

Edited by Vic Baker

**OBSERVATIONS, RECOLLECTIONS, AND IMPRESSIONS OF THE KANSAS GEOLOGICAL SURVEY AT THE UNIVERSITY OF KANSAS.** Daniel F. Merriam. Lawrence, Kansas: University of Kansas Department of Geology and Paleontological Institute Special Publication 7. 284 pp., 115 illustrations, 52 tables, appendices, list of names but no Index; paperback, \$25 plus mailing (order from Paleontological Institute, University of Kansas, 1475 Jayhawk Boulevard, Room 119, Lawrence, KS, 66045, USA; [www.paleo.ku.edu](http://www.paleo.ku.edu)).

Having informed and enlightened us about the geology of Kansas in many articles dating back to the 1950s as well as in his books on *Raymond C. Moore: Legendary Scholar and Scientist* (2007) and *Geology at The University of Kansas* (2009), Dan Merriam now presents a valuable overview of the Kansas Geological Survey (KGS). The long title of the book is on target, as Merriam was a first-person witness of key years in the Survey's evolution. His richly documented recollections and interesting impressions provide the reader with insight into the workings of one of the country's premier geological institutions.

One striking aspect of the book is the wealth of photographs, graphs, and tables. The author and archivists deserve kudos for the time and effort involved in amassing such extensive photo-documentation. Many of the people, places, and points made in the text are accompanied by relevant visual aids. Most of the figures feature staff members in formal and informal settings; several figures provide clear and graphic timelines of major events in the development of the Survey; and a few illustrate organizational flow charts. Tables offer a variety of lists that reinforce points made in the text. Table 52 documents the sobering news that the number of KGS staff geologists fell from twenty-five to ten in the period of 1993 to 2010, while technical staff tripled and administrators doubled. Signs of the times . . .

Another noteworthy facet of the text is the sheer amount of detail concerning the evolution of the KGS and its personnel. Anyone interested in the Survey will be rewarded, but it is also true that the research projects, the goals of the directors, and the range of interests within the Survey serve as mirrors for the worldwide maturation of the geosciences from 1860 to 2010. At the outset we learn of the four 'phases' of growth of the KGS: (1) Reconnaissance; (2) Geological Foundation Building; (3) Analysis and Synthesis; and (4) Reorientation for the twenty-first century. These broad categories also reflect the development of geology over the last 150 years. In the course of pursuing those major headings, Merriam presents a well-researched and spectacularly photo-documented narrative of one survey's evolution. The early directors—Mudge, Swallow, and 'Daddy' Haworth—may not be well known to twenty-first-century readers, but the eminence of KGS directors becomes evident with such names as William H. Twenhofel, Raymond C. Moore, Kenneth K. Landes, John C. Frye, and William W. Hambleton. The Survey's personnel and contributors included, among many other worthies, John W. Harbaugh, Hollis D. Hedberg, Daniel F. Merriam, Norman D. Newell, and Curt Teichert. The research topics pursued by KGS scientists are indicative of the evolution of geology over a century and a half: classical field stratigraphy; paleontology; facies recognition and early visions of sequence stratigraphy; oil and gas exploration; groundwater investigation; environmental geology and pollution; atomic-waste disposal; computers and mathematics as applied to geology; and educating the public and politicians about the importance of understanding our natural world.

Detailed recounting of the history of the Kansas Geological Survey obviously serves anyone interested in the geology of Kansas but it also has value for a wider audience. The case histories involved in telling the Kansas story have relevance to other institutions and they provide a window on the development of geology since 1860. They also show how governmental bodies responded to the research, educational, and public-use aspects of

science. It is fair to say that the amount of detail provided in the volume may be welcomed by many but could be seen as a bit intrusive by others. Who but a geologist-cum-historian would list every formation and every quarry that supplied building stone for every geology-associated building in Lawrence, Kansas? Along with the enumeration of details, however, there are numerous anecdotes and real-world examples of how KGS scientists got things done, from surmounting field hardships to squeezing money out of administrators and politicians. Even current-news events make an appearance, such as the issue of Federal ‘earmarks’, which is discussed in the context of Senator Robert Dole’s (Republican Kansas) success in getting a KGS-developed Digital Petroleum Atlas supported.

Geologists reading the book receive a bonus in the form of a twelve-page ‘Brief Outline’ of the geology of Kansas. And they are treated to a great deal of interesting geology—admittedly limited to Mid-Continent layer-cake geology: accounts of the famous ‘salted-silver-ore hoax’ of 1879; the El Dorado oil play that put Kansas at the top of oil-producing states in 1915; how the Humboldt Fault affects river geometry and earthquake activity; and how the Atomic Energy Commission viewed Kansas salt beds as an ideal host for radioactive waste in the 1960s (until they belatedly realized how many oil-well holes were punched through the salt-bearing formation). Historians will appreciate the rich tapestry of names, dates, and accomplishments of Survey staff members. Even computer and math-oriented readers will enjoy the first-hand comments by the author, himself a key player, of how geologists finally befriended and learned to utilize the power of computers. The tale is evocative for those of us who lived through the revolution as it passed through the eras of punch cards and IBM 650 and 7040 computers, to the powerful software programs and quasi-magical hardware that could print out entire maps, and now to the present state of the computational arts.

There is a great deal to enjoy and profit from in this set of “observations, recollections, and impressions”. Reviewers need to reveal their nit-picky natures in order to avoid being seen as cheer-leaders, so a few debits might be noted. In such a name-rich narrative, it strikes me as unfortunate that a mere listing of names, with no clue as to page numbers, is all that we get in the way of an index. There are also a few instances where an editor could have helped the author, as when the discussion (p. 164) about Survey organization does not match Figure 87 (p. 167), or when (p. 5) the provocative labeling of ‘The Upheaval Years’ and ‘The Healing Years’ does not receive any subsequent illumination. But quibbles need to be balanced with praise for the major merits of the story told and the illustrations provided. Chapter 17 reviews the four ‘phases’ noted early in this review, supplying the cover-to-cover reader with a quick summary, and giving the jump-around reader a coherent overview of the Survey’s history. In the last chapter, Merriam provides brief comments and reflections about the future. The final, post-narrative pages (pp. 234–284) include a strong References section, Obituaries, and an Appendix that provides thumbnail accounts of KGS Directors. Other appendices include a long list of Survey particulars, ranging from the pioneering efforts of KGS scientists to the names of fossils honoring Survey staff. The mechanical elements of the publication are excellent: paper grade—no ‘bleed-through’ when using hi-liters or liquid-ink pens; high quality of binding; good font readability and darkness of the print; and excellent clarity of illustrations, in both black and white and color.

The heritage of Kansas geology deserves to be known. Dan Merriam has already given us excellent accounts of the contributions of R. C. Moore and the University of Kansas Department of Geology. In this book he paints an evocative portrait of the Kansas Geological Survey. Of particular value is the potential of these specific cases to illuminate the history of geology for the last century and a half, in places far beyond Kansas.

