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MICROMORPHOLOGY AND MINERALOGY OF SOME ACID BROWN SOILS (UMBREPTS) IN THE MEADOWS OF THE CENTRAL CALCAREOUS APENNINE (ABRUZZO - ITALY)

Summary — Micromorphological, chemical and mineralogical aspects of ten brown acid soils in the Abruzzi region (Italy) are presented and discussed. Central characteristicts of such soils are emphasized.

A cover of piroclastic materials was found to have a large part in the pedogenesis of these soils.

Riassunto — Gli Autori analizzano i caratteri chimici e mineralogici di dieci profili di suoli bruni acidi di prateria delle montagne calcaree abruzzesi. Vengono elencate una serie di caratteristiche precipue di questi suoli.

E' stato possibile definire l'esistenza di una copertura di materiali piroclastici che hanno influenzato fortemente l'evoluzione pedogenetica.

INTRODUCTION

The Apennine mountains of Abruzzi, central Italy, are mainly formed by limestones and calcareous-dolomitic rocks dated back to mesozoic age. These rocks are strongly tectonized by two sistems of faults, one in the direction of the chain and the other at 90° degrees from the previous one. For this reason the widest valleys are roughly oriented NW-SE and limited by mountains that are often higher than 2000 m, with sharp morphology, jagged peaks, screes and colluvial fans, glacial cirques and karstic phenomena.

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In this region in general we may distinguish a sequence of three zones in the altimetric distribution of vegetation: basal, mountain and subalpine-alpine zone. The stations of our studies are in the higher band of the second zone (beech climax) near the boundary with the third zone.

The pedological pattern in this area is variable, morphology appears the most important pedogenetic factor, especially at the considered altitudes.

On strong slopes rock outcrops and rendzinas (rendolls), that intergrade to brown rendzinas or brown calcareous soils, where slope is more gentle, are found; the more frequent is however the brown acid soil (umbrept), especially in areas with lower erosion; in the bottom of small valleys and sinkholes there are hydromorphic soils on colluvium; podzols (ferrods) were observed only in connection with covers of piroclastic materials.

Methods and materials

Ten profiles were choosen, carefully described and sampled for usual analytical determinations, according to the procedures of the 7th Approximation (1967). Four of these profiles were sampled for mineralogical and micromorphological determinations, using Brewer's technique (1964). Field descriptions were made according to Soil Survey Manual U.S.D.A. (1951), microscopical description of mineral horizons with Brewer's classification (1964); for top soils Barrat's scheme (1968) was used; Malesani's (1966) methodology for textural determinations.

Mineralogical analysis of sandy fraction were carried out with optical and diffractometric methods, the clay materials were examined by X-ray and D.T.A. with standard procedures.

The published figures are mean values of analythical results. Profile description, and analythical figures are available by the Authors.

The environment

The soils were sampled near Campo Imperatore, M. Scindarella (Gran Sasso Group); Mailletta (Maiella mountains); Val di Corte, M. Vitelle and Terraegna (National Park of Abruzzi).

The sites of soils, we studied, were selected in order to have omogeneous conditions for independent pedogenetical parameters. Thus we choose Festuca and Nardus type meadows, where F. BRUNO and Al. (1965) observed a great frequency of acid brown soils in comparison to other evolution trends.

Heights range from m 1800 o.s.l. to m 2000 o.s.l.; the exposure is not always the same, but in our profiles is nearly E and such kind of soils is found on gentle slopes (8° - 15°) of valleys, in sinkholes and farther down the screes foot of limestones.

The rocks under the soils are limestones with the common characteristics of a very low content of acid-insoluble material (less than 1%).

This area was covered by pyroclastic deposits, the origin and of which we shall discuss later.

The climate presents two sharp rain maxima at the beginning of spring and at the end of Autumn. Summer rains of great intensity are frequent, mean year precipitations range from 1200 to 1400 mm; mean year temperature varies from 4° C up to 8° C, with 2-3 monthly averages below 0° C. Snow cover is 4-5 months.

Meadows are mostly anthropic as shephards used to cut the wood to gain surface for pasture.

