

Natural theology in the eighteenth century, as exemplified in the writings of Élie Bertrand (1713–1797), a Swiss naturalist and Protestant pastor

KENNARD B. BORK

Department of Geosciences, Denison University, Granville, OH 43023 USA

Corresponding author (e-mail: bork@denison.edu)

Abstract: For Élie Bertrand (1713–1797) and his like-minded contemporaries, God's design and providence set the stage for understanding the workings of the Earth. Bertrand used various methods, including field observations, to accumulate considerable geological knowledge, which he published in his *Dictionnaire universel des fossiles* (1763) and *Recueil de divers traités sur l'histoire naturelle* (1766). By examining Bertrand's life and writings, we may come to appreciate the strengths and shortcomings of his visions of the natural world. His focus on collecting, cataloguing, and classifying natural objects and phenomena fitted the classic concept of natural history in his era. On the basis of his observations, he dared to systematize and theorize. His work provides a window on his time and on attempts of natural theologians then to understand the products and operation of the world. Once a counsellor to the King of Poland, a correspondent of Voltaire, and a contributor to the *Encyclopédie*, Bertrand's name has largely vanished from view. His hope to observe the world of nature so as to comprehend the word of God yielded constructive results but did not succeed in fulfilling natural theology's boldest aspirations.

It is difficult to transport ourselves back 250 years in time so as to think like a naturalist in the mid-eighteenth century. But we need to do so if we ever hope to gain deep insight into the musings of pious Christian writers who were genuinely excited about combining the word of God with the world of nature. Their fervent hope was to reinforce their religious beliefs while furthering their understanding of the workings of the Earth.

In this post-Darwin era of secular science, it may be asking a great deal to suggest that we need to entertain the 'argument from design' when marvelling at a beautiful insect, or to be grateful for God's providence when explaining the nature of majestic mountains. However, to truly understand the history of our discipline, we must at least consider the excitement and attraction of natural theology as a catalyst for investigating topics in the Earth sciences during the late seventeenth and much of the eighteenth century. It is also relevant to consider the point recently made by Brooke (2007, p. 10) that it is possible for historians to see 'a fascinating picture ... of scientific activity grounded in, and justified by, theological considerations'. Marshall (2006) noted that the cliché of 'warfare' between religion and science is an inadequate description of the historical record. The desire of Brooke (1991) and Lindberg & Numbers (2003) to move away from oversimplified 'conflict' models to a more complex reading of the intersections between theology and science is relevant to the following discussion. The voluminous work of

eighteenth-century natural theologians, dated though it may seem, serves to reinforce these points.

The goals of this paper are to: (1) consider the nature and impact of natural theology and outline its allure for its adherents; (2) use the writings of Élie Bertrand, a Francophone Swiss naturalist and Protestant pastor, as illustrative examples of how a Christian naturalist viewed the world and made contributions to the nascent discipline of geology; and (3) comment on why the amalgam of 'the word' and 'the world' did not achieve the exciting goals of natural theology.

Natural theology and its allure

Imagine being brought up as a Protestant Christian who used the Bible as a guidepost for the operation of your entire world. Imagine being in a country that had just had a wrenching civil war and was striving for stability and a sense of order. Imagine being enthralled with the new Baconian methods of experimentation and observation to understand nature. And think of how it felt to watch Isaac Newton use rational mathematical methods to order the universe. That was the case for the British natural theologians of the late seventeenth century. The post-Civil War, post-Cromwell British gave us a panoply of Protestant natural theologians, many of whom are familiar names: John Ray (1627–1705), Thomas Burnet (1638–1704), William Whiston (1667–1752) and William Paley (1743–1805). In

the nineteenth century, the British vision of the intersection of natural theology with then-contemporary thought was provided by the Bridge-water Treatises *On the Power, Wisdom, and Goodness of God, as manifested in the Creation*. Of particular note is Volume VI on *Geology and Mineralogy Considered with Reference to Natural Theology* (Buckland 1836). Reasons for natural theology finding such fertile ground in Britain have been discussed by Gillespie (1987).

The European and Catholic practitioners of natural theology could be said to go back to Augustine (354–430) and Thomas Aquinas (1225–1274), both of whom could see God's handiwork in the beauty and plenitude of the natural world. By the late seventeenth century, French natural science was advancing, and Fénelon (1651–1715) could tell young René Antoine Ferchault de Réaumur (1683–1757) that naturalists could show adoration of God through an exposition of the marvels of nature (Bourdier 1960). The French name that serves as the most noteworthy French eighteenth-century exemplar of natural theology is the Jansenist cleric, Abbé Noël-Antoine Pluche (1688–1761), whose *Spectacle de la nature* (Pluche 1732) was intended to attract young nobles to natural history and ended up entrancing a wide spectrum of Francophone readers. Pluche commented that nature is the best, but one of the least understood, books in the world's library. He firmly stated that fossil shells were the natural product of the sea (Pluche 1732, p. 252). He also proclaimed that, 'After faith... we have nothing more precious than reason' (Pluche 1732, p. 504), and therefore 'Man should be religious in proportion to his being reasonable' (Pluche 1732, p. 512). Pluche went on to speak of three possible 'Ideals' for the power of human reason: (1) to wish to know nothing (indolence); (2) to wish to know everything (temerity); or, as he counselled, (3) the wish to do research and put to profit what one can know (prudence) (Pluche 1732, p. 519). Roger (1963) has seen the origin of natural theology as occurring in Britain, with Pluche following suit in France and passing the torch to Élie Bertrand, Albrecht von Haller and Jean-Jacques Rousseau.

