MINING WASTE OF NON-METAL PITS AND QUERRIES IN SLOVENIA

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ABSTRACT

Mining is an important human activity that creates wealth and supplies materials for maintaining standard of living and for further human development. Mining also has negative impacts on the environment and society; one of them is the production of mining waste throughout the mining cycle, particularly in the mine development and operation / production stage. Due to the EU Directive 2006/21/EC on the management of waste from the extractive industries and its implementation in Member states, the estimation on quality and quality on mining waste of active non-metal mines in Slovenia was carried out. In the selected mines, mining and processing were examined. With material flow analysis, quantity and characteristics of mining waste were defined for several mines of different commodities. Data on mining waste were afterwards generalized in order to get an overall country evaluation on mining waste "production" of non-metal mines.

Key words: mining waste, non-metals, Slovenia.

INTRODUCTION

Humans have been using earth resources since prehistoric times. Minerals have helped to raise standards of living and their importance has been such that archaeologists named periods of history after the resource being used (Stone Age, Bronze Age, etc.) (Shields & Šolar, 2006). Earth resources were mined, at its very beginning they were probably just picked up from the ground, and throughout the human history mining became a complex economic activity.

The beginnings of mining in Slovenia are in prehistoric times. Mining was intensified in the industrial era; nowadays it is still present, but in smaller scale. Two, once important metal mines, Idrija (mercury) and Mežica (zinc and lead), are in the stage of closing down like some of underground coal mines. The only two underground mines are coal mines in Velenje and Trbovlje, all other mines are non-metallic surface mines that are prevailing. In spite of "sunset of mining" in the past decades, mining activity represents 8% of industrial production, non-metallic mining in particular has a 4.6% share of the Slovenian industry production (Marc et al., 2005). The mineral resources production of Slovenia remains at the same level for the past few years. There is 4.5 million tones of coal (lignite and brown coal) produced, beside non-metals where construction materials – aggregates are predominant (Table 1).

Table 1: Non-metal production in Slovenia 1983-2006

Geological Survey of Slovenia
Dimiceva 14
Ljubljana, SLOVENIA

NON – METALS PRODUCTION IN SLOVENIA

(in metric tones)

		1983	1988	1993	1998	2002	2003	2004	2005	2006
Bentonit				20	447	201	187	141	140	130
Calcite			142.208	105.402	103.000	204.603	119.606	128.725	164.752	271.509
Kaolin		67.290	35.514	20.171						
Chalk		17.942	4.740	2.090	945	685	607			
Quartz sand		650.295	861.579	374.164	518.755	394.342	449.733	264.349	254.195	278.041
Tuff			109.000		84.101	65.041	84.333	88.884	95.126	88.013
Industrial dolomite								260.367	279.555	294.645
Chert		26.910	30.744	17.477	18.200	13.725	20.824	20.325	19.445	15.445
Ceramic clay		67.490	172.740	152.268	98.588	56.085	79.900	69.561	78.683	86.443
Industrial minerals and rocks		**829.927**	**1.356.525**	**671.592**	**824.036**	**734.682**	**755.190**	**832.351**	**891.895**	**1.034.227**
Brick clay		607.942	1.034.168	883.420	632.696	591.794	573.584	508.232	730.670	638.329
Building stone	limestone	9.456	34.830	54.321	31.474	32.692	38.942	21.538	102.635	52.459
	tonalite (granodiorite)	27.000	29.344	21.600	54.478	28.237	30.850	21.867	36.488	56.587
	other		9.318	2.465	1.139	1.820	5.713	23.940	29.741	24.392
Building stone		36.456	73.491	78.386	87.091	62.748	75.506	67.344	168.864	133.438
Raw materials for lime								1.111.417	1.691.696	2.089.495
Raw materials for cement		1.533.912	1.249.387	1.520.954	1.479.644	1.313.047	1.400.423	1.409.780	1.306.889	1.324.803
Construction materials		**2.178.310**	**2.357.046**	**2.482.760**	**2.199.431**	**1.967.589**	**2.049.513**	**3.096.773**	**3.898.118**	**4.186.065**
Crushed stone	limestone	2.549.348	4.714.443	4.620.273	6.748.784	6.053.203	6.623.054	5.939.214	5.926.378	7.242.777
	dolomite	891.376	3.402.742	3.068.666	4.502.498	6.981.502	8.391.079	7.729.802	6.197.589	6.712.996
	other				99.963	14.970	26.207	50.872	99.215	257.546
Crushed stone		3.440.724	8.117.185	7.688.938	11.351.245	13.049.675	15.040.340	13.719.888	12.223.182	14.213.319
Sand and gravel		1.466.141	3.455.355	2.668.860	2.440.115	3.106.679	3.437.911	2.712.174	3.750.707	6.871.519
Construction materials – aggregates		**4.906.865**	**11.572.540**	**10.357.798**	**13.791.360**	**16.156.353**	**18.478.252**	**16.432.063**	**15.973.889**	**21.084.838**
NON - METALS		**7.915.102**	**15.286.111**	**13.512.150**	**16.814.827**	**18.858.624**	**21.282.954**	**20.361.187**	**20.763.902**	**26.305.130**

