TECHNICAL SERVICES DEPT.

02nd October 2020 – Geology Updated

Welcome to Tujuh Bukit Project

Tujuh Bukit, photo by Andi

Krisma Anditya
Teknik Geologi UPN Veteran Yogyakarta
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2000 - 2005

- Junior Geologist at Harita Prima Abadi Mineral (exploration and project generation of bauxite deposit in West of Borneo)
- Geologist at Energi Kaltim Persada (exploration and wellsite geologist at coal deposit in East of Borneo)
- Geologist at Sorikmas Mining (exploration, wellsite, and coreshed geologist at low sulphidation and sediment hosted gold deposit in North of Sumatra)
- Project geologist at Tansri Madjid Energy (exploration, wellsite and coreshed geologist at low sulphidation gold deposit in Lebong Tambang Bengkulu)
- Senior geologist at Bumi Suksesindo (exploration, wellsite, core handling and logging at porphyry and high sulpidation gold deposit in Banyuwangi East of Java)
- Senior mine geologist at Bumi Suksesindo surface mine of high sulphidation gold deposit in Banyuwangi East of Java)

OUTLINE


Tujuh Bukit, photo by Krisma

- CURRICULUM VITAE OF KRISMA ANDITYA
- REGIONAL OF TUJUH BUKIT PROJECT
- MODEL OF MAGMATIC ARC Cu-Au-Ag
- FORM OF EPITHERMAL DEPOSITS AND ACID HYDROTHERMAL FLUIDS
- CHARACTERISTIC OF EPITHERMAL TEXTURES
- MINERALS OF EPITHERMAL HIGH SULPHIDATION
- ALTERATION FACIES OF EPITHERMAL HIGH SULPHIDATION
- PARAGENESIS OF EPITHERMAL HIGH SULPHIDATION IN THE TUJUH BUKIT PROJECT
- OVERVIEW EXPLORATION OF UPPER HIGH GRADE ZONE
- CORESCAN

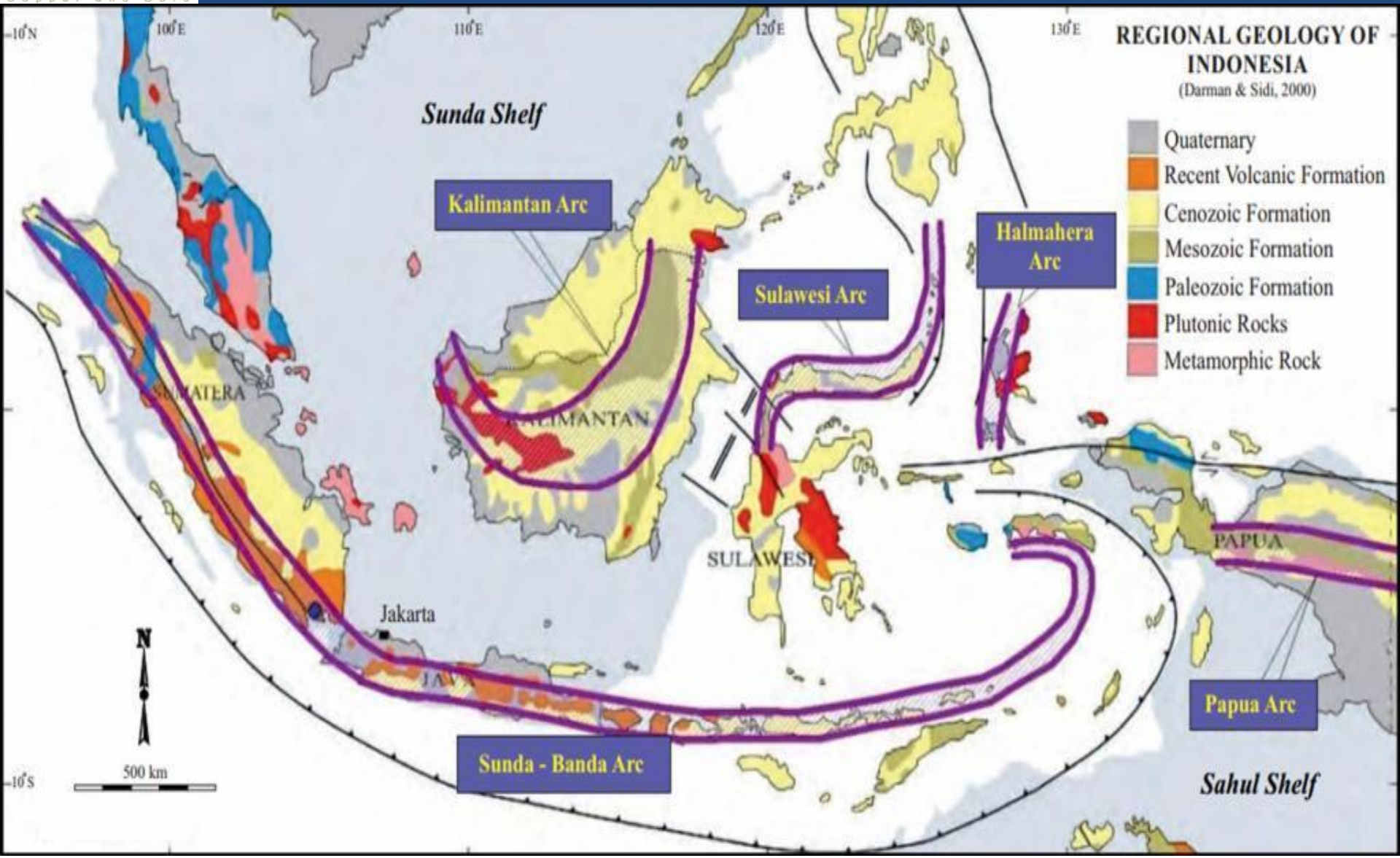
Rossete of peacock covellite *CuS* transform to malachite

Welcome to Tujuh Bukit Project

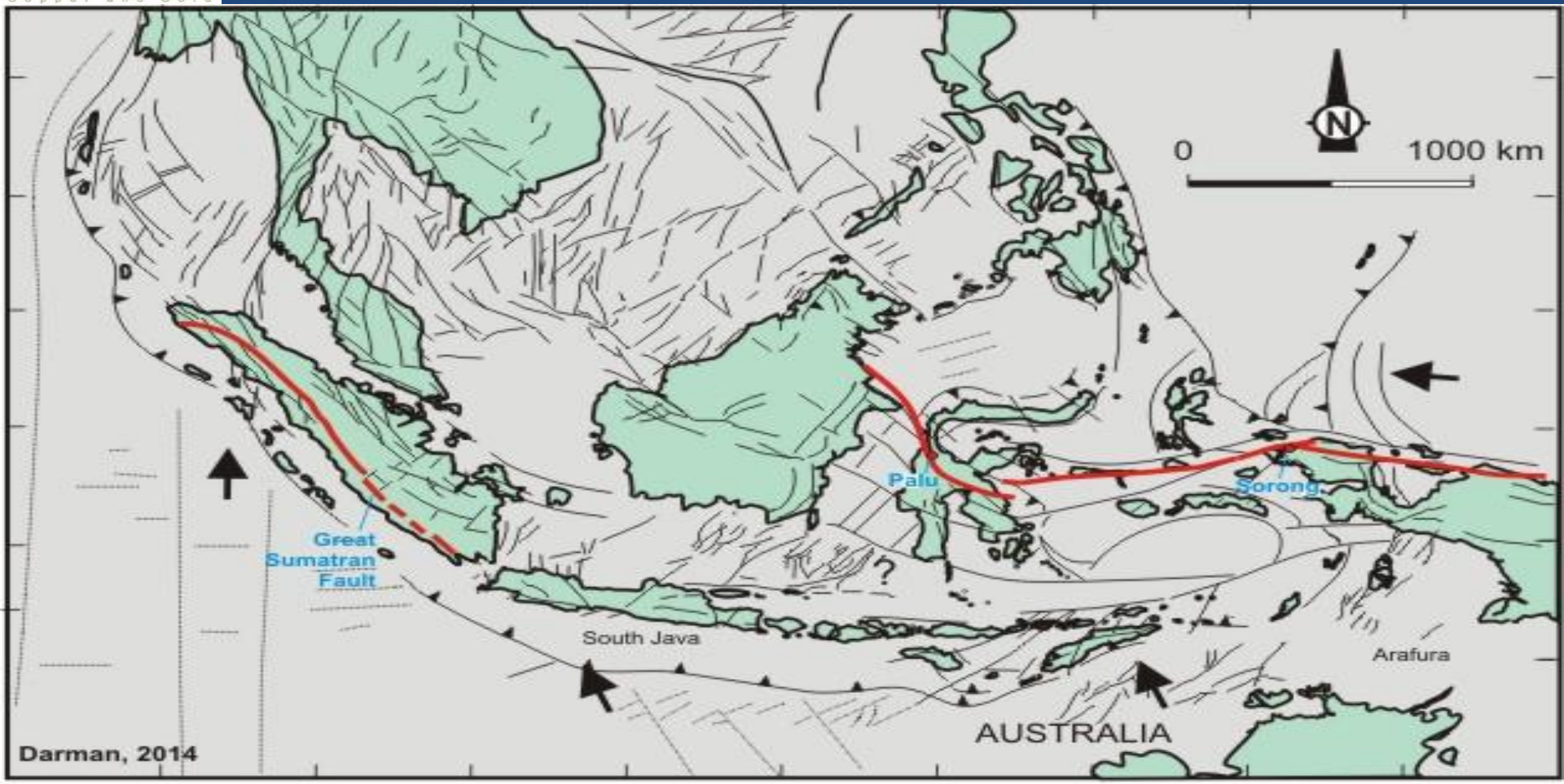
Aerial view looking South East towards Tujuh Bukit (2012)

Location of Tujuh Bukit Project

Tectonics of Indonesia



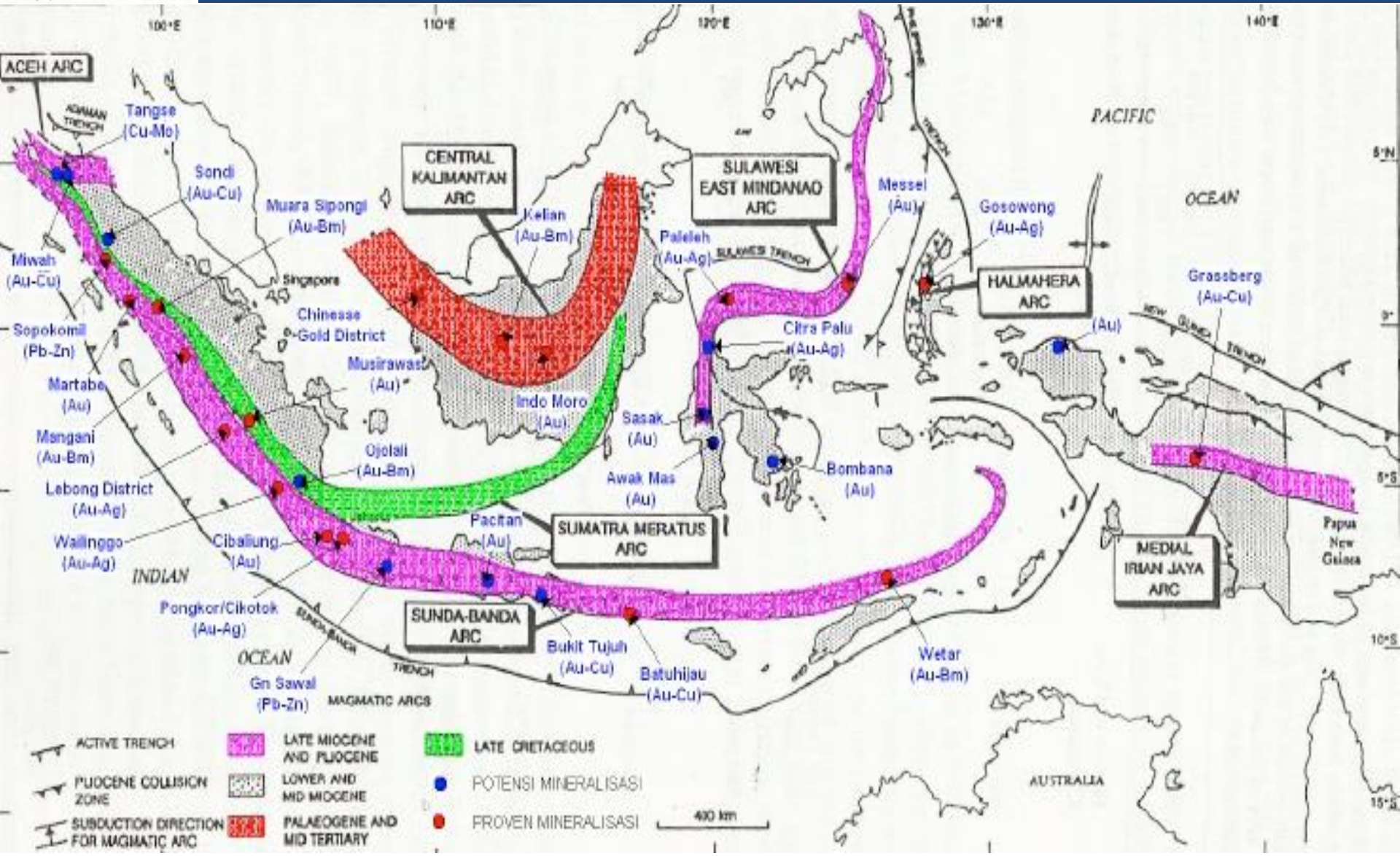
Regional Structure Geology in Indonesia



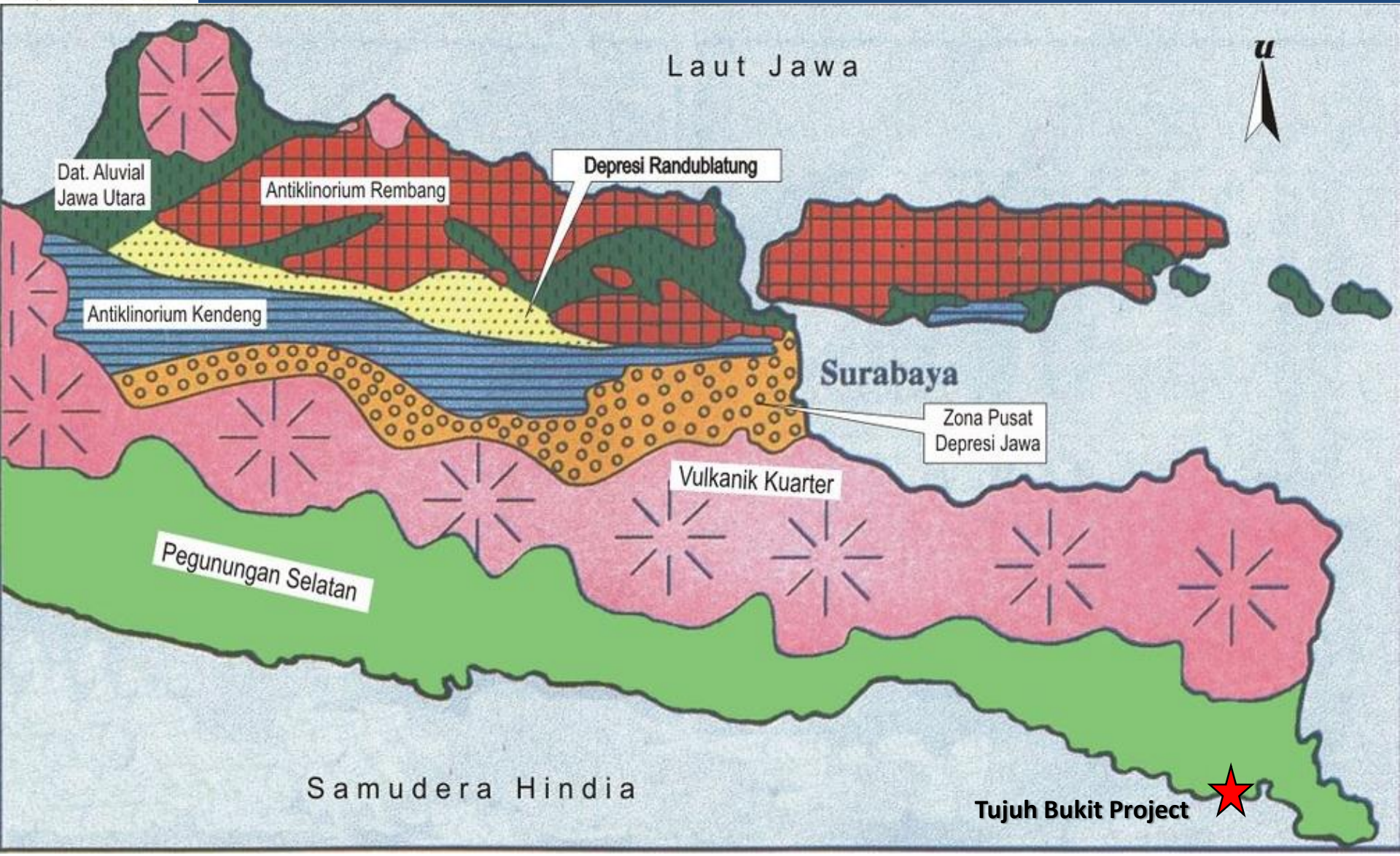
Legend

- Major intra & inter plate shear
- Cross plate tensional fault
- Back arc spreading axes
- Major trust faults and trenches
- Magnetic lineation & transform faults
- Direction of plate motions

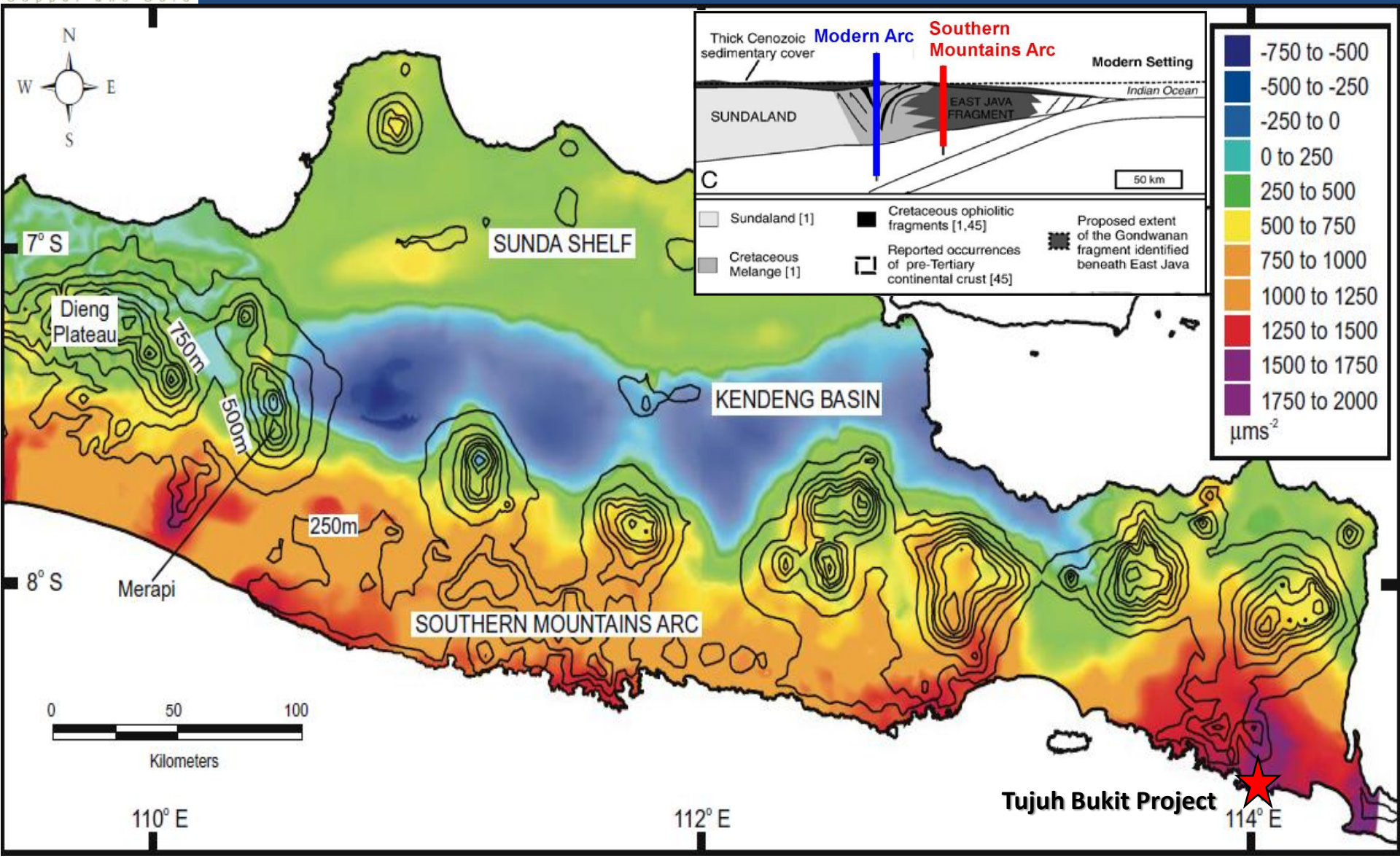
Spatial distribution of the major porphyry and epithermal deposits of Indonesia



