



Chapitre de livre

2009

Accepted version

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How to cite

DEBARBIEUX, Bernard. The Mountains between corporal experience and pure rationality: the contradictory theories of Philippe Buache and Alexander von Humboldt. In: High Places. Denis Cosgrove and Veronica della Dora (Ed.). London : Taurus Libri, 2009. p. 87–104.

This publication URL: <https://archive-ouverte.unige.ch/unige:8455>

**MOUNTAINS BETWEEN CORPORAL EXPERIENCE AND PURE
RATIONALITY: BUACHE AND VON HUMBOLDT'S
CONTRADICTORY THEORIES**

Published in Denis Cosgrove and Veronica della Dora, *High Places*,
Taurus Libris

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On November 15, 1752, Philippe Buache, a qualified mathematician and architect, and deputy geographer to the Royal Academy of Sciences since 1730,¹ presented a paper to the academy entitled: “Essai de géographie physique, où l’on propose des vues générales sur l’espèce de Charpente du Globe, composée des Chaînes de Montagnes qui traversent les Mers comme les Terres, avec quelques considérations particulières sur les différents Bassins de la Mer, et sur sa configuration intérieure” (Essay in physical geography proposing general perspectives on the structure of the globe, which is made up of mountain ranges crossing the oceans and lands, with some particular considerations regarding the different sea basins and the internal configuration of the sea)². The title is grandiose, as was the paper’s ambition: to propose a new theory regarding the position of all oceans, mountains, islands and rivers on a world scale. Buache’s theory was as follows: the Earth is marked by chains of mountains which join together from one end of the continents to the other. These mountain ranges divide immense “river basins”, which then open into *three large “seas”*; which he calls the Ocean (the Atlantic), the Sea of the Indies (the

Indian Ocean), the Great Sea (the Pacific Ocean). Each of these large seas is divided into maritime basins – always three per ocean – which are separated from each other by “marine” mountain ranges. These marine mountain ranges are consistently the underwater extensions of the terrestrial mountain ranges, invisible to the observer except where they graze or rise above the surface of the seas in the form of “islands, reefs or shoals”. [Fig. 6.1]



Fig 6.1: P. Buache, *Carte physique de l'Océan (...)*, 1754. Bibliothèque Nationale de France (BnF), Cartes et Plans (Richelieu), GE DD 5400 (2) RES.

Crédits photographiques : BnF, Département de la reproduction, Paris.

When applied to South America, this ordering principle assumes the existence of several major mountain ranges: those for which Buache already possessed several descriptions, such as the Andes; and those which were deduced from his theory and according to him lay between the Orinoco, the Amazon and the River Plate basins, and between Brazil and Guinea toward the Fernando de Noronha islands. [Fig. 6.2] In truth Buache didn't invent the range which separates the Orinoco and Amazon basins; it had already been suggested on several previous maps, notably by Hondius (1606 and 1630) and Fritz (1690). However, the accounts of the American Indians brought back by seventeenth and eighteenth century explorers and cartographers, such as Sanson (1656) and later, La Cruz (1776,) led some to believe that such a mountain range did not exist; the two basins were being said to communicate via one or several water courses used by the local people and their small crafts. But Buache didn't take these accounts seriously, arguing that the natives were accustomed to carrying their light canoes over short distances to pass from one water-course to another. Moreover, in his planispheres, just as in his maps of Guiana commissioned by the colony's Governor, Philippe Buache shows a mountain range between Orinoco and Rio Negro as great as the watercourses it separates. In a note attached to this map, he writes that "the communication which is supposed to exist between the Orinoco and the Amazon is a geographical monstrosity which la Cruz's map has groundlessly propagated and in order to correct this matter one need only recognize the direction of the great range which divides the waters".³



Fig 6.2 : P. Buache, *Carte physique de l'Océan (...)*, 1754, detail. Bibliothèque Nationale de France (BnF), Cartes et Plans (Richelieu), GE DD 5400 (2) RES.

Crédits photographiques : BnF, Département de la reproduction, Paris.

On May 20, 1800, Alexander von Humboldt and Aimé Bonpland feigned to take up Buache's invitation. They had left Corunna several months earlier for the four-year expedition that would take them across the north of South America⁴. They arrived in the continent at the port of Cumana on the Caribbean coast. From there, they organized their first expedition of nine months covering the eastern part of Nueva Granada. In mid-May 1800, they spent ten days following the Cassiquiare, a tributary of the Rio Negro, and, without setting foot on land, arrived at the Orinoco, which empties most of its waters into the Caribbean. They proved in this way that the Orinoco and Amazon basins do communicate via this curious water-course, an imposing bifurcation in the river from one basin to the other. In truth, Humboldt had been sure of this tributary's existence even before

leaving Cumana; his own research and his local informants had convinced him that this communication did in fact exist:

For half a century, no one has doubted the communication which exists between these two great river systems. The main objective of our navigation was therefore only to establish by way of the stars the point where it enters the Rio Negro and its junction with the Orinoco”.⁵ However, he was well aware that he was dealing with a curious geographical phenomenon worthy of being confirmed and observed: “a phenomenon which seems so bizarre that I went on location to check for myself (and which) calls for special attention.”⁶

The coordinates taken from his observation (“3° 10’ North latitude and 68° 37’ West of the Paris meridian line longitude”) served as proof and facilitated verification at a later date. As for Humboldt’s actual observations, which were recorded in abundant notes and cited in several later publications, these were instrumental to a general school of thought on the locations of mountains and the best method to adopt in order to determine their location. Humboldt makes an ironic reference to Philippe Buache’s theory: “I was fairly pleased to recognize this mountain range (guessed at by Buache) once on location. During the night I passed through the part of the Orinoco on my pirogue where Mr. Buache hypothesized that the river bed was broken by a cordillera”.⁷ He continues to mock the theories of geographers from the middle of the previous century; “This bifurcation, which so long mystified geographers when they were making their maps of the Americas”⁸ gave him the opportunity to denounce more

simplistic lines of thought – “mountain ranges (in the New World) do not stand up like walls on horizontal planes”⁹ – and their Europe-focused visions:

Accustomed to considering the rivers of Europe only in those parts where their course was enclosed by two crest lines, ... we have a great trouble in conceiving of the simultaneous existence of these winding courses, these bifurcations, these river communications of the New World.¹⁰

