

NOTICE CONCERNING COPYRIGHT RESTRICTIONS

This document may contain copyrighted materials. These materials have been made available for use in research, teaching, and private study, but may not be used for any commercial purpose. Users may not otherwise copy, reproduce, retransmit, distribute, publish, commercially exploit or otherwise transfer any material.

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specific conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.



10. Flowering and Decline of Thermal Bathing and Other Uses of Natural Heat in the Mediterranean Area, from the Birth of Rome to the End of the First Millennium

Abstract: Thermal balneology was developed systematically by the Romans from the 2nd century B.C. From that period on, the use of spas spread throughout the territory under Roman domination. Thermal springs were used as sites for spas whenever possible; however, where none existed, especially in Rome, artificially heated baths were built. At the same time, the Romans developed uses for numerous geothermal by-products.

The boom for both activities peaked in the Mediterranean area in the 1st through 3rd centuries A.D., declined from the second half of the 4th century, continued to fall rapidly in the 5th and 6th centuries, and, particularly in Italy, entered a long inactive period extending beyond the end of the first millennium.

Revised, English version of Chapter 4, *La Geotermia en el período Precolombino en las áreas Mediterránea y Mesoamericana*, by R. Cataldi, P. D. Burgassi, and M. C. Suárez Arriaga (1992). *Geotermia, Revista Mexicana de Geoenergía*, 8, no. 3, pp. 265-288.

by
Raffaele Cataldi
Pier Domenico Burgassi

THERMAL BATHING: *AB URBE CONDITA* TO THE FALL OF THE ROMAN EMPIRE (7TH CENTURY B.C.-5TH CENTURY A.D.)

EVEN WITH THE MANY THERMAL LOCALITIES AROUND ROME, between 750 and 500 B.C. the early Romans were not yet in the socioeconomic condition needed to profit from the experiences of their Etruscan neighbors by extracting and using hydrothermal products at these sites and practicing thermal bathing. However, such practices began to influence the Romans after the end of the monarchal period, when, starting in the 5th century B.C., they exerted political and military pressures on their neighbors, first to consolidate their young republic and later to extend Roman rule over the entire Italian peninsula.

In the 5th and 4th centuries B.C., the Romans may have used some imported hydrothermal products for pottery, such as kaolin and iron oxides, and Roman soldiers on military expeditions may have made occasional visits to hot springs for thermal

bathing. Clearly, the energies of those Romans were not directed toward developing glass- and pottery-making technologies that included processed hydrothermal products or toward thermal bathing, by then widespread in Etruscan territories, especially those north of Rome.

However, during this time, the Romans understood the commercial importance of Etruria's mineral resources, including the hydrothermal products of the Boraciferous region (Cataldi and Burgassi, 1992a; Cataldi and Chiellini, 1995). The Romans probably had also grasped the strategic importance of Etruscan roads that linked many geothermal localities (see map in Chapter 9). In this light one can understand why several Etruscan centers located near hot springs, such as Cerveteri, Veio, Tarquinia, Populonia, and Saturnia, were later chosen by the Romans as sites for military encampments (*castra*).

The slight importance attributed by the Romans to hydrothermal products and thermal bathing would change rapidly after the annihilation of the Etruscans in the 3rd century B.C., especially after the defeat of Hannibal at Zama in 202 B.C. and the destruction of Carthage in 140 B.C., which allowed Rome to rule the entire Mediterranean. Although balneotherapy became more widespread among the Romans between the late 3rd and early 2nd centuries B.C., it still was practiced sporadically, mostly by the elite class at localities with natural hot springs.

From the second half of the 2nd century B.C., Roman attitudes toward thermal bathing changed radically. The republic was now consolidated, the conquered territories were vast, and trade and commercial dealings were intense. Thus, Romans became more familiar with the life styles and technologies of other peoples, the state was wealthy, and people had the time and economic resources to care for their bodies and practice balneotherapy. Now the first public baths (*balnea* and *thermae*) appeared.

In cities such as Rome with no natural hot springs, artificial thermal baths were built and fed with hot water heated in centralized boilers by wood fires. Such a heating system, without pumps to move the hot water, proved inefficient and expensive. Thus the common people of Rome did not practice thermal balneology until several decades later at the beginning of the 1st century B.C.

Then an ingenious Roman citizen of Neapolitan origins, Caius Sergius Orata, inspired by features constructed in previous centuries in natural Greek spas, designed a system of rooms artificially heated to different temperatures by hot air circulation. Fed with steam from a boiler,

