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Occurrence of leucophosphite in a soil from Elephant Island, British Antarctic Territory[1]

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Abstract

An intermediate form of leucophosphite occurs in an ornithogenic soil profile in Elephant Island, British Antarctic Territory where it formed by the reaction of penguin guano with layer silicate minerals.

Various isomorphs of leucophosphite $(K,NH_4)(Al,Fe)_2(PO_4)_2OH \cdot 2H_2O$ exist, including end members with potassium and iron and with ammonium and aluminium (Haseman *et al.*, 1950); intermediate forms have also been synthesized (Arlidge *et al.*, 1963). The mineral was first discovered in Western Australia (Simpson, 1932), where it apparently formed as a result of the reaction of bird guano with serpentinite rock, and it has since been found in somewhat similar circumstances in cave deposits in Liberia (Axelrod *et al.*, 1952) and Brazil (Simmons, 1964). In addition to these occurrences of organic origin, leucophosphite has also been identified in pegmatites, where it occurs as a product of late-stage hydrothermal alteration of phosphatic minerals (Lindberg, 1957; Bhaskara Rao and Adsumilli, 1965), and in weathered nodules of diagenetic origin containing apatitized fossil wood (Gulbrandsen *et al.*, 1963). All natural samples, apart from the original material which contains both iron and aluminium, seem to be of the ferriferous variety.

We have found leucophosphite of intermediate chemical composition in a soil profile from Elephant Island, British Antarctic Territory. The island is located approximately 800 km (500 miles) southeast of Cape Horn, at the eastern end of the South Shetland Islands. The soil profile, which was sampled by Mr. R.M.G. O'Brien during a Joint Services Expedition to Elephant Island in 1970–1971, occurs at Chinstrap Camp on the western side of the island (61°10'S, 54°45'W), in an area completely occupied by a colony of nesting chinstrap penguins. The soil is approximately 45 cm deep and is developed on till derived from dark grey and green chloritic phyllites. Leucophosphite was found in all size fractions of the soil but particularly in the 75–2000μm fraction, from which it could be obtained in a reasonably pure form by electromagnetic separation. It occurs as fine-grained, brown aggregates that are translucent in thin section.

The X-ray powder pattern of the mineral compares well with that of the intermediate leucophosphite from Australia (Axelrod *et al.*, 1952), being characterized by strong reflections at 6.77, 5.99, and 3.05Å and by reflections of medium intensity at 7.61, 4.75, 4.06, 3.35, 3.20, 2.90, and 2.83Å. However, the pattern also matches that of a synthetic ferriferous variety (Arlidge, 1958), and although ammonium–aluminium leucophosphite has a slightly smaller unit cell (Smith and Brown, 1959), it seems doubtful whether identification of an intermediate form can be made on the basis of X-ray powder diffraction data alone. The chemical composition of the Elephant Island leucophosphite is similar to that of the Australian material (Simpson, 1932; Table 1) in that it contains ammonium, aluminium, potassium, and iron; it has, however, a higher content of ammonium. The presence of ammonium was confirmed by the characteristic infrared absorption bands at 3.2 and 7.0μm (Arlidge *et al.*, 1963). In general, the spectrum is consistent with an intermediate form of leucophosphite, possibly of poor crystallinity. Calculation of the molecular formula gives $[K_{0.41}(NH_4)_{0.55}Ca_{0.2}][Al_{0.8}Fe_{1.2}][PO_4]_2OH \cdot 2H_2O$, with excess iron and water.

The origin of leucophosphite in the Elephant Island soil, like that of the Australian material, appears to be related to the interaction of guano (in this case deriving from the nesting penguins) with silicate minerals. In all probability, ammonium phosphate solutions from the guano react with the chloritic and

TABLE 1. Chemical composition of leucophosphite from Elephant Island and from Western Australia

	1.	2.	3.
SiO_2	9.93	-	-
Al_2O_3	8.43	9.33	12.73
†Fe_2O_3	27.20	30.10	32.82
CaO	0.45	0.50	tr
MgO	0.27	0.30	0.73
K_2O	4.02	4.45	7.88
Na_2O	n.d.	n.d.	0.13
$(NH_4)_2O$	2.96	3.27	0.09
TiO_2	0.91	-	-
P_2O_5	29.30	32.42	26.69
H_2O-(105° C)	5.28	5.84	6.59
H_2O+(105-1000° C)	12.46*	13.79	12.28
Total	101.21	100.00	99.94

1. Elephant Island leucophosphite (Analyst D. C. Bain)
2. Analysis corrected for SiO_2 and TiO_2 impurities
3. Western Australia leucophosphite (Simpson, 1932) after correction for 52.75% quartz and chalcedony, 0.48% rutile, 1.07% chromite and 1.03% carbon.

† total iron * determined after subtraction of $(NH_4)_2O$

n.d. = not determined tr = trace

micaceous minerals in the soil—a hypothesis supported by examination of thin sections of resin-impregnated soil blocks, which show many phyllitic rock fragments surrounded by what appears to be a reaction rim of leucophosphite. Although Ugolini (1972) found little evidence for the alteration of clay minerals in the ornithogenic soils (organic soils of the Antarctic penguin rookeries) of Ross Island, the different findings for Elephant Island may be related to the fact that it lies in the region of Oceanic Antarctica, thereby probably experiencing a wetter and less rigorous climate with higher temperatures.

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