THE INFLUENCE OF SOME SOIL FORMING FACTORS ON THE MORPHOLOGY, MICROMORPHOLOGY AND MINERALOGY OF SOILS FORMED FROM CALCAREOUS ROCKS

by

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Introduction.

The lithology of the area Jabalcuz-Los Villares (Jaén, Spain) is dominantly calcareous although there is an array of different rocks such as limestones, dolomites, marls and sandy limestones. Differences in relief, vegetation and age of formation manifest themselves. For example, in the case of relief, there are marked slope differences. Profiles were sampled both in forests and in xerophytic grasslands. The geologic formations have been studied in considerable detail by Garcia-Yebra and Sanz de Galdeano (1973) and are Jurassic and Cretaceous in age. Owing to the variability in soil-forming factors, we have decided to emphasize the role of each of them in the area.

The Geographic Setting

Climate. - Climatic data for Jabalcuz and los Villares indicate that a Mediterranean climate prevails. (Fig. 1).

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Vegetation. - Although the vegetation is quite variable, we were able to distinguish four main types:

(A). Deciduous forest with a lower story comprised mainly of poplars, willows and elms with an undercover of mesophytes. Profile 1 was sampled in such an environment.

(B). Arid pastures and scrub heath following from climax degradation. Site of profile 2.

(C). Saline grasslands with communities of Rudero-Secalinetea and Thero-Brachypodietea. Profiles 3, 4 and 5 were obtained from this environment.

(D). Rush-meadows. Site of profile 6.

The soils. - The location of the studied profiles is shown at the Fig. 2.

The morphology of the soils is outlines in the tables I and II.

RESULTS AND DISCUSSION.

The results obtained are schematized at the follows Tables III, IV, V and VI.

Profile I is typical a poorly developed soil which is not strongly leached having a base saturation of 100%. The micromorphology of this soil indicates that it has been formed by the gradual weathering of the parent rock by meteoric waters.

Even though Profile 2 is somewhat shallow, there is much evidence for soil development in the differences in texture, structure and colour manifest in different horizons and which ought to presuppose eluviation and red mottles and clay skins present in the E horizon. A degree of base saturation of 50 % in a soil developed over calcareous materials suggests that, indeed, a strong illuviation has taken place. A micromorphological study shows that the skeleton is dominated by chalcedony, further evidence of the leaching of limestone.

The total mineralogical composition of the coarse sand fraction indicates that the large grains are composed only of chalcedony whilst calcite occurs only in very small amounts, usually as nodules surrounded by chalcedony. In some instances, the chalcedony has invaded the calcite nodules (Fig. 3) whilst in others only streaks of calcite were observed in the nodule (Fig. 4). Finally, nodules were observed in which a nucleous of chalcedony is s$\overset{u}{\text{o}}$rrounded by an outer coating of chalcedony supposing a dissolution of calcite with a simultaneous replacement by chalcedony. The micromorphology, thus presents complementary evidence for the supposedly strong leaching to which the profile had been subjected.

Profile 3 is also apparently poorly developed. Is this a profile very little interesting but the coarse sand fraction contains abundant spherical grains which have corrugated surfaces, some red and some translucent white. In thin lamina they show this structure is likely determined by an external covering consisting of radial septum (partitions) or by an organization of hexagonal symmetry occurring around a nucleus lacking these structures as is shown in Fig. 5 and 6 .

From structural characteristic previously described it may be supposed that one is considering remains of fossil organisms, in particular, megaspores of the genus Isoetes.

The profile 4 is a very developed soil and have a poligenic character, there is a buried profile with characteristics very different to those to the overground profile, this one have a horizon sequence similar to the profile 3 and it is laying on a relict soil which have lost its superficial horizon by wearing and in which the leaching of carbonates and the eluviation of clay were very strong.

The textural data shows as the horizon A11, A12, C1 and C2 are very similar and there is a lithological discontinuity at the E2bt horizon.

The study of the $CO_3^=$ suggest the pedogenic process of this soil is as follows : on a limestone rock was formed a soil with a strong leaching of carbonates which gave origin to the horizon IIE3bca and facilitate the clay illuviation which gave origin to the horizon IIE2bt. The whole horizon A disappeared by wearing and on the horizon IIE2bt was established by transport a marly sediment which has been the parent rock of the present soil.

The micromorphological study of this profil 4 have confirmed the formely said: so the plasmic fabric of the horizons of the present soil is argillasepic with insepic domains, those of IIE2bt horizon strongly sepic and that of IIE3bca horizon argillasepic due to the high amounts of CO_3Ca presents.

In addition, a study of the coarse sand and clay fractions confirm the above observations.

Profile 5 is poorly developed and one has every reason to suspect that high amounts of $CaCO_3$ in the soil material have impeded its further development.

Profile 6 likewise shows evidence of inhibited development. Undoubtedly, the composition of the coarse sand fraction differs significantly from those in profiles 3 and 5 but has similar morphology and morphogenesis. The fact that calcite occurs in much smaller quantities than in those profiles (3 , 5) and quartzs and readily weatherable minerals such as feldspars are observed in this, one suspects that it have occurred close to a river where successive flooding has brought these minerals into the soil material.

The clay mineral assemblages in these soils are rendered in Table IV and these include illite, kaolinite, chlorite, montmorillonite, quartz, calcite, dolomite feldspars and diverse interstratified minerals. All these minerals are inherited from the original material.

The clay minerals show a clear degradation in superficial horizons produced by the edaphic process. From the soils developed on marls at the profiles 3, 5 and 6, the montmorillonite and the illite have suffered a degradation without transforming into other minerals (these profiles haven't stratified layers).

In the soil 1 also developed on marls the clay minerals inherited have been illite, chlorite and kaolinite. The chlorite has been quite degraded giving stratified layers with montmorillonitic sheets.

On the other hand in the soils developed on limestones (Profiles 2, 4) as they are a more evolutioned soils, the montmorillonite and/or chlorite have been completely degraded, while the Illite remains although very degraded.

In these soils the stratified layers are very abundant, appearing a great deal of sheets of true vermiculite.

Calcite, dolomite, quartz, montmorillonite, illite and kaolinite are inherited from the parent materials. Feldspars and much of the quartz represent contamination : the former from the river and the latter from a strata of rocks containing radiolaria.

With regard to the presence of chlorites, profiles 2 and 4 must be differentiated from profile 1. In the formed two, where montmorillonite is absent both from the soil and parent rock, the chlorite must be considered as neoformation (or pedogenetic). In profile 2 which is developed over marls dominated by montmorillonite there appear small quantities of chlorite which are thought to have been developed from montmorillonite mainly due to the forest keeping the soil considerably more moist.