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**THE SECOND JURASSIC DINOSAUR RUSH. MUSEUMS AND PALEONTOLOGY AT THE TURN OF THE TWENTIETH CENTURY.** Brinkman, Paul D. 2010. Chicago and London: University of Chicago Press. 345 pp. Hardcover. \$US 49.00.

It was Edwin Colbert, the pioneer historian of dinosaur history (as of much else in vertebrate paleontology) who first referred to “the first great western dinosaur rush, fully as strenuous and exciting for the participants, and as filled with drama, as the famous gold rushes that loomed so large in the settlement of the western states” (Colbert 1986). Colbert defined the limits of this rush that “began with Cope and Marsh in 1876 and 1877” to its “final phases . . . seen in the excavations of the American Museum . . . at the Bone Cabin quarry, and Earl Douglass and . . . the Carnegie museum of Pittsburgh at what is now Dinosaur Monument in the early years of the twentieth century”. This period is chronologically, stratigraphically and geographically diverse, while the other rush he recognised, the “Canadian Dinosaur Rush”, is much more focused. Here, only two major institutions were active in the Cretaceous rocks largely of a single Canadian province, within a short period *ca* 1910 to *ca* 1917. As a descriptive term it remains in general use with little modification (Spalding 1999).

As geologists continue to refine stratigraphy, so paleontological historians are refining the divisions of their history. Much attention has been paid to the earlier part of Colbert’s first rush (perhaps most notably in Jaffe 2000), but no definitive account of the later part of this period has appeared. In 1990 John McIntosh summarised what he called “The second Jurassic dinosaur rush” in this journal (McIntosh 1990). Starting in “the years 1898–1899 and continuing for a quarter of a century”, this was roughly the latter half of Colbert’s first rush. It was led by Osborn of the American Museum and Holland of Pittsburgh’s Carnegie Museum, with lesser involvement by Chicago’s Field Museum.

For this volume, Brinkman has used the same name, but his period both begins and ends earlier than that summarised by McIntosh. Brinkman’s “Second Jurassic dinosaur rush”, began in 1895 before the deaths of Cope (1897) and Marsh (1899), heated up in 1897, and was ended by 1905, before Douglass took charge at what became Dinosaur Monument (1909). Brinkman reasonably justifies leaving out contemporary finds of Cretaceous dinosaurs in a brief reference to the first *Tyrannosaurus* skeleton, which (while discovered in 1902) was not described till 1905, by which time Osborn and others were shifting primary attention to the Cretaceous.

Brinkman has thus defined his period clearly. His focus is on three institutions: the American Museum of Natural History; the Carnegie Museum in Pittsburgh; and the Field Columbian Museum in Chicago. Their key museum staffs grew up professionally by assisting, admiring, or sometimes resenting Cope and/or Marsh. The paleontologists’ key objectives were: “[a] race to collect and exhibit the first and largest sauropod dinosaur” and a burning desire to revise (and if possible, correct) Marsh’s dinosaur research.

Brinkman is well qualified to tackle this work. Himself a curator, he has technical as well as scientific experience, and a PhD in the history of science. Moreover, he has been employed in one of the institutions he is studying. He tells the reader he is adopting “a microhistorical approach to . . . a rich archival record”. And he endeavour[s] to cover the three major museums and all the personnel involved . . . with an eye toward telling an interesting and coherent story about scientific practice”. In this he has succeeded admirably.

While the broad outlines of the story have been known for a while, Brinkman’s detailed research allows him to retell it with much rich and often unfamiliar detail. The earlier struggles between Cope and Marsh continue to resonate, as the next generation of professionals searched for bigger and better specimens, tried to secure the best sites and acquire the most capable staff, and developed the most effective techniques. The programs were funded (and sometimes initiated) by friendly millionaires, but there were tensions

between all levels of staff, and each museum struggled with the physical and psychological impact of acquiring tons of bones in their workshop, storage and exhibition space.

We are told of Cope's life-size paper reconstruction of *Camarasaurus* and the small Carnegie, who took pleasure in big things, using Marsh's reconstruction of *Brontosaurus* to impress his museum committee. Morris Jessup believed fossil vertebrates conveyed moral lessons to the illiterate masses (if you don't behave you might become extinct?), while Farrington at Field believed dinosaurs might have gone extinct through selfishness. Osborn succeeded Marsh as vertebrate paleontologist at the Geological Survey and distributed Marsh's incomplete projects among the next generation of paleontologists. While moralizing about the misbehaviour of Cope and Marsh, and preaching friendly cooperation, he pursued potential staff and specimens ruthlessly wherever he could find them, and—like his hero Cope—continued to 'collect dirt' on Marsh in case it might subsequently come in useful.

The stories of many important collectors, paleontologists and administrators are told. We learn about principal players such as Barnum Brown, Gilmore, Granger, Hatcher, the entomologist Holland ("an extraordinary bootlicker"), Kaise, Lull, Matthew, Miller, Peterson, Reed, Riggs, Thomson, Williston, and Wortman. There are also walk-on parts for German paleontologist Eberhart Fraas (later to tackle Tendaguru in Africa), as well as Butch Cassidy and the Sundance Kid, who carried out robberies near Como Bluff, and perhaps sought refuge in Patagonia because they had read Hatcher's articles in *National Geographic*.

A century ago, field operations were still carried out in the 'Wild West'. Paleontologists scouted each other's sites (sometimes travelling under an alias). The railways were the primary means of communication with Union Pacific providing free passage for fossil hunters. Through intervention of millionaire patrons, there was often free transportation for specimens, and for Osborn even a private car and a chef. But there were also train wrecks (and shipwrecks)! As in a gold rush, there were (dinosaur-)mining claims, claim jumping, legal battles, dynamite, and tunnels.

Although it was a pioneer period, some of the incidents sound surprisingly modern. Then as now, ownership of fossils was complicated, and rents and finder's fees were paid to landowners. The press made field visits; paleontologists checked their press clippings; magazine articles were full of errors; and newspapers full of superlatives. The public came in droves, attracted by moonlight picnics at sites, and included souvenir hunters who would "steal the halo off of Christ's crown".

The American Museum won the race with a temporary mount of *Brontosaurus* in 1901, completed in 1905, the first permanently mounted sauropod in the world. It was closely followed by Carnegie's *Diplodocus* (known as "Dippy"). Carnegie sent casts of it to major museums around the world and it has probably been seen by more people than any other fossil. Chicago had a "distant third place finish".

During this period there were major improvements in field, laboratory, and display techniques, which "transformed America's natural history museums" by putting dinosaurs on display, appealing to visitors and patrons. Dinosaurs became status symbols and museums took over prime responsibility for vertebrate paleontology from universities. The foundations of dinomania were established.

