

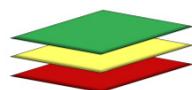


SITES OF GEOLOGICAL AND GEOMORPHOLOGICAL SIGNIFICANCE IN THE VEAC CENTRAL WEST INVESTIGATION AREA

A report to the Victorian Environmental Assessment Council

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DISCLAIMER

Information contained in this report is correct as far as possible within the scope of the project and at the time of writing. It can be used to inform management practice or project design criteria, but is not intended for specific engineering design.

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Cover picture:

Google Earth image of the Landsborough Ridge and Site SR021 (the Landsborough Hill cutting) 32 km west-north-west of Avoca, Victoria.

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Executive Summary

This document, and the accompanying spreadsheet (*VEAC Central West Geoheritage.xlsx*) and geospatial file (*VEAC Central West Geoheritage FINAL.kmz*) comprise a report on the known geoheritage in the VEAC Central West investigation area (public lands within defined areas around Mt Cole/Pyrenees, Wombat/Macedon, and Wellsford). This is a desktop study based on existing registers from the Geological Society of Australia (Victorian Division Heritage subcommittee), the Australian Heritage Commission and the Victorian Geological Survey.

Within the defined areas, this investigation finds no sites of international importance, one site of national level significance, 13 state-level sites, 29 regional-level sites, 20 sites of local significance, and a destroyed site located on public land.

The state- and national-level sites are summarised in Table 1, and their locations shown in Fig. 1.

Geoheritage includes both geology and geomorphology. The sites identified in the examination area include either or both aspects of geoheritage, for example The Camel's Hump (ML 003), which is an unusual volcanic landform whose shape is derived from its high-viscosity lava chemistry; the site has good outcrop containing uncommon amphibole minerals and a conspicuous weathering pattern of vertical cooling joints. Other valuable attributes of sites identified in this investigation include excellent exposures of uncommon or scientifically important rock sequences, fossils, an unusual development of karst in granitic lithologies, and mineral springs charged by carbon dioxide outgassed from the late Cainozoic new volcanics.

Management information for each site is provided in the spreadsheet. Broadly, effective management of geoheritage in the investigation area involves:

1. Recognition that geological and geomorphological heritage is valuable and should (like other kinds of heritage) be protected;
2. valued geological outcrops should be protected from revegetation, rehabilitation, or on-ground works that compromise heritage values;
3. valued outcrops and landforms should not be compromised by inappropriate development or poorly-placed infrastructure, and should be protected from damaging types or levels of visitation;
4. resources should be protected from over-use;
5. explanatory signage should contain correct and up-to-date geological and geomorphological information.

During this investigation, a broader issue was identified: the existing geoheritage database lacks a field for coordinate datum; the existing coordinates are likely to be a mixture of map grid systems, in some cases leading to a possible location error of up to 200 m.

Table 1 Sites of national or state levels of significance.

ID	Name	Investigation area	Significance level	Site Description	Significance statement
ML 014	Hanging Rock trachyte volcano	Wombat	National	A late Cainozoic volcanic mamelon of solvsbergite (Soda-trachyte) forms a prominent landscape feature in the region. Erosion controlled by radial cooling joints in the rock has formed a pattern of radial drainage and impressive pinnacles. Wind and water erosion through weaknesses in the case-hardened exterior has resulted in caves, holes and indentations in the pinnacles. The highly viscous nature of the solvsbergite lava ensured that the volcano initially erupted as a prominent hill or mamelon, with little of the lateral movement which characterises the younger and more fluid mafic volcanics found elsewhere. When fresh the rock is greenish in colour, but weathering has generally altered the colour to a grey or brown. Phenocrysts of anorthoclase are contained in a groundmass of sanidine laths, aegirine, riebeckite, arfvedsonite, cossyrite, quartz, apatite, opaques and biotite(?). Dating of Hanging Rock volcanics and adjacent similar eruption points using K-Ar methods indicates a Late Miocene age (6 Ma) placing them in the earlier phase of the Newer Volcanics, and considerably younger than the nearby Devonian volcanics (360 Ma) of the Macedon Range (ML 329) into which they were intruded.	Soda- trachyte occurs at only a small number of sites in the state (e.g. Hanging Rock, Camels Hump-ML 03, and Brock Monument-ML 02) where its extrusion has resulted in the development of steep-sided rocky hills. These volcanoes, which lie in the Gisborne/ Woodend and Daylesford areas, constitute a distinctive, small volcanic province that has affinities with provinces in the Eastern Highlands of NSW and Queensland. At Hanging Rock the impact of weathering on radial cooling joints has produced particularly impressive rock outcrops. The site is an important teaching and reference site because it illustrates the influence of lava composition on volcano form and is the best example of its type in Victoria.
BL 091	Cave Hill rock overhang	Pyrenees	State	A rock overhang in granite 200 m long and 30 m high. It is open to the southwest and is visible from the Middle Creek Camping Ground.	The best documented example of a rock overhang in granite in the State.
BL 092	Cave Hill Creek cave	Pyrenees	State	A small cave located amongst granite boulders choking a small creek. The cave is 10-15 m long and 2 m high.	This cave is significant due to its unusual location amongst granite boulders.
BL 126	No 2 Creek waterfall Pyrenees Formation	Pyrenees	State	Type locality of the Pyrenees Formation. The sandstone and mudstone beds are west dipping and west facing over 600m of outcrop in the creek. Well developed, subvertical cleavage and individual graded sandstone	Type locality of the Pyrenees Formation and an excellent and accessible site showing the complex features of the stratigraphy, structure and



				beds are up to 2.5m thick. The features include sand-rich turbidite facies, moderately to well sorted, variably rounded quartz with minor feldspar and lithic grains in quartz silt or clay matrix; medium to thick bedded; unfossiliferous; weathered to partly kaolinised.	metamorphism of the formation.
BL 128	View Point road cutting	Pyrenees	State	Type locality of the Beaufort Formation Marine turbiditic interbedded siltstone & mudstone with minor sandstone; mudstone is thin-bedded, pyritic; slightly higher regional magnetic response than other sediments; gravity response mostly moderate to high; high K, moderate to high Th, U. There is intense carbonate spotting	Type locality of the Beaufort Formation. The fine grained silts are characteristic of the formation and the site shows the complex features of the stratigraphy, structure and metamorphism present.
ML 003	Camels Hump (The)	Wombat	State	The Camels Hump lava dome (1010 m above sea level) forms a prominent feature of the Macedon Ranges and forms part of the early phase of the late Cainozoic Newer Volcanics. The structure formed when viscous soda-trachyte (solvbergite) of Miocene age (6.1 Ma) extruded through Devonian volcanic rocks and solidified into a steep sided mamelon. The conspicuous weathering pattern is greatly influenced by vertical cooling joints. When fresh the rock is greenish in colour with phenocrysts of anorthoclase, but generally it has weathered to a greyish or brownish tint. On the southern slope of the Camels Hump some of the rocks show a distinct bluish tint due to the relatively uncommon amphibole minerals riebeckite, aenigmatite and aegirine in the groundmass.	Camels Hump is one of a small group of prominent outcrops in the area derived from relatively silica-rich lavas of high viscosity that have formed distinctive domes or plugs at the vent. This site is one of the best examples of an unusual trachytic volcano found in this area of Victoria.
ML 032	Willeys quarry	Wombat	State	Willeys quarry is noted for the abundance and diversity of graptolites within Lower Ordovician slates and siltstones. It is particularly noted for its Yapeenian Zone 2 graptolites. Among the more notable forms are: <i>Dichograptus octobrachiatus</i> , <i>Tetragraptus quadribrahiatus</i> , <i>T.serra</i> , <i>Phyllograptus sp.</i> , <i>Goniograptus speciosus</i> , <i>Trigoniograptus ensiformis</i> , <i>Didymograptus v-deflexus</i> , <i>Isograptus caduceus australis</i> , <i>Pseudisograptus m.manubriatus</i> , <i>Skiagraptus gnomonicus</i> , <i>Oncograptus upsilon</i> , <i>Cardiograptus morsus</i> , <i>Maeandrograptus tau</i> .	This is the best Yapeenian fossil locality in the region and is the type locality for the species listed.



