Available online at www.sciencedirect.com

ScienceDirect

Procedia Earth and Planetary Science 17 (2017) 65 – 68

Procedia Earth and Planetary Science

15th Water-Rock Interaction International Symposium, WRI-15

Application of different geothermometrical techniques to a low enthalpy thermal system

Mónica Blasco[a,1], Luis F. Auqué[a], María J. Gimeno[a]

[a]*Earth Sciences Department, University of Zaragoza. C/Pedro Cerbuna, 12, Zaragoza 50009, Spain*.

Abstract

The reservoir temperature of the waters in the low temperature carbonate-evaporitic geothermal system of Arnedillo has been estimated by using two different techniques: 1) chemical geothermometers and 2) geothermometrical modelling. By combining the results of both techniques a reliable range of temperature of 90 ± 20 ºC has been proposed for the waters in the reservoir. Despite being a carbonate-evaporitic system, the cationic geothermometers have provided good results, which, together with the geothermometrical modelling, indicate that the waters have reached equilibrium with anhydrite, quartz, calcite, dolomite, albite and K-feldspar in the reservoir.

Peer-review under responsibility of the organizing committee of WRI-15

*Keywords:*Geothermal system; Thermal water; Chemical geothermometers; Geothermometrical modelling

1. Introduction

This study aims to determine the reservoir temperature of the low enthalpy Arnedillo thermal system which is hosted in carbonate-evaporitic materials. This has been done by using two different techniques: chemical geothermometers and the geothermometrical modelling.

There are different types of chemical geothermometers. The classical geothermometers are those based on the dissolved silica or cation contents. The cationic geothermometers often present problems when applied to low temperature or carbonate-evaporitic thermal systems as they have been calibrated with waters from high temperature systems and hosted in different materials (e.g. granites)[1,2]. Other chemical geothermometers, such as Ca-Mg and SO_4-F geothermometers[1], have been specifically calibrated for their use in medium- to low-temperature carbonate-evaporitic systems. All of them have been used in this work.

* Corresponding author. Tel.: +34-976-761071; fax: +34-976-761106.
E-mail address: monicabc@unizar.es

Peer-review under responsibility of the organizing committee of WRI-15
doi:10.1016/j.proeps.2016.12.034

The geothermometrical modelling presents some advantages over the chemical geothermometers since it also allows determining 1) which are the minerals in equilibrium with the waters in the reservoir and 2) the presence of secondary processes during the ascent of the thermal waters to the surface[3].

These two different approaches are used in this study in order to test their applicability in this kind of systems.

2. Geological setting

The studied thermal springs are in Arnedillo, La Rioja (Spain), in the NW part of the Iberian Range, close to the contact between the Cameros Range (Triassic, Jurassic, and Cretaceous materials) and the Tertiary Ebro Basin[4] (Fig. 1). The aquifer of the Arnedillo thermal waters is placed in the carbonates of the Lower Jurassic in contact with the Keuper Facies[4]. The springs are characterised by a flow rate of about 22 l/s and nearly 50 ºC, and the waters are of chloride-sodium type[4] with total dissolved solids (TDS) around 7,000 ppm.

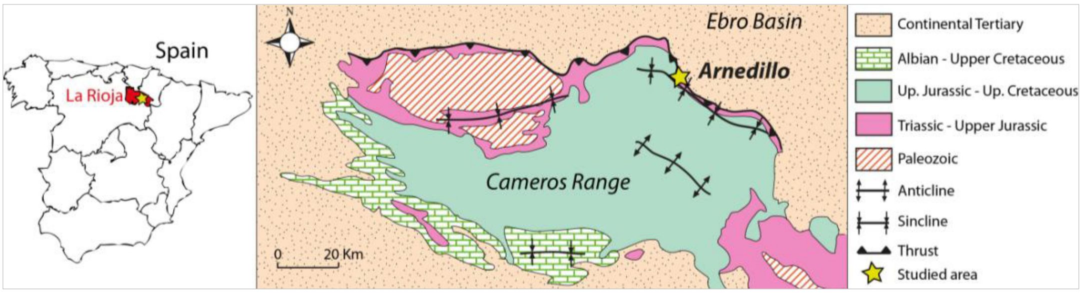

Fig. 1. Geographical and geological location of the studied area.

3. Methodology

Two springs were sampled following the standard procedures of water sampling. Temperature, pH and electrical conductance were measured *in situ*. The major and minor cations were analysed by ICP-OES and ICP-MS, respectively. Alkalinity was determined by tritation, chloride and fluoride by selective electrode and sulphates by colorimetry. The reservoir temperature has been calculated by two different techniques: 1) chemical geothermometers; and 2) geothermometrical modelling.

The use of chemical geothermometers consists of determining the temperature of the waters in the reservoir using empiric or experimental calibrates. These calibrates are deduced from temperature-dependent heterogeneous chemical reactions which control the elemental contents of the waters and assume that the contents have not been modified during the ascent of the waters to surface[5]. A great number of chemical geothermometers, with different calibrates, are available in the literature[2]. The ones that have been used in this work are presented in Table 1.

Table 1. Chemical geothermometers and their calibrates used in this study. The results (in ºC) obtained for the two samples (AR1 and AR2) are also shown.

Geothermometer	Author of the calibrate	AR1	AR2
SiO_2-quartz	Truesdell[6]	95.15	92.90
	Fournier[7]	95.01	92.76
	Michard[8]	96.20	93.95
SiO_2-chalcedony	Fournier[7]	64.60	62.19
	Arnorsson et al.[9]	66.34	64.08
Na-K	Giggenbach[10]	96.71	104.75
	Fournier[11]	75.44	83.61
K-Mg	Giggenbach et al.[12]	61.02	63.62
Na-K-Ca (β=4/3)	Fournier et al.[13]	88.18	90.99
Ca-Mg	Chiodini et al.[1]	108.89	110.22
SO_4-F	Chiodini et al.[1]	-8.46	-9.29