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Volcano Tourism in the New Kanawinka Global Geopark of Victoria and SE South Australia

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Introduction

Landforms due to volcanism have been constructed during all phases of the Earth's history, and subjected through time to erosional processes which have modified the original landforms. Volcanic features are in large part constructional but sit on earlier landscapes which have often influenced cone-building, ash deposits and lava flows; for example, existing valleys may often control lava flows.

There is an increasing tendency to include volcanoes in both natural protection areas, and in tourism, wherever they exist in significant numbers or as measured by activity. The actual mechanism to achieve this is increasingly a variant of the national parks that are found in virtually all countries across the Globe. Australia's first geopark is on the broad Western Plains of Victoria and the adjacent part of south-eastern South Australia in the south of the country, and this includes some 100 well-studied volcanoes ranging in age from five million years to just a few thousand years old.

Classifying volcanic landforms

A system of classification of landforms due to volcanic processes provides a necessary starting point for any discussion of volcanic features, and this should also be followed by a further classification of the effects of erosional processes through time. Volcanic landforms are mainly *constructional*, produced by processes, which have built up deposits on pre-existing landscapes. Some are *destructional*, for example, maar craters formed by phreatomagmatic explosions often extend below the original ground surface, and may expose underlying rock in their inner walls. Calderas are generally destructional, collapsing over subsurface spaces formerly occupied by ascending magma. Erosional processes are responsible for post-eruption landform changes, and a sequence of changes over time (a chronosequence) in landforms, weathering, soils and drainage development can be used to estimate the time which has passed since volcanic activity occurred and so help in estimating the possibility of future eruption (Joyce, 2005).

A further level of classification of volcanoes and their deposits is provided by the chemical composition of the ascending magma, which directly influences the violence of eruption, and thus the landforms constructed. Magma compositions may range from basalt (basic magma), giving mild eruptions with generally small volcanoes and extensive mobile flows, to rhyolite and andesite (acid magma), giving violent eruptions and over long periods of time constructing large volcanoes, with little lava flow but possibly extensive ash deposits including ignimbrite sheets,

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and at the eruption points perhaps large collapse calderas.

Two classifications of types of eruptions and related landforms, based on several textbooks, are given in Tables 20.1 and 20.2.

It can be argued that detailed classifications such as these are not the best way to approach the study and description of volcanic features, when the audience may include mostly non-geologists. A simple geological and geomorphological scheme of classification may be better, leaving more scope for discussions of non-geological cultural heritage, including historic, artistic, aesthetic and other values, which may be of equal or greater interest to many of the visitors to volcanic areas.

The classification into eight types of eruptions (Table 20.1) can be simplified into just two main groupings of *small* and *large* volcanoes – that is, based on the size of the landform constructed at the eruption point. Small and large volcanoes often have other differences, which can be characterized by the amounts and types of lava and ash produced, which are in turn related to their chemical composition. The discussion which follows deals with small volcanoes, which are more directly relevant to geoparks.

Small (monogenetic) volcanoes

Numerous small scoria (cinder) cones, characterized by Strombolian/Hawaiian activity, broad but low elevation lava shields, explosive maar craters, and associated and often long basaltic flows, 65km or longer, following pre-existing slopes and river valleys, are characteristic of monogenetic (single episode of activity) volcanoes. A single magma type, generally basalt, predominates in the activity, which may continue over millions of years, with many short-lived individual volcanoes scattered with a high density across a broad area; the volcanism is often termed 'areal' or 'polyorifice' to describe the regional distribution.

Table 20.1 A classification of volcanic activity and landforms

Type	Magma	Flows and explosivity	Landforms
Icelandic	Basic, low viscosity	Thick extensive flows from fissures, weak explosivity	Lava shields and lava plains, with cones along fissures
Hawaiian	Basic, low viscosity	Thin extensive flows from central vents, weak explosivity, but sometimes water-generated phreatic explosions	Broad lava domes and shields, and long lava flows, fed by internal lava tubes, sometimes scattered scoria cones, spatter cones, maar craters and tuff rings, built up by lava fountains, i.e. areal volcanic activity
Strombolian	Moderate viscosity; mixed basic and acid	Flows often absent, weak to violent explosivity	Cinder (scoria) cones with shallow craters and short flows; sometimes more extensive lava flows, scattered scoria cones, spatter cones, maar craters and tuff rings, built up by lava fountains, i.e. areal volcanic activity
Vulcanian	Acid, viscous	Flows often absent, moderate to violent explosivity	Ash cones, explosion craters
Vesuvian	Acid, viscous	Flows often absent, moderate to violent explosivity	Large cones built up of alternating ash and lava, i.e. stratovolcanoes, extensive ash fall, explosion craters and large collapse calderas
Plinian	Acid, viscous	Flows may be absent, very violent explosivity	Widespread pumice and ash deposits
Pelean	Acid, viscous	Domes and/or short very thick flows, nuées ardentes, moderate explosivity	Domes, spines, ash and pumice cones, ash flows forming ignimbrite plains and plateaus
Krakataun	Acid, viscous	No flows, cataclysmic explosivity	Large explosion caldera

