

ANNALS OF BRYOZOLOGY 3



EDITED BY
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Paper in:

Patrick N. Wyse Jackson & Mary E. Spencer Jones (eds) (2011) *Annals of Bryozoology 3: aspects of the history of research on bryozoans*. International Bryozoology Association, Dublin, pp. viii+225.

Sir Charles Lyell's fossil bryozoans from Gran Canaria

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1. Introduction

Charles Lyell (1797–1875) was the leading geologist of his day.¹ His work proved enormously influential to natural historians seeking to understand both the physical processes involved in the formation of geological structures, and the nature of the fossil record. The key concept of uniformitarianism – ‘the present is the key to the past’ – owes more to Lyell than to any other geologist. Among numerous other notable achievements, he was responsible for the subdivision of the Tertiary into Epochs that could be recognized largely from the proportions of extinct vs. extant species they contained. It is well known that Charles Darwin carried with him on the voyage of H.M.S. *Beagle* a copy of Volume 1 of Lyell's *Principles of Geology* (Lyell 1830). This seminal book allowed Darwin to interpret the geology he saw in terms of gradual physical processes that have shaped the earth over the immensity of geological time; indeed, time sufficient to accommodate Darwin's emerging belief that the diversity of life developed by the slow transmutation of species from a common ancestor, i.e. evolution.

One of Lyell's abiding interests was in the formation of volcanic craters. During the early 19th century this was a matter of considerable dispute. Leopold von Buch (1774–1853) promoted a ‘craters of elevation’ theory whereby volcanic craters formed by sudden, catastrophic and explosive uplift of lavas and ashes that were once horizontally

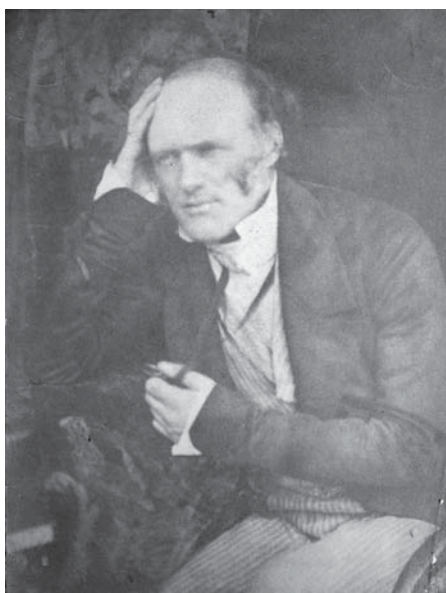


Figure 1. Photograph of Charles Lyell taken in 1846 (NHM Archives).

disposed. In contrast, Lyell (1850) advocated a ‘craters of denudation’ theory, involving gradual accumulation of lavas and ashes on the sloping sides of the cone accompanied by erosion of the centre to form a crater.

Von Buch’s ideas were developed largely from his detailed studies of the volcanoes of the Canary Islands. It was thus imperative for Lyell, a renowned geological traveller, to visit the Canary Islands in order to falsify von Buch’s theory once and for all (Wilson 2007). One way in which the catastrophic theory of von Buch might be disproved in favour of a gradualistic origin for volcanic craters would be by finding, interbedded among the lavas and ashes, sedimentary rocks containing fossils that demonstrated formation of the volcano over a long interval of geological time rather than through a single catastrophic event. Indeed, Lyell succeeded in finding such fossils on Gran Canaria. Most of these fossils comprised gastropods and bivalves but there were also some bryozoans, the focus of the present paper. Our aims are to introduce Lyell and his fieldwork on Gran Canaria, the scientists and others who helped him (George Busk, William Lonsdale and Pedro Maffiotte), and to describe the bryozoans he collected and their significance to his work on the origin of volcanic craters.

2. Lyell and his fieldwork on Gran Canaria

Charles Lyell

Born near Forfar in Scotland, Charles Lyell (Figure 1) was the eldest of ten children.² He was educated at private schools in the south of England before entering the University

of Oxford where he graduated with a BA in Classics in 1819. While at Oxford he attended lectures given by William Buckland on mineralogy and geology, these areas of the natural sciences adding to his boyhood interest in entomology. Although Lyell entered the legal profession and was called to the bar in 1822, his passion was for geology. In the following year he was elected to serve as Secretary of the Geological Society of London, becoming acquainted with such luminaries as Georges Cuvier (1769–1832) and Alexandre Brogniart (1770–1847).

Lyell enjoyed an income sufficient to allow him to indulge his interest in geology by travelling widely. In 1824 he accompanied Brogniart's former student Constant Prévost (1787–1856) on a geological tour of southern England, and four years later visited sites in continental Europe with fellow Scottish geologist Roderick Impey Murchison (1792–1871). During this latter excursion he first witnessed active volcanoes, namely Vesuvius and Etna, and was impressed by the occurrence of sediments containing relatively modern marine shells associated with these volcanoes but now far above present-day sea-level, attesting to a link between volcanic activity and crustal uplift.

In July 1830, the first volume of Lyell's *Principles of Geology* was published. As Rudwick (2004) has noted, the ambitions of the book are immediately apparent in the subtitle: 'an attempt to explain the former changes of the earth's surface, by reference to causes now in operation'. Indeed, the book focused mainly on present-day geological processes such as volcanoes, earthquakes, erosion and sedimentation. Lyell became Professor of Geology at King's College, London in 1831, and also lectured at the Royal Institution in the same city. This work brought him little satisfaction, or income, and he resigned his academic position at King's College in 1833. Volumes 2 and 3 of *Principles of Geology* appeared in 1832 and 1833, establishing Lyell as a major figure in the geological sciences. Many honours followed: he was elected to the presidency of the Geological Society of London (1835–37), was knighted (1848) and eventually received a baronetcy (1864).

William Whewell's review of the second volume of *Principles of Geology* introduced the terms 'uniformitarian' and 'catastrophist' (Rudwick 2004), Lyell being acknowledged as the main proponent of uniformitarianism. *Principles of Geology* ran to numerous editions and was followed by the equally popular *Elements of Geology* (1838a). In a later book, *Antiquity of Man* (1863), Lyell reviewed what was known of the fossil record of humankind at that time.

