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UPPER JURASSIC (TITHONIAN) AMMONITES FROM THE SPITI SHALES IN WESTERN ZANSKAR (NW HIMALAYAS)

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Key-words: Paleoecology, Biostratigraphy, Ammonites, Upper Jurassic, Zanskar (NW Himalayas).

Abstract. A description is given of the ammonites collected during the Italian expedition to the Zanskar region of the NW Himalayas in 1984. The paleontological analysis is made in the context of a depositional and ecological model proposed for Spiti Shales facies. The genera *Uhligites*, *"Virgatosphinctes"*, *Aulacosphinctes* and *Parapallasiceras* are identified. An upper-to uppermost Lower Tithonian age is assigned for the highest levels of the Spiti Shales Fm. in the sector examined, although it may be possible that the extreme base of the Upper Tithonian is also represented.

Introduction and geological setting.

This paper deals with a small ammonite fauna found near Sneatze (Western Zanskar) in the famous unit of the Spiti Shales.

During the Italian geological expedition in Zanskar in the summer of 1984, one of us (A.T.) surveyed in particular the Jurassic units (Jadoul et al., 1985; Gaetani et al., 1986). As regards the Mesozoic, most of the expedition took place in the Zangla Nappe (Baud et al., 1984), but a few observations were made also along the front of the Zumlung Nappe (Baud et al., 1984). Three main lithostratigraphic units are distinguishable between Ringdom Gompa and Tantak, even though they are often incompletely present as a result of the heavy tectonics of the area (Gaetani et al., 1985). The Kioto Limestone is uppermost Triassic-Late Liassic in age (Gaetani et al., 1986) and is rather poor in macrofossils there. The top of this unit is characterized by boring, dolomitisation and colonisation by large ostreids, possibly related to an important gap (Jadoul et al., 1985). The Ferruginous Oolite Formation sharply overlays the Kioto Limestone; its Callovian

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age is confirmed by a few ammonites (Jadoul et al., 1985). The Spiti Shales Formation continues upwards, perhaps with a further time gap in the lowermost part.

More recently one of us (A. T., during a 1987 expedition) focused the same units in the Zumlung Nappe: the Kioto Limestone is there richer in fossils and upward it gradually gives way to the Laptal Beds (Heim & Ganser, 1939). The Ferruginous Oolite Fm., perhaps with no time gap, overlays the Laptal with its characteristic facies, here usually rich in brachiopods, pelecypods and a few ammonites. Preliminary identification of the fauna gives a Bathonian age for the Laptal Beds and perhaps for the lowermost Ferruginous Oolite Fm. (*Oxycerites* sp. ind., *Hecticoceras* sp.) also. However the bulk of the latter formation is Callovian (*Indosphinctes* sp., *Hubertoceras* sp., *Ivanoviella* sp.). The lack of unconformity between the Kioto+Laptal and Ferruginous Oolite Fm., along with a richer content in fossils, is consistent with a more basinal environment towards the north. Furthermore, the presence of Bathonian fossils in the Ferruginous Oolite Fm. confirms the heterochrony of the unit already evidenced in the Zangla Nappe (Jadoul et al., 1985).

We see no reason to consider the Ferruginous Oolite Fm. as the basal member of the Spiti Shales (Westermann & Wang, 1988, p. 297) and so, in accordance with other previous authors (Arkell, 1956; Krishna, 1981; Gaetani et al., 1986), we maintain the classical three-part subdivision though the uppermost member, the Lochambel Beds, is not present in this area.

The Spiti Shales, with a sharp contact in their base, are superimposed everywhere on the Ferruginous Oolite Fm. In the Zangla Nappe, the thickness of this unit is between 20 and 60 m, while it seems to be greater in the Zumlung Nappe. Usually, in this structural unit, only the lower member, the so-called *Belemnopsis gerardi* Beds, is present. As everywhere, this member is rich only in belemnites, ammonites being very rare. Carefull sampling was carried out in different sections in order to find ammonites, but with no positive results: nodules are often present, but empty. Only at one site, near Sneatze and close to the confluence of the Oma and Zanskar Rivers, an ammonite assemblage was recovered, but it has turned out to be characteristic of the Chidamu Beds (the middle member of the Spiti Shales). The fossiliferous level lies just below a tectonic contact with the Giumal Sandstone, but it is above a main tectonic line running all along the Zangla Nappe.

