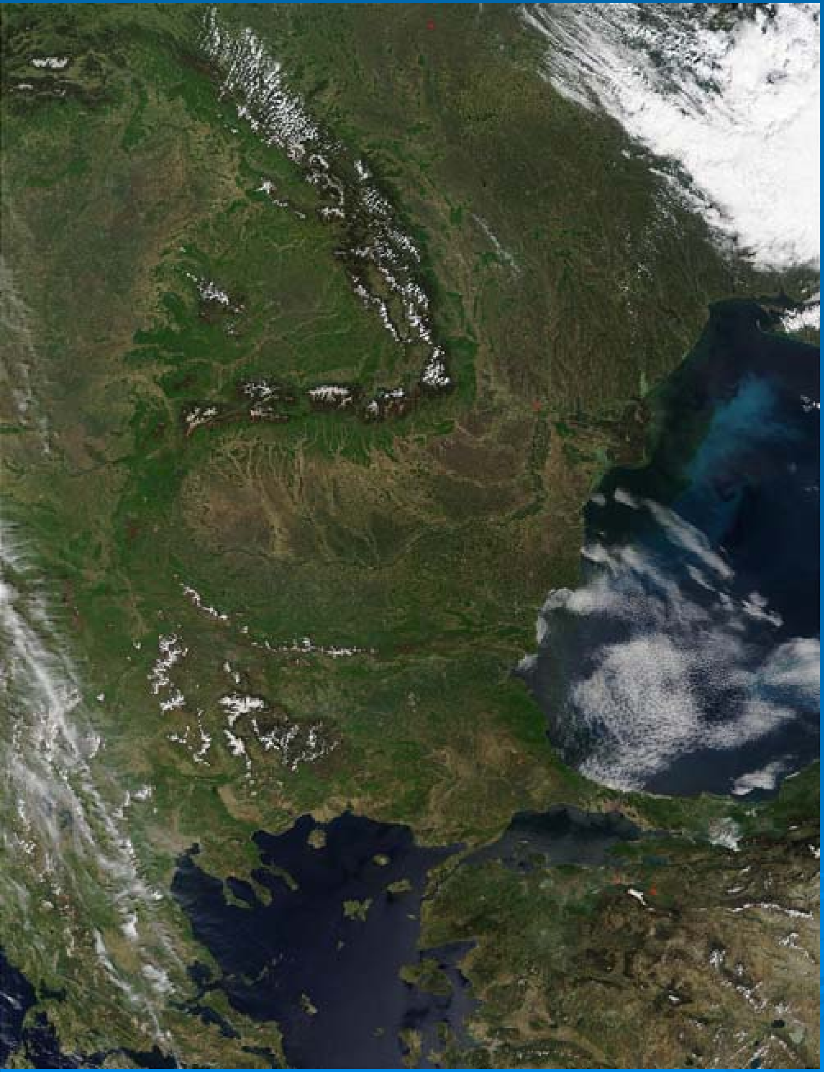
Advances In Regional Geological and Metallogenic Studies in the Carpathians, Balkans, Rhodope Massif and Caucasus (Romania, Serbia, Bulgaria and Georgia).

Conference, Bor Serbia



MINERAL COMPOSITION OF THE BREZNIK-BARDOTO Au EPITHERMAL ORE OCCUREMCE (PRELIMINARY DATA)

