Petrographic Inspection Report

Title:	Petrographic Inspection Report for Penrice Quarry Aggregate
Prepared for:	Penrice Quarry
Date Sampled:	Unknown
Sample Description:	14mm Aggregate
Source:	Penrice Quarry
Work Request:	PO:1105010542
Date of Inspection:	27/09/2019
Report Issued:	3/10/2019
Project/ File Ref.:	P2019_105_001

Author:

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Rock Identity

Classification: A mixed aggregate containing marble, biotite schist and calcareous sandstone

For Engineering Purposes 2758.1: Marble, biotite schist and calcareous sandstone, metamorphic to sedimentary rocks

Key Material Risk: High content of micas in the biotite schist

Introduction

This report provides the results of a general petrographic assessment of a sample which was submitted to the Groundwork Plus petrographic laboratory and describes the method and standards used to assess the sample. The thin section was prepared and analysed by Groundwork Plus with instructions from the client to conduct petrographic testing to ASTM C295 and recommend further testing if significant deleterious characteristics are identified pursuant to Clause 16.3 of this standard. The supplied sample was sampled by the client and reduced using the riffle box method (where applicable) at the Groundwork Plus petrographic facility. The provided modal mineral percentages relate to the supplied sample which is understood to be representative of material on site. Assessment regarding the Alkali-Silica Reactivity (ASR) potential of the aggregate has been advised by AS1141.65-2008 and is communicated pursuant to Clause 9. Communication of findings are advised by AS 1726-1993 Geotechnical Site Investigations.

Method

The petrographic assessment of the slide was carried out using a Nikon polarising microscope equipped with a digital camera at the Groundwork Plus petrographic laboratory. A photograph of the hand specimen and thin section photomicrographs showing grain sizes and any particular aspects of the minerals were included as part of the report (Plates 1 to 6). Modal analysis was conducted on the sample using JMicroVision image analysis software on 200 points (Table 2 – Modal Analysis of Minerals).

The petrology assessment was based on:

- ASTM C 295 Standard Guide for Petrographic Examination of Aggregates for Concrete.
- AS2758.1 – 1998 Aggregates and Rock for Engineering Purposes Part 1: Concrete Aggregates (Appendix B).
- AS1141 Standard Guide for the Method for Sampling and Testing Aggregates.
- Alkali Aggregate Reaction - Guidelines on Minimising the Risk of Damage to Concrete Structure in Australia - Cement and Concrete Association of Australia and Standards Australia (HB 79-2015).
- The accepted definition of free silica is set out in the Queensland Department of Transport and Main Roads Test Method Q188, and tested pursuant to the AS1141.65-2008 Methods for sampling and testing aggregates – Alkali aggregates reactivity – Qualitative petrological screening for potential alkali-silica reaction and AS1141.26 Secondary Mineral Content.

