Geology of Facade Stones

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FAR EAST CONSORTIUM LTD.


ON HOUSE 永安集

- Common stone types
- Geology of special façade stones
- Production process
- Common tests and properties
- Problems encountered
- Inspection and monitoring

Common rock types

- Granite (diorite, gabbro, gneiss): crystalline rock
- Limestone (limestone, travertine): crystalline, carbonate
- Sandstone (sandstone, onyx etc.): clastic, sedimentary
- Marble: crystalline, carbonate
- Volcanics (basalt,…): crystalline
- Slate (slate, phyllite etc.): foliated
- Synthetic stones

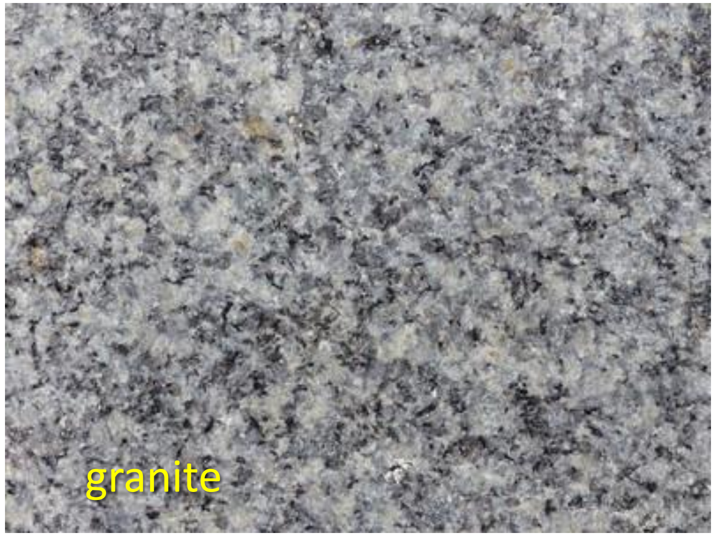
Usage:

Interior

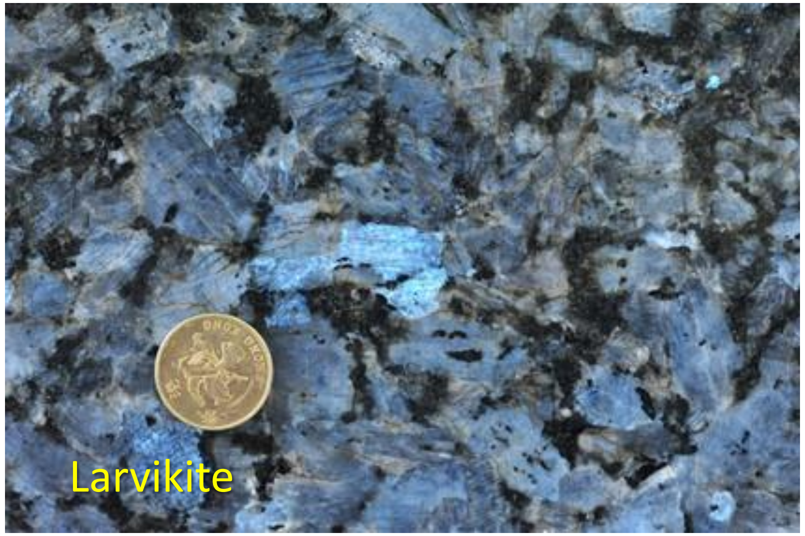
Exterior

Paving stones

‘Granites’


