CAPSIZE OF BULK CARGO CARRYING BAUXITE FROM KUANTAN: INVESTIGATION OF GEOTECHNICAL PROPERTIES OF KUANTAN BAUXITE

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GEOTECHNICAL ENGINEERING

Geotechnical engineering is the branch of civil engineering concerned with the engineering behavior of earth materials. Geotechnical engineering is important in civil engineering, but also has applications in military, mining, petroleum and other engineering disciplines that are concerned with construction occurring on the surface or within the ground. Geotechnical engineering uses principles of soil mechanics and rock mechanics to investigate subsurface conditions and materials; determine the relevant physical/mechanical and chemical properties of these materials; evaluate stability of natural slopes and man-made soil deposits; assess risks posed by site conditions; design earthworks and structure foundations; and monitor site conditions, earthwork and foundation construction.

Terzaghi, K., Peck, R.B. and Mesri, G. (1996), *Soil Mechanics in Engineering Practice* 3rd Ed., John Wiley & Sons, Inc.

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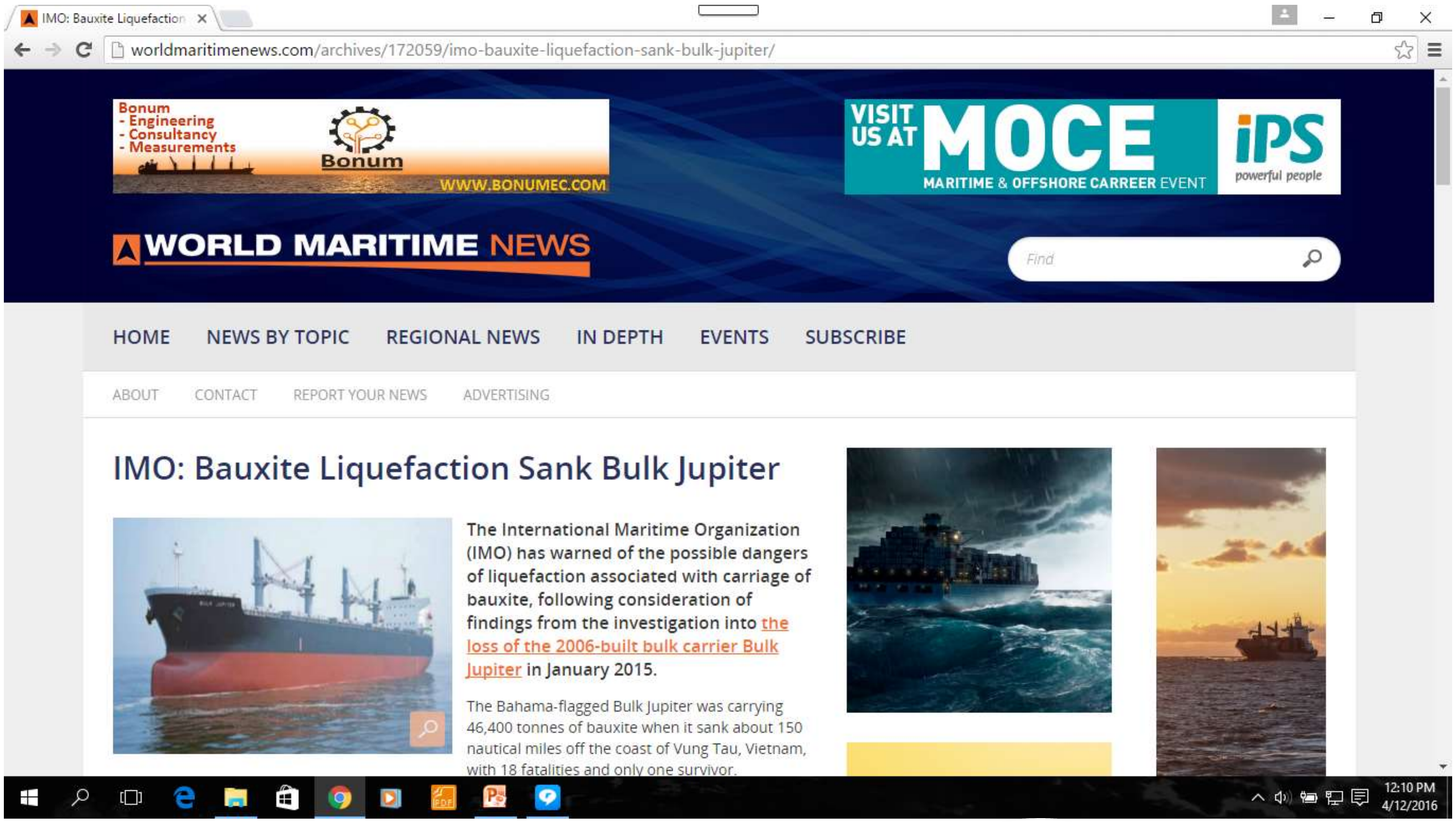
MAIN ISSUE


IMO: Bauxite Liquefaction

worldmaritimenews.com/archives/172059/imo-bauxite-liquefaction-sank-bulk-jupiter/

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IMO: Bauxite Liquefaction Sank Bulk Jupiter

The International Maritime Organization (IMO) has warned of the possible dangers of liquefaction associated with carriage of bauxite, following consideration of findings from the investigation into the loss of the 2006-built bulk carrier Bulk Jupiter in January 2015.

The Bahama-flagged Bulk Jupiter was carrying 46,400 tonnes of bauxite when it sank about 150 nautical miles off the coast of Vung Tau, Vietnam, with 18 fatalities and only one survivor.

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TRAGEDY OF BULK CARGO JUPITER

http://www.xaluan.com/

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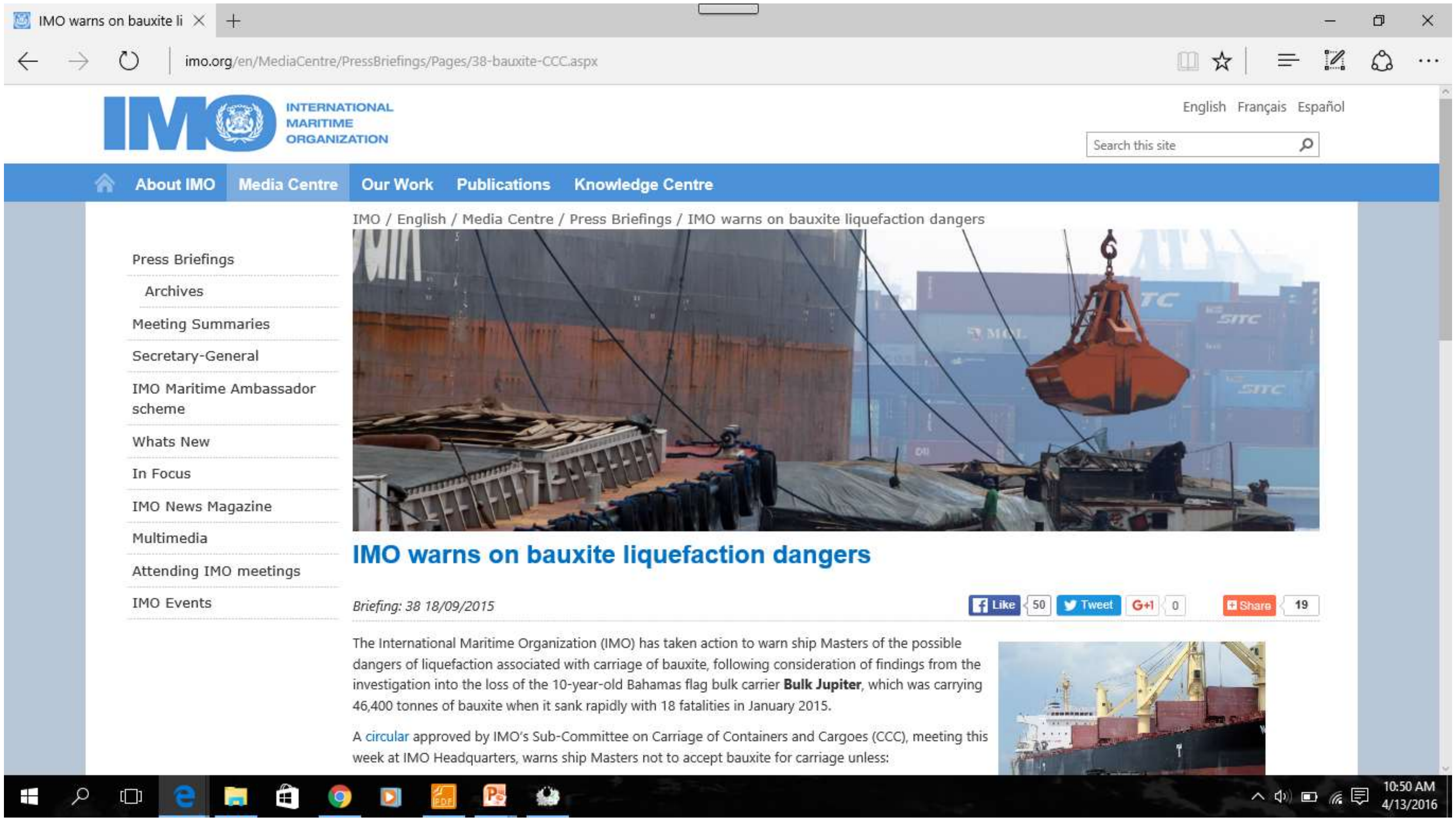

