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Abstract. Comparison of landforms in adjacent watersheds shows stripped forms in lower Fresno Creek basin and alluvial forms in Lajitas basin. The hypothesis is presented that these landforms resulted from a sequence of stream captures in which Lajitas drainage diverted headwaters of Terlingua Creek, and that later capture of the same headwaters by Fresno Creek established modern drainage lines. Interpretation of the evidence shows that physical features of each basin result from specific factors, including stream energy, within each stream system.

Presented here is the hypothesis that the erosional development of precipitous canyon country in Lajitas area, Presidio and Brewster counties of Texas, is the result of a complex history of stream captures. Two adjacent drainage basins display unlike land forms although they developed in the same general area and under similar conditions. The reason for unlike land forms does not emerge with a comparison of forms, but through an interpretation of the history of each drainage system. Any geomorphic study in this area must take into account the history of each of the contributing drainage basins as a part of a whole picture.

Additional energy available to Fresno Creek through the capture of extensive drainage from the Solitario uplift, a singular structural dome (U. S. Geological Survey Topographic map, Terlingua Sheet), enabled Fresno Creek to begin enlarging its basin. The resulting

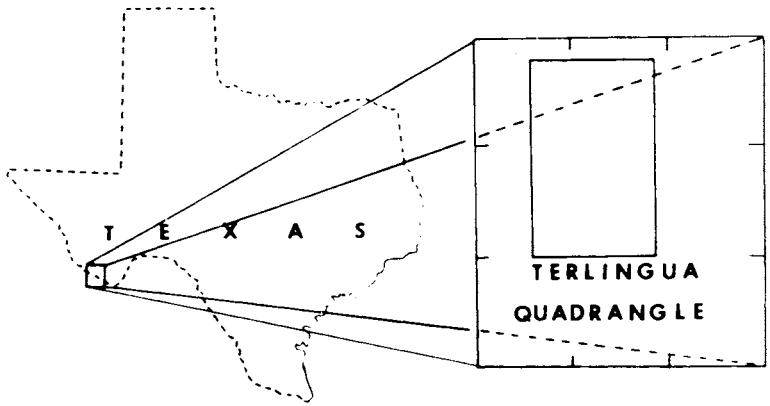

Figure 1. Index map showing location of Terlingua Quadangle and Fresno Creek areas.

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land forms are the result of degradation, and any previously developed alluvial deposits have been swept from the stream system.

In contrast to Fresno Creek, the drainage system east of Lajitas Mesa exhibits residual aggradational features relic from its past. The residual forms are important in interpretation of the earlier erosional history of the area. More recent history is interpreted from the Fresno Creek basin. Both areas must be considered in interpretation of the regional history.

Each of the drainage systems here is a part of the larger Rio Grande system. The Rio Grande is a delicately balanced instrument of erosion as are all streams. Any variation of condition in any one of its parts must certainly have some effect on the other parts. Although the Rio Grande is temporary base level for all the tributaries, changes in condition of the tributaries may also affect the upstream areas of the Rio Grande system.

Previous Work

In adjacent areas other geomorphic problems which have been attacked concern correlation and classification of stream terraces adjacent to the Rio Grande and in the tributary drainage basins. DeFord and his graduate students dealt with the problem at some length (DeFord, R. K., 1951). It is interpreted that the DeFord group classifies the stream terraces on the basis of position above present drainage, although the areal extent of the terrace affects its position in that classification. John Dietrich, of the University of Texas, is working on alluvial terraces near Presidio, Texas.

Field Work and Acknowledgments

Brief observations of the area during March and May, 1955, led to a longer visit in August, 1955. Additional map study completed the observations. A. N. Strahler, S. E. Clabaugh, R. K. DeFord, C. H. Behre, Jr., and S. D. Tuttle read and criticized the manuscript.

