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Mineralogical considerations on the topstratum of some mine tailings from the Fundu Moldovei area, Romania

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Abstract

The present study was conducted on a number of 14 tailings samples collected from the topstratum (0–20 cm depth) of three mine tailings deposits located within the Fundu Moldovei mining perimeter, Romania, namely Dealu Negru, Prașca I and Prașca II. The main objective of the study was to determine the mineralogy of these tailings by means of XRD, as well as to establish a link between the mineralogical composition and the conditions in which the tailings have been deposited. The Powder XRD analyses showed that the main minerals are quartz and Fe-rich chlorite, while the accessory minerals are muscovite-illite, sometimes pyrite or albite. The trace minerals identified were the following: albite, pyrite, jarosite (resulting from the weathering of pyrite), talc, gypsum and stilpnomelane.

Keywords: mine tailings, mineralogy, XRD, tailings pond.

Introduction

The mine tailings within the Fundu Moldovei mining perimeter are generally associated to the massive volcanic sulphide ore deposits that have been exploited in the area over the years, mainly for their high Cu-rich pyrite and chalcopyrite contents. The industrial activities carried out on these mine tailings have ceased years ago, leaving the topstratum of the barren material (0–20 cm) exposed to the environment for a long period of time. Some of the tailings deposits are pond-storage sites, like in the case of the Dealu Negru mine tailings, which are related to the Fundu Moldovei ore processing station, while others have been constructed through dry stacking. Presently, the water of the Dealu Negru draining pool has dried out, leaving only a

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relatively moist, sandy tailings material, while the Prașca I and Prașca II mine tailings consist of distinct rock fragments. The purpose of the present study is to investigate the impact that the different depositing conditions have left on the mineralogical composition of the tailings.

Geological setting

The Fundu Moldovei village lies at the intersection of the 47º30’N parallel with the 25º15’E meridian, in western Suceava County, between the slopes of Obcina Mestecănișului, highly fragmented by small tributaries of the Moldova river.

As visible in Figure 1, from a geological point of view, the studied area lies within the Tulgheș low-grade metamorphic unit, in the Crystalline-Mesozoic Zone of the Eastern Carpathians.

The Tulgheș metamorphic unit was the major Mn producer in Romania and it also accounted for a notable output of Pb, Zn, Cu, pyrite and barite (Balintoni, 2010). The Tulgheș metamorphic unit is of Ordovician age and is divided into four formations (Vodă and Balintoni, 1994):

A. The Căboaia sub-unit (Tg_1) – a quartzitic formation;
B. The Holdița sub-unit (Tg_2) – a quartzitic-graphitic formation;
C. The Leșu Ursului sub-unit (Tg_3) – a volcanic-sedimentary rhyolitic formation;
D. Arșița Rea sub-unit (Tg_4) – a phyllitic-quartzitic formation.

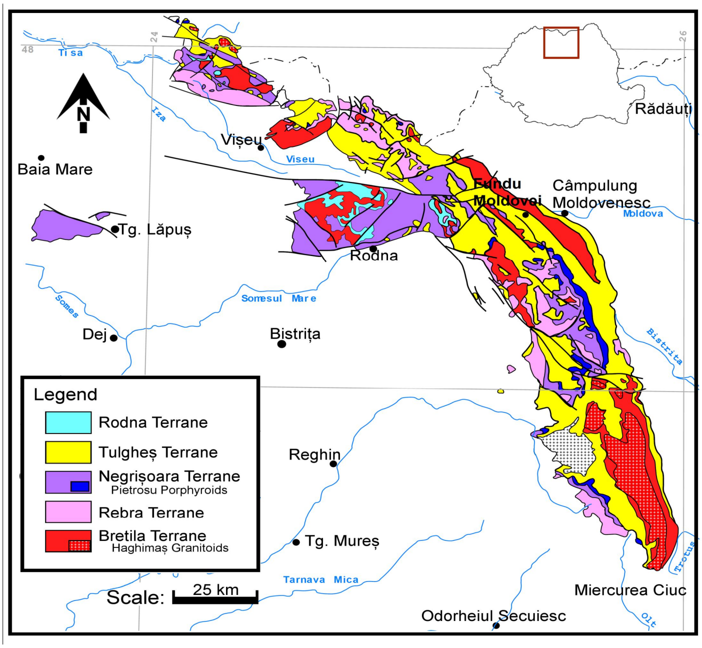

Fig.1 Location of the village of Fundu Moldovei (modified from Balintoni, 2010).

The Leșu Ursului sub-unit is in fact a sedimentary volcanogenic sequence, which contains important stratiform accumulations of metallic sulphides (Balintoni, 1997), mainly pyrite and chalcopyrite, sphalerite and galena (Stumbea, 2007). This sub-unit is the formation associated with the mineralisations that have been exploited at Fundu Moldovei, generating the studied tailings deposits: Dealu Negru, Prașca I and Prașca II (Fig. 2).

