# Geological treasure of Guryul ravine section in Kashmir Himalaya – a case report

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January 20, 2022

**Abstract**

Globally researchers have unraveled unique locations that helped to understand the chronology of the critical events concerning the Earth's past. Among such geological events, the time-shot of the Permian-Triassic (P-Tr) extinction event is one of the significant revelations concerning the end and start of life on Earth. Among various geological sites in the world that contain the critical information regarding the P-Tr extinction event, Guryul ravine in Kashmir India is geologically a treasure. It bears specimens of primordial corals, small invertebrates, plants, and a group of mammal resembling reptiles, called therapsids. Due to its immense importance, the Government of India had decided to accredit the site of Guryul ravine section as an international fossil park. However, due to political turmoil in the region and unabated mining and industrial activities within the vicinity of it, has threatened the very existence of this scientific wealth. This paper reviews the importance of the Guryul Ravine Section, paleoclimatic conditions of that time, and the current threats it is facing to stimulate the stakeholders for the conservation of this site in the global scientific interest.

**Keywords**: Paleo Climate Change; Permian–Triassic (P–Tr) boundary; P–Tr mass extinction; Guryul Ravine; Kashmir Himalaya

**Introduction**

Guryul ravine is a fossil enriched area of Kashmir, just south of the Srinagar city. It is a representative of the Permian–Triassic (P–Tr ) extinction event, or the Great Permian Extinction (Chen et al. 2009; Tiwari et al. 2015). Guryul thus possesses a record of a significant geological phenomenon that took place about 251.9 million years ago during the pre-dinosaur Permian period (Becker et al. 2001). Guryul Ravine was known to British geologists as back as the 1880s Sir Walter Lawrence (1895) places on record in his famous book "Valley of Kashmir" of having obtained specimens of Triassic age from the area. He also mentions the fossils specimens being collected earlier by Lieutenant-Colonel Henry Haversham Godwin-Austen, a British Geoscientist, who first discovered Guryul's fossils in 1886 (Lawrence 1895). Since then, in every decade, geologists from all over the world have been writing and researching about Guryul (Sweet 1970; Teichert et al. 1970; Kapoor and Sahni 1971; Furnish et al. 1973; Shimizu 1981; Wang 1990; Kapoor 1996; Algeo et al. 2007; Brosse et al. 2017). Fig. 1 shows the location of the Guryul ravine in relation to the Kashmir valley, UT of Jammu and Kashmir, and India.

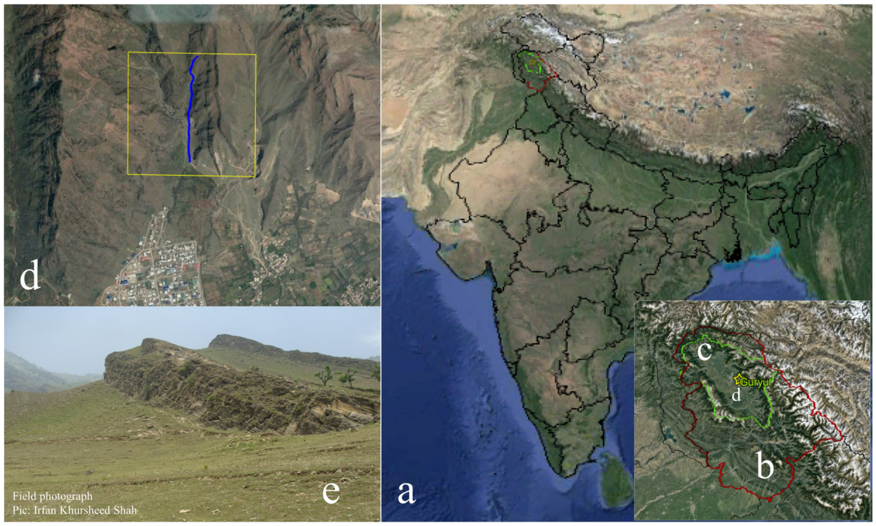



**Fig. 1** The location map of the Kashmir valley (c) in relation to the UT of Jammu and Kashmir (b) and India (a). The location map of the Guryul ravine (d) in relation to the Kashmir valley. Field photograph of the Guryul ravine (e). The map coordinates are in the UTM 43 (North) World Geodetic System (WGS-1984) reference system

