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THE SOILS AND AGES OF THE "RAÑA" SURFACES RELATED TO THE VILLUERCAS AND ALTAMIRA MOUNTAIN RANGES (WESTERN SPAIN)

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SUMMARY

The soils of "raña" surfaces related to the "Sierra de las Villuercas" and the "Sierra de Altamira" (Western Spain) were studied with reference to vegetation cover and geomorphic position. These soils were highly weathered, with kaolinite dominant in the clay fraction and almost no weatherable minerals in the sand fraction. Iron oxides were segregated in some of the horizons giving a formation of "pseudoplinthite". This high degree of weathering and the patina of their quartzite stones are comparable to those of soils developed on the oldest raña surfaces studied in Central Spain. The soils classified as Palehumults and Palexerults are given, tentatively, a Middle-Upper Pliocene age.

1 INTRODUCTION

In Spain, "rañas" are continental detritic formations which always appear associated with quartzitic mountain ranges of the so-called "Macizo Hespérico" (Central and western Spain); raña formations associated with calcareous or granitic mountain ranges have not been described so far. They are glacis-piedmont type of surfaces and generally their sediments overlie a previous erosion surface (ESPEJO 1985).

The term "raña" has both a stratigraphic and a morphological meaning: it refers either to the raña sediments or to the corresponding flat geomorphic surface. Although an Upper Pliocene is the most generally accepted age for rañas there is increasing evidence of the existence of more than one raña level (ESPEJO 1985); consequently more detailed studies are needed to stablish, at least, a relative chronology for them.

The characterization of raña soils has become a good method to stablish differences between raña surfaces (ESPEJO 1985). The purpose of this paper is to characterize the soils of raña surfaces in an area which is typical in the literature abozt raña formations and to estimate their possible age.

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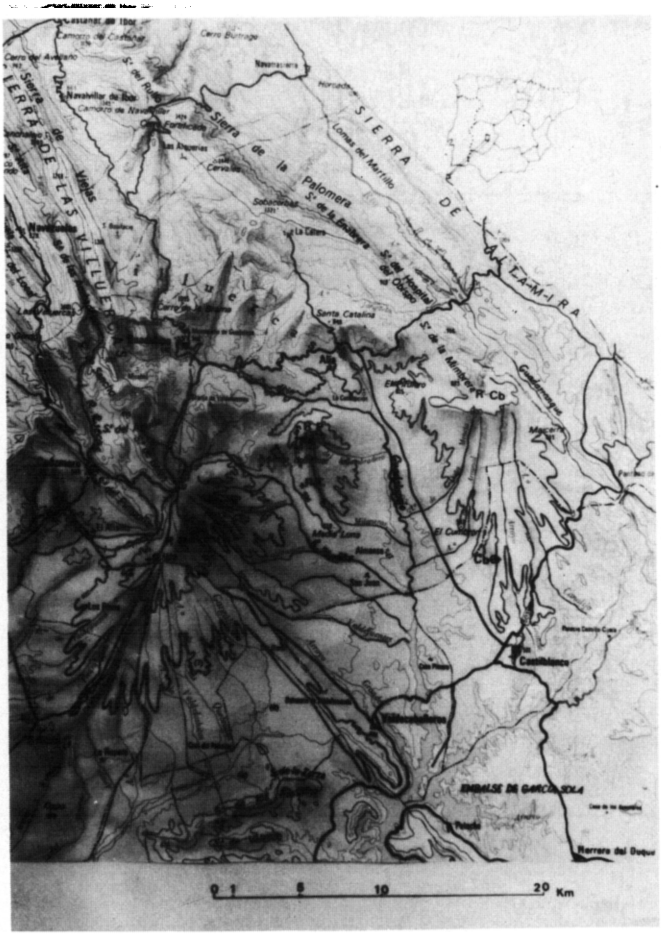

Photo 1: *Map showing location of study area. Contour interval: 100 m.*

2 STUDY AREA AND ENVIRONMENTAL CONDITIONS

The study area lies in western Spain (Photo 1). The rañas studied are related to the quartzitic mountain ranges of "Sierra de las Villuercas" and "Sierra de Altamira". The general appearance of the locality is shown on the ERST-1 satellite photograph (Photo 2). Three raña surfaces have been studied and are, from West to East, the raña of Cañamero (R.C.), the raña of Pinar (R.P.) and the raña of Castillblanco (R.Cb.).

2.1 CLIMATE

Climate data for the period 1951–1976 are from the nearby station of Guadalupe (39° 27‘ 20“N, 5° 19‘ 33“W; elevation 640 m). The mean annual temperature is 14.9°C and the average annual rainfall 830 mm. Average annual evapotranspiration (Thorntwaite) is 798 mm. There is a marked summer drought (from June to September, the total pre-

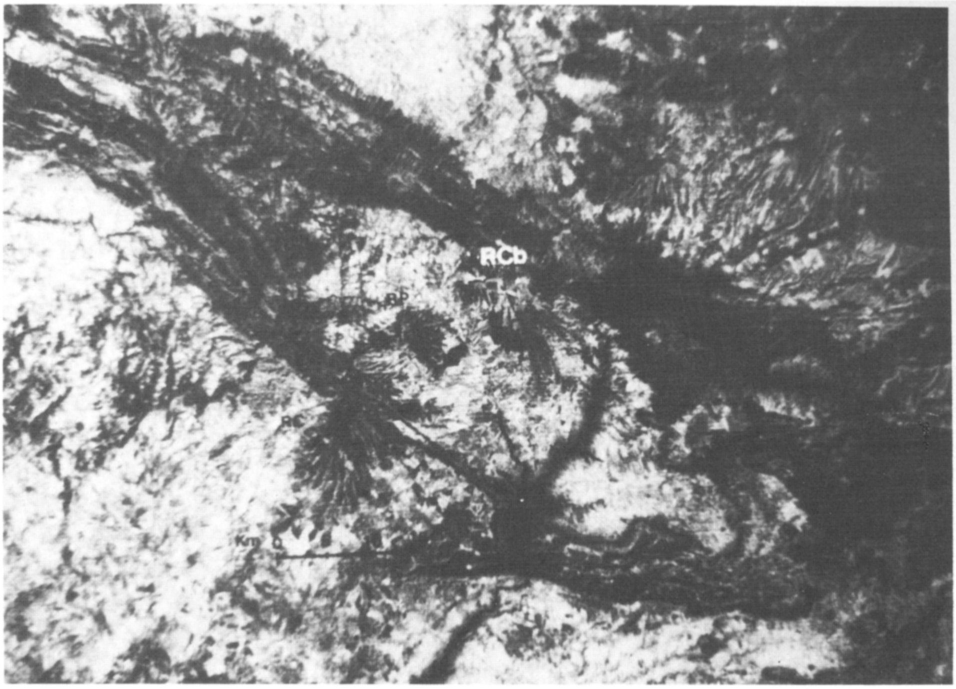

Photo 2: *ERST-1 satellite photograph showing the general appearance of study area.*

cipitation is 82 mm whereas the total evapotranspiration is 507 mm) and a surplus of water from October to May (for this period, total precipitation is 748 mm, whereas total evapotranspiration is 291 mm). The soil hydric regime is, therefore, Xeric (ESPEJO 1978).

2.2 VEGETATION

The natural vegetation (and land use) differs from the flat surfaces of the raña formations to the slopes of the valleys entrenched on them.

In the flat surfaces, the natural vegetation appears degraded because of man's activities. In the areas not cultivated to rye or olive there is a scrubby vegetation corresponding to the association *Halimio-Ericetum umbellatae* (RIVAS GODAY 1964), with *Erica umbellata, Halimium occymoides, Pterospartum tridentatum* and *Poligala microphyla*. This vegetation is far from the tree climax, a cork-oak (*Quercus suber*) forest (LADERO 1970). Only in the flat surface of the raña of Pinar (R.P.), the most inaccessible of the ones studied, it is possible to find the association *Genisto-Cistetum ladaniferi* (RIVAS GODAY 1964), more close to the climax and having *Genista hisruta, Cistus ladaniferus, Erica australis, Lavendula stoechas* and *Rosmarinus officinalis*.

On the upper and sunnier parts of the lateral slopes, there is a scrubby vegetation with *Arbutus unedo, Phyllirea angustifolia, Cistus ladaniferus, Cistus populifolius, Lavendula stoechas, Erica australis* and some isolated specimens of coark-oak. On the lower and shadier parts, the bush is similar to the former, but the arboreal climax is a gall oak (*Quercus faginea*) forest (LADERO 1970).

