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Origin and interactions of fluids circulating over the Amik Basin (Hatay, Turkey) and relationships with the hydrologic, geologic and tectonic settings

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ABSTRACT

We investigated the geochemical features of the fluids circulating over the Amik Basin (SE Turkey–Syria border), which is crossed by the Northern extension of the DSF (Dead Sea Fault) and represents the boundary area of three tectonic plates (Anatolian, Arabian and African plates). We collected 34 water samples (thermal and cold from natural springs and boreholes) as well as 8 gas samples (bubbling and gas seepage) besides the gases dissolved in the sampled waters. The results show that the dissolved gas phase is a mixture of shallow (atmospheric) and deep components either of mantle and crustal origin. Coherently the sampled waters are variable mixtures of shallow and deep ground waters, the latter being characterised by higher salinity and longer residence times. The deep groundwaters (from boreholes deeper than 1000 m) have a CH_4-dominated dissolved gas phase related to the presence of hydrocarbon reservoirs. The very unique tectonic setting of the area includes the presence of an ophiolitic block outcropping in the westernmost area on the African Plate, as well as basalts located to the North and East on the Arabic Plate.

The diffuse presence of CO_2-enriched gases, although diluted by the huge groundwater circulation, testifies a regional degassing activity. Fluids circulating over the ophiolitic block are marked by H_2-dominated gases with abiogenic methane and high-pH waters. The measured $^3He/^4He$ isotopic ratios display contributions from both crustal and mantle-derived sources over both sides of the DSF. Although the serpentinization process is generally independent from mantle-type contribution, the recorded helium isotopic ratios highlight variable contents of mantle-derived fluids. Due to the absence of recent volcanism over the western side of the basin (African Plate), we argue that CO_2-rich volatiles carrying mantle-type helium and enriched in heavy carbon, are degassed by deep-rooted regional faults rather than from volcanic sources.

1. Introduction

The Amik Basin is the intersection domain of several active, regional-scale structural lineaments (Fig. 1), namely the N trending sinistral Dead Sea Fault (DSF), the NE trending sinistral East Anatolian Fault (EAF) and the NE trending contractional Cyprus Arc (CA). These three regional scale tectonic structures represent the margin of the Anatolian, Arabian and African plates (Mahmoud et al., 2013). Such complex geological setting is reflected in the outcropping of a large variety of rock units.

The Amik Basin is a well-recognised depression bounded by elevated shoulders. It is the widest and deepest part of the Karasu rift, and its main depocenter (Fig. 2). The eastern and western margins of the rift display morphological differences: the western margin (the Amanos Mountains) is uplifted to a height of up to 2250 m, while the eastern margin has a relatively low topography up to 800 m asl as a consequence of the asymmetric evolution of the basin.

The DSF is a seismically active tectonic structure crossing Israel, Jordan, Syria and Turkey following a nearly N–S direction (e.g. Quennell, 1958; Muehlberger, 1981; Garfunkel et al., 1981). In the

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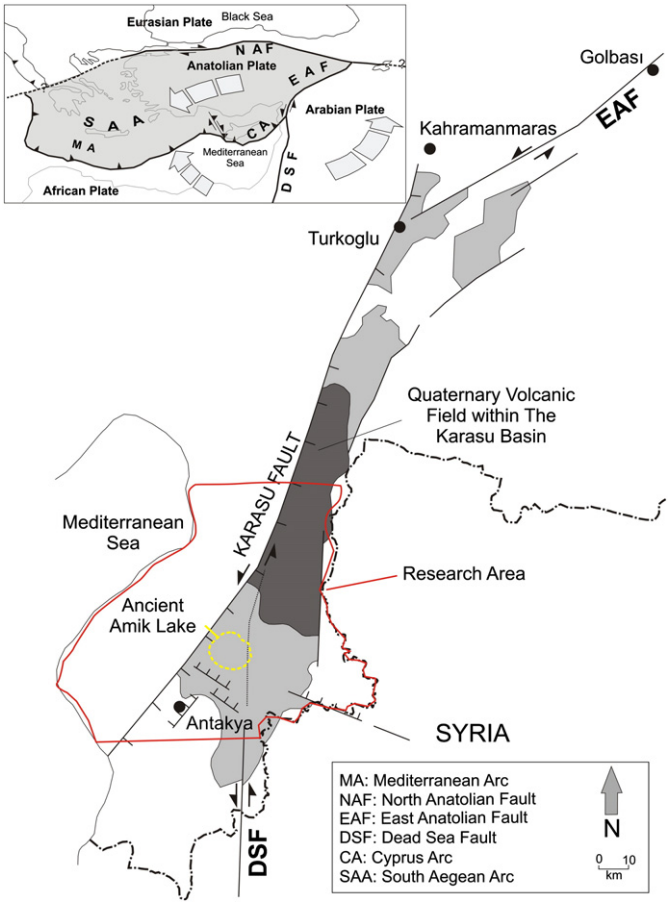

Fig. 1. Sketch map of the study area in the mainframe of the three tectonic plates.

