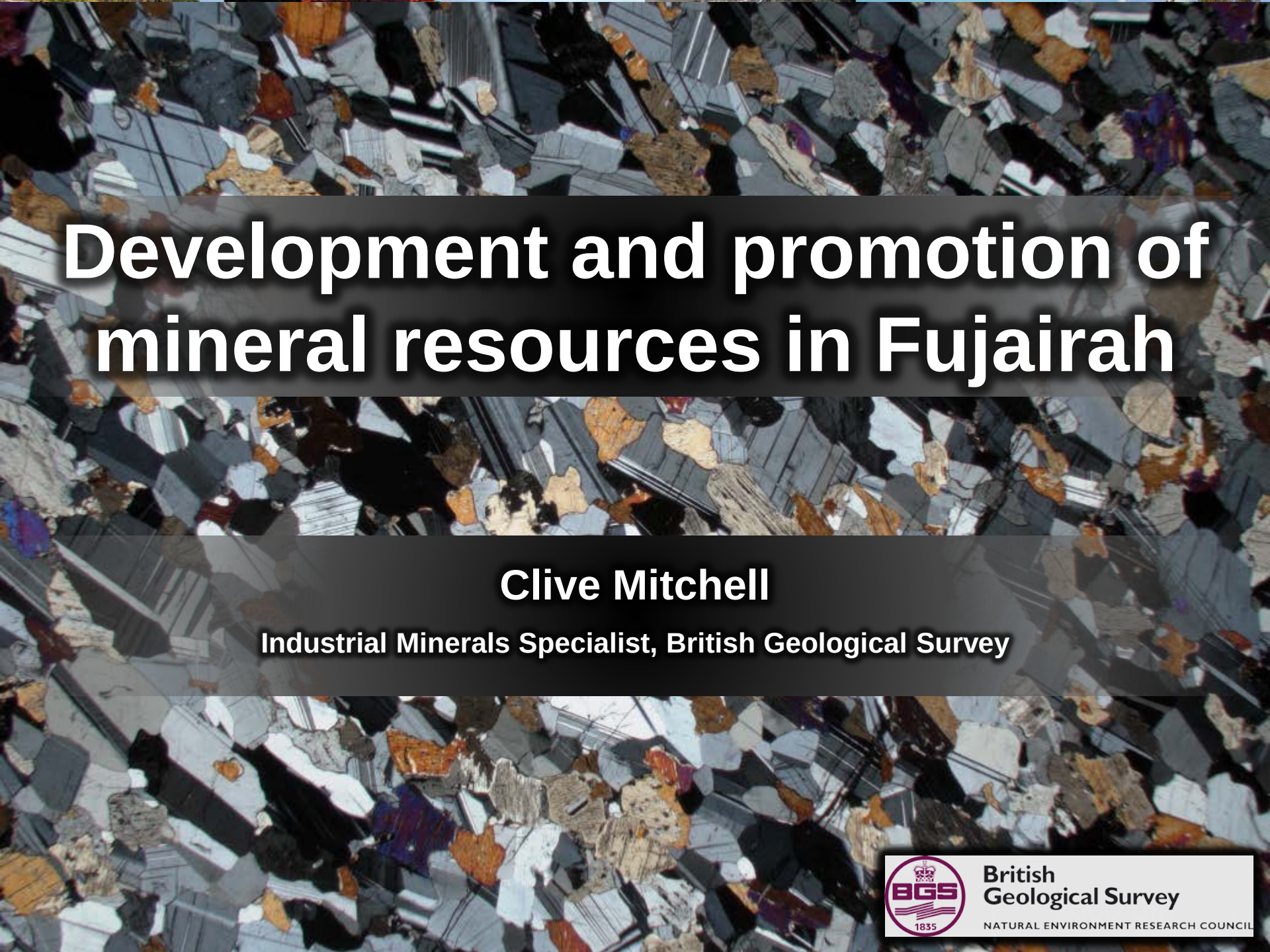


Development and promotion of mineral resources in Fujairah

Clive Mitchell

Industrial Minerals Specialist, British Geological Survey

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Outline of presentation

- Minerals at the British Geological Survey
- Overview of geology & mineral resources
- Resource assessment
- Mineral Promotion
- Conclusions

British Geological Survey

- National geo-survey for the UK focusing on Public National Good science and geological research.
- Our understanding of the subsurface helps society
    - Use its natural resources responsibly
    - Manage environmental change
    - Be resilient to environmental change
- Over 500 scientists working with other 40 universities & institutes
- More information: www.bgs.ac.uk

