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

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The tectonic and thermal evolution of the Precambrian Salma eclogite in Kola Peninsula, Russia, one of the oldest eclogites of the world, is significant key for understanding the Precambrian geodynamic mechanisms. However, there has been much debate about the timing of eclogite-facies metamorphism: Archean (2.72–2.70 Ga) or Paleoproterozoic (1.91–1.88 Ga). The controversy is due to the difficulty to decide which zircon formed during the eclogite facies metamorphism owing to the absence of garnet or omphacite inclusions in zircon. In this study, we present geochronological, petrographic, and geochemical data from the Salma eclogites. The Archean metamorphic zircons (2.73–2.72 Ga) that contain inclusions of garnet + amphibole + plagioclase + quartz + rutile ± biotite are unzoned grains with dark CL, and they are relatively enriched in HREE. In contrast, the 1.89–1.88 Ga sector, patched, and cloudy zoned zircons with pale grey CL include inclusions of garnet + omphacite + calcic clinopyroxene + amphibole + quartz + rutile ±biotite, and they have the flat pattern of HREE due to the amounts of abundant garnet during the eclogite facies metamorphism. Microstructural observations, P-T analyses, zircon inclusion analyses, and U-Pb zircon dating revealed multiple metamorphic stages that the Salma eclogite had undergone. The amphibolite facies metamorphic event firstly occurred at 2.73–2.72 Ga. In the Paleoproterozoic period, the Salma eclogites underwent prograde metamorphism from the epidote-amphibolite or amphibolite facies to eclogite facies metamorphism. The eclogite facies metamorphism occurred 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 during cooling. Whole rock chemistry indicates that the Salma eclogite was originally tholeiitic basalt formed at the mid-ocean ridge. Our data suggest that the oceanic basalt was first metamorphosed at 2.73–2.72 Ga, and then deeply subducted to form the eclogite at 1.89–1.88 Ga, implying that the continent–continent collision between the Kola and Karelian continents occurred during the Paleoproterozoic, rather than the Archean. This and previous studies imply that the deep subduction accompanying eclogite may have begun in the Paleoproterozoic, and that the geothermal gradient in the Precambrian subduction zones gradually decreased, as evidenced by changes from the oldest Neoarchean high pressure granulite through Paleoproterozoic eclogite, to Neoproterozoic blueschist.

Keywords: Paleoproterozoic eclogite, Kola Peninsula, P–T–t path, polymetamorphism, subduction, geothermal gradient

