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A possible explanation for the observed increase in effective elastic lithosphere thickness on Mars

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Analysis of topography and gravity data suggests that the thickness of the elastic lithosphere on Mars increased rapidly during the Noachian and grew slower subsequently; an observation which is also made in thermal evolution models. Nevertheless, in places like Coracis Fossae analysis of the rift valley topography shows that the effective elastic lithosphere was only 12 km thick during the transition from the Noachian to the Hesperian which is inconsistent with previous thermal evolution models as in these models the elastic lithosphere grows to more than 100 km thickness within the first few hundred million years. This inconsistency could arise from a phenomenon which has been neglected in previous thermal evolution models: If a primordial crust enriched in radioactive elements and with a low thermal conductivity is considered in thermal calculations, the crust could be thicker than the elastic lithosphere - defined by a 1050 K isotherm - during the early phases of the evolution. This means that in this case the effective elastic lithosphere is not determined by the 1050 K isotherm for olivine-rich mantle material but by the lower isotherm for crustal material, e.g. 700 K for diabase. As a result the effective elastic lithosphere would be much thinner than previously thought. As soon as the planet cools enough so that the 1050 K isotherm is within the mantle and not within the crust, the thickness of the elastic lithosphere is controlled by this isotherm, i.e. mantle material is strong enough to support loading, and the effective elastic thickness increases rapidly. Thermal evolution models which include a crustal layer enriched in radioactive elements show that this may be the case even after the Noachian, thereby giving an explanation for the inconsistency between observations and previous thermal evolution models.