ML 071	Mount Franklin	Wombat	State	<p>Mount Franklin is a late Cainozoic Newer Volcanics scoria cone 185 m high consisting of basaltic breccia, blocks and bombs, lapilli deposits with minor basalt flows to the north. The deep crater is breached to the southeast. The predominant rock types are potassic nepheline normative hawaiites and nepheline normative mugearites. The olivine anorthoclase basalt also forms a plug in the crater where phenocrysts of anorthoclase up to 6 cm in length have been found. Crystals of olivine, anorthoclase and black augite can be found on the road inside the crater, weathered out from the tuffs and scoria. It also contains large, metasomatised mantle megacrysts. The volcano erupted towards the end of the Newer Volcanics extrusions and a K-Ar age on a hawaiite sample yielded an age of 470,000 yr BP (Wallace, 1990).</p>	<p>Well developed pyroclastic cone with an excellent view from the summit. The crater is one of the deepest in the Central Highlands area and is most important for the study of deep crustal xenoliths study.</p>
ML 085	Lerderderg Gorge	Wombat	State	<p>The gorge cuts through Ordovician beds and a nearly continuous 145 m section of Permian glacial sediments. The folded Ordovician turbidites have been weakly metamorphosed. The Permian deposits consist of tillite and glacial outwash sandstone and conglomerate, and contain ice-rafted erratics, possible mudflows and erosion surfaces (also see ML 294). North (1.4 km) of the swing (Morven) bridge is the uncommon feature of a glacial pavement cut into an earlier till by a glacial re-advance. Several sedimentary sandstone dykes intrude the tillite. Thinly bedded dark grey lacustrine (?) siltstone is a source of Permian spores.</p>	<p>Impressive gorge exposing excellent sections through Permian glacial sediments. The structure and sedimentology of Ordovician beds are also visible. An important excursion locality.</p>
ML 092	Korkuperrimu I Creek	Wombat	State	<p>A thick sequence of Permian glaciogene sediments, including tillites and fluvio-glacial sandstones and conglomerates, is exposed along the creek. The beds are faulted against Ordovician bedrock.</p>	<p>Together with Pykes Creek (ML 221) this composite section provides an excellent section through Permian glaciogene sediments. This is a classic site in Victoria' geology. Overseas researchers interested in glacial sediment and the Permian will generally visit this site when in the State. The sequence of sediments and stratigraphic relationships exposed</p>



					are important in understanding the Permian in southeastern Australia. With regard to the understanding of the Permian of northeastern Gondwana they are not as significant as the Mortons quarry outcrops (ML 91). The site is used for teaching purposes.
ML 104	Bacchus Marsh Council trench	Wombat	State	The trench ~800 m along Tramway Lane exposes cross-bedded quartz sandstone, siltstone and conglomerate. The site is rather unprepossessing, but of importance to the understanding of the reconstruction of Gondwanaland. The sediments are considered to be of freshwater origin and Triassic in age on the basis of poorly preserved plant impressions recovered from weathered yellow siltstone. The Triassic unconformably overlies Permian marine sediments. This site is one of only a handful of Triassic outcrops in Victoria presumably indicating a period of erosion, with limited sedimentation.	Triassic sedimentary exposures are extremely rare in Victoria and this is the only known locality with the only fossils of clearly Triassic age preserved.
ML 174	Hepburn Springs	Wombat	State	Mineral water springs occur in Lower Ordovician sediments. The free carbon dioxide in the waters is thought to be derived from outgassing of the late Cainozoic Newer Volcanics.	There are a number of mineral spring sites in central Victoria of the same type with a number having significant tourist values. The springs at Hepburn Springs are probably the best known in the state and are a good accessible example of this type of feature.
ML 201	Lerderderg River Permian sequence	Wombat	State	The Lerderderg River has exposed a nearly continuous 145 m section of Permian glacial sediments. A wide variety of deposits are preserved including tillite, glacial outwash sandstone and conglomerate, ice rafted erratics dropped into sandstone beds, mudflow beds and erosion surfaces. The Permian glacial sequence lies with angular unconformity on Ordovician sediments.	The glacial beds of Bacchus Marsh are part of a glacial episode that affected all of Gondwana. This site displays a wide variety of glacial depositional and erosional features. The marked unconformity in the cliffs south of the ford, provides an opportunity to compare the composition and structures of the glacial conglomerates with overlying river deposited gravels.



ML 221	Pykes Creek Permian glacial features	Wombat	State	Permian glacial tillites outcrop in the cliffs above Korjammunnip Creek (also see ML 92). At several localities, the angular unconformity of the Permian with the underlying Ordovician sediments is exposed. The contact surface on the Ordovician varies from uneven to smooth and in places there are small striations. The exposed sections are complex and extend into the parking area in the reservoir reserve. On the southwest side of the lake, Permian fluvioglacial beds faulted against steeply dipping Ordovician, are exposed in the north face of the road cutting. On the southeast the cuttings expose Permian and Tertiary sequences. The Permian consists of subaqueous outwash of a very complex nature (eastern-most cutting), and lacustrine sediments with slump deposits, rippled sandstone and other sandstone. Overlying the Permian are Tertiary gravels displaying excellent large scale cross-bedding.	These major exposures of Permian rocks show many complex features, and cuttings by the freeway are probably the most accessible Permian sections in Victoria. Within the area, the relationship with several other geological units can be seen. The glacial pavements are good examples, but unfortunately they are located in a restricted area high on a steep slope. The sequence of sediments and stratigraphic relationships exposed are important in understanding the Permian of southeastern Australia. With respect to understanding the Permian of northeastern Gondwana, the site is not as significant as Mortons Quarry (ML 91).
ML 043	Upper Coliban Dam quarry xenolith site	Wombat	Unknown	A quarry east of the road on the ridge overlooking the Coliban Dam, has exposed a flaggy trachyandesite(?) containing abundant xenoliths of gabbro and felsic gneiss. These represent the largest known suite of lower crustal xenoliths in Australia, but are as yet undescribed. Road cutting above Coliban Dam where a basaltic lava flow with abundant crystal xenoliths were exposed.	The xenolith suite has national significance because of its abundance and size. The site may be threatened by either restoration or roadworks. Note: This locality was a road cutting and quarry operated by the former CRB. It has been entirely removed. Samples and photographs of the xenoliths are in the Museum Victoria collections.



