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global environmental solutions

Reporting Aggregate and Industrial Mineral Resources and Reserves

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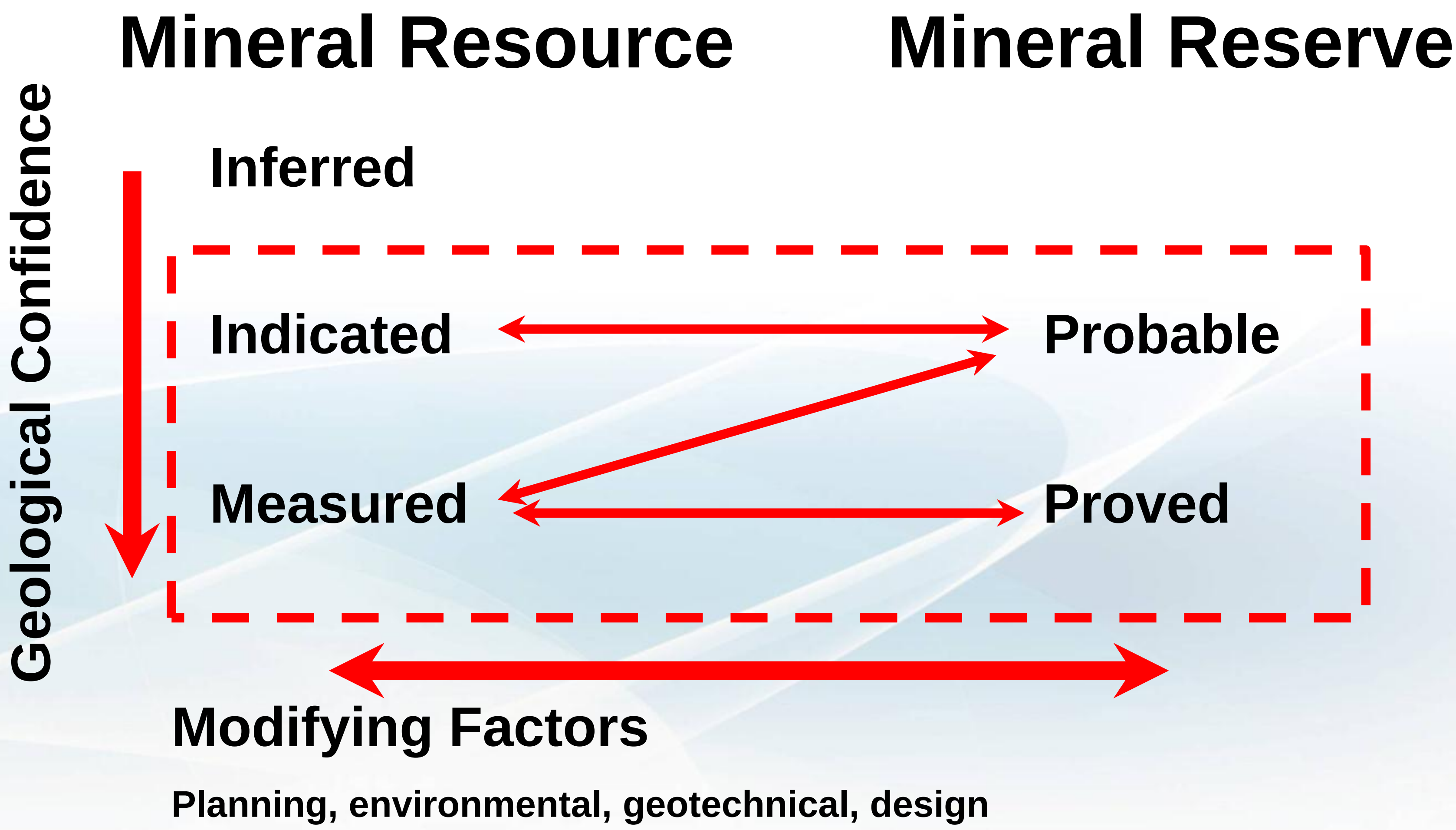
DEFINITIONS - THE CODE



