Rise and fall of the Paratethys Sea during the Messinian Salinity Crisis

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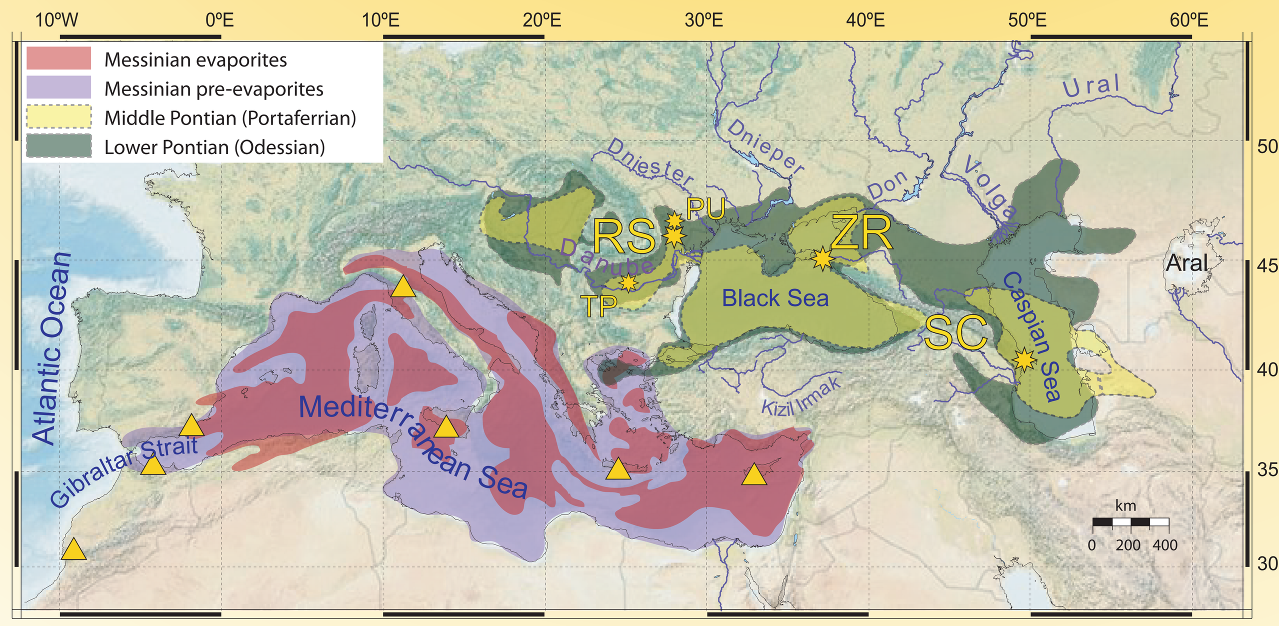

Figure 1. Paleogeographic map of Mediterranean and Paratethys during MSC interval. Stars indicate locations of sections and research areas. In Dacian Basin RS and PU = Râmnicu Sarat and Putna sections located in the east Carpathian foredeep and TP = Topolog section in the south Carpathian foredeep. In the Black Sea Basin ZR = Zheleznyi Rog section on Taman Peninsula of Russian Black Sea margin; SC = South Caspian basin - Azerbaijan. Triangles locate astronomically dated Mediterranean MSC sections .

Introduction

Extremely thick evaporite units were deposited during the so-called Messinian Salinity Crisis (MSC: 5.96-5.33 Ma) in a deep Mediterranean basin that was progressively disconnected from the Atlantic Ocean. A crucial, but still poorly understood component in Messinian evaporite models is the connectivity between Mediterranean and Paratethys, i.e. the former Black Sea domain (Fig. 1). Inadequate stratigraphic correlations and insufficient age control for Paratethys sediments have so far hampered a thorough understanding of hydrological fluxes and paleoenvironmental changes.