In the 2000s, when the expanding cement industry of Kashmir started encroaching and crushing fossils to cement, the outcry regarding the conservation of the Guryul was wide-spread (Basu 2008; Tiwari et al. 2015). Some measures were taken to prevent the loss but not sufficient to prevent the criminal damages caused by encroachment and mining mafia. Recently Guryul has been again in the news for good reasons, as the government yielding to local activism has finally decided to protect Guryul and rechristen it as International Fossil Park (Kashmir Reader 2016). However, since 2016 due to the political turmoil, the whole process has been on halt. On the contrary, there is every possibility that if the current imbroglio continues in the region, time is not far that we will lose this scientific treasure to human greed. This paper summarizes the most critical publications carried on the Guryul ravine and using them to stress upon the stakeholders of the Union Territory of Jammu and Kashmir of the need for its conservation.

**Guryul – A geological treasure**

Guryul provides a critical material for the study of paleo-life forms and paleoclimate dynamics. Similar sites are found in other parts of the world, however not as best preserved as Guryul (Furnish et al. 1973; Singh et al. 2015). Hundreds and Thousands of pre-dinosaur fossils lie strewn in the rocks of the ravine, rated by geologists as the world‘s premier site for the study of species from the Permian period (Brookfield et al. 2013). Guryul Ravine section is comprised of beds equivalent to the highest horizons of Permian and lowest horizons of Triassic (Orchard et al. 1994). Well-preserved marine elements, as well as some terrestrial remains, have been recovered from the Guryul Ravine section and thus rendering important biologic perception of the Permian–Triassic boundary (PTB) event (Hongfu et al. 2001; Singh et al. 2015). Fossil beds in the rocky Guryul Ravine bear specimens representing a diversity of ancient life like primordial corals, small invertebrates, plants, and a group of mammal resembling reptiles, called as therapsids (Schönlaub 1991; Brosse et al. 2017). The lower part of Guryul Ravine contains beds with fossils of brachiopods, crinoids, and bryozoans (Wignall et al. 2005).

In contrast, as in the upper part of the shale bed, these fossils disappear, and relics of the Triassic period appear (Haas et al. 2004). The fossilified samples obtained from rocks depict the mass extinction event that probably happened between the Permian and Triassic periods about 251 million years ago (Huang et al. 2019). Patwardhan (2012) describes Guryul Ravine as the most illustrious and well preserved faunal assemblage of mega fossils. The Guryul Ravine section, in Kashmir, with support from the Pahalgam section, is one of the best reference sections for the transition beds (Kapoor 2003; Kozur et al. 1995; Kumar et al. 2017). The PTB section at Guryul Ravine, Kashmir, is greater than a hundred meters thick (Algeo et al. 2007). Further, conformable succession of mixed siliciclastic–carbonate sediments in the ramp setting of this ravine is apparent (Mir et al. 2016). Fig. 2 shows the geology of the area in and around Guryul ravine.

