HERITAGE
CONSERVATION PRACTICE NOTES

TECHNICAL NOTE

3.6

STONE MASONRY IN SOUTH AUSTRALIA

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOUCES

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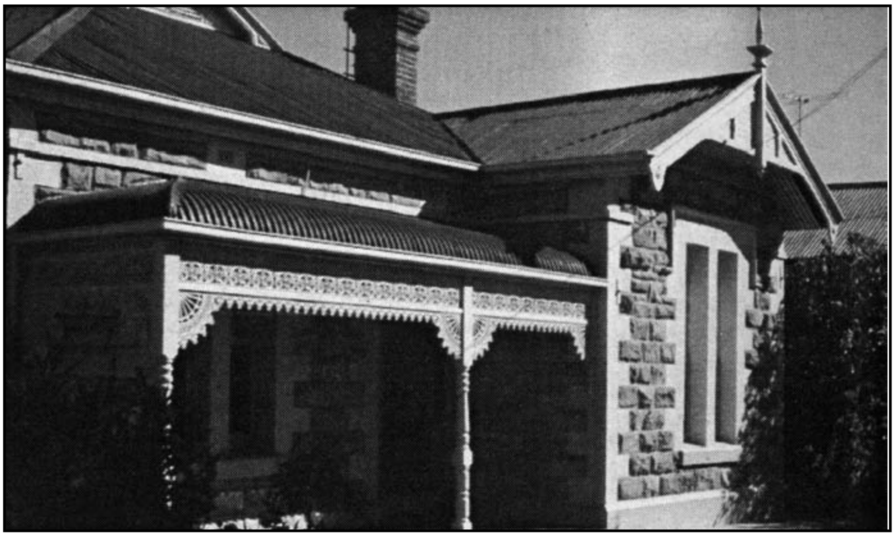
**Cover photo: Carved penal in Sydney Sandstone.
Former Marine and Harbours Building, 1884,
Victoria Square.**

CONTENTS

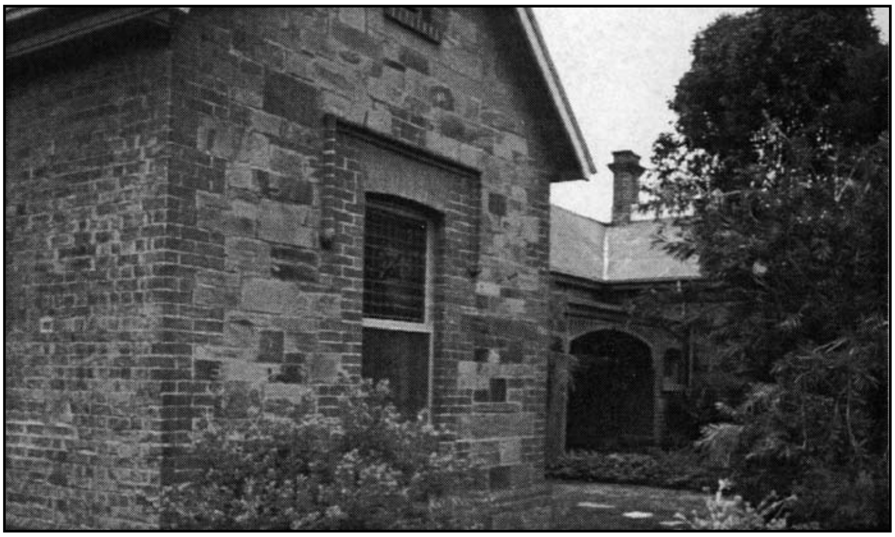
Stone has long been used as a building material in South Australia, both of necessity and as a luxury. Stone was one of the most readily available building materials for the settlers of the new colony. Rough nodular limestone underlay more than half of William Light's surveyed town plan for Adelaide and many early buildings were constructed of stone quarried on site. Even the parklands were quarried and the banks of the River Torrens became a series of brick clay and river gravel pits and shallow limestone quarries.

Stone had considerable thermal advantages in the hot climate and it was cheaper than brick in the earliest years. The high summer fire risks associated with timber walling and the hazards of termites meant that by 1860, the vast majority of all Adelaide city buildings were constructed of stone or brick. Local stone was often the only available walling material in rural areas in the mid-nineteenth century when transport of heavy items was difficult and expensive.

Stone gradually became a luxury as well as a useful building material. Many city buildings and suburban houses of the late-nineteenth and early twentieth centuries have front walls of carefully shaped and carved sandstone but side and rear walls of unshaped rubble of limestone, bluestone or sandstone.



Tapley Hill Bluestone (note the very square blocks) with brick quoins and dressings. Former Adelaide Workmen's Homes, 1899



Rock - faced Mount Lofty Sandstone with painted brick quoins

Even where the same type of stone was used on front and side walls (bluestone or sandstone) larger, squarer blocks were reserved for the more public face of the building.

In early buildings of irregular rubble limestone and bluestone, brickwork was used to form true square corners or quoins. This necessity later became a characteristic South Australian convention, for in squared sandstone work the use of an additional material for the corners was unnecessary. However, brick quoins did allow a neat turning of the corner into side and rear walls that were also of brick. Stone had become a luxury reserved for the front walls.

Today, stone is mostly a luxury, though the remarkable lightweight limestone from Mount Gambier (which has been worked since 1842) still finds economic use as sawn building blocks. Multi-storey buildings are no longer constructed with load-bearing masonry walls but with steel and concrete frames supporting a thin skin or cladding. The cladding may be panels of glass, concrete, metal, compressed fibre composites or, in more expensive buildings, stones such as granite and marble. Arguably, the longevity of a carefully-chosen and well-detailed granite cladding justifies the additional capital expenditure.

South Australia is a major producer of building stone and much (particularly granite) is exported to other states and overseas. A list, 'Operating Building Stone Quarries in South Australia', which includes details of location, operator and stone type for all building stones in current production is available from the Department of Mines and Energy. That department also has information on the physical properties of many of the stones in current production. A list of some of the important building stones to have been worked in the last 150 years is included as part IX of this Note.

This Technical Note is an introduction to the types of stone found in South Australian buildings and the history of their use. Also included are some aspects of the properties and use of stone which are important to understanding how masonry buildings should be conserved. Other Notes in this series deal with bricks, mortars, general maintenance, cleaning masonry, rising damp and salt attack, and the conservation of masonry.

I GEOLOGY OF BUILDING STONES

Geologists divide all rocks into three major groups based on their origin: igneous; sedimentary; and metamorphic. 'Stone' usually refers to rock that is quarried and utilised for some purpose, such as building.

Igneous rocks

Igneous rocks are formed by solidification (crystallization) of hot molten material known as magma which rises from deep in the earth's crust. When magmas solidify after reaching the earth's surface, volcanic rocks such as pumice and lava are formed. Basalt is a volcanic igneous rock often used in building particularly in Victoria. Magmas solidifying beneath the earth's surface produce plutonic rocks such as granite, syenite and gabbro. These are generally coarser in grainsize than volcanic rocks, the coarser grainsize indicating slower cooling. Many varieties of plutonic rocks have been used in building.

Sedimentary rocks

Sedimentary rocks are formed by the accumulation of sediment in water (aqueous deposits) or from air (aeolian deposits). The sediment may consist of rock fragments or particles of various sizes: sandstone being comprised of sand-size grains; siltstone of silt-size grains; and shale of compacted clay particles. Alternatively the sediment may consist of the remains of animals or plants (e.g. limestone and coal) or result from chemical precipitation or evaporation (producing materials such as salt and gypsum). Mixtures of these materials are common:

e.g. clayey-limestones and calcareous- (i.e. lime-bearing) sandstones. Tuff is wind-blown volcanic ash deposited on land or in water. Some special cases of sediments include those developed within the soil profile as a result of chemical action: these include laterite and the variety of limestone known as calcrete. Most of these sedimentary rocks have been used in building.

Metamorphic rocks

Metamorphic rocks are formed in the solid state from sedimentary or igneous rocks in response to pronounced changes of temperature and pressure within the earth's crust. Metamorphic rocks include marble (metamorphosed limestone), slate (metamorphosed shale and siltstone), gneiss and schist. These have all been used for building.

