Auxiliary sciences in archaeology, preservation of relicts and environmental engineering.
CD – No. 16, Ed. M. Pawlikowski

Identification of sandstone-related rocks composition using the X-ray analysis

Marián Košuth

Institute of Geosciences, Faculty of Mining, Ecology, Process Control and Geotechnology (B.E.R.G.), Technical University Košice, Park Komenskeho 15, 042 00 Košice, e-mail: Marian.Kosuth@tuke.sk

Abstract. *The article presents knowledge based on investigation of sandstones or siltstones composition from the Paleogene flysch terrains in North-East Slovakia. Samples of frequently crumbling clastic rocks were commonly considered to be close to sandstones, composed by predominant quartz. The set of such samples, belonging to Dukla Unit Sandstones were analyzed using the XRD analyses. Beside of quartz the diffraction patterns gave the evidence in significant carbonate share with some minor to minute feldspars, mica and chlorite contents. Among majority of analyzed samples we distinguish three groups of sandstones: (1) with the abundant calcite admixture, (2) the sandstones which contain meaning dolomite portion. The group (3) is representing the samples is formed the same by quartz as by both of carbonates, each of them could form important up to prevailed mineral component. Comparison of analyzed samples mineral composition shows remarkable trend of higher calcite and dolomite contents in younger clastic sediments.*

Key words: *X-ray analysis, mineral composition, sandstones, siltstones, calcite, dolomite*

Introduction

Clastic sedimentary rocks of higher or lower compaction are the predominant rock group, forming North-Eastern geological units of Western Carpathians. Beside the wide belts of flysh terrains, forming the main highland range along the Slovak-Polish border, included the lateral ranges and valleys, they shape Inner-Carpathian Paleogene units *(Koráb & Ďurkovič, 1978)* and also sedimentary infilling of the Eastern-Slovakian Neogene basin. This article is focused to the mineral composition of prevailed clastic quartzose rocks, usually labelled as sandstones or siltstones and thesignificant contribution of X-ray diffraction method to their determination. Using this analyses can be principal for the mineralogical investigation, event. for further structural research. It enable us relatively clear evidence in determination of rock of frequently hidden mixed-up composition, which is more miscellaneous and variegated in mineral contents. Just the case of studied samples, considered in a general way to be a classical sandstone or siltstone, it has brought us numerous surprising results and would allow widening present knowledge, same as the next-step interpretation. This article presents only a few representative examples of X-ray diffraction patterns, picked up among the analyses records of visually similar samples. These could serve as typological one with the exact determination of arenite rocks´ variegated mineral composition, filled up with subsequent overall, but framing quantification (*Johan et al, 1970*).

Studied samples of clastic sedimentary rocks

Dukla flysch units terrain spread along both sides of Slovak - Polish border, forming the huge rock formations of variously sorted and consolidated detritic sediments and rocks (*Żelaźniewicz et al, 2011)*. The same but incoherent sedimentary infilling is typical for the Inner Carpathian Paleogene basin across the Northern Slovakia. By a geologists´ traditional opinion, the composition of these regionally extended beds is considered to be relatively simple and unvaried, built of quartzy sandstones and/or of siltstones above all. Petrographically they are close to arenite or greywacke. Apart of predominant quartz usually expects itself some minor thin mica (muscovite) admixture, with the clay minerals in addition. The arcose arenite contain a feldspar portion too. The such a common composition of classical type sandstone exemplifies the X-ray analysis record, which was performed of quite finegrained sample labelled DD-18, typical for the *Podmenilite layers* of Dukla unit (*Dirnerová, 2007*).

