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***The civil uses of gunpowder: demolishing, quarrying, and mining (15th-18th centuries). A reappraisal<sup>1</sup>.***

I. With his usual sense of humour, Carlo M. Cipolla, in his successful volume on economic history of Europe, devoted a section to what he calls “negative production”: that is, the use of capital and labour not to create but to destroy wealth and human lives<sup>2</sup>. His choice of examples is extensive, from single murderers to armed bands, from terrorism to warfare; in the latter, he notes, capital consisted of cannons and the labour of soldiers. There is little doubt that, in the course of time from the 14th to the 18th centuries, most of the energy deriving from black powder was used for negative production. Even authors such as André Varagnac, who place the advent of explosives among the great energy revolutions in the history of man, only examined the cultural, social, institutional and political transformations resulting from the military use of gunpowder, but nothing else<sup>3</sup>.

In this work, instead, we consider the directly productive uses of black powder - which were certainly minor, especially initially - but which gradually increased, in absolute if not in relative terms, with the approach of the 19th century. The chemical energy liberated by black powder – a very rapid form of combustion, with the more or less instantaneous generation of large quantities of gas and thus of very high pressures – has long been historically exploited in two directions: either as a propulsive force – the case of firearms – or as a purely destructive one, for blasting purposes. The civil and productive uses are a development, or rather a disciplining, of the latter application. Clearly, the demolition of a wall or a building did not necessarily fall within military or civil scope; it depended on the

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<sup>1</sup> June 2009. We take up again, with some additions and updatings, a work already published in Italian in *Economia ed energia. Secc. XIII-XVIII*. Atti della XXXIV Settimana di studi dell’Istituto internazionale di Storia economica “F. Datini” (Prato, April 15-19 2002), ed. S. Cavaciocchi, Florence, 2003, pp. 865-878. It is a topic we already dealt with thirty years ago in our paper “Gli inizi dell’uso della polvere da sparo nell’attività mineraria: il caso veneziano”, *Studi veneziani*, n.s. 3 (1979), pp. 97-140. The work by J. Vozár, “Der erste Gebrauch von Schiesspulver im Bergbau (die Legende von Freiberg, die Wirklichkeit von Banská Štiavnica)”, published at almost the same time in *Studia Historica Slovaca*, 10 (1978), pp. 257-80, summarised the bibliography of the German area on the question and also published the essential records on the experiment of Schemnitz (now Banská Štiavnica). Since then, many elements have enriched our knowledge on the subject. As well as new research quoted below, of great utility were the reports, information and criticisms by Benny Arbel, Enzo Baraldi, Björn Ivar Berg, Pierpaolo Brugnoli, Brenda Buchanan, Gigi Corazzol, Graham J. Hollister-Short, Karl-Heinz Ludwig, Luca Molà, Walter Panciera, Francis Pierre, Julio Sánchez Gómez, Liviu Sofonea, Martin Štefánik, Rudolf Tasser, Marco Tizzoni and Heinz Walter Wild.

<sup>2</sup> C.M. Cipolla, *Storia economica dell’Europa pre-industriale*, Bologna, 1997<sup>6</sup>, pp. 129-31.

<sup>3</sup> A. Varagnac, *La conquête des énergies. Les sept révolutions énergétiques*, Paris, 1972, pp. 161-91.

objective of the moment. The first idea of blasting – not the true invention (we do not know if it was actually put into practice) – appears in 1403, when a Florentine engineer pondered on how to open a breach in the walls of Pisa by exploding a charge of black powder inside an old walled-up gate<sup>4</sup>. His objective, in this case, was military. Perhaps as early as 1409 (the date is very uncertain), blasting was used to demolish the walls of the convent at Chablis (near Auxerre, in Burgundy) to recover stone for building<sup>5</sup>. In this case, the aim was productive.

It must be noted that many of the first records of blasting, especially in the 15th century but also occasionally in the 16th, remain dubious. In the case of blasting for military use, the sources do not always distinguish truly explosive mixtures from the incendiary ones which had been used since ancient times in warfare. In addition, in both fields of application, military or civil, there is often confusion between blasting and fire-setting (*mise-à-feu*, *Feuersetze*, *lavoro a fuoco*), a well-known technique which had been practised for thousands of years in quarrying, mining, and other spheres of activity.

It is very probable that black powder ‘mines’ were already being used around 1450 for military purposes, as suggested in the famous drawings of the Tuscan engineer Jacopo Mariano, called Tàccola. In any case, the first certain evidence of the underground blasting is that of the sieges of Sarzanello (Liguria) in 1487 and Castel Nuovo in Naples in 1495<sup>6</sup>. As regards civil uses, as we shall see, the first definite record only appears around 1480. But whereas blasting for military purposes then spread all over Europe, for more than a hundred and fifty years civil and productive applications were extremely rare. For example, in 1606, the decision of the Archbishop of Salzburg to use gunpowder to demolish one of the fortified towers of the city was greeted with astonishment<sup>7</sup>. The reasons for this delay are two-fold. The first was the scarcity and consequently high price of the main ingredient of black powder, saltpetre. This was a strategic commodity, and governments kept it under strict control and were not prepared to sacrifice it for purposes other than for defence and war<sup>8</sup>. Only later, between the 16th and 17th centuries, the diffusion of nitre works meant that saltpetre became more easily available and the effect of economic and political restrictions on the civil use of black powder waned.

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<sup>4</sup> C. Promis, *Della origine delle moderne mine. Memoria storica V*, appendix to Francesco di Giorgio Martini, *Trattato di architettura civile e militare*, ed. C. Saluzzo, part II, Turin, 1841, p. 330.

<sup>5</sup> A. Salamagne, “L’attaque des places-fortes au XV<sup>e</sup> siècle à travers l’exemple des guerres anglo- et franco-bourguignonnes”, *Revue historique*, 117 (1993), n. 585, p. 101.

<sup>6</sup> J.R. Partington, *A History of Greek Fire and Gunpowder*, Baltimore, 1999<sup>2</sup>, pp. 171-74.