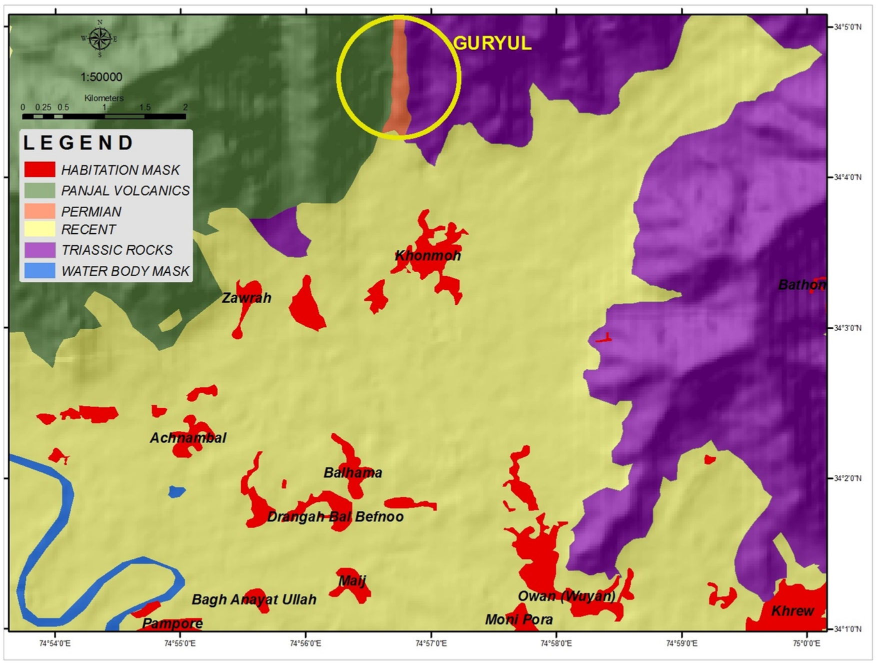
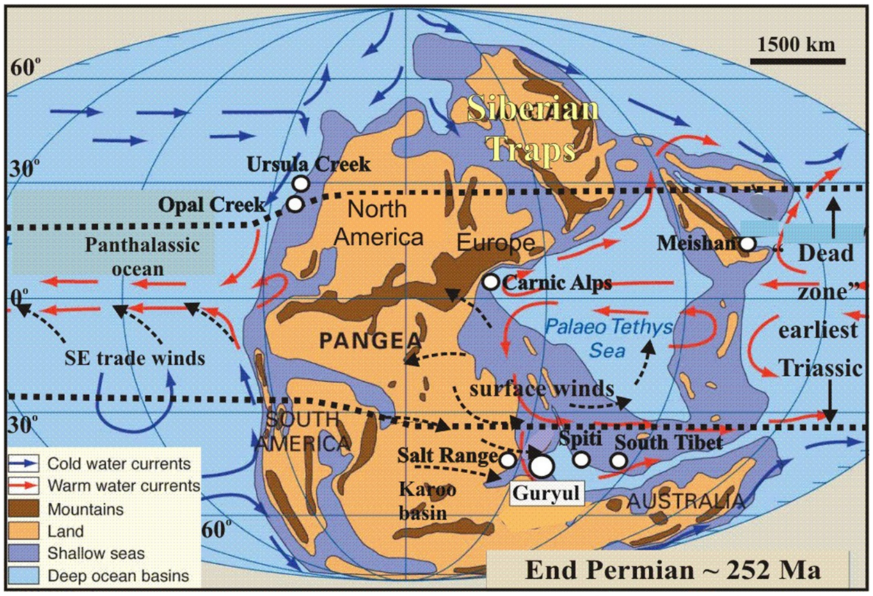



**Fig. 2** Geology map of the area in and around Guryul Ravine

Guryul ravine is one of the very few places in the world where the Permian-Triassic boundary can be seen clearly (Rostovtsev and Azaryan 1973). Guryul ravine section is divided into different chronozones (standard time units), and each chronozone is equivalent to almost 5m thick unit at Guryul standard section (Guirong and Grant 2003). Some geologists have reported Guryul as a continuous unbroken record of PT strata (Wadia 1919; Grant and Cooper 1973; Sokratov 1983; Orchard et al. 1994). In contrast, some workers have reported a sort of physical discontinuity between the top of Zewan Unit D and the base of Khonmoh Unit E (Wang 2002). The Guryul Ravine P–Tr boundary succession in the Kashmir Himalaya belongs to the peri-Gondwanan region that covered the northern margin of Gondwana and the southern margin of Palaeotethys/Neo-Tethys (Fig. 3) (Singh et al. 2015; Wang et al. 2017; Brookfield et al. 2019). It was considered as a standard reference section (SRS) for both upper Permian and lower Triassic biostratigraphy and provided an excellent P-T boundary record (Haas et al. 2007).




Adapted from Brookfield et al. 2020

**Fig. 3** Late Permian palaeogeography of the Guryul ravine (adapted from as it is, Brookfield et al. 2020)

The Guryul section has been investigated for the possible causes of the mass extinction as well as for the geochemical records for post-depositional alteration (Brookfield et al., 2013). The P–Tr boundary section at Guryul represents a catastrophic event in Earth's history, in which more than 96% of marine and 70% terrestrial life went extinct (Haas et al. 2007). The Guryul Ravine section retains some of the original geochemical depositional signatures (Williams et al. 2012). Positive cerium anomaly recorded at the Guryul Ravine P–Tr boundary section by Algeo et al., 2007, the formation of pyrite frambroids (Wignall et al. 2004) points towards a wide-spread anoxia event occurring in the Tethys during the late Permian period (Williams et al. 2012). Shukla et al. 2002, also concluded that the ferruginous layer was deposited during anoxia event. Global ocean anoxia is also considered one of the widely accepted theories explaining the End Permian extinction. The other theories of mass extinction during P–Tr include Mercury anomaly (Sanei et al. 2011) and methanogenic bursts from microbes (Rothmana et al. 2014).