Location

The area which centers at Lajitas Mesa and Contrabando Mountain is shown on the Terlingua Sheet, U. S. Geological Survey Topographic map, southern Brewster and Presidio Counties, Texas. Lajitas, on the east side of the mesa, is 120 miles south of Alpine, Texas, and 15 miles south of Terlingua. The south side of the Solitario structural dome is 6 miles north of Contrabando Mountain. One of the watersheds studied is Fresno Creek, an ephemeral stream, which flows south to the Rio Grande on the west side of Contrabando Mountain and Lajitas Mesa. The unnamed stream system

east of Lajitas Mesa flows southward and empties into the Rio Grande at Lajitas.

General Geology

The complex of deeply dissected volcanic debris and complicated structural patterns is eroded to rugged mountains and deep, narrow canyons. Udden (1907) and Baker (1935) described the geology as did Lonsdale (1940), whose work includes a geologic map and a discussion of the petrology of the Solitario-Terlingua area. These authors stated that the Lajitas Mesa-Contrabando Mountain area is a part of the downfaulted block of Tertiary sediments and igneous material which is intensively deformed by folding and faulting. Thompson (1949) showed that intense deformation affected Paleozoic and Mesozoic rocks. The last stages of deformation include normal faulting followed by igneous activity (Tertiary) and minor faulting. The layers of volcanics in Contrabando Mountain-Lajitas Mesa are nearly horizontal at the north end and dip gently southward near the Rio Grande. Lonsdale (Plate 1, 1940) showed undifferentiated Terlingua and Boquillas (Cretaceous) beds in the valley of Fresno Creek and the Lajitas district. The rocks are buff and yellow, thin bedded and platy limestone with resistant ridges of coarsely crystalline calcite which fills steeply inclined joints and fractures. The limestone units are resistant to erosion and form stripped benches above the narrow canyons. Beveled rock benches dip gently away from the high point of a structural dome centering in the lower part of Fresno Creek valley west of Lajitas Mesa.

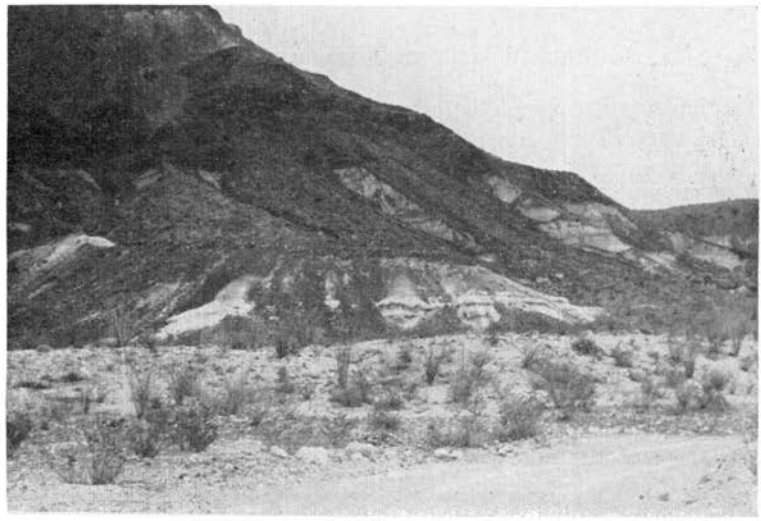

Figure 2. View southeast toward Lajitas Mesa showing two old veneered slopes and younger erosional slopes (light gray).

Volcanic debris, including tuffs, breccia, and a variety of flow rocks, presumably Tertiary (Lonsdale, 1940), rests on the eroded dip slopes of the Cretaceous limestones. Dark brown and dark green, resistant ledges of eruptive rock (including ignimbrite, lava, and breccia) project through the accumulated talus and occur above fresh pastel-shaded exposures of tuffaceous rocks. Rocks in the residual mountain were described by Lonsdale (1940, p. 1563) from exposures "2.4 miles southwest of B.M. 2662" Terlingua Quadrangle.