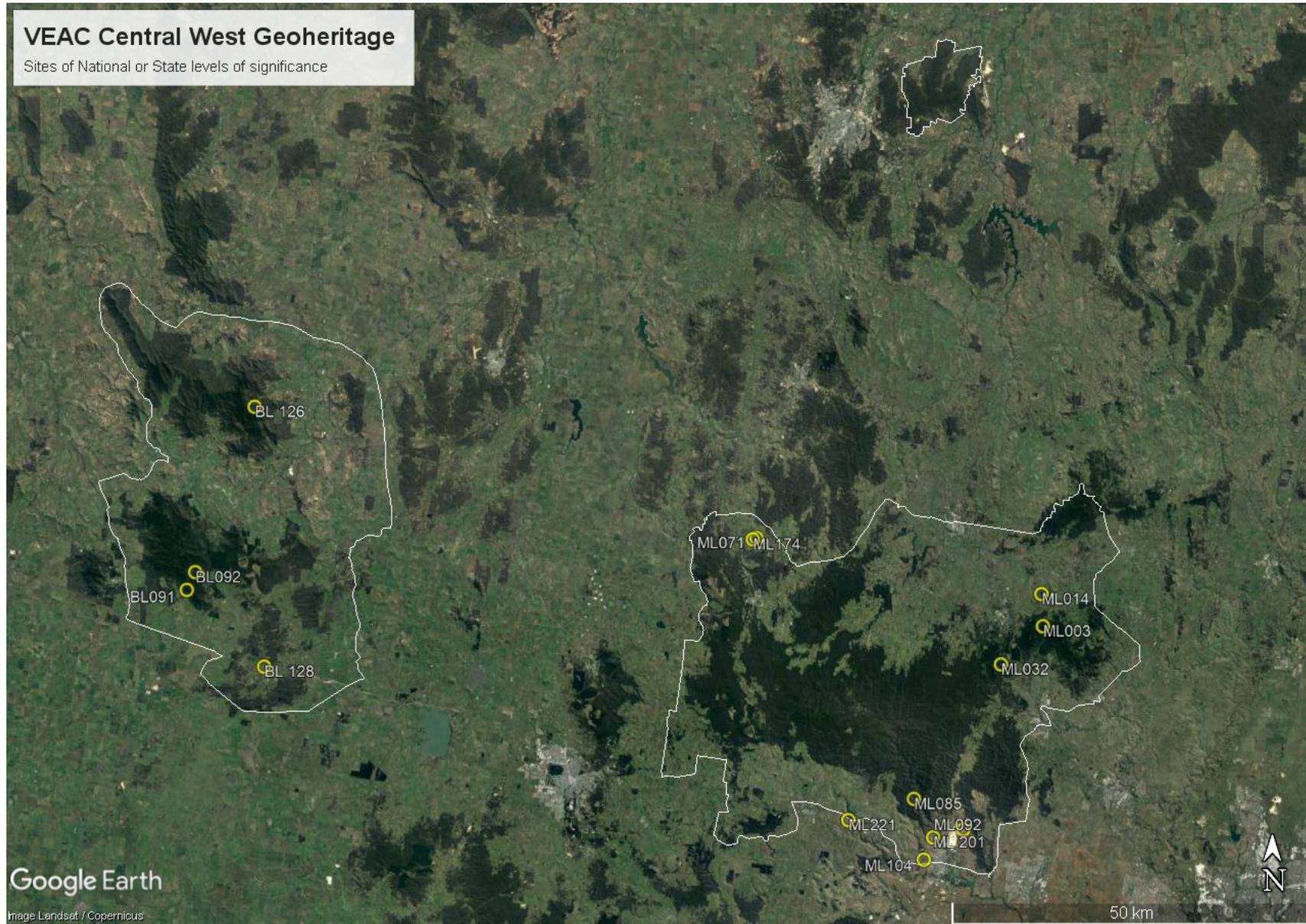


Fig. 1 Location of the VEAC Central West’s national- and state-level geoheritage sites.



1 Introduction

In 2017 Wakelin Associates was commissioned by the Victorian Environmental Assessment Council (VEAC) to compile an overview of geoheritage in the Central West Investigation area: three separate blocks (Mt Cole/Pyrenees, Wombat/Macedon, and Wellsford) (Fig. 2), focusing on public land as defined under the VEAC Act (Crown land and freehold land owned by government agencies/ departments). The project's goals were to –

- report on the geological and geomorphological sites of significance in the study area;
- compile an inventory of known sites;
- within the scope of the study, assess the significance of sites of state-level significance or greater;
- provide recommendations for conservation or management requirements for sites of state (or higher) levels of significance.

In this report, the most significant of the identified sites are listed in Table 1, and all identified sites are listed in Table 2. An expanded version of Table 2 is also supplied as a Microsoft Excel spreadsheet (*VEAC_CentralWest_Geoheritage.xlsx*). Site locations are supplied as a Google Earth file (*VEAC Central West Geoheritage FINAL.kmz*), and locations of sites with significance at or greater than state-level are shown in Fig. 1). Site numbers within this report are those of the Geological Society of Australia (Victoria) heritage database.

This is a desktop study. The sites reported here are those documented as at 1/9/17 within the registers and records of the Geological Society of Australia (Victorian Division Heritage subcommittee), the Australian Heritage Commission and the Victorian Geological Survey. Some additional sites are referred to in source material but are not presented here, as they have insufficient locational data to place their position, and/or insufficient other information with which to establish their nature, values, or significance. Examples of such sites, from Rosengren 1986 and Rosengren 1994, are Baird Hill (ML114), Bankin and Selward Hill (ML115), and Cataract Creek Falls and Basalt Columns (ML372).

1.1 Assessment of Geoheritage

Assessment of geological (including geomorphological) significance is undertaken in Victoria by the Geological Society of Australia (Victoria Division) Heritage Subcommittee. The GSA is a volunteer learned society, whose protocol for the assessment of geological significance (White et al. 2003) has been accepted by organisations such as the Australian Heritage Council. A recently-developed protocol for more complex or broad-scale assessments (White and Wakelin-King 2014) is partly based on the GSA process.

Information is reviewed from informed experience, fieldwork, literature review and consultation between geologists with specific knowledge and expertise. Discussion and consensus is a key part of assessment, especially for sites of International and National significance, where an extensive understanding of comparable sites outside Victoria is desirable. A site's significance rating is periodically reassessed in the light of new information or changes to site condition.

Geological and geomorphological significance is largely unrelated to landscape aesthetics. Some highly significant sites may be not at all aesthetic (e.g. quarry faces, road cuttings), while visually pleasing views may be of low significance. Instead, geological sites should possess at least one of the following attributes to be considered as significant:

- a type section of a geological unit
- a fossil locality
- a representative example of a geological feature or landform type
- exposure of a range of features characteristic of the rock/sediment/landform
- exposure of features unusual in the rock/sediment/landform
- an unusual occurrence of a particular feature or mineral
- an illustration of geological/geomorphic processes
- features which enable palaeoclimatic reconstruction,
- active or relict demonstration of processes of landform evolution (weathering, erosion, deposition).

In addition, sites may be considered with reference to specific criteria, such as those of the National Heritage List.