granite


gabbro

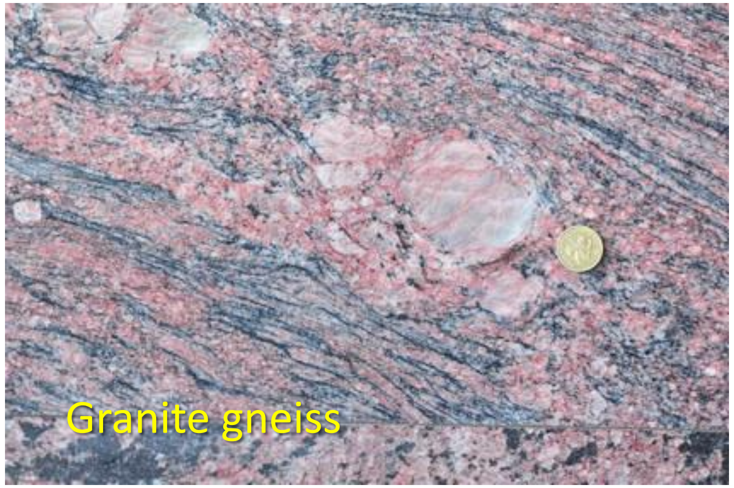

Larvikite

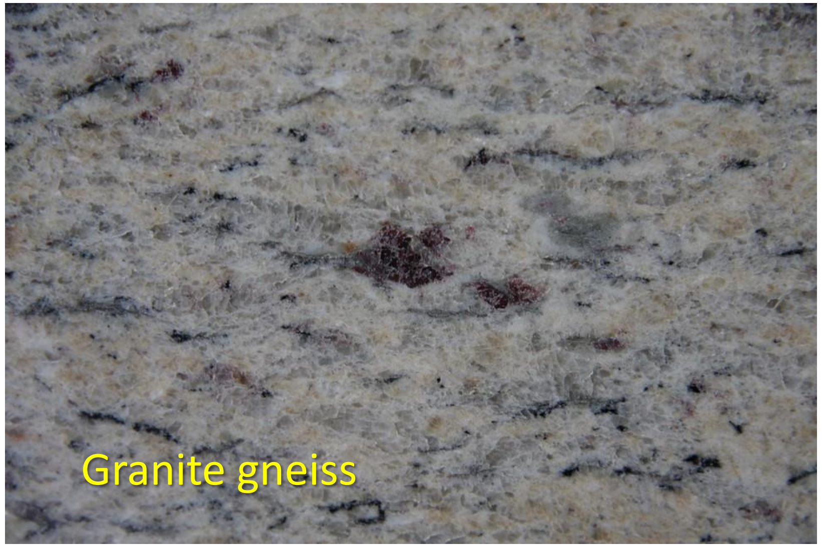

rapakivi granite

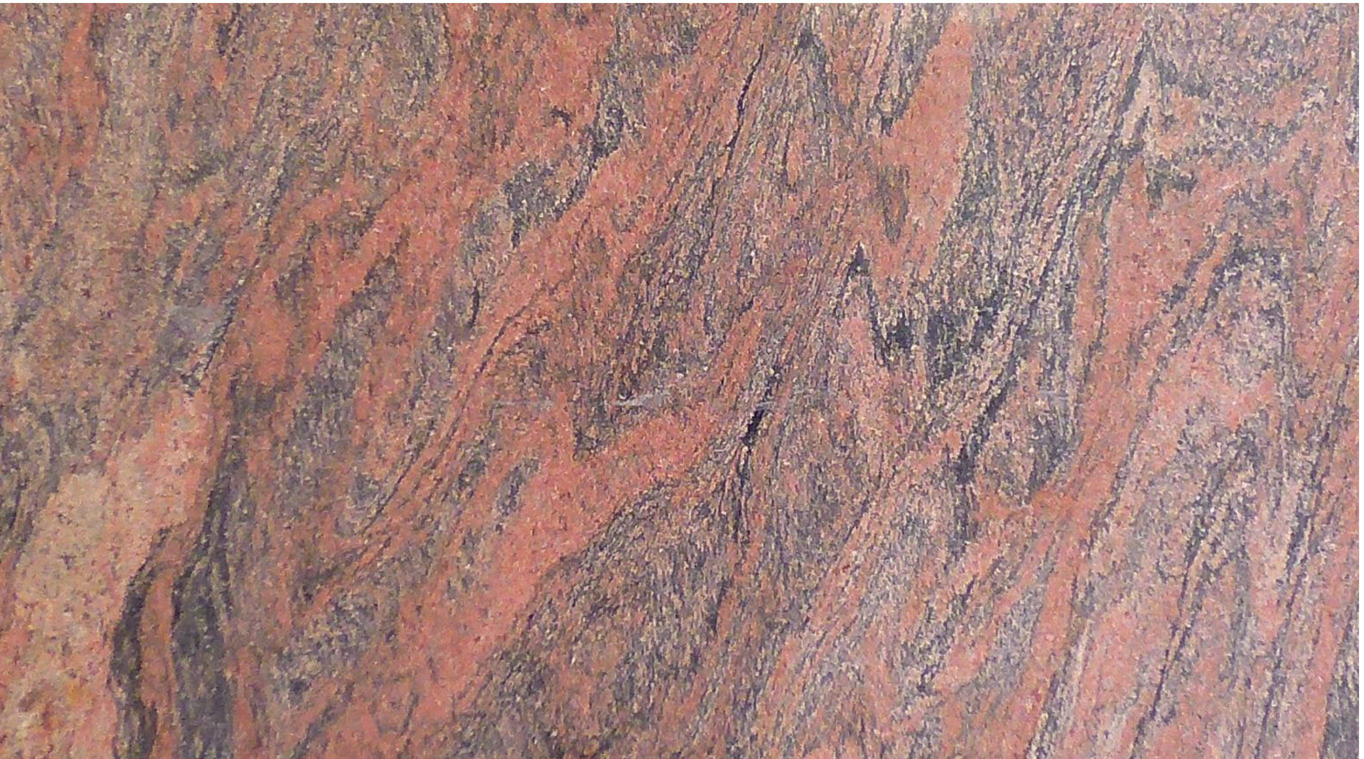

Feldspathic granite


syenite

Gneiss and metamorphic rocks



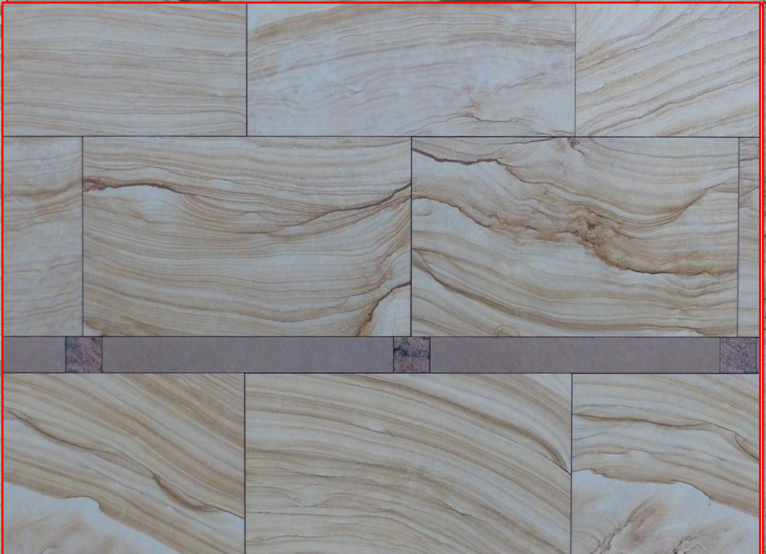


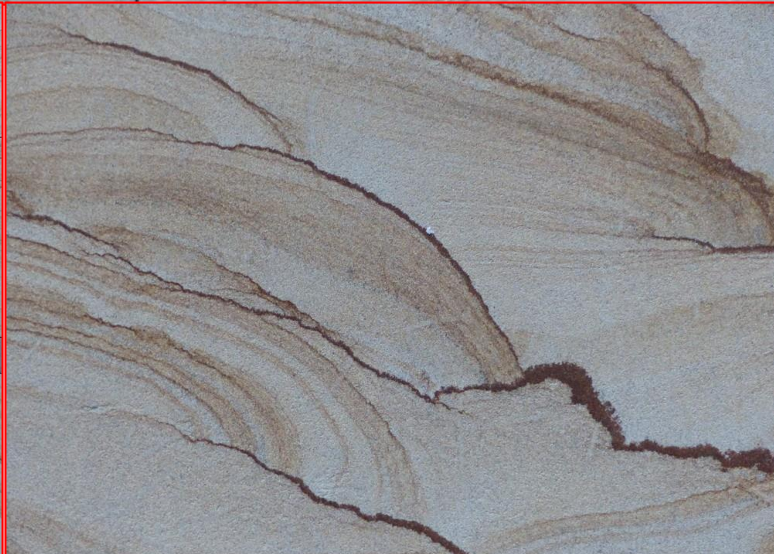


Migmatite

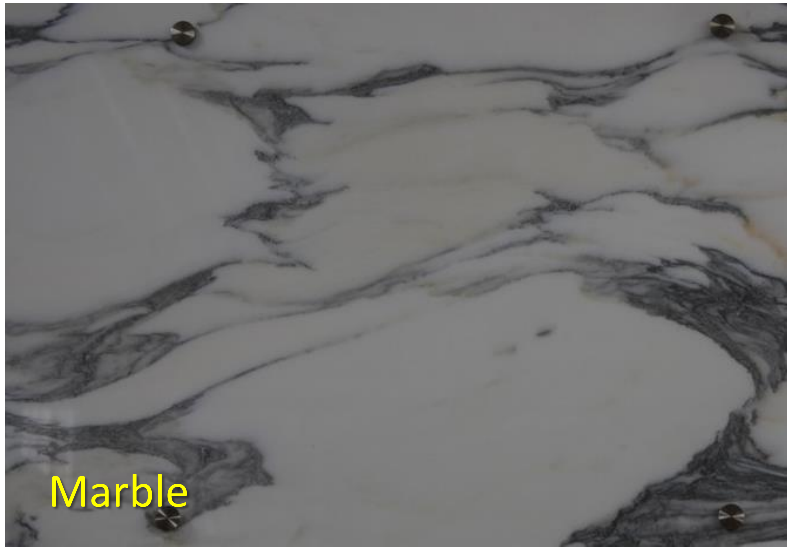
Sandstone

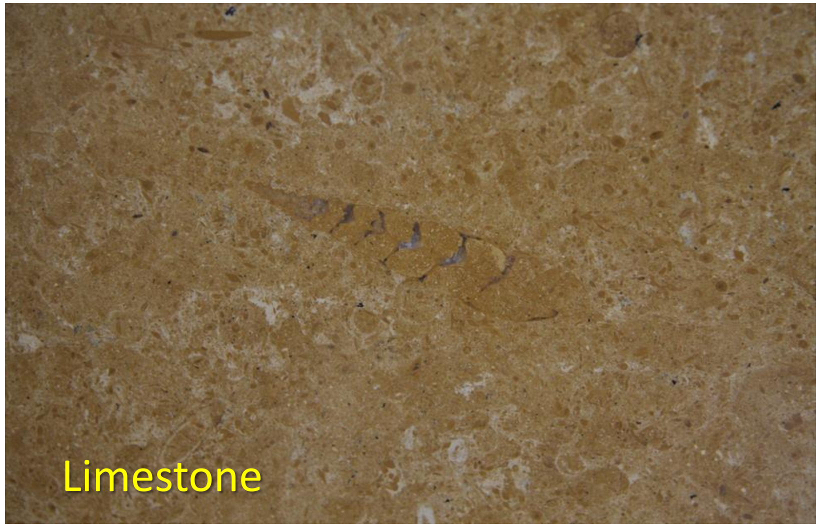
Esplanade – Theatres on the Bay



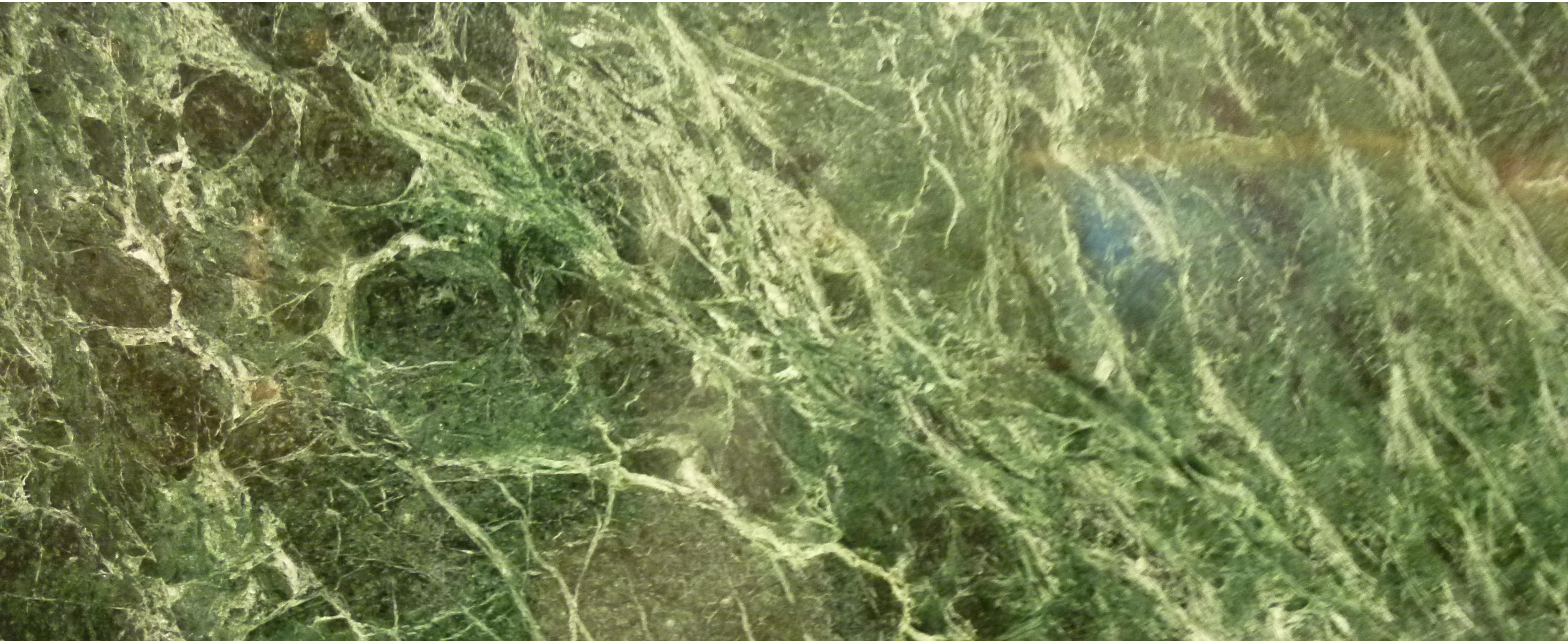


Marble and Limestones

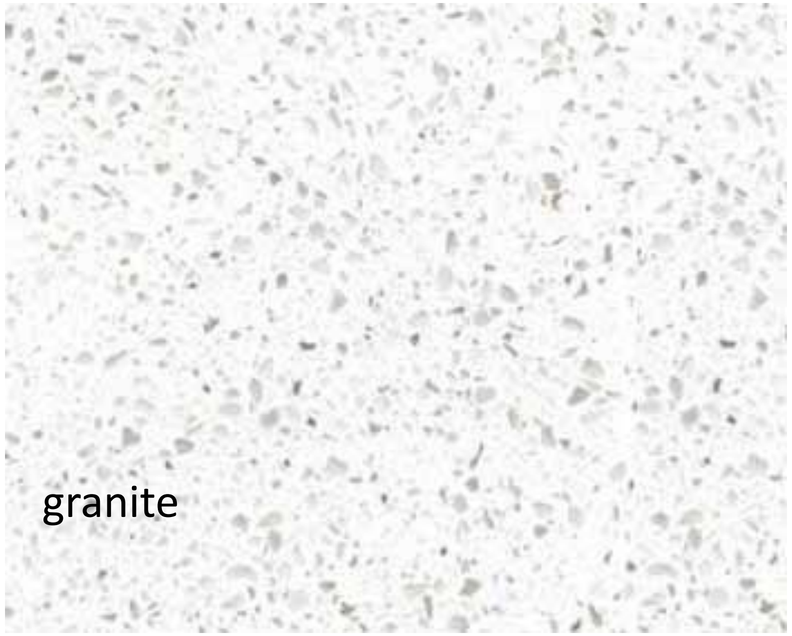