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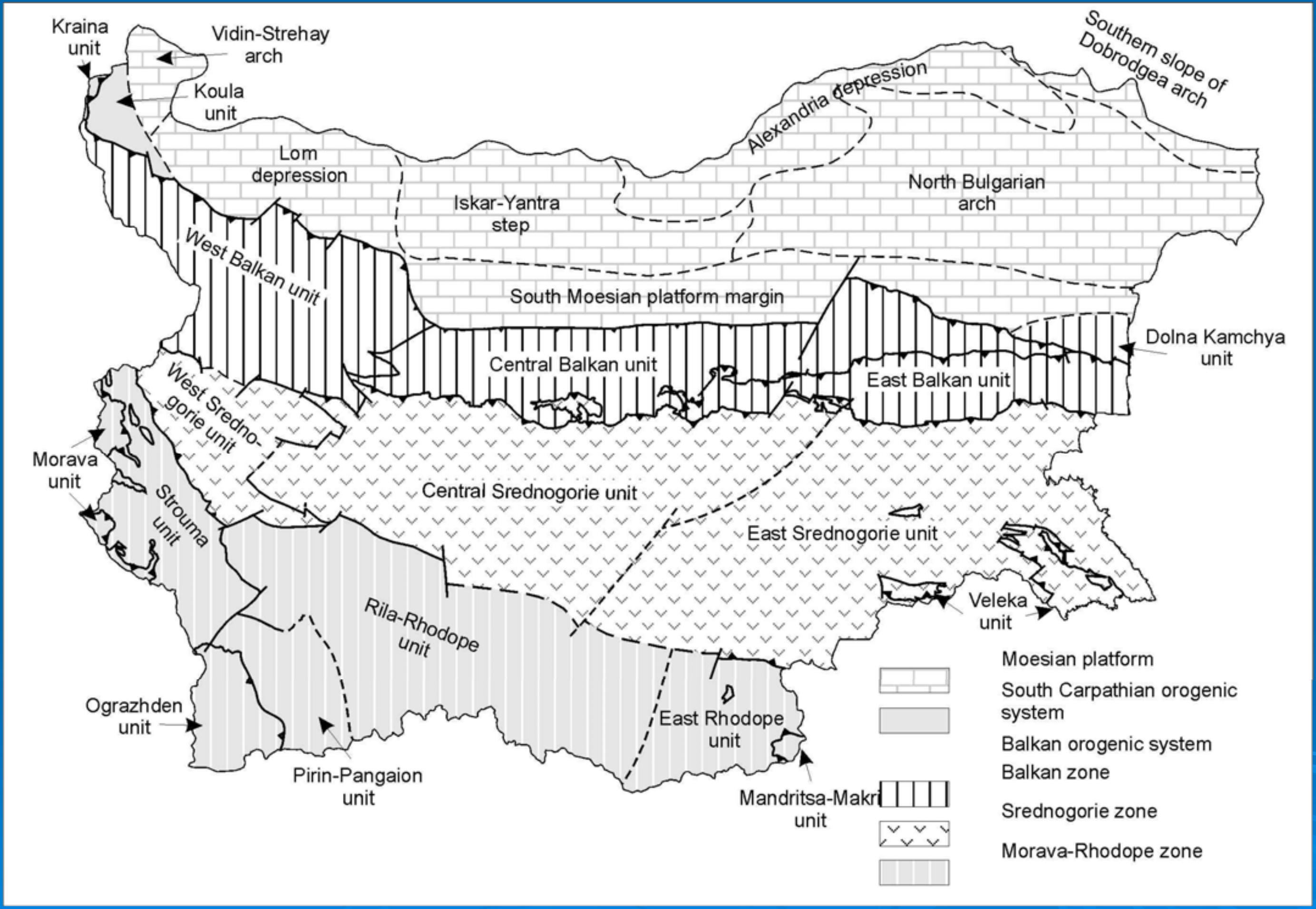
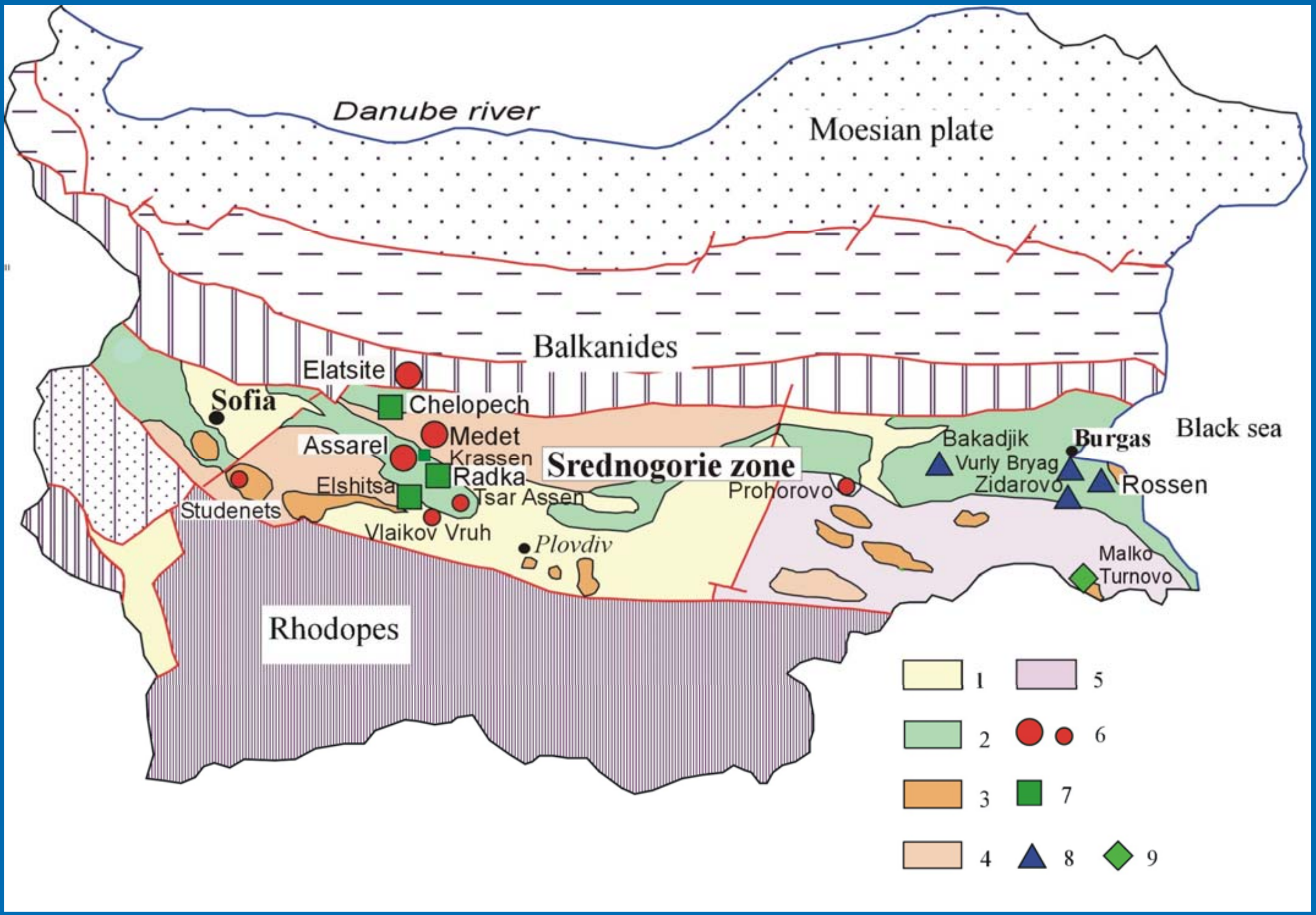
