Geologija hidrotermalnog Cu-Au sistema Čukaru Peki

Miloš Velojić

GEOLOGIJA HIDROTERMALNOG Cu-Au SISTEMA ČUKARU PEKI

Miloš Velojić
Rudarsko-geološki fakultet, Beograd, Srbija
E-mail: milos.velojic@rgf.bg.ac.rs

Ključne reči: Timočki magmatski kompleks, bakar, zlato, porfirska ležišta, masivni sulfidi

Hidrotermalni Cu-Au sistem Čukaru Peki je jedan od najvećih rudonosnih sistema otkrivenih na prostoru Evrope u 21. veku. Na osnovu današnjeg stepena istraženosti, smatra se da sadrži više od 2,3 milijardi tona rude, odnosno više od 17 miliona tona bakra i više od 380 tona zlata u metalu.
Prostorno i genetski posmatrano, ovaj sistem je nastao u vezi sa produktima prve faze magmatske aktivnosti Timočkog magmatskog kompleksa. U rudonosnom sistemu Čukaru Peki su izdvojena tri osnovna tipa mineralizacije: 1) Porfirski tip (tzv. Donja zona) koja se nalazi u dubljim delovima hidrotermalnog sistema, u rasponu od -180 m do -1900 m n.v.; 2) Prelazna epitermalna zona (koja se takođe naziva *Overprint* mineralizacija), između zone visoke sulfidacije i porfirskog dela rudonosnog sistema; 3) Zona visoke sulfidacije (tzv. Gornja zona) izgrađena od masivnih sulfida sa piritom, kovelinom i enargitom.
Dimenzije i oblik Donje zone sistema Čukaru Peki nisu detaljno određene zbog velike dubine ležišta i niskog stepena istraženosti. Pretpostavlja se da su najdublji delovi ležišta na dubini većoj od 2100 m od površine terena. Prema preliminarnim procenama, u vertikalnom rasponu mineralizacije do -1152 m n.v nalazi se više od 730 miliona tona rude, dok je u celom rudonosnom sistemu sadržano više od 2 milijarde tona rude. Najzastupljeniji tipovi alteracije u ovoj zoni su kalijska metasomatoza, kvarcno-sericitska alteracija i hloritizacija. Na osnovu terenskih, rudnomikroskopskih ispitivanja i analize fluidnih inkluzija, utvrđeno je da je mineralizacija bakra i zlata u Donjoj zoni nastala u dva stadijuma. Porfirski stadijum je formiran u temperaturnom intervalu od 600-400°S i tokom njega je deponovano četiri tipa žica: 1) kvarcne žice tipa A bez rudnih minerala, 2) kvarcne žice tipa B sa halkopiritom, bornitom i piritom, 3) piritske žice tipa D sa malim zrnima halkopirita i bornita i 4) magnetitske žice sa hematitom, pirotinom i halkopiritom. Mlađi, epitermalni stadijum obuhvata tri tipa žica nastalih na temperaturama oko 300-200°S: 1) ljubičaste anhidritske žice sa piritom, halkopiritom, kovelinom i enargitom, 2) sulfidne žice sa piritom i kovelinom i 3) narandžaste anhidritske žice bez rudnih minerala. Prelazna epitermalna zona se karakteriše preovlađujućim tipom argilitske alteracije. Predstavljena je sistemom anhidritskih i gipsnih žica, sa pratećim rudnim mineralima - kovelinom, halkopiritom, digenitom i enargitom, kao i lokalnim pojavama samorodnog sumpora. Gornja zona je izduženo-ovalnog oblika sa približnim dimenzijama u planu oko 300h350 m. Vertikalni interval mineralizacije je oko 550 m. U ovoj zoni je sadržano oko 53 miliona tona rude sa 2,43% Cu, 1,53 g/t Au i 2,92 g/t Ag. U hipsometrijski najvišim delovima rudonosne zone preovlađuje masivno-sulfidni tip mineralizacije, tzv. „apikalna kapa" izgrađena od masivnog pirita i kovelina. Dominantna facija hidrotermalne alteracije u Gornjoj zoni sistema Čukaru Peki je napredna argilitska alteracija sa kvarcom i alunitom. Na osnovu terenskih i rudnomikroskopskih ispitivanja, ustanovljeno je da je Gornja zona formirana u više sukcesivnih stadijuma: 1) Masivni pirit (Py1); 2) Py-en žice sa piritom i enargitom; 3) Py-cov žice sa piritom, kovelinom i enargitom; 4) Py2 žice sa sitnozrnim piritom; 5) Markasitske žice sa arsenopiritom i sfaleritom i 6) Kalcitsko-anhidritske žice bez rudnih minerala.

