Ammonoid stratigraphy of the Spiti Shale (Upper Jurassic), Tethys Himalaya, India

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With 4 figures and 1 table in the text

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Abstract: The Spiti Shale (Formation) of the Malla Johar area, Uttar Pradesh, is divided into two: (A) Lower Spiti Shale division (Oxfordian – Kimmeridgian) which is abundantly belemnitiferous and (B) Upper Spiti Shale division which is prolificly ammonoid bearing. The upper division reveals a succession of five distinct ammonoid assemblages ranging from Lowest Tithonian to Berriasian-Valanginian. It is proposed to adopt the Malla Johar area as the type locality for the Spiti Shale.

Key words: Lower Spite-Shale Formation (Oxfordian-Kimmeridgian), Upper Spiti-Shale Formation (Tithonian-Valanginian), section, shale, sand, limestone, nodule, biostratigraphy, ammonite fauna, population; Uttar-Pradesh (Malla Johar).

Zusammenfassung: Die Spiti Shale (Formation) von Malla Johar, Uttar Pradesh, wird aufgrund unterschiedlicher relativer Häufigkeiten von Ammoniten und Belemniten zweifach unterteilt: (A) in eine Untere Spiti-Shale-Stufe (Oxford – Kimmeridge) mit überwiegend Belemniten und (B) eine Obere Spiti-Shale-Stufe, die vorwiegend Ammoniten enthält. Die Ammoniten-führende obere Schicht weist eine Abfolge von fünf charakteristischen Ammoniten-Vergesellschaftungen auf, die vom Untersten Tithon bis Berrias-Valendis reichen. Das stratigraphisch und paläontologisch besser untersuchte Malla-Johar-Gebiet wird als Typ-Lokalität für den Spiti-Shale vorgeschlagen.

Introduction

The Spiti Shale (Formation) is a classic Upper Jurassic to early Lower Cretaceous stratigraphic unit of the Tethys Himalaya known for its rich and well preserved ammonoid fauna. In India, the rocks of this formation are exposed in Spiti Valley (Himachal Pradesh) in the west and Malla Johar region (Uttar Pradesh) in the east. Farther east, it continues in Nepal and is well exposed in Thakkhola region. Although named after the Spiti Valley in Himachal Pradesh, the Spiti Shale shows a much better and differentiated development in Malla Johar region, Uttar Pradesh.

GRIESBACH (1891) subdivided the Spiti Shale into three divisions: (a) the lower division of dark splintary shales with only belemnoids; other fossils are rare, (b) the middle division of friable dark shales with concretions containing ammonoids, and (c) grey shales with few fossils and at the top containing sandy layers. Later DIENER (1895) gave names to these subdivisions as (a) Belemnites gerardi beds (Lower Spiti Shale) - Upper Oxfordian, (b) Chidamu Beds (Middle Spiti Shale) -Lower Tithonian to Upper Kimmeridgian and (c) Lochambel beds (Upper Spiti Shale) – Upper Tithonian to Valanginian, These subdivisions were also adopted by UHLIG (1910) (in ARKELL 1956). However, these three subdivisions are not described from a single section and there is a considerable overlap in them, especially between the Chidamu and Lochambel beds. Out of the three subdivisions the lowest is named after a fossil, while the other two are named after localities in the Malla Johar region. Further 75% to 80% of the ammonoid species described from the Spiti Shale (UHLIG 1903–1910) are based on figured types from Malla Johar region. In the background of the above facts and in accordance with the current concept of the stratigraphic nomenclature it is most logical to adopt the Malla Johar region as the type section area for the Spiti Shale.

The ammonoid stratigraphy briefly presented in the present paper is based on our preliminary results. Ammonoid succession and association are proposed in conjunction with similar data from other parts of the Tethys realm areas. Some of the earlier generic assignments of the ammonoids have been revised in the light of post UHLIG work. Detailed systematics, inter-regional and inter-continental correlations, biogeographic relations and their implications on geodynamics are beyond the scope of this paper and shall be discussed later elswhere.

The present work is based on the collections of ammonoid fossils made in the neighbourhood of Laptal camping ground (Fig. 1) during three expeditions in 1972, 1973 and 1974. The first two expeditions were organised by the Wadia Institute of Himalayan Geology of which one of us (S. K.) was a member while the third expedition was sponsored by the Geology Department, Lucknow University of which two of us (S. K. & I. B. S.) were the members. A small collection of ammonoids obtained by one of us (J. K.) from Dr. V. K. GAIROLA of the Geology Department, Banaras Hindu University (a member of 1973 expedition of the Wadia Institute of Himalayan Geology) proved to be a good supplement.

