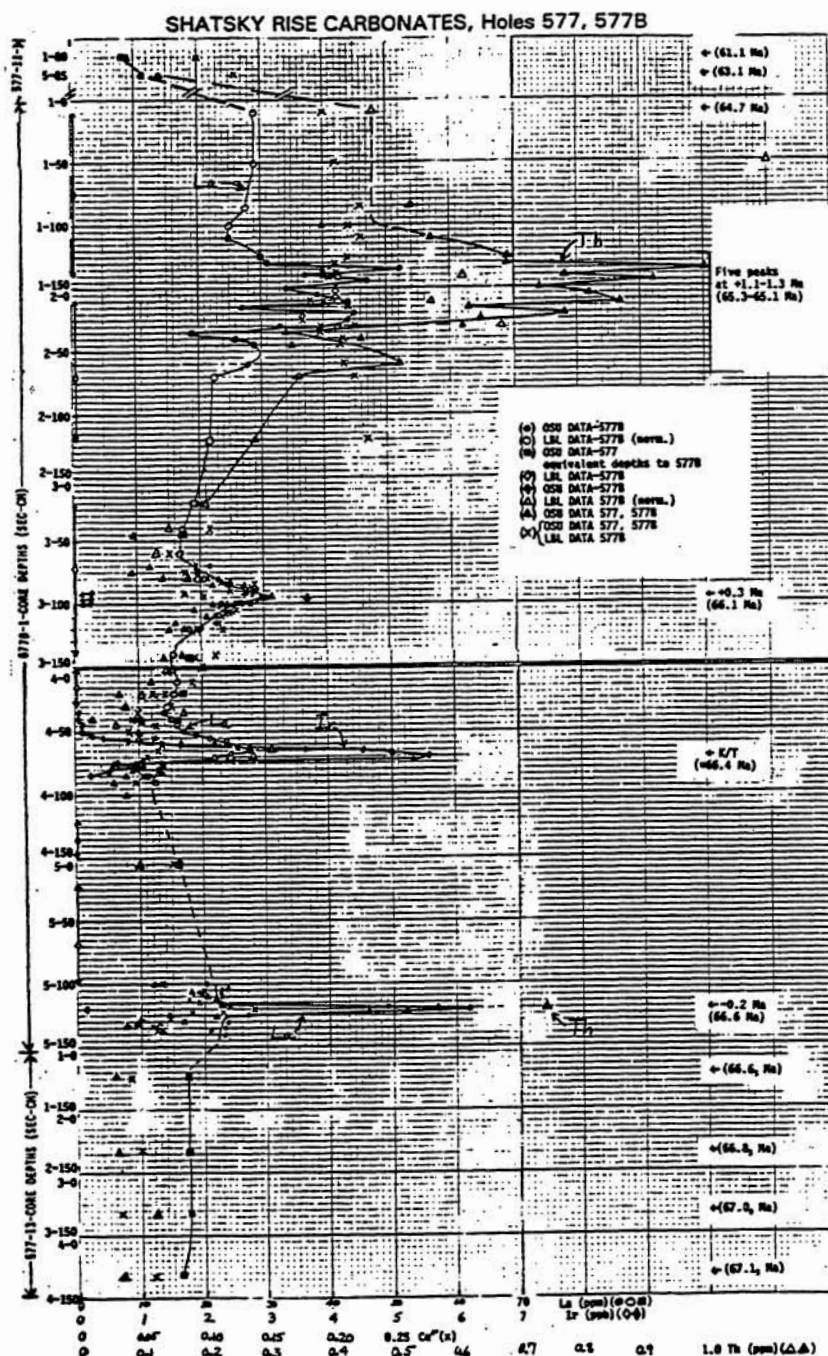


SHATSKY RISE EVIDENCES SUPPORT HYPOTHESIS THAT BOTH A BOLIDE (ASTEROID OR COMET) IMPACT (BI) AND DECCAN TRAP FLOODINGS (DT) CAUSED CRETACEOUS/TERTIARY (K/T) EXTINCTIONS AND NOT HYPOTHESIS OF EITHER BI OR DT ALONE, I; R.A. Schmitt^{1,4}, Y.-G. Liu^{1,2}, and R.J. Walker^{1,3}, ¹The Radiation Center and Departments of ²Chemistry and ³Geosciences, and ⁴College of Oceanography, Oregon State University, Corvallis, Oregon 97331

Because the K/T boundaries in the European area are clayey, it is difficult to decipher any information other than the Ir peak. However, in the "pure" Shatsky Rise (S.R.) carbonates (>95% CaCO₃), chemical signals abound and allow us to search for clear signals (elemental and isotopic) which may be attributed to the events associated with the K/T boundary [1-5]. In the studies of S.R. carbonates [2,3], it has been observed that many elements with different properties were significantly enriched at K/T time with Ir (62 ng/cm²) and at -0.2 Ma before K/T but with much lower Ir, i.e. $\leq 0.02X$ the Ir at K/T. A few samples at $\sim +1.2$ Ma after K/T also indicate enrichment of elements with background Ir. In addition to the data reported in [3], 41 CaCO₃ samples from the S.R. Holes 577B and 577A were analyzed for 26 elements via INAA for possible peaks at +0.3 Ma as suggested by the L.B.L. data for samples 577B-1-3-80-81 and -100-101 and for possible peaks between +1.1-+1.3 Ma as suggested by the LBL data for three samples 577B-1-1-140-141 to -2-31-32 [2].

Relevant LBL data [2] are also presented after normalization for systematic analytical differences between the two laboratories. Observations from these data in Fig. 1 are



summarized as follows.

