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On the affinity of *Chuaria circularis* Walcott: A multidisciplinary study

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In this study, we utilized biometric, structural engineering and micro-FTIR (Fourier Transform Infrared Spectroscopy) analyses to examine the possible biological affinity of *Chuaria circularis* Walcott, collected from the Mesoproterozoic Suket Shales of the Vindhyan Supergroup and the Neoproterozoic Halkal Shales of the Bhima Supergroup of peninsular India. On the basis of these studies, contrary to the present belief, we conclude that *Chuaria circularis* was most likely a cylindrical body of algal origin. Biometric analyses of well preserved carbonized specimens collected from both these litho-units show wide variation in morphology and uni to bi-modal distribution. Specimens with notch/cleft and overlapping preservation, mostly recorded in the size range of 3-5 mm, are of special interest. The notched specimens are found at mature stage of the life cycle. Spores were released on maturity through notches/cleft in *Chuaria* though alternative explanations exist. Various models proposed for the life cycles of *Chuaria circularis* are debatable; a new model suggesting variable cell wall strength and algal affinity is proposed.

Structural engineering tools investigate the implications of possible geometrical shapes (sphere and cylinder), membrane (~cell wall) stresses and ambient pressure environment on *Chuaria circularis*. Besides, geometry, affinity and life cycle of *Chuaria* is also not well established, hence the theory of 'Thin Walled Pressure Vessel' has been applied to both the spherical and cylindrical shapes assuming a closed thin walled container subjected to internal pressure (P). Reasons for choosing these parameters are based on the most possible considerations under which *Chuaria* thrived and subsequently preserved. Mathematical structural analysis was carried out assuming the outer diameter of *Chuaria* equal to 1 to 10 mm and the wall thickness equal to 0.5-2.5 and 2.3 to 5 μm for degraded and sectioned well preserved specimen respectively. The results suggest that membrane stresses developed on the *Chuaria* were directly proportional to radius and inversely propositional to the thickness in both cases. In case of hollow cylindrical structure, as suggested above, the membrane stresses in longitudinal direction are half of that of radial direction indicating that rupture or fragmentation in the body of *Chuaria* would have occurred in the radial direction due to high stresses. It appears that notches and discontinuities seen on the specimens may be related to rupture in the radial direction suggesting their possible location in a 3D *Chuaria*. These results may help understand the mechanical environment in which *Chuaria* flourished and on maturity developed fracture or notches. Furthermore, structural analysis provides a relationship, perhaps for the first time, between ambient pressure environment and mechanical properties of the vesicle akin to *Chuaria*. However, more data are required on other parameters such as density, modulus of elasticity of *Chuaria* membrane to predict its 3D geometry and establish life cycle.

The micro-FTIR spectra of *Chuaria circularis* are characterised by both aliphatic and aromatic absorption bands. The aliphaticity is indicated by prominent alkyl group bands between 2800-3000 and 1300-1500 cm^{-1}. The prominent absorption signals at 700-900 cm^{-1} (peaking at 875 cm^{-1}, and 860 cm^{-1}) are due to aromatic CH out of plane deformation. A narrow, strong, band is centred at 1540 cm^{-1} which could be N-H deformational band. The presence of strong aliphatic bands in FTIR spectra suggests that the bio-geopolymer of *Chuaria circularis* is of aliphatic nature. The wall chemistry indicates the presence of ‘algaenan’ i.e. a biopolymer of algae.