

SOILS AND VEGETATION IN ABANDONED PENGUIN ROOKERIES (MARITIME ANTARCTIC)

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Abstract: Occurrence of abandoned ornithogenic soils resulted from the changing of nesting places due to recent geological events in this region. During the Holocene period King George Island has been lifted up to more than 50m high as an effect of isostatic movement. At the same time penguin rookeries have been shifted down onto the newly emerged rocks and new beaches, whereas the higher nesting areas have been abandoned. In several points dramatic changes in local environmental condition forced the penguins to abandon their nesting places totally. The areas deserted by penguins have been colonized by the vegetation. Ornithogenic soils have been hidden from view under a dense carpet of lichens, mosses and grasses. Rich in nutrients, phosphatic clays forming these soils proved to be relatively long-lasting in the climatic conditions of maritime Antarctic, because after many hundreds and thousands of years they have retained specific chemical and mineral properties. Thus the ancient ornithogenic soils of abandoned rookeries have been a valuable source of easily available nutrients for the formation of terrestrial ecosystems during the Holocene period. Our survey has found this problem to be common and important in this region.

1. Introduction

Poor maritime Antarctic tundra ecosystems are formed on ice-free coastal spots under a heavy influence of animals visiting these places during their reproduction period. Especially important here are penguin rookeries (MYRCHA *et al.*, 1985). In the area of penguin activity a loose stony ground has been filled to capacity with phosphatic products of guano mineralization and with products of reaction of guano solutions with underlying rock. In this way the ornithogenic soils have been created (TATUR and MYRCHA, 1984). On the nesting sites the phosphatic clay is composed mainly of calcium phosphates, but in the surrounding area mainly of aluminium phosphates often breaching potassium and ammonia ions (TATUR and BARCZUK, 1984, 1985).

On the breeding rookery all the vegetation has been devastated due to excessive manuring and treading down by penguins. Only nitrophilous lichens can be noted on big stones and rocky walls. But in the marginal zone of penguin activity abundance of nutrients in water running down from the rookery ensures luxurious development of vegetation. Influence of actual manuring on plant communities has been studied by many authors.

However, up to now the problem of buried ornithogenic soils has been neglected in the area of abandoned or shifted penguin rookeries, and also its role in the forming of recent land ecosystems. These soils have not been easy to notice, because at the first sight they look like other common soils in Antarctica. Only thanks to chemical tests in the field was it possible to recognize many places with ancient ornithogenic soils in the coastal zone of maritime Antarctic.

2. Results

Large areas of ancient ornithogenic soils have been found in many searched places of maritime Antarctic (Fig. 1). They occur along the shore of King George Island, on the tip of the Antarctic Peninsula and in the vicinity of Anvers Island. The first description of buried phosphatic soils being studied as well as the problems we are faced with will be given in the presented paper.

Thomas Point Rookery on Penguin Ridge, near Arctowski Station, King George Island (Fig. 2).

Area deserted by penguins occurs above the recent rookery. Remains of nesting places have been observed along the crest of Penguin Ridge. Ancient ornithogenic soils at the highest and oldest sites have been almost entirely washed away by rain and melting water. Phosphatic clay removed from these soils has often been sedimented again in local depressions. Secondary accumulation of the phosphatic clay with many penguin bones in the small Green Valley (Fig. 2–point X) is of particular interest. This ornithogenic matter is forming a layer about 0.5 m thick at the depth of 1.5 m

