



## VON TIROL NACH VENEDIG: BERGBAU UND GEOLOGIE IN DEN SCHRIFTEN VON GIOVANNI ARDUINO (1714–1795) – EINE WERTVOLLE QUELLE ZUR BERGBAUGESCHICHTE UND GEOLOGIE

### FROM TYROL TO VENICE: THE PAPERS OF GIOVANNI ARDUINO (1714–1795) AS VALUABLE SOURCES FOR THE HISTORY OF MINING AND GEOLOGY

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Mit 7 Abbildungen und 1 Tabelle / with 7 figures and 1 table

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#### Zusammenfassung

Giovanni Arduino (geb. 1714 in Caprino bei Verona) begann schon in jungen Jahren seine technische Ausbildung als Bergbauassistent des Eisenbergbaus in Klausen/Tirol. Später wurde er Oberassistent im Blei- und Silberbergwerk von Tretto nahe Vicenza, Venetien und Direktor einiger Kupferbergbaue im Bereich von Senese in der Toskana. Obwohl einige dieser Bergbaue unwirtschaftlich waren, nützte Arduino seine vielen Exkursionen um in einzigartiger Weise seine Kenntnisse über das „*Mineralreich*“ zu erweitern. In der Zeit zwischen 1740 und 1757 erhielt Arduino seine Ausbildung in Metallurgie und Bergbaukunde; doch mit zunehmender praktischer Erfahrung verlagerte sich sein Interesse immer mehr in Richtung Schichtfolgen, Stratigraphie und Petrographie. Seine wissenschaftlichen Theorien in den Jahren 1760 bis 1770 waren stark von seiner praktischen Erfahrung geprägt. Er unterschied in seiner Publikation 1760 bereits 4 Einheiten: das „*Primär*“, „*Secundär*“, „*Tertiär*“ in den Gebirgsstöcken sowie eine vierte Einheit in den angeschwemmten und aufgefüllten Ebenen. Zweck dieser Gliederung war es die Hintergründe der Vererzungen die sich in den Bergbauen Tirols und der Venezianischen Voralpen abbilden, zu analysieren und hervorzuheben. Arduinos Arbeiten werden heute als Wegbereiter der modernen Geologie angesehen. Zahlreiche Dokumente belegen diese Ansicht, sie können in der Manuskriptsammlung „*Fondo Giovanni Arduino*“ in der öffentlichen Bibliothek von Verona eingesehen werden. Dort werden in eindrucksvoller Weise wichtige Quellen der Geschichte der Erdwissenschaften gerettet, restauriert und neu archiviert.

#### Abstract

The Italian scientist and mining expert Giovanni Arduino holds a significant place in the history of geology, in spite of a prolonged historiographical 'impasse' which has reduced the knowledge of his studies and research. His relevant mining background, achieved in mountain areas such as Tyrol and the Venetian pre-Alps (but also the Tuscan Apennines), was at the base of a new geological expertise which led to the lithostratigraphical theory presented by Arduino in 1760 and which is widely regarded by historians as one of the main contributions to the origin of modern geology. Several documents supporting this interpretation may be found in the collection of manuscripts „*Fondo Giovanni Arduino*“ in the Public Library of Verona, which today represents a significant case of recovery and reorganization of unpublished important sources for the history of the geological sciences. The catalogue of this precious collection, published in 1994, marked the conclusion of a long work started by the author in 1987. The existence of Giovanni Arduino's collection of manuscripts was known by geologists and historians since the early 20<sup>th</sup> century. Unfortunately Arduino's

papers were not of much use in the past because of the lack of organization within the collection contained in six boxes (about one thousand handwritten papers), now newly divided in thematic folders under various subject headings: geology, mineralogy, chemistry, metallurgy, mining, hydraulic engineering and agriculture. The majority of the collection consists of Arduino's correspondence, his notes, rough copies of his writings, his geological sketches and drawings. It is a significant example of the papers of an 18<sup>th</sup> century European scientist and an impressive collection of manuscript sources that constitute an interesting case of valuable cultural heritage in the history of geosciences and mining.



Fig. 1: Portrait of Giovanni Arduino (1714–1795): in Biblioteca del Museo Correr, Venezia.

