did were done in fine style, largely because of their great technical skills, when it came to the famous Gunks testpiece *Supercrack* things changed. Some of the special techniques used on the early ascents of recent valley extremes, such as *Phoenix*, came into play. These included hanging on the rope to rest, work out moves, check out holds and find protection. These techniques were not used on the first 2 ascents. Of course, we may, as they said in defence, have come so far in difficulty that such debasements of the high style of the past are needed to make the climbs possible and enjoyable in reasonable amounts of time. But I do not think so. Climbs like *Gravity's Rainbow*, the first ascent of *Supercrack*, as well as some, if not all, of the efforts of climbers like John Bachar, Dale Bard, Max Jones, Tony Yaniro and Jim Collins prove that today's hardest climbs can be done without the need to sacrifice style for difficulty. Someday, as ultimate difficulty is approached, this will happen. But I think it better to be forced into bad style then rather than to use human limitations now as an excuse for an easy path to success and notoriety.

Note

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The history of altitude

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(Translation: H. Pursey)

Writers of historical studies of mountains have concerned themselves only with their exploration and conquest. To us, it seems natural to admire the beauty of mountains and to find pleasure in mountaineering, and it seems remarkable that nobody showed any desire to climb them before the latter part of the 18th Century. A few ascents are recorded prior to this, such as Petrarch on Mont Ventoux or Antoine de Ville on Mont Aiguille, but these were rare, scarcely significant exceptions.

Mountains were in fact discovered during the 18th Century, not only as objects to be studied and explored, but also, in a deeper sense, as a geographical and physical phenomenon, the supreme manifestation of terrestrial relief. Certainly the word 'mountain' has always existed, as have the sensations of ascent, elevation, height and their converse. But everything indicates that these ideas remained wholly subjective, with no real understanding of the phenomenon of relief until measurement of altitude led to a more objective view. The vision of terrestrial relief which we have today seems natural to us, in the same way as perspective in painting. But in both cases these apparently simple representations were preceded by others which appear to us today to be more complex. It is this history of altitude, the first manifestation of terrestrial relief which I shall try to retrace.

Here, as in many other domains, everything starts in ancient Greece, where a theory was born called, by good luck, the theory of the rotundity of the earth. This problem obliged the Greek savants to make an objective assessment of the heights of

mountains in order to prove that these were negligible in comparison with the size of the Earth itself. Dicaearchus, in about 300 BC, and then Eratosthenes, known for his measurement of the terrestrial meridian, and Xenagoras, estimated the heights of various peaks, including Mount Olympus, at less than 2000 metres, a gross underestimate arising probably from incorrect assumptions in their work. As to the techniques employed, these can only be guessed at: Dicaearchus is credited with the invention of the dioptra, an instrument for the measurement of angles, and the most likely hypothesis is that he used a geometric method.

The results are remarkable both for their relative precision and their scientific interest. But there is no end to the opinions of antiquity concerning the height of mountains, and many other ideas on altitude, much less scientific, were put out by Polybius, Strabo, Aristotle and many others. Thus Polybius confuses height with climbing time: comparing the Greek mountains with the Alps, he assumes the latter to be higher because it took 5 days to reach the 'summit' (that is, the cols which allowed a crossing to be made), while one day sufficed in Greece. Pliny went further in estimating, for the same reason, the height of the highest peaks as 50 miles.

The reverence in which antiquity was held caused these arguments to be revived up to the 18th Century, indicating why the geography of altitude remained primitive. For, with such diverse opinions, we find the same concepts appearing from antiquity to the 'century of enlightenment'. Above all, altitude is the great region of myths; mountains are not part of real, useful space, but are 'out there'. This explains why they remained unknown up to the 18th Century, and enables us to understand the persistence of certain myths. Thus, speaking of Mount Olympus, Solin conjectures that the highest summits are out of reach of weather changes, so that inscriptions made in the dust remain readable from one year to another. Buffon and de Saussure also believed this, and one can find traces of this myth of the 'purity' of mountains in numerous more recent texts, including those of some alpinists.

