

Glacial retreat at Gold Harbour, South Georgia: discovering unforeseen geology, remembering unexpected guests.

Phil Stone, British Geological Survey, Edinburgh

Back in the early 1970s it was my good fortune to work on South Georgia for the British Antarctic Survey (BAS). I spent three austral summers deciphering the geology of the north-east coast from Barff Peninsula down to Cooper Bay, and for the 1971-72 season, with support from Eric Lawther as GA¹, my area of interest spanned from St Andrews Bay to Gold Harbour (Figure 1). Since then, the island's glaciers have retreated rapidly as a well-established result of global climate change, with those flowing out towards the north-east coast the most dramatically affected (e.g. Cook *et al.* 2010). Many parts of the coastline now have a very different appearance from that which I remember, none more so than Gold Harbour where, in 1972, the Bertrab Glacier had tumbled over a spectacular ice fall and extended to the sea (Figure 2). Today, the lower part of the glacier has vanished, the ice fall has gone, and only the top section of the glacier remains. In most respects these changes are to be regretted, but from the geological perspective there are some benefits. Large areas of clean, ice-smoothed rock are now exposed that were previously concealed, revealing a substantial section of folded strata on the south side of what was the Bertrab Glacier ice fall – more on that later, after some reminiscences and historical scene-setting.

Some preliminaries around Royal Bay

For the early part of the 1971-72 austral summer Eric and I had been based in the Royal Bay area, with a main field camp in Moltke Harbour, supplemented by outposts established briefly in Doris Bay (for Christmas 1971) and Little Moltke Harbour (Figure 3), all with the assistance of the BAS ships RRS *Bransfield* and RRS *John Biscoe*. Another ship that enlivened a day at Moltke Harbour was *Lindblad Explorer* (Figure 4), which arrived in early January and landed a party of tourists on 'our' beach. We were invited onboard and royally fêted, discovering that amongst our hosts were Lars-Eric Lindblad himself and the wildlife artist Keith Shackleton. When finally landed back at Moltke Harbour we were loaded with a cornucopia of fresh food, a generous bounty from *Lindblad Explorer* and a welcome supplement to our standard field rations: bread, meat, eggs, vegetables, fruit – I particularly enjoyed the pineapples (and the bottle of wine).

I believe that we were visited during the second of Lindblad's pioneering tourist trips to South Georgia. About a month later we learnt from radio chatter that *Lindblad Explorer* had run aground in Admiralty Bay (King George Island) in the South Shetlands during her second cruise of the season. All the passengers and non-essential crew had been safely taken off by the Chilean navy, and the ship was eventually

rescued by a salvage tug from Cape Town. With hindsight, this was an uncanny precursor to the ship's final fate when, renamed *Explorer*, she hit ice and sank off the South Shetland Islands on 23 November 2007, remarkably with no casualties.

There had been much earlier visitors to Royal Bay, the 1882–1883 German International Polar Year Expedition – Moltke Harbour was named after their ship (Hattersley-Smith 1980, p. 60). At the expedition's base, close to Köppen Point and not far from our campsite at Moltke Harbour (Figure 1), the remains of several huts could still be readily discerned in 1972.² One had incorporated large cubes of granite (probably as solid foundations or to stabilize scientific instruments) with the timbers held together exclusively with copper nails; it was clearly a structure intended for the collection of geomagnetic data. Equally curious was the twisted framework of the structure built to house an astronomical telescope (Figure 5) through which was observed a transit of Venus across the face of the Sun on 6 December 1882. Measurement of the transit had been one of the expedition's principal objectives and perhaps surprisingly, given the capricious South Georgia weather, it was successfully accomplished. Other details of the expedition's activities are described in Headland (1984, 58-60). The site was subsequently reoccupied so that the geomagnetic observations could be repeated: in 1909 by the relief party from the Argentine 'Orcadas' base in the South Orkney Islands (Figure 6) and in 1911 by Wilhelm Filchner's *Deutschland* expedition.

