
HEAVY 3
A ROOF FOR LIFE

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CUPA PIZARRAS
The world leader in natural slate

CUPA PIZARRAS corporate headquarters in Spain

CUPA PIZARRAS is the world leader in the sale and manufacture of natural slate. The Group has its origins in a company called Cupire Padesa which was founded in 1892.

Their aim was to develop their quarries and **produce the best quality roofing slate** in Spain.

The boom in natural slate turned this small business into the parent company of more than 60 subsidiary companies, the majority of which operated in the natural slate sector.

In 2006, the business changed its name to CUPA GROUP to reflect the global reach that the company now enjoys.

CUPA GROUP employs more than 2,000 workers and comprises of over 64 companies linked primarily to the building sector with annual sales at over £300 million.

Within CUPA GROUP, CUPA PIZARRAS, is the company responsible for the sales of natural slate that the Group manufactures.

It was created with the aim of providing the finest quality slate combined with exceptional customer service around the world.

CUPA PIZARRAS produces first class slate from quarries that have been operating for over 120 years, and is the world leading brand in natural slate.

With 16 quarries and 22 processing plants, it exports to more than 30 countries around the world including Scotland.

Today, **CUPA PIZARRAS can claim to manufacture one in every three roofing slates used around the world;** this, along with a total commitment to quality, reinforces the company's number one global status.

WHAT IS NATURAL SLATE?

Slate is derived from fine-grained sediments such as mud or occasionally volcanic ash laid down millions of years ago in layers known as bedding. As the pile of sediments thickened, the original open structure of the mud was compacted into a mudstone or shale. These rocks are easily split on the bedding planes and are referred to as flagstones. However, for a slate to form, subsequent intense geological forces associated with mountain building are required, during which the minerals present in the original mudstone are metamorphosed.

Some minerals, such as quartz grains, are flattened and stretched, while clay minerals are recrystallised as platy minerals: white mica and chlorite.

The quartz minerals give the slate strength and durability, while the platy minerals form cleavage planes, which do not correspond to the bedding planes, but which allow the rock to be split into much thinner slabs suitable as roofing material. Differences in the composition of the original mudstone and the degree of metamorphism affect the quality of the slates thus produced.

WHAT IS THE AGE OF SLATE?

The age varies depending on the regional geology.

For example in Scotland, Ballachulish slate was formed from sediments laid down approximately 700 million years ago and was metamorphosed 500 million years ago, while Spanish slate from the Orense area was formed from muds laid down over 450 million years ago and was metamorphosed 300 – 350 million years ago.

WHY USE NATURAL SLATE?

Natural Slate appearance is one of its strongest attributes. Its natural colour, texture and grain, when applied to a pitched roof deliver a clean, sculptured and strikingly beautiful appearance. Two slates are similar but never identical. Collectively they add compelling aesthetic value to buildings. **CUPA PIZARRAS slate is 100% natural.**

The value of slate lies in its properties, among the most important of which are: **impermeability, durability and versatility.**

Natural slate is often chosen for aesthetic reasons; subtle differences in colour and texture give natural variation to the roof which is very pleasing to the eye. It is also very versatile and can be used to cover any shape of roof.

It can be dressed to form mitres in hips and valleys and to be fixed around curves in turrets and the rounded cheeks of dormer windows.

This versatility allows builders to incorporate intricacies in their design that would be impossible to achieve in other materials and has contributed significantly to Scottish architectural tradition.

A criterion of greater importance when choosing a roofing material is performance; a good quality slate is very durable and will out-perform better than other roofing materials.

WHY USE NATURAL SLATE?

Not all natural slates are equally durable.
Heavy 3 can last over a hundred years, making it **a very cost effective roofing material.**
A poor quality roof needs constant repair and maintenance, but when good quality slate is used, not only the cost of re-roofing can be effectively discounted, but the repair and maintenance expenses during its lifetime are extremely low.
Hence the use of Heavy 3 slate results in very low whole life cost.

