5. 所期の目的の遂行状況及び成果

ウェブサイト公開用

（様式 10）
（海外特別研究員事業）
令和 2 年 4 月 1 日

海外特別研究員最終報告書

独立行政法人日本学術振興会 理事長 殿

採用年度 平成 30 年度
受付番号 201860407
氏　　名 田近周
（氏名は必ず自署すること）

海外特別研究員としての派遣期間を終了しましたので、下記のとおり報告いたします。
なお、下記及び別紙記載の内容については相違ありません。

記

1. 用務地（派遣先国名）用務地：ニューヨーク （国名：アメリカ合衆国）

2. 研究課題名（和文）※研究課題名は申請時のものと違わないように記載すること。
白亜紀頭足類における気室体積の成長曲線と生理学的側面の関連性の検証

3. 派遣期間：平成 30 年 4 月 1 日 ～ 令和 2 年 3 月 31 日

4. 受入機関名及び部局名
American Museum of Natural History, Division of Paleontology

5. 所期の目的の遂行状況及び成果…書式任意 **書式任意（A4 判相当 3 ページ以上、英語で記入も可）**
（研究・調査実施状況及びその成果の発表・関係学会への参加状況等）
（注）「6. 研究発表」以降については様式 10－別紙 1～4 に記入の上、併せて提出すること。

5．所期の目的の遂行状況及び成果

Research Project Report

Title of the project:

Comparison of growth trajectories of phragmocone chamber volume in Cretaceous cephalopods to explore their physiological aspects

AMANE TAJIKA

AMERICAN MUSEUM OF NATURAL HISTORY

[Summary]

In this project, I examined shelled modern and Cretaceous cephalopods. The aim of this project was to test the hypothesis of whether chamber volume development conveys information on physiological aspects (mainly metabolic rates) in various phrragmocone-bearing cephalopods.

To collect fossils needed for the project I conducted a fieldwork in South Dakota and Montana with the help of some amateur fossil collectors. The fieldwork yielded many fossil specimens (Cretaceous ammonoids and nautiloids). I applied computed-tomography (non-destructive) and grinding tomography (destructive) to the fossils at the host research institute (American Museum of Natural History) and other collaborating research institutes (Heidelberg University, Ruhr-University Bochum) to produce tomographic data (3D image stacks). Then, I used the tomographic data to measure chamber volume through ontogeny. In addition to the ammononid fossils and nautiloids fossils, I included some modern nautilid *Nautilus* and squid *Spirula* in the study as a comparison. Results reveal different patterns of chamber volume development in different cephalopods: fossil and modern nautilids show harmonic chamber volume development without fluctuation, while ammonoids and coleoids demonstrate abrupt drops of chamber volume during ontogeny. The difference lies in the present or absence of abrupt decrease in chamber volume between nautilids, ammonoids and coleoids. Assuming that growth and metabolic rates of animals are closely related, the presence or absence of abrupt drops is likely rooted in the difference in metabolic rates. If this holds true for all phragmocone-bearing cephalopods, ammonoids with abrupt drops in chamber volume are considered to have a higher metabolic rate. It is assumed that such a high metabolic rate in ammonoids was probably fatal in the low-food environments at the end of the Cretaceous.

The results of this project were published as a scientific paper and were also presented at a scientific meeting in the United States.

5. 所期の目的の遂行状況及び成果

[Details]

1. Research questions addressed in this study

- What are the typical patterns of chamber volume development in various cephalopod groups and how do they differ?
- What are the factors that alter patterns of chamber volume development between different cephalopod groups?
- What do these factors tell us about the ecology and extinction selectivity of cephalopods?

2. Materials

To answer the questions above, I chose specimens of various cephalopods. Some of the specimens are reposited at the American Museum of Natural History. I also carried out fieldwork in Pierre Shale in Montana and South Dakota to collect more specimens. Additional specimens were provided by collaborators at Ruhr-University Bochum (Germany), Museum of Nature and Human Activities, Hyogo (Japan) and the University of Zurich (Switzerland). I studied the following groups.

- Modern nautilid *Nautilus* (with no, moderate and fatal pathology)
- Cretaceous nautilid *Eutrephoceras* (no pathology)
- Cretaceous ammonoids *Gaudryceras* and *Tetragonites* (no pathology)
- Modern coleoid *Spirula spirula* (no pathology)

3. Methods

To reconstruct chamber volume development, I applied two tomographic methods to the specimens. X-ray computed cosmography, which is non-destructive, was applied to the specimens. In the cases, X-ray computed tomography did not yield good results due to a similar density between the shell and sediment infills. In such cases, grinding tomography, which is destructive, was applied.

Chamber volume was measured using a MATLAB program, developed by a collaborator at Kyoto University.

4. Results

I plotted chamber volume of the abovementioned groups through ontogeny (Fig. 1) and found the followings:

- In modern and fossil nautilids, chamber volume usually increases constantly during ontogeny without abrupt drops under normal and natural environmental conditions (with no or moderate pathology). Abrupt drops in chamber volume occur only under extreme conditions (e.g., specimens with fatal pathology; when individuals are reared in an aquarium).

- In ammonoids and the modern coleoid *Spirula*, chamber volume increases more or less constantly but it sometimes shows abrupt drops under natural ecological conditions during ontogeny.

