THE COMBINED STRENGTH OF THERMODYNAMICS
AND COMPARATIVE PLANETOLOGY: APPLICATION
OF ACTIVITY MODELS TO CORE FORMATION IN
TERRESTRIAL BODIES.

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Introduction: Recent models for accretion of terrestrial bod-
ies involve metal-silicate equilibrium as the metallic core formed
during growth [1-3]. Most elements considered are either refrac-
tory or well studied elements for which effects of pressure, tem-
perature, oxygen fugacity, and metallic liquid composition are
well known. There are a large number of elements that are both
siderophile and volatile, whose fate in such models is unknown,
largely due to a lack of data at comparable conditions and com-
positions (FeNi core with light elements such as S, C, Si, and O).
We have focused on Ge, In, As, Sb and determined the effect of
Si and C on metal-silicate partitioning, and developed a thermo-
dynamic model that allows application of these new data to a
wide range of planetary bodies.

New experiments: We have previously carried out experi-
ments with FeSi metallic liquid at C-saturated conditions at 1600
and 1800 °C [4]. In a new series of experiments we investigate
the effect of Si in carbon-free systems at 1600 °C for comparison.
Experiments were carried out at 1 GPa in MgO capsules using
the same basaltic starting composition as in previous studies.
The MgO capsule reacts with the silicate melt to form more
MgO-rich liquids that have 22-26 wt% MgO. Experimental met-
als and silicates were analyzed using a combination of electron
microprobe analysis and laser ablation ICP-MS.

Results: The new results can be interpreted by considering
Ge as an example, in the simple exchange equilibrium Fe + GeO
= FeO + Ge, where the equilibrium constant \(K_a\) can be examined
as a function of Si content of the metal. The slope of \(\ln K_a\) vs. (1-
\(X_{Si}\)) for this new series allows derivation of the epsilon interac-
tion parameter for each of these four elements and Si (both C-
saturated and C-free). All four elements have positive epsilon
values, indicating that Si causes a decrease in the partition coeffi-
cients; values are 6.6, 6.5, 27.8 and 25.2 for In, Ge, As, and Sb,
respectively, at 1 GPa and 1600 °C. As an example of how large
the effect of Si can be, these epsilon values correspond to activity
coefficients (\(\gamma\)) for As of 0.01 when \(X_{Si} = 0\), and up to \(\gamma = 23\)
when \(X_{Si} = 0.2\). Combining these new results with previous de-
terminations [5,6] of epsilon parameters for S and C for these
elements allows us calculate activity of Ge, In, As, and Sb in Fe-
Ni-Si-S-C-O metallic liquids. We apply this new model to sever-
al terrestrial bodies such as Earth (Si-rich core), Mars (S-rich
core), Moon (S-, C-, and Si-poor core), and Vesta, and examine
the resulting core and mantle concentrations of these elements.
Mantle concentrations of these four elements are well explained
for Earth and Mars in models that call for mid-mantle equilibra-
tion between Si-bearing and S-bearing FeNi cores, respectively.
Modelling results for the Moon and Vesta will also be presented.

2012. 43rd Lunar and Planetary Science Conference. Abstract #