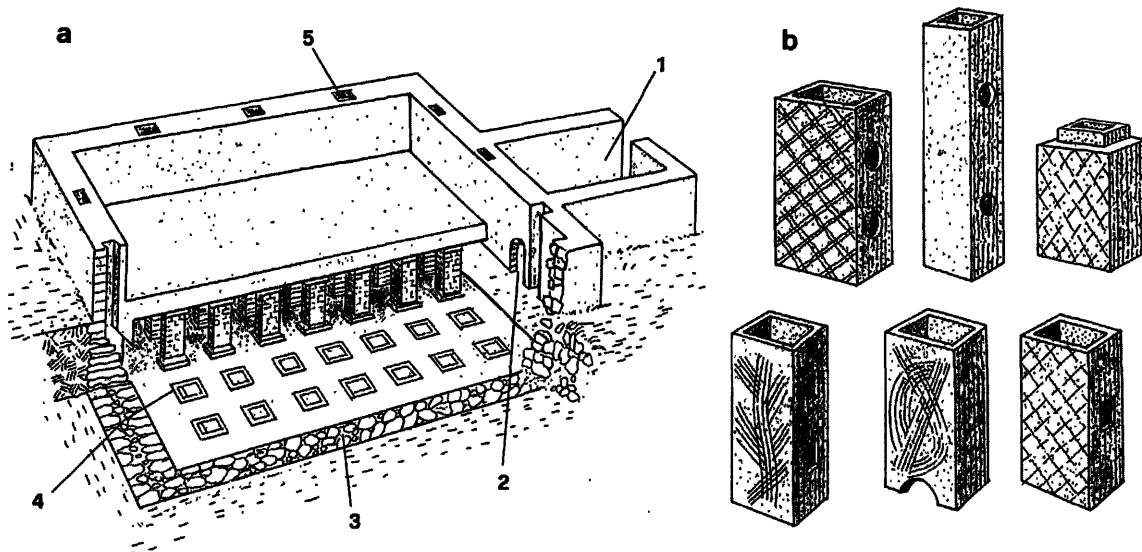


Figure 1. Artificial heating system using hot-air circulation for thermal baths in ancient Rome. a. Cut-away view showing heating system with *hypocaustum* and *alveola*: 1. boiler room; 2. hot air flow channel; 3. spa foundations; 4. underfloor interspace for hot air circulation (*hypocaustum*); 5. channels for the ascent of hot air (*alveola*). b. Sketches showing different types of *alveola*.

the system conveyed hot, humid air through a series of interstices (*hypocaustum*) located beneath the floors of the baths and into a series of channels (*alveola*) embedded in the walls (figure 1a). This system greatly reduced water consumption and lowered the operating costs of thermal establishments. It also made it possible to control the heat in individual rooms and keep each at its desired temperature.

The overall design and technical features—such as regulating the draft by using *alveola* of different diameters (figures 1b, 2), the positions of hot air outlets, external grooves on the *alveola* to firmly hold in place plaster and stucco (figure 1b), chimneys to expel smoke and spent hot air—help us to understand why the basic concepts of this advanced heat engineering system are still used today. Using *hypocaustum* and *alveola* to control temperatures, three types of heated bathing rooms were constructed in each artificial spa: the *laconicum* (“steam room”), the *calidarium* (“hot water pool”), and the *tepidarium* (“warm water pool”). Finally, a *frigidarium*, a “cold water pool,” was used to tone the body after a steam or hot water bath (figure 3).

Thus the practice of thermal bathing grew rapidly, peaking in the first three centuries of the Christian era. Besides the numerous private baths installed in practically every villa and many apartment buildings, there were over 1,000 public baths in Rome at the height of the Empire: about one for every 1,000 inhabitants (Montanelli, 1969). Two especially luxurious and spacious thermal complexes were the Baths of Titus and Trajan (80-110) and the Baths of

