EASTERN SUNDA ARC: AN EMERGING BELT FOR PORPHYRY Cu-Au AND EPITHERMAL Au DEPOSITS

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"Understanding Epithermal-Porphyry Deposits along Eastern Sunda Arc

Virtual Event, 12 June 2021

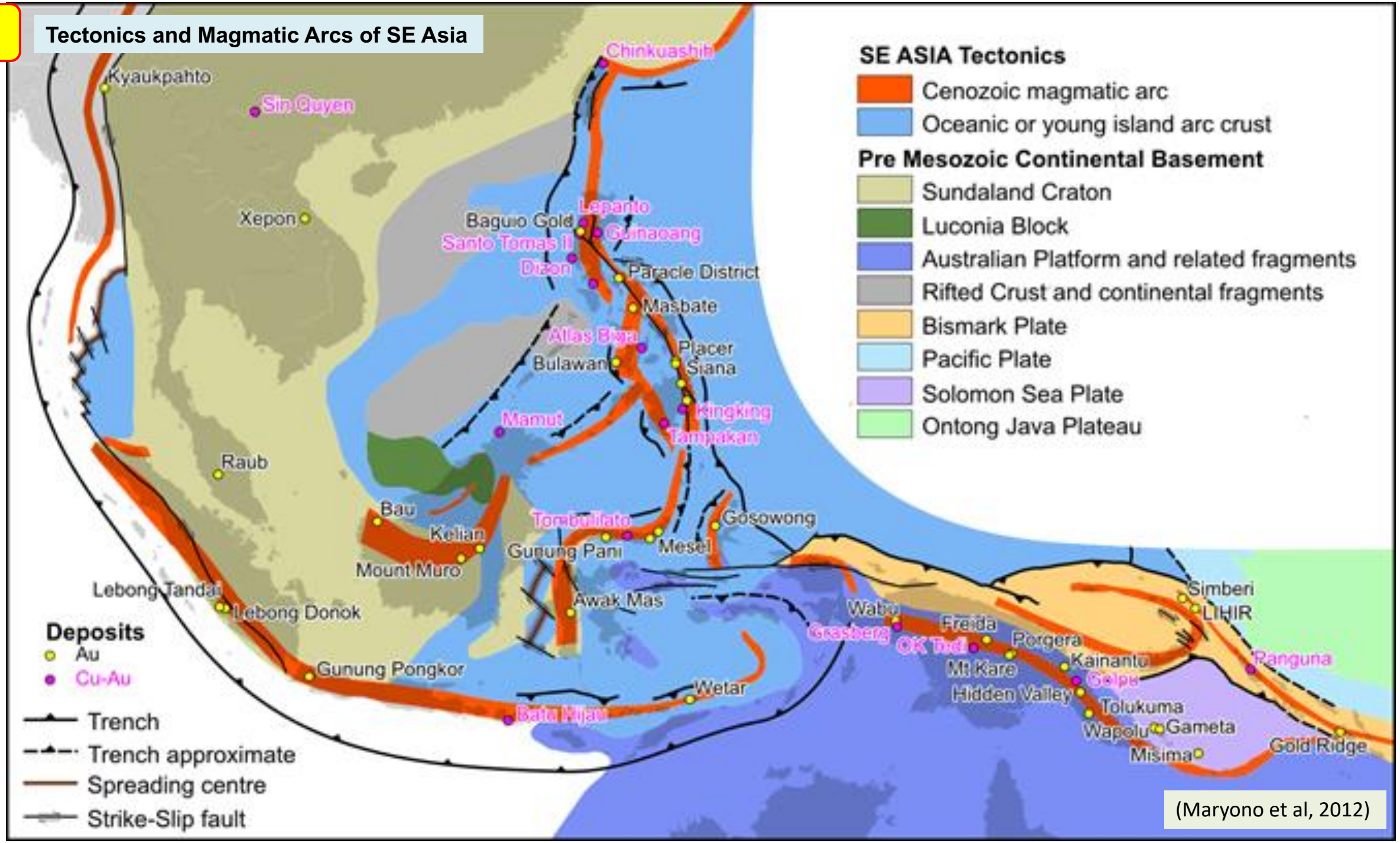
EASTERN SUNDA ARC: AN EMERGING BELT FOR PORPHYRY Cu-Au AND EPITHERMAL Au DEPOSITS

Outline

1. Tectonic and Magmatic Arcs
2. Epithermal and Porphyry Mineralization
3. Exploration Models for Porphyry and Epithermal Deposits
4. Au-Cu Mineralization in Southern East Java
5. Discussion

1

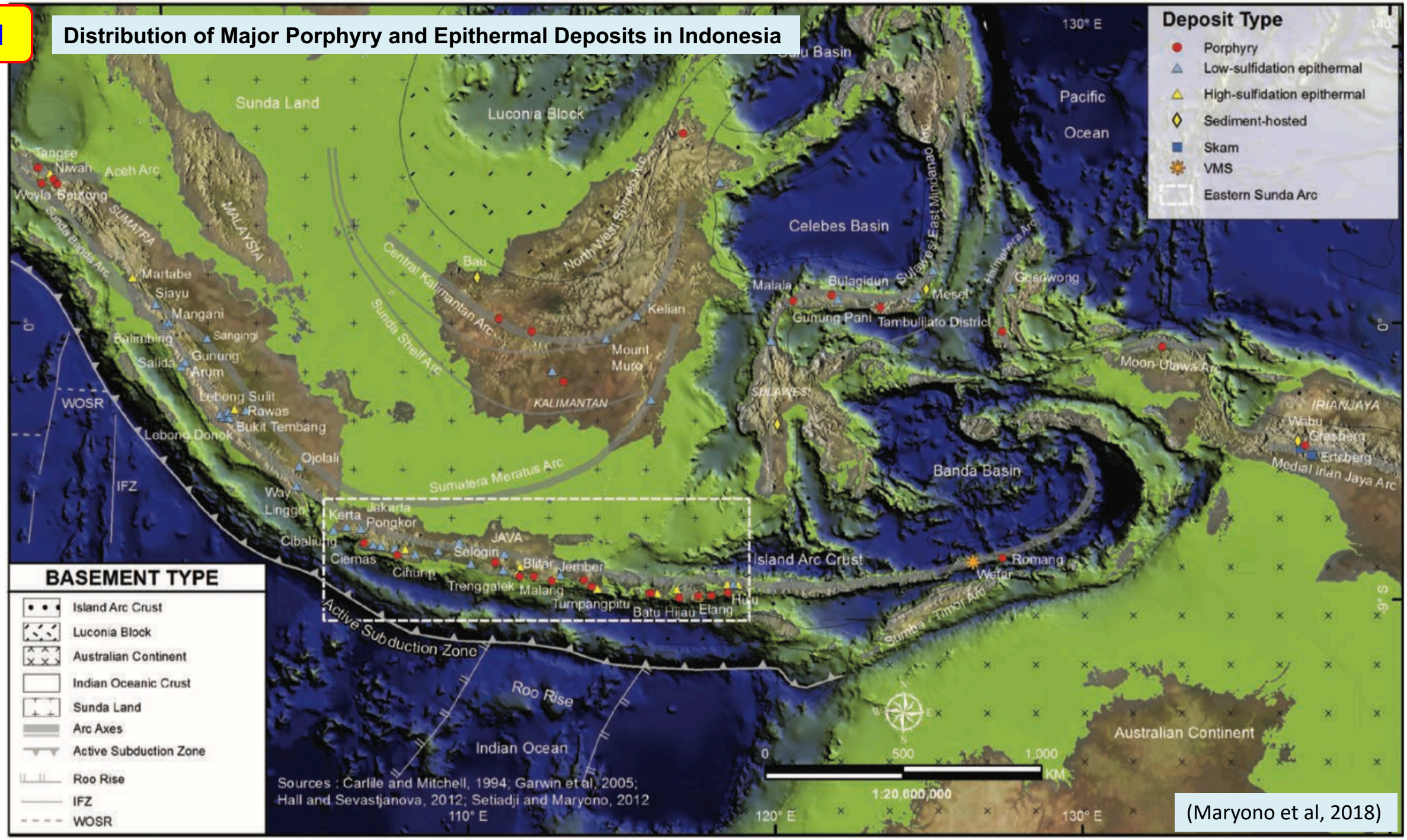
Tectonics and Magmatic Arcs of SE Asia



(Maryono et al, 2012)

1

Distribution of Major Porphyry and Epithermal Deposits in Indonesia



Sources : Carlile and Mitchell, 1994; Garwin et al, 2005; Hall and Sevastjanova, 2012; Setiadji and Maryono, 2012

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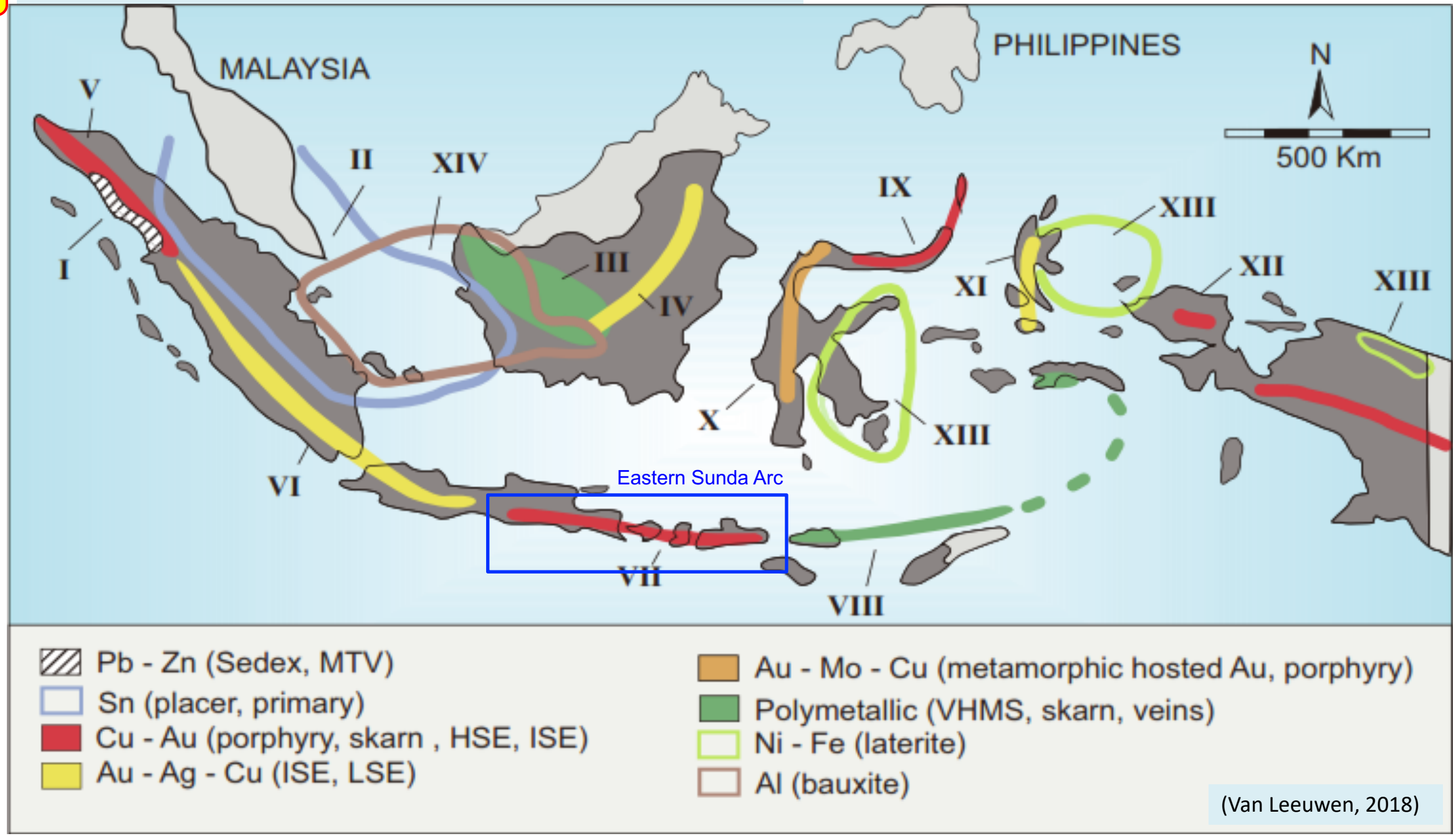
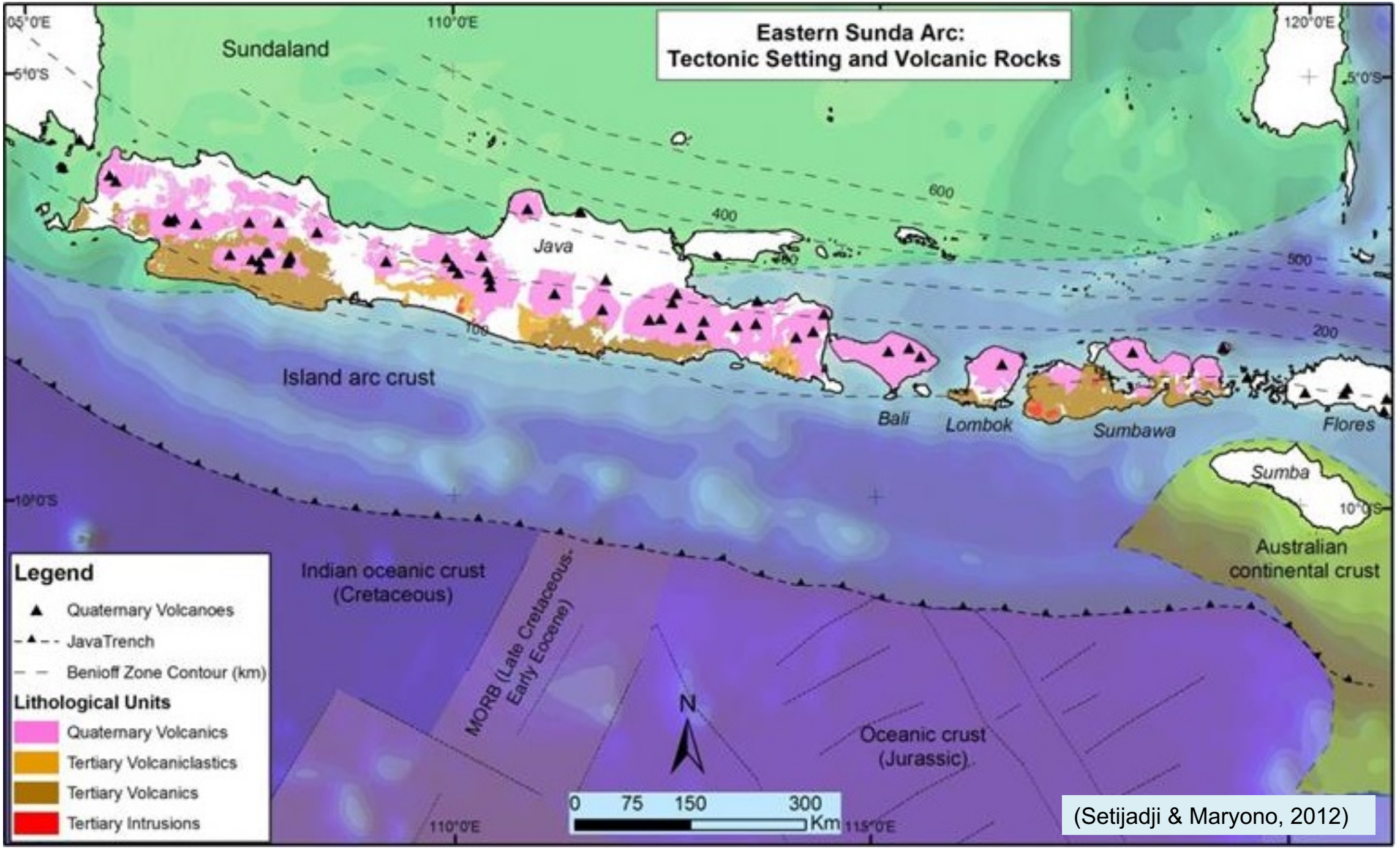


(Van Leeuwen, 2018)

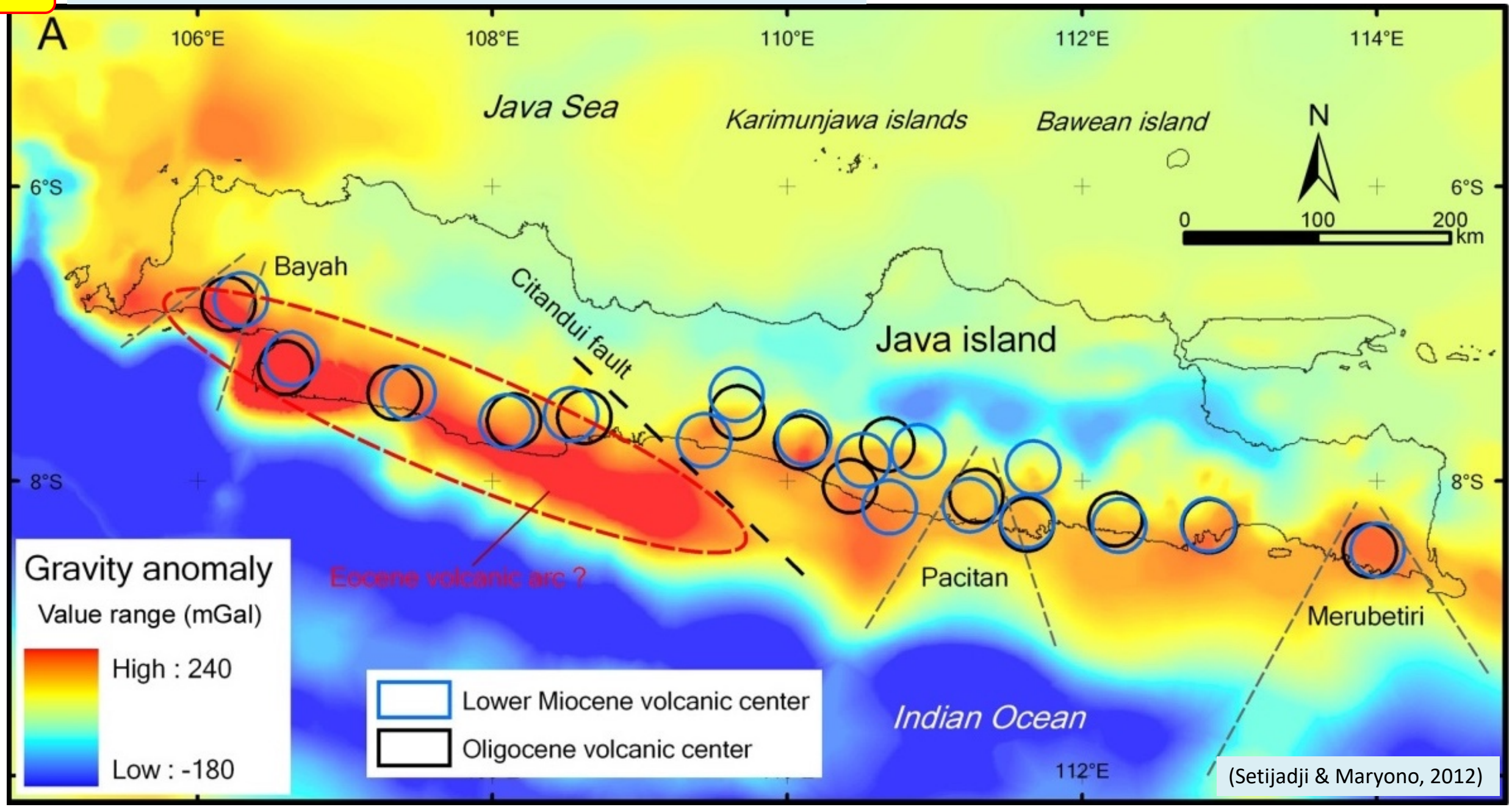
1



(Setijadji & Maryono, 2012)

