VEGETATION PATTERNS AND SOILS IN THE MAPIMI BOLSON (Chihuahuan Desert - Mexico). II. POLYGONAL PATTERNS.

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ABSTRACT.

Several types of patterned ground of polygonal appearance have been described, mainly in cool regions, but also in hot, arid lands where they are developed in saline and gypsic soils. In this paper, a polygonal patterned ground in the Mapimi Bolson is described. It consists of an irregular polygonus net whose edges are channels about 40 m in length, 1 m wide and .5 m deep. The channels are vegetated by a practically monospecific community of *Suaeda* cf. *nigrescens*, with the interchannel zone being bare ground. A gypsic horizon appears about 0.3 m deep and the soil profile is moderately saline with locally high concentrations. The genesis of the pattern seems to be due to dessication cracks in the soil surface combined with volume disminution of gypsum by water losses in hot summers. The union of several dessication cracks result in a polygonal pattern.

I. INTRODUCTION.

The term "patterned ground" is used to designate an organisation of the surface of the ground which may take the form either of a geometric pattern more or less orderly (polygons, circles...) or of a striped or a steplike pattern (WASHBURN 1950, 1956).

These formations have been described in numerous regions of the globe, but more specifically in cold environments where the action of the frost is important, and in hot and arid environments (KNECHTEL, 1951; BELLAIR, 1957;

MALDE, 1961; BONYTHON 1956; HUNT and WASHBURN 1966; OLLIER and SEELY 1977; TUCKER 1978; WATSON 1980).

In cold areas, the alternations between freezing and thawing account for the origin of the observed forms in the "patterned ground". In hot and arid zones, their genesis is bound to the intervention of physico-chemical processes such as the variations in volume of certain minerals or constituents under the effect of wet and drying cycles and salt action according to the dissolution-precipitation cycles.

We shall describe a "polygonal patterned ground" located in the Chihuahuan desert (Mexico) and we present a hypothesis to explain its genesis.

II. GENERAL DESCRIPTION OF THE ENVIRONMENT.

The study area is located in the Mapimi Biosphere Reserve (Fig. 1), in a region called "Bolson de Mapimi", belonging to the Chihuahuan desert, as SCHMIDT has defined it (1979).

The Mapimi Biosphere Reserve occupies an area of approximately 160,000 ha. It is delimited by Northern latitudes 26°30' to 26°52', and by Western longitudes 103°32' to 103°58'.

Figure 2, from MONTAÑA and BREIMER (1981), delimitates the main landscape units established according to geomorphology, soils and vegetation. The areas of relief and their pediment (sierras and bajadas) have an altitude between 1200 and 1500 m (3935 to 4920 ft.) and are constituted by volcanic rocks (basalt, andesites, rhyolites) (landscape Units Va, Vb and VII), of calcareous rocks (Unit VI) of the cretaceous age, and of a colluvial-alluvial cover of the aforementioned materials which have been spread over glacis (pediments). The landscape Units I and II correspond to an alluvial plain (playa) which collects most of the surface water and concentrates them in a lagoon located in the northwest corner, a depression with a high saline concentration. On the northern part of the Reserve we go progressively past an area of transition between the fluvial and the eolian reliefs (Unit IV) to an area of ancient sand dunes (Unit III) fixed by the vegetation.

The soils are essentially yermosols and xerosols (F.A.O. classification) divided into areas of "playa" and of "lower bajada", presenting horizons enriched with salts (most often NaCl), gypsum and calcium. On the reliefs and their pediments ("sierras" and "upper bajada"), soils of the lithosol and regosol type prevail. Locally, around the "Laguna de las Palomas", solontchaks, with a high concentration of NaCl, have developed.

The vegetation is constituted, on one hand, of a microphyllous desert "matorral" dominated by *Larrea tridentata* with a variable degree of presence of succulent species, and on the other hand, of steppes with half-shrubby halophytes occupying the lower part.

The climate is of altitudinal arid tropical type, with an annual rainfall average of 271 mm, showing great variability; the coefficient of variation is of 42% (Ceballos station 1956-1981). The estival rains from June to September inclusive, which represent 60.7% of the annual total, have a stormy characteristic and take the form of localized showers, with high intensities. The annual average of temperatures is of 20.2°C. The minima average for the coldest month (January) is of 1.5°C and that of the maxima for the hottest month (June) is of 37.2°C.

The human occupation of the Reserve is quite scattered and unimportant.

The population is distributed in a few "ranchos" and "ejidos"* whose main economic activity is extensive cattle breeding.

III. THE "POLYGONAL PATTERNED GROUND" OF THE RESERVE. DESCRIPTION.

The polygonal pattern clearly appears on the air photographs (scale 1:25000), whereas on the ground, it is difficult to notice its existence. It is constituted by lines or segments cutting each other and this pattern is made obviously by the vegetation which, densely settling along the lines, brings out and amplifies the polygonal pattern, in contrast with the spaces between the lines which are almost devoid of vegetation. The zone occupied by this formation occupies a surface of about 5 km^2.

In detail, (Fig. 3), the polygonal pattern appears to be very irregular, with bands oriented in all directions and sometimes interrupted. The lines are 10 to 40 m long and 5 to 8 m wide with the vegetation. The average general slope of the area is 0.2% with a north-north-east aspect.

Microtopographic surveys (Fig. 4) show in the middle part of the bands, depressions or hollows in the surface of the ground, of a concave form, 10 to 30 cm deep and 1 to 2 m wide. These depressions are present on every band and along all their length.