In large projects, priorities may need to be decided between an unusual place, and an excellent representative example (e.g. McRae-Williams et al. 1981, Davey & White 1986, Joyce 1996, White & Wakelin-King 2014). In this context, previous usage of the word “outstanding” in heritage assessment was ambiguous. In this report we use “unusual” for atypical or distinct features, and “outstanding” for features of excellent quality or value.

The level of geological significance is expressed in terms of spatial scale: site significance is described as being local, regional, state, national or international.

- International Significance: sites which are rare in the world, global type examples, of international scientific significance, and/or comparable with examples known internationally.
- National Significance: sites which are rare in Australia, are important nationally by virtue of their scale or state of preservation, are widely used as reference sites by the Australian geological community, or are included in the Register of the National Estate. Hanging Rock (ML014) is the only nationally-significant site in the Central West investigation area. It is an exemplary example of a type of igneous rock that is rare nationally.
- State Significance: sites which are important in defining the geology and geomorphology of Victoria, and may be reference sites or type examples; for example, sites BL126 and BL128 are the type-localities for their rock types.
- Regional Significance: these sites include landforms or geological features representative of regions of about 60 km radius; for example, Mt Blackwood (ML065) is a prominent scoria cone landform, which is an important landform in this part of Victoria.
- Local Significance: these features are representative of small areas in a region, and inform an understanding of the local area (~20 km radius), ; for example, the Cobaw road cuttings (ML185) are good exposures of the Ordovician rocks in the area.
- Sites may be of unknown significance due to lack of study, or from having been destroyed (their heritage values have been reduced); for example, the Upper Coliban Xenolith Site

(ML043) was nationally important because of its xenoliths, but it has been completely removed by quarrying.

1.2 Geological Context of the VEAC Central West Area

The geology of the VEAC Central West Investigation area is dominated by five groups of geological units. From oldest to youngest they are (Fig. 3):

- Early Palaeozoic (Ordovician to Silurian) marine sediments, which have been folded and faulted; they are part of the western Lachlan Fold Belt.
- Granite batholiths and their associated rocks which have intruded into the fold belt sedimentary rocks; these are the original source of the area's alluvial gold.
- Permian glacial and fluvial-glacial deposits.
- Triassic fluvial sediments.
- Interbedded Cainozoic sediments and basaltic (and other) volcanic rocks; these are mostly unconformable on the Palaeozoic fold belt rocks, and on or around the granite batholiths..

In the investigation area, some key geological relationships are:

- The fold belt rocks have been faulted and re-faulted over time, which has influenced landscape response to uplift. In addition, extensive structural features developed during post-Gondwana breakup (rifting between Australia and Antarctica). The structural history has shaped present-day geomorphology, especially with respect to topography and elevation.
- In the study area, there was uplift and/or outcropping of basement rocks from the post-Devonian to the early Cainozoic. Consequently, there are almost no late Palaeozoic or Mesozoic deposits; the Permian sediments are unusual, and Triassic sediments exist in Victoria only as a single small outcrop.
- During the Cainozoic, depositional land surfaces were widespread: that is, sediments were deposited and preserved from erosion. Some palaeosols are also preserved. Intermittently during this time, volcanic activity deposited basalt flows across the landscape. Consequently, the Cainozoic geological record includes places where basalts have flowed over the top of the rivers and streams of that time. Some of those ancient stream beds included alluvial gold deposits; these alluvial + volcanic gold associations are the 'deep leads' which were so important to Victoria during the gold rush times.

Summaries of Victoria's geological history are available at the websites of the Geological Survey of Victoria and the Geological Society of Australia – Victorian Division (see Reference list). A detailed central reference for Victorian geology is Birch (2003) *Geology of Victoria*; the sections on geomorphology of the Western Uplands (chapter 18.6), gold (chapter 13) and Cainozoic igneous activity (chapter 12) are especially relevant to the Central West area. Information on specific places is available from published 1:250,000 scale geological maps (available online from the Geological

Survey URL <http://earthresources.efirst.com.au/Default.asp?c=20513>) and their accompanying explanatory notes (available online from the Geological Survey Reports page URL <http://earthresources.efirst.com.au/categories.asp?cID=39>). The online mapping tool GeoVic (URL <http://earthresources.vic.gov.au/earth-resources/maps-reports-and-data/geovic>) can be used to generate the user's own specific searches and maps.

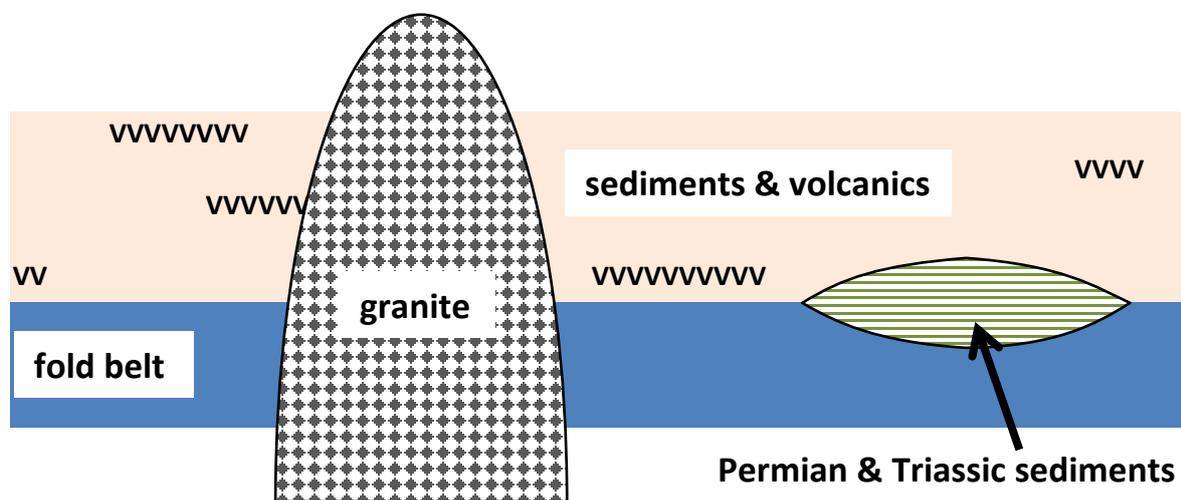


Fig. 3 Schematic stratigraphic relationships between the main lithological groups.

1.3 Geospatial Context of This Report: Wider Implications

The parameters of this report, as defined by the VEAC commission, involved compiling a spreadsheet based on the existing Geological Society of Australia (Victorian division) geoheritage database, with additions from other documents and records. The database records (including grid references) are taken as being correct. Site grid references were used to create points within the Google Earth (.kmz) file that constitutes part of this report. The datum of the Google Earth file is WGS84 (which is the native datum used by Google Earth: Google Earth does not have the option of operating in other datums). WGS84 is almost identical to the datum (AGD84) used for the Map Grid of Australia 1994 (MGA94). The points generated to display in WGS84 can be imported directly into an MGA database, especially considering that the error margin of coordinates derived from hand-held GPS or reading coordinates from a paper map is considerably in excess of the slight difference between WGS84 and AGD84.

