7. Geology and Geomorphology

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Geology

The surface geology of the study area is predominantly a complex of Lower to Middle Palaeozoic rocks, with substantial outcrop of these sedimentary, igneous, and metamorphic rock materials (Figure 7.1, 7.2, Plate 7.1). Figure 7.1 indicated the major structural lineaments of the area derived from satellite image interpretation. Figure 7.2 is a very generalised geological map, with an insect showing the main structural subdivisions. The study area lies across three major tectonic units of the Lachlan Geosyncline (part of the Tasman Geosyncline) – the Heathcote Axis (or High), the Melbourne Trough, and the Mount Wellington Axis (High), (see inset to Figure 7.2). It includes essentially continuous record of sedimentation from the Cambrian to the Lower Devonian. A basement of Cambrian to Middle Devonian marine sediments has been folded, faulted and subjected to igneous activity in the Late Devonian. This activity included massive outpourings of volcanics, cauldron subsidence, and the intrusions that form the Marysville Igneous Complex. Other large granodioritic and granitic plutons intruded at that time were at Cobaw, Strathbogie and Mount Disappointment. Upper Devonian to Lower Carboniferous sediments and volcanics then accumulated in the far east of the study area under non-marine conditions. The Palaeozoic formations have strong linear structures both internal and external to the rock complex, such as bedding planes, fold axes, fault lines, cleavage and joint planes. These structures are often clearly evident in the present-day topography as long straight stream channels (Plate 7.2), and as parallel or arcuate ridge and valley systems (Figure 7.1, Plate 7.3).

Plate 7.1 Boulder-strewn surface of the Cobaw Granite near Tooborac.

The Mesozoic Era and early Tertiary Period were times of erosional activity, but in the Miocene a new epoch of volcanic activity commenced that effected the west of the area, and continued intermittently into the Pleistocene. Tectonic activity since the late Palaeozoic caused uplift and initiated the development of erosion surfaces that persist at various elevations.

There is considerable published literature that includes aspects of the geology and structure of the study area. Crook and Powell (1976), and Spencer-Jones and VandenBerg (1976) discuss the structure and evolution of the Tasman Geosyncline in Victoria, and there are detailed papers by several authors discussing aspects of the study area in the volume edited by Douglas and Ferguson (1976). Other major works that deal with stratigraphy and structure are: for the western section (Ballarat Trough and Heathcote Axis), Harris and Thomas (1938), Thomas and Singleton (1956), and Talent and Thomas (1973); for the central section (Melbourne Trough), Hills and Thomas (1954), Williams (1964), VandenBerg and Schleiger (1972), VandenBerg (1973), Garratt (1983); and for the eastern section, VandenBerg (1977), and Marsden (1973). The Cobaw igneous rocks are discussed by Stewart (1966), the Strathbogies by White (1954), the Mount Disappointment intrusion by Williams (1964), and the large Marysville Igneous Complex by Hills (1929, 1932, 1959).

The geology of the entire region is mapped at 1:250,000 scale on the Melbourne, Warburton, Bendigo and Wangaratta sheets, but published larger scale mapping is uneven. The available maps are the

Kinglake, Sunbury, and Jamieson 1:63,360 sheets, Quarter sheets 2, 3, 4 and 6 at 1:31,680 which cover the Kilmore area, and Parish Plan 93 (Lancefield).

