STONE QUARRYING LANDSCAPES AS WORLD HERITAGE SITES

This document is offered as a first stage draft towards establishing TICCIH/ICOMOS guidelines on potential World Heritage stone quarry sites for discussion by TICCIH delegates at Teruel (Spain) in October 2014 with a view to the presentation to ICOMOS of a comprehensive revised version in December 2014.

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Stone quarrying landscapes – a definition

Stone quarrying landscapes are those formed by human intervention in the natural environment in order to extract stones and useful earths.

In practice there is considerable overlap between quarrying landscapes and mining landscapes. Both are shaped by extractive industry, and may in fact work the same minerals. For the purposes of this study, quarrying landscapes are defined as those which at the least:

- remove stone (granite, limestone, marble, sandstone, slate and others) from its geological formation for the construction of upstanding buildings and other structures, sculpture and other decorative arts, or for the manufacture of tools or for the production of aggregate, in a *quarry*

These landscapes may, furthermore, provide evidence for:

- *processing sites* where quarried stone is turned into a commercial product, whether by hand-tools, or mechanical or chemical means
- *transport* of stone, whether in its quarried or processed state, and of unprofitable rock
- the human society brought into being as *accommodation* for the workforce

These landscapes may additionally include evidence for:

- The *end-use* of stone, in buildings and other structures, sculpture and other decorative arts, as tools or as aggregate

This definition does not include the working of coal as sedimentary rock, nor of mineral-bearing rock.

Not relevant to a definition of quarrying landscapes as distinct from mining landscapes is whether the workings are open to the sky or underground. In the English language, the word 'quarry' is generally applied to open-air workings, but also includes some which are, or were, worked underground, such as Bath stone and Merionethshire slate. In Italy, the mining law of 1859 distinguished simply between *minieri* (mines) and *cave* (quarries). The French law of 1810 divides workings into *mines*, *minières* and *carrières*. Workings for gold, silver, lead, copper, sulphur, coal and iron ore constitute *mines*. *Minières*, for which there is no exact translation in English, include bog-iron ore, pyritous earths fit for working, sulphate of iron, aluminous earths, and peat, whilst *carrières* work stone, clay or sand, whether above or below ground.

Stone quarrying landscapes – an historical introduction

Stone quarrying landscapes are little understood in their global context and no attempt has been made to consider them as valorised heritage on a world-wide basis. As yet, TICCIH does not have a section dedicated to quarrying. Sites demonstrating extraction of stone by open and underground quarrying are under-represented on the World Heritage List. Sites associated with extraction of metal ore-bearing rocks, coal and salt extraction are much better represented.

The removal of stone from its geological formation for human purposes is an ancient activity, predating the use of iron, and is central to the evolution of human society. Quarried stone, once processed (whether by trimming, splitting, sawing, drilling, shaping, crushing, chemical process or burning), has been variously used:

- for the construction of upstanding buildings and roofing elements, as well as other structures, such as defensive and harbour walls
- for the creation of artistic sculptures
- for the fabrication of tools such as axes, millstones and whetstones
- as a fertiliser
- as a flux
- as aggregate
- as a component in cement and concrete.

It is as important to the history of civilisation as the use of ceramics, as the use of organic materials such as timber, turf and clay, and as the use of metals.

In this context, however, it is also important to bear in mind that by no means all world cultures have made extensive use of stone. In Japan, it is only with the Meiji restoration of 1868 that stone begins to replace traditional timber architecture on a significant scale. It is under the Tang dynasty (616-907CE) that stone (and brick) buildings begin to predominate in China, though stone was used where it was easily available in defensive structures, most notably in the Great Wall (Needham 1971, 38-91). In West African traditional architecture, mud/adobe buildings are common; Central Africa makes use of thatch and wood and other perishable materials. In East Africa the pattern is more varied, but stone is common only in the northern and southern parts of the continent.

However, it is European expansion into other continents from the 15th century onwards that (very gradually) brings the use of quarried stone into parts of the world where it had previously been uncommon or unknown, such as North America, Siberia, West Africa and Oceania. The global reach of quarried stone over the last 500 years has expanded dramatically, and by the 19th century was promoted by the practice of government-sponsored scientific testing of different types of rock for durability and water-resistance. Broadly speaking, however, and with exceptions discussed below, until recently the only stones exported over long distances were those intended for specialist purposes or as decorative elements such as columns and facades.

Technological developments have led more recently to the new generation of ‘super quarries’, with examples in the UK, India and China, exporting significant amounts of stone over great distances. Conversely, there is pressure from geo-conservationists to re-open older and much smaller quarries to provide specialist stone to rebuild historically significant structures.

The use of quarried stone in buildings and other structures is as much a matter of prestige as of geology. Pericles rebuilt Athens in marble; Augustus found Rome brick, and left it marble, and the ninth Inca, Pachakuti, ordered Cuzco to be rebuilt in stone *c.* 1438 CE (Protzen 1985). The use of a particular stone far away from its place of origin can in places be identified as the particular architectural 'signature' of a power-group, such as the Caen stone associated with the Norman expansion of the 11th century, used on Canterbury, Chichester, Rochester, Norwich and Durham cathedrals as well as at the White Tower in London. Mussolini encouraged the use of Italian marble, and made a gift of columns from the Carrara quarries to the Dome of the Rock/Masjid Qubbat As-Sakhrah in Jerusalem as part of his policy of extending Italian influence over the Middle East.

The use of stone as a building material in locations such as these reflects the emergence of a centralised authority that is conscious of the need to express power and identity through the use of a costly and durable material, and that might also need to guard its resources by building defensive walls. This authority need not necessarily be imperial, monarchical or presidential – it can be a merchant elite in a free town, or a sacerdotal caste in a religious community. Both secular and religious authorities might also be the patrons of sculptors in stone, skilled artisans who were supported by a social network of studios and workshops.

This authority will have access to landscape resources. The first of these is a suitable geological formation to open a *quarry*, and sometimes also the space to tip unworkable or unproductive rock.

A second landscape resource may well also be a suitable location for a *processing site* where rough stone can be turned into a commercial product. Sometimes a processing site might be located where water power is available to operate machinery. This may be in the quarry itself or immediately adjacent to it. Alternatively, it may be near the *point of use*, or at any point in between along whatever transport route connects them.