Evidence of sea-level rise during the late Permian is found in the lower sections of Guryul Ravine, and the up sections show a decrease in thickness and occurrence of storm beds, and a general reduction in grain size (Baud et al. 1996; Brookfield et al. 2003; Korte et al. 2010). Faunal and lithological change in several sections also suggests that marine transgression occurred (Shen et al. 2006). At Guryul Ravine, there is a depletion of diversity in the benthic community; the reduction in diversity consequences with the appearance of Hindeodusparvus, other nektonic ammonoids, and other Triassic taxa (Brookfield et al. 2003; Bhargava et al. 2020). Marine transgression coincides with, and probably caused the spread of anoxic bottom waters over well-oxygenated shallow shelves (Demaison and Moore 1980; Wignall et al. 2004; Williams et al. 2011). Marine transgression had a minor, if any, role in the End Permian extinction (Brookfield et al. 2003; Nabbefeld et al. 2010; Schoepfer et al. 2012). Many "transgression" researchers believe the End Permian extinction to be gradual (Twitchett et al. 2001; Ward et al. 2005). The transgressive period led to the spread of low $O_2$ waters onto the shallow shelf, which further impacted the species abundance and diversity (Röhl et al. 2001; Harper et al. 2004).

Brookfield et al. (2013) proposed that the Guryul ravine section contains 7m thick seismite-tsunamite successions. The research interprets two, 2-m-thick sandstone to sandy limestone containing liquefaction features as seismites, while three lenticular, graded, hummocky cross-stratified bioclastic grainstones as tsunami deposits. The same research attributes frequent Tsunamis at that time to massive early explosive eruptions of the Siberian Traps large igneous province (Payne and Clapham 2012). The global anoxia and the Tsunami theory at that time are illustrative (Virgili 2008). However, the proposed Tsunamite theory is contested by many workers who believe that local seismic activity seems to be a far more logical explanation of the Guryul formations than the eruption of the Siberian Traps more than 6000 km away (Janbu et al. 2004; Shellnutt 2016).

In July 1984, members of the Permian-Triassic Boundary Working Group (PTBWG) polled it informally as a favored stratotype for the Permo-Triassic. During a workshop at Calgary meeting (1993), the PTBWG again proposed four candidates for the stratotype of this boundary, i.e., Meishan of Zhejiang, Guryul Ravine of Kashmir, Shangsi of Sichuan, and Selong of Tibet (Tewari et al. 2015). In 1996, Guryul was a candidate for the Permian–Triassic Global Stratotype Section and Point (GSSP) by International Commission on Stratigraphy (ICS). But due to political turmoil in Kashmir, and absence of significant work done to satisfy the ICS conditions, Meishan-D in Zhejiang Province, China, was selected as GSSP (Yin et al. 2001). Despite not being a GSSP it continues to be favorite among geoscientists due to the advantage of being intensely condensed to the extent that an interval of early Triassic time recorded in the Southern Alps of Italy, Primorye, or the western United States of 100 m of rock is represented in the Guryul Ravine section by as little as 9m to a maximum of only 29 m (Brookfield et al. 2020). The Proximal inner continental margin conditions are also well preserved in the units at the Guryul Ravine P–Tr boundary section in Kashmir (Algeo et al. 2007).

**Conclusion and need for the conservation of Guryul**

The above review bears the testimony about the tremendous wealth of knowledge that has got unraveled through Guryul ravine in the field of Pr-Tr event. Hence, Guryul is nature's living laboratory that holds the lessons not only on Pr-Tr event but on the impact of climate change on the global earth system. It is reported that anoxia during the P-Tr event was due to heating of the Earth's atmosphere. Mushrooming of cement industries and open-cast and low-intensity mining of limestones in the area has made it imperative to protect Guryul Ravine so that scientists from all over the world keep deriving enthralling facts from its study. Declaration of Guryul Ravine as an international fossil park is an essential step in this direction; however, it must be initiated as soon as possible so that mining and industrial activity, through stringent legislation, ceases in its surroundings. Further, the amount of research that has been done on Guryul can be used as evidence to support the Geoscientific community that strives to certify the guryul as GSSP site. It is also vital that other adjoining complementary P-Tr Sections of Mandakpal, Pahalgam, Barus, and Liam should also be protected in the global scientific interest and spared from mining (Fig. 4). International scientific fraternity must stand for guryul and bring forth its importance to the local policymakers.