Brinkman's text is complemented by brief biographic sketches of paleontologists (but not, oddly, the millionaire funders), an appendix listing the dinosaurs discussed, detailed notes connecting to sources, a bibliography, and an index.

The jacket cover bears a splendid image—a Cretaceous dinosaur from the wrong country and period munching on a high-rise building—which is alas quite irrelevant. Otherwise, the illustrations are a useful complement to the text, including photographs, maps, museum plans, drawings and a cartoon. Some quarry maps are rather small in relation

to the amount of detail they contain and the poorer quality photos do not always reproduce well without glossy paper.

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**THE STORY OF VAIONT: TOLD BY THE GEOLOGIST WHO DISCOVERED THE LANDSLIDE.** By Edoardo Semenza, 2010. Ferrara, Italy: K-flash. 205 pp. Softcover, €28.

Everyone knows that one rationale for the damming of rivers is the prevention of flood disasters. People living along a river downstream of a projected dam are commonly supportive of the project because of the promise that, among the potential benefits of a dam that might be built primarily for hydropower generation or water supply, there will be an additional benefit of protection against flooding. Yet, how often are these same people informed about the limited nature of this benefit? How often do the political and economic arguments for dam construction get weighed against the very possible, if low probability, reality that a dam-related failure can result in flooding far more devastating than would occur if the dam had not been built at all? If people downstream of dams were informed of this truth by responsible public authorities, what would be the level of support for the proposed project?

Despite rigorous engineering, complying with prevailing standards and regulations, dams do fail. Fortunately such failures are exceedingly rare. Unfortunately, when they do occur, the common response tends to overemphasize the assignment of blame, especially when political interests have been involved. What can be lost in the resulting accusations, and their inevitable sensationalizing by the media, is the perspective that much can be learned scientifically from these very rare failures. Dams can fail for different reasons, each specific to local circumstances, and geology commonly turns out to be a critical factor. The *Story of Vaiont* provides a sober reflection on one of most infamous dam-related flood disasters of modern times. Its author, Edoardo Semenza (1927–2002), long-time Professor of Geology at Ferrara University, was closely involved with the major events that led to the failure, as well as with much of the subsequent saga. Indeed, Professor Semenza's father, Carlo Semenza, was the engineer who designed the dam.

At 10.39 p.m. on 9 October, 1963, a huge mass of rock (about 240 million m<sup>3</sup>) slid into the reservoir that was held behind the Vaiont Dam in the Italian Alps, north of Venice and just south of the Austrian border (in Italian the spelling is 'Vajont'). When the concrete arch dam was completed in 1960, it was then the second highest (264.5 m) in the world. Water displaced by the rockslide overtopped the dam and surged down valley in a flood wave seventy metres in height. Approximately 2,000 people died, most of them in the

village of Longarone, which lay in the direct path of the flood wave, two kilometres downstream from the dam. The dam itself remained intact, and today it remains as a stark reminder of the disaster. Indeed, the circumstances that led up to the disaster and the subsequent events have been likened to a Greek tragedy. Civil and criminal trials, political recriminations, several books, novels, a play and film have all centred on the failure, and much of this has, according to this new book, been more imaginative than factual.

The *Story of Vaiont* provides an excellent overview of both what happened and what was learned from one of the greatest of modern dam-related disasters. It does this by providing a considerable amount of technical detail. This includes the description of how the ancient landslide was originally recognized. There is even a photograph of Edoardo's field notebook sketch of August 26, 1959, in which he makes what was later found to be the correct interpretation of the extremely complex geological relationships that contributed to the 1963 disaster. Many detailed photographs, maps, and diagrams show field relationships and interpretations of the complex geology. The book is excellently produced in glossy format with both colour and black-and-white illustrations. A very useful appendix summarizes the succession of events, both before and after the disaster, paying special attention to the geological aspects.

In February 1960 experimental filling began behind the newly completed dam. As the water rose to near the limit of the testing level in November, 1960, a landslide of about 700,000 cubic metres moved into the reservoir, where it generated a two-metre high wave. Carlo Semenza immediately had the reservoir drained, but slowly so that the removal of the water would not further destabilize the valley sides. The senior advisors and consultants to the project regarding engineering geology either did not recognize the significance of the ancient giant landslide discovered by Carlo's son, or they concluded that movement of the rock mass would be slow enough that it would not endanger the project. In contrast, the young Edoardo Semenza, then a junior geologist, was the only proponent of the view that a very large ancient landslide that had once blocked the valley might well be reactivated to do so again when the reservoir was full. The state of understanding for engineering geology was such in 1960 that no one anticipated a very rapid, catastrophic reactivation of this ancient slide mass. But Carlo Semenza was immensely troubled by this issue. In a letter to his supervisor, Vincenzo Ferniani, dated 20 April 1961 (Appendix I of the book), he called attention to the ancient slide mass that eventually failed; and he expressed extreme caution in regard to any filling the reservoir. He proposed a programme of safety measures, beginning with the construction of a by-pass tunnel that would allow water to flow around a potential constriction of the valley by the landslide that would both compromise power generation and also generate flooding of a small village upstream from the dam. Tragically, Carlo Semenza died from a cerebral haemorrhage on 30 October 1961, possibly related to the stress associated with these decisions.

In the period that followed Carlo Semenza's death there were a number of developments that ultimately became sensationalized in subsequent media and popular depictions. These included the nationalization of the power industries of Italy, which transferred the management of the project to the National Electric Energy Agency. A second filling of the reservoir, to a much higher level than in the first, took place through 1962. Movement of the valley sides and the potential slide mass was carefully monitored. When the movement reached 1.5 cm/day in November 1962, the reservoir was again slowly lowered, at which time all movement ceased. During these tests, none of the movements in the valley sides reached the levels seen in 1960, when Carlo Semenza became highly alarmed about the sliding issue.

A third filling was initiated in April 1963 and the landslide movements resumed though at very low velocities—less than 0.5 cm/day. The velocities remained relatively constant for several months even when the reservoir level reached the height at which an

acceleration in movement had occurred during the second filling. The reservoir was then raised another ten metres at the end of June, without generating a significant increase in velocity. Then, in September a continuous increase in velocity began, reaching 2 cm/day by 26 September, at which time a reservoir lowering was ordered. Despite this lowering, the acceleration did not decrease, as it had done previously. By 4 October the movement was 5 cm/day. On the morning of 9 October it had reached 30 cm/day. The failure late that night involved a movement at approximately 60 to 100 km/hr.

