Dr. Evgenii Ermolin

Geophysical technologies for LS-Epithermal Au-Ag deposits exploration

Relevance and study objective

Relevance

Over the past several decades, no large deposits have been discovered.

Relevance and study objective

Objective

To developing an optimal method for LS-epithermal gold deposits exploration.

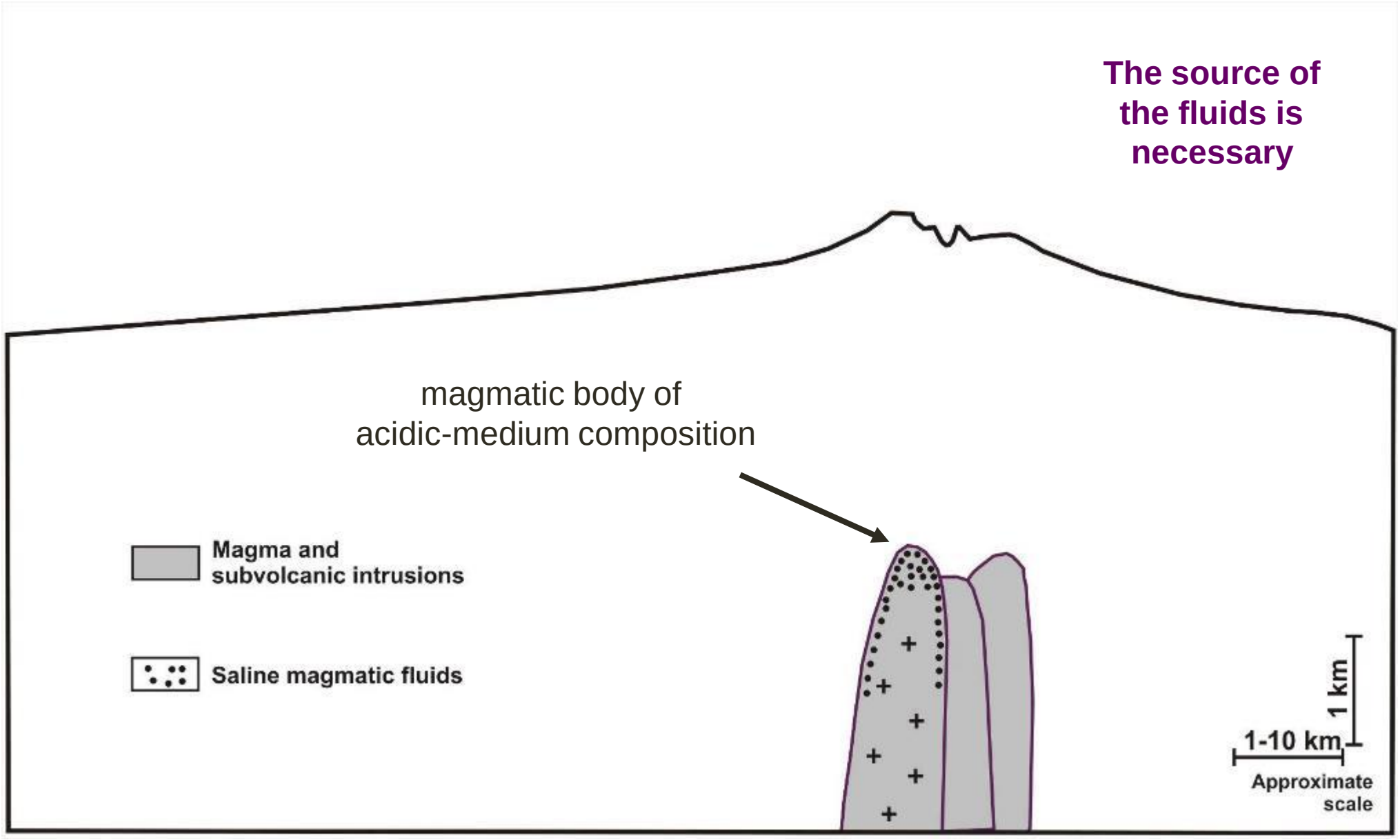
Plan of Presentation

- Schematic geological-genetic model of the epithermal deposit

- Physical-geology model

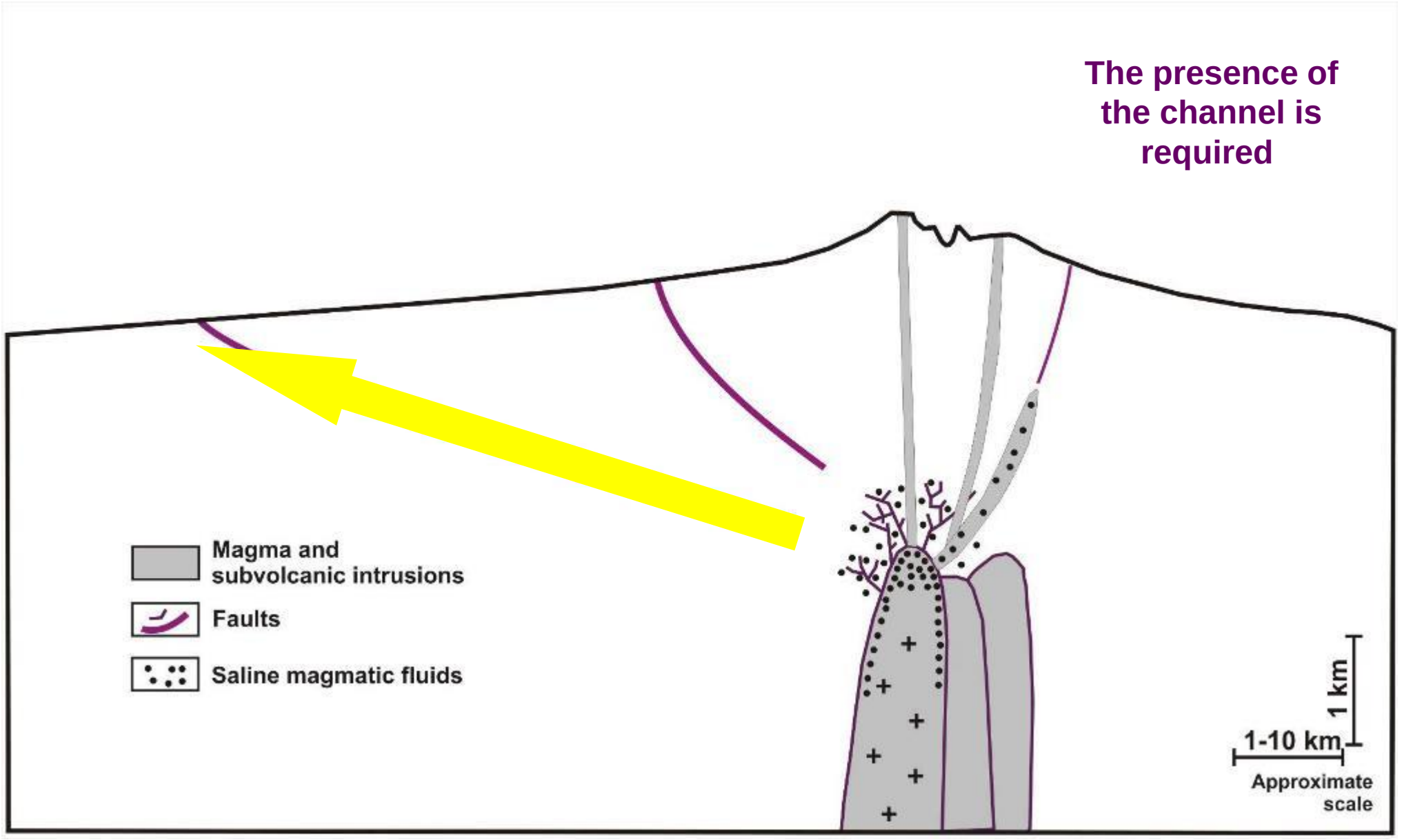
- Strategy of exploration

Schematic geological-genetic model of the epithermal deposit



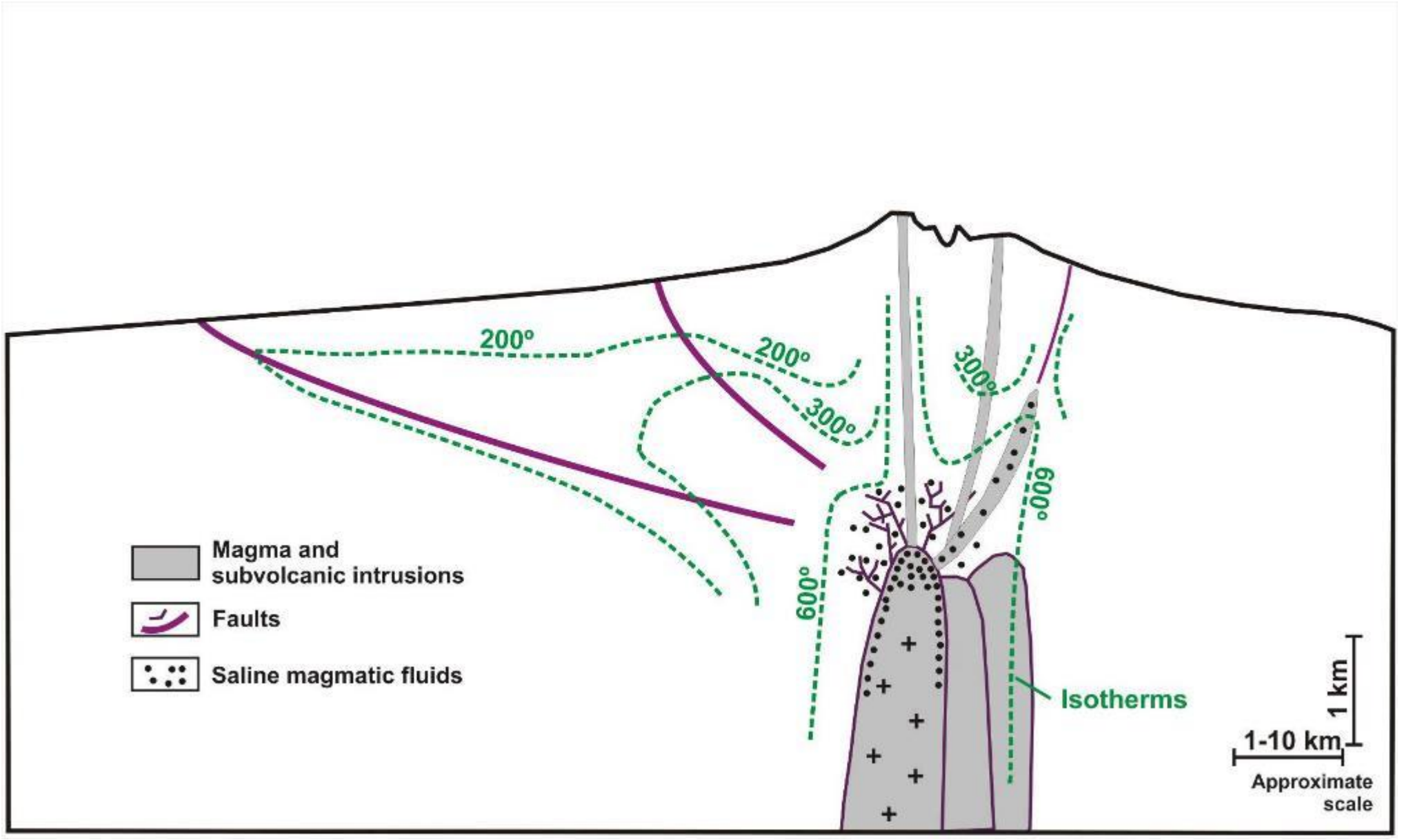
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



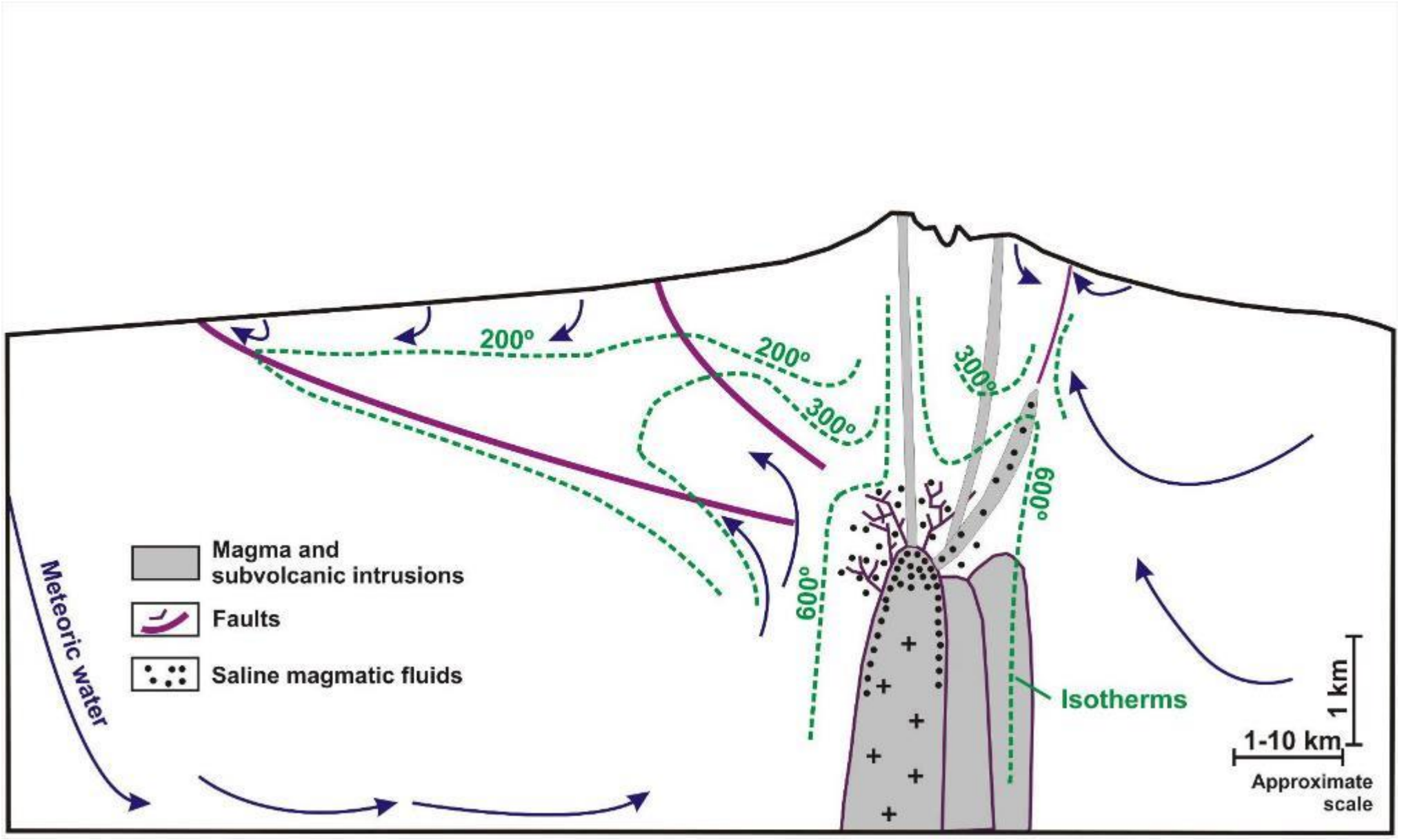
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



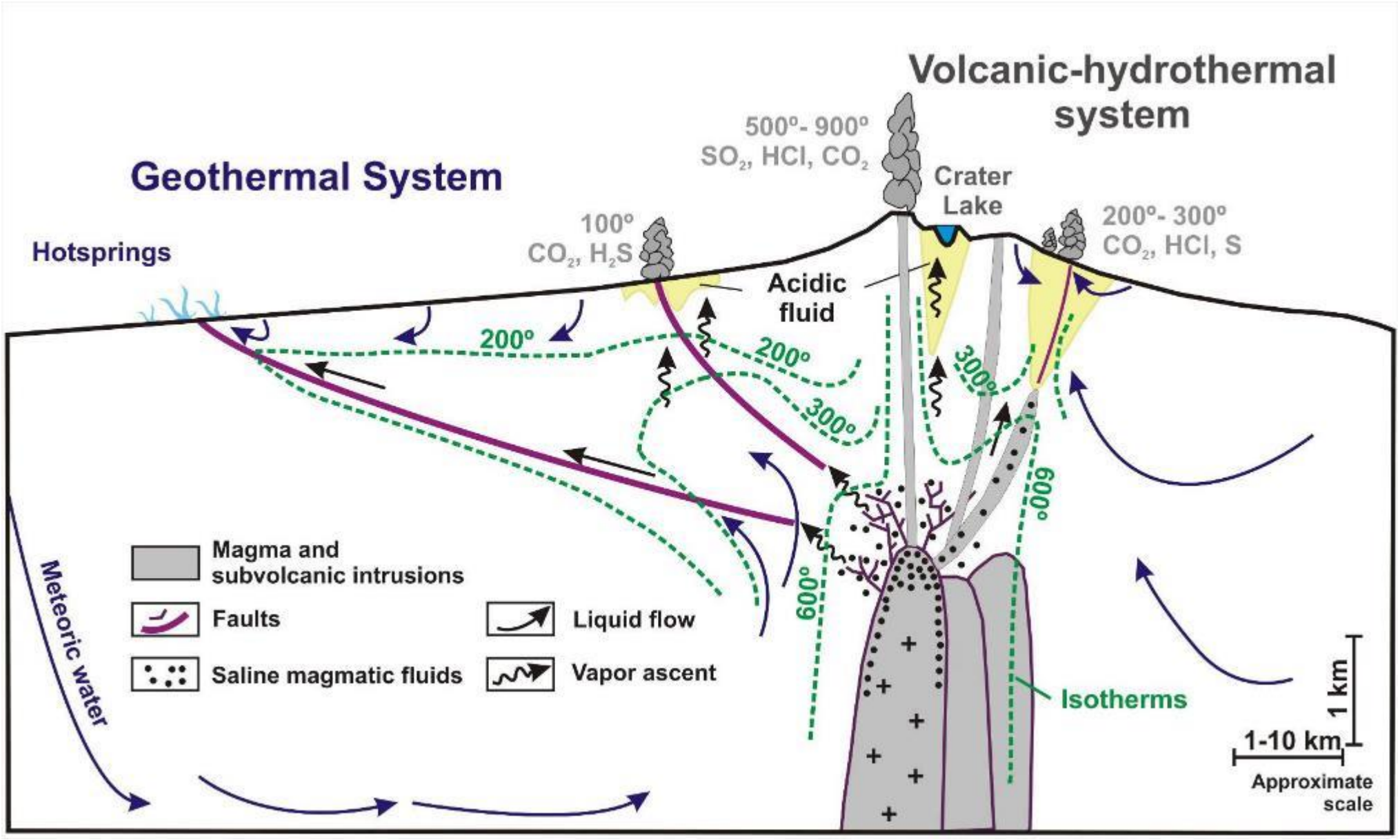
(*Hedenquist et al. 2000,* modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



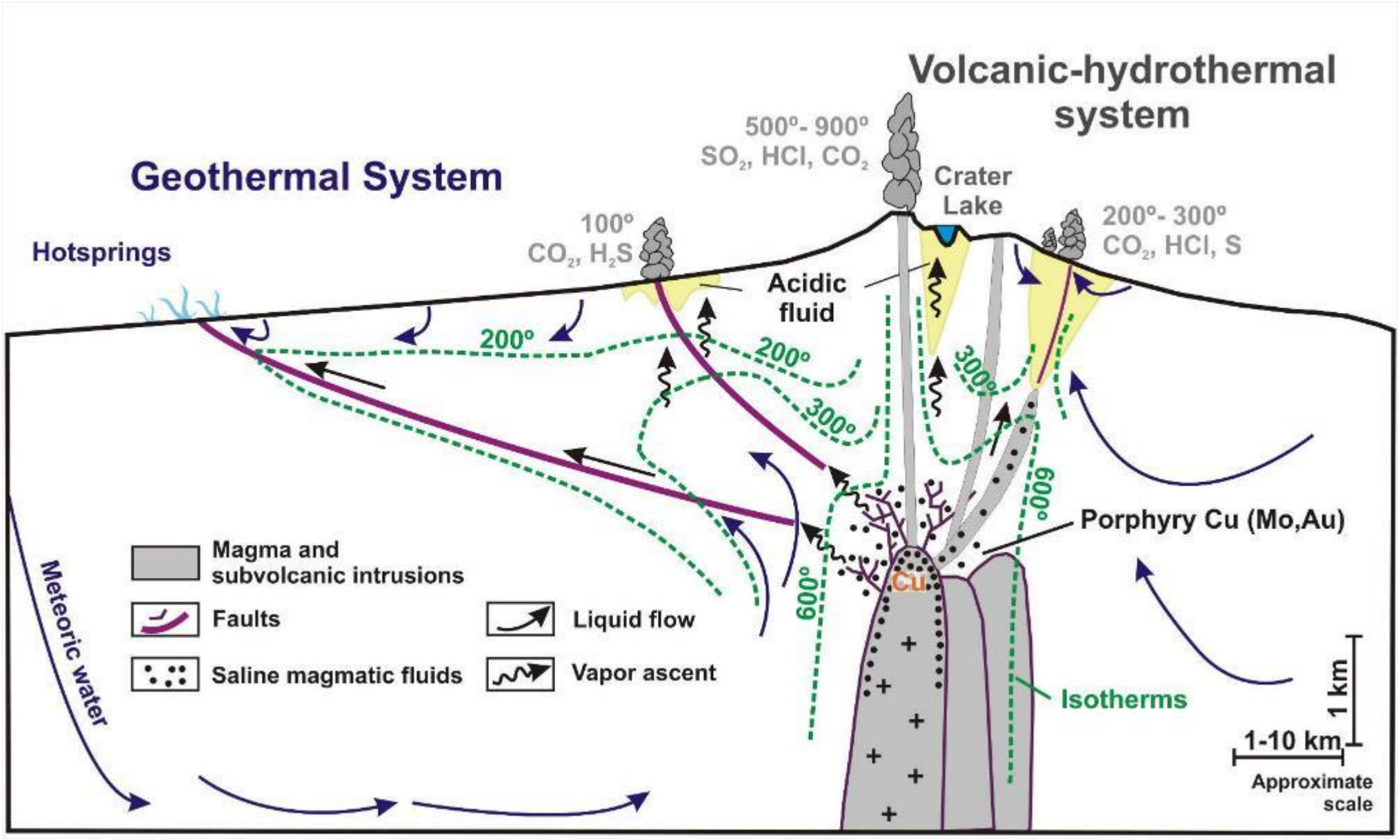
(*Hedenquist et al. 2000,* modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



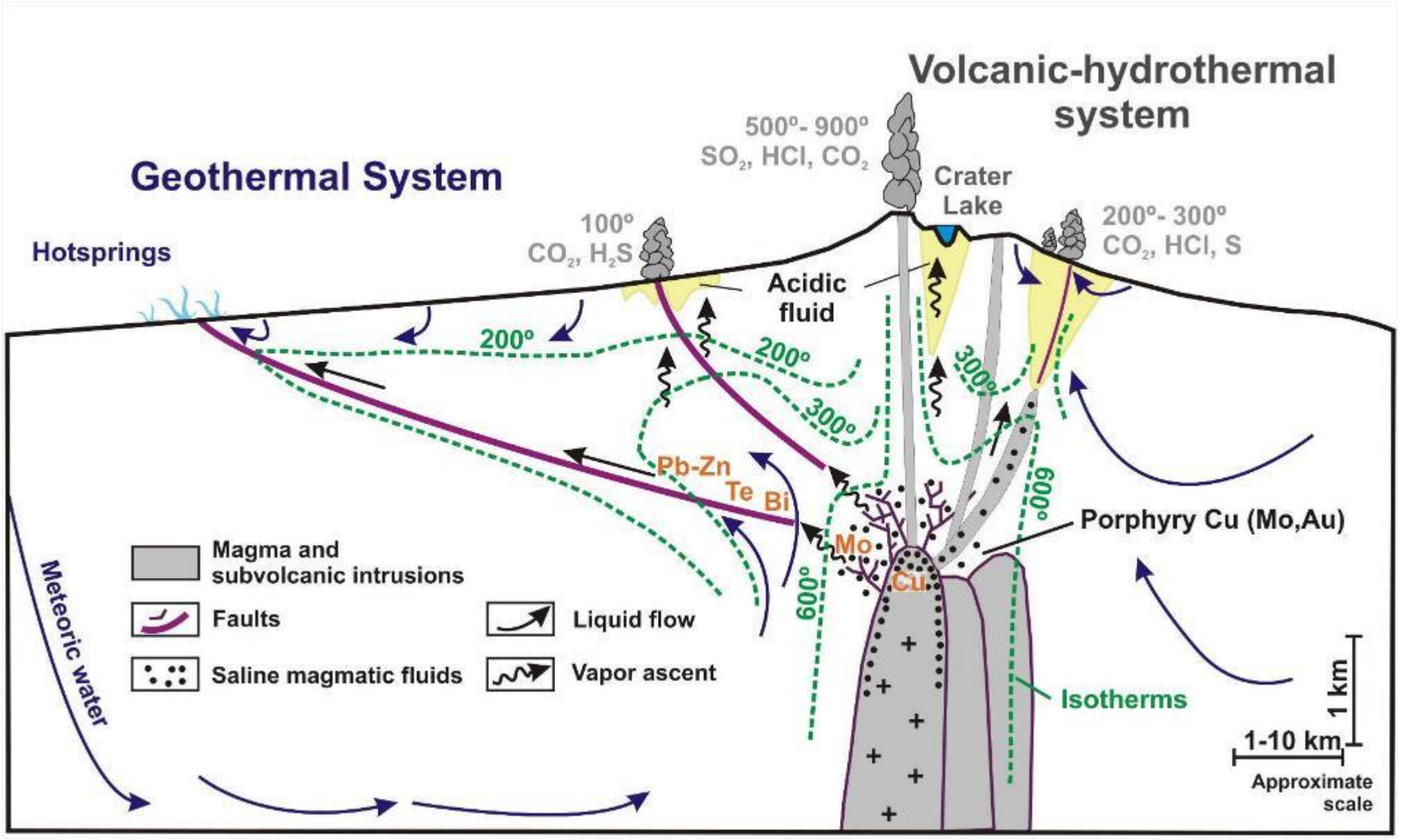
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



