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Permo-Triassic climate change and faunal turnover in the Salt and Surghar ranges, Northern Pakistan

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Abstract

One of the greatest biological crisis which happened at the Permian-Triassic boundary (250 million years (My) ago) is best documented in the well-exposed rocks of the Salt Range and the adjacent Surghar and Khisor Ranges in northern Pakistan which has been intensively studied since the pioneer work of Waagen in 1895. In these ranges the Upper Permian to Middle Triassic is represented by mixed siliciclastic carbonate sediments, named (in ascending order) the Chhidru, Mianwali, and Tredian formations. The present studies have brought in new insights to stratigraphy, faunal turn-over dynamics and environmental conditions of the Permo-Triassic (PT) sequence exposed in western Salt Range continuing in the adjoining Surghar Range.

The Permo-Triassic (PT) boundary is reportedly diachronous in the Salt and Surghar Ranges. The conodont fauna suggest that the PT boundary coincides with the disconformity at the Chhidru-Mianwali formations but the palynological assemblages from the upper-most Chhidru Formation have affinities with Permian as well as Griesbachian (basal Early Triassic). The Ammonite fauna from the Lower Triassic Mianwali Formation shows at least two episodes of radiation-extinction in the time interval from the Griesbachian to the early Spathian: within just three-to-four million years' time span. The palynological and the carbon isotope analysis of the Upper Chhidru-Mianwali-Lower Tredian sequence suggest series of reduced humidity events which coincides with positive shifts in global carbon isotopes record. The particulate organic matter record of the Mianwali Formation does not support the prolonged 'Early Triassic marine anoxia' but suggests rather oxygenated environmental conditions. In summary, the diversification patterns and environmental changes after the end-Permian extinction event are much more complex than previously thought, which are being highlighted in this paper.

Keywords: Permian-Triassic mass extinction; Recovery; Salt Range; Surghar Range; Northern Pakistan.

1. Introduction

The Permian-Triassic mass extinction (around 250 My; PT) was the largest global biodiversity collapse in the Phanerozoic, eliminating almost 78% of marine genera and more than 95% of marine species (Raupand Sepkoski, 1982). It equally devastated the terrestrial life, ~70 to 80% of terrestrial life did not survive into the Triassic (Maxell, 1992; Benton et al., 2004). This biotic crisis is generally interpreted as a single extinction event around 252.3 My ago and has been extensively studied in various parts of the world (for example Pakistan, India, Oman, China, Canada, USA etc.) yet the nature of the end-Permian mass extinction has remained a subject of intense debate: both its timing and causation are key facets that are yet being actively pursued. A wide range of extinction mechanisms have been proposed for the PT marine mass extinction, including marine anoxia, volcanic winter, hypercapnia, global warming, ocean acidification and increased sediment flux (Song et al., 2013). The end-Permian mass extinction played a pivotal role in the reversal of taxonomic and numerical dominance of the brachiopods, crinoids, and corals (i.e. Paleozoic fauna) faunasto Ammonite-bivalves-conodonts dominated faunas (i.e. bivalve dominated Modern fauna) in Early Triassic, all happening within a short interval of five million years (Preto et al., 2010). This unique faunal turnover is well documented in the beautifully exposed exceptionally fossiliferous Permian and Triassic rocks sequence of the Salt Range continuing west and southwest in the Surghar Range (Fig. 1) and the Khisor-Marwat ranges.

The Salt Range, the Surghar Range and the Khisor-Marwat Ranges is one of the most intensely studied region since the early nineteenth century for the quality exposure of the Permian and Triassic rocks with a rich diverse fauna and flora contained therein (Fig. 1B), (see Kummel &Teichert (1970) for detailed review of the past work). This paper summarizes the salient findings of a multidisciplinary investigation of the Upper Permian-Lower Triassic rocks of the Salt and Surghar Ranges conducted jointly by the Paläontologisches Institute und Museum der Universität Zürich, Zürich (Switzerland) and the Earth Sciences Division, Pakistan Museum of Natural History (PMNH), Islamabad (Pakistan). The present study has adopted an elaborate field-cum-laboratory study program including bed-by-bed sampling of different faunal groups, taxonomic study of a few selected faunas, Unitary Association methods, diversity analyses, palynology and particulate organic matter analysis as well as diverse paleo environmental proxy data, such as δ13C of carbonates and organic matter, and δ18O of conodont apatite.