Today's visitors to Royal Bay would enjoy rather different scenery to their predecessors. Observers from 1882 to 1972 saw the dramatic ice wall across the south-west side of the bay created by the merging of the Ross and Hindle glaciers (Figure 5). Now, in 2019, from the same vantage point overlooking at the remains of the German observatory, it is doubtful whether the glacier snouts would be visible at all. The two glaciers have separated and retreated into their own valleys – about 4 km of retreat for Hindle (on the left in Figure 5), a bit less for Ross (on the right) – whilst the map of South Georgia recently published by BAS (2017) shows a new small island, previously ice-covered, to the south-west of Little Moltke Harbour.

Bjornstadt Bay to Gold Harbour

From Royal Bay and Moltke Harbour Eric and I were moved around to Bjornstadt Bay on 3 February 1972 by *Bransfield*. Although I didn't realise it at the time we were following in the footsteps of Duncan Carse and Alec Trendall who had camped there from 23 March to 4 April in 1954, during the second of the three South Georgia Survey Expeditions (Trendall was the expedition's geologist so I was shadowing him in more ways than one). They had suffered very bad weather, with Trendall (2011, p. 89) reporting that of their twelve days only four or five were fit for outside work, whilst even then consistent low cloud prevented anything but local surveying. We enjoyed rather better weather, with only 13 'impossible' days out of 43, and some of the best days were spent at Gold Harbour.

My first sight of Gold Harbour was on 7 February 1972 when Eric and I trekked down from Bjornstadt Bay. Having thus proved the route, we revisited later in the month equipped with a lightweight mountain tent and spent four nights close to the north side of the Bertrab Glacier (Figure 7). The name, Gold Harbour, was first used formally by Wilhelm Filchner's German Antarctic Expedition (1911-1912) although the locality was also known to the sealers as Anna's Bay (Hattersley-Smith 1980); in their *Visitor's Guide to South Georgia* Sally Poncet and Kim Crosbie (2005, p. 148) give the original sealers' name as Anna's Harbour. The most likely inspiration for 'Gold' derives from the colourful dawn effect when, given the right weather conditions, the upper snowfields of the Bertrab Glacier³ glow golden yellow in the light of the rising sun. I did wonder about an alternative origin for the name after finding that quite large crystals of iron pyrite – fool's gold – were present in the rocks at the north end of Gold Harbour and this possibility was taken-up in the Poncet and Crosbie *Visitor's Guide*.

The dramatic changes at Gold Harbour since Eric and I camped there in 1972 are illustrated by the two photographs in Figure 8. They show the extent of the Bertrab Glacier's retreat and a striking geological feature now revealed on the deglaciated rock faces: a large, tight and overturned fold structure. I've been fortunate to acquire from several recent visitors to Gold Harbour a selection of photographs showing the clean rock faces around what was the ice fall from a variety of directions. Most show the clearest manifestation of the fold structure on the south side of the glacier and waterfall (Figure 9, arrowed), whilst others illustrate its less obvious continuation on the north side (Figure 10). Taken together, the various images allow the fold structure's three-dimensional form and orientation to be deduced and integrated into its broader geological context. To visualize the structure, it helps to think of the features on either side of the waterfall as mirror-images of each other; an idealised attempt to illustrate this is shown in Figure 11a. The low-angle intersection of the cliff faces with the fold structure creates the stretched-out impression of the fold hinges that is particularly marked on the cliff extending north from the waterfall (Figure 10, arrowed).

The regional geology of South Georgia has been summarised by Macdonald *et al.* (1987). The folding now exposed at Gold Harbour affects Lower Cretaceous (about 120 million-year-old), sandstone and mudstone strata of the Cumberland Bay Formation. These have been deformed and thrust north-eastward over a succession of rather different sandstone and mudstone, the Sandebugten Formation, which is also probably Lower Cretaceous in age but has different deposition and deformation histories to those of the Cumberland Bay Formation⁴. The major thrust plane separating the two formations has a regional dip of about 15-20° to the SW. It traverses South Georgia from Cumberland Bay to Gold Harbour where it emerges close to the northern headland (Gold Point), which is formed of Sandebugten Formation rocks (Figure 1).

