

The German geologist Georg Hartung (1821–1891) and the geology of the Azores and Madeira islands

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Abstract: In 1853 and 1854, the German geologist G. Hartung (1821–1891) was living in Funchal, on the Portuguese island of Madeira. During this time Charles Lyell visited the archipelago to carry out the fieldwork that led the famous British geologist to write *On the Geology of Some Parts of Madeira*, published in the *Quarterly Journal* in 1854, and to make abundant references to the geology, morphology, palaeontology and living flora and fauna of the islands in the sixth edition of the *Elements of Geology* (1865) and in the 1868 edition of the *Principles of Geology*. Lyell was accompanied by Hartung during the visit to Madeira and to the Canary Islands. Hartung left on him a deep and lasting influence, so that Lyell wrote that his German colleague had ‘proved a most active fellow-labourer’. Lyell liked to talk to young geologists from whom he felt ‘old stagers’ had much to learn, and that was probably the case with Hartung.

Hartung visited the Azores archipelago in 1857 and in 1860 produced a book (*Die Azoren in ihrer äusseren Erscheinung und nach ihrer geognostischen Natur*) and an atlas with very fine plates of views of the volcanic landscape of S. Miguel Island. In 1864, he published *Geologische Beschreibung der Inseln Madeira und Porto Santo* on the geology of Madeira and Porto Santo that was the result of his ideas and field observations made from 1850 to 1854. Both books have palaeontological sections written by German-speaking authors. *Betrachtungen über Erhebungskrater, ältere und neuere Eruptivmassen nebst einer Schilderung der geologischen Verhältnisse der Insel Gran Canaria*, published in 1862, also refers to Madeira and the Azores.

Hartung’s work on these archipelagos was important from both a geological and a historical point of view, and he became involved in the discussion of Leopold von Buch’s ‘upheaval’ and Charles Lyell’s ‘upbuilding’ theories.

This is an account of the geological work carried out in the mid-1800s by the German naturalist Georg Hartung (1821–1891) in the Portuguese archipelagos of Madeira and Azores in the Atlantic Ocean. It focuses on the importance of Hartung’s work in advancing the scientific understanding of such volcanic islands, and also on his contribution to the debate on the so-called Erhebungskrater (‘craters of elevation’) or upheaval theory of Leopold von Buch (1774–1853), and the opposite theory of upbuilding, promoted by Charles Lyell (1797–1875).

Hartung also visited the Spanish Canary Islands in order to discover more about their geology and the volcanic processes that were responsible for their origin and physical development, and to compare them with Madeira and the Azores.

The Madeira archipelago of which Madeira and Porto Santo are the main islands with Funchal being the capital city, and the Canary archipelago which comprises the main islands of La Palma, Gomera, Hierro, Tenerife, Gran Canaria, Fuerteventura and Lanzarote, both lie off the northwestern part of the African coast. They are relatively close to

each other (some 650 km apart) but in the mid-1800s there were poor links between them, such that Hartung sometimes had to travel from one island group to the other via mainland Europe. The Azores archipelago which comprises the islands of S. Maria, S. Miguel, Terceira, Pico, Faial, S. Jorge, Graciosa, Flores and Corvo is located in the middle of the North Atlantic, some 1300 km west of Lisbon, and again Hartung had to travel from Europe in order to visit the islands. This created severe problems in carrying out geological work, and certainly was expensive. He paid for the travelling and living expenses himself and received no funds for his work from governmental or institutional sources. A case *d’amour à l’art*, one might say.

This bio-bibliographic sketch is based mainly on a reading of the prefaces of his books and on letters that he exchanged with Charles Lyell. Unfortunately, we did not have access to letters from and to other scientists (such as the Swiss palaeontologist Oswald Heer (1809–1883) from Zurich), with whom Hartung worked and corresponded.

Bio-bibliographic sketch

Georg Friedrich Karl Hartung was born on 13 July 1821 in Königsberg, (now Kaliningrad, then in Prussia) and died, unmarried, in Heidelberg on 28 March 1891. He was the first child of Georg Friedrich Hartung (1782–1849) and Anna Maria Sophie Greis (1797–1870). His father, a freeman and a municipal councillor of Königsberg owned a prosperous printing and publishing house in the city, and also edited the traditional liberal Königsberger Journal *Hartung'sche Zeitung*. A year before his death he left his older son his house, and the firm was later passed on to Georg's younger brother Hermann (1823–1901) who had a degree in mathematics from the University of Königsberg. These family assets were almost certainly the source of funds for Hartung's travels and it is possible that he received some practical preparation in the printing and publishing business that allowed him to make a living. In 1871 the family sold the printing house.

It is not clear from his writings whether or not he had an interest in science before going to Madeira in 1850, but he never received any preparation in order to become a naturalist. He attended the Insterburg Classical Grammar School for seven years, and in 1838 when he was 16 years old had qualified for entry to university. Rather than follow a university career immediately, he probably joined his father's firm, where his ability to execute fine drawings was most useful (Wilhelm 1997).¹

Hartung's artistic capabilities were amply demonstrated in his books, and his progress in adapting to be a geological artist was praised by Charles Lyell in 1854 and again in a letter dated January 1855: 'He draws tolerably, and improves in this daily'. What is surprising is that no representation of Hartung is known to exist except for a small watercolour that depicts him and Charles Lyell during one of their geological excursions in Tenerife (Lyell 1881; Wilson 1998).