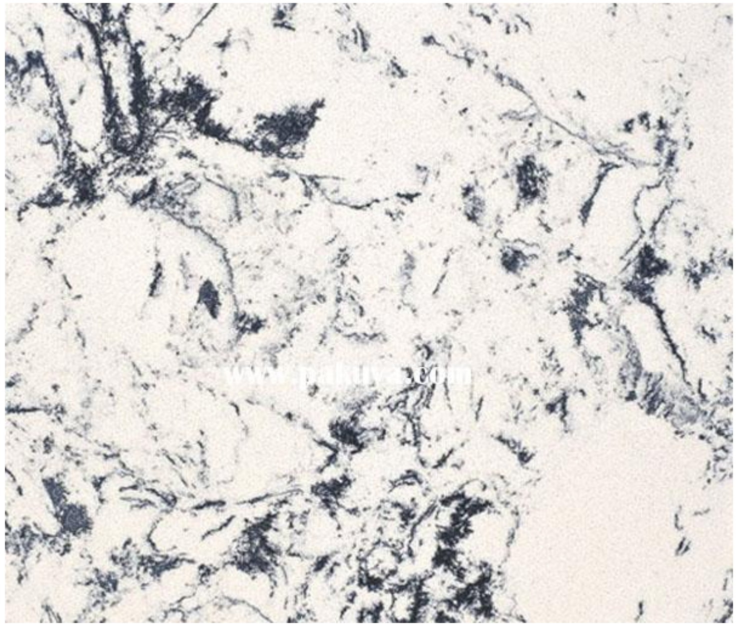


Serpentinite

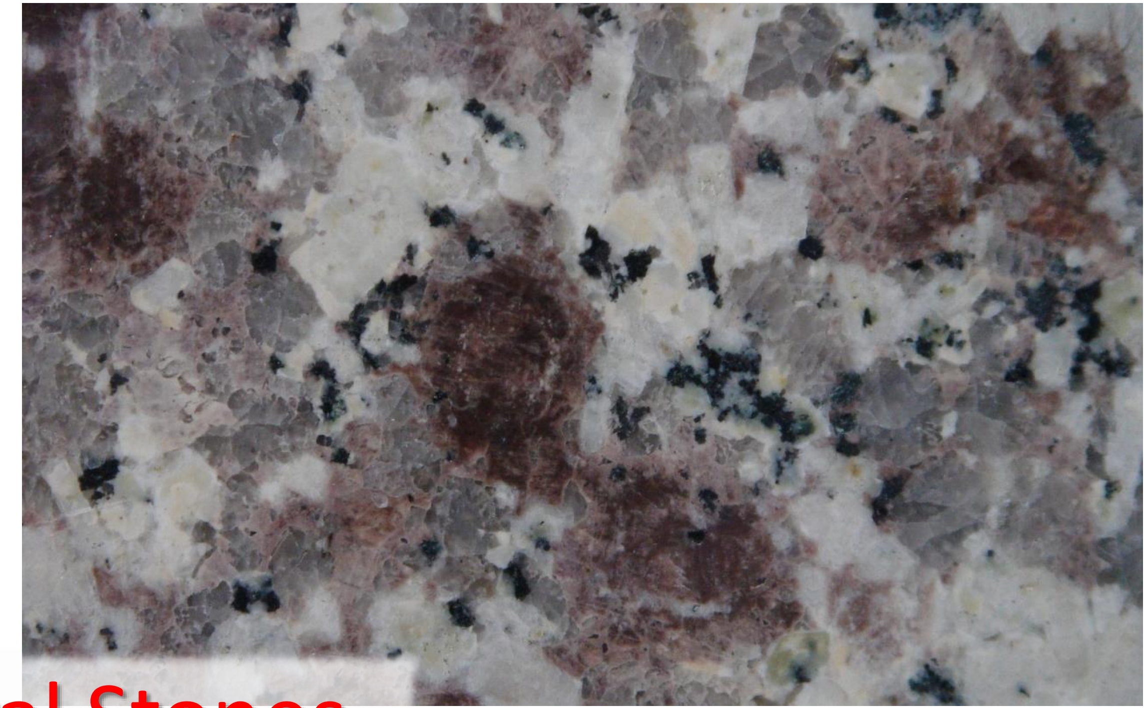


Synthetic Stones



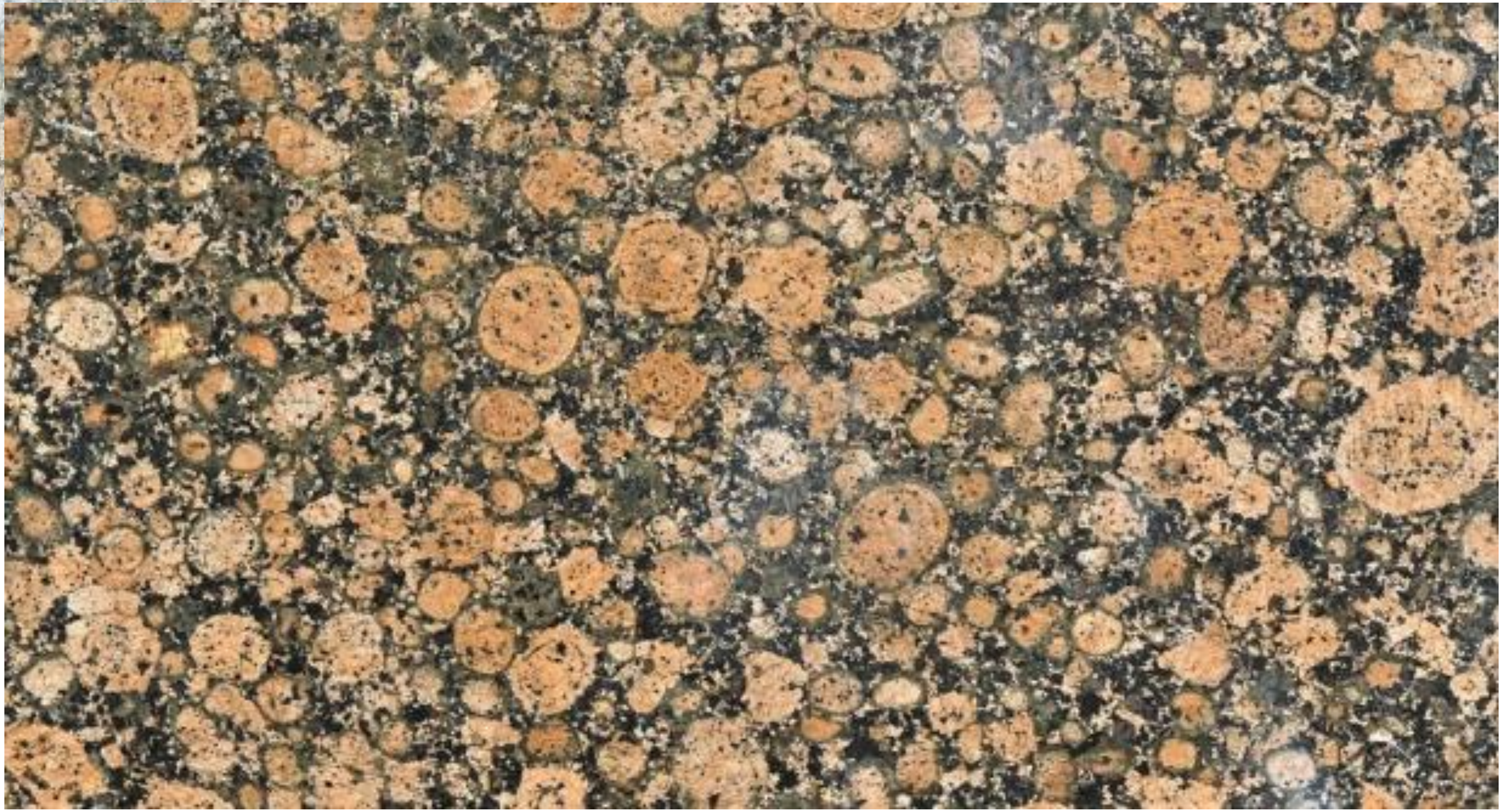


Natural Stones



Rapakivi Granite

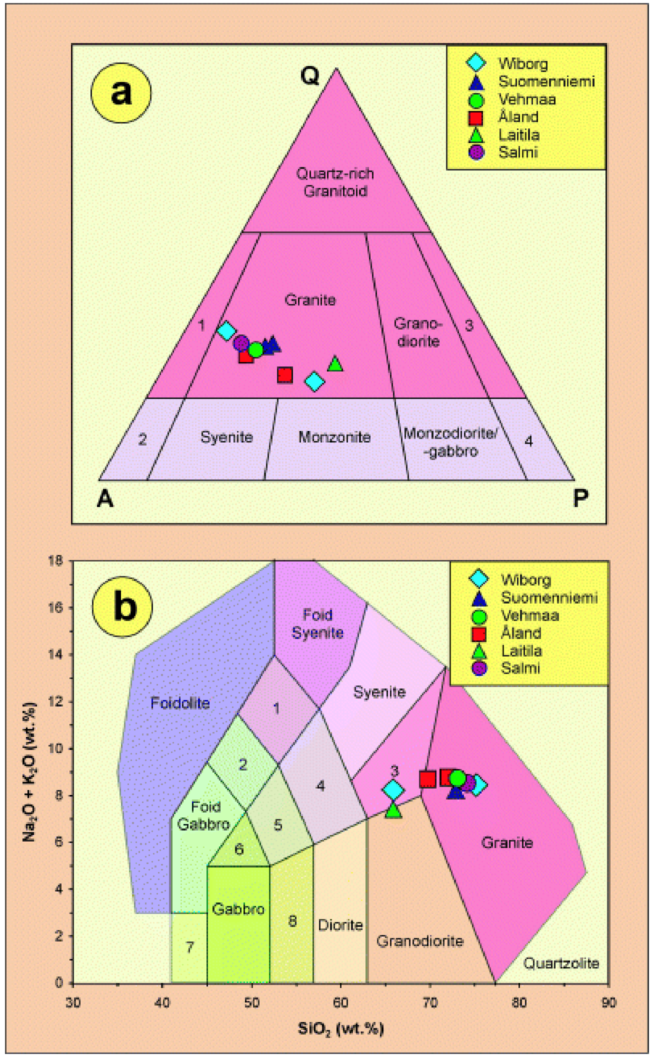
- High viscosity melt
- Crystal and melt have similar surface tension



Rapakivi granites

Characteristics

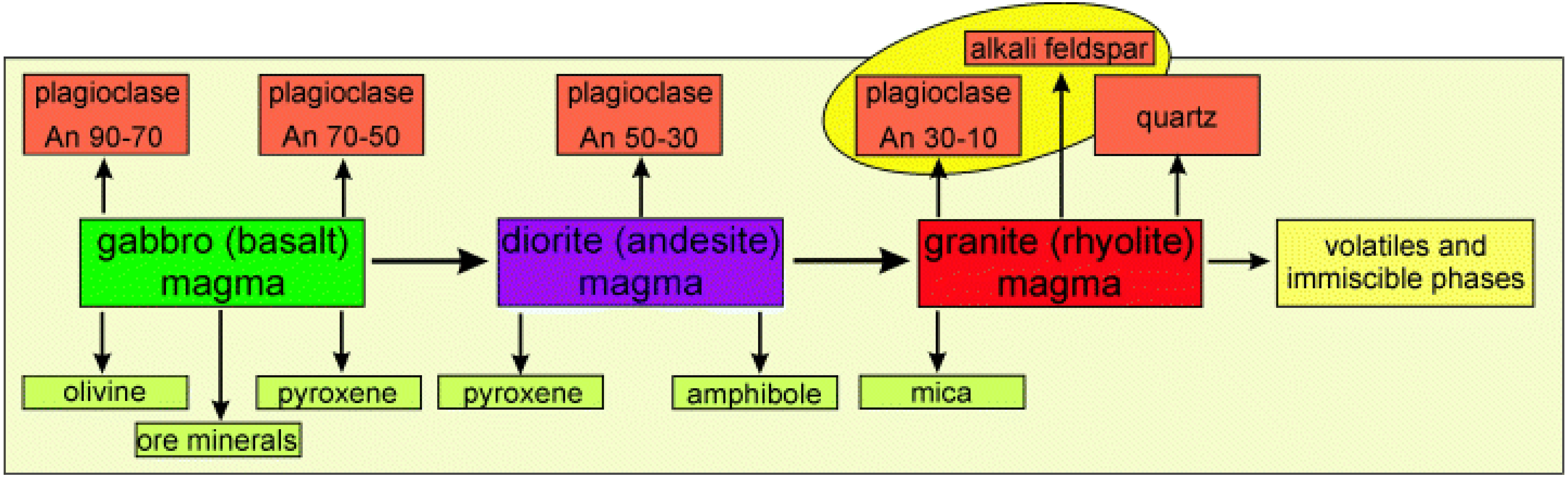
1. Geochemically A-type granite
2. Ovoids of K-feldspar
3. Plagioclase mantle of K-feldspar ovoids
4. 2 generations of feldspar and quartz crystallization



