Integrating Exploration Data to Develop and Modify Exploration Models: Case Studies from two Sites in Indonesia. Implications for Exploration.

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The field exploration was undertaken by a small group of dedicated Indonesian and expatriate geologists and assistants who accepted the struggle and found satisfaction and reward in seeing discovery of new or significant extensions to bodies of mineralisation.







Displaying presenter notes in PDF file – these can be ignored or opened as shown – not all slides have notes, only those with small icon top left corner of slide.



Digital Elevation Model and Bathymetry of Indonesia



RUTHERFORD MINERAL RESOURCE CONSULTANTS ABN: 60 396 553 906 The Indonesian Archipelago





Subduction Zones & Island Arc Model Setting We start learning and exploration with conceptual models







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Expressions of structural host sites for mineralisation

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Sillitoe conceptual models of porphyry and related mineralised systems.





Geophysical & alteration expression of mineralisation



Batu Hijau - Indonesia



Geology

Young Tonalite

- Intermediate Tonalite
- Equigranular Quartz Diorite
- Porphyritic Quartz Diorite
- Porphyritic Andesite Intrusive
- Volcanic Lithic Breccia
- Fine Grained Volcaniclastics



Sulphides

Bornite + Chalcopyrite Chalcopyrite Dominant Chalcopyrite > Pyrite Zone Pyrite > Chalcopyrite



Alteration

 Moderate to Strong Secondary Biotite
Sericite - Chlorite +/- Clay
Feldspar Destroyed (Clay - Mica)
Epidote Present



Magnetics

RTP



Bata Hijau the classic model for Indonesian porphyries.





Regional setting of project areas and mineral deposits





Pliocene palaeogeography and magmatic arcs of the Indonesian region showing major mineralised centres. Sumatra Fault defines a major break between the old Palaeozoic continental crustal areas and the continental margin in a classic island arc trench setting.



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The terrain in Aceh is an exercise in fractals – just as bad at all scales and even harder when you have to work in it.











The topography really is as bad as you think.























Continental margin facies rocks





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Published 1:250,000 scale geology map of southern Aceh





Regional stream sediment survey undertaken by Rio Tinto in early 1990s before the Aceh conflict commenced highlighted a number of regions of potential interest. Later sampling by a Meekatharra Minerals-Teck JV located gossanous outcrop at the two most prominent sites.





Reduced to pole total magnetic intensity

protimately 60 km of stille

First vertical derivative magnetic intensity

200 and 100 metre spaced flight lines Nominal 50-70 metre flight height flown North-South (terrain considerations) using a helicopter. To obtain necessary detail of the regional magnetic patterns relatively close flight line spacing is required.

Due to access & logistical constraints geological mapping and detailed heliborne magnetics were used early in the program to outline regional setting, aid interpretation and for definition of target sites.



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Airborne magnetic data detail and 3D inversion modelling merged with field mapping enabled anomaly discrimination.



Mineralised magnetite bearing endoskarns in elongate microdiorite intrusives and garnetwollastonite prograde and retrograde exoskarns (Cu-Au-Mo) about contact with limestone

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Numerous magnetic features of interest highlighted – some clearly larger intrusive bodies, others narrow continuous features mirroring the mapped stratigraphy, in particular limestone-intrusive contacts which however are related to major dilatant regional structures formed by oblique slip arc deformation.

Importantly the area for initial exploration could be significantly reduced.

Mutia

Samadua Nth

Samadua Sth

Panton

Luas

NE Panton Luas

Central Region

Samadua East

Seemingly all barren magnetite rich endoskarns and related magnetite rich coarse grained diorite to granodiorite intrusives into older metasedimentary sequences.

Payabu Nth A/B

Mersak Ea

Pala Kuini Zor



(17 metre interval from 212 metres @ 1.27g/t Au and 0.7% Cu)



(1 m interval 1.47 g/t Au; 0.49% Cu) RUTHERFORD MINERAL RESOURCE CONSULTANTS

Example of outcropping magnetite endoskarn hosted

within epidote-bearing retrograde altered microdiorite

Early drilling was focused on the strongly magnetic microdiorite hosted targets with results giving sufficient encouragement to expand activities to other regional targets.



§ Mapping demonstrated that pronounced magnetic lows marginal to intense linear magnetic features were often sites for prograde garnet-pyroxene±wollastonite skarns which subsequently became altered by mineralised hydrothermal fluid derived from the intrusive. These intrusives are anomalous in Au and Cu and contain abundant magnetite.

