Deep Continental Crust Subduction During Incipient Orogeny: Metamorphic And Magmatic Consequences

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We performed systematic two-dimensional numerical modeling of the early stages of continental collision associated with subduction of the lithospheric mantle. Results of our experiments show that the formation and exhumation of coesite- and diamond-bearing rocks metamorphosed at 700 to 900^{o}C in presence of dense supercritical silicate fluids and melts may be explained by a transient “hot channel effect”. Anomalously high temperature is caused by intense viscous and radiogenic heating in the channel composed of deeply subducted radiogenic upper-crustal rocks (especially, sediments of passive margin origin) and mantle rocks at the beginning of collision. Heating is also associated with intense flow of aqueous fluids relieved by rapid dehydration (deserpentinization) of the overriding mantle lithosphere that has been hydrated during previous subduction stages. The channel can penetrate along the plate interface down to the bottom of the lithosphere of the overriding plate (150-200 km) and is characterized by metamorphic temperatures reaching 700 to 900^{o}C. Low effective viscosity of rocks subsequent to increased temperature, partial melting and fluid infiltration permits profound mixing of hydrated mantle and crustal rocks. The hot channel exists during the early stage of collision only but rapidly produces large amounts of ultrahigh-pressure, high-temperature rocks. Further collision closes the channel through squeezing rheologically weak, partially molten, buoyant rocks between the strong lithospheric mantles of the two colliding plates. Assemblage of complicated P-T paths with repetitive loops characterizes exhumation of ultrahigh-pressure rocks in the convoluted flow pattern of the hot channel. The establishment of hot channel tectonics crucially depends on the intensity of internal heating. Numerical experiments without viscous heating and/or lower radiogenic heat production evolve into different transient processes such as tectonic underplating of subducted crustal rocks beneath the overriding lithosphere. In this case, mixed crustal and hydrated mantle rocks extrude from the deep tip of the channel in form of chemical plume, which is colder but yet positively buoyant compared to the asthenospheric mantle. Lateral spreading of relatively cold plume into the hot (>1000^{o}C) mantle gradually heats up subducted rocks above 1000^{o}C, which leads to melting at pressures of 4-5 GPa (i.e., under UHP-UHT conditions). The development of similar structures called “mixed cold plumes” has been studied for both oceanic and continental margin subduction and has been shown to have strong implications for the magmatic activity in volcanic arcs.