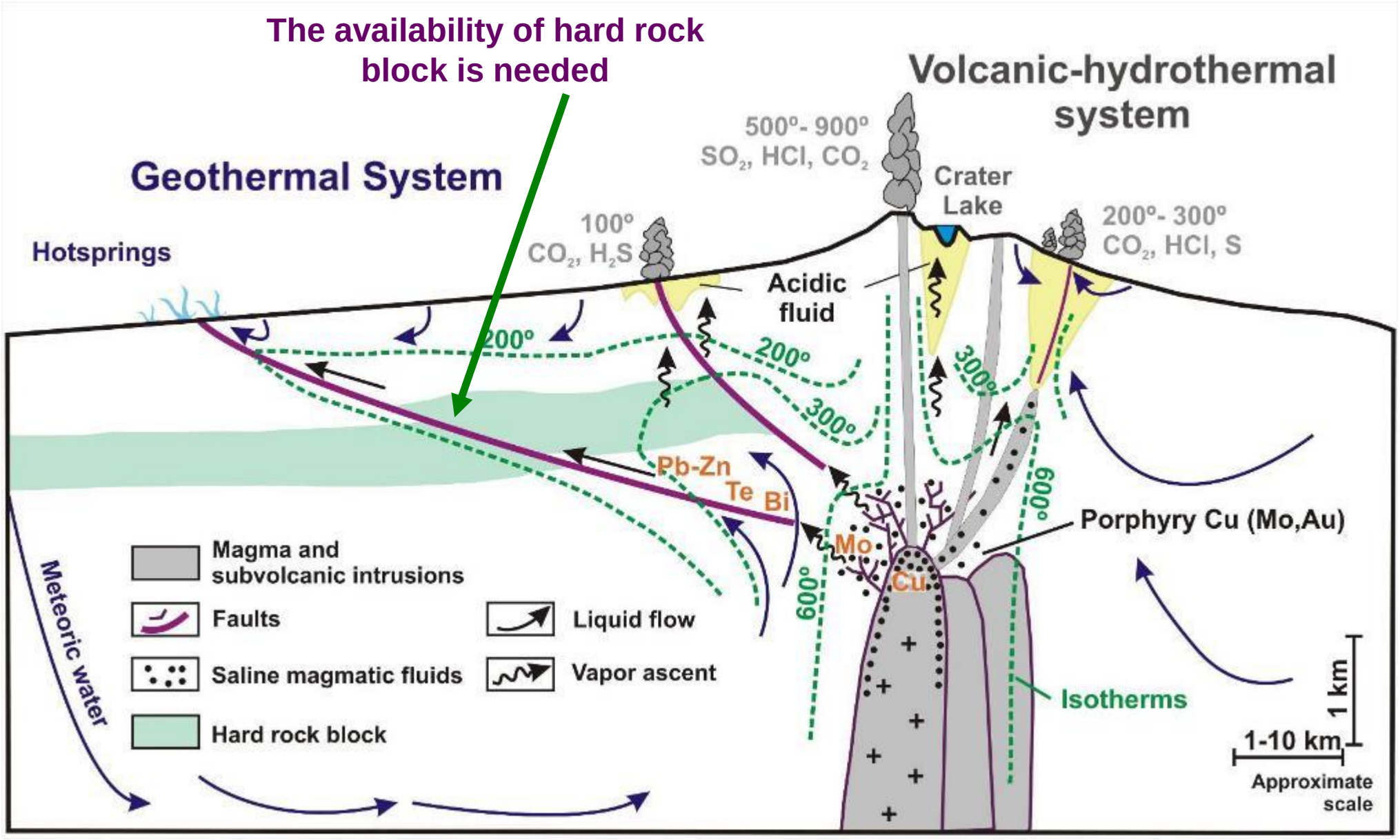
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



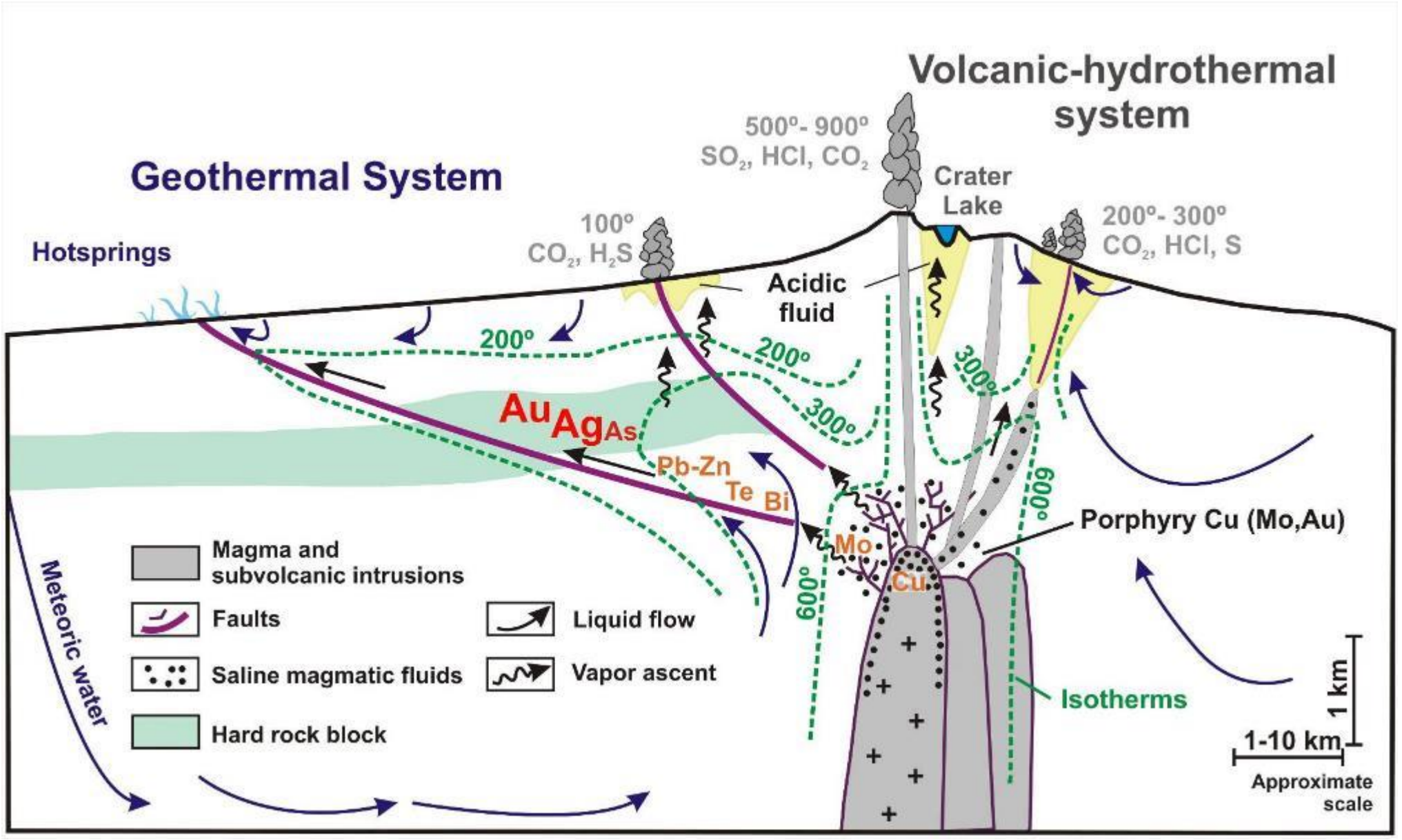
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



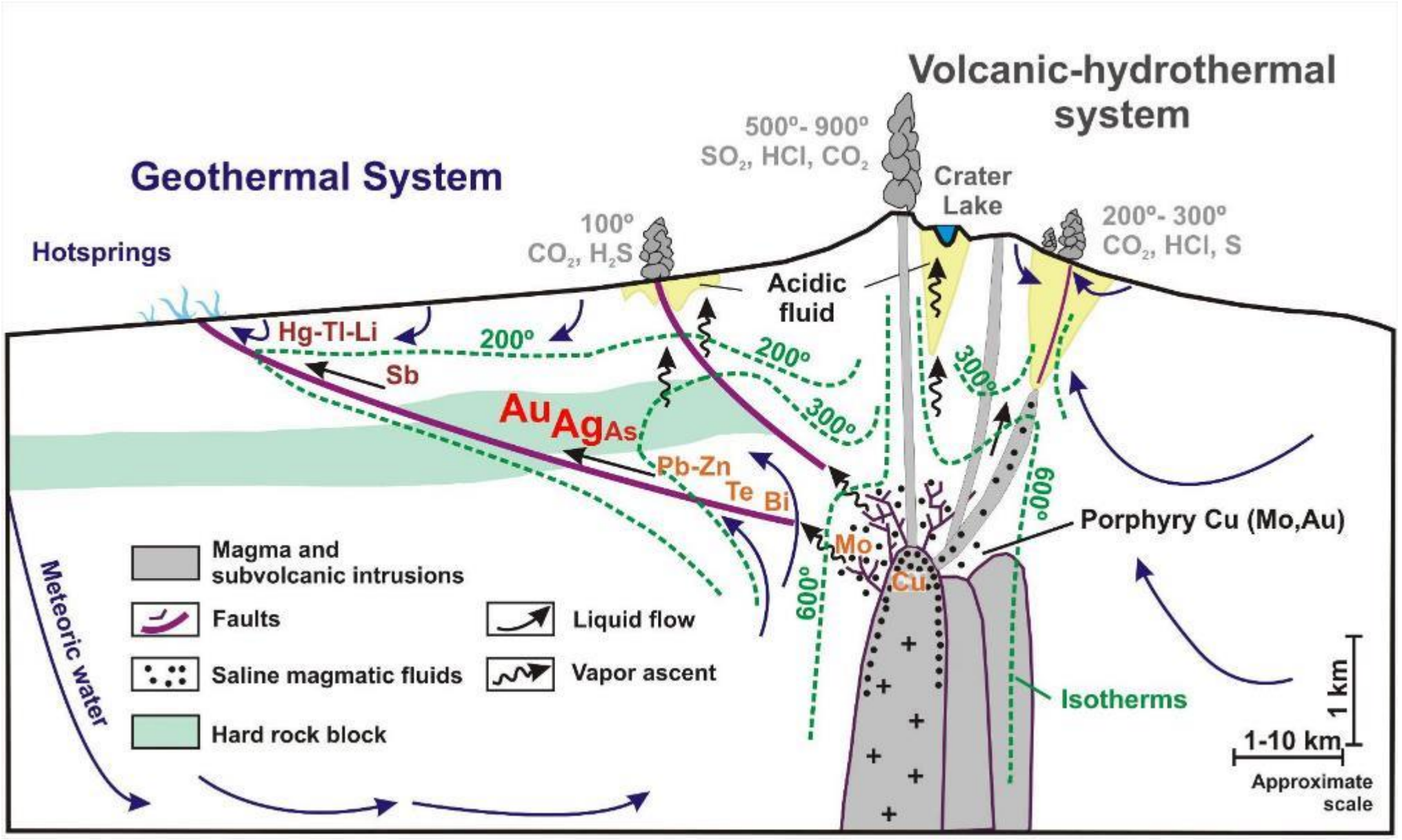
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



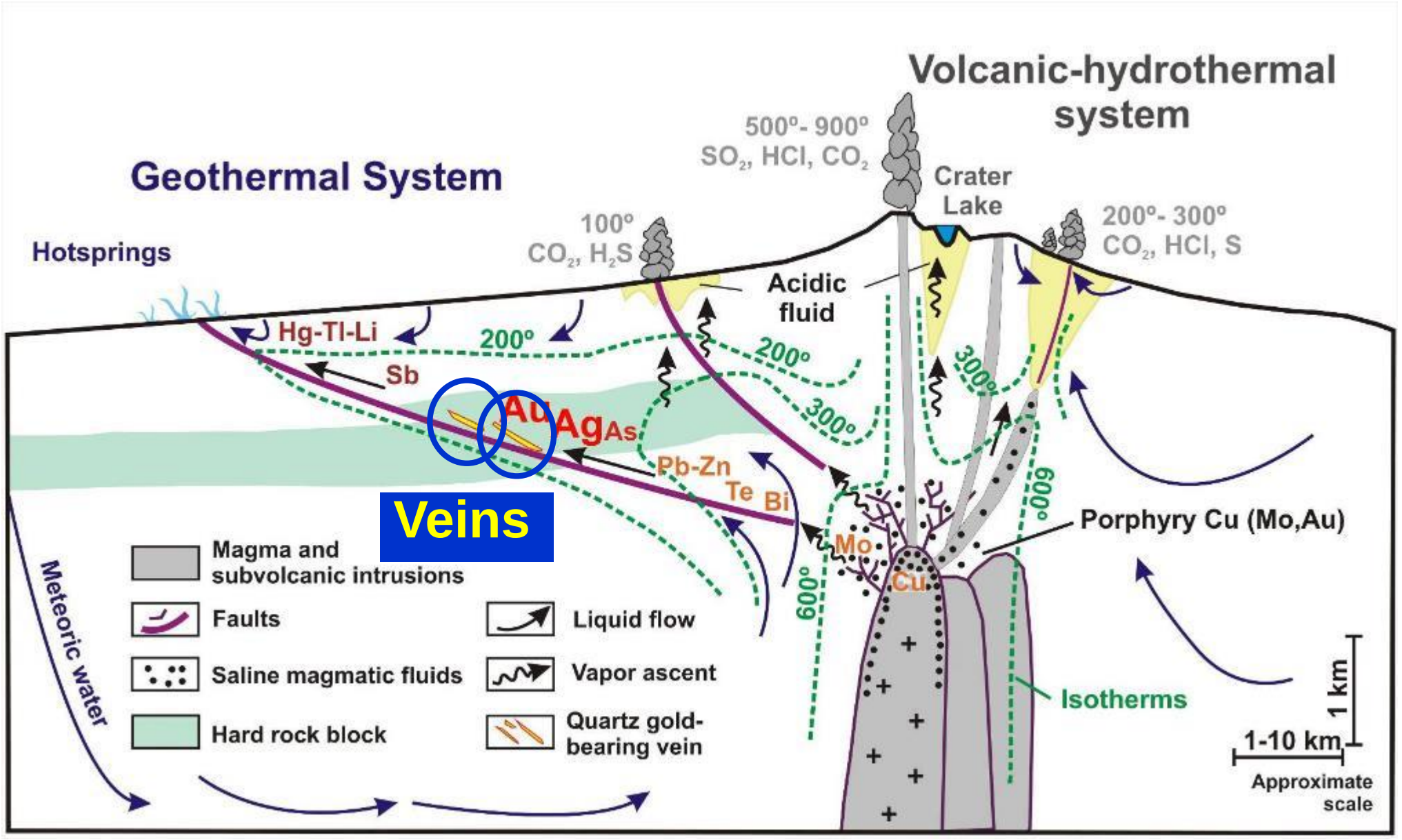
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



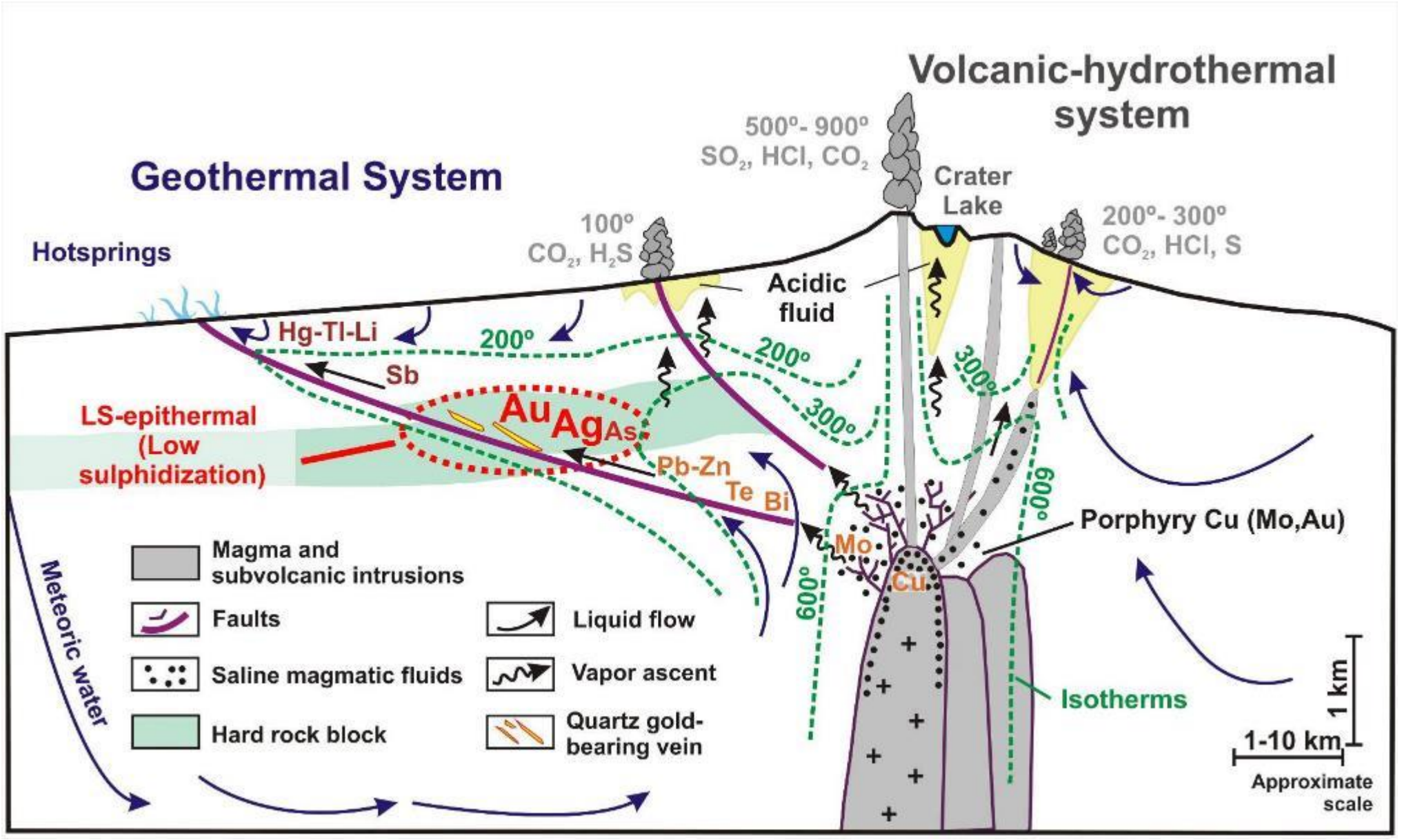
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



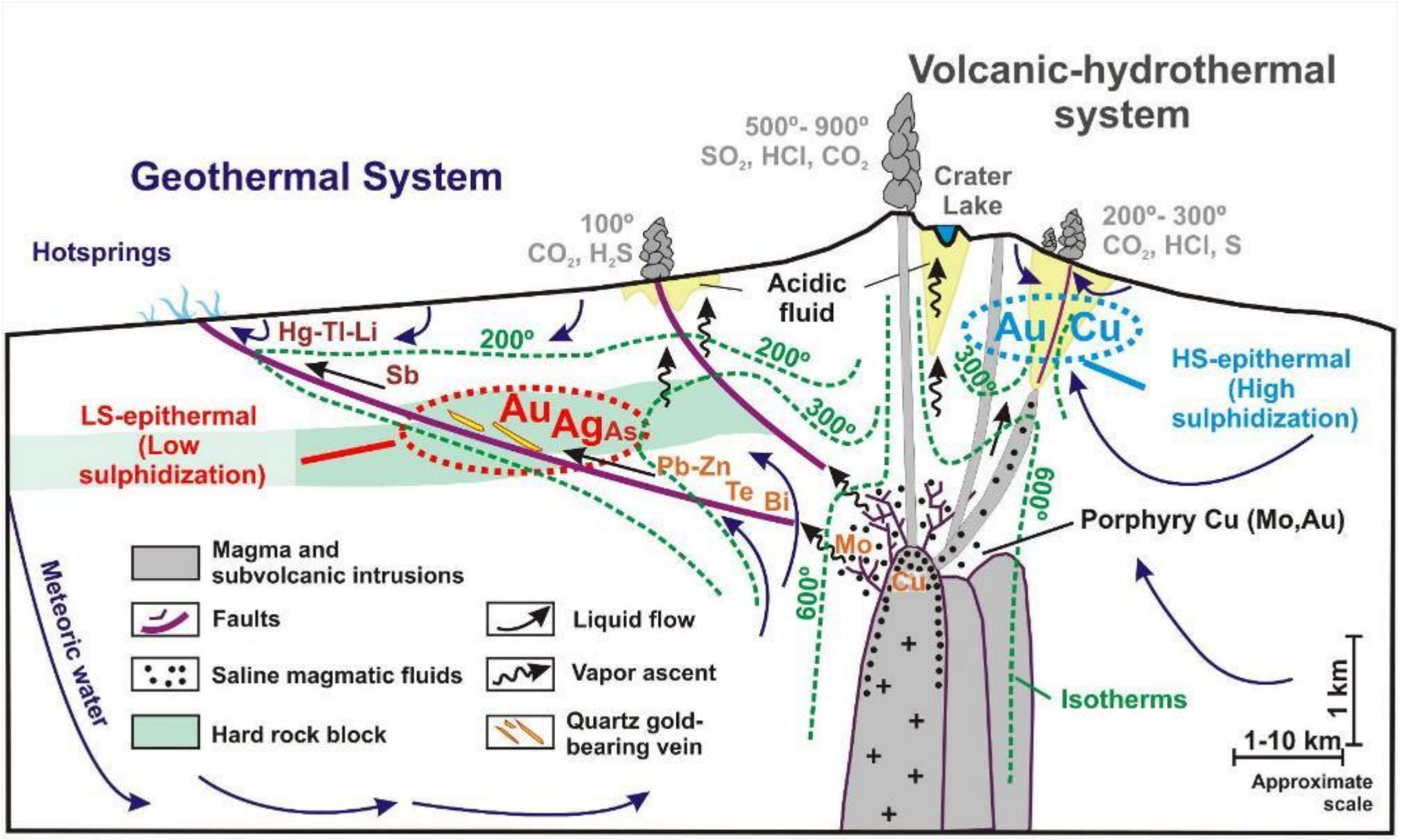
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



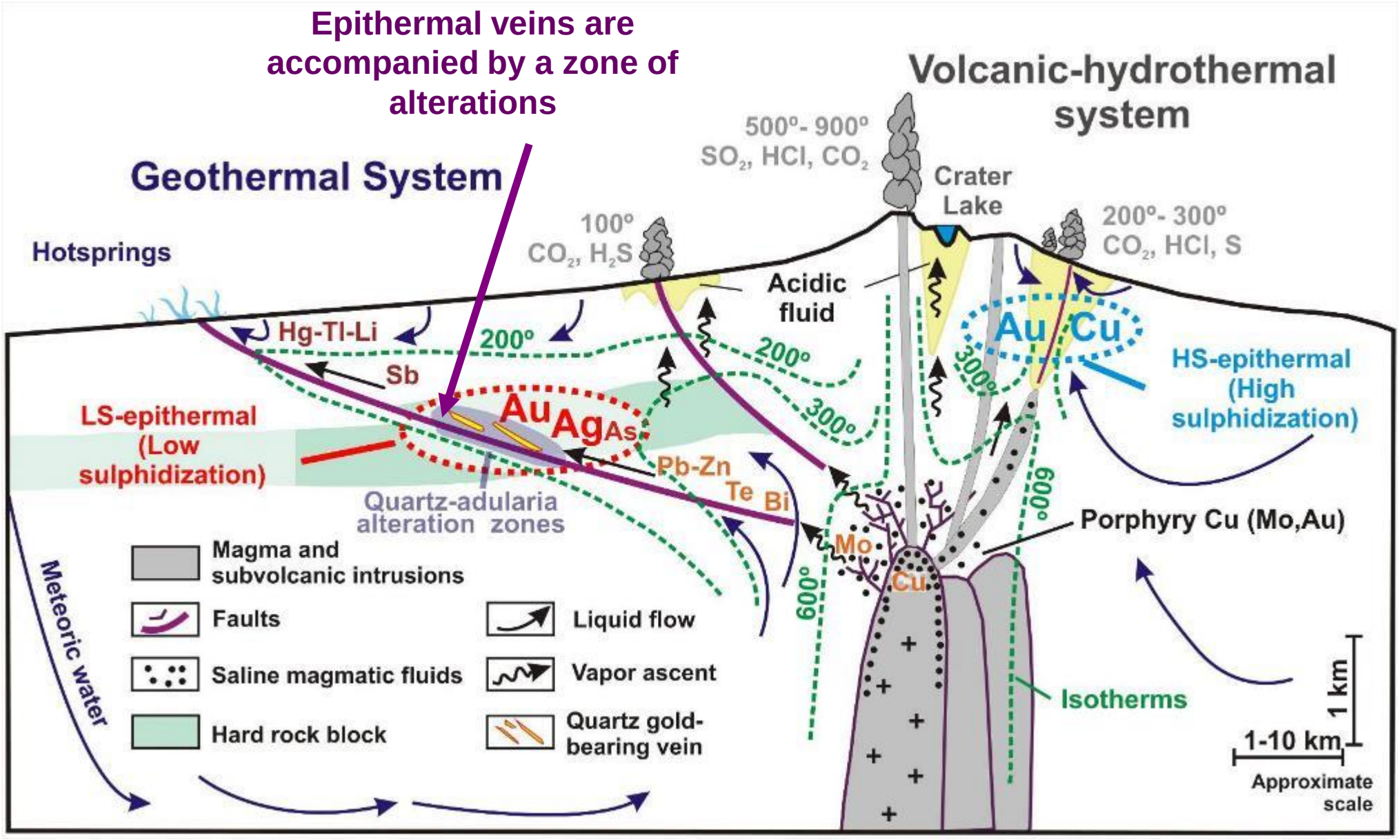
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Schematic geological-genetic model of the epithermal deposit