Lyell was a great geological traveller, visiting geological localities not only in Europe but also the USA. His fame allowed him to establish a network of contacts able to provide guidance for him and his travelling companions in the field.

Fieldwork on Gran Canaria

In December 1853 Lyell began a four-month visit to Madeira and the Canary Islands (Wilson 2007). Lyell's party, consisting of his wife Mary and Frances and Charles Bunbury, arrived at Las Palmas, the capital of Gran Canaria, in late February 1854. His

geological guide on Gran Canaria was the Spanish engineer and polymath Pedro Maffiotte (see below), who accompanied him during his initial forays into the field. During two weeks on Gran Canaria, Lyell and Bunbury journeyed from north to south across the island and back again (Wilson 2007, fig. 4). One of the main regions of Lyell's interest was in the north-east of the island, close to Las Palmas. Here an ancient cliff-line forming the landward border of the coastal plain exposed volcanic lavas and tuffs interbedded with fossiliferous sediments. Many of Lyell's fossils, including more than 60 species of molluscs, came from these sediments. However, Lyell also collected in excess of 50 species of marine molluscs from a raised beach, 25 ft above modern sea-level, exposed to the north of Las Palmas between the ancient cliff-line and the present-day coast.

Maffiotte continued to send Lyell specimens from Gran Canaria after he had left the island. Two boxes of fossils were dispatched while Lyell was still in the Canary Islands, reaching him before he departed from Tenerife to return to England on 8 April (Ben'tez 1928). On receiving these specimens Lyell wrote to Maffiotte to say that they were mostly the same species he had collected earlier but included a few new species.

Further correspondence relating to the geology of northeastern Gran Canaria ensued between Maffiotte and Lyell until 1866 (Benítez 1928, Virgili 2007b). For instance, Lyell wrote to Maffiotte on 10 May 1856 that almost all of the fossils he found at high elevations near Las Palmas belonged to extinct species. On 4 January 1858 Maffiotte sent Lyell a geological cross section of Santa Catalina accompanied by a long essay of the geology of the Canaries.

In a letter to the British Vice Consul on Gran Canaria dated 22 November 1856, Lyell stated that he had presented all of his fossils from the island to the British Museum. However, the bryozoans were not part of this donation as they were by then in the hands of George Busk in Harley Street (see below).

Pedro Maffiotte

In contrast to Lyell, Pedro Maffiotte Arocha (1816–1870) (Figure 2) came from a humble background, his family being fishermen, with the exception of his father who served in the military and was honoured with a Santa Helena's Medal by Napoleón III. Maffiotte was born in Santa Cruz de Tenerife and lived on Gran Canaria between 1851 and 1865. He was accustomed to travelling very often between the Canary Islands, giving him a deep knowledge of this archipelago. Highlights of his engineering works included the new dock at Santa Cruz, Tenerife, and the neoclassical Casa Consistorial at La Orotava on the same island. As an engineer he possessed an understanding of the basic scientific principles essential to geology and palaeontology. Maffiotte collaborated not only with Charles Lyell, but also with Georg Hartung, Karl von Fritsch and Thomas Vernon Wollaston.

Another aspect of Pedro Maffiotte's life was his involvement in the Canarian Arts world. He was in charge of the 'Academia de Dibujo Lineal' with Manuel Ponce de León, and also founded the 'Sociedad de las Bellas Artes' (Society of Fine Arts) that existed in



Figure 2. Portrait of Pedro Maffiotte.

Santa Cruz, Tenerife from 1850 until 1868. He himself was painter: one of his works, *British attack in Santa Cruz de Tenerife -25 July 1797–1848*, is currently in El Museo Naval, Madrid.

The fact that Maffiotte had an extensive knowledge of Gran Canaria, especially its natural history, made him an ideal choice to guide Lyell. Maffiotte's disappointment that the book of the geology of Madeira and the Canaries mooted by Lyell never came to fruition was strongly felt after all of his efforts to furnish Lyell with fossils and his essay on the geology of Gran Canaria.

3. Busk's and Lonsdale's studies of Lyell's Gran Canaria bryozoans

An early indication of Lyell's interest in the fossil bryozoans from Gran Canaria came in a letter written on 13 November 1854 to his travelling companion and brother-in-law Charles Bunbury:

'Of my four species of Bryozoa from the Grand Canary, one is recent and three unknown, so says the first-rate authority, Mr. Busk. I imagine the age may be Miocene or falunian; but this is a mere guess as yet.' (Lyell 1881, p. 199).

Along with Lyell's Gran Canarian fossil bryozoans in the Department of Palaeontology at the NHM are two unpublished letters and several pages of manuscript notes. The first letter (Figure 3A), dated 21 January 1856, was from William Lonsdale to Lyell and accompanied the return of the specimens that Lonsdale had been given for examination at an unknown earlier date. The notes on the bryozoans written by Lonsdale and referred to by him as 'memoranda' were included with this letter. Lyell immediately (22 January 1856) (Figure 3B) wrote to George Busk, sending him the specimens as well as Lonsdale's notes and letter. Busk, therefore, had a second opportunity to see Lyell's specimens.

Later in 1856 (5 October) Lyell wrote to George Hartung: 'The Bryozoa have been examined by a competent geologist, Mr. Busk, as a favour to me.' (Lyell 1881, p. 233). It is unknown whether Busk ventured any opinions about the bryozoans beyond those expressed in Lyell's letter to Bunbury quoted above. The specimens themselves probably remained in Busk's possession until his death and were then presented by his daughter to the British Museum (Natural History) on 13 July 1899 along with the rest of the Busk

