Contrasting Crust and Upper Mantle Structure Along Two Seismic Transects Across the Coast Mountain Batholith, British Columbia

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The western margin of British Columbia manifests terrane accretion and subsequent distillation of large granitic batholiths throughout the late-Mesozoic and early Cenozoic. Remarkable is the 55-50 Ma magmatic flareup that created the Coast Mountain Batholith (CMB) and was contemporaneous with laterally variable exhumation along the orogen. Distillation of the CMB requires a complementary ultramafic root that could be negatively buoyant if the distillation occurs at >30 km depth. Determining the fate of such a potentially negatively buoyant root is critical to understanding the processes of crustal evolution.

Analysis of data from 42 broadband PASSCAL seismic stations that operated for 15 months along two transects (north and south line, Fig. 1) provides images of the crust and upper mantle. The two transects were chosen to contrast their different exhumation histories with the very similar granite distillation histories during the 55-50 Ma flareup. While both lines distilled similar volumes of granite, the north line underwent large-scale exhumation whereas the south line did not.

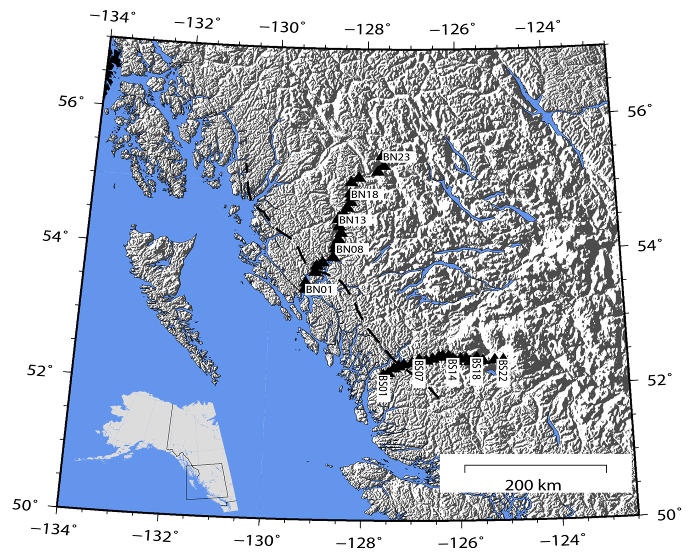


Figure 1) Topographic map of Western British Columbia showing the location of the North and South seismometer line arrays (black triangles). The white lines are the datum used in the seismic results.