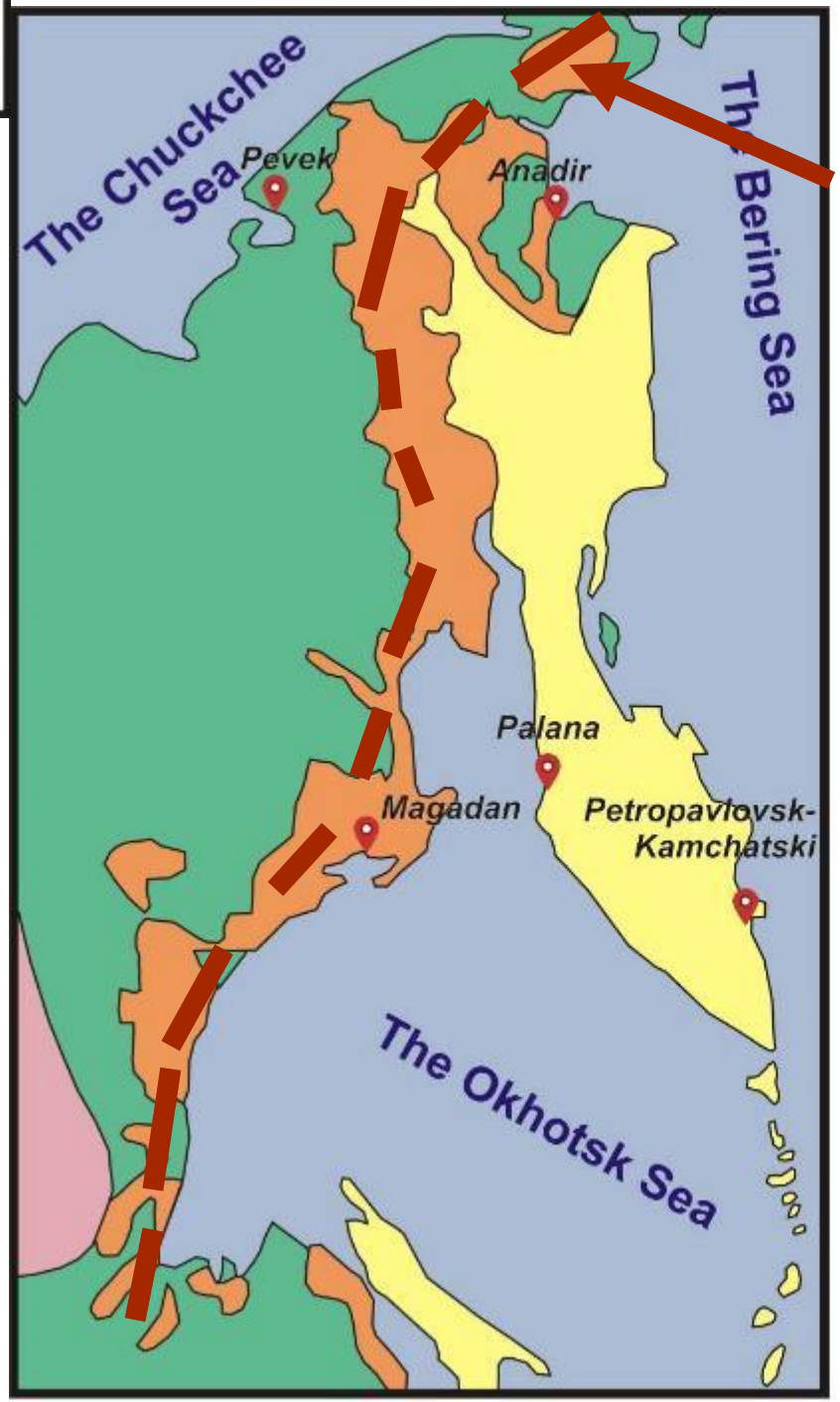
(Hedenquist et al. 2000, modified Ermolin and Savichev 2018)

Plan of Presentation

- Schematic geological-genetic model of the epithermal deposit
- Physical-geology model
- Strategy of exploration

The position of the research area on the tectonic scheme of Russia

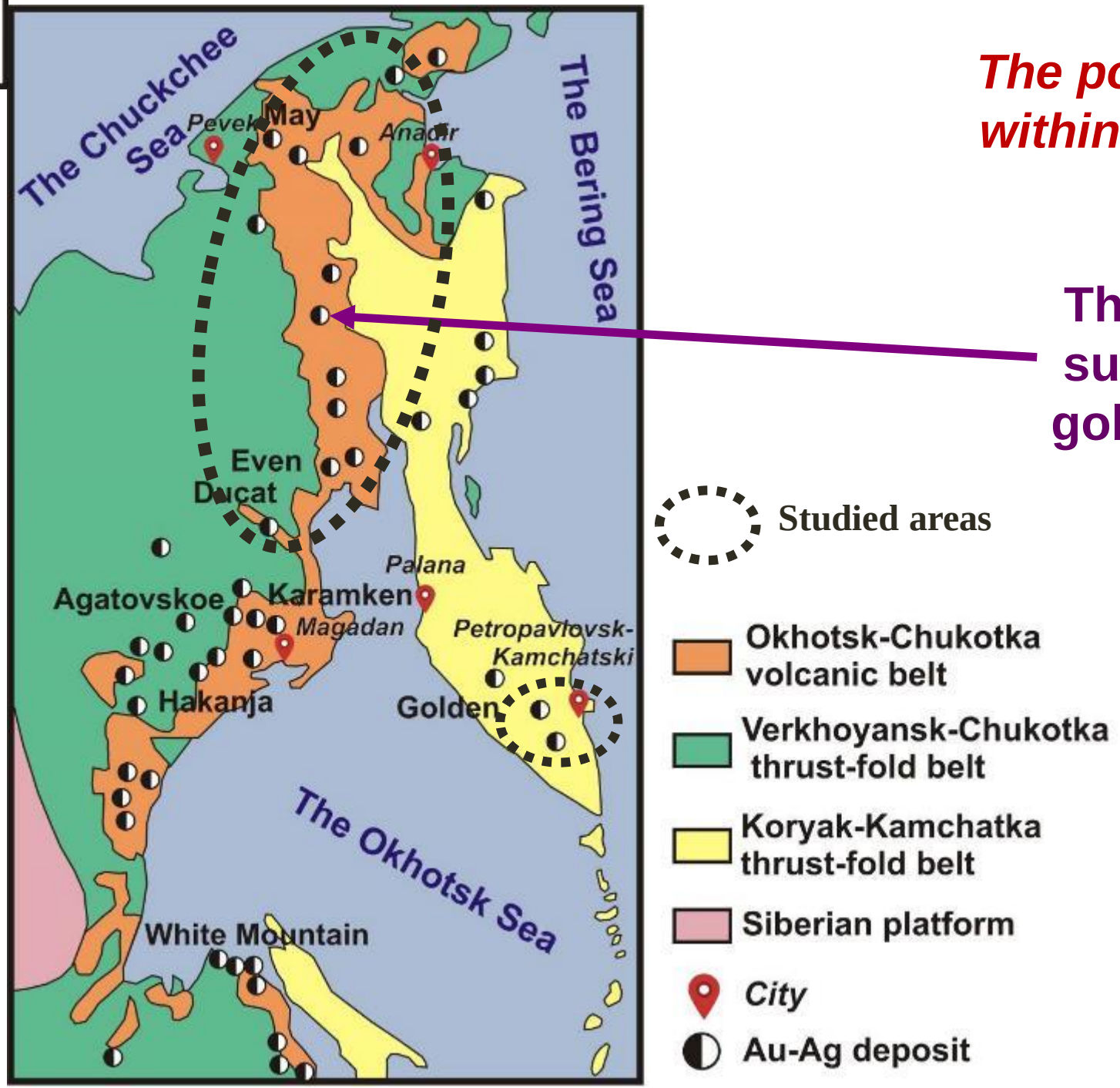
(on Sidorov A.A., modified)



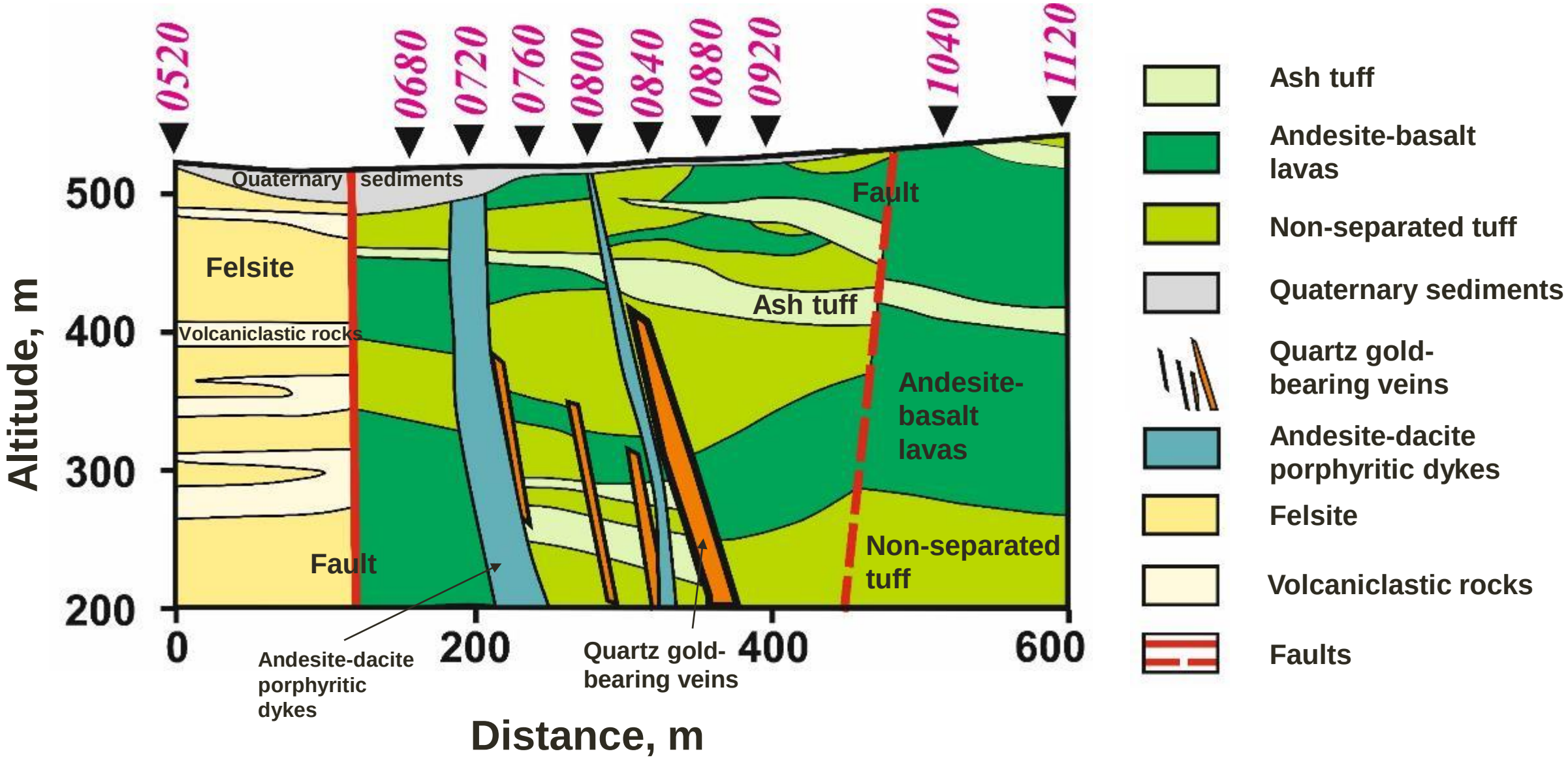
GM SERVICE

The position of gold deposits within the Okhotsk-Chukotka volcanic belt

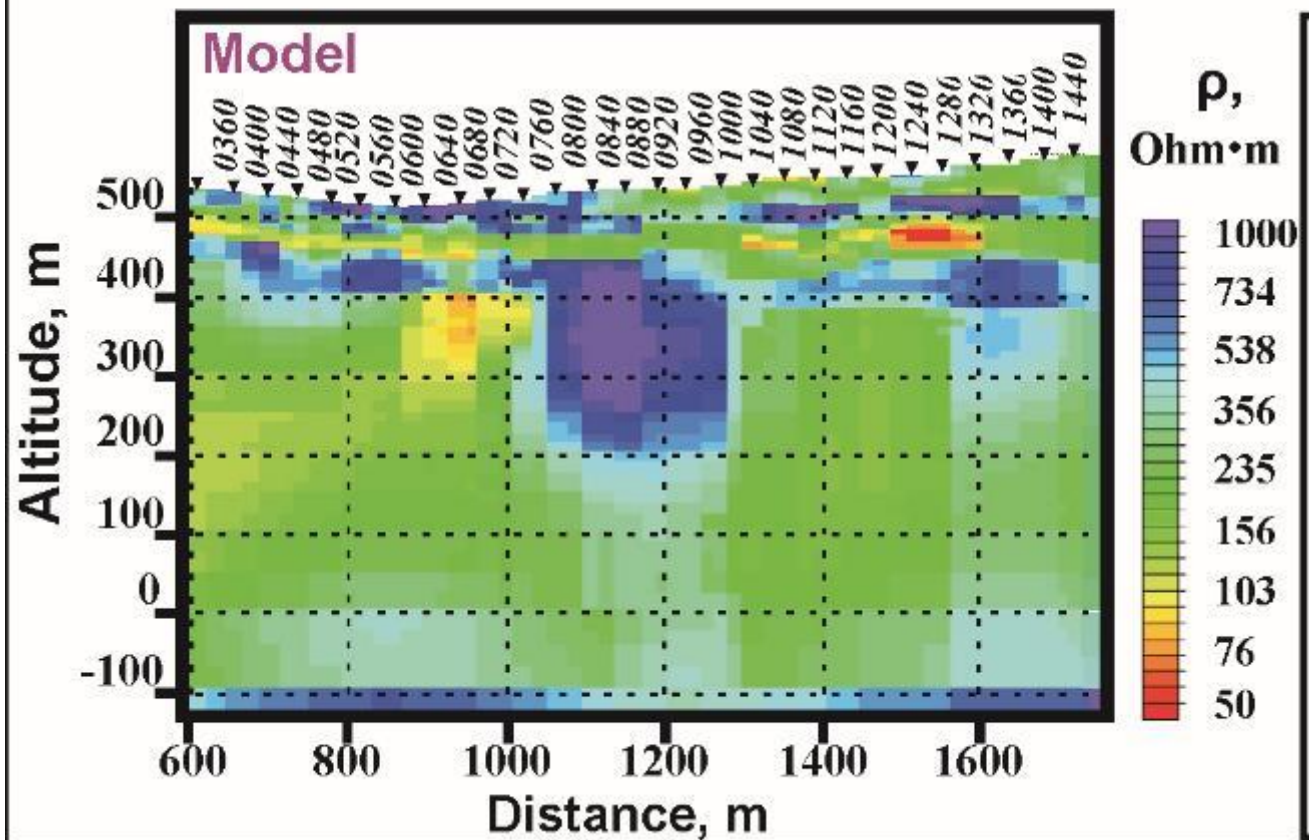
There are a lot of low-sulfidation epithermal gold deposit inside the belt



