

Natural History of Fossils Until Cuvier

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퀴비에까지의 化石의 自然史

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요 약

자연의 '역사성', 즉 시간의 흐름 및 이에 따른 변화상에 대한 인식은 18세기말 경부터 化石의 정체와 화석이 지닌 이 '역사성'에 대한 논의가 활발해지면서 여러 학자들의 의식 속에 구체적으로 자리잡히기 시작했다. 그 이전까지는 化石은 일반적으로 다른 암석 및 광물류와 함께 그저 '땅 속에서 파 내어진 것들' 중의 일부로 언급되어 왔으며 그 근원 및 생성과정에 대한 납득할 만한 설명은 매우 어려운 일이었다. 미셸 푸코는, 化石 속에 담겨져 있던 '시간'이라는, 당시로서는 未分化된 덩어리 같은 존재로부터 현대 서구 사회가 가지고 있는 '역사성'을 인화해 낸 것이 조르주 퀴비에였다고 지적하고 있으며, 퀴비에의 이 化石을 통한 '역사성'의 인식이 그의 동물에 대한 해부학적 지식과 통찰력에 의해 가능했다는 이야기는 일반적으로 받아들여지고 있는 사실이다. 그러나 퀴비에 홀로, 마치 박물관의 어떤 그릇 속에 담겨져 있던 동물의 형태 속에 해부학적 기능과 함께 숨겨져 있던 化石에 담긴 '역사성'을, 그 그릇을 깨뜨리고 꺼내듯이 표현한 푸코의 이야기는 化石에 대한 自然史의 관점에서, 그리고 생물의 형태와 기능에 대한 관점에서도 역시 지나친 단순화임에 틀림이 없다. 이 논문은 18세기 초부터 퀴비에에 이르는 化石에 대한 주요 연구 내용을 프랑스 학제를 중심으로 소개함을 주요 내용으로 하며, 이어 퀴비에에 대한 푸코의 해석을 여러 각도에서 다시 살펴봄으로써 化石에 대한 自然史의 다양하고 종합적인 성격을 진술해 보이려는 시도이다.

From the end of the eighteenth century, fossils became to be recognized as an important tool for the investigation of the "history" of nature. In the writings of Barthélemy Faujas de Saint-Fond (1741—1819), Jean Baptiste Pierre Antoine de Monet de Lamarck (1744—1829), and Georges Cuvier (1769—1832), the importance of fossils for the interpretation of the past of the earth was repeatedly argued, and it also reflected their recognition about the origin and meaning of fossils themselves. According to Michel Foucault, it was Cuvier who decisively revealed the historicity in fossils, and led people into the search of the history of nature hidden in fossils through his incisive anatomical knowledge on animals.¹⁾ But Foucault's expression of Cuvier's

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1) Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York, Vintage Books, 1973), pp. 137—138.

achievement as being like breaking jars, in which the "historicity" of nature had been hidden as a form of the invisible functional dimension of the animal, is rather misleading. This paper aims to describe some aspects of the eighteenth-century French natural historians' notions and researches about fossils through my brief reading on some of the representative writings of fossils. Monographical writings by Antoine de Jussieu (1686—1758), René-Antoine Ferchault de Réaumur (1683—1758), Pierre-Augustine Boissier de Sauvages (1710—1795), Jean-Etienne Guettard (1715—1786), Faujas, and Lamarck will be briefly introduced, and some rather anachronistic notes on Cuvier's achievement will be added.