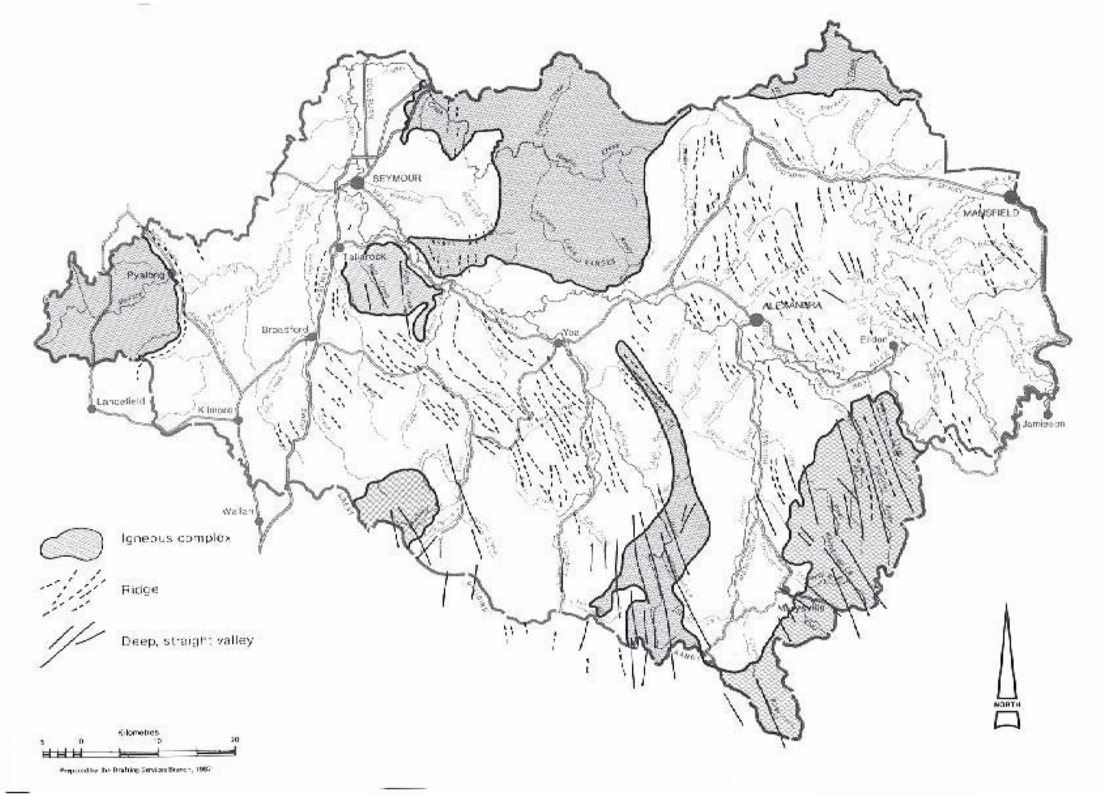


Figure 7.1 Major structural lineaments (ridges and deep straight valleys) plotted from LANDSAT image.

Stratigraphy and structure

The oldest rocks are Cambrian lavas and unfossiliferous shales at Mount William, overlain comformably by Ordovician sediments. In the major central part of the study area (the Melbourne Trough), the succeeding Silurian to Lower Devonian sediments are over 7,000 metres thick, and, with the exception of beds in the Cathedral Range, are entirely of marine origin. The sedimentary rocks were folded and faulted in the Tabberabberan Orogeny which ended the long period of marine deposition in the Melbourne Trough. The style of deformation of the Palaeozoic sediments differs east and west of the Heathcote Axis. West of the axis, the Ordovician is deformed into anticlinoria and synclinoria with tight folding and development of slates, while the Siluro-Devonian of much of the Melbourne Trough has more open, regularly spaced simple anticlines and synclines, and slaty cleavage is less developed indicating a lower degree of deformation. Structures in the trough become more complex east of Yea across the Mount Easton Axis to the Mount Wellington Axis.

Plate 7.2 Joint-controlled stream channel (tributary of Stewart Creek) on the Strathbogie Granite.

Cambrian

The Cambrian rocks are altered basic volcanics and black shales, which outcrop along a narrow, faulted belt, in the Mount William Range east of Lancefield known as the Heathcote Axis. This Axis is a major structural and stratigraphic boundary in the Lachlan Geosyncline, as it separates the Ordovician sediments of the Ballarat Trough (to the west) from the Siluro-Devonian sequence of the Melbourne Trough to the east. The eastern boundary of the Cambrian rocks is a fault with high angle reverse movement, that brings the Cambrian Mount William Group abruptly against Middle to Upper Silurian sediments. The contact is mostly masked by Newer Volcanic lavas, alluvium, and slope wash along the valley of Back Creek. Just north of Mount William, the Cambrian beds are truncated by the intrusions of the Cobaw massif, the sequence reappearing 19 kilometres to the north at Tooborac.