Lyell described Hartung as being 'very zealous', 'helpful', 'a most active fellow-labourer' and an 'apt scholar'. It is not surprising that Lyell got on well with Hartung; it was well known that Lyell was sympathetic to and liked to talk to younger geologists from whom he felt 'old stagers' like himself had much to learn; Hartung was no exception (Lyell 1881; Macomber 1993; Wilson 1998).

It was most probably after his arrival in Madeira, where from 1850 he had begun to spend the winter to escape the harsh climate of his native land, that he became attracted to natural history at the relatively advanced age of 29 years. Hartung lived in Funchal, where he shared a house with Oswald Heer, who had been advised by von Buch to stay there to recover from a severe, dangerous cough.

This suggests that Hartung had also travelled to Madeira for treatment which, at the time, was common among Europeans suffering from chest diseases. This supposition is supported in letters from Hartung addressed to Lyell in which he wrote that suffered from catarrh and usually got much better after staying in Madeira. His interest in natural history was fostered largely due to the influence of Heer, and included not only geology but also botany, entomology and, according to Lyell, agriculture (Hartung 1857*a, b*, 1860*a, b*, 1862, 1864; Lyell 1881). His preparation as a field geologist resulted from his practical interest in that science and from accompanying Earth scientists, like Heer and Lyell, on field trips around the island. From his observations, conversations and the exchange of letters with these and many other scientists, and from readings books by von Buch, Lyell, Charles Darwin and others he read the conceptual models put forward on the formation and development of the volcanic islands that he visited, and more importantly began to develop his own models.

Hartung was concerned that he had not received any formal education in geology, and so in 1855 he thought of reading geology at the University of Heidelberg for at least one semester. However he missed the beginning of the academic year and so decided instead to have private lessons in geology and mineralogy, and these continued intermittently because of his travels to the islands, in that and in the following year.²

In October 1862, according to a very short paragraph in one of his letters addressed to Lyell, he received the degree of Doctor of Philosophy from the University of Königsberg, most probably in recognition of his work in the volcanic islands of the Atlantic.³ This explains why on the title page of his book on Madeira and Porto Santo (1864) is printed '*Dr. G. Hartung*' and probably explains why he is referred to as 'geologist' and 'Dr. h. c.' (*honoris causa doctor*) in a recent publication for German-speaking visitors to Madeira (Wilhelm 1997).⁴ It also explains why Heer referred to him in the preface of his 1877 book *Flora Fossilis Arctica* as '*my friend Dr. G. Hartung*' (Heer 1877).⁵ Curiously, for no apparent reason, Charles Lyell addressed him as 'Professor George Hartung' in a letter dated October 1856 (Lyell 1881).

Hartung spent much of the early 1850s engaged in his geological travels to the Atlantic islands, but dedicated most of the later 1850s and 1860s to writing up and publishing the results of his observations and ideas (Hartung 1857*a, b*, 1860*a, b*, 1862, 1864; Hartung & Arlett 1858; Fritsch *et al.* 1867).⁶ He published articles first on the Canary Islands in 1857 and 1858, then on the Azores: *Die Azoren in ihrer äusseren Erscheinung und nach*

ihrer geognostischen Natur (1860); then on the various archipelagos (*Betrachtungen über Erhebungs-krater, ältere und neuere Eruptivmassen nebst einer Schilderung der geologischen Verhältnisse der Insel Gran Canaria* (1862); then about Madeira and Porto Santo: *Geologische Beschreibung der Inseln Madeira und Porto Santo* (1864), where he had started his geological activities some thirteen years before and where he had worked accompanying Lyell some eleven years before; and finally in 1867 about Tenerife. Only one scientific manuscript by Hartung is known to exist, on the geology of the Terceira island (Azores) written in French in 1857; it is in the library of the Instituto Geológico e Mineiro (formerly the Geological Survey of Portugal) in Lisbon.

In later years Hartung also published works on his travels in Scandinavia, which he undertook on account of his interest in glacial geology which he had first developed in the Azores. There, according to letters dated 1858 addressed to him from Lyell and from Darwin to Lyell and to J. D. Hooker, he had found erratic boulders and plants showing that icebergs had been stranded there (Hartung 1877a; Hartung & Dulk 1877; Lyell 1881).⁷

Hartung's travels around various Atlantic islands

That Hartung should have travelled to the Portuguese island of Madeira in 1850, is not surprising on two accounts: first it was a well-known haven for those suffering ill-health, and secondly the German-speaking community on the island was a relatively large one, in the second half of the nineteenth century, because many were associated with the export of embroidery and Madeira wine to Europe through Hamburg (Wilhelm 1997).⁸

Hartung accompanied Heer for some five to six months on his excursions in the island. Heer, who had travelled from Switzerland to Madeira in 1850, specialized in palaeobotany and entomology and was also interested in geology. He became a full professor at the prestigious University of Zürich and also at the Eidgenössische Technische Hochschule (ETH) in the same city (Wilhelm 1990, 1997).