An assessment of the recent photographs from Gold Harbour confirms that the fold hinges trend approximately NW-SE and are exposed more-or-less continuously along the line of the cliff beneath the remains of the Bertrab Glacier. The axial planes of the fold pair are almost parallel to the overall bedding attitude, but the upper fold hinge (the anticline) is partially sheared out by movement along that combined plane. The asymmetry implies top-to-the-NE tectonic movement consistent with the thrust-emplacement direction of the Cumberland Bay Formation (Figure 11b). The Gold Harbour folds lie only a short distance above the main thrust plane at the base of the Cumberland Bay Formation and most probably developed in association with that major feature. Hence they are compatible with the principal folding regime previously established for this part of South Georgia from less impressive features (Stone 1980).

So much for the geology, but it's not just the physical appearance of Gold Harbour that has changed since 1972; there have been equally marked changes to the wildlife populations. Poncet and Crosbie (2005) put the recent population of King Penguins at 25 000 breeding pairs; in February 1972, Eric and I were delighted to discover only about 500 of the birds. Conversely, we decided there were around 1000 Gentoos present, but the Poncet and Crosbie (2005) account describes only "approximately 300 pairs of gentoo penguin". Elephant seals were pretty abundant in 1972, as they are now, but there was only a scattering of fur seals sporadically lurking in the tussock grass. From accounts given by recent visitors there are now so many fur seals on the Gold Harbour beach that trying to land anywhere can be difficult and quite hazardous at certain times of the year.

I don't think *Lindblad Explorer* landed tourists at Gold Harbour in 1972, but there were, nevertheless, signs of recent visitors. From our camp sites at Bjornstadt Bay and Gold Harbour, Eric and I had seen ships out to sea, and at night had been able to count the lights of six or seven vessels from a Russian fishing fleet then active off South Georgia (Figure 12). They had not restricted their activities to the offshore area, and several of the rock faces and large boulders around Gold Harbour carried scratched graffiti in Russian script. I noted-down one example which looked like three sets of initials and a date:

ДБВ
СИЯ 3.1.71
СВГ

We would seem to have missed our Russian visitors by about a year, and it would be two more before I came across another Russian landing party, farther north in St Andrews Bay.

A finale at St Andrews Bay

Eric and I had reconnoitred the south side of St Andrews Bay in December 1971 from our campsite at Doris Bay. At that time, the combined Cook and Heaney glaciers flowed to the coast and ended in a rather dirty and unstable ice wall with a narrow strip of shingle at its base (Figure 13). Whilst I busied myself amongst the rocks, Eric investigated the shingle strip and at low tide crossed to the north side of the bay beneath the Cook-Heaney glacier snout, in the process becoming almost certainly the first person to walk across St Andrews Bay at sea level. I had previously looked down on the Cook Glacier from the north, from the summit of Mount Hunt (Figure 12) in early January 1971 – the peak was anonymous at the time but in 2015 was named to commemorate Sir Rex Hunt (1926-2012), Governor of the Falkland Islands 1980-1985. That had been the southern limit of my geological work in the 1970-71 austral summer, so I was keen to get across and link the two sets of geological observations. Unfortunately, we were afflicted by much bad weather and ran out of time at Doris Bay, so my traverse of St Andrews Bay had to be postponed.

For much of the 1973-74 field season I was based at Cooper Bay, at the SE end of South Georgia, but as something of a grand finale to my work on the island I was landed back on the south side St Andrews Bay, from *Bransfield*, on 19 February 1974, accompanied by Roger Daynes. I had been expecting an easy stroll along the beach to the north side of the bay, in front of the glacier snout, but in that I was disappointed. The shingle strip at the foot of the ice had become very narrow, whilst the ice wall looked even more unstable than it had been in December 1971, with lots of evidence of recent collapses. So, we took to the glacier and picked our way across around the myriad crevasses. Traversing for the second time on 24 February, we were astonished to see, looking out into the bay, that a ship's lifeboat full of people was approaching. It's not easy to hurry across a crevassed glacier so by the time that we got down off the ice, the lifeboat had been beached, and our visions of a maritime disaster had been dispelled by its occupants beginning a game of football, displacing the seals and penguins. We had stumbled on a party of Russian fishermen (well, 31 men and 2 women) who had decided on a run ashore.

