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Information Sheet

Geology of the Clare Valley

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INTRODUCTION

The Clare Valley is not so much a valley as a series of mostly north–south ridges and valleys in the undulating hills of South Australia's Mid- North. Most of the vineyards are situated between the two highest ridges, that to the west being formed of Rhynie Sandstone and that to the east of Gilbert Range Quartzite, though more recent plantings have extended eastward from there onto the more subdued hills underlain by siltstone of the Tapley Hill Formation. What is the origin of these and other ancient rocks from which the rich soils of the Clare Valley, so favourable for growing vines, are derived? What do they tell us about the history of the region?

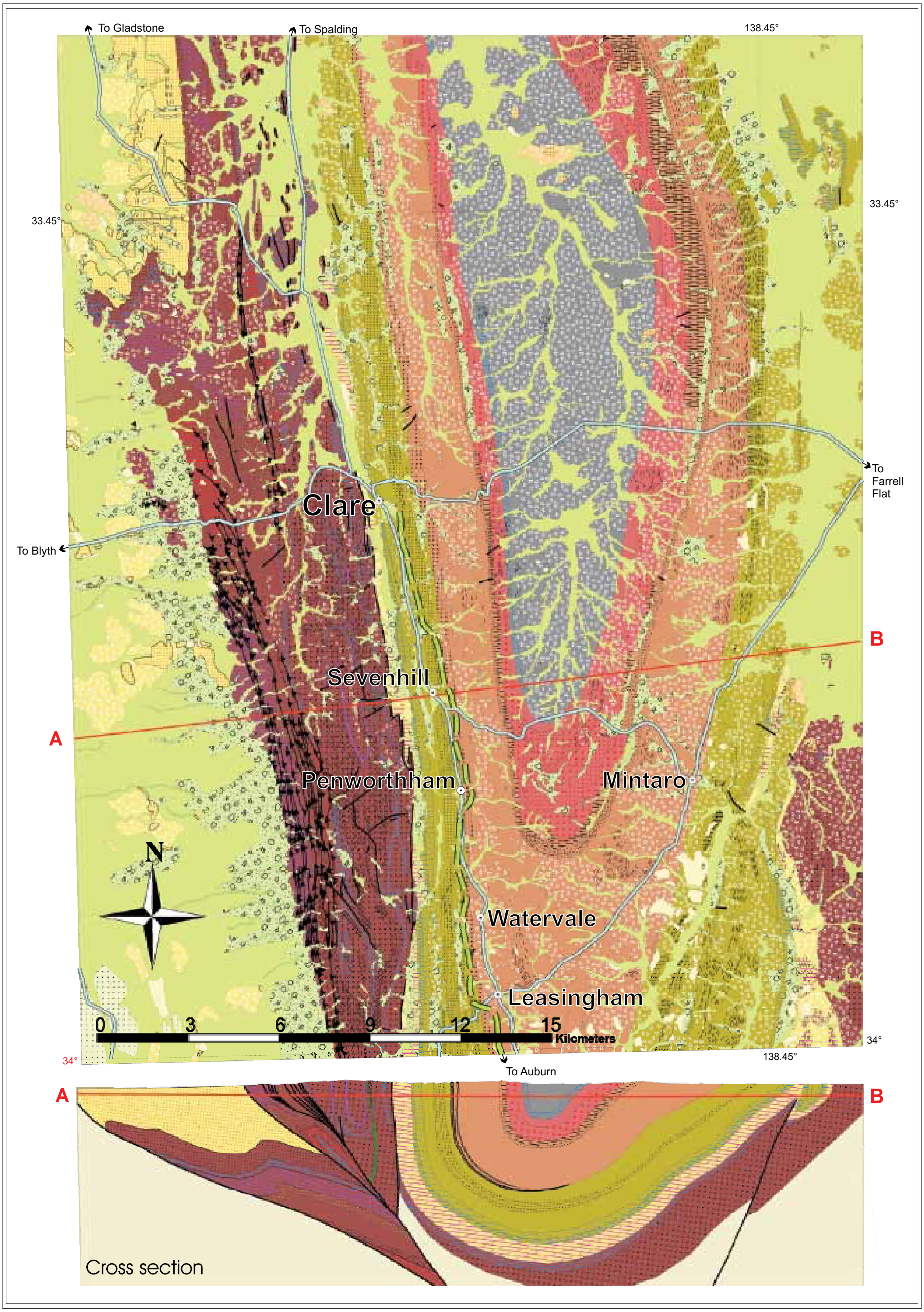
Almost all of the rocks are of sedimentary origin. For a period between about 800 and 500 million years ago, during the Neoproterozoic Era, they were deposited as silt, sand and carbonate in a largely marine sedimentary basin. This basin, known as the Adelaide Geosyncline, extended far beyond the limits of the Clare Valley — at least as far north as Oodnadatta and as far south as Kangaroo Island, and probably beyond into Antarctica, which was still joined to Australia at that time. Over this period of 300 million years, a thickness of 10–15 km of sediment, derived from erosion of adjoining landmasses, accumulated on the subsiding sea floor. As the successive layers were buried, they became compacted, consolidated, and cemented to form sedimentary rocks.

