POLICY FORUM ON MINING: PERSPECTIVE FROM A MINING COMPANY

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Hotel Jen, Manila, Philippines

DISCLAIMER

- The views presented in this paper are entirely those of the author and do not represent those of macroasia mining corporation, other mining companies nor the chamber of mines of the Philippines.
- Some data presented are results of researches which involve the author and refences therein in collaboration with other institutions such as Kyushu University and UP-NIGS.
- Some slides presented are adopted from works of other experts but with permission to the authors.

OUTLINE OF DISCUSSION

- INTRODUCTION: SCIENCE AND TECHNOLOGY AND THE IRR
- VALUE-ADDING SCHEMES:
  - EXPLORATION: "THE UNCONVENTIONAL METALS"
  - MINING OPERATION
  - PROMOTING DOWN STREAM TECHNOLOGY
- RESEARCH AND DEVELOPMENT (R & D)
  - THE MANDATE
  - CASE SITUATION: LATERITE DENSITY & GEOCHEMISTRY
  - OTHER SCHEMES
- INNOVATION
  - SAMPLING AND THE QA/QC
- ENCOURAGE OR INTRODUCE "GREEN TECHNOLOGY" – A BONUS?
  - WASTE IN A NICKEL OPERATION: THE ULTRAMAFIC BEDROCK
  - THE CARBON CAPTURE AND SEQUESTRATION
- CONCLUSION

SCIENCE AND TECHNOLOGY AND THE IRR

SOCIAL AND COMMUNITY DEVELOPMENT AND RESEARCH AND DEVELOPMENT

The Mining contractors/operators **shall allocate a minimum of 1% of their direct mining and milling costs** for the following:

• Development of the host and neighboring communities and mine camp, including the construction and maintenance of social infrastructures to promote the general welfare of the inhabitants in the area. Such infrastructures include roads and bridges, school buildings, churches, recreational facilities, housing facilities, water and power supplies, etc.;

• For the development of mining technology and geosciences, particularly those related to improved efficiencies and environmental protection and rehabilitation;

The mining contracts under the regimes of MPSA and FTAA also provide for the mandatory Filipinization program, technology transfer, and the training and priority employment of local residents. These contracts further mandate that mining operations shall maximize the utilization of local goods and services, the creation of self-sustaining generating activities, and skills-development.

SCIENCE AND TECHNOLOGY AND THE IRR

ON SOCIAL ACCEPTABILITY

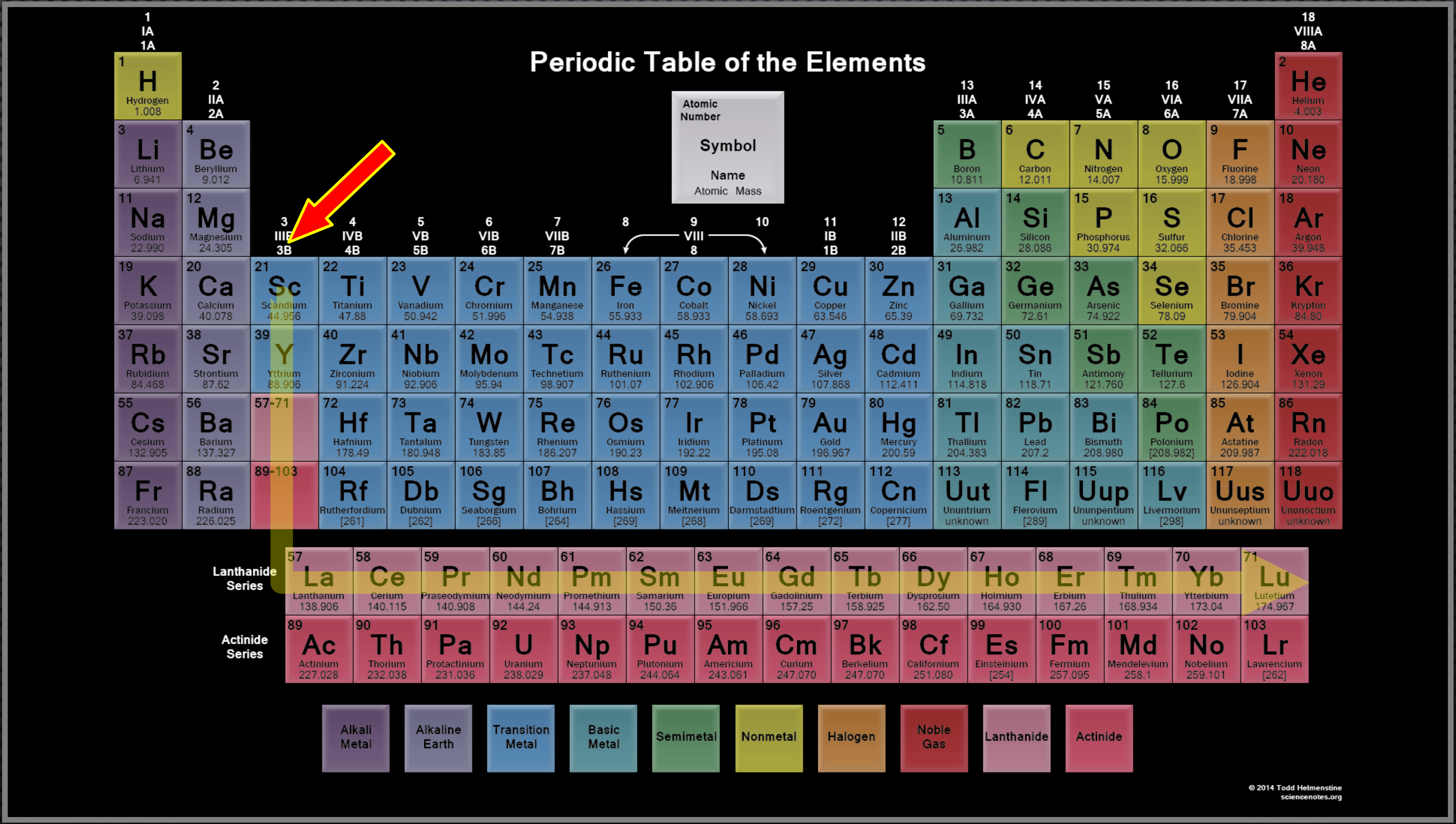
Mining contractors/operators shall **allocate a minimum of 1% of their direct mining and milling costs** for the development of the following:

- Host and neighboring communities and mine camp to promote the general welfare of inhabitants in the area. This includes construction and maintenance of infrastructures such as roads and bridges, school buildings, housing and recreational facilities, water and power supplies, etc.;

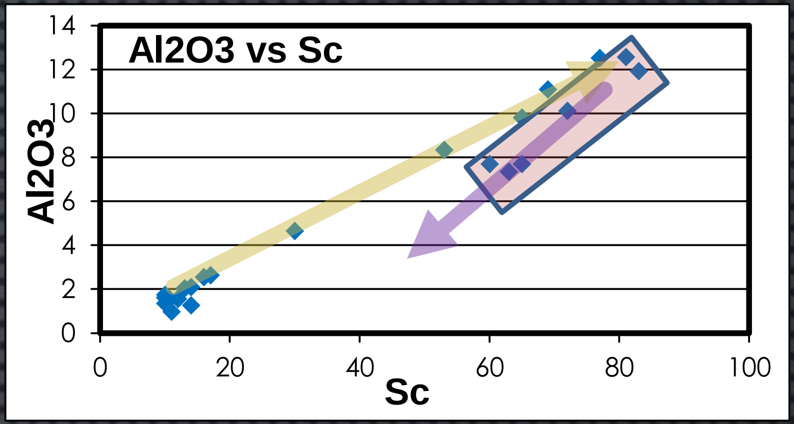
- **Mining technology and geosciences, particularly those related to improved efficiencies and environmental protection and rehabilitation.**

I. VALUE- ADDING SCHEME IN EXPLORATION

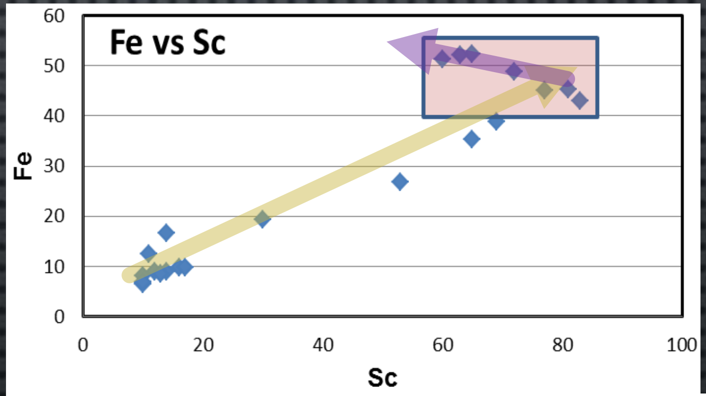
SCANDIUM & RARE EARTH'S ELEMENTS

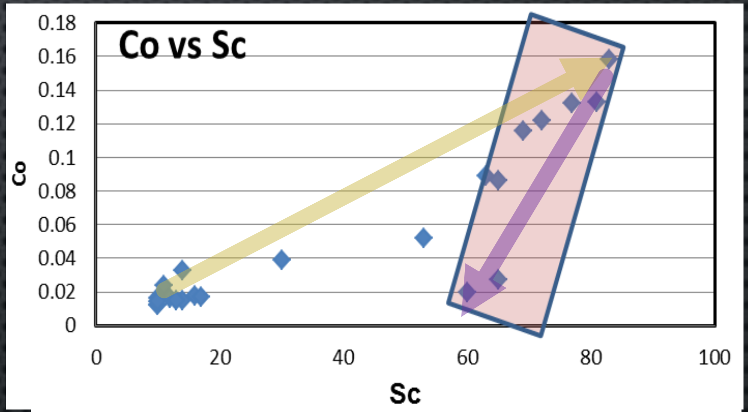


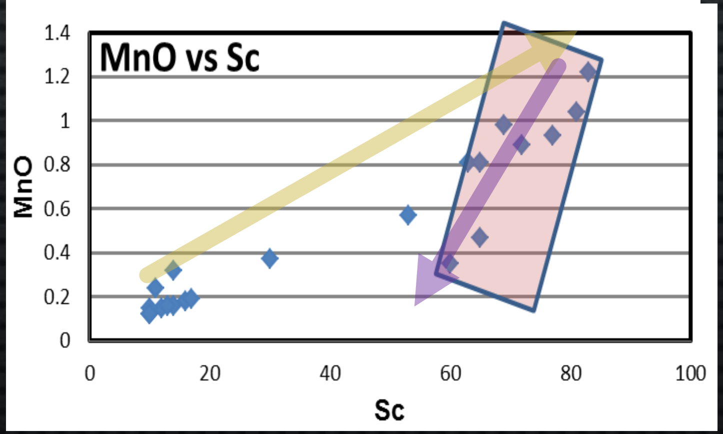
VALUE ADDING DURING EXPLORATION: LOOKING FOR “UNCONVENTIONAL METALS”

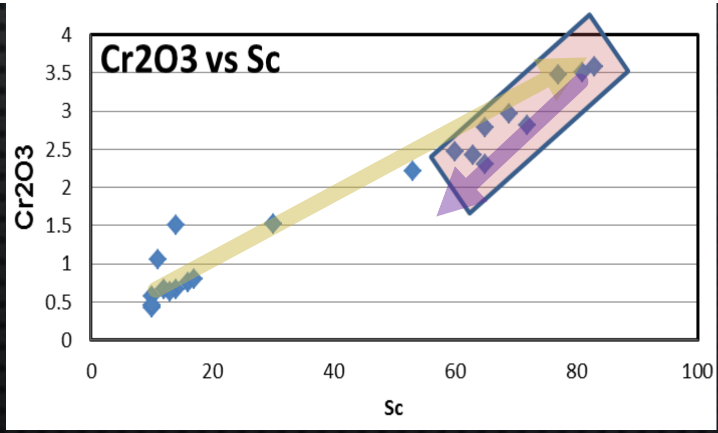


- Within the laterite profile **Sc** has the largest concentration within the limonite;
    - Sc shows linear positive correlation with Fe, Co, Mn, Al, and Cr from bedrock to earthy saprolite expressing its susceptibility in weathering;
    - Reversal in trend which marks the boundary between earthy saprolite and limonite may imply processes occurring within the limonite



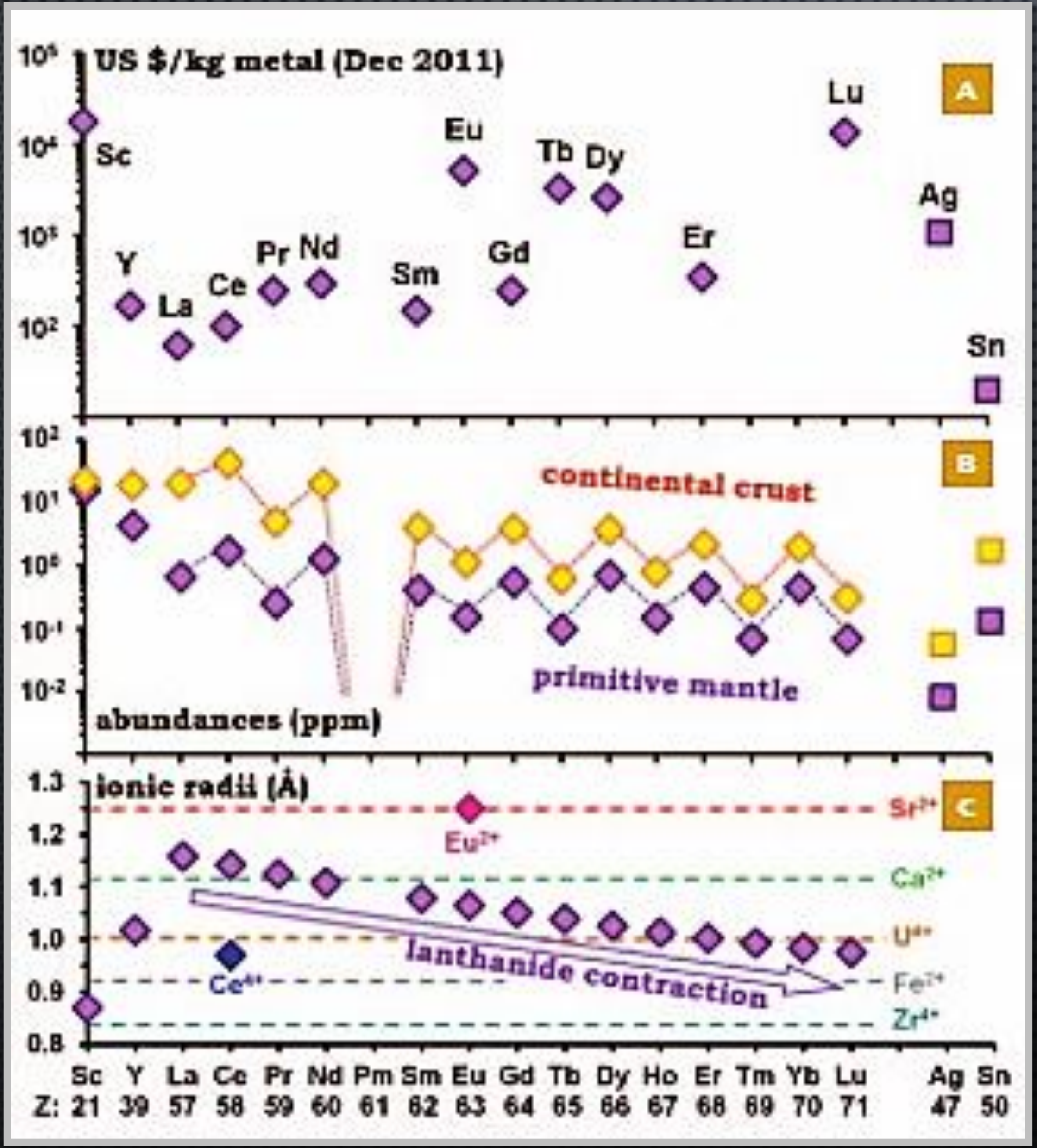






SCANDIUM CHEMISTRY

Scandium and the REEs



- Scandium (Sc) forms part of the REE family to include Yttrium (Y)
- The small ionic radius of Sc easily substitute for Fe^{+2}, Mg, Zr, and Sn
  - As such it occurs in a diverse of resource types igneous ilmenite, hydrothermal Sn-W ores, to residual bauxite and laterite (Chackmouradian & Wall, 2012)
- Sc is one of the most expensive commodity among REEs and the most abundant too in laterites
- Sc, occurring as trivalent ion, has small ionic radii making it classified as part of HREE

