

# REVIEW OF HISTORIOGRAPHIC ASPECTS OF GEOTHERMAL ENERGY IN THE MEDITERRANEAN AND MESOAMERICAN AREAS PRIOR TO THE MODERN AGE

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## INTRODUCTION AND AIMS

The occasion offered by the Symposium on the History of Geothermal Energy, held at Mexico City in January 1992 in the framework of the Third Latin American Congress on the History of Science and Technology, gave the cue to this writer and to several Italian and Mexican colleagues to begin an investigation into the relationships that man had with geothermal energy in some regions of the world prior to the Modern Age. This investigation has the aim not only of gaining greater insight into the ancient uses of natural heat and its by-products; but, also extends to gathering elements for comprehending what kind of "impact" the presence of geothermal manifestations, and the occurrence of volcanic eruptions may have produced on the ancient inhabitants of those regions.

An investigation of this type proves to be rather laborious and time-consuming for two reasons: the first relates to the effort needed to track down and find pertinent study sources, such as works by ancient authors, reports on archeological findings, old printings and other documents that directly or indirectly refer to various aspects of geothermal energy; the second difficulty lies in the interpretation of the sources in light of the research objectives, aimed at understanding what kind of "rapport" may have been established in prehistorical and ancient times between man and the differing types of geothermal phenomena.

These difficulties are enhanced by the fact that, contrary to exogenous energy sources (sun, wind, etc.), the manifestations of terrestrial heat were a "tangible phenomenon" for man in only a few specific places on earth, such as the areas of active volcanism or those in which particular geological situations allow hot fluids to rise to the surface. In other words, for the whole period prior to the Modern Age, the various types of geothermal phenomena were known to man through direct experience in only a few localities of the inhabited world of that time; in most other localities, on the contrary, ancient man could have at best an indirect and vague notion of the existence of active volcanoes, hot springs and other geothermal manifestations, initially through oral accounts of travelers from far-off lands, and afterwards through the works of geographers, historians, poets and philosophers.

For this reason, geothermal heat, though known and used by man since very ancient times in a number of localities, could never attain that generalized level of daily "relationship" with man, which the exogenous sources of energy attained in all inhabited zones on earth since the darkness of prehistory. As a matter of fact, experience was independently accumulated

in the different inhabited areas where geothermal manifestations occurred; moreover, distinct and often non-coeval knowledge was gained on the forms in which the terrestrial heat manifests itself at the surface. Hence, ancient man could have only site-specific experience with geothermal energy, so that the "rapport" between the inhabitants of geothermal areas and the various types of natural manifestations could develop in ways that differed greatly from zone to zone.

In certain places, geothermal manifestations were considered by ancient man a kind of *ludus naturae* (i.e. a "prank of nature"); in other places they were regarded as the surface manifestation of gods of the underworld (at times evil and punitive, at others benevolent and gracious with man) who dwelt beneath the ground in specific localities of the earth. Therefore, three differing types of relationship could have developed in time between man and geothermal energy: (1) a "rapport" of a pragmatic nature, concerning the use of natural heat or the exploitation of hydrothermal products for practical purposes, (2) a "rapport" of confidence (in certain cases even of worship) with those manifestations that occurred in non-dangerous form, and (3) a "rapport" of caution and circumspection (sometimes also of fear) with those manifestations that occurred in dangerous form (fumaroles, volcanic eruptions, volcano-tectonic events, etc.).

The subjects of ancient sources taken into account for the purpose of the investigation in question include: descriptions of volcanic eruptions and their effects, citations of seismic events, practical uses of natural heat and of its by-products, references to thermal springs, popular beliefs and myths directly or indirectly associated with various types of geothermal phenomena, divinity cults related to volcanic features and hot springs, magical or ritual practices carried out in some geothermal localities, poetic images and any other elements in some way related to surface evidence and to the direct uses of terrestrial heat.