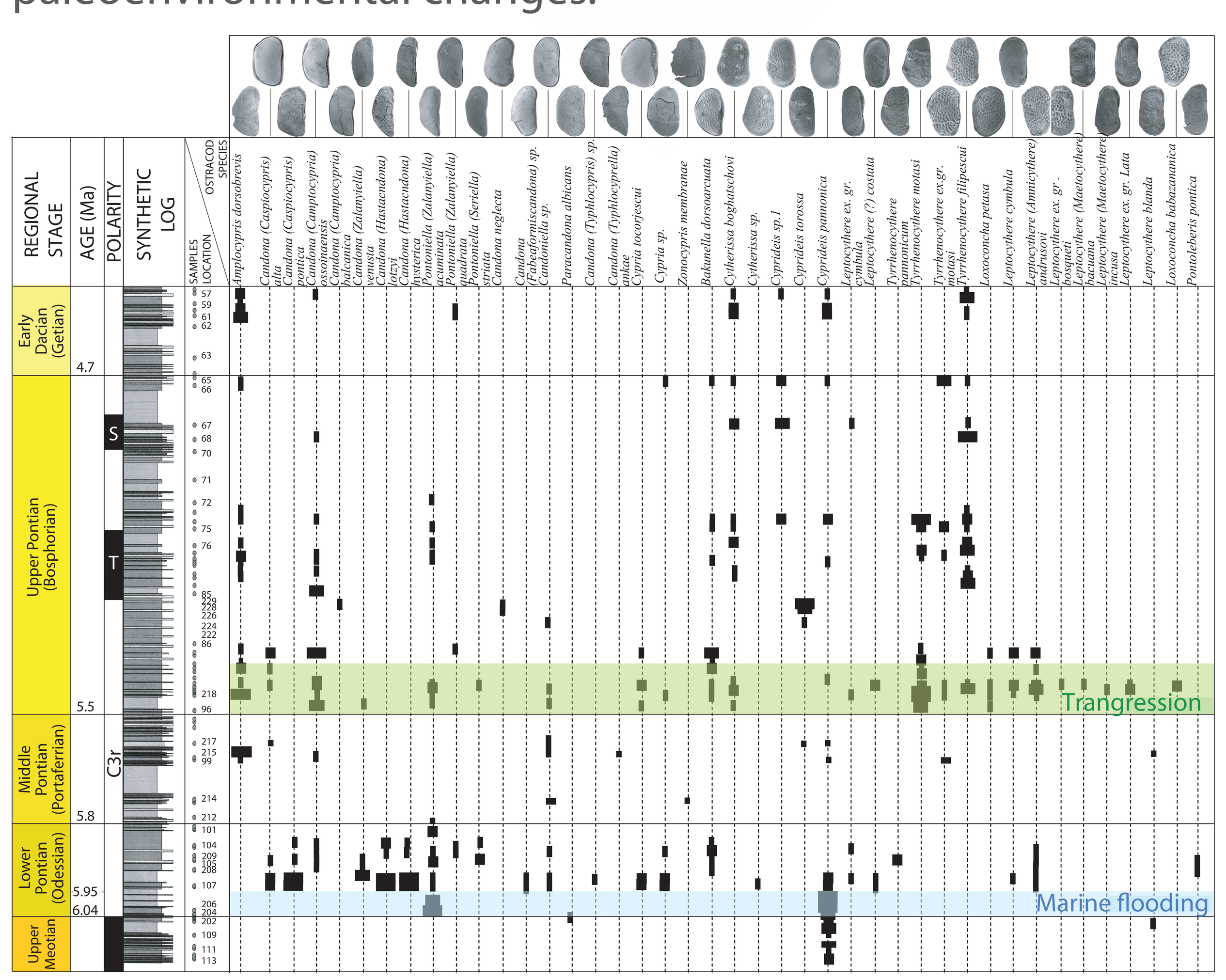

Figure 2. Ostracod distribution of Râmnicu Sarat section. The magnetostratigraphic pattern is after Vasiliev et al. (2004) and correlates excellently to the GTS. It allows high-resolution dating of the ostracod assemblages and related stages and substages. The resulting new ages of the (sub)stage boundaries are indicated.