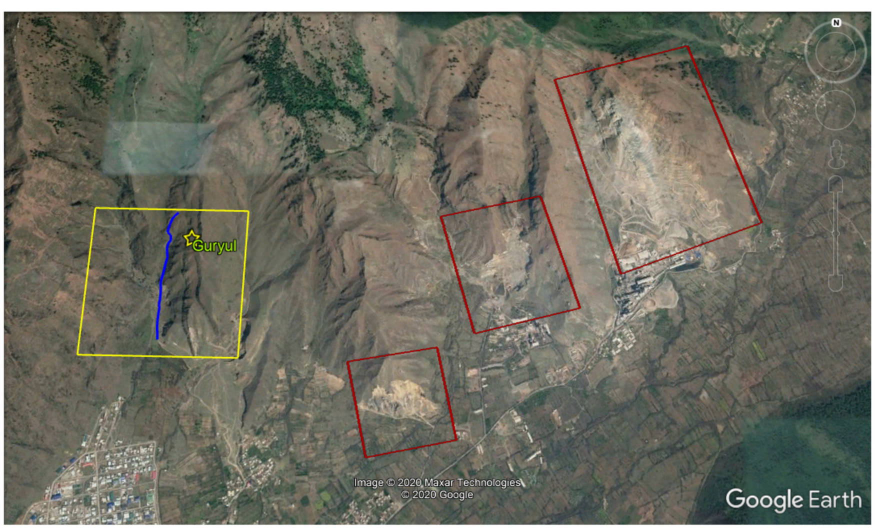


**Fig. 4** Google Earth snapshots of mining activities happening in and around Guryul ravine.

**Acknowledgments**

The authors would like to thank Prof. G. M. Bhat, Postgraduate Department of Geology, University of Jammu, Jammu and Kashmir State, India for his tireless efforts spanning more than 30 years in bringing the Guryul ravine to the global research platform.

**References**

Algeo, T. J., Hannigan, R., Rowe, H., Brookfield, M., Baud, A., Krystyn, L., Ellwood, B. B. (2007). Sequencing events across the Permian–Triassic boundary, Guryul Ravine (Kashmir, India). Paleogeography, Palaeoclimatology, Palaeoecology, 252(1-2), 328-346.

Basu P (2008) Indian fossil bed being ground into cement. National Geographic. http://news.nationalgeographic.com/news/2008/02/080206-fossils-cement.html. Accessed 15 March 2016

Baud, A., Atudorei, V., Sharp, Z. (1996). Late Permian and Early Triassic evolution of the Northern Indian margin: carbon isotope and sequence stratigraphy. Geodinamica Acta, 9(2-3), 57-77.

Becker, L., Poreda, R. J., Hunt, A. G., Bunch, T. E., Rampino, M. (2001). Impact event at the Permian-Triassic boundary: Evidence from extraterrestrial noble gases in fullerenes. Science, 291(5508), 1530-1533.

Bhargava, O., Singh, B. P., Pandey, B., Ganai, J., Bhat, G., Prasad, S., Rashid, R. (2020, march). Contributions to the Palaeozoic and Mesozoic of the Himalaya. In Proc Indian Natn Sci Acad (Vol. 86, No. 1, pp. 217-226).

Brookfield ME, Twitchett RJ, Goodings C (2003) Palaeoenvironments of the Permian–Triassic transition sections in Kashmir, India. Palaeogeogr Palaeoclimatol Palaeoecol 198: 353–371.

Brookfield, M. E., Algeo, T. J., Hannigan, R., Williams, J., Bhat, G. M. (2013). Shaken and stirred: seismites and tsunamites at the Permian-Triassic boundary, Guryul Ravine, Kashmir, India. Palaios, 28(8), 568-582.

Brookfield, M. E., Stebbins, A. G., Williams, J. C., Wolbach, W. S., Hannigan, R., Bhat, G. M. (2020). Palaeoenvironments and elemental geochemistry across the marine Permo-Triassic boundary section, Guryul Ravine (Kashmir, India), and a comparison with other North Indian passive margin sections. The Depositional Record, 6(1), 75-116.

Brosse, M., Baud, A., Bhat, G. M., Bucher, H., Leu, M., Vennemann, T., Goudemand, N. (2017). Conodont-based Griesbachian biochronology of the Guryul Ravine section (basal Triassic, Kashmir, India). Geobios, 50(5-6), 359-387.

