WG3.5 From greenhouse to icehouse worlds

New Drilling prospects after 2013 in ODP sciences. -Reconstructing External and Internal Forcing of Earth climate-

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Abstract

The Cenozoic climate is a still important target of Deep Sea Drilling Program. The general trend of the climate has been revealed based on many paleoceanographic studies from DSDP to IODP drilling data. We propose here several new science prospects concerning future deep-sea drilling.

A new climate theory is that intensity of galactic cosmic rays has affected cloudiness and finally albedo in the surface of the Earth. Solar magnetic activity and paleomagnetic intensity are also related to amounts of cosmic ray influx into the Earth surface.

Concerning geochemical methods, the diatom ^{18}O as a proxy of salinity and temperature and ^{30}Si and ^{15}N of diatom opal as a proxy of nutrient utilization in the past could be tested in the Quaternary to Miocene sediments. These methods may enable us high - quality analysis of climate change in the siliceous oceans as well as the calcareous ones.

Platform improvement is also important for a new drilling. The deep drilling down to Paleogene sequence could need an ability more than 2000 m drilling. Among three platforms, the Chikyu that has a riser and non - riser modes and can penetrate the sequence down to 4000 m (or 7000 m) msbf. Hence, new IODP research, if we can use the Chikyu System, enables us deep–one - hole study that penetrate from surface to Paleogene basement rocks. In particular, the North Pacific region has a thick sedimentary sequence that causes little recovery of the older sediments such as Paleogene and early Neogene. The long complete coring is a significant improvement in new science after 2013.

1. General trend in Cenozic climate

The Cenozic age is characterized by a transition time from the Cretaceous greenhouse to the "Quaternary" icehouse. Although the Paleocene climate is still unclear in detail, it is known that a rapid warming occurred during the Late Paleocene to Early Eocene (Zachos et al., 2001). The oxygen isotope values gradually increased from Middle Eocene to the Oligocene spanning from 50 through 33 Ma (Figure 1). The first rapid cooling is observed at the Eocene/Oligocene boundary, while the second cooling started in the Middle Miocene, approximately 15 Ma. The climate change from the Oligocene to the Quaternary is characterized by a stepwise cooling. The first distinct expansion of the Antarctic ice sheet is inferred around the Eocene/Oligocene boundary when the Oi-1 isotope event was recorded (Coxall et al., 2005). The second Antarctic ice sheets expansion occurred around 15 Ma in the Middle Miocene (Zachos et al., 2001; Holbourn et al., 2005). The typical glacial-interglacial cycles such as the Quaternary glaciation are recognized since about 2.75 Ma, close to Pliocene/Pleistocene boundary. The latest change in climatic cycle from 40 kyr to 100 kyr occurred at about 1 Ma that is called the Mid Pleistocene revolution (MPR)(Berger et al., 1993).

2. New driving Force of climate change?

There are three driving force or control factors of climate those are albedo, solar radiation and greenhouse gases. Solar radiation is strongly connected with orbital factors of the Milankovitch cycles (eccentric, tilting and precession) and intensity of sun activity itself (black spots cycles of 11 and 22 years), while effect of greenhouse gases affected both period of short-term (ka-scale) and long-erm (myr-scale).

Recently, the cosmic scientists proposed a new theory that changes in the intensity of galactic cosmic rays alter the Earth's cloudiness (Svenmark, 2007). In this theory, variations in the cosmic-ray influx change due to solar magnetic activity, and control the formation of cloud on decadal to millennial scales. The positive relationship between the variations in global cloud cover and cosmic rays influx is observed in the low - level (<3.2 km) atmosphere (Carslaw et al., 2002). The geomagnetic intensity also affects variations in the cosmic-ray influx.

Since the effect of albedo seems to be underestimated in the past oceanographic science, we need to reevaluate cosmic effects based on measurement of carbon isotope

(^{14}C), ^{10}Be record and geomagnetic intensity in the sediments. The new paleocenography so-called “Cosmic Oceanography” may be proposed in this view of point.

3. New methods for analysis of climate change in Arctic regions

The high-latitude area is still an important target to understand a transition of the Cenozoic climate. However, lack of calcium carbonate sediments prevents high level of climate study because most of paleoclimatic studies are based on geochemical analysis of shells of calcium carbonate (e.g., oxygen and carbon isotopes, Mg/Ca ratio, and alkenone). Furthermore, no drilling studies have been performed since the ODP Leg 145 (Site 881-887) in the North Pacific sector. On the other hand, the IODP drilling results in the Arctic Ocean proposed a new insight concerning the history of the Arctic ice-sheet development (Moran et al., 2006). The appearance of Arctic ice-sheet could be reevaluated.

Recently, geochemists are challenging to test several new measurement methods for siliceous fossils. For example, the^{18}O of diatom is considered to be useful as a proxy of salinity and temperature, ^{30}Si and ^{15}N as a proxy of nutrient utilization (Brzezinski et al., 2002; De La Rocha, C. L., 2006). These proxies are developed for the Quaternary to Miocene siliceous sediments. If these methods are consolidated, they could greatly improve our knowledge of climate change in the siliceous oceans. Thus, a new estabilishment of non-calcareous proxies and their application for climate science to calcareous-depleted sediments could be a interesting target in the IODP science.