1. The Natural History of Fossils from Jussieu to Cuvier

Jussieu and Réaumur were the representative writers on fossils during the early eighteenth century in France. Both of them were members of the Royal Academy of Sciences in Paris, and they also shared the characteristic skepticism and logical rigor with ardent empiricism, which were quite common to the members of the Royal Academy of Sciences in Paris.²⁾ Jussieu and Réaumur tried to glorify the Frenchman Bernard Palissy (1510—1590) as a man who had begun the investigation of fossils already long ago, but the most significantly referred-to natural historian by Jussieu and Réaumur was the Englishman John Woodward (1665—1728). Woodward has been mainly remembered and frequently cited as the author of his theory-oriented book, *An Essay Toward a Natural History of the Earth...* (1695), in which he explains the organic origin of the fossiliferous sediments through the Universal Flood,³⁾ but what was the most impressive for Jussieu and Réaumur was not Woodward's theory of the earth but his field-based methodology and collections. Still, the influence of Woodward's theory is evident, and Jussieu's explanation of the formation of the plant impressions on stone reflects the influence of Woodward's theoretically-oriented explanation on the horizontal layers of the fossiliferous strata by the result of specific gravity. For Jussieu, it was a surprising singularity that each of the internal surface of the two lime plates of a stone represented only one face of the leaves. One plate had the leaves' relief, and the other had the leaves' hollow mold.⁴⁾ Why both sides of the lime(silt) plates have the impression of same face of the leaves? The leaves floated from remote areas would have sunken when they were imbued by bituminous lime. After the other limes covered them, the leaves would be corrupted and be taken away. Then, the upper lime would have been precipitated upon the lower lime so that the upper lime conserved the same print of the mold of the lower lime. This supposition also provided the reason why only the coal mine areas were

2) The influence of René Descartes (1596—1650) and Bernard le Bovier de Fontenelle (1657—1757) was evident. See Kennard B. Bork, "Cross-channel currents: eighteenth century French-language responses to British theories of the earth," *Histoire et nature* 19—20 (1981—1982), p. 44.

3) John Woodward, *An Essay Toward a Natural History of the Earth: And Terrestrial Bodies, Especially Minerals: as also of the Sea, Rivers, and Springs. With an account of the Universal Deluge: and of the Effects that it had upon the Earth* (London: Printed for Ric. Wilkin at the Kings-Head in St Paul's Church-yard, 1695).

4) Antoine de Jussieu, "Examen des causes des impressions des plantes marquées sur certaines pierres des environs de Saint-Chaumont dans le Lyonnais," *Mémoires de l'Académie Royale des Sciences* 1718 (1741), pp. 291—294.

well preserving the impressions of plants although lots of leaves from the same remote places would have transported to the other areas, and through this reasoning, it became unnecessary to mention sports or caprices of nature to explain the cause of the impressions on the figured stones.⁵⁾ Indeed, Woodward was the most influential British natural historian for the Continental natural historians on fossils during the entire eighteenth century,⁶⁾ probably because he was neither a naive theorist of the earth nor a mere collector. As Woodward argued, however skeptical and however empirically oriented French academicians were, they had to acknowledge that reasoning beyond mere observation is important for the natural history.⁷⁾ The fame of Réaumur was mostly from his works on insects and technological problems, but concerning fossils, he left a good monograph on a huge mass of fossil shells in *Touraine*. The mass was several meters in thickness, and consisted of pure fossil shells without other materials like earth or rocks. This mass was located 36 leagues from the seashore of today, and a General Deluge could have passed this distance easily. But whether the Deluge lasted long enough to accumulate layers of shells 20 feet in thickness is doubtful. Thus he reasoned that this place might be immersed in water for a long time, and a General Deluge could not explain the formation of the shell mass of *Touraine*.⁸⁾ But Réaumur was very prudent in his further reasoning. He found that there were many possible alternative explanations for the formation of shell mass in *Touraine*, and there seemed to be no reason why someone should prefer a certain explanation to any other. Thus he retreated from the effort to provide the explanation of the origination of the shell mass in *Touraine*.⁹⁾ Interestingly enough, Réaumur's hesitation to provide the explanatory cause for the formation of shell mass in *Touraine* may be closely related to, and fit into, his "actualistic" attitude. According to Ellenberger, Réaumur's actualistic attitude "towards a kind of geological agnosticism" was to be bequeathed to Guettard.¹⁰⁾

During the mid-eighteenth century, writings on fossils became more voluminous and extensive. Writings of Sauvages, consisting of a series of three articles with more than 100 pages, was an unprecedented geological treatise which dealt with ten chains of hills, and contained deliberate expressions of the concept of the various rise and distortion of the earth with different intensity.¹¹⁾

5) *Ibid.* pp.294—296.

6) Bork, *op. cit.* p.40.

7) John Woodward, *An Attempt toward a Natural History of the Fossils of England; in a Catalogue of the English Fossils in the Collection of J. Woodward, M.D. Containing a Description and Historical Account of Each; with Observations and Experiments, made in order to Discover, as Well the Origin and Nature of Them, as their Medical, Mechanical, and other Uses*, 2 vols (London: F. Fayram, J. Senex, and J. Osborn and T. Longman, 1729), II : xii-xiv.