<sup>7</sup> K.-H. Ludwig, “Die Innovation des bergmännischen Pulversprengens. Schio 1574, Schemnitz 1627 und die historische Forschung”, *Der Anschnitt*, 38 (1986), p. 120.

<sup>8</sup> G.E. Sandström, *The History of Tunnelling. Underground Workings Through the Ages*, London, 1963, pp. 277-79. Cf. particularly for the Venetian case, W. Panciera, “Ancien régime e chimica di base: la produzione del salnitro nella repubblica veneziana (1550-1797)”, *Studi veneziani*, n.s. 16 (1988), pp. 45-48.

The other reason for the delay is the intuitive fact that the civil and productive applications of blasting required a far greater degree of control than purely destructive, military ones. There is of course a great difference between a military ‘mine’ of fourteen barrels of powder, as depicted in the famous engraving by Biringuccio (1540), and a charge of only one or two pounds, which was the weight commonly used for blasting in mining in the late 17th century. But, as we shall see, there were also intermediate dosages. And above all, there is a strong continuity, both technical and conceptual, between the two situations<sup>9</sup>. In both cases, the quantity of black powder, in proportion to the purpose for which it was to be used, was placed in a closed environment, either a mine chamber, or a hole expressly bored in the rock. A whole series of small inventions, adaptations and improvements took place over many decades, and dealt with the composition of the powder itself and its appropriate quantity, the shape of the tool used to penetrate the rock (the borer), the nature of the cartridge containing the explosive, and so on. Miners were very commonly employed as sappers in times of war in Europe from at least the 14th century onwards, and they probably represented a channel of transmission, and a refining instrument, of new competences in black powder<sup>10</sup>. This was one prelude to its entry into the sector of mining, the principal one in the framework of the civil and productive applications of this new source of energy.

2. The first civil uses of gunpowder of which we have certain knowledge mainly refer to demolition works: we are still close to the techniques of military blasting, which generally required considerable quantities of black powder. This also explains why it was so rare. Mention has been made of the use of powder for the *pertuis du Viso*, a gallery excavated between 1478 and 1480 in the mountain of the same name, to facilitate communications between the Dauphinate and the Marquesate of Saluzzo<sup>11</sup>. But available sources exclude the use of powder, and indicate rather the ancient technique of fire-setting<sup>12</sup>. At that time the controlled use of underground explosives was a practice still in its infancy.

<sup>9</sup> On this point, we dissent from the view of G.J. Hollister-Short, “Gunpowder and Mining in Sixteenth- and Seventeenth-Century Europe”, *History of Technology*, 10 (1985), p. 54, who definitely denies any continuity.

<sup>10</sup> R. Vergani, “Entre la mine et la guerre: la circulation des hommes et des techniques du XIV<sup>e</sup> au XVII<sup>e</sup> siècle”, paper presented at the international conference *Les mines en Europe du Moyen Age au XX<sup>e</sup> siècle* (Paris, January 27-29 2000). Partially published in Italian under the title “Tra la miniera e la guerra: minatori veneti a Candia 1648-1669”, *Archivio veneto*, n.s. 159 (2002), pp. 5-17.

<sup>11</sup> As stated by G. Castelnovo, “Tempi, distanze e percorsi in montagna nel basso medioevo”, in *Spazi, tempi, misure e percorsi nell’Europa del Basso medioevo*. Atti del XXXII Convegno storico internazionale, Spoleto, 1996, p. 232.

<sup>12</sup> Cf. L. Vaccarone, *Le pertuis du Viso. Étude historique*, Turin, 1881, pp. 10, 15, 57, but particularly p. 91, where a record dated January 23 1478 mentions “cutting down wood... for fire-setting” (“coupper le bois... pour donner le feu”).

In 1481-82, black powder was used to widen the Brenner road between Bolzano and Bressanone and make it fit for traffic. This information comes from the Dominican friar of Ulm, Felix Faber, who passed through those parts in 1483, on his way to the Holy Land: “the duke – he writes in his travel diary, referring to Sigismund of Austria –, using fire and cannon gunpowder, shattered stones, flattened rocks and moved great boulders” (“*Dux fecit arte cum igne et bombardarum pulvere dividi petras, et scopulos abradi, et saxa grandia removeri*”) <sup>13</sup>. Between 1511 and 1520, the stretch of the Predil road between Tarvisio and Caporetto, in eastern Friuli, was repaired and widened “with special fire” (“*cum ignibus appositis*”) <sup>14</sup>. This may have meant blasting, but equally fire-setting. Unfortunately, direct sources do not remove this doubt <sup>15</sup>.

In other cases, what may be defined as a ‘civil’ use took place in a military context which, for well-known reasons, also made black powder easier to obtain. In 1515, for example, the French troops led by Gian Jacopo Trivulzio advanced across the western Alps, blowing up “enormous boulders” with ‘mines’ <sup>16</sup>. This was certainly not an isolated instance: a late 16th-century artillery manual states that, whereas the old workers often used picks, iron wedges, and fire-setting “to shatter solid rock rapidly, in order to open up a passage for armies and water.., in our times, experienced masters of ‘mines’ do this work with gunpowder” (“*per rompere con prestezza i vivi sassi et aprir il passo à gli eserciti et alle acque.., si è tolto à nostri tempi da valenti maestri delle mine l’uso di romperli con la polvere*”) <sup>17</sup>.

Civil uses of gunpowder became relatively more frequent in the second half of the 17th century. In London, during the Great Fire of September 1666, which razed entire quarters of the city to the ground, one last outbreak was isolated and finally quenched by demolishing the surrounding houses with gunpowder <sup>18</sup>. In 1671, black powder was used to open up the road between Valsassina (Lombardy) and the Chiuso bridge <sup>19</sup>. Between 1666 and 1692, a colossal engineering work – the building of the Languedoc canal, connecting the Mediterranean and the Atlantic – was finally terminated. The highest part of the canal passes through a gallery 165 metres long – the first time gunpowder was used in work of

<sup>13</sup> F. Fabri, *Evagatorium in Terrae Sanctae, Arabiae et Egypti peregrinationem*, ed. C.D. Hassler, I, Stuttgartiae, 1843, p. 71. Cf. also G. Conta, “Le carte itinerarie di Erhard Etzlaub (1455 ca.-1532). Le Alpi e i passi alpini”, *Archivio per l’Alto Adige*, 93-94 (1999-2000), pp. 133-34.