SCANDIUM ABUNDANCE vs REEs IN LATERITES

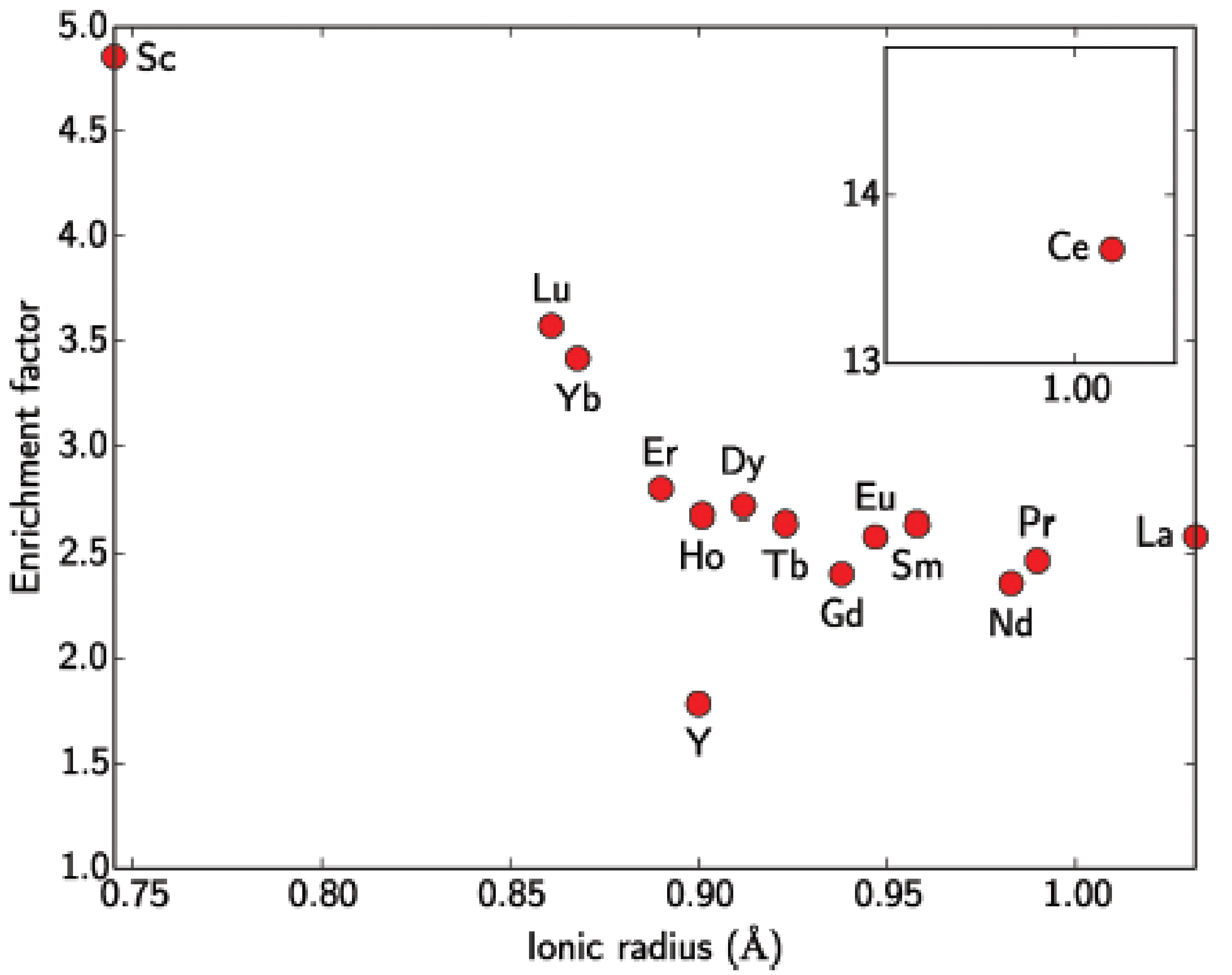
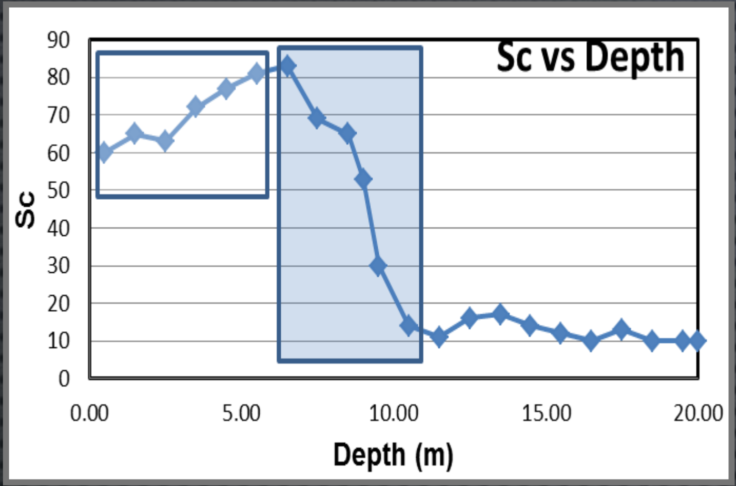
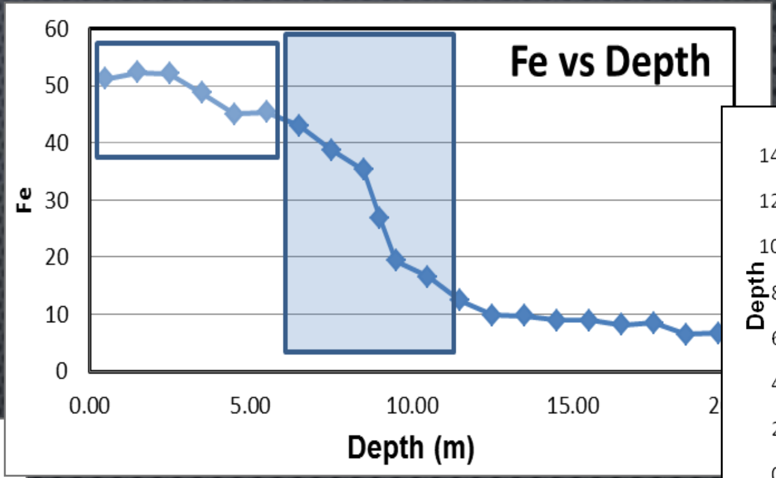
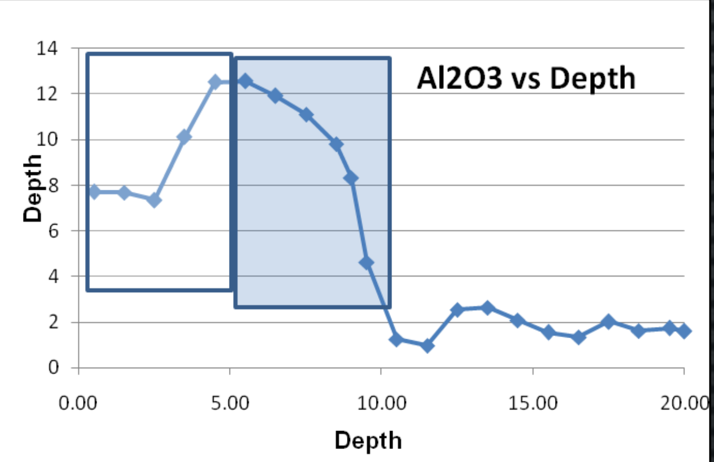


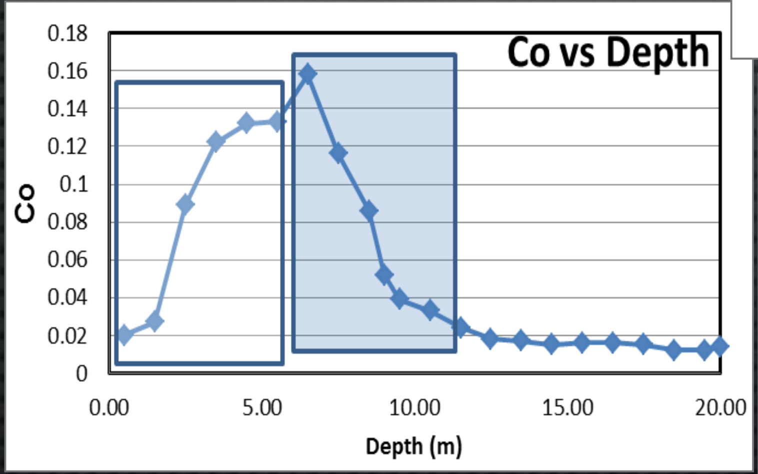
Figure S-2 Enrichment factor of rare earth elements in the lateritic deposit versus ionic radius in octahedral coordination. Values are after Shannon (1976).