Obviously, all these subjects are rather much scattered from the geographic point of view because they refer to geothermal areas that are mostly located at considerable distance from each other; moreover, the ancient sources that directly or indirectly address aspects regarding the earth's heat, although unexpectedly numerous and rich in interesting details for the purposes of the investigation under review, are very heterogeneous. Indeed, alongside geographic and naturalistic descriptions, many other kinds of documents can be found: historical, philosophical and poetical works, epigraphs, medical treatises, epistolary correspondence, drawings, engravings, archeological finds, etc., which explicitly refer to geothermal phenomena and localities, or



which indirectly allude to the practical usage of natural heat prior to the Modern Age.

Despite the difficulties mentioned above, these types of sources enable us to understand the effects that the occurrence of geothermal manifestations and volcanic phenomena had on the settlement and development of man in some areas of the world; as a consequence, they also enable us to start reconstructing the "relationships" that were gradually established in ancient times between man and the various manifestations of terrestrial heat. In this light, the research undertaken can be considered as a first contribution to the historiographic knowledge of geothermal energy.

## SUMMARY OF WORK CARRIED OUT

The information gleaned from the documents found so far for the areas mentioned in the title has made it possible to prepare the two works (1) and (2) cited in the footnote.

- The first is a volume containing about 130 bibliographic cards, each summarizing the elements of geothermal interest found in the works consulted. Additionally, each card is accompanied by one or more pages of the work concerned, so that the passages related to the above-mentioned elements can be read in the original ancient language and/or in the modern language of its translation.

- The second work is a monographic paper which is based in part on the information inferable from the above-mentioned volume. The chief aim of this paper is to outline the presumable initial development, and the evolution in time of the "relationship" of man with geothermal energy in the Mediterranean and Mesoamerican areas, from an indeterminate moment in the Lower Paleolithic to the end of the Middle Ages.

On the basis of prevalently inductive considerations, the first part of the paper (chapters 1 and 2) discuss what may have occurred in the time period from the aforementioned moment in the Lower Paleolithic ( $10^5$  -  $10^6$  years ago) until the end of the Neolithic. Throughout this extremely long period, which the authors comprehensively call *year zero of geothermics*, the "relationship" of man with the various manifestations of terrestrial heat and with its associated products was (for the zones where these manifestations were

present, obviously) quite close and intense for those times. Indeed, in addition to the initial development of the direct uses (hot baths, cooking of prey in boiling waters, first usage of hydrothermal products and muds, and the working of obsidian), this "relationship" with geothermal energy also involved man's "cultural sphere", as is demonstrated by the interest in observing and depicting certain types of geothermal phenomena (Figure 1), and as can be inferred from the formation (presumably beginning in the Lower Neolithic) of embryonic religious sentiments towards "beings" (malevolent or benevolent, according to the cases) dwelling underground in geothermal areas.