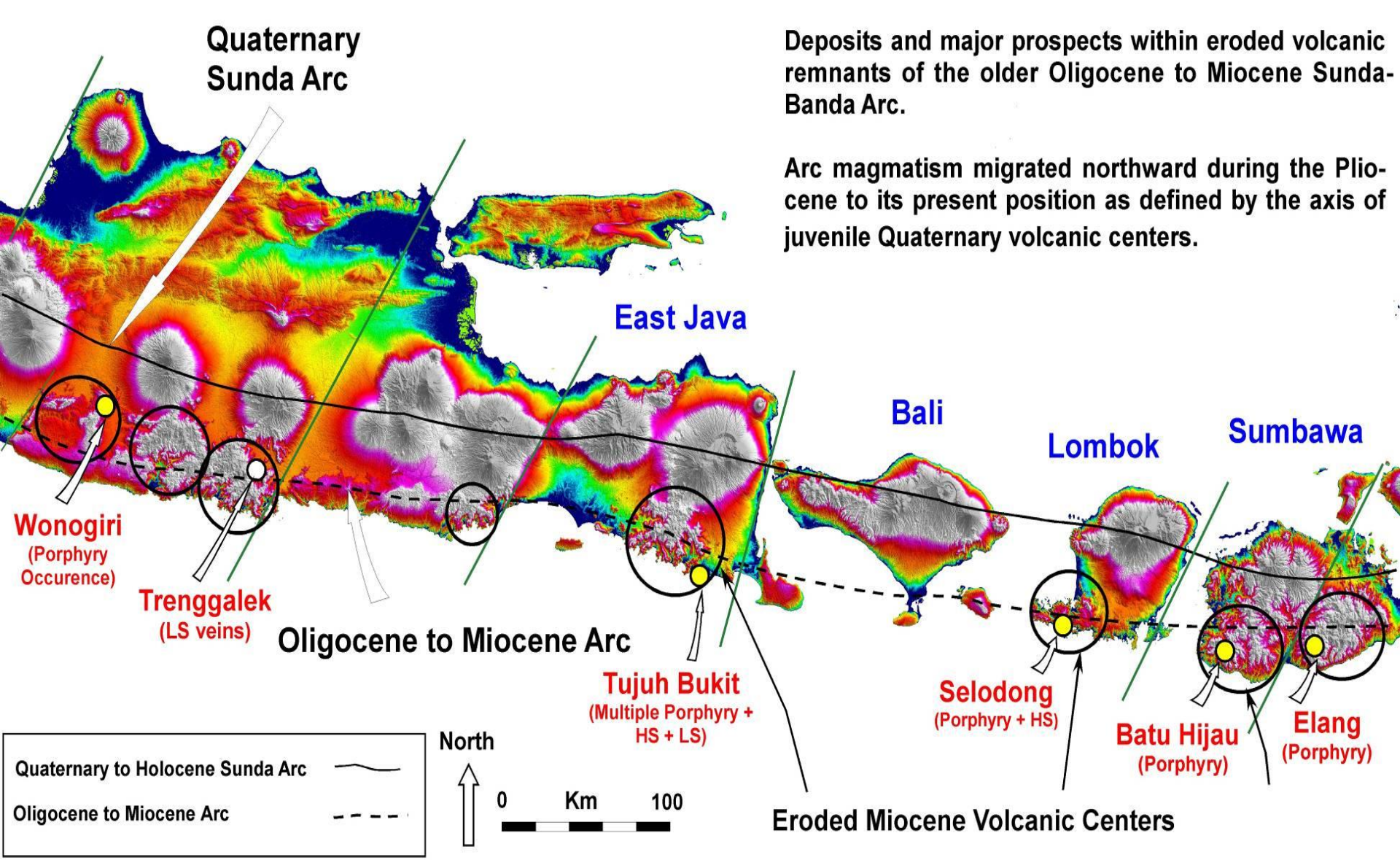
Physiographic Map of East Java



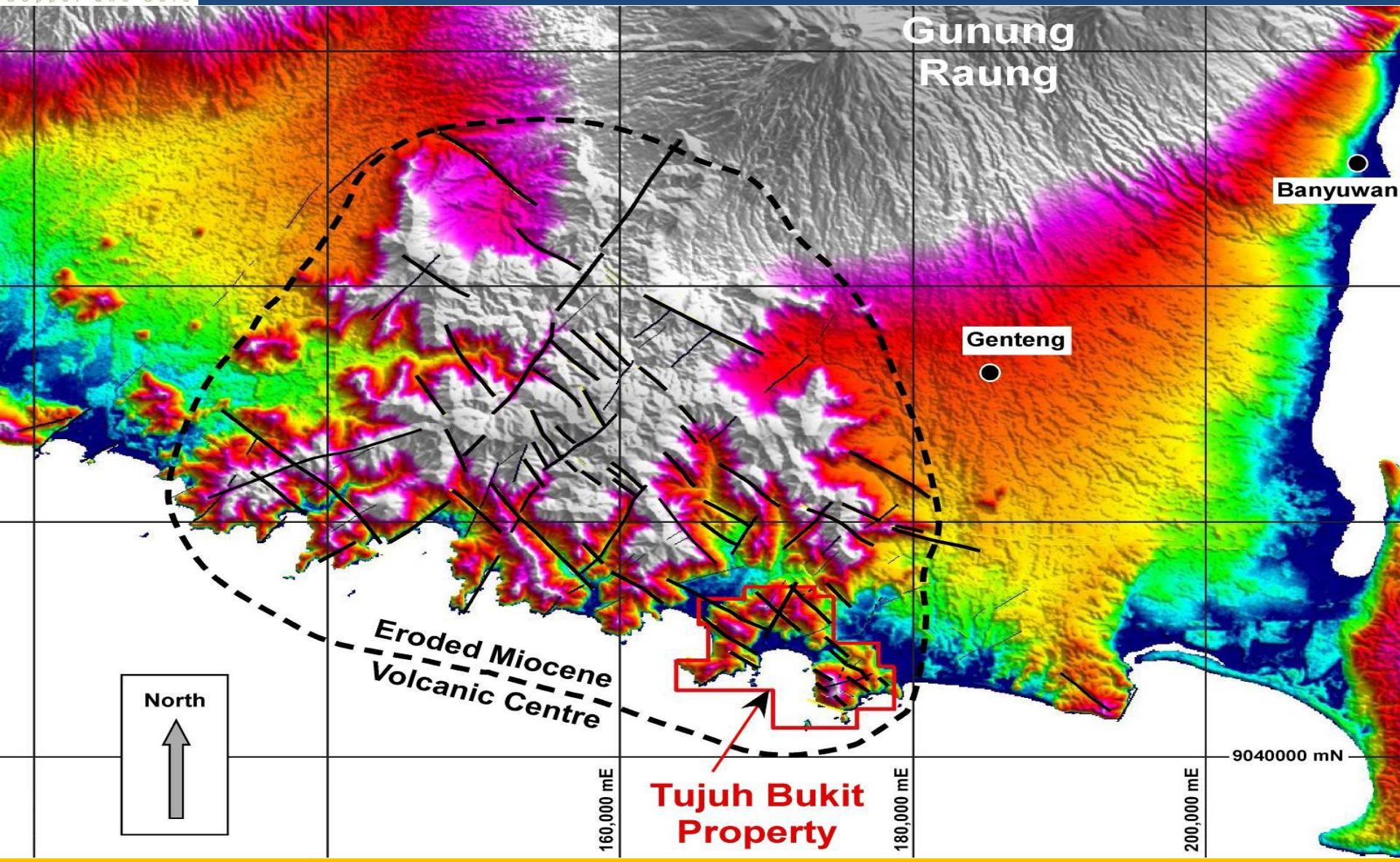
Bouger Gravity Map of East Java



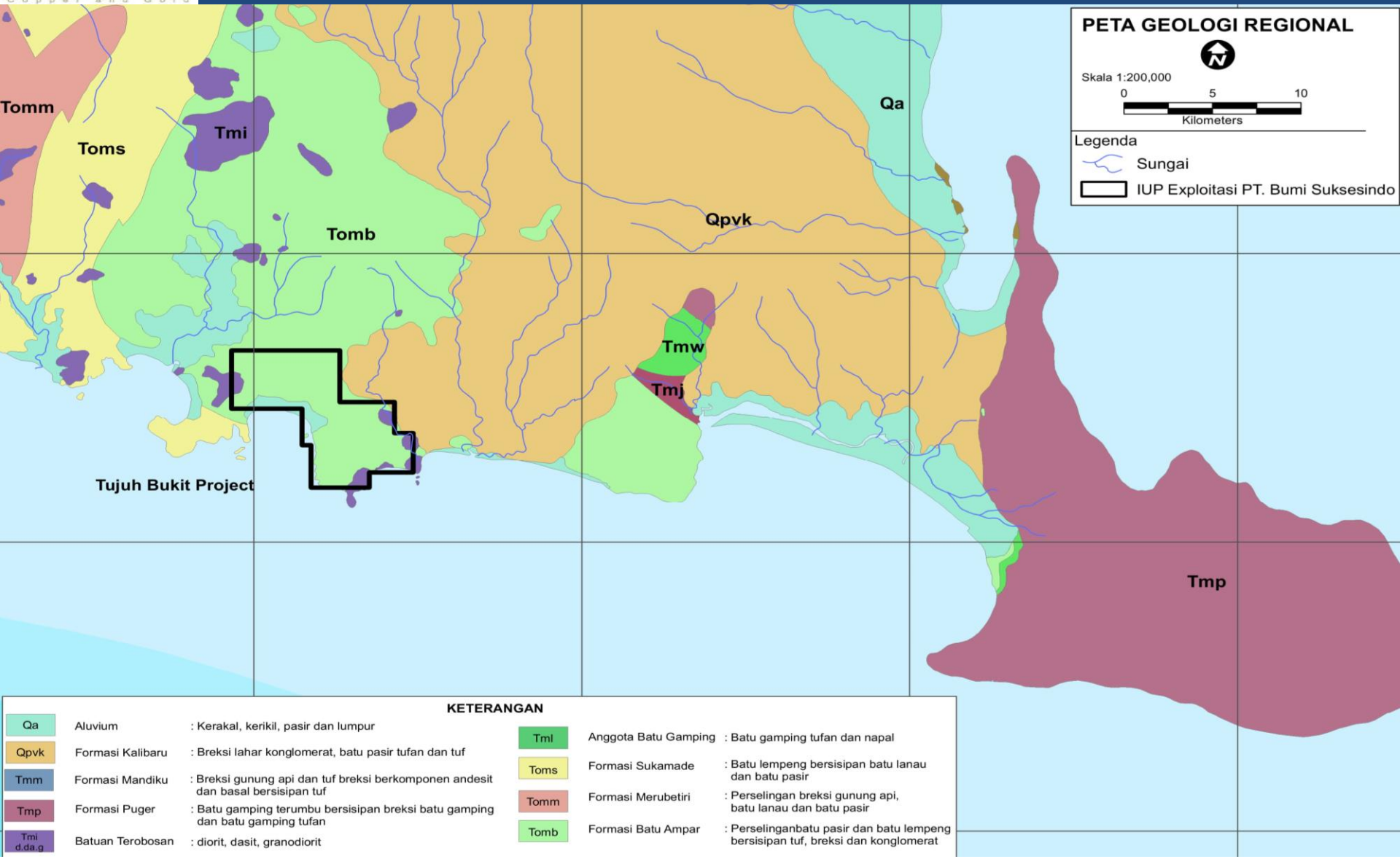
Volcanic Arc in Sunda Banda Arc



Eroded Volcanic Miocene Around Tujuh Bukit

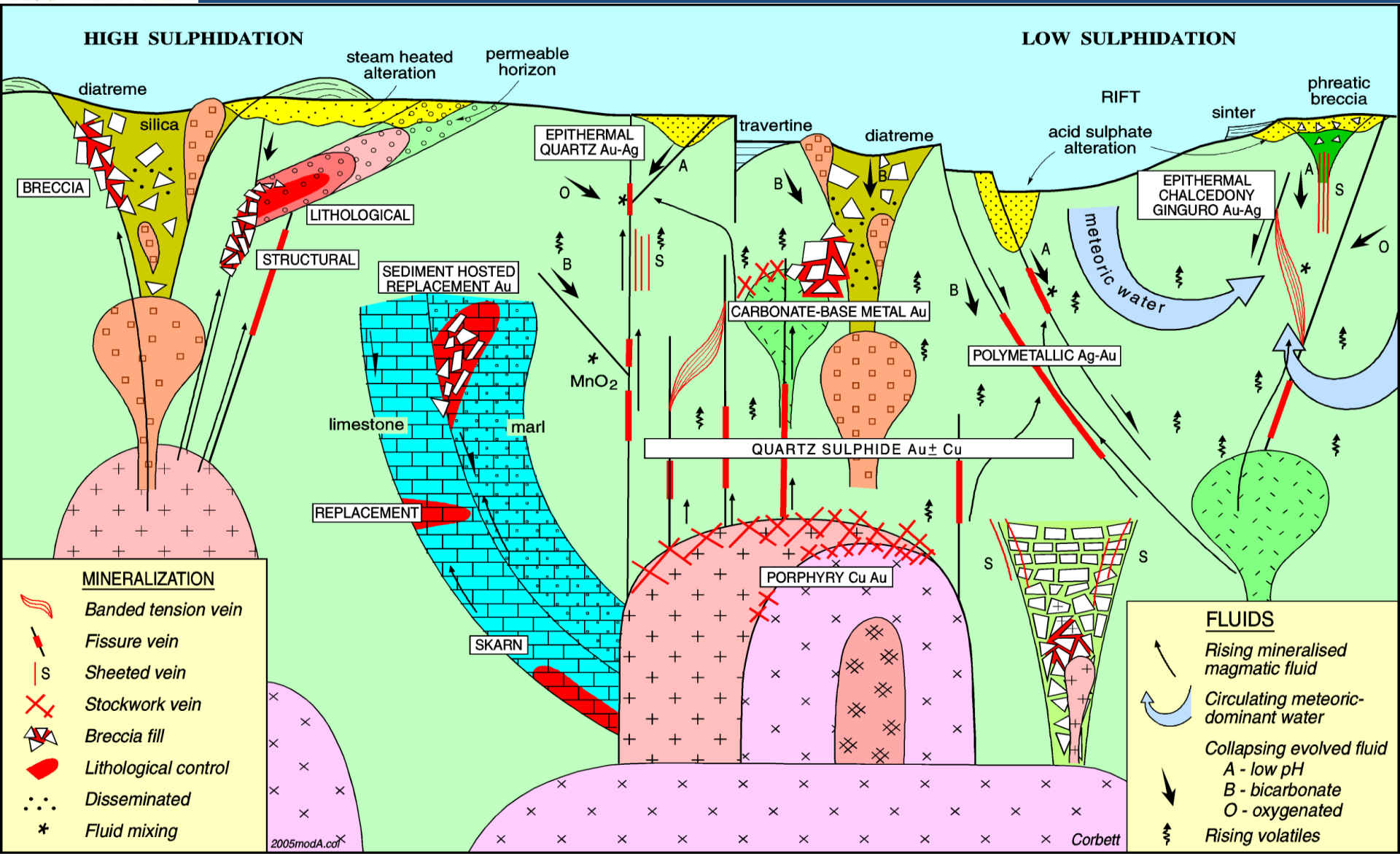


Geology Regional in Tujuh Bukit Project



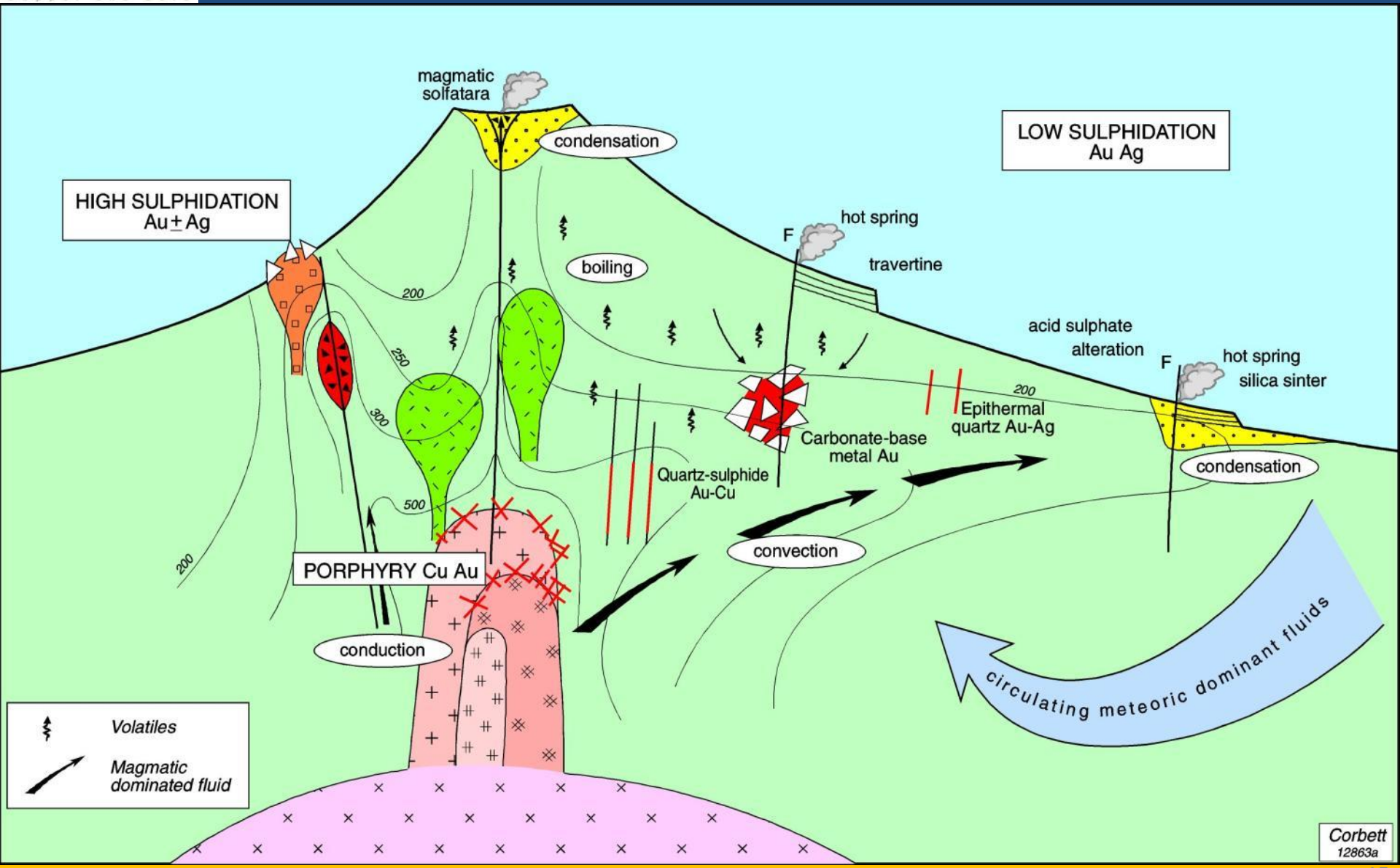
Model for Magmatic Arc Cu-Au-Ag

Courtesy of Corbett course 2007



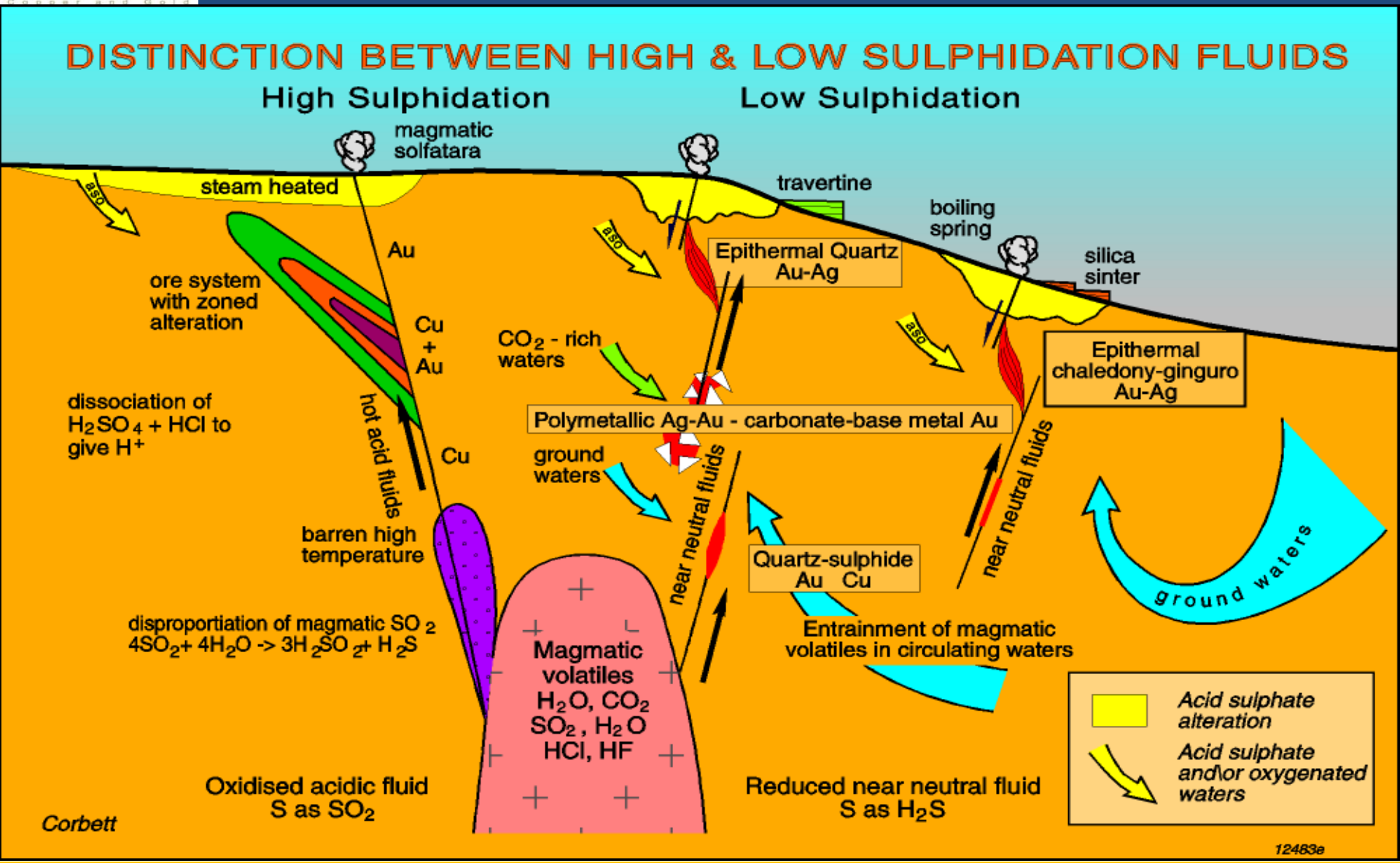
Magmatic Arc Au-Ag Mineralisation

Courtesy of Corbett course 2007



Distinction Beetwen High & Low Sulphidation Fluids

Courtesy of Corbett course 2007



WHERE DO THEY OCCUR

Courtesy by Noel White 2019

Tujuh Bukit, photo by Krisma

Silisic alteration of sediment rock (intercalated of siltstone, claystone and volcanic sandstone)

HIGH SULPHIDATION	LOW-INTERMEDIATE SULPHIDATION
• CALC-ALKALINE VOLCANICS	• CALC-ALKALINE TO ALKALINE VOLCANICS
• MOSTLY SUBAERIAL ENVIROMENTS, RARELY SUBMARINE	• SUBAERIAL ENVIROMENTS
• PROXIMAL VOLCANIC SETTINGS (BUT NOT STRATOVOLCANO)	• MOSTLY INTERMEDIATE TO DISTAL VOLCANIC SETTINGS
• IN VOLCANIC ROCKS, LESS COMMONLY IN BASEMENT	• IN VOLCANIC ROCKS OR BASEMENT