Source: Based on Ollier, 1969 and Gray, 2004; from Joyce, 2009

Table 20.2 Four types of volcanic landforms

Types of landforms	Landforms and morphogenesis	Examples
Constructional volcanic landforms	• volcanic cones, shields, domes and spines • central, fissure or areal in extent • with or without craters and calderas • large to small in height, and in crater diameter and depth • single or multiple landforms; nested or parasitic • characterised by their shape and slope angle	Paricutín in Mexico, with several cones and craters, steep scoria (cinder) slopes, airfall ash deposits and extensive blocky to aa lava flows.
Original constructional volcanic landforms affected by subsequent erosion	• erosion by water, wind and ice • mass movement including landslides, and mudflows (lahars) • development of radial drainage, and perhaps parasol ribbing and planezes • wind erosion forming yardangs	Exposure of volcanic necks (Le Puy-en-Velay in France), dykes (Ship Rock, New Mexico), dyke swarms (Iceland) and sills (the Whin Sill of Northern England).
Lava flows	• original flow surfaces including pahoehoe and aa flow surfaces; (the names come from Hawai'i) • flow ridges and tumuli due to flow pressure, as well as flow collapses • formation of lava channels and lava caves (lava tubes) • tree moulds • pillow lavas when flows enter water or travel over wet ground • flows channelled down valleys • burial of alluvial sediments – buried alluvium deposits containing gold, tin or other minerals are known as deep lead or placer deposits • littoral cones and lava deltas built where flows enter seas and lakes • plateau surfaces formed as streams lateral to flow edges erode valleys, causing inversion of relief • waterfalls at plateau edges, often showing exposures of columnar jointing • extensive and often thick piles of basaltic lava formed from flood basalts, apparently rapidly and catastrophically emplaced • flow landforms, like cones, can be degraded by later weathering and erosion	Lava flows of Hawai'i, lava deltas of Taveuni Island in Fiji, flood basalts of the Deccan Traps of India. Plateaus, waterfalls, columnar jointing of the Newer Volcanic Province of South-eastern Australia.
Ash falls and ash flows	• airfall mantle bedding • phreatomagmatic base surge deposits • ash flows (nuée ardente) • ignimbrite plains and plateaus	

Source: Joyce, 2009

Such monogenetic, areal basaltic fields are widely distributed across the world, largely as intraplate volcanism (i.e. volcanism away from plate boundaries). Well-studied examples include the Auckland region of New Zealand, the Eifel area in Germany, the Newer Volcanic Province of south-eastern Australia, the Auvergne region of south-eastern France, and the Rift valleys of East Africa and Ethiopia. Other areas include China, Korea, Mexico, south-west United States, north-eastern Spain, Armenia, western Hungary and southern Slovakia. Similar examples of monogenetic volcanic activity can often be found superimposed on areas of current large-scale volcanism, such as Hawai'i and Iceland.

Geoparks and volcanic regions

Some 48 geoparks are currently listed by UNESCO but of these so far only 4 are volcanic, and are mostly based on small monogenetic volcanoes. The numbers of nominations for geopark status is growing rapidly, and given UNESCO's recent indication of increasingly limited potential for further inscriptions of volcanic sites on the world heritage list, volcanic sites will probably be important in any future geopark nominations. In this regard, six new volcanic geoparks have been listed in China, including Wudalianchi, last active in 1721 (Dowling and Newsome, 2006, p150). Other recently listed or proposed global geoparks with volcanic values include the Giant's Causeway (Ireland), and the Vulkaneifel in Germany (Frey et al, 2006).

In Australia the new Kanawinka Global Geopark is part of the extensive Newer Volcanic Province of south-east Australia. Significant geological features and sites have been documented over many years in the Newer Volcanic Province, including the internationally significant lava caves (Joyce and Webb, 1993), and a review of the main eruption points has been documented (Rosengren, 1994), sponsored jointly by the Geological Society of Australia and the National Trust (Victoria). Equally, the Llancanelo and Payun Matrú Volcanic Field together with about 800 small mafic volcanoes near Malargüe, Mendoza (Argentina) is one of the volcanic fields on Earth that have the highest density of volcanoes. This field is suggested as a potential candidate for a UNESCO geopark, and would be one of the first in South America (Risso et al, 2006).

Geoparks, with their allowable large extent, and associated human and cultural values, fit well with the features of small (monogenetic) volcanic fields. In contrast large (strato) volcanoes are often more localized, and often sparsely settled, and may already be part of a park or reserve, and so fit best with world heritage requirements. Any analysis of possible world heritage volcanoes, and possible global geopark volcanoes, would probably suggest that this division between large and small volcanoes is a good approach in planning future volcanic heritage reserves.

The young volcanoes of south-eastern Australia

Extensive volcanic areas, both old and young, are features of the Australian landscape, with Quaternary monogenetic (single short-lived eruption) scoria cones, lava shields and flows, and maar craters with ash deposits, found in south-eastern Australia (Figure 20.1) and also in north-east Queensland. The young volcanic regions of south-eastern Australia, known as the Newer Volcanic Province, occupy broad coastal plains, and an elevated upland to the north of the plains. Beginning about 6–7Ma ago, but mainly since 5Ma, a new volcanic province was formed, and nearly 400 small, monogenetic scoria cones, maars and lava shields were built up by Strombolian/Hawaiian eruptions (Nicholls and Joyce, 1989).