MINING WASTE

In a course of mineral extraction and beneficiation (processing) not all mined materials are used as products. These materials are (mining) waste even if within mining community they are not perceived as waste. Strictly speaking mining waste includes waste from mining (extraction), and beneficiation (also processing). Extraction waste is overburden, waste rock, including soil, beneficiation waste is waste derived from beneficiation processes. For the purposes of our work we distinguished among overburden, waste rock and beneficiation waste. Overburden consists of soil and unwanted rock above the deposit, waste rock is unwanted material within deposit or near by (that needs to be extracted due to extraction plans). Beneficiation waste is waste from the beneficiation process and material that does not meet product requirements. Furthermore separation was made between provisional and permanent mining waste. Provisional waste, such as overburden, is usually used for mine reclamation purposes, permanent mining waste is deposited on heaps. Waste is also classified with regard to its potential hazard to the environment (Colman et al., 2003):

- Inert
- Non-hazardous
- Hazardous
- Mineral containing dangerous substances (e.g. cyanide) as a result of mineral processing or treatment.

After several years of discussion on different levels the Directive 2006/21/EC on the management of waste from extractive industries was adopted. The purpose of the directive

is to provide measures, procedures and guidance to prevent or reduce as far as possible any adverse effects on the environment, in particular water, air, soil, fauna and flora and landscape, and any resultant risks to human health, brought about as a result of the management of waste from the extractive industries (EU Directive 2006/21/EC). The Directive has to be incorporated into the Member States' legislation within a two years period.

SLOVENIAN CASE

In order to support and ease its implementation into the Slovenian legislation, a study on mining waste of active non-metal surface mines was carried out. Its aim was to quantify and determine the characteristics of mining waste.

Table 2.: Type of beneficiation process for some mineral resources.

MINERAL RESOURCE	BENEFICIATION PROCESS
calcite	crushing, washing
chert	washing, drying, classification, crushing
quartz sand and gravel	washing, drying, classification, crushing, sowing, flotation
clay	kneading, milling
dimension stone	cutting
crushed stone	crushing, classification, washing
sand and gravel	crushing, classification

The main method used in the study was material flow analysis for mining and beneficiation process that was done for each non-metals commodity. Extraction that takes place within mining / extraction area starts with removing overburden (soil and overburden rock).

Material extraction from the ground is done by blasting. It is also the cheapest, but has associated negative environmental impacts such as noise and seismic vibration. Overburden is usually stored on the other part of extraction area as provisionally and it is aimed to be used mostly for reclamation. Mineral resources/useful materials are transported to a beneficiation facility, where, with regard to material characteristics and desired product, different beneficiation methods are used. Most common of them are crushing, milling, washing, drying classification, flotation. In table 2 beneficiation process for some non-metals commodities extracted and beneficiated in Slovenia is presented.