2. Geological background

The Salt Range, the Surghar Range and other adjoining ranges, during the Permian and Triassic times were located on the northern Gondwanan margin, about 30° south of the equator on the southern side of the Tethys Ocean (e.g. Smith et al., 1994; Fig. 1A). In these ranges the Permian to Triassic is represented by mixed siliciclastic carbonate sediments, named (in ascending order) the Permian Zaluch Group (composed of Amb Formation followed up by Wargal Formation topped by the Chhidru Formation), the Lower Triassic Mianwali Formation, Middle TriassicTredian Formations and the Upper Triassic Kingriali Formation (Fig. 2; see Shah, 1977 for detail description). The Zurich-PMNH Team concentrated on the stratigraphic and paleontological studies of the uppermost Chhidru Formation and the Mianwali Formation. The Chhidru Formation consists of limestone and sandstone with intercalated siltstones deposited in subtidal to intertidal environments. It was dated as Changsinghian based on conodonts (Wardlawand Mei, 1999) but palynological assemblages from the uppermost part of the Chhidru Formation give a Permian as well as Griesbachian (basal Triassic)age (Hermann et al., 2012). The Mianwali Formation is made up of limestone, sandstone, and siltstone with some dolomite, forming discrete laterally traceable lithological packages at different stratigraphic levels such as Lower Ceratite Limestone (LCL) etc. (Fig. 2).These lithological packages have been used to further subdivide the Mianwali Formation into the Kathwai Member, the Mittiwali Member, and the Narmia Member (Kummel and Teichert 1970; Shah et al., 1977). The Mianwali Formation with a rich Ammonite fauna has been dated from middle Griesbachian to late Spathian. The AnisianTredian Formation is again characterized by a predominant siltstone and sandstone alternation. The contact between the Chhidru Formation and the overlying Mianwali Formation is an erosional unconformity interpreted as a sequence boundary (Hermann et al., 2012) and representing a temporal hiatus of different magnitude in the exposed belt between depositions of the two formations. The extinction of marine biota generally has been described to coincide with the formational boundary between the two formations (Schindewolf, 1954). However, recent faunal studies, especially on conodonts, suggest the extinction event transcends the formational boundaries, and place the Permian-Triassic boundary within the basal or middle part of the Kathwai Member of the Mianwali Formation (see Pakistani-Japanese Research Group,1985; Wardlawand Mei, 1999).

Waagen's (1879;1895) monumental study of the Permian and early Triassic Ammonite fauna of the Salt Range has made this area a classic global Early Triassic locality and for documenting the disruption between the late

Permian to Early Triassic faunal realm. He also established a detailed lithostratigraphic succession, and precisely recorded the occurrence of the taxa he described within this lithostratigraphic scheme. Waagen's novel approach of tying up fossil occurrences within the local stratigraphic framework enabled him for a very detailed recording of the Permian-Triassic faunal turnover in the Salt Range; thus being one of the earliest documentation of end-Permian extinction event. Waagen's lithostratigraphic subdivision was used almost for one century until Kummel and Teichert and associates in 1960's redefined the litho stratigraphy of the Salt Range and Surghar Ranges in terms of modern stratigraphic nomenclature practices as well as piloted a detailed paleontological study of the rich Late Permian and Early Triassic faunas; such as brachiopods, Ammonites, conodonts, bivalves, fusulinids, etc. The Waagen's biostratigraphic subdivisions (1895) as modified by Kummel and Teichert Team was adopted by all subsequent researchers. However, there were still some minor gaps and anomalies in the biostratigraphic zonation of the Salt and Surghar Ranges fauna shindering in its correlation with the global late Permian and early Triassic biostratigraphic subdivisions which the Zurich-PMNH team has attempted to improve upon.

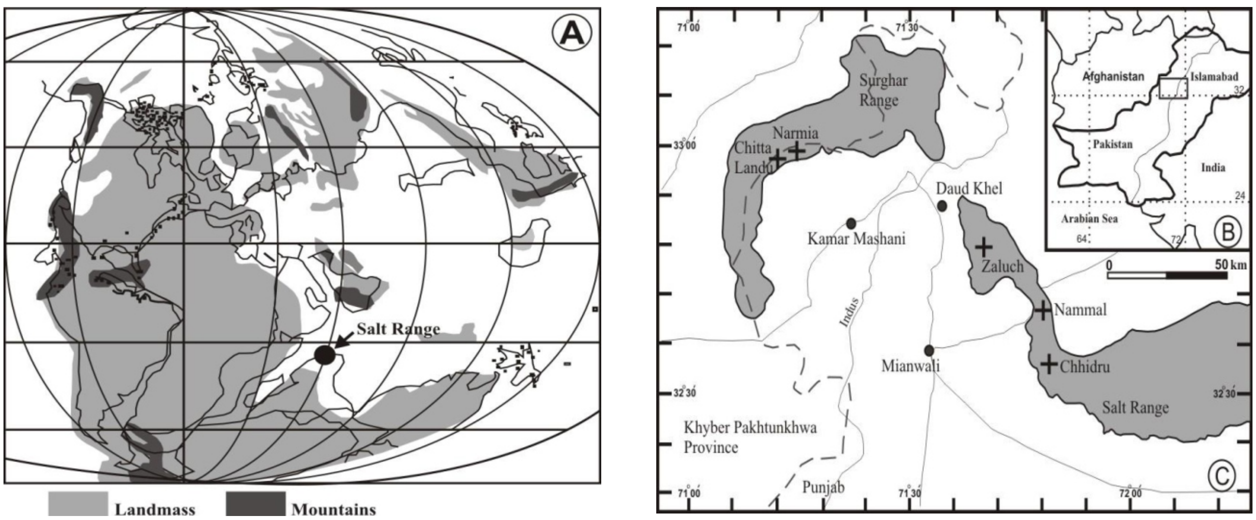

Fig. 1. (A). Paleogeography of the Pangea in Early Triassic showing the paleoposition of the Salt Range and the Surghar Range; (B) Regional map of Pakistan showing the location of the Salt Range and the Surghar Range; (C) Western Salt Range and the Surghar Range indicating the sections studied (adapted from Hermann et al., 2012).