Silurian-Devonian

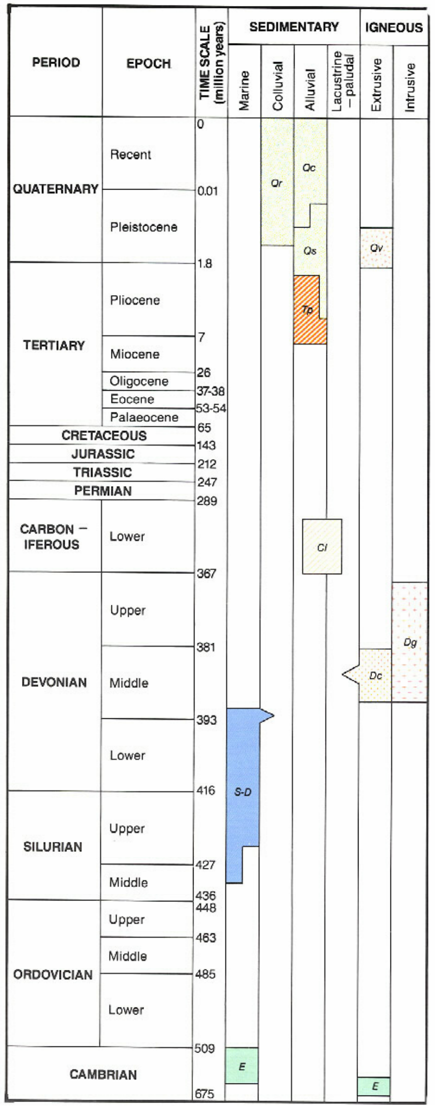
The most widespread sedimentary rocks of the study area (with outcrop from west of Kilmore to Jamieson) are the marine clastic sediments of the Melbourne Trough. Along the eastern and western margins of the trough, Lower to Middle Silurian sediments are exposed, but in the central region the Silurian is generally blanketed by thick siltstones of the Lower Devonian Humevale Formation. The older formations crop out only in the eroded core of structures such as the Reedy Creek and Yea anticlines. In the eastern part of the trough, a long narrow belt extending south from Bonnie Doon exposes an almost complete Silurian sequence in the faulted Mount Easton Axis. The Siluro-Devonian is subdivided on the basis of a graptolite and shelly fossil fauna, and by the plant *Baragwanathia longifolia* that occurs in the Yea Formation and the Wilson Creek Shale (Garratt 1979).

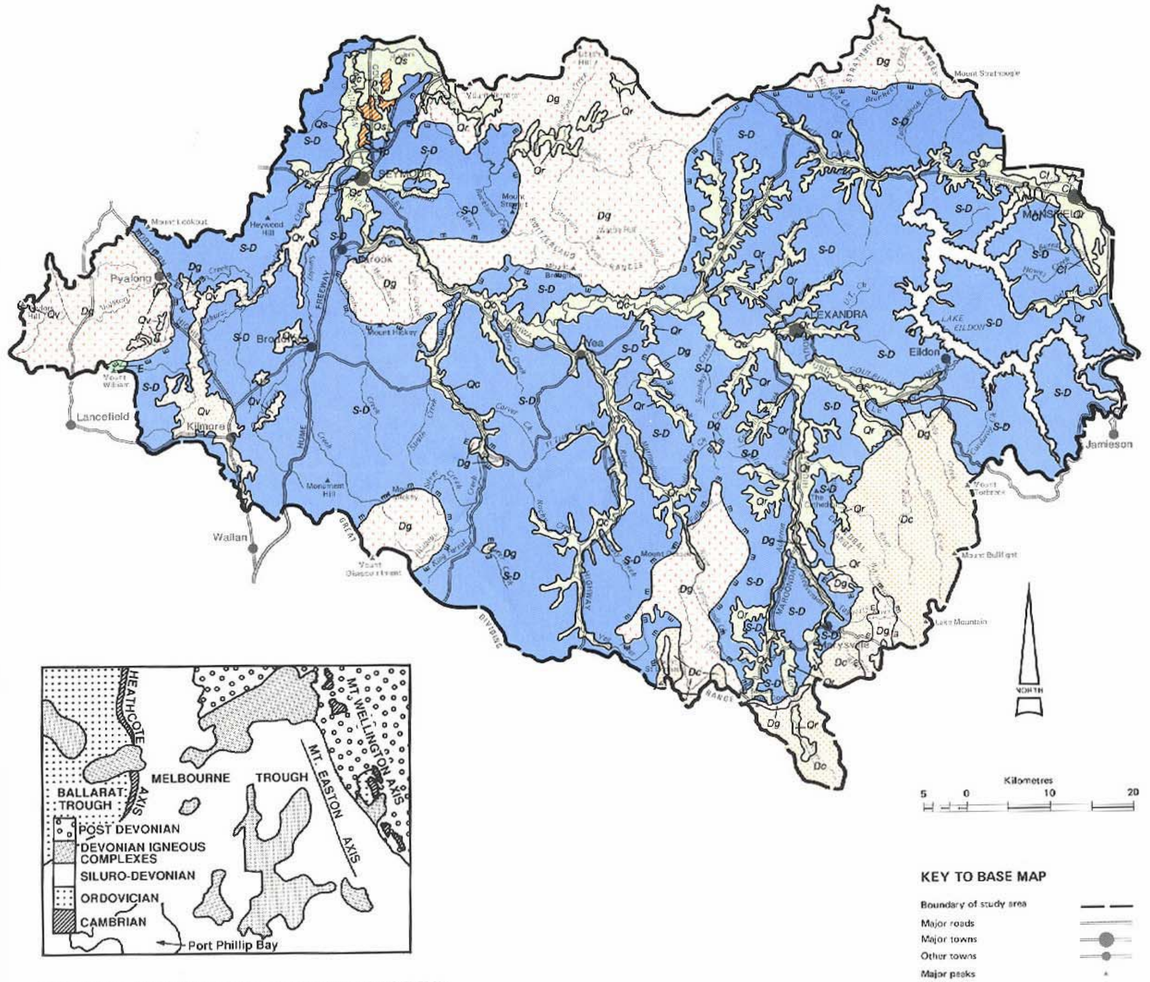
A conspicuous structural feature of the Melbourne Trough is the arcuate and persistent folds in the Silurian and Lower Devonian strata, and these have strong topographic expression between Kilmore, Broadford, Yea and Kinglake. North-east of Melbourne, the trend of this belt is 25^{o} to 30^{o} east of north, but north of Kinglake the strike of the fold axes swings through an arc of over 90^{o} to trend west north-west between Reedy Creek and Yea. Close to the Strathbogie Batholith, the fold trend again becomes more northerly (Figure 7.2).