However, man has always managed to make use of mountains when necessary: mines, communication routes, pasturage, sometimes penetrating far into the territory of 'altitude'. In fact, it is our own conception of mountains which is ill adapted to the human geography of height; formerly, it was the model of utility—social, economic, but eventually theological and mythical—which governed the ideas on high mountains, rather than any abstract notion of height. Only the cols and the frequented areas were cited; before the 18th Century the idea of the summit, in a real sense, did not exist. The high mountain was perceived as an entity, and the same word could indicate a col, the valley it overlooked or the mountains surrounding it; but in no case did one draw attention to a particular point just because it was higher than the others. In fact no attention was paid to relief, and this explains the poor quality of the maps prior to the 19th Century, as well as the fact that people compared seriously reliefs as different as Mont Afrique (584m) near Dijon and the Alps, and the Alps themselves with Tunbridge Wells.

So altitude remained in the realm of myth in a second sense; the phenomena which occur there are not rational and quantifiable, but qualitative and subjective. Mountains are viewed in an impressionistic way, emphasizing the spectacular aspects, with no reference to the quantifiable aspects which would easily cover notions such as depth and height.

So one should not be surprised to find that great confusion reigned on the subject of altitude until the 18th Century. Most frequently people were content to repeat the opinions and speculations of the ancient world. Thus, the highest mountains were the 'Mountains of the Moon' or Mount Olympus. The very rough methods of

calculation seemed only to confirm these subjective impressions. Thus Buridan, in the 14th Century, calculated the height of Mont Ventoux (1512m) as 16km by measuring the slant height and the gradient. Furthermore, such calculations were very rare. To understand the epistemological barriers which had to be surmounted to reach a precise understanding of the problem of altitude, one must remember that the savants of the Middle Ages believed without difficulty that the sea was higher than the land, and that rivers flowed upwards towards the sea, from subtle consideration of Aristotelean physics.

Hence the Arabian geographers of the Middle Ages imagined that mountains must be at the edge of the oceans to prevent them from spilling over. These theories, moreover, often seemed to imply an intimate relationship between orography and hydrography. From the land, the highest mountains appeared to be those which gave birth to the largest rivers (as the 'Mountains of the Moon') or the greatest number of rivers (as in the case of the St Gotthard).

It was essentially in the Alps that scientific altimetry was born. From antiquity to the Renaissance, the only Alpine summit often mentioned was Monte Viso (3841m). Its reputation is accounted for by its situation at the sources of the Po, largely dominating the neighbouring mountains, and well visible from the plains of Piedmont—3 striking factors which focus one's view on the mountain and make one aware in a subjective manner of its great height. The same considerations explain the subsequent renown of Rochemelon (3538m). There are other summits of spectacular height—Mont Canigou in the Pyrenees, Monte Rosa from Milan or Mont Blanc from Geneva.

But an objective knowledge of altitude first arose at Puy de Dôme in the Auvergne in 1648; it was there that, at the request of Pascal, his brother-in-law measured the density of the air, using a mercury column whose height varies with altitude. This was the beginning of a series of experiments of enormous importance in the birth of alpinism, although few people now are aware of it. Not that the experiments led to an immediate interest in altitude. Pascal put forward the idea that the barometer could be used to calculate the height of mountains, without pursuing the matter any further. But the barometer required a knowledge of altitude: every study of air pressure needed correction for altitude to obtain meaningful values of the other variables which proved more interesting to the 18th Century scientists. Also, these barometric studies necessitated journeys into the high regions: Gassendi confined himself to studies of variation of barometric pressure between the basement of the Observatory and the towers of Notre Dame, but much greater displacements soon became necessary. And it became apparent that the relationship between altitude and the height of a mercury column was complicated and required a calibration by other methods, such as levelling (used by Monge and Deluc) or trigonometric measurement. Thus, from purely conjectural calculations on unseen mountains they passed on to direct experiments on the most readily accessible peaks; geographers gave way to physicists. These methods of height measurement were in fact well known in the 17th Century, and were used in many professions—for instance by land surveyors, by the army and often to estimate the height of buildings; they had been fully described in the great geographical works of the 17th Century, such as the *Geographia generalis* of Varenius and the *Geographia reformata* of Riccioli. It was not until the 18th Century, however, that they were applied to mountains.