Interpretation

- The supplied aggregate represents three distinct meta-sedimentary lithologies; Coarse-grained marble (80%), biotite schist (15%) and fine-medium grained calcareous sandstone (5%).
- The aggregate is described as fragments of white, deep green and light brown metamorphic and sedimentary rock varying grain sizes. Crushing has not resulted in planar separation coincident to evident planes apart from subordinate schistose material. The aggregates are essentially unweathered and regarded as exceptionally hard, of high strength and durable. Minor sulphides are observed in hand sample as pyrite.
- Petrographic analysis confirms that the presence of three distinct lithologies. The marble, which comprises 80% of the supplied aggregates, is composed principally of recrystallised calcite (76%) with quartz (2%), tourmaline (1%) and opaques (1%). The biotite schist, which comprises 15% of the supplied aggregate, is composed of foliated biotite (7%), muscovite (3%), quartz (3%), feldspar (1%) and opaques (1%). The calcareous sandstone comprises 5% of the supplied aggregate and is composed of calcite (3%) and quartz (2%), with trace opaques.
- The rock possesses 7% free silica as unstrained to mildly strained quartz crystals which are regarded as innocuous in relation to Alkali-Silica Reactivity (ASR) in concrete. As the marble does not show the independent rhombic forms diagnostic among potentially reactive dolomitic rock the aggregate is regarded as innocuous in relation to Alkali-Carbonate Reactivity (ACR).
- When proven through materials testing this aggregate is expected to be suitable for use in Unbound Pavements, Concrete and gabion/revetment (from source rock) provided it is not exposed to acidic conditions including low pH runoff or groundwater. The sample, with the exception of the mica schist lithology, is expected to produce quality manufactured sand with further crushing and should bolster the pozzolan in concrete mixes due to its marble content. The aggregate may also augment calcareous aggregate used in concrete to make sewerage pipes and manhole covers. Calcareous aggregate provides a buffer against sulphide attack and will extend the usable life of these pipes.
- For engineering purposes the rock may be summarised as:
    - Mixed rock types representing a predominantly carbonate meta-sedimentary sequence.
    - Essentially unweathered with minor ferruginous staining present in some marble aggregates.
    - Exceptionally hard, of high predicted strength and regarded as durable provided the aggregate is not exposed to acidic conditions.
    - No significant internal fractures are observed and the marble is without voids and non-porous.
    - Containing 7% free silica as unstrained to mildly strained crystals and duly regarded as innocuous in relation to ASR in concrete.

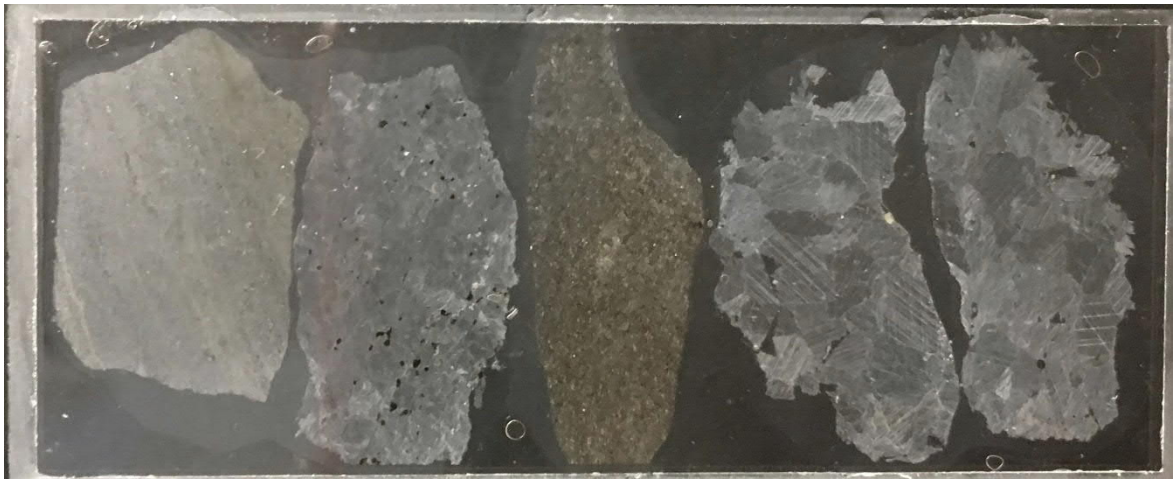

Plate 1: The thin section prepared of the sample which shows left to right; calcareous sandstone, marble, biotite schist, marble and marble aggregates. Slide width is 25.1mm

Plate 2: Photograph of the washed sample, shows the abundance of the different lithologies.