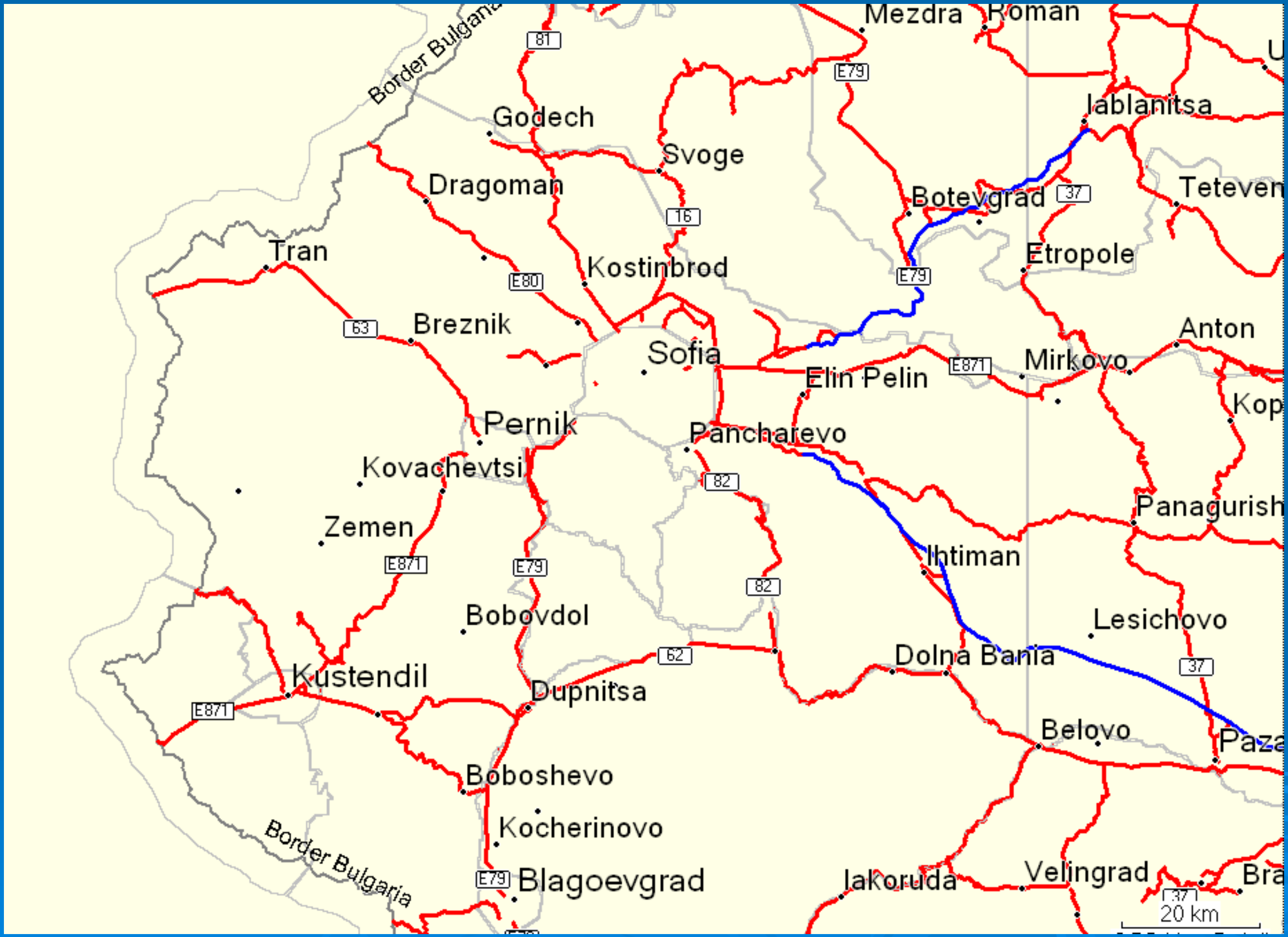
Bulgarian tectonic scheme (after Dabovski et al., 2002)