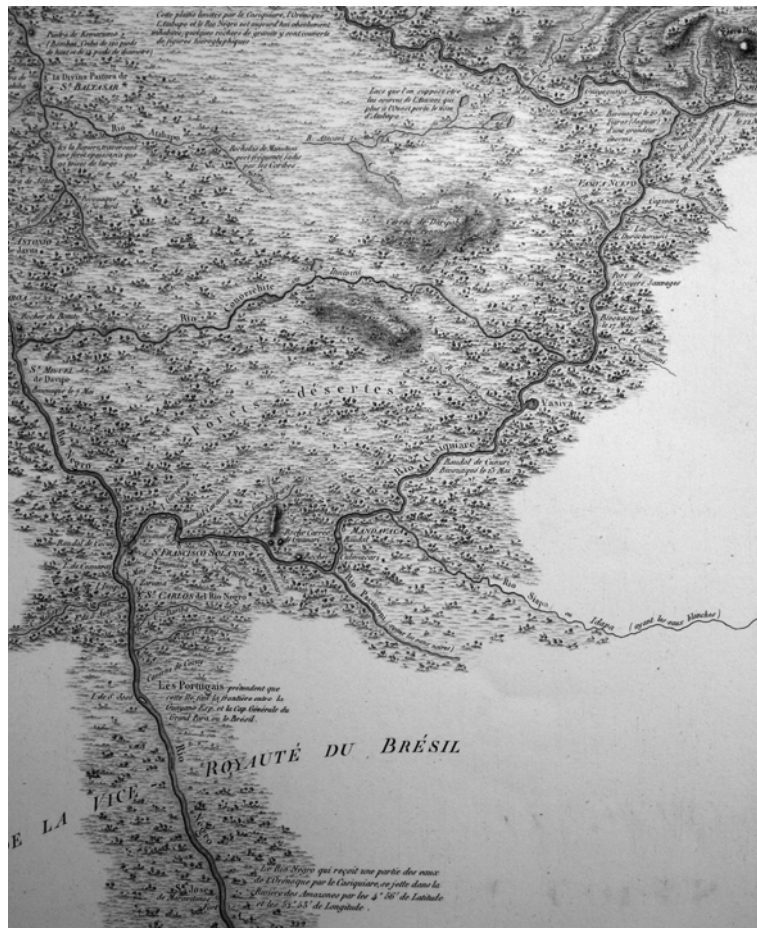


Fig 6.3: “Carte itinéraire du cours de l’Orénoque, de l’Atabapo, du Casiquiare et du Rio Negro... dressée sur les lieux en 1800... » par A. de Humboldt. From A. de Humboldt, Atlas géographique et physique du nouveau continent, 1814, Paris, Schoell,

He also took the opportunity to criticize an era of geography which had been excessively theoretical and for which field observation had been of little interest. In May 1800, Bonpland and Humboldt definitively concluded a controversy which had raged for over a century.

The Cassiquiare controversy could be treated as merely an anecdote about the confrontation of two opinions and two attitudes concerning an imaginary mountain range. It could also be taken as a symbolic example of a scientific controversy between one person who formulates a theory and another who shakes this theory's very foundation by making a contradictory observation. So be it. Here, however, I want to suggest much more: a confrontation between two ways of conceiving mountains as objects of knowledge and, more particularly, two ways of perceiving natural objects, first as an element in a planetary structure, second as a form born from a particular lay-out of the Earth's materials. When analyzed in this way, it is certain that the Cassiquiare controversy opposes two states of knowledge and two different methods for constructing scientific knowledge, but also, and more particularly, two theories of knowledge which each accord quite a different status to mountains, especially in regards to their materiality.

Thoughts and Names for Mountains in the Eighteenth Century

In order to establish the gravity of this controversy, one must remember that it uses a term, "mountain", whose accepted meanings varied greatly at the time when Buache published his *Essai de Géographie Physique*. In the *Encyclopedia* edited by Diderot and d'Alembert, the article on mountains written by d'Holbach gives this definition: "great masses or inequalities of

the Earth which make its surface rough”.¹¹ But, throughout the volumes and the pages of this encyclopedia, the term is used to designate not only the “the Andes cordillera”, but also the seven hills upon and around which Rome was built, “Table Mountain” near Cape Town, as well as the original site of the town of Angoulême, situated on a limestone acropolis between Bordeaux and Poitiers. The volumes from the Royal Academy of Sciences accept a similar diversity of definitions: a *mémoire* published in 1755 was entitled “Discovery of a Petrified Tree Stump Found in a Mountain in the Étampes Area”.¹² Today we would describe this hillside at best as the rim of a plateau located about thirty kilometers south of Paris. Besides, common usage has appointed the toponym “Montagne Saint-Geneviève ” to a feature which rises modestly a few meters higher than Notre-Dame de Paris. In a similar vein, French explorers baptized a hill with an altitude of around 200 meters just outside Montreal as a “mountain”, sometimes known as “Mont Royal”.¹³

When they came to the Alps and the Pyrenees, the travelers of the century were very hesitant as to the terms they should use to describe such an environment; some speak of mountains to designate the slopes which frame the deepest valleys¹⁴; others speak of “mountains piled one on top of another; in such a way that once you arrive at the summit of one, you find a plain where the foot of another mountain begins”.¹⁵ Lastly, there are those who were fooled by the meaning given to the words “mount” and “mountain” by the Alpine residents, which in fact designated high pastures and passes, and who were therefore disappointed upon arrival at Mont Saint Gothard, conceived by Buffon and Buache as the culminating point of the Alps, to find only prairies and summits of secondary altitude.¹⁶

In Buache and Humboldt's time, the word "mountain" therefore had several very different significations and, more importantly, it designated realities based on very different environmental practices and conceptions. In everyday speech, it referred to a point of passage on an itinerary (Saint-Gothard), as well as a place for the cultivation of pastures (the mountains of the Savoie shepherds), and even a modest hill standing out on the horizon (Sainte-Geneviève). In the technical vocabulary, the term designated both forms that were very modest in altitude and gradient (la Montagne d'Étampes), as well as very large series of peaks. It wasn't until the beginning of the nineteenth century that scientific terminology decided on a relatively homogenous set of meanings and expressions ("mountain massif", "mountain range") which were relatively stable and shared in common among specialists in different disciplines.¹⁷

Bearing these conditions in mind, the analysis of the Cassiquiare controversy involves more than questions of disagreements over the facts – is there or isn't there a mountain range between the Orinoco and Amazon basins? – one must discover the exact meaning and scientific status of the concept of mountains¹⁸ for both of the authors implicated.

The Mountain according to Buache: an element in a system of objects

In the middle of the eighteenth century, a number of Buache's contemporaries recorded their research into the complexity of the configuration of terrestrial forms. In 1749, the Count de Buffon presented his own *Théorie de la Terre* and reported an apparent lack of order: "this immense globe displays on its surface heights and depths, plains, seas, marshes, rivers, caves, chasms, volcanoes, and upon our first inspection we can see no regularity, no order to it".¹⁹ Buache's *Essai de géographie*

physique... must also be understood as the expression of his desire to find order in this apparent disorder, and to identify some principles by virtue of which natural objects may hold together. The theory of the continuity of mountain ranges rests upon these assumptions. It treated mountains analogically as “a kind of framework, which [he] envisages as the support for different parts of the terrestrial globe and which is formed of high ranges encompassing and crossing it”.²⁰ With the continuity of mountain ranges postulated in this way, river basins can be understood as mere surfaces enclosed by the pieces of the framework. As these basins were better identified than mountains in the eighteenth century, Buache’s theory allows him to define mountains by way of understanding rivers:

I thought that ... I had to use the clues left by the rivers. We can’t deny that the origins of rivers and streams naturally indicate the height of the terrains where they source their water to nourish and fertilize the lands they cross as they descend from the high places, whether it be by steeper or shallower slopes, until they empty themselves into the sea. Neither can we doubt the liaison and the relationship that mountains have with rivers.²¹

By the same reasoning, maritime “basins”, understood as the extension of river basins, correspond to the areas circumscribed by the underwater mountain ranges, themselves the extension of the terrestrial ranges. Buache’s system is therefore first and foremost logical ordering of natural objects in space, objects which are organized into reasonably simple and complementary categories.

