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Archean to Paleoproterozoic polymetamorphic history of the Salma eclogite in Kola Peninsula, Russia

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One of the most important questions in the Earth Science is when and how plate tectonics operate in the Precambrian time. The tectonic and thermal evolution of the Precambrian eclogite is significant key for understanding the Precambrian geodynamic mechanisms. Eclogites in Kola Peninsula, Russia are some of the oldest eclogites of the world, but there has been much debate about the timing of eclogite-facies metamorphism: Archean (e.g. Volodichev et al. 2004; Mints et al., 2010) or Paleoproterozoic (e.g. Skublob et al., 2011, 2012). The controversy is mainly because of the lack of zircon dating coupled with the formation of garnet and omphacite.

In this study, we present geochronological, petrographic, and geochemical data from the Salma eclogites in the Kola Peninsula, Russia to characterize subduction and collision processes in the Precambrian. Microstructural observations, P-T analyses, zircon inclusion analyses, and U-Pb zircon dating revealed multiple metamorphic stages that the Salma eclogite underwent. The amphibolite facies metamorphic event firstly occurred at 2.73–2.72 Ga during Archean. In the Paleoproterozoic period, the Salma eclogites underwent prograde stage of epidote–amphibolite facies metamorphism. The eclogite facies metamorphic event took place under the P–T condition of 16–18 kbar and 740–770 °C at 1.89–1.88 Ga, with a subsequent granulite facies metamorphism during decompression stage from 18 kbar to 9–12 kbar. Finally, later amphibolite facies metamorphism occurred at 8–10 kbar and 590–610 °C on cooling. The Archean metamorphic zircons that contain inclusions of Grt + Am + Bt + Pl + Qtz + Rt are unzoned grains with dark CL, and they are relatively enriched in HREE. In contrast, the 1.89–1.88 Ga sector or concentric zoned zircons with pale-grey CL include inclusions of Grt + Omp + Ca-Cpx + Am + Bt + Qtz + Rt, and they have the flat pattern of HREE due to the amounts of abundant garnet during the eclogite-facies metamorphism. Whole rock chemistry indicates that these eclogites were originally tholeiitic basalts formed at the mid-ocean ridge. Our data suggest that the ocean plate was exposed once during Archean, and then they deeply subducted to form the eclogite and exhumed during Paleoproterozoic. The 1.89–1.88 Ga eclogite-facies metamorphism implies that the continent–continent collision between the Kola and Karelian continents occurred during the Paleoproterozoic, rather than the Archean. The prograde metamorphism of epidote–amphibolite facies for the Salma eclogites represents a warm subduction in the Paleoproterozoic, as well as some Phanerozoic eclogites such as the Besshi District, Sambagawa (Enami et al., 1994), and Hubei Province, central China (Zhou et al., 1993) and as the tectonic blocks in the Franciscan Complex, California (Oh and Liou 1990).