GENERAL DESCRIPTION OF SOIL

The horizon sequence is ABC. A horizon is 50-70 cm thick and 3 subhorizons are distinguished; boundaries within A subhorizons and with B horizon are gradual and wavy. Structure in the top part of the A horizon is weak, platy for compression due to grazing animals; becomes than fine and medium, weak, crumby; in the lower part of the A is medium, moderate crumby with a tendency to blocky. Slightly sticky, and plastic in the higher part, it is sticky and slightly plastic in A3.

Limestone skeleton is usually absent. Drainage is medium. Pores are common small and medium. Biological activity and roots are common. In A3 subhorizon rare pressure-faces are present. Colour varies from 7.5YR2/2 up to 3/4 in A1 and from 7.5YR4/2 up to 4/4 in A3.

B has the characteristics of a cambic horizon, with a range in thickness from 30 to 60 cm and a sharp boundary to the limestone, often with pockets in the rock. Structure is angular blocky, fine, moderate, but sometimes becomes massive when dry. Rounded iron-manganese concretions are common. Common and typical pressur-faces. Plastic, slightly sticky. Skeleton of weathered limestone is rare, small, but is more abundant near the rock. Few clay-skins well separate were found only in the lower part of the thickest profiles. Biological activity and roots are uncommon. Colours range between 7.5YR3/4 and 4/4 or redder. Limestones under laying the soil are strongly corroded.

Chemical characteristics of soil

Chemical analysis show an organic carbon content that decreases regularly with depth, with 8% in A1 and 1% in B. Total nitrogen is well distributed in the profile, with a maximum of 0,60% in the roots layer; the pH (H_2O) ranges in the A horizon from 5.5 up to 5.8, with higher figures in the A11; in the upper part of B it reaches 6.0 and this figure is exceeded only near the limestone. Free iron remains constant with depth (0.13%). In A1 and B C.E.C. is 50-60 meq/100 gr, while in A3 figures are usually smaller. Exchange acidity decreases with depth (max 45 meq/100 gr in A1, min 25 meq/100 gr in B). Mg^{++} oscillates between 1.0 meq/100 gr and 2.0 meq/100 gr. Ca^{++}, with a mean of 10 meq/100 gr in all the profile, grows up to 18 meq/100 gr near the bedrock. Base saturation is about 20-25% in A1 and A3, 45% in B where influence of limestones is stronger. Exchangeable Al (Yuan [1959]) has figures with a mean of 24 meq/100 gr, and is constant with depth. Exchangeable H^+ (Yuan [1959]) decreases regularly from the top soil to the bedrock (max 0,2 meq/100 gr. min. 0.1 meq/100 gr).

Micromorphological description

The following characteristics are results of a synthesis carried out on micromorphological descriptions of four profiles.

Skeleton: randomly distributed, silt and fine sand, frequent minerals are: Sanidine, augite and micas strongly decoloured, garnets; less frequent corroded magnetite, small pieces of flint are common.

Plasma composition: reddish yellow or yellowish brown becomes redder with depth. In the top layer is very dark for the presence of organic matter. Anisotropic dominions, slightly present in surface material, increase with depth, where plasma is strongly birefringent, expecially in the lower part of B.

Plasmic fabrics: asepic in A1, is sligthly skelsepic or mavosepic in A3, the last type of plasmic fabrics is typical in B.

Related distribution: A1 is usually agglomeroplasmic, and A3 porphyroskelic; this kind of distribution is more marked in B.

Voids: the top of A has composed packing voids owing to fine pellets and interconnected metavughs due to larger pellets, vescicles are less frequent. In the lower part of A1 meta-skew planes are present expanding in vughs with pellets inside; in A3 the characteristic voids are similar to the previous, but mammillated surfaces are found instead of pellets; skew-plans are strongly dominant in the B horizon, where few irregular metavughs are interconnected by slender planes.

Organic matter: the top of A1 is characterized by fragments of plant remains, slightly humified and by faecal pellets well discernable; in the lower A1 and in A3 few vegetal tissues strongly humified are seen and organic matter is intimately associated with the mineral fraction.

Plasma separations: see plasmic fabrics.

Orthic plasma concentrations: In A iron and/or manganese noduls and concretions were observed, the same features occur more frequent in B, while in the lower part, near the rock, rare ferriargillans, mangans and neomangans were found.

Orthic bioformations: A strong biological activity is present, in the shapes of orthotubules, mammilated vughs, faecal pellets, roots holes with no peculiar distribution in the profile.

Pedorelicts - absent.

