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Tales from the crypts: Early adaptation of cryptobiontic sessile metazoan

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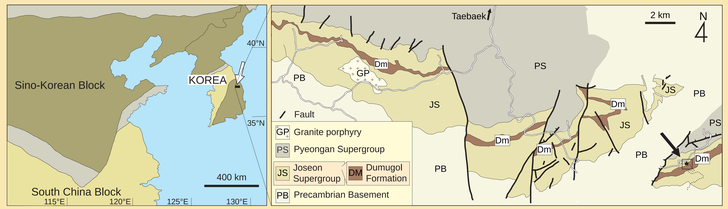
Abstract

The cryptic ecosystems of modern and ancient reefs contain substantial amounts of biodiversity; however, when and how metazoans adapted to such space is a key question that has yet to be answered. Early Cambrian reef systems witnessed the rise and fall of the earliest known cryptic sessile metazoans. Subsequent middle Cambrian to Early Ordovician microbial-dominated reefs were generally devoid of true frame-building metazoans, as well as of crptic sessile fauna. The Early Ordovician microbial-siliceous sponge patch reefs of Korea represent one of the oldest *in situ* spiculate sponge-bearing cryptic communities exploiting intraskeletal cryptic environments. Less than half of these small millimeter- to centimeter-scale crypts contain low-diversity sessile cryptic assemblages of spiculate sponges and microbialites. The cryptic sponges that attach to the wall of the cavities or on top of internal sediments do not show any skeletal distortion at their contacts with hosting organisms, indicating a probable post-mortem association. The behavior of occupying transient cryptic habitats is interpreted as an incipient stage of sessile metazoan adaptation to a cryptic space by an opportunistic member of the epibenthic community. This resulted in the extension of the open surface community into the crypts far in advance of the previously known advent of obligate cryptic forms. The current study provides a critical link for establishing the origin and evolutionary history of early cryptic sessile metazoan adaptation.

1. Purpose

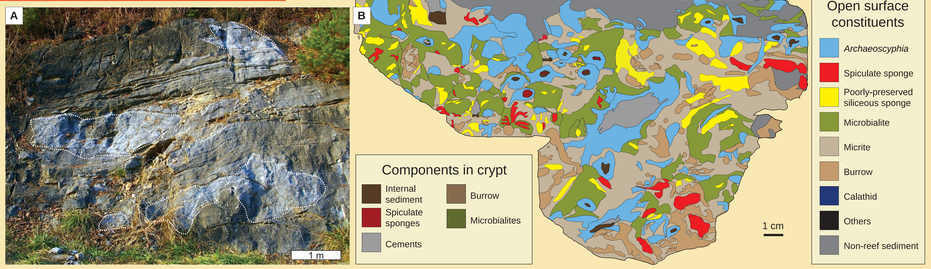
1. Analyze pioneering strategy of spiculate sponges into cryptic space.
2. Assess implication of such behavior for the emergence of sessile cryptic fauna.

2. Geologic Setting



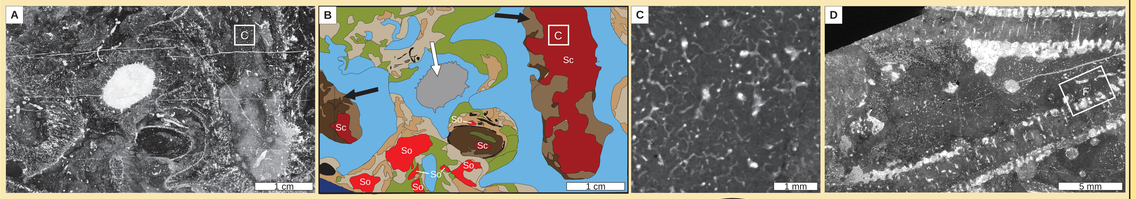
Tectonic elements of the Eastern Asia and geologic map of the study area showing distribution of the Dumugol Formation. Sample location is marked by black arrow. Modified after Chough et al. (2000).

3. Dumugol Patch Reefs

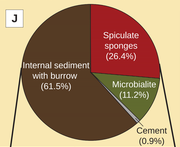


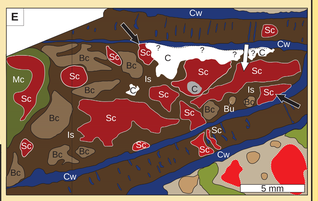
A) Photograph of three meter-scale Dumugol patch reefs intercalated with intraclastic packstone to grainstone and bioturbated mudstone to wackestone. **B)** Interpretive tracing of a Dumugol boundstone slab showing two-dimensional distribution of constituents characterized by dominant siliceous sponges, microbialites, and micrites without large growth-framework cavities. These features are comparable to widely occurring Early Ordovician biogenic structures of Laurentia (Toomey and Nitecki, 1979), Precordillera (Cañas and Carrera, 1993) and South China (Adachi et al., 2012).

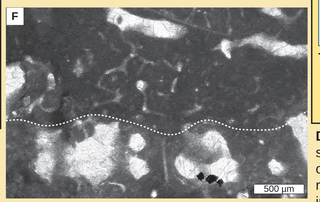
4. Characteristics of Crypts and Cryptic Communities

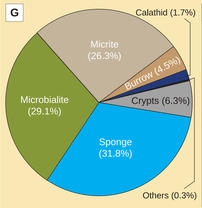


A) Thin section photograph of Dumugol boundstone dominated by cone-shaped siliceous sponge *Archaeoscyphia*. **B)** Interpretive sketch of A demonstrating development of intraskeletal cryptic space within *Archaeoscyphia*. Some cryptic spaces are filled with cryptobionts (black arrows) of spiculate sponges and burrows, whereas some are without such cryptobionts (white arrow). Note the occurrence of spiculate sponges both in open (So) and cryptic space (Sc). **C)** Photomicrograph of white rectangle in A and B showing networks of reticulately arranged straight to weakly curved spicules interpreted as spiculate sponge.