The mineralogical composition of the coarse sand fractions is given in Table VI from which it appears that calcite is very common in this fraction in most soils (Profiles 1, 3, 4, 5 and 6) but scarce in profile 2 which has been strongly leached of its carbonates. Calcite is not so abundant in Profile 6 as in Profiles 1, 3, 4 and 5 as the river, close by, has likely contributed detrital minerals such as quartz and feldspars. The biostreme calcite is assumed to be inherited from the parent material as, only locally (Profile 4, horizon IIB3bca), have signs of a secondary recrystallization being observed in the coarse sand fraction.

As the chalcedony is angular and contaminated with compounds of iron and clay and thus likely derived pedogenetically whilst the quartz and feldspars contained in these fractions are inherited. The agglomerates are also assumed to be pedogenetic.

The following transformations of iron minerals in the heavy fractions have occurred :

- Pyrites → hematites (martites)
- Pyrites → hematites → goethites
- Pyrites → hematites with iron gels → hematites with maghemites

Dorronsoro and Delgado (1974) in a study of the coarse sand fractions in soils developed over limestones reported also nodules of martite which are identical to those observed in this study (Fig. 7 and 8); some well preserved others altered to goethite and even others with variable contents of maghemite. In order to come to a conclusion about the possible origin of these grains, 5 Kg. were extracted from soils and artificially weathered and in the final residue only martite was found with neither trace of goethite, maghemite, nor agglomerates. The authors draw the conclusion that as much goethite as pyrite as well as aggregates are of pedogenetic origin whilst the transformation of pyrite to hematite took place in the parent rock. The limestones were formed in an anaerobic environment so it is likely that iron will form as pyrite. After consolidation and uplift above water, oxidation will take place and pyrite should be transformed to hematite. The martite is brought into the soil by erosion from the parent rock. In the aerated, well drained horizons hematite remains unchanget but in poorly drained soils it is converted to goethite. These authors confirm that the above is also valid in their soils developed over calcareous rocks. Now that the abundance of goethite in the marls from which profiles 1, 3, 5 and 6 have been derived has been confirmed, it is submitted that the crystals of martite, nodules of hematite and fossil remains of ammonites, conchs and gasteropods in hematite have all been transformed in a greater or less degree to goethite. Given the poor drainage of these sediments it would be logical to believe that goethite would be more stable than hematite. In all probability the goethite, as well as, various forms of hematite in the soil are derived from its parent material increasing the amount developed by pedogenetic processes, which for Profiles, 1, 3, 5 and 6 principally goethite. On the contrary, in profiles 2 and 4 hematite is more common than goethite. These are undoubtedly well drained soils in oxidising environments.

The change from hematite to goethite has been achieved experimentally by Bedarida and Pedemonte (1971) who exposed crystals of hematite to atmospheric weathering under controlled conditions of 90 % humidity and at 20°C. Schwertmann (1971) explains this transformation as being partly a solution of the hematite followed by a recrystallization into goethite. In these soils under discussion, the recristallization takes place generally in situ without movement to that the grains retain their formed external shape, (Fig. 9) but part of the iron may migrate in greater or lesser amounts according to the existing conditions and produce cutans (Fig. 10).

As far as the maghemite is concerned, it is known to be a common mineral in soils. All authors concur that it is formed pedogenetically partly from the amorphous forms of iron and partly from lepidochrocite with organic matter playing an important role (Marel, 1951 , Schwertmann , 1959 Oades, 1963 and others).

Another interesting aspect worthy of consideration is the origin of the laminated texture called polyframboidal by love and Amstutz (1966). This is well manifest in the iron compounds in the coarse sand fractions of these soils.

It is reported as an aggregation of spheres (called framboids), each sphere in its turn, consisting of a collection of microcrystals displaying faint concentrity (Figs. 11, 12).

Theories explaining the origin of this phenomenon have support of two schools of thought. Some authors (Schneiderhöhm, 1923, Love, 1957 and Fabricius 1961) believe that these framboids have an organic origin representing fossilized bacterial colonies. For other authors (Love and Amstutz, 1966; Berner, 1969; Richard 1970 and Love 1971) this theory presents a number of objections one of these being the perfect internal order of the supposed bacterial colonies. Another objection is that the form of the crystals is not a good representation of the morphology of bacterial colonies. The latter authors believe strongly in an inorganic origin and explain the order obtaining in the microcrystals as being due to physical-chemical processes which regulate the precipitation of these compounds.

Although the theory of inorganic origin has gained wide acceptance, Berner (1969) synthetized framboids in a sterile biologic medium. The distribution of these microcrystals forming the framboids is based on a classical crystallographic model such as the cubic system.

The pedogenetic processes obtaining in these soils is clearly a function ot the parent material (limestones and calcareous marl). Calcareous marl morely disintegrates physically and minor amounts of organic material are incorporated into the upper horizons.

The physical weathering of the marl is essentially brought about by variations in soil moisture content and the accompanying changes in volume commensurate with the high contents of swelling clay minerals. These changes lead to a rapid and progressive disintegration of the marl to form a profile free of diagnostic horizons possibly due to the high content in calcium carbonate in the profile.

The weathering of the parent marl liberates its basic constituents of clay minerals and calcium carbonate into finely-divided active particles : this is confirmed by the results of chemical and micromorphological analyses. There is, however, a certain accumulation of salts of alkaline and alkaline earth elements which may not assume sufficient proportions to satisfy the diagnostic characteristics of saline and calcic horizons. No neoformations or transformations occur and the clay minerals are merely inherited from the parent material.

Owing to the ease with which these marls weather physically their low permeability does not prevent a profile of significant being formed.

The nature and characteristics of the parent material and the climatic and vegetation factors impose a limit on the amount of plant remains being interred. These are mineralized and humified rapidly to small amounts of mull humus so that an Ochric epipedon is formed. Later we must consider the exception posed by profile No. 1 which is situated under forest and where the humidity and vegetation regimes produce a kind of melanization which changes the whole character of the soil inasmuch that a mollic horizon is formed as well as changes in clay mineral composition.

We must, thus, distinguish two types of profiles in the soils developed over marls (profiles 1, 3, 5 and 6) according to the type of vegetation they support. Profiles 3, 5, and 6 support a xerophytic vegetation which supplies the soil with little organic matter which is rapidly mineralized so that only an ochric horizon may develop. These soils have not developed further than the Entisol stage although there are some local variations. Their further genesis has been inhibited by the high amount of calcium carbonate present. Thus, profiles 3 and 5 have exclusively ochric horizons without any other diagnostic parameter. Given that the climatic characteristics of both will be Xerorthens. Now, profile 3 by virtue of its position in the terrain represents a greater degree of alteration and being higher inclay assumes some vertisolic characteristics (although not sufficient to be diagnostic) so that it could possibly be a Vertic Xerorthent whilst profile 5, where the alteration is more advanced, is a Typic Xerorthent.