<sup>14</sup> U. Tucci, “La strada alpina del Predil e Venezia”, in *Erzeugung, Verkehr und Handel in der Geschichte der Alpenländer. Herbert-Hassinger-Festschrift*, Innsbruck, 1977, p. 356.

<sup>15</sup> Archivio di Stato di Venezia, Provveditori ai confini, busta 148, reg. *Filum seu liber Regiorum ab anno 1533 usque ad 1535*, f. 233r-v.

<sup>16</sup> S. Romanin, *Storia documentata di Venezia*, V, Venice, 1856, p. 301.

<sup>17</sup> L. Colliado, *Prattica manuale dell’artiglieria*, Milan, 1606<sup>2</sup>, p. 218. The first edition was published in Venice in 1586.

<sup>18</sup> *The London Gazette*, September 3-10 1666, p. 1.

<sup>19</sup> G. Arrigoni, *Notizie storiche della Valsassina e delle terre limitrofe*, Milan, 1840, p. 310.

this kind<sup>20</sup>. But in those times, techniques for underground control of explosions were already available, having been gradually improved in the sector of mining.

One original, if not unique, use was made of black powder between the 18th and 19th centuries, in the middle valley of the river Brenta (Veneto), where it was used to move rock and construct the typical terraces for growing tobacco along the slopes of the nearby mountains<sup>21</sup>.

3. Instead, some practices, which differed in principle, exploited the displacement of air caused by an explosion to clean up the atmosphere. For example, at Vicenza, during an epidemic of plague which struck the major cities of the Republic of Venice in 1575-1576, “bombs” (presumably some kind of hand-bomb or grenade) were exploded every so often, to purify the air<sup>22</sup>. Although far from effective, this practice did follow the health concepts of the times, when “miasmas” were believed to contribute towards spreading disease.

One not dissimilar function, although in a completely different context, is that described in a mining work published in Germany in 1622. The author illustrates a device using black powder which, he reports, is made to explode in underground galleries to remove and disperse the fumes caused by fire-setting. However, no mention is made of the use of powder in mining, as if such a thing were, in those times, completely unknown<sup>23</sup>.

4. The two attempts undertaken in Venice between 1560 and 1563 to use black powder to recover sunken ships do not appear to have had any sequel<sup>24</sup>. One of the two attempts, that of Bartolomeo Campi in 1560 failed, and there is no information regarding the outcome of the second, made by Antonio Surian in 1563. Gunpowder did play a somewhat secondary role in salvage operations. Available sources indicate that it was supposed to remove sunken ships from the sea bed rather, as has been hypothesised, than to expel water from the ships’ hulls and thus render them buoyant enough to rise to the surface<sup>25</sup>. In any case, searches in

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<sup>20</sup> Sandström, op. cit. (8), pp. 72-73.

<sup>21</sup> B. Scarello, *La coltivazione del tabacco nel Canal del Brenta*, degree thesis, tutor G. Morandini, Facoltà di Magistero, University of Padua, ac. year 1964-65, pp. 17 and 36.

<sup>22</sup> D.G. Kestenbaum, *Padua, Verona and Vicenza during the Plague Years, 1575-1578*, unpublished Ph.D. dissertation, School of History, Tel Aviv University, 2006, p. 304. The source is the *Cronica di Vicenza* by Carlo Arnaldi, in the Biblioteca Bertoliana, Vicenza, ms. Gonz. 22.9.40 (= ms. 2819), year 1576.

<sup>23</sup> Vozár, op. cit. (1), p. 264. This is the work by E. Montanus, *Bergwerckschatz...*, Frankfurt am Main, 1622.

<sup>24</sup> Vergani, op. cit. (1), p. 101 and notes. A similar project, which does not appear to have been followed up, was presented a few years later by a Sicilian, Gioseffe Bono: Archivio di Stato di Venezia, *Collegio, Risposte di dentro*, filza 2, f. 232, February 16 1568.

<sup>25</sup> This is the hypothesis of Hollister-Short, op. cit. (9), p. 54.

the indexes and registers of the *Senato Mar* in the State Archives of Venice lead to the conclusion that the idea was definitively abandoned after the 1560s.

5. Although the historical technical literature states that the use of black powder in stone quarrying goes back much earlier, our research has not revealed any information before the 17th century. The oldest mentioned date is that of 1621, when a chronicle of the small town of Bautzen in Saxony describes blasting operations in the local quarry in some detail (the size of the chamber and the weight of the charge – 11-12 pounds of explosive), although it also notes immediately afterwards that the experiment was not particularly economical, in view of the high cost of the black powder<sup>26</sup>. Instead, in England, the practice of blasting in stone quarries, using similar techniques and making considerable savings in terms of time and money, appears in a written report by Robert Boyle in 1671<sup>27</sup>. And in the Venetian Republic of 1717 we know that army sappers also had the task of obtaining the stone necessary for constructing public buildings by blasting<sup>28</sup>.

Overall, however, blasting generally appears to have been limited to excavating less valuable materials, such as coarse stone, limestone, and so on. Quarrying manuals state that explosive charges can be successfully employed only when it is unimportant whether or not the material obtained is much fragmented<sup>29</sup>. But this does not apply when the desired end-products are whole, uncracked blocks, like marble or cut trachyte, and other valuable types of stone. In the Carrara marble quarries, blasting was introduced, albeit on an occasional basis, during the 18th century, but only became systematically applied from 1831 onwards. However, it was soon observed that the resulting material was mainly unusable because of its small size and many cracks. This problem was later solved by the adoption of the wire saw, introduced at Carrara in 1895<sup>30</sup>. In records for the marble quarries of the Lessini Mountains, near Verona, gunpowder is only mentioned for the first time in 1905, but its use remained quite sporadic, and was soon supplanted by the adoption of the wire saw<sup>31</sup>. In the trachyte quarries of the Euganean Hills, near Padua, blasting was introduced but only very occasionally practised during the 18th century, and was quite rare until around 1880. After that time it tended to become generalised, but only in quarries producing base materials, such as coarse stone, filling rubble, or limestone, the demand for which was then greatly increasing; whereas cut trachyte was still quarried by hand for several decades thereafter,

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<sup>26</sup> H.W. Wild, W.G. Kramer, “Die Entwicklung des Zündens von Schwarzpulververladungen von den Anfängen bis zur Erfindung der brisanten Sprengstoffe”, *Bergbau. Zeitschrift für Bergbau und Energiewirtschaft*, 46 (1995), p. 459.