1

Reconstructed Cenozoic Volcanic Centers over Regional Gravity Image



(Setijadji & Maryono, 2012)

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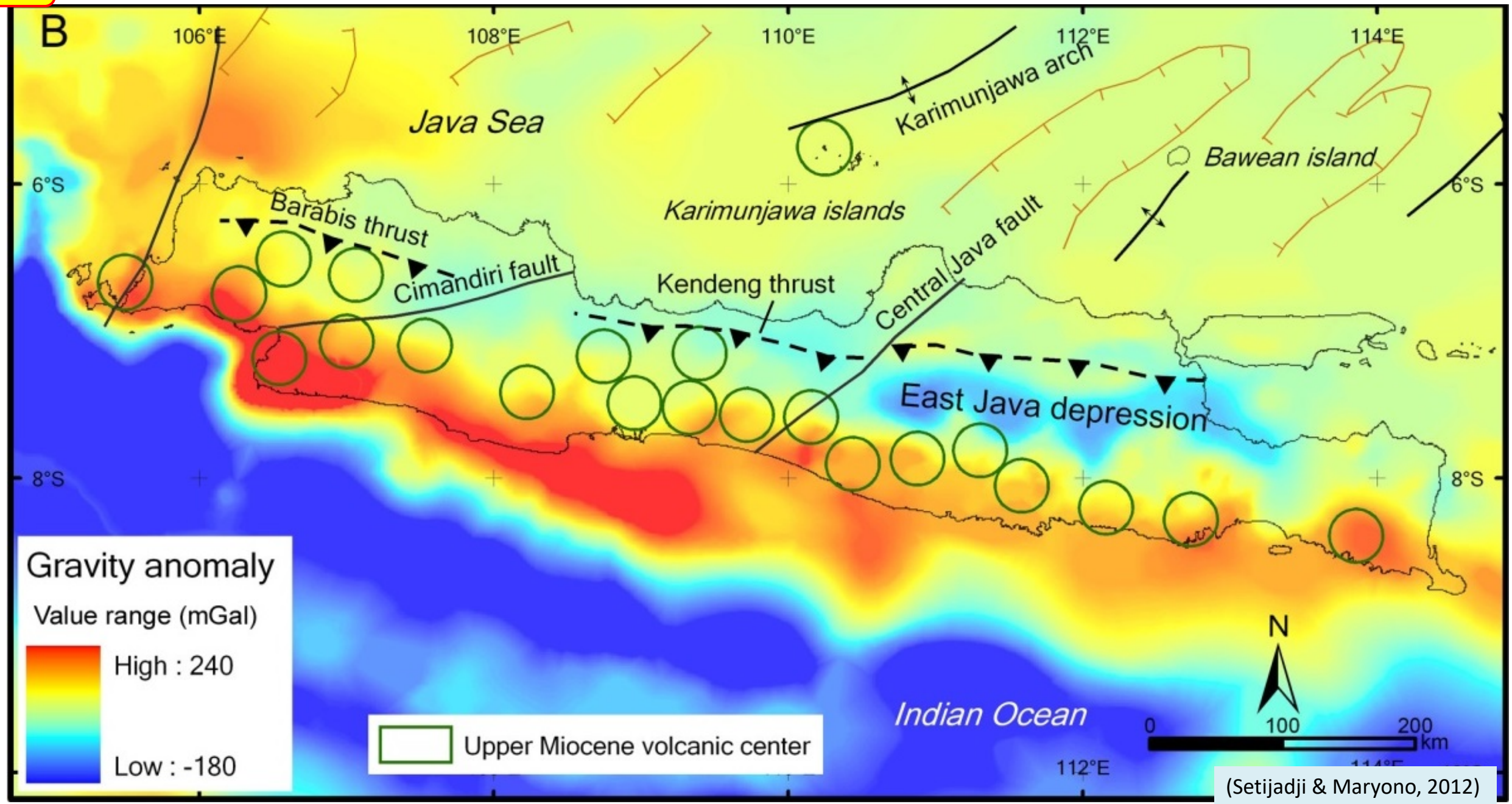

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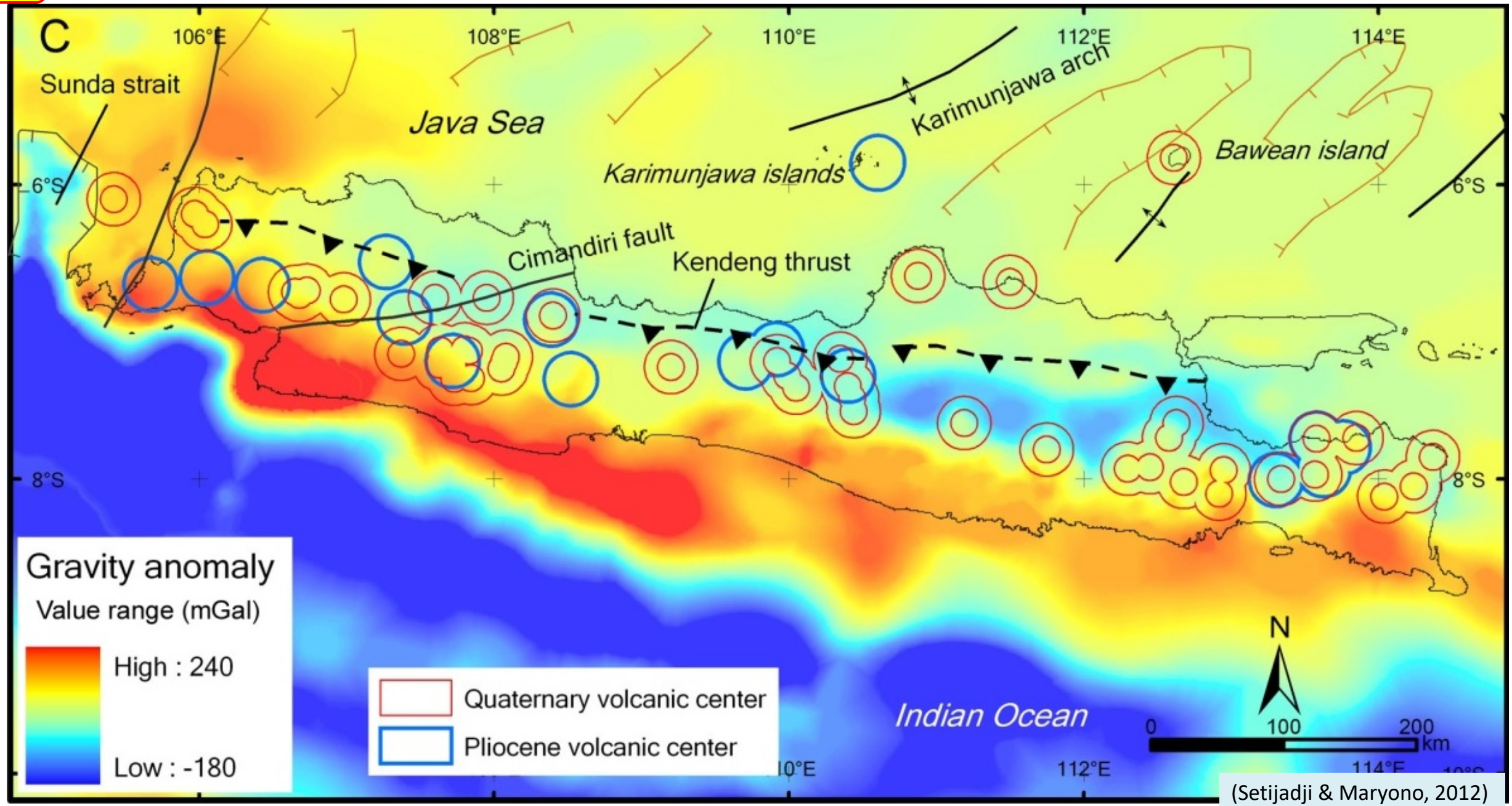
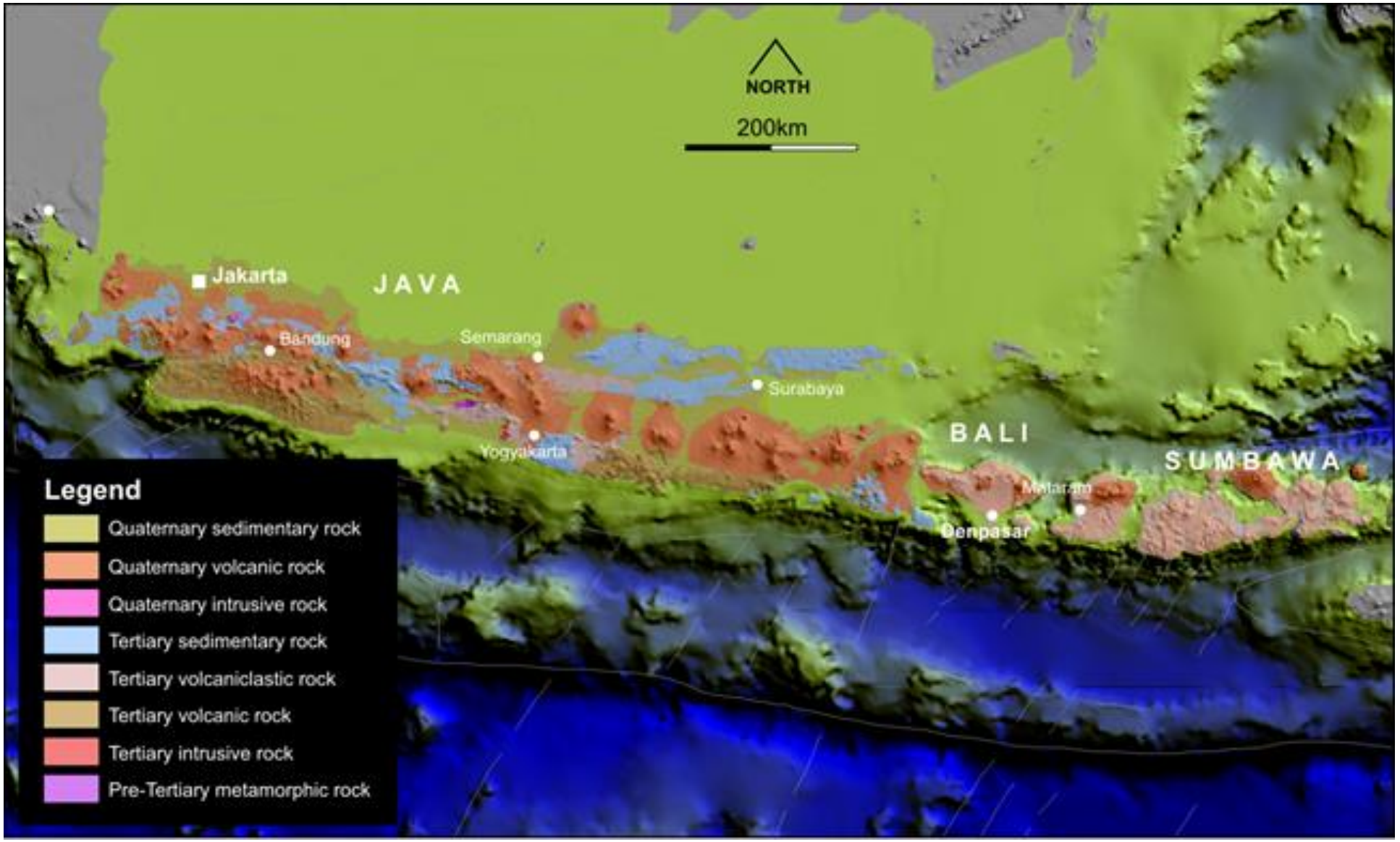


(Setijadji & Maryono, 2012)

1 Reconstructed Magmatic Belts of Eastern Sunda Arc



(Maryono et al, 2020)

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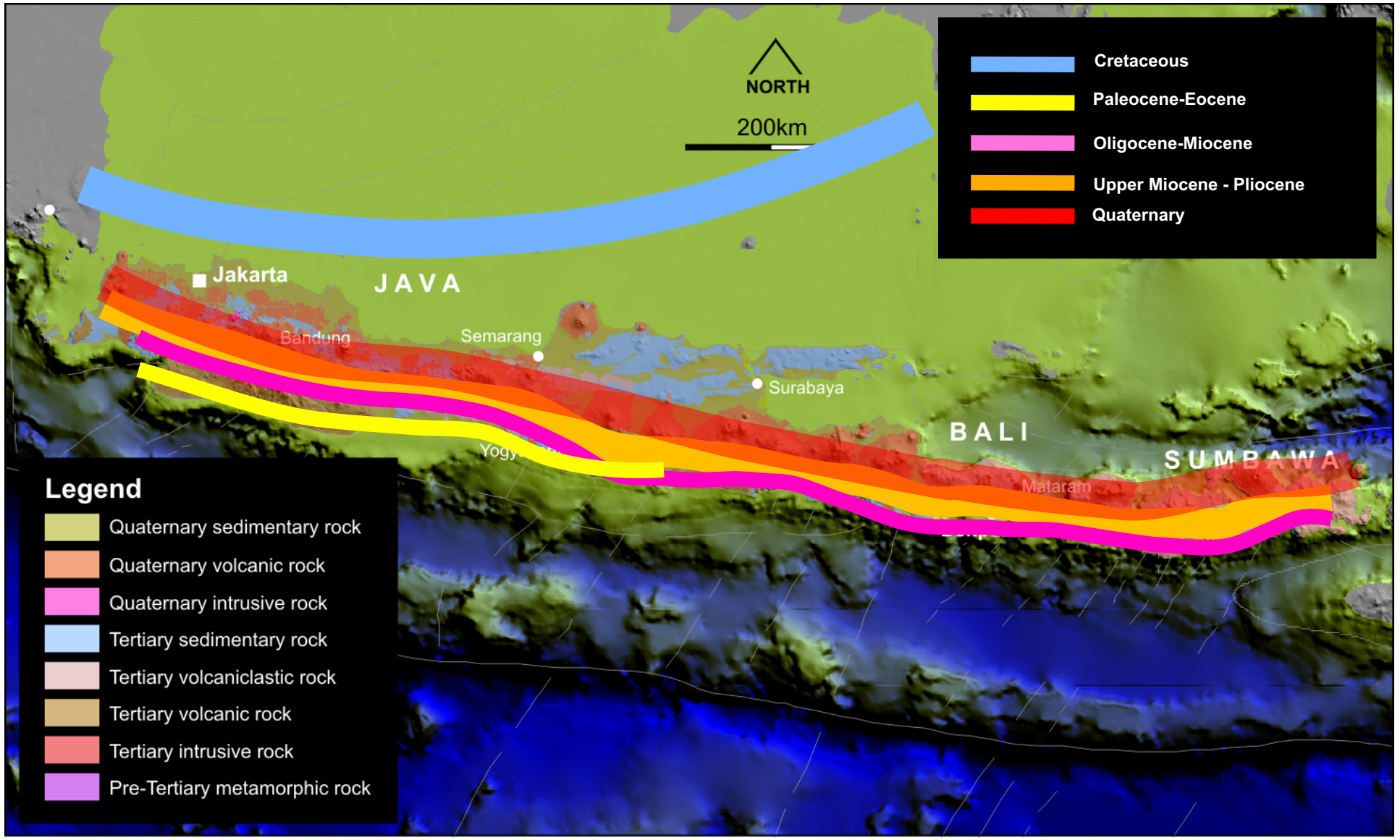
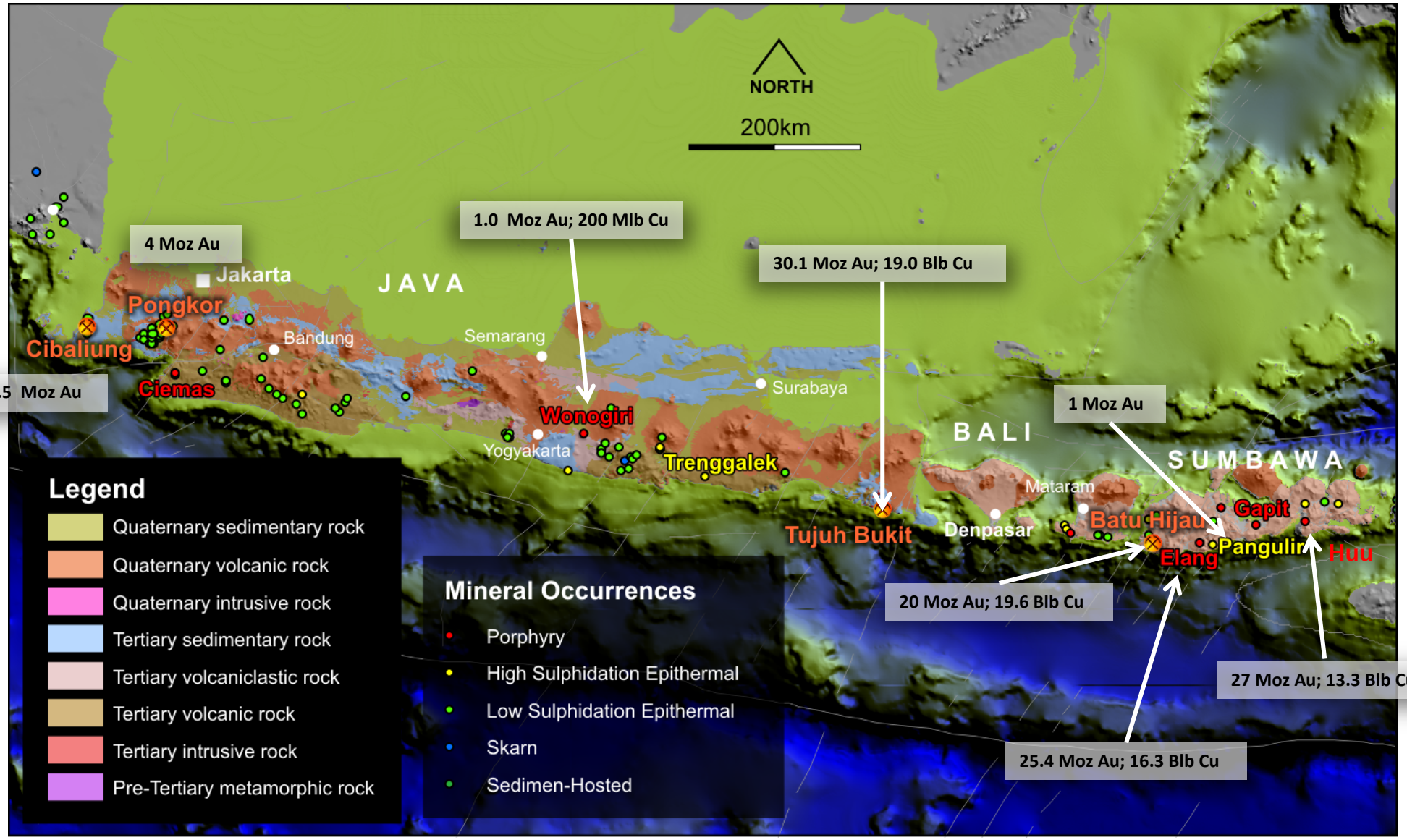


