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The plume head -lithosphere interactions near intra-continental plate boundaries

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In continents, zones of plume-lithosphere interactions (PLI) are often located near intra-plate boundaries, where lithospheric thickness and strength variations are expected to affect plume head dynamics. The PLI have important consequences both for tectonic and mineralogical evolution. For example, Archean metallogenic crises at the boundaries of the West African and Australian cratons coincide with the presumed plume events. Diamond occurences and distribution of kimberlites in the African continent - probably related to deep mantle upwellings - show a spatial correlation with Archean cratons. According to our numerical thermo-mechanical experiments that account for free surface, visco-elasto-plastic rheology and stratification of the lithosphere, it turns out that lateral heterogeneities have three major effects on PLI: (1) horizontal plume head flattening is blocked from one side by cold vertical boundary of the craton, leading to faulting at the cratonic margin; (2) return flow from the plume head results in sub-vertical down-thrusting of the mantle lithosphere at the cratonic margin providing sharp sub-vertical “cold” boundaries; (3) topographic signatures of the plume-lithosphere interaction show basin-scale uplifts and subsidences at the cratonic margins, and a topographic plateau centered over the craton. Rayleigh-Taylor instabilities that develop at the top and sides of the plume head provide a mechanism for crustal delamination. Lateral flow of mantle lithosphere, from plume head to the base of the craton suggests a new mechanism for crustal growth, where surface magmatism is not required. Lithospheric faulting at cratonic edges and enhanced magmatic activity could explain the apparent plume-related metallogenic crises, as suggested for West Africa and Australia. PLI can explain a number of other key phenomena such as simultaneous occurrence of climax of extension of the young plates/segments and climax of compression in the surrounding belts.