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Jakub KIERCZAK[1], Catherine NEÉL[2], Jacek PUZIEWICZ[1]

Ni AND Cr DISTRIBUTION IN THE DUMP AND SOILS ON THE NEIGHBOURHOOD OF THE SZKLARY NICKEL MINE AND SMELTER (LOWER SILESIA, POLAND): PRELIMINARY DATA

Abstract : Ni and Cr are concentrated in the slags being the product of Ni-ore extraction in Szklary (Lower Silesia, SW Poland). The soils formed on the ore extraction waste as well as those in close surrounding contain numerous slag fragments. The weathering and decomposition of slags leads thus to soil enrichment in Ni and Cr.

Keywords : Ni-smelter, serpentinite, slag, nickel, chromium, soil.

INTRODUCTION

The Szklary serpentinite massif is located in the southern part of the Niemcza zone (Fore – Sudetic Block, NE Bohemian Massif). It forms a chain of hills which are situated ca. 7 km north of Ząbkowice Śląskie (Fig. 1). The serpentinites are cut by granitoids, aplites, pegmatite and lamprophyre veins (Niśkiewicz 1967). Tertiary weathering crust and the Quaternary sediments, both *in situ,* cover nearly the whole studied area.

The weathering cover of the Szklary massif was a source of nickel for over 100 years. The dumps consisting of mining and metallurgical waste accumulated close to the nickel works. One of the dumps is situated close to the road from Wrocław to Ząbkowice Śląskie (Fig. 1). It is approximately 200 meters long, 150 meters wide and 12 meters high. The dump consists of various materials, mostly a mixture of glassy slag, incinerator ashes and fragments of industrial constructions. Although the smelter and mining activity have stopped two decades ago, the deposited wastes still represent actual sources of Ni and Cr contamination for soils and vegetation of the surroundings.

This paper aims at locating the Ni and Cr in the top soil layer covering the dump materials and in the surrounding cropped soils. Mineral composition of the dump and cropped soils are compared with those of the formerly exploited weathering crust.

[1] *Institute of Geological Sciences, University of Wrocław, Cybulskiego 30, 50-205 Wrocław, Poland; jakier@ing.uni.wroc.pl; jpuz@ing.uni.wroc.pl*
[2] *LASEH – UMR CNRS 6532 - Géologie, Faculté des Sciences, Université de Limoges, 123 Avenue A. Thomas, 87060 Limoges Cedex, France; neel@unilim.fr*

