The Bolnisi mining district, Southern Georgia: present knowledge and open questions about volcanism, geodynamics and ore formation

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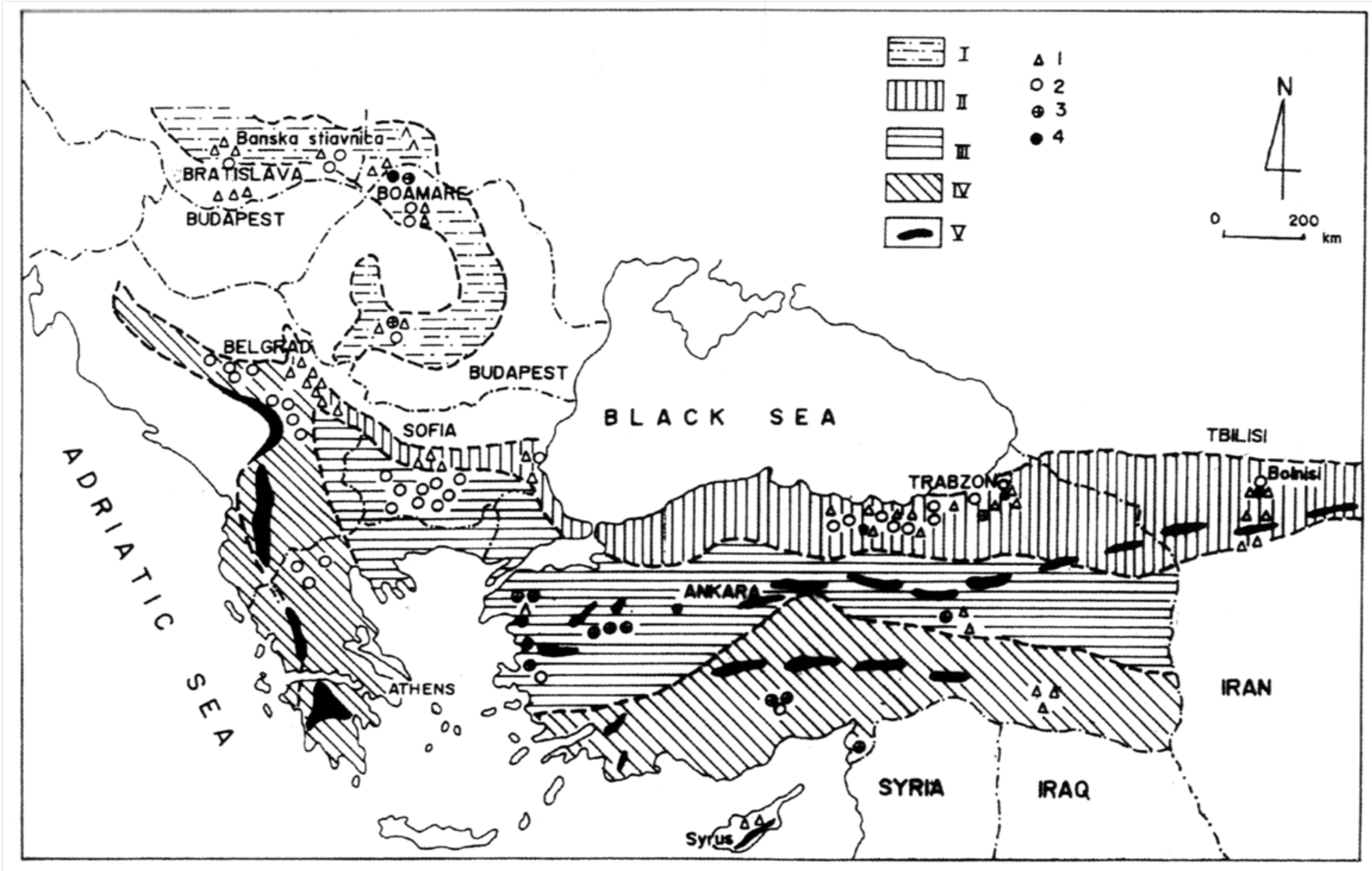


Fig.1. Metalogenic scheme of the cooper-pyrite, lead-zinc, gold and silver deposits of the lesser Caucasus, Turkey, Balkans and Carpats: I - Karpatian zone, II - Artvin-Bolnisi, Turkish Pontieds, and Bulgarian Srednegora zones, III - Anatolids, IV - Taurids, V - Ophiolitic outcrops; 1 - Copper-pyrite, 2 - Lead-zinc, 3 - Silver, 4 - Gold

