# The Art of Manual Stone Carving as a Leap to Its Virtual Future

Jacques Beck
Sculptor
Chemin des Baraques 10
B-1410 Waterloo, Belgium
E-mail: point.lumiere@gmail.com

## Abstract

In conjunction with the talk and the exhibited multisculpture works in stone complementing our participation to the Pécs 2010 conference [1], this paper wants to deliver in phenomenological terms a closer look at the very generic side -geometrical aspects and mechanics- of the perennial practice of manual stone carving. This can become a base for future bridging to maths and applied maths that nowadays buttress all knowledge, including the most subjective : art itself. The possibility for modeling is evidenced by the literature available in the neighboring domain of the tooling industry devoted to percussive rock drilling. One can even start dreaming of beyond. As this short paper holds but limited iconography, more and larger images are provided on the Conference Disk.

## As a Thousands of Years Old Art Form, Stone Carving Requires a Philosophical Preamble

At first glance, it seems difficult to cast the craft and art of manual stone carving into a mathematical form, a very different language, one of logical deductions. Stone carving follows a number of rules that belong rather to the language of a more intuitive experience. However, a parallel can be drawn between science and art, as Jean d'Ormesson says : *Les hommes découvrent et ils inventent. Quand ils découvrent, les unes après les autres, les lois cachées de la nature et ce qu'ils appellent la vérité, ils font de la science. Quand ils se livrent à leur imagination et qu'ils inventent ce qu'ils appellent de la beauté, il font de l'art. La vérité est contraignante comme la nature. La beauté est libre comme l'imagination* [2]. {Men discover and invent. When they discover, one after the other, nature's hidden laws and what they call the truth, they do "science". When they give free rein to their imagination and they invent what they call "beauty" they do art. Truth is as exacting as nature, beauty is as free as our imagination.}

True art transcends time. In this, it is very different from science, where each successive step taken is likely to render obsolete those taken in the past, before themselves being rendered obsolete by some new discovery in the future. It would seem art is static and timeless versus a dynamic and evolving science. But enough of absolutes: who would wish to assert that Euclid is obsolete ?

To paraphrase Umberto Eco [3], the tools (point chisel and mallet), are *biological* extensions of the hands. Machines do not, as yet, possess biological features (but for how long? Isn't the dexterity of certain manual gestures already transposed into another, equally rich, manual handling of small machines ?) Electro-mechanical tools require a source of energy which dents our autonomy and freedom (but also gives us some new form of freedom in exchange; but then, at what price?)

Anyway, I personally like keeping myself from using too many machines for cutting and carving stone, an activity that expresses itself in an intense dialogue of which the tools guided by the hands are the main vectors. To use an audacious metaphor, if math can break through Planck's Wall by reasoning, the generative act of the artist empowered by an overwhelming emotion may prove capable of crossing a hypothetical *Planck's Wall of Art*. Just as the sudden *high* the artist sometimes experiences, a disconnect from the space-time reality, brings us to kind of a *Gödel's Theorem of Art*, or the principle that 'you

cannot be both judge and party', in turn might suggest a *Heisenberg Uncertainty Principle of Art*... (Incidentally, frontier journeys speaking, all 3 found together in [4]).
In this paper, I wish to analyze multilateral relations exerted by each hand of the sculptor, the stone and the link in between, the point chisel, one of the main carving tools, chosen here for the occasion, and its fellow mallet.

## The Sculptor, as the Inspired Creator

Considering only those who are right-handed, the sculptor holds in his left hand the tool, that he strikes with a mallet held in his right hand. Thus, the active hand is the left hand, and by extension, the left arm and the left side, controlled by the right brain, that part which is said to govern the creative aspect of ourselves as well as our understanding of space. Could this advantage right handed sculptors ? The right hand of the sculptor is working through the mallet, and gives the force acting on the 'point chisel' vector. It is clear that this force must be controlled, whilst keeping in mind that the direction given to it emanates from the left side. Interestingly, a deeper study might assess if this two-handed aspect of sculpture means that, depending on the relative merits of contradictory effects there could be any difference in terms of right or left handedness between a sculptor and a painter, in favor of a left handed painter and a right handed sculptor.

## The Point Chisel, Vector of the Intention of the Left Hand

We only consider here the point chisel (Fig. 1d) and not the tracing point the use of which is directed to another goal. It is the roughing tool par excellence: the impacting tip of the point, which creates in the stone a region determined by the translated impact force and direction of the strike on the head of the chisel, on the one hand, and on the other by the characteristics of the tip (Fig. 1d), it adapts to all surfaces, irregular, rounded, indented, concave, convex, flat, sawn, raw, and to all kinds of stone.
The *shape of the tip* depends on the hardness of the stone. The angle of the conical taper of the tip ranges from 45° for granite, to 20° for marble (semi-hard). For the former, the tip is coated with tungsten carbide, for the latter, it may be carbide-tipped too, or only hardened steel.
The *section of the chisel,* generally of octogonal section, depends on the fineness of the work to be obtained: 0.8 to 1.2 cm for fine cutting, 1.2 to 1.5 cm for roughing.
The *position on the stone* requires an angle that opens with the hardness of the stone, as well as by the nature of work to do. The open angle of incidence required for hard stones (about 70°), measured from the plane tangent to the stone as looks natural to sculptors) causes a deeper rough and a pulverizing shattering of the stone. A more closed angle of incidence (e.g. 30°) provides a shallower rough and thicker and longer chunks. An angle of 30° also allows greater accuracy of work. The percussion can never be orthogonal to the target as then the tool *buries,* which would result in the formation of a crater and injure the stone in depth, as marked by the apparition of a *stone bruise* or *white mark* (Fig. 1a) which may


Figure 1. *a. Stone bruises or white marks by point chisel; b. point chiseled texture; c. mainly point chiseled works in various kinds of stone; d. point chisels, mallets and safety glasses.*

occur several years later on smoothed and polished stones. The same phenomenon occurs inevitably with the bush hammer if we soften the stone.

