Empirical equations for representing vapor-liquid equilibria in the CO_2-H_2O system at 110-350°C

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Results and Discussion

Empirical isothermal equations have been developed to represent vapor-liquid equilibria (VLE) in the CO_2-H_2O system at 110-350°C. The expressions accurately reproduce the CO_2-H_2O VLE data of Takenouchi and Kennedy (1964), Blencoe et al. (2001), and Blencoe (in prep.) (Figs. 1-2). However, additional accurate CO_2-H_2O VLE data are needed for 250-360°C to facilitate development of reliable *polythermal* functions for representing the phase relations. These equations would have numerous, important applications in geochemistry, high-temperature aqueous chemistry, and chemical engineering.

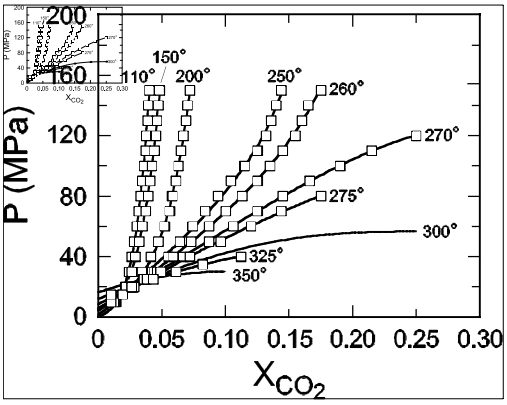

Figure 1. Bubble-point data (open squares—Takenouchi and Kennedy, 1964; filled circles—Blencoe et al., 2001, and Blencoe, in prep.), and calculated bubble-point curves (this study), for CO_2-H_2O fluids at 110-350°C.

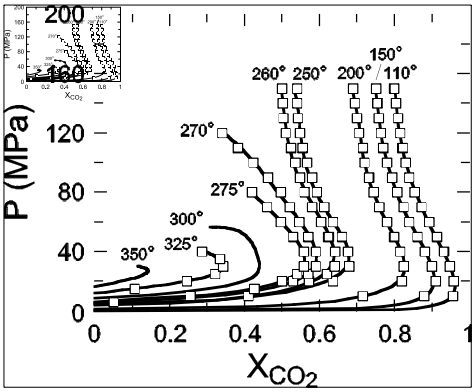

Figure 2. Dew-point data (open squares—Takenouchi and Kennedy, 1964; filled circles—Blencoe et al., 2001, and Blencoe, in prep.), and calculated dew-point curves (this study), for CO_2-H_2O fluids at 110-350°C.

^{176}Lu-^{176}Hf, ^{147}Sm-^{143}Nd, and ^{92}Zr isotope systematics in eucrites

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Fifteen basaltic and three cumulate whole-rock eucrites form a statistically significant ^{176}Lu-^{176}Hf isochron (MSWD = 1.6) with slope and intercept of, respectively, 0.09036±0.00033 and 0.279734±0.000011 (2-sigma propagated error). All but two of the 25 chondrites of [1] plot within error on this isochron, thus confirming the Lu-Hf parameters for BSE. Using the mean age of eucrites of 4.563 Ga [2] yields a value for λ_{176Lu} of 1.896±0.009 10^{-11} y^{-1}, corresponding to a half-life for ^{176}Lu of 36.56±0.18 Ga. This new estimate is consistent with previous experimental results but has a smaller error. Within the present error limits (±16 My) and in accordance with ^{53}Mn-^{53}Cr chronology [2], the cumulate eucrites Moore County, Serra de Magé, and Moama do not appear younger than the basaltic eucrites. Relative to the chondritic value, the Lu/Hf ratio is higher for cumulate and lower for basaltic eucrites. Fifteen of the eucrites further form a statistically significant ^{147}Sm-^{143}Nd isochron with a slope of 0.0295±0.0015, which corresponds to an age of 4372±194 Ma. The two systems differ by their range in parent/daughter ratios, which is much larger for the Lu-Hf system. The younger apparent ^{147}Sm-^{143}Nd (and U-Pb) age for Moama (4.14 Ga) is in conflict with the position of this meteorite straight on the ^{176}Lu-^{176}Hf eucrite isochron, suggesting disturbance of the Sm-Nd (and U-Pb) system.

The main group of basaltic eucrites can be interpreted as representing either large-degree melts of a chondritic planetary body [3] leaving a gabbroic residue or melts derived from the re-melting of cumulates laid down in a magma ocean. The parent melt of cumulate eucrites experienced ilmenite subtraction, thereby enhancing Lu/Hf fractionation. This is particularly evident from the low Hf/Sm of these meteorites (0.4-0.6) that contrasts with basaltic eucrites and most terrestrial and lunar basalts (0.7±0.1). We suggest that basaltic eucrites represent major surges of mildly differentiated melts while cumulate eucrites formed by impregnation of a feldspathic crust by residual liquids that had previously precipitated ilmenite.

None of the eucrites analyzed here show significant ^{92}Zr anomalies outside the analytical error of about 0.3 epsilon units. This may reflect that the Nb/Zr ratio of chondrites, eucrites, and the Earth was not sufficiently different to grow in Zr isotopic differences. Alternatively, the lack of ^{92}Zr anomalies could indicate the absence from the early Solar System of the rare *p*-isotope ^{92}Nb.

References

[1] Blichert-Toft J. and Albarède F., (1997), *EPSL* **148**, 243-258 [2] Lugmair, G.W. and Shukolyukov, A., (1998), *GCA* **62**, 2863-2886 [3] Stolper, E.M., (1977), *GCA* **41**, 587-611.