An overland *transport route* forms the third landscape resource. Topography needs to be favourable to the movement of large loads towards the point of use or to a shipping point, and a dedicated transport system needs to be engineered and maintained. From ancient to modern times, cities have often had their own quarries near at hand, reflecting the difficulties of moving stone long distances – examples are Pentelikon for Athens, Combe Down for Bath (UK), and Beacon Hill for Boston (Massachusetts). Because stone is heavy, it needs carters and carriers and their technologies to move it overland, and in some cases specialised vessels are required if it is to be transported by water.

A quarrying industry also requires human resources – stone can be difficult to extract and to process, and therefore requires a capable and experienced workforce, though unskilled labourers can also be required. Workers, supervisors and their families require *accommodation*.

In some cases, sources of quarried stone lay near the *point of use*, which might be a town or city which makes distinctive use of the stone. In other cases, and more commonly, this will be a distant settlement in which various types of quarried stone will be used in conjunction with other building materials.

The quarry

The layout and arrangement of a stone quarry depends on geology and topography. A quarry may be opened on a hillside or as an open pit. In either case, the rock may be worked as one face or may be made up of stepped working benches in a hill-slope. This practice is known from the Roman period

(Pearson 2006) but at the turn of the 18th and 19th centuries it was developed on a major scale at the Penrhyn slate quarry in North Wales (Lindsay 1974). It favoured the use of railway systems for removing useful rock and for dumping waste, and becomes common where geology permits.

A quarry may also be worked underground. Limestone has been worked underground near Bath and near Dudley (UK); slate has been worked underground in the French and Belgian Ardennes, in Maine-et-Loire (France) and in Gwynedd (UK) (Voisin 1987; Soulez Larivière 1979; Lindsay 1974). From the 17th century, Paris limestone, quarried underground on the outskirts of the city, was raised to the surface in vertical shafts by winch or tread-wheel (de Rochefort 1672).

Long-established methods of extracting stone from the quarry rock face include frost-splitting and fire-shattering. Egyptian stone-masons shaped the quarried rock by pounding it with balls of dolerite, and it has been suggested that Inca quarrymen, who had no knowledge of iron-working, used similar methods (Protzen 1985). Other early tools include wooden and bronze bars; wooden hammers have remained in use until modern times. Iron tools include picks, hammers and wedges; percussive rods were used to create holes to enable the rock to be split by plug-and-feathers or (from the 17th century) by blasting. This was initially carried out by gunpowder; high explosives were introduced in the 19th century. The use of electrical charges to detonate explosives is recorded at Holyhead to supply stone for a breakwater, a project which went on from 1845 to 1873 (Hayter 1875-6).

The use of cranes in quarries is of great antiquity. Vitruvius (*c.* 15BC) discusses their use on building sites but it is likely that they were also used at extraction points (Vitruvius 10 2). Jib cranes have been identified archaeologically in Medieval quarries (Moorhouse 1990). Redvers-Higgins, Willies and Wain 2011 describe the innovative use of cranes in the Bath stone quarries in the 18th century. The adoption of steam power and of railways in the 19th century meant that cranes could lift larger loads and could be moved. Ropeway haulage systems are recorded from the Medieval period in French slate quarries (Soulez Larivière 1979). The blondin ropeway, named after Charles Blondin who walked across Niagara falls on a tightrope in 1852, was developed in the Scottish stone industry from the first installation at Kemnay Quarry in Aberdeenshire in 1872. Their use spread to other types of quarry and to civil engineering works (Donelly 1979).

Mechanical drilling and channelling were introduced in the mid-19th century, making use of steam, compressed air and electricity. Mechanical excavators (from 1839) and draglines (from 1904), both initially devised to cut canals, found an application in stone quarries. Wire-sawing was introduced at the Carrara marble quarries in Italy in 1895 (*Enciclopedia Italiana* 1934) and is now extensively used in slate, granite, limestone and marble quarries.

Hillside quarries are generally self-draining. Pits and underground quarries may require pumping, and adopted the technologies used in mining. A Newcomen-type steam engine was installed to pump an Ardennes slate quarry before 1771 (Voisin 1987). The Easdale (Èisdeal) slate quarries in Scotland were also early users of Newcomen technology (Tucker 1976). As quarries grew larger in the 19th century, pumping systems evolved in mining were increasingly adopted, such as the use of flat-rods and other forms of prime-mover.

Processing sites

Processing sites in which quarried stone is turned into a commercial product may be located at any point between the quarry and the point of use. This category therefore includes masons' yards in towns and cities. They take many different forms, and may preserve traces of incompletely worked stones, and of structures and machinery.

Stone was, and is, processed by hand-tools such as crowbars, picks, chisels, hammers and plug-and-feathers. Hand-processing can include initial reduction of the quarried blocks, which calls for both skill and physical strength, but might equally include the delicate work of carving the capital of a Corinthian column, which requires great dexterity. Work such as this might take place in the open, sometimes in rudimentary shelters such as the wind-breaks erected by French slate *fendeurs* (splitters) or the 'quarr houses' of Purbeck (Phillips 1996).

A tool with a long history in the stone industry is a wrought-iron saw in which a paste of sand and water acts as the cutting agent. This technology was used to process building stones for the pyramids. Pliny states that sand from Ethiopia was used in such saws (Pliny 36 9).[1] Hand-held and -operated saws of this sort were to be found into the 20th century even in such massive undertakings as the Carrara marble quarries (*Scientific American* 1902) but archaeological evidence also indicates water-wheel powered versions from the second part of the 3rd century AD in Phrygia and Anatolia (Turkey) (Grewe 2009; Mangartz 2010). They are attested by written sources in the 4th century AD in Gallia Belgica, on the banks of the Moselle, preparing stone for the imperial city of Trier (Ausonius). Ramelli shows sand-saws operated by horse and by water-wheel cutting marble in his machine book of 1588 (Ramelli 1994, plates 134-5).

