Using 3D/4D modeling tools in exploration of gold-polymetallic potential areas in Greece

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Study area

3D Geomodels

Deposit scale

- North-East Chalkidiki peninsula

1)Mavres Petres, 2) Olympias, 3) Skouries

- Western Thrace

4) Perama, 5) Aghios Demetrios

Semi-regional scale

1) Polymetallic deposits in North-East Chalkidiki peninsula

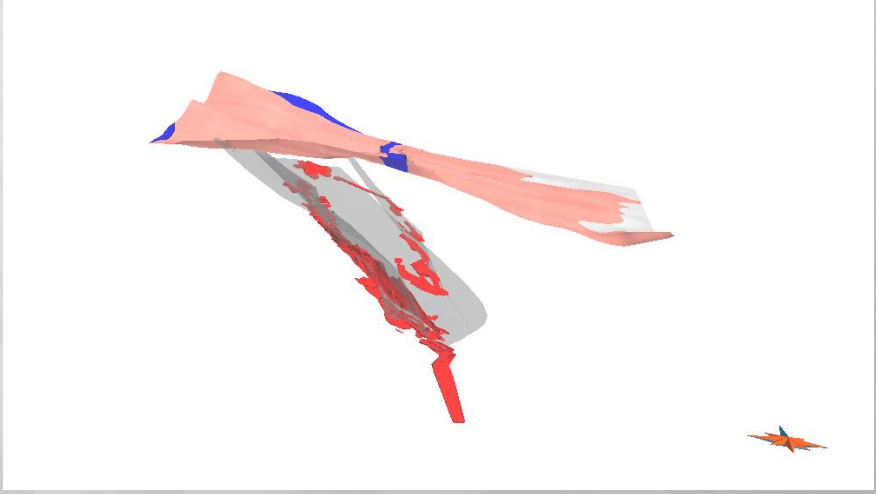
2) Epithermal gold deposits in Western Thrace

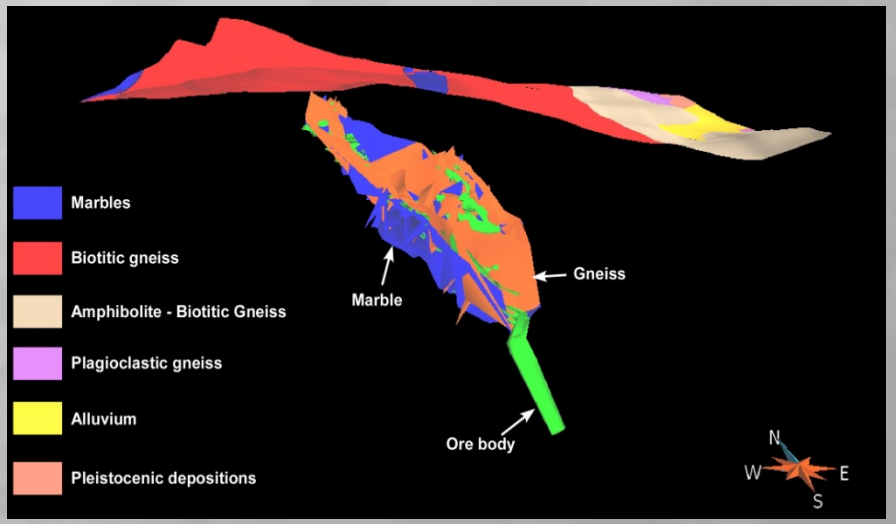
Olympias polymetallic replacement deposit

- Massive stratabound replacement ore body within marbles of the Kerdylia formation in the Serbomacedonian massif.
- The ore body develops within the lower marble horizon along the contact with an overlying unit of gneisses.

Data that have been used:

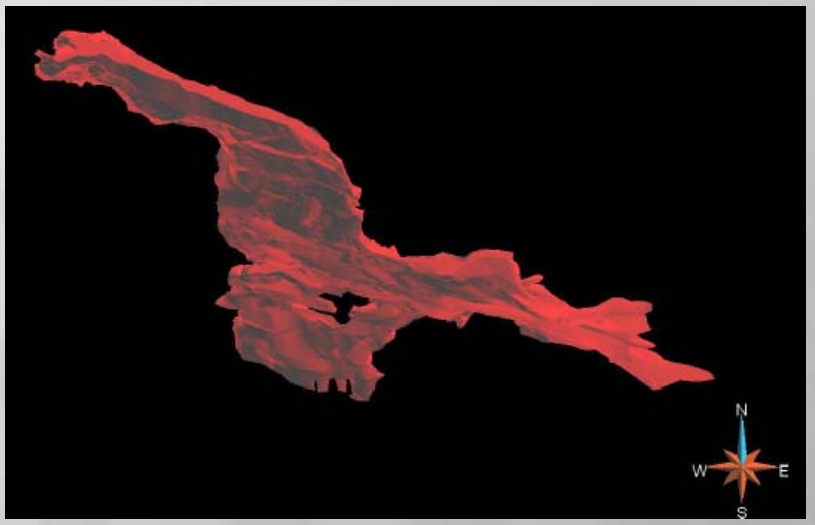
- Regional geological and structural data
- Lithological and tectonic data using logging from the 668 drill holes
- Data of chemical assays from the drill holes
- Alteration data from the drill holes

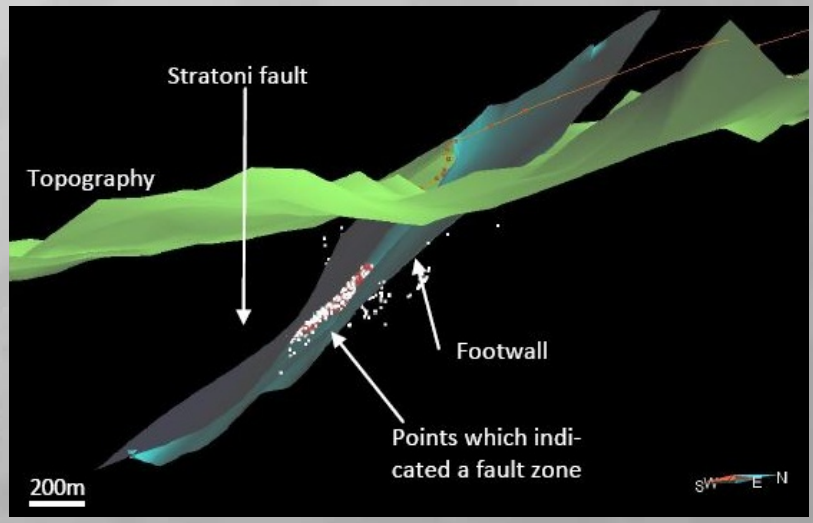




Mavres Petres polymetallic replacement deposits

- Mavres Petres is a massive stratabound replacement deposits within the marble of the Kerdylia formation in the Serbo-Macedonian massif.
- The mineralization is controlled by a combination of marble horizons and the deep seated faults
- The deposit is cross-cut by the major Stratoni-Varvara thrust fault and the sulphide ores extend westwards along the thrust into gold-bearing manganese deposits

