the part of the Patkai–Manipur–Lushai hills, one of the 25 microcentres of endemism. The Lushai hills rise to a mean elevation of 1200 m in the west and 1600 m in the east, and in places even up to 2400 m (Mt. Phawngpui or Blue Mountains). The flora of this region mainly constitutes the Indo-Myanmar elements.

The genus Rhynchanthus occurs in these phytogeographical provinces and extends up to South China. Another closely allied monotypic genus, Stadiochilus R.M. Sm. also occurs in the Indo-Myanmar mountain systems. These two genera are remarkably alike in general facies. The unique micro-habitat specificity of R. longiflorus may be one of the reasons for restriction of this taxon to the Lushai hills.

Proper and adequate information regarding the taxa is essential for the conservation and preservation of the species. This may be the main reason why this species is not listed in the IUCN red list category, Red Data Book of Indian flowering plants and the scheduled category of plants in the Indian Wild Life Protection Act 1972. The major threat to R. longiflorus is habitat loss due to anthropogenic intervention. In Mizoram, people practice a primitive method of shifting cultivation called ‘Jhumming’ cultivation, where all the virgin forests are cut down, burnt and the land is used for rice cultivation for two or three years. Thus a major portion of the evergreen forest of Mizoram has vanished and has been transformed into a secondary forest, especially bamboo brakes of Melocanna baccifera Kurz. and grasslands of Saccharum arundinaceum Hook. f. This poses a major threat to the existence of the taxon. Deforestation in this area also brings in a natural catastrophe; the landslides that wipe out the remnants of the fragmented patches of evergreen forest. This species survives in some of the islands of fragmented forests of Saireptang and Kolasib. The population of this taxon in these areas is not viable, because the population size is insufficient for the successful existence of a species according to the conservation rules. The narrow distributional range, microhabitat specificity, nonviable population, etc. are bringing this species closer to extinction. Our efforts to introduce this species into the Calicut University Botanical Garden were not successful due to climatic conditions. Both ex situ and in situ conservation strategy should be adopted to save this remarkable species from the verge of extinction. Any natural disaster like landslides, diseases, pest attack, etc. may eventually wipe out the remaining populations of this species.

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First record of Middle–Late Jurassic palynomorphs from the Lamayuru Complex, Indus Suture Zone, Ladakh, India

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We report here Middle–Late Jurassic palynomorphs bearing sediments from the Lamayuru Complex, exposed along the Indus-Tsangpo Suture Zone in Ladakh. Apart from addition of new data towards understanding the geodynamics of the India-Asia collision zone, this will be helpful in understanding the formation of the slope-deep marine passive margin turbidites basin along the Indus Suture Zone, its palaeogeography and the processes of sedimentation and tectonics during subduction of the Indian plate beneath the Asian plate. The presently recorded Middle–Late Jurassic palynomorphs from the Lamayuru Complex also help to further strengthen our viewpoint that the Permian and Mesozoic palynomorphs bearing sediments were reworked from the Zanskar–Lamayuru Complex Tethyan realm and transported through the Lamayuru Complex to the Nindam basin during ongoing geodynamic processes operative within the India-Asia trench-forearc subduction complex between Cretaceous–Palaeocene time span.

In northern India, the Ladakh block lies between the Indian plate in the south and the Asian plate in the north. To the west, the Ladakh block is largely separated from the Kohistan Complex by the Nanga Parbat–Haramosh syntaxis and to the east it is cut off from the Lhasa block by the Kara-


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Koram Fault (Figure 1). Most workers interpreted the Ladakh block and Kohistan Complex as a single accreted island arc terrane. The Ladakh block is delineated by two suture zones – the Indus Suture in the south and the Shyok Suture to the north. These sutures mark the closing of different branches of the Tethys Ocean and finally the collision of India with Asia at 60–50 Ma. The more northerly Shyok Suture (Figure 1) separates Ladakh from Asian continental rocks of the Karakoram mountains to the north and contains ophiolitic mélanges, rifted back-arc basin detritus and thrusted components of the southern Asian margin that were juxtaposed as Kohistan/Ladakh collided with Asia at 102–85 Ma. To the south, the Indus Suture is tectonically juxtaposed against slope-to-deep marine sedimentary rocks of the Lamayuru–Karamaba Complex, interpreted to be the deep-marine passive margin of the Indian plate. (Figures 1–3). Farther south, the Lamayuru Complex is separated by a south-dipping post-emplacement regional backthrust from the platform carbonates of the Zanskar region (Figures 1b and 2). All along its length, the Indus Suture is represented by obducted remnants of the Neo-Tethyan oceanic crust. The complex sequence of rocks that occur along the Indus Suture includes turbidites, ophiolitic mélanges with basalts interpreted as accreted seamounts, calc-alkaline volcanics, a granite batholith and post-orogenic molasse sedimentary deposits (Figures 1b, 2). Some representative rock formations along the Indus Suture in Ladakh are named as the Lamayuru Complex, Ophiolitic Melange, Nindam Formation, Dras Volcanics, Indus Formation and Ladakh Batholith.

