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JURASSIC/CRETACEOUS BOUNDARY IN THE SPITI HIMALAYA, INDIA

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ABSTRACT

The Jurassic/Cretaceous boundary in the Spiti region of the Tethys Himalaya, was identified near the contact of the Spiti Shale with the Guimal Sandstone Formation, being marked by the first appearance of the genera *Odontodiscoceras* and/or *Neocosmoceras* and last appearance of the genus *Virgatosphinctes*.

Keywords: Jurassic–Cretaceous Boundary, ammonoids, Spiti Himalaya

INTRODUCTION

The demarcation of the Jurassic/Cretaceous Boundary has been a subject of debate for over one and half century. The boundary, so far suggested in different parts of the world, is based mainly on the evolutionary history of ammonoids, while calpionellids have also been used in some localities. The internationally accepted Jurassic/Cretaceous boundary is marked in the Tethyan realm between Tithonian and Berriasian stages (Harland *et al.*, 1990; Hallam *et al.*, 1985). Earlier, this boundary was placed at the base of Grandis Zone (Le Hegard, 1973; Enay and Geyssant, 1975). Later this boundary was questioned as it was not sharply demarcated. At the 1973 *Colloque sur la limite Jurassic-Cretace,* the desirability of adopting the *Berriasella grandis – B. jacobi* zonal interval as the lowermost Cretaceous ammonoid zone in the Tethyan realm was seriously considered. In the 27th International Geological Congress (1984), the boundary was suggested between *B. jacobi* and *B. grandis* zones. A workshop was organized by the Lower Cretaceous Working Group of IGCP-262 (Tethyan Cretaceous Correlation) in 1990 at Digane, France. In this workshop, *Berriasella jacobi* has been preferred as the index species of the first Berriasian Zone (Jacobi Zone) which is currently used in the identification of the Jurassic/Cretaceous boundary in the Tethys, and so also in the present investigation.

By means of calpionellid fauna, Remane (1983) defined the Tithonian/Berriasian boundary between the Zones A and B (base of *Calpionella alpina* Zone). In terms of absolute ages, a maximum of 145.5 Ma seems to be reasonable (Gradstein *et al.*, 2004), while based on the magnetic polarity time scale (Ogg and lowrie, 1986; Ogg and Steiner, 1985) the Jurassic/Cretaceous boundary falls within the normal polarity Chron M 19 as a working global definition.

In India, the fossiliferous marine Tithonian-Berriasian outcrops are exposed in two regions: one in the mixed siliciclastics and carbonates of western India (Kachchh and