In 1866 the large maar volcanic crater of Tower Hill in western Victoria was set aside as a public park, and in 1892 state legislation was passed which made the Tower Hill volcano Victoria's first national park. Significant geological features and sites in the Newer Volcanic Province were first discussed in Joyce and King (1980). A review of the main eruption points, sponsored jointly by the Geological Society of Australia and the National Trust (Victoria) was published in 1994 (Rosengren, 1994). Some of the other National Trust classified landscapes in western Victoria include Mt Elephant, Tower Hill, Mt Leura, Lake Purrumbete, Lake Gnotuk and Lake Bullen Merri (Figure 20.2), Lake Keilambete, and the Stony Rises and Mt Porndon. Other landscapes

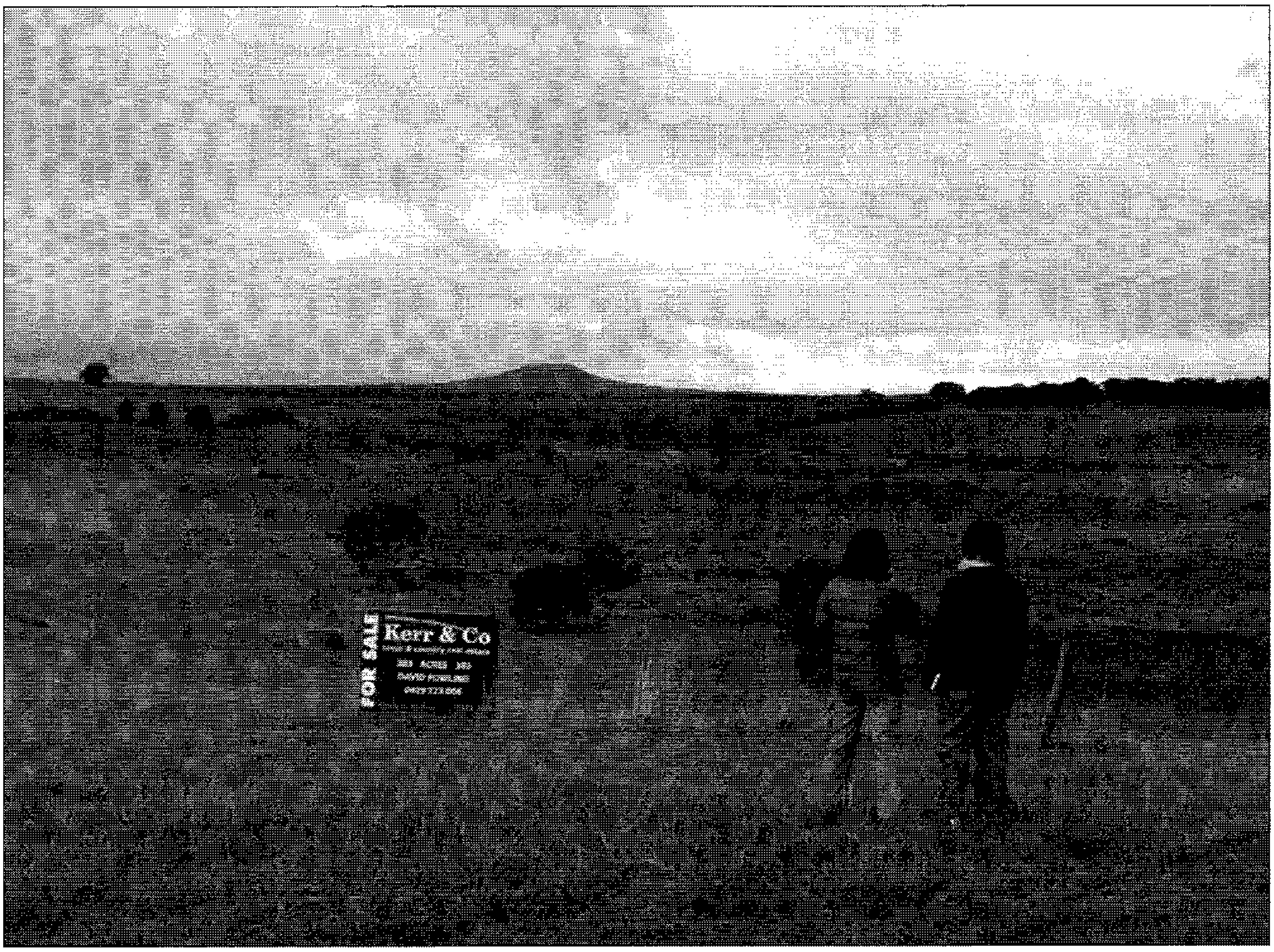

Figure 20.1 Mt Napier lava shield, south of Hamilton, looking down on the well preserved young stony surfaces of the Byaduk valley flow from Mt Napier lava shield, in the Kanawinka Geopark, Western Victoria. The youthful flow surface was damaged by rock crushing, rolling and stone raking in 2004 to allow more productive farming

Note: The flow is on the Register of the National Estate.

