AUGELITE – FIRST OCCURRENCE IN THE CARPATHIANS

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Abstract: For the first time in the Carpathian belt augelite was found in the Podpolom (Klokoč, Javorie Mts., Slovakia) high-sulfidation type epithermal gold deposit. The augelite occurs in the small cavities of the barren, gray, siliceous hydrothermal breccia. The phosphor content of augelite can be originated by the decomposition of the apatite in the host diorite stock but the phosphor could also have been mobilized from the apatite of the Hercynian granite below the stratovolcanic sequence.

Key words: augelite, topaz, siliceous breccia, Podpolom, high-sulfidation,

Introduction

The augelite [$Al_2PO_4(OH)_3$] is a very rare phosphate mineral, which occurs in pegmatites, hydrothermally altered andesites and relatively high-temperature Al-rich hydrothermal deposits (Nriagu and Moore 1984, Duggan et al. 1990, Visser et al. 1997). In the Podpolom gold deposit its presence was proved by different analytical methods.

Geology and mineralization of the Podpolom deposit

The Podpolom deposit is situated at the central part of the Javorie andesite stratovolcano formed from the Badenien through Pannonian. It is one of the hydrothermal centers related to the stock-like-form dioritic bodies that intruded the andesitic stratovolcanic sequence (Štohl et al. 2000). The high sulfidation-type gold mineralization occurs in an oxidized, ferruginous breccia that has developed in the central core of a barren silicified zone. The average gold grade is 1-2 g/t. The primary gold is associated with pyrite but in the oxidized ferruginous rocks gold grains occur in the small cavities of goethite and are of 1-2 μm in size. Most of the rock types display extreme silicification and multiply brecciation. Beside quartz, topaz, corundum, and – in the more argillic types - pyrophyllite, diaspore and alunite are characteristic with minor zunyite, kaolinite and illite. In association with the alunite Ca-phosphate-sulphate minerals with REE content also occur (Bajnóczi at al, 2002). Rutile is relatively abundant, present in a few percent. It frequently occurs in the vug-fillings of the silica matrix indicating that Ti was carried by the late hydrothermal solutions.

Characteristics of augelite in the examined rocks

The augelite was found in the drillhole R7 at 84.2 m, in the matrix of gray, siliceous breccia. This rock is hard, strongly siliceous and has light to darker gray color, with 2-5 mm large, angular fragments. The fragments are gray silica displaying multiply brecciation. The dominating matrix is very fine-grained, shattered, rock flour-like quartz, but silica is present also in colloidal form. This rock type doesn't contain any pyrite. XRD analysis on the separated matrix shows – beside abundant quartz - the presence of augelite and topaz, with minor hematite, illite and smectite *(Fig. 1)*.

The augelite and topaz appear in he vugs and small cavities of the silica matrix. The augelite forms tabular crystals of 0.1-0.5 mm *(Fig. 2)*. Sometimes it completely fills the vugs. It is a pure phase with no other elements detected but Al and P *(Fig. 3, 4).* The Al : P ratio is 2 : 1. Minor amount of other phosphates, which could not be detected by XRD analysis were also observed in association with the augelite in form of irregular patches *(Fig. 5).* These minerals are Ca-dominant Al-phosphate-sulphates (APS) with Sr, Ba and minor amount of REE *(Fig. 6).* These minerals are a mixture of the end-member APS compositions of crandallite [$CaAl_3(PO_4)_2(OH)_5.H_2O$], woodhousite [$CaAl(PO)_4(SO_4)(OH)_6$], svanbergite [$SrAl_3(PO_4)(SO_4)(OH)_6$] and gorceixite [$BaAl_3(PO_4)_2(OH)_5.H_2O$] (Stoffregen & Alpers 1987). In certain vugs the augelite is intergrown with topaz. The topaz also forms clusters of tabular crystals about 10 μm across or encrustings of rutile cores *(Fig. 7).*

Genetic aspects

Many studies show that secondary hydrothermal phosphates are formed by the decomposition of primary apatites (Nriagu & Moore 1984, Visser, Felius, & Moree 1997, Dill 2001). In the examined samples the abundance of augelite – and other phosphate minerals in the deposit - indicates that the hydrothermal system was rich in P and Al. It can be assumed that the hydrothermal fluids mobilized phosphor not only from the apatite of the host dioritic stock but that of the Hercynian granitic basement as well. The aluminum can be originated by the extremely acid leaching of host rock.

