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Exploitation and use of brown coal from the Nováky deposit and ist environmental impact

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Abstract: The Nováky brown coal deposit is located in the Handlová-nováky coal basin. The basin is located in Central Slovakia and it is within the intramountainous basins of Western Carpathians. The Nováky deposit is most significant brown - coal resource in Slovakia. The Nováky coal bed contains the following coal lithotypes listed in order of importance: detritic, xylitic-detritic, xylitic, detritic-xylitic and mother of coal. Most dominate maceral group in the deposit is huminitic, represented with humotelinite, humodetrinite and humokolinite. Other maceral groups identified in the bed liptinite (kutinite, suberinite, rezinite) and inertinite (inertodetrinite, fuzinite and sklerotinite). With respect carbonization the Nováky coal bed is included in the brown-coal stage of the change with medium vitrinite reflectance ($R_0 = 0.275\%$). The mean caloricity value of the Nováky coals is 12.08 MJ.

The mineralization Nováky coal bed consists of clays, tuffs, quartz various forms, sulphides of iron and arsenic, and dolomite. Iron sulphides (pyrite, marcasite) commonly occur in the form of micronodules. Arsenic sulphides (realgar and auripigment) occur at discontinuity areas (layered areas, dilatation cracks, dislocations) and are related to the Vtáčnik volcanic activity.

The Hornonitrianske bane š.p. (Mines of Upper Nitra), at present, are producing approximately 2.8 million tons of coal and lignite. The Baňa Cígeľ production is 29%, Baňa Handlová 31% and Baňa Nováky 40% of the total respectively. The Cígeľ and Handlová mines produce brown coal, and Nováky mine lignite. All coal production has been used for power generation and chemical processing.

The Nováky coal can be chracterized by the following facts: 1. highest caloricity value in main coal seam was found in its central part; 2. rocks sulphur contents were shown to increase with depth; 3. sulphur contents in volcano-sedimentary rocks are nearly half, when compared with coal; 4. As contents, when compare to sulphur, decrease with depth; 5. contents of other harmful elements, F and Cl, in coal and in overburden are approximately the same and do not show significant changes with depth; 6. Fe contents in volcanosedimentary rocks are approximately double when compared to the coal and in coal and overburden there is increase with depth ; 7. in lateral element distribution, to As, S, Fe decrease to the north of deposit; 8. F contents in the deposit are more or less homogenous and Cl levels show moderate tendency to increase towards the centre; 9. increased S content in the seat rock, in part can be results from the gypsum concentration, its occurrence increases in the seat rock.

***Key words*:** coal basin, coal deposit, coal bed, maceral group, vitrinite reflectance, coal geochemistry, coal bed mineralization, element distribution, soil types, geochemical mapping

Introduction

Handlovsko-novácka basin (the coal basin of Handlovská-Nováky) is located in the Horná Nitra (Upper Nitra) region. From the hydrological view the region belongs to Nitra River catchment basin, and most significant tributary is Handlovka River. Near city of Prievidza, there is thermal spa, Bojnice, of national significance. The Horná Nitra Region is highly industrialized, dominant industries are mining, power generation and chemical production, respectively. Long-term industrial activities of the region caused environment deterioration of the soils, water and atmosphere. Therefore the Upper Nitra region was included in Slovakia environmental policies that included "hot spot regions" with emphases on immediate landscape revitalisation.

Geology of the Handlová-Nováky coal basin

Nováky brown coal of is in the Handlová-nováky coal basin. The basin is located in central Slovakia in the intramountainous basins of Western Carpathians. The Nováky deposit is most significant brown- coal resource in Slovakia.

The basin basement rocks consists of crystalline rocks of Choč and Krížna nappies and melaphyre series. This is overlain by sedimentary rocks of the Subtatra Group of Central Carpathian paleogene. The sedimentary rocks consists of mudstone, flysch and sandstone. The upper Paleogene is missing due to denudation. In the northern part of the basin, lower sediments unconformably overlie the Paleogene.

The Neogene sedimentation began in Baden with conglomerate beds that represent immediate underlying productive layers. It consists of epiclastic volcanic conglomerates and sandstones with irregular to lentil-formed bedding.