Heavy 3 is also more cost effective than concrete or ceramic tiles, which typically last approximately 50 years. Other characteristics of slate, such as strength and impermeability, are also superior to those of concrete and ceramics. Thus thinner slates can be used, the weight of roofing material for a given area is less and the load on the roofing structure thereby reduced.

In addition, due to the impermeability of slate, this load does not increase significantly after rain, unlike the man-made products.

TO SUMMARISE, THE **BENEFITS OF NATURAL SLATE** ARE:

IMPERMEABLE
TO WATER

WEATHER AND UV RESISTANT

CHEMICAL RESISTANT,
NOT AFFECTED BY CHEMICALS OR POLLUTANTS (ACID OR ALKALI)

NOT DAMAGED
BY FUNGI, MOSS, INSECTS, ANIMALS OR BIRDS

STRONG, WHILE WEIGHING SUBSTANTIALLY LESS THAN MAN-MADE ROOFING TILES

NON-COMBUSTIBLE

HISTORY OF NATURAL SLATE IN SCOTLAND

SLATE HAS BEEN USED AS A ROOFING MATERIAL THROUGHOUT SCOTLAND SINCE THE MIDDLE AGES. QUARRIES WERE LOCATED IN SEVERAL AREAS, OF WHICH THE MOST IMPORTANT WERE:

A

Easdale and the surrounding Slate Islands south of **Oban**.

B

Ballachulish, near the southern end of the Great Glen.

C

Highland Boundary: a series of quarries on a line from Arran to Dunkeld.

Some of the earliest references are to Easdale, from which slate was sent to St Andrews in 1197, and to Glasgow to roof the cathedral also in the 12th century. Reliable records began in 1745 when the Earl of Breadalbane and others established the Marble and Slate Co of Netherlorn to extract slate from Easdale Island.

As demand increased during the 18th and 19th centuries, the company expanded to neighbouring islands. Slates were transported by sea around the north coast to all the major towns on the east coast and through the Crinan Canal to Glasgow and other west coast centres.

Ballachulish is the best known Scottish slate, both in terms of quality and quantity.

Production began at the end of the 17th century and expanded rapidly to overtake the Slate Islands in the 1860s. The quarries were ideally located close to Loch Leven, which enabled slates to be transported by sea around Scotland.

Highland Boundary slate was produced from a series of quarries just north of the Highland Boundary Fault of which Aberfoyle is the best known.

They are grouped together because of similarities in their geology, but have very different histories.

Proximity to the coast was initially the most important factor limiting production; for example, slates from the island of Bute were reputedly used in the 15th century and from Arran in the 18th century.

With improved communications in the 19th century, sea transport was no longer essential and inland quarries such as Aberfoyle came into their own.

The rise and fall of the Scottish slate industry mirrored that in other parts of Britain. Starting slowly, it reached its zenith around 1900, producing 25-30 million slates per annum.

However the beginning of the 20th century was marked by a depression in the building trade, compounded by a shortage of manpower during two World Wars. While the Welsh and English quarries survived, the Scottish industry could not compete with tiles and imported slate. The Ballachulish quarries closed in 1955 and the remaining quarries in the 1960s.

PRODUCTION PROCESS

1. SLATE DEPOSIT

Prior to the extraction of slate from a quarry, CUPA PIZARRAS carries out a full site investigation to determine the geological and geotechnical properties of the slate seam.

After the orientation and extent are established, the most suitable method of extraction is determined to maximise the yield.

The overburden is then removed and the site made ready for the extraction of slate blocks.

2. SLATE EXTRACTION

Explosives are rarely used today in the extraction of slate; instead diamond-tipped wire saws are used to remove large blocks of rock. To do this, two holes are drilled at right angles, through which the saw blade is threaded. Water is used throughout the cutting process, both as a coolant and in order to remove waste; this water is cleaned and reused. The blocks extracted from the quarry are then transported by truck to the processing sheds.

3. PROCESSING

The extracted blocks are cut using diamond saws into smaller blocks with dimensions slightly larger than the finished slates.