The abbreviated section measured by Lonsdale is given below.

Top Unit No.	Thickness in Feet
7. Augite trachyandesite	175
6. Vitric rhyolite breccia	20
5. Tuffaceous conglomerate	30
4. Augite trachyandesite similar to No. 7	75
3. Diabasic basalt	175
2. Tuff, reddish to grayish	30
1. Vitric rhyolitic tuff	100

The section quoted above occurs in approximately the same area as shown in Figures 2, 3, and 4. The locality for the figures is 2.5 miles southwest of the north point of Contrabando Mountain.

Units 1, 2 and 3 are the most important in this study. Most of the talus weathered from unit 3, and the talus blankets units 1 and 2 in the older graded slopes. Less resistant gray and pink tuff of

Figure 3. View southward of area shown in Figure 2, illustrating relatively gentle old slopes and lighter gray younger slopes.

units 1 and 2 crop out in younger steep erosion slopes which intersect the older graded slopes.

Debris-covered slopes occur above unit 3 near the top of the mesa with scattered breaks in the veneer which expose higher tuffaceous beds. Breaks in the veneer at high elevations are rock streams on the mesa flanks. Unsorted piles of talus streams high on the mesa add further evidence of mass movements at high elevations.

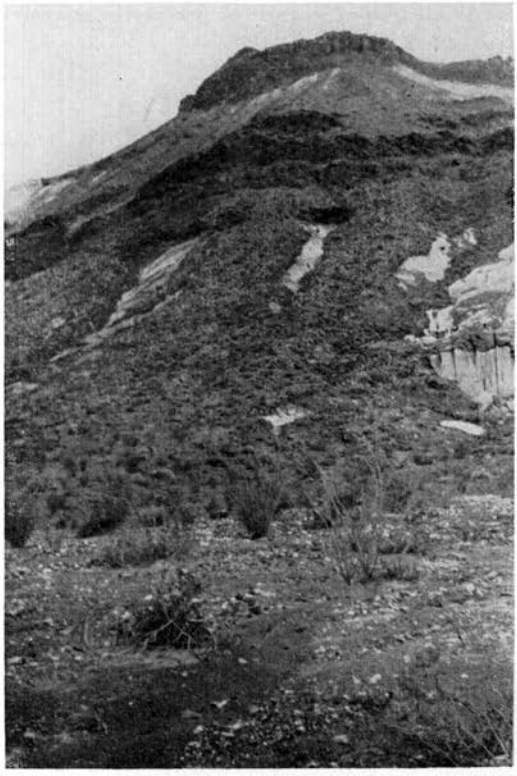

Figure 4. View eastward of Lajitas Mesa showing older veneered slope, a portion of ungraded slope, and the "waning slope" with sand and gravel surface in the foreground.

Description of Erosional Features

The west side of Lajitas Mesa, which is a part of Fresno Creek watershed, yields, under erosion, a system of benches built on flow rocks and steep slopes on less resistant rocks. Dark colored debris, consisting of rounded cobbles and pebbles weathered from the flow rock layers, blankets graded slopes to a uniform depth of 2 to 3 feet. The graded slopes support a crop of thinly scattered native grasses.

Two of the older graded slopes near the base of Lajitas Mesa in Fresno Creek valley are shown in Figure 2. The older slope declines at an angle of 6°, and the steeper of the two declines at an angle of 15°. Intersecting both of the graded slopes is the slope of more recent erosion, curving hyperbolically upward from the Cretaceous limestone bench.

