnants or high plains bounded by escarpments. The flattened surfaces of Mount Baw Baw, Mount Buffalo, Mount Macedon and the Bogong High Plains are examples of this process. In northern Victoria and the Wimmera, planation surfaces are covered by river alluvium, in the Mallee it is wind-blown sediments that blanket the plains while in much of western Victoria plains result from the spread of sheets of viscous basalt lavas.

The Origin of Victorian Plains Landscapes

Elements of the Victorian landscape pre-date the separation of Australia from Antarctica. The main remnants of older landscapes (as distinct from older rocks) are small glacially scoured surfaces near Heathcote and Bacchus Marsh which must be as least as old as the glacial deposits (Permian). Pre-separation tectonic events in the Cretaceous created the basins that filled with sediment to later become the Otway Ranges and South Gippsland Hills. Early in the Tertiary began the tectonic and volcanic activity that, along with denudation, would ultimately shape the present-day topography of Victoria. Landscapes result from the interaction of geological materials and geomorphological processes. Geomorphological processes are determined by climate, sea level, tectonics and volcanism.

The climates under which the landscapes in Victoria have evolved over the last 60 million years have generally been warmer, and at times much wetter than today, although the last few million years have seen major climatic oscillations. The most marked of these changes has been the onset of cold conditions often coinciding with periods of aridity. There is no certain evidence of Pleistocene glacier formation in Victoria, although piles of boulders and shattered rock in places in the highlands show it was cold enough to freeze the ground. Climatic changes, including wetter periods, are reflected in the alluvial geomorphology and ancient river systems of the plains of northern Victoria, while stabilized dunes and sand sheets (on both inland and coastal plains) show the influence of periods of more intense aridity and stronger winds.

Sea level has also varied greatly. Sea level is affected by tectonics as continents shift and move over million year time scales, but over shorter terms (a few thousand years) these changes are manly due to the accumulation of glacial ice. Over the Pleistocene epoch (the last 1.8 million years), sea level at the Victorian coast has varied from perhaps 10 metres higher to certainly over 100 metres lower. The last 10,000 years has seen a rapid rise in sea level. Sea level determines the size and shape of the continent, changing the maritime influence on various locations, affecting climate and biological responses over broad areas. Eighteen thousand years ago Australia was a much bigger continent, and some places that are now coastal were then hundreds of kilometres from the sea. When sea level is lower, rivers can incise but as sea level rises river systems deposit sediment as floodplains.

In simple terms, tectonics is the movement of the earth's crust. Although many complex causes may be traced, tectonics is responsible for uplift and subsidence. This may be on a broad scale producing the Victorian Highlands, or on a local scale such as the Rowsley Fault scarp. Tectonics produce subsided areas such as the Werribee Plains (now basalt covered) and the lowlands around Westernport Bay. Tectonic movements also accelerate geomorphological change by increasing the erosive power of streams and causing slopes to steepen.

Volcanic rocks in Victoria range in age from some of the oldest rocks in the State (Cambrian lavas near Heathcote) to the Tower Hill volcano which erupted less than 30,000 years ago. The volcanic activity produced the sheets of basalt lava covering the Western District Plains and lava remnants cap many of the High Plains in north-eastern Victoria and east Gippsland.

Volcanic Plains

Western District Volcanic Plains

One of the largest geological units in Victoria is the Newer Volcanics Province, a region extending from north of Melbourne west to Portland. Although some of the most obvious volcanic features occur on the Western District Plains, there are also many volcanoes in the western highlands or Midlands around Daylesford, Creswick and Clunes. Evidence from radiocarbon dating (D'Costa et al., 1989) suggests that there has been no volcanic activity in Victoria for at least 20,000 years although Mount Gambier (S.A.) was active less than 5,000 years ago.

A catalogue of the known eruption points of the Newer Volcanics Province identified 355 volcanoes which are believed to have been active over the last four to five million years (Rosengren, 1994). Although there are a large number of eruption points, most were active only for a short period of time and individual volcanos are small. Most of the eruption points are in the Midlands and produced short lava flows following and often filling valleys.