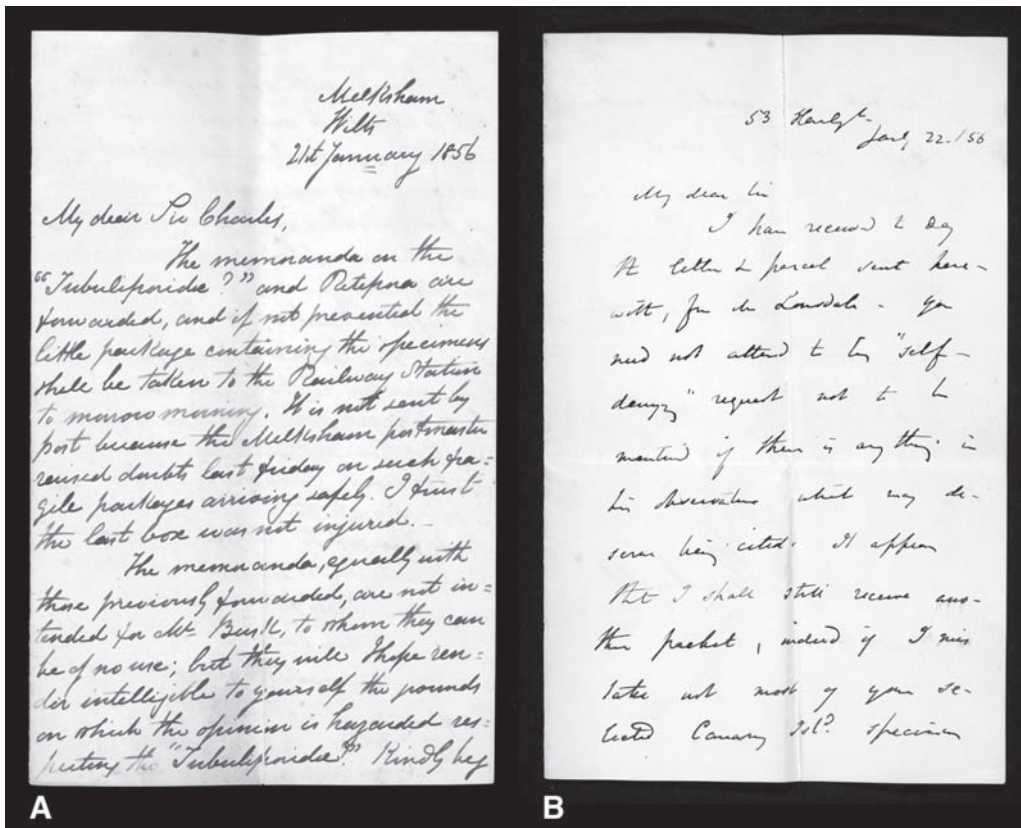


Figure 3. A. First page of Lonsdale's letter to Lyell, dated 21 January 1856, concerning the bryozoans from Gran Canaria. B. First page of Lyell's letter to Busk, dated 22 January 1856, that accompanied the bryozoans and Lonsdale's notes.

collection of recent and fossil bryozoans (Gardiner 1980). The Canarian bryozoans were initially registered into the collections of the Department of Zoology under the number 90.8.28.2 before being transferred to the Department of Palaeontology in August 1936.

Lonsdale's letter of 21 January 1856 to Lyell and the accompanying 'memoranda' are crucial to the story. In a characteristically modest tone, Lonsdale wrote:

'The memoranda, equally with those previously forwarded, are not intended for Mr Busk, to whom they can be of no use; but they will I hope render intelligible to yourself the grounds on which the opinion is hazarded respecting the "Tubuliporidae?". Kindly beg Mr Busk, with my complements, not to allude to my name in the slightest manner, in his descriptions. It can carry no weight, and may do harm. This wish does not, I trust, bear the semblance of discourtesy on my part, for no such feeling can or ought to exist.'

Lonsdale went on to remark that the Canaries bryozoans would be the last he would ever look at. The surviving 'memoranda' written by Lonsdale comprise handwritten sheets headed: *Cellepora* No. 1; *Cellepora* No. 2; *Eschara* No. 1; *Eschara* No. 2; *Idmonea*; "*Retepora*"; and "Tubuliporidae?". In addition to providing morphological descriptions of the bryozoans, Lonsdale's manuscripts compared the bryozoan taxa from Gran Canaria with others from Touraine, specimens of which were included among the material sent to Lonsdale. Lyell had evidently sent this material, which probably comes from the Miocene Faluns de Touraine, believing that it might be possible to identify species in common and therefore make a stratigraphical correlation between the two deposits. However, Lonsdale's determinations were not as conclusive in this respect as Lyell would have wished. For example, he noted that specimens of '*Cellepora* No. 1' from Gran Canaria and Touraine were similar but not necessarily identical. Likewise, specimens of '*Eschara* No. 1' from Gran Canaria and Touraine, which Lonsdale compared with *E. monilifera* Milne Edwards (i.e. *Metrarabdotos moniliferum*), were regarded by him as possibly belonging to different species, as were the respective species identified as '*Idmonea*'. The 'Tubuliporidae' from Gran Canaria examined by Lonsdale was determined as *Fron dipora* which he stated he did not know to occur in Touraine, while he left Busk to determine the 'amount of agreement' between the "*Retepora*" from the two localities.

In several places, Lonsdale's memoranda refer to drawings or 'delineations' made by Busk, by implication of the bryozoans from Gran Canaria, in which case they would have been made when Busk received the specimens from Lyell for the first time. Unfortunately, the whereabouts of these drawings is unknown and they are presumed lost.

The NHM Archives holds several undated manuscript pages under the title *Papers relating to the fossils of Madeira and P. Santo*. These include a list of species with living habits from San Catalina (400 metres north of Las Palmas, 50 m from the seashore and 8 metres above high water mark). No bryozoans are mentioned. However, a separate list of fossils from 'Las Reyojas, near Las Palmas, Miocene?' and headed Zoophyta (Bryozoa) includes the following determinations:

Cellepora ramulosa

Cellepora sp. indet.
Eschara fistulosa Reuss?
Eschara exilis?
Retepora n. sp. aff. *cellulosa*
Lunulites n. sp.

Although it is possible that these names were supplied to Lyell by Busk, they cannot be linked directly to the surviving Gran Canarian material known to have been studied by Lonsdale as this includes no examples of specimens that might have been determined as either '*Retepora*' or '*Lunulites*'.

