Certificate of Examination
Petrographic Examination of Natural Stone
BS EN 12407: 2000

Client and Sample Details

Full client and sample details are given in Page 2

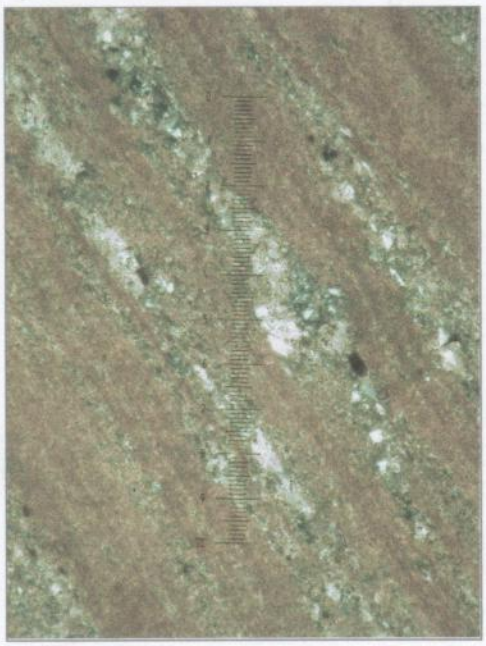
Methods of Examination and Results

The detailed methods of examination, including guidance for some of the terms used in the description, are given in Page 4 of this Certificate of Examination. The detailed petrographic examination results are given in Page 2 with a summary given below. Important photomicrographs are given below with additional photomicrographs given in Page 3.

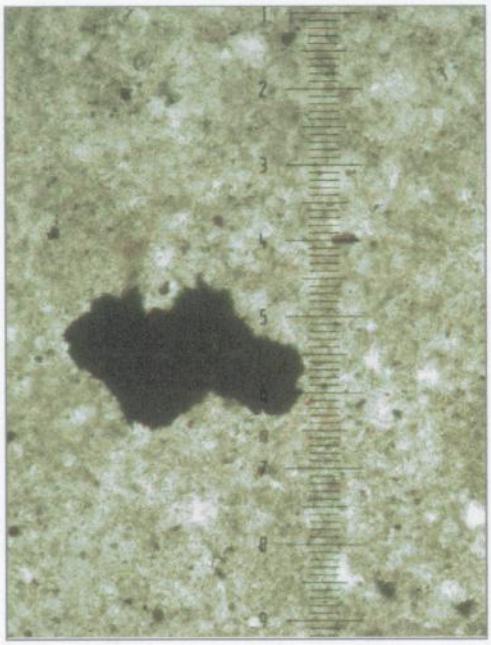
Summary Overview

Client	The Ardósia Slate Company Limited
Sample Details	400mm square tile sample of advised Ardosia slate
Geological Classification	Slate
Major Minerals	Phyllosilicates, calcite
Minor Minerals	Quartz, pyrite
Textural Features	Cleavage parallel to thin bedding laminations
Other Details	Preferred orientation of the phyllosilicates

Photomicrographs



General view in cross polarised light of the banding present within the stone; the coarser bands comprising calcite and quartz whilst the fine bands contain mostly phyllosilicates. Approx. magnification: x24



Close view in plane polarised light of one of the many fine opaque particles comprising apparent pyrite. Approx. magnification: x200

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A full description of the examination methods is given in Page 4

Client and Sample Details			
Client	The Ardósia Slate Company Limited, The Chase, Park Street, Lynton, Devon, EX35 6BY		
IBIS Ref. No	1113/10	**Sample No**	10
Source and Sample Location Details	Advised Ardosia slate from Brazil		
Sampled by / Date	Client / Not advised	**Date Received**	29.06.03
Examined by / Date	BJH / 29.06-17.07.03	**Condition on Receipt**	Dry
Thin-Section Details	Orthogonal set of slices		

Material Description *(incl. strength, weathering, crystal/ grain size, structure, alteration, name, secondary structure)*	Very strong, fresh, greyish green, very fine to extremely finely crystalline, thinly laminated SLATE exhibiting a tight, closely spaced bedding cleavage.

Material Component	Point Count[1]	Volume %	Crystal/Grain Size	Origin[2]
Phyllosilicates	---	80	< 10μm	Primary
Calcite	---	15	10μm – 100μm	Primary
Quartz	---	4	Up to 40μm	Primary
Opaques	---	1	< 2μm – 200μm	Primary
Muscovite	---	Trace	2μm – 10μm	Primary
Feldspar	---	Trace	10μm - 30μm	Primary

1 Point count normally only carried out when requested.
2 Primary - originally part of the rock; Secondary - an alteration/weathering product.

