THE ORIGIN AND EARLY HISTORY OF THE PACIFIC MARGIN OF SOUTH AMERICA: THEIR INFLUENCE ON THE DEVELOPMENT OF THE ANDEAN CORDILLERA

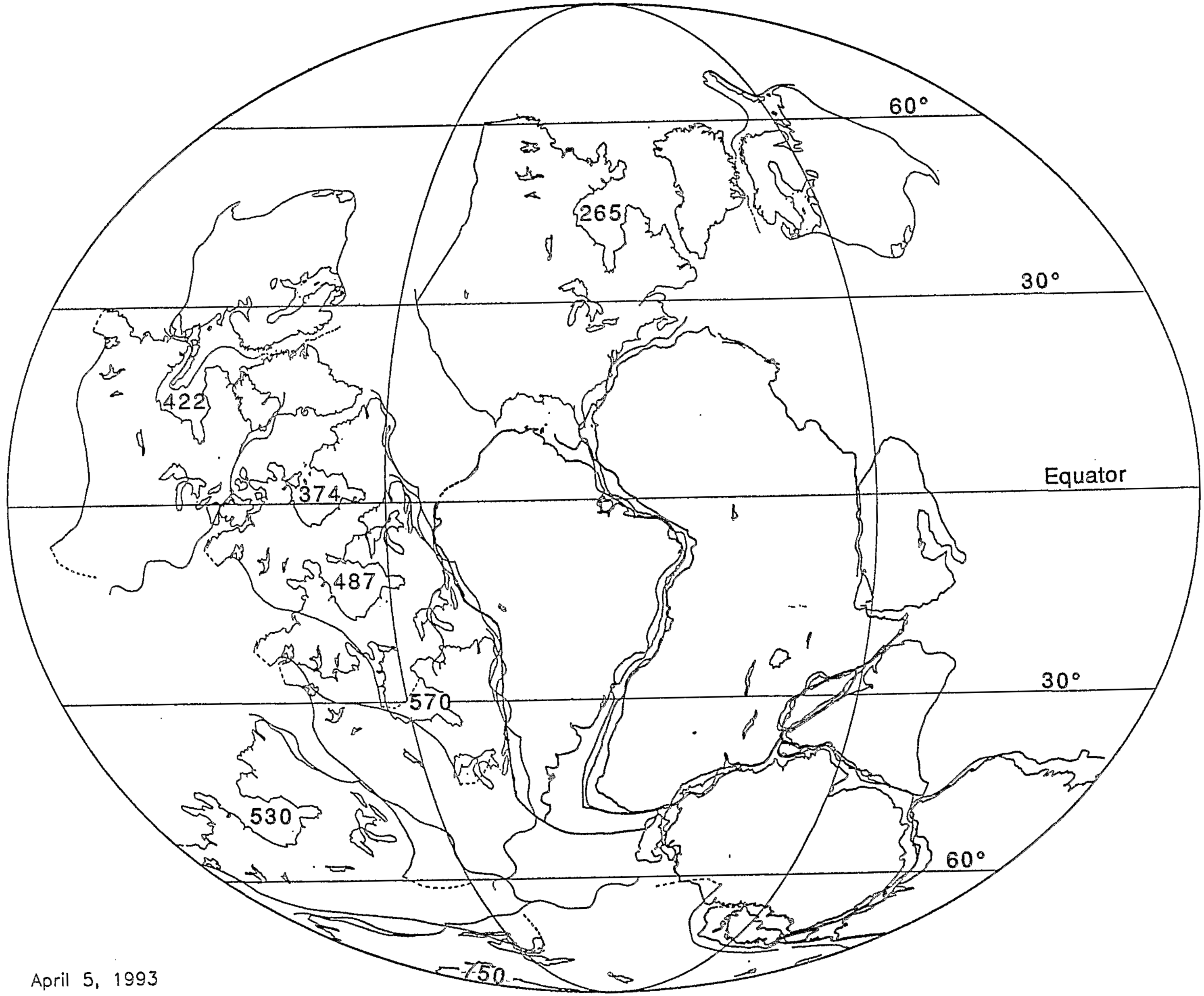
Ian W. D. DALZIEL

Institute for Geophysics
8701 Mopac Boulevard
Austin, Texas 78759-8397 USA

For nearly a century, various aspects of the foundation of the Andean Cordillera have led geologists (e.g. Burckhart, 1902; Steinmann, 1923; Dalmayrac et al., 1980) to speculate on the existence of a major continent to the west (present coordinates) of South America during the Paleozoic. Recently Moores (1991) and Dalziel (1991) have revived earlier ideas (Eisbacher, 1985; Bell and Jefferson, 1987) that the Pacific margins of North America and East Antarctica-Australia may have been juxtaposed in the late Precambrian. This has led to the idea that Laurentia, the Precambrian core of North America, may have "broken out" from between East Antarctica-Australia and South America during the Neoproterozoic to Cambrian amalgamation of Gondwanaland (Dalziel, 1991; Hoffman, 1991). According to this hypothesis the Neoproterozoic opening of the Pacific Ocean basin was balanced on a globe of constant radius by the closure of several ocean basins between the cratons that amalgamated to form Gondwana, and "southern Iapetus" opened at the end of the Neoproterozoic between Laurentia and the coalescing cratons of West Gondwana (Dalziel, 1992a,b).