The Venetian scientist Giovanni Arduino (Fig. 1), born in Caprino near Verona in 1714, started his technical apprenticeship as a mining assistant in the iron mines of Klausen in southern Tyrol at an early age, probably between 18 and 21, around the years 1732–1735<sup>1</sup>. According to his own words, he worked *“still young in the mines of Klausen and elsewhere*

*in Tyrol, in order to learn Metallurgy; I went there by chance, and I was urged to stay by my natural very strong inclination for the universal Mineralogy, and for all the matters concerning the Science of the Fossil Kingdom”*<sup>2</sup>. There are very few sources available on the early years of Arduino's life, but it is known that in this period he visited other mining areas in the alpine territory of the Bishop of Brixen, as well as the vitriol furnaces in Pergine and Agordo<sup>3</sup>. Afterwards, from 1740 to 1748, he became Supervisory Assistant and then Director of the lead and silver mines of Tretto near Vicenza, in the Venetian Republic. From 1748 to 1752 he worked as land surveyor (*“Pubblico Perito Agrimensore”*) in Vicenza, before to be nominated in 1753 Director of some copper mines in the Senese area in Tuscany and four years later in the Apennines of Modena<sup>4</sup>.

Although some of these mines were a failure in economic terms, Arduino utilized his numerous field excursions to greatly improve his knowledge of the *„mineral kingdom”*. During this formative period from 1740 to 1757 Arduino obtained his metallurgical and mining knowledge, but his interest in the study of the Earth's strata and in the interpretation of different kinds of rocks grew together with his advanced experience in mining. This practical expertise,

together with the results of several geological excursions undertaken mainly in Veneto during the decade 1758–1768 (while he was working again as *“Public Engineer”* and land surveyor in Vicenza), determined much of his scientific theories of the 1760s and 1770s, in particular the lithostratigraphical subdivision of rocks into four units (*ordini*), published in 1760 and refined in 1774. It was a new *‘classification’* based on lithology and mineralogy, which included mountains defined as *„Primary”*, *„Secondary”* and *„Tertiary”*, as well as the terrain of the alluvial plane which was considered as belonging to a fourth unit<sup>5</sup>.

Arduino was one of the most interesting Italian geologists of the second half of the 18<sup>th</sup> century, although from 1769 to 1795 (the year of his death) he lived and worked in Venice, as Supervisor of Agriculture in the Ministry for the improvement of uncultivated land of the Venetian Republic<sup>6</sup>. His lithological researches concerned mostly the lithostratigraphy of the Venetian Alps and pre-Alps, but also the possible volcanic nature of the rocks of the same area<sup>7</sup>. These studies gave him a huge reputation within the European scientific community. His printed works, above all the *Due Lettere sopra varie osservazioni naturali* (Two letters on some natural observations) to Antonio Vallisnieri junior (1708–1777), published in 1760 in Venice and the *Saggio Fisico-Mineralogico di Lythogonia e Orognosia* (Physical-Mineralogical Essay of Lithogony and Orognosy), printed in Siena in 1774, were well known outside of Italy<sup>8</sup>. In Germany, for example, the main works of Arduino were part of private and academic scientific libraries, as they were included in the German translation of the anthological *Raccolta di Memorie Chimico-Mineralogiche* (Collection of Chemical-Mineralogical Essays)<sup>9</sup>. This edition was printed in Dresden in 1778 (Fig. 2) and was translated by the mining officer August Constant von Ferber (1746–1816)<sup>10</sup>, companion in studies and good friend of Abraham Gottlob Werner (1749–1817) in the renowned Mining Academy (Bergakademie) of Freiberg in Saxony<sup>11</sup>.

