

by M. Kölbl-Ebert

Observing orogeny — Maria Graham's account of the earthquake in Chile in 1822

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“As to ignorance of the science of Geology, Mrs. [Graham] confesses it: and, perhaps, that circumstance, and her consequent indifference to all theories connected with it, render her unbiassed testimony of the more value.” (Callcott, formerly Graham, 1835)

In November 1822, part of the Chilean coast was devastated by an intense earthquake. This report of geological phenomena by Maria Graham, later Callcott (1785–1842) — being one of the earliest detailed descriptions dealing with geologically relevant facts — gave rise to a vituperative debate lasting several years at the Geological Society of London about the effects of earthquakes and their role in mountain building. Although Mrs Graham's account was entirely reasonable from a present-day view, she became trapped between the millstones of two conflicting theories which were then held.

Introduction

In November 1822, Maria Graham (1785–1842) witnessed a devastating earthquake on the Chilean coast. Her description of the earthquake and of vertical movements of the land as a consequence of the quake — recorded in her *Journal of a Residence in Chile* (Graham, 1824) — 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 of London, 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 on the field of honour.

It is too simple to assume that the conflict between Graham and Greenough was only the result of a chauvinistic and sexist attitude on the part of the latter. For there were other scientific and resulting strategic reasons. The affair can be best illustrated by a metaphor, which is not so farfetched, since both Charles Lyell and George B. Greenough had studied law.

Imagine the incident as a legal case brought before the High Court of the Geological Society. The defendant is “The Earthquake” being accused of having elevated land in general and on the western coast of South America in particular. The attorney for the defence, pleading “not guilty” and denying that such things have ever happened, is George Bellas Greenough. The public prosecutor for the crown is Charles Lyell, who rests his case upon his major eye-witness Maria Graham. But, when Greenough bluntly attacked this witness and undermined her credibility in a most offensive way, Lyell did not ride as a knight might ride to the defence of such a “Lady in distress”, but simply looked for other witnesses in his case against the Earthquake. Lawyer Lyell was thus not really defending Maria Graham, he was prosecuting the alternative case of elevation by

means of earthquakes, — any rehabilitation of Maria Graham being only a by-product.

The case became more and more entangled by circumstantial evidence, in which the testimony of witnesses for both parties was found to conflict. But then came a lucky break, if only for Maria Graham and Charles Lyell, but not for the poor people of Chile... While the jury was still out, in 1835 the “criminal” struck again, only to be caught ‘in flagrante’ by a special task force in the area at that time “The Beagle-Expedition”, which included the “private detective” Charles Darwin, who accidentally was at the right place and just in time to settle the case. So, as we will see, the “criminal” was finally found “guilty” but — because this is not a simple story about “goodies” and “badies” — for the wrong reasons!

Maria Graham (1785–1842)

Maria Graham (Figure 1) 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 the histories and politics of the countries she visited.

Born in 1785, she was a daughter of Rear-Admiral George Dundas. In 1808 she sailed with her father for India. On board the ship she fell in love with Captain Thomas Graham, whom she married on their arrival in India. In 1811, they returned to England and Maria Graham lived in London, while her husband was absent most of the time on foreign service.

In 1821, she accompanied her husband, by then commander of his own ship, to South America. During this journey, Captain Graham died of a fever off Cape Horn in April 1822. After her arrival in Valparaiso, the widow was lent a cottage by friends, and 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 books on Brazil and Chile. A few months later she was again back in Brazil as governess to Donna Maria, daughter of the Prince of Portugal and Emperor of Brazil.



Figure 1 Probably a self-portrait of Maria Graham. Strongly enlarged detail from the frontispiece of Graham (1824).

In 1827, she returned to England where she married again. Her second husband was artist Augustus Callcott. In 1831, Maria ruptured a blood vessel and became an invalid, but was obviously not affected in her intellectual abilities, as her reaction to Greenough's attack proves. Maria died on November 28, 1842. (*Dictionary of National Biography*, Robinson, 1990, Creese & Creese, 1994; the sources are somewhat contradictory but this does not affect the periods of time relevant to this article.)

