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BIBLIOGRAPHY OF THE AVAILABLE DATA ON
THE SOLUBILITY OF SILICA IN WATER SUBSTANCE

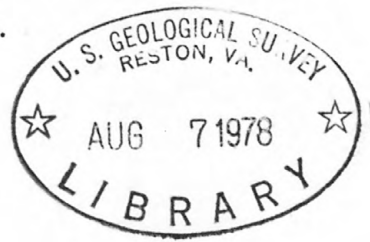
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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

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National Center for the thermodynamic data of minerals report prepared for Working Group IV of the International Association of the properties of steam.

The following bibliography represents the currently available experimental data for the solubility of silica in water substance as a function of temperature and pressure. These references were compiled by the silica subcommittee of Working Group IV at the 1977 meeting of IAPS in Moscow. The data summarized in these references cover the temperature range of 0° to 900°C at pressures from atmospheric to 1000 mega pascals.

Preliminary examination of the data suggests that a good correlation of the solubility of silica can be obtained from temperature and log specific volume of water (Fig. 1). The available solubility data (log weight percent silica) tend to lie along smooth curves at constant temperature as a function of log specific volume of water. In addition the data appear to be reasonably consistent, such that a single equation can be derived that describes the solubility of quartz from 0° to 900°C at pressures up to 1000 mega pascals.

- Alexander, G. B., Heston, W. M., and Iler, R. K., 1954, The solubility of amorphous silica in water: *Journal of Physical Chemistry*, v. 58, p. 453-455.
- Anderson, G. M., and Burnham, C. W., 1965, The solubility of quartz in supercritical water: *American Journal of Science*, v. 263, p. 494-511.
- Åstrand, L., 1956, Kieselsäure im Dampf: *Mitt. VGB [Vereinigung Grosskraftwerk Betreiber]* 14, H. 40.
- Avakov, V. A., 1972, Comparative solubility of some silica modifications: *Stroit. Mater.*, v. 11, p. 35-36. (Russian)
- Beal, A. J., and Godbert, A. L., 1955, The solubility of quartz dust: Ministry Fuel and Power (Britain), Safety in Mines Research Establishment, Research Report No. 115, 22 p.
- Brady, E. L., 1933, Chemical nature of silica carried by steam: *Journal of Physical Chemistry*, v. 57, p. 706.
- Coulter, E. E., Pirsh, E. A., and Wagner, E. J., 1955, Selective silica carry-over in steam: *American Society of Mechanical Engineers Transactions*, Paper No. 55-SA-19
- Crerar, D. A., and Anderson, G. M., 1971, Solubility and solvation reactions of quartz in dilute hydrothermal solutions: *Chemical Geology*, v. 8, p. 107-122.
- Elmer, T. H., and Nordberg, M. E., 1958, Solubility of silica in nitric acid solutions: *Journal of the American Ceramic Society*, v. 41, p. 517-520.
- Feitsma, R., 1961, Die Löslichkeit von Kieselsäure in Wasserdampf: *Mitt. VGB [Vereinigung Grosskraftwerk Betreiber]* 170, H. 72.
- Fournier, R. O., and Rowe, J. J., 1962, The solubility of cristobalite along the three-phase curve, gas plus liquid plus cristobalite: *American Mineralogist*, v. 47, p. 897-902.
- Fournier, R. O., and Rowe, J. J., 1977, The solubility of amorphous silica in water at high temperatures and pressures: *American Mineralogist*, v. 62, p. 1052-1056.
- Frederickson, A. F., and Cox, J. E., Jr., 1954, Mechanism of solution of quartz in pure water at elevated temperatures and pressures: *American Mineralogist*, v. 39, p. 886.