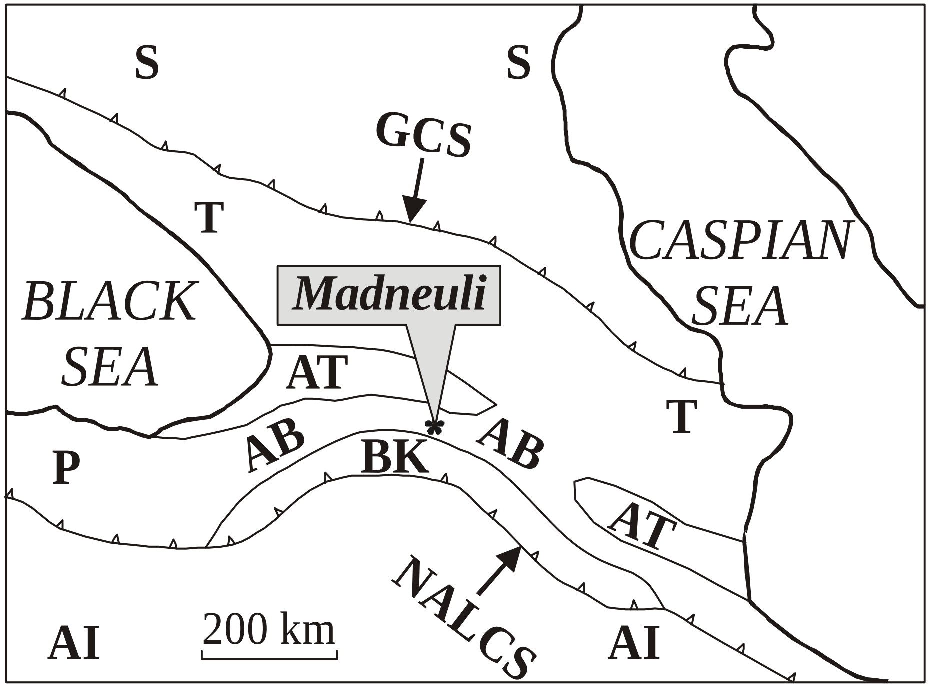
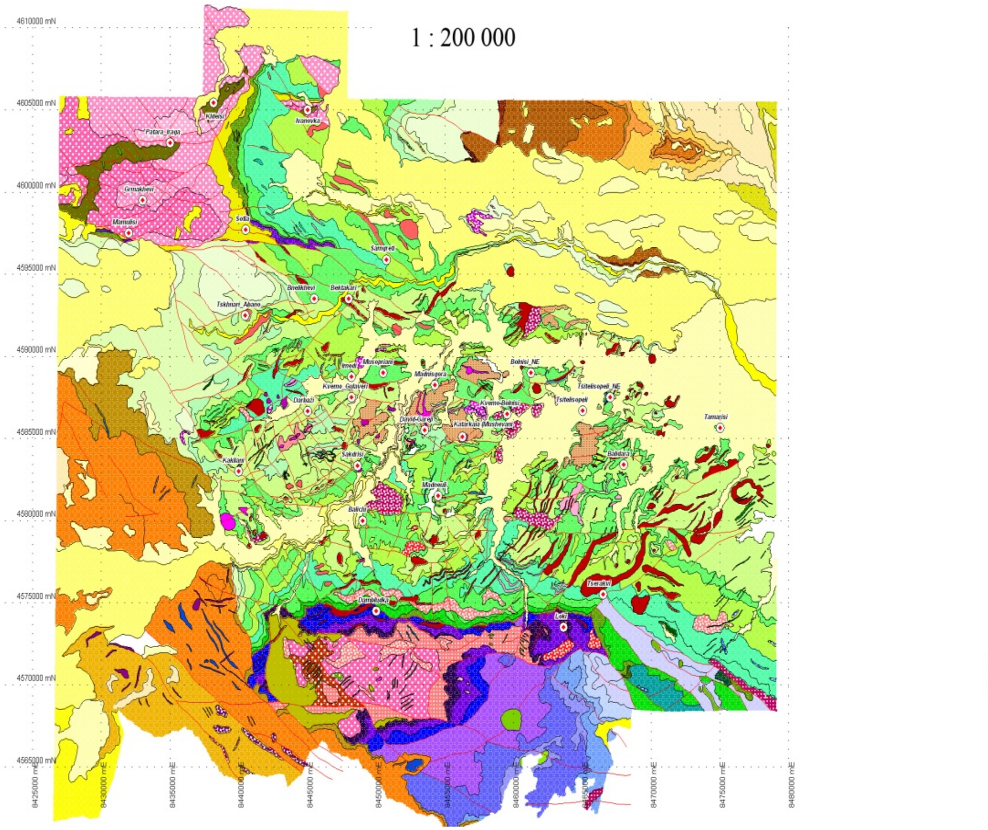


Fig. 2 Location map of the Madneuli deposit

The Artvin-Bolnisi is characterized by the Upper Carboniferous molasses and an Upper Jurassic-Cretaceous arc association. This unit is bordered to the north by the Southern Black sea Coast-Achara-Trialeti Unit and to the south by imbricated Bayburt-Karabach Unit.



Above mentioned tectonic unit (Artvin-Bolni-si) represented by the fragments of Paleozoic grani-toids and metamorphic salient (Locki Massif to the south and Khrami Massif to the north-west) covered by Mezo-Cenozoic volca-no-sedimentary units consists mainly of Jurassic, Cretaceous and Tertiary cal alkaline volcanic suites.

Fig. 3. Geological Map of Bolnisi Ore District

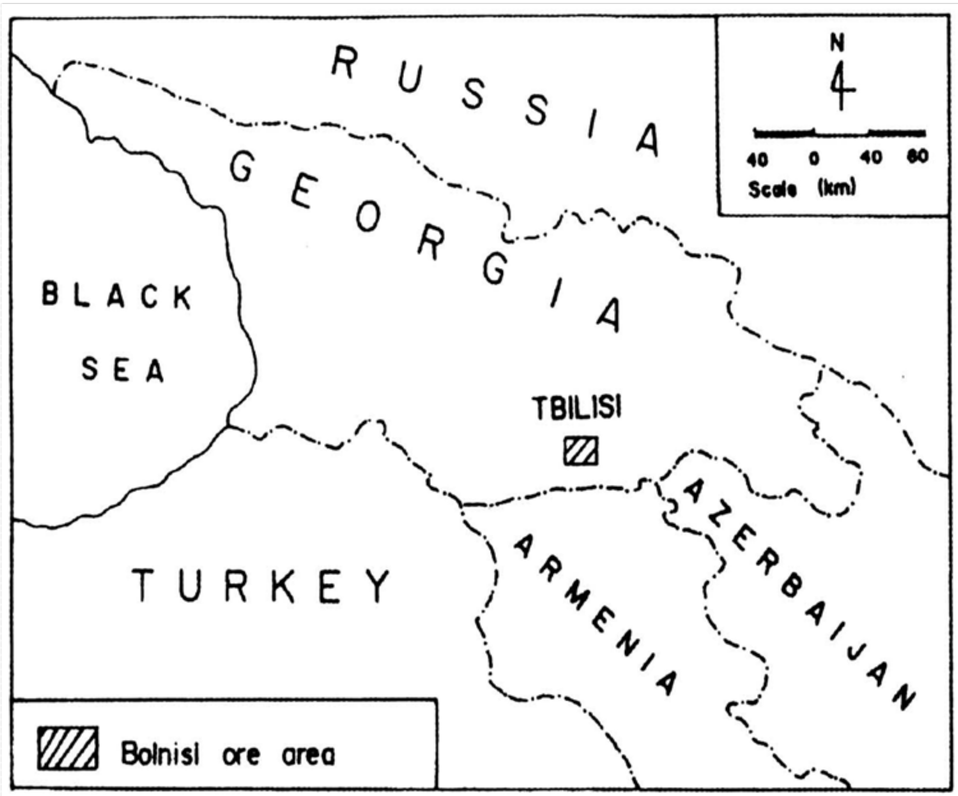


Fig. 4. Location map of the Bolnisi ore area

The Bolnisi ore district is situated 60-80 km South-west of the capital of Georgia, Tbilisi, in the vicinity of the administrative centre of the Bolnisi region.