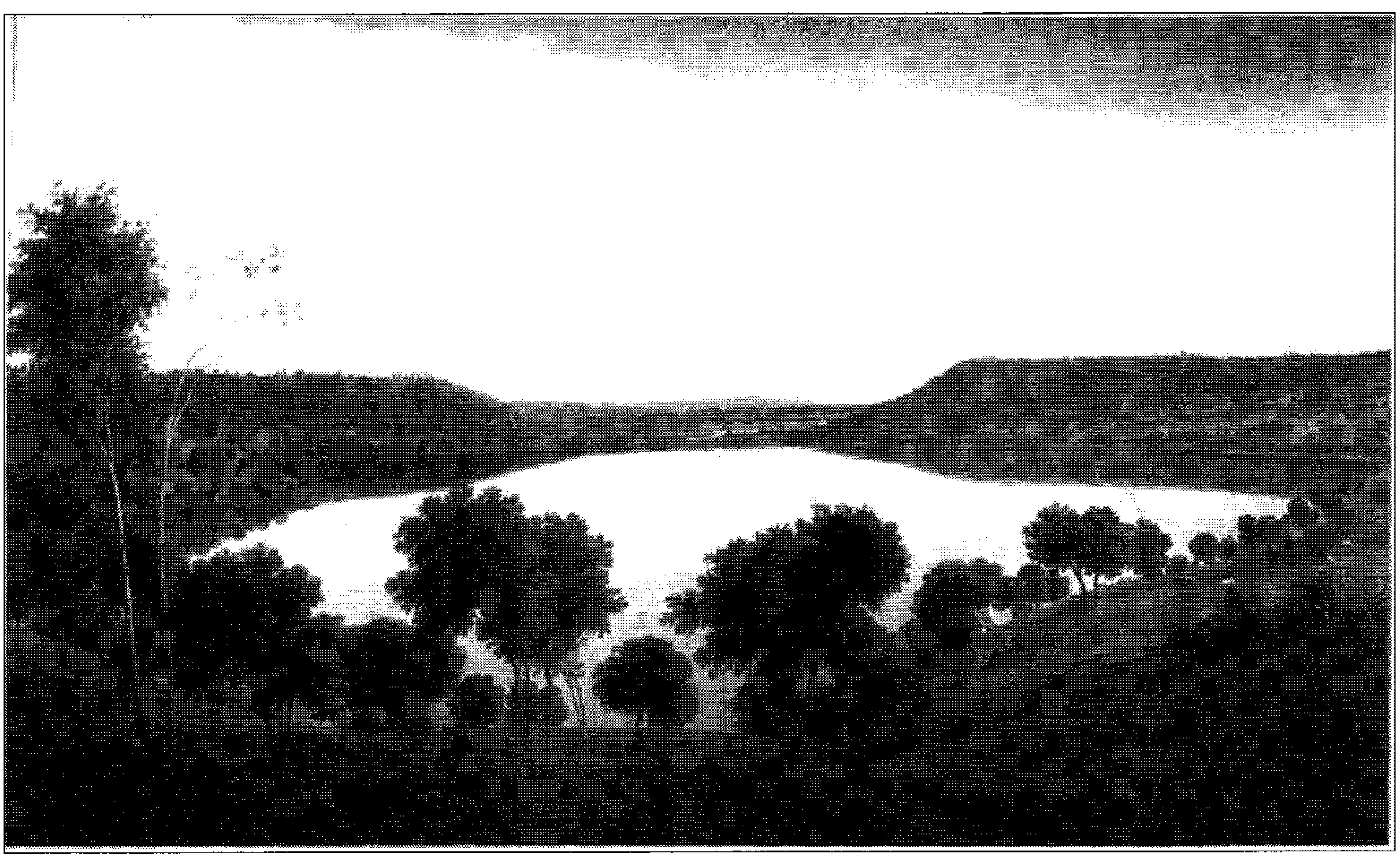

Figure 20.2 Lake Bullen Merri maar crater, near Camperdown, Kanawinka Geopark, Western Victoria

Source: Painting by von Guerard 1857

of interest include the Western Plains Grassland, Lake Condah and the Floating Islands, and coastal areas such as the Port Campbell National Park and the Bay of Islands Coastal Park, and Bridgewater Bay.

Nomination of the volcanic areas of western Victoria and south-east South Australia as the Kanawinka Global Geopark

Australia's first geopark is on the broad Western Plains of Victoria and the adjacent part of south-eastern South Australia, with some 100 well-studied volcanoes ranging in age from five million years to just a few thousand years. Within the area of the new Kanawinka Geopark are many important volcanic features including lava caves of international significance, open volcanic vents, major tumuli groups, and springs and waterfalls. Coastal features include limestone cliffs, calcareous dunes, basalt headlands and cliffs, drowned lava flows and a large offshore volcanic island. Extensive karst plains and limestone caves are found in the west, and in the east Quaternary, often saline, lake/lunette systems are major Ramsar sites. Cultural features include indigenous heritage such as stone houses and fish and eel traps, and also post-contact basalt stone walls and historic buildings (Figure 20.3). An active art and history movement is part of the cultural heritage of the local people.

Figure 20.3 Reconstruction of a stone house on the Tyrendarra stony rise flow

Note: The Tyrendarra Indigenous Protected Area, demonstrated by Darryl Rose of the Gunditjmara people, in the Budj Bim National Heritage Landscape, was declared by the Australian government in July 2004 for its outstanding values as part of Australia's national heritage.

