MINOR AND TRACE ELEMENT COMPOSITION AND AGE OF YUKON PROBABLE-MICROTEKTITES; S. Q. Boundy-Sanders, Department of Geology, UC Berkeley, Berkeley, CA 94720 and R. L.Hervig, CSSS, Arizona State University, Tempe, AZ 85287.

Major, minor, and trace element composition of the candidate microtektites from Yukon Territory suggest a possible impact site of hydrothermally altered limestone and sand or chert, or possibly a carbonatite. Their REE/chondrite curve is similar in character to, but higher than, shale composites of North America, Australia, and Europe. Relative to these same composites, the Yukon droplets are enriched in Y, F, S, Sr, P, Mn, Mg, and Ca. They are depleted in Rb, Li, Th, Nb, Ti, K, Na, Fe, Si, and Al. Biostratigraphic constraints on the droplets indicate they are Middle to Late Devonian, more likely Middle Devonian, in age.

Table 1 shows major elements analyzed by electron probe, and minor and trace elements analyzed mostly by ion probe, with some repeated by electron probe. The high calcium and magnesium contents suggest a carbonate-rich source [1]. Alumina is low compared to shale composites and other microtektites and indicates a paucity of micas or clays. The extremely low Fe, K, and Na preclude any significant igneous component, except possibly carbonatite. The major element composition most strongly suggests a sedimentary carbonate-and-silica source, either dolomitic limestone and quartz sand, or dolomitic limestone and chert, in either case with minor amounts of clays or micas, but virtually no alkali feldspar or mafic grains. A sedimentary input is also suggested by the rare earth element pattern of the droplets, which is compared in Figure 1 to published shale composites [2-7] and the Beloc K-T glasses [8]. The Yukon REE pattern is similar in character to shale composite patterns, but richer in REE by 20 to 100%. Water content was measured by ion probe at <0.2 wt % -- below the range for igneous rocks.

Of particular interest is the extremely high fluorine content of the droplets. The analyses will require careful calibration, but both electron and ion probe analyses indicate abundances of 1 wt %. Such high values are found in only a few environments, which we can evaluate based on major and trace element chemistry. Fluorine can be abundant in micas and clays, but the low alumina content of the Yukon droplets indicates that these phases were a minor component of the source and could only have provided a small portion of the observed REE. Fluorapatite could provide both F and REE, but the F/P weight ratio is inappropriate (0.2 for typical fluorapatite and ~4 for the Yukon droplets) and indicates that this too is at best only a partial contributor of F and REE. The most feasible source of fluorine appears to be fluorite- which would typically be found in hydrothermally altered limestone or in carbonatite and would likely be associated with high-REE minerals. Fluorine and REE values as high as these are found only in bodies of restricted size, and the data necessitate that the meteorite impact melted principally F-rich material. This indicates a small crater (<1/2 km diameter) and therefore a small meteorite.

Sulfur values in the droplets are high and comparable to values in the Beloc glasses. However, since we don't know the source of the Yukon droplets, we can't identify a source phase as readily as Sigurdsson and co-workers were able to do for the Beloc glasses [8]. Evaporites, sedimentary-exhalative massive sulfides, Mississippi Valley-type deposits, and pyrite precipitated during prolonged worldwide oceanic anoxia are common in Early and Middle Paleozoic sedimentary rocks. All represent feasible sources for the sulfur. At this point, the sulfur represents a promising test of any proposed site but we don't yet regard it as a particularly useful beacon for locating potential sites.

The Yukon droplets are crystal-free glass and have a highly homogeneous composition. These attributes rule out origins as volcanic ejecta, fly ash, slag, and fulgurites [9-12]. All data so far are consistent with an impact origin of the Yukon droplets, and all other interpretations are ruled out by multiple lines of evidence.

A new biostratigraphic age constraint is provided by conodonts from Oklahoma, occurring with the same radiolarian species found at the Yukon droplet site. The conodonts suggest the droplets are more likely Middle than Late Devonian in age [13].

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COMPOSITION OF YUKON MICROTEKTITES: Boundy-Sanders S. Q. and Hervig R. L.