Where information from older undigitised records was added to this report's spreadsheet, site coordinates were commonly based on AMG66. The difference between AMG66 and MGA94 is ~200 m. Consequently, the coordinates for these additional sites were recalculated to place them within WGS84.

However, it has become apparent during this process that there is no systematic record within the Geological Society of Australia (Vic)'s geoheritage database of the datum underlying the various grid references contained therein. Further, it is likely that the database contains an undocumented mixture of AGD66 and WGS84 coordinates. This is an undesirable situation for the ongoing accuracy

of site records, and will become further complicated when Australia's new datum (GDA2020) is released in 2017, and the Australian Terrestrial Reference Frame (ATRF) becomes available in 2020.

A lack of precision in site locations will be of only minor importance for many sites, e.g. where a single coordinate represents a large area, or where the site is of only local significance. However, specific location is important for some sites (for example, type-sections and -type locations).

It is a recommendation of this report that

- future entries into the Geological Society of Australia (Vic)'s geoheritage database include datum information with coordinate information;
- consideration be given to adjusting the geoheritage database to include a field for datum, and retrospectively adding that information to the existing sites;
- since the GSA (Vic) geoheritage subcommittee is a small body of volunteers and standardising the database's geospatial information is likely to be a substantial task, funding be sought to engage professional assistance with the work.

2 Geoheritage Sites in the Central West

The VEAC Central West investigation area contains one site of national level of significance: the Hanging Rock trachyte volcano (ML 014). The investigation area contains 12 sites of state-level significance:

- the Cave Hill rock overhang (BL 091)
- the Cave Hill Creek Cave (BL 092)
- the Number 2 Creek waterfall (BL126)
- the View Point Road cutting (BL128)
- the Camel's Hump (ML 003)
- Willey's Quarry (ML 032)
- Mount Franklin (ML 071)
- Lerderderg Gorge (ML 085)
- Korkuperrimul Creek (ML 092)
- Bacchus Marsh Council Trench (ML 104)
- Hepburn Springs (ML 174)
- Lerderderg River Permian sequence (ML 201)
- Pykes Creek Permian glacial features (ML 221).

Descriptions and significance statements of these sites are given in Table 1.

The investigation area also holds 20 sites of local significance, 29 sites of regional significance and a destroyed site. A summary of their locations, descriptions and values is given in Table 2. The full information for all sites is given in the spreadsheet *VEAC Central West Geoheritage.xlsx*

The existing registers also showed a small number of sites with insufficient documentation to determine their location, attributes or significance; they are not included in this report.

2.1 Site Management Issues

Effective management of geoheritage in the investigation area falls within one or more of the following concepts:

1. Recognition that geological and geomorphological heritage is valuable and can be compromised, and that geological/geomorphological information should be included in heritage registers considered in management plans. Those features that contribute to a site's geological value should be retained or enhanced rather than obscured, damaged or destroyed. An example where this has not happened is the destroyed site ML 043, the Upper Coliban Dam Quarry site, where a nationally-important suite of lower crustal xenoliths has been entirely removed.
2. In the relevant sites, prioritisation of highly-significant geological attributes over other features of lesser significance. This is especially relevant where visual aesthetics is involved. Revegetation is a common threat to good rock exposures; an example of the successful application of this concept is ML 104, the Bacchus Marsh Council Trench, where a scientifically important but visually unprepossessing outcrop of Triassic rocks has been protected from inappropriate revegetation schemes.
3. Protection of areas from overdevelopment or inappropriate development, such as housing development on valued landforms, or poorly-placed infrastructure, such as battering or shotcreting over excavated slopes which are good rock exposures, or placing explanatory signage where it obscures outcrop.
4. In the relevant sites, protection from over-use of a resource may be required. For example, Hepburn Springs (ML 174) would be diminished if its water sources were drawn down by extraction; the Bacchus Marsh Council Trench (ML 104) is the only known Victorian locality with clearly Triassic fossils, so the loss of any fossil specimens would be detrimental. Similarly, quarrying volcanics for gravel or rock rubble should not take place where it compromises heritage values.
5. Where explanatory signage is displayed, obtaining appropriate and correct advice for the geological and geomorphological components.

Details of management goals for individual sites can be found in the spreadsheet *VEAC Central West Geoheritage.xlsx*.

Table 2 Geoheritage sites in the Central West investigation area; full details in *VEAC Central West Geoheritage.xlsx*.

ID	Name	Significance level	Location	Brief Description	Significant attributes
ML 014	Hanging Rock trachyte volcano	National	Woodend	Volcanic landform, rock exposure, caves, scenic locality	Geology, geochronology, stratigraphic relationships, landform, links with national geology
BL 091	Cave Hill rock overhang	State	Raglan	Karst landform (overhang)	Unusual landform for this lithology
BL 092	Cave Hill Creek cave	State	Raglan	Karst landform (cave)	Unusual landform for this lithology
BL 126	No 2 Creek waterfall Pyrenees Formation	State	Avoca	Outcrop along creek of the Pyrenees Formation	Scientifically important (type locality)
BL 128	View Point road cutting	State	View Point	Rock outcrop along road cutting	Scientifically important (type locality)
ML 003	Camels Hump (The)	State	Woodend	Volcanic landform, rock exposure, weathering landforms	Geology, geochronology, stratigraphic relationships, landform, unusual mineralogy
ML 032	Willeys quarry	State	Macedon	Slate quarry	Scientifically important (type locality for an important suite of graptolites)
ML 071	Mount Franklin	State	Daylesford	Scoria cone with deep crater, breached	Volcanic landforms, phenocryst mineralogy, geochronology
ML 085	Lerderderg Gorge	State	Bacchus Marsh	Gorge, deep exposure of Ordovician and Permian rocks, exposed glacial pavement	Scientifically important, visually impressive, teaching locality
ML 092	Korkuperrimul Creek	State	Myrniong	Deep exposure of Permian sediments, faulted against Ordovician	Permian glacial geology, stratigraphic relationships, teaching locality
ML 104	Bacchus Marsh Council trench	State	Bacchus Marsh	Trench exposes Triassic sediments (extremely rare in Victoria)	Scientifically important sedimentary exposures, geochronology, fossils
ML 174	Hepburn Springs	State	Hepburn Springs	Mineral springs, scenic locality	Hydrology, relationships between groundwater and active volcanics
ML 201	Lerderderg River Permian sequence	State	Bacchus Marsh	River exposure of glacial sediments, features include tillite, erratic dropstones, mudflow beds, and the angular unconformity of the Permian over the Ordovician	Stratigraphy, sedimentological process relationships, palaeoenvironment
ML 221	Pykes Creek Permian glacial	State	Greendale	Cliff and creek outcrop of Ordovician,	Major exposures of important rock types,