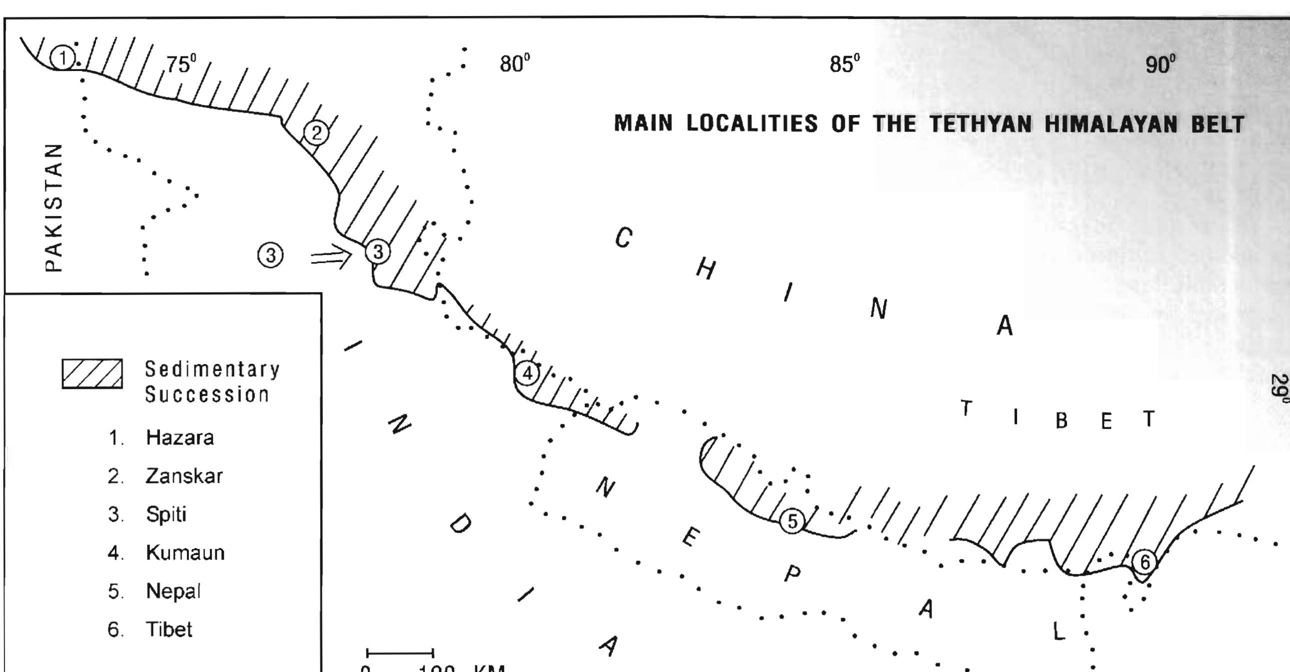

Fig. 1. Distribution of the Tethyan sedimentary succession in the Himalayan belt.

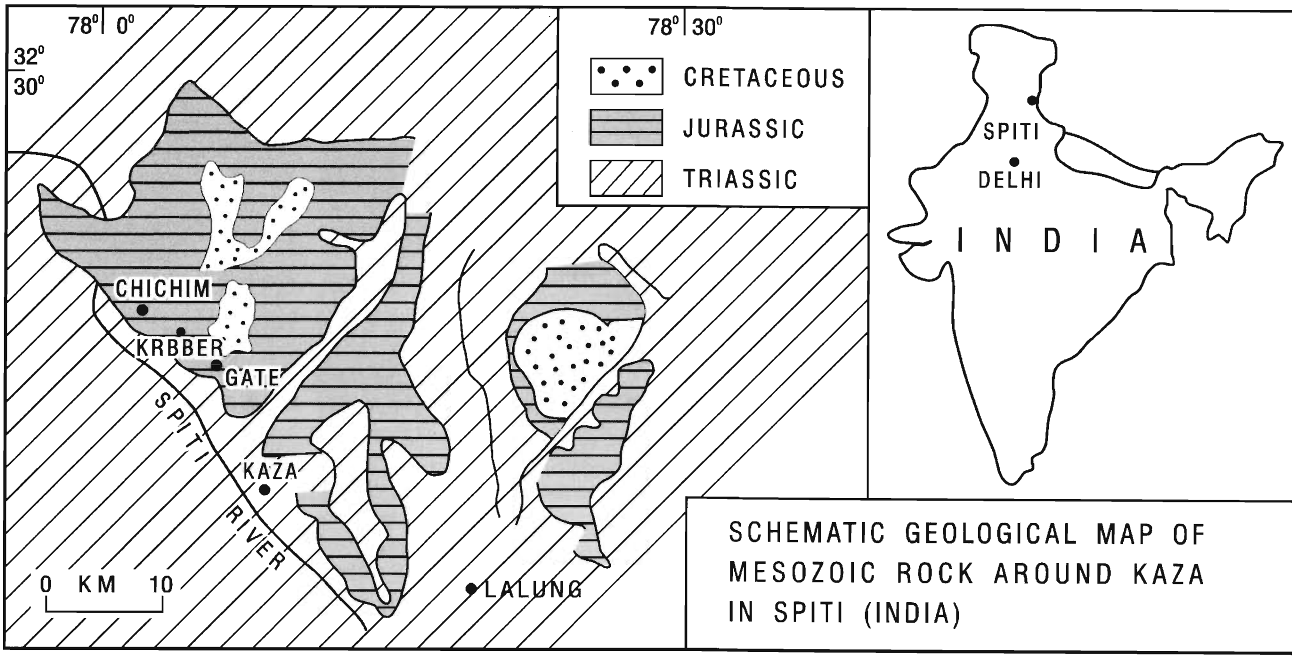

Fig. 2. Geological-cum-location map of the investigated area.