H	Constituents		%
Sponge	*Archaeoscyphia*	26.9	31.8
	Spiculate sponge	2.7	
	Poorly-preserved sponge	2.2	
Microbialite			29.1
Micrite			26.3
Burrow			4.5
Calathid			1.7
Others			0.3
Crypts	Internal sediment	2.2	6.3
	Burrow	1.2	
	Spiculate sponge	1.2	
	Microbialite	0.5	
	Cement	1.2	
Total (646.4 cm²)			100.0

I Cavity provider	Number of total cavities	Cavities with cryptobiont		Cryptobiont type	Size (cm³)
Archaeoscyphia	47	21	6	S*	0.1 - 0.2
			4	S + B†	0.8 - 7.9
			3	M‡	0.1 - 2.3
			1	M + B	1.0
			7	B	0.3 - 3.6
Calathid	1	1		S + M + B	1.8
Gastropod	1	1		S + M	1.2
Total	49	6			

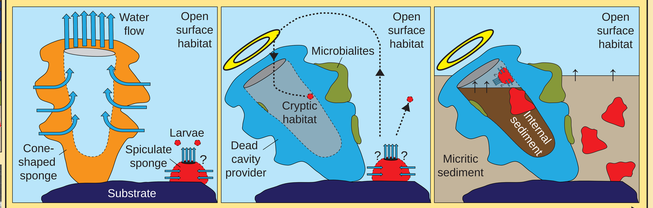
*Spiculate sponge; †Burrow; ‡Microbialite

G-H) Spatial abundance of components in Dumugol boundstone. **I)** Cavity providers and cryptic constituents of the Dumugol intraskeletal space. **J)** Spatial abundance of components in cryptobiont-bearing cavities. Note the partial occupation of cavities by sessile members including spiculate sponge and microbialite.

► *Cavities of the Dumugol reefs*
- Small (0.1-7.9 cm²) intraskeletal crypts predominantly developed within cone-shaped siliceous sponge *Archaeoscyphia*

► *Low diversity cryptic sessile community of spiculate sponges and microbialites*
- Similar composition of epibenthic and cryptic communities → indication of weak polarization
- Partial infilling of these cryptic spaces
- Spiculate sponges in cavities
  - Occur in both open and cryptic space → no differentiation yet
  - Larger biomass (230% more) in open surface than in cryptic space
  - Interpreted to invade the cryptic cavities shortly after demise of host organism

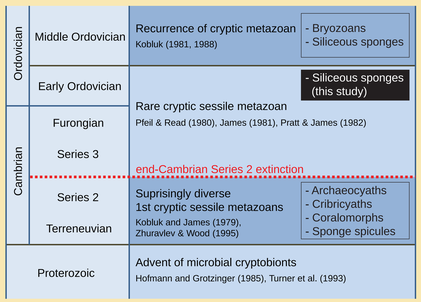
Transiently established cryptic spaces by demise of host organisms → **Settlement of opportunistic epibenthic spiculate sponges!**



Schematic reconstruction of the early adaptation of the spiculate sponges into cryptic habitat.

D) Photomicrograph of toppled central cavity of a calathid filled with spiculate sponges and internal sediments with burrows. **E)** Interpretive sketch of D showing spiculate sponges attaching to the inner wall of calathid (black arrows) and on top of micritic internal sediments (white arrow). **F)** Enlargement of white rectangle in D showing no discernible skeletal distortion at contact between spiculate sponge and host, indicating possible post-mortem association.

5. Discussion and Conclusions



Evolutionary history of cryptic metazoans from the Proterozoic to early Paleozoic. The cryptic spiculate sponges of the Dumugol patch reefs represent the oldest *in situ* siliceous sponges in cavity, far older than previously known examples from the Middle Ordovician metazoan-dominant reefs (Kobluk, 1981).

Hypothesis of sessile metazoan invasion of cryptic space

- Extension of open surface communities into cryptic space → Simultaneous biotic developments in both open and cryptic habitats (Zhuravlev and Wood, 1995)
- Dumugol cryptic system: partial utilization of short-lived intraskeletal space by spiculate sponges → 1st direct evidence explaining initial metazoan adaptation into crypts

Epibenthic metazoans constantly explored ways to exploit cryptic space → Repeated settlement of open surface benthos into cryptic space → Extension of epibenthic forms into cryptic space / no obligate cryptic forms yet → Eventual emergence and establishment of obligate cryptic faunas?

The Dumugol cryptic system

- Thus the Dumugol intraskeletal cryptic system demonstrates the initial exploitation of crypts by epibenthic siliceous sponges and warrants the critical need for further studies of Paleozoic cryptic system for more comprehensive understanding of evolutionary pathways of the cryptic sessile metazoans.

Key references

Kobluk, D.R., 1981. Cavity-dwelling biota in Middle Ordovician (Chazy) bryozoan mounds from Quebec. Can. J. of Earth Sci. 18, 42-54.
Kobluk, D.R., 1988. Pre-Cenozoic fossil record of cryptobionts and their presence in early reefs and mounds. Palaios 3, 243-250.
Kobluk, D.R., James, N.P., 1979. Cavity-dwelling organisms in Lower Cambrian patch reefs from southern Labrador. Lethaia 12, 193-218.
Zhuravlev, A.Y., Wood, R., 1995. Lower Cambrian reefal cryptic communities. Palaeontology 38, 443-470.

Acknowledgments

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