	features			Permian and Cainozoic rocks, extensive exposure, glacial pavement	stratigraphic relationships
BL 017	Mount Lonarch amphitheatre	Regional	Amphitheatre	Natural amphitheatre created by lithologically-driven differential erosion, scenic locality	Landform, geomorphic processes, mineralogy
BL 120	Ararat water supply & road cutting	Regional	Warrak	Road cutting exposure of structural geology and sedimentary structures	Geological processes (sedimentary processes) structural geology, geological history
BL 121	Warrak-Raglan road cutting	Regional	Warrak	Road cutting exposure of turbidites	Geological processes (sedimentary processes) structural geology, geological history
BL 122	Warrak - Raglan Rd quarry	Regional	Warrak	Quarry walls expose rocks showing a number of structural geology features and metamorphic lithologies	Geological history shown in the structural geology features and metamorphic mineralogy
BL 124	Pyrenees Hwy Cutting 1	Regional	Eversley - Elmhurst	Road cutting, outcrop	Rock exposure
BL 125	Pyrenees Hwy Cutting 2	Regional	Elmhurst	Road cutting, outcrop	Rock exposure
BL 127	Beaufort Railway cuttings	Regional	west of Beaufort	Road cutting, outcrop	Rock exposure
BL 129	Donkey Hill Lead workings	Regional		Old mine	Economic geology
BL 130	Mt Cole -Eversley Road Cutting	Regional		Road cutting	Rock exposure
BN 011	Sugarloaf Range	Regional	Axedale	Sugarloaf Range, strike ridge of resistant sandstone, scenic locality	Lithologically-driven differential erosion reveals structural geology in a scenic landform
ML 024	Mount Bullengarook flow and cutting	Regional	Bullengarook	Prominent scoria cone in a plateau, possible remnant crater, basaltic flows, exposures showing bedrock blocks	Volcanic landforms, scientifically important megacryst site
ML 030	Trentham Falls	Regional	Trentham	Waterfall developed in basalt, Cliff face exposing Cainozoic volcanics and sediments	Landform processes, stratigraphic relationships between Cainozoic volcanics and sediments
ML 033	Salt Water Creek	Regional	Gisborne	Exposure of Ordovician rocks, graptolite fossils	Geochronology (reference locality)
ML 065	Mount Blackwood	Regional	Myrniong	Scoria cone and basalt flows along palaeodrainage channels	Volcanic landforms, interaction between basalt flows and palaeotopography



ML 077	Myrniong Creek and tributaries	Regional	Myrniong	Valley flows of older basalt, horizontal jointing, Permian glacial outcrops and pavements	Excellent exposures of local geology
ML 084	Lauriston Sandstone	Regional	Lauriston	Permian sandstone	Good exposure, teaching site
ML 111	Bullengarook slate quarries	Regional	Bullengarook East	Slate quarries, rejected overburden includes graptolite fossils, unusual efflorescent minerals	Fossils, mineralogy
ML 115	Golf Course Hill (Old Racecourse Hill) and quarry	Regional	Woodend	Good exposure of a particular basalt type, tuffs, lherzolites	Volcanic lithotypes
ML 197	Bullengarook basalt flow and lateral streams	Regional	Bullengarook	Twin lateral streams incising at the edges of a basalt flow. The flow is now a high lenticular plateau between the streams.	Inverted topography and stream development
ML 200	Buckley Road	Regional	Darley	Observation point for Pleistocene river terraces and the Rowsley Fault scarp	Landforms, tectonic history
ML 219	Dales Creek-Coimadai Fault	Regional	Greendale	Fault scarp, basic dyke in the fault plane	Landforms, tectonic history
ML 230	Council gravel pit (Bullengarook Gravels)	Regional	Gisborne	Quarry exposure of the Cainozoic rock	Sedimentary history
ML 231	Merrimu Gravel Member	Regional	Darley	Exposure of Cainozoic gravels	Sedimentology, example of local geology, teaching location
ML 245	Mount Wilson	Regional	Bullarto	Trachytic eruption point	Volcanic landforms, volcanic lithology, contrast with sedimentary rock landforms
ML 328	Mount Macedon	Regional	Macedon	Acid volcanics, igneous complex	Unusual rock type for the area, different volcanic chemistry produces different landforms
ML 371	Antimony Mine, Pyrete Range	Regional	Coimadai	Antimony mine in a shear zone	Mine history, mineralogy, structural geology
ML 380	The Blowhole	Regional	Hepburn Springs	Tunnel excavated along the fault zone	Best exposure of a reverse fault
ML 381	Tipperary Springs	Regional	Daylesford	Mineral spring discharging at surface	Carbonated mineral water, rare in Australia
ML 385	Upper Coliban Reservoir	Regional	Lauriston	Unconformity between glacials with erratics and overlying porphyritic glassy volcanics.	Stratigraphy
BL 034	Ben Nevis	Local	Eversly	Prominent peak, granite cliffs	Landforms



BL 035	Beaufort Western Highway cutting	Local	Beaufort	Road cutting exposing rock types	Good exposure local rock types
ML 093	Coopers quarry	Local	Darley	Quarry exposure of sedimentary rocks	Good exposure, local stratigraphy
ML 094	Alkemades quarry	Local	Darley	Quarry exposure of sedimentary rocks	Geochronology, stratigraphy, structural geology
ML 110	Sailors Creek cutting	Local	Daylesford	Road cutting exposes black shale, graptolites	Good exposure
ML 113	Lake Merrimu southern road cuttings	Local	Darley	Road cutting exposes Permian glacial sediments unconformably overlying Ordovician sediments	Lithology, stratigraphy
ML 152	Babbington Hill	Local	Daylesford	Trachyte lava dome, eruption point	Landform
ML 185	Cobaw road cuttings	Local	Cobaw	Road cutting, sedimentary rocks, graptolites, contact metamorphism	Good exposure, diversity of features, fossils, teaching site
ML 186	The Sugarloaf	Local	Newham	Low volcanic hill	Good example
ML 188	Braemar College Road cutting	Local	Woodend	Devonian rhyodacite showing spheroidal weathering	Unusual to find this rock type so well exposed
ML 189	Lily Pond	Local	Woodend	Disused quarry showing young volcanic flow and scoria	Unweathered basalt
ML 193	Cobaw Range tors	Local	Cobaw	Granite tors, scenic locality	Landform
ML 237	Little Bullengarook	Local	Gisborne	Relatively recent volcanic flows over alluvial sediments, silica-rich lithologies	Geochronology, landscape reconstruction
ML 288	Werribee River valley	Local	Blakeville	River incised into Ordovician rocks and Cainozoic basalts, cliff and road cutting exposures	Local geology and stratigraphy
ML 314	Sailors Falls	Local	Daylesford	Small waterfalls over basalt	Landforms
ML 325	Sugarloaf Hill (Spring Hill)	Local	Glenlyon	Dome-shaped eruption point	Landforms, stratigraphy, unusual rock type
ML 382	Wombat Hill Pyroclastic deposits	Local	Daylesford	Road cutting exposing basaltic pyroclastic fall	Good exposure of interesting material
ML 383	Yankee Reef Mineralisation	Local	Blackwood	Fault zone, mineralised quartz veins	Mining history, local geology
ML 384	Tunnel Point	Local	Blackwood	alkali-olivine basalt dyke with phenocrysts, xenocrysts, and xenoliths	Good exposure of a fresh dyke
SR 021	Landsborough Hill cutting	Local	Landsborough	Road cutting exposing turbidites	Good exposure



ML 043	Upper Coliban Dam quarry xenolith site	Destroyed	Upper Coliban Dam, Kyneton	Quarry exposure of trachytic rocks containing Australia's largest known suite of lower crustal xenoliths	This exposure was of national scientific significance and was never described; it has since been removed by quarrying. Museum specimens have been retained.
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References

Report References

Davey, A.G. & White, S. 1986. Victorian Caves and Karst: Strategies for Management and Catalogue. Department of Conservation, Forests and Lands; Melbourne, Victoria.