Jaisalmer basins) representing embayment of the Tethys, and the other in the predominantly fine-grained siliciclastic sediments of the Tethys Himalayan region. The demarcation of the Jurassic/Cretaceous boundary in Kachchh is tentative, due to an apparently complete absence of the ammonoids in the Late Tithonian/Early Berriasian beds. In recent years, based on the ammonoid fauna (Krishna *et al.*, 1993) also supported by absolute age determination (Srivastava *et al.*, 1993), the Jurassic/Cretaceous boundary has been suggested at the base of the youngest, out of the three green oolitic beds of the Umia Member (Umia Formation) in the Umia-Lakhapar area of western part of the Mainland Kachchh. In the Ler-Katrol region of the eastern part of the Kachchh Mainland, the boundary has been tentatively placed at the base of the very coarse to gritty sandstone bed forming the highest ridge in the area (Krishna *et al.*, 1993). In contrast, the benthic foraminiferal studies in Kachchh (Pandey and Dave, 1993) have indicated a hiatus covering Late Tithonian-Early Berriasian interval in the western part of the Kachchh Mainland.

The marine fossiliferous Late Jurassic and Early Cretaceous sedimentary rocks are developed over a considerable length all along the Himalayan belt (Fig. 1) represented by the Spiti Shale Formation and the Giumal Sandstone Formation (Arkell, 1956). It forms a classic area for delineation of the Jurassic/Cretaceous boundary in view of its ammonoid-rich, almost continuous Tithonian-Berriasian succession (Uhlig, 1903-10). The Tithonian-Valanginian ammonoids have been studied in detail by Uhlig (1903-10); however, these cannot be used for biostratigraphic purpose due to lack of their proper lithostratigraphic details. The Jurassic/Cretaceous boundary in the Kumaun Himalaya has been suggested on the basis of ammonoids (Krishna *et al.*, 1982) and dinoflagellates (Jain *et al.*, 1984) within the top 90m of the Spiti Shale Formation, without proper identification of the contact of the Spiti Shale Formation and the overlying Guimal Sandstone Formation.

Our knowledge of the Jurassic-Cretaceous biochronostratigraphy of the Himalaya is poorly known in comparison with the resolution achieved in other parts of the world (Le Hegart, 1973; Abstracts – *3rd Inter. Symp. Jurassic Stratigraphy, Poitiers, France,* 1991). However, recent contributions on the ammonoid-based biostratigraphy of the Upper Jurassic of Spiti (Pathak, 1993; Pathak and Krishna, 1994) and Thakkhola, Nepal (Gradstein *et al.*, 1992) indicate the possibility of much better refinement. The results of the present study are expected to be useful not only in the Himalayan belt but also farther east in Indonesia, New Guinae and New Zealand, where similar fauna and facies are found (Westermann, 1992). The present data have been obtained from the study of a section, east of the village Gate (Gaitey) in the Spiti region of Himachal Pradesh (Fig. 2), with maximum

EXPLANATION OF PLATE I

1. ***Virgatosphinctes densiplicatus*** (Waagen), Bed 12, Himalayites Zone, latest Tithonian, east of Gaitey (Gate), lateral view.
2. ***Spiticeras eximus*** Uhlig, Bed 12, Himalayites Zone, latest Tithonian, east of Gaitey (Gate), lateral view.
3. ***Neocosmoceras octagonus*** (Strachy–Blanford), Bed 14, Neocosmoceras Zone, Lower Berriasian, east of Gaitey (Gate), a.lateral view, b. ventral view.
4. ***Odontodiscoceras odontodiscus*** Uhlig, Bed 13, Neocosmoceras Zone, Lower Berriasian, east of Gaitey (Gate), a.lateral view, b. ventral view.
5. ***Odontodiscoceras odontodiscus*** Uhlig, Bed 15b, Odontodiscoceras Zone, Lower Berriasian, east of Gaitey (Gate), a.lateral view, b. ventral view