Circular saws for cutting stone seem first to have been introduced in the North Wales slate industry, in the first decade of the 19th century, possibly inspired by the block-making machinery installed by the Royal Navy at Portsmouth (Lewis and Williams 1987). The Hunter saw, an early application of renewable tip tooling, was used in Irish and Welsh slate quarries and in Scottish freestone quarries from the 1850s. Though wire sawing was and is most commonly employed at the quarry face it can also be used in processing (Wood 2006c). The Bessemer process, patented in 1855, made it possible to use steel as a component in cutting and crushing technology. Gantry cranes derived from engineering workshop practice also come into common use in the 19th century, particularly where stone-processing sites were served by railway. These could be used to lift raw blocks off wagons and sort them by size, or distribute them to the machines by which they would be sawn or shaped (Fitzgerald 1990, Stanier 1995, Wood 2006c).

Water-power had become the most important energy source for powering stone-cutting machinery by the 19th century, and processing sites are for this reason often located where there is a good fall of water, rather than immediately adjacent to where the rock was quarried or to the point of sale. By the mid-19th century, cheap and reliable steam plant could also be put to operating machinery. A stone-processing plant often came to resemble a classic factory of the period, dominated by a chimney for a stationary steam engine and with all the paraphernalia of a time-office, siding access, coal bunkers and a weigh-bridge. A variant is the 'horseshoe shed' of the USA granite industry, arranged around a derrick crane (Wood 2006c).

Quarried stone may also be processed by chemical reaction, when limestone is burnt to create an agricultural fertiliser or (in conjunction with an aggregate) to make mortar. Lime-burning is attested in Europe since at least the 2nd century BC (Cato 38, Newby 2001). Early 'clamp kilns' involve layers of fuel and limestone stacked together in a mound, covered with clay or turf and burnt slowly; permanent structures, either 'flare kilns' (also known as 'intermittent' or 'periodic' kilns) and 'perpetual', 'running' or 'draw' kilns, came later. An annular kiln was patented in Britain in 1841, followed by the Brockham patent kiln and the Belgian De Witt kiln later in the century. Experimental continuous kilns were being built in the 1780s; as developed by Friedrich Hoffmann their use spread world-wide in the 1870s (Johnson 2002). The development of these sophisticated multi-cellular lime-

[1] In chapter 6 of the *Historia Naturalis*, Pliny suggests that the palace of Mausolus at Halicarnassus was the first to be covered with cut marble, 403 *ab urbe condita* = 350 BC.

kilns helped sustain the great population boom and the urban development of the classic Industrial period by providing agricultural fertiliser on a much greater scale than hitherto, thereby ensuring that the new industrial working-classes could be adequately fed.

Transport

Transport systems associated with stone quarrying landscapes include both internal systems within an extraction point to move quarried stone to a yard and to dump unworkable rock, as well as longer systems which give access to a processing site, to navigable water or to a point of use. They are considered together here.

Primitive systems using sledges, carts, cradles and rollers, drawn by horses and oxen, lasted into the 20th century (Wood 2006b). Wheelbarrows were in use in a European context by the 12th century, and were doubtless to be found in quarries early on (Lewis 1994).

Transport of stone between the quarry, the saw-mill and the point of use is little understood before the rise of Industrial techniques in the 18th century. Parts of the *lithagogia*, the road which carried stone from the Pentelikon quarries to Athens, have recently been identified. The total length was 17.4km long, and it was engineered so that it ran downhill in favour of the load. The initial descent from the quarry was accomplished by loading the stone onto carts which were lowered down an inclined plane, using a rope as a brake; thereafter the blocks were moved by animal-drawn carts (Malacrino 2010). Pentelic stones for Eleusis were drawn by 37 yoke of oxen, and it has been suggested that the *hyponomoi* recorded in the inscriptions were prepared stone rut-ways (Lewis 2001). Vitruvius (*c.* 15 BC) discusses techniques for using sleds to move long columns (Vitruvius 10 2, 2-14). The *lizzatura* (sledging) of the Carrara marble quarries is attested in the zig-zag roads that climb the mountain sides. Among the most remarkable monuments of quarry transport from earlier times are the rut-ways in limestone quarries on Malta and Gozo, which seem to reflect the use of single-axle carts, but there is no scholarly consensus as to whether they date from the late Bronze age, the Punic period and the Roman empire, or even as early the Neolithic or as late as the Arabic period (*c.* 870). Those at Misrah Ghar il'Kbir are widely known as 'Clapham Junction' because in their complexity they resemble a modern railway (Mottershead, Pearson and Schaefer 2008).

Otherwise, railways, both internal networks and overland systems connecting a quarry to navigable water or to a point of use, are evident from the 18th century, having already been used for many centuries in metalliferous mines and (since at least the early 17th century) in collieries. The first significant system was in England, Ralph Allen's wooden railway of 1731 near Bath which connected his Combe Down quarries to the river Avon, and which was integrated with the use of river-boats and cranes to formed an integrated industrial handling system (Redvers-Higgins, Willies and Wain 2011; Lewis 1970). In Ireland, a short wooden railway was installed in 1740-1741 to connect a quarry at Ballycastle, Co. Antrim, with harbour improvement works (Rynne 2006). In South Wales, limestone outcrops were connected to the iron-works by iron railways from the 1790s, to supply flux to the furnaces (van Laun 2001). Others are the Haytor in Devon (1820) and the Quincy railroad in Massachusetts (1826), both of which built their rails out of the same stone they transported (Ewens 1977, Gamst 1997).

A more important early quarry system is the Penrhyn iron railroad in Wales (1800-1801), which both served for internal movement within the quarry and transported finished slates and slabs to the sea. Its gauge of approximately 0.6m soon became common in Welsh quarries. By the late 19th century, following the example of the nearby Festiniog Railway, built to serve the local slate industry, this technology was being widely copied for both industrial and public railways across the globe. However, depending on the nature of the rock to be moved and the distance, quarry railway systems

were also built to other gauges, up to and including 2.140m (7’ 0¼”), which was used in the UK, the Isle of Man, the Açores and South Africa to connect quarries with breakwaters. Other significant rail systems serving stone quarries include la Ferrovia Marmifera di Carrara (the Carrara Marble Railway), operational from 1876 (extended 1890) to 1964 (Scheibner 1891). Some USA quarry railroads operating on severe gradients used articulated locomotives initially developed for the logging industry (Wood 2006b). Inclined planes were also used to overcome differences in height, either within the quarry or on an overland transport system, seen to spectacular effect at Portland (Jackson 1999), and in the slate and granite quarries of North Wales (UK) (Mountford 2013; Hindley 1986).