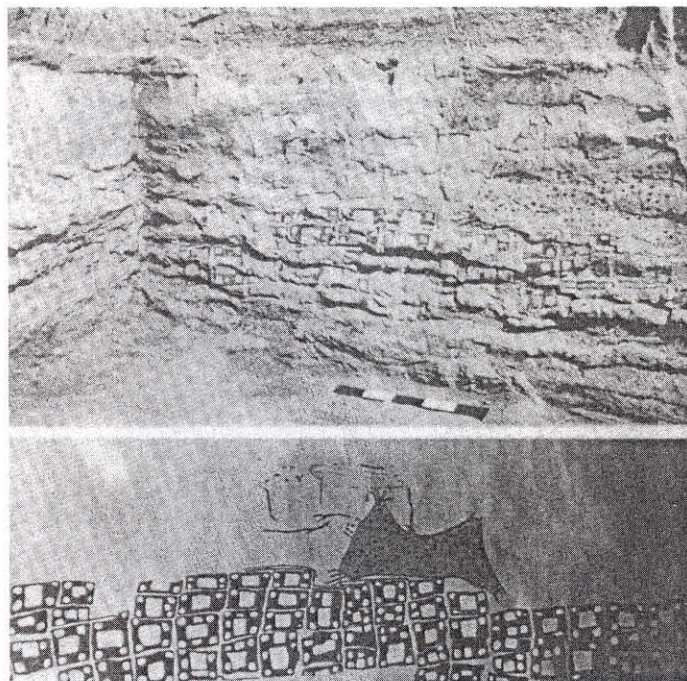


Figure 1. Neolithic village of S-E Anatolia (Turkey) with the volcano Hazandag during eruption (~6200 B.C.) in the background.

- a. Wall painting found in "level vii" of the Catal Huyuk Neolithic settlement.
- b. Reconstruction of the original wall painting.

The second part of the paper (chapters 3 to 5) regards the development of direct uses and the importance that thermal balneology attained in some regions of the Mediterranean area in historical times, from several thousand years ago to the end of the Middle Ages. In particular, these chapters illustrate the impulse given by the Etruscans to the exploitation and processing of hydrothermal products, the blossoming of balneotherapy and the multiple functions of the spas in Roman times (\*), the

(1) P. D. Burgassi, R. Cataldi, J. L. Hernandez Galán, M. Moggi, R. Rubinovich, J. J. Saldaña: Primera Contribución al Conocimiento Historiográfico de la Energía Geotérmica en el Área Mediterránea y en la América Latina. Pisa, Mexico city, January 1992 (\*).

(2) R. Cataldi, P. D. Burgassi, M. C. Suárez: La Geotermia en el Período Precolombino en las Áreas Mediterránea y Mesoamericana. Geotermia: Revista Mexicana de Geoenergía. First part in Vol. 8, No. 2, 1992; pp. 145-175. Second part in Vol. 8, No. 3, 1992; pp. 251-303. The remaining two parts of the paper are scheduled for publication in the next two issues of the same journal.

(\*) This work has been published in a limited number of copies and is available for consultation at selected places. Information on these places can be obtained from R. Cataldi or J. L. Hernandez Galán.

(\*) It is worth mentioning in this regard that more than 1000 artificially-heated spas and many hundreds of natural thermal spas were in operation in the territory of the Roman Empire during the period of its maximum expansion (III century A.D.). The main natural spas of that period were highlighted in the official geographical map of the Empire (the so-called *Tabula Peutingeriana*), that dates back to the beginning of IV century A.D. (Figure 2).