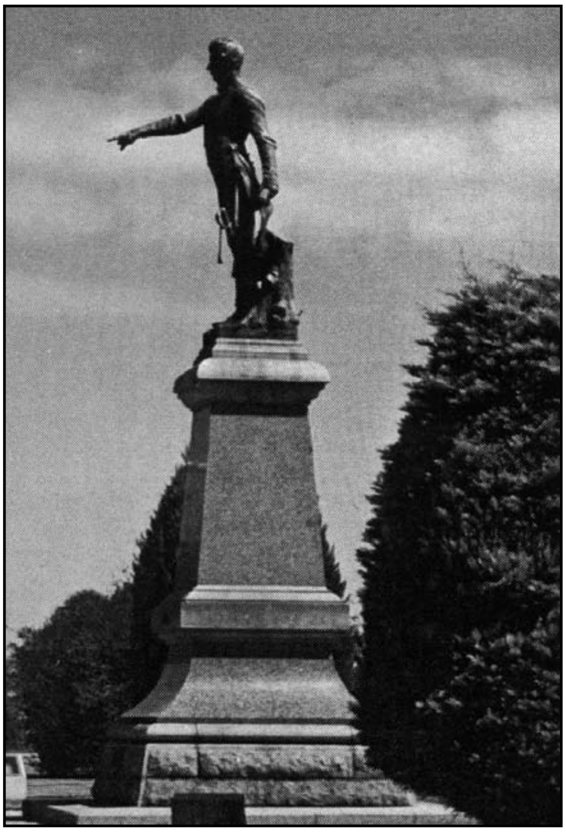
II CLASSIFICATION OF SOUTH AUSTRALIAN BUILDING STONES

The term 'building stone' used in this note includes all natural stones used as building, monumental and ornamental materials. A less commonly used term is 'dimension stone'. This refers to natural building stone that is trimmed or cut to specified shapes or sizes. It should be distinguished from 'diminuted stone': stone that is crushed and used as an aggregate, industrial mineral or chemical raw material.

Much confusion results from geologists and the building industry using different terms when describing stones. The following classification, into six major types, is based on terms that are commonly used in the building industry, and not on strict geological nomenclature. It thus reflects the use of a stone in addition to providing some clues as to its geological origin.

Granite

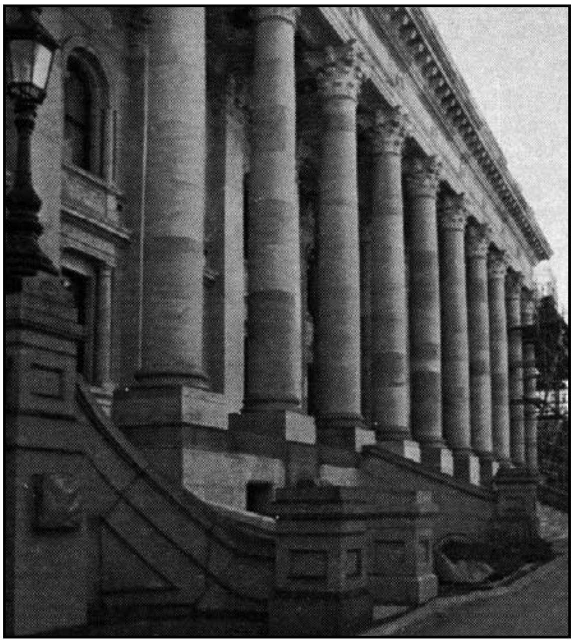
All plutonic igneous rocks, and some metamorphic rocks, including granite, adamellite, diorite, gabbro and norite are known to the building stone industry simply as granites. Thus the Black Hill Granite from Black Hill near Mannum, which in geological parlance is a norite, is known commercially as Imperial Black Granite. Granites are generally composed of three main minerals: grey quartz, coloured feldspar and lesser amounts of black mica or pyroxene. The feldspar, which may be white, red, pink, green, blue or black, is principally responsible for the overall colour of the stone. Granites have a terrazzo look, or perhaps more correctly, terrazzo has a granite look.



Pale bands of Monarto Granite in pedestal of Murray Bridge Granite. Colonel William Light's statue, Montefiore Hill

Marble

The term covers all carbonate rocks capable of taking a good polish. Fine-grained dense chemical and detrital limestone and dolomite (which are really sediments) are included in addition to true marble, which is metamorphically recrystallised limestone. The most widely used South Australian marble is that from Angaston; like the Carrara marble from Italy, it is a true marble. Unlike granites which are a mixture of silicate minerals, marbles are almost wholly composed of the single mineral calcite (calcium carbonate). Minor impurities give rise to colour variations and highlight the often diffuse pattern in the stone. Angaston Marble is coarsely crystalline (small fingernail size crystals can be clearly seen) and is dominantly light grey to white coloured.

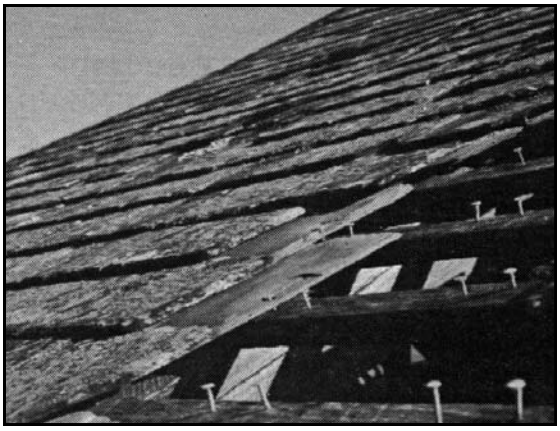


Kapunda Marble superstructure (including columns) on base of West Island Granite. Parliament House, 1883-39, North Terrace (cleaning in progress).

Slate and flagstone

Slate is a term applied to many paving stones whose natural form is thin planar slabs. Most are more correctly flagstone: siltstone, fine-grained sandstone or schist with regular well-developed parting or fissility along bedding-planes. These can have properties similar to true slates and are often referred to as such, e.g. Mintaro Slate. Because of their ability to be split into very thin sheets, true slates have been used as roofing shingles: examples include Willunga and Penrhyn (Wales) slates. Most slates are fine-grained stones with a uniform and characteristic grey colour, though pale purples and greens are also found. The coarser materials are described as flagstone, e.g. Kanmantoo and Wistow Flagstones. Flagstones show a greater colour variation and often have yellow brown iron-oxide coatings on their surfaces.

Very large slabs of state are freed from the querry floor prior to splitting and sawing to required sizes. Mintaro Slate quarry, circa 1988.



Lichen covered Willunga Slate roof showing overlapping and nailing of slates. Bangor Slate Quarry, Willunga.

Bluestone

This term is applied to quite different stones in different Australian states. In Victoria bluestone means the widely used basalt, a volcanic igneous rock formed by the cooling of molten lava.

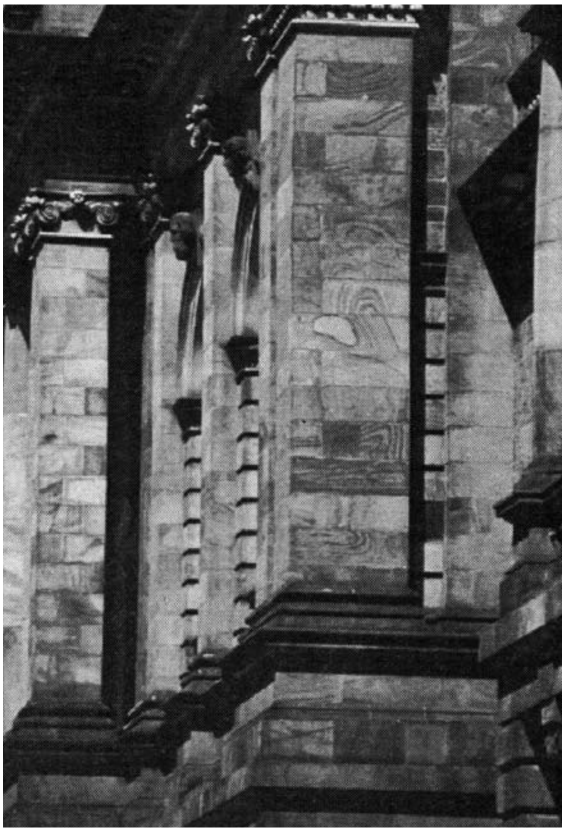
In South Australia bluestone is a broad term related to slate and flagstone and includes many sedimentary and metamorphic rocks. These are siltstone, fine-grained sandstone, limestone, shale, meta-siltstone, schist and gneiss. Most are dense and internally dark grey coloured; occasionally they are bluish. Regular joints or cleavage planes which facilitate quarrying and dressing, are often naturally coated with iron-oxides giving rise to the characteristic yellow-brown and black colours (e.g. Tapley Hill Bluestone). Note that the geology of some quarries is such that they produce both thin paving stone (slate and flagstone) and thicker walling stone (bluestone) (e.g. Kanmantoo and Wistow).