In the last years a reafforestation with *Eucalyptus globulus* has been carried out on the slopes and some parts of the flat surfaces.

2.3 GEOLOGY AND LITHOLOGY

The source area for the raña sediments lies in the Paleozoic mountain ranges placed to the North. These ranges have a NW-SE direction (see Photo 2) and have a series of materials ranging in age from lower Cambrian to upper Devonian; in these series shales, greywackes and quartzites predominate; only between the upper Devonian materials appear some limestonic inclusions. The crest of the mountain ranges is usually made of hard and compact quartzite whereas the shales predominate in the valleys.

In the Permo-Triasic, the area became a denudation surface, and during the Alpine orogeny, it was affected by vertical movements that created elevated and depresses areas. The latter were filled with detritic sediments through the Miocene. At the end of Miocene a new erosive cycle developed a peneplane and removed the upper miocenic sediments. Between the formation of the postmiocenic erosion surface and raña deposition there was a period of geomorphic stability as suggested by a deep paleosol preserved on the top of Miocene sediments (ESPEJO 1978).

At the beginning of the Quaternary the present river system was entrenched in the raña formations and consequently, the large and uniform initial raña surfaces were divided into several small ones which now remain between the river valleys. The slopes of these valleys are covered by a colluvium from the raña sediments.

The raña sediments have a relatively uniform thickness ranging from 3 to 6.5 m as observed in the frequent lateral gullies which flank the platforms (ESPEJO 1978). They overlie the post-miocenic erosion surface, as suggested by GEHRENKEMPER (1978), and they can be described as an oligomictic conglomerate consisting essentially of quartzite pebbles and blocks in a psammo-pellitic matrix. In the neighbourhood of the source area, quartzitic blocks up to 2 m^3 can be observed in the raña sediments (ESPEJO 1978). Rock fragments different from quartz and quartzite are lacking in the skeleton of raña sediments although shales and greywackes are very common in the source area. As it will be shown later, raña materials have undergone strong post-depositional changes which have even affected the hard and compact quartzitic pebbles.

Fig.1 shows a synthesis of the geology of the area, taken from the I.G.M.E. (1970).

2.4 GEOMORPHOLOGY

The rañas are large flat platforms, nearly horizontal, which contrast with the abrupt landscape of the nearby quartzitic mountain ranges. Because they were originated before the entrenchement of the river system, they appear at higher altitudes than the sequences of river terraces and they constitute frequently the divide between the river basins (ESPEJO 1985).

In our area, rañas are glacis-piedmont

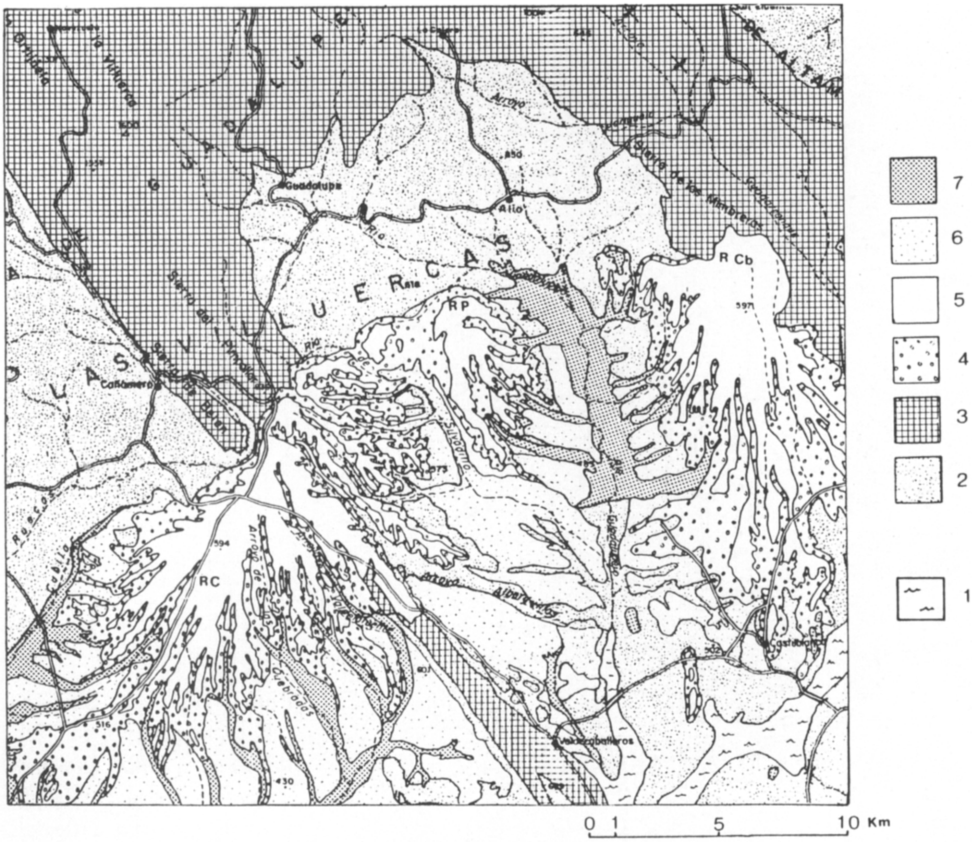

Figure 1: *Geological synthesis of the study area.*
1: Water reservoir; 2: Pre-Cambrian; 3: Paleozoic; 4: Miocene; 5: Raña formations; 6 and 7: Quaternary river deposits.

type of surfaces; they have a North-South direction. Since their sediments overlie the postmiocene erosion surface and not major variations have been observed in the thickness of raña cover, it may be assumed that the general slope of raña formations must be similar to the one of the previous erosion surface (ESPEJO 1978).

The platform of the raña studied break off towards the South into a series of narrow, finger shaped ridges set apart by creek valleys (see photos 1 and 2 and fig.1).

The "Cañamero" raña has the appearance of a big talus cone spreading towards the South; it acts as a divide between the Ruecas and the Silvadillos river basins. Its altitude ranges from 645 m in the North to 515 m in the South and has a general slope gradient of about 0.7 per cent. This platform has, in its broader northern part, several shallow depressions which usually are filled with water in winter and dry in summer.

The "Pinar" raña is placed between

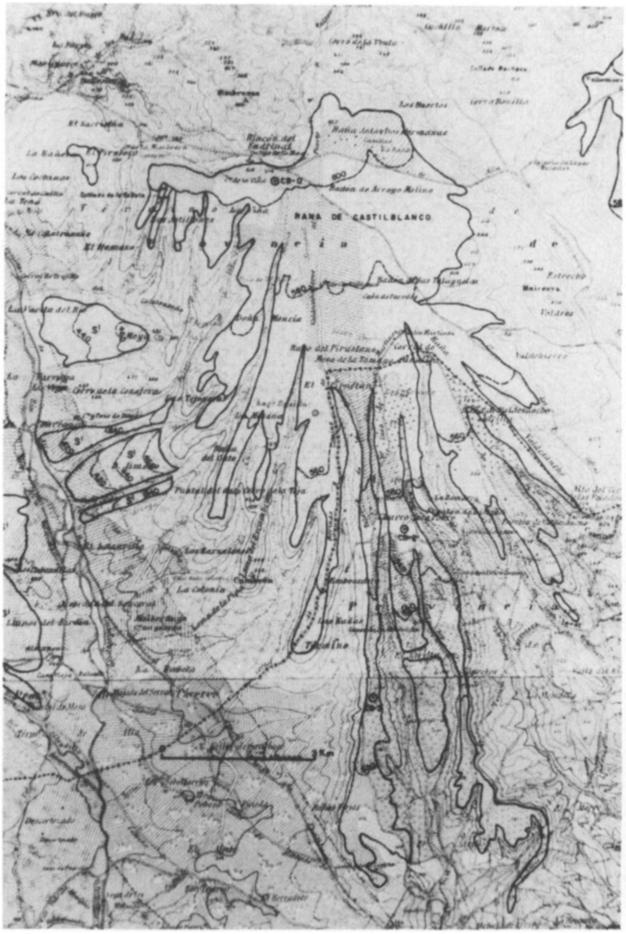

Photo 3: *Map showing the topography of "Castillblanco" raña. The area of raña surface is delineated. Contour interval: 20 m. S': Quaternary deposits of Guadalupejo river.*

the Gaudalupejo and the Silvadillos rivers; this surface appears as a large flat-topped inselberg; it has been carbed by a tributary of the Guadalupejo river. Its altitude ranges from 620 m in the North to 550 m in the South and has a general slope gradient of about 0.9 per cent.

