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3D modeling tools jointly applied on Gerakario (Greece) and Kadiica (FYROM) porphyry copper mineralisations

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Abstract

The geotectonic setting of Serbo-Macedonian Zone(SMZ) facilitates the formation of porphyry copper mineralisations. This zone hosts many known deposits having been discovered and located in the areas of Pontokerasia, Vathi, Skouries, Gerakario and Fissoka in Greece, and Buchim, Ilovitza and Osogovo in FYROM. The SMZ metallogenetic belt consists of strongly deformed metamorphic rocksof Palaeozoic age superimposed by Tertiary magmatic activity.The 3D modeling tools are frequently used to make cost- och time-efficient tools in mineral exploration, to visualize, correlate and interpret geological data. This paper aims at presenting a comparative evaluation of the porphyry copper mineralisations of AgiosPavlos (Gerakarioarea) and Kadiica (Bukovik-Kadiica area) based on 3D modeling tools of respective geological settings, deformation structures and geochemical distributions, in terms of better understanding related ore-genetic processes and exploration potential.

Keywords: Porphyry copper deposits, 3D modelling,mineral exploration.

Introduction

The 3D geo-modeling has through years come to become a potential tool in mineral exploration. In this study ge-models are used on the porphyry copper mineralisations of Aghios Pavlos, in northern Greece, and Kadiica in eastern FYROM, hosted by SMZ rocks, extendingfrom Serbia and western Bulgaria, inthe north, to northern Greece in the south. Gneiss, mica schist amphibolite and marble are the main basement rock types. The age is uncertain, but zircon U/Pb dating in meta-rhyolites suggests Paleozoic times of around 560 ma (Meinhold et al., 2003).

Substantial porphyry copper mineralisations and deposits occur associated with acidic stocks of Tertiary age, making shallow intrusions into SMZ Paleozoic metamorphic formations. The mineralized and host-rocks belong to Oligocene-Miocene calc-alkaline complexes of dioritic, granodioritic and syenitic composition. It is likely that the widespread calc-alkaline igneous suites resulted from an anatectic partial smelting of the lowermost continental crust, in post collision activity processes.

The northern part of SMZbetween Serbia and FYROM, is generally considered to comprise an Upper (low-grade) and a Lower (medium to high grade) unit (Dimitrijević, 1959). The protoliths of both units are reported as volcano-sedimentary formations, which have later been intruded by igneous rocks during several magmatic pulses (Antic et al., 2012).

The southern part of SMZ between eastern FYROM and northern Greece consists of two major lithostratigraphic units of Paleozoic age, known as the Kerdylia and Vertiskos formations, separated by the NW-striking Stratoni-Varvara fault, a major structural feature that dominates the area (Kockel et al., 1977). The major part of igneous activity in the area is related to North Aegean Tertiary activity, taken place from the Oligocene to lower Miocene (Fytikas et al., 1980). Aegean volcanism evolved during the Cretaceous in Bulgaria and extended progressively southwards, through northern Greece, during the Oligocene to lower Miocene, to develop the currently active (from Pliocene until now) South Aegean volcanic arc. The subvolcanic porphyry stocks and dykes, for the Greek part,are mainly related to the Vertiskos formation and shows Oligocene to Miocene ages (Frei, 1992).

Geology of Agios Pavlos–Gerakario area

In the area of Gerakario the geological setting is dominated by a complex series of porphyric stocks and dikes of quartz diorite-monzonite composition(Frei R., 1992), while the countryrocks are schist – gneisses (Tompouloglou, 1981). Potassic and phyllic alterations of syenite and granodiorite porphyries, respectively, are the main mineralogical features. The stock show lensoid forms with the long axis striking for 600 m NE-SW and 300 m NE-SE. Most parts of the volcanic rock are hydrothermally altered, predominantly to sericite and quartz mineral facies. Quartz enrichment occurs in the form of veinlets and silicified zones (Kelepertzis et al., 1986). Sulfides form stockwork and dissemination mineralisations consisting of chalcopyrite and pyrite. An oxidation zone including malachite, azurite, goethite and limonite is occasionally present. Alteration is weakly developed, dominated by silicates, with biotite being the main alteration mineral.(Apostolou and Stefanidis, 1987; Economou-Eliopoulos M., Eliopoulos D., 1992). The mineralisation occurs as veinlets, of a few mm to some cm thick, as fillings of joints, as disseminations, especially when hosted by narrow shear zones in the wall-rocks.The main Cu-mineralisation is associated with potassic alteration zones within syenite porphyry, similarly to the porphyry copper style mineralization at Skouries (Frei R., 1992).

Local Geology of Kadiica – Bukovik/Kadiica region

Bukovik-Kadiica deposit is located in the eastern part of the FYROM in a hilly region close to the border with Bulgaria and 2 km northeast of the town of Pehcevo. The deposit can be described as one of a number of dacite plugs of Neogene origin that exist within the SMZas part of the volcanic complex intruding into Palaeozoic sediments, andesites and gabbros. On a larger scale the Kadiica region is underlain by metamorphic rocks (metadiabases, schists, gabbro, diorite and younger grantoids) of Upper Proterozoic to Palaeozoic age (Tasev, 2010; Tasev et al., 2012).