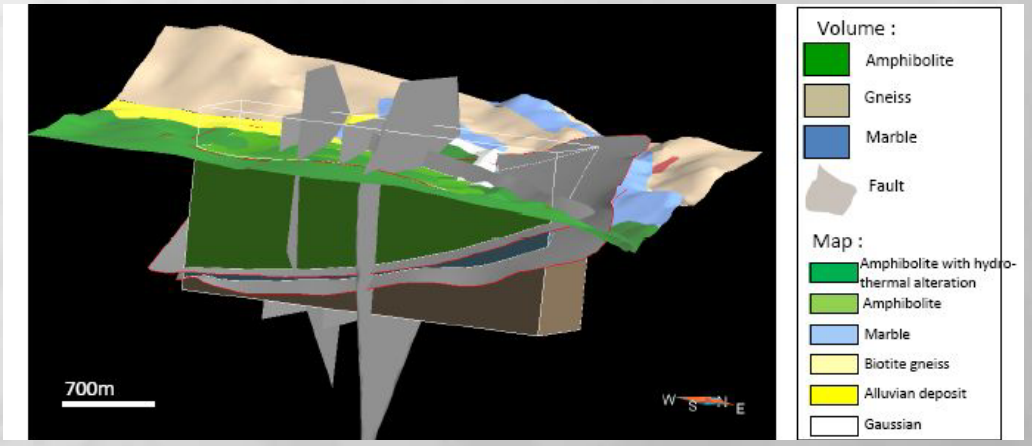


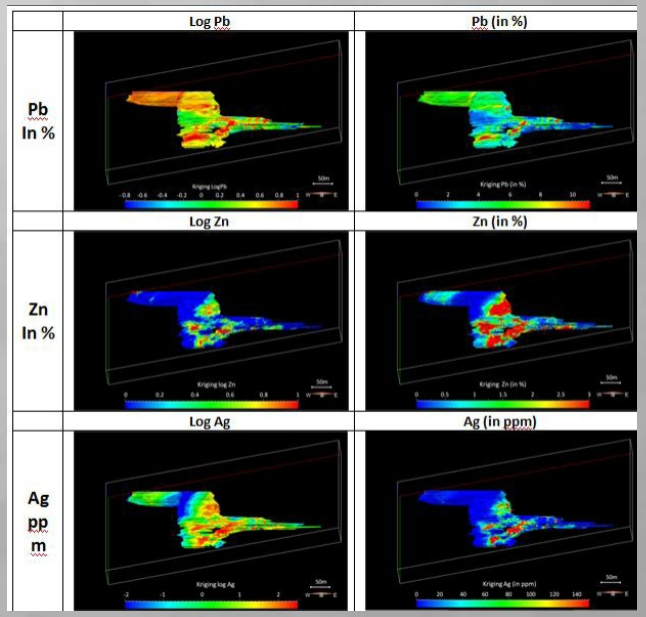


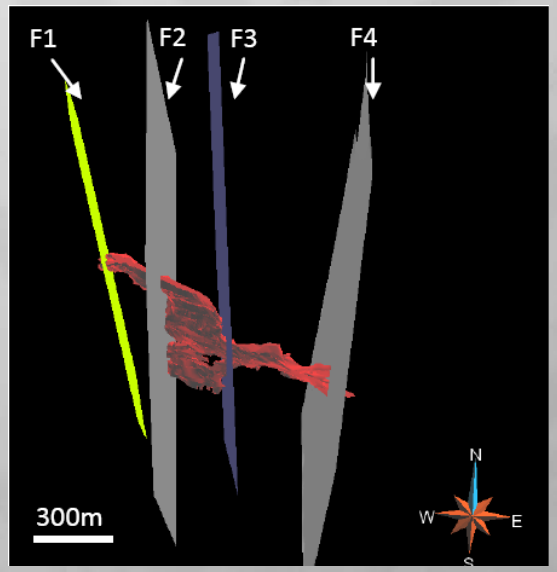
Mavres Petres polymetallic replacement deposits

Available data:

- Geological data
- Lithological data
- Tectonic data from the drillholes
- Interpreted and observed faults
- Cross sections
- Mining reports

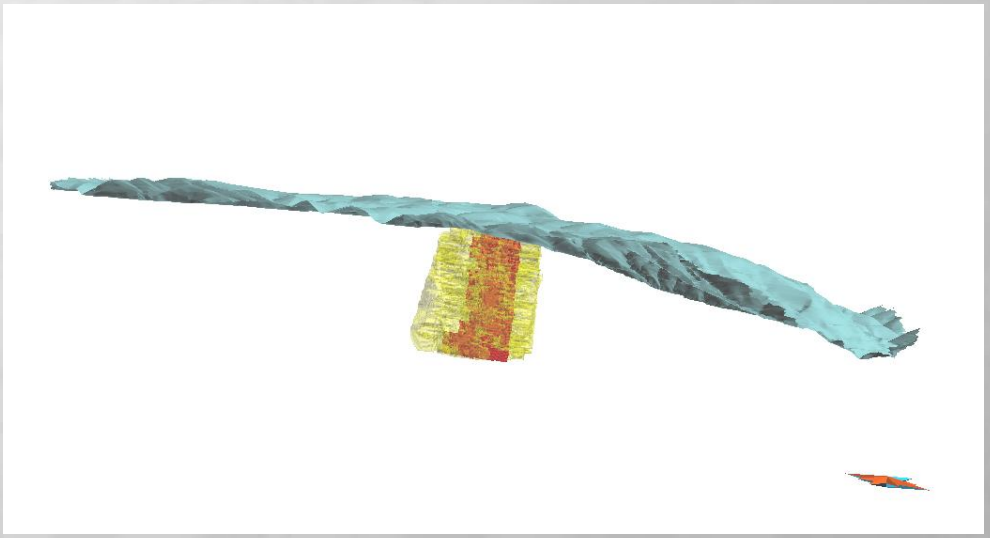






Skouries porphyry copper deposit

- A series of dominantly dioritic to andesitic porphyritic dikes and stocks were emplaced in NE - SW trending intrusive belt in NE Chalkidiki
- The porphyry Cu deposit occurs as a pipe-like, mineralized subvolcanic body with surface dimensions of 180m N- S and 200m E-W with a vertical extent of at least 700m
- The deposit is characterized by concentric potassic, propylitic, phyllic and argillic alteration zones, affecting mostly the host schists



