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12. Utilization of Geothermal Resources in Italy from the 11th through the 16th Centuries

by
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Abstract: For about six centuries after the fall of the Roman Empire in the 5th century A.D., the development of natural heat and its by-products progressed in Italy at a very slow pace. Then development resumed, starting from the second half of the 11th century when systematic exploitation of hydrothermal products began in the Boraciferous region in Central Italy for pharmaceutical, industrial, and craft purposes. These products gradually increased in commercial importance over the next five centuries, eventually causing a series of disputes in the Late Middle Ages between some Tuscan communes and the Bishopric of Volterra for ownership of the area where they were found.

Thermal balneology and other uses of natural heat remained slow until the 13th century, but in the next three centuries it flourished once again when over 100 thermal localities were developed in Italy for balneotherapy and recreation.

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*The sun did not stop in the opposite half of the sky,
nor did the dawn of the second millennium remain dark.
The ground shook again that day;
volcanoes still erupted streams of lava,
and Earth continued to give mankind
the fertile heat of her restless body.*
—R. Cataldi

THE TRANSITION PERIOD, BETWEEN THE 1ST AND THE 2ND MILLENNIUM

HOWEVER WIDESPREAD AND SINCERE THE BELIEF MAY HAVE been that the world would end in the year 1000 (Cataldi and Burgassi, 1992b), the reawakening at the dawn of the 11th century began a period of deep renewal of customs and lifestyles in Italy that in the succeeding centuries would lay the historical groundwork for the Renaissance.

The revival is attributed to many reasons, such as the end of “barbarian” invasions in Central and Southern Europe, rapid population increase, decrease in feudal anarchy, Muslim expansion, birth and development of local autonomies, a maturing religious spirit, conflicts among different religions, and the Crusades to the Holy Land. It was expressed in numerous flourishing commercial enterprises that gradually established a market economy in nearly all fields of producing and processing raw materials. From the first decades of the 11th century, many old mining extraction activities were revitalized, new deposits of metal-bearing ores and nonmetallic minerals were discovered, and systematic exploitation began in a number of areas. These activities became especially intense in the Metalliferous Hills in Tuscany (Central Italy) where they contributed substantially to the development of the regional economy (Bargellini, 1984).

Hydrothermal products, however, were an initial exception. Indeed from the 9th century on, some of them, particularly boron compounds used for preparing pharmaceuticals, were imported from the Middle East by Saracen traders following the Saracenic expansion into Northern Africa and sectors of Southern Europe. The most important compound imported in the 9th and 10th centuries was tincal, most probably a mixture of borax $\text{Na}_2[\text{B}_4\text{O}_5(\text{OH})_4]\cdot 8\text{H}_2\text{O}$, colemanite $\text{Ca}[\text{B}_3\text{O}_4(\text{OH})_3]\cdot \text{H}_2\text{O}$, and ulexite $\text{NaCa}[\text{B}_5\text{O}_6(\text{OH})_6]\cdot 5\text{H}_2\text{O}$ extracted from sedimentary deposits in Iran and volcanic-lacustrine deposits in Western Anatolia. The word “borax” derives from the Arab *buraq*, meaning “white.”

In the following centuries, bitter maritime clashes for commercial supremacy in the Mediterranean greatly hindered large-scale trade of hydrothermal products. The conflicts included those between the Saracen fleet and the Italian marine republics of Amalfi and Pisa (9th to the 13th centuries), and of Genoa and Venice (10th through the 16th centuries). However, with the possible exception of some borates, these products did not have the economic importance of many other raw materials and manufactured goods then traded by sea.

Because importing tincal from the Middle East had become impossible, new initiatives were launched in the mid-11th century to exploit the rich hydrothermal deposits of the Boraciferous region in Tuscany. These efforts paved the way for the birth of the geothermal chemical industry at Larderello in the following century. However, thermal bathing remained depressed nearly everywhere until the early 13th century.