George Busk

Born in St Petersburg, Russia, George Busk (1807–1886) was a naval surgeon, based for 25 years on hospital ships at Greenwich (Foote 2004), who devoted his retirement to natural history. Although he made important studies of Neanderthal bones from Gibraltar, putting his medical expertise to good use, most of Busk's research concerned recent and fossil bryozoans. His most important bryozoological publications include a monograph of the fossil bryozoans from the Plio-Pleistocene crags of eastern England (Busk 1859), descriptions of recent bryozoans collected during the *Rattlesnake* (Busk 1852a) and *Challenger* (Busk 1884, 1886) expeditions, and catalogues of bryozoans in the zoological collections of the British Museum (Busk 1852b, 1854, 1875). Busk was the author of numerous bryozoan species and some higher taxa, for example, the orders Cheilostomata and Cyclostomata.

William Lonsdale

The life of William Lonsdale (1794–1871) has been summarized by Wyse Jackson (2008) in a previous volume of *Annals of Bryozoology*. Briefly, Lonsdale was a soldier who left the army at an early age and developed an interest in the geology of the area around his parent's home in Bath. He served as honorary curator of the Bath Literary and Philosophical Institution (1825–29) before being appointed to the salaried post of curator, librarian and indexer of the Geological Society of London (1829–1842). While at the Geological Society, Lonsdale met many of the leading geologists of the day and established a reputation as an authority on fossil 'zoophytes'. Lonsdale's reputation meant that he was also consulted by Charles Darwin (Pierce 2004). He published several papers on corals and bryozoans and, for example, is the author of the Cretaceous cyclostome bryozoan genera *Siphoniotyphlus*, *Petalopora* and *Choristopetalum*. In an appendix to Murchison's *Geology of Russia* (1845), Lonsdale (1845) described the earliest example of a thin section of a fossil bryozoan (Wyse Jackson 2008). By the time that Lonsdale received Lyell's Canarian fossil bryozoans he was suffering from ill health and living in Melksham, Wiltshire, not far from Bristol where he died in 1871.



Figure 4. Bryozoans (?Pliocene) from the Lyell Collection of Gran Canaria labelled by William Lonsdale 'Canaries (Cellepora No 2)' and comprising two branch fragments of heteroporid cyclostomes. NHM BZ5791.

4. The fossil bryozoans

The following batches of Gran Canarian bryozoans from the Lyell Collection which were examined by William Lonsdale can be recognized in the fossil collections of the NHM:

(a) A slip of blue paper labelled 'Canaries (*Cellepora* No 2)' to which is glued two small bryozoan branches (Figure 4). These are clearly the specimens referred to under the same title in Lonsdale's notes. Perceptively, Lonsdale remarked that: 'This fossil appears to me to be more nearly allied to *Heteropora* of De Blainville than to *Cellepora*..' The bryozoans are indeed heteroporid cyclostomes (Figure 5A).

(b) Several branch fragments of an adeoniform cheilostome, eight affixed to three wooden slides and 27 from a paper packet labelled '*Eschara*' (Figure 6). Slides '2' and '3', containing three and one fragments respectively, are labelled 'Canaries. Fossil. Sir C Lyell', whereas Slide '1' containing 4 fragments, bears the additional locality information 'Las Palmas'. These bryozoans can be identified as *Metrarabdotos* (Figure 5F) and are probably the ones referred to by Lonsdale as '*Eschara* No. 1' which he compared with *E. [M.] monilifera*.

(c) A white card to which were originally affixed 10 branch fragments, two now detached and represented by patches of glue (Figure 7). The card is labelled 'Canaries, *Cellepora* No. 1' and bears additional information written in pencil. To judge from its close similarity to the handwriting in Lonsdale's 'memoranda', this too was written by Lonsdale. The bryozoans are arranged in three rows annotated with the pencil descriptions 'Cells inclined upwards in general', 'Cells inclined outwards more or less' and 'Aged or flattened [?] branches – cells inclined in all directions'. The bryozoan represented is probably the same species as in sample (d).

(d) Thirty-four branch fragments contained in a small red box labelled 'Polyzoa from Las Palmas, Canary. Sir Chas Lyell. A' (Figure 8), and with a Lonsdale label stating