Chen, Z. Q., Tong, J., Zhang, K., Yang, H., Liao, Z., Song, H., Chen, J. (2009). Environmental and biotic turnover across the Permian–Triassic boundary on a shallow carbonate platform in western Zhejiang, South China. Australian Journal of Earth Sciences, 56(6), 775-797.

Demaison, G. J., Moore, G. T. (1980). Anoxic environments and oil source bed genesis. AApG Bulletin, 64(8), 1179-1209.

Furnish, W. M., Glenister, B. F., Nakazawa, K., Kapoor, H. M. (1973). Permian ammonoid Cyclolobus from the Zewan Formation, Guryul Ravine, Kashmir. Science, 180(4082), 188-190.

Grant, R. E., Cooper, G. A. (1973). Brachiopods and Permian correlations.

Guirong, X., Grant, R. E. (2003). 9 Permo-Triassic brachiopod successions and events in South China. Permo-Triassic Events in the Eastern Tethys: Stratigraphy Classification and Relations with the Western Tethys, 2, 98.

Haas J, Demény A, Hips K, Zajzon N, Weiszburg TG, Sudar M, Pálfyf J (2007) Biotic and environmental changes in the Permian—Triassic boundary interval recorded on a western Tethyan ramp in the Bükk Mountains, NE Hungary. Glob Planet Change 55(1-3):136—154.

Haas, J., Demény, A., Hips, K., Zajzon, N., Weiszburg, T. G., Sudar, M., Pálfy, J. (2007). Biotic and environmental changes in the Permian–Triassic boundary interval recorded on a western Tethyan ramp in the Bükk Mountains, Hungary. Global and Planetary Change, 55(1-3), 136-154.

Haas, J., Hips, K., Pelikán, P., Zajzon, N., Götz, A. E., Tardi-Filácz, E. (2004). Facies analysis of marine Permian/Triassic boundary sections in Hungary. Acta Geologica Hungarica, 47(4), 297-340.

Harper, D. A., Hammarlund, E. U., Rasmussen, C. M. (2014). End Ordovician extinctions: a coincidence of causes. Gondwana Research, 25(4), 1294-1307.

Hongfu, Y., Kexin, Z., Jinnan, T., Zunyi, Y., Shunbao, W. (2001). The global stratotype section and point (GSSP) of the Permian-Triassic boundary. Episodes, 24(2), 102-114.

Huang, Y., Chen, Z. Q., Algeo, T. J., Zhao, L., Baud, A., Bhat, G. M., … Guo, Z. (2019). Two-stage marine anoxia and biotic response during the Permian–Triassic transition in Kashmir, northern India: pyrite framboid evidence. Global and Planetary Change, 172, 124-139.

Janbu, N. E. (2004). Tectonic control on turbiditic sedimentation: the Late Cretaceous–Eocene successions in the Sinop–Boyabat Basin of north-central Turkey. Unpublished Dr. Scient. Dissertation, University of Bergen.

Kapoor, HM (2003). Permo-Triassic of the Indian subcontinent and its intercontinental correlation. In Sweet WC, Yang Z, Dickens JM, Yin H (ed) Permo-Triassic Events in the Eastern Tethys. Stratigraphy, Classification and Relations with the Western Tethys, Cambridge University Press, Cambridge, pp 21-35

Kapoor, H. M. (1996). The Guryul ravine section, candidate of the global stratotype and point (GSSP) of the Permian–Triassic boundary (PTB). The Paleozoic-Mesozoic Boundary: Candidates of the Global Stratotype Section and Point of the Permian-Triassic.

Kapoor, H. M., Sahni, A. (1971). A Shark Tooth from Zewan Series of Guryul Ravine, Kashmir.

Kashmir Reader (2016) Srinagar to have international Fossil Park soon. http://kashmirreader.com/2016/03/srinagar-to-have-international-fossil-park-soon/. Accessed 27 March 2016

Korte, C., Pande, P., Kalia, P., Kozur, H. W., Joachimski, M. M., Oberhänsli, H. (2010). Massive volcanism at the Permian–Triassic boundary and its impact on the isotopic composition of the ocean and atmosphere. Journal of Asian Earth Sciences, 37(4), 293-311.