Hutabargot Project, photo by Krisma

Multiphase of quartz breccia with abundant manganese oxides

Form of Deposits

Courtesy of Rene I. Gonzales 2010

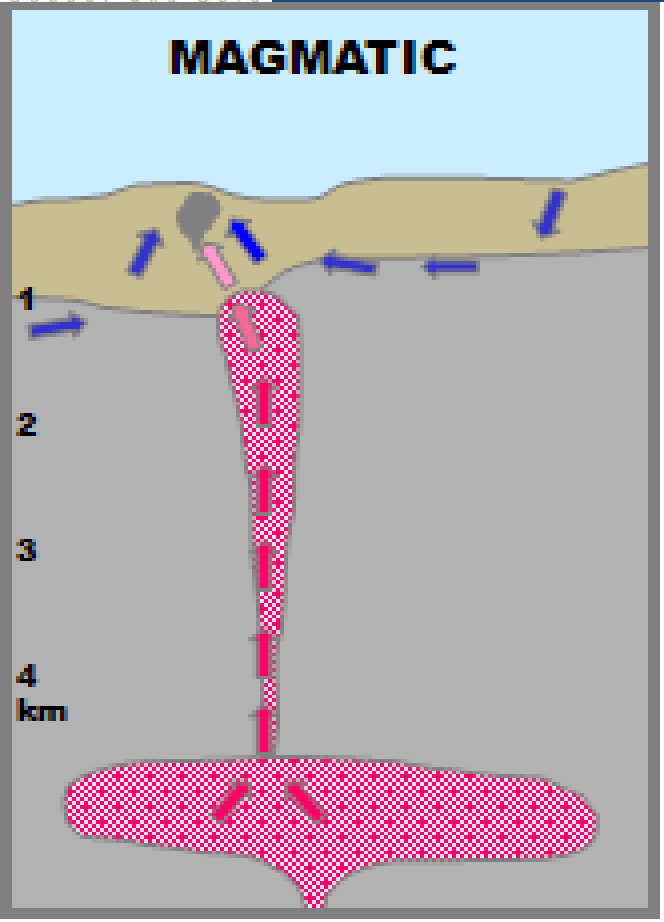
Au-Ag

Au-Ag-Zn-Pb

Au-Ag-Cu

Hydrothermal Fluids

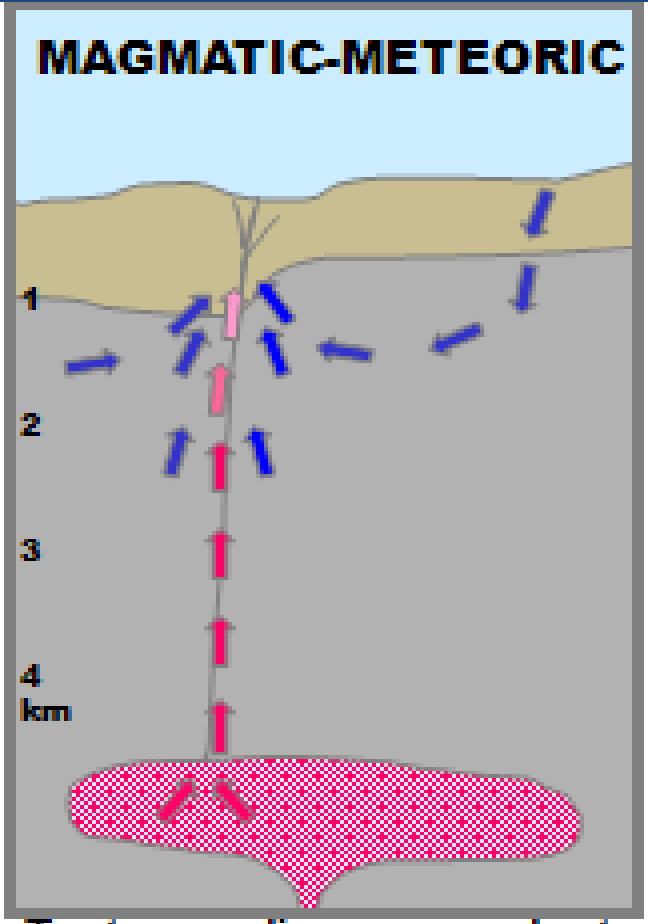
Courtesy of Noel. White 2009



Textures: restricted

HIGH SULFIDATION

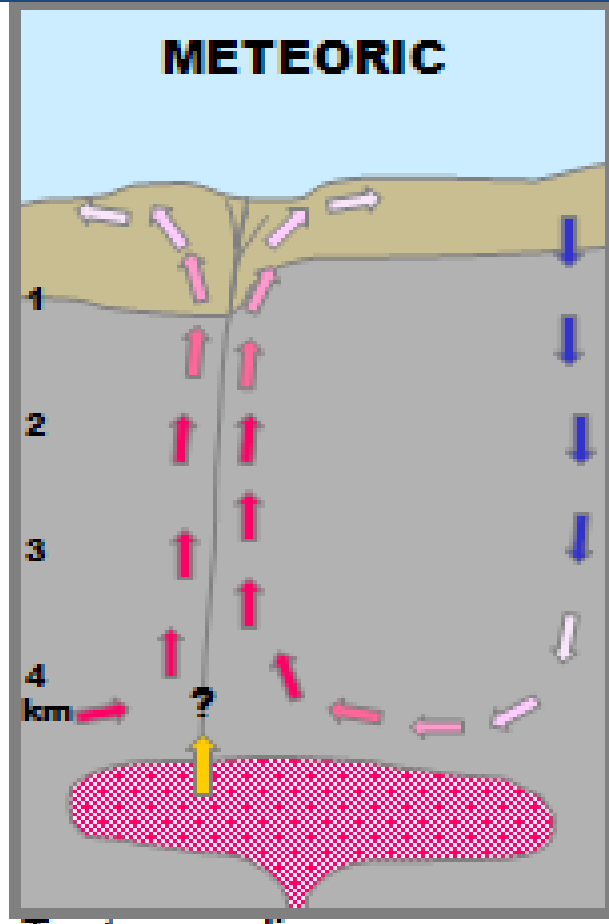
Au-Ag-Cu



Textures: diverse, modest

INTERMEDIATE SULFIDATION

Au-Ag-Zn-Pb



Textures: diverse, spectacular

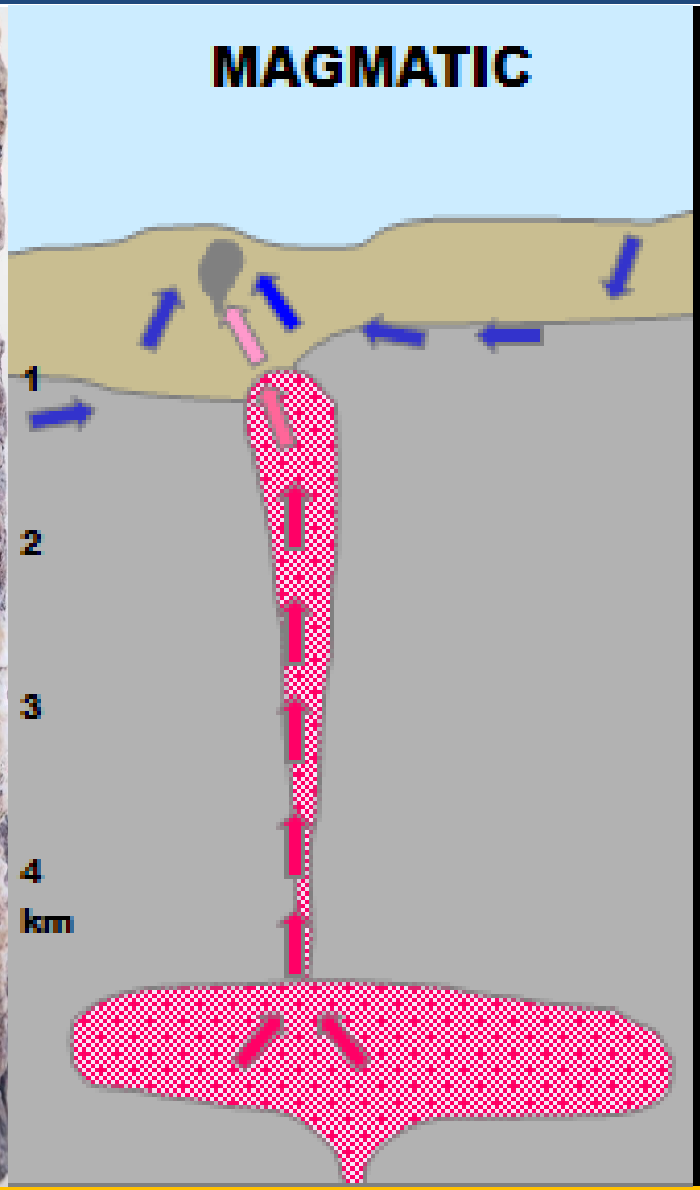
LOW SULFIDATION

Au-Ag

High Sulphidation Hydrothermal Fluids

Courtesy of Noel. White 2019

Tujuh Bukit, photo by Krisma



Characteristics

Fluids:

Magmatic dominant in core mixed with meteoric on margins

Metal Associations:

1 I-type: a) Au-Ag-Cu

b) Zn-Pb-Ag

2 S-type: Sn-Ag (Zn-Pb)

3 A-type: Au-Ag

Alteration:

1a, b and 2: proximal very acid

3 proximal not seen; distal neutral

Examples:

1a) Tujuh Bukit, Indonesia

1b) Cerro de Pasco, Pero

2 Cerro Rico de Potosi, Bolivia

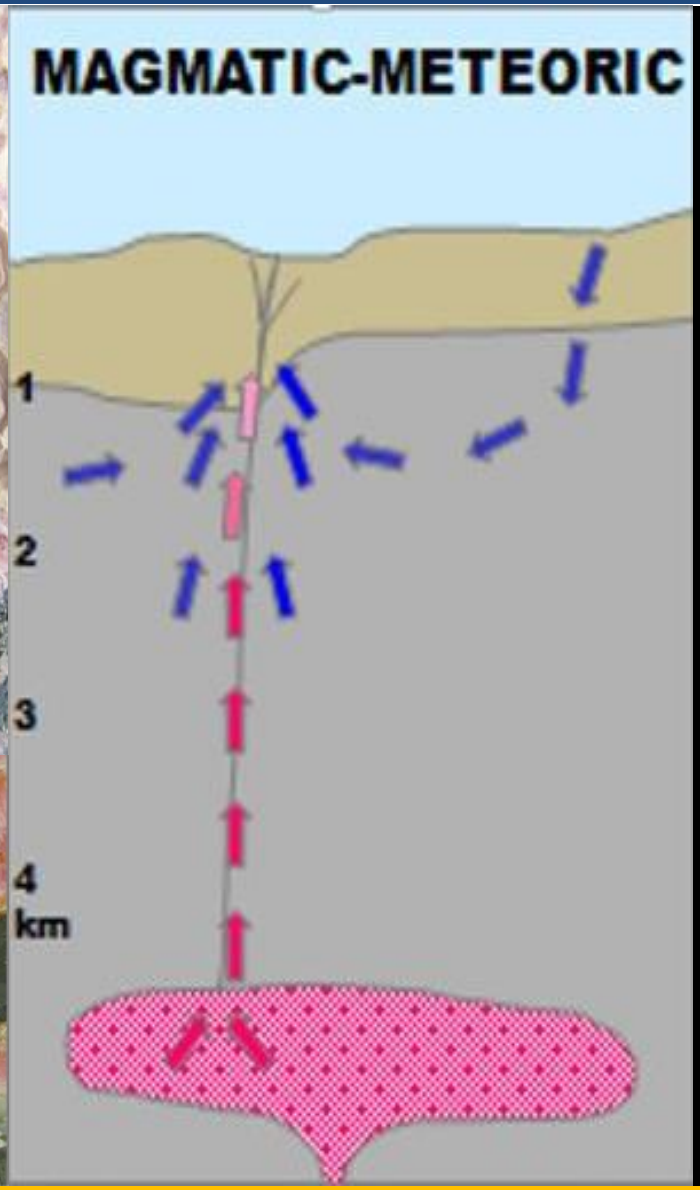
3 Porgera, PNG

Bedding of tuff and crystal lithic tuff with intense vuggy texture, silica alunite altered

Intermediate Sulphidation Hydrothermal Fluids

Courtesy of Noel. White 2019

Banded rhodocrosite with pyrite



Characteristics

Fluids:

Dominantly meteoric, with high salinity magmatic fluids at depth

Metal Associations:

Ag-Zn-Pb-(Au)

Ag-Zn-Pb-(Cu-Sn)

Alteration:

Mostly neutral pH

Examples:

Fresnillo, Mexico

Comstock, USA

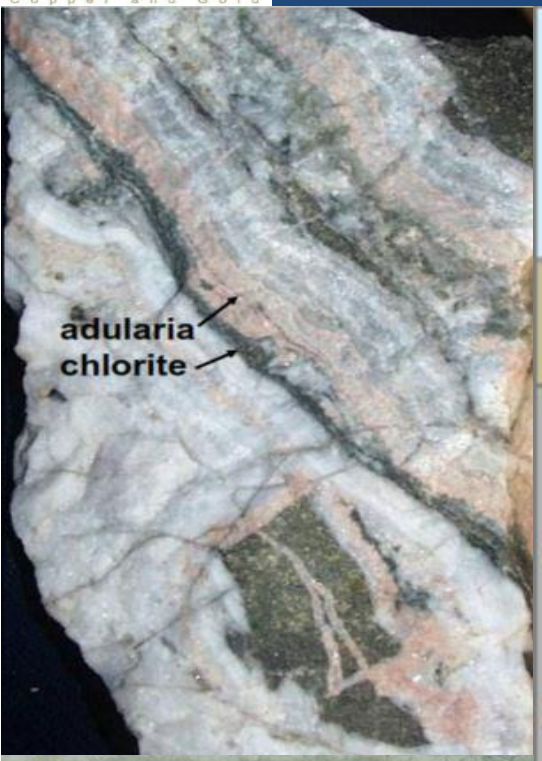
Acupan and Antamok, Philippines

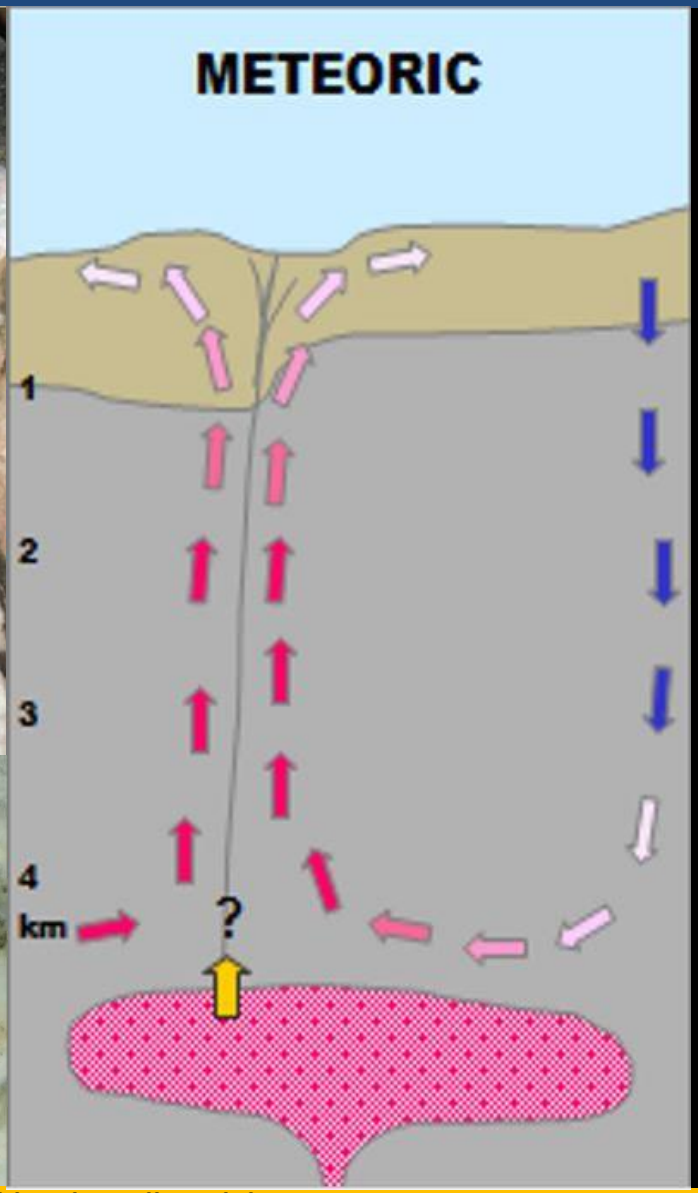
Cikotok, Indonesia

Aisasjur, Philippines

Low Sulphidation Hydrothermal Fluids

Courtesy of Noel. White 2019





Characteristics

Fluids:

Meteoric (± magmatic)

Metal Associations:

Au-Ag (very minor Zn, Pb)

Alteration:

Hypogene - neutral pH;

Gas condensates - acid

Examples:

McLaughlin, USA

Hishikari, Japan

Lebong Donok, Indonesia

Gunung Pongkor, Indonesia

Waihi, New Zealand

Diwalwal?, Philippines

High grade ore with visible banded gold and needles adularia

IJEN CRATER

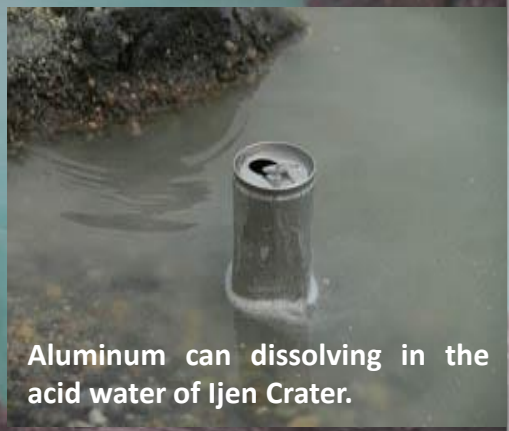
Photo: Ulet Ifansasti/Getty Images, 2009

Courtesy of Rene I. Gonzales 2010

World's Largest H_2SO_4 Crater Lake

Condensation of magmatic vapor + HCl + SO_2 generates acidic waters (pH ~1 or less):

Causes leaching of rocks (vuggy quartz), and hypogene advanced argillic alteration (alunite, kaolinite)



Aluminum can dissolving in the acid water of Ijen Crater.

Ijen Crater, East Java, Indonesia – 1 km wide & 200 m deep lake filled with a solution of H_2SO_4 & HCl with a pH of 0.5 & temperature of about 33°C.

SULPHUR MINE IN IJEN CRATER

Do we see high sulphidation deposits forming today ?

BLUE FIRE of IJEN CRATER

geological phenomenons due to the extremely high sulfur content at crater reacting with high pressure geothermal heat (oxidation process)

CHARACTERISTIC TEXTURES

Courtesy of Rene I. Gonzales 2010

Tujuh Bukit, photo by Krisma

Neutral-pH, meteoric Low-Sulfidation	Acid-pH, magmatic High-Sulfidation
banded veins	'vuggy quartz'
breccia veins	massive quartz
drusy cavities	massive sulfide veins
crustification	crudely banded veins
lattice texture	

Massive silica altered, intense vuggy textures, hematite-goethite oxides, locally cut by oxides veinlets (after sulphides?)

VUGGY TEXTURES

Samples from Pit B East

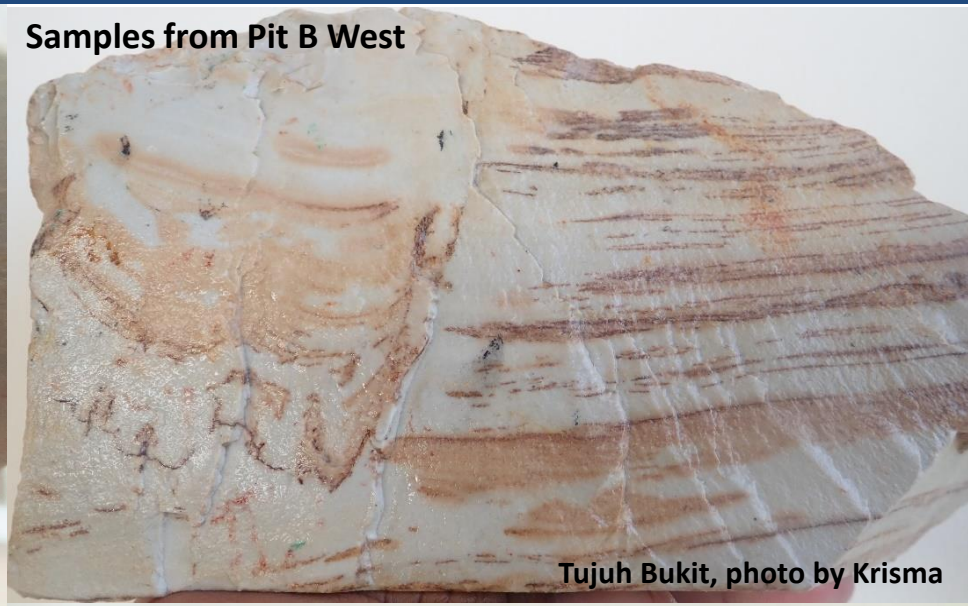
Tujuh Bukit, photo by Krisma

Samples from Pit A

Tujuh Bukit, photo by Krisma

Typically vuggy textures, if the host rock has phenocrists or clasts

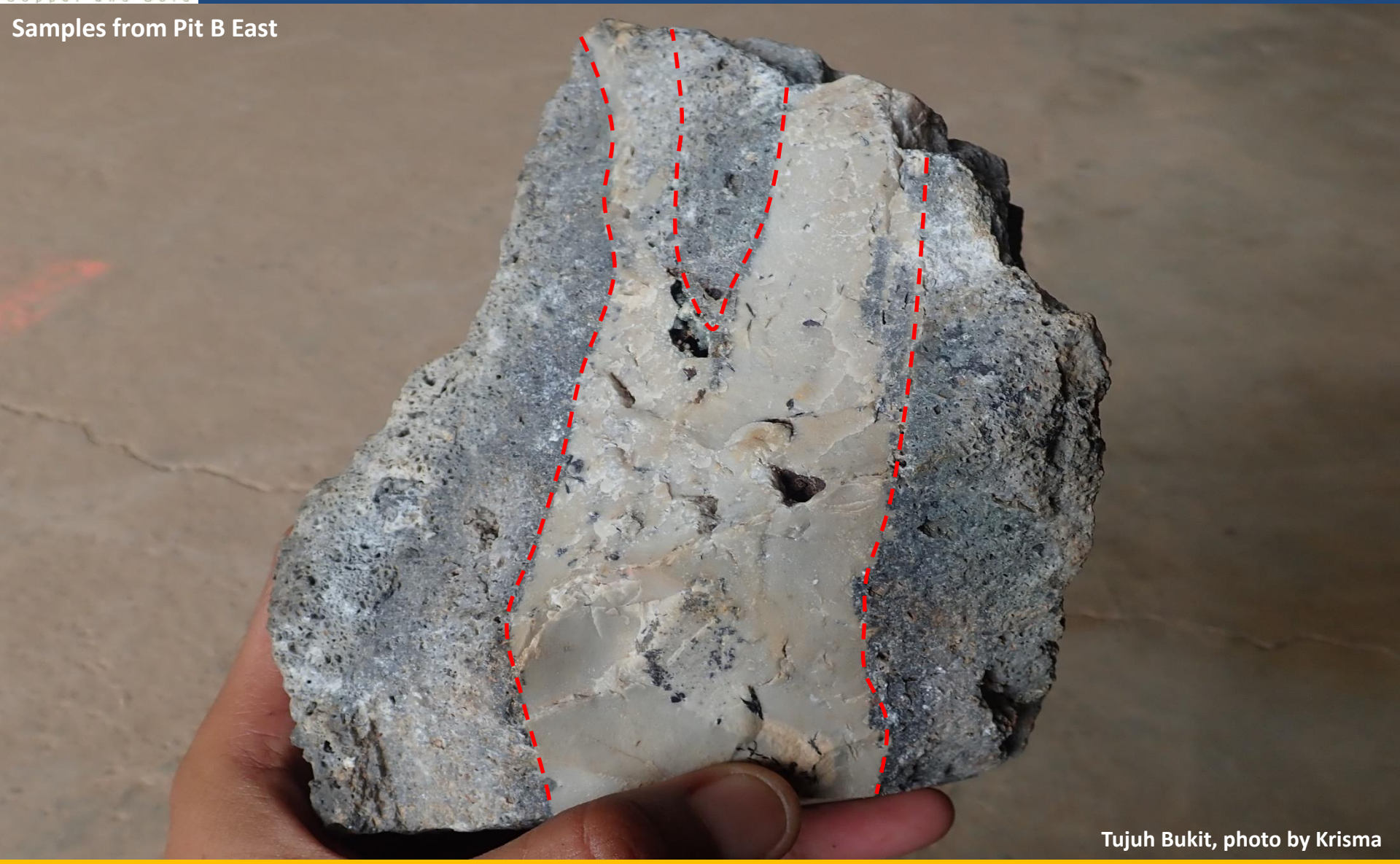
MASSIVE SILICA TEXTURES



Massive silica textures (not present of vuggy textures, depend of the host rock)

