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OF SPIRIT LEVELING IN TEXAS
1896 TO 1910, INCLUSIVE**

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R. B. MARSHALL

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

BULLETIN 468

RESULTS OF SPIRIT LEVELING
IN TEXAS

1896 TO 1910, INCLUSIVE

R. B. MARSHALL, CHIEF GEOGRAPHER

WORK DONE IN COOPERATION WITH THE STATE OF TEXAS
DURING 1902, 1903, 1909, AND 1910



WASHINGTON
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1911

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GEOLOGICAL SURVEY BENCH MARKS.

A. Tablet used in cooperating States. The State name is inserted at G.
 B and D. Copper temporary bench mark, consisting of a nail and copper washer.
 A, C, and E. Tablets for stone or concrete structures.
 F. Iron post used where there is no rock.

RESULTS OF SPIRIT LEVELING IN TEXAS, 1896 TO 1910, INCLUSIVE.

R. B. MARSHALL, Chief Geographer.

INTRODUCTION.

Scope of the work.—All results of spirit leveling in Texas previously published by the United States Geological Survey and all the results of later work are included in this report, rearranged by quadrangles. Elevations are based on heights of bench marks along precise-level lines of the Coast and Geodetic Survey as adjusted in 1907, and on the precise-level line of the United States Geological Survey from the Texas-New Mexico boundary line to El Paso. The elevations of certain bench marks in Brewster, El Paso, and Presidio Counties are based on railroad datum, as noted in the separate headings, and are, therefore, only approximate.

Personnel.—The field work from 1896 to 1906, inclusive, was done under E. M. Douglas, geographer, and the later work under E. C. Barnard, geographer, under the general direction of R. B. Marshall, chief geographer. The names of the various levelmen are given in the introduction to each list. The office work of computation, adjustment, and preparation of lists was done mainly by S. S. Gannett, geographer, and D. H. Baldwin, topographer, and since 1907 under the general direction of E. M. Douglas, geographer.

Classification.—The elevations are classified as precise or primary, according to the methods employed in their determination. For precise-level lines instruments and rods of the highest grade are used, each line is run both forward and backward, and every precaution is taken to guard against error. The allowable divergence between the forward and the backward lines in feet is represented by the formula $0.017\sqrt{D}$, in which D is the distance in miles between bench marks. For primary lines standard Y levels are used; lines are run in circuits or are closed on precise lines, with an allowable closing error in feet represented by $0.05\sqrt{D}$, in which D is the length of the circuit in miles, sufficient care being given to the work to maintain this standard. For levels of both classes careful office adjustments are made, the small outstanding errors being distributed over the lines.

Bench marks.—The standard bench marks are of two forms. The first form is a circular bronze or aluminum tablet (*C* and *E*, Pl. I), $3\frac{1}{2}$ inches in diameter and one-quarter inch thick, having a 3-inch stem, which is cemented in a drill hole in solid rock in the wall of some public building, a bridge abutment, or other substantial masonry structure. The second form (*F*, Pl. I), used where masonry or rock is not available, consists of a hollow wrought-iron post $3\frac{1}{2}$ inches in outer diameter and 4 feet in length. The bottom is spread out to a width of 10 inches in order to give a firm bearing on the earth. A bronze or aluminum-bronze cap is riveted over the top of the post, which is set about 3 feet in the ground. A third style of bench mark with abbreviated lettering (*B* and *D*, Pl. I), is used for unimportant points. This consists of a special copper nail $1\frac{1}{2}$ inches in length driven through a copper washer seven-eighths inch in diameter. The tablets, as well as the caps on the iron posts, are appropriately lettered, and cooperation by States is indicated by the addition of the State name (*G*, Pl. I).

The numbers stamped on the bench marks described in the following pages represent the elevations to the nearest foot as determined by the levelman. These numbers are stamped with $\frac{1}{16}$ -inch steel dies on the tablets or post caps to the left of the word "feet." The office adjustment of the notes and the reduction to mean sea level datum may so change some of the figures that the original markings are 1 or 2 feet in error. It is assumed that engineers and others who have occasion to use the bench-mark elevations will apply to the Director of the United States Geological Survey, at Washington, D. C., for the adjusted values and will use the markings as identification numbers only.

Datum.—All United States Geological Survey elevations are referred to mean sea level, which is the level that the sea would assume if the influence of winds and tides were eliminated. This level is not the elevation determined from the mean of the highest and the lowest tides, nor is it the half sum of the mean of all the high tides and the mean of all the low tides, which is called the half-tide level. *Mean sea level is the average height of the water, all stages of the tide being considered.* It is determined from observations made by means of tidal gages placed at stations where local conditions, such as long, narrow bays, rivers, and like features will not affect the height of the water. To obtain even approximately correct results, these observations must extend over at least one lunar month, and if accuracy is desired they must extend over several years. At ocean stations the half-tide level and mean sea level usually differ but little. It is assumed that there is no difference between the mean sea level as determined from observations in the Atlantic Ocean, the Gulf of Mexico, or the Pacific Ocean.