Resource and Reserves Reporting

Aggregates, Industrial Minerals and Dimension Stones

Purposes

Usage

Definitions

Levels of Geological Confidence Required

- Information
- Investigation
- Testing
- End-Use Compliance

Modifying Factors

- Planning and Environmental
- Geotechnical Assessment
- Extraction Design Parameters

Resource and Reserves Reporting

Aggregates, Industrial Minerals and Dimension Stones

PURPOSES

- Internal Management and Planning

- Stock Market Listing Requirement

- Valuation for Raising Capital

- Valuations following major lending bubble and economic bust to see what can be salvaged

Resource and Reserves Reporting

Aggregates, Industrial Minerals and Dimension Stones

CURRENT INDUSTRY USAGE – SLR Experience

- **Ireland**
  - Low to moderate use of reporting codes
  - Many small to medium operators and small number of larger operators
  - No geologists employed directly by companies
  - Strong link to valuations – RICS methodologies extensively used
- **GB**
  - High acceptance and use of reporting codes
  - Market dominated by “Big 5” who are market listed
  - “Big 5” employ geologists in discrete geology departments responsible for resource definition, delineation, quality assurance and reporting.

DEFINITIONS

AGGREGATES

"Particles of rock which, when brought together in a bound or unbound condition form part (or the whole of) an engineering or building structure"

Low spec. fills, high spec. fills, concrete blocks, pre-cast concrete, bituminous bound materials (roads, runways) etc.

DIMENSION STONE

"Dimension stone is natural stone or rock that has been selected and fabricated (i.e., trimmed, cut, drilled, ground, or other) to specific sizes or shapes" – e.g. Limestones, marbles, massive igneous lithologies etc.

INDUSTRIAL MINERALS

"Industrial minerals are geological materials which are mined for their commercial value, which are not fuels and are not sources of metals"

Technically includes aggregates, but generally refers to non-aggregate items such as high purity limestone (lime, cement), brickclays, fireclays, halite, gypsum, kaolinite, talc, barite, vermiculite, phosphate, sulphur, zeolites, perlite, etc.

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IMPROVING GEOLOGICAL CONFIDENCE

A Planned and Incremental Process

Each phase informs the extent and nature of successive phases with increasing confidence (and cost)

Initial Geological Assessment

Desktop compilation, mapping data, previous publications, interpretation etc.

Geophysics

Electromagnetics, resistivity, seismics, microgravity

Direct Geological Investigation

Face mapping, trial pitting, shell and auger boring, air hammer drilling, rotary coring, trial excavation etc.

End-Use Compliance - Laboratory Testing and Standards

Physical property testing, petrography, chemical analysis etc.