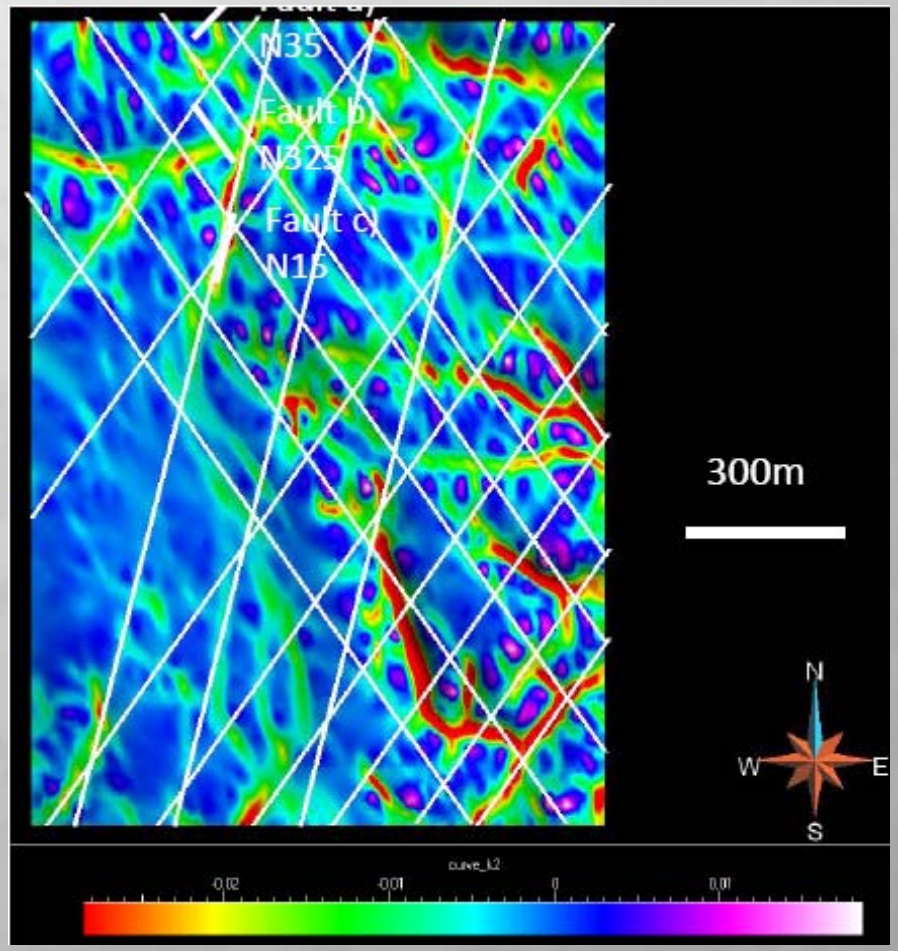
Skouries porphyry copper deposit

Available data:

- The topography of the area
- The surface lithological & tectonic data that obtained from the geological maps
- The magnetic map of the area

Produced data:

- The building of the faults.
- The mapping of the curvatures.



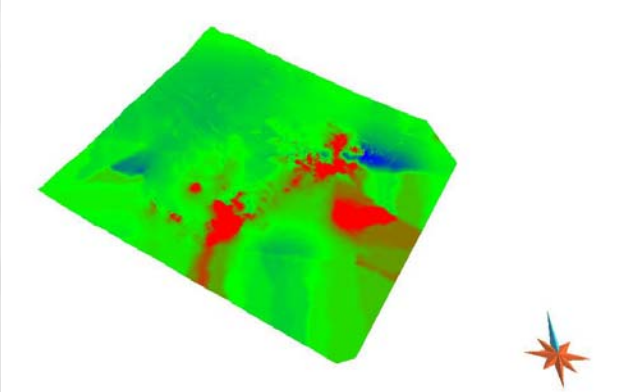
North-Eastern Chalkidiki semi-regional 3D model

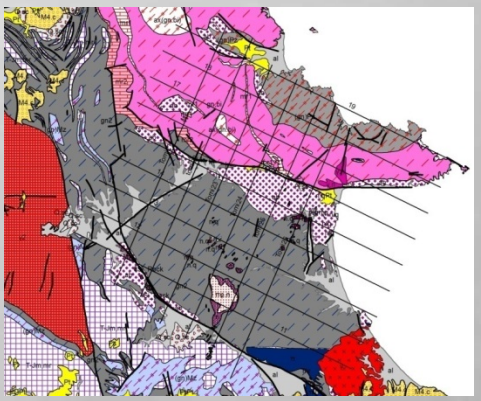
Available data:

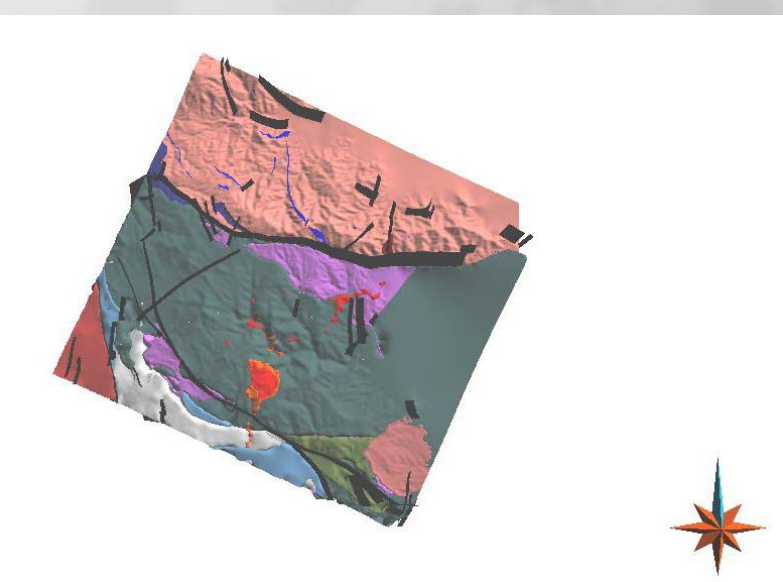
- Lithological & tectonic data
- Geophysical data
- Geologic maps

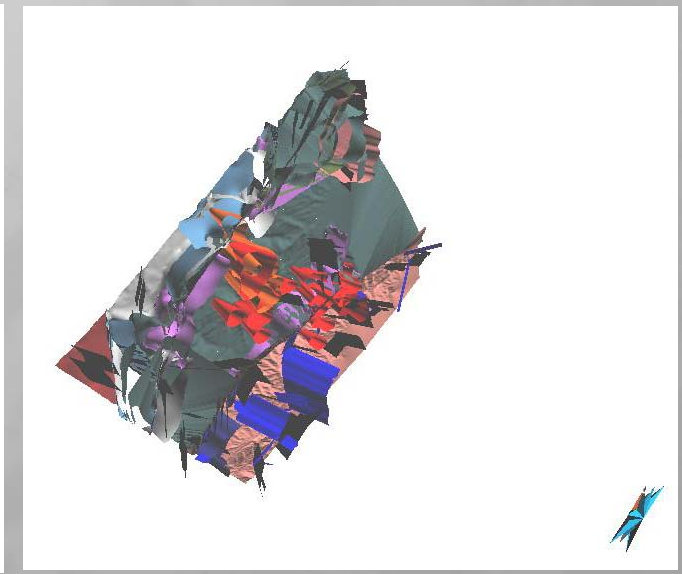
Produced data:

- 3D geology of the area









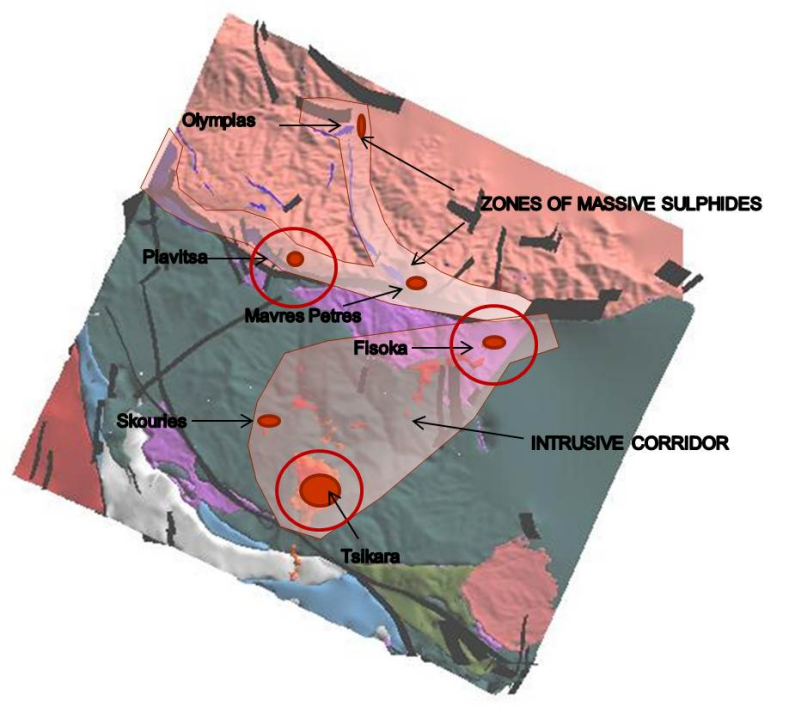
North-Eastern Chalkidiki semi-regional 3D model

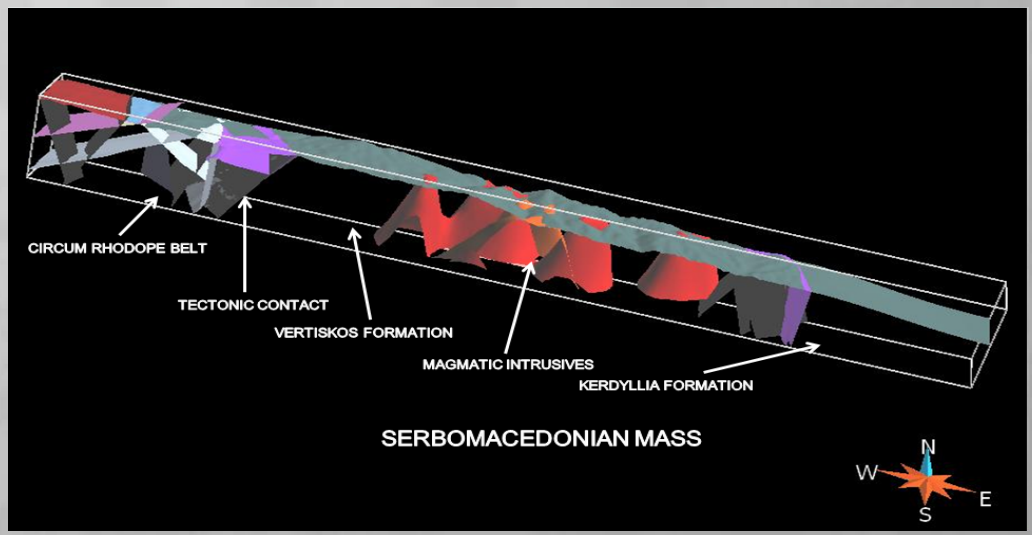
Available data:

- Lithological & tectonic data
- Geophysical data

Produced data:

- 3D modelization of the intrusive bodies
- 3D modelization of the bedrocks and the whole geological zones





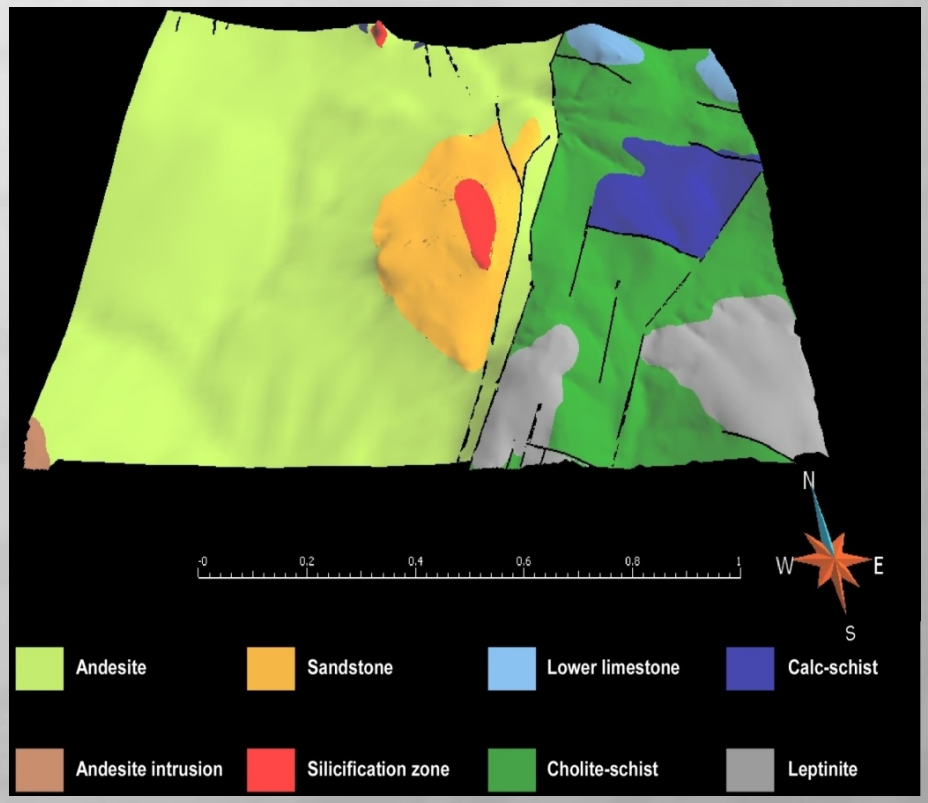
ProMine

http://promine.gtk.fi

4D Modelling of Halkidiki peninsula mineral belt

Perama epithermal gold deposit

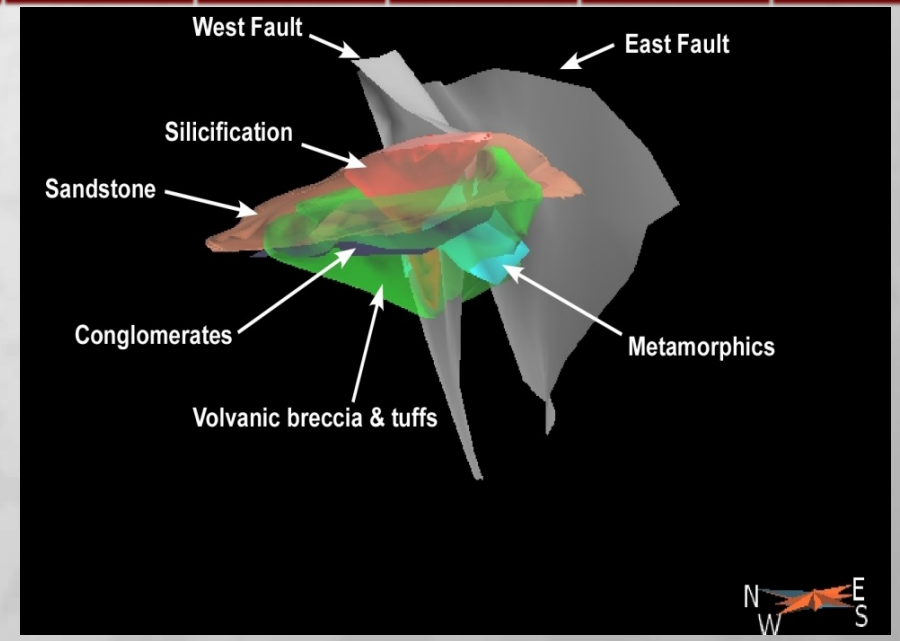
- The mineralization is hosted by sandstones
- Fractured silicified zones and hydrothermal fracturing is expressed at the contact of greenschists-calcschists (Mesozoic metamorphic rocks) and Perama sandstones
- Advance argillic alteration is the main alteration assemblage in the deposit.

