Iron-sulfide biomineralization of a hydrothermal vent snail: Modern analogue for the evolution of Cambrian metazoan skeletons

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A snail recently discovered in a deep-sea hydrothermal field at the Rodriguez triple junction, Indian Ocean has a foot covered with scale-shaped exoskeletons called sclerites, which are composed of iron sulfides and proteins. The appearance of the iron-sulfide sclerites recalled the primitive skeletons of enigmatic metazoans flourished during the Early to Middle Cambrian. Molecular phylogenetic and anatomical characterizations, however, placed the snail within a clade endemic to modern hydrothermal vents. The simultaneous evolutions of the inorganic material and morphology of skeletons were widespread during the Cambrian, which spurred, at least in part, the dramatic diversification of metazoans known as the Cambrian explosion. If the iron-sulfide sclerites are truly an evolutionary innovation, it is plausible to consider the snail as a modern analogue for the Cambrian animal evolution. A variety of analytical tools were applied to decipher the nature and function of the iron-sulfide sclerites, including the isotopic analyses of sulfur and iron, nanometer-scale crystallographic characterizations, and magnetic and mechanical measurements. The iron-sulfide formation, which requires the sources of iron and sulfur from hydrothermal fluids, is highly controlled by the snail in terms of mineral phase, morphology, and location. The superior mechanical property of the sclerites stands sharp contrast to their non-optimized magnetization for a compass, suggesting they function as protective armor rather than for magnetic sensor. The modern skeletal evolution demonstrated in the present study provides fundamental insights into the abrupt appearance of animal skeletons during the Cambrian.