Kozur, H., Ramovs, A., Wang, C. Y., Zakharov, Y. D. (1995). The importance of Hindeodus Parvus (Conodonta) for the definition of the Permian-Triassic boundary and evaluation of the proposed sections for a global stratotype section and point (GSSP) for the base of the Triassic. Geologija, 37(38), 173-213.

Kumar, K., Tewari, R., Agnihotri, D., Sharma, A., Pandita, S. K., Pillai, S. S., … Bhat, G. D. (2017). Geochemistry of the Permian-Triassic sequences of the Guryul Ravine section, Jammu and Kashmir, India: Implications for oceanic redox conditions. GeoResJ, 13, 114-125.

Lawrence WR (1895) The Valley of Kashmir. Oxford University Press, London

Mir, A. R., Balaram, V., Ganai, J. A., Dar, S. A., Krishna, A. K. (2016). Geochemistry of sedimentary rocks from Permian–Triassic boundary sections of Tethys Himalaya: implications for paleo-weathering, provenance, and tectonic setting. Acta Geochimica, 35(4), 428-436.

Nabbefeld, B., Grice, K., Twitchett, R. J., Summons, R. E., Hays, L., Böttcher, M. E., Asif, M. (2010). An integrated biomarker, isotopic and palaeoenvironmental study through the Late Permian event at Lusitaniadalen, Spitsbergen. Earth and Planetary Science Letters, 291(1-4), 84-96.

Orchard, M. J., Nassichuk, W. W., Rui, L. (1994). Conodonts from the Lower Griesbachian Otoceras Latilobatum Bed of Selong, Tibet, and the Position of the Permian—Triassic Boundary.

Orchard, M. J., Nassichuk, W. W., Rui, L. (1994). Conodonts from the Lower Griesbachian Otoceras Latilobatum Bed of Selong, Tibet, and the Position of the Permian—Triassic Boundary.

Patwardhan AM (2012) The dynamic earth system, 3rd eds. PHI Learning Pvt. Ltd, New Delhi

Payne, J. L., Clapham, M. E. (2012). End-Permian mass extinction in the oceans: an ancient analog for the twenty-first century?. Annual Review of Earth and Planetary Sciences, 40.

Röhl, H. J., Schmid-Röhl, A., Oschmann, W., Frimmel, A., Schwark, L. (2001). The Posidonia Shale (Lower Toarcian) of SW-Germany: an oxygen-depleted ecosystem controlled by sea level and palaeoclimate. Paleogeography, Palaeoclimatology, Palaeoecology, 165(1-2), 27-52.

Rostovtsev, K. O., Azaryan, N. R. (1973). The Permian-Triassic boundary in Transcaucasia.

Rothmana DH, Fournier GP, French KL, Alm JE, Boyle EA, Cao C, Summons RE (2014) Methanogenic burst in the end-Permian carbon cycle. PNAS 111(15): 5462–5467.

Sanei H, Grasby S E, Beauchamp B (2011) Latest Permian mercury anomalies. Geology 40 (1):63

Schoepfer, S. D., Henderson, C. M., Garrison, G. H., Ward, P. D. (2012). Cessation of a productive coastal upwelling system in the Panthalassic Ocean at the Permian–Triassic boundary. Paleogeography, Palaeoclimatology, Palaeoecology, 313, 181-188.

Schönlaub, H. P. (1991). The Permian–Triassic of the Gartnerkofel-1 core (Carnic alps, Austria): conodont biostratigraphy. Abhandlungen der Geologischen Bundesanstalt, 45, 79-98.

Shellnutt, J. G. (2016). Igneous rock associations 21. The early Permian panjal traps of the western Himalaya. Geoscience Canada, 251-264.

Shen, S. Z., Cao, C. Q., Henderson, C. M., Wang, X. D., Shi, G. R., Wang, Y., Wang, W. (2006). End-Permian mass extinction pattern in the northern peri-Gondwanan region. Palaeoworld, 15(1), 3-30.

Shimizu, D. A. I. K. I. C. H. I. R. O. (1981). Upper Permian brachiopod fossils from Guryul Ravine and the Spur three kilometers north of Barus. Palaeontologica Indica, new series, 46, 67-85.

Shukla AD, Bhandari N, Shukla PN (2002) Chemical signatures of the Permian-Triassic transitional environment in Spiti Valley, India. Geol S Am S 356:445-453.

