PHOSPHATIC NODULES FROM A SOIL PROFILE OF SANTA FE ISLAND, GALAPAGOS

by

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INTRODUCTION

Sante Fe Island of Galapagos Archipielago is situated in the Pacific Ocean about 1.100 Km. west of Ecuador. Galapagos Islands are great shield-volcanoes, whose formation, begun in the latter part of Tertiary, continued until recent times; its surface consists mostly of vesicular olivine-basaltic lavas and pyroclastic materials.

The coastal belt of Santa Fe Island belongs to what is call "arid zone" (Laruelle, 1966). It has a locally dense vegetal association of xerophitic grass and bushes with more or less sparce cacti species. As for the neighbouring Santa Cruz Island, it was established by Laruelle (1966) that the arid zone extends from the sea level up to an altitude of about 100-120 m. The climatological data for the arid zone of this island indicates of about 500 mm. of annual precipitation distributed from January to April, and an average annual temperature oscilatting between 22º and 24 ºC. (Eswaran et al., 1972). Although we have no precise data about Santa Fe Island, the surface extension and climatic characteristics of Santa Fe arid zone must be similar to those of Santa Cruz Island.

Besides the lithosolic soils, superficialy or interstialy developed in the basaltic rock, the arid zone locally shows deeper soils, ranging in colour from brown to reddish-brown, and generally clayey. Despite the fact

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that these soils may be found in morphologically different places of that zone, they are always bound with a flat position whatever be the surface extension (Laruelle, 1966).

The soil profile SF III, developed on basaltic colluvium, is located in this arid zone at an altitude of 10 m. over the sea level, and concerns the well developed soils already mentioned. This profile was described and sampled by Dr. J. Laruelle in the course of "Galapagos International Scientific Project 1964". Classified as an Typic Haplustalf (Soil Taxonomy, 1975), it presents the following sequence of horizons : A_1 (0 - 10 cm), B_2t (10-75 cm.), C (75-100 cm.), IIC (100-110 cm.).

The micromorphological analysis of this profile (in preparation) permitted us to detect in the A_1 horizon the presence of certain rounded, sharp nodules, some of 300 μ in diameter on an average, and of moderate relief and yellowish colour in plain light, and whose prominent characteristic is their isotropy, revealed upon observation in polarized light (see plate I). These nodules are not incorporated in the S-matrix but remain free in the compound packing voids, characteristic of the loose microstructure of the A_1 horizon. On the other hand, some nodules of similar characteristics in plain light may be found in the same sample, although they present certain birrefringent strias similar to those produced by anisotropic clay, (gray and yellow of first order).

Given the characteristics of these nodules and due to their adequate size for being separated from the soil sample, we decided upon the investigation of their mineralogic characteristics. In this respect, preliminary comments on this features were made by author (Morras, 1975 a - b).

Methods and results.

Some white-yellowish nodules having soft consistency, found in the soil sample of A_1 horizon, were impregnated with Vestopal with a view to preparing petrographic thin sections, with the purpose of observing their optical properties. These thin sections thus prepared enabled us to determine that these nodules exhibit the same characteristics of isotropy as those nodules observed in the original soil thin section. Parallely, a preliminary colorimetric analysis of the silica and alumina content led us to establish that in these nodules, these elements are found in reduced quantities (Si, 6 % ; Al 3.2 %), consequently putting aside the possibility of finding us in the presence of amorphous alumino-silicate materials.

On the other hand, the diffractometric X-ray analysis (fig. 1), (radiation Cu$K\alpha$; filter Ni) enables us to establish that this analysed material is a calcium phosphate which might respond to the basic formula $Ca_{10}(OH)_2(PO_4)_6$ (hydroxiapatite). The weak expression of the peaks obtained permits us to infer that the material is found poorly crystallised, which is in concordance with the isotropic character in thin section. In the same manner, a semiquantitative, preliminary analysis of X-emission by means of an electron microprobe, enables us to confirm that phosphorus and calcium are principal constituents of these nodules, it being possible to detect also silica, aluminum and magnesium in inferior proportion.