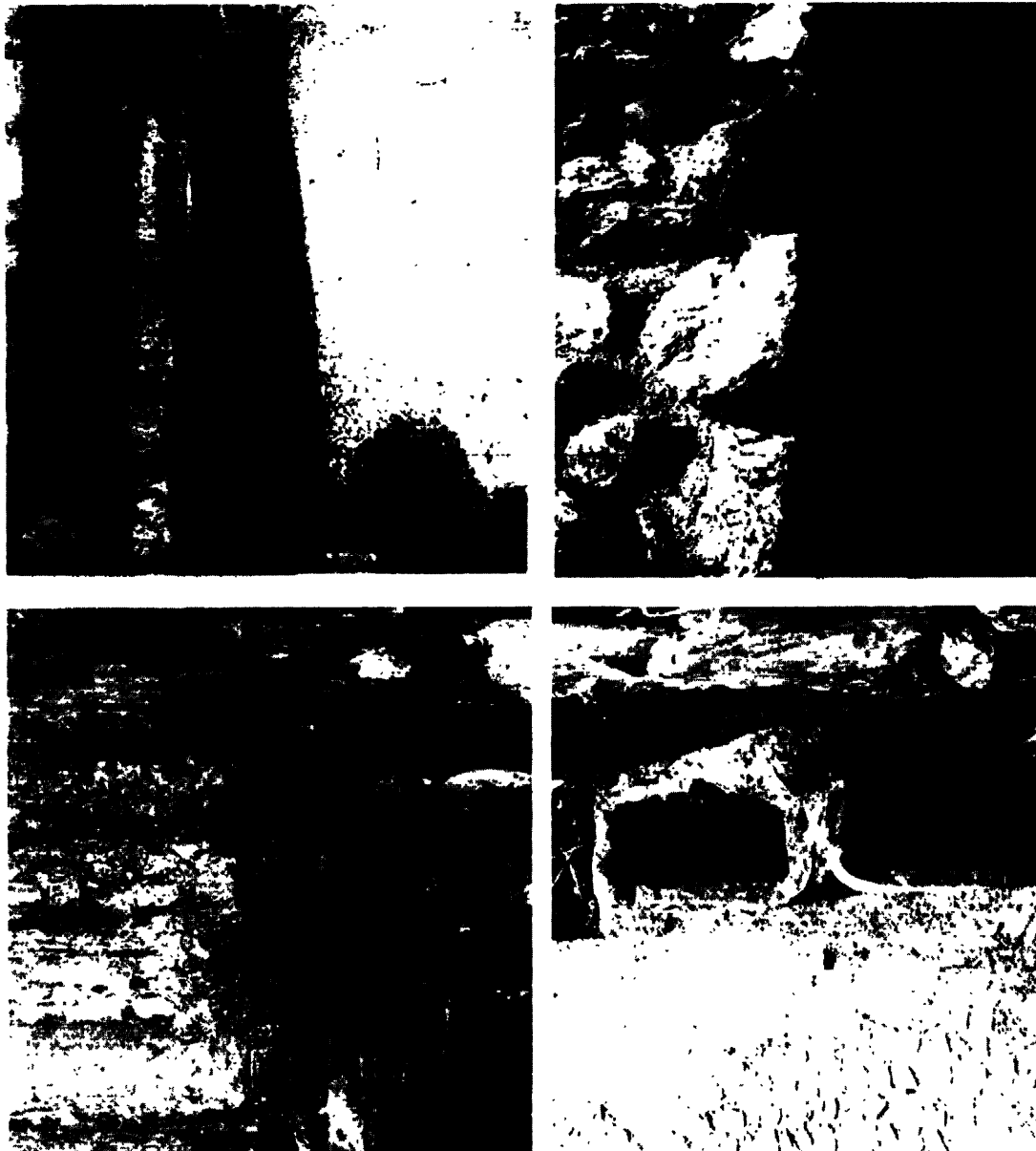


Figure 2. Different types of *alveola* in the ruins of Roman mansions at Roselle, Tuscany. *Photos by the authors, c. 1967*

Caracalla (217). The latter, enlarged by Aurelian in 275, remained in continual use until the early 6th century (see patio in initial illustration).

During the imperial period, thermal bathing became so widespread and deeply rooted at all levels of society that the *thermae* were a daily meeting place, a reference for every aspect of civic life. Physical exercise was undertaken in attached gymnasiums, reading and study in internal libraries, and there were areas for beauty treatments (massage, shaving, hairdressing, and depilating), recreation (ball games and entertainment), conversation and political discussions,

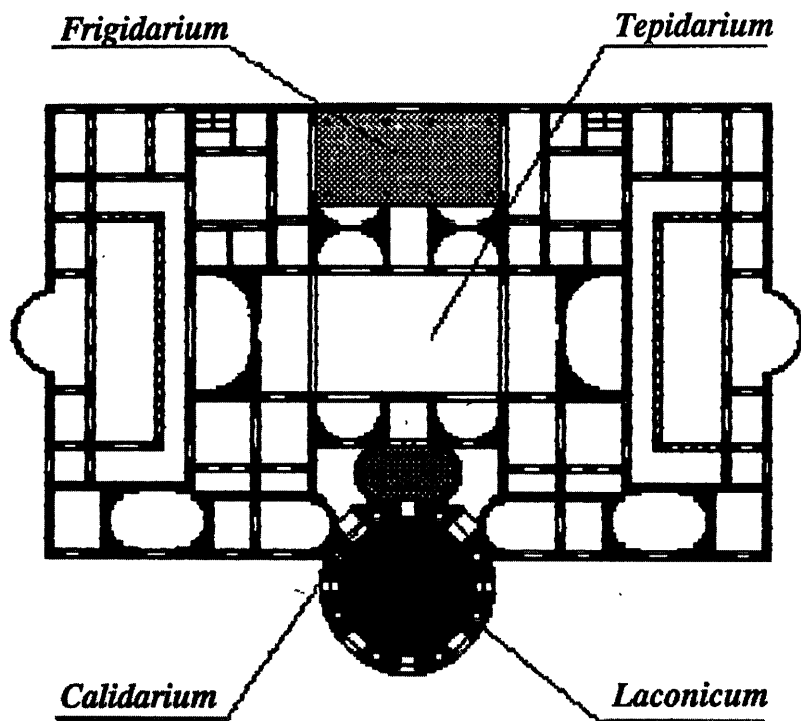


Figure 3. Layout of a typical Roman spa, showing positions of the main bathing rooms. Many other rooms existed for physiotherapy and other purposes.

business dealings, snacks, and formal meals. The baths became institutions for hygiene and recreation and, perhaps most of all, cultural centers where ideas were circulated, public opinion was formed, and basic political choices were prepared.

The boom in thermal balneology during the imperial period was concentrated mostly in Rome and at Baia, near Naples, but it spread rapidly throughout the Empire to the most remote villages. Outside Rome, a number of private mansions had artificially heated thermal pools, and many bathing complexes were built with the heating system devised by Caius Sergius Orata (figure 4). Where possible, the complexes were built near thermal

The boom in thermal balneology during the imperial period was concentrated mostly in Rome and at Baia, near Naples, but it spread rapidly throughout the Empire to the most remote villages.



Figure 4. The patio in the Casale mansion, Piazza Armerina, Sicily, dating to Roman times, is an example of a private thermal pool, heated artificially. P. D. Burgassi, c. 1967

manifestations, taking advantage of the natural heat and the therapeutic properties of hydrothermal salts and muds.

The liveliness at the baths in the 1st century A.D. and the bustle dominating each thermal complex inspired Seneca (c. 60) to write this witty passage about Baia:

“I live just above the public baths; imagine a clamor, a shouting in every tone, that makes you long to be deaf; I hear the moaning of those who are taking exercise: they let out hisses and breathe with difficulty. If someone stays still long enough to have a massage, I hear the slapping of hands on shoulders and it is a different sound depending on whether the slap is given with a flat or a curved hand. When someone arrives wanting to play ball but is unable to do so, if he doesn't shout and begin to count the strikes aloud, it means that the game is finished. There are also the mischief-maker, the robber caught red-handed, the chatterer who, when he speaks, is fascinated by the sound of his own voice; and then there are those who dive into the pool to swim, noisily splashing the water everywhere. But these at least use their own voices! Think of the depilator, who does not keep quiet but, when he relieves someone of their hairs, screams together with the person being depilated. Not to mention the cries of the vendors of drinks, of sausages, of cakes, and of the inn attendants who wander around offering their goods, each one with his own modulation of voice...” (translated by the authors from Paoli's Italian version, 1977).

