3. GEOLOGY AND PHYSIOGRAPHY

Geology and geomorphic history

Information on geology of the catchment has been obtained from two maps published by the Geological Survey of Victoria at a scale of 1:250 000 – Bendigo SJ 55-1 and Melbourne SJ 55-5.

The oldest rocks in the study area are of Cambrian age, and comprise a thick sequence of basic lavas and interbedded sedimentary rocks. Subsequent deep burial has converted many of igneous rocks to 'greenstones', which now outcrop in a north-south trending ridge near Heathcote (Thomas *et al* 1976). Faults on either side of the ridge have brought the Cambrian rocks in contact with Silurian-Devonian sediments to the east and Ordovician sediments to the west.

Ordovician rocks and their metamorphic derivatives are the most widespread in the study area. During the Ordovician a sequence of up to 3,000 m of sandstones and siltstones was laid down.

From the Silurian to mid Devonian further marine sedimentation took place, including sandstones and mudstones that outcrop in the east along the McIvor Range as the result of fault-related upthrust.

The Upper Devonian was characterised by extensive igneous activity, involving mostly the intrusion of granitic complexes – for example, the Cobaw, Crosbie and Harcourt Batholiths. Extrusion of magma formed the erosion-resistant hypersthene rhyodacite massif of Mount Macedon (Marsden 1976). Surrounding the igneous intrusions, contact metamorphosed Ordovician sediments often form prominent ridges.

The interval from the Carboniferous t the early Cretaceous was a time of tectonic stability and prolonged erosion. The flat summit of the Mount Macedon massif – the oldest recognisable land surface – probably dates back to the Mesozoic (Jenkin 1976). The only major deposition during this time occurred in the Permian, when parts of south-eastern Australia were subject to glaciation, and glacial sediments have been exposed in the Spring Plains-Derrinal area (Bowen and Thomas 1976).

During the early Tertiary, or possibly the late Mesozoic, uplift of the highlands throughout south-eastern Australia began.

An early uplift led to the deposition of gravels. Deep weathering during the Tertiary resulted in silification and ferruginsation of these gravels, increasing their resistance to erosion. Remnants occur to the east of Bendigo.

Table 5 – Major stages of geological and geomorphological development

Era	Period	Epoch	Age (m.y.)	Major Events
Cainozoic	Quaternary	Recent	0.01	Recent alluvial and lacustrine deposits
		Pleistocene	1.8	Renewed uplift centred in the east of the state. Deposition of thick sequences of alluvium
	Tertiary	Pliocene	7	Extrusion of Newer Volcanics - a series of basic lava flows emanating in the south of the catchment
		Miocene	26	
		Oligocene	37-38	
		Eocene	53-54	
		Palaeocene	65	Uplift begins, resulting in rejuvenation of streams and deposition of gravels
Mesozoic	Cretaceous		136	
	Jurassic		190	Prolonged erosion and tectonic stability
	Triassic		225	
Palaeozoic	Permian		280	Extensive glaciation and deposition of glacial sediments (tillites)
	Carboniferous		345	
	Devonian	Upper		Extensive igneous activity, mostly granitic plutons - a notable exception being the extrusion of rhyodacite (Mount Macedon)
		Middle		Folding and faulting, uplift of Cambrian to Lower Devonian rocks
		Lower	395	Continued deposition of marine sediments in a trough contracting to the east
	Silurian		440	
	Ordovician		500	Deposition of deep marine sediments
	Cambrian		570	Deposition of submarine volcanics and sediments

Newer Volcanics were extruded during the late Tertiary (Dasch and Millar 1977; Wellman 1974) and accompanied the Pliocene to early Quaternary uplift. The lavas emanated from a number of centres in the south – for example, Green Hill, Kangaroo Hill, Racecourse Hill and Blue Mountain – and flowed in a general northerly direction. The earlier more viscous extrusions such as the intermediate trachytes and solvsbergites, flowed over short distances. The later more fluid basic olivine basalts flowed further, with some flows extending along an earlier Campaspe River valley to Barnadown and Avonmore. These lava flows covered the pre-extrusion stream-beds and diverted the stream laterally (Ollier 1967). Being relatively resistant to erosion in the south the flows now frequently occupy higher positions relative to the adjacent Palaeozoic bedrock. The gradient of the basaltic terrain, however, is steeper than that of the modern river system, and to the north of Barnadown the basalt is buried by alluvium.

From the late Tertiary to the early Pleistocene renewed uplift of the highlands resulted in rejuvenation of streams and the deposition in the north of a thick sequence of alluvium over the early Tertiary deposits, basalt and Palaeozoic bedrock to form a riverine plain. Butler (1950) proposes that aeolian dust has also accumulated on the plain and adjacent slopes. The most recent episode has been alluvial deposition on the flood-plains of the creeks and rivers.

General Physiography

The catchment is dominated by lands of gentle relief, although steeper lands ten to occupy the central areas, both on Palaeozoic sediments an granitic rocks. Prominent above the general landscape are Mount Macedon on the southern boundary and Mount Alexander on the western boundary. Metamorphic aureole ridges frequently surround the granitic plutons in the central areas, and north-south trending ridges of the Mount Camel and Mount Ida ranges occur on the eastern boundary.

In the north extensive alluvial plains along the Campaspe River and Bendigo Creek valleys, represent southern extensions of the Riverine Plain.

Basaltic plains are common in the south, with a number of associated volcanic cones.

Physiographic units used in land classifications

Four broad physiographic units have been used to define land zones, an these are described in terms of relief and slope using categories consistent with the Australian Soil and Land Survey Handbook (McDonald *et al*. 1984). In the first unit – mountains with moderate to steep slopes – Mount Macedon comprises the only area in the catchment.

Hills with moderate to steep slopes are common in the cental and southern areas on Palaeozoic granitic and sedimentary rocks. Massive rock outcrops and boulders characterise the areas on granitic rocks around Mount Alexander and the Cobaw Ridge. Steep ridges of metamorphosed sedimentary rocks usually surround these granitic areas. An upthrust ridge of Devonian sediments occurs to the east of Heathcote. The steeper terrain on Ordovician sandstones and mudstones in the centre of the catchment is characterised by short and relatively steep slopes, and a moderate to close spacing of the drainage depressions. The stream patter is influenced by faulting and by differential erosion of the steeply dipping resistant sandstones and softer mudstones.

Hills with gentle slopes comprise the third unit – common throughout the catchment – and covers almost half of the total area. It is characterised by subdued hills with gentle, often long, slopes, infrequent rock outcrop and significant accumulations of alluvium in the drainage depressions. It is most common on sedimentary rocks, although other significant occurrence are found: on granitic rocks, including relatively extensive areas near Sutton Grange and tongues of gentle terrain between steeper rocky hills north of the Cobaw Ridge; on dissected volcanic plains in the south; on Mount Camel Range, an upthrust ridge of Cambrian volcanic rocks north of Heathcote; and on Permian glacial sediments to the west of Heathcote.

Plains, level or gentle undulating, make up the fourth unit. The largest areas are alluvial and form a southern extension of the Riverine Plain into the Campaspe River valley. These plains are generally level except where stream activity has produced small scarps and narrow flood-plains. Other notable areas are basaltic plains, which are most extensive in the south, commonly with scarps bounding them. Several small parcels of cemented gravels, remnants of Tertiary alluvial plains, persist to the east of Bendigo.