GEOCHEMISTERY AND ISOTOPIC COMPOSITION OF MINERAL AND THERMAL WATERS FROM THE UPPER RHINE-GRABEN (BADEN-WURTTENBERG AND ALSACE)

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The studied thermal and mineral waters are located in the upper Rhine graben approximately between Basel and Baden-Baden. Most of these springs are located along the extensively fractured margins of the graben. Meteoric waters flowing through the fractured system reach deep aquifers, heat and mineralise at depth, and ascend to the surface. The heating is further increased by a general geothermal anomaly of the Rhine graben This anomaly is especially pronounced in the North where it may reach 10 degrees C/100m.

During this study fifty-four localities were sampled twice in this study. These samples were analysed for major, minor and trace elements. Stable isotope analyses of d18O, d2H, and d13C were also made.

Most of the studied waters have been analyzed at least one time in the past. Chemical analyses are provided regularly from control measurements for those springs which supply thermal stations or mineral water factories. These data were compiled and integrated in the present study. For comparison, we included a large number of water samples issued by the same aquifers, but located outside the geographic area of this study. These include the southern and western Vosges, the Southern and Eastern Black Forest, and the deep ground waters from Northern Switzerland.

In order to reduce the time required for data reduction and analysis, I developped a computer program that is designed to process the hydrochemical data. The main feature of the program HYDROWIN are its interactive and easy to use graphical representations, including most diagrams used in hydrochemistry, and the interface to three hydrochemical modelling packages: PHREEQE, SOLMINQ, and NETPATH.

In the first part of this study, the chemical and isotopic methods are presented and critiqued. Only three geothermometers were found to give reliable results at low temperature: SiO2(Quartz or chalcedony) >K/sqrt(Mg) > Na-K-Ca-Mg

A new formula is proposed for the geothermometer K/sqrt(Mg). The error of d18O measurements due to salinity was evaluated and found to be negligible in all measured samples. The PHREEQE thermodynamic data base was updated and enlarged.

The main part of this work is dedicated to the systematic description of the chemistry and isotopic signatures, and the geologic settings of the studied waters. The springs on both borders of the graben are then compared to each other. I have also documented differences between the northern part of the graben which is dominated by Na-Cl fluids, and the southern portion of the graben which has more varied hydrochemical facies. This southern portion is further characterised locally by a high

CO_2 flux which plays a major role in water-rock interaction processes. The isotopic analyses of the dissolved carbon in these waters reveals that it is of deep origin.