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Sydney sandstone: Proposed ‘Global Heritage Stone Resource’ from Australia

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(Received October 10, 2014; Revised accepted November 11, 2014)

This paper suggests Sydney sandstone as the first Global Heritage Stone Resource to be nominated from Australia. Sydney sandstone underlies much of the city of Sydney. It is also the most widely utilised dimension stone in the city. Its use in Sydney has extended over 200 years and it continues to be quarried today for Australian domestic use as well as for export. Existing documentation ranges from extensive technical assessment of the stone, heritage lists with abundant illustrations, as well as a Wikipedia entry. Its earliest international use was probably in New Zealand during the 1830s.

Introduction

Sydney is Australia’s oldest and largest city, having being founded in 1788. The city is fortunate to have been established on an extensive and a relatively undeformed layer of Triassic-age sandstone that has proved to be an excellent construction material. These are the most conspicuous building stones in Sydney, but have also been drawn upon for breakwater stone, concrete aggregate, road base and marine ballast. Recent historical reviews of Sydney sandstone are provided by Branagan (2013) and Franklin *et al.* (2014).

The uppermost and conspicuously cliff-forming sandstone in the Sydney Basin sandstone has long been known to stratigraphers as the Hawkesbury Sandstone, because a rock unit using the name, Sydney, and occurring in Nova Scotia, Canada, has been considered to have name precedence (Clarke, 1878; Branagan 2000a). However, the term “Sydney sandstone” has long been informally used (for example by Baker, 1915), even to the extent of being the feature of several published books, including the title (Deirmendjian 2000). In stratigraphic terms, the Sydney sandstone comprises not only the Hawkesbury Sandstone, until recently the predominant source of dimension stone within the region, but also the upper part of the underlying Narrabeen Group, that outcrop to the north of Sydney (see Fig. 1).

This contribution formally nominates Sydney sandstone as a ‘Global Heritage Stone Resource’ (GHSR). The nomination has been

modelled on the published proposal for Portland Stone from the United Kingdom (Hughes *et al.* 2013). This formal designation as a heritage stone will technically formalise the term, “Sydney sandstone”. Cooper (2014) and Cooper & Kramer (2014) have already suggested that “Sydney sandstone is Australia’s most prominent potential Global Heritage Stone Resource and details are readily available in publication to make the nomination.”

This paper makes abundant use of McNally and Franklin (2000), an important collection of 28 technical papers on Sydney sandstone published by the Environmental, Engineering and Hydrogeology Specialist Group of the Geological Society of Australia. Also of significance are the dedicated volumes of Baglin and Austin (1980) and Deirmendjian (2000). These are popular publications with profuse colour images of Sydney sandstone use, plus important heritage information. There is also a useful summary article on Sydney sandstone in Wikipedia at http://en.wikipedia.org/wiki/Sydney_sandstone. Another recent book (Jones, 2013) examines the sandstone landscapes of the Sydney region and the artists who depicted these.

Rock character

The Hawkesbury Sandstone is a massive stratigraphic unit of Triassic age, 100–200 metres thick, composed largely of quartz sandstone with ~5% shale. It covers an area of approximately 12,500 square kilometres within the Permo-Triassic Sydney Basin (Branagan, 2000a, b). Figure 2 shows an example of coastal outcrop adjacent to Sydney Harbor. Branagan and Packham (2000) provide excursion itineraries that direct participants to abandoned quarries at Pyrmont and Bondi as well as to heritage Sydney sandstone buildings.

The Hawkesbury Sandstone originated in a Triassic braided stream system carrying sand from the south-south-west. This was subsequently weakly lithified, uplifted and mildly deformed over the past 250 million years. Its most distinctive feature is its inclined cross laminations and lenticular beds, resembling flattened pillows, 1–10 metres thick and 100–500 metres in lateral extent (Standard 1964, 1969; Conaghan, 1980).

When fresh, the colour of Sydney sandstone is often grey, cream or white. When aged it is typically yellow, buff or brown due to the presence of iron oxides. Detailed geological studies by Wallace (1971),

Figure 1. Generalised geological map showing Sydney Basin sediments in the region around Sydney. The city of Sydney is centred on the south side of the coastal inlet (Sydney Harbor) immediately above the Sydney label (reproduced from Ray, 2000).