**TABLE I**

**Arduino's lithostratigraphical theory (1760 - 1775)**

(from Vaccari 2006, p. 172)

UNITS ( <i>ORDINI</i> )	MOUNTAIN TYPE	ROCK TYPE	CAUSES
1	Basement / primeval rock <i>roccia primigenia</i>	Crystalline schist <i>schisto</i>	Fire cooling of the original Earth surface
	Primary or Mineral Mountains <i>Monti Primari o Minerali</i>  a) first subdivision  b) second subdivision	Granite, porphyry and mineral-bearing crystalline rocks ( <i>rocce vetrescibili</i> ); sandstone and conglomerates without fossils	Fire, Wind & Water  a) volcanism  b) volcanism and erosion due to wind and water
2	Secondary Mountains <i>Monti Secondari</i>	Marbles and stratified limestones with fossils; stratified rocks like <i>vetrescibili</i> but without mineral veins	Water & Fire Marine sedimentation and modifications due to the reprise of volcanism
3	Tertiary Mountains <i>Monti Terziari, Colline</i>	Gravel, clay, fossiliferous sand, volcanic material	Fire & Water Volcanism and sedimentation within sea waters
4	Plains <i>Pianure</i>	Alluvial deposits, sometimes stratified	Water Erosion caused by rain and rivers



Fig. 2: Title pages of Arduino 1775 (left) and Arduino 1778 (right).



Fig. 3: G. Arduino, Notes on the mines of Schio, near Vicenza, taken by Arduino from an anonymous report (probably compiled in 1740s): in Biblioteca Civica, Verona – "Fondo G. Arduino", b. 758, II.b.27.

Arduino had also an intensive correspondence with several European scientists especially in Germany and in Sweden. Some letters were printed, mostly in the weekly *Giornale d'Italia*, a scientific journal published in Venice from 1764 to 1796<sup>12</sup>; however a considerable amount of his correspondence was never published, like several of his scientific writings. Nevertheless, Arduino kept carefully all his papers, even the rough copies of his letters: every note, letter or drawing concerning various matters (mainly mining, geology, chemistry and agronomy) (Figs. 3–6), were ordered in files, according to subject. He also kept all the correspondence he received in the relevant subject files<sup>13</sup>.

Some of the original labelled folders are still preserved in the „Fondo Giovanni Arduino“ manuscript collection, kept in the Biblioteca Civica (Public Library) of Verona in northern Italy, probably since the beginning of the 20<sup>th</sup> century<sup>14</sup>. However it is now impossible to determine their original contents as these were never catalogued by Arduino himself and after his death all the papers were in disarray.

The existence and the potential importance of this collection, especially for the study of late 18<sup>th</sup> century Italian geology, is well known to historians of Earth Sciences. The Veronese geologist Giuseppe Stegagno wrote a booklet in 1929 on the contribution of Arduino to the development of modern geological sciences, using some parts of this collection of manuscripts<sup>15</sup>. Thanks to Stegagno's research, Victor Eyles at the end of the 1960s and David Oldroyd in 1979 were able to quote the manuscripts of Arduino<sup>16</sup>. Nevertheless, from 1929 to 1990, only a few scholars examined the papers of Arduino, mainly because of the badly disorganised state of the collection in the Manuscripts Department of the Public Library of Verona<sup>17</sup>. Mario Gliozzi, in the fourth volume of the Biographical Dictionary of the Italian people, had already recalled the existence of this collection in 1962, but wrongly regarded it as being a consultable collection of handwritten papers and drawings, ordered by the geologist Tommaso Antonio Catullo (1782–1869) in the previous century<sup>18</sup>.

In reality, until the beginning of the work of reorganization, which was started by the author in 1987, the papers were contained in six boxes without any scientific or bibliographical organization. Indeed, various pages of the same manuscript were found distributed in more than one box. The classification mentioned by Gliozzi, originally contained in blue folders which are still preserved, was only begun but never completed by Tommaso Antonio Catullo and was probably lost during some troubled successive removals. The labelled folders of Catullo proved not to be useful for the new classification of the collection as the distribution of the manuscripts within the files does not now correspond with the subject headings as in the case of the original folders of Arduino. Catullo was Professor of Natural Sciences at the University of Padua and became owner of the Giovanni Arduino collection of manuscripts in the middle of the 19<sup>th</sup> century, probably in 1835, after

the death of his colleague Luigi Arduino (1759–1834), Professor of Agriculture in Padua and only nephew of Giovanni<sup>19</sup>. Catullo is also known as the first relevant biographer of Arduino: he wrote a long eulogy in 1839, utilizing a part of the manuscript papers purchased some years earlier<sup>20</sup>. Unfortunately, Catullo split up the collection as he made presentations of several letters and some manuscripts to friends and to Italian public libraries<sup>21</sup>. Since 1869, the year of Catullo's death, the collection has had a troubled history: part of it was probably lost and the remaining papers appeared to be jumbled and disorganized when Stegagno started his research.