1. In addition to the elemental enrichment peaks at the K/T boundary and at -0.2 Ma before K/T, which have already been defined in [3,6], peak at +0.3 Ma and five peaks at +1.1 to +1.3 Ma after K/T time are defined. Th is plotted as an indicator element for detrital particulates in the sedimentary carbonate samples, and La, as representative of the 14 REEs in Fig. 1. Ir enrichment is only observed at the K/T boundary. At other elemental peaks, Ir contents are under our detection limit, <0.13 ppb for the -0.2 Ma peak and <0.27 ppb for the +0.3 Ma peak. More accurate LBL data [1,2] for composite samples also show background Ir at these positions. The recent analyses of limestones in a 10 Ma interval (71.5 to 61.5 Ma) at Gubbio, Italy, confirmed that there is only one Ir anomaly at the K/T boundary [7]. The singular Ir enrichment at the K/T boundary indicates Ir and other enriched elements (>26) were from different sources. Also at the K/T the close association of the Ir peak with the peaking of >26 other trace elements indicates a crucial relationship between the events which caused the enrichment of them.

2. The normalized abundances (to Al = 100%) of Al, Hf, Ta, and Th in the S.R. carbonate samples are tabulated in Table 1 of the abstract part II of this work (this volume). Within their dispersions, the normalized abundances of Al, Hf, Ta, and Th are the same for detrital clay particulates within the -0.2 Ma, K/T, +0.3 Ma peaks, and the five peaks at +1.2 Ma, and before and after these peaks during the Paleocene, and all normalized abundances essentially overlap the N.A.S.C. (North American Shale Composite) abundances [8]. Such N.A.S.C. sediments are assumed to be representative of average sediments and soils on the continents, and therefore, representative of the average composition of fine particulates available for global eolian transport for deposition as fallout over the oceans and continents. These results demonstrate that the detrital component in the S.R. carbonates resemble the N.A.S.C. and not ash or dust from the Deccan Trap floodings (DT). The alkalis Rb and Cs in S.R. carbonates also show a N.A.S.C.-like abundances. The average abundances of Rb and Cs in the detrital clay components of the -0.2 Ma, K/T, +0.3 Ma peaks and five peaks at +1.2 Ma are 113 ± 26 ppm and 7.5 ± 2.0 ppm, respectively, which overlap their N.A.S.C. abundances (Rb = 125 ppm, Cs = 5.2 ppm). Abundances of Rb and Cs in the detritus of the samples before and after these peaks also overlap the N.A.S.C. abundances.

3. The La data at the +0.3 Ma peak suggest that the overall peak may actually consist of one main peak at 3-95 (section-cm) and one smaller satellite peak at an earlier time of 3-115 depth. The -0.2 Ma peak at 5-120 and 66.6 Ma rests on a base of 22 ppm La and over a broader La base of 17 ppm from 67.1₅ Ma to 66.5 Ma. The peaks of K/T, +0.3 Ma, and the five peaks at +1.1 - +1.3 Ma seem to be superposed on a smoothly increasing La baseline from 12 ppm (at 4-90 and 66.4 Ma) to 30 ppm (at 1-10 and 64.7 Ma). The increase of the La baseline suggests the increase of La concentration in seawater and therefore the input of La (and other REEs) from the continents to the oceans. (In sedimentary-oceanic carbonates with 50-93% CaCO₃ contents, 50-95% of the REEs in the bulk samples originate from REE growth from seawater mainly onto the detrital clay particulates and secondarily onto the Fe-Mn-oxyhydroxide coatings of CaCO₃ minerals during their sedimentary exposure in $\sim 10^4$ - 10^6 years to direct seawater and to interstitial seawater.) Fluvial transport of the weathering products of continental rocks, sediments and soils is considered to be the major contributor of the REEs into the oceans. The higher CO₂ (and SO₂) in the atmosphere, acid rain, and higher temperatures may be the main factors for accelerating the weathering processes. At 63.1 and 61.1 Ma, La concentration returns to "normal" values of 11 and 8 ppm, i.e., relative to La = 8 ± 1 ppm in other central Pacific carbonates deposited in Hole 316 at <1-35 Ma [9].

4. The Ce^{A*} (Ce anomaly) values increased gradually from 0.05 (also equal to the present average Ce^{A*} of 0.06 ± 0.01 in the deep 1000-6000m Pacific Ocean [10]) to about 0.10 from 67.1₅ Ma to 65.9 Ma, and with higher values of 0.13 under the -0.2 Ma peak and a ~30% increase under the K/T and +0.3 Ma peaks. However, at -65.5 Ma (corresponding to 577B-1-2-120 depth) the Ce^{A*} values increased dramatically to 0.23 and continued at 0.22 ± 0.01 over a 0.8 Ma interval. Ce^{A*} returned to 0.10 at 61.1 Ma. The Ce anomaly in seawater and carbonate sediments is attributed to the oxidation of Ce⁺³ to Ce⁺⁴ which is enhanced by the precipitation of Ce(OH)₄. The pH of seawater is a major controlling factor for the Ce anomaly, and has been related to the P_{CO₂} in atmosphere [9]. The higher Ce^{A*} values from 65.5 to 64.7 Ma suggest a lower pH ($\Delta pH \approx -0.12$) of seawater and therefore higher P_{CO₂} in atmosphere and a greenhouse effect. This is also consistent with the observed increasing La baseline during this period.

Based on these observation, the hypothesis that both a bolide impact and Deccan Trap floodings caused K/T extinctions is suggested in part II of this work in this volume.

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