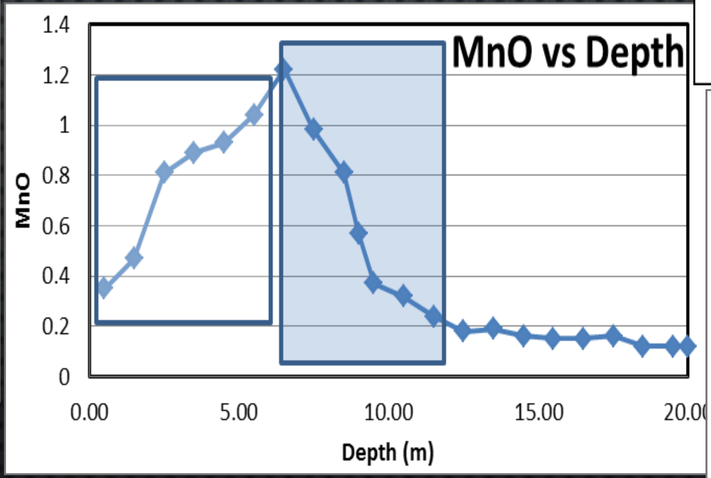
SCANDIUM VS OTHER METALS

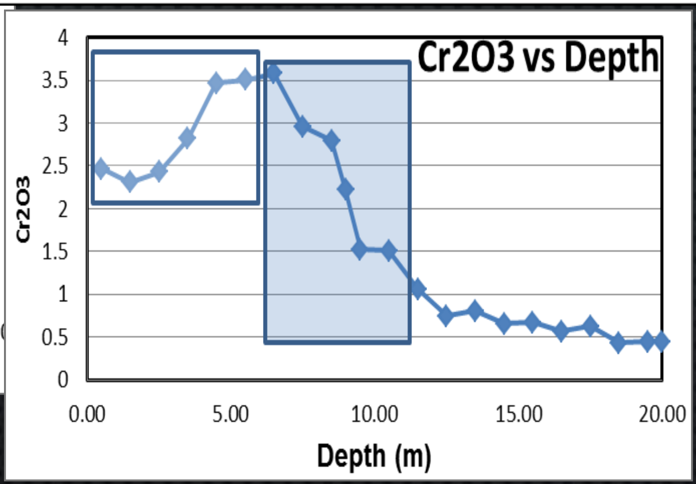






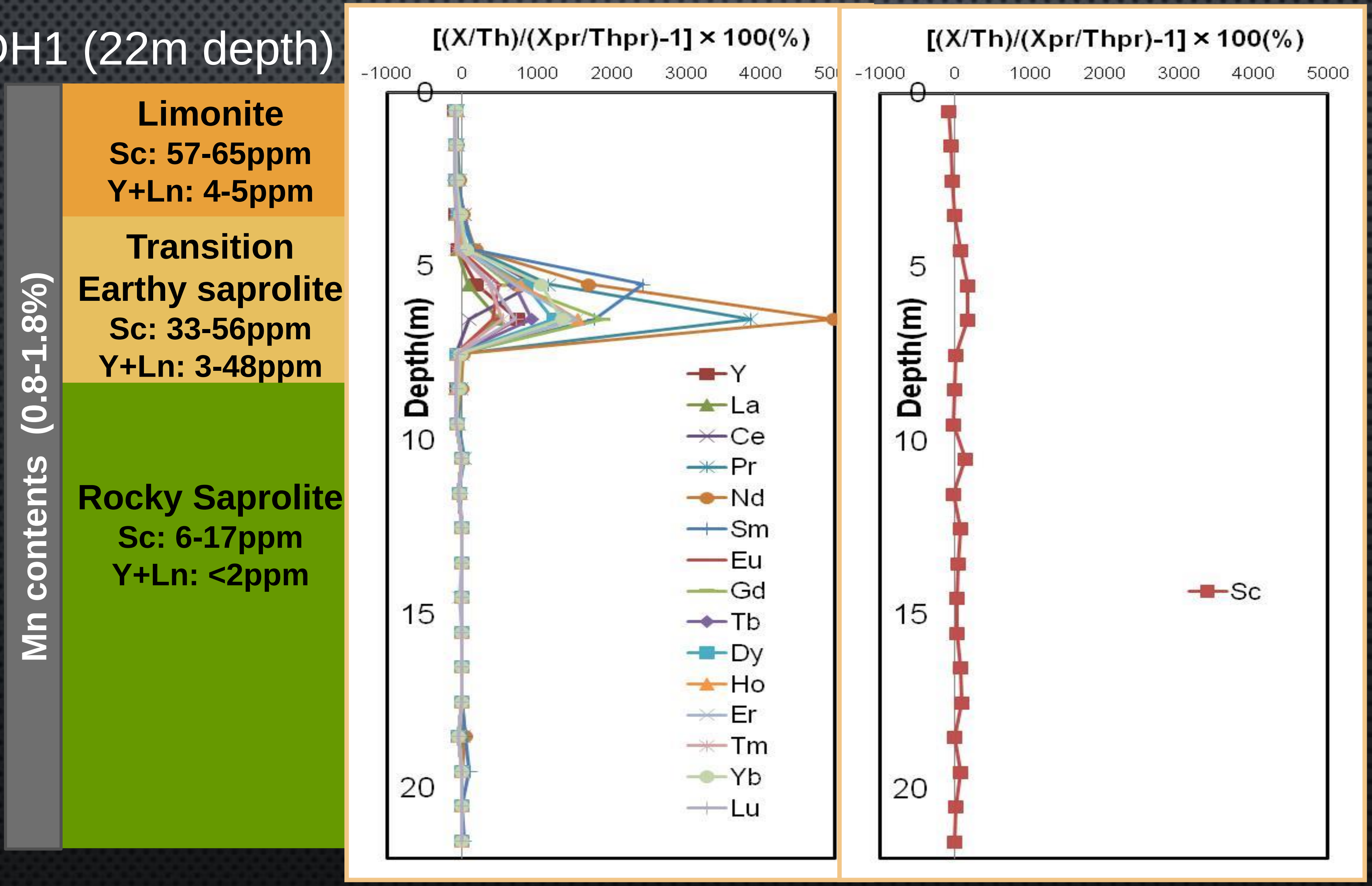






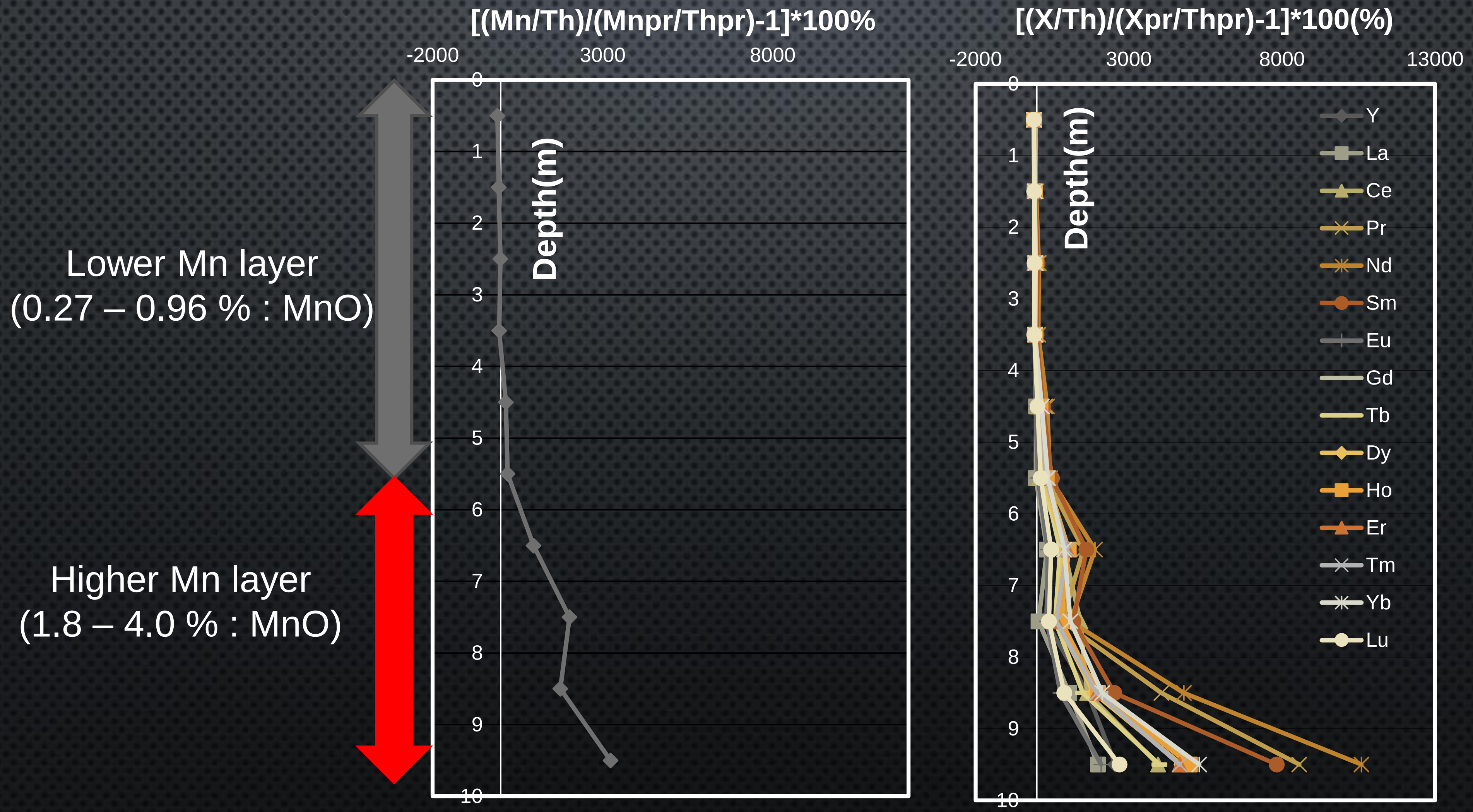
SCANDIUM GEOCHEMISTRY

DH1 (22m depth)

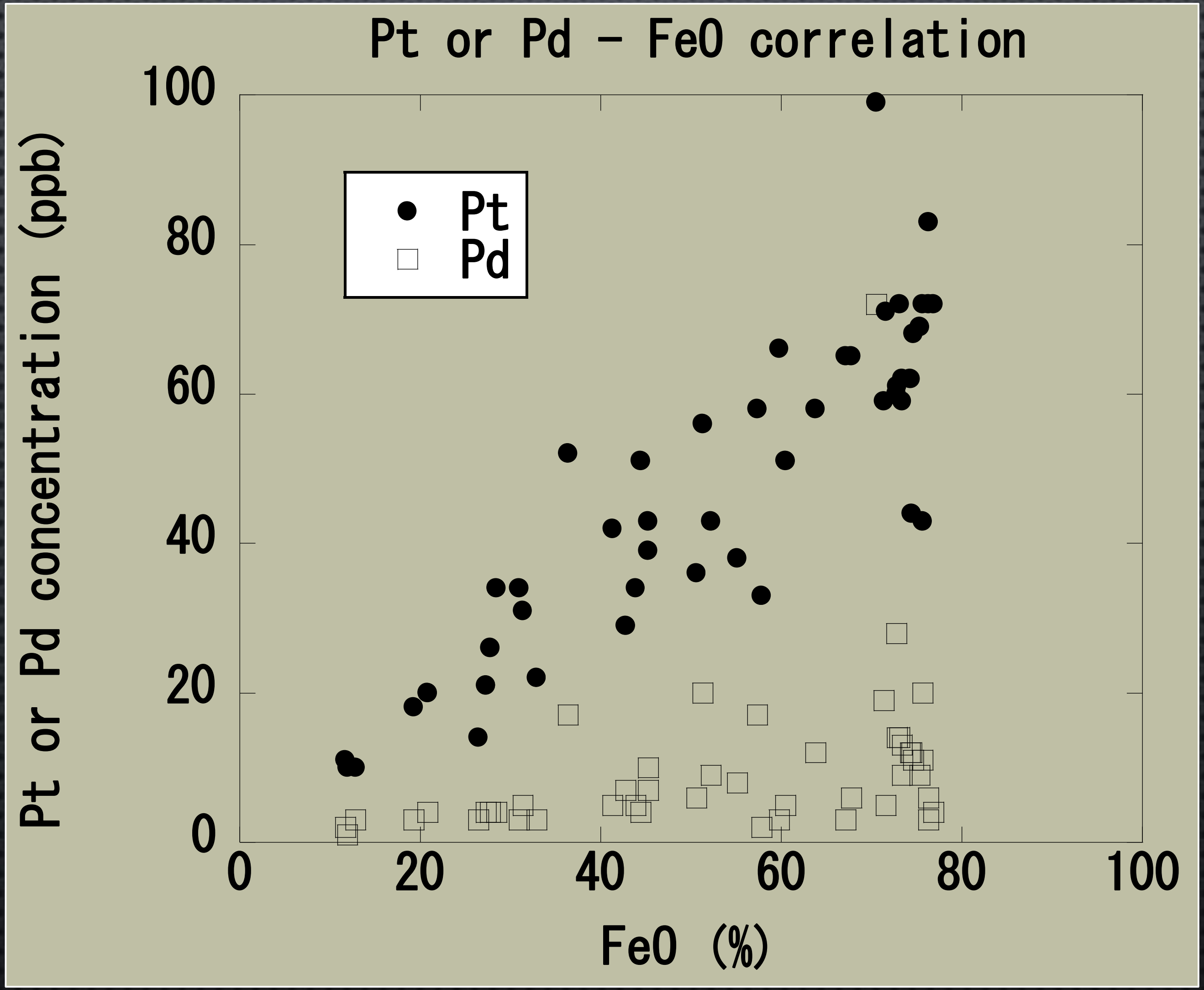


Sc (+REEs) vs MANGANESE GEOCHEMISTRY

Manganese concentration as absorbent of REE



PT-PD IN LATERITE



▪Relatively good positive correlation (especially, with Pt)

⇒Limonite zone includes more Pt.

II. VALUE- ADDING SCHEME IN MINING OPERATION

‘Value Add’ in the Philippines: ~50ktpy Ni metal in 2@HPAL Plants operated by Sumitomo

- There are 2 @ HPAL plants operated by Sumitomo:
  - **Coral Bay in Palawan (2@10,000tpy Ni metal Equiv]**
  - **Taganito in Mindanao [1 @ 30,000tpy Ni metal Equiv]**
- There are no Ferronickel plants in the Philippines
- There is no policy in place to force “miners” to value add

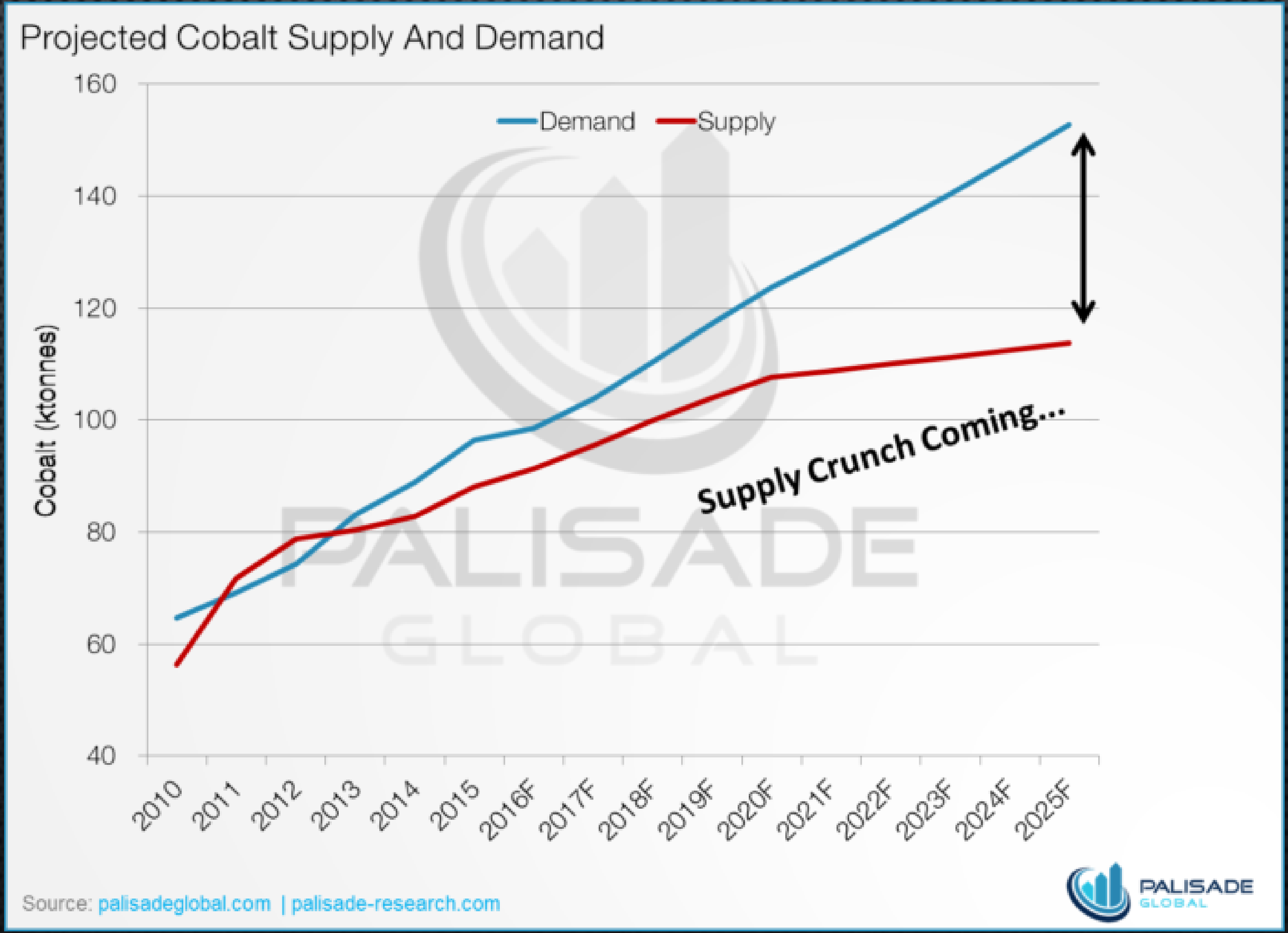
Value-adding in mine operations

- Leaching (vat & agitated tank) vs high pressure acid leach (hpal)
  - for a 30,000 tpy plant: Leaching costs US$ 157M vs US$1.8 B for HPAL
  - Energy requirement: low for leaching vs high for hpal

- Recovery of associated metals – PGE, REE +Sc, Zn
- The forecasted "cobalt crunch" may further increase the value of ores

- A government subsidy or assurance is needed?