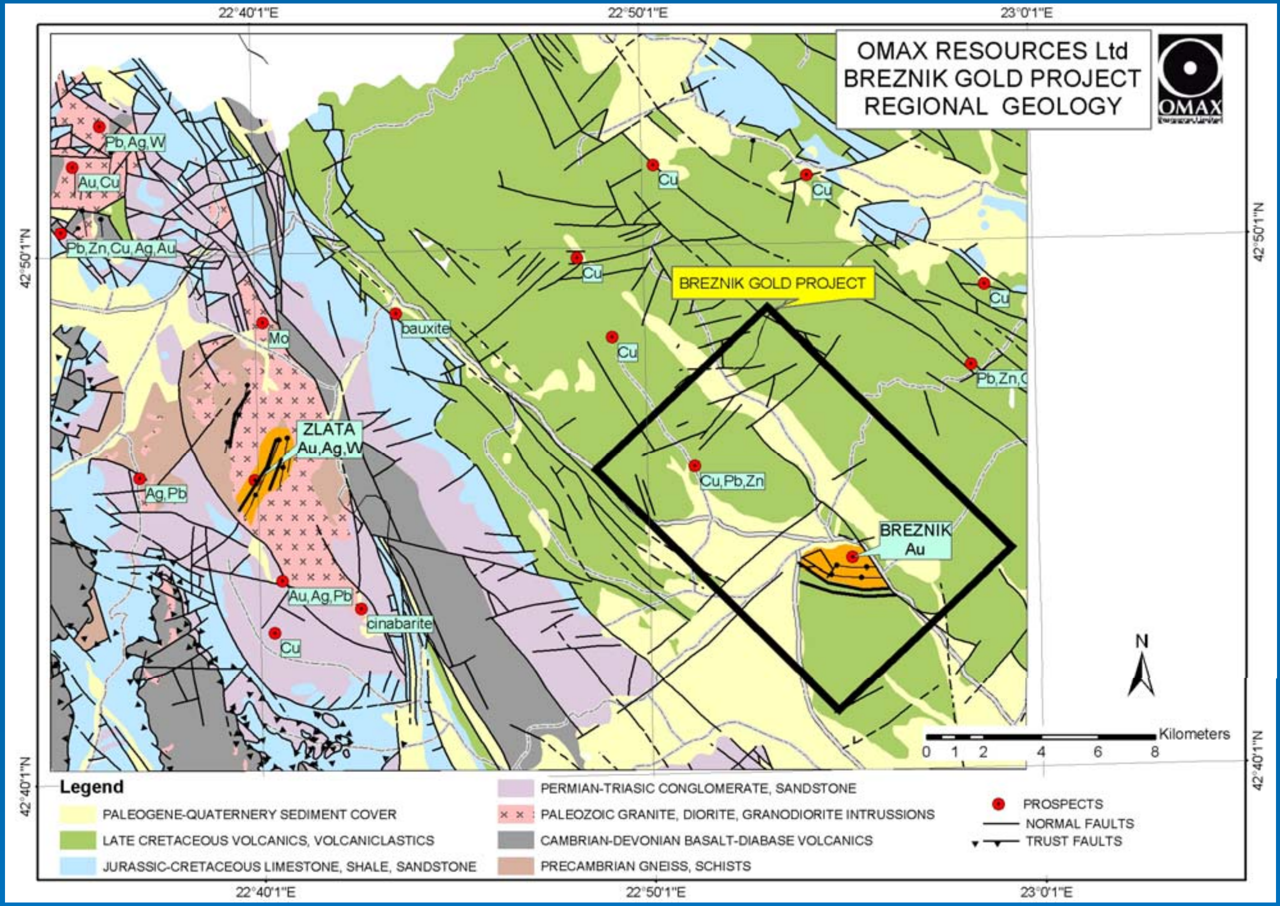


1 – Cenozoic sediments; 2 - Late Cretaceous volcanic rocks; 3 – Late Cretaceous intrusions; 4 - Paleozoic granites and metamorphic rocks; 5 – Paleozoic and Mesozoic metamorphic rocks; 6 Porphyry copper deposits; 7 Epithermal deposits; 8 Vein copper deposits 9 –Skarn deposits.

The Bardoto prospect is a part of the Breznik epithermal gold occurrence, which is located in the Western Srednogorie zone. Near town of Breznik, about 35 km W of Sofia.



