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Geomorphological Research in Middle America

Geomorphological research in Middle America by geographer, has followed the general trends of this type of research in other areas, but often reflects a slight time lag in the methodology and applicability of the research. For reasons of organization, this report will concentrate on the activities in the Middle American area and will exclude references to coastal geomorphology except where overlaps cannot be avoided.

A brief scrutiny of the literature soon discloses that nearly 40 percent of applicable references focus on Mexico and that the references stress physiographic description, karst regions, volcanic features, and fluvial studies. Cuba, Puerto Rico, and Guatemala claim about 10 percent of the references each whereas the remainder are spread over the rest of the Caribbean and Central America; the former incorporating about twice as many citations as the latter. The topics covered in these areas remain relatively unchanged except for the addition of erosional surfaces to the lines of inquiry. Much of the total geomorphological research has been the product of very recent work in Middle America, for nearly 42 percent of all the references utilized in this report have been published within the decade.

Review of the literature

The establishment of particular lines of investigation and a continual development of either geomorphological theory or regional inquiry has been partially handicapped by the paucity of investigators involved in long-term projects in Middle America. More that 75 percent of the persons cited in the accompanying bibliography have contributed but one publication to the geomorphology of Middle America. Only 5 investigators, or 6 percent, have produced more than two publications in this field. Despite the shortage of continuing investigations, several important themes have been raised and their contributions are summarized below.

Nearly one-third of all the references to Middle American geomorphology involve physiographic description (see Atwood, 1935; Ordonez, 1946; Ysaigue de Massip,

1966). Some of these incorporate new concepts (Raisz's physiographic map of Mexico), whereas others are attempts at reorganizing data on different scales or the incorporation of recent areal analysis (Alvares, 1961; Tamayo, 1941). There is no doubt that one of the basic endeavors of most geomorphological work in Middle America is to produce a regional geomorphological synthesis that is both original and meaningful. In certain cases, the map is the end product (Box, 1942) but the more complete and therefore more areally restricted contributions incorporate the geomorphological significance of the variety of features (Hammond, 1954) and may even discuss morphological origins (Guerra, 1966). Although physiographic descriptions are still being produced, their greatest contribution should be a detailed geomorphologic map that will serve as a data base for integrating other variables.

The investigations into karst phenomena occupy about 20 percent of the references. This line of inquiry has produced a considerable amount of field data, karst terminology, karst categorization, and one of the few geomorphological theories in Middle American geomorphologic research. Although many of the early accounts were basically descriptive (Lobeck, 1922), more recent work has stressed the significance of climatic processes in producing specific karst morphologic responses, essentially indicating that tropical karst differs from mid-latitude karst (Lehmann, 1954; Corbel, 1959; Gerstenhauer, 1950; Blume, 1966; Panos and Stelcl, 1968). All but Panos and Stelel argue that there is a climatic basis for the specific karst forms found in Middle America and that even large scale morphometric variation is attributable to climate. Panos and Stelcl add the variables of tectonic history, lithologic variation, and weathering crusts to the data matrix and de-emphasize the importance of climate without negating it totally. The process-response models developed for karst studies provide the direction for further work in geomorphology as well as refinement within the field of karst investigations. With the inclusion of elevation, a wide variety of climatological regions is encompassed in Middle America and there would be opportunity to expand the karst models.

Another line of inquiry that has received considerable attention is the recognition of erosional surfaces and the attempts at the establishment of a Quaternary surface chronology. Weaver (1961, 1962, 1966) has been the primary investigator of erosional surfaces and has used the principles of altimetric frequency to designate these levels. His work has been directed toward the identification of surfaces on the Caribbean islands which could then be interpreted as either sea

level fluctuations of tectonic instability of the islands. There are too many interacting factors to establish a definite chronology at this time, but several working hypotheses are being explored and numerous observations are being integrated (Ducloz, 1963; Martin-Kaye, 1963; Jones, 1964). The Quaternary chronology is also being advanced by researchers in a broader geomorphological context as indicated by the study of fluctuating lake levels, paleo-climatology, and early man (Clements, 1963; Arnold, 1957) or by Quaternary erosional sequences with or without the inclusion of man (Bryan, 1948; Cook, 1963).

An additional line of geomorphological inquiry that is related to climatic geomorphology or morphogenetic systems lies within the realm of weathering, mass movement, erosion, and slope development. Krynine (1936) early laid the basis for a specific! type of climatic weathering that has recently received serious questioning. Subsequent mass-movement studies avoided the climatic context (Box, 1939; Peeters, 1963; Monroe, 1964) but lately there has been a welcome return to the consideration of the larger physical environment as background to landslides and slope development (Birot, 1966, 1967; Cunningham, 1968). In these later cases, the responsive slope is judged in terms of the climatic environment and the foundation for additional morphogenetic inquiry is formed.