In April 1851, Hartung and Heer departed the island for Cadiz, Spain, and from there they travelled to the Canary Islands where they visited Lanzarote, Fuerteventura and Gran Canaria. It is believed that Hartung spent the winter of 1851 to 1852 there (Wilhelm 1990).

In 1852 Hartung was again in Madeira where he spent that and the following winter, according to Charles Lyell. Both Hartung and Lyell worked together for two months during the winter of

1853–1854, and Lyell benefited greatly from his company since the German naturalist was able to speak Portuguese and had a broad knowledge of the topography and the geology of the island (see maps that accompany Wilson's paper in this volume for routes and places visited). These observations made in Madeira were to be included in a book by Lyell that would contain a report of the result of their joint observations; a plan was outlined by Lyell in a letter dated January 1855 in which he also mentioned the German's good work on the island (Lyell 1881). No report, as a separate piece within a book, was ever published, although Lyell did write a paper on the geology of Madeira that was presented in 1854 to the Geological Society of London (Lyell 1854)⁹ and in 1855 prepared a manuscript with notes on the visit to the island with Hartung (Fig. 1).¹⁰

In 1854, Hartung spent a month with Lyell visiting the Canaries, where they visited Tenerife and Palma and he again returned to Gran Canaria, where he had the opportunity to hear Lyell's thoughts and ideas on the local geology of the islands and on volcanic mountains in general. That helped Hartung understand what he had observed in all the islands, and clarified what had not been clear from reading von Buch's concepts. He spent the summer of 1854 in Europe, where he prepared geological sketches for Lyell, and travelled around in Germany and Switzerland where he met with Heer in Zürich; in November he returned to Madeira (Lyell 1881; Wilhelm 1997). He worked there and in Lanzarote and Fuerteventura until April 1855 and used an interesting method of transport which he described thus: 'I may mention the way in which I travelled in these islands. The mode of conveyance is on camels, which are the most ungeological animals you can imagine'.¹¹

In May 1855, Hartung travelled from Madeira to London where he spent several weeks with Lyell. The visit had both social and scientific purposes, but not much is known about it. He then went to Germany where he stayed for the rest of the year, travelling to various parts including Darmstadt, Königsberg and Heidelberg. During this time he saw to some family business, worked on his geological samples, prepared geological sketches and took private lessons. In a letter dated December 1855 he described what he did in terms of advancing his geological education during this tour of England and Germany:

As for my studies, I arrived somewhat late to take full advantage of the 'Semester' as they call the lectures of one half year. However I was not sorry for that, because I had had such a rare occasion to learn much more in a short space of time during those weeks which I spent in London. But at the same time I was anxious to get if possible as much as could be given in one semester, notwithstanding all that, which you taught (*sic*) me. I contrived therefore

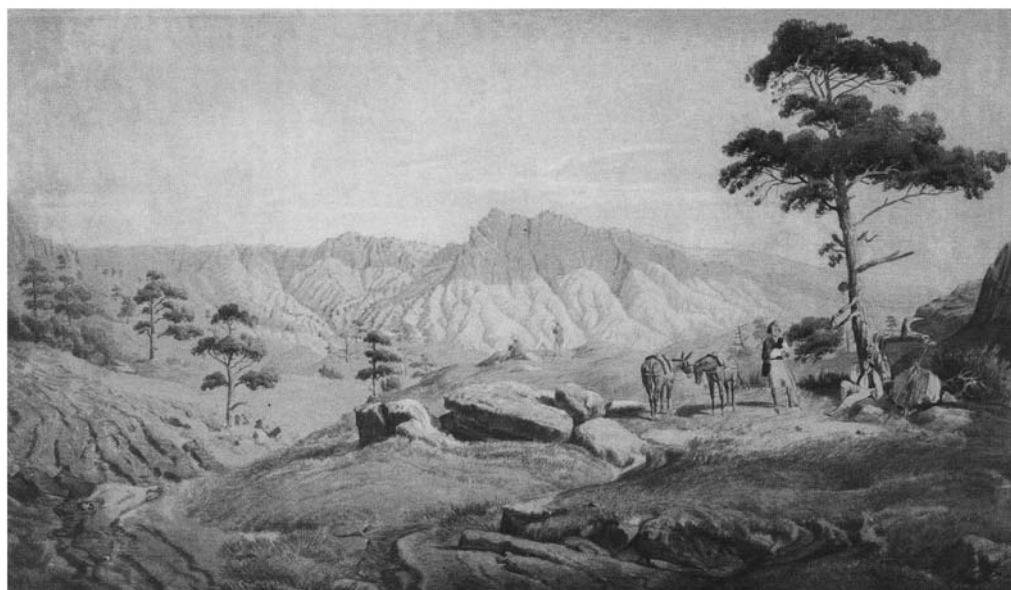


Fig. 1. Hartung and Lyell with their guides at Degollado di Cedro, Tenerife, about 2.00 pm on 30 March 1854; looking SE over las Canadas. Watercolour by Georg Hartung. (Courtesy of Malcolm Lyell; from Wilson 1998, p. 32, Fig. 7.)