Geology Today
Volume 23, Issue 3, pages 114-120, 25 JUN 2007 DOI: 10.1111/j.1365-2451.2007.00616.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2451.2007.00616.x/full#f4

Key debates:

- Ovoid forms of feldspar crystals
- Reversed order of crystallisation

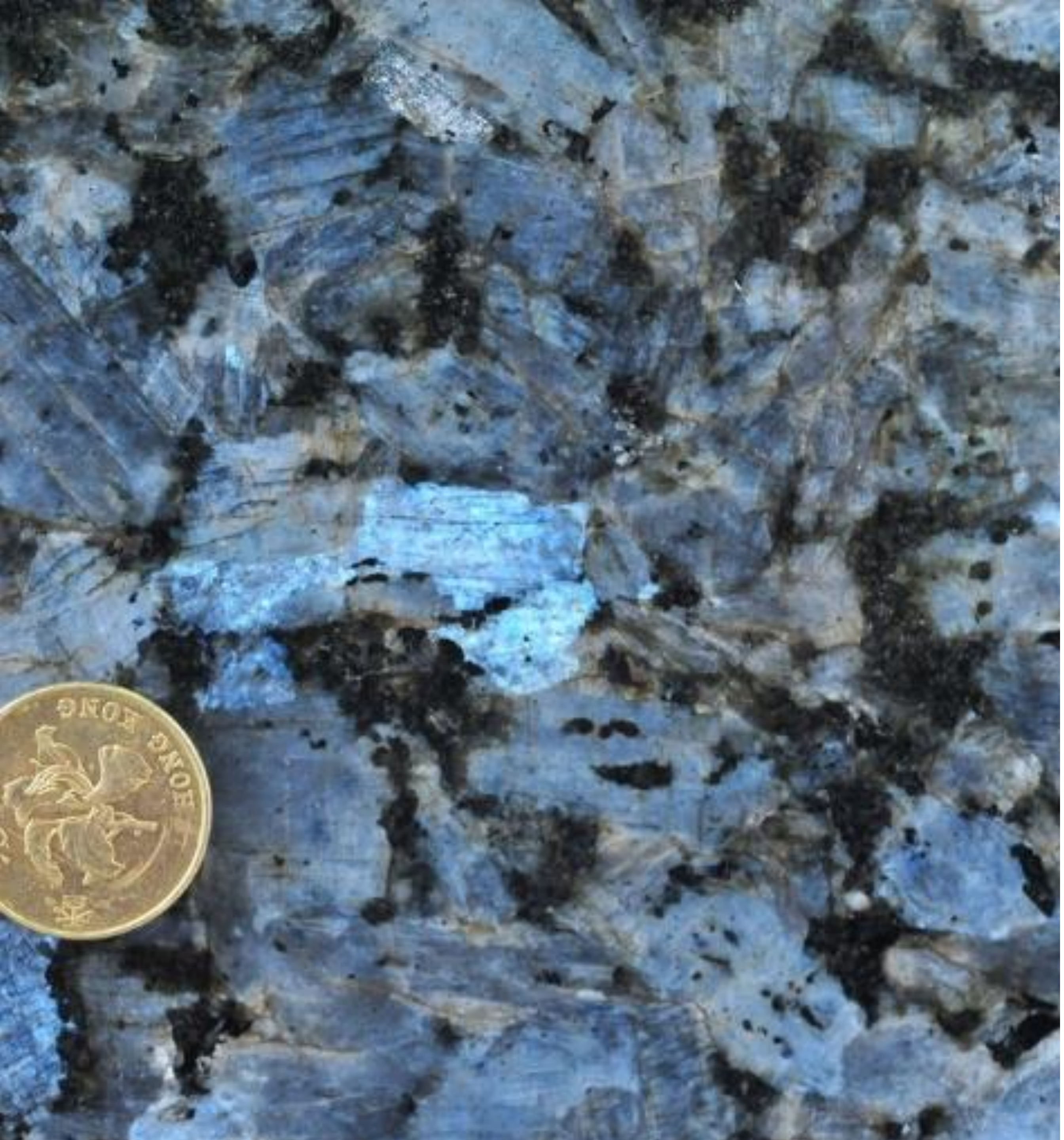


Geology Today
Volume 23, Issue 3, pages 114-120, 25 JUN 2007 DOI: 10.1111/j.1365-2451.2007.00616.x
http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2451.2007.00616.x/full#f5

What causes the abrupt change in physiochemical conditions?

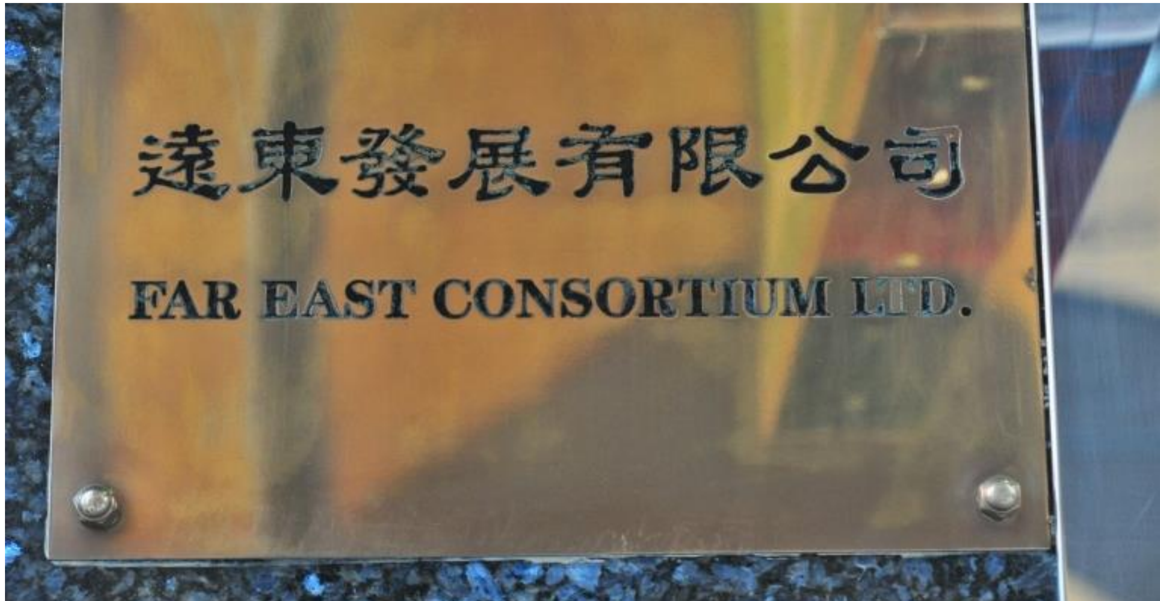
- Magma mixing
- Sudden change in pressure at constant temperature
- Uneven distribution of melt composition

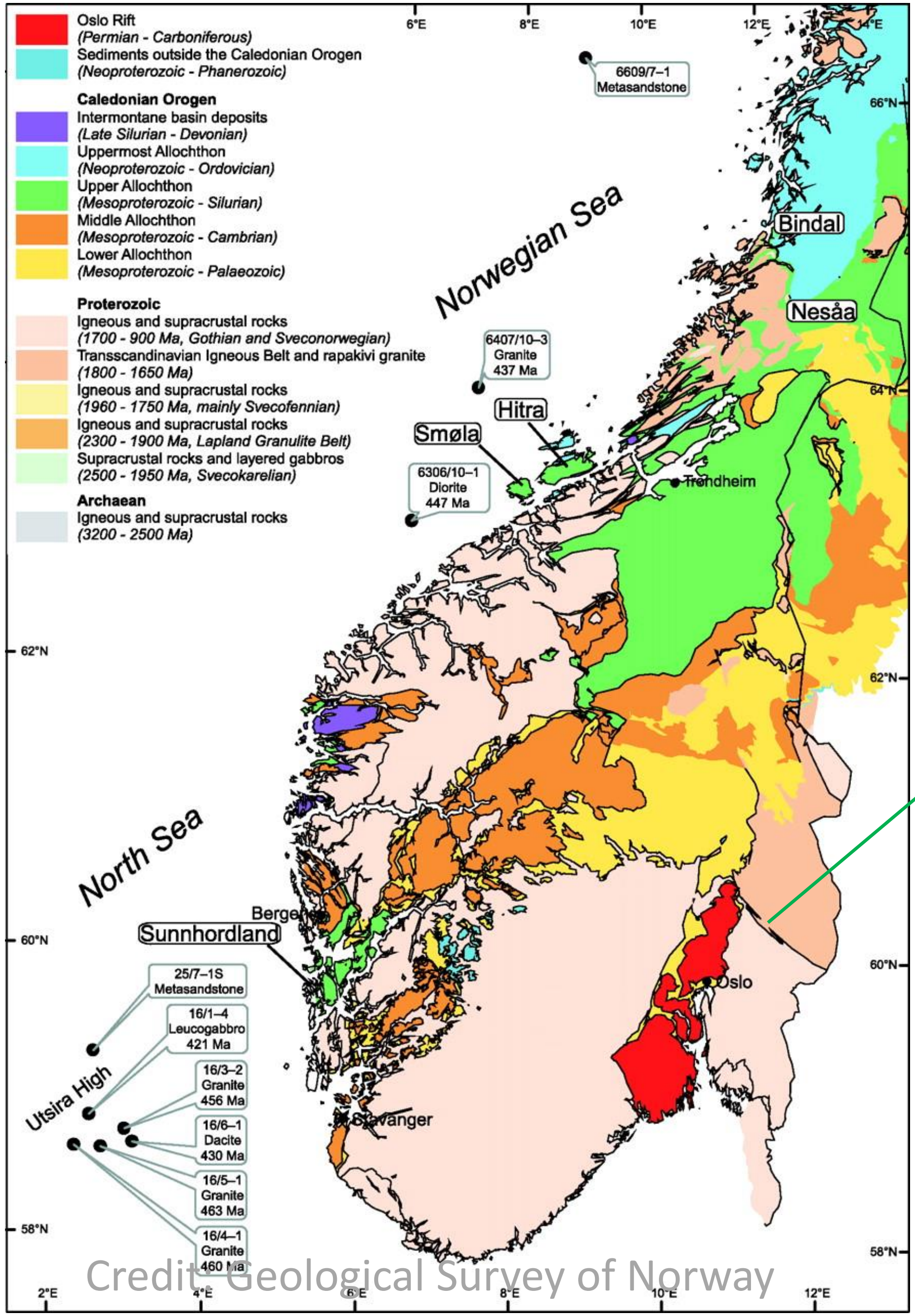
Issue is still debated.