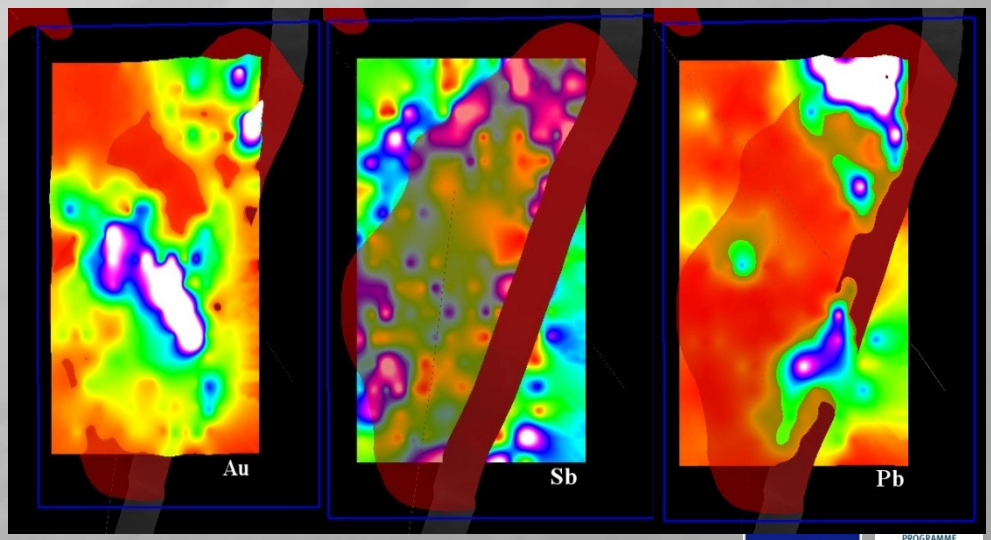


Perama epithermal gold deposit

Available data:

- Topography
- Surface geological and structural data
- Lithological and tectonic data from the logging of 194 drill holes
- Data of chemical assays (drill holes)
- Alteration data (drill holes)
- Soil geochemical data of Au, Ba, Sb, Pb





Perama epithermal gold deposit

From the 3D model observed:

- The mineralization was first structurally controlled
- The contact (fault graben) between Mesozoic rocks and Tertiary rocks was the channel way of the hydrothermal fluids
- The sandstones are lithologically the favorite site of gold deposition
- The deposit is characterized by vertical zonal pattern of the ore metals distribution. The main part of the base metals sulphide mineralization is hosted by volcanic breccias and tuffs at depth.
- The gold mineralization is hosted within sandstones at surface while the main part of the basemetals is hosted by volcanic breccias and tuffs at depth

Aghios Demetrios epithermal gold deposit

Geological structure:

- Strongly altered agglomerate andesitic tuffs, lavas and volcanic breccias
- Quartz – monzodiorite intrusive rocks

Alteration zones:

➢Four main and two overlapping alteration zones are distinguished:

- Siliceous zone (hydrothermal eruption vents breccias)
- Advanced argillic zone (subzone of alunite, subzone of diaspore, subzone of argillic alteration and subzone of pyrophyllite)
- Propylitic alteration
- Potassic alteration