The most distinctive volcanoes of the province are the higher and steeper scoria cones such as Mount Elephant, Mount Noorat, Mount Napier and Mount Kooroocheang (Smeaton hill) resulting from fire-fountaining and mild explosive activity. However, the great volume of volcanic material came from lower, less steep volcanoes such as Mount Cottrell which produced broad shields or long lava flows, and it is on this terrain that the grasslands and grassy woodlands now occur.

The volcanic activity of the Newer Volcanics Province is similar to that now active in Hawaii, with the dominant volcanic product being coherent, fluid basalt lava with only a small component of pyroclastic (fragmental) material (mainly basaltic scoria and tuff). Lavas of this type can spread rapidly across the landscape, and in places extend over 50 kilometres from the volcano.

The volcanic plains is therefore built up of thin lava flow units just one or two metres thick and sometimes just 20 or 30 centimetres. Overlapping of flows from a single eruption point have built to a thicknesses over 60 metres in places. New lava surfaces were hard and rough and cooling, cracking and convergence of lava flows in places produced complex, fractured surfaces called stony rises. This lava topography is well-preserved on the Tyrendarra flow from Mount Eccles. Stony rises occur where several lava flows intersect, or where part of a flow collapses and sags, resulting in a complex topography of ridges and depressions with many swamps and lakes.

Although there are literally hundreds of volcanoes, most were active for only a few years or decades. If the province has been active over the last four million years and given that there are about 400 volcanoes, on average an eruption took place only every 10,000 years. There were long periods when there was no volcanicity and weathering and other subaerial processes was the main geological activity. The direct impact of this type of volcanicity is relatively restricted. Lava flows cause fires but there is not the massive volume of fine volcanic debris that occurs with more explosive volcanic events. Vegetation could have survived right at the edge of lava flows, being able to send out colonisers onto the new land surface.

The most explosive volcanicity occurred in a small area around Camperdown and Colac where there are a number of circular craters (known as maars) containing lakes or swamps. The percentage of fine-grained volcanic debris (volcanic ash) in soils is higher around maars such as Tower Hill than around the lava flow volcanoes

Because of the great range in age (and to a lesser extent in type) of the parent volcanic materials across the Western Plains, land surfaces vary considerably. The stony rises have rugged topography dominated by angular, almost unweathered boulders, while on the older flows there is a deep weathering profile with complete decomposition of rock to depths of several metres. The volcanic landscape is therefore a complex mosaic of land systems with differences in topography, soil, climate and vegetation. In places, such as on the Werribee Plains, the plains are very flat and a combination of aridity, heavy clay soils and poor drainage may be major factors inhibiting tree growth (Willis, 1964).

Alluvial plains

Alluvial plains in Victoria may be classed into two groups:

(a) modern flood plains that lie adjacent to and within reach of flooding from active river channels, and
(b) older alluvial plains that were built by flooding from rivers carrying higher discharge (both water and sediment) than the modern streams.

The alluvial plain of northern Victoria is a series of gently sloping alluvial fans and floodplains, and is part of a much larger unit known as the Riverine Plain, comprising the fluvial plains of the Murray, Murrumbidgee, Goulburn and Lachlan Rivers and their tributaries (Butler et al., 1973). In Victoria, these streams are the Ovens, Broken, Goulburn, Campaspe, Loddon and Avoca Rivers.

The alluvial plains are built of sediment derived from the erodible sandstones, mudrocks and igneous rocks of the Victorian Highlands and spread by rivers down the mountain flanks both north and south of the Divide. These sedimentary surfaces are quite unlike the volcanic surfaces of western Victoria and formed under a completely different geological regime. These sediments, deposited and redistributed by rivers and wind, buried the older bedrock surfaces and produced a complex landscape of low relief and gentle slope. Like the volcanic plain, it is a mosaic of materials, ages and forms.