<sup>27</sup> R. Boyle, *Some considerations touching the usefulness of experimental natural philosophy*, II, Oxford, 1671, pp. 14-15, quoted in Hollister-Short, op. cit. (9), pp. 48-49.

<sup>28</sup> Vergani, op. cit. (1), p. 103.

<sup>29</sup> Cf., for instance, S. Bertolio, *Cave e miniere*, Milan, 1908, p. 187.

<sup>30</sup> L. and T. Mannoni, *Il marmo. Materia e cultura*, Genoa, 1978, pp. 68-72.

<sup>31</sup> P. Brugnoli, M. Donisi et alii, *Sant’Ambrogio in Valpolicella e i suoi marmi dall’artigianato all’industria (secoli XIX-XX)*, Sant’Ambrogio di Valpolicella (Verona), 2003, pp. 177 and 370.

until the advent of more advanced techniques capable of preserving the integrity of large blocks<sup>32</sup>.

The tendency to use black powder only to obtain coarser products is also confirmed by various activities which took place outside Italy. In a series of studies on French quarries for building stone in Brittany, at Caen, in Anjou – studies concentrating on Medieval times but also containing information on techniques up to the 19th century – gunpowder is never mentioned<sup>33</sup>. In the millstone quarry of Quaix-en-Chartreuse, near Grenoble, blasting was employed during the 18th century, but only to remove the layer of weathered, cracked rock covering others of good quality.<sup>34</sup> And in the quarries extracting *pierre bleue*, a sedimentary rock apparently similar to the granite found in Hainaut, a 1857 report states that blasting was not used for obtaining cut stone, but only when layers which were unsuitable for cutting were encountered, and that the resulting material was used either as blocks of coarse stone (*moellons*) or limestone.<sup>35</sup>

6. We have already seen that blasting in metalliferous mines was, from the quantitative aspect, the most important of the civil uses to which black powder was put in the 17th and 18th centuries. However, before getting down to our topic, it is as well to disencumber the field of a couple of baseless legends, which still circulate, dealing with the presumed use of gunpowder – the first in the mines at Rammelsberg in the Harz during the 12th century, and the second in the gold mines of Transylvania around 1395-96. In the first case, confusion clearly arose with the ancient technique of fire-setting, extensively practised at Harz ever since the first mines had been opened in the region<sup>36</sup>. The latter is a misunderstanding which arose in the interpretation of a 19th-century French text which does mention *mines*, but in the sense of underground tunnels and explosions for military purposes, not mining industry. This information, with the addition of several imaginary details, then passed into the

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<sup>32</sup> R. Vergani, “I costi dell’ estrazione: cave, frati e polvere da sparo nella Monselice del Settecento”, *Archivio veneto*, s. 5, 140 (1993), pp. 147-55; M.C. Billanovich, R. Vergani, “Strumenti e tecniche delle cave euganee: documenti e testimonianze”, *Terra d’Este*, 5 (1995), n. 5, pp 59-80.

<sup>33</sup> Reference is made here to the works of J.-P. Leguay, L. Musset and D. Prigent, in *Pierre et métal dans le bâtiment au Moyen Age*, ed. O. Chapelot and P. Benoît, Paris, 1985.

<sup>34</sup> A. Belmont, “La pierre et le pain. Les carrières de meules de moulin de Quaix-en-Chartreuse (XVI<sup>e</sup>-XVIII<sup>e</sup> siècle)”, *Histoire et sociétés rurales*, n. 16 (2001), p. 50.

<sup>35</sup> J.-P. Ducastelle, “Extraction et débitage de la pierre bleue. Le cas des carrières de Maffle (Belgique)”, in *Carrières et constructions en France et dans les pays limitrophes*, ed. J. Lorenz and P. Benoît, Paris, 1991, pp. 43-45.

<sup>36</sup> J.H.M. Poppe, *Geschichte der Technologie*, II, Göttingen, 1810, p. 557. The note would not deserve mention if it were not for the fact that it is made, without comment, also by J.U. Nef, *La guerre et le progrès humain*, Paris, undated (orig. ed. *War and Human Progress*, Cambridge, Mass., 1950), p. 45. Poppe not only repeats the well-known legend of Barthold Schwarz as the inventor of black powder, but also writes that cannons were fired in the 11th century (*Geschichte der Technologie*, II, pp. 556 and 557).

Romanian technical literature, in which it was repeated without criticism until the present day<sup>37</sup>.

In fact, as we already demonstrated in our 1979 essay, the first documented use of black powder in metalliferous mines is that of Giovanni Battista Martinengo, about 1574, in the mountains of Schio (Veneto). But even more important in the relevant documentation is the fact that this is the first, albeit brief but clear and incontrovertible, description of the specific aspect of the new technique, the shot-hole. Filippo de Zorzi, an inspector of mines for the Republic of Venice, writes twenty years later that Martinengo, “making a little hole in the rock with artillery powder wished to open up and shatter the mountain by force, and thus discover whatever was within” (*“facendo un picciol foro nel sasso della montagna con la polvere dell’artiglieria voleva aprire per forza, et spezzar il monte, et così scoprire quello che là dentro vi si stava nascosto”*)<sup>38</sup>. For an equally vivid and direct description of the shot-hole and its use in mining, almost seventy years were to pass, until Caspar Morgenstern moved from Harz to Freiberg, in Saxony, in 1643, to give a practical demonstration<sup>39</sup>. Not even in the records of Caspar Weindl, the celebrated technician who, in 1627, introduced blasting in the mines of Schemnitz (now Banská Štiavnica) is there any mention of the technical and practical aspects of the innovation<sup>40</sup>.

