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$^{87}Sr/^{86}Sr$ ratios in thermal water from the southern Upper Rhine Graben, Germany

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Abstract

The present study of thermal water from Bad Bellingen, Steinenstadt, Bad Krozingen, Mooswald, and Weinheim located in the southern part of the Upper Rhine Graben was undertaken in the framework of a multidisciplinary hydrogeochemical research project and concerns $^{87}Sr/^{86}Sr$ isotope investigation. The aquifer lithologies of thermal waters are Triassic Upper Muschelkalk, Jurassic Hauptrogenstein and Tertiary Miocene sediments. The $^{87}Sr/^{86}Sr$ ratios (N=9) range from 0.70912 to 0.71096. The Sr isotopic composition of thermal water is controlled by the fault system of the Rhine Graben rift. Fluids from Upper Muschelkalk aquifers ascent along the Eastern Boundary fault zone. The deep-water ascent most likely reaches into the crystalline basement.

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Keywords: Rhine Graben; Thermal water; Deep fluids; Groundwater; Strontium isotopic ratios

1. Introduction

The present study of thermal water in the southern part of the Upper Rhine Graben (URG) was undertaken in the framework of a multidisciplinary hydrogeochemical research project to identify possible imprints of deep fluids in shallow Quaternary aquifers through the $^{87}Sr/^{86}Sr$ isotopic ratios. The temperature increase with depth is especially high in the southern part of the Upper Rhine Graben and thus interesting for the use of geothermal energy.

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2. Geological setting

The wells which yield the studied thermal water are located in the southern Upper Rhine Graben (Bad Bellingen, Steinenstadt, Bad Krozingen, Mooswald, Weinheim). Weinheim is located in the N of the study area (Fig. 1a). The graben formation started in the Oligocene. The rift valley extends over a distance of 300 km between Basel in the S and Frankfurt in the N, with an average width of about 40 km. The uplifted graben shoulders are deeply eroded and expose Hercynian crystalline basement, the Vosges in the W and the Black Forest in the E (Fig. 1b)[1]. Thermal water from two different limestone aquifers, Hauptrogenstein (Middle Jurassic) and Upper Muschelkalk (Middle Triassic), and from Tertiary sediments (Miocene) was analyzed.

3. Sampling and analysis

Eight water samples were collected during June 2013 in a region southwest of Freiburg (SW Germany) (Fig. 1a). Samples were collected from Bad Bellingen (TB2 Leodegar Quelle, TB3 QIII, TB4 Markus-Ruf-Quelle), Steinenstadt (Georgen-Quelle), Bad Krozingen (TB2 Theresienquelle, TB3, TB4), and Mooswald (TB1 Kurt-Sauer-Quelle/Eugen-Keidel-Bad Freiburg).

a b

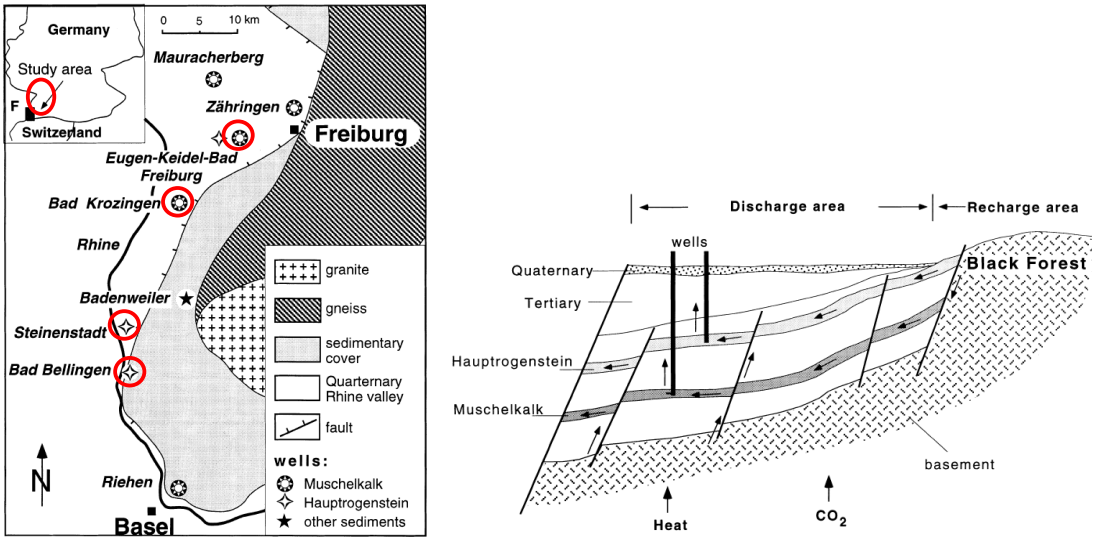

Fig. 1. (a) Geological map adapted from[1] with sample locations (red circles) from this work; (b) Schematic section across the valley showing the general geological and hydrogeological relationships of the Hauptrogenstein and Muschelkalk limestone aquifers[1].

Thermal water from Weinheim was collected in February 2015. Sample handling was performed in a cleanroom lab under laminar flow clean air benches. The Sr separation technique involves cation-exchange chromatography in HNO_3 medium. Isotopic ratios were determined by thermal-ionization mass spectrometry on a multi-collector Finnigan MAT 262 mass spectrometer. The reproducibility was tested by 10 replicate analyses of NBS 987 standard ($SrCO_3$) and the mean value obtained during the collection of isotopic data was 0.710269 ± 9 (± 2σ).

4. Results and discussion

The $^{87}Sr/^{86}Sr$ ratios and Sr contents of thermal water samples (n=9) range from 0.70912 to 0.71096 and 6.25 to 319 mg/l, respectively (Tab.1). The wells from Bad Bellingen and Steinenstadt (Georgenquelle) are drilled in Jurassic carbonatic sediments from the Hauptrogenstein Formation (Fig. 1b). Hauptrogenstein is a marine oolithic