Three main elements comprise the Riverine Plain — fluvial, lacustrine and aeolian. Fluvial elements include the modern streams which are incised up to 5 metres into the plain in well-defined channels with steep banks. These streams carry a suspended load of silt and clay with very little sand. Anabranches or distributary branching channels are a feature of the Loddon and Avoca Rivers. Remnants of ancient streams (prior streams and ancestral channels) in the form of shallow, winding channels bordered by low levee banks, filled with sand and gravel, are widespread on the plain. The form, dimensions and sediments of these ancient channel deposits shows they were deposited by streams carrying much higher discharge than the modern rivers. The old stream channels are crossed, or in places followed, by the modern rivers.

Lacustrine (lake) elements are generally ephemeral or intermittent shallow lakes and are typically saline or brackish. The most distinctive aeolian (wind-blown) feature of these plains is the lunette, a crescent-shaped ridge of fine sand, silt, clay often containing pellets of salts including gypsum and occurring on the eastern side of lakes such as Lake Cooper in the depression east of the Colbinabbin Range. The composition and form of lunettes, like the ancient river channels is used to interpret the climates and geomorphological processes of the Quaternary when the Riverine Plains were built.

In northwestern Victoria, the Riverine Plain gives way to the Mallee where the influence of the wind in shaping landforms is more evident in the form of dunefields now fixed by vegetation. The most common form is a low, linear dune roughly aligned west-east although in the ‘desert’ country (Big Desert, Little Desert and Sunset) the dunes are higher, irregular or parabolic in plan or are transverse to the east-west winds.

Other Plains

Gippsland

In Gippsland there are grasslands on plains north and west of the Gippsland Lakes. Some of these occur on floodplains of the Latrobe and Macalister Rivers but most are on deflation corridors or zones blown out by the wind. They occur on leached sandy soils with perched watertables and many swamps and small lakes.

Mountains

Grasslands occur up in the highlands on mountain summit, plateau and high plains where low temperature or cold air drainage suppresses tree growth. At the moment, that low temperature envelope is very narrow and occurs generally above 1,600 metres, but in colder Pleistocene times the tree line may have been as low as 1,000 metres. Although a number of the grassy High Plains are developed on basalt of the Older Volcanics (20 million to 40 million years old), the high plains occur on various geologies. For example, the Bogong High Plains is a complex of different geological and geomorphological units.

Coastal

Coastal grasslands occur on foredunes (both ridged and terraced) along the Victorian coast, although many dunes have been greatly modified by the planting and accidental spread of introduced species. Coastal dune grasslands are typically narrow and linear and are ephemeral and seasonal according to episodes of foredune “cut and fill”. On a prograding coast, as new frontal dunes form, grasses on the older dunes are replaced by shrub and woodland vegetation. The main native coastal grasses such as *Spinifex* and *Festuca* are being overwhelmed by the introduced *Ammophila* which tends to encourage the growth of high, ridged foredunes replacing the terraced or low profile dunes formed by the native species (Rosengren, 1981).

Summary

The grasslands of Victoria occur predominantly on plains of low elevation, both in northern and southern Victoria. However, these land surfaces have very different geological and geomorphological histories. Volcanicity produced an initially barren surface in western Victoria that required extensive modification by weathering to be a suitable plant habitat. Although intermittent, the volcanic activity provided a mosaic of landforms and soils of different ages. The volcanic events may have also triggered fires and local ash fallout that impacted on vegetation.

On the northern plains, the landscapes were affected by floods spreading coarse alluvium. As a result, stream courses changed more frequently, rapidly and extensively than they now can. There is evidence of both wetter and more arid climates than today, resulting in characteristic landforms and other land surface changes. Coastal areas were affected by sea level changes as the sea alternately abandoned and then reoccupied coastal terrain. In the mountains, freezing climates alternated with warmer, drier and windier times than now.

Terrain occupied by grasslands has thus experienced a variety of influences. A common theme is that they are geologically young landforms that have experienced climatic and tectonic change affecting land surface stability and character. These changes were of sufficient magnitude, intensity and frequency to influence vegetation processes.

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