BGS Minerals and me

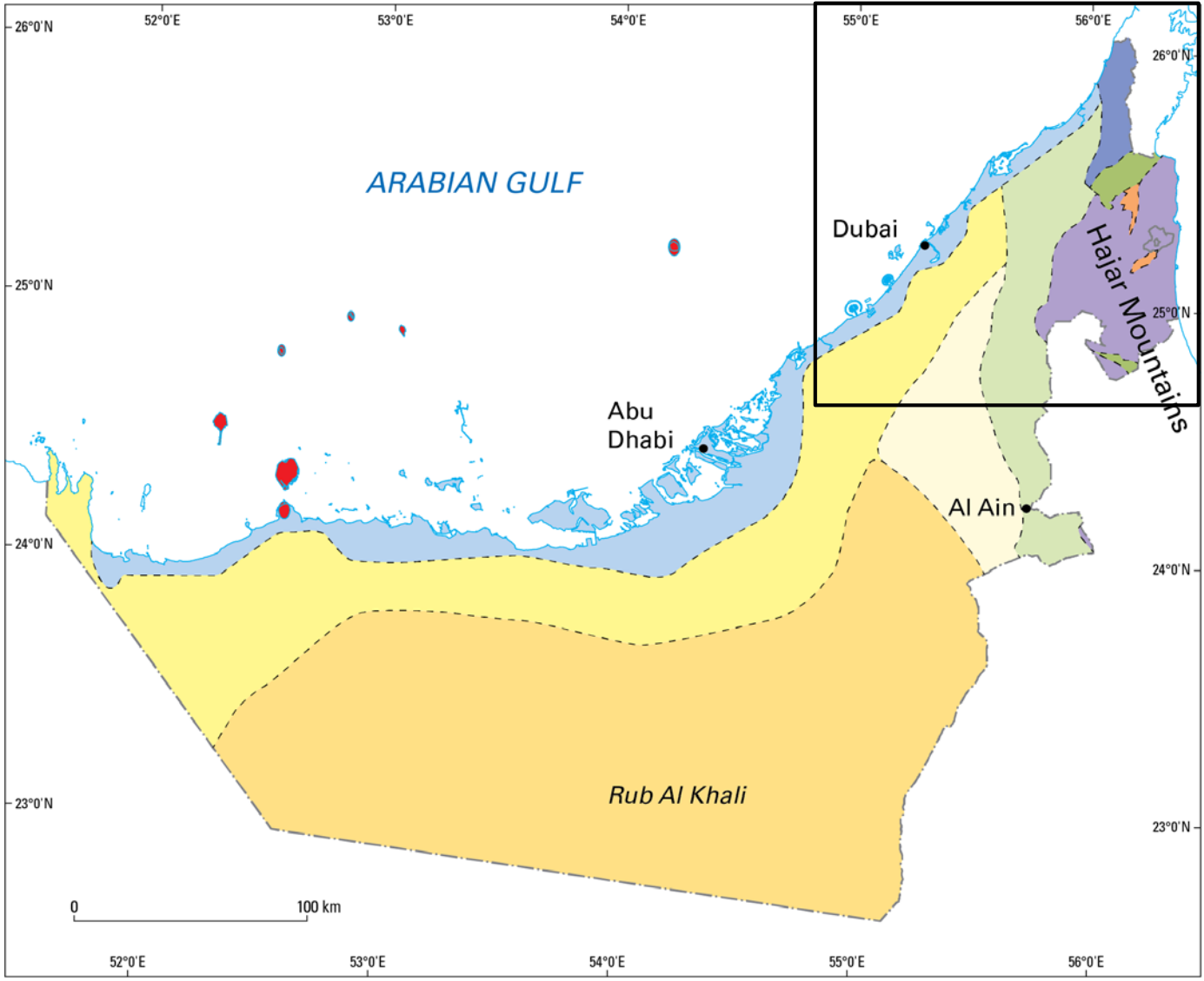
Clive at a silica sand quarry in UK

http://www.bgs.ac.uk/staff/profiles/1159.html

- Mineral statistics for UK, Europe & World
- Spatial mineral resource information
- Research (metallogenesis, land-use impacts of extraction, resource security)
- BGS minerals information via www.mineralsUK.com
- Industrial Minerals Specialist, 27 years at BGS, travelled far and wide for mineral evaluation, and based at BGS in UK