Edoardo Semenza finds it most difficult to interpret the events of the two months immediately preceding the disaster. In hindsight, it is possible to understand the reasons for what turned out to be mistaken behaviour. More difficult is the assignment of blame and responsibility. One factor seems to have been the concern by the on-site technicians for the abutments of the dam. As noted at the beginning of this review, if the dam fails, there could be an immensely worse flood than nature might have generated. This dam was 260 meters high and failure would have been truly catastrophic. In 1960 there was only limited knowledge of how failures might occur. Landslides into reservoirs were known to pose a hazard, but they generally developed when reservoirs were drained. Such an event had occurred on 22 March 1959 at a nearby hydroelectric reservoir named Lake Pontesei, and this experience weighed on those responsible for Vaiont. Another problem was communication among those responsible for key decisions and their advisors. The third filling began when the administration of the project passed from the private company to the National Electric Energy Agency. This transition, plus the death of the highly experienced Carlo Semenza, seems to have greatly compromised the decision-making process. Also, a water crisis in 1963 may have generated pressure to fill the reservoir, thereby contributing to the decisions that led to the ultimately disastrous third filling.

The author presents a balanced, objective view of events. He notes that writing this book was not easy. He had close associations with many who died. He also knew of the personal anguish of a site engineer who claimed to have been falsely accused of negligence in regard to the disaster, and who took his own life on the eve of one of the trials that followed that disaster.

The original Italian version of the book appeared in 2001, the year before Edoardo's own death. It was his hope that "all those who are truly interested will have the patience to read this account, and thereby . . . [to] understand the true story of Vaiont . . . [for] only in this way can the lesson of Vaiont, with its terrible pain, be useful in the future for a more profound understanding of the causes and a more correct practice of operations".

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**TRAVELS OF HOCHSTETTER AND HAAST IN NEW ZEALAND, 1858–60.** Mike Johnston and Sascha Nolden. Nelson, New Zealand: Nikau Press. 336 pp. Hardcover, \$NZ 50.00.

In December 1858 the Austrian frigate *Novara* anchored in Auckland harbour. It was on a world trip, advertising the power and commercial potential of the Austrian empire, and carried a small group of scientists including Ferdinand Hochstetter who had been seconded from the Austrian Geological Survey. The local settlers were keen for Hochstetter to visit and report on newly discovered coal seams near Drury, on the outskirts of Auckland.

This was the first visit of a professional geologist to New Zealand, and within days of Hochstetter completing a well-received report he was invited to stay in the colony and undertake reconnaissance surveys with an eye on potential mineral deposits. The

commander of the *Novara* agreed that Hochstetter could stay and generously granted him six month's leave on pay.

At a reception for the German community in Auckland, Hochstetter was introduced to Julius Haast, a young traveller representing an emigration company, who had only arrived the day before the *Novara*. The two men got on well, and it was soon agreed that Haast would accompany Hochstetter on his travels. At this stage it was clear that Hochstetter was the geological professional and Haast the field assistant, but Haast was a quick learner and was able to work independently as a geologist by the time that Hochstetter left eight months later. Indeed, it was his mentoring by Hochstetter that set Haast on a prestigious career in New Zealand in his own right.

This book is a copiously illustrated account of their travels. Hochstetter and Haast initially explored the Auckland area, but their main project was an epic seventy-nine-day circuit around the central North Island, including visits to Kawhia, the active Taupo volcanic zone, and Tauranga. Soon afterwards, Hochstetter examined the goldfields of Coromandel. After completing a report and public lecture, he and Haast travelled south to Nelson where they spent two months exploring and visiting mineral prospects as well as geologically mapping much of the Province. It was during a visit to the chromite and copper mines that Hochstetter coined the name dunite for the olivine-rich rock that makes up much of Dun Mountain (so called because of the colour of the weathered surface of the rock).

Hochstetter finally departed on 2 October 1859, but Haast was to spend the following year exploring the West Coast as far south as Greymouth for the Nelson Provincial Council. Hochstetter incorporated the results of Haast's work in the reports and maps that he subsequently published.

Today Hochstetter is regarded as the father of New Zealand geology. His travels have been documented over the last 150 years, but previous accounts have almost entirely been based on material written in English. This book gives a new picture from major unpublished sources written in German, many held in Austrian archives but also some in Switzerland. It also uses the ongoing correspondence between Hochstetter and Haast that has been translated by Sascha Nolden.

One of the most appealing aspects of the new book is the large number of colour illustrations of water colour sketches, previously unseen by the world at large, which are held with the Hochstetter papers in Europe. The colour reproduction is excellent.

Hochstetter published the first New Zealand geological maps, including the southern part of Auckland Province and most of Nelson Province. He also published a detailed geological map of the Auckland volcanoes (partly based on Charles Heaphy's work) which now provides a record of some of the volcanic cones that have since been quarried away. One of his most valuable maps covers the area around Lake Rotomahana near the Pink and White Terraces which were partly destroyed by the 1886 Tarawera Eruption. Hochstetter's carefully surveyed 1859 map has been a key piece of information in recent efforts to relocate the terraces. These maps are all reproduced in the book in full colour.

As well as geology, both Hochstetter and Haast had a broad interest in natural science and ethnology, and Hochstetter's brief was to expand the natural history collections of the *Novara* while he was in New Zealand. Indeed, the species named after him include a vivid blue toadstool, a primitive frog, and a large carnivorous land snail. It was a time when moa remains were still being discovered, and Hochstetter assembled the first complete skeleton from bones found in a cave in Golden Bay in the northern coast of the South Island.

The book provides a comprehensive record of the places that Hochstetter and Haast visited between 1858 and 1860. On one level it is a well-written travelogue, using new sources to expand and illustrate a story that was already fairly well known. But what makes it a major contribution to the history of science is the evidence of the two-way linkage between exploration in New Zealand and the development of scientific ideas in Europe in



the mid-nineteenth century. Also the publication of manuscript maps and beautiful watercolours. Mike Johnston and Sascha Nolden have combined their skills to produce a valuable overview of some of the earliest geological exploration of New Zealand.

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**SILK PARACHUTE.** John McPhee, 2010. New York: Farrar, Straus and Giroux. 227 pp. Hardcover, \$25.00.

When your mother is ninety-nine years old, you have so many memories of her that they tend to overlap, intermingle, and blur. It is extremely difficult to single out one or two, impossible to remember any that exemplify the whole. . . . The assertion is absolutely false that when I came home from high school with an N-minus she demanded an explanation for the minus. . . . There was the case of the missing Cracker Jack at Lindel's corner store. Flimsy evidence pointed to Mrs. McPhee's smallest child. It has been averred that she laid the guilt with the following words: "Like mother like son" is a saying so true, the world will judge largely of mother by you." . . . I have absolutely no recollection of her saying that bout the Cracker Jack or any other controlled substance.

John McPhee, *Silk Parachute*, 2010

The appearance of a new John McPhee book excites a tribe of readers. I am one of them. Late Sunday afternoon I heard about *Silk Parachute*, called my bookstore minutes before they closed, and asked them to hold their only copy. Early Monday afternoon, beating a crowd leaving a talk across town on diagenesis of the Jurassic Navajo Sandstone, I drove to the bookstore. *Silk Parachute* was there, under the counter.