The triumph of cartographic order and the disdain for experience

Buache's system thus accords great scientific importance to absolute space. Natural objects explain each other through their respective location on the surface of the Earth. However, if terrestrial space constitutes the system's reference point, it is through the space on the map that Buache construes and expresses the system's intelligibility; for Buache was a prolific cartographer, and a specialist who made the map a tool for understanding and reasoning. It was a tool for communication in the sense that Buache expected maps to give an immediate account of the layout of terrestrial forms. In a 1756 planisphere,²² he adopted a projection centered on the North Pole, something quite rare for his time, which allowed a view of the continents of the northern hemisphere as they close in on one another, their promontories and the ranges that cross them almost touching. In another planisphere which he made for the Dauphin to whom he taught geography,²³ Buache was one of the first to place America to the east of the Old World so as to reveal more clearly the imagined continuation of mountains between Alaska and Siberia.²⁴

The map was also a tool of reasoning in the sense that Buache expected it to show not only the formations that had already been observed by explorers, but also those objects whose existence could be deductively surmised. For this reason, his maps demonstrate not so much the state of knowledge established by the explorers of his time as the product of his own logical reasoning. That reasoning was based on the idea that the proximity of natural objects to each other comes from their mutual determination. The cartographic proximities between mountains and water courses are evidence of the cause and effect relationship which he

imagined existed between them: “It is good to see the liaison between them [mountains and basins] and their mutual dependence. This is what this system shows at the very first glance”.²⁵ In this attitude Buache was unquestionably a geographer, if we regard eighteenth-century geography, like today’s, as a discourse which explains phenomena according to their respective locations.²⁶

According to Buache then, maps were an essential mode of expression and reasoning, to the point that their authority exceeded on-site validation of theories and direct experience of natural formations. He himself did not travel; we only know of a few trips linked to his work on the northern half of France. He did of course invite those who lived or worked in the areas about which he spoke to recount their observations, particularly the sailors from whom he claimed to collect observations of shoals.²⁷ He certainly compiled travel and exploration notes, but these were not collected in a systematic fashion and he was known to reject facts brought back to him if they contradicted his theory. This was the case for the Cassiquiare, as the reliability of the field information was deemed uncertain.

Buache expressed no more interest in questions of mountain geology. His observations only ever concerned topography, never the nature of the rocks revealed at the surface. Neither did he attach great importance to measurement. There were however many specialists from the previous century who attempted to measure the gradients and altitudes of mountains, but their estimations were not systematic and varied greatly between specialists. Yet from the middle of the eighteenth century, the methods of measuring things improved radically and the Academy of Sciences’ records reveal a growing number of observations and technical

refinements. Buache accords them barely any importance at all in his own works. Nonetheless, he himself had occasion to resort to some systematic measurement when it proved essential to his analysis: he carried out depth soundings in the English Channel from which he deduced a map of isobaths.²⁸ This method allowed him to prove the existence of an underwater “mountain range” under the Straits of Dover. But although he suggested that such a mapping procedure be adopted for measuring and representing contour lines, he doesn’t seem to have pursued this. In truth, he preferred to deduce altitudes from the slope of rivers:

I thought one could refer to the knowledge given us by the slopes of several rivers according to several observations of erosion or experiments on their speed, etc. This can lead us to determine the difference between the height of their source and their mouth; as it seems that if one knows the slope of the river courses, one can determine the elevation of the places where they source their water.²⁹

But this proposition doesn’t seem to have been followed up.

The Hierarchy of Mountains

This attitude does not belie an indifference towards establishing a hierarchy of mountains and their ranges; quite the opposite, such an idea was essential to his system. But his hierarchy is a structural one and is not concerned with mass, volume or altitude. In Buache’s system, terrestrial mountain ranges and water courses are graded into three types according to their position in the ensemble: the “great mountain ranges” that correspond

to the continental back bones. The “lateral mountains” are primary branches from these and circumscribe the basins and main water courses, which he proposes to call “*fleuves*”. “Coastal mountains”, themselves branches of the “lateral mountains”, fall into the sea, marking the separation of the “coastal” river basins.³⁰ The major ranges are joined to what he calls “plateaus”:

Terrestrial ranges seem for the most part to extend like rays from certain places which may be the highest on the Earth, and a sort of plateau, formed by mountains as if grouped together and piled one atop the other ... I observe that of these plateaus, the most remarkable are approximately in the middle of Asia [Fig. 6.4] and of each of the two parts of America, also that there is at least one very large one in Africa, and two lesser ones in Europe”.³¹

In other words, the importance he accorded to water courses and to mountains had nothing to do with quantitative values (I would prefer “intrinsic features”) of height or matter, but everything to do with their position in the system. And for this purpose, the map counts for far more than field observation. Therefore, the absence of a high altitude mountain range in the place where his theory supposed it to be does not constitute a major problem in Buache’s eyes; a range, even modest in verticality, remains major within the structure if it separates river basins orientated towards different large seas.



Fig 6.4 : Ph. Buache, Carte physique de la Mer des Indes (detail), in *Cartes et tables de la géographie physique ou naturelle, présentées au roi le 15 mai 1757*, Paris, quay de l'Horloge.

Bibliothèque Nationale de France, Paris, site Tolbiac - Rez de jardin – Magasin. Cote G-1841

Reasoning that was modern but whose scientificity is disputable

We could consider Buache and his reasoning pre-modern and link both to theories in vogue throughout previous centuries, such as tenth-century Arab geography³² and the “theories of the Earth” from the sixteenth and seventeenth centuries, which, like Buache’s, credited empirical observation less than deductively constructed global systems. However, Buache’s theory was eminently modern on several levels. Contrary to his predecessors and to some of his contemporaries, Buache imputed absolutely no authority to medieval or ancient knowledge and eliminated any metaphysical or religious speculation: the system he described had no Creator³³ or historical teleology. Buache’s method was also modern in his absolute confidence in deductive reasoning: for example, although

knowledge of the Antarctic was still extremely tenuous at the time, he formulated a theory on the configuration of this continent from observations of the size of blocks of drifting ice (not yet called icebergs) reported by sailors.³⁴ Isabelle Laboulais-Lesage has suggested that this way of working, writing and mapping, reflects Buache's concern with manipulating the institutional rhetorics of science within the Royal Academy of Sciences, in which geography did not enjoy unanimous recognition.³⁵

On the other hand, his system was echoed widely across French and German geography into the nineteenth century, as well as in political philosophy and economics, which advocated the adoption of "natural borders" to determine the territorial limits of states within Europe and America.³⁶ This application took little account of mountain geology or the material advantages, minimal as they may have been, of determining limits by way of watersheds. The main advantage of fixing borders along watersheds, according to those who supported the idea, is that it follows the "order of nature" and has the convenience of easy cartographic representation, being perceptible "at first glance"; whence it is deduced that borders are difficult to agree indisputably by any other criteria.³⁷

Yet, the modernity of Buache's theory was no guarantee of its scientific status. The lack of importance Buache gave to having his theories empirically validated and the scant regard he paid to observations contradicting his system quickly discredited his propositions within scientific circles. Direct experience of those objects for which he had devised a system was not considered a criterion for validating them, an attitude which quickly proved to be at odds with the scientific method dominant during his lifetime. Consequently, even though one can find

traces of his influence in a great number of major eighteenth-century scientific documents, he was increasingly the subject of veiled criticisms by naturalists well before Humboldt began to publish. However, it wasn't until Humboldt entered the scene that the break was complete and definitive.

