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A Short Story of the Long Relationship Between The Human Race and Geothermal Phenomena

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ABSTRACT

From his darkest past, prehistoric man used volcanic rock, silex, obsidian, ignimbrites, flint and basalt to manufacture tools and weapons. Some of his descendants knew how to use lava extrusions to make homes with hard rock, cooking by steam at fumaroles or on naturally hot rocks and how to use thermal waters and mud in body hygiene, in curing wounds and in tempering arrows and lances for hunting and war. Washing and bathing from thermo-mineral springs, irrigation and therapeutic and recreational applications occurred at different times in diverse ancient cultures spread in all the continents.

Bathing in geothermal waters was an essential part of life in many older, advanced civilizations. There is a long line of bathing cultures, starting with antique prototypes in the Old World of Greeks, Romans, Turks, Chinese, Finnish, Japanese, Jews, Arabs, Mesoamericans, Maoris, Koreans and Indonesians. Spas (*Sales Per Aqua's*) or health through waters containing mineral components, were used not only for curing rheumatic, sciatic, gynecological and other physical diseases, but also for treating psychiatric problems and for relaxation.

Geothermal energy also played an important role on human occupancy of some territories, because volcanic activity should have determined alternate emigration-immigration fluctuations over the population in the affected zones. At the same time, the economic, social, agricultural and artisan development of the people living in volcanic sites were influenced by volcanic eruptions. The mythical religious interpretations of geothermal phenomena occurred very early, reflecting a profound respect toward terrestrial heat.

Many ancient cultures throughout the world developed close to recent volcanic areas, interacting with geothermal events. Now some of their descendents are developing and using spas, space heating/cooling and agricultural geothermal programs, while others are commercializing its by-products or building greenhouses and electrical power generation plants. This perspective emphasizes the prehistoric antiquity of the cognitive processes and practical uses of geothermal phenomena. This work is a general outline on the common points of contact between different human societies and the thermal Earth.

1. INTRODUCTION

Humanity has always lived on a geothermal planet. During millions of years many areas in this planet were very rich in active geothermal manifestations: earthquakes, volcanoes, thermal springs, fumaroles, mud lakes, hydrothermal deposits and *lagoni*. In these sectors a profound relationship emerged very early between humans and geothermal phenomena. With their beauty and destructive powers, the volcanoes have inspired the imagination of human beings and influenced their beliefs. Extraordinary civilizations often emerged at the shores of big rivers: the Nile, Euphrates, Tigris, Yangtze, Yodo, Danube, Seine or Tiber. That was not the case in America on either the Amazon River or the Mississippi River. There is evidence that the development of civilizations in some areas has been strongly conditioned by the occurrence of geothermal phenomena. Volcanic activity should have determined alternate emigration- immigration fluctuations over the old population in the affected zones. The relationships of humanity – territory - geothermal events developed as confluent streams that emerged from the man's first contacts with the Earth's heat and date to prehistoric times. Those contacts should appear in areas of the planet with active geothermal manifestations: thermal springs, steaming ground, hydrothermal minerals, fumaroles, *lagoni*, cracks, eruptions, deposits and earth-quakes of volcanic origin.

Through millennia, populations increased and geothermal contacts continued developing. They consolidated in regions where the terrestrial heat was not of eruptive type, facilitating for example, the cooking of food at the vapor of fumaroles or in naturally hot rocks, bathing in thermal waters and other practical uses such as irrigation and therapeutic applications. This work is focused on how geothermal events have affected mankind, exploring their influence on the relationship between humans and territory and on the material and spiritual development of many cultures in Africa, Asia, Europe, America and Oceania.

2. THE ORIGINS OF HUMANS AND THEIR FIRST CONTACTS WITH TERRESTRIAL HEAT

The first contacts of hominids with the Earth's heat go back to prehistoric times: *Homo Habilis*, of the late Tertiary and basal Quaternary Periods (from 8 to 1.5 million years ago), *Homo Erectus*, of the early and middle Pleistocene (from 1.5 million to 10^5 years ago) and *Homo sapiens* of the late Pleistocene (from 10^5 to 10^4 years ago). In Africa, several thermal springs are known to exist in the northern zone, Algeria, Morocco and Tunisia. But the largest concentration of geothermal manifestations is found in the East African Rift Valley, Lund (1999). This geographical site is believed to be the cradle of humanity where ancestors of humans were in close contact with all kind of geothermal phenomena for two million years. Lund (1999) reported that human fossil remains and footprints, corresponding to the *Homo Habilis*, have been found and preserved in volcanic ash in northern Tanzania. Many tools made from volcanic rocks, such as hammer stones, cobbles and choppers, were found on the shore of Lake Turkana in northern Kenya. Both are about two million years old. About 200 human fossil remains of the *Homo Erectus*, dated at about 1.6 million years ago, were discovered at Lake Turkana (*ibid*).

Homo sapiens are thought to have first appeared about 400,000 years ago, certainly in Africa and perhaps in parts of Asia as well, *Encyclopaedia Britannica* (1999). But recent findings in Eritrea, in east-northern Africa, suggest that *Homo Sapiens* appeared for the first time between one million and 600,000 years ago at the northern end of the African Great Rift where numerous thermal springs and fumaroles existed, Lund (1999). *Homo Sapiens* and *Homo Erectus* probably began migrating out of Africa one million years ago, spreading their descendants into India, China, Southeastern Asia and Europe. The Neanderthal and the Cro-Magnon species appeared in Europe about 125,000 and 40,000 years ago, respectively.