The main thermal complexes in the territory of the Roman Empire toward the end of the 3rd century are shown on the map (figure 5). However, many of them existed long before the onset of the Roman rule. Inside or very near every thermal complex were statues, inscribed pillars, and temples honoring the gods, including Jupiter, Juno, Minerva, Mars, and Apollo (Panessa, 1983). In many thermal localities, cults of health-giving divinities were documented, most notably those of Asclepius (Musial, 1990), Hygieia (Daremborg and Saglio, 1899), and Sulis Minerva (Salway, 1981). The existence of cults is not surprising if one considers that in Antiquity, springs in general and hot springs in particular were thought of as fountains of life and health—divine gifts and therefore sacred. This explains why the cult of the waters was widespread in Antiquity throughout the whole Mediterranean area.

The recurring presence of monuments to the gods and votive pillars in or near all bathing complexes suggests that thermal springs may have been a catalyst for strengthening religious sentiments and their gradual spread among people of every social class and culture. Such sentiments had begun to form instinctively in prehistoric times (Cataldi, 1992), evolving by historical Antiquity into a mature body of faith. In certain cases, however, the decision to build temples, oracles, or altars near thermal springs may have met a need to justify visiting them for bathing and recreation.

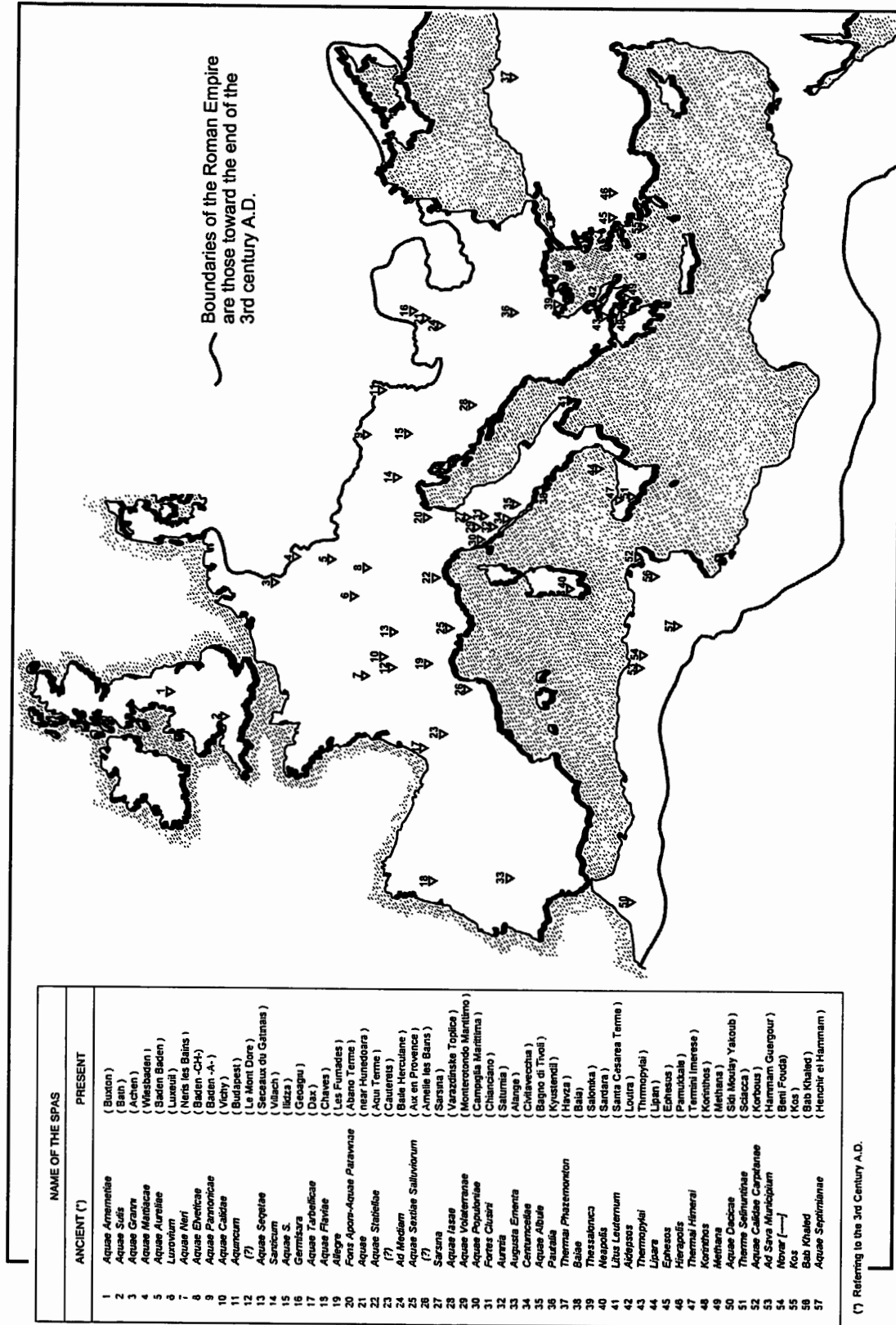


Figure 5. Location of the main natural baths at the height of the Roman Empire.

At any rate, the fact that thermal balneology was practiced by many peoples favored the development of local markets, trade centers, popular festivals, and athletic games at or near important thermal sites. In the latter case, athletes frequently trained at thermal sites to reach top form (*valetudo*) before the games began, and winners built thanksgiving pillars to healing divinities or demigods such as Athena (Minerva), Ares (Mars), and Hercules. The thermal springs of Methana (Peloponnesus, Greece) and the athletic games established at Corinth (near the thermal locality of Loutraki, not far from Methana) are significant in this regard (see Chapter 6 in this volume).

The widespread development of thermal balneology, together with the multiple functions undertaken at thermal sites before and after the start of the Christian era, provided a cohesive element among social classes and contributed significantly to the progress of civilization and cultural aggregation of Mediterranean peoples. Sometimes Roman rulers might have built thermal establishments with the aim of gratifying the masses and easing social tensions, thus curbing (at least in the more remote provinces) attempts at rebellion.