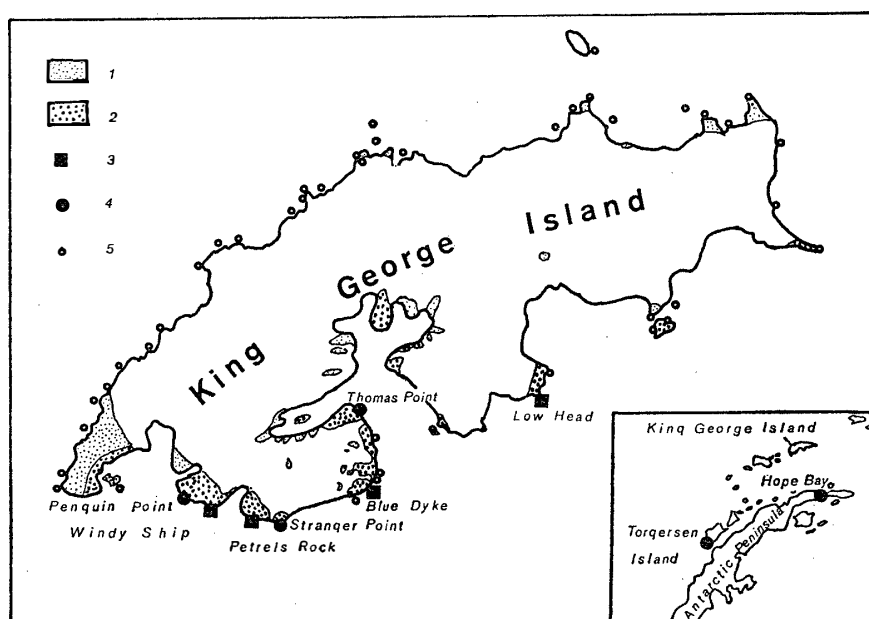


Fig. 1. Localization of actually functioning and abandoned penguin rookeries. 1: ice-free area, 2: ice free area visited by authors, 3: rookeries abandoned, 4: rookeries shifted down, 5: other functioning rookeries (JABŁOŃSKI, 1984).

below the surface of the soil. At present almost the whole area deserted by penguins is covered by diversified vegetation.

A profile through loose Holocene sediments has been done (Fig. 3) in the Green Valley surrounded by hills with remains of ancient penguin nest on its top (TATUR and DEL VALLE, 1986). Phosphatic clay with penguin bones was washed out from the rookery and was accumulated at the foot of the hills at the time when the rookery was occupied. This material has been covered by alluvial sand up to two meters thick. In the upper part, the sand is interbedded with lenses and layers of the peat. The age of the oldest peat layer has been determined by BIRKENMAJER (1981a) and equals 4950 years B.P. Thus the ancient rookery on the hills around the Green Valley has to be older.

Subfossil penguin bones of this ancient rookery have been collected from layers 3, 4, 5 (Fig. 3) and are presented in Fig. 4. These poorly preserved bones (juvenile forms

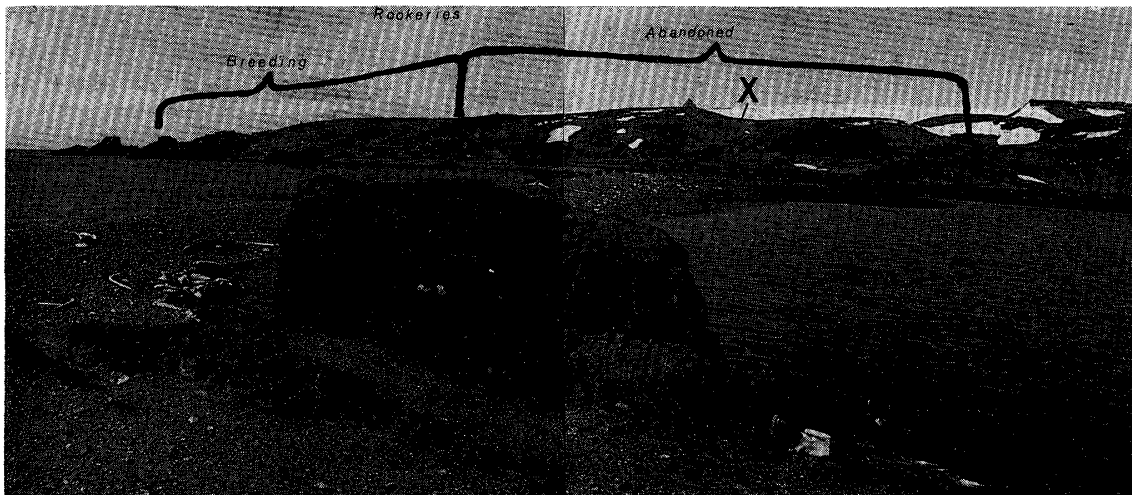


Fig. 2. Thomas Point Rookery on Penguin Ridge.