According to Smith & Lehr (1966), the apatites in phosphorites and rock phospates are poorly crystallized and their composition differs considerably from pure hydroxiapatites, but their X-ray diffraction patterns are typically apatitic with slight shifts, showing changes in the cell parameters. These authors also indicate that most sedimentary phosphorites contain considerable

amounts of carbonate and are often considered carbonate apatites or francolite.

The differential thermal analysis of these nodules observed in the profile SF III produced a clearly exothermic curve with a maximal peak at 340 ºC. Although this characteristic does not correspond to the thermic reaction of the major part of the phosphates (1), Smith & Lehr (1966) indicate that francolite shows exothermic effects that are not observed with fluor or hydroxiapatites.

Finally, the observation on this nodules by scanning electron microscopy makes evident quite a particular morphology, very porous, with zone of "crateriform" aspect formed by the arrangement of little globular individuals. (Plate 2).

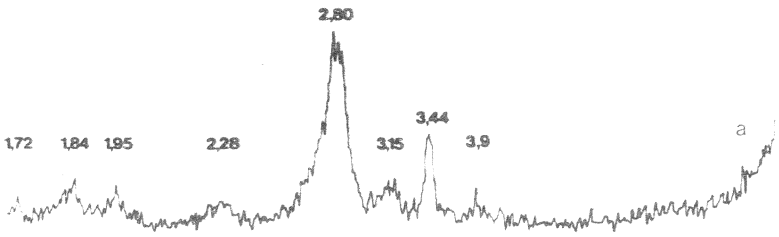


Figure 1: X- ray diffraction diagram of isotropic nodules. (The numbers are in Angstroms).

Conclusions.

The results obtained till the present, with regard to the isotropic nodules observed in this profile from Galapagos Islands permit us to establish that they consist of a calcium phosphate, there also existing some eviden-

(1) Compare Mackenzie, R. (1972), Differential thermal Analysis. Academic Press.

ce indicative of a composition nearing that of carbonate apatites or francolites. With this material are associated diverses impurities (silica, aluminum, magnesium, etc.) which could correspond, at least partly, to silicate minerals mixed with the phosphate; this kind of contamination of sedimentary phosphates with clays, feldspars and quartz is also mentioned by Smith & Lehr (1966). The birrefringency observed in some similar nodules present in the soil thin section however is not a settled question in respect to its cause, but Kerr (1959) indicates similar interference-colours in dahllite, a secondary phosphate very akin to francolite. Also contamination with clay minerals may partly explain such birrefringency.

The morphologic and microscopic characteristics, the analytical data as also the originating source of these nodules (insular arid zone) lead us to the consideration that they are of animal origin (guano), resulting from the accumulation and transformation of excrements, probably of birds.

According to Carozzi (1953), the guano in its fresh state is an extremely complex product, which suffers from continous chemical modifications with effect from the moment of its deposition. However, the aridic climatic conditions retard its decomposition, consequently favouring the accumulation of the same.

These phosphatic nodules could explain also the results obtained by Laruelle & Stoops (1967) while studying the trace element content of soils from Galapagos. There, they noticed detectable amounts of sulphur and phosphor in soils of the arid zone of the Santa Fe and Santa Cruz Islands, whereas in soils of other zones, these elements were not found. These authors attributed the presence of these elements to the probable contamination with material of organic origin an interpretation which is in consonance with the existence and characteristics of the nodules observed in profile SF III.

Finally, it should be indicated that, as far as we know, there does not exist previous description of similar materials in soil thin sections; the material that is described herein consequently incorporates a new possibility of interpretation of isotropic features, observable in micromorphology. However, the distribution of these features should be restricted to regions which give the combination of an adequate fauna with climatic conditions favouring the preservation of these phosphatic materials.