Table 1. Risk Rating for Specific Applications and Source Rock Quality

Risk Rating for Application	Low	Mod	High	Comments (Pending material testing and assuming the sample is indicative of overall source rock quality)
Coarse Aggregate in Concrete	✓			Marble and calcareous sandstone mechanically well-suited and ideal as aggregate in concrete used to extend the life of sewerage pipes and covers
Aggregate Unbound Pavements	✓			Suitable hardness, strength and durability
Cover Aggregate	✓			Suitable hardness, strength and durability
Manufactured Sand	✓			Suitable, provided biotite schist aggregates don't contribute significantly.
Gabion and Revetment	✓			Suitable
Risk Rating Source Rock	**Low**	**Mod**	**High**	
Alkali Silica Reactivity	✓			Innocuous in relation to ASR
Secondary/weak Mineral Impacts	✓			Biotite (7%) and muscovite (3%) are present exclusively in the biotite schist lithology
Durability	✓			High
Strength	✓			High
Hardness	✓			High
Free Silica Content	✓			12%
Sulfides	✓			Minor sulphides present in the marble identified as pyrite
Bitumen Affinity	✓			Expected to exhibit adequate bitumen affinity
Aggregate Polishing	✓			Carbonate rock may display polishing in service particularly with repeated exposure to acidic waters. Polished Aggregate Friction Value testing recommended prior to allocation as Asphalt Aggregate
Heir-line fractures	✓			No heir-line fractures observed
Voids	✓			Non-porous
Light particles	✓			10% micaceous phases exclusively located in the biotite schist aggregates

*Low risk means a low probability of causing source rock related issues in regard to material performance in any particular applications. Risk is recommended to be considered in conjunction with a sampling frequency protocol for production of any particular product.