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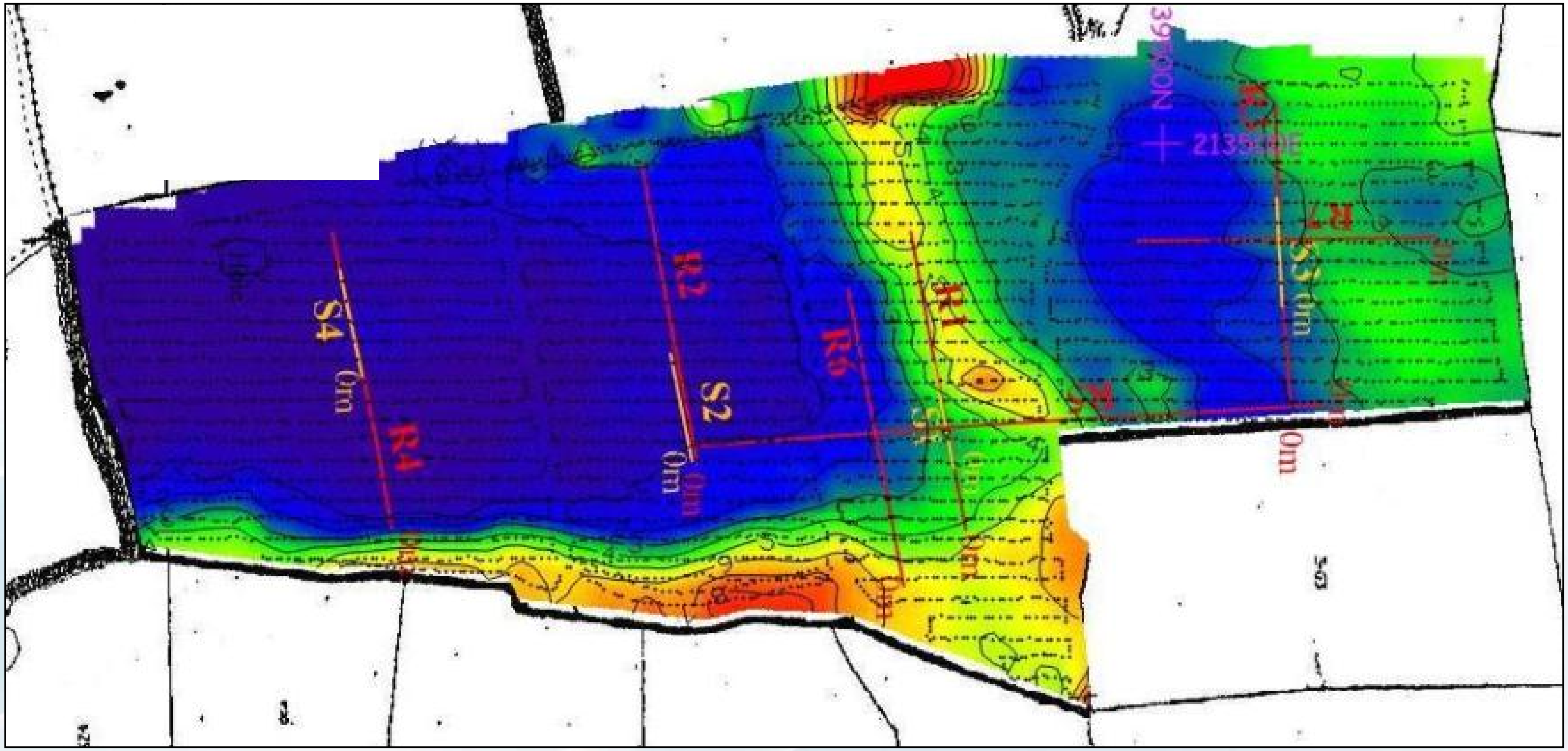