Singh V, Pandita SK, Tewari R, van Hengstum PJ, Pillai, SS, Agnihotri D, Kumar K, Bhat, GD (2015). Thecamoebians (Testate Amoebae) Straddling the Permian-Triassic Boundary in the Guryul Ravine Section, India: Evolutionary and Palaeoecological Implications. PLoS ONE 10 (8): e0135593. DOI:10.1371/journal.pone.0135593

Singh, V., Pandita, S. K., Tewari, R., van Hengstum, P. J., Pillai, S. S., Agnihotri, D., ... Bhat, G. D. (2015). Thecamoebians (testate amoebae) straddling the Permian-Triassic boundary in the Guryul Ravine section, India: evolutionary and palaeoecological implications. PloS one, 10(8).

Sokratov, B. G. (1983). Oldest Triassic strata and the Permian-Triassic boundary in the Caucasus and the Middle East. International Geology Review, 25(4), 483-496.

Sweet, W. C. (1970). Permian and Triassic conodonts from a section at Guryul Ravine, Vihi district, Kashmir.

Teichert, C., Kummnel, B., Kapoor, H. M. (1970). Mixed Permian-Triassic fauna, Guryul Ravine, Kashmir. Science, 167(3915), 174-175.

Tewari, R., Pandita, S. K., McLoughlin, S., Agnihotri, D., Pillai, S. S., Singh, V., ... Bhat, G. D. (2015). The Permian–Triassic palynological transition in the Guryul Ravine section, Kashmir, India: implications for Tethyan–Gondwanan correlations. Earth-Science Reviews, 149, 53-66.

Twitchett, R. J., Looy, C. V., Morante, R., Visscher, H., Wignall, P. B. (2001). Rapid and synchronous collapse of marine and terrestrial ecosystems during the end-Permian biotic crisis. Geology, 29(4), 351-354.

Virgili, C. (2008). The Permian-Triassic transition: Historical review of the most important ecological crises with special emphasis on the Iberian Peninsula and Western-Central Europe. Journal of Iberian Geology, 34(1), 123-158.

Wadia, D. N. (1919). Geology of India for students. Dalcassian Publishing Company.

Wang, C. (1990). Some problems on the Guryul Ravine section of Kashmir as Permian-Triassic boundary stratotype. In Palaeontologia Cathayana (pp. 263-265). Springer, Berlin, Heidelberg.

Wang, L., Wignall, P. B., Sun, Y., Yan, C., Zhang, Z., Lai, X. (2017). New Permian-Triassic conodont data from Selong (Tibet) and the youngest occurrence of Vjalovognathus. Journal of Asian Earth Sciences, 146, 152-167.

Wang, X. (2002). On steps and methods for the establishment of global boundary stratotype section and point (GSSP) from the viewpoint of integrated stratigraphy. Science in China Series D: Earth Sciences, 45(11), 1027-1041.

Ward, P. D., Botha, J., Buick, R., De Kock, M. O., Erwin, D. H., Garrison, G. H., ... Smith, R. (2005). Abrupt and gradual extinction among Late Permian land vertebrates in the Karoo Basin, South Africa. Science, 307(5710), 709-714.

Wignall PB, Newton R, Brookfield ME (2004) Pyrite framboid for oxygen-poor deposition during the Permian-Triassic crisis in Kashmir. Palaeogeogr Palaeoclimatol Palaeoecol 216:183-188

Wignall PB, Twitchett R J (1996) Oceanic anoxia and the End Permian mass extinction. Science 272:1155-1158

Wignall, P. B., Newton, R., Brookfield, M. E. (2005). Pyrite framboid evidence for oxygen-poor deposition during the Permian–Triassic crisis in Kashmir. Paleogeography, Palaeoclimatology, Palaeoecology, 216(3-4), 183-188.

Williams, J. C., Basu, A. R., Bhargava, O. N., Ahluwalia, A. D., Hannigan, R. E. (2012). Resolving original signatures from a sea of overprint—The geochemistry of the Gungri Shale (Upper Permian, Spiti Valley, India). Chemical Geology, 324, 59-72.

Williams, M., Vannier, J., Corbari, L., Massabuau, J. C. (2011). Oxygen as a driver of early arthropod micro-benthos evolution. PloS one, 6(12).

Yin, H.F., Zhang, K.X., Tong, J.N., Yang, Z.Y., Wu, S.B. (2001) The Global Stratotype Section and Point (GSSP) of the Permian-Triassic boundary. Episodes, 24, 102–114.