The thickness is however 16 times that of the finished product. Using hand tools, these blocks are then split and re-split equally a total of four times until 16 single slates are finally produced.

Water is again used throughout this process both to cool the diamond tipped saws and to keep the blocks wet to facilitate splitting.

The final stage in the process is to ‘dress’, i.e. bevel, the edges. This is to ensure that water runs freely down the slate and off the roof.

The individual slates are inspected and then packed in wooden pallets in order to be transported to the central warehouse.

4. PACKAGING AND STORAGE

Slates from all the CUPA PIZARRAS quarries are sent to the central warehouse prior to dispatch. Individual pallets are labelled with a bar code which captures all the data for a particular batch.

This is part of CUPA PIZARRAS comprehensive quality assurance procedure, covering the entire production, packing and transport operations, which ensures the traceability of each pallet from origin to final destination and enables the source of any problems to be identified.

5. QUARRY REINSTATEMENT

Slate production is essentially a mechanical process and does not require any chemical treatment.

All the waste produced is original rock which, when the quarry has been worked out, can be used for landscaping prior to reseeding and planting.

This process is supervised by the environmental authorities.

HEAVY 3

• Heavy 3 slate is quarried from the CUPA PIZARRAS Nº3 quarry in San Pedro de Trones (León) in northern Spain. This quarry has been in operation since 1892 and produces around 25,000 tonnes each year.

• The slate is dark-grey with a slightly gritty texture, and in some samples well defined parallel lines are clearly visible on the cleavage surfaces.

• Another obvious feature of the slate is the presence of metallic cubes approximately 2mm in size. Sometimes these cubes are randomly distributed throughout the slate, while in other cases they are concentrated in discrete bedding layers. These cubes are of iron sulphide, known as **pyrite.**

• Slate from San Pedro quarry is produced in two thicknesses, 3.5mm and 7-8mm; the thicker variant being the preferred choice in Scotland.
The extra thickness and weight give it strength to withstand the high wind speeds and driving rain common throughout Scotland.

• No slate is a true match for Ballachulish, the best-known of Scottish slates. However there are many similarities between Ballachulish and our Heavy 3.

• Both are blue-grey in colour and have similar thickness, and pyrite crystals are usually present in both. In the absence of a new source of Scottish slate, Heavy 3 is the best choice for repair and replacement of traditional roofs in Scotland.

Heavy 3 Natural Slates are available in the following **sizes**:

30x20cm (12x8")
35x20cm (14x8")
40x20cm (16x8")
40x25cm (16x10")
50x25cm (20x10")

CASE STUDY 01.

PORTAVADIE MARINA, LOCH FYNE

• Set in a man-made lagoon, situated on Loch Fyne, Portavadie Marina is one of the UK most modern marinas, with deepwater, sheltered berthing and stunning purpose built facilities.
Situated just a few miles to the north of the Isle of Arran, Portavadie Marina is handily positioned amidst the beautiful cruising grounds of Loch Fyne and is ideally located to give access to the Firth of Clyde and some of the finest sailing waters in the world.

• Restaurants, bars, accommodation and 230 berths make this destination great for yachters, walkers and families alike.

• **Heavy 3 was the choice for this prestigious project.** Matching the highest standards in terms of **aesthetics and functionality.**

MAIN CONTRACTOR
Loch and Glens

ROOFING CONTRACTOR
D&M Roofing contractor

ARCHITECT
Loch and Glens

CASE STUDY 02.

ARDGARTAN HOTEL, LOCH LONG

• The history of this beautiful part of the West of Scotland beside the shores of Loch Long as a leisure destination begins in 1936 when a mansion and 70 acres of countryside were acquired for use as a youth hostel and recreational land in the newly created Argyll national forest park.
Since then, this location has been popular with travelers who want to enjoy the famous Scottish scenery.

• In 2009 the old youth hostel was demolished and in 2012 the Lochs & Glens Holiday company completed the construction of a new 124 bed, four storey hotel.