Vegetation.

The vegetation is constituted by a quasi mono-specific community of *Suaeda* cf. *nigrescens*, having colonized the band with shrubs from 1 to 2 m high well developed and in good condition.

Under this shrubby strata we find a herbaceous strata very poor in species

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*"Ejidos" is a mexican type of land tenure. The State is the owner of the land, but he commits it to a farmer's group for its utilization.

and with a very low percent cover, essentially constituted of *Hilaria mutica*, *Sida leprosa*, *Heliotropium* cfr. *curassavicum*, *Euphorbia dentosa*, *Setaria* cfr. *viridis*, *Bouteloua barbata*...

In the spaces between the bands, the ground is bare. We can only find a few *Suaeda* in very bad condition and dead shrubs.

SOIL.

On the pedologic level, the "polygonal pattern" zone is relatively homogeneous and profile POLY 1 (see localization on Figure 3) described below, is representative of the soils of the whole area.

Profile POLY 1 = located in a zone without vegetation, slope less than 1%. Micro-relief on the surface.

A11 Horizon. 0 to 4 cm = light brownish gray (7.5 YR 8/2) dry, gray-yellowish-orange (10 YR 6/3) moist - high effervescence with acid - no coarse elements - sandy loam - granular structure - few very fine pores, tubular and inter-granular - few very fine and fine roots - firm - clear and smooth boundary.

A12 Horizon. 4 to 30 cm = gray-orange (7.5 YR 6/3) dry, gray-brown (7.5 YR 5/3) moist - high effervescence with acid - no coarse elements - clay loam - weak fine angular blocky structure - few very fine pores, inter--granular and tubular - very firm - few very fine and fine roots - abrupt and smooth boundary.

B21Cs Horizon. 30 to 55 cm = gray-orange (7.5 YR 6/3) dry and moist-high effervescence with acid - numerous crystals of gypsum, from 1 to 4 mm, spread out in the horizon, juxtaposed with fine earth - sandy - clay loam - no coarse elements - fine angular blocky structure, very fragile structure -

friable - few pores, intergranular porosity - very fine and fine roots - gradual and smooth boundary.

B22t Horizon. 55 to 140 cm observed = gray orange (7.5 YR 6/3) dry, gray-brown (7.5 YR 5/3) moist - high effervescence with acid - crystals of gypsum especially in the upper part of the horizon and with a content decreasing with depth - no coarse elements - clay - very fine angular blocky structure from 55 to 90 cm, then fine angular blocky structure from 90 to 140 cm - very firm, hard - very few pores - few sticken sides, not well developed, not shiny, in the upper part of the horizon.

Classification: "Yermosol gypsique" (FAO); Gypsiorthid (not typic) (Soil-Taxonomy).

The main analytic characteristics of this profile are the following (Table I): the texture, from sandy-silty on the surface, becomes very rapidly clayed-silty then clayed.

- Organic matter, in small quantity (less than 1%), is well developed with low rates in C/N.

- The pH is superior to 8 and increases slightly with depth.

- The content in calcium carbonate goes from 16% on the surface to 22% in depth. It is primary limestone of lithologic origin, no form of secondary redistribution (pseudo-mycelium, stains...) is visible in the profile.

- Gypsum, on the other hand, has a secondary origin, in horizon B21Cs, where it is present in the form of crystals of the gypsum flower ("rose des sables") type.

- The electric conductivity becomes noticeable from the gypsum horizon and is maintained further on. The salinity is essentially due to sodium chloride.

This type of profile is representative of the soils in the area with a "polygonal pattern". However, on the vegetation bands, variations appear in the morphology of the pedologic profile. As we have indicated above, the surface of the ground at the median part of the bands is in a hollow, reaching a depth from 10 to 30 cm and 1 to 2 m wide.

Vertically from this concave median zone we find, in the soil profile, a subsidence of the horizons, particularly in the gypsum level (Fig. 5 and 6). This peculiar disposition of the horizons allows us to suppose that there has been a collapse of the gypsum level in a space of the subjacent clayed horizon, correlated with a subsidence of the surface horizons and lowering of the level of the ground surface, which gives the present aspect of this surface as a depression.

The various soil profiles, perpendicularly to the lines of vegetation, which we have realized in the study area (POLY 2, POLY 3 and POLY 5) show the same peculiar morphology of the horizons at the level of the median axis of the bands. On the analytic level [III and IV of profile POLY 2, (Fig. 5 and Table 2) and II, III and IV of profile POLY 3 (Fig. 6 and Table 3)], we find the same soil characteristics at the level of the vegetation bands as in the typical profile above. At the most we may note a finer texture of the surface horizon: silty-clayed to clayed-silty instead of sandy silty. The gypsum in horizon B21Cs presents, in the subsided zone, the same aspect and a similar content in gypsum as in the undisturbed equivalent horizon.

Along the lines, at about 2 meters of their median axis, we find outgrowths with a circular appearance, without vegetation, on the ground surface. These micro-mounds, about 1.20 m in diameter and 10 cm high in their center, are located along the edge of the vegetation bands, but with an irregular distribution.

The cuts transversal to the bands of vegetation of the studied pedologic profiles cut these micro-mounds in POLY 2 (I and II, Fig. 5) and POLY 3 (I, Fig. 6). They are areas with a high salt concentration: the conductivity reaches 40 to 50 mmhos/cm (Table 2 and 3) in the 50 to 60 upper centimeters of the ground, where there are numerous whitish efflorescences, in the form of fine stains uniformly distributed, and which correspond to secondary salt deposits (likely sodium chloride). Correlatively, the structure is very degraded, taking a characteristic aspect, "puffed", particularly with high porosity, resulting in the spreading of the clays in an environment where the pH reach and exceed 9. The other analytical characteristics are similar to those of the typical profile.