Coal-bearing sediments are represented by the Nováky and Handlová beds of Sarmatien age, respectively. There is one developed coal bed in Handlová part, while in the Nováky, there is the so called main coal bed, with a thickness of about 10 m (Petrik - Verbich, 1995). The coal bed are autochtone and they often contain tonsteins and carbonaceous shale partings. The coal beds in the Handlová have complicated tectonic structure, while in the Nováky deposit there is overwhelming germanotypic structure (Petrik - Šimeček, 1988). The faults general trend is N-S with minor faults displaying a NE-SW direction, only in northern part of the Nováky deposit is the trend of the faults NW-SE dominate.

Coal-bearing overlying rocks consist of claystone and marls beds of the Koš that in Nováky deposit consist of diatomitic claystone. In higher stratigraphicly rocks there is a deposit, consisting of detritic-volcanic rocks of the Lehota group. In the Handlová deposit overlying the Lehota group are deposits volcanism related to the of Vtáčnik mountains. They are consist of flows of andesites and pyroclastics.

Coal - petrographic characteristic of coal beds

The coal beds of Nováky contain the following coal lithotypes, in order of importance: detritic, xylitic-detritic, xylitic, detritic-xylitic and mother of coal. The dominate maceral group in the coal is huminitic, represented by humotelinite, humodetrinite and humokolinite. Other maceral groups identified included liptinite (kutinite, suberinite, rezinite) and inertinite (inertodetrinite, fuzinite and sklerotinite).

Vitrinite data the coal Nováky bed is consistent with the brown-coal stage of the coalification with medium vitrinite reflectance: R_0 = 0.275%. The coals from the Handlová deposit, influenced by overlying volcanic rocks, have higher coalification with a medium reflectance of vitrinite: R_0 = 0.324%.

The mineralogy of the Nováky coal beds

Is a predominance of clays tonsteins, tuffite, quartz, sulphides of iron and arsenic, and dolomite. Iron sulphides (pyrite, marcasite) most have form of micronodule. Arsenic sulphides (realgar and auripigment) occur at discontinuity areas (layered areas, dilatation cracks, dislocations) and are related to the Vtáčnik volcanic event (Petrik - Šimeček, 1988).

Within the geochemical-ecological survey of the Nováky coal deposit (Vrána et al., 1991) were in coal identified following minerals by means of RTG-analysis, optically mineralogy and spectrochemically analysis:

- silicates - plagioclase and K-feldspar, biotite, chlorite, muscovite, pyroxenes, amphiboles, garnets, clay minerals (mainly kaolinite, illite, minor halloyzite and montmorillonite), hydromicas;
- carbonates - calcite, siderite, manganocalcite;
- phosphates - apatite (?), rock phosphate;
- oxides - quartz, opal, limonite, magnetite;
- sulphides - pyrite, arsenopyrite, realgar, auripigment;
- sulphates - gypsum, anhydrite, melanterite.

From mineralogical research results of the Nováky coals reveal autigenous and allogenous minerals, and detrital minerals, or minerals of the hypergenous zone.

Geochemistry and chemical-technological characteristics of coal

Coal geochemistry of the Handlová-Nováky coal basin has been object of intensive study since 60's. Over the years, various analytical methods were used, and various element suites were investigated.

Petrik (1964) performed 102 coal analyses and 32 samples by qualitative spectral analyses. From the coal analyses he revealed that sulphur contents in the Nováky coals of ranged from 1.81-11.57% with the modal interval 3-5%.

Mecháček-Petrik (1967) studied coal bed geochemistry from Handlová-Nováky coal basin. Based on 400 semiquantitative spectrochemical analyses of coal sampled from the Handlová, Cígeľ and Nováky mines, element contents were classified in following groups:

- amount above 1%: Al, Ca, Fe, K, Mg, Si, rarely Ba, Na;
- 0.01- 1%: Ba, Mn, Ti, rarely Be, Na, Sr;
- 0.01% - traces: B, Be, Mn, Sr, Ti, rarely Ag, As, Ba, Co, Cr, Cu, Mo,Ni, Pb, V, Zn;
- rarely or only in some areas, most only in trace contents: As, Bi, Cd, Ga, Ge, Li, Sb, Zn, W.

