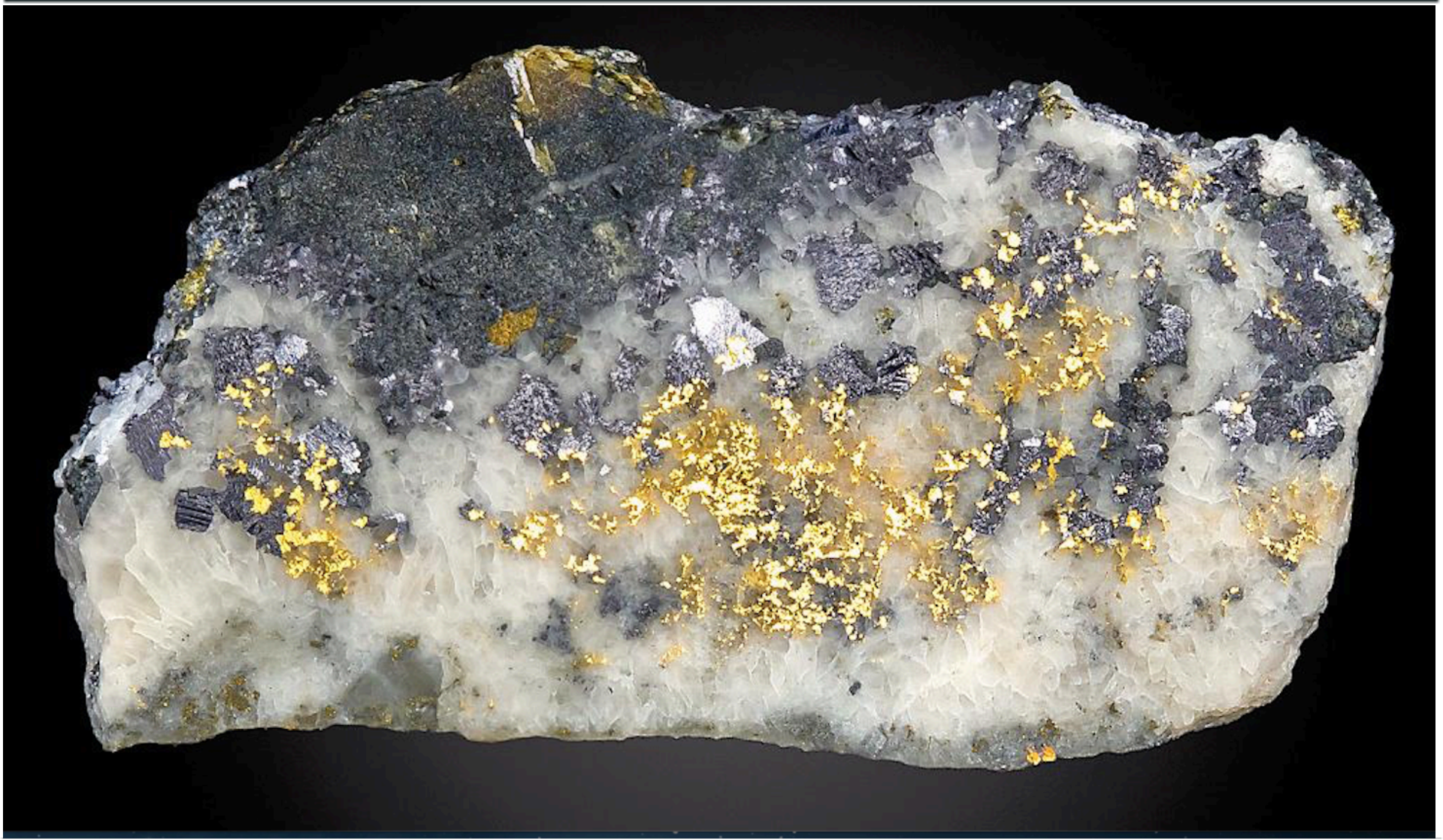
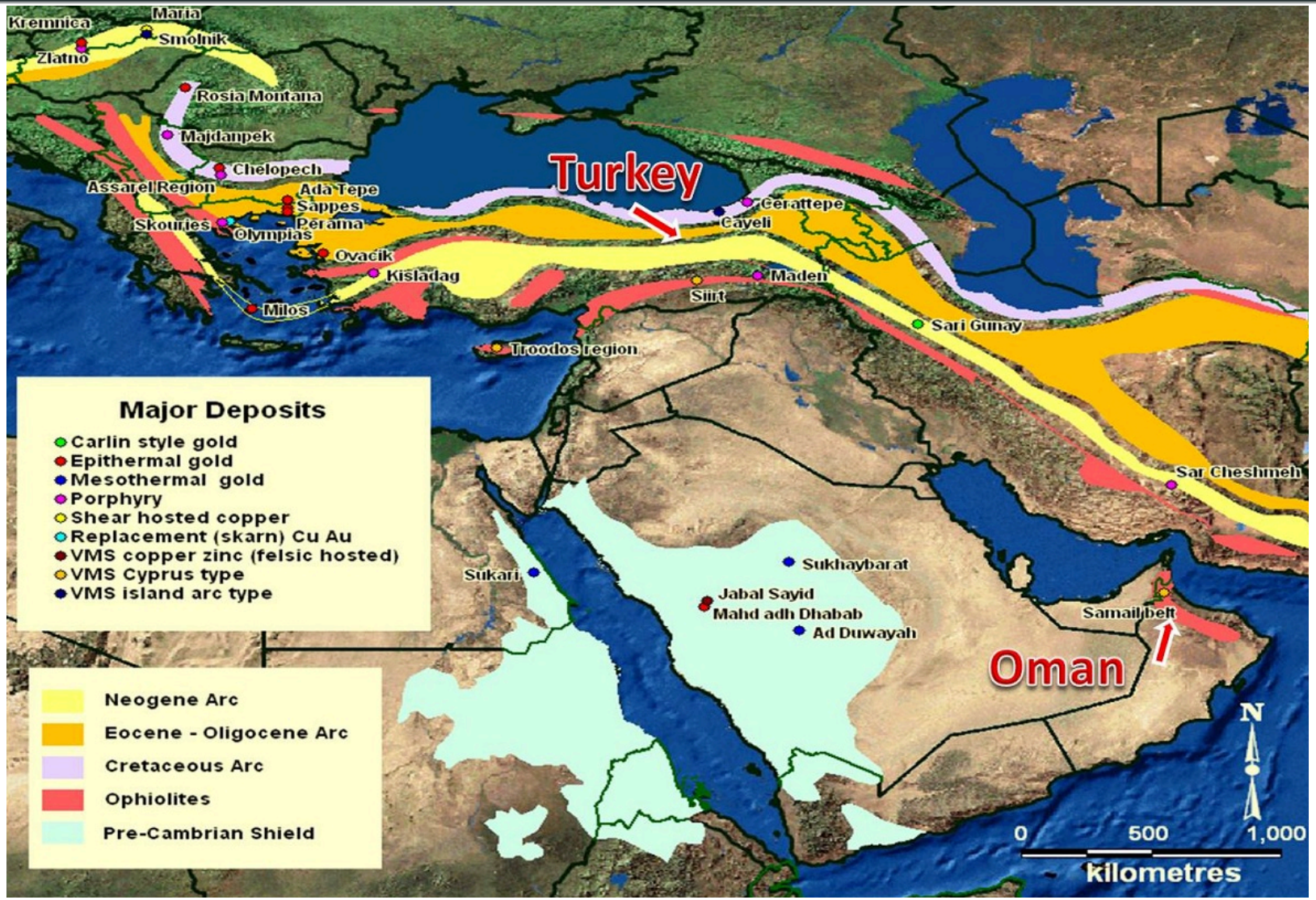
Rubicon

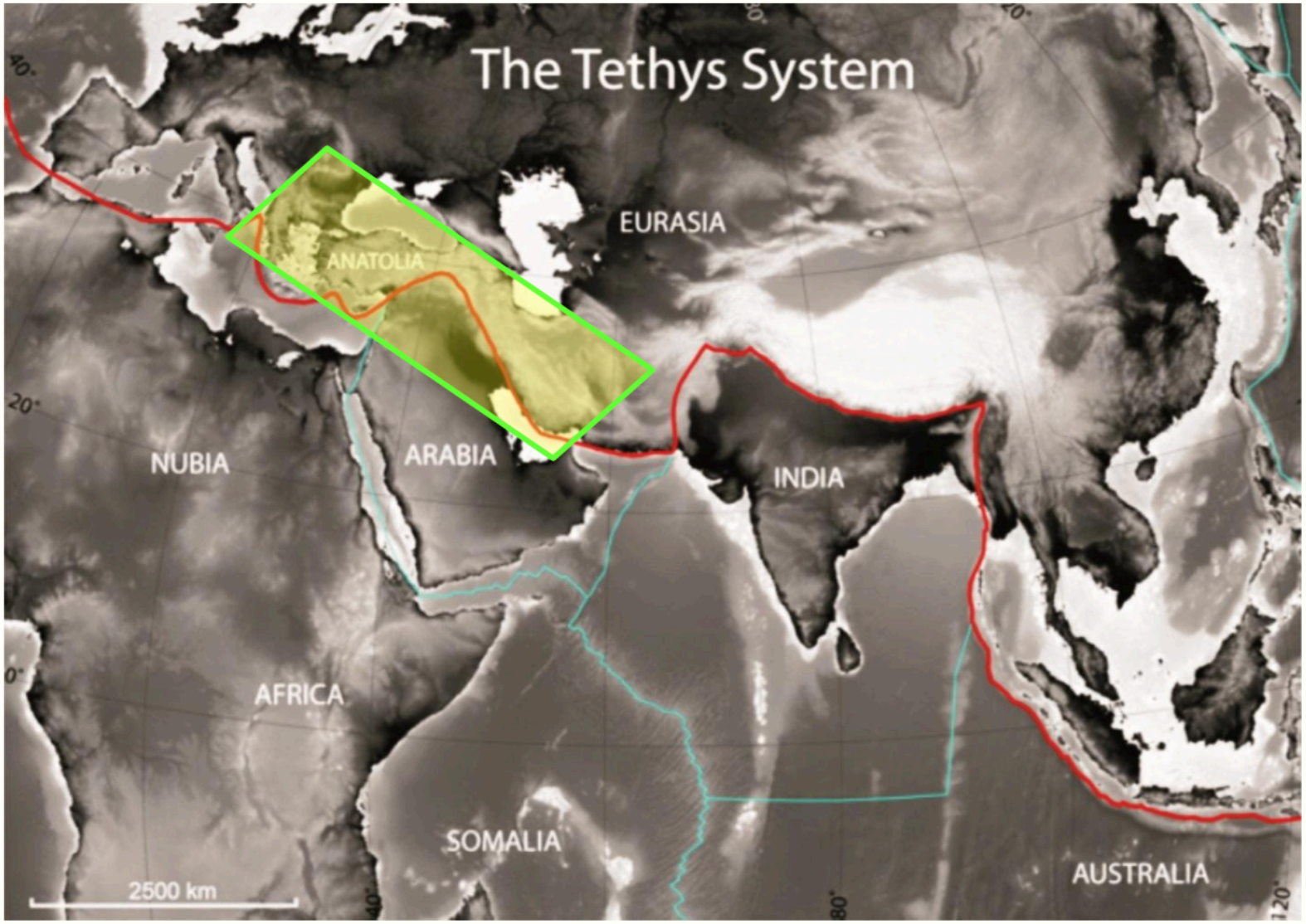
Come to Turkey

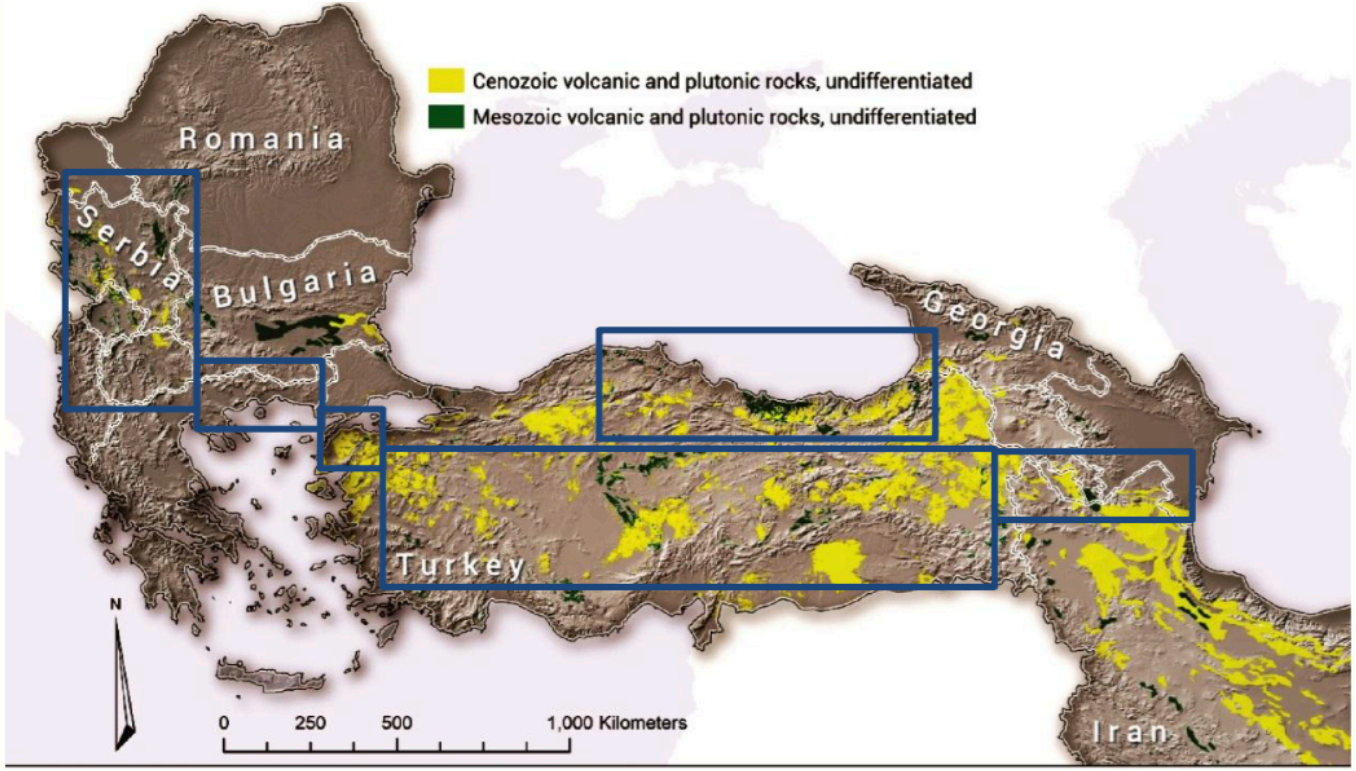
TURK

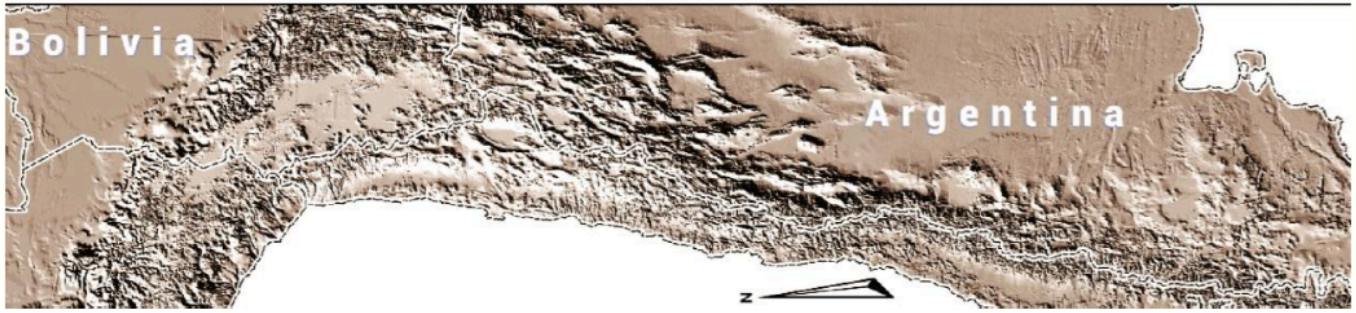
Mine-TurnkeyConsultancy www.RubiconMining.com

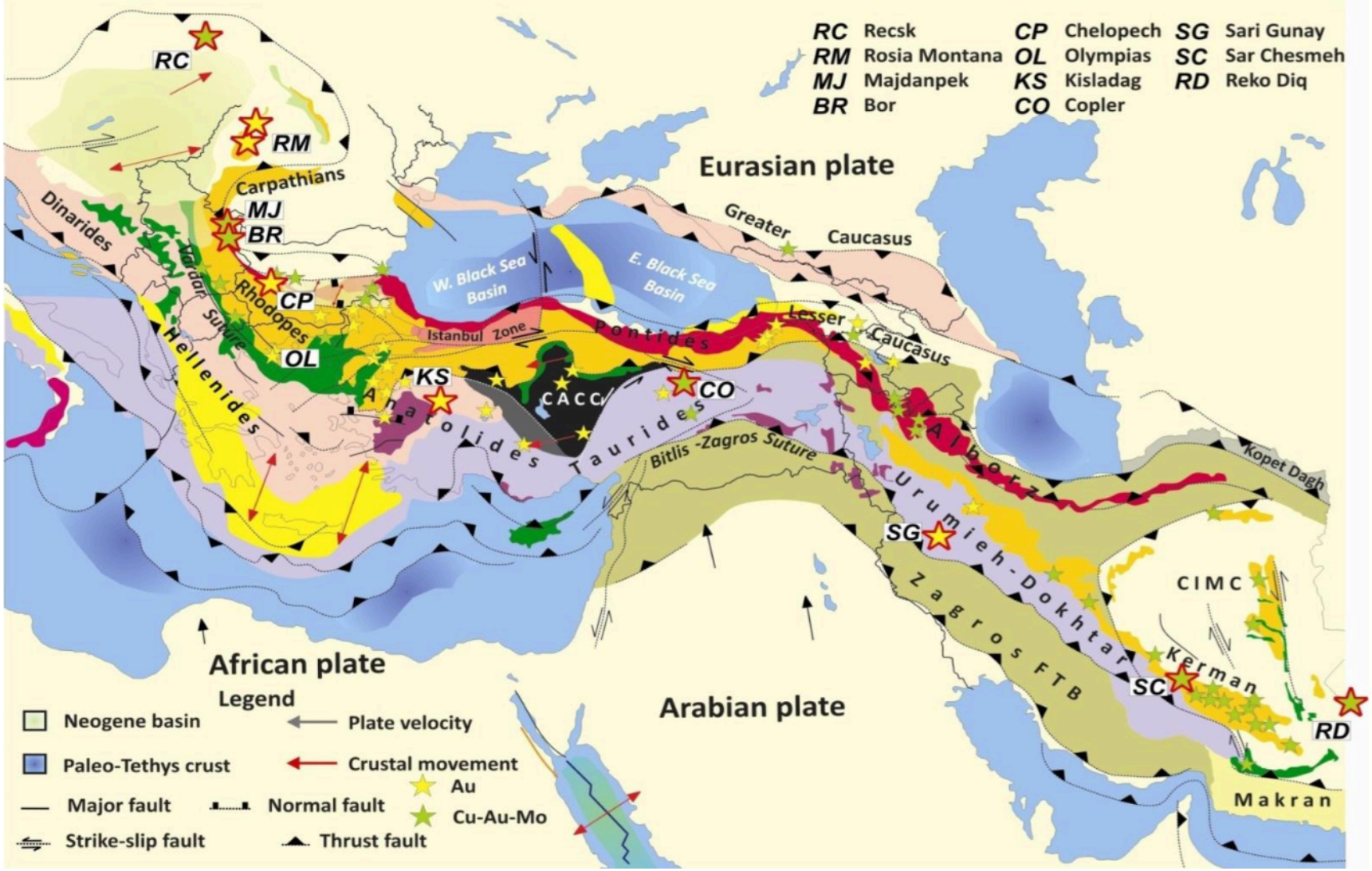



Kremnica
Maria
Smolnik
Zlatno
Rosia Montana
Majdanpek
Chelopech
Assarel Region
Ada Tepe
Sappes
Perama
Skouries
Olympias
Ovacik
Kisladag
Milos
Turkey
Cerattepe
Cayeli
Maden
Siirt
Sari Gunay
Troodos region
Sar Cheshmeh
Major Deposits
Carlin style gold
Epithermal gold
Mesothermal gold
Porphyry
Shear hosted copper
Replacement (skarn) Cu Au
VMS copper zinc (felsic hosted)
VMS Cyprus type
VMS island arc type
Sukari
Sukhaybarat
Jabal Sayid
Mahd adh Dhabab
Ad Duwayah
Samail belt
Oman
Neogene Arc
Eocene - Oligocene Arc
Cretaceous Arc
Ophiolites
Pre-Cambrian Shield
N
0
500
1,000
kilometres


The Tethys System
EURASIA
ANATOLIA
NUBIA
ARABIA
INDIA
AFRICA
SOMALIA
AUSTRALIA
2500 km

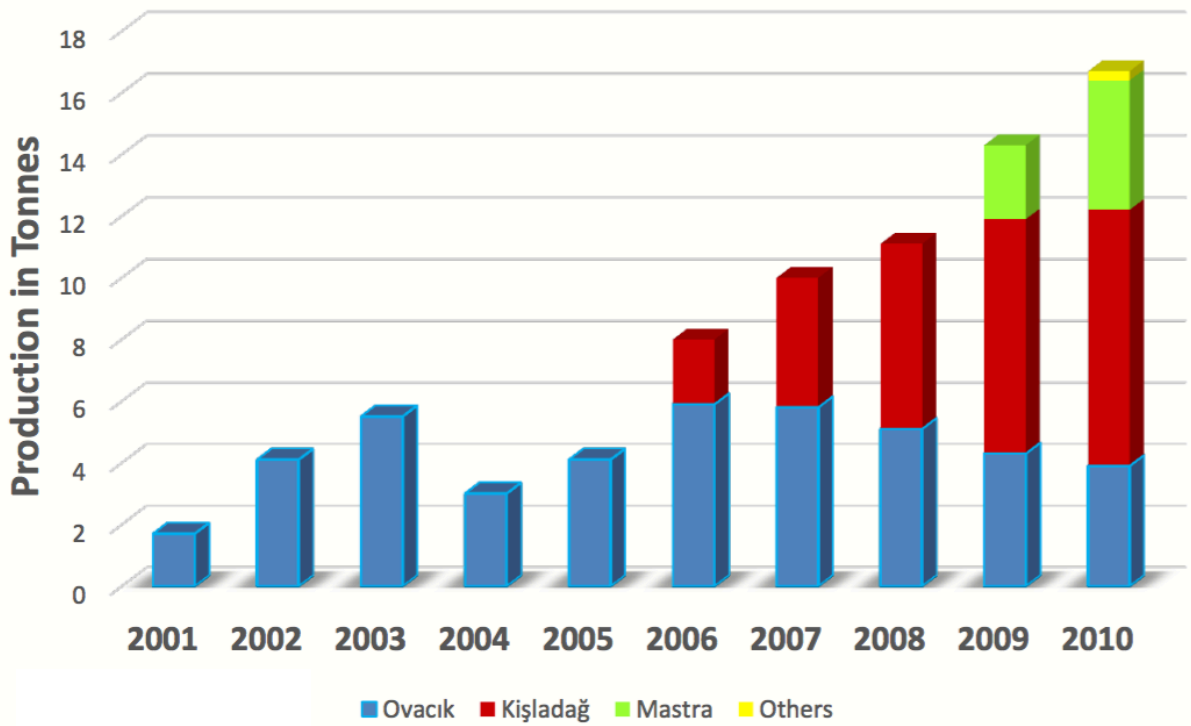

Cenozoic volcanic and plutonic rocks, undifferentiated
Mesozoic volcanic and plutonic rocks, undifferentiated
Romania
Serbia
Bulgaria
Georgia
Turkey
Iran
N
0
250
500
1,000 Kilometers


Bolivia
Argentina
N

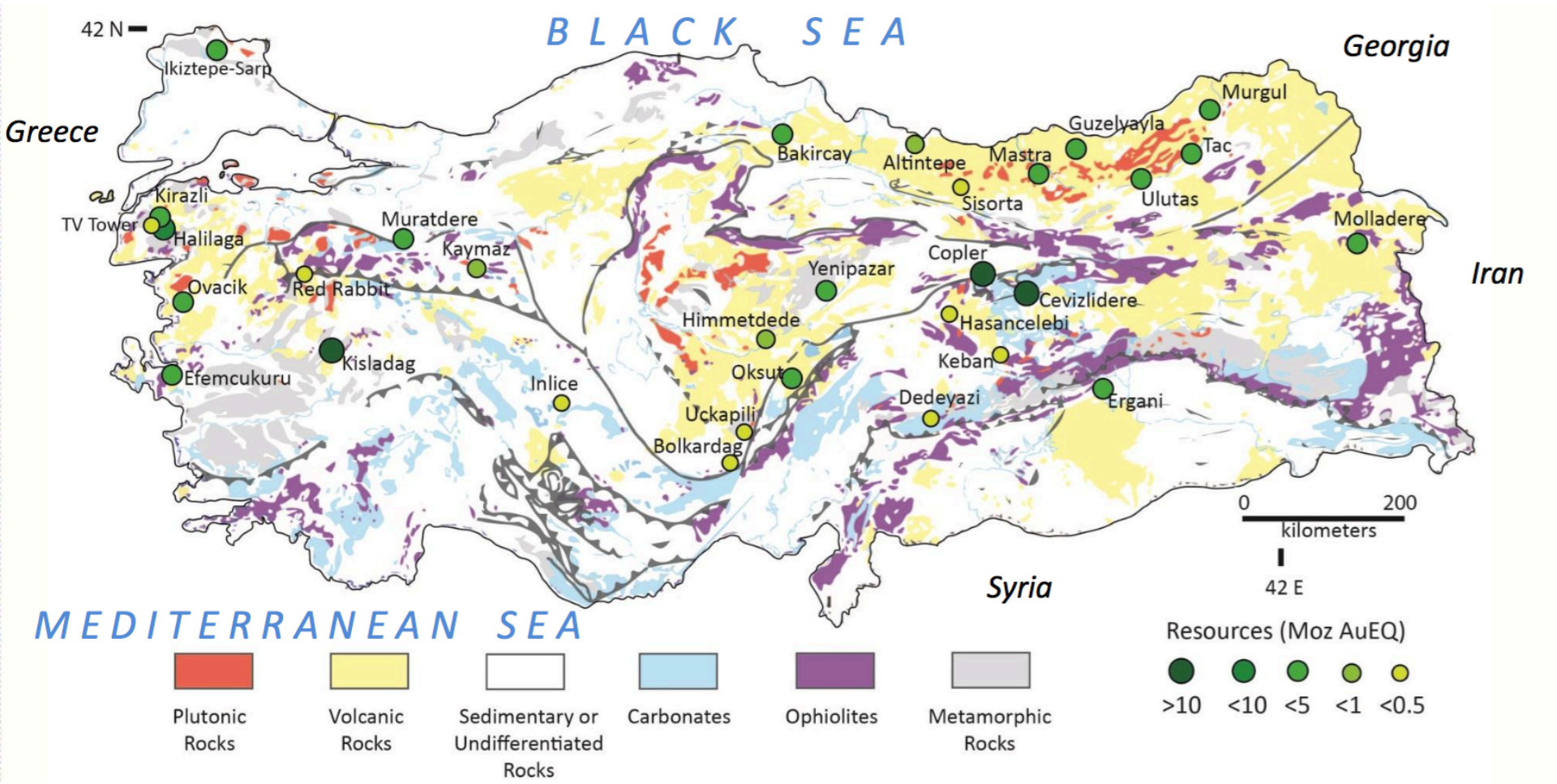

RC Recsk
RM Rosia Montana
MJ Majdanpek
BR Bor
CP Chelopech
OL Olympias
KS Kisladag
CO Copler
SG Sari Gunay
SC Sar Chesmeh
RD Reko Diq
Eurasian plate
African plate
Arabian plate
Carpathians
Dinarides
Vardar Suture
Hellenides
Rhodopes
W. Black Sea Basin
E. Black Sea Basin
Istanbul Zone
Pontides
Greater Caucasus
Lesser Caucasus
CACC
Anatolides
Taurides
Bitlis -Zagros Suture
Alborz
Urumieh-Dokhtar
Zagros FTB
Kopet Dagh
CIMC
Kerman
Makran
Legend
Neogene basin
Paleo-Tethys crust
Major fault
Strike-slip fault
Plate velocity
Crustal movement
Normal fault
Thrust fault
Au
Cu-Au-Mo

| Deposit type | Resources (Mt) | Operator | Au (g/t) | Cu (%) | Mo (g/t) | Ag (g/t) | Zn (%) | Pb (%) |
|---|---|---|---|---|---|---|---|---|
| Çopler porphyry Cu-Au + IS epithermal Au, Turkey | 96.0 | Alacer Gold | 1.49 | | | | | |
| Efemçukuru LS epithermal, Turkey | 7.9 | Eldorado Gold | 9.57 | | | | | |
| Kişladağ Au-Cu porphyry, Turkey | 1009 | Eldorado Gold | 0.65 | | | | | |
| Mastra LS epithermal, Turkey | 2.2 | Koza Gold | 9.80 | | | 5.30 | | |
| Ovaçik LS epithermal, Turkey | 3.5 | Koza Gold | 10.00 | | | | | |
| Cayeli VMS, Turkey | 9.0 | Inmet Mining | 0.50 | 3.20 | | 41.00 | 4.30 | |
| Chelopech HS epithermal deposit, Bulgaria | 16.36 | Dundee PM | 4.10 | 1.27 | | 5.82 | | |
| Ellatsite Cu-Au porphyry, Bulgaria | 242 | Geotechmin | | 0.39 | | | | |
| Rosia Poieni Cu porphyry, Romania | >1,500? | CupruMin (state) | | 0.36 | | | | |
| Bučim Cu-Au porphyry, Macedonia | 85 | Solway Industries | 0.35 | 0.30 | | | | |
| Bor Cu-Au porphyry + Au-Cu epithermal deposits, Serbia | 611 (>1000?) | RTB Bor | 0.21 | 0.62 | | 1.81 | | |
| Majdanpek Cu porphyry, Serbia | >1000 | RTB Bor | 0.35 | 0.60 | | | | |
| Sar Cheshmeh Cu-Mo porphyry, Iran | 1300 | NICICo | | 1.13 | 0.03 | | | |
| Deno Gold - Kapan polymetallic, Armenia | 335.8 | Dundee PM | 0.48 | 0.11 | | 8.39 | 0.41 | |
| Halilağa Cu-Au porphyry, Turkey | 198.6 | Teck - Pilot Gold | 0.26 | 0.23 | | | | |
| Altintepe HS epithermal, Turkey | 8.4 | Teck - Stratex Intl. | 2.00 | | | | | |
| Skouries Cu-Au porphyry, Greece | 264 | Eldorado Gold | 0.67 | 0.49 | | | | |
| Olympias polymetallic replacement, Greece | 13.6 | Eldorado Gold | 8.70 | | | 132.00 | 5.90 | 4.40 |
| Rosia Montana LS-IS epithermal, Romania | 214.9 | Gabriel Res. | 1.46 | | | 6.88 | | |
| Ilovitza Cu-Au porphyry, Macedonia | 374 | Euromax Res. | 0.32 | 0.21 | | | | |
| Krumovgrad Ada Tepe sediment-hosted LS epithermal , Bulgaria | 7.99 | Dundee PM | 3.50 | | | 2.00 | | |
| Kiseljak Cu-Au porphyry, Serbia | 301 | Dunav Resources | 0.26 | 0.27 | | | | |
| Amulsar HS epithermal prospect, Armenia | 80.1 | Lydian International | 0.80 | | | 3.40 | | |
| Sari Gunay LS epithermal , Iran | 52 | State-private | 1.77 | | | | | |

- Active mines in 2013: Kişladağ (Uşak), Ovacık, Mastra, Çöpler, Efemçukuru;
- Mines in development: Kaymaz, Inliçe, Red Rabbit;
- $630 million spent on exploration between 2001 and 2012;
- Projected to reach tier of 15 countries in terms of gold production by 2016;
- Geological models suggest that Turkey hold c.a. 6,500 tons of recoverable gold




