論文内容の要旨

論文題目

Micro-CT based study of the endocranial and related ectocranial morphologies of Minatogawa I and IV, Late Pleistocene *Homo sapiens* crania from Okinawa Island, Japan
（沖縄島出土後期更新世 *Homo sapiens* 港川Ⅰ号・Ⅳ号のマイクロＣＴを用いた頭蓋内腔形態と関連外部形態に関する研究）

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Human fossil remains excavated from the Minatogawa limestone quarry fissure site in southern Okinawa Island, Japan are some of the best preserved specimens among a small number of the Late Pleistocene *Homo sapiens* fossils that has been found in East Asia. Description and accurate assessment of their morphology and clarification of its significance is important in understanding the dispersal and evolutionary process of early *H. sapiens* populations in this area. The purpose of this thesis is to provide new insights on aspects of the cranial form of the Minatogawa series by describing and evaluating the endocranial morphology of the Minatogawa I and IV crania, which has not been described aside from a report of endocranial volume estimation with millet seeds. The analysis was performed by using micro-CT and three-dimensional printer systems, which enables a fuller access to endocranial morphology than previously possible.

Since the reliability of the endocranial data to be analyzed depends on the reconstruction quality of endocranial cavity, the potential error of the CT-based endocranial volume estimation was thus first examined. In a comparative study of intra- and interobserver errors, micro-CT based endocranial volume estimation was confirmed to be more accurate compared to the conventional millet seed method. However, in CT based measurement, it is critical to properly place the boundary between bone and cavity air. Regarding this, I developed a step-wise thresholding method that combines an initial global threshold and locally applied secondarily adjusted values. This method was found to be more accurate (estimated error ±0.25%) than using a single global threshold throughout the skull (estimated error ~1%). CT slices three times thick resulted in a further 50% or so increase of error, totaling up to ~1.5% (15 cc per 1000 cc). Error other than that stemming from thresholding is mostly related to blocking of foramina and canals (~0.1%) and error due to the limits of voxel size calibration (±0.15%). Adding up these various effects, it was demonstrated that error involved in endocranial volume estimation of an intact cranium based on high resolution CT data can be limited to ±0.5% error (±5 cc per 1000 cc).

After the above investigation of potential error, the endocranial volume of the Minatogawa I cranium, which is well preserved with minor breakage, was estimated based on the micro-CT data to be around 1335 cc. On the other hand, the Mintogawa IV cranium is more damaged and exhibits

some clear postmortem distortion. I thus reconstructed the endocranium of this specimen after correcting the distortion and breakage by combining the digital and manual restoration procedures, and established its reliable endocranial volume estimate to be around 1170 cc. These results confirmed the suggestion of the previous work of Suzuki (1982) that the Minatogawa series have small endocrania compared with modern Japanese and Jomon populations. This character is unlikely to reflect an ancestral condition, because the Late Pleistocene/early Holocene *H. sapiens* populations in Southeast Asia, southern China, and Australia likely had a larger endocranial volume. In addition, the relatively cold climatic environment the Minatogawa people or their immediate ancestral group should have experienced may not have given a small endocranial volume advantage. Therefore, the small endocrania of the Minatogawa people may need another explanation such as adaptation to an insular environment.

Based on the digital and physical models, the endocranial morphology of Minatogawa I and IV was described quantitatively and qualitatively and then interpreted in the context of evolution by consulting the later *H. sapiens* samples (mainly of Jomon and Japanese) as well as a number of fossil *H. sapiens* and archaic *Homo* specimens. In addition, the endocranial basis of some of the previously debated distinct ectocranial features of the Minatogawa series such as the marked postorbital constriction and rounded cranial outline in occipital view was also discussed.

The Minatogawa endocasts were found to have some derived features of *H. sapiens* such as an elevated parietal region, endocranial widening extending dorsoventrally at a relatively anterior position, and a narrow internal occipital crest. The Minatogawa series also had the following distinct endocranial features: a combination of weak parietal boss and strong temporal bulge, a weakly swollen lateral frontal region, and a relatively low endocranial shape for a *H. sapiens* cranium. These characters unlikely suggest any primitive retention from archaic *Homo*. Regarding this, Minatogawa I's rounded ectocranial outline in occipital view, a feature previously cited as a possible primitive retention from archaic *Homo*, can be associated with endocranial morphology, particularly a strong temporal bulge, best interpreted as a variant condition of *H. sapiens*. However, a strong temporal bulge and weak parietal boss are seen in earlier Late Pleistocene *H. sapiens* (Skhul V and Qafzeh 9), and may represent the ancestral condition for *H. sapiens* in general. A marked postorbital constriction relative to the upper facial breadth of the Minatogawa series (especially Minatogawa I), comparable to that of Skhul V, can be regarded as a primitive character for *H. sapiens*. This occurs despite endocranial frontal width as large as in the Japanese specimens, and can be mainly attributed to a large upper facial breadth related to the well-developed masticatory muscles. A relatively large neuro-orbital disjunction of the Minatogawa series also likely affects the marked postorbital constriction, although the degree of influence may be marginal. The Minatogawa endocasts were also found to have a closer affinity to those of the Jomon specimens than to those of the Japanese specimens, in having relatively broad endocranial shape, a relatively low frontal and occipital

endocranial region, a strong temporal bulge and weak parietal boss. The characteristics are expressed intensely in Minatogawa than in Jomon, and partly consistent with the Skhul V condition. If the Skhul V condition represents the ancestral early *H. sapiens* morphology, the similarities observed between Minatogawa and Jomon can be considered to reflect different degrees of retention of the ancestral early *H. sapiens* condition. However, the similarity does not support a hypothesis of Minatogawa–Jomon genealogical closeness since it is not exclusively seen among *H. sapiens* examples.