鹿児島大学南太平洋海域研究センター主催

シンポジウム「有孔虫からみた環境と古環境」
Foraminifera as indicators of marine environments in the present and past

期日：1998年2月28日(土)（13時－17時）
場所：鹿児島大学稲盛会館

主催　鹿児島大学南太平洋海域研究センター
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プログラム

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報告

1．有孔虫はなぜ環境や古環境の指標として使えるのか？

北里　洋（静岡大学理学部）

Why Does Foraminifera Act as Useful Proxies for Modern and Ancient Marine Environments ?

Hirosi KITAZATO (Faculty of Science, Shizuoka University)

有孔虫は現在あるいは過去の海洋環境の指標としてよく用いられる生物である．有孔虫のどのような特性が環境に相関しているのだろうか？　種の分布がある特定の環境要素に対応しているのだろうか？　また，ある環境によって発現する形態的な特徴があって，それが環境復元の際に役に立つのだろうか？　このような，有孔虫と環境との相関を考えるときに，環境を制御した飼育実験が有用なアプローチとなる．

私たちの研究室では，有孔虫の殻形態が示す意味を理解するために，温度・塩分・溶存酸素量・餌・光量などの環境要素を制御した飼育実験を行っている．実験の結果，有孔虫の殻形態には環境要素と強い相関を持って変異が現れる形質があることが明らかになってきた．これが，有孔虫が環境の指標として使える主な理由である．講演では，飼育実験の経過とその結果を示し，有孔虫の殻形態を遺伝的な要素と環境に左右されやすい要素とに分解することを試みる．

2．Larger Foraminifera - Microscopical Greenhouses Indicating Shallow-water Tropical and Subtropical Environments in the Present and Past

Johann HOHENEGGER, (Universitaet Wien)

Larger Foraminifera with test sizes from 2mm up to 13cm are characteristic organisms inhabiting shallow water subtropical and tropical environments today. They prefer clear, nutrition depleted water as can be found in the surroundings of coral reefs.

Two main factors acting as single gradients regulate the distributions of larger foraminifers within coral reef complexes. All living larger Foraminifera house symbiotic microalgae and are thus restricted to the photic zone (down to 150m), getting independence from food resources outside the cell in various degrees. Differences in water movement, mostly correlated with substrate type, and light availability are managed in various ways. Test constructions in combination with attachment mechanisms of the protoplasm combat strong water movement, while light penetration is handled by test ultrastructure. Larger foraminifers inhabiting intertidal and extremely shallow subtidal environments block high irradiation by thicker tests or porcelaneous structures, making the walls impenetrable. In contrast, species living near the base of the photic zone facilitate light penetration by thin transparent test walls facilitating light penetration and by developing light-collecting mechanisms such as nodes and pillars. Water turbulence, often extreme in coral reef environments, are handled in different ways, but are restricted to a few paradigmatic test forms. Similar tests were developed in various phylogenetic lines at different climatic climaxes during earth history starting from the Late Paleozoic (325,000,000 years ago). This can be interpreted as analogous developments in handling the main environmental gradients light penetration and water energy.

3．西太平洋における浮遊性有孔虫の分布と日周期運動

八田明夫（鹿児島大学教育学部）

Distribution and Daily Migration of Planktonic Foraminifera in the West Pacific

Akio Hatta (Faculty of Education, Kagoshima University)

化石有孔虫から古環境を推定するためには，現生有孔虫を採取し，その生息環境を明かにして化石有孔虫の持つ情報を把握しなければならない．そのために現生の浮遊性有孔虫がどのような海域に分布しているのか，どのような深度や温度の海域にいるのかを調べた．200mまでの深度を4層準に分けて浮遊性有孔虫を採取した．西太平洋における浮遊性有孔虫の種類別の地理的分布と日周運動を明かにして，これまでに知られている他の海域の浮遊性有孔虫と比較した．

その結果*Globorotalia tumida*や*Globorotalia menarudii*や*Pulleniatina obliqueroqulata*などの熱帯海域に多い種類や，温帯海域に多い*Globigerinoides ruber, Globigerinoides sacculifer, Globigerinoides oblicquus, Globigerinita glutinata, Globigerina rubescens*などの分布の違いも明かとなった．