It is difficult to state unequivocally that Martinengo or perhaps his collaborators were the true “inventors” of the shot-hole or not. It should be noted that, in his petition of 1572, Martinengo does not ask the Republic of Venice to grant him a patent on what he defines as a “device and new mode” of excavating mines<sup>41</sup>. Yet he presumably does not ignore the advantages of such patents, seeing that just ten years later he requests and obtains a patent for “certain buildings” for working linen. The law covering patents at that time mainly laid down two requirements: the invention should constitute a novelty within the ambit of the Republic, and it should also have an immediately productive application<sup>42</sup>. However, none of this is sufficient either to state that the procedure was absolutely novel, or, on the contrary, that Martinengo imitated or learnt from others a technique which had already been tested previously.

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<sup>37</sup> The French text is that of J.-T. Reinaud, I. Favé, *Histoire de l’artillerie. 1<sup>re</sup> partie. Du feu grégeois, des feux de guerre et des origines de la poudre à canon d’après des textes nouveaux*, Paris, 1845. Pages 278-79 report a document taken from a Latin codex in the Bibliothèque Nationale, which mentions military black powder ‘mines’, without a shadow of doubt. The codex, as noted on pp. 220-21, was composed between 1384 and 1444, and may have been subject to later addition. As regards the Romanian literature, we quote as just one example I.M. Stefan-E. Nicolau, *Scurta istorie a creatiei stiintifice si tehnice românești*, Bucarest, 1981, pp. 30-31. Particular thanks are due to Prof. L. Sofonea of the University of Transylvania, Brasov (Romania).

<sup>38</sup> Vergani, op. cit. (1), p. 104.

<sup>39</sup> Hollister-Short, op. cit. (9), p. 43.

<sup>40</sup> *Ibidem*, p. 56.

<sup>41</sup> A. Alberti, R. Cessi, *La politica mineraria della Repubblica veneta*, Rome, 1927, p. 99.

<sup>42</sup> G. Mandich, “Le privative industriali veneziane (1450-1550)”, *Rivista di diritto commerciale*, 34 (1936), part I, pp. 218-19.



On the basis of the subjective interpretation of a single fragment of a document, it has been stated that Martinengo only used blasting on the surface<sup>43</sup>. Apart from the fact that, as regards technical procedure, it does not appear to be very important – except from the viewpoint of workers’ safety – whether shot-holes were made outside or inside the gallery, our knowledge of both the context and all the records seem to indicate the exact opposite. Martinengo, according to de Zorzi, worked for “a few years”<sup>44</sup>, which certainly does not mean that he spent all his time on the surface. The area of Tretto, where he proposed to reactivate some “abandoned” silver mines, had been extensively worked about 1430, but especially between 1480 and 1530, when a complex, deep tangle of galleries, clearly visible in a later drawing of 1681, had been excavated in the subsoil. Here, workers mined not only argentiferous ore, until its apparent exhaustion around 1530, but also kaolin (“white earth”), which was mined even afterwards. In fact, in his petition of 1572, Martinengo writes that “in these places, a great quantity of kaolin is mined, beside which silver veins are usually found ... but, being in very hard rock, they are not worked” (“*in detti luochi si cava gran quantità di tere bianche, appresso le quali è solito trovarsi la vena de l’arzeno... et per esser in sasso durissimo non si mette in esecutione di cavarla*”)<sup>45</sup>. We may conclude that blasting was certainly used under-ground, and that the immediate motivation for its use lay in the hardness of the rock.

7. Once Martinengo has been given his due, it must be stated that his unquestionable record appears to have been totally ignored for several decades – the fate of many “inventions”. However, after 1980, research on areas far from “classical” ones brought to light other cases and allows us to establish the renewed use of black powder in mining at least a decade earlier than at Schemnitz.

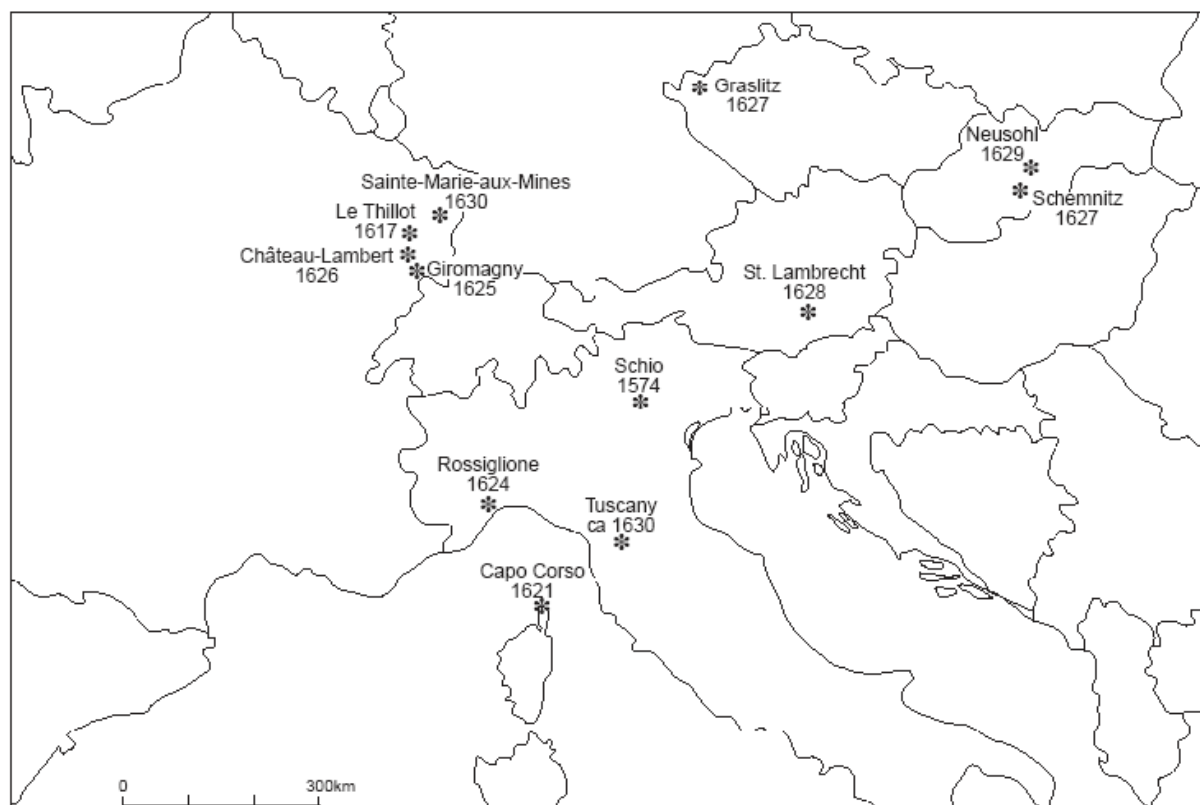
In this sense, a pilot area gradually appeared in the southern Vosges, between Lorraine, Alsace and France-Comté. In the copper mining accounts of Le Thillot, black powder appears for the first time in the fourth trimester of 1617 “to blow up the rock” (“*pour faire saulter la roche*”), and continues to be mentioned with increasing frequency in the following years, until an annual consumption of about 2000 pounds is reached in 1624. Although blasting was very probably used because of the hardness of the rock, it does not appear to have led to any significant increase in productivity with respect to the traditional