The Bolnisi mining district is located in favorable economic-geographic position. It is connected by railway and high-way with Tbilisi (70 km) and Black sea ports (400-500 km), situated on the 700 m above sea level.

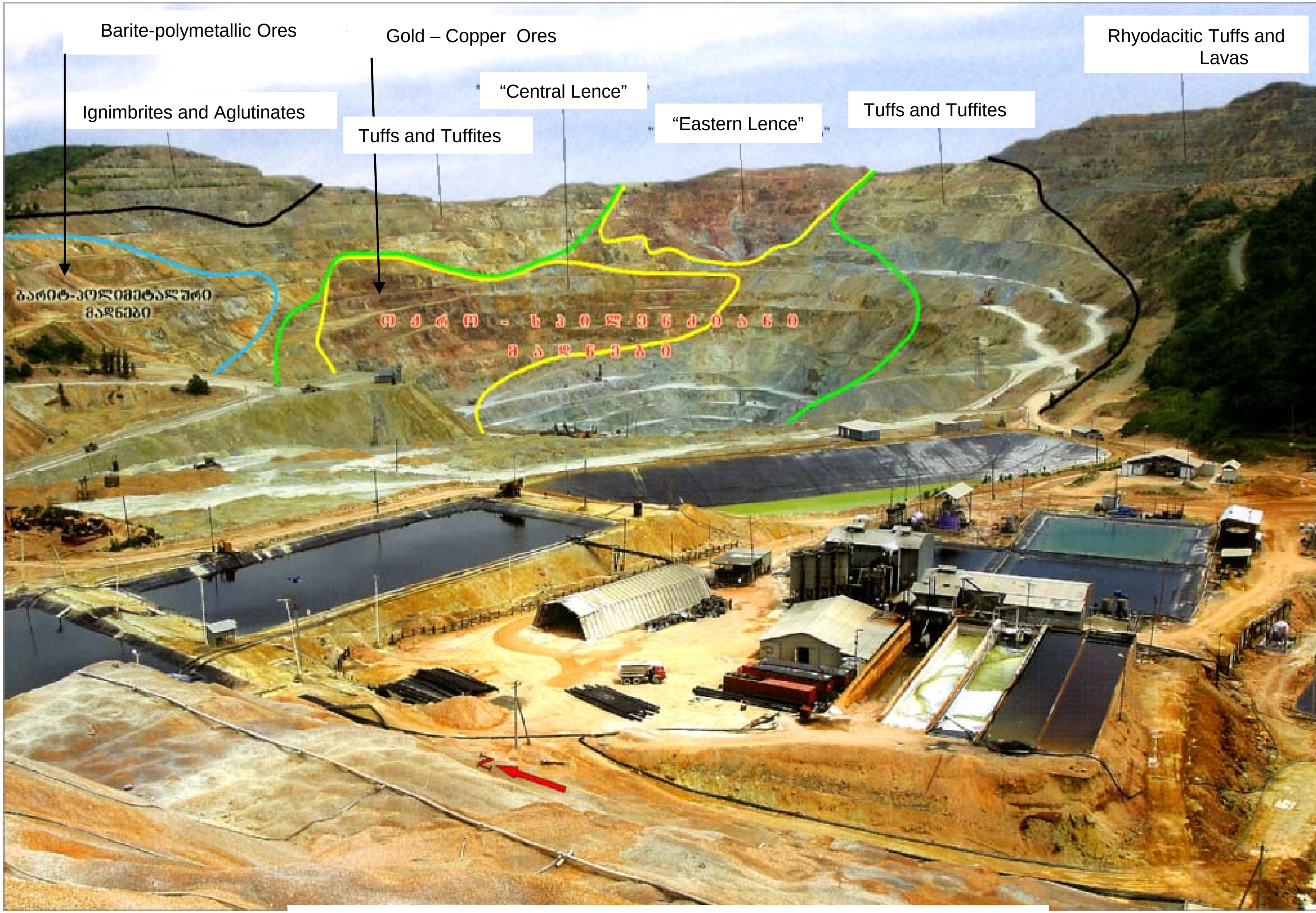


Fig. 5. View of the Madneuli quarry from South-East

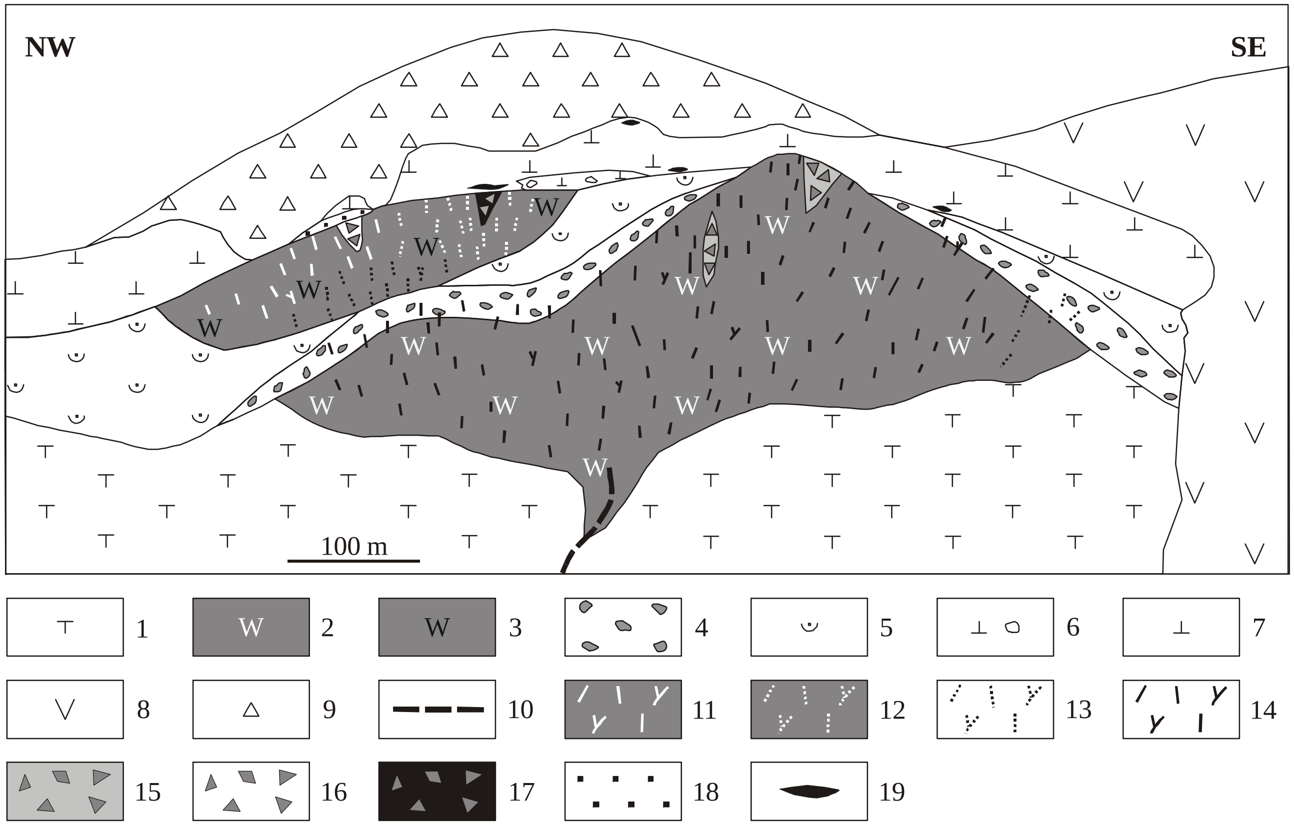
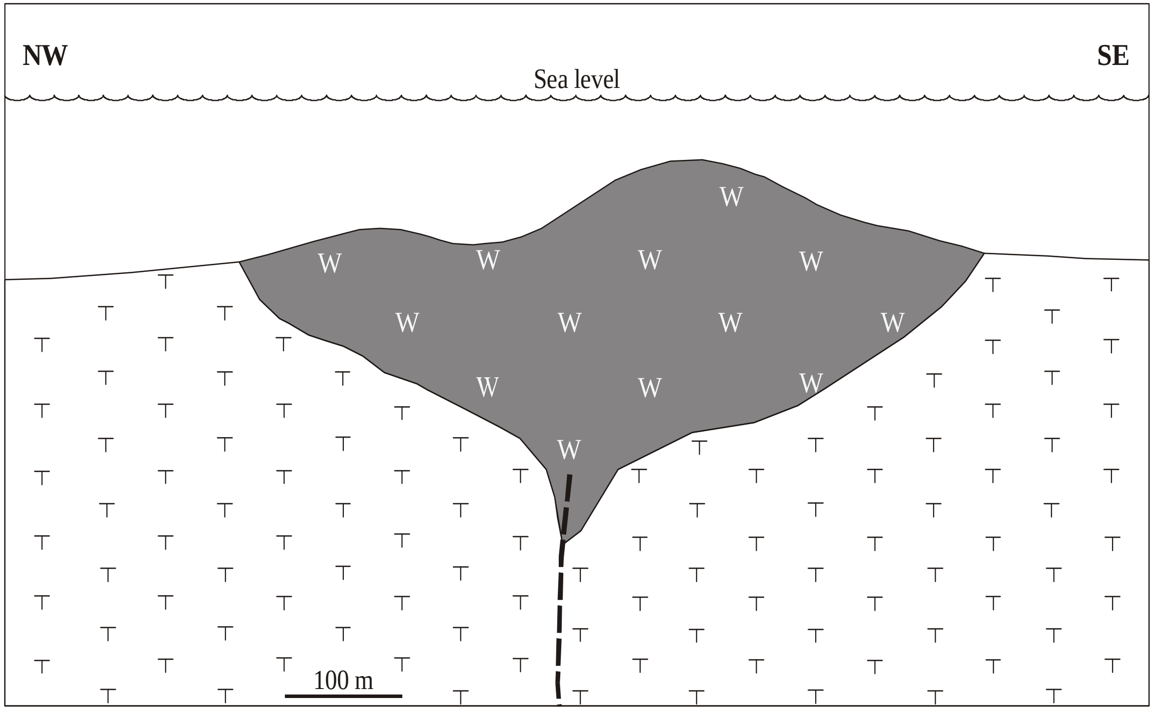