There was much hand-shaking and back-slapping. One of our 'guests' spoke good English and introduced himself as an ichthyologist – a fish scientist. He and the rest of the party were from a ship, a trawler I think, called *Jantar* which, with the end of the fishing season, had met with the rest of the fleet to trans-ship the catch. That was to be taken for sale in South Africa, whilst *Jantar* was returning to the home port of Kaliningrad. As any good fisherman would, our ichthyologist friend claimed that the catch that season had been very poor. He and his colleagues had seen our pyramid tent (bright pink so hard to miss) but, he claimed, had assumed that it must be some sort of remote navigational beacon. There was clearly a relaxed dress code aboard *Jantar*, but the landing-party was reasonably kitted-out for the circumstances, except for one man who wore a suit and shiny shoes and whom we assumed must have been the political officer. Altogether it was a rather surreal experience. The Russians spent about two

hours on the St Andrews Bay beach before heading back out to sea, and that night we saw the lights of six ships on the horizon. Next morning, they had gone.

Over the following three weeks I completed my geological work in the area and Roger and I were picked-up by *John Biscoe* on 15 March 1974. Six days later I was back in Stanley and heading home.

Acknowledgements.

None of my work on South Georgia would have been possible without the support of a succession of GAs¹: Jim Whitworth (1970-71), Eric Lawther (1971-72), Dog Holden (1973-74) and Roger Daynes (1974); Eric Lawther has also provided the photographs used for figures 3, 4 and 7. The interpretation of the Gold Harbour fold structure has been enabled by photographs kindly provided by Bob Burton, Mike Norman, Tom Sharpe and Jim Wilson. For permission to use the recent images of the Bertrab Glacier I am grateful to Dan McGrath and Matthew Kennedy (Earth Vision Institute and Extreme Ice Survey) for Figure 8 (2014), and to Tom Sharpe for Figures 9 and 10. The 1909 photograph from Moltke Harbour, Figure 6, is reproduced by permission of Edinburgh University Centre for Research Collections. Helpful discussion with Bruce Mair led to improvements in the text. At the British Geological Survey, Edinburgh, Craig Woodward assisted with production of figures 1 and 11, and Brian McIntyre prepared images for inclusion in the photographic figures.

Notes

Note 1 ... In BAS shorthand, GA stands for General Assistant; the name does not do justice to the role. Recruited as experienced mountaineers, they would be designated a ‘field leader’ in the Antarctic programmes of any other nation. If you asked a GA to provide a job description it would probably be something like “babysitting the scientists”.

Note 2 ... Around the hut foundations was a scattering of relics abandoned by the German expedition, with broken bottles and jars disappearing under the tussock grass and subsiding into seal wallows. Some of the earthenware bottles were quite attractive objects (Figure 14) and although none were intact, Eric and I both came away with nice examples. Several years ago, I was able to return mine to the South Georgia museum at Grytviken, and when we were reminiscing over this article for Falkland Islands Journal, we decided that it was time for Eric’s souvenirs to find a good home. No more were needed at Grytviken, but Andrea Barlow was keen to have them for the Falkland Islands Museum and that’s where they have gone, back to the South Atlantic. For escorting them down to Stanley we are indebted to Hugh Osborne.

Note 3 ... The Bertrab Glacier was also named by Filchner’s German Antarctic Expedition, 1911-1912. It celebrates Dr von Bertrab, chairman of the expedition

committee who was also a General and head of the German Land Survey (Hattersley-Smith 1980).