<sup>43</sup> Hollister-Short, op. cit. (9), pp. 34 and 36-37.

<sup>44</sup> Cfr. the report by Filippo de Zorzi of 1595, published by E. Oreglia, *Notizie sull’industria mineraria nella Venezia sotto il dominio della Repubblica*, Rome, 1915, p. 28.

<sup>45</sup> Alberti, Cessi, op.cit. (41), p. 100. For the general context, see also R. Vergani, *Miniere e società nella montagna del passato. Alpi venete, secoli XIII-XIX*, Sommacampagna (Verona), 2003, pp. 35-61.

method with hammer and pick, at least initially<sup>46</sup>. In the copper-lead-silver mines of Giromagny, in the former district of Belfort, black powder was certainly used from 1625 onwards. But archaeological studies in one of the remaining 17th-century galleries, together with archive data, show that definite traces of boring may go back to ten years earlier<sup>47</sup>. In the nearby mines of Château-Lambert, blasting was currently used as early as 1626, and further north, at Sainte-Marie-aux-Mines, the first definite evidence is only found in 1630<sup>48</sup>.



*First documented records of the use of gunpowder in European mines until 1630*

Another area in which the new technique appeared was between Liguria and Corsica. In the iron mines of Farinole and Olmeta, on Capo Corso, blasting was used from 1621 onwards. Shots were soon made, for prospecting purposes, when they had not yet decided whether to start mining or not and veins were still being sought. There are mentions of shot-firing both on the surface and underground<sup>49</sup>. In 1624 at Bonardo, in the territory of

<sup>46</sup> F. Pierre, “Les mines de cuivre et d’argent de la haute Moselle. Apparition et évolution des techniques de percement à la poudre noire. Le Thillot (Vosges)”, *Lotharingia*, 5 (1993), pp. 102-03 and 106-07.

<sup>47</sup> F. Liebelin, *Mines et mineurs du Rosemont, Giromagny (Belfort)*, 1987, pp. 69-70.

<sup>48</sup> *Ibidem*, p. 141 note.

<sup>49</sup> Archivio di Stato di Genova, *Corsica, Litterarum venentium ex Corsica*, filza 985, July 5 1622 and January 31 1623. The powder was used regularly from 1622 onwards, according to J.-P. Comiti, “Le fer en Corse au XVII<sup>e</sup> siècle: l’apport des textes et de l’archéologie”, in *Le fer dans les Alpes du Moyen-Âge au XIX<sup>e</sup> siècle. Actes du Colloque international de Saint-Georges d’Hurtières*, Montagnac (Hérault), 2001, p. 124.

Rossiglione (Genoa), thirty workers spent two months in an iron and silver mine, using fire-setting and blasting<sup>50</sup>. Liguria and Corsica are very close to Tuscany, where the practice of blasting was perhaps known around 1630<sup>51</sup>. In his petition of 1632 or 1633, Caspar Weindl stated that seven years previously, while in Florence, he had decided to go to Schemnitz to test blasting in the local mines<sup>52</sup>, and this might mean that he had had some experience of Tuscan methods.

In any case, this proliferation of evidence in various regions of Europe leads to two considerations. First, the unilinear hypothesis, following the scheme innovation-transmission-diffusion – a hypothesis which was once based on the Schemnitz record – is now definitely replaced by that of a new technique, which occurred in an independent and (relatively) simultaneous way in various mining areas of Europe. The second consideration deals more specifically with the locations in which the innovation appeared for the first time before 1627. In almost all cases, they were recently worked areas, where significant mining activity had only started a few decades before. They were perhaps culturally more open to innovation than the ‘historical’ locations, where traditional habits, technological inertia, and corporative resistance combined to hinder the advance of progress. Something similar had taken place a long time previously, with the introduction of the water-driven fulling-mill, which originally became popular in peripheral and ‘underdeveloped’ areas from the 11th century onwards, and only later, after diverse manifestations of opposition and hindrance, in regions of more ancient wool-working tradition like Flanders or the eastern part of England<sup>53</sup>.

8. The various stages of the spread of blasting in European mining after 1627 are well-known. However, in our opinion, we should distance ourselves, more than we have done hitherto, from an ancient and often repetitive technical literature, especially from the German area, no less ‘provincial’ than other national literatures and now repeatedly proved erroneous by ongoing research. The appendix lists in chronological order the first records known until now – at times definite, at others only probable<sup>54</sup> – of the use of black powder in European mining, with the additional observation that the list can always be integrated,

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<sup>50</sup> Archivio di Stato di Genova, *Eccellentissima Camera*, filza 158, July 2 1624.

<sup>51</sup> E. Baraldi, “Ricerca mineraria, esperti e pratici fonditori nel granducato di Toscana (XVI-XVIII secolo)”, *Ricerche storiche*, 24 (1994), p. 21.