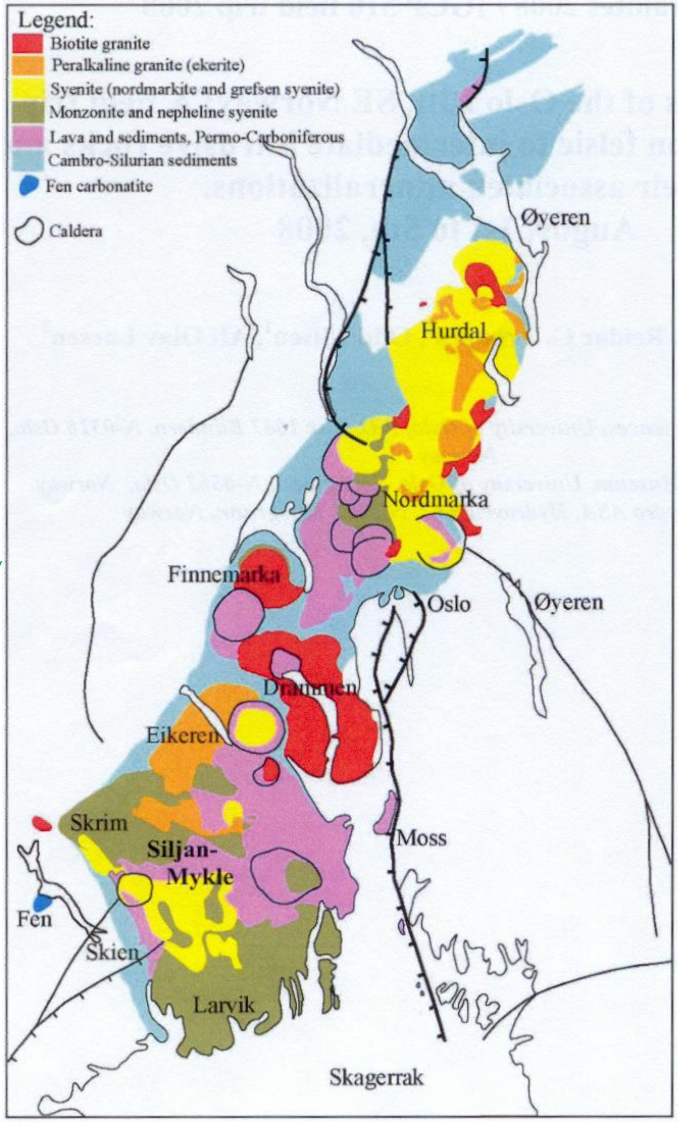
Larvikite

- A variety of monzonite
- Perthitic feldspar (tenary feldspar; not simply labradorite)
- Schiller effect (result of light being dispersed along the plagioclase and K-feldspar crystal boundaries)
- Formed in Oslo Rift, Norway, an Igneous complex in lower crust





Credit: Geological Survey of Norway



Credit: J. Geological Society

Oslo Rift, Norway

Permain age gabben system with lower crust igneous complex

Exsolution of K-feldspar and Anorthite

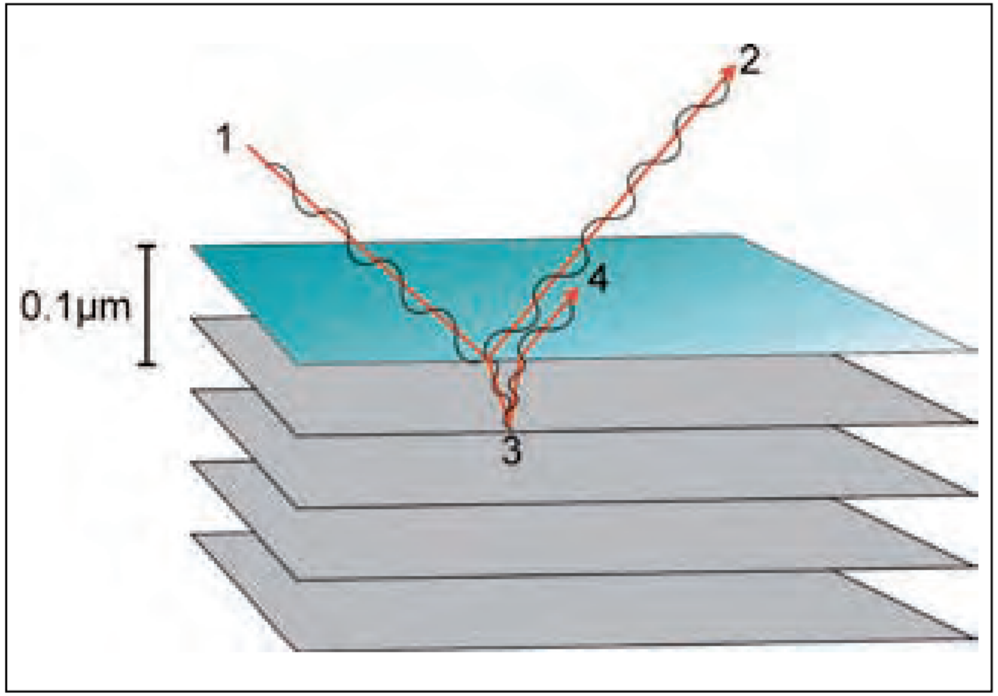


Figure 5. Principle of how iridescence forms in a media, such as feldspar crystals. The reflected light beam (1–2) and the refracted beam (1–3–4) reinforce each other because their phase difference is an integral number of wavelengths. Other wave-lengths present in a beam incident at this angle will interfere, resulting in the optical interference colours.

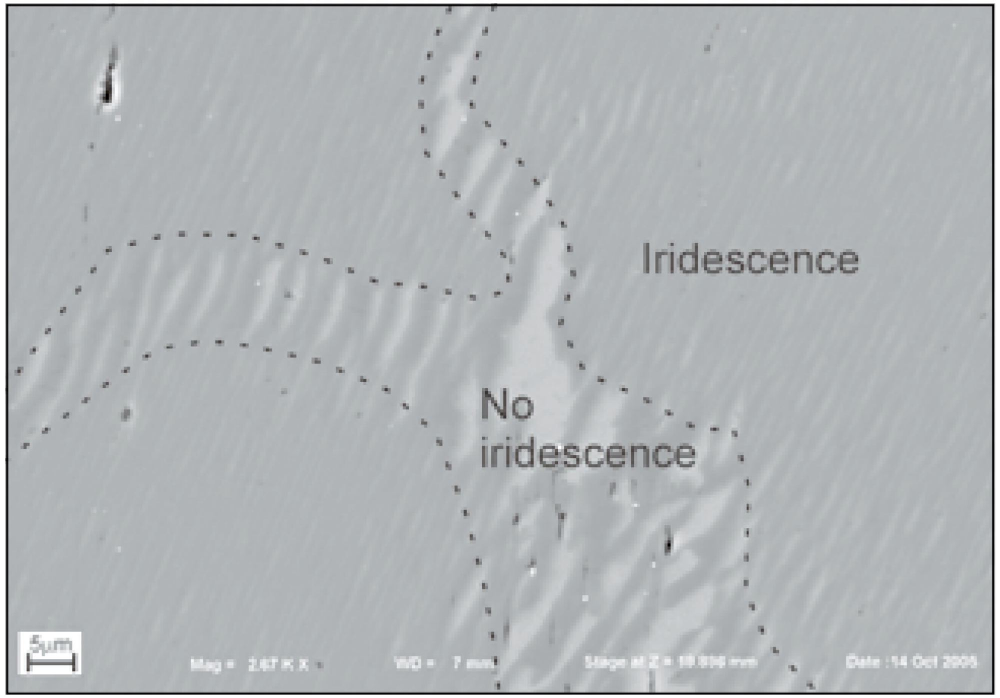
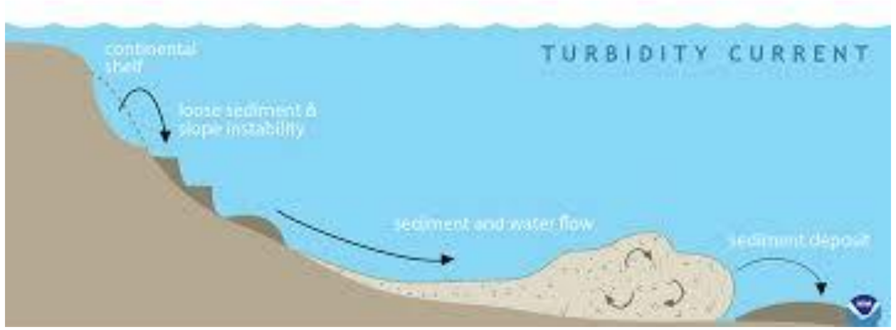


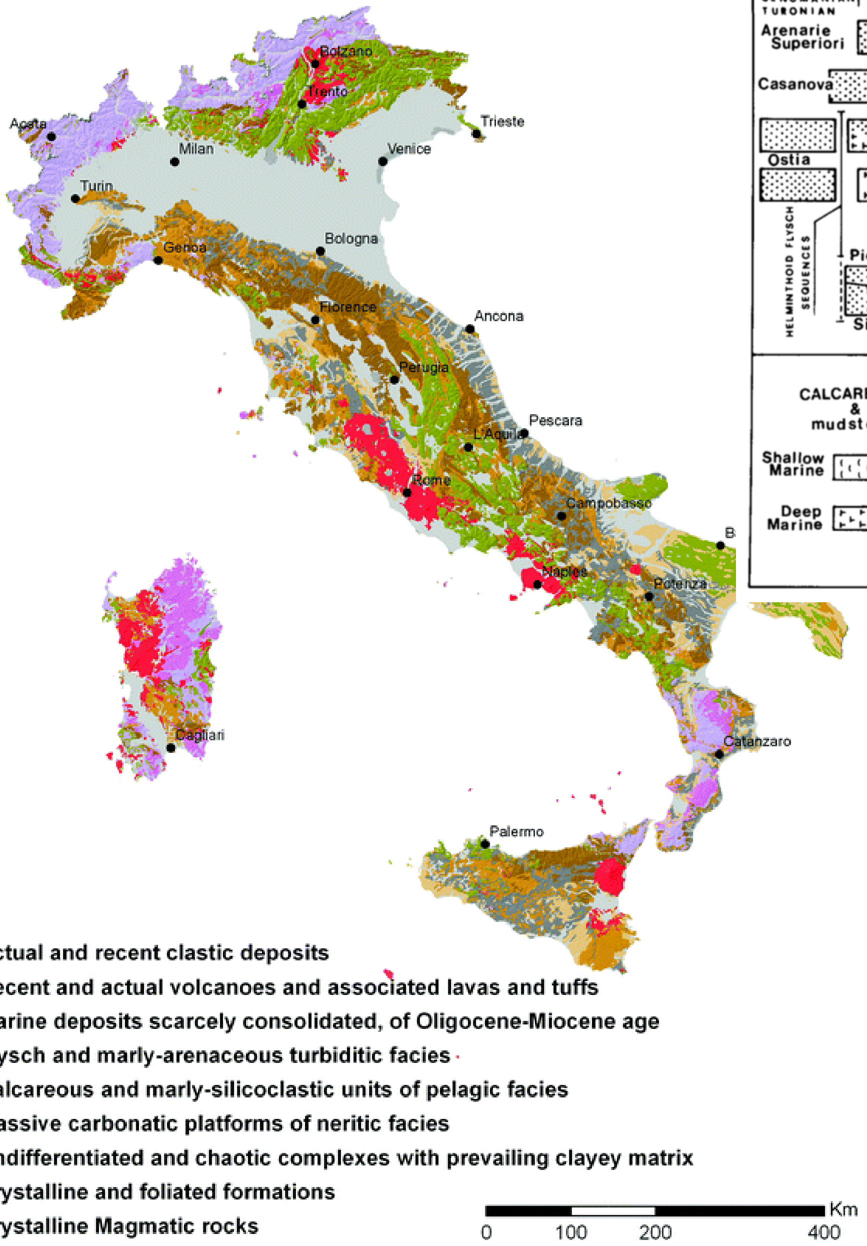
Figure 6. Scanning electron microscope photo of exsolution lamellae in larvikite. Iridescence occurs when the spacing of the lamellae is from 500 to 1000 Å (marginal parts of the photo).

