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Late Barremian – early Albian climate of the northern middle latitudes: Stable O- and C-isotope evidence from brachiopods and molluscs of the Caucasus

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Until now only a few Aptian ammonoid shells from the Caucasus (*Tetragonites, Cheloniceras, Hypophylloceras*), partly diageneticaly changed, were used for geochemical analyses (Zakharov et al., 2000). O- and C-isotope ratios were measured now mainly on well-preserved fossils from the upper Barremian (Western Georgia), lower Aptian (Dagestan and Western Georgia), upper Aptian (Dagestan, West, Northwest and Central Caucasus and Western Georgia) and lower Albian (Western Georgia).

Late Barremian palaeotemperatures, calculated from belemnite rostra of the Securiformis Zone, are very low (12.19-14.21 °C). Terebratulid brachiopod shells from the same zone give comparable palaeotemperatures of 10.85-12.98 °C. Both belemnites and the mentioned benthic forms inhabited cool waters of epipelagic depths.

In contrast, investigated lower Aptian fossils show significantly higher palaeotemperatures. Those obtained from brachiopod shells of the Ridzewskyi-Turcmenicum Zone and an oyster bivalve shell of the Deshayesi Zone, located stratigraphically higher, range from 20.36 to 22.27 °C and from 16.97 to 17.34 °C, respectively.

Isotopically investigated lowest upper Aptian invertebrate skeletons from the Subnodosocostatum Zone, with exception of belemnite and *Salfeldiella* ammonoid ones, were secreted in highest temperature conditions; fossils from the overlying Melchioris-Abichi Zone of the upper Aptian also give comparatively

high, but somewhat lower palaeotemperatures. Bivalve shells from the Subnodocostatum and Melchioris-Abichi Zone show palaeotemperature of 25.33-37.10 and 24.11-27.19 ^{o}C, respectively. Those obtained from gastropod and most ammonoid shells of the Melchioris-Abichi Zone fluctuate from 15.60 to 20.78 ^{o}C and from 14.97 to 25.74 ^{o}C, respectively.

Palaeotemperatures determined on the basis of isotope analysis of middle upper Aptian brachiopod and ammonoid shells from the Nolani Zone (19.12-20.16 and 15.3-18.17 ^{o}C, respectively) and uppermost Aptian bivalve and ammonoid shells from the Jacobi Zone (13.56 and 19.64-21.32 ^{o}C, respectively) are similar or lower than those calculated from fossils of the Melchioris-Abichi Zone. The $\delta^{18}O$ values, recorded in the Subnodosocostatum, Melchioris-Abichi and Nolani zones, probably reflect earliest late Aptian extremely warm conditions following cooler conditions by the mid Aptian.

Belemnites from the lower upper Aptian Subnodosocostatum and Tobleri zones and apparently lower Albian Mammillatum Zone, as well as phylloceratid ammonoid *Salfeldiella* from the Subnodosocostatum Zone, showing significantly lower palaeotemperatures (10.85-11.26, 11.85-13.21 and 12.66-13.79 ^{o}C, respectively), as distinct from co-occurring fossils, seem to be migrants from adjacent deeper marine zones (they preferred apparently mesopelagic conditions, being mainly cool-requiring animals, which is consistent with published data on other areas (e.g., Zakharov et al., 2014, 2016). We have not possibility to confirm the existence of the late early Aptian climatic optimum, discovered on the Russian Platform (Bowerbanki Zone), because of lack of suitable material in this level in the Caucasus. However, some new evidences suggest that highest temperature conditions (up to 37.10 ^{o}C) took place during the earliest late Aptian. The highest $\delta^{13}C$ values (up to +8.26‰) were derived just from some earliest late Aptian fossils, which illustrates the highest marine biological productivity of that time.