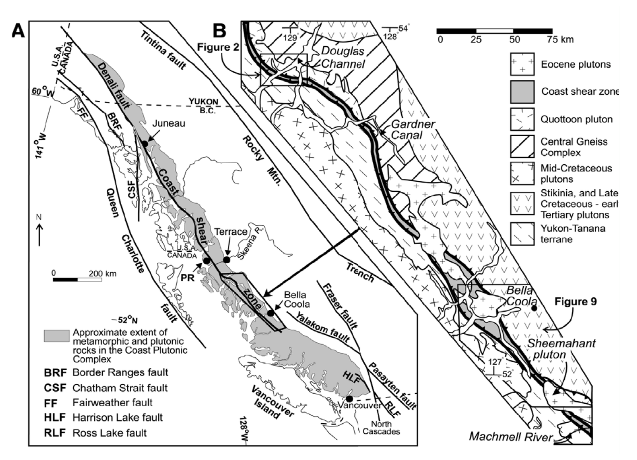
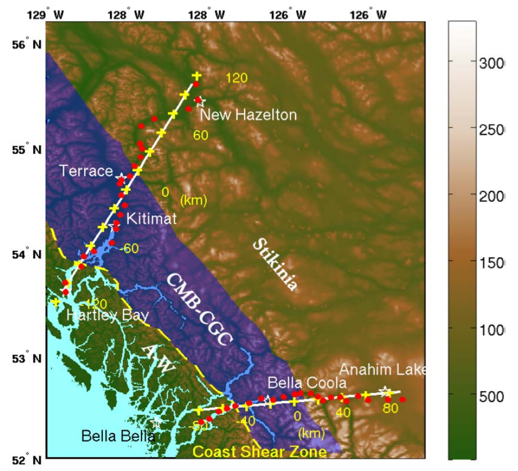
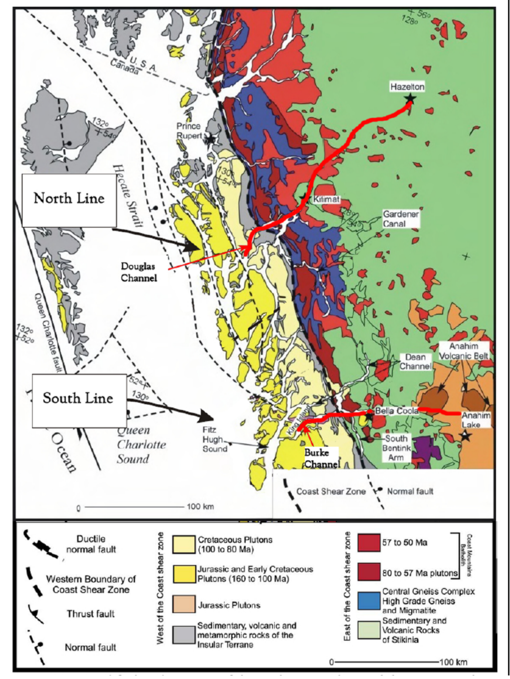
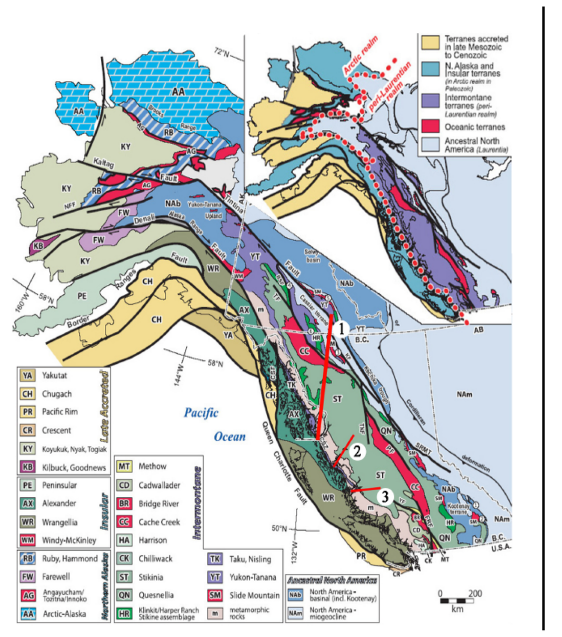
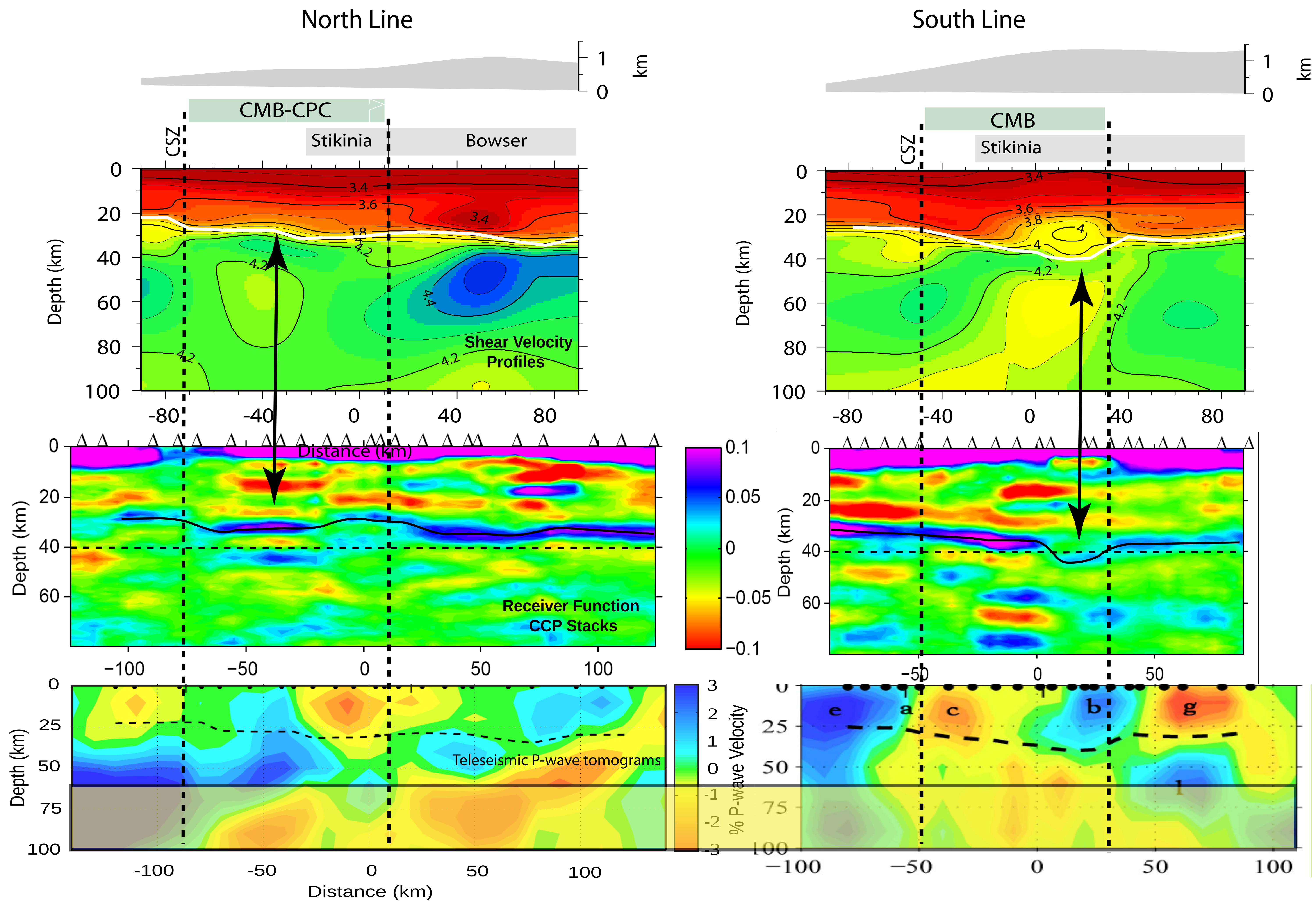