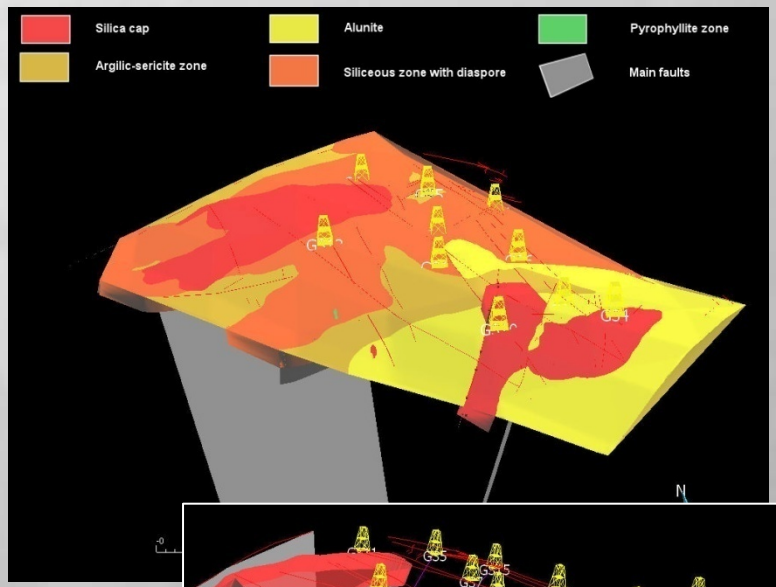
➢Overlapping alteration zones

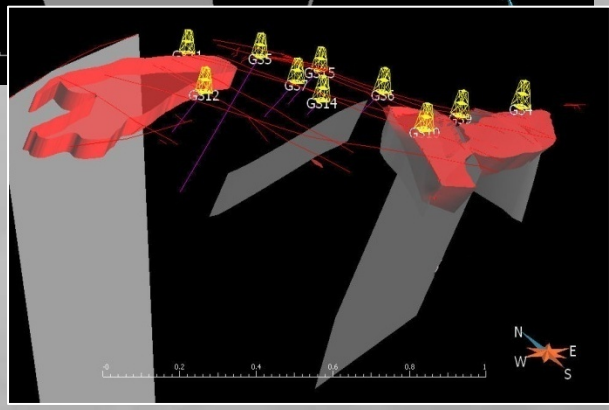
- Sericite zone
- Zone of adularia

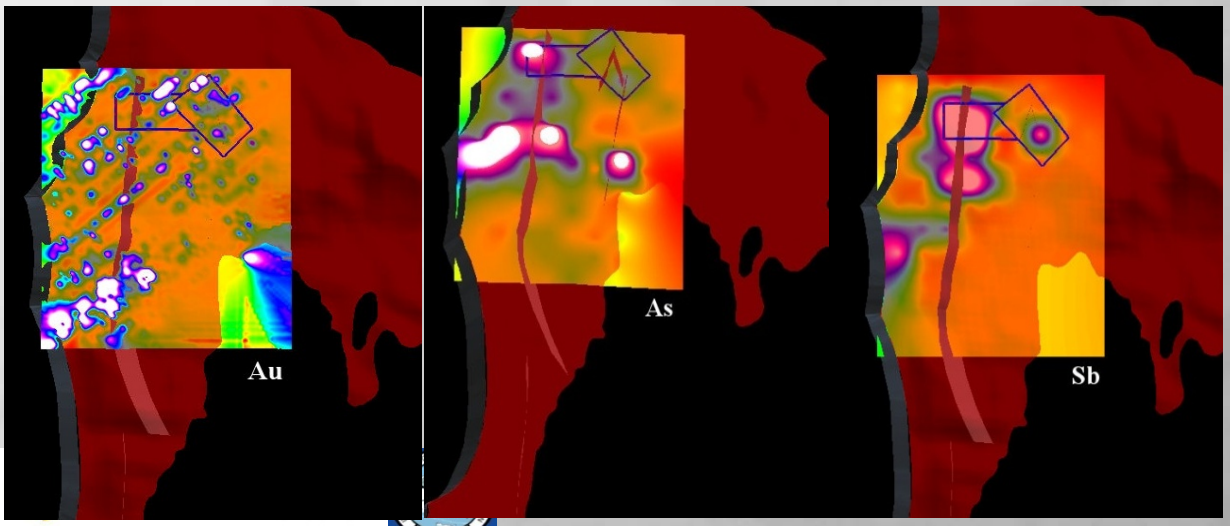
Aghios Demetrios epithermal gold deposit

Available data:

- Geological map (scale 1:1.000)
- Logging data of twelve (12) drill holes
- Drill hole mineralization intersections
- Alteration zones (surface & drill hole data)
- Fault development
- Soil geochemical data of Au, As, Sb



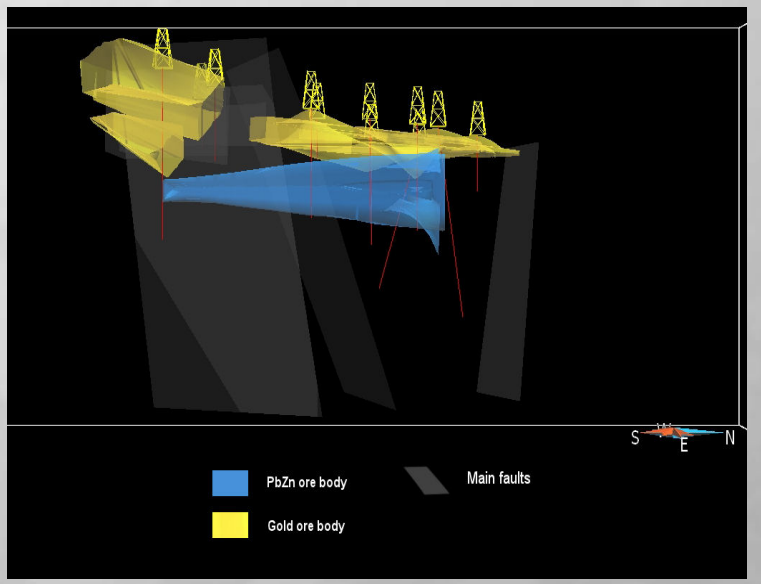


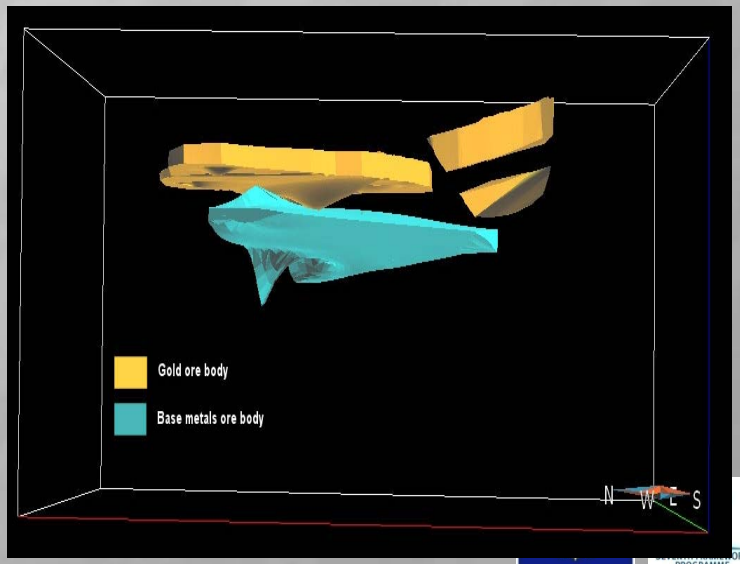


Aghios Demetrios epithermal gold deposit

From the 3D model can be concluded:

- The gold ore body occurs at surface forms a flat lying and trends to N-W, south-east. It dips N-NE at 5º-10º
- The north-northeastern part of the area presents considerable potential for development of the ore body
- The dimension of the ore body is approximately 550 meters long and the width varies from 100-160m

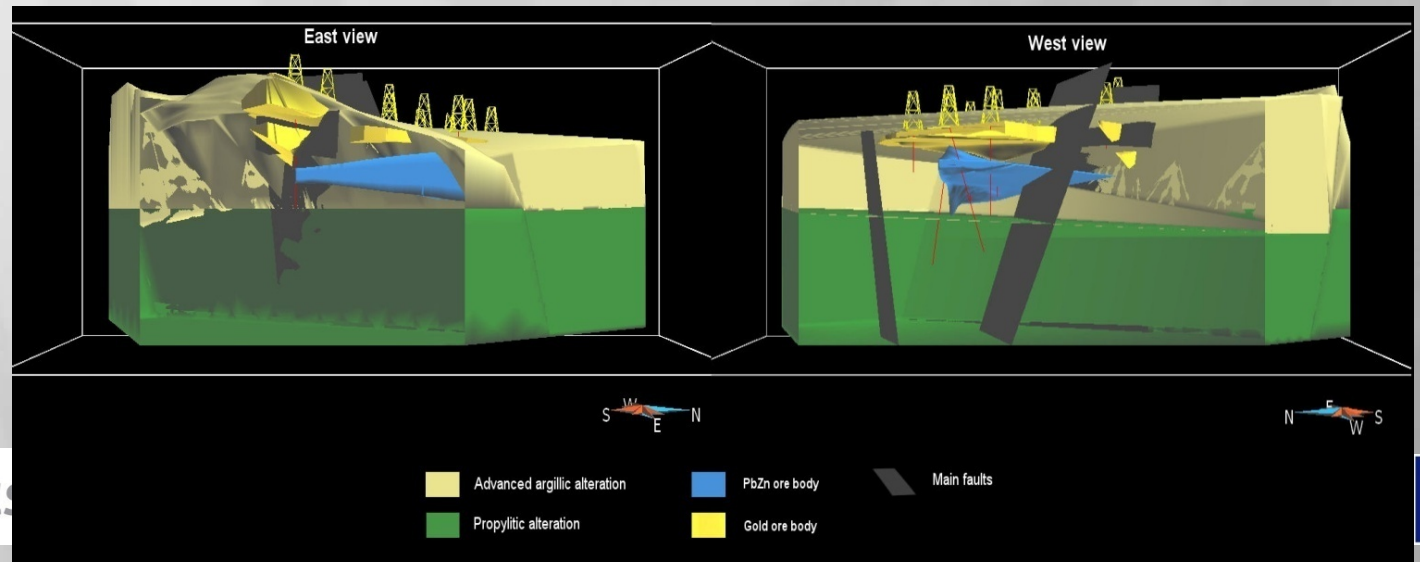




Aghios Demetrios epithermal gold deposit

From the 3D model can be concluded:

