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An elevated geothermal gradient prior to early Cenozoic collapse of the North American Cordillera: evidence and implications

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The Okanogan region of British Columbia, Canada, and Washington, USA, experienced early Eocene magmatism, sedimentation, and tectonism associated with core complex development during early Cenozoic collapse of the North American Cordillera. Magmatism and tectonism in the Okanogan region were generally synchronous: various studies from throughout the region describe volcanism from 56.5 $\pm$2.5 to 45.5 $\pm$4.5 Ma, plutonism from 55 $\pm$5 to 47 $\pm$1 Ma, and normal faulting from 53.5 $\pm$5.5 to 48 $\pm$3 Ma. The temporal overlap between thermal and tectonic events obscures the principal catalyst: did extension, advection, and decompression melting drive magmatism, or did magmatism lead to thermal weakening and orogenic collapse?

We used apatite and zircon (U-Th)/He thermochronology to constrain the geothermal gradient in the Okanogan region prior to extension. Apatite and zircon (U-Th)/He age-elevation relationships were generated from 3 vertical transects in the upper plate of the Shuswap Metamorphic Core Complex. The pre-extensional geothermal gradient was constrained with the vertical distance and temperature difference between modeled apatite and zircon closure isotherms. The calculated pre-extensional geothermal gradients at these three vertical transects in the Okanogan Range are 62 $\pm$6˚C/km, 52 $\pm$21˚C/km, and 27 $\pm$6˚C/km at 60 Ma. Additional, though poorly constrained, apatite and zircon pairs suggest even steeper geothermal gradients existed in some areas around 55 Ma. The depth of apatite and zircon closure isotherms below a pre-

served, pre-Eocene surface datum in the Okanogan Range is consistent with a modeled geothermal gradient around 50˚C/km in the early Eocene. Therefore, we caution against estimated rates or magnitudes of exhumation, either erosional or tectonic, based on the assumption that samples cooled through a typical ($\sim$25˚C/km) geothermal gradient.

The evidence of an elevated geothermal gradient prior to Eocene extension in the Okanogan region supports the hypothesis that thermal weakening facilitated early Cenozoic collapse of the North American Cordillera. However, similar thermochronologic approaches have lead to dissimilar conclusions in the Basin and Range province of the western USA, where the geothermal gradient seems to have been low prior to Miocene extension.