BOOK REVIEWS

A Tectonic Amalgamation

Geology of Western Gondwana (2000–500 Ma). Pan-African-Brasiliano Aggregation of South America and Africa. ROLAND TROMPETTE. Balkema, Brookfield, VT, 1994. xii, 350 pp., illus. $99 or Dfl. 175. Translated from the French by Albert V. Carozzi.

The appearance of this book is a major publication event. It brings together for the first time the scattered and diverse geological data, mainly on Africa and South America, that document the amalgamation from formerly separate land masses of the western part of the supercontinent Gondwana some 500 to 600 million years ago (Ma). It should thus add new underpinning to the ongoing vigorous discussions about the nature of Earth history in the period 500 to 1000 Ma, the time leading up to and witnessing the development of animals and the widespread flourishing of life on Earth, an event known in geologic circles as the Cambrian-Precambrian boundary or the onset of the Phanerozoic eon.

Some 25 years ago, the concepts of plate tectonics produced a revolution in Earth sciences, sweeping aside old concepts and replacing them with a new unifying paradigm. According to this new world view, the Earth's crust and outer mantle form a number of segments or plates, which are in motion with respect to each other. Three types of plate boundaries exist—divergent boundaries, such as the mid-oceanic ridges, where plates move apart and new material wells up in the void thus created to form new oceanic plates; convergent boundaries, where the descent of one plate beneath another causes shallow to deep earthquakes to occur and volcanoes to form on the overriding plate; and conservative or transform fault boundaries, where one plate slides past another. Most hazardous Earth activity, such as earthquakes and volcanoes, occurs along these plate boundaries. For example, recent convergent margin events include volcanic eruptions of Mount St. Helens, USA, (1980), Pinatubo, Philippines (1992–94), Unzen, Japan (1992), and Nevado del Ruiz, Colombia (1986), and earthquakes of Kobe, Japan (1995), Mexico City (1985), Alaska (1964), Chile (1960), Colombia (1995), and Armenia (1988). All of the Pacific margin of North America lies along either a convergent or a transform fault boundary, the most famous segment of which is the San Andreas Fault system, giving rise to such calamities as the 1989 Loma Prieta and the 1994 Northridge earthquakes. Recognition of the close coincidence of major society-affecting geologic events with plate tectonic motion has given new meaning to the historian Will Durant's statement that "Civilization exists by geologic consent, subject to change without notice."

A major corollary of plate tectonic activity is that continents are passive riders on the plates, moving apart from each other along divergent plate margins, such as the Mid-Atlantic Ridge, and moving toward and even colliding with each other, as along the mountain systems stretching from Gibraltar through the Alpine and Mediterranean region into the Himalaya. In response to this passive motion, continents have clustered and dispersed throughout recent geologic history. Aspects of this "dance of the continents" are well known, not only to scientists, but to the public at large. As this familiar story goes, a supercontinent including all land on Earth, named Pangaea, existed some 200 Ma. Fragmentation of this land mass by opening of the central Atlantic and Mediterranean regions resulted in two other large supercontinents, Laurasia (chiefly North America and Eurasia) and Gondwana (chiefly Africa, South America, India, Australia, and Antarctica). These fragmented further by opening of the North and South Atlantic oceans and the Indian Ocean to give the present land patterns of Earth.

This well-known story is good as far as it goes, but it covers only the last 4 percent or so of Earth history (200 million years versus the 4.5-billion-year age of the Earth). In the past quarter century much effort has gone into mostly successful attempts to extend the tectonic scenario further back into the past. We now believe that Pangaea itself was an amalgamation of formerly separate continents. The timing of continental fragmentation and assembly can be read from the geologic record, preserved chiefly in world's mountain or orogenic systems, which represent the scars of convergence and collision of formerly separate continents. Maps of continental positions in the past 500 million years have become mainstays of studies of patterns of climate and of evolution in the past. Indeed, the patterns of continental assembly and dispersal probably played a major role in shaping the principal evolutionary trends since abundant life first appeared on Earth about 550 Ma.

Until recently, however, little progress had been made in extending the paleogeographic scenario much further into the past. A contributing factor has been the loss of good fossil control on strata older than basal Cambrian (about 550 Ma). In addition there has been uncertainty on such questions as the shapes of the continents themselves and the permanence of the Pacific Ocean basin. Recent recognition of possible separation, approximately 750 Ma, of formerly joined Antarctica-Australia and western North America has led to a breakthrough in our understanding of geologic events from 500 to 1000 Ma. A currently popular model holds that assembly about 1000 Ma of an earlier supercontinent broke up some 750 to 500 Ma to form a proto–North America (often called Laurentia) and proto-Europe (called Baltica). Reassembly of some of the pieces produced the supercontinent of Gondwana, which existed from about 500 Ma until its later breakup as described above.

Much of the evidence for or against this new model resides in the continents of the former Gondwana, because it is there that the record of Gondwana-producing convergence is preserved. Much of that evidence is poorly known or widely dispersed in regional publications and thus has been difficult for the international geological community to access.