Canals and navigable rivers have also been used for moving stones. Some performed the task of supplying building sites in growing cities, like the Middlesex canal which moved granite from the Chelmsford quarry in Massachusetts to the Charles river and thence to Boston (Wood 2006a). Others provided agriculture and industry with the stones they needed, such as the Llangollen canal which carried limestone from the Welsh hills for use as a fertiliser and as an ironworks flux in the English midlands. Lime-kilns are frequently located by the side of canals (*Canal Monuments* 1996).

Accommodation

Accommodation for quarry- and stone-workers and their families may take the form of nucleated towns and villages, or suburbs within them; scattered settlements, sometimes as part of a dual economy of industry and agriculture; barracks for free workers; and prison and camp accommodation for coerced workers.

Archaeological evidence from the Roman granodiorite quarry at Mons Claudianus in Egypt revealed a settlement of 1,000 people, mainly soldiers and free civilian quarrymen, who were well-paid and well fed, who brewed their own beer and grew their own vegetables (van der Veen 1997). It has been suggested that building remains at pre-Hispanic quarry sites in Peru are houses for supervisors and quarters for quarrymen, suggesting a hierarchically-organised workforce (Protzen 1985). The town of Carrara in Tuscany was developed for marble-quarrymen by the Romans from the 2nd century BC and evolved into a city-state in post-Roman times. Generally however, the revival of quarrying in Europe in the Medieval period does not seem to have led to the creation of ‘free towns’ such as were brought into being by gold, silver, lead and copper mining, and significant urban development for quarry workers seems to be a function of the 19th century. When they become evident, they take many forms – developments on the fringes of existing or evolving settlements, planned company towns, and uncontrolled developments where often newly-arrived workers would begin their working life.

A quarrying industry could lead to the establishment of institutions of higher education. Carrara has a specialist academy of stone carving and the fine arts, the Accademia di Belle Arti Carrara, founded by Maria Teresa Cybo-Malaspina in 1769, and in some towns, such as Bangor in North Wales (UK) and Middletown (Connecticut, USA), universities owe their existence to money generated by locally-based quarrying industries.[2]

Because quarrying was often seasonal, or might not provide sufficient income by itself, quarry workers and their families often created dual economy settlements on upland small-holdings. Other distinctive types of upland accommodation might be barracks for free workers, often located near, or within, the quarry and away from other settlement. They are particularly a feature of the Welsh slate industry.

[2] These are the University College of North Wales (now Bangor University) and Wesleyan University.

Accommodation for coerced labour is also evident in some places. The use of prisoners has been a feature of quarrying since Antiquity; it is recorded by Josephus (Yosef ben Matityahu) in Ancient Egypt (Josephus 1 26). The use of convicts and of the enslaved for unskilled work in quarries was revived in the Modern period. Examples are Dartmoor prison (UK) where conscientious objectors were put to work from 1917 to 1918, the Nazi-era Mauthausen concentration camp (Austria), one of several where 'incorrigible political enemies of the Reich' worked in quarries owned by Deutsche Erd- und Steinwerke GmbH (Kopalek 2013), and the World Heritage site of Robben Island (South Africa), where Nelson Mandela was put to work in a quarry.

Quarry- and stone-workers have frequently identified with progressive and radical politics. Generally, unionisation was common in industries such as stone quarrying where, by the late 19th century, competition was strong, the margins tight, and large capital investment in machinery drove down wages (Wood 2007). Within a non-revolutionary tradition, Welsh slate quarrymen's dedication to the values of Liberal protestant nonconformity is evident in their *cabanau* (lunchtime discussion places) and impressive workers' chapels as well as in the fabric of Bangor University, to which they contributed regularly. The revolutionary approach is evident in Carrara (Italy) where the Anarchist Federation of Italy has been located at Piazza Matteoti since 1944; the town is also home to an anarchist bookshop and has a memorial to the regicide Bresci. Carrara's marble quarrymen lived at a high altitude on a diet of bread, cheese, fruit and rainwater, which not only made them fiercely independent but also made them ill-disposed to the introduction of new machinery. They frightened respectable Yankee opinion when they emigrated to join the already multi-ethnic workforce in the quarries of the USA. Italian stonemasons built the Socialist Labor party block at 46 Granite Street, Barre (VT) in 1900, which is now a National (USA) Historic Landmark and the headquarters of the local Historical Society (Tomlinson 1854 'Marble'; Benjamin 1891; *New York Times* 19 January 1894; *Scientific American* 1902; Wood 2007).

End-use

The extent to which end-use of a particular stone is evident within a particular landscape that also includes the other elements identified above depends on the nature of the stone and the markets it achieved. Stones can be, and often have been, exported world-wide. Any major city will include building elements from all over the world, chosen for reasons that might be pragmatic (cost and durability) or ideological (prestige, statement and identity).

Even so, and even in widely spread and highly organised states, it is rare for stones to be moved over great distances. Under the Roman empire, quarries were worked from Northumberland to Aswan, yet in most of the 719 sites which have been identified, production was distributed locally. In 151 cases, distribution was, or is believed to have been, regional, and only in 31 cases, was distribution inter-regional. These are mainly stones from Greece and the eastern provinces, though it is suggested that Caen stone was exported to Britain in this period (Russell, online gazetteer). Cross-channel distribution of British freestone in the Roman period may reflect the role of the *classis Britannica*, the provincial naval fleet of the empire (Heyward 2009). Professor Miles Lewis' discussion of stones used in early colonial Australia suggests that imports from Britain were common in the early days until suitable sources were identified nearby, and that thereafter only specialist stones were brought in over long distances. Even after the building of the transcontinental railways, timber (and brick) architecture continued to predominate in Siberia and the American West.

Examples of quarry landscapes where a particular stone was exported widely but has also shaped the immediate environment are Aberdeen, Bath and Carrara. The landscapes of North Wales demonstrate extensive use of locally-quarried slate not only for roofing but as a walling material, and in fences. Slate is also unusual in that its cost-to-weight-to-durability ratio means that it is worth

exporting globally as a common element in building, and there is abundant evidence that slate from Wales and from France was to be found all over the world (Lindsay 1974; Soulez Larivière 1979)

Stone quarrying landscapes as World Heritage sites – some considerations

Can a stone quarry landscape be considered as a World Heritage site? If so, what Outstanding Universal Value or Values do they exhibit, and on what intellectual basis might inscription be possible? There are clearly many challenges to the process, not least the fact that there has hitherto been very little in the way of comprehensive study of the landscape-type, even though detailed research may tell us much about particular area, particular industries or particular historical periods. On the other hand, the fact that there is as yet no such site on the World Heritage list represents a significant thematic gap in view of the fundamental importance of this type of social and economic activity.