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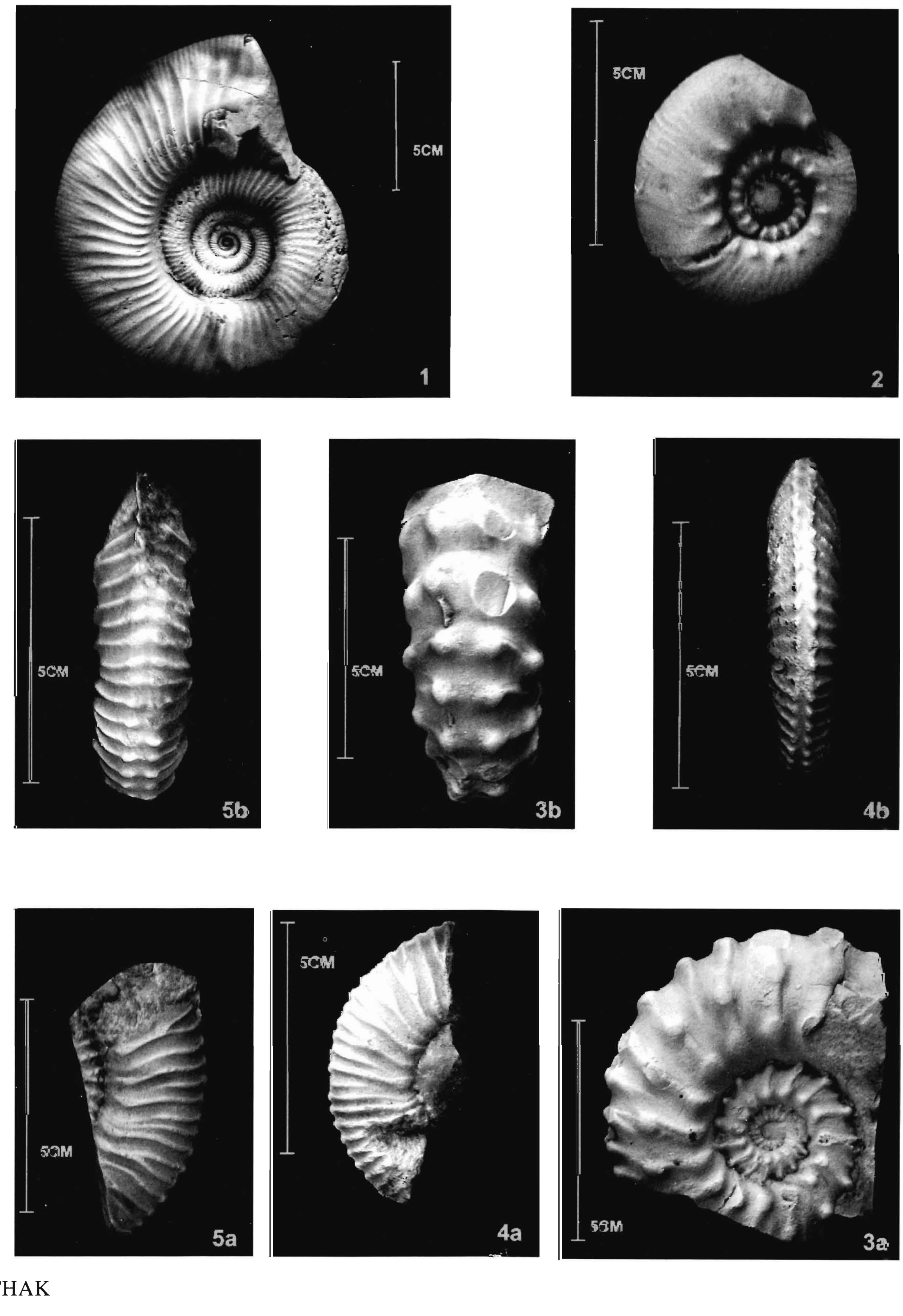
Plate I



