



A NEW MINERALS FROM KUPFERSCHIEFER TYPE DEPOSIT, SIEROSZOWICE MINE, POLAND

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The Kupferschiefer copper-silver deposit was described in over 600 papers and books (e.g.: Kucha and Pawlikowski 1986; Piestrzyński 2008; Borg et al. 2012). The mineralogy of this deposit was described in details by Pieczonka and Piestrzyński, (2000), Pieczonka et al. (2008), Pieczonka (2011). In general, sulfide copper mineralization transgresses all sediments close to the Lower-Upper Permian border. The Kupferschiefer organic shale contains the highest metals concentrations, however the Permian Weissliegende sandstone that overlies Rotliegende sandstone, host the biggest Cu-Ag reserves.

The first discovery of gold in the Lubin deposit took place in 1973 (Kucha 1974). However, gold deposit was described in 1994 during routine mineralogical study (Piestrzyński et al., 2002). Several gold-silver amalgams were identified within the zone characterized by secondary oxidation profile in sandstone (Weissliegend) and elevated gold concentration. Tetra-auricupride, native gold of high purity, bornite, Se-bearing chalcopyrite and coffinite have been identified in intergrowths with amalgams.

Thalcosite - $Tl_2Cu_3FeS_4$ was found in the Kupferschiefer deposit horizon in the Sieroszowice Mine. It is first discovery of thallium copper sulphide in Poland. This mineral was found in the horizon containing an economic concentration of copper. Thalcosite is occurring in association with Ag-native, stromeyerite, galena, sphalerite, chalcocite and covellite (Pieczonka et al. 2019). In the whole World exists only several places with occurrences of thallium minerals. Two the most important occurrence are known in Europe: the Allchar deposit in Macedonia (Jankovic, 1989) and Lengenbach quarry Binntalvalley in Switzerland. This deposit is characterize with Pb-Zn-As-Ba-Tl mineralization (Hofmann and Knill, 1996). Two deposits are known from China. Nanhua deposit in Yunnan Provice (Zhang et al., 1996), and Lanmuchang deposit in Guizhou province. Au-As-Tl mineralization is also common in Carline type of deposits (Percival and Radtke, 1993).

Quantitative WDS analyses were carried out in the Critical Elements Laboratory of the KGHM PM S.A. and Faculty of Geology, Geophysics and Environmental Protection, AGH-UST Cracow using JEOL SQ8200 microprobe (EMP).

WDS analyses show variable content of major elements in amalgams. The Ag content is ranging from 20.788 to 37.900 wt%, gold: from 41.688 to 66.803 wt% and Hg: 7.879 to 19.929 wt%. One analytical point shows also 10.997 wt% of copper (Pieczonka et al. 2019). This data not fit to the described in literature phases. From the group of amalgams presence of three different alloys can be pointed out. To the first group belongs phases containing low amounts of silver. Their atomic proportions are as follow: $Au_{1.0000}Ag_{0.5681-0.8105}Cu_{0.0422-0.0823}Hg_{0.1595-0.1728}$. The next group is representing by phase containing high amounts of silver: $Au_{1.0000}Ag_{1.166-1.3670}Cu_{0.0600-0.0931}Hg_{0.3011-0.4698}$. Finally one point has high copper content. Its atomic proportions are as follow: $Au_{1.0000}(Ag_{0.5963}Cu_{0.5404})_{1.1367}Hg_{0.12230}$. Taking into account concentration of major elements and atomic proportions it can be concluded that a new line of Au-Ag-Cu-Hg alloys have been documented. This minerals are related to the secondary oxidation system developed on the redox low temperature barrier.

All analyzed thalcosite grains reveal almost stoichiometric composition. The average content of major elements is as follow: Tl – 53.12 wt%, Cu- 26.692 wt%, Fe- 6.751 wt% and S- 16.426 wt%. Small amounts of Ag, Sb, Au and As were also documented. From the all measured admixtures in thalcosite, gold content seems to be realistic. The average content of Au is on the level of 0.087 wt% and maximum concentration



CAGG-AGH-2019

reach 0.139 wt%. In point 9 - 0.056 wt% of Se was additionally measured. Standard deviation and coefficient of variability of all measured elements are as follow: for S - 0.120 and 0.73%, Cu - 0.225 and 0.91%, Tl - 0.504 and 0.95%, Fe - 0.13 and 1.93% respectively. Statistic parameter of minor elements are much higher, and in the case of As, coefficient of variability overprint 100%. Very low statistical parameters of major constituents confirm also high quality of WDS analyses. Based on WDS measurement the average atomic composition of thalcosite is as follows: $Tl_{2.023}Cu_{3.025}Fe_{0.909}Ag_{0.010}Sb_{0.002}Au_{0.03}As_{0.006}S_{3.989}$.

Presence of both group of minerals e.g thallium minerals and gold amalgams confirmed presence of low temperature stage in the famous Cu-Ag Kupferschiefer type deposit in Poland. Atomic proportion based on chemical composition are as follows: $Tl_{2.023}Cu_{3.025}S_{3.989}$, phases containing high amounts of silver and copper: $Au_{1.0000}Ag_{1.166-1.3670}Cu_{0.0600-0.0931}Hg_{0.3011-0.4698}$ and $Au_{1.0000}(Ag_{0.5963}Cu_{0.5404})_{1.1367}Hg_{0.12230}$.

Acknowledgement: The authors are grateful to Messrs. G. Kozub and A. Włodek from Critical Elements Lab. KGHM PM S.A - Faculty of Geology, Geophysics and Environmental Protection UST-AGH Krakow for the WDS analyses. The authors are also grateful to UST-AGH Krakow for financial support, grant no 11.11.140.161.

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