The alluring result of all of this British and French musing about how best to comprehend the nature of God and the world was that one could combine the power of God's scriptural commentaries with the insights of contemporary science. The involved participant could have a richer vision of God while deepening his or her understanding of the working of the designed world. It was an exciting time. As Lynch (2002) observed, the eighteenth-century scholar may not have recognized the present definitional separation of 'science'

versus 'religion' and may have sincerely believed in pursuing a powerful amalgamation of approaches. Thus, the real power of natural theology, in its own time, was that it melded the word and the world while forcefully demonstrating God's design. A brief definition of natural theology is that it seeks to understand the nature of God through human reason and attention to nature, as opposed to relying solely on revealed truth, as sanctioned by the clergy and presented in the Bible. In practice, it allowed the use of selected Cartesian methods, Baconian empiricism, and Linnaean visions of order in the organic realm. Along with the cosmic order provided by Newton, natural theology helped the naturalist develop a sense of optimism about understanding the workings of the planet Earth.

Protestant Swiss proponents of natural theology included Louis Bourguet (1678–1742) and Élie Bertrand (1713–1797). The Francophone Swiss are interesting because they shared with the French a language and the analytical tools, if not mechanistic philosophy, of Descartes. That is, they could employ rational elements from his *Discourse on Method* (Descartes vuvo 1637) (one should doubt established doctrines; subdivide huge problems; be systematic in reasoning; and try to be complete and rigorous in stating conclusions) while avoiding over-mechanistic explanations for God's sometimes mysterious modes of operating in the world. The Protestant Swiss also had deep religious empathy with the British clerical writers of natural theology and natural history. As Bertrand wrote, 'Let's try to study nature so as to celebrate the Author' (Bertrand 1766, p. 113).

Élie Bertrand

The life and thought of Élie Bertrand are instructive on many counts (Carozzi & Carozzi 1984; Weidmann 1986; Bork 1991) (Fig. 1). His dates (1713–1797) lie within the Enlightenment, and he died in the same year that James Hutton expired and Charles Lyell was born. He contributed to the famous *Encyclopédie* of Diderot and d'Alembert, and he corresponded with Voltaire (1694–1778) and other mid-century luminaries. Just one example of that correspondence is a letter, dated 5 January 1759, from Voltaire to Bertrand expressing the view that, 'Opinions have caused more ills than the plague or earthquakes on this little globe of ours'. Intellectually, Bertrand had a rich heritage. He was familiar with Cartesian logic and frequently employed the Cartesian method of breaking down major problems into smaller, more approachable packages. He could, of course, comprehend the exciting work of the French science establishment,



Fig. 1. Portrait of Élie Bertrand, painted by Sigmund Barth in 1749. From Weidmann (1986). The original painting is in the Musée du Vieil Yverdon, Switzerland.

centred in Paris. But it was British-based natural theology that drove his interest in observing nature as a means to communicate with a wide audience about the glories of God. A Protestant pastor by vocation, Élie Bertrand was also a member of numerous learned societies, and he served as a counsellor to the King of Poland. Bertrand added significantly to the accumulation of proto-geological knowledge and was a widely read author with a flair for popularizing natural history.

Some authors (Furon 1943; Guyénot 1957) have written demeaning things about how dull most of the eighteenth century was, in the context of the evolution of science and natural history. However, I have to agree with Dezallier d'Argenville (1742) that the early decades of the century were rich in advances for natural history. Also, Greene (1971) correctly observed that systematic natural history really is a brand of 'science', and that mid-eighteenth-century observers, describers and classifiers deserve a place in the pantheon of noteworthy contributors to the evolving geosciences. Knight (1976) made the point that many of the naturalists of the first half of the eighteenth century were collectors and describers, in the Aristotelian mould,

rather than Platonic thinkers anxious to use mathematics and deduction to generate basic laws of nature. Bertrand fits well into the category of collectors and amateur naturalists who furthered the evolution of natural history and provided significant building stones for the burgeoning discipline that was to become geology at the end of the eighteenth century.

Bertrand's two major works are the *Dictionnaire universel des fossiles* (Bertrand 1763) and the *Recueil de divers traités sur l'histoire naturelle* (Bertrand 1766). The *Dictionnaire universel* was one of the most read natural history books of the eighteenth century and d'Archiac (1862, p. 282) commended it as being a strong contribution for its time (Fig. 2). Its goal was to systematize the complex world of nature. Johns (2003) described the situation well when he noted that the early Enlightenment dictionaries came from a culture of patronage, were typically written by single authors, were dedicated to monarchs, and had as their audience a 'cosmopolitan republic of letters'. As Roger (1980) has suggested, classifying, along with the associated endeavours of collecting and cataloguing, really was a critical aspiration of the era.

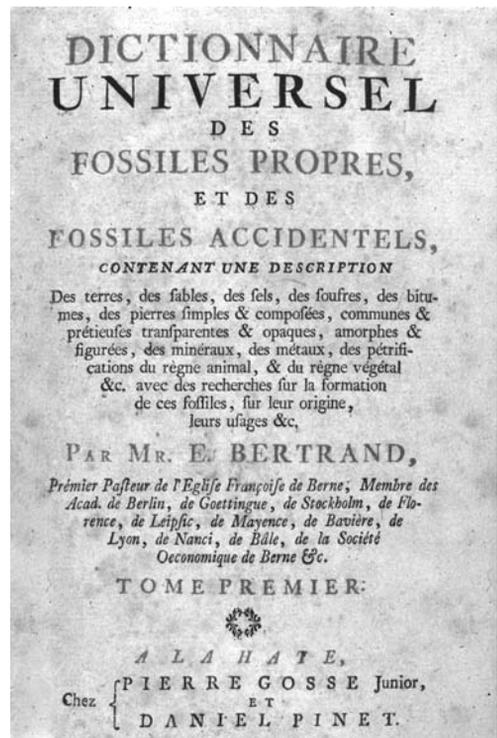


Fig. 2. Title page of *Dictionnaire universel* (Bertrand 1763). From the author's personal copy of the book.

