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THE ANDEAN CORDILLERA AND CIRCUM-PACIFIC TECTONIC EVOLUTION

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There is evidence that the Pacific Ocean basin has had a remarkable permanency at least through Phanerozoic time (Coney, 1990). The orogenic systems that have evolved around its margins since the early Paleozoic are accretionary continental margin orogens and there is little or no evidence of continental collisions in their evolutionary history. This evolution is in dramatic contrast to that found in Circum-Atlantic and Tethyan realms where repeated openings and closures of, or successive transfer of continental fragments across, ocean areas that were relatively never large are typical of the tectonic evolution. In other words, the Wilson Cycle has dominated tectonic evolution of Atlantic and Tethyan realms, but has not been important in the Phanerozoic Circum-Pacific.

The Circum-Pacific can be divided into three major tectonic segments each of which reflects somewhat diverse tectonic evolutions. The north and northeastern Pacific margin, extending from northeastern Siberia to Ecuador and including the North American Cordillera (Coney, 1989), is for most of its length a "classic" continental margin accretionary system dominated by very significant volumes of once fringing or "exotic" intraoceanic magmatic sedimentary terranes of various types and other "oceanic" accretions now found outboard of, or thrust upon, variable and often displaced distal continental margin terranes, and in the case of western North America, a well developed Paleozoic miogeocline. The volume of intraoceanic "suspect" terranes in this segment is much larger than in any other part of the Circum-Pacific. Most of the "oceanic" magmatic-sedimentary terranes are late Paleozoic to mid-Mesozoic in protolith age and were progressively consolidated into adjacent cratons mainly in mid- to late Mesozoic to Cenozoic time. In the case of the North American Cordillera the major accretions and consolidation are coincident with the "absolute motion" advance of North America into the Pacific realm as a result of the opening of the Central and North Atlantic.

The northwestern margin of the Pacific Ocean is the collage of Asia

(Sengor, 1987) which was produced by Tethyan tectonics, not Pacific tectonics – ie., the progressive transfer of Gondwanaland fragments across Tethys to collide with Baltica-Siberia. Within the Tethyan collage most major tectonic trends are east-west and perpendicular to the Pacific margin. Only since early Mesozoic time have minor Pacific accretions, such as Japan, produced a present narrow Pacific margin.

The southeastern, southern, and southwestern margin of the Pacific Ocean is the central and southern Andes of South America, West Antarctica (Dalziel and Grunow, 1985), and eastern Australia (Coney et al., 1990). Through Paleozoic-early Mesozoic time these were joined in a very enigmatic Pacific margin orogenic system 20,000 km long on the Pacific margin of Gondwanaland. Lack of a well developed "classic" miogeoclinal terrace is notable, and upper Precambrian but mostly lower Paleozoic fairly deep-marine turbiditic and occasional submarine volcanic facies are common often directly juxtaposed against the cratonic interior. A prolonged Paleozoic to early Mesozoic history of variable and often quite local convergent to transpressive and accretionary tectonics, sometimes associated with extraordinary magmatism, and extensional episodes progressively consolidated a considerable volume of "quasi-continental" to "quasi-oceanic" largely distal continental margin type terranes into the Gondwanaland craton. Since the fragmentation of Gondwanaland in the mid-Mesozoic only the Andean margin has continued convergent consolidation, apparently coincident with the advance, in the "absolute motion" sense, of South America into the Pacific with the opening of the South Atlantic Ocean.

The origins of the Pacific Ocean basin are still somewhat obscure and a matter of current discussion, but recent very stimulating and provocative suggestions (Dalziel, 1991; Hoffman, 1991; Moores, 1991) that it opened in late Proterozoic time as the result of the break-up of a Proterozoic "supercontinent" are very attractive even if still unproven. Following Hoffman (1991) the Proterozoic "supercontinent" had North America as its core and the break-up peeled an amalgam of Australia-India-East Antarctica away from the present western margin of North America to open the Pacific Ocean basin. The Amazon craton and the principal cratons of Africa broke away from the present eastern and southern margin of North America to open a proto-Atlantic and all the above mentioned fragments then joined to form Gondwanaland. The resulting collisions and convergent accretions were the long mysterious Pan African orogenies. These orogenies are important in the early evolution of the Andean Cordillera in particular and the Pacific margin of Gondwanaland in general.