*data from Turkish Gold Miners Association*


42 N
BLACK SEA
Georgia
Greece
Iran
Syria
MEDITERRANEAN SEA
Ikiztepe-Sarp
Kirazli
TV Tower
Halilaga
Ovacik
Red Rabbit
Muratdere
Kaymaz
Kisladag
Efemcukuru
Inlice
Bakircay
Altintepe
Sisorta
Mastra
Guzelyayla
Murgul
Tac
Ulutas
Molladere
Copler
Cevizlidere
Yenipazar
Himmetdede
Hasancelebi
Keban
Oksut
Uckapili
Bolkardag
Dedeyazi
Ergani
0
200
kilometers
42 E
Plutonic Rocks
Volcanic Rocks
Sedimentary or Undifferentiated Rocks
Carbonates
Ophiolites
Metamorphic Rocks
Resources (Moz AuEQ)
>10
<10
<5
<1
<0.5

## Ovaçık (Au, Ag)

**Koza Altin:** 4.5 Mt @ 4.34 g/t Au and 2.79 g/t Ag (M+I)

## Yuntdağ (Au)

**Global Resources Corp:** exploration identified anomalies

## Arapdağ (Au, Pb, Sb)

**Historic:** Reserves of 500 – 600 kg Au, adjacent Pb + Sb occurrences

## Karaburun (Hg)

**Historic:** 120,000 tons ore @ 0.54% Hg (pre WWI)
29,000 tons ore @ 0.45% Hg (post WWI)

## Efemçukuru (Au)

**Eldorado Gold:** 5.89 Mt @ 8.71 g/t Au (M+I)

**Legend**

*Simplified geology*

- Plutonic rocks
- Cenozoic Volcanics
- Carbonates
- Ophiolites
- Metamorphic rocks

Structure
- Fault
- Suture zone

*Deposits*
- Epithermal
- Orogenic Au

## Menderes (Au)

**Frontline Gold:** Resistivity highs and geochemical anomalies southeastern extension to Kestanebeleni vein

## Tire (area) (Au)

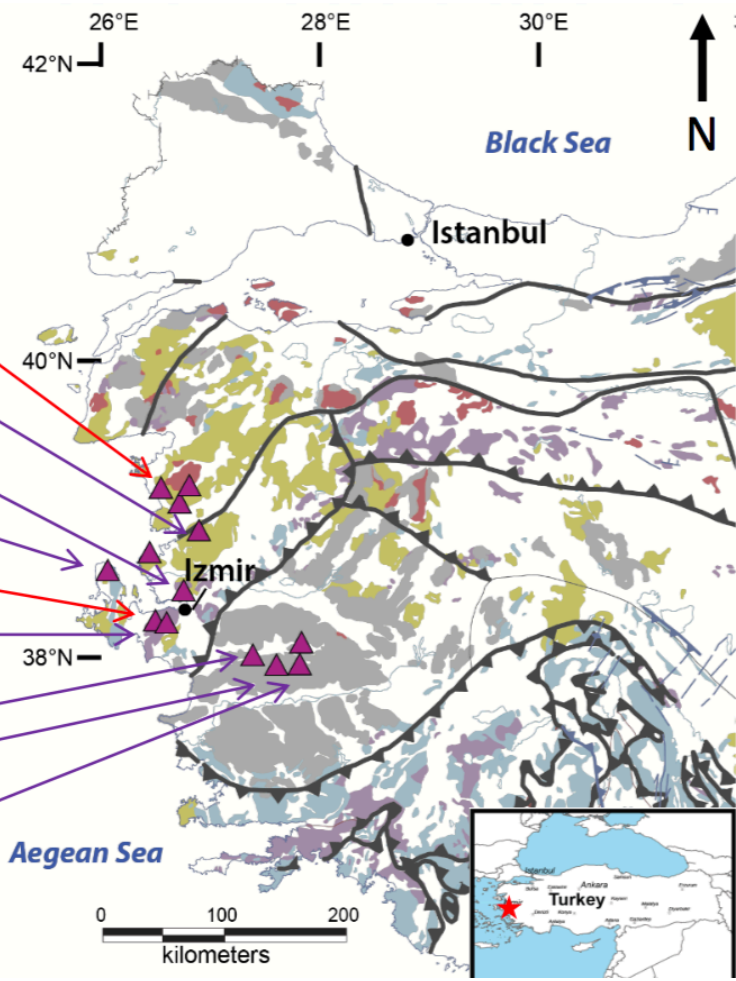
**Historic:** low concentrations of Hg (< 200 flasks Hg)

## Kure (area) (Au)

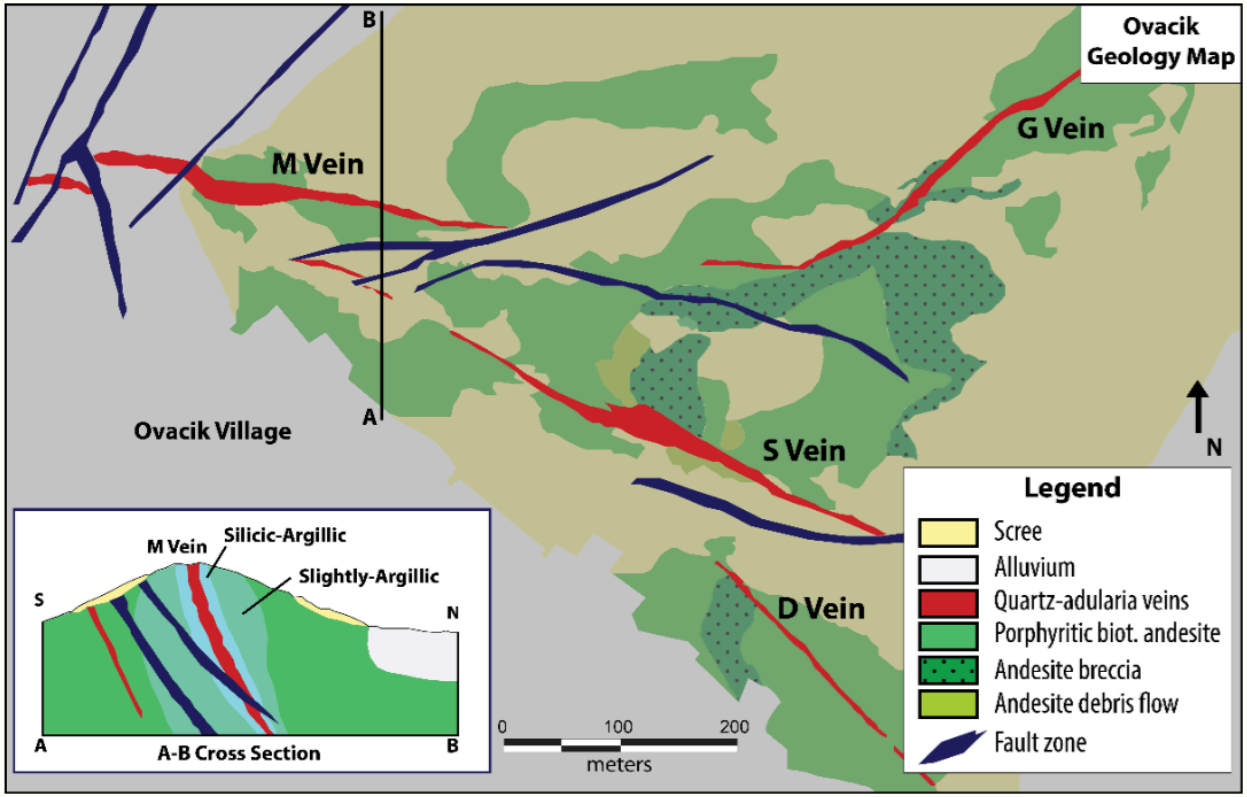
**Frontline Gold(?):** ?

## Ödemiş (area) (Hg, Sb)

**Frontline Gold:** Halikoy (Hg)
**Historic:** Emirli (Sb)



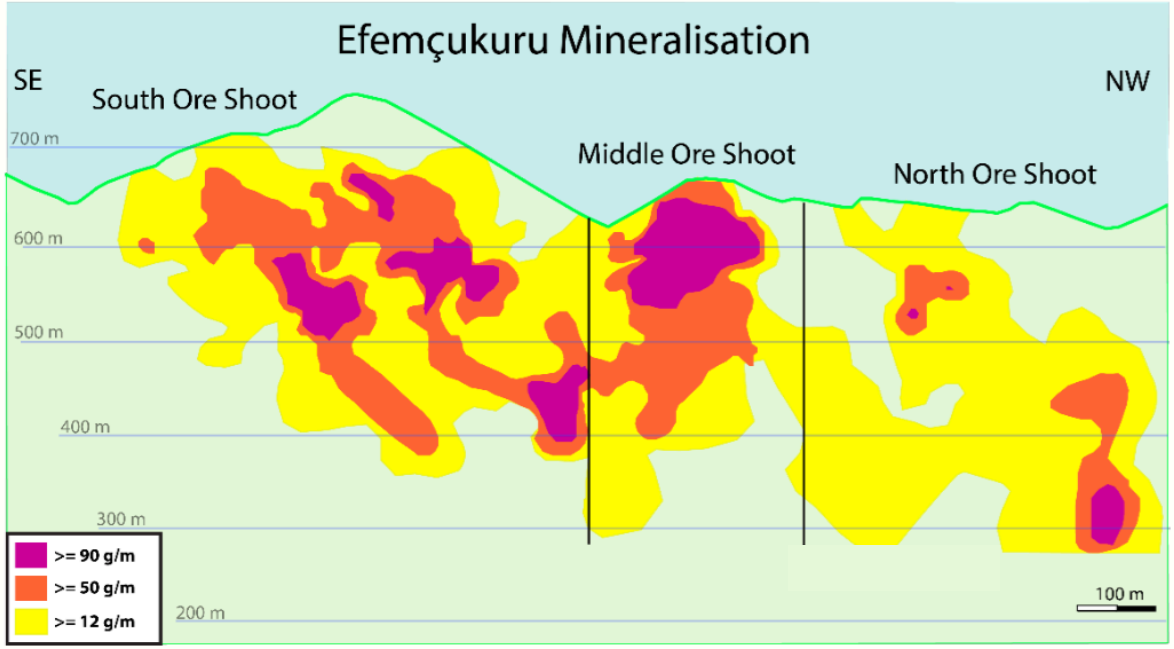
**4.5 Mt @ 4.34 g/t Au and 2.79 g/t Ag**

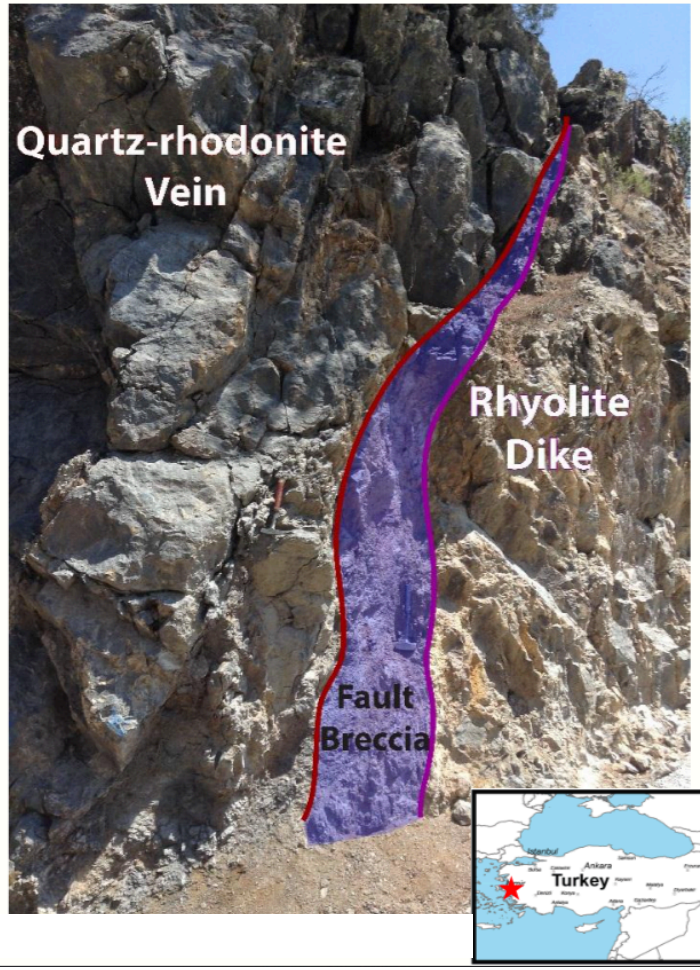


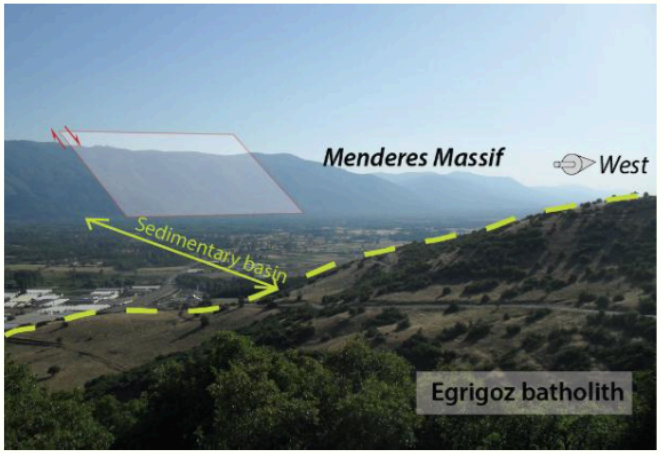

- Turkey's first modern operating Au mine, currently owned by **Koza Altin**.
- Swarm of ENE-trending **quartz-adularia veins** hosted by **Miocene andesitic lava.**

- An active mine owned by **Eldorado Gold Corp**.
- Quartz-rhodonite vein-hosted **LS epithermal** deposit
- NE trending veins collinear with rhyolite dikes

**5.89 Mt @ 8.71 g/t Au**





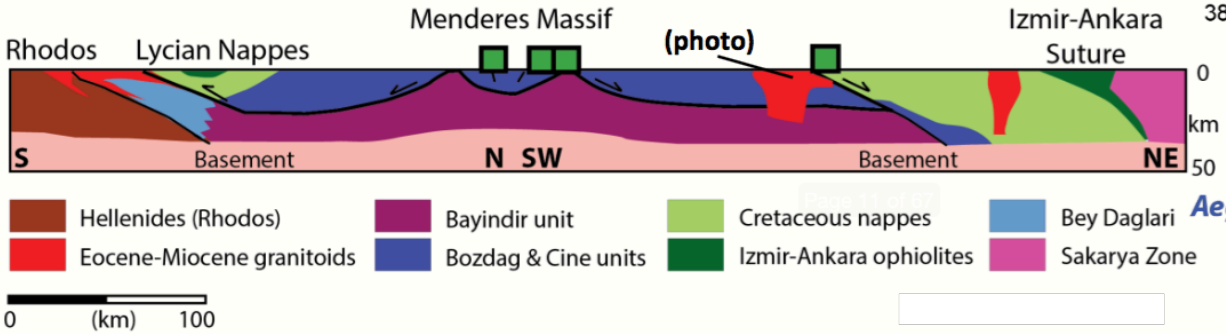

## Uşak area prospects (Au)

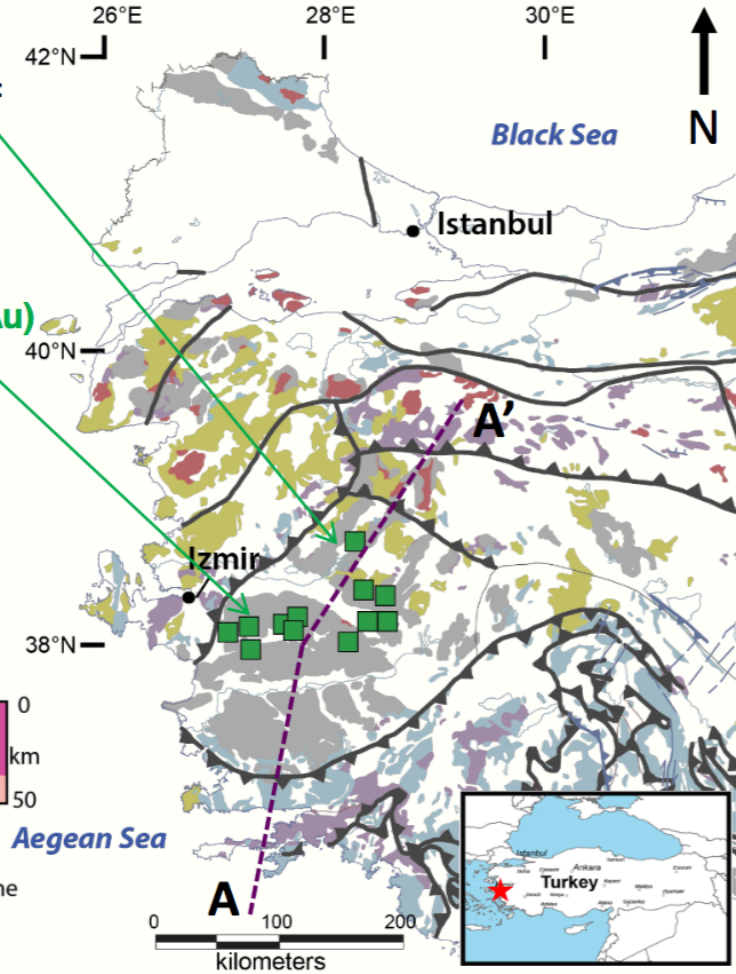
**VAB Natural Resources:** Güneyköy reserves: 3.751 Mt, probable 28.670 Mt
Balabançı: 5.78 Mt, probable 49.12 Mt @ 22.2-63.3 g/t Au ;
sheeted arsenopyrite veins >18 Mt

## Menderes Massif Prospects (Au)

**Aribasi, Yusufli, Zeytinlik, Umurbaba, Cavuslar, Beylerderesi:** small discontinuous quartz veins with associated arsenopyrite: Au , Bi anomalies

**** Epithermal overprinting – unclear orogenic origin!***



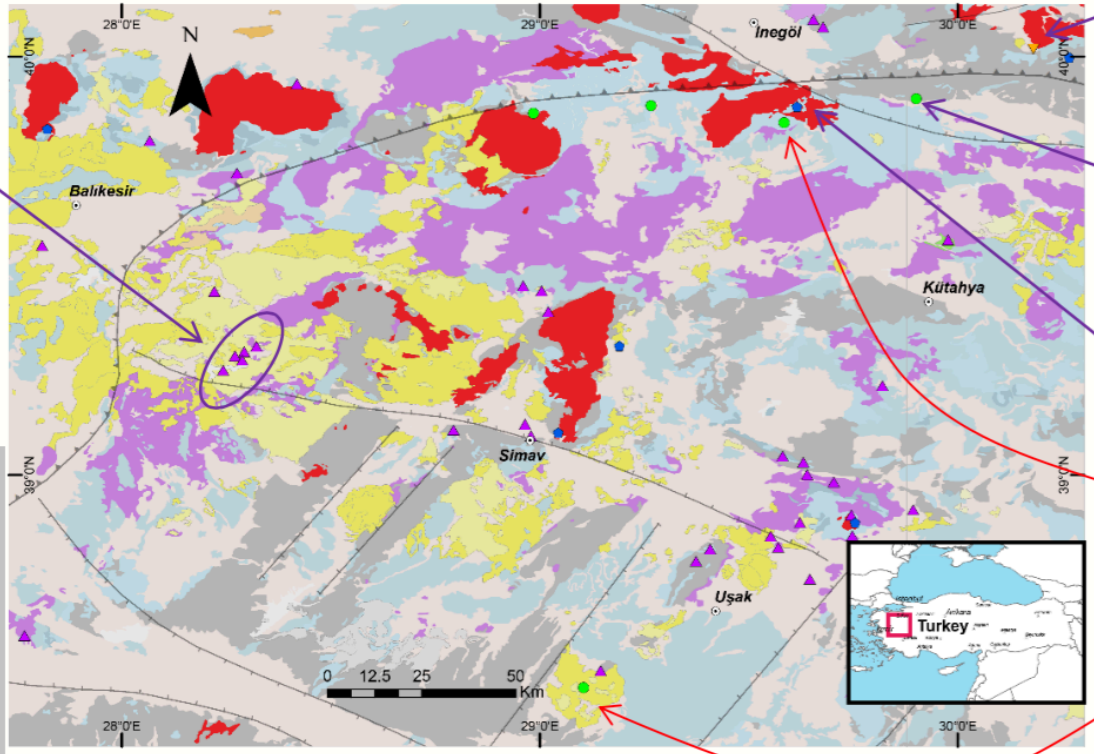



## *Bursa - Balıkesir - Kütahya - Uşak districts*

**Red Rabbit project (low-sulphidation epithermal):** Mine under construction → 2.17Mt @ 2.82 g/t Au and 42.5 g/t Ag including:

- Kızıltepe sector: Kepez, Kızıltepe, Kızılçukur and Karakavak
- Tavsan sectors

(Ariana Resources)




**Legend**

*Simplified geology*
- Plutonic rocks
- Sediments
- Carbonates
- Ophiolites
- Metamorphic rocks

*Simplified lithology for volcanic rocks*
- Upper Miocene
- Lower Miocene
- Eocene

*Deposits*
- Epithermal
- Porphyry
- Skarn
- Carlin

Structure
- Fault
- Normal fault
- Suture zone

| Ovacık | Deposit |
|---|---|
| *Koza Gold* | *Company* |

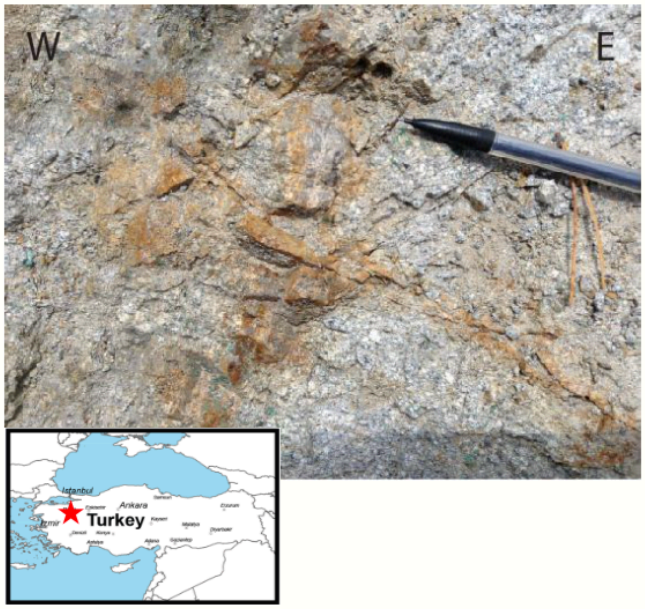
**Söğüt (Carlin?):** Feasibility → 1.87Mt @ 8.59 g/t Au and 0.97 g/t Ag (resources) (Koza Gold)

**Muratdere (Porphyry):** Resource definition → 51Mt @ 1.25 g/t Au, 0.03% Cu, 23.8 g/t Ag (Stratex)

**Demirtepe (Skarn):** Cu-Au-Ag exploration target (Columbus Copper)

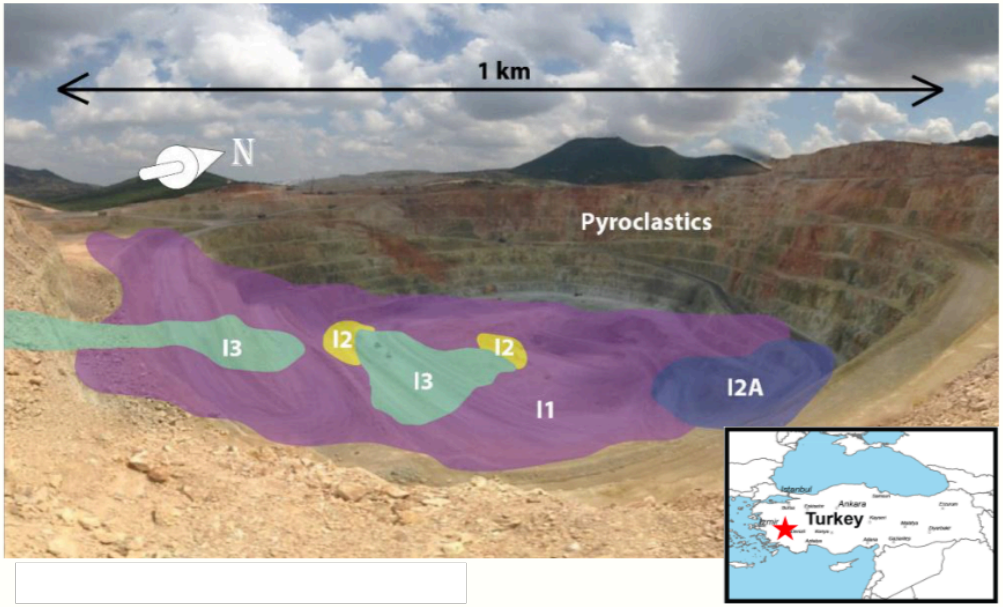
**Karapınar (Cu ± Au-Mo Porphyry):** Resources definition (Columbus Copper)

**Kişladağ (Porphyry):** Production → 10.5Moz Au @ 0.71 g/t (Eldorado Gold)




**Advanced exploration (Bursa district):**

- Cu-bearing quartz stockwork at the Karapınar Cu ± Au-Mo porphyry prospect (Columbus Copper Corp.).
- 4,358 m of drilling in 2013
- KDH028: 31.2m @ 0.45% Cu and 0.08 g/t Au




**Production (Uşak):**

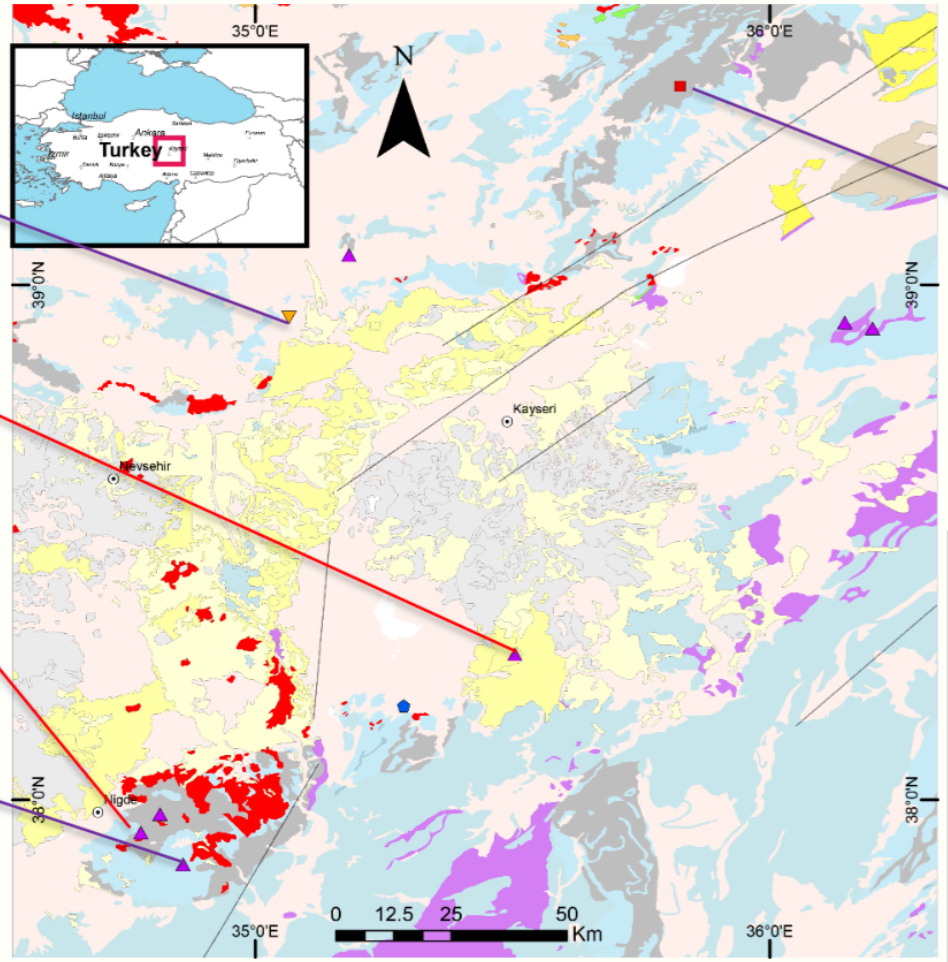
- Kişladağ alkaline Au porphyry deposit (Eldorado Gold/Tüprag)
- Horse-shoe-shaped ore body (I1)
- Reserves (P+P): **10.516Moz @ 0.71 g/t Au**

**Himmetdede (Carlin?):** Mine under construction → 31Mt @ 0.71 g/t Au (Koza Gold)

**Öksüt (high-sulphidation epithermal):** Resources definition → 23.8 Mt @ 1.37 g/t Au (Centerra Gold)

**Gümüşler (Hg-Sb-Au epithermal?):** Exploration drilling (Kenz Madencilik)

**Üçkapılı (Cu hydrothermal):** Exploration drilling (Kenz Madencilik?)




**Yenipazar (VMS):** Feasibility → 2.17Mt @ 2.82 g/t Au and 42.5 g/t Ag including:

- Kızıltepe sector: Kepez, Kızıltepe, Kızılçukur and Karakavak
- Tavsan sectors

(Aldridge Gold)

**Legend**

*Simplified geology*
- Plutonic rocks
- Sediments
- Carbonates
- Ophiolites
- Metamorphic rocks

*Simplified lithology for volcanic rocks*
- Quaternary
- Pliocene
- Upper Miocene
- Lower Miocene

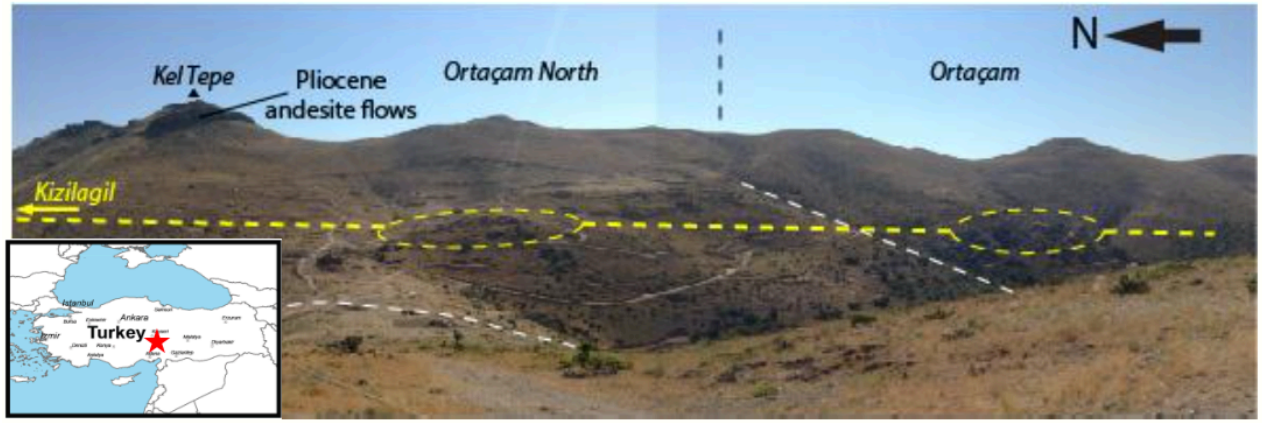
*Deposits*
- Epithermal
- VMS
- Skarn
- Carlin