Spry (2000) and Franklin (2000) have determined six types of Sydney sandstone that are used as dimension stone. These are:

1. Grey Sandstone
2. 'Yellow Block' sandstone
3. White sandstone
4. Quartz-rich sandstone
5. Colour-banded sandstone
6. Typical surface Hawkesbury Sandstone

The so called "Yellow Block" sandstone – actually pale pink to pale orange in colour due to siderite oxidation – is the most prized type in heritage construction. However the quartz-rich sandstone is the most abundant in the greater Sydney area and is now the most extensively quarried variety.

Australian heritage

The earliest use of Sydney sandstone was undoubtedly by Australia's indigenous aborigines, who utilised the stone for grinding, sharpening tools and carving as well as for shelter (Baglin and Austin, 1976; Ray, 2000). However cutting and spear point artefacts had to be quarried from harder rock distant from Sydney so the region's aborigines have been described as a 'stone-age people without good stone'.

Following foundation of the city of Sydney in 1788, the use of sandstone for building was well recorded by the time of Governor Lachlan Macquarie (1810-1821) and the convict architect Francis Greenway (Wallace, 1971; Franklin *et al.*, 2014). A very early geological description of the Sydney sandstone by Russian naturalist, Fedor Ivanovich Stein, in 1820 has been translated into English and published in Branagan (2010). A few years later, in 1839-1840, eminent US geologist J.D. Dana provided much more geological information on the same stone (Dana, 1849).

Subsequently in the late 19th century, most prominent public buildings in Sydney including the Town Hall, General Post Office (Fig 3), Art Gallery of New South Wales and State Library of New South Wales were all constructed using Sydney sandstone.

Also in the late 19th and early 20th century, Sydney sandstone was used for major construction in most other major Australian cities especially Melbourne, Adelaide and Brisbane to the extent that complaints were expressed that suitable local stone materials were being neglected (Cooper, 2012, p. 24).

Innumerable sculptures utilising Sydney sandstone also embellish Australian heritage constructions ranging from decorative friezes and capitals to significant monuments (Baglin and Austin, 1976; Deirmendjian, 2002, Fig.3).

Quarries

Branagan (1996) notes that a map prepared by a convict in June 1788 shows a quarry, most likely in Sydney sandstone, near the site of the present Sydney Opera House. Gibbons in Franklin *et al* (2014) noted that there is an 1823 painting of stone quarrying at State Library of New South Wales (Mitchell Library). The same author also recorded that a valuable "freestone" resource had been recognised by the late 1820s and 1830s and that major sandstone quarries were established in the inner Pyrmont area of Sydney, probably by the late 1840s. It was here that the famed "Yellow Block" sandstone was extracted.

Quarrying continued in this, now inner urban area, until the early 20th century. These quarries are now largely built over, although attempts were made to extract further "Yellow Block" in the 1980s. An early description of sandstone quarrying at this locality in an international journal was provided by "Scientific American" in the late nineteenth century (Anonymous, 1884).

Quarrying of Sydney sandstone continues today. In 2000, there

Figure 2. Outcropping Hawkesbury Sandstone at the The Gap, Watsons Bay at the entrance to Sydney Harbor

were 33 significant operating sandstone quarries, including dimension stone and aggregate operations around the city (Ray, 2000). Quarrying today also occurs at active building sites where stone is removed to facilitate Sydney construction. However Sydney building sandstone is now mainly sourced from the upper Narrabeen Group in the Gosford area more than 50 km north of Sydney. Smaller dimension stone quarries are located in the lower Blue Mountains to the northwest and in the Bundanoon area to the southwest. Quarries in the outer suburbs of Sydney supply sandstone for road base, filling, residential and landscaping purposes. “Yellow Block” sandstone for remedial stone masonry is now obtained from recycling yards, since the last quarry closed in 1970.