Results

Here, we present a new chronology for the Eastern Paratethys by integrating biostratigraphic and paleomagnetic data from Mio-Pliocene sedimentary successions of Romania and Russia (Fig. 1). The Maeotian/Pontian boundary is dated at 6.04 Ma (Fig. 2) and corresponds to a major faunal change triggered by a marine flooding of the Paratethys, as evidenced by the presence of planktonic foraminifera (Figs 3 and 4). This indicates that sea level in both Mediterranean and Paratethys was high at the beginning of the MSC.

Conclusion

We argue in favor of changes in Paratethys-Mediterranean connectivity to initiate the MSC in combination with elusive tectonic processes at the Gibraltar sill. A subsequent fall of Paratethyan water level closely coincides to the Mediterranean isolation-event, corresponding in age to the glacial cycles TG12-14 (Fig. 5). The lowermost Pontian substage relates to a general high-stand in the Paratethys, possibly with Mediterranean connections. The onset of MSC evaporites closely coincides in age with the bloom of Odessian ostracods in the Paratethys at ~5.95 Ma. The peak of the Messinian salinity crisis at 5.6-5.5 definitely ended Mediterranean-Paratethys connectivity in the Portaferrian, causing a sudden drawdown of Paratethys water levels of at least 50-100m and isolating the Caspian Sea and the Dacian Basin from the Black Sea domain. From 5.5 Ma onward a major change in Eurasian climate, resulting in much warmer and humid conditions changed the hydrological balance and resulted in a wide-spread transgression in Mediterranean and Paratethys. The Miocene/Pliocene boundary may correspond to the Portaferrian/Bosphorian boundary in the Dacian basin and to the top of the red layer in Zheleznyi Rog, i.e. within the lower Kimmerian of the Black Sea basin, but certainly not to the Pontian/Dacian boundary in the Dacian Basin, which is dated ~600 kyr younger at 4.7 Ma. Our data suggest that changing the connectivity to the Paratethys in the northeast could play an essential role in the onset of gypsum formation, which should give ample ammunition for new ideas and models concerning evaporite formation in semi-isolated basins.