また，浮遊性有孔虫の日周運動でも他の小動物のそれと違う動きが認められた．これは二酸化炭素の動態を考察するうえで重要な要素になると考えられる．

4．海洋古環境の復元をめざしてー浮遊性有孔虫からのアプローチー

尾田太良（熊本大学理学部）

Reconstruction of Marine Environments in the Past--A Planktic Foraminiferal Approach

Motoyoshi Oda (Faculty of Science, Kumamoto University)

古環境解明のため深海堆積物の分析，デー タの解析と解釈に関して， 従来より様々な方法が試されてきた．その中でも，Lmbrie and Kipp (1971) による浮遊性有孔虫による

主因子分析により水温に相関の高い種を抽出し，それをもとに重回帰分析による変換関数 (transferfunction) は，現在までかなりの評価を得ている (CLIMAP, 1976)．この方法は，石灰質ナンノプランクトンや放散虫・珪藻にも適用されている．しかしながら，大西洋や大平洋などの海域の地域性の問題などから，各海域での確立が必要である．また，プランクトンの成育は緯度や四季によってその生産性が変動する．海洋古環境のより正確な復元を行っていく上で，どのくらいの割合で各季節の情報が堆積物に記録されるのか，浮遊性有孔虫フラックスと海洋古環境要因の関係などを把握する必要がある．現在セヂメントトラップなどを用いた海洋古環境のための基礎的な資料が蓄積されつつある．今回，以上の事の現状と黒潮海域での最終氷期以降の海洋古環境の復元について述べる．

5．新生代地球環境の変遷と有孔虫

野村律夫（島根大学教育学部）

Cenozoic Environmental Changes of the Earth and Fossil Foraminifera

Ritsuo NOMURA (Faculty of Education, Shimane University)

哺乳類の時代ともいわれる新生代は，現在の地球環境の形成を理解するうえで極めて重要な時代にあたる．そのメカニズムの解明には海洋に生息する有孔虫の群集解析や有孔虫の殻の酸素・炭素の同位体分析が有効である．有孔虫群集が記録する主要な古海洋イベント，すなわち地球環境の変化には次のようなものがある．(1) 暁新世末の底生有孔虫の絶滅イベント，(2) 始新世中期から後期の浮遊性・底生群集の段階的な変化，(3) 初期漸新世の浮遊性群集の爆発的発展，(4) 初期中新世末期から中期中新世初期の底生・浮遊性群集の漸次的絶滅と発展，(5) 後期中新世の現世型生物群集の発展．進化である．

これらのイベントは，海洋－大陸（山脈・高原の上昇）－大気の複雑な相互作用の中で起こっており，テーチス海の消滅，南極氷床の発達，グローバルな深層循環と表層水における生産性の変化，大陸分布，ヒマラヤ‐チベットの上昇，大気中のCO_2のような温室効果ガスの存在量の変動がキーワードになる．

6．鹿児島市は冷たい海の底だった - 底生有孔虫化石から読み取れる氷河期の証拠

大木公彦（鹿児島大学理学部）

Kagoshima under Cold Sea Water Told by Fossil Foraminifera

Kimihiko ŌKI (Faculty of Science, Kagoshima University)

鹿児島市吉野町琉球人松の崖に海成堆積物から成る城山層が露出している．下部の泥層には40㎝前後の大きなカキ（*Ostrea gigas*）の化石が林立してカキ堆（oyster bank）を形成している．このカキは，現在，北海道のサロマ湖（海とつながっている）と厚岸湾に生息している．そこで，この泥層から花粉の化石を抽出したところ，松・杉のほかにトウヒ・モミ・ツガなどの寒い地域の植物が多く含まれていた．さらに，底生有孔虫化石を調べた結果，内湾浅海域の指標である*Ammonia tepida*と，浅い冷水塊に生息する*Buccella frigida*の２種が群集の大半を占めていた．