## The Mallet, Force of the Right Hand

The mallet (Fig. 1d) represents the controlled force, and its longstanding shape stems from centuries of practice. High speed camera images could show that the mallet is accelerated in a curved movement and driven against the head of the chisel in a perfect tangential alignment to its axis defined by the left hand. The curved path results from the body movements, the main one being a circular swing of the forearm around the elbow held close to the side of the chest to shorten the kinematic links for precision (during the Middle Ages companionship training, apprentices were required to hold two bottles under the armpit, I'd rather recommend plastic ones now!) To ease the handling through the wrist and ensure a flat impact on the head of the chisel, the mallet head is slightly curved according to the curve of the swing movement, and has its striking sides tapered in an alignment along the local radius of the curve at the impact point. It goes without saying that the geometry is chosen by the sculptor to fit his/her personal style. It is always manufactured in forged steel, with a weight that varies with the nature of the work to do but usually ranges from 750gr. to 1.5kg. Like in sport, new technologies help improve efficiency and alleviate stress.

## The Nobility of Stone

Each type of stone has its own morphology. Within each species there are significant differences in terms of cohesion, hardness and even color (Fig. 1c). Each block has a personality that makes it unique and captivating, with its areas of weakness, its flaws, laminations, inclusions, but also by its hardness, strength, beauty. What is required from the sculptor is knowledge, respectful attention, and even intuition, which binds him in love to the stone. Often, the sculptor is looking for a structure that is as homogeneous as possible, as determined by the quality of the stone. So for Carrara marble, *statuary* is the quality most prized. Nevertheless, an excellent statuary looks like a sugar cube with an almost perfectly homogeneous structure. It's the same for the blue stone categories ABC, where category A is reserved for sculpture. These features allow greater freedom to the sculptor without leaving any say to the stone. In my case, I much prefer dialogue, respect for the material with its zones of hardness and brittleness, which require the artist to fit in with flexibility and respect with the materials with which he works, rather than act with superiority and conceit.

### Bringing All Four Ingredients into a Dynamic Relationship

Having briefly outlined the four levels of stone carving, I propose to relate them temporally: a choreography of the hands of the sculptor acting on the stone through the tools. The sculptor seeking to obtain a shape provides to the point chisel a *force x* in three stages: the first and second hits, light, are used to engage the tip of the tool. The third hit, heavier, aims to break off a chip of matter. It would be too simple, though, to reduce this operation to the three strokes. Indeed, a steady *rhythm* will result in greater regularity of work. This music generated by the tool divides time as sounds that the sculptor perceives as a healthy area for a clear sound, or a structural weakness of the material in case of a dull sound. The third hit, the power hit, paramount, is the one which requires the most craftsmanship to produce the desired effect, and is itself divided into three stages. At the time of the impact of the mallet on the top of the tool-first stage-, the hand that guides it must let it go, let it act so as not to hinder its effectiveness by retaining it and thereby absorbing some of the shock aimed at the stone -second stage-. If there is coordination between the two first parts of the stroke, then the shattering of the stone may be optimal -third stage-, because the tool will bounce off the stone and the shock waves spread on the

surface, in order to weaken it and for it to be chipped away. This third phase will also require raising the point chisel in a concave upward movement in the shape of a spoon, this seeks to shatter the stone and remove splinters. Nevertheless, it is important not to hurt it, which would lead in time to in-depth micro-cracks inducing *spalling*. Bush hammering, for example, causes this type of phenomena. Finally let's insist on how important it is to keep fixing one's gaze on the tip of the chisel rather than on the head, for precision and ...for saving fingers !

### Conclusions and Expectations for Virtual Progress

These phenomenological thoughts can only be fully understood and dominated by feeling, and thus by extensive practice. This shows a deep pleasure experienced by the artist (I would highly recommend movies [5]). But, after insisting on the manual approach, central in this paper, it certainly also highlights the difficulty of an adequate modeling that helps improve the tools, understand the materials and guide the hands, in an arts setting, as opposed to a traditional industrial setting. It was indeed the need to use powerful drilling machines that was the basis for detailed scientific investigations of the mechanisms of stone fragmentation by abrasion and/or percussion. The fine numerical simulation techniques, such as the finite element method [6, 7, 8], themselves made possible by using ever more powerful computers and algorithms to include an important number of factors, provide optimum results which incidentally start echoing, still without matching in all its very specifics, what the artist happens to feel in the exercise of his profession. One could even foresee, like in many other domains, when all the facets of craft (first) and of art (the most subjectively difficult) are mastered by computers, that one day we might see emerge robots overtaking human artists as acknowledged by blind comparisons [9]. But before that, it shouldn't take long for instrumented human hands to induce virtual sculptures in stone where the whole process of generation would be re-playable at will, and accessible from all possible viewpoints, as directed by the 'performer'.

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