Throughout the second half of the eighteenth century, physical geography texts that first criticized Buache's theory didn't wholly distance themselves from it. The same can be said for the *Encyclopedia*, which nonetheless cites Buache only once.³⁸ In the entry devoted to "physical geography", Nicolas Desmarests radically shifted the field and methods of this branch of geography by thoroughly criticizing "*géographie de cabinet*" (armchair geography). He advocated a type of geography which was closer to physics and the study of causalities between physical phenomena:

Nearly all phenomena ... are only useful in the relationship they have with other phenomena ... The true Philosophy lies in discovering those relationships hidden to near-sightedness and carelessness ... We shall gradually rise to more general views, through which we shall grasp several objects at once: we will understand the natural order of facts; we will link phenomena; & we will cover at a single glance a series of analogous observations, which will build effortlessly on one another".³⁹

It was also necessary to give precedence to the patient observation of the facts *in situ* for all explanations:

We are now fairly convinced of the inconveniences associated with this idle presumption which leads us to guess at nature without consulting it ... Therefore we want facts & observers appropriate for grasping and successfully gathering them ... the observer must guard against any preconception, any bias which is static and dependent on a system which has already been devised.

As for the observation of nature *in situ*, he mistrusted fast or superficial observations- “A general & rapid casting of the eye teaches us nothing but what is vague” - and advocated that particular attention be paid to the materiality of natural objects:

An intelligent observer will not restrict himself so much in his technical discussions to the external forms or structure of an object, without also taking an exact knowledge of the matter itself which in its diverse amalgams contributed to producing it; he will even exactly link one idea with the other. This matter, he will say, affects this form; he will conclude one from the other, & vice versa”. The physical geography advocated by Desmarests is therefore light years away from Buache’s geography and close to the natural history project which was then taking shape, and which the former would get even closer at the end of the century.⁴⁰

However, he borrowed the hypotheses of continuity, including submarine continuities, and the hierarchy of mountain ranges, from the river basin theory:

All mountains form different principal ranges which are linked, united with each other, & which touch the surface of the continents with their main trunks and with their collateral ramifications. Mountains, which are truly the primary stems, represent very great masses in both height and volume; they ordinarily occupy and cross the center of the continents: those of a lesser height are born from these principal ranges; they gradually decrease in size as they move away from their main stem, & expire either on the coasts of the sea or in the plains.⁴¹

Other authors tried their best to juxtapose these two geographical approaches to mountains within two different branches of the discipline: Robert de Vaugondy proposed that

we still distinguish geography into 1) natural; in regards to the divisions that nature has put on the surface of the globe by the seas, mountains, rivers, isthmuses, etc. and in relation to the colors of the different peoples, to their natural languages, etc. 2) historical ...; 3) civil or political ...; 4) holy ...; 5) ecclesiastical ...; 6) and lastly physical geography; this last branch considers the globe of the Earth, not so much from the point of view of what forms its surface as from what makes up its substance.⁴²

Even if his method was criticized from early on, Buache's publications lastingly influenced scientific circles through his conception of a privileged object of their interest: the continuity of mountain ranges.

Mountains according to Humboldt: form, matter and experience

Thus, in disputing the course of the Cassiquiare Humboldt was not the first to oppose Buache's system. But he was one of the first, along with Conrad Malte-Brun, to renounce it completely. The location and linking of mountain ranges greatly interested Humboldt, but he never addressed these subjects with the help of Buache's theory. He did sometimes use Buache's vocabulary, although often in order to distance himself from it.⁴³ In order to formulate his own idea of the ordering of relief on the Earth's surface, he made observations in Europe, in America and most notably in Central Asia in 1829 through an expedition sponsored by the tsar. He also collected eye-witness accounts and proceeded to draw a marked distinction between local informants familiar with a given region and those who worked from presupposition, termed by Humboldt as "dogmatic and careless".⁴⁴

But above all, his study of the "direction of the different mountain systems" was motivated by his desire to understand the structure of the globe, believing that the design of mountain systems "offers one of the characterizing traits of the internal make-up of our planet".⁴⁵ In his research into this make-up, he moved progressively further and further away from the Neptunist conceptions of his tutor in geology, Abraham Gottlob Werner, and favored "the action that the interior of a planet works on its outer crust", which he called both "volcanism"⁴⁶ and "volcanity".⁴⁷

Early nineteenth-century thinking on the formation of mountain ranges was in flux and Humboldt wanted to contribute to it through his understanding of mountain systems. His curiosity about the “internal make-up of our planet” directed his attention to the material composition of mountains, to the physics of the Earth in the sense that Desmarests spoke of: “physics, as its name implies, restricts itself to explaining the phenomena of the natural world through the properties of matter”.⁴⁸ The way Humboldt drew the landforms of Andean volcanoes proves his attention to the matter. [Fig. 6.5]

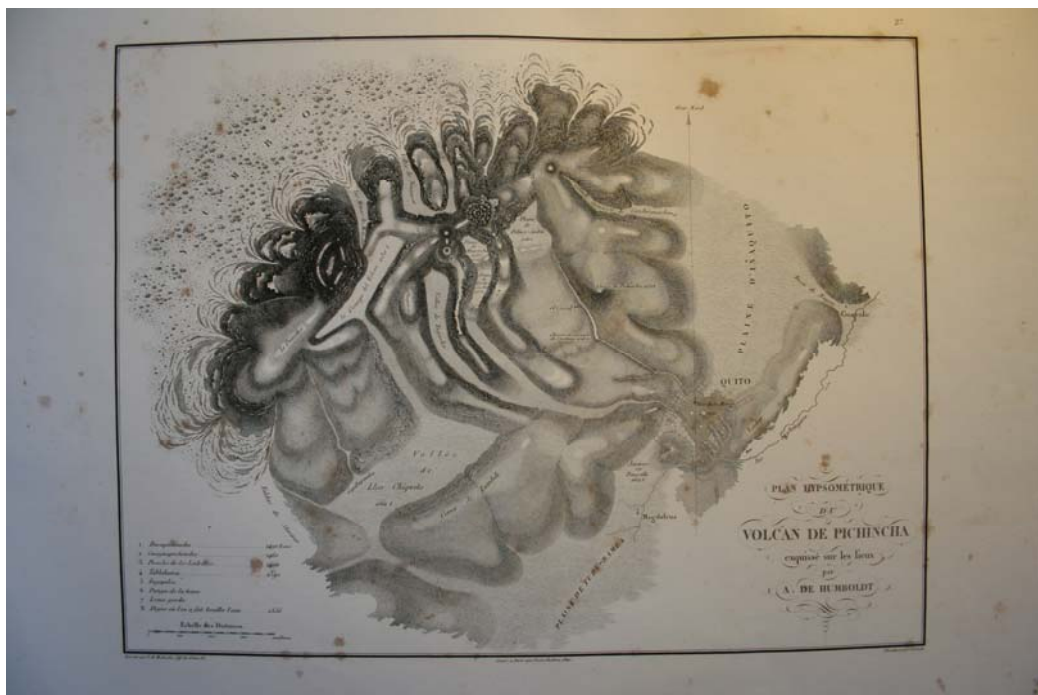


Fig 6.5 : Humboldt’s “Plan hypsométrique du volcan de Pichincha tel qu’observé sur les lieux”. The drawing proves how much Humboldt is curious of landforms. From A. de Humboldt, *Atlas géographique et physique du nouveau continent*, 1814, Paris, Schoell, Bibliothèque Publique et Universitaire de Genève, cote Fb 803