Observing earthquakes

Of course, earthquakes have accompanied humanity since its very beginnings, but as Charles Lyell said in the introduction to his chapters on earthquakes, the available historical reports were "almost exclusively confined to the number of human beings who perished, the number of cities laid in ruins, the value of property destroyed, or certain atmospheric appearances which dazzled or terrified the observers." (Lyell, 1830, vol. I, p. 399) And even the 35 earthquake reports that Lyell compiled for the *Principles of Geology* (Lyell, 1830, vol. I, chapters 23–25) are mostly not detailed enough to draw much geological information from them.

Thus, Maria Graham's account was one of the earliest detailed and geologically meaningful earthquake reports, and set a new standard for other observers.

The only other earthquake studied in such detail was the series of shocks in Calabria, Italy in 1783, when several natural historians were present to report what happened. But the effects of this incident were nowhere near as intense as those in Chile, and since some observers in Calabria reported subsidence, some reported tilting of strata and others reported reverse faulting, it remained unclear what its final outcome was (see Lyell, 1830, vol. I, chapter 24).

Mountain building and earthquakes

Before the 19th century, tectonics was recognized only as a local phenomenon, leading, for example, to the explanation of tilted strata as a result of cave collapse or of local down-slope movements. Around the end of the 18th century, authors such as Leopold von Buch, became convinced that volcanism was a tremendous force, able to push up large masses of rocks. This led to the concept that all mountain ranges were a result of vertical elevation caused by igneous activity. This was the prevailing opinion at the beginning of the 19th century, at least in Europe: Hutton had postulated before 1795 that hot magma was able to ascend within the earth's crust and to dome up the overlying rocks leading even to elongated mountain ranges. Peter Simon Pallas observed in 1777 a "granitic" central axis in the Ural and Altai mountains, to which he attributed deformation and elevation. George Poulett-Scrope in 1825 uttered similar thoughts (Sengör, 1985).

Charles Lyell in 1830 included vertical movements caused by earthquakes along with volcanic phenomena "under the general heading of igneous processes, because he followed the Huttonian view that there was a close causal relationship between them: earthquakes and volcanic eruptions are essentially alternative manifestations of the same processes of magmatic intrusion and expansion occurring at great depths" (Rudwick, 1990). The idea of elevation of a mountain range by rising granite was therefore not widely controversial in Maria Graham's time.

As we know, today the concept of elevation of a mountain range like the Andes by rising granite is obsolete. Geology at the end of the 20th century depicts Chile as lying above a subduction zone (Figure 2), where the Nazca-Plate moves underneath the South American plate down into the earth's mantle. Stress is built up by friction and compression along the plate margins until the rocks break along a fault plane. The shaking caused by this rupture produces earthquakes. Earthquakes which resemble those of 1822 and

1835 — by being very intense and able to generate tsunamis — occur within the accretionary wedge, leading to reverse faulting and hence "elevation" of the coast.

The 1822 evidence of the earthquake in Chile

Maria Graham's account of the Chilean earthquake of 1822 (Graham 1823) is from any present-day point of view perfectly reasonable. It concentrates on objective facts, most of them observed by Graham herself, deals 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 soils and their fluidization, the systematic formation of new cracks in solid, granitic rock, and their comparison with older, healed fractures:

"The granite on the beach is intersected by parallel veins, from a line to an inch in thickness, most of which are filled with a white shining matter, but some are only coated with it on their sides, and present hollow fissures. After the earthquake of the 19th, the whole rock was found rent by sharp recent clefts, very distinguishable from the older ones, but running in the same direction." (Graham, 1823)

