

SORET DIFFUSION: A POSSIBLE CAUSE OF COMPOSITIONAL HETEROGENEITY WITHIN TEKTITES; J. W. Delano¹, Y.-G. Liu², and R. A. Schmitt^{2,3}. ¹Department of Geological Sciences, State University of New York, Albany, NY 12222. ²Depts. of Chemistry, Geosciences, and the Radiation Center, Oregon State University, Corvallis, OR 97331. ³College of Oceanography, Oregon State University, Corvallis, OR 97331

Although a terrestrial origin for tektites is well-established on geochemical evidence [e.g., 1-3], the physical processes involved in tektite formation have been largely ignored by geochemists and petrologists. For example, two observations that potentially bear on the physics of their origin are the following: (a) The flange of an australite is often *more* heterogeneous than its core; and (b) microtektites are compositionally more diverse than tektites [e.g., 4,5].

The first observation contradicts the traditional view of flange formation [e.g., 6] since a second heating to super-liquidus temperatures [i.e., >1350°C; 7] during atmospheric re-entry should, by chemical diffusion and mixing, have tended to homogenize the melt as it flowed off the leading edge of the core to form the flange. Analyses of an australite flange have been performed by electron microprobe (15 keV acceleration potential; 25 nA specimen current; 40-second count-times per element, plus backgrounds collected on each analysis). The results of those analyses (Figure) emphasize the magnitude of the heterogeneity, as well as the well-defined elemental correlations that may constrain the process responsible for it. Specifically, note the inverse correlations with Si of Al, Fe, Ca, and Mg. Of special importance, note the positive correlations with Si of Na and K at SiO₂<75 wt.%, but their negative correlation with Si at SiO₂>75 wt.%. To explain these data, we offer a working hypothesis that is currently undergoing experimental investigation in collaboration with C. E. Leshner. The hypothesis is that some process operated *during* flange formation that promoted compositional heterogeneity (Figure). The process may have been Soret diffusion, which operates at super-liquidus temperatures in the presence of strong thermal gradients. Support for this hypothesis includes the remarkable resemblance of the elemental correlations (Figure) with experimental results for Soret diffusion on peraluminous compositions [8]. In addition, super-liquidus temperatures and strong thermal gradients are conditions that would have prevailed during atmospheric re-entry of australites [e.g., 9,10]. The principal question is whether sufficient time existed for Soret diffusion to occur. Although this is currently unresolved, our preliminary calculations based upon Soret coefficients [8,11] suggest that (a) temperatures in excess of 1000°C above the liquidus, (b) for times approaching ten seconds, and (c) in the presence of strong thermal gradients along the leading edge of the tektite [9,10], seem adequate. However, Soret experiments are being conducted on a natural tektite to furnish better quantitative constraints on the exact values for the Soret coefficients so that this hypothesis can be rigorously tested. If these experiments ultimately furnish additional support for Soret diffusion, the use of australite flar as flight data recorders [12] should provide information about the physics of each tektite's passage through Earth's atmosphere (e.g., temperature/time history is relevant to entry angle and velocity). In the current absence of any other competing hypothesis for these observations, the possibility of Soret diffusion warrants investigation due to the new insights that it may offer for the physics of tektite formation.

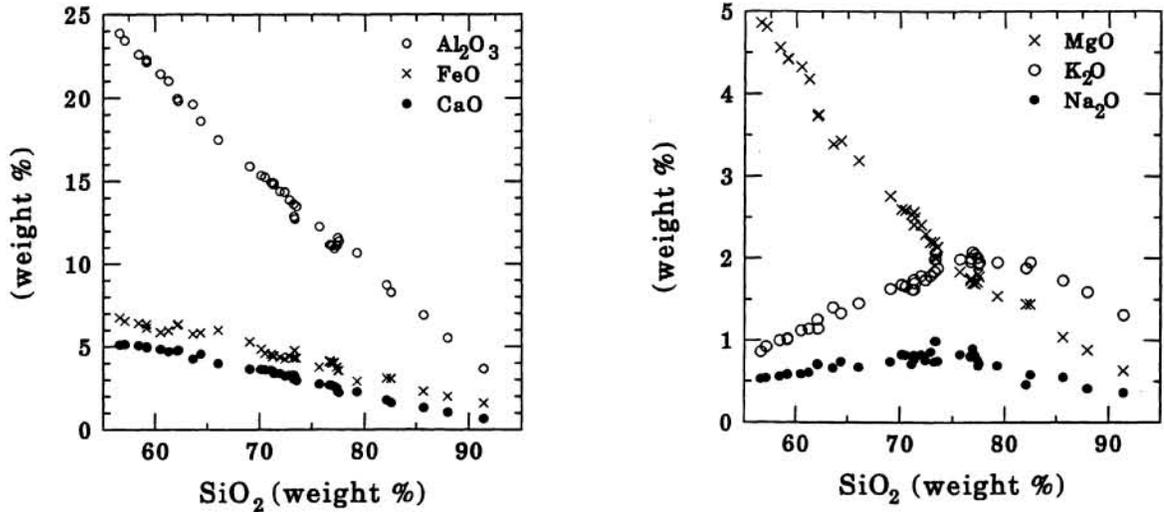
The second observation that the bulk compositions of microtektites are more diverse than the tektites within the same strewnfield is a well-known characteristic [e.g., 4,5,13,14], for which no quantitative explanation has been offered. The current investigation has involved the analysis of forty-three Australasian microtektites from the Wharton Basin (core V19-153; samples kindly supplied by B. P. Glass) by electron microprobe, as well as trace-element abundances on fifteen of these microtektites by INAA (Table). As noted by Cassidy et al. [13], individual microtektites often display large compositional heterogeneities. Our work has shown that the heterogeneities *within individual microtektites* often display the same patterns of elemental correlation previously noted for the australite flanges (Figure). This observation, in tandem with the fact that domains within australite flanges resemble bulk microtektites [14,15], seems to underscore a genetic relationship between the formation of australite flanges and microtektites. In response to those observations, we propose that microtektites are droplets of Soret melt shed from australites during their atmospheric re-entries. Owing to their low masses (Table: generally <100 micrograms), they would have settled through the atmosphere more slowly than the larger tektites, and hence been more widely distributed by upper atmospheric winds than the tektites.