These areas of saltiness, with their circular form, evoke a concentration of runoff water, which, after a particular obstacle (micro-relief, presence of a bedding...), could not leak out normally when it came in contact with the vegetation bands. This water, which turned into salts during its drainage, has stayed this way locally, on the surface of the ground where it has infiltrated. Following desiccation, the salty solutions have a tendency to be lifted up towards the surface and little by little the salts have deposited in the upper part of the profile in the form of efflorescences. This salt concentration has provoked the degradation of the structure by spreading the clays, in a phenomena accompanied by a bulge of the ground surface, this process being probably emphasized by the crystalization of the salts, by the thermic expansion of the salts and/or their increase in volume during the phases of remoistening of the soil (COOKE and SMALLEY, 1968; GOUDIE, 1974, 1977; EVANS, 1970; CHAPMAN, 1980; MCGREEVY and SMITH, 1982).

IV. HYPOTHESES OF THE POLYGONAL PATTERN GENESIS.

Organizations of the ground in a pattern similar to the polygonal pattern have been described, in hot and arid areas, in numerous regions of the globe: in Irak (TUCKER, 1978), in Namibia (OLLIER SEELY, 1977; GOUDIE, 1972, WATSON, 1980), in North Africa (Tunisia, Algeria, Lybia), in the Middle East, in the United States, in Mexico (survey and critical review in HUNT and WASHBURN, 1966 and WATSON, 1979; WASHBURN, 1950, 1956).

This type of formation is essentially developed either in gypseous or calcareous environments or in environments rich in salts.

In a gypseous environment, we find soil with secondary gypsum accumulation of the encrusting and crust type, with a surface organized according to two types of pattern (WATSON, 1980): either small polygons less than 1 m in diameter, or in greater polygons from 2 to 6 meters in diameter. In the first case, the vegetation is quasi-non-existent, in the second case, it develops along the sides of the polygons in an herbaceous form, whereas the rest of the ground is bare. The polygonal pattern would be due (TUCKER, 1978, WATSON, 1980) on one hand to the physical and mineralogical modifications of certain minerals following the daily and seasonal variations in temperature, on the other hand to the alternations of desiccation and moistening of the ground.

GOUDIE (1972) and WATSON (1980) have reported the presence in Namibia of a network of polygons from about 5 to 20 meters in diameter, on the surface of a soil with a limestone crust, whose sides are occupied by a herbaceous vegetation based on *Stipagrostis gonatostachys*.

In the environments with a high saline concentration, the polygons have a size not exceeding 10 m in diameter and they present the peculiarity of having their edges in relief forming ramps with the interior spaces of the polygons, which gives a very characteristic aspect to those formations. They are successive saline crystallizations which thus clearly delimit the polygonal network. There too, alternations of humidity and drought and variations of temperatures have originated those formations (HUNT and WASHBURN, 1966).

The polygonal pattern observed in the Mapimi Reserve, is similar by its morphology to the various polygonal patterns reported and described everywhere in the world, but is of a different type. Actually, it neither develops in a very saline environment, nor in an environment highly enriched in limestone or in gypsum. As we have seen, the conductivity stays average and the contents in gypsum and limestone are well below those of the gypseous or limestone crusts. Moreover, we must note here the relatively important size of the polygons, compared to that of the other know patterns.

The genesis of this polygonal pattern is based on the intervention of various combined physico-chemical processes. It begins, as we observed in the field, with the appearance of lines on the surface of the ground, of variable length (10 to 20-30 m), actually corresponding to cracks of desiccation, which, under the effect of the drought, gradually open to reach a width of several centimeters and a depth of several decimeters. Similar cracks, much deeper though, (1 to 3 meters) have been described by WHITE (1970, 1972) in South Dakota and KNECHTEL (1951) in New Mexico. This phenomenon is frequent, in dry periods, in environments rich in "bulging" clay of the smectite type*.

In this vacuums or cracks so created on the 50 to 60 cm of the upper part of the soil, the gypsum level being more friable than the other horizons shows a tendency to "flow" (leak out) towards the base of the crack, which is found in the clayed horizon, and to progressively fill it up. When a rain occurs, there is a progressive closing of the crack, especially in the clayed level, following a phenomenon of bulging (moistening-absorption) of the clays. In the upper horizons, the crack "closes", but in a process of filling up by materials coming from the edges of the initial crack of dessication. It thus results in a lowering and formation of a hollow zone on the surface of the ground, as the ones which we observed in the median zone of the vegetation bands.

It is likely that these various phenomena: lowering of the gypseous horizon to the level of the clayed horizon and collapsing of the surface of the ground, are favored and intensified on one hand by the alternations of dissolution-deposition of gypsum, on the other by the variations of the volume in gypsum under the effect of the drought, during its change from the hydrated form to the semi-hydrated form (CHATTERJI and JEFFERY, 1963; COOKE and SMALLEY, 1968).