The youngest sediments preserved in the Melbourne Trough are the Cathedral Beds, which crop out around the margins of the Cerberean Cauldron and form the conspicuous escarpment and ridge of the Cathedral Range (Plate 7.4). These are sandstones and mudstones displaying cross-bedding and ripple marks, are red-purple in colour and regarded as shallow marine or partly non-marine sediments.

Middle – Upper Devonian

The Tabberabberan Orogeny brought to an end the long period of marine sedimentation in the Melbourne Trough, and introduced a period when large granitic intrusions, dyke swarms, and complex associations of volcanics and intrusive bodies were emplaced. These include the large plutons of the Cobaw Batholith, the Strathbogie Batholith, and the smaller oval-shaped intrusion at Mount Disappointment. The Marysville Igneous Complex – comprised of the Cerberean Cauldron, the Acheron Cauldron, and the Black Range Ring Dyke – overlies and intrudes the sediments of the Melbourne Trough. This extensive igneous activity is the principal feature of the Late Devonian geological history of the study area, and the materials produced by that activity remain as major relief features of the present landscape. The cauldrons are roughly circular areas bounded by ring fractures and dykes, and traversed by faults, in which principally explosive and some effusive volcanic products have accumulated. These volcanics were derived from a shallow intruding granitic magma. The deletion of this magma allowing crustal sagging or cauldron subsidence leading to further expulsion of lavas from the resulting ring fracture. The volcanics are acidic rocks and are dominantly ignimbrites, dacites, and rhyolites, with combined thickness of up to 2,000 metres. The Archeron and Cerberean Cauldrons form distinctive dissected highland and plateau topography, the margins of the volcanics being sharply defines by escarpments.





INFORMATION DERIVED FROM THE DEPARTMENT OF MINERALS AND ENERGY
1:250,000 GEOLOGY MAP SERIES: BENDIGO, MELBOURNE, WANGARATTA AND WARBURTON

Figure 7.2 Generalised geology and structure map of the Alexandra Region. Inset shows tectonic subdivisions of the Lachlan Geosyncline.

Plate 7.3 Ridge and valley systems determined by strike of Silurian-Devonian sediments south of Yea.

Upper Devonian – Lower Carboniferous

The far eastern part of the Alexandra region encloses the western edge of the Mansfield Basin, one of the synclinal structures of the large Mount Howitt Sedimentary and Volcanic Province (Marsden 1976).