MineralsUK
Centre for sustainable mineral development

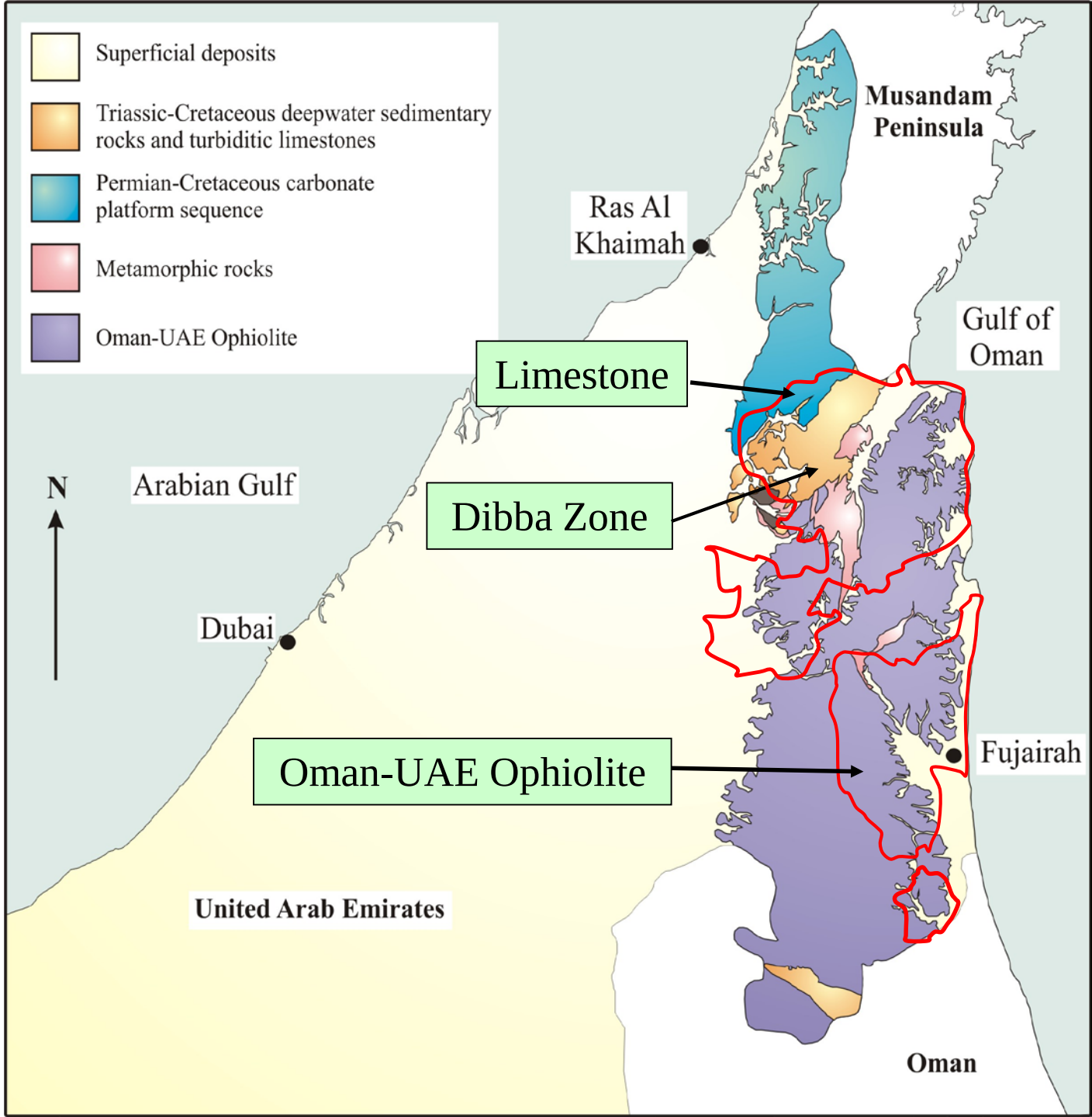
Simplified geology of the UAE



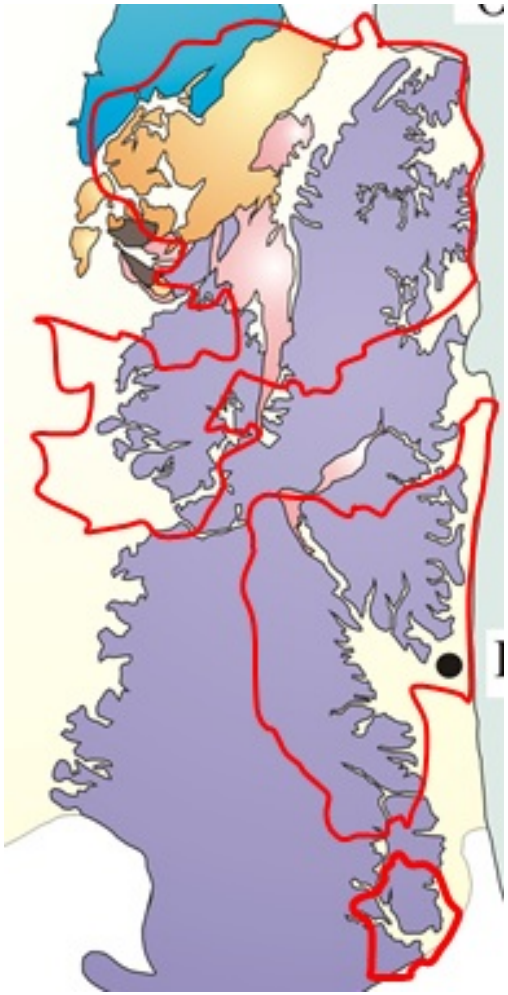
Key

- Quaternary to recent aeolian sand
- Holocene marine and near-shore carbonates
- Salt domes
- Late Miocene sedimentary rocks
- Fluvial gravels
- Late Cretaceous to Palaeogene Foreland Basin sediments
- Polydeformed metamorphic rocks
- Dibba Zone and Hatta Zone - Mainly deformed sediments
- Triassic to Upper Cretaceous - Mainly limestone
- UAE-Oman ophiolite

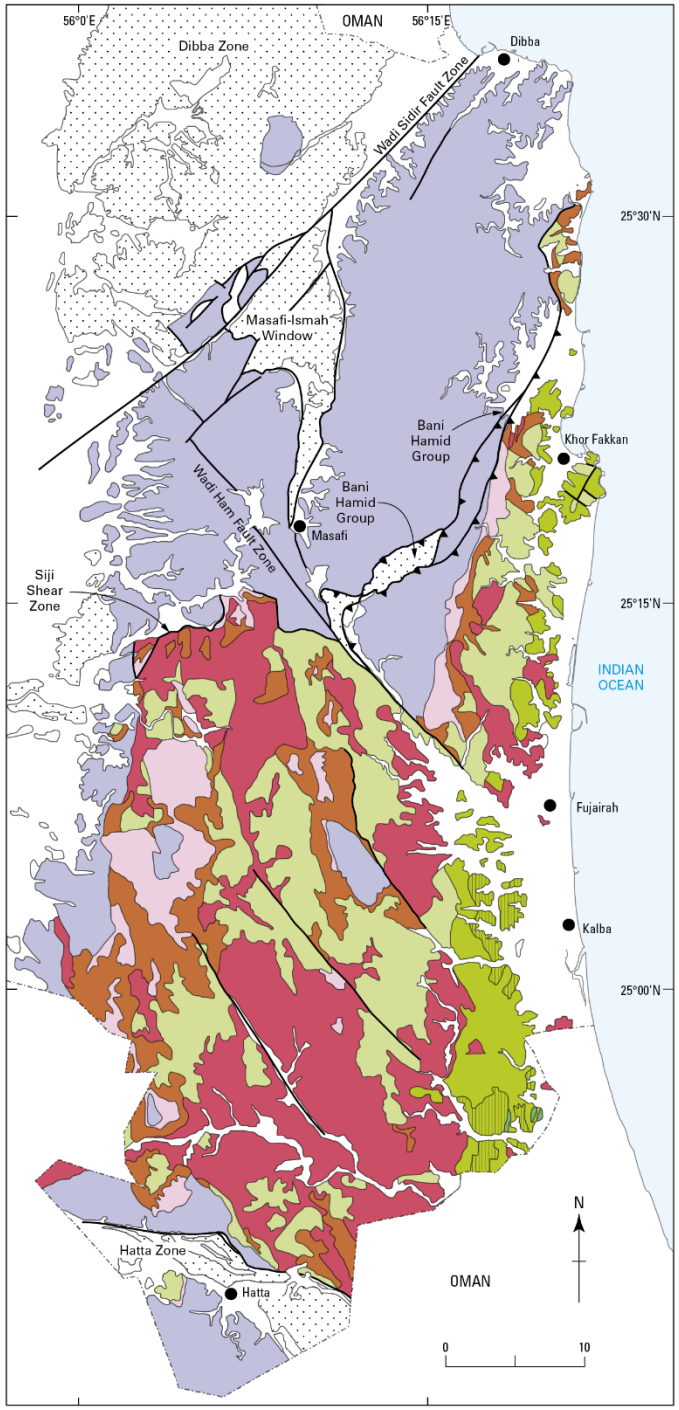
Simplified geology of the northern Emirates, UAE