GHSR Nomination/Citation requirements

For the purpose of GHSR nomination, the HSTG Terms of Reference state that citations should contain specific information. This is further discussed in Cooper *et al.* (2013) where a Check List of requirements is provided. Consequently in order to nominate Sydney sandstone as a GHSR the following definitive details are summarised below.

Formal Name

Sydney sandstone (using small ‘s’ for sandstone as suggested by McNally, 2000).

Origin of Name

From the Australian city of Sydney

Stratigraphic (or Geological) Name

McNally (2000) has suggested that the term “Sydney sandstone” is a convenient collective name for a number of sandstones that outcrop around Sydney of which the stratigraphic unit Hawkesbury Sandstone is the “most important by far”. Spry (2000) accepts this definition of Sydney sandstone and refines the term further to include related, but not identical, Triassic sandstones in the Sydney-Gosford region thus allowing the less commonly quarried sandstones from the Narrabeen Group also to be included in the Sydney sandstone.

Other Names

Sydney sandstone is also known as “Yellow Block” or “Pymont Freestone” in specific reference to quarries in the Pymont area of Sydney.

Commercial Designations

Other past and present names used for Sydney sandstone often used regional locality or quarry names include Debden, Wondabyne, Gosford, Kurrajong, Kariong, Somersby, Bondi, Wilton, Maroubra, Bundanoon, Piles Creek and Mount White. The sandstones from these quarries are marketed under a wide range of commercial names.

Area of Occurrence

Despite the large, near-surface outcrop area of sandstone, the earliest large quarries was in the immediate city area, primarily at Pymont. Sandstone is now mainly sourced from the Kariong area north of Sydney, and to the northwest and southwest of Sydney.

Excellent outcrop occurs across much of the Sydney Basin notably in coastal cliffs, for example at the entrance to Sydney Harbor (Fig.2), and in road cuttings around Sydney.

Principal Location of Quarry or Quarries

Some currently operating dimension stone quarries in and around Sydney include:

Bundanoon	Bundanoon Sandstone International Pty Ltd
Mount White	Gosford Quarries Pty Limited
Piles Creek, Kariong	Gosford Quarries Pty Limited
Somersby	Gosford Quarries Pty Limited
Wondabyne	Gosford Quarries Pty Limited
East Kurrajong	Gosford Quarries Pty Limited
Glenorie	Gosford Quarries Pty Limited
Cattai	Gosford Quarries Pty Limited
Kurrajong	Sydney Sandstone Pty Ltd
Glenorie	Sandstone Sales Pty Ltd
Wollombi	Wollombi Sandstone
Central Mangrove	Mangrove Mountain Quarries Pty Ltd

Numerous smaller quarries supply sandstone to the commercial, residential and landscaping markets.

Geological Age and Geological Setting

Hawkesbury Sandstone is a Lower Triassic (Anisian) age deposit that occurs stratigraphically in a sedimentary succession within the Sydney Basin, underlain by the Narrabeen Group and overlain by the Wianamatta Group, these adjacent units being more diverse in lithology.

Petrographic Name and detail

The abundant “Quartz-rich sandstone” contains 70-85% quartz and 8-15% clay (Franklin *et al.* 2014). Minor constituents include 0-3.5% mica, 0-2% feldspar/lithics, and 0-1.2% iron oxides (adapted from Franklin, 2000).

The more limited “Yellow Block” is made up of 55-68% quartz, 18-25% clay, 2-10% siderite with 2-7% voids (adapted from Franklin, 2000).

Primary Colour(s), Aesthetics and Natural Variability of Stone

‘Yellow Block’ sandstone is considered to be a “self-colouring” sandstone. It is grey when quarried but oxidises and darkens on exposure to a warm-yellow brown colour. When aged, other varieties of Sydney sandstone are more stable, retaining their colour or aging to a pale yellow or buff hue (Franklin, 2000).

Most Sydney sandstone varieties are grey, white and cream when fresh, but rarely orange red and brown. The abundant quartz-rich sandstone variety may be pale yellow or dark brown or banded. In outcrop, Sydney sandstone may possess all colours ranging from white, grey, orange, deep brown and banded.