Mecháček (1975) studied qualitative and quantitative trace elements distribution and their relationships in the coals from Tertiary basins of Slovakia. For the Nováky some very high contents of B, Ba, Sr a Ge (Tab. 1), a statistical correlations of the elements resulted in the following values: Ni/Co = 0.8, Ba/Sr = 0.9, B/Ba = 0.6, B/Sr = 0.7, B/Cu = 0.5, B/Ni = 0.5, V/Ni = 0.7, V/Cr = 0.5, V/Co = 0.6, V/Cu = 0.6, Cu/Co = 0.7.

Table 1: Statistical characteristics of trace element distribution in coal (ppm)

Element	Minimum	Average	Maximum	Median
B	20	1665	3200	150
Ba	100	1170	3000	800
Sr	70	965	3000	490
Ni	5	25	90	20
Co	2	10	80	10
V	10	125	740	80
Cr	5	35	360	20
Cu	5	50	280	35
Pb	-	56	310	-
Ge	-	15	170	-
Mo	-	22	70	-

Petrik -Šimeček (1988) studied elements distribution and compared the three parts of the Handlová-Nováky coal (Tab. 2), whereby the Nováky deposit was based on the average highest concentration: Sr, Ge and Pb, respectively. The authors studied coal petrographical composition, carbonization rate, and mineralogy of the coal bed. Main significance is of their study regional resource characteristics, petrographical lithotype and the influence of hydrothermal solutions.

Table 2: Mean trace elements values (ppm)

Element	Handlová	Cígeľ	Nováky
B	2300	1890	1600
Ba	1620	1300	1300
Sr	880	740	1250
Cr	90	73	45
V	440	195	210
Ni	100	75	30
Co	50	20	20
Ge	?	?	10
Cu	205	150	65
Pb	30	25	55
Ag	traces	traces	traces
Sn	15	34	12
Mo	40	24	22

Halmo, J. et al. (1991 in Vrána et al., 1991) studied the distribution of As and S in coal from Nováky in 73 exploratory wells, drilled during 1977-1990 survey. The authors concluded the following As distribution heterogeneity:

- As content is highest in a coal uppermost part and it is decreasing towards bottom (24 boreholes). As highest content was in the borehole Z-309 - 3.64%. As contents maximum contents
- occur near the roof rocks contact and ranged from 0.1% to 0.3% and rarely 0.06-0.07%.
- As content is lowest in a seam upper part and increases towards underlying bed: 7 boreholes. This is contrary trend, when compared to above case. This type of trend in vertical As distribution is less frequent in the Nováky deposit. Below the roof rock contact As values range 0.01-0.04%, and above seat rock As ranges from 0.1 to 0.14%.
- As content is nearly uniform throughout the coal bed profile: 17 boreholes. This distribution type should be used for the boreholes, where is not possible to follow the change in As content in vertical direction. As determined contents range in interval 0.03-0.14%.
- As content maximum is below the roof rock contact, and from it decreases both towards the seat rock and roof rock - 25 boreholes.

As content in coal of the Nováky deposit, with some exceptions, decreases from the roof rock to the seat rock. Sulphur content show similar trends in vertical distribution.

Vrána et al. (1991) using geochemical, mineralogical and ecological research tools studied both chemical element and their lateral distribution. Element contents were determined by AAS method. Based on lateral variations elements can be classified in following six groups:

- The element contents decrease in N and NE directions from the deposit with no distanced local maximums and minimums in central and northern parts of the deposit - As, Ba, Cr, Fe, Ge, S, and Sr.
- Increase in NE direction - Mn.
- Increase in W direction - B, Cd, Cu and Pb.
- Medium growth in direction towards the deposit center - Cl.
- Medium decrease towards the center of deposit with no distanced marked local maximums and minimums - Hg, Mo, Ni, Sb, Se, V, and Zn.
- No visible trends of the elements - F, Sn.

