PART V

PLUME DYNAMICS THROUGH EARTH HISTORY

INTRODUCTION

In this Part, the history of Pacific superplume is reviewed together with a series of paleogeographic maps from 1.0 Ga to the present by Ustunomiya et al. The structure and compositional profile of the Pacific superplume is the integrated state since at least the formation of supercontinent Rodinia which was made up right above the present Pacific Ocean and Pacific superplume at 1.0 Ga (Fig. 1). Over 1.0 billions of years, the Pacific superplume evolved to change its structure through several pulsation periods such as the Cretaceous pulse.

The african superplume was born at the initial stage of the break-up of Pangea, ca. 250 Ma, when the largest-scale of mass extinction occurred, one order of magnitude higher than that of the end-Cretaceous dinosaurus extinction. This is the so-called

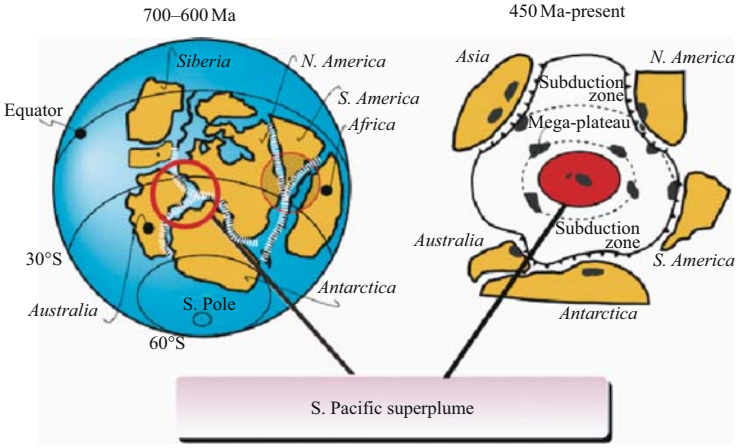


Figure 1. The history of the Pacific superplume since its birth to the present. Left: Simplified paleogeography of Rodinia at 750 Ma at the time of the birth of the Pacific superplume, after Maruyama (1994). The Pacific Ocean was created by 600 Ma by the rifting of Rodinia, and it widened until 500–450 Ma, when circum-Pacific subduction zones developed. Right: Since then, the Pacific Ocean has decreased in size.

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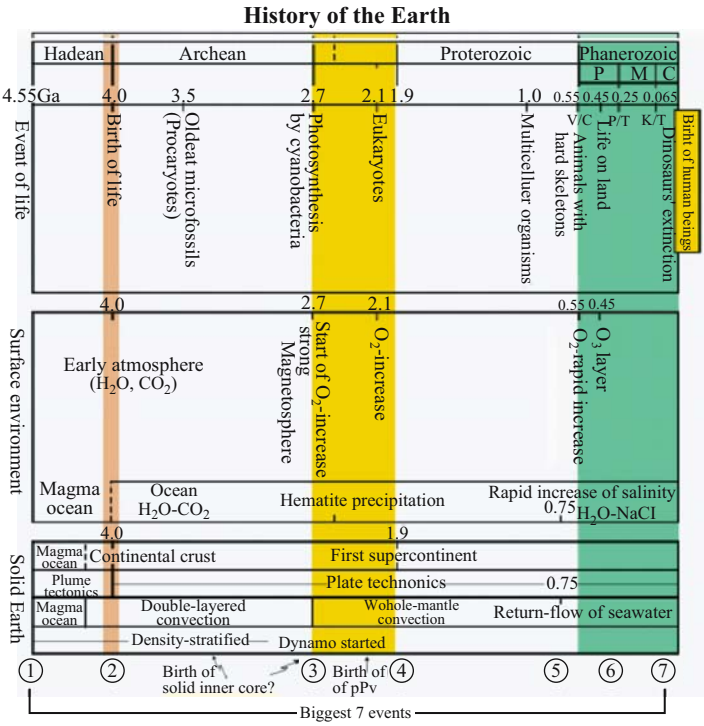


Figure 2. The history of the Earth, showing the biggest 7 events: (1) the birth of the Earth; (2) the birth of the continental crust, and life, and initiation of plate tectonics at 4.0 Ga; (3) the dynamo started by the birth of a solid inner core, and resultant increase of photo-synthetic oxygen in the atmosphere at 2.7 Ga; (4) the birth of the first supercontinent presumably related to the birth of the post-perovskite phase on the CMB; (5) the initiation of the return-flow of seawater into the mantle at 750 Ma, and the resultant appearance of the large continent above sea-level and the diversification of life on the Earth; (6) the Paleozoic/Mesozoic boundary and mass extinction; and (7) the birth of human beings, and their change of the Earth and planets (Maruyama et al., 2001).