これらの化石から，城山層下部層は，今の鹿児島よりはるかに寒い時期の内湾浅海域に堆積したと考えられる．上部層から温帯の貝化石が産出しており，城山層は気候が寒冷から温暖に変わる頃，つまり氷河期から間氷期へ至る海進時期の堆積物であることが分かる．この層が堆積した年代は，上下の地層から30～10万年まえと考えられ，ミンデ

ル氷河期からミンデル-リス間氷期，あるいはリス氷河期からリス-ウルム間氷期への移行期に堆積した可能性が強い．

いずれの氷河期にせよ，城山層の堆積当時の海は現在の海水準より50～100mほど低かったと考えられている．現在，この地層が標高50m付近に分布していることから，吉野台地は100m以上も隆起したことになる．

閉会挨拶：鹿児島大学　南太平洋海域研究センター長　井上晃男

1．Why Does Foraminifera Act as Useful Proxies for Modern and Ancient Marine Environments?

Hirosi Kitazato (Faculty of Science, Shizuoka University)

Foraminifera is the organism often used as indicators of present or past marine environments.What feature of foraminifera is interrelated to the environment? Does species distribution corresponds to specific environmental factors?Are morphological features correlated to special environmental conditions and are those available for the reconstruction of the paleoenvironment ?

When we investigate such interrelationships between foraminifera and environment, rearing experiment under controled conditions is a useful approach to such researches.

At our laboratory, to understand the significance of the morphology of foraminiferal tests, we treated experiments in which environmental factors such as temperature, salinity, dissolved oxygen, the quantity of feed, and light intensity are controled.They have clarified that some characters of the foraminiferal tests show variations which are in response to these environmental factors mentioned above.This is the main reason why the Foraminifera can be used as indicators of the marine environment in the present or past.

2．Larger Foraminifera - Microscopical Greenhouses Indicating Shallow-water Tropical and Subtropical Environments in the Present and Past

Johann Hohenegger (Universitaet Wien)

Larger Foraminifera with test sizes from 2㎜ up to 13㎝ are characteristic organisms inhabiting shallow water subtropical and tropical environments today. They prefer clear, nutrition depleted water as can be found in the surroundings of coral reefs. Two main factors acting as single gradients regulate the distributions of larger foraminifers within coral reef complexes. All living larger Foraminifera house symbiotic microalgae and are thus restricted to the photic zone (down to 150m), getting independence from food resources outside the cell in various degrees. Differences in water movement, mostly correlated with substrate type, and light availability are managed in various ways. Test constructions in combination with attachment mechanisms of the protoplasm combat strong water movement, while light penetration is handled by test ultrastructure. Larger foraminifers inhabiting intertidal and extremely shallow subtidal environments block high irradiation by thicker tests or porcelaneous structures, making the walls impenetrable. In contrast, species living near the base of the photic zone facilitate light penetration by thin transparent test walls facilitating light penetration and by developing light-collecting mechanisms such as nodes and pillars. Water turbulence, often extreme in coral reef environments, are handled in different ways, but are restricted to a few paradigmatic test forms. Similar tests were developed in various phylogenetic lines at different climatic climaxes during earth history starting from the Late Paleozoic (325,000,000 years ago) This can be interpreted as analogous developments in handling the main environmental gradients light penetration and water energy.

3. Distribution and Daily Migration of Planktonic Foraminifera in the West Pacific

Akio HATTA (Faculty of Education, Kagoshima University)

When we estimate a paleoenvironment from fossil Foraminifera, we must get hold of the information of the habitat of the recent living Foraminifera. I investigated the distribution of planktonic Foraminifera and, depth, temperature and salinity of the habitat sea area. Foraminifera was gathered by vertical towing from the divided 4 horizon between depth of 200m to 0m. Consequently, the geographical distribution and daily migration of respective species of planktonic Foraminifera in the west pacific were made clear, and were compared with those of another sea area. There were a distinct difference in the distribution of tropical species, *Globorotalia tumida, Globorotalia menarudii, Pulleniatina obliqueroqulata* and so on, and the temperate zone species, *Globigerinoides ruber and Globigerinoides sacculifer, Globigerinoides oblicquus, Globigerinita glutinata, Globigerina rubescens.* Moreover, there were characteristic daily migration in the planktonic Foraminifera as compared with another small animal. This is an important factor of consideration about the movement of the carbon dioxide.