The present day slope of transportation at the base of Lajitas Mesa compares to the "waning slope" and the older, graded slopes

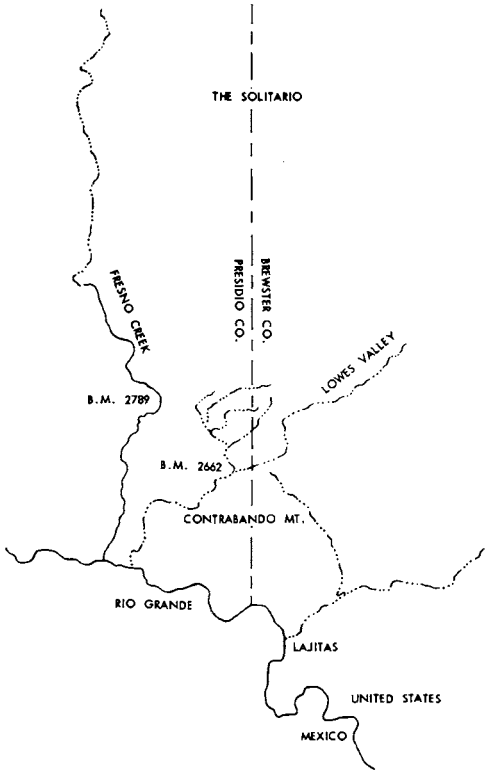

Figure 5. Sketch map showing essential drainage in the Fresno Creek-Lajitas area.

compare to the "constant slope" in the terminology of King and Fair (1944). The present day constant slope is not graded and indicates rejuvenation of Fresno Creek.

Sheet and rill wash are actively removing the less resistant tuffaceous beds of units 1 and 2. The gently inclined surface of transportation at the base of Lajitas Mesa is shown in Figure 4. The floor of the transportation slope is smoother, gently inclined toward Fresno Creek and underlain by fairly well sorted rill and sheet washed sand and lag cobbles. Sparsely scattered blocks of freshly broken lava

and weathered talus indicate that mass movements occur as a result of sapping by the growing drainage system.

The lower part of Fresno Creek basin west of Lajitas Mesa is entrenched a maximum of more than 100 feet below the bordering Cretaceous limestone bench which lies below the section described in the quotation from Lonsdale, given above. Evidence of rejuvenation is less conspicuous upstream from B.M. 2662 north of Contrabando Mountain and B.M. 2789, 4 miles northwest of Contrabando Mountain. At these points are sharp increases of stream gradient and angular bends in Fresno Creek and its adjacent stream. The features are suggestive of two knick points located at two elbows of capture. Evidence presented below favors the interpretation that the supposed elbow of capture at B.M. 2662 marks the first point of capture; that at B.M. 2789 occurred later.

The base of the east slope of Lajitas Mesa, facing the valley of the unnamed stream emptying into the Rio Grande at Lajitas is a graded, debris-covered slope comparable to the older graded slopes facing Fresno Creek. Figure 6 shows the east face of Lajitas Mesa and the valley of the trunk stream in the valley. There is no evidence of slope dissection at the edge of the principal stream. Most intermittent tributaries have bordering graded slopes also. Although they do not appear in Figure 6, scars exposing tuffaceous beds occur on the east face of Lajitas Mesa, just as they do on the west side. The slope scars and scattered slide-rock piles derived by weathering

Figure 6. View northward toward Lajitas Mesa. Main stream channel trends from right to left just beyond light colored Cretaceous bench in foreground. Note subdued, rounded slope on Lajitas Mesa and dark colored, debris-covered flat area at base of the mesa.

from layered flow rock indicate that gravity movements are active agents of gradation on Lajitas side of the mesa.

Graded slopes bordering the trunk stream grade into the widespread alluvial cover in the valley bottom. Near the mouth of the stream at Lajitas, the alluvium merges imperceptibly into a dissected alluvial terrace. Present day drainage is incised more than 100 feet below the upper surface of the terrace.

Remnants of three terrace surfaces occur in Lajitas drainage basin. The lowest surface exposed in the head of the basin is a narrow bench bordering the modern drainage lines. Older erosion remnants are above present drainage lines northeast of Contrabando Mountain.