THE COBALT CRUNCH



III. PROMOTING RESEARCH AND DEVELOPMENT

MACROASIA MINING CORPORATION: OUR CONTRIBUTION TO NICKEL RESEARCH

Title	Authors	Venue
Quality Control Monitoring of Mining and Shipment Samples, Berong Nickel Corporation Assay Laboratory	VT Hizon, RAL Flores, RA Santos	GEOCON 2008, Makati City, Philippines
Significance of Company and Internal Quality Assurance/ Quality Control (QAQC) XRF Results and Field Sample Reduction Procedures from the Macroasia Nickel Laterite Deposit, Brooke's Point, Palawan	RAL Flores, RPL Pineda, RA Santos	GEOCON 2009, Makati City Philippines
When Limonite Gets Denser: A Bulk Density Study of Palawan Laterites	RA Santos, RAL Flores, AE Gabata, RS Victorino, JM Gonzales, Jr.	GEOCON 2011, Surigao City, PHILIPPINES
Comparative Geochemical Analysis of Nickel Laterite Samples from Infanta Nickel Project Area, Brooke's Point, Palawan	MBMC Jumangit, RPL Pineda, EA Ranches, RA Santos, RN Santos	1st Asia Africa Mineral Resources Conference, Kyushu University, Fukuoka, JAPAN (Dec. 2011)
Geochemistry of Nickel Laterite I: Elemental Behavior During Laterite Formation	RA Santos, RAL Flores, RN Santos, MBMC Jumangit, RPL Pineda, ER Ranches	International Symposium on Earth Science and Technology –CINEST, Kyushu University, Fukuoka, JAPAN (Dec. 2011)
Geochemistry of Nickel Laterite II: The Grade-Density-Profile Thickness Correlation	RA Santos, RAL Flores, RN Santos, MBMC Jumangit, ER Ranches, AE Gabata, MM Fajatin, RPL Pineda	1st Asia Africa Mineral Resources Conference, Kyushu University, Fukuoka, JAPAN (Dec. 2011)
Exploration and Resource Estimation of Nickel Laterite Deposit: the Case of MacroAsia Corporation's Infanta Nickel Project in Brooke's Point, Palawan**	RA Santos, RAL Flores, RN Santos	Seminar/Workshop – Reporting of Exploration Results, Mineral Resources, and Ore Reserves for Philippine Deposits Compliant with International Standards **, Quezon City, PHILIPPINES (June 2012)

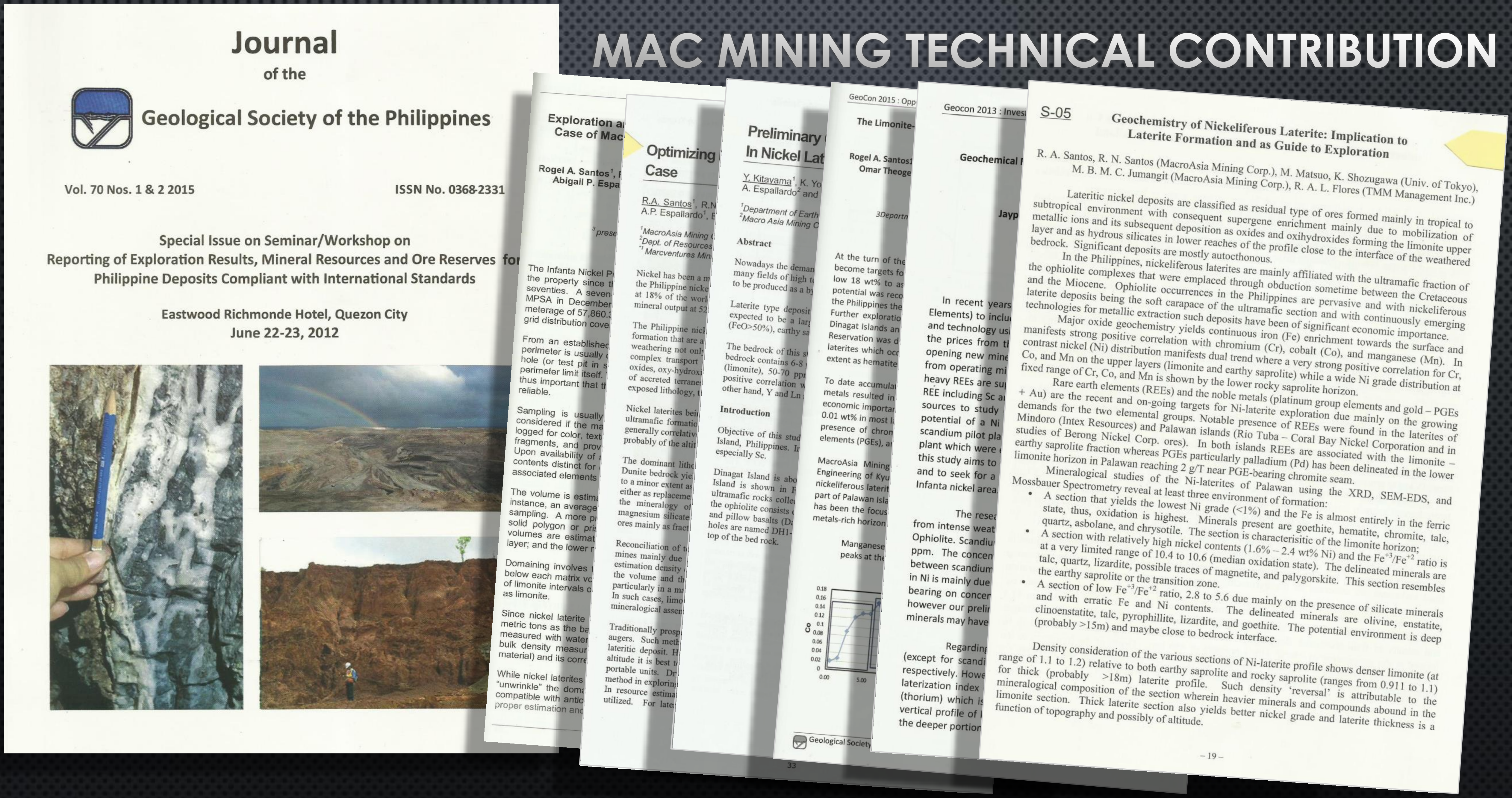
MACROASIA MINING CORPORATION: OUR CONTRIBUTION TO NICKEL RESEARCH

Geochemistry of Ophiolitic Chromite Revisited: Implication on Chromite Formation in Changing Tectonic Regime	**RA Santos, K Suzuki, A Imai, RN Santos, RAL Flores**	**2nd Asia Africa Mineral Resources Conference, Bandung, INDONESIA (Sept 2012)**
Geochemistry of Ni-laterite: Elemental Behavior and the Grade- Laterite Thickness-Density Correlation	RA Santos, RAL Flores, RN Santos, MBMC Jumnagit	Tribute to Mentors, University of the Philippines, Quezon City, PHILIPPINES (Feb 2013)
Nickeliferous Laterite Geochemistry: Implication to Laterite Formation and as Guide to Exploration	RA Santos, RN Santos, MBMC Jumangit, K Yonezu, M, Matsuo, K Shozugawa, RAL Flores	Japan Resource Geology Annual Meeting 2013, University of Tokyo, JAPAN (June 2013)
Delineating Nickeliferous Laterite Horizons: Studies on Some Mineralogical Phases and its Environment of Formation	RA Santos, RN Santos, M. Matsuo, K Shozugawa, K Yonezu, MBMC Jumangit	3rd Asia Africa Mineral Resources Conference, Mongolian University of Science and Technology, Ulaan Bataar, MONGOLIA (Sept. 2013)
Optimization of Drill Spacing in Nickel Exploration in Philippine Setting through Geostatistics	RN Santos, RA Santos, MBMC Jumangit	3rd Asia Africa Mineral Resources Conference, Mongolian University of Science and Technology, Ulan Bataar, MONGOLIA (Sept. 2013)
Geochemical Behavior of REE in Laterite of MacroAsia's Infanta Nickel area, Palawan, Philippines : A Preliminary study	K Noda, K Yonezu, JA Gabo, J Juanerio, E Laguerta, RN Santos, RA Santos	GEOCON 2013, Makati City, Philippines (Dec 2013)

MACROASIA MINING CORPORATION: OUR CONTRIBUTION TO NICKEL RESEARCH

Preliminary study on PGE associated with laterite of MacroAsia's Infanta Nickel Area, Palawan, Philippines	**K Yonezu, S Hara, K Noda, JA Gabo, J Juanerio, E Laguerta, RN Santos, RA Santos**	**GEOCON 2013, Makati City, Philippines (Dec 2013)**
Determination of Optimal Cut Off Grades in Reporting Nickel Laterite Resource	RN Santos, MBMC Jumangit, RA Santos, J Junanerio, E Laguerta	GEOCON 2013, Makati City, Philippines (Dec 2013)
Laterite Geochemistry vs. pH-Eh Values: Implications to Nickeliferous Laterite Stratification	RA Santos, RN Santos, MBMC Jumangit, JD Juanerio, EL Laguerta, K Yonezu, JA Gabo, K Noda, AP Espallardo, E Villaflor	4th Asia Africa Mineral Resources Conference, UTHB, Algiers, Algeria (Sept. 2014)
Ultramafic Rocks in Ophiolites as Potential Carbon Repositories: Initial Results of Carbon Capture and Sequestration Experiment	RA Santos, R Takahashi, K Ohkawa, RN Santos, K Yonezu, JA Gabo,K Noda, MBMC Jumangit	GEOCON 2014, Makati City, Philippines (Dec 2014)
Geochemistry of Scandium in Nickeliferous Laterite: the Case of Philippine Ni-laterite	RA Santos, RN Santos, K Yonezu, JA Gabo-Ratio, K Noda, EL Laguerta, AP Espallardo, E Villaflor, AV Duran, MBMC Jumangit	Crust-Mantle Evolution in Active Arcs, Quezon City, Philippines (Feb. 2015)
The Limonite-Saprolite Interface as "Bonanza Horizon" for Metals in Nickeliferous Laterite	RA Santos, RN Santos, K Yonezu, JA Gabo-Ratio, K Noda, EL Laguerta, AP Espallardo, E Villaflor, AV Duran, MBMC Jumangit	5th Asia-Africa Mineral Resources Conference, UP-Diliman, QC, Philippines (July 2015)
Density-Swell Factor Correlation: Contraints on Mineralogy and Mineral Ratios in Nickeliferous Laterites	RA Santos, RN Santos, K Yonezu, JA Gabo-Ratio, K Noda, OTA Alfonso, EL Laguerta, AP Espallardo, E Villaflor, AV Duran	GEOCON 2015, Makati City, Philippines (Dec 2014)
Optimizing Exploration Techniques: The Nickeliferous Laterite Case* **	RASantos	2016 Hunt for Ore Deposits: Emerging Trends, Davao City, Philippines

MAC MINING TECHNICAL CONTRIBUTION



R & D

- Geologists, Mining Engineers, and Chemists won't feel that they simply function as "glorified samplers and mappers", "laboratory aide", or "top tier encoders or loggers".
- Young minds are nurtured:
  - They were tasked to prepare research papers and present them in scientific conferences and symposia both local and international
  - Mining companies usually have a wealth of data from their archives – from exploration to early stages of mining operation to shipments.

- The Government may initiate a system of recognition or incentive to home-grown technology and perhaps require companies to have research outputs be reported or published. With the advent of the CPD Law (Continuing Professional Development) R & D may be a good way to gain CPD points.

Field Density Sampling Flowchart

Ground clearing and template set up

Material excavation and volume of matrix determination

Apparatus set up and volume of sand in mold determination

Retrieval of excess sand from apparatus and sand in cone and mold

Packing and Bagging

R & D CASE: DENSITY AND THE LATERITE RESOURCE

Poor estimates of bulk density result in poor estimates of tonnage. This may affect not only the total Resource or Reserve estimate but also the amount of metal predicted in a mine schedule or design.

Historically neglected, considerably more effort has been put into measurement of bulk density over the last decade. Nonetheless, quality assurance / quality control (QA/QC) principals remain less commonly applied for density measurement than for geochemical analyses. There is a need for the mining industry to continue to improve the process of density measurement and quality control, thereby reducing error and risk in Resource estimates.

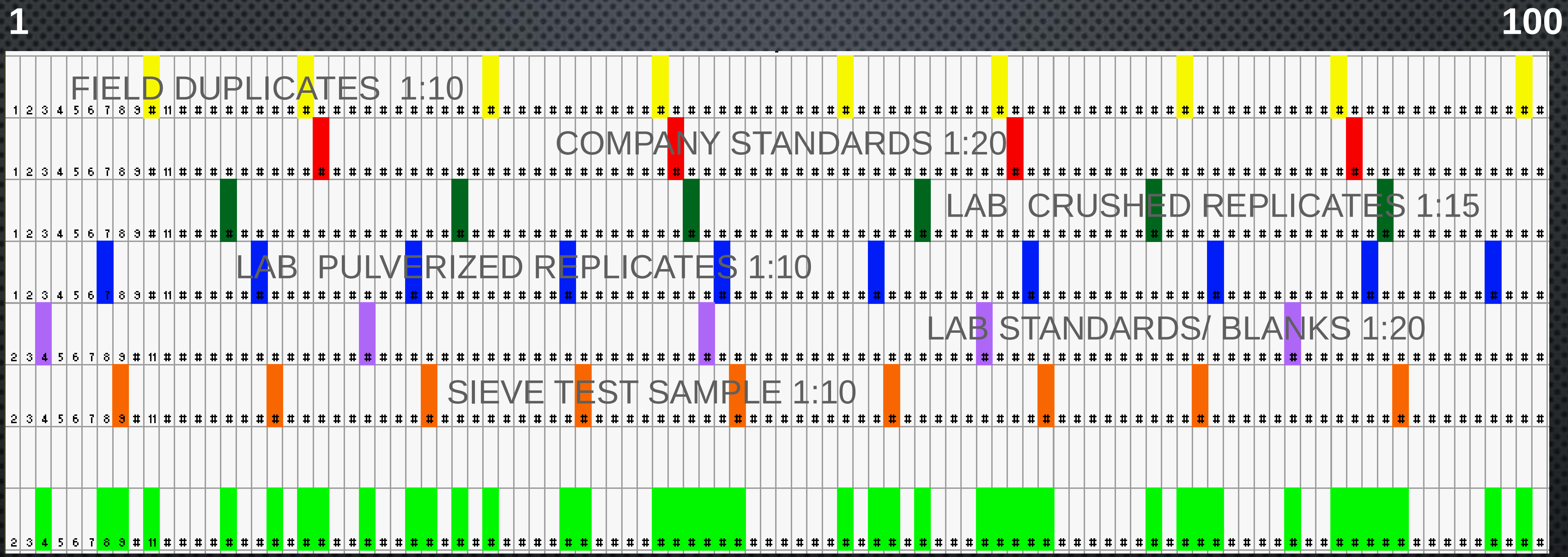
Finally, volume estimates are converted to tonnage estimates by multiplying by the dry bulk density. Although the density is a major parameter in the final estimate of both ore tonnage and contained product, estimation of density commonly receives less attention than is paid to geochemical

data and may be based on fewer data points derived from less controlled measurement practices. QA/QC processes that are routinely applied to sampling and geochemical analysis are less commonly applied to the collection of density data, yet are equally important.