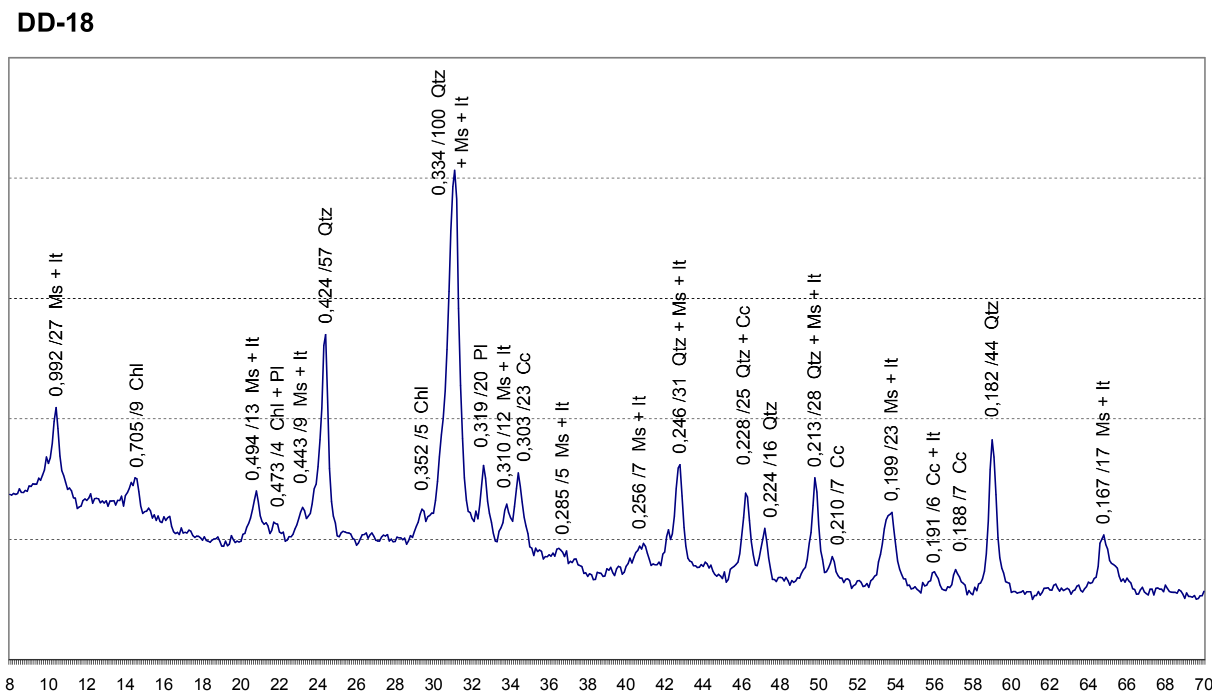

Fig.1. *X-ray diffraction pattern of typical siliciclastic arenite sample DD-18;*

The made out XRD analysis *(Fig.1)* clearly exhibits the low amounts of muscovite (*Ms*), and plagioclase (*Pl*), with scarce chlorite (*Chl*) admixture. To determine the share of chlorite group mineral has enabled its measured specific d_m reading of three low angle basal reflexes, calculated in sense of Bragg's equation. The main diffraction line 0,705 nm nearly collides here with the main kaolinite reflex of $d_m = 0{,}718$ nm, however the structure of chlorite differs by very slightly lower basal (002) interplanar distance. The presence of chlorite in studied sandstones was confirmed also by diffraction patterns of another siliciclastic sediment samples even with the initial 1,4 nm peak (001). The DD-18 sample contains some accessory calcite admixture too, assumed to be a younger cementing component. As a questionable we consider here an illite (*It*) impurity – because of its structurally resembling diffraction pattern to muscovite - sericite.

The X-ray research of clastic sedimentary rocks with carbonate share

The powder X-ray diffraction analysis we consider to be a powerful assement tool for the sandstones and siltstones components identification, especially in case of its finegrained detritus and lower compaction. Despite of its objective character, it do not belong to methods, utilized by petrographers. In case of siliciclastic sedimentary rocks this one can be very useful because of delimited thin section microscopic investigation, which require specific preparation (indurations need) and section accustomed problematic grinding. Opposite to this, measured X-ray data of powdered sample explicitly show to even hardly distinguishable rockforming minerals and compared intensities of its main diffraction lines enable quick informative quantification from the same X-ray diffraction pattern. It also permits next-step exact determination of even very fine heavy minerals, partially concentrated from the floated off sediment.

