Chapter 12
Late Phanerozoic Magmatic Evolution of Asia

A comprehensive approach to study of the late Phanerozoic, as a time interval with common geologic evolution, is substantiated by marine Sr-isotope stratigraphy demonstrated persistently increasing $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in sea water from 0.7068 to 0.7092 in the past 160 Ma. The preceding time interval of 320–210 Ma was marked by $^{87}\text{Sr}/^{86}\text{Sr}$ ratios as high as 0.7078–0.7084 with a single minimum of 0.7070 centered at the early events of 262–258 Ma in the Emeishan large igneous province (McArthur et al. 2001; Chaps. 11 and 13).

Directions and velocities of lithospheric plate motions, at the first approximation, were connected with driving forces created by mantle density and viscosity heterogeneities. From retrospective analysis of plate kinematics in coordinates of fixed hotspots, high kinetic energy of plates was inferred to exist in a time interval of 100–84 Ma. The subsequent decreasing kinetic energy occurred mainly at the expense of reduction of poloidal (spreading/subduction) component of plate motions at a relatively constant component of their toroidal (transform/spin) motions with transition to a minimal kinetic energy at $\sim 43$ Ma. This minimal energy was considered to be maintained until the present (Lithgow-Bertelloni and Richards 1998; Lithgow-Bertelloni and Guynn 2004).

Globally, kimberlite magmatism has been recorded in time intervals of: (1) 240–215 Ma, (2) 160–140 Ma, (3) 105–95 Ma, and (4) 60–45 Ma. The last three intervals are characteristic for North America and Yakutia. Kimberlites are unknown in time ranges of 324–240 Ma and $<45$ Ma. Unlike North America and Yakutia, in South Africa, kimberlites show continuous sequences of 120–105 Ma and 95–70 Ma and less representative events of $\sim 235$ Ma, 190–150 Ma, and 53–50 Ma (Brakhfogel 1995; Brakhfogel et al. 1997; Heaman et al. 2003).

Timing of magmatic processes was an object of global and regional studies. Kennett et al. (1977), Johnson and Rich (1986), and Dobretsov (1997b) emphasized globally significant geologic processes with periodicity of $\sim 30$ m.y. Segev (2000) systematized anorogenic magmatic events, accompanied disintegration of Gondwana during the time interval of the past 205 Ma, and came to a conclusion on the monotonic character of magmatic evolution with quasi-periodicity of 13 m.y. Rasskazov et al. (2000b) and Rasskazov (2002) reported geochronological data on late Tertiary
and Quaternary volcanic rocks from southern Siberia and adjacent southeastern Asia and recognized intervals of more frequent volcanic quasi-periods from 2.6 to 0.1 Ma.

Causes of late Mesozoic through Cenozoic tectonic and magmatic processes in Asia have been debated for several decades. Leading driving mechanisms have been attributed to mantle plumes, plate subduction, or collision. The first hypothesis assumes the origin of magmatic liquids to be upwelling of hot material from the core–mantle boundary, the second emphasizes the role of convergence between plates of the Pacific or Neo-Tethys and Eurasia, and the third gives priority to collision and post-collision interaction between Eurasia and other tectonic units (Molnar and Tapponnier 1975; Tapponnier et al. 1982; Windley and Allen 1993; Yarmolyuk et al. 1994; Rasskazov 1991, 1993, 1994a, b; Enkhtuvshin 1995; Sengör and Natal’in 1996; Rasskazov et al. 1998, 2000b, 2003b, c, 2004a; Rasskazov and Taniguchi 2006).

The relative roles of these geodynamic factors can be estimated by comparative study of magmatic evolution in such key regions as Tibet, Sea of Japan, and Central Mongolia (Fig. 12.1). On the one hand, Cenozoic magmatism in the latter region distinctly shifts northwards (Devyatkin 1981), assuming a southward motion of the lithosphere above a deep mantle plume (Yarmolyuk et al. 1994, 2007). On the other hand, Central Mongolia is situated in front of Indo-Asian collision zone and volcanic rocks reveal here geochemical signatures similar to those of volcanic rocks from Tibet (Rasskazov et al. 2008b). At last, in spite of its large distance from the Sea of Japan (ca. 2500 km), a possible explanation of Cenozoic deformations and volcanic eruptions in the whole territory of Inner Asia assumes also a mechanism of block extrusion towards this part of a “free continental margin” (Tapponnier et al. 1982; Jolivet et al. 1994).

In fact, seismic images of the mantle and geochemical data on volcanic rocks from Central Mongolia (Barry et al. 2003, 2007; Yarmolyuk et al. 2007; Chuvashova et al. 2007; Mordvinova et al. 2007; Barruol et al. 2008; Rasskazov et al. 2008b) are not plausible for the plume hypothesis. High-resolution seismic tomography shows a low velocity domain, which extends not deeper than 200 km in the upper mantle with significant seismic anisotropy. The measured $^3\text{He}/^4\text{He}$ ratios in basalts range within values of the shallow mantle sources. Paleo-magnetic data on the Early Cretaceous and Early Miocene volcanic rocks from the area (Kovalenko et al. 1997) yield no reliable solution on the lithosphere displacement above the “fixed plume” because of negligible change of paleolatitudes (within error of measurements).

On the contrary, data on influence of the Indo-Asian convergence on recent tectonics and seismicity in Central Asia have been presented in numerous papers. It is obvious that tectonic strains propagate from the Indo-Asian interplate boundary northwards, eastwards, and southeastwards. Uniform crustal deformations are traced in Western and Central China through earthquake mechanism solutions and GPS measurements (Zoback 1992; Qin et al. 2002; Calais et al. 2003; Chen 2007). From the Cretaceous to the present, essential crustal shortening between India and Mongolia with northern limits in Mongolian Altay and Gobi Altay have been recorded by paleomagnetic data (Halim et al. 1998). The maximal integrated contraction effect of the Indian indenter in Tibet and its negligible role in Central Mongolia with a transition...