平成２５年度第１次募集（平成２４年１０月入学含む。）

新潟大学大学院自然科学研究科博士前期課程入学者選抜試験問題

一　般　入　試

環境科学専攻

地球科学コース

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専門科目（地球科学）

注意事項

1　この問題冊子は，試験開始の合図があるまで開いてはならない。

2　問題冊子は，表紙を含めて全部で７ページある。

3　解答は，すべて解答用紙の指定された箇所に記入すること。

4　受験番号は，各解答用紙の指定された箇所に必ず記入すること。

5　解答時間は，１８０分である。

6　下書きは，問題冊子の余白を使用すること。

1　現在，あなたが行なっている課題研究（卒業研究）について，研究のタイトルを書いた上で，下記の項目に分けて，分かりやすく論理的に述べよ．

（1）あなたの研究分野における研究動向

（2）先行研究における問題点

（3）研究目的とその意義

（4）研究計画と研究手法

（5）現在までの進行状況

（6）あなたの研究の優れている点

（7）最初に設定した目的を達成するために今後注意すべき点

2　ユースタシー（eustasy）は，地球の中心から海面までの絶対的な距離であり，過去にさまざまな周期で変動してきたことが地質学的に明らかにされている．一般にその周期性は階層性を示し，第一次から第五次までの階層が認識されている．下記の文章は，そのようなユースタシー変動の階層性の要因について解説したものである．この文章に関連して，（１）～（４）の問いに答えよ．

FIVE ORDERS OF CYCLES

Five orders of cyclic sea level change have been defined, with periodicities ranging from hundreds of millions to tens of thousands of years. The definition of the cycles is somewhat subjective (Vail et al., 1977b; Miall, 1990). First-, second- and third-order cycles lack a regular periodicity. However, fourth- and fifth-order cycles, with durations of much less than one million years, do appear to reflect a regular cyclic control.

First-order cycles

Two first-order cycles lasting 200–400 m.y. are recognized in the Phanerozoic, and are widely interpreted to be related to the accretion and subsequent splitting apart of supercontinents (Vail et al., 1977b; Worsley et al., 1984). When continents are joined together (as in the Permian Pangea), the volume of spreading ocean ridges is minimized and ocean basin volume is maximized (due to thermal subsidence). This results in a global lowering of eustatic sea level. These conditions are reversed at times of supercontinent breakup, when new spreading ridges form and displace water onto continental margins.

Second- and third-order cycles

Second-order cycles consist of a grouping of third-order cycles. The third-order cycles represent the highest frequency sea level events portrayed on the Exxon curve[注1].

Second-order cycles span 10 to 100 m.y. and are exemplified by the cratonic sequences documented by Sloss (1963). These sequences have been convincingly correlated between four different continents (Soares et al., 1978), suggesting a global sea level control. The explanation of Hallam (1963), now widely accepted, is that second-order cycles reflect changes in the volume of oceanic ridges, related to changes in spreading rate. These ideas were more quantitatively elaborated by Pitman (1978).

Third-order cycles have durations of 1–10 m.y., but are typically shorter than 3 m.y. They are ubiquitous in the Phanerozoic record (Haq et al., 1988; Miall, 1990), but their control is problematic and controversial. Vail et al. (1977a, b) and Haq et al. (1988) suggest that these

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注1　Exxon curve：エクソン・カーブ．Vail らによってまとめられた，過去のユースタシー変動を総合的に示すグラフのこと．

cycles can be correlated globally. However, because many third-order cycle boundaries are spaced close to or below the limit of biostratigraphic resolution, it may never be possible to resolve their ages with sufficient precision to prove precise global synchroneity. Nevertheless, some studies (e.g., Ross and Ross, 1988) provide persuasive evidence that third-order cycle boundaries can be accurately correlated within and between continents. Detailed stratigraphic work in the Cretaceous of the Alberta Basin shows that the chronostratigraphic position of many sequence boundaries and lowstand[注2] deposits corresponds with those predicted by the third-order cycle chart of Haq et al. (1988).

Possible controls on third-order cyclicity

Although Haq et al. (1988) and Vail et al. (1977a) imply control of third-order cycles by the waxing and waning of continental ice masses, there is good evidence (e.g., Hayes et al., 1976) that the growth and decay of ice sheets takes place over much shorter periods of time (10^4 to 10^5 years). Kauffman (1984) noted that third-order marine transgressions in Cretaceous strata in the western United States corresponded to periods of active Cordilleran tectonism and volcanism, whereas lowstands were marked by relative tectonic and volcanic quiescence. These relationships suggested a causative link in which accelerated ocean ridge spreading (causing a eustatic rise), was coupled with accelerated subduction (promoting thrusting and volcanism along convergent margins). Harrison (1990) agreed that variations in spreading rates on ocean ridges (or segments of ridges) could account for the timing of third-order cycles, but that the amount of eustatic change would be an order of magnitude less than that suggested by the rock record. Amplification by tectonic subsidence would result in the greater water depths suggested by the rock record.

In contrast to explanations related to spreading and subduction, Cloetingh (1988) hypothesized that episodic changes in the horizontal stress field within plates might influence third-order cyclicity. The stress changes were postulated to result from the jostling of plates, and were calculated to induce tens of metres of subsidence or uplift over a time scale of about 10^6 years. This in turn would result in simultaneous transgressions and regressions within individual basins. These conclusions have, however, been disputed by Christie-Blick et al. (1990), who show that there need be no direct relationship between horizontal stress, basin deformation and the formation of sequence boundaries.