Two centuries prior to Roger's contention, Élie Bertrand had stated that our finite knowledge can grow perpetually if we collect, describe, and classify God's products (Bertrand 1763). Linnaeus (1707–1778) had already advanced his *Systemae Naturae* (Linnaeus 1735, 10th edition, 1758) and the public was attuned to seeing order in nature. Bertrand responded to this drive for order by classifying the natural products of the Earth. For him, dictionaries were fundamental to understanding any subject and had value for the specialist as well as for the common reader. He stated this clearly. 'To reunite principal objects into a dictionary, and that in a common language, is, it seems to me, to render an essential service to the public' (Bertrand 1763, p. xiiij). He provided examples of valuable dictionaries in the realms of medicine, pharmacy and alchemy, and called attention to the brilliant accumulation of knowledge in the *Encyclopédie*. In his view, a strong dictionary in 'oryctology' (palaeontology, geology, mineralogy) was sorely needed, because public interest in natural history was high, yet study and progress within the field was still 'in the shadows'. The utility of oryctology was patently evident to Bertrand. Demonstrating his practical side, while offering a vision of what we now call geological maps, he called for a *Carte Oryctographique* for each country (Bertrand 1763, p. xxvj). It would reveal topography, beds of strata, wells, landslides and places where one might drill the ground in the quest for resources. He explicitly stated that: 'Contemplation of all the parts of nature always leads to God and the sage spirit which attaches to that Being, which is the cause of all that exists' (Bertrand 1763, p. xxv). Offering a book that combined study of nature with a pathway to comprehending the gifts of God was his goal in writing the *Dictionnaire*.

He also felt that it was important to eliminate the confusing multiplicity inherent in having distinct names from different locales. What was needed was a major amalgamation of terms and a decrease in subdivisions within a particular class of rocks or fossils. His somewhat caustic observation was that rampant splitting of names often was done to serve the egos and self-promotion of an author rather than furthering knowledge. Although he deemed the task of distilling names and creating synonymies a 'disgusting' one (Bertrand 1763, p. 65), because it was arduous and time-consuming, he saw the merit of having a universal vocabulary for fossils, rocks and natural materials. As he wrote, systematic terminology is 'the soul of true science, and the torch for one who wishes to instruct himself about nature' (Bertrand 1763, p. xv). Thus, one of the major services of the *Dictionnaire* was to provide stable names for the plethora of terms, often tied to a given country or locality, that

burdened nomenclature at that time. The book was, in essence, an invaluable compendium or accumulation of discrete elements. It attempted to bring order out of chaos.

Communicating the essence of his message to his audience was important to Bertrand. Thus, he laid out (Bertrand 1763, pp. x–xij) the design and goals of the *Dictionnaire*. It is worth noting that although he wanted to illuminate the reality of God's work, he specifically commented that using the imagination, instead of experience and observation from nature, would lead natural scientists into error. The natural objects discussed were presented in alphabetical order of their French names. Bertrand felt that French was the 'universal language' of science, and that commonality was a significant goal for communicating with the reading public. Occasional synonyms in Latin, German, Italian and English were also provided. The key characters then received attention, following the Linnaean ranking concept of Class, Order, Genus, Species and Variety (Bertrand 1763, p. xvj). When possible, origins were discussed and comments made about the use or utility of particular 'fossil'; this term was used in the broad sense of anything dug from the Earth. In many cases Bertrand cited authors, such as J.-J. Scheuchzer and J. T. Klein, but asked his readers to be indulgent and not presume plagiarism on his part if a point was made but a specific original author was not named.

It was widely felt that, thanks to the power of the 'great chain of being' and of divinely established relationships within nature, affinities among organisms and inorganic products could be surveyed and summarized. In a designed world, in which organisms existed in a sequence from fungi to corals to archangels, it should be possible to place a particular animal, plant, or fossil in a recognizable slot in the scheme of things. Bertrand none the less admitted that gaps might be evident until our knowledge of nature was more complete and allowed all of the connections to be recognized. The goal of the *Dictionnaire* was huge: he hoped to offer a truly universal dictionary on such significant topics as fossils, minerals, rocks and metals. Equally impressive were the sources of the incorporated knowledge: nature itself, thanks to Bertrand's willingness to do fieldwork; various books; natural history 'cabinets' (personal collections), which he hoped would instruct as well as amuse their owners; and contributions from other scientists. Modestly he admitted that the dictionary was just an imperfect 'essay', but he went on to state: 'I do flatter myself that my work will not be entirely useless for other authors' (1763, p. xij).

If great rulers such as Frederick V, Elector Palatine of the Rhine, and the kings of Sweden and

Denmark could be attuned to the enlightening potential of natural history, why could the topic not find its way into the schools and colleges? One suspects that Bertrand's own educational experiences had not been very enlightening, because he exclaimed, 'All the teachers teach Latin and Greek, which one learns only imperfectly and soon forgets. No one learns things useful to the country, applying our time, money, talents, and studies to useful things [such as natural history]' (Bertrand 1763, p. xxxij). He continued: 'Isn't it astonishing to see twenty Masters teach dead languages and not one teach Practical Science, in which progress could make for the richness of the country and prosperity of the state?' The answer might not come to formal education programmes for many years, he feared. That was all the more reason to write informative books of a 'popular' nature. In its day, the *Dictionnaire universel* took a few steps toward educating the populace about the significance of the contemporary views about natural history, while furthering the aspirations of natural theology.