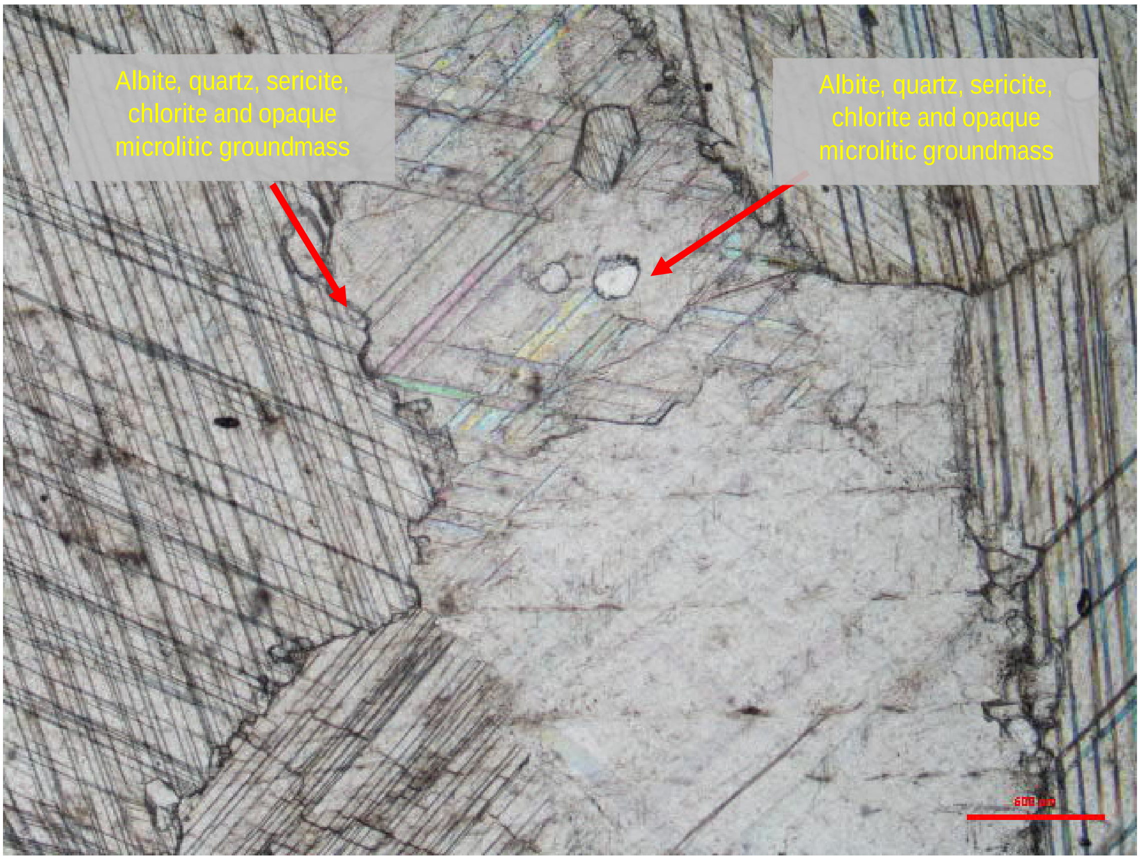

Plate 3: Microphotograph of the marble lithology at 40x magnification utilising plane polarised light. Scale = 500um x 40 magnification. F.O.V 5.2mm.

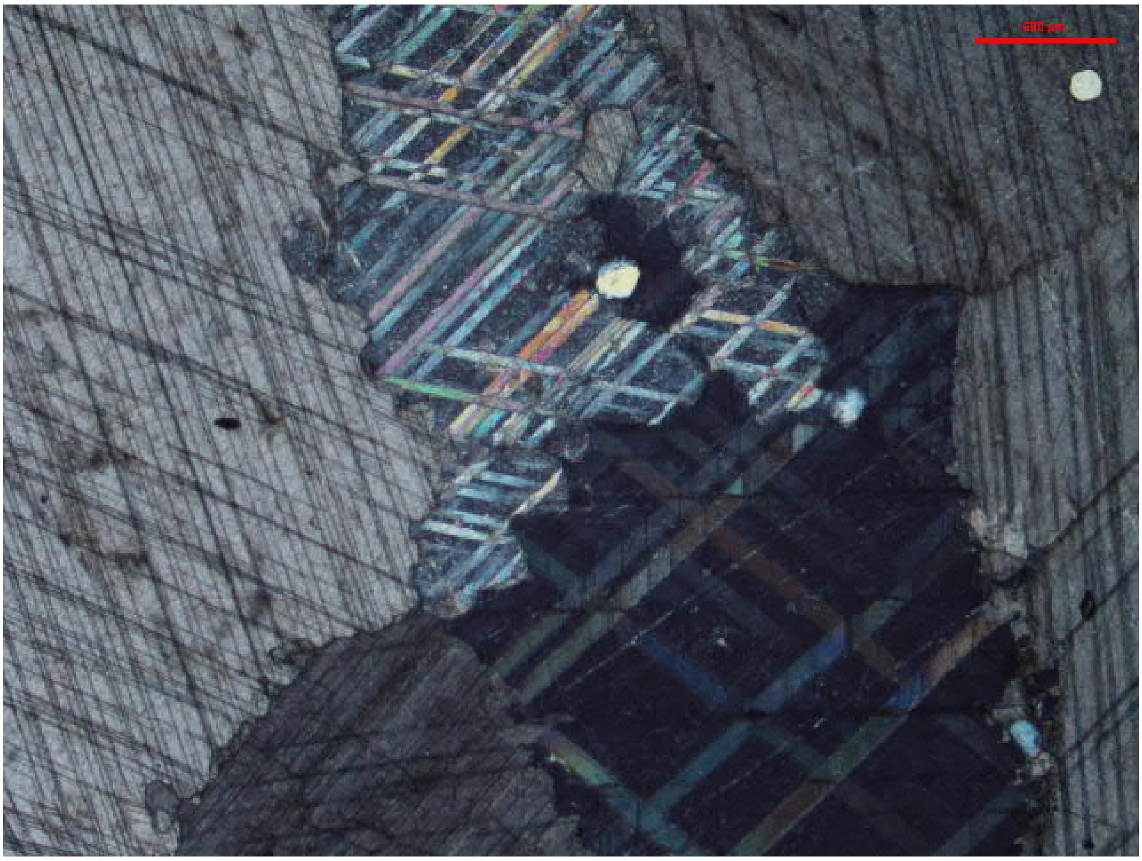

Plate 4: The same image from Plate 3 under crossed polarised light. Scale = 500um x 40 magnification. F.O.V 5.2mm.”””””””””””””””””””””””””””