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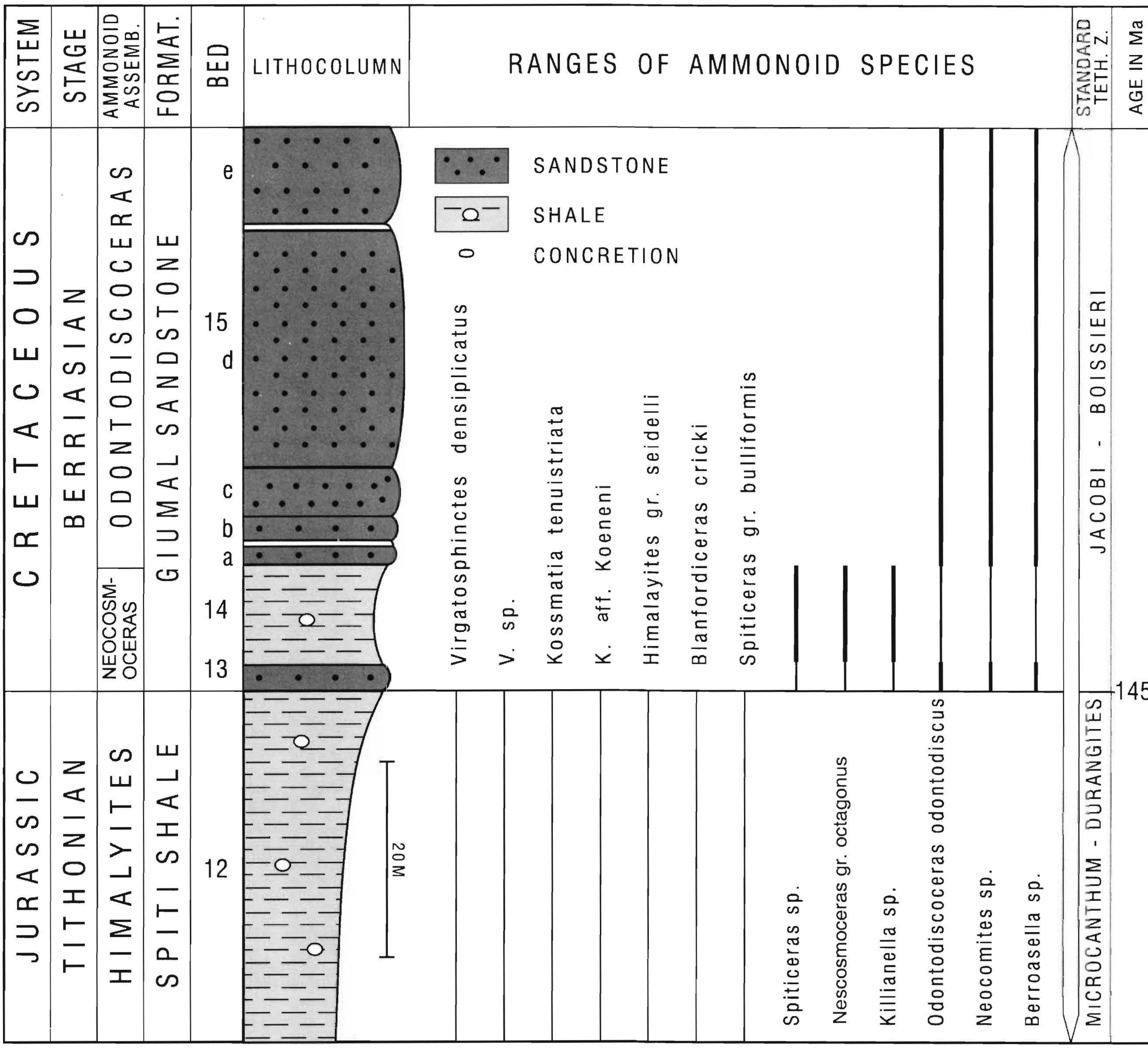

Fig. 3. Ranges of ammonoid species in the Jurassic/Cretaceous boundary beds at Gate in the Spiti Himalaya (HimachalPradesh). The thick lines represent frequent occurrence while the thin lines represent the relatively rare occurrence of the ammonoid fauna at those levels.

possible biostrtigraphic control carried out on the basis of collected ammonoids. This research is a part of the programme initiated by the author in 1991 on the Upper Jurassic-Lower Cretaceous ammonoids in the Spiti Himalaya.