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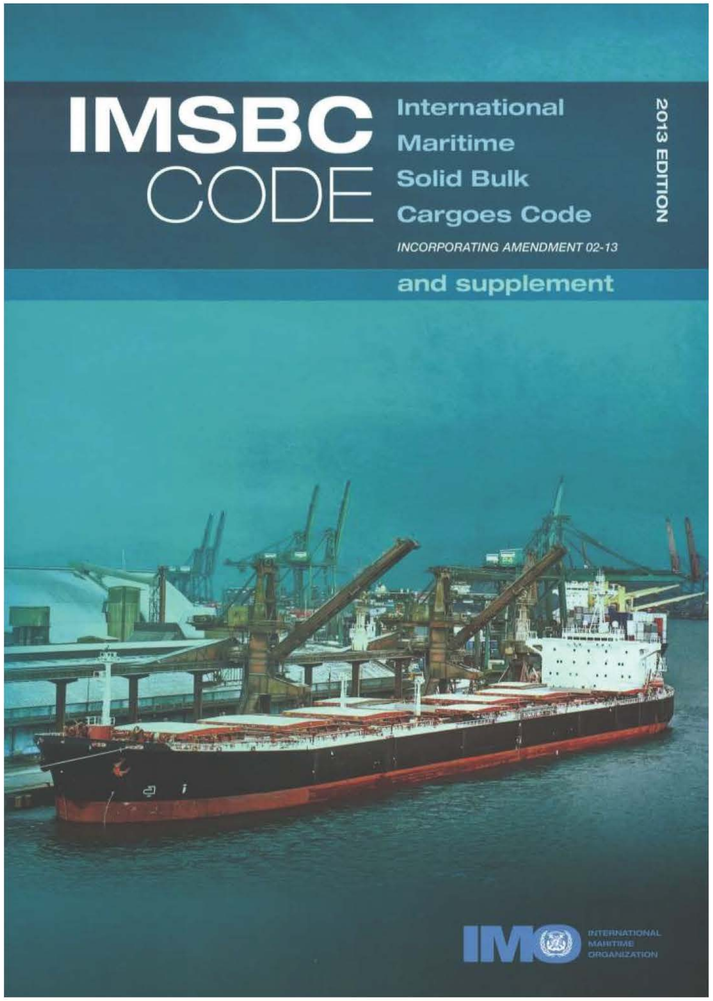
LIQUEFACTION

"Liquefaction occurs when a cargo (which may not appear visibly wet) has a level of moisture in between particles. During a voyage, the ship movement may cause the cargo to liquefy and become viscous and fluid, which can lead to cargo flowing with the roll of the ship and potentially causing a dangerous list and sudden capsize of the vessel. Special consideration and precautions should be taken when loading a cargo which may liquefy. "



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IMSBC CODE

BAUXITE

DESCRIPTION

A brownish, yellow claylike and earthy mineral. Moisture content: 0% to 10%. Insoluble in water.

CHARACTERISTICS

ANGLE OF REPOSE	BULK DENSITY (kg/m^3)	STOWAGE FACTOR (m^3/t)
Not applicable	1190 to 1389	0.72 to 0.84
SIZE	**CLASS**	**GROUP**
70% to 90% lumps: 2.5 mm to 500 mm 10% to 30% powder	Not applicable	C

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IMSBC CODE

Clients will be aware that bauxite is classed as a Group C cargo in the International Maritime Solid Bulk Cargoes (IMSBC) Code i.e. neither liable to liquefy (Group A) nor to possess chemical hazards (Group B). Bauxite is described as 'a brownish, yellow claylike and earthy mineral, insoluble in water.'

In order to be classified as Group C bauxite must have properties within the following parameters:
Moisture content between 0% to 10%.
Size - 70% to 90% lumps, varying between 2.5 mm and 500 mm and 10% to 30% powder.

Section 2.1 of the IMSBC Code, states:
"Many fine-particled cargoes, if possessing a sufficiently high moisture content, are liable to flow. Thus any damp or wet cargo containing a proportion of fine particles should be tested for flow characteristics prior to loading".

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EFFECTS OF LIQUEFACTION CAUSED BY THE EARTHQUAKE ON APARTMENT BUILDINGS IN NIIGATA

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NIIGATA EATHQUAKE 1964

There were 3,534 houses destroyed and a further 11,000 were damaged. This level of damage is explained by the influence of poor sub-soil conditions. Most of the lower part of the city of Niigata is built on recent deltaic deposits from the Shinano and Agano rivers, mainly consisting of unconsolidated sand. Shaking during the earthquake caused liquefaction with instantaneous compaction and formation of many sand volcanoes. Maps of areas of subsidence and sand volcanoes were found to match closely with old maps of the position of former river channels. Subsidence of up to 140 cm was measured over wide areas associated with the liquefaction. In one area of apartment buildings built on reclaimed land by the Shinona River, most of the blocks became inclined, one of them being completely overturned. This was despite relatively low levels of ground acceleration recorded by strong motion accelerographs placed in one of these buildings.

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LIQUEFACTION

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LIQUEFACTION

CARGO LIQUEFACTION

Ref: Iron Ore Fines Risk Of Carriage By Sea

- The cargo starts to shift in one direction with the ship's rolling and does not return to the center. Further rolling of cargo causes listing. This situation may generate loss of ship stability and potentially capsizing [5].