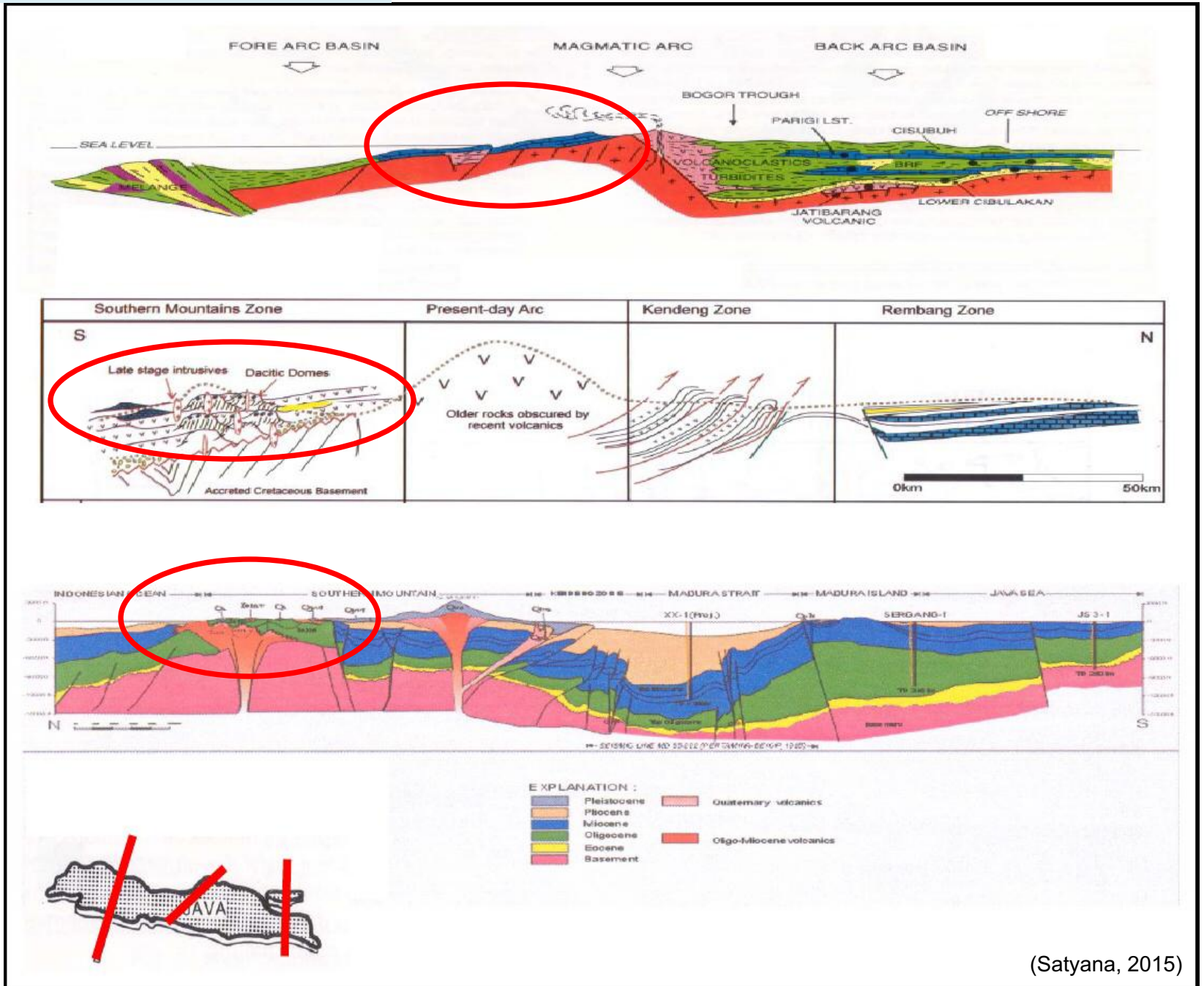
(Maryono et al, 2020)

2 Reconstructed Magmatic Belts of Eastern Sunda Arc and Mineral Deposit/ Occurences



(Maryono et al, 2020)

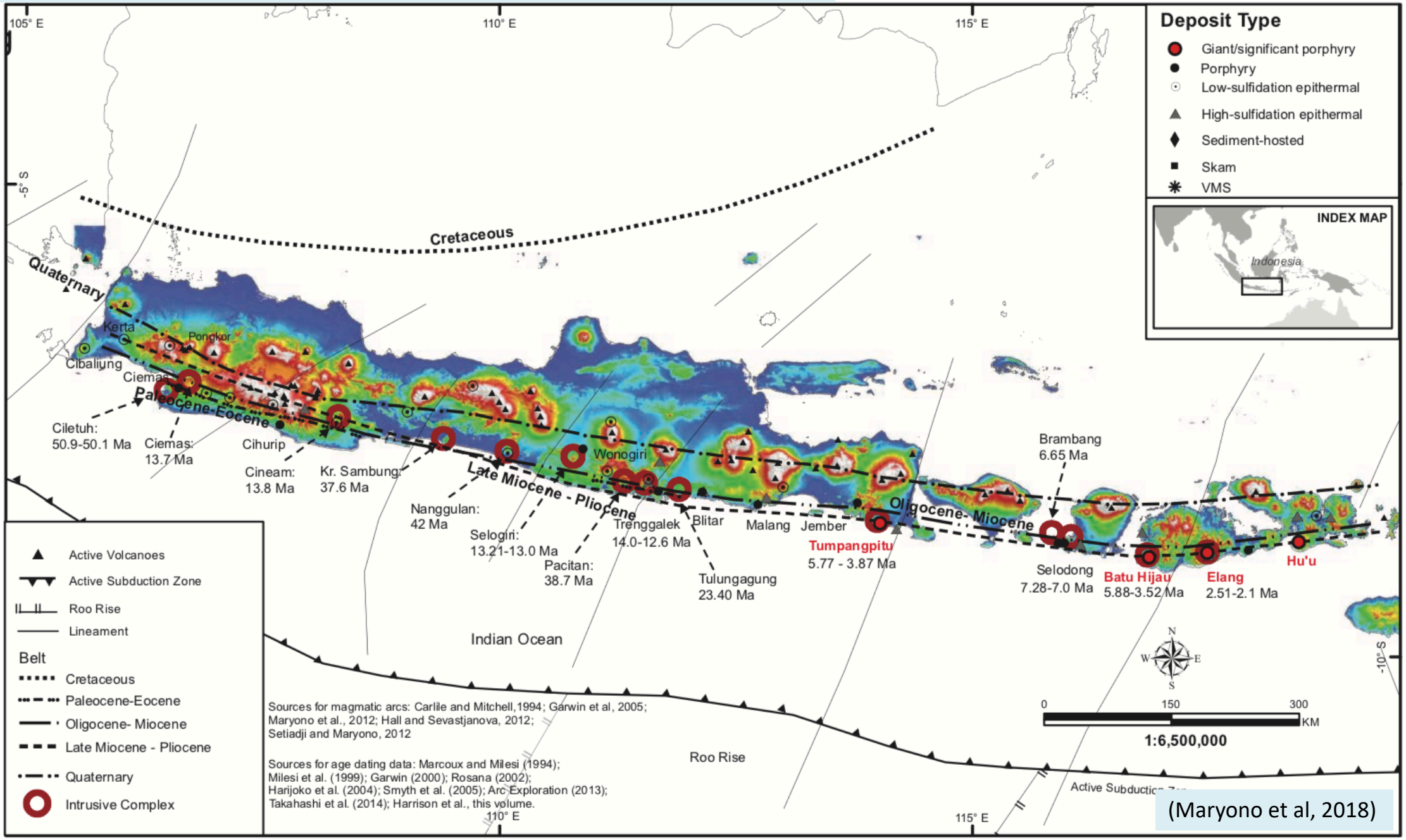
1 Old Magmatic Belts of Java – in Cross Section



(Satyana, 2015)

2

Remnants Volcanic Centers (Paleocene – Pliocene) of Eastern Sunda Arc

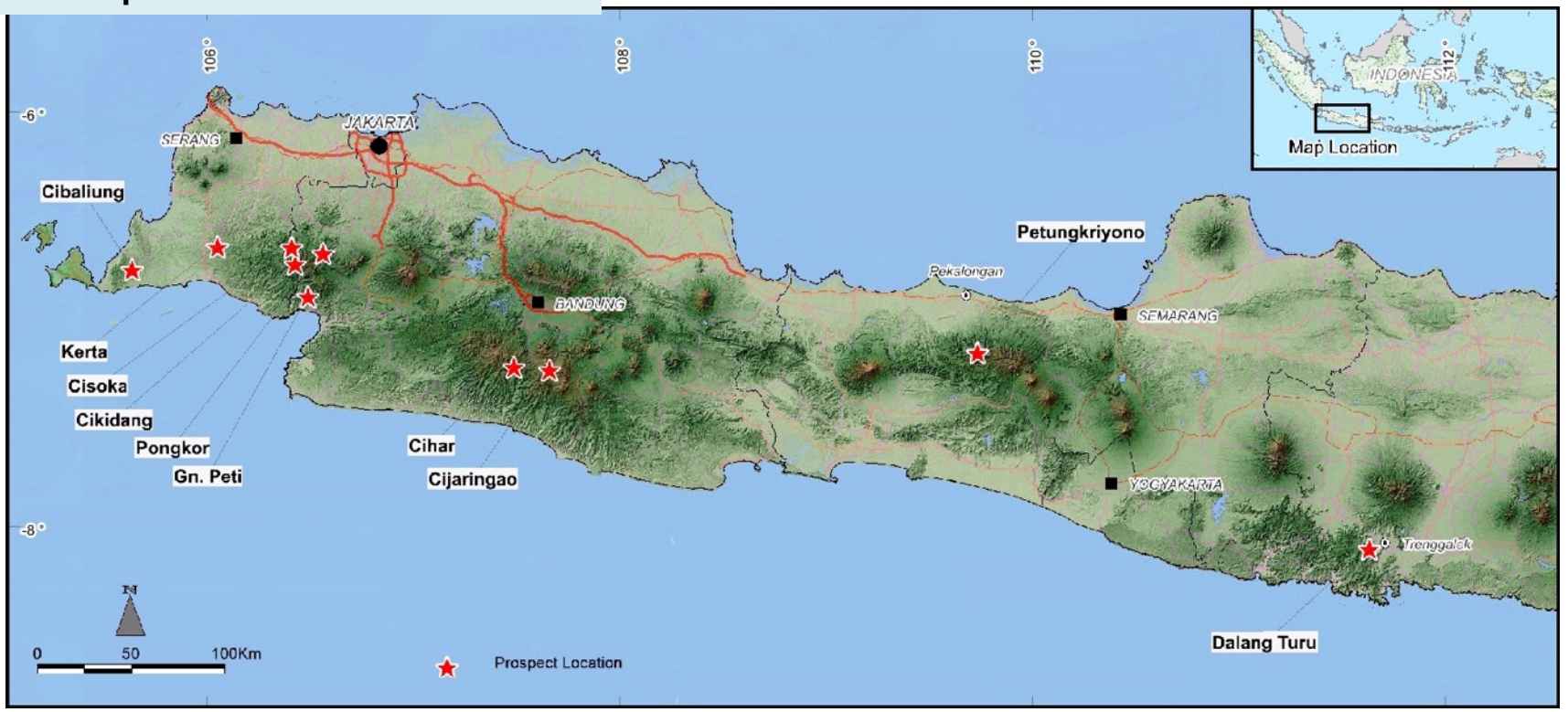


(Maryono et al, 2018)

2

Low-Sulfidation Epithermal Gold Deposits/ Occurrences in Java

1. Cibaliung
2. Kerta
3. Cisoka
4. Pongkor
5. Cikidang
6. Gunung Peti
7. Cihar
8. Cijaringao
9. Petungkriyono
10. Dalang Turu



Classic LS Epithermal Characteristics

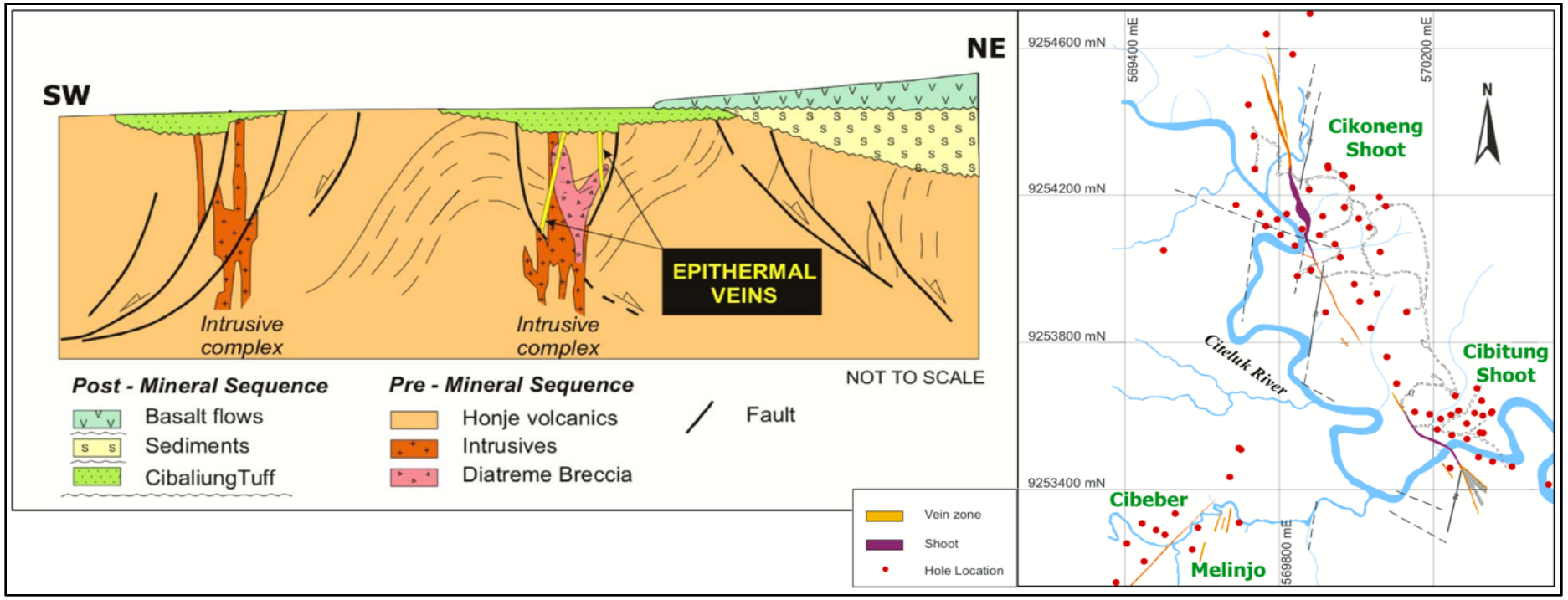
- Vein system: quartz+/-carbonate+/-Mn-oxides+/-clay
- Crustiform-colloform banded textures, containing chalcedony
- Bladed carbonate (pseudomorph) in some prospects
- Low salinity of hydrothermal fluid (from fluid inclusion study)
- As and Sb association in some prospects (very high in Kerta)
- Mn-oxides related high Au in some prospects
- Sinter layers in some prospects

Cibaliung Discovery Outcrop

(Prihatmoko & Idrus, 2020)

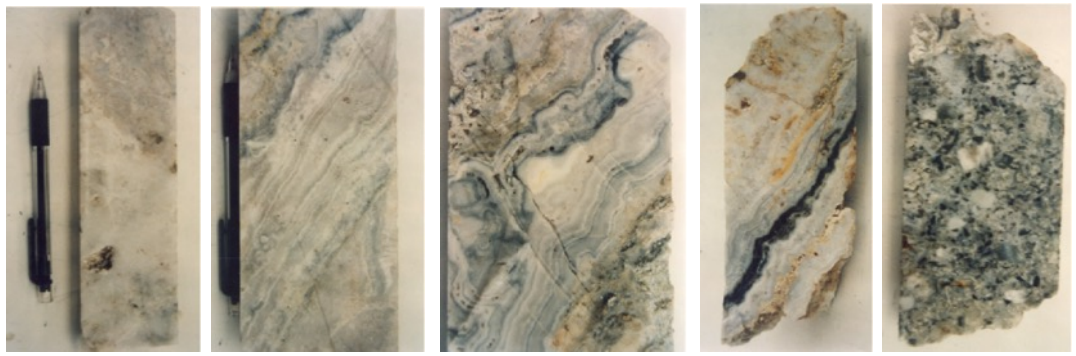
2 Low-Sulfidation Epithermal Gold Deposits/ Occurrences in Java

CIBALIUNG



Key Characteristics

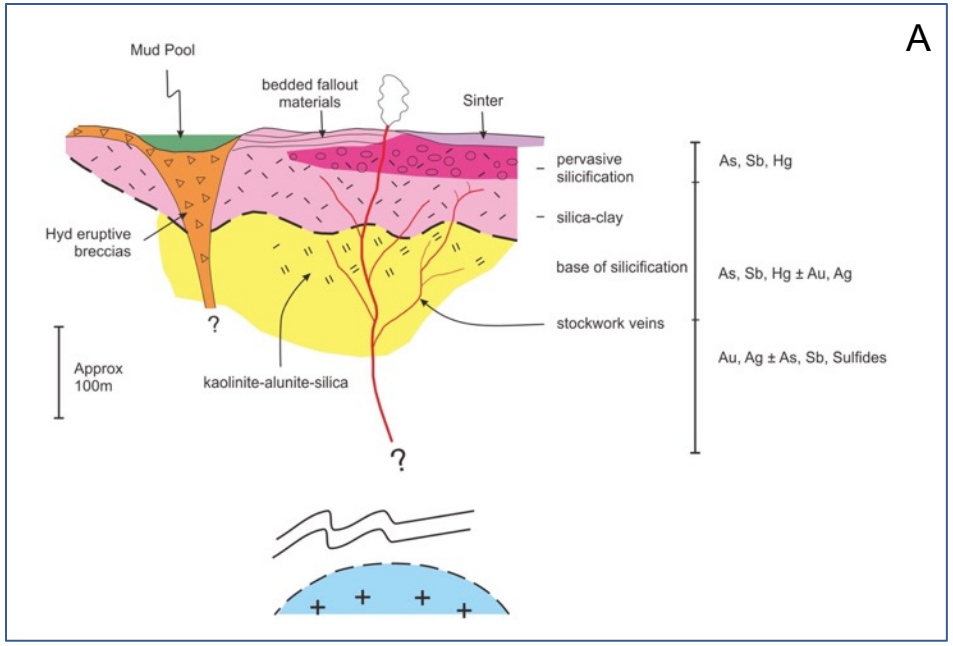
- Classic LS epithermal textures
- Hosted by basaltic andesite volcanics, associated with diatreme breccias and diorite intrusives
- Covered up by Cibaliung Tuff (dacitic pyroclastics), 4.9Ma, minimum 30m thick, and also covered by basaltic lava
- Rhyolitic domes at about 20km north of Cibaliung → bimodal volcanism environment

