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Book review: *Quaternary Geology and Geomorphology of South America* by C. Clapperton

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BOOK REVIEW

Quaternary Geology and Geomorphology of South America by C. Clapperton

Elsevier, Amsterdam, 1993, xvi + 779 pp.
Price: Dfl. 350.00 (US$200.00).

Dr. Clapperton is to be commended for having taken on the monumental task of a review of the present state of knowledge of the Quaternary of the entire continent of South America. ***Quaternary Geology and Geomorphology of South America*** is a massive, interestingly written, but expensive volume that covers exactly what its title suggests. In spite of the paucity of information on many aspects of the Quaternary geology of this continent, which extends from north of the equator nearly to the Antarctic, the author has succeeded in reviewing and synthesizing most of the material that does exist. To do so he accessed a wide range of published and unpublished material. And although the bulk of his personal research has been in the northern Andes, he visited much of the continent and investigated Quaternary problems in several areas.

The book is well organized and well illustrated. Following an introductory chapter, an overview of the physical geography of South America, the author discusses Quaternary tectonics of the continent and the effects of the tectonism on rivers, slopes, glaciers, and coastlines. Seismic activity and intense precipitation generate major debris flows and landslides in the steep slopes of rivers draining the tectonically active Andes. Two chapters cover the volcanic regions and the significance of Andean volcanism to Quaternary geology. The remainder of the book follows both a regional and a thematic approach, using the morphostructural divisions of South America: the Andean region, the alluvial basins, and the highlands of the shield areas. The Andean Chain is further subdivided on structural and tectonic characteristics into the Northern, Central, and Southern Andes.

Much of South America east of the Andean Cordillera consists of alluvial basins that have received large volumes of sediment derived from the

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rising Andean chain during the Quaternary. Although information is sparse regarding the sedimentary stratigraphy and the effects of Quaternary climatic changes on these basins, which now are in tropical and subtropical regions, much of what is known is well summarized in these three chapters. In the author's review of the "Refuge Theory" of Amazonia and criticism of it, he calls attention to problems that exist in interpretation of radiocarbon dates in the region. Extensive eolian sediments — paleodunes and loess — indicate that the alluvial basins have been drier and windier than today. He also points out that some of the hypotheses regarding geomorphic development, based on once current interpretations of events in Europe and North America, no longer are acceptable.

Although the extra-Andean highlands of Brazil were not glaciated, they probably were affected by geocryogenic (periglacial) processes. Underlain by Precambrian and Paleozoic rocks, these highlands display some erosional landforms and colluvial deposits that had been interpreted by earlier workers as the results of glaciation. Less well known because it has not been studied systematically is the Quaternary geology of the highlands of the Guyana Shield and of Patagonia.

The author devotes 5 chapters (11-15) and nearly 200 pages (275–471) to the glaciations and glacial history of the Andes. In the first of these chapters he reviews the modem glaciers and the glacial landforms in the chain, some of which provide truly spectacular scenery. As in the chapters on tectonics and volcanoes, Dr. Clapperton discusses separately the northern, central and southern Andes. A brief treatment of late Miocene glacial deposits in Patagonia is followed by Pliocene glacial sediments of Patagonia and Bolivia, then deposits of the Early and Middle Pleistocene glaciations.

Much better known are the records of the Late Pleistocene (Isotope Stages 7-2). Moraines attributed to the penultimate glaciation (isotope stage 6), though not precisely dated, have been mapped in Venezuela, Peru, the Aconcagua region, and Patagonia. Relative dating techniques suggest that some moraines in these same regions were deposited in the early part of the last glaciation, although none have been clearly dated as Isotope Stage 4 equivalents. Best known, however, is the record of the Last Glacial Maximum, or LGM (Isotope Stage 2), moraines of which are recognized throughout the Andes. The author provides a critique of the differences in late glacial history that have resulted from studies of moraine morphology and pollen stratigraphy. Northern Andean glaciers evidently responded to thermal decline as early as 40,000 years ago, but in the Southern Andes the LGM was nearer 20,000 BP. He also point out some of the problems that are unsolved in understanding the Late Glacial and Holocene Andean glaciations.

The age and origin of the Patagonian Gravel Formation have been in dispute for decades; chapter 16 reviews recent studies that show them to be

more than a single unit, to be polygenetic, and to range in age from Late Miocene to Early Pleistocene. The chapter (17) on paleolakes of the arid regions deals with the many endoreic lake basins of the Altiplano-Puna from Lake Titicaca southward, most of which are now salares, and the extent to which fluctuations corresponded with the expansion and contraction of Andean glaciers during and since the Last Glacial Maximum. Most of them evidently reached maximum size soon after 34,000 years ago.

Geocryogenic/periglacial processes are active today in the dry Central Andes and in Patagonia. Much more extensive during the late Pleistocene, relict patterned ground has been recognized in both of these regions, where the features suggest mean annual air temperatures about 7°C lower than the present. The Malvinas (Falkland) Islands experienced extensive geocryogenic activity; nearly half of the chapter reviews these features.

Changes in global sea level and tectonic activity have combined to make the Quaternary coast line record of South America a complex one. Raised marine benches are present around much of the continent, some along the west coast more than 300 m above sea level are dated by amino acid racemization of shells as about 690 ka. Submerged coastal deposits on the Argentine shelf record both lowered sea level and crustal warping.

Much of the present understanding of Quaternary climatic conditions in South America is based on palynological studies. Chapter 20 reviews the pre-late- Quaternary pollen record, which is based on studies of long cores from Colombian lakes. Bogs in southern Chile record vegetation changes only since the last interglaciation. Far more data are available for the last glaciation and the Holocene than for earlier parts of the Pleistocene. Considerable work has been done in the Northern and Southern Andes, where bogs are abundant; much less is known about vegetation changes in the Central Andes. The pollen data suggest last glacial maximum temperatures 2.5° to 5°C lower than the present; temperature at 12.5 to 10.0 ka was 1° to 2°C lower with increased precipitation in Patagonia; estimates for the Northern Andes are 1° to 3° lower with slightly decreased precipitation.

A final chapter overview summarizes the Quaternary of the continent and poses several questions about Andean glaciations, particularly the differences between glacial activity in the Northern and Southern Andes. The author points out, in concluding, that the record of environmental changes in South America for the past 3.5 Ma seems to correspond closely to those recorded in marine cores.

Dr. Clapperton writes in a very readable style, and this book is generally well edited. As might be expected in a volume of this size, however, it contains a scattering of typographical errors, as well as some mistakes in the text and in reference citations in the parts dealing with northwestern Argentina, the area I am familiar with. Perhaps worthy of mention are the age

of an ash bed dated at 360,000 BP (not 250,000-300,000 as on pp. 370-371) that was noted by L. Espizua de Bengochea (1989). And in Table 11.1 (p. 281), Aconcaqua is at 70°W, not 7°W. There undoubtedly are other errors of a similar nature that I failed to recognize. In spite of these and the cost of the volume, this book is one that will serve as a landmark — a readily available source of information and a critical review of most of the research on the Quaternary of South America as of the early 1990's. It should be in every university library.

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