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Revealing Historical Thermo- and Oligo - metallic Springs of Western Crete

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Abstract

In this work, we present a brief description of hydro-chemical data from mineral springs reported in a historical study (Lekkas, 1938). The springs are located in different stratigraphical level and lithological units that outcrop in western Crete. These springs were monitored during the last three years. The outcomes of this monitoring work add to the existing knowledge, which is figured in the map of IGME (Figure 1). Athanassoulis et al., 2009 studied springs in most areas of Greece except Crete and the Ionian islands due to decreased interest and a small number of thermal springs. As shown in the map, four cold springs were recorded in Crete (Figure 1), although no further reference for Crete is mentioned in the technical report.

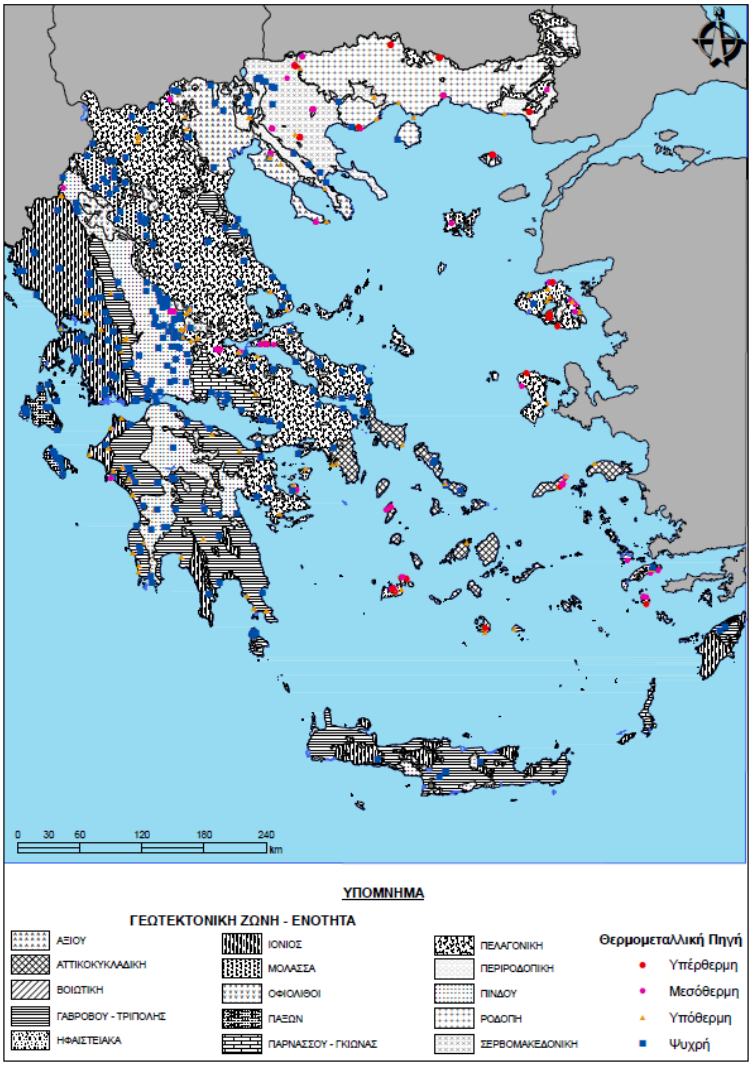

Figure 1. Geological map of IGME presenting the geotectonic zones of Greece and the distribution of thermal and mineral springs within them (after Athanassoulis et al. 2009)

As mentioned in the historical study on the thermal and mineral waters of Greece (Lekkas, 1938), Crete has 101 mineral springs most of which are saline or ferrous (Figure 2). Although, many of them were used as healing springs during the Ancient, Roman and Byzantine era, they faded into oblivion because the main concern of the authorities were focused in providing drinkable water to every settlement, city and more recently to the touristic infrastructures of the island as a result of the growing demands.