Elsewhere in the Zangla Nappe the Spiti Shales, or rather their lower member, seem to pass gradually to the Giumal Sandstone itself. The presence of Chidamu Beds faunas in the Sneatze outcrop may help in clarifying the structure of the area. It is possible that the area comprising the Sneatze site belongs to a different tectonic unit than the Zangla one. In particular, there are some resemblances with the more northern ones, i.e. the Zumlung Nappe, in which the Spiti Shales are widely exposed with both *Belemnopsis gerardi* Beds and Chidamu Beds. In fact, if we assume that the shelf was sloping toward the North, it is probable that the Spiti Shales facies deposition lasted longer in deeper and more distal environments than closer to the land providing clastic supports (Giumal Sandstone).

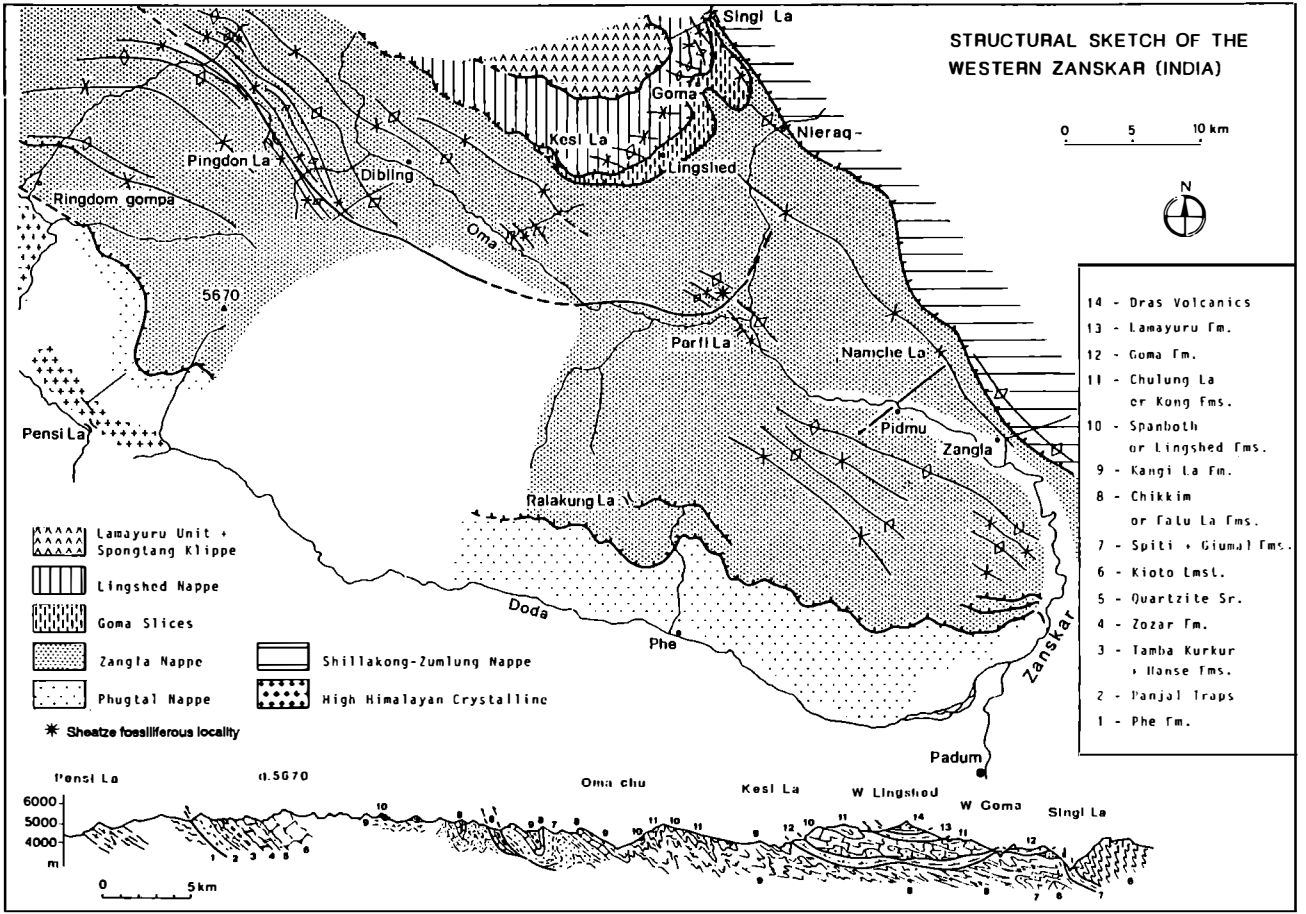

Fig. 1 - Structural sketch of the Western Zanskar (after Gaetani, Garzanti & Jadoul, 1985, slightly modified).

The finding of this small fauna is also of interest because collection was made in great detail, thus allowing good opportunities for correlation with other areas both in the Himalayas and elsewhere. Furthermore, this record represents the most westerly known fossiliferous locality in the Spiti Shales.

