Published in Hydrogeology Journal 17, issue 6, 1543-1546, 2009
which should be used for any reference to this work

A conversation with Werner Käss (Germany) about his contributions to tracer hydrogeology and characterisation of mineral waters and spas

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Keywords Profiles · Interview · Tracer tests · Thermal and mineral water · Germany

Introduction

Every hydrogeologist dealing with tracer tests is aware of the textbook of Werner Käss (born 1924 in Stuttgart, Germany; Figs. 1 and 2) on *Tracing Technique in Geohydrology*, which was first published in German (Käss 1992), then translated into English (Käss 1998) and finally published as a second German edition (Käss 2004). There is probably no other hydrogeologic discipline where a single book has such unrivalled status as a unique standard reference, gathering all available knowledge. The book is internationally used for teaching, research and professional application, and is frequently cited. Many authors contributed (e.g. H. Behrens, H. Moser, H. D. Schulz, H. Hötzl), but Werner Käss acted as lead author and editor. However, he did far more than collect knowledge. He was, and still is, among those who developed and improved the techniques of water tracing, particularly in the field of fluorescent dye analysis, but also for the characterisation of contaminant transport.

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His achievements in the field of thermal and mineral water research are internationally less well known, but in Germany, he is also an authority in this field. A voluminous reference book on all German spas, which he edited together with his wife Hanna, was published in autumn 2008 (Käss and Käss 2008). Probably, there is no comparable oeuvre elsewhere.

On 5 October 2008, the authors visited Werner Käss and Hanna in their home in Umkirch near Freiburg, Germany (Fig. 2), to talk about his life and research. The interview was held in German, but an English translation is available as electronic supplementary material (ESM).

The most remarkable thing about Werner Käss, who retired from the State Geological Survey in Freiburg in 1989 and is already well into his 80s, is his indefatigable scientific curiosity and activity. We asked him when he did his last tracer test, and he confessed that he had just injected two tracers, borax and uranine, at the alluvial aquifer experimental site 'Merdingen' near his home in order to study borate transport in groundwater (Fig. 1). Sampling was still ongoing, and he did the analyses in his laboratory at home, where he has a spectral fluorometer, an atomic absorption spectrometer, and a spectral photometer.

On many occasions, Werner Käss emphasises the important role of his wife Hanna, a trained nurse, for his achievements. She did all of the text processing for his books, and he characterises her as somebody who always thinks and contributes through many suggestions.

Werner Käss comes from a time when science was less English-dominated than today. Therefore, most of his work was published in German-language journals (e.g. *Steirische Beiträge zur Hydrogeologie*) that were highly renowned at that time but have now lost their importance, while English-language journals now prevail. A significant part of his work was achieved in cooperation with colleagues from the Association of Tracer Hydrology (ATH), an international group mainly composed of researchers from Germany, Austria, Switzerland and Slovenia. This profile focuses on the achievements of Werner Käss in the field of tracer techniques, but also outlines other contributions to hydrogeology that are less known outside German-speaking regions such as his research on mineral water.

Fig. 1 Werner Käss (*right*) with Nadine Goeppert at the Merdingen test site, close to his home in Umkirch, southwest Germany. Although well into his 80s, he is still doing tracer tests and analyses the samples in his private laboratory, often in cooperation with Diploma or PhD students (photo: N. Goldscheider)

Besides his research and applied projects, he has also been teaching at the University of Freiburg since 1968, including lectures on petroleum geology, geochemistry and hydrochemistry, as well as summer courses in tracer hydrology. In 1988, he was nominated Extraordinary Professor in appreciation of his decades of teaching. He has also supervised numerous Diploma and PhD students and observed that "the female students are more active than the male students". Practical problems encountered during his tenure at the Geologic Survey were often the starting point for Diploma and PhD projects.