The "Castillblanco" raña is flanked by the Guadalupejo and the Guadarranque rivers. Its altitude ranges fromm 620 m in the North to 500 m in the South and has a general slope gradient of about 0.6 per cent. This raña surface, like the raña of Cañamero, has several shallow depressions. Photo 3 shows the morphology of this raña surface; the general appearance of the broader half North of this surface is shown in the aerial view of photo 4.

3 FIELD AND LABORATORY METHODS

The sites at which the soil profiles were described were chosen according to type

Photo 4: *Aerial view of the broader part of "Castillblanco" raña surface.*

of vegetation and geomorphology. Profile Pinar-1 (P-1) was located in the platform of "Pinar" raña, where the natural vegetation was more close to the arboreal climax. Profile Cañamero-1 (C-1) was placed in the broader part of "Cañamero" raña, in a zone where the natural vegetation had been recently eliminated. Profile Castillblanco-3 (Cb-3) was located in one of the finger shaped ridges which supports an old olive tree orchard; a very close gully was utiliced to description of deepest horizons. Profile Pinar-3 (P-3) was located in a colluvium of the lateral slope in the "Pinar" raña; this slope had been reafforested with *Eucalyptus globulus*.

Standard terminology for describing soil horizons and horizon designation is from F.A.O. (1977) guidelines. Colour for moist specimens was described using Munsell Soil Color Charts (1954). The soil profiles were classified according to "Soil Taxonomy" (1975).

Soil samples were taken to the laboratory where they were air-dried and passed through a 2 mm mesh sieve prior to analyses. Those analyses followed published methods. Particle size distribution was determined by the method of KILMER & ALEXANDER (1949); three particle size determinations were carried out, for the "naturally" dispersed sample (dispersed in water), for the dispersed sample with Na-hexametaphosphate and for the dithionite-treated and Na-hexametaphosphate dispersed sample. Fine clay was separated and determined by centrifugation according to JACKSON (1969). The pH was measured with a glass electrode in both soil-water (1:2.5) and soil-KCl (1M KCl; 1:2.5) suspensions. Organic matter was determined by the method of WALKLEY & BLACK (1934). Cation exchange capacity (CEC) was measured by the NH_4OAc procedure (U.S.D.A. 1972); in the extracts, Na and K were determined by flame emission, Ca and Mg by atomic absorption. Extractable Al was removed with 1N KCl solution and determined according to YUAN (1959). "Free" iron oxides were estimated by dithionite-citrate-bicarbonate extraction (MEHRA & JACKSON 1960); iron in the extracts was measured by atomic absorption. Total iron was also determined by atomic absorption after destruction of silicates with HF (PRATT 1965). Fine sand was separated into light and heavy fractions by bromoform (sp.g. 2.82); mineralogy of each fraction was determined with a petrographic microscope according to PEREZ MATEOS (1965). Clay minerals were identified by X-ray diffraction according to WHITTIG (1965). Micromorphology was observed in thin sections prepared from blocks impregned with a polyester resin.

4 RESULTS AND DISCUSSION

4.1 SOIL PROFILES

4.1.1 Profile Pinar-1 (P-1)

Physiographic location: Platform of "Pinar" raña (39° 24'25"N 5° 14'48"W; elevation 605 mm).

Vegetation: Scrubby vegetation of association *Genisto-Cistetum-ladaniferi*.

Topography: Nearly level, less than 0.5% slope gradient.

A_{u1}: 0–15 cm. Very dark gray (10YR 2.5/1.5); sandy; very weak subangular structure; friable (moist); many very fine, fine and medium roots; 60% by volume of quartzite pebbles less than 2 cm with a black (10YR 2/1) patina; gradual smooth boundary to

A_{u2}: 15–26 cm. Very dark gray (10YR 2.5/1.5); sandy; very weak subangular structure; friable (moist); many very fine, fine and medium roots; 40% by volume of quartzite pebbles less than 2 cm in diameter with a black (10YR 2/1) patina; gradual smooth boundary to

AB: 26–40 cm. Brownish yellow (10YR 5.5/7) with yellowish red zones (5YR 4.5/6) toward lower boundary; sandy loam; weak subangular structure; firm (moist); common fine and medium roots; 20% by volume of quartzite pebbles less than 2 cm in diameter with a yellowish brown (10YR 5/3.5) patina; gradual smooth boundary to

B_{t1}: 40–82 cm. Strong brown (7.5YR 5/7) with a 20% of yellowish red zones (5YR 4/6); clay loam; weak subangular structure; zones of 7.5YR colour are firm (moist) and zones of 5YR colour very firm (moist); few medium roots; 25% by volume of weathered quartzite pebbles less than 3 cm in diameter with a dark red (10R 3/4) core and strong brown (7.5YR 5/7) patina; gradual smooth boundary to

B_{t2}: 82–120 cm. 60% yellow (10YR 7/6) and 40in nearly horizontal bands; sandy clay loam; nearly laminar structure determined by colour segregation; zones ot 5YR colour are very firm (moist) and with many medium and fine pores and zones of 10YR colour are firm (moist); isolated medium roots; 40% by volume of weathered quartzite stones up to 25 cm in diameter with a red (10R 5/7) or dark red (10R 3/4) core and a strong brown (7.5YR 5/7) patina; these weathered quartzites are soft enough to be breakable by hand; gradual smooth boundary to

B_{t3}: 120–150 cm. 80% strong brown (7.5YR 5/7) bands with a dark red (10R 3/4) core and 20% white (10YR 7.5/2) bands in a nearly horizontal distribution; clay; zones of 7.5YR and 10R colour are very firm (moist) and with many pores and zones of 10YR colour are slightly sticky and plastic (moist); nearly laminar structure determined by colour segregation; isolated dead roots; 60% by volume if weathered quartzite stones up to 45 cm in diameter with a red (10YR 5/7) or dark red (10R 3/4) core and a patina which has the same colour segregation than matrix; these quartzite stones are of similar hardness to those of above horizon; gradual smooth boundary to

B_{t4}: 150–180 cm. This horizon has a morphology which only differs from the one of the above horizon in the percentages of colour distribution: 70% strong brown (7.5YR 5/7) bands with a dark red (10YR 3/4) core and 30% white (10YR 7.5/2), and in the percentage and size of weathered quartzite stones: 75% up to 60 cm in diameter; gradual smooth boundary to

B_{t5}: 180–225 cm. This horizon has a morphology which only differs from the one of above horizon in the percentages of colour distribution: 60% strong brown (7.5YR 5/7) bands with a dark red (10R 3/4) core and 40% white (10YR 7.5/2) bands.

4.1.2 Profile Cañamero-1 (C-1).

Physiographic location: Broader part of the platform of “Cañamero” raña (39° 19‘50“N, 5° 14‘48“W, elevation 620 m) .
Vegetation: Rye farm; the scrubby vegetation (an *Halimio-Ericetum-umbellatae* association) had been recently eliminated.
Topography: Nearly level; less than 0.5% slope gradient.

A_p: 0–31 cm. Dark brown (7.5YR 3/4); sandy; vera weak subangular structure; friable (moist); many fine and medium roots; 30% by volume of hard quartzite pebbles less than 2 cm in diameter with a very dark grayish brown (10YR 3/2) patina; gradual smooth boundary to

AB: 31–70 cm. Yellowish brown (10YR 5/8); sandy loam; weak subangular structure; friable (moist); common fine and medium roots; 25% by volume of hard quartzite pebbles less than 2 cm in diameter with a brown (10YR 5/3) patina; gradual smooth boundary to

B_{t1}: 70–99 cm. Yellowish brown (10YR 5/7) with a 20% of red (2.5YR 4/7) zones; sandy clay loam; weak subangular structure; friable (moist) and red zones, firm; isolated fine and medium roots; 45% by volume of weathered quartzite pebbles and blocks up to 25 cm in diameter with a red (10R 4/6) core and a yellowish (10YR 7/8) patina; these weathered quartzite stones are soft enough to be breakable by hand; gradual smooth boundary to

B_{t2}: 99–180 cm. 70% yellowish red (5YR 4/7) and red (10R 3/6) bands and 30% white (10YR 7.5/2) bands in a nearly horizontal distribution; clay; zones of 5YR and 10R colours are very firm (moist) and have many medium and fine pores; zones of 10YR colour are slightly sticky and plastic; few medium roots, most of them dead; 75% by volume of weathered quartzite stones up to 50 cm in diameter with a red (10R 4/6) core and a patina which has the same colour segregation than matrix.

