



Riverstone Natural Roofing Slate

**the geology, test
performance and use**

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This report concerns the geology, test performance and use of Riverstone natural roofing slate from Argentina. The report principally draws information derived from a variety of independent sources on behalf of SSQ Group. Most of the test results are derived from STATS Consultancy who have commented on the potential performance of the slate for roofing purposes.

The Riverstone natural roofing slate exhibits a range of properties that make it suitable for use as roofing slate. The supply is well developed with considerable and apparently consistent reserves available for the future.

Initial testing to current British, French, German and American standards, indicates that a service life in excess of 75 years is expected. Additionally, the Riverstone slate has very low contents of potentially problematic inclusions such as pyrite and calcite meaning that it will not discolour or suffer from pitting.



The Geology around La Florida and La Represa Quarry

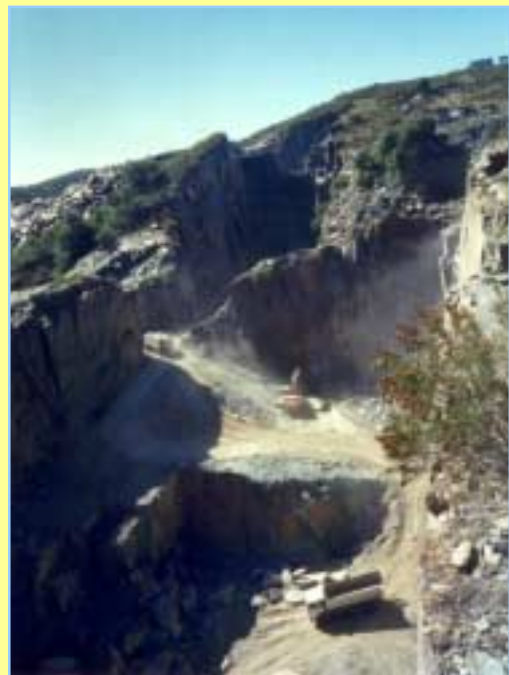
The La Florida area is situated to the north east of the city of San Luis in the centre of Argentina. Within the La Florida area is the La Represa Quarry that produces the Riverstone slate. The geology of the region is very old and complex and has suffered a variety of major phases of tectonic activity, i.e. the upheaval of the rocks as a result of pulling, pushing and shearing forces on a continental scale.

The Riverstone natural roofing slate occurs within a sequence of Pre-Cambrian age (Over 640 million years ago). Originally the material that now forms the Riverstone natural roofing slate was part of a series of silt and mud sediments that built up within a large deep sea basin.

The sediments were subjected to heat and pressure modification that folded, tilted and recrystallised the sediments, metamorphosing them into a range of new rock types. Interlayered in amongst the sediments were also lava flows.



Left: La Represa quarry. The beds are clearly vertically inclined (bottom right).



Above: La Represa quarry. Larger blocks are obtained from deeper levels.

The rock sequence now found in the La Florida region is a mixture of phyllites, schists, metamorphosed volcanics and quartz veins.

The exploitable sequence of rocks is some 50km in length and 5km wide with the Riverstone natural roofing slate found in the centre of this strip.