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CARGO LIQUEFACTION

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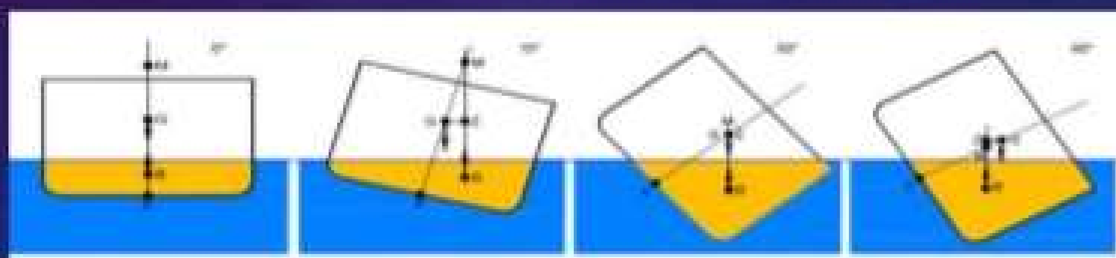
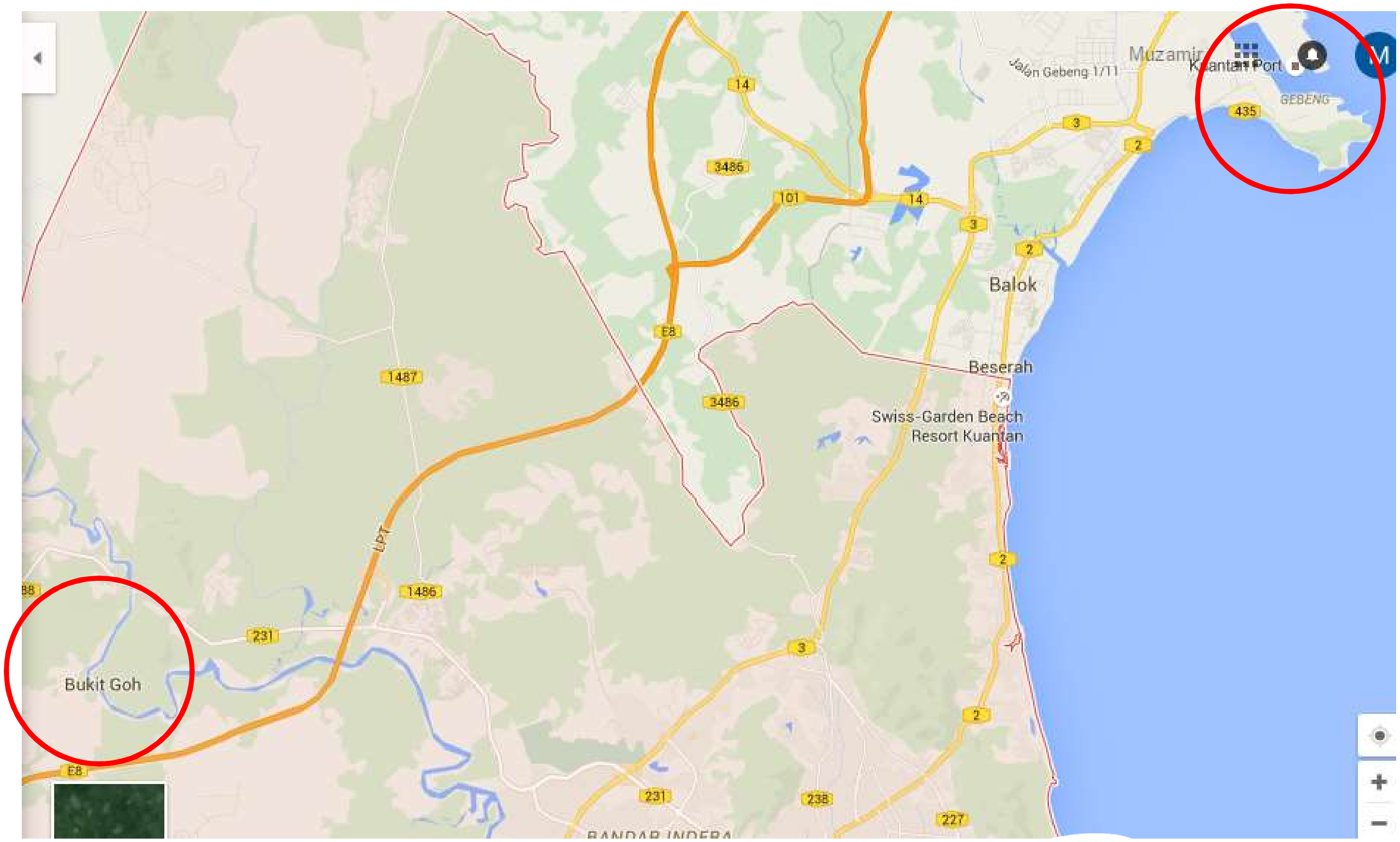
CARGO LIQUEFACTION

- There have been a series of total losses and near misses caused by cargo liquefaction. This may result in serious stability problems as loss of lives and total loses of ship.



- Liquefaction which reduces ship's positive stability and metacentric height (GM) may cause possible loss of the ship [8].

CASE STUDY



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BAUXITE

Bauxite, an aluminium ore, is the world's main source of aluminium. It consists mostly of the minerals gibbsite ($Al(OH)_3$), boehmite (γ-AlO(OH)) and diaspore (α-AlO(OH)), mixed with the two iron oxides goethite and haematite, the clay mineral kaolinite and small amounts of anatase (TiO_2) and ilmenite ($FeTiO_3$ or $FeO.TiO_2$). In 1821 the French geologist Pierre Berthier discovered bauxite near the village of Les Baux in Provence, southern France. In 1861, French chemist Henri Sainte-Claire Deville named the mineral "bauxite".

Source: https://en.wikipedia.org/wiki/Bauxite

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BAUXITE SAMPLES

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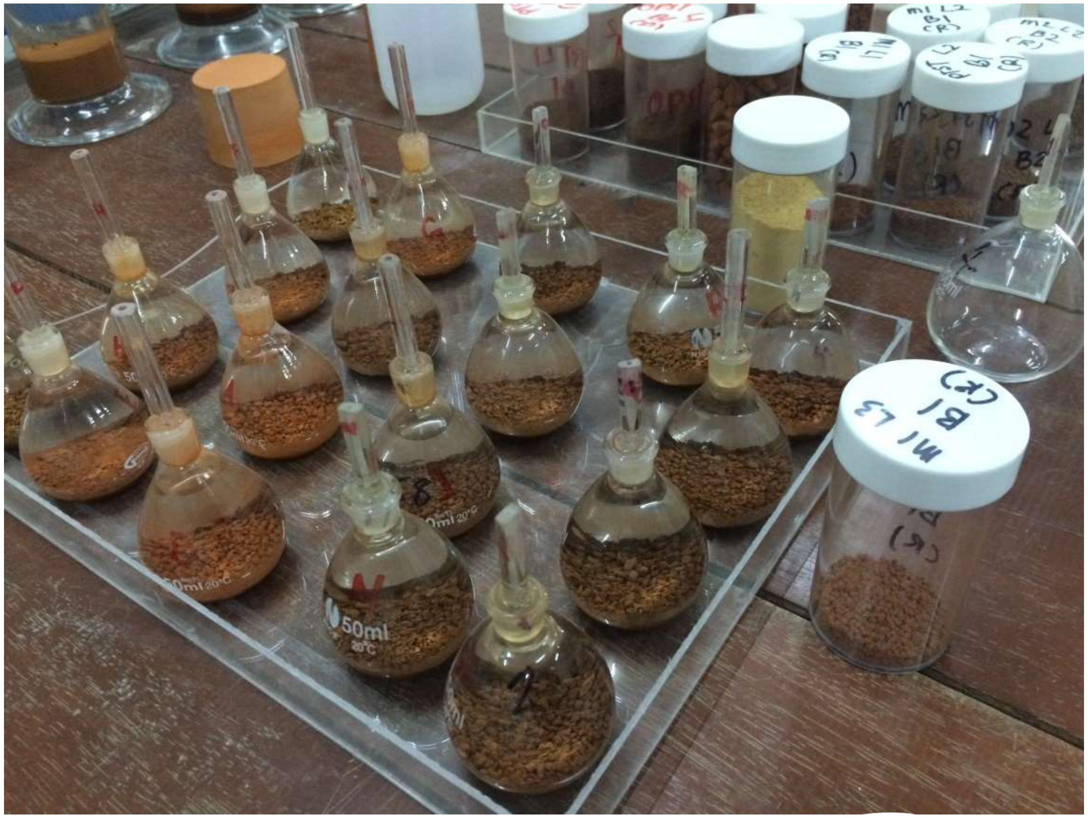