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

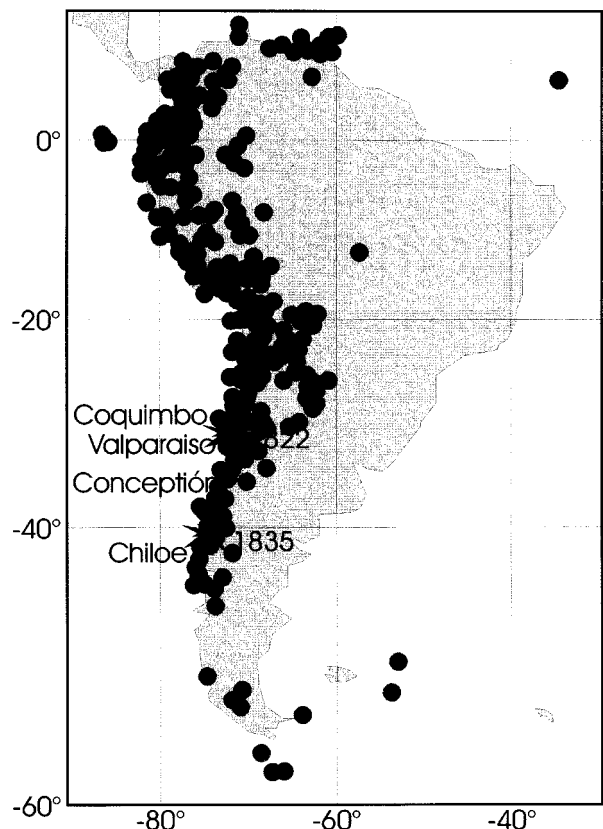


Figure 2 Bullets: Devastating earthquakes in South America since the early 16th century, according to CERESIS (<http://www.dgf.uchile.cl/ceresis.html>); Stars: Assumed epicentre locations of the earthquakes in 1822 and 1835.



Figure 3 Charles Lyell in 1836. (Portrait from Rudwick 1985, fig. 4.6.)

land, although its place on the shore had not been shifted. The alteration of level at Valparaiso was about three feet, and some rocks were thus newly exposed, on which the fishermen collected scallop shell-fish, which was not known to exist there before the earthquake. At Quintero, the elevation was about four 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, mussels, and other shells adhering to the rocks on which they grew, the fish being all dead and exhaling most offensive effluvia." (Graham, 1823)

Departing from 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)

Lyell (Figure 3) used in his *Principles of Geology* (vol. I, p. 403) two different accounts of this earthquake, but most of his text is quoted from Mrs. Graham and her name is mentioned in connection with her conclusion. Lyell also used Graham's account in stating: "We also find that a district in Chile, 100,000 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, vol. I, p. 473)

G.B. Greenough pleads "Not guilty"

More than three years elapsed before George Bellas Greenough (Figure 4), then president of the Geological Society of London, took up the issue in 1834, and launched a public attack on Maria Graham, denying the elevation of land by earthquakes. In a rhetorically brilliant address to the Geological Society (Greenough, 1834), he tried to undermine Graham's credibility by means of selective quotation,



Figure 4 George Bellas Greenough in the 1830s. (Portrait from Rudwick 1985, fig. 4.2.)

deliberate misunderstanding of Graham's statements and sophistry. There is no direct hint of her sex, but he clearly implies that evidence by male navy officers would be much more acceptable.

Greenough is depicted in literature as objecting to both generalization of evidence and to theorizing in the new science of geology: "Even the basic concepts of the science needed to be purged of all unacknowledged theoretical overtones. What was of value in geology, he maintained, was the diligent accumulation of unadorned factual observations." (Rudwick, 1985, p. 66).

Nevertheless, he had a fairly rigid frame of mind. Although Greenough, contrary to other statements (for example, the *Dictionary of National Biography*), did not study under Werner in Freiberg (Torrens, 1998, Eyles in Gillispie, 1975), he was nevertheless strongly influenced in his geological thinking by neptunistic ideas, and as can be deduced from the examples he gives, he thought that the geological processes that built mountain chains lasted only a few thousand years (see Greenough, 1834, pp. 63-64).

Elevation in 1834 was a commonplace among geologists, but they did not know where to look for the causes in current operation. Greenough (Greenough, 1834) mentioned in his address earthquakes, subterranean fires, aqueous vapour, some chemical reactions, gas, undescribed expansive forces from beneath, magnetism, changes in the position of the axis of the earth, and a stratum of concentrated atmospheric air under the ocean as proposed agents. Greenough used this "perplexity" to ridicule the whole concept of elevation. He seemed not to be able to admit that it was possible to observe a fact, but nevertheless be at a loss to explain the observation.

