Anniversaries

Earthquake 200 years ago

MARIA GRAHAM OBSERVED OROGENY IN 1822

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In November 1822, Maria Graham witnessed a devastating earthquake on the Chilean coast (Kölbl-Ebert 1999). Her description of the earthquake and of vertical movements of the land as a consequence of the earthquake were considered so important, that they found their way into the Transactions of the Geological Society of London as the first publication by a woman in that journal (Graham 1823). In 1830, Charles Lyell included – among other earthquake reports – Mrs. Graham's account in his "Principles of Geology" (Lyell 1830). Following this renewed interest in her work, George B. Greenough, President of the Geological Society, publicly accused Mrs. Graham (Greenough 1834) of wilful falsehood, thus starting a dispute which, among male opponents, might easily have ended with a choice of pistols at dawn.

Maria Graham (1785–1842) was a productive, and in later years well-known author. She published books on art and architecture, tales for children and five travelogues, that emphasize history and politics in the countries she visited. In 1821 she accompanied her husband, a navy captain, to South America. During this journey Captain Graham died of a fever in April 1822. After her arrival in Valparaiso, the widow stayed for a year in Chile, where she experienced the great earthquake of 1822. In 1823 she travelled back via Brazil to England, where she published her books on Brazil and Chile. A few months later she was again back in Brazil as governess to the daughter of the Brazilian Emperor. Returning to England in 1827, she married the artist Augustus Callcott.

Maria Callcott, painted by her second husband, Augustus Callcott (Image: Public Domain – USA).

The 1822 Eye Witness Account

From a present-day view, Maria Graham's account of the earthquake of 1822 is perfectly reasonable. It concentrates on objective facts dealing with meteorological observations, timing, duration and qualitative magnitude of individual shocks, the type of motion during the main shock, the accompanying sounds, regular displacement of furniture in her house, a second-hand description of the tsunami that followed after the main shock, the expulsion of water from unconsolidated alluvial deposits and their fluidisation, the systematic formation of new cracks

in solid, granitic rock, and their comparison with older, healed fractures. And last but not least, her account dealt with the permanent raising of the land as a result of the earthquake:

> It appeared on the morning of the 20th that the whole line of coast from north to south, to the distance of above 100 miles, had been raised above its former level. I perceived from a small hill near Quintero, that an old wreck of a ship which before could not be approached, was now accessible from the land, although its place on the shore had not been shifted. The alteration of level at Valparaiso was about 3 feet, and some rocks were thus newly exposed, on which the fishermen collected the scallop shell-fish, which was not known to exist there before the earthquake. At Quintero the elevation was about 4 feet. When I went to examine the coast, ... although it was high water, I found the ancient bed of the sea laid bare and dry, with beds of oysters, muscles, and other shells adhering to the rocks on which they grew, the fish being all dead, and exhaling most offensive effluvia. (Graham 1823)

Leaving her role as a mere observer, she ended with a well-founded, scientific conclusion:

> I found good reason to believe that the coast had been raised by earthquakes at former periods in a similar manner; several ancient lines of beach, consisting of shingle mixed with shells, extending in a parallel direction to the shore, to the height of 50 feet above the sea. The country had in former years been visited by earthquakes, the last of any consequence having been 93 years ago. (Graham 1823)

Rivalling Interpretations

Charles Lyell used in his *Principles of Geology* (Lyell 1830: 403) two different accounts of this earthquake, but most of his text is quoted from Mrs Graham. Lyell then continued to argue for the mainstream contemporary theory of mountain building, i.e. uplift through granitic intrusions into the central axis of the mountain range:

> …we also find that a district in Chili, one hundred thousand square miles in area, has been uplifted to the average height of a foot or more, and the cubic contents of the granitic mass thus added in a few hours to the land, may have counterbalanced the loss effected by the aqueous action of many rivers in a century. (Lyell 1830: 473)

In 1834, George Bellas Greenough, then President of the Geological Society of London, picked up the issue and launched a public attack on Maria Graham, denying the elevation of land by earthquakes. He tried to undermine Graham's credibility by means of selective quotation, deliberate misunderstanding and sophistry. He also implied that evidence by male navy officers would have been much more acceptable (Greenough 1834). The severity of the attack was astonishing, as in 1834 elevation of land was common-place among geologists, although they debated the causes. Greenough, however, personally favoured an older, neptunistic theory (Kölbl-Ebert 2009), for which mountains and the granite they contained were primordial features, which emerged from the sea as the global ocean slowly receded. He strongly objected to "the popular theory which accounts for Elevation by the forcible Inroad of igneous rocks into sedimentary" (Greenough 1834). As he said:

> Granite is one of the rocks most usually considered as an Agent in Elevation, for what reason I am at a loss to consider. Solid Granite has no inherent principle of motion; if it move, it can only be by virtue of the impulsion it has received from some other body, not in consequence of its igneous origin or its want of stratification. ... On the other hand, the arguments adduced against the doctrine that Granite while fluid has been forcibly injected from beneath into its present position, are to my mind conclusive;

> especially that which is founded on the frequent transition which takes place from Granite to the rocks that adjoin it. (Greenough 1834: 68)

Greenough feared that Graham's observations concerning the vertical movement of the land were in favour of Lyell's views, and that they left no alternative interpretation. Consequently, he decided to attack Graham, who seemed – at first view – an easier target than Lyell himself. Greenough was quite unable to believe Maria Graham's statements, and even asked, how could an elevation be proved when "the soundings at sea [were] completely changed?" (Greenough 1834, p. 56). Wasn't the changing of the soundings the very proof, he was looking for?

