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INTRODUCTION TO THE SPECIAL ISSUE ON CORRELATIONS BETWEEN PLATE MOTIONS AND CORDILLERAN TECTONICS

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This special issue contains papers that grew out of the American Geophysical Union Symposium "Models for motion of North America and plates of the Pacific basin, and the tectonic history of the western Cordillera--a search for correlations." This symposium was held in San Francisco on December 13 and 14, 1982. Forty-two papers were presented on such diverse topics as plate motion and microplate accretion histories, paleomagnetism of Cordilleran terranes and their displacement histories, the volcanic and plutonic history of the western Cordillera, and the timing of important geological episodes of regional extent (onset of extensional tectonics, onset and termination of episodes of strike slip faulting, etc.). Mechanisms of deformation within the Cordilleran continental margin were also discussed. The reader is referred to Eos Trans. AGU (vol. 63, no. 45, 1982) for the full set of abstracts.

The symposium was designed to test the following propositions:

1. Orogeny is a product of plate interactions. Therefore, major changes in the nature of plate interactions will leave a clear record in the geology of major orogenic belts.

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2. With regard to the North American Cordillera, current plate models and geological histories are sufficiently well formulated and precise so that a detailed comparison of the two will reveal important, unmistakable correlations. These correlations represent cause-and-effect relationships between plate processes and orogeny (and perhaps vice versa), and thus will provide insight into the mechanics of mountain building.

In retrospect, these were somewhat naive assumptions; the case is much more complicated than this. Nevertheless, several convincing correlations between changes in plate motion and important tectonic events in the Cordillera were pinpointed by the symposium:

1. In late Jurassic time geological events long associated wiht the Nevadan orogeny seem to have coincided with a first-order reorganization in plate motions, involving North America and both the Kula and Farallon plates. This transition also is reflected in the apparent polar wander path for North America, and probably represents rotation of North America away from Africa at the initiation of opening of the central Atlantic.

2. Laramide events within the Cordillera correlate well with a period of unusually rapid, highly oblique convergence between North America and both the Farallon and the Kula plates.

Other correlations with geological events on a more local scale also appear possible. However, many complications are encountered. These include one obvious problem--neither plate models nor geological histories are sufficiently precise as yet to resolve and correlate events more closely than perhaps to within several tens of millions of years. Thus only the most important tectonic and plate motion changes can be associated with much confidence. What follows is a partial list of other complicating factors:

1. The position of the North America-Kula-Farallon triple junction for late Mesozoic and early Tertiary time is not known. Since North America-Kula and North America-Farallon relative motions were significantly different during much of this time, the precise location of this triple junction is crucial to explaining the tectonics of much of western North America.

2. Migration of triple junctions along a continental margin can make some important geological transitions (as from compression to strikeslip faulting) diachronous. Since triple junctions will change their motion in response to essentially trivial changes in relative plate velocities, this particular complicating factor can produce great geological confusion. Ridge-jumps add further to the problem, because they can convert a long segment of continental margin form one tectonic regime to another essentially overnight.

3. The "docking" of a major microplate must have profound tectonic consequences (shallowing of subduction angle, trench jump, temporary cessation of magmatism as examples), yet such an event need not correlate with a first-order change in motion of the carrier plate. Thus in theory major Cordilleran orogenic events may go totally unrecorded in the plate record. However, it seems likely that any event as important as the transfer of a large crustal fragment from an oceanic to a continental plate would so alter the set of boundary forces that the plate motions themselves would change. This does not seem to have been demonstrated, however. Precise dates for the docking of large allochthonous terranes (Wrangellia and the large terranes of western Mexico, for example) would be very useful in this regard.

4. The orogenic response of continental crust to boundary conditions imposed by plate interactions must depend to an important extent on the physical properties of the interacting plates. Old, cold continental crust may behave in a brittle fashion under conditions where younger crust, or crust softened by prolonged magmatism, will show a more ductile response. Likewise, old, cold oceanic lithosphere may subduct passively into the asthenosphere at a relatively steep angle, whereas under identical kinematic conditions (speed and angle of convergence) younger and more buoyant lithosphere may require forceable underthrusting and assume a much shallower subduction angle. Thus whether the overriding plate experiences compression or extension must depend to some degree on the age of the plate it overrides. This (the age of the overridden plate) may remain constant for long periods of time, or it may change (steadily or abruptly) in response to more factors than can possibly be summarized here. Back arc extension and Cordilleran compressional tectonics thus may have the same plate motion "signature." As in point 3 above, it seems likely that changes in the boundary conditions will affect plate motions (for instance, a change from passive subduction to forceable underthrusting eventually should slow convergence), but the response probably would be slow and complicated.

5. Many orogenic "effects" must lag their plate tectonic "causes" by millions or tens of millions of years. Several obvious examples, and several that are less obvious, were brought into focus by the symposium. Certainly arc-related magmatism must lag initiation of subduction by at least the time it takes for magma to work its way to the surface. Likewise, if back arc extension requires softened lithosphere, then several tens of millions of years conceivably might separate plate tectonic cause (initiation or acceleration of subduction) and geologic effect (extension). Similarly, strike slip faulting driven by oblique convergence may be localized by the mechanical properties of the continental crust. Thus faulting may begin in the forearc region and migrate into the arc itself--with no change in relative plate motion. Finally, there may be "thresholds" to overcome before some tectonic responses occur. For example, no recognizable plate tectonic trigger exists for the immense outpouring of basalt that occurred behind the Cascade arc in mid-Miocene time; slow, steady subduction of relatively young Farallon plate seems to have been the rule before,

during, and after the event. It has been suggested that thermal energy related to Farallon subduction may have accumulated in the upper mantle until resistance to extension finally was overcome—at which point a small amount of extension was able to trigger massive partial melting. Other explanations are possible, of course, but the example remains--orogenic (and magmatic) events that appear abrupt and dramatic may result from plate tectonic processes that go on uniformly for long periods of time.

One of the most useful aspects of this symposium was the interchange of ideas between relatively insular subdisciplines, and it seems clear that progress in solving basic problems of Cordilleran orogenesis increasingly depends on such cooperation. The symposium suffered from a lack of input from geochemistry and isotope geology, and there was too little attention paid to processes—how the things we study and describe come about. The next symposium should displace its emphasis slightly in these directions.

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