

Are dendrolite and thrombolite macrofabrics always primary? Examples from the Cambrian of Shandong, China

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Dendrolite (dendritic) and thrombolite (clotted) microbial carbonate macrofabrics are well developed throughout the Cambrian (Series 3) Zhangxia Fm (~500 Ma) near Jinan, Shandong, China. In outcrop and hand specimens these fabrics are conspicuous as mm-cm dark grey to brown masses, variously shrub-like, curved, elongate or rounded, in lighter-colored, typically yellow to reddish, matrix. In thin-section the dendrolites are composed of the calcimicrobe *Tarthinia*, with thick diffuse micritic walls surrounding poorly defined spar-filled chambers. These are associated with partly altered wackestone and with bioclastic packstone matrix containing recrystallized trilobites, ostracodes, and sponge spicules. In contrast, the fabrics that macroscopically resemble thrombolites appear in thin-section to be composed of wackestone surrounded by microspar and spar which we infer to be altered wackestone and other, unidentified, matrix.

Comparisons of macrofabric and microfabric show that micritic fabrics (*Tarthinia* and wackestone) are dark in both thin-section and hand-specimen, whereas the recrystallized and/or dolomitized areas that were originally wackestone and packstone are light colored in both thin-section and hand-specimen. The alteration of the wackestone and bioclastic packstone affects the macrofabric in two distinct ways. First, the dark fabric dominated by *Tarthinia* is augmented by adjacent patches of dark unaltered allomicrite. Second, the pale matrix, which emphasizes the darker macrofabric, is enhanced by alteration. As a result, the darker component of the fabric is heterogeneous in origin, comprising both microbial carbonate and matrix, and the surrounding lighter component only represents part of the matrix.

Bright fluorescence in the microbial carbonate (*Tarthinia*) and allomicrite suggests the presence of organic carbon, whereas the packstone and the altered fabrics show lower signals. We propose that the presence of organic carbon protected both the microbial carbonate and the allomicrite from alteration by hindering diagenetic fluid flow, whereas the organic carbon-poor grainy fabrics (packstone, recrystallized shells) were less protected and therefore prone to alteration. We envisage the following stages of fabric development:

- (i) Erect shrubby growths of *Tarthinia* were syndementarily surrounded by allochthonous micrite and bioclasts that formed interstitial wackestone and packstone matrix.
- (ii) Burial diagenesis preferentially affected the wackestone and packstone fabrics, partly overprinting them with aggradational spar and replacive dolomite but also leaving some areas, particularly of wackestone, unaltered.

As a result, areas that appear dark in hand-specimen and thin section include both *Tarthinia* and unaltered wackestone, and areas that appear light are altered areas of wackestone and packstone.

These results show that the dendritic and clotted macrofabric consists of *Tarthinia* and/or allomicrite. Consequently, the dark apparently dendrolite and thrombolite fabrics are not always entirely microbial, but represent calcimicrobes (in this case *Tarthinia*) augmented by unaltered allochthonous wackestone-packstone matrix. In contrast, the light matrix is enhanced by recrystallization/replacement but nonetheless only represents part of the matrix. In these examples, augmentation of the dendrolite macrofabric appears relatively minor and the dark fabric does generally reflect the distribution of the calcimicrobes. Conversely, the thrombolite-like fabric appears to be largely a product of alteration. We conclude that some thrombolite-like macrofabrics may not only be substantially enhanced and/or modified by alteration, but could be virtually entirely products of diagenesis.