An open valley extends northeastward from Lajitas, curving around the north side of Contrabando Mountain and continuing northwest to merge with the valley of Fresno Creek. That part of the valley between Contrabando Mountain and B. M. 2789 contains meager tributaries of Fresno Creek. The principal tributary between B.M. 2789 and B.M. 2662 drains southeast to Fresno Creek drainage at B.M. 2662. Therefore, the valley between B.M. 2662 and B.M. 2789 is anomalous as judged by drainage basin morphology in homogeneous rock masses. The evidence suggests a former stream which occupied the entire valley from Lajitas to the west side of the Solitario. The alluviated valley east of Lajitas Mesa and the depositional terrace at Lajitas lead to the further postulate that the supposed former master stream was an aggrading one and that it had a gradient lower than that of the present stream near its head. Comparison of drainage basins eastward of Lajitas suggests that Lajitas drainage passed through a cycle similar to that of Fresno Creek and that headward tributaries of Terlingua Creek, which lies east of Lajitas drainage, were captured by the Lajitas drainage system also.

Geologic History

Interpretation of the evidence presented here leads to the hypothesis that an aggrading master stream once drained all the area from the mouth of Lajitas to the west side of the Solitario. The characteristics of the stream were controlled, in part, by the surface of the Rio Grande as temporary base level.

Ancestral Fresno Creek, having once established itself on the steep slopes west of Lajitas Mesa, grew headward to become the master of a watershed including the high slopes west of the mouth of modern Fresno Creek. Young, vigorous, ancestral Fresno Creek drainage, degrading streams with high gradient, continued to grow headward to capture the headwaters of the master stream flowing

toward Lajitas. Probably the first point of capture occurred at B.M. 2662. As shown on the map, considerable drainage from the south side of the Solitario uplift and from the valley between B.M. 2662 and B. M. 2789 flows through Fresno Creek drainage via the stream at B. M. 2662. Particularly significant is the fact that drainage from Lowes Valley, on the south side of the Solitario uplift, crosses the beheaded valley north of Contrabando Mountain within a few hundred feet of drainage lines to Lajitas, but at an elevation 50 feet lower than Lajitas tributaries. It is assumed that, if capture had occurred first at a point other than B.M. 2662, then Lowes Valley would now drain toward Lajitas.

As a result of the increased discharge following capture, rejuvenated Fresno Creek tributaries began growing headward at an increased rate. A second point of capture occurred at B. M. 2789. The second capture reduced the length of drainage line, increased the gradient and established modern Fresno Creek drainage lines.

What remains of the beheaded stream is now the unnamed ephermeral stream which drains the relatively small basin east of Lajitas Mesa. Although the characteristics of the ancestral stream were controlled by the Rio Grande, it is possible that the ancestral tributary also exerted some reciprocal temporary base level control on the Rio Grande upstream from Lajitas.

Conclusion

In this preliminary study, valley slopes in two adjacent drainage basins are compared and the conclusions contribute useful information on erosional development in this area. The results of the study show that two debris-covered slopes facing Fresno Creek, Presidio County, Texas, which developed under previously more stable conditions, are being dissected. Slopes facing the adjacent valley at Lajitas, Brewster County, Texas, are graded. The Fresno Creek drainage area is a single stripped surface with low hogbacks projecting above the present levels. In contrast, Lajitas drainage area contains remnants of three erosion surfaces above the present alluviated lower valley. Interpretation of the evidence yielded by this study confirms the conclusion cited by Thornbury (1954, p. 161) that the number and position of terraces in separate watersheds is not necessarily an indication of time relation. Furthermore, interpretation of the evidence shows that the physical characteristics of each drainage system are the result of specific factors, including stream energy, within each stream system. An understanding of the land forms in a specific watershed requires, in addition to a catalogue of the land forms, an investigation and interpretation of the historical record preserved in each basin. Interpreted history of

tributary basins must be considered as only a part of the whole Rio Grande history.

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