Credit: Geological Survey of Norway

The feldspar is ternary with compositions in the range An (4–30%), Ab (58–82%), Or (3–35 %) (Barth 1945)

Macigno Group, Tuscany





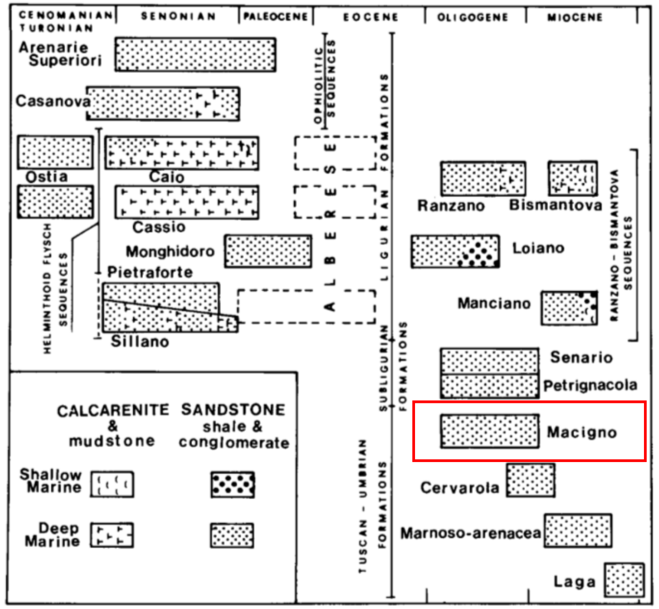
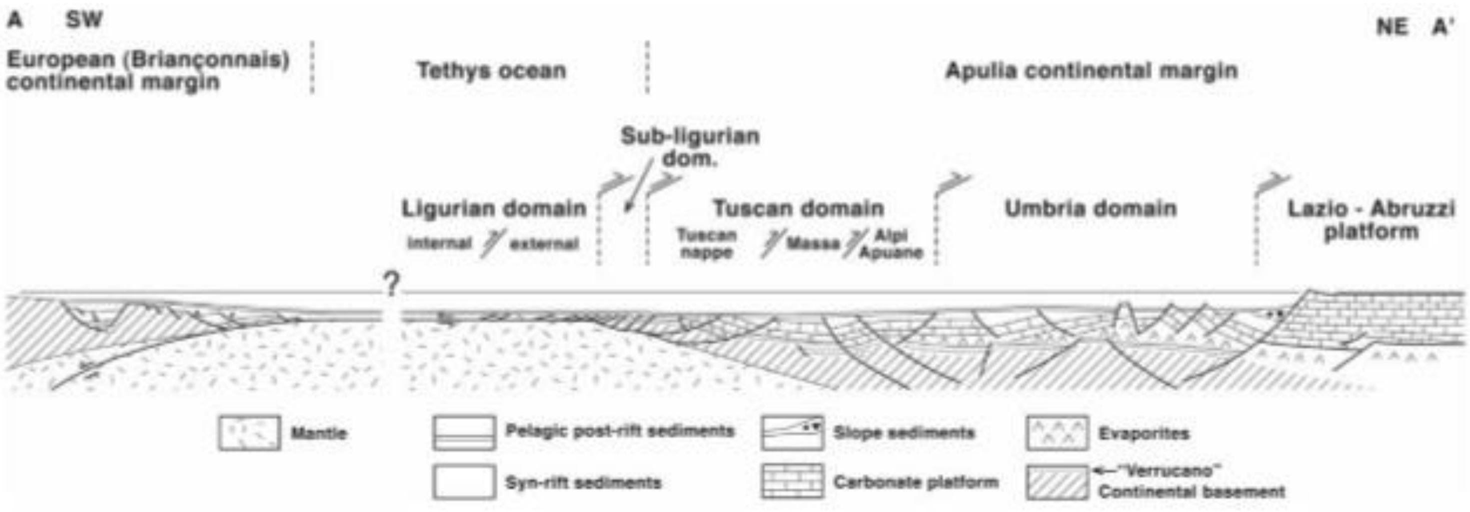
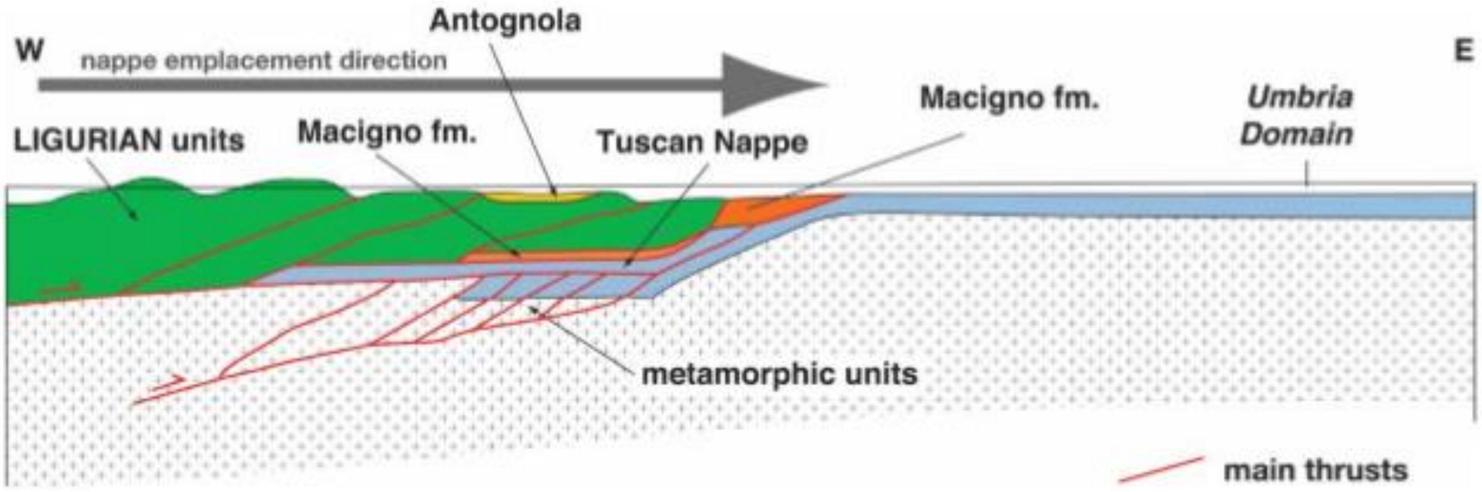


Figure 2. Principal arenaceous formations deposited during the Alpine orogenesis in the northern Apennines schematically displayed, with horizontal axis approximating stratigraphic position and longitudinal axis approximating paleogeographic position (modified from Sestini, 1970).