It was in the name of this primacy of matter in the physical study of mountains that Humboldt was able to refer back to Buache's theory and propose an alternative:

It is ... by a false application of the principles of hydrography, that from the safety of their office desks, geographers have tried to determine the direction of mountain ranges in countries whose river courses they believed they understood precisely. They imagined that two large water basins could only be separated by large elevations, or that a large river could only change direction because a group of mountains blocked its course. They forgot that very often, either because of the nature of the rocks, or because of the incline of the strata, the highest plateaus don't give rise to any water course, and the sources of the greatest rivers are far from high mountain ranges. Also, up to this point, attempts to draw physical maps according to theoretical thought have not been entirely felicitous.⁴⁹

Mountains put to the test of direct experience and scientific instruments

Strong in his materialist convictions and in his mistrust for any claim lacking empirical validation, Humboldt accorded the greatest importance to the *in situ* observation of the objects he spoke about. His accounts of his expedition in South America demonstrated how carefully he had examined surface exposures of rock, whilst Bonpland examined, categorized and took samples of the flora they encountered. During his trip along the

Cassiquiare, Humboldt increasingly observed the rocks and their juxtaposition, drawing from Werner's geology training. This concern for detailed observation can also be seen in the importance that he and Bonpland gave to very heterogeneous phenomena: the Chiriva palm-trees, the black and white veins which streaked the granite on the river banks, the mosquito attacks, the temperature of the water, the air vapours which prevented them from seeing the beauty of the night sky.⁵⁰ Later, during his expedition to Central Asia, he declared an even greater faith in direct field observation. At the end of *Central Asia*, he added an historical note which gave a clear account of his traveling conditions and demonstrated his concern for familiarizing the reader with what he really did and saw. And in the same breath, he criticized Marco Polo for having treated equally what he had seen and what he had been told.

Humboldt's observations relied very much on sight; but he also made great use of scientific instruments. He devoted a large part of his activities in America to measuring such phenomena as the geometrical position of places, summit altitudes, the times of sunrise and sunset, atmospheric pressure, temperature, intensity of the blue of the sky, etc. Everything that the instruments of his time could measure, he measured. He travelled with a collection of instruments - sextants, theodolites, barometers, thermometers, chronometers, quadrants, compasses, eudiometers, electrometers, hygrometers, etc. - collected before his departure⁵¹ and which he learned to use in Germany. The direct experience of mountains which he considered to be so decisive thus combined unmediated sense observation, measurement by scientific instruments and causal and classificatory reasoning. Wishing to be truly in touch with nature, he structured his report by alternating between his observations,

with or without instruments, and the interpretation of his findings. One of his favorite measurements was altitude as determined by barometer measuring the decrease in atmospheric pressure with elevation, not because it was the most original of measurements, but because it provided a point of reference for the ensemble of his observations and comparisons. In this way, Humboldt measured several hundred summits,⁵² constructed numerous “height tables” and slope cross-sections juxtaposing measured altitudes and on-location surveys. Last but not least, he invented diverse modes of graphical representation which allowed him to compare the altitude of similar phenomena in several mountain ranges. So, Humboldt’s version of the mountain, contrarily to Buache’s, had dimensions (the height of the summits, the average height of each range, the surface of the massifs, etc.) which he tried to relate to the material constitution of mountains.

Mountains put to the test of the body

One of the most original and least noted aspects of Humboldt’s method lies in his observations of the reactions of his own and his traveling companions’ bodies to the influences of the environment. Generally speaking, in accordance with his holistic view of nature, he attributed a power to excite the senses and to develop one’s sensitivity to immersion in the natural world.

In the forests of the Amazon, as on the slopes of the Andes, I felt that the surface of the Earth was alive everywhere with the same spirit, the life even which is in the rocks, the plants and the animals, as in the heart of humanity from one pole to the

other. Everywhere I went I realized just how much the relationships I formed in Jena [where I conducted part of my academic training] were having a profound influence on me, and how much, inspired by Goethe's perspectives on Nature, I had gained new organs of perception.⁵³

He also spoke of scientific instruments as "new organs".⁵⁴ The body, whether assisted by instruments or not, and the mind are the attributes which allow humans to enter into a relationship with nature.

Moreover, in the name of the physical method he adopted, Humboldt endeavored to identify his body's responses when exposed to the elements. Before even immersing himself in the tropical world, he used his body in order to observe reactions to exogenous stimulation.⁵⁵ At the summit of the great Tenerife peak, Humboldt observed the effect of the extreme temperatures on his skin;⁵⁶ in the Amazon, he recorded Bonpland's illnesses, as his colleague was more sensitive than he to the humidity and mosquito bites. However, it is in his report on his ascent of Chimborazo that this feature of his research is most apparent. His ascent of the Andean volcano, then considered the highest summit on Earth, proved to be a defining moment in his journey.⁵⁷ In his scientific writings he constantly played down the heroic aspects and scientific value of this venture, but his correspondence and the booklet he published much later⁵⁸ show that he was very attentive to the bodily of and responses to this climb, for example the pain in the hands caused by contact with the rock: "We had to use hands and feet in places where the ridge turned into a sort of isolated and very sheer shelf ... As the rock was at very acute angles we were wounded quite badly, especially in the hands".⁵⁹ He related this back to similar

experiences during his trips in the Alps and his climb up Tenerife. He explained the different pains experienced in the different contexts by the different nature of the rocks encountered. He also reported pain in his foot “caused by the accumulation of *niguas (pulex penetrans)*”⁶⁰ under the skin that the altitude and the cold had apparently awakened. He reported his own and his companions’ sicknesses, his “need to vomit” and his difficulty in breathing, bleeding from the face [Fig. 6.6]; and, as often as possible, he analyzed these inconveniences the way he had done so many other manifestations of the effects of altitude observed in other contexts:

Our gums and lips bled. The layer of conjunctivitis over our eyes, for all of us without exception, was filled with blood. These externalizations of blood in our eyes and bleeding from the gums and lips did not worry us at all as we knew about them from a great number of previous examples. In Europe, Mr. Zumstein showed blood at a much lesser height on Mont-Rosa.⁶¹

Lastly, by way of synthesis, he writes:

All these phenomena vary greatly, depending on age, constitution, skin sensitivity and previous physical exertion; however, for each individual they are a sort of measurement of the rarefaction of air and the altitude reached. According to my observations in the Andes they occur, in white men, when the barometer rests between 14 inches and 15 inches 10 lines. We know that ordinarily the heights to which aeronauts claim

to have risen deserve little faith, and if Mr. Gay-Lussac, a sure and extremely exact observer, did not show blood on September 16, 1804 at the prodigious height of 21,600 feet, and therefore between Chimborazo and Illimani, it should perhaps be attributed a total absence of muscular movement.⁶²

