PERMIAN-TRIASSIC TRANSITIONAL ENVIRONMENT IN SPITI VALLEY, HIMALAYAS, INDIA

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Introduction : The Permian–Triassic mass extinction event has been attributed wholly or partly to climatic stress due to Siberian volcanism [1,2], regression of sea [3], oceanic anoxia [4,5], overturning of deep anoxic oceans [6] and impact [7,8] or combination of all these factors [9]. Their relative roles in causing mass extinction, however, have not been evaluated. The impact hypotheses has received some support from the work of Retallack [10] who reported occurrence of planer defects in quartz in the Permian-Triassic sections from some localities of Antarctica and Australia. India was a part of the old Gondwanaland in which Antarctica, Australia, Africa etc. were located close together during Permian-Triassic time. If impact really took place at Falkland, as proposed by Rampino [8], then Indian sections, because of their proximity, are in a better position to record these events compared to the Northern Hemispheric sections e.g. Carnic Alps and China.

It has been observed that a thin (~2cm) limonitic band separates the Permian and Triassic succession in the Spiti valley and should represent the Permian-Triassic Boundary. The absence of high iridium and presence of a large positive Eu-anomaly in Guling and Lalung P-Tr sections of Spiti valley of Himalayas would indicate a eucritic or anorthositic bolide in an impact scenario [7].

Limonitic Layer : To understand the extent of the limonitic layer, its mineralogical and chemical characteristics and geological context, we have carried out study of several sites in Lahaul and Spiti valley. Field observations indicate that the limonitic band separating the Permian grey-black shale and Triassic limestone is present throughout the Spiti valley and also in Lahaul valley. From the macroscopic and physical examination and X-ray diffraction studies of this limonitic material which is well developed near Attargoo village in Spiti valley, we find that it consists of goethite, quartz, gypsum and feldspar. Maganese in form of oxide with minor iron has also been observed by SEM studies, indicating a marine component in this clay whereas presence of gypsum shows components of sub-aerial origin. A large drop in the sea level and aerial exposure of sediments can probably result in the mixed mineral assemblages seen here but it can not easily explain the high europium anomaly observed in dark nodules found at the base of the limonitic layer. The presence of multiple components of diverse origin in the limonitic layer could also be ascribed to an impact ejecta [7].

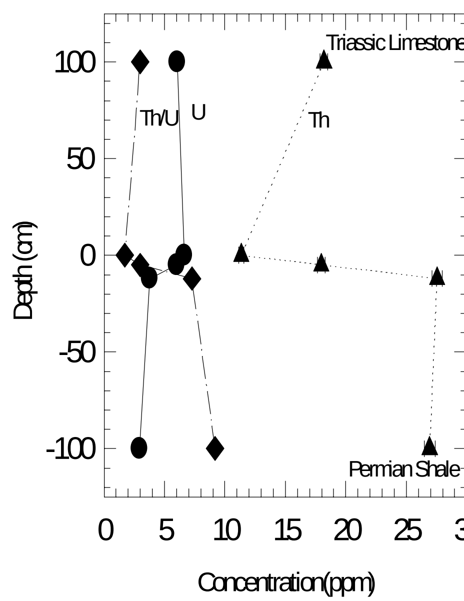

Fig.1. Profile of U, Th and Th/U ratios in the Attargoo section.

Trace element composition: To characterize the samples in detail we have carried out geochemical studies of samples of P-Tr sections in Spiti valley as well as from Kashmir (Guryul) using neutron activation analyses. U, Th and K measurements were made using gamma-ray spectrometry. Some major elements have also been measured using ICP-AES and AAS techniques.

Th, U and Th/U ratios show a drastic variation in the section as shown in Fig.1. Generally Th/U is considered as an indicator of redox conditions prevailing at the time of sediment deposition, since under anoxic conditions U is tetravalent and forms insoluble compounds which remain in the sediments while in oxic environment, U changes to hexavalent state and forms the soluble uranyl carbonate. In the Attargoo section, we find that Th/U ratio starts decreasing from 5 cm (7.27) below the limonitic layer and attains a minimum value in the limonitic layer (1.72). Thereafter it increases during Triassic (to 3.0). This variation suggests that much before the deposition of the layer the oxygen in the sea started depleting, although the concomitant variation in Th

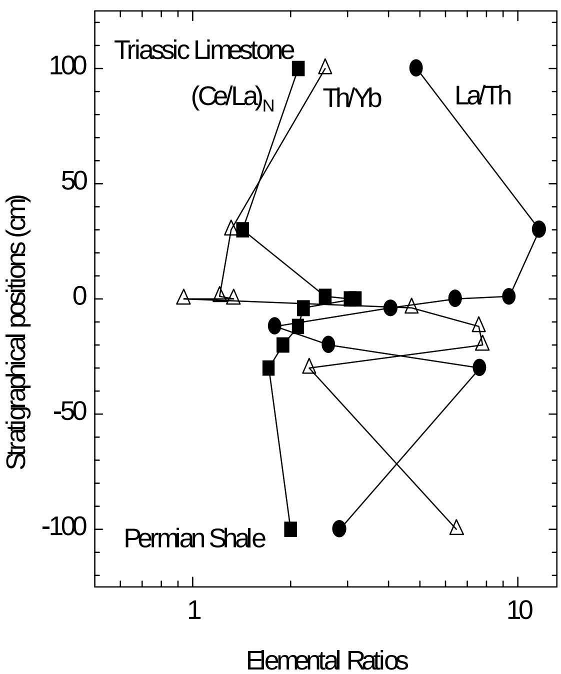

Fig 2. Profile of diagnostic elemental ratios in the Attargoo P/Tr section.

concentration suggests simultaneous changes due to lithological variations. The anoxic condition at the time of deposition of the limonitic layer can also be inferred from the high $(Ce/La)_N$, which is similar to those occurring in Austrian sections [11]. Thus the anoxia starts building up before the deposition of this limonitic layer. This decrease in oxygen also reflects in the colour of shales which change from grey to black [11]. The duration and extent of anoxia seems to vary from place to place as can be inferred by comparing Th/U and $[Ce/La]_N$ in Attargoo section with austrian and chinese (Meishan and Shangsi) sections [12].

The boundary samples from four localities (Lalung, Guling, Attargoo and Ganmachidam) show parallel trends in REE.The REE content is high in the limonitic layer compared to the adjacent samples above and below it. La/Th and Th/Yb also show similar depth profiles in these sections. The Permian shales have low La/Th and high Th/Yb, similar to granites whereas the Triassic limestone have high La/Th (4.9 to 11.6) and low Th/Y (1.2-2.5) respectively, similar to basalts. This could possibly be due to Panjal and Phe volcanism which occupied large areas in the adjoining Kashmir and Zanskar basins in the Tethyan realm of north-western Himalayas.

We thank Harald Strauss for conducting a very useful field trip in the Spiti Valley under IGCP 386, which allowed us to collect samples used in this study.

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