Greenough promoted instead a "chronic and almost imperceptible impulsion of land upwards" (Greenough 1834, pp. 58 f.), as was recognized in Scandinavia, and he only accepted "elevation" as a local phenomenon of no general importance. He strongly objected to "the popular theory which accounts for Elevation by the forcible Inroad of igneous rocks into sedimentary." 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, p.68)

Greenough instead proposed an alternative model for elevation, using hydraulic forces. The extraction of lava, gases and ash from volcanoes is said to leave large cavities in the vicinity of volcanoes. These cavities were thought to be filled with water, being water-tight except near the high (volcanic) mountains, where a regular supply of rain-water and melted snow enters the caves through fissures. The hydrostatic pressure of the water-column was then the driving force for the gradual elevation of the lower lands (Greenough, 1834, p. 68). This model was for Greenough also the most likely explanation of ancient sea-cliffs and beach terraces as observed by Maria Graham in Chile (Greenough, 1834, p. 69).

The long time span between the publication of the "*casus belli*" and Greenough's reaction gives a first hint that the factual observations of Maria Graham were not the focal point of the debate. What triggered Greenough's attack was their increasing use by Lyell and others as a key argument in their theory of mountain building (i.e., the elevation of mountain chains by the intrusion of igneous rocks into the central axis) — a theory to which Greenough objected, and which is today as obsolete as Greenough's own model.

Greenough was obviously convinced 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. He chose to attack Graham, who was at first sight a much easier target than Lyell. But this was a serious scientific mistake: it denied facts stated by a lay person, one who was definitely not interested in strengthening Lyell's theory, since Graham probably had no idea what that theory was and was simply relating what had actually happened. Greenough was here violating his own principle of accumulating mere facts. But it is in any case impossible to fight facts, it is only possible to fight their interpretation, and that is why Greenough's failure was just a matter of time.

Greenough was quite unable to believe Maria Graham's statements; he even asked, how could an elevation be proved when "the soundings at sea [were] completely changed?" (Greenough, 1834, p. 56) But was not the changing of the soundings the very proof he was looking for?

Greenough felt that there was no justification for the position 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, p. 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 this, Greenough denying it. Maria Graham never postulated this mechanism, and probably had never even thought about it!

The earthquake of 1822 was the only case, Greenough claimed (Greenough, 1834, p. 58), in which the testimony of eye-witnesses had been adduced to prove the raising of land by earthquakes. This is also wrong, since among the 35 earthquakes Lyell mentioned in the *Principles* there are at least five which resulted in “elevation”. Admittedly none is documented so well as Graham’s documentation of the 1822 earthquake. Lyell personally named Alexander von Humboldt, Sir Stamford Raffles (governor of Java) and three officers of the Royal Navy, none of whom was such an easy target as the female, non-geologist, non-official and “somewhat-lower-class” Maria Graham.

Seeking additional evidence

Lyell did not seem to take Greenough’s attack particularly seriously, contrary to Maria Graham, who was deeply offended. In her eloquent reply to Greenough (Callcott, formerly Graham, 1835) which shows how well-versed she was as an author, she pointed out “the unjust insinuations, selective omissions of important details, errors and inconsistencies” (Creese & Creese, 1994, p.30). Lyell, like Greenough, only seemed to be busy searching for other witnesses of “better” reputation, i.e. male and preferably naval officers.

As early as March 1835, the news of another earthquake in Chile (February 20, 1835) reached the Geological Society (Figure 5), and the correspondent, Mr. Alison, also mentioned an 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.

Alison had described a most violent tsunami destroying several towns along the coast, which might well be blamed for other alterations on the shore. “Large fissures are stated to have been made in



Figure 5 Conception after the earthquake of 1835 (Illustration from Darwin, 1986)

the earth, and water to have burst from some of them.” (Proc. Geol. Soc. II, #42, p. 209) This might be interpreted as direct corroboration of Greenough’s “hydraulic hypothesis”: The seams of Greenough’s water-filled caves were simply leaking during the earthquake. In addition, Alison mentioned the eruption of a submarine volcano: another feature which could easily be blamed for the alteration of the soundings near the coast.

So Lyell did not gain much when Alison also dutifully reported fossil beaches near Valparaiso or that “a rock which in 1817 could be passed over in a boat, is now dry, except at spring tides.” (Proc. Geol. Soc. II, #42, p. 210)

Lieutenant Bower, referring to the earthquake of 1822, reported that after he arrived “from England in February 1823, [he] found everything in the same situation as when he quitted it twelve months previously.” (Proc. Geol. Soc. II, #42, p. 213). But he added, that since the earthquake, the water had gradually receded and “that a row of stores and substantial dwellings had been erected where the sea formerly flowed.” (Proc. Geol. Soc. II, #42, p. 213) This is somewhat strange: How did he know that the change was gradual, when he was not present during the quake; and why did he say that nothing had changed, when a new row of houses had been built where formerly the sea flowed?