In an attempt to explain inferred regional sea level oscillations of up to 50 m in less than one million years, Cathles and Hallam (1991) suggested that horizontal stress changes within plates could cause rapid, plate-scale changes in lithospheric density. These would result in isostatic changes in freeboard of a few metres. Despite the novelty of this hypothesis, it does not explain the cause of frequent changes in the stress field.

The idea of geoidal[注3] eustasy, as advanced by Mörner (1981, 1987a, b), is based on the

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注2 lowstand：低海水準期
注3 geoidal：ジオイドの

discovery (using satellite geodesy) that the ocean surface has "sags" and "bulges"注4 with an amplitude of up to 180 m. This relief reflects irregularities in the gravitational field of the earth. Mörner argued that the migration of these oceanic sags and bulges would result in diachronous sea level changes. However, it has been pointed out (Devoy, 1987b) that changes in the gravitational field probably reflect mantle convection, which is extremely slow. Concomitant drift of the ocean surface topography must be correspondingly slow, on a time scale of millions of years, not thousands of years as inferred by Mörner (1987b). More importantly perhaps, Christie-Blick et al. (1990) emphasize the fact that geoidal changes affect not only the oceans but, over geological time, the solid earth as well. The land bulges up under an oceanic bulge, and no net sea level change results. Geoidal eustasy is therefore not likely to produce significant changes in relative sea level.

Sabadini et al. (1990) argue that variations in centrifugal force caused by long-term wander of the Earth's axis of rotation produces third-order eustatic sea level fluctuations that are nonsynchronous from hemisphere to hemisphere. Polar wandering results from poorly understood variations in the structure and viscosity of the mantle.

It is clear that an improved understanding of the mechanisms responsible for third-order cycles awaits better geophysical models of the Earth's interior, together with an order of magnitude improvement in the temporal resolution of sea level events from different parts of the world.

Fourth- and fifth-order cyclicity

Fourth- (500,000–200,000 yr) and fifth-order (200,000–10,000 yr) cycles are widely documented in many parts of the Phanerozoic, both in shallow-marine and pelagic rocks (see Fischer, 1986 and Kauffman, 1988 for reviews). These cycles are most easily explained by changes in climate driven by various cyclic perturbations of the Earth's tilt and orbit. These astronomical perturbations are known as Milankovitch cycles, after the Serbian mathematician who first calculated their periodicities and effects. The Milankovitch theory holds that fluctuation in the seasonal distribution of incoming solar radiation is the principal control on the growth and decay of Quaternary ice sheets (Imbrie and Imbrie, 1979; Ruddiman et al., 1986; Martinson et al., 1987; Raymo et al., 1989). The simplest way of producing sea level changes at the fourth- and fifth-order scale is by the alternate accumulation and melting of continental ice caps, in response to Milankovitch cycles. This can be convincingly demonstrated for the Quaternary.

Milankovitch cycles

There are three principal orbital rhythms (periods given in brackets) related to 1) changes in the eccentricity of the Earth's orbit around the sun (400,000 and 100,000 years), 2) changes in the tilt of the Earth's axis with respect to the plane in which it orbits the sun (41,000 years), and 3) a wobble (precession) due to the tilt axis sweeping out a cone (21,000 years). These orbital rhythms produce cyclical variations in the intensity and seasonal distribution of incoming solar

注4 "sags" and "bulges"：「へこみ」と「でっぱり」

radiation. In combination, these factors affect the length of the summer melt period, such that at times, the winter snowpack does not melt completely. As the snowpack builds up, ice sheets of continental dimensions can develop, and large amounts of water are removed from the ocean.

出典：Plint, A. G., Eyles, N., Eyles, C. H. and Walker, R. G., 1992, Control of sea level change. *In* Walker, R. G. and James, N. P., eds., *Facies Models: response to sea level change*, Geological Association of Canada, 15–25.（一部を改変）

（1）第三次オーダーの周期性の原因は，この文章が書かれた時点ではどのように理解されているか，日本語で簡潔にまとめよ．

（2）この文章によれば，多くの大陸が接合して超大陸を作っている状態では，ユースタシーはどういう状態になるか，またその理由は何か．日本語で簡潔に答えよ．

（3）この文章は，第四紀のユースタシー変動がミランコヴィッチ・サイクルによる日射量変動でよく説明できるとしている．日射量変動が直接的にユースタシーを変化させる理由は何か，日本語で簡潔に答えよ．

（4）問題文の記述に基づき，次の表を日本語で完成させよ。

ユースタシー変動の次数	変動の周期（年数）	変動の原因
第一次	(ア)	(イ)
第二次	(ウ)	(エ)
第三次	(オ)	(カ)
第四次	(キ)	(ク)
第五次	(ケ)	(コ)

3　以下の英文は地球の構造と変動について述べたものである．全文を和訳せよ．

For centuries we have been fascinated by the shapes of continents and ocean basins, the linearity of mountain chains, the distribution of volcanoes, and the motions along large faults that produce earthquakes. We know today that most such features are the products of deep-seated processes that have been operating since the Precambrian to shape both past and present configurations of tectonic plates on the Earth. We are constantly reminded by the effects of earthquake and volcanic activity that the Earth is a dynamic planet, indicating the plates are driven by awesome forces. The lives of most of the Earth's population are influenced every day by tectonic activity; unfortunately, many are threatened by the potential for earthquakes and volcanic eruptions. Aside from the imminent danger and practical need to comprehend the processes that produce earthquakes and volcanoes, most geologists feel a basic scientific urge to understand these processes.

出典：Hatcher, R. D., 1995, Structural geology: principles, concepts, and problems-2nd ed. Prentice-Hall, Inc., 525 p.