Duggan et al. (1990) found augelite and other Al-phosphates with topaz and rutile formed by hydrothermal alteration of Triassic andesite and calculated the formation temperature between 450-500 ˚C.

Visser et al. (1997) found in metamorphic quartzites that augelite had developed after crandallite as a result of continued transformation due to an increase in temperature and pressure. During this stage Ca, Sr and Ce are partly removed from the rock. This kind of transformation could take place also in the Podpolom system. For the first, as a late phase of alteration, APS minerals formed in the vugs of the silica matrix of hydrothermal breccia. The formation of the dioritic stock is a result of multiply emplacement (Štohl et al, 2000), during which an increase in temperature could have resulted the transformation of former phosphates into augelite. The formation of topaz in close association with augelite can also be connected to this later, higher-temperature phase. In the drillhole R7, between 35-65m the topaz content increases as high as 16 % with 2-3 % corundum, which also suggests a higher-temperature effect (Bottrill, 1998).

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Fig.1 XRD diagram of the matrix of gray siliceous breccia from R7-84.2m showing the presence of quartz, augelite, topaz, minor hematite, illite and smectite (wavelength 1,54186, Cu tube, 40kV, 30 mA, step 0,04, scanrange 2-66°2theta, max I 11174)

Fig. 2 Tabular crystals of augelite, filling the vugs of the silica matrix. R7-84.2m, siliceous breccia. Transmitted light, +N

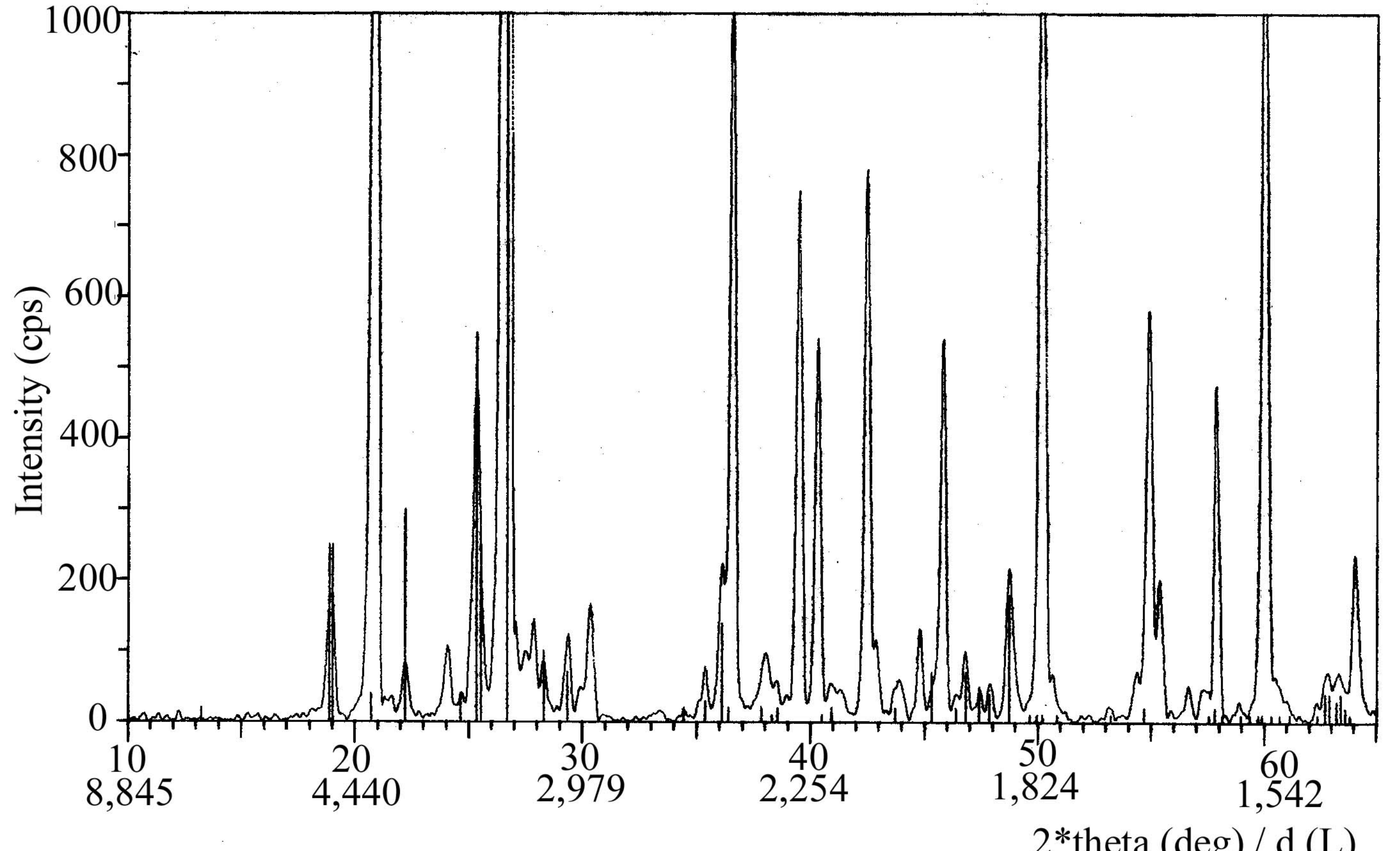
Fig. 3 Tabular augelite in a vug. Lighter small patches in augelite are topaz. R7-84.2m, siliceous breccia. BSE image

