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Isotopic analysis, hydrogeochemistry and geothermometry of Tang-Bijar oilfield springs, Zagros region, Iran

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ABSTRACT

This study is focused on warm and cold springs in Tang-Bijar oilfield of southern Iran. The springs emerge from fractures and faultlines within the carbonate and evaporitic rocks of Zagros Thrust Belt (ZTB) and vary in temperature between 20 and 44 °C. Chemical analyses define three main chemical water associations reflecting different hydrochemical processes including: (1) Ca-HCO_3,(2) Mg-SO_4 and (3) Na-Cl. Based on isotope analysis, meteoric water is the origin of these spring waters. Two distinct hydrogeological systems are postulated: a deep moderate-temperature (40 to 45 °C) geothermal system recharged by meteoric waters mixed with oilfield brine and a shallow cold aquifer system related to local groundwater.

1. Introduction

The Zagros fold-thrust belt (ZTB), which extends for approximately 2000 kilometers from southeastern Turkey to northern Syria and Iraq, through western and southern Iran with numerous hydrocarbon fields, is the most resource-prolific fold-thrust belt in the world (Alavi, 2004; Alavi and Mahdavi, 1994). This fold-thrust belt is a result of structural deformation of the Zagros (peripheral) proforeland system, represented by present day Persian Gulf and continental Mesopotamia basins, which are made up of mostly platformal and continental shelf deposits (Alavi, 2007; Baltzer and Purser, 1990; Kassler, 1973; Lees and Falcon, 1952; Purser, 1973) (Fig. 1).

The ZTB is also a potential geothermal province, hosting warm springs with average temperature of about 40 to 45 °C. The warm springs have been used for their curative purposes, as well as numerous cold springs which are used for domestic consumption purposes (average temperature of about 22 °C). The springs discharge mostly from carbonate formations and their distribution are closely controlled by faults, joints and fractures. Approximately 400 warm springs have been identified in Iran, including those in the Zagros area (Ghafori, 1987). However, very few attempts have been made to classify these springs on the basis of the physical and chemical properties of their water. The geochemical characteristics and fluid–mineral interaction of the warm waters have rarely been studied in detail (Karimi and Moore, 2008; Kompani-Zare & Moore, 2001; Mosavi, 1993), especially in the Zagros region. Very few studies have focused on the nature and evolution of the warm springs, including their age, origin, water/rock interactions and eventual mixing between geothermal and shallow colder groundwater (Kompani-Zare & Moore, 2001).

This study presents chemical and isotopic data from two warm and 10 cold springs from the Tang-Bijar region, situated in the southwest of Ilam, Zagros region in Iran (Fig. 1). The origin and evolution of these springs are poorly understood, mainly because of the general paucity of field studies in the region stemming from the location close to Iran–Iraq boundary. Therefore, the main goal of this study is to characterize water properties of these springs using chemical and isotopic data, with an emphasis on the origin and temperature of the springs, using chemical geothermometry and oxygen and hydrogen isotopes.