Element distribution mean values and caloricity values in the vertical direction of a coal bed and interstratified beds are documented in Table 3. Distribution character of ecologically most sensitive elements in "main coal" bed is summarised in Table 4, and from it is very clear their distribution is high variability at coal bed average thickness of 8.35 m.

Mean content of S in Nováky coal is 3.4%. Lowest S content are in upper part of coal seam (3.03%) and they increase with depth to 3.17% in middle part of the coal bed, and 3.76% in bottom part. Mean S contents in the volcanoclastics, when compared with coal, are nearly 1.77%, and lowest in interstratified beds of "main coal" bed (1.25%). Sulphur content in the volcanoclastics also moderately increase with depth.

From genetic view sulphur in the Nováky coal deposit can be divided into four basic types:

- sulphide-S, mainly pyrite, less realgar and auripigment;
- sulphate-S, mainly gypsum, less anhydrite and melanterite, into this group is included sulphur precipitated from sulphate and water (liquid) phases;
- organic-S;
- elementary-S, a product of secondary pyrite decomposition.

Arsenic: mean As content in the Nováky coal is 900 ppm and in interstratified beds is 941 ppm. Minimum and maximum As contents for coal are 249 a 3137 ppm, with most analysed samples in the range 600-800 ppm (31 samples). As contents are related with sulphide minerals (realgar and auripigment, but there is an assumed on organic matter). With depth, As content in the Nováky coal decrease from 1121 ppm in the upper part of the coal, 880 ppm in the central part, to 770 ppm in bottom part. In roof rock of "main coal" bed mean As content is 522 ppm. Similarly As decreases with depth and also occurs in terrigene-volcanogenic interstratified beds.

Caloricity: the mean value of the Nováky coal is 12.08 MJ. The coal from the "main coal" bed central part has highest caloricity - 12.30 MJ and in direction to roof stone and seat rock id decreases in 0.64 or 0.72 MJ, respectively in the coal of the underlying seam the heating value is 9.95 MJ.

Hydrogeochemical studies of the Nováky deposit mine-water showed that water chemistry has following

Table 3: Mean values of selected elements and coal heating value in the Coal deposit of Nováky

Units	N	Q	S	As	F	Cl	B	Hg	Cd	Pb	Se	V
	MJ	%	ppm									
1	154	11.86	3.29	860	659	56	270	0.06	0.13	4.52	0.14	50.0
2	138	12.08	3.24	900	663	57	280	0.06	0.12	4.25	0.14	46.0
3	21	11.66	3.03	1 121	664	54	277	0.06	0.11	7.74	0.15	39.0
4	94	12.30	3.17	880	667	54	296	0.05	0.12	3.67	0.14	45.1
5	23	11.58	3.76	770	652	75	217	0.07	0.14	3.60	0.13	56.9
6	16	9.95	3.66	522	614	42	180	0.08	0.17	6.50	0.17	79.7
7	27	3.00	1.77	941	668	62	137	0.08	0.16	8.60	0.29	87.9
8	7	2.53	1.25	1 375	741	70	95	0.05	0.17	10.40	0.33	33.6
9	10	3.60	2.25	336	575	38	147	0.10	0.14	8.40	0.33	121.0

Units	Cr	Ge	Cu	Sr	Ba	Zn	Mn	Fe	Sb	Mo	Sn	Ni
	ppm											
1	8.00	3.0	8.10	170	170	32	249	10 329	0.14	3.0	1.0	9.00
2	9.00	3.0	7.10	186	178	32	225	8 844	0.14	2.7	1.0	10.00
3	11.00	7.7	7.80	78	168	25	253	6 721	0.16	3.1	1.0	15.00
4	7.70	2.2	6.50	243	190	29	217	7 716	0.14	2.6	1.0	7.50
5	9.40	2.7	8.70	50	146	51	227	12 468	0.11	2.4	1.0	13.00
6	5.20	3.9	16.30	35	87	34	464	23 246	0.09	1.2	1.0	4.00
7	14.80	3.2	16.40	250	209	48	289	16 079	0.20	2.3	1.3	18.70
8	9.10	1.0	11.70	643	478	42	295	12 508	0.30	1.0	2.8	7.10
9	20.60	5.7	18.60	148	129	53	252	20 438	0.12	2.0	1.0	26.90