Samples studied within our study were taken from the *Cisnianske* layers (*Senonian*), belonging to so called *Beneath-Menilite* group layers (Eocene). Some has appertained also to *Cergowa* layers (*Early Oligocene*) of the wider *Menilite* group layers of Dukla unit (*Dirnerová, 2007*), forming a huge part of Slovak and especially Polish side of Carpathian flysh belt (*Żelaźniewicz et al, 2011)*. By sampling works at overall were taken 11 samples of finegrained to medium grained clastic rocks, visually determined as sandstones composed mostly of quartz, with disseminated muscovite tiny flakes. Predominance of quartz was proved explicitly in all analysed samples. Among the other silicate minerals, the sandstone samples analysed in our Institute laboratory contained both types of feldspars: plagioclase (*Pl*) same as K-feldspar: (*K-Fs*), with some phylosilicates of muscovite structure (*Ms, It*) and chlorite too. Along with them various, but usually significant contents of two or only one carbonate minerals were observed, represented by calcite and/or dolomite.

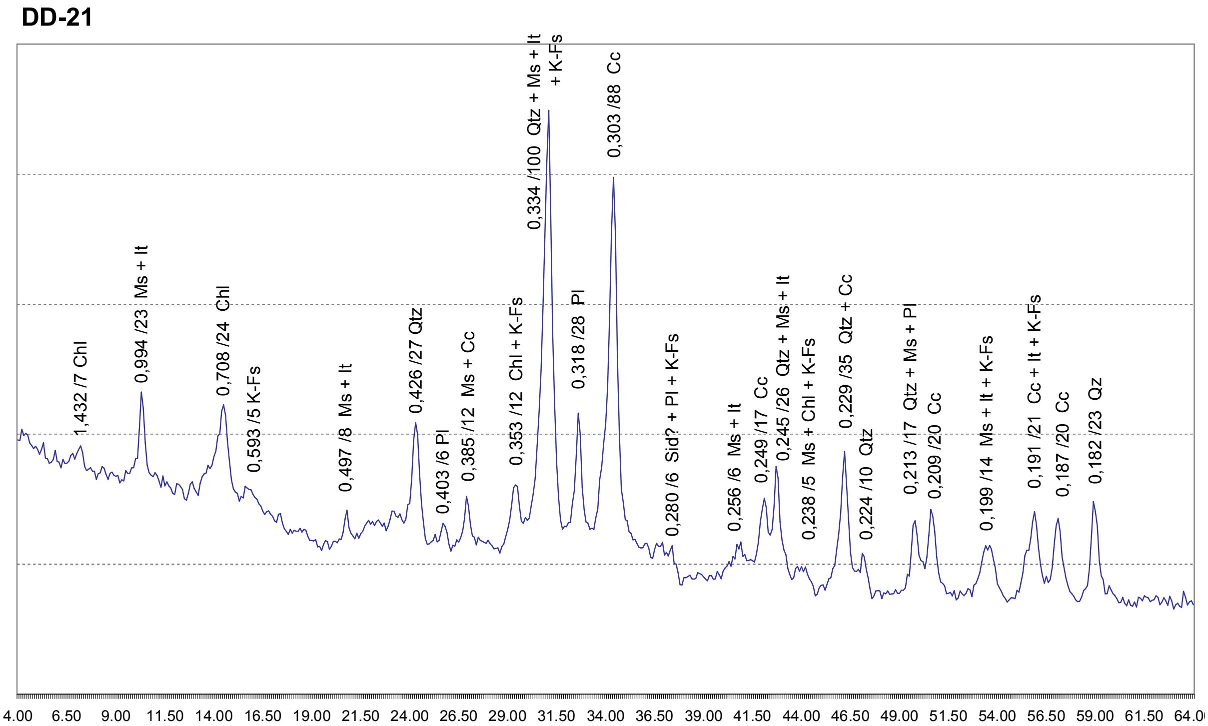

Fig.2. X-ray diffraction pattern of sample DD-21 with significant calcite portion;