Structure
- Fault
- Normal fault
- Suture zone

**Ovacık** ***Koza Gold*** **Deposit** ***Company***

**Old mine:** Rasih-Ihsan Hg-Sb-W vein within metamorphic basement (Gümüşler district)

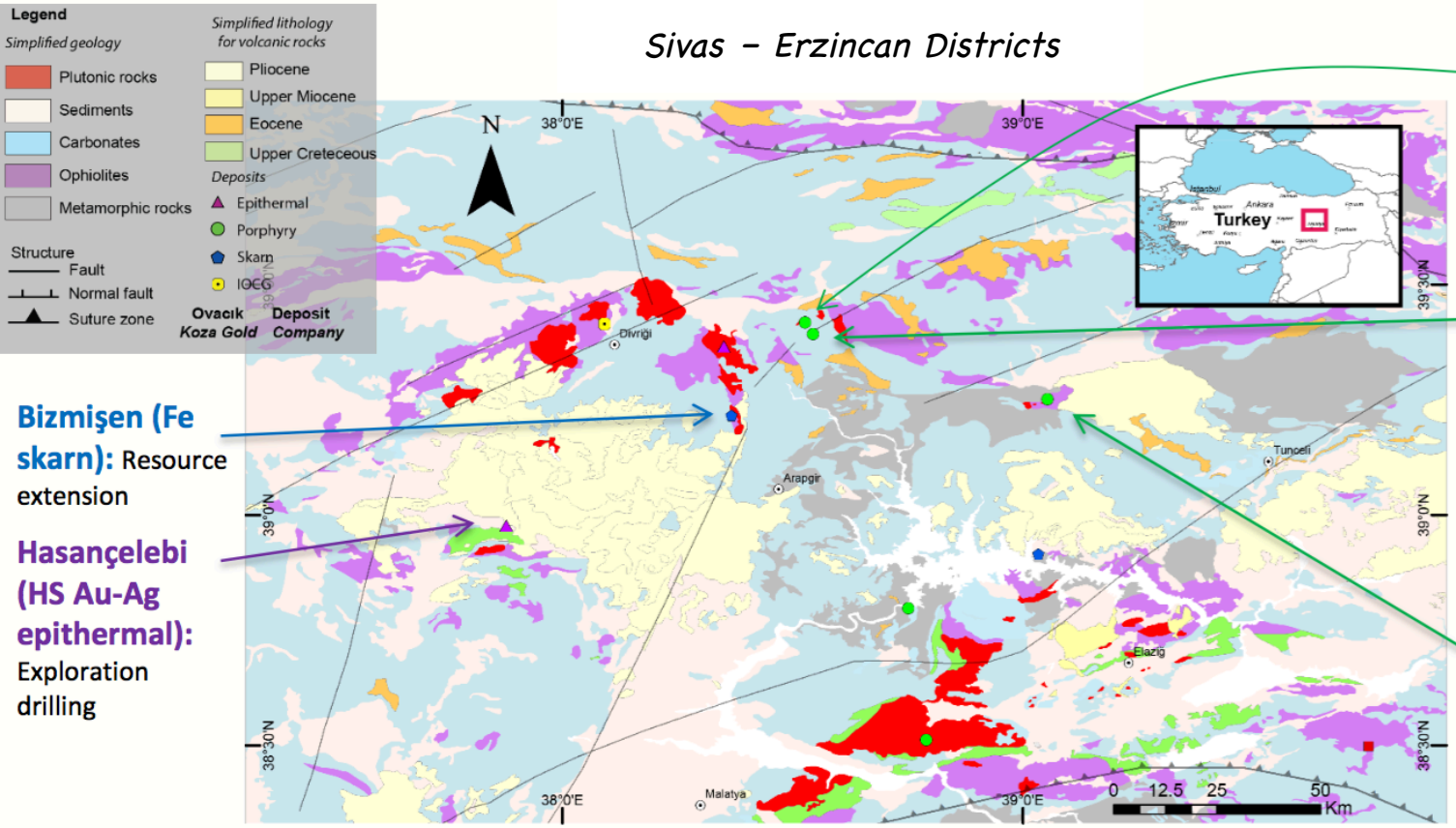
**Current drilling:** Au-Cu exploration (Kenz Madencilik) along E-trending pegmatite veins




**Infill drilling:** High-sulphidation epithermal Au deposit (Ortaçam, Öksüt) by Centerra Gold

- Miocene andesites along the major NE-trending strike-slip Central Anatolia Fault Zone
- NNE-trending silica ledges affected by brecciation (diatreme)

## Sivas – Erzincan Districts




**Çöpler (Porphyry):** Production → 74.4Mt @ 1.4 g/t Au (reserves) and 146.2Mt @ 1.4 g/t Au (resources

**Karakartal (Porphyry):** Resources definition → 13.8Mt @ 0.5 g/t Au, 0.29% Cu (indicated resources) and 17.8 Mt @ 0.3 g/t Au, 0.22% Cu (inferred resources)

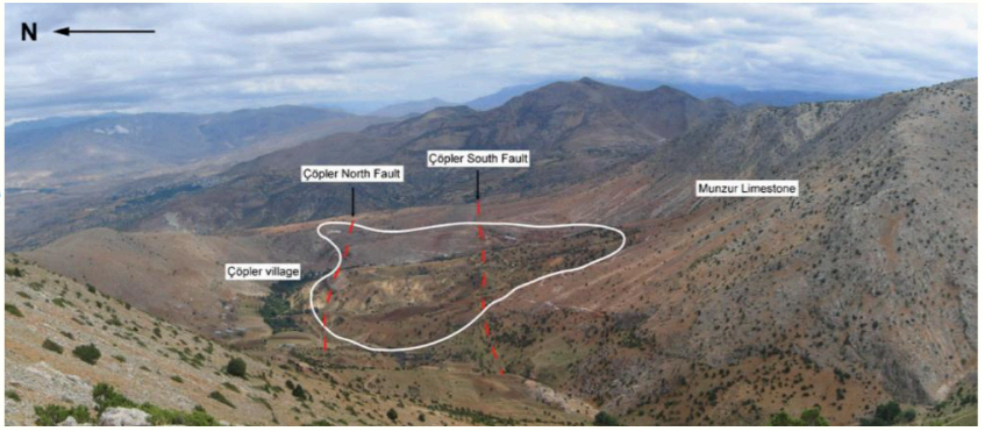
**Bizmişen (Fe skarn):** Resource extension

**Hasançelebi (HS Au-Ag epithermal):** Exploration drilling

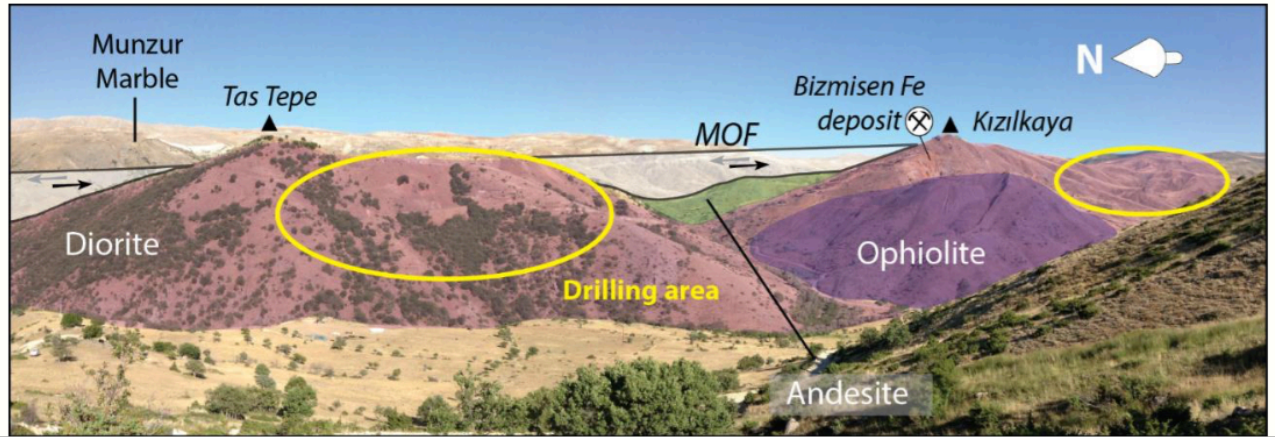
**Cevizlidere (Porphyry):** Resources definition → 445.7Mt @ 0.11 g/t Au, 0.38% Cu, 48ppm Mo (inferred resources)

**Production (Sivas district):**

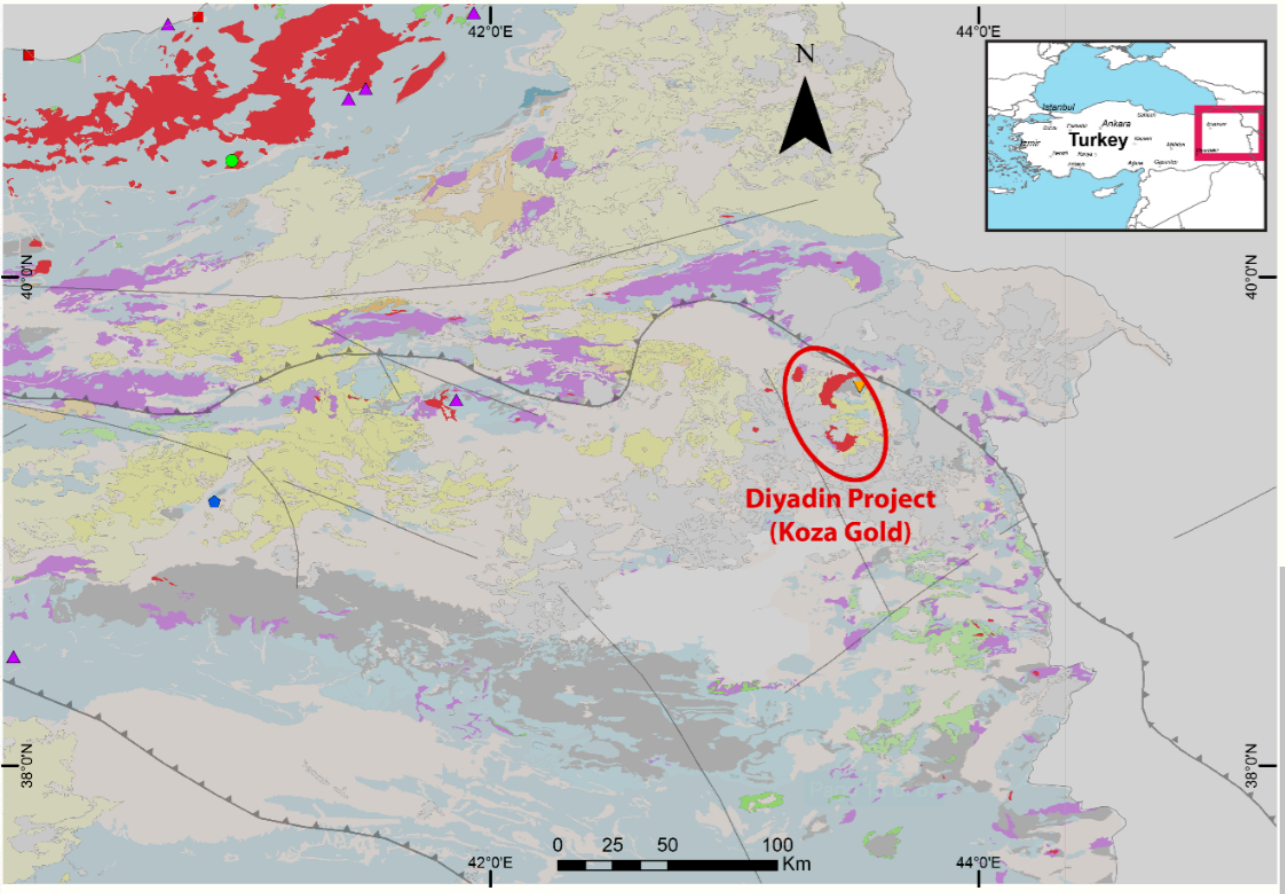
- Çöpler porphyry Au open-pit (80% Alacer Gold, 20% Lydia Mining
- Epithermal-porphyry system within an Eocene composite diorite to monzonite porphyry body intruding
- Crossed by two ENE-trending faults
- Three main zones: Main Zone, Marble Contact Zone, Mn Mine Zone
- Quartz-pyrite stockwork, potassic alteration, superimposed by epithermal-style mineralization




*Çöpler porphyry deposit*




**Brownfield exploration (Sivas district):** extension of the Fe resources, Bizmişen Fe skarn deposit (Bilfer Madençilik)




**Pre-feasibility:** Carlin project in Mollakara-Diyadin area (Koza Gold) that includes:

- Mollakara
- Çakili Tepe
- Taşkapi
- Ağadeve
- Samanyolu

**Eastern Turkish plateau:**

- Widespread Pliocene – Quaternary volcanism
- Low exploration efforts

**Legend**

*Simplified geology*
- Plutonic rocks
- Sediments
- Carbonates
- Ophiolites
- Metamorphic rocks

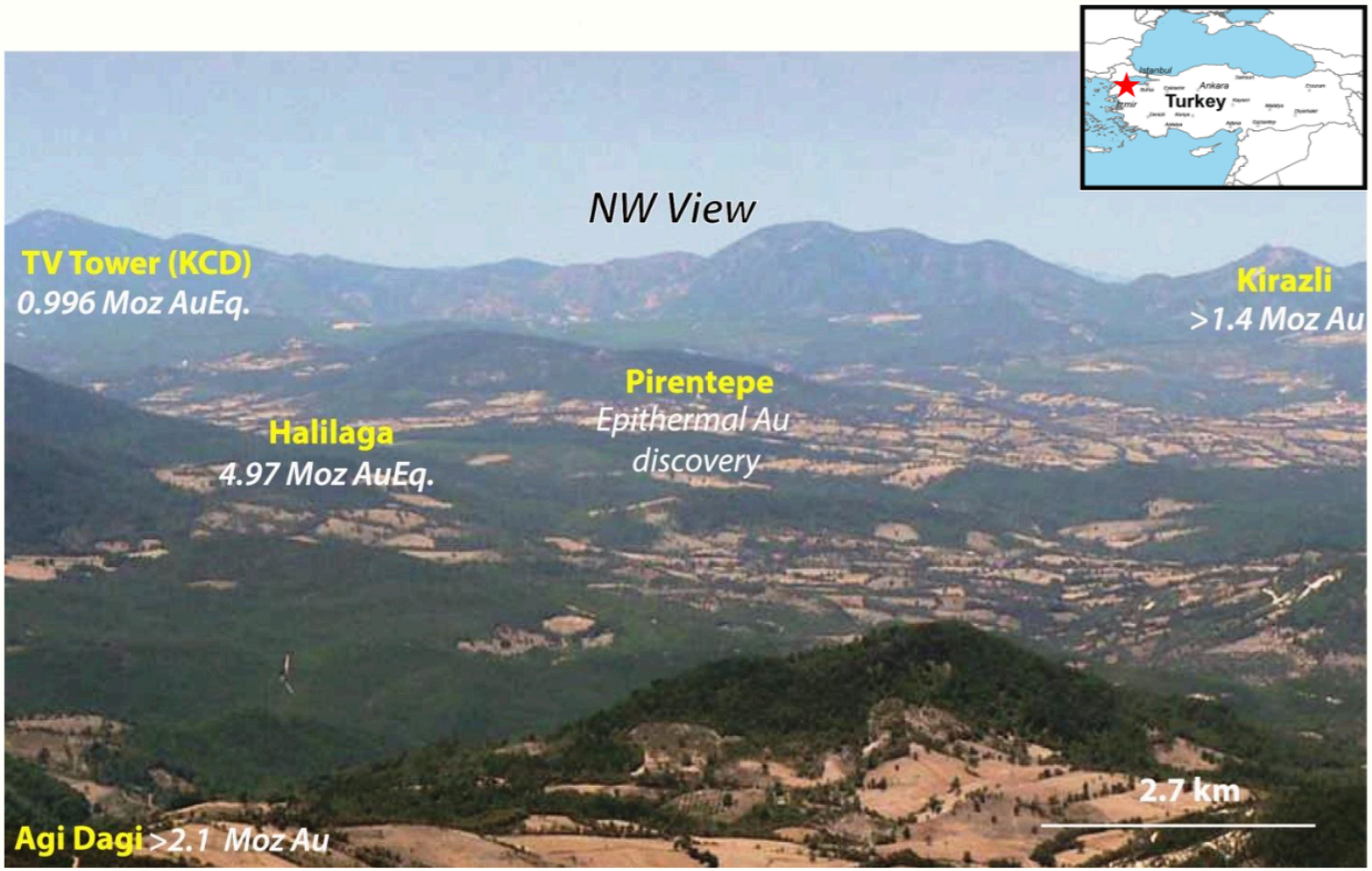
Structure
- Fault
- Normal fault
- Suture zone

*Simplified lithology for volcanic rocks*
- Quaternary
- Pliocene
- Upper Miocene
- Lower Miocene
- Oligocene
- Eocene
- Cretaceous

*Deposits*
- Epithermal
- Porphyry
- Skarn
- VMS
- Carlin

**Mastra** *Koza Gold* **Deposit/prospect** *Company*

- Increasing trend of positive drilling and resource calculations
- The central Biga Peninsula features a relative clustering of Au-Ag +/- Cu occurrences
- Halilağa, Kirazli, Agi Dagi, Kestanelik and Kartaldağ all have defined mineral resources and are currently poised for production




*Resources from: www.pilotgold.com; www.teck.com; www.alamosgold.com*

**Kestanelik** - Chesser Resources
LS epithermal Au-Ag

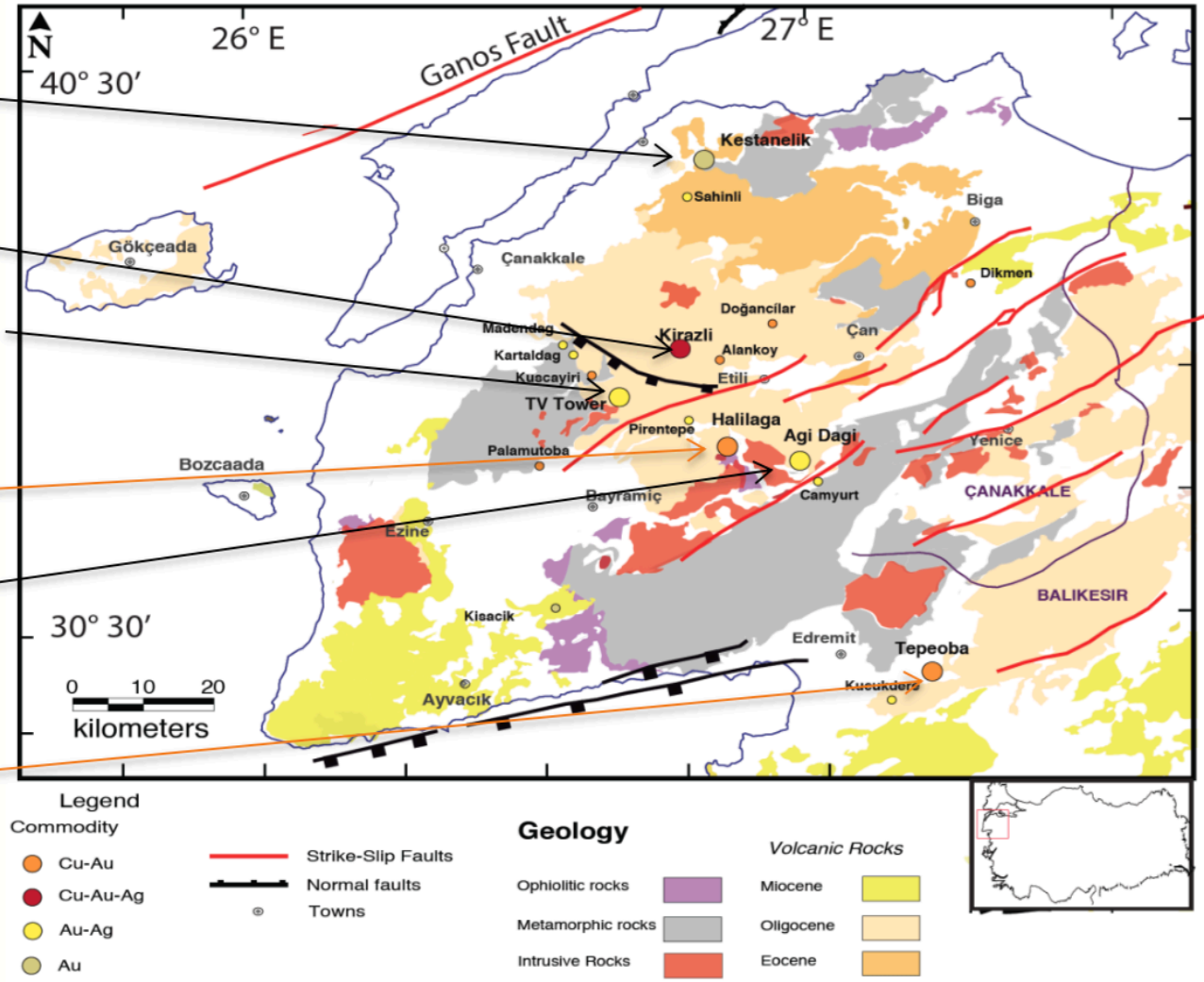
**Kirazli** - Alamos Gold Inc.
HS epithermal Au-Ag

**TV Tower** - Teck/Pilot Gold Inc. (JV)
HS epithermal Au-Ag

**Halilağa** - Teck/Pilot Gold Inc.(JV)
Au-Cu Porphyry

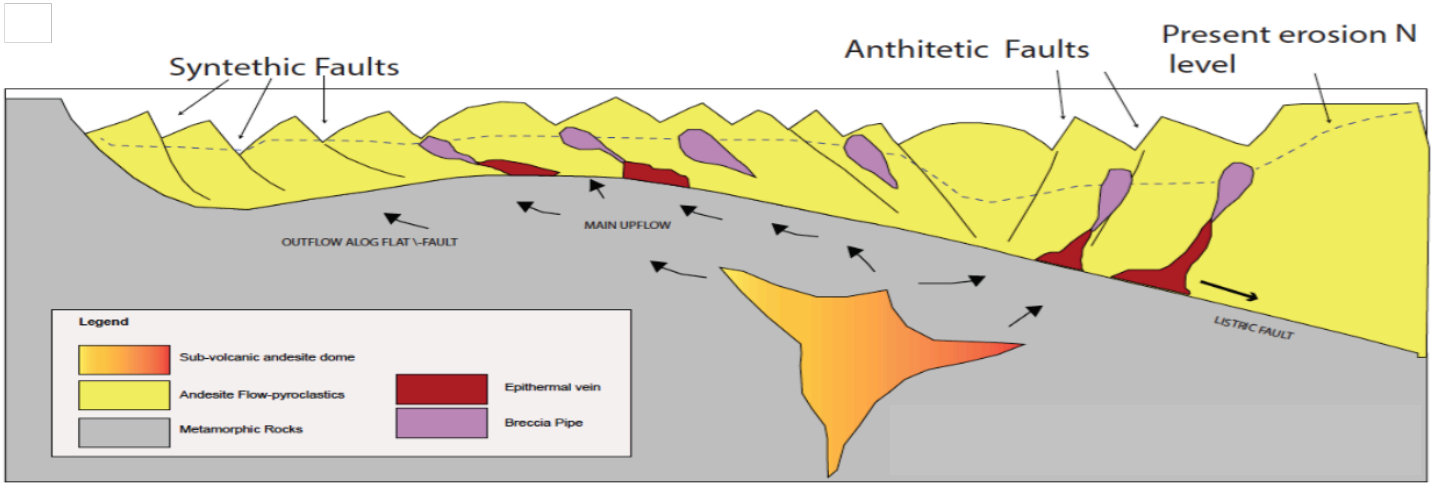
**Aği Daği** - Alamos Gold Inc.
Epithermal Au-Ag

**Tepeoba** - Özdoğu
Cu-Au-Mo Porphyry



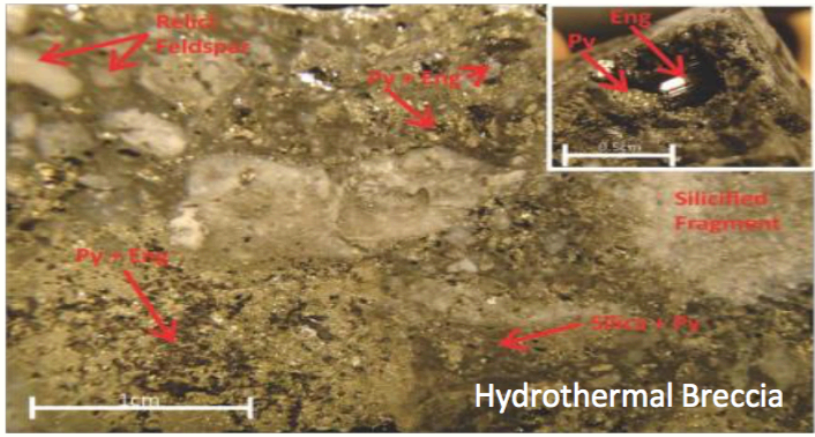
- Low sulphidation epithermal veins hosted within a Paleozoic metamorphic rocks in proximity to the contact of a Oligocene to Miocene porphyry stock.
- Prefeasibility drill program recently completed.
- Resources: 1.6 Mt. at 3.53 g/t Au and 2.6 g/t Ag (183,000 oz Au; 135,000 oz Ag; indicated). 8.5 Mt. at 1.89 g/t Au and 1.8 g/t Ag. (521,000 oz Au; 493,000 oz Ag; inferred).
- Exploration: Chesser Resources

Low sulphidation epithermal vein with calcite after quartz pseudomorphs

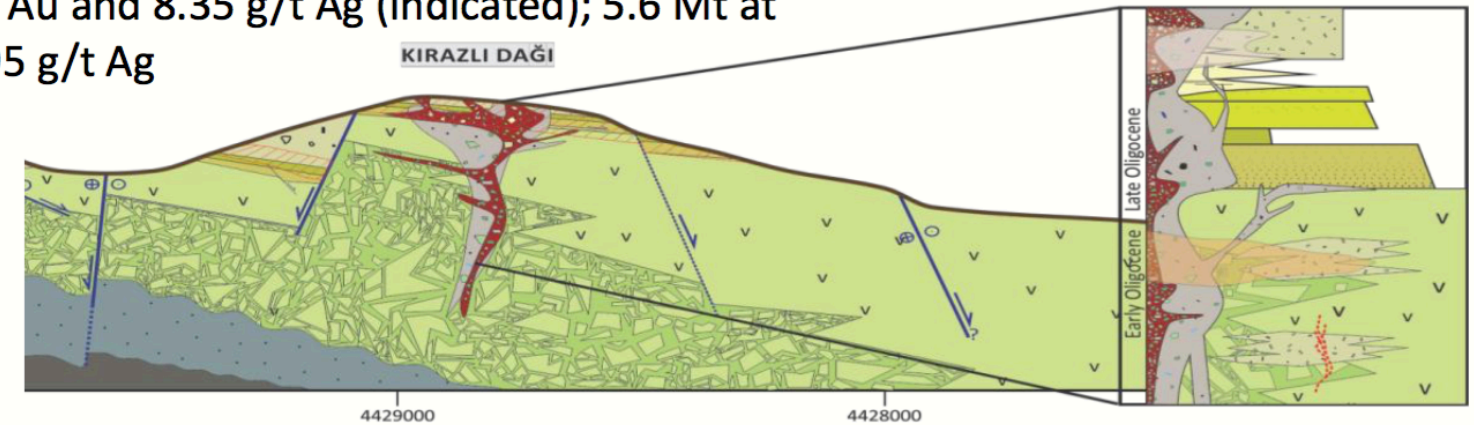


Exploration: Alamos Gold Inc.

- HS epithermal breccia and stratiform-hosted Au-Ag deposit;
- Structurally and stratigraphically controlled Au –Ag mineralization
- Mine life projected for ca. 5 years yielding 495,000 oz. Au and 3,006,000 oz. Ag



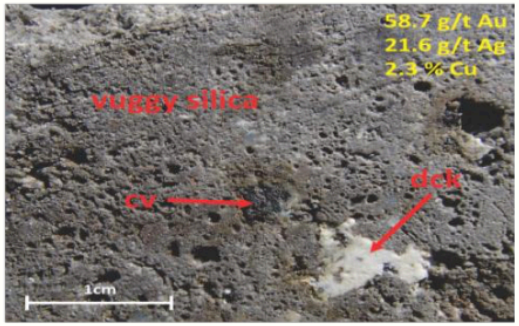

**Resources:** 0.88 Mt at 1.17 g/t Au and 13.22 g/t Ag (measured); 29.9 Mt at 0.70 g/t Au and 8.35 g/t Ag (indicated); 5.6 Mt at 0.52 g/t Au and 9.95 g/t Ag



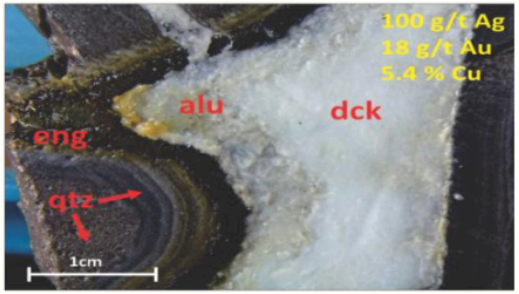
Exploration: Teck Resources / Pilot Gold Inc. (JV)

- High-low sulphidation, breccia and stratiform-hosted Au-Ag;
- Similar stratigraphy and structural setting as Kirazli
- Küçükdağ resource announcement 2014

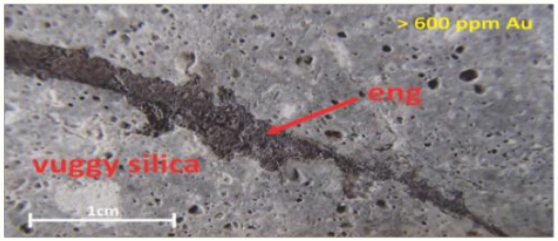
**Küçükdağ**



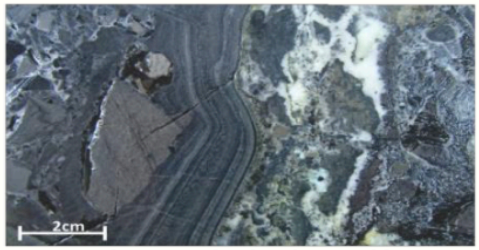
Stratiform Au-Cu in vuggy, blebby tuff



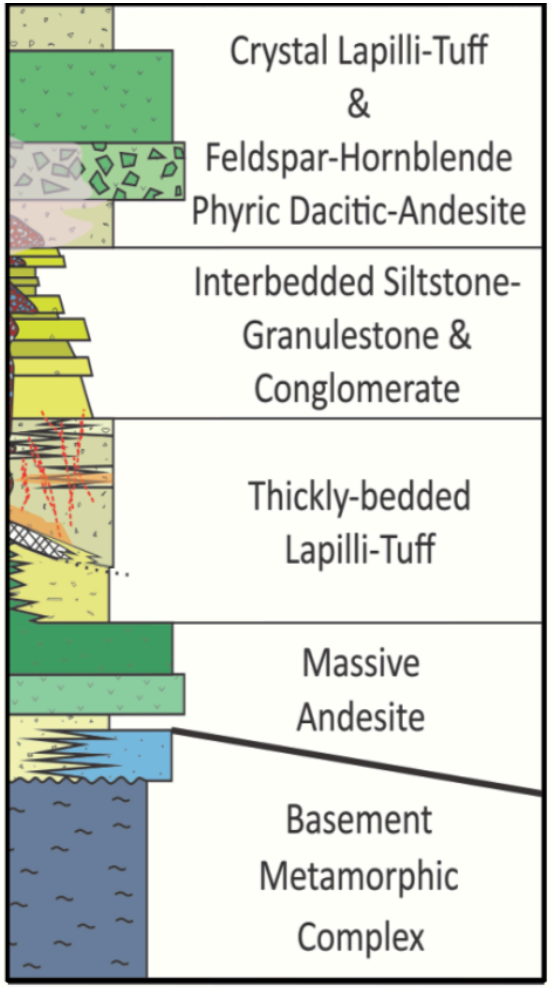
Au - Cu in hydrothermal breccia.



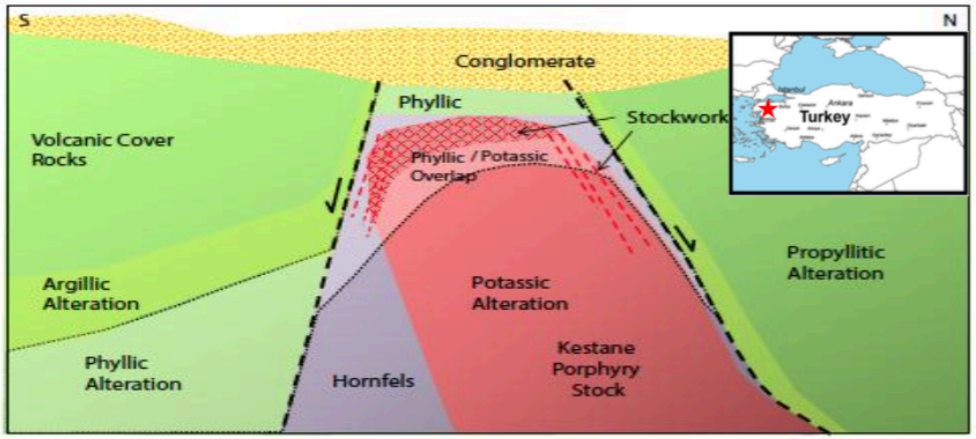
Vein - Au in vuggy silica, blebby tuff



Au in multi-stage hydrothermal breccia.
More detail in petrography section.