Notes: 1 - coal total, 2 - coal. main coal seam, 3 - coal. main coal seam upper part, 4 - coal. main coal seam central part, 5 - coal. main coal seam bottom part, 6 - coal. seat rock of main coal seam, 7 - terrigenic-volcanogenic cliffs total, 8 - terrigenic-volcanogenic cliffs of main coal seam, 9 - terrigenic-volcanogenic cliffs in seat rock

Table 4: Elements of environment concern in main the coal seam (N = 138)

Parameter	S	As	F	Cl	B	Mn	Fe	Zn	V	Ba
	%	ppm								
Minimum	1.59	249	364	13	65	25	569	7	1	1
Mean	3.24	900	663	57	280	225	8844	32	46	178
Maximum	8.25	3137	1420	386	684	813	51528	365	213	1627
Standard Deviation	0.79	504.8	197	53	121	122	6714	39	42	210

character: Ca-Mg-HCO_3, Na-HCO_3, Na-Ca-HCO_3. The mine-waters are lower in sulphate, and therefore in the silicate-hydrosilicategenous water group.

Elements of ecological concern (Ni, Se, Sr, Co, Cd, Pb, Hg) are mobilized only slightly by ground water and their concentrations in ground water are below limits defined by the drinkable water standard. Studies revealed that As contents, predominantly in pore-water reach values that are higher than the standard. There is only mobilization of Zn and Cu in ground water. Concentrations of Sr, Fe, Mn and Al have heterogeneous and from ecological point of view, introduce no serious problem.

Because of the possible future use of Handlová-Nováky basin coals utilizing new technologies and developing new products mean values of selected chemical and technological parameters are given in Table 5 (Boroška, 1995).

Coal exploitation and use

The Nováky coal deposit is located in the western part of the Upper Nitra basin and has a total area 37 km^2. The Nováky coal deposit was discovered during 1937-1938. In 1937, V. Čechovič mapped the Čausa's formation (eggenburgien) towards to the west Nováky deposit. Based on this information he came to the conclusion that of Nováky area should contain an independent coal deposit and it should be a thinness extension of the deposit of Handlová. Drilling started in 1939 under Mr. Čechovič leadership and confirmed the existence of the coal deposit (Halmo - Verbich, 1995). The coal rights, in the mineral territory of Nováky, were obtained Handlovské uhoľné bane, mining company in March 27, 1940, when first inclined shaft started to be driven.

Brown coal production in the Nováky deposit in period 1940-1994 is shown in Figure 1. Exploitation steadily increase, reaching a maximum in 1964 (1943.9 kt). Since 1964 exploitation decreased until 1980 (1256.2 kt), and then it increased gradually until 1985. Since 1985 exploitation has permanently decreased. During the exploitation history of the Nováky deposit three deep mines have been in operation: the Mine Youth (1940-42, 1948-presence), the Mine of Peace (1942-1977), the Mine Le-

Tab. 5: Coal quality parameters and major oxides for the Handlová-Nováky coal basin

Parameter	Symbol	Unit	Cigeľ mine	Handlová mine	Nováky mine
Caloricity	Q_i	MJ/kg	11.56	12.90	10.70
Water	W^a_t	%	20.70	24.32	33.90
Ash	A^a	%	15.20	33.90	7.00
Volatile substances	V^{daf}	%	55.60	55.04	57.62
Arsenic	As^r	ppm	62	67	590
Sulphur total	S^r_t	%	1.35	1.36	1.99
of it: organic	S_o	%	0.79	0.82	0.83
sulphatic	S_{SO4}	%	0.11	0.10	0.10
pyritic	S_p	%	0.47	0.44	1.06
Sulphur in ash	S_A	%	0.31	0.13	0.69
Sulphur volatile	S_C	%	1.04	1.23	1.30
Carbon	C^{daf}	%	63.5	62.9	59.5
Hydrogen	H^{daf}	%	8.86	8.09	9.66
Nitrogen	N^{daf}	%	5.36	6.71	5.74
Oxygen	O^{daf}	%	26.32	24.38	27.31
Ash					
SiO_2		%	45.6	50.4	44.2
Al_2O_3		%	18.6	17.4	19.8
Fe_2O_3		%	13.8	12.0	12.3
CaO		%	8.6	5.3	8.7
MgO		%	4.3	3.2	4.8
Na_2O		%	0.67	0.95	1.04
K_2O		%	1.71	1.69	1.92
Start of caking	t_s	°C	900	960	925
Point of softing	t_A	°C	1220	1200	1200
Point of melting	t_B	°C	1295	1360	285
Point of flowing	t_C	°C	1310	1310	1280