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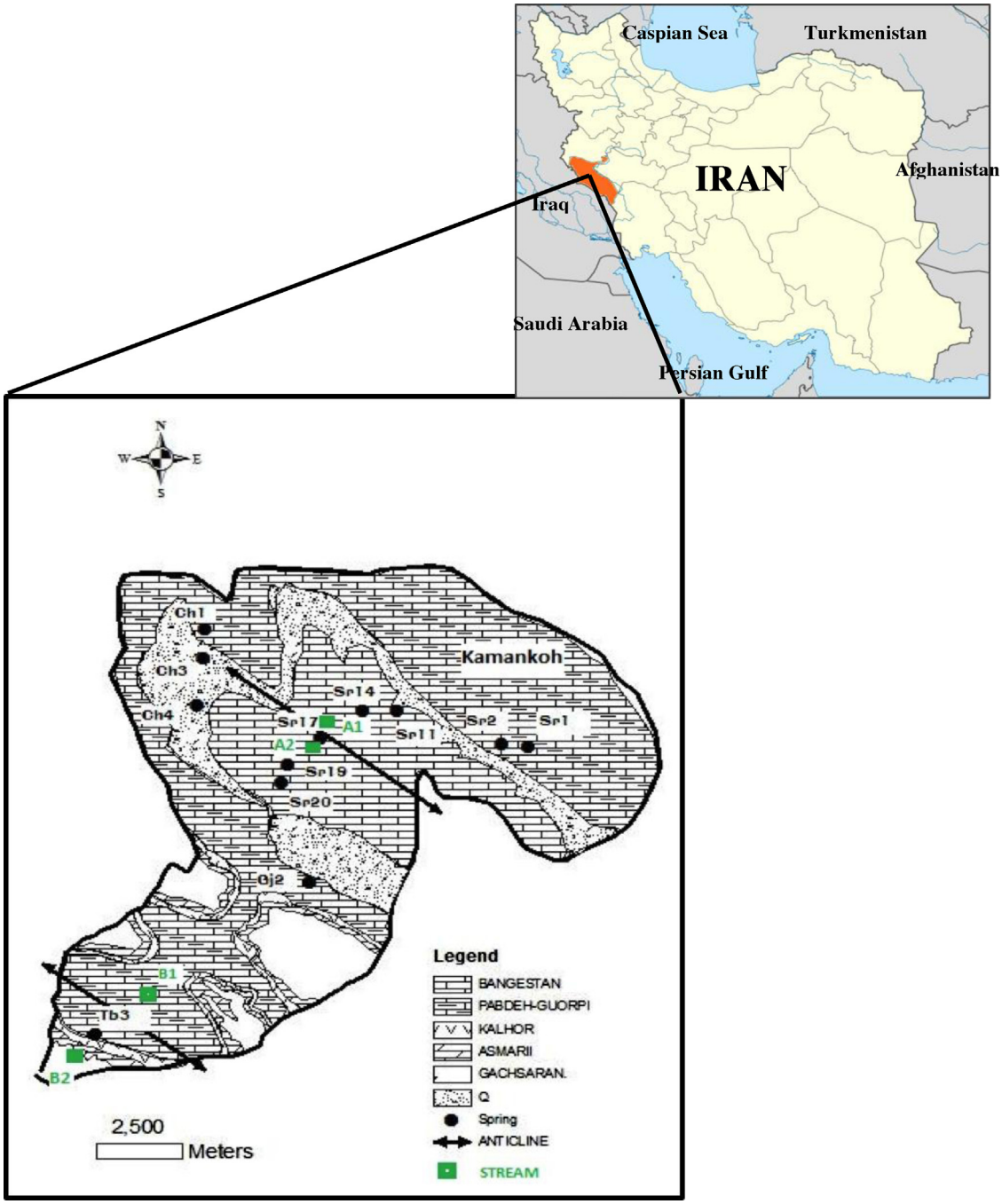

Fig. 1. Location and geological map of studied area (Ghaeemi et al., 2012).

2. Geological and hydrogeological setting

The study area is situated in northwest ZTB, which is a part of the Lorestan territory in west Ilam Province (Fig. 1). It is located in the tropical zone in an arid to semi-arid climatic area giving rise to two dry (summer and autumn) and two rainy seasons (spring and winter). The wet months are from January through April. Mean annual rainfall increases from south to north and the annual mean temperature is 26 °C. The maximum elevation (about 1000 m above the sea level) is in the northern parts of the studied area in Kamankoh Mountain.

The stratigraphic and structural setting of the Zagros Mountain Range in this area consists of carbonate, evaporate, marl and shale formations described in detail by Alavi (2004, 2007), Ghaeemi et al. (2012), Hessami et al. (2001), McQuarrie (2004), Molinaro et al. (2005), and Stocklin and Setudehnia (1977). The sedimentary of Cretaceous (Sarvak, Sorgah, Ilam and Gurpi), Paleogene (Talezang, Kashkan, Shahbazan, Pabdeh and Kalhur), Neogene (Asmari, Ghachsaran, and Mishan) ages and Quaternary alluvial deposits (Table 1). The Sarvak formation is one of the important petroleum reservoir host rocks in this area, which crops out in the center of Tang-Hamam anticline (Fig. 2).

The study area comprises a series of subparallel, NW–SE trending anticlines and synclines formed by compressional tectonics during the Miocene (Fig. 2). The folds appear as refolded asymmetrical and concentric anticlines and synclines with a fold axis coordinate of N51°W, 0 and an axial plane coordinate of N51°W, 78SE (Ghaeemi et al., 2012). Tang-Hamam and Tang-Bijar