Sandstone

Sandstone is a sedimentary rock composed predominantly of quartz (sand) grains though many have high proportions of feldspar and clay. The natural cements that bind the granular material include silica, clay, calcium carbonate and iron-oxide. Sandstones are generally light coloured off-whites, creams, and pale pinks and browns. They often show stronger colours associated with iron-oxide figuring, which unlike bluestones, is dispersed through the body of the stone and gives rise to banding and wavy patterns which are often mistaken for the natural bedding of the stone. Sandstones can sometimes be distinguished from each other on the basis of grainsize: many nineteenth century (hand-dressed) stones were very coarse grained (e.g. Mitcham and Mount Lofty sandstones) while more recent (sawn) stones are finer-grained (e.g. Basket Range in the Adelaide Hills where building sandstones are still worked).

Limestone

Limestone is a sedimentary rock consisting chiefly of calcium carbonate. Limestones used for building are commonly pale-coloured calcarenites (compacted masses of shell or coral fragments), e.g. Mount Gambier Limestone; or oolitic limestones (composed of minute concretionary spheres of calcium carbonate), e.g. Bath Limestone (England). These are aqueous deposits. Aeolian (wind-blown) limestones occur in coastal areas of western and southern Australia. Though mostly calcium carbonate they can have the granular appearance of and are often mistakenly described as sandstones: examples include the coastal limestones of the South-East, e.g. Robe. Another variety of limestone is the near surface material, calcrete (formerly known as kunkar) which is developed within the soil profile as a result of chemical action. It is widespread throughout South Australia and its rough nodular appearance is commonly seen in nineteenth and early twentieth century buildings.



Tea Tree Gully Sandstone showing strong iron-oxide figuring, capitals of imported limestone. Supreme Court, 1867-69, Victoria Square.

Note: Freestone

The traditional international use of the term freestone is to describe fine-grained sandstones or limestones that can be readily worked in any direction. Locally, the term has also been applied to stone that is loose on the ground (fieldstone), or is naturally jointed into easily-quarried pieces, and is thus ‘free’. Freestone is also used to describe a style of walling in which the pieces are laid in an apparently random or free pattern. To avoid confusion between sandstones and limestones, it is recommended that the term freestone not be used to classify stone types.

III HISTORY OF STONE USE IN ADELAIDE

For convenience we can divide the history of the use of stone in Adelaide into four periods:

- an early phase from 1836 to about 1855
- Victorian boom period from 1855 to about 1885
- a period of diversification through two depressions and two world wars from 1885 to 1945
- a modern period from 1945 to the 1990s.

1836 - 1855 The limestone and bluestone period

The earliest stone buildings of Adelaide, constructed shortly after the founding of the colony in 1836, were built of locally available materials: gravel from the River Torrens and the surface limestone or calcrete that occurs extensively through the areas of North Adelaide and Prospect. The calcrete was also burnt for lime to make mortar.

In 1838 the Green Hill Slate and Flag Quarry Company began operations at Beaumont producing bluestone. The Adelaide foothills from Magill through to Mitcham produced many bluestones in subsequent years. The most important was the Glen Osmond Bluestone, first quarried in 1851, and widely used in housing and also larger buildings, e.g. the former St Paul's Church, Pulteney Street, built in 1857.

Quarrying into the banks of the River Torrens on the present sites of the Parade Ground, Festival Centre and Railway Station produced the white-to-cream coloured Adelaide Limestone. Principal activity in this government-run industry was in the 1840s and 1850s and surviving examples of this stone include Holy Trinity Church (1838), Adelaide Gaol (1841) and Old Parliament House (1854-55).

Calcrete (limestone) rubble with brick quoins and dressings. Large amounts of mortar were required with the rough nodular stone.

1855 - 1885 The sandstone and bluestone period

This period is marked by the prospering of the colony and the consequent building boom which produced more substantial buildings of more imposing materials. Principal sources of stone were the Glen Ewin and Tea Tree Gully sandstone quarries and bluestone quarries at Glen Osmond and Dry Creek (the latter in the grounds of the Yatala Stockade, later the Labour Prison).

Prominent buildings of this period were often constructed with an outer face of hand-dressed squared sandstone with a backing of bluestone or brick (General Post Office, 1867). Less expensive buildings were dominantly bluestone rubble with quoins and dressings of sandstone (Pilgrim Church, 1865). Though hard to work and hence expensive, the Glen Ewin and Tea Tree Gully Sandstones are among the most durable sandstones to have been used for building in Australia. Examples of their use include most of the important public, financial and religious buildings of the period, e.g. Adelaide Town Hall (1863), Supreme Court (1866), and Edmund Wright House (1875).

1885 - 1945 Limestone, bluestone, sandstone, granite & marble

This is a period of diversification in stone use, prompted by depressions and wars and by improvements in transportation which made carting stone over longer distances more feasible. The beginning of this period saw the first substantial use of granite and marble in South Australia with the construction (1883-89) of the western third of Parliament House of Kapunda Marble on a plinth of West Island Granite. The remainder of the building was completed in the 1930s of the same materials.

Rising costs of working the hard sandstones encouraged development of alternatives: the river cliffs at Murray Bridge providing the most-used, a honey-coloured limestone. With the completion of the railway to Murray Bridge this stone became competitively priced for use in Adelaide and it progressively replaced the Glen Ewin and Tea Tree Gully Sandstones for use in major buildings. Adelaide's two cathedrals, St Francis Xavier's and St Peter's, record the change from the sandstones to the limestone. Construction of both began in sandstones and was completed in Murray Bridge Limestone. Similarly the 1891 extensions to the GPO in King William Street, though architecturally matching the original building, were carried out in the limestone. North Terrace buildings of Murray Bridge Limestone include the Art Gallery (1898 &1936), Museum (1908) and Bonython Hall (1933).

Always in competition with the limestone was sandstone brought from the Sydney region. From the mid 1870s through to the 1930s, substantial quantities of Sydney sandstone were used in bank and major office buildings. Examples include the facade of the 1884 former Marine and Harbours Building in Victoria Square where a Sydney sandstone superstructure sits on a plinth of Melbourne bluestone (basalt), and the 1934 former AMP Building at 19-23 King William Street which is of buff coloured Hawkesbury Sandstone.

Bluestone quarries at Tapley Hill and the Mount Lofty Sandstone quarries (near Stirling) were opened in the 1880s. Their materials were used principally in housing, though one of the Tapley Hill quarries produced very large regular blocks suitable for multi-storey buildings.

Improving transport facilities enabled the use in Adelaide of stone from country areas. Tarlee and Auburn Bluestones and Waikerie and Ramco Limestones (again from the river cliffs) were among those used in the city.

Orange-pink granite was worked near Murray Bridge and light grey at Monarto. These were used as base courses, particularly of bank buildings, in which the superstructure was either South Australian limestones or Sydney sandstones.

1945 - 1990 Modern construction: sawn granite, marble & sandstone

With the widespread use of steel and concrete frames, multi-storey buildings now have thin external claddings rather than load-bearing masonry walls. Consequently the types of stone used have changed from sandstones and limestones to granites and marbles which lend themselves to slabbing and polishing. Stone has faced stiff competition from other materials: glass, metal, concrete and composites, and although well-selected and detailed stone is more durable, it is also more expensive. Modern transport has seen considerable importation of granite and marble from around the world (particularly marbles and granites from Italy, and granites from Scandinavia), to the detriment of the local product and industry.

In domestic construction, the hand-dressing of sandstone was replaced by machines with advent of carborundum, and then diamond, tipped tools. Sawn sandstone from Basket Range was popular in the 1950s but was gradually replaced by softer, more cheaply sawn stone from Kapunda, Brinkworth and

Manoora. Since the resurgence of interest in natural materials in the 1970s, Basket Range stone is again available and there has been considerable use of bluestones from Wistow and Kanmantoo.

