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GEOLOGY OF PYRITE and CONSTRUCTION MATERIALS

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4th December 2013

GEOLOGY of PYRITE and CONSTRUCTION MATERIALS - A ROUGH PLAN

- What is reactive pyrite?
- When is pyrite reactive and when is it not?
- How does pyrite cause heave?
- What rock types are likely to host reactive pyrite?
- What other factors are important?

PYRITE DISTRIBUTION AND FORMATION

- Pyrite is an exceptionally common and widely distributed sulphide mineral
- Other sulphide minerals (e.g. marcasite, pyrrhotite, chalcopyrite, arsenopyrite, sphalerite, galena etc.) are also widely distributed in Ireland but are less common (although locally very abundant)
- Iron sulphides originally form in rocks due to
  - Sulphidation of iron in low-oxygen reducing depositional environments by sulphogenic bacteria ($Fe + H_2S \rightarrow FeS_2$)
  - Crystallisation from magmas in volcanic settings
  - Growth during metamorphic re-crystallisation
  - Introduction into pre-existing rock by hydrothermal fluids
  - Deposition of detrital pyrite in sediments

PYRITE IN IRISH ROCKS

- Pyrite is present in significant quantities in a range of Irish rock environments:
  - Very dark grey to black calcareous shales and mudstones - e.g. Viséan shales and mudstones (esp. Upper Viséan), Namurian shales and mudstones, Lr. Palaeozoic black shales etc.
  - May be locally present within dark grey to black limestones (e.g. “Calp”) - although many of these limestones have low pyrite or may be considered almost pyrite free
  - A number of metamorphic lithologies
  - Some volcanic rocks, e.g. Avoca Volcanic Formation, some Granitoids in Western Ireland
- **The vast majority of limestones, sandstones, gritstones, slates, granites, andesites, dolerites, volcanic rocks and many metamorphic rocks have very low or almost absent quantities of pyrite – as have sands and gravels**

WHAT IS REACTIVE PYRITE?

- Pyrite is one form of iron sulphide (FeS_2).

- It is a naturally occurring, common and widespread mineral found in many (most) rock types

- **Sulphide minerals may render rock a deleterious construction material if:**
  - **Rock is weak, non-durable and/or foliated (mudstones, siltstones, shales, part argillaceous lithologies)**
  - **Sulphides are present in sufficient quantities**
  - **Sulphides are reactive**
  - **Sulphides are exposed to water and air (oxygen)**

WHAT IS REACTIVE PYRITE?

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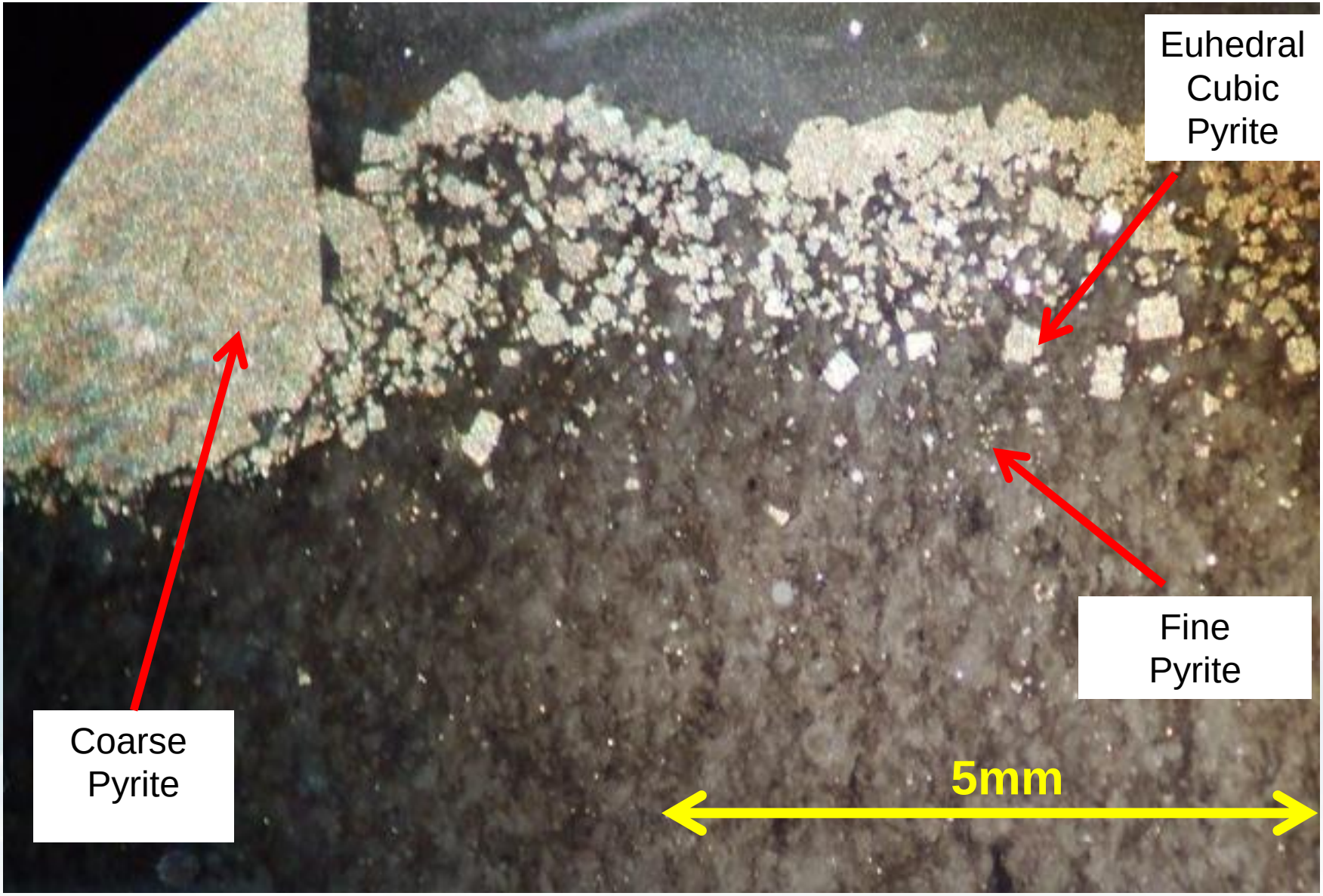
Euhedral
Cubic
Pyrite
Coarse
Pyrite
Fine
Pyrite
5mm

WHAT IS REACTIVE PYRITE?