Waagen, 1895			Kummel & Teichert, 1970		PJRG, 1985			This work	
Ceratite Formation	Dolomite Group	Topmost Limestone	Mianwali Formation	Narmia Member	Mianwali Formation	Narmia Mb.		TL	TRIASSIC
		Dolomitic Beds				Mittiwali Member	Unit 5	NI	
	Bivalve Limestone	Bivalve Beds					Unit 4	BB	
		Upper Ceratite Limestone		Mittiwali Member				UCL	
	Ceratite Beds	Ceratite Sandstone					Unit 3	CS	
		Ceratite Marls					Unit 2	CM	
		Lower Ceratite Limestone					Unit 1	LCL	
Upper Productus Limestone				Kathwai Member		Kathwai Mb.		KM	
			Chhidru Formation		Chhidru Fm.				P.

Fig. 2. Lithostratigraphic nomenclature of the Upper Permian and Lower Triassic rocks used in the Salt Range and its Trans-Indus extensions (namely Surghar Range, and Khisor Range). Our Group has mainly adopted the Kummel &Tiechert scheme with a few minor adjustments. PJRG: Pakistan Japanese Research Group.

3. Summary of paleontological studies

The present study carried out extensive faunal collections with precise contextual stratigraphic information at some of the key sites, such as Nammal, Zaluch, and Chhidru nalas (nala (s) local words for canyon/gorges) in western Salt Range, and the Landu and nearby Narmia nala in the Surghar Range (Fig. 1B). The detailed faunal studies focused on the key taxa, namely the Ammonites, bivalves, and palynology, which has shed new lights on multiple extinction and faunal recovery events in the Early Triassic of the region. Here we summarize salient results of the selected taxa studies.

3.1. Bivalves

The bivalve fauna described by Wasmer et al. (2012) was collected from Lower Triassic sequence in three areas: the Nammal nala in the Salt Range and the Landu nala and the Narmia nala in the Surghar Range (Fig. 1C) where the formation thickens westwards; from 117m in Nammal to 130m in the Surghar Range (Fig. 3). Almost all the bivalves were disarticulated and found concentrated within limestones or coquina beds; probably as storm accumulations. Wasmer et al. (2012) described 15 species in 11 genera and 10 families, from beds dated between 251 Myr to 249 Myr (Fig. 3). The general analysis of the bivalve fauna shows that:

(1) Six genera have Panthalassan records in Early Triassic *(Palaeoneilo, Pinna, Bakevellia, Leptochondria, Scythentolium* and *Permophorus)*, four have Tethyan records *(Bakevellia, Leptochondria, Scythentolium* and *Astartella)*, one from the boreal *(Plagiostoma)*, and three are known exclusively from Pakistan, at least during the Olenekian *(Eobuchia, Dimorphoconcha* and *Pseudocorbula).*

(2) On the species level, 10 of the 15 species seems to be endemic to this region, namely *Paleoneilo? fortistriata, Bakevellia?* sp. *nov., Eobuchiapunjabensis, Eobuchia?* sp. *nov., Leptochondriaviezzenensis, Scythentoliumkokeni, Dimorphoconchaglobosa* sp. *nov, Astartella?* sp. *nov., Pseudocorbula?* sp. *nov.,* and *Plagiostoma* sp.

(3) Five species known from other regions are: three species from Panthalassan regions *(Pinnamuikadanensis, Leptochondria cf. curtocardinalis* and *L. xijinwulanensis)*, and two from Tethyan region *(Leptochondria virgalensis* from China and *L.viezzenensis* from northern Italy).

(4) The unusual provinciality shown by the bivalve fauna has also been observed in the coeval Ammonite fauna of the Salt Range and the Surghar Range.

(5) More than half of the Early Triassic genera (six out of eleven) have continued from the Permian times *(Palaeoneilo, Pinna, Bakevellia, Leptochondria, Permophorus* and *Astartella).* Thus, the bivalve fauna, at least in this area, to a large degree has survived the Permian-Triassic extinction event.

(6) The Early Triassic gastropod fauna from this area also seems to be Paleozoic survivors or holdovers (Kaim et al., 2013); corroborating the notion that some taxonomic groups, perhaps the benthic, locally have fared well through the extinction event.

3.2. Ammonites

Since Waagen taxonomic detailing of the Ammonite fauna collected from his 'Ceratite formation' (Mianwali Formation) in 1895, the Salt Range has been a key area in the Early Triassic Ammonite biostratigraphy of the world (see Bruhwiler et al., 2012 and references therein). Hence, Salt Range and its westward adjoining Surghar Range extending south to the Khisor Range have extensively been studied, especially for the Triassic and Jurassic Ammonite faunas (e.g., for Permian-Triassic faunas see Kummel and Teichert, 1970; PJRG, 1985; Bruhwiler et al., 2012; Ware et al., 2015) (Fig. 1). Recent taxonomic revision of the Dienerian and Smithian Ammonite faunas by Ware et al. (2015) and Bruhwiler et al. (2012) with much larger stratigraphically-controlled collections from the Salt Range and the Surghar Range have provided a new insight into the dynamics of Ammonite evolution on a millennium scale, albeit the extinction-recovery patterns as proposed by Waagen (1895) broadly remains the same. These researchers described 43 species of Dienerianage from the Kathwai Member (basal Mianwali Formation: the 'Lower Ceratite Limestone (LCL)' and basal 'Ceratite Marls (CM)' (Fig. 2) and 40 genera and 67 species of Smithian age from the overlying Mittiwali Member (Fig. 2 and 4). Within this approximately two-million-year time spanning the Dienerian and Smithian stage, these researchers by applying the Unitary Association (UA) method, have identified in time successive orders, 13 UA-zones in the Dienerian times and 12 UA-zones in the Smithian times; all of these were traceable in the field and can be tied up with actual lithostratigraphy of the sections (Bruhwiler et al., 2011, 2012; Ware et al., 2015). Based on this new UA-zonation scheme, the Ammonite biodiversity dynamics for the Dienerian-Smithian time show the following trend which in general supports the known global pattern of the Early Triassic Ammonite recovery at the genera level:

- Moderately high diversity in the early Dienerian
- Decline followed by very low diversity throughout the middle Dienerian
- A very slight increase in diversity in the late Dienerian
- Marked increase in diversity during the early Smithian
- Drastic extinction in late Smithian
- Overall high species turnover throughout the Smithian.