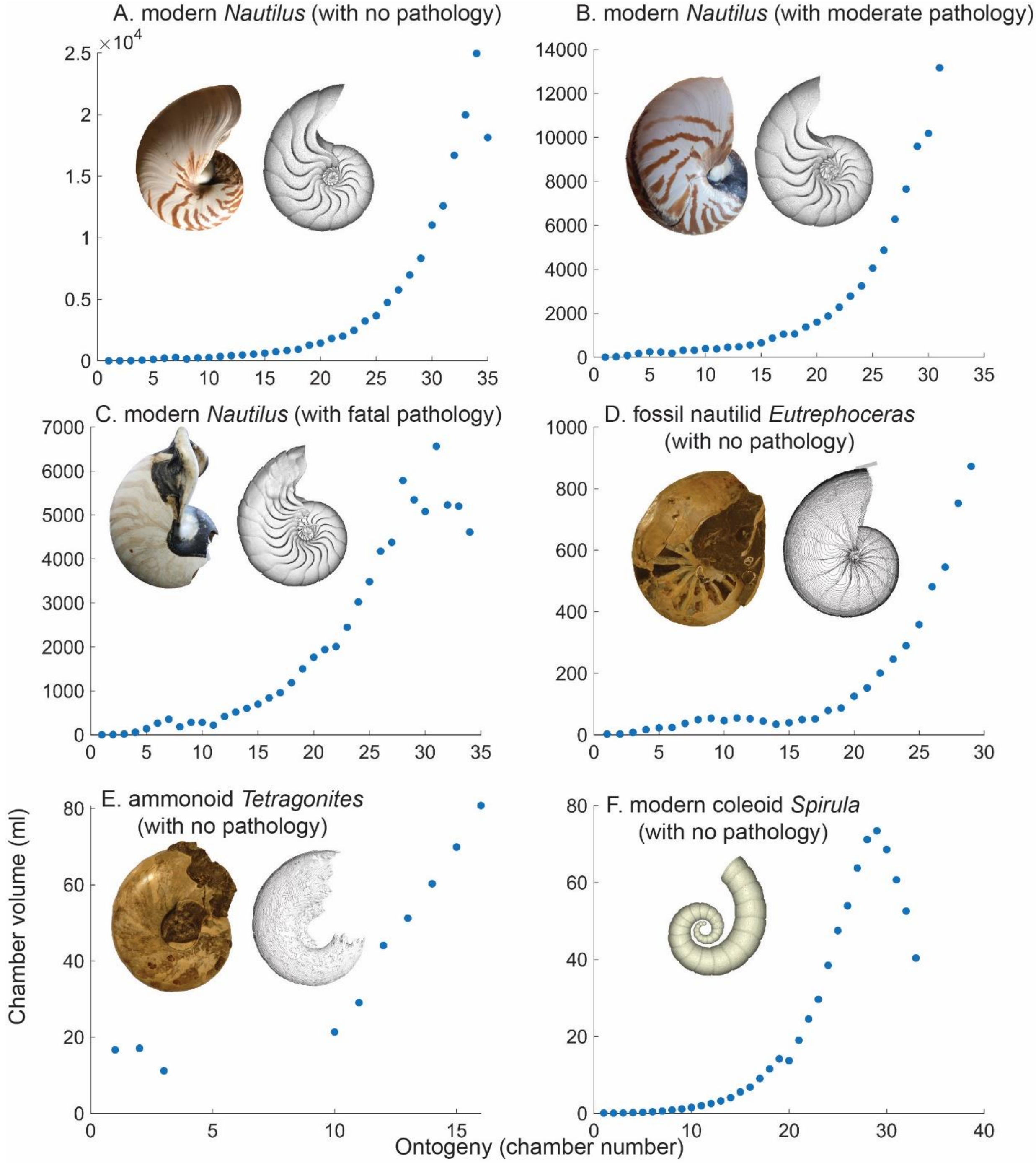

Fig. 1. Chamber volume development in modern *Nautilus* (A: without pathology, B: with moderate pathology, C: with fatal pathology), fossil nautilid *Eutrephoceras* (D, without pathology), ammonoid (E: without pathology) and modern coleoid *Spirula* (F: without pathology).

5. Discussion & Conclusion

Here are some hypotheses to explain the difference in chamber volume development between nautiloids, ammonoids and coleoids.

i) Change in mode of life

ii) Change in habitat

iii) Differences in metabolic rates

I concluded that the differences cannot be fully explained by the hypotheses (i) and (ii) and that hypothesis (iii) is the most reasonable explanation. The reason is that (1) there is a direct link between metabolic rate and growth in some animals and (2) metabolic rate is reflected in phenotypic plasticity in response to environmental changes, although the relationship between metabolic rate and growth needs further investigation.

Additionally, it is assumed that animals with a high metabolic rate were disadvantageous in the low-food environments, and thus a metabolic rate was a contributing factor for their extinction at the K/Pg mass extinction event.

6. Publications and conference abstracts related to the results of the project

- **Amane Tajika**, Landman N., Hoffmann R., Lemanis R., Ifrim C., Morimoto N., Klug C. (2020) Chamber volume development, metabolic rates and selective extinction in cephalopods. *Scientific Reports* 10, 2950 (2020). https://doi.org/10.1038/s41598-020-59748-z
- **Amane Tajika**, Hoffmann R., Landman N., Lemanis R., Ifrim C., Morimoto N., Klug C. (2019) Morphogenesis of phragmocone chambers in modern and fossil nautiloids, and some Cretaceous ammonoids reconstructed by high-resolution computed- and grinding tomography. *Geological Society of America (GSA) annual meeting*, Phoenix, United States.
- **Amane Tajika**, Klug C. (2020) How many ontogenetic points are needed to accurately describe the ontogeny of a cephalopod conch? A case study of the modern nautilid *Nautilus pompilius*. *PeerJ*