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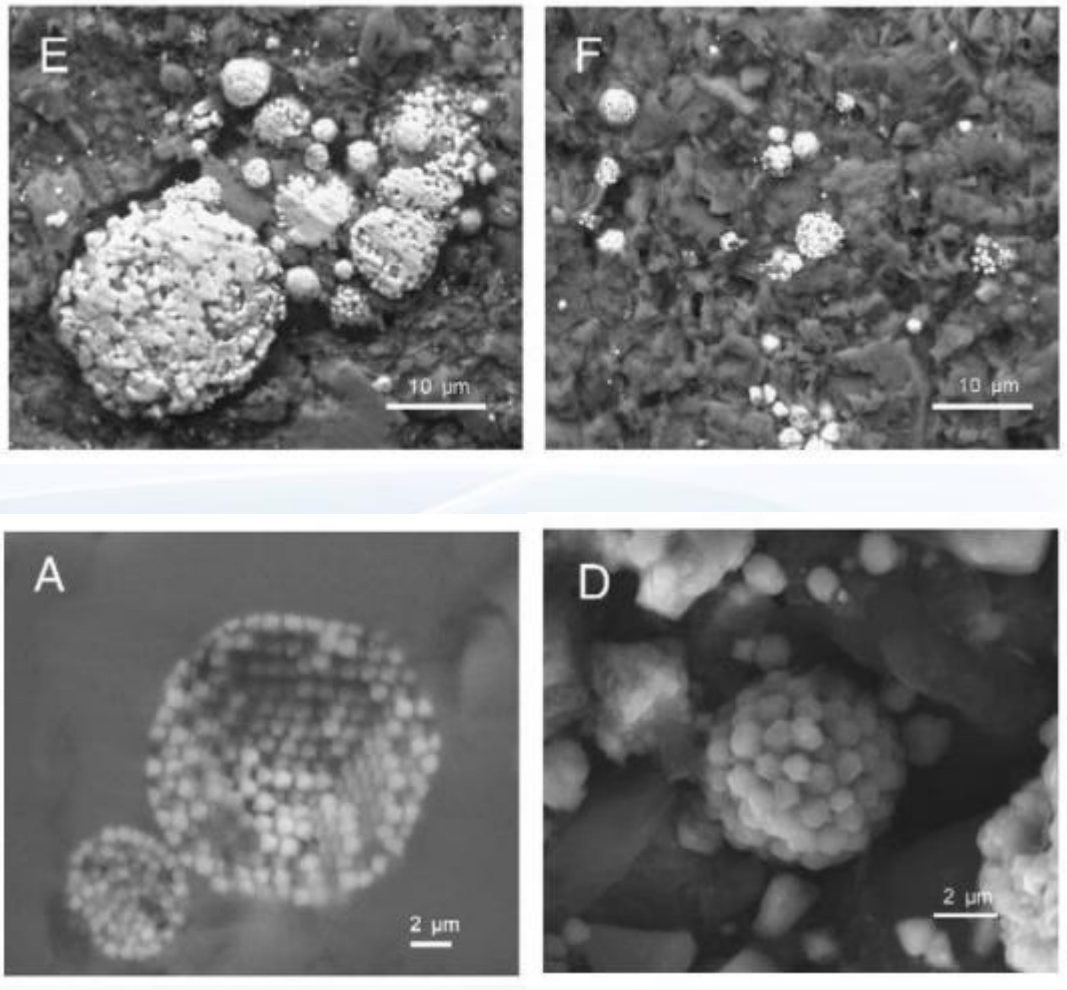


PYRITE OXIDATION REACTION

$$2FeS_2 + 2H_2O + 7O_2 \rightarrow 2FeSO_4 + 2H_2SO_4$$

Ferrous sulfate

$$4FeSO_4 + O_2 + 2H_2SO_4 \rightarrow 2Fe_2(SO_4)_3 + 2H_2O$$

Ferric sulfate

$$Fe_2(SO_4)_3 + 6H_2O \rightarrow 2Fe(OH)_3 + 3H_2SO_4$$

Iron III Oxide “Yellow Boy”

