INTERNATIONAL SUMMER SCHOOL on Direct Application of Geothermal Energy
Under the auspice of:
Division of Earth Sciences

Chapter 1.2

THERMAL SPRINGS IN GERMANY AND MIDDLE EUROPE

Prof. Dr. Klaus Knoblich

Institute of Applied Geosciences, Justus-Liebig-University
Diezstrasse 15, D-35390 Giessen, Germany

Historic introduction

Thinking of mineral springs and thermal springs in middle Europe, names like Carlsbad, Wiesbaden, Baden-Baden, Spa immediately come to one's mind. Furthermore this thought associates with an epoch, during which many spas played an important part in the social and cultural life. This was the 19th century and the first decades of the 20th century, a time when the leading classes not only of Europe gave the spas their unique character. This society felt the need to relax and to take care of their health. They probably were convinced that this could be achieved by curing at a spa and drinking the waters. Those places provided by nature with mineral and thermal springs used their good fortune. Their investments in spa houses, parks, hotels, casinos have probably been profitable.

At first the visitors came from the nobility, from barons and counts to kings and emperors. The wealthy bourgeoisie soon followed, since they didn't want to miss the opportunity to mix with the noble. Increasingly, artists, writers, thinkers were attracted. For the ladies it was an excellent opportunity to present their marriageable daughters at balls, concerts, in the theatre and parks. The men would do businesses and diplomacy. It was exquisite publicity for the spa when the czar and the czarina with their entire court came for a visit. Very welcome were the regular stays of the Prussian kings and later emperors. Very often came the Austrian emperor with his wife, Napoleon III with Eugenie, Queen Victoria, and innumerable German princes. Maharajas from India brought an oriental atmosphere to the spas. Bismarck was a frequent visitor. Cavour and Disraeli showed up and then there were Beethoven, Dostojewski, Nietzsche, Victor Hugo, Grillparzer, Richard Wagner, and of course, Goethe, conceited and eager to mix with the noble. Several times a year, often for weeks, he enjoyed life at the spas, of which he preferred Carlsbad and Marienbad. Let me remind you of the "Marienbader Elegies". He left his wife at home or sent her to Bad Lauchstädt, a spa for the lower classes. On July 8th, 1802 Goethe writes in his diary: "Visited prince Reuß after breakfast, later joined princess Lubo-

mirska and count Polocky”. On July 15th, 1802 he writes: ”Dined with the count of Hesse, later took a stroll with princess Narischkin”. Similar entries are found each day. On July 28th he writes to his wife in Bad Lauchstädt: ”Enjoy yourself, have yourself a nice day occasionally. You wouldn’t like Carlsbad.”

The Belle Epoch of the spas lasted until the 20th century. Until the 1950´s oriental potentates visited the spas. Then there was a change. Now the visitors were working people with financing from the health insurance. This period is coming to an end, too and considering the lack of money of the public health insurance, new concepts have to be found.

I could talk about the old times for hours, but I will stop here and talk about the thermal waters.

Nature of thermal waters

The formation of thermal waters requires, that precipitation infiltrates into great depths, that there is a sufficiently long time of contact with the rock, and that there is a pos-sibility for the water to ascend to the earth’s surface again. A low geother-mal gradient supports the evolution of thermal waters. These conditions can be found in zones of tectonic movement, e.g. along the margins of tectonic graben systems. The result are thermal springs, i.e. ground water, which flows freely from the earth's surface. Of course one can help nature by developing the thermal water with deep wells in places, where the conditions seem favourable or where thermal springs already exist.

Depending on the type of rock and the time, the infiltrating and ascending heated water is in contact with the rock, the resulting thermal waters will have different chemical compositions. A number of thermal waters in Germany and middle Europe have a low concentration of the major ions Na, Ca, Mg, and Cl, SO_4, HCO_3. These are akrato-thermal waters, which have been in contact with rocks containing little or no soluble components. These are silicate rocks like granites, diorites, quartz porphyries, quartzites, slates, gneiss’s. Table 1 shows some examples of these thermal waters. With concentrations of total dissolved solids (TDS) below 1000 mg/l one speaks of “low concentration”.