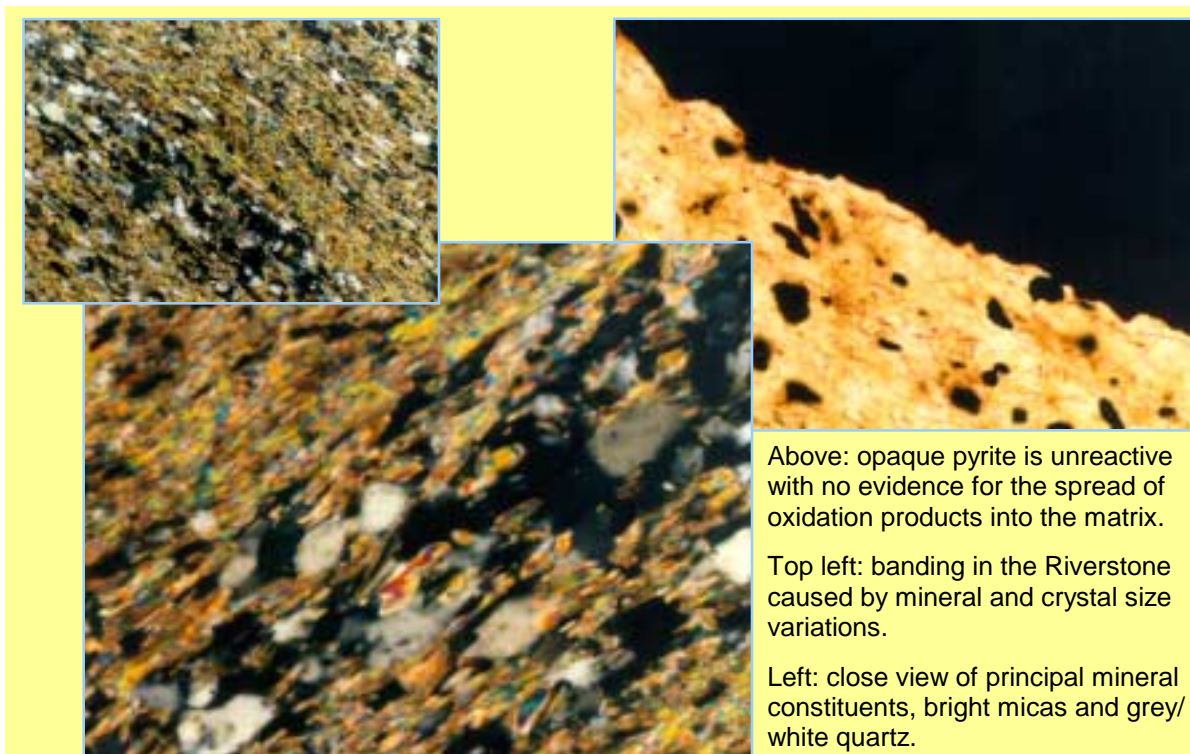
The metamorphism formed the primary cleavage of the Riverstone natural roofing slate; this is observed at an angle to the original sedimentary bedding plain. The alternation of micaceous and more coarsely crystalline siliceous bands reflects the original sedimentary conditions at the time of formation. When the sedimentary structures cut the main cleavage, this results in apparent banding. This banding may be visible either due to subtle colour variation and/or rippling due to the different competency of the layers.

Other structures influencing the geology include the presence of quartzitic veining related to tectonic movements and decompression of the rock. Joint sets are exploited during quarrying to assist extraction. For commercial purposes, the largest blocks are obtained from deeper levels within the quarry.

Mineralogy of the Riverstone Natural Roofing Slate

The Riverstone natural roofing slate comprises predominantly phyllosilicate minerals of chlorite and muscovite mica, and quartz. Traces of calcite and opaques are also present. The opaques included a small proportion of pyrite.

The split face of the slate is the primary cleavage plane. This plane is found to be uneven as a result of relict bedding variations in competency, providing a rippled surface.

