# Western Australian dimension stones for the 21st century

by J. M. Fetherston

***Abstract***

Dimension stone is a rock material quarried for the manufacture of blocks and slabs for use in the construction industry. The stone must possess appropriate physical properties for a particular end use as well as having an attractive appearance. Dimension stone's principal application is in the cladding of large buildings as panels, slabs, and tiles. It is also used in the construction of private homes, streetscapes, and retaining walls as blocks, tiles, and pavers. Dimension stone is also widely used for the construction of public and private memorials and stone artworks. Western Australia has numerous deposits of high-quality dimension stone, predominantly granites and gneisses, and the prospectivity for further deposits is excellent. Deposits of black granite, limestone, sandstone, quartzite, and marble also have considerable potential for future development.

In recent years, Western Australian dimension stones have received recognition through their use in many national and international building projects. Granites and gneisses from the west Kimberley region, Esperance, and Fraser Range have been used to clad a number of city buildings in Sydney, Melbourne, and Southeast Asia, as well as providing material for city streetscapes. In 2003, a green granite from Jerramungup was used to construct the Australian War Memorial in London. Currently, a light-coloured granite–gneiss from Bruce Rock is in demand for slabs and tiles. Sandstones from Donnybrook and the west Kimberley continue to be used in the cladding of buildings and in the construction of streetscapes, such as Melbourne's spectacular Federation Square project completed in 2003. In the Perth region, the natural limestone industry is gaining momentum, with increasing demand for limestone blocks and housing bricks for use in the construction of private homes, subdivision and landscaping projects, and retaining walls, both locally and interstate.

Currently, Western Australia has a small but vibrant dimension stone industry. However, much work is required for industry to realize the full potential of the State's dimension stone resources and to further identify new niche markets for this material, both at home and abroad.

**KEYWORDS:** dimension stone, construction materials, dolerite, granite, gneiss, limestone, marble, ornamental stone, quartzite, sandstone, quarries, mineral processing, Western Australia.

## *Introduction*

Dimension stone is a natural rock material that plays a significant role in today's construction industry. It is commonly used in the construction of buildings such as city offices, hotels, and shopping centres, as well as surrounding streetscapes, and private homes. Dimension stone comprises a subset of construction materials that may be defined as "*…a natural rock material quarried for the purpose of obtaining blocks or slabs that meet specifications as to size (width, length and thickness) and shape*" (Barton, 1968).

In addition to the foregoing definition, the physical properties of potential dimension stone must meet end-use requirements and the stone must be attractive to the customer. Properties such as colour, grain texture, pattern, durability, and strength, as well as ability to take a polish or other surface finish, are all important requirements. Most dimension stones are cut or trimmed to specified shapes with one or more sides having a mechanically dressed or polished surface. Other dimension stones, such as flagstones and slates, are often left in their natural state. Demand for stone is commonly influenced by contemporary architectural tastes and styles, as well as availability and consistency of physical properties, especially colour.

## *Applications*

Dimension stone has a number of important applications. The most common of these is the total or partial

cladding of large buildings with precut stone panels, slabs, and tiles. These may be applied on interior or exterior wall and floor areas. Wall panels are generally between 20 and 30 mm thick, and of variable length and breadth, depending on the application and physical properties of the stone. In harsh climates, certain dimension stones, especially limestones and marbles, are suitable only for interior use.

In the construction industry, cut stone blocks are used to build solid stone-walled buildings and free-standing and retaining walls. Today, constructions of this type are usually in the form of architect-designed homes and offices, generally of no more than two stories. The most common materials used in this application are limestone and sandstone blocks. In the past, particularly during Australia's colonial days, more-elaborate buildings were constructed from these materials, and there are many outstanding examples of this form of architecture preserved in Perth city, Fremantle, and a number of towns throughout the State.

Urban communities have been using dimension stone for paving public areas for many thousands of years. Rough cut or sawn stone blocks were laid to form roads, footpaths, and market squares, and rock slabs were shaped for use as kerbstones and gutters. These practices still continue today, particularly in the refurbishment of old, inner city areas.