After four years of work, from 1987 to 1990, the collection was definitively reordered by the author and a detailed catalogue of the papers was published<sup>22</sup>. Now the entire collection, more than one thousand papers, is divided in new thematic folders. They are distributed within six boxes (location numbers: *buste* 757–762), according to the different subjects of their contents. The chronological order of the papers inside every folder was always maintained as far as possible. The individual documents are all numbered: for example, „II.b.7“ means that the paper is in the second box (b. 758), folder „b“, number 7. Every box has its title: the first box (b.757), containing the correspondence of Arduino from 1758 to 1793 (sent and received letters), has a strict chronological subdivision; some of the correspondents were distinguished European scientists, such as Ignaz von Born (1742–1791), Johann Jakob Ferber (1743–1790), Alberto Fortis (1741–1803), Anton Maria Lorgna (1735–1796), Jahan Anders Retzius (1742–1821) and John Strange (1732–1799). The other boxes contain many handwritten papers, notes and drawings concerning the different fields of the scientific work of Arduino. The most important subject headings (b. 758) regard his researches about geology, mineralogy and mining of the Venetian area<sup>23</sup>, including his reports of chemical and metallurgical experiments, documents about the scientific controversies on the process of the fusion of iron and about the project for a new furnace for the evaporation of vitriol<sup>24</sup>; his agricultural and hydraulic writings for the Venetian government (b.759) and his geological sketches, mining drawings and bibliographical summaries, together with pieces of information received from various people concerning the fields of his main scientific interests (b. 760)<sup>25</sup>.

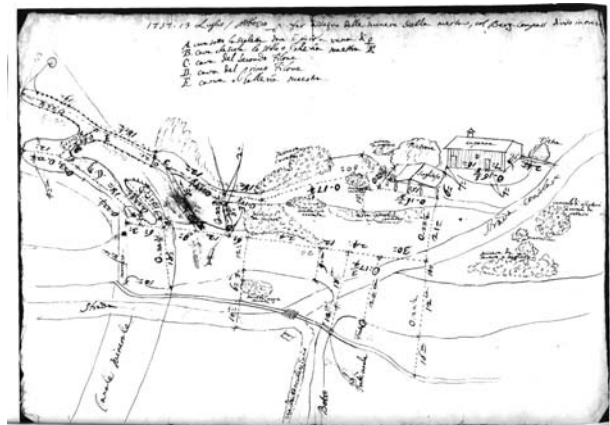


Fig. 4: G. Arduino, Map of the copper mines of the Merse Valley in Tuscany (dated 13 July 1757): in Biblioteca Nazionale, Firenze – "Palatino", 1151, c. 23.

A considerable part of the collection (b. 761) contains some handwritten writings and letters of Giovanni's younger brother, the botanist Pietro Arduino (1728–1805), and other manuscripts of Pietro's son Luigi: all these autographed papers concern various agronomical problems.<sup>26</sup> In the same box are also kept the geological correspondence between Luigi Castellini (1770–1824) and Pietro Maraschini (1774–1825), both interested in the geology and paleontology of northern Italy and Sicily during the first half of the 19<sup>th</sup> century, together with some of their geological writings and notes<sup>27</sup>. Finally, the last box (b.762) contains manuscript copies by Castellini of some printed works of Arduino and of his correspondents. These Castellini papers were also owned by Catullo, who probably acquired them around