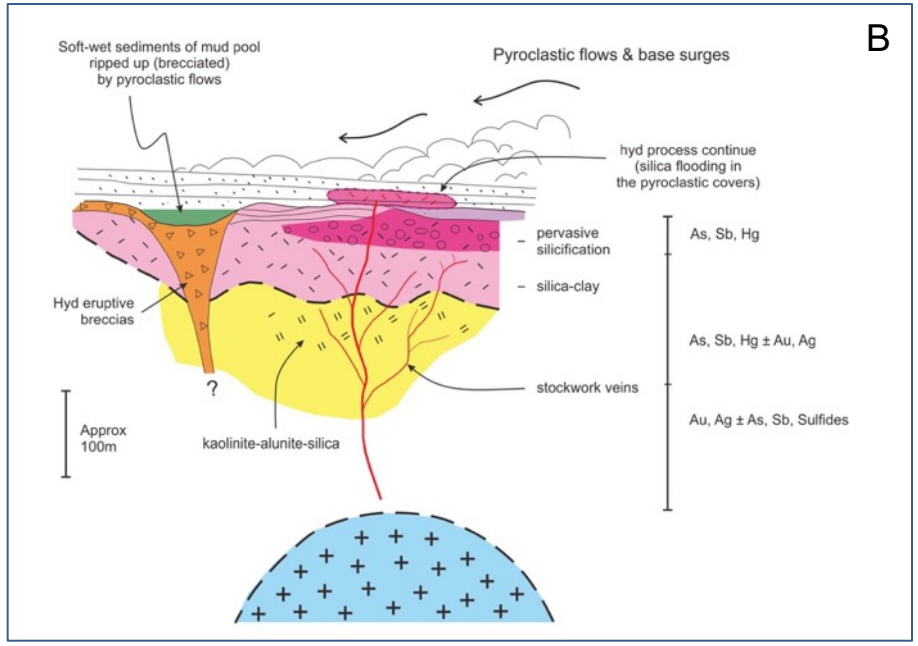


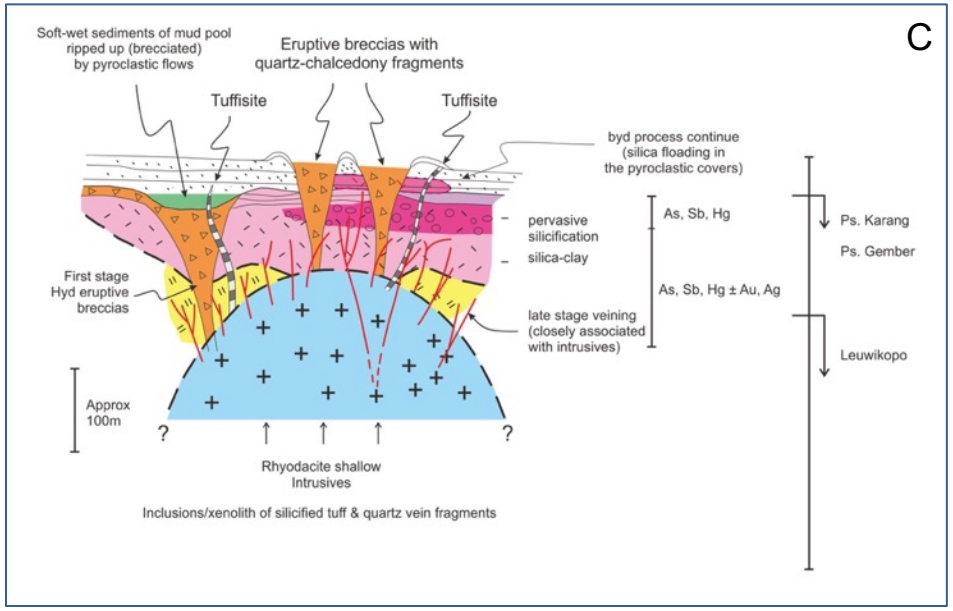
(Prihatmoko & Idrus, 2020)

2 Low-Sulfidation Epithermal Gold Deposits/ Occurrences in Java

KERTA







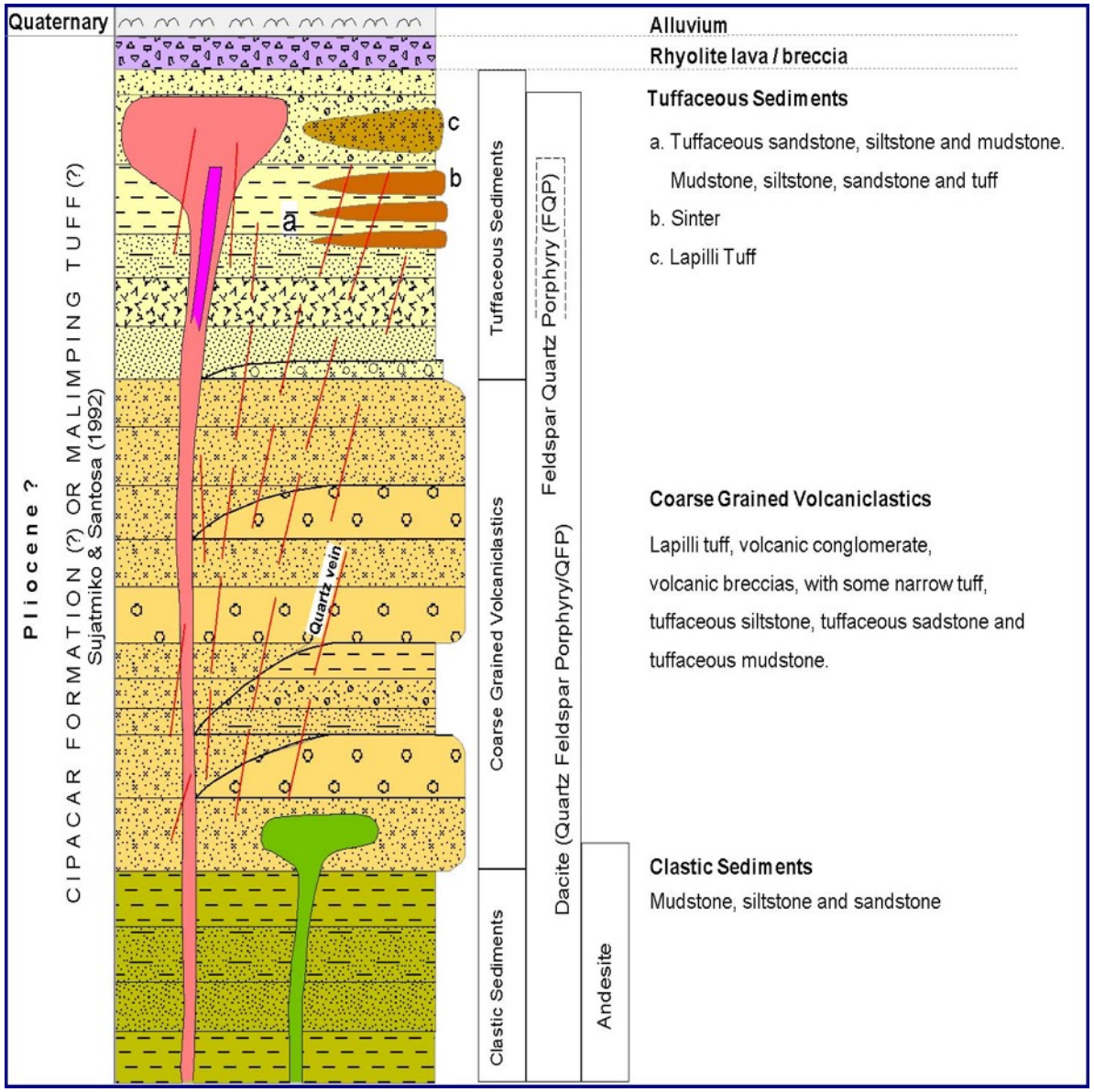
Key Characteristics

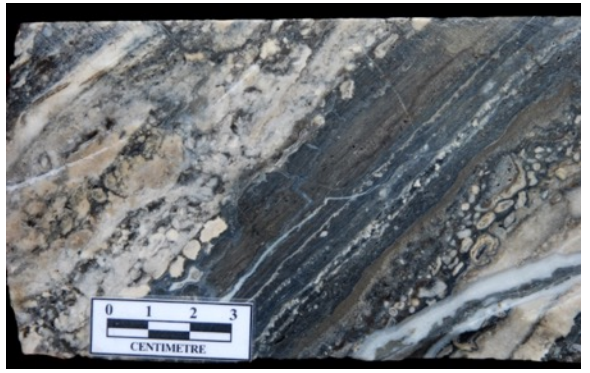
- Classic LS epithermal textures (4.2Ma)
- Hosted by andesitic-dacitic volcanics/ pyroclastics (Malingping Tuff)
- Associated with subvolcanic rhyolite/ rhyodacitic domes, and diatreme (eruptive) breccias
- Associated with episodic silica sinter (at least 3 layers) – cropped out over 10 areas
- Arsenic – commonly high, associated with arsenical pyrites, marcasites
- Mineralized vein zones – reflected by high resistivity of CSAMT

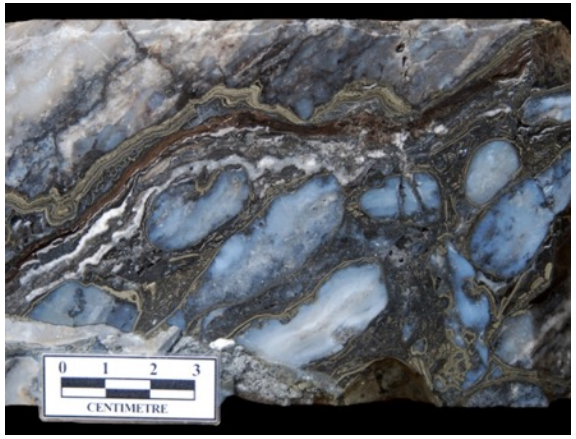
(Prihatmoko & Idrus, 2020)

2 Low-Sulfidation Epithermal Gold Deposits/ Occurrences in Java

KERTA







(Prihatmoko & Idrus, 2020)

2

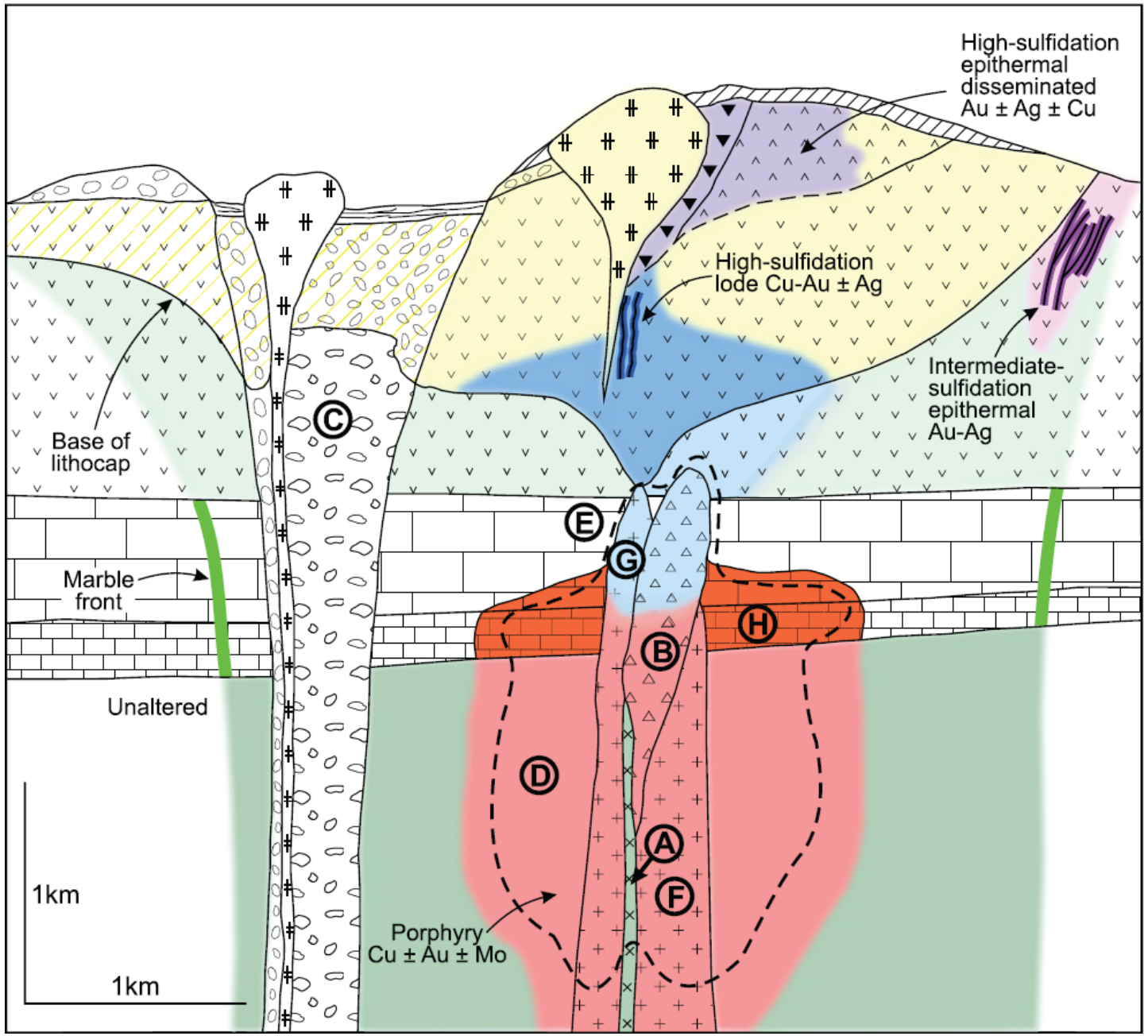
Summary of Characteristics of LS Epithermal Gold Deposits/ Occurrences in Java

Deposit/ Occurrence	Au Cont. (t)	Ag/ Au Ratio	Age (Ma)	Deposit/ mineraliza -tion Style	Metal Signature	Fluid Inclusion Salinity (wt% NaCl eq)	Genetically related igneous rock	Tectonic Setting	Reference
Cibaliung	14.9	8.5	11.2-10.7	Vein	Au, Ag	<1	Diorite intrusion & rhyolite plugs	Extensional structures, bimodal volcanism	Angeles et al (2002); Harijoko et al (2004); Harijoko et al (2007); Carlile et al (2005)
Kerta	NA	15.8	4.16-4.11	Vein, stockwork	Au, Ag, As, Sb	1.5-5.7	Rhyodacite & rhyolite plugs	Extensional caldera, bimodal volcanism	Lubis et al (2012); Kuroda (2016)
Pongkor	98	10.4	2.05	Vein	Au, Ag, Mn-oxide	0.2-1.8	Rhyodacite domes/ plugs	Extensional structures, caldera	Milesi et al (1999); Rionanda and Widjajanto (2012)
Cikidang	2.7	5.6	2.4	Vein	Au, Ag	<3	Andesite dyke/ plug	Extensional structures at the caldera edge	Prihatmoko (2000c); Rosana and Matsueda (2002)
Cisoka	NA	1.8	Pleistocene (?)	Vein	Au, Ag	0.18-0.89	Andesite, dacite (plug?)	Extensional structures (?)	Prihatmoko (2006); Muhammad (2015)
Gunung Peti	NA	2.4	Pliocene-Pleistocene (?)	Vein	Au, Ag	NA	Andesite dykes	Extensional structures (?)	Hinman et al (2007); Lubis (2007)
Cihar	NA	5.8	Pliocene-Pleistocene (?)	Vein	Au, Ag, Mn-oxide	NA	Andesite dykes	Release structures (?)	Prihatmoko (2001); Coote (2001); Rosana et al (2014)
Cijaringao	NA	1.5	Pliocene-Pleistocene (?)	Vein	Au, Ag, Mn-oxide	NA	Andesite (?)	Extensional structures (?)	Prihatmoko (2000b)
Petungkriyono	NA	1.7	Pleistocene (?)	Vein	Au, Ag, As, Sb	0.6	Andesite, dacite plugs, diatreme breccias	Extensional basin, caldera	Hartono et al (2003) Prihatmoko et al (2005); Trisetyo et al (2007)
Dalang Turu	NA	6.9	16.29	Vein, stockwork	Au, Ag, As, Sb	0.2-0.46	Andesite (plug)	Extensional structures (?)	Prihatmoko (2000d); Prihatmoko & Kusumanto (2005); Arc Exploration (2013)

NA: not analysed

(Prihatmoko & Idrus, 2020)

3 Deposit Model of Magmatic Related Deposits



PART OF LITHOCAP
- Phreatic breccia

MAAR-DIATREME COMPLEX
- Dacite porphyry plug-dome
- Lacustrine sediment
- Phreatomagmatic breccia

PORPHYRY STOCK
- Intermineral magmatic-hydrothermal breccia
- Intermineral porphyry
- Early porphyry

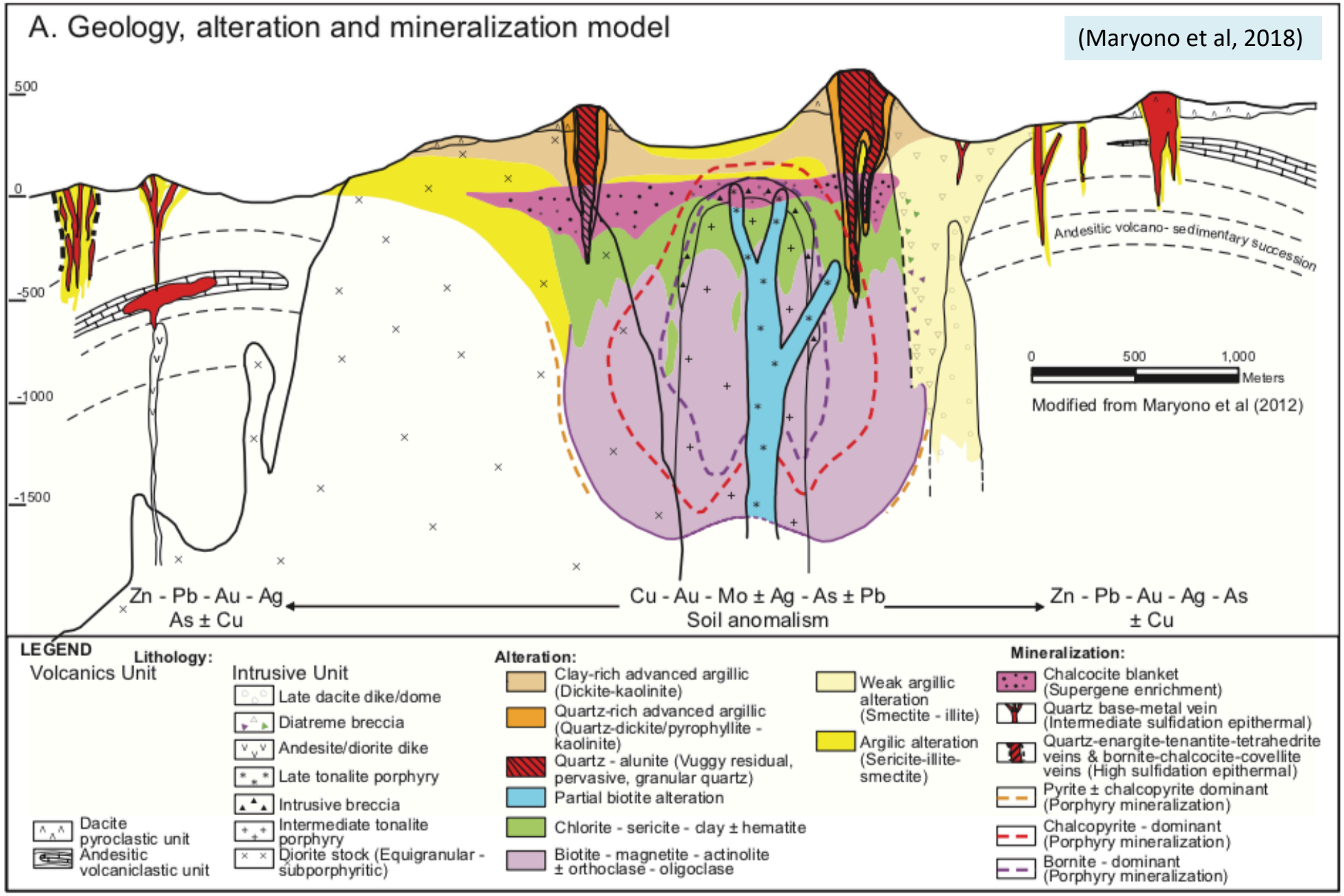
HOST ROCKS
- Dacite dome
- Felsic tuff unit
- Andesitic volcanic unit
- Massive carbonate rocks
- Thinly bedded carbonate rocks
- Mafic rocks

ALTERATION
- Steam heated
- Intermediate argillic
- Quartz-kaolinite
- Quartz-alunite
- Vuggy quartz + silicification
- Quartz-pyrophyllite
- Sericitic
- Chloritic
- Skarn
- Potassic
- Propylitic

(Sillitoe, 2012)