THE GEOLOGY OF HYDROTHERMAL Cu-Au SYSTEM ČUKARU PEKI

Miloš Velojić
Faculty of Mining and Geology, Belgrade, Serbia
E-mail: milos.velojic@rgf.bg.ac.rs

Key words: Timok magmatic complex, copper, gold , porphyry deposits, massive sulfides

The Čukaru Peki hydrothermal system is one of the largest Cu-Au deposits discovered in Europe in the 21st century. The current estimates imply that this system contains more than 2,3 billion tonnes of ore, containing 17 million tonnes of Cu and 380 tonnes of Au.

This system is genetically and spatially associated with the products of the first magmatic phase of the Timok magmatic complex. Three types of mineralization can be distinguished in this hydrothermal system: 1) Porphyry zone (also called Lower zone) is located in deeper parts of the hydrothermal system, at depth interval between -180m and -1900 meters below the surface; 2) Transitional epithermal zone (also called *Overprint* mineralization) located between the porphyry zone and the high-sulfidation zone and 3) High-sulfidation zone (also called Upper zone) consisting of massive sulfides with pyrite, covellite and enargite.

The dimensions and the shape of the Lower zone of this system are still not defined due to the large depth of the deposit and the low level of exploration. It is assumed that the deepest parts of this zone are located at more than 2100 meters from the surface. Preliminary estimates suggest that the zone above the vertical level of -1152 meters below the surface contains more than 730 million tonnes of ore, with 0,762% Cu and 0,165 g/t Au, whereas the entire hydrothermal system contains more than 2 billion tonnes of ore. The most common types of alterations in this zone are potassic alteration, sericitic (phyllic) alteration and chloritization. Using the methods of core logging, ore microscopy examinations and fluid inclusion analysis, it is determined that the Lower zone was formed in two stages. The porphyry stage was formed at temperatures between 600 and 400°C and it consists of four types of veins: 1) quartz veins type A without mineralization; 2) quartz veins type B with chalcopyrite, pyrite and bornite; 3) pyrite veins type D with subordinate chalcopyrite and bornite and 4) magnetite veins with hematite, pyrrhotite and chalcopyrite. The younger epithermal stage was formed at temperatures between 300 and 200°C and it includes three types of veins: 1) purple anhydrite veins with pyrite, with subordinate chalcopyrite, covellite and enargite; 2) sulfide veins with pyrite and covellite and 3) orange anhydrite veins without mineralization.

The transitional epithermal zone is characterized by argillic alteration (with quartz, clay minerals and sericite). It consists of a system of anhydrite and gypsum veins, whereas the main ore minerals in this zone are covellite, chalcopyrite, digenite and enargite with ocassional native sulfur.

Upper zone has an extended oval shape with approximate dimensions of 300h350 m in plan view. The vertical interval is around 550m. This mineralization ore zone contains around 53 million tons of ore with 2,43% Cu, 1,53 g/t Au and 2,92 g/t Ag. The hypsometrically highest parts of this zone contains the massive sulfide mineralization, so called “apical cap”, which is mainly composed of massive pyrite and covellite. The dominant alteration in this zone is advanced argillic alteration with quartz and alunite. Using the methods of core logging and ore microscopy examinations, it is determined that the Upper zone mineralization was formed in several successive stages: 1) Massive pyrite (Py1); 2) Py-en veins with pyrite and enargite; 3) Py-cov veins with pyrite, covellite and enargite; 4) Py2 veins with fine-grained pyrite; 5) Marcasite veins with arsenopyrite and sphalerite and 6) Calcite-anhydrite veins without mineralization.