+ ***Acidithiobacillus ferrooxidans***

$$2Fe(OH)_3 \rightarrow + Fe_2O_3 + 3H_2O$$

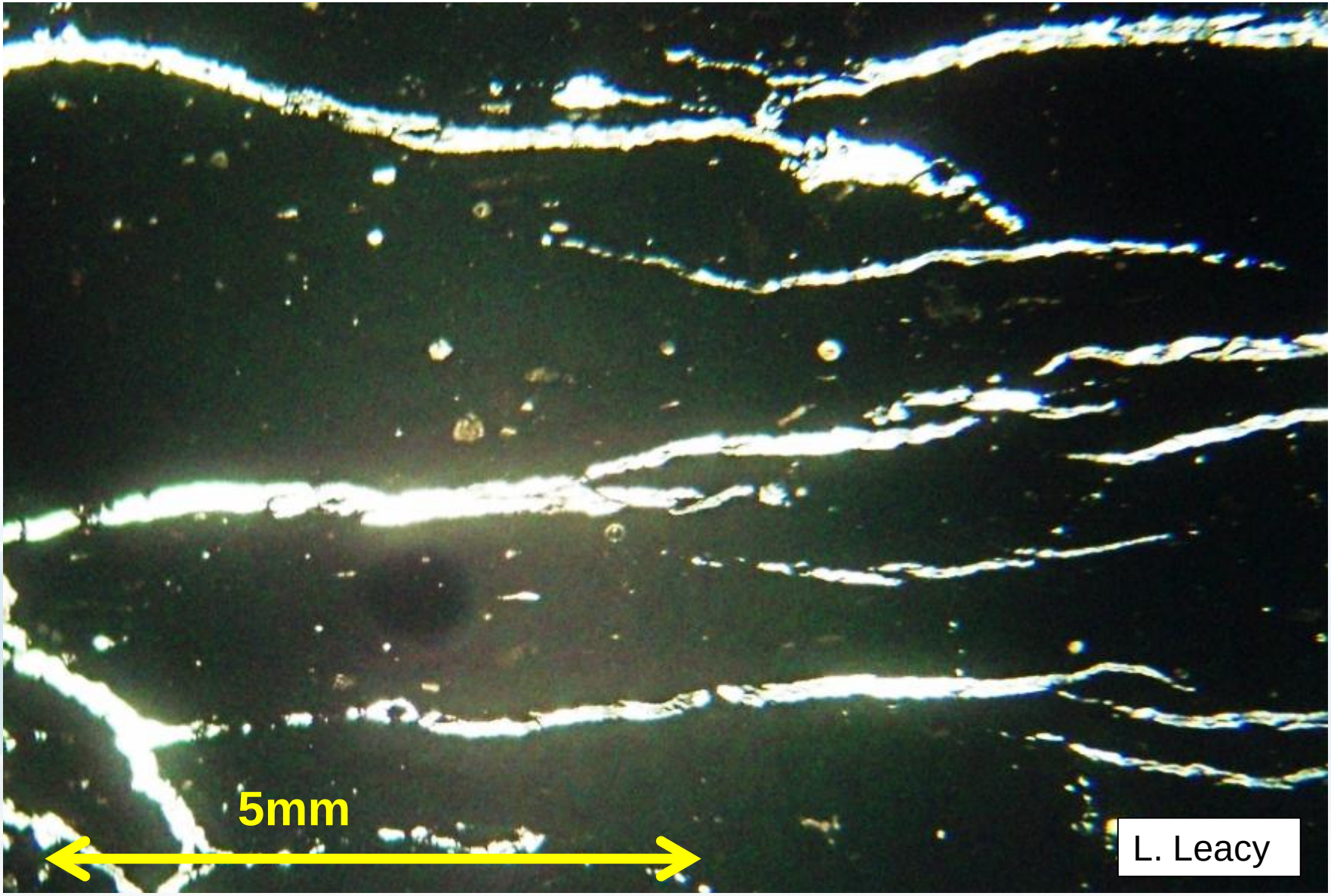
PYRITE OXIDATION - CONSEQUENCES

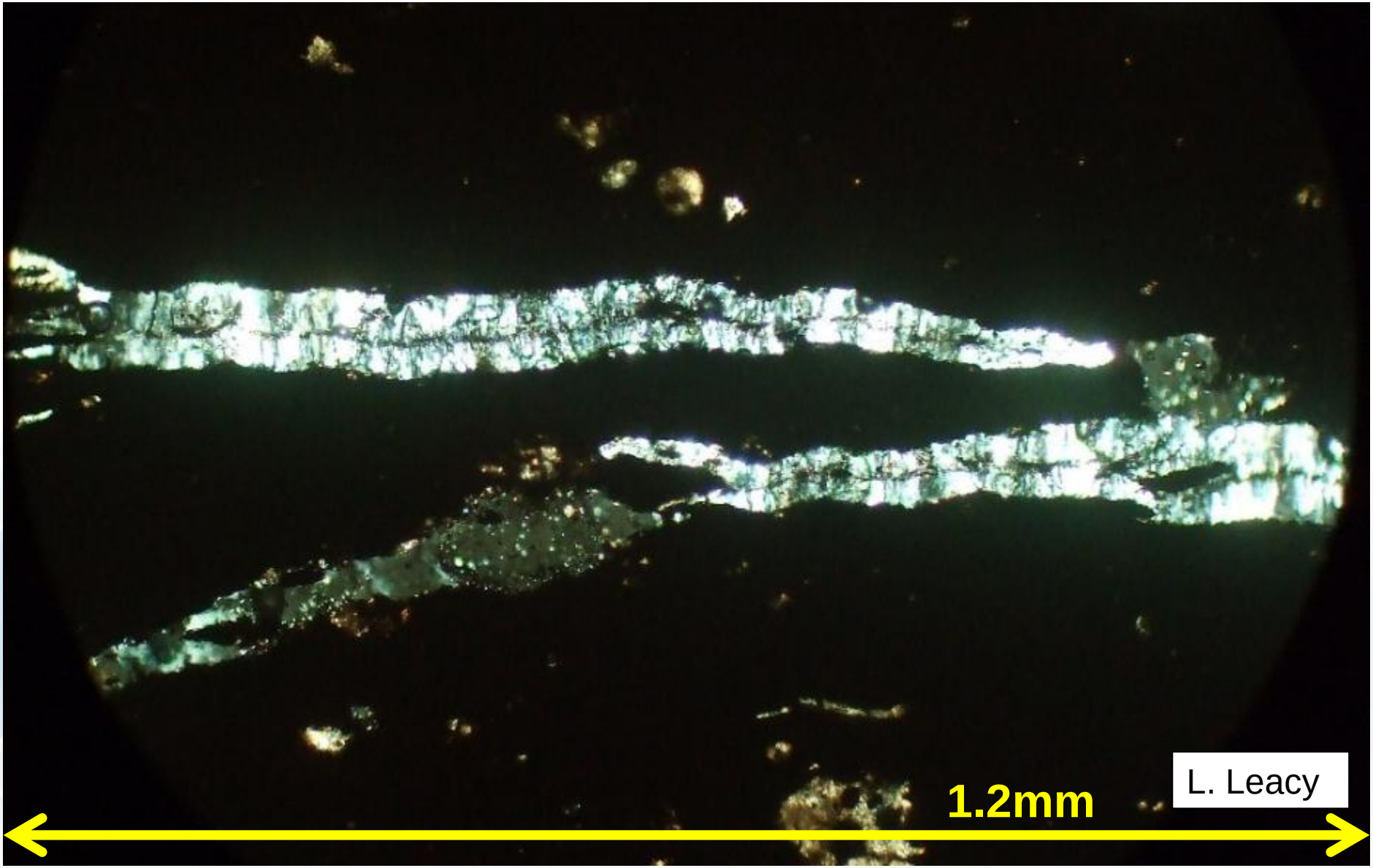
- **In calcareous rocks the carbonate - acid reaction leads to gypsum formation**

- $H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4 \cdot 2H_2O + CO_2$

- **If the rock is weak and non-durable, and the amount of gypsum formation is excessive, expansion of the rock will occur.**

- **The reaction will then continue as fresh pyrite is exposed to more air and water**