Although architectural ensembles are well represented on the World Heritage list, in very few cases does the inscription record a distinctive named stone from a located source as an element of its Outstanding Universal Value. One that does is the Tower of London (UK), with its walls of Kentish limestone and ashlars of stone from Caen. Though the inscription of Bath (UK) mentions Ralph Allen, as sponsor of the Palladian town, it does not make reference to his ownership of the quarries from which the town was remodelled. Yet clearly the decision to build in stone, and the choice of stone to be used, says much about the type of human society that made these settlements possible, and about the élites that were able to command these resources; the stone is therefore likely to be one of the fundamental Attributes which contribute to the Outstanding Universal Value of these existing World Heritage sites.

High-status architectural ensembles and élite buildings are, however, well represented on the World Heritage list, whereas sites of human industry still constitute a thematic gap.

Throughout history, stone quarrying has required those who work in it as an industry to evolve new skills in removing rock from the face, and to develop new techniques for transporting and processing it. Yet on the whole, the continuities within quarrying as an industry world-wide are more striking than change or innovation, at least until the 19th century. Foregoing sections (above) indicate just how conservative are the technologies associated with quarrying. Cato the elder would have recognised and understood the operation of a small rural lime-kiln in early Victorian England. Marcus Aurelius Ammianos, to whom the 3rd century Phrygian stone saw-mill is credited, could have seen very similar machines at work in a Welsh slate quarry in the 1920s. Even when quarrying grows in scale in the 19th century, few of the technologies that are introduced are macro-inventions or derive from the industry itself. This is not to down-play the capacity of the stone industry to innovate in the Modern period, since the transfer of technology by identifying, choosing and adapting potentially useful systems from elsewhere is as much part of the skill of innovation as outright invention. A number of examples can be suggested.

One technology that the quarrying industry adapts in this period is the circular saw (and its renewable-tip version, the Hunter saw). This is clearly significant, but reflects developments in related areas, such as timber sawing. The multi-cellular Hoffmann kiln reflects contemporary developments in brick-making. Another example is the narrow-gauge railway, with the important additional factor that the way in which these systems were adapted to carry compact minerals in North Wales made them suitable for further adaptation world-wide, either as low-cost public railways, as industrial railways in other contexts, or as military railways. In this context, it is worth quoting the ICOMOS study *Railways as World Heritage Sites* – 'Railways have always been built as a means to some other end, and it would be fitting if this fact were reflected by the inclusion of

railways as integral parts of locations designated as parts of World Heritage sites partly or chiefly for other reasons' (Coulls 1999).

More important to quarrying landscapes than engineering skills, and the capacity to adapt and invent, are the investment of physical strength and of craft skill on the part of the workers in quarries and in processing sites. The demands on workers in both respects were considerable, and the skills had to be acquired and perfected over many years. These are not easy to distinguish as visible Attributes within stone quarrying landscapes other than by the sheer scale of a quarry and the physicality of the site. However, skill as an Attribute may also be exemplified in the evident intellectual, political or religious liveliness of quarry workers' communities and in the infrastructure that sustained it. A further Attribute of skill is the readiness of quarry workers to move from one part of the world to another, taking with them their prized knowledge of a particular type of rock and how to work it, and bequeathing evidence of their way of life in the host communities that received them. This is difficult to identify in pre-Modern quarrying but is well recorded from the 19th century onwards.

Skill as an Attribute may be found in the end-use of a stone product. In this sense it merges with the skill of the builder and of the architect, but what should be more clearly understood is that urban development relies not only on those who design and erect buildings but also on a much wider network of less well-acknowledged trades and crafts, including those associated with stone.

Proposed criteria for internationally significant quarrying landscapes

Quarrying landscapes are cultural landscapes, and as such may potentially fulfil one or more of the following criteria:

Criterion 1: a masterpiece of human creative genius

Although quarries are in a sense 'engineered' landscapes, they differ from (for instance) a major transport route in that they are gradually evolved over long periods of time. For this reason, evolving craft-skill and an affinity for the materials being quarried and worked are more important than individual creative genius. In addition, many of the technologies associated with quarrying have either evolved over very long periods of time or have been imported from other industries.

Criterion 2: to exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design

This criterion may potentially apply to many significant quarrying landscapes, given that they are often the result of a lengthy process, sometimes extending over millennia, which reflects social context as well as geological opportunity. They also nurture a skilled workforce that can sell their labour and their knowledge in other parts of the world. The choice of a particular stone, and the resources available to quarry, process and transport it, has exerted a profound influence on sculpture, architecture, town planning and bridge-building. Where a particular stone is exported world-wide and has had a distinctive impact on architecture and town- and city-scapes, this criterion might apply.

Criterion 3: to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared

The quarrying and processing of stone is in many cases skilled work, and as such can promote strong cultural traditions amongst its workforce, based around shared values and skills. This is most apparent amongst skilled sculptors and monumental masons but is also true of the ordinary qiuarry worker. Conversely, some forms of stone quarrying call for physically demanding but unskilled labour, which has meant that in many cases, and from earliest times to the present day, coerced labour has been a feature of the industry.

Criterion 4: to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history

This criterion may apply to certain quarries as technological ensembles, though it is noted above that on the whole quarrying technologies are imported from other industries.

Criterion 5: to be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change

This criterion may apply when quarrying is on a significant scale and has generated a workforce with its own strong cultural traditions, and has exerted a profound influence on the surrounding environment, through working and processing the rock, and though the building of transport systems and workers' settlements.

Criterion 6: to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria)

This criterion might potentially apply to stone quarrying landscapes associated with sculptural masterpieces.