In many areas of the world, especially Europe, dimension stone in the form of natural slate has been used extensively as a roofing material. In areas such as north Wales and northwest England, large slate quarries supplied a substantial part of this market for hundreds of years. Although this application is somewhat diminished today, both natural and machined slates are used extensively as interior floor tiles. In this application, slate's popularity stems from the vast array of colours and surface textures that are available, together with its pleasant, cool feel underfoot. Although high-quality slate is currently mined in South Australia, most slate is sourced from India, China, and Brazil.

Dimension stone is also much sought after for use in the monument stone industry, which uses it for a vast array of applications and structures. In the mortuary industry, monuments range from simple grave markers and tombstones, to vaults and large mausoleums. In the public arena, stone memorials can be single shaped blocks bearing a commemorative inscription, through to elaborate and vast stone statues or bas-reliefs, intricately carved by artisans, commemorating a person or an event. Non-commemorative works of art carved in stone are often erected in public places such as town squares, parks, universities, and art galleries.

Granite and marble are the preferred dimension stones for monument and artisinal work because of their ability to take a high polish and their high resistance to the weathering processes of most climates. This is illustrated by examples of granite obelisks carved in ancient Egypt about 3500 years ago. To this day, many of these monuments retain their smooth surfaces, and their carved hieroglyphs show little evidence of weathering. Other dimension stones that have been used in monuments, such as sandstone, slate, and limestone, often show evidence of staining, spalling, cracking, and chemical dissolution over comparatively short periods of exposure to the elements (as little as 50 to 100 years).

## *Dimension stones of Western Australia*

The prospectivity for deposits of high-quality dimension stone in Western Australia is excellent. Numerous potential dimension-stone deposits and prospects have been identified, extending from the west Kimberley region in the north of the State to the area around Esperance on the south coast. However, comparatively few deposits have been mined in the past, and only a small number are currently in production. In 2002–03, reported production of dimension stone was only 1303 t. However, this figure does not include an estimated 126 000 t of sawn limestone building blocks, as well as unreported production from quarries operating on private land. In the State, most dimension stone falls into five main categories: granite and gneiss, black granite, limestone, sandstone and quartzite, and marble.

### Granite and gneiss

Western Australia has numerous Archaean to Neoproterozoic granitic rocks and gneisses potentially suitable for use as dimension stone. Granitic rocks are found in many areas, and may display a variety of textures combined with numerous colours. Colours range from pink to red and mid-brown, and also from green to grey. Textures vary from fine-grained equigranular granites to very coarse grained and porphyritic forms commonly displaying large and often attractively coloured phenocrysts of potash and/or sodic feldspars. Currently, visually attractive granites are mined at Jerramungup (*Laguna Green*), Esperance (*Desert Brown*), and Watheroo (*Verde Lope* and *Mulroy Green*). Locations for these granites and all other dimension stones mentioned are shown in Figure 1.

Possibly the State's most unusual granitic dimension stone is the Boogardie orbicular granite, located about 300 km north-northeast of Geraldton. This relatively uncommon granitic rock contains large, closely spaced, light- to dark-grey, egg-shaped orbicules measuring about 10 cm along the longest axis (Fig. 2). The orbicules comprise radiating and granular concentric shells of mainly hornblende and plagioclase surrounding coarsely crystalline cores of variable composition in a coarse matrix of granitic composition (Bevan, 2004).

Other suitable gneisses with attractive colours and banding patterns have been identified in the southern part of the State. Granite–gneisses such as *Austral Juperana*, *Austral Waterfall*, and *Austral Coffee* are quarried in the Bruce Rock area about 220 km east of Perth. *Austral Juperana* is a beige to deep-yellow rock featuring prominent narrow, black, swirling irregular bands and larger pale-green, brown, and pink irregular bands and blebs. *Verde Austral* is sourced from Fraser Range