Lithorelicts - small «lapilli» and fragments of pyroclastic materials are common.

Grain-size analysis

All the samples, dispersed with H_2O_2, have shown a granulometric uniformity with unimodal distribution, good sorting and a little negative skewness.

The sand, mostly fine, is constant in the profiles with approximate values of 15%, the silt is about 55% and clay, also constant in every horizon, is around 30%. With such figures the particle size is assigned to silty clay loam.

The average of the medians is 3,30 μ with a standard deviation of 0,67 μ. The particle size distribution analysis of the EDTA insoluble fraction of the underlying limestones showes a distribution much more symmetric than the soil samples, with a lower medians ($Me = 2{,}25$ μ, $\sigma = 0{,}30$ μ).

Mineralogy

The mineralogy of soils showes an uniform composition in both, sandy and clayey fractions.

In the sandy portion (> 63 μ) we found always these unweathered minerals: augite, sanidine, plagioclases (generally acid), vermiculite, magnetite, almandine garnet and small amounts of ilmenite and melanite garnet. Glasses, pumices and rare cherts are also present in the sandy portion. Few and hard subspheric concentration of amorphous material of Fe and Mn and traces of goethite have also been observed.

The clay fraction composition is the following with the same order of abundance: trioctahedrical montmorillonite (saponite?), orderly kaolinite, mixed layers illite-montmorillonite, illite and chlorite.

Only in one profile kaolinite is more abundant than montmorillonite the sequence of other minerals remaining the same.

The mineralogical study has also been extended to the underlying limestones. The acid insoluble fraction varies from 0,60% to 0,25%. The following minerals were found: quarz, rare feldspar (K feldspar and/or plagioclase), and mostly clay minerals (chlorite, mixed layer illite-montomorillonite and/or montmorillonite and illite).

CONCLUSIONS

Mineralogical data emphasize a slight contribution of limestones to the formation of soil. In fact the mineralogical composition of the sandy fraction of soils is quite different, from that of the acid insoluble matter of bedrock.

The mineralogical composition of weathered materials has to be related to volcanic ashes, comparable to the sands of Avezzano (PEDERZOLI GOTTARDI [1958]), Ladispoli (GOTTARDI, MITTEMBERGHER [1955]), Nettuno (GOTTARDI [1952]), resulting from break down of tuffs of late quaternary volcanic activity in Latium.

The distance from explosive activity craters is responsible for the silty fraction is prevailing. The particle size distribution also indicates that limestones are not the main parent material. Infact the size distribution of the acid insoluble residue of limestone has a median less than that one of the soil. In the frequency distribution max grains are around 400 - 500 μ, while in the soil we observe dispersion in the particles up to 2 mm. This granulometric tail in the coarser material is formed by small «lapilli».

It is very interesting to point out that in our soils micas are mainly vermiculite, a weathering product of biotite; kaolinite is probably deriving from weathered feldspars of volcanic ash.

The studied soils are Cryumbrepts according to the 7th Approximation USDA (1968). The cambic horizon is emphasized by field, chemical and physical analysis and furtherly by the lack of evident leaching of clay from the upper horizons.

Cutans occurring in the lover part of the profile are related to «in situ» weathering of micas and in small amount to oblique movements of water near the bedrock. However do not exceed the boundary of 1% in some parts of the horizon to be an argillic horizon. The absence of such plasma concentrations in other levels of the soil are to be related to argillic-pedoturbations by the shrinking and swelling of clay and faunal pedoturbations by animals (earthworms and mammals).

The presence of a compact structureless horizon in the deeper part of soil is discontinuous, but characteristics are not enough to fullfill the fragipan definition. Increasing density with depth is pointed out by the increase in the same way of anisothropic characteristics of plasma and by the trend of the related distribution from agglomeroplasmic to porphyroschelic arrangement. The same meaning has nature and arrangement of voids, appearing in this order from top to depth: packing voids, vughs and planes.

Common features of examinated soils are:

a) an umbric epipedon with base saturation lower than 50% and C/N ranging between 11 and 17 with higher figures in top horizon;

b) free iron percentage is uniform with depth;

c) pH (H_2O) between 5,5 and 6,0 with the min. figures in A3 and max. in B;

d) colours are in the page 7.5YR of Munsell Soil Colour Charts;

e) presence of cambic horizon.

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