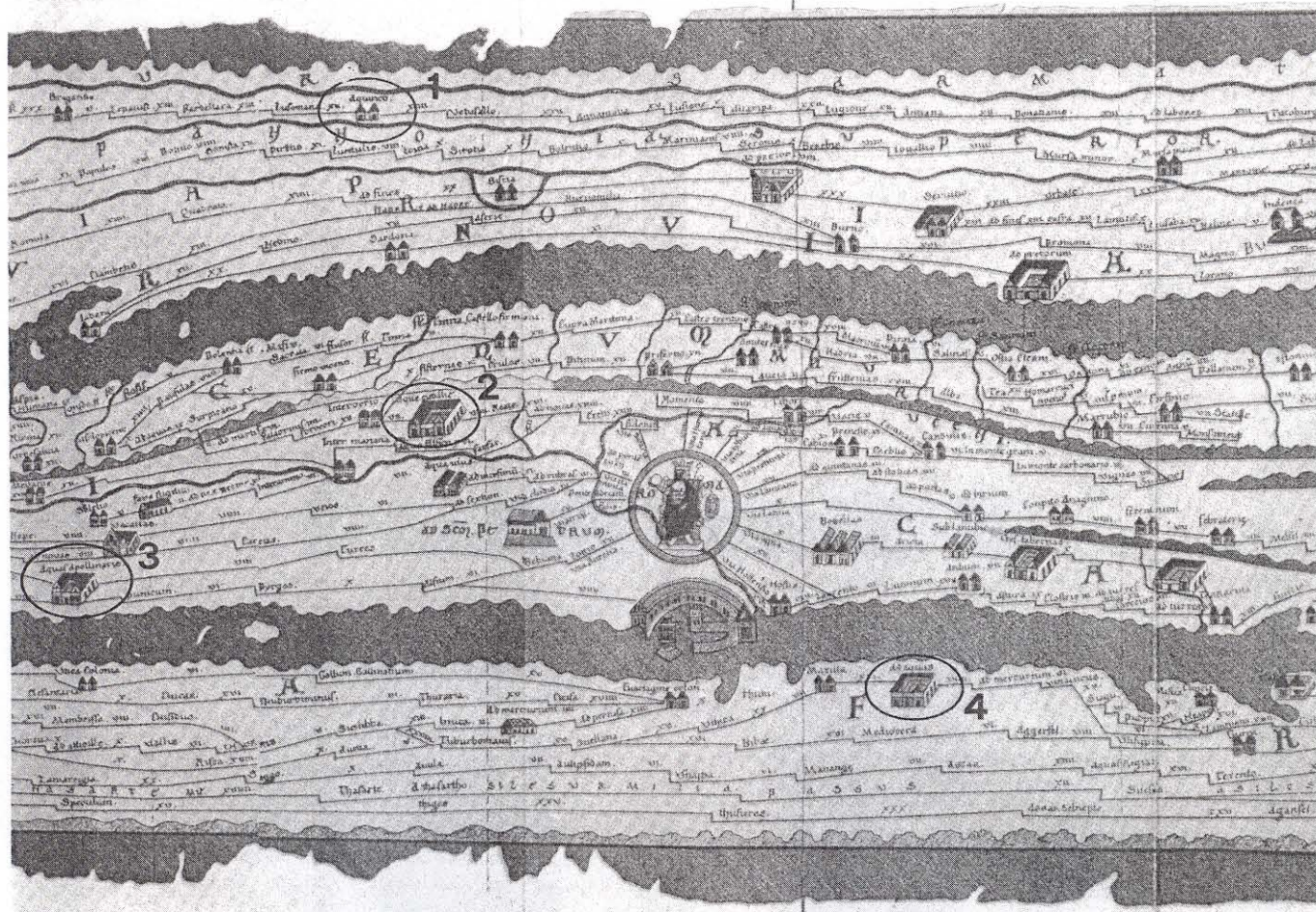


Figure 2. Tabula Peutingeriana: Area corresponding to central Italy with a sector of southern and central Europe in the upper part, and of northern Africa in the lower part of the figure. Some of the main spas in operation during the III Century A.D. are highlighted: (1) Aquincum (Pest, Hungary), (2) Aquae Cutilliae (Palombara Sabina, Central Italy), (3) Aquae Apollipares (Bracciano, Central Italy), and (4) Ad Aquas/Aquae Carpitanae (Hamman Lif, Tunis).

decline of all direct uses between the 5th and 6th centuries A.D. following the collapse of the Roman Empire, and the intensive exploitation of the manifestations of Larderello between the 11th and 16th centuries. To have an idea of the importance that utilization of the by-products of geothermal energy reached in antiquity in the Mediterranean area, reference can be made to Table 1.

The third part of the work (chapters 6 and 7) refers to the Mesoamerican area (Mexico and neighboring regions) and covers the period extending from several millennia before the Christian era until the time of the voyages of Columbus. In this area, ancient uses of geothermal energy were similar in scope to those applied in the Mediterranean area; however, most of them apparently underwent an autochthonous evolution as a result of the peculiar culture which characterizes Mesoamerica as compared to the type of culture developed in the Mediterranean area prior to the Modern Age. Among the

many examples of the peculiar "rapport" which established between Mesoamerican man and geothermal energy, the practice of the so-called *temazcal* (\*), as well as the sacredness of active volcanoes as a source of life and symbol of regeneration could be mentioned.