DEVELOPMENT IN THE BORACIFEROUS REGION

EXPLOITATION OF HYDROTHERMAL COMPOUNDS

THE BORACIFEROUS REGION IS BY FAR THE MOST IMPORTANT GEOTHERMAL ZONE IN ITALY; IT IS located in Southern Tuscany in the area presently known as Larderello. The systematic development of geothermal resources started here in the second half of the 11th century when the bishops of Volterra, who administered the region in the name of the Holy Roman Empire, authorized local businessmen to mine the rich hydrothermal deposits associated with the high-temperature geothermal manifestations of the area (Volpe, 1923). These manifestations were then called *allumiere* or *lumaie*. *Lumaie*, with its Latin etymology, signifies either a locality with minerals with glittering specks (*lumen*) or a place where *allume* (“alum”) is mined; hence, the name *allumiere*. These deposits are now better known in local jargon as *biancane* or *lagonicci*. The term *biancane* (“whitish spots”) reflects the dominant white color in areas with geothermal alterations. *Lagonicci* comes from *lagone* (“hot water pool”) and refers to the hydrothermal deposits covering ground around high-temperature manifestations.

The following compounds were increasingly produced and traded from the 12th through the 16th centuries:

- Yellow sulfur (S), much in demand for the preparation of pharmaceuticals (ointments and salves), bleaching solutions for the wool industry, and from the 13th century onward, a component of gunpowder
- Alum ($\text{KAl}[\text{SO}_4]_2 \cdot 12\text{H}_2\text{O}$), a product used in processing wool
- Green vitriol (ferrous sulfate heptahydrate: $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$), widely used to prepare disinfectants and hemostatic products, and as a component of dyes for the wool industry and other processes
- Blue vitriol ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), used as a disinfectant, antiparasitic, and coloring component
- *Nitro volterrano*, which, on the basis of manuscripts from 1527, 1531, and the work of Mercati (1717), is now identified as boric acid (H_3BO_3). From very ancient times

this product was recommended—and is still used today—for treating eye diseases and as a weak acid for disinfecting sores.

Throughout this period, all of these products gradually increased in commercial importance; consequently, a series of disputes arose over awarding mining contracts. Several bitter struggles occurred from the 12th century onward between the Tuscan communes of Florence, Pisa, and Siena and the Bishopric of Volterra for ownership of all or part of the Boraciferous region. A state of permanent conflict among these communes, and between some of them and the Bishopric of Volterra, continued for three centuries. Finally, after a relentless war between the Commune of Volterra and the Republic of Florence, the whole Boraciferous region was passed to the Signory of the Medicis in 1472 (Targioni Tozzetti, 1769; Nasini, 1930). A painting of the pitched battle during this war is shown in the photograph at the front of this chapter.

Now the Florentine Republic assigned control for mining the *lumaie* to its flourishing wool guild, called *Arte della Lana* (“wool merchants”). With no need to pay duties on the hydrothermal products necessary to process wool and dye fabrics, the guild soon became so prosperous that it gained a near monopoly over the Italian textile industry, a situation that lasted well beyond the end of the Renaissance.

OTHER USES

BEGINNING IN THE 13TH CENTURY, ALMOST CERTAINLY THE *LAGONI* OF THE BORACIFEROUS region were used for small local crafts. This seems especially true for the *Lagòn Cerchiaio*: according to Fazio degli Uberti (c. 1350), the boiling waters of this pool were used to soak barrel staves and to expand the metal hoops used to bind the staves together. Moreover, by very ancient tradition (perhaps dating to Etruscan times), the steam manifestations of the Boraciferous region were used to dry farm produce and cook chestnuts. Until a few decades ago, the latter were a staple of the region’s inhabitants. Often the chestnuts were boiled in steam escaping from very hot manifestations. The soil of the fields immediately around the manifestations, made fertile both by natural heat and impregnated potassic salts, was often used to grow vegetables and grapes. Balneotherapy was practiced in some localities with hot springs in the Boraciferous region, beginning around the end of the 12th century. The most important localities were *Bagno a(d) morba*, Bagnolo, and Terme Antica Querciolaia. *Bagno a(d) morba* means “bath of the illnesses,” and the persistence of the Latin word *morba* shows the site’s ancient fame as a place for treating diseases with steam baths and thermo-mineral muds. Several

authors of the Late Middle Ages wrote about this spa, including Dante Alighieri (c. 1300), Ristoro d'Arezzo (1282), M. Savonarola (1523), Ugolino da Montecatini (1553), and Mengo Blanchello Faentino (1553).