By studying the succession of sedimentary strata, a geologist can reconstruct the ancient history of the region. Firstly, a geological map is produced from observations made in the field and interpreted with the help of aerial photography. The map shows the distribution and relationships of the various layers of rock of different compositions and ages. If these strata had remained horizontal as they were laid down, we would see only the uppermost layer at the Earth's surface today. However, examination of the numerous outcrops of bedrock in the Clare Valley shows that almost all of the layers have been tilted in various directions. The geological map (Figure 1a) shows how they have been folded and faulted. The most obvious fold is the large syncline (a fold that is U or V-shaped in crosssection and contains younger rocks on the inside and older on the outside) which turns around at the southern end of the Clare Valley near Auburn, and is separated from a much more complex region to the west by a north–south fault that runs just west of Clare township. The rocks west of this fault, the Clare–Spalding Fault, are generally older and much more tightly folded. All of this deformation occurred during a period of mountain building known as the Delamerian Orogeny, about 500 million years ago, when deposition of sediments ceased.

At the western margin of the hilly country is a fault scarp, one of many that bound the Mount Lofty and Flinders Ranges in South Australia. This fault has been active in the relatively recent past (during the last few million years) and has uplifted the ranges relative to the flatter country to the west. Rocks exposed on this fault scarp also show evidence of earlier intense deformation, including shearing, when older layers were repeatedly pushed westward over younger ones along numerous thrust faults during the Delamerian Orogeny.

The Geological Survey of South Australia has carried out detailed geological mapping of the Clare Valley as part of its wider program of mapping to enhance understanding of the geological history and mineral potential of the state. The geological map in this brochure is derived from this work, and shows the detailed subdivision of rock units. Rock units are grouped by relative age, as indicated on the map and legend (Fig. 1a, c) by the background colour, while overprint patterns give an indication of rock types: a dotted pattern indicates sandstone and quartzite, and a brick pattern indicates carbonate rocks such as limestone and dolomite. Red triangles are used to denote tillite (glacial deposits of unsorted sandy and pebbly siltstone). They are arranged in order of age in the legend, with the youngest at the top and oldest at the bottom of the stratigraphic column. It can be seen that there are many separate layers of sandstone, siltstone, dolomite and quartzite, as well as the pebbly siltstone units that were deposited from the melting of ice.