Between the 5th century B.C. and the 3rd century A.D., many Greek and Latin writers mentioned natural manifestations and dealt with aspects of geothermal phenomena. Citing all the works that refer to hot springs or other geothermal phenomena would be impossible, but some important authors are Anaximenes, Apuleius, Aristophanes, Aristotle, Caesar, Catullus, Democritus, Dio Cassius, Herodotus, Juvenal, Hippocrates of Kos, Lycophron, Ovid, Pausanias, Pliny the Elder, Poseidonius, Seneca, Strabo, Suetonius, Tibullus, Virgil, and Vitruvius.

Major thermal establishments are prominent on a world-famous cartographic document known as the *Tabula Itineraria Peutingeriana*, the official geographic map for the final period of the Roman Empire (a portion is in figure 6). This parchment was discovered in 1507 in a library in Alsace, France, and published by Konrad Peutinger, from whom the *Tabula* took its name. It is actually the work of an unknown cartographer who lived between the late 3rd and early 4th centuries and who relied on numerous *itineraria scripta* (“written itineraries”) and *itineraria picta* (“mapped itineraries”) to construct the map. The cartographer also used a relief model of the imperial territory, which was initially conceived by Caesar, later approved by Augustus, and eventually constructed by Agrippa in 20 A.D.

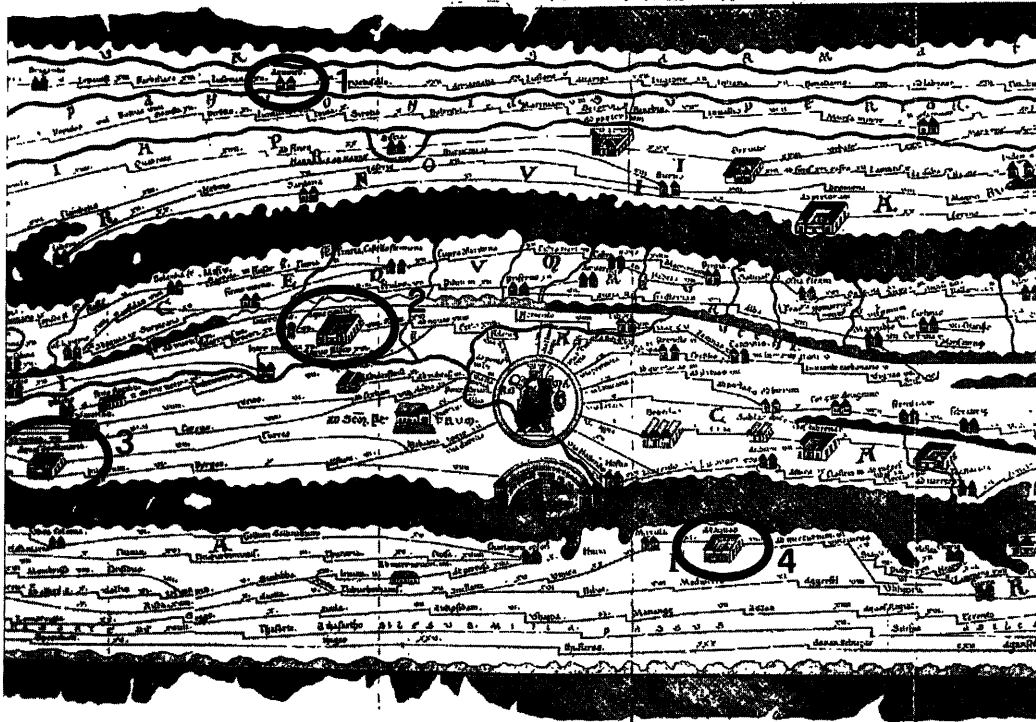


Figure 6. *Tabula Itineraria Peutingeriana*: the area corresponding to Central Italy with a sector from East-central Europe in the upper area and Northern Africa below. Some main baths operating during the 3rd century A.D. are highlighted: 1. Aquincum, Pest, Hungary; 2. Aquae Cutiliae, Palombara Sabina, Central Italy; 3. Aquae Apollinaris, Bracciano, Central Italy; 4. Ad Aquas/ Aquae Carpitanae, Hamman Lif, Tunisia. *P. Burgassi, from a copy of the Tabula in the archives of ENEL SpA/Geothermal Department at Larderello, with highlights added by the authors. Courtesy of ENEL SpA/Geothermal Department*

The parchment was composed of a single sheet over 7 m long and just 34 cm high, showing from west to east nearly all of Europe, much of Africa, and all of Western Asia as far as the Ganges River Valley. After its discovery, the original document was subdivided into 12 sheets, the first of which (covering Britain and Spain and bearing the author's name) was unfortunately lost.

The need to represent an enormous expanse of territory on a single sheet required that the author flatten all the land forms and compress the sea areas to thin ribbons. Therefore, the map must be read with the help of the place names and knowledge of the distances between the localities, which are given in leagues (2220 m) for Gaul, miles (1480 m) for the rest of Roman territory, parasangs (6000 m) for ancient Persia, and Indian miles (7000 m) for India (Brancati, 1986).

Only a few of the thermal sites in the Empire are on the *Tabula*, probably those baths that were strategically located, well developed, and famous for balneotherapy and commerce (Burgassi,

1987). Otherwise, why did the cartographer use graphic symbols that emphasized the thermal sites instead of choosing the less prominent graphic symbols selected for most other localities?

The following table summarizes the development of thermal bathing in Roman times from the 8th century B.C. to the 5th century A.D.