The connection with tidal stations for bench marks in certain areas that lie at some distance from the seacoast is still uncertain, and this fact is indicated by the addition of a letter or word to the right of the word "Datum" on tablets or posts. For such areas corrections for published results will be made from time to time as the precise-level lines of the United States Geological Survey or other Government organizations are extended.

Topographic maps.—Maps of the following quadrangles wholly or partly in Texas have been published by the United States Geological Survey up to May 1, 1911. They may be obtained, except as noted, for 5 cents each or \$3 a hundred, on application to the Director of the Survey at Washington, D. C.:

Abilene.	Kerrville.
Albany.	Lampasas.
Alpine.	Linden.
Anson.	Llano.
Atlanta (Tex.-Ark.-La.).	Marfa.
Austin.	Mason.
Ballinger.	Meridian.
Bastrop.	Montague (Tex.-Okla.).
Blanco.	New Boston.
Brackett.	Nueces.
Brady.	Palo Pinto.
Breckenridge.	Pulvo.
Brownwood.	Rio Grande.
Burnet.	Roby.
Cerro Alto.	Rock Springs.
Chisos Mountains (double sheet, 10 cents).	Ruidosa.
Chispa.	Salt Basin.
Cleburne.	San Angelo.
Coleman.	San Antonio (double sheet, 10 cents).
Dallas.	San Carlos.
Denton (Tex.-Okla.).	San Saba.
Eagle Mountain.	Shafter.
Eastland.	Sherwood.
Eden.	Sierra Blanca.
El Paso.	Stephenville.
Flatonis.	Sweetwater.
Fort Davis.	Taylor.
Fort Hancock.	Temple.
Fort McKavett.	Terlingua.
Fort Worth.	Terlingua special.
Fredericksburg.	Texarkana (Tex.-Ark.).
Gainesville (Tex.-Okla.).	Texas contour map (15 cents).
Gatesville.	Uvalde.
Georgetown.	Valentine.
Granbury.	Van Horn.
Hamilton.	Waco.
Hayrick.	Weatherford.

PRECISE LEVELING.

Courchesne and El Paso Quadrangles.

• EL PASO COUNTY.

The following are the unadjusted results for the Texas portion of a precise level line run in 1905 by M. S. Bright along the Atchison, Topeka & Santa Fe Ry., from Albuquerque, N. M., to El Paso, Tex. The elevations accord with an elevation at Rincon determined by precise leveling from Yuma.

COURCHESNE QUADRANGLE.

La Tuna south along Atchison, Topeka & Santa Fe Ry. to El Paso.

	Feet.
Vinton, 21 feet east of main line under Vinton signboard; iron post stamped "3774"-----	3,785.773
Canutillo, 80 feet east of main track, at southwest corner of J. J. Cumfid's house; iron post stamped "350-B-1905"-----	3,763.541
Montoya, in front of signboard, top of rail-----	3,753.41
Montoya, 1.5 mile south of, 40 feet west of road crossing, 5 feet east of fence corner; iron post stamped "354-B-1905"-----	3,749.837
Whites spur, top of rail-----	3,746.096
Whites spur, 2.8 miles south of, 0.25 mile north of milepost 1150, 50 feet east of track, 16 feet east of public road; iron post stamped "357-B-1905"-----	3,738.892
Whites spur, 5.25 miles south of, 240 feet north of public road crossing, 100 feet east of river, 45 feet east of track, 12 feet east of wagon road; iron post stamped "359-B-1905"-----	3,732.126
International boundary line monument 1; top of masonry at north-east corner (Boundary Commission elevation, 3,713.6)-----	3,725.166

EL PASO QUADRANGLE.

Union Station via City Hall to El Paso County courthouse and return to Union Station.

El Paso, Atchison, Topeka & Santa Fe Ry. station, in front of; top of rail-----	3,708.45
El Paso, city hall, in west end of lower stone step at north entrance; aluminum tablet stamped "3698" (C. & G. S. unadjusted elevation, 1911, 3711.731 feet)-----	3,709.607
El Paso, city hall, in east end of steps at south entrance, in cement; aluminum tablet stamped "365-B-1905" (C. & G. S. unadjusted elevation, 1911, 3710.699 feet)-----	3,708.581
El Paso County courthouse, in west end of lower step at south entrance; aluminum tablet stamped "363-B-1905" (C. & G. S. unadjusted elevations, 1911, 3711.359 feet)-----	3,708.706
El Paso County courthouse, on top of pyramid stone at west side of north entrance; cross (city bench mark)-----	3,710.086
El Paso, in front of Southern Pacific R. R. station; top of rail-----	3,724.03
El Paso, in front of Union station; top of rail-----	3,724.07