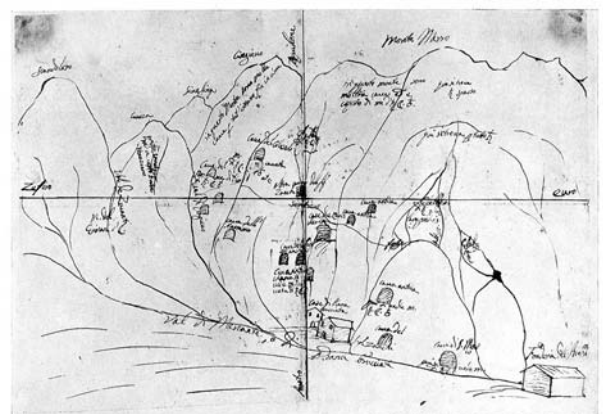


Fig. 5: G. Arduino, Map of lead and silver mines in the Valle dei Mercanti, in the Venetian Prealps, north of Vicenza (probably drawn in 1740s): in Biblioteca Civica, Verona – "Fondo G. Arduino", b. 760, IV.c.19.

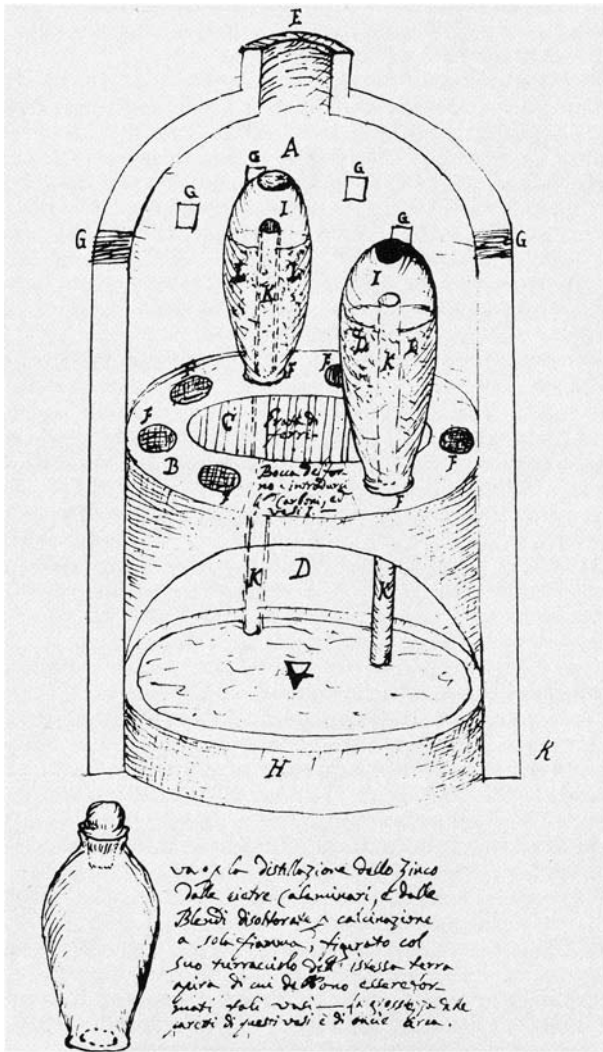


Fig. 6: G. Arduino, drawing of a furnace for zinc as described by the English chemist Peter Wolff (dated 9 January 1781): in Biblioteca Civica, Verona – “Fondo G. Arduino”, b. 760, IV.b.9.

1841, when he successfully completed the purchase of Castellini's paleontological collection for the University of Padua<sup>28</sup>. Moreover, the fact that Castellini copied some of the more significant works of Arduino shows the influence of Arduino himself on the Venetian geologists and collectors during the first half of the 19<sup>th</sup> century<sup>29</sup>.

The „Giovanni Arduino” collection is now reorganized and scientifically classified. It reveals the real essence of the handwritten papers of an 18<sup>th</sup> century distinguished scientist: in fact, not only are the letters important for the reconstruction of the circulation of scientific ideas, but also the rough copies or the brief notes can help in understanding the growth

of a scientific theory and the development of a particular research. During the 1990s the availability of Arduino's papers has allowed new studies and researches on his scientific and technical work, which were mostly converged in the symposium held in Verona in February 1996<sup>30</sup>. Among Arduino's papers some original writings stand out, such as the incomplete but very interesting *Risposta Allegorico Romanzesca* (Allegorical Fictional Reply) on the genesis of the Earth's surface, started at the end of 1771 and directed to the Swedish mineralogist Johann Jakob Ferber<sup>31</sup>; rough notes concerning Arduino's fieldwork, like the description of the volcanic rocks (basalt is listed among them) in S. Giovanni Ilarione in the Alpone Valley, near Verona<sup>32</sup>; beautiful sketches concerning the mines of the Tretto hills and the stratigraphy of the Agno Valley (Fig. 7), two districts in the territory of Vicenza in the north-east of Italy<sup>33</sup>.