The edge of the basin is delineated by the Mansfield Fault. In the Blue Range just south of Mansfield, the Upper Devonian basal conglomerates and pebbly sandstones of the basin are succeeded by acid lavas. These are overlain unconformably by Early Carboniferous conglomerates and the distinctly coloured fine sandstone and siltstone 'red-beds'. The steep dips of this sequence at the basin margin are well displayed in the Blue Range where they form a hogback ridge. All the sedimentary materials of the Mansfield Basin are of non-marine origin.

Cainozoic

Volcanicity in the late Tertiary and early Pleistocene affected the western parts of the study area, and eruption points and lava flows are conspicuous in the Kilmore district. The earliest dated Tertiary volcanics are at Bald Hills where a radiometric age of
22.5 ± 0.1 million years was obtained (McKenzie, Nott, and Bolger, 1984). This miocene age places the lavas here in the Older Volcanics series. It is possible that other volcanic remnants east of Kilmore at Reedy Creek, Clonbinane, and Hazeldene are also Older Volcanics.

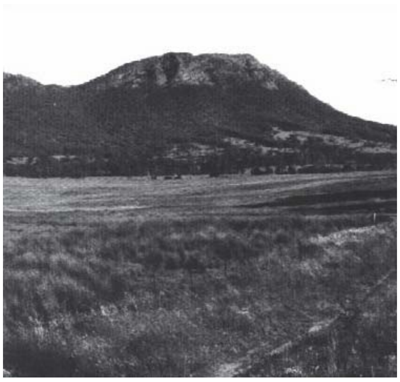


Plate 7.4 Escarpment and broad alluvial fans of the Cathedral Range.

There are numerous eruption points and lava flow remnants of Newer Volcanics in the Kilmore district, including Pretty Sally which lies right on the Great Dividing Range at the Kilmore Gap.

Colluvial and alluvial sediments have accumulated in valley floors and as foot slope deposits in the Quaternary period.

Around the plateau margins of the Cerberean and Acheron Cauldrons there are dissected boulder fan deposits, and a coalesced series of fans at the foot of the Cathedral Range has deflected the Acheron River to the western side of the valley. Flood plain alluvium is most extensive along the Goulburn, Yea, and Acheron Rivers, and King Parrot Creek. Most streams in the lowland areas are bordered by narrow often terraced floodplains (Plate 7.5).

Plate 7.5 Small terraced floodplain of Johnson Creek near Alexandra.

Geomorphology

The study area lies on and north of the Great Dividing Range, and is characterised by upland surfaces of moderate elevation that have undergone varying degrees of dissection. There are several planar surfaces readily recognised from maps, aerial and space images. The most distinctive of these are the Mount Disappointment and Kinglake Plateaux. Former planar surfaces, now dissected, are identified by a marked accordance of summit and ridge crest levels, particularly in the Yea-Strath Creek district. As in some other sectors of the Eastern Highlands, the Divide is not a dominant topographic feature, and the highest summits of the Alexandra region (Mount Torbreck 1,514 metres, Mount Bullfight 1,485 metres, and Lake Mountain 1,433 metres) actually lie inside the Goulburn catchment rather than along the Main Divide. Most of the terrain is of moderate to steep slopes, with areas of flat low plain occurring only along the floodplains of some streams. There is a close accordance between terrain variation and geology, and the boundaries of geomorphic units commonly correspond to faults, other tectonic structures, or changes in lithology. The Palaeozoic and Cainozoic igneous rocks form distinctive upland and plains topography, and strike ridges of resistant Palaeozoic sandstone are common.

Drainage networks are well-defined by long narrow-crested ridges, and sub-catchments are delineated by an irregular network of branching secondary spurs (Plate 7.6). Drainage patterns are strongly influenced by rock structure, notably strike of sedimentary beds, joining in the igneous massifs, and the edges of lava flows. Fluvial processes including slope wash, stream incision and flood plain deposition are predominant.

Landslides and rockfalls occur on rocky escarpments. Higher terrain (over 1,000 m) is seasonally effected by freeze-thaw activity, and snow-melt contributes to runoff of streams draining the south-eastern section.

Geomorphological Regions

The geomorphology of parts of the study area has been mapped by numerous authors, from the viewpoint of recognising various erosion surfaces that indicate broad stages in the evolution of the landscape (Baragwanath 1925, Hills 1934, Garratt 1973, VandenBerg 1973, 1977, and Jenkin 1976). The geomorphological classification used in this report modifies the principles and terminology used by those authors and recognises 18 mapping units (Figure 7.3). These units are composite and have been determined on the basis of elevation, slopes, local relief, spacing and pattern of stream valleys, orientation of ridge crests, and occurrence of distinctive features or processes such as a high degree of rock outcrop or an abrupt change in stream gradient.