Note 4 ... Both the Sandebugten Formation (SF) and the Cumberland Bay Formation (CBF) were deposited by multiple turbidity currents but their sediment sources were very different. The SF is composed largely of quartzo-feldspathic sand grains whereas the CBF contains an abundance of sand grains derived from an active volcanic terrain. Both formations have suffered polyphase deformation but of contrasting style and intensity. In general, the deformation of the SF has produced an abundance of tight folds cut by intense cleavages whereas the folding of the CBF is more open and the cleavages less penetrative. The CBF contains fossils that define its Lower Cretaceous age. No fossils have been found in the SF, but its Lower Cretaceous age is established by the local interbedding of its distinctive sandstones with those of the CBF (Stone 1980; Macdonald et al. 1987).

References.

British Antarctic Survey. 2017. South Georgia and the Shackleton Crossing, 1:200 000 and 1:40 000 scale, BAS (Misc 12). Cambridge. British Antarctic Survey.

Cook, A. J., Poncet, S., Cooper, A. P. R., Herbert, D. J. & Christie, D. 2010. Glacier retreat on South Georgia and implications for the spread of rats. *Antarctic Science*, **22**, 255-263.

Hattersley-Smith, G. 1980. The history of place-names in the Falkland Islands Dependencies (South Georgia and the South Sandwich Islands). *British Antarctic Survey Scientific Reports*, **101**. 112 pp,

Headland, R. 1984. *The Island of South Georgia*. Cambridge University Press. 293 pp.

Macdonald, D. I. M., Storey, B. C. and Thomson, J. W. 1987. *South Georgia*. BAS GEOMAP Series, Sheet 1, 1:250 000, Geological map and supplementary text, 63 pp. Cambridge, British Antarctic Survey.

Poncet, S. & Crosbie, K. 2005. *A visitor's guide to South Georgia*. WildGuides Ltd. 179 pp.

Stone, P. 1980. The Geology of South Georgia: IV. Barff Peninsula and Royal Bay areas. *British Antarctic Survey Scientific Reports*, **96**. 45 pp, 8 plates.

Trendall, A. 2011. *Putting South Georgia on the map*. Albany, Western Australia. 216 pp.