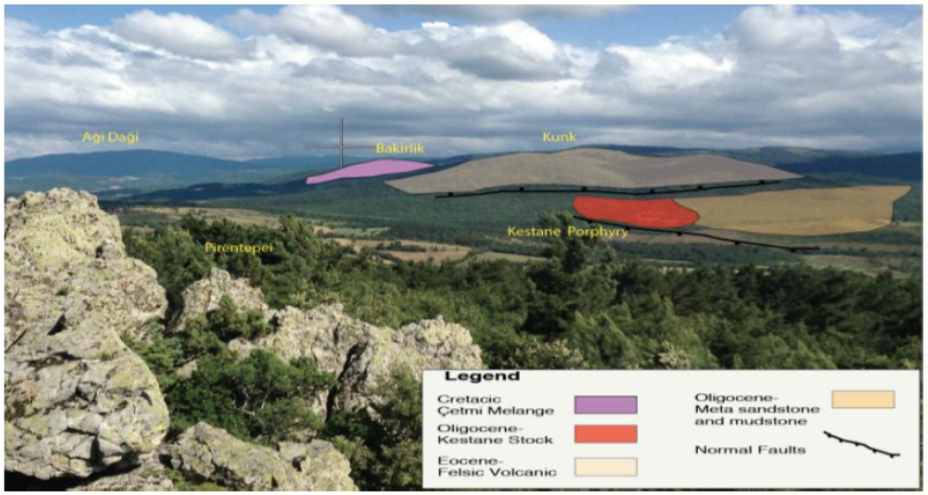


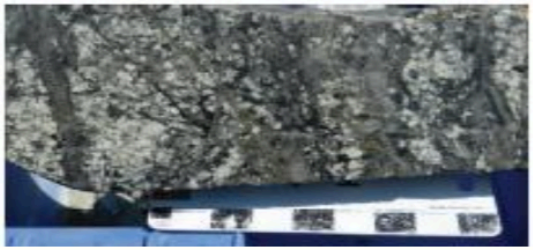
- Oligocene age (24.81, 25.15 Ma);
- Includes a porphyry Cu-Au dominated stock (Kestane), a HS epithermal prospect (Kunk), and a skarn-type occurrence (Bakirlik);
- Early stage of mineralization associated with biotite and magnetite veins
- Structurally modified post-emplacement




Resources (PEA):
168.167 Mt at 0.31 g/t Au , 4.07 g/t Ag and 0.30% Cu (indicated);

198.668 Mt @ 0.26 g/t Au ,2.86 g/t Ag and 0.23% Cu (inferred)



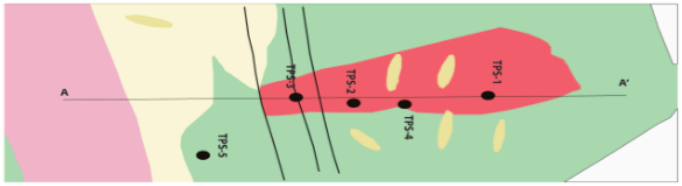


Exploration: Özdoğu

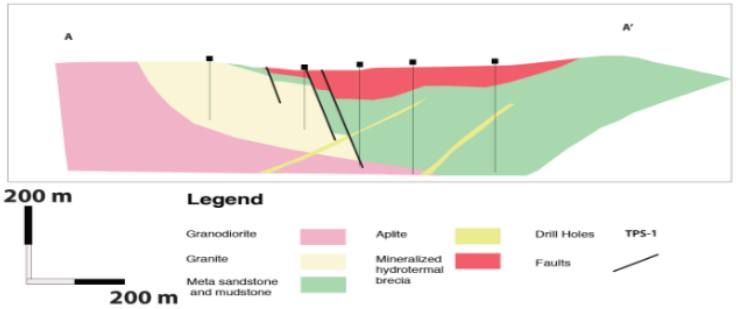
- Associated with volcano-plutonic complexes of ages ranging from Eocene to Early Miocene
- Breccia-hosted Cu- Au-Mo with surrounding veins and veinlets containing: pyrite, chalcopyrite, molybdenite, Au, bornite, malachite, magnetite, hematite;
- Late Oligocene granodioritic and granitic porphyries intruded in metamorphic rocks

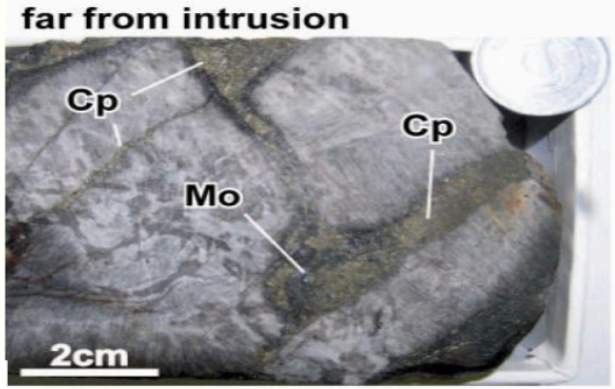
Resource: 19.24Mt at 0.33% Cu, 0.041% Mo + 4.86 Mt at 0.32% Cu, 0.046% Mo (Yigit, 2012)

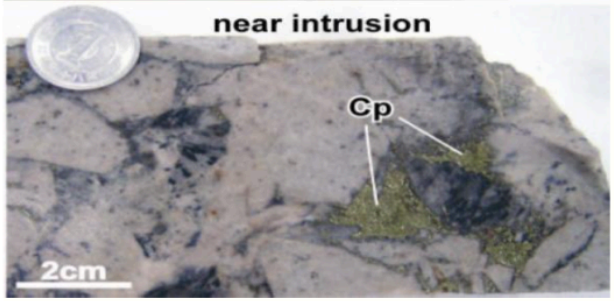
Tepeoba Geology




Geological Cross Section



## NW Turkey

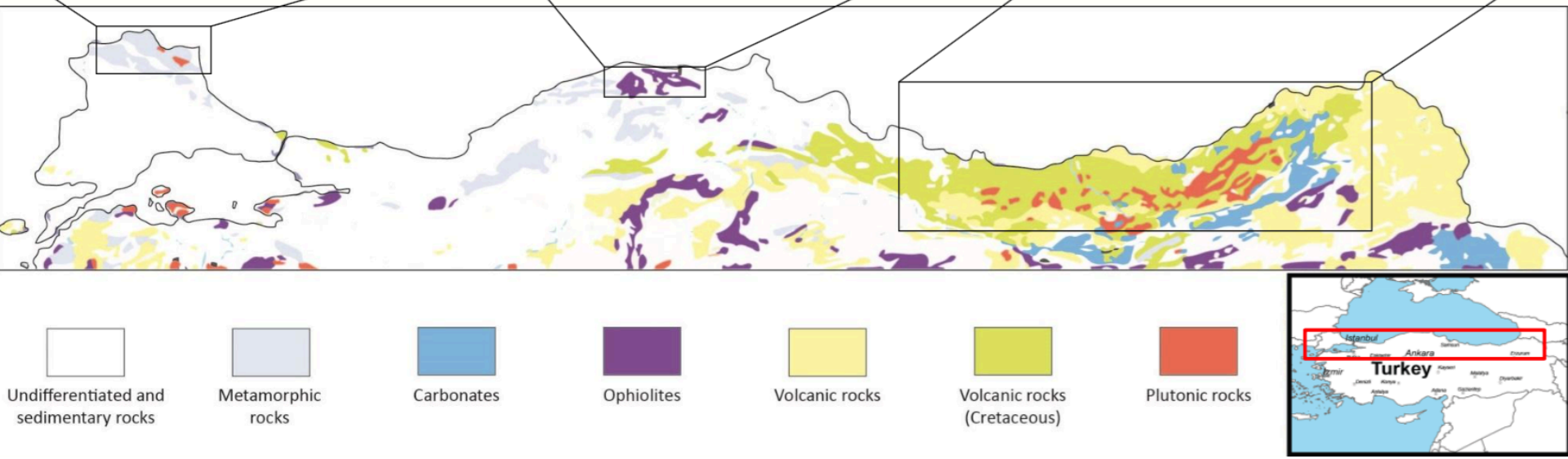
Porphyry Cu-Mo, Cu-Mo-W and skarn systems associated with the Upper Cretaceous granitoid stocks

## Central Pontides

The Cyprus-type VMS Cu system(s) associated with ophiolite-related pre-Liassic basaltic sequences

## Eastern Pontides

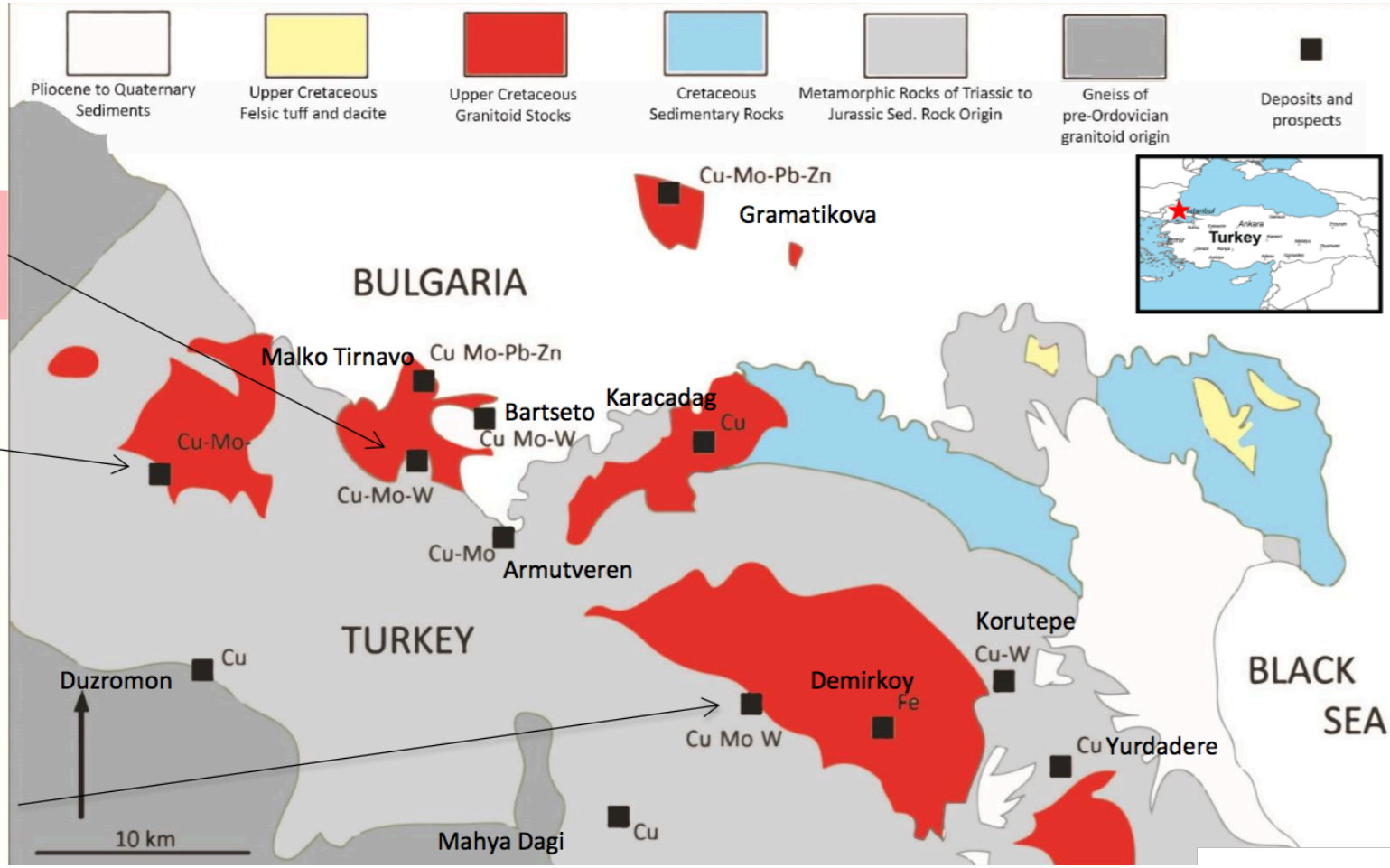
Porphyry Cu-Mo, epithermal Au-Ag, Au-Ag-Pb-Zn, and Kuroko-type VMS systems associated with the Late Cretaceous-Eocene magmatic rocks

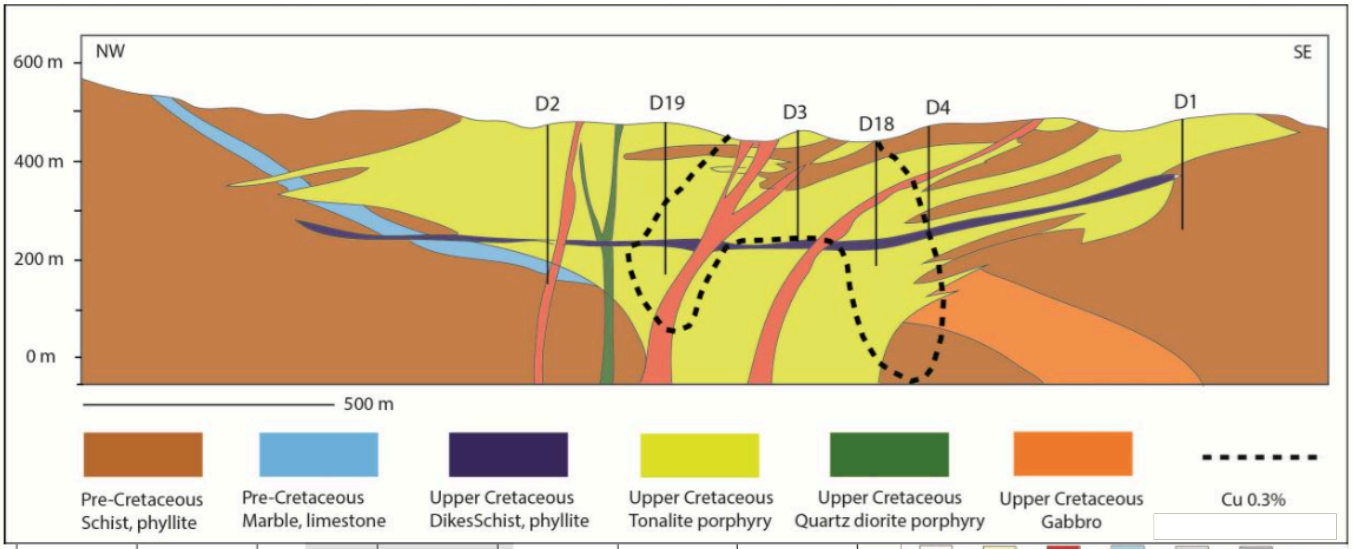


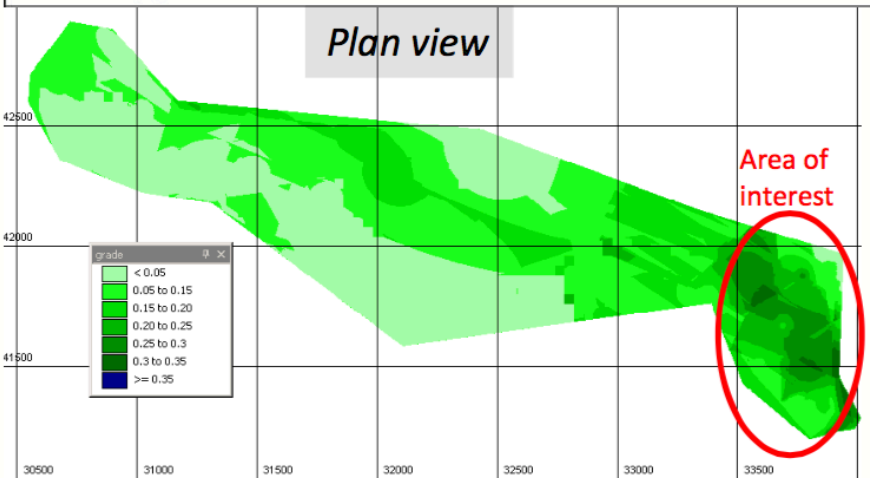
***Sukrupasa***; 0.3-0.4 % Cu; 0.01-0.02 % Mo; 0.01 % $WO_3$; 8 Mt (visiable+probable); MTA

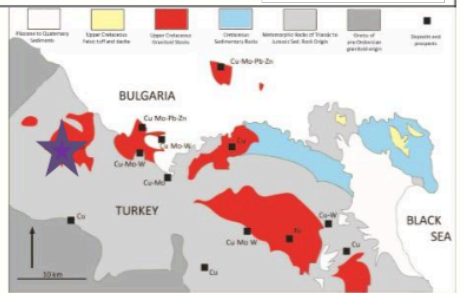
***Derekoy***, 0.25-0.4 % Cu , 0.003 % Mo, 0.01 % W; 220 Mt (possible+probable); MTA

***Ikiztepe***, 0.5 % Cu; 8 Mt (visiable+probable); MTA



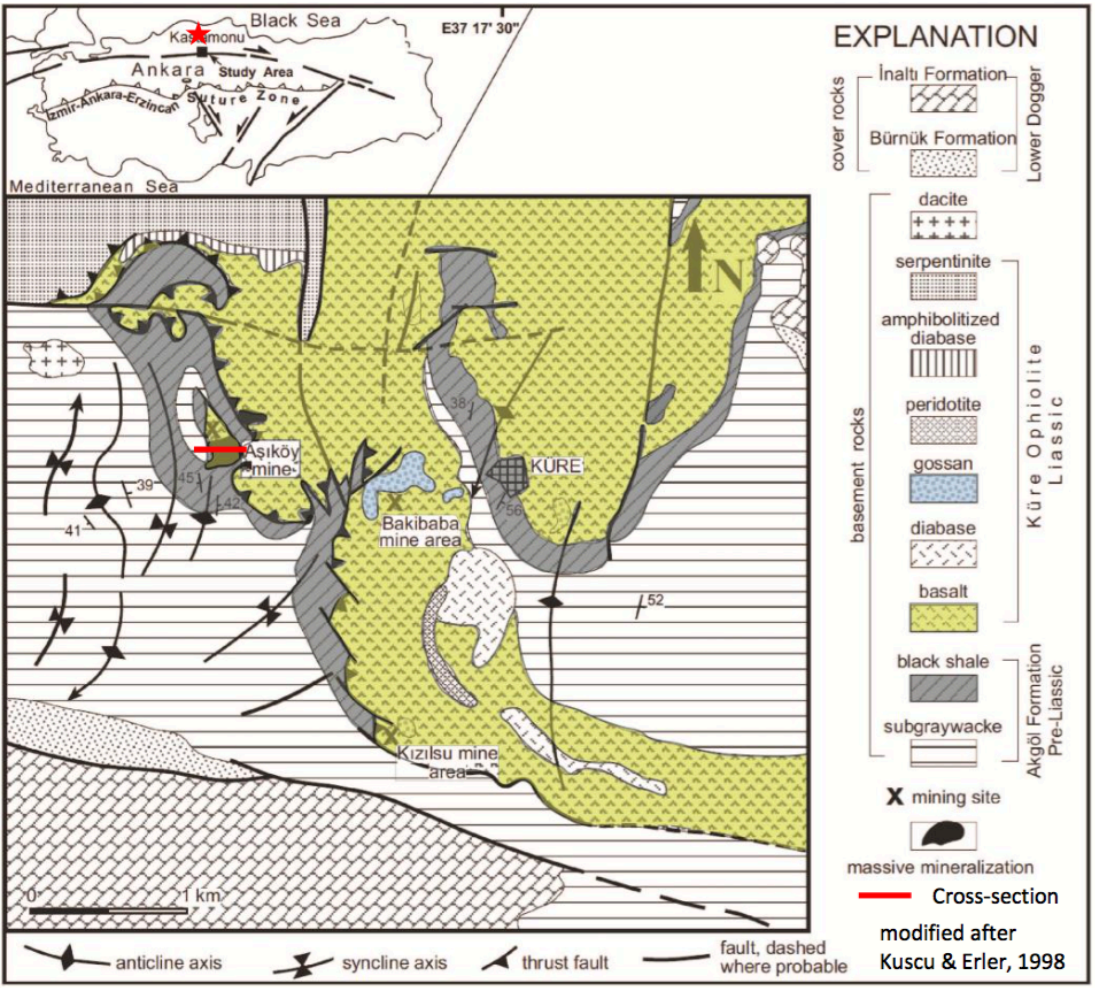


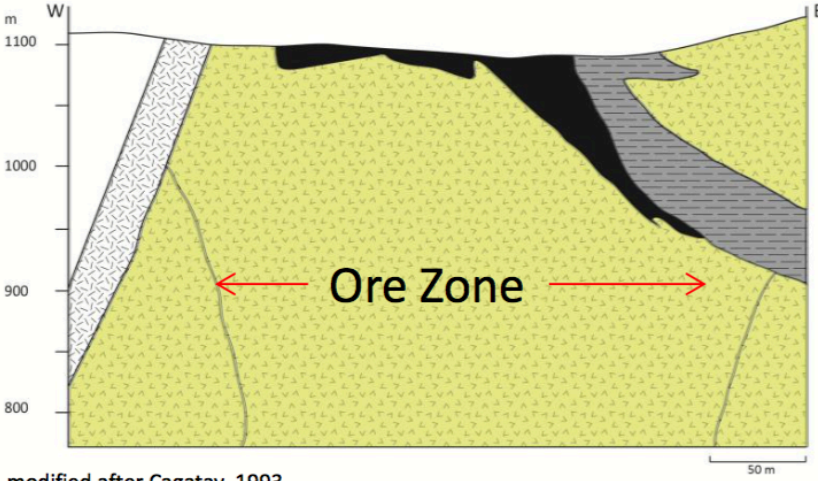
Grade distribution of Derekoy Cu deposit, (2008)

- Resource: ***270 Mt at 0.284% Cu*** (Mutschler et al., 1999); or ***221 Mt at 0.27% Cu*** equiv. (Ersecen, 1989)
- Orebody and structure: Disseminations and stockworks; E-trending monzonite porphyry dikes (Yigit, 2009)
- Age of mineralization: ***76.7 ± 3.8 Ma*** (K-Ar on tonalite porphyry, potassic zone;
- Status: Prospect

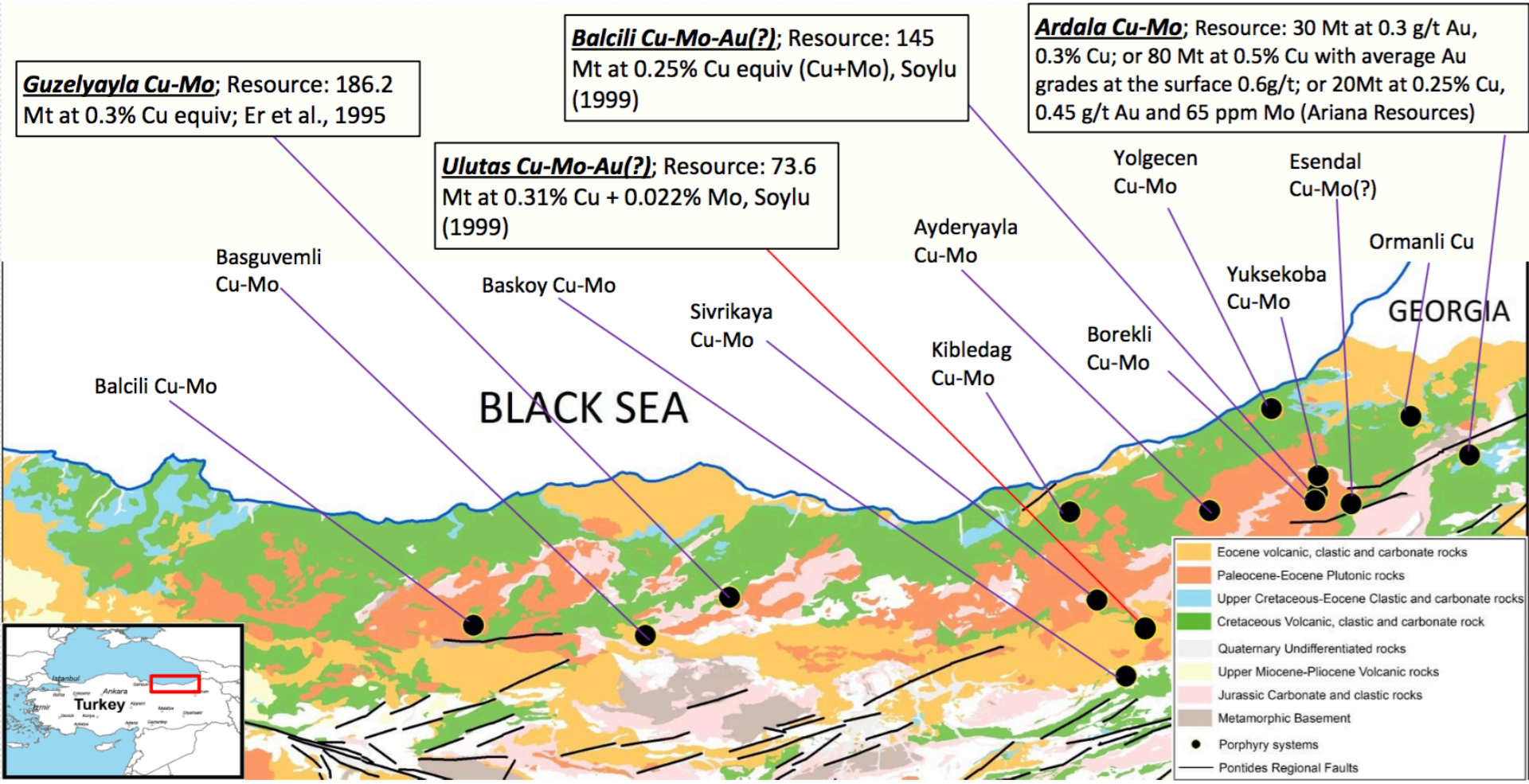


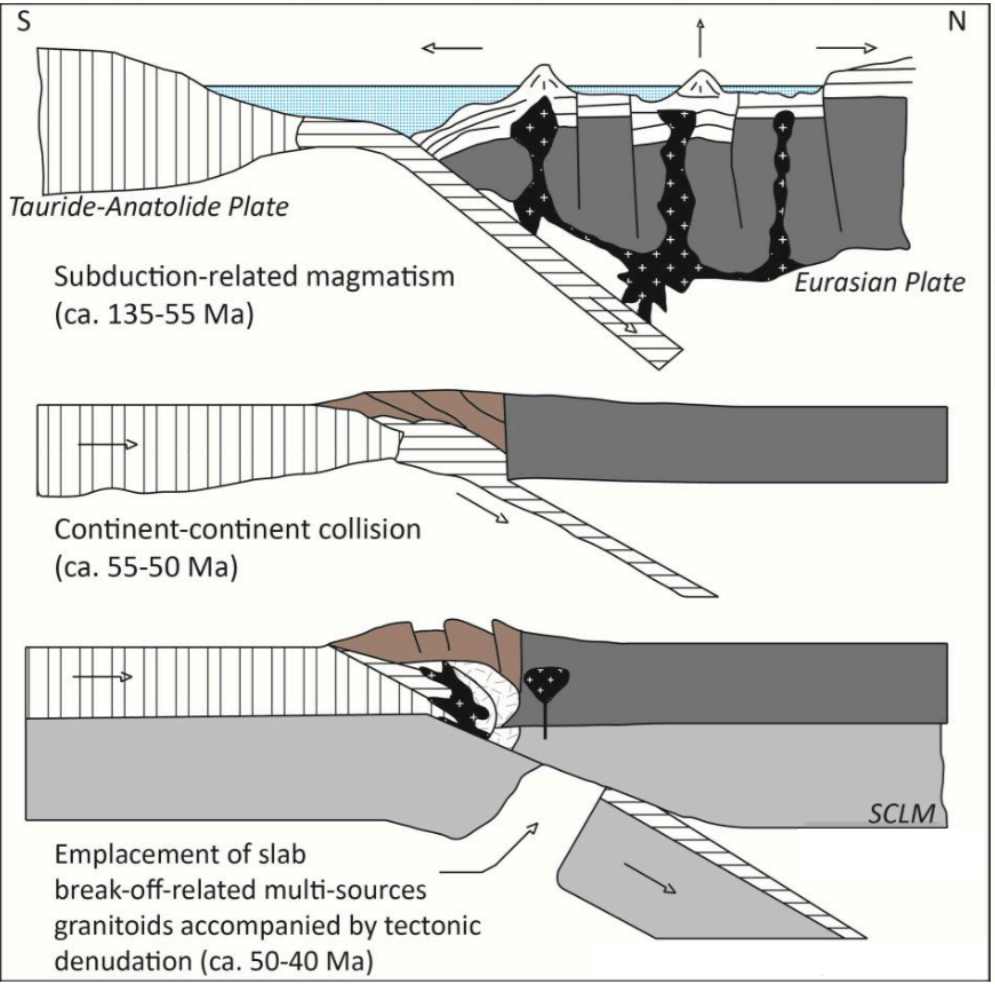

modified after Kuscu & Erler, 1998

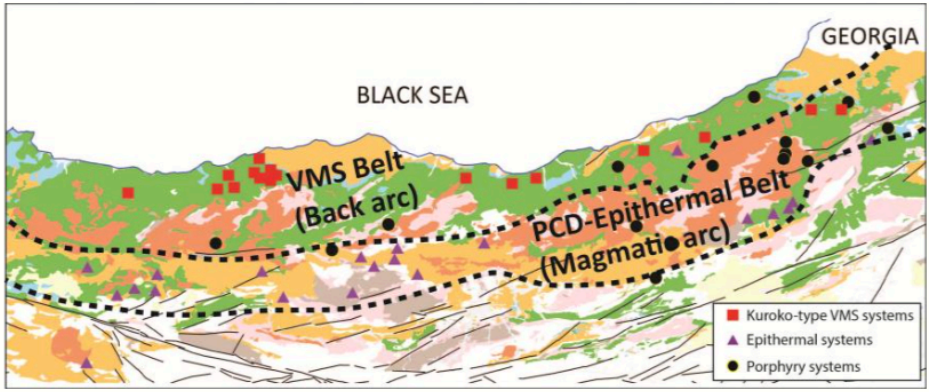
- Kure is a Cyprus-type VMS Cu-Au-Ag mine.
- Reserve: 11.23 Mt at 1.56% Cu, 2.48 g/t Au, 10 g/t Ag
- Hosted by ophiolite-related pre-Liassic basaltic sequences;
- A lithological control on ore formation. Black shale – basalt contacts regarded as the primary target zones for further exploration programs.




