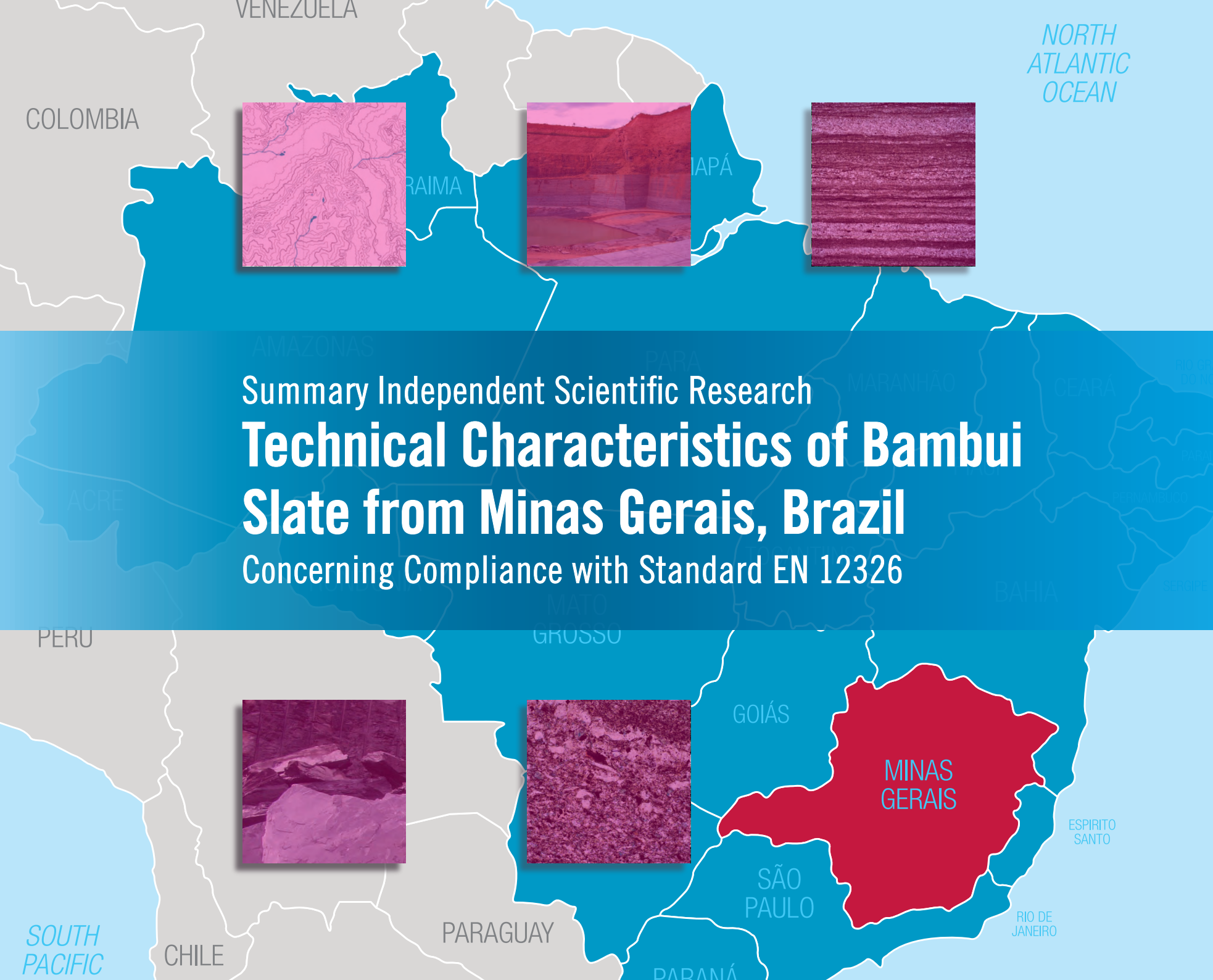


Summary Independent Scientific Research

Technical Characteristics of Bambui Slate from Minas Gerais, Brazil

Concerning Compliance with Standard EN 12326

Technical properties of Bambui Slate from the State of Minas Gerais (Brazil) to ascertain its compliance with the Standard EN12326 and whether it is entitled to CE marking.

The Fundación Centro Tecnológico de la Pizarra carried out an investigation of slates from Minas Gerais in Brazil to ascertain whether they comply with Standard EN 12326 for slate, and are therefore entitled to a CE marking. The results are presented in a report 'Study about five slate variants from the state of Minas Gerais (Brazil), from the point of view of its technological characteristics and CE marking' written by F. López G. Mesones.

It is estimated that the Minas Gerais area of Brazil is responsible for around 95% of the country's slate production.

Geological Background

Brazilian slate production is located in the State of Minas Gerais, approximately 200 km north of the state capital, Belo Horizonte. There are seven different types of slate produced, five or which are used for roofing purposes.

These are referred to as

- Grey slate
- Green Slate.
- Brown slate
- Black slate
- Multicoloured slate

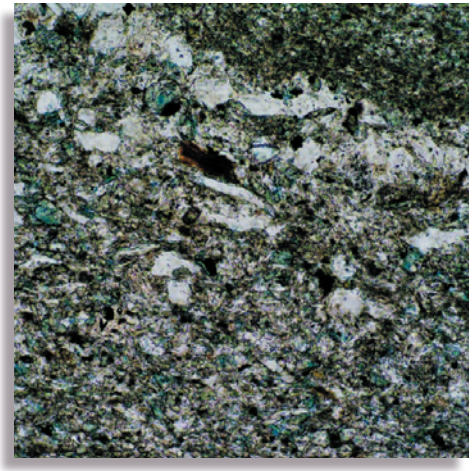
All the slate is extracted from the Santa Helena formation, part of the Bambui Group of sedimentary rocks. These rocks were formed from fine-grained sediments, such as mud, laid down at the bottom of a shallow sea over 600 million years ago. As the pile of sediments thickened, the original open structure of the mud was compacted into mudstone or shale. The horizontal stratification, seen in the quarry faces (See Figure 1 to the left, which shows a typical quarry with original sedimentary layers), is the bedding layers of the original mud.