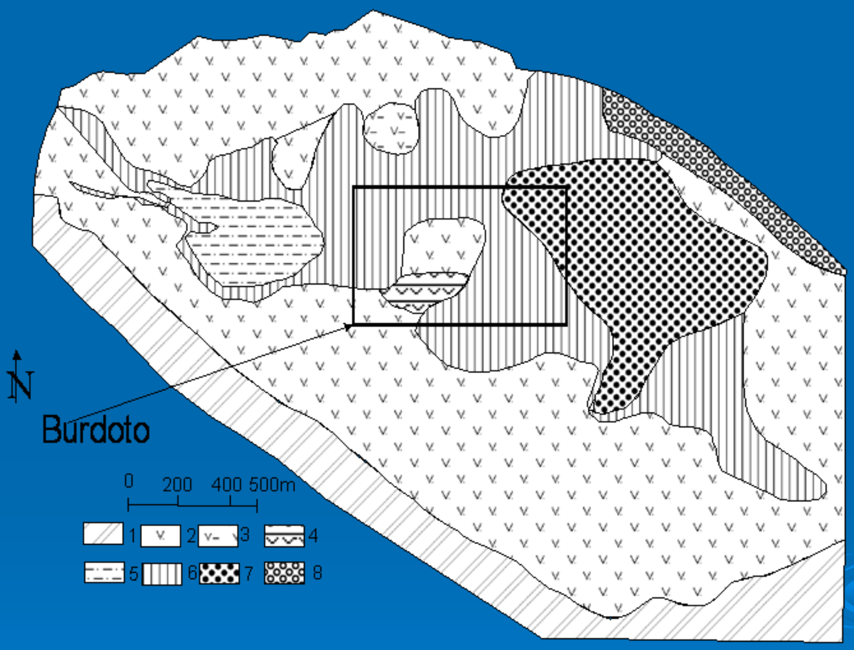
Geological map of the Breznik area



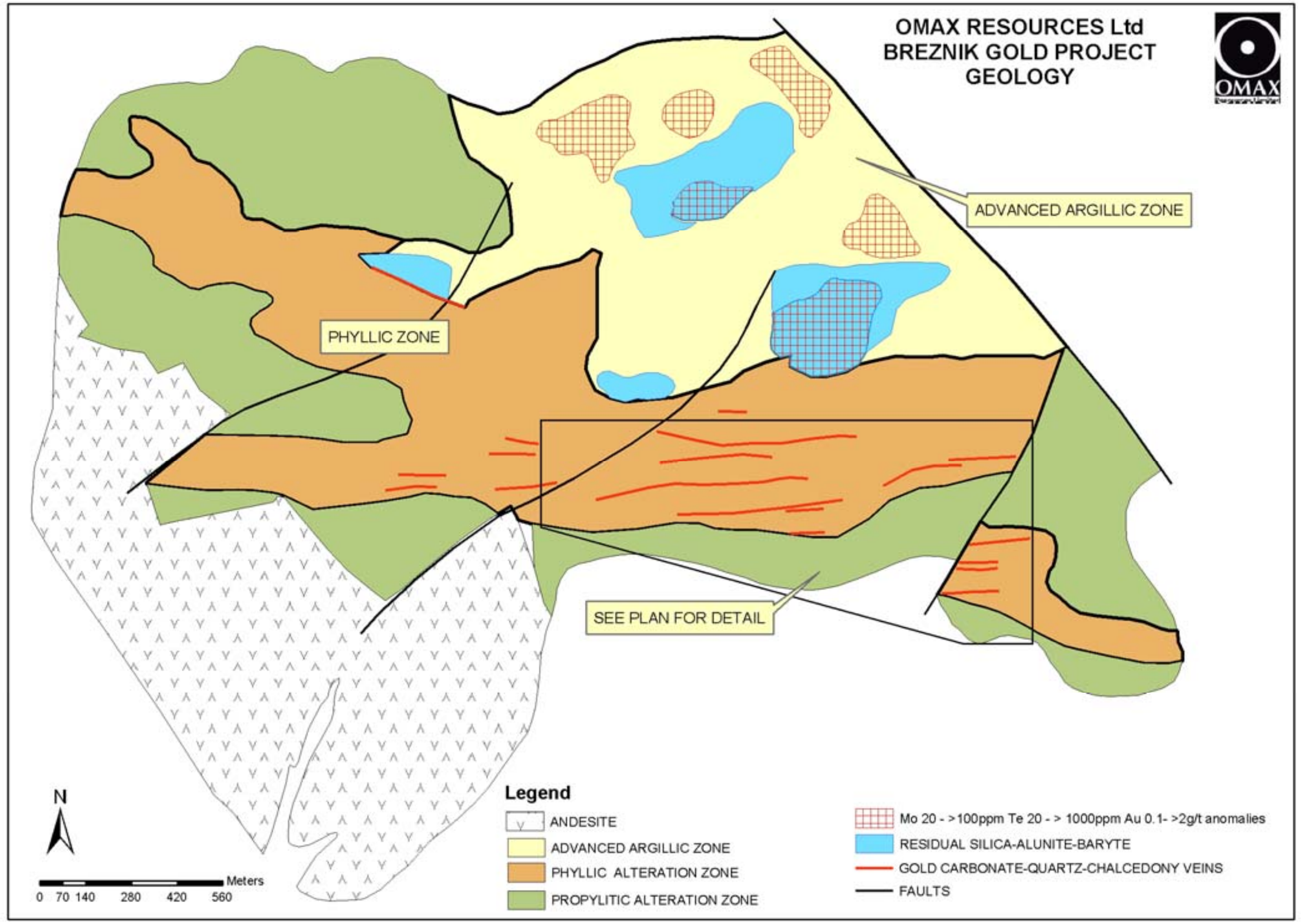
The Breznik prospect is hosted by Late Cretaceous volcanic and volcanoclastic rocks of andesitic, trachyandesitic and trachybasaltic composition, intruded by porphyry stocks and dikes of gabbrodioritic composition belonging to the Western Sredongorie belt. Basement rocks in the Breznik area consist of Precambrian gneiss and schists, Cambrian-Devonian mafic volcanic rocks, Paleozoic granitic intrusions, Permian-Triassic clastic sedimentary rocks, and Jurassic-Cretaceous limestone, shale and sandstone.