5mm
L. Leacy


1.2mm
L. Leacy


J. Colthurst


J. Colthurst

WHERE DOES THE PROBLEM OCCUR

- **Framboidal pyrite primarily forms in depositional environments where oxygen levels are extremely low and reducing conditions are present.**

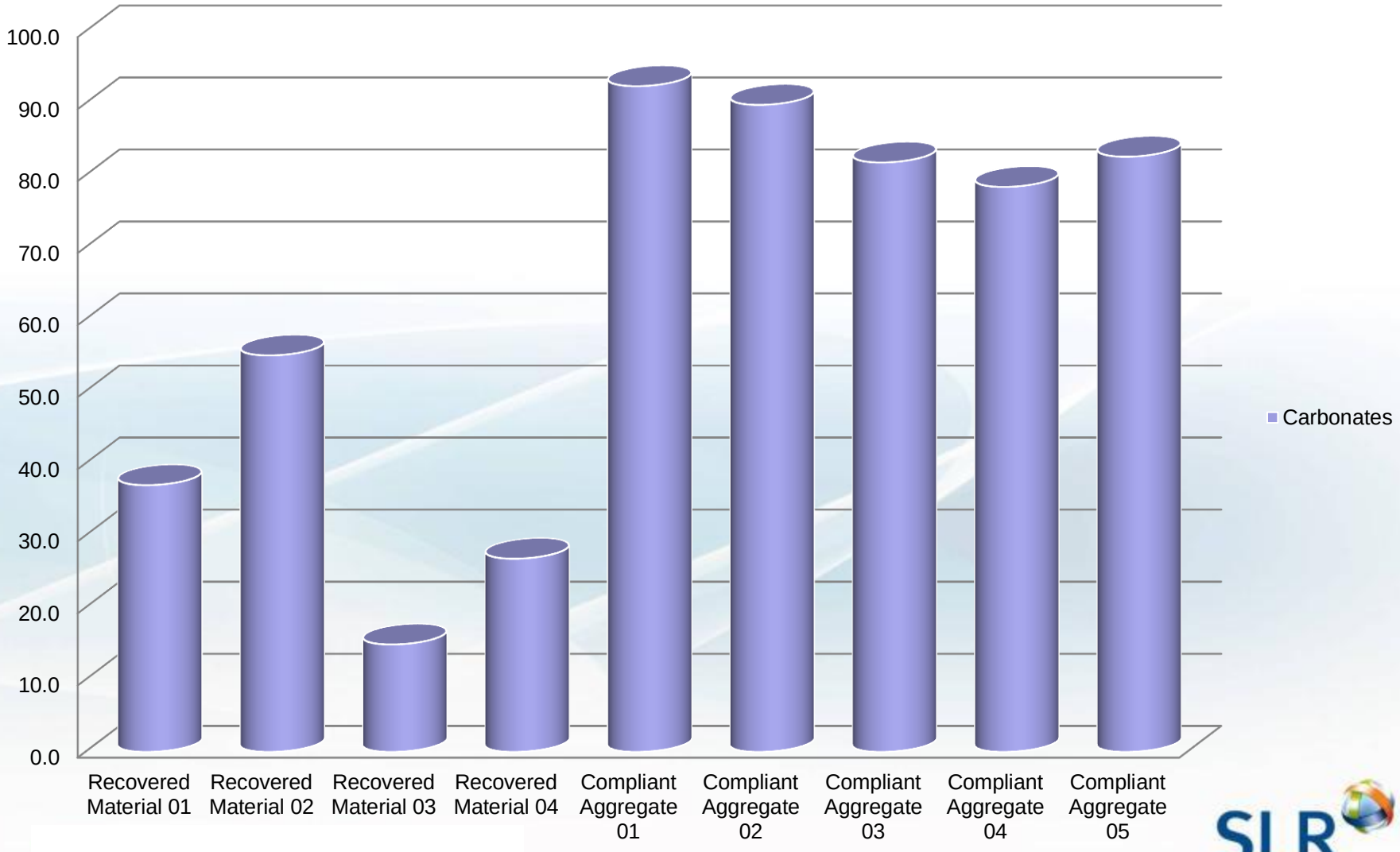
- **Rock types deposited in these environments are typically dark-grey to black mudstones, shales, siltstones, argillaceous limestones – i.e. weak and non-durable**

- **Tober Colleen Formation, Rush Formation, Loughshinny Formation, Namurian Shales, Ordovician Black Shales interbedded with Rhyolites , etc., etc., etc.,**

- **These lithologies fail standards on lithology, strength, durability, water absorption in any case and should never get to the stage where TS and AS testing is required**