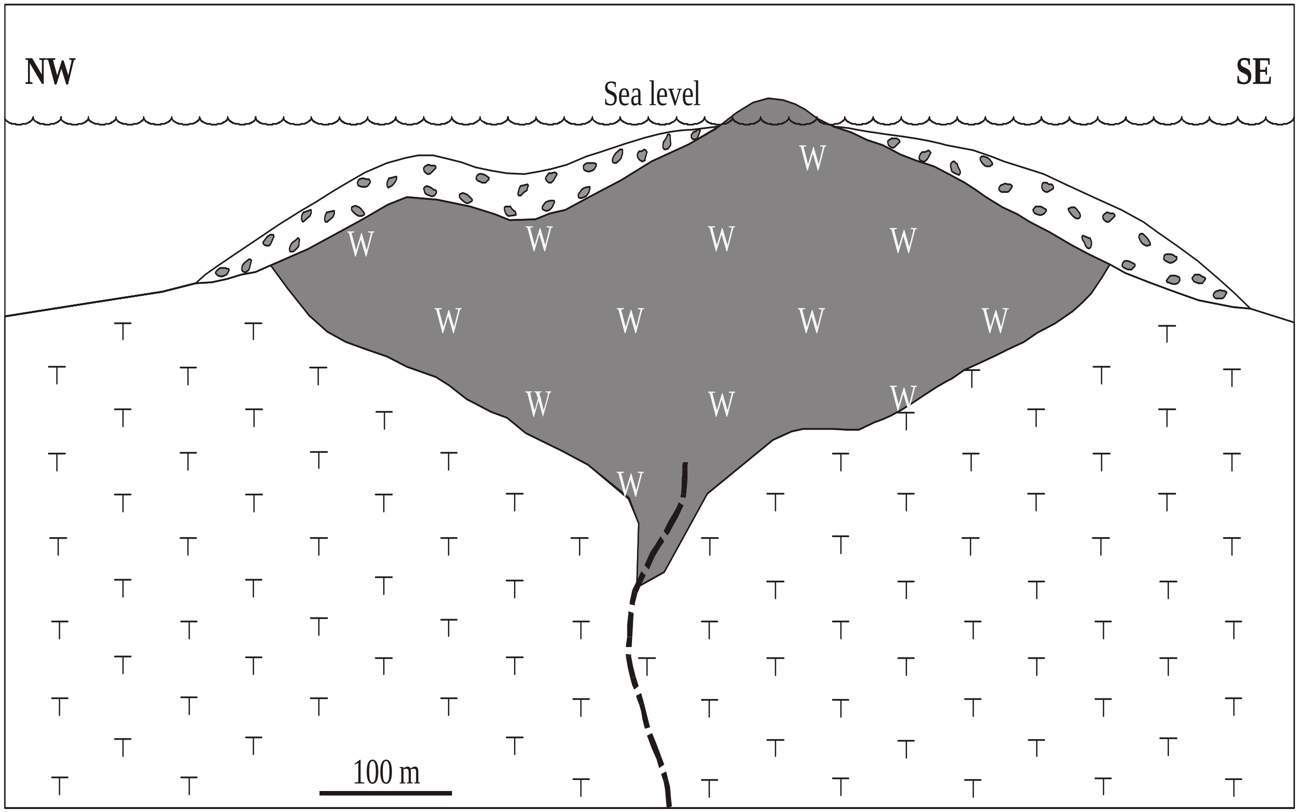
Fig. 6. An idealized section through the Madneuli deposit.

1. Tuff hosting lower lens; 2. Quartz-rich lower body; 3. Quartz-rich upper body; 4. Breccia-conglo-merate; 5. Tephroid; 6. Tuffconglomerate-tuffbreccia; 7. Tuff with pisolitic interlayers; 8. Rhyodacitic extrusion; 9. Ignimbrite; 10. Inferred fault; 11-14. Vein-disseminated ores: 11. Barite; 12. Barite-sphalerite-galena-pyrite; 13. Sphalerite-pyrite-chalcopyrite; 14. Chalcopyrite-pyrite-quartz; 15-17. Breccia ores: 15. Chalcopyrite-pyrite-quartz; 16. Barite; 17. Barite-sphalerite-galena-pyrite; 18-19. Exhalative ores: 18. Sandy barite; 19. Massive sulfide ore.



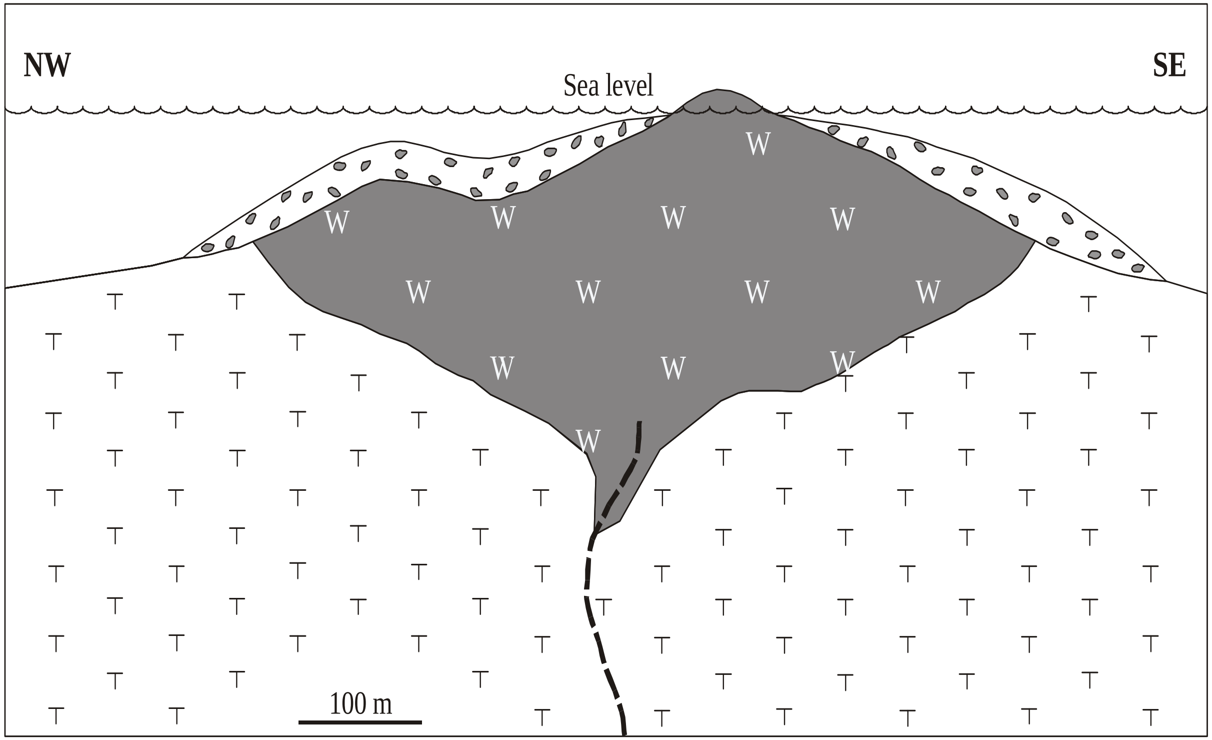
Sedimentation of fine-grained pyroclastics in Late Cretaceous shallow (<200m) sea environment; intrusion of felsic magma about 1km beneath the sea floor; initiation of hydrothermal upflow sy-stem by magmatic heat; forma-tion of a funnel-shaped body of silica-rich metasomatites to be exposed on the seafloor;

Fig. 7. The first step of model. Symbols as for Fig. 4.