• Heavy 3 close likeness to the look and feel of traditional Scottish Balachullish slate made it the **perfect choice as a roofing material** for this project.

MAIN CONTRACTOR
Loch and Glens

ROOFING CONTRACTOR
D&M Roofing contractor

ARCHITECT
Loch and Glens

CASE STUDY 03.

DRUM OF GARVOCK
DUNNING

• Designed for a prominent client, the mission was to provide a home of distinction, whilst closely following the previous building's footprint.

• Drum of Garvock is conceived as a series of living spaces linked from a cylindrical drum.

• With over 30,000 sq.ft of living accommodation which is linked vertically via the drum and horizontally via the entrance hall.

• The hall is modulated and enlivened by a series of perforations and narrower spaces opening up to a light filled break-out and display space.

• In the absence of quality Scottish slate, Heavy 3 became the perfect choice for such a project. This ensured a very Scottish look, as well as **the reassurance that can only be delivered by a product of this quality.**

MAIN CONTRACTOR
Stuart Miller

ROOFING CONTRACTOR
Fraser Roofing

ARCHITECT
Mcallister Architects

CASE STUDY 04.

BALHOUSIE CASTLE
PERTH

• The origins of Balhousie Castle are said to date back to the 12th century. Originally an L-shaped tower house what we see today is the central section, possibly dating from the 17th century. In its present form, the Castle dates from the 1860s.

• During the Second World War, the property was used by the Auxiliary Training Service as the Officers Quarters. After the War, it housed a detachment of Royal Army Service Corps and the Headquarters, Highland District, Corps of Royal Engineers.

• In 2008 The Black Watch Heritage Appeal was launched to buy, develop and endow Balhousie Castle to create a permanent home for The Black Watch in Perth at the heart of the Regimental area. The Appeal succeeded in raising £3.5 million and a major redevelopment project began in May 2012 and was completed by June 2013.

• It was particularly important for the planning authorities that the roofing material specified **would blend seamlessly with indigenous slates used on other elevations of this B listed building**. Heavy 3's close likeness to the look and feel of traditional Scottish slates made it the perfect choice as a roofing material for this project.

ROOFING CONTRACTOR
Braisby Roofing

ARCHITECT
Arta Architects

CASE STUDY 05.

TRINITY PARK
CALA HOMES EDINBURGH

• This much sought after suburb of Edinburgh combines a village atmosphere with all the advantages of being located right in the heart of the Scottish capital.

• Trinity Park is a place where glorious architectural tradition meets modern-day inspiration, with a limited release of 81 homes.

• Showcasing an eclectic mix of Georgian inspired Edinburgh villas, mews and spacious apartments, which cleverly combining neo-classical influences with contemporary design excellence.

• Heavy 3 premium credentials, its unparallel quality and likeness to Scotland´s indigenous Ballachulish slate, placed it as the perfect material for a roofing solution for this development.

• **With Heavy 3 100 year guarantee** there is not only peace of mind for the developer, in this case, Trinity Park, but also its customers. The end result delivers a quality look that completes these premium houses.

MAIN CONTRACTOR
Cala Homes

ROOFING CONTRACTOR
SouthWest Roofing

ARCHITECT
Susan Stephen architects

CASE STUDY 06.

MARITIME MUSEUM
IRVINE HARBOUR

• The Irvine museum is located at Irvine Harbour, situated within the category A listed former Engine Shop of Alexander Stephen and Sons, which was salvaged and relocated from their derelict Linthouse shipyard in Glasgow during 1991.

• The site operated by The Scottish Maritime Museum contains the exhibitions and collections that tell the story of that great maritime tradition.

• The Linthouse Engine Shop, originally built in 1882, holds a substantial part of the museum's collections in open store.

• Together with its 100 years guarantee, Heavy 3 ensures **a high quality traditional look standing the test of time no matter what the climate throws at it.**

ROOFING CONTRACTOR
Braisby Roofing

CASE STUDY 07.