CRUDELY MASSIVE BANDED SILICA AND VUGGY TEXTURES

Samples from Pit B East



Tujuh Bukit, photo by Krisma

Silisic alteration of host rock and cross cutting by gray massive silica

MASSIVE ENARGITE TRANSFORM TO MALACHITE (COPPER OXIDES)

Samples from Pit B East

Tujuh Bukit, photo by Krisma

HYDROTHERMAL BRECCIA

Samples from Pit A, B East & B West

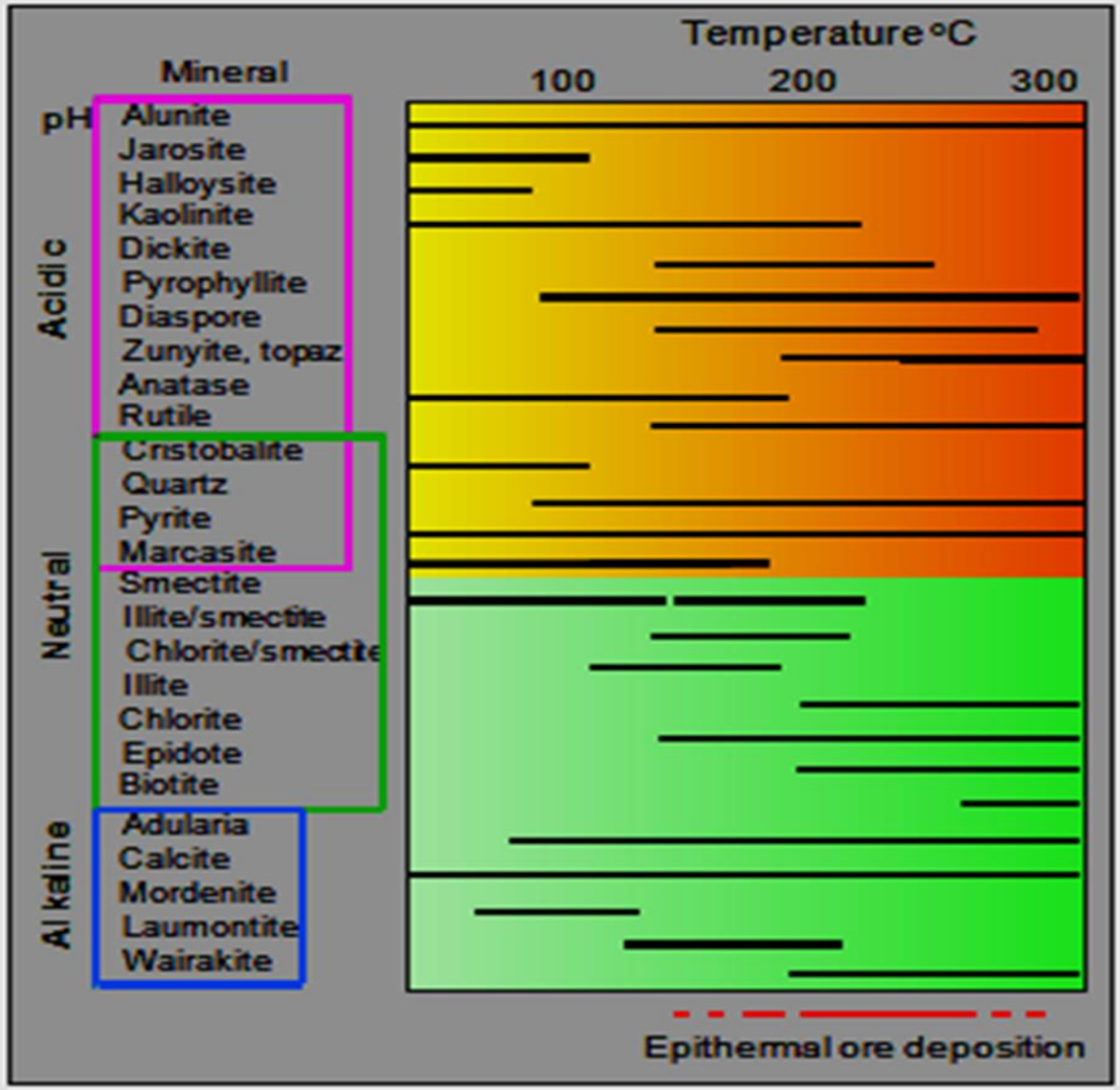
Tujuh Bukit, photo by Krisma

Tujuh Bukit, photo by Krisma

Vulcanic breccia intense vuggy textures cross cut by hydrothermal breccia as a second stage of mineralization

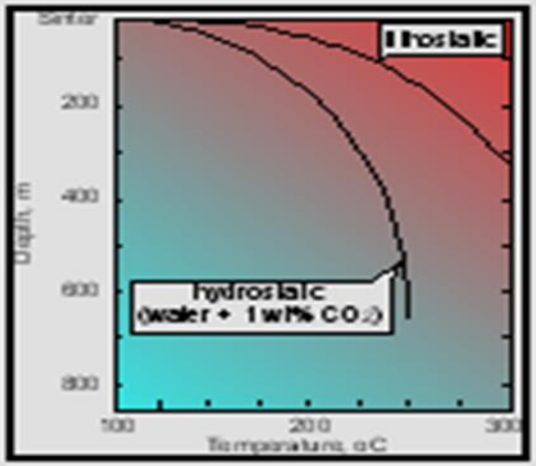
Epithermal Mineral Assemblages

Courtesy of Hedenquist 1998



Mineral Stability

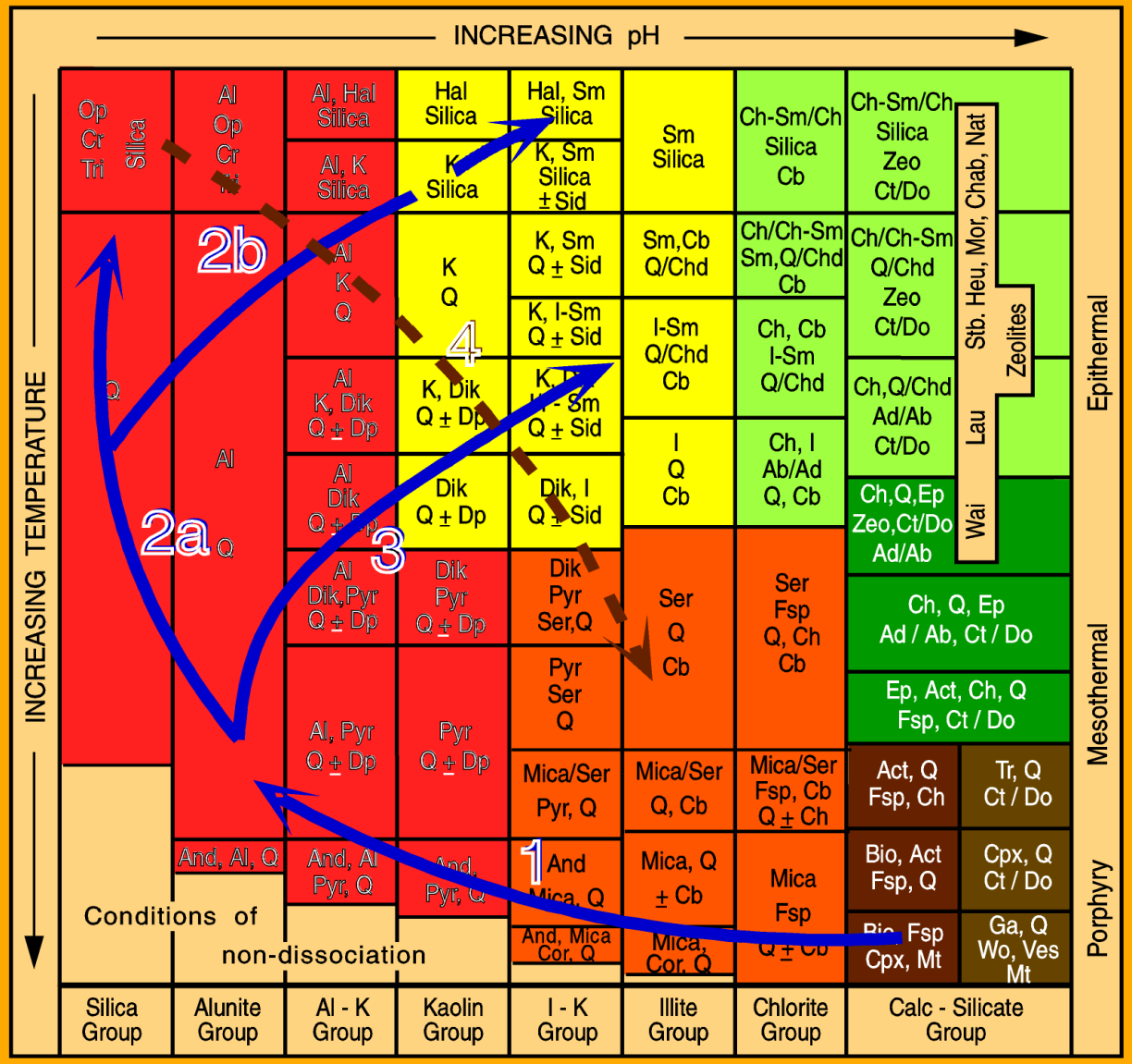
Mineral assemblages allow us to estimate temperature and acidity



Hedenquist et al., 1998
after Reyes, 1990

Mineralogy of High Sulphidation System

Courtesy of Corbett course 2007



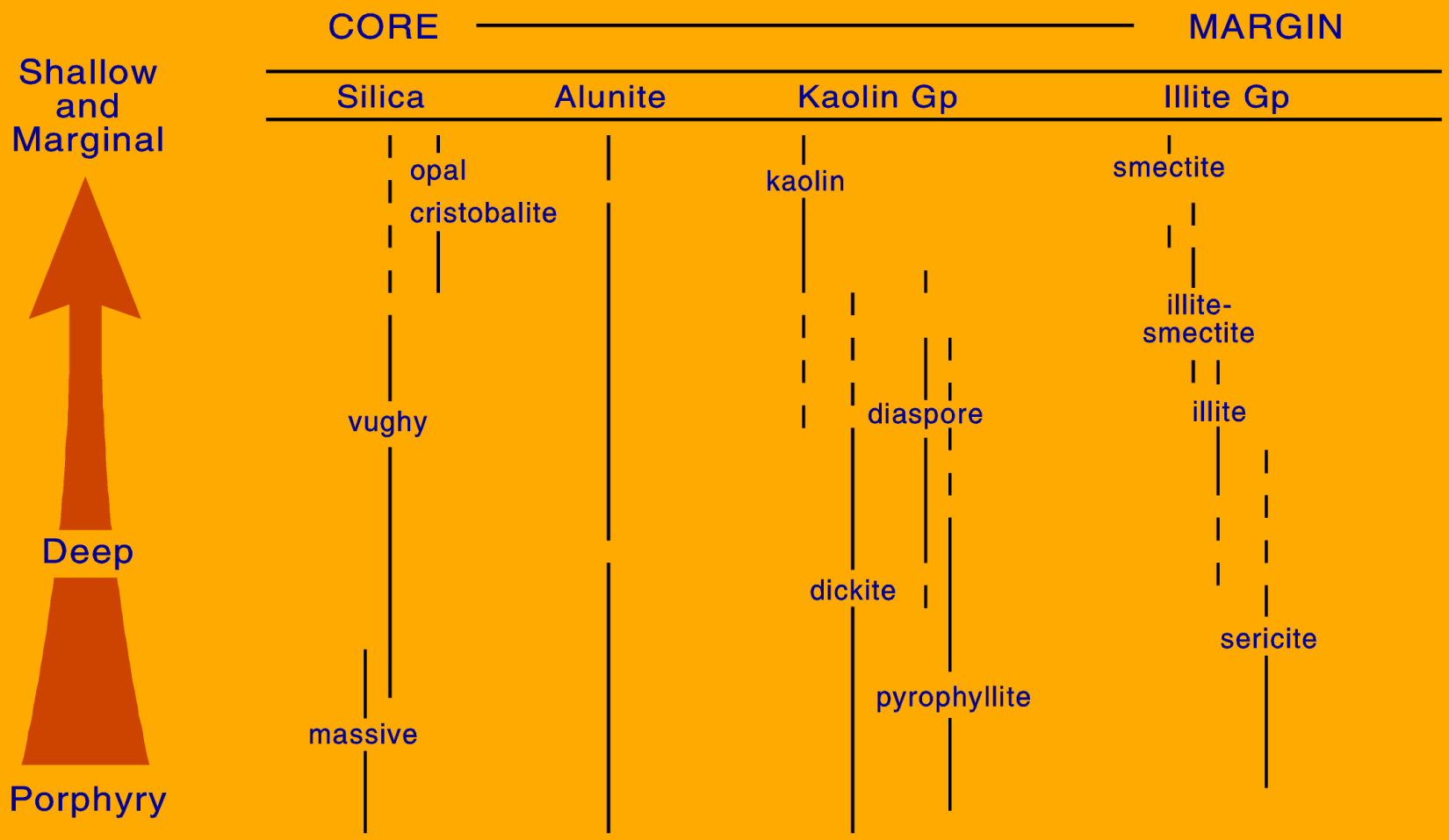
High Sulphidation Systems Alteration Mineralogy

1. Porphyry high sulphidation systems
2. Structural high sulphidation systems
   a. Silica core
   b. Peripheral zones
3. Lithological high sulphidation systems
4. Descending cool acid sulphate fluids

- Argillic
- Pottasic
- Adv. Argillic / Silissic
- Skarn
- Phyllic
- Inner / outer propylitic

High Sulphidation at Different Levels

Courtesy of Corbett course 2007



Magmatic Arc Au-Ag Mineralisation

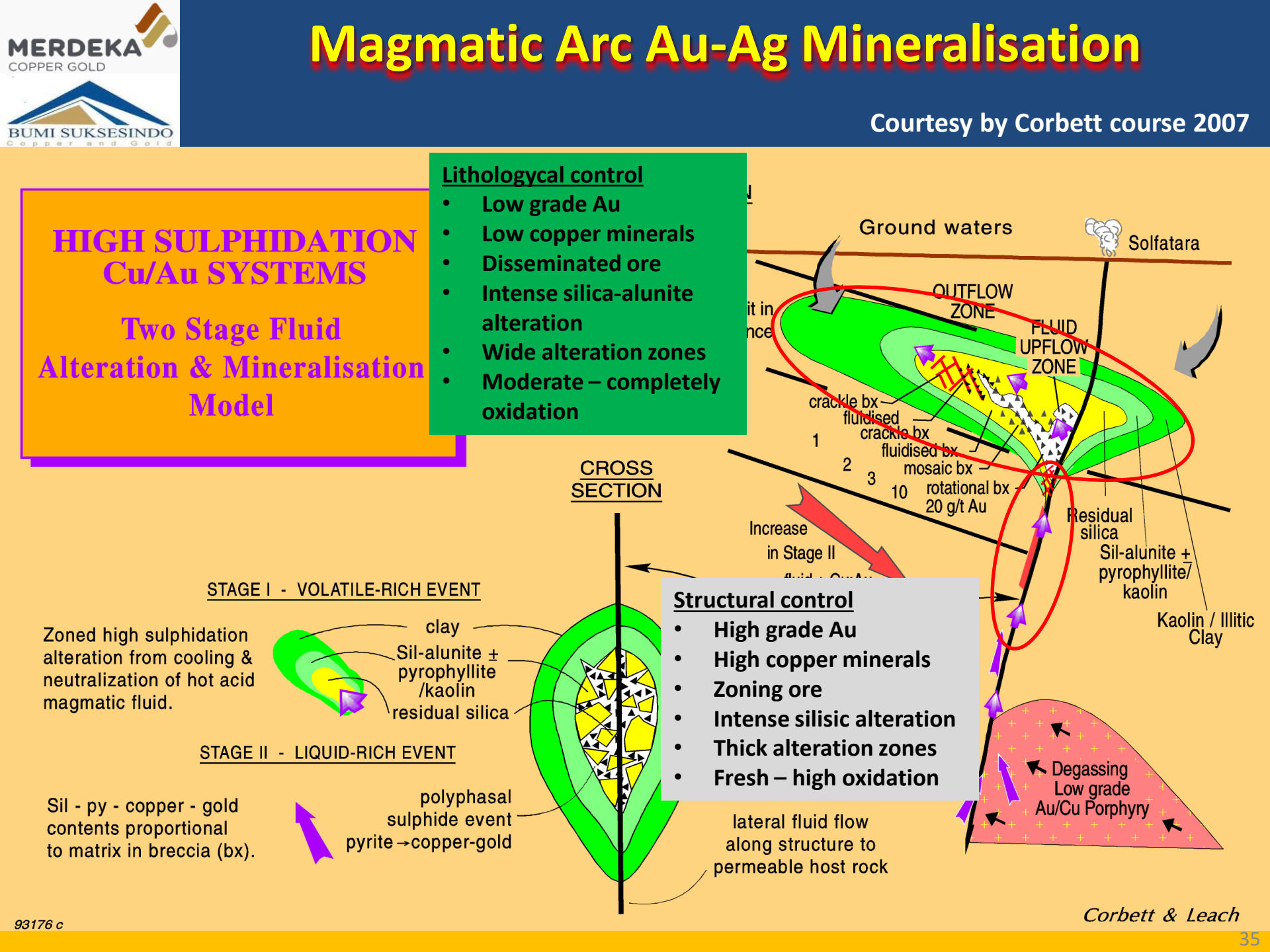
Courtesy by Corbett course 2007

HIGH SULPHIDATION Cu/Au SYSTEMS

Two Stage Fluid Alteration & Mineralisation Model

Lithologycal control

- Low grade Au
- Low copper minerals
- Disseminated ore
- Intense silica-alunite alteration
- Wide alteration zones
- Moderate – completely oxidation



Structural control

- High grade Au
- High copper minerals
- Zoning ore
- Intense silisic alteration
- Thick alteration zones
- Fresh – high oxidation

93176 c

Ore Minerals

Rossete of hexagonal crystal peacock covellite *CuS*

Samples from Pit B East

Tujuh Bukit, photo by Arya

Ore Minerals

Black monocline chalcocite *(Cu2S)* transform to be massive malachite *Cu(CO3) (OH)2*

Samples from Pit B East

Tujuh Bukit, photo by Krisma

Ore Minerals

Green massive malachite *Cu(CO3) (OH)2* formed by platy blue indigo covellite *(CuS)*

Samples from Pit B East

Tujuh Bukit, photo by Krisma

Ore Minerals

Disseminated of orthorhombic enargite *CuAsS4* on massive gray silica

Samples from Pit B East

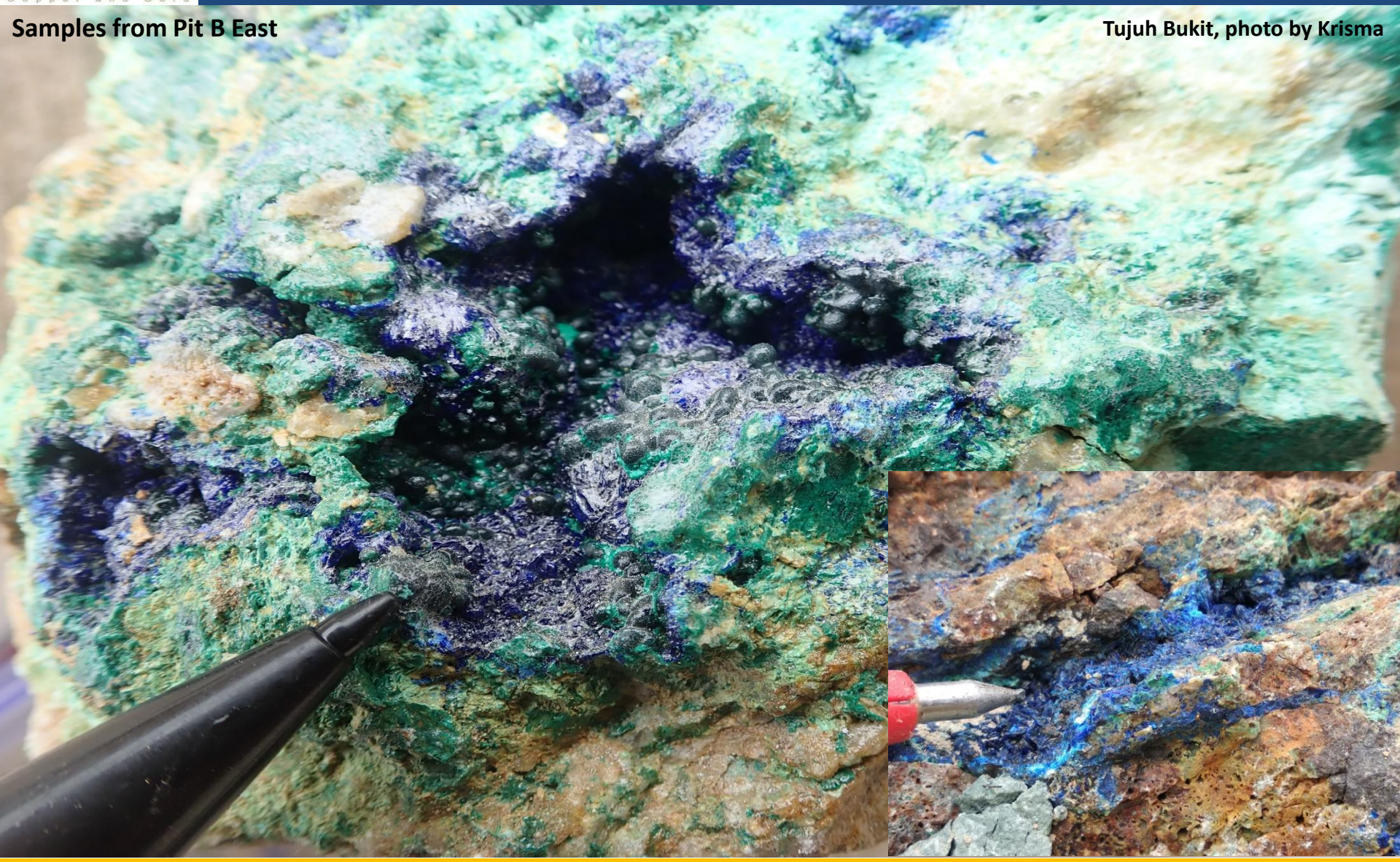
Tujuh Bukit, photo by Krisma

Ore Minerals

Blue azurite *Cu3(CO3)2 (OH)2* fill in vuggy and disseminated malachite *Cu(CO3) (OH)2*

Samples from Pit B East

Tujuh Bukit, photo by Krisma



Ore Minerals

Banding of hematite-limonite oxides (after sulphides?)