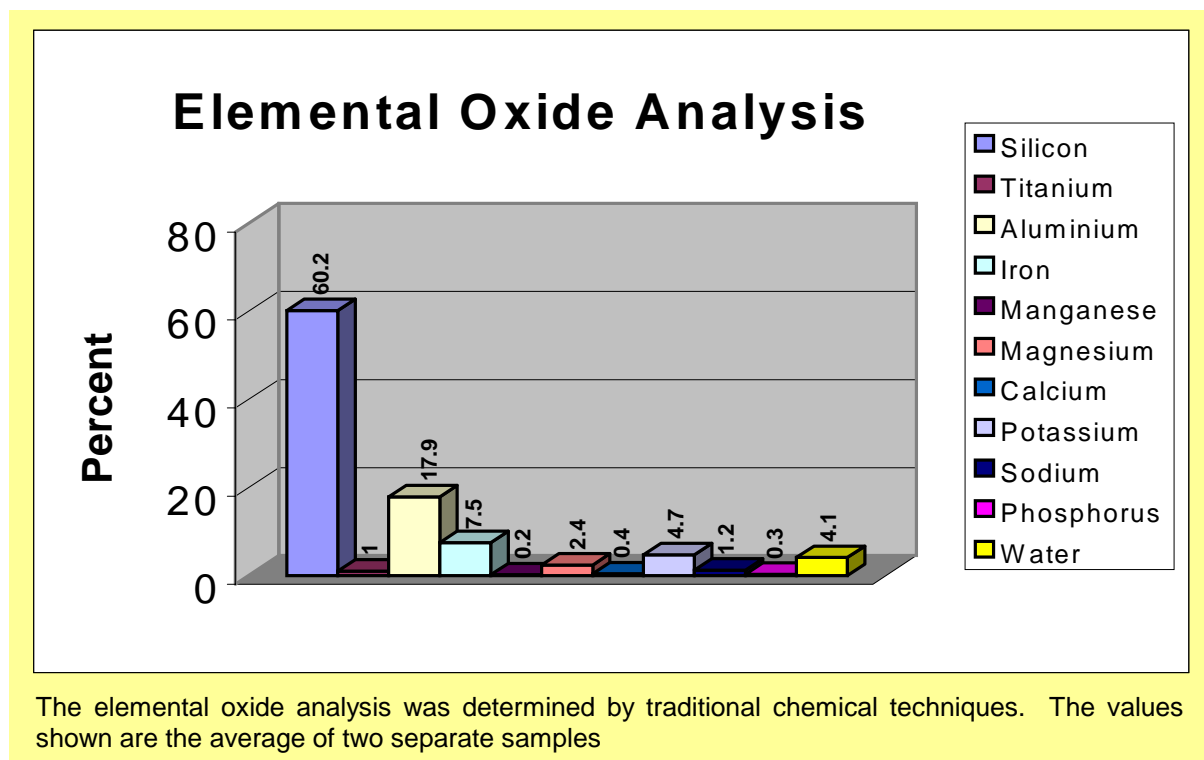


These three photographs are all views taken through the petrological microscope

The phyllosilicate minerals have a platy structure and are typically aligned sub-parallel to the primary cleavage with a 'preferred orientation'. The quartz is clearly distinguished amongst the phyllosilicates, appearing micro-granular. The larger quartz grains are typically flattened and elongated sub-parallel to the primary cleavage. The pyrite traces occur as well-formed crystals. Calcite occurrence is irregular, usually as large crystals surrounding the other constituents (porphyroblastic texture).

Elemental analysis shows the Riverstone natural roofing slate to be rich in silica and aluminium with substantial proportions of iron, potassium, magnesium, sodium and titanium. Lesser proportions of phosphorus, calcium and manganese were present.

The silica, aluminium, iron, potassium, magnesium and sodium would all form part or all of the major minerals identified. The titanium may be present forming ilmenite,



possibly identified as the opaque matter finely disseminated throughout the slate. The calcium would be mostly used up for calcite but also one or two other minerals. The phosphorus and manganese are harder to explain but may reflect the original sedimentary conditions and the accumulation of organic matter.

Classification of Riverstone Natural Roofing Slate

The Riverstone natural roofing slate is difficult to classify geologically as it lies in a zone between what is clearly true slate and true phyllite. However, BS 6100 is much clearer in this matter describing a roofing slate as any natural material that can be split and dressed for roofing purposes.

It is the borderline nature of the Riverstone that provides its character. Essentially the Riverstone has a slightly coarser grain size than most slates, which provides it with a rougher surface texture that imparts a more rustic feel.

The Testing of Riverstone Natural Roofing Slate

The Riverstone natural roofing slate has been tested to current British, French, German and American standards for roofing slate materials. The standards have a number of tests that are similar; however, there are some tests unique to a country as a result of differing climate or perception of the final use.

The most recent results available at the time of writing are summarised in **Table 1**. The Riverstone natural roofing slate passed all the different test criteria where given by the four countries.

It must be remembered that rock materials are natural products that will vary in composition and other features; this is particularly relevant for the Riverstone natural roofing slate and the La Represa quarry. Test results will vary with time and should be updated regularly to assess trends and whether any significant changes are taking place.