Schematic geological map of the hydrothermal alteration of the region south of Breznik (after Velinov, 1967) with additions

- 1 - Tuff-marl complex;
- 2 – Agglomerates, pyroxene and pyroxene – amphibole tuffs, epidote- chlorite facies,
- 3 – Uralite – epidote-chlorite facies,
- 4 - actinolite- epidote-chlorite facies,
- 5 – Quartz-epidote-cericite facies,
- 6 – Quartz-sericite facies,
- 7 – Alunite-quartz facies,
- 8 – Terciery sediments.



Schematic geological map of the hydrothermal alteration of the Breznik region (after Dimitrov, 2006)

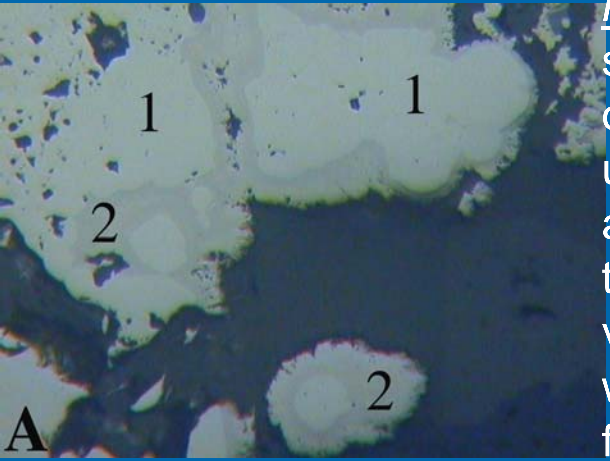


The northern part displays an advanced argillic alteration with small and shallow zones consisting of quartz, kaolinite and alunite surrounded by an alteration halo with kaolinite and sericite. This part of the prospect shows local anomalies of Mo, Te and Au (locally over 2 ppm).

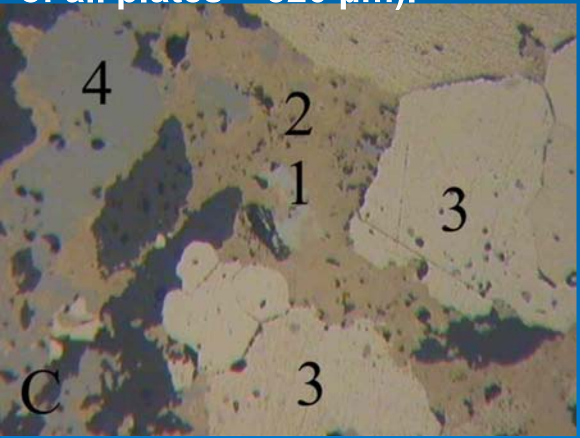



Mineral composition of ores

- The assemblage includes minerals such as enargite, luzonite, tennantite, tetrahedrite, pyrite, chalcopyrite, goldfieldite, arsenosulvanite, colusite, galena-claustalite, Au-Ag tellurides, typical for the high sulphidation type of mineralization (Crummy et al., 2001);
- The recent study is based on samples from the area Bardoto, which is a part from the mineralised zone of Au-epithermal occurrence Breznik. Following ore minerals are determined in the samples – pyrite, (also arsenian pyrite) chalcopyrite, galena, sphalerite, tennantite, tetrahedrite, pyrrhotite, native gold, electrum, magnetite, hematite, marcasite, ilmenite, chalcocite, covellite, malachite, cuprite and cerusite.

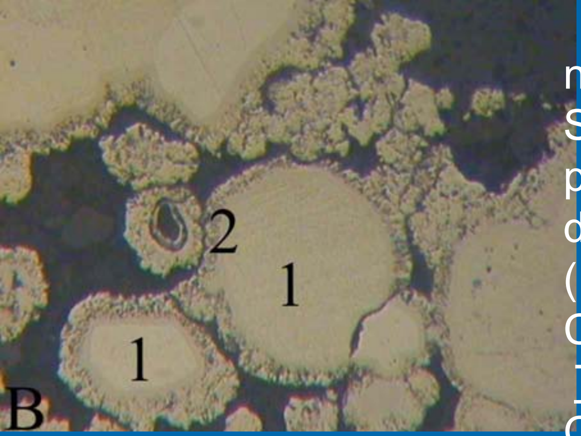


A. Pyrite (1) rimmed by As-pyrite containing (2) As between 7 – 10 wt.%., II N, (Size of the observation field of all plates = 320 µm).

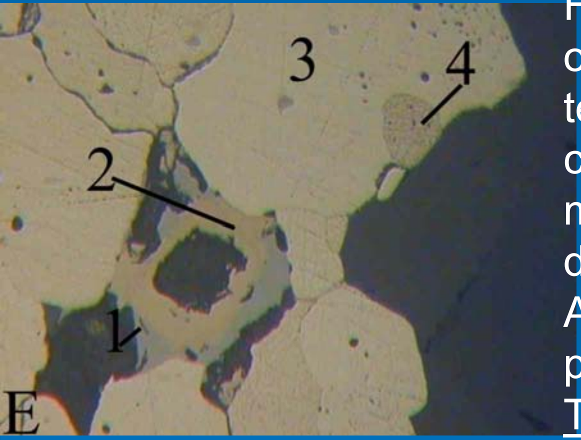


C. Irregular inclusion of Se-bearing galena (1) in chalcopyrite (2), crosscutting pyrite (3) aggregate. (4) – tennantite. II N

