**ASTEROIDAL DEPTH-PRESSURE RELATIONSHIPS AND THE STYLE OF THE UREILITE ANATEXIS**

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Ureilites are restite peridotites from an uncommonly C-rich (3 wt%) asteroid. Mafic silicate (especially olivine) rims show these restites were altered at the end of their igneous evolution by a FeO-reduction, C-oxidation disequilibrium process that was in a loose sense "smelting". Some authors [e.g., 1,2,3,4] argue that smelting also occurred as an equilibrium, pressure ($P$) controlled process during the main stage of ureilite anatexis. Mass-balance problems [e.g., 5] militate against this peculiar [but not altogether unprecedented: 6; cf. critique by 7] notion of depth-linked, $P$-controlled smelting. Still, the richly diverse ureilites typically get short shrift as a "confusing" and "controversial" rock type.

Another reason to dismiss the depth-linked, $P$-controlled smelting (D-LP-CS) hypothesis stems from an analysis of relationships among depth and volume and $P$ within an asteroid, in terms of implications for the relative abundances of different compositions that D-LP-CS would produce. The implied compositional spectrum is to be compared with an observed ureilite data set [8; cf. 1] that shows a pronounced bias toward the ferroan end of the overall range (Fo75-96), and in particular has ~58% of all ureilites in the range Fo76-81. The equation for $P$ as function of depth $z$ in a body of uniform density $\rho$ (a close enough approximation) is well known. Solved for $z$, it yields: $z = R - (R^2 - 3P/[2\pi G\rho^2])^{1/2}$. More to the point, it can also be solved for $F$, the volume fraction of the body above (at lower pressure than) the level of $P$: $F = (R^2 - 3P/[2\pi G\rho^2])^{3/2}/R^3$. Using this equation, it is easy to show that proposed compositional layering as a result of D-LP-CS [1,2,3] should have resulted in a body with magnesian (shallow) ureilites far more abundant than ferroan (deep) ones. In particular, a slight extrapolation from [3] translates into an implication that no more than 8.5% of the body (and much less than that, if $R$ is not close to the ideal ~ 190 km) would become Fo76-81. If the extrapolation is further constrained to be fully consistent with thermodynamically constrained $fO_2$-$P$-$mg$ relationships [9; cf. 2] and a correlation between equilibration $T$ and Fo [4], the maximal implied Fo76-81 fraction decreases from 8.5 to 3.2%; i.e., less than the observed 58% by a factor of 18. Extrapolations starting from other variants [1,2] of the D-LP-CS model have similarly implausible Fo-volume implications.

The problem with depth-linked, $P$-controlled smelting is not only that the ferroan ureilites should be a small fraction of the parent body. That fraction must occur deep (just above the base of the mantle, for its vol% to be as large as cited above), where no straightforward model would imply a strong bias in the impact-driven sampling process. I suggest calling the alternative model smash-before-smelt, where aside from an acronym for Simple-Melting Anatexis with Smelting Holdback, smash connotes catastrophic impact-disruption of the parent asteroid [9].

**References:** [1] Goodrich C. A. et al. (2004) *Chem. Erde* 64, 283-327. [2] Goodrich C. A. et al. (2007) *GCA* 71, 2876-2895. [3] Wilson L. et al. (2008) *GCA* 72, 6154-6176. [4] Singletary S. J. & Grove T. L. (2003) *MPS* 38, 95-108. [5] Warren P. H. & Huber H. (2006) *MPS* 41, 835-849. [6] Sato M. (1979) *PLPSC* 10, 311-325. [7] Fogel R. A. & Rutherford M. J. (1995) *GCA* 59, 201-215. [8] Downes H. et al. (2008) *GCA* 72, 4835-4844. [9] Warren P. H. & Kallemeyn G. W. (1992) *Icarus* 100, 110-126.