Source: Photo courtesy of Chris Pavich

For these reasons, the area was recognized as the Kanawinka Global Geopark in June 2008, and in the following 12 months the geotourism of the area has been under development, with programmes to assemble further information, and develop new material for use by geotourists, geotourism operators and local government bodies. The accuracy and usefulness of the volcanic information must be based on the extensive past scientific studies of the volcanoes and other geological and cultural features of the area, but will also make use of the new approach of the 'Geomorphosites and Volcanism' chapter in *Geomorphosites* (Joyce, 2009).

The Kanawinka Geopark of south-east Australia as an example of volcano tourism

The young volcanic areas of the Western Plains of Victoria and adjacent South Australia have more than 100 small scoria cones, maars and lava shields, built up by Strombolian/Hawaiian eruptions over the past five million years. Fluid basalt flows spread laterally around vents, often for many tens of kilometres down river valleys. Where the lava flows blocked drainage, lakes and swamps were formed. Phreatic eruptions deposited ash and left deep maar craters, often now with lakes. The youngest dated eruption is that of Mt Gambier in south-eastern South Australia, at 4000–4300BC. The highest volcano is Mt Elephant, near the centre of the plains. It rises nearly 200m above the plains to an elevation above sea level of 393m, with a crater 90m deep, and is similar in size to Mt Kooroocheang, the highest volcano in the Western Uplands. First identified as a volcanic region nearly 170 years ago the Newer Volcanic Province of south-eastern Australia is now one of the best studied of the world's many young basaltic monogenetic lava fields.

Both the European cultural history of the plains, and the first recognition of its volcanic geology go back to the explorer Major T. L. Mitchell, who in 1836 was the first person to identify volcanoes and flows on the plains, and he also provided the first written description of the

Western Plains – 'We now travelled over a country quite open, slightly undulating and well-covered with grass ... vast plains, fringed with forests and embellished with lakes ... the open plains extended as far as the eye could reach' (Mitchell, 1838).

In the 1840s and 1850s several books and scientific journal articles made the area widely known, at a time when popular interest in volcanoes was growing. James Bonwick, an inspector of schools, recorded his observations of western Victoria and many of its geological features in a book published in 1858, and in 1866 he compared the volcanic rocks and features of Victoria with those of the area around Rome, in a scientific paper in the Proceedings of the recently founded Royal Society of Victoria. The Reverend Julian Tenison Woods, working across the border in South Australia, published a book in 1862 which described the volcanic features of Mt Gambier and Mt Schank in detail, and he also gave a public lecture series in Portland in 1865 on the volcanic features of the plains. One of many later workers was E. D. Gill, from the Museum of Victoria, who helped start a new phase of study of the volcanoes in the 1960s, and was the first to make use of the newly invented radiocarbon dating technique to determine the ages of young volcanoes such as Tower Hill.

The geology of the geopark, which stretches from near Colac in western Victoria, to Mt Gambier and beyond in South Australia, is based on scientific study going back over 150 years, and the area is one of the best studied of the world's young basaltic lava fields. Equally important to the success of the application have been the studies of local history, plants and animals, and indigenous features, as well as cultural aspects including art and architecture (Joyce, 2007).

The indigenous heritage of the plains includes a complex of Aboriginal fish and eel traps, and remains of stone houses, in the stony rise flow landscapes of the Mt Eccles volcano. Historic 'bluestone' (basalt) houses, bridges, churches, other town buildings and the many striking stone walls help record European post-contact settlement. These cultural features, supported by a detailed geological and geomorphological story, made the area an ideal candidate for nomination as a geopark.

Parks and reserves include Tower Hill, the Mt Eccles volcano, flows and lava caves, and the Mt Napier volcano and its flows and lava caves. New reserves have recently been developed at Mt Elephant and Mt Rouse volcanoes, there have been improvements to interpretation at other sites, and across much of the volcanic plains of Victoria and South Australia the Volcanoes Discovery Trail has been set up (Figure 20.4). A National Trust landscape study of Stony Rise lava flows, and the establishment of the Penshurst Volcanoes Discovery Centre (Figure 20.4), near the Mt Rouse volcano, are also promising developments. In the future the integration of volcanic research, local history study, and heritage interpretation could be the key to developing a greater awareness, not just of heritage values, but also of volcanic hazard and risk concepts, a research area of growing interest to volcanologists working in this geologically youthful and potentially active volcanic area.