LITHOSTRTIGRAPHIC FRAMEWORK

The Kioto Limestone Formation is the oldest lithostratigraphic unit exposed in the study area. It is a succession of about 500m thick bedded limestone and dolomites alternating with shales ranging in age from Late Triassic to Middle Jurassic and forming cliff on the eastern bank of Spiti river. The top of this formation is marked by a 2.5m thick, highly fossiliferous ferruginous oolitic bed disconformably underlying the Spiti Shale Formation. The record of *Reineckites* from the ferruginous oolite bed and *Mayaites* and *Epimayaites* from the basal part of the Spiti Shale Formation indicates a hiatus (Late Callovian to Early Oxfordian). The Spiti Shale Formation representing the Upper Jurassic time interval in the Himalaya, is a lithologically distinct unit of ca 300m thick black shale dominating succession with abundant ammonoids particularly in the middle part. Calcareous concretions of different sizes are common throughout the succession often with a fossil nucleus, while a few beds of sandy limestone/calcareous sandstone are invariably interspersed within the shale. The abundance of ammonoids and belemnoids or coleoids throughout the succession and occurrence of dark shales over a distance in excess of 1500 Km. all along the Himalaya suggest the presence of large open marine basin with low-relief hinterland and relatively uniform conditions. The Spiti Shale Formation is overlain by the Giumal Sandstone Formation of Early Cretaceous age. It is ca200m thick, medium to fine grained, pinkish yellow to brownish, quartzitic sandstone beds alternating with dark black, grey to earthy shales. The thickness of the sandstone beds increases upwards in the column. The lithostratigraphic contact of these

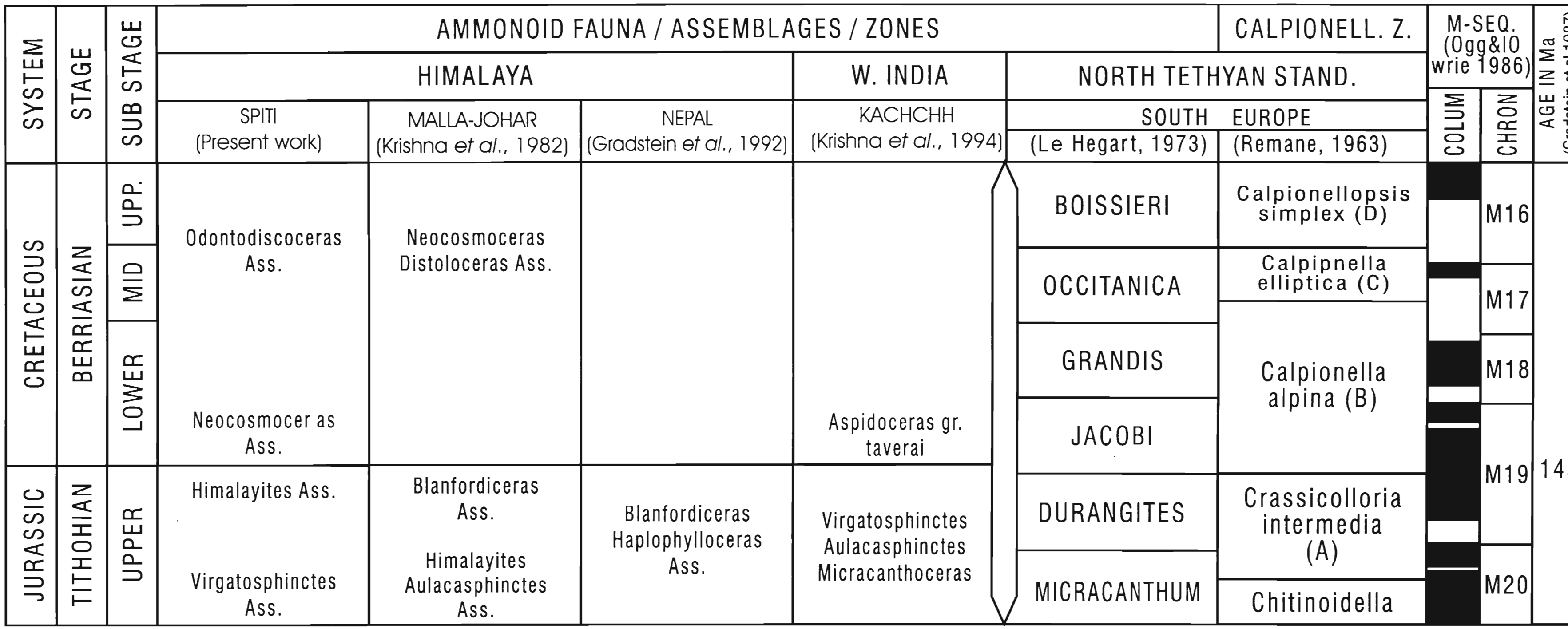

Fig. 4. Biostratigraphic correlation of the Jurassic/Cretaceous boundary ammonoid assemblages between the Himalaya, western India and the standard Tethyan scheme along with their integration with the known radiomagnetochronologic dates.

