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K-T IMPACT(S): CONTINENTAL, OCEANIC OR BOTH? V.L. Sharpton, B.C. Schuraytz, A.V. Murali, G. Ryder, and K. Burke, Lunar and Planetary Institute, 3303 NASA Road One, Houston TX 77058

Although geochemical [1] and mineralogical [2] evidence indicate that a major accretionary event occurred at the K-T boundary, no impact crater of suitable size and age has been recognized [e.g. 3]. The 35 km Manson Structure, Iowa, has been suggested recently as a possibility and $^{40}Ar/^{39}Ar$ determinations indicate that its formation age is indistinguishable from that of the K-T boundary [4]. In order to test a possible association between Manson and the K-T boundary clay, we are comparing the geochemistry and mineralogy of the K-T boundary clays at the Scollard Canyon section, Alberta [5] and the Starkville South section, Colorado [6] with three dominant lithologies affected by the Manson impact [11]: Proterozoic "red clastics", underlying "late-stage" granites, and gneisses. Here we report on the chemical and mineralogical makeup of the Scollard Canyon boundary clay and its clastic constituents, commenting on the implications for impact models.

Data. We have analysed the 3 cm thick Scollard Canyon boundary clay in two splits, the upper 1.5 cm (SCU) and the lower 1.5 cm (SCL). REE abundances are shown in Figure 1; elemental abundances, determined by XRF and INAA, are given in Table 1. Mineral separates have been examined for indications of shock metamorphism; the chemistry of those feldspars indicating shock twinning or lamellae were determined by electron microprobe analysis. Figure 2 summarizes the An-Ab-Or content of the 27 analyses completed thus far. No clastic material of igneous origin other than quartz and feldspar has been observed.

Analysis. The oceans were favored initially as the probable impact site because of their greater surface area [eg. 1] and results of isotopic analyses of sanidine spherules within K-T deposits from marine sections [7] lend support to this suggestion, although some uncertainties exist because of the authigenic nature of these spherules. On the basis of REE abundances, Hildebrand and Boynton [8] have suggested that the impact penetrated the ocean crust and excavated considerable quantities of oceanic mantle to a depth of at least 40 km. On the other hand, major element chemistries of sediments from marine K-T sections indicate that mantle components are minor or negligible [9]. Our results for the (continental) Scollard Canyon K-T section (Table 1) support the conclusions of [9]: high Si and Al and low Mg and Ca are difficult to reconcile with any impact model calling for ejection of oceanic crust and/or mantle. Furthermore retention of the La/Lu > 1 (Figure 1) indicative of terrigenous materials would not be expected if much greater volumes of ocean crust (La/Lu < 1) were incorporated into the ejecta cloud.

Because it could be argued that the elemental abundances of the highly shocked, highly altered boundary clay constituents do not accurately reflect the chemistry of the target material we turn to the clastic constituents of the boundary clay which indicate relatively weak shock (< 200 kb). The clastic grains are clearly continental in affinity [10] but have been explained in models invoking oceanic impacts as representing a sedimentary veneer overlying the ocean crust [8]. Several lines of evidence suggest to us that this scenario is unlikely: First, clastic sediments with such large grain size (up to 0.6 mm) are not volumetrically significant in the ocean basins and Izett [10] calculates that more than 1.2 km^3 of shocked clastics were deposited in the K-T sections of Western N. America alone. Second, pyroxene clasts, to be expected if the target were ocean crust, are absent and the plagioclase feldspars we have analysed (An_{0-50}; Figure 2) are considerably less calcic than those of ocean crust. Third, approximately one-third of the quartz grains in our sample of Scollard Canyon boundary clay show multiple sets of planar features (a result consistent with measurements from other Western N. American sites [2,10]). Comparison of shock expressions at craters in sedimentary targets with those in crystalline targets [11] shows that less than 5% of quartz grains in sedimentary target rocks develop shock lamellae, whereas shock lamellae are observed in the majority of the quartz grains in crystalline rocks shocked to comparable pressures. This appears to be a response to the presence of pore spaces in sedimentary targets [11] and suggests that poorly consolidated sedimentary materials are not the source of the concentration of shocked quartz at the K-T boundary.