- A N-E trending fault zone intersects and separates the ore body. This fault zone has also caused displacement of the wall rock alteration zones.
- Gold mineralization is mainly connected with hydrothermal eruption vent breccias
- Base metals mineralization is developed at deeper levels
- The deposit is characterized by vertical zonal pattern of the alteration zones distribution

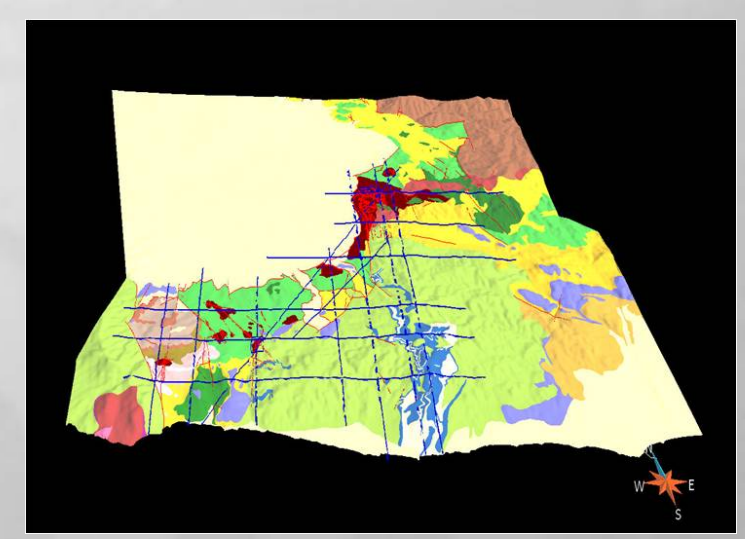


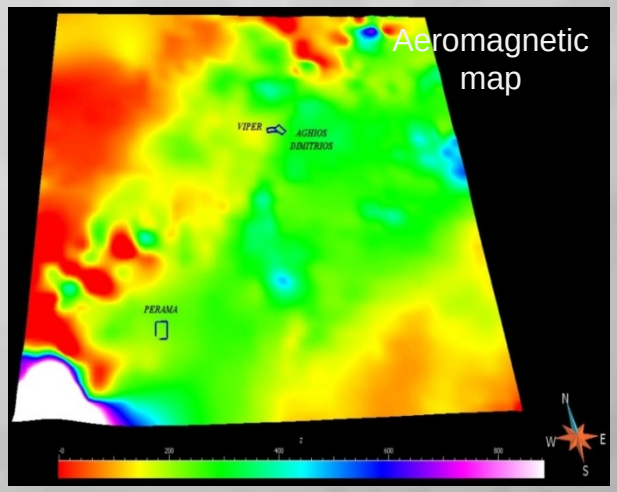
Semi-regional 3D model of Thracian epithermal gold deposits

Available data:

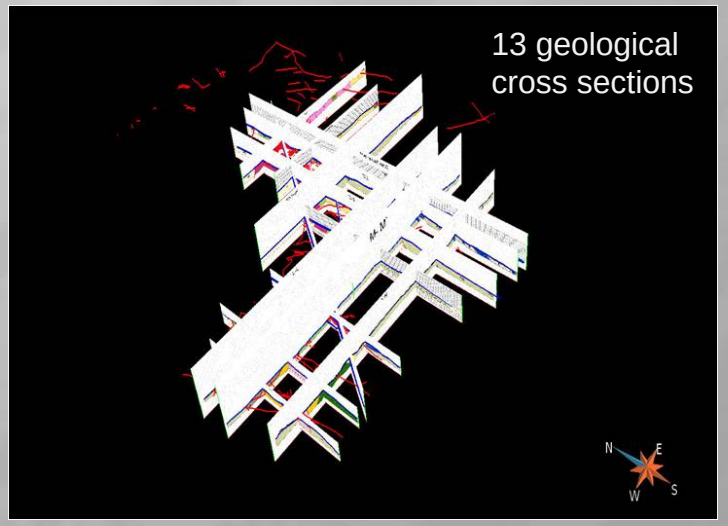
- Cross sections
- Aeromagnetic data
- 3D models in deposit scale

Thirteen (13) geological cross sections were used across the Petrota and Kirki Tertiary basins