Paleomagnetic data are compatible with clockwise rotation of Laurentia around the Pacific margin of Gondwana during the Paleozoic *en route* to final "docking" with northwestern Africa (present coordinates) to form Pangea (Dalziel, 1991, Fig. 2). Indeed several lines of evidence suggest that, following initial separation in the latest Neoproterozoic to Early Cambrian, Laurentia may have tectonically interacted with the Pacific margin of South America in the course of this motion (Dalla Salda et al., 1992a,b; Dalziel et al., 1992 and in press). The accompanying figure shows hypothetical, but paleomagnetically acceptable, relations of Laurentia and South America at specific times from the end of the Precambrian to the assembly of Pangea in the latest Paleozoic. The reconstructions may explain several long-standing tectonic problems, yet they do not appear to conflict with well-established interaction between Laurentia, Baltica, and other tectonic units of the present-day North Atlantic region. Critical elements of the overall hypothesis are outlined below. The suggestion of specific times of continent - continent collision is not meant to imply simple tectonic settings. The zone between the continents would have been as complex as the Tethys or present-day Mediterranean.

<u>Latest Precambrian (570 Ma)</u>: The Labrador-Greenland promontory of Laurentia rifts from the Arica reentrant in the Gondwana margin, possibly while some Brazilide basins are still closing. The Arequipa massif is a fragment of the Ketilidian-Makkovik provinces of Greenland and Labrador. The Paleozoic intracratonic basin between the Arequipa and the Amazonian shield may mark a failed arm of the rift system.
<u>Cambrian-Early Ordovician (500 Ma)</u>: Laurentia rifts from the proto-Andean margin, isolating the benthic trilobite fauna of the continent. The "southern cone" (from Georgia in the east to Trans-Pecos Texas in the west) may have remained attached to Gondwana in the vicinity of the present-day Weddell Sea.
<u>Mid-Ordovician (487 Ma)</u>: Laurentia and Gondwana collide to form the Taconic-Famatinian (Ocloyic) orogen, possibly continuing into the Shackleton Range of Antarctica. Upon subsequent rifting (possibly pre-Ashgillian), the Precordilleran terrane of northwestern Argentina is detached from the Ouachita



April 5, 1993

embayment of Laurentia, and the Oaxaca terrane of Mexico is detached from the area of the Arica reentrant of South America.
Late Ordovician and Silurian (422 Ma): Laurentia and Gondwana separate. Laurentia occupies temperate to tropical latitudes while the Pacific margin of Gondwana undergoes glaciation.
Devonian (374 Ma): Following the Laurentia-Baltica collision that ended the Caledonian orogeny, Laurentia and Gondwana collide once again in a dominantly right-lateral transpressive mode. Much of what is known as the Acadian orogeny in North America may reflect this interaction. Distribution of the Malvinokaffric and Cosmopolitan faunas would have been strongly influenced by the changing paleogeography over this time interval. Subduction of Pacific Ocean floor commences beneath the central Chilean margin.
Latest Paleozoic (265 Ma): Laurentia finally docks with present-day northwestern Africa in the Ouachita-Alleghanian orogenesis to terminate the Appalachian revolution and complete the amalgamation of Pangea. Pacific Ocean floor is subducted beneath the entire proto-Andean margin.

The hypothesis, if basically correct, has several major implications for the development of the Andean Cordillera in the Mesozoic and Cenozoic. For example: 1. As suggested by others (e.g. Dewey and Lamb, 1992) from a purely South American standpoint, the Arica reentrant may be an original feature and may have exerted control over the tectonic development of the Pacific margin throughout the Phanerozoic. The Patagonian and Colombian oroclines may also date from initial rifting. 2. The crust beneath the Altiplano may have been thickened initially in Grenvillian collision of the Laurentian craton with Amazonia. 3. Laurentia may have played a critical role in the diachronous initiation of subduction of Pacific Ocean floor beneath South America. 4. Subduction erosion along the Pacific margin of South America may have been limited to material accreted during the Phanerozoic.

