Formation of the Earth

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Drake and Righter (2002) concluded that most of the Earth accreted from material derived from a narrow annulus centered on 1 AU and the Earth accreted from partially hydrous material. The argument for a narrow feeding zone is reinforced by the increase in $^{53}Cr/^{52}Cr$ ratios from Earth to Mars to the asteroid belt (Lugmair and Shukolyukov, 1998).

This conclusion, based on major element and isotopic characteristics of Earth, Mars, comets, and asteroids, is broadly consistent with dynamical calculations (Chambers, 2001). A key, probably irresolvable disagreement between geochemistry and dynamics, is the conclusion of the dynamics approach that Earth's water is derived from a single planetesimal from the asteroid belt having chemical and isotopic characteristics unlike any object falling to Earth at present.

The picture of accretion that emerges differs from the conventional heterogeneous accretion hypothesis (Wänke, 1981), in which accreting material becomes progressively more oxidized by about three orders of magnitude from the IW buffer to the QFI buffer. Rather, Earth accreted a mixture of metal and silicate ("Earth chondrite or achondrite") including some hydrous material. This material need *not* have become progressively more oxidized with time. Initially metal would dominate the redox state and a metallic core would form. However, hydrous phases would break down at elevated pressures and temperatures (Okuchi, 1997), sequestering hydrogen as iron hydride in the core and releasing OH to oxidize the mantle. With time the mantle would be increasingly oxidized due to this process until accreting metal was no longer stable. Objects accreting post core formation would be oxidized and remain in the upper mantle, perhaps providing the misleadingly-named "late veneer" Alternatively, the "late veneer" could be an anhydrous ordinary chondrite planetesimal from the asteroid belt as required by Os isotopic composition (Meisel *et al.*, 2001) and suggested by dynamical numerical experiments (Chambers, 2001), in which case Earth's water would still come from an indigenous source.

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Revised critical curve for the system H_2O-NaCl

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Literature data on the PVTX relations along the critical curve of the system H_2O-NaCl are in substantial disagreement with each other and with accurate PVTX data from the one- and twophase regions. In order to resolve these discrepancies, a careful, in-depth evaluation of the available data was carried out and new formulae are proposed.

All available P-T data are in good agreement to about 500°C. Above 500°C, critical pressures of Knight & Bodnar (1989) and correlations by Povodyrev et al. (1999) are up to 20% lower than other experimental data (Shmulovich & Tkachenko (1995), Urusova (1974), Sourirajan & Kennedy (1962)) and EOS (Anderko & Pitzer (1993), Tanger & Pitzer (1989)), which all agree within stated errors. A fit of the latter yields critical pressures slightly below the critical isochore of pure water at low T and above it at high T (10% at 700°C).

Revised T-X data are in good agreement to about 500°C. Urusova’s (1974) and Knight & Bodnar’s (1989) data above 500°C are in fair agreement, while the Sourirajan & Kennedy (1962) data and the Anderko & Pitzer’s (1993) EOS provide too low X_{NaCl}. An undulation in the curve above 380°C as claimed by Povodyrev et al. (1999) is probably an artifact of overfit, ignoring experimental uncertainties.

The T-ρ relation is most difficult to evaluate. The Khaibullin & Borisov (1966) and Knight & Bodnar (1989) experimental data disagree already at 405°C. Accurate liquid and vapour densities (Urusova (1975), Gehrig (1983)) bracket the critical density at temperatures to 550°C and indicate that the Knight & Bodnar (1989) values are too high. The Anderko & Pitzer (1993) EOS gives too low values in accordance with its prediction of too low X_{NaCl}. If the latter EOS is used with “correct” X values and if the Knight & Bodnar data are corrected for errors resulting from EOS extrapolations, then all data follow a single curve within 3%.

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