Geology of Fujairah



- Late Cretaceous Ophiolite igneous rocks (gabbro & layered gabbro, harzburgite, dunite, sheeted dykes and pillow lavas)
- Dibba zone sequence of thin limestones, deep water sediments, volcanic rocks & mélanges.
- Limestone and dolomite of the Triassic – Late Cretaceous carbonate platform



Key

- Thrust
- Fault
- Superficial deposits
- Sedimentary & metamorphic rocks

UAE-OMAN OPHIOLITE

Phase 2 magmatic rocks

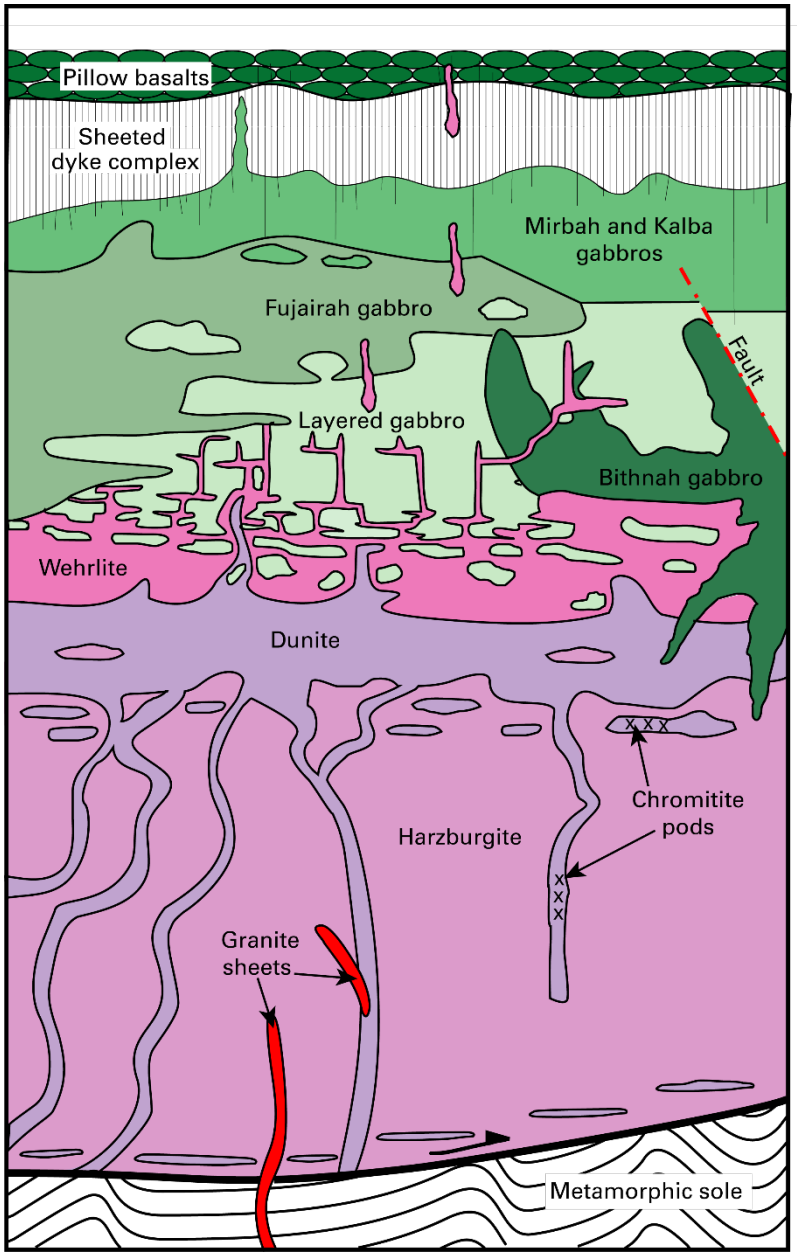
- Gabbro
- Mixed Unit (at the Moho Transition Zone)

Phase 1, MORB-type, magmatic rocks

- Pillow basalt
- Sheeted dyke complex
- High level gabbro
- Layered gabbro

Mantle rocks

- Dunite
- Harzburgite



Ophiolite sequence from the mantle to the crust

Oman-UAE Ophiolite

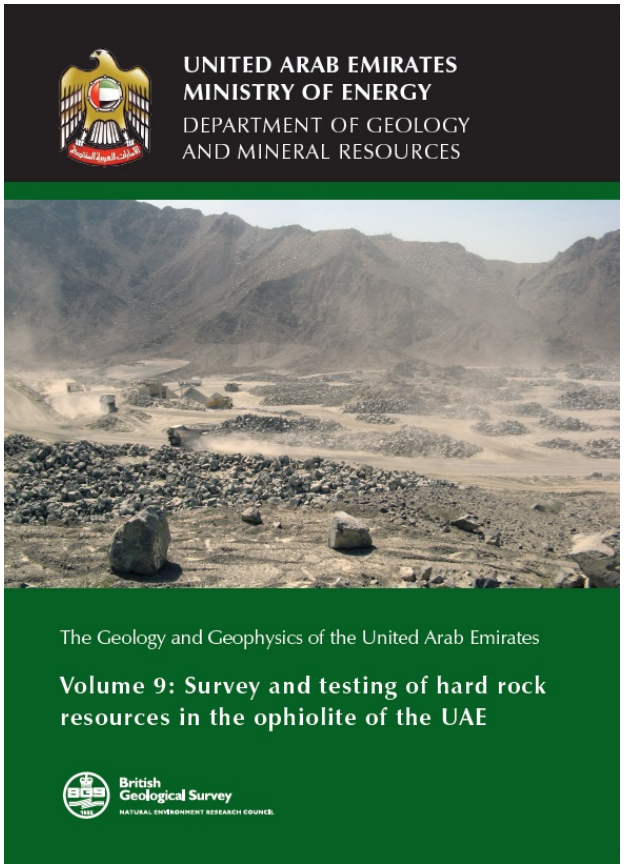
Carbonate platform sediments – Dhera Limestone Formation