Samples from Pit A

Tujuh Bukit, photo by Krisma

Ore Minerals

Vuggy textures with intense –goethite- hematite-limonite oxides (after sulphides?)

Samples from Pit B West

Samples from Pit A

Ore Minerals

Botroydal textures of hematite-goethite oxides (after sulphides?)

Samples from Pit A

Tujuh Bukit, photo by Krisma

Samples from Pit B West

Tujuh Bukit, photo by Krisma

Ore Minerals

Oxides of lignocelluloce $C_6H_{10}O_5$ (branch wooden fossil)

Samples from Pit B West

Tujuh Bukit, photo by Krisma

Ore Minerals

Banded Sphalerite veinlets ZnS

Gangue Minerals

Massive orthorhombic sulphur S_8 fill in vuggy

Samples from Pit B East

Tujuh Bukit, photo by Krisma

Gangue Minerals

Bladed orthorhombic crystal of barite $BaSO_4$

Samples from Pit A

Tujuh Bukit, photo by Krisma

Gangue Minerals

Trigonal crystal quartz SiO_2 intergrowth in vuggy

Samples from Pit B East

Tujuh Bukit, photo by Krisma

Gangue Minerals

Disseminated cubic crystal of pyrite FeS_2

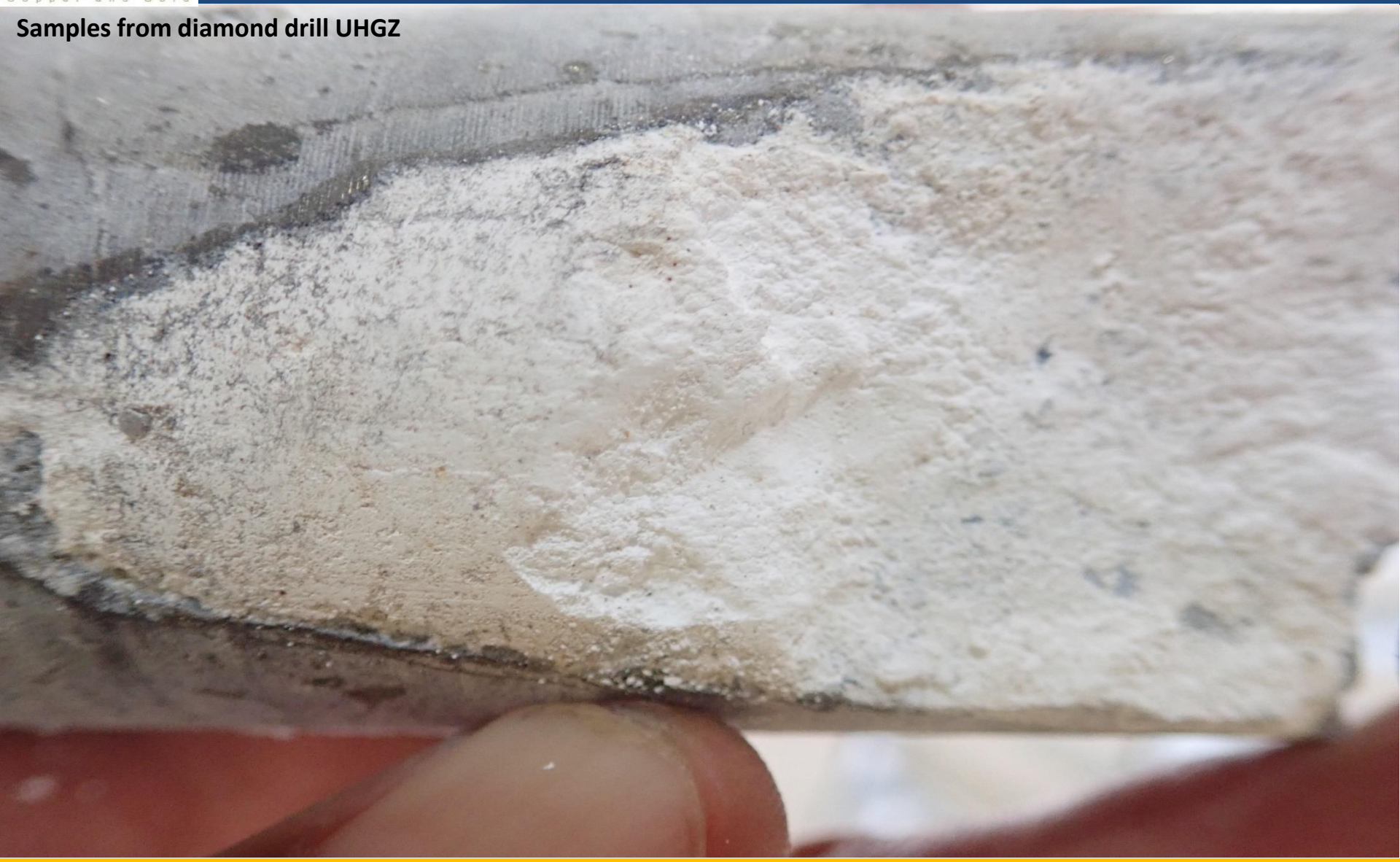
Samples from diamond drill UHGZ

Tujuh Bukit, photo by Krisma

Gangue Minerals

White powdery of dickite $Al_2(Si_2O_5)(OH)_4$

Samples from diamond drill UHGZ



Gangue Minerals

White soapy of veinlets pyrophilite $Al_2Si_4O_{10}(OH)_2$

Samples from diamond drill UHGZ

Tujuh Bukit, photo by Krisma

Gangue Minerals

Crystal isometric of zunyite ($Al_{13}Si_5O_{20}(OH,F)_{18}Cl$)

Samples from Pit B East

Tujuh Bukit, photo by Krisma

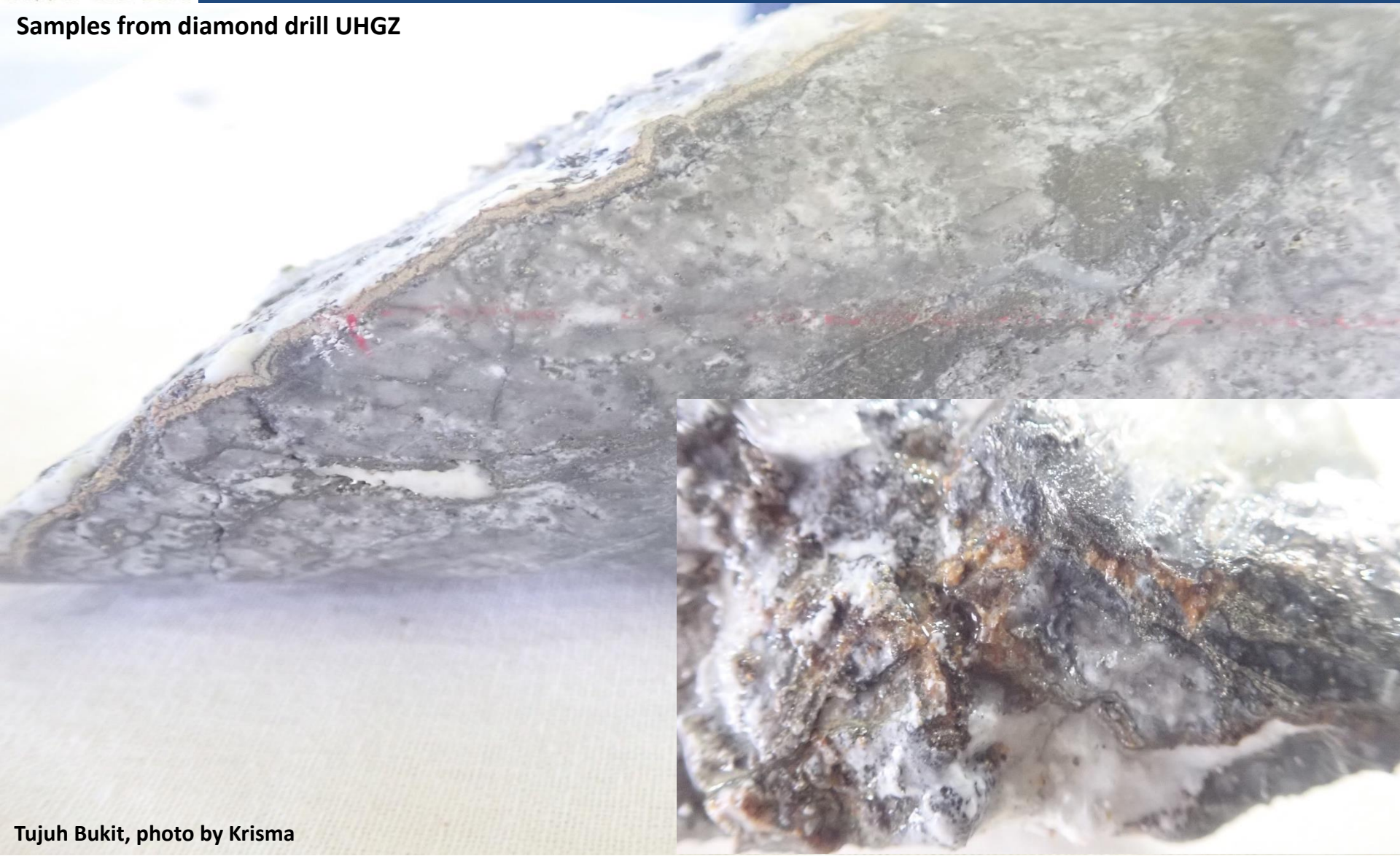
Samples from diamond drill UHGZ

Tujuh Bukit, photo by Krisma

Gangue Minerals

Pale brown of stringer tourmaline

Samples from diamond drill UHGZ



Tujuh Bukit, photo by Krisma

Gangue Minerals

Pinkies of massive sparkling hypogene alunite (Na-Alunite)

Samples from diamond drill UHGZ

Tujuh Bukit, photo by Krisma

Gangue Minerals

Bladed crystal of supergene alunite $KAl_3(SO_4)_2(OH)_6$

Samples from Pit B East

Tujuh Bukit, photo by Krisma

Gangue Minerals

Yellowish green jarosite KFe3+3(SO4)2(OH)6

Samples from Pit A

Samples from Pit B East

Tujuh Bukit, photo by Krisma

Tujuh Bukit, photo by Krisma

Gangue Minerals

Massive kaolinite

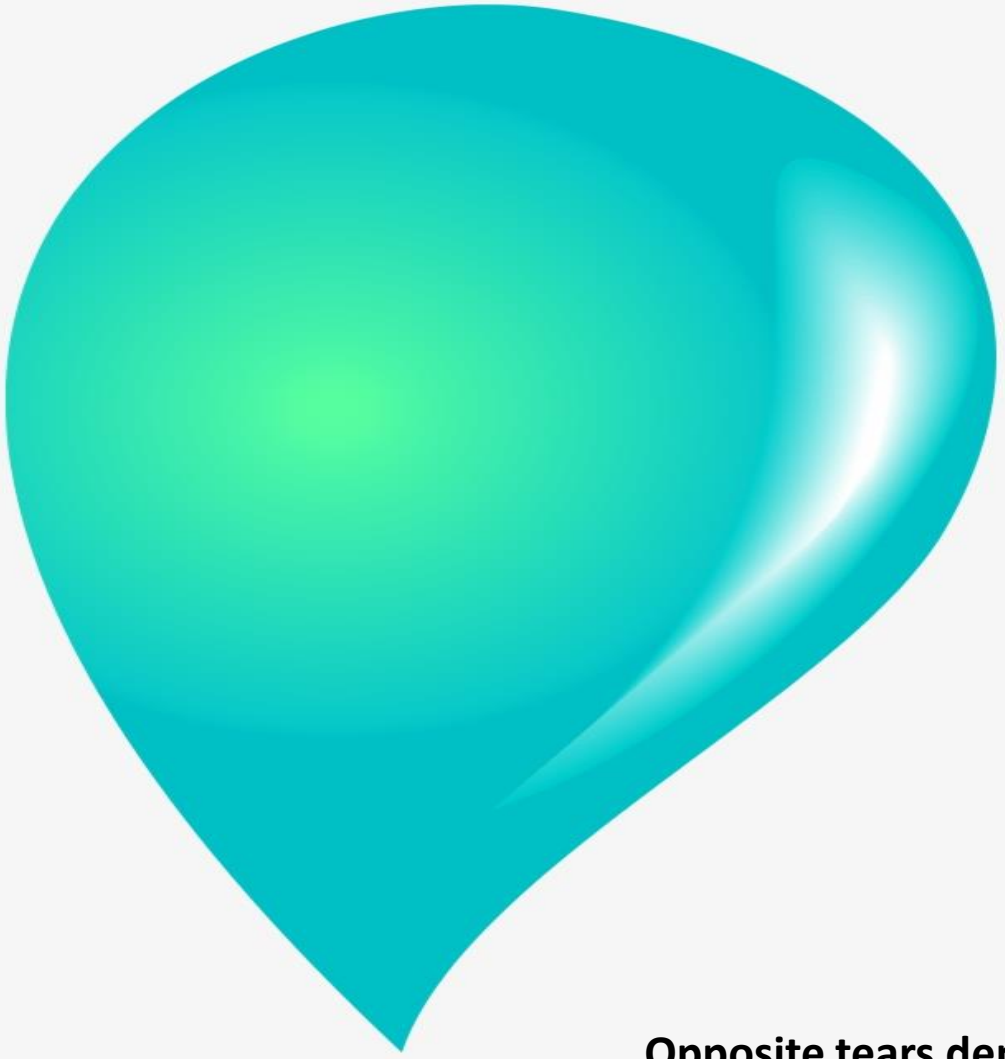
Samples from Pit B West

Tujuh Bukit, photo by Krisma

Alteration Facies of High Sulphidation

Courtesy of Mirasol Recources LTD

Alteration Facies



Opposite tears deposite

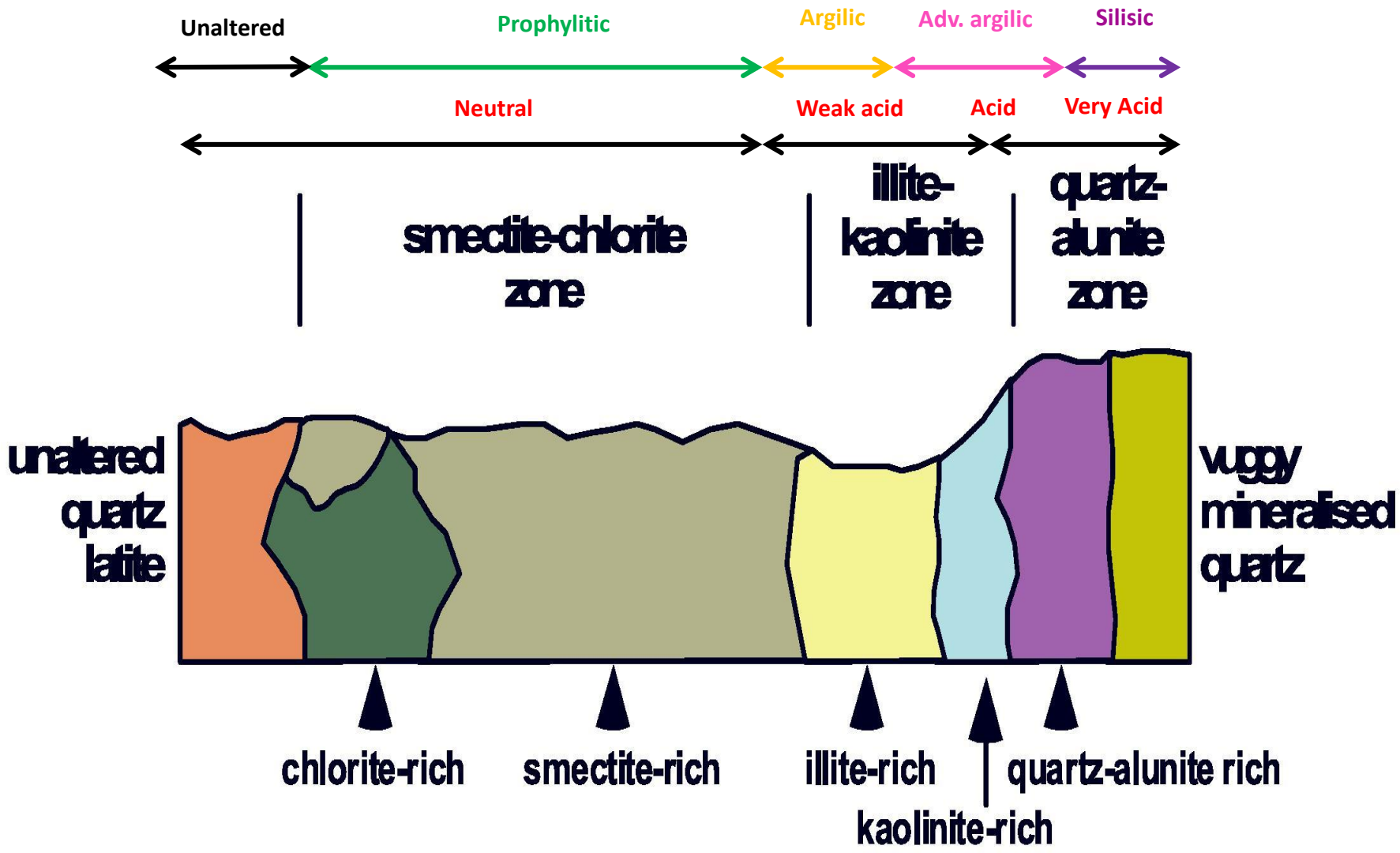
Gold Distribution

Alteration Mineral Assemblage

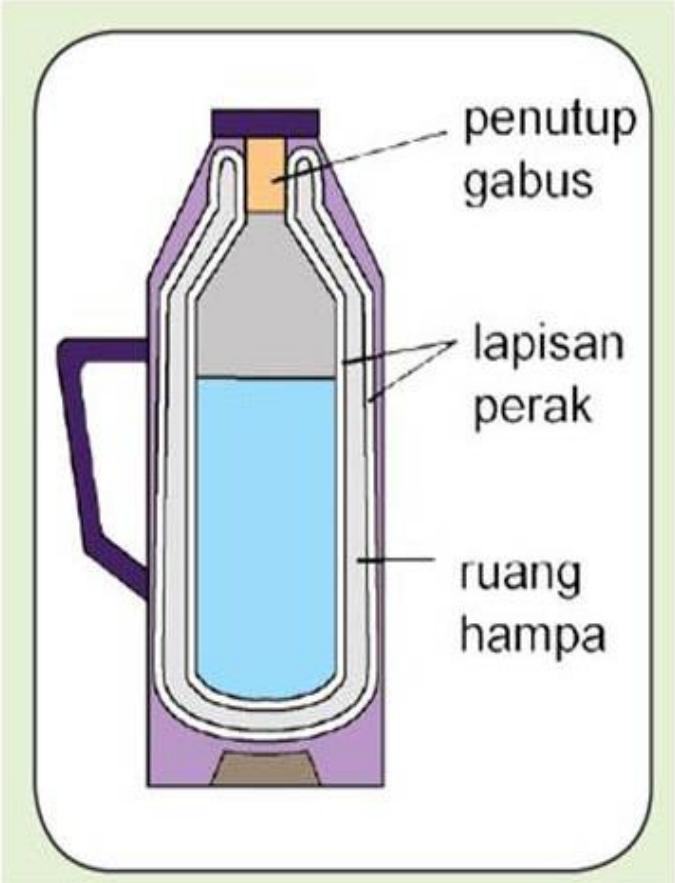
Carrot deposite

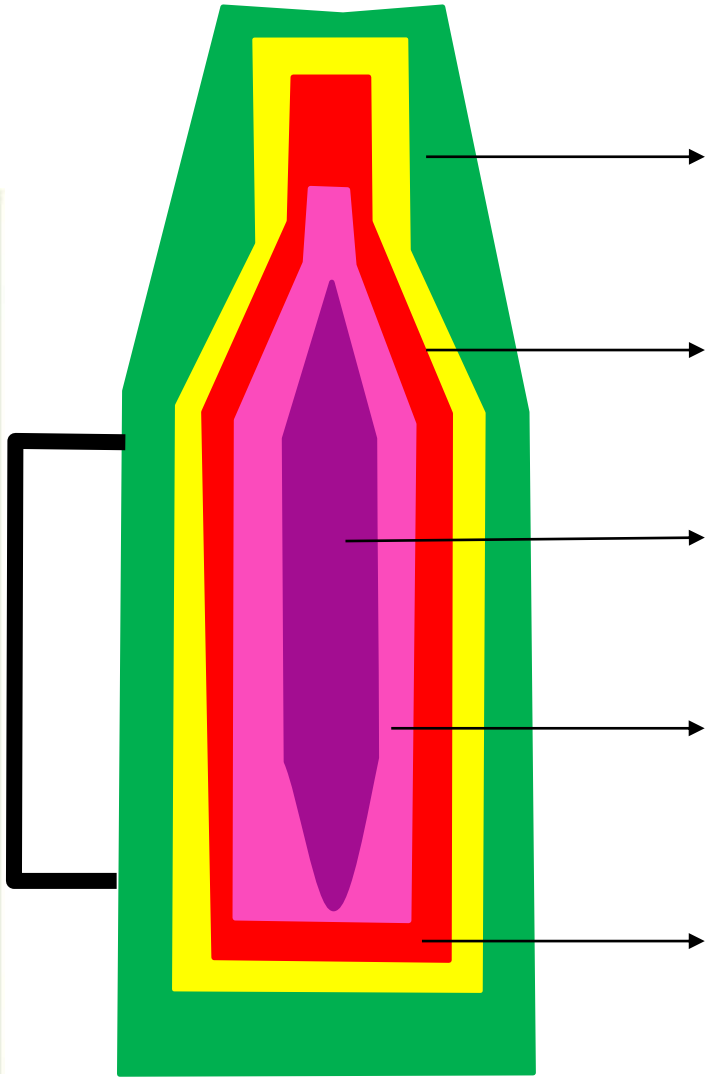
Alteration Facies of High Sulphidation

Courtesy of Rene I. Gonzales 2010



HOT WATER THERMOS vs HYDROTHERMAL ALTERATION





Wadah termos dari plastik (chlorite-cy alteration)

Dinding logam termos (clay alteration)