Geological cross-section

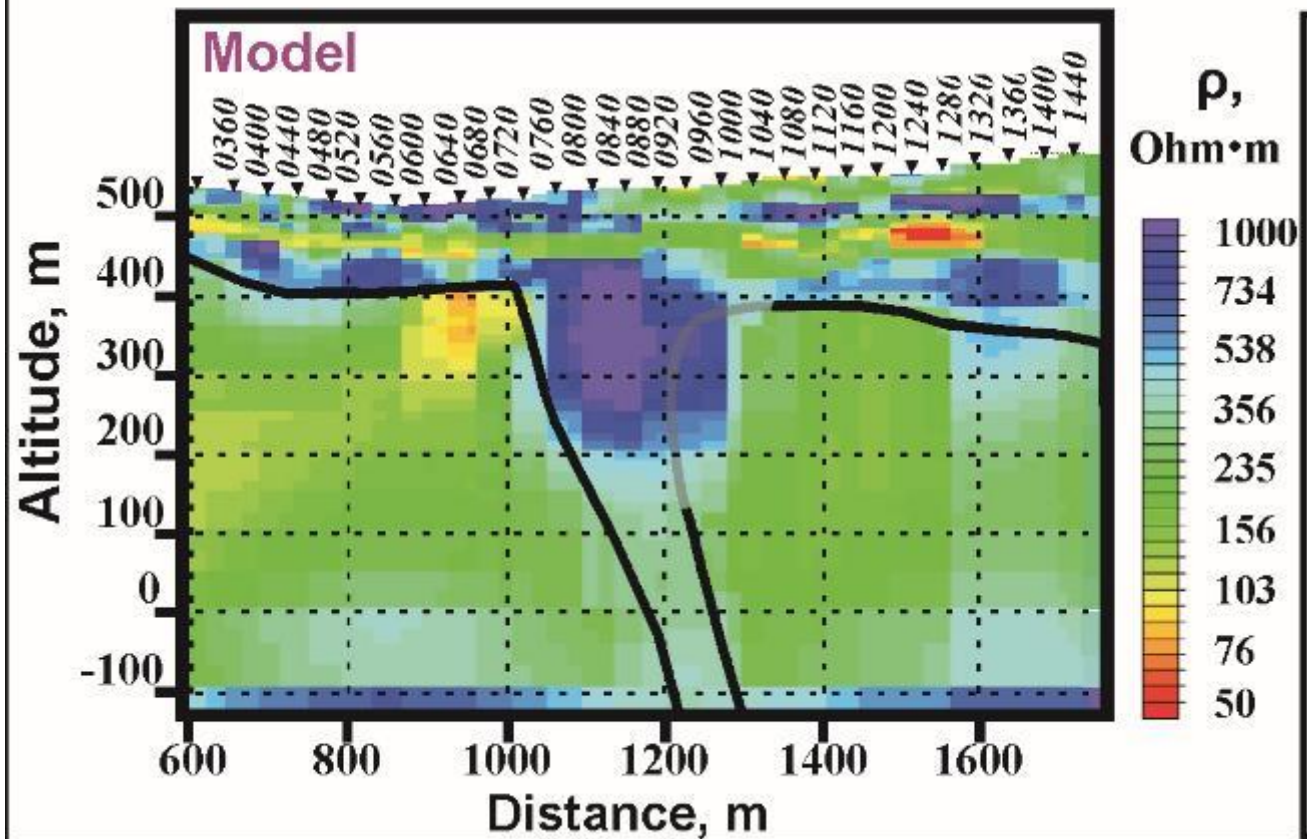


Ledgeng for the model



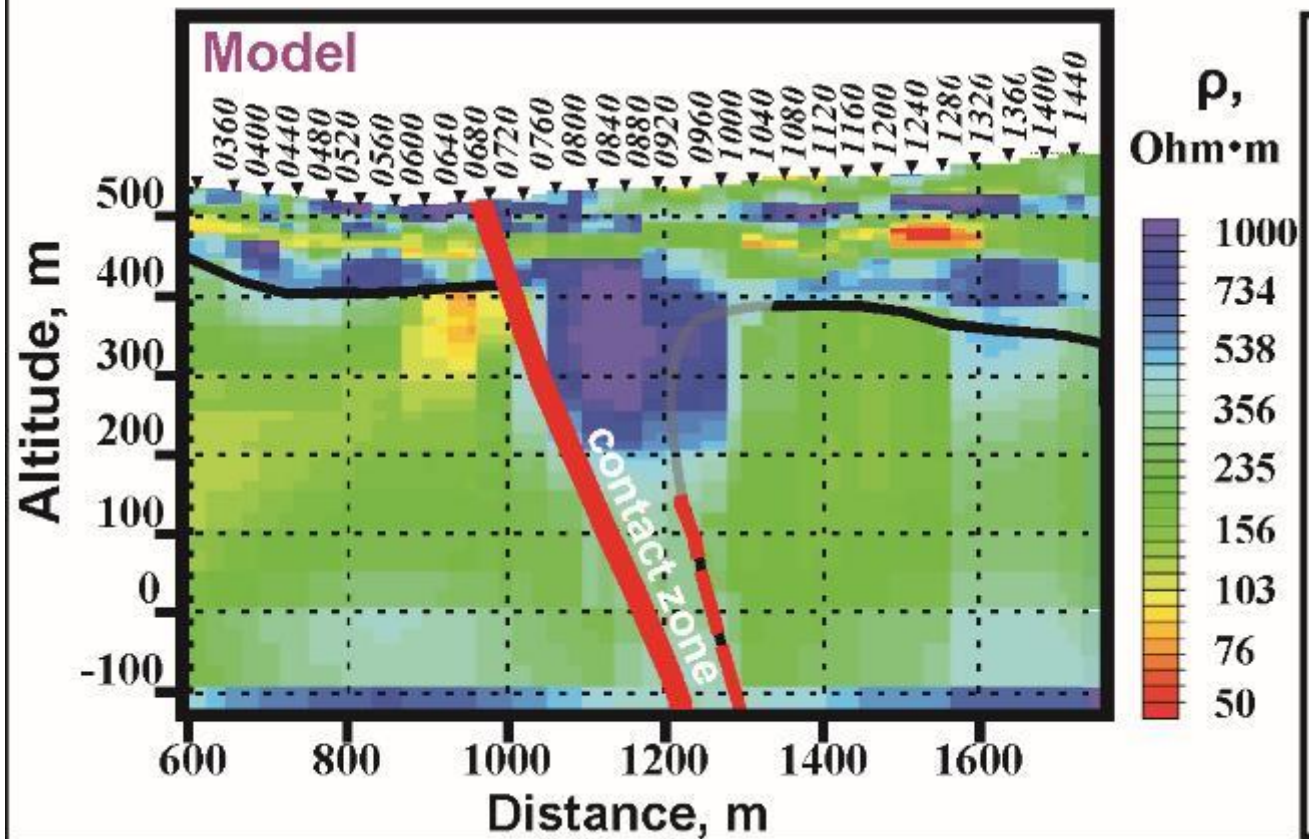
GM SERVICE

Ledgeng for the model

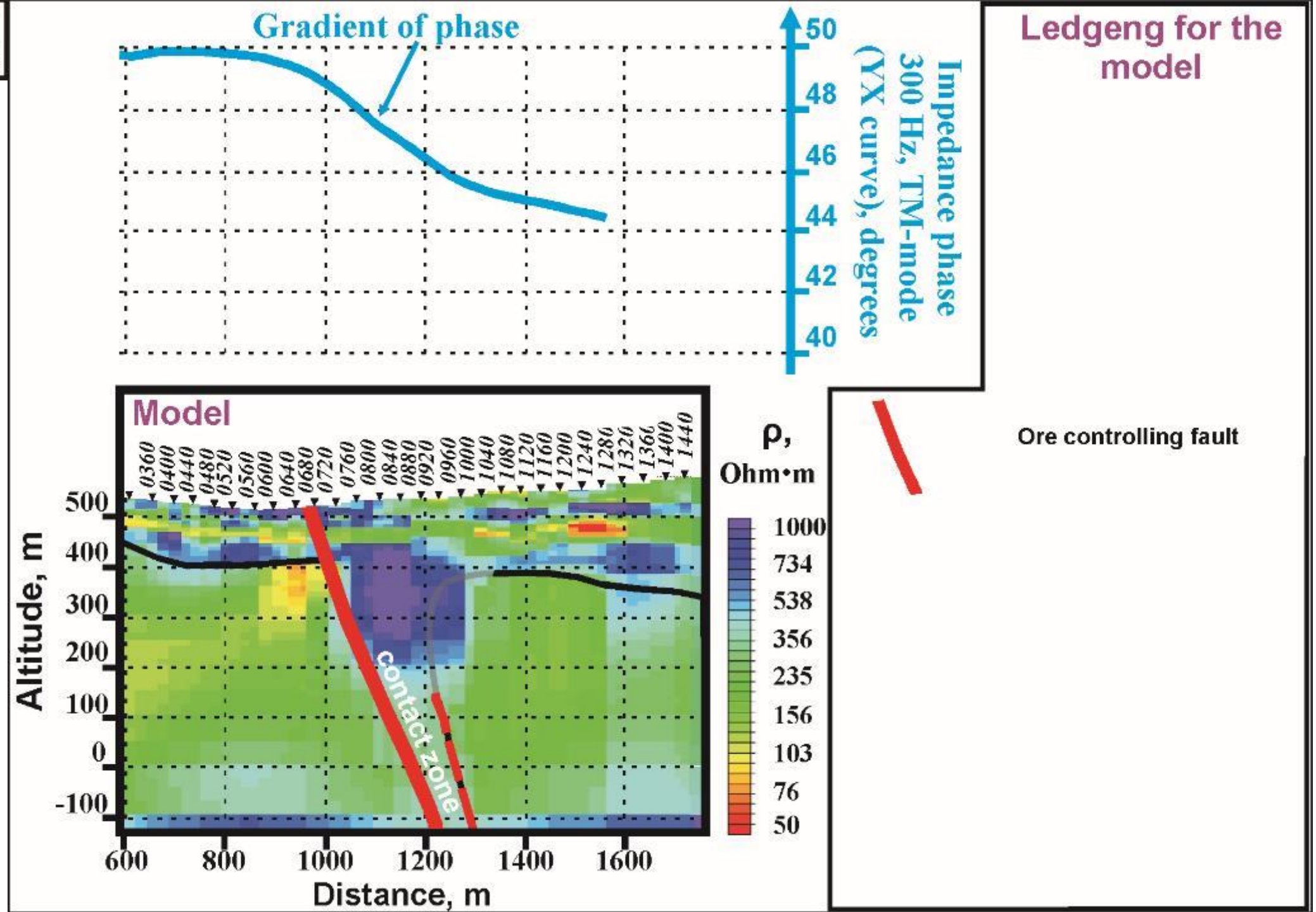


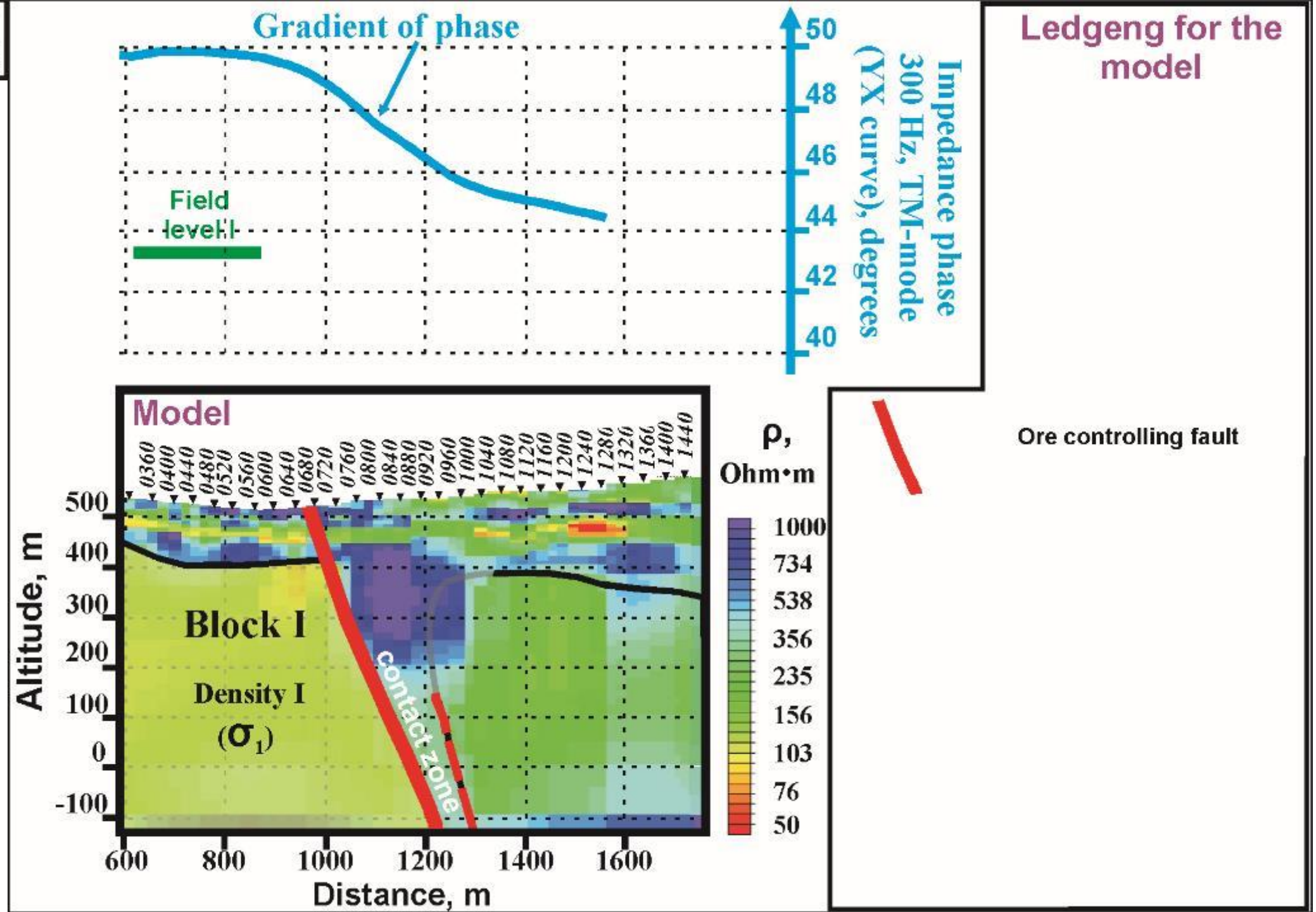
GM SERVICE

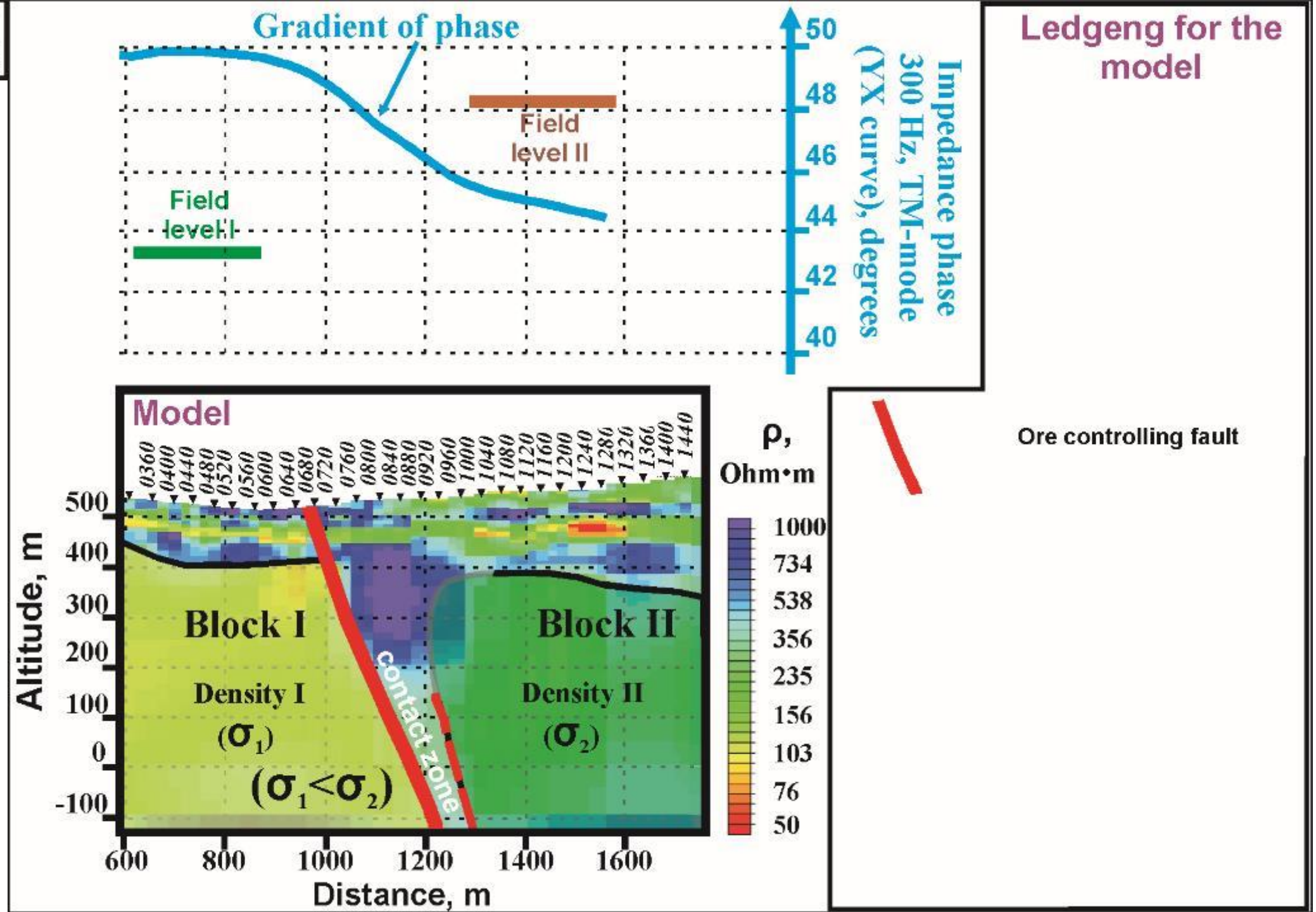
Ledgeng for the model

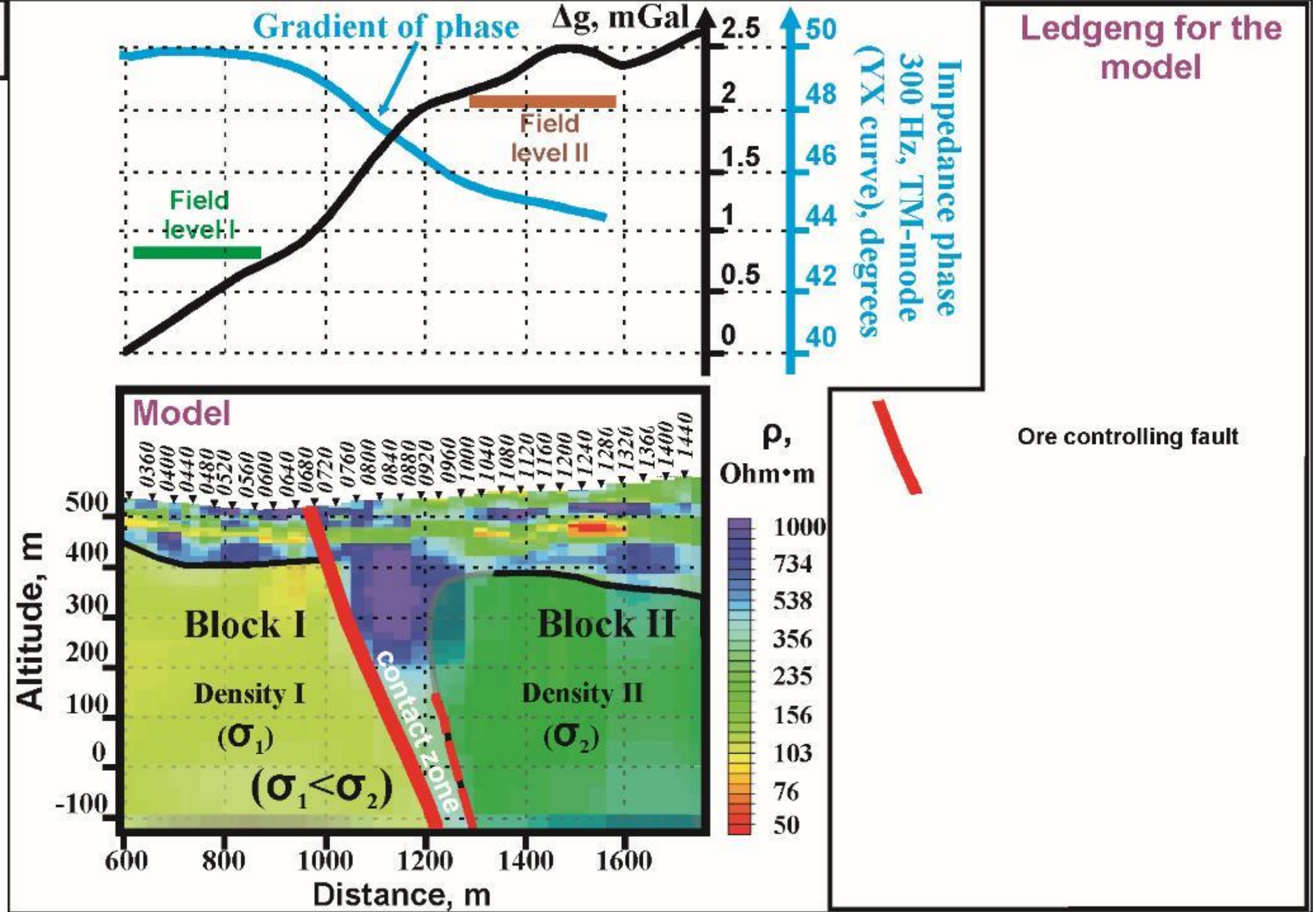


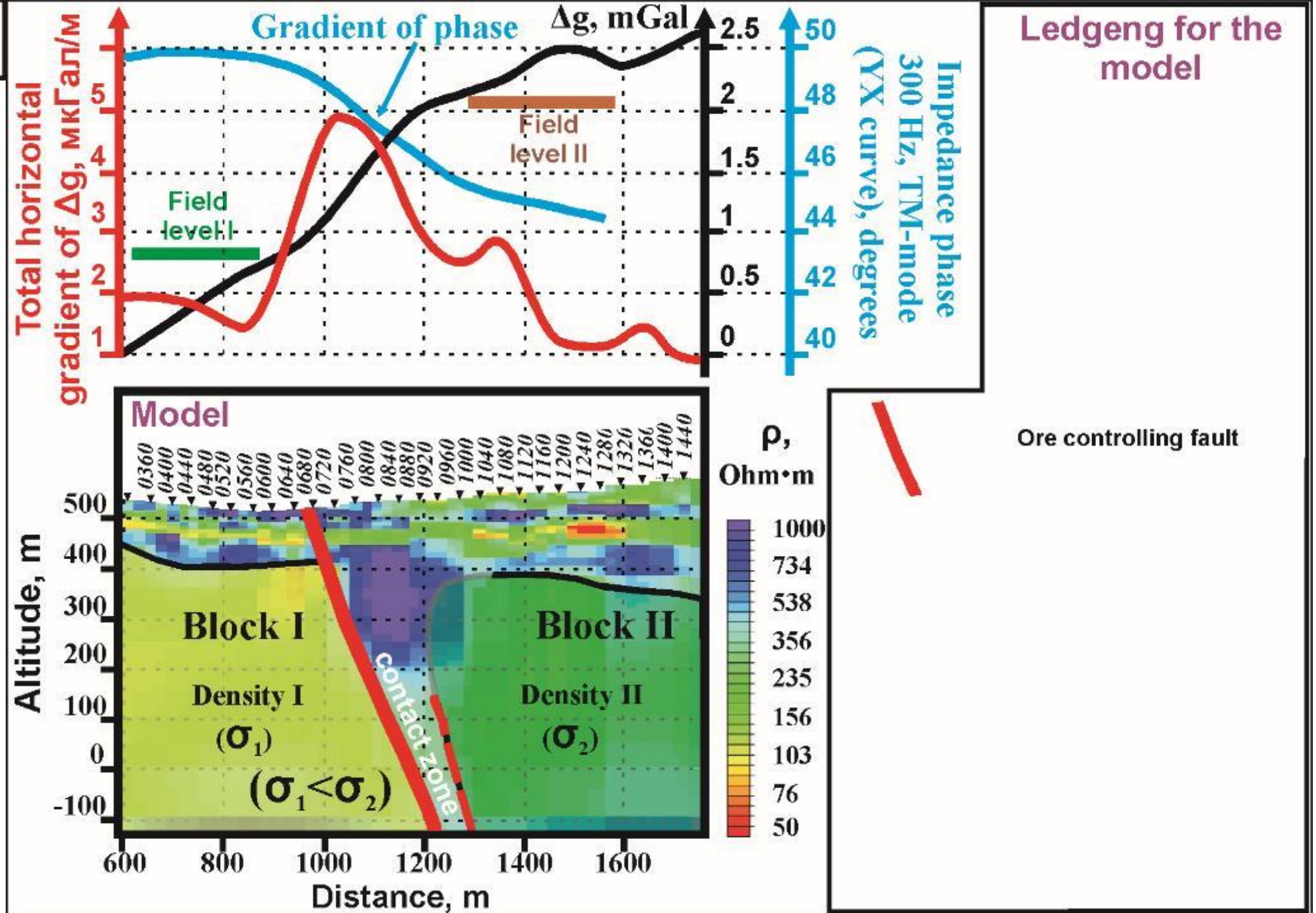
Ore controlling fault

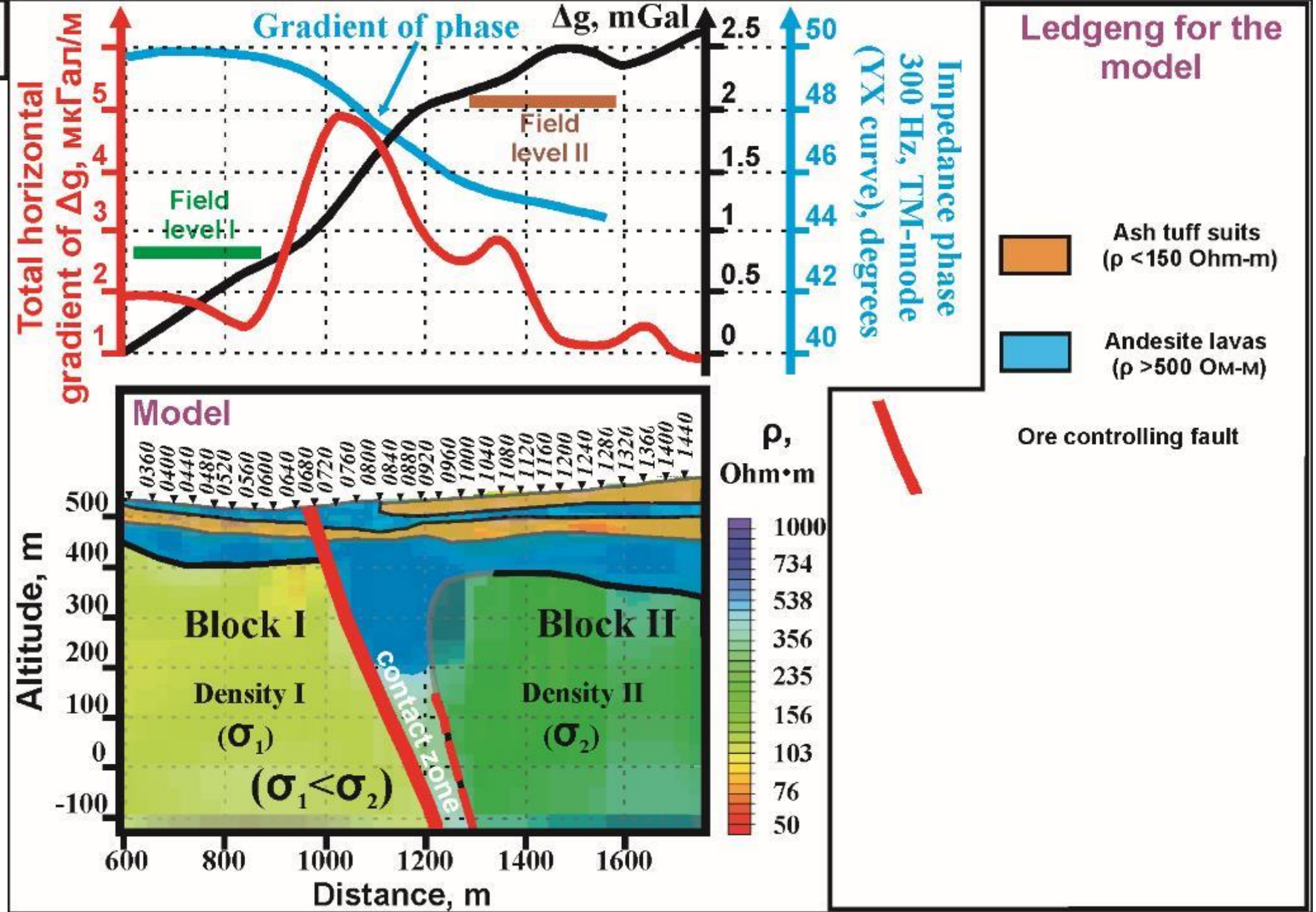

Gradient of phase
50
48
46
44
42
40
Impedance phase
300 Hz, TM-mode
(YX curve), degrees
Ledgeng for the model
Model
0360
0400
0440
0480
0520
0560
0600
0640
0680
0720
0760
0800
0840
0880
0920
0960
1000
1040
1080
1120
1160
1200
1240
1286
1326
1366
1400
1440
500
400
300
200
100
0
-100
Altitude, m
600
800
1000
1200
1400
1600
Distance, m
contact zone
ρ,
Ohm•m
1000
734
538
356
235
156
103
76
50
Ore controlling fault

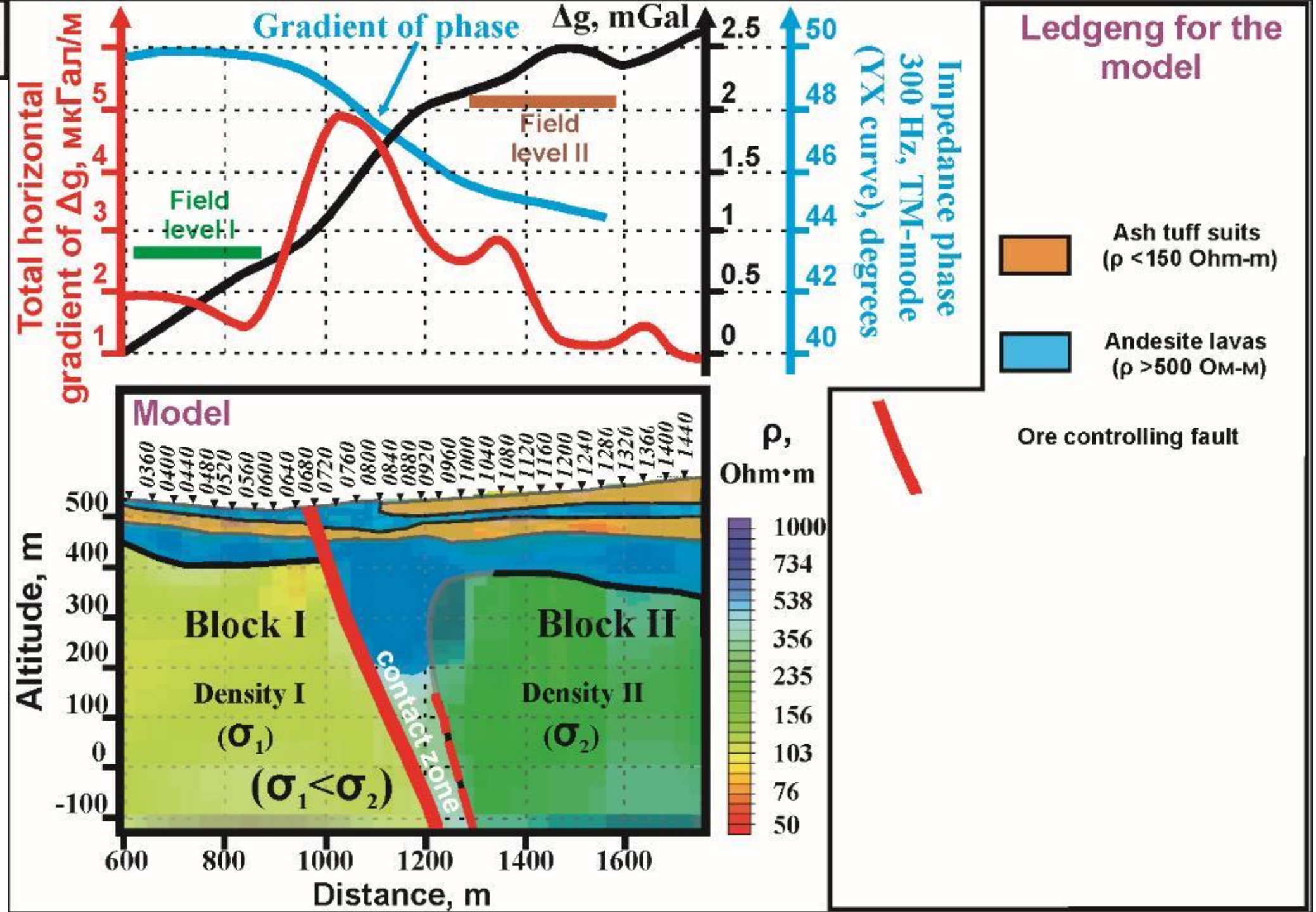

Gradient of phase
Field level
50
48
46
44
42
40
Impedance phase
300 Hz, TM-mode
(YX curve), degrees
Ledgeng for the model
Model
0360
0400
0440
0480
0520
0560
0600
0640
0680
0720
0760
0800
0840
0880
0920
0960
1000
1040
1080
1120
1160
1200
1240
1286
1326
1366
1400
1440
500
400
300
200
100
0
-100
Altitude, m
Block I
Density I
(σ1)
contact zone
600
800
1000
1200
1400
1600
Distance, m
ρ,
Ohm•m
1000
734
538
356
235
156
103
76
50
Ore controlling fault

