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ON AUSTRALIAN BAT GUANO AND SOME MINERALS OCCURRING THEREIN.

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In caves situated in different parts of Victoria there exist more or less extensive deposits of guano, which are generally believed to have been formed from the excrements and other remains of bats. Some of these accumulations have little or no commercial value, while in others the guano contains sufficient nitrogen and phosphoric acid to entitle it to rank with useful fertilisers. The following are analyses of some inferior qualities:—

	Hamilton.	Portland.	Warrnambool. (1).	Warrnambool. (2).
Water	35·71	19·97	20·30	37·48
Organic matter ..	33·77	41·33	8·95	18·30
Ash	30·52	38·70	70·75	44·22
	100·00	100·00	100·00	100·00
Total nitrogen ..	1·08	1·28	0·91	1·89
Phosphoric acid ..	2·41	11·88	7·45	9·98

The samples from Hamilton and Portland fairly represented the average of the contents of the caves. In the case of the Warrnambool guano the first sample was taken from near the surface at the entrance of the cave, and the second from a depth of four feet in the centre of the deposit in the same cave. This guano, as obtained from the depth mentioned, has distributed throughout its mass, though only very sparingly, minute glistening particles of a mineral presently to be noticed, viz. *Newberyite*.

But the only important deposits of bat guano yet discovered in Australia are those in the Skipton caves on the estate of the Hon. Francis Ormond, about thirty miles south-west of the city of Ballarat. The bottom of each of these extensive basaltic caverns is covered with the guano to a depth of thirty feet in some places, and the origin of the deposits is pretty well indicated by the fact that until lately myriads of bats made the caves their home during daylight, and could be seen hanging in countless clusters from the roof.

The Skipton guano varies very much in appearance and composition. In the older and drier deposits it is light brown in colour, nearly odourless, and contains white nodular phosphate of magnesium and ammonium disseminated throughout its body together with fine colourless or slightly tinted prismatic crystals of the mineral which I in 1878 named *Hannayite*—

$$[Mg_2H_2(PO_4)_2.MgH_2(NH_4)_2(PO_4)_2+8H_2O]$$

in honour of my friend Mr. J. B. Hannay, and rhombic crystals of another mineral which I in the same year called *Newberyite* $[Mg_2H_2(PO_4)_2+6H_2O]$ in compliment to Mr. J. Cosmo Newbery, C.M.G., the well-known Australian chemical authority. The great bulk of these deposits, however, consists of dark brown or brown-black guano containing so much water that when dug out it comes away in lumps, whereas the older deposits are powdery. This moist, or I should say wet, material is thickly studded with large and often perfect crystals of *Struvite* $[Mg_2(NH_4)_2(PO_4)_2+12H_2O]$.

In the following table I have arranged some analyses of Skipton guano after the removal of all crystals of the minerals mentioned:—

	I.	II.	III.	IV.	V.
Water	16·74	30·52	30·96	33·50	44·50
Organic matter ..	22·00	44·98	31·21	44·66	32·60
Ash	61·26	24·50	37·83	21·84	22·90
	100·00	100·00	100·00	100·00	100·00
Total nitrogen ..	2·40	4·51	5·05	6·95	3·8
Nitrogen as nitric acid	0·39	0·87	1·26	1·34	0·46
Phosphoric acid, P_2O_5	7·64	4·10	10·87	3·61	7·80

I. Sample was light in colour and contained neither *Struvite* nor *Hannayite*, but only *Newberyite*, and amorphous phosphate of magnesium and ammonium.

II., III., and IV. Samples had a rich brown colour, and contained much *Struvite* and also some *Hannayite*. *Newberyite* was absent in each case.

V. Sample was brown-black, and full of *Struvite*, but neither of the other minerals was present. All the samples contained nitrates. The ash was found to contain only traces of sulphate and carbonate of calcium, and to be composed of siliceous matter, oxide of iron, traces of manganese, phosphates of magnesium and calcium, chloride of sodium, and a little potassium.

When treated with water the guano gives up a considerable part of its phosphoric acid and nitrogen, together with organic matter, yielding a dark brown solution. This solubility indicates the fitness of the manure for top-dressing grass-land and young cereals, and extensive field trials made under my direction in various parts of the colony gave eminently satisfactory results. If any objection could be urged against the guano, it would be on the score that its first effect on tender plants is of a "too forcing" character.

Turning from the consideration of the guano to the minerals that occur in it, I may mention that the crystallographic characters of *Struvite*, *Hannayite*, and *Newberyite* have been most minutely examined by Professors vom Rath, of Bönn, and G. Ulrich, of the University of New Zealand, to both of whom I sent some excellent specimens. The results obtained by these gentlemen are to be found in the latest edition of Dana's "Mineralogy," so that I need not here further refer to them.

Struvite.—Analyses of this mineral have already been published by Ulex and by J. C. Newbery, but the following results may not be wholly uninteresting:—

	Found.	Theory.
Magnesium oxide	16·069	16·327
Ferrous „	0·810	—
Manganous „	0·163	—
Ammonium „	10·567	10·612
Phosphoric „	28·819	28·980
Water (as difference) ..	43·572	44·081
	100·000	100·000

When exposed for a long time to the air crystals of struvite lose some of their water of crystallisation, and become thinly coated with a white powder. The nodular phosphate of magnesium and ammonium in the guano of the older deposits is in my opinion only altered struvite.

Hannayite.—Crystals of *Hannayite* do not lose water by exposure to the atmosphere or to a temperature of 100° C. At 110° to 115°, however, they give up about two-thirds of their water of crystallisation, and lose their transparency. When heated over a Bunsen the crystals swell considerably, become opaque, and ultimately assume peculiar "maggot-like" forms. The residue is soluble in nitric acid, but only partially in hydrochloric acid, proving it to contain pyro- and meta-phosphates of magnesium—

$$Mg_2H_2(PO_4)_2 \cdot MgH_2(NH_4)_2(PO_4)_2 = Mg_2P_2O_7+Mg(PO_3)_2+2NH_3+2H_2O.$$

The crystals of this mineral are frequently found adhering to those of *Struvite* in such a way as almost to indicate that they had been formed from the latter. Further, I may mention that *Hannayite* occurs most abundantly in guano containing the nodular double phosphate already referred to, and no distinct crystals of *Struvite*. The following is an analysis of *Hannayite*:—

	Found.	Theory.
Magnesium oxide.. ..	18·545	18·869
Ferrous „	0·310	—
Manganous „	0·087	—
Ammonium „	8·095	8·176
Phosphoric „	44·711	44·654
Water (as difference) ..	28·252	28·301
	100·000	100·000

Newberyite.—It is extremely difficult to free this mineral from the guano that exists locked up in the body of the crystal. However, I succeeded in getting a sufficient quantity of pure substance to make an analysis:—

	Found.	Theory.
Magnesium oxide.. ..	22·368	22·988
Ferrous „	0·850	—
Manganous „	0·206	—
Phosphoric „	40·728	40·805
Water (as difference) ..	35·838	36·207
	100·000	100·000

The crystals do not part with water at 100° C., but lose the whole six molecules at about 170° C., and on ignition leave pyrophosphate only.

I may, in conclusion, mention that two other phosphates of magnesium and ammonium new to science exist in Skipton guano, and these I have named *Muellerite* and *Dittmarite* respectively. I propose to make these minerals the subject of a future paper.

SHORT TITLES OF CHEMICAL PERIODICALS CURRENT IN 1887.

By H. CARRINGTON BOLTON.

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