Local uplift and erosion of the silicified sea floor due to magma doming and deposition of a breccia-conglomerate apron around the arisen dome.

Fig. 8. The second step of model.



Subsidence and submergence of the dome; sedimentation of a tephroid alternation from subaq-ue-ous pyroclastic flows.

Fig. 9. The third step of model

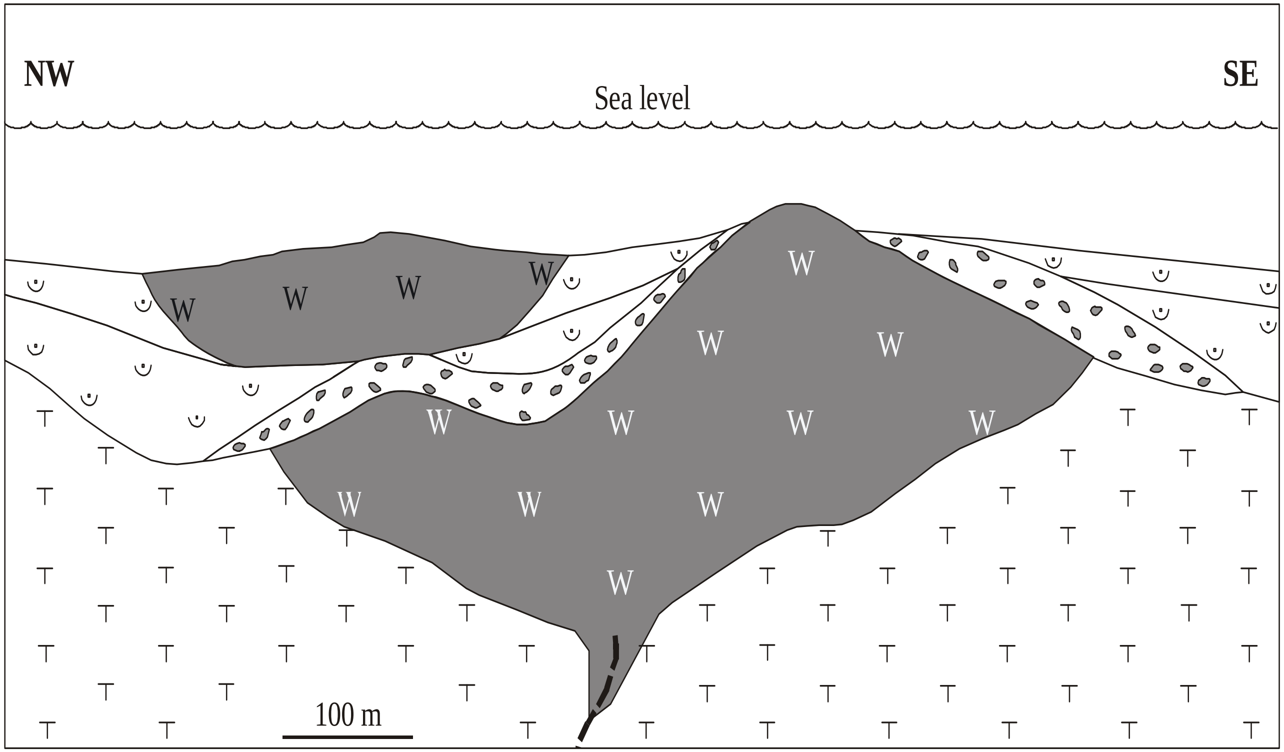
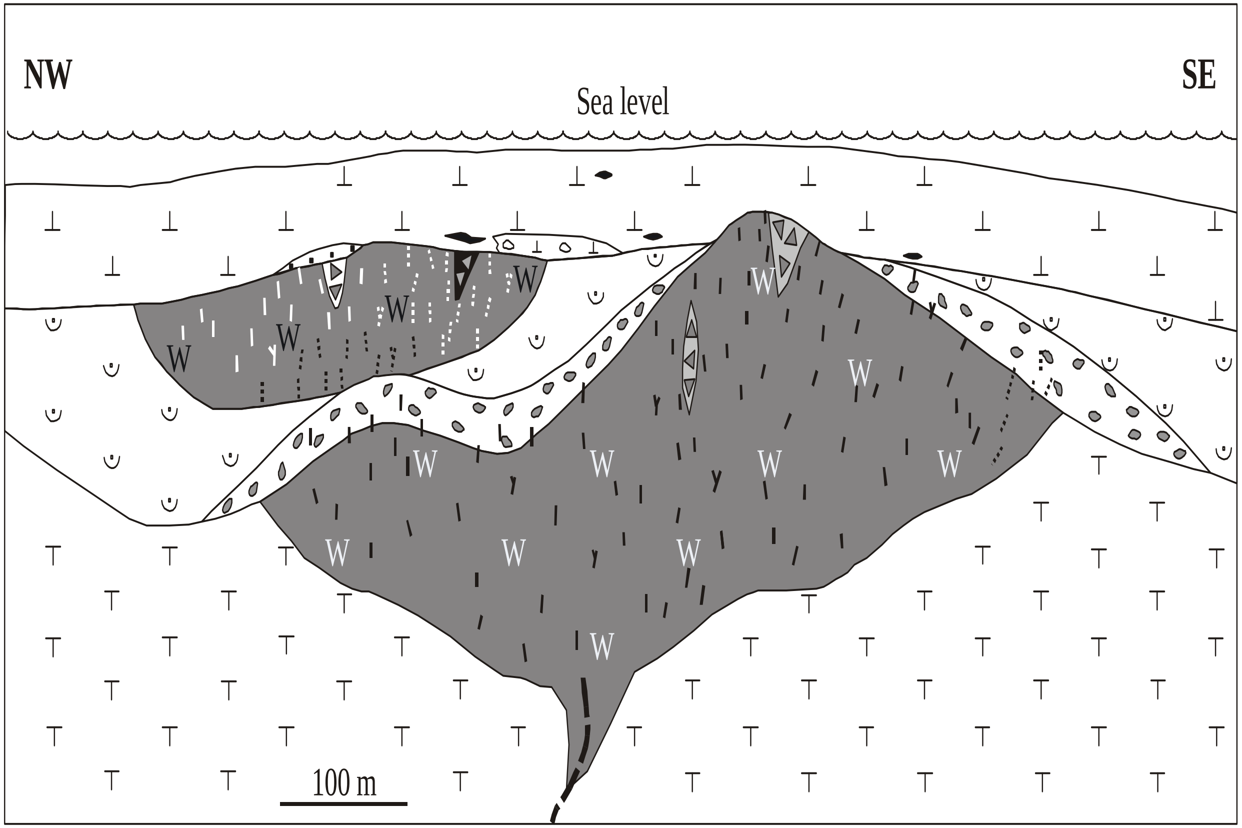