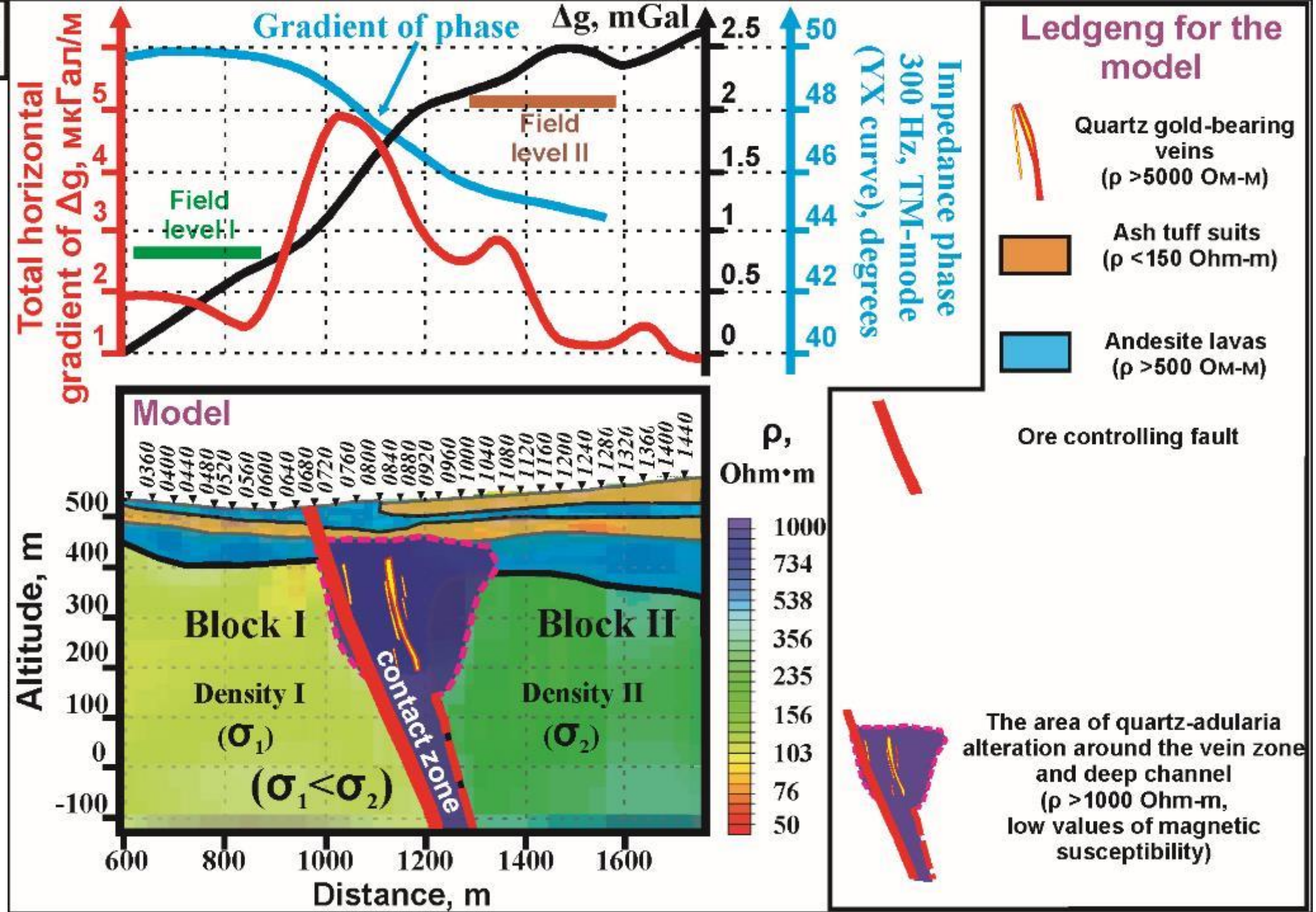

Gradient of phase
Field level II
Field level I
50
48
46
44
42
40
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Ledgeng for the model
Ore controlling fault
Model
0360 0400 0440 0480 0520 0560 0600 0640 0680 0720 0760 0800 0840 0880 0920 0960 1000 1040 1080 1120 1160 1200 1240 1286 1326 1366 1400 1440
500
400
300
200
100
0
-100
Altitude, m
Block I
Density I
(σ1)
(σ1<σ2)
contact zone
Block II
Density II
(σ2)
ρ, Ohm•m
1000
734
538
356
235
156
103
76
50
600
800
1000
1200
1400
1600
Distance, m

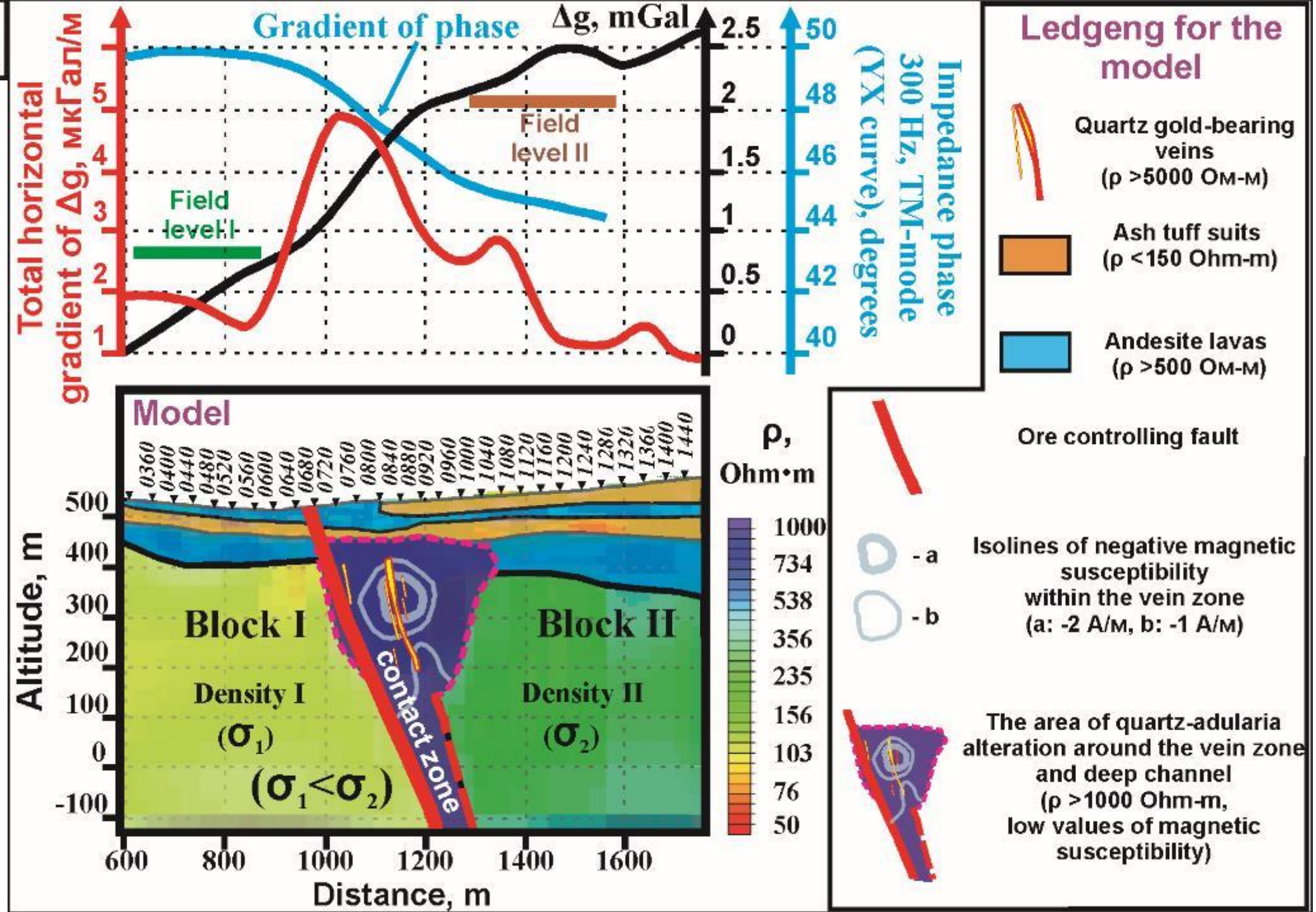

Gradient of phase
Δg, mGal
Field level I
Field level II
2.5
2
1.5
1
0.5
0
50
48
46
44
42
40
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Ledgeng for the model
Ore controlling fault
Model
ρ, Ohm•m
1000
734
538
356
235
156
103
76
50
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
Altitude, m
500
400
300
200
100
0
-100
600
800
1000
1200
1400
1600
Distance, m

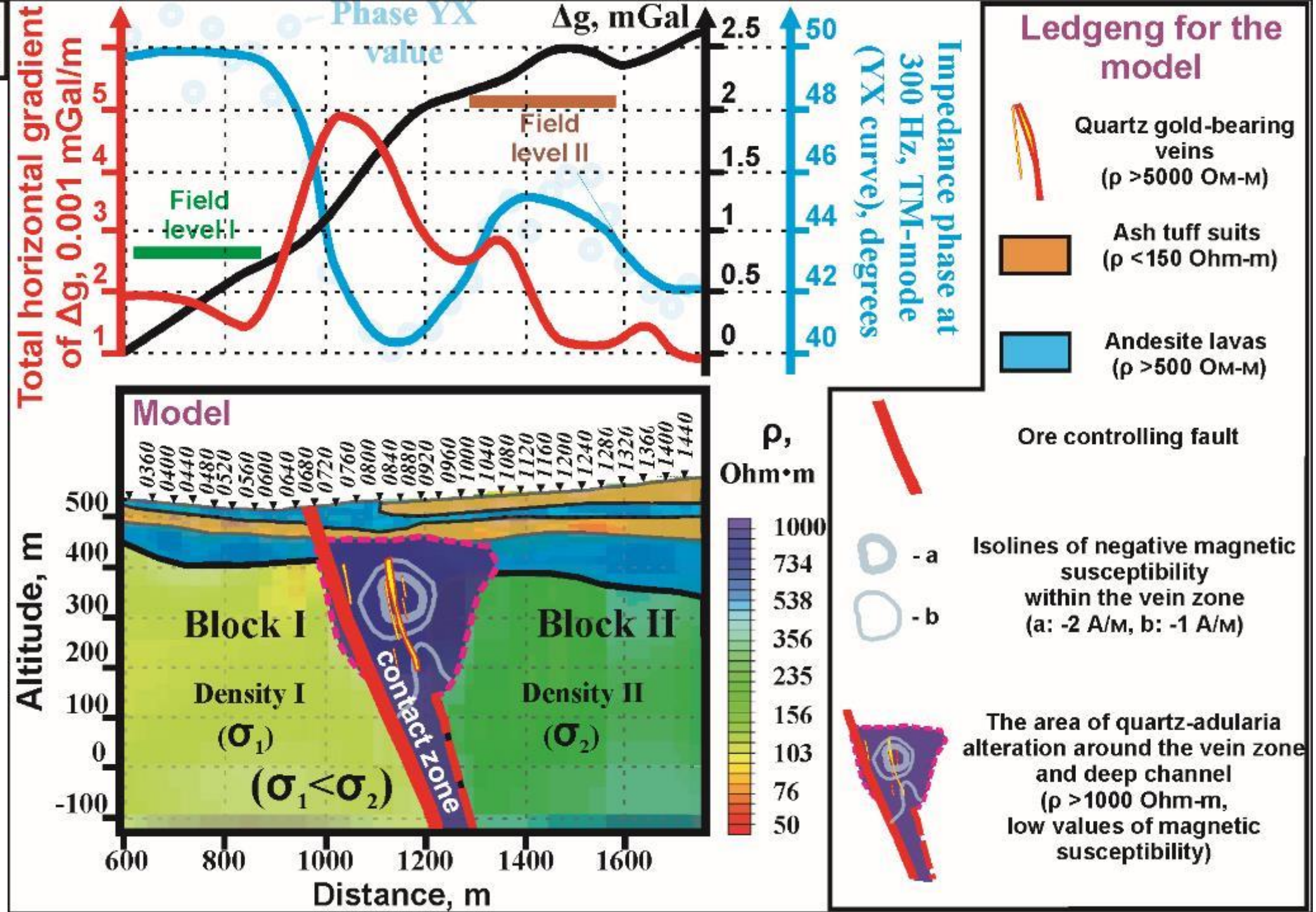

Gradient of phase
Δg, mGal
Total horizontal gradient of Δg, мкГал/м
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Field level I
Field level II
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
ρ, Ohm•m
Ledgeng for the model
Ore controlling fault

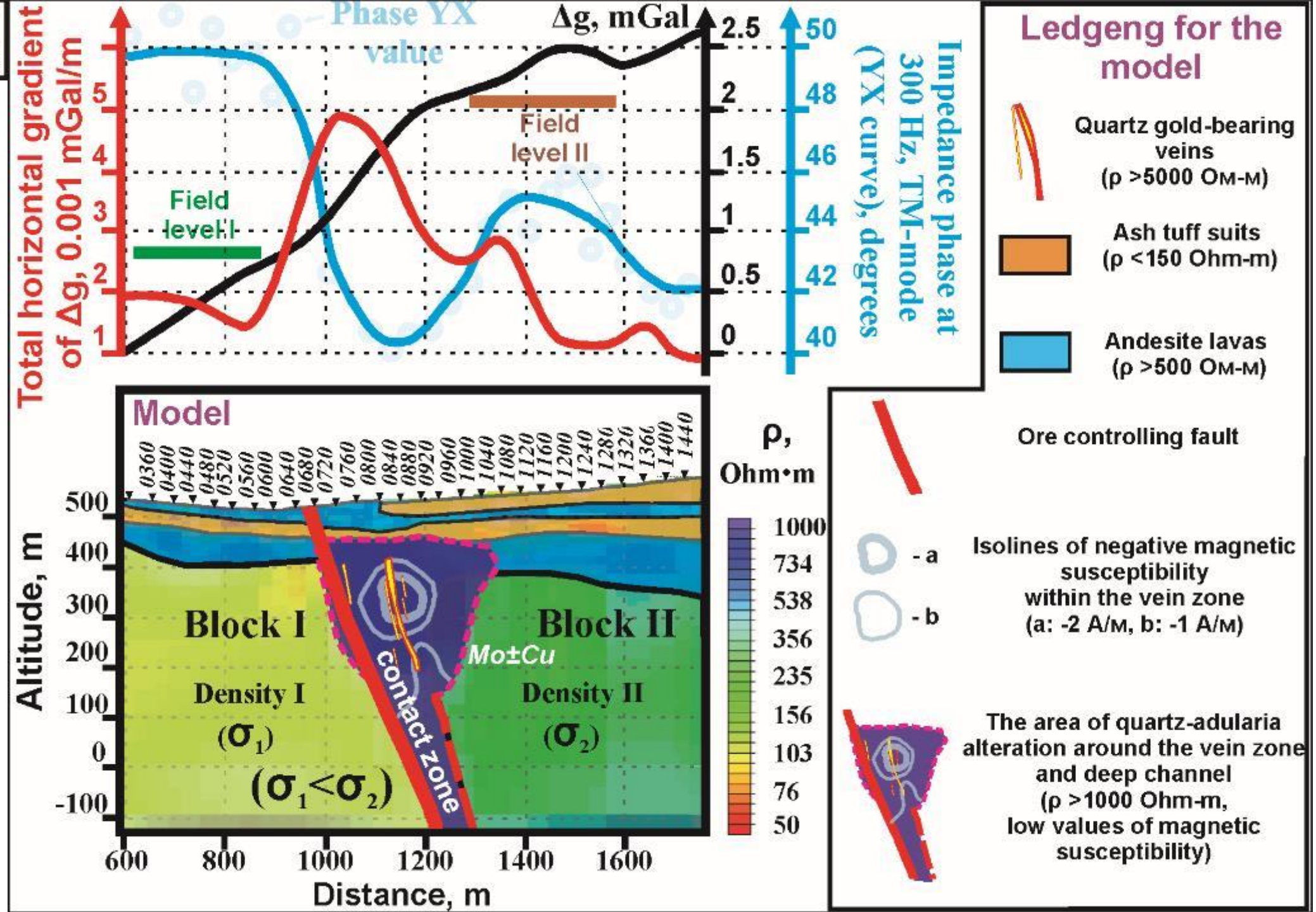

Gradient of phase
Δg, mGal
Total horizontal gradient of Δg, мкГал/м
Field level I
Field level II
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
ρ, Ohm•m
1000
734
538
356
235
156
103
76
50
Ledgeng for the model
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault

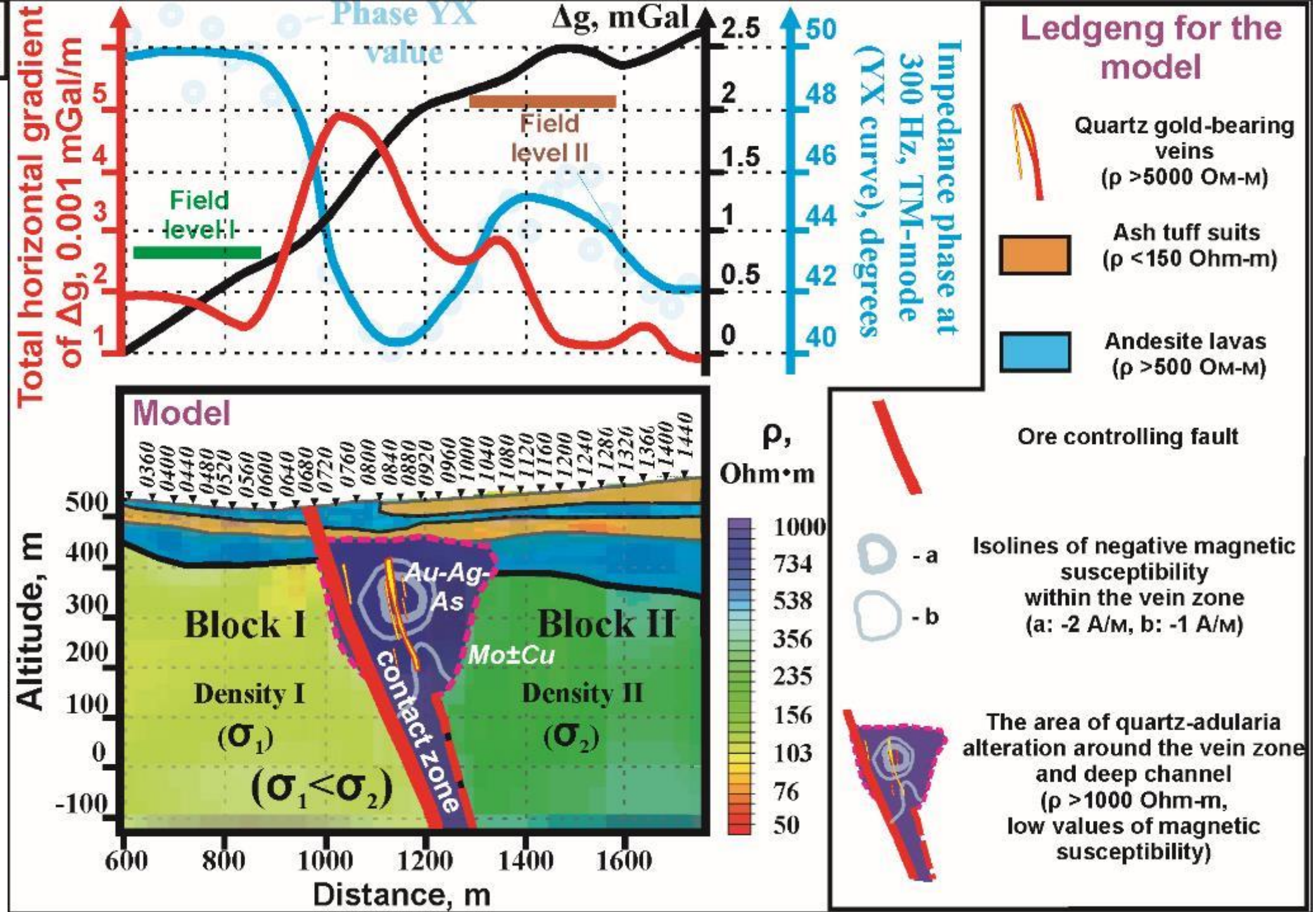

Gradient of phase
Δg, mGal
Total horizontal gradient of Δg, мкГал/м
Field level I
Field level II
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
ρ, Ohm•m
1000
734
538
356
235
156
103
76
50
Ledgeng for the model
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault

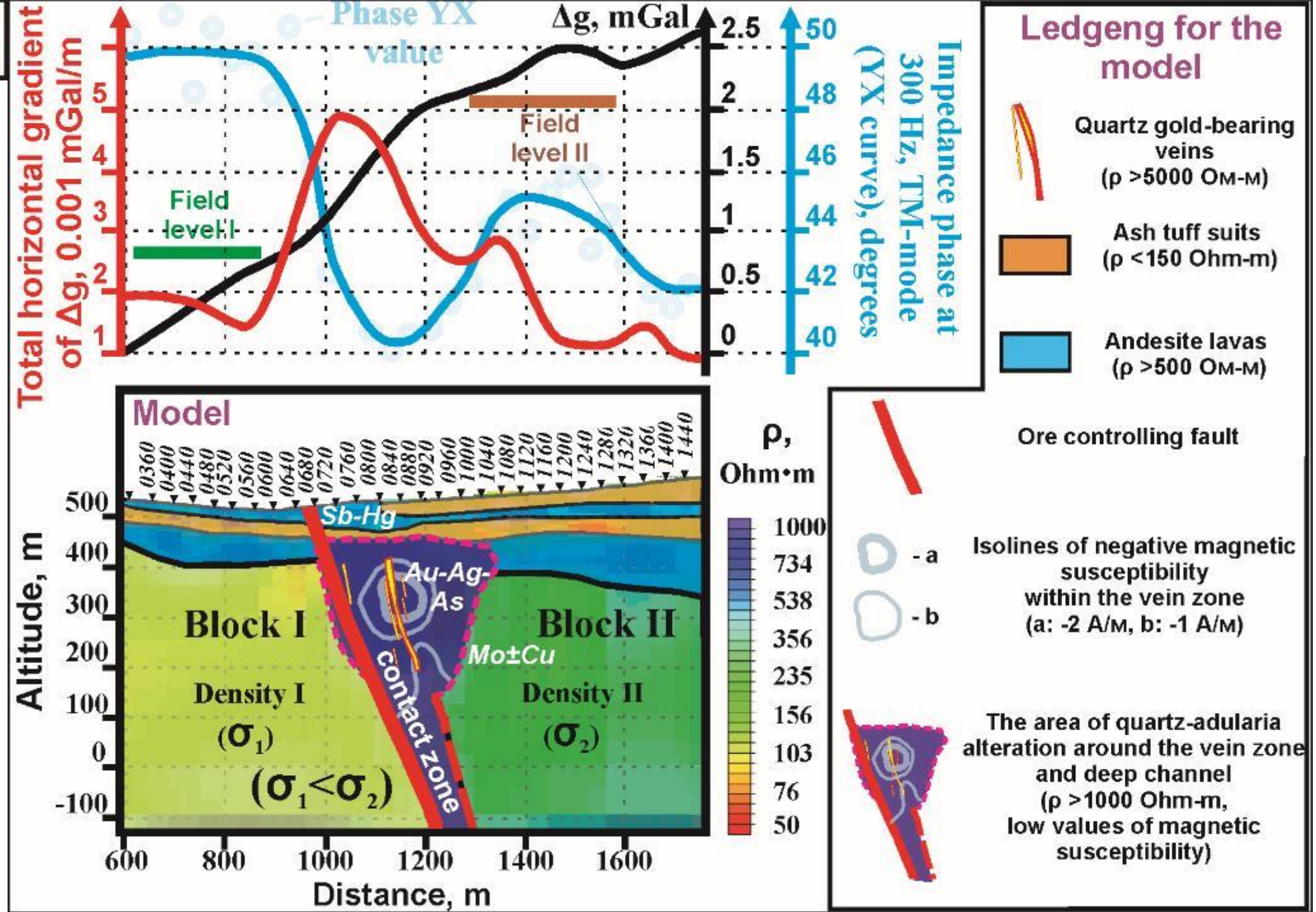

Gradient of phase
Δg, mGal
Total horizontal gradient of Δg, мкГал/м
Field level I
Field level II
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
ρ, Ohm•m
Ledgeng for the model
Quartz gold-bearing veins (ρ >5000 Ом-м)
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault
The area of quartz-adularia alteration around the vein zone and deep channel (ρ >1000 Ohm-m, low values of magnetic susceptibility)

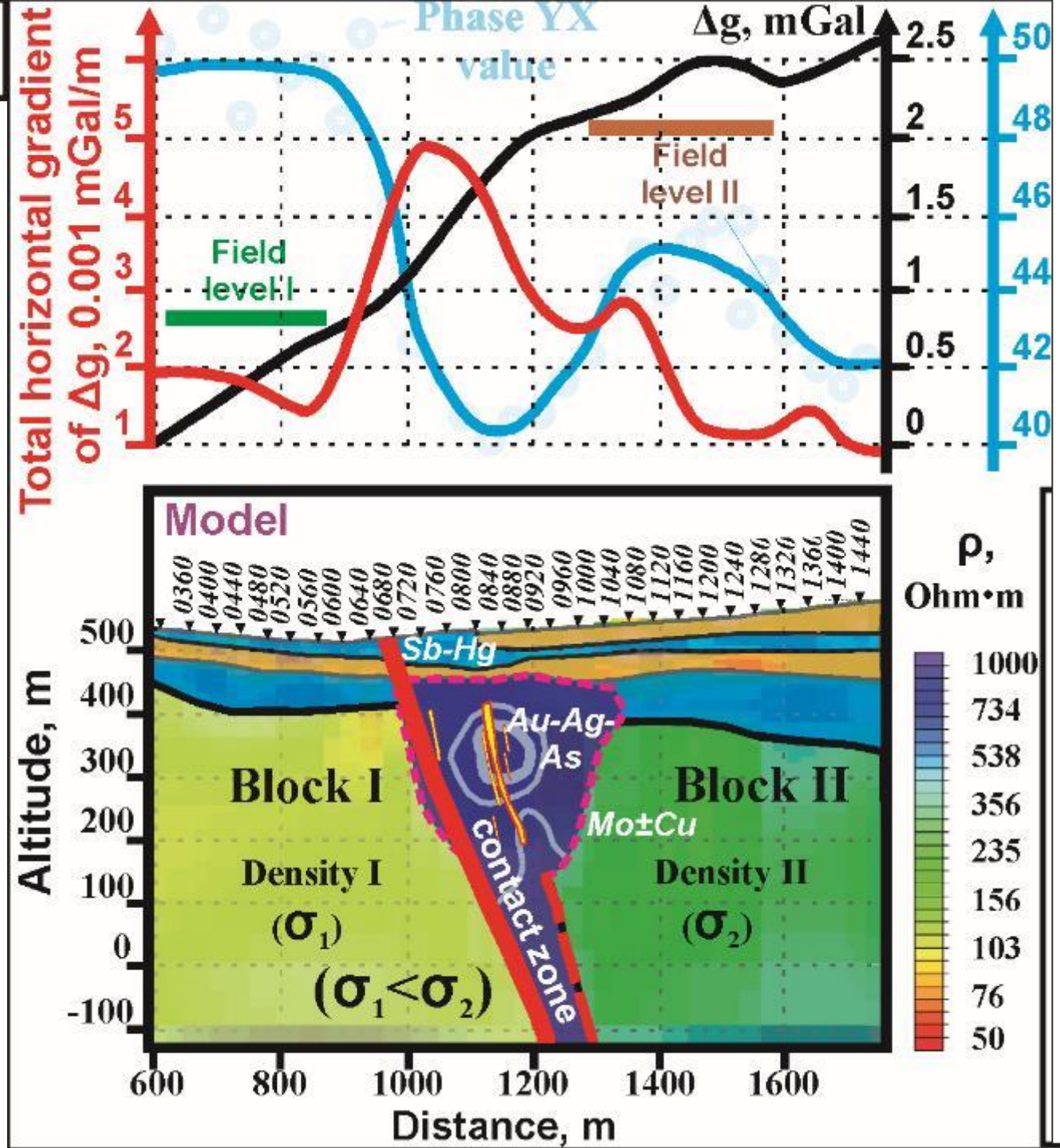

Gradient of phase
Δg, mGal
Total horizontal gradient of Δg, мкГал/м
Impedance phase 300 Hz, TM-mode (YX curve), degrees
Field level I
Field level II
Model
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
Altitude, m
Distance, m
ρ, Ohm•m
Ledgeng for the model
Quartz gold-bearing veins (ρ >5000 Ом-м)
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault
- a
- b
Isolines of negative magnetic susceptibility within the vein zone (a: -2 А/м, b: -1 А/м)
The area of quartz-adularia alteration around the vein zone and deep channel (ρ >1000 Ohm-m, low values of magnetic susceptibility)


Total horizontal gradient of Δg, 0.001 mGal/m
Phase YX value
Δg, mGal
Impedance phase at 300 Hz, TM-mode (YX curve), degrees
Field level I
Field level II
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
contact zone
ρ, Ohm•m
Ledgeng for the model
Quartz gold-bearing veins (ρ >5000 Ом-м)
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault
- a
- b
Isolines of negative magnetic susceptibility within the vein zone (a: -2 А/м, b: -1 А/м)
The area of quartz-adularia alteration around the vein zone and deep channel (ρ >1000 Ohm-m, low values of magnetic susceptibility)


Total horizontal gradient of Δg, 0.001 mGal/m
Phase YX value
Δg, mGal
Field level I
Field level II
Impedance phase at 300 Hz, TM-mode (YX curve), degrees
Model
Altitude, m
Distance, m
Block I
Density I
(σ1)
(σ1<σ2)
Block II
Density II
(σ2)
contact zone
Mo±Cu
ρ, Ohm•m
Ledgeng for the model
Quartz gold-bearing veins (ρ >5000 Ом-м)
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault
- a
- b
Isolines of negative magnetic susceptibility within the vein zone (a: -2 А/м, b: -1 А/м)
The area of quartz-adularia alteration around the vein zone and deep channel (ρ >1000 Ohm-m, low values of magnetic susceptibility)


Total horizontal gradient of Δg, 0.001 mGal/m
Phase YX value
Δg, mGal
Field level I
Field level II
Impedance phase at 300 Hz, TM-mode (YX curve), degrees
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
Au-Ag-As
Mo±Cu
contact zone
ρ, Ohm•m
Ledgeng for the model
Quartz gold-bearing veins (ρ >5000 Ом-м)
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault
- a
- b
Isolines of negative magnetic susceptibility within the vein zone (a: -2 А/м, b: -1 А/м)
The area of quartz-adularia alteration around the vein zone and deep channel (ρ >1000 Ohm-m, low values of magnetic susceptibility)


Total horizontal gradient of Δg, 0.001 mGal/m
Phase YX value
Δg, mGal
Impedance phase at 300 Hz, TM-mode (YX curve), degrees
Field level I
Field level II
Model
Altitude, m
Distance, m
Block I
Block II
Density I
(σ1)
Density II
(σ2)
(σ1<σ2)
Sb-Hg
Au-Ag-As
Mo±Cu
contact zone
ρ, Ohm•m
Ledgeng for the model
Quartz gold-bearing veins (ρ >5000 Ом-м)
Ash tuff suits (ρ <150 Ohm-m)
Andesite lavas (ρ >500 Ом-м)
Ore controlling fault
- a
- b
Isolines of negative magnetic susceptibility within the vein zone (a: -2 А/м, b: -1 А/м)
The area of quartz-adularia alteration around the vein zone and deep channel (ρ >1000 Ohm-m, low values of magnetic susceptibility)



Conclusions

Thin veins are very complex objects for geophysics. But geophysics can work. We just need an integrated approach and combining with geochemical data.