3

Exploration Model for Porphyry and Epithermal Deposits in Eastern Sunda Arc



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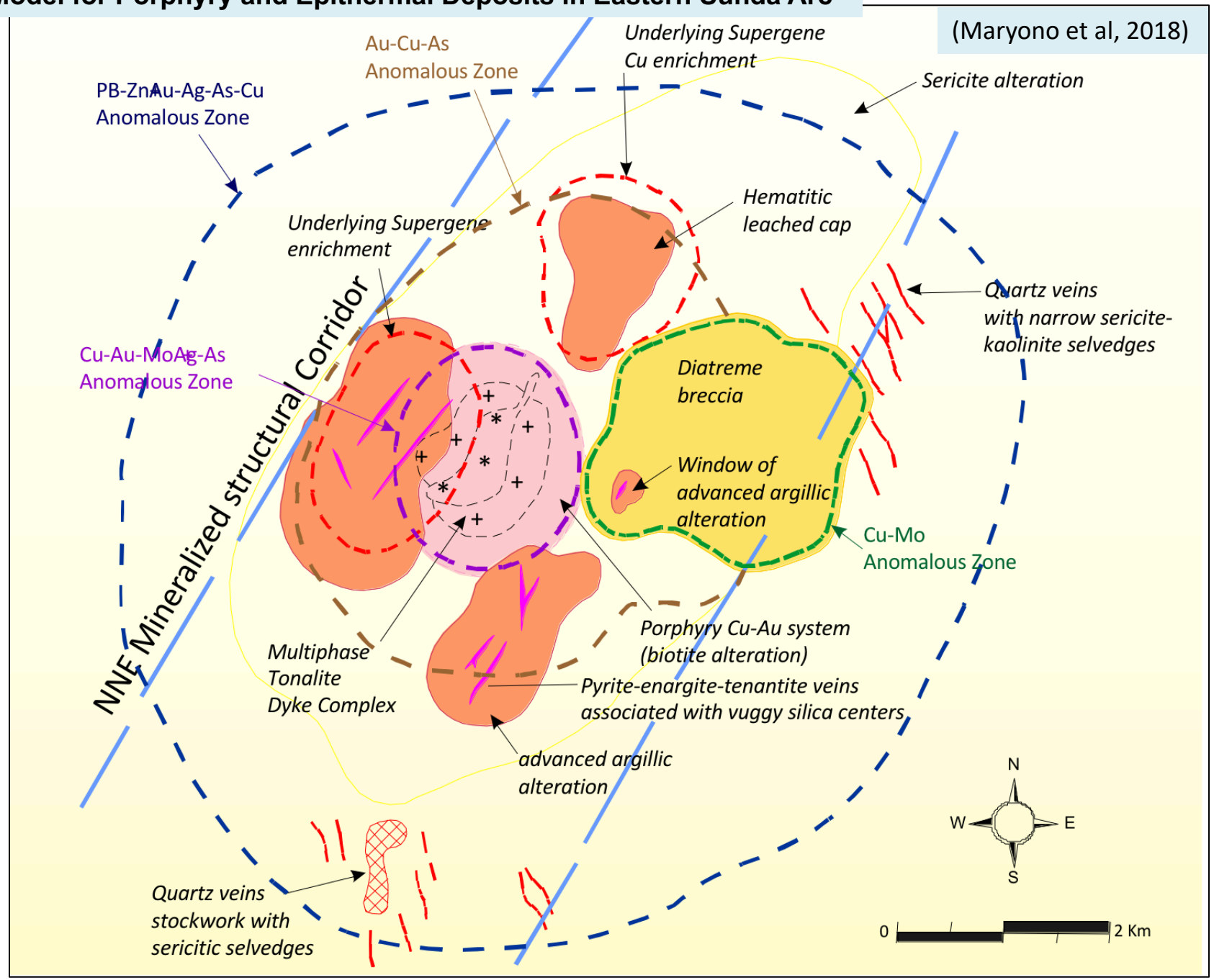

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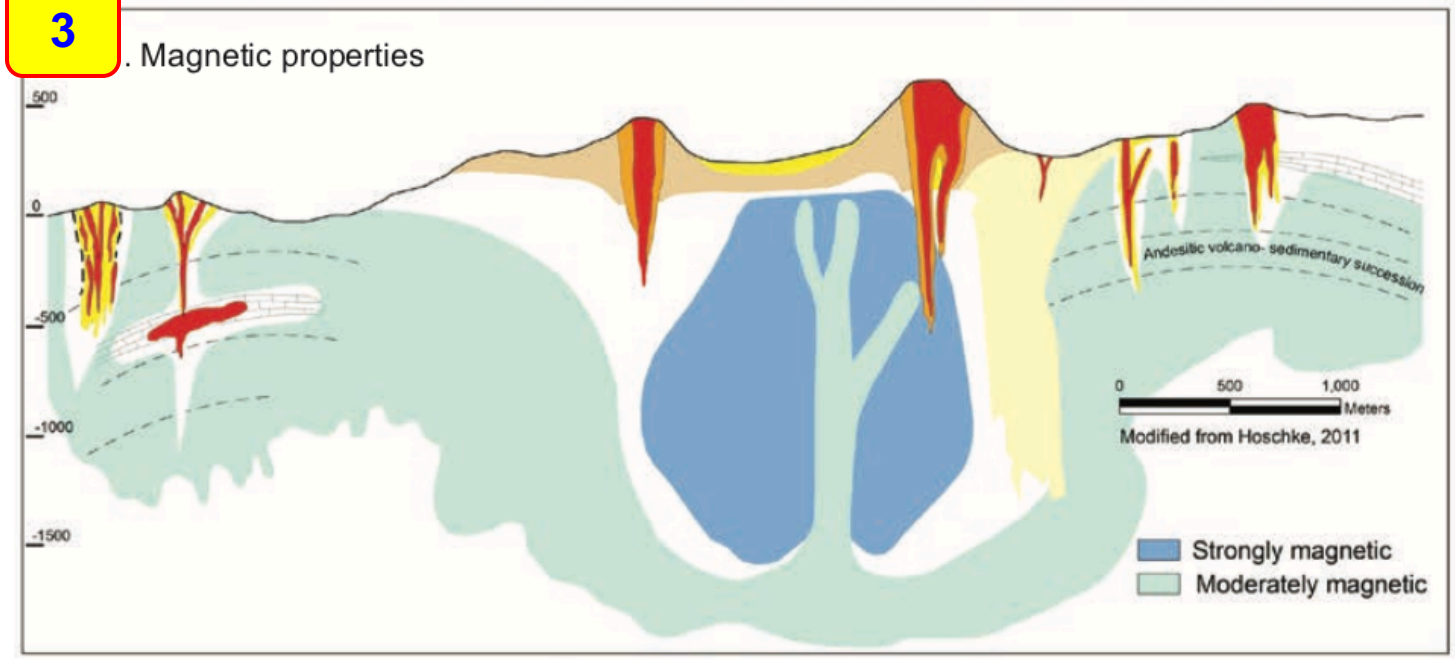

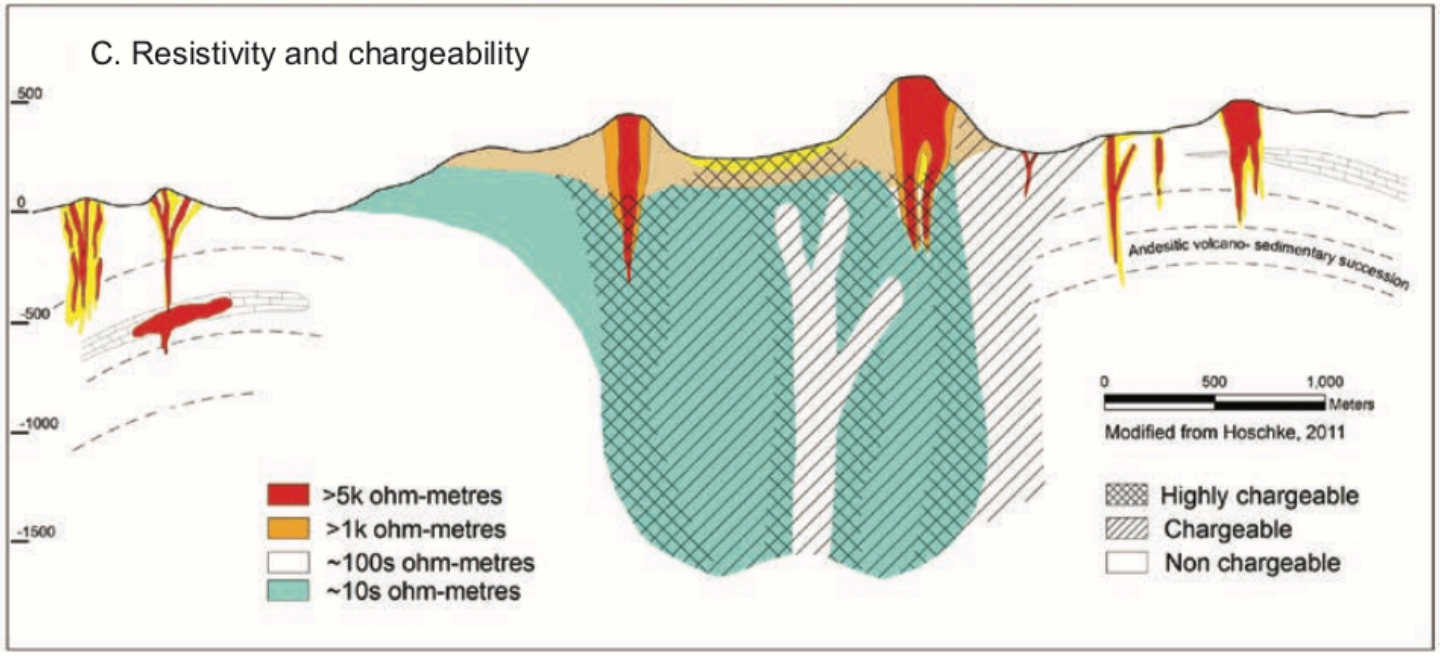

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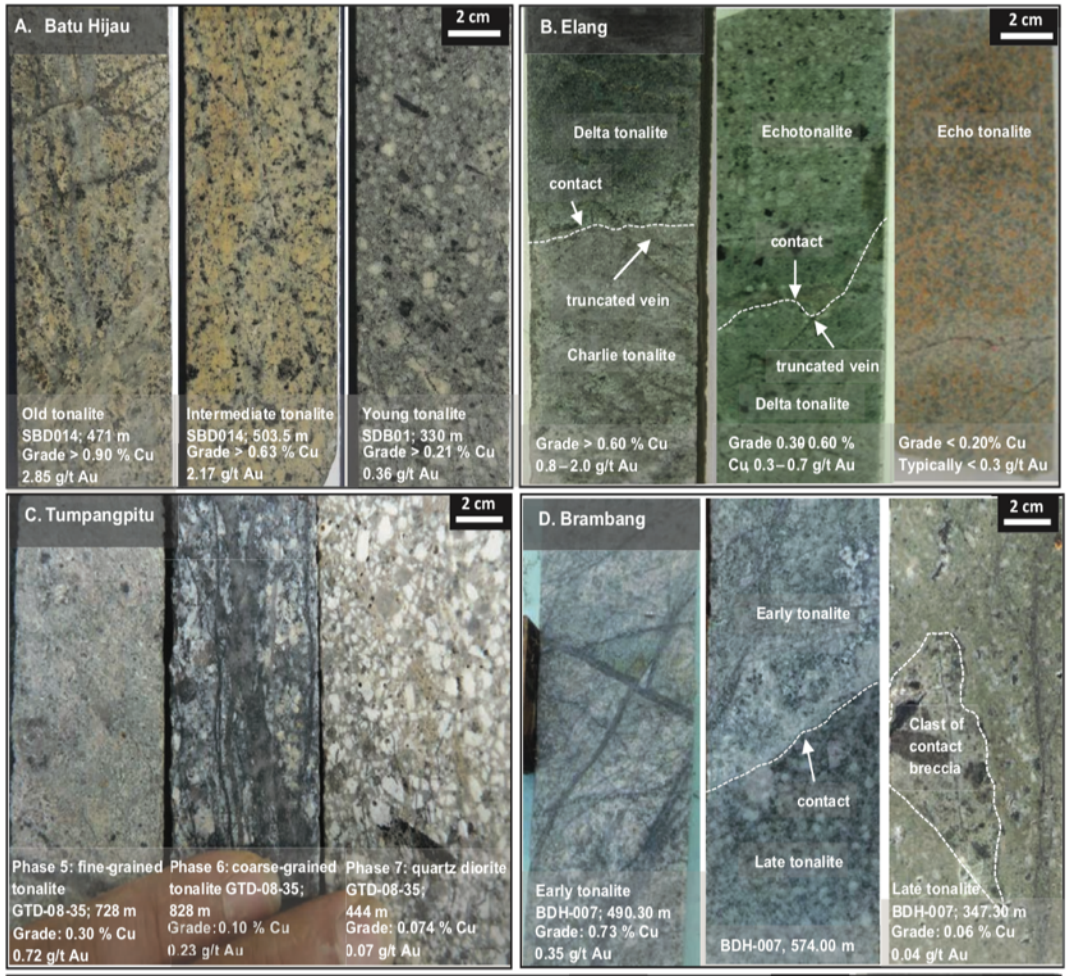
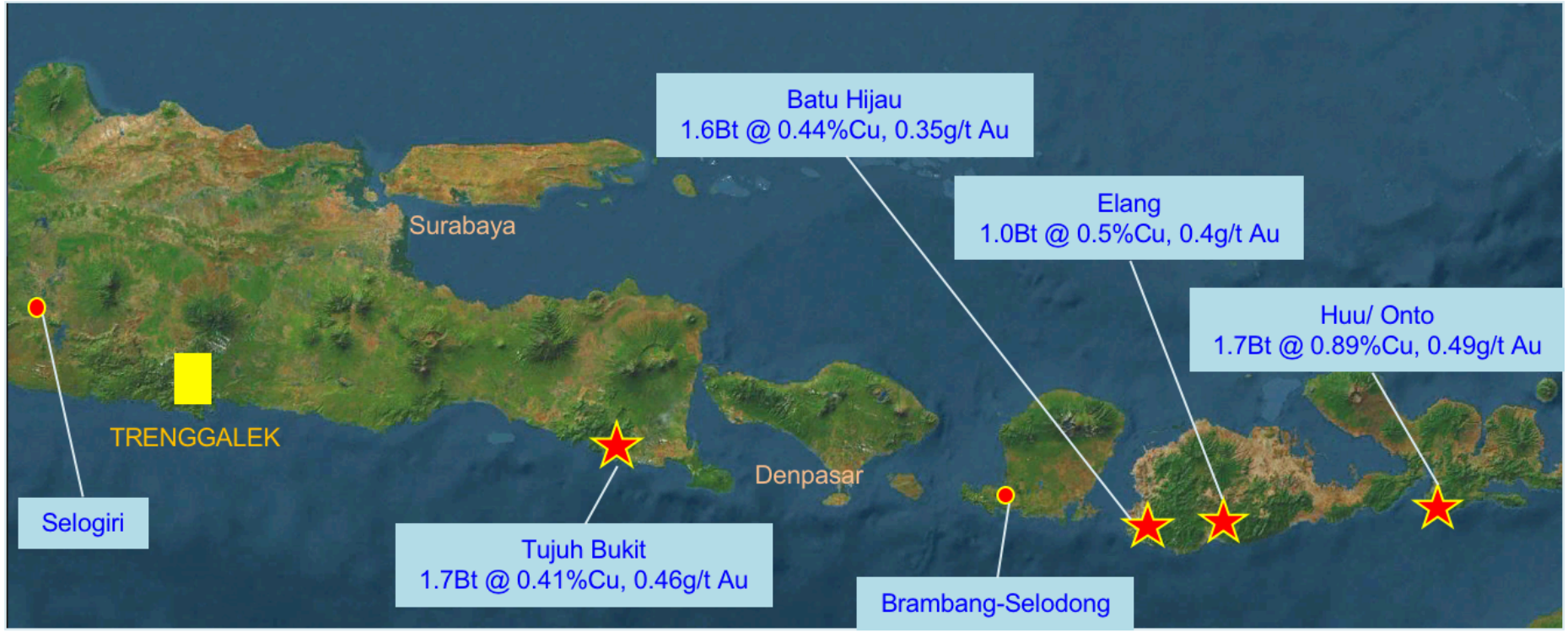


(Maryono et al, 2020)

4 Mineralization in Trenggalek District – Southern East Java



Exploration Key Points on Trenggalek District

1. Located in an emerging fertile magmatic arcs of Eastern Sunda → marked by a new discovery of Huu-Onto
2. Unique multiple mineralization types → Porphyry, HSE & ISE occurred in a district with LSE, *c.f. Tombulilato District, Northern Sulawesi*
3. Identified by "hit and run" type of exploration → less matured exploration
4. Resource number just from ISE vein type mineralization → not from the porphyry, HSE and LSE yet

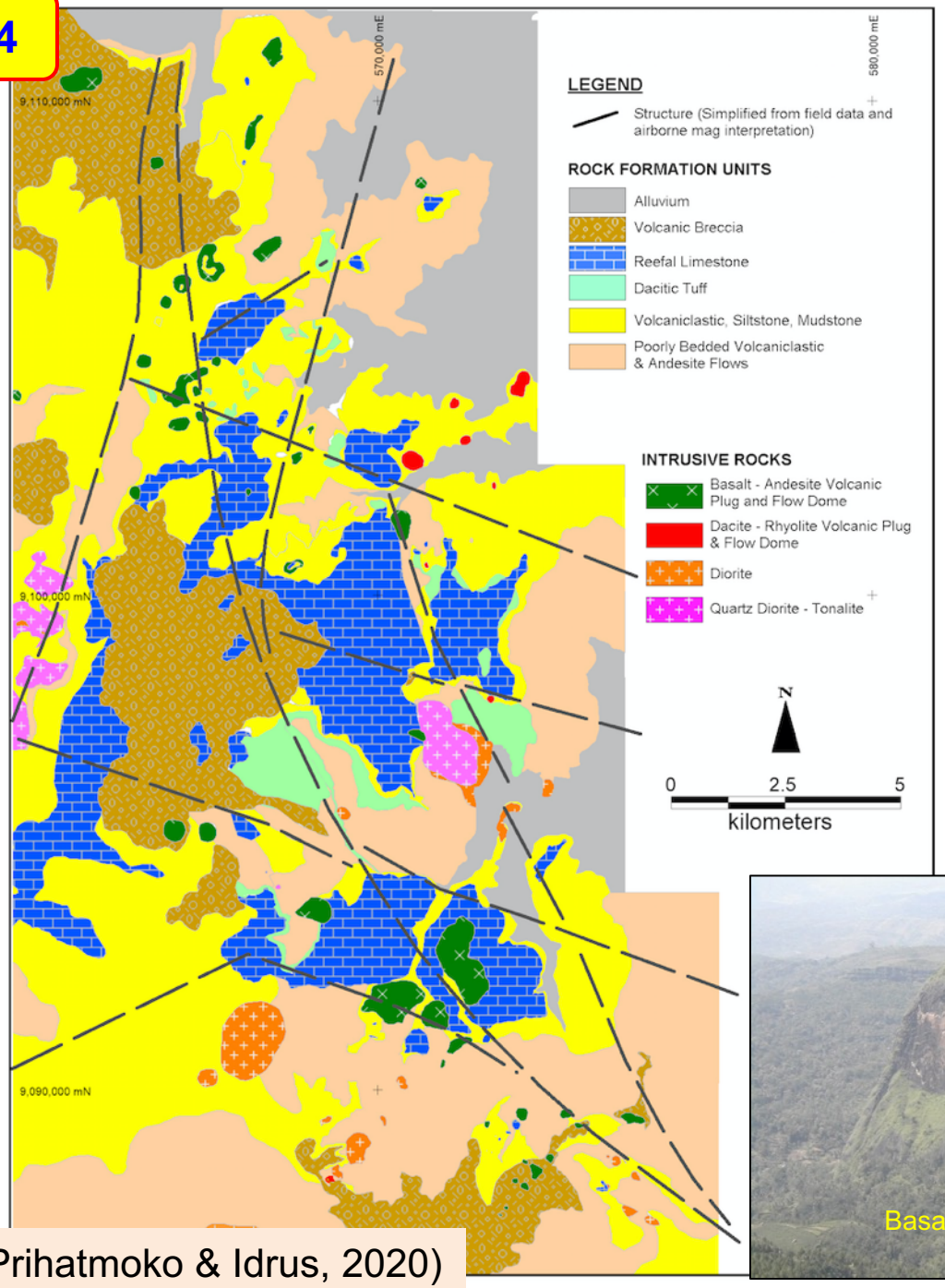
Exploration History

1. ANTAM → 1995-2003
2. Austindo/ Arc Exp/ SMN → 2006-2018
3. Arc with Anglo American → 2012-2014
4. Arc with Pama → 2015-2018
5. Back to SMN (Sumber Mineral Nusantara) → 2019 - recent

