LARGE METEORITE IMPACTS, VOLCANISM AND POSSIBLE ENVIRONMENTAL DISRUPTION AT THE JURASSIC-CRETACEOUS BOUNDARY

S, Misra[1], A. Mazumder[2], M.A.G. Andreoli[3,4] and D. Ray[5]

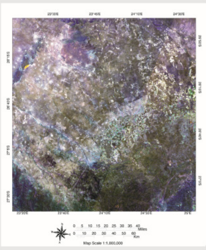
[1]Department of Geology, University of KwaZulu-Natal, Durban - 4000, South Arica (misras@ukzn.ac.za)
[2]Birbal Sahni Institute of Palaeobotany, Lucknow - 226007, India (abhimazumder@gmail.com)
[3]NECSA, Pretoria - 0001, South Africa
[4]Department of Geoscience, University of Witwatersrand, Wits - 2050, South Africa (macro.andreoli@necsa.co.za)
[5]Planex, Physical Research Laboratory, Ahmedabad - 380009, India (dwijesh@prl.res.in)

Introduction:

The Jurassic-Cretaceous (J-K) boundary, like the K-T boundary, is found to be equally important in terms of geological events. In the following review we try to find out any relationship between geological catastrophes and biological mass extinction across this boundary.

Impact Events

The Morokweng impact crater (Latitude: 26˚20'S; Longitude: 23˚32'E) [Fig. 1], South Africa, was formed at 145.0 ± 0.08 Ma close to the J-K boundary on the Kaapvaal craton by an impact of LL-6 chondrite. Recent observations suggest that the original diameter of the crater was probably between ~160 and 240 km, and the buried morphology of this crater resembles to that of the multiring impact craters on inner Solar System planets.



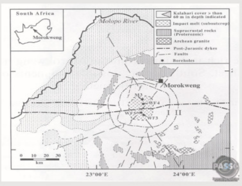
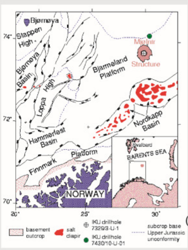


Figure 1: Morokweng Crater;
(A) Satellite view
(B) Interpretated geology of crater

The other impact events close to the J-K boundary were the Mjølnir crater, Norway (Latitude: 73˚48'N; Longitude: 29˚40'E; ~40 km, 142 ± 2.6 Ma) [Fig. 2] and Glosses Bluff crater, Australia (Latitude: 23˚49'N; Longitude: 132˚19'E; ~22 km, 142.5 ± 0.8 Ma) [Fig. 3].



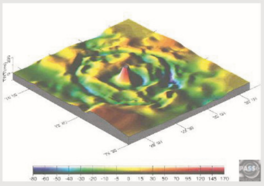
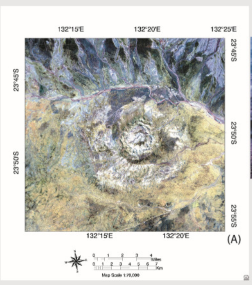


Figure 2: Mjolnir Crater;
(A) Location
(B) Seismic perspective diagram



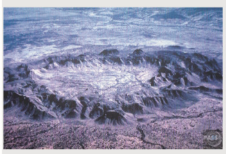


Figure 3: Glosses Bluff Crater;
(A) Satellite view
(B) Aerial photographs

There are also a impacto-clastic layer at the Bosso River Gorge, Italy, and evidences of high Ir within a phosphatic limestone from northern Siberia suggesting the possibility of a global impact.

Volcanic Events

1. Biocalcification in neritic and pelagic setting was suggested to be ralated to volcanism, and extremely low Mg/Ca ratios was perhaps related to high production rate of oceanic basalt (Fig. 4).

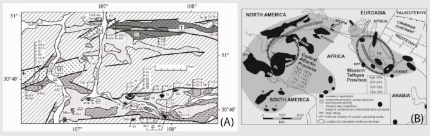
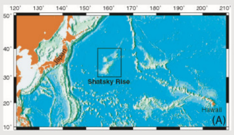


Fig. 4(a) Presence of rift-related extensive basaltic-rhyodacitic volcanism across the J-K boundary from the Tugnui-Khilok Sector, Central Asia [After Vorontsov & Yarmolyuk, 2007]; (b) Presence of bimodal basalt-rhyolite volcanism from northern Benue Trough, and the Liberian margin of the Jurassic Central Atlantic province [After Segev, 2002].

2. The last magmatic events of the Karoo igneous provinance in Patagonia, Antarctic Peninsula, northern South Africa (Bumbeni, Kuleni complexes), Southern India and southeast Australia also straddle the J-K boundary at ~ca. 145 Ma.
3. Report of ~740 km^3 volcanic (acidic, intermediate & basaltic igneous) rocks at the J-K boundary from the coastal range of central Chile.
4. An event of marine volcanism at the J-K boundary is the Shatsky Rise in the northwestern Pacific Ocean with an aerial extent of ~480,000 km^2 (Fig. 5). These lavas were extruded at rates similar to those of the many continental flood basalts.