The origin of man in America does not introduce any epistemological problem. Here no one has ever found human remains from predecessors of *Homo Sapiens* as in Africa, Asia and Europe. It is accepted that the proto-Americans came from Asia some 50,000 years ago and that they passed through the Bering Straits in the northwest. The first immigrations may have come from the shore of the river Amur in Siberia and from the southern zones of Central Russia, Ruiz (1987) and Sodi (1992). The first passages occurred during the Wisconsin glaciation (70,000 - 30,000 years B.C). This agrees with the oldest human fossils discovered in America, Carmona (1993). The Mongoloid immigration, with the *Olmecas* and *Mayan* ancestors, should have occurred after the second glacial period, around the year 12,500 B.C., at the end of the Woodfordiense interglacial period.

The first contacts of the proto-American *Homo Sapiens* with the Earth's heat probably happened soon thereafter when the nomads passed through the northern portion of the Ring of Fire between the North American and Pacific plates. As new populations progressed southward, they reached the Cascade Range and found many active geothermal manifestations. Subsequently, in their slow expansion, they discovered the imposing manifestations of what is today Yellowstone Park and The Geysers Geothermal Field. Later, some ancestral nomads arrived at today's Cerro Prieto Geothermal Field in northern Mexico and to other geothermal fields in the Valleys near the present Mexican border with the USA. Those archaic groups should have spread slowly towards the center and south of Mexico, seeking better soils and climates, Suarez *et al*. (1999). By now, mankind was familiar with geothermal energy around the world.

3. THE FIRST USES OF TERRESTRIAL HEAT

From the remote and dark past, prehistoric man used volcanic rock, silex, obsidian, flint and basalt to manufacture weapons and tools. Tales and legends tell of the use of thermal waters and mud for body hygiene, curing wounds and tempering arrows and lances used for hunting and for war, Suárez and Cataldi (1993). The first systematic uses of natural heat arose with the beginning of stable human settlements devoted to the cultivation of plants in the rich soils close to volcanic zones, places with thermal springs, fumaroles, gas exhalations, mud lakes, volcanoes, *lagoni*, kaolin, sulphur, iron oxide, boron and many other hydrothermal deposits. Some prehistoric people cooked food by indirect contact with the heat of the earth, as the natives still do in the geothermal zone of Ixtlán de los Hervores in Mexico. Diverse kinds of documented evidences reported and published by Cataldi, Hodgson & Lund (1999), show that in the present territories of the African Rift, China, Japan, India, Greece, Italy, Turkey, Macedonia, Russia, Kamchatka, Crimea, Georgia, Armenia, Azerbaijan, the Carpathian region, Romania, Hungary, Poland, Jordan Valley, Korea, Indonesia, Philippines, Indonesia, New Zealand, North America, Mesoamerica and Andean region, hot springs were known since prehistoric times and today are used for thermal bathing and curing diseases and infirmities. Volcanic eruptions and phreatic explosions, mentioned in Greek mythology, took place on some Greek islands during prehistoric and historic epochs. Ancient Greeks and Aztecs used volcanic rocks for tools, artifacts and building and they often frequented the thermal springs.

Since 7000 B.C., the inhabitants of Anatolia in Turkey used the hundreds of hot springs for recreation and therapeutic treatments. So we may assume that thermal balneology was a worldwide tradition since the dawn of history. Innumerable old societies knew the healing and medicinal properties of thermal waters and mud to alleviate stress and arthritis, to embellish the body and cure wounds, and to treat rheumatism, leprosy, psoriasis, paralysis, skin ailments, dyspepsia and leucoderma.

There were many other common uses of the natural Earth's heat by prehistoric peoples. Washing, bathing, recreation, cooking food and rituals were some of the first uses of natural heat in many regions of the world. Some North American Indian tribes kept thermal springs as neutral areas where any person could enter safely. Many African tribes believed in the curative properties of hot springs. All these people, from Africans and Greeks to Aztecs and Maoris, had very similar experiences with geothermal energy.

4. HUMAN OCCUPANCY OF TERRITORIES AND GEOTHERMAL ENERGY

The presence, thousands of years ago, of resident communities in many zones with geothermal manifestations, often near volcanoes, was verified by geographical research and archaeological discoveries. The presence of such settlements would be enough to infer that from very remote times, mankind established a convivial relationship with volcanoes and other surface manifestations of the Earth's energy. One of the earliest pieces of art known is the mural found at the Neolithic town of Catal Höyuk, Özgüler & Kasap (1999), depicting the eruption of the volcano Hasan Dag in 6200 B.C. The eruption of volcanoes destroyed population centers but people returned to the areas, attracted by traditions and fertility of the volcanic soils, natural heat, water storage in craters, good climatic conditions and nearby by hard rocks to make houses, monuments and tools.

Several European and Asian civilizations flourished in the cradle of Anatolia, Turkey, located in a volcanic and tectonic zone with hundreds of hot springs, fumaroles, mud pools and mineral resources. Sometimes national capitals have been located and founded because of the presence of thermal springs. This was the case for Addis Ababa, the capital city of Ethiopia since 1889, Lund (1999). In Mexico some 12,000 archaeological sites have been discovered, Bernal (1979), the majority near to volcanic areas. The Mexican Volcanic Axis, located in south-central Mexico, has an imposing series of 3,000 volcanic structures and ten volcanoes are still active. The region is particularly rich in geothermal manifestations, active and fossil. The altitude varies between 1500 and 3000 meters, the zone is temperate, and this sector was the heart of Mesoamerican civilizations.