Tracer techniques

Werner Käss explained that his engagement with tracer techniques was in good part due to the geology of his home region Baden-Württemberg, southwest Germany, where there is a lot of karst such as the Upper Jurassic limestones of the Swabian Alb, and the Muschelkalk (Fig. 2). In the 1950s and 1960s, many water supplies had serious contamination problems, often caused by agriculture and wastewater releases into dolines. Therefore, the State Geological Survey started to do tracer tests in order to reveal the causes of water contamination. Werner Käss joined the Survey in 1957, as head of the geochemistry section, and established the chemical laboratory. At that time, his colleagues mainly used salt and uranine as tracers, but the only method of uranine detection was the observation of visible green colouring in the spring water. Werner Käss was facing the task of establishing more sensitive and more quantitative methods in tracer techniques, and he had the idea to achieve this by measuring the fluorescence of uranine independently and parallel to developments by other institutions such as the GSF-Research Centre near Munich. In the early 1960s, he was finally able to analyse uranine quantitatively and with very low detection limits by means of spectral fluorometers, resulting in detailed breakthrough curves (Käss 1964, 1965, 1967a, b). So his work on tracers started with analytical innovations in a chemical laboratory and was motivated by the resolution of contamination problems in karst aquifers. The invention of the synchronous-scan techniques by his ATH colleague Horst Behrens (Behrens 1970) from the GSF was a major next step in the development of improved analytical methods for fluorescent dyes—even before this technique was published in Nature by Lloyd (1971).

Werner Käss did his first field tracer tests in cooperation with the ATH, which was established in 1966; he was among the founding members, together with Viktor Maurin from Graz (Austria). In 1970, he organised the second ATH meeting, which took place in Freiburg, Germany. This meeting focused on the hydrogeology of the Swabian Alb,

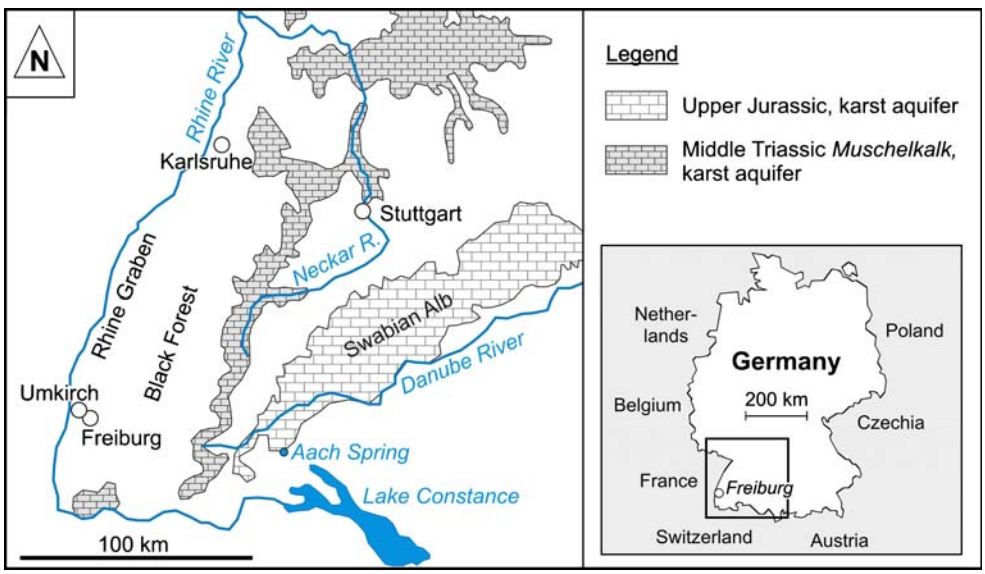

Fig 2 Generalised hydrogeologic map of Baden-Württemberg, southwest Germany, showing karst aquifer systems and locations mentioned in the text (modified after Pfeiffer and Hahn 1972)

where the Danube River sinks underground into karstified Upper Jurassic limestone and reappears 12 km farther to the south in the Aach spring, Germany's largest (karst) spring (Fig. 2). The first systematic and quantitative tracer test in the history of hydrogeology was carried out in the Danube-Aach system (Knop 1878). Werner Käss collected all available knowledge about this area (Käss 1969) and contributed to many tracer tests, making this region one of the international prime examples for the use of artificial tracers in karst hydrogeology, as described by Ford and Williams (2007) who also mention his achievements in the development of quantitative tracer detection (cited here in the preceding). In the interview, Werner Käss particularly acknowledged the cooperation with Heinz Hötzl from the University of Karlsruhe (Fig. 2) who prepared his habilitation about the hydrogeology of the Swabian Alb karst region (Käss and Hötzl 1973).