Topographic profiles have been drawn to illustrate the form of the mapping units (Figure 7.4). All profiles are to the same scale with the same degree of vertical exaggeration.

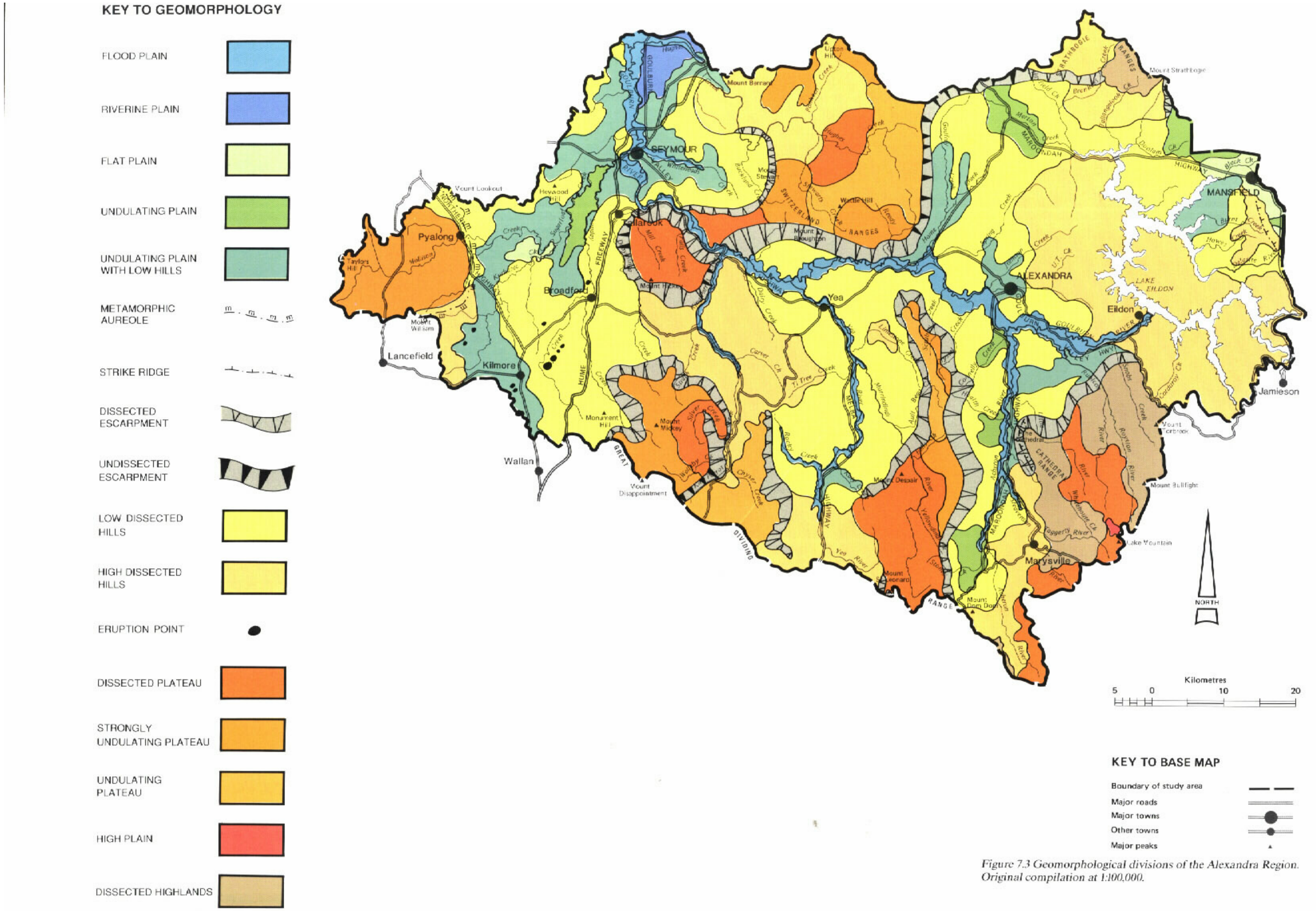


Figure 7.3 Geomorphological divisions of the Alexandra Region. Original compilation at 1:100,000.

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