Material Component	Petrographic Details[3]
Phyllosilicates	A mixture of extremely finely crystalline sheet silicates minerals, probably white micas and chlorites. The minerals exhibited a preferred orientation parallel to a bedding lamination and also the apparent cleavage direction. The white micas may have comprised phlogopite or some similar mineral.
Calcite	Mostly concentrated in to bands forming the more coarsely crystalline laminations. The calcite typically enclosed the other minerals present other than the fine phgyllosilicates.
Quartz	Small grains most commonly observed distributed throughout the calcite bands. There may have been a siliceous cement assisting the phyllosilicate laminations but this could not be confirmed.
Opaques	Typically highly irregular crystal grains of black colour and yellow reflectance indicative of the iron-sulfide mineral pyrite.
Muscovite	Occasional flakes visible within the calcite laminations.
Feldspar	Plagioclase feldspar grains noticeable due to the presence of multiple twinning structures.
Other details	The slate was thinly laminated as a result of the compositional alteration from phyllosilicate rich bands to calcitic bands. This is probably the result of changes in the chemistry of the original depositional environment, possibly representing a seasonal drying out of a large lake or bay. The laminations were parallel to the apparent cleavage, which possibly has occurred as a result of competence variations rather than any secondary period of applied pressure resulting in re-crystallisation. Therefore the stone has a bedding cleavage and not a true slaty cleavage. It is difficult to consider the rock as true geological slate but there is no other appropriate classification as there has been sufficient alteration to move the stone away from classification as 'mudrock', specifically shale.

3 Details mainly relate to components or features of possible engineering significance.

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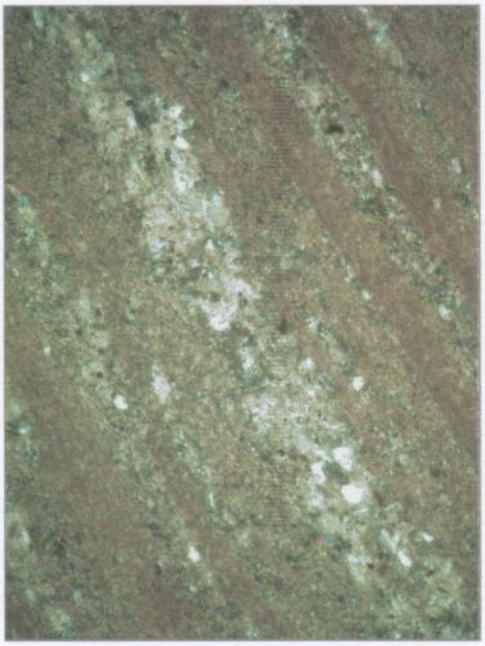
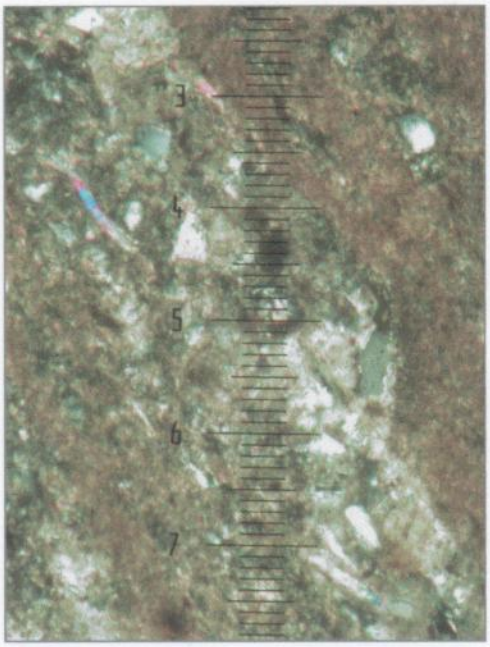
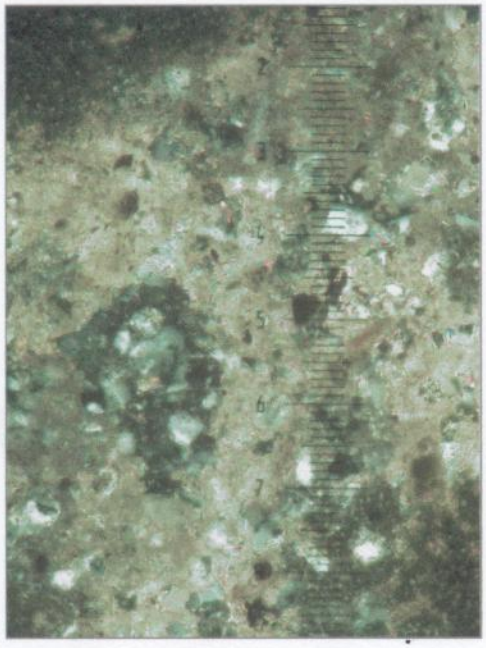
Additional Photomicrographs