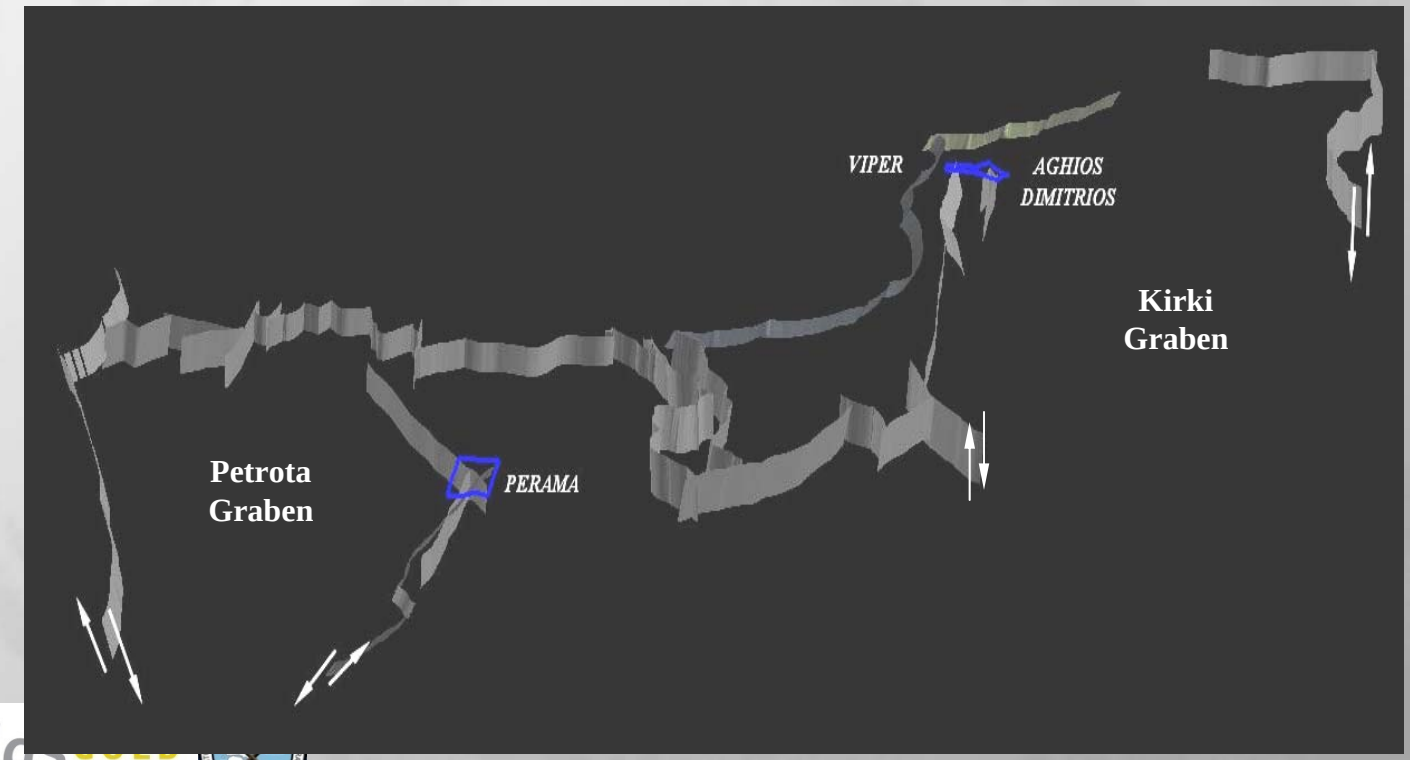


Aeromagnetic map


13 geological cross sections

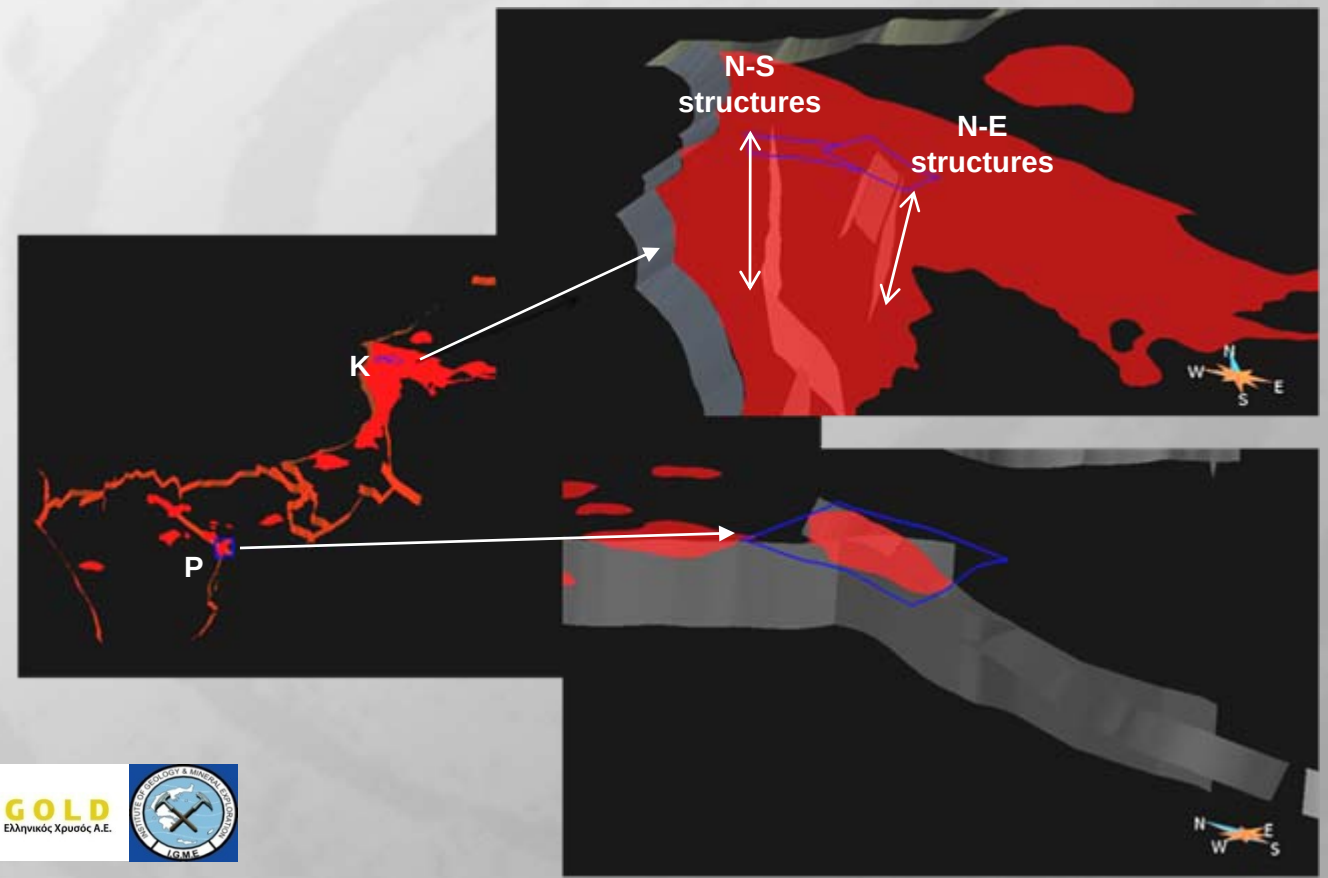
Semi-regional 3D model of Thracian epithermal gold deposits

- The N-NE, N-W, E-W and N-S structures are deep structures forming regional scale rift-fault basins (Petrota and Kirki graben).
- The andesitic, rhyodacitic and rhyolitic stocks and dikes in Konos-Sappes epithermal system appear to have the same N-S structural control.



Semi-regional 3D model of Thracian epithermal gold deposits

- In Kirki Tertiary basin a strong N-S structure of about 7,5 Km long at the western part of the area is considered to mark a fissure vent system.
- A set of younger N-E faults have caused displacement of the structure.



Conceptual 4D model of epithermal Au deposits in Tertiary basins of Western Thrace

Conclusions

- The Mavres Petres mine 3D modelling revealed a series of parallel faults, vertical to the main Stratoni-Varvara fault, and established a reliable tool for exploration of new ore potential areas at depth and along the westward extension of the main fault structure, in the area of Piavitsa
- In the semi-regional scale 3D modelling of NE Chalkidiki peninsula, the interaction between faults and magmatic intrusions was very much obvious. In addition the geological sections across the area indicated the types of mineralization processes taken place

Conclusions

- In general the 3D model of Aghios Demetrios provides the geometry and orientation of the ore body, the pattern metals distribution zones, the role of later faults in displacing the ore body and the reserves verification of the deposit. In the Perama Hill epithermal gold deposit, the 3D model shows the development of mineralization zones, as well as the structural and lithological control of ore deposition.
- A geological reconstruction of the epithermal deposits in Thrace region, at semi-regional scale, shows that N-NE (Perama Hill) and N-S (Aghios Demetrios) trending structures seems to have been the conduit of hydrothermal fluids and the fissure vent systems. These faults correspond to deep structures forming the rift/graben Tertiary basins.

Conclusions

- 3D models not only contributes to ore feasibility evaluation, which is a key factor in mining industry, but also enables better understanding of the mineralizing processes that led to the ore formation, and to assist the exploration of new deposits as well as the expansion of known
- The 3D models are very useful tools for improving the knowledge of the ore deposition and conduct an efficient and successful mineral exploration for locating deep-seated mineralizations. Given the multi-disciplinarity of the existing data and the advanced IT capabilities it is realistic to further develop 3D into 4D models when the time parameter is combined and added. This will secure even more and make the exploration efficiency more sustainable to determine additional potential areas and discover new exploitable deposits with the same or different resource

Thank you for your attention

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In memory of Gabor Gaal