8) René-Antoine Ferchault de Réaumur, "Remarques sur les Coquilles Fossiles de quelques cantons de la Touraine, & sur les utilites qu'on en tire" *Mémoires de l'Académie Royale des Sciences* 1720(1722). pp.405—411.

9) *Ibid.* pp.411, 416.

10) François Ellenberger, "Théories géodynamiques en France au XVIII siècle," *Revue d'histoire des sciences* 33 (1980), pp.38—39.

11) Pierre-Augustine Boissier de Sauvages (l'Abbé de Sauvages), "Mémoire sur différentes pétrifications tirées des animaux et des végétaux", *Mémoires de l'Académie Royale des Sciences* 1743 (1746), pp. 407—418; Sauvages, "Mémoire contenant des observations de lithologie, pour servir à l'Histoire Naturelle du Languedoc, & à la théorie de la Terre," *Mémoires*. 1746 (1751), pp.713—758; Sauvages, "Suite du mémoire contenant des observations...", *Mémoires*. 1747 (1752), pp.699—743.

Around his home country Alais, Sauvages found a vein of earth, which extended to several leagues with its same kinds of gravel and ocher continuous despite its interruption by the cutting of the streams, rivers, and hills. Sauvages found a rich inventory of the "petrifications" in several parts of this vein, and through the observation of them, he became to be convinced that the fossils and minerals are found in groupings accompanying specific sorts of earth.¹²⁾ It can be safely said that his writings are full of stratigraphical expressions.¹³⁾ Upheavals were more violent in some places than others, but often the earth turned and disturbed can be seen through the interpretation of the relative position of the shells of the ancient sea beds and those deposited long time after then.¹⁴⁾ In the same area, Sauvages found a petrified wood, *lithoxylon* which was the trunk of a tree, one and half feet in width and little bit less in height. At first he thought it as a real wood because the color and fibers looked so real. But the original wooden matter was completely replaced by stony matter, and this tree-trunk stone was heavier than the ordinary stone with similar volume. Still this stone wood retained the traces of worm holes and of rotting appearances through which he could think about the conditions of the tree when it became to be petrified.¹⁵⁾ What was the most remarkable to Sauvages was the fact that the petrified trunk was intersected horizontally or obliquely by some veins of white flint-stony materials which were very thin. They intruded the whole thickness of the trunk so that they actually cut the trunk into several parts. The materials around the white veins were, rather more fragile than other parts. Petrification seemed to happen in the coal surroundings in which salts, sulphurs, and bitumens were abundant, but Sauvages could not explain the white flintstony vein infiltrating the petrification. What agent push those materials into such a hard matrix of stone wood? For Sauvages, it could not but be a "mystery of nature" which he "would not dare to undertake to explain."¹⁶⁾

While Sauvages' series of articles were prepared mainly from the geological perspective, and dealt with all sorts of fossils he encountered during his geological research, Guettard's three articles published in the *Mémoires* of the Royal Academy of Sciences in Paris were mainly on fossils themselves, especially on the fossil shells.¹⁷⁾ According to Ellenberger, Guettard's style of studying fossil organisms—gathering big collections with the description of their location, exact description of the kinds of fossils, and the criticisms on terminology—formed the model for the later fossil research.¹⁸⁾ He found that some fossil shells had been attached to other shells, some had been bored by other animals, and some had worn shell crusts. Those features seemed to him so similar to the feature of the living shells, he concluded that the accidents which had affected the fossil shells must be the same kinds with the happenings which were affecting the living

12) Sauvages, 1743 (1746), pp. 407—408.

13) Ellenberger, *op. cit.*, pp. 54—55.

14) Sauvages, 1747 (1752), p. 741.

15) Sauvages, 1743 (1746), p. 412.

16) *Ibid.* pp. 413—414.

17) Jean-Ftienne Guettard, "Mémoire sur les accidens des coquilles fossiles, comparés à ceux qui arrivent aux coquilles qu'on trouve maintenant dans la mer," *Mémoires de l'Académie Royale des Sciences* 1759 (1765), pp. 189—225, 329—356, 399—419.