BAUXITE SAMPLES

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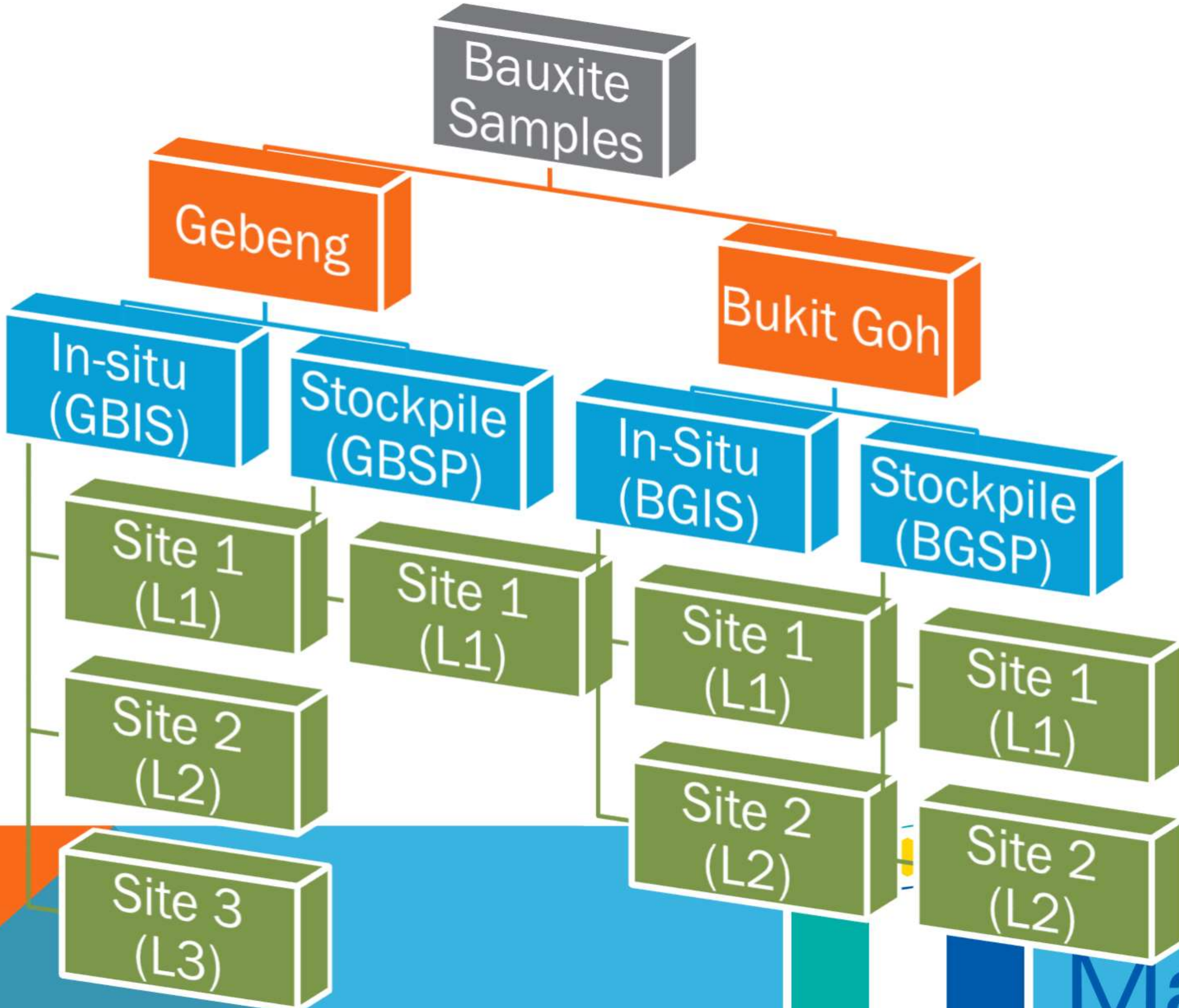
SAMPLES


Bauxite Samples
Gebeng
Bukit Goh
In-situ (GBIS)
Stockpile (GBSP)
In-Situ (BGIS)
Stockpile (BGSP)
Site 1 (L1)
Site 2 (L2)
Site 3 (L3)
Site 1 (L1)
Site 1 (L1)
Site 2 (L2)
Site 1 (L1)
Site 2 (L2)

MOISTURE CONTENT (OVEN DRY) – "OVEN HOT" LOCATION: BUKIT GOH (IN-SITU)

Sample No. : **LOC1 BUCKET#1)**		**1**	**2**
Mass of wet soil + container (m2)	g	587.05	573.79
Mass of dry soil + container (m3)	g	510.84	496.71
Mass of container (m1)	g	236.92	217.11
Mass of moisture (m2 - m3)	g	76.21	77.08
Mass of dry soil (m3 - m1)	g	273.92	279.60
Moisture Content,w= $\frac{(m2 - m3)}{(m3 - m1)}$	%	27.82	27.57
Average moisture content w,	%	27.69	