Previous work

The discovery of the ammonoids from the Spiti shales goes back to STRACHEY (1851) and SCHLAGINTWEIT BROTHERS (in OPPEL 1863) which were worked out respectively by BLANFORD (in SALTER & BLANFORD 1865) and OPPEL (1863). GRIESBACH (1891, 1893) attempted to collect ammonoids with some stratigraphic control which subsequently resulted in the monographic work of UHLIG (1903–1910). Later HEIM & GANSSER (1939) made some observations on the litho-



Fig. 1. Location and geological map of the Laptal area, Malla Johar, Kumaon Himalaya, India. – 1. Kioto Limestone, Laptal Formation and Ferruginous Oolite Formation; 2. Spiti Shale; 3. Giumal Sandstone.

stratigraphy and ammonoid biostratigraphy of the Spiti Shale. GANSSER (1964) very briefly summarised the status of this unit as available up to that time. Some information on the comparable ammonoid fauna is now available from the neighbouring regions of Nepal (BORDET et al. 1964; HELMSTAEDT 1969; MOUTERDE 1971).

Geological setting

The Spiti Shale, made up of ca. 250 m thick black friable shales crops out in the Tethys Himalayan Zone in a very hazardous terrain with height ranging from 3400 to 5400 m. The area is accessible only during the months of July to September and for the rest of the year it is covered by snow.

The Spiti Shale conformably overlies the Ferruginous Oolite Formation (Callovian) and upward grades into the Giumal Sandstone (Fig. 2, Tab. 1). It constitutes the lowermost formation of the Sancha Malla Group of KUMAR et al. (1977), and forms part of the folded sequence (HEIM & GANSSER 1939; KUMAR et al. 1977). Mesoscopic folds and a number of faults are present which often make the lithostratigraphy of the Spiti Shale quite complicated.

The lower part of the Spiti Shale contains thin sandy intercalations and the uppermost part shows presence of sand-chert layers. The entire succession is characterised by the calcareous nodules which on breaking yield very well preserved fossils, mostly ammonoids. There are horizons rich in belemnoids, particularly in the

m		Gi	umal	HAUTERIVIAN - Albian	
240			LOCHAMBEL BEDS	NEOCOSMOCERAS - DISTOLOCERAS	BERRIASIAN -
				ASSEMBLAGE	VALANGINIAN
210				BLANFORDICERAS ASSEMBLAGE	LATE UPPER TITHONIAN
		VTED		HIMALAVITES - CORONGOCERAS-	EARLY UPPER
	1.555			AULACOSPHINCTES ASSEMBLAGE	TITHONIAN
180		N	CHIDAMU BEDS		
150		AMMONOID-DOM UNIT		HILDOGLOCHICERAS- VIRGATOSPHINCTES ASSEMBLAGE	MIDDLE TITHONIAN
90				<u>TORQUATISPHINCTES</u> - <u>AULACOSPHINCTOIDES</u> ASSEMBLAGE	LOWER TITHONIAN
60 30		BELEMNOID-DOMINATED UNIT	<u>B</u> <u>Gerardi</u> Beds	NO AMMONOIDS -	OXFORDIAN - Kimmeridgian
	000000000000000000000000000000000000000	Fei	rugir	CALLOVIAN	
	= = <u>=</u> 1		2	···· 3 4	5

Fig. 2. Lithology of the Spiti Shale formation with ammonoid zones near Laptal area. The boundaries of the ammonoid assemblages in the litholog are only tentative. - 1. Shales; 2. Sandy intercalations; 3. Nodules; 4. Bands of nodular limestone; 5. Chert layers.

lower part. Besides ammonoids and belemnoids the other megafossils are gastropods, brachiopods and lamellibranchs.

The environment of deposition of the Spiti Shale is a shelf mud region of an open sea (KUMAR et al. 1977). However, the presence of bedded chert and trace fossil *Zoophycus* in the uppermost part of the succession indicates deposition in the deeper part of the continental shelf to shallower parts of the continental slope (SINGH et al. 1980).