These various bands depressions thus appear little by little on the surface of the ground, and by cutting each other delimit a more or less

* We should note that these cracks originate at the top of the clayed horizon 50/60 cm deep, where, due to the intense drought during the estival period, desiccation takes place. The upper horizons, however, little clayed, are less favorable to the formation of cracks and these do not necessarily reach the surface of the ground.

polygonal pattern. Their hollow microtopography turned them into privileged zones for the concentration and accumulation of water during the rainy phases, where the humidity of the ground is maintained longer. In a semi-arid environment, this peculiar dynamics in the water can only favor the progressive colonization of the bands by the vegetation, which is realized, as we have observed, by germinations almost uniquely constituted of *Suaeda*, progressively developing to become, in the middle run, bands of dense vegetation, showing evidence of the polygonal pattern that we presently observe. This is the hypothesis that we find most plausible that has been formulated to explain the genesis of the polygonal pattern in Mapimi.

V. CONCLUSIONS.

The "polygonal patterned ground" of the Bolson of Mapimi is located in an area of extensive cattle raising, for which studies are being realized to procure a better use of the resources. In view of this, we must determine the evolutive dynamics for this polygonal formation which is a "sterile" environment of no use for fodder production, since, in case of extension, the areas still "productive" would be reduced.

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Tableau 1. Analytical Data of the Profile POLY 1.

Depth (cm)	Horizon	Coarse fragments (>2 mm) *	Texture (<2 mm fraction) %			pH in water	Organic carbon (%)	Nitrogen (%)	C/N
			Clay (<0,002)	Silt (0,002 - 0,050)	Sand (>0,050)				
0 - 4	A11	0,8	18,3	26,3	55,4	8,2	0,36	0,042	8,6
6 - 12	A12 >	0,2	40,3	14,3	45,4	8,1	0,40	0,033	12,1
18 - 25	A12 <	2,0	38,0	16,7	45,4	8,2	0,35	0,039	9,0
32 - 45	B21 cs	8,0	24,3	28,3	47,4	8,1	0,30		
58 - 68	B 22t	6,5	44,0	18,7	37,3	8,9	0,19		
75 - 85	B 22t	8,0	48,3	30,3	21,4	8,7	0,13		
110 - 120	B 22t	7,6	60,3	20,3	19,4	8,7	0,14		

* weight percentage =

	CaCo3 (%)	Gypsum (%)	Electrical Conductivity (mmho/cm)	Water extract from Satured paste (meq/liter)			CEC (cation exchange capacity) (meq/100 g)
				Ca	Mg	Na	
0 - 4	16,3	0	1,5	5,70	0,58	7,57	18,6
6 - 12	15,3	0	3,0	7,75	0,83	12,13	23,6
18 - 25	18,4	0	4,0	11,00	1,08	13,48	25,5
32 - 45	21,4	28,1	12,5	32,50	4,16	15,39	23,2
58 - 68	19,4	16,3	25,0	19,50	9,33	15,69	23,0
75 - 85	21,4	12,0	20,0	15,90	6,41	15,56	23,5
110 - 120	22,4	10,0	20,0	17,50	5,75	15,52	25,9

Tableau 2. Analytical Data of the Profile POLY 2.

	Depth (cm)	Texture % (fraction 0 - 2 mm) Clay	Silt	Sand	pH water	Organic carbon %	$CaCO_3$ (%)	Gypsum (%)	E.C. (mmho/cm)	CEC (meq/100g)	Water extract from satured paste (meq/liter) Ca	Mg	Na
I	0- 2	40,3	4,3	55,4	8,1	0,31	22,4	0,0	6,5	23,0	10,2	1,1	14,9
	8-16	58,6	10,0	31,4	8,5	0,37	18,4	2,9	50,0	27,0	21,5	3,7	16,5
	28-40	46,7	10,7	42,6	9,2	0,22	18,4	26,3	50,0	25,1	3,5	8,2	16,3
	48-52	54,3	12,7	33,0	9,0	0,16	22,4	13,0	30,0	28,5	9,0	7,3	15,7
	63-67	65,0	16,0	19,0	9,1	0,16	19,4	11,9	30,0	27,6	10,3	10,4	16,3
II	0- 3	11,4	30,4	52,2	8,0	0,28	20,4	0,0	4,5	24,1	22,8	2,1	13,7
	10-15	29,4	36,4	34,2	8,5	0,27	—	3,2	25,0	25,4	4,3	3,2	16,2
	22-30	23,4	20,4	42,2	8,9	0,16	18,4	27,4	45,0	26,1	5,9	10,5	16,4
	35-40	45,4	18,4	36,2	9,0	0,19	18,4	14,0	45,0	25,0	6,2	7,9	16,3
	60-67	57,4	18,4	24,4	9,2	0,10	22,4	—	40,0	26,6	9,3	10,9	16,5
III	0- 3	40,7	18,0	41,3	8,4	0,40	20,4	0,0	31,5	24,9	2,8	0,3	14,1
	12-18	34,7	40,0	41,3	8,1	0,33	22,4	0,0	2,25	25,9	4,7	0,4	11,3
	30-38	52,7	16,0	31,3	8,0	0,18	20,4	27,0	3,0	23,8	18,7	2,5	8,0
	57-62	32,7	38,3	29,0	8,1	0,14	22,4	—	10,0	25,2	18,7	5,9	15,5
IV	0- 6	36,7	30,0	33,3	8,5	1,04	20,4	0,0	3,0	25,9	—	—	—
	16-26	38,7	32,0	29,3	8,1	0,38	20,4	3,0	4,0	22,7	22,9	1,6	12,8
	38-48	54,7	14,0	31,3	8,2	0,37	19,4	0,0	3,5	24,7	22,5	1,8	12,0

Tableau 3. Analytical Data of the Profile POLY 3.

