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Comparative crystallography of nacreous layer in a Cretaceous inoceramid bivalve: a preliminary study

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The extinct bivalve family Inoceramidae are prominent among Mesozoic molluscs in terms of diverse shell form, widespread distribution and biostratigraphic utility. They had been conventionally classified into the subclass Pteriomorphia without controversy based on its shell microstructure, apparent ligament form and muscle scar. However, their taxonomic position is recently disputed: Johnston and Collom (1998) claimed a different theory as to ligament morphology of inoceramids and assigned them to the Protobranchia. Debates on their "Bivalve Heresies" have focused on comparative morphology of limited available characters that are likely to be homoplacious, but an alternative clue to elucidate phyllogenetic position of the enigmatic creature may lie on crystallographic properties of their shells that are poorly understood.
In the present study, orientation of aragonite crystals in the nacreous shell layer was studied in a total of eight bivalve species that covers three subclasses and includes a Cretaceous inoceramid Sphenoceramus naumanni. Distribution of crystallographic orientation was analyzed using electron backscatter diffraction (EBSD) attached with a SEM for in situ measurement at a submicron scale. An EBSD orientation mapping was successfully obtained in a well-preserved fossil specimen recovered from the Upper Cretaceous Yezo Group, Hokkaido, northeast Japan. The EBSD mapping portrays coherent orientation for each nacre tablet which is a sign of fine taphonomic condition at a crystallographic level. The EBSD analyses revealed wide variation in crystallographic orientation within the Bivalvia: b-axes of nacre crystals were well aligned perpendicular to the growth lines in pterioid and trigonioid species, whereas preferred orientation of the b-axis is unclear in nucloid and unionoid species as well as in S. naumanni. The present study discovered a common crystallographic feature between inoceramid and protobranch bivalves which may provide corroboration for the "Bivalve Heresies". Comparison of crystallographic preferred orientation among taxa seems to be fruitful for phyllogenetic studies of extinct organisms. Further analyses and refinements will expand the paleontological utility of the crystallographic approach.

Keywords: nacre, crystallographic orientation, EBSD, inoceramids