modified after Cagatay. 1993

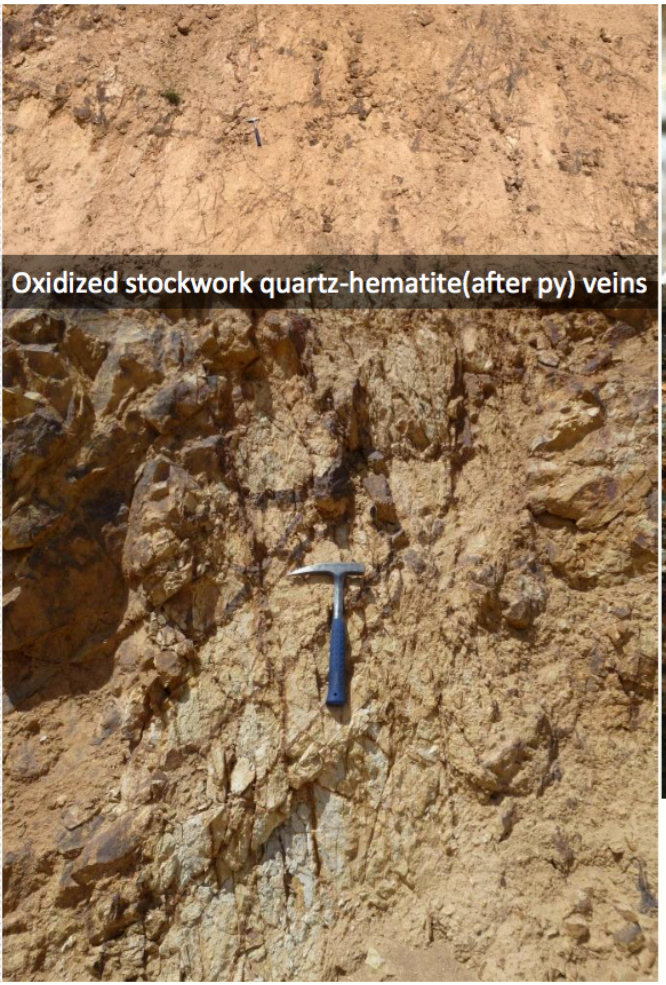

Guzelyayla Cu-Mo; Resource: 186.2 Mt at 0.3% Cu equiv; Er et al., 1995
Balcili Cu-Mo-Au(?); Resource: 145 Mt at 0.25% Cu equiv (Cu+Mo), Soylu (1999)
Ardala Cu-Mo; Resource: 30 Mt at 0.3 g/t Au, 0.3% Cu; or 80 Mt at 0.5% Cu with average Au grades at the surface 0.6g/t; or 20Mt at 0.25% Cu, 0.45 g/t Au and 65 ppm Mo (Ariana Resources)
Ulutas Cu-Mo-Au(?); Resource: 73.6 Mt at 0.31% Cu + 0.022% Mo, Soylu (1999)
Yolgecen Cu-Mo
Esendal Cu-Mo(?)
Ayderyayla Cu-Mo
Ormanli Cu
Basguvemli Cu-Mo
Yuksekoba Cu-Mo
Baskoy Cu-Mo
GEORGIA
Sivrikaya Cu-Mo
Borekli Cu-Mo
Kibledag Cu-Mo
Balcili Cu-Mo
BLACK SEA
Eocene volcanic, clastic and carbonate rocks
Paleocene-Eocene Plutonic rocks
Upper Cretaceous-Eocene Clastic and carbonate rocks
Cretaceous Volcanic, clastic and carbonate rock
Quaternary Undifferentiated rocks
Upper Miocene-Pliocene Volcanic rocks
Jurassic Carbonate and clastic rocks
Metamorphic Basement
Porphyry systems
Pontides Regional Faults
Istanbul
Ankara
Turkey




## ***Northward vs. Southward subduction***

- Association of Kuroko-type VMS deposits and back-arc region
- Spatial distribution of Late Cretaceous arc magmatic rocks and syn- and post-collision related early-middle Eocene magmatic rocks
- Presence of adakitic signature and possibly related with slab break-off subducted slab and delamination of SCLM

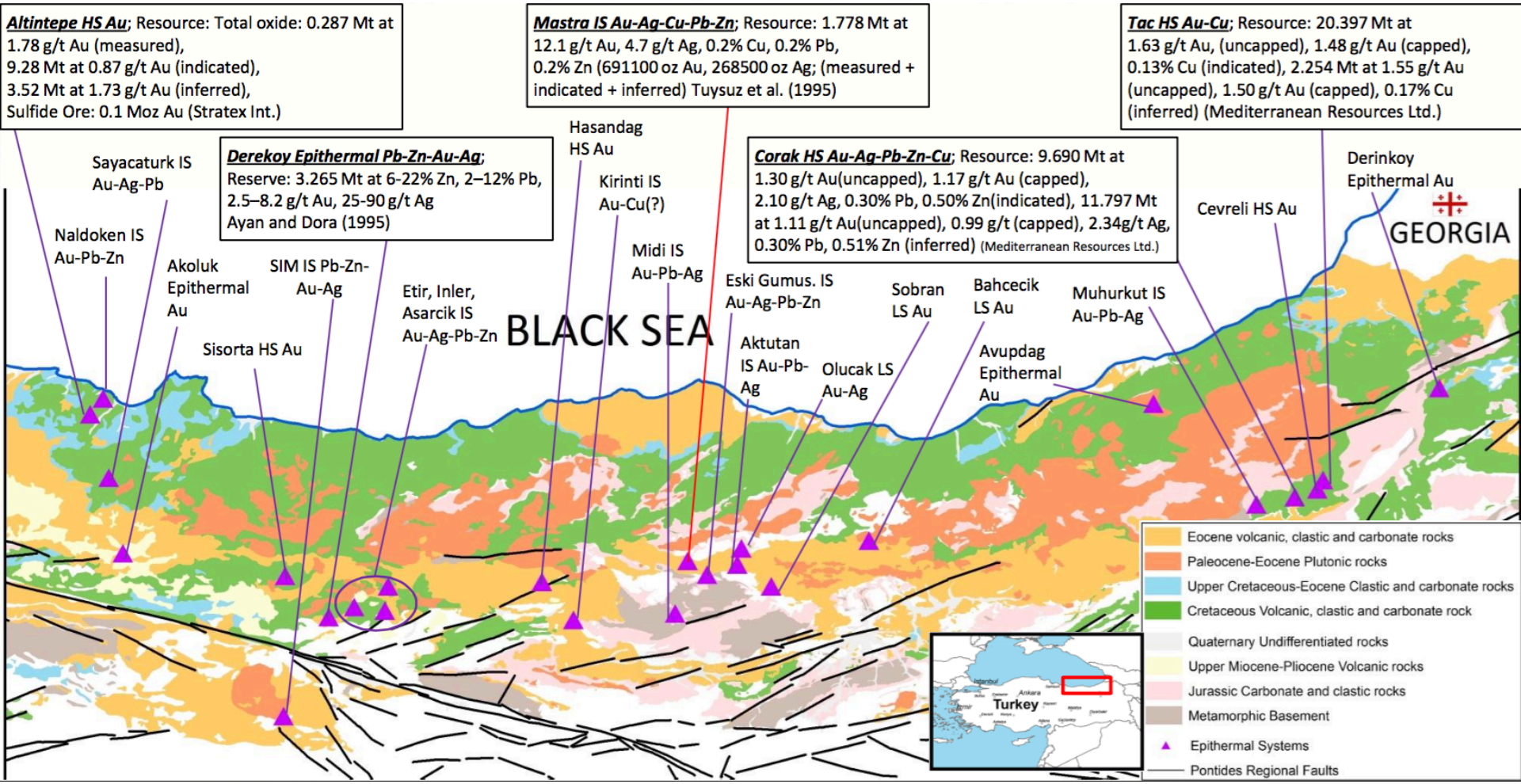


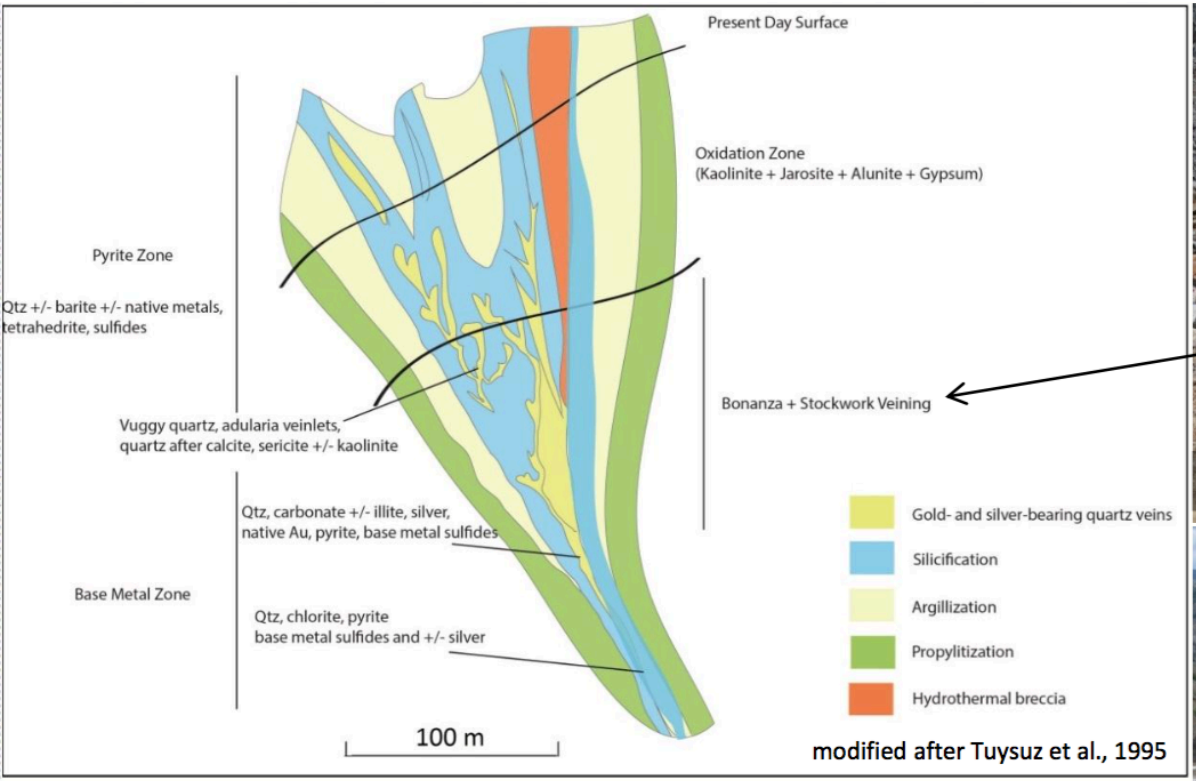
Oxidized stockwork quartz-hematite(after py) veins

Molybdenite-chalcopyrite-pyrite-quartz-malachite association

Stockwork qtz-moly veins in potassic-phyllic transition zone

Currently drilled by Demir Export Mining


Altintepe HS Au; Resource: Total oxide: 0.287 Mt at 1.78 g/t Au (measured), 9.28 Mt at 0.87 g/t Au (indicated), 3.52 Mt at 1.73 g/t Au (inferred), Sulfide Ore: 0.1 Moz Au (Stratex Int.)
Mastra IS Au-Ag-Cu-Pb-Zn; Resource: 1.778 Mt at 12.1 g/t Au, 4.7 g/t Ag, 0.2% Cu, 0.2% Pb, 0.2% Zn (691100 oz Au, 268500 oz Ag; (measured + indicated + inferred) Tuysuz et al. (1995)
Tac HS Au-Cu; Resource: 20.397 Mt at 1.63 g/t Au, (uncapped), 1.48 g/t Au (capped), 0.13% Cu (indicated), 2.254 Mt at 1.55 g/t Au (uncapped), 1.50 g/t Au (capped), 0.17% Cu (inferred) (Mediterranean Resources Ltd.)
Derekoy Epithermal Pb-Zn-Au-Ag; Reserve: 3.265 Mt at 6-22% Zn, 2–12% Pb, 2.5–8.2 g/t Au, 25-90 g/t Ag Ayan and Dora (1995)
Corak HS Au-Ag-Pb-Zn-Cu; Resource: 9.690 Mt at 1.30 g/t Au(uncapped), 1.17 g/t Au (capped), 2.10 g/t Ag, 0.30% Pb, 0.50% Zn(indicated), 11.797 Mt at 1.11 g/t Au(uncapped), 0.99 g/t (capped), 2.34g/t Ag, 0.30% Pb, 0.51% Zn (inferred) (Mediterranean Resources Ltd.)
Sayacaturk IS Au-Ag-Pb
Naldoken IS Au-Pb-Zn
Akoluk Epithermal Au
SIM IS Pb-Zn-Au-Ag
Sisorta HS Au
Etir, Inler, Asarcik IS Au-Ag-Pb-Zn
Hasandag HS Au
Kirinti IS Au-Cu(?)
Midi IS Au-Pb-Ag
BLACK SEA
Eski Gumus. IS Au-Ag-Pb-Zn
Aktutan IS Au-Pb-Ag
Olucak LS Au-Ag
Sobran LS Au
Bahcecik LS Au
Avupdag Epithermal Au
Muhurkut IS Au-Pb-Ag
Cevreli HS Au
Derinkoy Epithermal Au
GEORGIA
Eocene volcanic, clastic and carbonate rocks
Paleocene-Eocene Plutonic rocks
Upper Cretaceous-Eocene Clastic and carbonate rocks
Cretaceous Volcanic, clastic and carbonate rock
Quaternary Undifferentiated rocks
Upper Miocene-Pliocene Volcanic rocks
Jurassic Carbonate and clastic rocks
Metamorphic Basement
Epithermal Systems
Pontides Regional Faults
Turkey

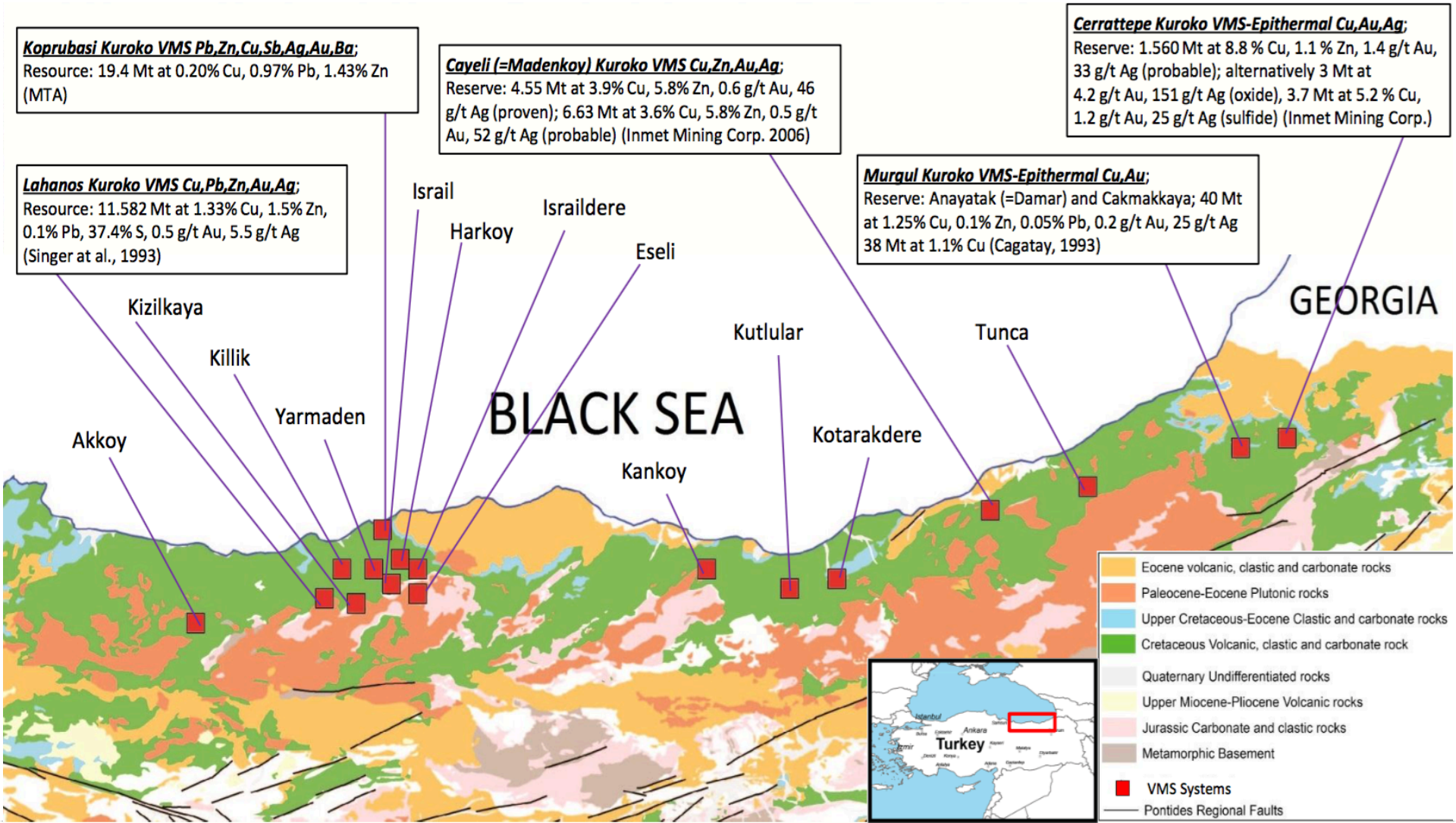


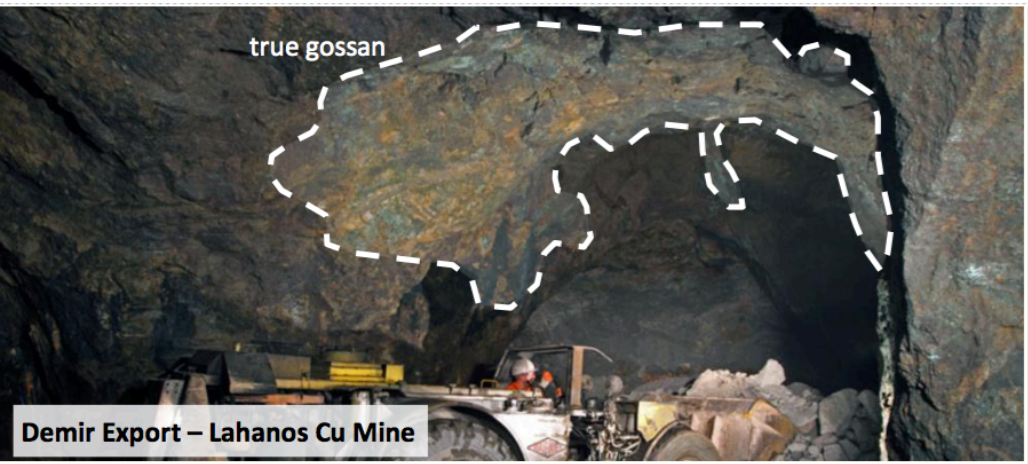

modified after Tuysuz et al., 1995

Mineralized zone trending in N50-70W/60-85SW

An overturned syncline to the south

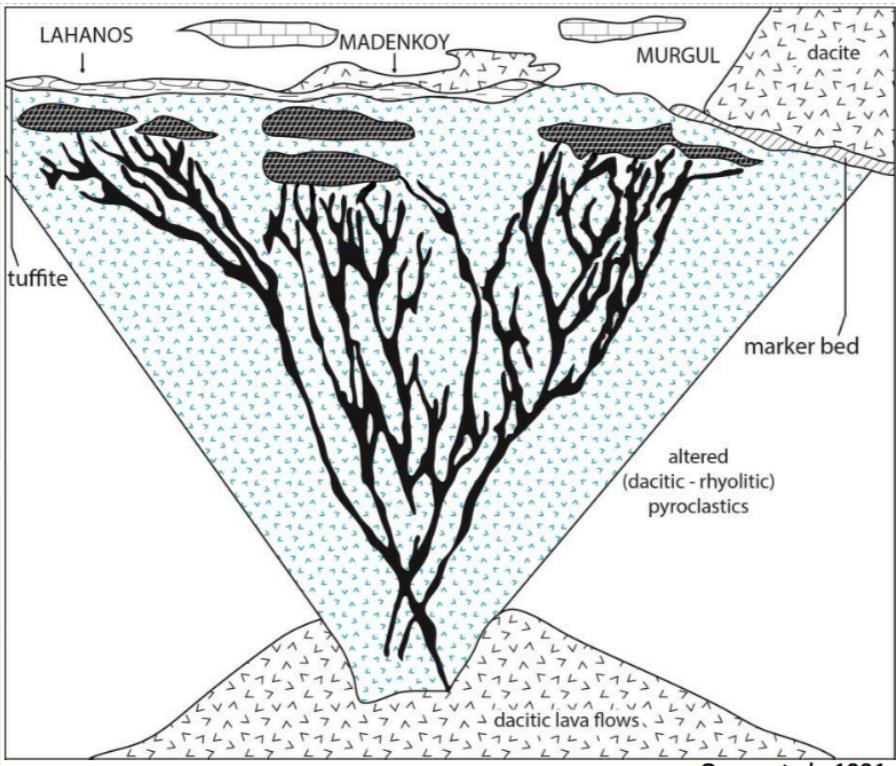
- Resource: ***1.778 Mt at 12.1 g/t Au***, 4.7 g/t Ag, 0.2% Cu, 0.2% Pb, 0.2% Zn, (***691100 oz Au***, 268500 oz Ag; measured + indicated + inferred)
- Ore body and structure: Stockworks with local brecciation; NW trending shear zone
- Age of host rocks: Eocene
- Status: Mine


Koprubasi Kuroko VMS Pb,Zn,Cu,Sb,Ag,Au,Ba;
Resource: 19.4 Mt at 0.20% Cu, 0.97% Pb, 1.43% Zn (MTA)
Cayeli (=Madenkoy) Kuroko VMS Cu,Zn,Au,Ag;
Reserve: 4.55 Mt at 3.9% Cu, 5.8% Zn, 0.6 g/t Au, 46 g/t Ag (proven); 6.63 Mt at 3.6% Cu, 5.8% Zn, 0.5 g/t Au, 52 g/t Ag (probable) (Inmet Mining Corp. 2006)
Cerrattepe Kuroko VMS-Epithermal Cu,Au,Ag;
Reserve: 1.560 Mt at 8.8 % Cu, 1.1 % Zn, 1.4 g/t Au, 33 g/t Ag (probable); alternatively 3 Mt at 4.2 g/t Au, 151 g/t Ag (oxide), 3.7 Mt at 5.2 % Cu, 1.2 g/t Au, 25 g/t Ag (sulfide) (Inmet Mining Corp.)
Lahanos Kuroko VMS Cu,Pb,Zn,Au,Ag;
Resource: 11.582 Mt at 1.33% Cu, 1.5% Zn, 0.1% Pb, 37.4% S, 0.5 g/t Au, 5.5 g/t Ag (Singer at al., 1993)
Murgul Kuroko VMS-Epithermal Cu,Au;
Reserve: Anayatak (=Damar) and Cakmakkaya; 40 Mt at 1.25% Cu, 0.1% Zn, 0.05% Pb, 0.2 g/t Au, 25 g/t Ag 38 Mt at 1.1% Cu (Cagatay, 1993)
Israil
Harkoy
Israildere
Eseli
Kizilkaya
Killik
Yarmaden
Akkoy
Kutlular
Tunca
Kotarakdere
Kankoy
BLACK SEA
GEORGIA
Eocene volcanic, clastic and carbonate rocks
Paleocene-Eocene Plutonic rocks
Upper Cretaceous-Eocene Clastic and carbonate rocks
Cretaceous Volcanic, clastic and carbonate rock
Quaternary Undifferentiated rocks
Upper Miocene-Pliocene Volcanic rocks
Jurassic Carbonate and clastic rocks
Metamorphic Basement
VMS Systems
Pontides Regional Faults
Turkey

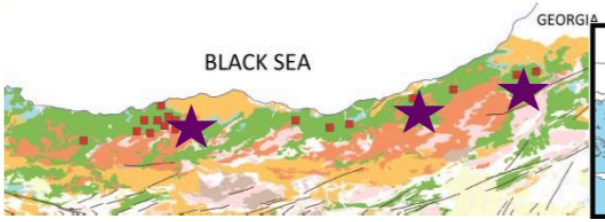


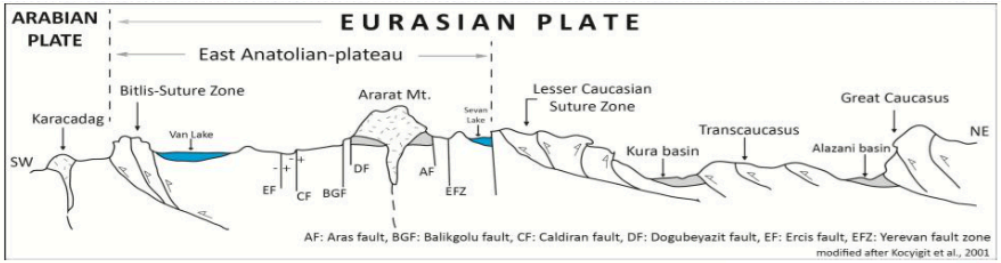

Demir Export – Lahanos Cu Mine

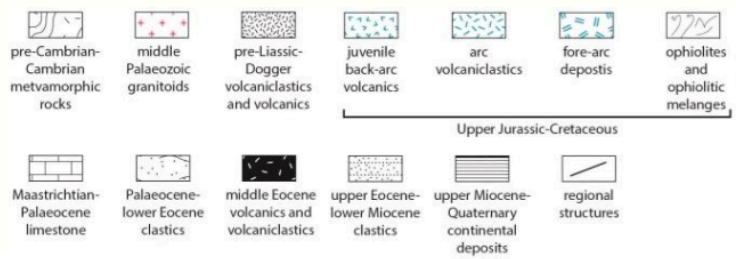
Murgul Cu Mine, hosted by Late Cretaceous dacites (purple)

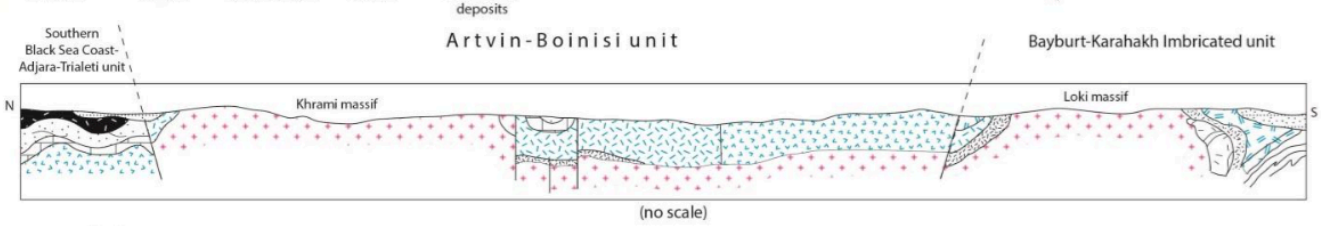


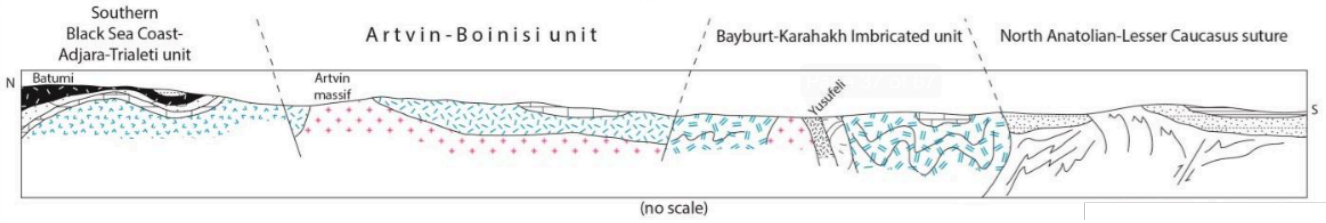

Ozgur et al., 1991

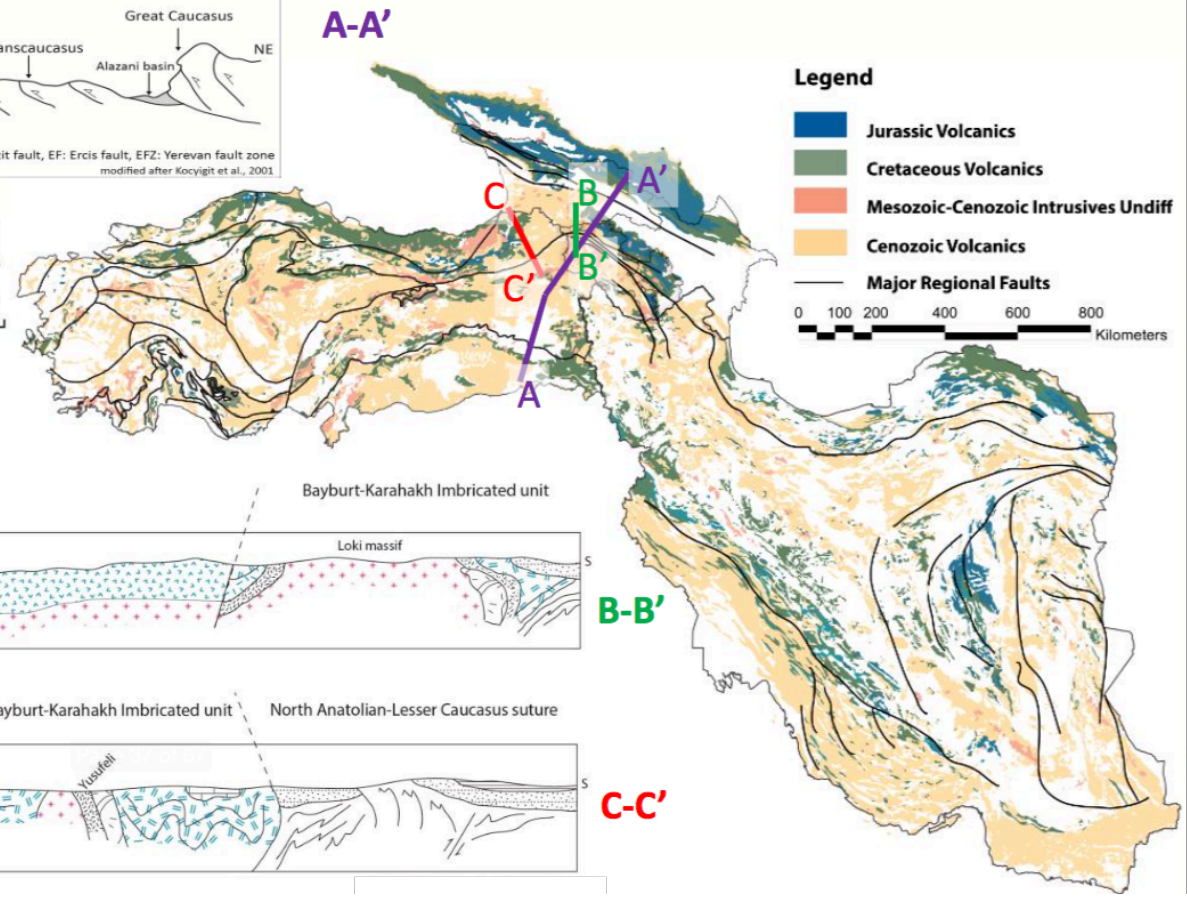



ARABIAN PLATE
EURASIAN PLATE
East Anatolian-plateau
Bitlis-Suture Zone
Ararat Mt.
Lesser Caucasian Suture Zone
Great Caucasus
Karacadag
Van Lake
Sevan Lake
Transcaucasus
Kura basin
Alazani basin
SW
NE
EF
CF
BGF
DF
AF
EFZ
AF: Aras fault, BGF: Balikgolu fault, CF: Caldiran fault, DF: Dogubeyazit fault, EF: Ercis fault, EFZ: Yerevan fault zone
modified after Kocyigit et al., 2001


pre-Cambrian-Cambrian metvamorphic rocks
middle Palaeozoic granitoids
pre-Liassic-Dogger volcaniclastics and volcanics
juvenile back-arc volcanics
arc volcaniclastics
fore-arc depostis
ophiolites and ophiolitic melanges
Upper Jurassic-Cretaceous
Maastrichtian-Palaeocene limestone
Palaeocene-lower Eocene clastics
middle Eocene volcanics and volcaniclastics
upper Eocene-lower Miocene clastics
upper Miocene-Quaternary continental deposits
regional structures