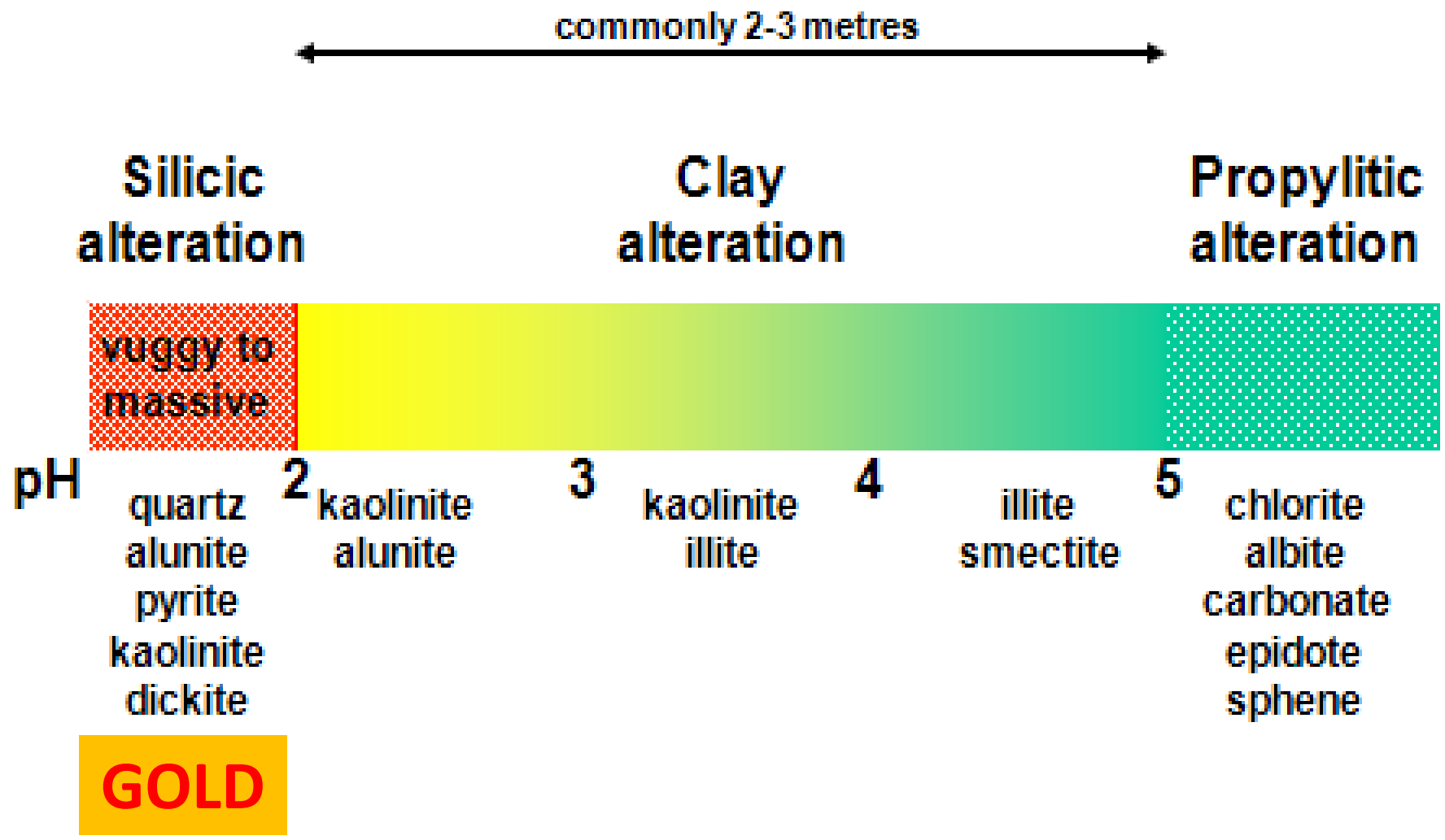
Air panas dalam termos (silica alteration)

Dinding dalam kaca termos (Silica-alunite alteration)

Dinding luar kaca termos (Sil-cy / cy-sil alteration)

Alteration Zoning
Nansatsu type – high sulphidation epithermal deposits

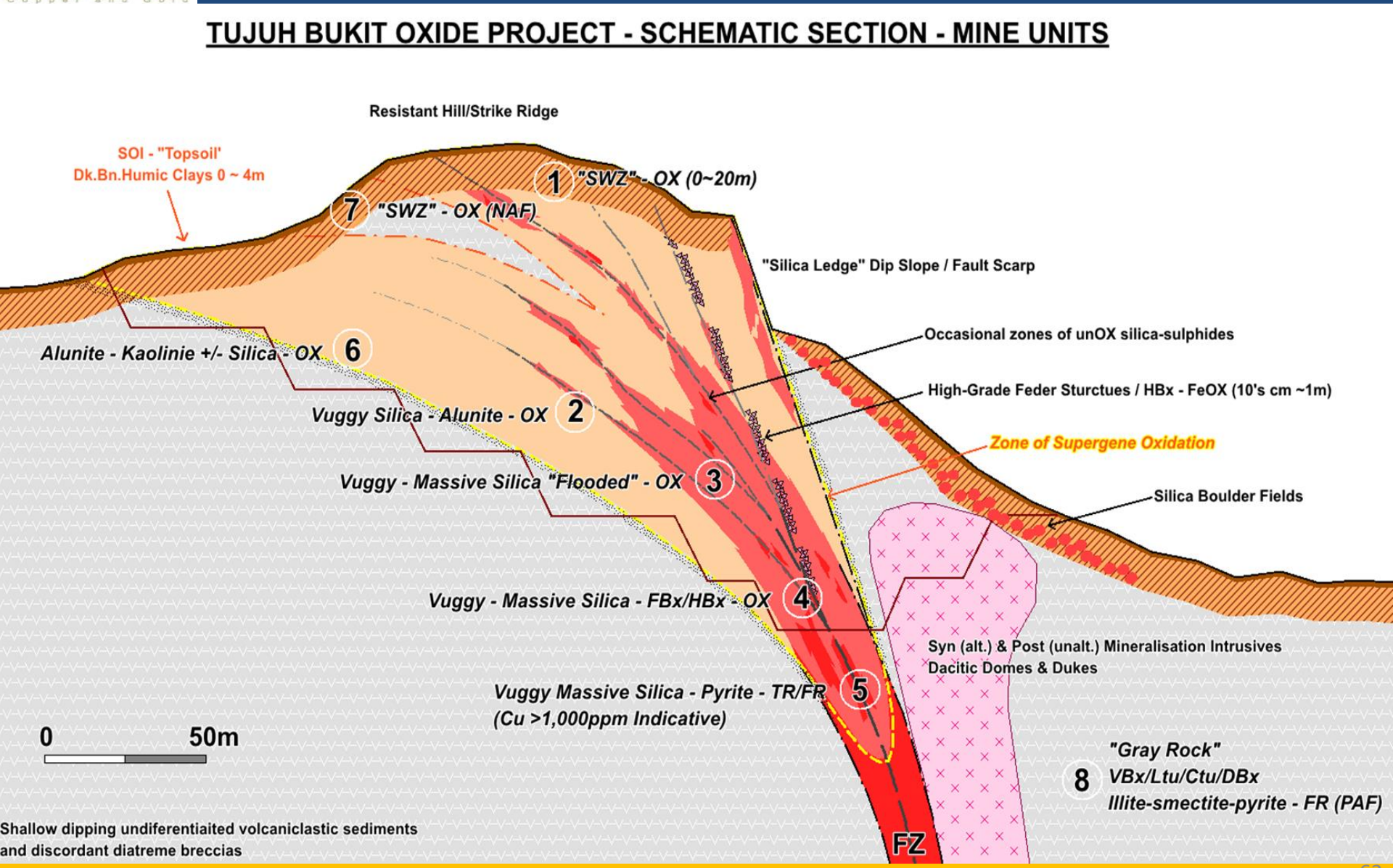
Courtesy of Rene I. Gonzales 2010



White, 1990

Schematic Section of Tujuh Bukit High Sulphidation

Courtesy of Julian Bartlett 2015



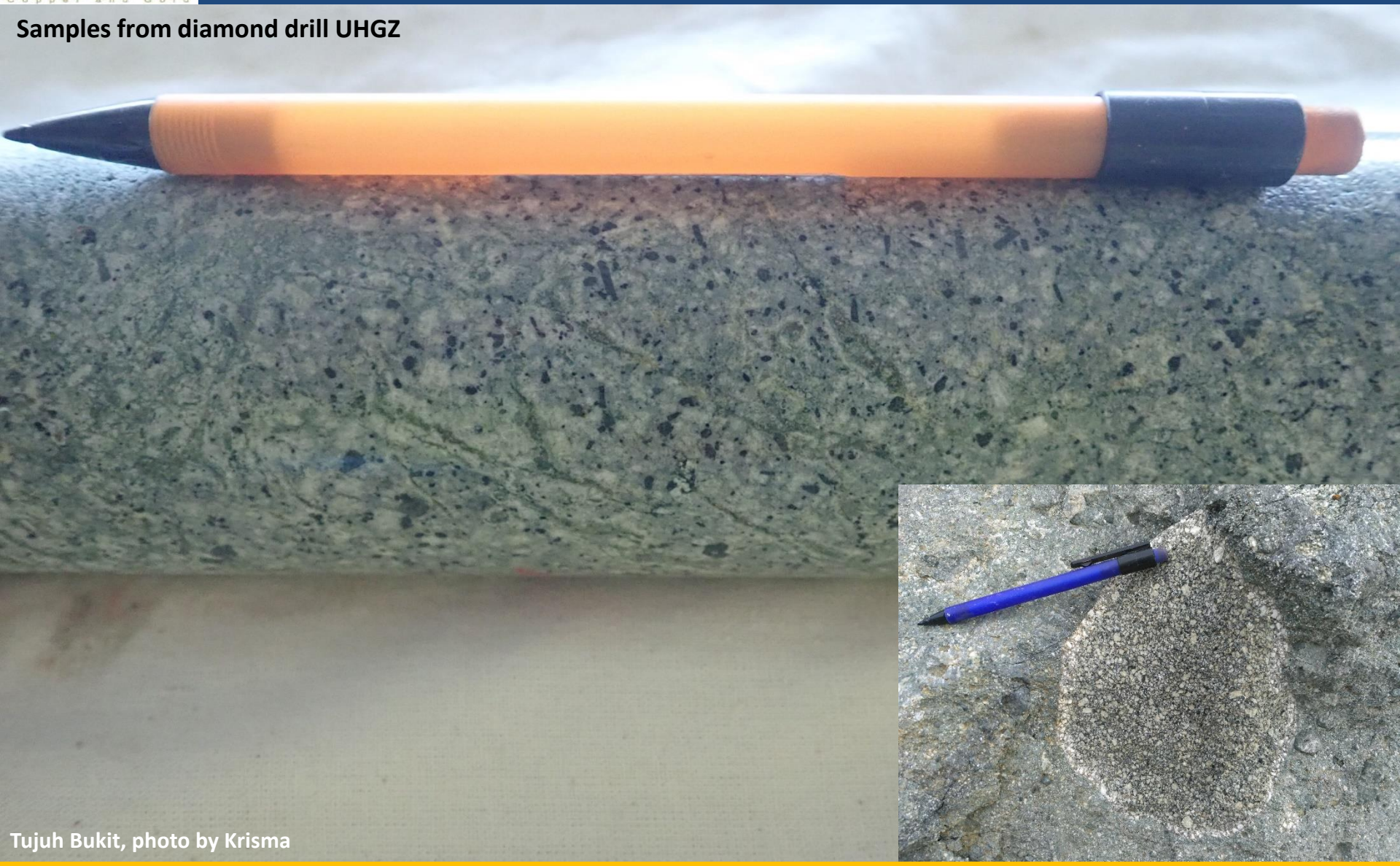
Dyke Diorite? – Clay altered
Oldest alteration? in Tujuh Bukit Project

Final wall in Pit E

Tujuh Bukit, photo by Krisma

Phase 1st of Hydrothermal Alteration
Clay – chlorite - calcite ± pyrite altered
Distal zones, neutral pH of hydrothermal fluids

Samples from diamond drill UHGZ



Tujuh Bukit, photo by Krisma

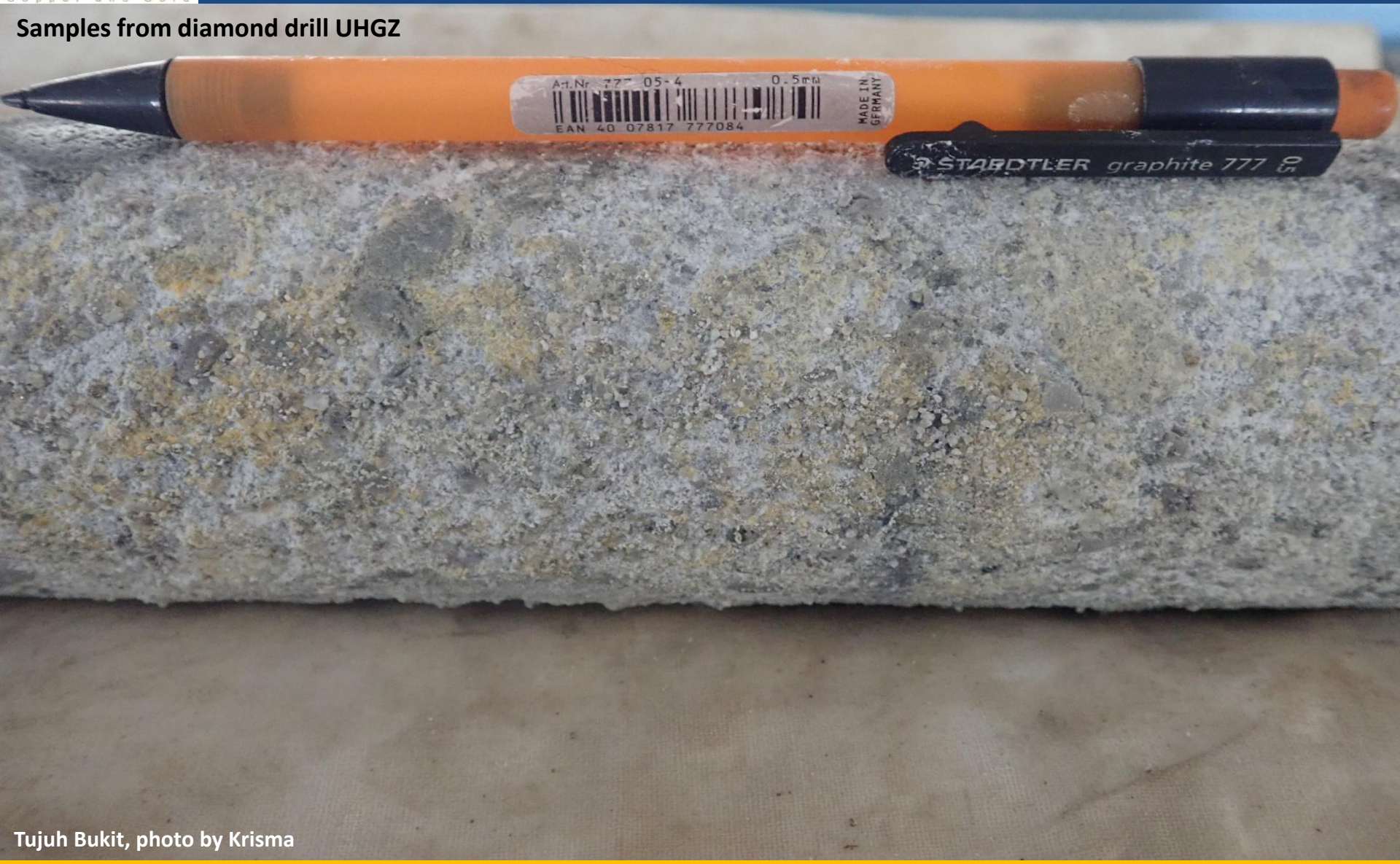
Phase 1st of Hydrothermal Alteration
Clay (illite?) ± pyrite altered
Distal to medial zone, weak acid hydrothermal fluids

Samples from diamond drill UHGZ

Tujuh Bukit, photo by Krisma

Phase 1st of Hydrothermal Alteration
Clay – silica – alunite ± pyrite alteration
Medial to proximal zones, acid hydrothermal fluids

Samples from diamond drill UHGZ



Tujuh Bukit, photo by Krisma

Phase 1st of Hydrothermal Alteration
Silica – alunite – pyrophylite – dickite ± chalcocite altered
Proximal zones, acid hydrothermal fluids

Samples from diamond drill UHGZ

Spotted black chalcocite

Abundant of white pinkies
hypogene alunite

Tujuh Bukit, photo by Krisma

Phase 1st of Hydrothermal Alteration
Massive silica with wormy textures of pyrophyllite ± pyrite altered
Proximal zones, acid hydrothermal fluids

Samples from diamond drill UHGZ

Wormy / gossano textures :

- Gusano texture is increasingly reported from HS deposits in South America
- Gusano consists of pyrophyllite, diaspore and alunite in a siliceous matrix forming a patchy or wormy texture
- It can occur at the base of the vuggy quartz alteration zone as transition to underlying altered rocks
- It is also reported to occur at any level in some deposits
- Its origin is obscure

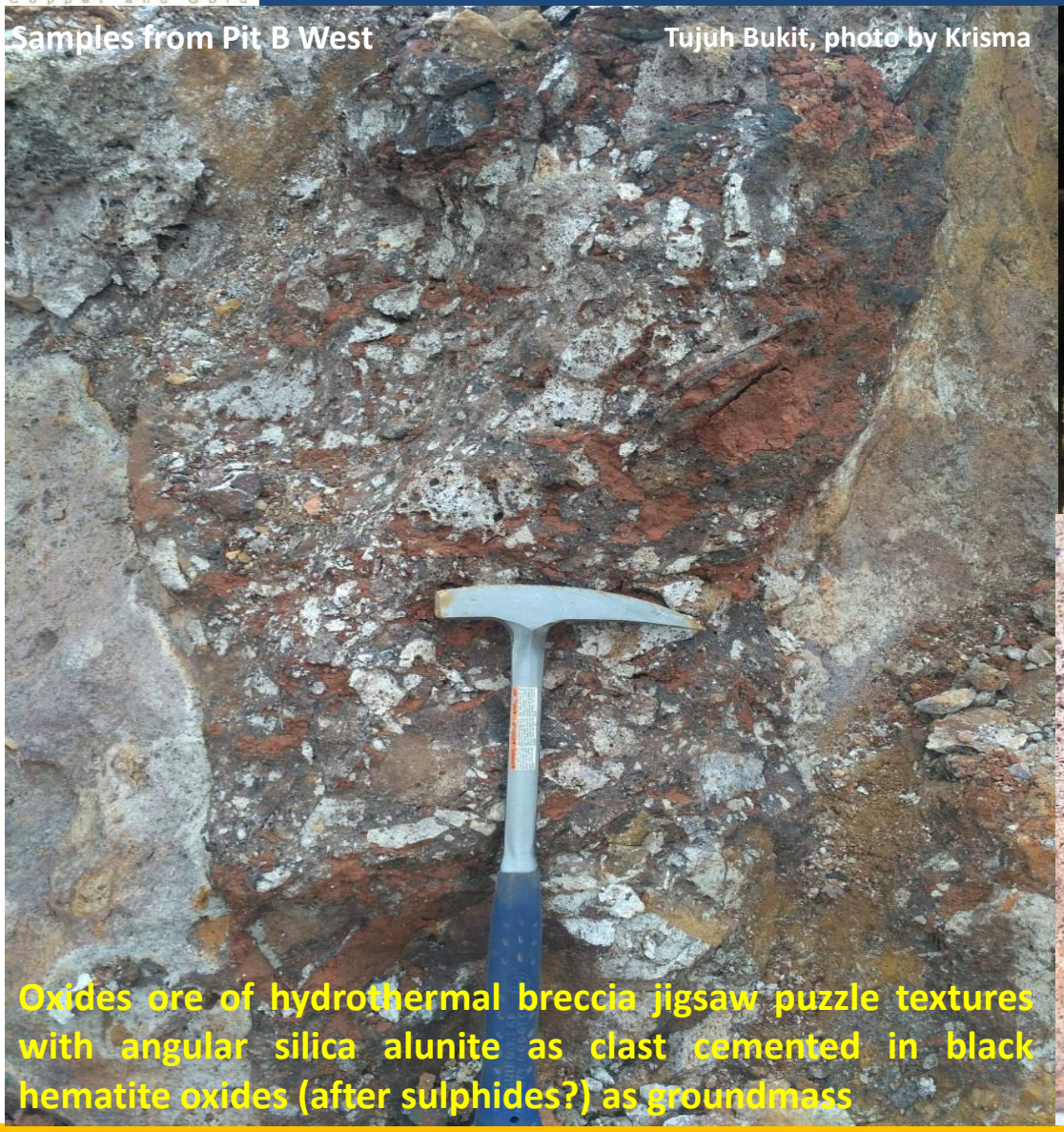
Tujuh Bukit, photo by Krisma

Phase 1st of Hydrothermal Alteration
Massive silica, vuggy textures with disseminated pyrite ± dickite
Central zone, acid hydrothermal fluids

Samples from diamond drill UHGZ

Tujuh Bukit, photo by Krisma

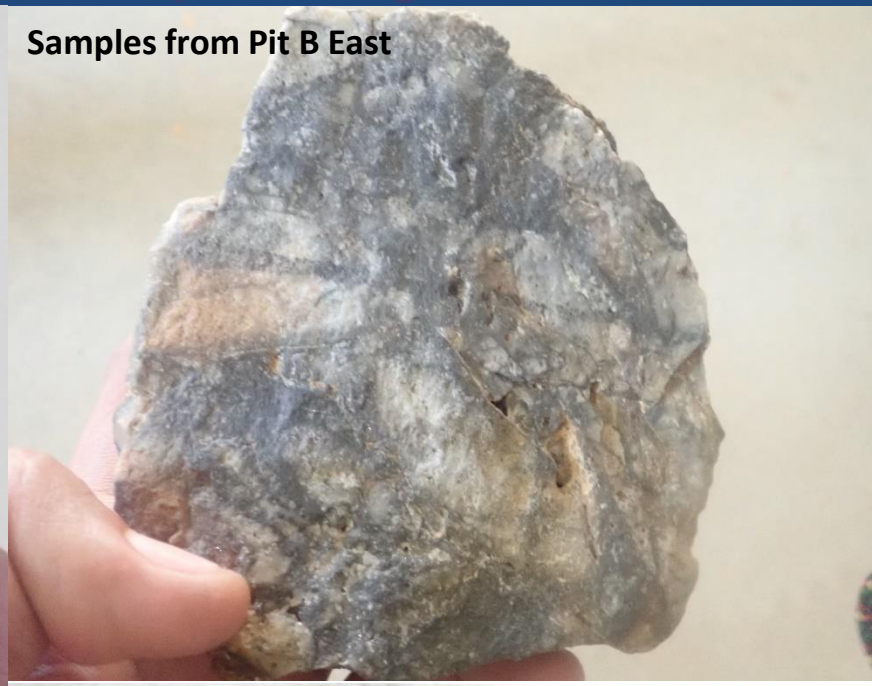
Phase 2nd of Hydrothermal Alteration
Breccia hydrothermal jigsaw puzzle textures with angular host rock as clast cemented in sulphides as groundmass



Oxides ore of hydrothermal breccia jigsaw puzzle textures with angular silica alunite as clast cemented in black hematite oxides (after sulphides?) as groundmass

Phase 2nd of Hydrothermal Alteration
Breccia hydrothermal jigsaw puzzle textures with angular host rock as clast cemented in sulphides as groundmass