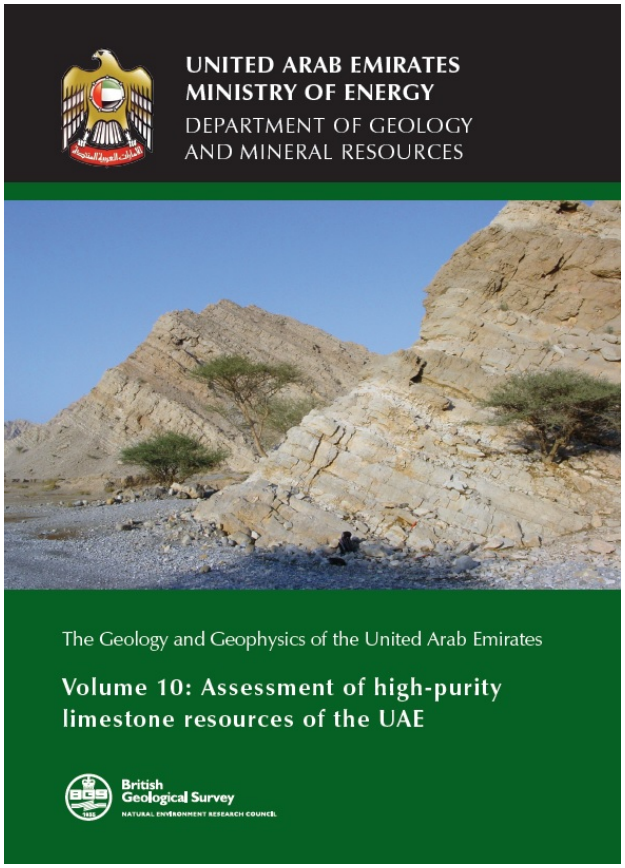
Folded deep water sediments in Dibba zone

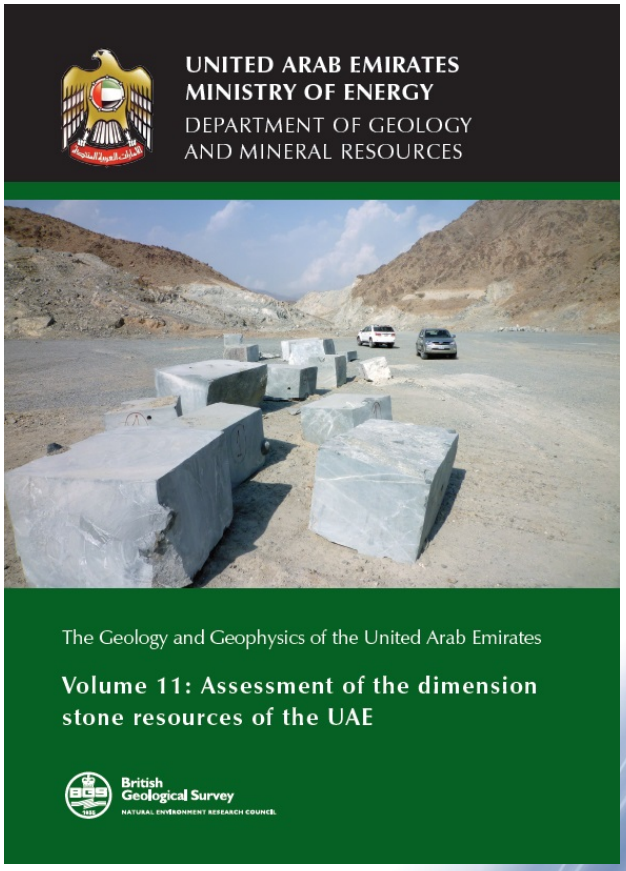
Mineral resources of Fujairah

- Gabbro for Construction Aggregate
- Basic igneous rock for Rock Wool
- Ophiolite & carbonate rocks for Building Stone
- Limestone and shale for Cement
- Shale for Ceramics
- No proven economic metal resources

BGS resource assessment in UAE







All geological reports and maps available from the UAE Ministry of Energy website here:

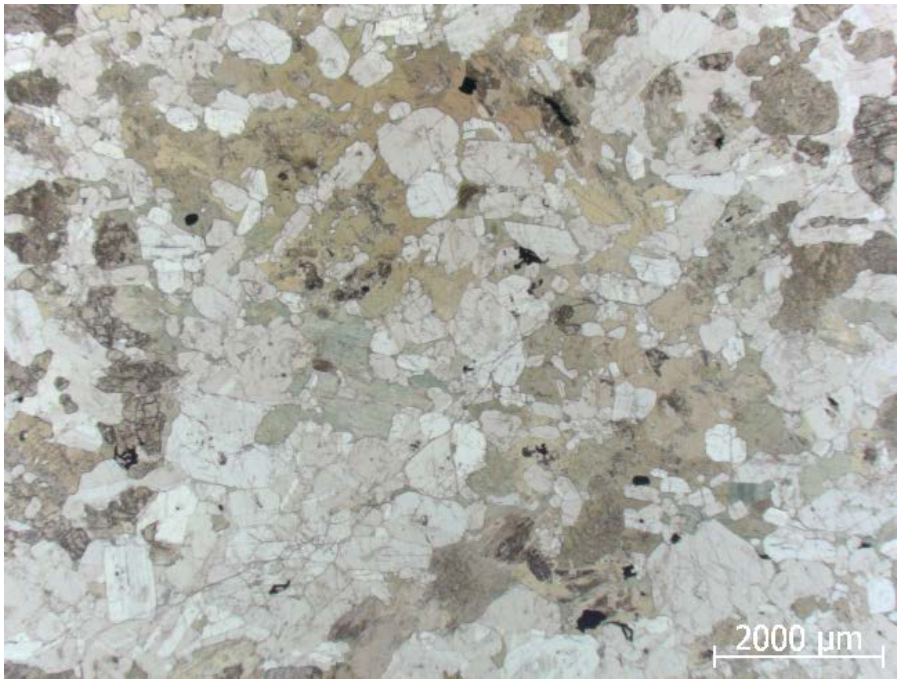
http://www.moenr.gov.ae/en/our-services/geological-reports.aspx