Phil Stone

British Geological Survey, The Lyell Centre, Edinburgh EH14 4AP

Figures

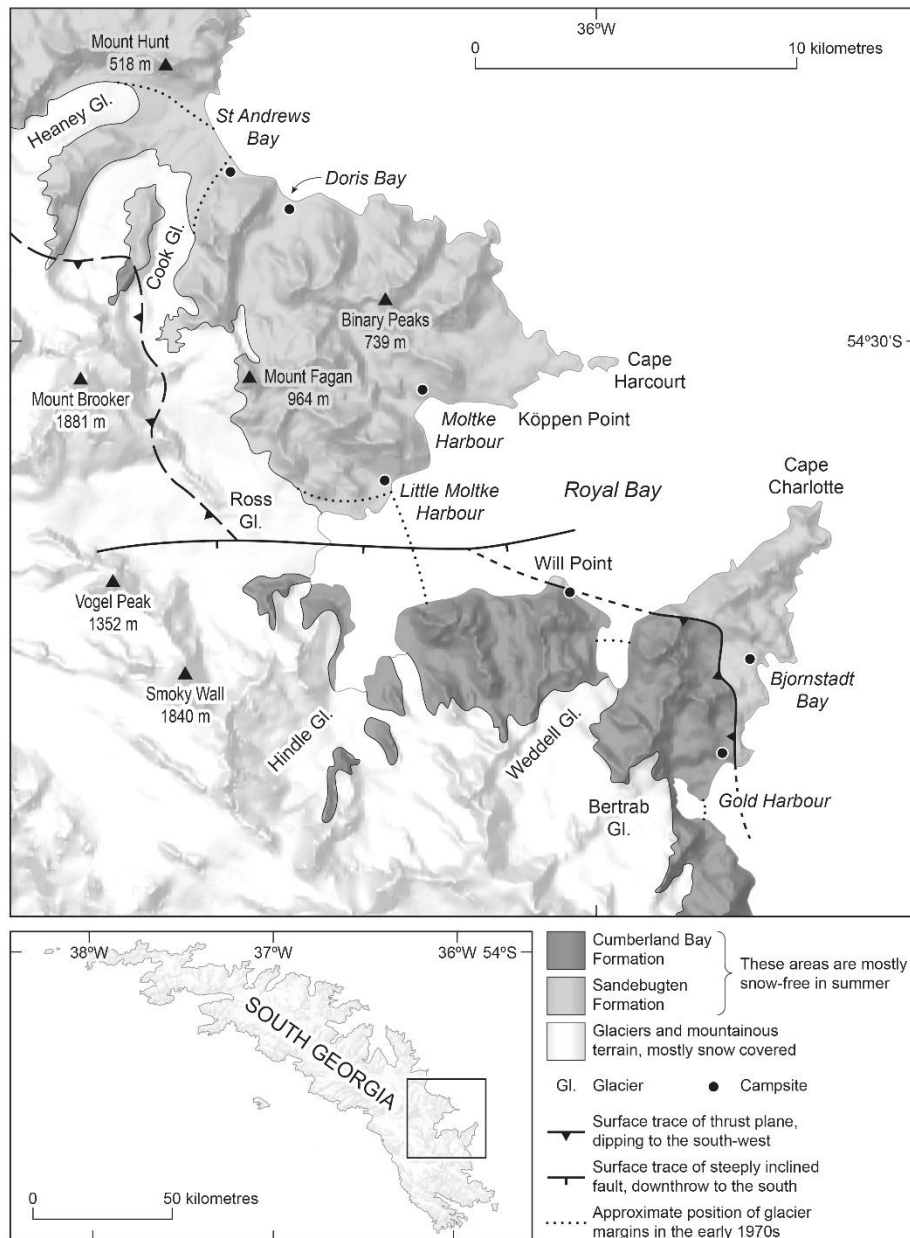


Fig 1. Outline geology for the St Andrews Bay – Royal Bay – Gold Harbour section of the north-east coast of South Georgia.



Fig. 2. Gold Harbour and the Bertrab Glacier in February 1972 (photograph by Phil Stone). Since then, the glacier has retreated substantially so that only the upper snowfield remains.



Fig. 3. Camp site at Little Moltke Harbour, sheltered from the wind blasting off the Ross Glacier by a huge glacial erratic, but a bit too close to the sea and the elephant seals for complete peace of mind: 27 December 1971 (photograph by Eric Lawther).



Fig. 4. *Lindblad Explorer* in Royal Bay. Will Point can be seen just astern of the ship: 11 January 1972 (photograph by Eric Lawther).



Fig. 5. The remains of the astronomical observatory at the site in Moltke Harbour occupied by the 1882-1883 German International Polar Year Expedition (photograph by Phil Stone). In the background, seen across Royal Bay in December 1971, is the combined snout of the Ross and Hindle Glaciers. The two glaciers have retreated substantially since then and have separated into individual valleys.



Fig. 6. The relief party from the Argentine ‘Orcadas’ base in the South Orkney Islands reoccupying the German huts at Moltke Harbour in 1909. Note the large surveying tripod in the right foreground. The identity of the original photographer is unknown but was possibly Ernest Alexander Miller; this digital image (78349d) was provided by Edinburgh University Special Collections. It is one of a series of eight photographs recording the event, reference Gen.1647, Box 50, item 15, held by Edinburgh University Library within the William Speirs Bruce archive. Efforts to trace potential copyright holders were unsuccessful and correspondence concerning this issue would be welcome.



Fig. 7. Camp site at Gold Harbour amongst the tussock grass, sheltered by the rock bluff from the wind off the glacier: 20 February 1972 (photograph by Eric Lawther).