The Bukovik-Kadiica ore district has been located in the most eastern parts of the Besna Kobila-Osogovo-Tassos metallogenic zone (Aleksandrov, 1992; Janković et al., 1995) and has been characterized by complex polymetallic mineralisation. Within the same ore district there were determined ore body systems and intersected dykes of quartz-latites with an absolute age of 24–12 Ma (Serafimovski et al., 2001; Serafimovski T. et al., 2010).

According to Singer et al. the ore of Kadiica deposit has an 1x0.6 km axis dimension and covers an area of 0,5Km^2.

3D model of Kadiica mineralization

Using the lithological and the geochemical data from 11 drill holes a 3D grid was created that depicts the distribution of each assay (Ag, As, Au, Mo, Pb, Zn, Cu; Fig. 1, 2).

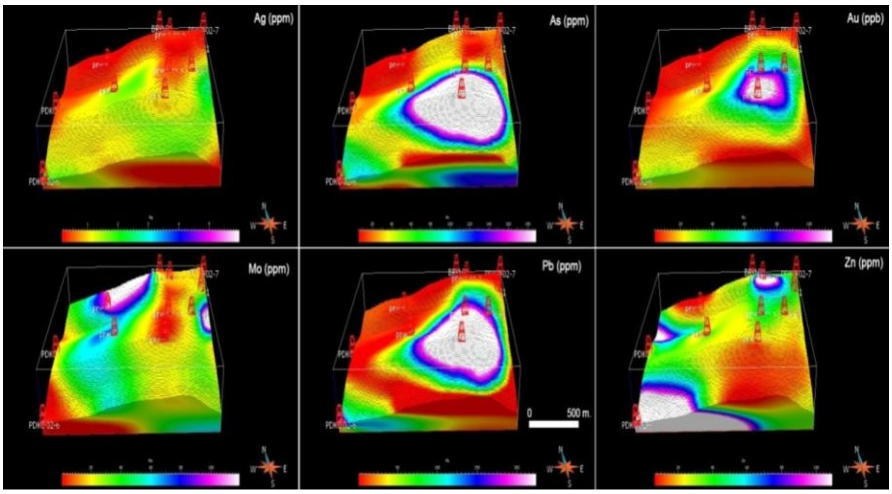

Figure 1: 3D geochemical distribution in Kadiica deposit for the following assays: Ag, As, Au, Mo, Pb, Zn.

The software gives the opportunity to the user to create slices of the 3D grid and take a closer look to the spatial variation of an assay. From the grid showing the Cu distribution, an ore body with dimensions of 1000x600m.and 50m thick,could be indicated

From the geochemical distributions it could be illustrated that high values of As are followed by high values of Au and Pb and low values of Zn. Different to Au and Pb the Cu mineralization is located at deeper levels.
Higher-grade Cu mineralization appearsalso in the western part of the main ore body (Fig.2).

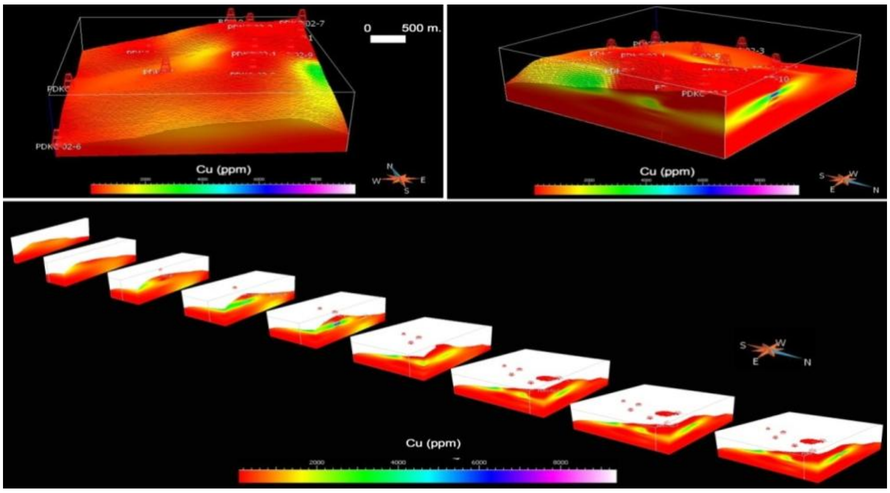

Figure 2: 3D geochemical distribution of Cu along withE-W geological sections across Kadiica deposit.

3D model of AghiosPavlos mineralization

From the 3D model of Aghios Pavlos mineralisation the following can be obtained:

i) The ore body responds to an area of 350x330m, and has a thickness of 20-60m. (Fig.3). ii) the mineralization dips 30^{o} S, iii) the mineralization seems to extend to south where over the explorationneeds to be focused, andiv) there are two ore bodies indicated, a western and an eastern one.