But we should firstly take note of 2 precursors, the brothers Nicolas and Jean-Christophe Fatio de Duillier. From Geneva they would often have seen Mont Blanc, and they decided in 1685 to make measurements of it. They would do this

trigonometrically since climbing was out of the question; their result (4728m) is relatively accurate since 2 errors cancelled out—over-estimation of the height of Lake Geneva and under-estimation of Mont Blanc compared to the Lake. It was however the birth of the supremacy of Mont Blanc which became more or less definitive a century later. From 1702, J.J. Scheuchzer travelled in the Alps with his barometer to make height measurements, and throughout the 18th Century explorers carried round this fragile, heavy and cumbersome, but nevertheless useful instrument. And what a world of high peaks was revealed—where previously the Alps had been limited to a few cols, now the mountains appeared in abundance. The St Gotthard, confused with the Titlis by Micheli du Crest in 1755, had its partisans in 1780; later the Schreckhorn, Monte Rosa, Piz Stella in the Grisons and Mont Pourri were the main competitors of Mont Blanc. Among the great explorers of high altitudes the brothers Deluc stand supreme. Anyone familiar with the history of Alpinism will recognize their importance, with the first ascent of the Buet in 1770. The sole reason for this climb was altimetry and in particular to study the variations in the density of air over a greater range than before. Jean-André Deluc made precise measurements both by barometry and by measuring the boiling point of water.

37 Using the barometer in the mountains (Photo: S. Jouty collection)

We have therefore witnessed, during this story of 18th Century altimetry, a complete reversal of values. At first, the main objective was the study of the effect on atmospheric pressure of various criteria, including altitude, but also temperature, time, humidity etc. Subsequently interest focused on obtaining a precise knowledge of the altitude at a given place. From there, alpinism was born, and it became possible to study other phenomena associated with altitude: botany, geology, geography and people. The famous 'feeling for mountains' arose as much from barometry as from a changed aesthetic sensibility.

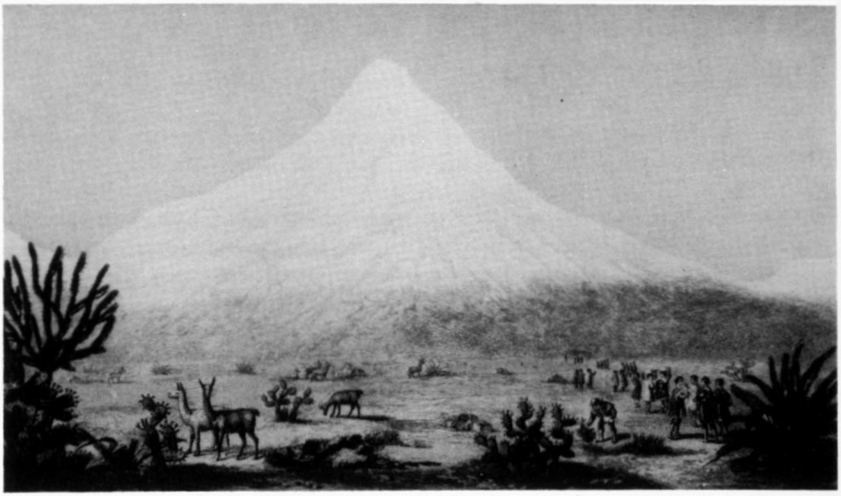
Around 1800, following the work of Fatio, Loys, Chéseaux, Deluc and de Saussure, there was general agreement over the supremacy of Mont Blanc. But altimetry was still an uncertain science, and susceptible to myths—false '4000s' appeared regularly: Mont Iseran and the Aiguille de Chambeyron were examples. The growth of measurement was slow and in 1824 von Welden could only give the altitudes of 40 peaks in the Alps, that of the Grand Combin being still unknown.

But the barometry of the first alpinists was not so useless as has sometimes been suggested. In addition to the precise measurements made by barometry, 2 other systems developed during the 18th Century contributed to a better visualization and understanding of relief—firstly, relief maps, of which the first appeared towards the end of the 17th Century; the most celebrated is General Pfyffer's map of the Oberland, which all travellers went to see from 1762 onwards. Secondly, there was the development of the use of contour lines, which had their origins in the measurement of sea depth, systematized as bathymetric lines at the start of the 18th Century. At the end of the Century the idea was adapted by the geographers du Carla and Dupain-Triel to terrestrial relief. From that time onwards, all the necessary instruments for understanding relief being available, knowledge of mountain regions progressed by giant strides.