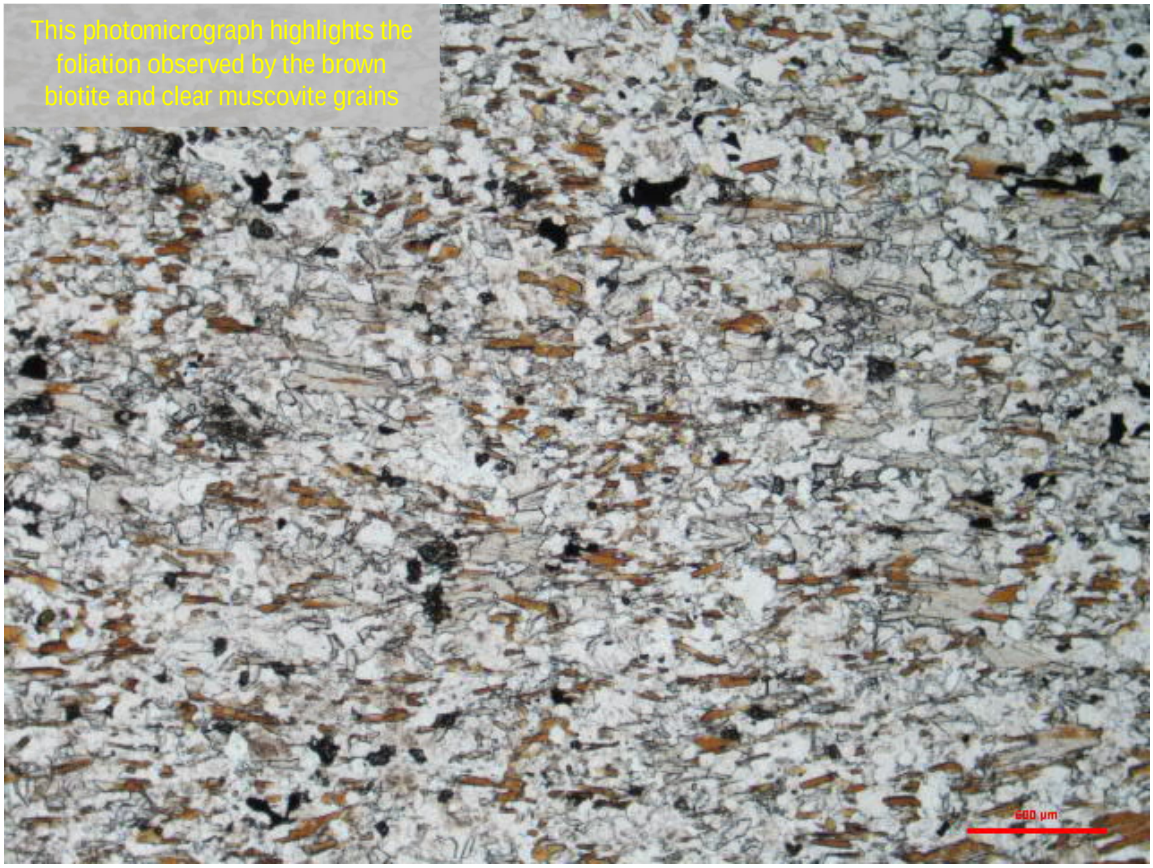

Plate 5: Microphotograph of the biotite schist lithology at 40x magnification utilising plane polarised light. Scale = 500um x 40 magnification. F.O.V 5.2mm.