The *Recueil* of 1766

It is Bertrand's 1766 collection of essays that provides one of the best windows onto the natural history landscape visible at mid-century (Fig. 3). It was fundamentally a selection of Bertrand's own mid-century articles describing and classifying the products of nature. The compendium was invited by a publisher who felt that Bertrand's commentaries were insightful and were no doubt of interest to a public desirous of learning more about the natural world. It was the work of an 'accumulator' rather than a paradigm shifter. As much as we celebrate the geniuses capable of shifting research programmes, there does remain a place for the plodders and toilers who lay the foundation blocks for the superstructure of science or society. As Rousseau (1979) noted, the evolution of natural science following the era of John Woodward (1665–1728) depended upon a slow and incremental 'accretion' of knowledge. Also, Glacken (1967, p. 406) related natural theology directly to the accumulation mode of Bertrand's contributions by observing that, in the minds of many eighteenth-century naturalists, it was the detailed observations that served to illuminate the great power of design.

But the *Recueil* went beyond mere descriptions of natural phenomena, however valuable they might be. In places it hearkened back to the natural theology of John Ray, as in its discussions of the 'usage of mountains'. It also (1) argued for using observations from the field; (2) treated

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Par M. E. BERTRAND, ci-devant premier Pasteur de l'Eglise
Françoise de Berne, & Secrétaire de la Société Économique,
maintenant Conseiller de la Cour du Roi de Pologne; des
Académies de Berlin, de Goettingue, de Suede, de Florence,
de Leipzig, de Mayence, de Munich, de Lyon, de Nancy,
de Bâle; des Sociétés d'Agriculture de Paris, de Lyon, de
Rouen, de Dublin; &c. &c.



A A V I G N O N ,
Chez LOUIS CHAMBEAU, Imprimeur - Libraire,
près les RR. PP. Jé suites.

M. DCC. LXVI.

Fig. 3. Title page of *Recueil de divers traités sur l'histoire naturelle* (Bertrand 1766). From the author's personal copy of the book.

major topics, including the nature of fossils and the structure of the Earth; and (3) even provided some theoretical speculation about the nature and origin of earthquakes and mountain ranges. The specific subtitles and dates of the original essays were: (1) Memoir on the Interior Structure of the Earth (1752); (2) Essay on the Usage of Mountains (1754); (3) Memoirs on Earthquakes (1757); (4) Essay on Mineralogy, or Distribution of 'Fossils' (1754); (5) Essays concerning the Canton of Berne (1754); (6) Letter on the Flooding of the Nile, and Use of the Mountains of Abyssinia (1754); (7) Letter on the Diminution of the Oceans, and the Origin of Mountains (1754). That last article was a strong reaction to the wild visions of the French diplomat Benoît de Maillet (1656–1738) whose *Telliamed: Or, Discourses Between an Indian Philosopher and a French Missionary, on the Diminution of the Sea, the Formation of the Earth, the Origin of Men and Animals, And other Curious Subjects, relating to Natural History and Philosophy* (1748; published posthumously and known, in manuscript form, for more than a decade; see Carozzi 1968) raised the spectres of a great age for the Earth, a dynamic record of sea-level change associated with

deposition of the world's strata, and transmutation of species.

This is not the place for an exhaustive analysis of Bertrand's many specific contributions within the *Recueil*. Rather, we will focus on just a few elements that highlight his vision of natural theology in action. In discussing the interior structure of the Earth, Bertrand introduced many ideas of recent and contemporary writers, but also called on the naturalist to use fieldwork to understand glaciers, caverns, mountains and the layers of the Earth. By mid-century he was quite scathing of 'system builders' and theorists who conjectured about the world without grounding their concepts in field-based reality. Whiston, Burnet and Woodward were particular targets for the sweep of their vision, which was seemingly unrelated to empirical fact (Bertrand 1766, pp. 57–64). Bertrand criticized Woodward by stating that his musings about the Earth being dissolved during the biblical Flood represented a hypothesis, 'well removed from the simplicity that nature follows, reason approves, and a Philosopher demands' (Bertrand 1766, p. 64). He went on to say that it was better to describe realities than attempt to build 'explanations' that are counter to nature. One can almost feel his facts-only 'accumulator' mentality at work.

Despite his own warnings about theorizing, Bertrand wanted to give his readers the full story of the Earth's interior structure, so he boldly reported on its three key elements: (1) the deep interior, which was regular and uniform, and which had been generated at the creation of the world; (2) the shallow surface layers of complexly related deposits of sand, marsh and sediment, which owed their origin to the biblical Flood; (3) the superficial and recent 'accidents' that included everything from figured stones to caverns. (See Rappaport (1982) for an in-depth commentary on the interpretation of 'accidents' in eighteenth-century natural history.) We cannot read Bertrand's mind, but it is evident that there were occasions when he took what might appear to be dichotomous stances, such as arguing for 'facts' but providing highly theoretical comments about the structure of the Earth, or when he demanded careful observation of nature, but used the biblical Flood to produce major results. This disconnect might strike many observers in the twenty-first century as problematical. Was Bertrand playing the role of empirical scientist one moment but retreating to miracles when it seemed necessary to invoke God's power? It is perhaps necessary to view him in his own time and his own place. He really was the servant of two masters: emerging modern science and his theological tradition of accepting God's occasional active involvement with the world.

It is also fascinating to see Bertrand struggle with the nature of fossils (in the modern palaeontological sense, not the eighteenth-century all-inclusive vision of anything dug from the Earth). In the text (Bertrand 1766, p. 74) he claimed that the organic-seeming features were just like all other rocks and were created by God in the very beginning. But then, in a footnote on the same page, he admitted that he had been wrong in his original 1752 essay, and that by 1766 he had realized that marine fossils were truly organic remains, many of which had lived in seas that post-dated the creation. The mid-eighteenth century can be seen as a dynamic era, and the honest scholar could find himself in the jaws of a dilemma as he tried to explain the natural world without refuting his long-held religious beliefs. One minute an author could wax eloquent about the amazing amount we knew about nature, and in the next moment he could throw up his hands and say (Bertrand 1766, p. 80) that true reasons explaining many phenomena were simply unknown and it was important to admit our ignorance in the face of God's infinitely complex world.