Figure 2) Regional geologic maps of Western British Columbia (Rusmore et. al., 2001) A) Tertiary strike-slip faults including the Coast Shear Zone B) Coast Shear Zone and adjacent units in the area between the Douglas and Burke Channels (north and north seismic lines).









Where the north line crosses the Coast Mts. Batholith, a relatively flat 32 km thick crust is found. While where the southern line crosses the Coast Mts. Batholith, a thicker 36 km crust with a welt that extends to 42 km depth is found. This welt is filled with high velocity lower crust from 42 to 25 km depth. This biggest difference between the north and south lines is that while the north line underwent massive exhumation to bring 9 kb gneissic rocks to the surface, the south line had very little tectonic exhumation.. Our speculation is that the northern line has dropped off its batholithic root below 30 km depth (depth at which garnet becomes stable in a granitic restite), while the south line has not dropped its batholitic root.

Surface Wave Inversion for Shear Velocity
- Ambient noise cross correlation for group velocities (5-25 sec.)
- Two-plane wave technique for phase velocities (20-120 sec.)
- Group and phase velocities inverted along profiles using crustal thickness estimates from CCP stacks as constraints

Receiver Functions:
- 70 events binned by backazimuth/slowness
- ~2 events per bin
- Events in the same bin simultaneously inverted for one receiver function estimate
- Source spectrum estimated in the frequency domain using a spline smoother

P wave Tomography:
- 90 teleseismic events
- Variance reduction is 74% and 63% for north and south lines