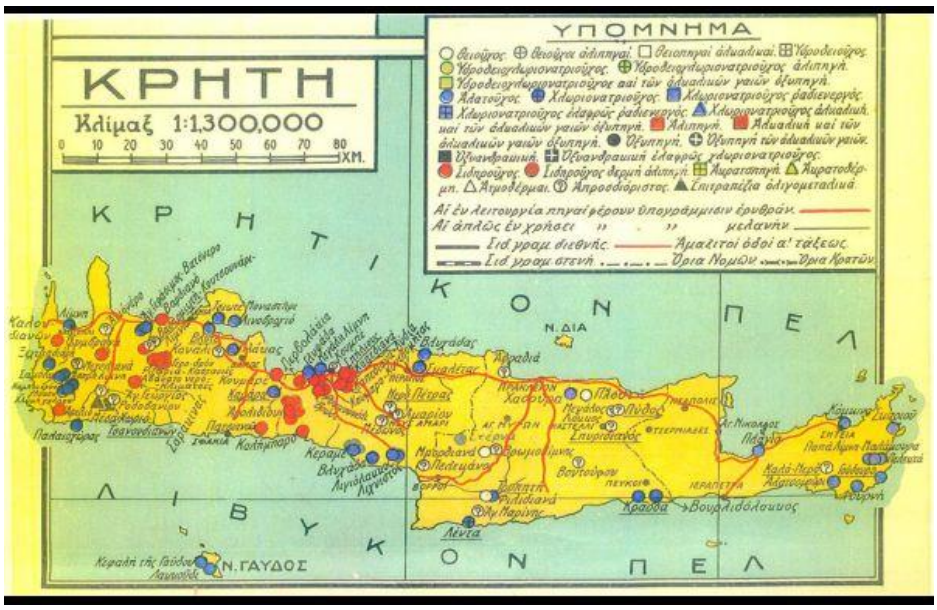

Figure 2. Distribution of thermal and metallic springs of Crete (after Lekkas, 1938)

Water samples were collected during, at least two wet and two dry periods in order to monitor and study the fluctuations in the physical characteristics but also their mineral content. The temperature (*T*), the pH the electrical conductivity (EC), and the total dissolved solids (TDS) of water samples were measured *in situ* by portable instruments. The samples were filtered, with 0.45μm filters and were stored in HDPE bottles. The aliquots for major and trace metal analyses were preserved by acidification with 2% HNO_3. The analysis of cations and trace-elements was carried out by ICP-MS (7500cx, Agilent Technologies), while the analysis of anions was carried out by phasmatophotometry (Hach DR2800).

(i) The springs hosted in the Phyllite Nappe are namely, Ksinonero, Temenia, Arelio and Moustakos:

The **Ksinonero** spring water is cold (14ºC, approximately) has pH equal to 3.2 and is connected with ferric depositions at its discharge. The concentration of dissolved iron (Fe) varies from 4 to 6g/l.

The historical healing springs of **Temenia** (Mesa Chorio and Tzanoudiana) are the only springs of Chania and Western Crete that have been recognized and utilized as healing springs with the Royal Decree of 31 August 1957, as diuretic. The temperature of the water of Mesa Chorio spring varies from 14.1-19.3°C, is slightly acidic (pH 5.7-6.4) and has very low TDS (50 mg/L to 140 mg/L).

The water of **Arelio** spring is cold (17º C), and lightly acidic (pH 6.3-6.8), and has very low TDS (50 mg/L). Periodically it contains Copper (Cu) up to 0.3 mg/L. During the Ottoman occupation, Bey's were transferring the water to the city of Chania, using large glass containers (Lekkas, 1938).

Moustakos spring has outlet temperature that varies from 18.7 to 22.5 ºC, pH varies from 5.3 to 6, and has also very low TDS (50-70 mg/L). Periodically, it has high manganese (Mn) content up to 1347 μg/L and iron (Fe) up to 0.2 mg/L.

(ii) The springs hosted in the Neogene formations are namely Kyrali, Lissos and Kares.

The **Kyrali** spring, located near to the Frangokastello fortress, is coastal and hosted under a relatively large alluvial fan. Moreover, is warm (21-27ºC) and connected with travertine depositions. Also, it contains fluorine (F) up to 0.2 mg/L. The remains of a round shaped pool in the sea, indicates that the warm water was used for bathing.

Lisssos spring is well known since the ancient era, as it is located to the Asklepius Temple of the homonymous ancient city. The water is hypothermic (20-22ºC), has near neutral pH that varies from 7.1 to 7.4, and relatively low TDS which varies from 200-400 mg/L. Periodically it contains up to 200 μg/L of zinc (Zn).

Kares Springs have outlet temperature 18.5-20 ºC, neutral pH and TDS that varies from 380-400 mg/L. The main dissolved constituents are HCO_3 (380 mg/L, approx.) and SO_4 (200 mg/L, approx.). Moreover the water contains 0.6 mg/L of dissolved fluorine (F) but also small quantities of trace elements including Li, Mo, Sr, etc.

The main characteristics of the waters that discharge from springs in the Phyllite Nappe are their very low TDS and the slightly acidic pH, except from the Ksinonero spring water which is extremely acidic. On the other hand the springs hosted in the Neogene formations exhibit extreme characteristics including travertine deposition or high content in dissolved trace elements.

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