

**Volatile loss during chondrule formation.** D. W. G. Sears, Lu Jie and P. H. Benoit. Cosmochemistry Group, Dept. Chem. and Biochem., Univ. of Arkansas, Fayetteville, AR 72701, USA.

The question of Na-loss from chondrules has been controversial for over two decades. Many chondrules contain their cosmic complement of Na, which is surprising in view of the ease with which Na is lost in laboratory experiments (1). Either these chondrules were heated under very unusual conditions (2), or they were heated too briefly for Na loss. Many contain relict grains indicating the lack of complete melting (3). However, 35% of the chondrules in the essentially unmetamorphosed Semarkona chondrite not only show major depletions in Na, but also show volatility-related depletions in at least 6 moderately volatile elements (4, 5). They have distinctive cathodoluminescence (CL), which enables sorting into Group A1 (yellow CL mesostasis, with red CL ol/py, includes type IA, 4) and Group A2 (yellow CL mesostasis, little or no CL from the ol/py, includes PP). The better known 'Na-rich' chondrules, Group B (which include type II, 10), actually have flat CI-normalized abundance patterns, and none of their phases are cathodoluminescent (7).

Figure 1 shows liquidus temperatures, calculated by the method of ref. 8, 9, as a function of Na content for the chondrules from refs. 4, 7 and 10. A negative correlation between liquidus temperature and Na is clearly present among the Group A chondrules, which also implies a relationship between FeO and Na content since A2 generally have higher Fe than A1 (7). The two chondrules furthest from the line have unusual characteristics, chondrule 28-12 is the only BO in Group A1 and chondrule 23-8 has atypically low CaO in its mesostasis. As expected, the Group B chondrules (10) show no evidence for a Na-liquidus temperature trend. In fact, since these chondrules probably did not reach the liquidus, their calculated temperatures are physically meaningless.

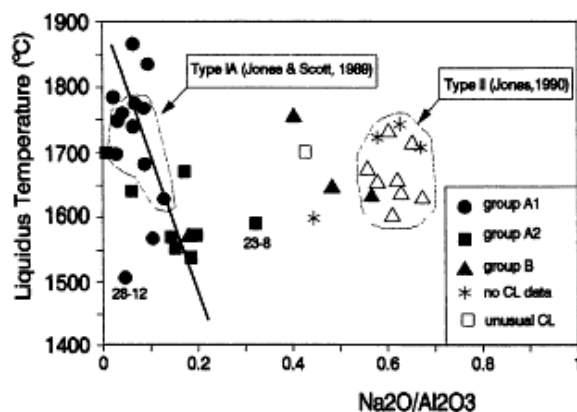


FIG. 1. Liquidus temperature vs.  $\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$  for chondrules from refs. 4, 5, 10.

We have argued that the reduction of silicates accompanied loss of volatiles during chondrule formation (5). Others have argued that the redox state and volatile content reflect precursor composition (*e.g.*, 4, 10). Hewins (9, quoting R. Jones) has suggested that if Na was lost during chondrule formation, then there would be negative correlation between liquidus temperature and Na, as we have observed for the Group A chondrules. The inverse zoning occasionally observed in the chondrule olivines, their small size relative to Group B chondrules and their elemental abundance patterns, which are volatility controlled, are additional evidence that, unlike Group B chondrules, Group A chondrules suffered reduction and devolatilization during chondrule formation. References: (1) Tsuchiyama *et al.* (1981) *GCA* **45**, 1357. (2) Wood (1988) *Protostars and Planets II*, 687. (3) Nagahara (1983) *Chondrules* 211. (4) Jones and Scott (1989) *PLPSC* **19th**, 523. (5) Lu *et al.* (1989) *LPS* **31**, 720. (6) DeHart (1990) Ph.D. thesis, Univ. Arkansas. (7) Lu *et al.*, this issue. (8) Herzberg (1979) *GCA* **43**, 1241. (9) Hewins (1991) *GCA* **55**, 935. (10) Jones (1990) *GCA* **54**, 1785.