4.1.3 Profile Castillblanco-3 (Cb-3)

Physiographic location: Flat topped finger-shaped ridge of platform of “Castillblanco” raña (39° 19‘20“N, 5° 5‘58“W, elevation 520 m)
Vegetation: Old olive tree orchard
Topography: Nearly level; less than 0,5% of slope gradient.

A_p: 0–18 cm. Dark reddish brown (5YR 3/2); sandy; weak subangular structure; slightly hard (dry); many very fine, fine and medium roots; 50% by volume of hard quartzite pebbles less than 3 cm in diameter with a dark brown (7.5YR 3/2) patina; gradual smooth boundary to

AB: 18–38 cm. Yellowish red (5YR 3.5/6); sandy loam; weak subangular structure; slightly hard (dry); common fine and medium roots; 30% by volume of hard quartzite pebbles similar to those of above horizon; toward lower boundary appear soft, weathered quartzite pebbles up to 5 cm in diameter with a red (10R 5/7) core and a brownish yellow (10YR 6/7) patina; net boundary (by colour changes) to

B_{t1}: 38–59 cm. Brownish yellow (10YR 6/7); clay loam; weak subangular structure; slightly hard (dry); common fine, medium and coarse roots; 40% by volume of soft, weathered quartzite pebbles up to 7 cm in diameter with a red (10R 5/7) core and a brownish yellow (10YR 6/7) patina; gradual smooth boundary to

B_{t2}: 59–114 cm. 60% yellowish red (5YR 5/7) bands and 40% reddish yellow (7.5YR 6/7) in a nearly horizontal distribution; toward the lower boundary, the 5YR bands have a red (10YR 5/7) core; clay loam; nearly laminar structure determined by colour segregation; bands of 5YR colour are hard (dry) and with common pores and bands of 7.5YR are slightly hard (dry ; isolated coarse and medium roots; 70% by volume of soft, weathered quartzite pebbles and blocks up to 25 cm in diameter, with a red (10R 4/6) or light red (10R 6/7) core and a patina which has the same colour segregation than matrix; gradual smooth boundary to

B_{t3}: 114–180 cm. 70% yellowish red (5YR 5/7 bands with red (10R 5/7) core and 30% reddish yellow (7.5YR 6/7) bands in a nearly horizontal distribution; clay loam; nearly laminar structure determined by colour segregation; bands of 5YR and 10R colours are hard to very hard (dry) and have many pores and channels; bands of 7.5YR colour are slightly hard (dry); isolated dead roots; 80% by volume of soft, weahtered quartzite blocks up to 40 cm in diameter similar to those of above horizon. The morphology of deeper horizons was taken from a very close big gully.

B_{t4}: 180–600 cm. White (10YR 8/1), red (10R 4/7) and yellow (10YR 7/7) bands in a nearly horizontal distribution; these colour segregations are continuous through matrix and weathered quartzite blocks; clay to clay loam; structure, determined by colour segregation; the bands of 10R colour are very hard (dry) and have many pores; the bands of 10YR 7/7 colour are hard (dry) and the bands of 10YR 8/1 colour are slightly hard (dry); isolated dead roots which disappear below 400 cm; 80% by volume of weathered quartzite blocks up to 40 cm in diameter; abrupt boundary to

2BC: 600–900 cm. Variegated red (10R 4/6), pale red (10R 3/6) and white (10YR 8/1) colours; silty clay loam; frequent cylindric channels of 1–5 cm in diameter filled with a white (10YR 8/1) material; moderate coarse prismatic structure; the zones of 10R 4/6 and 10R 6/3 colours are hard (dry) whereas the zones of 10YR colour are slightly hard; clay coats are common in the white material of channels; gradual smooth boundary to

3C: 900–3000 cm. Psammo-pellitic material with intercalated levels of coarse sand; the colour ranges from weak red (10R 5/3) in the upper part to reddish yellow (7.5YR 6/7) toward the lower boundary.

4.1.4 Profile Pinar-3 (P-3)

Physiographic location: Colluvium of lateral slope of "Pinar" raña; (39°21'10"N, 5°13'53"W; altitude 480 m)
Vegetation: This slope had been reafforested with *Eucalyptus globulus*
Topography: The general slope gradient is about 45%; local slope gradient is 10%.

A_h: 0–15 cm. Yellowish red (5YR 3/5); sandy; weak subangular block structure; soft (dry); many fine and medium roots; 10% by volume of hard quartzite pebbles less than 8 cm in diameter; frequently, these quartzitic pebbles have a red (10R 4/6) core; gradual smooth boundary to

AE: 15–30 cm. Reddish yellow (5YR 6/7 → 7.5YR); sandy; weak subangular structure; soft (dry); many fine and medium roots; 10% by volume of quartzite pebbles similar to those of above horizon; abrupt boundary to

B_t: 30–75 cm. Dark red (2.5YR 3.5/6 → 10R); clay loam; moderate subangular structure; hard (dry); many fine and medium roots; 25% by volume of quartzite pebbles which are similar to those of above horizon; clear to gradual boundary to

2C: 75–105 cm. Light gray (2.5Y 7/1) with olive yellow (2.5Y 6/6) mottles; silty clay; weak subangular blocky structure; slightly hard (dry); common fine and medium roots; without stones.

4.2 SOIL MICROMORPHOLOGY

The most relevant micromorphological feature is the absence of features related to clay illuviation in the B horizons for the upper 100 cm of the profiles of raña platforms. Clear evidence of clay illuviation only appears at a depth below 150 cm, where there are frequent papules and voids covered by argillans. The papules appear very distorted, with frequent cracks filled with a mass rich in iron oxides; these papules may be even observed to depths down to 500 cm.

At depths from 100 to 150 cm there appear some isolated very small papules, presumably being desintegrated into the soil matrix.

Photos 5 and 6 show papules at 225 cm (P-1) and 425 cm (Cb-3).

4.3 PHYSICAL, CHEMICAL AND MINERALOGICAL PROPERTIES

Data for fine earth are given in four tables. Particle size distribution is given in tab.1; pH, cation exchange capacity exchangeable bases, base saturation, extractable Al and organic matter contents are given in tab.2; extractable and total iron, both expressed as oxides and fine sand mineralogy, are given in tab.3; minerals in the clay fraction are listed in tab.4. Data refering to iron oxides content and clay mineralogy for weathered quartzites are given in tab.5.

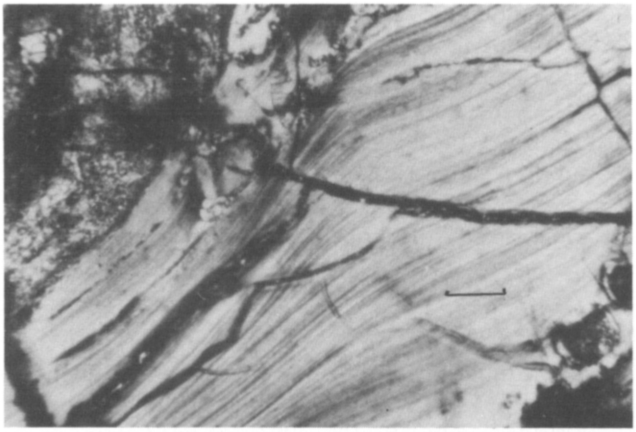

Photo 5: *Detail of papule at 225 cm in P-1 profile showing cracks filled with iron oxides. Escale length 0.33 mm..*

Photo 6: *Detail of a distorted papule at 425 cm in Cb-3 profile. Escale length 0.33 mm.*

Tab.1 shows for all profiles an increase in clay contents with depth, in particular for the fine clay fraction; the ratio fine clay/total clay increases with depth. Data refering to horizons with iron oxide segregations suggest that this segregation occurred after the clay illuviation process; this is supported by the fact that clay content in samples not treated with dithionite is lower in the zones with iron oxides accumulations than in zones without iron oxides (see columns II and III of clay in tab.1). In profiles developed on slope colluviums there is an abrupt textural boundary between the A and the B horizons which is not observed in the older profiles of raña platforms. There is a lithological discontinuity between the raña materials and the miocene sediments as deduced from their different contents in silt and coarse sand.