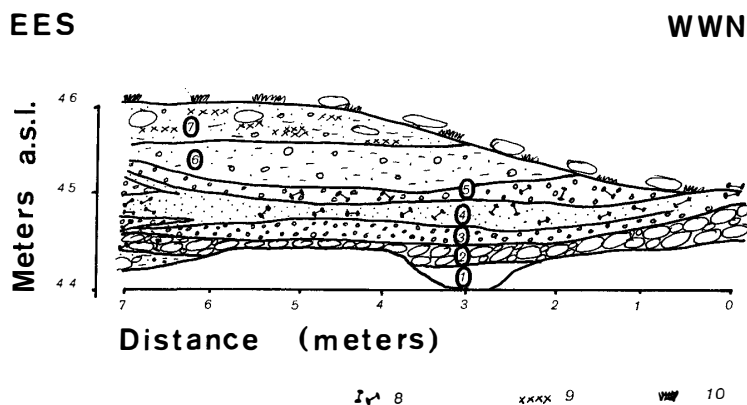


Fig. 3. Profile of sedimentary rocks in the area of abandoned rookery on Penguin Ridge. 1: loam(moraine), 2: boulders and gravel (penguin bones occurs in the east side), 3: gravel with penguin bones, 4: fine sand and silt rich in phosphates, penguin bones abundant, 5: sandy gravel with penguin bones, 6: sandy loam, 7: alluvial sand interbedded with peat, 8: penguin bones, 9: peat, 10: mosses.

are abundant) belong to Chinstrap penguins (*Pygoscelis antarctica*) and Adelie penguins (*P. adeliae*). The same species live today on the main rookery shifted down. The chemical and mineral composition of bones has been totally changed during a long time of lying inside the ornithogenic soil. Calcium phosphate has been replaced by

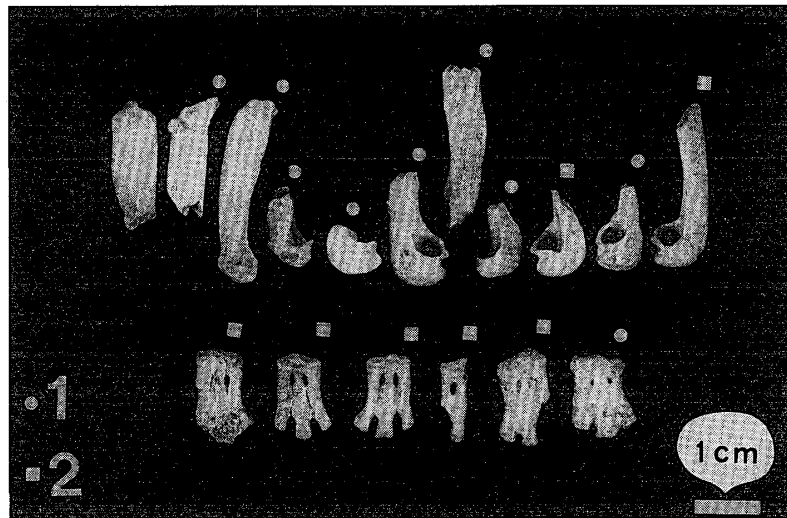


Fig. 4. Subfossil penguin bones from Penguin Ridge.
1: *P. antarctica*; 2: *P. adeliae*.



Fig. 5. Stranger Point Rookery.

aluminium-iron phosphates bearing potassium and (?) ammonia ions. However, a shape of bones has not changed (A. TATUR, in prep.).

Stranger Point Rookery, Potter Peninsula, King George Island (Fig. 5).

During the younger Holocene the penguin rookery on Stranger point has been shifted down from the cliff onto the recent beaches. Areas abandoned by penguins have been colonized by vegetation. Following the way of the rookery movement it was possible to study the plant succession processes. Lichenometric dating of *Usnea* sp. (HOOKER, 1980) and data dealing with island uplift will be used to estimate the age sequence of succeeding plants. There is also a rare occasion to study ornithogenic soil alteration processes in abandoned areas.

Hope Bay Rookery, Antarctic Peninsula, near English Base "Trinity House" and Argentinian Station "Esperanza" (Fig. 6).

In Hope Bay there is one of the greatest Adélie penguin rookeries in Antarctica. Population of penguins was counted here last time during the summer season 1985/1986 and equals about 123850 of breeding pairs (MYRCHA *et al.*, 1988). Recent nesting places occurred behind the line Boeckella Lake-Esperanza Station, but former ones could be found dispersed all over this large oasis. Most of nesting places in this field have been probably abandoned by penguins as a result of a human impact.

Anthropogenic influence has started since the beginning of the 20th century at the time of unexpected wintering by explorers of Swedish Nordenskjöld Expedition, and it was accelerated during advancing urbanization of this area after the Second World War. English and partially Argentinian bases stand on the ornithogenic soils of ancient rookery. Probably impact of man has caused the penguins to move to the new nesting sites, although it has not reduced their number finally (MYRCHA, *et al.*, 1988).