The first Vikings settlers that came to Iceland in the 9th century A.D. learned very quickly to use the numerous local hot springs for washing clothes, boiling food and

bathing. The oldest known geothermal pipeline was made in Iceland and dates back to the 13th century and in 1753 successful experiments were carried out to produce salt from seawater by vaporization using geothermal heat, Fridleifsson (1999). In France, in the small town of Chaudes-Aigues ("hot-waters") in 1334, an urban, geothermal, district-heating system was operating, Gibert & Jaudin (1999). Perhaps the first such system in the world to exist had been operating at Paquimé (also called Casas Grandes) in northern Mexico since about 1030 A.D., Hodgson (2004).

5. GEOTHERMAL PHENOMENA AND RELIGIOUS CULTS

From proto-historical times, the presence of thermal sources and other manifestations of terrestrial heat encouraged the birth of legends, traditions, myths, practices, cults and rituals in Africa, Asia, Europe, America and Oceania. Prehistoric tribes and ancient civilizations considered the "Fire of the Earth" a gift from the gods for the benefit of humans. The Sioux Indians in the USA described the fumaroles and the thermal springs as *Wakan Tanka* (Great Mystery); Lund (1999) and these were *Wahi Tapu* (Sacred) to the Maorís of New Zealand.

Huehueteotl, the volcanic god of terrestrial fire, was the oldest deity of Mesoamerica and considered father of the other gods (Fig. 1). His representation as an old man suggests the antiquity of mountains and volcanoes, Suarez *et al*. (1999). However in Japan, the god of fire was *Kagutsuchi* the youngest son of *Izanami* and *Izanagi*, the central deities. The Japanese believed that volcanic eruptions were due to the fury of this god living inside the volcanoes, Sekioka (1999).

Figure 1: A common representation of the God of Fire, Huehuetéotl. National Museum of Anthropology and History, Mexico City.

In Italy since the Neolithic Age, the inhabitants established religious cults and funerary rituals related to diverse geothermal manifestations. In addition to numerous cults in caverns with hypogeal waters, other rituals appeared in Italy in about 3000 B.C. Big vases and burials have been found in Sicily in natural tunnels with sulfurous steam at 39°C, Cremonesi (1999). Both could be offerings to an underground divinity.

In different epochs over the last 2,000 years, important religious factors existed in the Jordan Valley, especially for balneological practices, Jaffé *et al*. (1999). The ancient Greeks often used the curative properties of their thermal springs and expressed gratitude to the healing divinities of the thermal waters, erecting many temples to Asclepius, god of medicine, near the thermal springs all over Greece. They believed that thermal waters were sacred and special gifts of the gods of Olympus. The nymphs were also related to thermal waters. Greece, like many other important civilizations during the early stages of cultural formation, first developed a cosmogony and a set of universal principles based on mythological and religious perspectives, Fytikas *et al*. (1999).

In different cultures and epochs, probably each ethnic group in the world had a unique set of religious certitudes. But it is also true that those beliefs held many things in common. Several gods in antiquity performed the same functions but under different names in different languages (water, sun, rain, moon, volcano, war, heaven). For example, the devotion toward the sun and the volcanoes, considered as sacred objects, was immense and almost universal. These beliefs, expressed in traditions and religious rites practiced by thousands of generations were the origins of countless popular customs. That is why in many places and in different epochs, geothermal energy had a preponderantly religious interpretation and a dual ethical relationship: constructive / destructive, beneficial / harmful, good / evil, helpful / malicious, Suarez *et al*. (1993). This understanding deeply influenced the cosmic view of many people, proving that the mythical-religious interpretations of geothermal phenomena occurred very early and reflected a deep respect for fire and terrestrial heat in their diverse forms.

5.1 The Mesoamerican Cosmogony

Two stable, visible bodies in the heavens are the Sun during the day and the Milky Way during the night. Among the Aztecs, *Huitzilopochtli*, god of war born on the Earth, represented the Sun. His dismembered sister, the goddess *Coyolxauhqui*, characterized the Milky Way, Aguilera (1979). The Sun, dying at every sunset, undertook a daily trip through the underground to charge himself with the energy from the womb of his mother *Coatlicue*, goddess of the Earth. Only in this way could he be born again at sunrise, Suarez *et al*. (1999). For this culture, the divine energies were land, corn, volcanoes, wind, rain, lightning, sun, and stars.

Water was always related to the Mesoamerican people's origin, León-Portilla (1992). Water was the basic element in one of the first epochs of their existence. At the horizon the waters of the Earth joined the water of Heaven enveloping the world. That world was called *Cemanahuac*, (´that which is surrounded by water´). The cosmic meaning of water was so important that in the Nahuatl language, *atl* ("water") came to represent the phoneme "*a*". Because of such importance, *Tláloc*, the god of rain, was adored in all Mesoamerica. The Mayan called him *Chac*; the Mixtecas, *Cocijo*; the Totonacas, *Tajín*. In Náhuatl, city is translated as "*in atl in tepeli"*, literally: "water-mountain" (*ibid*.).