Chronological development of thermal bathing in the Mediterranean area, from the founding of Rome to the fall of the Roman Empire

Century	Event
8th-6th B.C.	Systematic spread in areas under Etruscan influence Limited development in other Mediterranean areas No interest by the Romans
5th-4th B.C.	Greatest development in Etruscan territories Moderate development in other Mediterranean areas Initial interest by the Romans at some thermal localities on the Italian mainland, primarily for strategic purposes. Commercial purposes were secondary.
3rd-2nd B.C.	Annihilation of the Etruscans (3rd century B.C.) and temporary decline of all geothermal uses in former Etruscan territories Moderate thermal bathing in Mediterranean areas First Roman visits to baths (elite enjoy bathing at thermal springs)
1st B.C.-3rd A.D.	Invention of a heating system with hot air circulation in artificial spas Rapid spread of natural and artificial baths Peak balneotherapy development over all of the Empire Over 1,000 public baths and hundreds of private baths (all artificial) in Rome Hundreds of thermal stations outside of Rome, nearly all natural Multiple functions of baths: <ul style="list-style-type: none"> • Balneotherapy (water, steam, muds) at different temperatures • Aesthetic practices (massage, shaving, skin care, hair styling, depilation) • Recreation (ball games, parties, and other social activities) • Food services (formal restaurants, snacks) • Centers for public information • Forums for political initiatives • Centers for business negotiations • <u>Magnets for social aggregation and cultural events</u> <hr/> <ul style="list-style-type: none"> • Centers for cults • Local markets <i>Only in localities with natural baths</i> • Sites for popular festivals • Sites for athletic games <hr/>
4th-5th A.D.	General decline of baths throughout Europe Thermal bathing practiced locally and at reduced levels Onset of the twilight period

USING GEOTHERMAL BY-PRODUCTS BETWEEN THE 3RD CENTURY B.C. AND THE 5TH CENTURY A.D.

THE ROMANS BEGAN TAKING AN ACTIVE INTEREST IN USING AND TRADING THE BY-PRODUCTS OF geothermal energy in the 3rd or perhaps the 2nd century B.C., particularly after the victory over Carthage in 140 B.C. With trade routes now secured, the Romans dedicated themselves to public works projects, constructing temples and residential villas, and to crafts, arts, aesthetic practices, and health care.

All the uses of geothermal by-products developed by the Etruscans and other Mediterranean peoples before the 3rd century B.C. (see Chapter 9 in this volume) were adopted anew and improved in Roman times, and the Romans developed the following new uses:

- Hydrothermal compounds and pyroclastic products (kaolin, bentonite, perlite, pozzolan, and tuffs) were used as basic components or additives in preparing mixtures for pottery, cement slurries, construction materials, and bleaching solutions. Most compounds came from geothermal localities in Italy's pre-Appennine belt (Tuscany, Latium, and Campania), a few islands in the Tyrrhenian Sea (Ponza, Lipari, and Pantelleria), the Southern Aegean (Milos, Santorini, Nisyros, and Lesbos), and to a lesser extent from other volcanic islands and inland localities in the Southern and Eastern Mediterranean.
- *Palle da cane*, prepared in particular areas with natural manifestations, was widely traded throughout Roman territories. These were cakes of smectic clay, rich in hydrothermal salts (borates and aluminum silicates) taken from mud on the bottom of the pools of high-temperature manifestations in the Boraciferous region and perhaps also from other localities in Southern Italy such as the Phlegraean Fields, Ischia, Lipari, and Vulcano. From the start of the Christian era, the cakes were used widely to cure skin disorders and probably to degrease and tone the skin. The curious name literally means "balls for dogs," perhaps because the cakes, before they were used on humans, were tested at length on domestic animals, especially dogs, to ensure their efficacy at drying and healing sores and curing skin diseases, such as mange (Burgassi, 1987).
- Borax products from geothermal manifestations in the Boraciferous region and iron oxides from the same zone and/or other geothermal localities were used to prepare the glazes needed to paint fine pottery, and the glazes have proved to contain boric



Figure 7. Interpretation of a typical Roman vase, of the type called *vasa sigillata*. Drawing by V. Svalova from Cataldi and Burgassi, 1992b



Figure 8. Interpretation of a typical trademark (*sigillum*) used by Roman factories as a guarantee of fine pottery. Drawing by V. Svalova from Cataldi and Burgassi, 1992b

compounds (Fiumi, 1943). Reddish-glazed ceramics from the 1st century B.C., called *vasa sigillata*, owe their name to the bas-relief figurines they bear, probably corresponding to the trademark (*sigillum*) of the ancient pottery workshop (figures 7, 8). Examples are displayed in the archaeological museum of Arezzo in Tuscany.