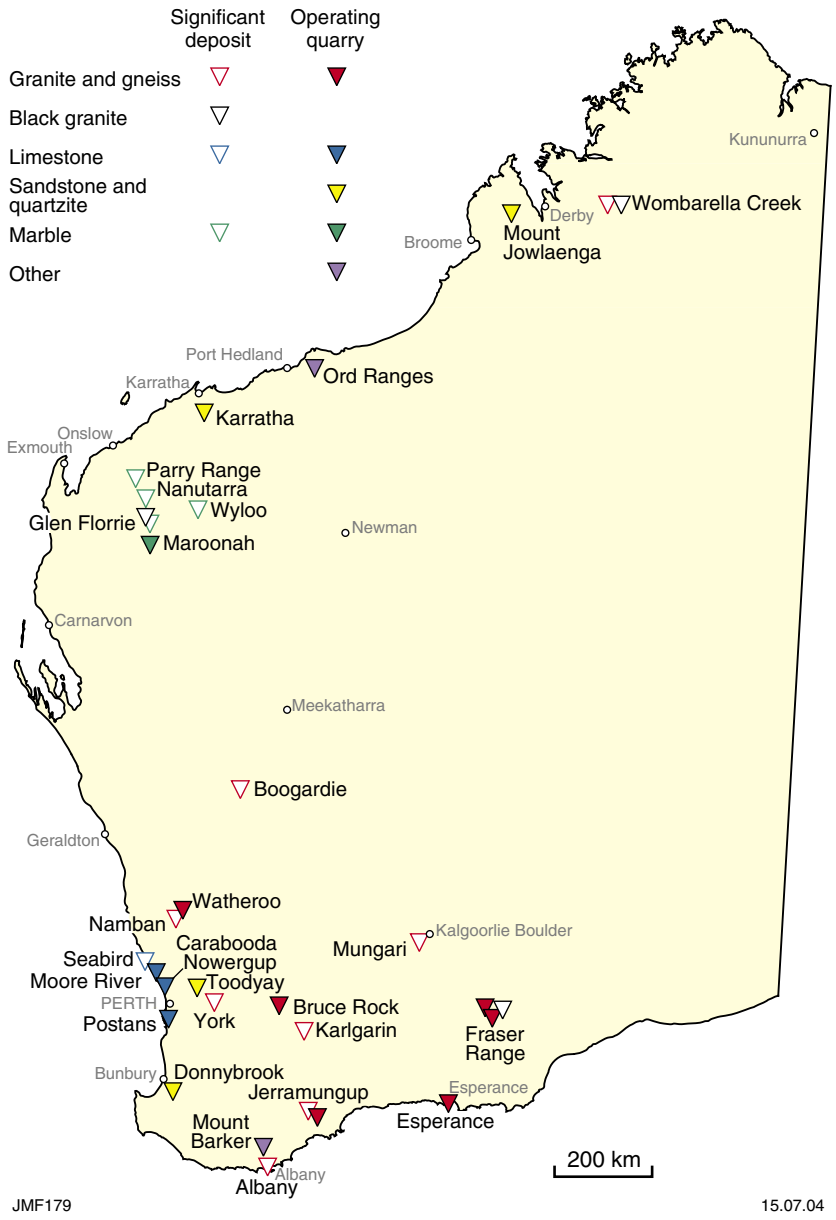


*Figure 1. Location of operating quarries and significant deposits of dimension stone in Western Australia*

about 200 km northeast of Esperance. It is a deep olive-green granite–gneiss with charnockitic affinities, and is physically very strong.

## Black granite

The term 'black granite' cannot be equated to true granitic rocks. Instead, it is a name adopted by the dimension stone industry to describe black, fine-grained intrusive igneous rocks — mainly dolerite and gabbro, and their metamorphosed equivalents metadolerite and metagabbro. In the early 1990s, high-grade black granites were quarried from Proterozoic dolerite dykes at Wombarella Creek in the Kimberley region, about 300 km east-northeast of Broome, and from metagabbro deposits at localities in the Fraser Range. In the Ashburton region, about 225 km southeast of Onslow, Proterozoic dolerite dykes were prospected for potential high-grade black granite at Glen Florrie. Between 1990–95, the Wombarella Creek operation produced black granite boulders up to 2–3 m in diameter. Slabs cut and polished from this material were mostly jet black in colour and were highly sought after by architects for interior and exterior feature cladding on buildings, and by the monument industry. Significant quantities of cut blocks were also exported to Japan.

## Limestone

In the Perth region, from Seabird in the north to Postans in the south, there are a number of deposits of Tamala Limestone, which is a Pleistocene calcarenite. Suitable-quality material, containing a sufficiently high calcium carbonate content (typically 74–86% $CaCO_3$), is used for dimension stone manufacture (Abeysinghe, 1998).