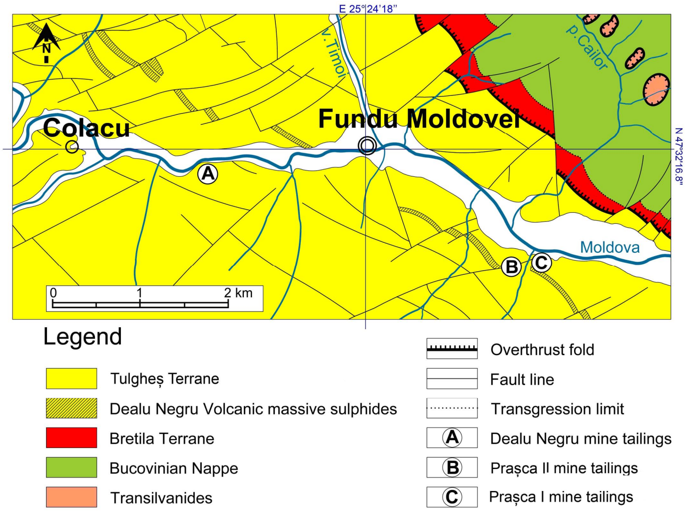

Fig.2 Locations of the Dealu Negru, Prașca I and Prașca II mine tailings (modified from Petrescu et al., 1975).

The studied mine tailings

Dealu Negru is, in fact, the tailings pond of the Fundu Moldovei ore processing station, found on the right bank of the Moldova river. The tailings occupy an area of approximately 56,000 m^2 and are a coastal-type deposit of average size. The site is closed since 2004.

The Prașca I mine tailings are correlated to the +790 Prașca horizon, through which the cupriferous pyrite ore has been reached. It is a rather small tailings deposit, which is now being used as a storage site for construction materials, as well as tree logs that have been cut down in order be delivered to wood processors. This site has also been officially closed since 2004.

The Prașca II mine tailings are common to the +840 Prașca horizon (on the right bank of the small Prașca river), which revealed the same accumulations as Prașca I. The deposit occupies approximately 44,000 m^2. The site was closed in 2004, along with all the other mining industry facilities of the Fundu Moldovei area.

Samples and methodology

For the present study, a number of 14 samples (Tab. 1) have been collected from the three mine tailings sites, as follows: for Dealu Negru – 10 samples (samples A1 to A10) (Fig. 3), for Prașca II – 2 samples (samples B1 and B2), and for Prașca I – 2 samples (samples C1 and C2).

The samples have been collected with a manual drill-type soil sampler, using the methods described in the literature (Borlan and Răuță, 1981; Clichici and Stoici, 1986; Florea et al., 1987).

The samples were first dried under normal conditions for 3 days, and then in the oven, at a temperature of 40-50°C, for 8 hours. Afterwards, the traces of vegetation found in different stages of decomposition were removed from the dried samples.

The granulometric fraction with a diameter of less than 2 mm was ground, at first with the help of an agate grinder, and then in a "Fritz" planetary mill, for 60 minutes, at speeds of 200 rpm, thus achieving a granulometric diameter of less than 0.01 mm.

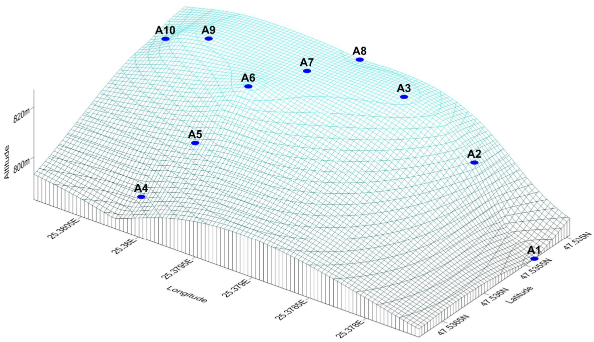

Fig. 3 The sampling points within the Dealu Negru mine tailings.

Tab. 1 Locations and weight of the samples from the Fundu Moldovei tailings sites

No.	Geographical coordinates						Alt. [m]	m [g]
	N Latitude			E Longitude				
	°	`	``	°	`	``		
A1	47	32	7.40	25	22	39.13	783	2360
A2	47	32	7.05	25	22	41.28	810	2032
A3	47	32	6.96	25	22	43.57	825	2275
A4	47	32	11.76	25	22	48.39	793	1994
A5	47	32	10.39	25	22	47.68	809	2124
A6	47	32	9.04	25	22	46.98	827	2396
A7	47	32	7.34	25	22	46.36	825	2006
A8	47	32	5.86	25	22	45.77	823	1909
A9	47	32	7.43	25	22	49.39	825	2491
A10	47	32	7.31	25	22	50.80	818	1957
B1	47	31	33.16	25	25	39.74	804	2357
B2	47	31	31.75	25	25	40.40	810	2188
C1	47	31	38.60	25	25	51.60	769	2219
C2	47	31	38.79	25	25	56.20	768	2233

In order to establish the mineralogical composition, the main and accessory minerals, as well as the trace minerals, the XRD powder pattern was recorded using a Philips X´Pert PW3710 diffractometer (Cu-Kα radiation generated at 40 kV and 40 mA), equipped with a 1° divergence slit, a secondary monochromator, a point detector and a sample changer (sample diameter 28 mm). The samples were investigated in a 2θ interval ranging between 2° and 80°, with a step size of 0.02° 2θ and a measuring time of 3 sec per step. The XRD analyses were performed within the Federal Institute of Geosciences and Natural Resources in Hannover, Germany, through the benevolence of D. Weck.