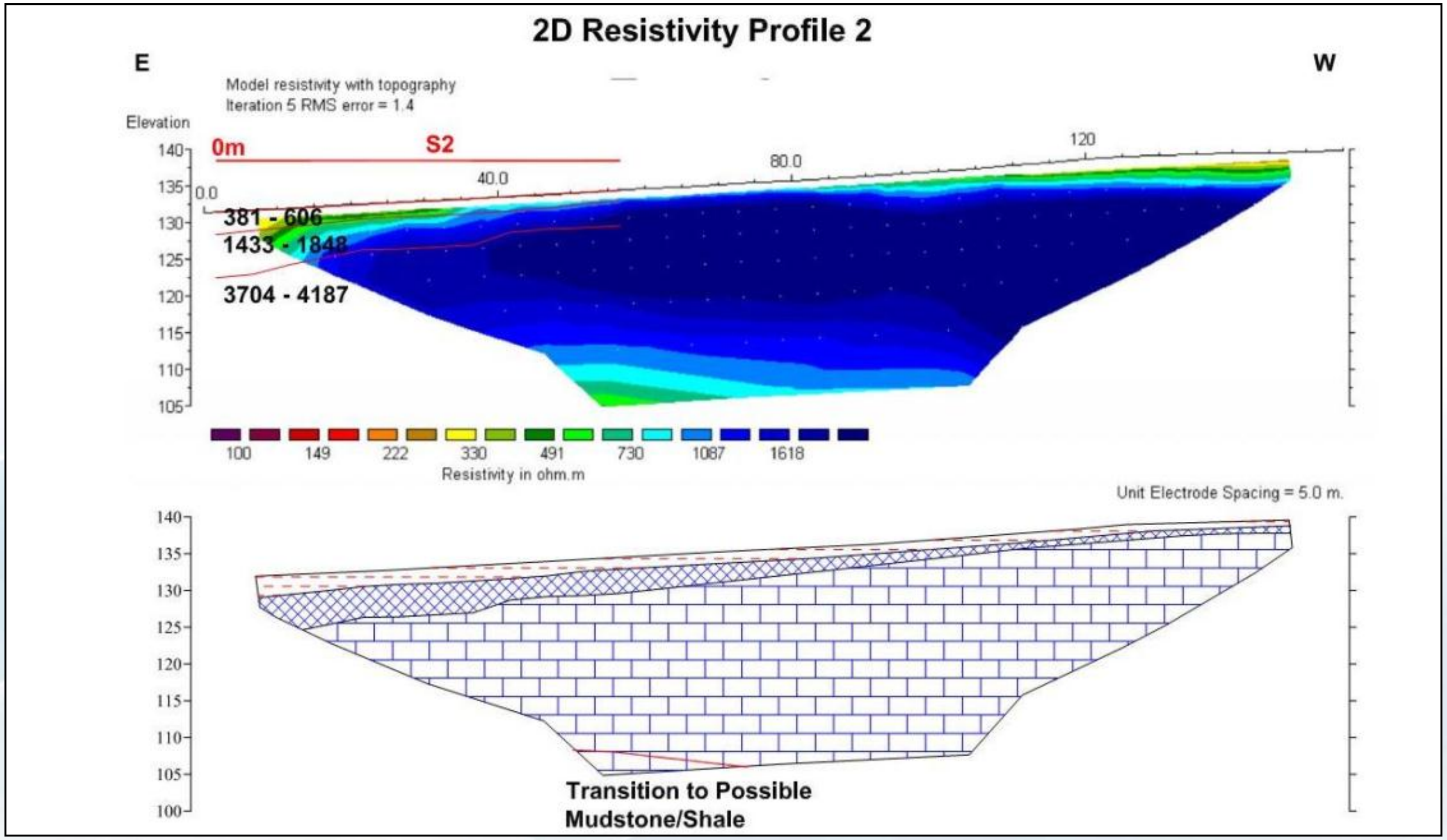
IMPROVING GEOLOGICAL CONFIDENCE