	Depth (cm)	Clay	Silt	Sand	pH (water)	Organic carbon (%)	CaCo3 %	Gypsum %	E.C. (mmho/cm)	Water extract from satured paste (meq/liter) Ca	Mg	Na
	0- 2	10,7	24,0	65,3	9,3	0,75	22,4	0	12,5	14,1	9,3	16,0
	8- 15	19,0	36,4	44.6	8,6	0,35	15,3	1,5	20,0	16,4	5,6	16,0
	22- 30	20,6	24,4	55,0	8,9	0,28	17,3	4,0	50,0	23,1	7,8	15,7
I	45- 53	29,0	20,4	50,6	8,7	0,14	18,4	25,8	25,0	22,6	7,7	16,1
	65- 75	49,0	16,7	34,3	8,9	0,12	19,4	12,0	15,0	16,4	5,8	10,0
	85- 95	59,0	20,7	20,3	8,9		21,4	8,2	30,0	13,7	9,4	16,6
	124-130	59,0	24,4	16,6	9,0		25,5	—	25,0	15,3	8,2	16,1
	4- 14	19,0	38,4	42,6	8,8	0,43	17,3	0	4,25	2,6	0,3	12,1
II	32- 42	23,4	40,0	36,6	8,1	0,37	19,4	0	2,5	11,9	1,5	10,1
	62- 72	29,4	16,4	54,2	8,1	0,25	20,4	25,5	5,0	26,2	4,2	14,3
	95-102	53,4	24,4	22,2	8,3	0,18	22,4	14,0	9,0	20,3	4,7	15,6
	10- 20	35,4	32,7	31,9	8,2	0,31	22,4	0	3,0	8,5	0,8	12,4
III	32- 44	43,4	18,4	38,2	8,2	0,19	21,4	27,5	5,0	24,6	4,7	14,6
	55- 65	58,7	10,0	31,3	8,6	0,18	21,4	10,5	10,0	15,0	3,9	15,8
	105-115	58,7	22,0	19,3	8,7	0,12	23,5	—	15,0	20,0	4,9	16,0
	5- 20	44,7	26,0	29,3	9,0	0,35	18,4	0	6,5	6,0	0,4	15,5
IV	38- 52	40,7	18,0	41,3	8,0	0,15	19,4	26,6	4,0	21,2	3,8	14,2
	78- 88	56,3	24,3	19,4	8,9	0,12	22,4	11,3	15,0	19,8	5,6	16,0
	112-122	63,0	19,6	17,4	8,9	0,11	21,4	—	15,0	15,1	4,3	15,9