The shown X-ray record of DD-21 sample (*fig.2*), coming from the *Beneath-Menilite* layers, exemplifies the composition of siliciclastic rock type with the distinct carbonatization. Clastic components of rock - apart of quartz (40,3 %) - were formed by plagioclase grains (5,4 %) too, with some muscovite and lithic particles of chlorite schists (each one about 5,5 %). We suppose also admixture of K-feldspar here. Calcite contents were calculated taking into account its high absorption coefficient under the used CoKα extinction. We assume its abundance at about 26 % contents level cannot be the consequence of the precipitated calcareous cement only, but apparently also of the limestone detritus form. Questionable phenomena on the composition represents parallel small siderite admixture.

The analogous group of compact siliciclastic rock samples represents here sandstones, eventually more finegrained siltstones, with meaning share of dolomite. By carbonate volume (*Weis - Chmielová, 1981*), they resemble to previously described samples with the high calcite contents. Such are the demonstrated sample DD-22, belonging to Cisnianske layers and the sample DD-34 from the Cergowa group layers, both of *Menilite* layers. The evaluated ratio of both these carbonate minerals bring near *tab.1.* Although we can notice mutual overlap of several minerals diffraction lines (*Ms, It, K-Fs*) in same angle 2θ position, as in case of main dolomite and quartz´ reflexes, we can belitle its influence onto peak’s intensities. Along with fundamental contents of quartz grains in a samples of visually saccharoidal character, presence of both carbonate we assume here mostly in a detrital form too – as a lithic clasts of dolomite rock up to dolomitic limestone.

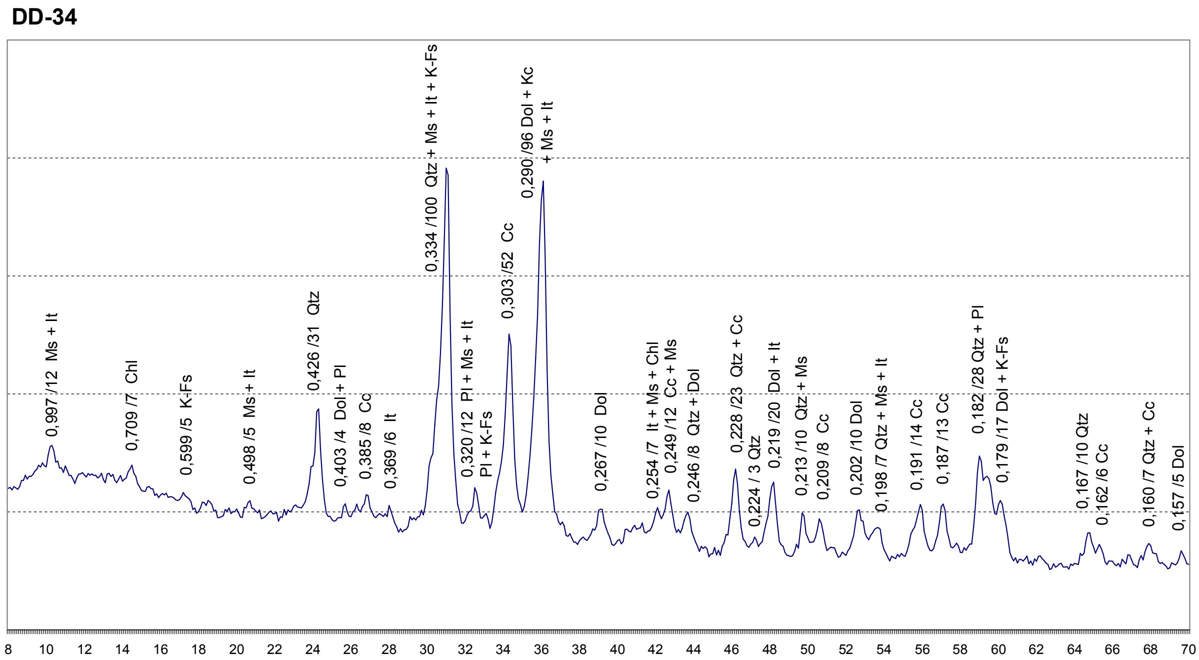

Fig.3. X-ray diffraction pattern of sample DD-34 with significant contents of dolomite

Tab.1: Evaluated contents of minerals, contained in analysed sandstone or siltstone samples from the Dukla unit.

