# Soil formation on mafic rocks of north Galicia, Spain. 1. Soils and classification

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**Abstract.** Soils on serpentinite, pyrigarnite and chloritized amphibolite in the wet Cfb climate of N Galicia have umbric and mollic surface horizons and cambic or spodic subsurface horizons. Spodic horizons are not recognized in the field, but fulfil the chemical criteria. Forest stands are better on pyrigarnites than on serpentinites, which may be due to high $Cr_2O_3$ and NiO contents in the latter.
*Key-words:* mafic rocks, serpentinites, umbrepts, orthods, udolls, nickel, chromium.

**Introduction.** The polymetamorphic area of Cabo Ortegal, between Cedeira and Ortigueira in northwest Spain (ca. 43°43′N; 4°15′W) contains an association of mafic and ultramafic rocks: amphibolites, metagabbros, peridotites, granulite-facies rocks (pyrigarnites), and serpentinites (Vogel, 1967). The area has a rolling relief, with a 600 m high steep descent towards the Atlantic in the northwest. The rainfall is estimated at 1500 mm/year; the climate is Cfb according to Köppen. When winds are blowing onshore, the area tends to be fog-clad. Vegetation is mainly herbaceous, with common heath and locally gorse. Soils were studied on serpentinites, pyrigarnites, and on chloritized amphibolites.

**Materials and methods.** Six soils on serpentinite (B, B+, E, O, S, U), three on chloritized amphibolite (D, J, K) and two on pyrigarnite (T, V) were described. Samples were taken for chemical, mineralogical and micromorphological analysis.

**Results.** Soils on serpentinite have well-developed Ah horizons with granular structure over brown, (sub)angular blocky Bw horizons, overlying unweathered serpentinite rock. pH-KCl is between 4.5 and 5.5. Organic carbon decreases regularly with depth. Clay contents vary from 10 to 40 %, depending on impurities in the parent rock. Sodium-dithionite-extractable Fe content is between 4 and 22 %; trends with depth are irregular. Dithionite-Al contents are below 2 %. Sodium pyrophosphate extractable carbon decreases with depth. In most profiles, base saturation is below 50 % in the topsoil and Mg is the dominating cation in all horizons. Exchangeable K and Na contents are low.

Soils on chloritized amphibolite are variable, because chloritization occurs in veins of varying thickness. Changes in texture are abrupt and strong. Ah horizons are less expressed than on serpentinite. All soils have impeded drainage which is expressed in gley phenomena shallower than 50 cm from the surface. pH and clay content have the same range as in serpentinite soils. Base saturation is generally over 50 %; either Mg or Ca is the dominant cation.

Soils on pyrigarnite have thick, dark Ah horizons and lighter Bw horizons. Biological activity is moderate and drainage is not impeded. Profiles are thicker than the average serpentinite soils and textures are more sandy: clay contents are 3–20 % and stoniness increases with depth. Both pyrigarnite profiles have illuvial humus-sesquioxide horizons, which were recognized through chemical analysis but not in the field.

Transport and illuviation of organic matter and sesquioxides were studied with sodiumdithionite and sodiumpyrophosphate extracts. The former determines the amount of non-silicate sesquioxides, the latter is supposed to extract carbon and sesquioxides from organic complexes. Both extractions are used in criteria for the spodic horizon (Soil Survey Staff, 1975). The B horizon of serpentinite profile S and of pyrigarnite profile V qualified for all criteria of the spodic horizon. B horizons of other profiles do not qualify and are cambic horizons.

Well-developed Ah horizons of serpentinite soils have a low base saturation and qualify for umbric epipedon if sufficienctly thick (B+, E, O. S). In very shallow profiles without a cambic horizon, base saturation in the Ah may still exceed 50 % and the topsoil may qualify for mollic epipedon (B, U). Most well-developed soils on serpentinite are Typic Haplumbrepts, but locally Typic or Lithic Hapludolls and Humic Haplorthods may occur.

Soils on chloritized amphibolite have cambic (gley) subsurface horizons and their humic topsoils range from ochric to mollic and histic. Classifications vary accordingly: Dystric Eutrochrept (D), Histic Humaquept (J) and Typic Haplaquoll (K).

Soils on pyrigarnites have umbric or ochric epipedons and cambic or spodic subsurface horizons. They classify as Typic Haplumbrept (T) or Typic Haplorthod (V).

In the serpentinite soils, the adsorption complex is dominated by Mg (Mg/Ca ~ 4.6), but compared with ratios in the parent rock (50) and in the total soil (6.4), domination is much reduced. This dominance of Mg is also encountered in soils on chloritized amphibolite, but to a lesser extent. Soils on pyrigarnite have slightly dominant Ca in the Ah and dominant Mg in the subsoils.

The serpentinite soils have not been put to agricultural use other than extensive grazing, and locally support very poor stands of *Pinus pinaster*. Soils on pyrigarnites support better forest stands. Soils on chloritized rocks cannot be assessed separately because of their limited extent. The main difference between the capacity of the various rocks to support a vegetation is probably due to the Mg/Ca ratio and to strongly different contents of $Cr_2O_3$ and NiO. On serpentinite, NiO contents range from 0.08 to 0.8 % in the fine earth fraction and from 0.19 to 2.5 % in the clay fraction. $Cr_2O_3$ contents are 0.5–8.2 % and 0.13–0.35 % respectively. Contents on pyrigarnite rocks are much lower: NiO: 0.0–0.05/0.02–0.19 and $Cr_2O_3$: 0.01–0.05/0.02–0.07 in the fine earth and clay factions respectively.

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# Soil formation on mafic rocks of north Galicia, Spain. 2. Soil micromorphology

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**Abstract.** Serpentine in soils weathers to undistinguishably small fragments, but in some soils, larger serpentine fragments may be protected by self-supporting iron hydroxide coatings. Unserpentinized minerals accumulate residually. Serpentinite soils have mull humus and locally moder humus, but no amorphous coatings. Characteristics of impeded drainage are few. Pyrigarnite soils have a sandy matrix which is due to the grainy character of the host rock. These soils have moder and amorphous humus, indicating transitions between Inceptisols and Spodosols. Soils on chloritized amphibolite have strong segregation of iron compounds.
*Key words:* mafic rocks, micromorphology, inceptisols, spodosols, serpentinite.

**Introduction.** Of the soils described by van den Born & Buurman (1985), profiles B, E and O on serpentinite, profiles D and K on chloritized amphibolite, and profile T on pyrigarnite were sampled for micromorphological investigation. The investigation supports conclusions on rock weathering and soils genesis.

**Methods.** From each of the profiles, undisturbed samples were collected in steel boxes (sized 15 cm × 8 cm × 5 cm). These samples were impregnated with plastic

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