Profile No. 6 situated some meters lower than Profile 5 and has been subject to innundations from a river which passes a few meters from it. This is reflected in the irregular distribution of organic matter down the profile so that it must be classified in the suborder Fluvent; under the climatic conditions obtaining in the zone it is considered as a Xerofluvent.

Profile No. 1 also on marl supports forest vegetation. The high amount of organic matter and the high degree of humification have contributed to form a mollic surface horizon with diagnostic qualities. As this soil contains more than 40% of the calcium carbonate equivalent in the whole profile it belongs to the suborder Rendoll. A typic Rendoll will be discussed here.

We see that the original material presupposed a soil in which there is high amounts of calcium carbonate and clay but also the vegetation and relief may influence its development : the vegetation to the level of Order and the latter only to the level of Suborder or Group.

On the other hand we must differentiate the soils developed over white limestones and those over flinty limestones which supply much less calcium carbonate and thus do not inhibit soil development and in which there can take place a more diverse range of soil forming processes principally:

Decarbonization

The process of weathering is being considered which affects the soils developed over limestones and which do not receive colluvial contributions of limestone. The superficial horizons contain more coarse limestone gravel and less calcium carbonate in their fine fractions than the deeper horizons. On the other hand the presence of active calcium carbonate has been increased in the upper horizons. This is obvious in Profile No. 4 in which there are deep horizons with accumulations of calcium carbonate (IIB3bca). A further manifestation of this process is in the coarse sand fraction where the limestone has been dissolved and replaced by chalcedony from the rock.

Once decarbonization has taken place., argillization or the formation of new clay minerals such as has happened in profiles 2 and 4 which contain chlorite but not the parent rocks. The argillization process is accompanied by illuviation of clays giving textural differentiation and clay skins.

Jointly with the process of argillization and illuviation, Rubefaction which has imparted the reddish colour to the soil, has taken place. The cause of the colour is the presence of hematitic ferriargillans. The hematite being derived from coarse-sand size pyrites inherited from the parent rock.

The process of argillization by illuviation of clay materials has made possible the development of a typical textural B horizon giving ABC type of profiles with a diagnostic argillic horizon.

These soils do not have other diagnostic horizons than the argillic which together with a degree of base saturation greater than 50 % places these, accordingly in the order Alfisol: given the climatic characteristics of the zone both soils belong in the suborder Xeralf. Profile No. 4 being a burried soil must acorded a certain relict character and thus treated as a Palexeralf, whilst profile No. 2 does not posses this characteristic nor a calcic horizon at depth so that it may be considered a Haploxeralf.

It can be seen in this case that the influence of relief is manifest only in profile depth and is not responsible for any taxonomic differences. Soils on flinty limestones do not occur under foest in this zone but it is suspected that Argixeroll soils with a mollic horizon would develop.

TABLE I

MACROMORPHOLOGICAL DESCRIPTION OF SOIL PROFILES

Profile	Parent material	Relief	Slope	Vegetation	Drainaje	Soil	Type
1	Cretaceous marls	Low mount	5°	Deciduous forest	Good	Typic	Rendoll
2	Flinty limestones	Mountainous	45°	Arid pastures	Good	Lithic	Haploxeralf
3	Calcareous marls	Mountainous	5°	Communities of Rudero-Secalinetea.	Medium	Vertic	Xerorthent
4	Flinty limestones	Mountainous	5°	Communities of Rudero-Secalinetea.	Good	Thapto palexeralfic typic	Xerorthent.
5	Cretaceous marls	Low mount	5°	Communities of Rudero-Secalinetea.	Very bad	Typic	Xerorthent
6	Cretaceous marls	Piedmont	3°	Rush-meadows	Good	Typic	Xerofluvent

TABLE II

MACROMORPHOLOGICAL DESCRIPTION OF SOIL PROFILE

Prof.	Horiz.	Dpth.	Colour	Texture	Structure
		(cm)	(dry)		
1	01	2-0	-	-	-
	A11	0-5	10YR3/2	sacl	Crumb
	A12	5-50	10YR4/3	sacl	Crumb
	AC	50-80	10YR4/4	sacl	Crumb
	C	78-100			
	IIR	>100			
2	A1	0-7	10YR5/4	l	Crumb
	B2t	7-30	5YR4/4	sacl	Subangular blocky
	R	>30			
3	A1	0-40	2.5Y6/4	c	Blocky
	C1	40-75	2.5Y7/4	c	Blocky
	C2	>75	2.5Y8/4	c	Blocky
4	A11	0-6	10YR7/3	l	Crumb
	A12	6-50	10YR6/4	cl	Subangular blocky
	C1	50-100	10YR6/4	cl	Subangular blocky
	C2	100-125	10YR6/4	cl	Subangular blocky
	IIB2bt	125-140	5YR4/6	c	Prismatic
	IIB3bCa	140-150	7.5YR6/8	sic	Subangular blocky
	IIC1	150-155			
	IIR	>155			
5	A11	0-15	10YR7/3	cl	Blocky
	A12	15-100	10YR6/3	cl	Blocky
	C1	>100	10YR7/6	cl	Massive
6	A11	0-15	10YR4/4	sacl	Subangular blocky
	A12	15-35	10YR4/4	sacl	Subangular blocky
	C1	>35	10YR7/3	sacl	Massive

Roots	$CO_3^=$	Pores	Clayskin	Bio. Act.	Boundary
-	-	-	-	-	Sharp
4	4	2	-	4	Clear
4	4	3	-	3	Diffuse
2	4	4	-	2	Diffuse
2	1	2	-	3	Sharp
1	1	2	3	1	Sharp
2	4	3	-	2	Plane and Diffuse
1	5	2	-		Plane and Diffuse
1	5	1	-		Sharp
2	4	3	-	3	
4	4	3	-	3	Diffuse
4	4	3	-	-	Sharp
-	4	1	-	-	Sharp
-	-	1	3	-	Sharp
-	4	1	1	-	Diffuse
-	-	-	-	-	
3	4	3	-	3	Diffuse
1	4	3	-	3	Sharp
-	4	1	-	-	
3	3	2	-	4	Diffuse
1	2	1	-	2	Sharp
-	2	1	-	-	