IV THE SLATE AND FLAGSTONE INDUSTRIES

Slate suitable for roofing was discovered at Willunga in 1840 and by the 1860s four quarries had been established and slate was shipped regularly from Aldinga to Adelaide and Melbourne. Despite its proximity to Adelaide, difficult transport conditions and competition from alternative materials meant that the Willunga slate industry went through a series of highs and lows. The industry developed at a time when thatching and timber shingles were the chief alternatives, declined with the introduction of galvanised iron in the 1850s and grew again with the Victorian building boom. In the 1920s and 1930s there was a revival but the production of roofing slate effectively ceased during World War II. Many roofs of Willunga Slate remain as testament to this industry. In the town of Willunga itself other uses of the material can be seen, notably large slabs used for paving, rainwater tanks and even walls.

Thick bedded slate (flagstone) was discovered at Mintaro in 1856 and has been almost continuously quarried since.

Mintaro Slate is more suited to paving applications than roofing. Large ‘flags’ paved the footpaths of Adelaide and Melbourne in the nineteenth century and sawn and random (crazy) paving remain the principal product. In the early years the slate was used locally for wine vats, troughs, tanks and even chimneys and fenceposts, diverse applications in which it was later replaced by concrete and stainless steel. Waste material from the quarries was used as walling for most of the town’s buildings. High quality billiard-table tops are a well known Mintaro Slate product.

The slate and flagstone industries of Willunga and Mintaro are of heritage significance in their own right and some of the quarries have been recognised under the terms of the South Australian Heritage Act.

V REGIONAL VARIETY AND DIVERSITY

> … usually no materials look so well as the local ones, which belong organically to their landscape, harmonize with neighbouring buildings and nearly always give the best colours’ (Clifton-Taylor, 1987).

Regional variety

Prior to World War II the cost of transport meant that the stone buildings of most country towns were constructed of locally quarried materials. The regional variety in building stone use is thus very much a function of the local geology. Hence the towns of the Mount Lofty and Flinders Ranges are built of sandstones and bluestones; those of the South-East of squared limestones; while the almost ubiquitous mantle of the surface limestone, calcrete, ensures that the buildings of vast areas of the state are walled in this rough nodular material. Calcrete is to be found across much of the lowland areas: Eyre and Yorke Peninsulas, the plains north of Adelaide and east of the Mount Lofty Ranges, the Murray Mallee and the Riverland.

The South-East

The South-East is a particularly interesting area from this perspective, for with the exception of some rare examples of tuff near the volcanic cones, all the older buildings are constructed of limestone, yet the variety of stones is considerable. The ease of quarrying and ready workability of the light coralline Mount Gambier stone was discovered in 1842 and has been exploited ever since. It is mostly white coloured in the Mount Gambier district, while yellowish variants occur at Glencoe and to the north at Struan and Naracoorte. Pink and gray dolomite limestones were quarried near Tantanoola and were used in some prominent buildings in the South East. From Naracoorte west to the coast is a succession of old dunes consisting of aeolianite (wind-blown lime sands of former beaches). These vary in grainsize and have grey, white and cream colours depending on small amounts of other minerals incorporated in the stone. Robe and Beachport are built of this type of limestone.

Some limestones of the South-East were dug from swamps. Soft, and almost cheese-like when 'quarried' (with a spade) they hardened into light grey and off-white stones of a fine-grained chalky consistency. This swamp limestone can be seen in some buildings at Penola.

The Mount Lofty Ranges

On a local scale we can follow beds of soft clayey sandstones in a north-south line along the Mount Lofty Ranges: from pale purples in Macclesfield, to rose pinks in Mount Barker and Nairne, to paler pinks in Woodside and creams in Birdwood.

Diversity

In certain localities nineteenth and early twentieth century buildings reflect the diversity of building stones occurring within that area. Only in the later twentieth century has modern transport and mass production enabled a veneer of uniformity to veil distinctive and often individual townscapes.

The Barossa Valley

The Barossa Valley is built of bluestones and marbles from the surrounding hills, and of ironstone (sandstone with a iron-rich cement) taken from the slopes of the gentler hills within the valley. Lyndoch buildings were constructed of reddish ironstone. Tanunda was progressively built of dark red ironstone, dark bluestone and white marble. Angaston is constructed of grey bluestone and white and blue-grey marble. Many villa-style cottages in Angaston are built entirely of white marble, which at first glance could be mistaken for sandstone.

Auburn and Gawler

The town of Auburn is built of a distinctive local bluestone in combination with calcrete and a pale grey sandstone from further north in the Clare Valley. Gawler has a similar rich mix of local materials: cream calcrete, khaki bluestone and pale sandstone.

Mining towns

Many mining towns incorporated by-products of their industry into local buildings. At the Wallaroo and Moonta Mines, dark waste rock from the copper mines together with red sandstones and yellow limestone can be seen in the massive walls of pump and engine houses. Overburden from mining operations provided a convenient source of stone for the buildings of Kapunda (bluestone) and Mintaro (slate). 'Stones' which are in fact cast blocks of smelter slag were used in some of the mining towns including Burra and Yelta.

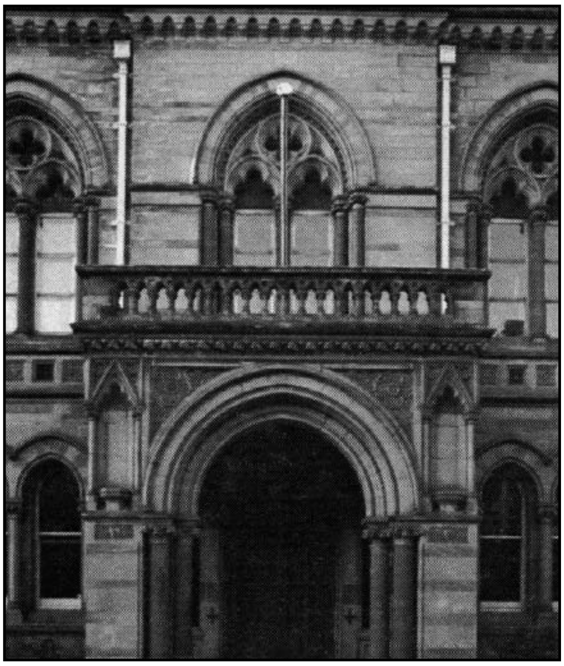
VI IMPORTED STONE AND THE BALLAST MYTH

It is often claimed that the stone for a particular building was imported as ship's ballast. Most of these claims can be discounted. True ballast, in the sense of very cheap rocks or waste material such as smelter slag was generally dumped overboard on arrival in Australia: only rarely would it have been salvaged and used for building. With a wide variety of locally available stone there was little need to import more.

However, there are some examples of stone being imported from overseas. They can be divided into three broad categories:

1. Good carving stone was not available locally (the sandstones of Glen Ewin and Tea Tree Gully were generally too hard to carve) and so, in the mid to late nineteenth century, limestones were imported from England, France and New Zealand. Examples include oolitic limestone from Bath which was

used in the capitals of the GPO tower and Caen limestone from Normandy in the capitals of Pilgrim Church in Flinders Street. These materials can be seen inside many churches as statues, screens and altar pieces.



An unusual example of imported stone: the colums are red standstone from Dumfries, Scatland. The surrounding ashlar masonry is white sandstone from Sydney region with horizontal bands of pale brown Manoora Sandstone. Mitchell Building, 1879-1881, University of Adelaide..

2 Imported stone was often preferred for monumental masonry - headstones, statues etc. Substantial quantities of white Italian marble were imported: the uniform white of a nineteenth century cemetery is because most of the stones came from the one source. Granites were also imported, for use in civic monuments and as prestigious detail in grand buildings.

3. Roofing slate was also imported from Wales and was used in competition with the local product from Willunga.

These are all high quality materials (and hence of some value) and while they would undoubtedly have helped to ballast ships, they were not simply ballast but profitable cargo, even though they may have been carried on a speculative basis.

Calcrete (limestone) rubble with brick quoins and dressings. Large amounts of mortar were required with the rough nodular stone.

VII PROPERTIES AND USE OF STONE

Stone selection and physical properties

Numerous factors determine the selection of building stone for a particular purpose, including:

- aesthetic qualities: colour, texture, grainsize
- strength and durability
- ease of working and cost of preparing and fixing in position
- accessibility of deposit, transport costs
- general acceptance of the stone by architects, designers and building owners.