Pilgrimages were made to the volcanoes several times over the solar year. The existence of lakes in various craters of old volcanoes reinforced the belief in the relationship volcano-water. This equivalency implicitly contains the

idea that mountains are big water reservoirs, preserved as reserves of rain by the gods. The Florentine Codex says:

"*All the high mounts, where the clouds join to make rain, are gods. To each one of them an image is made ... Like the image of the volcano Popocatépetl ('smoky mountain') or of her whose name is Iztaccíhuatl ('white woman'), or the image of the mount Poyauhtecatl ('that which is from the region of the fog')* ".

5.1.0 The Five Aztecs Suns

In many chronicles and oral traditions, in indigenous manuscripts and on the reliefs of several pre-Hispanic monuments, the idea is found that our time was preceded by four Eras named Suns by the Aztecs (Fig. 2). Each one of these epochs finished with the destruction of the world by different and terrible cataclysms generated by the energy of the Earth. Those missing worlds were in cosmological order: *atl* ("water"), *ocelotl* ("tiger"), *quiahuitl* ("rain") and *ehecatl* ("wind"), León-Portilla (1961). Our present world is designated on the Aztec calendar by the date *nahui ollin* ("4-Movement"), which means *earthquake*. The end of each age was governed by one of the 4 primal forces in nature: water, earth, fire or wind, Leon-Portilla (1983). Each age had great mythical importance; the meaning and the end of each one follows:

5.1.1 Atl-Tonatiuh ("Water Sun").
The first men were made from ashes. In this first catastrophe, humanity was destroyed by water in the form of floods and the inhabited land was invaded, converting men into fish.

5.1.2 *Ocelotl-Tonatiuh* ("Tiger Sun").
In this second age, the sun stopped at noon, interrupting its path. Suddenly night appeared and heaven was oppressed. At this time giants lived, who in spite of their corpulence, were in fact weak beings. When they fell because of an accident, they fell forever.

5.1.3 *Quiahuitl-Tonatiuh* ("Rain of Fire Sun").
In this third age, rock boiled, burning the people in a rain of fire coming down from volcanic eruptions called *"Tlaequiahuitl"* that destroyed the world. Men who existed then had a tragic end. They were transformed into turkeys. The date *4-Quiauitl*, which records the end of this time, is placed under the protection of *Tláloc*, god of rain and the god of fire, falling from the sky in the form of lightning rays and volcanic eruptions.

5.1.4 *Ehecatl-Tonatiuh* ("Wind Sun").
During this epoch, everything was destroyed by the wind in the form of terrible hurricanes, snowstorms and glaciations. Human beings were converted into monkeys and were scattered to the mountains. At the end of this fourth era, the gods met in the sacred city of Teotihuacán in order to once again create the world. By means of the sacrifice of one of them, who flung himself into the fire of an active volcano, the Fifth Sun emerged

5.1.5 *Ollin-Tonatiuh* ("Movement Sun").
This is the last of the cosmological Eras. The *nahuas* lived in the era of the Fifth Sun. We are still in the midst of this Era, which will be devastated by earthquakes. Its divinity is *Xiuhtecutli*, god of fire, who joins the heat of the Earth and heaven.

Figure 2: The Aztec Calendar or Myth of the 5 - Suns. Museum of The Templo Mayor, Mexico City.

In the myth of the suns, a strange depth is observed apart from the religious implications and geological coincidences. The original text emphasizes a penetrating consciousness concerning the relativity of the world and of existence, equivalent to the Tibetan certitude that nothing lasts for ever. In this legend, an implicit and resigned acceptance that everything passes, everything finishes, even the gods, is observed. This legend, by itself, makes up an extraordinary synthesis of the group of cosmological certainties that the latest heirs of Mesoamerica confront.

5.2 The calendar, geothermal energy and the concept of time

The Mesoamerican calendar has existed since the year 700 B.C. It is structured as a complex measuring system based on the idea of time as a material flow. The Aztecs conceived the time *Cáhuitl* under the concept of "that which is leaving us", Leon-Portilla (1961). Being of a flow, time must come from a divine source. It was another time, outside of the human scope, which originated man's time. At the beginning of the universe, the vital activities of the gods created this world. The order in which the mythical actions happened gave birth to the calendar. Every new engendered being will take for its name the name of the day when he was created, López (1990). Given the terrestrial nature of the oldest gods and the worldly origin of Sun and Earth, the symbols that formed part of the calendar to represent the days, months, years and centuries deeply reflected the influence of geothermal phenomena in the Aztec Calendar's final structure. Each cycle expressed the eternal return of things and the recurrent regularity of natural phenomena. It was considered that the complex reality of the world originated from the intersections and simultaneous influences of cycles from different times. The historic repetition was inevitable but only at the end of a gigantic cycle that includes all the possible combinations of the previous cycles:

"*... again it will be like this, again so will be the things, in some time, in some place*." [Florentine Codex].

The premier ring holding the 20 days of the Aztec Calendar shows again the importance the ancient Mexicans gave to the concepts related to geothermal processes: rain (water, fire or eruption), flint (production of knives and fire), movement (earthquakes) and serpents (related to the ground and to things underground). The most surprising concept is the one related to water {*"atl"*} essential in all its forms, whose patron saint was the god of fire *Xiuhtecutli*, González (1991). The Aztecs used the special name *atl tlachinolli* to say "water in fire" and the geothermal relation is immediately evident. On the central disk are a series of elements that, combined, provide the planetary cycle, the lunar phases, the period of comets and the eclipses.