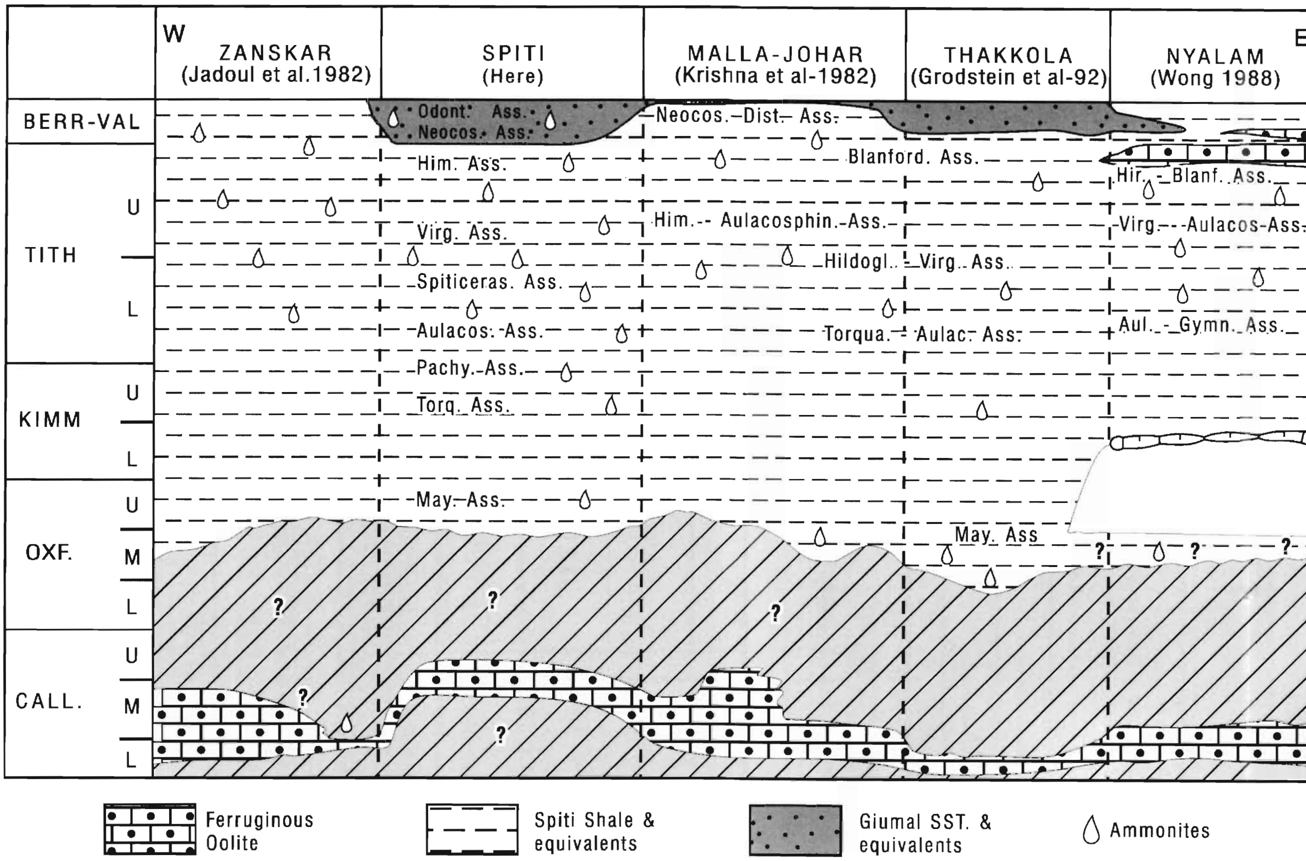

Fig.5. Stratigraphic and geographic distribution of the Spiti Shale Formation in the Himalayan belt.