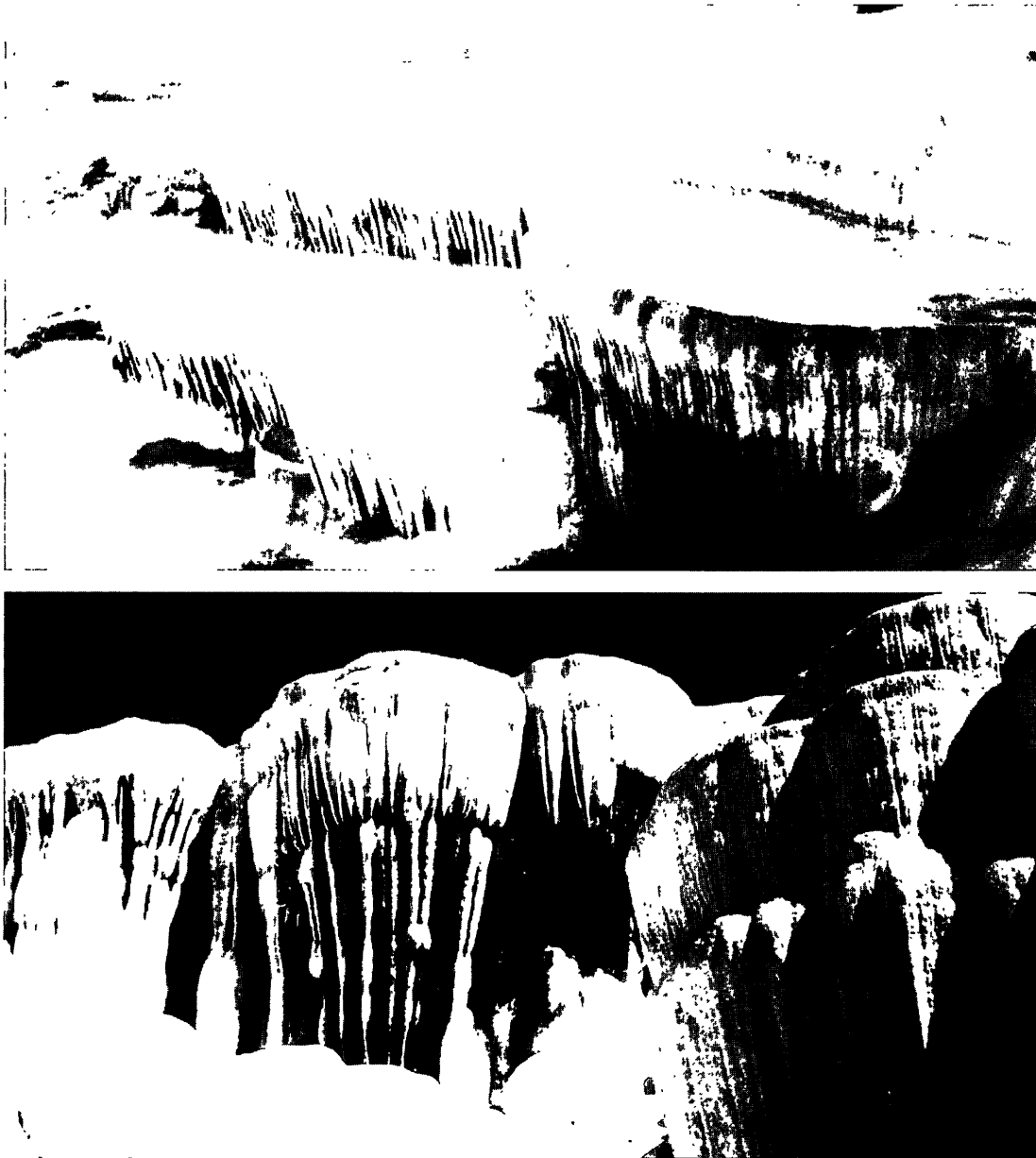


Figure 9. Panoramic view and detail of the travertine deposits of Pamukkale in Western Anatolia, Turkey. R. Cataldi, 1981

- Travertine (*lapis tiburtinus*, which means “stone from Tibur”) derives its name from the ancient city of Tibur, present-day Tivoli, where a large deposit exists. This typical by-product of geothermal energy was cut to make building blocks or facing stones for buildings and monuments throughout the Empire, including the Roman Colosseum and the Baths of Caracalla, the most famous. Among the many quarries exploited intensively in Roman times, the travertine deposits of Tibur (near Rome) and Pamukkale in Western Anatolia must be cited (figure 9). The latter is famous for its characteristic carbonate configurations of gracefully cascading cups, decorated with organ-pipe encrustations around the outer edges.

The following table summarizes the use of geothermal by-products in Roman times, from the 3rd century B.C. to the fall of the Roman Empire.

Uses of geothermal by-products in the Mediterranean area, from the 3rd century B.C. to the 5th century A.D.

Products	Uses
Hydrothermal compounds and fumarolized pyroclastic products (kaolin, bentonite, perlite, pozzolan, and others)	Basic components or additives for <ul style="list-style-type: none"> • pottery-making • cement and other building materials • bleaching solutions
Thermo-mineral muds	<ul style="list-style-type: none"> • balneotherapy • care of skin diseases • degreasing and toning skin
Borates and iron oxides	<ul style="list-style-type: none"> • glazes for painting fine pottery
Travertine	<ul style="list-style-type: none"> • facing slabs and building blocks for important buildings

A THOUSAND FERTILE YEARS FOR GEOTHERMAL RESOURCES (5TH CENTURY B.C. - 4TH CENTURY A.D.)

FOR NEARLY A MILLENNIUM, HUMAN RELATIONSHIPS WITH GEOTHERMAL RESOURCES WERE strong enough to be considered a propelling factor of civilization in the Mediterranean. We have discussed at length the influence of the Romans between the 2nd century B.C. and the 5th century A.D., but this does not mean that other Mediterranean peoples were not offering their own contributions to the development of thermal balneotherapy and the use of geothermal by-products. In reality, all Mediterranean peoples, including the Cretans, Phoenicians, Etruscans,

Gauls, Romans, Greeks, and Turks of Asia Minor, practiced and enjoyed balneotherapy in natural or artificial hot baths and found ways to use by-products of geothermal energy until the collapse of the Roman Empire. If the Etruscans deserve recognition as the historical fathers of the geothermal industry (Cataldi and Burgassi, 1992a), the development of natural heat during this millennium was a cultural heritage common to all the peoples of the Mediterranean and neighboring lands.

TWILIGHT AND THE AGE OF DARKNESS (5TH TO 10TH CENTURY A.D.)

