CARBONATE ACCUMULATION ALONG A CHRONOSEQUENCE IN THE PRESIDIO BOLSON, TEXAS

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ABSTRACT

Increasing accumulation of carbonates occur in gravelly soils along a sequence of landforms ranging from Holocene age to late to mid-Pleistocene age in the arid Presidio Bolson in the Trans-Pecos area, Texas. Shallow, weakly to moderately developed petrocalcic horizons are found on summit and shoulder positions in highly dissected fans of early to mid-Pleistocene ages. Thick calcic horizons are formed on either steeper back slopes of these old surfaces or in broad undulated fans probably of late-Pleistocene age. In younger surfaces, such as stream terraces and inset fans, secondary carbonate accumulates as discontinuous filament and thin discontinuous coatings around rock fragments, enough to qualify as cambic horizon. No visible carbonate segregation occurs in soils on the flood plains.

INTRODUCTION

Presidio Bolson is an open intermontane basin, covering approximately 120,000 ha., and filled with Tertiary and Quaternary deposits. This basin is flanked by stream terraces associated with Rio Grande drainage and alluvial fans and pedimented fan piedmonts in upslope positions. Pediment remnants are elongated, highly dissected, and divided by narrow stream valleys. Parent sediments on pediment remnants, fan remnants, and stream terraces consist mostly of gravelly to cobbly deposits extending from the mountain front to the flood plains of the Rio Grande. Dietrich (1966), mapped a portion of the Presidio Bolson, and recognized four stratigraphic units. Qg1, estimated late to mid-Pleistocene; Qg2, estimated late Pleistocene; Qg3, estimated late Pleistocene; and Qg4, Holocene alluvium.

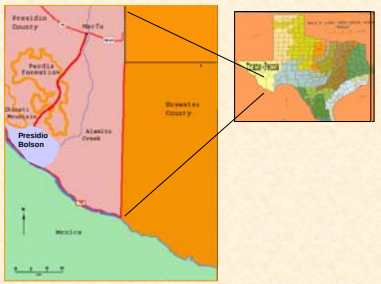
Soils developed in the Qg1, Qg2, and Qg3 units are related by a chronosequence, assuming that topography, parent material, climate, and vegetation are essentially constant in the study area. This soil chronosequence provides information to study soil development in an arid environment. The objective of this paper is to evaluate the impact of time on the rate of formation of carbonate-diagnostic horizons in the Presidio Bolson.

MATERIALS AND METHODS

Four soils located on surfaces of different ages (Dietrich, 1966) were selected on pediment fan remnants for study in the Presidio Bolson (Fig. 1). Site 1 is located on the oldest surface, Qg1, probably of late to mid-Pleistocene age. Site 2 is on the Qg2 surface, estimated to be late-Pleistocene age. Site 3 is on the Qg3, likely late Pleistocene time. Site 4 received significant deposition of sediments over the last 100 years (Corp of Engineers, 1976). Parent material consists of alluvium composed primarily of cobbly to gravelly, rhyolite, basalt, and tuffaceous sediments, deposited by streams in the form of alluvial fan systems. Temperature regime is hyperthermic and the soil moisture regime is ustic aridic. Vegetation is classified as desert shrub.

Soil profiles were described and sampled by horizon from road cuts (Site 1 and 2), an arroyo channel (Site 3), and pit (Site 4). Particle size distribution was determined by a modified Bouyoucos method (1951), and the carbonate accumulation by the morphological stage system proposed by Gile, 1966

Fig.1 Presidio Bolson location



RESULTS

Soil 1.
Loamy-skeletal, mixed, superactive, hyperthermic, shallow Ustic Petrocalcids
Location UTM:562959 E, 3292945 N
Elevation: 1188 m
Landform: Pediment remnants
Geomorphic Component: Crest
Slope:
Gradient: 4 percent
Shape: convex, convex
Carbonate accumulation: Stage IV

Soil 2.
Loamy-skeletal, mixed, superactive, hyperthermic, Ustic Haplocaldis
Location UTM: 561146 E, 3279817 N
Elevation: 912 m
Landform: Pediment remnants
Hillslope Position: summit
Geomorphic Component: Interfluve
Slope:
Gradient: 1.5 percent
Shape: linear, linear
Carbonate Accumulation: Stage III