hota (1952-1993) and one surface mine Lehota (1980-1988).

The Hornonitrianske bane š.p. (Mines of Upper Nitra) is producing approximately 2.8 million tons coal and lignite. The Baňa Cígeľ mine production is 29%, Baňa Handlová 31% and Baňa Nováky 40% of the total respectively. The Cígeľ and Handlová mines produce brown coal, and Nováky mine lignite. All coal production has been used for electric-power generations both small-scale and large-scale (mainly ENO Power Station, Zemianské Kostoľany), and chemical processing (Chemical works, Nováky). Nováky coal was exported to Schweiz during period 1943-1944 and was used mainly for chemical processing (Boroška, 1995).

Physiography of the Upper Nitra region

The Prievidza region is a partly closed basin with the south side open and by Nitra catchment basin connected with Nitra Basin. Considerable area is occupied by the Strážovské vrchy mountains, as well as the mountains ranges of Vtáčnik, less Malá Fatra, Žiar and Kremnické vrchy and Tribeč. Climatic conditions are represented by three climatic zones (warm, medium warm, and cool ones). Average annual temperature is 8.5°C with a annual precipitation of 685 mm. The region covers is 960 km^2 which is less than 2% of total Slovakia. Population of the region is 140 000 with a population density 147 inhabitants per km^2.

The region can be characterized as 37% agricultural and 53% forest. Natural soil conditions are normally, level and markedly differentiated. The agricultural land is suitable for cereals (20%), and for fodder crops (19%).

The existence of coal and the natural resources have influenced the region and changed it from agricultural to industrial. With this change power stations, chemical plants, engineering industry, production of constructional materials, shoe industry, textile industry, and other processing plants have developed in the region. Rapid growth of industry has also influenced the region (employment, dwelling construction, services, etc.), however their environmental influence has been negative.

Soils and their geochemical characteristics

Soil character and development in Upper Nitra region are controlled by geological structure, hydrological, and geomorphological conditions. Thirteen soil types have been identified in the region (Ranker, Rendzina, Pararendzina, Phaeozem, Orthic Luvisol, Albic Luvisol, Eutric Cambisol, Mollic Andosol, Podzol, Pseudogley, Gley, Fluvisol, Kultisol) with several forms and varieties. Most common are loamy soils, sand-loamy soils, and silty soils. Most productive agricultural soils (Fluvisols, Luvisols, Cambisols, and Pseudogleys) are protected in the region. Landscape morphology has marked influence on