In the paleontological descriptions a double number is given to each specimen: the first one is the field number (HZ...) while the second is the definitive catalogue number of the Paleontological Museum of the Dipartimento di Scienze della Terra of the Milano University.

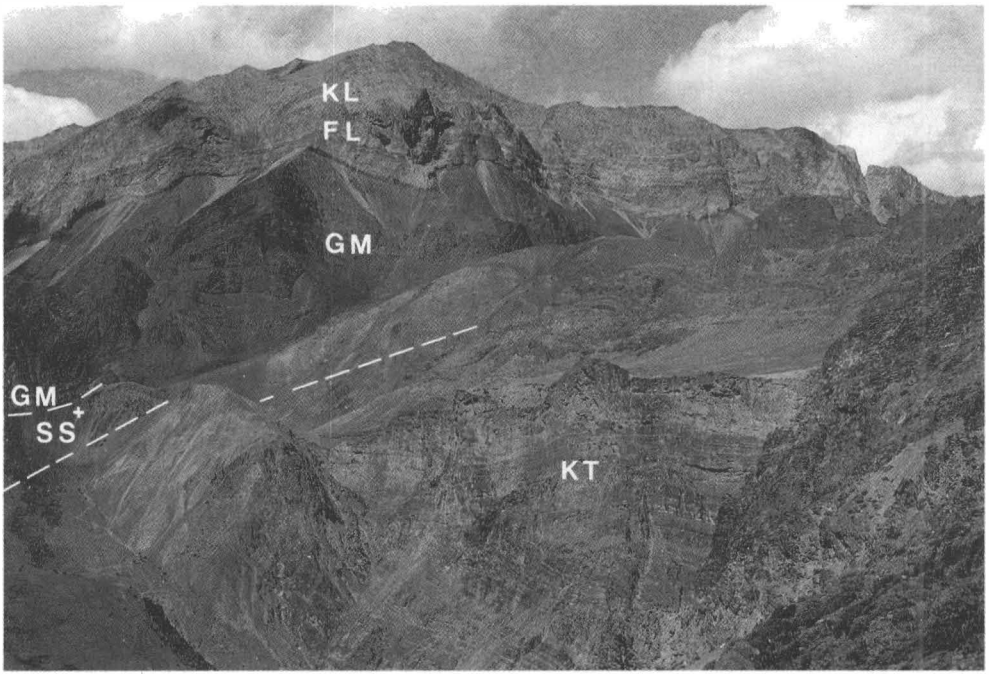

Fig. 2 - The Sneatze area from the Parfi La. +) The fossil locality; KT) Kioto Limestone; SS) Spiti Shales; GM) Giumal Sandstone; FL) Fatu La Formation; KL) Kangi La Formation; - -) fault.

Notes on ammonites.

In cases such as the present one, with a scarce but valuable collection of ammonites from a little known region, paleontological analysis tends to concentrate on the identification of the ammonites at the level of genus and/or species and the subsequent biostratigraphic interpretation for the correlation of the strata. Other considerations to do with ecological aspects are not usually taken into account in this type of analysis. However, Olóriz (1986) underlines the importance of ecological questions in the interpretation of the geographical distribution of ammonites, and also their effect on the in-

terpretation of questions related with systematics and evolutionary aspects. Thus, in the context of the eco-evolutionary model proposed by this author, we establish the following methodological sequence for the study of the material obtained by this expedition to the Himalayas: 1) description of the environmental framework and paleoecological considerations, and 2) a systematic approach at a low taxonomic level.

Environmental framework and paleoecological considerations.

Baud et al. (1984), Gaetani et al. (1986) and Garzanti et al. (1988) characterise the Tibetan Zone as a passive margin in which sedimentation was controlled more by eustasy than by tectonics. The hypotheses by these authors are without doubt the widest reference framework which refers to the most important geodynamic factors in this region, factors which determined, more or less directly and to a varying degree, the environments which developed there and the ecological dynamics which affected the different faunas inhabiting them. In this context Kumar et al. (1977), Jadoul et al. (1985) and Olóriz (1986) interpret the Spiti Shales facies as shelf deposits. The latter interprets these facies within the framework of the "Perigondwanian Platforms" as forming part of their "Meridional or Austral arc". This coincides with the interpretation of Krishna (1981) (1), who recognises the faunistic uniformity of the Tethyan Himalayas with the rest of the Indian subcontinent, the materials of which should be considered as belonging to shallow shelf areas.