18) François Ellenberger, "Esquisse d'une trajectoire de la géologie francophone jusqu'en 1832," *Histoire et nature* 1920 (1981—1982), p. 14.

shells.¹⁹⁾ But as was Réaumur, Guettard also was very cautious not to make premature generalizations, and with his several-page-long quotations and frequent references from various writings, Guettard's work looked similar to some other kinds of works that flourished during the mid-eighteenth century—the collection cabinet records, illustrated books, and the encyclopedic works on fossils.²⁰⁾ Thus, Rhoda Rappaport appraised Guettard as a “fact-gatherer of inexhaustible energy,” and continued to mention about Guettard that “the talent he most conspicuously lacked was that of genralization.”²¹⁾ But according to Marguerite Carozzi, Guettard was well aware of the lack of knowledge in comparative anatomy and other subjects which were necessary for the further reasoning about fossil-related questions including the origin of fossils.²²⁾

In 1799, Faujas published his work on the study of fossils, the *Natural History of the Mountain of Saint-Pierre in Maestricht*.²³⁾ In this local monograph, he dealt with a variety of fossils excavated from the Maestricht area, in which fossils from chalk series of the uppermost stage of the Cretaceous formation were contained.²⁴⁾ In the “Preliminary Discourse” of this work (pp. 1–36), he deplored the fact that natural history showed little advance in spite of the accumulation of vast data and material, and argued that natural history should be more an exact science, a science of fact founded on rigorous demonstration.²⁵⁾ In spite of his ardent advocacy, his monograph was by no means “exact and positive,” but his arguments were often incisive and seminal. Faujas' writing on fossils of Maestricht was much more extensive and voluminous comparing with the works of Jussieu, Réaumur, Sauvages, and Guettard, and this work was exclusively on fossils themselves. Furthermore, in this monograph, Faujas definitely considered fossils as kinds of living organisms which would have had certain organic function and form, and in this respect, he acknowledged his indebtedness to comparative anatomists, especially to Peter Camper (1722–1789) and Félix Vicq-d'Azir (1748–1794).²⁶⁾ Faujas claimed the necessity of awareness of the all kinds of other natural historical fields for the proper study of certain field of natural history. Thus he advised other natural historians not to attach themselves to the isolated facts nor to stick to a one-sided manner of presentation.²⁷⁾ As other natural historians after him, Faujas

19) See the title of his articles in note 17: “Memoire on the Accidents of Fossil Shells Compared with Those which Happen to Shells now Found in the Sea.”

20) Typical works are as follows: L. Bourguet, *Traité des petrifications avec figures* (Paris, 1742); A.J. Dezallier d'Argenville, *L'Histoire naturelle éclaircie dans une de ses parties principales, l'oryctologie, qui traite des pierres, des métaux, des minéraux et autres fossiles*, 4 vols (Paris, 1755); E. Bertrand, *Dictionnaire universel des des fossiles propres, et des fossiles accidentels* (Avignon, 1763).

21) Rhoda Rappaport, “The Geological Atlas of Guettard, Lavoisier, and Monnet: Conflicting Views of the Nature of Geology,” *Toward a History of Geology*, ed. Cecil J. Schneer (Cambridge, and London: The MIT Press, 1969), p. 277.

22) Marguerite Carozzi, *Voltaire's Attitude Toward Geology* (Geneva: Société de Physique et d'Histoire Naturelle, 1983), p. 54.

23) Barthélemy Faujas de Saint-Fond, *Histoire naturelle de la montagne de Saint-Pierre de Maestricht* (Paris: H.J. Jansen, 1799), 253 pages.

24) Modern interpretation from Karl Alfred von Zittel, *History of Geology and Palaeontology To the End of the Nineteenth Century*, trans. Maria M. Ogilvie-Gordon (London: Walter Scott, Paternoster Square, 1901), p. 107.

25) Faujas de Saint-Fond, *op. cit.*, p. 15.

26) *Ibid.*, p. 17.

27) *Ibid.*, pp. 114–115.

was in a different situation from the other writers on fossils before him, those of mid-eighteenth century. Faujas was well provided with the new knowledge of comparative anatomy and systematic taxonomy. He had much more to write about than the earlier writers on fossils because the more fossils and the "other fields of natural history" were available for him, and he wrote exclusively on fossils themselves because he had a clear concept of fossils as the remains of living beings rather than simple "things dug up."