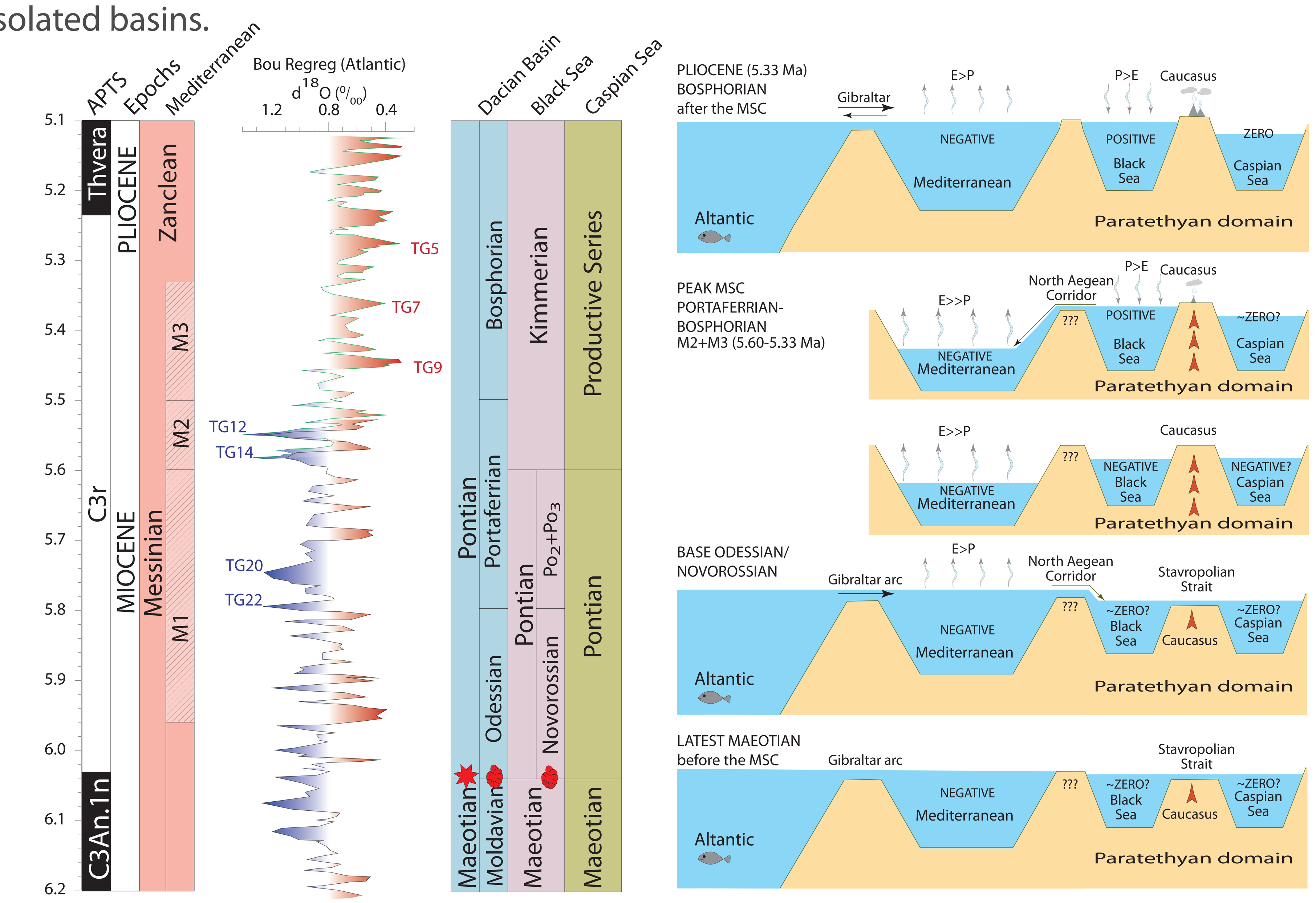

Figure 5. A new chronology for the different local and regional stages of the Paratethys allows detailed correlations to the GTS, the Mediterranean event stratigraphy during the MSC (M1-M3) and to the oxygen isotope curves of the Atlantic margin of Morocco (Hilgen et al., 2007). Red star/foraminifer indicates influx of marine nannofossils /foraminifera. Schematic cross-sections show the changes in connectivity and the phases of basin isolation of the Paratethys and Mediterranean during the MSC.