In the book, John McPhee has assembled ten, finely wrought essays, his most personal work. In the many McPhee books, the first person is sparsely used. Since *A Sense of Where You Are*, *A Profile of Bill Bradley at Princeton*, his first one (published in 1965), there have been 29 others. Always the stylist, there are no graceless circumlocutions in any of them.

The most interesting to geologists of John McPhee's works have been the four books on his travels with various members of Princeton's faculty or former Princeton students along the fortieth parallel from New Jersey to California. Only in the second book, *In Suspect Terrain*, is he accompanied for a long period by a non-Princetonian, Anita Harris, a Brooklyn native. Of the many earth scientists McPhee has worked and traveled with, only Ms Harris was cool to plate tectonics, which has now gained nearly universal acceptance by geologists.

The four geology volumes—*Basin and Range* (1981), *In Suspect Terrain* (1983), *Rising from the Plains* (1986), and *Assembling California* (1993)—were artfully folded into *Annals of the Former World* (1998), all published by Farrar, Straus, and Giroux, New York. *Annals* is a superb piece of writing, a mammoth effort, for which John McPhee was awarded the Pulitzer Prize. In it, Randy Van Schmus, geochronologist at the University of Kansas, guided McPhee to the geology and history of basement rocks in the Midwest, roughly between Cheyenne, Wyoming, and Chicago, Illinois. This final essay on the dating of Precambrian basement rocks completes the book.

Several of the essays in *Silk Parachute* draw on themes in *Annals* or on the four books that preceded it. The longest piece, "Season on the Chalk", has not been published previously in a book, but was in slightly different form, printed in *The New Yorker*, as was much of *Silk Parachute*. Probably the best-known chalks are the Cretaceous ones exposed in cliffs on both sides of the English Channel. McPhee spends delightful hours in France, some of it with his daughter, her husband, and grandchildren. His five year old granddaughter,

Livia, proclaims that, “asteroid or volcano” killed the dinosaurs, which is about where I have long been on that question.

McPhee’s writing is characterized by his ability to handle a tremendous variety of subjects. He writes winningly on just about anything. Here he romps through exotic and strange foods (43 of them) he has sometimes been served and ingested during his travels, long-exposure view-camera photography, a U.S. Open golf championship (Tiger Woods and all at Oakmont in Pennsylvania), a year of post-high school studies at Deerfield Academy before entering Princeton University, fact-checkers of manuscripts, and lacrosse, as sport my older son played on a club team at the University of Utah.

As a boy, McPhee went on outings with his mother and once asked her in freezing weather to go to LaGuardia Field to watch planes landing and taking off. She stood “there in the icy wind for at least an hour, maybe two.” He deliberately overturns canoes at summer camp. He says that he has never seen a rattlesnake in the field, unbelievable considering the land McPhee has tromped on.

John McPhee is not a geologist, which he readily acknowledges. At Princeton he majored in English and for many years taught Humanistic Studies there. Presently he is a staff writer at *The New Yorker*. Like self-taught lawyers of the distant past who studied on their own, he has learned much about the science, and would more than hold a spot at any department gathering or coffee cluster of geologists. Clearly he has read and studied extensively. And he has spent many days and weeks in the company of genial companions and excellent teachers: F. B. Van Houten, Karen Kleinspehn, Kenneth Deffeyes, Anita Harris, David Love, Eldridge Moores, and Randy Schmus. (For the record: Except for Ms. Harris and Randy Van Schmus, I know or knew all of these people and some are close friends. With pleasure, I have talked briefly to John McPhee several times.)

John McPhee likes geologists and they like him. His extensive travels in the field and obvious inquiries into the literature are unlikely to be duplicated by many, or perhaps no writers in the future. The beautiful book cover on *Silt Parachute*, designed by Abby Kagan, shows the English chalk cliffs, and inlet on the English Channel, and part of a parachute, the lines rising from a red balloon (?) on the gravel beach to disappear in clouds above the finely bedded chalk.

In March 2011, John McPhee turned eighty. The forty-six years since the Bill Bradley book have flown. Here’s wishing that genes from McPhee’s mother passed undiminished, and that John McPhee continues to plant his ass on a chair for hours at a time to write, as he once said was necessary.

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**THE FORGOTTEN EXPLORERS: PIONEER GEOLOGISTS OF WESTERN AUSTRALIA 1826–1926.** John Glover with Jenny Bevan. 2010. Carlisle, Western Australia: Hesperian Press, 246 pp. Softcover, \$Au 40.00.

The western third of Australia has often been ignored by historians of geology, and this book seeks to redress the situation with a detailed overview of geologists and their activities in Western Australia (WA) during the first hundred years of European settlement. The effort is especially welcome given that WA is currently home to about 1,500 geologists, more than any other Australian state, and contains some of the world’s most significant current mining developments, spanning iron ore, gold, alumina, nickel and diamonds. It is also an admirable complement to a volume entitled *A Rich Endowment* by Kenneth Spillman, which was published in 1993 and focuses on Government and Mining in WA.

This 231-page paperback volume, embracing eighteen chapters, aims to satisfy most categories of readers, be they professional geologists, members of the public, or historians of geology, and it succeeds remarkably well. It is copiously illustrated with about 150 historical images of people, field scenes, and maps, as well as several newly prepared illustrations. It is also written in a light, engaging style. For the historian, there are also twenty pages of listed source materials, plus both a 'General Index' and a 'People Index'.

To encourage the general readership, Chapters 1–7 provide a review of WA geology and its importance, as well as an overview of the critical historical events in nineteenth-century geology. These chapters are also supported by a 'Glossary of Terms', located near the end of the volume. For the historian, these chapters are somewhat uneven in content, yet are still useful. For example, here there is a good general introduction to the WA gold rushes (commencing 1892/1893) and a suitable focus on iron ore, though there is only minimal discussion of the early occurrence of copper mining during the 1840s, the discovery of artesian water, and the development of coal and building stone resources. A suite of diagrams showing the time ranges of geological activities by individuals and their association with the gold rushes is particularly useful in this introduction.

The central core of the book, extending from Chapter 8 to Chapter 18, focuses on the pioneering geologists themselves, and it succeeds admirably in its wide coverage of the people who worked on WAn geology over a century. Whilst centred on the people, the book does not neglect several critical and important themes that recur throughout the volume and are reinforced in a concluding review in Chapter 18. First and foremost of these is the importance of the Geological Survey of Western Australia, which flourished under the direction of Andrew Gibb Maitland during the period 1895–1926.

Another important theme is the changing public support of geology within WA that preferred prospectors in the early years but turned to favour extensive scientific assessment via a Geological Survey during the gold rushes in the 1890s.

There are also important sub-themes that have been critical to West Australian geology. These include the determination and interpretation of iron ore, including jaspilite, the recognition of gold telluride minerals, and the appreciation of the rare diamond-bearing rocks.