TABLE III

SOME ANALYTICAL DATA FROM SOILS OF JAEN

Prof.	Horiz.	Coarse % sand	Fine % sand	Silt %	Clay %
	A11	27,43	22,22	19,28	31,07
1	A12	32,40	21,50	15,45	30,65
	AC	45,13	15,04	17,51	22,32
2	A1	30,12	14,96	29,87	25,05
	B2t	32,11	15,03	20,16	32,70
	A1	4,03	10,54	19,40	66,03
3	C1	4,77	8,24	27,56	59,43
	C2	4,65	14,38	30,13	50,84
	A11	0,54	27,42	45,25	26,79
	A12	6,53	18,76	46,68	28,03
4	C1	1,64	27,32	50,75	20,29
	C2	2,12	23,64	40,23	34,01
	IIB2bt	1,40	13,71	30,22	54,67
	IIB3bca	3,06	4,19	46,02	46,73
	A11	10,39	21,63	33,23	34,75
5	A12	9,55	22,64	34,71	33,10
	C1	8,38	26,07	33,35	32,20
	A11	20,78	43,68	10,14	25,40
6	A12	9,43	52,22	15,23	23,12
	C1	12,97	45,65	17,78	23,60

$CaCO_3$ equiv.	pH(H_2O)	Org. matter.	C/N	S	T
43,58	7,58	4,03	15,24	-	31,74
49,80	8,00	1,70	13,18	-	18,23
60,81	7,07	0,40	10,16	-	16,93
5,38	7,20	0,50	11,00	13,08	25,61
4,79	7,63	0,38	10,06	14,11	25,17
58,04	7,61	0,60	12,70	-	17,36
71,16	7,93	0,31	11,00	-	18,66
71,53	7,91	0,17	8,01	-	18,66
36,70	7,92	0,60	23,00	-	15,49
35,36	7,92	0,31	14,13	-	15,66
38,20	7,90	0,18	8,10	-	14,79
44,19	7,82	0,12	7,68	-	9,50
0,43	7,84	0,11	8,47	-	17,75
45,99	7,82	0,10	8,79	-	14,38
62,70	7,80	0,96	24,04	-	15,75
65,50	8,03	0,80	19,13	-	17,05
60,08	8,03	0,24	12,31	-	16,70
20,36	7,87	0,87	19,10	-	13,45
16,27	7,95	0,80	10,64	-	14,15
18,48	8,12	0,30	10,42	-	15,66

TABLE IV

MICROMORPHOLOGICAL CHARACTERISTICS

		FABRIC	
Profile	Horiz.	Related distribution	Plasmic
1	A11	Intertextic	Argillasepic
	A12	Intertextic	Argillasepic
	AC	Intertextic	Argillasepic
2	A1	Porphyroskelic	Skelvoinsepic
	B2t	Porphyroskelic	Skelinsepic
3	A1	Intertextic	Argillasepic (crystic domains)
	C1	Intertextic	Argillasepic (crystic domains)
	C2	Intertextic	Argillasepic (crystic domains)
4	A11	Intertextic	Argillasepic(insepic domains)
	A12	Intertextic	Argillasepic(insepic domains)
	C1	Intertextic	Argillasepic
	IIB2bt	Porphyroskelic	Strongly vo skelmosepic
	IIB3ca	Porphyroskelic	Argillasepic
5	A11	Intertextic	Argillasepic
	A12	Intertextic	Argillasepic
6	A11	Intertextic	Argillasepic
	A12	Intertextic	Argillasepic
	C1	Porphyroskelic	Argillasepic (crystic domains)

CUTANS

lumber	Surface affected	Mineralogy	Interpretation
1	Channels	Organans	Dropping
–	–	–	–
1	Voids	Argillans	Stress
1	Skeleton grains and voids	Argillans	Stress
4	Skeleton grains	Ferriargillans	Illuviation, stress
–	–	–	–
–	–	–	–
–	–	–	–
1	Channels	Organans	Dropping
–	–	–	–
–	–	–	–
5	voids, skeleton grains	Argillans	Stress, illuviation
3	Peds, voids	Argillans	Illuviation
–	–	–	–
–	–	–	–
–	–	–	–
2	Skeleton grains	Argillans	Inherited
–	–	–	–

TABLE IV

MICROMORPHOLOGICAL CHARACTERISTICS (Continued)

		GLÄEBULAS		
Prof.	Horiz.	Types	Nature	Number
1	A11	nodules	$CO_3^{=}$	2
	A12	nodules, pedodes	$CO_3^{=}$	2
	AC	nodules, pedodes, pedorelicts.	$CO_3^{=}$	3
2	A1	nodules	$CO_3^{=}$, Fe	2
	B2t	nodules	$CO_3^{=}$, Fe	2
3	A1	nodules, glaebular halos	$CO_3^{=}$, Fe	1
	C1	nodules, pedorelicts	$CO_3^{=}$, Fe, clay	4
	C2	nodules, litho, pedorelicts	$CO_3^{=}$, Fe, clay	4
4	A11	pedorelicts, nodules	$CO_3^{=}$, Fe, clay	3
	A12	nodules	$CO_3^{=}$, Fe,	2
	C1	nodules	$CO_3^{=}$, Fe	2
	IIB2bt	nodules	Fe	4
	IIB3ca	nodules	Fe	4
5	A11	nodules	Fe	1
	A12	nodules	Fe, $CO_3^{=}$	1
6	A11	nodules	$CO_3^{=}$, Fe	1
	A12	nodules, pedo, lithorelicts	$CO_3^{=}$, Fe	4
	C1	nodules, pedorelicts	$CO_3^{=}$	4

CRYSTALLARIA		VOIDS	
Nature	Number	Types	Number
-	-	Channels, vughs	3
-	-	Compound packing voids, channels vughs	4
-	-	Channels, vughs, planar voids	2
-	-	Compound packing voids, channels planar voids.	4
-	-	Compound packing voids, channels vughs	4
$CO_3^{=}$	1	Vughs, channels	1
$CO_3^{=}$	4	Packing voids, vughs, channels	1
$CO_3^{=}$	2	Vughs, channels	2
-	-	Packing voids, channels, vughs	5
-	-	Vughs, channels	4
-	-	Packing voids, channels, vughs	2
-	-	Packing voids, channels, vughs	4
-	-	Vughs, channels	4
-	-	Channels, vughs	4
-	-	Channels, vughs	4
-	-	Packing voids, channels, vughs	4
-	-	Vughs, channels	3
$CO_3^{=}$	-	Vughs, channels	1