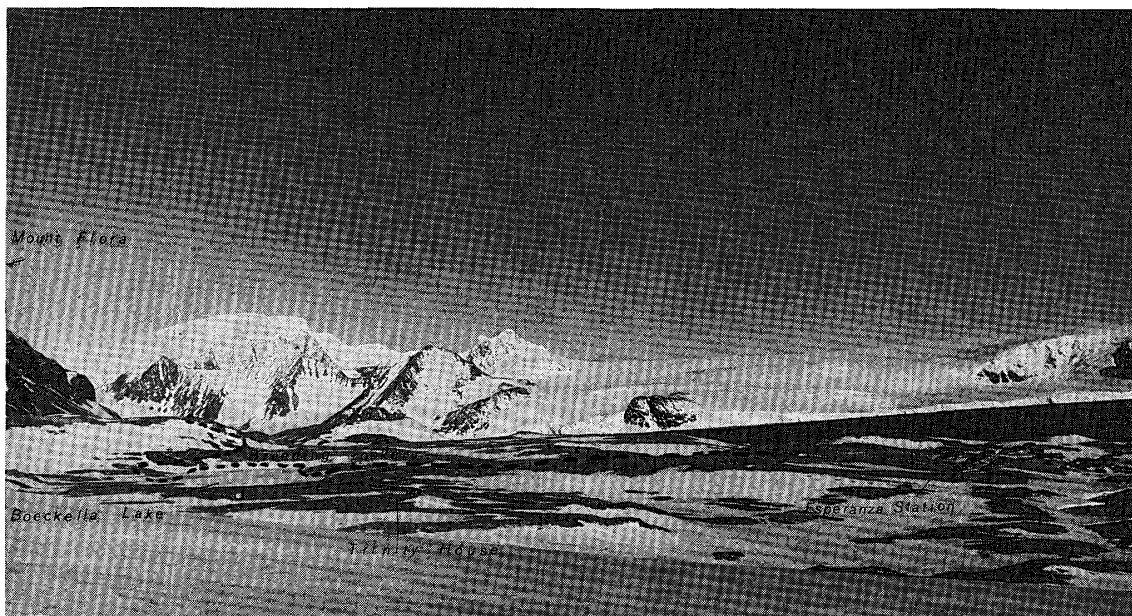


Fig. 6. Hope Bay Rookery.

Torgersen Island Rookery, near Anvers Island, west side of Antarctic Peninsula.

Traces of nesting places have been found on the top of a little flat Torgersen Island, far away from breeding rookery. Also, on the sea shore ancient ornithogenic soils were dug up under compact patch of grass *Deschampsia antarctica*.

Penguin Point Rookery, Burton Peninsula, King George Island.

There are buried phosphatic soils over a little penguin rookery, but below the Southern giant petrels (*Macronectes giganteus*) colony. Soils are covered by mosses. This situation is not clear. Ornithogenic soils could have been formed as a result of ancient penguins' or recent giant petrels' activity.

Abandoned Penguin Rookery at Low Head, King George Bay, King George Island (Fig. 7).

Low Head is a flat promontory about 200 m long and 100 m wide. In this area a large penguin rookery was located. Now only ornithogenic soils and penguin bones can be observed under the carpet of vegetation. Penguins abandoned this area forever. Ancient nesting places with guano remains bearing calcium phosphates have been found only in a few sites, but phosphatic clay containing aluminium and iron phosphates is abundant in soil cover all over Low Head. Diversified plant communities grow now on the deserted ornithogenic soils. Very common among them are lichens *Usnea* sp. and grass *Deschampsia antarctica*. In small areas free of vegetation intensive mechanical destruction of ornithogenic soils can be observed. Area of this rookery has been partially devastated during the neoglacial events. Penguin bones have been noted