With the establishment of European settlement in WA in 1826 it was serendipitous that the first 'geologist' to provide comment was none other than Charles Darwin. On visiting the south coast in the *Beagle* in 1836 he wrote: "I do not think we have visited any place so very dull and uninteresting". Fortunately for geologists, fellow *Beagle* voyager, John Lort Stokes, returned in the same ship in 1837–1838 and published more significant geological observations. J. B. Jukes followed in 1843.

The Government appointment of a German visitor, Ferdinand von Sommer, during 1847–1878 to search for coal and other minerals, is afforded a separate chapter in the book. In hindsight, his short period in WA can be considered unusual. Research by the German scholar K. R. Bierman over the past fifty years has revealed that von Sommer was a 'confidence man', having little known geological experience before arriving in Australia. However, in the 1840s he travelled hundreds of kilometres in unknown parts of WA and produced a report, with geological map, that reflects some geological expertise. It confirms that in the early nineteenth century, institutional education and recognition were not the only attributes necessary to make a geological contribution.

The four Gregory brothers were primarily homegrown geological talent in the fledgling colony where they arrived as children in as early as 1829. Their geological understanding proved astounding as they discovered new pastoral land and found coal. As early as 1848, J. W. and T. T. Gregory submitted a geological map of WA to the Geological Society of London. And in 1861, during a visit to London, F. T. Gregory liaised with Roderick Murchison, who transmitted a paper on the Gascoyne River region for publication

by the Geological Society. The superb diagrammatic sections produced in this paper are reproduced in the book under review.

The Government appointments of H. Y. Brown (1870–1872) and E. T. Hardman (1883–1885) were the first sign that the geological profession was being permanently established in WA. However, only with the appointment of H. P. Woodward in 1887 was there continuity. In one prophetic statement Woodward made the observation that WA had enough iron ore to supply the world, thus predating reality by eighty years.

Yet it was under the guidance of Andrew Gibb Maitland (1864–1851) that geology first flourished in the western third of Australia. During his Directorship of the Survey (1896–1926) some notable geologists were appointed to the agency, which published no less than ninety-one scientific bulletins and geologically mapped almost half the State—no mean feat given that it encompasses more than 2.5 million square kilometres of largely hostile desert.

By way of a personal contribution Gibb Maitland successfully explored for artesian water and assessed the Pilbara goldfields. Then there were significant review publications, notably his Survey Memoir: ‘Mining Handbook of Western Australia’.

Within Gibb Maitland’s Survey there were also several appointments that Glover and Bevan judge to have made significant contributions to world geology. There was John T. Jutson, a pioneering geomorphologist who produced a landmark monograph on physiography in 1914, and also worked with Johannes Walther. However, Jutson’s monograph (republished in 1935) did not prevent his retrenchment from the Survey in 1918 as a consequence of wartime financial stress.

Another appointment to Gibb Maitland’s Survey was E. S. Simpson, a mineralogist, who amongst many achievements, attempted the dating of uranium minerals using radioactive decay as early as 1910 and went on to publish a comprehensive manual of West Australian minerals in 1932. W. D. Campbell, an early environmental geologist; C. S. Honman who recognised the sedimentary origin of jaspilite in 1917; and H. W. B. Talbot, an untrained field assistant, who rose to become a highly regarded geologist and explorer, are others who worked under Gibb Maitland. However, I could not read this book without appreciating that much more could be researched about this dynamic organization.

In the period under consideration, geologists were also appointed to the Kalgoorlie School of Mines from 1904, notably C. O. G. Larcombe, and to the University of Western Australia from 1913, notably W. G. Woolnough, M. Aurousseau and E. de Courcy Clarke. This volume suggests that their institutional influence was generally less than that of the Geological Survey under Gibb Maitland, despite significant fertile interaction between the two bodies

Chapter 16 provides details on eight specific individuals who made unique and varied contributions to West Australian geology. It shows that there were numerous disparate strands to the development of geology in this remote region, which nevertheless liaised with the wider world. Here we learn of Robert Austin, an explorer who after a disastrous expedition in 1854 prophetically predicted the occurrence of gold using the ideas of Roderick Murchison. Then there was the clergyman, Charles Grenfell Nicolay, who, during the 1880s, acted as a geological advisor to the Government, published *Some Notes on the Geology of Western Australia* and established in 1881 a Registry of Minerals. This evolved into a Geological Museum in 1891 and eventually into today’s Western Australian Museum. And then there was Arthur Holroyd who prepared exhibits for international exhibitions and arguably had the major role in recognizing the gold telluride minerals that held perhaps 20% of Kalgoorlie’s gold.

Chapter 17 is virtually a dictionary of other geologists who worked on West Australian geology in the pioneering period, with summary details on more than fifty individuals and their contributions. Here we learn about Herbert Clark Hoover (later a US

President and translator of Agricola's *De re metallica*) and his low-grade mining operations as well as numerous other geologists who have contributed to the West Australian gold rushes. Here also are references to the summary contributions of other explorers and geologists who are perhaps better known for their work in other Australian States.

Overall, this volume is a valuable source and reference book on the first hundred years of West Australian geology. It is also recommended to any historian of geology interested in the pioneering application of geology in a remote region where the geology has numerous unique characteristics.

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**LETTERE DI GIOVANNI ARDUINO (1714–1795) GEOLOGO.** Edited by Ezio Vaccari. 2008. Conserve: Edizioni Think Adv, 239 pp. €30.00.

This volume on Giovanni Arduino's correspondence manifests a recent wave of Italian historiography in the Earth Sciences and pre-historical archaeology, investigating and documenting the enormous Italian legacy, hitherto mostly unknown to both national and international audiences. Besides *Arduino's Correspondence* by Ezio Vaccari, one can mention *Fossils and Reputations* by Pietro Corsi (2008) and *Gli scavi di Scarabelli a S. Giuliano di Toscanella: un inedito secolare* by Gabriella Morico (2007), both of which shed new light on leading and pioneering scientists, still found more in the realm of legend rather than expertly evaluated for their writings.

Ezio Vaccari is the leading specialist historian of Arduino, having published a complete monograph on his life and works in 1993, and a series of special papers on Arduino's wide-ranging interests within the Earth Sciences.

The current volume opens with an introduction to Arduino's scientific life, which goes hand in hand with the selected letters—sixty out of a total of more than 600 received and sent from 1753 to 1795, with only a few previously published—extending from 1757 to 1785, and documenting Arduino's life as a geologist. A schematic Arduino's bio-bibliography, and an updating of his previously published bibliography (Vaccari 1993) follows.