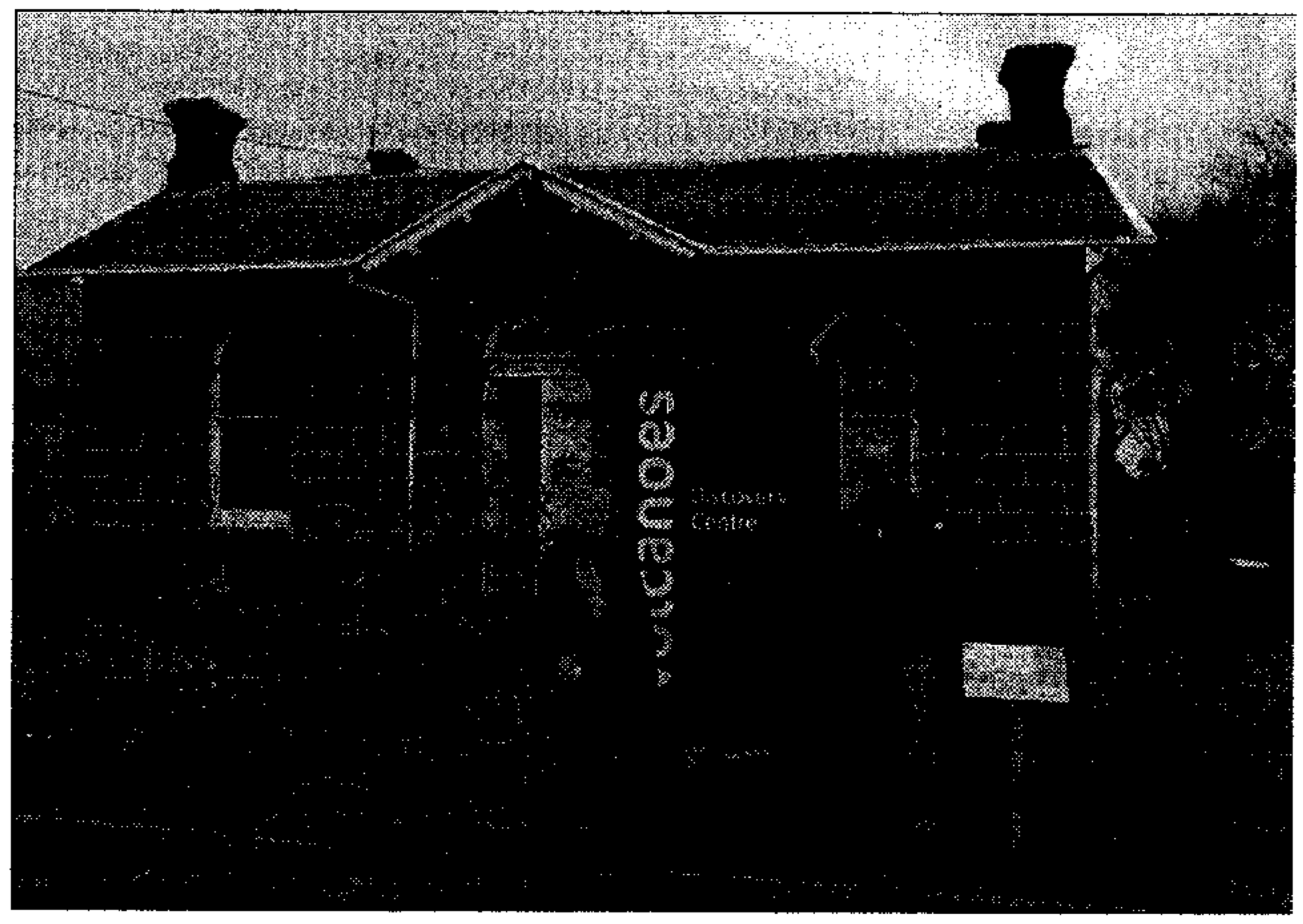

Figure 20.4 Old 'bluestone' (basalt) Volcano Discovery Centre at Penshurst, with Kanawinka Geopark Director Joanne McKnight (left)

Source: Photo courtesy of Chris Pavich

Sustainability is one of the suggested attributes of an area which is to become a geopark. Fortunately volcanic areas often provide 'rugged' geomorphological sites – that is, resistent to human damage. In the Kanawinka Geopark several large areas have been set aside as national parks (Mt Eccles, Mt Napier), under full state government protection and management. Other areas are under the control of local government (Bullen Merri and Gnotuk craters), community groups (Mt Leura, Mt Elephant), or enlightened private owners (Mt Noorat), all of whom are anxious to provide sustainable geotourism activities.