Currently, limestone blocks used in building construction (Fig. 3) are extracted from quarries located in the Carabooda–Nowergup area in the northern Perth Metropolitan Area, and at Moore River about 70 km north of Perth. These quarry-cut limestone blocks are 1.0 or 0.5 m in length, 0.35 m high, and of variable thickness, and have a rough-textured, more natural appearance than diamond-cut blocks, which makes them ideal for the external walls of homes and for landscaping projects such as walls and paving. Smaller quarry blocks, approximately 0.5 m in length, are diamond cut to produce housing bricks with a smoother texture and more-accurate dimensions than quarry-cut blocks.

Apart from standard limestone building bricks, blocks are also diamond sawn and machined into many other shapes, including window sills, corbels, copings, cappings, fireplaces, bullnoses, and other special profiles. In the Carabooda–Nowergup area and at Postans to the south of Perth, softer material unsuitable for block cutting is crushed and mixed with cement in the manufacture of reconstituted limestone blocks, which are mainly used for inner wall courses in building construction and for landscaping projects, especially retaining walls.

JMF183 25.10.04

*Figure 2. Ornamental water sphere of Boogardie orbicular granite in Forrest Place, central Perth. Sphere is approximately one metre in diameter*

JMF184 25.10.04

*Figure 3. A private residence built from quarry-cut blocks of Tamala Limestone from Moore River (courtesy Limestone Resources Australia Pty Ltd)*

### Sandstone and quartzite

There are a number of sandstone and quartzite dimension stone sites throughout the State. The best known of these is located close to the town of Donnybrook, about 30 km southeast of Bunbury, where the *Donnybrook Sandstone* is quarried. This unit is an indurated, fine- to medium-grained, feldspathic and kaolinitic Cretaceous sandstone with colour varying from white to beige, and pink. This sandstone has been quarried for over 100 years and has been used in the construction of many historic buildings. In recent years, up to three companies were extracting sandstone blocks from quarries in this area.

In the north of the State at Mount Jowlaenga, about 100 km northeast of Broome, the Early Cretaceous Melligo Sandstone outcrops in a series of low hills. This unit is fine grained, thinly bedded, flat to low-angle cross-bedded, and contains bivalve fossils (Gibson, 1983). The sandstone varies from light beige to multicoloured forms, displaying prominent, concentric Liesegang banding varying from yellow to pink, red, and mauve over a beige-coloured, sandy matrix. In the area, two dimension stones are quarried from the Melligo Sandstone. These stones, known commercially as *Kimberley Sandstone* and *Kimberley Quartzite*, have different physical strengths related to the degree of resilicification of the rock at different sites.

Natural quartzose flagstones are mined in two areas of the State. In the Pilbara region, an indurated red-brown sandstone, known locally as *Karratha Stone*, is quarried from the Archaean Hardey Formation in the Pinderi Hills, about 50 km southeast of Karratha. This material varies in colour from cream to brown, light green, and pink. About 10 km south of Toodyay, in the Perth region, are several quarries from which Archaean quartzite flagstones are extracted. This material, named *Toodyay Stone*, varies from milky white to grey, or from cream- to red-brown, depending on the location. The rock commonly exhibits thin, pale-green bands of fuchsite, a chrome-mica mineral, along cleavage planes (Low, 1960).

### Marble

In the Ashburton region, between 75 and 250 km southeast of Onslow, high-grade dolomitic marble has been identified at various sites in eight localities. These deposits are found in both the Palaeoproterozoic Duck Creek Dolomite and the Mesoproterozoic Irregully Formation. Several of these deposits were quarried for brief periods in the past, but currently the State's only marble mining operation is located at Sheela Bore on Maroonah Station. The Maroonah marble, known as *Desert Green*, is an attractive deep-green dimension stone displaying thin, black swirling veins, and small, irregular white blebs. Other marbles in the region range from thinly bedded to massive, and a few deposits are intensely brecciated, especially at Wyloo. Colours range from white to cream, pink, deep red, mauve, green, grey, and black.