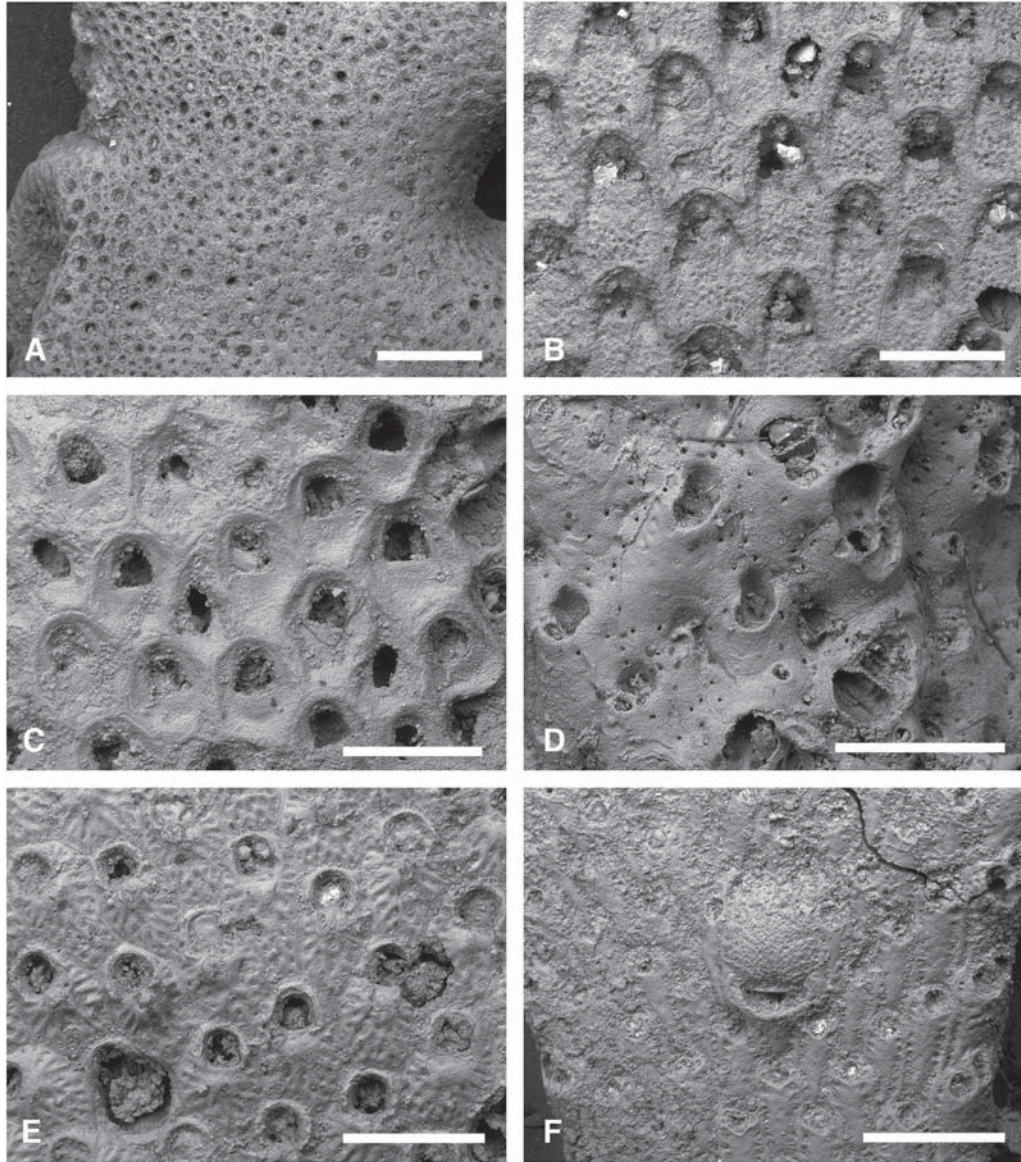


Figure 5. Scanning electron micrographs of ?Pliocene bryozoans in the Lyell Collection from Gran Canaria. A, heteroporid cyclostome, NHM BZ5791. B, Labioporella, NHM D6523. C, Onychocella, NHM D6527. D, ?Omalosecosa, NHM BZ5790. E, Cryptosula, NHM D6527. F. Metrarabdotos, NHM BZ5785. Scale bars A, F = 1 mm; B-E = 500 μ m.

‘Canaries *Cellepora* No. 1 loose specimens’. These specimens can be identified provisionally as ?*Omalosecosa* (Figure 5D).

In addition to these specimens, all demonstrably examined by Lonsdale, there are other Lyell bryozoans in the Busk Collection (see Appendix). Notable among these are two



Figure 6. Adeoniform bryozoans (?Pliocene) from the Lyell Collection of Gran Canaria identified by Lonsdale as 'Eschara' [=Metrarabdotos]. NHM BZ5785.

pieces of bryozoan-rich limestone with a label, possibly written by Pedro Maffiotte, stating: 'Du barranquillo de Santa Catalina au point 9 (gauche) de la coupe 11-12'. Fragments of *Metrarabdotos* dominate but there are also pieces of *?Omalosecosa* and cyclostomes. Some other bryozoans are labelled as coming from Monte San Roque, Las Palmas. There are also several poorly preserved lunulites (*Cupuladria*) from unspecified localities in the Canary Islands.

In summary, Lyell's fossil bryozoans from Gran Canaria represent a moderately diverse biota containing at least six cyclostome (*Fron dipora*, *Nevianipora*, *Exidmonea*, *?Mecynoecia*, *Hornera*, Heteroporidae gen. undet.) and eleven cheilostome genera (*Chaperiopsis*, *Labioporella*, cf. *Rosseliana*, *Onychocella*, *Cupuladria*, *Trypostega*, *?Omalosecosa*, *Cryptosula*, *?Smittina*, *Metrarabdotos*, Phidoloporidae gen. undet.). As noted below, the most probable age for most or all of these fossils is Early Pliocene.

Table 1 summarizes what is known about the history Lyell's Gran Canarian bryozoans.

Table 1. Summary history of the fossil bryozoans collected by Charles Lyell on Gran Canaria.

1854	
February-March	Lyell spends two weeks on Gran Canaria, collecting fossil bryozoans and other invertebrates.
13 November	Lyell writes to C.J.F. Bunbury mentioning four bryozoan species from Gran Canaria which, according to Busk, comprise one Recent and three unknown species. Lyell suspects a Miocene ('falunian') age.
1856	
21 January	Lonsdale writes to Lyell enclosing his notes ('memoranda') and returning Lyell's specimens. Letter implies that Busk would be formally describing the material.
22 January	Lyell writes to Busk sending him Lonsdale's notes and his own specimens from the Canaries with comparative material from Touriane.
10 May	Lyell writes to Maffiotte acknowledging the receipt of fossils sent in April.
1858	
6 January	Maffiotte writes to Lyell acknowledging receipt of fossils sent in April. Letter mentions fossil bryozoans from a locality near Las Palmas, along with molluscs and echinoderms, from 'important' levels. Almost all of these fossils are said to be extinct species.
1899	
13 July	Lyell bryozoans presented to NHM by Miss Busk, including 12 packets from Gran Canaria and Touraine originally registered into the NHM Department of Zoology collections as 90.8.28.2.
1936	
August	Gran Canarian and other Lyell fossil bryozoans transferred to the Department of Palaeontology, NHM.

5. Subsequent studies on fossil bryozoans from Gran Canaria

Not only have Lyell's important historical collections of bryozoans been ignored, but surprisingly little research has been undertaken at all on fossil bryozoans from Gran Canaria, with nothing published during the last 50 years.

Rothpletz and Simonelli (1890) listed 6 bryozoan species, mostly from a locality called La Vista, as follows:

Fasciculipora sp. ind.

Eschara monilifera M.E.

Eschara lamellosa (Mich.)