Ammonoid biostratigraphy

Ammonoids occur prolificly at several horizons interspersed in the 250 m thick succession of the Spiti Shale but their abundance is particularly felt in a 15–20 m thick zone lying about 80 m above the base of this formation and again at the uppermost 30–40 m of the succession. It is surprising but significant that the basal ca

Supergroup	Group	Formation	Lithology	Age
M a 1 1 a	Sancha Malla Group	Giumal Sandstone 400 m	Glauconitic sandstone, shales, siltstone and radiolarian cherts	Hauterivian- Albian
J o h a r		Spiti Shale 250 m	Black friable shales and siltstone with abundant nodules containing ammonites	Berriasian – Valanginian to Oxfordian
S u P e r g	Rawali- bagar Group	Ferruginous Oolite Formation 10 m	Ferruginous oolitic limestone and shale	Callovian
r o u p		Laptal Formation 70 m	Shell limestone, limestone, oolitic limestone, marl and shales	Liassic

Tab. 1. Lithostratigraphic subdivision of a part of the Tethys sediments, Malla Johar area (after HEIM & GANSSER 1939, modified by KUMAR et al. 1977).

80 m thick succession has not yielded ammonoids although booming with belemnoids.

On the basis of the distribution of belemnoids and ammonoids the Spiti Shale is broadly distinguished into two divisions: (A) Lower Spiti Shale division which is largely belemnitiferous and (B) Upper Spiti Shale division which is proloficly ammonitiferous. The lower part of the Upper Division is dominated by virgatosphinctin ammonoids and upper part of the Upper Division is characterised by strongly ornamented berriasellids. The checklist of ammonoid genera in the present collection is as follows:

Torquatisphintes SPATH, Aulacosphinctoides SPATH, Subdichotomoceras SPATH, Aulacosphinctes UHLIG, Katroliceras SPATH, Virgatosphinctes UHLIG, Uhligites KILIAN, Gymnodiscoceras SPATH, Haplophylloceras SPATH, Kossmatia UH-LIG, Paraboliceras UHLIG, Paraboliceratoides SPATH, Corongoceras SPATH, Himalayites UHLIG, Spiticeras UHLIG, Berriasella UHLIG, Blanfordiceras COSS-MANN, Boehmiceras GRIEGORIEVA, Odontodiscoceras SPATH, Neocomites UHLIG, Substeuroceras SPATH, Bochianites LORY, Distoloceras SPATH, Acanthodiscus UH-LIG, Neocosmoceras BLANCHET, Pterolytoceras SPATH and Phylloceras UHLIG.

These ammonoids belong to 5 more or less distinct ammonoid assemblages appearing in succession within the Upper Spiti Shale (Figs. 3 and 4). These assemblages are as follows (in ascending order):

- 5. Neocosmoceras Distoloceras assemblage (Berriasian Valanginian) early Lower Cretaceous
- 4. Blanfordiceras assemblage (late Upper Tithonian)
- 3. *Himalayites Corongoceras Aulacosphinctes* assemblage (early Upper Tithonian)
- 2. Hildoglochiceras Virgatosphinctes assemblage (Middle Tithonian)
- 1. Torquatisphinctes Aulacosphinctoides assemblage (Lower Tithonian).

The tentative position of these ammonoid assemblages is indicated in the litholog (Fig. 2).

Ammonoid assemblages

1. Torquatisphinctes – Aulacosphintoides assemblage (Lower Tithonian): The assemblage mainly comprises Torquatisphinctes aff. alterneplicatus (WAAGEN), T. sp., Aulacosphinctoides uhligi SPATH, A. infundibulum (UHLIG), A. aff. chidamensis (UHLIG), Katroliceras sp., Subdichotomoceras sp., Uhligites sp., and Gymnodiscoceras acucincta (BLANFORD). Virgatosphinctin genera Torquatisphinctes and Aulcosphinctoides are the dominating elements of this assemblage. Aulacosphinctes and Virgatosphinctes are also present although these are better represented in the successive younger assemblage. Uhligites and Gymnodiscoceras are recorded in good number but are not restricted to this assemblage.

The virgatosphinctin ammonoids present in this assemblage show bi- and multiplicate ribbing with or without single rib intercalations and appear to intergrade and infringe upon one another in tightness of coiling, whorl section etc. Consequently these are understood differently, erratically and arbitrarily by different workers and thus need a thorough revision. Therefore, the present generic assignments are rather provisional.

