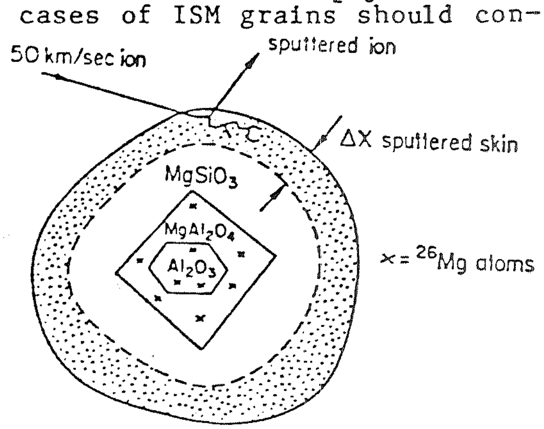
EXCESS DEPLETION OF Al, Ca, Ti FROM INTERSTELLAR GAS. Donald D. Clayton, Rice University. Although data is somewhat variable, it does not appear distorted by the following statement: the fraction of interstellar Mg or Si (typical refractory elements) residing in the gas phase is at least ten times greater than the fraction of Al or Ca (superrefractory elements) residing in the gas phase. This seems inexplicable by thermal condensation because all of these elements eventually condense in a thermal cooling gas unless the condensation sequence is artificially terminated immediately after the condensation of Ca. It also seems inexplicable by cold sticking because it requires Ca to stick ten times more efficiently than does Mg. It also seems inexplicable because sputtering by interstellar shock waves should vaporize surface Ca as efficiently as it does surface Mg.

A self-consistent explanation seems possible by combining these ideas with a chemical memory of the condensation sequence. Because Al_2O_3 condenses prior to $MgSiO_3$, for example, the refractory cases of ISM grains should contain Al-rich cores surrounded by $MgSiO_3$ mantles, as illustrated in the figure, taken from Clayton (1982, Q. J. Roy. Astron. Soc. 23, 174). As a result, interstellar shocks must sputter away the entire $MgSiO_3$ mantle (as well as any overlying cold-accreted mantle) before sputtering the Al. The grain must be completely destroyed before the Al is even touched. It therefore becomes important in the construction of cyclical histories for ISM grains to distinguish between sputtering that only removes 90% of a grain and sputtering that totally destroys each grain core (a much more restrictive condition). The same argument applies to Ca and Ti because those elements, like Al, take up initial residence within the superrefractory cores.



Because of this shielding against sputtering, it appears that incorporation into stars (astration) is the major destruction mechanism for superrefractory cores, even if sputtering is the major mechanism for converting dust mass into gaseous mass. To retain the preferential depletion of Al, therefore, it appears necessary and sufficient that in all subsequent mass loss the Al must again recondense primarily into refractory cores of grains. That is, Al is so depleted because it is not ejected in gaseous form from stars except with very low efficiency. In the useful nomenclature SUNOCON ≡ supernova condensate (thermal) and STARDUST ≡ stellar thermal condensate, we would say that freshly synthesized Al first appears in SUNOCON cores and astrated Al is reinjected in STARDUST cores (Clayton 1978, Moon and Planets 19, 109).

The importance of this extra depletion of Al and Ca thus becomes its indicator of the structural history of the refractory parts of interstellar grains. What is now needed is detailed numerical modelling of the total chemical history in coordination with details of observed depletion patterns.