Pyrite is the most often found ore mineral in the samples studied. It forms mainly semi-euhedral, xenomorphic, euhedral or rarely colloform rounded grains and aggregates within 20 µm up to 2 – 3 cm. Larger aggregates are usually slightly fractured and cemented by gangue or later formed sulphide minerals. On the basis of its textures and chemical composition at least three varieties of pyrite could be distinguished. The first one is related with the pre-ore hydrothermal alteration and it is presented by fine disseminated grains of pyrite without any trace elements over 0.0n wt. % in it. The second one associates with other sulphide minerals which often corroded or cut it (Plate C). In some of its relatively larger aggregates are found fine grains (20 – 50 µm) with well-expressed anisotropic features, grey-yellowish color and distinct lower reflectivity compared with the normal pyrite. Quantitative microprobe analyses established in this variety significant content of Cu and lower content of Ni. The most unusual is the third variety of pyrite forming rounded colloform aggregates with zonal texture (Plate A, B and D). Their central parts are set up by pyrite containing Cu and As about 0.5 wt.% and they are rimmed by bends of pyrite with extremely high content of As and significant contents of Cu and Sb. The described findings with high As content could be nominated as arsenian pyrite according Chvileva et al. (1988) which mentioned that As content in this variety could reach 14.5 % and Sb up to 2 %. Colloform textures are very typical for it as it is in this case.



B. Atoll-like textures of pyrite (1) aggregates rimmed by marcasite and As-pyrite (2), II N

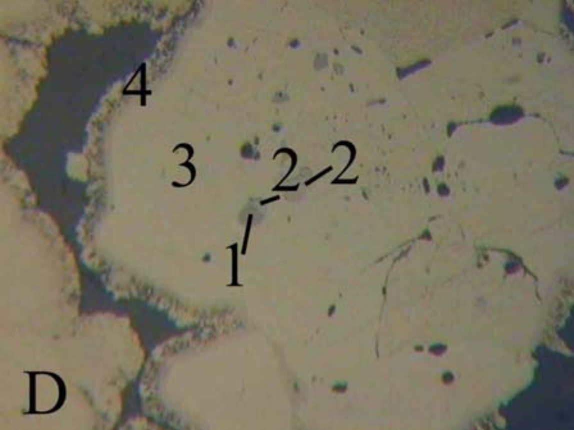


E. A rim of tennnatite (1) around chalcopyrite (2) as fine nest among larger pyrite aggregate (3). (4) – inclusion of slightly rounded Cu-rich anisotropic pyrite in matrix of normal pyrite, II N

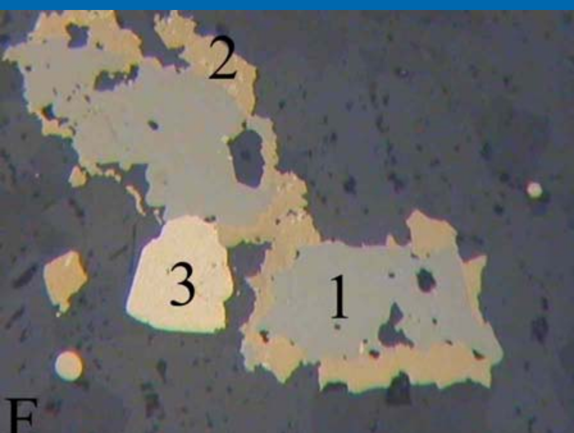
Low concentrations of As in pyrite as trace element are found in numerous deposits in Bulgaria, especially in copper deposits from the Srednogorie zone. Higher content of As (4.08 wt.%) is reported for pyrite in the Sedmochislenitzi low-temperature (teletermal) Pb-Zn-(Cu) deposit (Vratza ore region, Western Stara Planina) by Shadlun et al. (1975). Petrunov (1994) mentioned high content of As in pyrite from Chelopech.

Tennantite is often found in association mainly with chalcopyrite (Plate C). It forms thin rims around it (Plate E) or it replaces larger chalcopyrite aggregates (Plate F). It show constant presence of trace elements such as Ag, Fe and Mn. A very low Sb content determines the phases very close to the end-member of tennantite-tetrahedrite serie. Relatively high Fe content nominate it as feroan tennantite according classification offered by Chvileva et al. (1988) where maximal iron content in tennatnite established is mentioned as 7 wt. %. Very high is also Mn content which normally is typical one for tetrahedrite. It should be mentioned that the most tennantite phases analyzed in samples from deposits in the Central Srednogorie contain Zn, here not detected; Ag content is relatively low but tennantite should be registered as potential carrier of this element;

Tetrahedrite is very rare distributed only as small rounded inclusions in pyrite (Plate D) in association with galena of size 10 – 30 μm. It is characterized by relatively high As content (up to 8.17 wt.%) so it could be concluded that the most phases from tennantite-tetrahedrite serie found in Breznik are much more belonging to the As rich and intermediate sector of the row. Zn content is high and the phase could be nominated as Zn-rich tetrahedrite. Compared with described above tennantite this phase has relatively higher Ag content (> 2 wt. %).