A prime example of divine power's operation in altering the planet's structure was the biblical Flood and its impact. Again, we see Bertrand struggle with his desire to provide answers for his reader, but back away from offering a single coherent theory that would explain everything. He could firmly state that the Flood was real and had the power to create many of the features we saw in the structure of the Earth. As examples, the work of violent erosion and large-scale deposition led to existing strata, and structural cataclysms related to foundering of the vaults of the Earth's interior could have produced the complex rock structures seen in mountains. However, he had to wonder at the source of the phenomenal amount of water and how the flood mechanisms actually operated. He concluded that searching for explanations was unnecessary because the visible effects were fundamentally due to the immediate action of God. Thus, secondary causes need not be of sole concern. Natural theologians had a powerful tool at their disposal and when rational explanations faced insurmountable difficulties, they could invoke a truly divine power. As we will see, that comforting concept would have its shortcomings in a more secular world. Bertrand may be an exemplar of the rear-guard of the authors struggling to combine observation and explanation of nature with the tradition of final causes.

Along with oceans, mountain ranges are among the largest and most striking major structures on the Earth's surface. They must, Bertrand felt, have been expressly designed by God to perform important tasks. Following in the footsteps of

John Ray, Bertrand proposed, in his 'Essay on the Usage of Mountains', a number of detailed reasons why our planet is graced by mountains. As noted above, the post-Darwinian cynic may snigger, but imagine the allure of comprehending the works of God and the operation of the natural world as you gaze on the majesty of mountains. Isn't it obvious that mountains supply natural beauty? They also affect climate, are the sources of springs and rivers, serve as 'skeletons' or backbones for the planet's surface, divide peoples and create natural boundaries, and are, of course, superb illustrators of God's design. Even the obvious inequalities in mountain height and nature are not due to blind causes, but are the work of a wise hand that guides providential results (Bertrand 1766, p. 107). The sky-scraping mountains of Asia and South America, as well as the low Appalachians of North America, were known quantities at the time, so their variations had to be considered. Well before Horace Bénédict de Saussure (1740–1799) climbed Mont Blanc (in 1787) and the Romantics dramatized alpine scenes, Bertrand was writing lyrically of the beauty of mountains and the potent messages they conveyed about the ability of properly interpreted nature to reveal divine beneficence. Even the bounty of wineries and the fine taste of highland game were due to the existence of just-right slopes. Such claims may strike the modern reader as overreaching, but Bertrand had a happy vision, and he wanted his readers to join him in the celebration. For example why are there huge holes in the ground? Because caverns give proportion to the heights of mountains and thus provide orbital stability for the globe. Again, we may recoil from such explanations, but Bertrand actually did go down into caverns and was forcefully struck by their combination of crystalline beauty and dark mystery. He proposed an empirical research programme for taking cavern and hot-spring temperatures worldwide. The more we know, the more we understand. He explained (Bertrand 1766, p. 201) to the reader that, 'If we transport a Savage from North America into a European palace, he will not know the purpose of things, but that is due to his ignorance, not lack of purpose (in the palace's design).' In an almost Leibnizian view of the best of all possible worlds, Bertrand claimed that all mountains formed at the same time, provided us with innumerable benefits, and were the designed product of a mandatory set of external and internal structures. Showing the depth of his desire to combine God's word and the world, he argued that 'the authority (of brilliant precursors) cannot convince me . . . and nothing can lead me away from what the Holy Scriptures teach me, which is always in accord with experience' (Bertrand 1766, p. 206).

Following the discussion of the usage of mountains, the *Recueil* presented 'Memoires historiques et physiques sur les tremblemens de terre'. An 'Avertissement' from the publisher made the point that earthquakes are terrible events and are obviously associated with the internal structure of our globe. Furthermore, he commented that Monsieur Bertrand was among Europe's most distinguished naturalists and that readers should therefore appreciate his insights regarding major Earth phenomena. Thus, Bertrand's cataloguing of noteworthy tremors throughout recorded history was a significant advance in the public's knowledge about earthquake activity. His account hearkened back to the Ancient Greeks and Romans, all of whom saw a God as first cause in the shaking of the earth. Pagans of the past were suspect, in Bertrand's theological view, but he applauded the fact that they saw the work of a deity as critical to understanding the world of nature. Equally suspect were excessively theoretical constructs that purported to explain complex realities, although Bertrand concluded that conjecture was occasionally helpful in illuminating a topic. He shared the view of his Swiss confrère and contemporary, Charles Bonnet (1720–1793), who commented, in his *Contemplation de la nature*, 'To entirely banish from physics the art of conjecture would reduce us to pure Observation; and to what would Observation serve if we couldn't draw out the least consequence?' (Bonnet 1764, p. xi).

Thus, Bertrand discussed the potential causes of Earth tremors: internal fire, winds, action of subterranean water, and volcanic activity. Experiments on volcanology, by Lémery, and on sulphurous vapours, by Flamsteed and Hales, were cited as relevant to understanding the violent Earth. Attracted to the potential for pyrites and sulphurous products to be a cause, Bertrand noted that the actual placing of such materials in specific zones was up to God. The keys to generating earthquakes were therefore (1) chemical action and (2) the resultant heat. Italy was prone to instability because of the richness of pyrite veins in that country, whereas Switzerland had so much surface and internal water that conflagrations were suppressed. As might be expected, Bertrand retreated somewhat from purely theoretical musings and stated that naturalists needed to describe every aspect of earthquakes in great detail. The great 1755 earthquake of Lisbon was cited as an example of a horrific event that none the less provided considerable helpful information about the nature of earthquake motions and the structural consequences of shaking edifices. Admitting that mere human beings were a long way from full understanding of why the Earth quakes, Bertrand went on to offer a valuable compendium of earthquakes through time. He reported that a

quake in AD 563 killed those who deserved to die; epidemics were associated with a tremor in 802; fountains turned red after an event in 1021; and shaking continued for 40 days after a violent quake in 1128. Counting on historical records to provide exact dates could be inexact, and gathering true observations of ancient events was, Bertrand acknowledged, a difficult proposition. Thus, he concentrated on analysing the well-documented Lisbon quake and tremors felt in Switzerland after 1755. His descriptions were detailed, but his aim was broad, in that he hoped to show that events operating on Earth scale could only be due to the power of God. Here was a topic worthy of natural theology. Bertrand presented eight 'Mémoires' focused on earthquakes. All of the authors cited and contentions laid out in the somewhat repetitive accounting need not concern us here, but the underlying reason for the depth of attention is evident. If human observation and description could illuminate the workings of God's most impressive actions, a new depth of scientific comprehension could be combined with rewarding insight into the laws and powers of divine design.