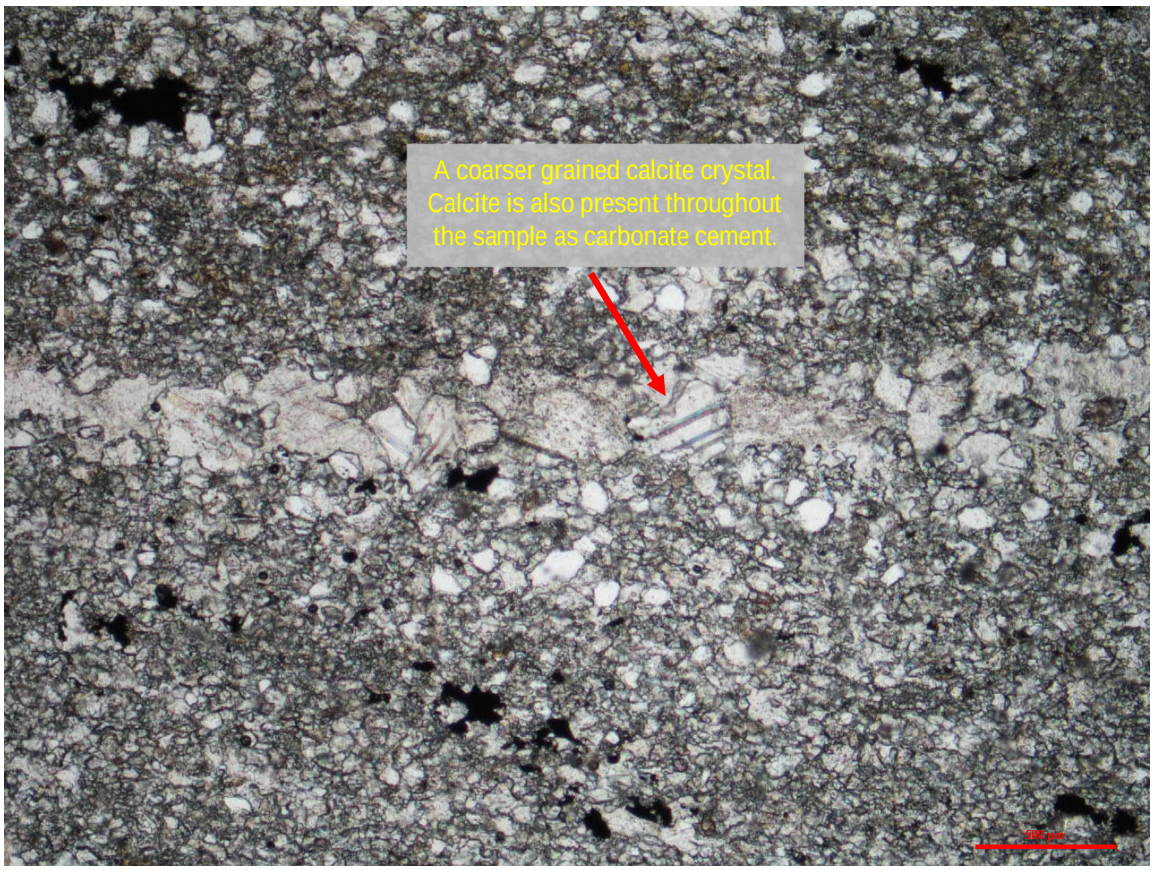

Plate 6: Microphotograph of the mica schist lithology at 40x magnification utilising plane polarised light. Scale = 500um x 40 magnification. F.O.V 5.2mm.

Thin Section Description

Petrographic analysis reveals that the aggregates represent a meta-sedimentary sequence which includes 3 distinct lithological varieties. The first of which is a coarse-very coarse grained, recrystallised marble. The marble is relatively pure being composed principally of tightly intergrown 1.0 to 5.0mm calcite grains with isolated and insipid iron oxide staining. Accessory phases are present in minute quantities, present predominantly as sub-rounded 0.2mm quartz and tourmaline inclusions. Cubic opaque grains are also present in minor quantities, interpreted to be pyrite. The second lithology observed in the sample was a fine-grained biotite schist, which represents approximately 15% of the total aggregates supplied. The schist is dominated by foliated biotite and muscovite, which are disrupted by rounded quartz grains and subordinate feldspars. The sample also contains 0.1mm opaque grains, identified to be magnetite due to their cubic habit. Approximately 5% of the aggregates define a third lithology, which was classified as a fine-medium grained, moderately sorted calcareous sandstone. The sample is predominantly composed of sub-rounded 0.2mm quartz grains of moderate sphericity, embedded in a carbonate cement. This lithology also contains 1% sub-rounded to cubic opaque grains, identified as magnetite.