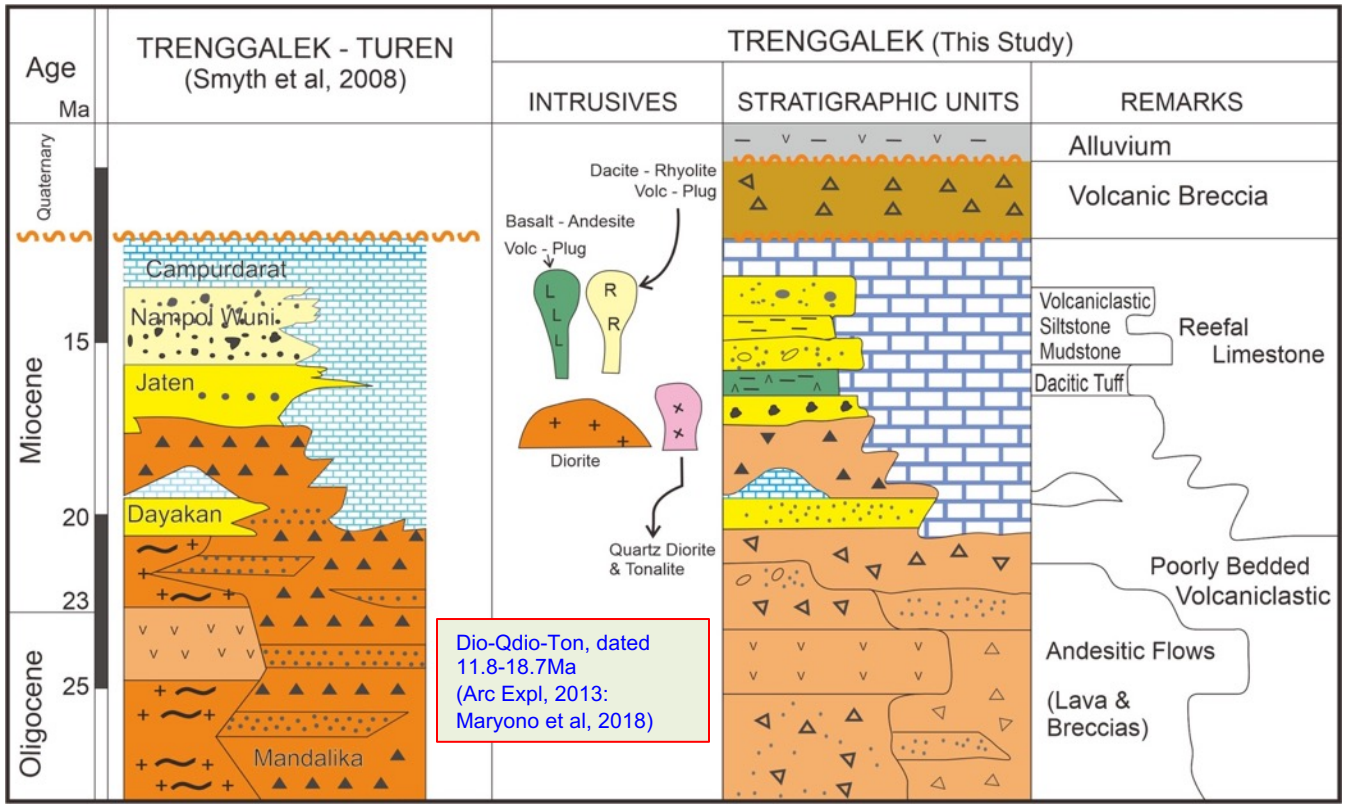
(Prihatmoko & Idrus, 2020)

4

Geology and Stratigraphic Sequence of Trenggalek

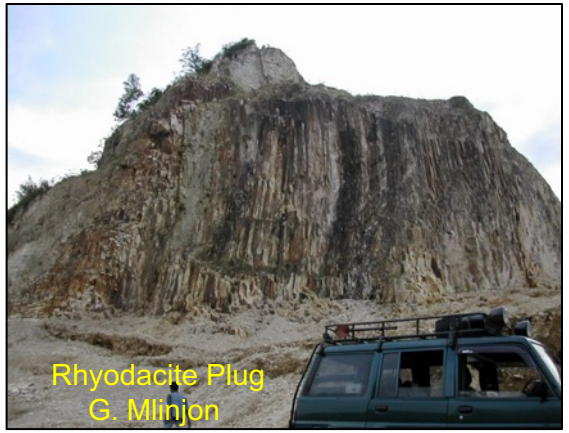


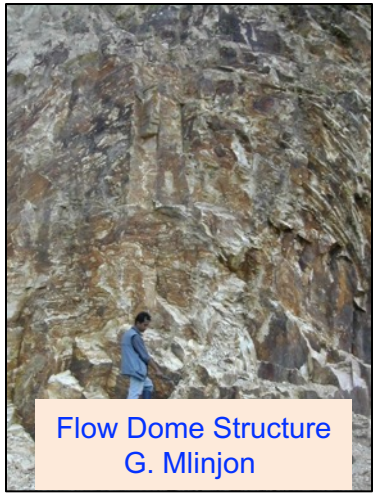
(Prihatmoko & Idrus, 2020)



Dio-Qdio-Ton, dated 11.8-18.7Ma (Arc Expl, 2013: Maryono et al, 2018)


Basaltic Andesite Plug
G. Lingga


Rhyodacite Plug
G. Mlinjon


Flow Dome Structure
G. Mlinjon

Mineralized Prospects in the District

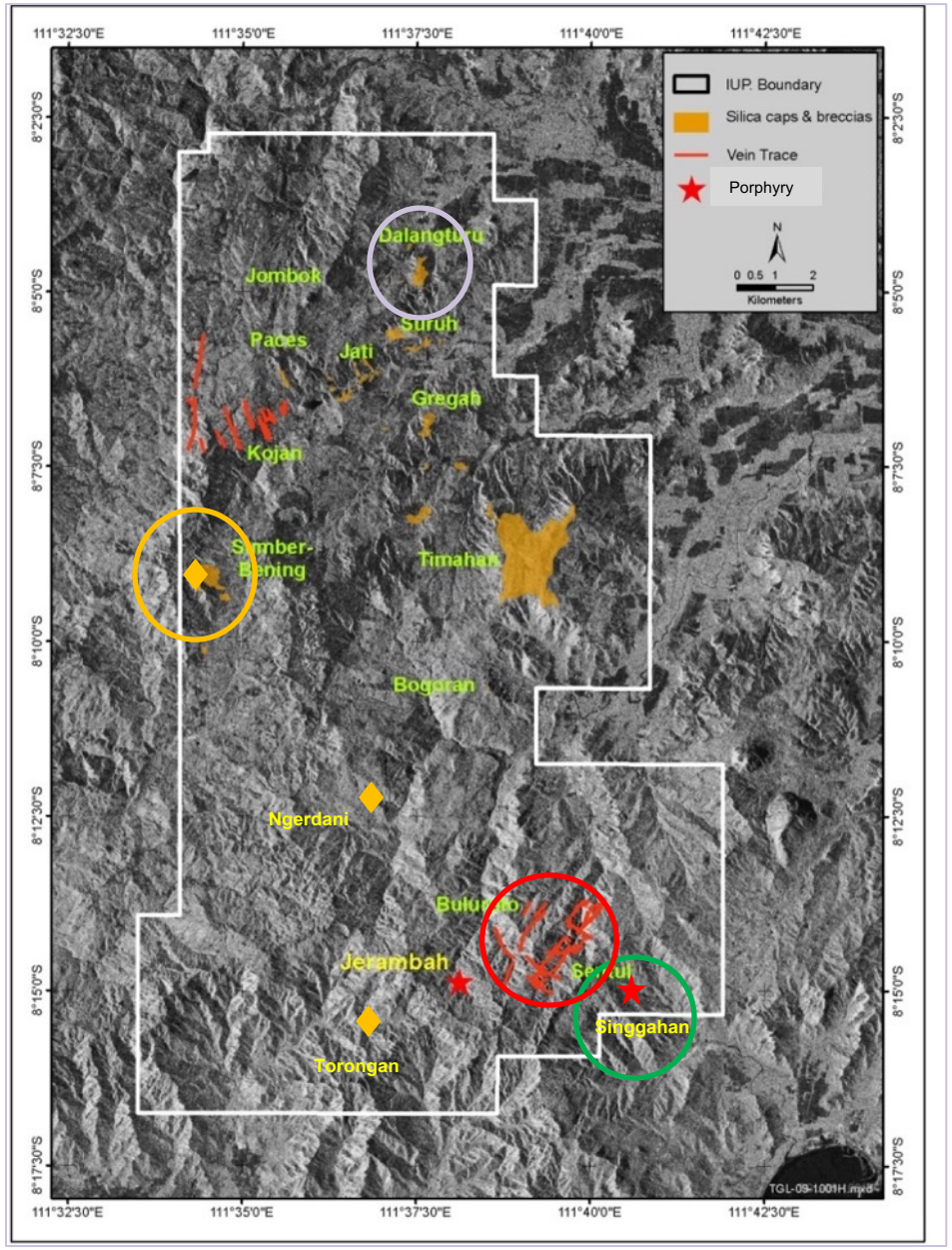
Jombok & Jati
Vein Boulders
Au-As-Sb
IS (?) Epithermal Veins
Drilling 3 holes for 307m (Jati)

Kojan
IS Epithermal Veins
Au-Ag
Drilling 15 holes for 1,636m

Sumber Bening
HSE Lithocap
Altered QDio
Cu-Bi-Mo-As
Completed 3DIP Survey

Ngerdani & Torongan
HSE Lithocap
Au-As-Cu
Prominent soil and rock anomalies

Jerambah
Jasperoid/ Skarn & Porphyry
Altered Dio/ QDio
Cu-Au-Mo
Drilling 4 holes for 2,450m



Dalang Turu
Suruh & Gregah
LS Epithermal Veins + Sinter,
Hydrothermal Breccias
Au-As-Sb-base metal
Drilling 6 holes for 1,132m

Timahan & Bogoran
Silicified Limestone
"Jasperoid"
& Stockwork / Altered Diorite
Au-As-Sb-Mo
Drilling 4 holes for 423m
(Timahan)

Sentul & Buluroto
IS Epithermal Veins
Au-Ag-As-base metal
Drilling 44 holes for 5,906m
Res: 3.66Mt@1.05g/t Au; 7.18g/t Ag ~ 137Koz Au.eq

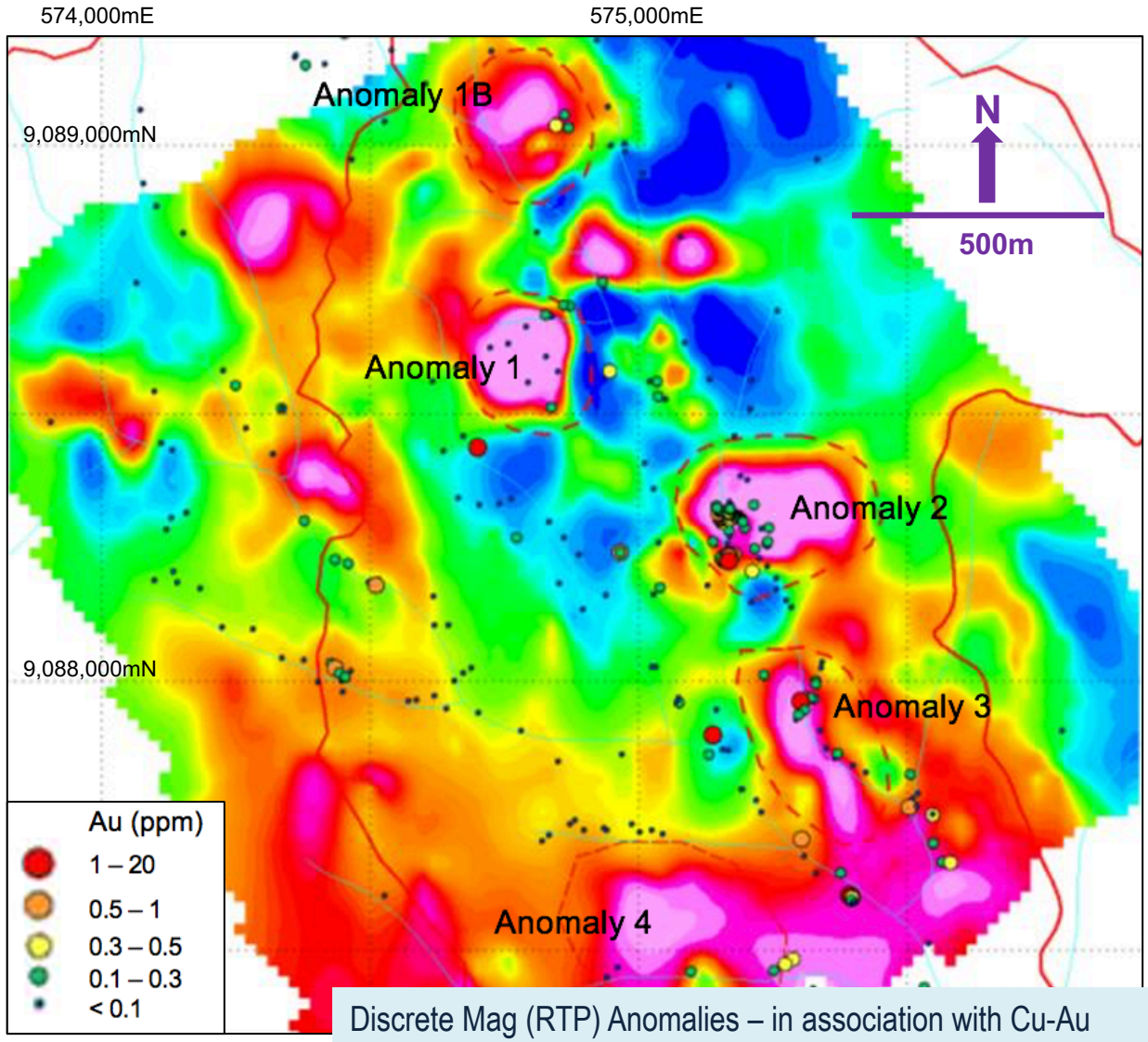
Singgahan
Porphyry & Jasperoid/ Skarn
Altered Dio/ QDio
Cu-Au-Mo
Drilling 4 holes for 1,541m

Exploration Data

- Airborne magnetics & radiometrics survey 3,675 line-km
- Geol Mapping & Prospecting
- Surface Geochem
  >300 stream seds
  >10,000 soils
  >4,000 rocks
- Ground Mag, IP/ Resistivity at Suruh, D.Turu, Sumber Bening, Singgahan
- Exploration drilling : 11,967 metres in 80 holes (multiple prospects)

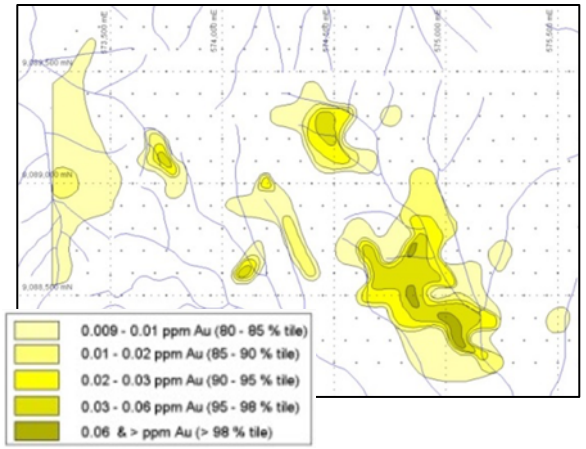
(Prihatmoko & Idrus, 2020)

SINGGAHAN
Porphyry Cu-Au

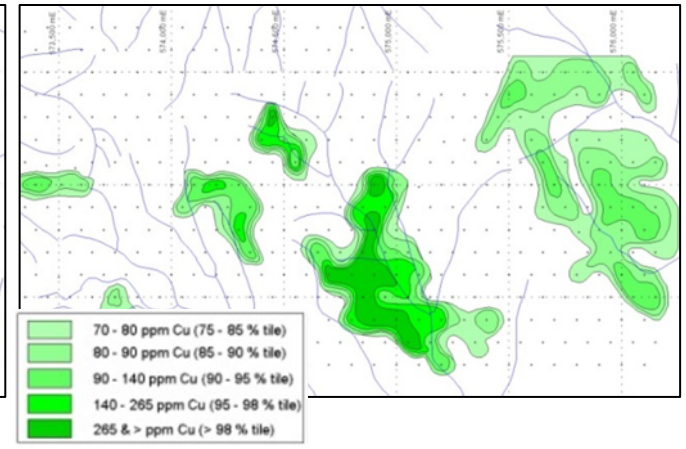


Discrete Mag (RTP) Anomalies – in association with Cu-Au anomalies (in rocks and soils), and quartz stockworking on surface and drill holes

Au in Soil



Cu in Soil

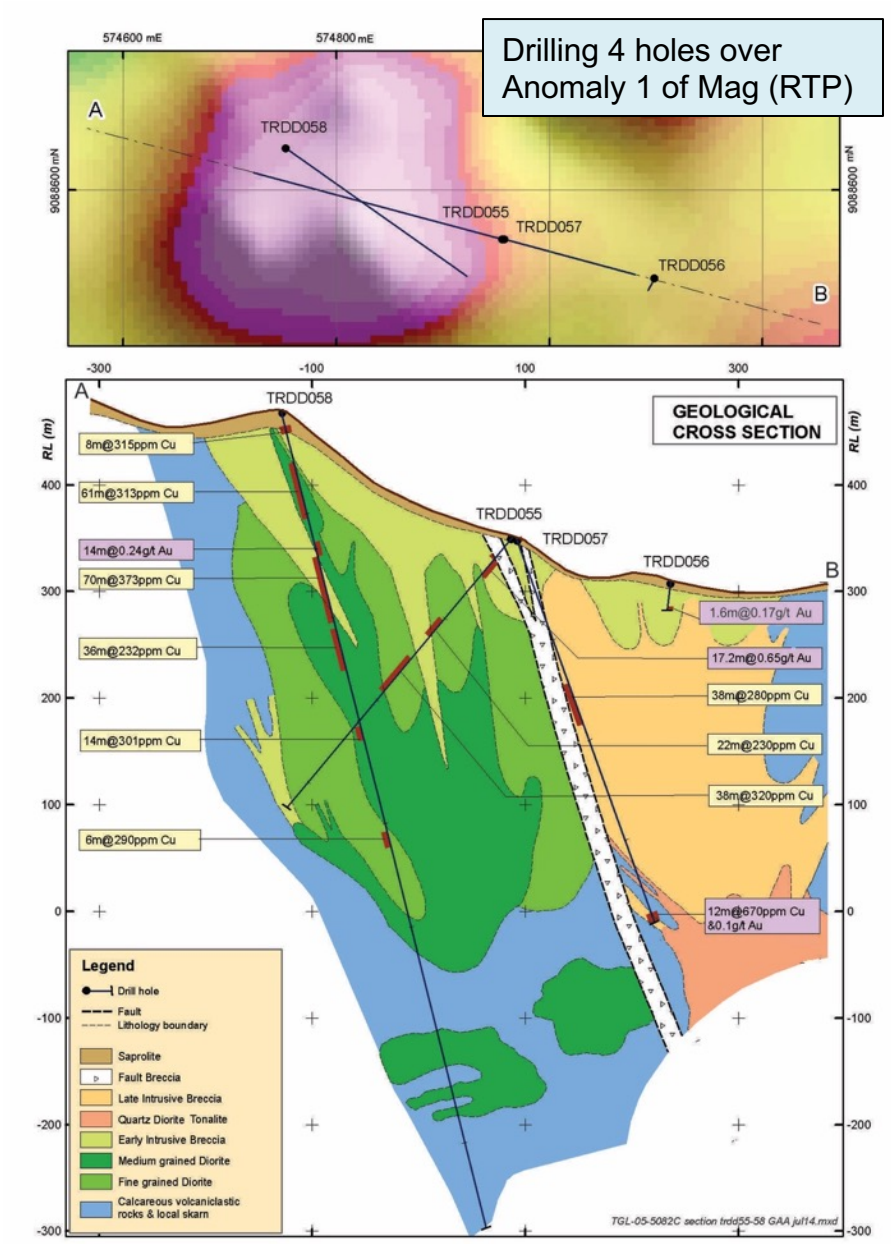


- 1200x500m alteration zone with quartz stockworks
- K-feldspar-biotite-actinolite/ tremolite-magnetite-chalcopyrite (prograde) and chlorite-carbonate-zeolite-illite-pyrite-chalcopyrite overprint (retrograde)
- Drill Hole TRDD057 intersected mineralized stockwork from 371m depth with elevated grade, i.e. 12m @ 0.067% Cu, 0.096 g/t Au (maximum 815 ppm Cu, 0.14 g/t Au.), and open at depth