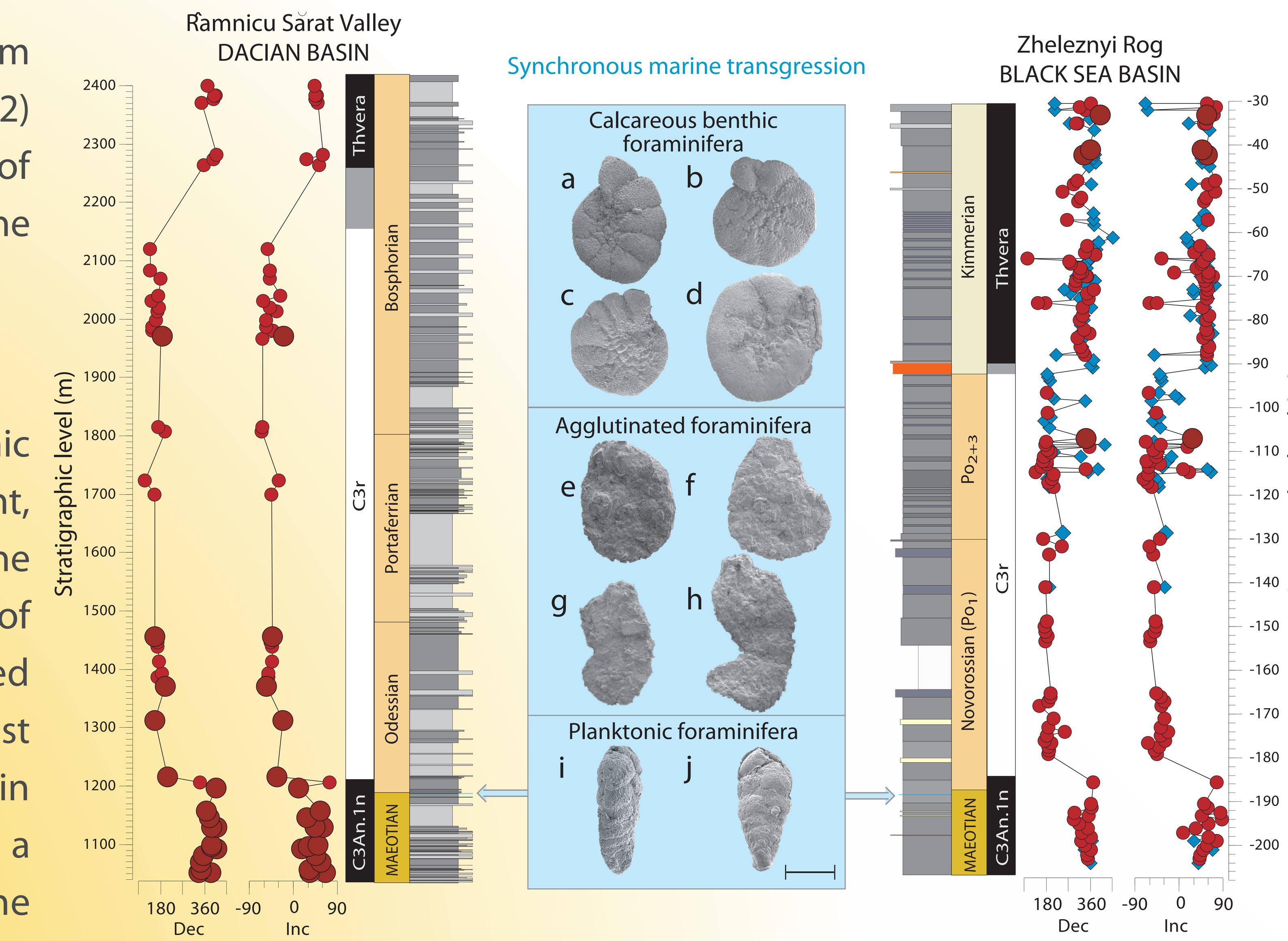

Figure 3. Detailed integrated stratigraphic data of the Maeotian/Pontian interval. Pontian-Kimmerian are regional stages of the Black Sea Basin. Magnetostratigraphic data from Râmnicu Sarat are after Vasiliev et al. (2004), from Zheleznyi Rog (this paper). Red circles represent reliable directions from thermal demagnetization, whereby small circles denote greigite, large circles magnetite. The blue diamonds indicate directions from alternating field demagnetization.The Maeotian-Pontian boundary interval is marked by a short influx (a-j) of marine calcareous benthic foraminifera (a-d), agglutinated foraminifera (e-h) and planktonic foraminifera comprising Streptochilous sp. (i-j).