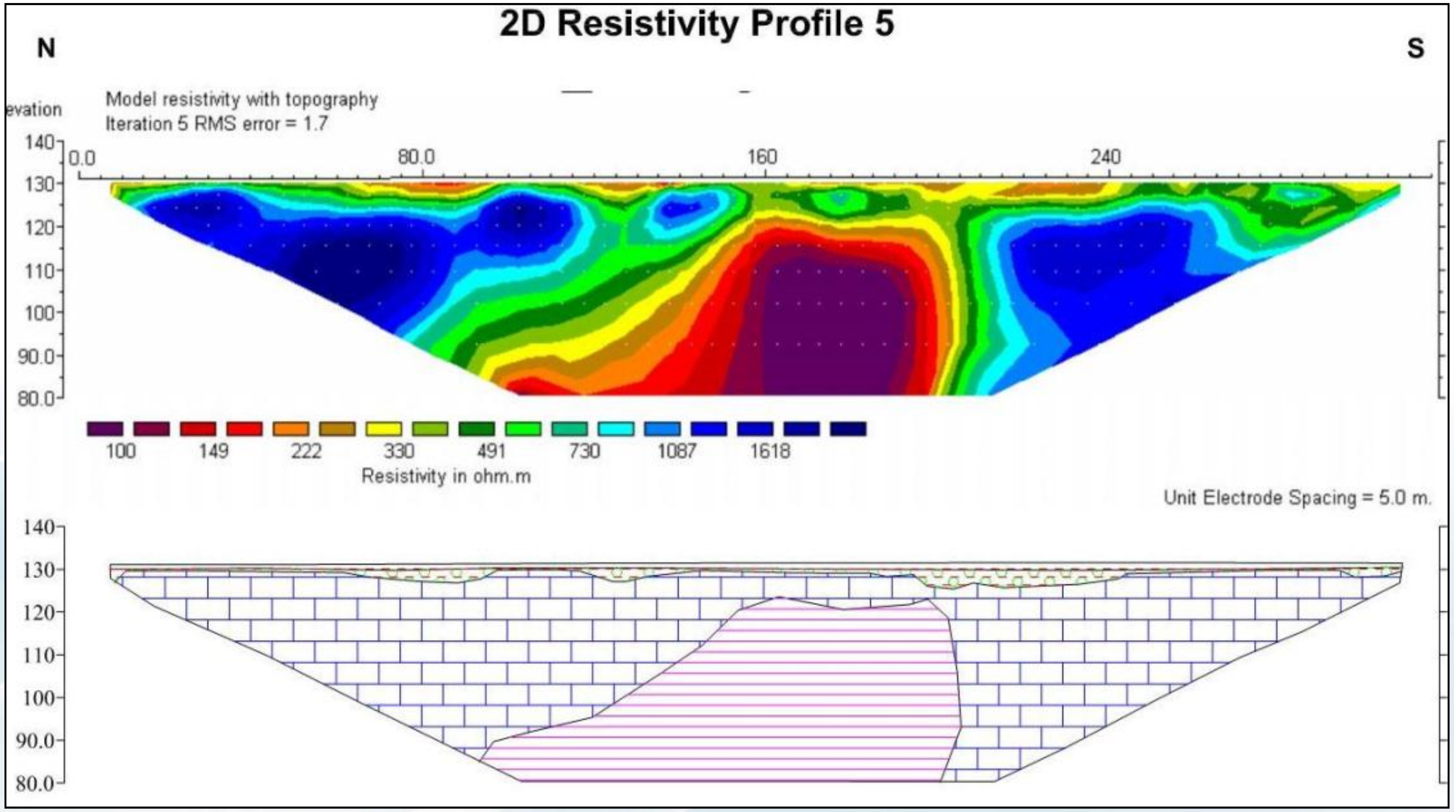
EM31 Survey – Overburden Thickness, Karst, Structure etc.