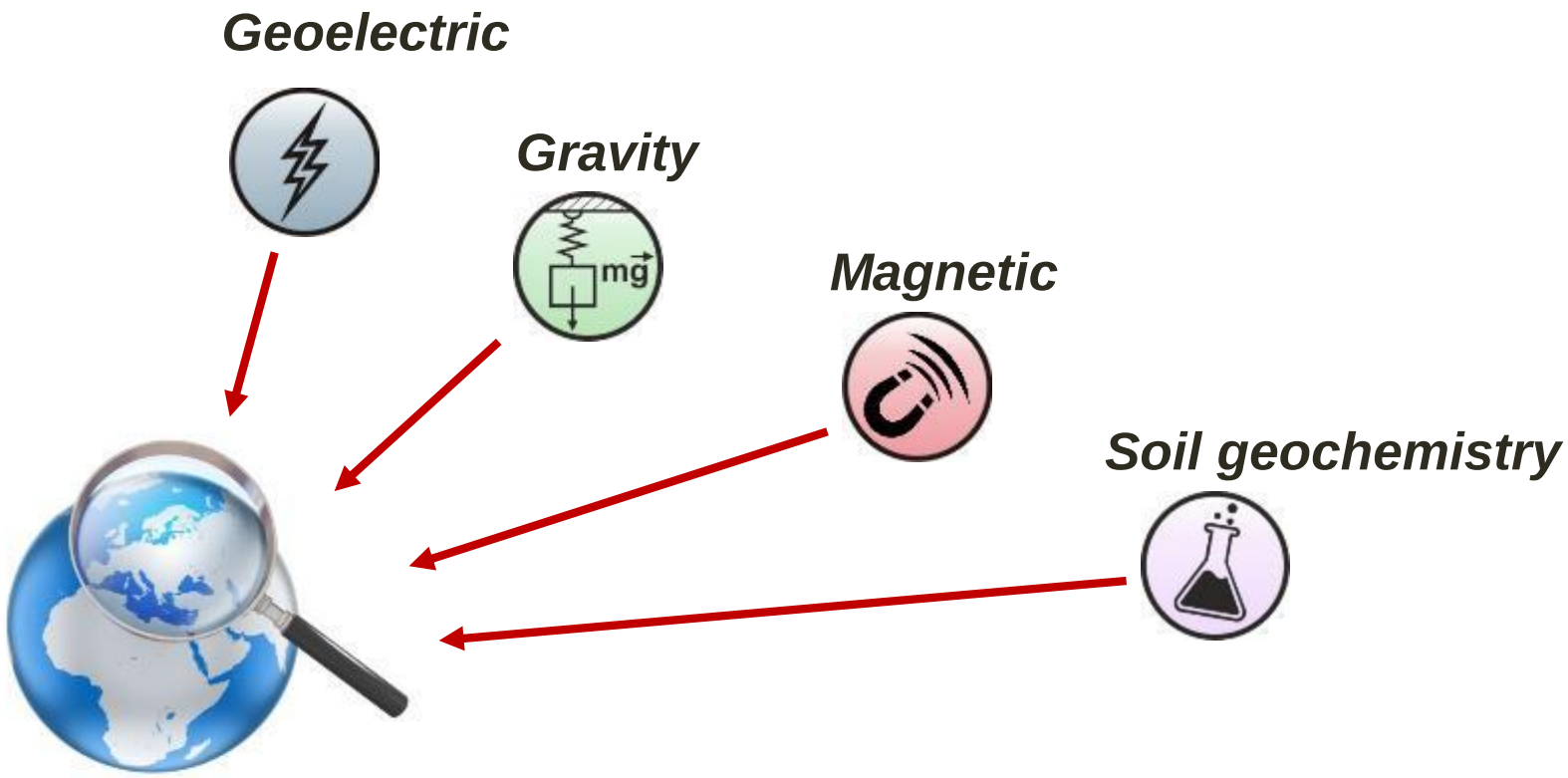
Plan of Presentation

- Schematic geological-genetic model of the epithermal deposit

- Physical-geology model

- Strategy of exploration

«GM-Service» technologies



Stage 1. Localization of “Targets”

UAV

- Magnetic survey
- Gamma spectrometry

Land survey

- Gravity
- Soil geochemistry
- Gamma spectrometry
- Magnetotelluric
- Magnetic

Stage 1. Localization of “Targets”

Precise UAV-based magnetic survey

High quality

Flight time UP TO 1 HOUR
- **MAGNETIC SURVEY**
- **GAMMA-RAY SPECTROMETRY**
- **LIDAR DRONE MAPPING**

UP TO 500 SQ KM IN A MONTH*
(5 000 LINEAR KL IN A MONTH)

GEOSCAN

High productivity

Flight time UP TO 8 HOURS
- **MAGNETIC SURVEY**
- **AERIAL PHOTOGRAPHY**

UP TO 5 000 SQ KM IN A MONTH*
(50 000 LINEAR KM IN MONTH)

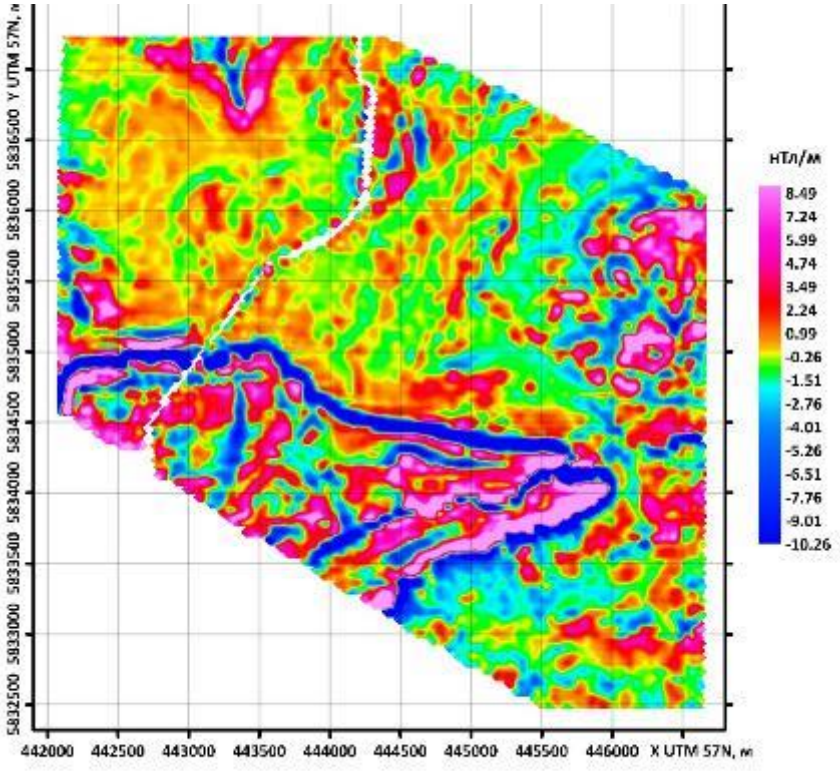
***subject to good weather**

Precise UAV-based magnetic survey

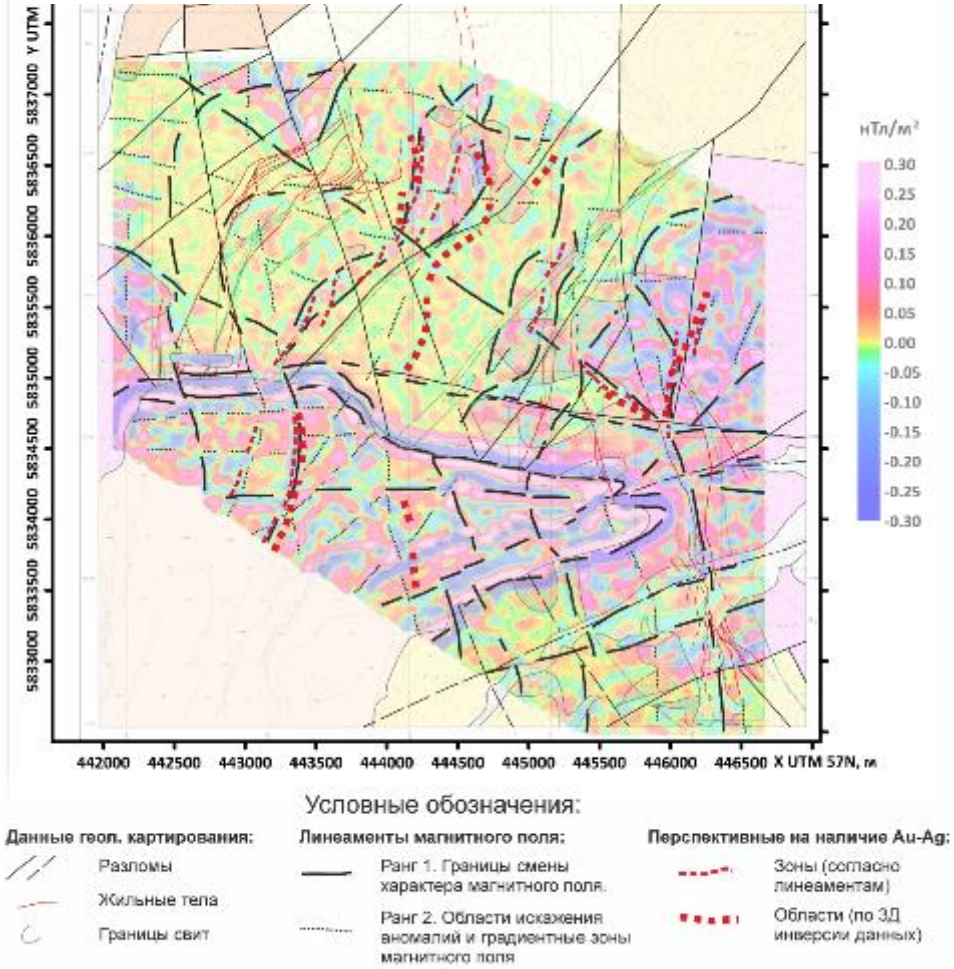
Kamchatka region

GEOSCAN

Vertical derivative

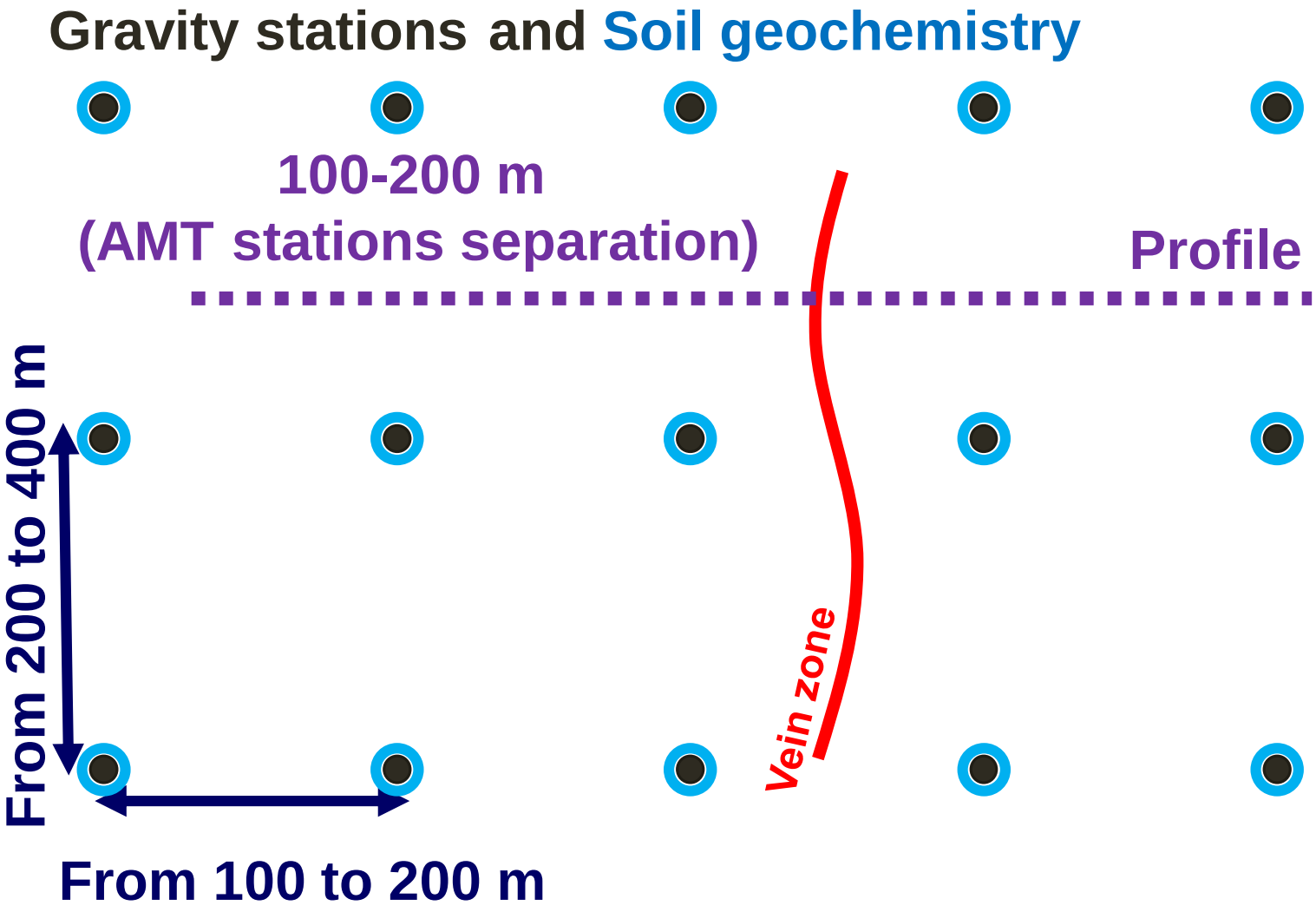


Schematic structural map



Field work – “Geoscan”
Data processing and interpretation – “GM-Service”

Stage 1. Localization of “Targets”

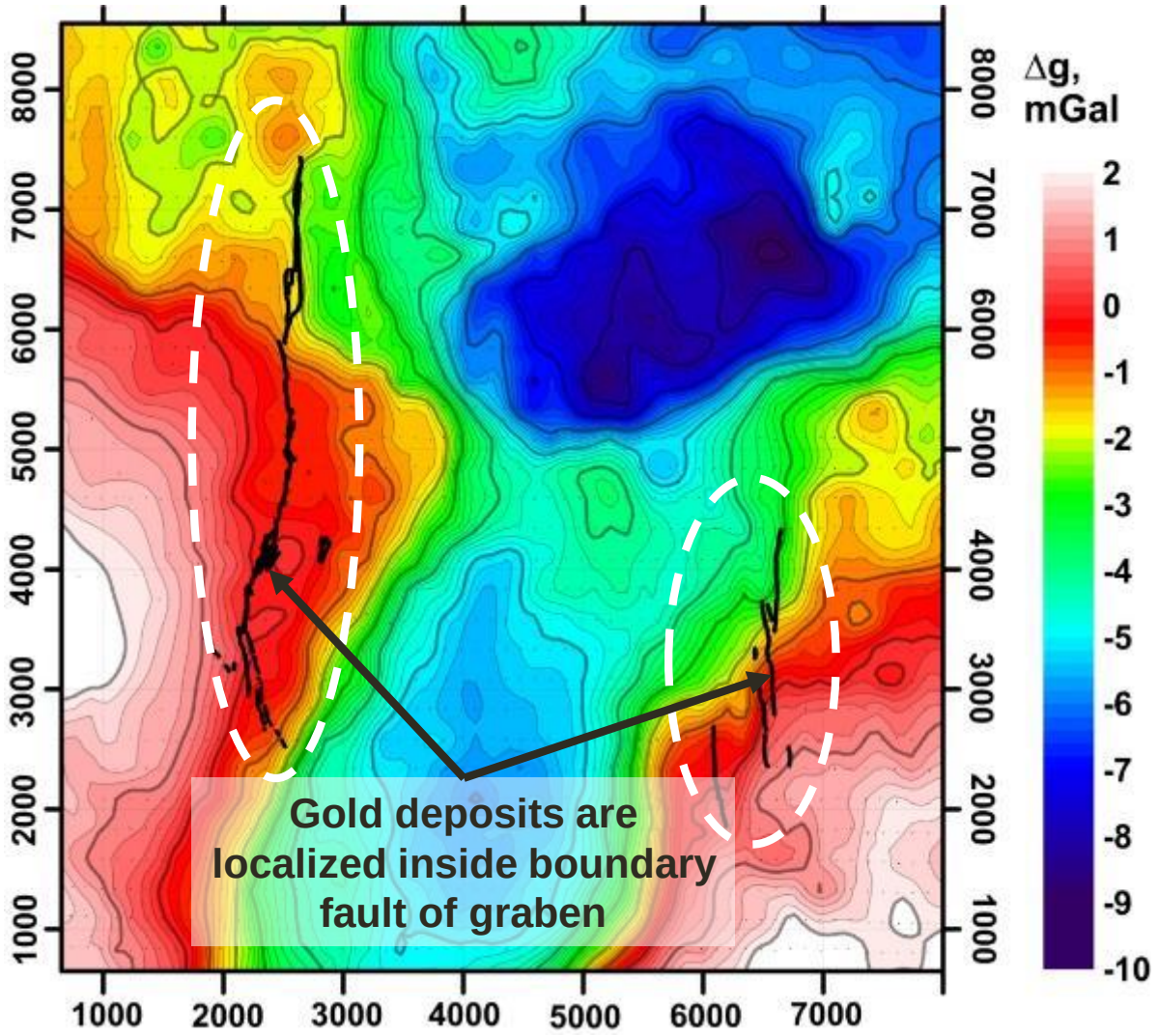


Land survey

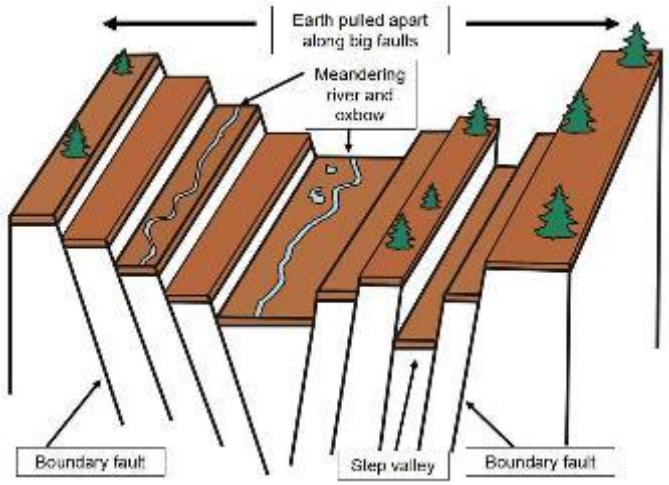
- Gravity
- Soil geochemistry
- Gamma spectrometry

- Magnetotelluric

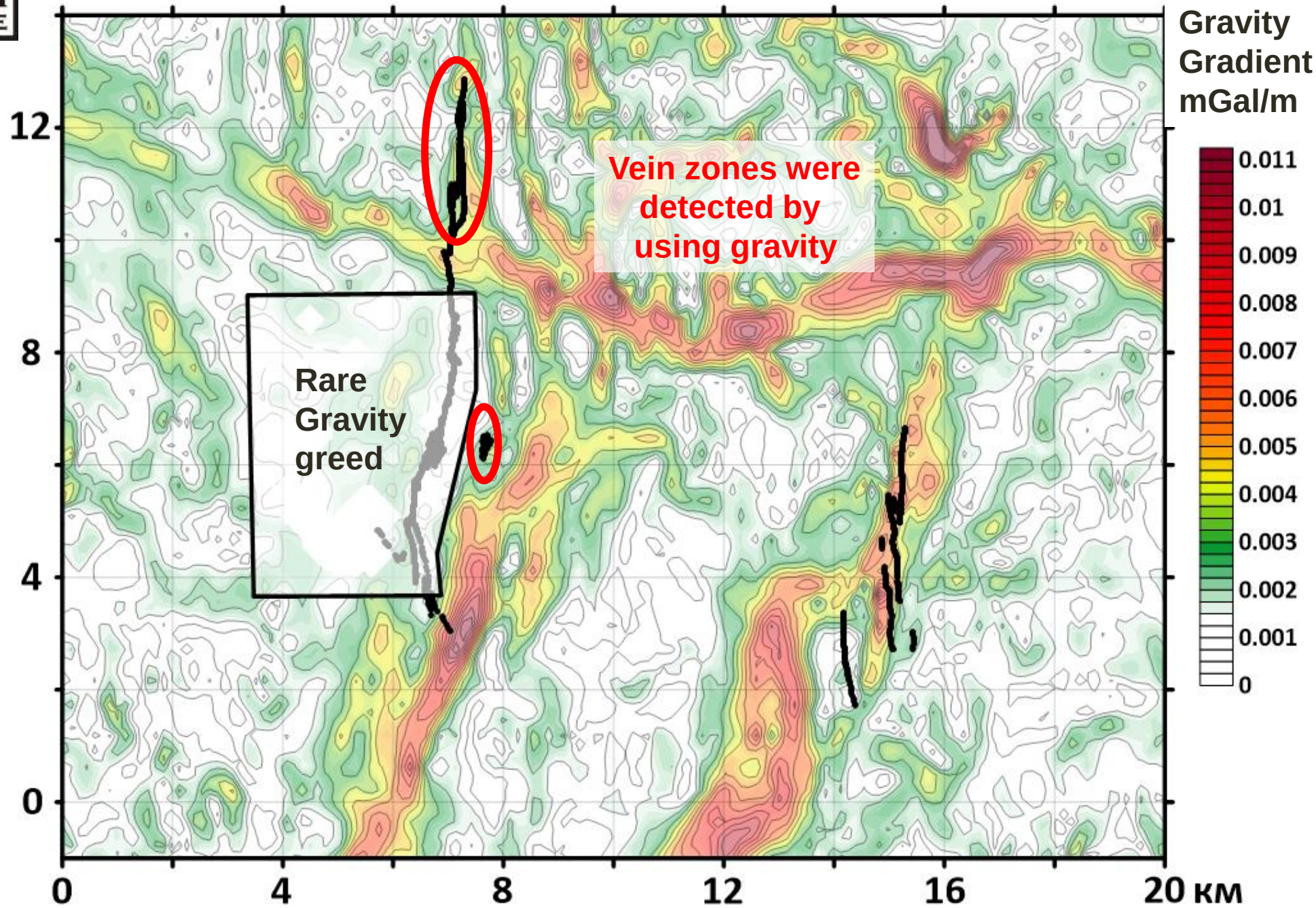
Graben structure was detected by gravity