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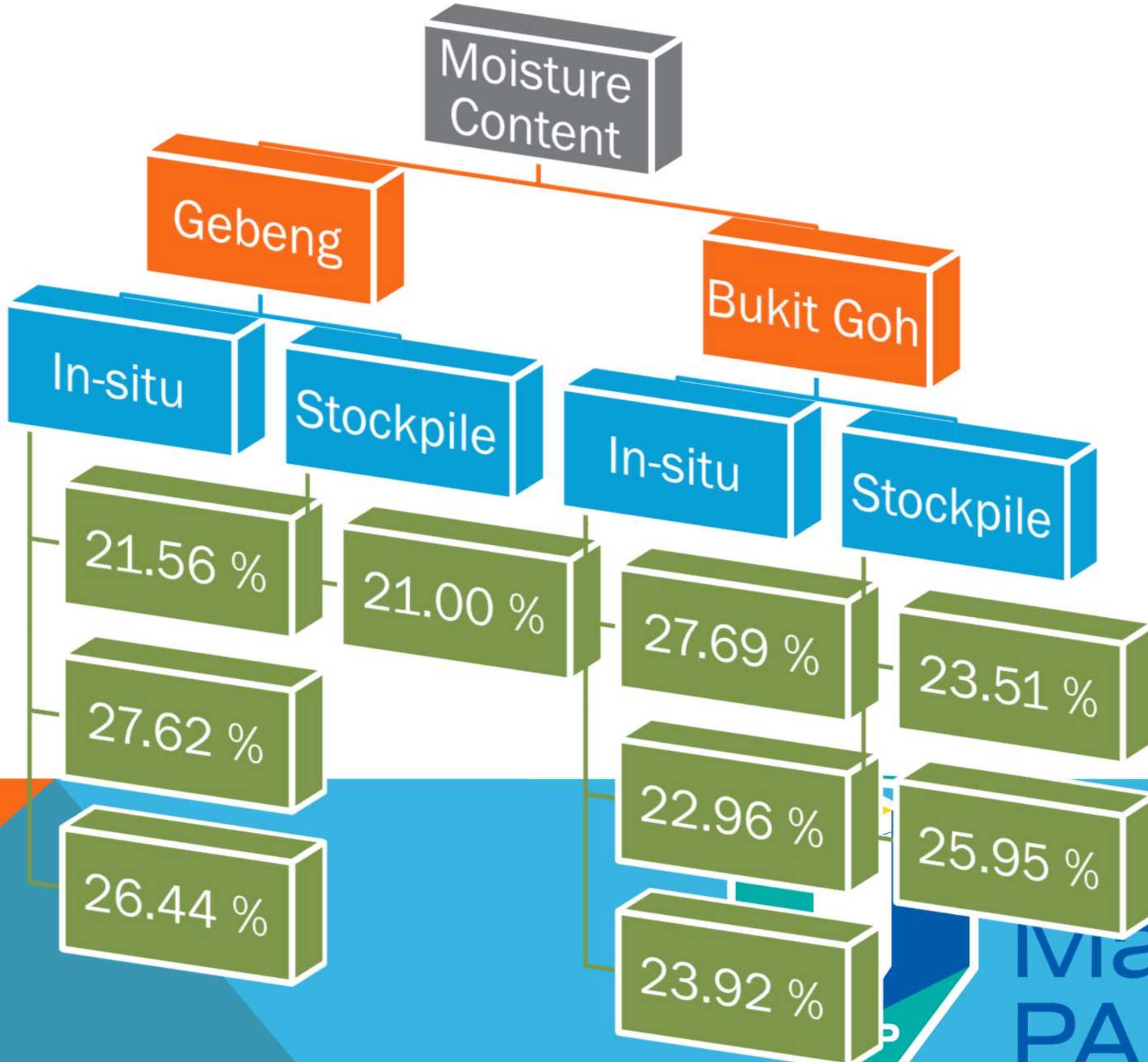
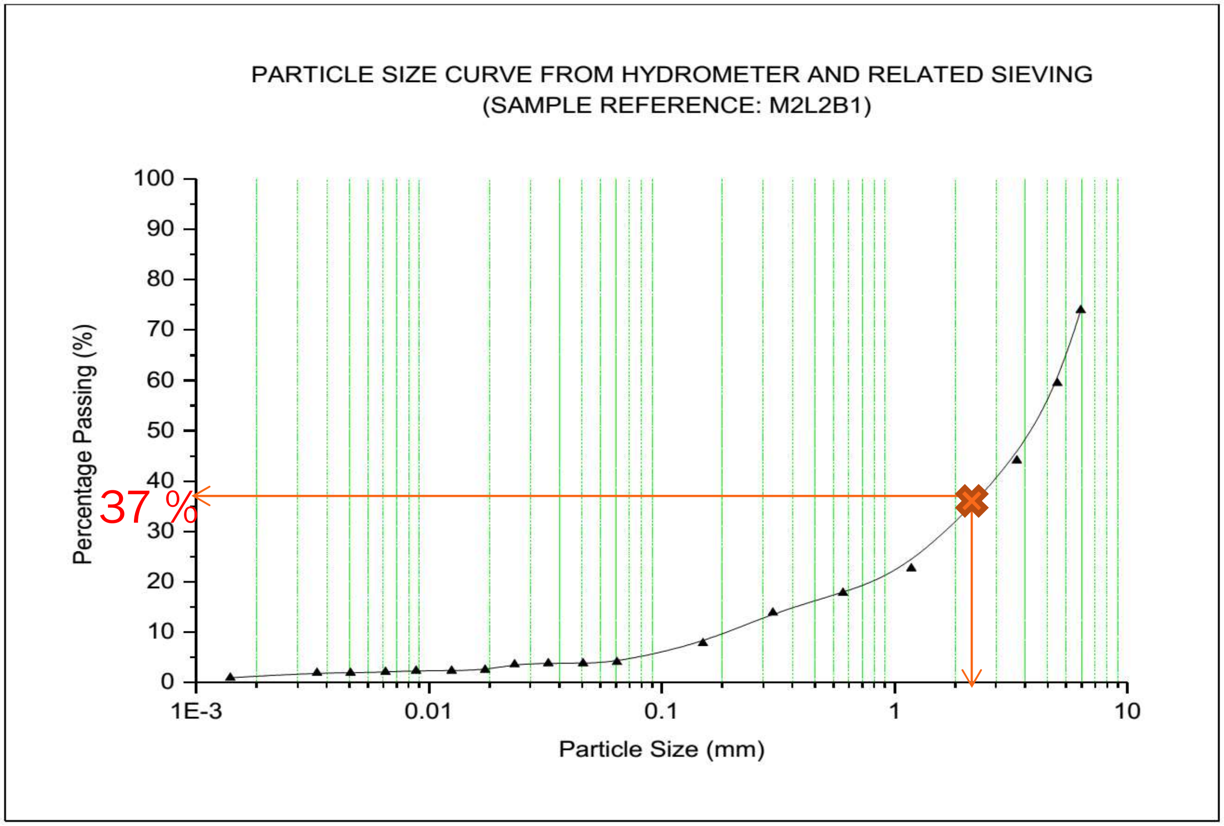
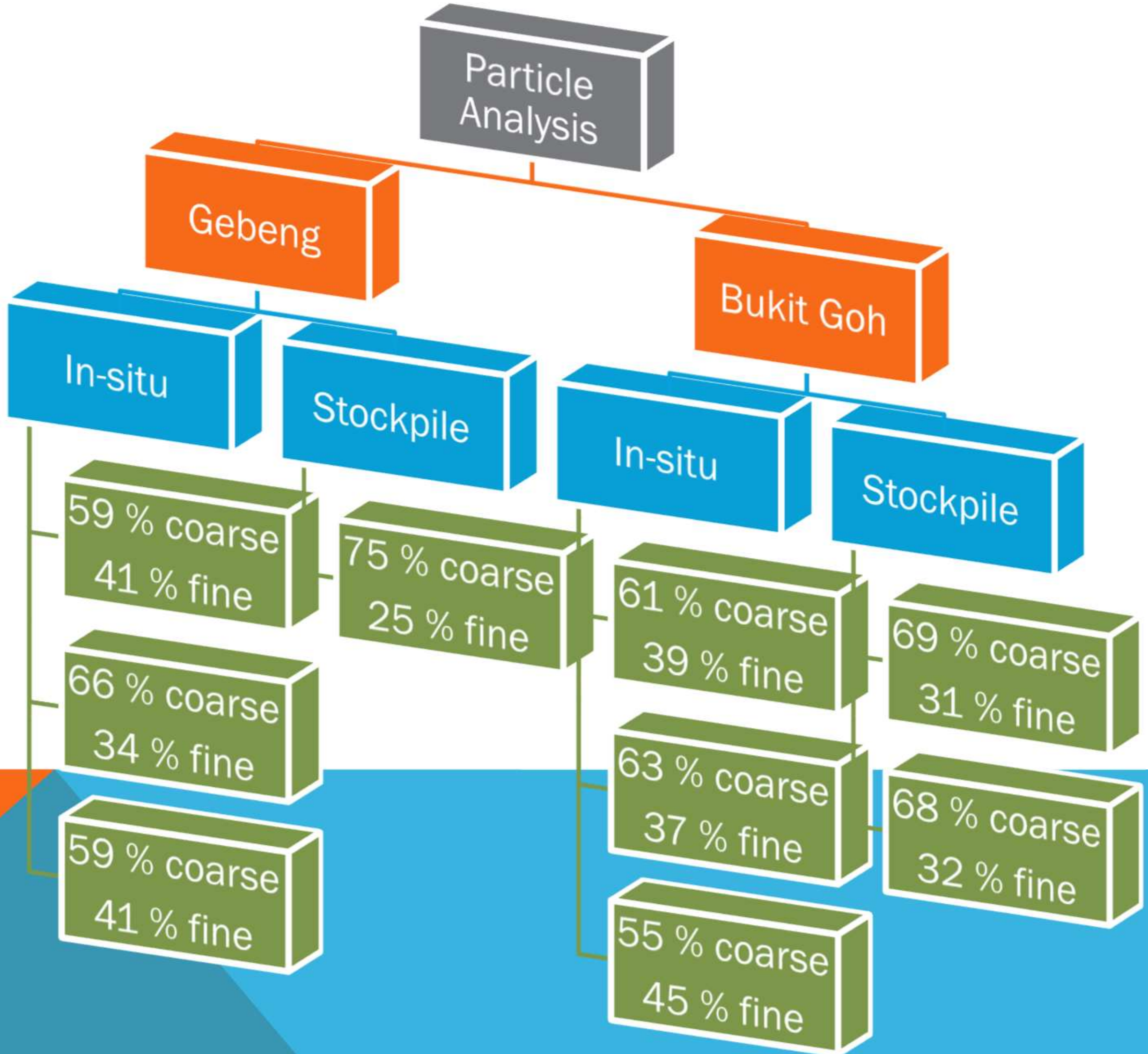
MOISTURE CONTENT



PARTICLE SIZE ANALYSIS
LOCATION: BUKIT GOH (IN-SITU)



PARTICLE SIZE ANALYSIS



SPECIFIC GRAVITY
LOCATION: GEBENG (IN-SITU)

Item	Description		M1 L1 B1		M1 L2 B1	
1	Density bottle no.		A	B	C	D
2	Weight of density bottle	g	22.11	19.79	21.54	22.04
3	Weight of density bottle + Stopper	g	27.33	24.84	26.72	27.02
4	Weight of density bottle + Stopper + Dry Soil	g	34.88	32.39	34.30	34.60
5	Weight of density bottle + Stopper + Dry Soil + Water	g	83.31	81.72	82.95	82.34
6	Weight of density bottle + Stopper + Water	g	78.49	76.93	78.13	77.51
7	Weight of Dry Soil	g	7.55	7.55	7.58	7.58
8	Weight of Water	g	51.16	52.09	51.41	50.49
9	Weight of Dry Soil + Water	g	48.43	49.33	48.65	47.74
10	Specific Gravity	Mg/m^3	2.77	2.74	2.75	2.76
11	Average Specific Gravity	Mg/m^3	2.751		2.751	