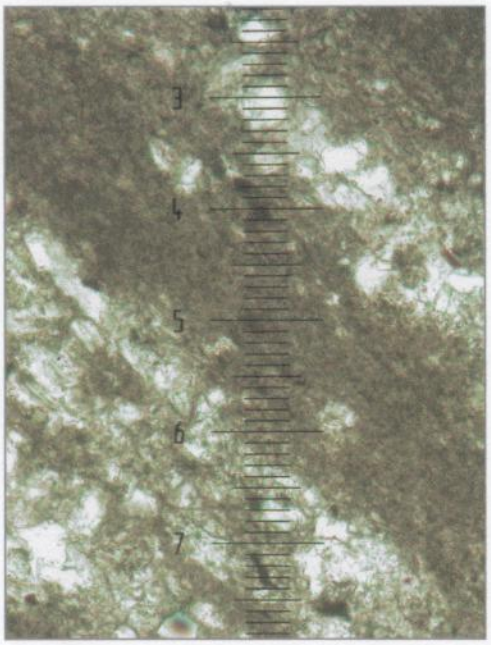
Another general view in cross polarised light of the laminations present within the stone and their obvious variation.
Approx. magnification: x24



Close view in cross polarised light of one of the calcite rich laminations and the quartz grains (grey) and traces of muscovite (bright) found within it.
Approx. magnification: x150



Cross polarised light perpendicular view of an area rich in calcite, the grey and white quartz within standing out quite clearly.
Approx. magnification: x110



View in plane polarised light highlighting the fineness of the phyllosilicate rich layers (darker coloured masses).
Approx. magnification: x150

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Investigation Methods

The submitted sample was subjected to a petrographic examination following the methods given in BS EN 12407: 2000, Natural stone test methods – Petrographic examination.

A visual and low-power microscopic examination was carried out assisted by a Leica Wild M8 binocular zoom microscope employing magnifications up to x80. This examination was supported by a variety of simple physical and chemical tests. Low-power photomicrographs (photographs taken through the microscope) may be prepared to illustrate general character. The examination is used to select specimens for the preparation of a thin-section and, where applicable, a highly polished specimen, for high-power microscopical examination.

Thin-sections are typically prepared after impregnation of the sample with an epoxy resin containing an ultraviolet light sensitive fluorescent dye. Highly polished specimens are prepared by grinding with successively finer abrasives finishing with a ¼µm diamond paste.

The high-power microscopical examinations are carried out using a Leitz Aristoplan microscope with individual magnification and zoom facilities providing continuous magnification up to x5000. Thin-section examination may be carried out in both plain and cross-polarised light, reflected ultraviolet light and darkfield illumination. Highly polished specimens may be examined in reflected polarised light, brightfield and darkfield illuminations. High-power photomicrographs may be prepared to illustrate microscopical features of importance.

Glossary of Common Terms Used in the Description

Proportions	**Major**: constituent present at 10% level and above; **Minor**: constituent present at 2% to 10% level; **Trace**: constituent present at below the 2% level
Frequency	Increasing Frequency ▼ **Rare** - only found by thorough searching **Sporadic** - only occasionally observed during normal examination **Common** - easily observed during normal examination **Frequent** - easily observed with minimal examination **Abundant** - immediately apparent to initial examination
Size	**Mega**: >60mm; **Macro**: 2-60mm; **Meso**: 60µm-2mm; **Micro**: 2-60µm; **Crypto**: <2µm; **Glassy**: without visible crystallinity
Hardness	**Very soft**: can be penetrated easily by a finger; **Soft**: scores with a fingernail; **Moderately soft**: scores using a copper coin; **Moderately hard**: scores easily with a penknife; **Hard**: not easily scored with a penknife; **Very hard**: cannot be scored with a steel point or knife.
Strength	**Very weak**: indented by thumbnail; **Weak**: can be peeled with a pocket knife; **Moderately weak**: shallow indentations made by firm blow with the point of a geological hammer; **Moderately strong**: specimen fracture by single firm blow of geological hammer, cannot be peeled with a pocket knife; **Strong**: specimen requires more than one blow to fracture it; **Very strong**: specimen requires several blows to fracture it; **Extremely strong**: specimen can only be chipped with a geological hammer.
Alteration	**Faintly**: traces of oxidation along crystal grain boundaries and mineral decay; **Slightly**: discoloration noticeable, common alteration of some minerals; **Moderately**: many minerals exhibit partial alteration and discoloration may be considerable; **Disintegrated/Decomposed**: loss of crystal bonds, most minerals heavily altered. Note: beyond moderate alteration the rock may be reclassified.
Bedding/Layering	**Thick**: <600mm; **Medium**: 200-600mm; **Thin**: 60-200mm; **Very thin**: 20-60mm
Lamination	**Thick**: 6-20mm; **Thin**: 2-6mm; **Very thin**: 600µm-2mm; **Extremely thin**: <600µm
Cleavage	**Extremely wide**: >2mm; **Very wide**: 600µm-2mm; **Wide**: 200-600µm; **Medium**: 60-200µm; **Close**: 20-60µm; **Very close**: 6-20µm; **Extremely close**: <6µm.
Voids	**Sporadic**: <1%; **Occasional**: 1-5%; **Frequent**: 5-10%; **Abundant**: 10-25%; **Honeycombed**: >25%

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Barry J Hunt
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