The Alps were by far the best known mountains at the end of the 'century of enlightenment', but it was never thought that they were the Earth's highest.

In antiquity, the highest points of the world were thought to be Mount Olympus, the 'Mountains of the Moon' or the Caucasus (so high that its summit is still gilded by the sun after the observer is plunged into night). But after the Renaissance other rivals were put forward, though now again forgotten. Generally, these were spectacular mountains overlooking the ocean: the fact that from a knowledge of their height one could in theory determine at what distance they would appear over the horizon (a fact of interest to sailors) contributed in no small way to their success. This was the case for Adam's Peak in Sri Lanka, the peak of Sao Jorge in the Azores, and especially the peak of Tenerife in the Canaries, the real top of the Renaissance world in 1753. Years before it had been regarded by Christopher Columbus as the world's highest peak. The fact that it was climbed in 1582 gave it a certain lead over Everest. To speak of 'highest mountain' assumes some estimation of altitude, and these were by no means lacking, particularly from the Renaissance onwards. In 1649, Scipione Chiaramonti devoted a whole book to the height of the Caucasus. But the results left some room for speculation: the greatest scientists of the 17th Century gave estimates for the Pic de Tenerife between 1000m and 100km! To understand this one must enter the spirit of the age. For Eratosthenes, the height of mountains was a means of verifying a geodesic theory. For scientists of the Renaissance and the 17th Century, speculating on the heights of mountains was not yet considered as experimental science (which was born from the astronomy of Galileo and Newton); rather it was a problem in itself, a subject for marvelling before the mysteries of nature, in the same way as the intelligence of stones, in which Kepler believed.

By the 18th Century the climate had changed; experimental science was born, and one had passed from 'the world of more-or-less to the universe of precision', in the words of the scientific historian Alexandre Koyré, while barometry was leading to a growing interest in height for its own sake. This is why the myth concerning the Pic de Tenerife started to wane in 1724, when the elder Feuillée calculated the height by trigonometry—nevertheless the method had been known from the end of the 16th Century. Since the Pic de Tenerife measures only 2215 toises (1 toise = 6 ⅔ ft approx) the Alps should have won easily. But in 1735 another event occurred: the Paris Academie des Sciences sent a group of scientists to S America to measure the arc of the meridian. During the course of this great undertaking Bouguer measured Chimborazo, giving it a height of 3220 toises (6279m). It still dominated the world without challenge in 1808. All the geographers of the Century believed in the supremacy of the Andean Cordillera, and one remembers Acosta, who in 1596 maintained that the Alps were by comparison as 'houses next to towers'.



38 Chimborazo (Photo: AC collection)

By the early 19th Century altimetry was well and truly born. Every explorer had his barometer and estimates of height came in from all over the world. Then in 1804 the idea of the supremacy of the Himalaya began to appear. In 1808-09 Webb calculated the height of Dhaulagiri as 8187m. This was the end of the supremacy of Chimborazo; in 1847 Kangchenjunga took over and, in 1852, the surveyor General A. S. Waugh, successor to Sir George Everest, calculated the height of Peak XV of Nepal: 8840m. After a long series of trials and errors the roof of the world at last emerged. Could it be said that this was the end of the story of altitude and that alpinists now took over from calculators? Not entirely. At regular intervals, the myth of a 'higher than Everest' seems ready to reappear.

And a few anecdotes show how far altitude, notwithstanding the rigour of modern calculations, remains a political matter: the battle between France and Italy for sovereignty over the summit of Mont Blanc; the Indian journals which present Nanda Devi as an '8000 er', or again Pakistan, which has recalculated the height of K2 so that Everest now appears to dominate by only 2 rope lengths.

Bibliography

There are very few references available on the history of altitude. The following list gives some articles which may be consulted:

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In addition to these articles information can be gleaned from a variety of sources: histories of geography, science and techniques, Alpine history, etc.