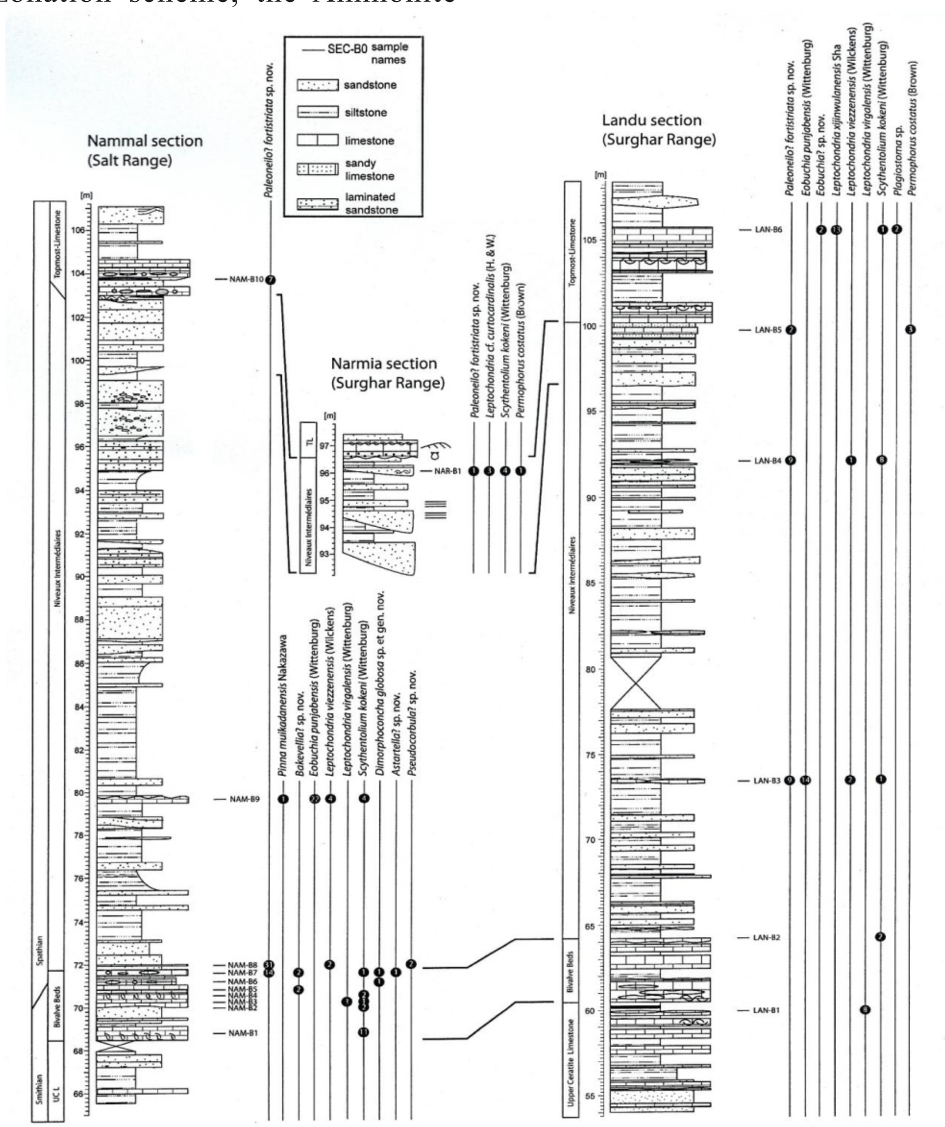

Fig. 3. Bivalve species distribution in the Early Triassic Mianwali Formation exposed in Nammal (western Salt Range), and Narmia and Landu (Surghar Range) sections. Lithology, sedimentary structures, sample locations of bivlaves and of other key fossil groups are recorded. (Adapted from Wasmer et al., 2012)