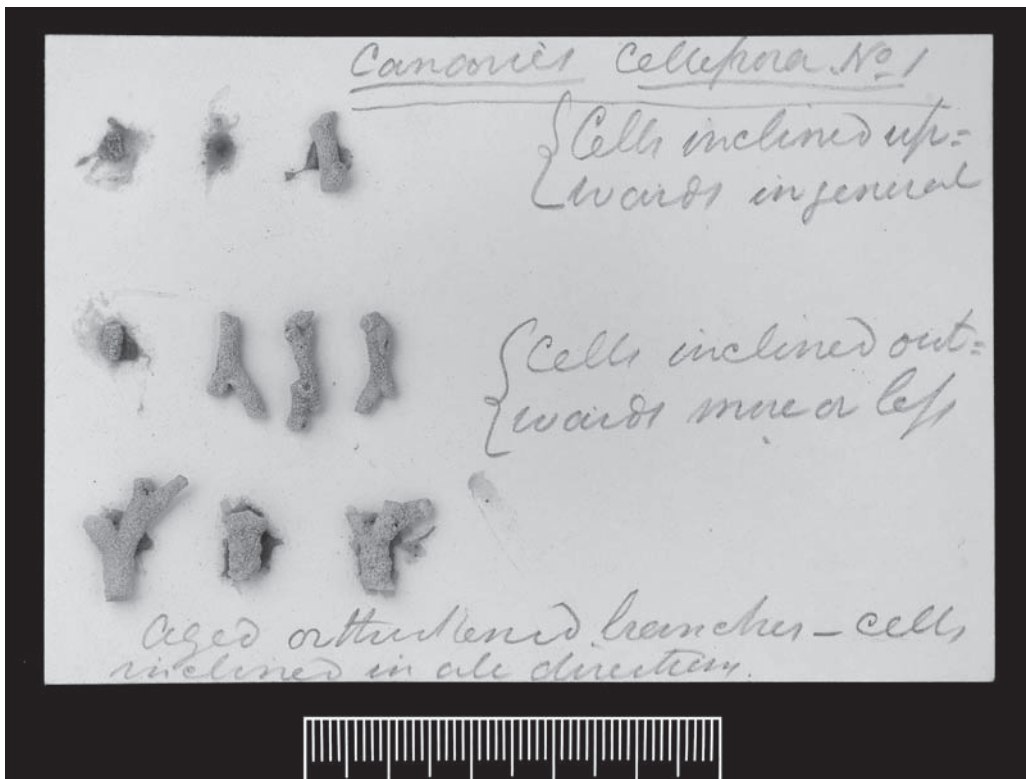


Figure 7. Bryozoans (?Pliocene) from the Lyell Collection of Gran Canaria labelled by Lonsdale 'Canaries (Cellepora N° 1)', probably *Omalosecosa*. NHM BZ5784.

Retepora cellulosa L.

Celleporaria verrucosa Rss.

Cupularia intermedia (Micht.) [sic]

This list, barring some spelling mistakes and minor changes, was repeated by Benítez (1928) in his book on the history of the Canary Islands.

Darteville (1937) noted that bryozoans are diverse in the Miocene of Gran Canaria and went on to describe, very briefly and without figures, the following species from the Museo Benitez: *Cellaria mutabilis* Canu, 1909, *Myriozoum* sp. and *Crisia admota* Canu & Lecointre, 1933. He drew attention to the similarities between these bryozoans and the bryozoan faunas of the Faluns de Touraine and Faluns de Anjou in France.

Finally, Cheetham (1968) described *Metrarabdotos (Porometra) helveticum canariense* subsp. nov. from the Miocene of Monte San Roque, Las Palmas. This subspecies was based on material in the NHM collected by Caroline Birley (1851–1907)³ and received as a bequest in 1907, together with some paratypes from the Pliocene of Rhodes in the collections of the USNM, Washington.