Similarly, it would be gratifying to understand those amazing 'figured stones' found in mountains and throughout the rock strata. They certainly resembled shells found in modern seas. Guettard (1759) had taken Bertrand to task for saying (pre-1766) that fossils found in the mountains could not be the same as those in the sea. In the view of Guettard (1759, p. 413), 'Why have recourse to the supreme and immediate will of God, when one can explain the effect by a closer cause?' Such criticisms had weight, and here we see Bertrand's willingness to change his mind and to yield to potent observations from nature. Contrary to his prior views, by the time of the *Recueil*, he admitted (Bertrand 1766, p. 74) that he had changed his mind and could no longer deny the organic nature of marine fossils. He went on to note that it was difficult to decide if they were deposited in the rock record after the Flood itself. However, he had no doubt about what the figured stones were saying: 'It is useful to generate catalogues of fossils in order to appreciate the beauty, excellence, and grandeur of these magnificent works of the Creator' (Bertrand 1766, p. 150).

In his 'Essai de minéralogie ou distribution méthodique des fossiles propres et accidentels', incorporated in the *Recueil*, Bertrand discussed classification, specifically noting his debt to Linnaeus. He commented on the difficulty of recognizing affinities between organisms, he defended the chain of being, claiming that it would be unbroken if only we knew enough about nature, and he presented previous theories regarding the distribution of fossils in rock strata. Modern readers not familiar

with eighteenth-century linguistic conventions might be surprised to find, in an essay on 'fossils', a classification scheme (Bertrand 1766, p. 389) for the inorganic products of the Earth. For Bertrand, 'fossils' included all materials found buried in the Earth's surface. Just as Linnaeus could classify organisms in the plant and animal kingdoms, the astute naturalist could subdivide the mineral kingdom. Thus, Bertrand's 'General Division of Fossils' listed: (1) earths; (2) salts; (3) bitumens and sulphurs; (4) rocks; (5) minerals and demi-metals; and (6) metals. Orderly relations could be seen within the mineral kingdom if only scholars could explore nature fully and recognize the underlying relationships that God had created. Evidence of God's providence was everywhere.

Order, in the form of a great chain of being, was evident in the organic realm. Louis Bourguet (1678–1742) had beautifully illustrated that chain in his *Traité des pétrifications* Bourguet (1742) (Fig. 4). He showed his readers a presumed 'fungus' (a 'sea-mushroom', although actually it appears to be a horn coral) as figure 1 in his plate 1. He then moved up the ladder of creation, through corals, clams, crinoids, ammonites and the known fossil invertebrates, until reaching the vertebrates. His final link in the chain (figure 441, in his plate 60) purported to illustrate a skeletal remnant of *Homo diluvii testis* ('Man, witness of the Deluge'). The impact of Bourguet's story is undercut by the fact that the specimen was subsequently shown by Georges Cuvier (1769–1832) to be a salamander skeleton. Despite attributions that today are seen as invalid, the potential for a reader to witness graphic evidence of the long parade of God's creatures, from fungi to hominids, had to be an exciting, stimulating and rewarding experience. Bertrand shared that feeling of excitement at seeing such obvious order in the organic realm. However, he was not blind to the mysteries of nature, nor to the problem of perceiving an oversimplified and diagrammatic chain. The facts that life has degrees of similarity across nomenclatural boundaries and displays shadings of classification were not lost on him. Some vegetation shows 'sensitivity' to external conditions, some animals grow much like plants, some animals seem to have roots and flowering elements, and the 'zoophytes' dwell in a twilight realm between animal and plant. In the final analysis, however, he had proclaimed in the *Dictionnaire* that 'Order is one of the great merits of a properly classified collection of natural history' (Bertrand 1763, p. xij), and he expressly endorsed the chain of being, as promulgated by Leibniz and Bourguet.

Moving from the cosmic to the local, Bertrand included materials in the *Recueil* that had a focus on Bern, Switzerland. The 'Essai de la minérographie, et de l'hydrographie du Canton de Berne'