Most of the volume is devoted to fifty-nine unpublished Arduino's letters, followed by his most famous *Lettera seconda ad Antonio Vallisneri*, dated 1759 and published in 1760. The letters are chronologically arranged. Half of them are addressed to Antonio Vallisneri Jr, the others to nineteen different scientists, among whom the most prominent are Alberto Fortis, Giovanni Targioni Tozzetti, Friedrich Heinrich Wilhelm Martini, Carlo Allioni, Martin Brännich, Ignaz von Born, Johan Anders Retzius, and Benedetto Spirito Nicolis di Robilant. The volume is the third in a series aiming at 'unravelling', by means of correspondence, the roles played by savants and naturalists of the Venetian region of northeast Italy in the development of modern science.

The letters are of great interest especially for an international audience, so that their lack of an English translation is highly regrettable.\* Therefore a wide-ranging review of the numerous items of interest is offered here, with extended comments.

As an immediate result of the reading, a lively characterization of the man, known from only a few portraits, is obtained. Through the different editions of the *Encyclopaedia Britannica* and a series of stratigraphy and geology textbooks, Arduino is one of the most quoted early Italian geologists for having introduced as early as 1759 the terms Primary,

\* But see the paper by Theodore Ell in the present issue of *Earth Sciences History* (ed.).

Secondary, Tertiary, and by extension Quaternary, two of which are still extant and of growing use. In fact, in spite of the successful replacement of the first two with Palaeozoic and Mesozoic and the equivalence of the second two with Cenozoic, Tertiary and Quaternary are even more used, and the terms Primary and Secondary were never discontinued or abolished (Vai 2007). Interestingly, the reason for introducing the junior synonyms Palaeozoic and Mesozoic was their difference in biotas—the same major difference stressed by Arduino a century earlier in making his distinction.

What was the nature of Arduino the scientist and man? His letters reveal that he was individualistic in **character**, strong in feeling yet at the same time unassuming, aware of his worth and a confident defender of his discoveries, continuously claiming not to have sufficient time for engaging in field research and writing his thoughts because of his professional and institutional commitments. He frankly admitted to having no special training or aptitude in languages and having little experience of writing books, declaring however: “I may lack ability but not materials”.

Arduino was not competitive or envious of anybody. Moreover, he appreciated the merits and labour of others. “I know well my faults and admire others’ virtues and doctrines, even if [only] a little” (I believe ‘little’ is an adjective referring to ‘virtues’ and ‘doctrine’). However, his letters reveal the challenges in dealing with envious and unscrupulous colleagues.

He sought precision at all times: professionally, in research, and in technical **terminology**. For example, he did not accept publishers’ modification of his use of the Italian term *minera* = mine, instead of the common Italian *miniera*.

**Biographical** notes are widespread in the letters. It is a pleasant surprise to know that Arduino was warmly wishing for the wellbeing of “our Italy” more than a century before the political unity of the country was accomplished in 1861, suggesting that a common national feeling was growing beyond the possession of a common language. In this context it is useful to know that in the second half of eighteenth century many savants in Germany and Sweden cultivated Italian, and the scientific magazine *Giornale d'Italia* was “available all over Italy, in Germany, France, and even England”.

At least two references are made in the correspondence to the peak decades of the Little Ice Age during the mid-eighteenth century. Arduino was greatly hampered by rain and snow during his Recoaro travel in October 1758. And a shortage of wood fuel was increasingly being felt (1771). We also learn that Arduino requested a print run of 50 to 100 copies of his two letters, printed in the Venetian *Nuova raccolta* by Father Angelo Calogera in 1760.

Arduino was, one might say, really in love with his stones: “I like my stones, and except when I have to donate them for some important reasons, they feel well with me”. Although constantly busy with his engineering profession, Arduino did not put aside his “research on fossils, their origin and meaning for understanding the great Book that Nature maintains open to let us understand its true history, which only a few have attempted”. But he was also adept at interrogating Nature with the assistance of machinery. For example, in his work at a pit in some post-Tertiary alluvial deposits, a large manual screw-drilling tool (or auger) is mentioned for investigating the most suitable sites for construction work on the foothill plains. Besides using such mechanical aids, Arduino had extremely good observational powers.

In his letters, Arduino **quotes** usually with respect or admiration the following scientists: A. Vallisneri senior, M. Mercati, G. Buffon, C. Linnaeus, B. Maillet, N. Steno, V. Donati, G. Baldassarri, G. Targioni-Tozzetti, J. H. Pott, J.J. Becher, A. Barba, J. J. Rousseau, J.E. Guettard, J. Strange, Plato, Aristotle, W. Whiston, J. Woodward, I. de Born, J. J. Ferber, John Stuart of Bute, A. F. Cronstedt, J. F. W. Charpentier, H. B. de Saussure. However, he does not hesitate to criticise on specific topics Buffon, Linnaeus and Guettard.

**Palaeontological** remarks on fossil remains are relatively common in the correspondence, with “hardened” or “petrified shells” being considered as fragmented lithic components of “soft stones [such] as those in the Berici Montains”.

Arduino was aware to have found fossil corals in the Venetian rocks, and was looking for verification by his peers. The same applied to the nummulites that he collected in the Venetian and Tuscan hills. Arduino knew Linnaeus’s *Systema Naturae* well and was happy to share Buffon’s opinion “that Linnaeus’s system [wa]s out of nature”.

To make the point clear, Arduino stated “one should not be fanatically captured by men’s opinion, even though they might be renowned”: a rejection of any ‘authority principle’ in science. But like many scientists of his time, Arduino was a Roman Catholic **believer**—yet evidently aware of the differences between, and the autonomy of, science from metaphysics and theology.

Arduino was an outspoken **experimentalist** and a follower of the school of natural history established by U. Aldrovandi, M. Malpighi, N. Steno, A. Vallisneri, L. F. Marsili, and the *Istituto delle Scienze di Bologna*. So, like many other Italian geoscientists, Arduino did not become involved in the **Neptunist/Plutonist** controversy. His position (representing the majority of Italian Earth scientists) involved a balanced and realistic interplay of the actions of water and fire, based on his wide-ranging field researches.

As an example of aqueous action, Arduino was one of the first authors, after G. Monti in 1720 (Sarti 2003), to speak about fluid (“water and air”) inclusions, which he had observed inside minerals like opal and other gems deposited from water in the process of petrification.

As an example of the action of fire or heat, Arduino stated that “[a]ll types of Gabbro that I have observed in Tuscany and the Duchy of Modena . . . seem to have been originated from the subterranean Fire”. The conclusion was “The more I observe the structures, materials, and phenomena of our Globe, the better I am convinced that both Neptune and Vulcan have been the main builders, at least in the visible part[s] of the Globe”.

Arduino rarely used the term geology (except at the beginning of his *Prima lettera* in 1760) or the term geognosy, but sometimes he wrote Geogony and more often referred to **Oryctology and Oryctography**, the latter term having a meaning very close to the word ‘stratigraphy’ as later used by W. Smith in 1817, A. d’Orbigny in 1849, and G. Scarabelli in 1859 (Vai 2007). This stratigraphic meaning was quite different from the geognostic (strongly petrographic-linked) approach of the Freiberg School. It is not, I suggest, by chance that Arduino did not quote any of the leaders of that School, except for the map-maker Charpentier.