5.3 Cosmogony in New Zealand

In New Zealand all natural resources were valuable natural treasures derived from god. Geothermal resources were revered in traditional times throughout New Zealand, Severne (1999). In the Taupo Volcanic Zone The Maori people used geothermal resources for many traditional purposes, including cooking, heating, bathing, healing and agriculture. The Maori people regarded these resources as natural treasures that were preserved for future generations by guardians living in the area. Maori legends and songs speak of the spiritual connections of the Maori with this resource. They didn't allow improper use or disrespect. The springs in early times were used for ceremonies. Many of the springs and pools are sacred and were used for burial or bathing the dead, childbirth and some pools were even used by menstruating women. Maori communities made geothermal resources integral parts of their lives.

5.4 Cosmogony and geothermal uses in The Philippines

The Philippine Archipelago consists of about 7,100 islands on the western margin of the Pacific Ocean and is about the size of Italy or slightly smaller than Japan, Ote *et al*. (1999). There are many legends about the formation of so many islands but volcanism is not mentioned as the cause. Instead, there were gigantic battles between the sea and the sky. In the Philippines 110 ethno-linguistic groups are comprised of about 12 million people. Investigators sought to learn if the early Filipinos also used the Earth's heat, so abundant in their lands. Because of the nomadic lives of indigenous people, written information about terrestrial heat is unavailable. Heat is usually associated with volcanoes, which early Filipinos revered as homes for their gods and symbols of fair maidens in myth and legends. These were passed orally form generation to generation. Also they may have used Earth's heat for dressing slaughtered poultry and swine and steam-cooking rice and root crops. The ancient peoples prepared a mixture of oil and bits of sulfur-rich rocks for medicinal purpose. However, the Earth's heat appears to have played only a small role in the lives of the early inhabitants of the Philippines. Today that role is changing and the benefits of electricity generated form geothermal resources will reach the indigenous cultural communities.

5.5 Cosmogony and geothermal culture in Indonesia

In Indonesia, almost every island is volcanic and volcanoes and other geothermal phenomena reverberate from the core of ancestral memory, Tjetiep *et al*. (1999). The geothermal influences date from over a millennium and half ago when Indian religious traditions first came to Indonesia. The influences reach into mists of prehistory for ancient legends and beliefs and return at last to modern-day practices. There was a great influence of the Indian culture by Hinduism and Buddhism. A Cosmic Mountain is important in many early Hindu creation epics and perhaps Indian cosmology matched naturally with the Indonesian concept of a sacred mountain; for example volcano Mound Semeru. Certainly the Cosmic Mountain theme has influenced many religious and secular forms of expression on Bali. From the earliest times, the Balinese have believed in a ordered universe stretching from the heavens and volcanic peaks, home of divine spirits who brings prosperity and good fortune down to the plunging depth of the sea, home for threatening harmful forces. All that is holy is associated with height and mountains and the direction upstream. There are many famous and inspired Buddhist monuments in Indonesia. Its art is from Hindu origin and this is influenced by volcanic surroundings and materials. One of the most sacred places in every Bali temple is a shrine of offerings dedicated to the volcano *Gunung Agung*. Still today, high volcanoes are regarded with life and spirit of their own and venerated. Not only religious rites and legends centered around volcanoes, but practical uses were made of volcanic resources, such as obsidian (knife blades, points, etc.) Indonesian hot springs still are used for religious rituals, medical cures and pure enjoyment. Hot springs and fumaroles were considered sacred places and most were in remote areas, the isolated tropical jungles on volcanic slopes.

5.6 Legends and geothermal uses at The Geysers

The Geysers is one of the largest geothermal fields in the world and it is located in northern California. By the mid-1800s, six Indian tribes lived in this area, Hodgson (1999); before then the Geysers was untouched wilderness. The Indians all spoke different languages, had distinct cultures and lived in well-defined areas of the field. However the fumaroles and hot springs were available to all and used for healing and, perhaps, ceremonies. Archaeological sites often were found near hot springs. Sulphur salt was used for medical purposes by the Wappo tribe. Different kinds of waters, used for healing, were found in springs at The Geysers. An old, Indian woman remembered: "*Every kind of water came out of the mountain, ice cold, lukewarm and boiling hot.*" A human head carved in stone today still stands witness to a legend of The Geysers told by the Indians. Between 1848 and 1854 tourists started coming to The Geysers and soon the Geysers Resort Hotel was built. Visited by many famous people from around the world, the beautiful hotel opened the age of organized tourism at The Geysers.

6. THERAPEUTIC APPLICATIONS OF THERMAL BATHS

There is a long history of bathing cultures. They started with classical prototypes in the Old World. The use of thermo-mineral waters for curing stomach disorders, for balneology and for other therapeutic purposes probably started in the Mediterranean area at least in Neolithic times, Cremonesi (1999). The ancient Greeks who often frequented their thermal springs used the curative properties in many ways. Thermal balneology was developed systematically by the Romans from the 2nd century B.C., spreading the use of spas throughout the whole territory dominated by the Empire. Natural thermal springs and artificially heated baths were equally used. These activities peaked between the first and the third centuries A.D. and declined rapidly from the second half of the 4th century to the 6th century A.D. During the imperial period, thermal bathing became very popular at all levels of society, Burgassi *et al*. (1992); Cataldi & Burgassi (1999):

"A *thermae was a daily meeting place for physical exercise, reading, massage, shaving, hairdressing, depilating,*

recreation, conversation, political discussions, 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 made".