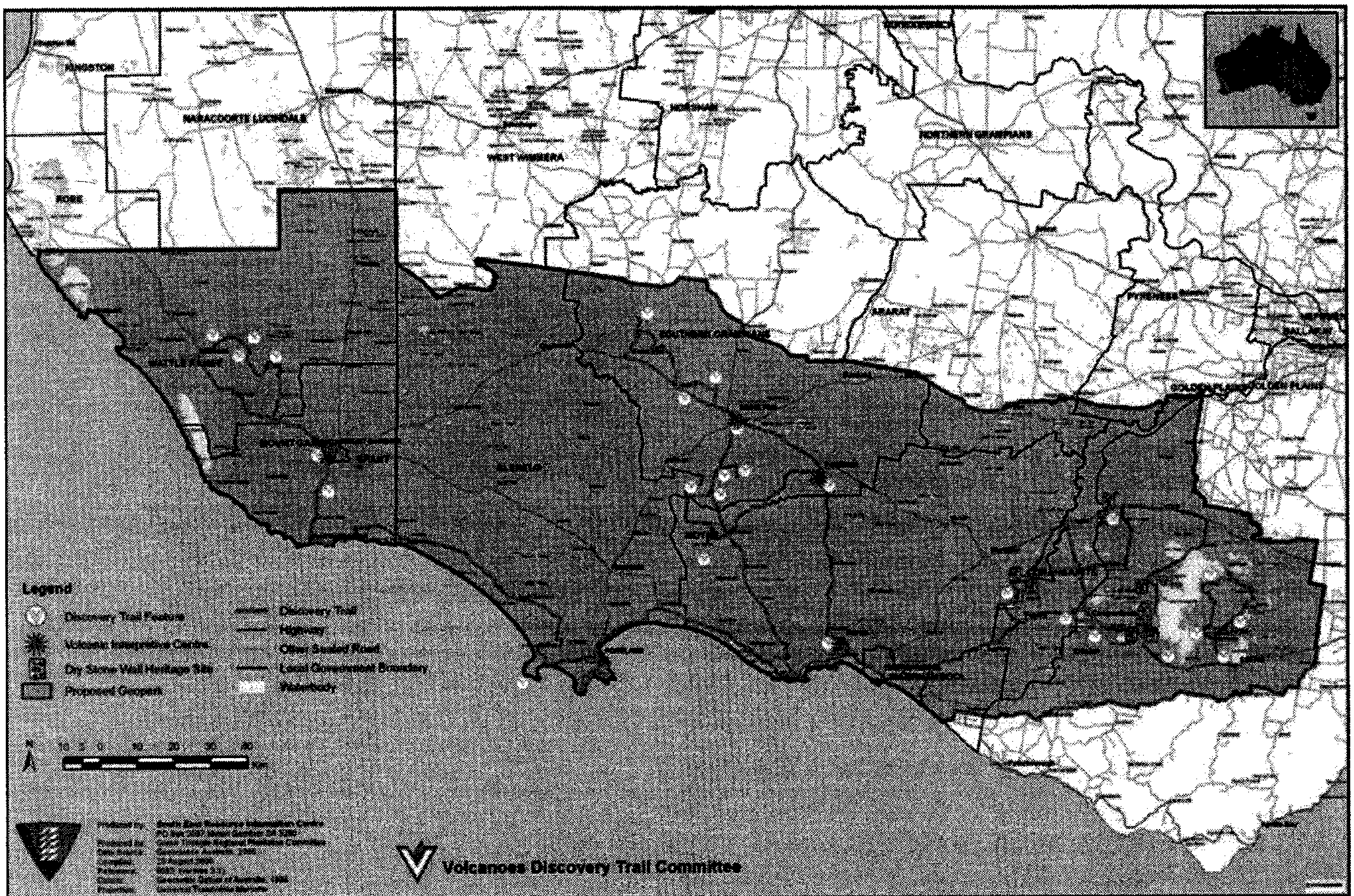

Figure 2: Kanawinka Geopark Boundary & Volcanoes Discovery Trail

Figure 20.5 Map of the Kanawinka Global Geopark area

After four years of work by local people, UNESCO approved the proposed Kanawinka Global Geopark in western Victoria and south-east South Australia on Monday, 23 June 2008 at a meeting in Germany (Figure 20.5). It is Australia's first geopark, and one of only a few in the southern hemisphere.

Conserving geological sites in the Kanawinka Geopark

A small number of volcanic landforms in western Victoria have been set aside as reserves. Mt Eccles and Mt Napier are national parks, and Tower Hill is a state game reserve. Mt Leura cone is a reserve run by the local shire, and a part of the rim, Mt Sugarloaf, is owned by the National Trust. Much of the Leura volcanic complex is private land, and includes a large active scoria quarry, with further areas under threat. Similarly, Red Rock and Mt Rouse volcanoes have access roads and viewpoints, but are essentially private land, with some quarries, mostly not in current operation. Mt Elephant is owned by the Trust for Nature and the local Derrinallum community, with access and information available. Mt Noorat is private land, but the local shire oversees access, and information is provided. Lake Gnotuk and Lake BullenMerri maar craters have road access, but are private farmland, a golf course, and a recreation reserve and boat access areas.

These volcanic landforms have been classified by the National Trust, and also by the Geological Society of Victoria. Most of these volcanic landforms are on the Australian government's Register of the National Estate, but not on the state Heritage Register, or, with the exception of parts of the Mt Eccles lava flows, on the new National Heritage Register.

Threats to the volcanic landforms in the Kanawinka Geopark

The following are the major threats to the Kanawinka Geopark:

- Quarrying: although with increasing rationalization and control by the Geological Survey ofVictoria and the Mines Department, the number of active quarries is decreasing, but at the same time becoming more extensive.
- Excessive planting of vegetation: often following clearing of past, often exotic vegetation, but with the new planting likely to provide future problems with visibility of landforms, and views from the landform to the surrounding landscape. Both the Geological Society of Australia and the National Trust Landscape Committee have developed guidelines and policies on this problem.
- Covering over and landscape degradation by building of houses and other structures: especially in the suburban sprawl near Melbourne, for example, at Mt Aitken, Mt Ridley and Mt Cottrell north of Melbourne, but also inside the crater of Lake Gnotuk at Camperdown, and most recently as threats to the outer slopes ofTower Hill.
- Rock crushing, rolling and stone raking of young stony flow surfaces to allow more productive farming: for example, on the Register of the National Estate-listed Byaduk valley flow of Mt Napier, south of Hamilton, in 2004, and most recently in the National Trust-classified Stony Rises of Mt Porndon.