Arduino’s oryctography incorporated the concepts of Earth history (as a goal of research) and geologic time which was related to the succession of strata and their organic fossil contents (as a working tool). The geognostic approach made reference to rock types only. In fact, Arduino recognised different types of fissile (metamorphic) rocks (some primaeval, some younger) and different generations of granites (some older, some younger).

Arduino’s ‘four general Orders’ were rocks of partly different lithologies that were fundamentally identified and differentiated for being in succession to one another; and bearing the homonymic name of ‘Epochs’ had a direct chronologic implication. Unlike geognostic units, largely resembling our lithostratigraphic units, Arduino’s **orders/epochs** were the prototype of our chronostratigraphic/chronologic units, as they were introduced at the Second International Geological Congress in Bologna 1881 (Vai 2007). His orders were, for him, tools to unravel “the Physical History of the Earth . . . and the general Epochs of its formation”.

Rather like L. F. Marsili, Arduino’s unfulfilled dream was to publish a ‘**Theory about the formation and different ages of mountain strata**’. However, in many letters he reviewed or gave hints of the aims, scope and criteria of this goal. Important remarks that

were absent from, or only partly contained in, his famous *Seconda lettera* of 1760 are as follows.

- (a) “I am wondering about the innumerable diversity of Animals and Plants, most of them products of the sea imprisoned in such an immense amount in our Hills and Mountains”.
- (b) There are “different degrees of perfection in the species of petrified marine Animals, those in the lower strata being imperfect ( called Secondary by me) and those in the upper strata more and more perfect, following the order of their successive formation, so that in the last strata (I have called Tertiary species are the most perfect, and essentially the same as those which are found in the present sea. It is surprising to see that in the stony strata deeper than those referred to above, innumerable Productions are seen, like embryos or ‘attempts’” (1760). This offers a remarkable early preview of an evolutionary theory of life and earth history.
- (c) Marine sedimentation is briefly described in clear ‘uniformitarian’ terms (as we would say). (This is not surprising, having been observed even in Aldrovandi’s works in the late Renaissance: Vai [2003]). An early uniformitarian principle was formulated when Arduino wanted someone to make observations on Vesuvius and the Zolfatara near Naples “considering which differences are remarkable between the ancient and the modern eruptions” (1765). An even more explicit operational definition of uniformitarianism was given when he wrote that: “the marvellous effects produced by Water and Fire in our Globe during the most remote centuries are tentatively explained based on the analogous products they are providing at present” (1773).
- (d) After the publication of his *Seconda lettera*, Arduino was curious to compare his theory and classification with other systems. In the case of Guettard, “it does not seem to me that his zones [or mineral bands: *bandes*] may correspond to my great strata”. He argued that: “the theory of the Earth is still very defective and derived from inconsistent and not precise observations” (1764). This happens also because “many Cabinet’s Naturalists have seen almost nothing of nature except what is preserved in the Museums” (1764).
- (e) Also worthy of notice, Arduino was the first “to think about the Genesis of Mountains and Plains” (1764) and not only mountains. In fact his “Fourth Order” specifically referred to plains. This meant that “Mountains and Plains” were not regarded simply as landscape or geomorphological units, but as ‘geological’ entities, appropriate to be described and classified for their internal contents or constitution.
- (f) In later letters, Arduino claimed priority for discovering very ancient extinct volcanoes (1773). He also recognised that his ‘Language’ (Orders = Epochs) was becoming used both by naturalists and ‘amateurs’ who are “inclined to think” (1773). Such pride was shared by the Italian geoscience community as a whole when Arduino stated that “it should be known that the Subterranean Realm is observed not by ultramontane savants in the cold North alone” (1773).
- (g) A summary of Arduino’s chronostratigraphic/chronologic classification in Primaeval, (1) Primary, (2) Secondary, (3) Tertiary, and (4) Fourth Order is reported in many letters.
- (h) Perhaps the most interesting remarks provide some details about the Fourth Order, substantially an explicit predecessor of the Quaternary. It contained (i) coarse grained pebbles and blocks of different lithologies “deposited from Rivers at high altitude of our Mountains in the most remote centuries as I show in Sette Comuni, Folgaria and other places of the Feltre and Verona Mountains; (ii) bodies of small pebbles and gravel, more or less cemented, deposited after some *sea-level rise* [*italics added*] at



the foot of the Sette Comuni mountains, up to a level that is perhaps higher than the surface of our plains by a quarter or half a mile, as may be seen near Marostica, *etc.*” (1774). In Arduino’s mind, therefore, the Quaternary, or his Fourth Order, also contained sediments related to a late marine transgression.

- (i) Arduino’s classification was favourably received and soon gained international consensus and wide recognition, in part through some critical debates, especially with Alberto Fortis who, being located in Paris, enjoyed a wide audience. Arduino’s reference to Fortis stressed that the products of extinct or very ancient volcanoes are not limited to the Tertiary Order “but are often found in the Primary and Secondary Orders as well”. An additional remark of special significance is that “volcanic processes are manifested by their occurrence later than most of the other materials [found in the corresponding order] of mountains”. This concept in modern geology and volcanology is expressed by saying that ‘emplacement of volcanic rocks in the mountain belts is mostly a late-to-post-tectonic process’. That Arduino had already discovered and possibly understood this feature is an indication of the level reached by his observations.

I hope this summary will stimulate the interest of historians of geoscience, making the translation of the body of Arduino’s letters into English more valued and more feasible.

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1. Contact with the Editor or a Member of the Editorial Board prior to submission is welcomed.
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3. The text should be prepared in Times New Roman (10pt), but using 9pt for indented quotations. The title should be centered and in bold, 12pt. **Please do not use auto-numbering, auto-'bullet-points', or any form of auto-formatting other than for automated footnoting and 'smart' quotes.** The text should be single spaced and justified left and right.
4. Figures are welcome. Digital submission is required, on a CD for large files or by email attachment if transmission is possible. Half-tones should be scanned at 600 dpi and black and white documents at 1,200 dpi. The use of colour is possible, but authors will be charged for this. A cost estimate will be provided in advance for each case.
5. Tables and figures should be sent in files separate from the main text.
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## Format for References

### Books

- Bullen, K. E. and Bolt, Bruce A. 1985. *Introduction to the Theory of Seismology*. 4<sup>th</sup> edn. Cambridge: Cambridge University Press.
- Good, Gregory A. (ed.). 1998. *Sciences of the Earth: An Encyclopedia of Events, People, and Phenomena*. 2 vols. New York and London: Garland Publishing Inc.
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### Unpublished thesis or dissertation

- Wolter, John A. 1975. The Emerging Discipline of Cartography. PhD dissertation, University of Minnesota.

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