Lamarck was most articulate generalizer on the questions about fossils. In the appendix about fossils in his *System of the Invertebrate Animals...*²⁸⁾ he defined fossil as "the remain of living bodies, changed by their long sojourn in the earth or beneath the waters, but whose form and organization are still recognizable."²⁹⁾ The most usual types of fossils are those in which the animal portions—gelatinous or membranous parts are destroyed, and only the calcareous parts remain. Some fossils are not only robbed of their animal parts, but have also had their calcareous substance turned into silicious matter.³⁰⁾ His arguments on fossils came to be incorporated into the grand theory on the surface of the earth, which appeared in his *Hydrogeology...*, published in 1802.³¹⁾ A sound physics of the earth should deal with all of the important aspects of the earth's atmosphere, the characteristics and changing phases of the earth's external crust, and of the origin and development of living beings. Lamarck called these studies Meteorology, Hydrogeology, and Biology respectively.³²⁾ He was so deeply preoccupied by the importance of the living organisms in the constitutions of the earth's crust that he even tried to explain the origins of the most isolated deposits of minerals and stones as the results of the decompositions and modifications of the plants and animals.³³⁾ Careless persons interpreted the scattered fossils as the result of deluge. Some others deployed the convenient Universal Catastrophe for the explanation of the fossil remains. But the presence of fossils could be explained "through the actions of less extraordinary and much more natural factors" avoiding "unsupported hypotheses."³⁴⁾ All things in the earth are continuously and inevitably changed at different rates according to their situations, and the ocean basins also underwent inappreciable, slow displacements.³⁵⁾ If some dry lands were to be displaced into the sea bottom, and if they later came again to be dry lands, these places should have been shorelines twice, and the presence of littoral fossils would be the proof of the existence of the seashores. The presence of pelagic fossils in certain locations could be interpreted as the

28) J.B. Lamarck, *Système des animaux sans vertèbres ou tableau général des classes, des ordres et des genres de les animaux...* (Paris: Deterville, 1801).

29) Lamarck, p.403, quoted from D. R. Newth, "Lamarck in 1800: A Lecture on the Invertebrate Animals and a Note on Fossils Taken from the *Système des animaux sans vertèbres* by J.B. Lamarck," *Annals of Science* 8 (1952), p. 251.

30) Lamarck, *Ibid.*, pp. 404—405.

31) J.B. Lamarck, *Hydrogéologie ou recherches...* (Paris: l'auteur, 1802). Hereafter references are from the text trans. Albert V. Carozzi, *Hydrogeology, or investigations of the Effects of Running Water on the Surface of the Earth, of the Reasons for the Existence of an Ocean Basin and its Gradual Displacement over Various Parts of the Earth's Surface, and Finally, of the Influence of Living Organisms on That Surface* (Urbana: University of Illinois Press, 1964).

32) *Hydrogeology*, p. 18.

33) *Ibid.*, pp. 78—125.

34) *Ibid.*, pp. 59—61.

35) *Ibid.*, pp. 61—62.

evidence of a former sea bottom, but in fact we do not know much about the living organisms of the deep seas. So, for Lamarck, it seemed not reasonable to decide on the question of the extinction of those pelagic fossils before further research on the deep sea organisms.³⁶⁾ If catastrophe means “nothing but an upheaval jumbling and confusing everything,” it could not form the isolated fossil deposits in various countries.³⁷⁾ The most abundant shells are those of the littoral animals. If fossils were the result of complete flooding, all those littoral animals would have been drowned.³⁸⁾ Lamarck was willing to accept the concept of catastrophe as “partial or local upheavals” caused by geographically restricted agents like earthquakes, volcanic eruptions, or local floods. These catastrophes could be accepted as reasonable because his contemporaries were actually observing them, or at least they could perceive them as possible.³⁹⁾ For reasonable explanation for the above-mentioned fossil phenomena, especially for their enormous accumulations, enormous time was also required. “How ridiculously small the ideas of those who consider the earth’s age to be 6,000 odd years!”⁴⁰⁾