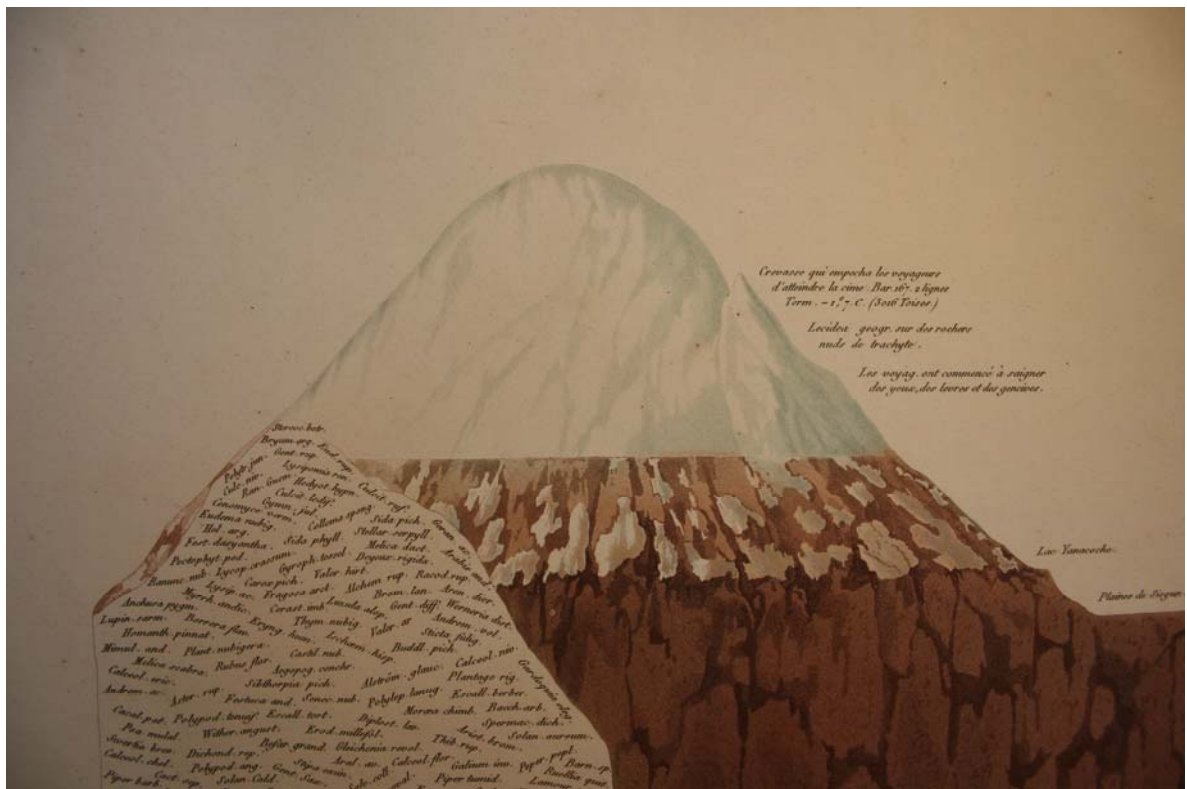


Fig 6.6: « Voyage vers la cime du Chimborazo tenté le 23 juin 1802 par AH, AB et Carlos Montufar».

From A. de Humboldt, Atlas géographique et physique du nouveau continent, 1814, Paris, Schoell, Bibliothèque Publique et Universitaire de Genève, cote Fb 803

Mountains put to the test of the emotions

Lastly, whilst Humboldt believed in the analytical virtues of experiencing high places directly, including through the immediate reactions of his own

body, he also believed in the more all-encompassing virtues of experiencing the entire landscape. Many authors have noted the new importance that Humboldt gave to landscape and the highly conceptual value it took on for him. In his writings landscape is the ordering of natural formations in space, an order which is perceptible “at first glance”. Although he does not deny the capacity recognized by Buache that maps and charts have to give summarizing information⁶³, the capacity of the vision to react to the environment *in situ* counts for much more. This capacity that his objectified landscape had to account for the ordering of natural objects was optimal in mountains: equatorial mountains were

the part of our planet’s surface where even in the smallest expanse, the variety of Nature’s impressions is as large as possible ... In the colossal mountains of Cundinamarca, Quito and Peru, scored by deep valleys, man may look upon all the families of plants and all the stars of the firmament all at once ... It is here that the bowels of the Earth and the two hemispheres of the sky lay out all the richness of their forms and the variety of their phenomena; it is here that the climates and the vegetation zones they determine are superimposed as if in layers, and that the laws of fall in temperature, easy to grasp to the intelligent observer, are written in indelible ink on the rock walls of the rapid slope of the Cordillera.⁶⁴

Furthermore, for Humboldt the virtues of objectifying landscape formations with the eye were inseparable from their effects on the emotions of those who looked upon them. He wrote ecstatic pages on tropical landscapes and the emotions they had provoked in him.⁶⁵ But in so

doing, he sought less to embellish his writings with subjective impressions than to open his field of research to the participation of human emotions in the general harmony of nature. This Goethian ideal of total knowledge, rich with the combined virtues of art and science, and whose scientific dimension included not only knowledge of the natural facts but also human experience of them, was best implemented in mountain landscapes:

The aspect of the mountains contributes no less than the forms, size and groupings of the plants, no less than the different species of animals, the shades of the canopy of heaven and the intensity of reflected light in determining the character of a landscape and the general impression that man receives of different zones of the Earth.⁶⁶

In this way, his method of knowledge opened the door to a “positive approach to phenomena in relation to human emotions”⁶⁷, in that Humboldt, in accordance with the *Naturphilosophen*, “considers phenomena in relation to the human emotions and mind as consubstantial with nature itself and a manifestation of humanity’s inclusion in the great interconnected totality of the universe”.⁶⁸

Conclusions

The Cassiquiare controversy, with which we opened this discussion and which opposed by several decades and several thousand kilometers Philippe Buache and Alexandre de Humboldt, represents much more than a simple disagreement between two specialists as to the existence or non-existence of a mountain range. It demonstrates two different conceptions of

scientific knowledge, two ways of considering (or not considering) the relationship between natural formations and the matter from which they are made, and two quite opposite evaluations of the benefit of field experience in the natural environment. Consequently, the notion of mountains about which both speak so abundantly did not designate the same thing. For Buache, they were elements in a natural structure which could only be understood with the distance provided by relating categories of natural objects cartographically. The form of mountains, and *a fortiori* their materiality and altitude, counted for very little in terms of their position in an architecture of the globe itself, of which he believed them to be constitutive. For Humboldt, mountains were volumes from the history of the Earth's crust and a source of diversity and complexity in the distribution of life on Earth; they were to be approached methodically and with particular attention to the evident relationships between substance, appearance and observable effects. In such circumstances, the notion of mountains employed by two such dissimilar projects had little chance of generating compatible statements in either form or content. The Cassiquiare project exposed this fundamental incompatibility. We can therefore view it as a decisive moment in the history of geography: the triumph of one concept of physical geography over another. But even though it was a triumph it was fleeting, as one of the deepest foundations of Humboldt's research – the belief in a fundamental harmony in the ordering of the forms and forces of nature and humanity – did not outlive him.

¹ Buache's biography is well developed in three texts: L. Drapeyron, Les deux Buache et l'origine de l'enseignement géographique par versants et par bassins, *Revue de géographie* (1887) 6-16; N. Broc, Philippe Buache: un Géographe dans son siècle, *Dix-Huitième siècle* 3 (1971) 223-35; L. Lagarde, Philippe Buache: cartographe ou géographe? in: D. Lecocq, A. Chambard (Eds), *Terre à découvrir, Terres à parcourir*, Paris, 1998, 147-166. The commemorative address given at the Academy can be of some help: Eloge de Monsieur Buache par Grandjean de Fouchy, *Histoire et Mémoires de l'Académie Royale des Sciences* (1772) 135-50. English texts are fewer: G. Kish, Early thematic mapping: P. Buache, *Imago Mundi* 28 (1976) 129-36; L. Lagarde, Philippe Buache (1700-1773), *Geographers Biobibliographical studies* 9 (1985) 21-27; A. Godlewska, *Geography Unbound: French Geographic Science from Cassini to Humboldt*, Chicago, 1999.