Fig. 4 EDS spectogram of augelite in Fig. 3

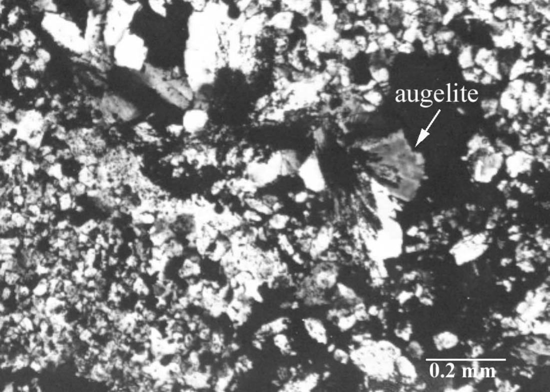
Fig. 5 Augelite, topaz, Ca-APS minerals and rutile in a vug of the silica matrix. R7-84.2m, siliceous breccia. BSE image

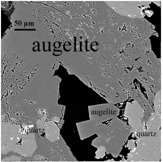
Fig. 6 EDS spectogram of Ca-bearing APS minerals in Fig. 5

Fig. 7 Rutile cores in topaz and augelite. R7-84.2m, siliceous breccia. BSE image

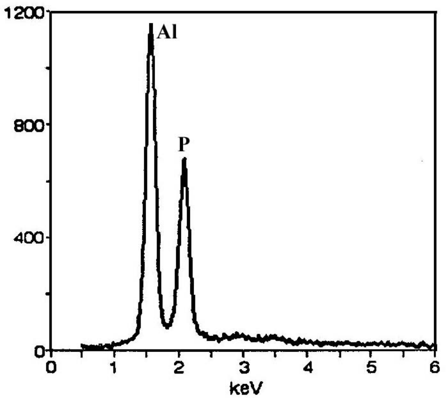


Reference pattern: 34-0151 Augelite Al2 (PO4)(OH)3

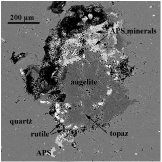

augelite
0.2 mm



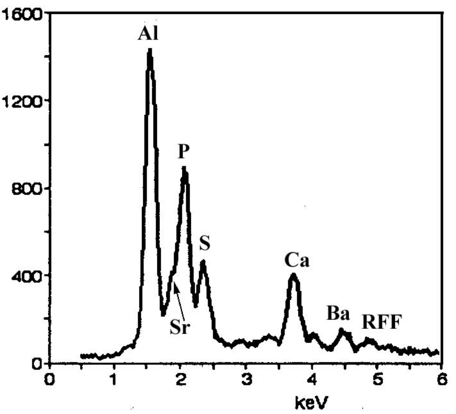
50 µm
augelite
augelite
quartz
quartz



1200
800
400
0
Al
P
0
1
2
3
4
5
6
keV



200 μm
APS minerals
augelite
quartz
rutile
topaz
APS


1600
1200
800
400
0
Al
P
S
Sr
Ca
Ba
RFF
0
1
2
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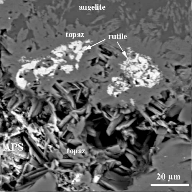
6
keV


augelite
topaz
rutile
APS
topaz
20 µm