Conclusions. An impact into crystalline material of continental affinity appears to be required to explain the mineralogy and chemistry of the Scollard Canyon (and other Western N. American K-T sections). The low REE abundances of some K-T boundary layers are unusual (Figure 1) but perhaps attempts should be made to understand the contributions of individual crustal components (e.g. carbonates, arkoses) as well as the potential for alteration involving these and other elements during and after impact-induced vaporization, before mantle excavation is invoked. If further studies confirm the results of published studies of marine boundary clays that indicate an oceanic target, attention must be paid to the possibility that multiple impacts occurred at the K-T boundary - one or more on the continents and one or more in the ocean.

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TABLE 1

	XRF (wt %)			XRF (ppm)			INAA (ppm)	
	SCU	SCL		SCU	SCL		SCU	SCL
SiO_2	61.4	60.7	Cr	50.96	32.11	Th	2.2±0.05	2.5±0.05
Al_2O_3	26.5	27.7	Ni	40.63	10.66	Sc	15.4±0.02	14.0±0.02
FeO(tot)	5.12	4.58	Cu	16.30	15.17	Co	25.5±0.07	16.0±0.05
MgO	1.64	1.53	Zn	55.06	41.87	Ir*	3.6±0.5	2.4±0.5
CaO	1.46	1.54	Rb	14.51	16.29	Au*	16.0±3	23.0±3
Na_2O	2.19	2.10	Sr	159.3	157.1			
K_2O	0.39	0.38	Y	2.37	1.66	(* ppb)		
TiO_2	1.23	1.41	Zr	91.44	84.83			
P_2O_5	0.02	0.02	Nb	5.45	10.22			
MnO	-	-	Ba	274.5	335.0			

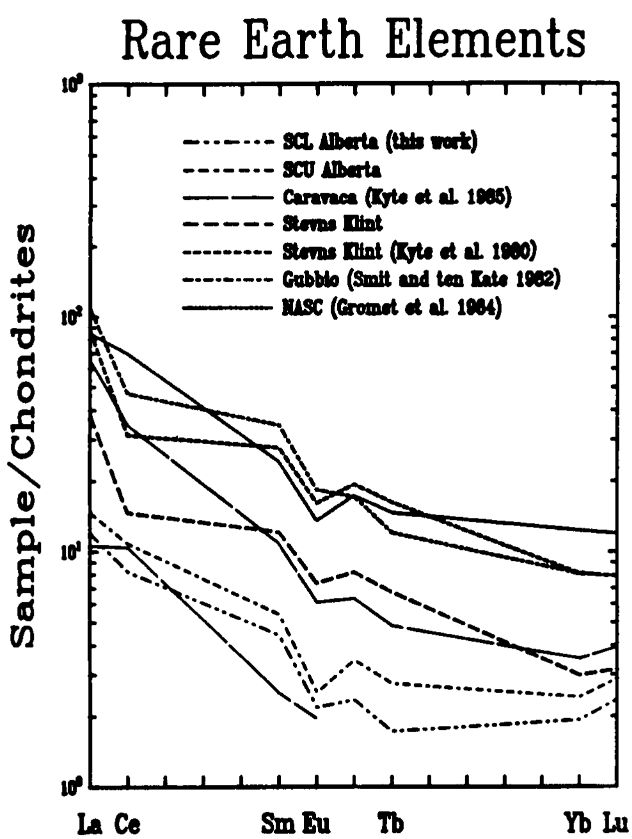

Figure 1

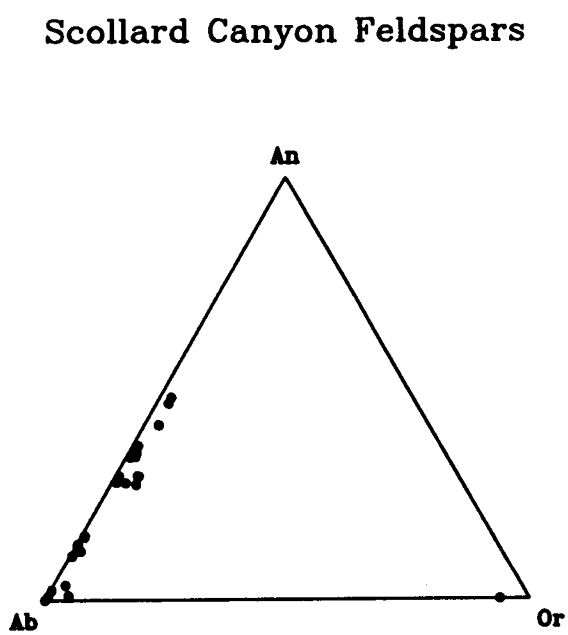

Figure 2