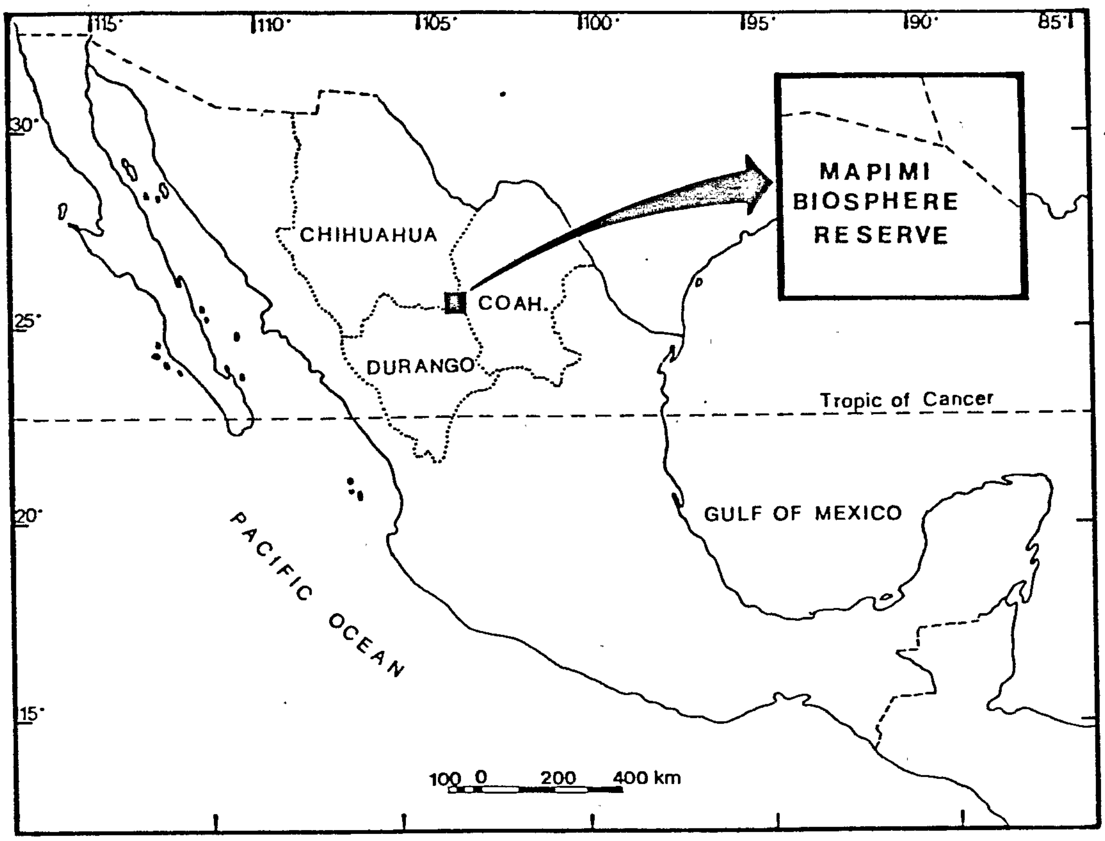
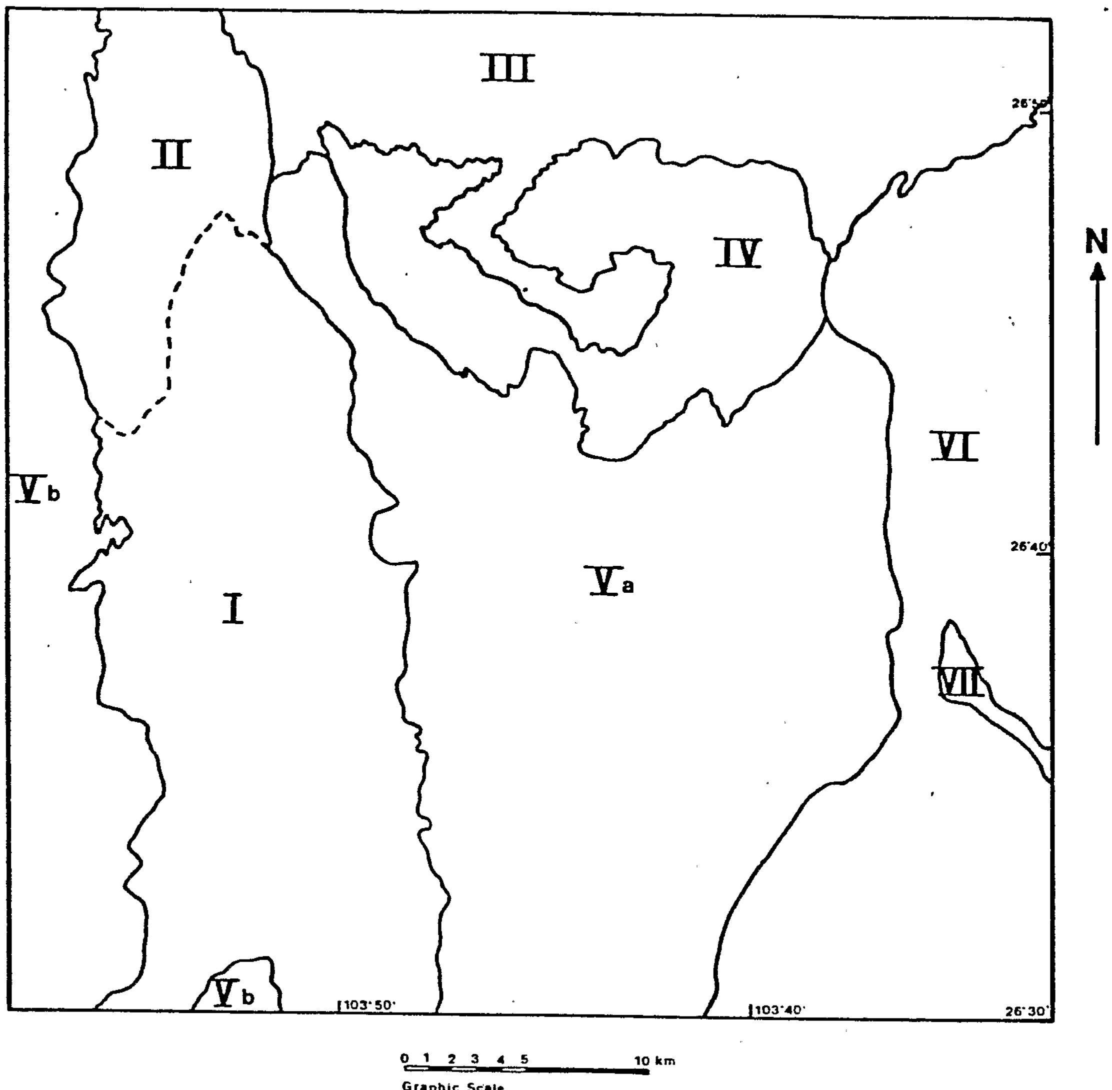


Fig. 1. Localization of MAPIMI BIOSPHERE RESERVE (Durango, Mexico).



I. SOUTHERN "PLAYA"
II. NORTHERN "PLAYA"
III. DUNES ZONE
IV. TRANSITION BETWEEN EOLIC AND FLUVIAL LANDSCAPE
V. "BAJADAS" AND "SIERRAS" OF IGNEOUS AND SEDIMENTARY ORIGIN
a. CENTRAL b. WEST
VI. "BAJADAS" AND "SIERRAS" OF CALCAREOUS ORIGIN
VII. BASALTIC LAVA ZONE

Fig. 2. Delimitation of landscape units, according to Geomorphology, soil and vegetation (from MONTAÑA and BREIMER, 1981).

