Tectonic Evolution of the Canadian Cordillera and the Record of a Continental Bulldozer – Evidence and Implications

Dan Gibson

Simon Fraser University

James Monger

Geological Survey of Canada (emeritus scientist)

Summary

The Canadian Cordillera is considered an "archetypal" accretionary orogen that has evolved along a convergent margin throughout latest Paleozoic to present. Although terrane accretion is recognized as a fundamental process during the development of the Canadian Cordillera, in this talk I will examine evidence that suggests that the westerly trajectory of the North American craton for the past 220 Myr was the primary driver of Cordilleran orogenesis. I will first examine the evidence in support of this hypothesis, and then will discuss the far-reaching implications this has for Cordilleran orogenesis and plate tectonics in general.

First, I will review linkages established by many workers over nearly five decades that show all major terranes in the Canadian Cordillera had been accreted (somewhere) along the western North American craton margin by the Middle Jurassic (~174 Ma). These linkages carry with them two important implications with regard to recent debates involving Cordilleran tectonics: 1) When considered in conjunction with other major lines evidence that include detailed stratigraphic studies, palinspastic restoration of the Foreland Belt, westernmost exposures of North American basement, isotope geochemistry, Lithoprobe seismic profiles, that place the NA craton basement far to the west of the RMT (200-400 km) preclude the possibility of a major Cretaceous terrane boundary within the Canadian Rockies that separate North American from exotic non-North American rocks. 2) The linkages that demonstrate the Insular terranes, the most outboard terranes to the west relative to the North American craton, were accreted (at least in part) by Middle Jurassic time, which strongly refutes the possibility of a 2000-4000 km ocean separating the Insular terranes from the Cordilleran western margin during this period of time.

I will also examine the driving force of northern Cordilleran orogenesis and the role played by terrane accretion. Some models of northern Cordilleran tectonic evolution propose, or imply, that Cordilleran orogenesis resulted from collision of terranes with the western margin of the stable continental interior (or craton). In these models, the craton acted as a passive "backstop" that fielded terranes carried by plates flooring the ancestral Pacific Ocean. However, isotopic and relative ages demonstrate that all large terranes in the Canadian Cordillera were associated with one another and the craton margin by earliest Middle Jurassic time (~174 Ma). As the entire ancestral Cordillera did not emerge much later until ca. 100 Ma, this raises the question "what drove Cordilleran orogenesis"?

The alternative model proposed herein is based on (1) the "absolute" trajectory of the North America craton and (2) analysis of Mesozoic-Cenozoic structures. (1) The trajectory is derived from paleomagnetic evidence which shows how the latitude of the craton has changed since 220 Ma, and from longitude changes based on the contention that Africa has been the least mobile continent geographically for ~300 million years. As the central Atlantic Ocean floor spread, starting ~190 Ma, the North American continent gradually moved away from Africa. (2) For much of Mesozoic-Cenozoic time the approximately north-south oriented western margin of North America

has been the site of arc magmatism, mostly generated by subduction dipping beneath it. Warm, weak arc/back-arc lithosphere, sandwiched between strong ocean floor and craton lithospheres focused strain that was recorded by structures whose styles and ages mirror different craton trajectory vectors. At times, from ~180 to 160 Ma (latest Early Jurassic and Middle Jurassic) and from ~120 to 60 Ma (Early Cretaceous to earliest Cenozoic), it appears that the craton moved due westward. Dominant structures formed then record orogen-normal compression and were accompanied by crustal thickening, uplift and erosion (i.e. orogeny). Structures mainly in eastern and interior parts of the Cordillera formed during the earlier episode at about the time as all major terranes were accreted. Structures formed during the later episode span the entire Cordillera, which became a structural and physiographic entity in Late Cretaceous-earliest Cenozoic time. Before and between these times, the craton migrated mainly northwestward; geological and paleomagnetic considerations show the terranes moved southward relative to the craton. After 60 Ma, southwestward craton movement coincided with northward relative displacement along dextral strike-slip faults that disrupt the previously established ancestral Canadian Cordillera. Correlation between structures formed by orogen-normal compression at times when the craton moved due westward, and orogen-parallel displacements when the craton had either a northward or southward component of motion suggest the craton, acting as a "continental bulldozer", was the primary driver of deformation and orogenesis.

Lastly, I will examine the farther-reaching implications of the continental bulldozer model with regard to the driving forces of plate motions, namely, slab-pull, ridge-push and mantle convection. I will review the evidence for each in light of the continental bulldozer model and the Mesozoic structural record imprinted along the western and eastern margins of the North American continent.