### Other rock types

Two unusual forms of dimension stone are quarried in the State. In the Ord Ranges, about 60 km east of Port Hedland in the Pilbara region, a jaspilite rock known as *tiger iron* is mined on an intermittent basis. *Tiger iron* contains thin, alternating, parallel bands of red jasper, black hematite, and smaller amounts of golden-yellow tiger eye (a silicified form of crocidolite used as a semi-precious stone). These bands vary from straight to highly contorted folds. As a dimension stone, this material is used as specialty floor and wall tiles.

In the far south of the State, spongolite, a pale-brown, porous rock, is present in the Eocene Pallinup Formation in the Bremer Basin (Gammon et al., 2000). Spongolite has similar properties to the industrial mineral diatomite, but is composed of siliceous, fossil sponge spicules. It has excellent insulating properties, and in recent years this material has been used as a lightweight building material. Building blocks of spongolite have been sawn from material quarried close to Mount Barker, and are used in building construction in the local area, where it is known as *Mount Barker Stone*.

## *Trends in dimension stone usage*

Towards the end of the nineteenth century, dimension stone quarrying and processing were major industries in Australia. At that time, natural stone was a major component in most substantial buildings, bridges, and other public works. It was used in walls, floors, staircases, roofs, paving, embankments, and supporting structures. In Western Australia there are many splendid examples of colonial buildings constructed of natural stone, especially in Perth, Fremantle, and Kalgoorlie. The extensive use of dimension stone continued until the mid- to late 1930s, when production was substantially reduced due to the onset of World War II. The demand for stone remained low for the next 40 years, but during the 1980s architects once again began to incorporate dimension stone in their designs, and substantial quantities were used in large building projects and contemporary homes. This trend has steadily increased over the last 20 years and today the use of dimension stone in the construction industry remains firmly in vogue. Natural stone blocks, cladding, and flooring are now frequently and extensively used in modern, large buildings such as city offices and shopping malls, as well as in private homes. The architect's skilful selection of stone, combined with innovative designs, often results in stunning visual effects.

Although most material is cut into large slabs, tiles, and paving stones, industry now has access to an extensive array of high-technology stone cutting and profiling equipment — in particular, high-pressure water-jet cutting — which makes it possible to create stone objects of virtually any shape or size (Ditria, 2004). Some material is manufactured into ornamental work such as listelli (decorative borders), which display frieze-like patterns for use on floors and feature walls, and granitic stone benchtops remain a firm favourite in private homes. Not all stones are produced with the traditional two-dimensional slab shape, or with matte or polished surfaces. For example, modern processes can produce


*Figure 4. Applications of Western Australian dimension stone in building construction and monuments: a) world headquarters of the ANZ Bank in Melbourne (centre foreground) clad in Desert Brown granite from Esperance; b) detail from the Australian War Memorial, Hyde Park Corner in London, featuring Laguna Green granite from Jerramungup; c) polished benchtop made from a slab of Austral Juperana granite–gneiss from Bruce Rock; d) contemporary building design in Perth employing pale-beige Donnybrook Sandstone cladding; e) a spectacular streetscape created in Melbourne's Federation Square using multicoloured Kimberley Sandstone pavers and blocks. Photo (b) courtesy H. Pronk, Tonkin Zulaikha Greer; photo (c) courtesy Melocco Pty Ltd and Discovering Stone (© Discovering Stone 2004); photos (d)–(e) courtesy Meteor Stone*

tumbled marble stones, and perfectly shaped granite spheres at least 1.0 m in diameter. A large, ornamental water sphere of Boogardie orbicular granite forms a spectacular focal point in Forrest Place in the centre of Perth city (Fig. 2). A similar-sized water sphere, donated to the Geological Survey by Mark Creasy, is on display at the Perth Core Library in Carlisle (see Frontispiece). Surfaces may also be honed, flamed, etched, split, rough sawn, and bush-hammered to produce a variety of surface textures that are not only visually appealing, but may also impart safety features such as rapid water drainage and non-slip surfaces.