<sup>52</sup> The petition is published by Vozár, op. cit. (1), pp. 279-80.

<sup>53</sup> P. Malanima, *I piedi di legno. Una macchina alle origini dell'industria medievale*, Milan, 1988, pp. 108-14, 128-31.

<sup>54</sup> For instance, recent in-depth research on direct sources has failed to confirm 1632 as the year when black powder was first used in the Harz mines, as the consolidated historiographic tradition believes: Chr. Bartels, “Umschwünge in der Entwicklung des Oberharzer Bergbaureviers um 1630, 1760 und 1820 in Vergleich”, in *Vom Bergbau- zum Industrievier*, ed. E. Westermann, Stuttgart, 1995, pp. 154-55.

corrected and updated. It is superfluous to mention that, in themselves, the first records are of only very relative value. At Schemnitz, we know that the practice of blasting continued and led to a considerable increase in productivity only from the petition made by Caspar Weindl in 1632 or 1633. And this source is suspect, seeing that he requested an extra reward and emphasised the fact that, in order to come to Schemnitz, he had refused an advantageous offer from Duke Ferdinand of Tuscany. In fact, the Viennese archives show that there was no particularly important continuation in the practice of blasting at Schemnitz in the first years after 1627<sup>55</sup>. To say “Gastein 1642”, as has been noted, means very little if we then discover that only a century later, in 1742, blasting had become very widespread, whereas for many decades most miners continued to work with hammer and pick<sup>56</sup>.

A simple glance at the chronology, in any case, shows a whole series of ways and factors which are very different from the concept of linear diffusion which was centred on the Slovakian mining area (although ‘German’ in meaning) and which expanded thence in every direction. For example, although the new technique had been imported into the Scandinavian countries in 1635 by German experts from Harz<sup>57</sup>, at Schwaz, blasting was definitely adopted in 1671, partly thanks to Italian miners<sup>58</sup>. Little is known of these ways and exchanges, although further knowledge by direct research of sources, neglecting the oldest historiography, may continue to supply new elements. On the other hand, comparisons between the diverse regional traditions shows us that, in several cases, the history of single areas was almost completely separated from that of other areas, especially as regards the ‘associated’ techniques which accompanied the spread of blasting: borers, plugs for shot-holes, cartridges, and so on. For example, the clay plug, which is said to have been “invented” in the German area by the Harz miner Carl Zumbe in 1687, was already known and used in the Agordo (Veneto) mines in 1682<sup>59</sup>. And the paper cartridge, which the old German historiography always considered to have been invented by the book-binder Hans Luft of Clausthal in 1689, appears already in general use in an Italian mining manual published in Bologna eleven years previously<sup>60</sup>. Even the development of the borer presents considerable regional variations – as seen, for instance, by a comparison between Saxony<sup>61</sup>

<sup>55</sup> Letter of January 22<sup>nd</sup> 2002 by K.-H. Ludwig to the author. Even in the neighbouring town of Neusohl (now Banská Bystrica), where blasting was introduced in 1629, its use was relatively limited, at least for the following decade: J. Vlachovic, *Slovenská med v 16. a 17. storocí*, Bratislava, 1964, p. 200 (thanks go to M. Štefánik for the translation).

<sup>56</sup> Ludwig, op. cit. (7), p. 121.

<sup>57</sup> B.I. Berg, “The production and consumption of gunpowder at the Kongsberg silver mines 1734-1865”, in *Gunpowder: The History of An International Technology*, ed. B. Buchanan, Bath, 1996, p. 219.

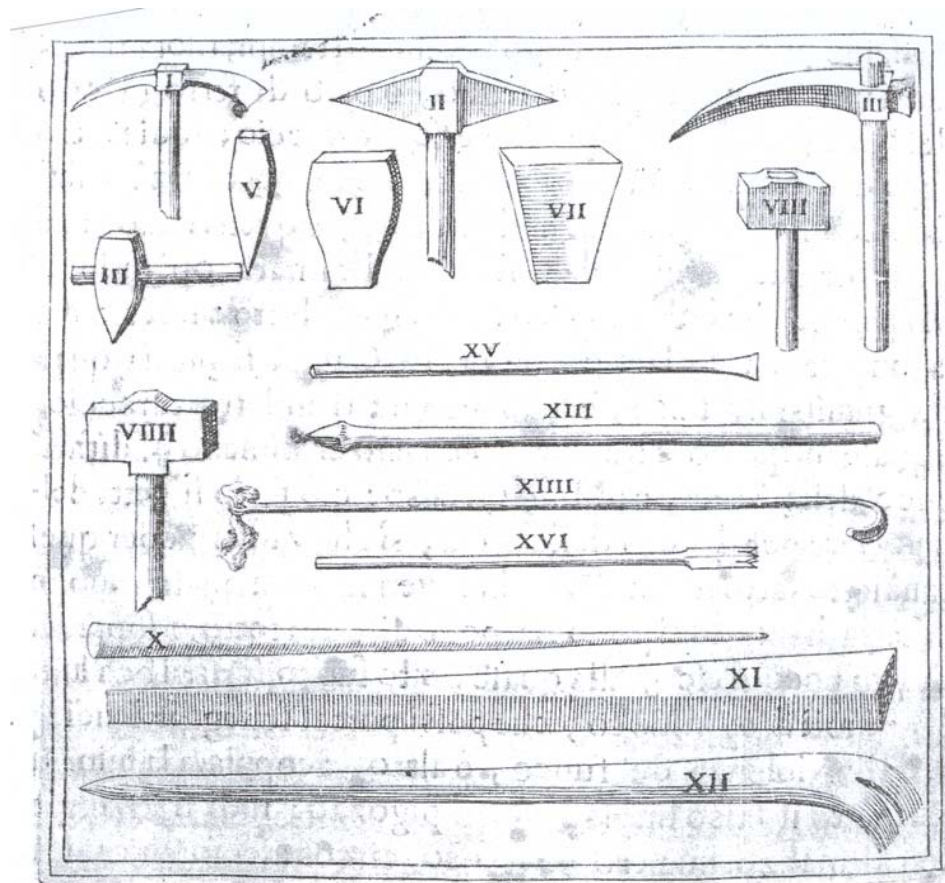
<sup>58</sup> Ludwig, op. cit. (7), p. 122, note 26.