Measurement of Bulk Density for Resource Estimation – Methods, Guidelines and Quality Control*

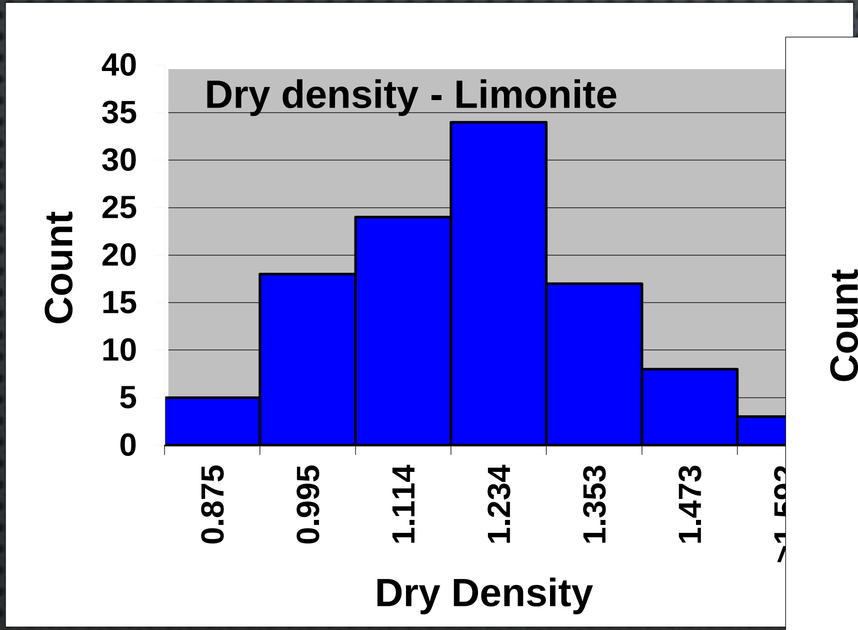
I T Lipton[1] and J A Horton[2]

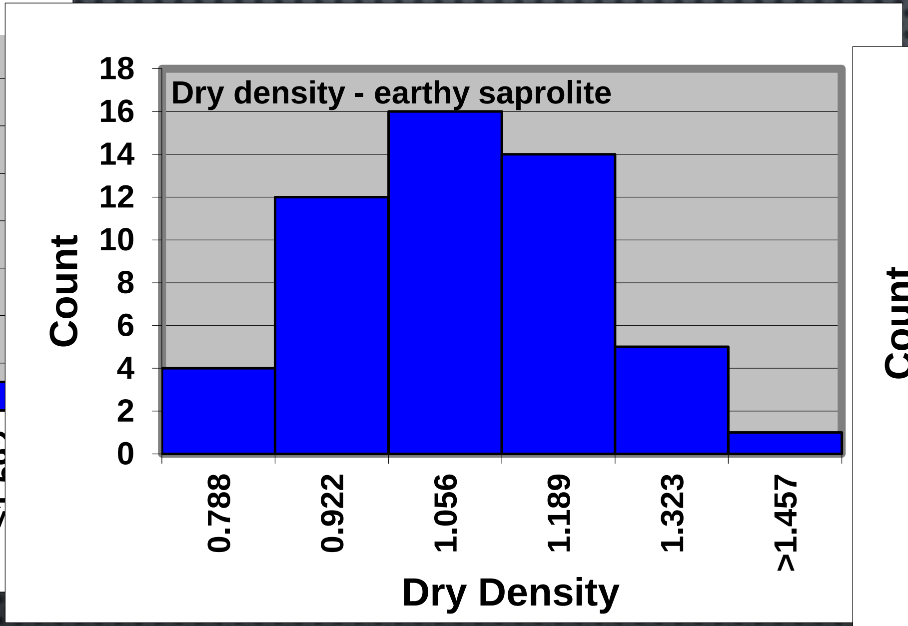
QA/QC SAMPLES FOR 100 SAMPLES

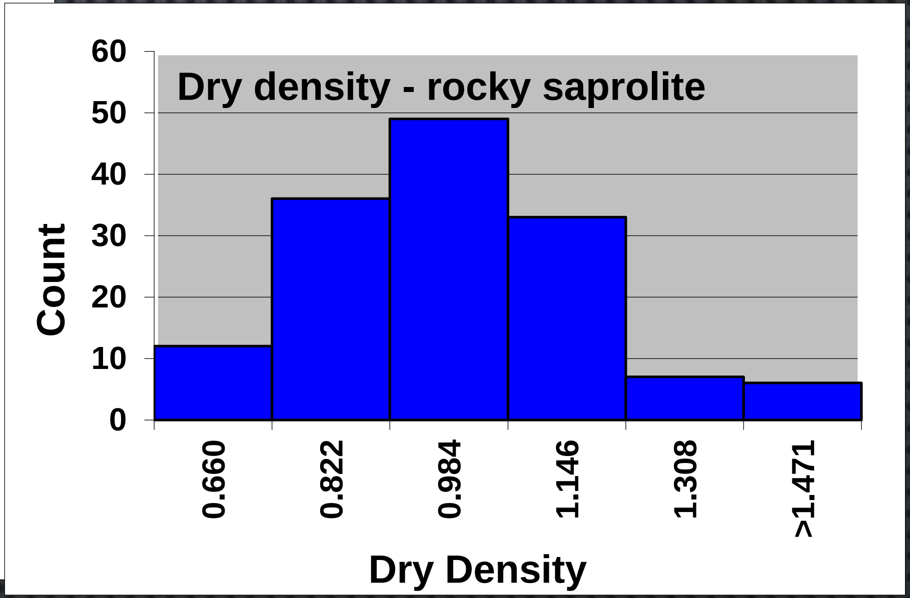


QAQC SAMPLE ~1:2

COMPARATIVE DENSITIES: PALAWAN VS DINAGAT







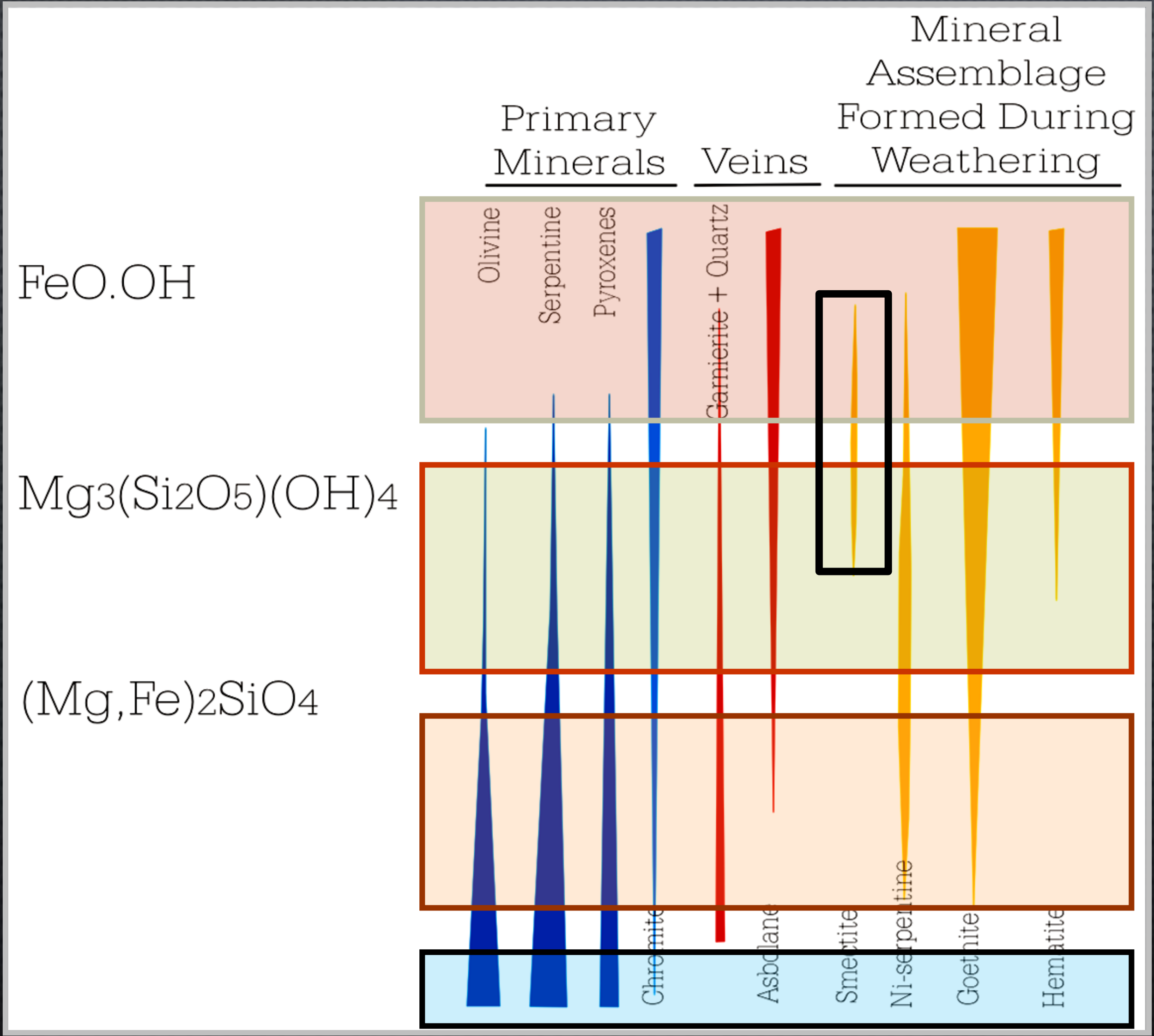
NONOC DEPOSIT – HISTORICAL BULK DENSITY AND MOISTURE CONTENT				
	PBM		MMIC	
Matrix	Bulk Density (t/m^3)	Moisture %	Bulk Density (t/m^3)	Moisture %
Limonite 1	1.29	29.30	1.37	31.10
Limonite 2	1.16	29.25	1.19	36.30
Limonite 3	0.96	46.71	0.88	39.60
Serpentinite 4	1.20	30.40	0.97	35.20

DENSITY AND THE LATERITE RESOURCE

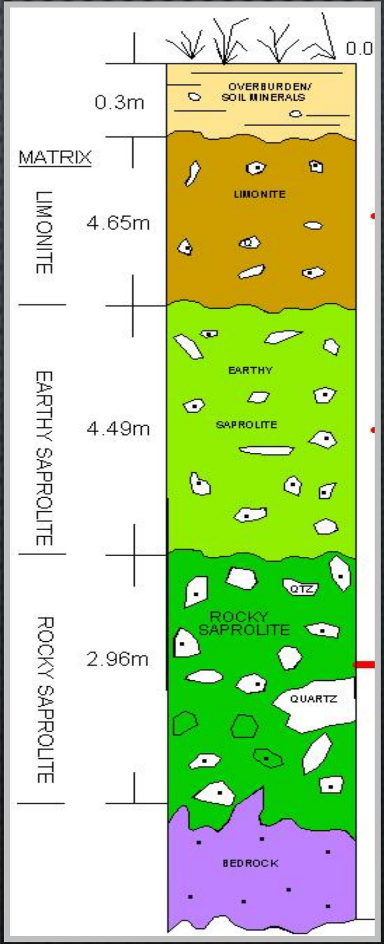
- In a well formed laterite stratigraphy, i.e. with distinct horizons of limonite, earthy saprolite, and rocky saprolite, density decreases from limonite downwards to rocky saprolite;
- The "reversed" trend is attributable to the mineralogical assemblage per matrix;

			RELATIVE ABUNDANCE		
OBSERVED MINERAL SPECIES increasing depth from surface to bedrock	THEORETICAL DENSITY	VOLUME%	LIMONITE	EARTHY SAPROLITE	ROCKY SAPROLITE
Goethite	4.27 - 4.29	5 - 30%	HIGH	MOD	LOW
Limonite	2.7 - 4.3	5 - 15%	HIGH	LOW	MOD
Fe Mg Si MIX/ Talc	2.7 - 2.8	15 - 35%	HIGH	MOD	LOW
Cr Minerals/ Spinels	4.50 - 5.09	5 - 7%	MOD	LOW	HIGH
Magnetite	5.1 - 5.2	<3%	HIGH	MOD	LOW
Asbolane	5.03	<5%	MOD	HIGH	LOW
Smectite	2.74 - 2.86	4 - 11%	LOW	HIGH	MOD
Pyroxene	3.20 - 3.88	2 - 12%	LOW	HIGH	MOD
Silica	2.65	2 - 11%	MOD	HIGH	LOW
Olivine	3.27 - 3.37	2 - 9%	LOW	HIGH	MOD
Serpentine	2.4 - 2.44	5 - 50%	LOW	MOD	HIGH
Ni Serpentine/ Garnierite	2.27 - 2.87	1 - 5%	ABSENT	MOD	HIGH

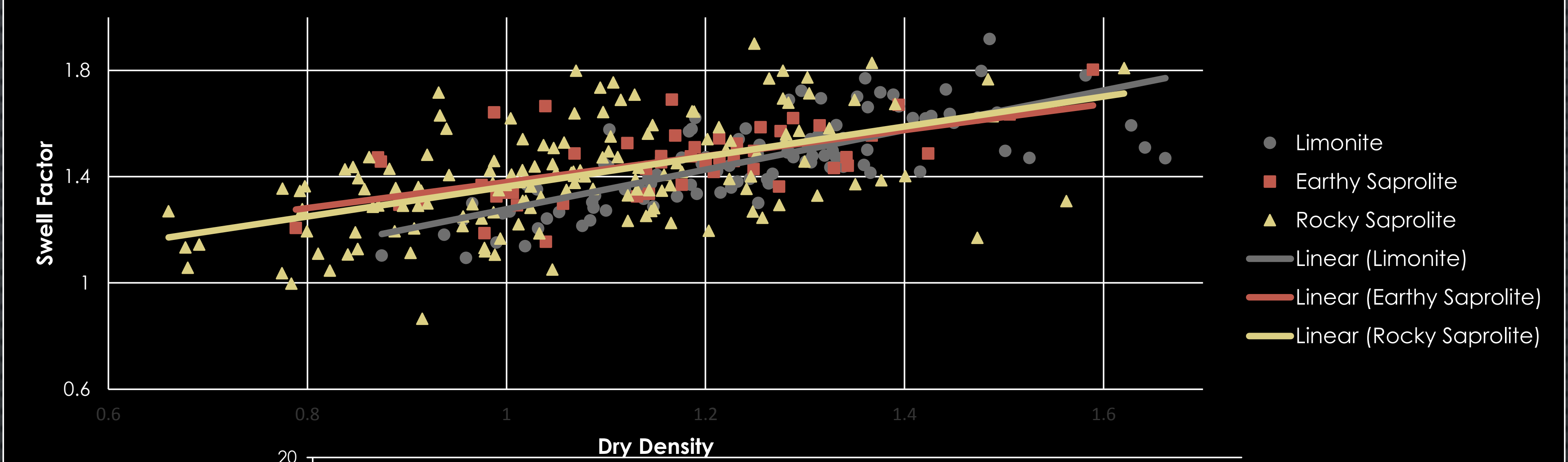
Density vs. Laterite Thickness

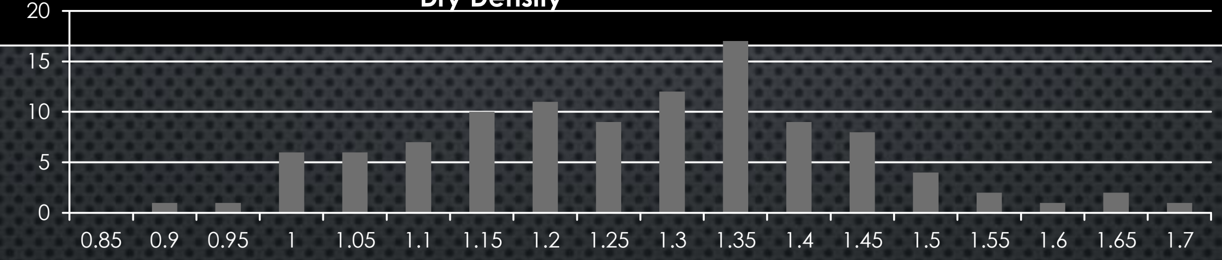


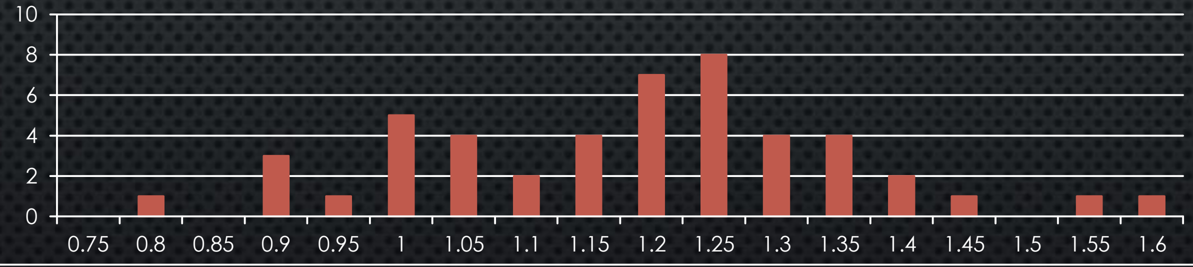
Silicate/Oxide Minerals distribution in Ni-laterite profile