Technical Properties

The overall engineering geology of the Sydney Basin has been comprehensively considered by Pells (1985a) with a specific paper on the Sydney sandstone (Pells, 1985b).

Heiman (2000) tested three samples, with the “best results” in terms of technical properties being obtained with his “Sample A” of

Hawkesbury Sandstone quarried near the top of the unit. Selected results are as follows:

Water Absorption (% weight)	3.1
Density (kg/m ³)	2290-2420
Apparent Porosity (% weight)	7.4
Uniaxial Compressive Strength – Dry (MPa)	76
Modulus of Rupture (dry), MPa	11.9

Spry (2000) summarised the properties of “Yellow Block” from Pyrmont as follows

Water Absorption (%)	3.0-4.2
Density (kg/m ³)	2.29-2.42
Porosity (%) mean	8.7
Compressive Strength – Wet (MPa)	13-31
Flexural Strength –Wet (MPa)	1.8
Modulus of Rupture MPa Wet	1.7-4.3
Durability (%) Loss Salt Crystallisation	0.6-2.2

Suitability

Sydney sandstone has, for more than 150 years, been utilised in major load-bearing construction and sculpture including significant public buildings in Sydney. Valuable geotechnical properties are homogeneity, durability and stiffness of the material (McNally, 2000). As a consequence, it has also been significantly utilised in the Sydney region for domestic housing (mainly foundation courses), retaining walls, dams (‘cyclopean masonry’), bridge piers, monuments, road pavements, kerb stones, wharves and sea walls. Baglin and Austin (1976) illustrate many of these utilitarian uses which include fireplaces, steps, chairs and slab paving.

Vulnerability and Maintenance of Supply

The major impediment to the supply and availability of Sydney sandstone is the continuing expansion of Sydney city and adjoining urban areas, and the desired environmental protection of outcrop areas. With respect to the latter, much iconic scenery in National Parks in the Sydney region has formed on Sydney sandstone.

The supplies of “Yellow Block” sandstone for heritage conservation are limited to recycled stone, and at least two other varieties of sandstone used for heritage conservation are extracted from single quarries. Little information on resources of high quality sandstone in existing quarries is publicly available. There are few, if any, provisions for ensuring availability of stone from some of the more significant quarries for conservation work after the quarries cease commercial operation.

Nevertheless there remain huge geological reserves of Sydney sandstone, though not “Yellow Block” for new construction as well as for export for the foreseeable future.

Historic Use and Geographic Area of Utilisation

Sydney sandstone is the building stone most strongly identified with the city of Sydney. Sydney is also Australia’s largest city and the city arguably most identified with Australia. However, it has also been used in other Australian cities, notably in buildings dating from the second half of the nineteenth century.

The oldest international usage of Sydney sandstone was probably in the “Stone Store” at Kerikeri, New Zealand (1832-1836), the oldest stone building in New Zealand. Wikipedia supplies further information

at http://en.wikipedia.org/wiki/Stone_Store. Notably Sydney sandstone was also exhibited at the International Exhibition in London in 1862 (Baker, 1915).

Over the past 20 years, Sydney sandstone has had significant exports as documented by quarrier, Gosford Quarries, at their website (www.gosfordquarries.com.au/export.html). Recent international projects, supplied by Gosford Quarries, include Mishima Golf Club in Japan, AlAwadi Tower in Kuwait, New World Resort in China and a Hard Rock Café in Florida, USA. Bundanoon Sandstone International Pty Ltd also advises at its website that “they are leading merchants and manufacturers taking Australian sandstone to the world” with “Discerning clients across Australia, US and Asia” (www.bsint.com.au). Sandstone is exported from their Bundanoon quarry.

Undoubtedly there are other international applications of Sydney sandstone, but confirmation has been difficult to locate.

Buildings etc

In the inner and central parts of Sydney, Sydney sandstone has been utilised in religious, educational, public (Fig.3) and commercial buildings. In addition, it can be found used for domestic housing, gate posts, walls, bridges (Fig.5), monuments, pavements gutters, wharves and sea walls. A summary list of the major use of Sydney sandstone follows.