TABLE V

CLAY MINERALOGICAL COMPOSITION OF SOILS

Prof.	Horiz.	I	K	Ch	Mo	Int.	Q	Ca	D	F
1	A11	5	2	1	Tr	Tr	1	–	–	–
	A12	5	2	3	Tr	Tr	1	–	–	–
	AC	4	1	3	–	Tr	1	–	–	–
2	A1	4	1	–	–	Tr	1	–	–	–
	B2t	–	1	–	–	3	1	–	–	–
3	A1	2	2	–	2	–	1	5	–	–
	C1	2	1	–	3	–	1	5	–	–
	C2	4	1	–	5	–	Tr	5	–	–
4	A11	1	1	–	–	2	2	–	1	–
	A12	1	1	–	Tr	3	2	–	–	–
	C1	1	1	–	–	3	2	–	–	–
	C2	1	1	1	–	1	3	–	1	–
	IIB2bt	1	1	1	–	1	2	–	1	–
	IIB3bca	1	1	5	–	–	2	–	–	–
5	A11	1	1	–	3	–	1	4	–	–
	A12	1	1	–	4	–	1	4	–	–
	C1	2	2	–	5	–	1	2	–	–
6	A11	2	1	–	2	–	1	–	1	1
	A12	1	1	–	2	–	1	–	1	–
	C1	4	2	–	5	–	1	–	–	–

I= Illite; K= Kaolinite; CH= Chlorite; Mo= Montmorillonite; INT= Interestratified; Q= Quartz; CA= Calcite; D = Dolomite; F = Feldspar.

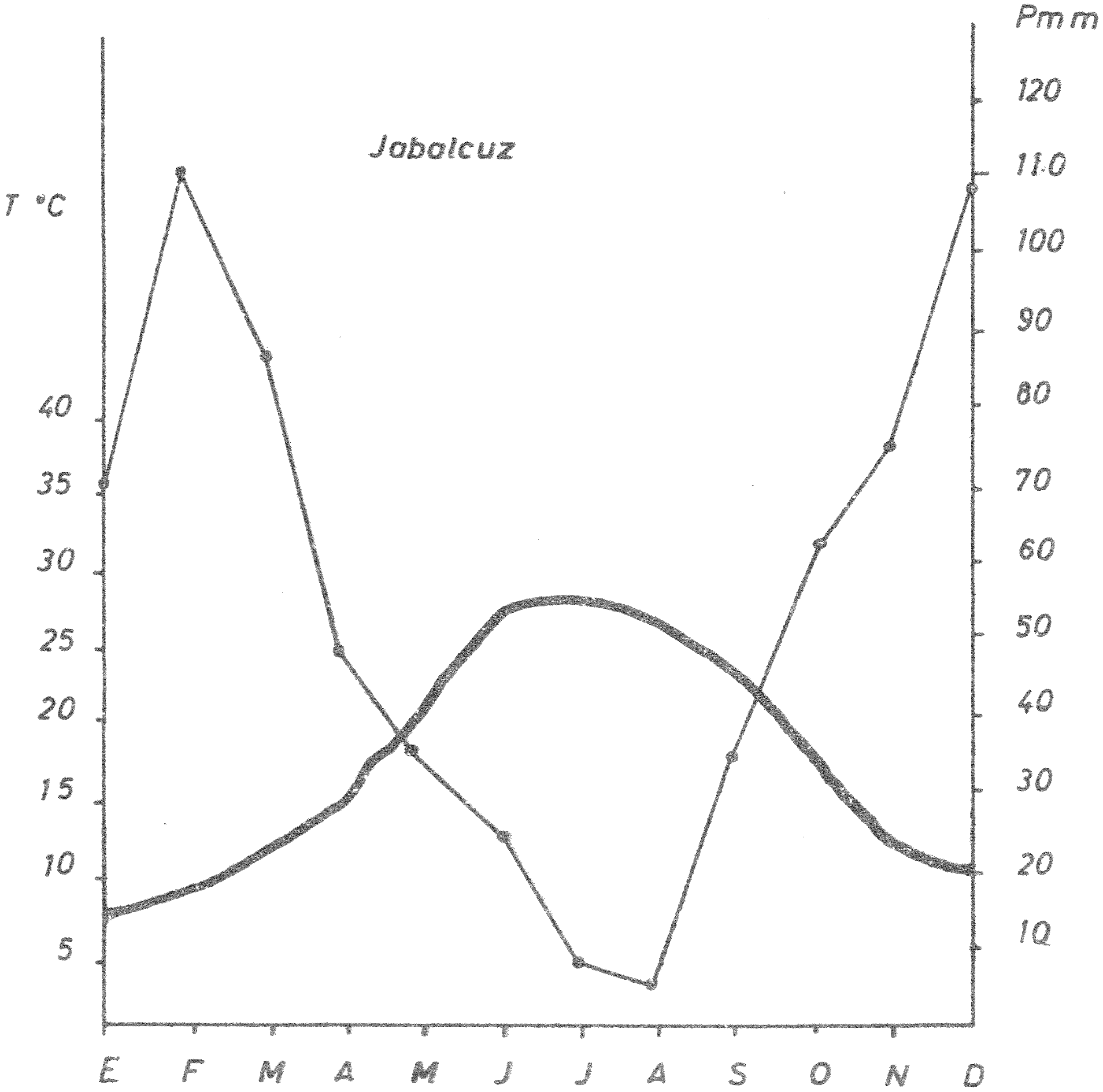
– = Absent Tr= Traces; 1= scarce; 2= Few; 3= Medium; 4= Abundant; 5= Very abundant.