THE RACE COURSE, MUSSELBURGH

• Situated close to River Esk, six miles east of downtown Edinburgh, Musselburg Race Course opened its doors for year-round programmes for both and flat national hunt meetings.

• The old Edwardian Grandstand sits side by side with new build facilities. A key feature of this project was to be able to provide a roofing slate that was not only in keeping with the surrounding traditional builds, but was also a close match to indigenous Scottish slate (which has not been manufactured for some 50 years).

• This made Heavy 3 the **ideal choice and further demonstrates its versatility** through use on the refurbished Grandstand as well as the new facilities.

MAIN CONTRACTOR
Robert Rollo & Sons

ROOFING CONTRACTOR
Robert Rollo & Sons

ARCHITECT
Michael Laird Arhcitects

CASE STUDY 08.

STIRLING FARM STEADING

• This typically Scottish farmstead conversion lies in the shadow of one of Scotland´s most historic castles that dates back to the 15th century. As a consequence, it was particularly important for the planning authorities that the specified slate were sympathethic to the surrounding area.

• Heavy 3 close likeness to the look and feel of traditional Scottish slates made it the perfect choice as a roofing material for this project.

MAIN CONTRACTOR
Crammond Select Homes

ROOFING CONTRACTOR
BHC

ARCHITECT
Bobby Halliday Architects

CASE STUDY 09.

THE GALLERY, TOBERMORY

• This former church built in gothic revival style is located on Tobermory (Isle of Mull), main street overlooking the harbour.

• Construction was completed in 1879 and ceased to be a place of worship in 1964.

• The church was then sold and converted into The Gallery with a coffee place and a store attracting thousands of visitors every year.

• For the planning authorities, it was of great importance that the roofing material specified would blend seemingly with Scottish slates previously used and decided to be kept on the turrets of the former temple.

• Heavy 3 close likeness to the look and feel of traditional Scottish slates made it the perfect choice as a roofing material for this project.

QUALITY STANDARDS

The compliance requirements given are for the highest grade of slate. The European Standard sets several grades for a single slate, depending on its performance in different tests. French Standard assigns an overall grade depending on the performance in all the tests.

	COMPLIANCE REQUIREMENTS OF EUROPEAN AND FRENCH STANDARDS		TEST RESULTS OF CUPA 3 SLATE		
TESTS	European Standard prEn 12326	French Norm NF 228-02/01/01	Tested by LNE Octobre 2014	Tested by ATG 2014	Tested by British Standards Nov 1996
WATER ABSORPTION	≤0.6%	≤0.4%	0.24%	0.22%	0.28%
SPECIFIC WEIGHT gm/cm³	No limit	≥2.60 gm/cm³	2.74 gm/cm³	2.74 gm/cm³	
MODULUS OF RUPTURE	No limit	No limit	62 MPa	64,6 MPa	
CARBONATE CONTENT	No limit	≤1.5%	0.46%	0.4%	
NON-CARBONATE CARBON CONTENT	≤2%	No limit	0.39%	NA	
THERMAL CYCLE	No leaching of metallic minerals	No leaching of metallic minerals	T1	T1	T1
SO_2 EXPOSURE TESTS	No affect	No equivalent test	S1	S1	S1
DEVIATION FROM DECLARED LENGTH	+5mm	Declared values +3 mm	Complies	Complies	
DEVIATION FROM DECLARED WIDTH	+5mm	Declared values +3 mm	Complies	Complies	
DEVIATION FROM SQUARENESS	≤1% of length		Complies	Complies	
DEVIATION FROM STRAIGHTNESS OF EDGES	≤5mm slate ≤500mm or ≤1% of length		Complies	Complies	
DEVIATION FROM FLATNESS	<1.5% of length for normal texture		Complies	Complies	
THICKNESS (INDIVIDUAL)	Nominal thickness ± 35%		Complies	Complies	
THICKNESS (100 PACKED SLATES)	Nominal thickness ± 15%		Complies	Complies	

EUROPEAN STANDARD:
EN 12326

BRITISH STANDARD:
BS EN 12326-1 : 2014

FRENCH SPECIFICATIONS:
NF 228-02/01/01

BELGIAN SPECIFICATIONS:
ATG H 571

HEAVY 3 GEOLOGICAL ANALYSIS

Slate is a fine-grained metamorphic rock derived mainly from mudstone and shale. During metamorphism the quartz and clay minerals present in the original shale are recrystallised and the clay minerals replaced by white mica and chlorite. The ability to split slate into flat sheets is due to the alignment of the white mica and chlorite minerals during recrystallisation the extent to which these processes have taken place affects the quality of the slate.

