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GEOMORPHOLOGY OF SOUTH-CENTRAL NEW MEXICO

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This paper is brief--for two reasons: for lack of time and opportunity to do adequate field work, and because so many other articles in this guidebook discuss various phases of the subject. Two or three views of a subject may be stimulating, but redundance is monotonous.

However, a few remarks may be given in summary and may be considered appropriate to this place.

The gross physiographic features of south-central New Mexico are fundamentally primary structural features, and, consequently, any study of the geomorphology of this area must be but an appendix to the discussion on structure. Of course, land forms everywhere reflect structure, but here the modifying effects of erosion have done less to obscure the major structural dislocations than in many other parts of the country.

This land is a land of abrupt relief, of fault-block mountains raised along steep-angled planes and zones to produce scarps and precipitous slopes. Between the uplifts are extensive basins, downfaulted, downwarped, more or less filled with debris extracted in the yet partial degradation of the mountains. This filling has tended to smooth out the lowlands, to produce a widespread surface, or series of narrowly joined surfaces, which has, or have, been extended across the mountain flanks by the development of pediments. The area of lowlands has thus been gradually enlarged. This lowland or surface may be called locally the Cuchillo surface, the Palomas surface, the Jornada surface, and is probably the correlative of the Ortiz surface to the north and the La Mesa surface to the south.

It is perhaps misleading to speak of the surface as a lowland, though it is definitely that in contrast to the mountains. It is, however, incised by streams of the area, to form the major valley of the Rio Grande and the numerous arroyos cut by tributaries of the Rio Grande. Where Rio Grande drainage does not extend, the surface is not deeply dissected and "lowland" is an appropriate term (though it may lie 4,000 feet and more above sealevel). The terrain here is relatively smooth, a feature which induced early travellers in this country to use the Jornada del Muerto rather than struggle with the ups and downs of the route in and out of arroyos along the Rio Grande. The surface is modified positively by late features, volcanic cones, lava flows, and pyroclastic accumulations. These, commonly more resistant to erosion than the alluvial deposits upon which they rest, are emphasized physiographically where dissection has occurred.

Basin filling was probably occurring widely in Miocene time. It continued into the Pliocene, when the Cuchillo-Palomas-Jornada surface began to appear as an integrated surface. The full development of this surface was probably not attained till Pleistocene time, though it is not necessarily true that it reached its maximum perfection everywhere at the same time, nor that dissection began everywhere simultaneously. It may be genetically and chronologically correlative with the Great Plains area to the east, but not, because of this, necessarily coextensive.

The course of the Rio Grande is a product of the process of basin filling. It is uncertain when the numerous basins produced by middle and late Tertiary faulting filled sufficiently to produce integrated drainage. The development of a through-flowing stream depended not only upon the degree of filling but on the water to supply such a stream as well. And as Kelley and Silver (1952) have suggested, the present principal watershed of the Rio Grande in southern Colorado was very likely a peneplain in Pliocene time (Atwood and Mather, 1932) and hence characterized almost surely by a much milder climate, by much less annual precipitation. Of course there may have been a supply farther north, but it seems probably that much of the Rocky Mountains region was low until late Pliocene or Pleistocene time.

Bryan (1938) has argued for a Pliocene "Rio Grande." His reasons spring from a consideration of the kinds of basin fillings to be expected--and to be found--in "closed" and "open" basins. If a basin be occupied by a through-flowing stream, Bryan contended, there should be two distinct kinds of deposits. There should be two sets of alluvial-fan deposits sloping toward the axial zone of the basin from the mountain fronts on either side and grading in fragment-size downward toward that axial zone. And there should be river-laid beds, truncating the trend of these other beds yet interfingering with them, consisting of floodplain and channel deposits--

sorted gravel, sand, and silt. The two kinds of deposits should be readily separable or distinguishable to the observer.

Closed basins, on the other hand, would show similar fan deposits but would display playa or salt-lake deposits in the interior parts, grading laterally into coarser material but maintaining a more or less continuous fabric with it.

Bryan declared that both types of basins received Santa Fe sediments, but he believed integration was completed by Pliocene time and that continuous stringers of river gravel along the axes of the various individual basins support this view.

Incontrovertibly, there is gravel in the Rio Grande depression, along the central trough and in the deposits of the fan apron as well. The evidence to support a distinction between "through-flowing" and "local-drainage" streams, however, is not yet clear and conclusive.