CLARE VALLEY



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(c) Legend

Main road
Fault
Thrust fault (barbs on upper plate)

CAINOZOIC (0 to 65 million years)
Holocene (0 to 10,000 years)
Wind-blown sand
Lacustrine clay
Talus and gravelly alluvium
Holocene to Pleistocene
Sandy clay alluvium
Pleistocene (10,000 to 1.6 million years)
Calcrete: limestone formed in former soil profile
Pooraka Formation: older alluvium with limy nodules
Ancient lake deposits
Hindmarsh Clay: dense clay with sand at base
Pleistocene to Tertiary
Undifferentiated sand and gravel
Tertiary (1.6 to 65 million years)
Thin soil and rubble over Tertiary deposits
Silcrete: hard, silica-cemented sand and silt
Ferricrete: iron oxide-cemented sediments or weathered bedrock
Sand, sandstone, gravel, conglomerate, siltstone

PALAEOZOIC (250 to 540 million years)
Quartz veins formed in Delamerian Orogeny (about 500 million years)

NEOPROTEROZOIC (540 to 1000 million years)
Umberatana Group
Nepouie Subgroup
Thin soil and rubble over Nepouie Subgroup bedrock
Tapley Hill Formation: thinly laminated dark grey siltstone
Unnamed sandstone beds in Tapley Hill Formation
Tindelpina Shale Member: Black pyritic shale and dolomite
Yudnamutana Subgroup
Thin soil and rubble over Yudnamutana Subgroup bedrock
Wilyerpa Formation: grey siltstone with occasional pebbly beds
Unnamed sandstone and quartzite beds in Wilyerpa Formation
Brecciated sandstone
Appila Tillite: glaciomarine pebbly siltstone

Burra Group
Belair Subgroup
Thin soil and rubble over Belair Subgroup bedrock
Kadlunga Slate: dark grey slaty siltstone
Gilbert Range Quartzite: medium-grained clean sandstone and quartzite
Mintaro Shale: laminated flaggy grey siltstone; rare pebbles found in quarry
Unnamed sandstone beds and sand dykes in Mintaro Shale
Unnamed dark grey dolomite beds in Mintaro Shale
Leasingham Quartzite Member: medium to coarse-grained feldspathic sandstone; local black chert pebbles
Bungarider Subgroup
Thin soil and rubble over Bungarider Subgroup bedrock
Saddleworth Formation: grey dolomitic siltstone
Unnamed sandstone beds in Saddleworth Formation
Auburn Dolomite Member: dark grey silty dolomite; minor black chert
Watervale Sandstone Member: feldspathic sandstone
Undalya Quartzite: feldspathic sandstone, quartzite
Woolshed Flat Shale: laminated grey siltstone
Unnamed sandstone beds in Woolshed Flat Shale
Mundallio Subgroup
Thin soil and rubble over Mundallio Subgroup bedrock
Brecciated rocks of Mundallio Subgroup
Skillogalee Dolomite (upper member): blue-grey dolomite with black chert
Marola Sandstone Member: medium to coarse-grained sandstone, partly dolomitic
Skillogalee Dolomite (lower member): cream to pale grey dolomite and marble
Unnamed sandstone in Skillogalee Dolomite
Emeroo Subgroup
Thin soil and rubble over Emeroo Subgroup bedrock
Brecciated sandstone of Emeroo Subgroup
Bungaree Quartzite: medium-grained feldspathic sandstone and quartzite
River Wakefield Formation: sandy siltstone, dolomite, quartzite, minor conglomerate
Benbournie Dolomite Member: blue-grey flaggy dolomite
Stradbrooke Siltstone Member: fine-sandy siltstone, often flaser-bedded
Unnamed sandstone beds in Stradbrooke Siltstone Member
Unnamed dolomite beds in Stradbrooke Siltstone Member
Ingomar Quartzite Member: medium-grained quartzite
Boconnoc Siltstone Member: fine-sandy siltstone, often flaser-bedded
Unnamed sandstone, grit and conglomerate beds in Boconnoc Siltstone Member
Unnamed thin dolomite beds in Boconnoc Siltstone Member
Blyth Dolomite: mid-grey to cream flaggy dolomite and marble
Anama Siltstone Member: grey siltstone with grit bands
Rhynie Sandstone: fine to coarse feldspathic sandstone with heavy mineral laminations; conglomerate lenses
Spalding Dolomite Member: cream marble, often silicified
Thin soil and rubble over basalt
Jarrold Basalt Member: altered basalt with quartz-filled amygdales (gas bubbles)
Unnamed dolerite feeder dykes, sills and plugs
Unnamed siltstone and fine sandstone member

The stratigraphic succession is divided into groups, and these are further subdivided into subgroups, formations and members. There are breaks in deposition between each of the subgroups. Also shown, for each subgroup, are areas where the bedrock is covered by a thin veneer of soil and rubble, and does not crop out.