Mr. Cuming, another resident of Valparaiso, was a witness of the catastrophe of 1822. “He never heard of the rocks having been heaved up, or of the permanent retirement of the sea until the publication of Mrs. Graham’s work, to the statements contained in which neither he nor his friends could subscribe.” (Proc. Geol. Soc. II, #42, p. 213)

Mr. Cuming ascribed the opinion that a change had taken place in the relative level of land and sea to the “accumulation of detritus at points where the tide flowed anterior to the earthquake, and on which houses, and even small streets, have been since erected.” (Proc. Geol. Soc., II, #42, p. 214) A present day reader is left to ask why the tide did no longer flow, so that the detritus could settle down.

In many of the reports brought forward, tsunamis seem to be a problem. People describing the earthquake had difficulties distinguishing between short-time retreat followed by swelling of the ocean when the tidal waves arrived and long-term change in the relative levels of land and sea.

Greenough retired as president of the Geological Society in 1835. Then Lyell followed and used his new office to persuade the Geological Society of the soundness of the theory of elevation by earthquakes, summing up the evidence (Lyell, 1836). He quoted a communication by Captain FitzRoy, commander of *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, p. 375)

It obviously depended on how people were asked concerning the effects of the earthquake. People seemed to find it more probable that the huge Pacific Ocean had retreated than that the land on which they dwelt might be able to rise, even when they had experienced a violent earthquake. Maybe those witnesses who denied elevation were simply asked the wrong question concerning the changes in 1822?

Lyell concluded: “It is scarcely necessary for me to advert to the striking analogy of the phenomena observed by Captain FitzRoy and those which were formerly described by Mrs. Maria Graham (now Callcott), and published in our Transactions respecting the Chilean earthquake of 1822.” (Lyell, 1836)

“To suppose that a set of imaginary phenomena, which appeared at first sight very improbable, and which no geologist could explain, should have been invented in Chile in 1822 by several intelligent observers, and that 13 years afterwards nature should realize, in the same country, the same phenomena, 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 (Figure 6) on board had returned to England, and shortly afterwards Darwin was



Figure 6 Charles Darwin around 1837. (Portrait from Darwin, 1986.)

ever, that since we have ascertained the fact of a rise of three, five, and even ten feet in parts of the same country in 1835, so distinctly attested by Captain FitzRoy, all doubts entertained as to the permanent effects of a preceding convulsion are comparatively of small interest." (Lyell, 1837, p. 505) With these words, he dismissed Maria Graham from further arguments.

In 1838, Darwin presented a paper to the Geological Society, that also settled the case of the earthquake of 1822. He "... discussed the nature and phenomena 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)

So the criminal was finally found "guilty" but as to how elevation was achieved, the "High Court" were led astray. Finding the "weapon" used in the "crime" was to need about another century of geological research.

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References

- Callcott, Maria [formerly Graham], 1835, On the reality of the rise of the coast of Chile, in 1822, as stated by Mrs. GRAHAM: *American Journal of Science and Arts*, v. 28, pp. 239-247.
- Creese, Mary R.S., and Creese, Th.M., 1994, British women who contributed to research in the geological sciences in the nineteenth century: *British Journal for the History of Sciences*, v. 27, pp. 23-54.
- Darwin, Charles, (1838): On the connexion of certain volcanic phaenomena, and on the formation of mountain-chains and volcanoes, as the effects of continental elevations: *Proceedings of the Geological Society*, v. II, no. 56.
- Darwin, Ch., *Reise um die Welt: 1831-36*: Edited by Gernot Giertz 1986: Stuttgart, Thienemann.
- Dictionary of National Biography, Callcott, Maria, Lady (1785-1842).

elected a fellow of the Geological Society. Darwin by this time also had formed an opinion in favor 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, p. 447)

Of course, Lyell used these favorable reports to further his own case and said in his Address to the Geological Society in 1837: "I may remark, how-