The virgatosphinctin ammonoids are distributed almost throughout the Indo-E. African and SE Asian regions generally at the level of Hybonoticeras hybonotum standard Chronozone marking the beginning of the Tithonian stage. However, it is likely that some species might have even appeared towards the close of the Kimmeridgian s.s. stage. On the other hand many such forms seem to continue in the two successive assemblages. This fauna is particularly distinct and uniformly present in East Africa (VERMA & WESTERMANN, personal commun.), Madagascar (COLLIGNON 1959, 1960) Kachchh (SPATH 1924–1933; JAI KRISHNA, unpubl. data), Jaisalmer (JAI KRISHNA 1975, 1979 and unpubl. data), Nepal (BORDET et al. 1964; HELMSTAEDT 1969), although in some areas the assemblage is much depleted.

2. Hildoglochiceras – Virgatosphinctes assemblage (Middle Tithonian): The ammonoids Hildoglochiceras kobelli (OPPEL), Virgatosphinctes densiplicatus (WAAGEN), V. kraffti UHLIG, Paraboliceratoides aff. mutilis (OPPEL), Kossmatia



aff. tenuistriata UHLIG, are present in this assemblage. Kossmatia and Paraboliceratoides are also present in the next younger assemblage. On the whole this assemblage is neither very distinct nor inseparable from the succeeding assemblage. In fact it appears to be mixed up with the next younger assemblage which mainly comprises himalayatin ammonoids. According to ZEISS (1968) Hildoglochiceras and Virgatosphinctes in Madagascar correspond to the Semiformis standard Chronozone of Europe; on the other hand Kossmatia is found associated with Corongoceras and Himalayites in Argentina and Mexico (VERMA & WESTERMANN 1973), while in SE Asia this fauna underlies himalayatin assemblage. However, it is surmised that future studies would establish this Middle Tithonian assemblage on better footing. This assemblage, although present, is scantly represented in Kachchh and often put together with Virgatosphinctes – Micracanthoceras – Aulacosphinctes beds in Upper Tithonian, while Middle Tithonian is considered devoid of ammonoids in Kachchh (ENAY 1973).

3. Himalayites – Corongoceras – Aulacosphinctes assemblage (early Upper Tithonian): It comprises Himalayites cf. seideli (OPPEL), H. ventricosus UHLIG, Corongoceras (two new species), Aulacosphinctes morekianus (OPPEL), A. sp., Virgatosphinctes multifaciatus UHLIG. This assemblage signals the beginning of Upper Tithonian (= Upper Kimmeridgian/Portlandian boundary), and is quite rich. The genus Corongoceras, an essentially S. American form is being reported and illustrated for the first time from the Tethys Himalaya or any SE Asian region. It is also not found anywhere east of Madagascar. The Malla Johar species of Corongoceras are, however, new and differ much from the S.American and Madagascar species. Occurrence of Corongoceras helps as an important tool for intercontinental correlation. It also suggests the availability of direct migration channel between the Tethys Himalaya and S.America through the Trans-Erythracean trough round the S.African coast in early Upper Tithonian. This assemblage is also present in

Fig. 3.

Torquatisphinctes - Aulacosphinctoides assemblage

1a: Lateral view of Torquatisphinctes aff. alterneplicatus (WAAGEN).

- 1b: Ventral view with whorl section of T. aff. alterneplicatus (WAAGEN).
- 2. Ventral view of Torquatisphinctes sp.
- 3a: Lateral view of a virgatosphinctin ammonoid (either Subdichotomoceras or Katroliceras or Aulacosphinctes).
- 3b: Ventral view of the same ammonoid as in 3a.

4 and 5: Lateral views of whorl fragments of Aulacosphinctoides sp.

Hildoglochiceras - Virgatosphinctes assemblage

^{6:} Lateral view of Virgatosphinctes densiplicatus (WAAGEN).

^{7:} Lateral view of Hildoglochiceras kobelli (OPPEL).

Himalayites - Corongoceras - Aulacosphinctes assemblage

⁸a: Lateral view of Corongoceras sp.

⁸b: Ventral view with whorl section of Corongoceras sp.



Madagascar (Collignon 1959, 1960), Kachchh (Spath 1924–1933), Nepal (Bordet et al. 1964; Mouterde 1971) as well as in South America (Verma & Westermann 1973).

4. Blanfordiceras s.s. assemblage (late Upper Tithonian): This assemblage is named after the genus Blanfordiceras s.s. [B. wallichi (BLANFORD) group], in view of its being the most dominant element in late Upper Tithonian in Malla Johar area. In terms of individuals it also forms about 20% of the entire ammonoids in the present collection. A single specimen of Spiticeras is also present in this assemblage. This fauna is distinctly identifiable in Madagascar (COLLIGNON 1960), Nepal (MOUTERDE 1971), Indonesia (SATO et al. 1978), New Guinea (GERTH 1969; HELMCKE et al. 1978) etc. and is considered equivalent of Proniceras – Substeuroceras assemblage of S.Europe and S.America (ENAY 1973).

