IRIDIUM AND SPHERULES IN LATE EOCENE IMPACT DEPOSITS. F. T. Kyte[1] and S. Liu[2], [1]Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095, USA (kyte@igpp.ucla.edu), [2]Department of Geology, University of Delaware, Newark, DE 19716, USA ([2]shaobin@udel.edu).

The impact record in the late Eocene is very different from that at the Cretaceous-Tertiary (K/T) boundary. The K/T boundary deposit is known at over 100 sites, its stratigraphy has been described in detail [1], and it is known to be derived directly from the Chicxulub impact event. When preserved, the K/T global fallout layer is a few mm thick and is composed almost entirely of spherules. Since some spherules have very high Ir concentrations [2-4], it is reasonable to expect that they were the principal carrier of the siderophile anomaly in the global deposit. Also, there is no physical evidence for more than one impact at the K/T boundary, and a lack of a significant ^{3}He anomaly rules out a comet shower at this time [5].

In contrast, the late Eocene probably experienced multiple impact events. There are two large impact craters [6]; the 90 km Chesapeake Bay and the 100 km Popigai structures. There are also at least two spherule deposits; the North American (N.A.) microtektites and the slightly older clinopyroxene-bearing (cpx) spherules [7,8]. Isotopic data are consistent with the N.A. microtektites being derived from the Chesapeake Bay impact and the cpx spherules being derived from the Popigai impact [9,10]. The late Eocene is also characterized by a 2.5 m.y. anomaly in the flux of ^{3}He that is interpreted to be caused by an increased flux of interplanetary dust [11], due to a comet shower that may be responsible for all these phenomena. In north Pacific core GPC3, a low-resolution pelagic clay core, this ^{3}He anomaly [12] is coincident with high concentrations of spinel-bearing cosmic(?) spherules [13] that are distinct from N.A. microtektites or cpx spherules.

We have been independently examining the Ir (FTK) and spherule (SL) contents of recently discovered late Eocene impact deposits from the south Atlantic and western Indian oceans. These include ODP Sites 1090 [14,15], 709 [10], and 699 [Liu in prep.]. Iridium abundances at these sites are within the typical range reported for late Eocene deposits, with peak concentrations between 100 and 1000 pg/g. In Table 1 we present estimated net Ir fluences (in ng Ir/cm^2) for these and nine other sites. Although there are fewer sites than the K/T boundary, the average of 9 ng Ir/cm^2 is probably a good estimate of the late Eocene global flux. This is enough Ir for a 6 km comet (assuming 250 ng/g Ir, ρ=1.5), is sufficient to produce the Popigai or Chesapeake Bay structures, and is 16% of the flux estimated for the K/T boundary (55 ng/cm^2 [16]). Figure 1 shows the relative abundances of Ir, glassy microtektites and cpx-bearing spherules in sediments from Sites 699 and 1090, which are separated by only 3100 km. Although these two sites have similar Ir anomalies, the abundances of spherules are quite different. Site 1090 has well-defined peaks for both types of spherules, with a peak of 562 cpx spherules/g, while Site 699 contains only a few glassy microtektites and no cpx spherules. While the different abundances of spherules may reflect a heterogeneous distribution of spherules on the Earth's surface, an equally likely cause of this difference may be differential preservation of spherules in the sediment.

We find that the spherules cannot possibly be the carrier of the Ir anomaly unless those recovered are only a trace residue of the initial impact deposit. Earlier work found 0.22 ng/g Ir in glassy microtektites from Site 689 [17], an insufficient concentration to support 0.16 ng/g in the bulk sediment at this site. We measured 15 ng/g Ir in a group of 95 cpx spherules from Site 1090 with sizes from 63 to ~200 µm, a set typical of the size distribution at this site. Although this is a significant concentration it also cannot support the Ir peak. We presently lack quantitative data on the mass concentration of cpx spherules in Site 1090 sediments, but it is certainly <1 mg/g in the peak sample. We estimate that the total fluence of cpx spherules >63 µm is about 2100/ cm^2 and at most this is about 5 mg/cm^2. This amounts to about 0.075 ng Ir/cm^2 in the spherules, or about 0.5% of the total Ir in the sediment. We attempted to concentrate an Ir-rich phase in fine (<63 µm) and coarse magnetic fractions, with cpx spherules picked from the latter. Preliminary results (radiochemical data uncorrected for yields) show that these fractions have Ir concentrations comparable to the bulk sediment, ~0.5 to 1 ng/g. Thus, the only sample we have managed to concentrate the Ir in is the cpx spherules.