The Use of Riverstone Natural Roofing Slate

The Riverstone natural roofing slate exhibits a well defined cleavage that allows even thickness slates to be prepared that exhibit little evidence of warping or curling.

The bulk phyllosilicate and silica minerals are effectively inert, being the weather resistant remains of former rocks. These will resist the potentially daily cycles of wetting and drying and heating and cooling. The combination of these minerals should also provide strength without significant brittleness, making holing smooth with few resultant breakages.

The very low absorption will help the slate resist the ingress of water, reducing the subsequent potential for freeze-thaw action. The high flexural strength will also resist expansive forces as well as those expected from strong wind uplift.

Significantly, there is a low pyrite content and this pyrite appears to be non-oxidisable. The proportion of calcite is also very low suggesting that the slate should resist even highly acidic atmospheres.

The geology, examination and testing of the Riverstone natural roofing slate indicate a resource that can produce roofing slates of high quality that should be durable under the expected range of conditions found across the British Isles and Europe. The results suggest that a service life of over 75 years should be expected; however, periodic removal by cleaning of moss, lichen and dirt build-up may considerably increase the potential life span.

Table 1, Summary of Test Results for Different Countries

Country	UK	France	Germany	USA	
Test	Results and Observations				
Water absorption, %	0.18	0.14	0.14	0.11	
Absolute density, Mg/m ³		2.80	2.80		
Porosity, %		0.4	0.4		
Thermal cycling	Pass	No change	<0.1% loss		
Acid resistance ¹	Pass		0.12/0.15		
			0.10/0.12		
Steps ²		None			
White deposits ³		None			
Pyrite		Non-oxidisable	<0.02%		
Frost resistance, loss, %		< 0.1	<0.1		
Annealing Loss, %			0.26		
Sulfur, %			<0.01		
Sulfate (SO ₃)			0.01		
Carbon as C, %			0.03		
Calcium carbonate, %		0.1	0.1		
Bending strength, MPa	Transverse, dry		107	109	82
	Transverse, wet		72		
	Longitudinal, dry			77	58
	After frost testing, transverse, dry		103		
Depth of softening, mm				0.01	
Classification	Pass	Class A	--⁴	Grade S₁	

Notes

- 1 The German test is for weight gain after 14 and 28 days, dry and saturated conditions.
- 2 A 'step' is an oblique fracture relative to the cleavage plane with a quartz infill between the two lips of the fracture.
- 3 'White deposits' are thin film deposits that may be affected by changes in colour.
- 4 No acceptance criteria for the German test standards.



Summary of Findings

The Riverstone natural roofing slate performs exceptionally well and meets all the highest requirements of the British, French, German and American roofing slate standards. The findings were as follows:

British	Pass
French	Class A (highest class)
American	Grade S ₁ (highest grade)

The German standard does not include acceptance criteria.

The physical, mechanical and chemical features are equivalent and often superior to many of the best roofing slates from around the globe, including those from the UK, Spain and America.

A service life in excess of 75 years should be expected for a correctly constructed and maintained roof.

SSQ will accept no responsibility for any loss or damage howsoever caused that may arise through reliance being placed on the content of this document. Natural slate resources typically exhibit lateral as well as vertical variations in composition and features and performance must be expected to change with continued quarrying. SSQ Group therefore cannot guarantee that the supplied product will exactly match the various results given in this document. However, SSQ Group, through regular appraisal of its resources, endeavours to ensure that a reasonably uniform product is supplied.

This report has been prepared by:

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Appendix A

British Standard Testing BS 680: 1971

(This appendix consists of 6 pages, including this)

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Test Report 207/0439/97/R2/AA/av by Stanger dated 5.8.97

Appendix B

French Standard Testing AFNOR NF P 32-302

(This appendix consists of 17 pages, including this)

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Test Report 80138/1 by STATS Consultancy dated 2 November 1999

Appendix C

German Standard Testing DIN 52 201

(This appendix consists of 25 pages, including this)

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Test Report 80138/2 by STATS Consultancy dated 2 November 1999

Appendix D

American Standard Testing
ASTM C406-96

(This appendix consists of 15 pages, including this)

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Test Report 80138/3 by STATS Consultancy dated 2 November 1999