Conclusions

Recent threats to the volcanic heritage of western Victoria, which includes many landforms of national and international significance have included quarrying of cones, housing development on cones and inside craters, and landform destruction of stony rises. New reserves have however been developed at Mt Elephant and Mt Rouse volcanoes, there have been recent improvements to interpretation at other sites, and across much of western Victoria a Volcanoes Discovery Trail has been developed, with maps, leaflets, signboards and a web site.

The western Victorian portion of the Newer Volcanic Province also has a strong cultural heritage, with its complex Aboriginal and early European settlement history, its historic 'bluestone' (basalt) houses, bridges, churches, other town buildings, monuments and stone walls. These, together with its detailed and well-studied geological and geomorphological story, have helped make it Australia's first geopark.

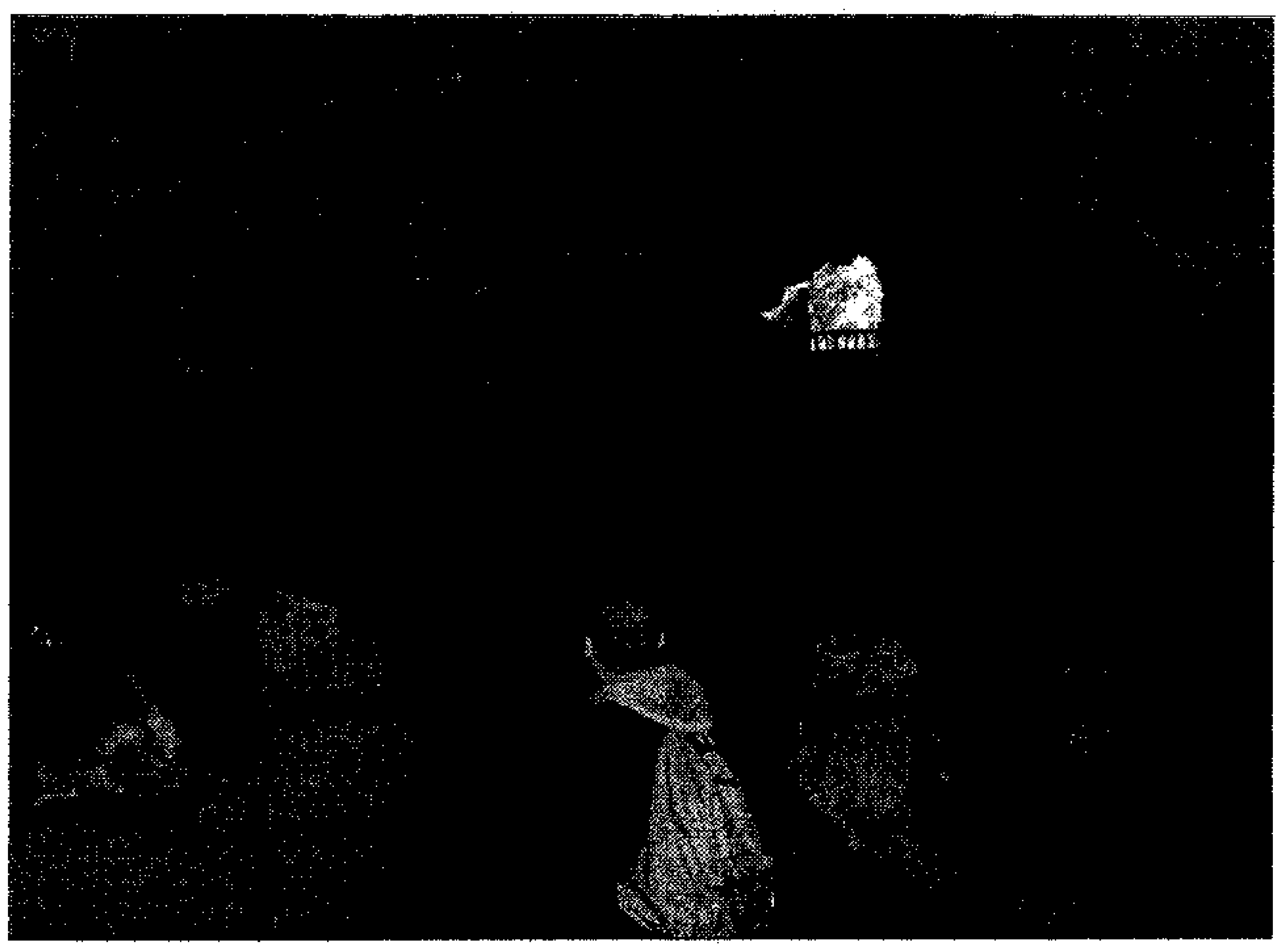

Figure 20.6 Group of geotourists inside Tunnel Cave, Mt Eccles volcano

Source: Photo courtesy of Chris Pavich

Both scientific and cultural values are being used to plan the management of the Kanawinka Geopark. Management must be based on continuing scientific studies, including the results of recent assessments of the possibility of further volcanic activity (Joyce, 2005). The story must be communicated to those involved in managing the geopark, and to those who live and work in the area, as much as to those who come as geotourists to see its scientific and cultural features (Figure 20.6).

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