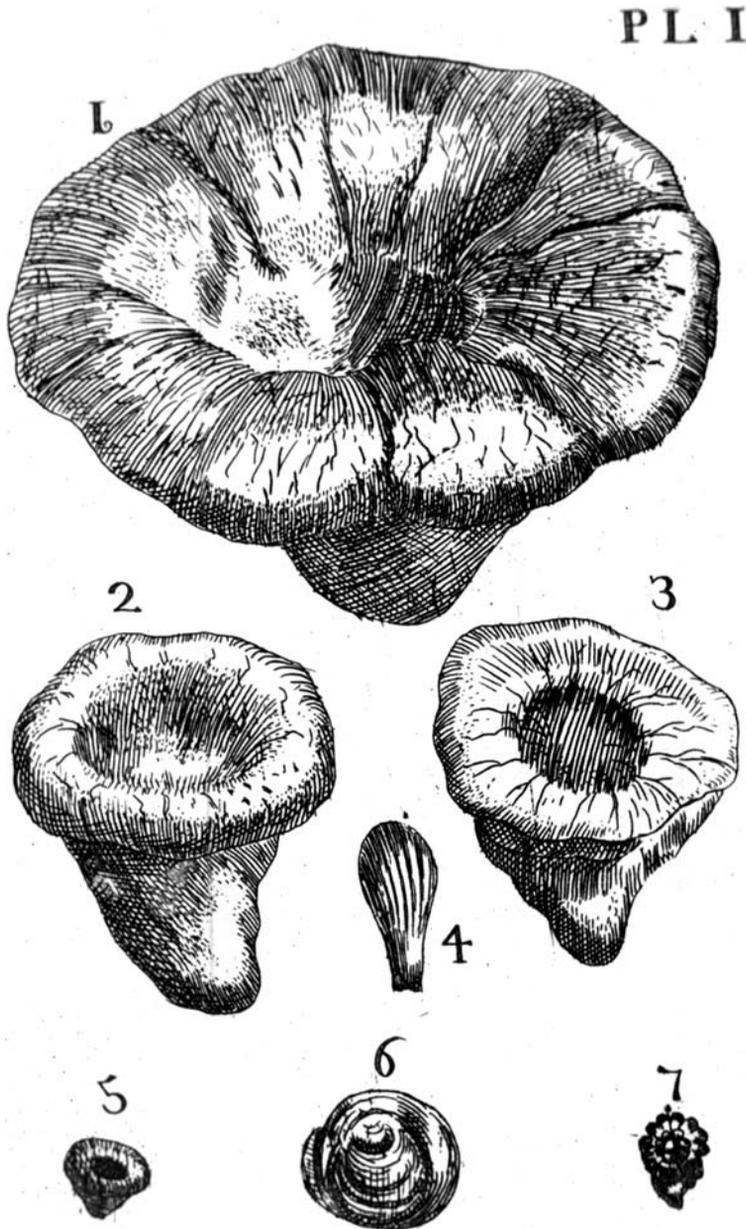


Fig. 4. The first and last figures from *Traité des pétrifications* (Bourguet 1742). From the author's personal copy of the book. (a) Figure 1 of plate I was said to be a 'sea mushroom' and (b) figure 441 of plate LX was a purported hominid (*Homo diluvii testis* or 'Man, witness of the Deluge').

and a 'Catalogue systématique des fossiles du Canton de Berne' gave the reader insight into Bertrand's application of his large-scale vision to the natural history of his home base. He bemoaned the lack of detailed knowledge about the region and the tendency of the Swiss to be dazzled by

the natural history of other countries, when their own area was so rich in earthly products. He also contrasted the interests of the physicist, desirous of finding abstract laws, with the naturalist, content to observe, classify and augment knowledge through experiences flooding into his own senses.

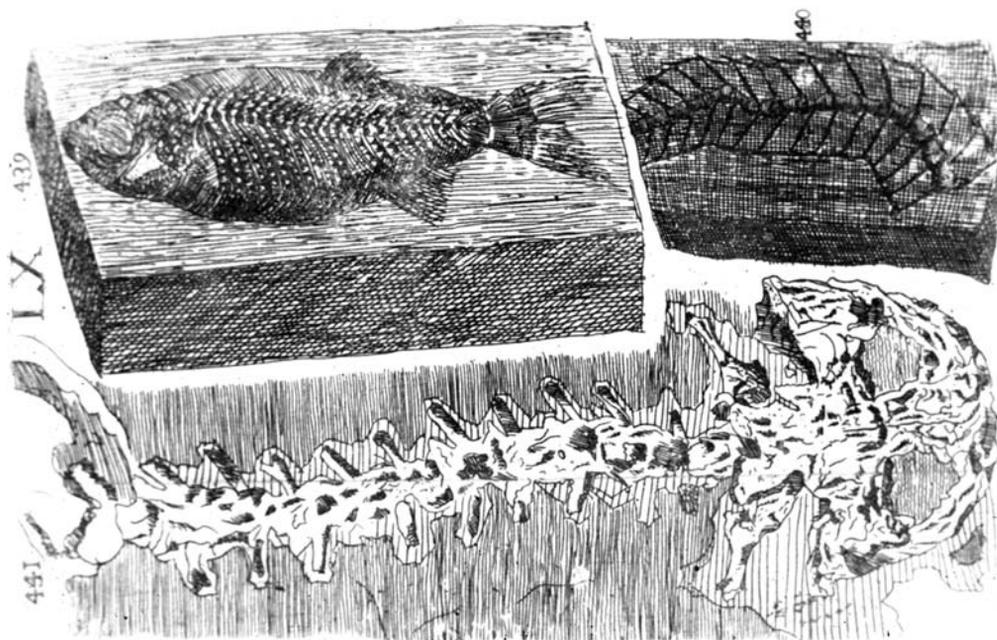


Fig. 4. (Continued).

If only the Swiss authorities would honour their local natural history the way the Swedes did, he lamented, Bern and the neighbouring cantons would be justly celebrated. The various fountains and mineral springs in the region around Bern received attention, as did the chemical composition of the surface and underground waters. Details aside, the key point was that all those sources of water served for the well-being of mankind. In discussing his own collection and catalogue of natural history specimens, Bertrand reported that rather than a scheme built on place names in alphabetical order, as was the case with some 'cabinets', he resorted to a systematic index based on genetic relationships. In a synopsis of his intellectual stance regarding natural theology, he noted: 'Insofar as nature is well studied, God will be better understood' (Bertrand 1766, p. 439).

