



## **Sedimentological and geochemical implications for the timing of native sulfur mineralisation in the Miocene (Badenian) of the Carpathian Foredeep (S Poland)**

Andrzej Gąsiewicz

Polish Geological Institute, 00-975 Warszawa, ul. Rakowiecka 4, Poland (Andrzej.Gasiewicz@pgi.gov.pl)

The Middle Badenian (Miocene) evaporitic unit is widespread in the Miocene of the Carpathian Foredeep (South Poland). The unit is up to 60 m thick and predominated by sulfates (gypsum + anhydrite) and locally in the northern marginal part of the foredeep contains sulfur-bearing carbonate complexes up to 45 m thick. The carbonate complexes are lithologically heterogeneous and change from clayey and marl interlayers to marly and pure limestones. They may be either sulfur-bearing or barren and locally are intercalated by sulfate beds and layers. The evaporitic series (sulfates + limestones) is covered by the Machów Fm., which is relatively thick up to a few hundreds of meters, marine, pelitic (mainly marls and siltstones) and of the Upper Badenian-Sarmatian age. According to epigenetic origin hypothesis the native sulfur mineralization should be closely linked to the Middle Badenian (Miocene) evaporitic unit. However, the native sulfur mineralization is not restricted only to the evaporite horizon. On the areas of the sulfur deposits or nearby, the lowest part of the Machów Fm. (up to a few meters thick) locally contains concentration of native sulfur up to around 10%. Sometimes the native sulfur fills up local fractures as fine crystals but commonly occurs as more or less dispersed sulfur granules (usually < 1-2 cm in size). The intensities of sulfur mineralization in this clastic series are much lower than those typical for the sulfur-bearing limestones and are clearly higher in the lowest part of the sequence and disappear upward. Simultaneously, the clastic series often reveals evident transport features, which include distinctly wavy clayey streaks and local lamination, the presence of various in size (usually up to few cm in size) limestone, marly limestone and marly rounded or angular intraclasts resembling sulfur-bearing limestones. In between irregularly dispersed the carbonate clasts also occur fine and well rounded, broken or fractured sulfur granules. Both the carbonate clasts and sulfur granules usually disappear gradually upward. Geochemical features of the lowest part of the Machów Fm. show that the series is generally more calcareous, enriched in MnO, Ba, sulfate and locally Sr. This part of the formation is characterized by distinct fluctuation of  $[U+F064]$   $\delta^{18}O$  values (ranging in between 0.6 and -7.6‰ PDB) and  $[U+F064]$   $\delta^{13}C$  ones (from -28.4 to 1.3‰ PDB). The fluctuations gradually equalize upward and stabilize around -2 to -1.5 and -1‰ respectively. All these data accordingly suggest that the upper part of the sulfur-bearing limestones was re-worked during the Upper Badenian transgression into marginal zone of the foredeep. This finding clearly indicates the Middle Badenian age of the native sulfur mineralization and may argue for syndepositional origin of the sulfur deposits.