Hard Rock resources

- Fujairah has a well established construction aggregate industry working the ophiolite complex
- BGS hard rock suitability map identified high-grade aggregate areas including gabbro and dunite based on field and lab evaluation
- Map will assist planning and extension of existing operations, avoiding poor quality rock areas
- Buffer zones around towns and roads will help planning, exploration & minimise environmental impact

Aggregate from gabbro – Gabbro quarry near Fujairah

Random orientation of crystals gives good shape properties



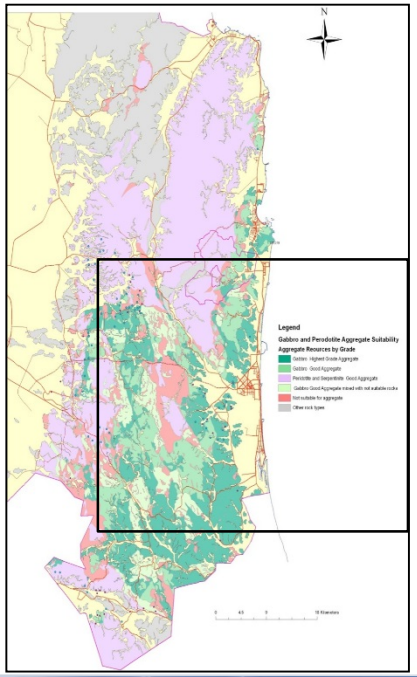
Aggregate suitability map

Legend

Gabbro and Perodotite Aggregate Suitability

Aggregate Reources by Grade

- Gabbro Highest Grade Aggregate
- Gabbro Good Aggregate
- Peridotite and Serpentinite Good Aggregate
- Gabbro Good Aggregate mixed with not suitable rocks
- Not suitable for aggregate
- Other rock types



High-purity limestone in UAE

- UAE imports 200,000 tpa of high-purity limestone (and dolomite) per year, no significant indigenous production
- Limestone survey identified high-purity limestone (and dolomite) resources in the northern Emirates
- Technical evaluation found they could be used for paint, paper, plastic, rubber, adhesives, glass, ceramics, food, pharmaceuticals and lime production.
- Development of these resources has potential to make substantial contribution to economic diversification of UAE

Limestone survey (2009-10): Mayhah Formation, Wadi Khabb

Limestone resources in Fujairah

- In Fujairah, the Dhera Limestone, Dibba, Mayhah, Muti and Sid’r Chert formations were evaluated to assess their potential for the production of high-purity limestone (or dolomite)
- Technical evaluation found that no occurrences of high-purity limestone (or dolomite) in Fujairah

Dimension stone resources

- UAE has a thriving dimension stone industry using imported stone e.g. from India, Saudi Arabia, Spain and China.
- However there is no significant production of dimension stone from UAE quarries
- Resources suitable for dimension stone in Fujairah include Ausaq Conglomerate, Dhera Limestone and Mayhah formations, Fujairah and Kalba Gabbro, Layered Gabbro and Harzburgite.

Dhera Limestone Formation, Ghub, Fujairah

Fujairah Gabbro, Al Badr quarry, Fujairah

TheNational

Volume 3 Issue 195

Sunday, October 31, 2010 www.thenational.ae

The search for marble

A team from the British Geological Survey are scouring the country for useful deposits of marble to reduce imports and boost the local economy. Above, Richard Ellison, left, and Clive Mitchell in Wadi Bih in Ras al Khaimah. Story, page a5. Jaime Puebla / The National

numbers

67,600
tonnes is the amount of marble imported last year

300
million years is the age of many stones in wadi areas of the UAE

90
million dirhams is the cost of the geological survey of the country

10
years is the estimated duration of the survey project

Surveyors looking for 'nice stones' in the rough

Clive Mitchell, left, of the British Geological Survey and Richard Ellison survey Wadi Bih for limestone and marble deposits. Photos by Jaime Puebla / The National

Team searches for sources of marble

Ten-year survey means every corner of the country has been under the geologists' hammers

Martin Croucher

RAS AL KHAIMAH // Dressed in khaki shorts and resembling a wiry school teacher, Clive Mitchell bounds enthusiastically across the rocks of Wadi Bih seeking slabs of marble, which could one day become gleaming facades in five-star hotels.

He and a team from the British Geological Survey (BGS) are scouring the country for useful deposits of the stone to reduce imports and boost the local economy. Their project is part of a Dh90 million study of the Emirates scheduled to last 10 years.

"Most of the decorative stones that you see in the UAE at the moment are imported, I'd say almost 99.9 per cent," Mr Mitchell said. "We want to see whether the country can substitute that material coming in for its own domestic industry."

The Emirates imported some US$18 million (Dh66m) in marble last year, or more than 67,600 tonnes, mostly from Iran and Oman but also from Turkey, Italy and China.

In March, the federal Ministry of Energy commissioned the BGS team to assess whether local stone could match that supply.

The project is a bolt-on to a survey which began in 2002 under its regional director Richard Ellison.

"We've found some nice stones," Mr Ellison said. "In fact, we saw a stone last week in Dubai which was imported from Turkey. It looked just like this one here," he said, pointing at a boulder at his feet.

The BGS report, expected to be ready by March of next year, is unlikely to make an overt case for exploiting any natural resources uncovered in the survey. However, the Ministry of Energy has expressed an interest in the findings should they yield evidence that might boost RAK's economy.

"If the report presents any economic implications, of course we will act on that," said Abdullah Gahnoog, an adviser in the ministry's petroleum and mineral resources sector.