Graben structure



GM SERVICE



Gravity Gradient mGal/m

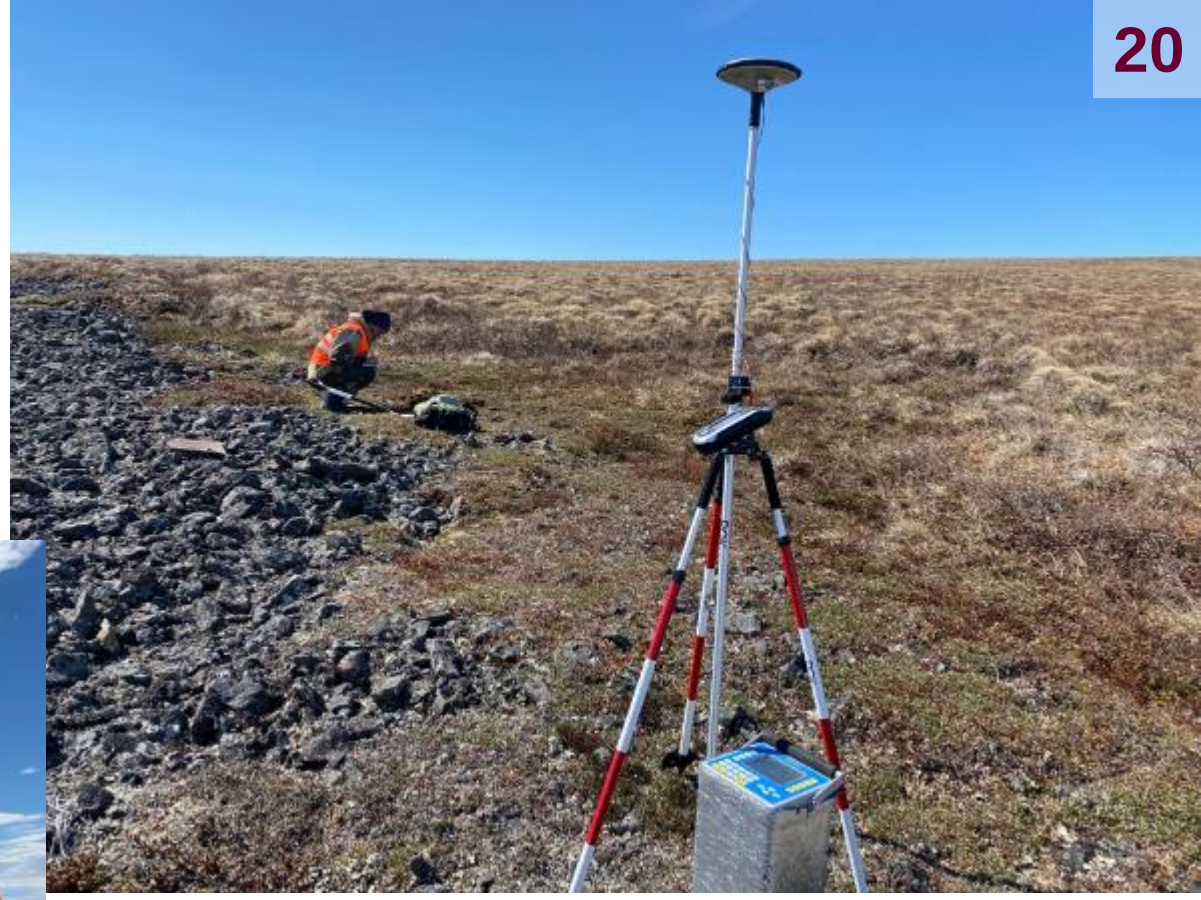
0.011
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0

Gravity grid
125 x 250 meters

Stage 1. Localize the object

Soil geochemistry and Gravity survey can be performed in the same time

It saves the budget and time



We covered 1000 sg km

In 2021 summer season

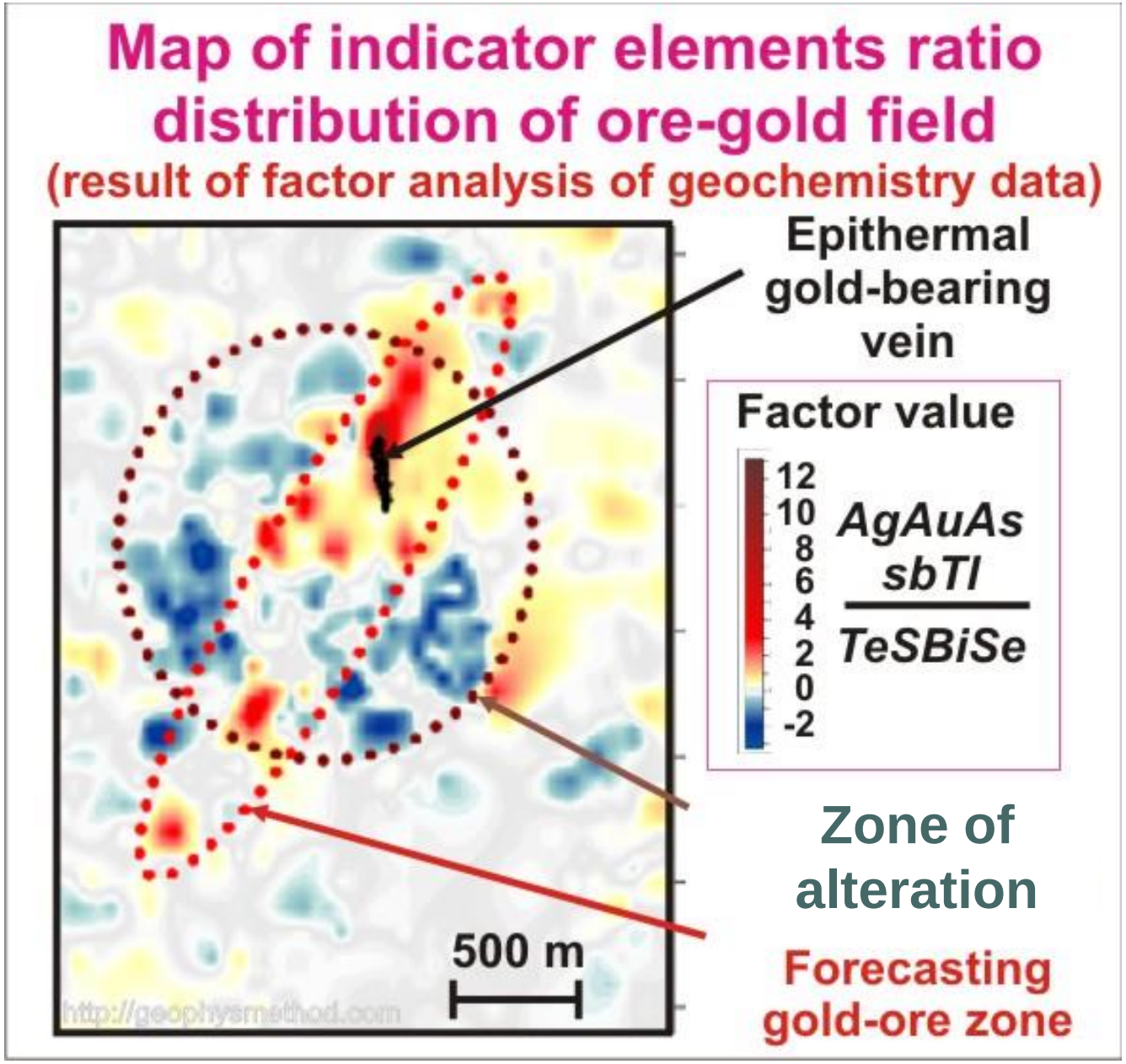
(3 month) in Chukotka region

GM-Service gravity and soil geochemistry team completed 1000 sq. km.

GM-Service team, September 2021

Dr. Evgenii Ermolin

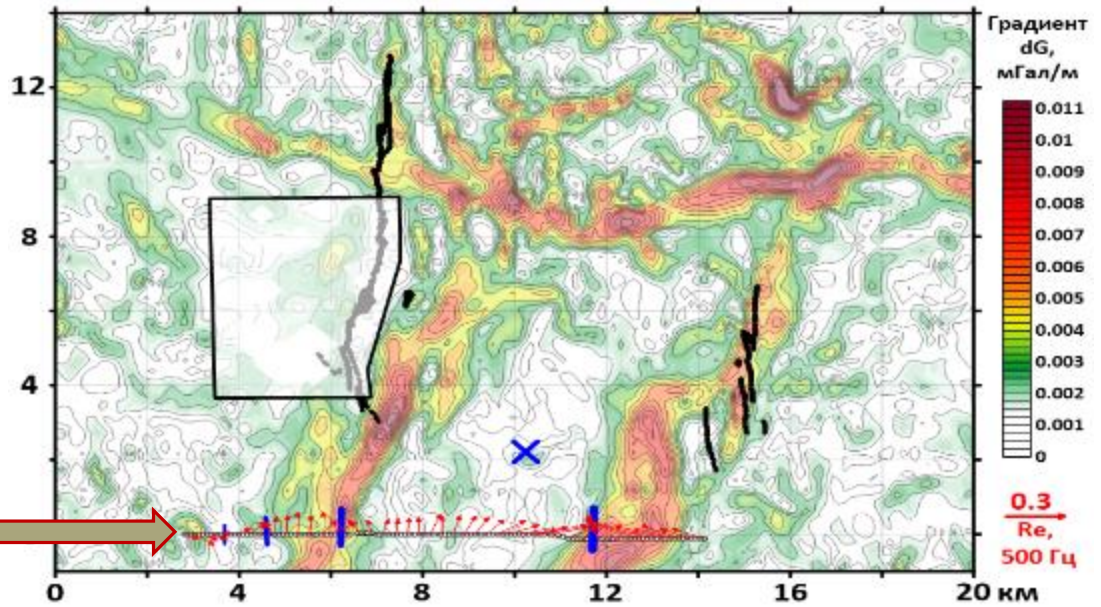
Stage 1. Localization of “Targets”



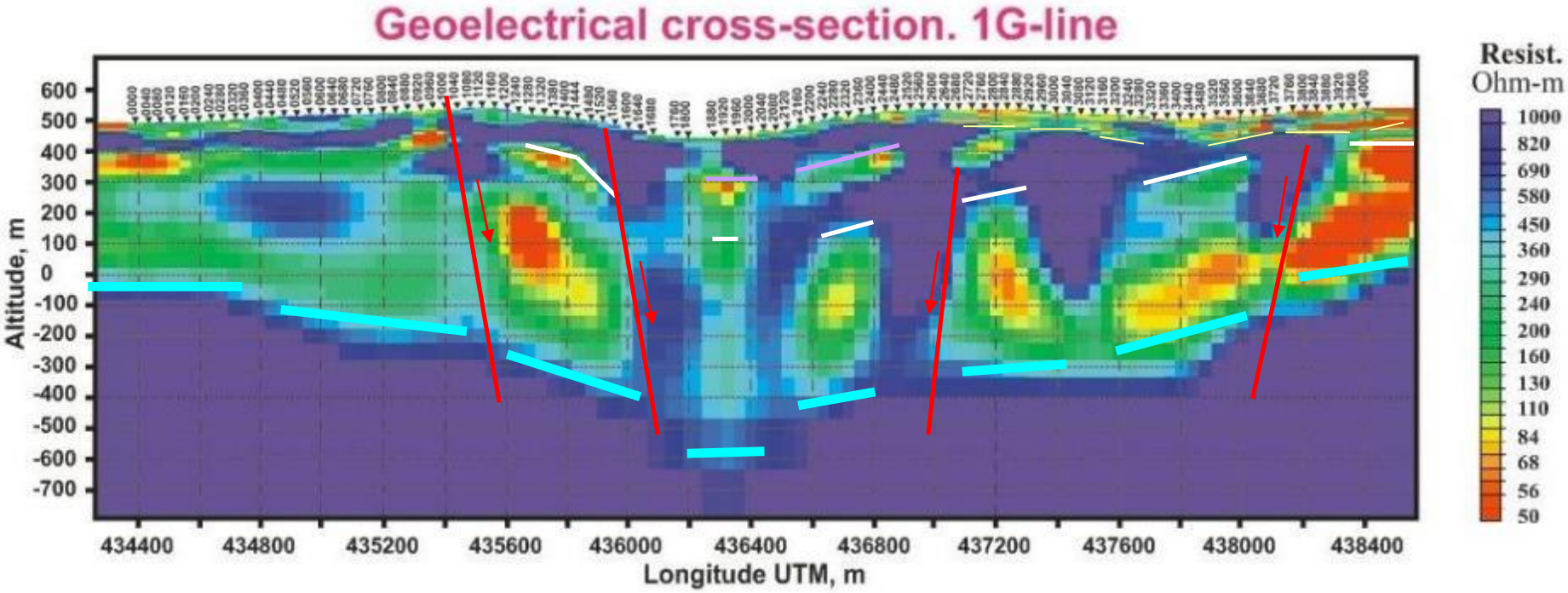
Soil geochemistry

Grid: 50 x 200 meters

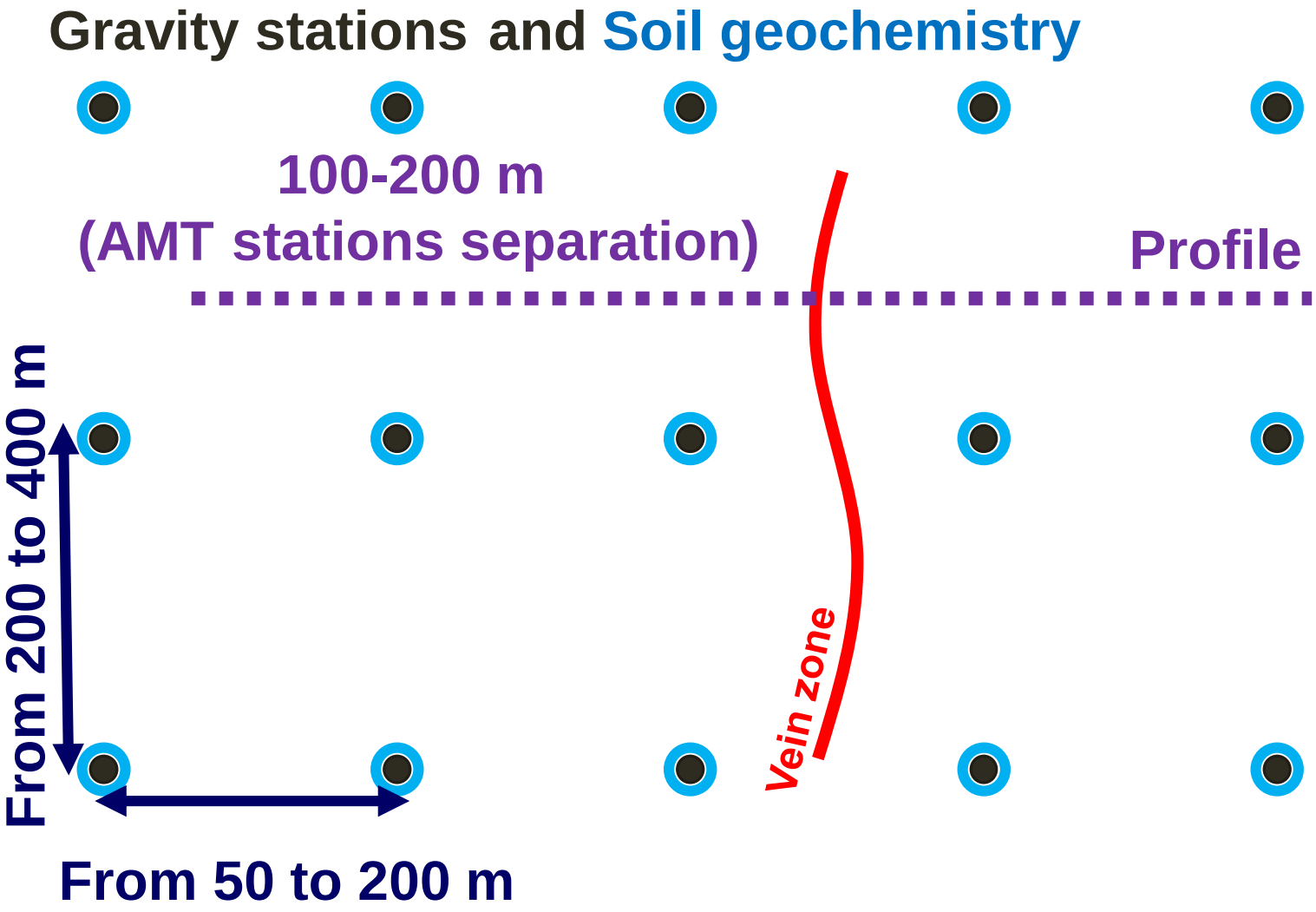
Stage 1. Magnetotelluric Sounding is the best way to understand geology of the area



AMT profile



Stage 1. Localization of “Targets”