Tab.2 shows that the pH values decrease with depth. The organic matter is related to the type of vegetation cover, corresponding the highest values to the profile in which vegetation is less altered (P-1) and the lowest to the profile which supports the old olive farm (Cb-3). The increase of extractable Al and decrease of pH value corresponds to a decrease in the percentage of water dispersed clay (see column I of clay in tab.1).

Data referring to free and total iron oxide contents (tab.3), show that in horizons with colour segregation, the white zones have the lowest content, whereas the red or yellow zones have the highest content. The fine sand mineralogy shows a great uniformity, with quartz and muscovite in the light fraction and zircon, rutile and tourmaline in the heavy fraction; all these minerals are very resistant to weathering.

The clay mineralogy (tab.4) is according to data refering to cation exchange capacity (see tab.2). In all horizons of soils developed on raña sediments the dominant clay mineral is kaolinite, the content of which increases with depth. The kaolinite has a high degree of cristallinity (data not shown) which might indicate an **in situ** neoformation. In the underlying Miocene sediments the dominant clay mineral is illite except for the uppermost 2–3 m that correspond to the buried paleosol, where kaolinite is dominant.

4.4 POST-DEPOSITIONAL WEATHERING OF THE RAÑA MATERIALS

The raña sediments have undergone strong changes since they were deposited. These changes have affected not only the fine matrix (weathering of the primary minerals, clay neoformation and illuviation, etc.) but also the pebbles and blocks. All the rock fragment less resistant to weathering than quartzite, that were very frequent in the source area (as shales or greywackes) and presumably present in the parent material of raña soils, have disappeared.

The quartzite stones are variegated, with red, yellow and white colours. These colours follow the same pattern than those of the surrounding soil matrix and there are not discontinuity between stone and matrix (fig.2). In all cases, the core of the stones is red or pale red.

Photo 7 shows the corroded surface of a quartz grain in a weathered quartzite. Because of dissolution of silice, the quartzites have become soft, crumbly and permeable; this seems to be the reason why the iron oxides distribution affects equally the matrix and the skeleton. Thus the quartzites appear as a ferruginous sandstone.

The colour of weathered quartzite stones is related to the amount and type of iron oxides (tab.5): The yellow colour is due to the presence of goethite; the red and pale red colours are caused by hemathite; the white colour is due to the absence of pigments (iron oxides).

In the upper 50 cm of the profiles of raña platforms, only small quartzitic pebbles may be found (see profile descriptionms); these pebbles have a black patina which has an high content of free iron oxides (see tab.5) and which are very hard. In Spain, these black pebbles are exclusive of raña formations (ESPEJO 1978, 1986).

The strong degree of weathering of coarse elements in rañas, could explain the absence of raña formations associated with limestonic or granitic mountain ranges: the granitic or calcareous pebbles would have been destroyed and incorporated into the matrix. Consequently, the lack of coarse elements in these case would have precluded an efficient protection against erosive action of the river system at the time when the rivers began to entrench on these sur-

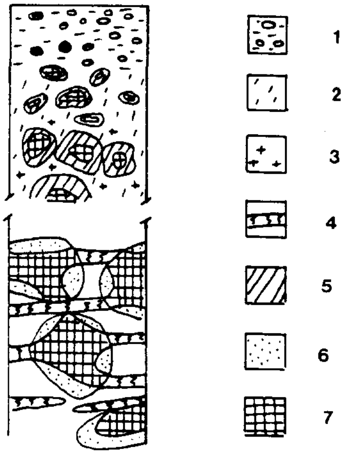

Figure 2: *Distribution of colours in matrix and weathered quartzite stones in raña soils.*

1. Epipedon with a black patinaed pebbles;
2. 10YR 5/7, 7.5YR 5/7 or 5YR 5/7 matrix;
3. 5YR 4/6 mottles;
4. 5YR 4/6 to 5/7 plus 10R 3/6 to 5/7 bands;
5. 10YR 5/7 to 7/6 or 7.5YR 5/7 to 7/6 quartzite patina;
6. 10YR 8/1 quartzite patina;
7. 10R 4/6 to 6/7 quartzite cores.

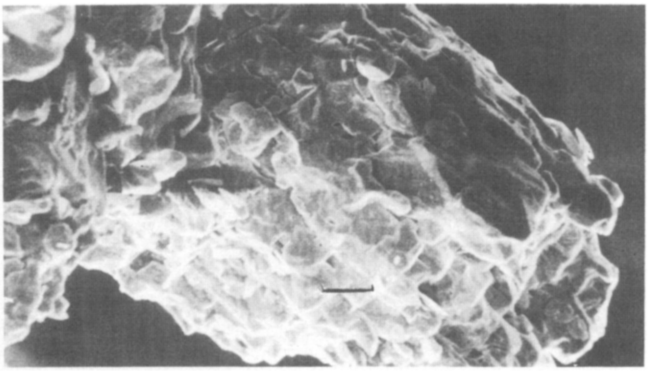

Photo 7: *Corroded surface of a quartz grain in a weathered raña quartzite.*
Escale length 0.0133 mm.

faces. In quartzitic areas, the quartzite blocks, although very weathered, gave a high resistance to the erosion of these formations during the Quaternary.

4.5 CLASSIFICATION OF THE PROFILES

According to "Soil Taxonomy" (USDA 1975), the epipedons of the soil profiles below a scrubby vegetation (P-1) or of those in which natural vegetation has been recently eliminated (C-1) fulfill the requirements of an umbric epipedon. In other soils such as those cultivated for a long time (Cb-3) or those in the reafforested slope colluvium (Cb-3), the epipedons are ochric.

The B horizons show a clay content higher than that of the epipedons; therefore they could be tentatively classified as argillic horizons. However only below a depth of about 150 cm there is micromorphological evidence of clay illuviation (argillans or papules). Consequently, these B horizons can only be classified as argillic because they have a fine/total clay ratio that increases with depth (tab.1). This lack of micromorphological evidence is a common feature in very old and weathered soils of subtropical and tropical areas (ROQUERO 1982, ISBELL 1983).

All the soil profiles studied can be clas-

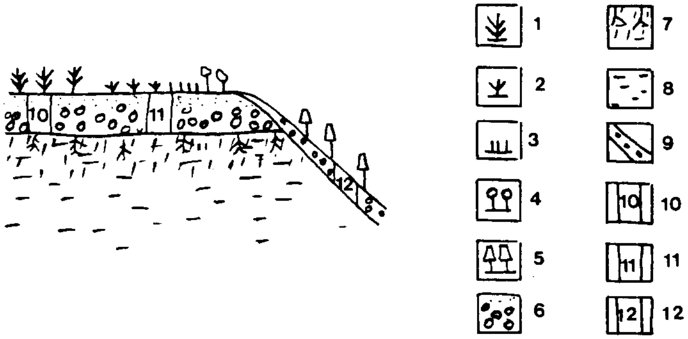

Figure 3: *Relation between soils, vegetation and physiographic location.*
1. *Genisto-Cistetum ladaniferi* scrub association; 2. *Halimio-Ericetum umbellatae* scrub association; 3. Rye farm; 4. Olive farm; 5. Reafforested with *Eucalyptus globulus* slope; 6. Raña sediments; 7. Pre-raña paleosol; 8. Miocenic sediments; 9. Slope colluvium; 10. Xeric Palehumults soils; 11. Palexerults (Humic plus Typic Palexerults); 12. Palexerults (Rhodic Palexerults plus Abruptic Rhodoxerults).

sified as Ultisols on account of their low base saturation at a depth of 1.80 m or just above a paralithic contact. Where natural vegetation has been in general preserved, the organic matter content of the epipedon is high and the soil is classified as a Humult (P-1). Otherwise the soils are Xerults because of their xeric hydric regime. At the great group level the soils are Palehumults or Palexerults due to the thickness of the argillic horizons and low content in weatherable minerals (soils of raña platforms) or to the abrupt boundary between A and B horizons and low content in weatherable minerals (soils of slope colluvium).

The P-3 profile, developed on the slope colluvium has a hue redder than 5YR in its argillic horizon. Because no "rhodic" greatgroup exists in "Soil Taxonomy" for the Xerults it cannot be classified as a hypotetical "Rhodoxerult".

The Xerults suborder is poorly developed in "Soil Taxonomy"; consequently subgroups have not yet been established for the Palexerults great group.