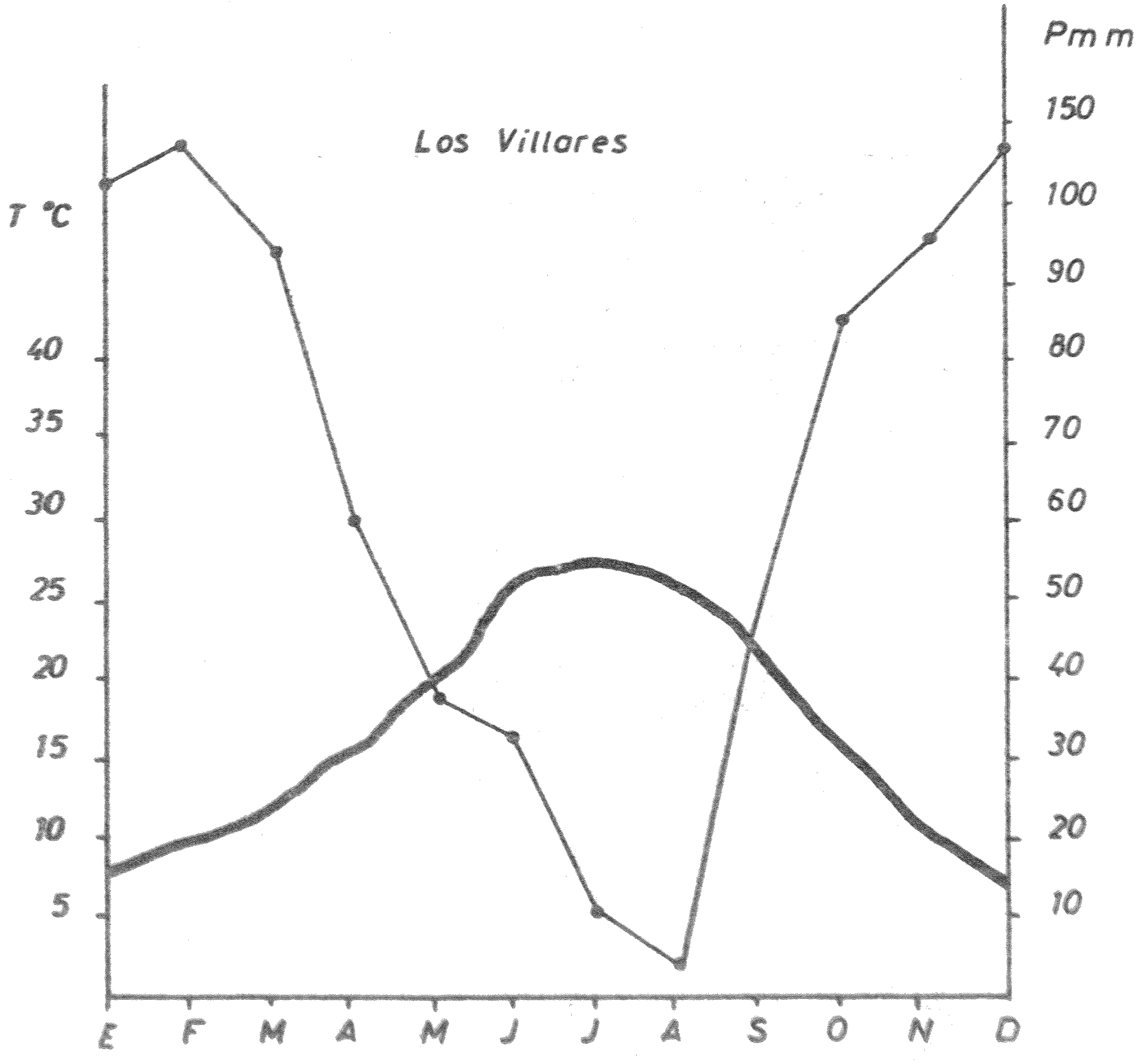
TABLE VI

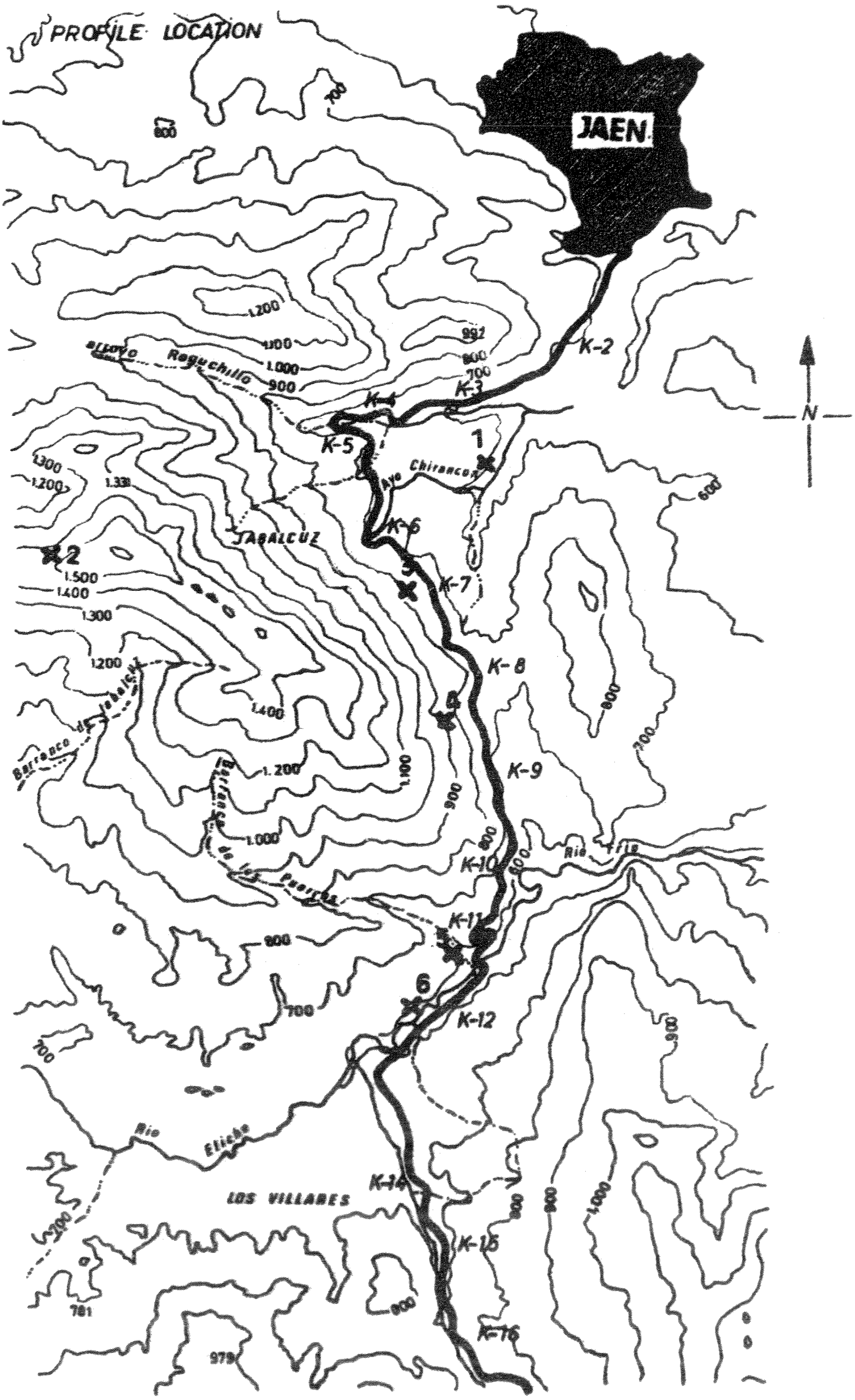
COARSE SAND MINERALOGICAL COMPOSITION OF SOILS

Prof.	Horiz.	Ca	C	Q	F	A	H	G	M
1	A11	91	9	Tr	–	–	Tr	Tr	Tr
	A12	93	7	Tr	–	–	Tr	Tr	Tr
	AC	96	4	Tr	–	–	Tr	Tr	–
2	A1	1	90	2	–	7	Tr	Tr	Tr
	B2t	2	96	Tr	–	2	Tr	Tr	Tr
3	A1	66	19	Tr	–	Tr	3	12	Tr
	C1	78	13	Tr	–	Tr	3	6	–
	C2	83	6	Tr	–	Tr	2	9	–
4	A11	92	–	–	–	1	5	1	1
	A12	90	Tr	–	–	1	6	2	1
	C1	88	1	1	–	1	4	5	Tr
	C2	91	–	–	–		4	5	Tr
	IIB2bt	28	38	15	–	13	3	3	–
	IIB3bca	64	14	11	–	5	3	3	–
5	A11	96	Tr	Tr	–	–	2	2	Tr
	A12	94	2	Tr	–	–	1	3	Tr
	C1	97	Tr	Tr	–	–	1	2	–
6	A11	53	3	26	9	–	4	5	Tr
	A12	81	3	6	1	–	3	6	Tr
	C1	70	1	19	2	–	2	6	Tr

Ca = Calcite ; C= Chalcedony; Q= Quartz; F= Feldspar; A= Aggregates; H= Hematite; G= Goethite; M= Maghemite. Tr= Traces.


Jabalcuz
T °C
40
35
30
25
20
15
10
5
Pmm
120
11.0
100
90
80
70
60
50
40
30
20
10
E
F
M
A
M
J
J
A
S
O
N
D


Los Villares
T °C
40
35
30
25
20
15
10
5
Pmm
150
100
90
80
70
60
50
40
30
20
10
E
F
M
A
M
J
J
A
S
O
N
D


PROFILE LOCATION
JAEN
N
K-2
K-3
K-4
K-5
K-6
K-7
K-8
K-9
K-10
K-11
K-12
K-14
K-15
K-16
1
2
3
4
5
6
arroyo Reguchillo
Ayo Chiranco
JABALCUZ
Barranco de Jabalcuz
Barranco de los Puercos
Rio Frio
Rio Eliche
LOS VILLARES
1.200
1.100
1.000
900
800
700
600
992
1.300
1.331
1.500
1.400
781
979