D. Inclusions of tetrahedrite (1) and galena (2) in pyrite (3) rimmed by marcasite and As-pyrite (4),II N



F. Tennatite (1) replacing central part of chalcopyrite (2) aggregate. (3) – semi-euhedral pyrite grain, II N

Chalcopyrite associates with pyrite as irregular aggregates cutting early formed pyrite (Plate C) or fine nests among large pyrite aggregates (Plate E). Typical is the association of chalcopyrite with tennatite (Plate F). In some cases tennatite rims chalcopyrite (Plate C) and in the other marginal parts are set up by chalcopyrite and it seams that tennantite replace it. The most probable is that both minerals are formed in narrow interval of mineralization process and both relations between them are available. Marginal part of chalcopyrite from upper levels is replaced by secondary copper minerals such as chalcocite and covellite. Fine chalcopyrite emulsion is rarely found in larger sphalerite grains;

Quantitative microprobe analysis of chalcopyrite established also significant a high content of As and low presence of Sb;

Galena presents as fine isometric slightly rounded inclusions in pyrite (Plate D) and as irregular shaped inclusions rarely in chalcopyrite (Plate C). Inclusions found in pyrite do not contain any trace elements while these found in chalcopyrite are characterized by presence of Se and Ag;

Sphalerite is also in minor quantity but relatively much often found compared to galena. It forms fine xenomorphic nests in association with the rest of sulphide minerals. It is observed as well fine veinlets in fractures of pyrite aggregates. Some of its grains are rimmed by tennantite. Chalcopyrite dissemination in it is not typical although it is observed in some cases. The size of its grains and aggregates usually is below 1 mm.

Results from quantitative microprobe analyses (Breznik, # 16276, drill hole 525, level – 169 m)

No	element (wt.%) mineral	Ag	Ni	Sb	Fe	Cu	Zn	Pb	As	Se	Mn	S	Total
1	pyrite	0.0	0.22	0.0	46.09	0.56	0.0	0.0	0.0	0.0	0.0	53.00	99.85
2	pyrite	0.0	0.0	0.0	45.88	0.67	0.0	0.0	0.45	0.0	0.0	52.51	99.50
3	As-pyrite	0.0	0.16	2.92	39.53	1.97	0.0	0.0	8.92	0.0	0.0	46.91	100.41
4	As-pyrite	0.0	0.0	2.09	39.40	1.75	0.0	0.0	9.38	0.0	0.0	46.44	99.05
5	As-pyrite	0.0	0.15	1.26	39.40	1.75	0.0	0.0	10.96	0.0	0.0	46.14	99.06
6	chalcopyrite	0.0	0.0	0.20	26.49	36.28	0.0	0.0	4.19	0.0	0.0	32.00	99.15
7	galena+Se	1.16	0.0	1.81	1.26	3.06	0.18	78.28	0.0	0.62	0.0	13.39	99.76
8	galena+Se	0.92	0.0	0.62	1.90	3.65	0.0	77.72	0.0	1.80	0.0	13.40	100.01
9	tennantite	0.30	0.0	0.57	5.94	40.05	0.0	0.0	23.69	0.0	1.95	27.59	100.09
10	tennantite	0.88	0.0	0.75	3.82	40.86	0.0	0.0	23.67	0.0	2.87	27.06	99.90
11	tennantite	0.76	0.0	0.95	4.94	41.02	0.0	0.0	22.51	0.0	2.57	27.20	99.83
12	tetrahedrite	2.04	0.0	20.81	2.67	37.23	6.00	0.0	8.14	0.0	0.0	23.34	100.23

Pyrite Quantitative microprobe analyses established in this variety significant content of Cu and lower content of Ni (an. # 1). Their central parts are set up by pyrite containing Cu and As about 0.5 wt.% (an.# 2) and they are rimmed by bends of pyrite with extremely high content of As and significant contents of Cu and Sb (an. ## 3, 4 and 5);

Chalcopyrite high content of As and low presence of Sb (an. # 6). Such high content of As is not typical for chalcopyrite and additional analyses are obvious for precise determination of chemical composition of this mineral;

Galena Inclusions found in pyrite do not contain any trace elements while these found in chalcopyrite are characterized by presence of Se and Ag (an. # 7 and 8).

Native gold is not observed

Conclusions

- Data obtained show some differences in mineral composition of ores reported by Crummy et al. (2001) for the northern part of the area. Mineral association reported by mentioned authors is much more typical for high to intermediate sulphidation type of copper-gold deposits. The absence of enargite, luzonite, arsensulvanite, colusite and other minerals usually found in the high sulphidation type. They are not observed here.
- As presents in high quantity in arsenian pyrite, which is one of the rare findings of this variety for the country. It is registered also in chalcopyrite and As-rich members of tennantite-tetrahedrite serie distinctly dominate in the samples studied. From this point of view misevaluation should be nominated as transitional type between intermediate to low sulphidation type of Au epithermal deposits.
- Evidences of boiling and relatively high temperatures of homogenisation of inclusions found in quartz, which is probably of magmatic origin, support the presumption of development of a porphyry system in depth below the gold mineralization.