4. Long-term complete sequence of the drill hole

Previous penetration depth of drilling using JR is limited at about 2000 m. The deep drilling down to Paleogene sequence generally needs a composite procedure of multi-drilling cores at several drilling sites. On the other hand, the Chikyu has a riser and non-riser modes and can penetrate the sequence down to 7000 m msbf. Hence, the new IODP research enables us deep–one－hole study that penetrate from surface of sediments to basement rocks. The continuous sequence is the best for research of a reconstruction of integrated timescale and continuous analysis of geochemical study in high－resolution study. In particular, the North Pacific region has a thick sedimentary sequence that causes little recovery of the older sediments such as Paleogene and lower

Neogene. The “ Complete sequence study” is possible using a new drilling ability of the Chikyu.

5. Summary of ISP planning

Although major topics of a new ISP are listed above, the another science target of IODP objectives still remains: 1) Climate change during warming mode in the Early Cenozoic, 2) Cause of cooling beginning at the Early/Middle Eocene, 3) Climate change during cooling mode spanning from the Late Oligocene to Late Miocene and its reevaluation of driving force of cooling, 4) Origins of monsoon and influence on the climate, 5) High - latitude climate change in Arctic and Antarctic Oceans, and 6) Gateway impact for climate change.

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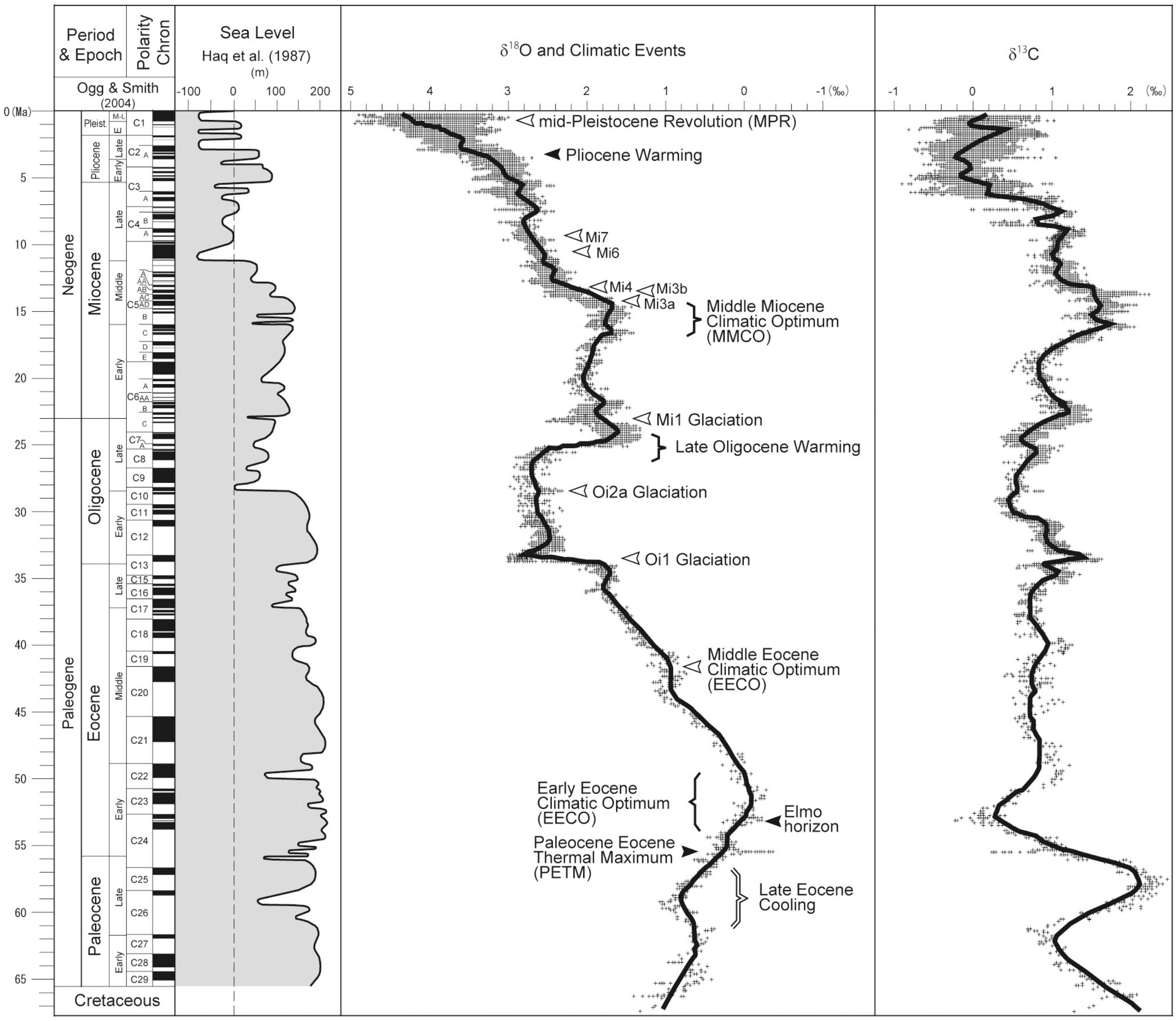

Figure 1. Climate trend during the Cenozoic. Modified from Zachos et al., (2001)