Above Elephant Butte reservoir, the Rio Grande is aggrading. The cause of this is, in part, the raising of effective local baselevel by delta building in the lake. This is not the only cause of aggradation, however, and probably not the most important. Arroyo cutting, contributing great quantities of sediment from tributary streams, may be the most significant process of all. Other causes are: wind-blown silt, increased loss of water because of domestic and irrigation usage, prevention of flooding by artifical levee building--thus preventing a natural discharge of debris upon the floodplain and consequently confining all aggradation to the channel. For the years 1936-1941, measurements along the 150-mile course of the Rio Grande from Cochiti to the head of Elephant Butte reservoir (average spacing of measuring station: 3 miles) indicate that the average annual increment of sediment to the channel is about 12,000 acre feet (Happ, 1948). A little better than half of this (approximately 55 per cent) settles in the 14-mile stretch immediately above the head of the lake.

The threat to agricultural land along the river and the danger of flood to densely populated river-bottom lands, such as in Albuquerque, is obvious, and a matter of considerable concern.

New Mexico is a land well-known for wind, and its effects are to be found in many features in the south-central part of the state. The White Sands of Tularosa basin are famous. Other dunes are present in the area but not so abundantly or distinctively. The effect of drifting sand in choking up the channels of dry arroyos, thus diverting the streams when freshets occur, has not been evaluated statistically, but it has probably played a more important role than has been suspected.

Where vegetation is sparingly present on the basin floors--the common situation, vegetation not forming a continuous mantle--wind has swept away silt and sand from between clumps of grass, sage, and other forms of plant life, producing a type of miniature butte or mesa--the vegetation forming the "cap rock." Any one driving a vehicle over such a surface knows the erosion-resisting effectiveness of this plant life--and is shaken by it.

The mountains of south-central New Mexico are rather typical of fault blocks. Their relief is due primarily to structural dislocations. Erosion has modified them only partially, producing such features as bench-and-slope topography on the steeper faces, deeply incised transverse canyons, and long tributary valleys along the strike of weaker strata.

The Lower Paleozoic carbonate section, consisting of rocks nearly uniform in resistance to erosion, generally forms a great cliff above the Precambrian base. Because minor variations in the rocks occur, steps also occur but they are comparatively narrow and comparatively steep. Above the Silurian, however, the Devonian-Mississippian Percha and equivalents are soft shales and form a definite break in the mountain face, a longer, more subdued slope. At the top of this slope, and forming the crests of most of the ranges, occur the distinctively bench-and-slope producing Pennsylvanian limestone and interbedded shale.

Inasmuch as the Pennsylvanian rocks so commonly form the crests of the mountain ridges, the Devonian-Mississippian shales, though almost totally nonresistant to erosion, are seldom the sites of subsequent valleys. Stratigraphically above the Pennsylvanian, however, subsequent strike-valleys are common. The stratigraphic zones or horizons generally occupied by these valleys are along the Pennsylvanian-Permian contact (upper Magdalena-lower Abo), within the Permian (lower Yeso) and in the Upper Cretaceous (Mancos). Where rocks of these ages occur, and where the dips are more than a few degrees, long tributary valleys are almost everywhere developed. The first two horizons produce prominent valleys in both the San Andres and the Caballo Mountains, and to a lesser extent in the Fra Cristobal Range. A valley in the Mancos is found at the north end of the Caballo Mountains, bounded by the resistant San Andres (Permian) below and the Dakota-Mesaverde (Cretaceous) ridges above.

Transverse canyons commonly are developed along faults, at least along parts of their courses, but some are entirely the work of stream action. No

stream-cut canyon, whether growing in a fault zone or growing independently, has yet cut down sufficiently to drain the basin on the opposite side of the mountain range. The stream in Palomas Gap in the Caballo Mountains and the stream in Rhodes Canyon in the San Andres Mountains and several others cut far back through the crests of the ranges to produce low passes, but the Jornada del Muerto does not yet drain through either range.

When cycles of erosion and sedimentation are interrupted by diastrophic accidents, the problem of age analysis becomes complicated. However, in the fault-block, arid-climate geomorphic cycle, south-central New Mexico is fundamentally still in youth; in places it approaches maturity. Greater age and/or smaller magnitude of dislocation and/or weaker rock account for the locally advanced stage.

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