Thus factors such as durability, which might be considered fundamental, are only a part of the overall selection equation. In addition, stones vary widely in their physical properties and a good understanding of the significance of these properties is required to both build effectively and to maintain and conserve buildings of value.

Porosity and permeability

Porosity and permeability are important factors affecting the performance of masonry materials. Porosity is the void space within a material, usually expressed as a percentage of total volume. All masonry materials are porous: porosities range from less than 0.5 % for granites and marbles, through 0.5 - 2.0 % for slates, 5 - 25 % for sandstones to 5 -35 % for limestones. There are always exceptions, one of the most dramatic is the Mount Gambier Limestone which has porosities averaging 55 %. The most obvious effect of a high porosity is to reduce the weight (or lower the density) of a block of stone.

If the pores are not connected then the material will be impermeable to water or air transport, but many interconnected pores will produce a permeable material. Stones with low porosity and low permeability will generally be more durable (weather resistant) than those with high values. The significance of porosity and permeability to building conservation is further discussed in the Technical Note: Conservation of Masonry.

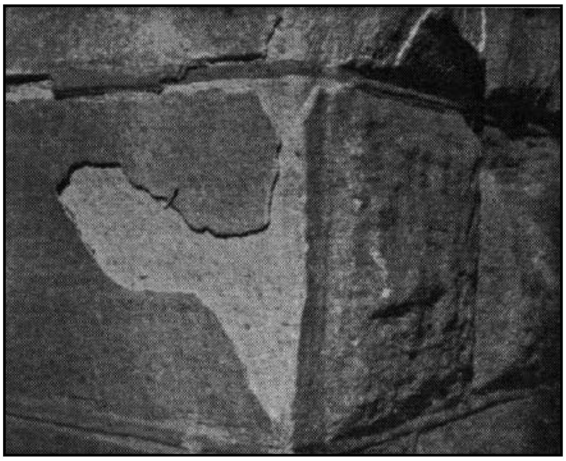
Bedding

Stones are rarely homogeneous. Most have some layering or planar structure such as bedding planes in sandstones and limestones (the natural layering produced by sedimentary deposition and often made apparent by changes in the minerals deposited) or cleavage planes and fissile partings (often along bedding planes) in slates and flagstones. Even granites and marbles can have incipient layering or foliation that may have some impact on stone properties.

Except where architectural detail (such as a cornice or an arch) requires otherwise, all sandstones and limestones (and other sediments) are laid 'naturally-bedded', i.e. horizontal. This is because layered stones such as sandstones and limestones may have fine layers of clay minerals lining the bedding planes: these can be both planes of weakness and also barriers to moisture transport within the stone. On both accounts the layering in a wall should be horizontal. Many examples of failed stonework are due to stones having been 'face-bedded' - laid with the natural bedding in the plane or face of the wall. The building trade knows these stones as 'shiners' for they were often deliberately laid incorrectly to improve the appearance of the wall. Face-bedded stones are liable to delaminate and shed their complete surface layer.

Case-hardening

Case-hardening is the gradual development over time of a hard skin or case; it can be critical to a stone's subsequent durability. It is best observed in sandstones and limestones but can occur in all masonry materials, bricks and mortar included. For stone, development of case-hardening is a two stage process. On exposure after quarrying and processing, a stone loses its 'quarry sap' as it dries, resulting in precipitation of semi-soluble salts at and just below the stone surface. These salts, which are likely to be the same as the stone's natural cement, have an additional binding effect producing the hardening of the surface. Secondly, during the life of a stone in a wall, moisture, as rain or as condensed humidity, penetrates into the porous stone where it dissolves a minute amount of the stone's constituents. As the moisture later evaporates this is brought back to the surface where it crystalises and reinforces the skin.



Adelaide Hills sandstone showing loss of case-hardened surface. Beneath the case-hardening the stone is soft and weak.

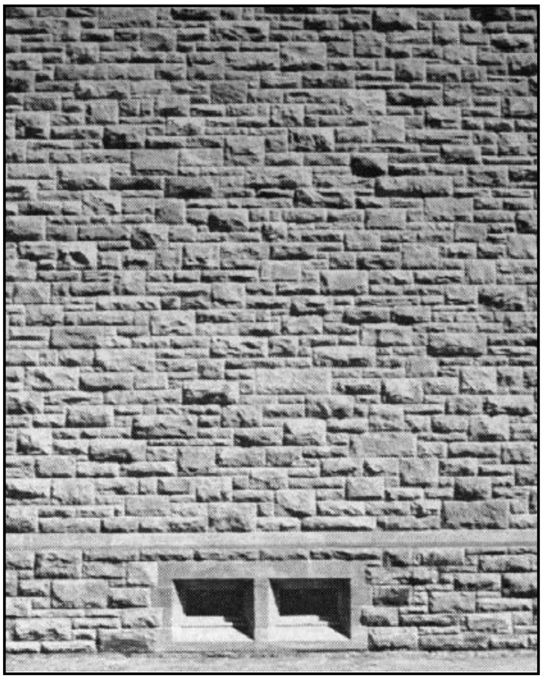
This second stage occurs not only in stone, but in walls of all other types of masonry, including brick, mortar, earth (adobe and pisē) and even concrete. The extent to which this case-hardening develops is a function of the solubility of the material (how readily it dissolves), its porosity and pore structure (and hence permeability), the amount of available moisture, the rate of wet-dry cycling of the wall, and time. With time the case-hardened surface becomes stronger, less permeable and hence more durable, but this occurs at the expense of the material that is just behind the surface. There the constituent parts are being progressively removed and so that zone becomes weaker and more porous.

Any action that removes or damages the case hardening (such as aggressive cleaning) is not in the long term interest of the stone, for without it the stone is much more susceptible to decay.

Stone finishes

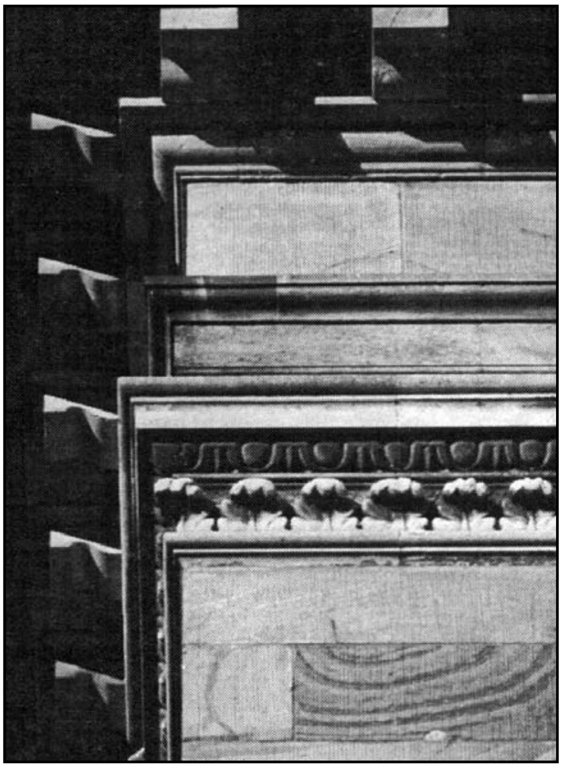
Many different finishes have been applied to stone. Originally these finishes were the result of hand dressing stones to produce regular building blocks: they were the product of necessity. Later, necessity became a convention, and standard methods of finishing stones emerged. Different types were chosen to suit the particular architectural style. Many of them are still reproduced today even though modern sawing techniques enable the production of accurate rectangular blocks. Finishes commonly seen in South Australia include:

- **Smooth-finished**, was produced by a final rubbing with a carborundum block or a harder stone.
- **Rock-faced** stones were produced by pitching off surplus stone from the face (using a special pitching chisel) to give a rock-like surface. This finish suited many of the coarse-grained sandstones of the Adelaide Hills. Some bungalows of the 1920s and 30s have rock-faced stones wich have been elaborately finished by rounding and smoothing and even picking.



Rock-faced Tea Tree Gully Sandstone. Memorial Hall, 1921, St Peters College.

Rock-faced Tea Tree Gully Sandstone with smooth-finished limestone ashlar spire and dressings. St Dominic's Priory Chapel, 1893, Molesworth Street, North Adelaide.