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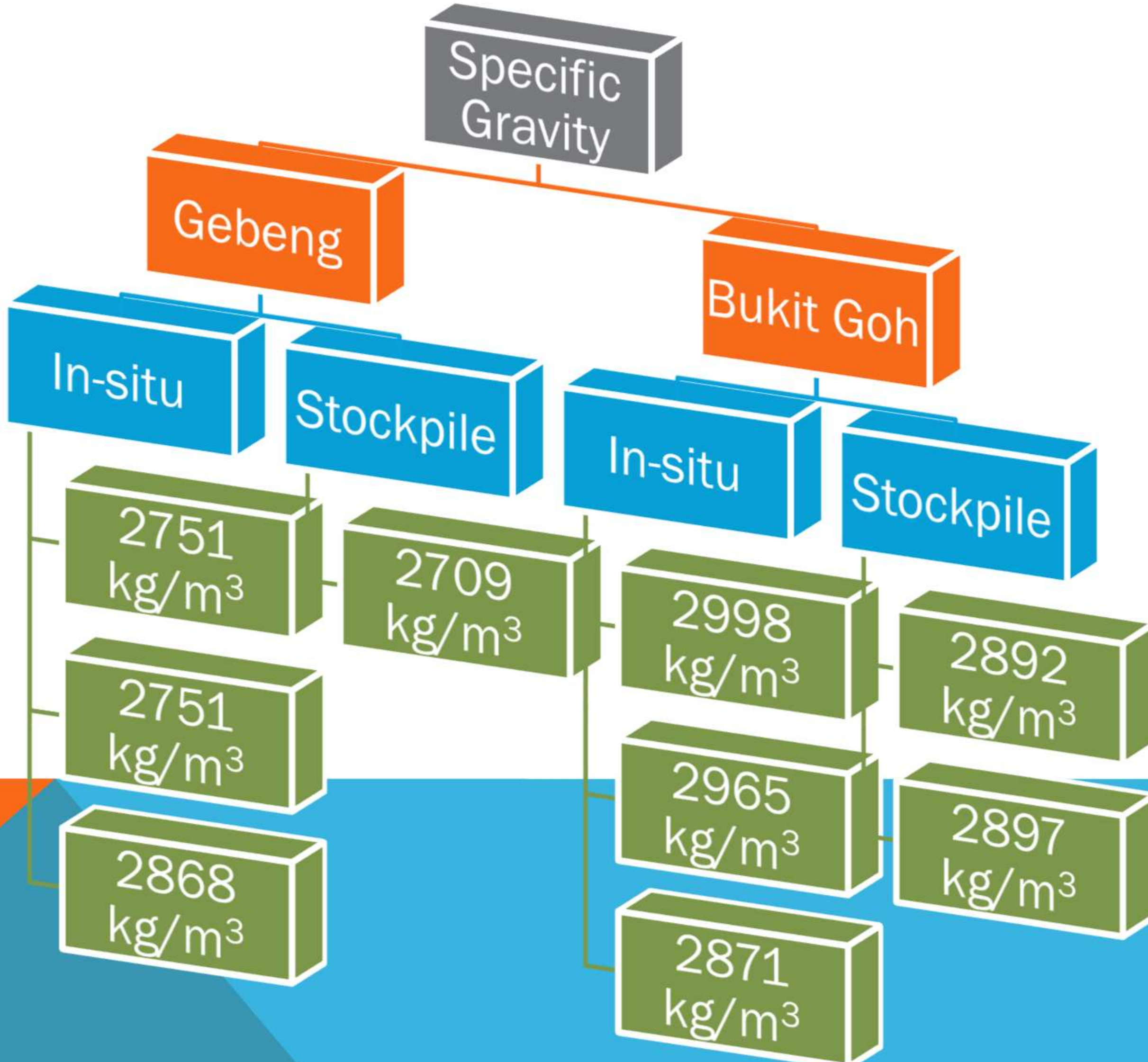
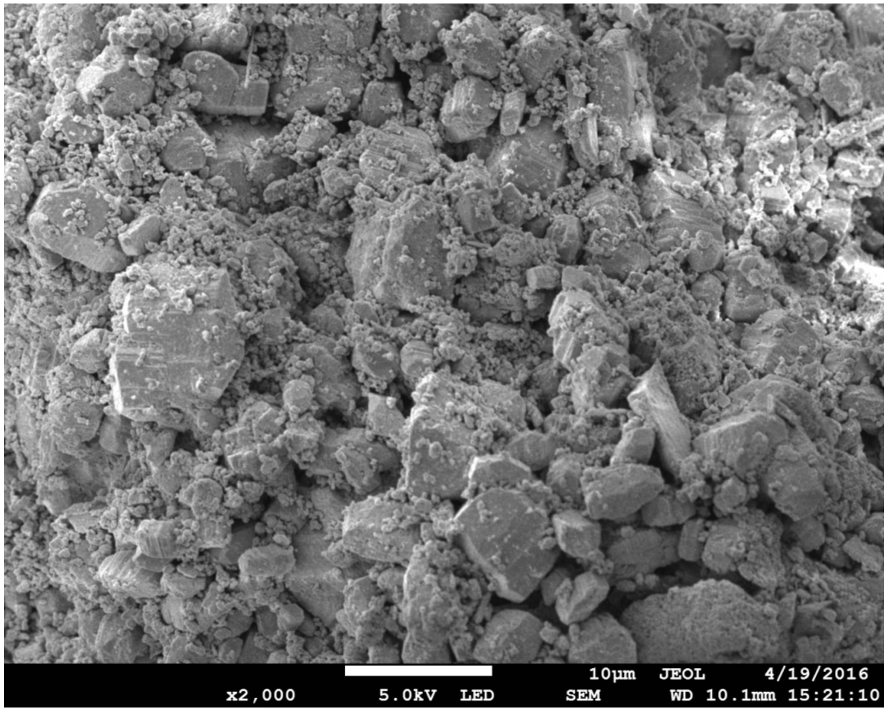
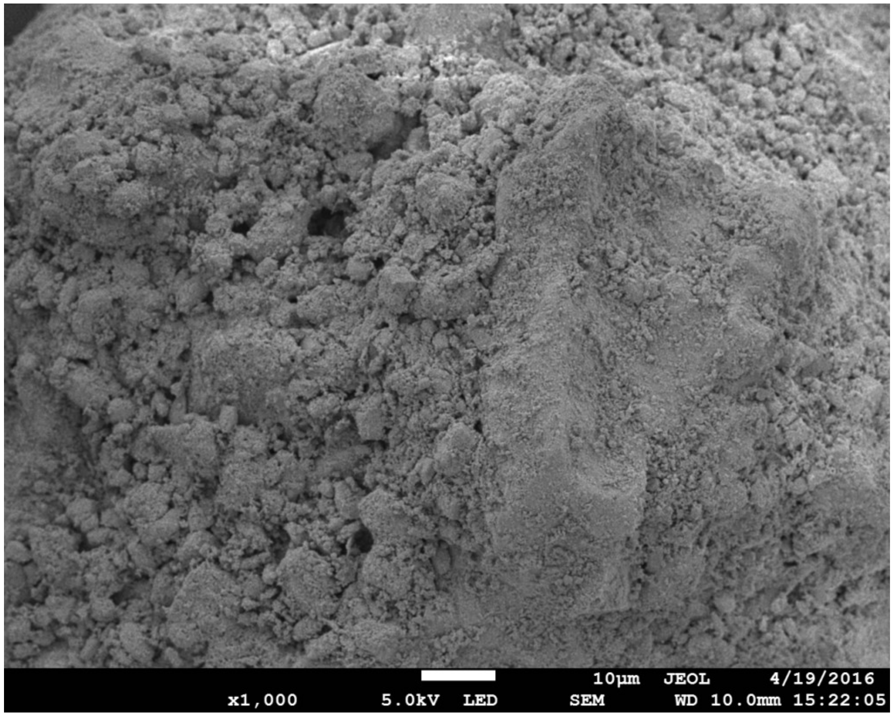
SPECIFIC GRAVITY