<sup>59</sup> R. Vergani, “Innovationen im Bergbau- und Hüttenwesen im Veneto vom 16.-18. Jh”, *Technikeshichte*, 54 (1987), p. 278.

<sup>60</sup> M.A. della Fratta et Montalbano, *Pratica minerale*, Bologna, 1678, pp. 11-14.

<sup>61</sup> H.W. Wild, “Black powder in mining. Its introduction, early use, and diffusion in Europe”, in Buchanan (ed.), op. cit. (57), pp. 210-11.

and Le Thillot. The latter case was recently the object of a very interesting study falling between archival and archaeological research<sup>62</sup>. Lastly, that the German element no longer played its old role of leadership in this sector is also proven by the fact that the German imprint, always very much to the fore in European lexicons on mining and metallurgical techniques in use until the 16th century, is practically absent from the terminology referring to blasting<sup>63</sup>.



*Tools for mine blasting. Numbers XIII, XV and XVI are types of borer for drilling rock. The borer is repeatedly struck with a hammer (tool VIII) or a sledge (VIII). Tool XIII serves to clear the shot-hole of rock debris*  
(from M.A. della Fratta et Montalbano, *Pratica minerale*, Bologna, 1678, p. 14)

Experiments and improvements in the field of associated techniques definitely increased the ‘technical’ efficiency of blasting, although obviously, in choosing it, comparisons with other mining methods and comparative calculations of costs and benefits (‘economic’ efficiency) were decisive in various local situations. According to a German study, the new technique, especially initially, was confined to a given range of applications which excluded both soft rock, where hand-work was cheaper, and extremely hard rock, where perforation operations were so long and costly that fire-setting was considered

<sup>62</sup> Pierre, op. cit. (46), pp. 139-52.

<sup>63</sup> R. Vergani, “Lessico minerario e metallurgico dell’Italia nord-orientale”, *Quaderni storici*, 14 (1979), pp. 69-70.

preferable<sup>64</sup>. This was the case at Rammelsberg, for instance, where fire-setting was in use until 1878, and was only replaced by the advent of the mechanical drill. Naturally, as at Rammelsberg, firewood had to be available at competitive prices. Conversely, in some mining areas of northern Scandinavia, the scarcity of wood was one of the factors favouring the spread of blasting from 1635 onwards<sup>65</sup>. In any case, one decisive element was the cost of black powder and the constraints on its use. In England, the advent of the new technique appears to have been particularly favoured by increased imports of saltpetre from India and the Far East around the mid-17th century<sup>66</sup>.

All scholars agree that black powder was not customarily used in European mines until the first half of the 18th century, although in many places, due to that mingling of both technical and economic factors which we have briefly mentioned, the traditional techniques of hand-work and fire-setting did continue to co-exist with blasting, more or less extensively, until well into the 19th century. Before then, the only technical advance of any importance was that of setting off several simultaneous explosions inside the mine, a practice introduced in Saxony and Bohemia in 1725<sup>67</sup>.

Clearly, in the course of their generous attempts at quantifying an energy balance of the pre-industrial world, some scholars do not consider the energy supplied by gunpowder<sup>68</sup>. This is not only because of the scarcity of available data which – and only for a few mines or mining districts – are limited to the number of tons of powder used or, to an even lesser extent, to the number of explosions performed in some period of the second half of the 17th century and the following one. It is also due to a doubt: whether it is legitimate to consider in this balance only the explosive energy used for civil purposes, and to exclude the quantitatively far greater energy destined over the centuries to what Carlo M. Cipolla has called “negative production”. But, in this case, what criteria must be applied? War, as we read even in the title of a well-known work by John U. Nef, has contributed not a little to “human progress”. This is a problem which, once again, directs us to the omnipresent, perennial ambivalences of technology.

*(English translation by Gabriel Walton)*

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<sup>64</sup> Wild, op. cit. (61), pp. 209-10.

<sup>65</sup> Sandström, op. cit. (8), p. 279.

<sup>66</sup> R. Burt, “The international diffusion of technology in the early modern period: the case of the British non-ferrous industry”, *Economic History Review*, 44 (1991), pp. 257-59.

<sup>67</sup> Sandström, op. cit. (8), p. 282.

<sup>68</sup> P. Malanima, “Tra due sistemi energetici. I consumi di energia in Europa fra il 1600 e il 1800”, *Meridiana*, n. 30 (1997), p. 18.

## *Appendix*

### First documented records of the use of gunpowder in European mines

1574	Schio (Veneto)
1617	Le Thillot (Lorraine)
1621	Capo Corso (Corsica)
1624	Rossiglione (Liguria)
1625	Giromagny (France-Comté)
1626	Château-Lambert (France-Comté)
1627	Schemnitz, now Banská Štiavnica (Slovakia)
1627	Graslitz, now Kraslice (Bohemia)
1628	St. Lambrecht (Styria)
1629	Neusohl, now Banská Bystrica (Slovakia)
1630 c.	Tuscany
1630	Sainte-Marie-aux-Mines (Alsace)
1632	Agordo (Veneto)
1632	Clausthal (Harz)
1633	Zillertal (Tyrol)
1635	Radmer (Styria)
1635	Nasafjell (Lapland, Sweden)
1637	Val di Scalve (Lombardy)
1637	Prettau (South Tyrol)
1642	Gastein (Salzburg)
1643	Freiberg (Saxony)
1650	Rhineland and Westphalia
1652	Bristenstock (Uri, Switzerland)
1655	Lilledal (Norway)
1657	Røros (Norway)
1659	Kongsberg (Norway)
1662	Derbyshire
1665	Valsesia (Piedmont)
1665 c.	Ecton (Staffordshire)
1671	Schwaz (Tyrol)
1683	Mendip (Somerset)
1685	Erzberg (Styria)
1686	Lecco (Lombardy)
1687	Griff (Warwickshire)
1689	Breage (Cornwall)
1698	Almadén (New Castille)