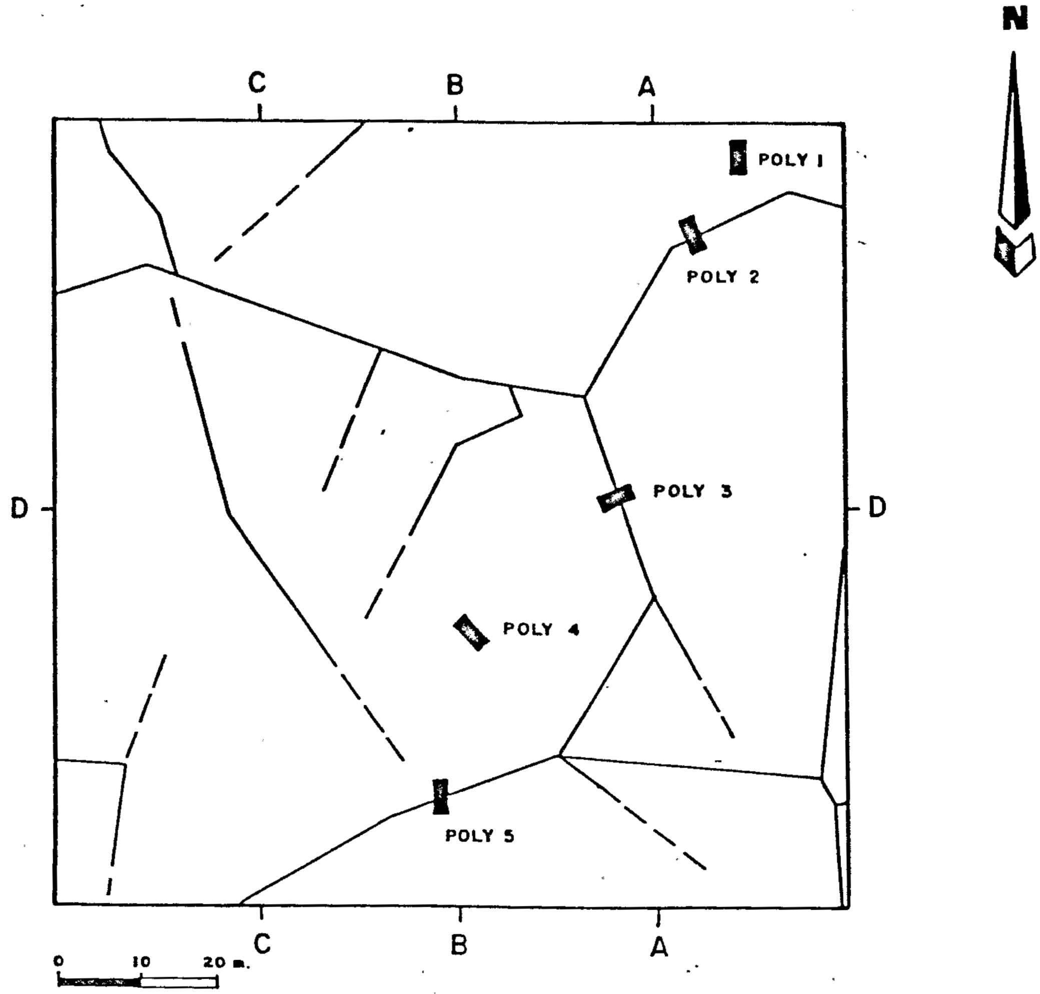


Fig. 3. Diagram of polygonal pattern (100 x 100 m)

POLY 1, 2... = soil profiles

AA, BB... = localization of microtopographic surveys (see Fig. 4).