5. Neocosmoceras – Distoloceras (Berriasian – Valanginian): Youngest of the ammonoid assemblages of the Upper Spiti Shale division represents both the Berriasian and Valanginian stages. It comprises Boehmiceras boehmi (UHLIG), B. asseni (BOEHM), B. celebrans (UHLIG), B. latidomus (UHLIG), B. middlemissi (UH-LIG), Bochianites sp., Pterolytoceras exoticum (OPPEL), Neocosmoceras (= Acanthodiscus) subradiatus (UHLIG), N. acanthicus_(UHLIG), N. octagonus (BLAN-FORD), etc. In comparison to the Tithonian stage, the early Lower Cretaceous stage sediments are much less in thickness in Malla Johar, most probably on account of slower rate of sedimentation. This assemblage is meagre and both the stages are apparantly mixed up. The first and the only lytoceratid ammonoid Pterolytoceras is an important element of this assemblage. This fauna, although not very distinct, is possibly present in Nepal (BORDET et al. 1964; MOUTERDE 1971; HELMSTAEDT 1969), Indonesia (HELMCKE et al. 1978; SATO et al. 1978), and New Guinea (GERTH 1965; SATO 1965) but is not known from E.Africa, Jaisalmer and Kachchh.

Stratigraphically further up the Spiti shales gradually grade into the Giumal sandstones. The contact seems to be gradual and conformable, but no ammonoids are present, probably related to deepening of the basin of deposition.

Fig. 4

3b: Lateral view of B. middlemissi (UHLIG).

Blanfordiceras assemblage

^{1:} Septal suture pattern of Blanfordiceras.

^{2:} Ventral view of B. wallichi (BLANFORD).

Neocosmoceras - Distoloceras assemblage

³a: Ventral view of Boehmiceras middlemissi (UHLIG).

^{4:} Lateral view of Bochianites sp.

^{5:} Lateral view of Pterolytoceras exoticum (OPPEL).

^{6:} Lateral view of Neocosmoceras subradiatus (UHLIG); x 0.5.

⁷a: Lateral view of Distoloceras sp.

⁷b: Ventral view of Distoloceras sp.

Conclusions

- 1. On the basis of the present study of ammonoids the Spiti Shale can be subdivided into two: (A) Belemnitiferous Lower Spiti Shale Division and (B) Ammonitiferous Upper Spiti Shale Division.
- 2. The age of the belemenitiferous lower division is favoured as Oxfordian Kimmeridgian in view of the Callovian-Oxfordian benthonic foraminifers (SINGH & KUMAR 1978), presence of mayaitin ammonoids (SPATH 1924–1933) and rich and distinctive dinoflagellates assemblage (K. P. JAIN personal communication) of Oxfordian – Kimmeridgian age from the topmost part of this division.
- 3. Absence of definite Kimmeridgian ammonoids is noteworthy in the Malla Johar region, but this observation is consistent with the still more baffling absence of definite Kimmeridgian ammonoids throughout the Indo-E. African, Tethys Himalayan and SE Asian regions, and yet no proper explanation of this consistence absence has come forth from any quarter.
- 4. Biostratigraphically the present study splits up the ammonitiferous Spiti Shale Division into five distinct ammonoid bearing zones which are easily correlatable with similar assemblages in Indo-E. African, SE Asian, S. European and S, American regions.
- 5. It broadly delineates the Jurassic/Cretaceous boundary in the Malla Johar area of the Tethys Himalaya and clearly establishes that the topmost 15–20 m of the Spiti Shale is definitely early Lower Cretaceous in age up to Valanginian or even lowest Hauterivian.
- 6. The major part of the Upper Spiti Shale Division is Tithonian which is divisible into Lower, Middle and Upper units with four ammonoid assemblages.
- 7. A revised checklist of ammonoids from Malla Johar area in the light of post UH-LIG literature is given.
- 8. Palaeoecologically, both the belemnoid bearing Lower Division as well as the ammonoid bearing Upper Division suggest a gradually increasing water depth, although confined within the continental shelf except for the early Lower Cretaceous part which might even extend to shelf slope edge.

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