LITHOLOGICAL DETERMINATION

XRD Analysis - Summary



LITHOLOGICAL DETERMINATION

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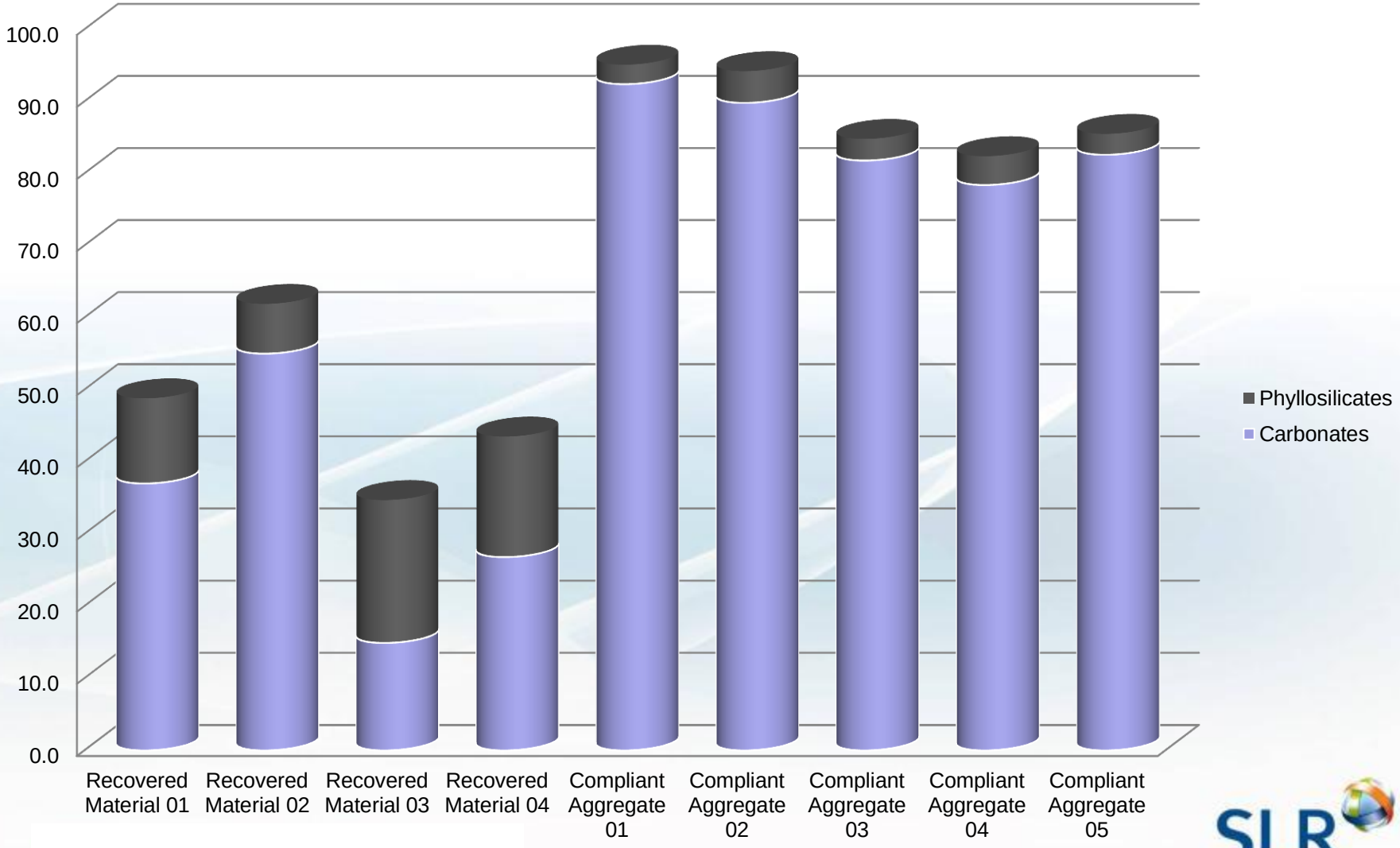

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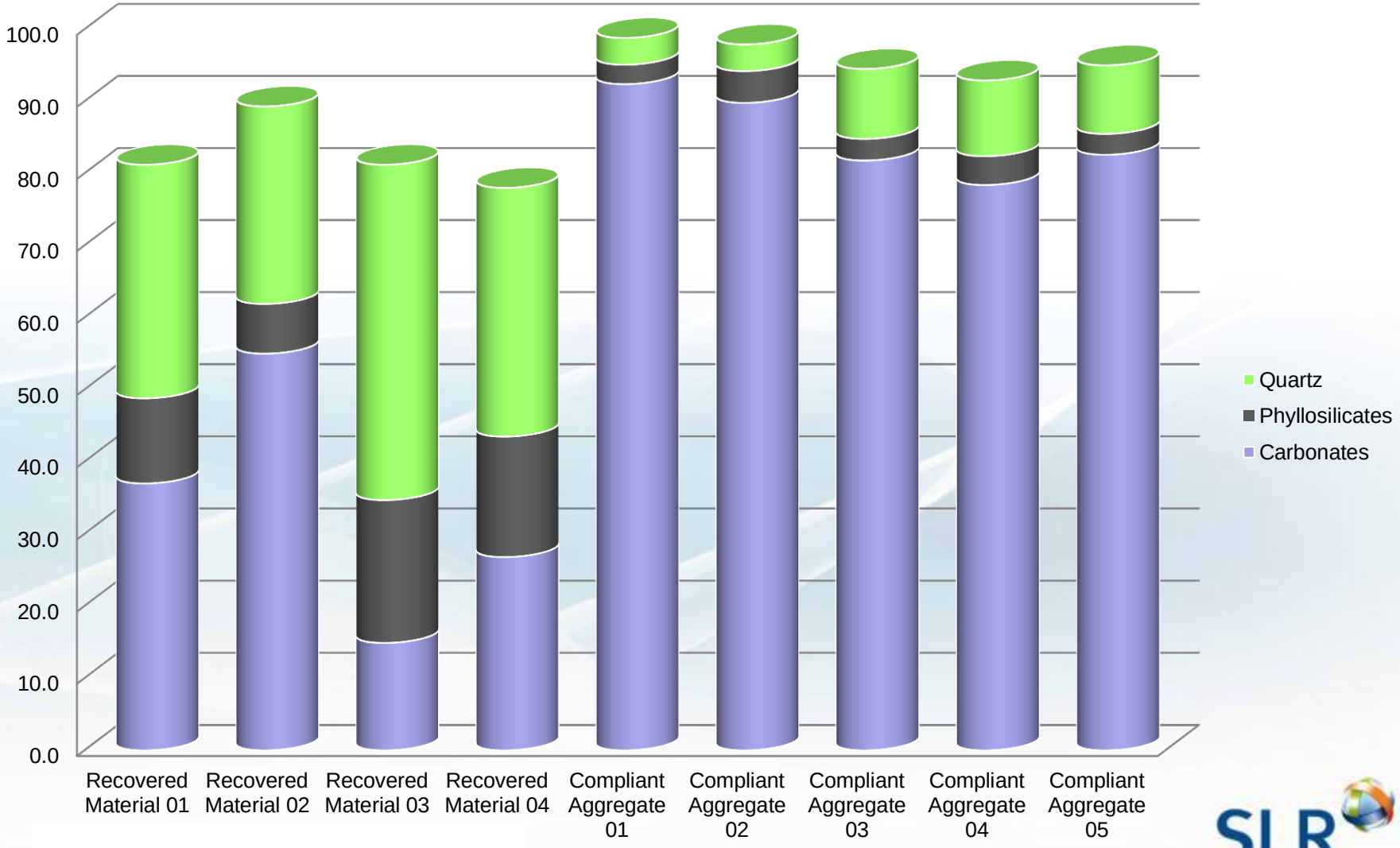