Apart from other rock formations, the syn-post-rift Triassic–Eocene sediments, slope-to-deep marine ocean basin and fine-grained turbidites of the Lamayuru Complex (Figures 1b, 2–4) were deposited on the leading passive edge of the Indian subcontinent (R. Upadhyay, unpublished). The NW–SE trending rocks are tectonically intercalated between...
the back-thrusted Mesozoic Zanskar platform sediments in the south and the Jurassic–Cretaceous Ophiolitic Melange zone of the active margin of the Indus Suture in the north (Figures 1b and 4). Shelf, fore-reef and basin margin (slope) olistoliths (exotic blocks of limestone) of Permian–Jurassic age are tectonically juxtaposed within the Lamayuru Complex. The long time span is shown by in situ Middle Triassic bivalve Daonella indica10–12, Late Triassic nannofossils21, Jurassic (Hettangian) Psiloceras ammonoid12,22 and Late Cretaceous to Early Eocene foraminiferal remains12.

Here we report the first record of Middle–Late Jurassic palynomorph-bearing sediments from the Lamayuru Complex, exposed along the Indus–Tsangpo Suture Zone in Ladakh. Apart from addition of new data towards understanding the geodynamics of the India–Asia collision zone, this discovery will also be helpful in understanding the formation of the slope–deep marine passive margin turbidites basin along the Indus Suture Zone, its palaeogeography and the processes of sedimentation and tectonics during subduction of the Indian plate beneath the Asian plate. This Middle–Late Jurassic palynomorph-bearing sedimentary succession is exposed ~300–400 m NW of the Khangral village, i.e. on a ridge situated on the left side of the Khangral–Chiktan road section (Figures 1b, c and 3). The thinly-bedded, fine-grained, grey and buff to dirty yellow-coloured calcareous shale has also yielded Hettangian (Early Jurassic) ammonoid-Psiloceras22. The presently recorded samples of thinly-medium-bedded, fine-grained siliciclastics of the Lamayuru Complex are lying a few meters (~5–10 m) above the Hettangian horizon (Figure 4). The collected samples were processed and studied to attempt and examine the presence of palynological assemblage. Interestingly, a detailed examination revealed the presence of a number of palynomorphs (Figure 5).

The samples were macerated in hydrofluoric acid 40%, followed by commercial HNO3 and washed in 2–5% KOH solution. The macerates were passed through 150 and 400-mesh sieves to get the final residues. Finally the residues were mixed with polyvinyl alcohol solution, spread on slides and mounted in Canada balsam. The samples and slides are deposited at the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

Eight samples were macerated out of which four have yielded palynomorphs. The samples are poor in spores and pollen grains. The assemblage comprises 13 genera and 12 identifiable species (Figure 5). These are Aequitriradites sp., Araucaricites australis, Alisporites grandis, Callialasporites trilobatus, C. dampieri, C. turbus, Coptospora sp., Cyathidites australis, Dictyophyllidites sp., Impardecispora apiverrucata, Muropora florda, Microcachryidites antarcticus, Perinopollenites elatioides, Podocarpidites grandis, Podosporites tripakshi and Podosporites sp. and few phytoplanktons.

Some reworked Permian palynomorphs were also recorded in the assemblage. These are Crescentipollenites, Striattites, Striatopodocarpites, Scheuringipollenites, Verticipollenites and Virkkipollenites.

The triletes are represented by 5 genera and 3 identifiable species, hilates by 1 genus, monosaccates by 3 genera and 5 species, bisaccates by 2 genera and 2 species and trisaccates by 2 genera and 2 species. The assemblage is dominated by monosaccates (61%) and followed by nonstripate bisaccates (28%). Trisaccates contribute 5%, triletes 3%, phytoplanktons 2% and hilates 1% to the assemblage. C. dampieri is the most common species (61%), followed by P. grandis (21%). Other counted species are A. grandis (7%), M. antarcticus (3%), M. florda (3%), P. tripakshi (2%), Coptospora (1%) and phytoplanktons (2%).