Explanatory note on figures

Plate 1 :

A – Soil thin section, A_1 horizon of profile SF III. On the right side is to be noted a phosphatic nodule and on the left feldspar grains Plain light. (The white bar on the photo has a lenght of 100 µ).

B – The same as A; partially crossed polarizers.

C – The same as above, but completely crossed polarizers. The isotropy of the phosphatic nodule is to be observed.

D – Aspect of the same phosphatic nodule with increased magnification. Plain light. (The white bar on the photo has a lenght of 25 µ

Plate 2 :

A – Surface of the phosphatic nodules showed by the S.E.M. 2.100 X.

B – Details of the anterior photo. 21.000 X.

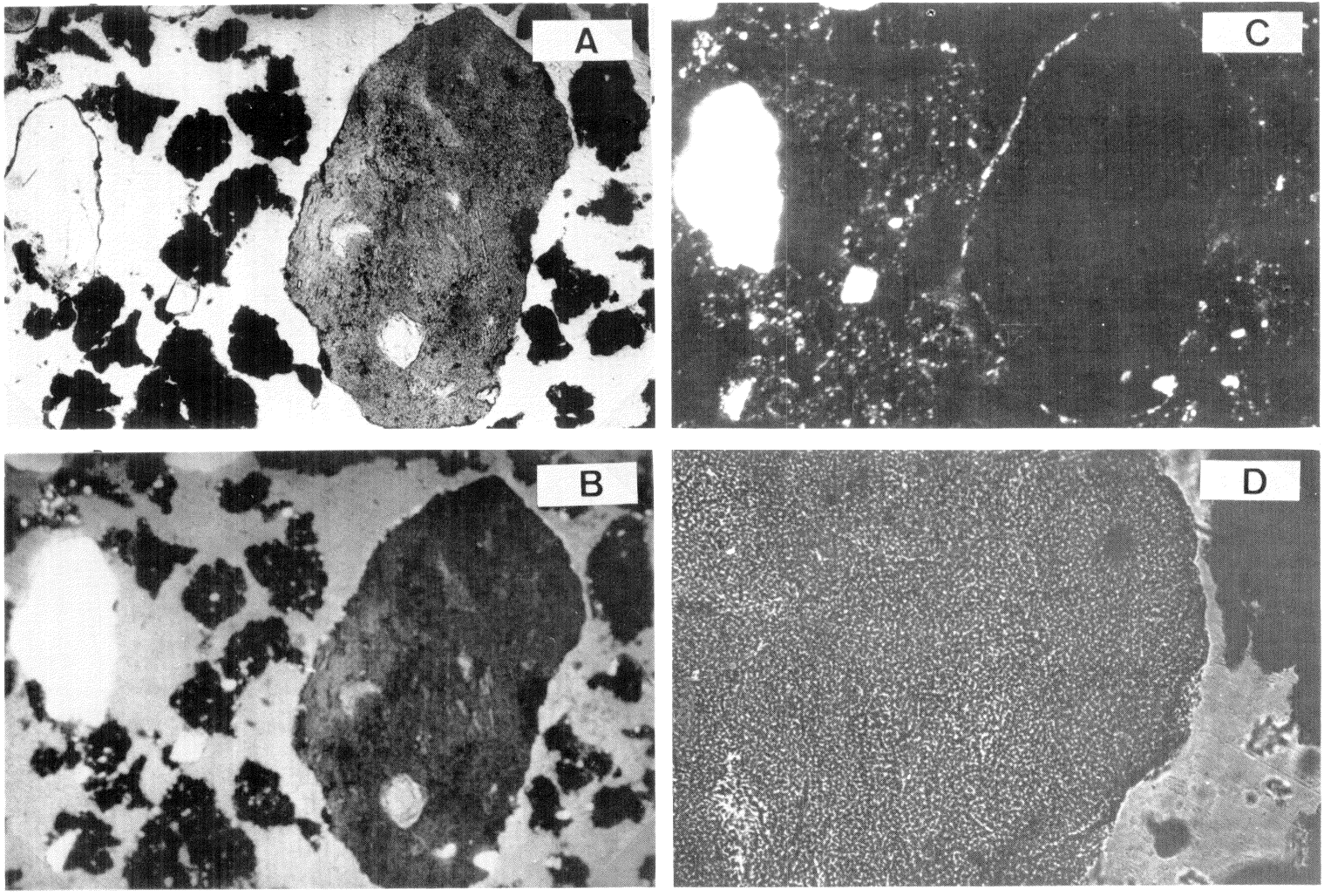
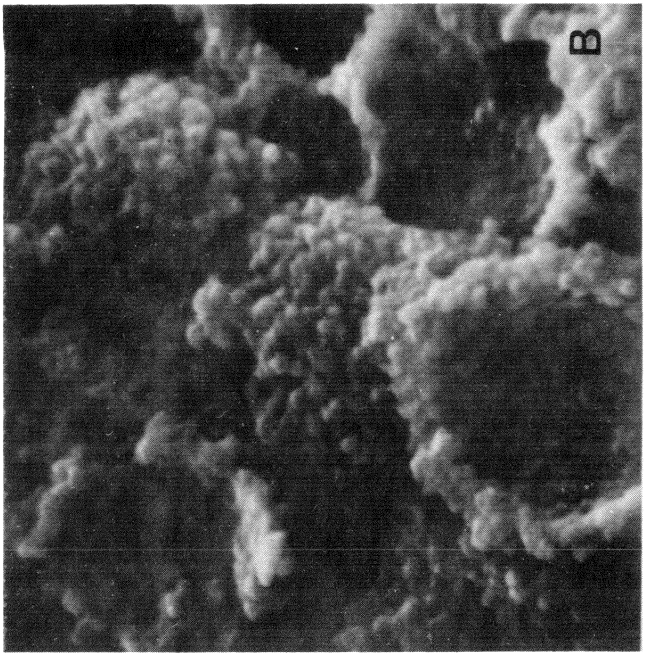