Giovanni Arduino, as many other less well known Italian scientists, also had a large collection of minerals, rocks and fossils. He collected them during his fieldwork in the Venetian Prealps in the 1760's, but also earlier, when he was mining director in Tuscany and Veneto<sup>34</sup>. He collected fossils and precious stones at the request of noble Venetians for enriching their naturalistic collections. Many specimens were also given to Arduino by various correspondents in Italy and abroad: in return he often sent them small collections of Italian material. For example, he sent to the German scientists Franz Karl Achard (1753–1821) and Nathanael Gottfried Leske (1751–1786) two boxes of minerals and volcanic rocks mostly from northern Italy and Vesuvius<sup>35</sup>. The story of the 65 specimens sent to Leske in 1782 is particularly interesting<sup>36</sup>: he incorporated them within his large collection in Leipzig and some of them can be easily identified as a descriptive letter by Arduino about the specimens may be compared with the catalogue of the Leskean Cabinet, edited by Dietrich Ludwig Karsten (1768–1810) in 1789<sup>37</sup>. After Leske's death the collection was bought by the Dublin Society and was moved to Ireland in 1792, where it is now kept in the natural history section of the National Museum of Ireland in Dublin. Some specimens from the Leskean collection kept in Dublin have been identified as those sent from Arduino to Leske by utilizing the English edition of Karsten's *Museum Leskeanum*, printed in Dublin in 1798 and translated by George Mitchell<sup>38</sup>. The collection owned by Arduino in Venice was purchased after 1795 by the marquis Gio-

van Battista Gazola (1757–1834) in Verona, however, in 1797 was confiscated by the French army and was probably brought to Paris. There is no list of Arduino's geo-mineralogical collection in his papers and to attempt to recover those specimens now seems a very difficult enterprise.

It is rare to find a collection so complex and so articulated such as that of Arduino's manuscripts in Italian libraries. The aim of this paper, therefore, is to provide a contribution to the knowledge of the precious heritage of Italian collections of manuscripts, which are often forgotten or ignored by the historians, in spite of their great interest for the history of geological sciences and mining.



Fig. 7: G. Arduino, lithostratigraphic cross-section of the Agno Valley, near Vicenza (dated October 1758): in Biblioteca Civica, Verona – "Fondo G. Arduino", b. 760, IV.c.11.