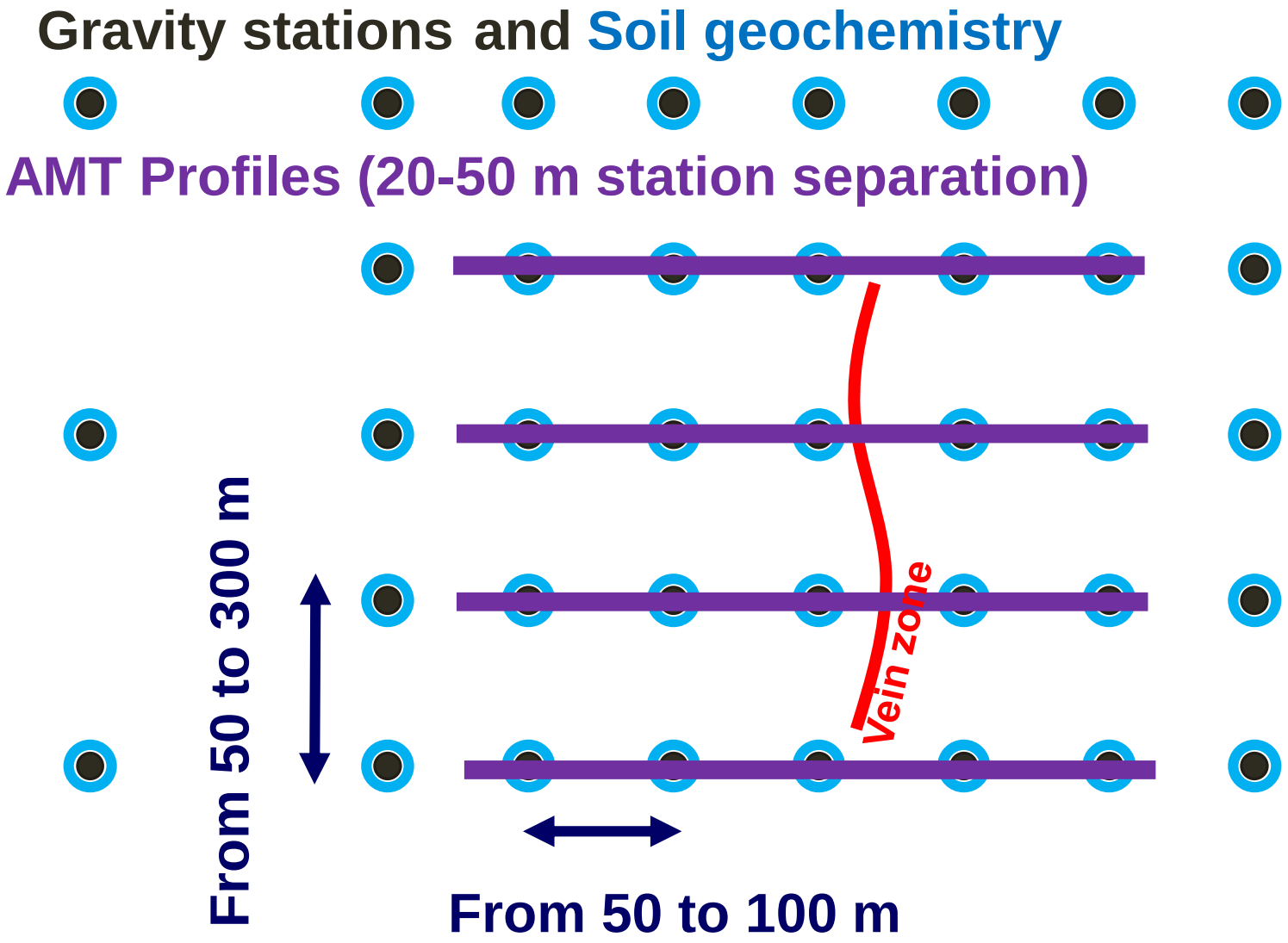


Land survey

- Gravity
- Soil geochemistry
- Gamma spectrometry

- Magnetotelluric

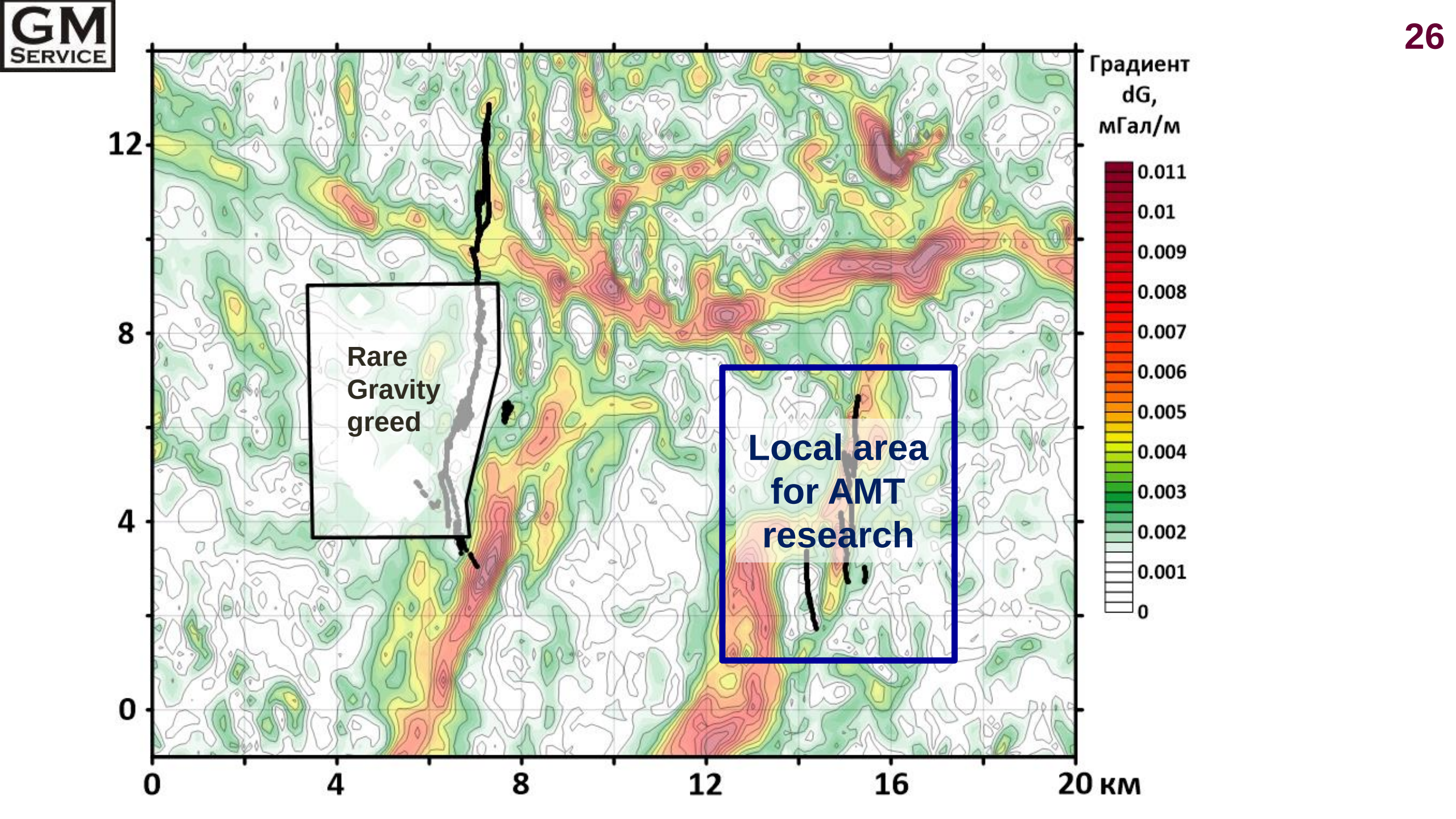
Stage 2. Exploration on focused areas



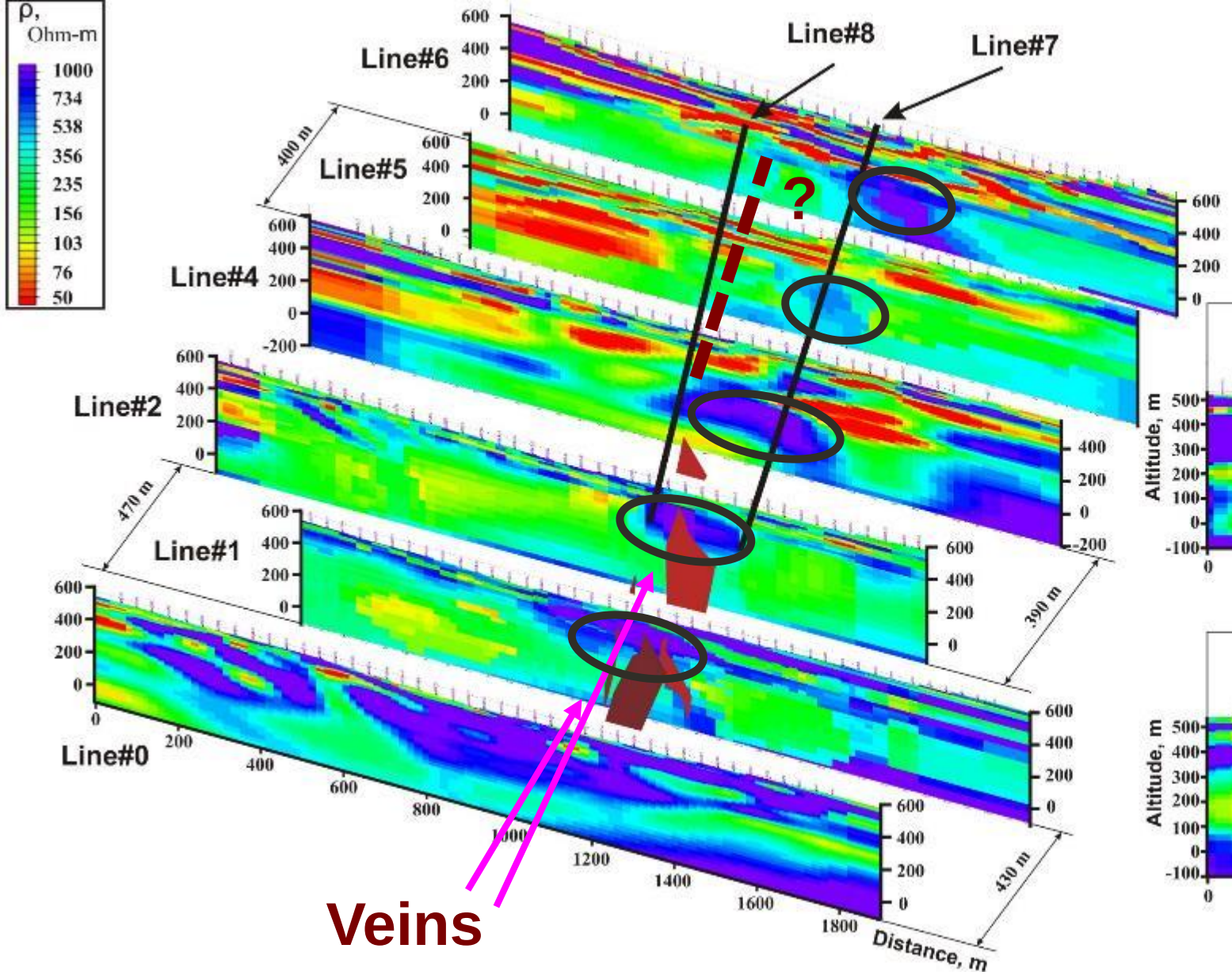
Land survey

- Gravity
- Soil geochemistry
- Gamma spectrometry

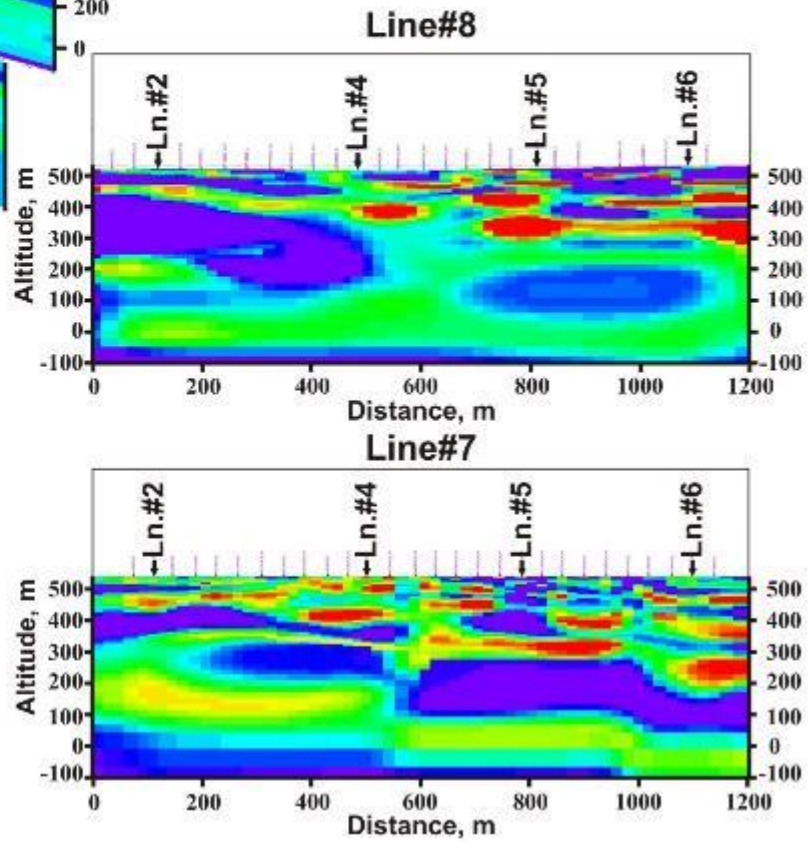
- Magnetotelluric


Rare
Gravity
greed
Local area
for AMT
research
Градиент
dG,
мГал/м
0.011
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
12
8
4
0
0
4
8
12
16
20 км

GM SERVICE

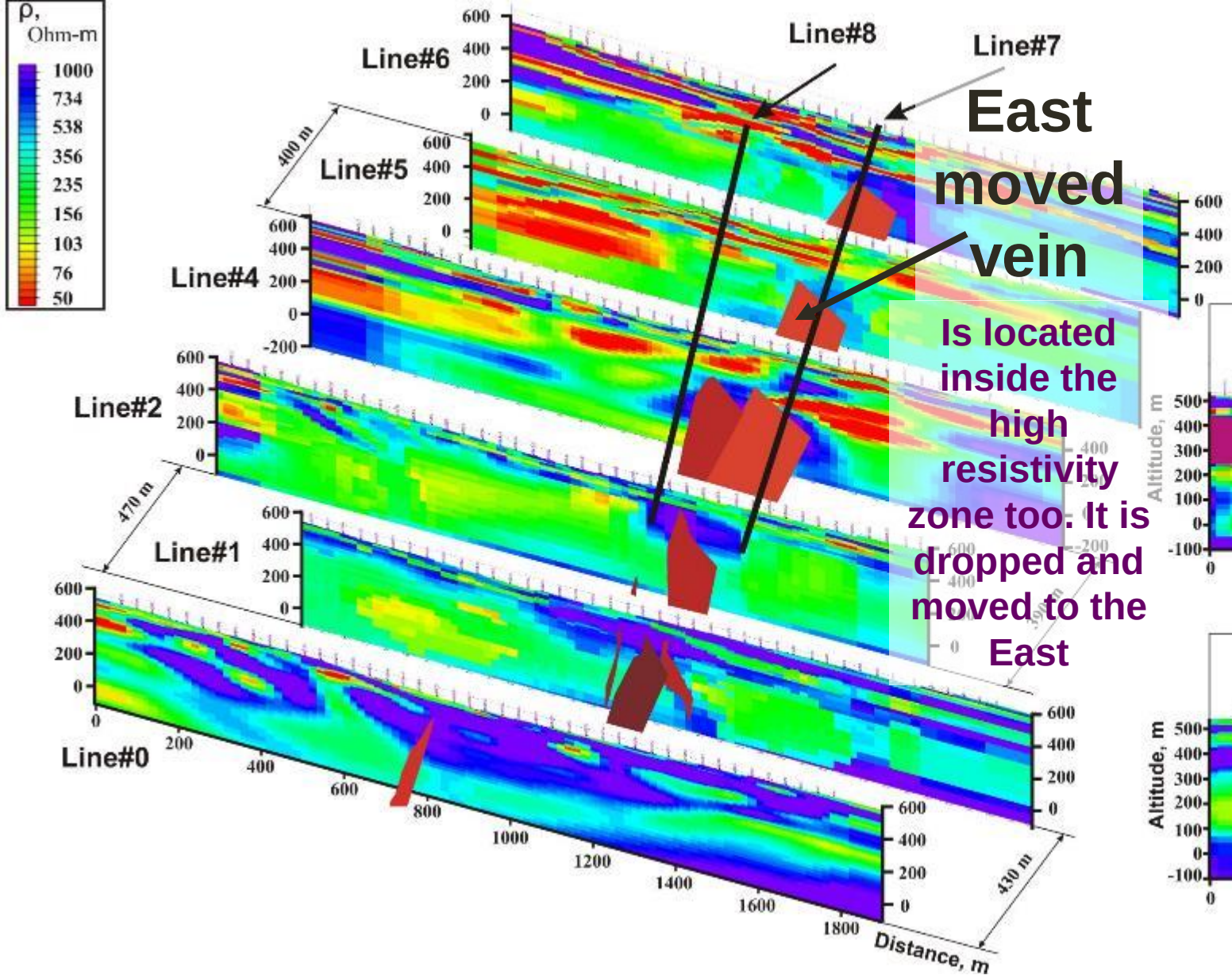


3D visualization of geoelectrical cross-sections



(This vein was detected before Geophysics forecast).
It is located inside the isolator structure

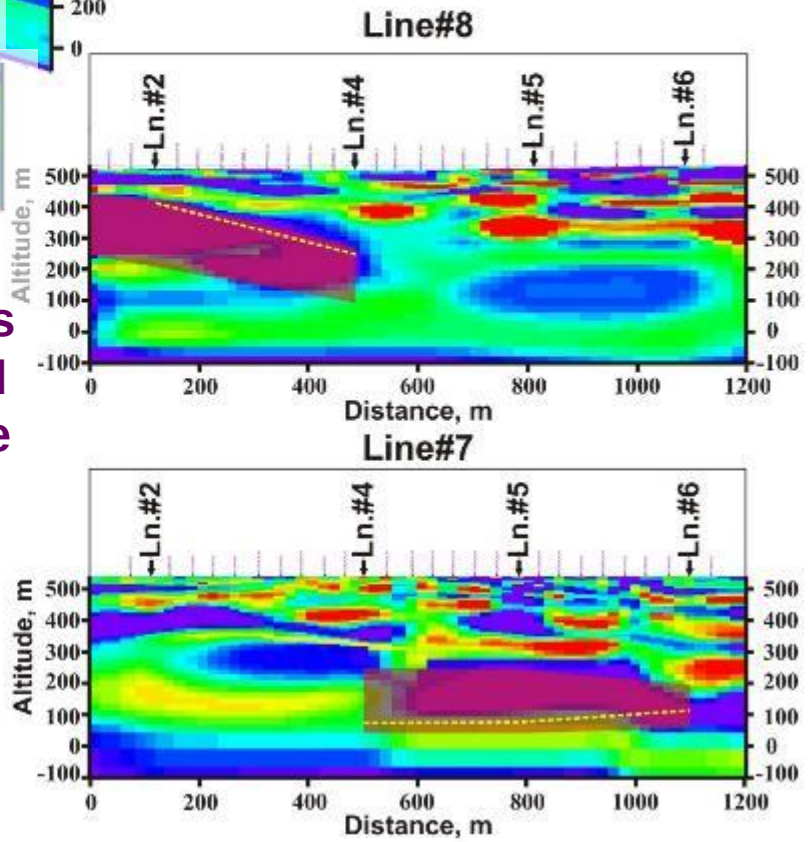
GM SERVICE



East moved vein

Is located inside the high resistivity zone too. It is dropped and moved to the East

3D visualization of geoelectrical cross-sections



35 days of work including report writing

Conclusions

Stage 1. Localization of «Targets»

- UAV-Magnetic (gamma spectrometry)
- Gravity + Soil geochemistry (100-400 m step)
- Magnetotelluric

Stage 2. Exploration on focused areas

- Magnetotelluric (20-50 m step)
- Gravity + Soil geochemistry (50-100 m step)
- Land magnetic survey (5-20 м step)

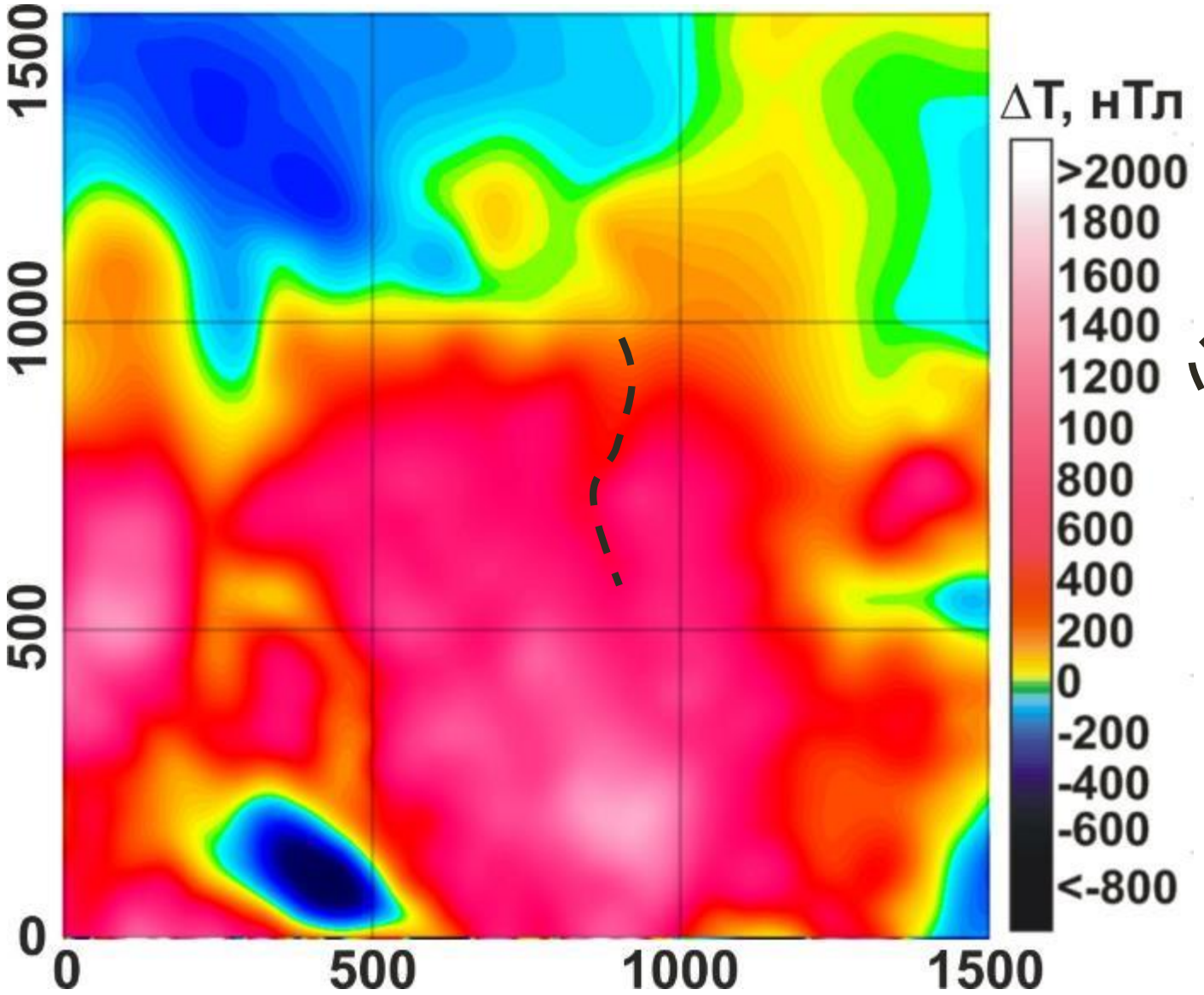
Thanks for your attention!

Professor
Jeffry Hedenquist
Is talking
about
“Sinter“ & “Feeder”

Geophysical service company
"GM-Service" Ltd.
Saint-Petersburg, prospect Prosvescheniya, 53-1, 195
Tel: +7-911-792-05-71
E-mail: geophysmethod@gmail.com
Website: http://GeophysMethod.ru/ (RUS)
Website: http://GeophysMethod.com/ (ENG)

Additional slides

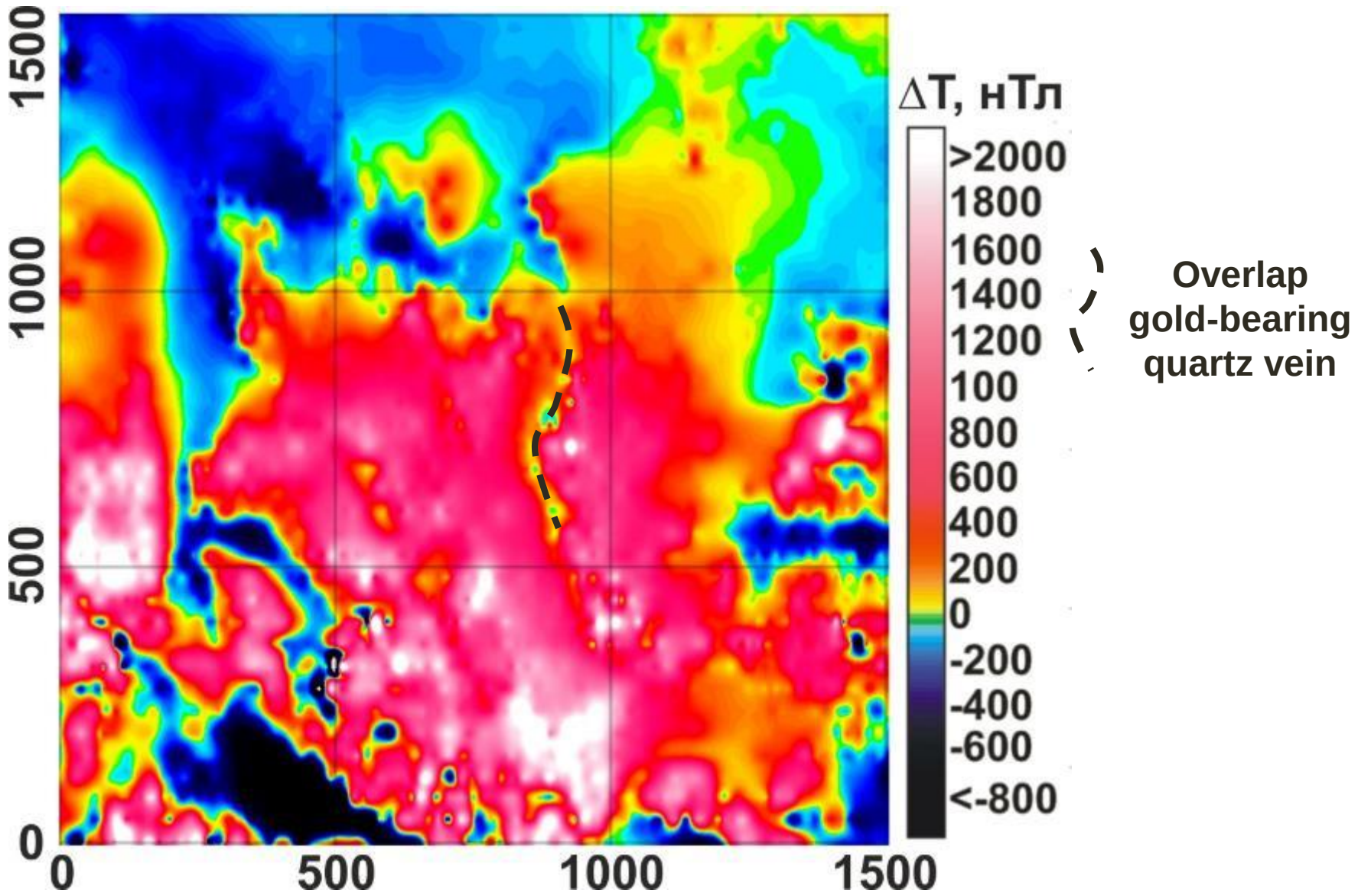
UAV-based magnetic survey (flying height 20 m)



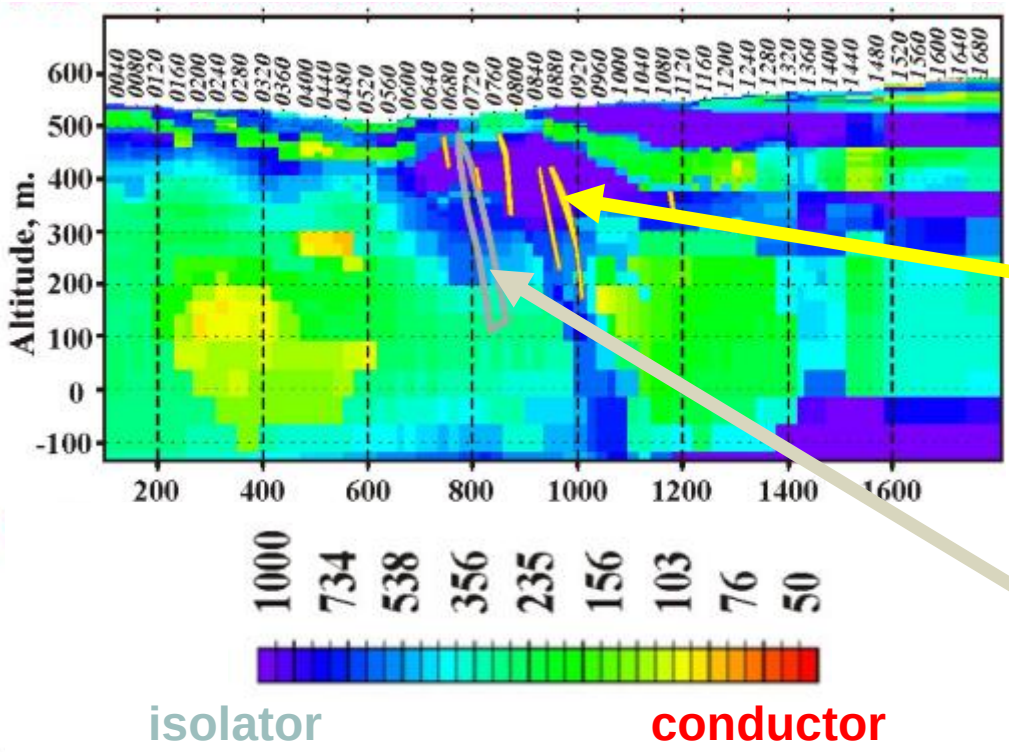
Overlap gold-bearing quartz vein

If the area square more than 100 sq km than Drone more actual

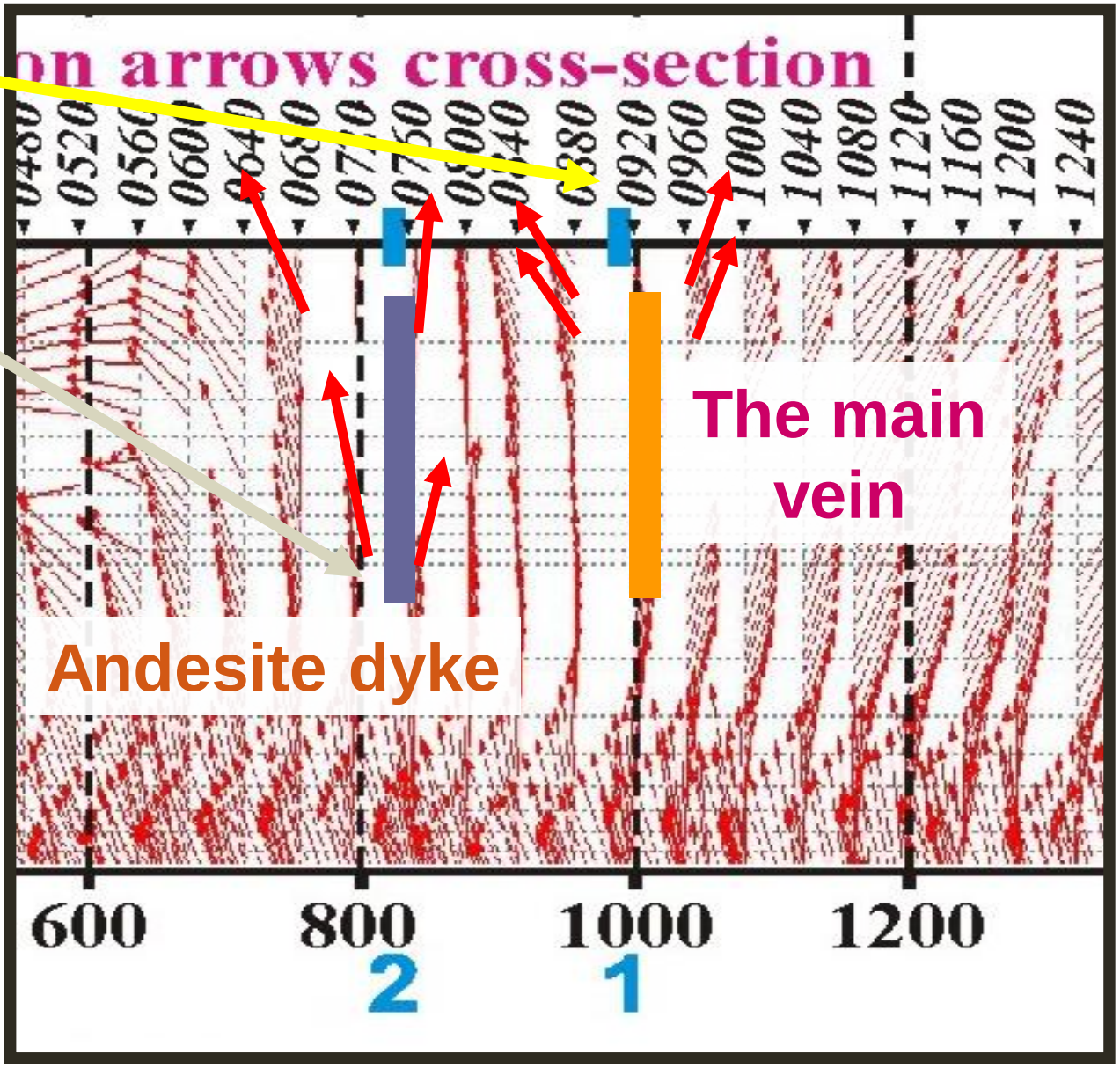
Detailed ground magnetic survey



Line 1. Geoelectrical cross-section



We can separate small objects inside high resistivity zone by using induction arrows



Induction arrows cross-section