Greenough felt that there was no justification to assume that a large coastal area in Chile "was uplifted to the average height of a foot or more; and the cubic contents of the Granitic Mass added in a few hours to the land" (Greenough 1834: 57). But here Greenough quoted Lyell, not Graham. Maria Graham had only mentioned granite as the type of rock in which she observed several generations of fractures. It was Lyell and Greenough, with their geological minds, who inferred that the earthquake was caused by rising granite – Lyell believing it, Greenough denying it. Maria Graham, sticking to factual observations never postulated such a mechanism.

While Greenough certainly had few followers in his denial of all elevation, his powerful position within the Geological Society, his wealth, political influence, and dominating personality certainly reinforced the impression his words made. Maria Graham, by now married a second time and going by the name of Mrs Callcott, was angry and deeply offended. Consequently, she circulated a printed open letter in which she refuted point for point Greenough's rude attack (Callcott, 1835). Lengthy diplomatic consultations followed to mediate between the parties and restore peace, and Greenough was eventually forced to apologize to Mrs Callcott (Kölbl-Ebert 2003).

The Earth Shakes Again

As early as March 1835, news of another earthquake in Chile (of 20 February 1835) reached the Geological Society, and the correspondent Mr Alison also mentioned elevation of the land. No reaction by Greenough found its way into the official publications of the Geological Society, possibly because there were several items in Mr Alison's account, that could be reconciled with Greenough's opinion (Kölbl-Ebert 1999).

1835 was Greenough's last year as president of the Geological Society, then Lyell followed and used his new office to "plead" before the Geological Society on behalf of elevation by earthquakes, summing up the evidence (Lyell 1836). He quoted a communication by Robert FitzRoy, Captain of HMS *The Beagle*, who stated that after the earthquake in 1835 "Some thought that the land had been elevated, but the common and prevailing opinion was that the sea had retired" (Lyell 1836: 375).

It obviously depended on how people were asked concerning the effects of an earthquake. People seemed to find it more probable that the interconnected global oceans had retreated than that the land on which they dwelt might be able to rise, even when they experienced a violent earthquake. Greenough felt the same:

> the sea wave begins with a retirement … Whenever a communic[ation] is open betw[een] the sea & subterraneous caverns the water will rush into these – hence the backwave which seems to be the first phenom[enon] by the heat below, the water so entering, returns in the form of steam & the coast before dry is now immersed some hundred fath[oms] perhaps in water ultimately this water forms new combinations beneath & protanto a permanent diminution of water takes place all over the globe the

> inrush of the sea traversing caverns produces the rumbling" (UCL Greenough Papers, 16/4)

Maria Graham alludes to this in her reply to Greenough:

> "She is indifferent whether Mr. Greenough ascribes this to a partial elevation of the coast of Chile, or to a change of level of the whole mighty Pacific Ocean, which must have extended to Polynesia, India and China: the fact is, that there was a change in the relative position of the land and water; and to save circumlocution, Mrs. Callcott will continue to use the word, raised, or elevated, in describing that change" (Callcott 1835).

Maybe those witnesses who denied elevation were simply asked the wrong question concerning the changes after the two earthquakes? Lyell at any rate concluded, that

> It is scarcely necessary for me to advert to the striking analogy of the phaenomena observed by Capt. FitzRoy and those which were formerly described by Mrs. Maria Graham (now Callcott), and published in our Transactions respecting the Chilian earthquake of 1822. … To suppose that a set of imaginary phaenomena, which appeared at first sight very improbable, and which no geologist could explain, should have been invented, in Chili, in 1822, by several intelligent observers, and that thirteen years afterwards nature should realize, in the same country, the same phaenomena, or others strictly analogous, so as to lend countenance to all the previous misconceptions, is to imagine a combination of circumstances almost as marvellous as the upheaval of a continent itself. (Lyell 1836)

In October 1836, *The Beagle* with Charles Darwin on board returned to England, and shortly afterwards, Darwin was elected Fellow of the Geological Society. By this time, he had formed an opinion in favour of Maria Graham:

> With respect to the historical evidence of the earthquake of 1822, Mr. Darwin says that he met with no intelligent person who doubted the rise of the land, or with any of the lower order who doubted that the sea had fallen. (Proc. Geol. Soc. II (48): 447)

In 1838 Darwin presented a paper to the Geological Society, where he "discussed the nature and phaenomena of mountain chains; and states his belief, that the injection, when in a fluid state, of the great mass of crystalline matter, of which the axis is generally composed, would relieve the subterranean pressure". He thought that "the earthquake of Conception marked one step in the elevation of a mountain chain". Inferring thereby "that the formation of mountain-chains is ... in progress" (Darwin 1838).

Thus, it was established that (some) earthquakes where indeed capable of uplifting land and that mountain chains were no primary features but growing even today. But as to how elevation was achieved, the geoscience community was led astray. Finding the mechanism had to wait for more than another century of geological research.

Further Reading

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UCL: Archive of the University College London

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