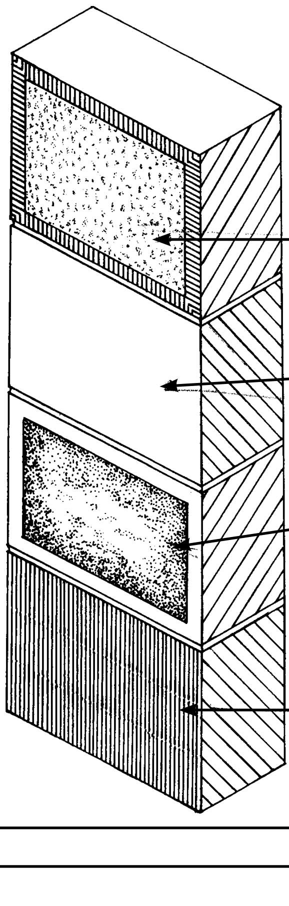


Tea Tree Gully Sandstone showing strong iron-oxide figuring, vertically tooled with a tooled margin to the corner, capital of imported limestone. Supreme Court, 1867-69, Victoria Square.

- **Drafted margins**, a margin around the face of a stone, were once a necessary part of guiding the dressing of the stone to the required surface. In South Australia, drafted margins are often seen with a tooled finish, with the parallel lines at right angles to the edge of the stone. They were used in combination with other finishes such as picked and rock-faced.

- **Tooled**, a series of more or less continuous parallel lines, produced by hitting a broad chisel (boaster or bolster and broad-tool) progressively across the face of a stone.

- **Pickedor punched** are similar finishes produced by repeated blows from different sized chisels or from a small mason's pick. Sometimes a punch (chisel) was worked progressively over the face in broadly spaced parallel lines, producing a distinctive pattern such as can often be seen on Gawler Bluestone.



Types of masonry

Masonry can be broadly divided into three types based on the degree to which the stones were dressed or shaped.

1. Rubble. Hard, difficult to work stones (e.g. hard bluestones very hard sandstones and calcrete) were often not dressed at all but laid in the wall as they came the quarry, with wide mortar joints filling the irregular spaces between stones.

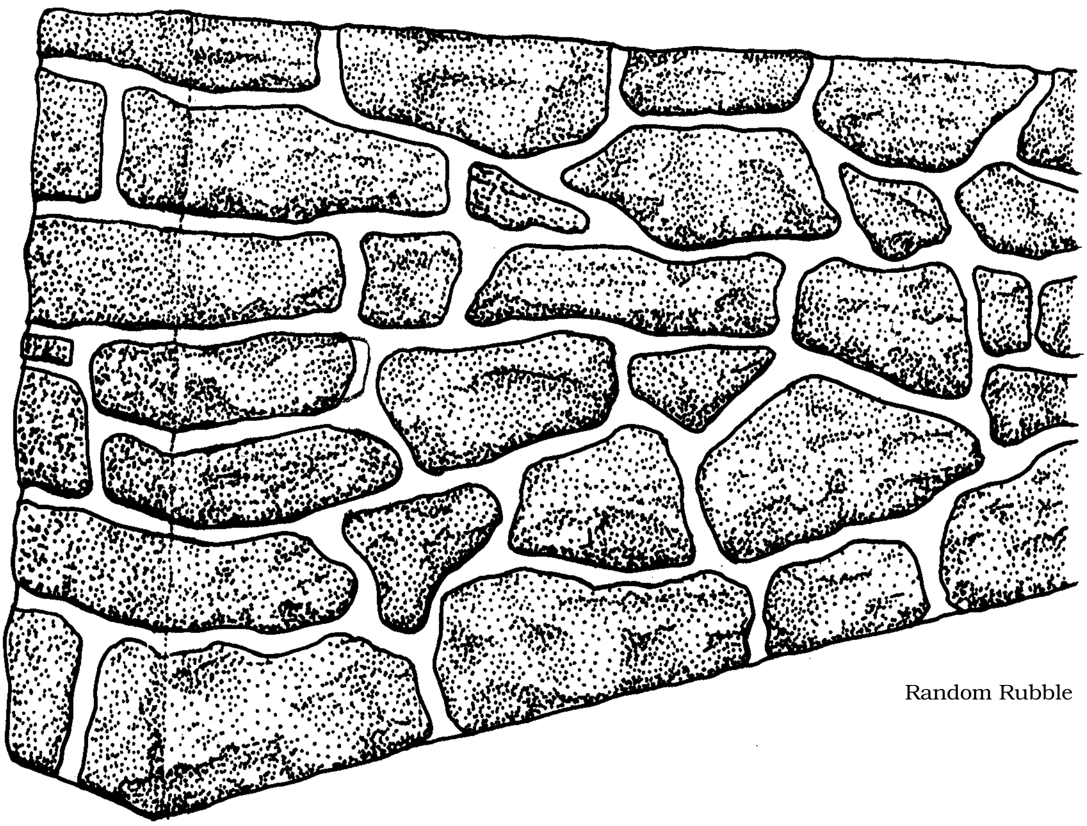
   This is rubble masonry and is common in South Australia.

2. Squared rubble is also common in South Australia. More workable stones (generally sandstones, limestones, and some bluestones) were dressed to roughly rectangular blocks, requiring thinner joints. twentieth century houses have squared rubble in the front walls but undressed rubble in the side and rear walls. The contrasting amounts of mortar required make the differences very clear, particularly in bluestone work.

3. Ashlar masonry is work in which softer, even-grained sandstones or limestones (true freestones) were generally finished smooth, worked to fine tolerances and laid in regular courses (or layers) with very thin joints. Ashlar work was reserved for more expensive buildings, and its use depended on the type of stones chosen. Ironically, today's diamond- sawing technology makes reproduction of ashlar much simpler than squared rubble with a picked finish and drafted margins. Mount Gambier Limestone blocks, which are directly sawn from the quarry floor, are known locally as ashlars.

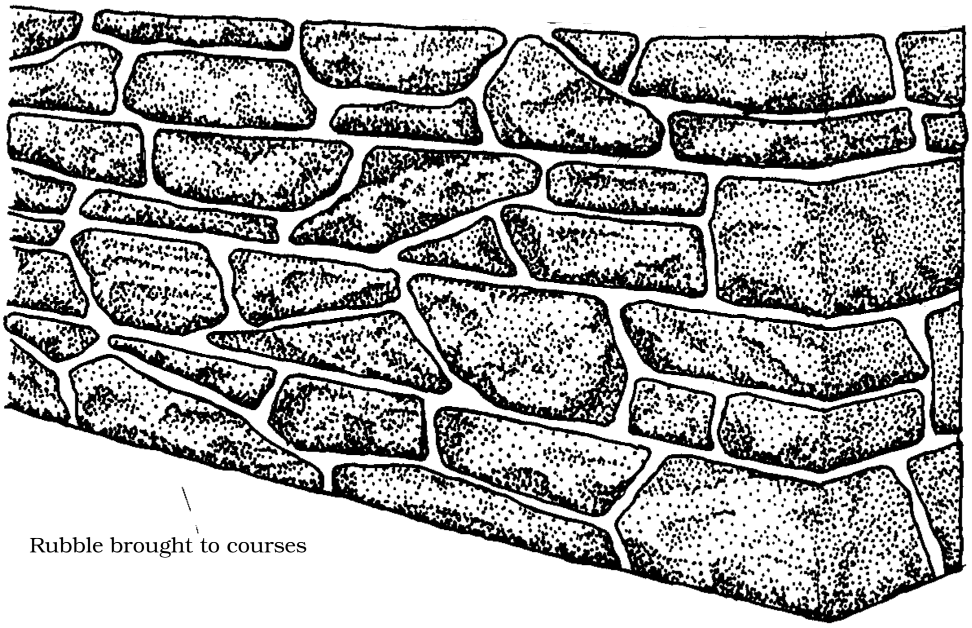
Rubble and squared-rubble can be further described by the bonding pattern of the stonework.

- **Random rubble** masonry shows no apparent organisation even though in well-executed work care has been taken to distribute different-sized stones along the wall and to ensure good bonding between stones.