Table 1: Examples for thermal waters of low ion concentration in Middle Europe.

	T° C	CO_2	Na	Ca	Mg	Cl	SO_4	HCO_3
Wildbad (Black Forest)	39,5	22,5	148	38	2,5	156	35,5	225
Schlangenbad (Taunus)	29	<50	107	14	2	154	7	73
Luxenil-les Bains (Eastern Vosges)	44	10	184	16	2	232	54	96
Bad Gastein (Eastern Alps)	45		86	20	0	31	138	55

Among these four thermal waters Bad Gastein is an exception, because of the radon content of these waters. They are termed radioactive thermal waters. The radon comes from uranium bearing gneiss’s. Radioactive waters can be found elsewhere, but not all of them are thermal waters. In Heidelberg there is a mineral water, which is considered a radioactive thermal water (Table 2).

Evidently, the Heidelberg thermal water has a very high concentration of solutes. It originates from Permian quartz porphyries, which give it its radioactivity, and from Tertiary evaporates of the Upper Rhine graben, which contribute to the high concen-

trations of Na and Cl. Throughout middle Europe many highly mineralised thermal waters can be found, since halite, gypsum, and carbonate rocks are widespread, e.g. the Tertiary of the Upper Rhine graben, the Triassic middle Muschelkalk and Röt, and the Permian Zechstein of northern and middle Germany. Some examples are listed in table 3.

Table 2: Examples for radioactive thermal waters.

	T°C	CO_2	Na	Ca	Mg	Cl	SO_4	HCO_3
Bad Gastein (Eastern Alps)	45		86	20	0	31	138	55
Heidelberg (Upper Rhine Graben)	24	137	22820	6556	567	50100	0	1124

Table 3: Examples for highly mineralised thermal waters

	T° C	CO_2	Na	Ca	Mg	Cl	SO_4	HCO_3
Boll	49	1100	1423	645	108	1734	1930	1136
Urach	54	1330	826	723	95	1102	1297	1458
Salzuflen	37		42351	1978	631	65924	50372	2440
Oeynhausen	33,5	1540	18710	1621	379	29020	4271	1437
Aachen	55		1421	63	15	1601	276	1031
Nauheim	33	1126	10416	1412	127	18124	44	2059
Wiesbaden	65	219	2673	351	48	4605	65	619
Baden-Baden	64,5		850	129	2	1437	155	1
Karlsbad	61	510	1726	132	45	624	1713	2319

The thermal waters of the north rim of the Rheinische Schiefergebirge, Carlsbad, the south rim of the Taunus get their salt content from the Permian Zechstein. Some of these waters travel a long distance from the area of recharge and salt dissolution to the area of ascent and discharge. This becomes obvious from the following Fig. 1.

Between the recharge and the discharge area, or within the discharge area some waters receive additional CO_2. Those thermal waters like in Bad Oeynhausen and Bad Nauheim are called acidulous mineral waters.

Thermal waters of the Schwäbische Alb and its foreland to Stuttgart-Bad Cannstatt and especially Urach, Boll, Überkingen are enriched with NaCl from the Triassic middle Muschelkalk and receive CO_2 from a late phase of the regional Tertiary volcanism.

In the Upper Rhine graben the thermal waters are influenced by Tertiary evaporates in the graben.

One must not forget to mention the sulphuric thermal waters. They contain dissolved sulphides or hydrogen sulphide. These constituents originate from pyrite bearing bituminous shales, like the Liassic Posidonia-shale, the Tertiary Pechelbronn series, or the copper-shale of the Zechstein. The thermal waters of Heidelberg, Bad Boll, Oeynhausen, and Füssing belong to this group. Füssing is situated in a zone, which comprises the Alps and the Molasse–foreland. Thermal waters of this zone are Bad Gastein, which I have already mentioned, Ragaz, Baden near Vienna, and Leukerbad. Although they are of different origin, they all have rather low ionic concentrations and show specific features like radon or hydrogen sulphide contents.