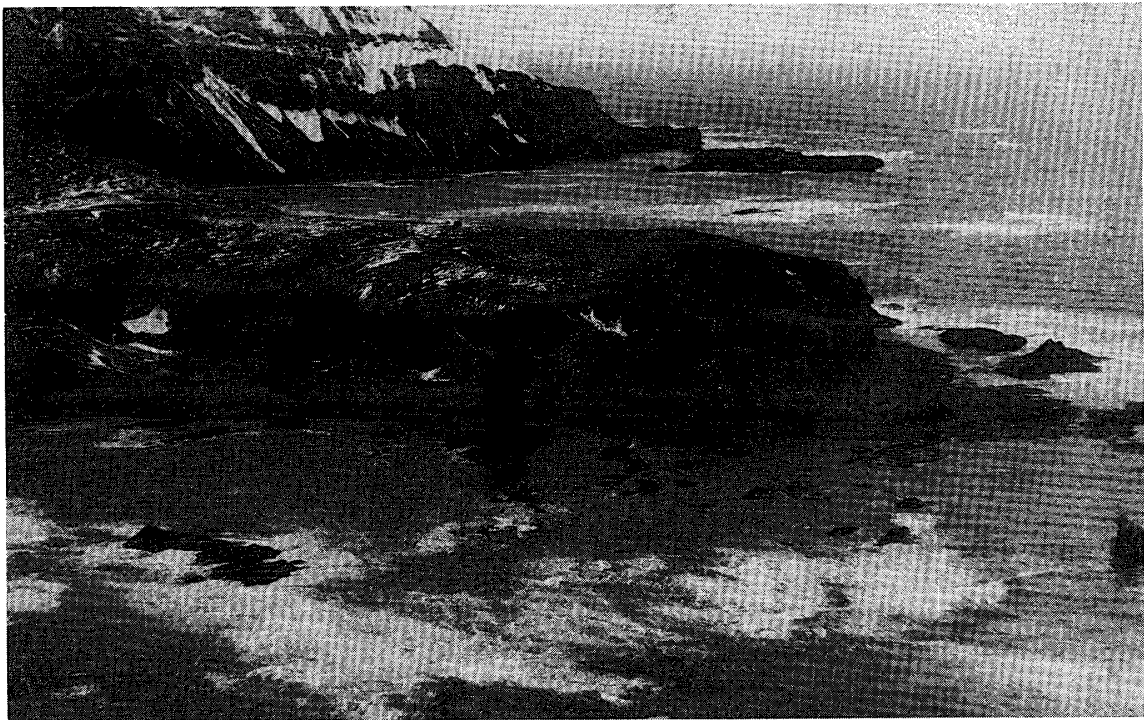


Fig. 7. Abandoned Rookery on Low Head.

inside the lateral moraines during the observation of outcrop formed on the sea shore by a heavy storm.

Penguin bones (Fig. 8) are dispersed all over the area of the abandoned rookery. Very high accumulation of bones was found in phosphatic sediments of a little pond. The rookery on Low Head was formed by Chinstrap penguins (*P. antarctica*) and Macaroni penguins (*Eudyptes chrysolophus*). Juvenile bones are abundant. Most popular was *P. antarctica*, confirming the previous determination of materials from the same place made by BOCHEŃSKI (1985). However, several bones belonged also to *E. chrysolophus*, as seen in King George Island which is only occasionally visited. *P. antarctica* used to nest in the same place each year. Changing of nesting sites is very rare. Thus abandonment of the rookery by these penguins has clearly resulted from extraordinary events. Several reasons can be considered: shutting nesting sites off from the sea by moraines, cutting off nesting sites due to steep cliff forming during uplift of the island, eruption of volcano on nearby Penguin Island (BIRKENMAJER, 1982; TATUR and DEL