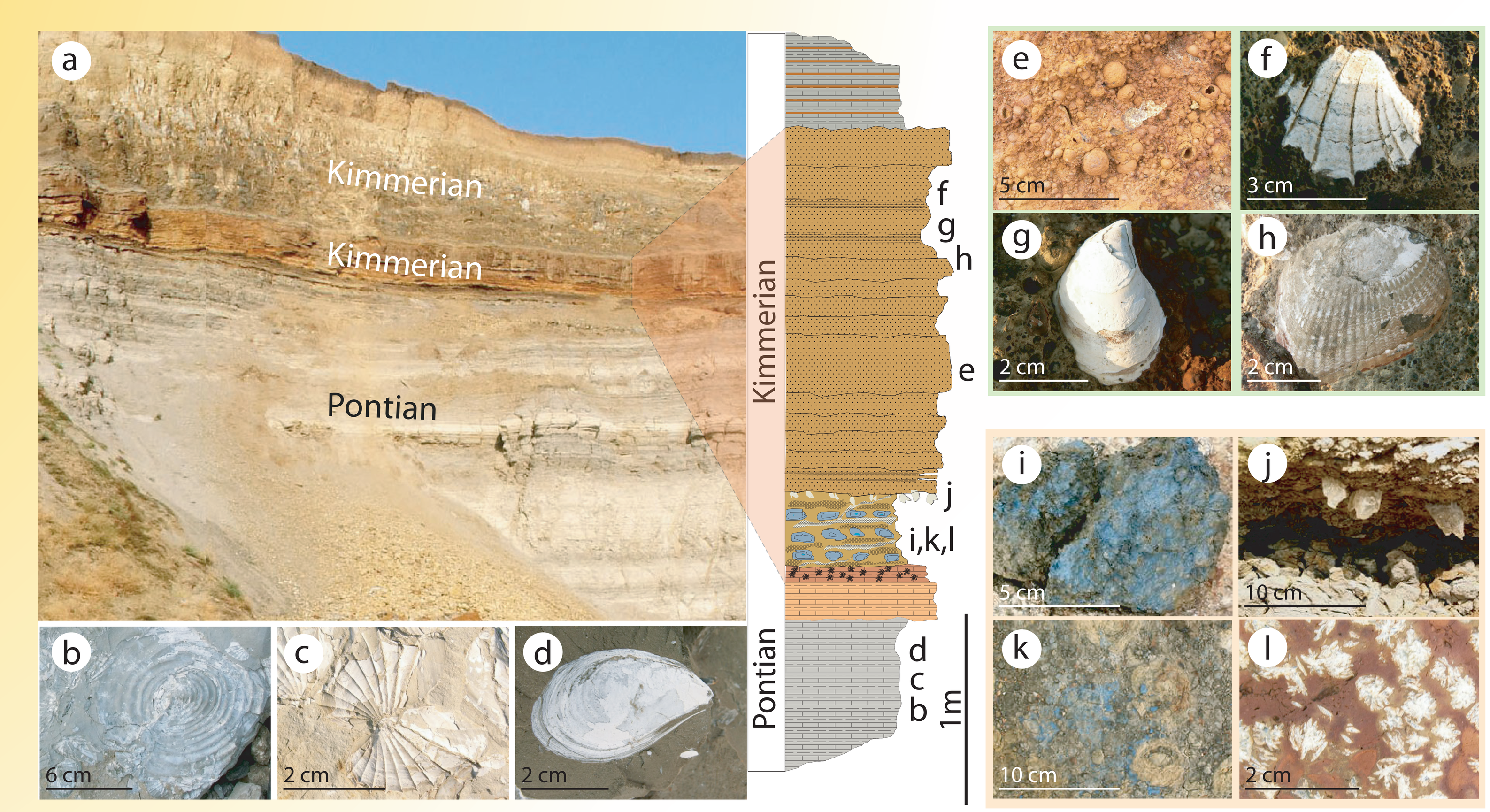

Figure 4. a) The reddish interval of the Zheleznyi Rog section. Portaferrian molluscs found in the marl interval below the red unit; b) Valenciennius sp., c) Paradacna abichi, d) Dreissena rostriformis. Characteristic mollusc species and the most relevant evaporitic minerals found in the reddish interval, marking the beginning of the Kimmerian: h) oolithic or pisolithic sandstone, f) Caladacna steindachneri, g) Dreissena rostriformis, h) Pteradacna edentula, i) celestine (jarosite), j) prismatic gypsum crystals, k) celestine (jarosite), l) radial gypsum. The levels of each picture from the panels b to l are indicated in the right hand side of the schematic lithological column.