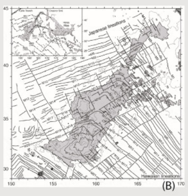


Figure 5: Shatsky Rise; (a) Location of the rise; (b) Tectonic setting of the area

Sedimentary Evidences

1. Studies on sedimentary rocks (and pollens) in western Europe and Sweden show that there was a climatic change from arid (or semi-arid) in the late Jurassic to humid at the J-K boundary.
2. A report of tsunami deposits at the J-K boundary from Boulonnais, France.

Biological Extinctions

Marine faunal extinction = ~5 to 6.5%

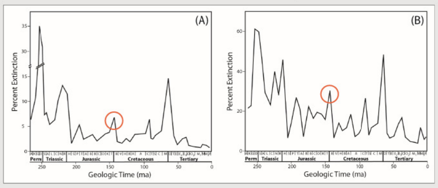


Figure 6: Overview of per cent extinction for marine familes (A) and genera (B) for the Permian to Recent interval (red circle shows J-K boundary) [After Raup and Sepkoski, 1986]

References:

Hallam, A. (1996). Global events and event stratigraphy in the Phanerozoic: Berlin, Springer, 265–283.
Raup, D.M., Sepkoski, J.J.Jr. (1986). Proc. Nat. Acad. Sci. (USA), 81, 801-805.
Segev, A. (2002). EGU Stephan Mueller Sp. Publ. Ser. 2, 171–191.
Vorontsov, A. A., Yarmolyuk, V. V. (2007). J. Volcanol. Seismol., 1(4), 213-236.

Marine mega-organisms:

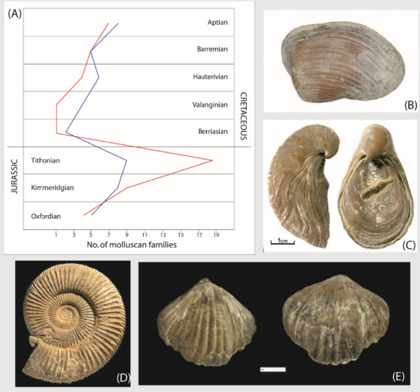


Figure 6: Marine mega-organism; (A) The extinction (red line) & origination (blue line) of molluscan families (After Hallam, 1996); 19 families of mollusca became extinct, (B) & (C) Bivalve (22% genera became extinct in Europe), (D) Ammonites (7 out of 11 families became extinct), (E) Brachiopod (significant events is noticed in Europe)

Marine micro-organisms:

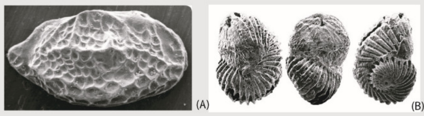


Figure 7: Marine micro-organism; (A) Ostracod (30-35% species extinct at Scotia Shelf of North America and Europe); (B) Benthic foraminifera (no such turnover in Europe, have changed in systematics composition in western Siberia)

Marine vertebrate:

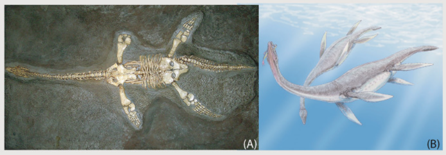


Figure 8: Extinction of long-necked plesiosaurs were claimed; (A) skeleton of plesiosaurs, (B) artist's illustration of living plesiosaurs (However, presence is reported in Cretaceous in England, where they persisted throughout the boundary)

Terrestrial faunal extinction = ~6 to 18%

This observation, however, may be an artefact effect on fossil record as there is no record of extinction even for either dinosaur or megafloras.

Discussion:

Present review suggests that the J-K boundary represents a period of geological upheavals and environmental disruption, which include large meteorite impacts, important submarine volcanism and climatic changes. Absence of important terrestrial mass extinction along the J-K boundary also supports the idea that large meteorite impacts and mass extinctions are not perhaps in a strict "cause and effect" relationship. As a Deccan size volcanism (~1.5 million km^2) cause mass extinction at the K-T boundary, it appears that there could be few more important marine volcanic events at the J-K boundary, which would have enhanced CO_2 (along with some toxic elements) of the ocean water above the endurance of the living organisms at that time, especially if combined to the effects of Milankovich climatic cycles. In conclusion, we still cannot quantify the relative influence exerted by impacts versus volcanic (marine/subaerial) events at the J-K boundary on the marine extinction episode identified for the same period.