EMEROO SUBGROUP

The oldest rocks occur west of the Clare–Spalding Fault and belong to the Emeroo Subgroup, including the Rhynie Sandstone, Blyth Dolomite, River Wakefield Formation and Bungaree Quartzite, and members of these formations. Outcrops of these rocks occur in the Spring Gully Conservation Park, where cross-bedded Rhynie Sandstone is exposed in many of the gullies. A folded layer of volcanic rock, an amygdaloidal basalt, can be traced around a syncline in the park; this is the only rock that is not of sedimentary origin. Pebbly sandstone and thinly bedded siltstone are prominent in the complexly folded region west of Watervale. River Wakefield Formation is exposed on the fault scarp west of the conservation park and along the Clare–Blyth road, which also traverses the Blyth Dolomite. The Emeroo Subgroup represents deposition in fluvial (Rhynie Sandstone) and shallow marine (Blyth Dolomite and River Wakefield Formation) environments.

MUNDALLIO SUBGROUP

East of the Clare–Spalding Fault, the rock succession in the large syncline commences with the lower marble membe of the Skillogalee Dolomite of the Mundallio Subgroup; the upper fine-grained, blue-grey dolomite member is only locally preserved. Dolomite marble is exposed in the valley of Skillogalee Creek. West of the Clare–Spalding Fault, the Mundallio Subgroup is represented by the Marola Sandstone Member, a sandy variant of the Skillogalee Dolomite. Near the western edge of the map, Emeroo Subgroup rocks have been thrust westward over the Marola Sandstone Member.

BUNGARIDER SUBGROUP

The Woolshed Flat Shale is the lowest (oldest) formation of the Bungarider Subgroup, and it sharply overlies the Skillogalee Dolomite near Skillogalee Creek. The remainder of the Bungarider Subgroup consists of siltstone and dolomite of the Saddleworth Formation deposited in deeper marine shelf environments. These alternate with shallow-water sandstone such as the Undalya Quartzite and Watervale Sandstone Member deposited in deltas, where rivers discharged their load into the sea.

BELAIR SUBGROUP

The Belair Subgroup commences with coarse-grained sandstone of the Leasingham Quartzite Member, which in places incorporates pebbles of black chert derived from the underlying rocks. The quartzite passes up to flaggy siltstone of the Mintaro Shale, which has been quarried at Mintaro for use as high-quality dimension stone since the early 1850s – the oldest continuously operating quarry in Australia. Sandstone dykes (fissures filled in with sand) can be seen in the old quarries and on surrounding hillsides. The siltstone passes up to the Gilbert Range Quartzite which forms the spine of the range east of Clare and can be traced around the closure of the syncline near Mount Horrocks. The quartzite then passes up to dark grey siltstone of the Kadlunga Slate.

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YUDNAMUTANA SUBGROUP

The Yudnamutana Subgroup includes all rocks deposited during the older (Sturtian) of two Neoproterozoic glaciations. Deposits resulting from these ice ages are widespread in South Australia as well as other parts of the country, and there are glacials of similar age on most other continents. The Yudnamutana Subgroup commences with the pebbly and sandy siltstone of the Appila Tillite, which can be seen in the hills east of Clare. The Appila Tillite, together with interbedded sandstone and quartzite, and siltstone of the overlying Wilyerpa Formation, can also be traced around the large syncline.

NEPOUIE SUBGROUP

Siltstone of the Tapley Hill Formation, Nepouie Subgroup, sharply overlies the Wilyerpa Formation, but is generally poorly exposed in the subdued uplands in the middle of the syncline. Outcrops can be seen on the Clare–Farrell Flat road. In fresh exposures, the siltstone is very dark grey to black, due to its contained organic matter, and shows very fine parallel laminations less than a millimetre thick, as the silt was deposited, lamina by lamina, in relatively deep, quiet water.