The plinthic-like segregation observed in the soils of the raña platforms do not fulfill the requirements for plinthite (irreversible hardening when dry) and can only be referred to as pseudoplinthite (SOMBROEK, personal communication, 1984).

Fig.3 shows a synthesis of soils distribution in the raña formations studied, according to vegetation and physiographic location; in brackets appear the hypothetical groups and subgroups which would may established if we apply the criteria of "Soil Taxonomy" for other close to Xerults suborders.

4.6 AGE OF RAÑA FORMATIONS

It is difficult to assign an absolute age to the rañas as pointed out by ESPEJO (1978). Only in the "Campo de Calatrava" (Central Spain), raña formations have been dated by MOLINA (1975) according to the K/Ar procedure applied to related volcanic lavas; their age ranges from 4.7 ± 0.7 to $3.2 \pm 0.2 \times 10^6$ years.

In our area the upper limit for the age of the rañas can be established on the basis of geomorphology, weathering status and soil morphology criteria.

Horizon	Depth (cm)	Particle size distribution (%)														Fine clay	Water disp. clay	Clay
		coarse sand (2–0.2 mm)			fine sand (0.2–0.02 mm)			silt (0.02–0.002 mm)			clay (<0.002 mm)			fine clay (<0.0002 mm)		Total clay	I / II × 100	Silt
		I	II	III	I	II	III	I	II	III	I	II	III	II	III	II		II
Profile Cañamero-1																		
A_p	0–31	24.0	22.5	21.0	64.5	62.0	61.0	5.0	6.0	9.0	6.5	8.5	10.0	1.5	2.0	0.17	76.0	1.40
AB-BA	31–50	16.5	13.5	14.0	67.5	60.0	60.0	6.5	8.0	10.5	9.5	16.0	18.0	6.5	8.5	0.40	59.4	2.00
AB-BA	50–70	15.0	12.0	11.0	72.5	53.5	51.5	6.0	9.5	11.0	6.5	26.0	26.5	14.0	17.0	0.53	25.0	2.70
B_{t1}	70–99	11.0	7.2	6.5	82.0	35.8	31.0	5.0	8.0	10.5	2.0	47.5	50.0	30.0	35.5	0.63	4.2	5.90
B_{t2}	99–180	13.5	8.1	7.0	82.5	32.0	29.0	3.5	8.5	9.5	0.5	50.0	53.0	35.4	39.0	0.70	1.0	5.80
B_{t3}	180–200	12.0	9.5	8.0	86.5	38.0	34.5	1.5	7.0	8.0	0.0	44.0	49.0	26.0	30.0	0.59	0.0	6.20
Profile Pinar-1																		
A_{h1}	0–15	23.5	22.0	17.0	69.5	65.5	68.5	5.0	9.0	10.0	2.5	4.5	5.0	tr.	tr.	-	55.5	0.50
A_{h2}	15–26	21.5	14.0	13.5	70.0	66.0	70.0	6.5	12.0	12.5	3.0	5.0	5.5	tr.	tr.	-	60.0	0.44
AB	26–40	14.0	13.0	9.6	71.0	62.0	63.0	9.0	10.0	10.0	5.5	17.0	17.5	2.0	3.5	0.12	34.3	1.75
B_{t1}	40–82	15.0	11.0	9.5	71.5	57.0	51.1	8.0	12.0	13.0	6.0	25.0	27.0	12.0	14.5	0.48	24.0	2.20
B_{t2}	82–120	16.0	13.0	11.0	78.5	48.0	43.0	4.0	9.5	11.0	2.5	30.0	35.0	16.0	19.8	0.53	8.3	3.18
B_{t3}	120–150	19.0	16.0	12.0	77.0	47.0	34.0	3.0	9.0	10.5	1.8	31.5	43.5	22.5	32.5	0.71	5.7	4.10
B_{t4}	150–180																	
	–(1)	15.0	13.0	12.0	72.0	41.0	33.0	3.0	5.5	9.5	0.5	41.0	46.0	n.d.	n.d.	-	1.2	4.80
	–(2)	26.0	18.0	11.5	70.0	46.0	35.0	2.5	5.0	9.0	1.5	30.0	43.0	n.d.	n.d.	-	5.0	4.70
	–(3)	21.0	16.0	10.0	75.0	44.0	39.0	3.0	6.0	8.0	1.0	35.5	44.0	26.0	34.0	0.71	2.8	5.50
B_{t5}	180–225																	
	–(1)	12.0	10.0	9.0	82.0	23.0	21.5	1.0	6.5	9.0	0.0	60.0	61.0	35.5	37.0	0.50	0.0	6.70
	–(2)	30.0	13.0	10.5	70.0	36.0	17.0	1.5	6.0	10.5	0.0	45.0	60.5	30.0	44.5	0.66	0.0	5.80
	–(3)	10.0	9.5	8.0	90.0	33.5	20.0	2.0	8.0	8.5	0.0	49.0	63.0	24.5	38.0	0.50	0.0	7.40
Profile Pinar-3																		
A_h	0–15	25.6	24.2	23.5	50.0	48.8	45.2	21.0	20.0	25.0	3.5	4.9	4.7	tr.	tr.	-	71.4	0.24
AE	15–30	27.5	25.0	23.0	50.0	48.3	47.6	19.5	21.0	23.5	3.0	4.8	5.0	tr.	tr.	-	62.5	0.18
B_t	30–75	11.5	11.0	9.5	43.9	18.8	18.0	31.0	15.0	13.0	13.6	56.5	59.0	30.0	32.5	0.53	24.0	3.70
2C	75–105	3.2	2.0	1.8	46.8	12.5	11.6	36.5	31.0	28.0	16.7	55.0	57.5	13.5	12.0	0.24	30.3	1.70
Profile Castillblanco-3																		
A_p	0–18	13.5	12.0	10.0	62.0	63.5	60.5	18.0	17.0	19.0	6.5	10.0	10.5	1.8	2.3	0.18	65.0	0.58
AB	18–38	13.3	13.0	10.0	61.2	60.0	56.0	17.5	19.0	21.0	9.0	12.0	13.0	2.5	3.0	0.20	75.0	0.63
B_{t1}	38–59	14.0	12.0	9.5	60.0	51.5	46.5	14.0	13.0	14.5	12.0	25.0	31.0	12.0	17.0	0.48	48.0	1.92
B_{t2}	59–114	14.5	9.0	8.0	66.5	55.0	30.0	11.0	12.0	16.5	8.0	40.0	44.0	22.0	26.0	0.55	20.0	3.30
B_{t3}	114–180	18.0	15.0	11.0	73.5	43.0	36.0	7.0	8.0	13.0	1.5	34.0	38.0	20.5	25.4	0.60	4.4	4.25
B_{t4}	225	17.0	14.0	10.0	72.8	46.0	39.0	9.0	6.5	11.0	1.2	37.0	41.0	22.0	26.0	0.59	1.2	5.69
	260	12.0	9.0	6.5	80.0	38.0	34.0	7.5	8.5	9.6	0.5	48.0	51.5	24.5	30.0	0.51	1.0	5.64
	300(1)	13.5	9.0	9.0	79.5	23.0	30.0	6.0	7.0	8.5	1.0	52.0	54.0	28.0	30.0	0.53	1.9	7.42
	300(2)	19.9	12.0	10.0	76.0	40.0	26.4	4.5	9.0	10.6	0.5	40.0	51.5	23.0	27.6	0.52	1.2	4.44
	450(1)	15.0	9.0	10.5	79.0	34.0	32.5	6.0	7.5	7.0	0.0	49.5	52.5	20.0	21.5	0.40	0.0	6.60
	450(2)	26.0	16.5	8.5	68.5	16.0	23.0	5.5	9.0	18.2	0.0	40.0	50.8	18.0	23.0	0.45	0.0	4.44
	600	14.2	7.0	5.0	81.3	30.0	24.0	4.0	11.0	14.0	0.5	48.0	55.0	20.0	28.5	0.41	1.0	4.36
28_tC	600–800	5.0	3.0	1.5	85.0	24.0	20.0	6.5	35.0	34.0	3.5	36.0	39.0	15.0	18.5	0.41	9.7	1.02
3C	1200	17.0	11.5	7.0	58.0	26.0	29.5	15.0	30.0	32.5	12.0	38.0	43.0	6.0	8.0	0.15	31.5	1.26
aC	2500	6.0	4.5	3.5	44.0	30.0	26.0	30.0	31.0	34.0	20.0	33.0	36.5	4.0	6.5	0.12	52.6	1.16