- Grozdanov, L., 1967, Über die Löslichkeit bei erhöhtem Druck auf die festen Phasen und die Stabilität einiger SiO₂-modifikationen: Comptes Rend. Acad. Bulgare Sciences, v. 20, no. 8.
- Hannay, J. B., 1879/80, On the solubility of solids in gases: Royal Society [of London] Proceedings, v. 30, p. 484.
- Heitmann, H. G., 1963, Die Löslichkeit von Kieselsäure in Wasser und Wasserdampf sowie ihr Einfluss auf Turbinenverkieselungen: Siemens-Schuckerwerk Aktiengesellschaft, Technische Stammabteilung, 255 p.
- Heitmann, H. G., 1965, Die Löslichkeit von Kieselsäure in Wasserdampf: Glastechnische Berichte, v. 38, p. 41-54.
- Heitmann, H. G., 1974, Solubility of inorganic compounds in water and steam, with particular reference to silica and iron oxides, and its deposits in power plant cycles: International Conference on Properties of Water and Steam, 8th, Proceedings v. 2, p. 686-712.
- Hemley, J. J., 1978, Solubility of quartz on the vapor saturated curve: Written communication to SiO₂ Subgroup, WG IV.
- Hemley, J. J., Montoya, J. W., Christ, C. L., and Hostetler, P. B., 1977, Mineral equilibria in the MgO-SiO₂-H₂O system: I talc-chrysotile-forsterite-brucite stability relations: American Journal of Science, v. 277, p. 322-351.
- Hitchen, C. S., 1935, A method for experimental investigation of hydrothermal solutions, with notes on its application to the solubility of silica: Institution of Mining and Metallurgy, Transactions, v. 44, p. 255-280.
- Hitchen, C. S., 1945, The solubility of silica: Economic Geology, v. 40, p. 361.
- Jeffreys, J., 1840, On the solubility of silica by steam: Royal Society [of London] Proceedings, v. 4, p. 232. Also in: Lieb. Ann., v. 39, p. 255 (1841).
- Khaibullin, I. Kh., and Senkevitsch, J. W., 1958, Über die Natur des Mitreissens der Kieselsäure durch Hochdruckdampf: Teploenergetika, v. 5, p. 16.