Results

The results of the XRD analyses carried out on the samples from the Fundu Moldovei mine tailings sites are given in Tab. 2.

Tab. 2 The main, accessory and trace minerals identified through XRD analyses for the samples collected from the tailings deposits studied

Smp.	Main and accessory minerals	Trace minerals
A1	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Albite, Stilpnomelane
A2	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Albite, Stilpnomelane
A3	Quartz, Fe-rich Chlorite, Muscovite-Illite	Pyrite, Jarosite, Albite, Talc, Stilpnomelane
A4	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite
A5	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Albite
A6	Quartz, Fe-rich Chlorite, Muscovite-Illite, Pyrite	Jarosite, Talc, Gypsum, Stilpnomelane
A7	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Pyrite, Stilpnomelane, Gypsum, Talc, Albite
A8	Quartz, Pyrite, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Talc, Stilpnomelane, Albite
A9	Quartz, Pyrite, Fe-rich Chlorite	Muscovite-illite, Jarosite, Albite, Stilpnomelane
A10	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Albite
B1	Quartz, Fe-rich Chlorite, Muscovite-Illite	Jarosite, Albite, Gypsum
B2	Quartz, Fe-rich Chlorite, Muscovite-Illite, Albite	Gyspum
C1	Quartz, Fe-rich Chlorite, Muscovite-Illite, Albite	Jarosite
C2	Quartz, Fe-rich Chlorite, Muscovite-Illite	Albite, Jarosite, Gypsum

Discussions

The results of the XRD analyses reveal that all of the samples have quartz as the main mineralogical component, along with Fe-rich chlorite and, occasionally, pyrite. These minerals derive directly from the primary rocks that host the Fundu Moldovei ore accumulations, mainly chlorite-quartz, sericite-quartz and sericite-clorite-quartz schists (Stumbea, 2007; Kräutner et al., 1983). Muscovite-illite, albite, talc and stilpnomelane have also been identified as trace minerals of the Fundu Moldovei formations by Kräutner et al. (1983). Jarosite, a hydrous potassium and iron sulphate, having the chemical formula $KFe^{3+}_3(OH)_6(SO_4)_2$, is a product of the supergene alteration undergone by the iron sulphides under the influence of weather conditions, especially water and moisture. The presence of jarosite is commonly associated with acid mine drainage, as well as the acid sulphate soil environments identified by Balaban et al. (2011) on the surface of the same tailings deposits.

We can divide the topstratum of the Dealu Negru tailings into two distinct environments, namely the top and the slopes. The top represents an area where there once was a tailing pond which has now dried out, a zone that is still moist and exposed to water accumulations from rainfall and/or snow. The slopes represent a different environment, where the topstratum is mostly dry and does not meet the requirements for water to settle in.

Based on the mineralogical data acquired on the Dealu Negru tailings (Samples A1 to A10), one can notice that raw pyrite only appears in five of the samples (A3, A6, A7, A8 and A9), sometimes not just as a trace mineral, but as an accessory one (sample A6). The position of the sampling points within the 3D-reconstructed map of the tailings sites (Fig. 3) reveals that pyrite only appears as a notable mineralogic component at the top of the tailings, where all of the above-mentioned samples are located. Albite is also present at the top of the Dealu Negru tailings, but in slightly lower proportions than on the slopes.

The samples collected from Prașca I and II sites, however, display a much more significant participation of albite in the mineralogical composition than in the case of the Dealu Negru mine tailings, probably because albite did not weather so quickly, as Prașca I and II are dry-stacked deposits, and albite easily weathers in aqueous environments. That would explain the higher quantity of albite present under dry-stacking conditions than in tailings ponds.

Conclusions

There are two distinct environments for the Dealu Negru mine tailings, namely the top, which is the place of the former draining pool and is still moist, and the slopes, which constitute a relatively drier environment.

The main and accessory mineralogical components identified through XRD analyses are quartz, Fe-rich chlorite, muscovite-illite and, sometimes, pyrite or albite, while the trace minerals are albite, jarosite (resulted from the weathering of pyrite), talc, gypsum and stilpnomelane.

The samples collected from the top of the Dealu Negru tailings reveal the presence of pyrite as a relatively significant mineralogical component.

On the slopes, pyrite is fairly absent and the proportion of albite tends to slightly increase, as in the case of the other 4 samples collected from the Prașca I and II mine tailings deposits, which display the same, drier weathering environment.

All the other minerals that have been identified through the present study are common to the complex sulphide-bearing rocks of the Fundu Moldovei mining sector.

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