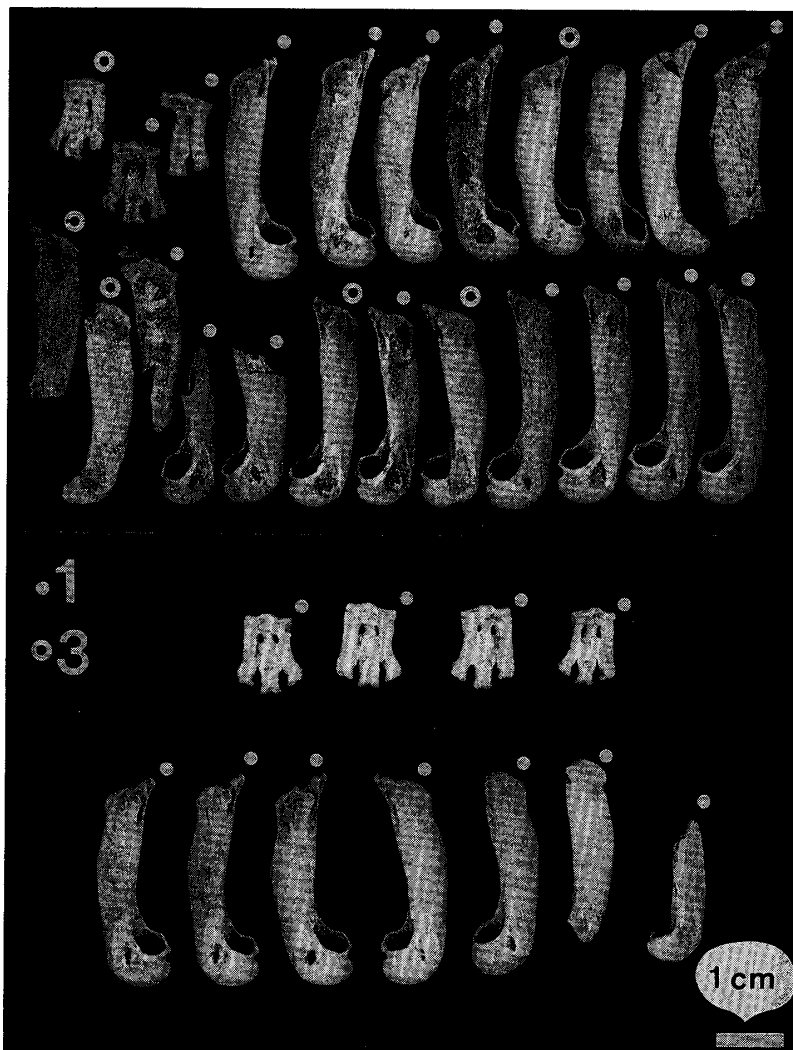


Fig. 8. Subfossil penguin bones from the abandoned rookery on Low Head.
1: *P. antarctica* 3: *E. chrysolophus*

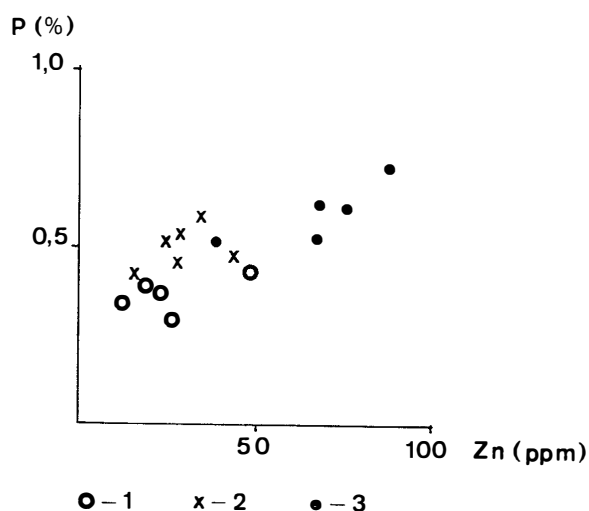


Fig. 9. Concentration of phosphorus and zinc in green leaves of *Deschampsia antarctica* (just before flowering) growing on varying sites. 1: control soils (Italy Valley), 2: ornithogenic soils of abandoned rookery (Low Head), 3: ornithogenic soils of actually functioning rookery (Thomas Point rookery).

VALLE, 1986), creation of new and better nesting sites in the other areas as a result of deglaciation, and uplift of the island (BIRKENMAJER, 1981b; JABLOŃSKI, 1984).

Discovery of large areas of abandoned penguin rookeries along the shores in maritime Antarctic puts an important biological question: are there nutrients of abandoned ornithogenic soils available to vegetation? To solve this question the chemical analysis of *Deschampsia antarctica* has been carried out. The example with phosphorus and zinc (Fig. 9) proved that nutrients of abandoned ornithogenic soils can be supplied to recent vegetation. However, for other elements the relation is not always so simple and it would need a detailed explanation.

Abandoned Penguin Rookery at Blue Dyke, Admiralty Bay, King George Island.

On the flat hill at the Blue Dyke rocks a small rookery of Gentoo penguins (*P. papua*) was located. Now vegetation is growing on phosphatic soils. *P. papua* used to change its nesting places more often than other penguins, thus abandoned rookeries of this species should not be surprising.

Abandoned Rookery at Petrels Rock, Potter Peninsula, King George Island.

There are ornithogenic soils on the top of a high cliff colonized by Southern giant petrels (*M. giganteus*). These soils are composed mainly of Al-Fe phosphates, phosphatization of the stony beach raised to 16 m a.s.l. has also been observed. This beach is near the Petrels Rock but off the giant petrels activity. Thus the ornithogenic soils can be attributed to recent Southern giant petrels colony or ancient penguin rookery. No traces of penguin bones have been found during the brief investigation.

Abandoned Rookery at Windy Ship, Burton Peninsula, King George Island.

Ancient nesting places have been noted on the slope near Windy Ship. There was not enough time to study this area in details.

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