The wider 10-year survey has covered every corner of the country and no area larger than two square kilometres will have escaped the eyes of BGS researchers when the fieldwork concludes next year.

The findings are likely to become a useful resource for builders, particularly in Masdar City. The plans for the world's first carbon-neutral city stipulate that its construction materials should come from within a 500km radius of Abu Dhabi.

"If a decorative stone has come from China, it's travelled a long way to get here," Mr Mitchell said. "It's a much higher carbon footprint than stones which are transported within the country."

Despite being unable to find gold, copper, diamonds or much platinum to speak of, a revolving team of around 40 BGS researchers has made some worthwhile discoveries.

Many of the stones found in the wadi areas of the country are 300 million years old and were underwater long before the tectonic plate on which the country sits was shoved up on land around 90 million years ago.

"This is an area which is of very high scientific importance," said Mr Ellison, his eyes glowing. "You don't normally see rock which has been under the ocean and is now on land."

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Mr Mitchell exams a rock in the mountains of Wadi Bih.

Mineral Development & Promotion

- Assessment of selected sites including market demand, infrastructure and extraction and processing
- Investment brochures, poster maps and book on UAE mineral resources
- Mineral Promotion website
- Exhibitions and showcase events e.g. Big 5 Dubai
- Use of UAE stone in nationally important and prestigious building projects as a showcase

United Arab Emirates
Ministry Of Energy
Department of Geology
and Mineral Resources

Dimension stone of the UAE

Dimension stone covers a wide variety of highly polished, natural occurring stones used for the external cladding, structural components and internal decoration of buildings. The United Arab Emirates (UAE) has a thriving dimension stone industry that relies on stone mainly imported from India, Saudi Arabia, Spain, China, Oman, Italy, Iran, Turkey, Greece and Pakistan. The quarrying industry in the UAE mainly produces crushed rock aggregate, building sand and cement raw materials; there is no significant production of dimension stone from quarries in the UAE.

As part of work funded by the UAE federal Ministry of Energy, the potential to develop the indigenous dimension stone resources of the mountainous area of the northern Emirates was assessed. The stone resources can be split into two broad groups, the limestone mountains to the east of Ras Al Khaimah and the ophiolite mountains to the west of Fujairah, as shown in Figure 1.

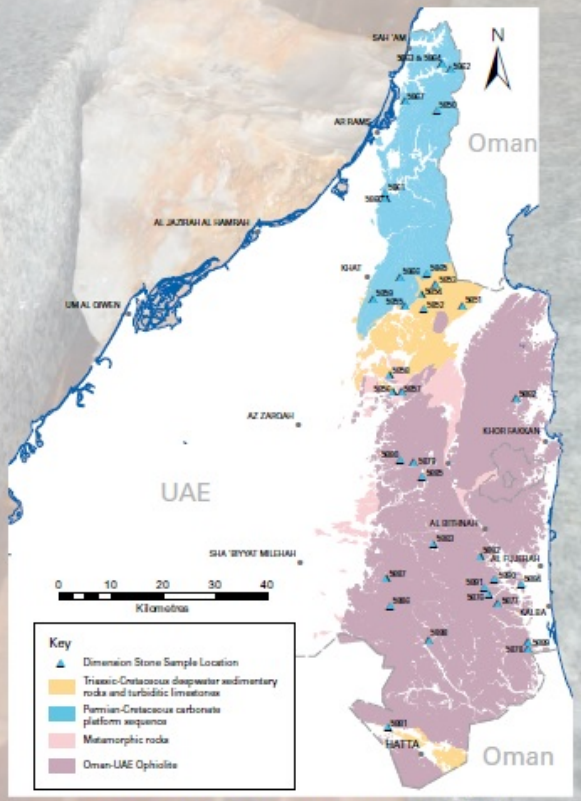

Figure 1. Location of potential dimension stone resources in the UAE.

United Arab Emirates
Ministry Of Energy
Department of Geology
and Mineral Resources

British Geological Survey
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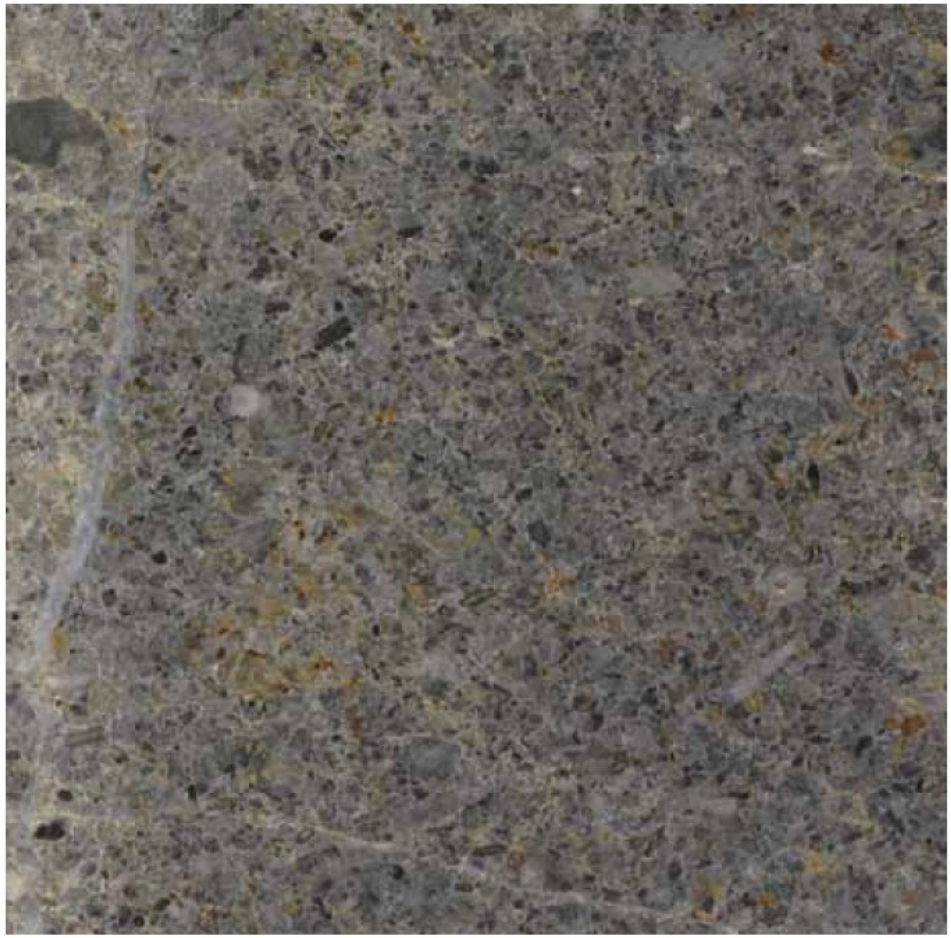
Dimension stone promotion brochure