The outcomes of benefaction are product and waste. The later is in most cases up and down sized grains. Benefaction waste is, also provisionally, stored separately from the extraction waste within the extraction area. In most cases all mining waste is planned to be used for mine site land reclamation. Since extraction and beneficiation processes for non-metals extracted in Slovenia is not complicated, material flow can be generalized (Figure 1). Note that there is no permanent heap planned or in place.

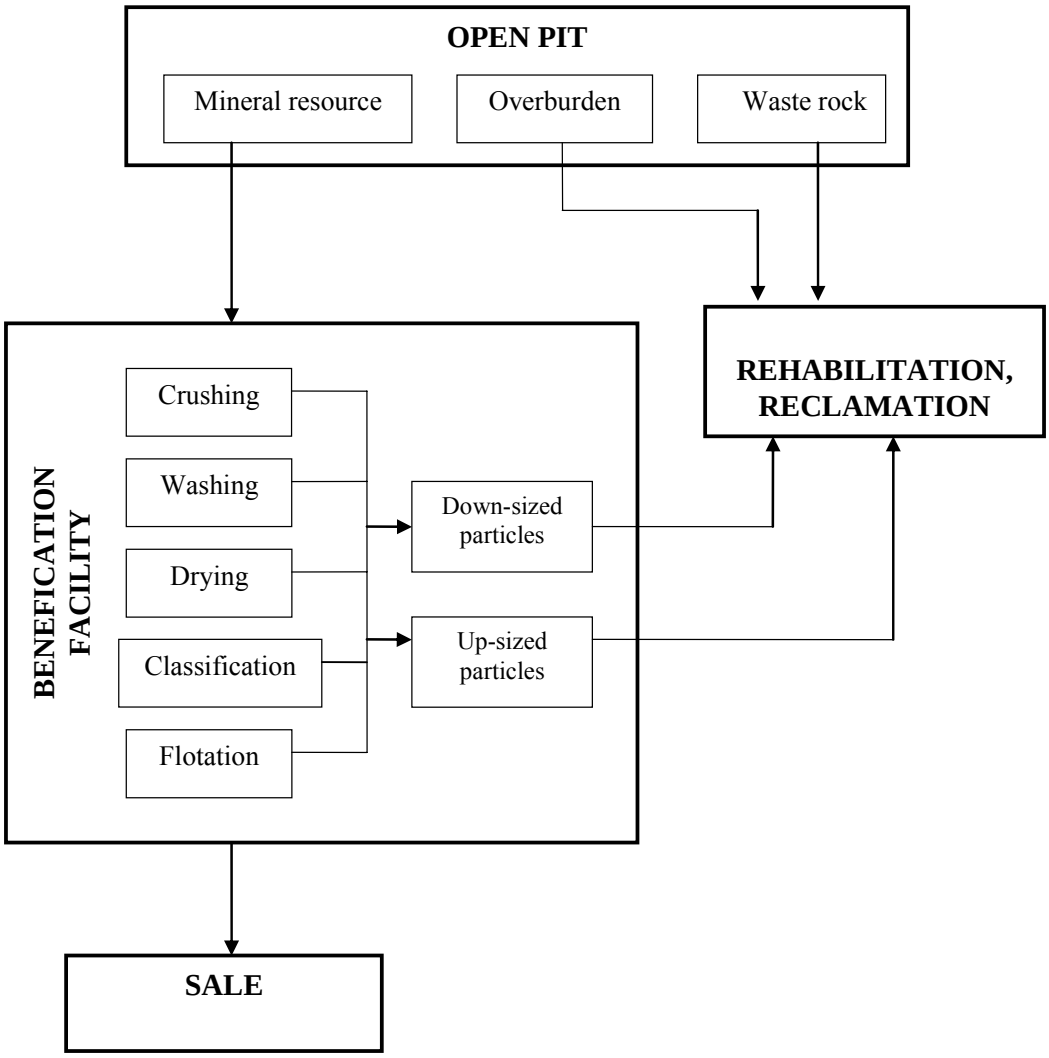

Figure 1.: Generalized material flow for extraction and beneficiation of non-metals in Slovenia.