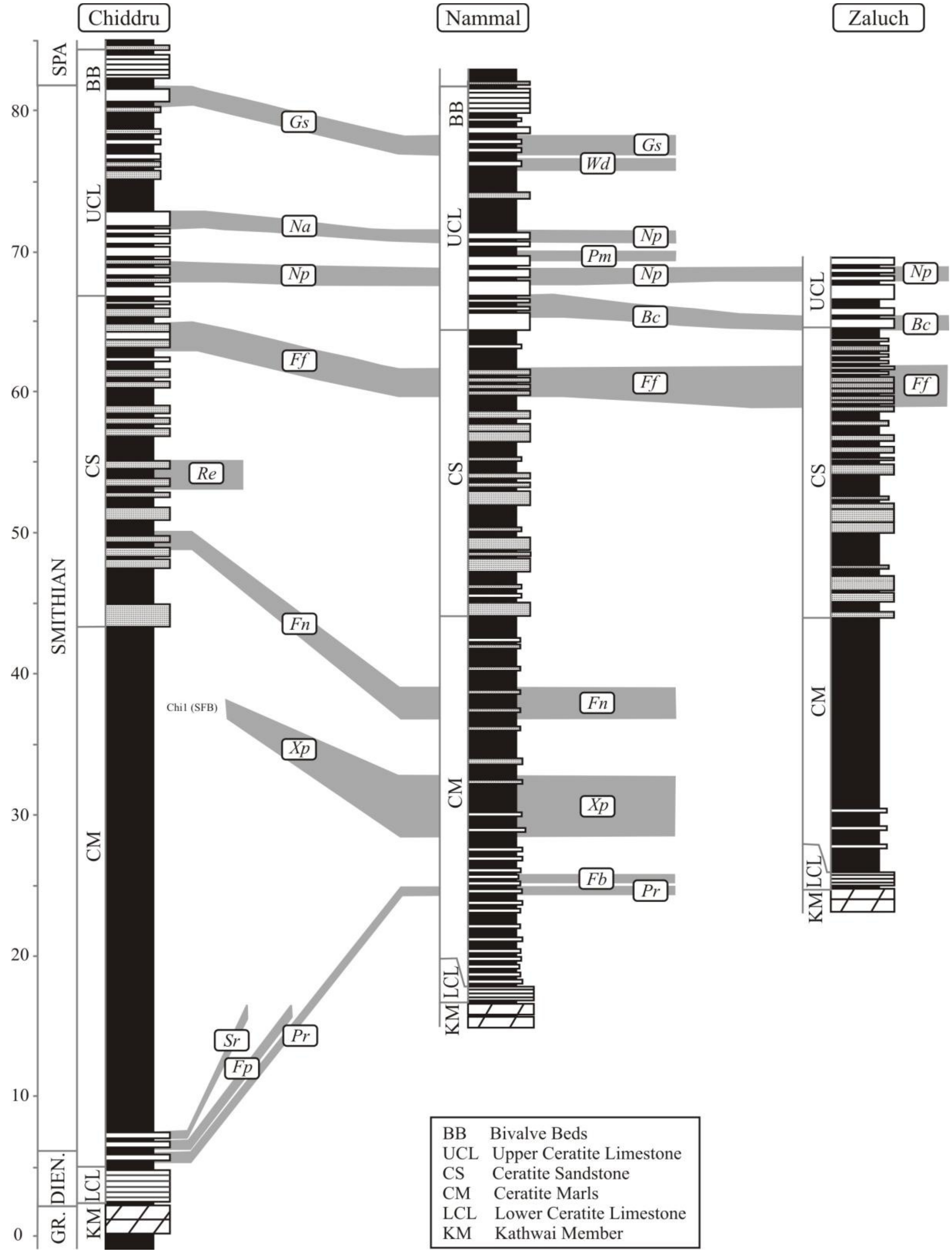

Fig. 4. Ammonite distribution and biostratigraphic correlation of Chhidru, Nammal and Zaluch sections, western Salt Range. The lithostratigraphic subdivisions adopted here is the amalgamation of the Waagen's classification of his “Ceratite beds” with Kummel &Teichert's stratigraphic scheme of Mianwali Formation.(From Bruhwiler et al., 2010). Ammonite 'zones' are Bc: *Brayarditescompressusbeds;* Fb: *Flemingitesbhargavaibeds;* Ff: *Flemingitesflemingianusbeds;* Fn: *Flemingitesnanusbeds;* Fp: *Flemingitesplanatusbeds;* Gs: *Glyptophicerassinuatumbeds;* Na: *Nyalamitesangustecostatusbeds;* Np: *Nammalitespilatoidesbeds;* Pm: *Pseudoceltitesmultiplicatusbeds;* Pr: *Prionolobusrotundatusbeds;* Re: *Radiocerasevolvensbeds;* Sr: *Shamaraitesrursiradiatusbeds;* Wd: *Wasatchitesdistractusbeds,* and Xp: *Xenodiscoidesperplicatusbeds.*

3.3. Palynology

Palynological studies of the Permian and Triassic rocks of the Salt Range and Surghar Range have attracted much less attention yet these investigations provide important vegetation and climate information of the region (for example see Balme, 1970; Hermann et al., 2011a, 2011b; Schneebeli-Hermann et al., 2015). These few studies have mainly investigated the uppermost Chhidru Formation and the lower Mianwali Formation exposed in Amb village (near Chhidru), Wargal (15 km southeast of Chhidru), and Narmia nala (see figure 1C for location). Schneebeli-Hermann et al. (2015) reconstructed the vegetation history across the Permian-Triassic boundary into five phases by studying the pollen and spores and well-preserved cuticle fragments of the uppermost Chhidru Formation and the basal Mianwali Formation in Ambarea near Chhidru (Fig. 2 and Fig. 5). These five phases are summarized as follows:

- Phase I. A mixed *Glossopteris–Dicroidium* flora association in the uppermost Chhidru Formation of Changhsingian (topmost Permian) age. The first-time discovery of the *Dicroidium* cuticle prove the presence of this typical Mesozoic corystosperm genus in Late Permian of the Indian subcontinent.