Trompette's book thus comes along at a highly propitious time to test these new ideas. This massive work presents a first-time-ever synthesis of the geologic evidence for amalgamation of western Gondwana (Africa and South America; eastern Gondwana comprises chiefly India, Australia, and Antarctica). Trompette documents the evidence for the existence in Africa–South America of five formerly separate large continents (cratons)—Amazonia (chiefly in Brazil, Venezuela, Surinam, Guyana, French Guiana, and environs); West Africa (in Mali, Senegal, Algeria, Morocco, Ghana, Ivory Coast, and environs); Rio de la Plata (Brazil, Uruguay, and Argentina); Kalahari (Botswana, Zimbabwe, South Africa, and environs); and Congo-São Francisco (Brazil, Cameroon, Nigeria, Zaire, Central African Republic, Angola, Zambia, Congo, and environs). He also marshals evidence for seven major orogenic belts of late Precambrian–

early Paleozoic age, collectively referred to as the "Pan-African-Braziliano" orogenic system, which separate the cratons and represent the scars of the convergence and collision of these former separate continents, and for an area of small cratons and complex structure encompassing part of northeastern Brazil, Cameroon, and Nigeria. Trompette envisions that Gondwana was formed about 650 to 500 Ma by early amalgamation of West Africa and Amazonia followed successively by the addition of Congo–São Francisco, Kalahari, and finally East Gondwana.

This dense, compactly written, stratigraphically oriented book is heavy going, even for the specialist. Many may disagree with some of Trompette's conclusions. Few nonspecialists will have the tenacity to get through it. However, it is hard to overemphasize the book's value for present and future discussions of tectonics. The reference list itself—approximately 1400 entries in four languages (Portugese, Spanish, French, English) is a major contribution. It alone should serve for years as a valuable research and teaching aid for stratigraphers, structural geologists, tectonicists, and petrologists interested in this vast and crucially important region.

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Zoological Ventures

Nature, the Exotic, and the Science of French Colonialism. MICHAEL A. OSBORNE. Indiana University Press, Bloomington, 1994. xviii, 216 pp., illus. $35. Science, Technology, and Society.

This is the first scholarly history of the Société Zoologique d'Acclimatation and its endeavor to introduce into France and its colonies foreign species deemed promising for agriculture. Though the episode is now largely forgotten, the society was in its time a broadly supported enterprise, gathering more than 2500 members during the first seven years of its existence, much more than most European scientific societies could then claim.

The Société Zoologique d'Acclimatation was founded in 1854 by Isidore Geoffroy Saint-Hilaire, then professor at the Faculty of Sciences of Paris and at the Muséum National d'Histoire Naturelle, where he was in charge of the menagerie. The son of Étienne Geoffroy Saint-Hilaire, Georges Cuvier's opponent in one of the most famous scientific debates of the century, Isidore was himself a respected scientist. Though mainly famous then, and still remembered for, his contributions to teratology, he was a man of broad interests, the author of a multivolume "general natural history," left incomplete at his death in 1861, in which he advocated the idea of limited species variability—a matter of obvious relevance for acclimatization. In the year in which the society was created, taking up a program originally conceived by the anatomist Jean-Marie Daubenton, he published a treatise, developed from a report prepared for the Minister of Agriculture, on the acclimatization and domestication of useful animals.

Illustration from a dinner menu of the Société d'Acclimatation, 1911. In addition to *filets de boeuf à la française* the menu featured seafoods from Mauritania, *croustades de foies gras de tortue marine, omelette au jambon végétal, graines de gingko grillées, germes de soja sautés, roquefort de soja,* and *popcorn à la sève d'érable.* [From *Nature, the Exotic, and the Science of French Colonialism*]

The society survived through the First World War. It had, however, an up-and-down history. The 1850s were years of success. The society's zoological garden, the Jardin d'Acclimatation, was opened in 1860. But Isidore died the next year, and during the 1860s the society began to lose audience and soon encountered acute financial difficulties. Moreover, after 1870, under the Third Republic, the society was unable to benefit from the sort of official patronage that the emperor, Napoleon III, had provided.

The society was, much more than any other institution of the scientific establishment such as the Académie des Sciences or the natural history museum, supportive of the colonial enterprise, and particularly of the program to settle Algeria (conquered in 1830) with French peasants. Napoleon III, uneasy with the factory system of labor and fearing the rise of syndicalism, was committed to *petite culture* in France and favored small landowners in his policy for the settlement of Algeria. As Osborne documents extensively and for the first time, the acclimatization society filled the vacuum left by more established institutions and, in the 1850s and 1860s, provided sustained informal expertise on the agricultural development in Algeria and encouraged research on the acclimatization of multifunctional animals that might be used by small landowners for traction and for food and other products of commercial interest, such as wool fibers.

Similar goals were pursued by some provincial organizations affiliated with the society. Osborne shows that the acclimatization movement was particularly strong in eastern France, in the Nancy and Grenoble regions. There sizable-scale experiments were conducted with yaks, llamas, angora goats, and ostriches (prized for their plumes, which were in great demand for fashion).

However, such attempts repeatedly proved to be utter failures. The animals died, markets vanished, and peasants showed little interest. None of the zoological ventures stimulated enduring industries in Algeria; only ostrich farming survived well into the Third Republic. In 1881, 20 years after the opening of the Jardin, its director admitted that it had not succeeded in diffusing a single new agricultural product. Moreover, as the French empire rapidly expanded at the end of the century, in the newer colonies of Asia and sub-Saharan Africa, it was not multifunctional animals or land tenure of small holdings that prevailed but factory-farm production, financial capital, and the cultivation for export of products such as peanut and palm oil.

Osborne writes that his main concern in writing this book has been to "elucidate the