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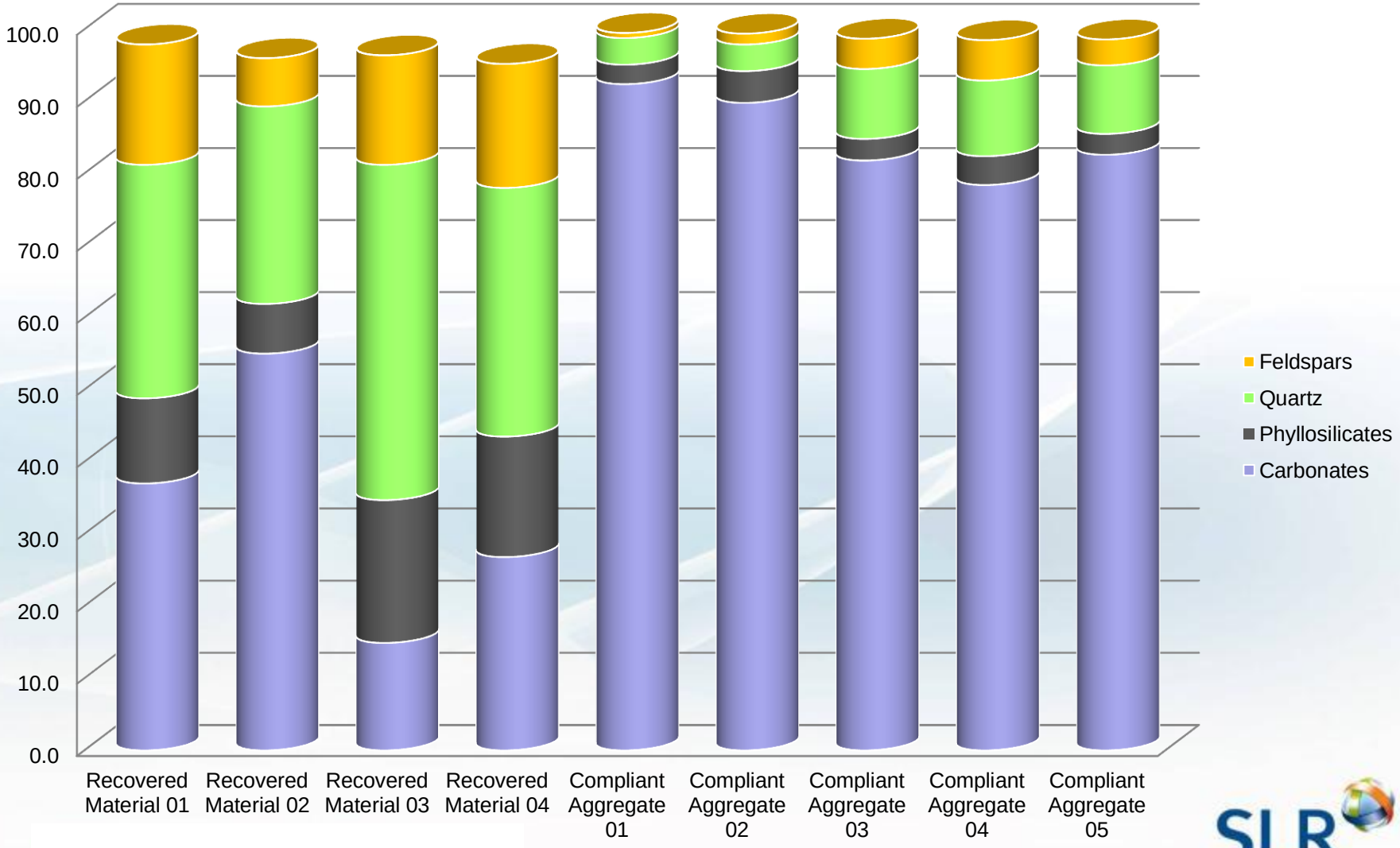

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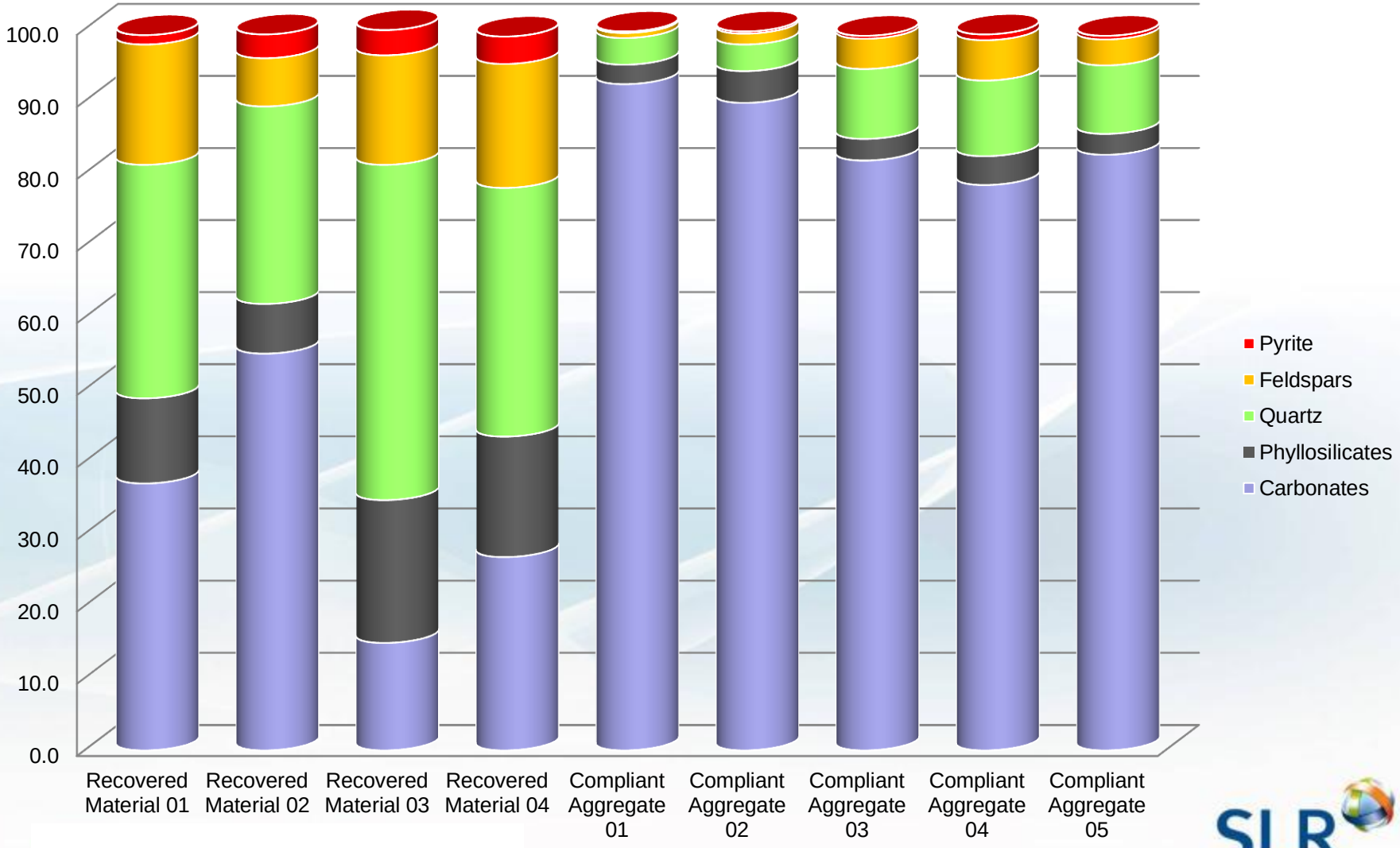