In recent years, Western Australian dimension stones, particularly the granitic stones, have featured prominently and achieved recognition in many national and international building and memorial projects. Most notable examples of this include: the *Desert Brown* granite from Esperance, which was used to clad, in entirety, the exterior walls of the ANZ Bank world headquarters in Melbourne (Fig. 4a); the lustrous, grey *Kimberley Pearl* granite, which was used on some external walls of the Crown Casino in Melbourne; and the *Laguna Green* granite from Jerramungup, which was used to create the recently dedicated Australian War Memorial in London (Fetherston, 2004; Fig. 4b).

Granitic gneisses have also been in demand in recent years. *Verde Austral* continues to find architectural approval and was used in the run up to the 2000 Olympic Games to refurbish streetscapes in central Sydney, as well as providing cladding for several city towers. *Austral Juperana* (as featured on the cover of this Review) has achieved considerable popularity for feature paving in and around large buildings, polished slabs for interior wall cladding, and as elegant bench tops in private homes (Fig. 4c). Recently, the stone has been specified for use in the prestigious Bovis Lend Lease development in Phillip Street, Sydney, designed by renowned international architect Sir Norman Foster.

*Donnybrook Sandstone* retains its popularity as a dimension stone due to its consistency of discrete colours and its ability to be cut into precisely shaped blocks. An example of the use of *Donnybrook Sandstone* in a contemporary building design is shown in Figure 4d. The *Kimberley Sandstone*, because of its visually attractive banding, has found popularity in the creation of streetscapes, and recently large quantities of this material were used in the paving and cladding of substantial areas of Melbourne's Federation Square (Fig. 4e). In 2003, a non-banded, beige-coloured variant of the *Kimberley Sandstone* was used to clad the exterior walls of the Motorola Building at the University of Western Australia.

In recent years the popularity of private homes constructed from Tamala Limestone blocks or bricks has been on the increase. Also on the increase is the demand pavers for light traffic areas and limestone blocks for use in free-standing and retaining walls.

There is a continual demand for black granite, especially for the cladding of the interior of buildings. Recently, non-polished, tile-sized black granite pavers have been used for roads in contemporary city streetscapes. As a result of this continuing demand, studies are underway to re-establish the black granite industry in the west Kimberley region.

## Summary

Dimension stone has continued to play an important role in construction for many thousands of years. Over the last 20 years there has been a resurgence in demand by architects and engineers for attractive dimension stones for use in the construction of large buildings, private homes, monuments, and landscaped areas. Currently, Western Australia has a small but vibrant dimension stone industry, specializing in limestone, granite, gneiss, sandstone, quartzite, and marble. Prospectivity for attractive dimension stones in the State is excellent, especially for granite, gneiss, and black granite. However, much work is needed to identify vital niche markets for Western Australia's dimension stones, both at home and abroad, in order to attract companies with the capacity to expand the industry in the face of competition from suppliers from overseas and other states.

## References

ABEYSINGHE, P. B., 1998, Limestone and limesand resources of Western Australia: Western Australia Geological Survey, Mineral Resources Bulletin 18, p. 33–34.

BARTON, W. R., 1968, Dimension stone: U.S. Bureau of Mines Information Circular 8391, 147p.

BEVAN, J., 2004, Archaean orbicular granitoids from Boogardie, near Mt Magnet, Western Australia *in* Dynamic Earth: Past, Present and Future *edited by* J. McPHIE and P. McGOLDRICK: Geological Society of Australia, 17th Australian Geological Convention, Hobart, Abstracts 73, p. 252.

DITRIA, T., 2004, Building and designing in stone: Discovering Stone, v. 3, no. 5, p. 12–16.

FETHERSTON, J. M., 2004, Jerramungup granite makes a striking memorial in London: Department of Industry and Resources Western Australia, Prospect magazine, March–May 2004, p. 6.

GAMMON, P. R., JAMES, N. P., CLARKE, J. D. A., and BONE, Y., 2000, Sedimentology and lithostratigraphy of Upper Eocene sponge-rich sediments, southern Western Australia: Australian Journal of Earth Sciences, v. 47, p. 1087–1103.

GIBSON, D. L., 1983, Broome, W.A.: Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes, 25p.

LOW, G. H., 1960, Notes on the occurrence of the 'Toodyay Building Stone', Toodyay district, S. W. Division, *in* Miscellaneous Reports for 1957: Western Australia Geological Survey, Bulletin 114, p. 93–94.