to arrange a 'Privatissimum' with Dr. Leonhardt ... who is lecturing to me alone. He ... has a very fine collection of specimens at his disposition. Every time he places before me a great number of rocks, which I may observe at my leisure, asking particular questions.¹²

In December 1855, Hartung rented a house in Heidelberg which he retained until his death, and spent most of 1856 working on his samples from Madeira and the Canary Islands. He again attended private lessons, this time in mineralogy with Dr Leonhardt. The second half of the year was dedicated to the preparation of the planned trip to the Azores. He kept in touch with Heer and also with Robert Bunsen (1811–1899) who was going to analyse the samples from S. Miguel.¹³ He also met Lyell, according to a letter sent from Munich and dated October 1856 in which the British geologist addressed him as 'Professor George Hartung' (Lyell 1881).

In December 1856, Hartung travelled to Madeira, where he stayed until April 1857 and from Madeira he went to the Azores where he remained from the middle of April until the end of August. There Hartung experienced serious difficulties in travelling around, not only between islands but also in each of the nine islands that compose the archipelago.¹⁴ He exchanged letters with Lyell in that year and again in 1858 about Lyell's 'upbuilding' theory and von Buch's 'upheaval' theory, and also noted in some letters his having found fragments of certain rocks

that Lyell believed to have been transported by ice (Lyell 1881).

In the first half of 1858 Hartung commuted frequently between Darmstadt and Heidelberg to study his rock and fossil samples, and to discuss them with Professor Heinrich-Georg Bronn (1800–1862), a professor at Heidelberg University. In September he started visiting districts in Germany in which volcanic rocks cropped out, and he made contact with several German scientists interested in volcanism. In the following year and the first half of 1860 the preparation of his book on the Azores took a great deal of his time, and it was published in June. During the remainder of 1860 he travelled through several volcanic areas of Germany; he also continued to study his samples from Madeira and Porto Santo. In 1861 he visited central Europe and later that year and in 1862 he visited the Auvergne. His letters show that he could not help but compare these very old volcanoes with the recent ones that he had seen in the islands.¹⁵

After 1857, Hartung did not return to Madeira, the Canary Islands or to the Azores. Even while he prepared his papers and books for publication, and the geological and topographic maps of Tenerife, which were assembled in conjunction with his colleagues Karl Fritsch (1838–1906) and Wilhelm Reiss (1838–1908), he saw no reason to return to make any additional local observations.

From the middle 1870s he began to travel to Scandinavia and continued to visit this region until 1880. In Volume 4 of Heer's immense *Flora Fossilis Arctica*, a work of 6 volumes plus a supplement that integrated contributions of a number of co-authors, Hartung contributed a short nine page report on the coal seams at Andö, but it is not obvious that he had participated in the fieldwork that was carried out between 1869 and 1875 under the direction of a mining expert (Hartung 1877b).

Hartung's publications on Madeira and the Azores

A main feature of Hartung's books related to the geology of Madeira and the Azores (and his book on the island Gran Canaria has to be included in this category) is that each one of them, although focusing on one of the island groups, refers to the others, and points out their similarities more than their differences.

Another feature is that the books deal with physiographical aspects of the islands and the field relationships of the rocks; these were normally depicted in very fine drawings and in paintings of landscapes and geological sections. Petrographical and fossil studies, the latter by respected palaeontologists, like Heirich-Georg Bronn and Karl Meyer-Eymar (1826–1907), also make up a significant portion of the books.

In all of the volumes, Hartung follows Lyell's concepts on volcanic processes relating to the origin and evolution of the volcanic islands, that is he adheres to the 'upbuilding' theory. The following is a quotation of a precise and concise description by Leonard Wilson of aspects of that theory and also of the work carried out in Madeira by Lyell and Hartung:

Craters of elevation

In 1835 ... von Buch, ... Élie de Beaumont and ... Dufrénoy launched a concerted attack on Lyell's theory centred upon the question of the age of the Mount Etna. In opposition to Lyell [they] insisted that Etna was quite young. It had arisen suddenly, they said, as a crater of elevation ...

During an extended visit to the Canary Islands in 1815 Buch decided that the great caldera on the island of Palma had been formed by a sudden upheaval of accumulated layers of lava, poured out originally in a horizontal position on the sea floor. In 1825 Buch published the theory at Berlin in his book on the Canary Islands and in 1836, to make the theory of craters of elevation better known, he published in Paris a revised and expanded French translation of his Canary Islands book ... The same year Élie de Beaumont published ... a long paper ... on the structure and origin of Mount Etna ... [where] ... he insisted that the lavas must have been poured out on a nearly horizontal surface and upheaved later ...