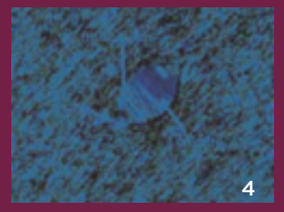

Fig 1. Plane Polarised Light
Fig 2. Cross Polarised Light
Fig 3. Plane Polarised Light
Fig 4. Cross Polarised Light
Fig 5. Plane Polarised Light
Fig 6. Reflected Light

PETROGRAPHIC ANALYSIS

Modus operandi: The slate was examined using traditional petrographic techniques, thin sections of slate (30µm thick) were examined under the optical microscope using both plane and cross polarised light. The principal minerals present were determined by X-ray diffraction and the chemical composition was determined by X-ray fluorescence analysis.

A. OPTICAL MICROSCOPY

Under the optical microscope, it can be seen that the Heavy 3 is a fine-grained slate with a pervasive foliation due to the alignment of platy minerals (Fig.1 & 2). This alignment of fine-grained minerals enables the rock be split into thin sheets suitable as roofing slates. At greater magnification (Fig.3 & 4) it can be seen that the principal minerals are chlorite, white mica and quartz. Chlorite is recognised by its green colour in plane polarised light (Fig.3), the white mica by its bright colours under cross polarised light and quartz by its grey colour also under cross polarised light (Fig.4). This assemblage of minerals is typical of low grade metamorphic rocks sometimes referred to as the greenschist facies.

When examining the large grain under cross polarized light, the intergrowth of the principal minerals is clearly visible. The iron sulphide minerals (pyrite) are present as large crystallised cubes approximately 1mm in diameter (Fig. 5 & 6). These crystalline cubes are very resistant to the effects of weathering. In contrast, pyrite in poor quality slates is usually amorphous and found disseminated throughout the rock. Other minerals, identified using the optical microscope, were zircon and tourmaline. These minerals are rare and do not affect the properties of the slate.

B. CHEMICAL COMPOSITION

The chemical composition of the slate (expressed as oxides) was determined using X-ray fluorescence analysis:

SiO_2 > 52.61%
$A_{12}O_3$ > 22.95%
Fe_2O_3 > 9.19%
Mg O > 2.98%
CaO > 0.35%
Na_2O > 1.34%
K_2O > 3.65%
TiO_2 > 1.12%
MnO > 0.09%
P_2O_5 > 0.24%
LOI* > 4.75%

*(Volatile material referred to as 'loss on ignition')

C. X-RAY DIFFRACTION

The principal minerals present were identified using XRD analysis. Combining the XRF and XRD results, the mineral composition of the slate was calculated as follows:

Principal Minerals
· White mica (31%)
· Chlorite (28%)
· Quartz (21%)
· Feldspar (11%)
· Clay (5%)

Secondary Materials
· Pyrite (1%)
· Anatase (1%)

QUALITY ASSURANCE

CUPA PIZARRAS success has been built on the high quality of the slate that is extracted from its quarries, and the comprehensive quality controls that each piece of slate undergoes.

• The area of quality is very important to CUPA PIZARRAS, and we invest heavily in its continuous improvement, to achieve the highest quality product available on the market today.
This reinforces CUPA PIZARRAS position as the industry global leader.

• CUPA PIZARRAS is responsible for geological studies, geo-technical analysis, prospecting, sampling, seam evaluation, allowing us to control every aspect of the natural slate production process.