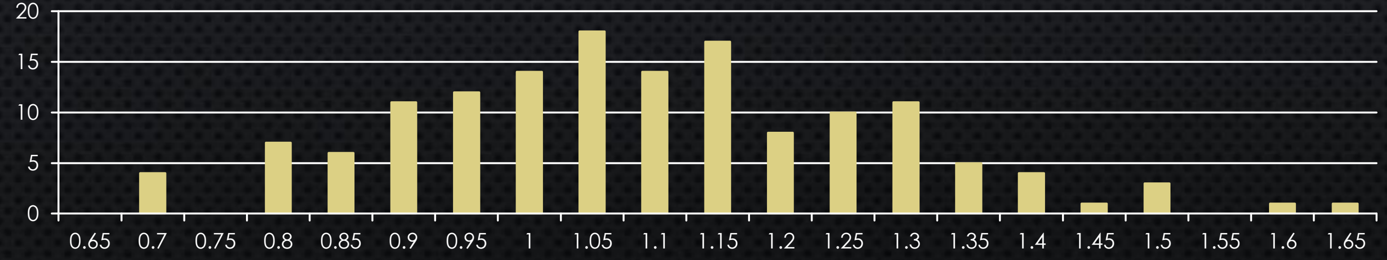


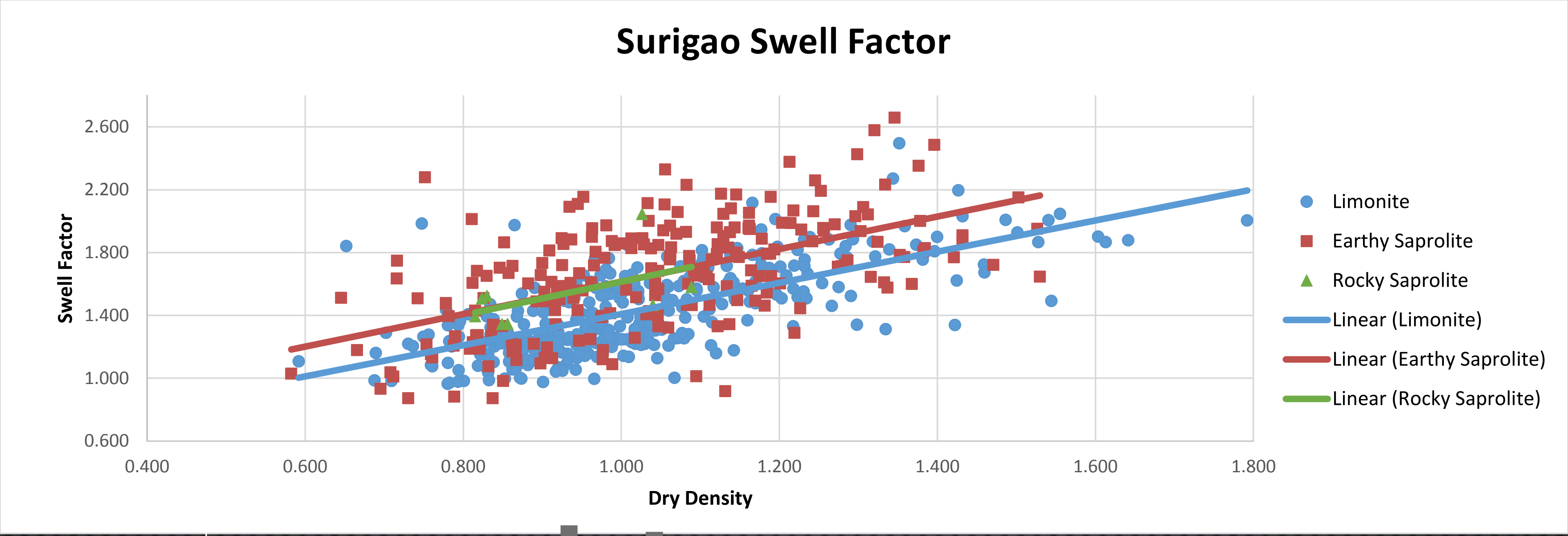
Palawan Swell Factor



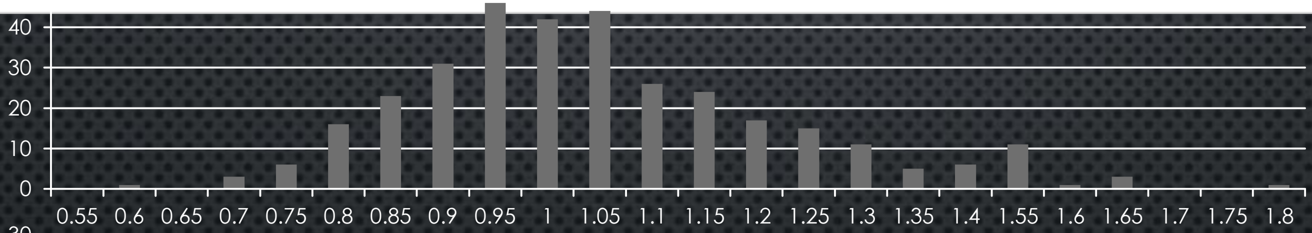




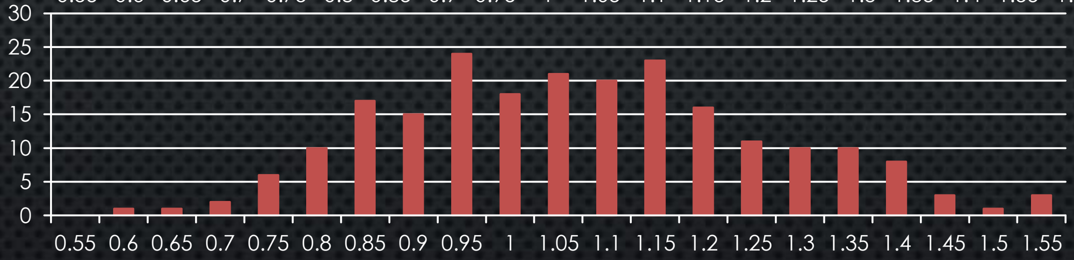




Surigao Swell Factor
Swell Factor
2.600
2.200
1.800
1.400
1.000
0.600
0.400
0.600
0.800
1.000
1.200
1.400
1.600
1.800
Dry Density
Limonite
Earthy Saprolite
Rocky Saprolite
Linear (Limonite)
Linear (Earthy Saprolite)
Linear (Rocky Saprolite)



40
30
20
10
0
0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4 1.55 1.6 1.65 1.7 1.75 1.8



30
25
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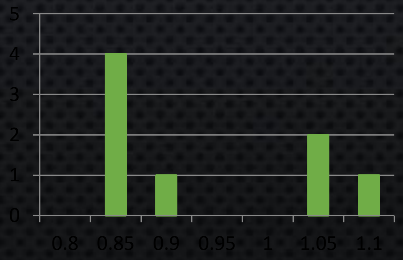
0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4 1.45 1.5 1.55



5
4
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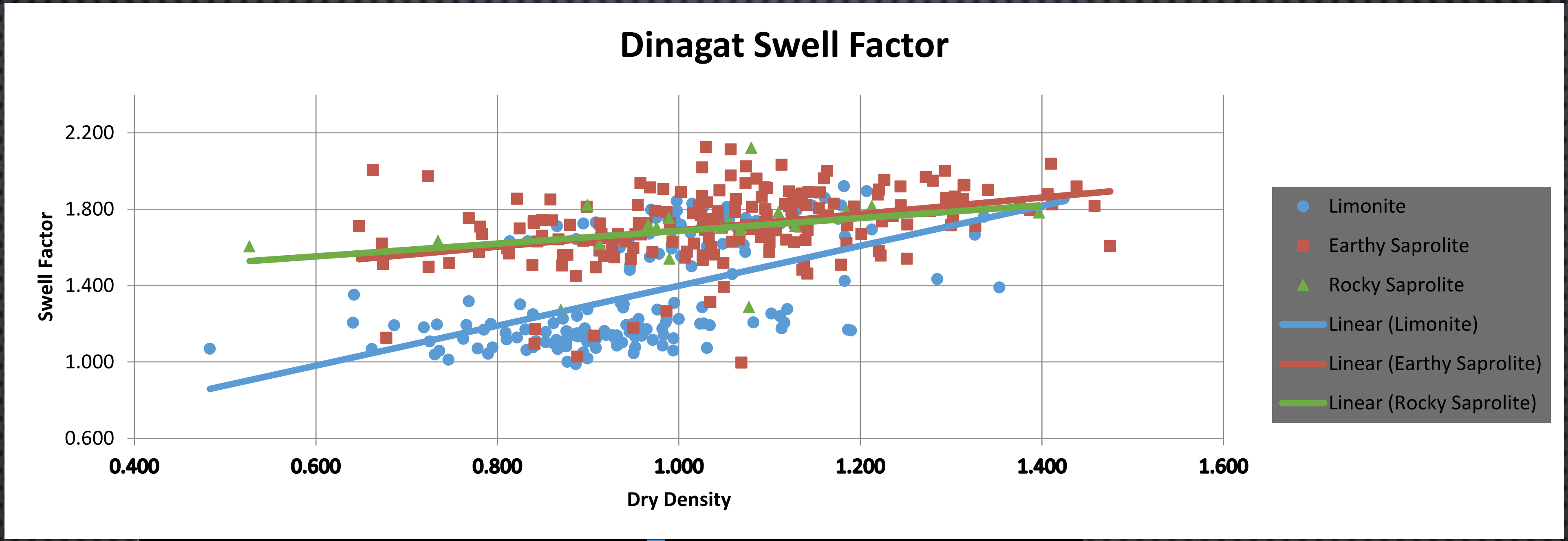
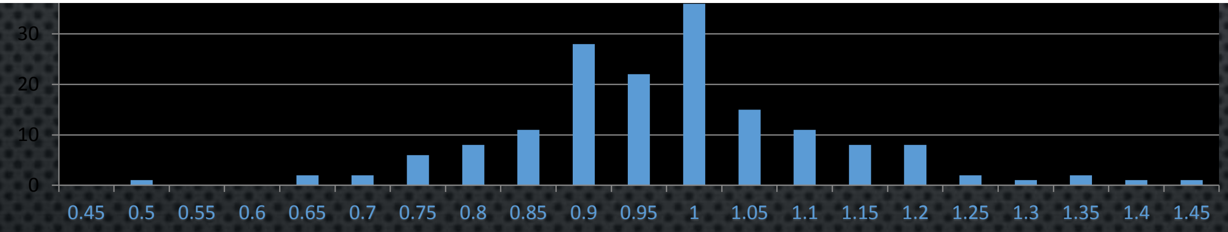
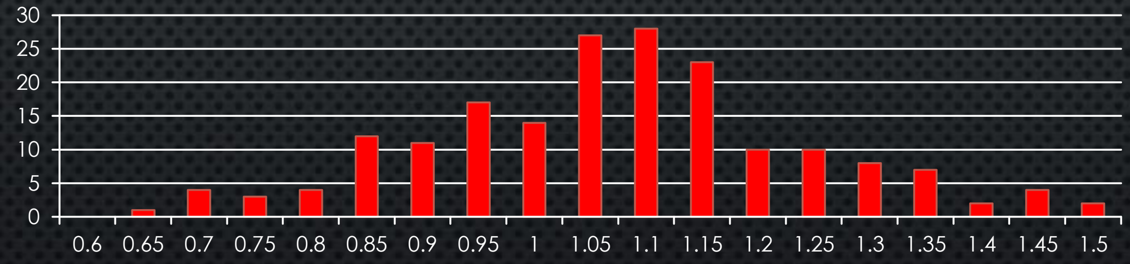
2
1
0
0.8 0.85 0.9 0.95 1 1.05 1.1


Dinagat Swell Factor
Swell Factor
2.200
1.800
1.400
1.000
0.600
0.400
0.600
0.800
1.000
1.200
1.400
1.600
Dry Density
Limonite
Earthy Saprolite
Rocky Saprolite
Linear (Limonite)
Linear (Earthy Saprolite)
Linear (Rocky Saprolite)


30
20
10
0
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45


30
25
20
15
10
5
0
0.6
0.65
0.7
0.75
0.8
0.85
0.9
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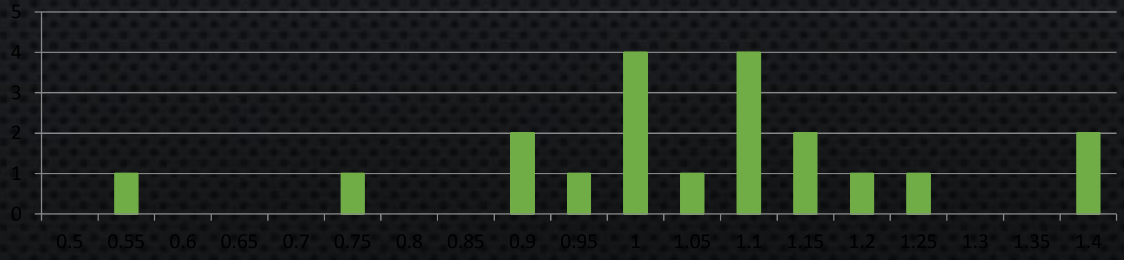
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5


5
4
3
2
1
0
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4

DENSITY AND THE LATERITE RESOURCE

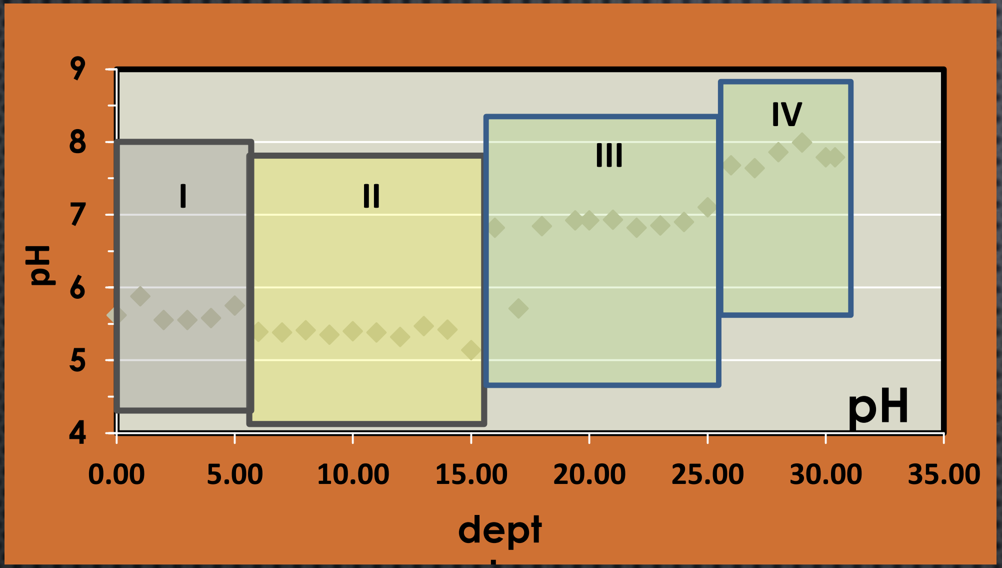
- In resource estimation density almost always receives the least attention on quality control
  - Geochemical analysis has check samples in form of duplicates, internal standards, etc.;
  - Drill hole location and topographic survey are always checked on the references used and take on re-shots;
  - Some mines take one value for density for the entirety of the deposit (for laterites)
- The Philippines is not an exception. Most mines simply adopt values from past exploration programs either by the mine itself or mines operating adjacent to it. Such became the root or irreconcilable figures between resource and reserve; reserve and shipped materials.
- Sand replacement method is very effective for in-situ, bulk density determination due to non-uniformity of particle sizes in various matrices of laterite;