The rock is easily split along these bedding layers into flagstones which, when used as roofing material, are often referred to as slates. However true slate has been subjected to metamorphism, and does not split along bedding but along planes associated with the realignment of minerals during metamorphism. This realignment, known as 'schistosity', bears no relationship to the original horizontal bedding planes.

Nevertheless, for convenience the rocks from the Bambui Group which are used commercially for roofing purposes will be referred to as slates in the remainder of this Report.

Petrographic Examination

The main minerals are: quartz, feldspar (plagioclase), sericite, muscovite and chlorite with variable amounts of clay and limonite. Sericite may have formed from the breakdown of feldspar and some clay may have altered to chlorite, but apart from these small changes, the mineral composition is essentially that of the original muds. Any layering present was formed at the time the original muds were deposited. This is generally found in strata rich in platy clay minerals (See Figure 2 to the right, which shows Laminations due to alternating layers of limonite and mudstone Scale x25).



Where the muds are rich in quartz and feldspar, no layering is observed (Figure 3 shown left. No laminations present in layers with a high quartz and feldspar content Scale x 25).

Technical Properties

According to Standard EN12326 Slate and stone products for discontinuous roofing and cladding Part 1: Product specification and Part 2: Methods of test, the commercial definition of slate is as follows; 'rock which is easily split into thin sheets along a plane of cleavage resulting from a schistosity flux caused by very low or low grade metamorphism due to tectonic compression'

As already stated, there is no schistosity in Bambui slate. Any stratification present is due to alignment of platy minerals settling parallel to bedding during deposition. Hence the Bambui slate does not fall within the scope of EN12326.

Although outside the scope of the Standard, the Bambui slates were nevertheless tested using some of the tests prescribed by EN12326. All the results were satisfactory except those for the following tests, which are discussed below:

- Water absorption test
- Freeze-thaw test

Water absorption test

The water absorptions of the different Bambui slates are given in Table 1. The Standard assigns an A1 grade to slates with a water absorption ≤ 0.6% and an A2 grade to those with values greater than 0.6%. A2 grade slates are then required to undergo the Freeze-thaw test (see below).

Table 1: Water absorption of Bambui slate

Slate Type	Green	Brown	Grey	Black	Multicolour
Water absorption %	0.81	0.69	0.46	0.60	0.52

It can be seen from Table 1 that the Grey, Black and Multicolour slates would be assigned an A1 grade. The Green and Brown would be assigned an A2 grade.

The water absorbency of all the slates is high when compared with that of most good quality slates. This can be seen in the limits set by the other national standards for slate e.g. the former British Standard BS680 set a limit of ≤0.3% for compliance.

Freeze-thaw test

To assess the vulnerability of slates to frost damage, the modulus of rupture or bending strength of slates which have been subjected to repeated cycles of freezing and thawing is determined and compared with that of untreated samples. In each case a minimum of 20 slates were tested and the mean value and standard deviation calculated (Table 2). To determine whether the difference in strength is statistically significant, the Student t test value was calculated. Values of t greater than 2.021 are deemed to be significantly different at the 95% confidence level.

Table 2: The bending strengths (moduli of rupture) of Bambui slates subjected to frost (R2) are compared with the average strength of untreated slates (R1) for each slate type and the standard deviations (S1) and(S2) and t value calculated.

Slate type	**Moduli of rupture (MPa)**		**Standard deviations**		**Student t test value**
	R_1 no frost	R_2 frost	S_1 no frost	S_2 frost	
Green	38.3	30.5	7.0	11.4	2.57
Brown	44.5	39.7	9.4	11.7	1.46
Grey	30.8	20.3	12.2	10.5	2.93
Black	39.5	28.6	9.0	9.2	3.82
Multicolour	38.3	19.9	9.0	10.8	5.85

It was seen that in each case, the strength of the treated samples had been reduced. Multicoloured slates were the most affected, with a 50% loss of strength, while Brown, the least affected, were 11% less strong. With the exception of the Brown slate, all t values are greater than 2.021 from which it is inferred that Bambui slates are vulnerable to the effects of freezing and thawing.

Conclusions

Although not within the scope of Standard EN12326, the slates were nevertheless tested according to the prescribed methods. The slates performed satisfactorily other than it was found that the water absorbency was high compared with that of good quality slates. It was therefore predicted that they would be vulnerable to damage by frost and this was substantiated by the significant loss of strength shown when subjected to repeated cycles of freezing and thawing.

True slate is split along cleavage or schistosity which formed during metamorphism. In contrast, Bambui slate is a sedimentary rock which splits along original bedding planes. The Standard EN12326 defines slate as a rock which splits along a cleavage or schistosity and excludes sedimentary rocks. The Bambui slates are therefore not in the scope of the Standard and hence are not entitled to a CE marking.

This summary of the Fundación Centro Tecnológico de la Pizarra's report into the 'Technical properties of Bambui Slate from the State of Minas Gerais (Brazil) to ascertain its compliance with the Standard EN12326' was wriiten by Consultant Geologist J A Walsh and is published by Galician & Spanish Slate. Visit www.spanishslateuk.com for more information.

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