Macigno Group

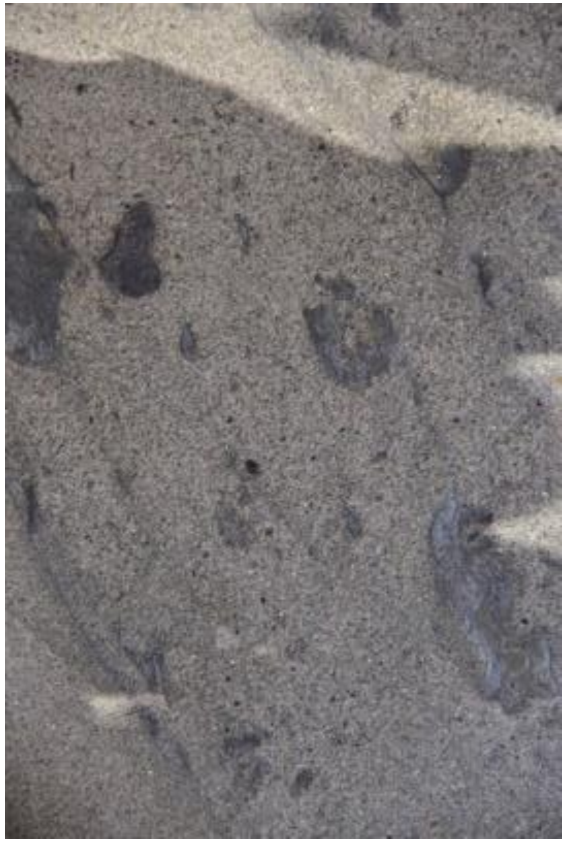


Palinspastic section of Tethys



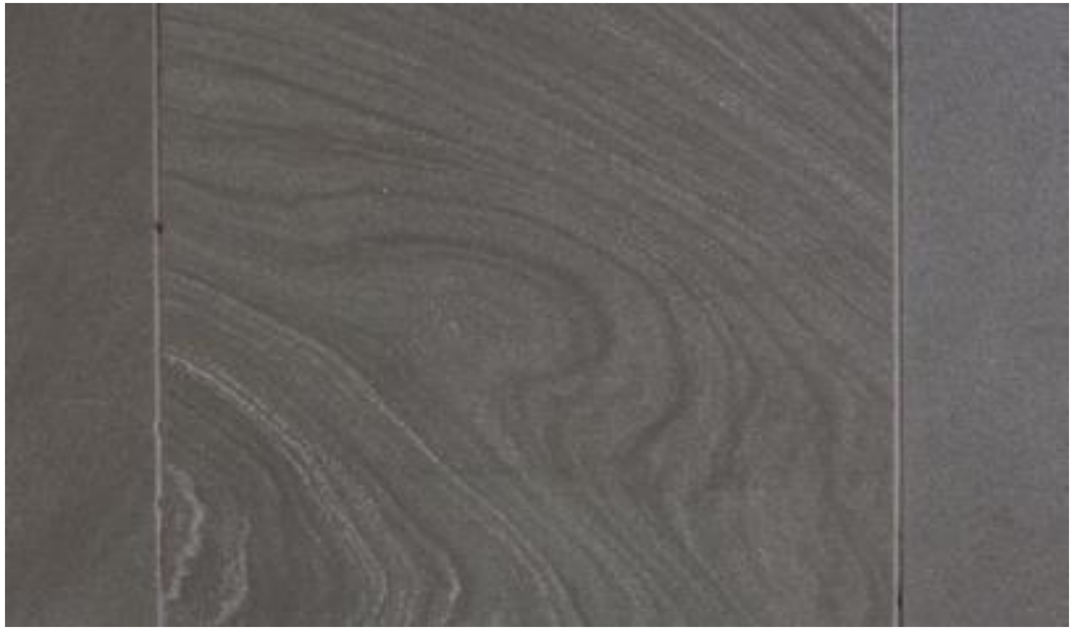
Northern Apennines during Miocene

Conti and Cornamusini, 2013

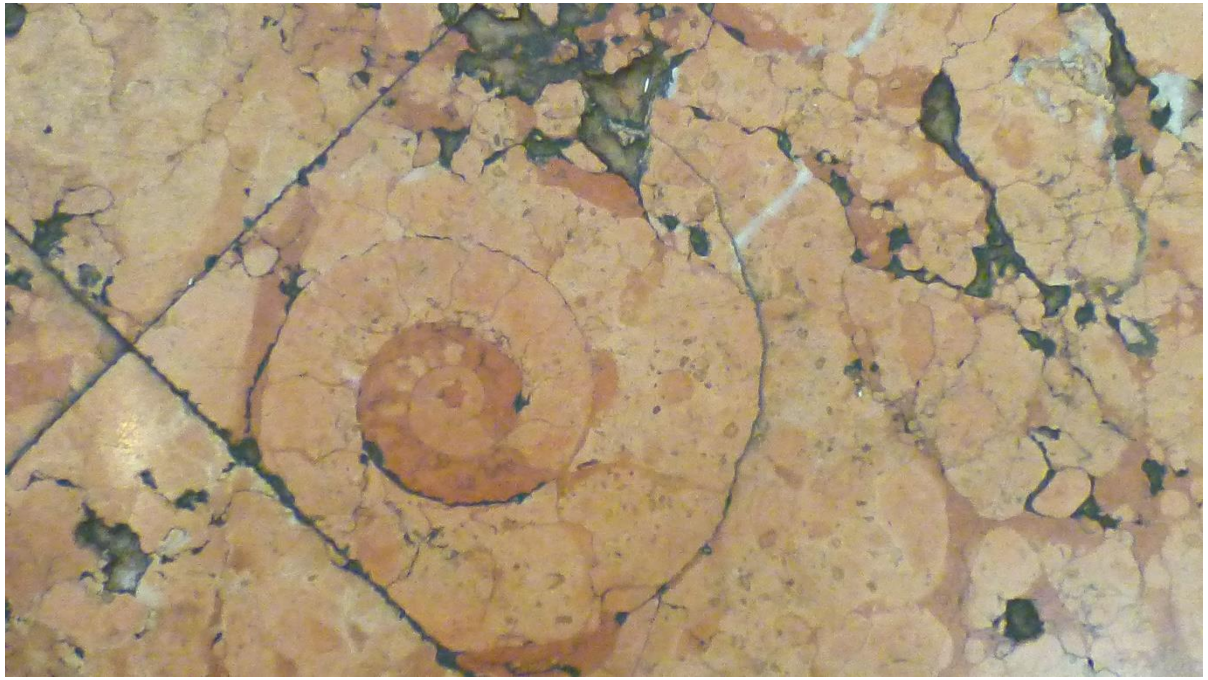


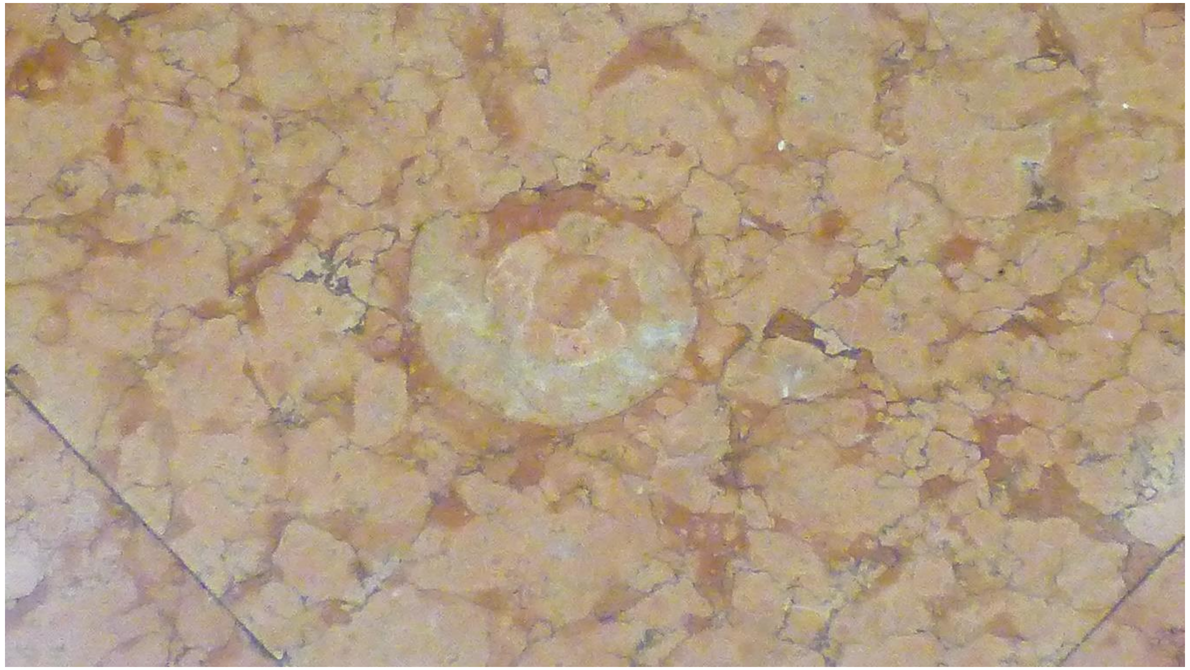
Turbiditic sandstone in Pacific Place

- Graywacke; lithic sandstone
- High density currents

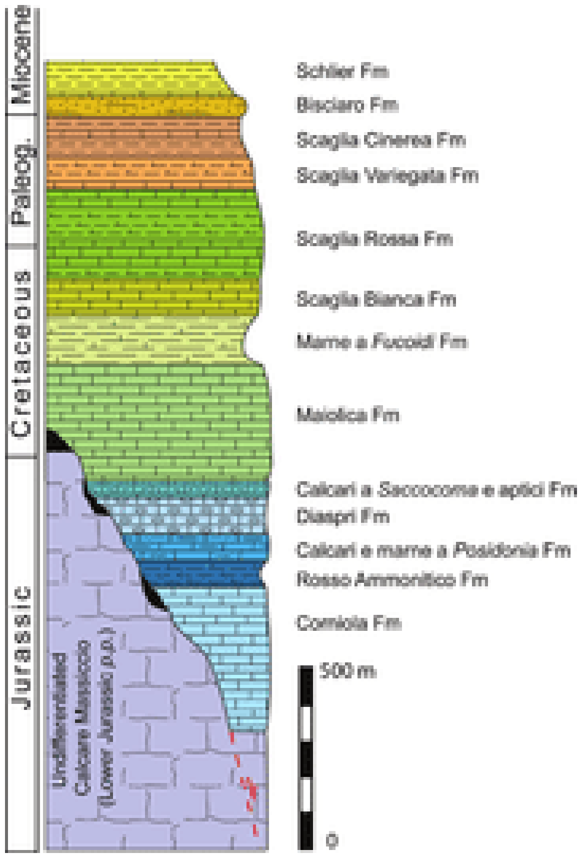


Limestone with fossils
Rosso Ammonitico
HKU Senior Common Room





Rosso Ammonitico



Credits: Images from open websites

Production of Stone Claddings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HELIX


SHENG DA

Common properties of concern

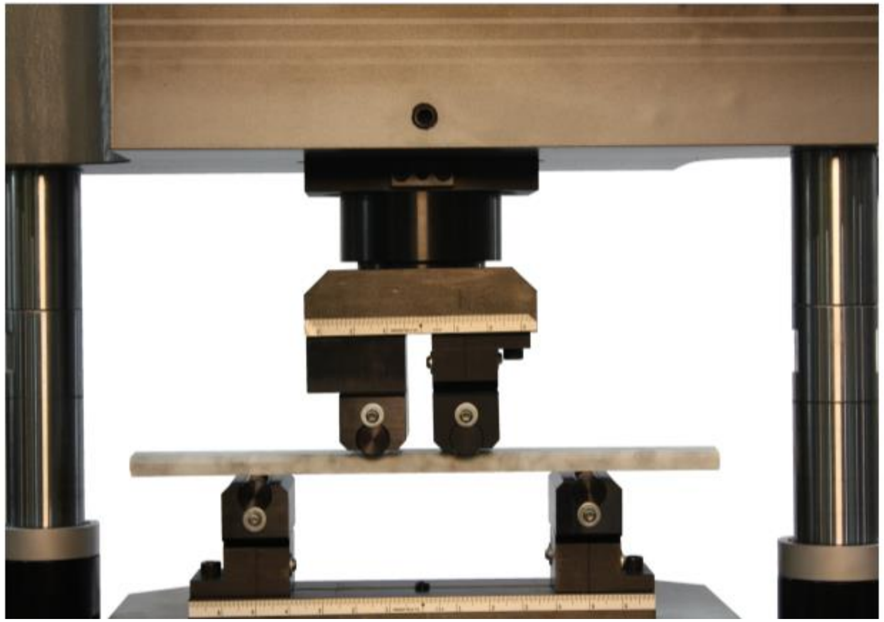
- Water absorption
- Abrasion resistance
- Compressive strength
- Acid sensitivity
- Specific gravity
- Flexural strength

Stone	Abrasion Resistance	Water Absorption	Acid Sensitivity	Flexural Strength
Granite	High	Low	Low	High
Limestone	Low	Moderate-High	High	Medium
Marble	Low	Moderate	Moderate-High	Medium-High
Sandstone	Medium	Moderate-High	Low	Low-medium
Basalt	High	Low-Moderate	Low	High
Slate	High	Low	Low	High

Strength Tests (BD APP-16)

Flexural strength

- Characteristic strength = Average strength – K × σ; (K = 3.41)
- Characteristic flexural strength > 3 x design allowable flexural strength x Flexural Safety Factor
- FSF: Granite = 4.5; Limestone =7.2; Marble = 6.3



Ageing tests for limestone

- 50 thermal cycles + 50 dry/wet cycles

Stone Type	Typical Flexural Strength Range (MPa)
Granite	30 - 6
Marble	22 - 6
Sandstone	15 - 3
Limestone	21 - 2
Slate	50 - 15

Geological properties

- Mineralogy and composition
- Cracks
- Microfissures and cleavages
- Clay seams and clay contents
- Porosity
- Chemical composition and acid sensitivity
- Iron content
- Expansivity