Cisnianske group layers									
sample\mineral	***quartz Qtz***	***calcite Cc***	***illite Ill***	***chlorite Chl***	***muscovite Ms***	***kaolinite Kln***	***dolomite Dol***	***plagioclase Pl***	***K-Fs***
DD-22 (6)	30,3	33,9	-	2,7	4,3	-	22,8	3,0	-
Beneath-Menilite group layers									
sample\mineral	***Qtz***	***Cal***	***Ill***	***Chl***	***Ms***	***Kln***	***Dol***	***Pl***	***K-Fs***
DD-15 (3)	23,3	23,6	13,0	8,6	11,7	8,4	6,5	-	-
DD-21 (7)	26,6	46,3	-	7,2	7,2	-	-	8,2	-
DD-16 (4)	58,5	26,1	-	3,0	2,6	-	2,5	2,5	-
DD-18 (5)	56,2	20,7	-	3,5	5,2	-	-	-	9,6
DD-40 (14)	37,0	14,3	-	-	15,9	-	20,8	-	7,2
averaged	40,3	26,2	13,0	5,7	8,5	8,4	9,9	5,4	8,4
Cergowa group layers									
sample\mineral	***Qtz***	***Cal***	***Ill***	***Chl***	***Ms***	***Kln***	***Dol***	***Pl***	***K-Fs***
DD-24 (9)	26,7	28,2	-	7,4	9,7	-	16,0	7,4	-
DD-28 (10)	27,7	23,0	2,2	1,7	3,1	-	31,6	6,0	-
DD-34 (11)	25,8	26,8	-	2,0	3,3	-	33,2	3,1	2,7
DD-35 (12)	24,4	33,5	10,3	2,2	3,9	-	17,3	3,7	-
DD-38 (13)	31,4	25,6	9,8	-	6,4	-	13,7	8,3	-
averaged	27,2	27,4	7,4	2,7	5,3	0,0	22,4	6,8	0,0