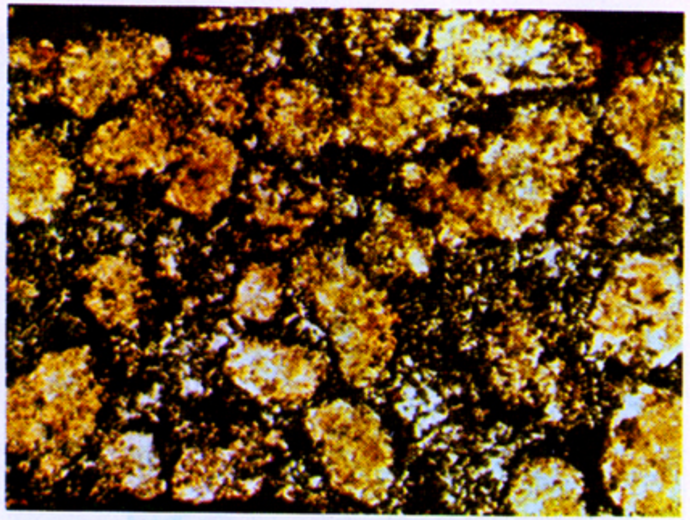


Fig. 3

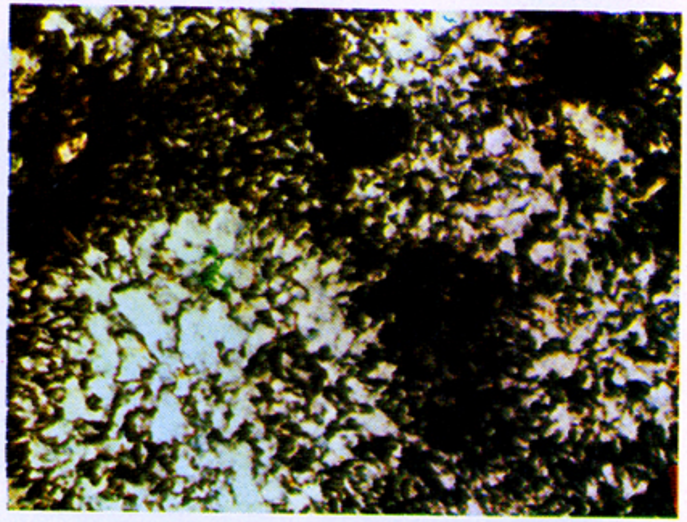


Fig. 4


Fig. 5

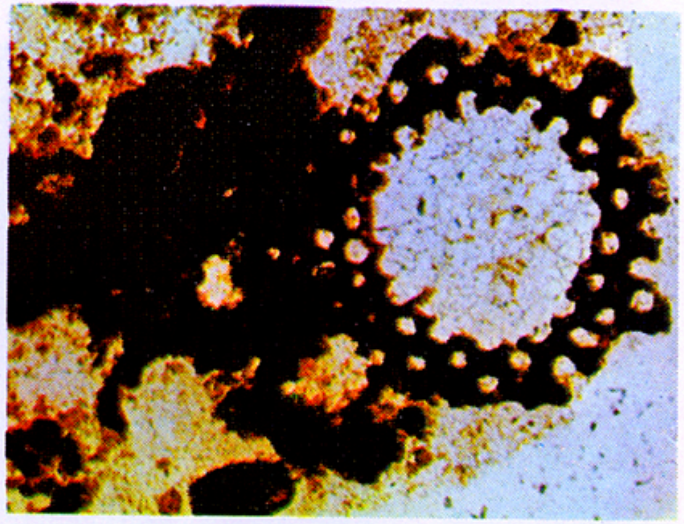


Fig. 6

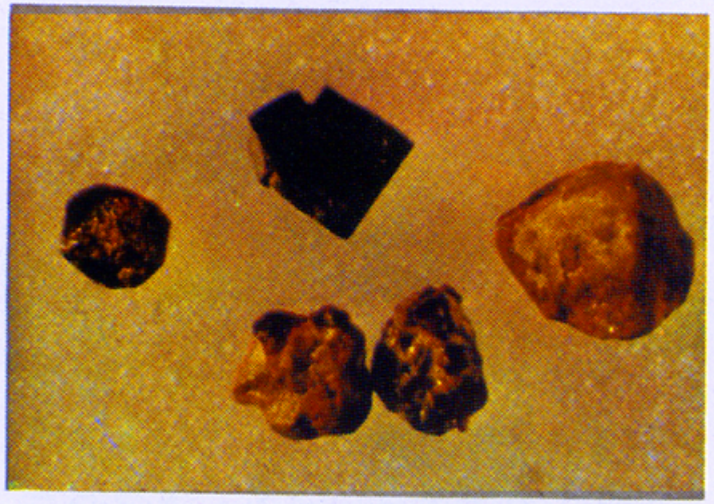


Fig. 7

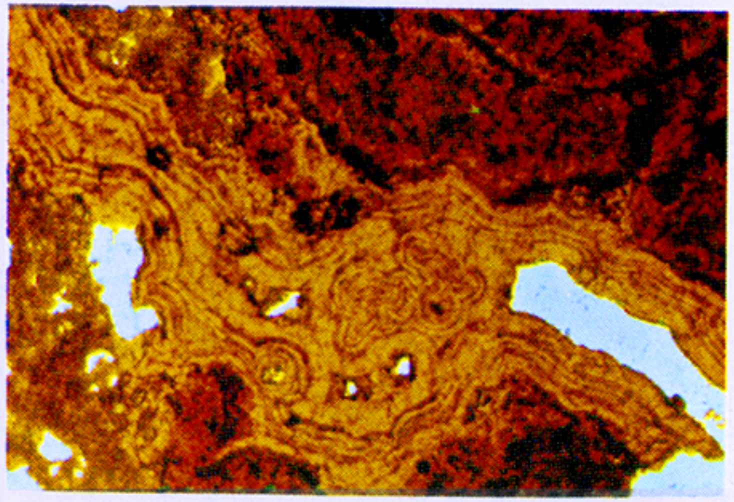


Fig. 8

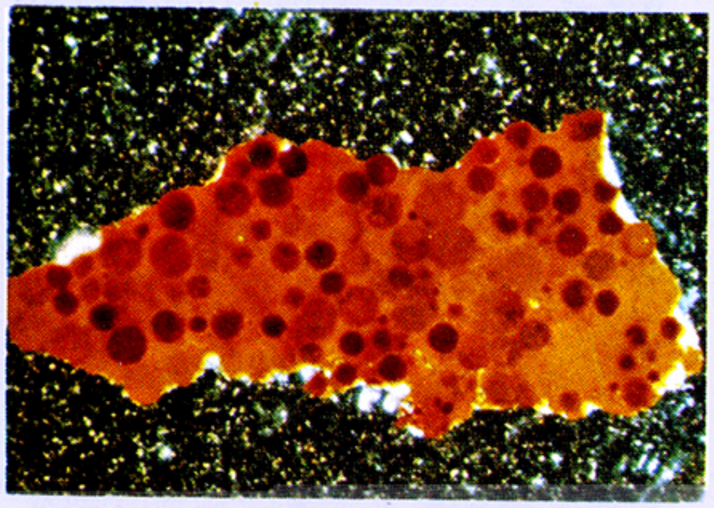


Fig. 9

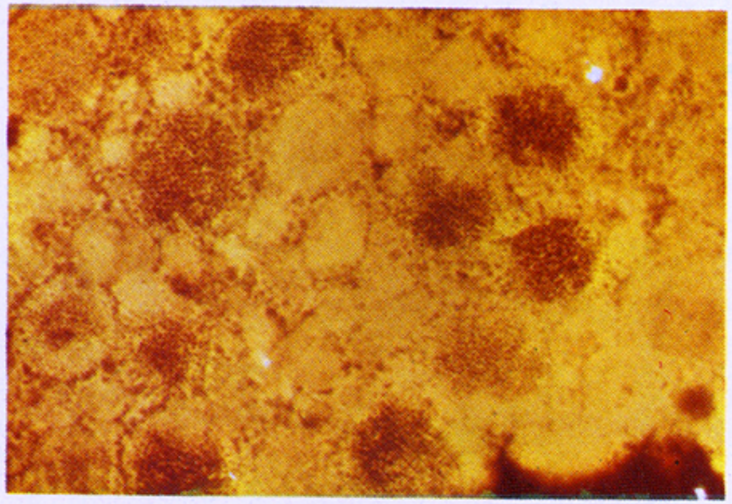


Fig. 10

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SUMMARY

We have studied the influence of some factors of soil formation (topography and vegetation) on the morphology and properties of soils developed on calcareous rocks in the area of Jabalcuz (Jaen).

We have pointed out as changes in vegetation produce modifications at the higher categories of the soils (level Orders) while topography changes only introduce modifications at suborder levels in these soils.

LITTERATURE CITED

BEDARIDA, F. and PEDEMONTE, G.M. (1.971) "Hematite to goethite surface weathering" Amer. Mineral. 56. 1.469-1.473.

BERNER (1.969) - Econ. Geol. 64, 383-4.

DORRONSORO, C. and DELGADO, M. (1.974) "Iron compound in the coarse sand fraction of some spanish soils". Soil Microscopy - The Limestones Press p. 682-694.

FABRICIUS, F. (1.961) "Die strukturen des Rogepyrits" als Beitrang zum Problem der "Vertzen Bakterien". Geol. Rund. 51. 647-657.