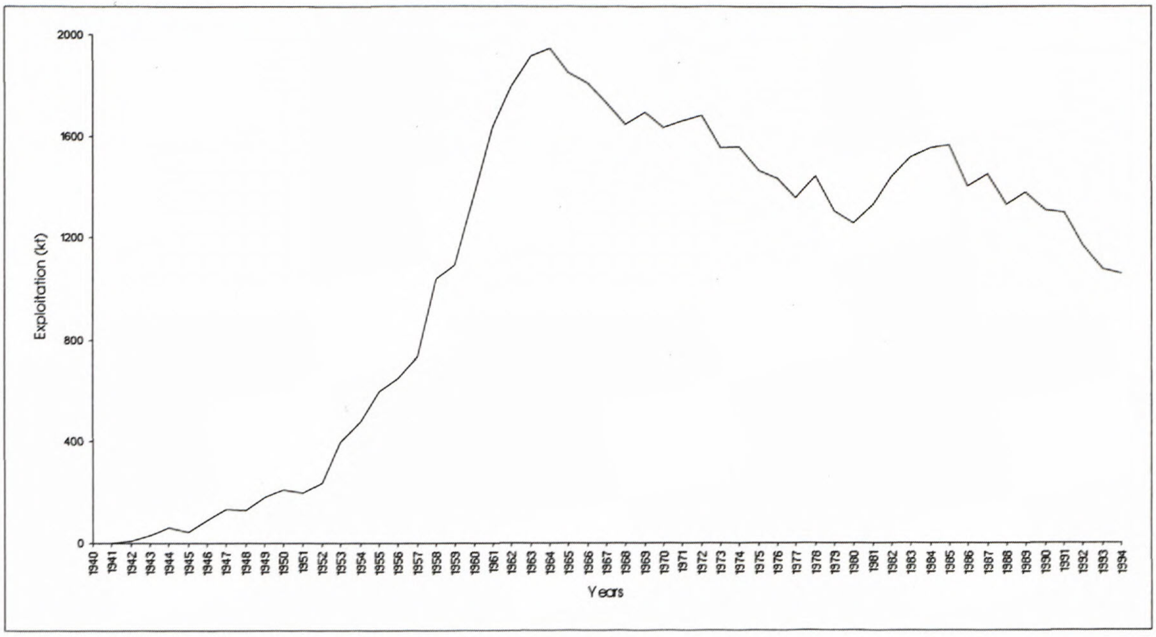

Figure 1: Coal production history for the Nováky mine

water erosion. Erosion risk in Prievidza county has been evaluated and listed below (Čurlík et al., 1993):

- week and medium erodible soils - 42.3%
- severely erodible soils - 16.5%
- very severely erodible soils - 4.7%.

Landslide have been delineated in the areas of Handlová, Chrenovec, Veľká Čausa and Malá Čausa, and is related to natural conditions (geological structure, hydrology and morphology of territory) and for land use.

The Prievidza region industrialisation has also effected on farming land use. Their acreages are permanently decreased due to mining activities, building up coal processing measures, construction of setting pits, and pit spoilpiles and to soil contamination with risk elements of organic and inorganic character.

Čurlík - Šefčík (1994) studied 60 Slovakian soil profiles and sampled the A and C horizons for analyses for total content 36 elements. Statistical analysis of risk elements contents (Tab. 6) conformed that soils of the region are enriched in A horizon, or contamined with elements As, Cd, Cr, Cu, Mo, Pb, Sb, and Zn, when compared to C horizon. On average risk elements contents do not exceed the limits given by legislation (MP SR, 531/1994-540), but some partial values of the set exceed the limits. This contamination results from processing technology and the coal utilization from the Handlová-Nováky basin. It is interesting that fluorine and mercury contents in C horizon are relatively higher than in A horizon and is the result of the mineralogical and petrographical composition of soil substrata.

Main direction of economical and social development of the region with aspect to environment

In agricultural and food industry it will be necessary, with aspect to ecological load of the region (38% farming land), to develop new guidelines for specific types of farming focused on special crops for industrial processing. Concrete possibilities are in winter rape and its processing to bionafta. Its should be oriented mainly to the farms focused on alternative farming types, to protected areas of water management, and for local transport vehicles.

Conservation of soil, forest and rock environment needs to reduce large-scale production of food crops in areas with chemical contamination (Nováky-Oslany). Similarly is desirable to look for a solution of the exploited coal mine lands used in the region and to implement revitalisation of the region disturbed by mining activities and areas eroded after deforestation.

Atmosphere purity will be conditioned by environmental constructions implemented by the ENO Zemianské Kostoľany. With these new additions marked reductions of SO_2 and nitrogen oxides emissions, and ashes; significant reduction of As, Cl, F and other risk elements. Similarly modernisation and new technologies application manufacture processes of the Chemical works, Nováky are planned and will reduce emissions of heavy metals, volatile organic substances, solid substances, and Cl and freons.