² P. Buache, Essai de Géographie Physique, où l'on propose des vues générales sur l'espèce de Charpente du Globe, composée des chaînes de montagnes qui traversent les mers comme les terres, avec quelques considérations particulières sur les différents bassins de la mer, et sur sa configuration intérieure, *Mémoires de l'Académie Royale des Sciences*, 1752.

³ Quoted in A. de Humboldt, *Voyage aux régions équinoxiales du nouveau continent, fait en 1799, 1800, 1801, 1802, 1803, et 1804*, vol.II, Paris, 1819, 538.

⁴ About this travel and, more generally Humboldt's work, see C. Minguet, *A. de Humboldt: Historien et géographe de l'Amérique espagnole (1799-1804)*, Paris, 1969; M. Dettelbach, Global physics and aesthetic Empire: Humboldt's physical portraits of the tropics, in: D. Miller, P. Reill (Eds), *Visions of Empire: Voyages, Botany and Representations of Nature*, Cambridge, 1996, 258-92; M. Dettelbach, Humboldtian Science, in: N. Jardine, J. Secord and E. Sparry, *Cultures of Natural History* (1996) 287-304 ; H. de Terra, *Humboldt: The Life and Times of A. Von Humboldt*, New York, 1955.

⁵ de Humboldt, *Voyage* (note 3), 490.

⁶ de Humboldt, *Voyage* (note 3), 515.

⁷ de Humboldt, *Voyage* (note 3), 537-38.

⁸ de Humboldt, *Voyage* (note 3), 515.

⁹ de Humboldt, *Voyage* (note 3), 517.

¹⁰ de Humboldt, *Voyage* (note 3), 515.

¹¹ D. Diderot and J. D'Alembert (Eds), *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers par une société de gens de lettres*, vol.X, Paris and Neuchâtel, 1751-1765.

¹² M. Clozier, *Mémoires de mathématique et de physique présentés à l'académie royale des sciences*, vol. II, Paris, 1755.

¹³ B. Debarbieux, The mountain in the city: Social uses and transformations of a natural landform in urban space, *Ecumene* 5 (1998) 399-431.

¹⁴ See for example « Angles correspondants des montagnes » in *l'Encyclopédie ou Dictionnaire raisonné des sciences...*, tome 1, Paris, 1751-1765, 464

¹⁵ Jaucourt « Montagnes », *Encyclopédie* (note 11).

¹⁶ It is the case of Saussure; see H.B. de Saussure, *Voyages dans les Alpes*, vol.IV, Neuchâtel, 1796, 14-15.

¹⁷ B. Farrington, Words as new as the hills: concept formation in the field of high altitude topography (1750-1850), *French Language Studies* 10 (2000) 45-70.

¹⁸ Henceforth the word will be written without quotation marks. However, one should regard the word not a description of geographical reality, but a discursively produced category.

¹⁹ G.-L. Leclerc, *Histoire et théorie de la terre*, Paris, 1749, 69.

²⁰ Buache, *Essai de géographie physique* (note 2), 401. Writing this way, Buache uses one the two recurrent analogies developed in response to the continuity of mountain chains, the other being the skeleton. The latter, very common during the Middle Ages, was still in use in the eighteenth century, for example in Diderot et d'Alembert's *Encyclopédie* where one can find in d'Holbach's text on "montagne": "Mountains can be compared to bones, which support the globe and makes it solid, as bones in the body support flesh and others parties..." vol.X, 1751-1765, 672.

²¹ Buache, *Essai de géographie physique* (note 2), 402.

²² Planisphère Physique centré sur le pole septentrional, in: *Cartes et tables de la géographie physique ou naturelle, présentées au roi le 15 mai 1757*, Paris.

²³ As a Royal Geographer, Philippe Buache taught geography to the royal family children. See L. Drapeyron, *Les deux Buaches et l'éducation géographique de trois rois de France, Louis XVI, Louis XVIII, Charles X avec documents inédits*. Paris : Institut Géographique de Paris(1888).

²⁴ P. Buache, Sur une nouvelle disposition de mappemonde, *Histoire de l'Académie Royale des Sciences* (1755) 121-24.

²⁵ P. Buache, *Cartes et tables*, Paris, 1754. The phrase – “premier coup d’œil” (at first glance) – is used at least four times in Buache writings. It underlines his belief in the pedagogic and heuristic qualities of tables and maps.

²⁶ H. Blais and I. Laboulais (Eds), *Géographies plurielles : Les sciences géographiques au moment de l'émergence des sciences humaines*, Paris, 2006, 29.

²⁷ “It would be appropriate for sailors to note, according to the concepts I have mentionned here, small phenomena that may be neglected, but which, when gathered, could lead to the discovery of a general cause ...” P. Buache, *Essai de géographie Physique* (note 2), 415-16.

²⁸ P. Buache, Carte et coupe du canal de la Manche et d’une partie de la Mer d’Allemagne, in: *Cartes et tables* (note 25).

²⁹ P. Buache, Parallèle des fleuves des quatre parties du Monde, pour servir à déterminer les hauteurs des montagnes de Globe physique de la Terre qui s’exécute en relief au dôme du Luxembourg, *Mémoires de l'Académie Royale des Sciences* (1753) 586-88.

³⁰ P. Buache, *Essai de géographie physique* (note 2), 402.

³¹ P. Buache, *Essai de géographie physique* (note 2), 408.

³² A. Miquel, *La géographie humaine du monde musulman jusqu’au milieu du 11e siècle*, Paris, 1980.

³³ Contrairement aux ouvrages qui se rattachent à ce que l’on convient d’appeler la théologie naturelle, notamment ceux que John Woodward consacre à la géographie physique du globe: J. Woodward, *Géographie physique ou essai sur l'histoire naturelle de la terre*, Paris, 1735.

³⁴ P. Buache, Observations géographiques et physiques où l’on donne une idée de l’existence des Terres Antarctiques et de leur Mer glaciale, avec quelques remarques sur un globe physique en relief, d’un pied de diamètre, qui sert de modèle pour celui de neuf pieds, *Mémoires de l'Académie Royale des Sciences* (1757) 190-204. He details the reasoning which allows him to deduce the morphology of the continent from the quantity of icebergs recorded by sailors.

³⁵ I. Laboulais, Le système de Buache: une nouvelle façon de considérer notre globe et de combler les blancs de la carte, in: I. Laboulais-Lesage (Ed.), *Comblent les blancs de la carte: Modalités et enjeux de la construction des savoirs géographiques, XVIIe-XXe siècle*, Strasbourg, 2004, 93-115.

³⁶ In French geography, Nicolas Buache de la Neuville, nephew of Philippe Buache, and Edme Mentelle, both members of the Institute, were the main promoters of this idea. See F. Labourie and D. Nordman, Introduction aux leçons de géographie de Buache et Mantelle, in: D. Nordman (Ed.), *L'Ecole Normale de l'an III : Leçons d'histoire, de géographie, d'économie politique* (Edition annotée des cours de Volney, Buache de La Neuville, Mentelle et Vandermonde), Paris, 1994, 137-61. Among German geographers, Johann Christoph Gatterer (1727-1799) borrowed the most from Buache's ideas and adopted his natural borders theory.