Geological Society of Australia – Victorian Division, no date. Victoria's Geology; URL www.gsavic.org/vic-geology.html. Accessed 19/10/2017.

Geological Survey of Victoria, 2015. Earth resources: geological history. Website, URL <http://earthresources.vic.gov.au/earth-resources/geology-of-victoria/geological-history>; State of Victoria, Melbourne. Accessed 19/10/2017.

Joyce E.B., with the Australian Heritage Commission and the Geological Society of Australia. Standing Committee for Geological Heritage, 1996. Assessing the significance of geological heritage : a methodology study for the Australian Heritage Commission. The Commission, Canberra.

McRae-Williams, M.S., Rosengren, N. & Kraemers S.M., 1981. Sites of geological and geomorphological significance in East Gippsland, Victoria. Environmental Studies Series (Victoria, Ministry for Conservation); no. 341.

White, S. and Wakelin-King, G.A., 2014. ESCoM, a comparative method for geoheritage assessment. Geographical Research. 52(2): 168–181; doi: 10.1111/1745-5871.12062.

White, S., King, R.L., Mitchell, M.M., Joyce, E. B., Cochrane, R.M., Rosengren N. J. and Grimes K.G., 2003: Conservation and heritage registering sites of significance. In: Birch W.D.(ed.), Geology of Victoria. Geological Society of Australia Special Publication 23. Geological Society of Australia (Victoria Division); pp. 703–711.

Field and Site References (see spreadsheet *VEAC Central West Geoheritage.xlsx*)

Archbold, N.W. 1992. Permian. In W.A. Peck, J.A. Neilson, R.J. Olds & J.D. Seddon (Eds) *Engineering Geology of Melbourne*. A.A. Balkema, Rotterdam Pp. 133-135.

Aziz-Ur-Rahman, A. & McDougall, L. 1972. Potassium-Argon Ages on the Newer Volcanics of Victoria. *Proceedings of the Royal Society of Victoria* **85(1)**, Pp. 61-69.

Beasley, A.W. 1970. Unusually Large Specimens of Topaz and Augite. *Victorian Naturalist* **87(2)**, Pp. 51-52.

Birch, W.D. 1988. Specimen Minerals. In J.G. Douglas & J.A. Ferguson (Eds) *Geology of Victoria*. Geological Society of Australia, Victoria Division, Melbourne, Pp. 482-495.

Bowen, R.L. & Thomas, G. 1988. Permian. In J.G. Douglas & J.A. Ferguson (Eds) *Geology of Victoria*. Geological Society of Australia, Victoria Division, Melbourne, Pp. 195-212.

Cas, R.A.F. & Vandenberg, A.H.M. 1988. Ordovician. In J.G. Douglas & J.A. Ferguson (Eds) *Geology of Victoria*. Geological Society of Australia, Victoria Division, Melbourne, Pp. 63-102

Cayley R.A. & McDonald P.A. 1995 Beaufort 1:100 000 map geological report. *Report of the Geological Survey of Victoria* **104**.

Chapman, F. 1927. Monograph of the Triassic Flora of Bald Hill, Bacchus Marsh, Victoria. *Memoirs of the National Museum of Victoria* **7**, Pp. 121 -155.

Coulson, A.L. 1954. The Volcanic Rocks of the Daylesford District. *Proceedings of the Royal Society of Victoria* **65(2)**, Pp. 113-124.

Crawford, W. 1939. The Physiography of the Gisborne Highlands. *Proceedings of the Royal Society of Victoria* **52**, Pp. 262-279.

Crowell, J.C. & Frakes, L.A. 1971. Late Palaeozoic Glaciation of Australia. *Journal of the Geological Society of Australia* **17**, Pp. 115-155.

Dasch, E.J. & Millar, D.J. 1977. Age and Strontium Isotope Geochemistry of Differentiated Rocks from the Newer Volcanics, Mount Macedon Area, Victoria, Australia. *Journal of the Geological Society of Australia* **24(4)**, Pp. 195-201.

- Douglas, J.G. 1976a. Triassic. In J.G. Douglas & J.A. Ferguson (Eds) *Geology of Victoria Geological Society of Australia Special Publication 5*, Pp. 143-144.
- Edwards, A.B. & Crawford, W. 1940. The Cainozoic Volcanic Rocks of the Gisborne District, Victoria. *Proceedings of the Royal Society of Victoria* **52(2)**, Pp. 281-311.
- Edwards, A.B. 1938. The Tertiary Volcanic Rocks of Central Victoria. *Quarterly Journal of the Geological Society of London* **94**, Pp. 243-320.
- Ewart, A. 1985. Aspects of the Mineralogy and Chemistry of the Intermediate-Silicic Cainozoic Volcanic Rocks of Eastern Australia, Part 2: Mineralogy and Petrogenesis. *Australian Journal of Earth Sciences* **32**, Pp. 383-413.
- Fenner, C. 1918. The Physiography of the Werribee River Area. *Proceedings of the Royal Society of Victoria* **31**, Pp. 176-313.
- Gawith, P. 1977. Geochemistry and Petrography of the Tertiary Volcanics from the Spring Hill-Tylden Area, Central Victoria. BSc (Hons) Thesis, La Trobe University (Unpubl.)
- Fisher, N. H. 1953. The Everton molybdenite mine. In A.R. Edwards (Ed.) *Geology of Australian Ore Deposits*. 5th Empire Mining and Metallurgy Congress.
- Gray, D.R., Cas, R.A.F., Clifford, B.A., Stewart, I.R. & Cowles, S. 1988. Lerderberg Gorge. In I. Clark & B. Cook (Eds) *Victorian Geology Excursion Guide*. Australian Academy of Science, Canberra, Pp. 245-253.
- Harris, W.J. & Crawford, W. 1921. The Relationships of the Sedimentary Rocks of the Gisborne District, Victoria. *Proceedings of the Royal Society of Victoria* **33**, Pp. 39-78.
- Hills, E.S. 1940. *Physiography of Victoria (3rd Edn)*. Whitcombe & Tombs, Australia.
- Hills, E.S. 1975. *Physiography of Victoria (5th Edn)*. Whitcombe & Tombs, Australia.
- Jacobson, R & Scott, T.R. 1937. The Geology of the Korkuperrimul Creek Area, Bacchus Marsh. *Proceedings of the Royal Society of Victoria* **50(1)**, Pp. 110-156.
- Joyce, E.B. & King, R.L. 1980. *Geological Features of the National Estate In Victoria*. Geological Society Of Australia, Victoria Division, Melbourne
- King, R.L. 1985. Explanatory Notes on the Ballarat 1:250 000 Geological Map, *Geological Survey Of Victoria Report 75*.
- King, R.L. 1990a. Geological Features on the Ballarat 1:250 000 Sheet. *Geological Survey Victoria Unpublished Report 1990/8*.
- King, R.L. 1990b. Geological Features on the Bendigo 1:250 000 Sheet. *Geological Survey Of Victoria Unpublished Report 1990/6*.
- King, R.L. 1990c. Geological Features' on the St Arnaud 1:250 000 Sheet. *Geological Survey Of Victoria Unpublished Report 1990/7*.
- Lawrence, C.R. 1969. Hydrogeology of the Daylesford District with Special Reference to the Mineral Springs. *Underground Water Investigation Report 12*, Department of Mines, Victoria.
- Mahony, D.J., 1931. Alkaline Tertiary Rocks near Trentham and at Drouin, Victoria. *Proceedings of the Royal Society of Victoria* **43**, Pp. 123-129.
- Mahony, D.J. 1937. Glacial Deposits of Victoria, *Records of the Geological Survey of Victoria* **5**, Pp. 513-520.
- McKenzie, D.A., Nott, R.J. & Bolger, P.F. 1984. Radiometric Age Determinations. *Geological Survey of Victoria Report 74*.
- McLaurin, A.N. 1976. The Yapeenian (Upper Lower Ordovician) Succession in Central Victoria, Australia. *Proceedings of the Royal Society of Victoria* **88**, Pp. 23-30.
- Mines Department 1949. *Victorian Building Stones*. Special Report of the Geological Survey of Victoria, Mines Department.
- Mitchell M. M., Cochrane R. M. & King R. L. 2000. Sites of geological significance in the Melbourne 1:2,50 000 mapsheet area. *Geological Survey of Victoria Technical Record 2000/1*.
- Moors. H.T. 1968. An Attempted Statistical Appraisal of the Graptolite Fauna of Willey's Quarry, Victoria, Australia. *Proceedings of the Royal Society of Victoria* **81**, Pp. 137-141.
- Nicholls I. A., Greig A. G., Gray C. M. & Price R. C. 1993. IAVCEI General Assembly Canberra, September 1993. Pre-conference field trip A-4 excursion guide: Newer Volcanics Province—basalts, xenoliths and megacrysts *Record of the Australian Geological Survey Organisation 1993/58*.
- Norris, N.D. 1977. The Geology and Igneous Petrology of the Trentham Area. BSc (Hons) Thesis, University of Melbourne (Unpubl.).