Buildings in Sydney: Places of worship

- St Mary's Cathedral (Architect: William Wardell from 1865) (Fig. 4)
- Garrison Church, Millers Point (1840)
- Great Synagogue (Architect: Thomas Rowe, from 1878)

Figure 3. Sydney General Post Office (1874), 1 Martin Place Sydney, excluding small granite columns and associated white marble sculpture

Figure 4. St Mary's Cathedral (1868), 2 St Mary's Road, Sydney

- St Andrew's Cathedral (Architect: Edmund Blacket from 1868)
- St Stephen's Uniting Church, Sydney (1875-1935)
- Scots Church, Sydney (Architect: Rosenthal, Rutledge and Beattie 1929)
- St Philip's Church, Sydney (Architect: Edmund Blacket, 1856)

Buildings in Sydney: Educational buildings

- Newington College (Architect: Thomas Rowe 1877)
- Saint Ignatius' College, Riverview, Main building (1880)
- St Joseph's College, Hunters Hill Main building and Chapel (1882)
- Sydney Grammar School, Main building (Architects Edward Hallen, Edmund Blacket 1832, 1857)
- University of Sydney - Great Hall; main quadrangle; original Fisher Library (Architects: Edmund Blacket, James Barnet and W.L. Vernon from 1868); Anderson Stuart Building; St John's College; St Andrew's College; St Paul's College (Architect: Edmund Blacket from 1854)

Buildings in Sydney: Galleries and Museums

- Art Gallery of New South Wales (Architect: Walter L. Vernon 1885)
- Australian Museum (Architects: Mortimer Lewis, James Barnet, 1846, 1864)
- Museum of Contemporary Art, Sydney (Architects W.H. Withers and D. Baxter 1947)
- Museum of Sydney (Architect: Denton, Corker Marshal 1993)

Buildings in Sydney: Public buildings

- Callan Park Hospital for the Insane now Sydney College of the Arts (Architect James Barnet 1883)

- Central Railway Station, Sydney (Architect: W.L. Vernon, 1901)
- Chief Secretary's Building (Architects: James Barnett and Walter Vernon 1873)
- Customs House, Sydney (Architects: Mortimer Lewis, James Barnett, Waklter L. Vernon 1845, 1885, 1903)
- Darlinghurst Gaol, now the National Art School (Architects: Mortimer Lewis, James Barnett 1836, 1885)
- Department of Lands building, including the statues in the niches (Architect: James Barnett from 1876)
- Department of Education Building (Architect: George McRae from 1912)
- Frazer Fountains, one in Albert Road, the other in Hyde Park (Architect: Thomas Sapsford 1884)
- Fort Denison (1841, 1855-1857)
- Gladesville Mental Hospital (Architect: Mortimer Lewis 1836-1838)
- Government House, Sydney (Architect: Edward Blore 1846)
- General Post Office (Sydney) (Architect: James Barnett, from 1864) (Fig 3)
- New South Wales Club, Bligh Street (Architect: Wardell and Vernon, 1884)
- Registrar-General's building (W.L. Vernon, architect, from 1913)
- Suspension Bridge, Northbridge (Designers J.E. F. Coyle & W.H. Warren, 1892) (Fig. 5)
- Sydney Observatory (1856)
- Sydney Town Hall (Architect: J.H. Wilson, T.E. Bradbridge, from 1868)
- "Saunders' Terrace" in Pyrmont (unknown designer, 1870s)
- Treasury building, Sydney (second stage)(Architect: W.L. Vernon from 1896)
- Hyde Park Barracks, Sydney (Architect: Francis Greenway 1819)
- Campbell's Warehouses, The Rocks (1844)

Buildings in Sydney: Commercial buildings

- AMFI building, King and Pitt Streets (Architect: G.A. Morell, 1881)
- AMP building, Pitt Street (architects Reed & Barnes 1860s) (now demolished)
- Burns Philp building (Architects: McCredie & Anderson, from 1898)
- City House, Pitt Street (now Skygarden complex) (Architect: G.A. Mansfield, 1893)
- Queen Victoria Building (QVB) (formerly Queen Victoria Markets) (Architect: George McRae from 1893)
- Radisson Plaza Hotel (formerly Fairfax Printers Building) (Architects: Manson & Pickering 1922) (Fig 6).