Plate 1



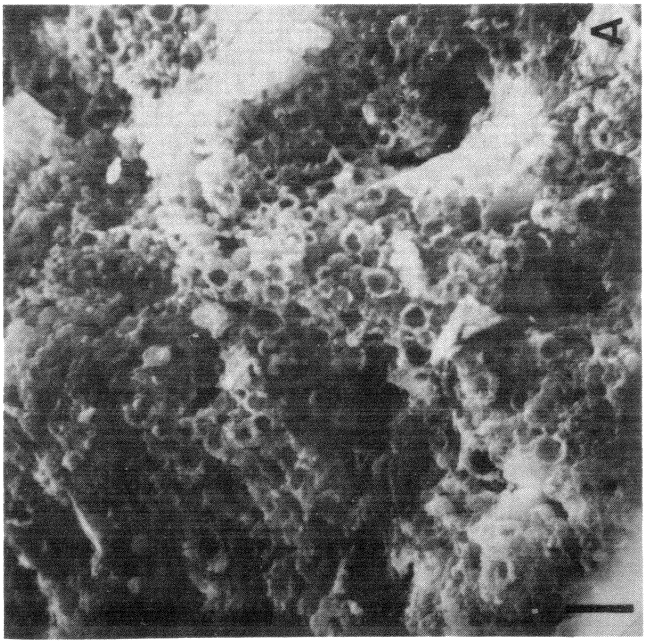


Plate 2

Acknowledgements.

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SUMMARY

During the micromorphological study of a soil profile from Santa Fe Island some isotropic nodules were observed. The various analyses carried on nodules collected from the soil sample and verified for its optical characteristic indicate that these are calcium phosphate nodules, whi ch show a particular morphology under the S.E.M. to the knowledge of the author there is no previous micromorphological description of such a material, which we consider to be of organic origin.

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