In his “Preliminary Discourse,” in the *Researches on the Fossil Bones of the Quadrupeds*, Georges Cuvier addressed that his purpose of using fossils in that Discourse was to study the history of the earth, especially, to prove “the nature of the revolutions of the globe.”⁴¹⁾ He knew that his works provided a new perspective for the domain of natural history. He was expecting the appearance of a “Newton” in natural history.⁴²⁾ Whether certain animals and plants were peculiar to certain layers, and whether there were some orders in the appearances of various fossils, had not been properly studied. “Cabinet naturalists” had paid little attention to the structure of mountains, and the “mere mineralogists” had not studied the varieties of animals and the complication of their parts sufficiently.⁴³⁾ Not all kinds of fossil were equally useful for the study of the history of the earth. Comparing shells, quadrupeds were more proper instrument for the precise research because the effects of the violent change in environments would be better preserved in the records of quadruped fossils. Marine animals suffered less by the violent change of the surface of the earth, and they were too numerous in kinds to determine whether their fossil forms were then lost or not.⁴⁴⁾ But quadruped fossils were not an easy instrument to use. Quadruped skeleton had been scarcely found intact. The layers contained only separate bones which had been scattered, broken, and fragmented. But when properly developed, comparative anatomy could enable us to surmount this difficulty. Every organized being forms a whole, the

36) *Ibid.*, p. 64.

37) *Ibid.*, p. 67.

38) *Ibid.* p. 68.

39) *Ibid.*, p. 72.

40) *Ibid.*, p. 75.

41) Georges Cuvier, *Recherches sur les ossements fossiles de quadrupèdes, ou l'on rétablit les caractères de plusieurs espèces d'animaux que les révolutions du globe paroissent avoir détruites*, 4 vols, vol 1 (Paris: Chez Deterville, 1812), separately paginated under the title of “Discours préliminaire,” p. 35.

42) Georges Cuvier, “Discours préliminaire,” trans. in his *Essay on the Theory of the Earth: With Geological Illustrations by Professor Jameson*, 5th ed. (Edinburgh: William Blackwood; London: T. Cadell, Strand, 1827), p. 5. (Hereafter cited as Cuvier).

43) *Ibid.*, pp. 47–49.

44) *Ibid.*, pp. 53–56.

parts of which mutually fit to function harmoniously. Change of some parts could not be possible without changing the other parts,⁴⁵⁾ and the print of a cloven foot demonstrated that the print was the remain of one of the rudiments. This print also suggested the specific forms of the teeth, of the jaws, of the vertebrae, leg bones and others, and this functional relationship between parts of body was "quite as certain as" theories in physics.⁴⁶⁾ The most solid achievement relating to the history of the earth in Cuvier's Preliminary Discourse was his research on the specific fossil animals with the layers in which the fossils were found, and it was decisively helped by his anatomical erudition. Cuvier pointed out that the oviparous quadrupeds were more abundant in the old layers, and appeared earlier than the viviparous.⁴⁷⁾ The enormous crocodiles and the tortoises were found in the Chalk Formation (layers in modern Jurassic Period), but there were no mammalian fossils in this layer. In the Coarse Shelly Limestone in the vicinity of Paris (layers in modern Cretaceous Period), marine mammals like seals appeared, but still there were no traces of bones of terrestrial mammals. Abundant land-animal bones were found in the deposits which rest upon the Coarse Limestone (layers in modern Tertiary Period), and this Coarse Limestone layer which provided Paris with its main construction material was the "last formed stratum which indicate a long and quiet continuance of the sea" upon the European continent.⁴⁸⁾ During his investigation, Cuvier did not value the system or hypothesis highly. Systems are just like abridged dictionaries (*lexiques*), and simply the means but not to be a goal.⁴⁹⁾ Furthermore, he did not accept the validity of the obscure metaphysics which were following Platonic method, the method which were "enveloped by poetic metaphors."⁵⁰⁾ Accordingly, although Cuvier acknowledged the striking analogy between the antennae of the insects and the nasal holes of the fish as the organs for smelling, he declined to go further to find some "chain of being" or phylogenetic relationship from this analogy. He believed that the aquatic animals had been created for the water, and the others for the air. Any phylogenetic argument which suggested that "some are the branches or the roots, or even the parts of a same trunk" sounded like metaphysics, and was not intelligible for him.⁵¹⁾ Thus, when Cuvier boasted of the predictability of his comparative anatomy, he addressed the "principle" of comparative anatomy which could enable him to surmount all the obstacles,⁵²⁾ but this anatomical principle never was about the "deductive laws of organic structure."⁵³⁾ In fact, a single tooth can not tell a paleontologist about the length of the legs nor the number of teeth the jaw held. A paleontologist knows certain teeth as a rhinoceros' because he knows that peculiar form has never been found but in rhinoceros.⁵⁴⁾

45) *Ibid.*, pp. 83-84.