Oxide or element@	Yukon range	Shale composites	Beloc+
SiO_2	44-47	62-63	48-52
Al_2O_3	7.5-8.6	18-19	12-14
FeO	0.34-0.59	6.5-7.4	4.7-5.3
MgO	5.9-7.2	2.2-2.9	3.9-4.1
CaO	35-36	1.3-4.2	21-25
K_2O	0.59-0.78	3.4-3.8	0.49-0.92
Na_2O	0.43-0.57	1.1-1.5	2.0-3.1
TiO_2	0.40-0.55	0.8-1.0	0.53-0.81
MnO	0.22-0.40	0.11-0.13	0.10-0.16
SO_3	0.57-0.91	--	0.77-0.92
F	9000-11000	--	190
P	2400-3200	700-960	--
Ba*	450-1100	580-650	760
Sr	440-540	200-450	1200
Rb	22-38	140-160	21

Element	Yukon range	Shale composites	Beloc+
La	51-55	32-41	18
Ce	94-99	73-81	36
Pr	11-12	7.9-10	--
Nd	41-51	32-40	19
Sm	11-14	5.6-7.3	4.2
Eu	1.9-2.5	1.1-1.5	1.1
Gd	--	4.7-6.0	4.3
Tb	1.3-2.1	0.77-1.0	0.7
Dy	9.5-12	4.4-5.8	4.8
Ho	2.2-2.9	1.0-1.2	--
Er	5.5-8.9	2.9-3.6	--
Tm	0.8-1.0	0.40-0.56	0.5
Yb	--	2.8-3.3	2.8
Lu	0.7-1.1	0.43-0.58	0.37
Y	77-83	27-30	--

Oxide or Element@	Yukon range	Shale composites	Beloc+
U	1.1-4.8	3.1-3.2	1.2
Th	2.7-3.8	11-15	4.2-5.3
Zr	200-230	200-210	147
Nb	4.0-6.2	19-20	--
Cs	17-18	5-15	1.3
Be	0.8-0.9	--	1.1
B	110-140	100	28
Li	26-35	60-75	12.5
H_2O	<0.2		

Table 1. Oxide and elemental composition of the Yukon droplets, with shale composites [2-4] and Beloc K-T glasses [5] for comparison. Symbols: @: Oxides except H_2O and F by electron probe in weight %. Elements other than F are in ppm, H_2O in wt. %, and were analyzed by ion probe. *: range of compositions in Yukon droplets includes analyses by both electron and ion probe. +: values for Beloc glasses include several analytical methods; single values in Beloc column are averages. Major element data modified from [1].

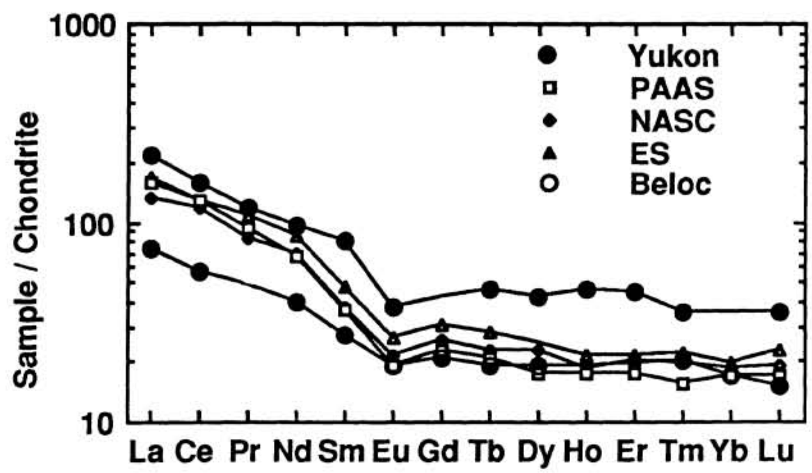

Figure 1. Rare earth pattern of Yukon droplets compared to shale composites and Beloc glasses [8]. PAAS = Post-Archean average Australian shale [5]; NASC = North American shale composite [6]; ES = European shale [7].

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