IMPROVING GEOLOGICAL CONFIDENCE



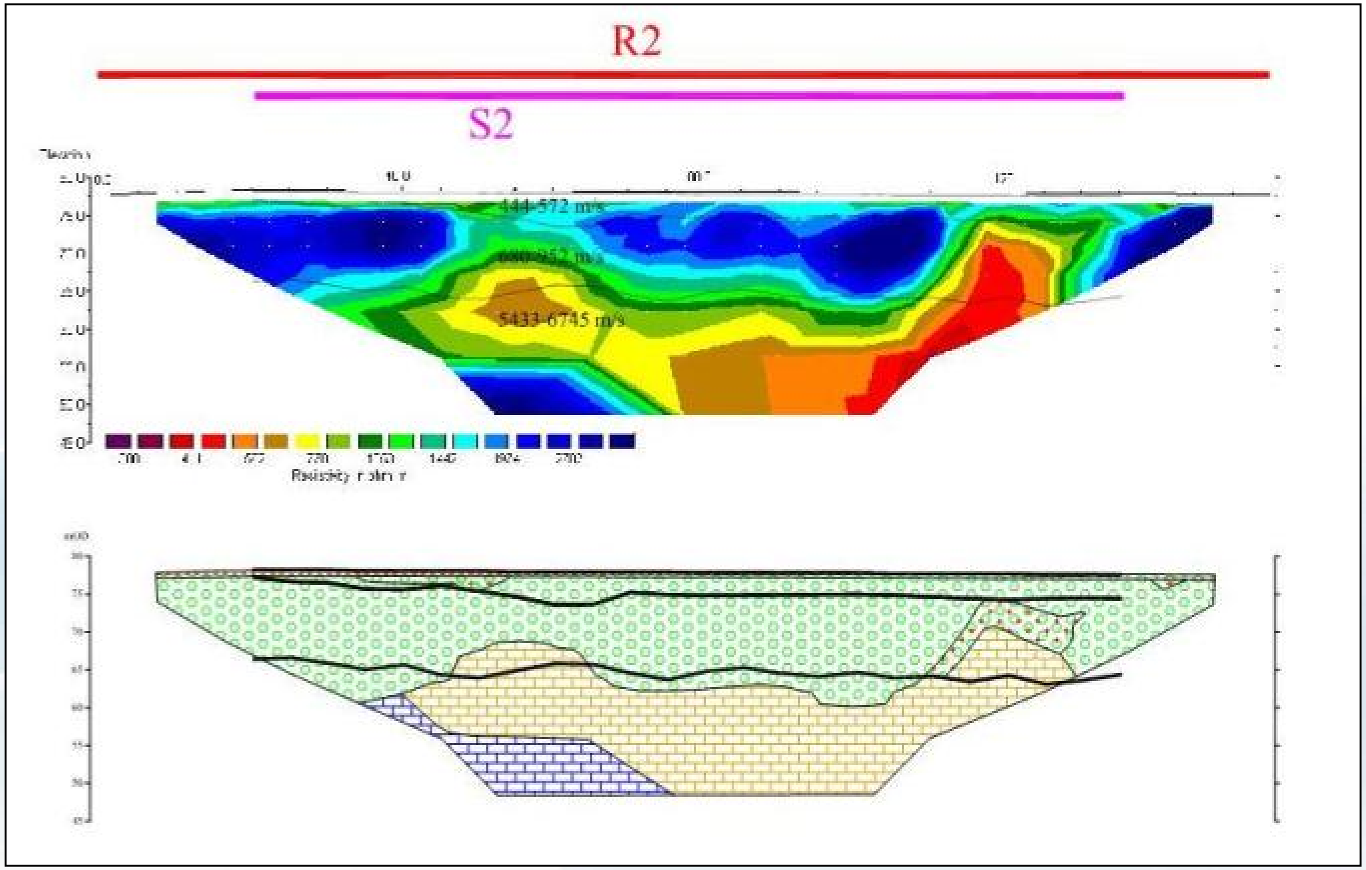
2D Resistivity and Seismics – OB and Bedrock

IMPROVING GEOLOGICAL CONFIDENCE



2D Resistivity and Seismics – OB and Bedrock

IMPROVING GEOLOGICAL CONFIDENCE



2D Resistivity and Seismics – Sand and Gravel

IMPROVING GEOLOGICAL CONFIDENCE

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Hard Rock Issues

- Need to identify, assess AND QUANTIFY potential issues that may impact resource - a wide range of geological experience is required

- e.g.
  - Karstification and clay infills in carbonates
  - Presence and distribution of dolomitisation or other alteration
  - Depth, degree and nature of weathering in non-limestone deposits
  - Lithological variability in mixed sequences
  - Potential presence of deleterious materials
  - Impact of geological structure – flat-lying or steeply dipping
  - Impact of geological structure – faulting
  - Presence of, and seasonal variation in, elevation of water table

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Sand and Gravel Specific Issues

• Geophysics is very effective at delineating and mapping zones of interest, but needs ground investigation and calibration

• Trial pitting very effective – but only to a 5m to 6m depth limit

• Shell and auger boring gives effective recovery, but refusal will occur on 1st boulder of note

• Air drilling effective to water table, but sample sorting - loss of fines will occur

• No sampling possible below water table

• Extraction feasible below water table by dredging – but leads to loss of high-value fine sands

IMPROVING GEOLOGICAL CONFIDENCE

DIMENSION STONE

- Rock mass properties, jointing frequency, bedding and other discontinuities determine potential block size for extraction and cutting
- Market research into marketability and point of sale value of stone is a key to determining if the material constitutes a resource
- Determination of likely wastage rates (can be up to 80%) is critical
- Sites may be multi-reserve – a determination of potential end-uses of waste materials is essential
  - General aggregates – waste rock crushed
  - Coastal Armour e.g. Larvikite - 95% of annual production (3.2Mt)

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DIMENSION STONE

ROCK TESTING

Identification and characterisation (geological assessment, petrography etc.)