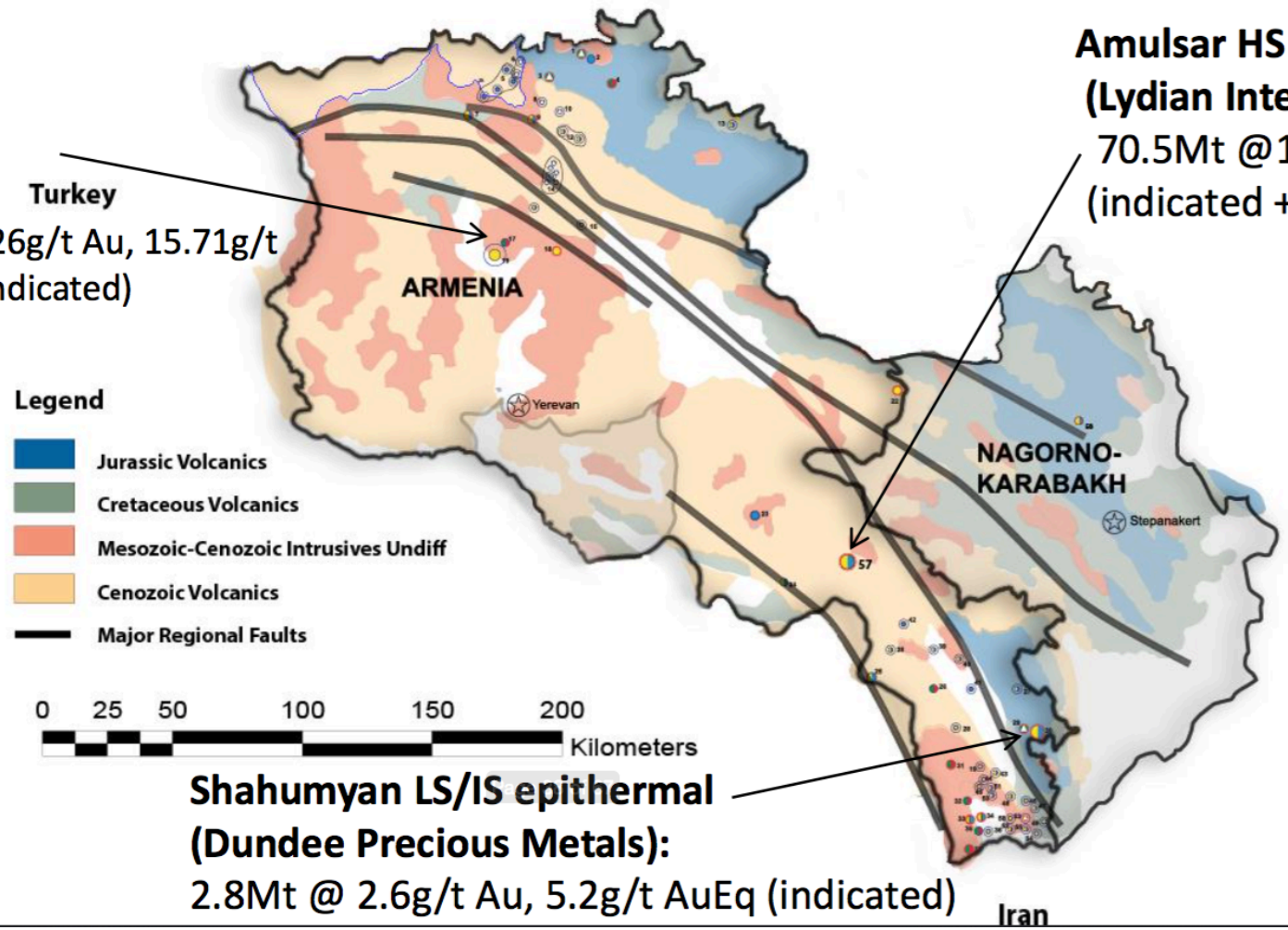

Southern Black Sea Coast-Adjara-Trialeti unit
Artvin-Boinisi unit
Bayburt-Karahakh Imbricated unit
N
S
Khrami massif
Loki massif
(no scale)


Southern Black Sea Coast-Adjara-Trialeti unit
Artvin-Boinisi unit
Bayburt-Karahakh Imbricated unit
North Anatolian-Lesser Caucasus suture
N
S
Batumi
Artvin massif
Yusufeli
(no scale)


A-A'
B-B'
C-C'
A
A'
B
B'
C
C'
Legend
Jurassic Volcanics
Cretaceous Volcanics
Mesozoic-Cenozoic Intrusives Undiff
Cenozoic Volcanics
Major Regional Faults
0 100 200 400 600 800
Kilometers

**Toukhmanuk (Global Gold)**
24.810 Mt @ 2.26g/t Au, 15.71g/t Ag (measure + indicated)

**Amulsar HS epithermal (Lydian International):**
70.5Mt @1.58 g/t Au (indicated +measured)



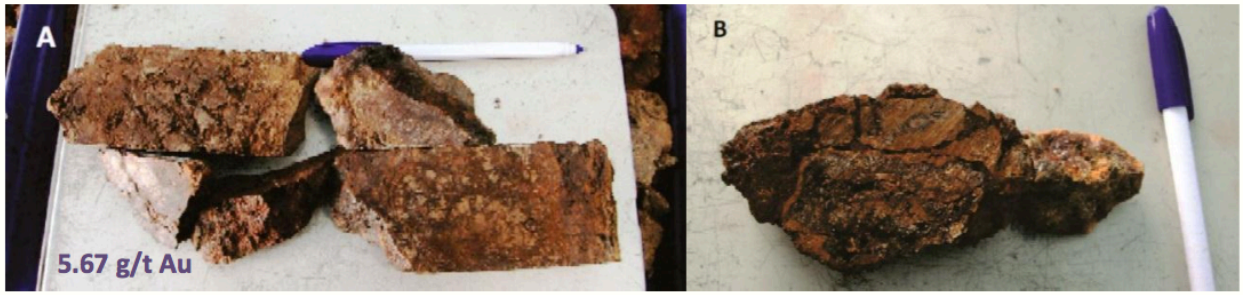

**Shahumyan LS/IS epithermal (Dundee Precious Metals):**
2.8Mt @ 2.6g/t Au, 5.2g/t AuEq (indicated)

**Host Sequence:** Eocene-Oligocene volcanic and volcano-sediments of basaltic to dacitic composition

**Tonnage:** 70.5Mt @1.58 g/t Au (indicated +measured)

**Mineralization:** Hydrothermal and phreatic breccias; an andesite sill trapped mineralized fluids leading to ponding at and beneath contact

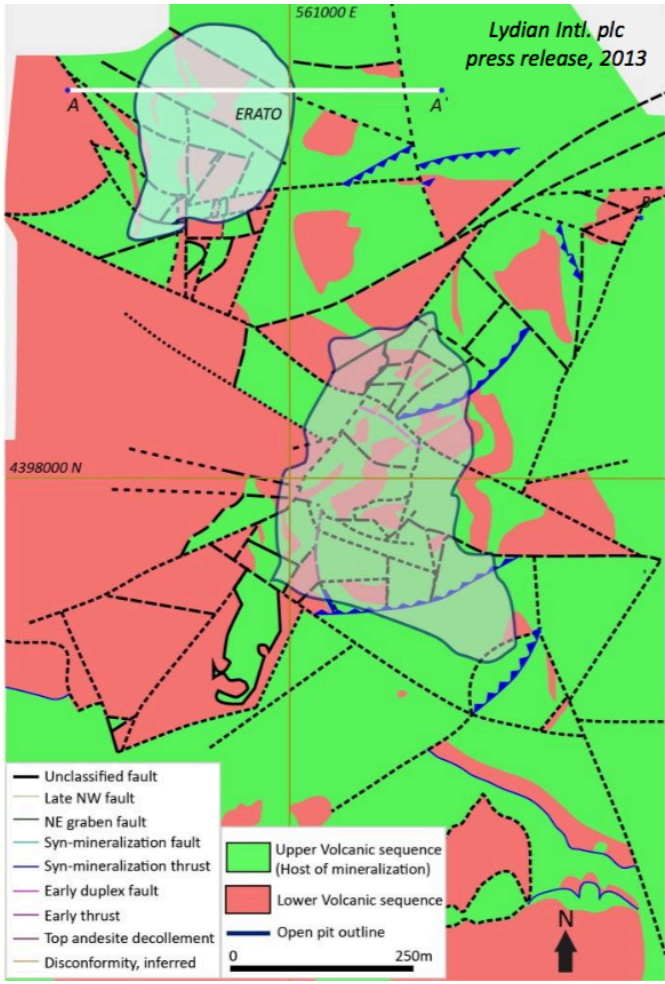
**Alteration:** Acid leaching resulted in silicification and vuggy quartz



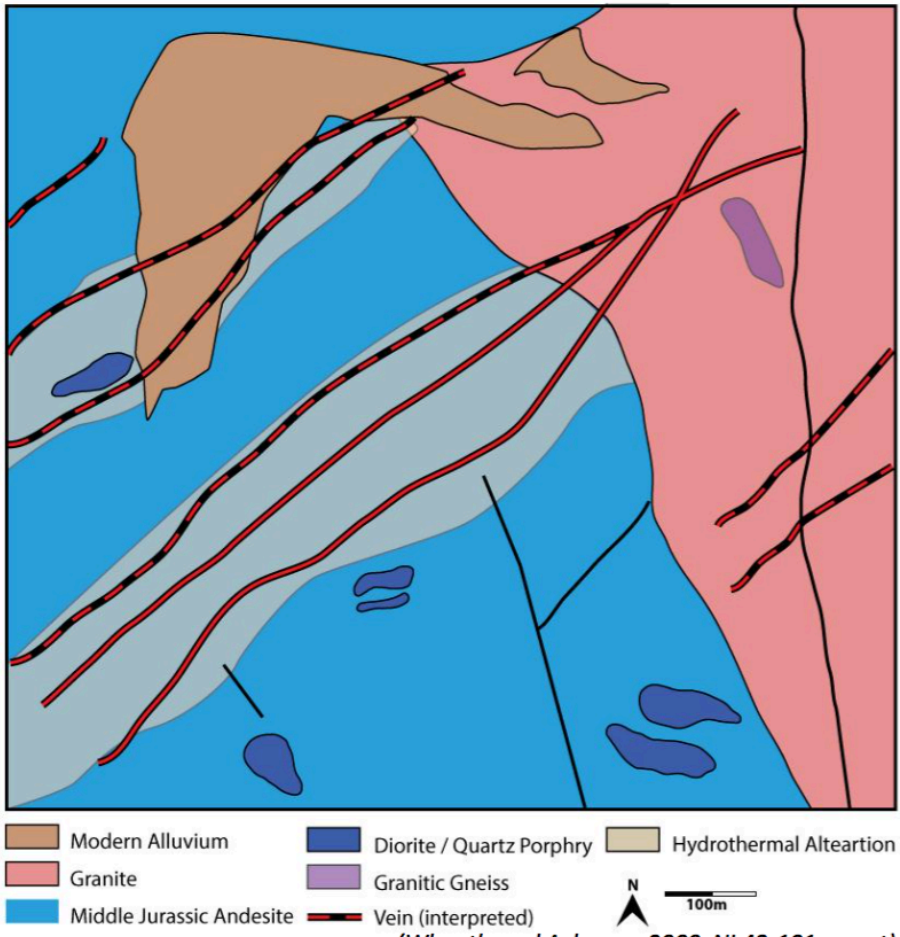

*Strongly altered and Fe-oxidized "Upper" volcanic breccias (Keller and Patrick, 2013, NI 43-101 report)*

**Structural controls:** Andesite sill, Ring structure with NE-SW normal faults and NW-SE sinistral strike slip faulting, both act as fluid conduits

**Exploration:** Continued development of project, DD programme. 2006-2013: Soil Geochemical analyses, 89,690m of Drilling (DD+RC)

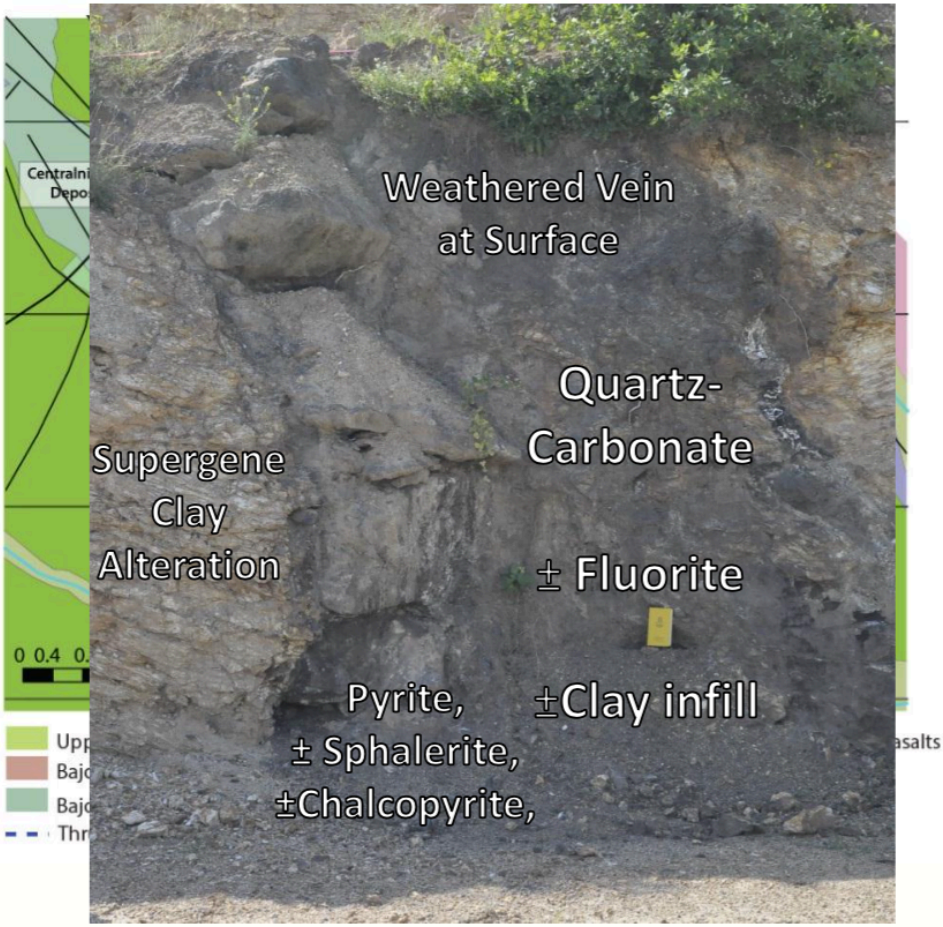


- **Host Rocks:** Jurassic- Cretaceous volcanics(andesite-dacite) & intrusives (granodiorite, granite)
- **Tonnages:** 24.810 Mt @ 2.26g/t Au, 15.71g/t Ag (measure + indicated)
- **Mineralization:** Steeply dipping veins (NE-SW trending, South dipping) and stock work mineralization
- **Alteration:** Sericite and kaolinite alteration proximal to veins
- **Regional Exploration:** Getik Prospect



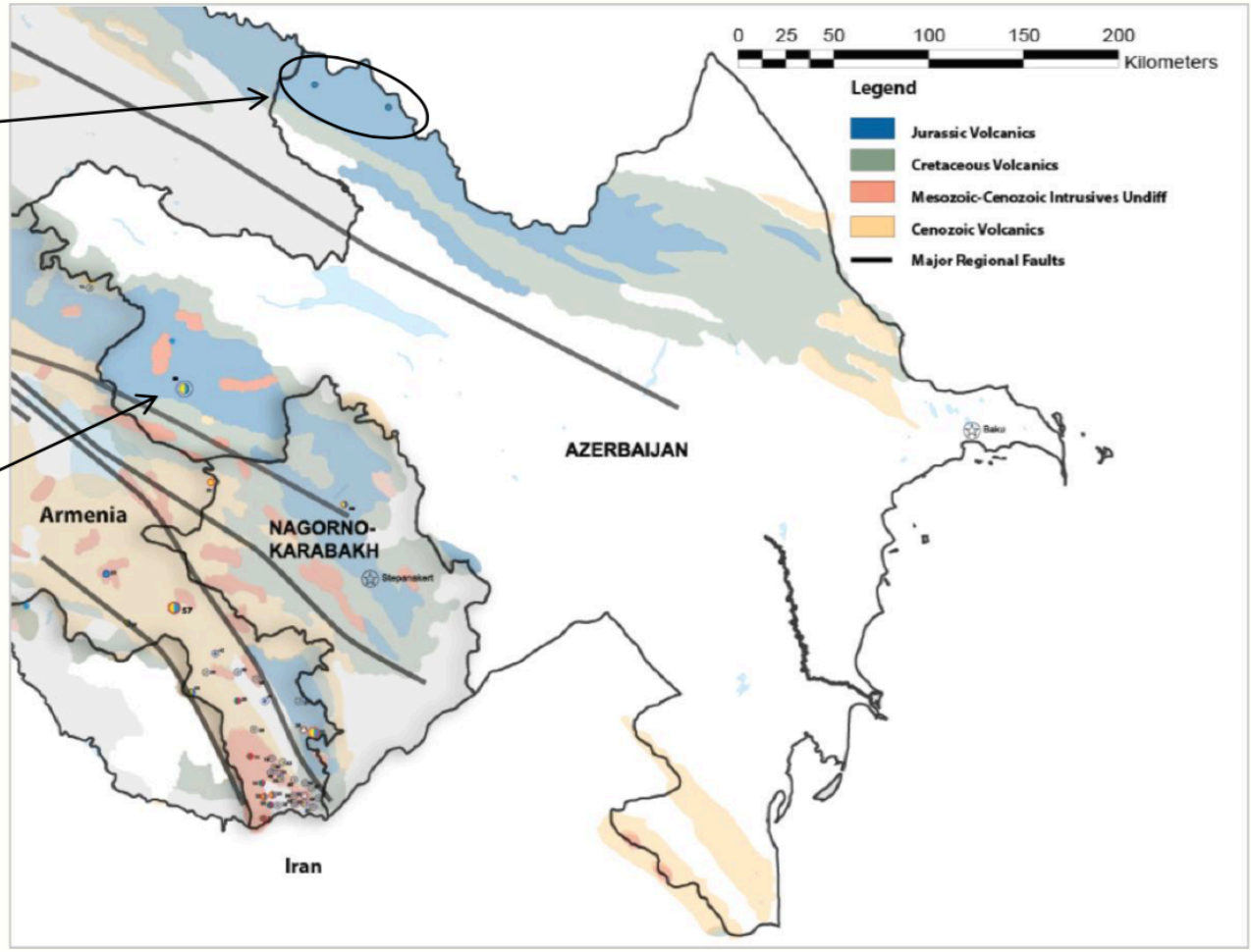

*(Wheatly and Acheson, 2009, NI 43-101 report)*

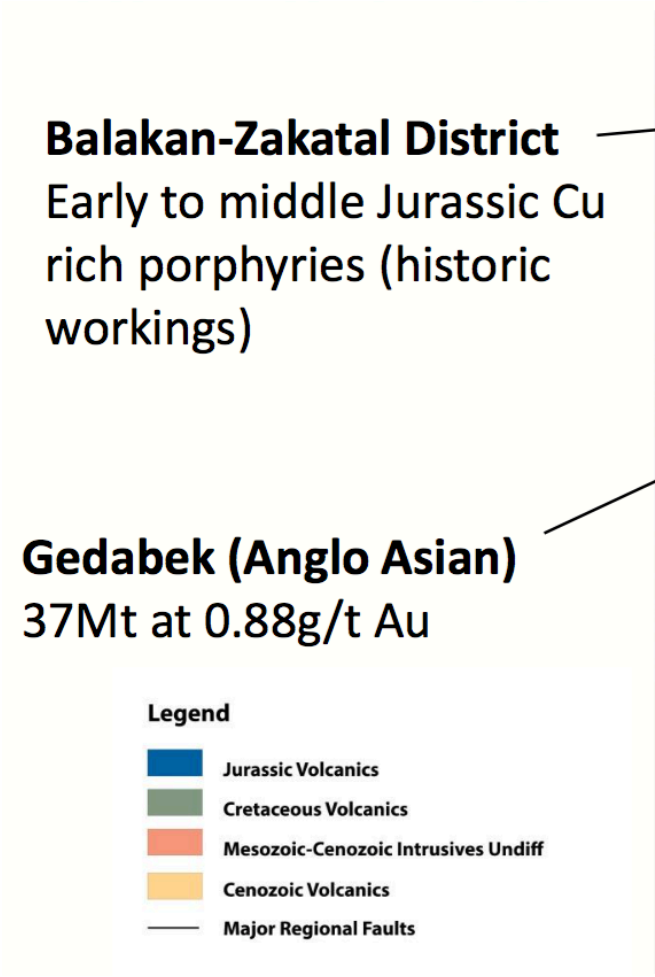
- **Host Sequence:** Middle Jurassic volcanic and volcaniclastic sequence (andesites to rhyodacites)
- **Deposits:** Shahumyan + Centralni East and West, Barabatoom (Dundee Precious Metals)
- **Tonnage:**
  - **Centralni (East, West):** ca. 31 Mt produced since 1843 grading 1.16% Cu
  - **Shahumyan:** Indicated: 2.8Mt at 2.6g/t Au, 5.2g/t AuEq
- **Mineralization:** Polymetallic (Cu, Zn, Pb, Au, Ag) epithermal veins
- **Alteration:** Narrow envelopes of Quartz-Sericite Pyrite / Clay(Illite)-Sericite-pyrite
- **Structural controls:** ~E-W trending steeply dipping extensional veins, formed from repetitive dilation and hydrothermal fluid pulses
- **Exploration:** Centralni (abandoned), Barabatoom (abandoned), Shahumyan (continued underground and surface exploration)



**Balakan-Zakatal District**
Early to middle Jurassic Cu rich porphyries (historic workings)

**Gedabek (Anglo Asian)**
37Mt at 0.88g/t Au



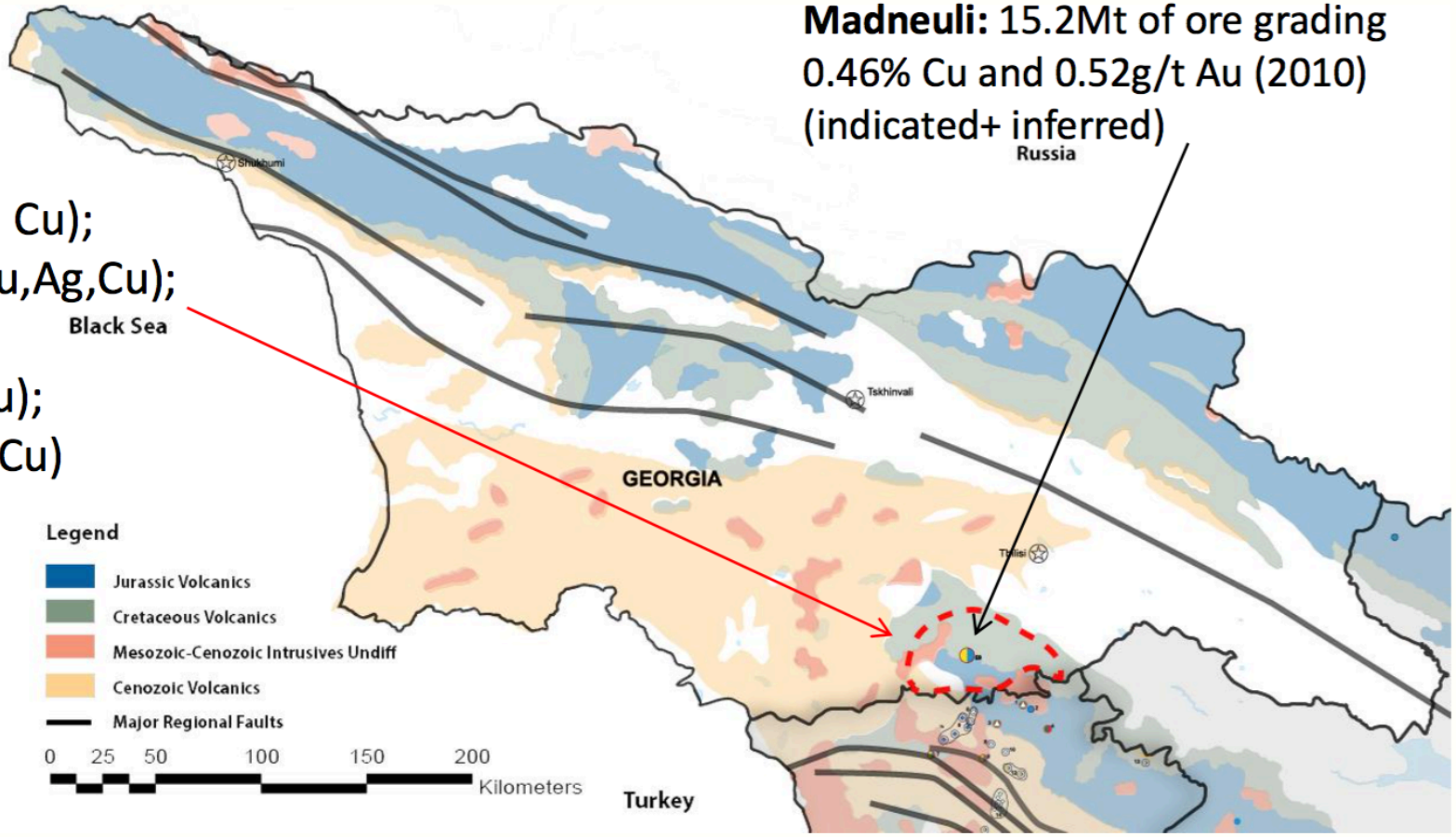



- **Tonnage:** 37Mt @ 0.88g/t Au
- **Host Rocks:** Andesitic-rhyolitic volcanics (Middle Jurassic), intruded by granodiorite, diorite-quartz diorite units(Upper Jurassic)
- **Mineralization:** Cu-Au +/- Zn (Epithermal)
- **Alteration:** Silicified bodies, Quartz-Sericite-Pyrite, intermediate argillic zones
- **Controls:** Lithology controlled, permeability of volcaniclastic rocks.
- **Exploration: Gedabek** (district scale) , **Gosha** (brown fields from Soviet era), **Ordubad** (green fields)

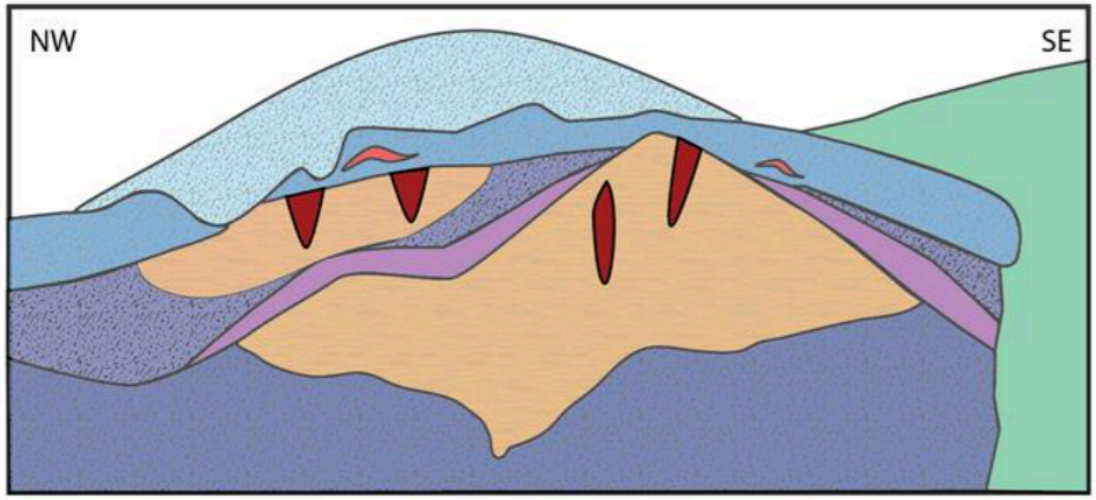
Silicified ore-hosted tuff layers Argillic alteration crosscutting silicified body with late stage calcite veins

**Madneuli:** 15.2Mt of ore grading 0.46% Cu and 0.52g/t Au (2010) (indicated+ inferred)

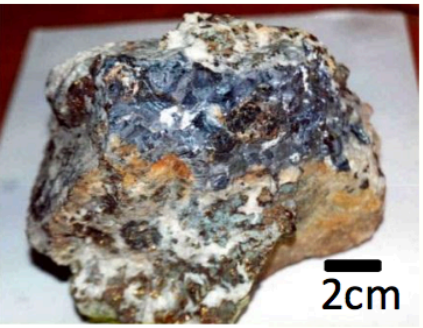
**Bolsini district**
Sakdrisi (Au,Ag, Cu);
Tsiteli Sopeli (Au,Ag,Cu);
David Gareji (Au,Ag,Pb,Zn,Cu);
Kvemo Bolsini (Cu)



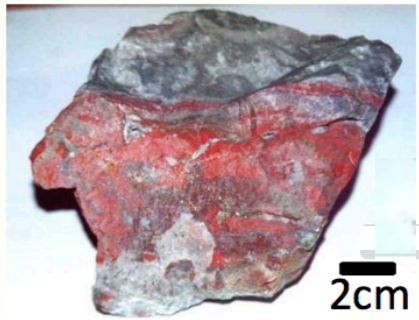
- **Tonnage:** (indicated and inferred) 15.2Mt of ore grading 0.46% Cu and 0.52g/t Au (2010)
- **Host Rocks:** Late cretaceous rhyo-dacitic tuffs and ignimbrites
- **Mineralization:** Polymetallic (Ba, Cu, Pb, Zn, Au) disseminations and lenses
- **Alteration:** Pervasive silicification



*A schematic cross section through the Madneuli Deposit*

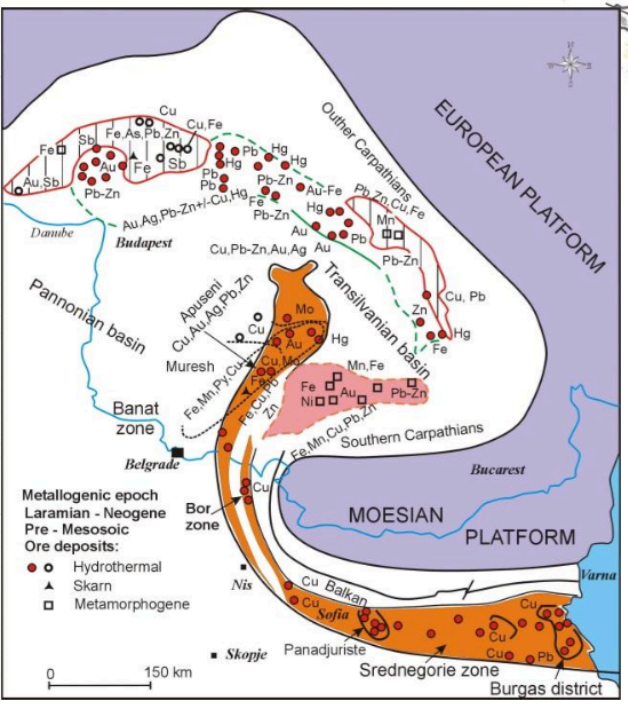


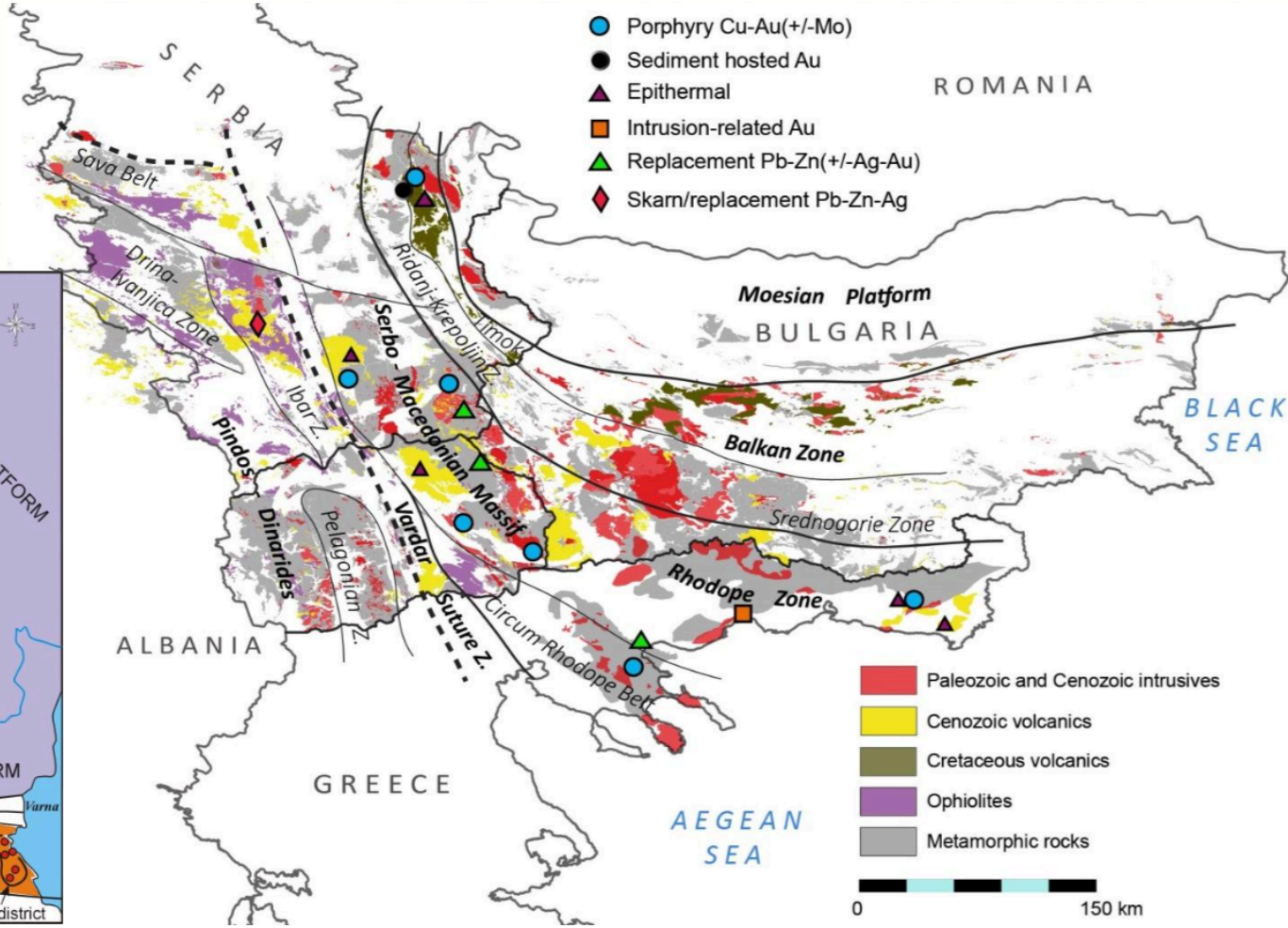

*Lead-Zinc Ore*




*Au-bearing silicified tuffs*

# Apuseni Banat Timok Srednogorie Metallogenic Belt



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Mine-Turnkey Consultancy www.RubiconMining.com

