GEOCHEMISTRY OF EUROPEAN BOTTLED WATER[1]

Geochemistry of European Bottled Water is based on the analytical data from 1785 samples of bottled water bought in European supermarkets in 2008. The samples represent 1189 different brands from 1247 wells at 884 locations. The samples were acquired as a result of a unique effort by the editors, Clemens Reimann and Manfred Birke, and a large number of colleagues from 38 countries in Europe. The declared purpose of the effort was to inform the public about the wide range of solute concentrations and the variability of other parameters pertaining to commercially available bottled water.

Chapter 1 provides an in-depth explanation of the motivation and the objectives of the research. Chapter 2 explains some aspects of the hydrochemistry of groundwater. Chapter 3, "Background Information," very briefly describes the geology, tectonic setting, past and active volcanism, distribution of precipitation, and soil types of Europe. The book does not present details on the geology or the hydrogeological background of a given sample of bottled water. This would clearly be a colossal enterprise, beyond the scope of the book.

Chapter 4 explains the analytical and handling procedures, including sampling, sample preparation, and the elaborate quality control of the analytical data. All samples were analyzed at the laboratory of the Federal Institute for Geosciences and Natural Resources (BGR) in Berlin, Germany. The laboratory analyzed 72 individual parameters for each sample using state-of-the-art analytical procedures. Repeated analysis of international standards assured analytical quality.

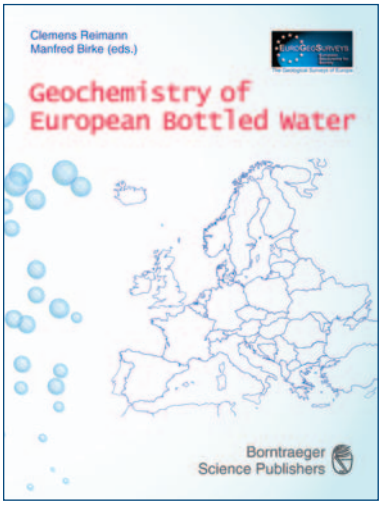
The concentration data for nine solutes are compared with the corresponding parameters printed on the bottle labels. For the calcium, magnesium, iron, sodium, sulfate, and fluoride contents, basically no outliers were identified on the appropriate diagrams. However, (too) many analyses showed large discrepancies for bicarbonate and dissolved silica. Some duplicate samples were acquired after some months and analyzed under the same conditions as the first set. Some parameters showed interesting and surprisingly large differences at some locations.

A strong alkalinity–pH correlation can be observed when comparing CO_2-bearing with noncarbonated water in glass bottles. Water in plastic containers shows a large scatter, and values are displaced to higher pH. Sorption and desorption related to the material of the bottles were clearly demonstrated. For example, in long-term experiments, cobalt increased in the water stored in blue-colored glass bottles and in soft-PET bottles.

Chapters 5 and 6 present additional new data from European drinking water (tap water), surface waters, and Norwegian groundwater, and compare these data with the data from the analyzed bottled water. The usefulness of these chapters is not evident to me, and the probability diagrams are difficult to read.

Chapter 7 presents detailed descriptions and diagrams for 67 analytical parameters in alphabetical order, from "alkalinity" to "zirconium," on two facing pages for each parameter. The chemical properties, occurrence, and use of the substance are portrayed on the left page. The right page shows the distribution of the parameter on a map of Europe using symbols of different size. Other diagrams show the probability of the parameter and curves for the concentration frequency. The table lists the locality with the lowest and the highest concentrations for the parameter and the average value.

This is the most extensive and entertaining part of the book. Here you can find out about your favorite solute. For example, bromine, one of my favorites, shows relatively high concentrations in waters from



Eastern Europe. The authors relate the data to the preference of consumers in this area for relatively highly mineralized water. This is consistent with the distribution map for electrical conductivity data (ec-values), which also shows a clear trend for high-ec water in the eastern and northeastern parts of Europe. Because all data can be found on Excel spreadsheets on the attached CD, I quickly prepared Cl/Br mass-ratio histograms, which showed that >75% of all waters have an evaporite signature, very few waters have a direct seawater character, and only <20% have Br-enriched signatures typical of crystalline basement. Interestingly but not surprisingly, more than 50% of the Norwegian groundwater samples have a Cl/Br ratio less than that of seawater. This little exercise was also performed rapidly thanks to the data repository on the CD.

Aluminum is an important but analytically difficult solute. It is often present in the form of colloids and particulates in the water, and measured concentrations can be far above what one would expect for dissolved Al. The median value for Al is given as 1.19 µg/L. This value seems very plausible because computed (PHREEQC) saturation states show undersaturation for common, primary, rock-forming silicates, such as feldspar and mica, present in most of the reservoir rocks, and oversaturation for typical secondary minerals, such as clays.

The median value for dissolved silicon (not SiO_2) is given as 6.5 mg/L. This value corresponds to very mild supersaturation with respect to quartz ($SI_{Qtz} = 0.4$) and saturation for chalcedony ($SI_{Cha} = 0$). This may indeed indicate Si control by a "silica ceiling" (authors), or, more accurately, a "chalcedony ceiling." The reported high-silica waters are oversaturated even with respect to amorphous silica and would tend to become turbid during storage.

Chapter 8 deals with the physiology of the most important parameters, their health effects, and the statutory threshold values. The statutory threshold values in drinking and mineral waters in European countries, the European Union, and the United States are also listed in a comprehensive table in appendix A. Appendix B lists all data used in chapter 7 and the additional water data used in chapters 5 and 6. All these data and new analyses of 579 tap-water samples are stored on the enclosed CD.

The book has been produced with much effort and concern for detail. It provides an excellent overview on the nature of European bottled waters and contains a wealth of information, some of which may be interesting and useful to you. Particularly interesting are the detailed parameter descriptions in chapter 7. Also helpful are the nutritional, physiological, and human toxicological appraisals of the various dissolved substances.

Purchasing the book is strongly recommended for hygienists, hydrogeologists, geochemists, and hydrochemists, and anyone else working in the broad fields of groundwater and mineral water.

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1 Reimann C, Birke M (eds) (2010) Geochemistry of European Bottled Water. Borntraeger Science Publishers, Stuttgart, 268 pp, 1 CD, ISBN 978-3-443-01067-6, €78 (http://borntraeger-cramer.com/9783443010676)