Physical properties (density, strength, abrasiveness)

Chemical properties (sulphides, SO_4, chloride, total silica, reactive silica etc.)

Durability (water absorption, sulphate soundness, los angeles value, aggregate impact value etc.)

Identification and quantification of contaminants (pyrrhotite, pyrite, gypsum, anhydrite, halite, heavy metals etc.)

Special tests for specific high-specification applications (e.g. high polished stone value {PSV} for roads surface dressing, coastal armour)

Geometric properties (grading, shape, flakiness etc.)

Chemical properties and contaminant quantification and distribution critical for Industrial Minerals suitability – typically very narrow acceptance windows and greater geological input and detail required

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INDUSTRIAL MINERALS

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POTENTIAL END-USE ASSESSMENT

Determine Test Result Compliance with Relevant Standards for End-Use

EN 13242 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction.

EN 12620 Aggregates for Concrete

EN 13043 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas

EN 13450 Aggregates for Railway Ballast

NRA and UK Highways Agency Manuals for Road Construction

etc. etc. etc. etc.

POTENTIAL END-USE ASSESSMENT

Determine Test Result Compliance with Relevant Standards for End-Use

<u>Example – Aggregates for Concrete</u>

Los Angeles Test – Durability and Strength

Aggregate Impact Value – Resistance to Repeated Impacts

Micro-Deval Test – Resistance to Wear

Polished Stone Value – Resistance to Polishing (Concrete Roads)

Aggregate Abrasion Value – Resistance to Abrasion

Density and Water Absorption – Density and resistance to freeze thaw

Magnesium Sulphate Soundness – Resistance to freeze thaw if WA>2%

Drying Shrinkage – Resistance to excessive shrinkage (organic carbon)

Alkali Silica Reactivity – Determination of reactive silica content

Chemical tests - Chlorides, sulphides, sulphates etc. etc. etc.

MODIFYING FACTORS

Planning and Environmental

Planning permission will state numerous factors that MUST be implemented in the extraction design and will impact on the extractable volume of the deposit

- Assuming resource present over wide area, the operators land holding
- There may be preferred/required locations for plant and overburden/soil storage etc. that may sterilise potential reserves
- Stand-off to boundaries - 10 to 20m
- Boundary screening and face crest access roadways – typically 10 to 15m in addition to above
- Stand-off to water courses – 30 to 50m
- Stand-off to residences 100 to 150m, if hardrock quarry and blasting
- Stand-off to archaeological sites of 50m

MODIFYING FACTORS

Geotechnical Design Inputs

• Extraction designs are strongly informed by inputs from a Geotechnical Assessment

• These assessments are a statutory requirement and MUST be undertaken by a competent person (Chartered Geotechnical Engineer or Professional Geologist with relevant experience)

• Governed by Health and Safety legislation (HSE in UK, HSA in RoI)

• Control maximum face heights, final face angles, final bench widths, depth of possible extraction and other factors which govern design and control maximum extractable volume/tonnage

