Special Issue

The Origin, Evolution and Present State of Continental Lithosphere

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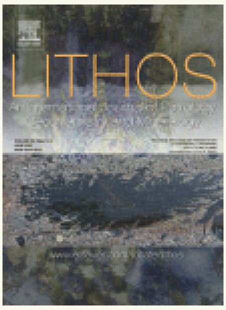

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Preface

The origin, evolution and present state of continental lithosphere

The continental crust comprises no more than ~0.5% of the Earth's mass, but it is an important geochemical reservoir because it is enriched in many incompatible elements, and contains probably >30% of Earth's Ba, Rb, Th, U, K, Pb budget. While continental crust is most accessible to us, a genuine understanding of its origin, accretion, bulk composition and evolution remains distant. The fact that the average continental crust is >2.5 Ga whereas the oceanic crust is <200 Ma tells us that the bulk continental crust is relatively permanent whereas the oceanic crust is not. The prevailing view is that the continental lithospheric mantle (CLM) represents partial melting residues of early Earth melt extraction events, and is thus compositionally depleted and physically buoyant (i.e., more refractory with high Mg/Fe and low Al_2O_3) with respect to the underlying asthenosphere. As a result, the buoyant CLM, ever since its inception, has been physically isolated from the convective mantle. It is the buoyant nature of the CLM that allows it to protect the overlying crust from being destroyed. The similar age of the CLM and the overlying crust in many cratonic regions not only points to their physical association, but probably the genetic link as well. Thus, the *origin*, *evolution* and *present state of continental lithosphere* is key to the understanding of many aspects of the continental crust. Is CLM forever? If so, the continental crust would be forever with the exception of terrigenous sediments transported to deep sea trenches and recycled into the deep mantle. If CLM is not forever, then the continental crust may not be well preserved. This has important consequences not only for the origin and evolution of continental crust over Earth's history, but also for the chemical geodynamics in the context of models of mantle circulation and crust–mantle recycling.

Recent studies have shown that not all the continental lithospheres are forever. Lithosphere thinning is well known at zones of continental rifts, and is inferred petrologically and seismically in tectonically active regions (e.g., Sierra Nevada, Basin-and-Range provinces in the western US, the southern Andes, and the Tibetan plateau). Lithosphere thinning has also been recognized in tectonically relatively stable regions like eastern Australia, eastern China, and in particular beneath some ancient cratons, which, by definition, should be stable (e.g., the Wyoming craton, North China craton, portions of South America etc.). What may have caused CLM thinning? Oceanic lithosphere subduction may lead to CLM "delamination". Continental collision could cause CLM thickening and then thinning through basal "delamination" or convective removal. These processes could also cause density-induced foundering of deep continental crust. However, this crustal foundering model is in apparent discrepancy with continental collision associated magmatism and its net contribution to continental crust growth. The crust-CLM coupling would also require coeval or co-genetic lithospheric contribution to stabilize the crust. What may have caused CLM thinning beneath stable cratons is more enigmatic. Thermal erosion by mantle plumes, regional extension/stretching, hydration-weakening, and continental subduction are among the popular hypotheses.

Given the significance of the scientific problem, an international conference, *The origin, evolution and present state of subcontinental lithosphere*, was held in Beijing, China, June 25th to 30th, 2005 (*Episodes*, 28, 209, 2005). This conference, co-sponsored by the IUGS Commission on Solid Earth Composition and Evolution (SECE), National Natural Science Foundation of China, Elsevier B.V., Peking University and China University of Geosciences (Beijing), brought together scientists of different disciplines world wide to discuss and share their views on this important problem. This conference was held in Beijing, China because of the unique geology. Eastern China, especially the North China Craton (NCC), presents us with an excellent example of CLM thinning since the Mesozoic. The existence of

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Paleozoic diamondiferous kimberlites in the NCC suggests a thick, ~200 km, lithosphere back in the Paleozoic, yet the lithosphere is <80 km thick at present as revealed through seismic studies and petrologic studies of mantle xenoliths associated with the wide-spread Mesozoic–Cenozoic "intra-plate" volcanism. The NCC is bounded to the south by the Triassic Qingling–Dabie–Sulu orogen, and to the north by the Permian–Triassic Central Asian orogen. In a broadest sense, the NCC is bounded to the east by the western Pacific subduction zones with subducted paleo-Pacific lithosphere still lying horizontally in the transition zone beneath eastern China as detected seismically. All these could have set a favorable boundary condition for the Mesozoic CLM thinning beneath the NCC. Ultrahigh pressure metamorphic rocks from orogenic belts in northwestern China offer different perspectives on the role of oceanic lithosphere subduction and continental collision in causing CLM thinning. The syncollisional and post-collisional magmatism in Tibet allows us to assess mantle contribution to continental crust accretion, and to infer whether continental subduction/collision can indeed result in significant CLM thinning.

The 18 articles of this Special Lithos volume result from this conference and deal with the origin and evolution of continental lithosphere with different emphases: (1) Concepts, observations, problems and hypotheses about CLM; (2) intraplate magmatism and petrogenesis of crustal rocks; (3) petrogenesis at active tectonic zones and orogenies; (4) ultrahigh pressure metamorphism and continental accretion; and (5) geophysical observations and quantitative interpretations. We highly value each of these contributions not much because they have solved some or any specific problems, but because they share new observations, offer new ways of thinking, and put forward new hypotheses for future research into this fundamental Earth problem. We predict with enthusiasm that this special volume will become a necessary source of reference for many researchers in the broad field of Earth Science.

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