UAE dimension stone properties

No.	Water Absorption %	Saturation Coefficient %	Apparent Density Mg/m³	Apparent Porosity %	Compressive Strength MPa
5850	0.15	0.78	2.70	0.49	236
5851	0.15	0.84	2.70	0.40	178
5852	0.37	0.82	2.66	1.04	184
5853	0.08	0.81	2.70	0.23	155
5855	0.25	0.79	2.69	0.85	206
5856	0.14	0.83	2.73	0.39	171
5857	0.09	0.94	2.73	0.24	243
5858	0.07	0.78	2.70	0.21	193
5859	0.02	0.81	2.70	0.07	277
5860	1.05	0.88	2.65	2.83	225
5861	0.19	0.41	2.82	1.35	186
5862	0.25	0.70	2.72	0.86	199
5865	0.01	0.79	2.71	0.04	241
5866	0.01	0.76	2.72	0.03	243
5867	0.15	0.78	2.69	0.45	199
5877	0.04	0.86	2.93	0.16	217
5878	0.07	0.79	2.95	0.25	294
5879	0.34	0.97	2.75	1.06	155
5880	0.22	0.83	2.78	0.87	151
5881	0.07	0.82	2.70	0.23	199
5882	0.05	0.86	2.94	0.15	216
5883	0.04	0.91	2.94	0.13	292
5884	0.04	0.74	2.95	0.12	332
5885	0.15	0.89	2.83	0.44	206
5886	0.10	0.75	2.73	0.37	178
5887	0.10	1.00	2.86	0.29	177
5888	0.08	0.79	3.01	0.24	294
5889	0.14	0.84	2.95	0.50	278
5890	0.70	0.79	2.91	2.40	236
5891	0.03	0.86	2.92	0.06	323
5892	0.17	0.84	2.88	0.59	182

Dimension stone from Fujairah



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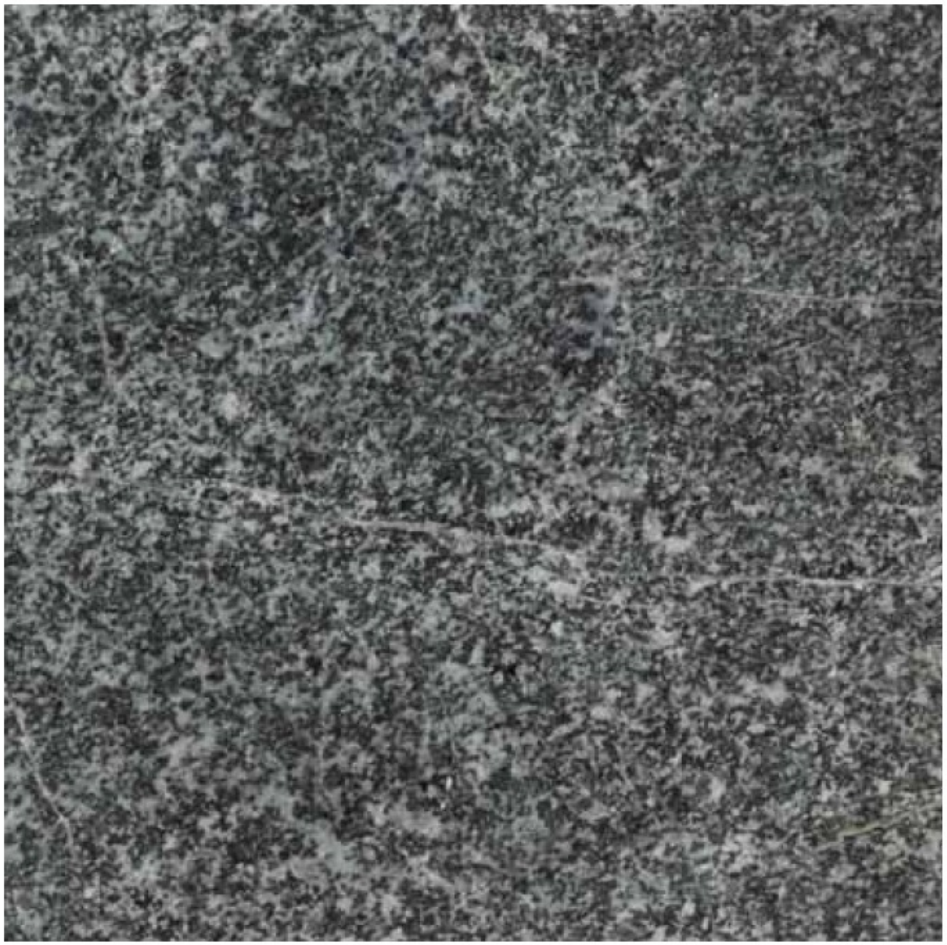
Dhera Limestone Formation, Ghub, Dibba, Fujairah



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Fujairah Gabbro, Fujairah

Conclusions

- Fujairah has large resources of rock for aggregate, future development guided by suitability map
- No apparent potential for the production of high-purity limestone in Fujairah
- Good potential for further development of dimension stone industry in Fujairah
- Mineral Promotion activity holds the key to future investment and development

Thank you for your attention!

Clive Mitchell

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