LATER HISTORY

Following deposition of the Tapley Hill Formation, sedimentation continued throughout the Adelaide Geosyncline for another 140 million years, during which time the rocks we now see were deeply buried by further sediments. Exposures of these younger sedimentary rocks occur in other parts of the Mount Lofty and Flinders Ranges. By the time folding commenced in the Delamerian Orogeny about 500 million years ago, the sedimentary rocks were heated to about 400°C and subjected to a pressure of 3000–4000 times atmospheric pressure due to burial, and these are the conditions under which the rocks were folded and faulted(see cross-section, fig. 1b). The more brittle rocks such as quartzite developed joints. Many of the fine-grained rocks such as siltstone developed slaty cleavage parallel to the axial planes of folds, at right angles to the direction of compression. Some, however, escaped this process, which is why the flagstone quarried at Mintaro parts into perfectly flat sheets along the original bedding, making it ideal for billiard tables. Although referred to as 'slate' in the industry, this rock totally lacks slaty cleavage.

Over the next 100 million years or so, the Delamerian mountains were worn down and their erosion products carried across to the deep-sea region now occupied by the eastern states. A thickness of about 10 km of the upper part of the Earth's crust was removed at this time. There is then no record of events in the Clare Valley until much later times, but it was during this period that Australia and Antarctica split and parted company. Then, perhaps 10–15 million years ago during the Tertiary Period, gentle uplift of the eroded plain commenced, and rivers cut channels through the exposed bedrock. Sand and gravel were deposited in these channels, then silicified by silica-rich groundwater passing through them.

Renewed and more severe uplift commenced 1–2 million years ago, when old faults at the margins of the present ranges again became active as the Australian continent came under the influence of east–west compressive forces. During the latest geological period, the Quaternary, the ranges as we know them today came into existence. With continuing uplift, erosion has cut valleys into the softer rocks such as siltstone and dolomite and left the harder rocks such as sandstone and quartzite as ridges. Many of the valleys containing the major streams (e.g. Skillogalee Creek, Hutt River, Hill River and River Wakefield) are partly filled with alluvial clay, silt and sand, derived from the breakdown and erosion of the bedrock. Only small remnants of the Tertiary river sediments have been preserved from erosion on a few hilltops. Alluvial fans were built out west of the escarpment. Most recently, soils were formed over both bedrock, where they are reddish brown coloured, thin and stony, and on the younger alluvium in the major valleys, where they are thicker, and commonly dark brown or black due to high organic content. Each of these soil types supports a number of grape varieties in the Clare Valley.

GROUNDWATER

Groundwater in the Clare Valley is found partly in shallow, gravelly alluvial sediments in valleys, but mainly in fractured rock aquifers. Because the underlying Neoproterozoic bedrock is dense and hard, lacking the porosity and permeability of many younger sedimentary rocks, rainwater can enter only through fractures and joints or, in carbonate rocks, solution cavities. Sandstone and quartzite beds tend to be strongly jointed due to stresses developed in these relatively brittle rocks during folding, and are therefore commonly a good target for drilling.

RIESLING TRAIL

The Riesling Trail is an easy walking and bicycle trail running along the length of the Clare Valley from Auburn to Clare. It follows the disused railway line, alongside paddocks, bushland, though cuttings, over bridges and under overpasses. The trail passes the historic towns of Watervale, Penwortham and Sevenhill, and the Clare Showground, before reaching the disused Clare Railway Station. Geologically, the trail runs mostly along the Bungarider Subgroup, with outcrops of siltstone (Saddleworth Formation), dolomite (Auburn Dolomite Member) and sandstone (Watervale Sandstone Member). At Leasingham and Penwortham, cuttings expose the Leasingham Quartzite Member, basal unit of the Belair Subgroup. The final section north of Sevenhill runs along the base of the Watervale Sandstone Member.

FURTHER INFORMATION

For further informatin on geology of the Clare Valley, contact:

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