QUALITY AND QUANTITY OF MINING WASTE

Research was carried out in 2006 for the production year 2005. Non-metals production, in almost 200 surface mines in Slovenia, that year was 20.7 million tones. The largest part, almost 16 million tones, was aggregates (crushed stone – limestone, dolomite; sand and gravel) (Šolar et al., 2006).

Data on mining waste were obtained by poll with questionnaires and visits to most characteristic surface mine and commodities. Mine managers were interviewed and the production (extraction and benefaction) processes were examined by material flow analysis. Since we did not get information from all the surface mines, obtained data / results

were generalized with regard to the type of extraction and commodity for the country's non-metal production.
Mining waste was classified according to Coleman's (2003) classification into inert, non-hazardous, hazardous and minerals with dangerous substances. Slovenian non-metal sector "produces" only inert and non-hazardous mining waste. Each commodity has at least one kind of mining waste, most of them of two or all three types (overburden, waste rocks, beneficiation waste). Inert and non-hazardous mining wastes are provisional and have already planned future potential that can be either reclamation or sale (Table 3). No hazardous wastes were tracked down in the production processes and no dangerous substances were being used in the beneficiation processes. In some mineral resources, potentially dangerous, pyrite is present, but its quantity is so low that it does not represent any hazard for the environment, health and safety.

Mining companies are optimizing their overall performance by maximizing positive economic effects and minimizing negative environmental and social impacts. This also is being met by using improved technical and technological process with waste reduction, and by using waste as products or semi products for company's purposes (reclamation) or profitable sales. In same companies more costly production technologies with smaller environmental (less waste) and social (less noise) impacts are used. An example is the dimension stone sector where the commodity is extracted in underground galleries. Mining waste is also used as a company's side-product. The Quartz Sand Company TERMIT is producing "artificially prepared soil" that is used for soil improvement.

Table 3.: Type and classification mining waste in Slovenia.

MINERAL SOURCE	TYPE OF MINING WASTE	CLASSIFICATION OF MINING WASTE	USE OF MINING WASTE
calcite	tailings, remain after treatment	non-hazardous	temporary heap
raw materials for cement industry	overburden, waste rock	inert	rehabilitation or site restoration, for sale, further production
chert	overburden, tailings, remain after treatment	non-hazardous	rehabilitation or site restoration
quartz sand	overburden, waste rock, tailings, remain after treatment	inert	rehabilitation or site restoration, further production
clay	overburden, waste rock, tailings, remain after treatment	non-hazardous	rehabilitation or site restoration
brick clay	overburden, waste rock, tailings, remain after treatment	non-hazardous	rehabilitation or site restoration
dimension stone	waste rock, tailings, remain after treatment	non-hazardous /inert	rehabilitation or site restoration, for sale
crushed stone (igneous and metamorphic rock)	overburden, waste rock, tailings, remain after treatment	inert	rehabilitation or site restoration, for sale
crushed stone (limestone)	overburden, waste rock, tailings, remain after treatment	non-hazardous	rehabilitation or site restoration, for sale
crushed stone (dolomite)	overburden, waste rock, tailings, remain after treatment	non-hazardous	rehabilitation or site restoration, for sale
sand and gravel	overburden, tailings, remain after treatment	inert	rehabilitation or site restoration, for sale

In spite of these and other efforts the non-metal sector in Slovenia "produces" 1.9 million tones of mining waste (almost 1 tone per capita) without mining waste from the dimension stone sector. A rough approximation of this sector for the year 2005 is around 230.000 tones of mining waste. The dimension stone sector produces the highest percentage of mining waste (90%) per product unit (block). Fortunately, by-products are made out of the waste form dimension stone's blocks, so that percentage of waste is much lower (40% products: 60 % waste). Due to the diversity of dimension stones and production process no optimal generalization can be done. This is the reason why the dimension stone sector was excluded from Figure 2 where a percentage of mining waste in each non-metal sub-sector is shown. Mining waste (from extraction and benefaction) is provisional and is planned to be used for reclamation. Aggregate production (dolomite, limestone, sand and gravel) is prevailing, so mining waste from aggregates is considerable. Among aggregates, crushed stone-dolomite waste "production" adds more then 55 % of all non-metal sector's mining waste. This is due to pulverization of dolomite and clay inter-layers. Other aggregates (crushed stone – limestone, sand and gravel) and quartz sand production add around 10% each to the total mining waste.