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- 11 According to Schall 1787, p. 193, the translator and editor of Arduino 1778 was the Swedish mineralogist Johann Jakob Ferber (1743-1790), while Hamberger & Meusel 1796, p. 310 and the anonymous obituary in *Freyberger Gemeinnützige Nachrichten für des Königl. Sächsische Erzgebirge – Freiberg*, vol. 17 (1816), p. 106-107, state that it was instead August Constant von Ferber. However, a copy of Arduino 1775 belonging to Werner's private library and now kept in the library of the Bergakademie Freiberg (signatur XVI.120), with the signature „A.C. de Ferber" in the frontispiece, widely annotated and partially translated by the same writing, clearly shows that August Constant von Ferber worked on the German edition of Arduino's book.
- 12 *Giornale d'Italia (from 1777: Nuovo Giornale d'Italia) spettante alla Scienza Naturale e principalmente all'Agricoltura, Arti e Commercio*. – Benedetto Milocco (Giovanni Antonio Perlini from 1790), Venezia, 1764-1796, 27 vol.
- 13 A calendar of Arduino's published and unpublished correspondence was printed in Vaccari 1990. A selection of letters will be published by the Author in 2007, within the series „Epistolario Veneto" (Edizioni Think ADV, Padova)
- 14 Biblioteca Civica, Verona – Fondo „G.Arduino", b. 757-762.
- 15 Stegagno 1929.
- 16 Eyles 1966, p. 85; Eyles 1969, p. 168-169; Oldroyd 1979, p. 210.
- 17 The long standing precarious state of Arduino's manuscripts was underlined by Curi 1988, p. 59.
- 18 Gliozzi 1962, p. 65. See also Marangoni 1965, p. 23. On Tommaso Antonio Catullo, see Alippi Cappelletti 1979, Piccoli 1996 and Morello 1999.
- 19 On this purchase, see Catullo's statement in *Enciclopedia Circolante – vol. 1 (1836)*, n. 31, p. 77 and in *Catullo 1844*, p. 285, note 1. On Luigi Arduino, see the biographical sketch by Giormani 1996.
- 20 Catullo 1839.
- 21 Other handwritten papers of Arduino, with marginal notes by Catullo, are kept in the following libraries: Biblioteca Bertoliana, Vicenza – Ms.1597 (23.11.12); Biblioteca Civica, Bassano del Grappa – „Epistolario Gamba", IV.A.11; Biblioteca Nazionale, Firenze – Palatina 1151. See also, for the fund kept in Florence, Ronconi 1866, p. 7-15.
- 22 Vaccari 1994.
- 23 Biblioteca Civica, Verona – „Fondo G. Arduino", b. 758, II.b.1-30.
- 24 Biblioteca Civica, Verona – „Fondo G. Arduino", b.758, II.c.1-7 II.i.1-16 II.e.1-22.
- 25 Biblioteca Civica, Verona – „Fondo G. Arduino", b. 760, IV.c.1-27 IV.d.1-15 IV.b.1-18.
- 26 Some of these papers have been studied by Vaccari 1992.
- 27 On this unpublished material, see Vaccari 1998a.

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## Footnotes

- 1 On Arduino's life and works, see Vaccari 1993, Curi 1996 and Vaccari 2002.
- 2 "Mi portai ancora giovane nelle miniere di Clausen, e d'altri luoghi del Tirolo, per apprendervi la Metallurgia; condottovi da occasione, e spinto dalla mia naturale fortissima inclinazione per l'universale Mineralogia, e per tuttociò, che riguarda la Scienza del Regno Fossile." Arduino 1770, p. 157.
- 3 See Arduino 1760, p. cxxiii. The mining center of Agordo was in the Venetian Republic, although half of the forge in Caprive was owned by the Bishop of Brixen and processed iron mineral coming from Tyrol until 1746 (Alberti & Cessi 1927, pp. 289, 331, 430).
- 4 See Vaccari 1993, pp. 57-76 and Vaccari 1996.
- 5 On this classification, outlined in Table I, see Vaccari 2006.
- 6 On his agronomic studies, see Vaccari 1992.
- 7 Arduino 1769, 1775b, 1792.
- 8 Arduino 1760, 1774. On the diffusion of Arduino's scientific work in Italy and in Europe, see Vaccari 1993, p. 169-175, 227-252, 285-306.
- 9 Arduino 1775a, 1778
- 10 Ferber was born in Dresden and enrolled in the Bergakademie Freiberg in 1771 (Gottschalk 1866, p. 226). Later he became a Bergkommissionsrat at Zöblitz in the Erzgebirge (Saxony).

28 On this purchase, see Lazzari 1999.

29 See Vaccari 1991a.

30 The proceedings are published in Curi 1999.

31 Biblioteca Civica, Verona - „Fondo G. Arduino“, b.758, I.a.1–3.  
See also the annotated edition of this valuable manuscript in Vaccari 1991b.

32 Biblioteca Civica, Verona - „Fondo G. Arduino“, b.760, IV.c.3.

33 Biblioteca Civica, Verona - „Fondo G. Arduino“, b.760, IV.c.12–27.

34 See Arrigoni 1985 and Alberti & Cessi 1927, p. 337; 377–379.

35 Arduino 1780, 1783.

36 For full details, see Vaccari & Monaghan 1993.

37 See Karsten 1789, vol. 2/II, p. 123–128, to be compared with Arduino 1783.

38 Karsten 1798, vol. 2, p. 480–485.

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