³⁷ On this topic, see, for the French context, D. Nordman, *Frontières de France: de l'espace au territoire, XVI-XIXe siècle*, Gallimard, Paris, 1999.

³⁸ For his contribution to the mapping of Mexico. Buffon is mentioned 233 times, and Riccioli, the Italian astronomer famous for his numerous, but approximate measurements of altitude during the seventeenth century, 79 times.

³⁹ N. Desmarests, Géographie physique, in: *Encyclopédie* (note 11). Following quotations are from the same text.

⁴⁰ I. Laboulais, Voir, décrire et combiner: les méthodes de la géographie physique selon Nicolas Desmarests, *Revue d'histoire moderne et contemporaine* 51 (2004) 38-57. On geography in *l'Encyclopédie*, see C. Withers, Geography in its time: Geography and Historical Geography in Diderot and d'Alembert's Encyclopedie, *Journal of Historical Geography* 19 (1993) 255-64 ; I. Laboulais, La géographie dans les arbres encyclopédiques de la seconde moitié du XVIIIe siècle, in: H. Blais and I. Laboulais (Ed.), *Les sciences géographiques au moment de l'émergence des sciences humaines*, Paris, 2006, 63-93 ; A. Godlewska, *Geography Unbound: French Geographic Science from Cassini to Humboldt*, Chicago, 1999.

⁴¹ Though faithful to Buache's theory, he mentions the case of the Cassiquiare: "I see only one exception to this general arrangement, it is the communication between Orinoco and a river which merges with the Amazon river", N. Desmarests, "Géographie physique", *Encyclopédie* (note 11), 622.

⁴² R. de Vaugondy, "Géographie", *Encyclopédie* (note 11).

⁴³ He happens to mention "this *massif* that one call vaguely le *plateau de Tartarie*"; but, immediately after mentioning it, he discusses its topography since many parts are of little height. A. de Humboldt, *Sur l'élévation des montagnes de l'Inde*, Paris, 13.

⁴⁴ A. de Humboldt, *Asie Centrale: Recherches sur les chaînes de montagnes et la climatologie comparée*, Paris, 1843, 155.

⁴⁵ de Humboldt, *Asie Centrale* (note 44), 51.

⁴⁶ A. de Humboldt, *Cosmos: Essai d'une description physique du monde*, Paris, 2000(1844), 57.

⁴⁷ de Humboldt, *Asie Centrale*, (note 44), 210.

⁴⁸ Letter of October 2, 1845, A. de Humboldt, *Lettres de Alexandre de Humboldt à Varnhagen von Ense (1827-1858)*, Genève, 1860. *Cosmos* contains the same idea : "Science begins for human beings when the spirit grasps the matter, when it strives to submit a collection of experiences to rational combinations". de Humboldt, *Cosmos*, (note 44), 87.

⁴⁹ A. de Humboldt, *Essai politique sur le royaume de la nouvelle Espagne*, Paris, 1811.

⁵⁰ de Humboldt, *Voyage* (note 3), 490-518.

⁵¹ On the role of scientific instruments and of measure in Humboldt's work, see: S. Provost, Les instruments de Humboldt et de Borda au volcan des Canaries, *Revue du Musée des arts et métiers*, 39-40 (2003) 112-14.

⁵² According to C. Minguet in his introduction of A. de Humboldt, *Essai sur la géographie des plantes*, Nanterre, 1990.

⁵³ A. de Humboldt, Lettre à Caroline von Wolzogen: May 14, 1806, in: *Lettres américaines d'Alexandre de Humboldt (1798-1807)*, Paris, 1904.

⁵⁴ de Humboldt, *Cosmos* (note 44), 651-66.

⁵⁵ A. de Humboldt, *Expériences sur le galvanisme et en général sur l'irritation des fibres musculaires et nerveuses*, Paris, 1799. For a detailed analysis, see W. Reise, The Impact of Romanticism on the experimental method, *Studies in Romanticism* 2 (1962) 12-22 and M.-J. Trumpler, *Questioning Nature: Experimental Investigation of Animal Electricity in Germany (1791-1810)*, PhD thesis, Yale, 1992.

⁵⁶ de Humboldt, *Voyage*, (note 3).

⁵⁷ The climb took place on June 23, 1802. Humboldt and Bompland reached the altitude of 18,000 feet, and were interrupted by a "defile" located a few hundreds meters below the summit.

⁵⁸ In the first pages of his text, he recalls how scientifically poor was such a climb: barometric measures were less reliable than trigonometric calculus made at a distance; rocks were hidden to geognostic observations; organic life was "dead in these high solitudes". However, by publishing this narrative, he seeks to answer the curiosity of his time : "Chimborazo has become the continuous object of questions addressed to me since my first return to Europe ... It will pick up from the still unpublished materials of

my dairies the very simple narrative of an excursion in mountains ... which cannot offer any dramatic interest..." A. de Humboldt, *Notice de deux tentatives d'ascension du Chimborazo*, Paris, 1838, 7-8. See also *Lettres* (note 53).

⁵⁹ de Humboldt, *Notice* (note 58), 21.

⁶⁰ de Humboldt, *Notice* (note 58), 21.

⁶¹ de Humboldt, *Notice* (note 58), 24.

⁶² de Humboldt, *Notice* (note 58), 25.

⁶³ A. Godleweska, has shown how innovative he was in this respect: From Enlightenment vision to modern science? Humboldt's visual thinking, in: D. Livingstone and C. Withers, *Geography and Enlightenment*, Chicago, 1999, 236-75; see also N. Rupke, Humboltian distribution maps: the spatial ordering of scientific knowledge, in: T. Frängsmyr (Ed.), *The Structure of Knowledge: Classification of Science and Learning since the Renaissance*, Berkeley, 2001.

⁶⁴ de Humboldt, *Cosmos* (note 44), 46. A few pages later, he writes that on equatorial mountains "it is given to human beings to observe all plant families and stars at the same time".

⁶⁵ Among very numerous possible examples, once again Chimborazo is paradigmatic: "On the shore of the South Sea, when the long winter rains are over, when the transparency of the air has suddenly increased, Chimborazo appears, like a cloud on the horizon; It isolates itself from the neighbouring peaks; it rises above the whole Andes cordillera, like that gorgeous dome - Michel-Angelo's genial work - rising above the ancient monuments encircling the Capitol" A. de Humboldt, *Sites des Cordillères et monuments des peuples indigènes de l'Amérique*, Paris, 1869, 76.

⁶⁶ A. de Humboldt, *Volcans des Cordillères de Quito et du Mexique*, Paris, 1854, 6.

⁶⁷ S. Briffaud, Le temps du paysage: A. de Humboldt et la géohistoire du sentiment de nature, in: H. Blais, I. Laboulais (Eds), *Les sciences géographiques au moment de l'émergence des sciences humaines*, Paris, 2006, 279.

⁶⁸ S. Briffaud, Le temps du paysage (note 67), 278-79. and immediately after: "The human subject of *Cosmos* is man considered as a spectator of nature, thus as a being who, in so far as he is impressed by the spectacle, in so far as he feels and sometimes reflects on it, bears within himself the unity of nature" Briffaud, *Le temps du paysage*, (note 67), 280.