- Phase II. Although diversity decreased towards the Griesbachian (basal Early Triassic) the Gymnosperms continued dominating the vegetation mosaic shared with pteridosperm. Cuticles recovered from the uppermost white sandstone beds of the Chhidru Formation resemble those of the peltasperm *Lepidopteris,* which also had been associated with Cycadopites and other younger groups.

- Phase III. This phase, at the transition of Griesbachian and Dienerian, is a time of major change with continuous decrease in Gymnosperm abundance while the lycopod abundance increases. This was also a time of significant sea-level change as indicated by palynofacies and the lithology.

- Phase IV. Lycopods, almost to 90%, dominate the flora of the middle Dienerian. However, the lycopods abundance substantially decreases in early Smithian time. Present also in good number (at places up to 60%) are coastal habitat plants forming monospecific-stands; such as *Pleuromeia* reported from Narmia, Nammal, and Amb sections.

Further analysis of the spore-pollen ratios shows significant changes at the Dinerian-Smithian, the Smithian-Spathian, and the Spathain-Anisian boundaries which have also been taken as a proxy of environmental changes, especially indicative of decreased or abruptly reduced humidity (see Schneebeli-Hermann et al., 2015, and reference therein). These humidity fluctuations are coincident with or are closely related to the Carbon-isotope record and taxonomic diversity, suggesting a causal relationship with global Early Triassic climate (Fig. 6).

4. Early Triassic climate

The paleontological summary of the three selected taxa (i.e. bivalves, Ammonite, and spore-pollens) presented above shows that the biotic recovery during the Early Triassic went through several origination-extinction cycles. The same pattern of several diversification pulses of merely 1-2 Ma durations have also been reported in other taxonomic groups, such as conodonts, benthic foraminifers, and ichnofaunas (see Romano et al., 2012 for references).

The biotic recovery-setback pulses that have been documented from the Salt and Surghar Ranges, are found to be a global pattern of the Early Triassic times (Pretto et al., 2010). Attempts by several animal and plants groups inhabiting different ecological niches to re-populate and stabilize are pointing to the fact that the earth climate remained in a flux for quite a long period after the end-Permian extinction event (~252 Ma) and through the Triassic (Trotter et al., 2015).

At the end of the Paleozoic and continuing into the Triassic, the earth was a single large landmass, the Pangea, with the deep oceanic Tethys gulf indenting around the low and mid-latitudes (Fig.1). This unusual physical configuration caused a continental climate dominated by hot summers and relatively cold winters but with strong monsoons, especially in the Tethyan region (see Pretto et al., 2010). The harsh green-house climatic condition that characterized the Late Permian and perhaps caused the end-Permian biotic catastrophe, continued on into the Early Triassic (Galfetti et al., 2007; Romano et al., 2012). This phenomenal climatic change is intimately linked to the Siberian Traps volcanism with main eruptive phase lasting for 1 to 2 Ma but igneous activities continued on for another 4-6 million years encompassing the Early Triassic (Galfetti et al., 2007). The extensive Siberian volcanism, covering an area of several million km², profoundly affected the regional and global environments; such as increased SO_2 and CO_2 in atmosphere and in waters, global warming, ocean acidification, enhance weathering, and ocean anoxia (Ramona et al., 2012). The Triassic climate went through at least three prominent warming events with several short-term warming-cooling phases but with an overall cooler climate which stabilized by latest Triassic (Trotter et al., 2015).