In 1848 ... Lyell was knighted, but it was not until 1854 that ... he was able to visit Madeira and the Canary Islands. ... In Madeira he met a young German, Georg Hartung, who joined him in studying the geology of the island. Lyell and Hartung found that Madeira consisted entirely of lavas and basalts produced by a long series of volcanic eruptions of centres on the island. Major cones of eruptions in the centre of the island had buried smaller cones of eruption around its periphery. The many streams of water flowing down from the central mountains had cut deep narrow valleys, providing sections through the accumulated lavas. Frequently they included sections through old volcanic cones buried under later flows of lava from higher centres of eruptions. Such sections revealed multitudes of small vertical dykes, marking channels where molten rock had risen through layers of lava and scoriae ... They showed also that lavas could form sheets of compact rock on steep slopes, and those had not been disturbed since they solidified. The valleys showed Lyell how much more powerful rivers were in eroding the land than he had thought previously ... From fossil plants in a bed of clay among volcanic rocks at Sao Jorge, hundreds of feet above the sea, Lyell discovered that when Madeira was only a half its present size, it was already covered with plants. The additional lavas that had built up Madeira had therefore flowed from the centres of eruption on land. They had not been poured out over the sea bottom. Some volcanoes had become extinct before others began to erupt, but the whole island was a product of a long succession of volcanic eruptions (Wilson 1998).

Hartung's book (1864) on Madeira and Porto Santo relied essentially on the work carried out in 1853 and 1854 by himself and Lyell, but, as the German naturalist worked there on his own after that field season, the book has a personal touch seen, for instance, in his fine drawings of landscapes and geological sections.

An initial section on submarine morphology of the surrounding area of Madeira, based on soundings made available to Hartung, was followed by a description of the subaerial landscape. A long discussion on the effects of sea erosion on the creation of the abrupt sea cliffs followed, and was linked to a discussion of the relative ages of the volcanic masses exposed on the cliffs. He also addressed the importance of the process of deposition of volcanic products relative to the processes of formation and accumulation of organic deposits seen in the island. From this Hartung deduced that fluctuations of the ground either downwards or upwards may have occurred. This section was followed by another lengthy discussion on the effects of running water, and of running water combined with natural trough formation on the cutting of the steep valleys seen in Madeira. This led him to propose a classification of the valleys into two types. Directions, sizes, shapes and slopes observed in ridges, plateaux, valleys, elevations and depressions in general were discussed and tentatively interpreted in terms of old and recent external geodynamic processes, which led to the conclusion that valley formation and evolution, whatever the valley type, had been due mostly, if not completely, to the action of running water. Petrographical and

field descriptions of the main rock types were given, as well as their distribution and modes of occurrence and jointing. The study of the internal structure of the mountains preceded a study of their formation and shaping. For the former purpose, he subdivided volcanic products into two main groups: (a) recent, external layers comprising volcanic cones (classified according to their shapes and relative ages) and lava flows (phonolites, dolerites, basalts, trachytes, trachydolerites) with which some landforms (channels, arches, grottos) were considered; and (b) old, deep layers composed of hyperstenites, diabases, melaphyres, syenites and porphyres, that, being older than the features described under the grouping (a), could not have their geological age determined. The study of the formation and shaping of mountains was accomplished by considering first the main mass of the mountains and then the peripheral mountain ridges of Madeira. The most important conclusion was that the Madeira and Porto Santo islands had grown gradually upwards from a wide base of sea floor as a consequence of repeated eruptions with deposition, accumulation and superposition of volcanic products, the young eruptions forming the main mass of the mountains most probably having taken place more or less in the middle of the island. These eruptions in the centre of the island had buried smaller peripheral cones of eruption.

The final chapters written by Hartung are about Porto Santo Island and an extended abstract with concluding remarks. The book ends with a study by Karl Mayer of the fossils not only from Madeira and Porto Santo but also from Santa Maria, one of the islands of the Azores. The bibliography was not thoroughly prepared by Hartung and did not include several papers and books published between 1818 and 1861 by Portuguese, British, German and Austrian authors about the geology and palaeontology of Madeira.

Following Lyell's visit to the Madeira archipelago made with Hartung in the winter of 1853–1854, his references to and writings on the geology changed not only in their content but also in their length. The 1846 edition of his *Principles of Geology* contained a short, one page conjectural account of its geology; his 1857 *Manuel de Géologie Élémentaire* and the sixth edition of *Elements of Geology* (1865) contained many pages on the volcanic aspects of the islands; whereas he devoted almost a complete chapter to the living and fossil flora and fauna of the archipelago in the 1868 edition of his *Principles of Geology*. According to Hartung, Lyell had not described the geology of the island in the 1855 edition of his *Manual of Elementary Geology* because he had insufficient field information about a very complex structure.