The criteria in practice – some significant quarrying landscapes

Note that these are purely indicative suggestions at this stage, to stimulate discussion at the TICCIH Teruel meeting. It includes a worked example by the present author, namely the Gwynedd (UK) slate industry – DG

Case 1. Caen stone quarries, France – medieval sites, Norman architectural 'signature' extending to London and to Durham

The stone quarries of Caen are suggested for inclusion in this study as evidence of the quarrying, distribution and use in high-status structures of a type of stone associated with one particular power-group.

Case 2. Carrara marble quarries, Italy – long-established sites with transport systems

The Carrara marble quarries are suggested for inclusion in this study for their longevity as an industry, their association with high-status buildings and artistic works, for their spectacular location, for their remarkable transport systems and for their radical workforce.

Case 3. Portland stone quarries, England – producer of building stone with international distribution

The Portland stone quarries are suggested for inclusion in this study as an industry that was already active in the Medieval period, for their association with important buildings and memorials and for the way in which they developed with the availability of highly engineered technology in the 19th century.

Case 4. Bath stone quarries, England – producer of building stone for World Heritage city

The Bath stone quarries have been exploited from early times but are particularly associated with the important and innovative technologies introduced by Ralph Allen, such as carnage and the use of railways. These quarries were used to build the World Heritage city of Bath.

The Bath quarries are suggested for inclusion in this study for their innovative technologies and their association with the city of Bath.

Case 5. Brownstone quarries, Basswood Island (Wisconsin), Hummelston (Pennsylvania), Portland (Connecticut), USA

These brownstone quarries are suggested for inclusion in this study as evidence of the movement of skills and population, the development of educational facilities and of end-use over the world.

Case 6. Anjou slate quarries, France – producer of roofing elements with international distribution

The slate quarries of Anjou were active from the late Medieval period to 2013, when the last operation closed down. The many quarries were initially worked as pits but came to be worked underground in the 19th century. Their products were to be found over northern Europe and beyond.

The slate quarries of Anjou are suggested for inclusion in this study as evidence for quarrying techniques, for the evolution of a skilled and radical working class

Case 7. Pentelikon marble quarries, Greece – ancient sites associated with Parthenon and Periclean Athens

The Pentelikon quarries were the source of the high-quality marble known in the 6th century BC but which was extensively worked to supply the Periclean rebuilding of Athens in the following century. It was used not only on the Parthenon and Propylaea but also on the temple of Hephaestos and later in the Olympeion and the Stoa of Attalus. It was also used for the arch of Titus in Rome and for the production of sarcophagi. The *Lithagogia* route has recently been identified archaeologically.

The Pentelikon quarries are suggested for inclusion in this study for their association with an historic city, as an ancient site, and for the archaeological evidence for an ancient transport route.

Case 8. Aberdeen granite quarries, Scotland – producer of building stone with international distribution

The Aberdeen granite quarries are suggested for inclusion in this study for their adoption of polishing machinery, steam-power and innovative overhead rope-way technology.

Case 9. St Petersburg quarries, Russian Federation – sites associated with building of modern town on territory captured from the Swedes

Suggested here as a possibility which could explore the use of quarried stone on a largely new-build but highly significant European city, under the patronage of Peter the Great.

Case 10. Egyptian stone quarries at Aswan, Gebel el Ahmar, Gebel Silsileh – ancient sites associated with Nile valley culture

The majority of these quarries lie in the Nile valley and have been extensively studied though are still considered poorly understood. Hard and soft stone quarrying is well attested in the Pharaonic era, and recent research has re-addressed the use of stone tools, the use of fire-setting, the development of specific quarrying skills and the formation of a skilled work-force based around kin-groups.

The Egyptian stone quarries at Aswan, Gebel el Ahmar and Gebel Silsileh are suggested for inclusion in this study as ancient sites associated with the Nile valley culture and the production of sculptures and obelisks.

Case 11. Stone quarries in Malta – Punic and Roman quarries with extensive cart rut-way transport systems

The stone quarries of Malta have been exploited since Prehistoric times, and several remain in active production. A distinguishing feature is the use of a cart-rut guided transport system, or uncertain date.

The stone quarries of Malta are suggested for inclusion in this study as ancient sites with an enigmatic early guided transport system.

Case 12. Barre granite quarries, Vermont, USA – producer of building stone

The Barre quarries are suggested for inclusion in this study for the international movement of labour, exemplified by the Socialist Labor party block at 46 Granite Street.

Case 13. Gwynedd slate industry, UK – producer of roofing elements with international distribution

The slate industry of Gwynedd (north-west Wales) encompasses many hundreds of sites, not only quarries but also mills to process slates and slabs, roads and narrow-gauge railways to transport them, and workers' settlements. However, the industry has historically been concentrated in four areas. These are: the Ogwen valley, where in the eighteenth century the huge Penrhyn quarry reaped the benefit of re-investment from its owner's West Indian sugar plantations and remains in active production; Nantperis, dominated by the Dinorwic quarry, where the elaborate former engineering workshops are now the National Slate Museum; Nantlle-Moel Tryfan (where quarrying dates to the Medieval period); and Blaenau Ffestiniog, where Llechwedd quarry is both still in active production and operates an underground visitor attraction which brings to life the way slate was won. There were also smaller 'outlier' groups of quarries elsewhere, such as around Porthmadog, and Talyllyn, Corris and Dinas Mawddwy in the southern part of the county.

Methods of extraction vary considerably, including stepped gallery workings at Penrhyn and Dinorwic, open pits at Nantlle and mining at Ffestiniog, what is apparent in all but the very smallest workings is their sheer landscape impact, particularly of the tips where unworkable rock was dumped. The mountainous landscape of Gwynedd displays them to good advantage, but quarries also contain smithies, workshops, locomotive sheds, offices, hospitals and barracks. Even in ruin, these exhibit their form and design, as well as their use and function, as components of the broader industrial landscape. Landed or banking capital is evident in some of the major buildings of the

industry, such as the Dinorwic workshops and the slab mills associated with Penrhyn and Gorsedda quarries, but the skilled work of the quarryman is evident in the way in which the rock-face was worked and in the rudimentary shelter where he reduced and split the raw blocks, just as his fondness for discussion, debate and singing is evident in his *caban* (lunch-time meeting place).