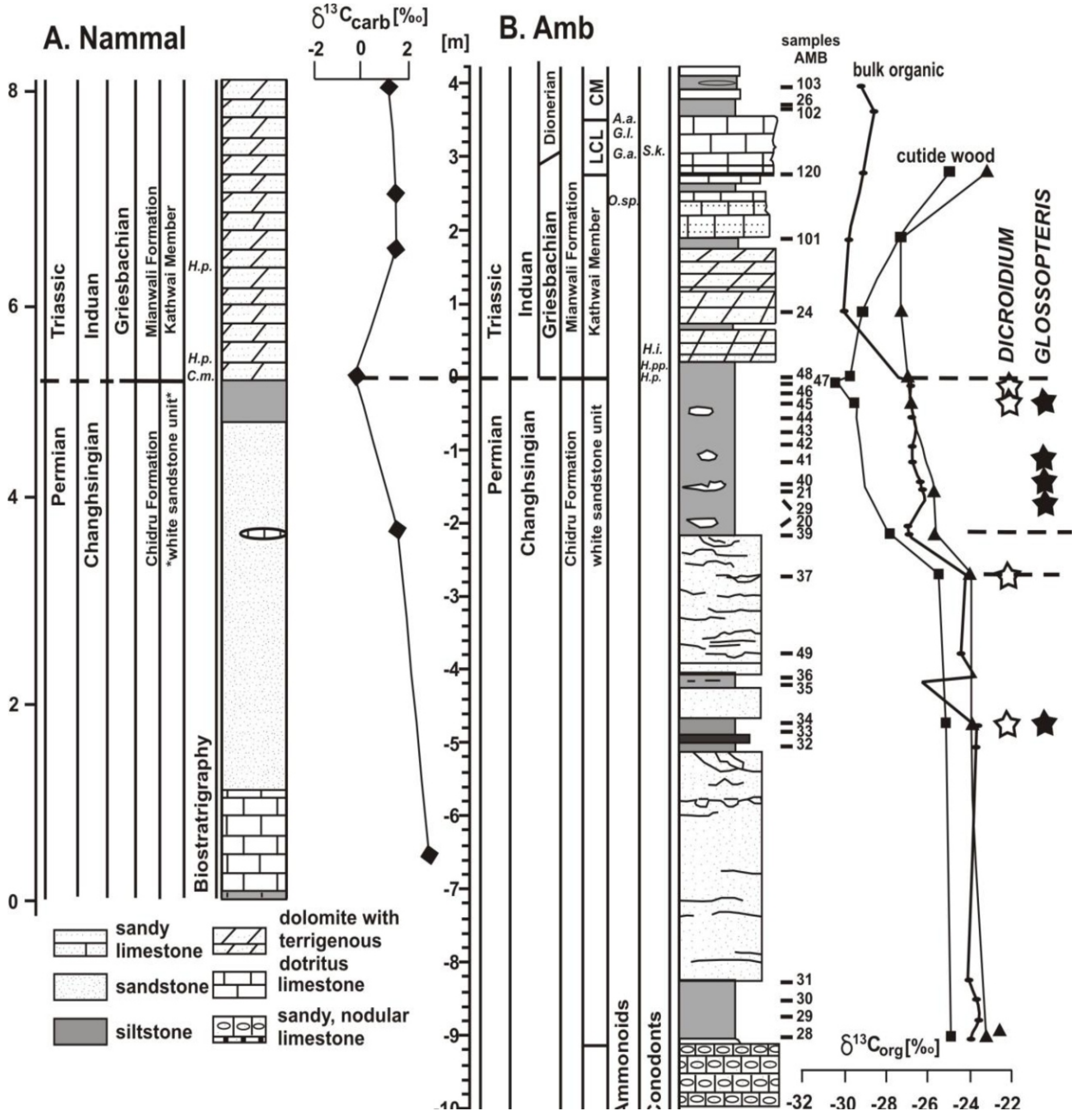

Fig. 5. Palynological and carbon isotope record from the theChhidru Formation and the Mianwali Formation with exact sample locations. Ammonite and conodonts zonations in the Nammal nala and Amb (near Chiddru) village are given for comparison. Conodonts biostratigraphic zonation are C. m. *Clarkinameishanensis,* H. p. H. *parvus,* H.pp. H. *praeparvus,* H.p.? *ambiguous* H. *parvus,* H.t. H. *typicalis,* and S.k. S. *kummeli.* Ammonite biostratigraphic zonations are A.a. A. *atavus,* G.f. G. *frequens,* G.d. G. *dubius,* and O.sp. *Ophiceras* sp. (for details Schneebeli-Hermann et al., 2015).