Problems

- Cracks
- Seams
- Spalling
- Decoloration
- Efflorescence
- Tenting

Spalling, Joint widening, Marly layers

Buckling and Tenting

- Differential swelling
- Shrinkage of substrate

Causes of disintegration

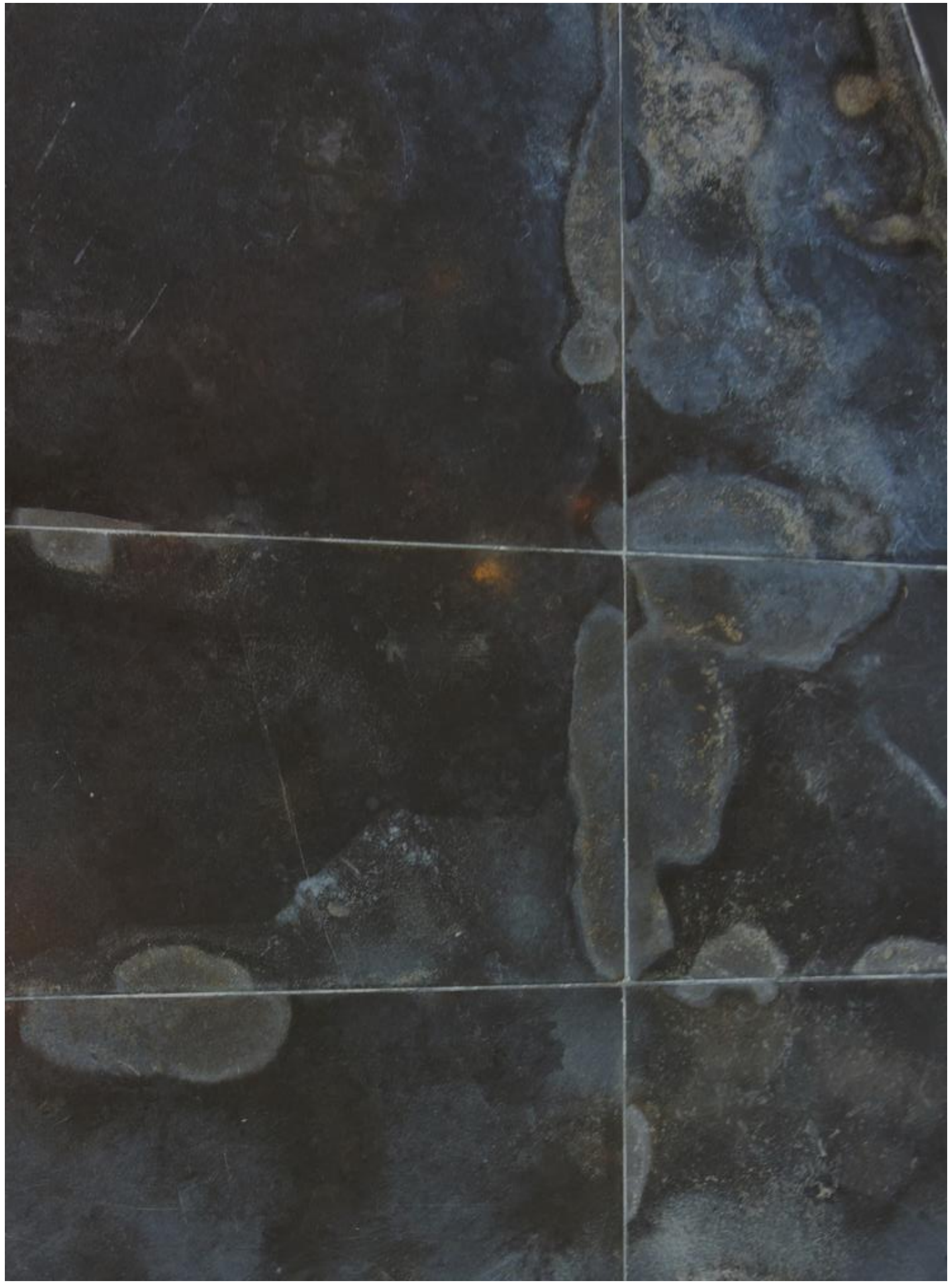
- Anisotropic properties of calcite
- Dissolution of cement

Acid sensitivity

Adverse cracks

Efflorescence

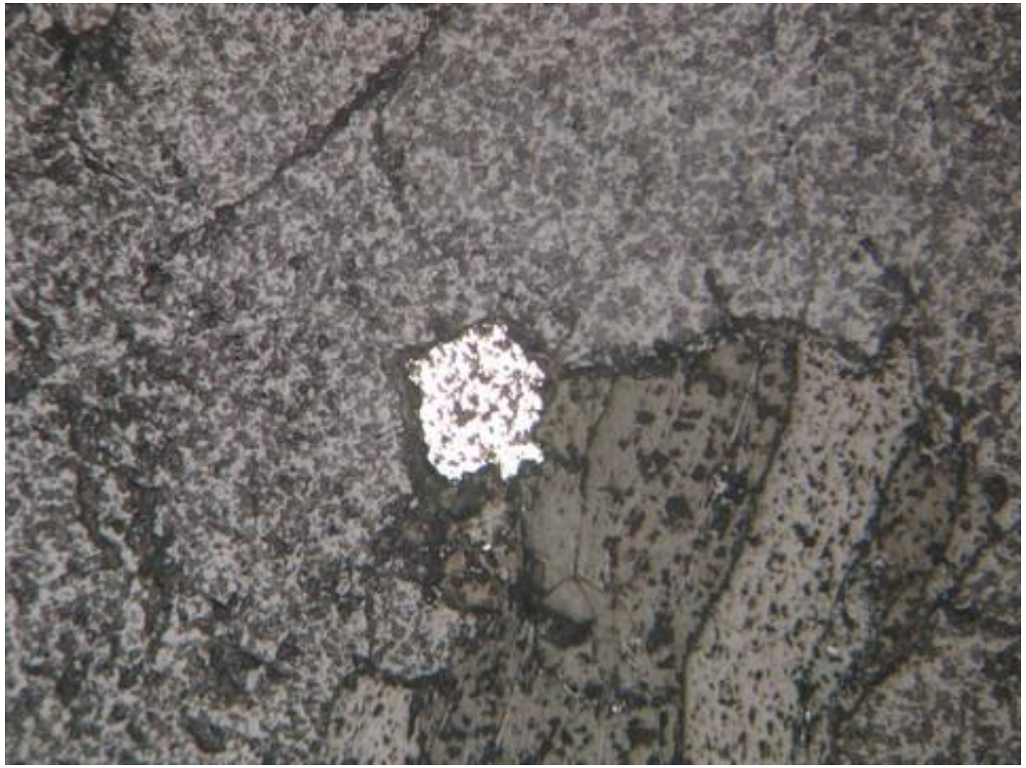
- Salt deposit originated from grout, mortar, material
- Alkalis, Ca- Na- and K- hydroxides or sulfates
- Reaction with air to produce carbonates

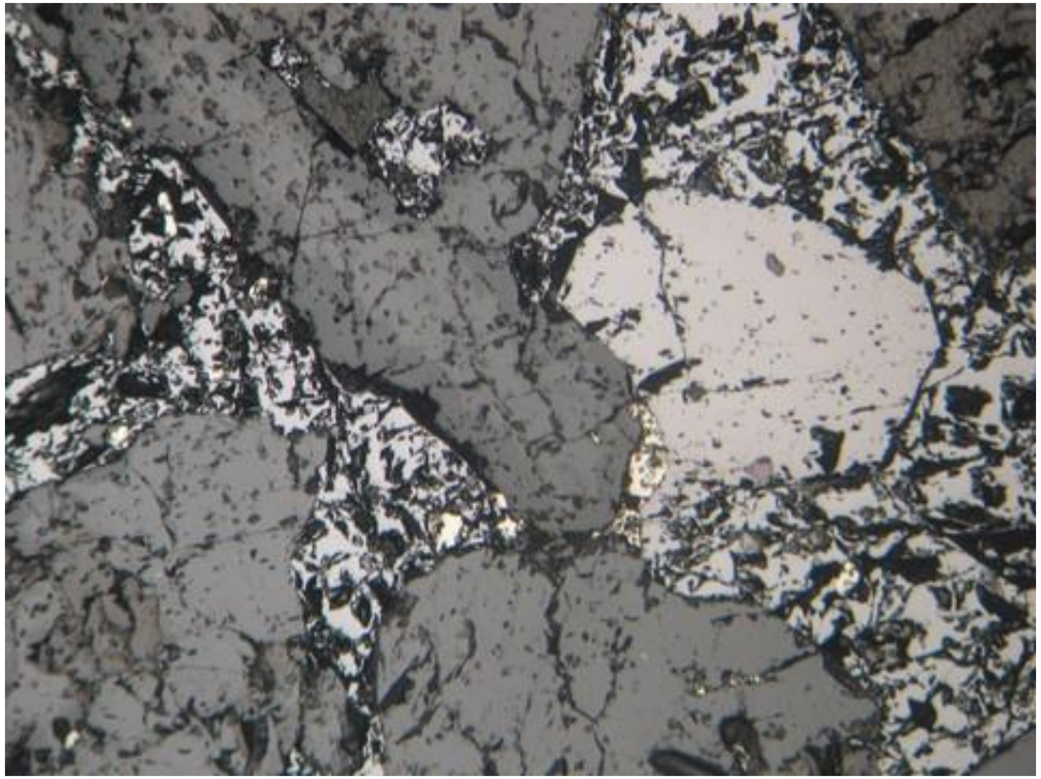


How may geological investigation help?

- Structural studies for cracks and fissures
- Clay seams
- Geochemical analysis (XRF)
- Thin section analysis
- Chemistry experiments

Reflection microscopy





XRF Results quantitative. MG: Mystic Grey LAL: Lanhelin

Sample name	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	MnO (%)	MgO (%)	CaO (%)	Na2O (%)	K2O (%)	P2O5 (%)	LOI (%)	TOTAL (%)
MG	46.24	1.60	24.48	7.79	0.09	3.10	12.30	2.47	0.75	0.20	0.23	99.26
LA	70.25	0.52	14.81	3.35	0.04	0.91	1.70	3.37	4.34	0.18	0.37	99.84
Standard - Dry Base												
BCR-2	53.759	2.361	13.374	13.772	0.157	3.535	7.092	3.484	1.849	0.348		99.73
BCR-2	54.1	2.26	13.5	13.8	0.196	3.59	7.12	3.16	1.79	0.35		
JG-1A	73.05	0.209	14.31	2.004	0.056	0.697	2.177	3.154	3.975	0.083		99.715
JG-1	72.3	0.26	14.24	2.18	0.063	0.74	2.2	3.38	3.98	0.099		
GSR-16	50.415	3.316	13.278	13.774	0.19	5.121	8.005	3.303	1.563	0.556		99.521
GSR-16	49.88	2.94	13.21	13.4	0.21	5.08	7.83	3.17	1.49	0.55		

Examination of Cladding Panels

- Rock type and origin
- Stone condition
- Susceptibility to weather elements
- Cracks and microfissures
- Crack orientation
- Aperture
- Seepage condition
- Clay filling
- Grouting and mortar condition

Geologist has a role to play:

Facade Stone Geology

Thank You!

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