AFTER THE *TABULA ITINERARIA PEUTINGERIANA* WAS DRAWN, PROBABLY IN THE FIRST DECADES OF THE 4th century A.D., thermal sites ceased to develop in the Mediterranean area. From the second half of the 4th century A.D. after the first sack of Rome, the practice of thermal bathing declined rapidly over the entire Empire, starting in the least important localities farthest from the capital. Although balneotherapy continued in some cases (the Baths of Caracalla in Rome, for instance, remained active at a reduced level until the early 6th century), thermal bathing gradually lost the custom of development, tradition, diffusion, and continuous renewal that had made it an international phenomenon for at least a millennium.

The decline continued and became more marked in the 5th and 6th centuries; it then proceeded apace with the dissembling process of the Roman Empire when Western Europe, Northern Africa, and the Middle East entered into a period of unrest, invasions, wars, and territorial partitions, forming the historical backdrop of the Dark Ages (Montanelli and Gervaso, 1965). The decline was not stopped by a precarious aggregation of people and lands established in some sectors of the former Roman Empire in the period between the 6th and 9th centuries when new geopolitical entities were formed in Europe (such as the Western and Eastern Roman, the Carolingian, and the Byzantine Empires).

A contribution to the decline of balneotherapy and the use of hydrothermal products may have come from a widespread belief in the last part of that period that the world would end by the year 1000. This event was insistently foretold to crowds by certain radical preachers for the last two centuries of the first millennium (Montanelli and Gervaso, 1965), and it discouraged visits to thermal baths for therapeutic and, especially, for recreational purposes. Within this framework of geopolitical, economic, and cultural gloom that affected a large part of Europe in the second half of the first millennium, one can hardly be surprised by the flourishing of many place names

that associated hot thermal manifestations with the infernal world, such as *Valle dell'Inferno* ("Hell Valley"), *Buca del Diavolo* ("Devil's Hole"), and *Monte Cerberi* ("Mount Cerberus"). All these names were links to legends and fables that attributed the formation of the manifestations to works of the devil; all postulated the existence of a subterranean world peopled with souls condemned to eternal flames. Thus for development of geothermal resources, the last centuries of the first millennium were for much of Europe, and especially for Italy, a period of Dark Ages.

CITED REFERENCES

- Brancati, A. 1986. *Civiltà confronto*, vol. 2. La Nuova Italia Edit., Scandicci (Florence).
- Burgassi, P. D. 1987. Historical outline of geothermal technology in the Larderello region. *Geothermal Resources Council Bulletin*, 16, no. 3, 3-18. (See Chapter 13 in this volume).
- Cataldi, R. 1992. El año cero de la geotermia. In *La geotermia en el período Precolombino en las áreas Mediterránea y Mesoamericana. Geotermia, Revista Mexicana de Geoenergía*, 8, no. 2, 155-175. (See Chapter 2 in this volume).
- Cataldi, R. and P. D. Burgassi. 1992a. Del misterio de la Atlántide a los primeros usos integrados de la energía geotérmica. In *La geotermia en el período Precolombino en las áreas Mediterránea y Mesoamericana. Geotermia, Revista Mexicana de Geoenergía*, 8, no. 3, 251-264. (See Chapter 9 in this volume).
- Cataldi, R. and P. D. Burgassi. 1992b. Florecimiento y decadencia del termalismo y de los otros usos directos del calor de la Tierra en el área Mediterránea desde el nacimiento de Roma hasta el fin del primer milenio. In *La geotermia en el período Precolombino en las áreas Mediterránea y Mesoamericana. Geotermia, Revista Mexicana de Geoenergía*, 8, no. 3, 265-288.
- Cataldi, R. and P. Chiellini. 1995. Geothermal energy in the Mediterranean area before the Middle Ages. *Proceedings of the World Geothermal Congress*, 373-380. (See Chapter 11 in this volume).
- Daremberg, C. and E. Saglio. 1899. *Dictionnaire des antiquités grecques et romaines*, vol. 3. Paris.
- Fiumi, E. 1943. *L'utilizzazione dei laghi boraciferi della Toscana nell'industria medievale*. University of Florence, CYA Edit., Florence.
- Montanelli, I. 1969. Storia di Roma: 753 B.C.-476 A.D. In *Storia d'Italia*. Rizzoli Edit., Milan.
- Montanelli, I. and R. Gervaso. 1965. L'Italia dei secoli bui. In *Storia d'Italia*. Rizzoli Edit., Milan.
- Musial, D. 1990. Sur le culte d'Esculape en Rome et en Italie. *Dialogues d'histoire ancienne*, 16, 231-238.
- Panessa, G. 1983. Le risorse idriche dei santuari greci nei loro aspetti giuridici ed economici. *Annali della Scuola Normale di Pisa*, 13, 359-387.
- Paoli, U. E. 1977. *Vita romana: Usi, costumi, istituzioni, tradizioni*. Mondadori Edit., Milan.
- Salway, P. 1981. *Roman Britain*. Oxford Clarendon Press, Oxford.
- Seneca. c. 60 A.D. Ad Lucilium; Epistulae morales. In *Seneca: Epistles, vol. 1*. Reprint 1917, R. M. Gummere, trans. Harvard University Press and W. Heinemann Ltd., Cambridge and London.

The Authors:

Raffaele Cataldi
55, Via del Borghetto
56124 Pisa, Italy
Telephone/Fax: 39.050.59.81.07
E-mail: rafcat@tin.it

Pier Domenico Burgassi
2, Via G. Galilei
56044 Larderello (Pisa), Italy
Telephone: 39.058.86.74.89



Statue of Hippocrates, famed medical doctor and scientist of ancient Greece, 5th century B.C. Considered the father of medicine, he was the first scientist to describe surface waters systematically and to classify them on the basis of chemical characteristics and temperatures. Eng. Demetrios Mylonas; kindly authorized by the Direction of the Hippocrates Museum in Kos, Greece