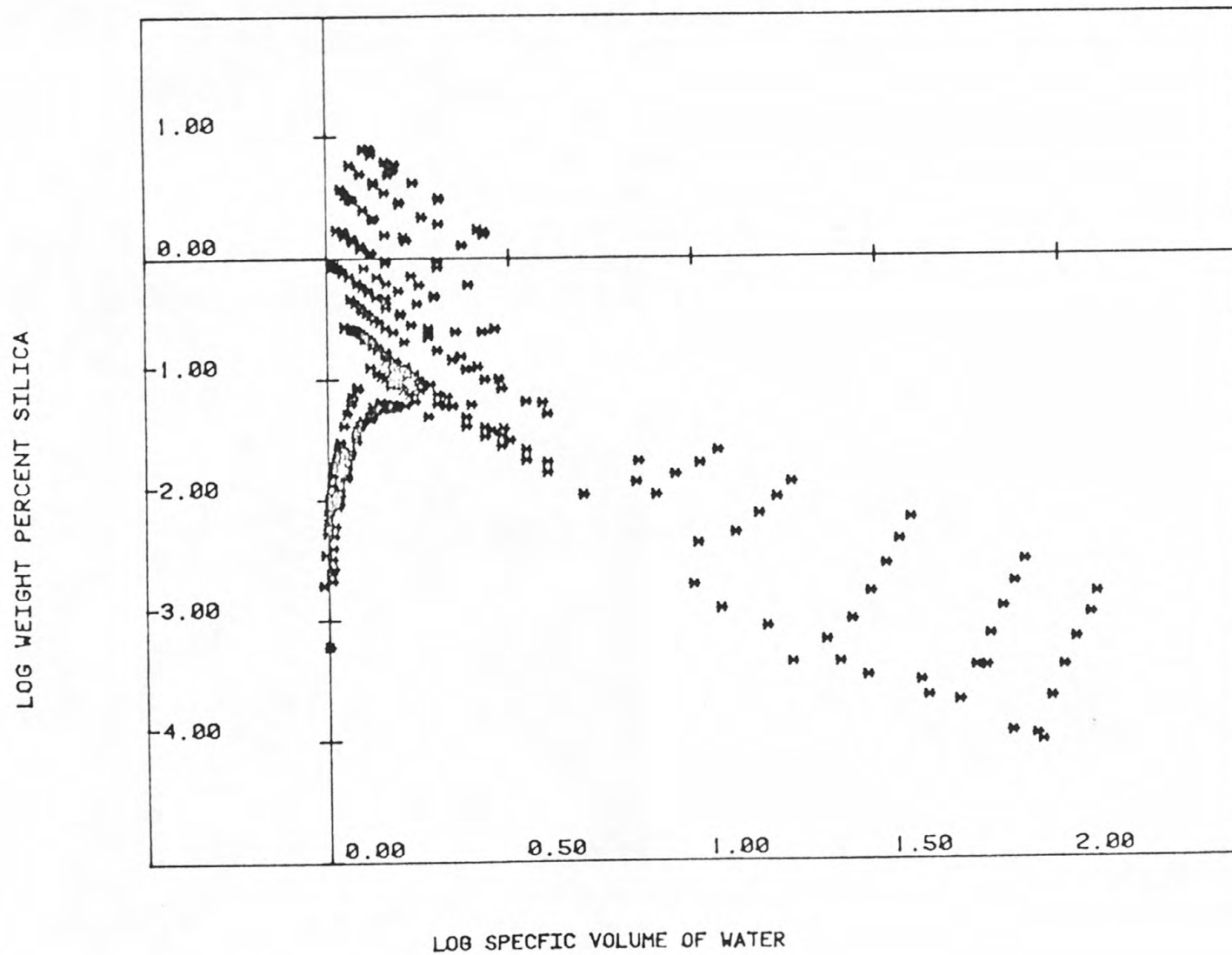
- Katkovskaya, K. Ya., 1953, The selective transfer of substances by steam in boilers at high pressures: Trudy Moskov. Energet. Insti., v. 1953, p. 135-151. (Russian)
- Kennedy, G. C., 1944, The hydrothermal solubility of silica: Economic Geology, v. 39, p. 25-36.
- Kennedy, G. C., 1950, A portion of the system silica-water: Economic Geology, v. 45, p. 629-653.
- Kennedy, G. C., Wasserburg, G. J., Heard, H. C., and Newton, R. C., 1962, The upper three-phase region in the system $\text{SiO}_2\text{-H}_2\text{O}$: American Journal of Science, v. 260, p. 501-521.
- Khitarov, N. I., 1956, The 400° isotherm for the system $\text{H}_2\text{O-SiO}_2$ at pressures up to 2000 kg/cm²: Geochemistry, v. 1956, p. 55-61.
- Khodakov, G. S., and Plutsis, E. R., 1958, Solubility of fine-ground quartz in H_2O : Doklady Akad. Nauk SSSR, v. 123, p. 725-728. (Russian)
- Kitahara, S., 1960, The solubility of quartz in water at high temperatures and high pressures: Rev. Phys. Chem. Japan, v. 30, p. 109-114.
- Kitahara, S., 1960, The polymerization of silicic acid obtained by the hydrothermal treatment of quartz and the solubility of amorphous silica: Rev. Phys. Chem. Japan, v. 30, p. 131-137.
- Kot, A. A., Dejava, S. W., and Pschemenski, A. A., 1961, Über die Löslichkeit von Quarz, Kieselsäure und Natriumsilicat in überhitztem Dampf: Elektr. Stanzii, v. 32, p. 9.
- Krauskopf, K. B., 1956, Dissolution and precipitation of silica at low temperatures: Geochimica et Cosmochimica Acta, v. 10, p. 1-26.
- Laudise, R. A., and Ballman, A. A., 1961, The solubility of quartz under hydrothermal conditions: Journal of Physical Chemistry, v. 65, p. 1396-1400.
- Lenher, V., and Merrill, H. B., 1917, Solubility of silica: Journal of the American Chemical Society, v. 39, p. 2630-2638.

