Microbial mat-related microstructures as proxies of depositional paleoenvironment in open marine clastic settings: case study from Silurian Graptolitic Shales [SGS], central Poland.

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Introduction:

Fossil microbial mats proved to be valuable indicators of some features of paleoenvironment, not only for carbonate rocks, but also for clastic rocks (summary in: Sakar et al., 2004; Schieber, 2004). Unfortunately, to date only proximal-to-land settings were documented in detail with respect to microbial mat-related microstructures. In this work, different open-marine microbial mat-related microstructures from Silurian Graptolitic Shales [SGS] are illustrated and interpreted.

Geological setting:

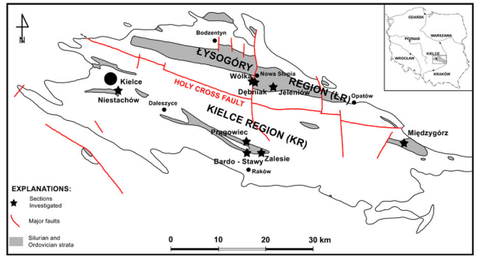

Fig. 1 - Simplified geological sketch of Holy Cross Mountains (HCM), showing occurences of the Silurian strata. Solid line outlines so-called "Palaeozoic core" of HCM.

Holy Cross Mountains [HCM] is the small range in Central Poland, consisting of "Palaeozoic Core", and Mesozoic Marginal Cover. "Palaeozoic Core" is divided into two regions: Łysogóry Region [ŁR] in the North, and Kielce Region [KR] in the South (fig. 1).

Lower Silurian strata consist of fine grained sediments known as Silurian Graptolitic Shales [SGS]. Among these sediments five lithological types can be distinguished:

(1) olive-green claystones with minor clayshales,
(2) brownish to brownish-grey, laminated clayey mudshales and clayshales,
(3) grey to dark grey, partly laminated calcareous mudshales and clayshales,
(4) dark grey, laminated siliceous clayey mudshales and clayshales,
(5) dark grey to black, laminated bedded cherts.

Total thickness of these sediments does not exceed 200 m in KR, and slightly exceeds that value in ŁR (fig. 2). Time span of their deposition is early Llandoverian to mid-Ludlowian (Tomczyk, 1962).

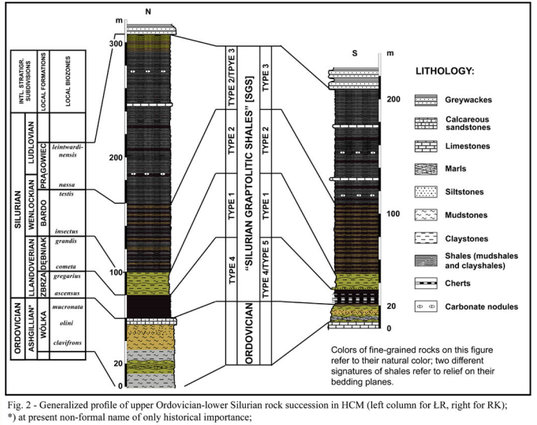

Fig. 2 - Generalized profile of upper Ordovician-lower Silurian rock succession in HCM (left column for ŁR, right for RK); *) at present non-formal name of only historical importance;

All lithological types are thought to be deposited in basinal (Tomczyk, 1962) or open-shelf, below storm wave base (Kremer & Kaźmierczak, 2005) settings. Mat microstructures can be observed within all listed lithological types and they are the main biogenic structures in all laminated shale lithologies (types 2-4) and cherts (type 5). Their microbial provenance was proven for cherts in lower part of the section (Kremer & Kaźmierczak, 2005).

Results:

Within all laminated lithologies mat-laminae are interlayed with detrital laminae. Microstructures observed within mat-laminae are presented on fig.3.