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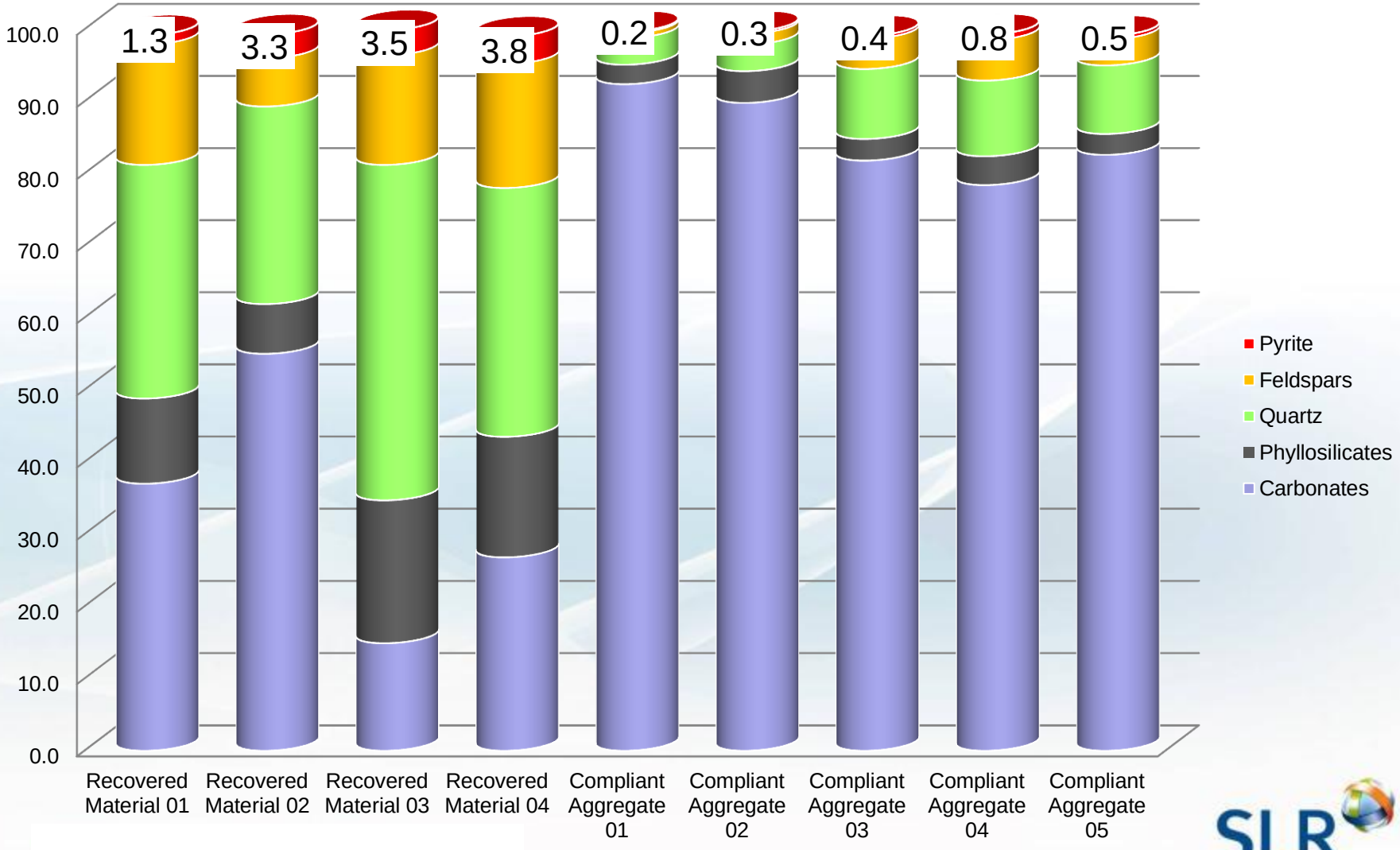
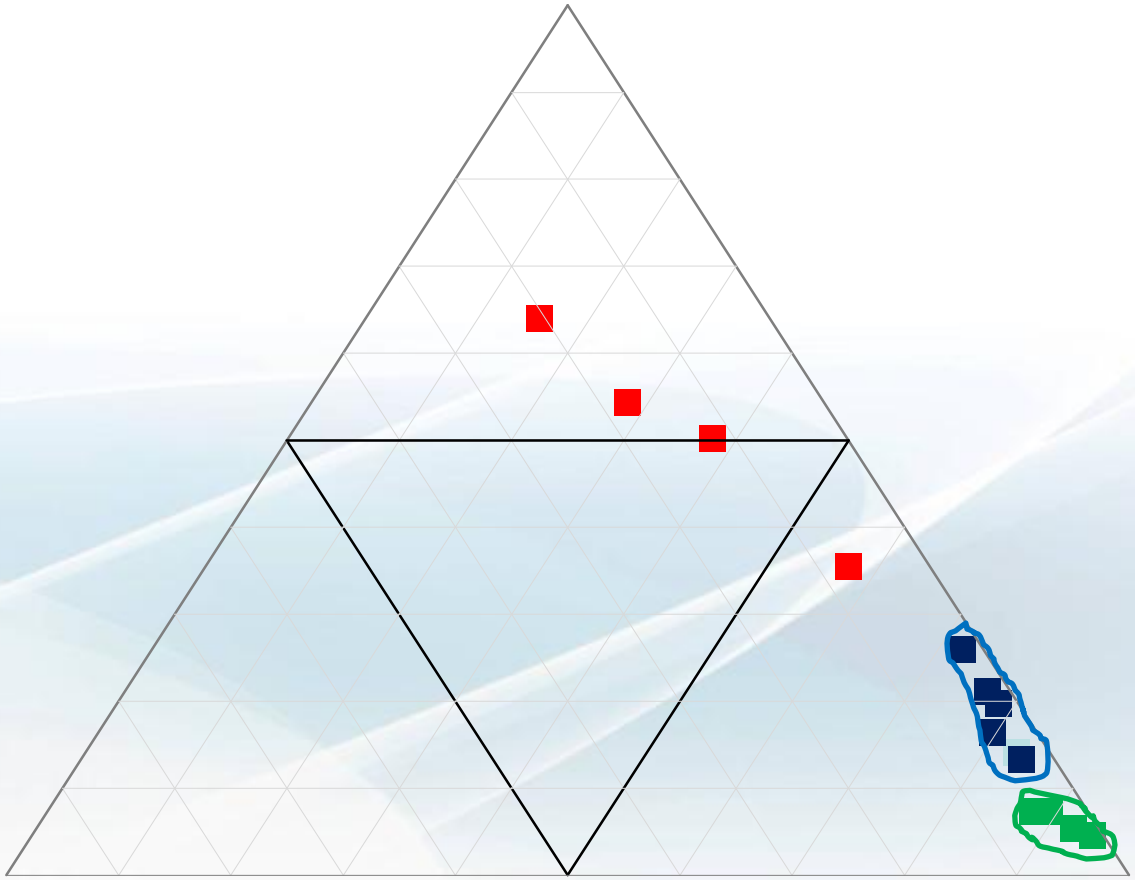