The prime point of the 'Lettre sur les inondations du Nil, et l'usage des montagnes de L'Abissinie' was the familiar one that mountains exist for a reason. In this case the mountains served as a feeder system for the waters that end up in the Nile and were used to irrigate Egypt. Mountains slow the motion of clouds and cause precipitation; thus, the water accumulates and flows into fluvial systems. Bertrand recognized that it would be best to have a good map of the Nile before speaking of lead-in tributaries, but he considered all available versions to be lacking in veracity. The mountains of Abyssinia were thus seen as the providential bulwark that

caused clouds to generate the precipitation that fed the Nile.

The *Recueil* ended with Bertrand's 1754 letter to the Perpetual Secretary of the Royal Academy of Sciences and Belles-Lettres of Prussia. In his 'Lettre sur la diminution des mers, et l'origine des montagnes', he commended Monsieur Formey for countering the preposterous views expressed in Benoît de Maillet's outrageous book *Telliamed* (de Maillet 1748). Accepting the fact that the waters of the biblical Flood once covered the planet, Bertrand none the less ridiculed de Maillet for his calculations about the diminution of those waters. The absurdity of presuming to calculate such events aside, Bertrand was scandalized by the length of time required, given the rate suggested by de Maillet. Such notions would require 'time immemorial' (Bertrand 1766, p. 531) and would never fit into the Mosaic chronology. Moving on to the origin of mountains, Bertrand discussed the work of Johann Georg Sulzer (1720–1779) in a positive light. Sulzer disagreed with de Maillet's mechanisms, but spoke of a shifting in the centre of gravity of the Earth, a notion that Bertrand found unacceptable. More believable, in his view, were causes related to earthquakes or diluvial deposition. Bertrand could not conceive of major mountains being formed after the creation or after the biblical Flood. He called for recognition of the fact that Earth history was likely to be limited to three dominant stages: creation, the Flood, and recent

events. We must never, he contended, move away from the Mosaic chronology and the beautiful and providential design that God had given our planet.

The dream is not fulfilled

Alas, perfect design was not everywhere evident. The mission of the natural theologians did not succeed, and the illustrious career of Élie Bertrand was soon forgotten. What happened? In general terms, the paradigms shifted, the old visions were replaced, and the work of the describers was largely forgotten.

More specifically, there were 'internal' and 'external' problems associated with the alluring dream. (1) Internally, the power of the programme of the natural theologians suffered from their own bickering: everyone had the best and only theory. As Porter (1979, p. 107) put it, 'the anarchic cacophony of opinions deafened ears and invited satire'. Even Bertrand entered the fray, claiming (Bertrand 1766, p. 206) that Burnet, Moro and Buffon were brilliant men and had interesting theories, but were wrong for trying to create systems that were not predicated on the Bible. (2) By the middle of the eighteenth century, Enlightenment rationality and increasing secularism were not fully receptive to explanations having a solely religious basis. (3) It might also be noted that the *philosophes* of France were moving toward a more secular view of the world, and the visions of a Francophone Swiss pastor and natural theologian were losing their attraction. The deep motivation to see the world as a product of final causes, whether in Aristotelian terms or in the context of an active God benefiting humankind, was being replaced by an increasingly empirical stance. (4) Thus, there was an aversion to theoretical constructs that lacked any potential for empirical testing. On epistemological grounds, non-testable theories were not in line with Baconian science. (5) There was also the problem of too many data. In an era of collecting, describing and cataloguing, the number of disparate 'facts' overwhelmed any single coherent theory. Voltaire could wax satirical in *Candide* about mid-century 'explanations' for the cause of earthquakes, because there was no easy way to explain the huge amount of data and specific facts. (6) Particularly suspect were those theories that depended upon the action of an intervening God for their operation. As Laplace (1749–1827) has been quoted as saying, there was 'No need for THAT hypothesis' (De Morgan 1915). The evolution from God-driven to secular science echoes the point made by Barton (2007) that God was a critical element of natural theology and natural philosophy in the late seventeenth and much of the eighteenth century, but by the nineteenth

century God was largely excluded from explanations, and the worldview gave way to natural science. It was an era in which 'geology was self-consciously created as a new kind of natural science' (Morrell, 2006, p. 614). (7) 'Externally', of course, there was the mid-nineteenth-century issue of Darwin and the demise of design. Once the world was seen as the product of natural selection and mechanistic chance, the edifice build on design foundered. Bertrand had already noted that disturbing potential, writing that, 'To attribute the formation, direction, or governance . . . to blind principles is to show that one is studying nature in a very superficial way and that one his little knowledge of the Divinity' (Bertrand 1766, p. 161).

However, by the time of Bertrand's death, change of organic form through time, and extinction of entire faunas, were well documented. Such realities hinted at an uncertain or incompetent designer. We may, of course, still see vestiges of design theory in the musings of some writers in the twenty-first century, but not from the central figures in establishment science. Sepkoski (2006) has presented an informative review of contemporary books treating the debate between advocates of evolutionary theory and those believing in intelligent design or some form of creationism. In sum, as far as the natural theologians of over two centuries ago are concerned, their beautiful aspiration of a cosmic synergism of scripture and science did not survive the Darwinian revolution.

On the individual level, Élie Bertrand's legacy dimmed because he was an 'accumulator' rather than a 'paradigm shifter'. His work as an observer, describer and popularizer was respected in his own time, but it did not have the innovative power to survive in the coming decades and centuries. At a time of spectacular illustrations, as in the *Encyclopédie* of Diderot and d'Alembert, his non-pictorial works suffered by comparison. More substantively, he could not 'deliver' on the promise of providing a gratifying synthesis of God's word and nature's record. As was the case with natural theology in general, his contributions to the evolving geosciences were helpful and catalytic when first proposed, but did not provide anything of value for the era of provocative and productive concepts that would stem from the Darwinian revolution. By the late eighteenth century, attempts to explain nature in the context of providential or anthropocentric notions related to divine purpose were losing their lustre and relevance. The exciting prospect of marrying the word and the world was becoming passé. Monsieur Élie Bertrand and his valiant efforts sank from view.

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