Quartz stockwork hosted by quartz-sericite altered Quartz Diorite in Anomaly 2 (0.67 ppm Au and 0.2% Cu)

(Prihatmoko & Idrus, 2020)

SINGGAHAN
Porphyry Cu-Au



SINGGAHAN PROSPECT – DRILL CORE ROCK PHOTOS & PHOTOMICROGRAPHS
(Petrology by Anthony Coote of Applied Petrological Services "ASPAR")

PORPHYRY-STYLE MINERALISATION

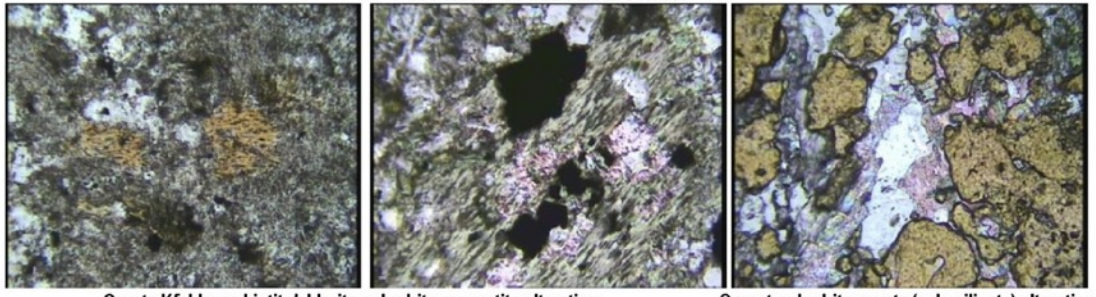
Disseminated chalcopyrite (yellow), bornite (purple grey) & magnetite (light grey)
propylitic-potassic altered diorite (TRDD055 & 58)

PORPHYRY-STYLE VEINING

Quartz-Kfeldspar-anhydrite-magnetite-chalcopyrite veins
in propyltic-potassic altered diorite (TRDD055 & 58)

Quartz-anhydrite-pyrite-chalcopyrite veins
in phyllic-potassic altered tonalite (TRDD057)

PORPHYRY-STYLE ALTERATION



Quartz-Kfeldspar-biotite/chlorite-anhydrite-magnetite alteration
in diorite / quartz diorite (TRDD057 & 58)

Garnet-anhydrite-quartz (calc-silicate) alteration
in calcareous volcaniclastic rock (TRDD058)

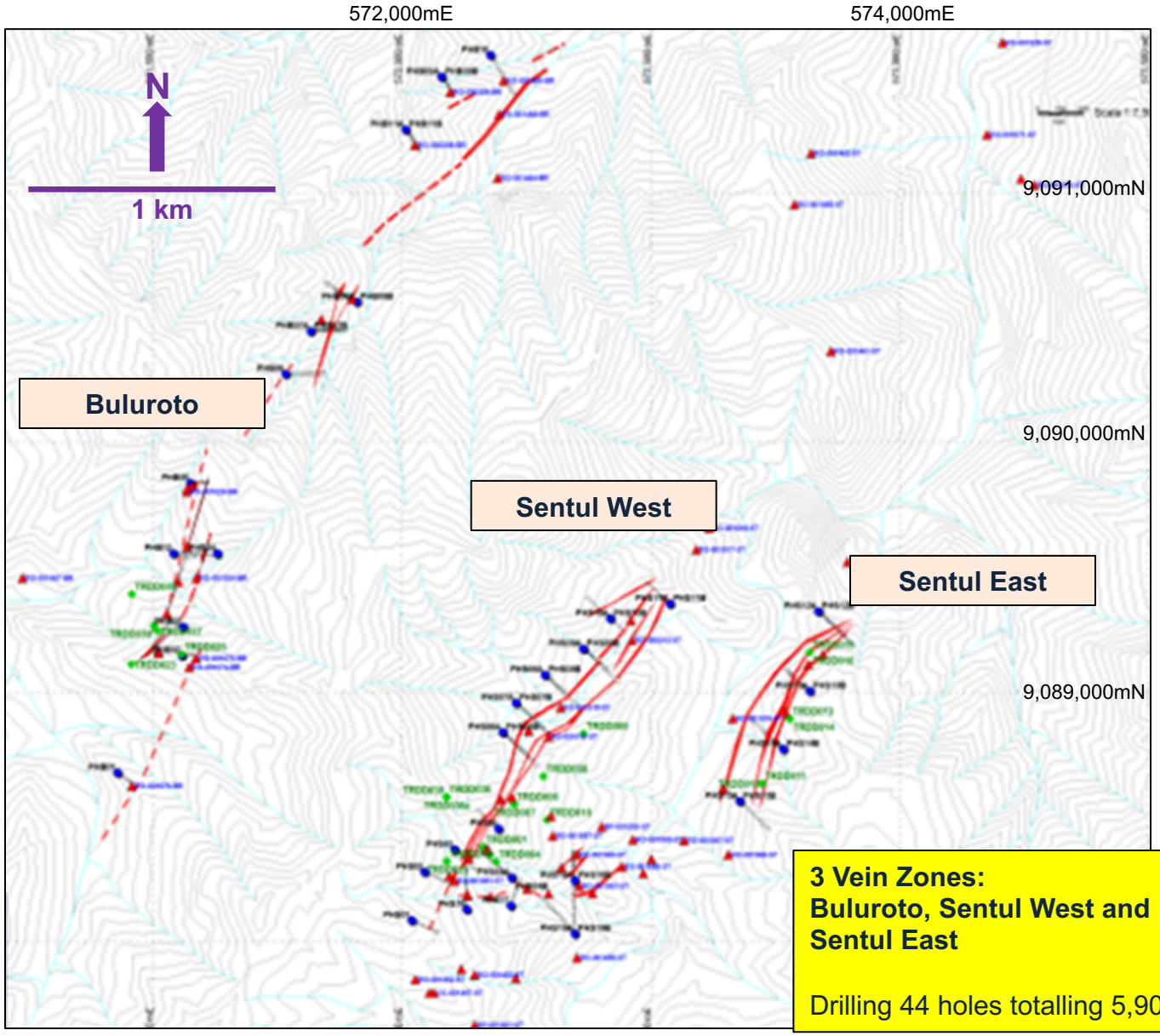
(Prihatmoko & Idrus, 2020)

SENTUL-BULUROTO
IS Epithermal Au-Ag-Base Metals Veins

Polyphase quartz-sulfide breccia veins (up to 1.5km long, up to 15m wide), hosted in silica-clay-pyrite altered volcaniclastics and limestone and intruded by andesite dykes. Geochemical association : Au+Ag+As+Sb+Cu+Mo+Pb+Zn.

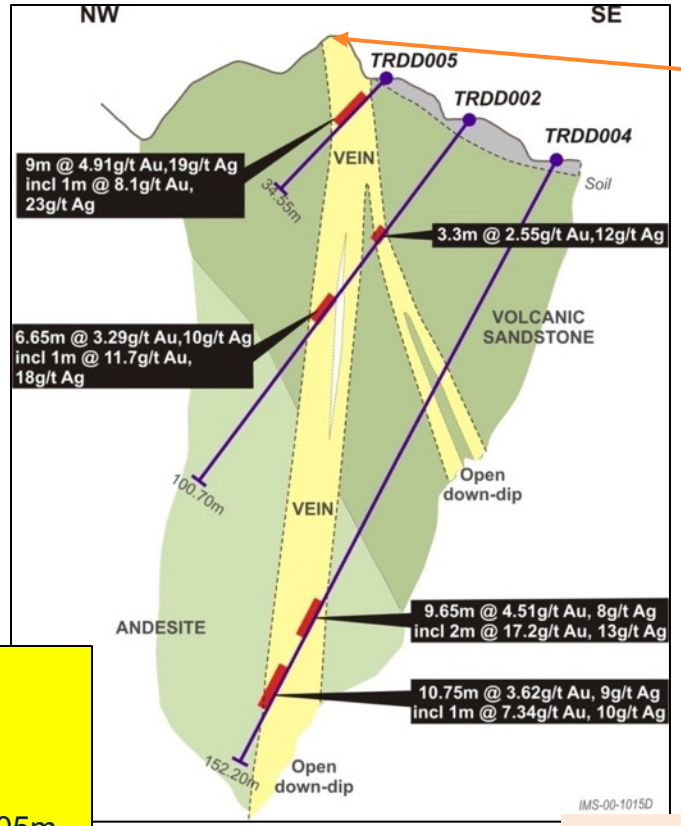
Best drill intercept:

- Buluroto: 2m at 8.7 g/t Au & 48 g/t Ag within 13.7m at 3.2 g/t Au & 60 g/t Ag in TRDD032 , and 24.5m at 0.51 g/t Au and 0.21% Cu in TRDD025
- Sentul: 2m at 17.2 g/t Au & 13 g/t Ag within 9.6m at 4.5 g/t Au & 8 g/t Ag f in TRDD004

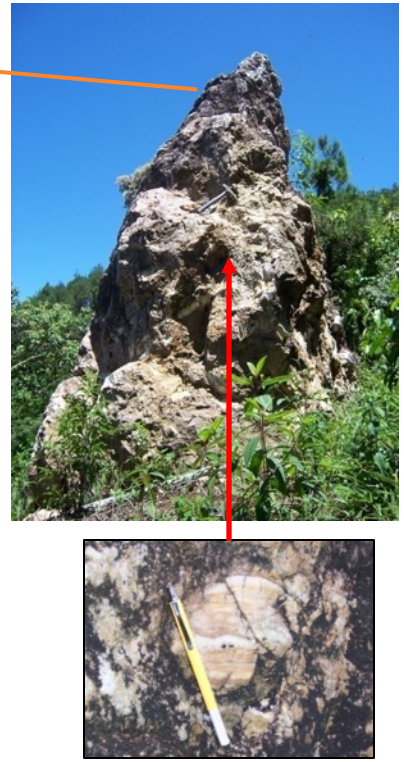


3 Vein Zones: Buluroto, Sentul West and Sentul East

Drilling 44 holes totalling 5,905m



Sentul West Vein

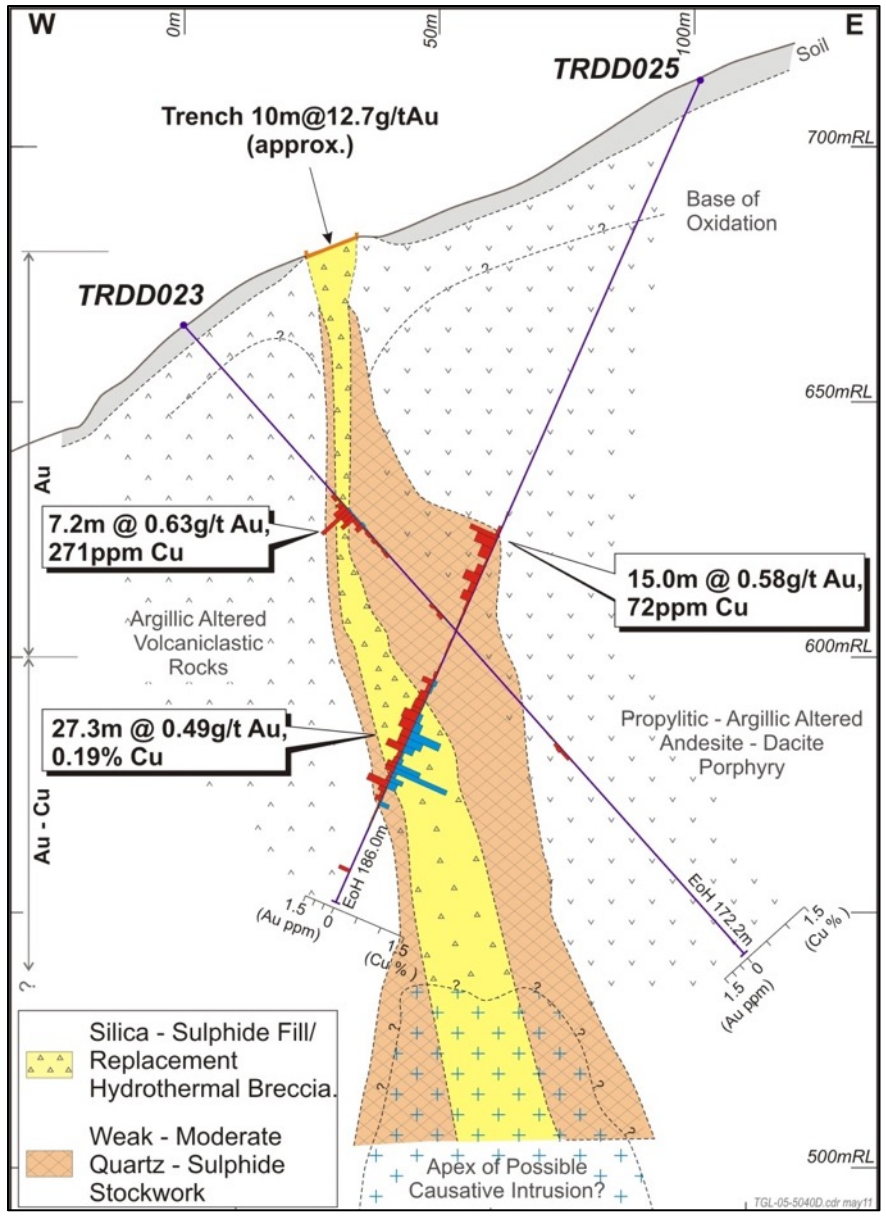


149 g/t Au

(Prihatmoko & Idrus, 2020)

SENTUL-BULUROTO
IS Epithermal Au-Ag-Base Metals Veins

Buluroto Vein

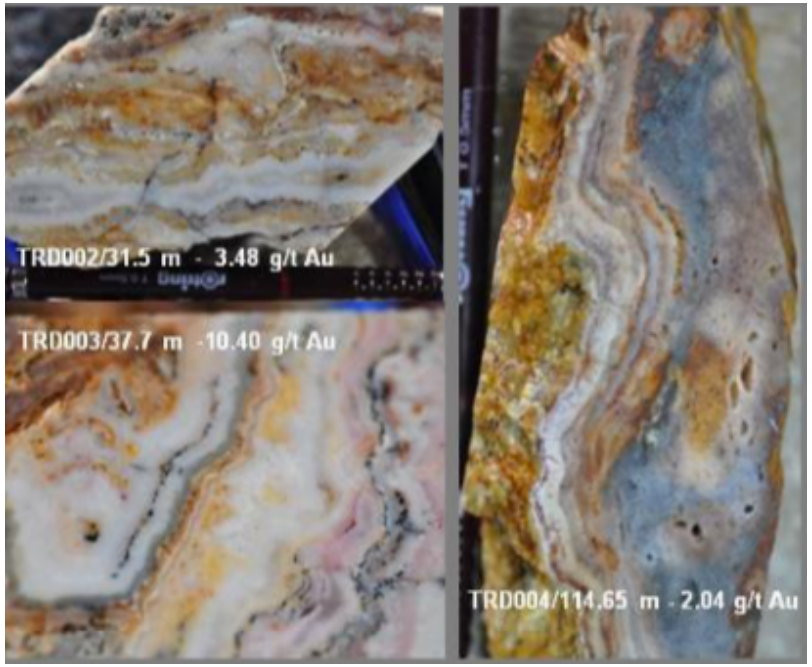


Buluroto Ore

TRD025/159m

Cu Sulfide Mineralization in breccia matrix - Buluroto

Sentul Ore



Drilling 44 holes totalling 5,906m

Resource	Indicated					Inferred				
	Ore (t)	Au (g/t)	Ag (g/t)	Au (oz)	Ag (oz)	Ore (t)	Au (g/t)	Ag (g/t)	Au (oz)	Ag (oz)
West Sentul	1.554.388	1,23	3,86	61.622	193.051	814.605	0,59	11,73	15.453	307.239
East Sentul	354.025	1,55	6,10	17.636	69.404	364.212	0,96	4,35	11.189	50.921
Buluroto	367.954	1,29	16,55	15.205	195.804	253.516	0,45	4,80	3.696	39.089
Total	2.276.367	1,29	6,26	94.463	458.259	1.432.333	0,66	8,63	30.338	397.249

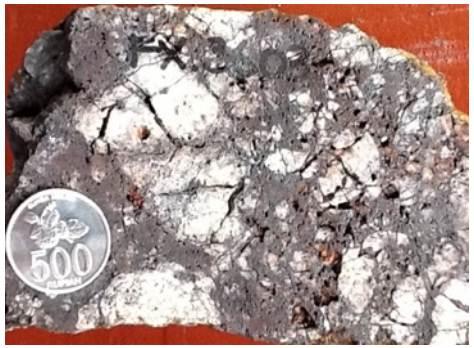
Total Resource (Inferred & Indicated): 3,708,700 tons @ 1.05 g/t Au; 7.18 g/t Ag ~ 137,119 oz Au.eq

(Prihatmoko & Idrus, 2020)

SUMBER BENING
HS Epithermal - Lithocap

LITHOCAP

+3km x 2km advanced argillic (sil-pyro-dick-kaol-alun-pyrite/hematite) alteration footprint.
Anomalous Cu-Au-Mo-Bi in soil & rock chip.
No drilling program yet