Amik Plain, the DSF goes along the Asi (Orontes) River which has a sharp turn due to (Fig. 2, Karabacak et al., 2010) the connection of Amik Basin (Hatay Region, Turkey) with the SW extension of the Karasu Fault connecting the Dead Sea Fault (DSF) and East Anatolian Fault (EAF) (Fig. 1).

The seismic activity of the area is widely documented throughout history and several strong earthquakes were recorded (Boulton and Robertson, 2008). Among them the most destructive happened in 526 (that caused about 250,000 casualties) and in 1114, 1822 and 1872, all with estimated magnitudes ≥ 7.

Two rock units of particular interest for this study outcrop at the margins of the basin: an ophiolitic block located on the west (African Plate) and basalts located on the east and north-east (Arabian Plate).

This paper accounts for the geochemical features of the fluids (thermal and cold waters as well as seepage and bubbling gases) vented from the southern border of the Amik Basin to the northern sector of Karasu Fault Zone. The basin hosts several aquifers located at different depths. Both hypothermal and cold waters are vented by springs located on both sides of the DSF. Moreover, large amounts of groundwater are pumped from recently drilled boreholes for agricultural purposes.

Samples of fluids including both gases and waters from all the above-mentioned sources have been collected with the aim to define the origin, interactions, mixing as well as to trace the occurrence of other processes involving both gaseous and liquid fluids over the tectonically active area of the Amik basin.

2. Geological and tectonic background

Following the Late Cretaceous to Miocene progressive collision of the African–Arabian plate with the Eurasian (closure of northward subducting southern Tethys, the Bitlis–Zagros Ocean, Sengör and Yılmaz, 1981), the Anatolian block migrated towards west-southwest along the "Eastern Mediterranean Arc" onto the African oceanic plate

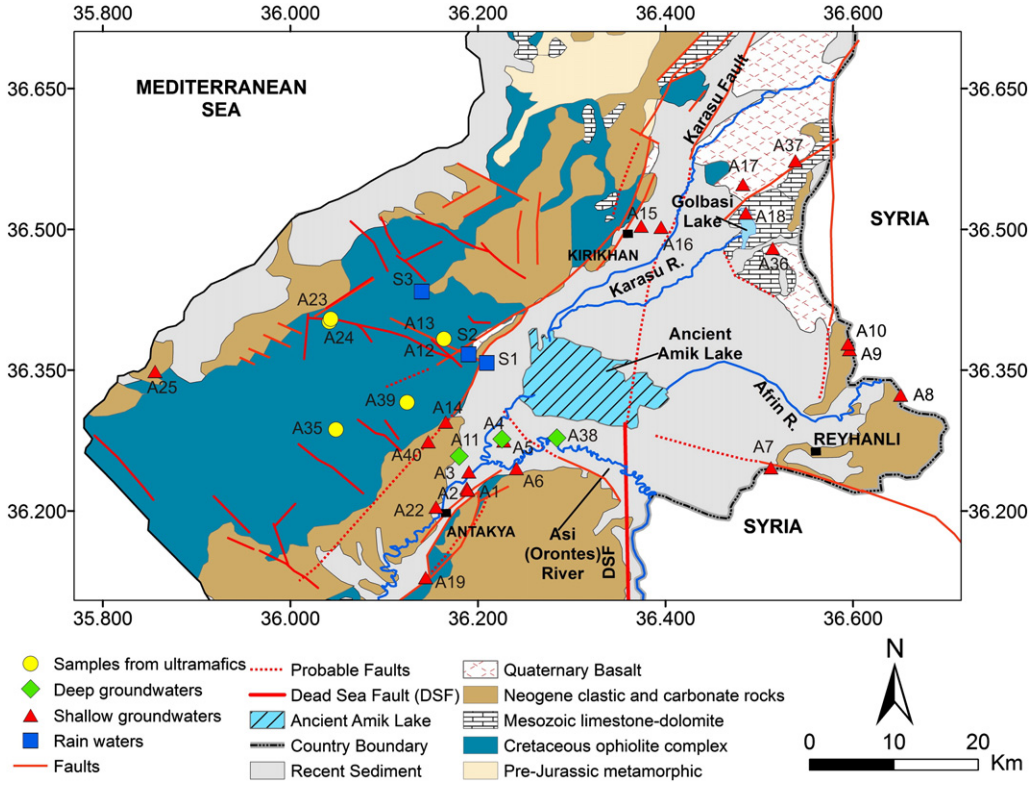

Fig. 2. Simplified geologic map with the sampling points. See Table 1 for sampling site details and coordinates.