Soil 3.
Loamy-skeletal, mixed, superactive, hyperthermic, Ustic Haplocambids
Location UTM: 562616 E, 3288570 N
Elevation: 1070 m
Landform: Pediment
Slope:
Gradient: 1 percent
Shape: linear, concave
Carbonate Accumulation: Stage I, II

Soil 4.
Fine silty, mixed, superactive, hyperthermic, Ustic Torrifluvents
Location UTM:560489 E, 3268756 N
Elevation: 1010 m
Landform: Flood plain
Slope:
Gradient: 0.5 percent
Shape: linear, linear
Carbonate Accumulation: none

Selected Soil Properties

Site	Horizon	Depth cm	Color Moist	Efferv. HCl 1N	Carbonate Morphology	Rock Frag. %	Texture
1	A	0 to 10	10YR 2/2	Violent	Many threads and thin coatings	50	GRV FSL
	Bkm	10 to 100	10YR 2/2	Violent	1cm-thick laminae, extremely coarse nodules	--	Cemented
	BK	100 to 300+	7.5YR 3/3	Violent	Many very coarse nodules	65	GRX MSL
2	A	0 to 8	10YR 4/3	Violent	Many continuous thin and medium coatings	65	GRX FSL
	Bk1	8 to 24	10YR 5/4	Violent	Many very coarse and coarse nodules	80	GRX FSL
	Bk2	24 to 56	10YR 5/4	Violent	Many medium nodules and medium soft masses	80	GRX FSL
	Bk3	56 to 100+	10YR 5/4	Violent	Many coarse nodules	80	GRX MSL
3	A	0 to 9	10YR 4/3	Strong	Few discontinuous threads	25	GR FSL
	Bw	9 to 28	10YR 4/4	Strong	Few threads and thin discontinuous coatings	35	GRV CoSL
	C	28 to 80	10YR 5/3	Strong	No visible carbonates	51	GRV LCoS
4	Ap	0 to 25	10YR 4/3	Strong	No visible carbonates	< 1	SiCL
	C1	25 to 58	10YR 4/3	Strong	No visible carbonates	< 1	Cl
	2C2	58 to 78	10YR 6/3	Strong	No visible carbonates	< 1	VFSL
	2C3	78 to 120	10YR 6/3	Strong	No visible carbonates	<1	SiL

DISCUSSION

Soil 1 accumulated more carbonate than younger soils. A 90 cm-thick, weakly to moderately cemented petrocalcic horizon with 1 cm-thick laminae is present. On backslopes with slopes higher than 6 percent , the petrocalcic horizon has degraded to a calcic horizon. Thickness of carbonate accumulation on the exposed road cut is greater than 300 cm.

Soil 2 accumulated significant amounts of carbonate with a prominent calcic horizon more than 90 cm in thickness. Calcium carbonate morphology consists of continuous soft masses and very weakly cemented nodules. The broad landform and gentle slope of this site suggest that the Qg2 surface has been stable for a long period of time. Absence of petrocalcic horizons in the Qg2 can be related to the time soil-forming factor.

Soil 3 had accumulated a limited amount of calcium carbonate as threads and thin, patchy coatings on rock fragments. The occurrence of incipient pedogenic carbonate and the weak soil development as indicated by the diagnostic cambic horizon are associated with soil age.

Soil 4 does not show carbonate segregation although carbonate is present as indicated by strong effervescence with 1N HCl, confirming it has the youngest soil of the chronosequence.

The sequence of soil development, as expressed by the stages of carbonate accumulation, is directly related to the relative ages of geomorphic surfaces of the studied soils. These results are in agreement with the data reported on soils in the Desert Project (Gile et al., 1981).

CONCLUSIONS

1. Carbonate accumulation in soils in the Presidio Bolson is a function of the time soil-forming factor.
2. Petrocalcic horizons are associated with geomorphic surfaces of late to mid-Pleistocene age.
3. Calcic horizons are associated with surfaces of late Pleistocene age.

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Acknowledgements

We thank Mr. Michael Margo for his assistance in collecting soil samples and pictures.