I: Water-dispersed sample; II: Na-hexametaphosphate dispersed sample; III: Na-Hexametaphosphate dispersed sample without free iron oxides
(1), (2), (3), refer to "pseudoplinthic" areas (see profile descriptions): (1): white bands; (2): 5YR 4/6 to 5/7 plus 10R 3/6 to 5/7 bands;
(3): bulk sample
tr.: traces; n.d.: not determined

Table 1: *Particle size distribution of the raña soils and the underlying miocenic sediments.*

Horizon	Depth (cm)	pH (1:2.5)		C.E.C.*		Exch. bases (meq./100 g soil)				V**	Extract. Al (meq./100 g) soil	Organic matter (%)
		H_2O	ClK	meq./100 g soil	meq./100 g clay	Ca	Mg	K	Na			
Profile Cañamero-1												
A_p	0–31	5.10	4.20	11.4	30.5	1.32	0.40	0.08	0.10	16.6	1.00	4.40
AB-BA	31–50	5.30	4.10	6.3	27.5	0.65	0.15	0.05	0.04	14.1	1.20	0.95
AB-BA	50–70	5.20	3.95	7.5	25.4	0.90	0.08	0.06	0.05	14.5	1.60	0.45
B_{t1}	70–99	5.10	3.75	10.5	22.1	0.95	0.09	0.03	0.07	10.8	3.50	0.20
B_{t2}	99–180	4.80	3.65	11.0	22.0	0.50	0.07	0.03	0.04	5.8	5.50	0.15
B_{t2}	180–200	4.60	3.55	9.5	21.6	0.45	0.05	0.03	0.03	5.9	5.60	tr.
Profile Pinar-1												
A_{h1}	0–15	4.95	3.90	18.6	24.4	2.25	0.60	0.10	0.50	19.2	1.10	8.70
A_{h2}	15–26	4.95	4.25	24.0	20.0	1.15	0.50	0.15	0.30	8.7	1.10	11.50
AB	26–40	4.90	4.20	6.0	25.4	0.50	0.20	0.08	0.18	16.0	1.60	0.84
B_{t1}	40–82	4.90	4.00	7.5	27.2	0.25	0.28	0.06	0.17	10.1	2.30	0.35
B_{t2}	82–120	4.70	3.90	8.0	24.6	0.40	0.18	0.04	0.20	10.2	3.60	0.25
B_{t3}	120–150	4.70	3.90	8.5	25.4	0.40	0.16	0.03	0.18	9.1	5.20	0.10
B_{t4}	150–180(3)	4.60	3.70	8.0	22.5	0.40	0.16	0.02	0.20	10.0	5.80	tr.
B_{t5}	180–225											
	–(1)	4.55	3.65	12.5	20.8	0.30	0.14	0.02	0.10	4.5	8.50	tr.
	–(2)	4.65	3.90	10.6	23.6	0.30	0.13	0.01	0.05	5.1	6.40	tr.
	–(3)	4.60	3.75	11.5	23.4	0.27	0.12	0.02	0.05	4.0	7.70	tr.
Profile Pinar-3												
A_h	0–15	5.75	5.15	7.3	27.6	2.90	1.30	0.46	0.10	65.2	0.50	3.00
AE	15–30	5.05	4.20	5.0	33.3	0.70	0.55	0.15	0.05	29.0	1.00	1.70
B_t	30–75	4.80	3.65	14.6	25.8	1.70	0.90	0.10	0.15	18.8	9.00	tr.
2C	75–105	4.55	3.45	34.0	61.8	2.10	3.55	0.25	1.00	20.3	8.00	tr.
Profile Castillblanco-3												
A_p	0–18	6.37	5.25	5.8	28.0	3.40	1.04	0.50	0.27	90.8	0.10	1.50
AB	18–38	5.90	4.55	4.2	25.0	1.90	0.45	0.15	0.10	61.9	0.65	0.60
B_{t1}	38–59	5.15	3.85	6.2	23.0	0.90	0.80	0.18	0.10	31.6	1.80	0.25
B_{t2}	59–114	4.85	3.70	8.7	21.2	0.45	1.60	0.20	0.08	26.7	3.00	0.10
B_{t3}	114–180	4.80	3.70	7.5	22.0	0.30	1.00	0.08	0.07	19.3	4.00	tr.
B_{t4}	225	4.70	3.60	8.7	23.6	0.55	1.15	0.07	0.15	21.9	5.00	tr.
	260	4.50	3.60	11.3	23.5	0.30	1.40	0.05	0.10	16.3	6.00	tr.
	300(1)	4.60	3.55	10.5	20.2	0.55	1.12	0.12	0.20	18.9	6.00	tr.
	300(2)	4.75	3.60	9.0	22.5	0.50	0.98	0.10	0.15	19.2	5.00	tr.
	450(1)	4.50	3.60	10.8	21.8	0.72	1.15	0.10	0.30	21.0	6.50	tr.
	450(2)	4.80	3.65	9.1	22.7	0.65	1.02	0.08	0.25	21.9	5.00	tr.
	600	5.10	3.75	12.5	26.0	1.26	2.10	0.15	0.40	31.2	4.50	tr.
28_tC	600–800	5.00	3.60	10.5	29.1	1.18	2.30	0.19	0.40	38.7	3.50	tr.
3C	1200	5.10	3.95	19.8	52.1	2.80	3.65	0.47	0.35	36.7	1.00	tr.
4C	2500	5.75	4.80	26.0	78.0	3.15	7.51	0.90	0.70	59.2	0.40	tr.

*: Cation exchange capacity

**: Base saturation

(1), (2), (3), refer to "pseudoplinthic" areas (see profile descriptions): (1): white bands; (2): 5YR 4/6 to 5/7 plus 10R 3/6 to 5/7 bands; (3): bulk sample

tr. traces

Table 2: *Chemical characteristics of the raña soils and the underlying miocenic sediments.*

Horizon	Depth (cm)	Fine earth (< 2 mm)			Fine sand						
		Fe_2O_3(f) (%)	Fe_2O_3(t) (%)	Fe_2O_3(f)/Fe_2O_3(t)	non opaque heavy fraction (%)				light fraction (%)		
					Zircon	Rutile	Tourmaline	Other	Quartz	Muscovite	Other
Profile Cañamero-1											
A_p	0–31	1.75	2.10	0.83	72	20	6	-	97	3	-
AB-BA	31–50	3.20	4.50	0.71	73	22	5	-	96	4	-
AB-BA	50–70	4.50	5.70	0.79	69	23	6	1z,1e	98	2	-
$B_{t}1$	70–99	6.60	7.30	0.90	66	22	10	2e	96	4	-
$B_{t}2$	99–180	7.55	8.20	0.92	68	20	9	1z,2e	97	3	-
$B_{t}2$	180–200	7.00	8.30	0.84	70	21	8	1e	96	4	-
Profile Pinar-1											
$A_{h}1$	0–15	1.70	2.80	0.60	74	18	7	1e	97	3	-
$A_{h}2$	15–26	2.10	3.10	0.67	76	14	9	1z	99	1	-
AB	26–40	4.10	5.00	0.80	83	10	5	2z	96	4	-
$B_{t}1$	40–82	6.40	6.90	0.92	75	15	6	2z,2e	98	2	-
$B_{t}2$	82–120	6.80	7.60	0.89	76	12	9	2z,1e	99	1	-
$B_{t}3$	120–150	5.50	6.10	0.90	81	9	6	1z,2e	98	2	-
$B_{t}4$	150–180(3)	6.00	7.50	0.80	77	11	10	1z,1e	97	3	-
$B_{t}5$	180–225										
	–(1)	0.75	0.98	0.76	80	12	7	1z,1e	96	4	-
	–(2)	16.70	18.60	0.89	76	10	12	1z,1e	97	3	-
	–(3)	10.50	11.30	0.89	82	8	10	-	97	3	-
Profile Pinar-3											
A_h	0–15	1.12	1.80	0.62	60	30	10	-	96	4	-
AE	15–30	1.12	2.00	0.56	62	28	10	-	96	4	-
B_t	30–75	3.50	4.90	0.71	72	15	12	1e	97	3	-
2C	75–105	1.80	2.10	0.81	80	15	5	-	96	4	-
Profile Castillblanco-3											
A_p	0–18	2.40	3.10	0.77	75	15	9	1e	97	3	-
AB	18–38	3.20	4.80	0.66	70	25	5	-	98	2	-
$B_{t}1$	38–59	4.10	5.30	0.77	80	14	6	-	99	1	-
$B_{t}2$	59–114	7.45	8.70	0.85	77	14	7	2z	96	4	-
$B_{t}3$	114–180	7.25	8.70	0.85	76	12	10	1z,1e	97	3	-
$B_{t}4$	225	6.70	7.80	0.86	83	10	6	1z	98	2	-
	260	6.50	7.65	0.85	81	11	7	1e	97	3	-
	300(1)	0.50	0.65	0.77	78	12	8	2e	97	3	-
	300(2)	11.95	13.10	0.91	78	14	6	1z,1e	96	4	-
	450(1)	0.80	1.15	0.69	76	16	7	1e	96	4	-
	450(2)	11.40	14.20	0.80	74	10	14	1z,1e	98	2	-
	600	7.85	9.10	0.85	73	12	15	-	98	2	-
$28_{t}C$	600–800	3.60	4.35	0.82	64	22	14	-	96	4	-
3C	1200	4.10	4.50	0.91	66	18	15	1e	96	4	-
4C	2500	3.10	4.80	0.64	70	13	17	-	97	3	-