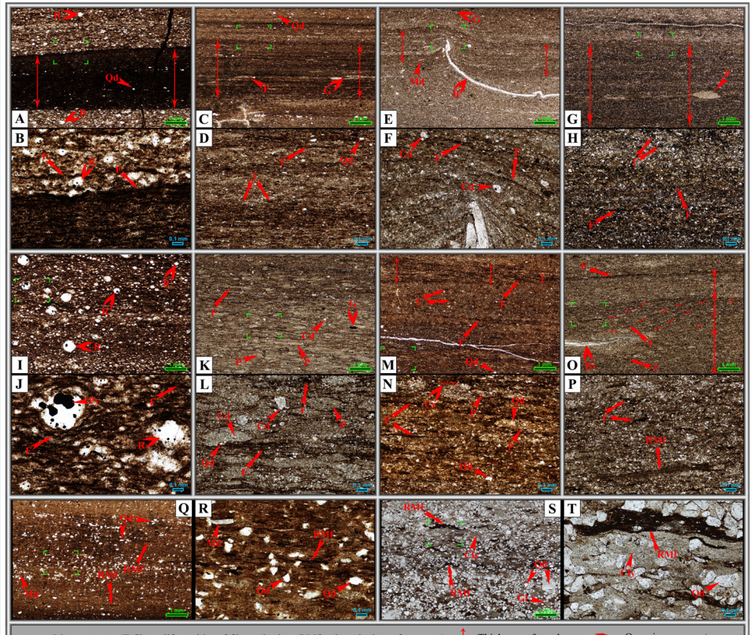

Fig. 3 - Variety of mat microstructures observed within SGS: A,B,I,J-Bardo-Stawy, cherts (type 5), Llandovery, C,D-Bardo-Stawy, siliceous clayshales (type 4), Llandovery, E,F,K,L-Pragowiec, calcareous mudshales (type 3), upper Wenlock/lower Ludlow, G,H-Dębniak, mudshales (type 2), Wenlock, M,N-Bardo-Stawy, mudshales (type 2), Wenlock, O,P-Niestachów, mudshales (type 2), lower Ludlow, Q,R-Zalesie, mudshales (type 2), lowermost Llandovery, S,T-Bardo-Stawy, mudstones with siltstones (type 1), Llandovery.

Mat structures differ in following features: (I) continuity of laminae-continous (e.g. 3B) vs. discontinous (e.g. 3M), and fragments (e.g. 3S), (II) thickness of laminea-from less than 0,5 mm (e.g. 3O) to over 1 cm, (III) appearance of laminea-distinct (e.g. 3A) vs. indistinct (e.g 3G), (IV) appearance of particular fibres-long vs short, connected vs isolated, (V) type (see: other features on fig. 3), and (VI) size of detritus material trapped in-between-, under-, or on- microbial meshwork-clay-size- vs. silt-size-dominated, (VII) macro- and microorganisms remains trapped in-between-, under-, or on-microbial meshwork (see: organism remnants on fig. 3).

All microphotographs were taken with Nikon Eclipse 600 housed in Laboratory of Scanning Electron Microscopy and Microstructures of Institute of Hydrogelogy and Engeneering Geology of Faculty of Geology, Warsaw University.

Interpretation:

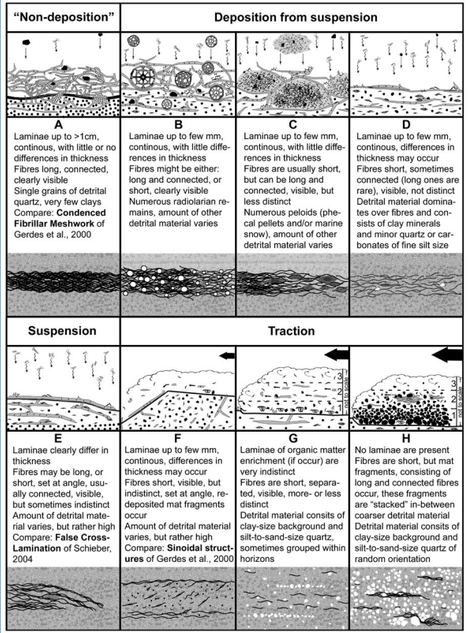

Fig. 4 Reconstruction of paleoenvironmental conditions resulting in observed microstructures. Numbers 1,2,3 reflect 3 stages of current development in section G and 3 zones of high-density flow: "plug flow" (sensu: Mulder & Alexander, 2001) on section H.

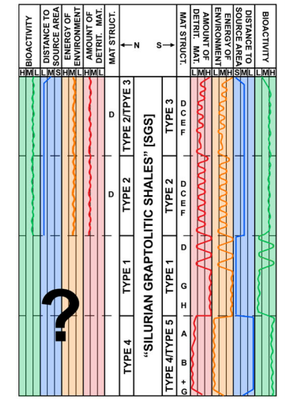

Fig. 5 Occurence of mat microstructures within profile with interpretation of plaeoenvironment based on microstructures.

Reconstruction of depositional processes resulting in microstructures observed, are shown on fig. 4. Their occurence within profile is summarized on fig. 5. Detailed analyses of these data allowed to interpret: (i) volume of sediment influx and tempo of deposition, (ii) energy of environment, (iii) distance to source area, (iv) "bioactivity" (also fig. 5).

Conclusions:

Microstructural record from ŁR and KR differs.
In KR: sediment influx varies greatly and depends on energy of environment, distance to source area "varies": during high-energy periods is very short, during low-energy periods is very long, "bio-activity" is high.
In ŁR: sediment influx and energy of environment are stable: sediment influx is medium to high, energy of environment is medium to low, distance to source area is long, "bioactivity" is low.

KR can be interpreted as intrabasinal rise, of rather small size, which might have been temporarily emerged.
ŁR can be interpreted as distal, open shelf of big continent.

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