The number of articles concerning volcanic geomorphology amounts to 15 percent of the list of references, the third largest grouping, but most of these predate the recent decade and offer little modern geomorphological data (Williams, 1950, 1952, 1955, 1960; McBirney, 1956, 1963). Certainly there is a paucity of geomorphologic theory involved, except perhaps for some of the publications by Williams. These publications are primarily descriptive and provide extensive lists of volcanic events. Detailed geomorphic maps are lacking and aside from a specific erosional sequence at Paricutín (Segerstrom, 1960, 1961), inquiry has not progressed much beyond the identification of volcanic features, establishment of a partial stratigraphy, and an application of caldera classification.

If the preceding statements appear to describe the volcanic geomorphological investigations as pedestrian, it is because the more significant contributions are incorporated within other aspects of geomorphology, an example of which is the recognition and relative dating of Middle America glacial events. Although the areal extent of Pleistocene glaciation is severely restricted, and at very high altitudes, several noteworthy publications have been produced in this field. The early papers are directed toward the recognition of glaciers and glacial events (Pristar, 1927; Robles, 1944), whereas the more recent contributions incorporate a

glacial chronology involving glacial geomorphic features and lava and ash stratigraphy (White, 1962; Magnani, 1965; Mitchell, 1966). White has presented an excellent paper on the recognition of glacial sequences in Mexico and it should be adopted and tested by researchers in this field.

Summary

Excluding the many physiographic descriptions, geomorphological accomplishments in Middle America have concentrated on karst development and the recognition of morphological sequences that were formed during the Quaternary. Most of the pertinent information has been derived from studies in Mexico and thus many gaps exist in other parts of Middle America.

Recommendations

If United States geographers are serious about improving the contributions of geomorphologists of other scientists in Middle America, a very basic accomplishment would entail the establishment of at least one data center for geographical publications. This center would facilitate reference work and ease the problems of library searching that currently exist. In addition to the availability of manuscripts, geomorphological investigations would be fostered by the accumulation and concentration of Middle American aerial photographs, maps and charts, and basic tabulated data. Given the facilitation of accessible data, inquiry could readily be directed toward the following geomorphological problems.

Middle America has a wide range of tropical climatic environments and given the establishment of the tropical karst process-response model as a successful venture into climatic geomorphology, additional work should be directed toward morphogenetic systems theory. Although slope studies have been partially incorporated in the karst work, additional inquiry should be accomplished on the morphometric analysis of slopes produced in different climatic regions. The significance of this morphogenetic systems approach is 1) to designate equilibrium conditions in present-day environments, and 2) to identify disequilibrium conditions that may be remnants from Pleistocene environments.

Drainage basin analysis has been seriously neglected as a type of geomorphological research in Middle America. A few publications incorporate hydrologic data but only Lewis (1969) has attempted to combine morphometric

and hydrologic data. With the increasing amount of stream discharge information becoming available in Mexico and Guatemala, the concepts of drainage basin analysis should be applied more frequently. The availability of large scale topographic maps may slow the process but should not preclude it.

Geomorphological investigations should be placed in a Quaternary framework rather than stand as individual, disconnected presentations. The landscape is complex and it is essential to recognize the actively developing geomorphic features as well as the remnants of older equilibrium forms. The Quaternary overview assists in the study of climatic geomorphology and places events in a chronologic framework. The inclusion of early man into this temporal sequence would serve to integrate the geomorphological and archaeological contributions.

A very important contribution is that of applied geomorphology. A detailed geomorphological map is a surrogate for a land capability classification. The type of information presented in geomorphological reports could provide data on slope stability, relative degrees of weathering, depositional or erosional surfaces, and many other items useful in evaluating the terrain. In this sense, land classification schemes that integrate many aspects of physical geography may be more appropriate (Kline and Bennett, 1958; McCullogh, 1956). It is obvious that a contribution to applied geomorphology must be more than pure geomorphology for specific sets of data must be included that will have further application. Without attempting to belabor the issue, applied geomorphological studies must proceed toward particular goals; that is, problem identification must be thoroughly investigated before conducting the research. If geomorphological mapping were the basic goal of a particular investigation, the increased use of aerial photography and other remote sensing techniques should be emphasized. Tricart (1967) has indicated the many applications of aerial photography in discerning sequential geomorphologic development and has shown the close association between land use and morphologic assemblage. This line of inquiry should be pursued further for it has direct application to land use planning. With the increased availability of radar imagery over Central America, large areas which have previously been absent from the aerial data bank will be subject to observation and interpretation.

Conclusions

The directions for further geomorphological investigation in Middle America should proceed along the following lines: 1) a continuing stress on climatic

geomorphology with the combined goal of determining present day equilibrium conditions as well as Quaternary modifications; 2) the practical application of geomorphological research as it may relate to land evaluation and land use planning, the traditional approaches will have to be altered to produce meaningful information for specific problems but this becomes a matter of more critical data selection rather than a change of geomorphological philosophy; and 3) the increased use of remote sensing techniques for areal identification and interpretation, as well as the expansion of established ground data to surrounding areas.

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