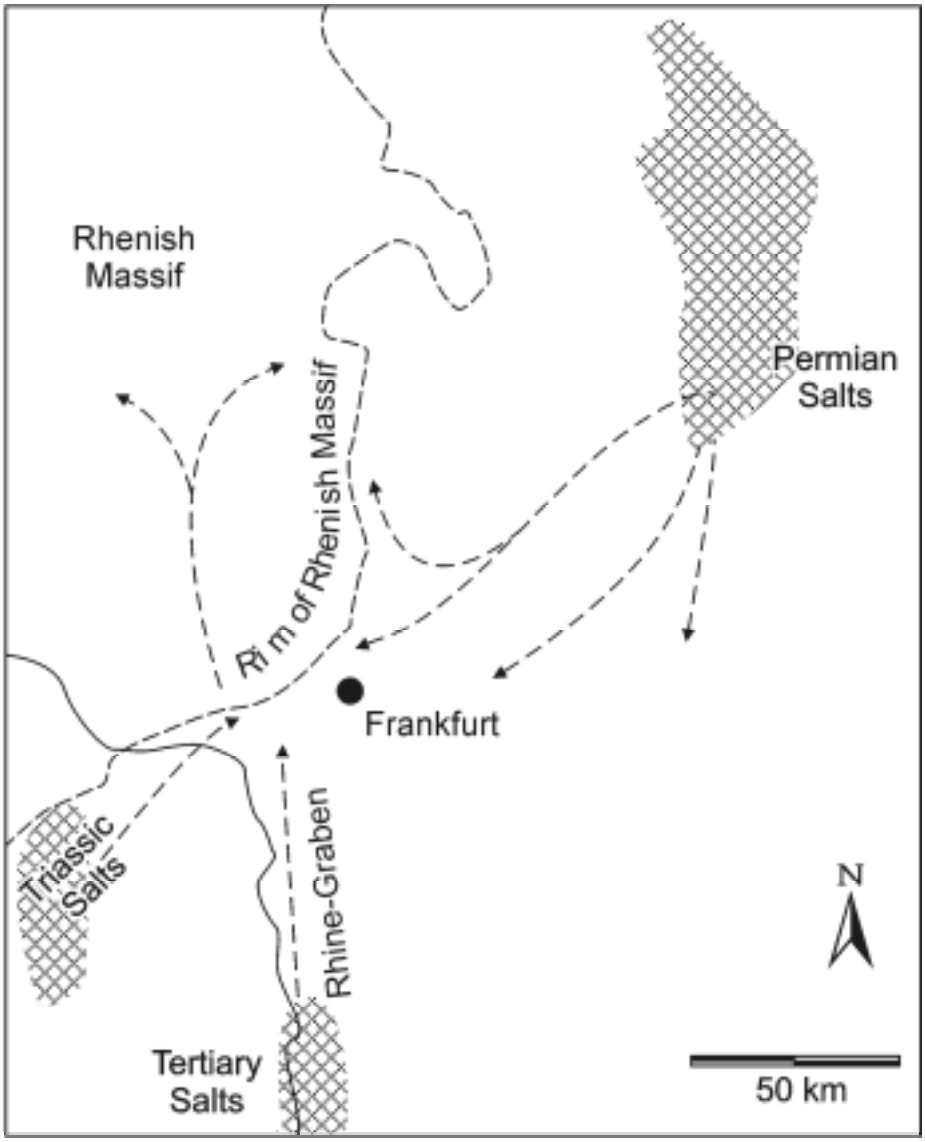

Fig 1: Salt water transport

Conclusions

I think, this overview gave an idea of the frequency and diversity of thermal waters in Germany and middle Europe, some of which are used for a very long time. Many of them show special attributes, like considerable concentrations of carbon dioxide, sodium chloride, sulphate, bicarbonate, hydrogen sulphide, or radon. Often, thermal waters of different composition occur within the same region and sometimes even at the same spa.

The great diversity of the thermal waters and their classification into different regional provinces is shown in the final Fig. 2.