LITHOLOGICAL DETERMINATION

Quartz and Feldspars



Phyllosilicates (Clay Minerals)

Carbonates

MANAGING VARIABILITY

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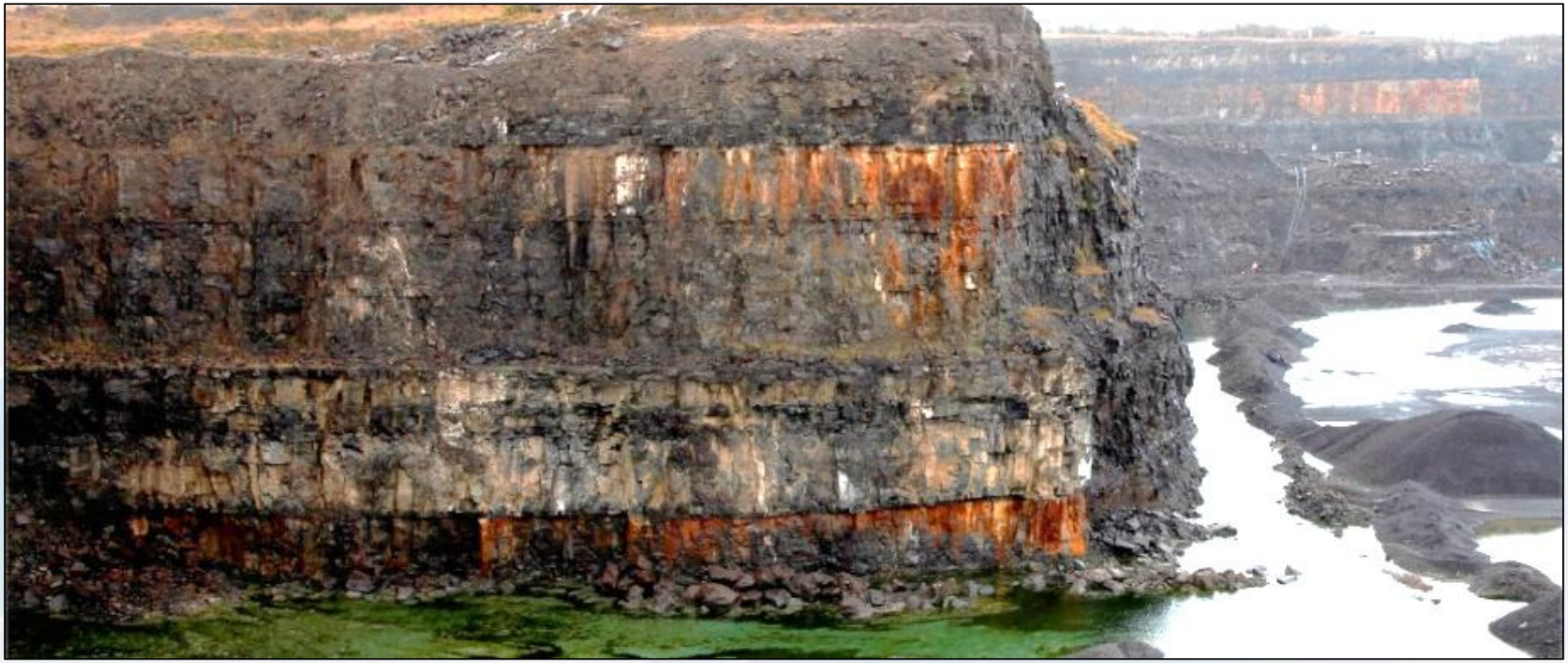

HUNSRÜCK SLATE

- **Hunsrück Slate outcrops in the Rhineland – Palatinate area bounded by the Moselle and Rhine, east of Luxembourg**

- **Building material quarried for construction, roofing and cladding since Roman times.**

- **Internationally renowned for it's pyrite content**