Until the early nineteenth century, the industry was characterised by low levels of technology. Slates are split by hand tools to this day, although initial reduction of the raw slate blocks came into general use from 1803. The most remarkable slate mill is at Ynys y pandy, designed on the lines of an industrial foundry, and erected in 1856-7 to serve Gorsedda quarry; it has been conserved and Scheduled as an Ancient Monument. Other examples of technical diffusion from outside the area include the remains of the Cornish water-driven pumping system of the 1840s at Pen y Bryn quarry in Nantlle and the iconic Cornish pumping engine installed at the nearby Dorothea quarry in 1904-1906, which survives complete; the Scottish blondin ropeway systems at two Nantlle quarries; and early hydro-power stations at Llechwedd and Maenofferen quarries in Ffestiniog, reflecting developments in Central Europe.

Water-power was central to the industry, reflected in the restored iron suspension wheel, built locally in Caernarfon in 1870 which drove the machinery in the Dinorwic quarry workshops and the 19th century water-balance shafts preserved at Penrhyn quarry. Water-wheels and water-channels aid understanding of how a quarry functioned by showing how a mountain reservoir might power a sequence of machines.

Transport of the finished slate to ports and harbour or later to a main-line rail-head was achieved by pack-horse routes, cart-roads and railway (as well as one very short canal). Rail transport, both for internal movement and to take the finished product to navigable water or to a main-line railway, was all-important from the early 19th century until lorries and bulldozers began to take over in the mid-20th century. Within the quarries themselves, the course of the railway lines, above all the massively-engineered inclined planes, indicate process flow, from the workings to the tips or to the mills and to the stack-yards, then away from the quarry to navigable water or to a main line. Overland transport routes include the Ffestiniog Railway, which adapted the engineering of the sinuous contour mineral line for steam operation and public carriage in the period 1860-1870, becoming a model adopted world-wide, and the Talyllyn, the first one to be purpose-built for steam traction and passenger transport. Both these railways were revived in the 1950s as heritage attractions, and now constitute some of the most completely preserved Victorian railway ensembles in the world.

The quarry workers' distinctive settlements all date from the 19th century. They include settlements sponsored by patrician owners, such as Mynydd Llandygái for Penrhyn quarrymen and their families, scattered moorland cottages, such as those of Moel Tryfan which inspired the fiction of the Welsh-language author Kate Roberts, and nucleated settlements which were created by their own working populations, such as Bethesda and Blaenau Ffestiniog. Tan y Grisiau, Nantlle and Abergynolwyn constitute 'company villages'. In every case, these settlements retain their distinctive way of life even where the industry has disappeared, and remain vibrant communities where the Welsh language remains strong. Blaenau and Bethesda are still home to working quarrymen. Substantial and ornate workers' chapels survive, many of which are still places of worship.

There is public access to several of the homes and gardens of the patrician owners of the slate quarries. The huge neo-Norman Penrhyn castle is owned by the National Trust and is open to the public. The grounds of Glynllifon, the former home of the quarry-owner Lord Newborough, form a county park. Plas Tan y Bwlch, once home to the owners of the largest Ffestiniog quarries, is now the Snowdonia National Park Study Centre, which promotes public courses on the history and industrial

archaeology of the industry. Its many historians, sociologists and archaeologists have benefited from knowledge-transfer from those who have worked in the quarries.

Even though Gwynedd slate was exported world-wide, its end use is also evident locally in its ingenious use in fencing, architectural slab-work, civil engineering and art, as well as on roofs.

David Gwyn

Case 14. Robben Island, South Africa – 17th century colonial quarries, prison labour

The Robben island quarries are suggested for inclusion in this study as examples of early European exploitation of natural resources in an imperial context and for the use of coerced labour in a quarry environment.

Case 15. Rajnagar marble quarries and Kishangarh saw-plant, Rajasthan, India – major modern industry with deep historical roots

The Rajnagar marble quarries and Kishangarh saw-plant are suggested for inclusion in this study for the antiquity and modern-day scale of extraction and processing.

Conclusions

For discussion among TICCIH delegates at Teruel, October 2014

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This draft has benefited greatly from discussion with:

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Select bibliography

Attanasio, D (2003), *Ancient White Marbles: Analysis and Identification by Paramagnetic Resonance Spectroscopy, Volume 1* (Rome 2003)
Ausonius, *D. Magni Ausoni Burdigalensis Opera Omnia*, vol 2. London, 1823
Benjamin, S G W (1891), 'The Granite Quarries of the New England Coast' in *Harper's Weekly*, 35 1777, 29-31.
Burford, A (1960), 'Heavy Transport in Classical Antiquity' in *Economic History Review* 2nd series 13, 1-18
Cato, M P, *De Agricultura*
Coulls, A (1999), *Railways as World Heritage Sites*. Paris: ICOMOS
Coulton, J J (1974), 'Lifting in Early Greek Architecture' in *Journal of Hellenic Studies* 94, 1-19
Dale, T N (1912), *The Commercial Marbles of Western Vermont*. Washington: Government Printing Office
Dix, B (1979), 'Roman Lime Burning' in *Britannia* 10, 261-2
Dix, B (1982), 'The Manufacture of Lime and its Uses in the Western Roman Provinces' in *Oxford*

