Metasedimentary rocks of the North Cascades continental magmatic arc: important trackers of the rheologic history of an arc system

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Metasedimentary rocks commonly preserve the metamorphic, partial melting, and deformation history and therefore the rheological evolution of continental magmatic arcs. The crystalline core of the exhumed Cretaceous–Eocene North Cascades arc, Washington, contains abundant metasedimentary rocks, some of which were host rocks (Napeequa Complex) and others that were incorporated into the arc during arc magmatism (Skagit Gneiss and meta-Methow rocks). The Napeequa Complex and meta-Methow unit from the western and eastern margins of the Skagit Gneiss and crystalline core as a whole showed higher pressures of 8.4–10.5 kbar at 570–700 °C. In comparison, the Skagit Gneiss metasedimentary rocks exposed in the center of the crystalline core yielded P–T conditions of 640–800 °C and 5.5–7.9 kbar. The Skagit Gneiss metasediments were incorporated into the arc from ca. 74–65 Ma. They subsequently underwent partial melting and were injected by leucocratic material during two pulses: ca. 68–58 Ma and 53–47 Ma. The timing of metamorphism and partial melting overlaps with two major high flux magmatic events from ca. 78–60 Ma and ca. 50–45 Ma. Geochemical and isotopic data do not indicate that partial melting of the Skagit Gneiss contributed significantly to the magmatism. Overall, the North Cascades crystalline core was in a dominantly dextral transpressional deformation regime until ca. 58–55 Ma, when it switched to transtension. Reconstruction of the P–T–t–isotopic–deformation history of the metasedimentary rocks indicates that a rheologically weak crust, due to a high flux magmatic event, combined with transpression facilitated underthrusting and metamorphism of the protolith forearc sediments to the Skagit Gneiss in the center of the core. Along the eastern boundary of the core, a step-over zone in the dextral oblique Ross Lake fault system allowed incorporation and burial of back-arc sediments that formed the meta-Methow unit. Parts of the host-rock Napeequa Complex were also buried and metamorphosed during transpression along the margin of the core. Transtension combined with a second phase of rheological weakening due to the youngest high magmatic flux drove exhumation of these mid- to lower-crustal rocks to shallow depths across the crystalline core from ca. 50–45 Ma.