The wide variety of uses of hydrothermal minerals in the following list explains why the exploitation of hydrothermal products and the use of natural heat for different purposes contributed considerably to the economic growth of the Boraciferous region during the first five to six centuries of the present millennium.

Uses of geothermal resources in the Boraciferous region from the 11th through the 16th centuries

Hydrothermal products and their uses	
Product	Use
Yellow sulfur (S)	Pharmaceutical compounds (ointments, salves, and others) Bleaching solutions for wool industry Gunpowder, from the 13th century
Alum (KAl[SO ₄] ₂ •12H ₂ O)	Processing wool
Green vitriol (FeSO ₄ •7H ₂ O)	Pharmaceutical compounds (disinfectants and hemostatic agents) Coloring agents (wool, textiles, and others)
Blue vitriol (CuSO ₄ •5H ₂ O)	Pharmaceutical compounds (disinfectants) Coloring agents Antiparasitic agents
<i>Nitro volterrano</i> (Boric acid: H ₃ BO ₃)	Pharmaceutical compounds (for eye diseases, disinfectants for sores, and others)
Other uses	
	Soaking staves and thermally expanding barrel hoops Drying farm produce Cooking chestnuts Growing vegetables and grapes Thermal bathing, from the 13th century

DEVELOPMENT IN OTHER AREAS

EXPLOITATION OF HYDROTHERMAL AND PYROCLASTIC PRODUCTS

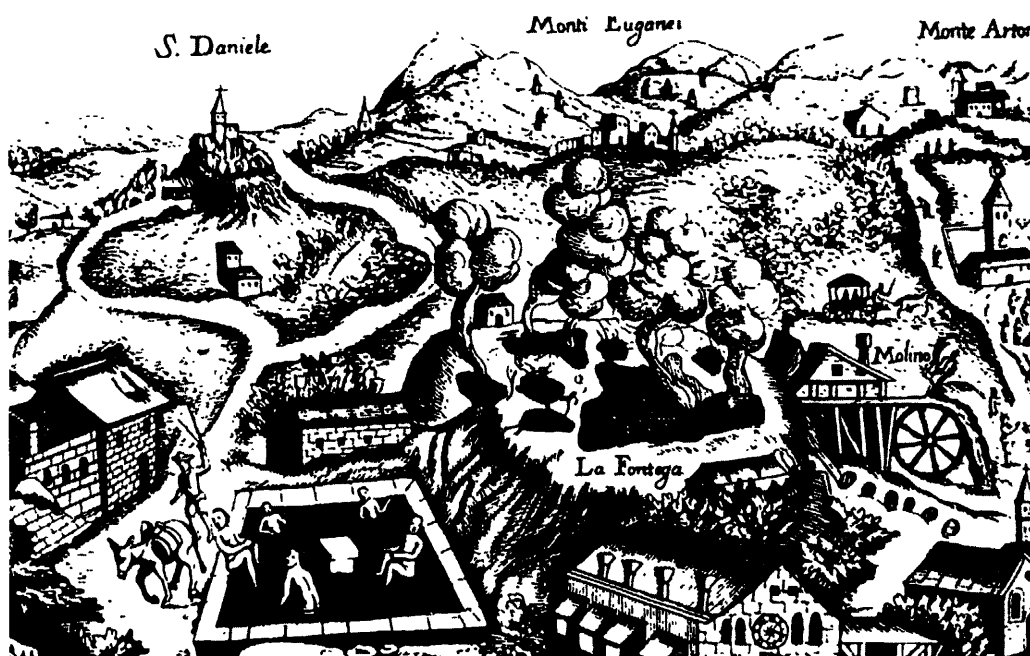
BESIDES THOSE OF THE BORACIFEROUS REGION, OTHER GEOTHERMAL BY-PRODUCTS WERE EXPLOITED during the Late Middle Ages in other areas of Italy. Most were located in Western

Latium, Western Campania, and on some islands of the Tyrrhenian Sea, especially Ponza in the Pontine Archipelago and Lipari in the Aeolian Archipelago.