Transition ore of hydrothermal breccia jigsaw puzzle textures with angular massive silica as clast cemented in young massive silica with abundant pyrite as groundmass



Tujuh Bukit, photo by Krisma

Alteration Facies of High Sulphidation At Tujuh Bukit Project

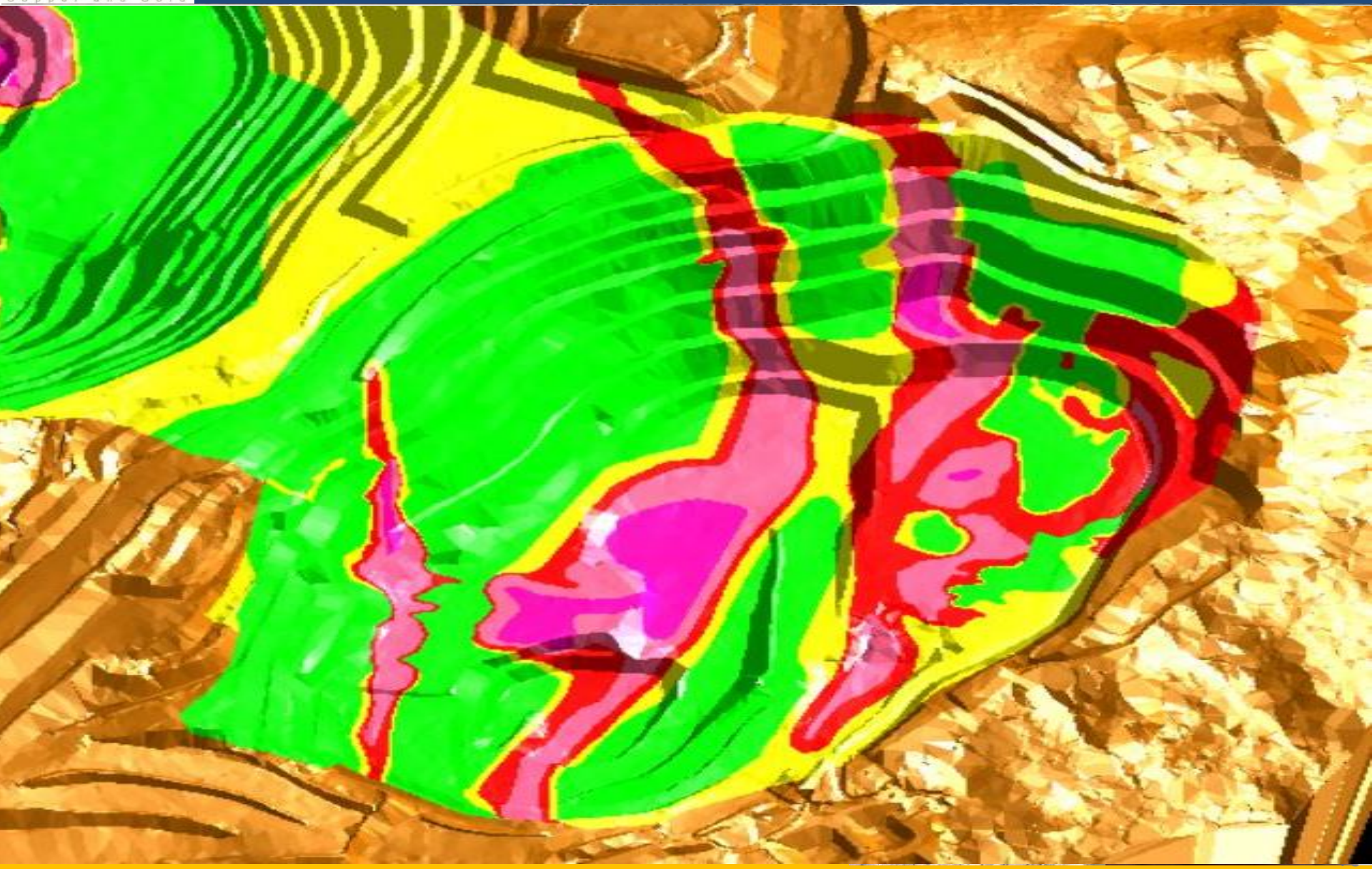
South Wall of Pit B West

Tujuh Bukit, photo by Krisma

MERDEKA COPPER GOLD

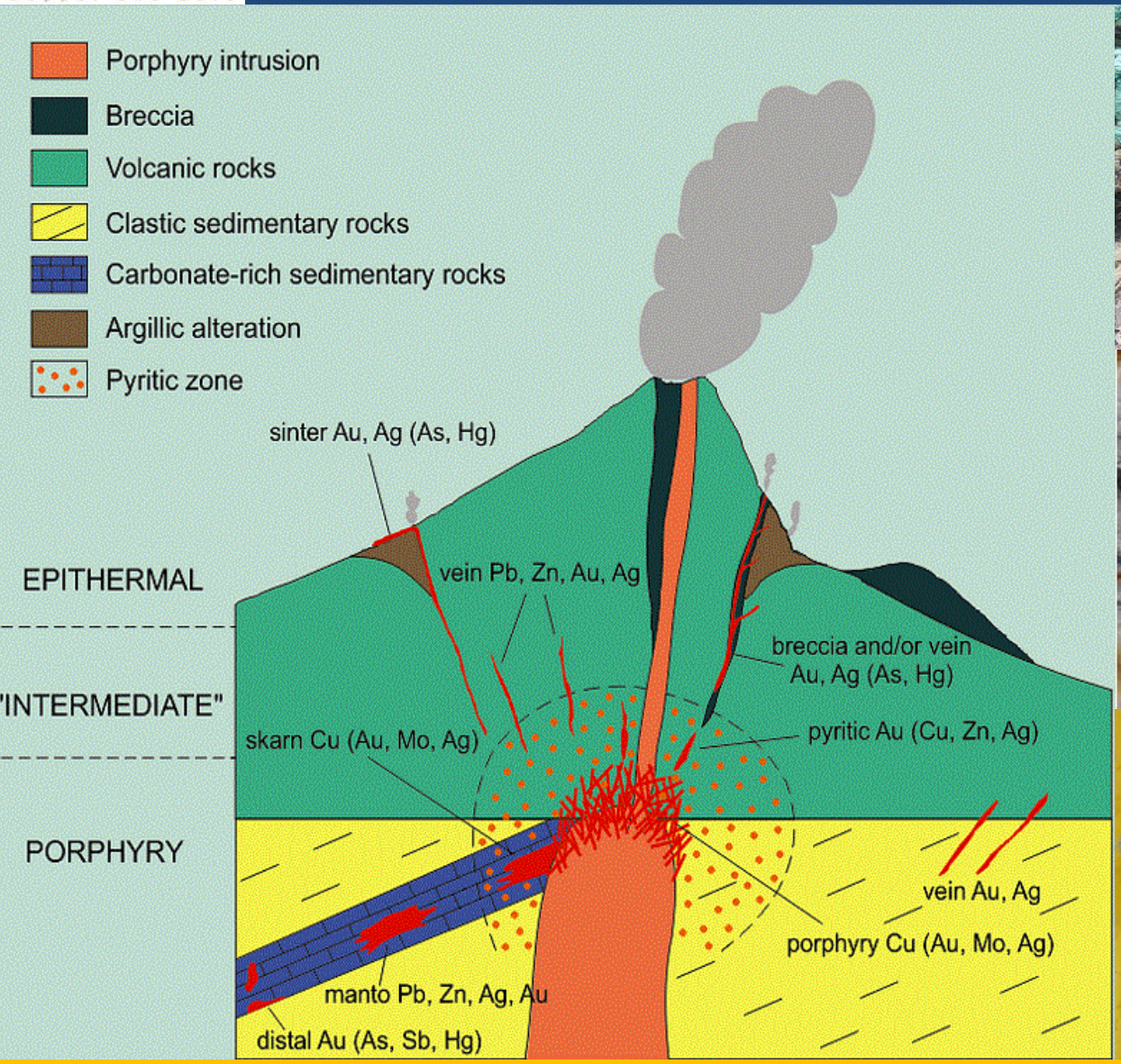
BUMI SUKSESINDO Copper and Gold

PARAGENESIS OF EPITHERMAL HIGH SULPHIDATION IN THE TUJUH BUKIT PROJECT



Sinclair's Porphyry to Epithermal Model Associated with Dacitic-Andesitic Stratovolcano

Courtesy of Rene I. Gonzales 2010



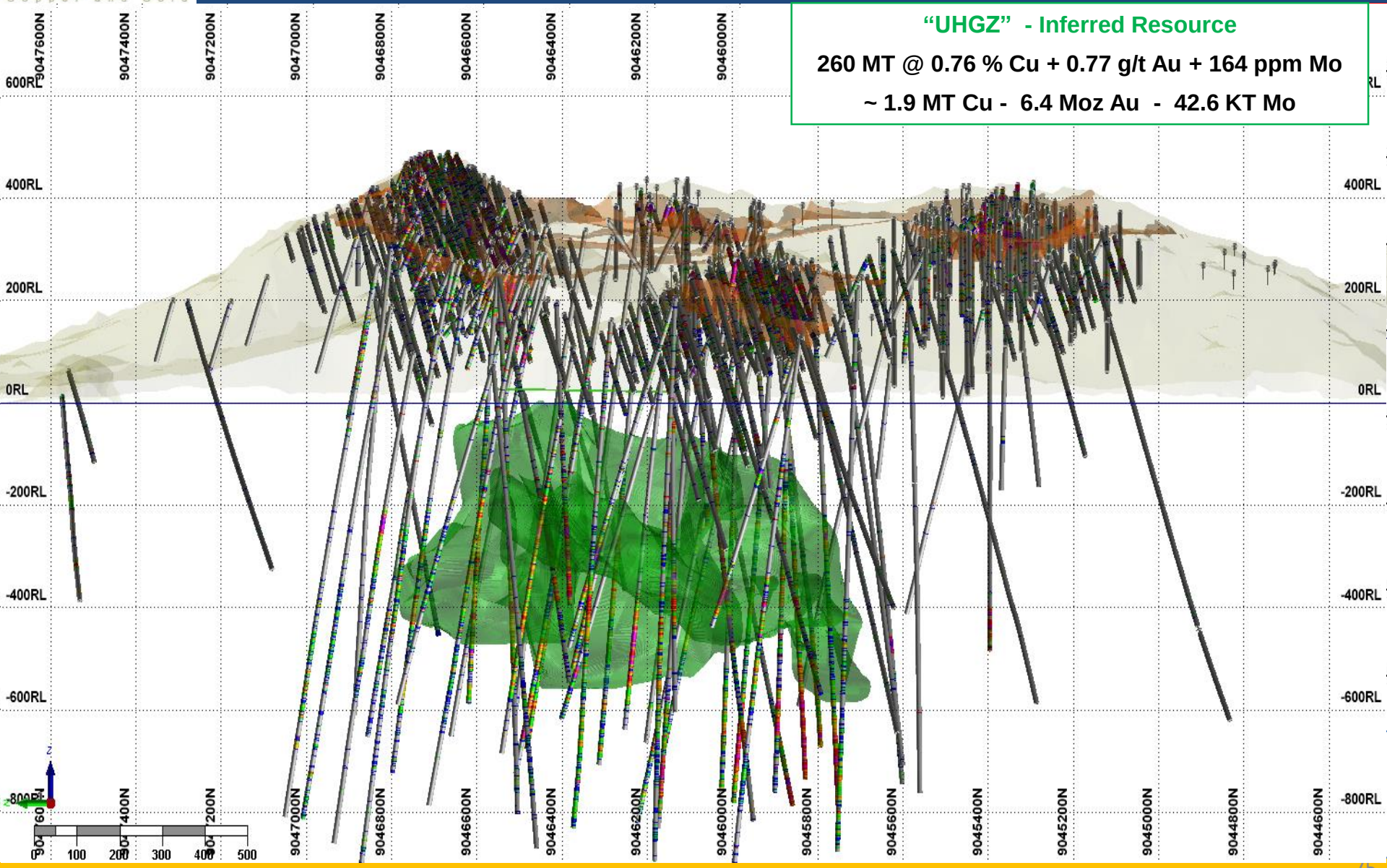
Pit B East, photo by Krisma

Pulau Merah, photo from Julian Bartlett

UHGZ Core, photo from Julian Bartlett

DECLINE UNDERGROUND PROJECT FOR DETAIL EXPLORATION

Courtesy of Julian Bartlett 2016



CORESCAN SPECIFICATIONS

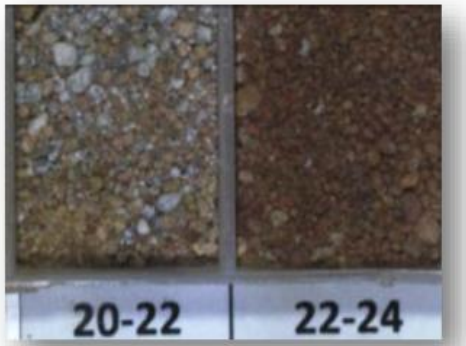
Courtesy of Corescan 2018

Corescan Scanning Specifications:

- Photographic core images at 0.05mm pixel size (50 micron)
- Hyperspectral images at 0.5mm pixel size (500 micron)
- Spectral range of 450nm to 2500nm @ 4nm resolution
- 510 channels covering the visible - near infra red - short wave infra red region
- 3D core profiler @ 0.015mm (15 micron) height resolution
- Configurable core box dimensions up to 1.5 m core row length
- High throughput – up to 500m per day

CORESCAN MEASURES AND LOGGING ALL TYPE of ROCK SAMPLES

Courtesy of Corescan 2018



Chips/Cuttings

Blast Hole Samples

Hand Samples

Met Samples

Whole Core

Split/Cut Core

CORE PHOTOGRAPHY

Courtesy of Corescan 2018

3D – LASER PROFILER

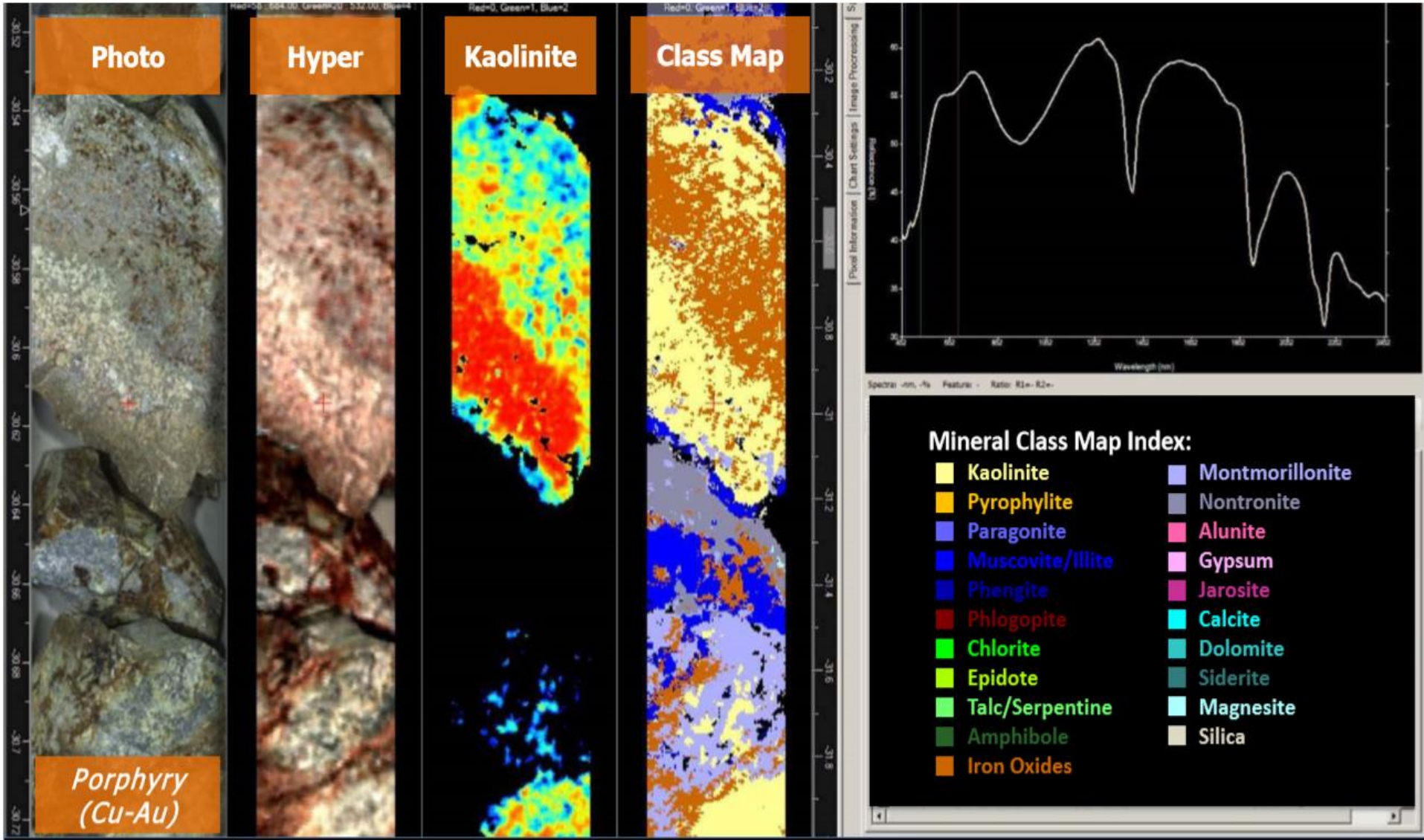
Courtesy of Corescan 2018

VNIR – SWIR SPECTOMETERS

Courtesy of Corescan 2018

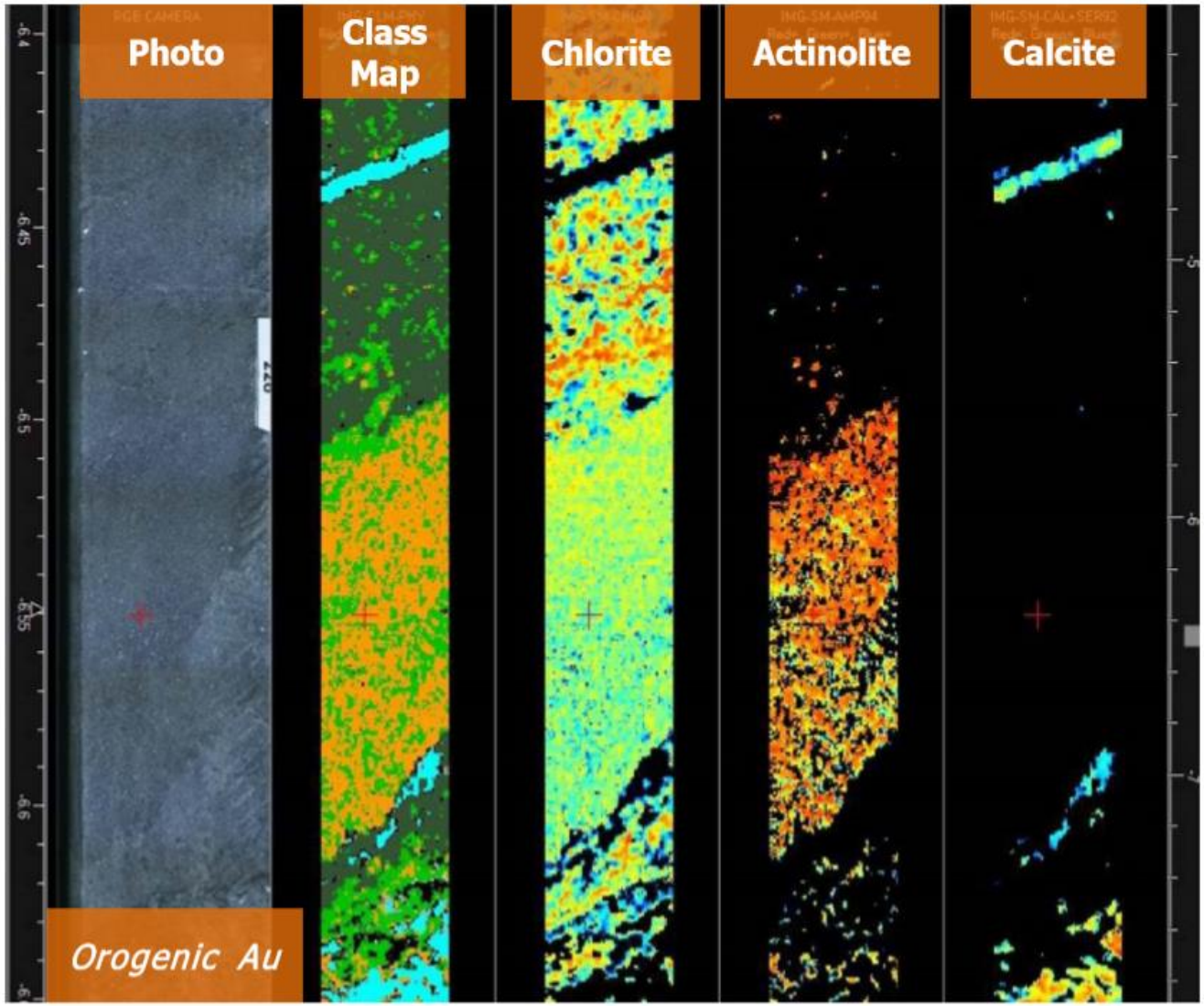
HYPERSPECTRALS IMAGERY (0.5 mm)

Courtesy of Corescan 2018



HYPERSPECTRALS IMAGERY (0.5 mm)

Courtesy of Corescan 2018



Chlorite (Fe-rich)

Chlorite (Mg-rich)