Paleozoic/Mesozoic boundary. This is the best-known and largest-scale mass extinction through the Phanerozoic time. More than 96% of large multi-cellular animals died. Summarizing the details of mass extinction at the P/T boundary, and of the paleo-environment in both the Paleo-Pacific Ocean and in China, Y. Isozaki proposes that there was a superplume winter, that occurred twice during this period.

Maruyama and others propose the mechanism of the formation of a superplume, turning the coldest mantle into the hottest mantle by the role of post-perovskite over 1.0 b.y. Through this process, an anti-crust develops as a mirror image of the continental crust on the surface. Moreover, they have speculated about the birth date of post-perovskite at CMB to be 2.3 Ga, based on the growth curve of the continental crust. They have proposed the evolutional sequence of mantle dynamics, from

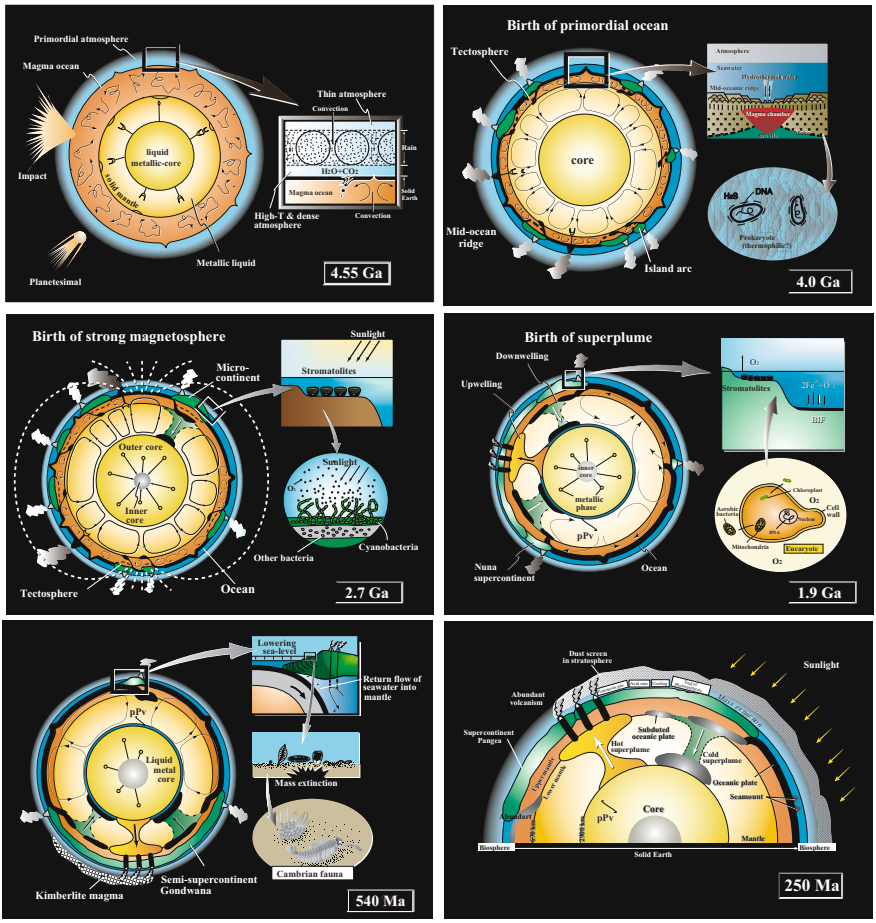


Figure 3. The evolution of the Earth at 4.55 Ga, 4.0 Ga, 2.7 Ga, 1.9 Ga, 0.7–0.6 Ga, 0.25 Ga and the present-day, showing the evolution of the Earth system. The Earth system has evolved by internal buffer to makeing the surface habitable for life, in spite of secular cooling. See also Figure 2 with a summary of the Biggest seven Events.

double-layered convection, catastrophic mantle overturn, birth of post-perovskite at CMB; thereafter the superplume cycle started, and the initiation of the return-flow of seawater into the mantle at the onset of the Phanerozoic era (Figs. 2 and 3).

REFERENCES

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Maruyama, S., S. Nakashima, Y. Isozaki, and B.F. Windley (2001) History of the Earth and life. In Nakashima, S. et al. (eds.) *Geochemistry and Origin of Life*, Universal Academic Press, Tokyo, pp. 285–325.