The word **SPA** probably means *Salus Per Aquis* ("health through waters"), a Latin expression used by ancient Romans to point out that thermal balneotherapy can help people maintain their bodies in good shape, prevent diseases and restore function to parts of the body. F. Jaffé and collaborators (1999) report that during the Hellenistic, Roman, Byzantine and Islamic historical periods, "*four major thermo-mineral spring systems were utilized intensively for bathing and therapeutic purposes in the Jordan Rift Valley, between the Dead Sea and the Sea of Galilee. ... Two of them, Tiberias and Hammat Gader are still in use."*

Probably the healing properties of the thermal springs in this area were appreciated and used since prehistoric times, peaking during the Roman Empire. These thermo-mineral waters were used particularly for the treatment of leprosy. But descriptions in the *Talmud*, recommend the use of the hot springs "*for sufferers from skin diseases, leprosy, ailments of the urinary, and digestive tracts, rheumatism, arthritis and nervous diseases."* (*ibid.*). In general, all the existent spas were far more important in antiquity than now.

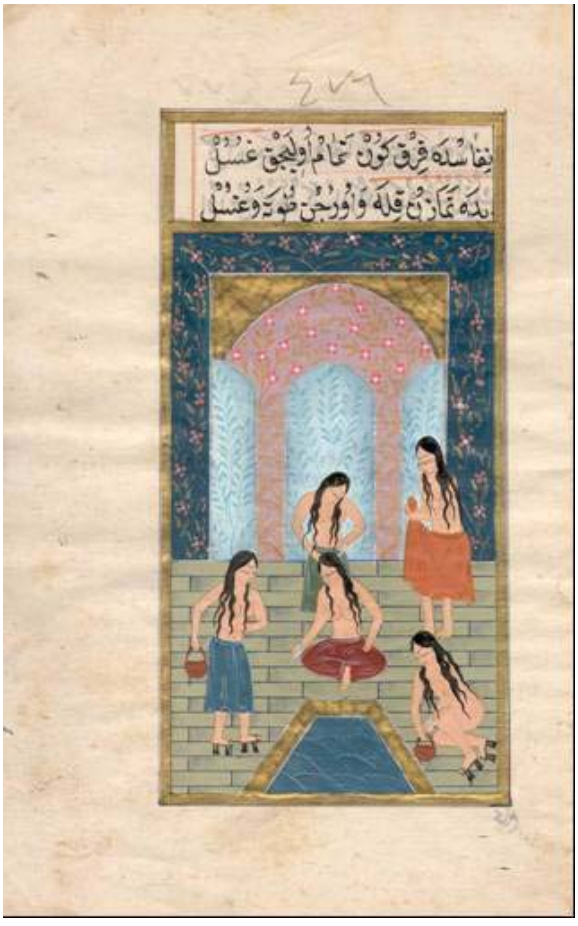

Figure 3: Women in a Turkish Bath; they are wearing high wooden shoes to protect their feet from the hot floor. Painting courtesy of Susan F. Hodgson (2004).

For the Turks, bathing in geothermal waters was an essential part of life (Fig. 3). The Turkish bath is very well known and popularly enjoyed worldwide. But its use today is relatively small. The widespread use of hot springs in Turkey started under the influence of the Romans, although Turkish baths are not direct descendants of ancient Roman baths. The thermo-mineral components of the spas were useful for curing rheumatic, sciatic, gynecological, kidney and psychiatric problems, Özgüler & Kasap (1999). The Finnish sauna and the Japanese baths with its historical hot spring bathing and spas, come from different roots. Arabian baths still exist today in the old city of Granada, Spain.

Macedonia is a crossroad of eastern and western cultures; rich in geothermal resources: "*Almost every village has some mineral sources."*, Popovski & Dimitrov (1999). Since 200 B.C., the Macedonians mixed the old traditions of the Greeks and Romans and used thermal springs for public bathing, combining with this the Turkish use of hot water and steam to cleanse the soul and body.

Similar habits existed in Mesoamerica, where some towns were accustomed to use the *Temazcal* for therapeutic and religious purposes, Krickeberg (1956); González (1991). The vapor bath was made by showering with cold water piles of hot volcanic rocks. The *temazcal* was used by pregnant women and babies.

In the Precarpathian area of Romania and in the Pannonian Basin of Hungary, Neolithic peoples settled near thermal springs and used the hot waters for therapeutic relief, Cohut & Árpási (1999).

China has over a 3,000-year tradition of using geothermal waters; its ancient peoples used thermal springs for cooking food, washing clothes, treating skin and sexual diseases, and for luxurious recreational activities at hot springs involving tea, wine and liquor. The Chinese experience includes hot springs in Taiwan and Tibet, Ji-Yang (1999). In Korea, hot springs at 14 ancient, low-temperature geothermal sites have been used for thermal bathing and therapy for millennia. Today there are 150 new hot springs, developed by drilling boreholes and almost all used for bathing, Yum (1999).

Very similar uses were found in Japan, which is formed by islands with active volcanism and has a very rich history of thermal-spring bathing with deep roots in prehistoric times (11,000 years B.C.). Japanese balneotherapy was recommended for chronic diseases since 1734, Sekioka (1999). Today, Japan has thousands of thermal springs, many of which have been converted into public spas. Most old spas are related to legends of the discoverer.