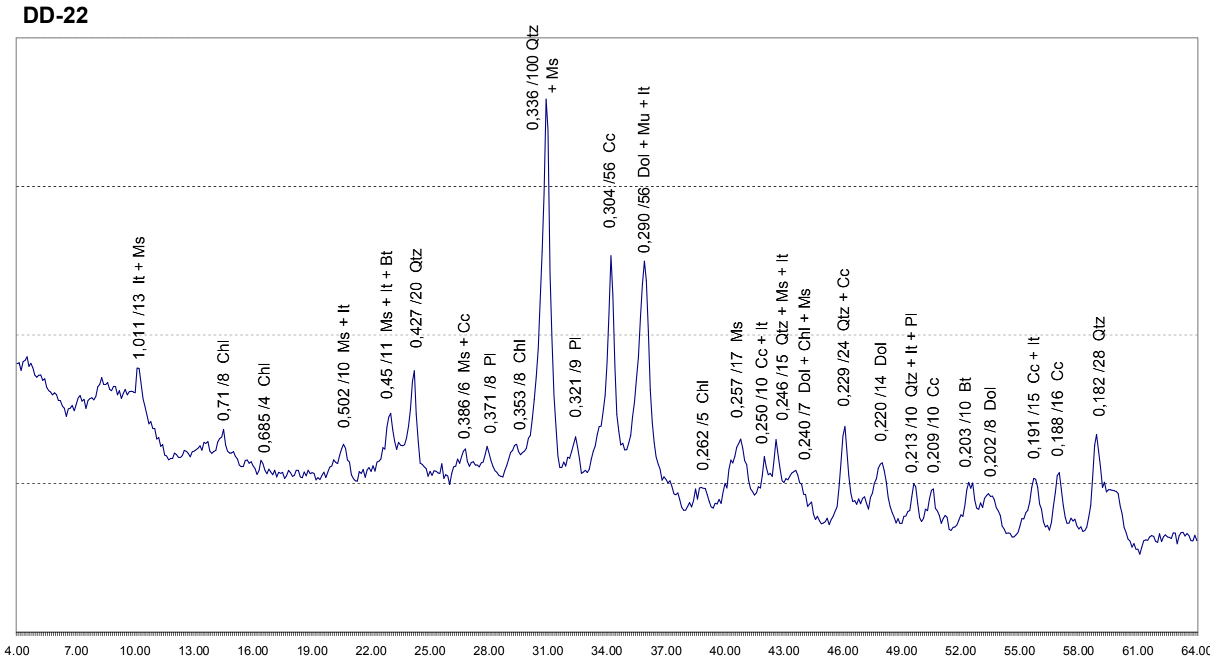

Fig.4. X-ray diffraction pattern of sample DD-22, contained distinct portions of dolomite and calcite too

Conclusion

The X-ray diffraction analyses of finegrained to mid-grained sandstones and siltstones, belonging to Dukla unit, the part of Flysh belt, has point out to frequent and significant carbonate minerals incorporation. Within the apparent sandstone rocks, formed by predominant quartz with minor plagioclase, muscovite and chlorite there were also kaolinite admixture registered too. The carbonatization phenomena express itself by increased to significant dolomite and calcite contents. But the contents of only one, or both carbonates, especially as much as in representative samples DD-34 or DD-21 we cannot interprete only as a consequence of intensive carbonate cement precipitation. More probably we consider its presence as a detrital component, that means the lithic clasts of limestome or dolomite rock here. The calculated contents of these minerals and its comparison (*tab.1)* indicate, the contents of calcite and dolomite – at the expense of quartz – is the higher, the younger analysed sedimentary rocks are. Fragments sampled from the younger layers allocate also the higher plagioclase contents, but lower chlorite share, in comparison with the samples from layers of older age. The diferences in mineral composition of analysed samples, especially calcite vs. dolomite prevalence are probably the result of diverse source territories, same as transportation length of sandstone detritus.

REFERENCES:

AMS, American Mineralogist Structure Data, webmineral com.

Johan, Z., Rotter R. and Slánský, E., 1970. Analysis of materials using the X-rays. SNTL, Prague, 1-249. *(in Czech)*

Dirnerová, D., 2007: Facial analysis of Dukla unit sediments around Starina locality, NE Slovakia. Diploma thesis. Faculty BERG of Technical University Košice, 1-111. *(in Slovak)*

Koráb, T. and Ďurkovič, T., 1978: Geology of Dukla unit (Flysh of Eastern Slovakia). GÚDŠ Bratislava, 1-194. *(in Slovak)*

Weiss, Z. and Chmielová, M., 1981. Modelling of X-ray diffraction patterns of selected carbonates and their mixtures. Čas. pro mineralogii a geologii, Prague, 26, 4, 371-387. *(in Czech)*

Żelaźniewicz, A., Aleksandrowski, P., Buła, Z., Karnkowski P.H., Konon, A., Oszczypko, N., Ślaczka, A., Żaba, J. and Żytko, K., 2011: Regionalizacja tektoniczna Polski, Komitet nauk geologicznych PAN, Wroclaw, 1-60.

Joint Commitee on Powder Diffraction Standarts (tabs JCPDS): Selected Powder Diffraction Data for Minerals. Swarthmore, Pensylvania U.S.A., 1974.

Acknowledgement :

This article was written thanks to the support of the Operation Program Research and Development for the Project 26220220031 co-financed from the sources of the European Foundation of Regional Development.