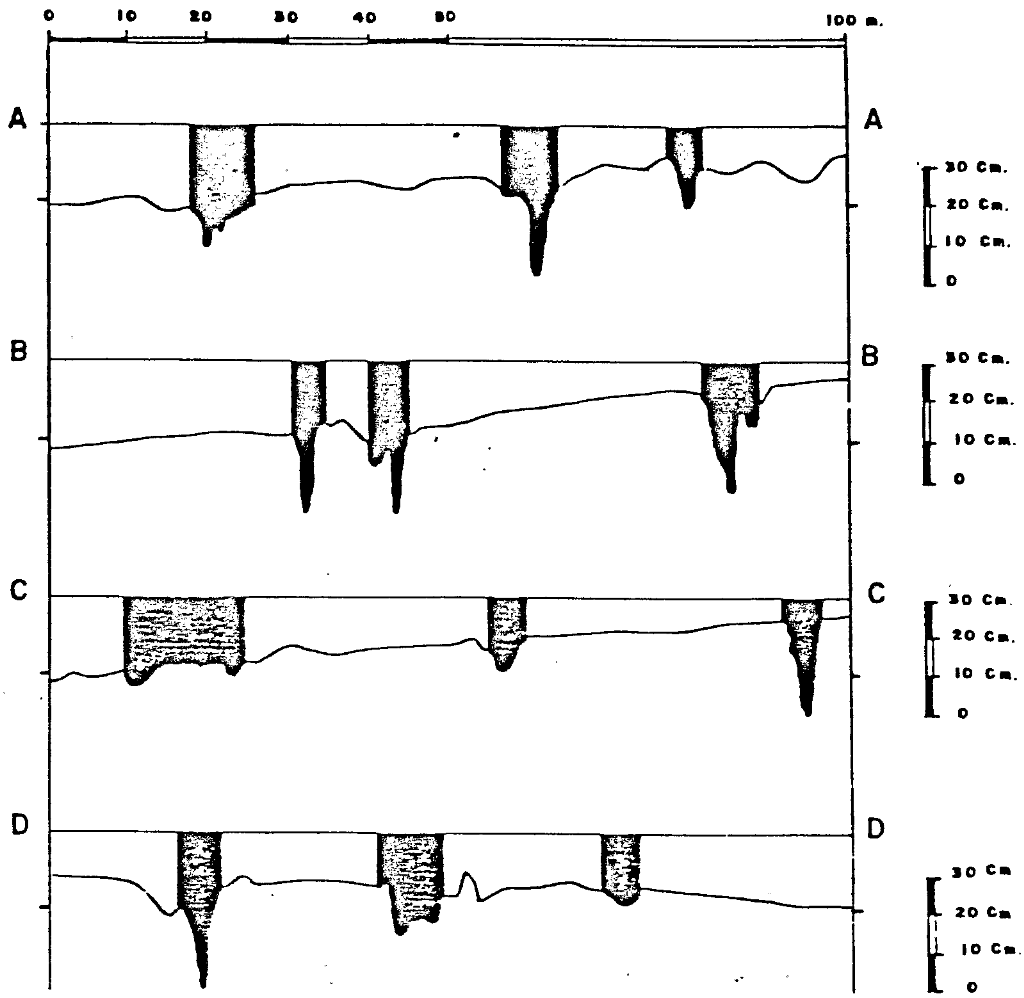


Fig. 4. Microtopographic surveys
(see localization on Figure 3)

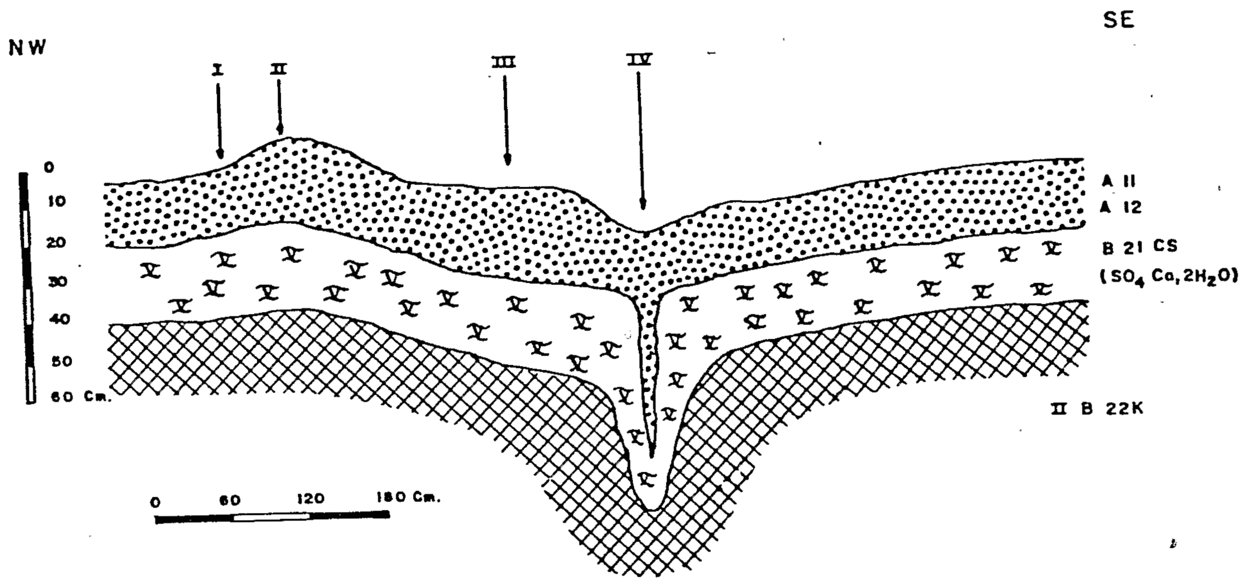


Fig. 5. Profile POLY 2.

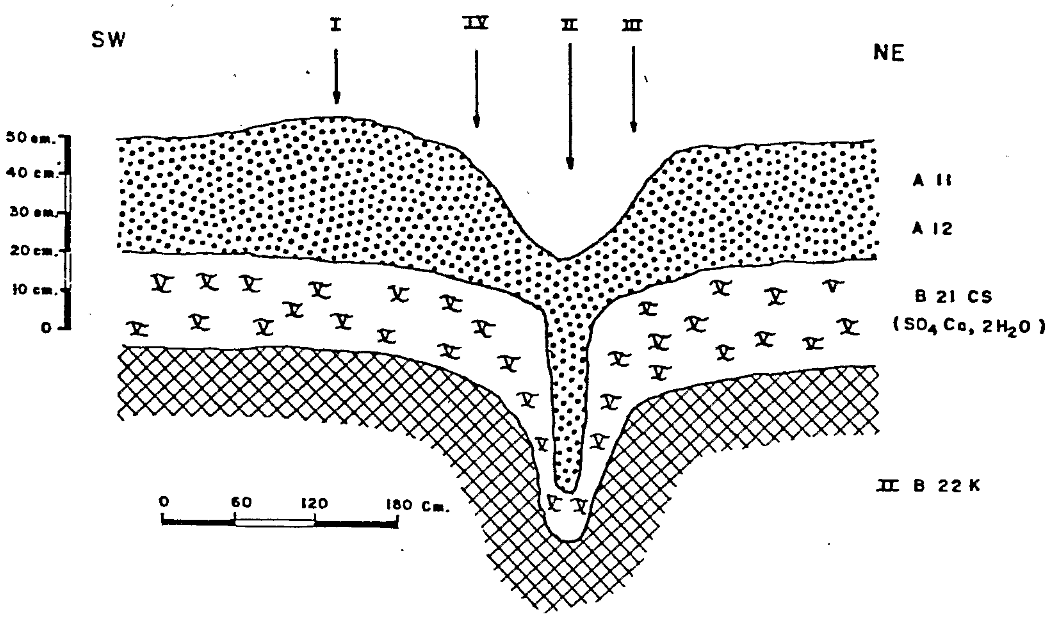


Fig. 6. Profile POLY 3.