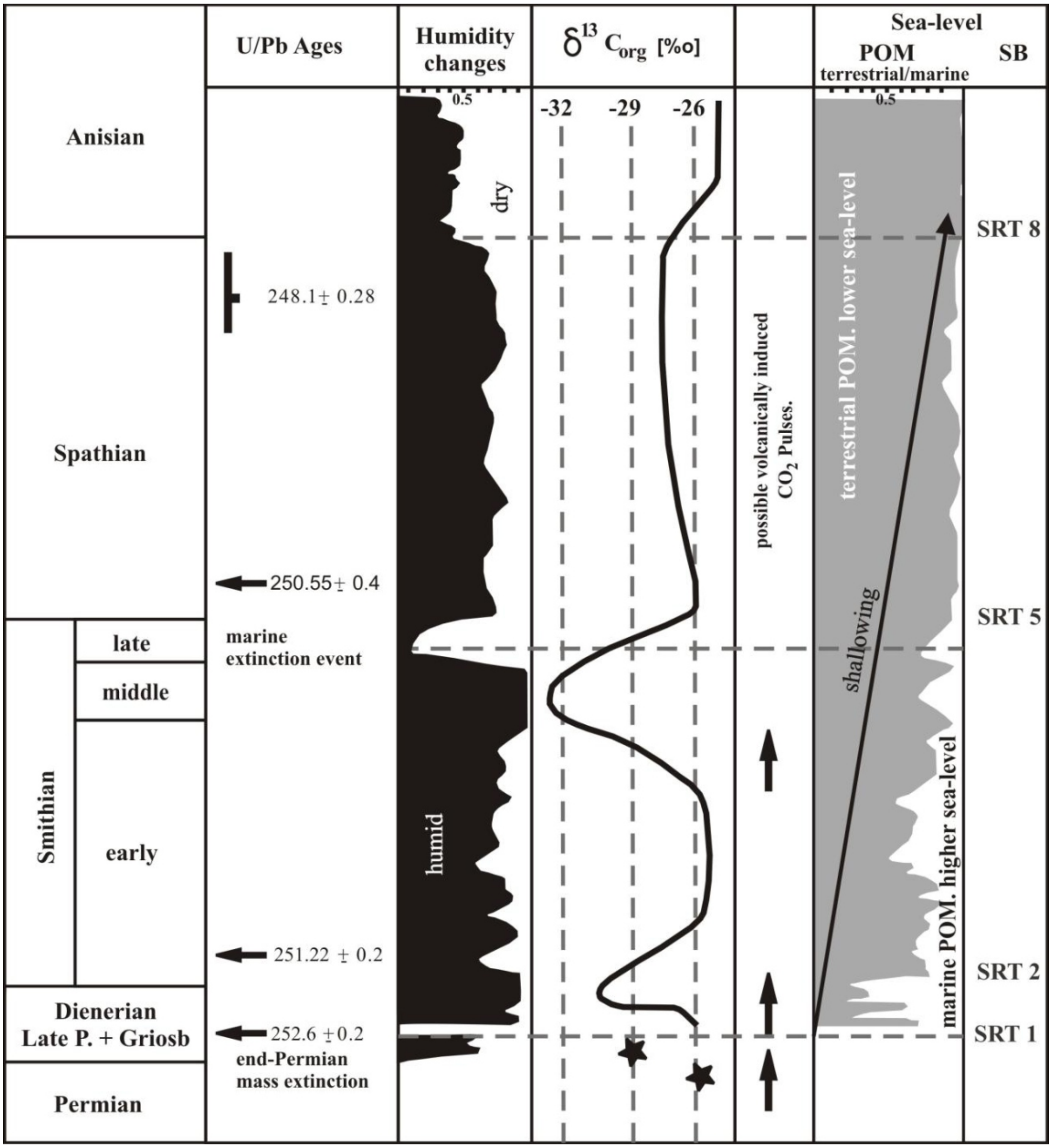

Fig. 6. Early Triassic environmental proxies and climate changes. O/A. Oxic/Anoxic; POM, the particulate organic matter content; S/P, Spore/Pollen ratio. (Adapted from Hermann et al., 2011a, Romano et al., 2012).

The Early Triassic climate inferred from the taxonomic and carbon isotopic analyses of the Mianwali Formation from the Salt and Surghar Ranges closely coincides with the global climatic pattern (Fig. 6). In the Salt and Surghar Ranges as elsewhere in the world, the climate was found to be continually warming up from the basal Triassic onwards reaching to the warmest by Middle Smithian times causing an intense greenhouse climate globally. The greenhouse climate triggered a series of changes and led to the most drastic climatic deterioration and substantial marine life extinctions by Late Smithian-Spathian boundary; merely 2 Ma after the end-Permian extinction. In the Salt and Surghar Range the Smithian-Spathian climatic deterioration seriously affected the life in the marine realm, especially the Ammonites and conodonts, and also on land gymnosperm dominated floras replaced the lycopod-dominated communities of the Dienerian–Smithian interval (Hermann et al., 2012). The Spathain climate was more arid with cooler temperature and well oxygenated seas; a trend which continued through making the world a substantially cooler place by end of the Triassic.

5. Conclusions

- The end-Permian massive faunal extinction has brought to an end to the brachiopod-crinoid etc. dominated marine biota and was taken over by the Ammonite (and other bivlaves) conodonts etc. dominated faunas in a brief period of three to five millions years of the Triassic time period. However, the diversification patterns after the end-Permian extinction event are much more complex than previously thought. For example, the Ammonite fauna from the Lower Triassic Mianwali Formation shows at least two episodes of radiation-extinction in Griesbachian through early Spathian stages: within just three-to-four million years' time span.

- The current faunal revisions, particularly the pollen-spore assemblages and the Ammonite fauna, shows several events of recovery and extinctions, reconfirming an unstable environmental conditions in Early Triassic times: a pattern noted at other places along the Northern Indian Margin and in South China (Bruhwiler et al., 2010; Hermann et al., 2011a; 2011b; Song et al., 2013)(Fig. 6). Some of these events had affected a much larger suite of taxa across the region coinciding with eustatic sea-level changes (for example see Hermann et al., 2011b).The spectacular proliferation of Ammonites and conodonts assemblages immediately after the end-Permian extinction corroborates well with the world-wide pattern of pelagic communities dominating the Early Triassic marine environment.

- The Permo-Triassic boundary is reportedly diachronous in the Salt and Surghar Ranges. The conodont fauna suggest that the PT boundary coincides with the disconformity at the Chhidru-Mianwali Formations but the palynological assemblages from the upper-most Chhidru Formation have affinities with Permian as well as Griesbachian (basal Early Triassic)

- The palynological and the carbon isotopes analysis of the Upper Chhidru-Mianwali-Lower Tredian sequence suggest series of reduced humidity events which coincides with positive shifts in global carbon isotopes record. The particulate organic matter record of the Mianwali Formation does not support the prolonged 'Early Triassic marine anoxia' but suggests rather oxygenated environmental conditions.

6. Recommendations

Paleontological investigations of the Upper Permian-Lower Triassic sequence, presented above, show a remarkable similarity in faunal turnover patterns with coeval rocks of the Northern Indian Margin and the South China Block (Galfetti al., 2007). These synchronous events have been interpreted to reflect global climatic changes, such as in humidity and temperature, which may have caused by extensive Siberian volcanism (Hermann et al., 2011). More detailed sedimentological, isotopic and paleontological studies of the Upper Permian-Lower Triassic rocks of the Western Salt Range and Surghar Range is needed to document local climatic perturbations and its correlation with global climate changes.

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Authors' contribution

Ghazala Roohi, the project coordinator, involved in field work and stratigraphic studies. S. Mahmood Raza did field work, analysis and write up. Elke Schneebeli- Hermann did field work, faunal studies and analyses. Hugo Bucher is the project leader, and performed field work and faunal studies. Aamir Yaseen helped in faunal collection and composing and finalizing figures. Khalilur- Rehman was

involved in filed work, preparation of bibliography and computer assistance. Muhammad Imran helped in faunal data-base and computer assistance, and reviewed the manuscript.

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