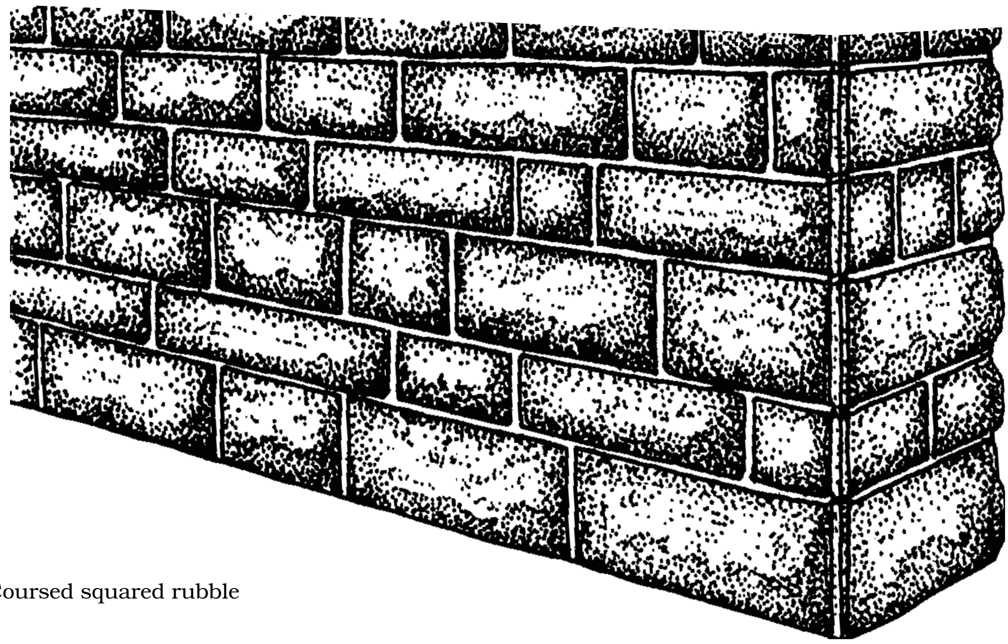


Random Rubble

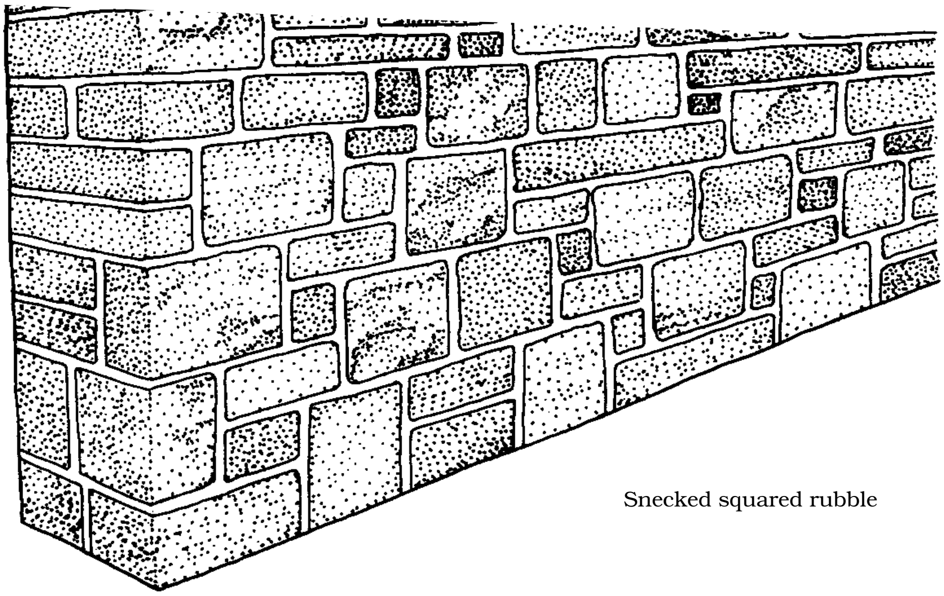
Rubble brought to courses is rubble work which is progressively built and completed in regular courses often to align with brick or stone quoins. In some walls this style of masonry is immediately apparent (being highlighted by the mortar pointing); in others more careful



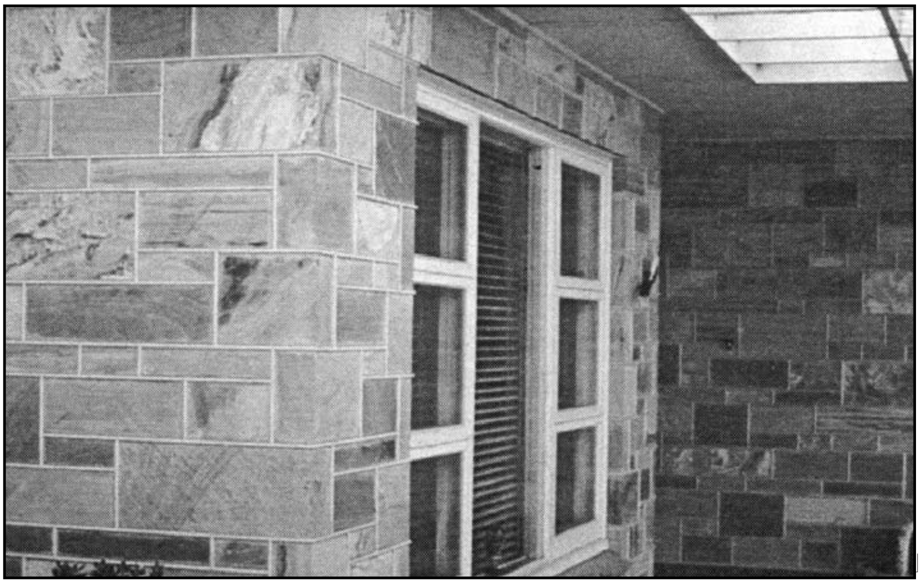
Rubble brought to courses



Coursed squared rubble



Snecked squared rubble

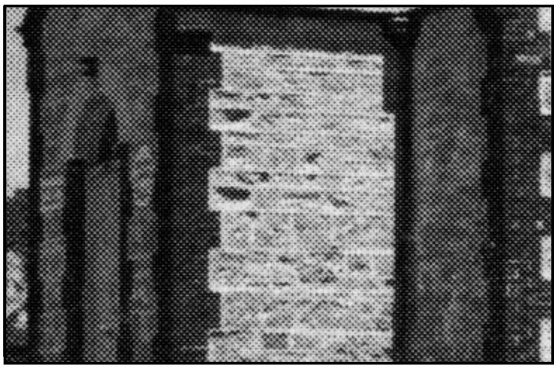


Snecked squared rubble (sawn blocks) of coloured Kapunda and Brinkworth Sandstones, with a protruding bead pointing, 1960s house, Adelaide.

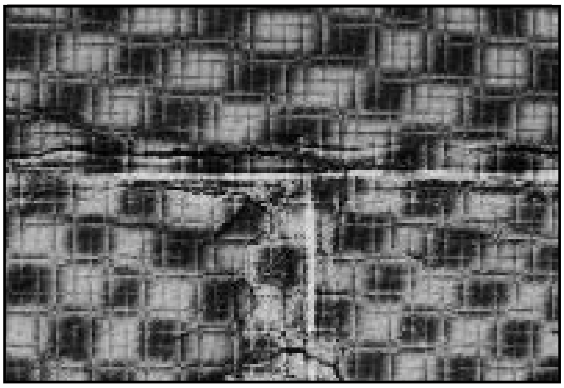
Mortar joints

Prior to the introduction of modern cements all mortars were made using lime as the binding material. Until World War II lime was the principal binding material in mortars for stone and brickwork (above the damp-proof course) in domestic construction. The filler in mortars is generally sand; sometimes crushed stone has been used. The appearance of stonework is partly due to the materials of the mortar and to the finish applied to the mortar joint. Many mortar joints have been pointed: that is finished with a pointing mortar that is different to the bedding mortar. The use of pointing meant that stronger mixes could be used for weatherproofing the joint, while also enabling the economic addition of coloured materials, such as special sands, charcoal, and brick dust.

Disguising the width of joints, and thus giving the appearance of higher quality stonework, was a common practice in South Australia. Charcoal and cinders from steam locomotives were added to light-coloured lime mortars to approximate the darker tone of surrounding bluestone. A narrow line was ironed into the setting mortar and when dry painted white in imitation of a thin joint. In this way, rubble stonework could be given the appearance of the more formal and more expensive ashlar work. Close inspection of many bluestone walls will reveal joint lines painted across the face of stones that got in the way of the artifice! With light coloured stones (sandstones and limestones) the mortar was not coloured but the lined joint was often painted black.