Buildings outside Sydney

- Stone Store, Kerikeri, New Zealand (1832-1836).
- Jervois Wing, State Library of South Australia, Adelaide (1879–84)
- E S & A Bank (now called "the Gothic Bank") (Architect: William Wardell, 1883), Melbourne
- Savings Bank Building, King William Street, Adelaide (1902)
- National Mutual Building (now the Bank of New Zealand) (Architect: Wright, Reed and Beaver, 1903) Melbourne

Figure 5. Northbridge Suspension Bridge (1892), Strathallen Avenue, Northbridge, metropolitan Sydney

Figure 6. Radisson Plaza Hotel (formerly Fairfax Printers Building) (1922), 27 O'Connell Street, Sydney

- St John's Cathedral, Brisbane external facings (Architect: J.L. Pearson and others, 1909–11)
- St Paul's Cathedral, Melbourne, tower and spires (Architect: James Barr, 1926)
- Union Bank, Brisbane (1916)
- National Parliament Canberra – Courtyard Sculpture by Ewa Pachuka entitled “Fossilised Architectural Landscape” (1988) utilising “Gosford Grey Sandstone” (Mayer 2009)

A more extensive list is provided by Deirmendjian (2002).

Other Heritage Issues

Three outcrop localities of Sydney sandstone, viz Cape Banks, North Bondi and Cut Rock near Kurradjong, are included in the compilation of the geological heritage of New South Wales (Percival, 1985).

In 2013, a decision was made to invite each Australian State to contribute “Federation Rocks” in order to inaugurate the “National Rock Garden” in the Australian National Capital of Canberra (www.nationalrockgarden.org.au). Sydney Sandstone or more specifically

“Yellow Block” sandstone was selected to represent the State of New South Wales as a Federation Rock (Fletcher 2013; Pillans 2013).

Acknowledgements

Greg McNally reviewed the article in detail and made numerous helpful suggestions.

The images were made available courtesy of the City of Sydney Archives.

The image photography is by Gary Deirmendjian, who first published the images in his book entitled “Sydney Sandstone” published by Craftsman House in 2002.

The School of Natural and Built Environments, University of South Australia provided excellent working facilities for BJC.

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Brenda Franklin holds an MSc and PhD from the University of New South Wales. Until 1996 she was Head, Department of Applied Geology, University of Technology, Sydney. Since then, she has been a consulting geologist and currently, also a member of the Australian IGCP committee. Brenda's main academic research has been in mineralogy and petrology. With consulting she has specialised in industrial minerals, including gemstones and building stone. Her recent research has often focussed on the conservation of heritage sandstone buildings in Sydney. This work involves selection and technical evaluation of the sandstone and research on weathering mechanisms affecting Sydney sandstone.

David Branagan is an Honorary Research Associate in the School of Geosciences, University of Sydney, where he was a teacher and researcher between 1959 and 1989, mainly in engineering geology and photo-interpretation. He has published a number of books and papers on aspects of Australian geology and its history. David was foundation editor of "The Australian Geologist" (1974-1984) and is an Honorary Life Member of the Geological Society of Australia. He was President of the "International Commission on the History of Geological Sciences" (1992-1996) and was awarded the Tom Vallance Medal by Geological Society of Australia in 2012 for his contribution to the history of geology. David was also awarded an Honorary DSc by the University of Sydney in 2007.

Helen Ray is a geologist with more than 20 years' experience with the Geological Survey of New South Wales. She now works for consultancy "Geos Mining". She has also completed many investigations and reports on dimension stone and industrial mineral resources, including a comprehensive study of the dimension stone resources of NSW. She has advised government, industry and individuals on dimension stone, heritage sandstone, industrial minerals and mineral exploration management. Her more recent dimension stone work has included advice on supplies of heritage sandstone and independent technical reports on dimension stone resources in Australia, Vietnam and China.