摘　要

花青螺 (*Notoacmea schrenckii*) 常見生長於岩礁海岸的潮間帶，以矽及鐵質構成之齒舌刮取生長於岩石上的藻類為生。由於花青螺齒舌上不同發育階段的牙具有不同的礦化程度，因此成為研究生物礦物沈積過程之理想實驗材料。

齒舌之造牙過程可由礦化程度之不同分為四個階段 ：stage Ⅰ 尚無礦物沈積發生，stage II 時開始觀察到鐵的沈積，而進入 stage III 時牙齒礦化程度漸增，至 stage IV 時，齒舌即完全成熟。

本研究利用光學顯微鏡、穿透式及掃描式電子顯微鏡所進行的形態觀察及元素分析顯示，在造牙過程的初期即有鐵的訊號出現在牙冠與牙基的交界處，而矽的訊號則早在 stage Ⅰ 尚無任何可以肉眼辨識之礦物出現時即可在牙基部分測得。穿透式電子顯微影像亦顯示 stage Ⅰ 階段，牙冠及牙基皆由有機質構成礦物沈積之骨架，此骨架在齒舌成熟過程中逐漸被礦物沈積包覆。

感應耦合電漿質譜分析的結果顯示，齒舌周邊的細胞在 stage I 及 stage II 階段細胞內含有多量的矽與鐵。隨著牙齒礦化程度的增加，細胞中鐵的含量漸減，而矽的含量則起伏不大。再對照感應耦合電漿質譜對齒舌所做分析顯示，矽可能在造牙過程相當早期的階段就已運送至齒舌中儲存。

藉由氫氟酸的使用可將齒舌中的矽由牙齒結構中移除，萃取出分子量小於 20kDa 之分子。此結果顯示這些分子與矽的沈積相關，並且在造牙過程中一併為礦物包覆沈積下來。胺基酸組成分析與資料庫比對結果顯示所分離出的分子與 mitochondrial carrier protein family 相似，可能與造牙過程中矽的運輸有關。利用上述結果，將齒舌結構以 NH_4F 加以輕度破壞，再外加足量的矽之後發現，齒舌表面有新生成矽沈積的跡象，顯示齒舌中的有機分子似乎的確具誘發矽沈積的功能。

ABSTRACT

Radulae of limpets are regarded as an ideal experimental material for studying biologically controlled mineral deposition for it possesses teeth in different mineralization stages. The possible mechanism of silica precipitation in the limpet *Notoacmea schrenckii* (Acmaeidae, Gastropoda) was explored in this study using electron microscopy, electron diffraction, energy-dispersive X-ray analysis, and ICP-MS. ICP-MS elemental analysis showed that iron and silica both infiltrate into the radulae in early stages during teeth development. Electron dense granules in nanometer size were observed in teeth ultrathin section specimen of early teeth formation stage, subsequent electron diffraction analysis indicates that silica is the primary component of these granules. Transmission electron microscopic images revealed the intimate association between silica granules and the organic matrix, which implied that the organic matrix may take more active roles in catalyzing other than merely functioning as physical constraints during mineral deposition. Low molecular weight peptides were harvested from cusp using HF extraction suggested the possibility of co-precipitation of the peptides together with silica. The amino acid composition result suggested that the peptides extracted from the cusps might be related to mitochondrial carrier protein family and thus might take part in silica transportation process. Milder NH_4F treatment of the cusps to expose the peptides and the appearance of silica spheres following the application of silicate suggest that the low molecular weight peptides embedded within the minerals may assist silica precipitation.