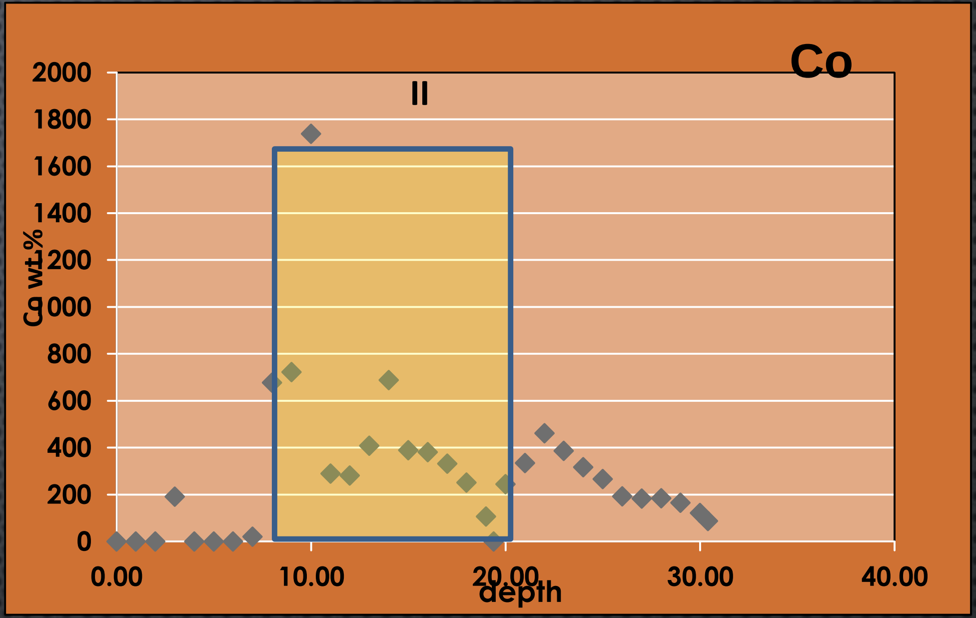
IV. INNOVATE

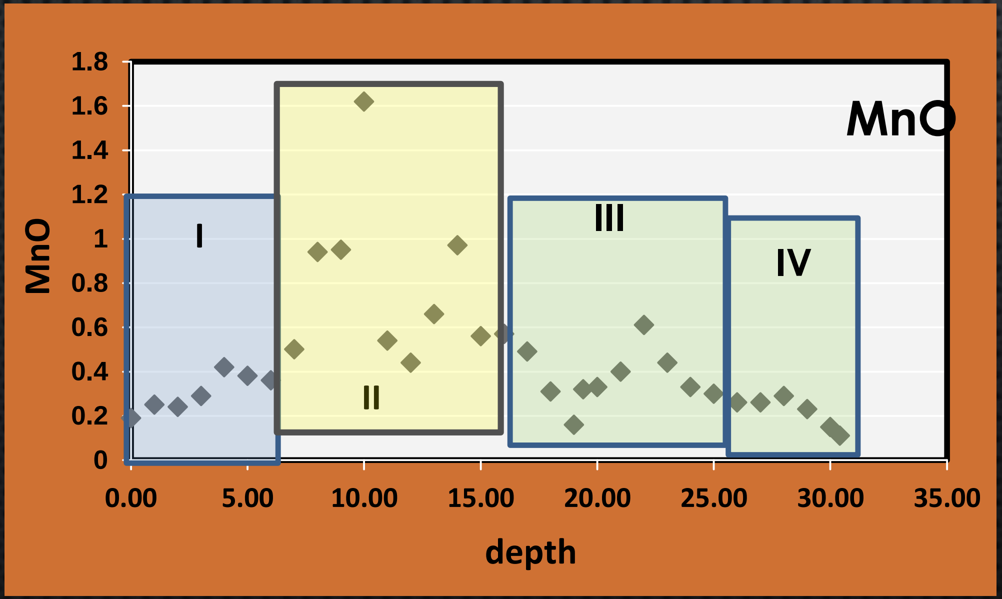
ENCOURAGE TO INNOVATE

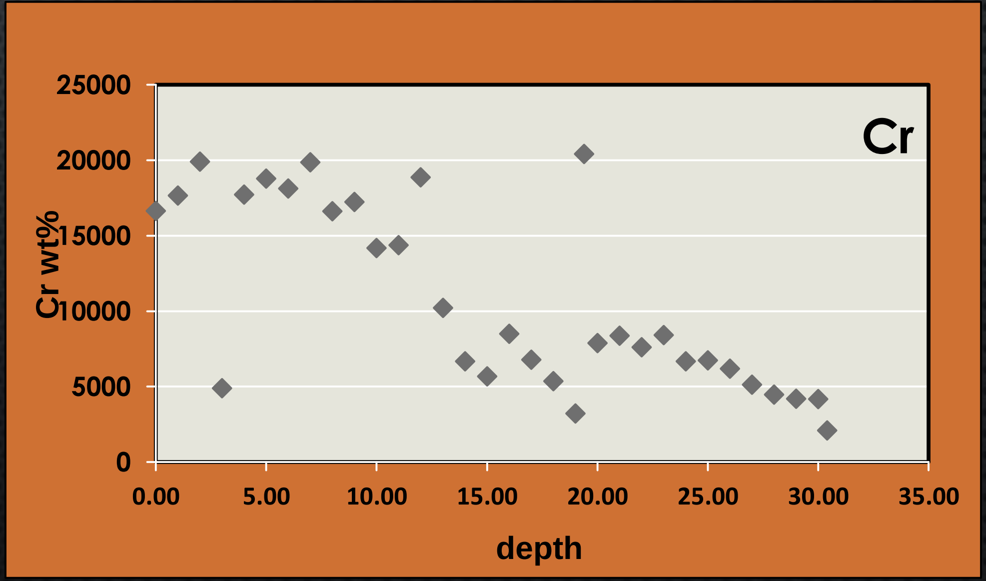
- Innovation can be done at any stage of mining – exploration to laboratory to mine
  - Sampling Protocols such reduction in the field to cut cost on sample bags, personnel requirement, and transportation to laboratory
- One good case example is on the reduction of error in pile sampling in Nonoc Nickel operations of PNPI then. It took 10 years to reduce the sampling errors in pile and trucks sampling to a minimum.
- A case situation is on pH tests of laterites and its bearing on metal contents

pH vs OTHER METALS









pH vs LATERITE GEOCHEMISTRY

- The pH-Eh values may imply the possible scenario of the laterite environment
- The pH trends serve as indicator to the geochemistry of laterite
  - The Mn trend is manifested by the shift or change to lower pH
  - Limonite is marked by slightly acidic signature
  - The earthy saprolite by near neutral to neutral pH
  - The rocky saprolite is caharcterized by slightly basic pH
- There are some other trends that are worthy looking at when it comes to pH trend
- Slope, groundwater flow rate and direction may bear relation to laterite stratification and substratification.

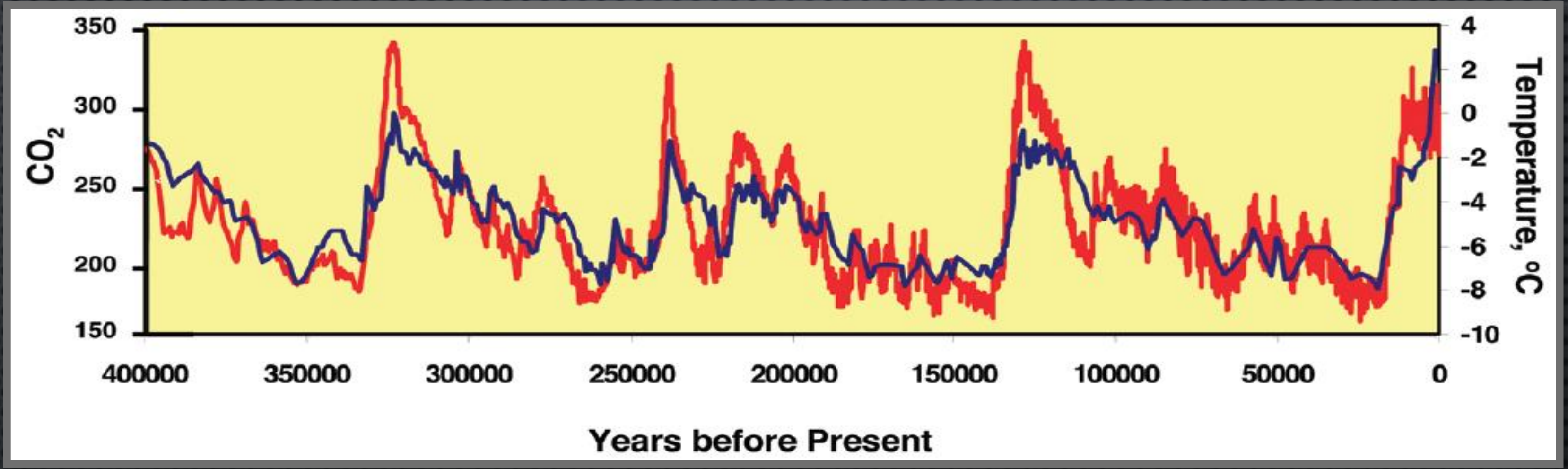
V. TOWARDS "GREEN TECHNOLOGY"

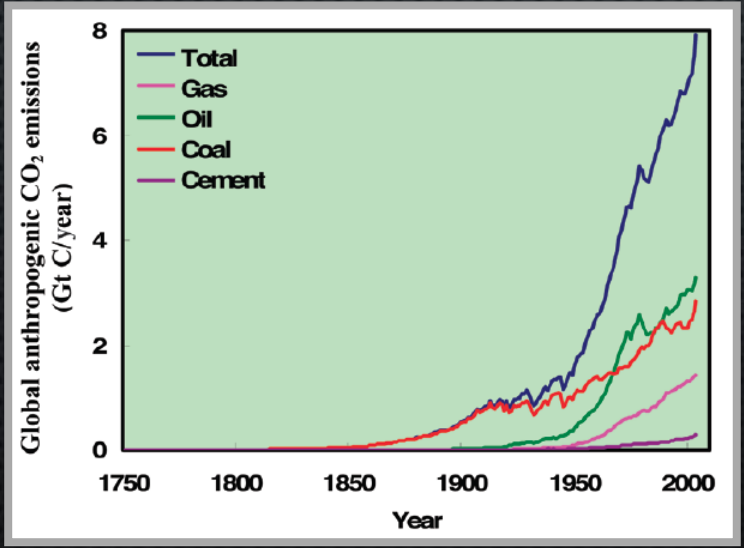
THE PERIDOTITE BEDROCK: AS CARBON REPOSITORY – LATERITE MINING "BONUS"?

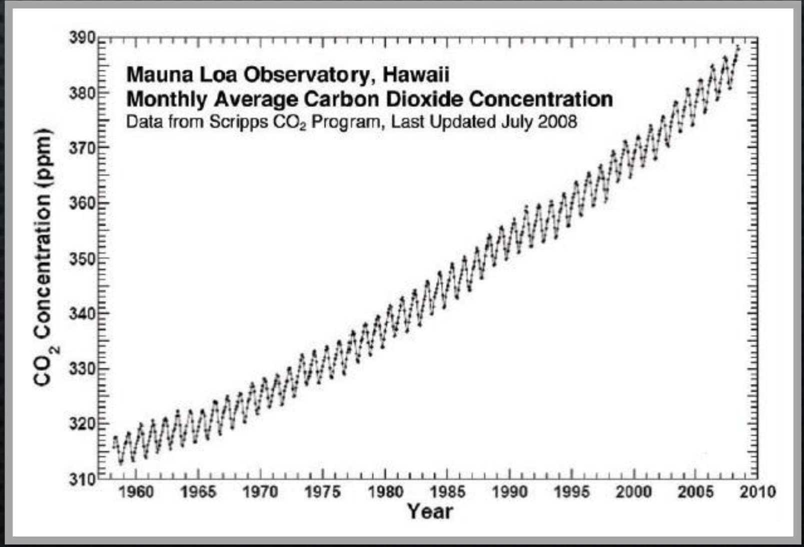
- Experiments for the past decade showed the high potential of harzburgite and dunite, protoliths or source rock of Ni-laterite, as carbon repository;
- The high magnesium (Mg) contents of the laterite bedrock react with CO_2 as gas or CO_2 dissolved in water to produce magnesite ($MgCO_3$) – a stable mineral which itself has industrial application;
- With such high Mg contents and the refractory nature of the peridotite bedrock make it potentially useful for acid mine drainage mitigation and as refractory brick respectively;
- Progress is technology utilizing these characteristics of the bedrock will lead to waste free or green technology mining for Ni-laterite or perhaps even in chromite mining.