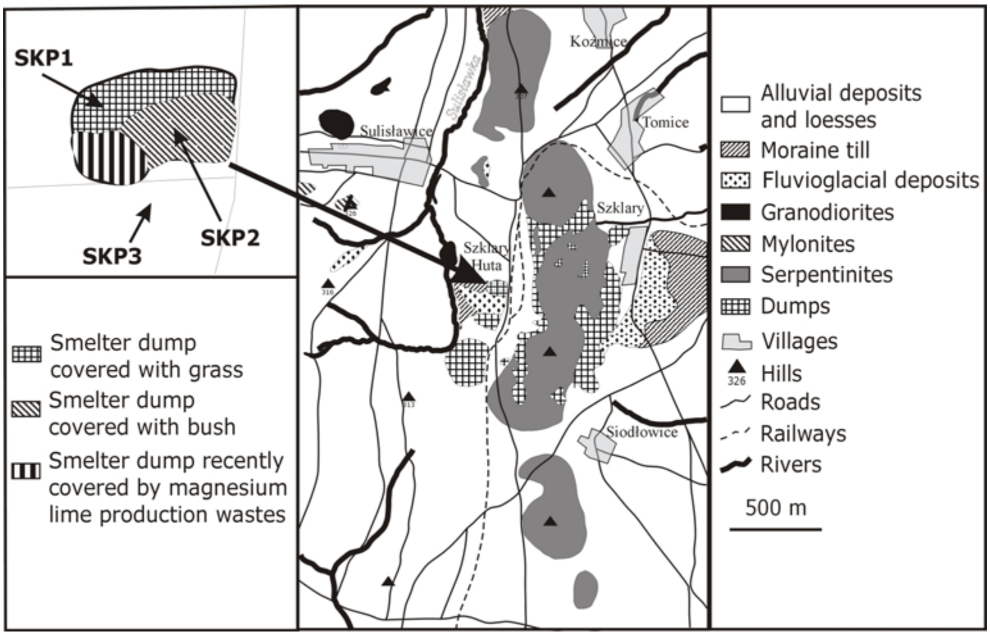


Fig. 1. Geological map of the Szklary Massif (modified after Badura and Dziemiańczuk 1981). The arrows indicate the studied dump and the locations of the soil sampling.

SAMPLES AND METHODS

Three samples of slags were collected on the top of the dump for bulk chemical analysis. Chemical analyses of dump material were done by a combination of AAS and titration after alkaline fusion. Three soil samples were taken (Fig. 1) from the top layer (0–6 cm): the first one comes from central part of the dump covered by small birch–trees and pines (SKP1), the second soil sample was taken from the western part of the dump naturally recovered by grass (SKP2), and the third one comes from a crop field located 50 meters beneath of the dump to the south (SKP3). Thin sections of soils and slags occurring in the soil layers were studied by optical microscopy and SEM-EDS at the University of Limoges. The bulk soil, $\varphi < 2$ μm grain fraction (oriented specimens) and ferromagnetic fraction were studied using X–ray diffraction (SIEMENS 5005, CuKα). Bulk chemical and XRD analysis were done at the Institute of Geological Sciences, University of Wrocław.

BULK CHEMISTRY

The weathering cover of the Szklary massif is recognized as the lower part of a typical weathering profile of ultrabasic rocks. The uppermost zone of the profile was exploited as a Ni ore. The bulk chemical compositions of the sampled slags **(Sz)** and of the exploited serpentinite weathering crust **(D)** are compared in Table 1. In spite of its extraction, Ni is still present in large amount in the slags.

Table 1. Bulk chemical analyses of slags occurring in the dump soil (Sz), of the kerolite – pimelite series (D1; after Dubińska *et al.* 2000), and of the serpentinite weathering cover (D2 after Niskiewicz 2000).

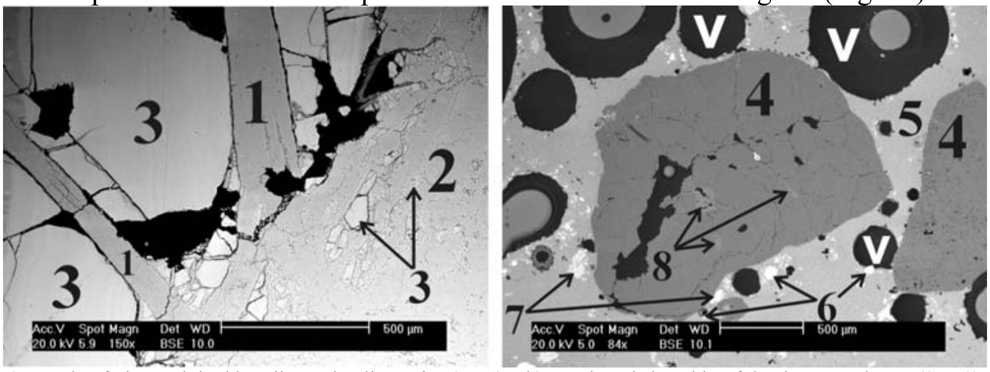
	Slags				D1	Deeper D2	Upmost D2
(wt. %)	**Sz 01**	**Sz 02**	**Sz 05**			> 15 m depth	from 2 to 8m
SiO_2	39.81	44.57	41.22		49.13 – 65.66	40.58 – 53.14	51.96 – 61.47
Al_2O_3	17.96	15.74	11.99		nd – 1.5	1.72 – 14.09	4.64 – 5.65
TiO_2	0.43	0.60	0.73		nd – 0.08	0.05 – 0.61	0.2 -0.25
FeO	5.42	5.37	26.70		nd – 0.38	-	-
Fe_2O_3	0.10	0.27	2.11		nd – 1.57	6.15 – 27.11	11.15 – 19.83
MnO	1.72	0.75	0.23		nd – 0.01	0.066 – 0.34	0.14 – 0.53
CaO	25.18	21.24	9.92		nd – 0.85	0.69 – 4.37	0.13 – 1.25
MgO	6.43	7.78	3.89		6.58 – 30.19	12.16 – 27.0	6.01 – 20.79
Na_2O	0.56	0.66	0.35		nd – 0.15	0.4 – 1.64	0.08 – 0.68
K_2O	0.60	2.18	0.75		nd – 0.21	0.15 – 0.74	0.12 – 0.28
P_2O_5	0.27	0.25	0.05		nd	nd	nd
LOI	0.18	0.43	2.74		6.05 – 9.08	3.56 – 9.67	3.40 – 5.21
Zn (ppm)	2500	1600	420		nd	nd	nd
Pb (ppm)	230	<100	ns		nd	nd	nd
Cr (ppm)	1100	370	6400		trace	360 – 8900	330 – 3200
Ni (ppm)	240	240	5600		0.84 – 25.4 (wt.%)	0.25 – 2.39 (wt.%)	0.41 – 2.3 (wt. %)
Co (ppm)	110	110	700		nd	30 – 160	70 – 210
Cu (ppm)	2200	1500	<100		nd	30 – 300	50 – 600