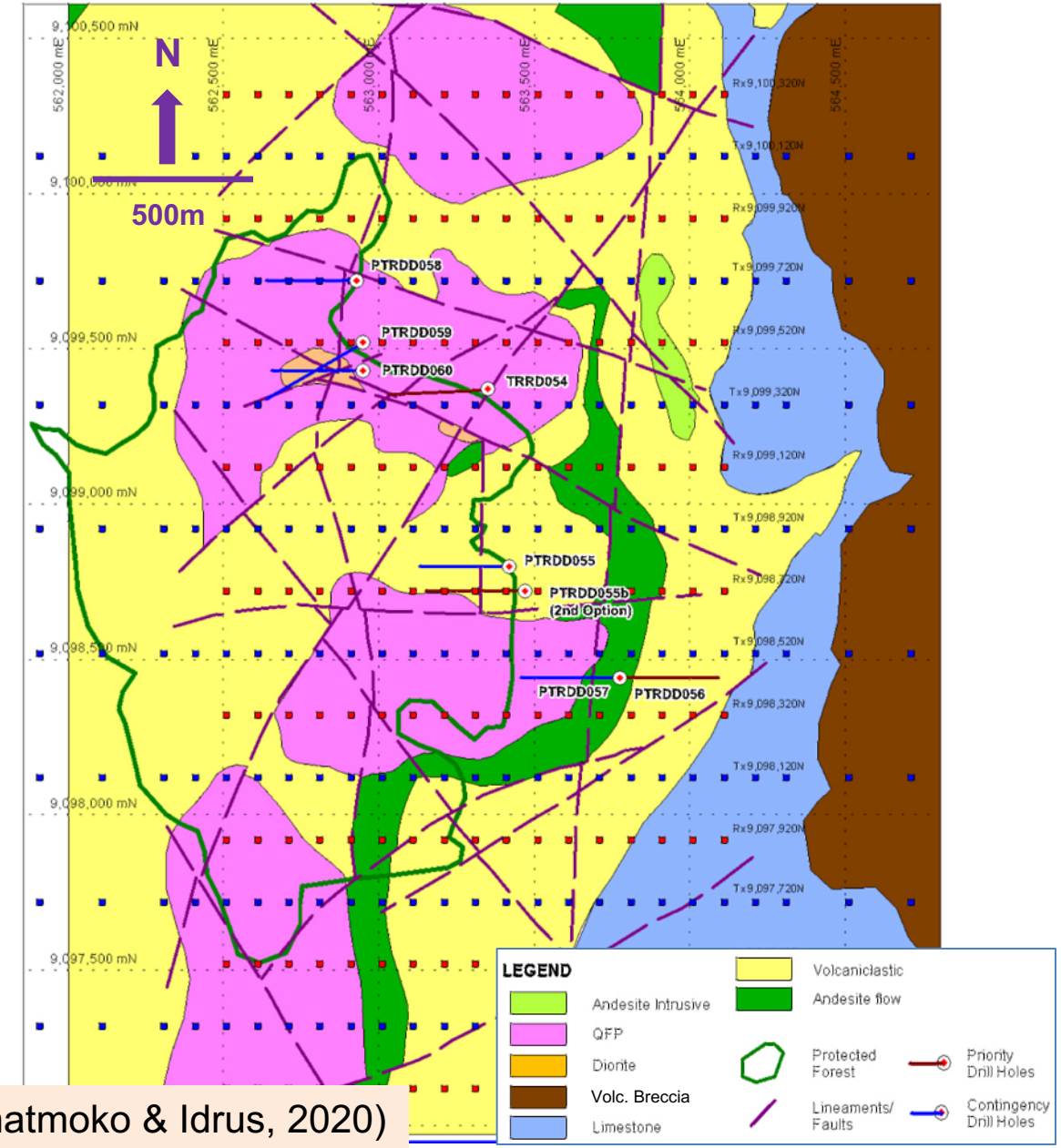


0.14 ppm Au; 277ppm Cu; 1410 ppm Bi; 37 ppm Mo

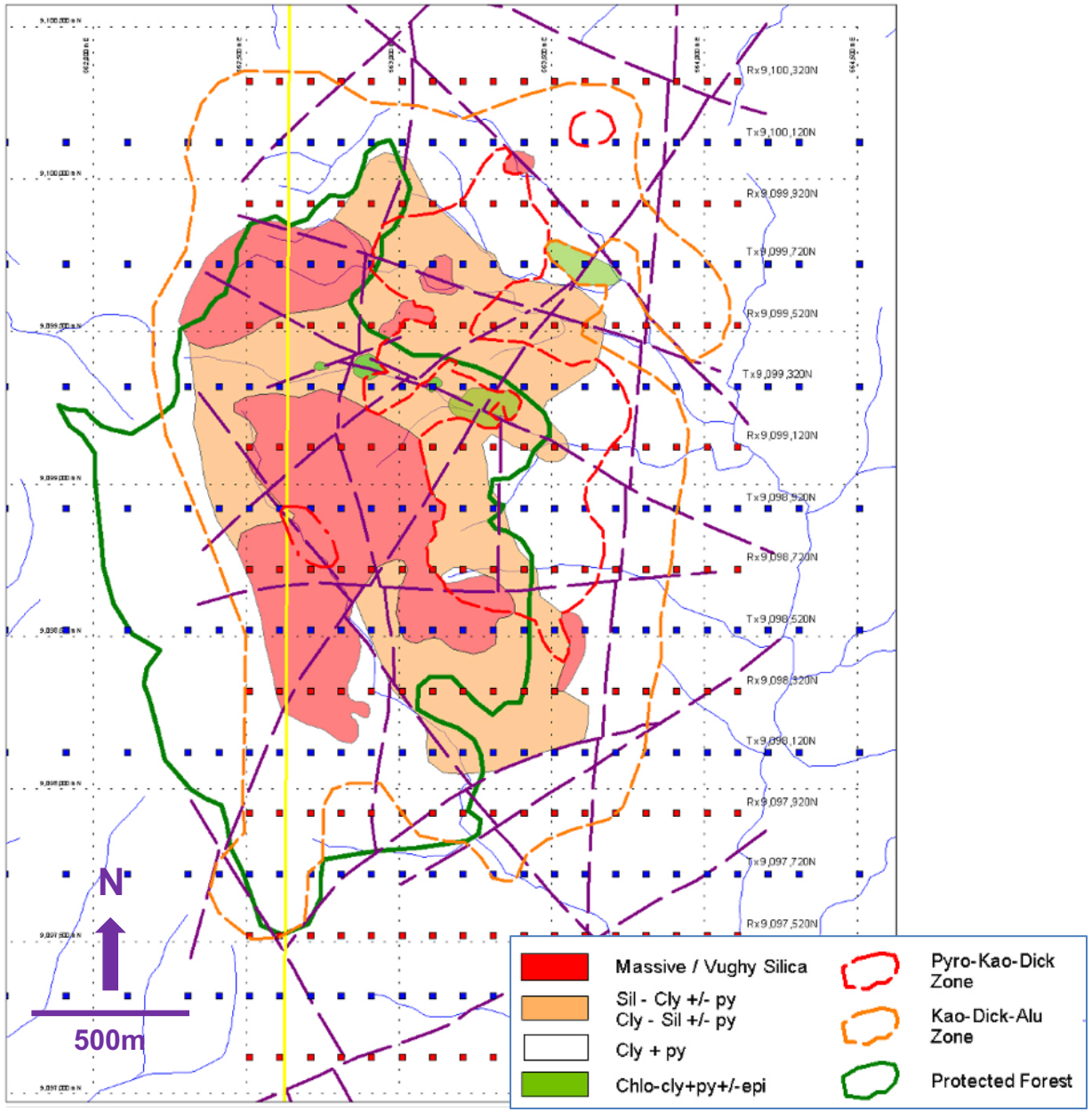
(Prihatmoko & Idrus, 2020)

SUMBER BENING
HS Epithermal - Lithocap

Geology



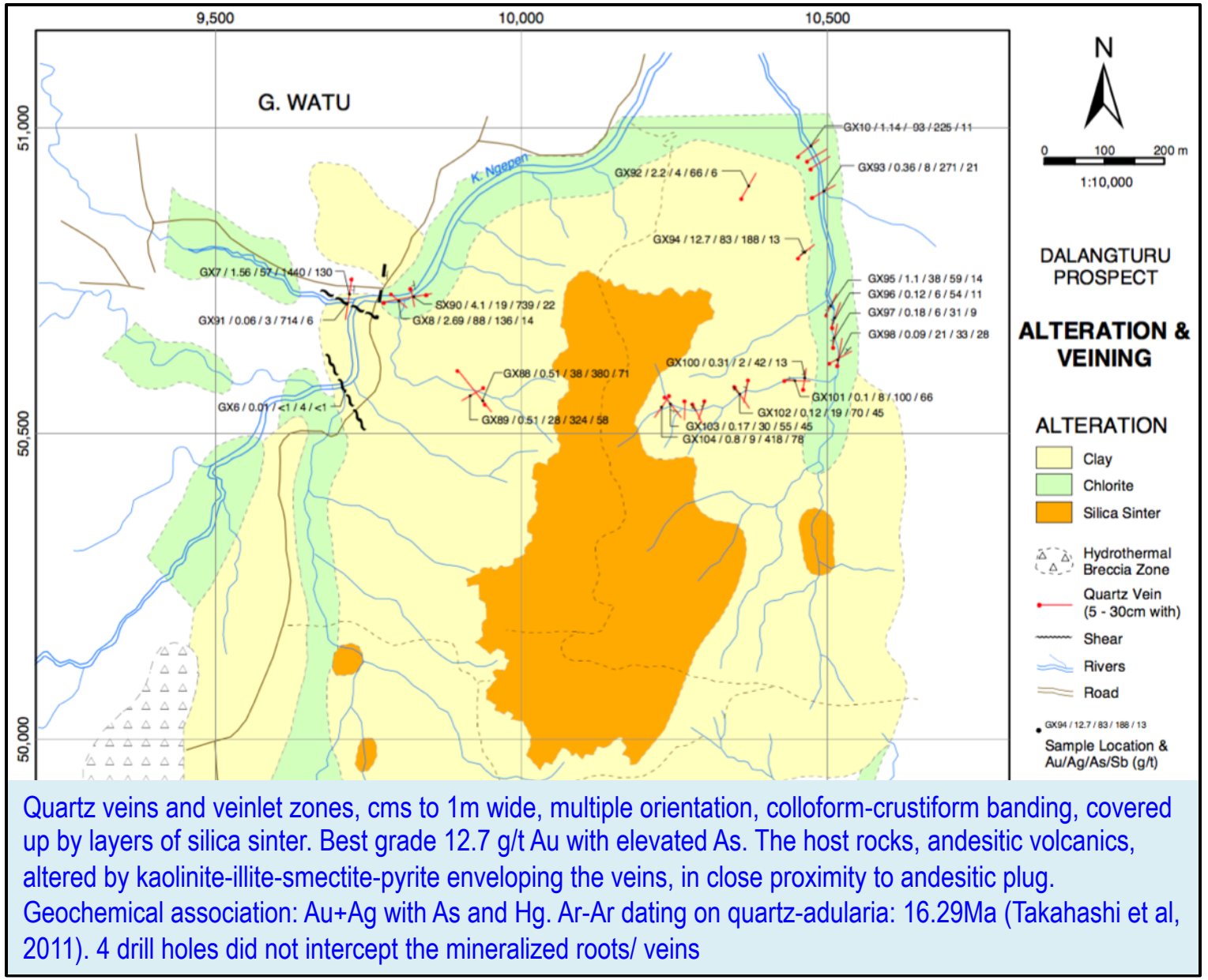
Alteration



(Prihatmoko & Idrus, 2020)

4

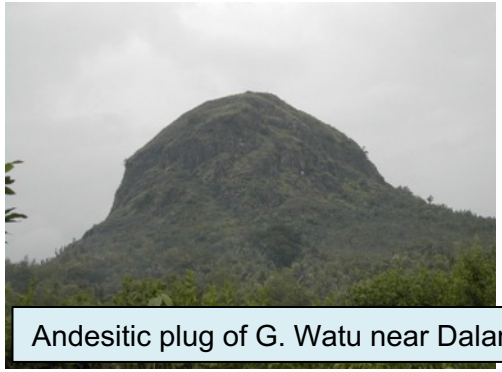
DALANG TURU
LS Epithermal - Sinter



Quartz veins and veinlet zones, cms to 1m wide, multiple orientation, colloform-crustiform banding, covered up by layers of silica sinter. Best grade 12.7 g/t Au with elevated As. The host rocks, andesitic volcanics, altered by kaolinite-illite-smectite-pyrite enveloping the veins, in close proximity to andesitic plug. Geochemical association: Au+Ag with As and Hg. Ar-Ar dating on quartz-adularia: 16.29Ma (Takahashi et al, 2011). 4 drill holes did not intercept the mineralized roots/ veins

Crustiform banded quartz veins

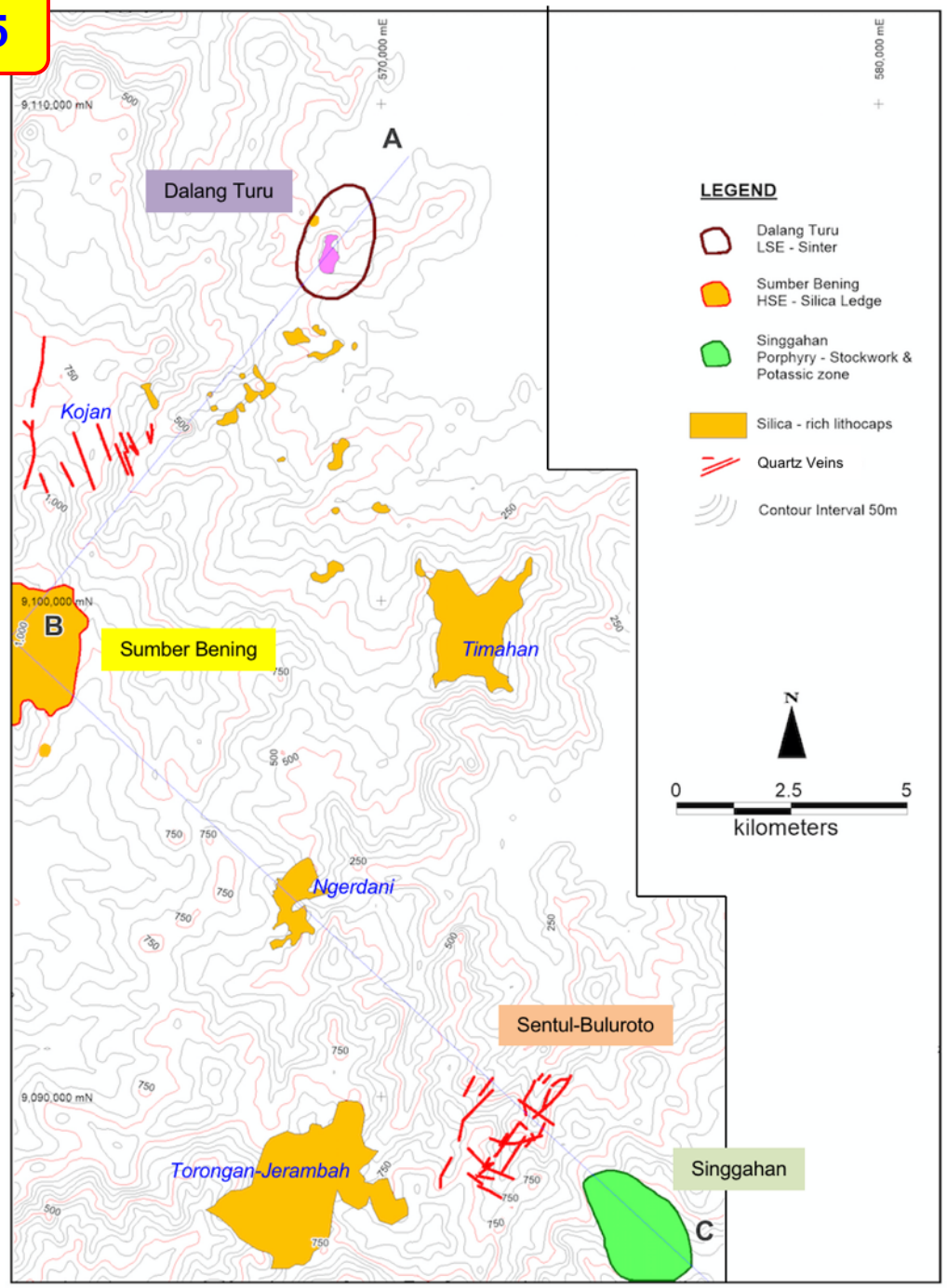
Sinter layer overlying the vein system



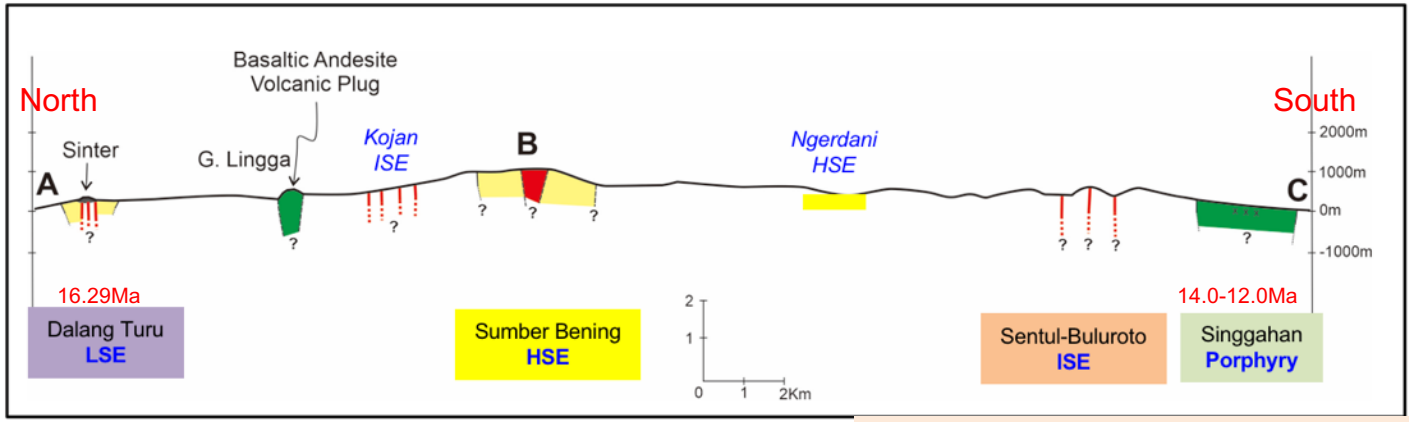
Andesitic plug of G. Watu near Dalang Turu

(Prihatmoko & Idrus, 2020)

5



Various Types of Mineralization in a District (Trenggalek)



(Prihatmoko & Idrus, 2020)

Discussion

- Various mineralization types, spread up from south to north in about 18 km distance, i.e. porphyry (Singgahan), ISE (Sentul-Buluroto), HSE (Sumber Bening), and LSE (Dalang Turu) indicate a dynamic hydrothermal and mineralization events in Early Miocene (18.7-11.8 Ma).

- The facts that Singgahan porphyry (potassic & stockwork zones) has been exposed, while the Dalang Turu's LSE and sinter system is still preserved at surface → the southern part of the district has been much more tilted and eroded than the northern part → *multiphase intrusions (Dio, Qdio, Tonalite) !!*

- The hybrid of LSE type (Dalang Turu) with intrusion related mineralization types (Sumber Bening's HSE, Sentul-Buluroto's ISE and Singgahan's porphyry) is unique → could be related to the tectonic setting of the district. One of the clues: a bimodal volcanism, indicated by various composition of sub-volcanic plugs and volcanic/ volcaniclastic sequences (from basalt to rhyolite) should be an important evidence of back arc extensional setting.

5 CLOSING REMARKS

1. Eastern Sunda Arc is an emerging magmatic belt in SE Asia/ Western Pacific for porphyry Cu-Au and epithermal Au deposits → *New Discovery of Tumpang Pitu, Huu, Kerta*
2. Comprehensive identification and assessment of all related data:
   - ✓ Geochemistry of rocks and soils
   - ✓ Mineral identification (petrography, terraspec etc)
   - ✓ Age dating
   - ✓ Geophysical survey (magnetic both airborne and ground), IP, etc
   - ✓ Drilling (drill cores) data

   combined with the assessment of geological context including tectonic and magmatic arc's setting, plus evaluation on the spatial position and timing of the mineral prospects are very important aspects to set up exploration strategy and further programs.

Matur Nuwun

3. Trenggalek district which is located in the Eastern Sunda Arc – an excellent address – emerging porphyry province – proven potential – yet underexplored

4. Exploration and development of Trenggalek – **An Unfinished Story**

The Beginning of a Big Story (?)