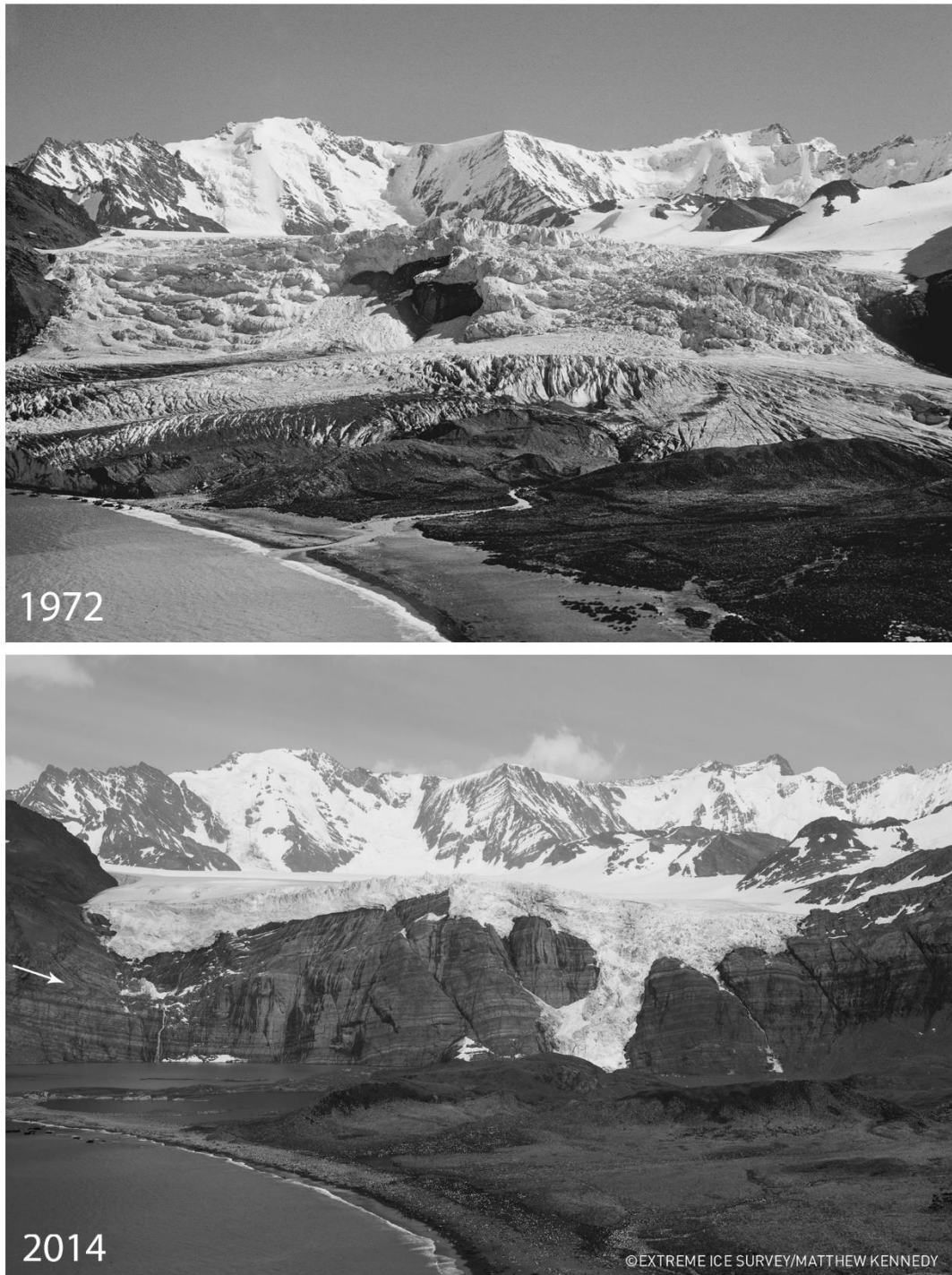


Fig. 8. The Bertrab Glacier, Gold Harbour, in 1972 (photograph by Phil Stone) and 2014 (photograph by Matthew Kennedy, Extreme Ice Surveys). The folded strata uncovered by glacial retreat are indicated by the arrow in the 2014 image.



Fig. 9. A recent view of Gold Harbour (3 February 2019, photograph by Tom Sharpe) showing the detail of the best-defined fold structure (arrowed, as in Figure 8) to the south of the waterfall that drains meltwater from the remains of the Bertrab Glacier. Note the less-obvious ‘mirror-image’ fold structure on the opposite side of the waterfall. The hundreds of white dots along the shoreline – King Penguins – give a sense of scale.