(f): "Free" Fe-oxides
(t): Total Fe-oxides
(1), (2), (3), refer to "pseudoplinthic" areas (see profile descriptions); (1): white bands, (2): 5YR 4/6 to 5/7 plus 10R 3/6 to 5/7 bands; (3): bulk sample
e: epidote; z: zoisite

Table 3: *"Free" and total Fe-oxides and fine sand mineralogy of the raña soils and the underlying miocenic sediments.*

Horizon	Depth (cm)	Kaolinite	Illite-mica	Chlorite	Smectite groups	Quartz	Goethite	Hematite
Profile Cañamero-1								
A_p	0–31	xx	x	x	n.p.	n.p.	tr.	n.p.
AB-BA	31–50	xx	x	x	n.p.	n.p.	tr.	n.p.
AB-BA	50–70	xxx	x	x	n.p.	n.p.	x	n.p.
B_{t1}	70–99	xxx	x	tr.	n.p.	n.p.	x	n.p.
B_{t2}	99–180	xxx	x	tr.	n.p.	n.p.	x	n.p.
B_{t2}	180–200	xxx	x	n.p.	n.p.	n.p.	xx	tr.
Profile Pinar-1								
AB	26–40	xx	x	x	n.p.	n.p.	tr.	n.p.
B_{t1}	40–82	xxx	x	x	n.p.	n.p.	tr.	n.p.
B_{t2}	82–120	xxx	x	tr.	n.p.	n.p.	x	n.p.
B_{t3}	120–150	xxx	x	tr.	n.p.	n.p.	xx	n.p.
B_{t4}	150–180(3)	xxx	x	n.p.	n.p.	n.p.	xx	n.p.
B_{t5}	180–225							
	–(1)	xxx	tr.	n.p.	n.p.	n.p.	n.p.	n.p.
	–(2)	xxx	tr.	n.p.	n.p.	n.p.	xx	x
	–(3)	xxx	tr.	n.p.	n.p.	n.p.	xx	tr.
	–(2)*	xxx	n.p.	n.p.	n.p.	n.p.	tr.	n.p.
	–(3)*	xxx	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Profile Pinar-3								
A_h	0–15	xx	xx	n.p.	n.p.	tr.	n.p.	n.p.
AE	15–30	xx	xx	n.p.	n.p.	tr.	n.p.	n.p.
B_t	30–75	xx	xx	n.p.	n.p.	n.p.	n.p.	n.p.
2C	75–105	x	x	n.p.	xx	n.p.	n.p.	n.p.
Profile Castillblanco-3								
AB	18–38	xx	x	tr.	n.p.	n.p.	n.p.	n.p.
B_{t1}	38–59	xxx	x	tr.	n.p.	n.p.	tr.	n.p.
B_{t2}	59–114	xxx	x	n.p.	n.p.	n.p.	x	n.p.
B_{t3}	114–180	xxx	x	n.p.	n.p.	n.p.	x	n.p.
B_{t4}	225	xxx	x	n.p.	n.p.	n.p.	x	n.p.
	300(1)	xxx	x	n.p.	n.p.	n.p.	n.p.	n.p.
	300(2)	xxx	X	n.p.	n.p.	n.p.	xx	x
	450(1)	xxx	x	n.p.	n.p.	tr.	n.p.	n.p.
	450(2)	xxx	x	n.p.	n.p.	tr.	xxx	tr.
	600	xxx	x	n.p.	n.p.	tr.	xx	tr.
28_tC	600–800	xx	xx	n.p.	n.p.	x	x	n.p.
3C	1200	x	xxx	n.p.	xx	tr.	n.p.	n.p.
4C	2500	x	xxx	n.p.	xx	x	n.p.	n.p.

x, xx, xxx mean, respectively: small, moderate and high contents
(1), (2), (3), refer to "pseudoplinthic" areas (see profile descriptions), (1): white bands;
(2): 5YR 4/6 to 5/7 plus 10R 3/6 to 5/7 bands; (3): bulk sample
()*: refers to fine clay
n.p. not present

Table 4: *Clay minerals in the horizons of the raña soils from X-ray diffraction data.*

Horizon	Depth (cm)	Patina or core colour	Fe_2O_3(f) (%)	Kaolinite	Illite	Chlorite	Smectite groupe	Quartz	Goethite	Hematite
Profile Pinar-1										
A_{u1}	0–15	10YR 2/1 patina	10.25	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
B_{t2}	82–120	7.5YR 5/7 patina	2.05	xx	tr.	n.p.	n.p.	x	xxx	n.p.
		10R 3/4 core	1.25	x	tr.	n.p.	n.p.	x	x	xx
B_{t4}	150–180	10R 3/4 core	1.40	x	tr.	n.p.	n.p.	x	x	xx
		10R 5/7 core	1.10	x	tr.	n.p.	n.p.	x	x	xx
		10R 7.5/2 patina	0.10	xx	tr.	n.p.	n.p.	x	n.p.	n.p.
Profile Cañamero-1										
A_p	0–31	10YR 3/2 patina	8.25	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
B_{t1}	70–99	10YR 7/8 patina	1.95	xx	xx	n.p.	n.p.	x	xxx	n.p.
		10R 4/6 core	1.20	xx	x	n.p.	n.p.	x	x	xx
B_{t2}	99–180	10YR 8/2 patina	0.05	xx	x	n.p.	n.p.	x	n.p.	n.p.
		10R 4/6 core	1.20	xx	x	n.p.	n.p.	x	x	xx

x, xx, xxx mean, respectively: small, moderate and high contents
n.d.: not determined; n.p.: not present; tr.: traces

Table 5: *"Free" Fe-oxides content and clay minerals (from X-ray diffraction data) of weathered quartzite stones of raña soils.*

a) **Geomorphology:** The raña surfaces studied act as the divide between river basins and so we can assume that they originated before the entrenchement ofthe actual rivers; consequently they are older than any river terrace type of deposit.

b) **Weathering status:** All the quartzite stones have a continuous weathering patina; because of this they have the appearance of a ferruginous sandstone. A similar degree of weathering has been found by ICOLE (1970, 1973) in the Northwestern Pyrenees for quartzite stones of the lower Lannemezan formation; this formation has an upper Pliocene age (ICOLE 1973).

c) **Soil morphology:** The soils studied show a higher degree of evolution than those developed on very old river terrace deposits (TORRENT 1976, MEDINA 1977). Alfisosl and not Ultisols are the soils developed on these deposits, a fact in accordance with (a).

The raña soils studied show many morphological features simmilar to those of soils of the higher level of the two raña levels of the "Puebla de Beleña" area (Central Spain), of a middle-upper Pliocence (Lower Villafranchian) age (ESPEJO 1985).

The lower limit for their age is established on the basis of the age of the erosion surface overlied by raña sediments. This surface has a post Miocene age (I.G.M.E. 1970). The parleosol which appears at the uppermost miocenic sediments has many common morphologicsl features with the one overlain by the higher raña level of "Pueblo de Beleña"; in this raña formation the erosion surface overlied is of a middle-Pliocene age (SCHWENZER 1936).

According to the former considerations we can assume that our rañas have an age ranging from middle to upper Pliocene (Lower Villafranchian).

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