two formations is known to be gradational (Krishna *et al.*, 1982). It is difficult to define the formational contact on the basis of physical appearance as shale's darker nature continues even up to much higher levels in the Giumal Sandstone Formation. On the other hand, the appearance of the first bed (bed 13 of Fig. 3) representing the typical Giumal Sandstone type of facies is abrupt. It is identifiable from a distance, throughout the study area and continues in the entire Himalayan belt. Thus, the lithostratigraphic contact of the Spiti Shale Formation and the Giumal Sandstone Formation can be safely placed at the base of this first sandstone unit. The upward transition from beds with marine biota to relatively poorly fossiliferous beds and the appearance of thick coarsening upward sequence with plant fragments strongly suggest a deltaic despositional setting for the lower part of the Giumal Sandstone Formation.

AMMONOID ASSEMBLAGES

A marked biotic change has been observed at the contact of the Spiti Shale Formation and the Giumal Sandstone Formation. Most of the Tithonian ammonoid genera (*Virgatosphinctes, Aulacosphinctes, Blanfordiceras, Himalayites*, etc.) abundant in the Upper Member (Pathak, 1993) of the Spiti Shale Formation, disappear near the top (Pl. I, figs.1-2), while new genera (*Odontodiscoceras, Neocosmoceras, Berriasella, Neocomites*, etc.) of the Berriasian (Pl. I, figs. 3-5) appear in the overlying bed (base of Giumal Sandstone Formation). Based on the taxonomic studies of the present ammonoid collections, the latest Tithonian and earliest Berriasian ammonoid assemblages have been identified respectively as *Himalayites* Assemblage and *Neocosmoceras* Assemblage, named after the most common forms in the respective intervals (Fig. 3).

Himalayites Assemblage

It represents the ca 60 to 90m thick part of the Spiti Shale Formation and includes *Himalayites* gr. *seideli* (Oppel), *H.*sp., *Virgatosphinctes densiplicatus* (Waagen), *V.*sp., *Aulacosphinctes* cf. *latouchei* Uhlig, *Kossmatia tenuistriata* Gray , K. aff. *koeneni* Uhlig, *Blanfordiceras cricki* Uhlig, *Spiticeras eximus* Uhlig and *S.* aff. *bulliformis* Uhlig. The genus *Himalayites* has been recorded from the Late Tithonian of the Himalaya (Uhlig, 1903-10; Pathak, 1997) and Spain (Tavera, 1985). *Virgatosphinctes densiplicatus* (Waagen) is a well known species of the Tithonian occurring from East Africa to Indonesia – New Guinae on the South Tethyan Margin, often in association with *Micracanthoceras* and *Aulacosphinctes.* These evidences suggest Upper Tithonian age for present *Himalayites* Assemblage (Fig. 4).

Neocosmoceras Assemblage

It represents the oldest 10 to 12m thick part of the Giumal Sandstone Formation. *Neocosmoceras, octagonus* (Strachey-Blanford) and *Odontodiscoceras odontodiscus* Uhlig are the most common elements within this interval. The genera *Berriasella, Neocomites* and *Kilianella* also make their first appearance here, while *Spiticeras* continues from the older beds. *Neocosmoceras* is known to range from Jacobi Zone to Early Boisseri Zone of the Berriasian in the Submediterranean Europe (Le Hegart, 1973; Tavera, 1985). In addition, the ammonoid genera *Neocomites, Kilianella* and *Berriasella* are well known in the Berriasian fauna of the Tethys. These evidences suggest a Berriasian age for the *Neocosmoceras* Assemblage (Fig. 4). It also indicates that the ammonite genus *Odontodiscoceras,* a common endemic Himalayan form recorded from several localities of the Himalayan belt (Uhlig, 1903-1910), appears in the Berriasian and not restricted in the Valanginian.

CONCLUSIONS

The first appearance of the ammonoid genera *Odontodiscoceras/Neocosmoceras* marks the beginning of the Cretaceous (Jurassic/Cretaceous boundary) in the Himalayan belt which also coincides with the last appearance of the genus *Virgatosphinctes* near the formational contact of the Spiti Shale and the Giumal Sandstone (Fig. 5). The rare appearance of the genera *Berriasella, Neocomites* in the Guimal Sandstone helps in regional and global correlation of this System boundary within the Tethyan realm.

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