海洋科普實驗室

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Learning Oceanography by cartoons

The Iron Hypothesis and the Glacial-Interglacial Period

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The growth of phytoplankton in one third of the oceans on the planet is mainly limited by iron. In these seas, major nutrient levels are relatively high, yet microalgae numbers are not as high as expected. The American oceanographer John Martin discovered that by adding iron into these high nutrient low chlorophyll (HNLC) domains, microalgae will multiply abundantly.

According to the elemental composition of microalgae, supplying one atom of iron into HNLC regions supposedly will allow phytoplankton to fix 100 atoms of phosphorus or 10,000 atoms of carbon. The HNLC region occupies a great majority of the waters around the South Pole and the concentrations of major nutrients are as high as 10uM. John Martin estimated that with the addition of Fe into the large HNLC regions, microalgae photosynthesis is then promoted under conditions replete with nitrogen, phosphorus, and iron. Atmospheric carbon dioxide will be converted to organic carbon and should be deposited into the ocean. The carbon dioxide content in the atmosphere will then fall to glacial period concentrations, about 200ppm and resolve the problem of global warming! This is the famous Iron Hypothesis.

The concept behind this hypothesis is reasonable. However, marine biogeochemical cycling is not that simple. For example, how much organic carbon generated by photosynthesis in the surface water can settle into deep water or can be buried in the sediment? In any case, the iron hypothesis shows that studying marine biogeochemistry is of great importance for understanding material cycling on the planet. Furthermore, based on the ice core record discovered in the South Pole or Greenland, dust or iron availability in the ocean of the glacial period was relatively much higher than the concentrations and availability of the interglacial period. The known concentrations of carbon dioxide of the glacial period were relatively low. The cause-effect relationship between carbon dioxide concentrations in the atmosphere and iron availability in the ancient oceanic surface water is another important concept of the iron hypothesis.

Is it lowered atmospheric carbon dioxide → lowered → temperatures → drier climate → wind-blown dust increase or dust input to the ocean increase → microalgae grow and multiply → atmospheric carbon dioxide decrease? Exactly who is the cause, and who is the effect remains unclear. The figure shows that the Taiwan Strait became land when sea level decreased up to 120-130m during the glacial period.