- Dictionary of National Biography, Greenough, George Bellas (1778-1855). Gillispie, Ch. C., ed., 1975, *Dictionary of Scientific Biography*: New York, Charles Scriber's Sons.
- Graham, Maria, 1823, An account of some effects of the late Earthquakes in Chili. Extracted from a Letter to HENRY WARBURTON, Esq. V.P.G.S.: *Transactions of the Geological Society London*, Ser. II, v. 1, pp. 413-415.
- Graham, Maria, 1824, *Journal of a residence in Chile, during the year 1822. And a Voyage from Chile to Brazil in 1823*: London, John Murray.
- Greenough, George Bellas, 1834, Address delivered at the Anniversary Meeting of the Geological Society, on the 21st of February 1834: *Proceedings of the Geological Society London*, v. II, 1833-1834, no. 35, pp. 42-70.
- Lyell, Charles, 1830, *Principles of Geology*, being an attempt to explain the former changes of the earth's surface, by reference to causes now in operation: v. I, London, John Murray.
- Lyell, Charles, 1836, Address to the Geological Society, delivered at the Anniversary, on the 19th of February, 1836: *Proceedings of the Geological Society London*, v. II, 1836, no. 44, pp. 357-390.
- Lyell, Charles, 1837, Address to the Geological Society, delivered at the Anniversary, on the 17th of February, 1837: *Proceedings of the Geological Society London*, v. II, 1837, no. 49, pp. 479-523.
- Proceedings of the Geological Society of London*, vol. II, no. 42.
- Proceedings of the Geological Society of London*, vol. II, no. 48.
- Robinson, Jane, 1990, *Wayward Women – A guide to women travellers*: Oxford, Oxford University Press.
- Rudwick, Martin J.S., 1985, *The Great Devonian Controversy. The Shaping of Scientific Knowledge among Gentlemanly Specialists*: Chicago, The University of Chicago Press.
- Rudwick, Martin J.S., 1990, Introduction to "Principles of Geology" by Charles Lyell, in Facsimile of the first edition of Ch. Lyell's "Principles of Geology": v. I, University of Chicago Press.
- Torrens, Hugh S., 1998, *Geology in peace time: an English visit to study German mineralogy and geology (and visit Goethe, Werner and Raumer) in 1816*, in Fritscher, B., and Henderson, F., eds, *Toward a History of Mineralogy, Petrology, and Geochemistry: Proceedings of the International Symposium on the History of Mineralogy, Petrology, and Geochemistry*, Munich, March 8-9, 1996.
- Şengör, A.M. Celâl, 1985, *Klassische Gebirgsbildungstheorien*, in Miyashiro, A., Aki, K., and Sengör A.M.C., 1985, *Orogenese. Grundzüge der Gebirgsbildung*: Wien.

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Observing Orogeny – Maria Graham and her Account of the Earthquake in Chile in 1822. Article. Mar 1999. EPISODES. Martina K bl-Ebert. In November 1822, part of the Chilean coast was devastated by an intense earthquake. This report of geological phenomena by Maria Graham, later Callcott (1785-1842) - being one of the earliest detailed descriptions dealing with geologically relevant facts - gave rise to a vituperative debate lasting several years at the Geological Society of London about the effects of earthquakes and their role in mountain building. Although Mrs Graham's account was entir Observing Orogeny – Maria Graham and her Account of the Earthquake in Chile in 1822. Article. Mar 1999. EPISODES. Martina K bl-Ebert. In November 1822, part of the Chilean coast was devastated by an intense earthquake. This report of geological phenomena by Maria Graham, later Callcott (1785-1842) - being one of the earliest detailed descriptions dealing with geologically relevant facts - gave rise to a vituperative debate lasting several years at the Geological Society of London about the effects of earthquakes and their role in mountain building. Although Mrs Graham's account was entir In 1821, Maria Dundas Graham sailed for South America on H.M.S. Doris, a ship sent to protect British mercantile interests in that volatile region. After her husband, the ship's captain Thomas Graham, died en route, the newly widowed Maria Graham landed in Valpara so, Chile. Resisting all efforts to hustle her back to England, Graham, a professional writer and highly educated woman, rented herself a cottage in the Chilean –not the British – section of Valpara so and traveled through Chile for nine months until driven out by a major earthquake and the threat of civil war. The resulting Journal of