4. Reconstruction of Marine Environments in the Past--A Planktic Foraminiferal Approach

Motoyoshi ODA (Faculty of Science, Kumamoto University)

Many attempts applying various methods to analyse deep sea sediments are hitherto performed to reconstruct environmental conditions of the past. Variousinterpretations of these data have been made. Transfer functions, derivatives of factor analytical methods as introduced by IMBRIE and KIPP (1971) were based on correlations between planktic foraminiferal assemblages and water temperature.

Paleotemperatures can now be estimated using the same multivariate function values gained on today's assemblages to fossil planktic communities. This method is also proved by calcareous nanno-planktons, Radiolaria, and diatoms. Because of the differences between the larger marine areas like the Atlantic and the Pacific oceans, however, the development of special standard functions for each marine area is necessary. Furthermore, we have to take into consideration the variations planktic reproduction in accordance with differing latitudes and seasons. The influence of seasonal variation of planktic foraminiferal reproduction has to be studied in detail, especially regarding the relations between the flux of planktic foraminiferas and the marine environment.

At present, fundamental data on these relations using sediment traps are accumulated. My talk for this symposium was mainly concerned with the present situation as stated above and the reconstruction of marine paleoenvironments in the area of the Kuroshio Current after the last glacial epoch.

5. Cenozoic Environmental Changes of the Earth and Fossil Foraminifera

Ritsuo NOMURA (Faculty of Education, Shimane University)

The Cenozoic, called "the Era of Mammals", is extremely important for understanding the development of present global environments. To clarify these developmental mechanisms, analyses of foraminiferal communities inhabiting the sea, together with the determination of stable oxygen and carbon isotopes deposited in their test walls are important. Major oceanological events affecting changes of the global environment are reflected in foraminiferal communities. These changes are :

(1) Extinction of some benthonic Foraminifera at the end of the Paleocene,
(2) Gradual changes of both planktic and benthic communities during the middle to the late Eocene,
(3) Radiation of planktic communities in the early Oligocene,
(4) Gradual extinction and development of both benthic and planktic communities toward the end of the early Miocene and beginningof the middle Miocene,
(5) Development of the present-living communities starting in the late Miocene.

These events demonstrate complex interactions amongst the oceans and continents, where mountains and plateaus rose, and the atmosphere.Some of them are noted here : the disappearance of Tethys Sea, the development of ice shields on the antarctic continent, productivity changes of the sea water in deep and surface layers caused by the global circulation, changes in thedistribution of continents, the rise of the Himalaya-Tibet area, and variations in the content of green-house-effect gases, such as CO_2, in the atmosphere.

6. Kagoshima under Cold Sea Water Told by Fossil Foraminifera

Kimihiko ŌKI (Faculty of Science, Kagoshima University)

Late Pleistocene Shiroyama Formation is exposed in the cliff of Ryukyujinmatsu, Yoshino-cho, Kagoshima City, and the lower mud bed of the formation yields large fossil oyster (*Ostrea gigas*) forming oyster bank. *Ostrea gigas* is living in Saroma Lake and Akkeshi Bay, Hokkaido.

This bed yields fossil pollen such as *Pinus, Abies, Tsuga, Picea* and *Fagus* which indicate a cool or cold condition at that time. Furthermore, *Ammonia tepida*, an index species of an inner and shallow bay, and *Buccella frigida*, an index species of cold water, occupy more than 50 % of the benthic foraminiferal fauna in this bed. On the other hand, abundant molluscan fossils of a warm shallow sea type are contained in the upper mud bed. The Shiroyama Formation was stratigraphically deposited during the period ranging from 0.3 to 0.1 Ma. From these facts it is concluded that the Shiroyama Formation is an inner-bay sediment deposited at the last stage of Mindel or Riss glacial age.

Sea level of the last stage of glacial age must be more than 50 m below Recent sea level, but the formation is distributed in the hight about 50 m above sea level. From this it may be inferred that the region was uplifted more than 100 m.

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