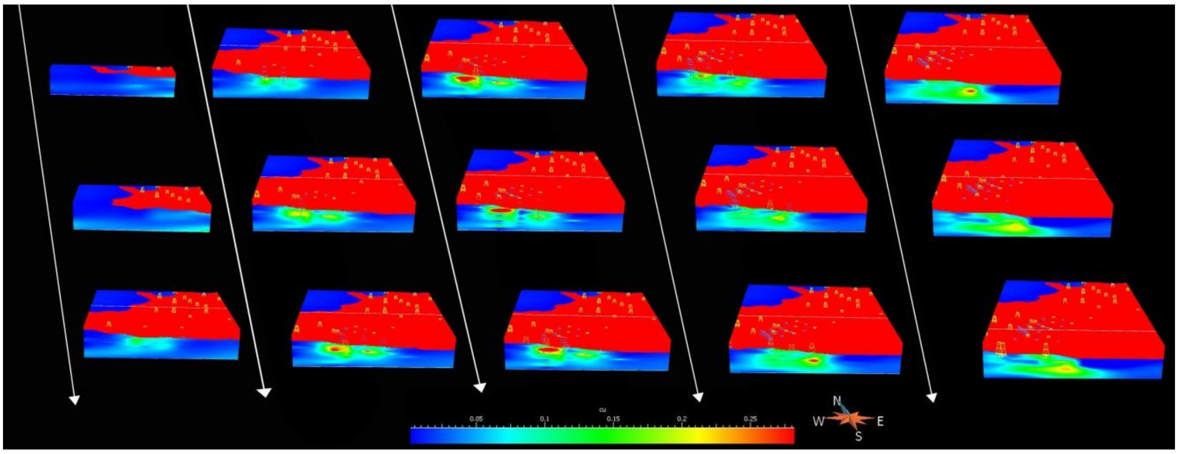

Figure 3: 3D geochemical distribution of Cu and along with W-E geological sections across AghiosPavlos mineralization.

From the cross-sections it can be obtained that the level of main sulfide mineralization is lower than the oxidation zone (Fig. 4).

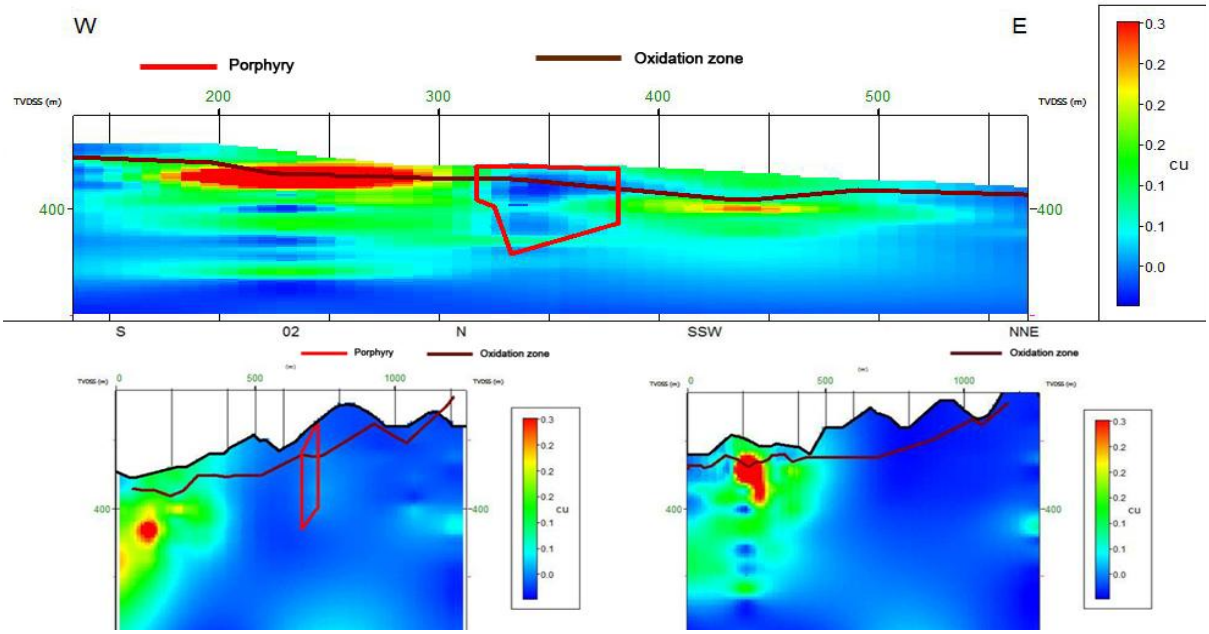

Figure 4: Cross-sections, striking W-E, S-N and SSW-NNE, cutting through Aghios Pavlos Cu mineralization

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