MORPHOLOGICAL – SCANNING ELECTRON MICROSCOPE

- GEBENG





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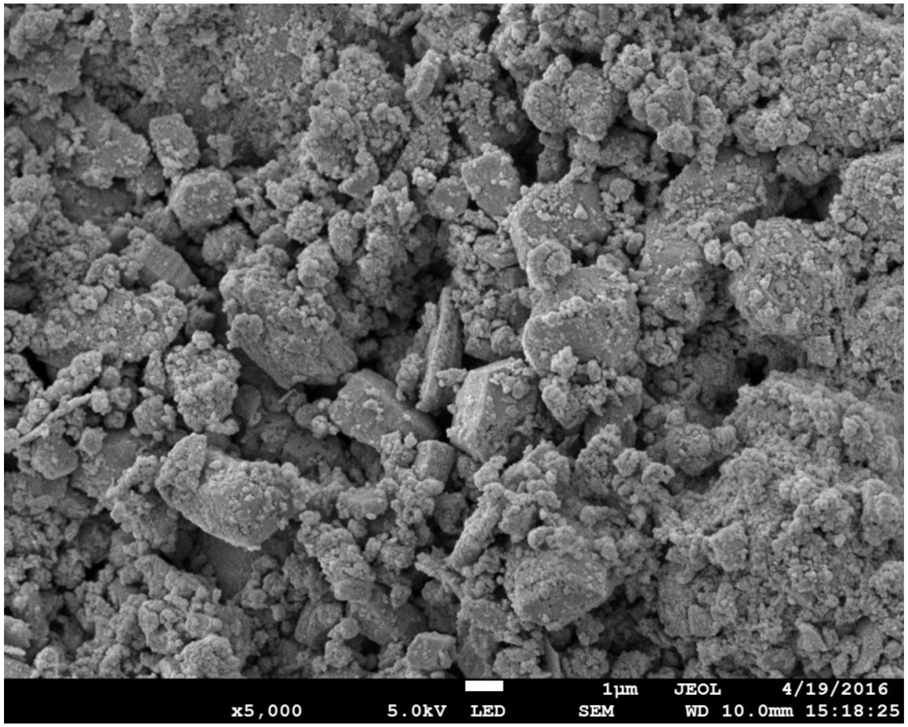
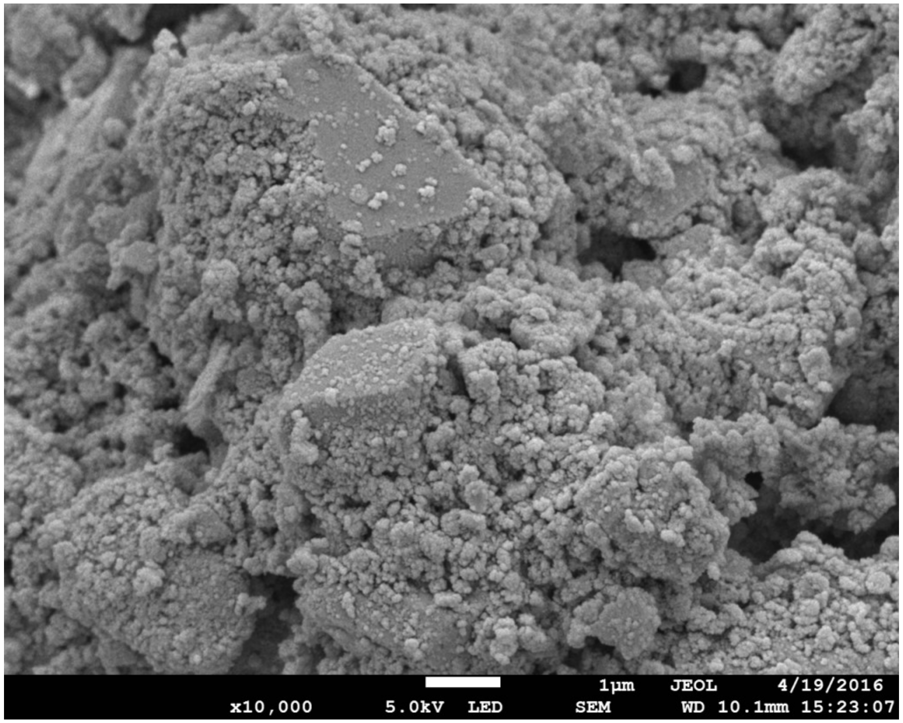
MORPHOLOGICAL – SCANNING ELECTRON MICROSCOPE

- GEBENG





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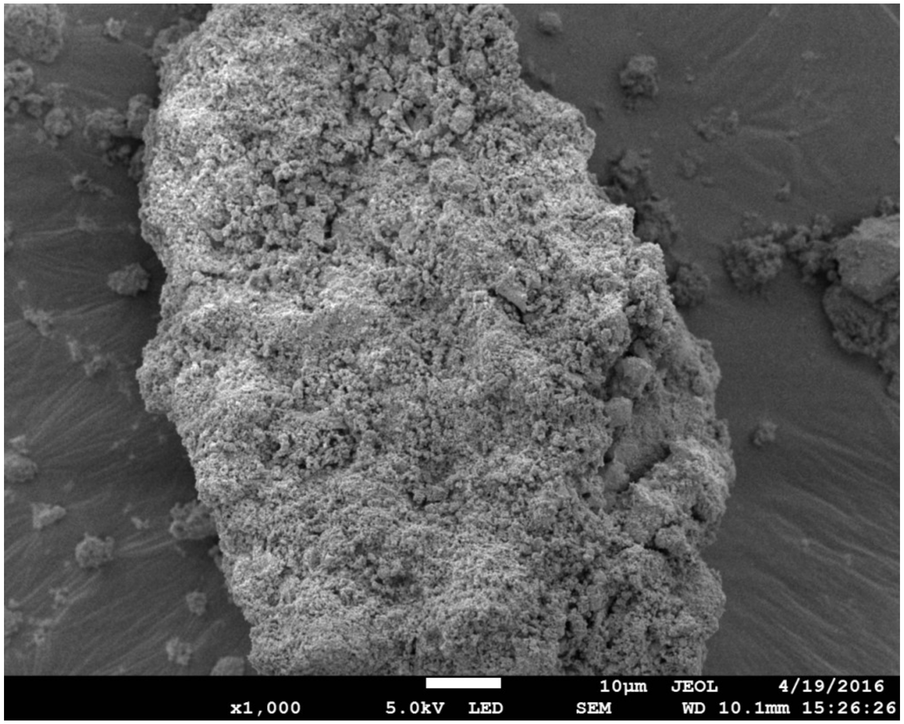
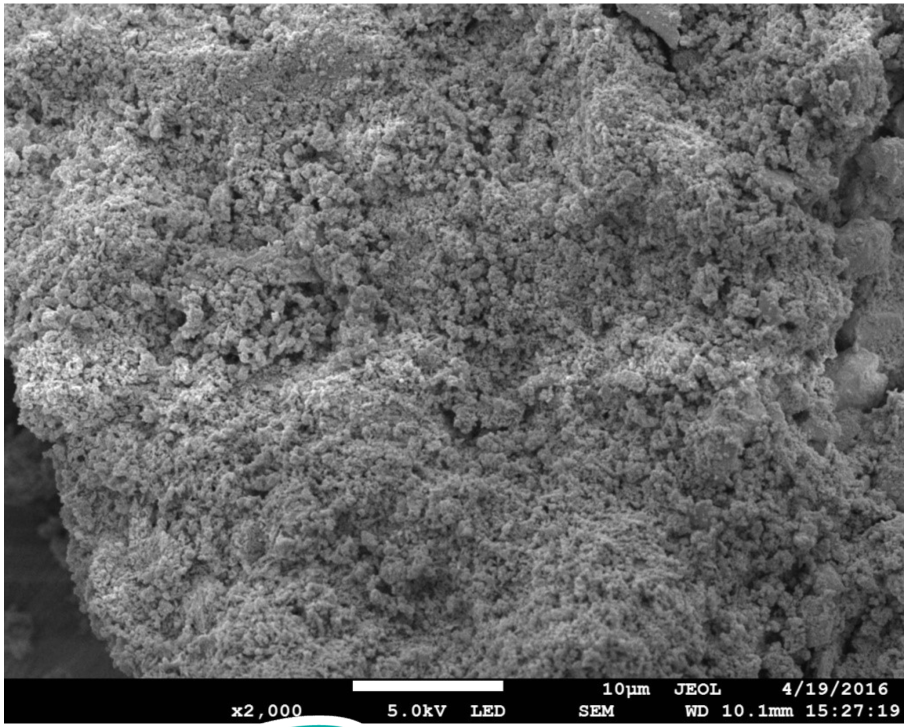
MORPHOLOGICAL – SCANNING ELECTRON MICROSCOPE