SOILS MINERALOGY

The glassy slag which is the main component of the dump occurs as pieces of different size (from few millimetres up to dozens of centimetres) and shape in the dump soils. The XRD analyses show that quartz, calcite, magnesioferrite and amorphous glassy material are present in all the investigated soil samples. However, the mineralogical composition of investigated soils varies between the studied samples. Bunsenite and native nickel occur in the ferromagnetic fraction of the sample **SKP2 (dump soil)**. Mineral association typical for soils developed on serpentinites (Ducloux et al. 1976) is found in the cropped soil **SKP3** : plagioclase, illite and chlorite. Except the mentioned minerals, significant amount of amorphous glassy slag occurs in the ploughed layer of the cropped soil sample SKP3, suggesting a contamination by the smelter activity.

Ni AND Cr SPECIATION

The nickel is concentrated in talc-like minerals (saponite, kerolite – pimelite series) in the exploited ore (Dubińska et al. 2000). These appear either as large crystals or in smaller veins (Fig. 2a). The chromium occurs in Fe-Al-Mg spinels (Gunia 2000). The weathered slag fragments occurring in the dump soil are vesicular. SEM-EDS analyses reveal large silica-rich grains with small grains of Fe - Ni sulphides and of chromo–picotite embedded in a silica rich glass (Fig. 2b).



a) sample of the exploited kerolite – pimelite series (DR1) b) weathered slag chip of the dump top layer (SKP2)

Fig. 2. SEM-BSE pictures of samples of the exploited material (a) and of a weathered slag occurring in the dump top-soil layer: V: vesicles, 1: Quartz, 2: Silica rich phases (> 95 Si at.%), 3: talc-like Ni-mineral; 4: Silica phases (> 95 Si at. %) including Ni and Cr impurities; 5: Glass poor in Ni and Cr (< 0,5 at. %), 6: Fe-Ni sulphides (> 40 Ni at.%), 7: Chromo-picotite (> 45 Cr at.%), 8: Fe-Al silicate.

CONCLUSIONS

The significant amount of Ni occurring in the dump material reveals an incomplete Ni extraction during the ore processing. The smelting of the ore material has also resulted in the concentration of the Cr in the dump. As the fragments of slags are present in large amounts in the dump soil as well as in the surroundings soils, we believe that the dumps represent an actual source of Ni and Cr contamination of the soils. The Cr and Ni speciation and mobility in soils will be investigated in a further study.

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