## Majdanpek (Cu, Au)

RTB Bor, production, 620 Mt @ 0.34 % Cu, 0.2 g/t Au *

## Korkan (Au)

Avala Resources, feasibility, 14.51 Mt @ 1.53 g/t Au

## Bigar Hill (Au)

Avala Resources, feasibility, 25.48 Mt @ 1.63 g/t Au

## Kraku Pešter (Au)

Avala Resources, feasibility, 6.32 Mt @ 1.31 g/t Au

## Veliki Krivelj (Cu, Au)

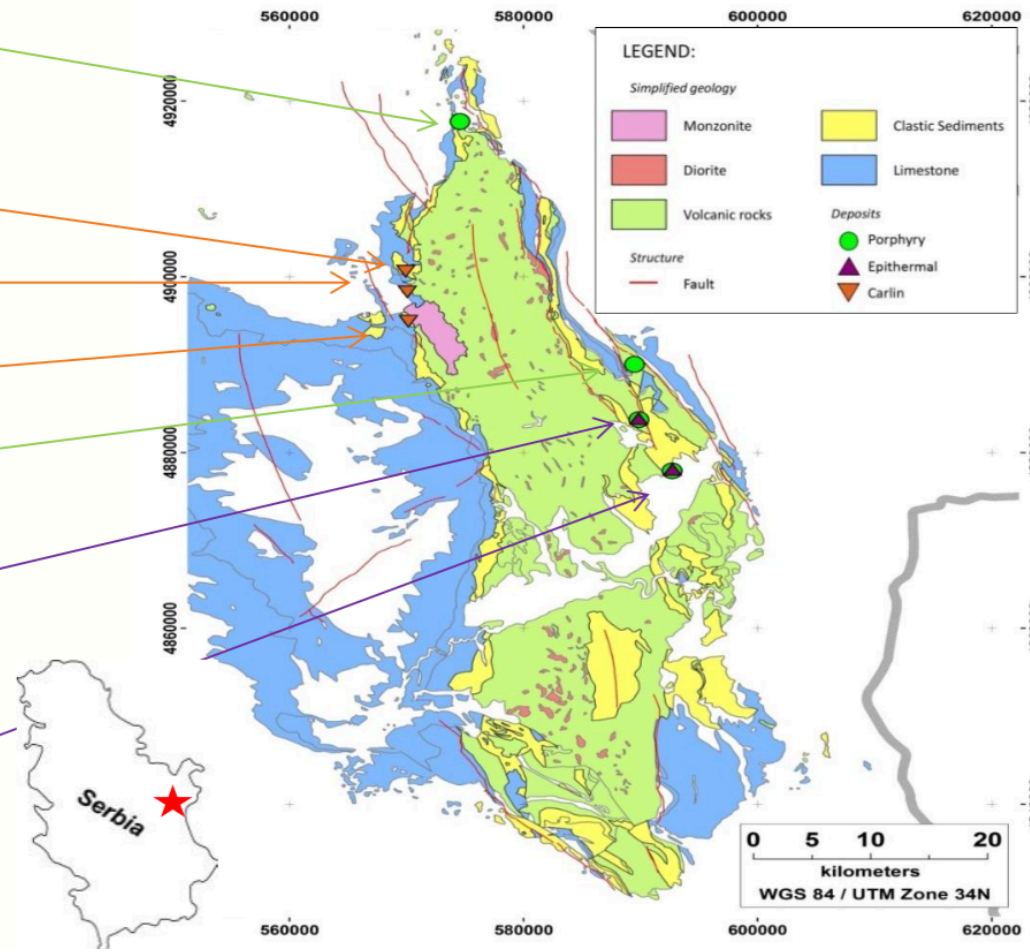
RTB Bor, production, 560 Mt @ 0.33 % Cu, 0.7 g/t Au *

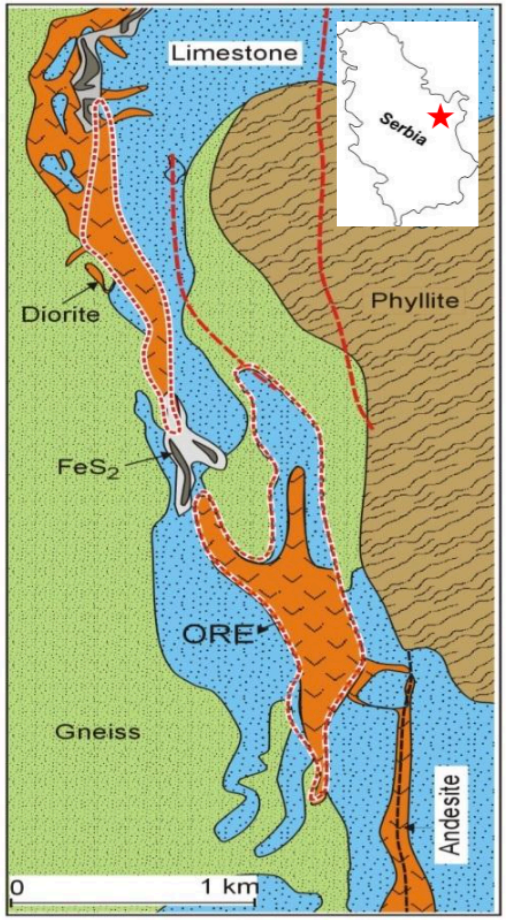
## Bor (Cu, Au)

Jama: RTB Bor, production, 14 Mt @ 0.8 % Cu, 0.27 g/t Au *
Borska Reka: RTB Bor, production, 1008 Mt @ 0.53 % Cu, 0.16 g/t Au *

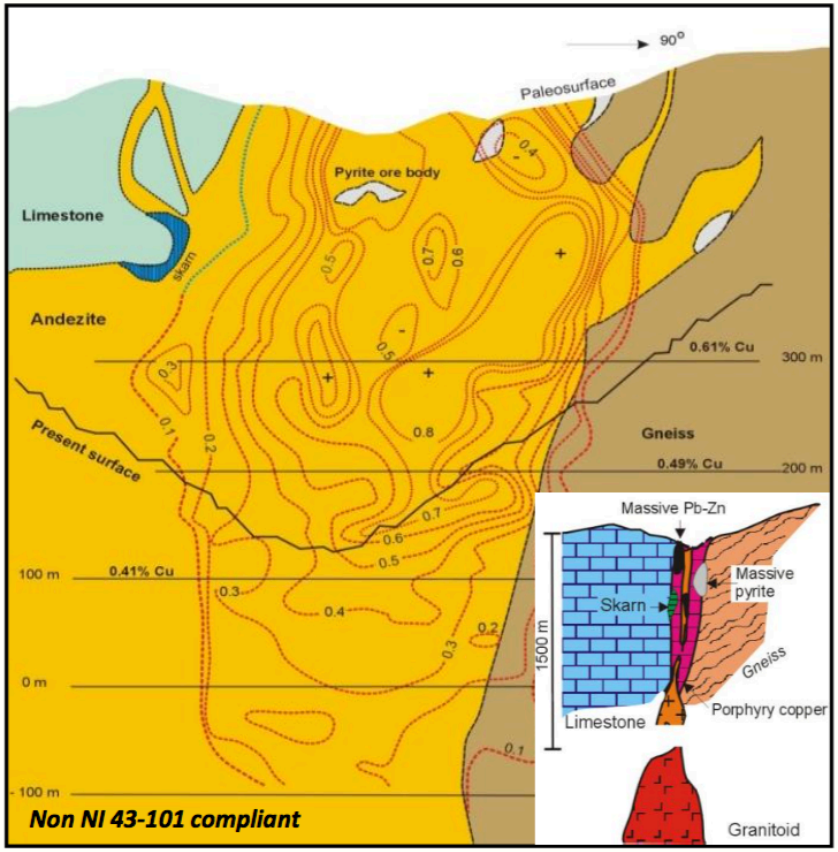
## Cukaru Peki (Cu, Au)

Reservoir Minerals and Freeport-McMoran JV, exploration, 160m @ 6.92% Cu and 5g/t Au

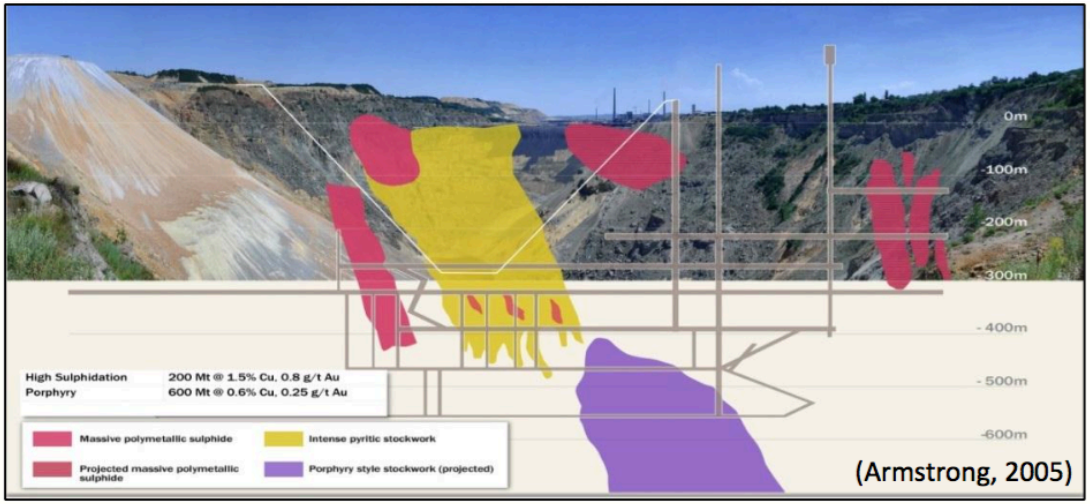





- State owned since 1956 (2 open pits)
- Historic production: 369 Mt of ore; 1,67 Mt Cu, 83 t Au, 429 t Ag*
- Porphyry Cu-Au mineralization related to transtensional oblique normal faulting 86-84 Ma
- NW-SE striking ore zones
- A multi-stage ore-forming events resulted in skarn, massive sulfide (pyrite), peripheral vein-hosted Pb-Zn mineralization

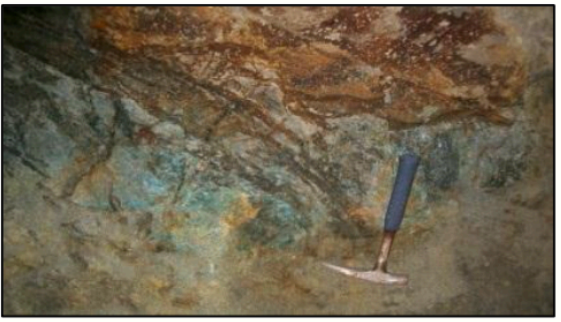



Copper grade contours on the cross section of the Majdenpek Southern Area open pit



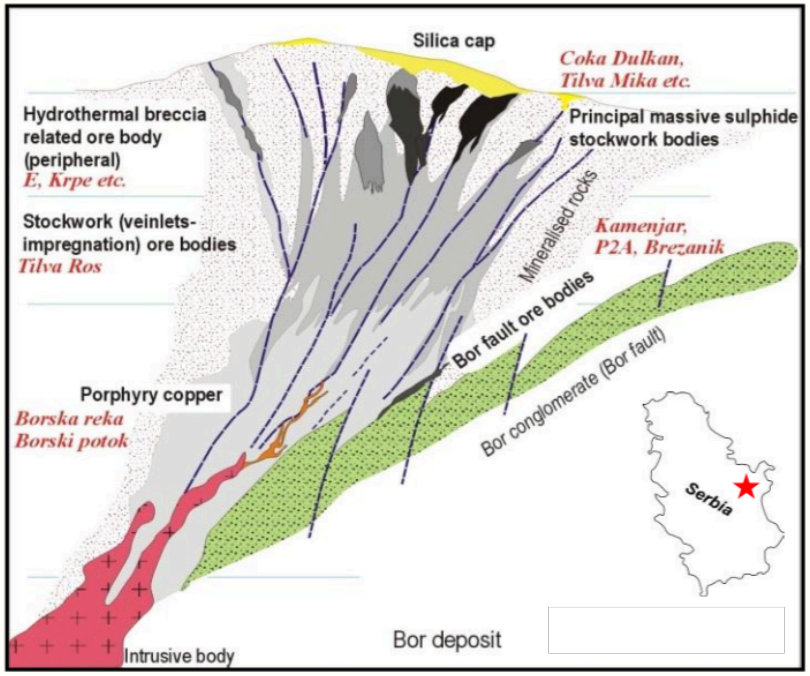
(Armstrong, 2005)

- World class porphyry-epithermal deposit with over 110 years of continuous Cu-Au mining
- State owned RTB Bor – open pit and underground mines

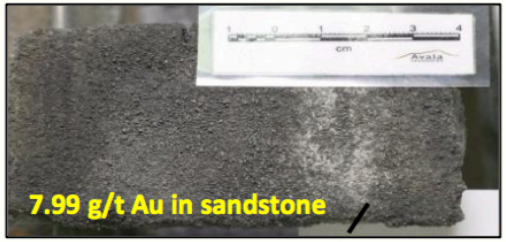


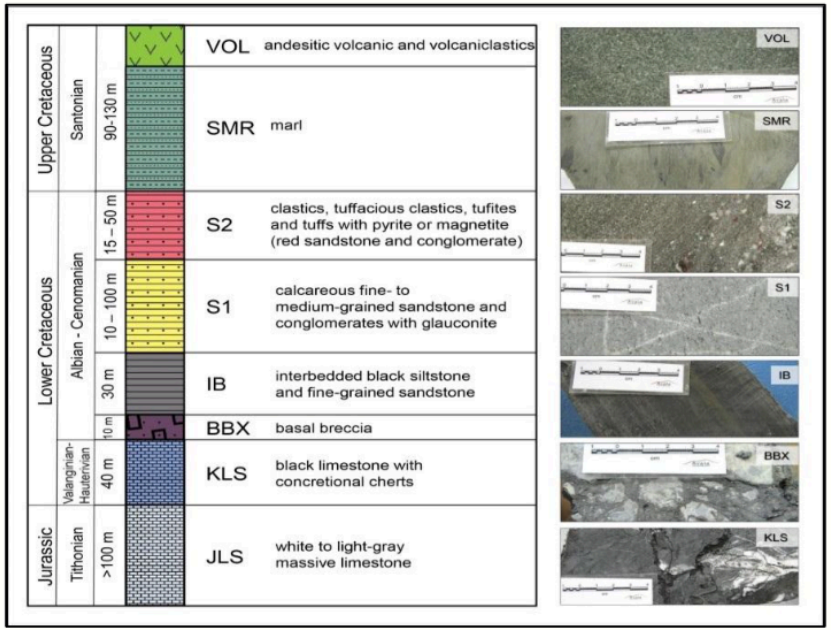
Oxidized hydrothermal breccias hosting massive Cu- sulphides

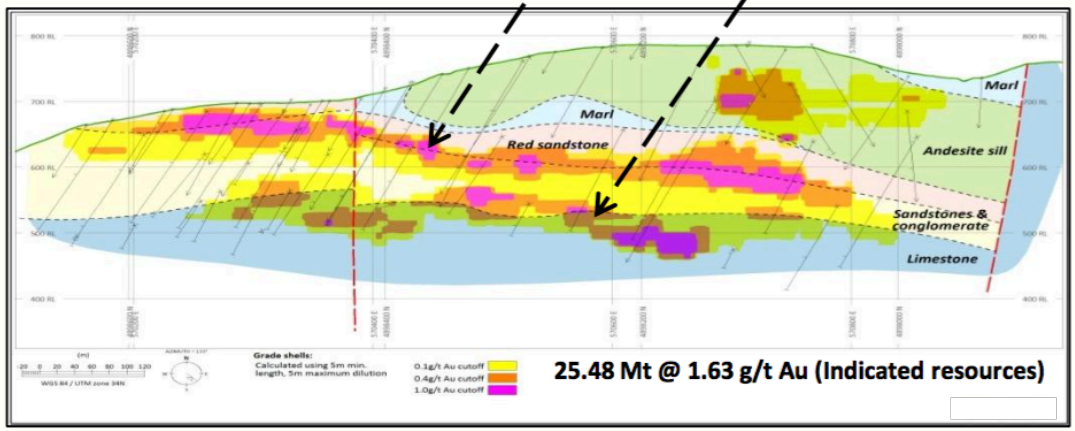
- A porphyry Cu-Au deposit associated with HS massive sulphide hosted in stockworks and hydrothermal breccias
- Ore mineralogy dominated by pyrite, chalcopyrite and subsidiary bornite, chalcocite and covellite.

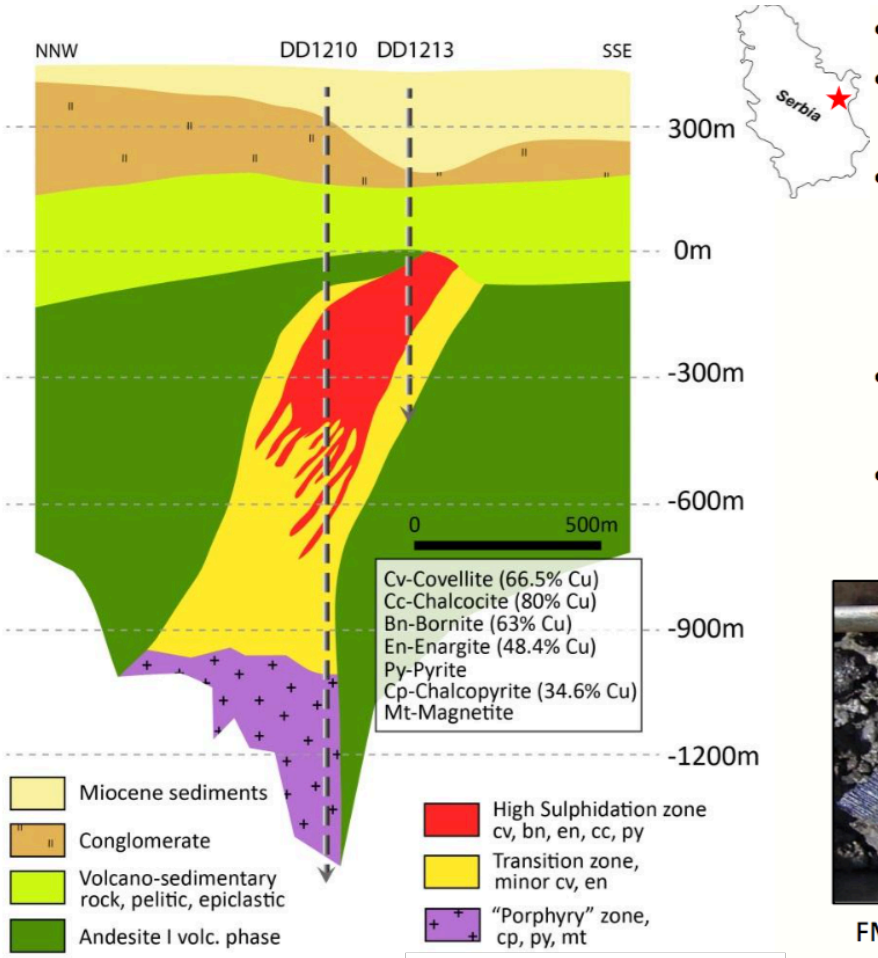


- Previously unrecognized style of sediment hosted Au mineralization in the Balkans; combined resources of 46.3 Mt at 1.56 g/t Au (indicated)
- Located along a major, N-S trending sedimentary basin flanking TMC from west
- Gold mineralization found within the Bigar Hill, Korkan and Kraku Pešter limestones (KLS), breccias (BBX), and along contact between calcareous (S1) and volcanic sandstone (S2)





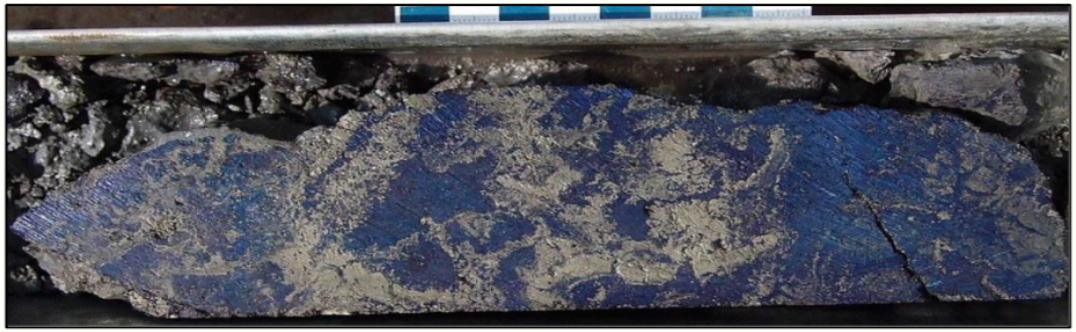







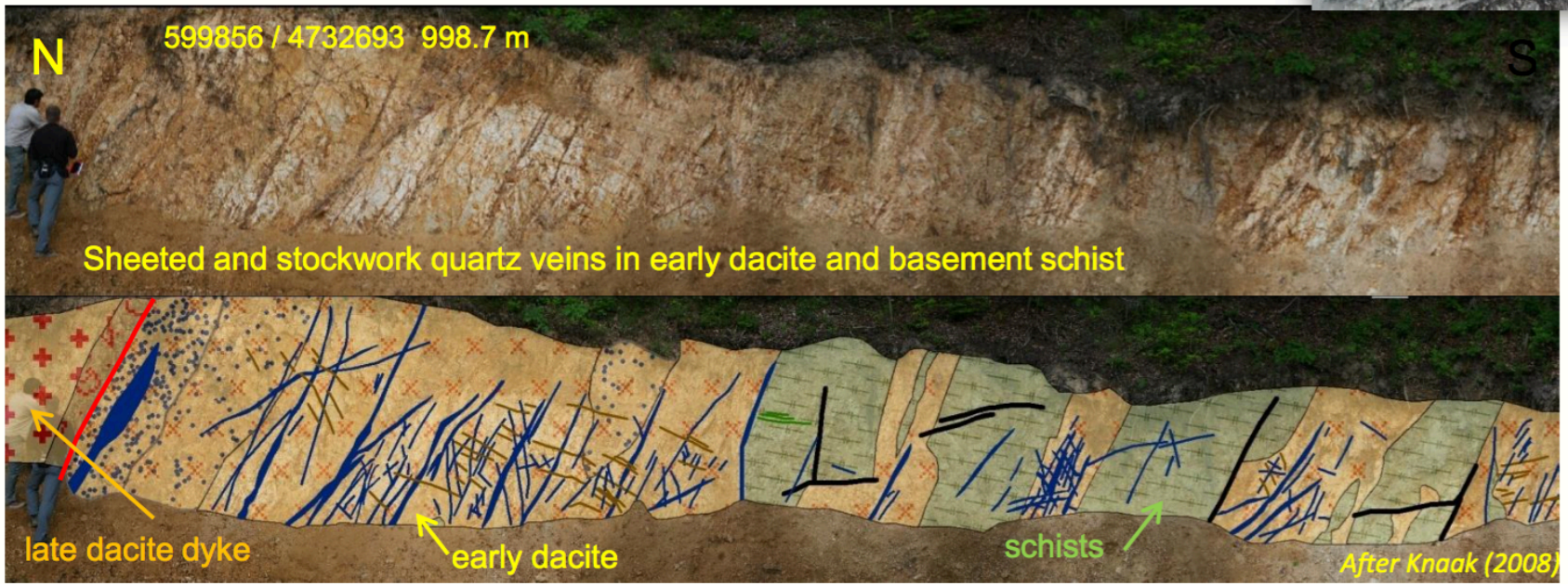


- A **blind discovery** in 2012 7.5 km SE of the Bor pit
- Potentially world-class Cu-Au epithermal/porphyry style mineralisation below 400 m of Miocene sediments
- HS Cu-Au "massive sulphide" mineralization with covellite bornite and chalcocite in veins, hydrothermal breccias and replacements hosted by strongly altered andesite
- Porphyry style chalcopyrite-pyrite with rare molybdenite intersected at greater depth
- Selected copper-gold drill hole intersections: **291.3 m @ 5.13% Cu and 3.4g/t Au; 160 m @ 6.92% Cu and 5g/t Au; 733.8 m @ 0.75% Cu and 0.10 g/t Au**

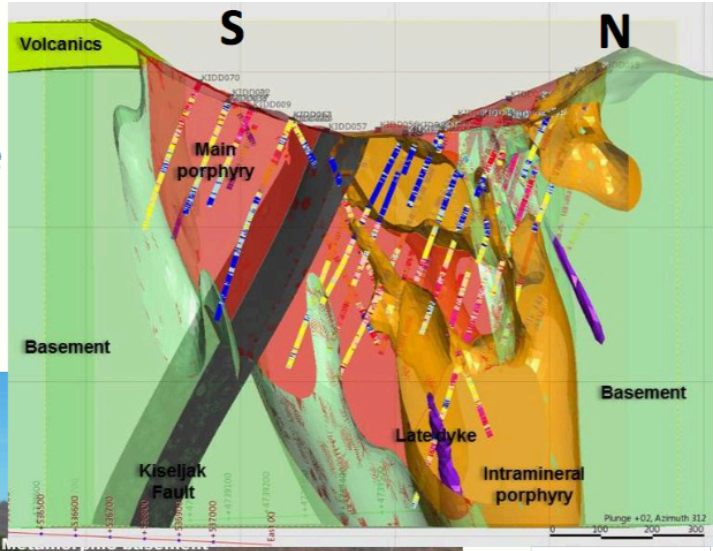


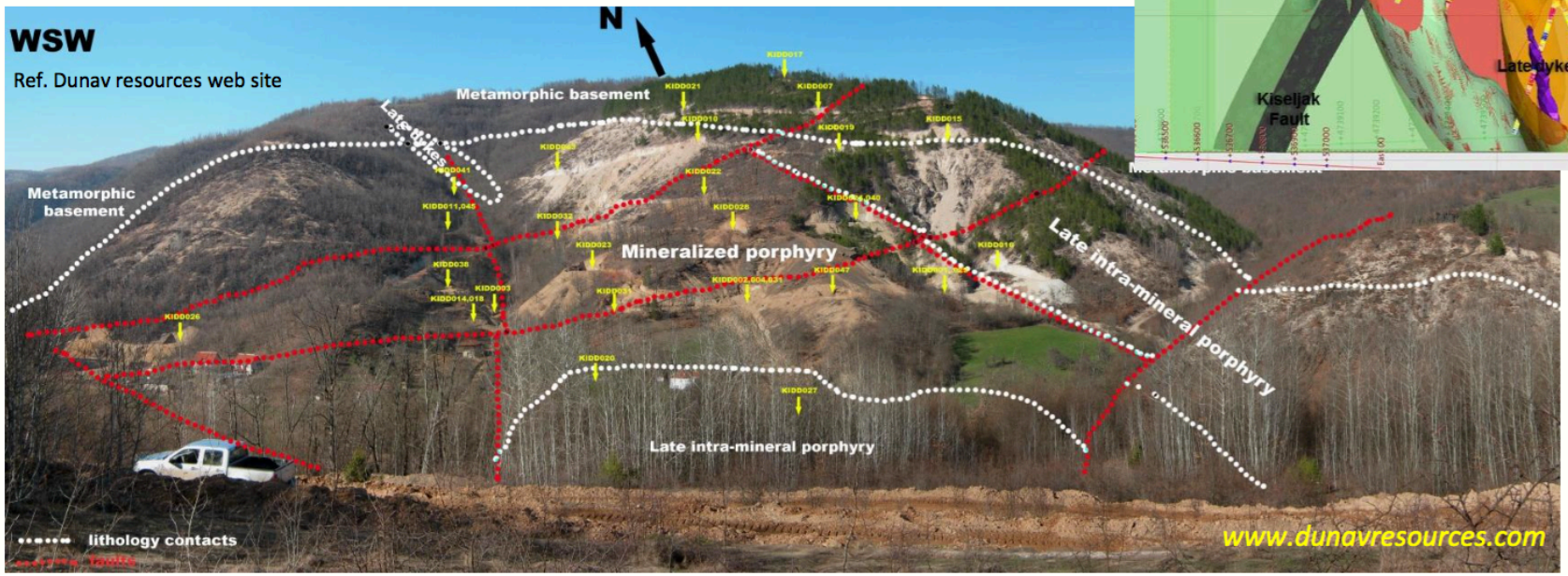
FMTC 1213, 508-509m 36.51% Cu, 8.50 g/t Au; Massive sulphide breccia with bornite and covellite

- Largest European molybdenum porphyry deposit with NI 43-101 compliant inferred resource of 125Mt @ 488 ppm Mo
- Formed on northern tip of the Surdulica Granitic Complex (33 Ma)
- Mineralization associated with early dacitic stock emplaced in the greenschist basement facies of the Serbo-Macedonian Massif



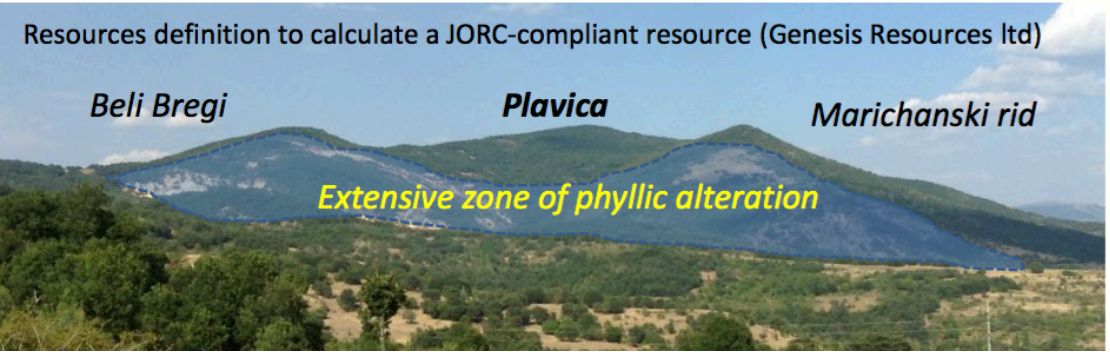
- NI 43-101 inferred resource of 300 Mt grading 0.27% Cu and 0.26 g/t Au
- Hosted in the Oligocene diorite porphyry stocks of the Lece Magmatic Complex (33.0 - 31.8 Ma; Tosdal, 2012);
- 3 diorite intrusive phases differentiated based on vein relationships and associated alteration parageneses

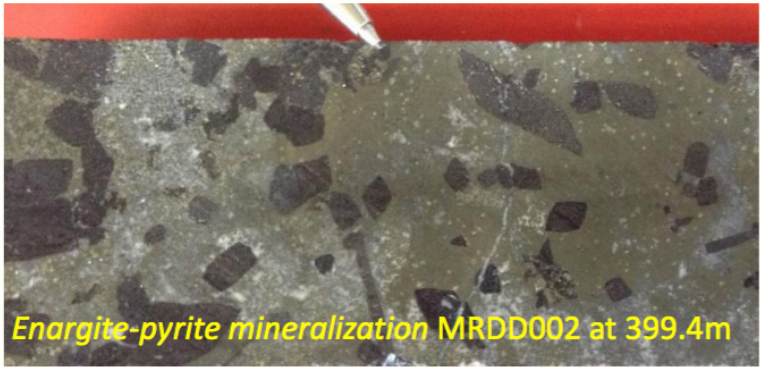


- Located in the Probistip fault-controlled basin within the Kratovo-Zletovo Magmatic Complex;
- Plavica: the site of historic Roman Au workings and limited underground in early 20th Century;
- HS epithermal character based on metal and ore mineral associations, alteration zoning and fluid chemistry;
- Possibility of a porphyry at depth (?)