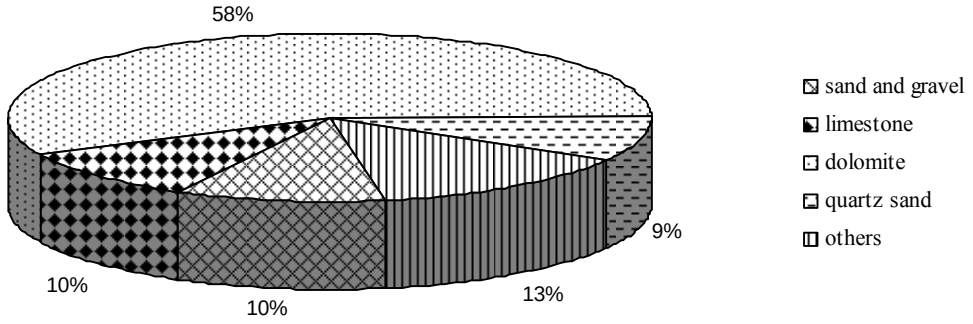

Figure 2.: Percentage of mining waste per each non-metal sub-sector.

CONCLUSIONS

A study on mining waste of non-metal pits and quarries was carried out in accordance with the EU Directive on management of waste from extractive industries. Its aim was to assess current situation in the largest part of Slovenian mining sector. Mining wastes from the extraction and beneficiation processes are inert or non-hazardous. The total amount of mining waste is around 2.1 million tonnes and it is provisional; planned to use mostly for reclamation, partly for side-products or sale; almost no waste is just deposited on a heap. The largest amount of waste per product unit is "produced" in the natural stone sector. Aggregate sector production is the largest in the non-metal sector and, therefore, also the

amount of mining waste is predominant. The mining sector is trying to minimize the mining waste by (Marc et al., 2005):

a) Reducing mining waste at the source (by choosing the proper mining method)
b) Reusing mining waste for different purposes (aggregates, mine reclamation, etc.)
c) Recycling or processing mining waste within the existing benefaction process.

Even though the amount of mining waste from non-metal production is large (around 1 tone per capita) none of it is permanent waste that would be deposited on heaps.

REFERENCES

(1) Colman, T.B., Highley, D.E., Gunn, A.G., Cameron, D.G. & Smith, B. An assessment of the nature of the waste produced by active mineral workings in the UK. British Geological Survey, pp. 44. (2003).

(1) (EU Directive 2006/21/EC) EU Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC - Statement by the European Parliament, the Council and the Commission

(1) Marc, D., Kortnik, J., Šolar, S.V. & Bajželj, U. Nova EU direktiva o ravnanju z odpadki rudarske industrije. (*New EU Directive on the management of waste from extractive industries).* In: Mineralne surovine v letu 2004. (*In: Mineral Resources in year 2004*). (ed.) Šolar S.V., Geološki zavod Slovenije, (*Geological survey of Slovenia*), pp. 173–188 (2005).

(1) Shields, D. J. & Šolar, S. V. The nature and evolution of mineral supply choices. In: Cardu, M. (ed.), Ciccu, R. (ed.), Lovera, E. (ed.), Michelotte, E. (ed.). 15th International Symposium on Mine Planning and Equipment Selection, Torino, 20-22 September 2006. Mine planning and equipment selection 2006. Torino, pp. 902-907, 2006

(1) Šolar, S.V., Štih, J. & Senegačnik, A. Pregled podatkov proizvodnje in zalog ter virov nekovinskih mineralnih surovin. (*Non-metal production, reserves and resources*) In: Mineralne surovine v letu 2005 (*In: Mineral Resources in year 2005*). (ed.) Šolar S. V., Geološki zavod Slovenije (*Geological survey of Slovenia*), pp. 7–61 (2006).