In New Zealand, the Maoris used geothermal energy for cooking, bathing, heating, therapy and agriculture. They venerated these natural resources and thought "*that they were preserved for future generations by guardians in the area."*, Severne (1999). This respect resembled that of Native American peoples.

7. GEOTHERMAL BY-PRODUCTS

Imaginably since the Paleolithic 50,000 years ago, Mediterranean peoples observed volcanoes and other geothermal phenomena with curiosity and fear. Neolithic settlements, formed in many geothermal Mediterranean

areas, were helped by the abundance of geothermal by-products. Several islands and places on the Eastern Mediterranean coast were important localities for mining and exporting obsidian, alum, bentonite, borates, iron oxides, kaolin, lapilli, perlite, pozzolan, silica and sulfur, Cataldi & Chiellini (1999). Neolithic artisans used these compounds to make pottery and pigments.

The ancient Greeks exploited for many practical uses minerals such as kaolin, iron oxides, sulfur, pozzolana, perlite and travertine, Fytikas *et al.* (1999). In Italy, geothermal by-products were numerous: kaolin and sulfur to prepare a mortar for binding pebbles; making weapons and tools using obsidian; using pumice and fine-grained pyroclastics for tempering and grinding materials for ceramic finishes and using sulfur for pigment and ointment mixtures, Cremonesi (1999). Cooking, thermal bathing and curing skin diseases with thermo-mineral muds probably was common at these places.

At the beginning of the 12th century B.C., the Etruscans started to live in Tuscany, Italy. The Romans spread thermal bathing throughout their territories but the Etruscans developed hydrothermal products. Because of their many products, they are considered as the fathers of industrial development for geothermal resources, Cataldi & Burgassi (1999).

By the end of year 200 B.C. and over five centuries, the Romans developed a systematic use of geothermal by-products. Some examples are following (*ibid.*): Pyroclastic rocks and hydrothermal minerals to prepare cement slurries; travertine, lavas, tuffs and lapilli for building; kaolin to make fine ceramics and bleaching solutions for the textile industry; boron compounds and iron oxides to prepare glazes and enamels for painting fine pottery; and soaps with hydrothermal minerals to cure skin diseases.

After the fall of the Roman Empire in the 5th century A.D., the use and development of geothermal by-products progressed in Italy very slowly. But between the second half of the 11th century and the 16th century, systematic exploitation of those products gradually progressed in the central Italy for pharmaceutical, industrial and craft purposes.

Thermal balneology and other uses of natural heat remained slow until the 13th century, but it flourished again during the next three centuries when more than 100 thermal localities were developed in Italy for balneotherapy and recreation. In this period, Cataldi & Burgassi (1999) the following hydrothermal compounds were exploited: yellow sulfur for the preparation of pharmaceuticals, bleaching solutions for the wool industry and as a component of gunpowder; alum for processing wool, green vitriol to prepare disinfectants, blue vitriol for making antiparasitics, disinfectants and coloring components, and boric acid for treating eye diseases and for disinfecting sores.

8. THE BIRTH OF MODERN GEOTHERMAL TECHNOLOGY IN THE LARDERELLO REGION

Geothermal resources in the Larderello area had a tremendous impact on the population from prehistoric times up to the 20th century. Here since the Upper Paleolithic, fumaroles, steam and gas jets, hot springs and hot natural pools with steam, gas and hydrothermal deposits at the surface (*lagoni*) were known. Here, too, since the beginning of the 19th century, engineers, technicians and scientists developed drilling technologies and industrial processes exploiting several boron compounds from geothermal fluids, especially boric acid discovered in 1777, Burgassi (1999).

In 1818 a company named Chemin-Prat-LaMotte-Larderel was formed by French exiles to produce boric acid. The Larderel family used innovative ideas to produce over 1,000 tons of boric acid in 1850. The first geothermal wells were ordered by Francesco Larderel in 1832 and drilled at a depth of 8 meters with about 10 cm diameter. By 1842 several technological improvements enabled drilling wells at a depth of 30 meters. By the end of the 19th century many new drilling techniques developed at Larderello, made it possible to drill wells 250 to 300 meters in depth (*ibid.*).

Between 1904 and 1910, also at Larderello, the geothermal-electrical industry was born with the first successful experiments carried out by Prince Piero Ginori Conti to generate electricity using natural steam. In 1905 the first prototype of a geothermal power plant went into operation. This first plant consisted of :

"*… a Cail reciprocating engine connected to a 20 kilowatt dynamo. In 1908 a second 20 Kw dynamo enabled electrification of Larderello's most important industrial plants and the main residential buildings ... By 1940, all establishments, plants, facilities and residences, plus a number of greenhouses and agricultural installations created by the Larderello Company were warmed using the residual heat of low-pressure steam.*" (*ibid.*)

Many laboratory analyses, technological geothermal innovations and scientific studies in geosciences were carried out in Larderello between the 16th and the 20th centuries, reflecting "*the high level of scientific knowledge, technological advancement and development reached at Larderello by the beginning of the 20thCentury.*" Burgassi *et al.* (1999). The achievements include: identification of hydrothermal processes and thermo-minerals, structural control of manifestations, formation of fractures, percolation of meteoric water through fractures and its interaction with reservoir rocks, self-sealing processes, origin of non-condensable gases mixed in the fluids, explanation of phreatic explosions and steam jets (*ibid.*).