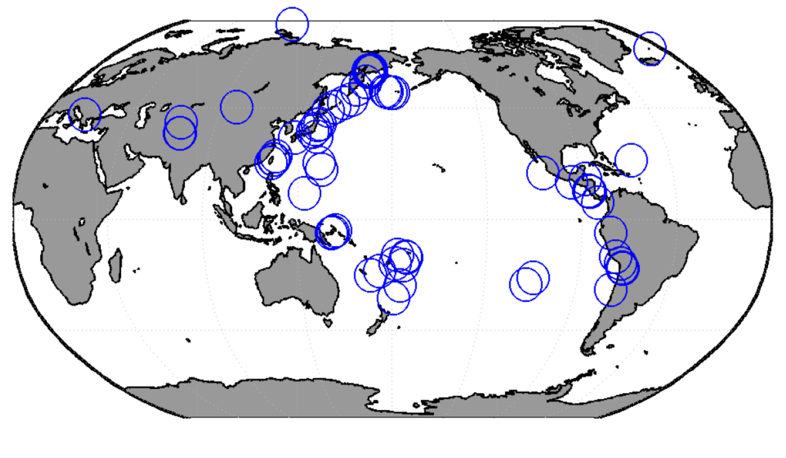
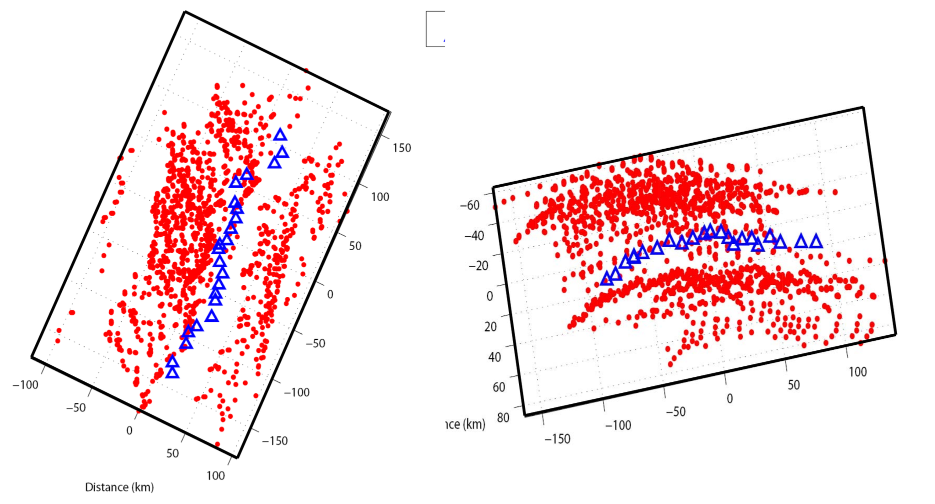


Figure 3) Global distribution of earthquakes used for tomography and receiver function results. P



Piercing points at 100 km depth for the north line and the south line.

The northern transect reveals a gradual crustal thickening from west to east with shear wave velocities that range from less than 3.4 km/s in the upper crust to 3.8 km/s near the crust-mantle boundary. In contrast, along the southern transect beneath the surface exposure of the CMB an 8-10 km thick crustal welt with shear wave velocities exceeding 4.0 km/s in the lower crust are imaged. Both cross sections exhibit upper mantle shear velocities 4-9% lower than global averages, consistent with the high heat flow observed in the region.