South America is a Pan African collage of basement blocks (Ramos, 1988; Hoffman, 1991) and as a result the Andean orogen does not show tectonic continuity along its length until the end of the Pan African-Brasiliano cycle which probably extended into early Paleozoic time. Much of the still obscure latest Precambrian to Cambrian thick muds and sands, scattered volcanism and plutonism and evidence of deformation found particularly in the southern Andes and also in the Transantarctic Mountains, West Antarctica, Northern Victorialand, and eastern Australia are probably related to the complex initial rifting and subsequent convergences along the margins of the consolidating Gondwanaland blocks and evolving "proto-Pacific margins" associated with the Pan African assembly. Much of the Cambro-Ordovician mud and sand found in so many of the continental margin type terranes along Gondwanaland's Pacific margin are probably largely debris from these eroding Pan African orogens. From the Ordovician until early Mesozoic time there is more through-going continuity in tectonic evolution along the Gondwanaland Pacific margin.

Recently proposed, but still controversial, gyrations in Gondwanaland's Paleozoic APW path (Van der Voo, 1988) may provide a partial insight into Andean mid-Paleozoic tectonic evolution. An intra-Silurian rapid excursion of the South Pole from North Africa to a position off southern Chile should have placed the Andean Pacific margin in a "neutral" or even extensional mode as South America retreated from the Pacific Ocean basin. The distinct lack of Silurian Rocks in many parts of the Andes and a noticeable lull in deformation and magmatism may express this movement. If the excursion placed the northern Andes and Africa in collision with eastern North America to produce Acadian orogeny in the Appalachians the effect on the northern Andes is detectable, but not severe. A much debated Devonian to Early Carboniferous excursion of the South Pole back into central Africa might help explain widespread Devonian to Early Carboniferous orogeny along the entire Pacific margin of Gondwanaland as that margin advanced into the Pacific Ocean basin. Subsequent movements of Gondwanaland in late Paleozoic time as it drove into North America to produce Pangaea are reflected in significant accretions and magmatism along the Pacific margin of the southern Andes (Herve, 1988), and the collision and tightening and subsequent separation between North and South America is at least permissibly detectable in the late Paleozoic - early Mesozoic tectonics of the northern Andes.

Convergence seems to have characterized the Andean margin during early Mesozoic time. Magmatic belts either stood off-shore or were draped along the margin, often outboard of shallow cratonic marginal seas, but their tectonic signatures seemed to have been "neutral" if not extensional. No widespread consolidation or massive orogenesis seems to have been typical. This character can be traced along most of the entire Pacific margin of Gondwanaland and is typical of western North America as well. As Gondwanaland began to break-up and fragment, however, this commonality is lost. The principal development is the opening of the Atlantic Ocean which influenced the tectonic evolution of the American Cordilleras. As first North America in the Middle to Late Jurassic then South America in the mid- to Late Cretaceous finally break free they begin a fairly rapid advance over the Pacific Ocean basin in an "absolute" motion sense. In each case this marked advance seems to be coincident with the initiation and progressive evolution of accretions, massive orogenesis, intraplate telescoping and consolidation, transpressive shear, oroclining, and crustal thickening and melting in the American Cordilleras which in the case of the Andes continues to the present day (Isacks, 1988).

The role of the "suspect terranes" in Andean tectonic evolution seems to have been quite minimal, at least as a driving force of orogenic evolution. The principal terrane types are largely continental margin terranes whose age of both protolith and "accretion" is Paleozoic. Most, with the possible exception of the Precordillera terrane, are probably of South American origin. Late Paleozoic disrupted accretionary terranes are found along the margin of the southern Andes. The only large Mesozoic-Cenozoic "exotic oceanic" magmatic-sedimentary terranes are in the northern Andes of Ecuador, Colombia (Restrepo and Toussaint, 1988), and Venezuela, the southern-most part of the belt mentioned earlier extending from northeastern Siberia through the North American Cordillera. There is no evidence that continental, or even terrane, collisions have significantly influenced the dynamics of Mesozoic-Cenozoic tectonic evolution in the Andean Cordillera.

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