Finally, the last part of the paper (chapters 8 and 9) attempts to reconstruct the birth and initial development of scientific thought regarding the various types of geothermal phenomena, starting from the oldest known illustration of a volcanic eruption (Figure 1) until the end of the Middle Ages. During this period, many authors began to give interpretative descriptions of the different kinds of geothermal manifestations and to discuss the origin of the thermal fluids.

(\*) *Temazcal* is a steam bath that was originally made by splashing the water on heaps of stones accumulated over high-temperature manifestations. This type of bath was practiced not only for hygienic-therapeutic purposes but also (or perhaps mostly) for ritual and social aims.



**Table 1. The Use of Geothermal By-Products in the Mediterranean Area From the 10th Century B.C. to the 10th Century A.D.**

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A) <u>Principle by-products</u> (in alphabetical order)	
- Alum	- Loose pyroclastic products (lapilli,
- Borates	pozzolana, perlite, etc.)
- Iron oxides	- Native sulphur
- Kaolin and other products of	- Silica
fumarolization processes	- Thermomineral muds
- Lithoid lava and tuffs	- Travertine

B) <u>Principle uses of by-products</u>	
- Manufacture of ceramics: <i>Kaolin and other hydrothermal clayey mixtures</i>	
- Manufacture of varnishes, lacquers and enamels: <i>borates, iron oxides</i>	
- Manufacture and coloration of glass: <i>silica, iron oxides</i>	
- Preparation of ointments and other pharmaceuticals: <i>sulphur, aluminum borates, thermomineral muds, iron oxides</i>	
- Fangoterapy and treatments of skin diseases: <i>thermomineral muds</i>	
- Textile industry (wool bleaching, treatment of clothes, etc.): <i>alum, sulphur</i>	
- Construction industry (mortars for cement, materials for buildings and facings, plasters, etc.): <i>bentonite, perlite, lapilli, scoriae, pozzolana, kaolin, lithoid lava and tuffs, travertine</i>	

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## CONCLUSIONS

The main conclusions to which work (1) and (2) lead us are as follows:

- (a) in some zones of the world, the direct utilization of terrestrial heat and its by-products definitely began in prehistoric times (> 10,000 years ago);
- (b) although experiences with the exploitation of earth's heat matured independently of one another in antiquity, a series of analogies exist on the direct uses in the various zones, which makes one think of geothermal development in terms of a "cultural heritage" common to many of the earth's ancient peoples;

- (c) the different types of geothermal phenomena had great importance for the purpose of the "man-territory relationship" in some parts of the world. In this regard, the three following principle effects of geothermal energy can be identified:

- an *attractive effect*, for all those places where the presence of "tranquil" natural manifestations induced man to settle in the vicinity of them. Among the many hundreds examples that could be made in this regard, the following can be mentioned: *Fons Aponi* (i.e. Abano, N-E Italy) and *Hierapolis* (i.e. Pamukkale, Western Anatolia, Turkey) for the Mediterranean area, and the numerous *Atotonilco* (i.e., villages developed near thermal manifestations in Mexico) for the Mesoamerican area;

- an *expulsive effect*, in those localities where the "violent" manifestations of terrestrial heat (destructive volcanic eruptions and earthquakes) obliged man to abandon his native grounds and emigrate to safer places. Among the countless cases of territorial displacement that man had to make in antiquity because of huge eruptions and/or castastrophic earthquakes, the examples of the island of *Thera* (Aegean Sea, Greece) and of *Antigua* (the old capital of Guatemala) could be made for the Mediterranean and Mesoamerican areas, respectively;

- a *propulsive effect* in those localities where the possibility of practicing thermal balneotherapy, and/or of using the by-products of terrestrial heat (hydrothermal minerals, travertine, obsidian, pozzolana, etc.) and/or of developing farming in fertile volcanic soils gradually helped man to improve the quality of his life.