- BUKIT GOH





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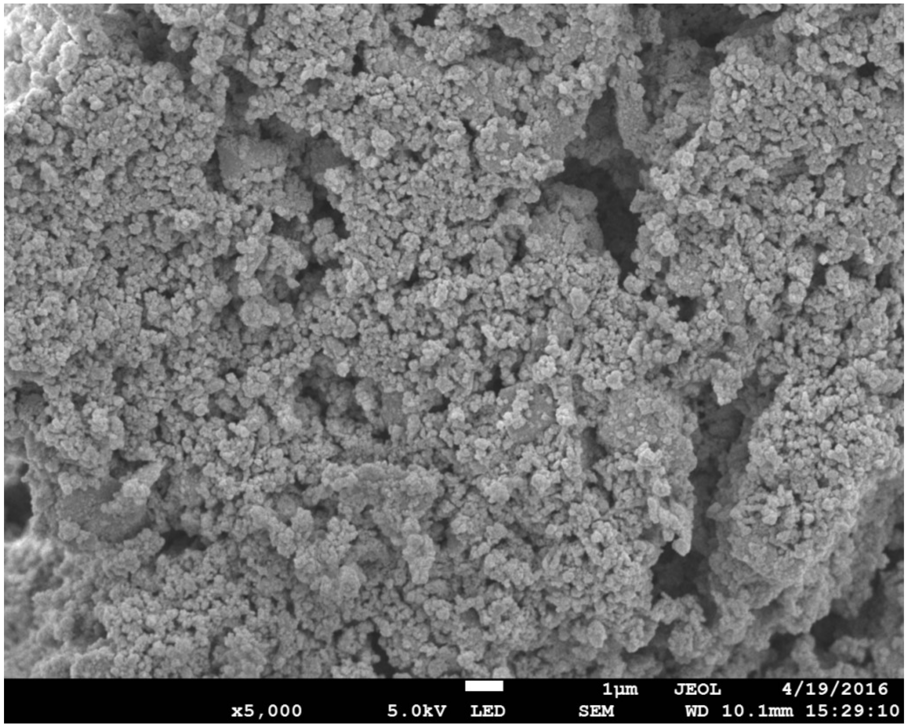
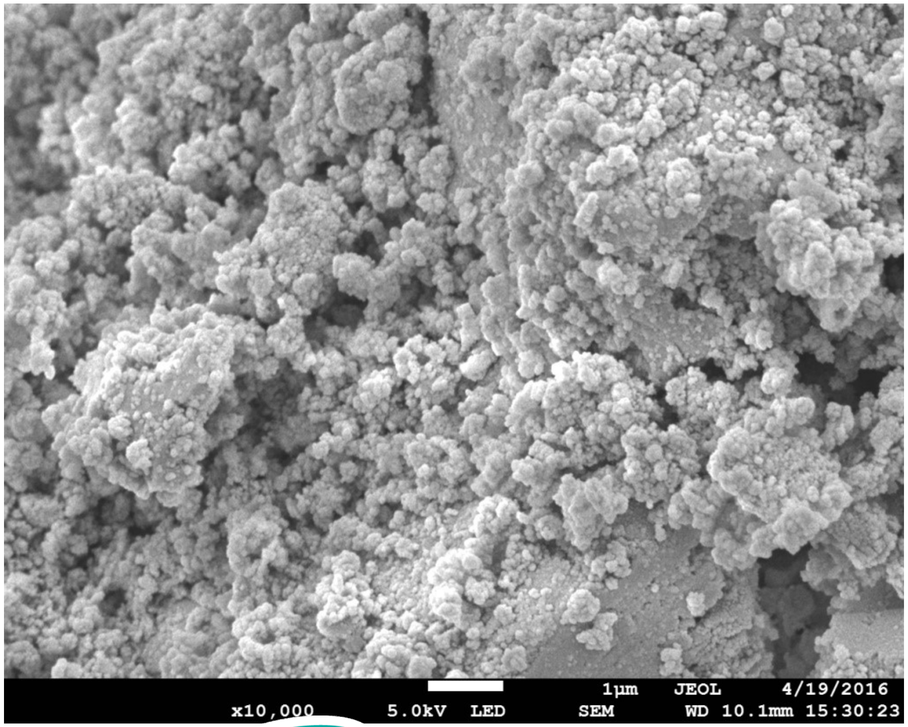
MORPHOLOGICAL – SCANNING ELECTRON MICROSCOPE

- BUKIT GOH





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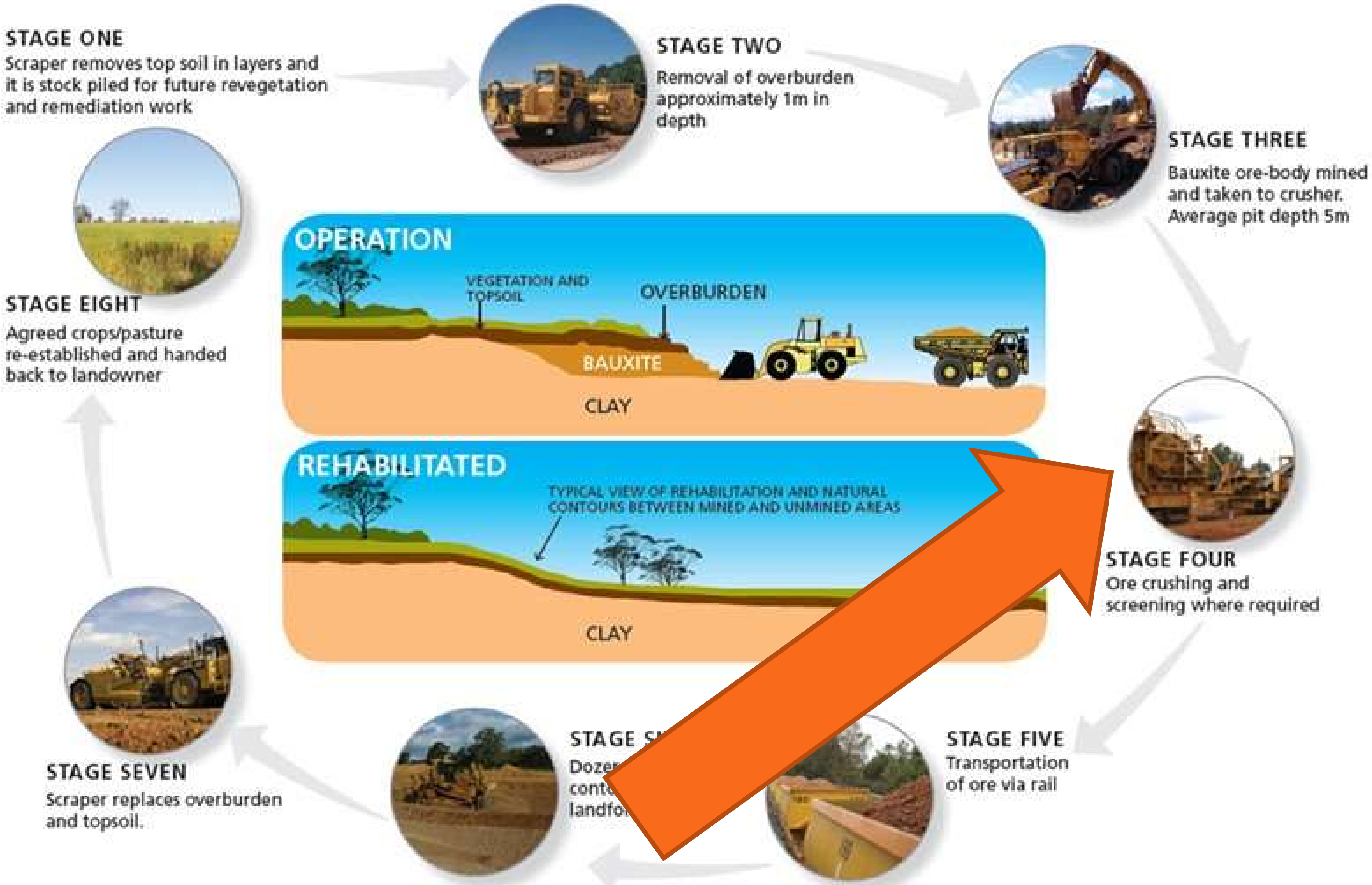
BAUXITE MINING



http://www.bajv.com.au/our-company/company-profile/bauxite-mining/

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BENEFICIATION

Unlike the base metal ores, bauxite does not require complex processing because most of the bauxite mined is of an acceptable grade. Ore quality can be improved by relatively simple and inexpensive processes for removing clay, known as "BENEFICIATION", which include washing, wet screening and mechanical or manual sorting. Beneficiating ore also reduces the amount of material that needs to be transported and processed at the refinery. However, the benefits of beneficiating need to be weighed against the amount of energy and water used in the process and the management of the fine wastes produced.

Source: http://bauxite.world-aluminium.org/mining/process.html

SUMMARY

- Moisture content for Kuantan Bauxite in average is > 20 %
- Kuantan Bauxite in average is consist of > 30 % fine material (powder) and < 70 % coarse material (lumps)
- From SEM test, image analysis prove that there were a lot of fine particles in bauxite samples
- In accordance to IMSBC Code, at this current condition, Kuantan Bauxite cannot be categorized as Group C.

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CONCLUSION

- Formation of soil from rock was from chemical and/or mechanical weathering processes. In this case, rock & bauxite ore did weathered and contribute to the existence of powder (fine particles).
- Kuantan bauxite's % of fine particles is higher than the maximum limit set by IMSBC Code.
- Due to high fine particles (which are soluble), it will absorb much more water compared to granular particles.
- The increase of fine particles will resulted in increase in moisture content.
- To solve this problem, raw bauxite must go through "beneficiation" process to reduce/eliminate fine particles (powder).

Thank You

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