- Morey, G. W., 1932, The volatility of silica with steam [abstr.]: American Geophysical Union Transactions, v. 13, p. 269.
- Morey, G. W., 1942, Solubility of solids in water vapor: American Society for Testing and Materials Proceedings, v. 42, p. 980.
- Morey, G. W., Fournier, R. O., and Rowe, J. J., 1962, The solubility of quartz in water in the temperature interval from 25° to 300°C: Geochimica et Cosmochimica Acta, v. 26, p. 1029-1043.
- Morey, G. W., and Hesselgesser, J. M., 1950, The solubility of quartz and some other substances in superheated steam at high pressures: American Society of Mechanical Engineers Transactions, Paper No. 50-A-73.
- Morey, G. W., and Hesselgesser, J. M., 1951, The solubility of some minerals in superheated steam at high pressures: Economic Geology, v. 46, p. 821-835.
- Morey, G. W., and Hesselgesser, J. M., 1951, The solubility of quartz and some other substances in superheated steam at high pressures: American Society of Mechanical Engineers Transactions, v. 73, p. 865.
- Mosebach, R., 1955, Die hydrothermale Löslichkeit des Quarzes als heterogenes Gasgleichgewicht: Neues Jahrbuch für Mineralogie Abhandlungen, v. 87, p. 351.
- Mosebach, R., 1952, Zur Kenntnis und petrologischen Bedeutung des Systems SiO₂-H₂O: Geologie, v. 1, p. 415.
- Mosebach, R., 1956, Die Löslichkeit der gefallten Kieselsäure und des Kieselglases in Wasser bei höheren Temperaturen und Drücken: Neues Jahrbuch für Mineralogie Abhandlungen, v. 89, p. 1.
- Okamoto, G., Okura, T., and Goto, K., 1957, Properties of silica in water: Geochimica et Cosmochimica Acta, v. 12, p. 123-240.
- Patterson, M. S., and Wheatley, K., 1959, Solubility and heat of wetting of silica powders: Journal of Applied Chemistry, v. 9, p. 231-240.
- Siever, R., 1962, Silica solubility, 0°-200°C, and the diagenesis of siliceous sediments: Journal of Geology, v. 70, p. 127-150.

- Smits, A., 1930, Das System Wasser-Siliciumdioxid: Rec. trav. chim., v. 49, p. 962.
- Sommerfield, R. A., 1967, Quartz solution reaction: 400°-500°C, 1000 bars: Journal of Geophysical Research, v. 72, p. 4253-4257.
- Syromyatnikov, F. V., 1956, Experimental data on the solubility of minerals and genetic conclusions: International Congress of Geology, 20th, Mexico City, Compt. Rend., Sect. 11-A, v. 1956, p. 321-346.
- Syromyatnikov, F. V., and Rumyantseva, G. V., 1974, Change in the solubility of quartz in water and alkaline solutions during nonuniform compression and at elevated temperatures: Metasomatizm Rudobraz., Mater. Vses. Konf., 3rd, p. 330-341. (Russian)
- Styrikovich, M. A., and Khaibullin, I. Kh., 1956, Phase equilibrium diagrams of the systems NaCl-H₂O, Na₂SO₄-H₂O, CaSO₄-H₂O and SiO₂-water: Doklady Akad. Nauk SSSR, v. 100, p. 1123-1126.
- Styrikovich, M. A., Khaibullin, I. Kh., and Tskhvirashvili, D. G., 1955, Solubility of salts in high-pressure steam: Doklady Akad. Nauk SSSR, v. 100, p. 1123-1126. (Russian)
- Styrikovich, M. A., 1957, The solubility of low volatility substances in high pressure steam: Radioisotopes Sci. Res., International Conference, Paris, 1957, v. I, p. 411-425. (Russian)
- Styrikovich, M. A., and Martynova, O. I., 1963, Contamination of steam in boiling-water [nuclear] reactors by impurities from the water: Atomnaya Energiya, v. 15, p. 214-218. (Russian)
- Tuttle, O. F., and England, J. L., 1952, Preliminary report on the system SiO₂ - H₂O: Geological Society of America Bulletin, v. 66, p. 149.
- Van Lier, J. A., 1958, Solubility of Quartz: U.S. Atomic Energy Commission, NYO-2293, p. 9-19.
- Van Lier, J. A., de Bruyn, P. L., and Overbeek, J. Th., 1960, The solubility of quartz: Journal of Physical Chemistry, v. 64, p. 1675-1682.

- Wasserburg, G. J., 1958, The solubility of quartz in supercritical water as a function of pressure: *Journal of Geology*, v. 66, p. 559-578.
- Weill, D. F., and Fyfe, W. S., 1964, The solubility of quartz in H₂O in the range 1000-4000 bars and 400-550°C: *Geochimica et Cosmochimica Acta*, v. 28, p. 1243-1255.
- Wendlandt, H. G., and Glemser, O., 1964, The reaction of oxides with water at high pressures and temperatures: *Angewandte Chemie, International Edition, English*, v. 3, p. 47-54.

Figure 1. A plot of all of the available experimental data for the solubility of silica in water substance versus the log specific volume of water at the temperature and pressure of the measurement.



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