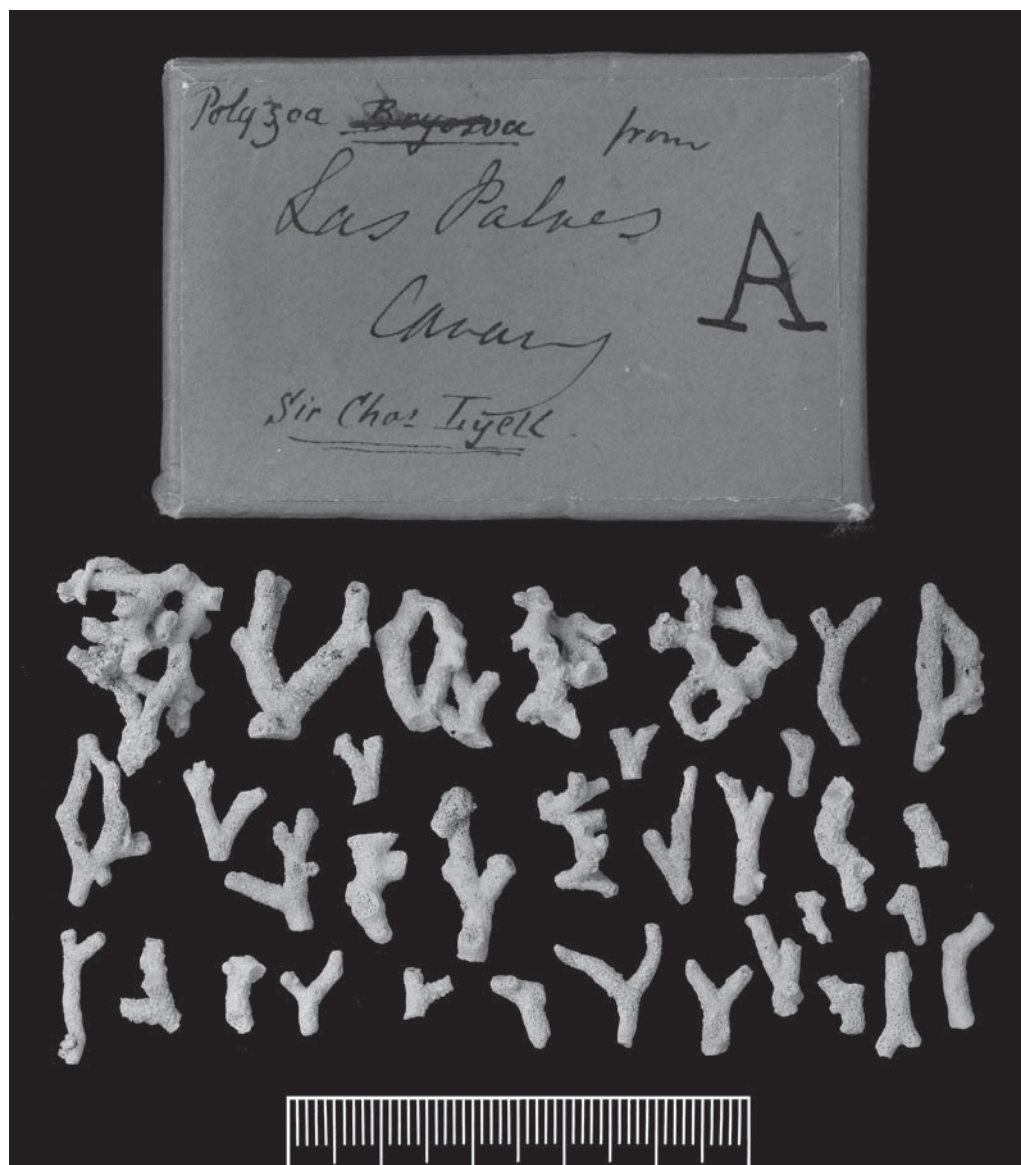


Figure 8. Red box labelled 'Polyzoa from Las Palmas, Canary. Sir Chas Lyell. A' and its contents (?Omalosecosa) examined by Lonsdale. NHM BZ5790.

6. Discussion

Lyell found ample support for his 'craters of denudation' theory from the fossils collected by him and subsequently by Pedro Maffiotte on Gran Canaria. Although the bryozoans did not provide him with precise information about the age of the fossiliferous sediments interbedded with the volcanic deposits exposed near Las Palmas, the

predominance of extinct species did suggest that they were geologically ancient and thus that the volcano had developed through uplift over a long period of time and not by the kind of catastrophic blistering event envisaged by von Buch. However, Lonsdale was unable to show that the Gran Canaria bryozoans were the same species as those found in Touraine and therefore could not provide the evidence sought by Lyell to indicate a Miocene age. The molluscs and other fossils proved to be more helpful in this respect, as is apparent in the following passage from the *Student's Series* edition of *Elements of Geology* (Lyell 1838b, pp. 538–9) summarizing Lyell's conclusions about the significance of the fossils found near Las Palmas:

'Grand Canary.—In the Canaries, especially in the Grand Canary, the same [as in Madeira] marine Upper Miocene formation is found. Stratified tuffs, with intercalated conglomerates and lavas, are there seen in nearly horizontal layers in sea-cliffs about 300 feet high, near Las Palmas. Mr. Hartung and I were able to find marine shells in these tuffs at a greater elevation than 400 feet above the sea; but as the deposit to which they belong reaches to the height of 1,100 feet or more in the interior, we conceive that an upheaval of at least that amount has taken place. The *Clypeaster altus*, *Spondylus gaederopus*, *Pectunculus pilosus*, *Cardita calyculata*, and several other shells, serve to identify this formation with that of the Madeiras, and *Ancillaria glandiformis*, which is not rare, and some other fossils, remind us of the faluns of Touraine.

The sixty-two Miocene species which I collected in the Grand Canary were referred by the late Dr. S.P. Woodward, to forty-seven genera, ten of which are no longer represented in the neighbouring sea, namely *Corbis*, an African form, *Hinnites*, now living in Oregon, *Thecidium* (*T. Mediterraneum*, identical with the Miocene fossil of St. Juvat, in Brittany), *Calyptraea*, *Hipponyx*, *Nerita*, *Erato*, *Oliva*, *Ancillaria*, and *Fasciolaria*.

These tuffs of the southern shores of the Grand Canary, containing the Upper Miocene shells, appear to be about the same age as the most ancient volcanic rocks of the island...

In proof that movements of elevation have actually continued down to Post-tertiary times, I may remark that I found raised beaches containing shells of the Recent Period in the Grand Canary, Tenerife, and Porto Santo. The most remarkable raised beach which I observed in the Grand Canary, in the study of which I was assisted by Don Pedro Maffiotte, is situated in the north-eastern part of the island at San Catalina about a quarter of a mile north of Las Palmas. It intervenes between the base of the high cliff formed of the tuffs with Miocene shells and the sea-shore. From this beach, at an elevation of twenty-five feet above high-water mark, and at a distance of about 150 feet from the present shore, I obtained more than fifty species of living marine shells. many of them, according to Dr. S. P. Woodward, are no longer inhabitants of the contiguous sea, as, for example, *Strombus bubonius*, which is still loiving on the West Coast of Africa, and *Cerithium procerum*, found at Mozambique; others are Mediterranean species, as *Pecten Jacobaeus* and *P. polymorphus*. Some of these testacea, such as *Cardita squamosa*, are inhabitants of deep water, and the deposit as a whole seems to indicate a depth of water exceeding a hundred feet.'

Lyell knew that his grand visions of modern geological processes and similar processes

in the past shaped earth history had to be tested from detailed observations. Throughout his career he enlisted palaeontologists to help in the identification of his fossil finds. For example, Lyell paid Gerard Deshayes (1797–1875) to identify fossil molluscs in support of his subdivision of the Tertiary and, as is evident from the quotation given above, S.P. Woodward played a crucial part in determining the antiquity of Lyell's molluscs from Gran Canaria.

Samuel Pickworth Woodward (1821–1865), best known for his book *A Manual of Mollusca* (1851–56), had worked under William Lonsdale at the Geological Society of London before becoming an assistant in the Department of Geology and Mineralogy at the British Museum in 1848 (Cleevely 2004). He was the elder brother of Henry B. Woodward (1832–1921) who became Keeper of the Department of Geology at the British Museum (Natural History).⁴ The diary of S.P. Woodward in the NHM Archives records numerous visits of Charles Lyell to the British Museum for almost 6 years between September 1854 and June 1860. For instance, on 16th, 18th and 19th September 1854, Woodward was employed 'Unpacking and examining fossils from Canary Ids. [with or for?] Sir C. Lyell'. On 29th and 30th November 1855 he was 'Engaged with Sir C. Lyell examining collection of Tertiary fossils from Canary Islands', while for 7 days in 1857 his diary entry is 'Sir C. Lyell re. Canary fossils'. These activities testify to the importance Lyell placed on the identification, and hence dating, of the fossils from the Canary Islands. Charles Darwin was also interested in the results obtained by Woodward's research: he remarked to S.P. Woodward in 1860 (?July) that, to judge from the finding of Miocene littoral shells, the Canary Islands as a volcanic group must be very old (letter 2630, Darwin correspondence project).