Supplementary data were in fact obtained in 1854 by Hartung who sent them to Lyell.¹⁶

Hartung's book (1860) on the Azores had a similar structure to that of his earlier book on Madeira and Porto Santo. The first part, describing the general geography, morphology and vegetation cover of the islands, was followed by an overview of the geology, general information on historical eruptions and earthquakes, then by a study of the fossils of Santa Maria, this time by H.-G. Bronn, and finally by a geological description of each one of the islands, in which he stressed the similarities and differences among them. An appendix included chemical analyses of lavas, and comments on the lack of limestone deposits. The figures in this book and the accompanying atlas, some of which were in colour, were fine illustrations, and the geological sections were very clearly drawn. From the book, the 1857 manuscript and the letters addressed to Lyell, it seems that Hartung worked in the Azores to his full capabilities, knowing what to look for and where to be able to draw conclusions about the relationship between the structure of the islands and their formation and relief. The main conclusion, again, was that the mountain chains of the Azores could not be interpreted as the result of upheaval but as the result of a gradual accumulation of volcanic products.

Another important idea of Hartung's regarding circular valleys that he had observed in the Azores, was that the structures might in fact be craters of explosion. He documented these ideas in a letter to Lyell dated 10 October 1857:

Since I have seen the Caldeiras (*sic*) of the Azores I feel sure that explosions on a very great scale must have constituted a power which produces immense circular valleys. I do not mean to say that I think it is impossible that a valley like the Caldera of Palma should have become excavated chiefly by aqueous erosion after one, two, or more rivulets have been produced, by which the water got access to the scor. format. [scoriae formation?]. But the outward physiognomy of the Azorean Caldeiras must induce the observer to speculate on the possibility of the pre-existence of circular depressions, caused by explosions.¹⁷

A few pages later, in the same letter, Hartung presented a genetic classification of the valleys of the Madeira, the Canaries and the Azores: 'Inter colline valleys', 'Valleys of aqueous erosion' and 'Valleys produced by explosion'.

Hartung's book on the geology of the Gran Canaria island *Betrachtungen über Erhebungskrater, ältere und neuere Eruptivmassen nebst einer Schilderung der geologischen Verhältnisse der Insel Gran Canaria* published in 1862 contains many references to the Azores and Madeira, although from the title of the book and certain chapters (About the origin of the Palma caldera; The geology of the Gran Canaria island; About the old and the young eruptive masses; and On the origin

of the local elevations) it would be impossible to know this. This is probably his most interesting book; in it Hartung compared the geological aspects of the three archipelagos and made a synthesis of his main ideas. There is a curious aspect related to it. In a letter addressed to Lyell dated November 1860, Hartung referred to a 'small pamphlet' that he had considered writing on the question of the so-called craters of elevation comparing the volcanic phenomena observed in several regions of Central Europe with those seen in the Atlantic islands that he knew so well. About two years later, in October 1862, in another letter also addressed to Lyell, Hartung announced that he had just published a pamphlet in Leipzig in which he addressed some theoretical questions on volcanism. The title of the pamphlet was *Betrachtungen über Erhebungskrater, ältere und neuere Eruptivmassen nebst einer Schilderung der geologischen Verhältnisse der Insel Gran Canaria*, and it was a book of some 115 pages!

Conclusion

Hartung was a man who first developed an interest in natural history, particularly in geology, when he was nearly thirty years old, thanks to his meeting with the Swiss naturalist Oswald Heer. Heer, like Hartung, had travelled to Madeira for health reasons, not to study science, but their meeting and friendship sparked off in Hartung an interest that was to yield some important contributions to the understanding of the geology of the island.

Hartung also had the rare chance of getting acquainted with Charles Lyell, one of greatest geologists of the time, whom he accompanied on field trips in Madeira and the Canary Islands and from whom he got not only a precious practical preparation in field geology, but also a conceptual model for the physical development of the Atlantic volcanic islands. Lyell once addressed Hartung as he being his 'first pupil in the volcanic line' (Lyell 1881) and it has to be concluded that was perfectly true by reading, in the numerous letters addressed to Lyell, the detailed descriptions of the observations made by the German naturalist and the strong argument that he used in favour of the upbuilding theory.

The question of the publication in co-authorship, by Lyell and Hartung, of a paper on Madeira is a topic that is tentatively raised in some of the Hartung's letters to Lyell including that of 14 September 1857:

If I could only show you my sketches and describe the configuration of the different islands, you would (I am sure) publish the Madeira paper without hesitation and even some doubtful passages, which are however so necessary that they could hardly be omitted, would loose at once their seeming ambiguity.

Was he still thinking of Lyell's promise, made in 1855, to send him a book containing the report of the result of their joint observations? In fact a short report of such observations, with Lyell as the sole author, had been published in 1854 in the *Quarterly Journal* of the Geological Society of London, under the title *On the geology of some parts of Madeira* (Lyell 1854). In writing that letter in 1857, Hartung was probably thinking of a different kind of account, a larger one and with his sketches, of their joint observations.

Through Lyell, the German geologist became involved in the discussion of Leopold von Buch's 'upheaval' and Lyell's 'upbuilding' theories. In the foreword of his 1862 book Hartung wrote that the evidence of occurrence of elevated craters had become so fragile that a totally different interpretation about craters like the Caldera of Palma, in the Gran Canaria island, should not be regarded as offensive to those honoured men who had defended the upheaval theory (Hartung 1862). This is the expression of a true gentleman scientist.