- O'Brien, P.E. 1986. The Permian Glacial Sediments of Central Victoria and the Murray Basin-Their Sedimentology and Geochemistry. PhD Thesis, University of Melbourne (Unpubl.).
- O'Hanlon, E.M. 1975. A Petrographic and Geochemical Study of the Devonian and Tertiary Volcanics of the Macedon District, Central Victoria. BSc (Hons) Thesis, La Trobe University (Unpubl.).
- Ollier, C.D. 1967. Landforms of the Newer Volcanic Province of Victoria. In J.N. Jennings & J.A. Mabbutt (eds) *Landform studies from Australia and New Guinea*. Australian National University Press, Canberra, pp. 315-339.
- Price, R.C. Gray, C.M., Nicholls, I.A., & Day A. 1988. Cainozoic Volcanic Rocks. In J.G. Douglas & J.A. Ferguson (Eds) *Geology of Victoria*. Geological Society of Australia, Victoria Division, Pp. 439-440.
- Roberts, P.S. 1984. Explanatory Notes on Bacchus Marsh and Ballan 1:50 000 Geological Maps. *Geological Survey of Victoria Report 76*.
- Roberts, P.S. 1985. *Bacchus Marsh 1:50 000 Geological Map*. Geological Survey of Victoria.
- Roberts, P.S. 1988. Bacchus Marsh. In I. Clark & B. Cook (Eds) *Victorian Geology Excursion Guide*. Australian Academy of Science, Canberra, Pp. 213-223.
- Rosengren, N.J. 1986. *Sites of Geological and Geomorphological Significance in the Western Region of Melbourne*. Dept Of Conservation, Forests & Lands, Victoria.
- Rosengren N.J. 1994. *Eruption points of the Newer Volcanics province of Victoria: an inventory and evaluation of significance*. National Trust of Australia (Victoria) and Geological Society of Australia, Victoria Division, Melbourne.
- Rosengren, N.J. & Joyce, E.B. 1997. Geological Heritage Of The Box-Ironbark Study Area: A Report for the Land Conservation Council of Victoria and the Australian Heritage Commission. 5th June 1997 (Unpublished Report)
- Selwyn, A.R.C 1868. A Descriptive Catalogue of the Rocks Specimens and Minerals in the National Museum Collected by the Geological Survey of Victoria, Pp. 24-25.
- Singleton, O.P., 1973a. Geology and Petrology of the Macedon District. In J. McAndrew & M.A.H. Marsden (Eds) *Regional Guide to Victorian Geology* (2nd Edn). School of Geology, University of Melbourne, Pp. 90-99.
- Singleton, O.P. 1973b. Geology of the Bacchus Marsh District. In J. McAndrew & M.A.H. Marsden (Eds) *Regional Guide to Victorian Geology* (2nd Edn). School of Geology, University of Melbourne, Pp. 59-64.
- Skeats, E.W. & Summers, H.S. 1912. Geology and Petrology of the Macedon District. *Geological Survey Of Victoria Bulletin 24*.
- Smarkman, R 1992. The Woodend-Mt Macedon District: A Study in Mineralogy and Geochemistry. BSc (Hons) Thesis, Monash University (Unpubl.).
- Stewart, A.J. 1966. The Petrography, Structure and Mode of Emplacement of the Cobaw Granite, Victoria. *Proceedings of the Royal Society of Victoria 79(2)*, Pp. 275-318.
- Thomas, D.E. & Singleton, O.P. 1957. The Cambrian Stratigraphy of Victoria. In A.A. Opik (Ed) *The Cambrian Geology of Australia*. Bureau of Mineral Resources, Geology & Geophysics Bulletin **49**, Pp. 149-163.
- Ulrich, G. 1866. *Quarter Sheet 15 SE Geological Map*. Geological Survey Department, Victoria.
- Wallace, D.A. 1990. Petrology and Geochemistry of the Newer Volcanics of the Western Highlands of Victoria, Australia. MSc Thesis, La Trobe University (Unpubl.).
- Webb, J. A. & Mitchell M, M., Stratigraphy and palaeoflora of the Triassic Council Trench Formation, central Victoria. *Proceedings of the Royal Society of Victoria* 118 (1): 113–127.
- Wellman, P. 1974. Potassium-Argon Ages on the Cainozoic Volcanic Rocks of Eastern Victoria, Australia. *Journal of the Geological Society of Australia 21*, Pp. 359-376.
- Wilkinson, H.E., 1977. Notes for the Heathcote portion of Excursion B, Geological Society of Australia Convention, February 1977. *Geological Survey of Victoria Unpub. Report 1977/25*
- Williams, W. 1988. Castlemaine. In I. Clark & B. Cook (Eds) *Victorian Geology Excursion Guide*. Australian Academy of Science, Canberra, Pp. 273-288.
- Willman, C.E, Bibby, L.M., Radojkovic, A.M, Maher, S., Haydon, S.J., Hollis, J.D., & Osborne, C.R., 2002. Castlemaine 1:100 000 map area geological report. *Geological Survey of Victoria Report 121*.
- Yates, H. 1954. The Basalt and Granite Rocks of the Ballarat District. *Proceedings of the Royal Society of Victoria 66*, Pp. 63-102.