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Garrels R M & Christ C L. *Solutions, minerals, and equilibria.* New York: Harper & Row, 1965. 450 p.
[Northwestern University, Evanston, IL and US Geological Survey, Washington, DC]

Various chemical aspects relating mineral solubilities to the natural solutions in which they are formed are presented. After chapters on activity-concentration relations, carbonate equilibria, and complex ions, the book is devoted to the depiction of mineral-solution equilibria, using, among others, Eh-pH, partial pressure, and ion-activity diagrams. [The *SCI*® indicates that this book has been cited in over 1,060 publications.]

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The book is the result of many years of developing techniques to represent quantitatively the stability of mineral phases as a function of their aquatic environment at low temperatures and pressures. Low-temperature aqueous geochemistry was in a primitive state prior to about 1950; few values of the Gibbs energy of formation of minerals were known. Geologists and water-supply scientists hardly communicated, and only a handful of groundwater analyses coexisted with mineralogic analyses of the enclosing rocks.

The first stability diagrams for minerals were developed at Northwestern University in the late 1940s, using oxidation potential and pH as the descriptive variables in portraying the relations of copper minerals—sulfides, oxides, native metal, sulfates, and carbonates. The next major development took place in the early 1950s at the laboratories of the US Geological Survey in Washington, DC. At that time my three-decade collaboration with Charles L. Christ, my coauthor, began. The exploration of uranium and vanadium deposits of the Colorado Plateau was booming. Uranium (with two valences and a complex solution chemistry), plus vanadium (with three natural valence states and an even greater variety of minerals than uranium), led us to produce many new oxidation potential-pH diagrams. These diagrams were a key device in showing that the deposits had been first introduced to the rocks in reduced mineral species, and later commonly oxidized secondarily.

I went to Harvard in 1955, and there, with my students in mining geology, spent a productive decade making a wide range of mineral-stability diagrams. By about 1960, with continued help from Christ, I had amassed a very large number of diagrams, so I asked my editor at Harper's, Kenneth Demaree, if we couldn't publish an atlas. He suggested adding some text. A preliminary 250-page book, *Mineral Equilibria*, came out in 1960; new techniques and diagrams resulted in the final version, *Solutions, Minerals, and Equilibria*, about twice as long, in 1965.

The original edition was published by Harper; Harper was taken over by Harper & Row, which permitted the book to go out of print. Fortunately, W.H. Freeman of Freeman, Cooper & Company reprinted the book,[1] and since 1975, it has been selling successfully.

An interesting sidelight is that the 1960 book was translated into Russian in 1962, and it has been used extensively in the training of Russian geochemists. I received no royalties from the use of this book, but I was honored by being invited to Moscow in 1973 as the first foreigner to give a lecture celebrating the birthday of the foremost Russian geochemist, V.I. Vernadskii.

The reasons for the extensive citations of this book are probably the publication of a large amount of useful new material, plus—chiefly due to Christ—a text that makes the book almost self-teaching while remaining concise. It really opened up the still exponentially expanding field of low-temperature geochemistry. [For a recent discussion of the field, please see reference 2.]

1. Garrels R M & Christ C L. *Solutions, minerals, and equilibria.* San Francisco, CA: Freeman, Cooper, 1975. 450 p.
2. Back W & Freeze R A, eds. *Chemical hydrogeology.* Stroudsburg, PA: Hutchinson Ross, 1983. 416 p.