REFERENCES: [1] Taylor (1973) *Earth Sci. Rev.*, 9, p.101-123. [2] Koeberl (1990) *Tectonophys.*, 171, p.405-422. [3] Love and Woronow (1988) *Geochim. Cosmochim. Acta*, 52, p.2085-2090. [4] Mason (1979) *Smithson. Contrib. Earth Sci.*, 22, p.14-26. [5] O'Keefe (1969) *J. Geophys. Res.*, 74, p.6795-6804. [6] Baker (1958) *Amer. J. Sci.*, 256, p.369-383. [7] Cassidy (1964) *Geochim. Cosmochim. Acta*, 28, p.999-1008. [8] Leshner and Walker (1991) in *Advances in Physical Geochemistry*,

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vol. 8, chap. 12, p.396-451. Springer-Verlag, New York. [9] Chapman (1964) Geochim. Cosmochim. Acta, 28, p.841-880. [10] Chapman et al. (1962) NASA TR-134, 24pp. [11] Leshner (1986) J. Geophys. Res., 91, p.6123-6141. [12] Delano (1992) Lunar Planet. Sci.-XXIII, p. 301-302. [13] Cassidy et al. (1969) J. Geophys. Res., 74, p.1008-1025. [14] Glass (1990) Tectonophys., 171, p.393-404. [15] Glass (1970) Earth Planet. Sci. Lett., 9, p.240-246.

FIGURE
Systematic compositional variations observed within an australite flange.
Note in particular the change in behavior of Na and K at about 75 wt. % SiO₂.



Sample	MT1	MT2	MT3	MT4	MT5	MT6	MT8	MT9	MT25	MT27	MT28	MT36	MT43	MT44	MT45	Uncertainty
Wt. ug	243.6	72.1	81.9	4.4	8.4	1.9	3.4	2.5	4.4	2.6	2.6	6.1	2.6	3.1	2.6	%
FEO	6.00	5.18	6.99	5.89	4.68	5.15	6.70	4.02	4.88	4.70	7.15	6.43	5.65	5.65	5.65	<3
CAO	2.1	3.3	2.8	-	-	-	-	-	-	-	-	-	-	-	-	15-20
NA ₂ O	0.61	1.53	0.77	1.32	1.38	1.35	2.04	1.48	1.55	1.19	1.18	1.76	1.60	1.15	1.81	5-10
(ppm)																
SC	10.3	13.3	11.6	14.8	9.6	13.9	19.1	10.1	12.1	13.4	20.6	18.2	14.2	15.6	13.6	<3
CR	357	76	481	284	187	151	130	59	91	95	130	138	80	105	118	<3
CO	28.5	16.1	36.8	23.4	24.7	15.4	16.3	12.1	13.6	13.5	12.6	17.0	16.9	19.1	18.3	3-5
RB	55	99	65	110	114	111	175	136	124	133	90	158	76	119	139	10-20
SR	138	177	195	-	-	-	-	-	-	-	-	-	-	-	-	15-30
CS	2.6	4.7	2.3	4.2	6.1	6.9	10.2	6.0	8.2	7.6	6.8	9.6	9.9	8.4	7.8	10-15
BA	292	442	318	387	360	471	541	-	-	-	-	-	-	-	-	10-30
LA	30.6	42.3	33.1	36.5	30.4	41.1	56.2	38.2	41.6	43.1	58.6	53.6	50.4	42.8	46.0	3-5
CE	68.1	87.3	72.9	75.7	66.0	84.9	119.3	82.0	85.1	74.6	114.3	110.3	125.4	94.4	98.8	3-5
ND	27.0	36.2	28.7	25.1	24.8	36.0	37.4	13.6	24.9	23.8	23.5	34.8	35.3	28.2	28.8	5-15
SM	5.39	7.74	5.85	6.81	5.68	7.17	10.1	6.98	7.24	6.69	9.71	9.09	7.44	7.23	8.91	3-5
EU	1.20	1.48	1.23	1.91	1.25	1.64	2.15	1.63	1.36	1.55	1.72	1.80	1.62	2.06	2.13	5-20
TB	0.64	0.73	0.73	0.95	0.59	0.69	1.32	0.51	0.92	0.93	1.50	1.07	0.97	0.73	0.85	15-30
YB	2.54	3.47	2.75	3.03	2.57	3.19	4.58	2.88	3.17	2.76	4.09	3.98	3.28	3.39	3.66	5-10
LU	0.29	0.40	0.30	0.37	0.29	0.35	0.53	0.41	0.44	0.36	0.52	0.51	0.41	0.31	0.49	5-10
HF	6.1	5.7	6.3	5.7	5.5	5.8	6.4	7.1	6.5	4.1	5.6	5.9	4.6	4.9	7.9	5-10
TA	1.1	1.2	1.1	1.4	1.1	1.5	1.9	-	-	-	2.5	1.6	1.9	1.4	-	10-30
TH	12.8	15.4	14.1	17.4	12.7	16.9	21.8	13.7	15.5	14.7	23.8	20.8	15.9	16.9	17.2	3-5
U	0.55	0.90	-	-	1.05	-	-	-	2.32	1.82	-	-	-	-	-	20-30