Fig. 10. The forth step of model

During later stage of tephroid sedimentation a re-commencement of functi-oning of silica-bearing hyd-ro-thermal system forming an-other silica-rich body conformable with host rocks.



Beginning of a new ten-dency of local uplift and shallowing of water up to the sea level; deposition of tuff horizon containing pi-solitic interlayers; commen-cement of ore precipitation, forma-tion of both extensive foot-wall and small-scale exha-lative ore minera-liza-tion.

Fug. 11. The fifth step of model

Based on this model, dr.Migineishvili concludes, that by its geotectonic position, as well as the composition of the host volcanic rocks, the Madneuli deposit is similar to Kuroko type VMS deposits (KTVMSD), as well as to volcanogenic epithermal gold deposits (VED), which are associated with calk-alkaline volcanism of subduction zones. Like KTVMSD, the syngenetic ores of the Madneuli deposit occupy certain stratigraphic levels, but, on the other hand, morphological features of this large-scale epigenetic mineralization resemble VED.

Ordinary KTVMSD are formed in deep water oceanic conditions. Unlike these, however, the Madneuli deposit has been formed in a coastal shallow sea environment, in a transitional submarine-subaeral setting.

Similar to both KTVMSD and VED, the hydrothermal system of the Madneuli deposit was driven by the heat engine represented by the subjacent synvolcanic intrusion.

Unlike in most KTVMSD, meteoric water was incorporated in the hydrothermal system of the Madneuli deposit, but unlike VED, which formed in subaerial settings, a contribution of seawater is also established. In contrast to KTVMSD, but similar to VED, the boiling of hydrothermal solutions is one of the mechanisms involved in precipitation of Madneuli's ores.

On his opinion the Madneuli deposit possesses a number of characteristics that are, in part, typical of KTVMSD, and in part resemble those of VED. Nevertheless it differs from KTVMSD/VED in a number of important attributes. Therefore, the Madneuli deposit cannot be assigned readily to either deposit type.

A number of ore deposits elsewhere in the world have been recognized as transitional in character between submarine base metal massive sulphides and volcanogenic gold deposits in the epithermal environment. These have been named VMS-epithermal transition deposits (Hannington, 1999; Hannington and Harzing, 2000).

Upon analysis of the above-stated material one can ascribe the Madneuli to VMS-epithermal transition deposits.

Gugushvili's opinion Sulfide deposits are related to Cretaceous volcanics. Among them the most significant are Madneuli,Tsiteli Sopeli and Sakdrisi.

The Cretaceous volcanic activity occurred in the shallow sea and is represented by alternation the ignimbrite ejections with acid, intermediate and basic tuffs and lava flows . Tuffs contain marine fauna and predominatly are tephroite style, whereas the ignimbrite flows are terrestrial. Terrestrial situation is rela-ted with tumescence of shallow sea bottom, caused by intrusion of acid magma and uplifting of islands. Ignimbrite ejection occur on the emerging islands. Mainly ignimbrite ejections are terminated with caul-dron subsidence. They are related to ring structures, confirmed by remote sensing, as well as by geophysical and paleovolcanigical data. Collapsed calderas are determined by rhyolite extrusive domes distributed around the ring structures of their subcidence. In the Bolnisis Mining District two age groups of extrusion domes were determined. The first is 86-89 Ma – around Lower Santonian calderas and the second is 69-75 Ma – around Upper Santonian. Cauldron subcidense terminated by transgression and subsequent subaquastic explosion of andesi-tic and basaltic tuffs and lava flows.

Each of deposit consists of two stratums: lower gold-copperporphyry and higher low sulfidation-gold bearing quartz-chalcedony and quartz-barite veins and stockworks in the silicificated and argillized rocks.

At the same time the clusters are divided by regional fault. SE cluster consist Madneuli, Tsiteli Sopeli, David Garedji, Kvemo Bolnisi etc., whereas NW cluster consist Sakdrisi, Bektacari, Imedi, Darbazi, Samgereti etc deposits and occurrences). The age of mineralization of SE cluster is 86-89 Ma and NW cluster-79.82 Ma. Se cluster is included in the Turonian-Lower Santonian volcanic rocks, whereas the NW ore cluster mineralization located in the Upper Santonian volcanic suite.

The Madneuli deposit is located into tumicent structure, terminated by Lower Santonian cycle of ignimbrite activity. In 80-ies the open pit cropped out the volcanic pipe of ignimbrites. It includes the huge block (xenolith) of quartzites with polymetallic ore. This is the evidence that the ore origin in the Madneuli deposit is preig-nimbritic. Beneath the deposit grano-diorite intrusive was discovered by drill holes in the depth of 300-500 (fig. 12).

