ON THE POSSIBLE TRANSPORT OF VOLATILE TRACE ELEMENTS IN METEORITE PARENT BODIES; N. Sugiura, J. Arkani-Hamed, and D.W. Strangway, Department of Geology, University of Toronto, Toronto, Canada, L5L 1C6

Concentrations of volatile trace elements such as Bi,Tl and In decrease with increasing metamorphic grade of chondrites. It has been debated whether this fractionation was due to a nebula condensation process or due to the metamorphism in parent bodies. We examined the latter possibility in this study.

The parent body model used in this study is the same as the one adopted for the possible transport of carbon (1). The model is based on the experimentally determined gas permeability of chondrites and a plausible thermal history of 30-50 km radius parent bodies. Vapourization process is assumed to be the reverse reaction considered in condensation models (2). Trace elements, vapourized from interior, condense near the surface of the parent body as their partial pressure exceeds their vapour pressure. The effect of a carrier gas (carbon monoxide) on the transporation of trace elements was also examined.

Vapour pressures of the trace elements strongly depend on the presence of pure phases, which in turn depends on the solubility of the elements in solid solution (2). Table 1 shows relative volatility of some elements which is defined by the ratio of the amount of the element in the vapour phase to the amount in the starting (solid) material. Heat of solution from (2) was used in the case of solid solution. CI abundance was used for the concentration in the starting material. It is seen that pure phases of Tl,Bi,In and Cd are more volatile than carbon, but if these elements are in the solid solution they are less volatile. (In is more volatile at 1000 K but becomes less volatile at higher temperatures.) In our previous calculation on the carbon transport (1), it was shown that carbon can be transported during metamorphism only if rather stringent conditions were met. Therefore, it was expected that transport of these elements would be difficult if they were in solid solution.

Numerical simulation of the transport of these elements, based on the thermodynamic data of (2), showed that these elements were mostly in the solid solution during metamorphism, and they (except for Cd) could not be removed from the interior of the parent body. The effect of a carrier gas was found to be rather small in the present models. The thermodynamic data (heat of solution (Table 1) and activity coefficient which was assumed to be 1) are, however, very uncertain. Within the uncertainty of the thermodynamic data, vapour pressures of these elements in equilibrium with their solid solution could be $\lesssim$1000 times higher than those shown in table 1. If we assume such higher vapour pressures, substantial amounts of Cd, In, Tl, Bi and Pb could be transported in the parent body during the metamorphism. Fig. 1 shows an example of the transport of Tl with an assumed heat of solution (30 kcal/mol).

References

1. N. Sugiura, J. Arkani-Hamed, D.W. Strangway and T. Matsui: in Abstract for 48th Meteoritical Society Meeting, 1985.
2. J. Larimer: Geochim. Cosmochim. Acta 37 (1973) 1603.

Table 1

	reaction	ΔHs(kcal/mol)	Mv/Ms at 1000°k Solid-solution	Pure phase
Tl	Tl(s)=Tl(g)	14	1.1×10^{-4}	1.9×10^{-1}
Bi	Bi(s)=Bi(g)	15	2.0×10^{-5}	2.9×10^{-2}
Pb	Pb(s)=Pb(g)	15	1.6×10^{-5}	1.0×10^{-3}
In	$Fe+2InS=FeS+In_2S(g)$	19	1.1×10^{-2}	$8.7 \times 10^{+1}$
Cd	Fe+CdS=FeS+Cd(g)	9	6.5×10^{-4}	1.1
Zn	Fe+ZnS=FeS+Zn(g)	(9)	9.2×10^{-7}	2.1×10^{-6}
C	$C+Olivine=Fe+SiO_2+CO$	-	-	2.3×10^{-3}

Mv : amount in the vapour phase
Ms : amount in the starting material
ΔHs : Heat of solution from Larimer (1973)

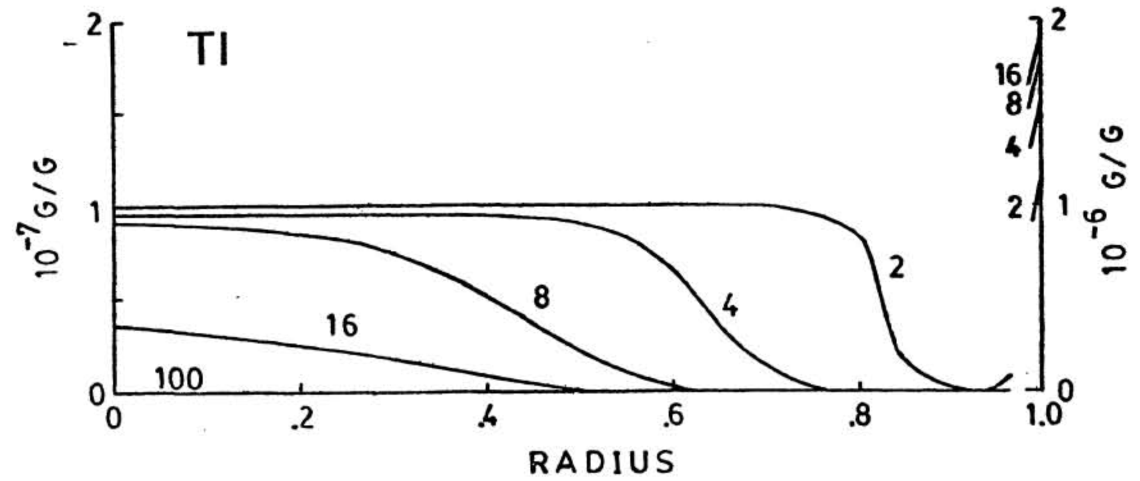

Fig.1 Concentration of Tl as a function of radial distance at various time steps (in million years) in a 40km parent body. A rather high heat of solution (30kcal/mol) was assumed. Note the scale for the concentration is different at the surface.