It is clear that although the late Eocene impact deposits contain an Ir anomaly, close in size to the K/T boundary, it is not presently possible to link this to a specific ejecta component. It is possible that most of the ejecta was in the fine fraction (which would be another difference from the K/T ejecta) and dissolution of this could have distributed the Ir throughout the sediment, but we currently have no specific data to evaluate this. We also cannot ignore the possibility that there may be an Ir-rich component that is not from the cpx-spherule impact event. The bottom line is that 99% of the meteoritic component in the late Eocene anomaly remains undefined.

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Table 1. Comparison of peak Ir concentrations and estimated net Ir fluences at 12 sites containing late Eocene impact deposits.

Site	Peak Ir (pg/g)	Ir Fluence† (ng/cm^2)	Reference
ODP Site 1090, Agulhas Ridge (S. Atlantic)	950	14	[15]
ODP Site 699, Georgia Rise (S. Atlantic)	600	12	this work
ODP Site 709, western Indian Ocean	180*	2.2*	this work
ODP Site 689, Maude Rise (S. Atlantic)	160	2.5	[18]
Massignano, Italy	200	6.6	[18]
Gay's Cove, Barbados	200	12	[19]
RC9-58, Venezuela Basin	4100	35	[20]
DSDP Site 149, Caribbean Sea	at least 410	>1	[21]
DSDP Site 292, equatorial Pacific	40	2.0	[8]
DSDP Site 315, equatorial Pacific	250	5.6	[8]
DSDP Site 462, equatorial Pacific	220	15	[8]
DSDP Site 612, eastern N. Atlantic	104	1.0	[8]

†Ir fluences estimated from literature data. Sediment bulk dry density assumed to be 1 g/cm^3 if no specific data are available. *Estimate based on preliminary, incomplete data

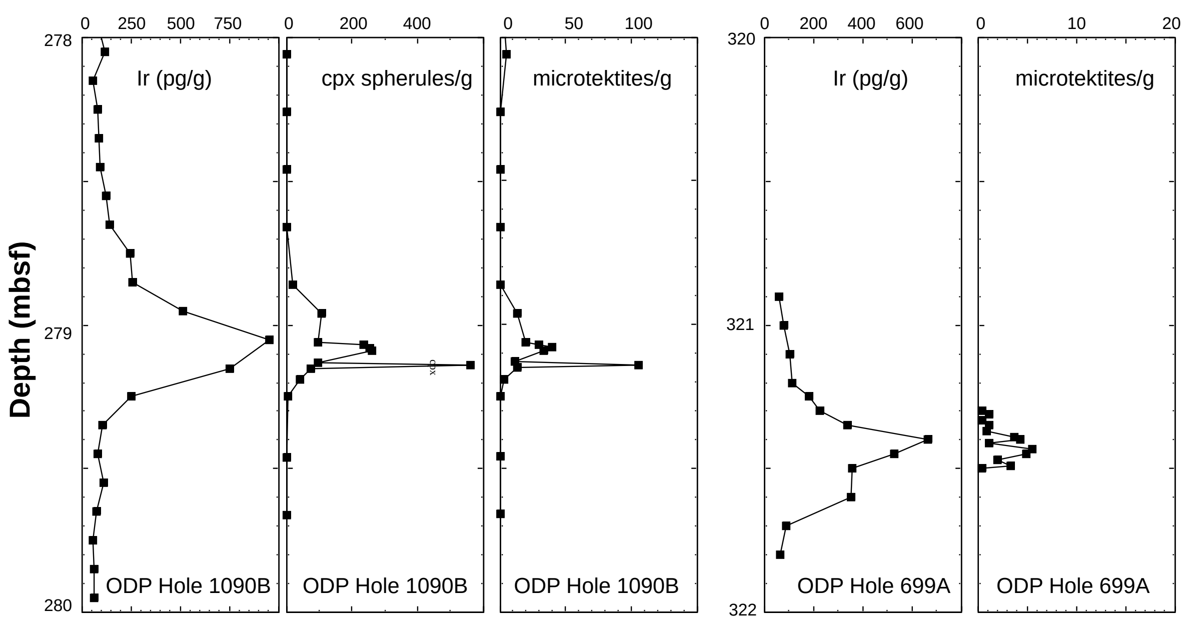

Figure 1. Abundances of Ir and spherules in late Eocene sediments from south Atlantic ODP Sites 1090 and 699.