9. CONCLUSIONS

By analyzing history of man and the Earth's heat, we find surprising similarities of the geothermal processes uses developed at completely different places, in different times and epochs, by different cultures. The relationship between mankind and geothermal energy is rooted in prehistory. It probably started two million years ago in Africa, hundreds of thousands of years ago in the Mediterranean Area, and dozens of thousands of years ago in Mesoamerica. This close relationship matured slowly in distinct sites and at different intervals. At first it was limited to cooking, bathing and washing, to using volcanic rocks to make weapons and tools, to using thermo-mineral mud for therapeutic applications, and to using hydrothermal compounds like cinnabar, iron oxides and sulfur to make pigments. In many places, geothermal energy was a principal backdrop for human development ever since the obscure and extensive dawn of prehistoric times.

In America, volcanic eruptions and other geothermal manifestations were well known and used since Prehistoric

times. Some 3,500 years ago, established settlements in Mesoamerica were devoted to the cultivation of soil and to the direct and indirect use of natural geothermal heat to cook food, for therapeutic applications and for steam baths. Here geothermal energy was the main background for human development since the obscure dawn of prehistoric times.

About 2000 B.C., the market for geothermal by-products started expanding to the Mediterranean coastal areas. By 700 B.C., the Etruscans developed improved methods for extracting and processing hydrothermal compounds and a Mediterranean market developed between 600 and 300 B.C. for several geothermal by-products. Between 100 B.C. and 200 A.D., the market greatly increased in the territories of the Roman Empire and almost all geothermal by-products held great importance in early Europe. They were an important support of the Roman economy.

The cosmic meanings of both water and heat have been universally recognized as signs of life. Cults devoted to all kind of waters, including thermal springs and geysers, are part of many ancient traditions. The practice of thermal balneology was common to all geothermal cultures and grew gradually in early and ancient Mediterranean civilizations. Even before the Roman Era, thermal bathing was popular in Greece, Anatolia, the Phlegraean Fields and Etruria. The peak period in thermal balneology occurred between 100 B.C. and 400 A.D., when the Romans built countless spas with and without natural thermal springs. In different epochs, in diverse societies, thermal bathing became a daily practice of people of every social class, ethnic group and gender in many cultures on Earth.

The first religious interpretations of geothermal processes occurred soon thereafter. This is evinced by the antiquity of the god representing terrestrial fire in various cultures. It is plausible that the primitive dual ethical concept of good and evil, intrinsic to the nature of all living beings, was partially inspired by the relationship between humans and geothermal energy: beneficial heat from hot springs, fertility of volcanic soils, hard rock to manufacture weapons, tools and homes, thermal waters for cleaning flesh and spirit; evil heat from lava expelled with violence, Diaspora forced by continuous earthquakes and volcanic eruptions, missing worlds as a result of terrible cataclysms. To the Aztecs *Tláloc*, god of rain and water, was the other form of *Tlequiauitl*, the rain of fire, lightning and volcanic eruptions.

Geothermal phenomena and astronomy formed the conceptual base for the Mesoamerican calendar. For the Aztecs, in four Eras the world was destroyed by gigantic catastrophes generated by the energy of the Earth. The present world, the fifth, has the same destiny: *Nahui Ollin*, "4 Movement", means *earthquakes*. Similar beliefs existed in other cultures around the world.

Since the beginning of the Twentieth Century, the world has developed its geothermal resources around the planet from almost nothing to a modest but great number of producers of geothermal electrical power that supplies important parts of national electrical power and agricultural-industrial applications,

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Human "races" are below the thresholds used in other species, so valid traditional subspecies do not exist in humans. A "subspecies" can also be defined as a distinct evolutionary lineage within a species.Â The validity of the traditional subspecies definition of human races can be addressed by examining the patterns and amount of genetic diversity found within and among human populations.Â However, the most important distinction between the candelabra and trellis models for the discussion at hand is that under the trellis model there was no separation of humanity into evolution-ary lineages, and hence human "races" are not valid sub-species. A human race is defined as a group of people with certain common inherited features that distinguish them from other groups of people. All men of whatever race are currently classified by the anthropologist or biologist as belonging to the one species, Homo sapiens.Â All races therefore have developed from this one family since the end of the flood in Noahâ€™s day. The Australian Aborigine, the Chinese, and the European have come into existence only in recent times.Â Studies on the relationship between skin color and health in a given environment, suggest the following origin of racial colors. After Babel, those who went to colder climates who had darker skin, would probably suffer Vitamin D deficiencies, such as rickets. The skin produces Vitamin D from sunlight. Geothermal energy also played an important role on human occupancy of some territories, because volcanic activity should have determined alternate emigration-immigration fluctuations over the population in the affected zones. At the same time, the economic, social, agricultural and artisan development of the people living in volcanic sites were influenced by volcanic eruptions. The mythical religious interpretations of geothermal phenomena occurred very early, reflecting a profound respect toward terrestrial heat.Â This perspective emphasizes the prehistoric antiquity of the cognitive processes and practical uses of geothermal phenomena. This work is a general outline on the common points of contact between different human societies and the thermal Earth. Welcome to r/Futurology, a subreddit devoted to the field of Future(s) Studies and speculation about the development of humanity, technology, and...Â Welcome to r/Futurology. A subreddit devoted to the field of Future(s) Studies and evidence-based speculation about the development of humanity, technology, and civilization. Posting Rules. Be respectful to others - this includes no hostility, racism, sexism, bigotry, etc.