46) *Ibid.*, p. 90.

47) *Ibid.*, p. 95.

48) *Ibid.*, pp. 96-98.

49) Georges Cuvier, *Lettres de Georges à C.M. Pfaff sur l'histoire naturelle, la politique et la littérature*, 1788-1792, trans. from Germany by Louis Marchant (Paris: Librairie victor masson, 1858), p. 72.

50) *Ibid.*, p. 270.

51) *Ibid.*, p. 270.

52) Cuvier, *Essays*, p. 83.

53) Stephen J. Gould, "The Stinkstone of Oeningen," *Natural History* 91-6 (June, 1982), p. 12.

54) *Ibid.*, p. 12.

2. Some retrospects on Cuvier's achievement

Opposing Cuvierian over-dependence on the quadruped fossils, Faujas claimed the importance of fossil shells for an adequate research of the history of nature because shell fossils are much more abundant, widely distributed, and found in many kinds of layers in the earth.⁵⁵⁾ For Cuvier, quadruped fossils were a more important and convenient instrument because the violent environments would be more conspicuously preserved in them, and thus they decisively showed the evidence of the extinction of certain species.⁵⁶⁾ But the determination of the species is elusive business, and the identification of fossil organisms must be even more artificial than that of the living beings. Important key for the identification of species was comparative anatomy, and comparative anatomy could have many criteria for the purpose of its deployment in the identification of species. One of the criteria is a functional aspect which is based on the importance of the parts of organs as device for survival. Another is a formal aspect which is about the identification of the anatomical elements by spatial relations. Cuvier put forward the functional aspect of the comparative anatomy,⁵⁷⁾ while Faujas rarely mentioned the functional point of view. In his argument about the similarity between the bones of crocodiles of Africa, Asia, and the bone of the Maestricht animal, Faujas just put three kinds of bones in one plate in order to show the differences and similarities among those three "same kinds of animal in a glance."⁵⁸⁾ It sounds naive, even innocent, but it means that the illustrations of the three kinds of bones show "formal similarity" although the bone of African crocodile looks thicker and stronger.⁵⁹⁾ There could be no definite consensus on the relative importance between these functional and formal aspects of the anatomical arguments.⁶⁰⁾ Although the jaw bone of the Maestricht animal provided Cuvier with evidence of the existence of a lost species, Faujas was still able to stick to the similarity between the fossil bone and the bones of the crocodiles now living. Fossil bones could be interpreted differently here, and the role of comparative anatomy for Cuvier could be that of a rather artificial tool which was useful for fitting into his own kind of "system," the fixity and unity of organic type and the extinction of species.⁶¹⁾ Furthermore, for Faujas and Lamarck, even the anatomical difference between fossil and living quadrupeds itself could be interpreted as the

55) Faujas, pp. 18, 28.

56) Cuvier, *Essays*, pp. 53–56.

57) W.R. Albury, and D.R. Oldroyd, "From Renaissance Mineral Studies to Historical Geology, in the Light of Michel Foucault's *The Order of Things*," *British Journal for the History of Science* 10 (1977), pp. 202–203. For the functional argument by Cuvier, see Cuvier, pp. 83–84, 90–91.

58) Faujas, *op. cit.*, p. 241. While Faujas was identifying this bone as crocodile, Camper had identified it as a kind of cetacea, and later Cuvier argued that this bone should be identified as a new kind of animal which has no living analogs.

59) See Faujas plate between pp. 240–241.

60) In retrospect, both of functional or formal aspects(analogous) of organisms became to be recognized as less important than the developmental aspect from basic plan(homologous) of organisms in systematics. See the argument between Cuvier and E. Geoffroy Saint-Hilaire in Albury and Oldroyd, pp. 202–203.