While the aggregate is regarded as representing hard, strong and durable rock this potential may be undermined if used in acidic settings due to the high and variable incidence of calcite throughout the rock. Calcite is highly reactive and susceptible to degradation in low pH settings which might include acid runoff or groundwaters. Provided these conditions can be avoided the rock type represented by this aggregate is predicted to have broad potential as quality Unbound Pavements, Concrete Aggregate, Cover Aggregate and Asphalt Aggregate as well as produce suitable manufactured sand. The calcareous nature of the aggregate is expected to buffer concretes used in sewerage pipes and manhole covers and extend their life. A potential issue is the high abundance and foliated nature of the micaceous phases in the mica schist. Allocation to Cover and Asphalt Aggregates should be preceded by PAFV testing due to the potential for stripping and polishing in service of schistose rock. A mode based on a count of 200 widely spaced points is listed in Table 2.

Table 2. Modal Analysis of Minerals

MINERALS	MODE (per cent)	COMMENTS
Marble (80%)		
Calcite	76	Coarse-very coarse 2-6mm, sutured grain boundaries
Quartz	2	Occurring as spherical rounded inclusions in calcite
Tourmaline	1	Occurring as brown pleochroic hexagonal inclusions
Opaques	1	Cubic opaque including minor pyrite
Biotite Schist (15%)		
Biotite	7	Occurring as foliated 0.2mm laths
Muscovite	3	Clear foliated laths
Quartz	3	0.05mm subrounded grains
Feldspar	1	Rare reconstituted plagioclase set among quartz crystals
Opaques	1	Cubic opaques identified as magnetite
Calcareous Sandstone (5%)		
Calcite	3	Calcite occurs predominantly as very fine-grained cement
Quartz	2	Quarts occurs as 0.2mm sub-rounded grains
Opaques	Trace	Trace opaques identified as magnetite
Total	100	

Summary

When proven through materials testing this aggregate is expected to be suitable for use in Unbound Pavements, Concrete and gabion/revetment (from source rock) provided it is not exposed to acidic conditions including low pH runoff or groundwater. The sample, with the exception of the mica schist lithology, is expected to produce quality manufactured sand with further crushing and should bolster the pozzolan in concrete mixes due to its marble content. The aggregate may also augment calcareous aggregate used in concrete to make sewerage pipes and manhole covers. Calcareous aggregate provides a buffer against sulphide attack and will extend the usable life of these pipes.

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- Containing 7% free silica as unstrained to mildly strained crystals and duly regarded as innocuous in relation to ASR in concrete.

Free Silica Content

46% free silica content.

Alkali-Silica Reactivity (ASR) / Alkali Carbonate Reactivity (ACR) Potential

The sample supplied contains a minor amount of quartz, therefore the specimen is assessed being INNOCUOUS IN RELATION TO ALKALI SILICA REACTIVITY.

Carbonates in the form of calcite were observed in the specimen, however, no dolomite was observed and the sample is therefore assessed as having INNOCUOUS IN RELATION TO ALKALI CARBONATE REACTIVITY.

Asbestiform Minerals

Asbestos can be defined mineralogically and by crystal habit. For the purposes of health screening asbestiform habit is relevant, which is defined as being hair-like (filiform) and flexible with a high aspect ratio. Based on the observable minerals in the thin section, the sample is considered FREE FROM ASBESTIFORM MINERALS.

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Samples are disposed of after 3 months from the date of report. Thin sections will remain on site indefinitely.

The analysis is based on a limited number of thin sections and sample provided by client, further investigation may be required. Interpretations are specific to the sample examined only.