Werner Käss also developed tracing techniques as a tool to better understand contaminant transport in groundwater, as summarised in his textbook and in Käss (1994). He was particularly involved in petroleum contamination (e.g. Käss 1972; Käss and Schweisfurth 1989) and even did tracer tests with petroleum in an alluvial aquifer (Bartz and Käss 1972). He also investigated the transport and lifespan of faecal and pathogenic bacteria in groundwater (Ritter and Käss 1983; Käss et al. 1983) and has used microbial tracers as surrogates to study pathogen transport, in cooperation with different colleagues (Hötzl et al. 1991; Oetzel et al. 1991). He also contributed to the development of fluorescent microspheres as groundwater tracers. Microspheres can also be used to simulate the transport of microbial pathogens such as bacteria and *Cryptosporidium* cysts. His method of microsphere detection (Käss 1992) is still used today (e.g. Göppert and Goldscheider, 2008). Werner Käss also participated in a working group dealing with the toxicological and ecotoxicological assessment of tracers, resulting in a short but very useful paper (Behrens et al. 2001). Readers interested in the history of tracer techniques are referred to the introduction chapter of his textbook (Käss 1992, 1998, 2004), which presents a detailed historic discourse, starting in the ancient world and ranging right up to the most recent international developments.

Mineral water

The hydrogeology and hydro-geochemistry of thermal, mineral and medicinal waters is his second major field of interest, which is documented in numerous publications, mostly in German (e.g. Käss 1967a, b, 2000). The authors had the chance to cooperate with Werner Käss in a study combining his two major fields of interest: multi-tracer tests in the artesian Muschelkalk karst aquifer of the mineral and medicinal springs of Stuttgart (Fig. 2), his native town (Goldscheider et al. 2003). The study was induced by the detection of chlorinated solvents, at very low concentration levels, in some of the springs. Two injections of the invisible fluorescent dye sodium naphthionate into two different observation wells, one in 1998 and one in 1999, in very large quantities (~150 kg) made it possible to better characterise groundwater flow and potential contaminant transport towards the mineral springs.

His latest and major achievement is the second edition of the *Deutsches Bäderbuch* [German Spa Book], which he edited together with Hanna (Käss and Käss 2008). Numerous authors from various disciplines, ranging from hydrogeology to medicine, contributed to this book. The first edition of the German Spa Book, by the way, was published in 1907. During the interview, he exhibited a copy of this old book with gold embossing and an imperial eagle on the leather cover. Werner Käss has a predilection for historical aspects, and it is quite typical that he took an antiquarian book as starting point. He is also a man of diligence, committed to the principle of completeness. Therefore, the book does not simply present some or most of the spas in Germany, but all 163 of them, in alphabetical order, starting with Aachen and ending with Zwesten. This book will probably never be translated into English, but it could serve as an example for similar reference books in other countries.

His work ethic and advice to a younger generation

While studying his books, working on common projects or during discussions with him, it becomes obvious that Werner Käss does his work with passion and energy. He works thoroughly, rigorously and precisely. There is no such thing as routine work for him, but he always reconsiders and optimises his approach. Working with him can be highly educational, but also fun, because he has a good sense of humour. He even compiled a couple of funny anecdotes that happened during tracer tests. However, he is not a man of compromise when it comes to scientific quality. It is easy to imagine, and he freely admits, that working with him can be troublesome for people who do not share his thoroughness and his understanding of science as a way to find out the truth, which requires tireless work and forthrightness.

When asked about his advice to the younger generation of hydrogeologists, his spontaneous answer was, "You must love science, and truthfulness." He explained [paraphrased], "Water is such an important substance, you must see it as a gift from heaven, a treasure that you must keep clean, that you must honour. As head of a laboratory, I have received hundreds, thousands of water samples. For me, every sample was an individual, not just a number. Several times, I had to annoy my colleagues. Some said they just want to know water hardness, nothing else. This is not sufficient for me as a scientist. So I always analysed my water samples on the basis of clear methodological considerations. The same is true, in a wider sense, for the hydrogeologist. He has to understand his work in a way that every problem is different and requires an individual solution. There is no simple recipe."

Acknowledgements We thank the former ATH members H. Hötzl (Karlsruhe, Germany), I. Müller (formerly Neuchâtel, Switzerland, now Hungary) and R. Benischke (Graz, Austria) for friendly support and valuable information; T. Bechtel (Lancaster, USA) for proofreading; and K. Milnes (Neuchâtel) for the recorder used for the interview.

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