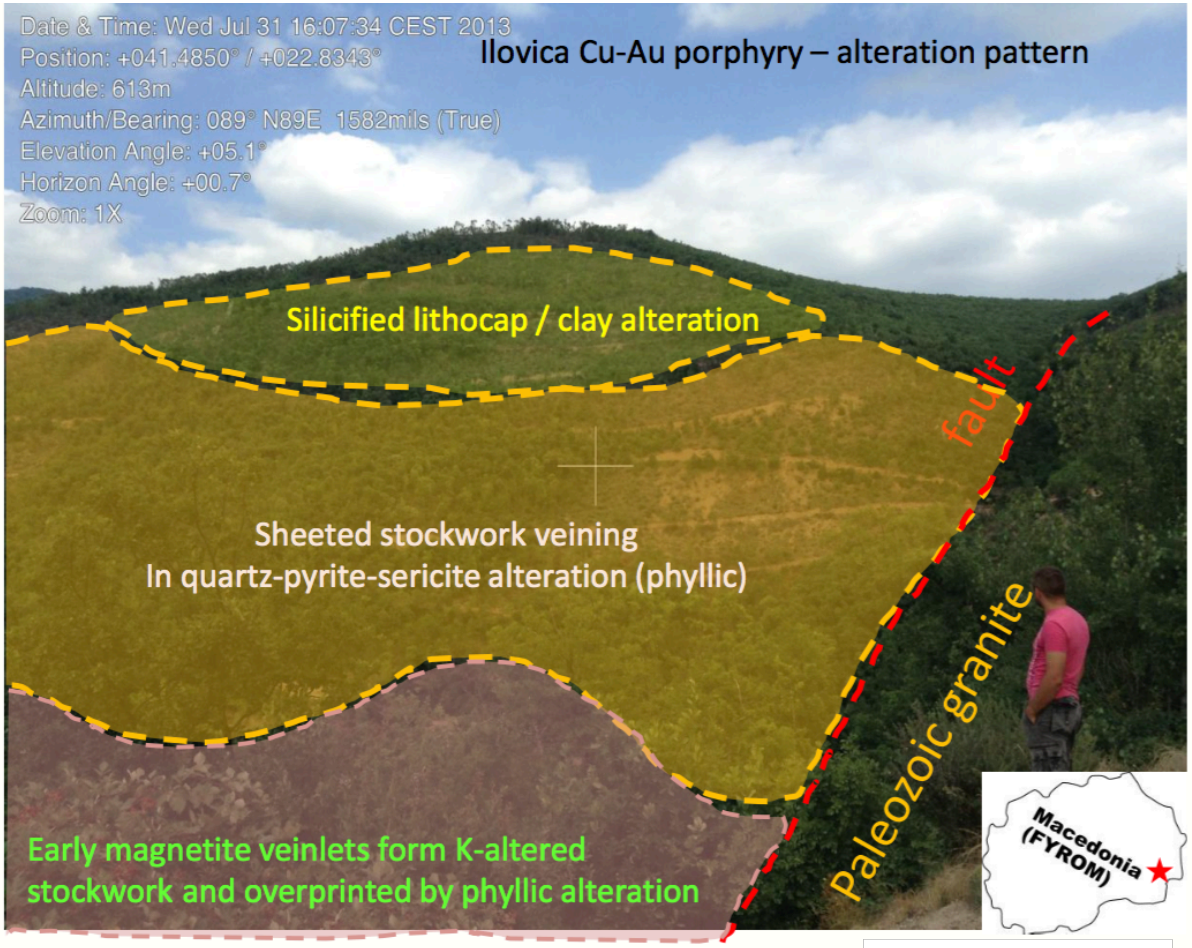
Bladed textured barite with enargite





Enargite-pyrite mineralization MRDD002 at 399.4m

- Hosted by dacite and granodiorite porphyries and breccias intruding Paleozoic granite.
- Measured and indicated resource of 237 Mt at 0.33g/t Au and 0.22% Cu containing 2.78 Moz Au and 1.1 Bn lb Cu
- Explored by Euromax Resources Ltd.

*Potassically altered stockwork with A type magnetite veins*



## Olympias Pb-Zn-(Cu)-Ag-Au Skarn deposit

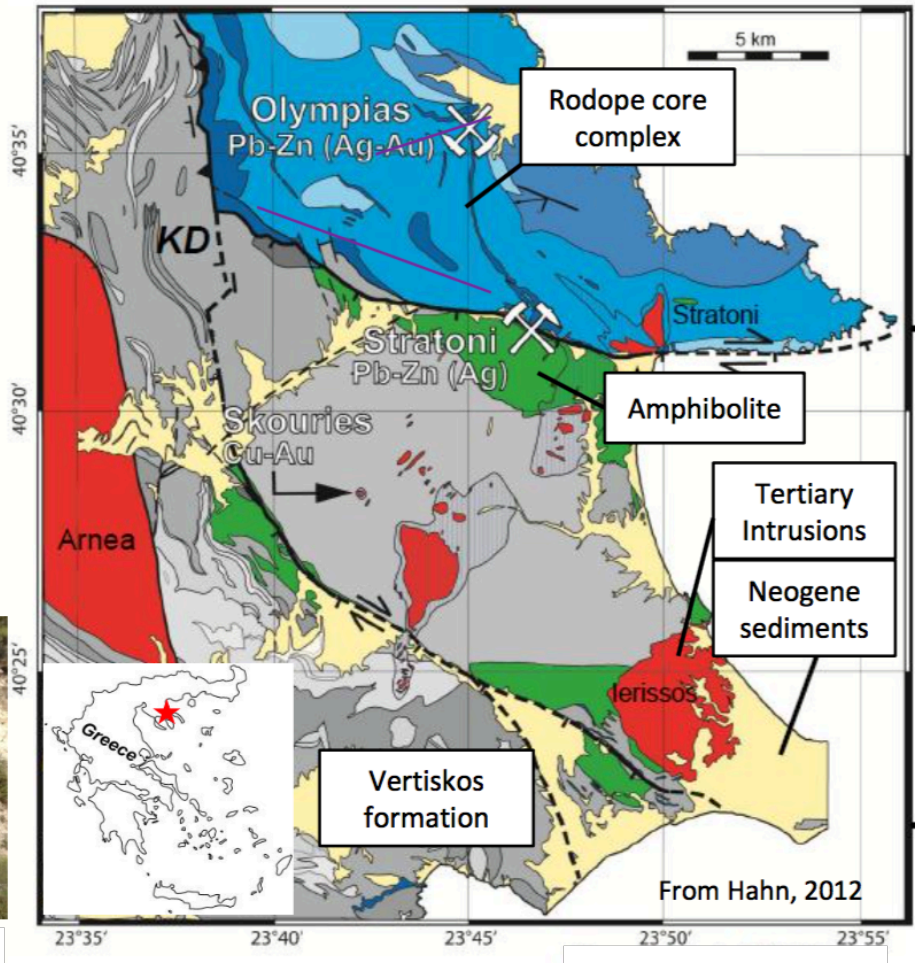
Mine under construction: 4.1 Moz @ 7.9 g/t Au, 58.8 Moz @ 114 g/t Ag, 599 Kt Pb, 796 Kt Zn
Proven + Probable (www.eldoradogold.com)

## Stratoni Pb-Zn-Ag Replacement deposit

Operating mine: 1.8 Mt @ 8.5% Zn, 6.3% Pb, 177 g/tAg =0.15 Mt Zn, 0.11 Mt Pb, 10 M oz Ag
Proven + Probable (www.eldoradogold.com)

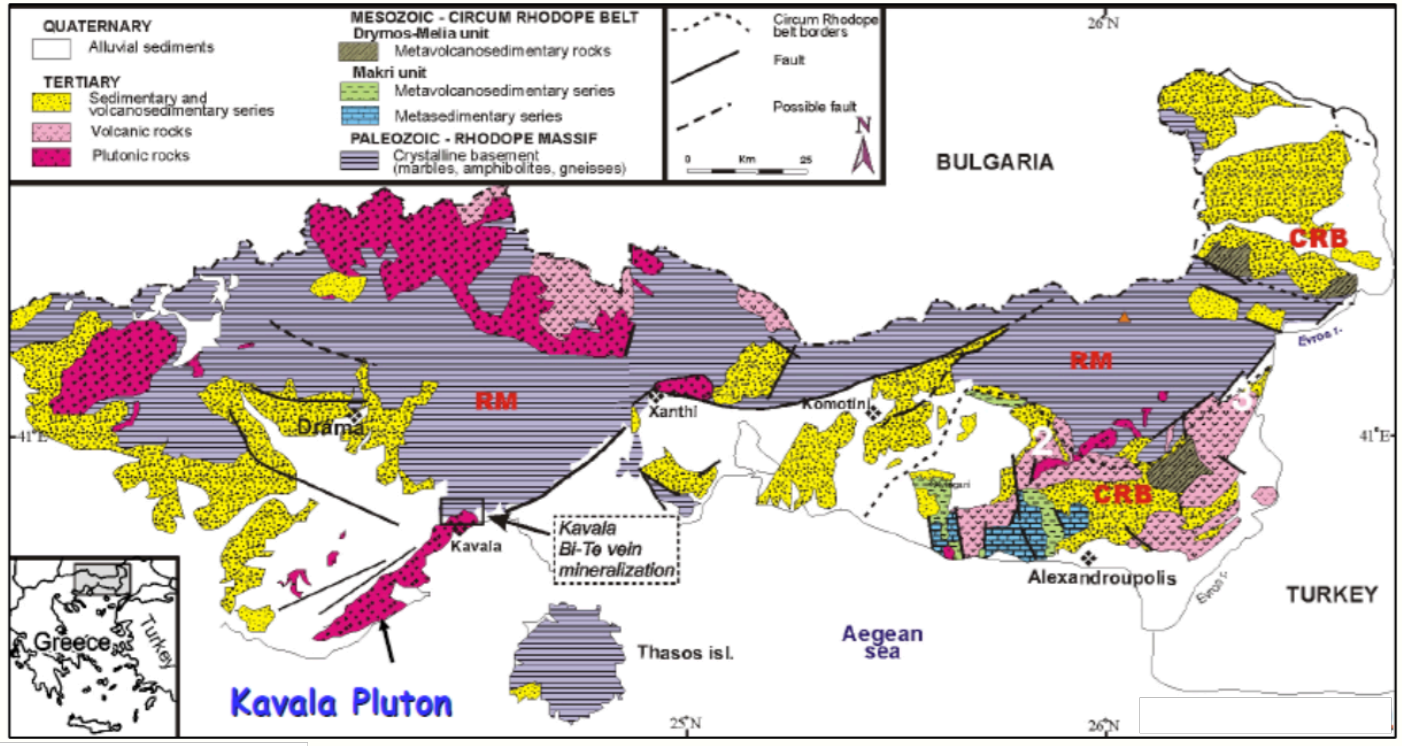
**Skorioes (Cu-Au Porphyry):** Mine under construction; Eldorado Gold Corp.
138 Mt at 0.8 g/t Au, 0.5% Cu = 3.6 M oz Au, 0.7 Mt Cu
Proven + Probable (www.eldoradogold.com)

*Oxidized Stratoni stockwork overprinted by quartz-sericite alteration*



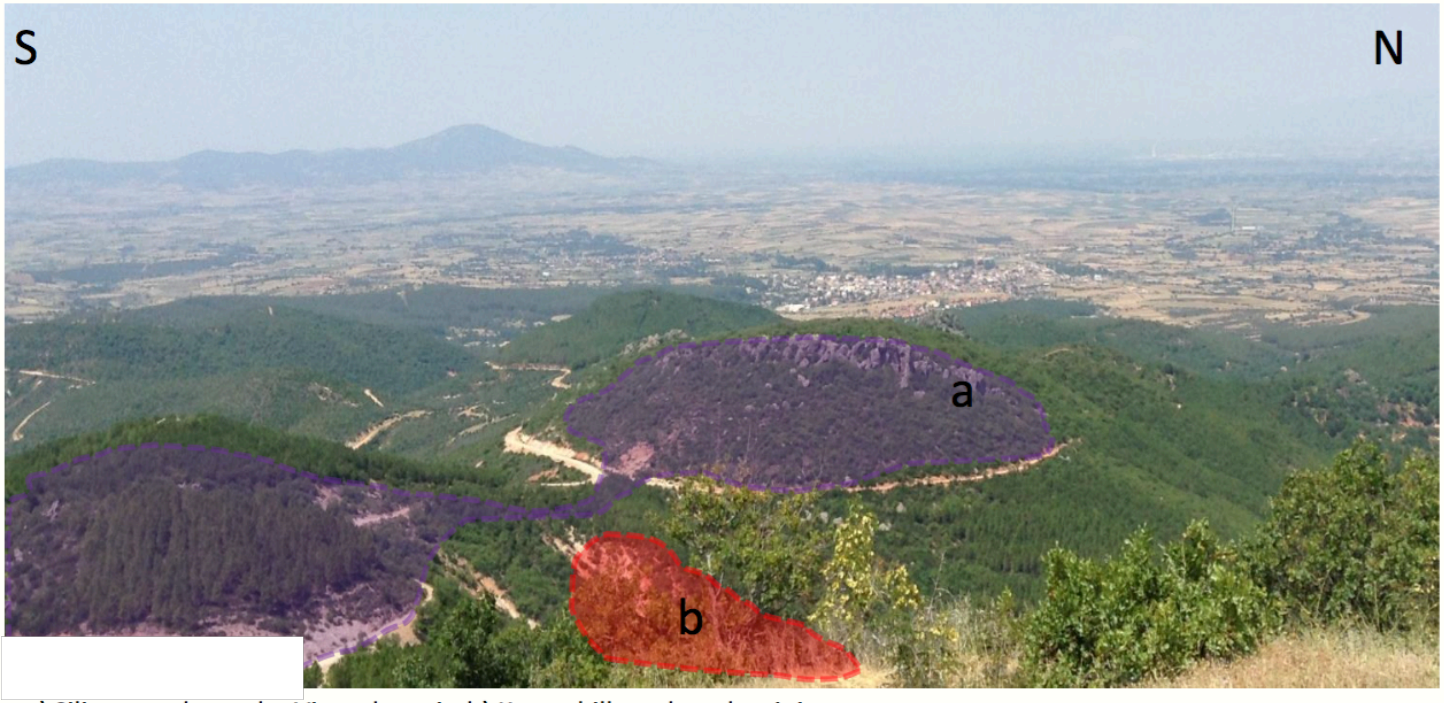

From Hahn, 2012

- Zones of silification delineated distinct Fe oxide zone
- Pinch and swell massive pyrite veins and pods
- Skarn pollymetallic Au



**Sapes HS epithermal Au deposit (three ore bodies Viper, St. Demetrios & Scarp):**
Hosted in extensive advanced argillic/silica cap overlying quartz-clay-alunite+/-barite altered volcanic rock? (a), JORC Measured and Indicated Resource of 0.83 Moz at an average grade of 9.8g/t Au (ref: Glory Resources website)

**Konos Hill Mo (-Cu) Porphyry prospect:**
Extensive zones of quartz+/-limonite veining stockwork (b) (Voudouris, 2013)

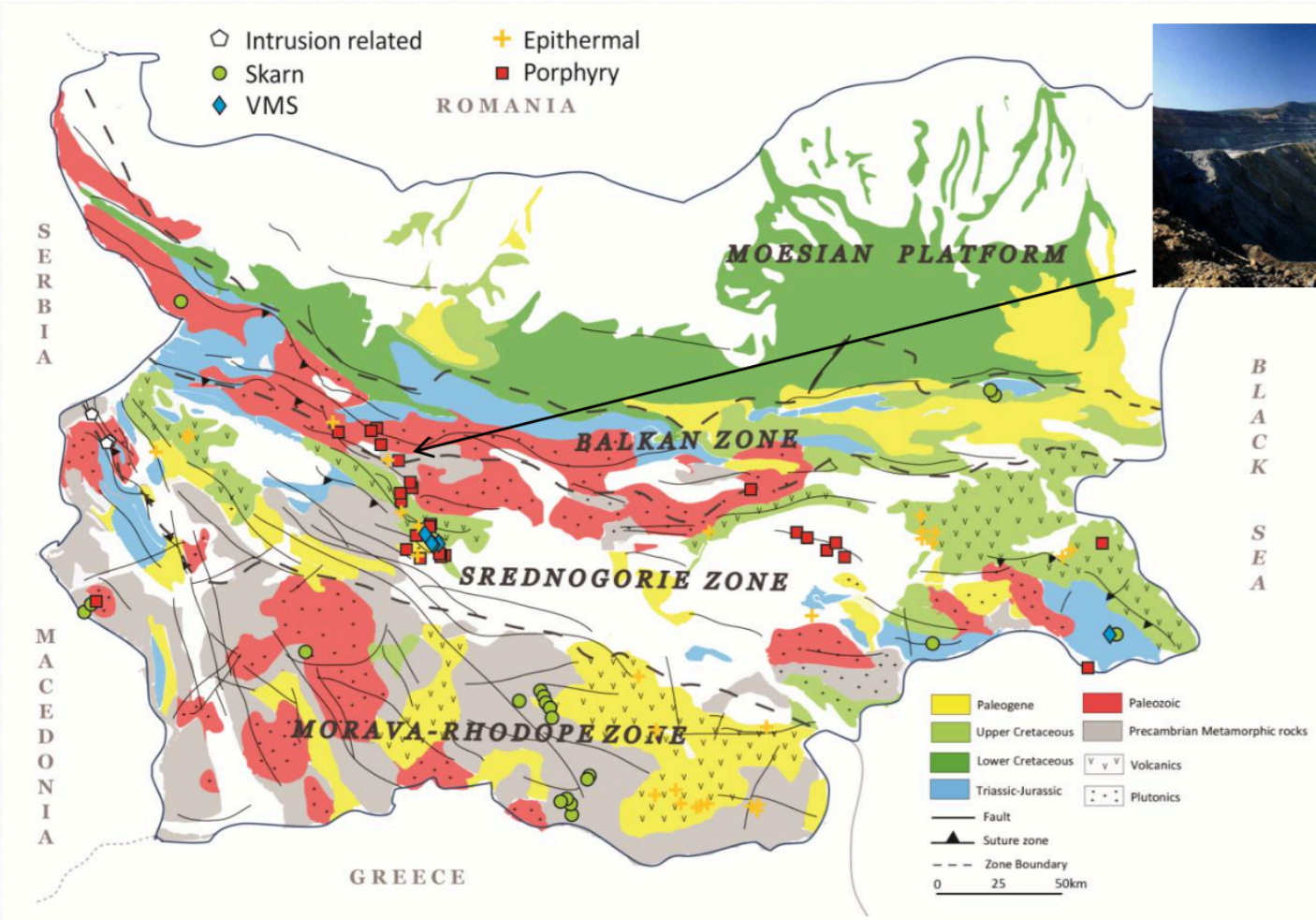


a) Silica cap above the Viper deposit; b) Konos hill stockwork veining

**Perama Hill epithermal Au deposit :** A strata-bound deposit characterized by HS-IS epithermal quartz+/-barite veins hosted by felsic volcaniclastic sandstones overlying a package of andesitic volcanic breccias.

- Measured and Indicated Resource: 1.38 Mt @ 3.46 g/t Au (www.eldoradogold.com)

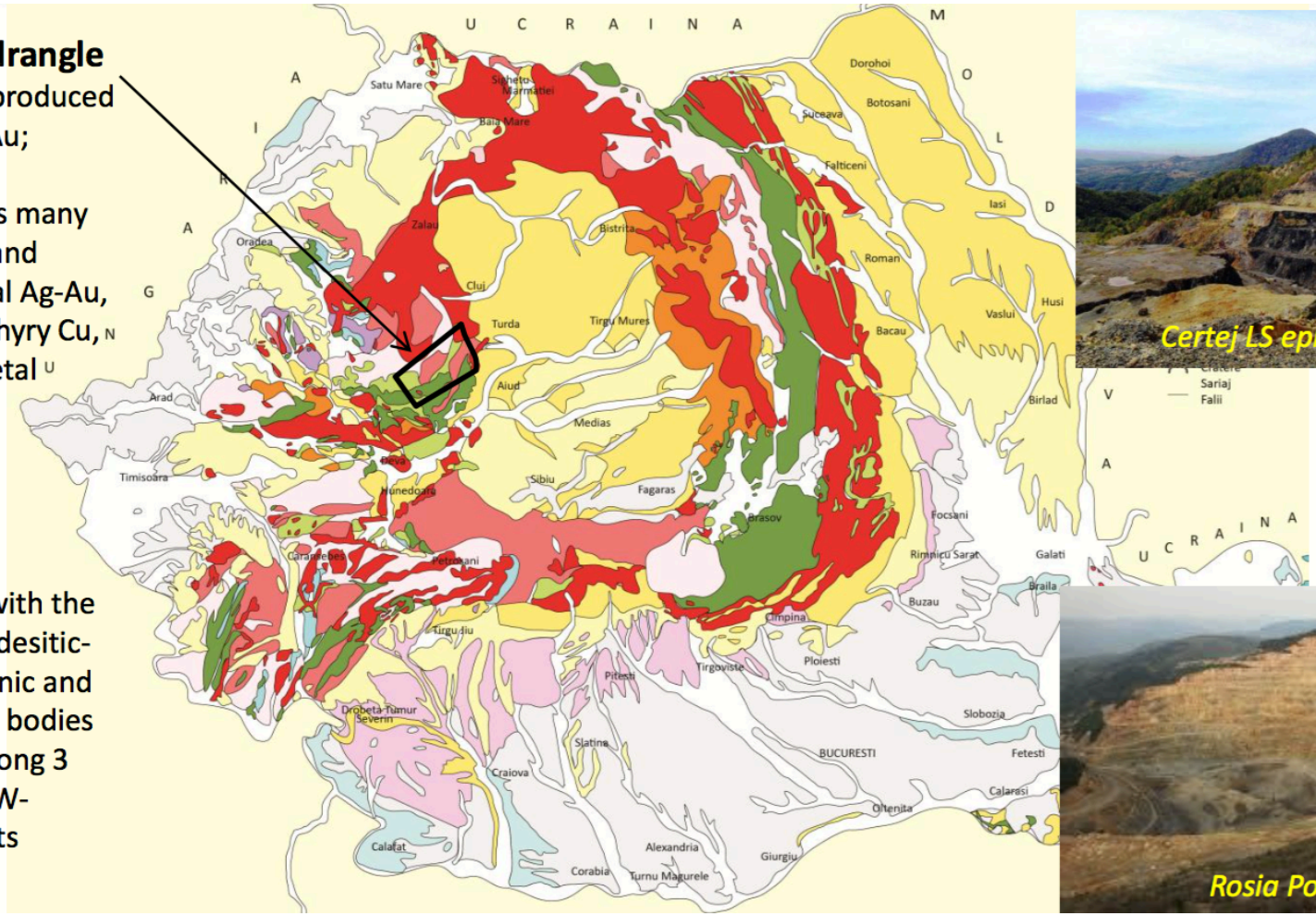
**Discovery Outcrop:** Set of banded quartz+/-barite veins, differs in thickness from few cm to up to 1m comprising different epithermal texture including drusy comb, crustiform and replacement texture



*Elatsite Cu-Au porphyry mine*

## Golden Quadrangle

- Historically produced 20-40 Moz Au;
- District hosts many epithermal and mesothermal Ag-Au, Cu-Au, porphyry Cu, and base metal deposits
- Associated with the Neogene andesitic-dacitic volcanic and sub-volcanic bodies emplaced along 3 distinct WNW-trending belts

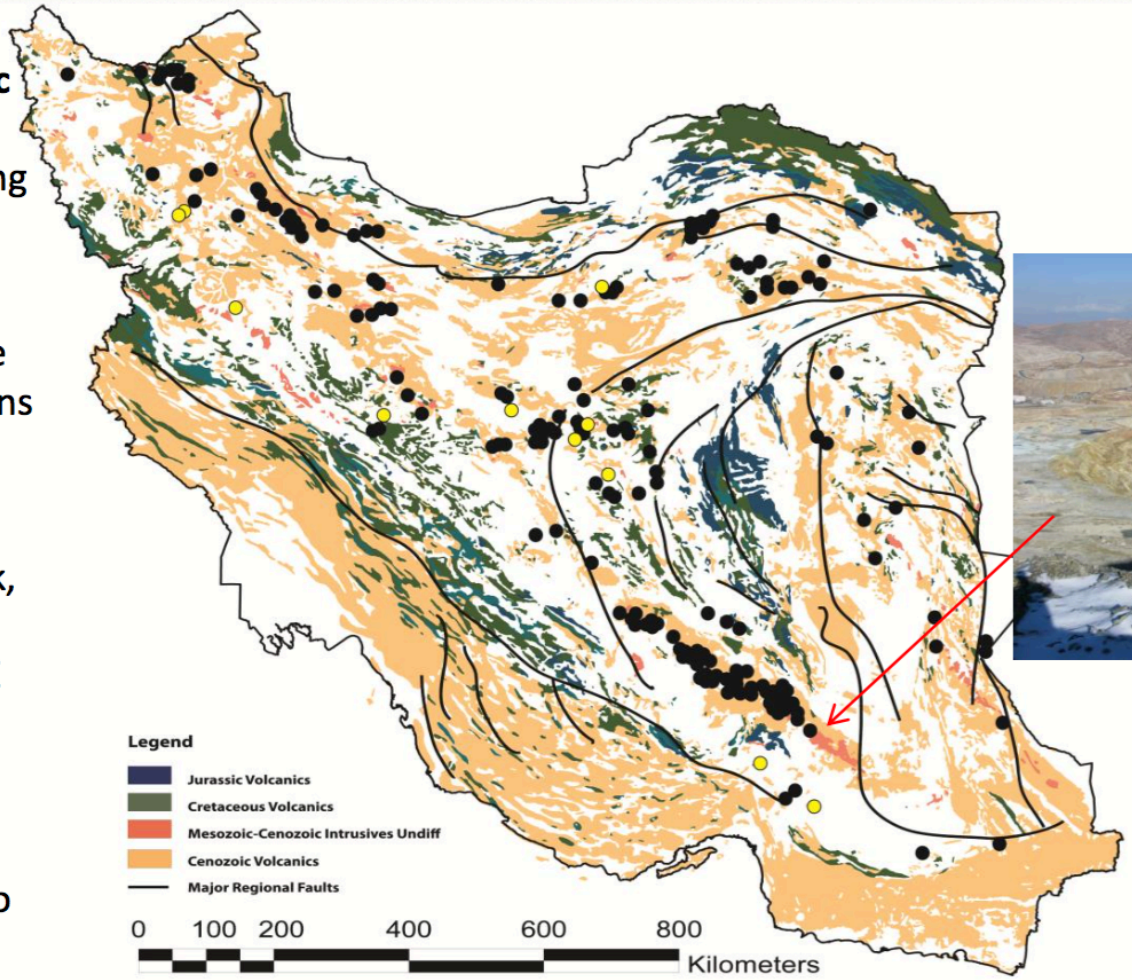


Certej LS epithermal Au-Ag

Rosia Poieni Cu porphyry

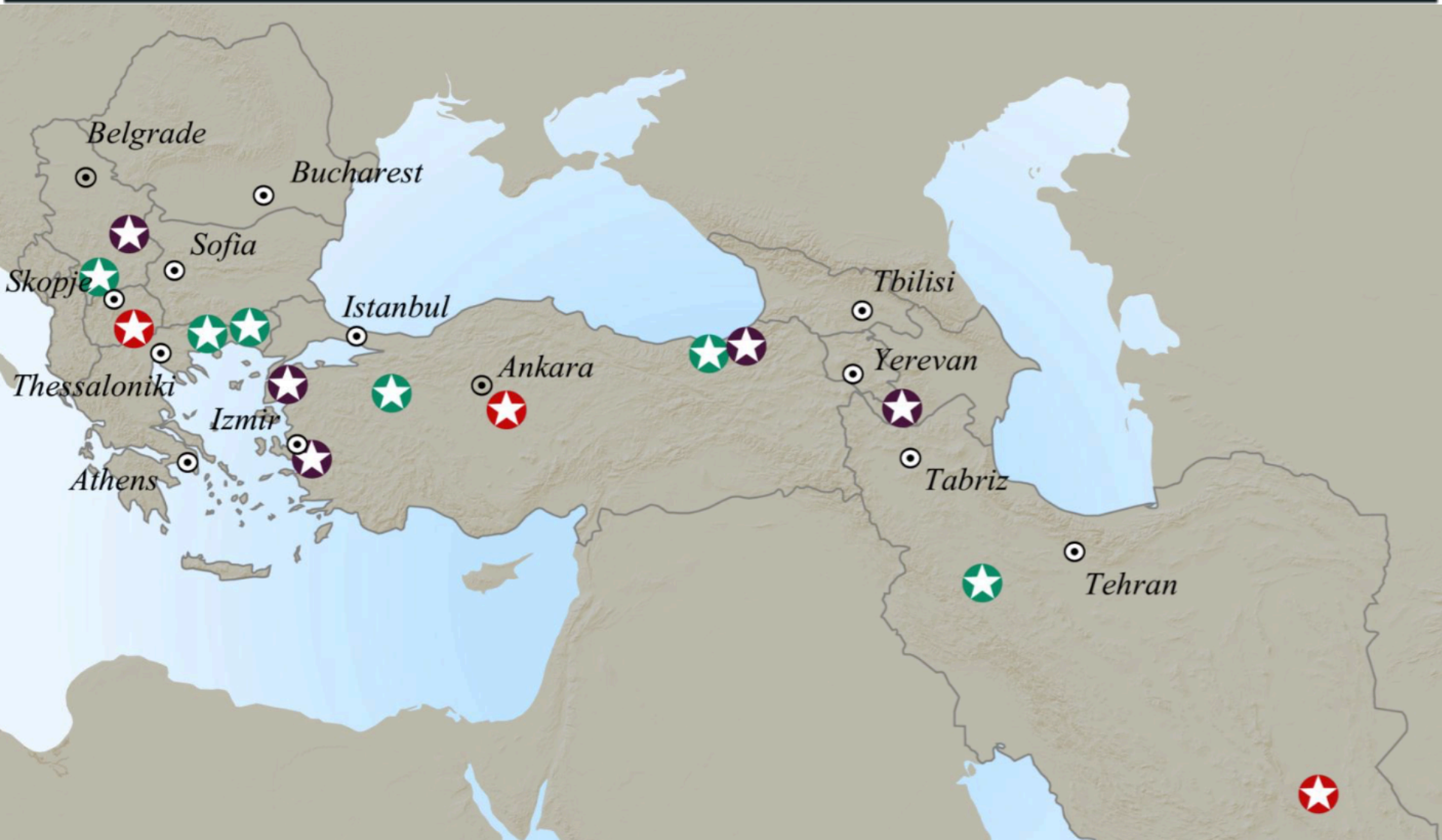
**Urumieh-Dokthar Arc**

- Main volcano-plutonic belt hosting Cu porphyries
- Dismembered by a series of transverse faults into 3 domains
- Large porphyry Cu deposits (e.g. Sar Cheshmeh, Meiduk, and Sungun) are restricted to the SE and NW sectors
- Cu mineralization was diachronous from 24Ma (NW) to 10 Ma (SE)



Rubicon

Come to Turkey

TURK

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