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Link between extension, dyking and subsidence as the reconstruction tool of intraplate rifting mechanism (backstripping data, modelling and geochronology)

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Correlation between subsidence and extension-related magmatism is key in determining mechanism of intracratonic sedimentary basins formation. The total volume of basic sheet intrusions and volcanics within sedimentary rock mass characterizes indirectly the degree of depletion and thinning of the rifted mantle lithosphere. At present the documented features of real-world intracontinental basins show a wide range of parameters characterizing the duration and rate of subsidence, degree of extension/thinning of the lithosphere, age and extent of dyking. For creation of general model of continental rifting it is important to reconstruct an evolution of basins finished at the continental stage, not entered an oceanic spreading phase. One of examples of such structure is the Vilyui sedimentary basin in the eastern Siberian Platform which includes the massive emplacements (10**5 km3) of extrusive and intrusive rocks of the Vilyui large igneous province.

We combine backstripping reconstructions of sedimentation and thermal regime during the subsidence with a numerical modelling based on the deformable solid mechanics. It is the first time that the evolution of sedimentation and subsidence which is nonuniform over the basin area has been analyzed for the Vilyui basin. The rift origin of the basin is proved. We estimate the spatial distribution of the parameters of crustal and mantle-lithosphere extension as well as expansion due to dike intrusions. According to the reconstructions, the type of subsidence curves for the sedimentary rocks of the basin depends on the tectonic regime of sedimentation in individual subbasins. The backstripping analysis revealed two stages of extension (sediments 4–5 km thick) and a foreland stage (sediments >2 km thick). With the two-layered lithosphere model, we concluded that the subcrustal layer underwent predominant extension (by a factor of 1.2–2.0 vs. 1.1–1.4 in the crust). In each section, dyke-related extension due to basic intrusion is predicted over a range of γ = 0.01–0.12 (average value 0.06, i.e., $\sim$6%). This value seems acceptable if we consider cumulative sills and dykes thicknesses in the outcrops and borehole sections in the Upper Devonian–Lower Carboniferous sediments. For better rifting age resolution we sampled dolerites from the western, eastern and central dyke swarms, which were then analyzed by stepwise 40Ar/39Ar heating. The determined ages of the monomineral plagioclase and pyroxene fractions from the dyke samples (345-378 Ma) coincide well with fast subsidence and sedimentation phase in the Devonian defined by backstripping data. Dating of dyke intrusions shows following succession of rifting episodes: extension by dyking starts near the central axes (364-378 Ma), extending to the periphery areas on the opposite sides of the rift through (345-362 Ma). The established sequence of dyke intrusions is alternative to the oceanic crust spreading, at which the age of intrusions is increased from the spreading center in rift-perpendicular direction. Results of thermo-mechanical modelling of formation of the Vilyui rift basin are presented. The goal of 2D finite elements modelling is to demonstrate that the deep troughs can form in the continental crust under its limited extension. The 2D numerical simulation shows the possibility of considerable localized subsidence near the rift axis and explains why mafic dike swarms are concentrated on the basin periphery. Thus, the mechanism of the Vilyui basin formation by means of magmatic rifting is corroborated [Polyansky at al., 2013]. RFBR grant no. 14-05-00188.