The fact that Lyell's fossils came from two sites in the vicinity of Las Palmas – older sediments interbedded with volcanics exposed in an ancient cliff, and a younger raised beach – has led to some confusion about the age of the molluscan and other fossils from Gran Canaria. Joaquín Meco and coworkers have done much to clarify this matter. New K/Ar ages from pillow lavas emplaced into the older sediments give an age of about 4.1 Ma (Early Pliocene) (Meco *et al.* 2007). In contrast, the raised beach at San Catalina approximately 0.4 km north of Las Palmas is apparently Late Pleistocene in age (Meco 1982).

Most, if not all, of the bryozoans in the Lyell Collection seem to have been collected from the older deposit, formerly regarded as Miocene but now dated as Early Pliocene as noted above. However, there is a need for a proper investigation of the fossil bryozoan fauna from Gran Canaria, not only to illuminate Lyell's research but also because of its palaeobiogeographical importance. This should include new fieldwork to discover comparable bryozoans from stratigraphical levels currently exposed and of known age.

7. Summary

Charles Lyell visited Madeira and the Canaries in 1854 with the prime purpose of disproving von Buch's theory of volcanoes as 'craters of elevation'. Aided by Pedro

Maffiotte, he collected fossiliferous sediments associated with volcanic deposits from localities close to the capital of Gran Canaria, Las Palmas. Establishing the age of these sediments became one of Lyell's major preoccupations during the next few years: if they spanned a long interval of geological time, then his idea of a gradual formation of volcanic cones would be favoured over von Buch's theory of catastrophic origin. Lyell recruited several palaeontologists, including S.P. Woodward and Edward Forbes to help him in the task of identifying the molluscs and echinoderms respectively, and George Busk and William Lonsdale for the bryozoans. The bryozoans, now in the collections of the NHM along with associated manuscript material, helped to demonstrate the ancient origin of the volcano near Las Palmas, although molluscs provided better correlations suggesting that the volcano had existed since at least the Miocene.

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Notes

- 1 Befitting his place in the development of the science of geology, much has been published about Charles Lyell's life and research. See, for example: Bailey (1962), Wilson (1972), Rudwick (1978), Blundell and Scott (1998), and Virgili (2007).
- 2 Bailey (1962) provides an easily readable summary of Lyell's life.
- 3 For a brief biography of Caroline Birley, see Bolton Museum and Archive Service [on line]. 2010. Caroline Birley. Retrieved 12 November 2010 from <http://www.boltonmuseums.org.uk/collections/geology/collectorscollections/caroline-francis-birley/>
- 4 For an introduction to the Woodward family of naturalists, see Sheets-Pyenson (1982).

Appendix

Inventory of Gran Canaria fossil bryozoans in the Busk Collection known or believed to have come from the Charles Lyell Collection.

NHM registration number	Locality	Original identification	Revised identification
D6523	Canary		<i>Labioporella</i>
D6524	Canaries	<i>Membranipora</i>	<i>Labioporella</i>
D6525	Canaries		cf. <i>Rosseliana</i>
D6526	Canaries	<i>Membranipora antiqua</i>	<i>Onyhocella</i> <i>?Omalosecosa</i>
D6527	Canaries	<i>Membranipora antiqua</i> B.	Cupuladria <i>Onyhocella</i> <i>?Rosseliana</i> Cryptosula
D6528	Canary		<i>Onyhocella</i>
D6529	Canaries	<i>Eschara monilifera?</i>	<i>Metrarabdotos</i>
D6531	Canaries	<i>Retepora</i>	Phidoloporidae
D6532	Canaries	<i>Retepora</i> sp.	Phidoloporidae
D6533	Canaries	<i>Fron dipora massigli</i> <i>Millepora truncata?</i>	<i>Fron dipora</i>
D6534	Canaries		Cupuladriidae
D6535	Canaries	<i>Lepralia</i>	<i>Trypostega</i>
D6536	Las Palmas, Canaries	<i>Cupuladria</i>	
D9264	Monte San Roque, Las Palmas, Grand Canary	<i>Chaperiopsis</i>	
D9271			<i>?Metrarabdotos</i>
D9281			<i>?Smittina cervicornis</i>

D9315			<i>Nevianipora</i>
D9316			<i>Exidmonea</i>
D9317			? <i>Mecynoecia</i>
D9340	Monte San Roque, Las Palmas, Grand Canary	<i>Fron dipora</i>	
D34539	Canaries	<i>Fron dipora reticulata?</i>	<i>Fron dipora</i>
BZ5760	G. Canary		Limestone with bryozoans
BZ5761	Las Palmas, Canary		Limestone with bryozoans
BZ5762	Santa Catalina, point 9, beds 11-12		Limestone with bryozoans
BZ5763	Canary Ids		<i>Cupuladria</i>
BZ5767	Canary Islands		<i>Hornera</i>
BZ5768	Canary Islands		<i>Onychocella</i>
BZ5769	Canary Islands		Celleporidae
BZ5770	Canary Islands		<i>Cupuladria</i>
BZ5771	Canary Islands		<i>Metrarabdotos</i>
BZ5772	Canary		<i>Cupuladria</i>
BZ5784	Canaries	<i>Cellepora</i> No. 1	? <i>Omalosecosa</i>
BZ5785	Canaries	<i>Eschara</i> No. 1	<i>Metrarabdotos</i>
BZ5790	Canaries	<i>Cellepora</i> No. 1	? <i>Omalosecosa</i>
BZ5791	Canaries	<i>Cellepora</i> No. 2	heteroporid cyclostome