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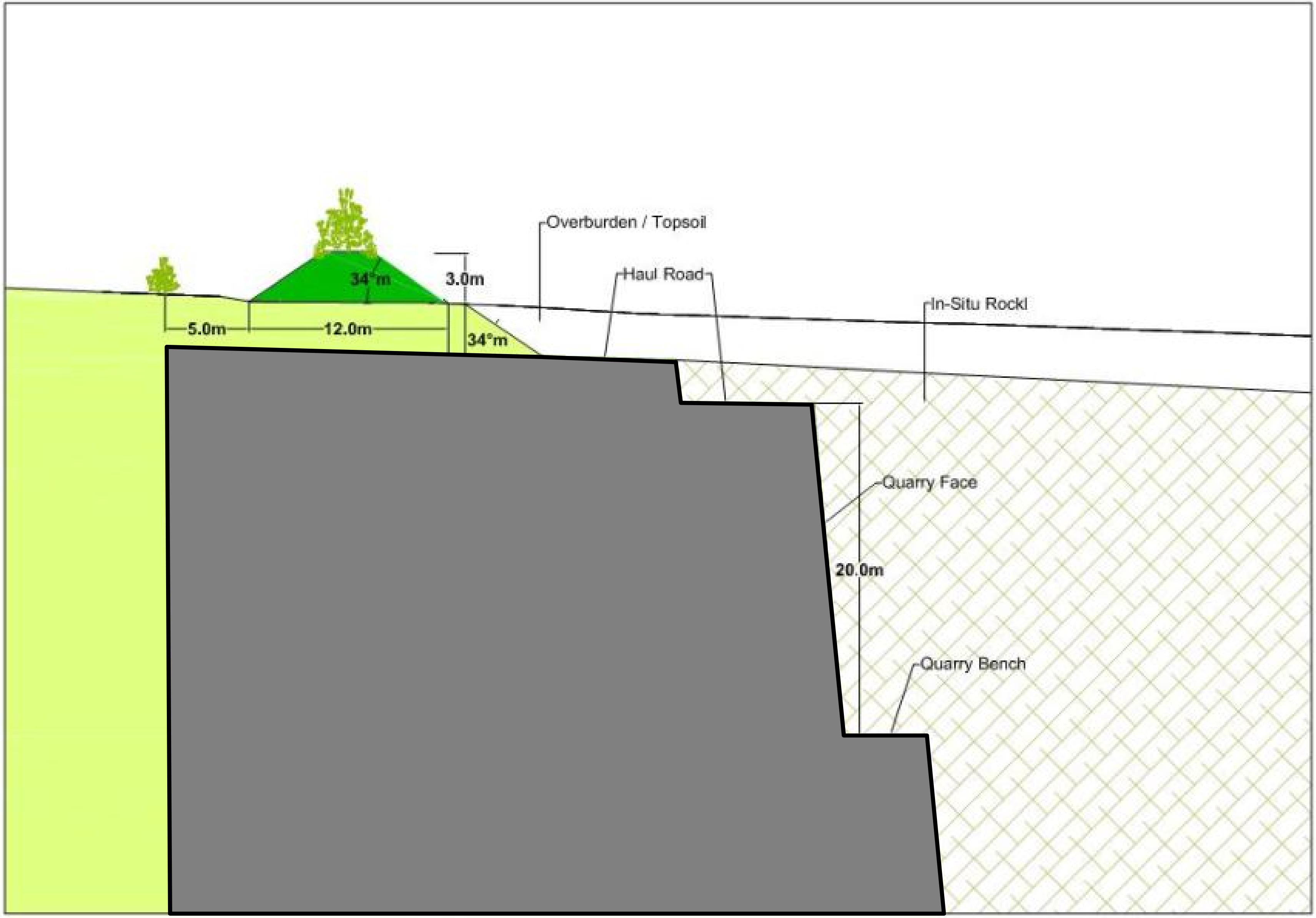
Overburden / Topsoil
Haul Road
In-Situ Rockl
34°m
3.0m
5.0m
12.0m
34°m
Quarry Face
20.0m
Quarry Bench

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VOLUME and TONNAGE DETERMINATION

- For open pit design, once the extraction area has been defined, a pit design incorporating all geological, planning and geotechnical inputs will be undertaken to determine the final pit layout
- This “Final Design” is subtracted from the existing site layout and the volume difference between existing and final is determined.
- This can be done as a single calculation or can be undertaken bench by bench or phase by phase depending on how the site is planned to be worked
- Individual geological units can be modelled
- Industry standard design, surface modelling and calculation packages are AutoCAD and LSS (Land Survey Systems) although GIS is now making inroads into the ACAD market
- Volumes are multiplied by densities as determined by testing
- Modifying geological factors may also be applied at this stage
- Standard -5% on tonnage due to processing losses (fines etc.), this may be increased if geological factors known to adversely affect this figure are present and identified