Discussion

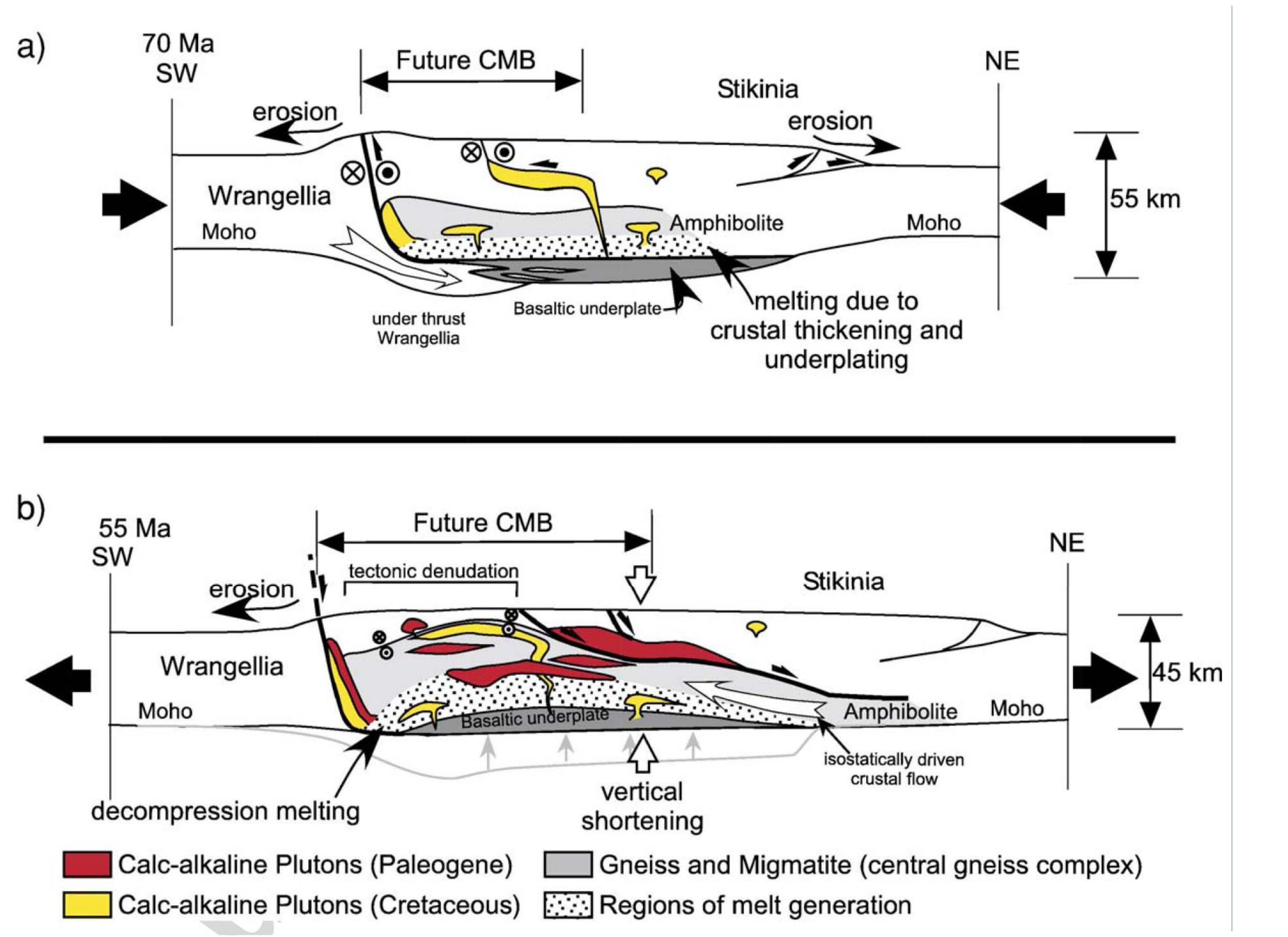


Figure 5) Interpreted geologic history of the Coast Mountain Batholith (CMB) from the ACCRETE project north of our study area (From Hollister and Andronicos, 2006) A) In the late Cretaceous the CMB region was in a state of transpression which lead to crustal thickening due to the underthrusting of the Wrangellia terrane. At this time the CMB was an active magmatic arc due to the subduction of oceanic lithosphere. B) In the late Paleocene, the arc under went a period of transtension leading to the tectonic denudation/exhumation of the Central Gneiss Complex and the emplacement voluminous granatoid batholiths, termed the Eocene flare up.

Given a similar amount of granitic material emplaced into the crust for both the northern and southern transect regions, the lack of high velocities in the lower crust beneath the northern transect, coupled with high rates of exhumation there indicate that foundering of the crustal root is plausible. Whereas beneath the southern transect, the lower crust conditions apparently have not been sufficient to promote an eclogite-driven density instability. This leaves the CMB distillation root in-situ, consistent with the elevated velocities and crustal thickening. Thus, the question remains as to when the north line foundered its restitic root and why the north line root foundered but the south line did not. The combination of geochemical and exhumation studies will provide constraint with respect to these unanswered questions.

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