• All quarries currently operated by CUPA PIZARRAS are endorsed in those countries where authorisation is mandatory.
Our compliance with the Standard ISO 9001:2000 (certified by AENOR) certifies our quality management system. In order to control the quality of our production, regular testing is carried out.

• Testing is done in certified laboratories in the countries to which we export. However, in order to offer the finest quality slate, CUPA PIZARRAS own laboratories carry out additional tests as part of our internal quality control system.

• CUPA PIZARRAS thorough and rigorous quality procedures allow the company to offer the guarantee of full traceability, where the origin and production history of each product can be provided.

ENVIROMENTAL STANDARDS

The environment is paramount to CUPA PIZARRAS, our commitment being rewarded by (AENOR) ISO 14001 certification.
To achieve this, CUPA PIZARRAS has actively created an Environmental System, which includes the implementation of correct environmental policies to prevent contamination and the compromise of the compliance of all the local, national and international environmental rules and norms. Individual offices and locations throughout CUPA PIZARRAS continuously adhere to these environmental objectives, with staff proactively engaged in minimising energy consumption and recycling all materials where possible.

TRACEABILITY STANDARDS

CUPA PIZARRAS operates a barcode system that identifies each pallet of slate individually. Our traceability procedure can be identified by means of this unique label that is placed on each pallet (once the pallet has completed inspection and quality controls in the manufacturing bay and in the central warehouse). This label contains information about the slate that has been packed and includes test results, the name of the quarry, size of the slates, the number of slates and even the name of the person who selected and packed the pieces.
This traceability system offers our customers an outstanding reliable experience when using our products that gives them peace of mind in their purchase.This extensive quality process is paramount to our service. **Customers can use our products with confidence.**

WHAT MAKES A GOOD ROOFING SLATE?

Slate is a fine-grained, low grade metamorphic rock, which can be split fairly thin, making it ideally suited as roofing material. It is formed from mud or silt deposited millions of years ago in calm water environments. As the sediments accumulated, the pressure and temperature of the lower layers increased and became compacted, until they were eventually consolidated into mudrock.

• These rocks retain the primary bedding layers, and, if they are thick enough, they can be used for roofing. Caithness flagstone is an example of this.

• The composition of mudrock varies depending on the source of the original mud, but the most common minerals are quartz, feldspar and clay minerals.

• Mudrock may be found in any location, but slate is only found in mountainous areas, since it is a metamorphic rock which requires for its formation the intense geological forces associated with mountain building.

• During metamorphism, stable minerals such as quartz are flattened and stretched in response to the main stress. They also grow in size and become increasingly crystalline.

• At the same time, less stable clay minerals are gradually replaced by more stable mica and chlorite. They increase in size and crystallinity with increasing metamorphism.

• All roofing slates have fairly similar composition, consisting primarily of quartz, chlorite and white mica, yet they do not all perform equally well on a roof. Some last hundreds of years while others fail after a few years of exposure.

• This is due to differences in the degree of metamorphism. In poorly metamorphosed slates, even the most stable mineral, quartz, if it is fine-grained, is vulnerable to weathering.

• Durability may be further compromised by the presence of certain deleterious minerals; clay minerals take up water and amorphous pyrite is prone to leaching and may react with other minerals present. At a higher metamorphic grade, quartz is usually coarser grained and more crystalline; the concentration of clay minerals is low and amorphous pyrite has often been replaced by crystalline cubes which are very resistant to weathering.

• Reliably predicting the durability of slate is only possible if a range of chemical and physical tests are carried out. However, some good pointers are a gritty texture and a good ring tone when hit with a hammer, both of which indicate crystalline slate.

Joan Walsh BSc (Chem), BSc (Geol),
PhD, FGS.
Consultant Geologist

HEAVY 3

A ROOF FOR LIFE

CUPAPIZARRAS

45 Moray Place
Edinburgh EH3 6BQ
United Kingdom
Ph. +44 (0) 1312 253 111
uk@cupapizarras.com

CUPAPIZARRAS.COM