One or more of the following by-products were exploited in these areas: pumice, pozzolan, bentonite, kaolin, sulfur, silica, and travertine. They were used mainly in cement slurries and building materials, and less importantly for crafts and pharmaceuticals. Most were used locally and never attained the economic importance of the hydrothermal compounds in Tuscany's Boraciferous region (Cataldi and Burgassi, 1992a and 1992b).

THERMAL BALNEOLOGY

FOLLOWING A LONG PERIOD OF RECESSION, BALNEOTHERAPEUTIC CUSTOMS BEGAN TAKING ROOT again in many thermal localities from about the second half of the 13th century, after autonomous municipalities (communes) were established and consolidated, especially in regions of Northern and Central Italy. The most important thermal establishments developed from the 13th through the 16th centuries were Acqui Terme, Abano (see engraving), Montegrotto, Bagno di Romagna, Bagni di Lucca, Montecatini, Chianciano, San Casciano dei Bagni, Bagno Vignoni, Viterbo, and Tivoli in Northern and Central Italy, and Pozzuoli, Ischia, Lipari, Santa Cesarea Terme, Sciacca, and Sardara in Southern Italy and on Italian islands.



A 16th century engraving of a bathing scene in the thermal pool of Abano in Veneto, Italy. From J. M. Couder and F. Jaudin, 1989. Courtesy of the authors, with authorization of the BRGM

Illustrious people visited many of these establishments for cures—sometimes becoming their patrons—and this contributed remarkably to the reputation and fame of the sites. Examples include Bagni di Lucca, where the Holy Roman Emperor Frederick II went for a cure in 1245, the Italian poet L. Ariosto in about 1530, and the French essayist M. de Montaigne in 1581; and Bagno Vignoni, where Pope Pius II Piccolomini went for treatment around 1460 and the Prince Lorenzo de' Medici (the Magnificent) in 1490 (Rosetti and Valenti, 1997).

At least 100 other minor thermal sites were active in Italy during the Late Middle Ages, and many were already in existence before Medieval times. Often these sites had simple facilities and were open during specific periods only to serve local workmen and common people from nearby areas.

CONCLUSIONS

THE REVIVAL OF THERMAL BALNEOLOGY DURING THE LATE MIDDLE AGES IN ITALY IS TESTIFIED to in treatises of natural history, medicine, and hydrology of the epoch, as well as in works by poets, geographers, and scientists of the same period and of the Renaissance. Many passages can be found in these works on the physical and chemical characteristics and the healing properties of thermo-mineral waters and muds at each locality, and on their abilities to cure internal and external diseases. In addition to those quoted for the Boraciferous region, the following authors deserve a special mention here: Bauer, better known as Agricola (1546 and 1556); Van Merle, called Merula (1605); and Fallopio (1606).

Simultaneously with the reawakening in Italy, thermal balneology started to thrive again, as in ancient times, in many Western and Central European countries, such as Austria, Bulgaria, the Czech Republic, France, Germany, Hungary, Iceland, Poland, Portugal, Romania, Slovakia, Spain, Switzerland, and the states of the former Yugoslavia. During the first half of the present millennium, thermal bathing again flourished at Bath in England and began taking root in the areas of Reykjavik, Ingolfafjall, and Hvitaholt in Iceland.

Mining some hydrothermal minerals became rather important during the Late Middle Ages in a few other European countries besides Italy. This is the case with native sulfur in Iceland (Sigurdsson, 1992) and bentonite and other minerals in some Greek islands of the Southern Aegean.