*Archaeological Journa*l 1, 331-45
Donelly, T (1979), 'Structural and Technical Change in the Aberdeen Granite Quarrying Industry 1830-1880' in *Industrial Archaeology Review* 3 3, 228-238
Ewans, M C (1977), *The Haytor Granite Tramway and Stover Canal*. Newton Abbot: David and Charles
Fitzgerald, R S (1990), 'The Anatomy of a Victorian Crane: the Coburg Boiler Shop Crane and its Technological Context' in *Industrial Archaeology Review* 12 2, 185-204
Gamst, F C (1997) (ed), *Early American Railroads: Franz Anton Ritter von Gerstner's Die innern Communicationen (1842-1843)*. Stanford: Stanford University Press
Grewe, K (2009), 'Die Reliefdarstellung einer antiken Steinsägemaschine aus Hierapolis in Phrygien und ihre Bedeutung für die Technikgeschichte' in Bachmann, M (ed.), *Bautechnik im Antiken und Vorantiken Kleinasien*, Byzas 9. Istanbul: Ege Yayinlari, 429-455
Hayter, H (1875-6), 'Holyhead New Harbour' in *Minutes of the Proceedings of the Institute of Civil Engineers* 44
Hayward, K (2009), *Roman Quarrying and Stone Supply on the Periphery — Southern England: a Geological Study of First-Century Funerary Monuments and Monumental Architecture*. Oxford: British Archaeological Reports, British Series 500. Archaeopress
Hindley PG (1986), 'The Penmaenmawr Quarry Inclines', *Industrial Railway Record*, 173-193
Jackson, BL (1999), *Isle of Portland railways Volume 1 The Admiralty and Quarry Railways*. Usk: Oakwood
Johnson, D (2002), 'Friedrich Edouard Hoffmann and the Invention of Continuous Kiln Technology' in *Industrial Archaeology Review* XXIV 2, 119-132.
Josephus, T F (Yosef ben Matityahu), *Contra Apionem*
Klemm, Dietrich D and Klemm, R (2201), 'The building stones of ancient Egypt – a gift of its geology' in *African Earth Sciences* 33 631–642 (http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.111.9099&rep=rep1&type=pdf)
Kopalek, T (2103), *Die Deutsche Erd- und Steinwerke GmbH am Mauthausen-Gusen 1938-1945*. University of Vienna, Mag. Phil. thesis
Korres, M (1993), *Apo tēn Pentelē ston Parthenōna: Ta archaia latomeia kai he historia enos ēmitelous dōrikou kionokranou tou prōtou marmarinou Parthenōnos*. Athens: Melissa
Lewis, M J T (1970), *Early Wooden Railways*. London: Routledge and Kegan Paul
Lewis, M J T (1994), 'The Origins of the Wheelbarrow' in *Technology and Culture*, 35 3, 453–475
Lewis, M J T (2001), 'Railways in the Greek and Roman World' in *Early Railways*. London: Newcomen Society
Lewis, M J T and Williams, M C (1987), *Pioneers of Ffestiniog Slate*. Maentwrog: Snowdonia National Park
Lindsay, J (1974), *A History of the North Wales Slate Industry*. Newton Abbott: David and Charles
Malacrino, C G (2010), *Constructing the Ancient World: Architectural Techniques of the Greeks and Romans*. Getty Publications
Mangartz, F (2010), *Die byzantinische Steinsäge von Ephesos – Baubefund, Rekonstruktion, Architekturteile*. Österreiches Akademie der Wissenschaften
Mottershead, D, Pearson, A and Schaefer, M (2008), 'The cart ruts of Malta; an applied geomorphological approach' in *Antiquity* 82, 1065-1079
Moorhouse, S (1990), 'The quarrying of stone roofing slates and rubble in West Yorkshire during the Middle Ages' in Parsons D qv, 126-145
Mountford, C (2013), *Rope and Chain Haulage: The Forgotten Element of Railway History*. Melton Mowbray (UK): Industrial Railway Society
Needham, J (1971), *Science and Civilisation in China 4, Physics and Physical Technology, Pt. 3. Civil Engineering and Nautics* (with the collaboration of Wang Ling and Lu Gwei-djen). Cambridge: Cambridge University Press
Newby, F (2001), Introduction to *Early Reinforced Concrete*. Aldershot: Ashgate, xiii-xxxv

Parsons, D (ed.) (1990), *Stone Quarrying and Building in England AD43-1525*. Chichester: Phillimore
Pearson, A (2006), *The Work of Giants: Stone Quarrying in Roman Britain*. NPI Media
Phillips, J (1996), 'Quarry Houses on the Isle of Purbeck, Dorset' in *Bulletin of the Peak District Mining History Society* 13 2, 155-162
Pliny, *Historia Naturalis*
Protzen, J P (1985), '*Inca Quarrying and Stone Cutting' in The Journal of the Society of Architectural Historian*s 44 2
Raepsaet, G (1984), 'Transport des tambours de colonnes du Pentélique à Eleusis au IVe siècle avant notre ère', in *L'Antiquité Classique* 53, 101-36.
Ramelli, A (1588), *The various and Ingenious machines of Agostino Ramelli*. New York: Dover (trans of *Le diverse et artificiose machine del Capitano Agostino Ramelli*)
Redvers-Higgins, N, Willies, L and Wain, I (2011), *'Finished Labour of a Thousand Hands': The Archaeology of the Combe Down Stone Mines, Bath, Somerset*. Oxford: Oxford Archaeology Monograph
Rochefort, A.J. de (1672), *Paris et ses environs.* Paris
Rynne, C (2006), *Industrial Ireland 1750-1930 An Archaeology*. Cork: Collins Press
Scheibner, C P (1891), 'The Carrara-Marble District Railway' in *Minutes of the Proceedings of the Institution of Civil Engineers* 103 1891, 342-351
Scientific American, The Carrara Marble Industry' in *Scientific American* 54 1376, 17 May 1902
Soulez Larivière, F (1979), *Les Ardoisières d'Angers*. Angers: Prestograph
Stanier, P (1995), *Quarries of England and Wales*. Truro: Twelveheads Press
Tomlinson, C (1854), *Cyclopaedia of Useful Arts*. London and New York: Virtue
Van der Veen, M (1997), 'High living in Rome's distant quarries' in *British Archaeology* 28
Van Laun, J (2001), *Early Limestone Railways*. London: Newcomen Society
Vitruvius, *De Architectura*, Book 10, chapter 2, 2-14
Voisin, L. 1987. *Les Ardoisières de l'Ardenne*. Charleville-Mezières: Editions Terres Ardennais.
Wood, P (2006a), 'Tools and Machinery of the Granite Industry' in *The Chronicle of the Early American Industries Association* 59 2, 37-52
Wood, P (2006b), 'Tools and Machinery of the Granite Industry' in *The Chronicle of the Early American Industries Association*, 59 3, 81-96
Wood, P (2006c), 'Tools and Machinery of the Granite Industry' in *The Chronicle of the Early American Industries Association* 59 4, 130-151
Wood, P (2006d), 'Tools and Machinery of the Granite Industry' in *The Chronicle of the Early American Industries Association* 60 1, 10-32

Online resources

Lewis M Australian Building
http://www.mileslewis.net/australian-building/

Russell, BJ Gazetteer of Stone Quarries in the Roman World. Version 1.0.
www.romaneconomy.ox.ac.uk/databases/stone_quarries_database/

Enciclopedia Italiana 1934 http://www.treccani.it/enciclopedia

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