Possible impact of Himalaya-Tibetan uplift and their erosion on Cenozoic global cooling and northern hemisphere glaciation

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Cenozoic is a time of global cooling, changing from the greenhouse world with no polar ice sheet to the icehouse world characterized by bi-polar ice sheets. It is well established that Cenozoic cooling process proceeded in three distinct steps. The first step was at ca. 34 Ma when large but unstable polar ice sheet appeared on Antarctica. The second step was at ca. 15 Ma when Antarctic ice sheet expanded and stabilized. And the third step was at ca. 4 Ma when northern hemisphere glaciation started.

It has been widely believed that formation of a large ice sheet on Antarctica approximately at 34 Ma was triggered by opening of Drake Passage and consequent establishment of Antarctic Circumpolar Current (ACC). However, recent simulation study by Deconto and Pollard (2005) suggests even more important role of atmospheric CO2 drop between 40 and 25 Ma on Antarctic glaciation. Although no consensus is reached regarding the cause of atmospheric CO2 drop between 40 and 25 Ma, it should be either through a) the increase in chemical weathering rate of silicate rocks, b) the increase in burial rate of organic carbon, or c) the decrease in CO2 degassing from the mantle. Recent studies on the uplift of Tibet tend to suggest that Tibet uplift started as early as 40 Ma and its major part reached close to the present level by 10 Ma (e.g., Rowley and Currie, 2006). It is also demonstrated that sediment flux from East Asia started to rise from ca. 45 Ma with the drastic increase approximately at 34 Ma (e.g., Clift, 2006). The increased sediment flux was the result of enhanced weathering which should have significantly contributed to the drawdown of atmospheric CO2 (e.g., Raymo and Ruddiman, 1992). It is also worth to note that these sediments are effectively trapped in the East Asian marginal seas, which were formed between ca. 35 and 15 Ma as a result of collision of Indian subcontinent and subsequent deformation of Asian continent. Sedimentation in these marginal seas significantly enhanced burial rate of organic carbon and should also have contributed the drawdown of atmospheric CO2. Thus, collision of Indian subcontinent and subsequent uplift of Hijmalaya and Tibet is considered as contributed in two ways to the decrease in atmospheric CO2 between 40 and 25 Ma.

It is suggested that northern hemisphere glaciation, which started around 4 Ma was triggered by the closure of Panama seaway (e.g., Keigwin, 1982). Recent simulation results also support this idea. For example, Motoi (2005) clearly demonstrated that closure of Panama seaway enhances snow accumulation in the northern parts of North America. However, detailed inspection of d18O data suggests that northern hemisphere glaciation started around 3.5 to 3 Ma which slightly postdated the timing of Panama seaway closure (e.g., Haug and Tiedemann, 1998). Thus, some additional mechanism may be required to trigger northern hemisphere glaciation. There are increasing evidences that suggest accelerated uplift of western Himalaya during Plio-Pleistocene (e.g., Jain et al., 2000; Vance et al., 2003). Climatic simulation results suggest that the increase in altitude of Himalaya and Tibet causes shift of westerly jet axis from approximately 40 N to 25 N especially during winter (e.g., Kitoh, 2005). Since westerly jet bounds cold air mass in the high latitude and warm air mass in the low latitude, this southern shift of westerly jet axis should create favorable condition for northern hemisphere ice sheets to grow.

Although much more researches are necessary, above idea suggests that collision of Indian subcontinent and uplift of Himalaya and Tibet could have played an important role on Cenozoic cooling and northern hemisphere glaciation.