The development of thermal balneology and the use of hot water for district heating and other purposes from the 11th through the 16th centuries are highlighted in other chapters of this volume for other European countries. From these chapters and from this, one can realize that the development of geothermal resources in Europe during the first five to six centuries of the second millennium was a phenomenon of international importance. Harnessing geothermal resources, however, did not then attain the peak of development and popular diffusion it had enjoyed about a millennium earlier in territory under Roman rule at the height of splendor of the Roman Empire.

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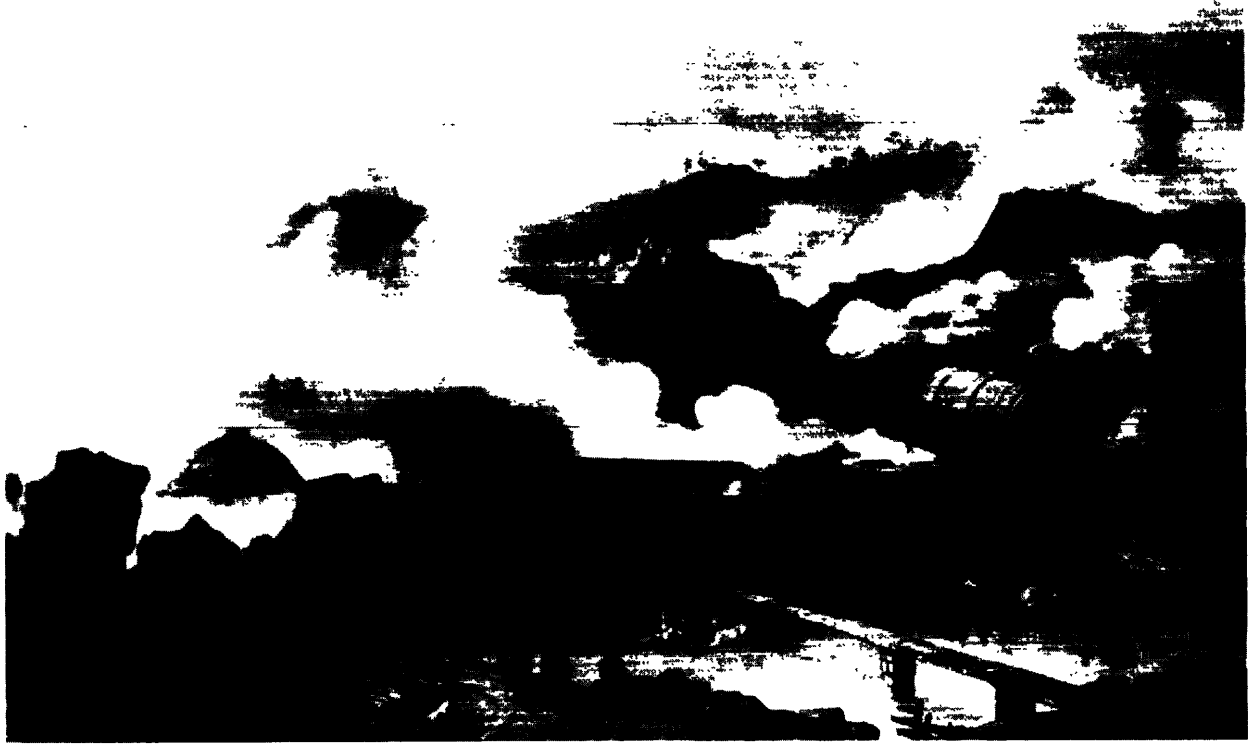
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Lithograph titled "View of one of the volcanic localities of Larderello," showing the different types of uncovered and covered *lagoni* ("boiling pools") and installations and facilities of the geothermal-chemical industry at Larderello, as seen around 1850. In describing Larderello as a volcanic area, the title's author reflects the belief of the time that the natural steam had an igneous origin.
