Diffusion in metal: application to zoned metal grains in chondrites

K. RIGHTER[1], A.J. CAMPBELL[2], M. HUMAYUN[2]

[1] Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721
[2] Department of the Geophysical Sciences, The University of Chicago, 5734 S. Ellis Ave., Chicago, IL 60637

Zoned metal grains in metal-rich chondrites [1-3] have been interpreted as condensates from a gas of solar nebular composition [e.g., 1]. However, deviations from solar Ni/Co values indicate operation of an additional process, such as diffusional re-equilibration or fractional condensation [3].

To evaluate the role of diffusion in generating zoned metal grains, we have measured diffusion coefficients for Ni, Co, Ga, Ge, Ru, Pd, Ir and Au in Fe metal from 1200 to 1400 ºC and 1.0 GPa. Diffusion couples were prepared from high purity Fe metal and metal from the IIA iron meteorite Coahuila or the pallasite Springwater, encapsulated with MgO, and held at run conditions between 18 and 76 hrs. Although the meteoritic starting metal was kamacite, at run conditions both coupled metals are taenite. Diffusion profiles were measured using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) [3], or electron microprobe (Ni, Co, P). Low concentrations of siderophile elements in the meteoritic metal allow determination of diffusion coefficients at concentration levels appropriate for natural systems.

Our new diffusion coefficients for Ni and Co are as much as 5x lower than some published values, perhaps due to several effects. The degree of crystallinity in our taenite could be different (perhaps even single crystal) from that of previous studies and this could affect the role of grain boundary diffusion. Also, Ni contents of the metals are slightly different from previous work, and diffusion of tracers in metal is known to be a function of Fe/Ni ratio. Our new data for Ni indicate that diffusion lengthscales could be 2-3x shorter than previous estimates [1], and that the lengthscales for Ni and Co should be similar (e.g., D_{Ni} and D_{Co} ~ 1.1 x 10^{-14} m^2/s at 1300 ˚C). Diffusion of Ni and Co in taenite should not significantly fractionate the Ni/Co ratio. On the other hand, the large difference in D_{Ni} and D_{Ir} (D_{Ir} is ~5x lower) and the similarity of D_{Ni} and D_{Ru} at all temperatures investigated indicates that Ni/Ir and Ni/Ru ratios in zoned metal grains will be useful discriminators. These new data on refractory and volatile siderophile elements will be used to determine the relative roles of fractional condensation from a supersaturated solar nebula and diffusive re-equilibration [3].

[1] Meibom, A., et al. (2001) Jour. Geophys. Res. 106, 32979-32801; [2] Weisberg, M.K. and Prinz, M. (1999) Proc. NIPR Symp. Antarct. Meteorites 24, 187-189; [3] Campbell, A.J. et al. (2001) Geochim. Cosmochim. Acta 65, 163-180.

Preliminary ^{10}Be chronology for the last deglaciation of the southern Scandinavian Ice Sheet

V. R. RINTERKNECHT[1], G. M. RAISBECK[2], F. YIOU[2], P. U. CLARK[2], A. BITINAS[3], L. MARKS[4], J. A. PIOTROWSKI[5], V. ZEL_S[6], E. J. BROOK[7]

[1] Department of Geosciences, Oregon State University, Corvallis, OR 97331, USA (rinterkv@geo.orst.edu,)
[2] Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, Orsay, France
[3] Geological Survey of Lithuania, Vilnius, Lithuania
[4] Polish Geological Institute, Warsaw, Poland
[5] Department of Earth Sciences, University of Aarhus, Århus C, Denmark (jan.piotrowski@geoserver1.aau.dk)
[6] Department of Geography, University of Latvia, Riga, Latvia
[7] Department of Geology, Washington State University, Vancouver, WA 98686, USA

Prominent moraines crossing the Baltic region mark the late Pleistocene maximum extent and recessional phases of the southern margin of the Scandinavian Ice Sheet (SIS). Five moraines present between the advance during the Last Glacial Maximum (LGM) and the Younger-Dryas Salpausselkä Moraines in Finland dated at 11.6 ± 0.5 10Be ka (Tschudi et al., 2000) suggest a millennial-scale signal for this sector of the ice sheet. However, dating control constraining the age of the LGM and retreat phases of the southern SIS margin in the region is all but lacking. We have sampled boulders for surface exposure dating with the cosmogenic nuclide ^{10}Be from moraines along a broad south-to-north transect spanning Poland, Lithuania, Latvia, Belarus, Estonia, and Finland. Here we report ^{10}Be concentrations on 54 boulders measured by accelerator mass spectrometry at the Tandetron facility, Gif-sur-Yvette, France. We used a production rate of 5.1 ± 0.3 atoms g^{-1} yr^{-1} scaled for latitude and altitude according to Stone's factors. No corrections for snow cover or erosion have been applied. Four boulders from the LGM have a weighted mean age of 18.7 ± 0.7 ^{10}Be ka. Twenty three samples from the Pomeranian Moraine have a weighted mean age of 14.8 ± 0.3 ^{10}Be ka. Eight samples from the Middle Lithuanian Moraine have a weighted mean age of 13.5 ± 0.6 ^{10}Be ka. Nine samples from the North Lithuanian Moraine have a weighted mean age of 13.0 ± 0.4 ^{10}Be ka. A single boulder on the Pandivere Moraine was dated at 14.4 ± 1.3 ^{10}Be ka. These results define a preliminary time frame for the deglaciation of SIS southern margin in this region. The chronology will be further refined based on ^{10}Be results from an additional 106 samples.