With the substantial increase of water pollutants there is a need to reduce pollution of waters by implementation of cleanwater technologies.

An important task will be the design of a waste economy, both from qualitative and quantitative aspects and increased waste recyclation. Main problem are ashes and other wastes from electric power plants and district heating plants, wastes from the building industry, and raw material exploitation, wood industry, rubber industry, and chemical industry.

Conclusions

From qualitative point of view the Nováky coal most important are characteristic the following:

Table 6: Distribution of elements in Prievidza region soils

Descriptive Statistics of A-horizon	Trace elements (ppm)													
	As	Ba	Cd	Co	Cr	Cu	F	Hg	Mo	Ni	Pb	Sb	Se	Zn
Mean	20.8	383.5	0.5	10.4	68.3	17.8	380.0	0.2	0.7	23.8	34.1	1.1	0.1	78.0
Median	16.2	397.0	0.5	10.0	70.0	15.5	300.0	0.1	0.5	19.0	29.5	0.8	0.1	72.0
Mode	11.2	399.0	0.2	10.0	90.0	14.0	150.0	0.1	0.5	24.0	26.0	0.9	0.1	57.0
Standard Deviation	15.3	104.0	0.3	3.7	25.0	8.4	382.7	0.1	0.7	18.0	18.4	0.8	0.1	38.1
Minimum	3.9	103.0	0.1	3.0	18.0	6.0	150.0	0.0	0.1	0.5	13.0	0.3	0.1	26.0
Maximum	90.0	587.0	1.7	21.0	130.0	44.0	1850.0	0.8	4.5	. 100.0	90.0	4.2	0.4	199.0
Count	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Descriptive Statistics of C-horizon	Trace elements (ppm)													
	As	Ba	Cd	Co	Cr	Cu	F	Hg	Mo	Ni	Pb	Sb	Se	Zn
Mean	28.3	396.5	0.3	11.3	71.2	17.6	454.0	0.1	0.6	28.0	18.2	0.7	0.1	65.4
Median	7.1	417.5	0.3	10.5	67.5	15.0	300.0	0.1	0.4	21.5	14.0	0.5	0.1	52.0
Mode	1.7	289.0	0.2	7.0	61.0	11.0	150.0	0.1	0.1	25.0	11.0	0.3	0.1	48.0
Standard Deviation	128.1	143.6	0.3	4.6	26.9	11.0	442.7	0.5	0.7	24.8	11.1	0.8	0.1	39.2
Minimum	0.9	135.0	0.1	3.0	11.0	2.0	150.0	0.0	0.1	0.5	8.0	0.1	0.1	24.0
Maximum	913.0	829.0	1.2	22.0	143.0	52.0	2000.0	3.4	3.6	124.0	54.0	4.9	0.4	248.0
Count	50	50	50	50	50	50	50	50	50	50	50	50	50	50

- highest caloricity in the "main coal" bed was found in its central part;
- sulphur contents were shown to increase with depth;
- sulphur contents in volcano-sedimentary overburden are nearly half, when compared with coal;
- As contents, contrary to sulphur case decrease with depth;
- contents of other harmful elements, F and Cl, in coal and in overburden are approximately the same and do not show significant changes with depth;
- Fe contents in volcanic - sedimentary overburden are approximately twice as much in the coal when compared for the overburden and both increase with depth ;
- lateral element distribution of harmful As, S, Fe decrease to the north of deposit;
- F levels in the deposit are more or less homogenous and Cl contents show moderate increase towards the centre;
- increased S content in the seat rock of coal seam may partly result from the gypsum concentration, its occurrence increased in seat rock.

According to the present ecological situation in the Upper Nitra region national environmental politics in the future should be focused on:

- atmosphere protection against pollutants and global environmental security;
- to secure drinkable water abundance and reduction of remaining water pollution under acceptable rate;
- protection of the soil against degradation and the prevention food contamination as well as other products;
- waste origination minimisation, recyclation and hygiene;
- biological diversity conservation, natural resources rational use and conservation, spatial structure optimisation, and optimum land use.

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