RATIONALE: CONCEPTS AND PRACTICES

- GENERAL ACCEPTANCE OF THE FACT THAT GREEN HOUSE GASES SUCH AS CARBON DIOXIDE (CO2) IS EVER INCREASING IN THE ATMOSPHERE;







RATIONALE: CONCEPTS AND PRACTICES

Rank	Country	CO_2 emissions (gigatons C/year)
1	United States	1.65
2	China	1.37
3	Russian Federation	0.46
4	India	0.37
5	Japan	0.34
6	Germany	0.22
7	Canada	0.17
8	United Kingdom	0.16
9	South Korea	0.13
10	Italy	0.12
11	Mexico	0.12
12	South Africa	0.12
13	Iran	0.12
14	Indonesia	0.10
15	France	0.10
16	Brazil	0.09
17	Spain	0.09
18	Ukraine	0.09
19	Australia	0.09
20	Saudi Arabia	0.08

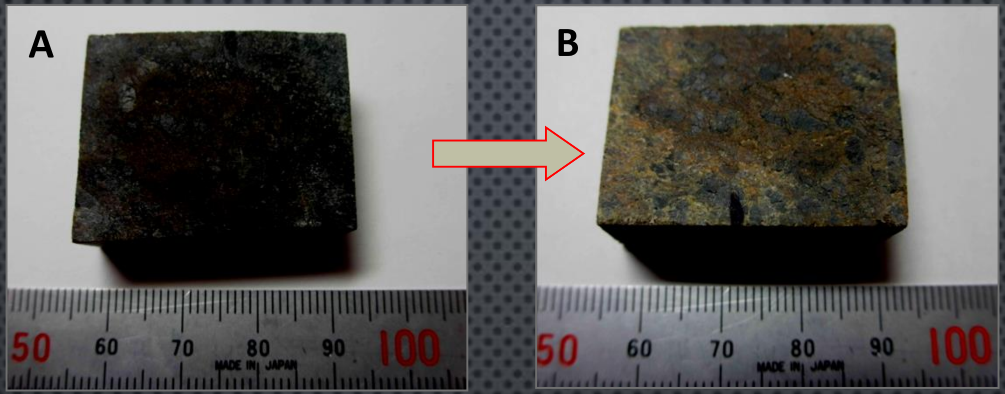
DISCLOSURE STATEMENT

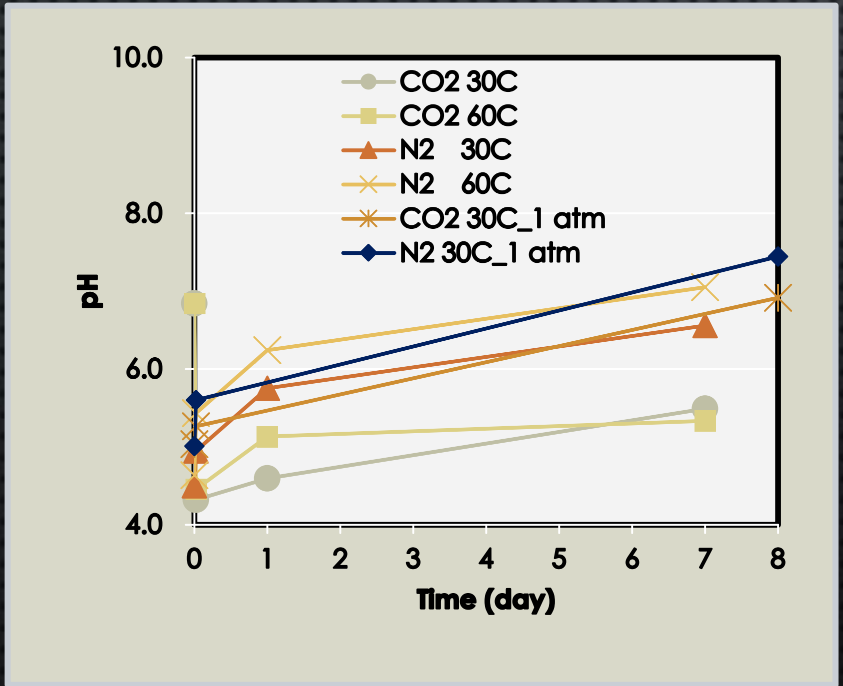
P.B. Kelemen and J. Matter have a provisional patent filing on the methods for CO_2 capture and storage via mineral carbonation that are described in their 2008 paper in the *Proceedings of the National Academy of Sciences*. Other than that, the authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

(After Marland in Oelkers and Cole 2013)

METHODOLOGY: Laboratory Set-up & the LINKAM
(courtesy of Akita University)

PRELIMINARY RESULTS: Water Chemistry

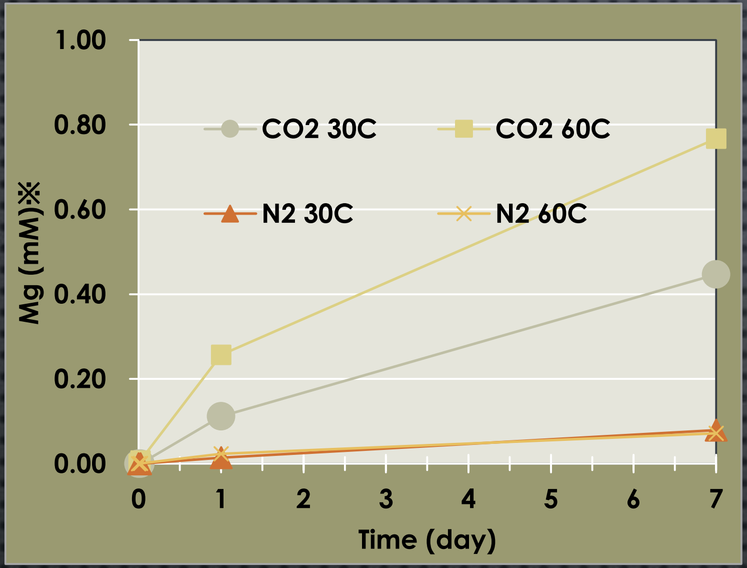


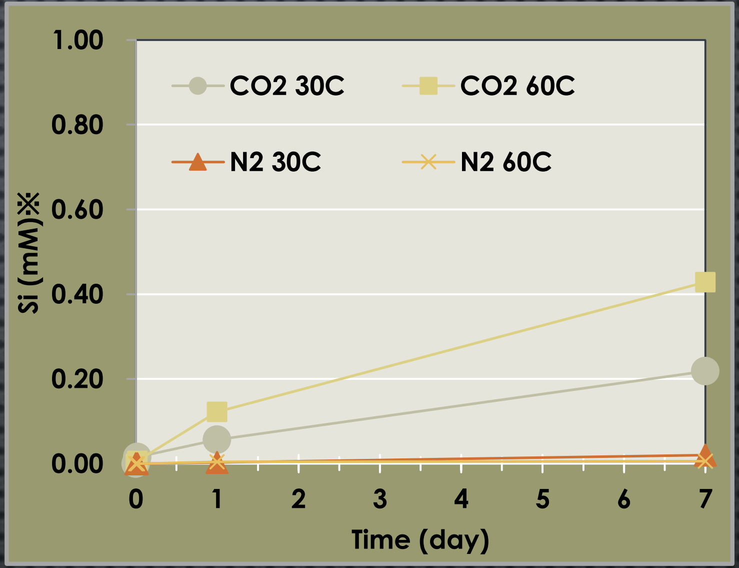


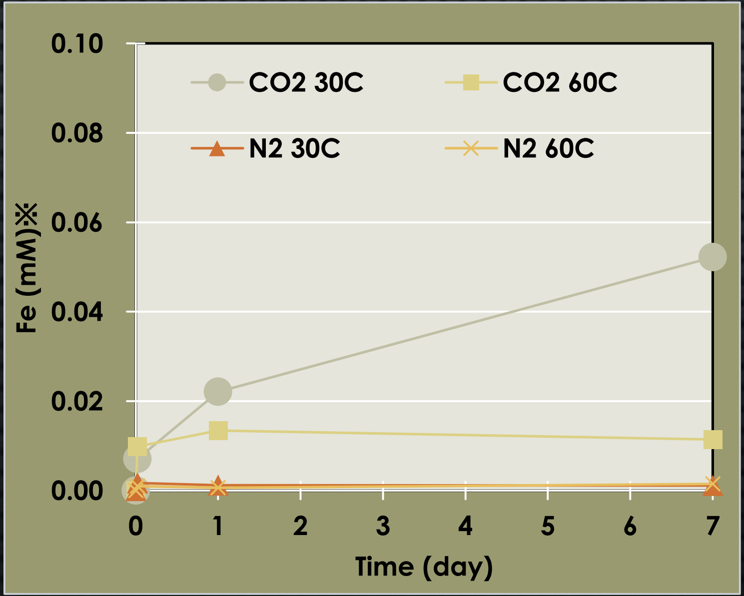
Results:

- At 1 atm (CO_2 and N_2) steep pH increase imply absence of buffering by HCO_3 thus saturation is far from completion or may never be obtained
- At 2 atm CO_2 and 60^{o}C tapering or lessening of bar slope implies saturation inCO_2 buffering of HCO3
- Silica starts to precipitate and followed by carbonate precipitation at a slightly higher pH (4.5)

PRELIMINARY RESULTS: Water Chemistry





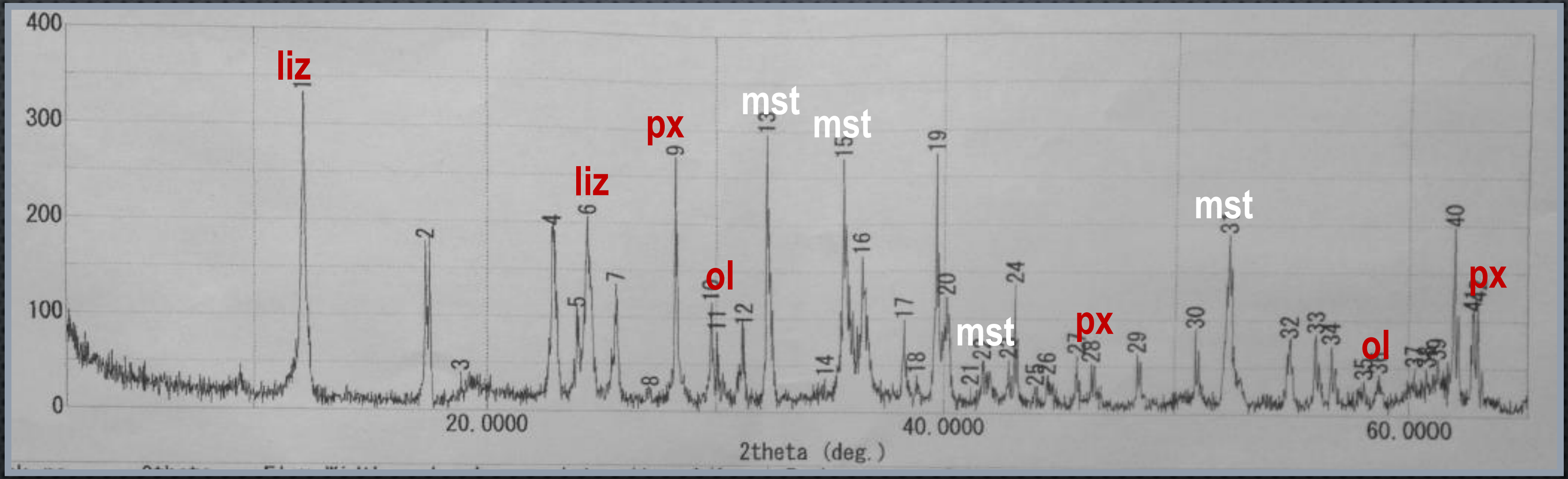


Results:

- With the exception of Fe, saturation is yet to be reached for Mg and Si and is highest in terms of dissolved contents in water at 60^{o}C and 2 atm (the P for all sets)
- For Ca, Al, and K the results are very low due to low natural abundance in ultramafic rocks

$$Mg^{++} + HCO_3^- + OH^- = MgCO_3 + H_2O,$$

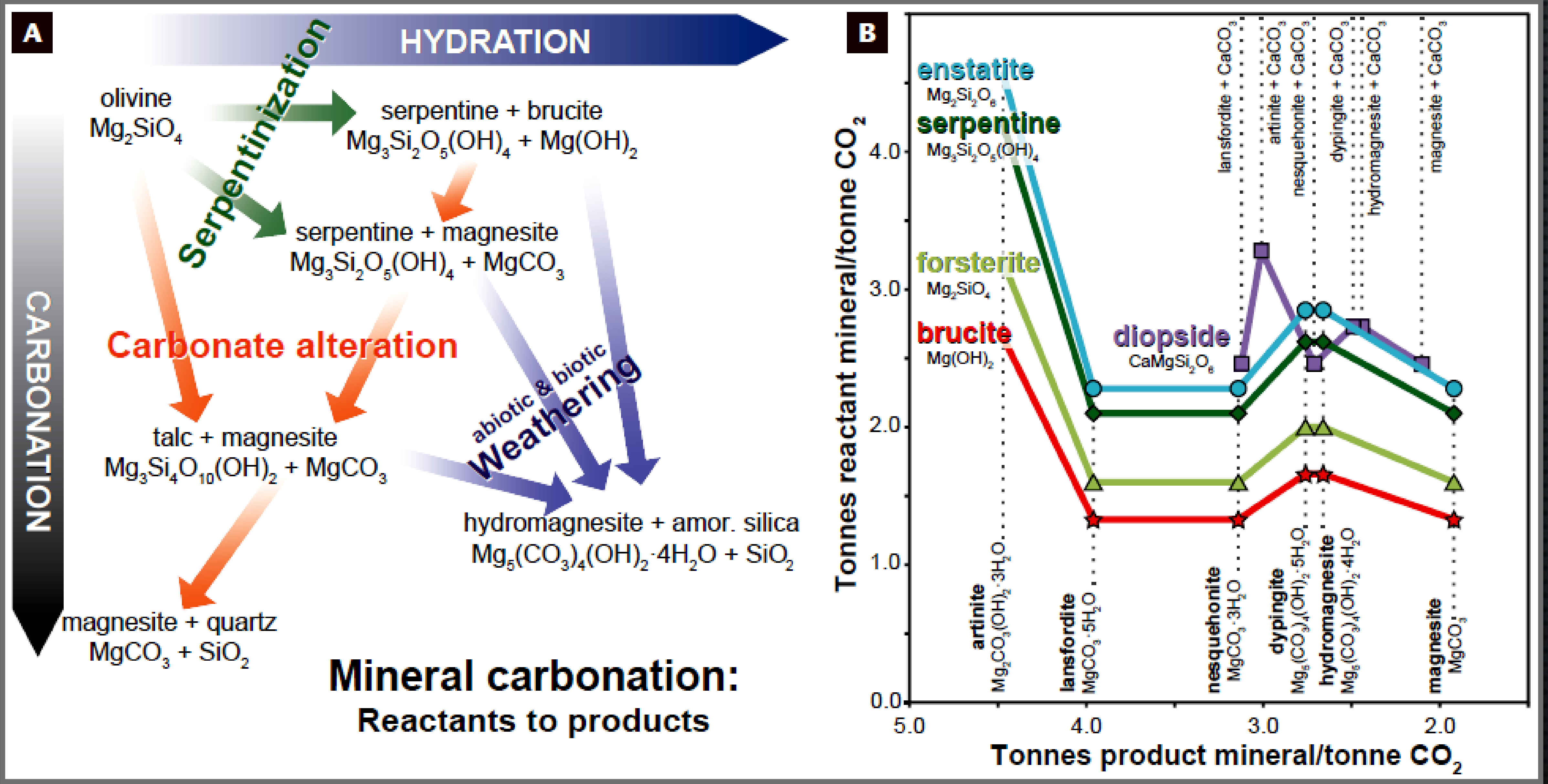
PRELIMINARY RESULTS: Harzburgite



Results:

- Probable presence of magnesite ($MgCO_3$) revealed by XRD (Kyushu University) within the harzburgite matrix
- It is yet for further confirmation since similar occurrence was observed even on runs under N_2.
- The results simply state the potential of the ultramafic units of ophiolites as stable repository for atmospheirc CO_2.

The Mineral Carbonation Concept



(After Power et al., 2013)

CONCLUDING REMARKS

- THE MINING LAW AND ITS IRR ARE COMPREHENSIVE ENOUGH FOR THE PROTECTION OF THE ENVIRONMENT AND SECURE A SIGNIFICANT IF NOT FAIR SHARE OF THE BENEFITS FOR THE NATIONAL AND LOCAL GOVERNMENTS.
- HIGHLIGHTED IN THE IRR IS THAT 1% OF OPERATING COST MUST BE SPENT IN PART TO MINING TECHNOLOGY RESEARCH AND GEOSCIENCES.
- THERE IS A LOT OF ROOM TO IMPROVE MINE OPERATIONS AND EVEN AT AN EARLY STAGE AS EXPLORATION
- ENCOURAGEMENT AND INCENTIVES MAINLY FROM THE GOVERNMENT SIDE IN ORDER TO PUSH COMPANIES TO GET INTO R & D, GO GREEN, INNOVATE.