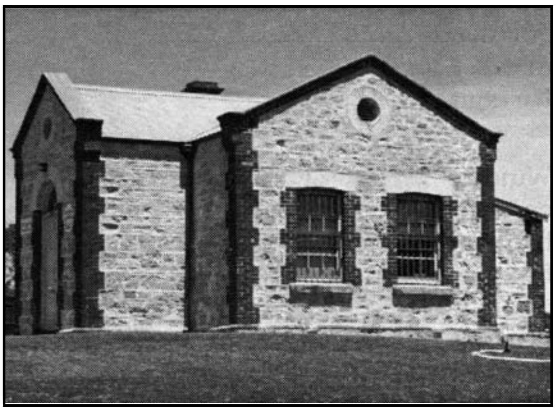


Rock-faced Mount Gambier Limestone brought to courses, with black-lined joints. 1950s house , Adelaide.



White lining of joints to give impression of high quality fine-jointed work. The mortar has been darkened with charcoal or cinders to tone in with the surrounding bluestone.

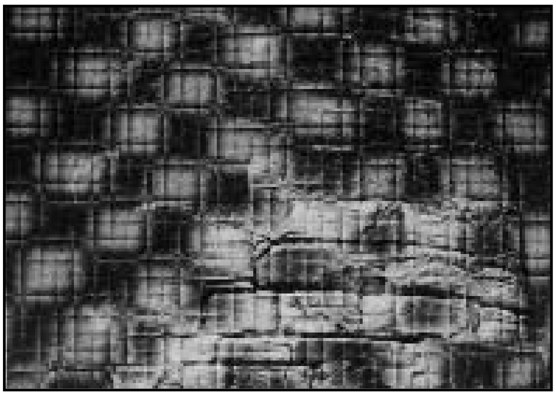
Tuck pointing of joints was another way of disguising their true width. Instead of painting a ironed line in the joint, a thin additional fillet of white lime putty was 'tucked' into a scored line leaving a small raised rectangular section. Tuck pointing of brickwork was common practice in New South Wales and Victoria but was less common in this state. A coarser form of protruding pointing (best described as ribbon pointing) can be seen on some South Australian bluestone and limestone walls (e.g. Adelaide Town Hall buildings of Dry Creek Bluestone).



Coastal aeolianite (limestone) with brick quoins and ribbon pointing of joints. Former custom house and council chamber, 1863. Robe.

Weathering and the colour of masonry

Weathering is the natural ageing of masonry materials that leads to the development of a patina on their surface. This patina is due in part to concentration at the surface of iron-oxide minerals and minor accumulation of dust in surface depressions. From a conservation point of view, a surface patina is evidence of a building's survival through time (it is a part of its cultural significance) and it should not be removed unless it can be clearly demonstrated that the patina is damaging the masonry. It is important to distinguish between patina and injurious grime.



The effect of weathering on the colour of masonry. The light colours near the base are the natural colours of the stones, made apparent by rising damp and salt attack. On the left the colours are due to wind-blown dust on the northern side, while those on the right are due to lichens on the weather side. Mine chimney, Kapunda.

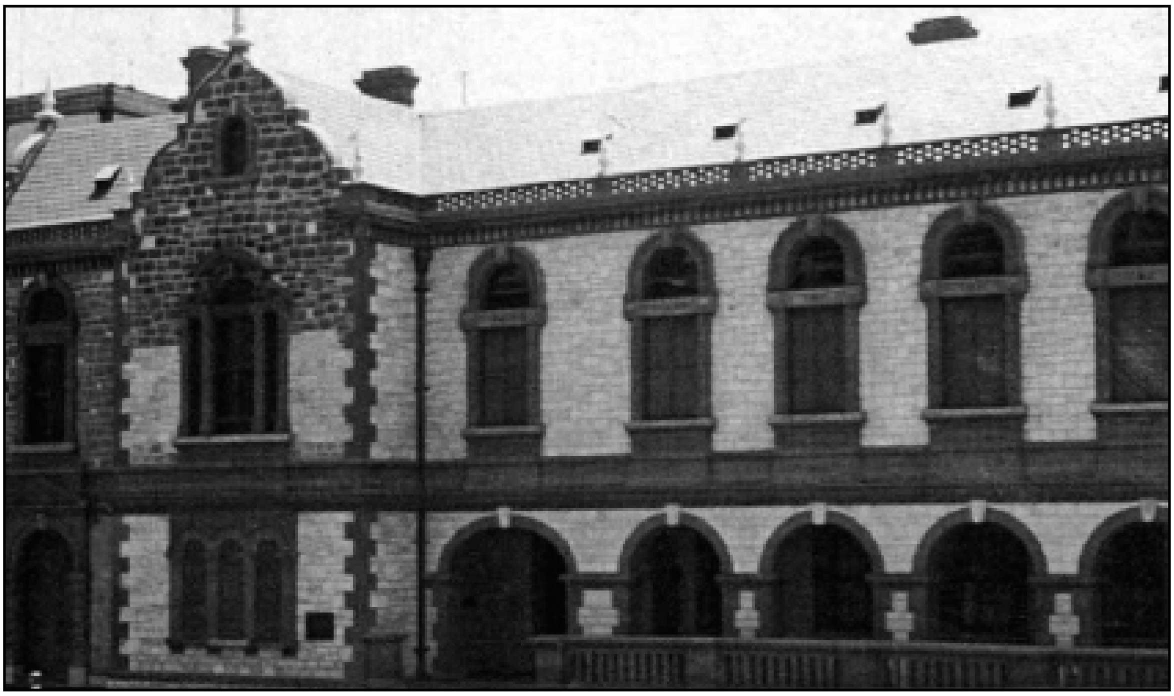
Differential weathering is most apparent on white limestone buildings where rain-washed parts of the building (such as cornices) remain clean while sheltered areas accumulate dust and grime and turn grey and black.

Wind-blown dust can make a significant contribution to the colour of masonry buildings. Picked or punched chisel finishes have deep recesses which retain dust and even smooth finishes on fine-grained stone will retain dust on the non-rainstruck side of a building. Naturally white sandstone can take on warm red or honey-brown colours, due in part to iron-oxides, but particularly to dust. Dust coatings can also accumulate on limestones, mortars and renders. The warm red colours of sandstones in the north and mid-north (e.g. in Clare, Gladstone, Jamestown, Quorn) are mostly due to dust. Washing it off would detract from the gracefully-aged and quintessentially Australian character that they have acquired over time.

VIII SYNTHETIC STONE

As stone became more expensive to work at the end of the nineteenth century, a small synthetic stone industry developed in South Australia. Imitation sandstone was made using sand and cement pressed or cast into moulds. It can be seen chiefly as rock-faced quoinwork in combination with real sandstone in housing of the early twentieth century. The clue to identifying it (even when painted) is regular repetition of the same cast pattern.

Cast forms were used in the nineteenth and early twentieth centuries for some decorative elements such as urns, and particularly for repeated details like balusters and vermiculated quoinwork, the latter being applied to a brick or stone backing.



Cleaning has highlighted the different stones which record the development of the building. White Adelaide Limestone and red brick quoins and dressings form the main section (1854-55) while the extension to the west is in Mticham Sandstone (1874-76). Old Parliament House, North Terrace.

IX HISTORICALLY IMPORTANT BUILDING STONES OF S A

Here is a list of some of the historically important building stones of South Australia, arranged alphabetically under each stone type. The names are geographical and may differ from trade names that have been or are still used.

Granit	**Slate & flagstone**	**Bluestone**	**Sandstone**
Black Hill	Mintaro	Auburn	Backet Range
Monarto	Willunga	Beaumont	Carey Gully
Murray Bridge		Clare	Finnis River
Victor Harbor		Dry Creek	Glen Ewin
West Island	**Limestone**	Gawler	Kapunda
		Glen Osmond	Manoora
	Adelaide	Magill	Mitcham
Marble	Murray Bridge	Mitcham	Mount Barker
	Mount Gambier	Tapley Hill	Mount Lofty
Angaston	Overland Corner	Tarlee	Sandy Creek
Kapunda	Ramco		Stirling
Macclesfield	Waikerie		Tea Tree Gully

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