§ High grade retrograde Au-Cu skarns occur as irregular pipe-like bodies adjacent to the intrusive margin or associated with often large limestones blocks incorporated within the intrusion. These are readily located using routine soil and rock geochemistry across the target zone.











Mineralisation is dominated by bornite-chalcopyrite assemblages in retrograde skarns; magnetitechalcopyrite in prograde endoskarns within the microdiorite intrusives.











Examples of high grade skarn mineralisation



Hydrothermal features are seen as magnetite veins, alteration of magnetite to pyrite, miarolitic cavities lined with feldspar and bornite crystals, pyrite-chalcopyrite vein fill within microdiorite.







Chalcopyrite as late fracture fill



Late hydrothermal breccias with limestone & mineralised microdiorite clasts



Mylonitic fabric high compression shear surface



Polymictic intrusive breccia





Evidence of tectonic and intrusion related events





Ongoing intrusive activity occurs as fracture fill reflecting continuing dilation along the same structural pathways





Pelumat Prospect Geology & Magnetic expression.







Rock chip Results over RTP TMI Image Mo-Sb rock chip results





Rock chip Results over RTP TMI Image Au-Cu rock chip results



esults





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Samadua Project – Location in the clouds







Samadua Project – Magnetics, geology and Cu-Au-Mo geochemistry





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USTRA










Magnetite-chalcopyrite endoskarn



Kuini Cu-Au-Mo Prospect



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Kuini Prospect – endoskarn skarn near margin of intrusive. Note blocks of limestone in intrusive.





intrusive against major structural break.

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Hydrothermal magnetite veins



Molybdenite-chalcopyrite-pyrite sheared and retrograde endoskarn





- § Magma intrusion is associated with structurally active dilatant regional fault traces.
- § Hydrothermal fluids sourced from the intrusions are also constrained by the structural boundaries and structural offsets related to the faults.
- § Magnetite crystallisation enables the structures to be identified in aeromagnetic surveys. Routine multi-element soil and rock geochemistry can identify ore mineralisation.
- § There may be extensive local alteration of intrusion hosted and country rock (skarns) and there is generally post mineralisation deformation.

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Beutong Copper Project

Potential for large open pit mineable copper-gold-molybdenum resources close to infrastructure





Beutong exploration project area north of Pelumat – approximately 150 Mt indicated and inferred.





An analogue at the other side of the world – without the trees



Summary geological section through Morococha District, Peru After Leon (2007)









RUTHERFORD MINERAL RESOURCE CONSULTANTS ABN: 60 396 553 906 Potosi Intrusion, Codiciada Area, Morococha, Peru Thanks to Honza Catchpole for the images.



Farewell to Aceh



Now to Java





Exploration of Gunung Rosa Au-Agbase metal mesothermal vein system in an eroded volcanic complex, Western Java, Indonesia



Gunung Rosa





RUTHERFORD MINERAL RESOURCE CONSULTANTS ABN: 60 396 533 906 Location of the Gunung Rosa Project





Pliocene palaeogeography and magmatic arcs of the Indonesian region showing major mineralised centres.





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Schematic volcanic intrusive model of Richards (2003)

Economic Geology V98: pp1515-1533







Mt Mahameru behind Mount Bromo, East Java. This highlights the short life of volcanic intrusive centres in active tectonic zones









Schematic model of a volcanic intrusive centre







Tectonic setting southern coast of Java









Terrain in the Gunung Rosa project area (2X vertical exaggeration)







Location of historic underground mining activities







The proposed 1992 plant site as seen today. It is planned to reuse this for the new development. Vein trace shown by yellow dashed line. North to right, view to west.







Tea plantation covers much of the area of interest beneath which the main vein occurs but it rarely outcrops.







Century Mines and Metals NL Resources above 900m RL using 3g/t cut off.

Historic mining and resource assessment blocks as in 1992.

(Data from Century Mines and Metals NL - ASX Report)







A 17 hole due diligence drilling program was undertaken from mid 2011 - early 2012 beneath the main 1992 development workings.