Fig. 10. A recent view of Gold Harbour (3 February 2019, photograph by Tom Sharpe) showing the stretched-out appearance of the fold structure (arrowed) running across the cliff face to the north of the waterfall. The effect is produced by the low-angle intersection of the cliff face with the line of folding.

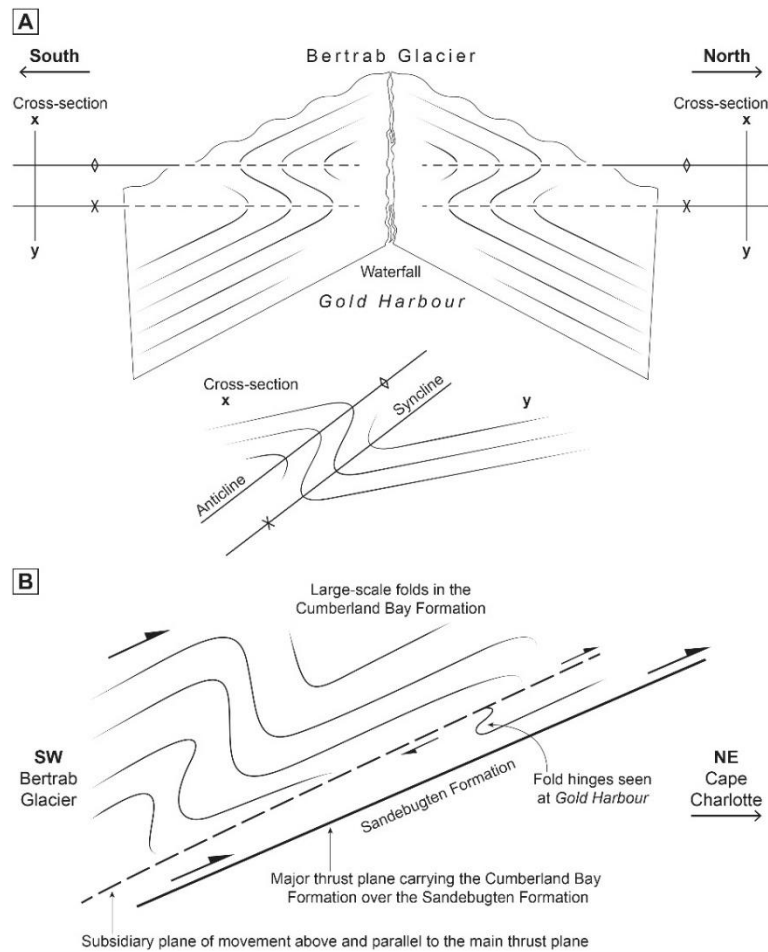


Fig. 11. Sketch cross-sections summarising the geological features newly exposed at Gold Harbour by retreat of the Bertrab Glacier: a ... An idealised attempt to illustrate the Gold Harbour folds in three-dimensions (the upper fold hinge, the anticline, has actually been largely destroyed by shearing along its axial plane); b ... The relationship of the Gold Harbour folds to the regional geological structure.



Fig. 12. Russian ships off Gold Harbour with the Bertrab Glacier in the background: 17 February 1974 (photograph by Phil Stone).



Fig. 13. St Andrews Bay and the combined snout of the Cook and Heaney glaciers in December 1971 (photograph by Phil Stone). The glaciers have now retreated about 2 km inland and have separated into individual valleys. The prominent flat-topped peak on the far side of the bay is Mount Hunt, so named in 2015 to commemorate Sir Rex Masterman Hunt (1926-2012), Governor of the Falkland Islands from 1980 to 1985, a tenure briefly interrupted in 1982 by the Argentine army.



Fig. 14. The two glazed, earthenware bottles from the 1882-1883 German expedition site in Moltke Harbour that were donated to the Falkland Islands Museum. They originally held mineral water and are trademark stamped with a lion rampant surrounded in a double circle by the word “SPRITZER”. Underneath that is stamped “EBZOGTHUM NASSAU”.