U-rich graptolite shales of Baltoscandia

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The formation of the Cambrian-Ordovician black shales extends from Sweden (alum shales) to Lake Onega, Russia. The marine graptolite shale (also known as Dictyonema shale, alum shale, black shale, graptolite-argillite) of the Early Ordovician age, underlies most of northern Estonia. It is a fine-grained, non-methamorphosed, organic-rich (8-20%) brown lithified clay belonging to the formation of black shales. The Estonian graptolite shale (GS) section ranges from less than 0.5 m up to 8 m (Osmussaare Island) in thickness [1].

GS is characterized by high to very high concentrations of uranium (up to 1000 ppm), molybdenum, vanadium, nickel and other heavy metals, and it is rich in N, S and O. Not much has been published about Estonian GS because it was covertly mined for uranium during the Soviet era. A total of 22.5 tons of uranium in 40-% chemical concentrate was produced from about 271 000 tons of the graptolite shale from an underground mine near Sillamäe between 1948 and 1952 [2]. During 1964 – 1991 approximately 73 million tonnes of GS was mined as a covering layer of phosphorite ore [2]. Geological reserves of GS in Estonia are estimated up to 70 billion tonnes. As GS is also a low-grade oil source, the potential reserves for oil are about 2.1 billion tonnes. More than 875 million tonnes of oil including significant low grade metals exists in the alum shale of southern Sweden. The potential reserves of uranium and molybdenum of GS are approximately 5 and 10 million tones, respectively. Resent studies in the Myrviken area of north central Sweden has established a resource of uranium approaching 45 million kg.

Together with alum shale of Sweden, the Estonian graptolite shales form an independent future energy reserve for EU. At the moment it is vital to use modern research methods and techniques to determine detailed geochemical peculiarities of these rocks and develop methods to minimize possible negative mining and processing impacts to the natural and social environment.

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New occurences of pumpellyite on Fore Sudetic Monocline

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Pumpellyite is one of the very important calcium silicates occurring in mafic rocks formed in pumpellyite-prehnite and pumpellyite-actinolite metamorphic facies conditions. This mineral is typical for ocean-floor metamorphic processes and can form in different temperatures and presses e. g. [1].

Several types of pumpellyite are present in samples from Bolewice-1 and Jeniniec-2 drill-cores (W Poland). The pumpellyite displays variable chemical composition and was formed both during metamorphic maxima and retrogressive processes. The oldest generation of pumpellyite coexisting with epidote is usually Fe-poor <10% Fe_2O_3 suggesting, that this mineral was formed in pumpellyite-actinolite facies conditions (temperature 250 - 300°C and relatively high pressure, higher than 2kB, e. g. [2]).

Pumpellyites formed during metamorphic retrogression are very frequent; this variety contains >10% Fe_2O_3 and coexist with prehnite. Often it is possible to observe change of chemical composition in the same sample, especially in amygdules. It is not possible to calculate geothermal gradient on the basis of pumpellyite composition because both Al and Fe pumpellyites are present in all samples.

The episode of pumpellyite formation started probably about 170 Ma and is probably genetically connected with extensional processes in Polish Basin connected with opening of Atlantic Ocean e. g. [3]. It was a product of metamorphism at high geothermal gradient connected to shallow position of the Moho level. This can be connected to extension during initial stage of opening of Atlantic Ocean.

[1] Ishizuka, H., (1999): *Mineralogical Magazine,* **63**, 6, 891–900. [2] Aguirre, L., Morata, D., Puga, E., Baronnet, A., Beiersdorfer, R. E., (1995): *Geological Society of America Special Paper,* **296**, 171–181. [3] Dadlez, R., Narkiewicz, M., Stephenson, R. A., Visser, M. T. M., Van Wees, J.-D., (1995): *Tectonophysics,* **252**, 179–195.