Main vein mined out in old workings





Cap Palu decline







All sub 900 m RL and below water table and old workings



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GUNUNG ROSA Hole GRD004- High Grade Intersection 152.8 – 155.8 Metres (Recovery ≈ 95%)

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GUNUNG ROSA Hole GRD005- High Grade Intersection 168.9 – 172.4 Metres (Recovery ≈ 95%)







GUNUNG ROSA – Hole GRD009 Assay Results – Grade Distribution in Hole

	From	То	Interval	Au g/t						
GRD009034	220.50	221.30	0.80	0.35						
GRD009035	221.30	222.30	1.00	0.25						
GRD009036	222.30	225.30	3.00	0.02						
GRD009037	231.35	232.35	1.00	0.17						
GRD009038	232.35	233.35	1.00	0.12						
GRD009039	233.35	234.35	1.00	0.04						
GRD009040	234.35	235.35	1.00	0.14		m-g		m-g		
GRD009042	235.35	236.15	0.80	3.80		3.04				
GRD009043	236.15	237.15	1.00	0.33		0.328				
GRD009044	237.15	238.15	1.00	0.48		0.477				
GRD009045	238.15	238.75	0.60	9.07		5.442		5.442		
GRD009046	238.75	239.25	0.50	7.63		3.815		3.815		
GRD009047	239.25	240.05	0.80	5.94		4.752		4.752		
GRD009049	240.05	240.75	0.70	25.70		17.99		17.99		
GRD009050	240.75	241.35	0.60	42.90		25.74		25.74		
GRD009051	241.35	242.45	1.10	3.41		3.751		3.751		
GRD009052	242.45	243.35	0.90	4.96		4.464		4.464		
GRD009053	243.35	243.75	0.40	0.48		0.1928				
GRD009054	244.25	245.15	0.90	3.16		2.844				
GRD009055	245.15	246.15	1.00	0.27						
GRD009056	246.15	247.15	1.00	0.04	9.30	72.8358	7.83	5.20	65.954	12.68

9.3 m @ 7.83 g/t ; including 5.2 m @ 12.68 g/t









Inferred Resource estimation at stated cut off grades for areas below 900m RL (2m minimum vein width, 0.5m mining dilution)

	Cut off	Tonnes*	Average Au Grade	Au oz*	Ag oz	Cu tonnes	Pb tonnes	Zn tonnes
	No cut off	3,161,080	4.51	458,090	1,137,270	9,250	13,330	45,880
	1 g/t	2,793,580	5.01	449,330	1,077,690	8,440	13,180	44,740
	1.5 g/t	2,467,240	5.50	435,950	1,045,220	8,230	13,020	43,810
RUTHERFORD	2 g/t	2,165,160	5.89	409,360	975,530	7,830	12,210	40,440
MINERAL RESOURCE CONSULTANTS ABN: 60 396 553 906	3 g/t	1,978,350	6.24	396,130	877,660	6,710	11,990	40,250









Field mapping revealed a range of intrusive and breccia events with various of alteration relationships and styles suggesting quite a different history than had been interpreted historically.











Milled breccia dykes, advanced argillic & silica pyrite alteration 🔜 UNSW RUTHERFORD MINERAL RESOURCE CONSULTANTS ABN: 60 396 553 906





Milled polymictic and hydrothermal breccias, mesothermal veins











Pebble breccia dykes in weakly to strongly altered intrusive.







Northern end of vein system – Cap Palu. Typically broader sections lower grade.



Southern end vein system. Chalcedonic silica fill, coarser sulphides. Far north vein breccia.

Sulphide veins & breccia










RTP TMI magnetics over 3D digital terrain model

Survey was flown along north south lines using 50 and 100 metre spaced flight lines and was completed in under 2 days.









Magnetite destruction related to vein and wall roc alteration can be delineated by detailed ground RUTHERFORD MINERAL RESOURCE CONSULTANTS magnetics.



















Preliminary metallurgical studies are very positive.

The Gurung Rosa Composite has a Au grade of 11.4 g/t. It also contains 52 g/t Ag, 7.08% Zn, 2.54% Pb and 0.61% Cu.

80% of the gold in the Gurung Rosa Composite is contained in the +0.038 mm fraction which accounts for 56% of the mass.

Gravity upgrading using a Falcon Concentrator and panning achieved a concentrate containing 2835 g/t Au and 1175 g/t Ag (Test 3 Pan Con 1) which represented 0.1% of the feed mass. The tailings product contained 6.5 g/t Au.

Bulk sulphide flotation of the ore showed that it was possible to recover a concentrate_ of 30% of the feed mass which contained more than 96% of the Au and Pb and more than 98% of the Zn and Cu (FLT.01).

The effect of conducting differential flotation on a cyanide leach residue was investigated in FLT.06. Despite the poor separation between metal sulphides the two-staged process resulted in the recovery of 92% Au, 90% Ag, 98% Zn, 94% Cu, 91% Pb and 30% of the mass.







Clay-silica-pyrite sample with supergene Au (147 g/t) being guarded by a drone.