References:

BELL, R. and JEFFERSON, C. W., 1987, An hypothesis for an Australia-Canadian connection in the Late Proterozoic and the birth of the Pacific Ocean: PacRim Congress 1987, Parkville, Australia, p. 39-50.
BURCKHARDT, C., 1902, Traces géologique d'un ancient continente Pacifique: Revista del Museo La Plata, v. 10, p. 179-192.
DALLA SALDA, L.H, CINGOLANI, C.A., and VARELA, R., 1992a, Early Paleozoic orogenic belt of the Andes in southwestern South America: Result of Laurentia-Gondwana collision?: Geology, v. 20, p. 617-620.
DALLA SALDA, L. H., DALZIEL, I.W.D., CINGOLANI, C.A., VARELA, R., 1992b, Did the Taconic Appalachians continue into southern South America?: Geology, v. 20: 1059-1062.
DALMAYRAC, B., Laubscher, G., Marocco, R., Martinez, C., and Tomasi, P., 1980, La chaîne hercynienne d'Amérique du sud; structure et evolution d'un orogène intracratonique: Geologische Rundschau, v. 69, p. 1-21.
DALZIEL, I.W.D., 1991, Pacific margins of Laurentia and East Antarctica-Australia as a conjugate rift pair: Evidence and implications for an Eocambrian supercontinent: Geology, v. 9, p. 598-601.
DALZIEL, I.W.D., 1992a, Antarctica; A tale of two supercontinents?: Annual Review of Earth and Planetary Sciences, v. 20, p. 501-526.
DALZIEL, I.W.D., 1992b, On the organization of American plates in the Neoproterozoic and the breakout of Laurentia: GSA Today, v. 2, p. 237-241.
DALZIEL, I.W.D., DALLA SALDA, L. H., and GAHAGAN, L.M., 1992, North America as an "exotic terrane" and the origin of the Appalachian-Andean mountain system: Geological Society of America Abstracts with Programs, v. 24, p. 288.
DALZIEL, I.W.D., DALLA SALDA, L. H., and GAHAGAN, L.M., 1993, Paleozoic Laurentia-Gondwana interaction and the origin of the Appalachian-Andean mountain system: Geological Society of America Bulletin (in press).
DEWEY, J.F., and LAMB, S.H., 1992, Active tectonics of the Andes: Tectonophysics, v. 205, p. 79-96.

EISBACHER, G.H., 1985, Late Proterozoic rifting, glacial sedimentation, and sedimentary cycles in the light of Windermere deposition, Western Canada: Paleogeography, Paleoclimatology, Paleoecology: v. 51, p. 231-254.

HOFFMAN; P.F., 1991, Did the breakout of Laurentia turn Gondwanaland inside out?: Science, v. 252, p. 1409-1412.

MOORES, E.M., 1991, Southwest U.S.-East Antarctic (SWEAT) connection: A hypothesis: Geology, v. 19, p. 425-428.

STEINMANN, G., 1923, Umfang, Beziehungen und Besonderheiten der andinen Geosynklinale: Geologische Rundschau, v. 14, p. 69-82.

VAN DER VOO, R., 1988, Paleozoic paleogeography of North America, Gondwana, and intervening displaced teranes: Comparisons of paleomagntism with paleoclimatology and biogeographical patterns: Geological Society of America Bulletin, v. 100, p. 311-324.

Figure Caption

Molleweide projection showing hypothetical, but paleomagnetically acceptable, positions of Laurentia with respect to South America during the Paleozoic. The figure is modified from an earlier diagram (Dalziel, 1991, Figure 2) that was constructed to show that Laurentia could have "broken out" from between East Antarctica-Australia and South America at the end of the Precambrian. In the present figure, Gondwana is reconstructed using marine geophysical data as before, with South America kept in its present-day coordinates. Paleomagnetic controls are mainly from Van Der Voo (1988).

Early Neoproterozoic Laurentia (ca. 750 Ma) is shown against East Antarctica-Australia as it may have been prior to opening of the Pacific Ocean basin and amalgamation of Gondwana (Moores, 1991; Dalziel 1991; Hoffman, 1991). Laurentia is shown in the late Neoproterozoic (ca. 570 Ma) with the Labrador-Greenland promontory located within the Arica reentrant (Dalziel, 1992b). The position for the Early Ordovician (500 Ma) is as in Dalziel (1991 and 1992a). The Laurentia-Gondwana collision suggested by Dalla Salda (1992a, b) to have resulted in the Taconic-Famatinian (-Shackleton?) orogen is shown at 487 Ma; this is perhaps about 25 million years too early for the main deformation and metamorphism, but the paleomagnetic control is better. The position for Laurentia at 422 Ma is that of Dalziel (1991). Right-lateral transpression between Laurentia and Gondwana suggested to account for the main effects of the Acadian orogeny is indicated at 374 Ma (Dalziel et al., 1992 and in press); this is rather late for the Acadian, but again the paleomagnetic control is better. The reconstruction of Pangea by ca. 265 Ma is based on marine geophysical data.