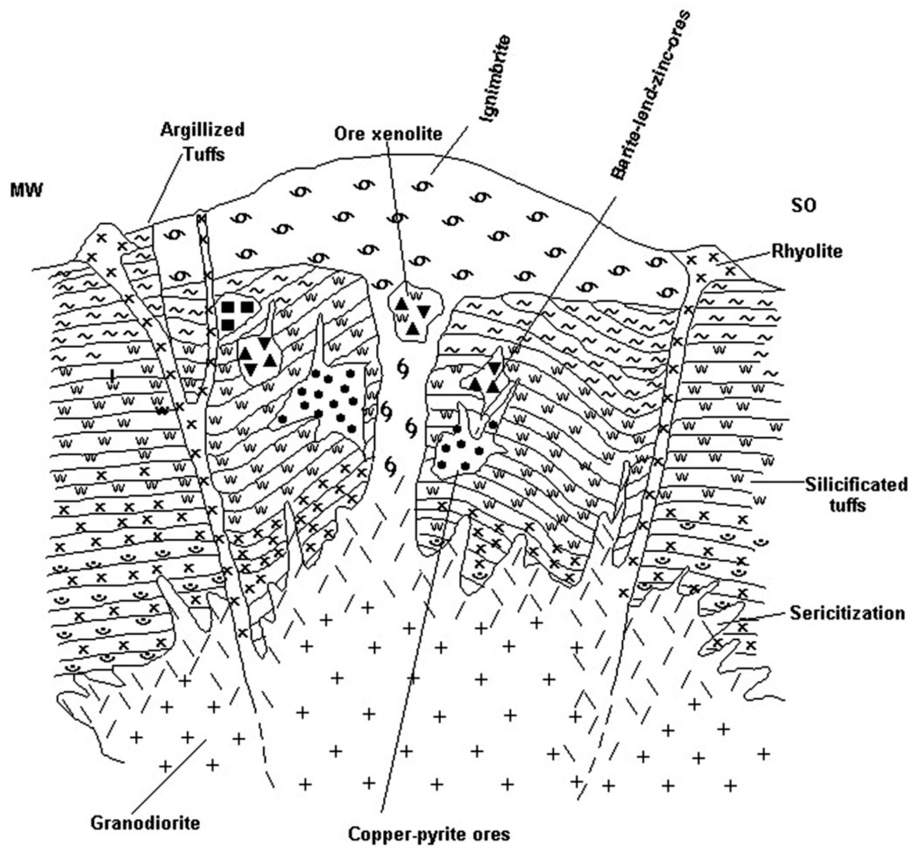


Fig. 12. Sketch cross-section of the Madneuli deposit

Paleogeographic development of Madneuli deposit must be following: In the Turonian-Coniacian the area of deposit was covered with shallow sea. Here were not active eruptions and tephra was brought by sea current and was deposited as tephriot series (fig.19. I).

In the Lower Santonian intrusion beneath sea bottom caused the bottom tumiscence and island emerging (fig. 19, II). Simultaneously the acid solutions coming from intrusive body caused intensive acid leaching of tephroits and as a result above the intrusive was formed a dense screen of the secondary quartzites (fig. 19, III). The quartzite pebbles in the surrounding tephroits are the evidence of the tumiscence and island emerging. Above the intrusive body, under the dense screen of quartzites accumulation of the gas exhalation caused the underground eruptions and brecciations of the quartzites. The ore-bearing solution cemented the brecciated zones and formed ore bodies (fig. 19, IV).

The several underground eruptions caused the origine of ore bodies of different composition: copper-pyrite, barite-polymetallic and quartz-barites.

The next stage of evolution was ignimbrite explosions. Noteworthy, that ignimbrites are not mineralized (fig. 19, V). Hence the Madneuli deposit was originated before ignimbrite ejections. The origin generation of the deposit was related to tumiscence of sea bottom by intrusion of magmatic chamber, therefore it can be classified as tumiscent (precursor) deposit described by Elstone (1991) and Rytuba (1991).

The origin of kuroko type is related to the termination of the cycle of ignimbritic volcanic activity, caldera collapse and intrusion of rhyolitic domes (Lambert and Sato, 1979, Sillitoe, 1980, Russel, 1989). However, as is well known the deposits origined before ignimbrite activity are attributed to tumiscence type (Elstone, 1991, Rytuba, 1991). They are precursors of Kuroko type deposits. Their origin is related to “preignimbritic” intrusion of shallow intrusives, later transformed into volcanic chamber of ignimbrite activity. These intrusives caused the tumiscence of the sea bottom. They are sources of the orebearing solutions. These ore occurences were discovered out of rings of cauldron subsidence (Rytuba, 1991, Elstone, 1991). Earlier the intracauldron tumescent deposits were not discovered. So Madneuli and Tsiteli Sopeli may be the first significant tumescent deposits described up to now, evolved within ring structure.

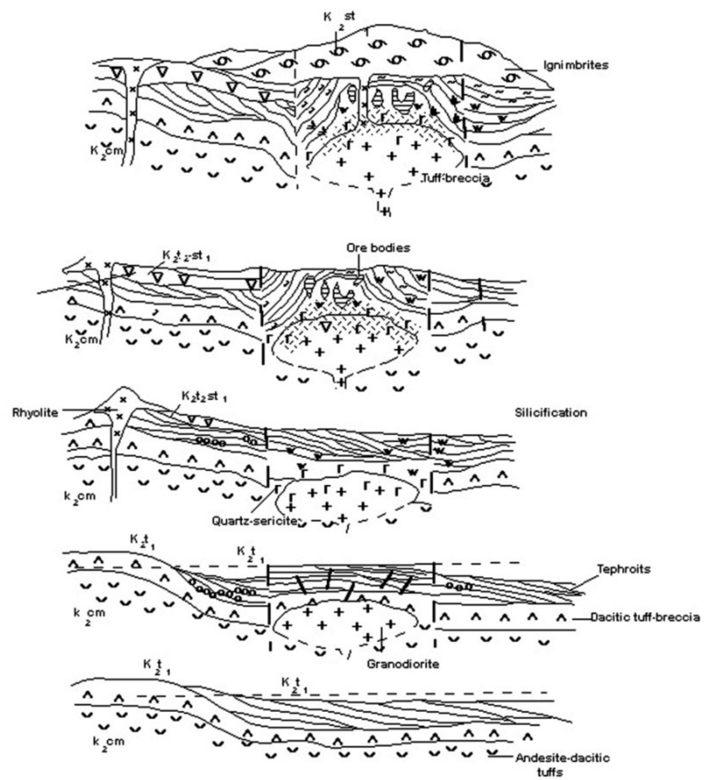


Fig. 13. Sketch of paleogeographic development of Madneuli deposits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