61) Very similar argument is in Michel Foucault, "La situation de Cuvier de la biologie," *Revue d'histoire des sciences* 23(1970), p. 69.

evidence of organic mutability rather than that of the extinction of fossil species.⁶²⁾

Faujas repeatedly argued the importance of fossil shells for the study of geology, and accordingly, for the study of the "history" of nature. He also felt that the fossil shells were not properly understood by his contemporaries in general, and opposed some naturalists' argument that all fossil shells were different from the shells then alive, and tried to expand the list of his living fossil analogs as much as possible.⁶³⁾ *Trigonia* was one of the cases. Until the living *Trigonia* was found in 1802, this shell had been known only as a fossil. Being found, this living shell was immediately named and listed as a living analog of fossil shell by Lamarck, but the appearance of living *Trigonia* did not render decisive triumph for the argument for Lamarck's species mutability nor could it provide Faujas the evidence of general paucity of species extinction.⁶⁴⁾ A decade after the appearance of the "living *Trigonia*," James Parkinson (1755–1824) recorded this story in his *Organic Remains of a Former World....* According to him *Trigonia* had been a commonly known fossil shell in "the LIAS and in MOST SUCCEEDING STRATA," but never had been found "in the remaining superior strata" after "hard chalk" until a living specimen was found recently.⁶⁵⁾ But the existence of the living analog of certain fossil shells can not disprove the possibility of the extinction of other species of fossil shells. Furthermore the arbitrariness in the classification of shells made the edge of the argument more blunt. Parkinson acknowledged that the newly found specimen can be classified as *Trigonia*, genus *Trigonia*, but he denied the existence of living analogs of *Trigonia* on the species level.⁶⁶⁾

As Faujas argued, natural history may be like a marching mass of accumulation, and the way of nature's march is "rich in all means."⁶⁷⁾ The history of quadruped fossils, shell fossils, and plant fossils, each of them has its own place in nature. Fossils of shells and quadrupeds played important roles in the recognition of the "historicity" of nature around the end of the eighteenth century. However, the plant fossils have their own "history," and fossils of shells and quadrupeds would not be helpful for the effort to explain the two cast and mold fossils about same face of one leaf described by Jussieu.⁶⁸⁾ Cuvier closed his "Preliminary Discourse" with rhetorical description of his expectation for new information from newly recognized fossiliferous layers. One of those layers mentioned by Cuvier was that of the legendary Oeningen, located near *Bodensee* (Lake Bodan) in Switzerland, in which many fossils of fresh-water fishes were said to be found. Late nineteenth century naturalists' records show that the most spectacular fossils found in that

62) For Faujas' expression on the organic mutability, see Faujas, *op. cit.*, pp. 35–36. But Faujas was not so ardent about general applicability of this notion. See Richard W. Burkhardt, Jr., *The Spirit of System: Lamarck and Evolutionary Biology* (Cambridge, Mass., and London: Harvard University Press, 1977), pp. 129–130, 136, 202.

63) Faujas, *op. cit.*, pp. 123–126.

64) For the detailed story about *Trigonia*, see Stephen Jay Gould, "Trigonia and the Origin of Species," *Journal of the History of Biology* 1 (1968), pp. 41–56.

65) James Parkinson, *Organic Remains of a Former World: An Examination of the Vegetables and Animals Antediluvian World; Generally Termed Extraneous Fossils*, 3 vols, vol. 3 (London: Whittingham and Rowland, 1811), p. 454.

66) *Ibid.*, p. 454.

67) Faujas, *op. cit.*, p. 35.

68) Jussieu, *op. cit.*, p. 294.

upper tertiary strata in Oeningen were not of quadrupeds but of insects.⁶⁹⁾ Those naturalists also calculated the temperature of that Oeningen layer when it was on the surface of the earth as 7°C warmer than now through evidence from fossil plants, neither from quadrupeds nor from shells.⁷⁰⁾ In the background of the expanded knowledge on animals and plants, the recognition of the fossil as the remains of former living bodies rather than something just dug up provided various new perspectives for the investigation of fossils. Cuvier must be the most active investigator who effectively deployed this recognition in his researches on fossils and the geological questions related with fossils.⁷¹⁾ But both the recognition of fossils as organic remains, and the knowledge on the animals and plants, which became the key to the understanding on fossils and the history of the earth, are the products of accumulated efforts of many people in many fields. Probably no one has opened all of the doors to the “historicity” of nature by himself.

69) Melchior Reumahr, *Erdgeschichte*, 2vols. 2: *Beschreibende Geologie* (Leipzig, 1887), pp.506—507.

70) *Ibid.*, p.507.

71) Kenneth L. Taylor, “The Beginnings of a French Geological Identity,” *Histoire et nature* 19—20 (1981—1982), p.79.