As the Prussian geologist and palaeontologist Curt Gagel (1865–1927) rightly pointed out, Hartung's very detailed, prolix descriptions of his observations in Madeira must be considered not only as a reaction to von Buch's theory, but also the result of the influence of Lyell's fascinating personality (Gagel 1913). In a letter addressed to Hartung, dated 16 October 1857, sent from Naples, Lyell wrote 'Lady Lyell desires her kindest regards, and begs me to say she is sorry you are not with us. So am I, but every day makes me feel that you would only have been confirmed in the true doctrines, which you have gradually and not hastily embraced ...' (Lyell 1881). He was certainly referring to Hartung conversion from von Buch's catastrophism ideas to his uniformitarianism concepts applied to volcanism.

Hartung contributed to the progress of the geological knowledge of Madeira, the Azores and the Canary Islands in collaboration with respected palaeontologists whose names he included with his on the books that he authored. These men included Heinrich-Georg Bronn, who, according to Goulvent Laurent (1997), was one of the greatest palaeontologists of the time, and Karl Mayer-Eymar, who became professor at the Eidgenössische Polytechnical School and at the University of Zürich. Among the fossils of Madeira described by others some such as *Cardium hartungi* Bronn, *Janthina hartungi* Mayer and *Ilex hartungi* Heer have names given in honour of the German naturalist (Zbyszewski *et al.* 1975).

Late in his life, when he was some 55 years old, Hartung changed direction in his research, and began to carry out studies on glacial geology in

Scandinavia, a subject that he had touched on in the Azores where he had made some discoveries that had interested Lyell and Darwin.

How well known are his works on the history of geology of Madeira and the Azores archipelagos? Apart from the fact that his books can only very rarely be found second-hand (partly explained by the small numbers of copies that were printed and sold as Hartung complained in a letter to Lyell dated October 1862)¹⁸ two or three other facts reveal that his scientific output has been forgotten. One of his books, *Betrachtungen über Erhebungskrater, ältere und neuere Eruptivmassen nebst einer Schilderung der geologischen Verhältnisse der Insel Gran Canaria* is not listed in bibliographic references to the geology of Madeira and of Azores although it discussed many aspects of the subject (Rodrigues & Aires-Barros 1992; Pinto 1998). Even Hartung's books on the Canary Islands were not referred to in a recent, extended bibliography about the archipelago (Cruz 2001). German scientific encyclopaedias and dictionaries make no reference to Hartung.¹⁹ The manuscript relating to the island of Terceira, found by one of the present authors (MSP) in Lisbon in the library of the Instituto Geológico e Mineiro, has never been cited in the literature.

Nevertheless his geological sections of the Azores islands are correct²⁰ and the interpretation of the geological evolution of Madeira as given by Gagel, a critic of Hartung's work, is, according to him, closer to the Lyell–Hartung model than to the monogenetic volcano model of the German volcanologist Alphons Stübel (1835–1904). Stübel's model was proposed after he had worked in Madeira in 1863 (Stübel 1910).

It seems that the only author who paid attention to Hartung's valuable work was Mitchell-Thomé who considered his books on the geology of Madeira and of the Azores to be classic geological works (Mitchell-Thomé 1976). The early study of these Atlantic islands was important in the formulation of ideas about the origin and evolution of volcanic islands in general. Hartung's unpublished letters to Lyell, which are detailed and well illustrated, are precious documents for the history of research on the geology of such islands. Hartung was a true geological traveller who certainly does not deserve to fall into oblivion, and whose publications should be regarded as classics.

We thank M. Kölbl-Ebert for her help in providing information and material not available in Portugal. The authors are also deeply grateful to L. Wilson for having made available copies of Hartung's letters to Lyell, the originals of which are located in the Special Collections Division of Edinburgh University Library. P. Wyse Jackson deserves special thanks for his careful 'editorial handling' of the draft.

Notes

¹See also: www.familysearch.org

Allgemeine Deutsche Biographie 1875–1912, herausgegeben durch die Historische Commission bei der Königl. Akademie der Wissenschaften. 56 Bände. Duncker & Humblot, Leipzig (Digitales Register—www.ndb.badw.de); Krollmann 1974, p. 253.

Verein für Familienforschung in Ost- und Westpreussen e.V., Hamburg 1980. Schriftenreihe Quellen- Material-Sammlung 1. Die Kartei Quassowski, Buchstabe H. Zusammengestellt von Helmut Zipplies. Im Selbstverlag des Vereins, Hamburg, p. 118; see also Die Abiturienten des Königlichen Gymnasiums und Realgymnasiums in Intersburg, 1861–1910 nebst einem Anhang: Die Abiturienten vor 1861. Von Prof. N. Biesenthal. Interburg. Dr Albert Bittners Buchdruckerei. 1910.

Stadt Heidelberg, Germany, Archiv—Letter, 25 August, 2003; see also *Heidelberger Zeitung* 31 March 1891.

²Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters addressed to Sir Charles Lyell, in Edinburgh University Library Special Collections Division.

³Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

⁴Wilhelm recorded that he had received directly from Königsberg University the indication that, according to the university records, Hartung had received a *h. c.* degree of Doctor of Philosophy.

⁵Hartung wrote a whole section in Heer's book: *Ueber die Pflanzen-Versteinerungen von Andö in Norwegen—1. Schilderung des Fundortes und der Lagerungsverhältnisse* (Hartung 1877b).

⁶Hartung (1857a): Hartung stated here that he was from 'Königsberg (Preusse)'. He wrote in the preface that he started travelling to Madeira in 1850, that he was forward to live in the same house as Prof. Oswald Heer, from Zurich, whom he accompanied for 5 months in his excursions on the island and with whom he also had travelled home through the South of Spain. He also mentioned that he had not received training to become a naturalist, but for a different profession.

Hartung (1857b): This book contains an appendix *Verzeichnis der aufgefundenen Tiere und Pflanzen. 1. Landmollusken, mit Bemerkungen über die Molluskenfauna der canarischen Inseln überhaupt, von Herrn Professor A. Mousson*, in which Albert Mousson (1805–1890) of Zürich, described some varieties of snails that Hartung had collected.

Hartung & Arlett (1858).

Hartung (1860a): Hartung wrote in the preface that he had been attracted by the wonderful natural phenomena seen in Madeira when he had the good fortune of spending some months there accompanying Prof. Heer. From visits to Madeira and to the Canary islands made in Lyell's company, Hartung got introductory views on Lyell's ideas on the formation of the islands that helped

him to understand what he saw in nature, contrary to what had happened with von Buch's ideas. He mentioned that Lyell intended to publish a book about Madeira and the Canary islands, more detailed than the 1855 edition of the *Manual of Elementary Geology*. About the Azores he mentioned difficulties in travelling there and stressed the similarities and differences between these islands and Madeira. Based on Lyell's ideas he tried to explain the relationship between the internal structure of the islands and the formation of mountain ranges. He thanked the various scientists who had contributed to the book. And finally he wrote about his attempt to describe the Azorean plants comparing them with the vegetation cover of Southern Europe, and of the Madeira and the Canary islands.

Hartung (1860b): This volume contains a map and 19 fine drawings, 3 of them in colour.

Hartung (1862): In the foreword Hartung wrote that the evidence of occurrence of elevated craters had become so fragile that a totally different interpretation about craters like the Caldera of Palma, in the Gran Canaria island, should not be regarded as offensive to those honoured men who had defended the upheaval theory. Then he gave an explanation why Lyell had not described the geology of the island in the 1855 edition of his *Manual of Elementary Geology*: insufficient field data (that both had gathered together) about a very complex structure. Hartung then explained that he tried to combine M. Reiss' study of diabases and lavas of the Palma island with von Buch's field observation and with his own observations in order to shed more light on the geology of the Gran Canaria. The importance of comparing the volcanic rocks composing the various Atlantic islands with similar rocks occurring in Germany was then described. Finally the origin of volcanic mountains was discussed.

Hartung (1864): Hartung stated in the preface that, having been encouraged by Prof. Heer to study some aspects of the geology of Madeira, he had the chance of confirming the origin of some agglomerates supported by Heer against prevailing opinions and that Lyell, in 1853, had been able to give a full explanation of the phenomenon. He then reported that Lyell's short visit to Madeira had been followed in 1854 by new works in Madeira, Lanzarote and Fuerteventura carried out by himself, Hartung, in order to compare old and recent lavas. The results of such works had been sent to Lyell who planned to publish in co-authorship with Hartung a geological description of Madeira and Porto Santo, but lack of time had prevented the British geologist from preparing a draft and so Hartung had decided to publish his material alone, stating that under Lyell's supervision it would have received a true appreciation. He also referred to his travels in the Azores and in several German regions to observe recent and old volcanoes. Finally, he thanked several scientists who had collaborated in the preparation of this book.

Fritsch, Hartung & Reiss (1867): Hartung wrote in the foreword that he had only visited the most important places in Tenerife, whereas the other authors had visited the whole island. Hartung had planned to visit this island once more, but it is not clear whether or not he managed a second visit: one in 1854 with Lyell and another one related to the preparation of this book.

⁷<http://darwin.lib.cam.ac.uk>

⁸Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell; A. Vieira, personal communication, 2003.

⁹This paper was presented on 22 March 1854, and was read by Leonard Horner. In it Lyell wrote that he had been favoured in nearly his excursions by the company of Hartung, who had proved a most active fellow labourer.

¹⁰www.nahste.ac.uk/GB/0237 Sir Charles Lyell Gen. 118 Lyell 2/59–76.

¹¹Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹²Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹³Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹⁴Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹⁵Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹⁶Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹⁷Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹⁸Hartung, G. 6 June 1854 to 23 May 1868. Collection of letters to Lyell.

¹⁹M. Kölbl-Ebert, and M. Guntau, personal communication, 2003.

²⁰V. H. Forjaz, personal communication, 2003.

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