Actinolite

Calcite

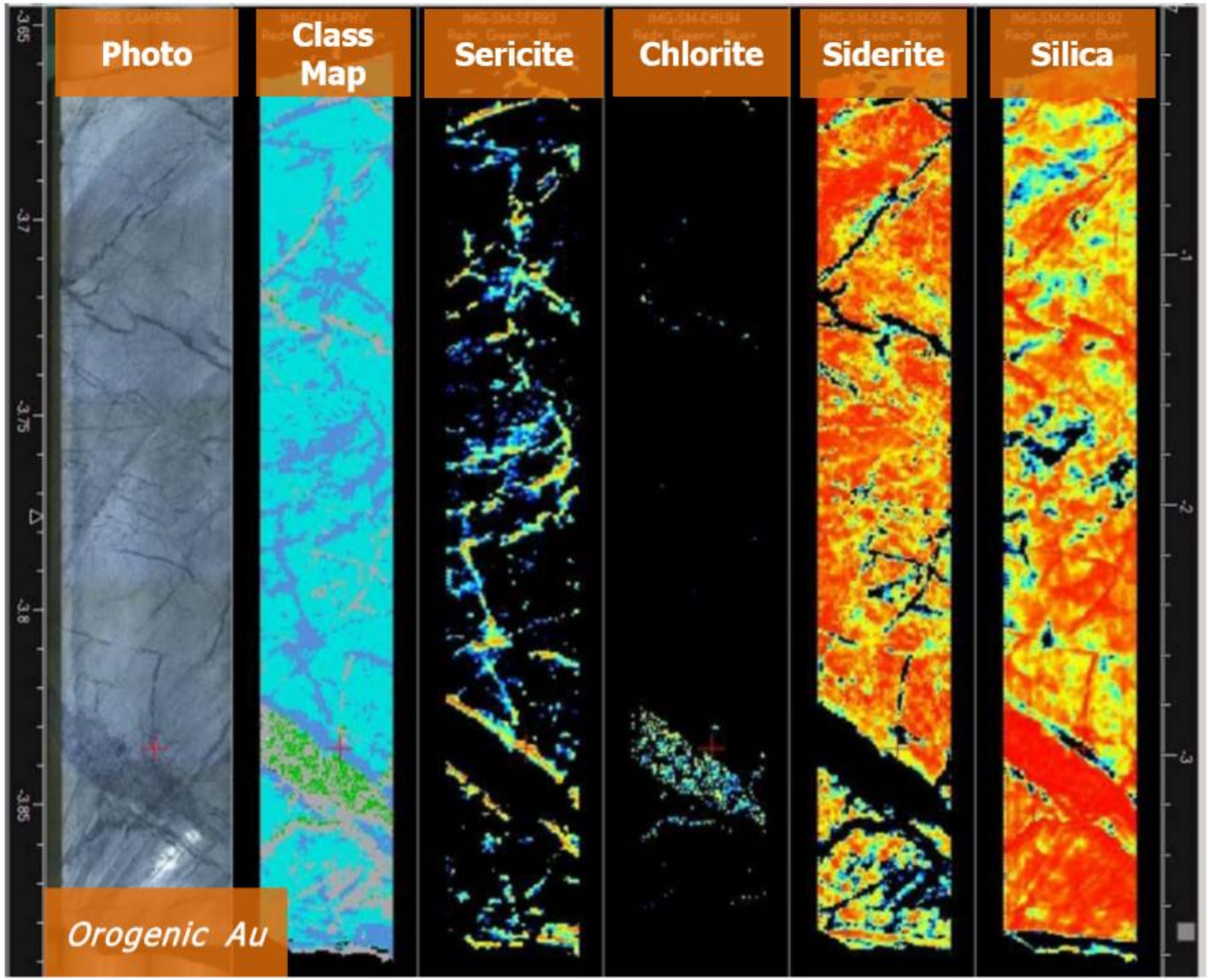
Relative mineral abundance

Low abundance

High abundance

HYPERSPECTRALS IMAGERY (0.5 mm)

Courtesy of Corescan 2018



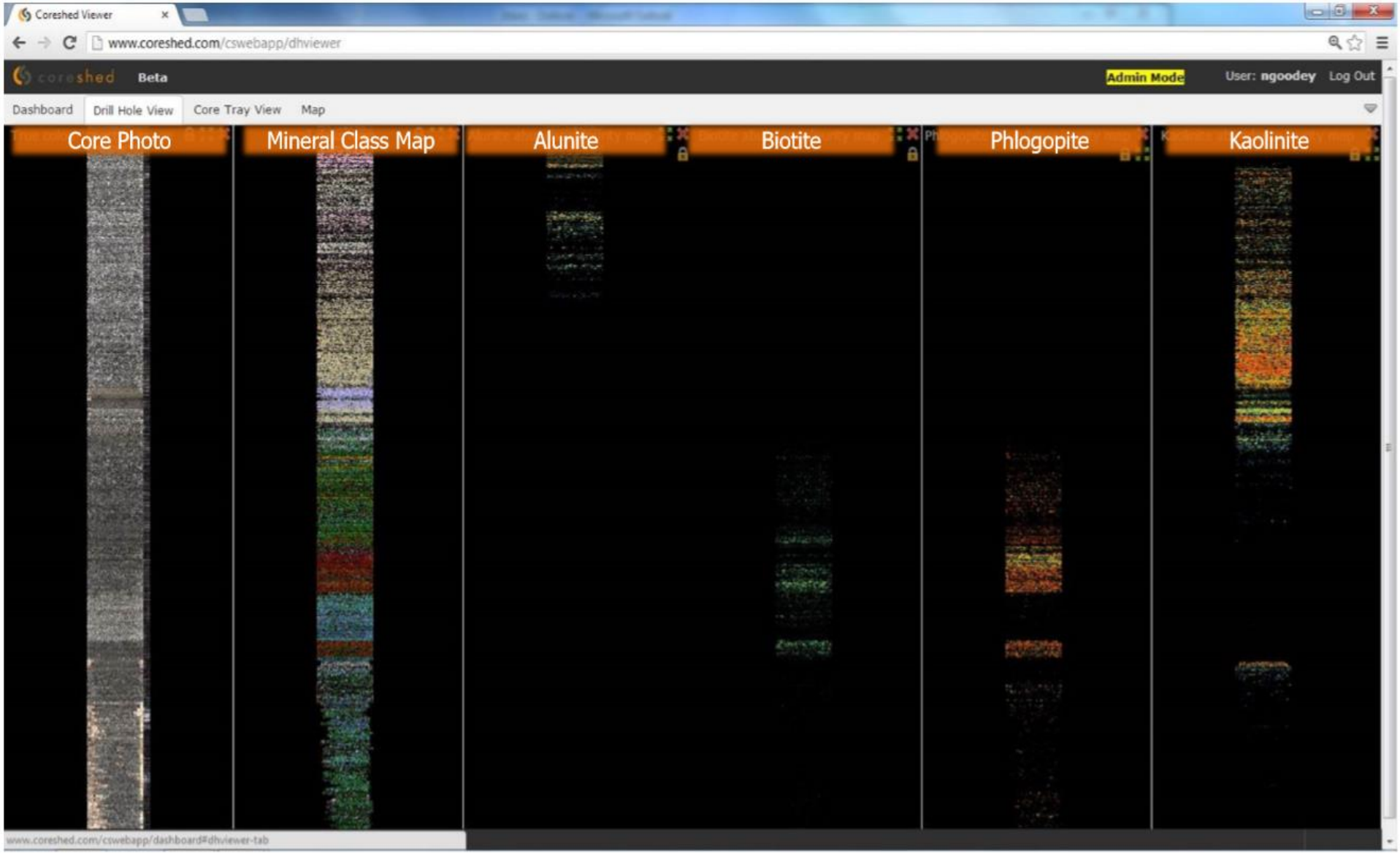
- Sericite
- Chlorite
- Silica
- Siderite

Relative mineral abundance

Low abundance — High abundance

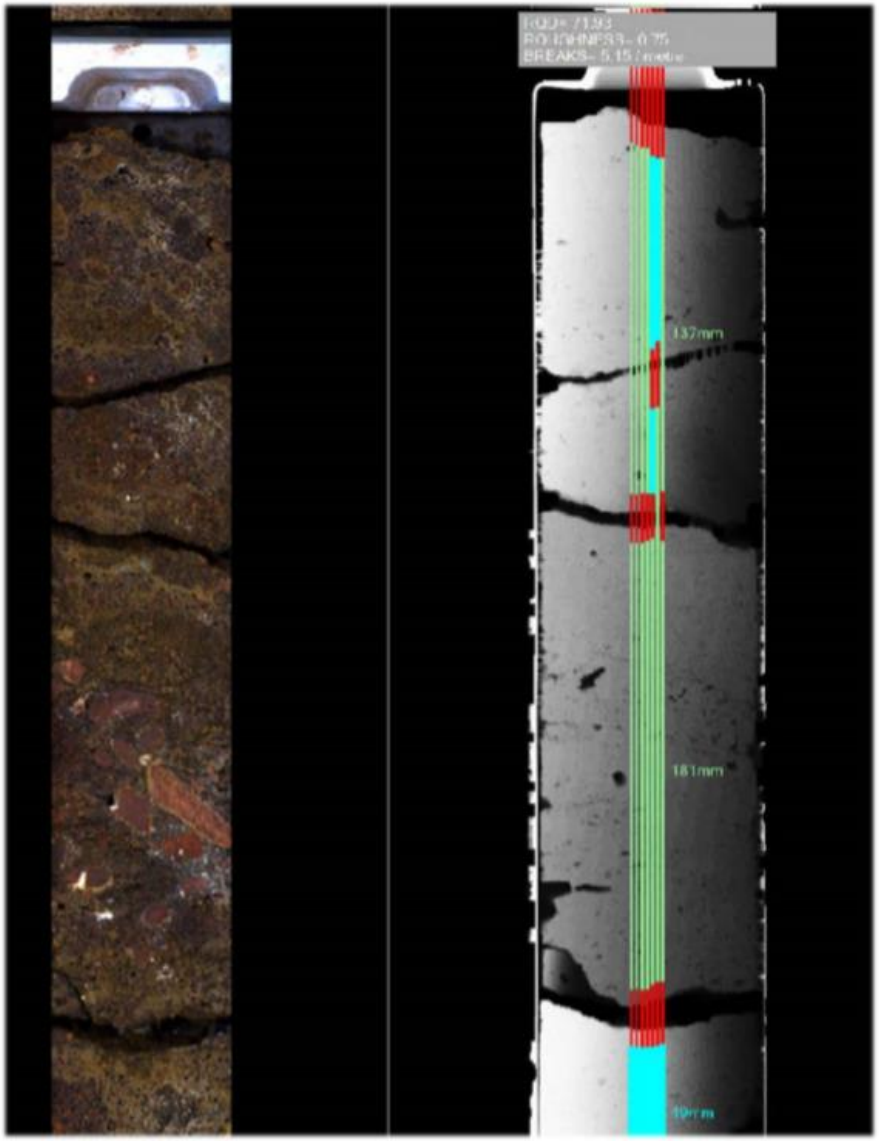
CORE DRILL HOLE IMAGE (MOSAIC IMAGES)

Courtesy of Corescan 2018



RQD / FRACTURE FREQUENCY

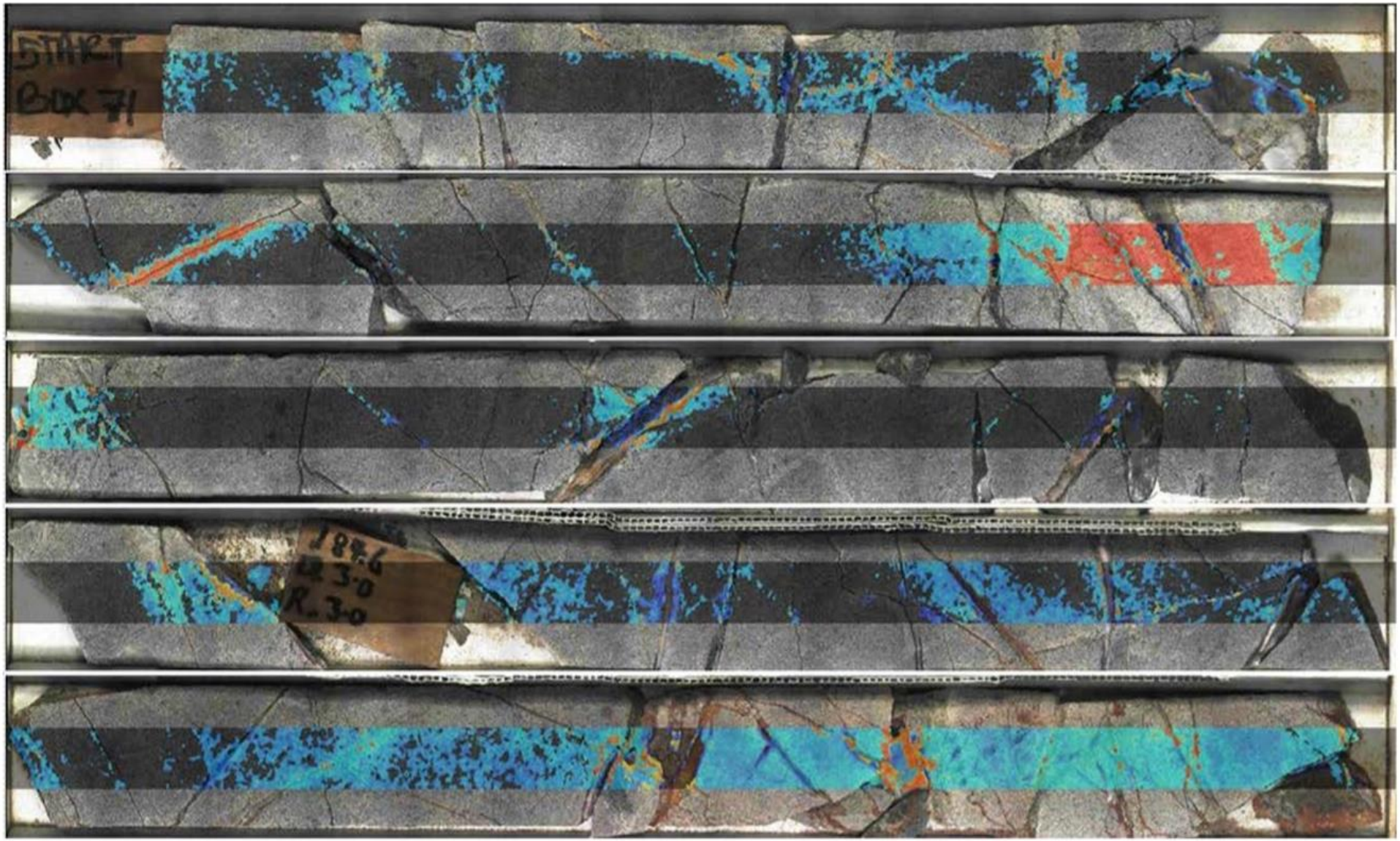
Courtesy of Corescan 2018



#hole_id	from	to	Breaks	RQD	Brokenness
DD14YBIL0003	-25	-26	3.87989	62.71748	0.80568
DD14YBIL0003	-26	-27	0.85228	91.63863	0.61076
DD14YBIL0003	-27	-28	1.50867	89.21133	0.82141
DD14YBIL0003	-28	-29	4.14587	79.66354	0.78667
DD14YBIL0003	-29	-30	3.10741	55.71052	1.03826
DD14YBIL0003	-30	-31	4.49234	36.13262	1.2541
DD14YBIL0003	-31	-32	2.22565	78.70395	0.78432
DD14YBIL0003	-32	-33	3.70184	71.26608	1.03432
DD14YBIL0003	-33	-34	3.42323	66.67975	1.07603
DD14YBIL0003	-34	-35	3.52536	59.74512	1.19142
DD14YBIL0003	-35	-36	3.44456	80.35633	0.9006
DD14YBIL0003	-36	-37	3.55159	57.54318	1.55863
DD14YBIL0003	-37	-38	4.06568	70.73612	1.00448
DD14YBIL0003	-38	-39	4.93222	57.42342	1.07332
DD14YBIL0003	-39	-40	2.69574	75.549	1.33053
DD14YBIL0003	-40	-41	7.03632	32.49085	1.61773
DD14YBIL0003	-41	-42	5.09593	38.20382	1.498
DD14YBIL0003	-42	-43	8.53123	5.54556	1.56476
DD14YBIL0003	-43	-44	5.73011	31.37862	1.63885
DD14YBIL0003	-44	-45	4.79906	63.18655	1.03853
DD14YBIL0003	-45	-46	3.23033	67.74624	1.36557
DD14YBIL0003	-46	-47	3.90295	45.37993	1.86721
DD14YBIL0003	-47	-48	1.8171	68.19396	0.97868
DD14YBIL0003	-48	-49	3.33834	45.58496	1.85271

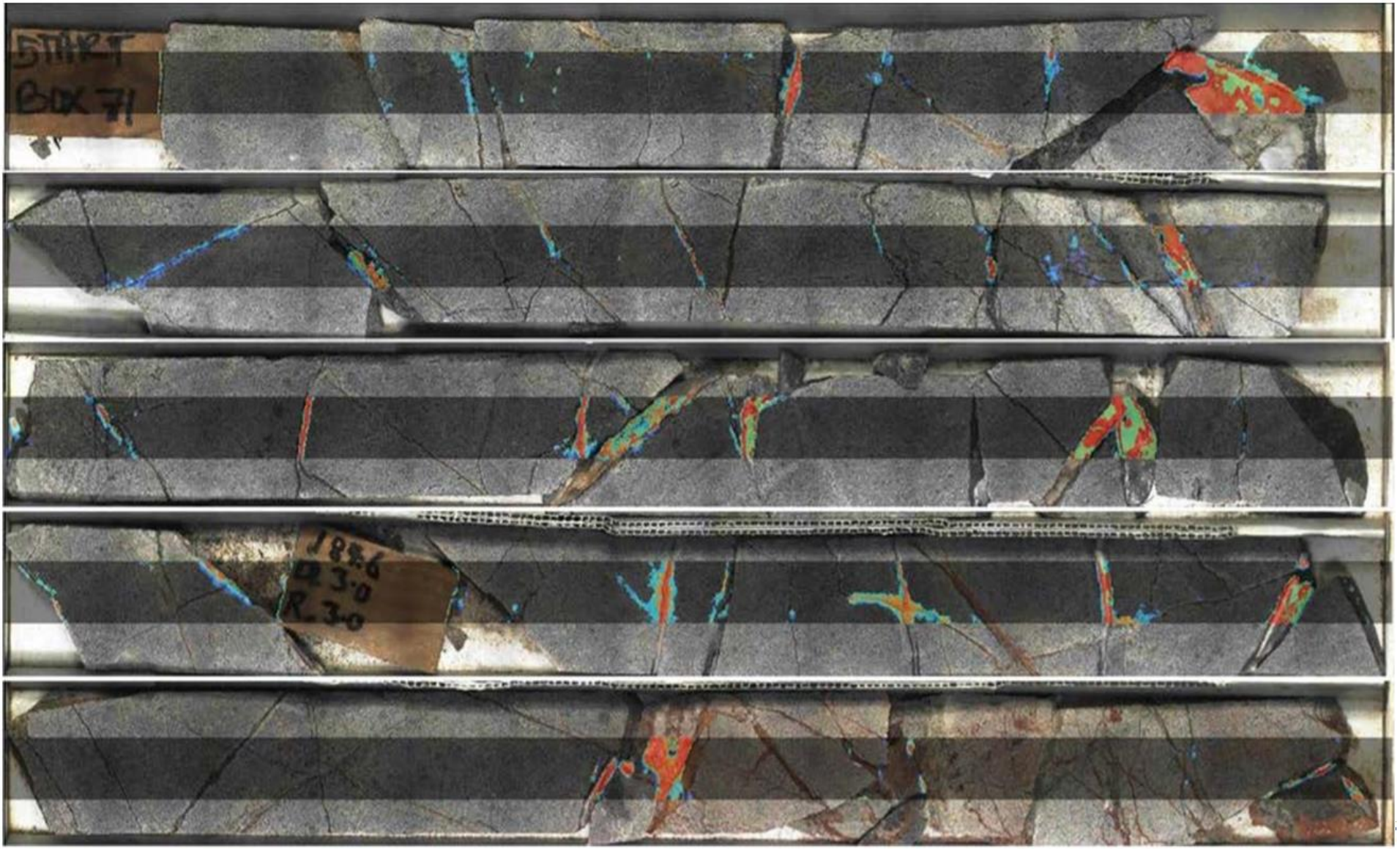
MINERALOGY IMAGES FOR CORE LOGGING - SERICITE

Courtesy of Corescan 2018



MINERALOGY IMAGES FOR CORE LOGGING - GYPSUM

Courtesy of Corescan 2018

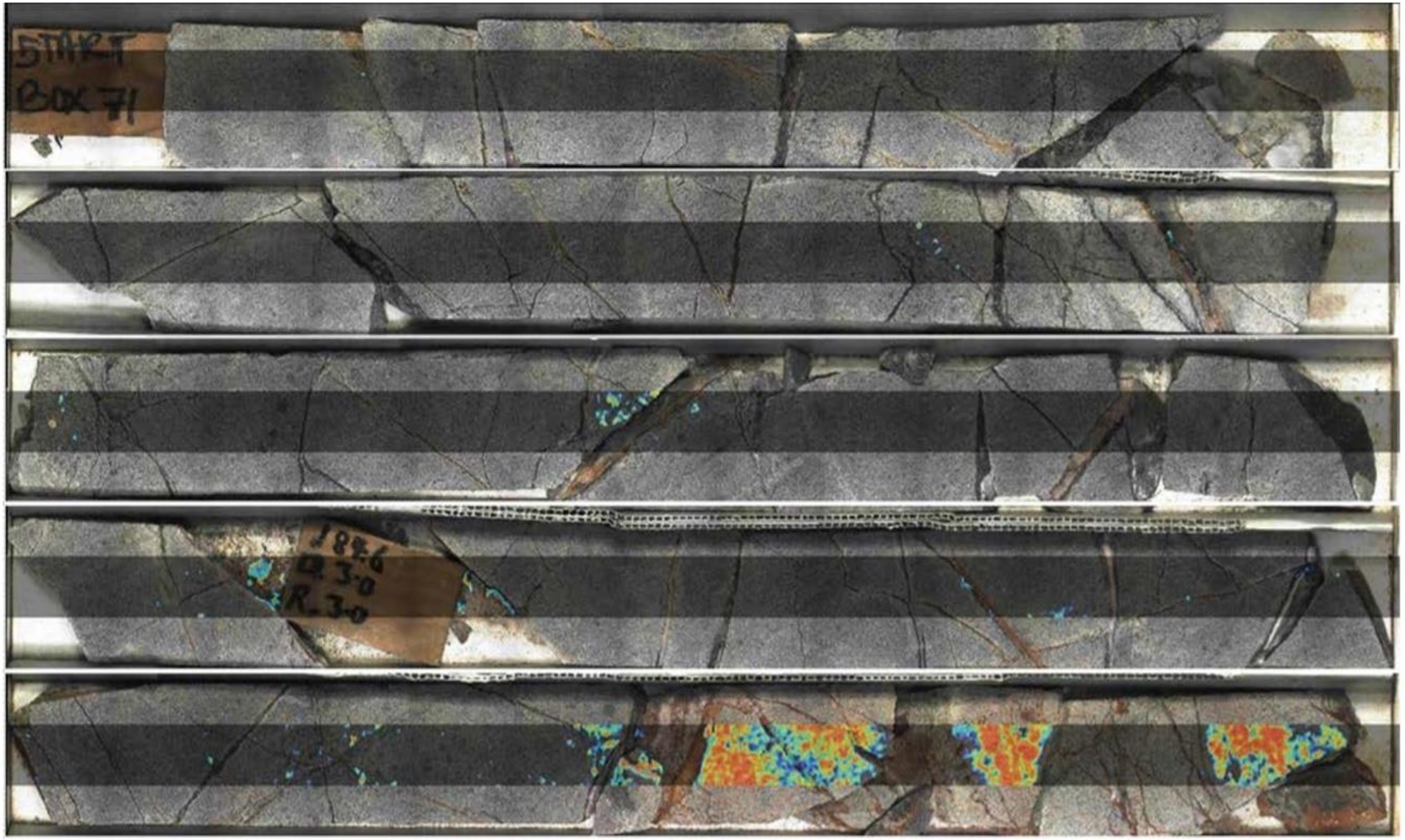


MERDEKA COPPER GOLD

BUMI SUKSESINDO Copper and Gold

MINERALOGY IMAGES FOR CORE LOGGING - KAOLINITE

Courtesy of Corescan 2018



BECAUSE of GOLD

1st shipment of bullion in March 2017

MATUR SUWUN

Sunset in Pulau Merah Beach 2015

Pantai Pulau Merah, photo by Krisma