GARCIA YEBRA y SANZ GALDEANO (1.973)"Datos estratigráficos sobre la unidad Jabalcuz-San Cristobal, e interpretación sedimentológica del Jurásico superior"Cuadernos de Geologia" nº 4 p. 129-139.

LOVE, L.G. (1.957) "Microorganisms and the presence of syngenetic pyrite" A.Jl. Geol. Soc. Lond. 113 429-40.

LOVE, L.G. (1.971)"Early diagenetic polyframboidal pyrite". Jour. Sediment. Petrol. 14. 1038-44.

LOVE, L.G. and AMSTUTZ, C.G. (1.966) "Review of microscopic pyrite" Fortschr. Miner. 73. 273-309.

MAREL, H.W. vand der (1.951) "Gamma ferric oxide in sediments" J. Sediment. Petrolog. 21, 12-21.

OADES, J.M. (1.963) "The nature and distribution of iron compounds in soils" Soils and Fertilizers. 29, 69-80.

RICHARD, D.T. (1.970) "The origin of framboides". Lithos. 3, 269-93.

SCHNEIDERHÖM, H.(1.923) "Chalkographische Untersuchung des Mansfelder Kupferschiefers". N. Jb. Miner. Geol. Plalaont. 47, 1-38.

SCHWERTMANN, U. (1.959)"Die fraktionierte Extraction der freien Eisenoxyde in Böden" Zeit. Pflernärch Düng. 84, 194-204.

SCHWERTMANN, U. (1.971) "Transformation of hematite to goethite in soils". Nature 232. 642-652.

SOIL SURVEY STAFF (1.967). "Supplement to soil classification "7th aproximation" ·Us Dep. Agric. Soil Conserv. Surv. Washington.