Jurassic palynomorph-bearing sediments are not well exposed in India except in Kutch23, Kota24, Rajasthan25, Vemavaram26, Durgapur27 and Rajmahal28. In Kutch, Gu-
The Jurassic sediments have a considerable thickness. In Australia, on the other hand, the Jurassic sediments are extensive and have wide geographical distribution. Different palynostratigraphic zones were established in Australia, which range from Hettangian to Albian besides some younger horizons. Helby et al. divided Hettangian to Albian sediments into two palynostratigraphic superzones: the lower Callialasporites dampieri Superzone (Hettan-
Figure 5. Spore/pollen grains recorded from the Lamayuru Complex, Indus Suture Zone, Ladakh (enlarged × 600, unless otherwise stated). 1, 3. Murospora florida Sl. nos 13050, 13048. 2. Cyathidites concavus Sl. no. BSIP13051. 4, 7, 8. Callialasporites dampieri Sl. nos BSIP 13053, 13055, 13052. 5. Araucariacites australiensis Sl. no. BSIP 13052. 6. Aequitriradites sp. Sl. no. BSIP 13049. 9, 16. Podocarpidites ellipticus Sl. nos BSIP 13055, 13049. 10. Impardecispora apiverrucata Sl. no. BSIP 13052. 11. Callialasporites trilobatus Sl. no. BSIP13049. 12. Matonisporites sp. Sl. no. BSIP13054. 13. Podosporites tripakshii Sl. no. BSIP13052. 14, 15. Microcachryidites antarcticus Sl. nos BSIP13055.

The Murospora florida Zone of Middle Callovian to Kimmeridgian age has a close similarity with the presently recorded palynomorphs in our samples, belonging to the Lamayuru Complex. Our palynomorph assemblage is dominated by C. dampieri along with the presence of A. australis, M. antarcticus, M. florida and P. grandis. On that basis, a Middle Callovian to Kimmeridgian (Middle–Late Jurassic) age is assigned to the presently recorded palynomorph assemblage of the Lamayuru Complex. This age assignment is logical in the sense that the Hettangian (Early Jurassic) ammonoid-bearing horizon has already been es-
established a few metres below the presently recorded Middle–Late Jurassic palynomorph-bearing, fine-grained siliciclastic sediments of the Lamayuru Complex. Although it is known that the Neotethyan sediments of the Lamayuru Complex span between Triassic and Eocene, it is for the first time that the Middle to Late Jurassic palynomorph-bearing sedimentary sequences are encountered within the Lamayuru Complex.

Interestingly, Upadhyay and co-workers recently also recorded Permian, Mesozoic and Palaeozoic palynomorphs from the Nindam forearc basin, exposed along the Indus Suture Zone in Ladakh. According to them, the Palaeozoic palynomorphs and sediments were transported to the Nindam trough from nearby elevated landward regions (islands). These Palaeozoic provenance areas were characterized by an estuarine, near-shore, tropical, warm-humid environment and were situated at equatorial palaeolatitudes. However, the occurrence of Permian and Mesozoic palynomorphs in the assemblage indicates that the Late Palaeozoic and Mesozoic Tethyan sedimentary rocks exposed along the northern margin of the Indian plate were redeposited onto the tectonically active Cretaceous–Palaeocene trench–subduction complex that existed between the Indian and the Asian plates until the collision took place at ~50–60 Ma.

Logically, apart from diverse implications towards understanding the palaeogeography, litho-tectonostratigraphy of the Lamayuru Complex and the India–Asia subduction and subsequent collision processes, the presently recorded Middle–Late Jurassic palynomorphs from the Lamayuru Complex also help to further strengthen our viewpoint that the Permian and Mesozoic palynomorph-bearing sediments were reworked from the Zanskar–Lamayuru Complex Tethyan realm and transported through the Lamayuru Complex to the Nindam basin during ongoing geodynamic processes operative within the India–Asia trench–forearc subduction complex between the Cretaceous–Palaeocene time span. The presently acquired data may assist future discoveries and be able to further modify the present state of knowledge and evolution of the Indus Suture Zone vs.-à-vis India–Asia collision in Ladakh.

Natural analogue study of Resubelpara Group of thermal springs at Garo Hills, Meghalaya for demonstration of safe geological disposal of nuclear waste

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A group of thermal springs (with temperatures up to 50°C) occurring around Resubelpara locality near Sarangkhol, East Garo Hills district, Meghalaya has been studied to elucidate the geological analogy of various geochemical, thermal and geological features around them with those expected around disposed nuclear waste over packs in granitic rocks in the depth range of 400–500 m in a geological repository. Discrete uraninite occurring in granites and high radon content have been considered to be analogous with a part of radio-active waste. High mobility of uranium is noticed under combinations of favourable groundwater chemistry (high concentration of carbonates and phosphates) and potential geological pathways. It is found that hot groundwater in granites is capable of transporting uranium into the biosphere when provided with suitable structural conduits like deep-seated faults. While in the areas of granites devoid of potential pathways, no significant transport of uranium is observed, the study demonstrates the capability of good host rock coupled with suitable geological set-up in providing long-term safe disposal of nuclear wastes. This is also an attempt to use natural analogue in India to demonstrate safety of nuclear waste disposal.

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