The data of Gaetani et al. (1986) on belemnite rich beds indicate a platform context which was, at most, moderately distal, and they exclude the possibility of strictly proximal areas. In this sense Krishna (1981) is of the opinion that everything seems to indicate that the belemnites in general preferred shallower nearshore conditions than ammonoids, and he suggests an environment which was a "nearshore shallower part of continental shelf" for "the belemnitiferous lower Spiti Shales, which are a bit sandy". This interpretation seems to be basically correct and is not modified by that of Jadoul et al. (1985), who consider the belemnitiferous intercalations to be secondary concentrations (storm events). Jadoul et al. (1985) do not give details of the type of contact of the base of the said graded biocalcirudites, but their data are consistent with a possible episodic accumulation (tsunami? cf. Jadoul et al., 1985, p.13) and it would not seem possible, given the information available, that such deposits could be related to eustatic sea-level changes.

In this context of shelf sedimentation, the deposition of black shales is normally related to situations of disconnection from the circulation of open sea currents. Olóriz

(1) The studies by this author mentioned in this paper were first brought to the attention of F. Olóriz in 1986.

(1986) suggested the possibility of a restricted circulation for black facies (Spiti Shales) on the Perigondwanian Platforms. Even under these conditions the areas in which this type of facies accumulated were colonized by ammonites, bivalves, gasteropods and some brachiopods. This suggests the existence of sea bottoms in not strictly anaerobic conditions, and that, apart from the fact that the environment was ecologically stressing to a certain degree, the anaerobic-disaerobic conditions must have been limited to a particular depth in the water-sediment interphase. The scarcity of brachiopods may indicate a certain turbidness, and also, possibly, a high nutrient content.

With regard to ammonites, the phenotypes expressed are frequently extreme within the known morphological spectra of the alluded genera, which reveals a marked Platform Effect (s. Olóriz, 1986). As the same author has recently suggested in an analysis of ammonites from the Upper Jurassic in Mexico (Olóriz, 1987b), ecological situations of this type determine ammonite associations subject, basically, to *r* ecological strategies, which can be deduced from the existence of populations with high intraspecific diversity and the presence of "extreme phenotypes" (Olóriz, 1987a).

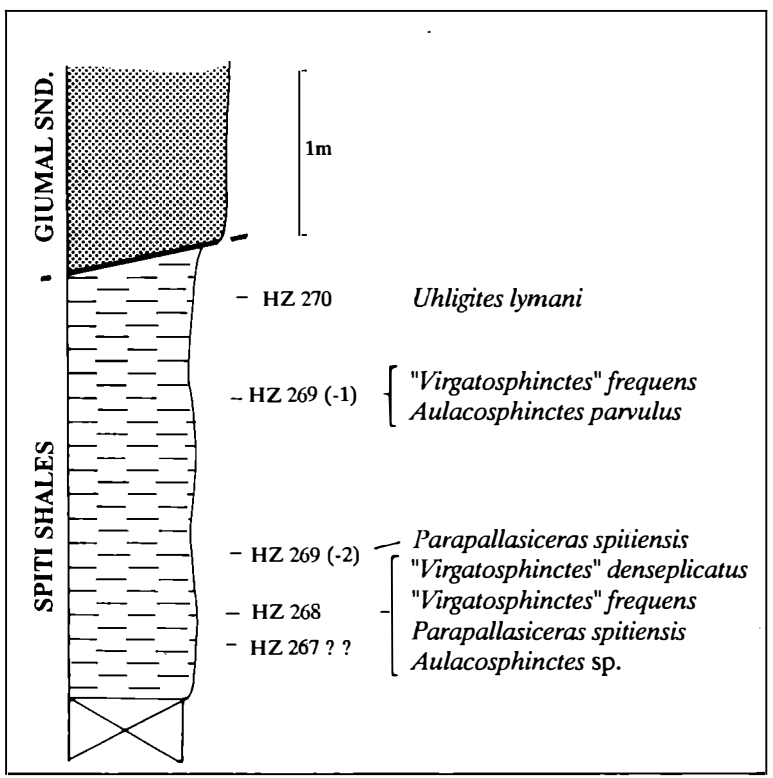

Fig. 3 - The samples position at the Sneatze locality. x—x: the tectonic contact between the Giumal Sandstone and the Spiti Shales.

In short, a possible interpretation for the Spiti Shales could be that of a relatively disconnected platform environment, at least regarding the lower member. The turnover from the predominance by belemnites (*Belemnopsis gerardi* Beds) to that of ammonites (Chidamu Beds) could be related to a deepening of the environment and/or to a collapse of paleogeographical barriers that perhaps opened the way to ammonite immigration. We must point out that the Upper Callovian, Oxfordian and part of the Kimmeridgian are poor in ammonites everywhere in the Indian subcontinent and in the Tethyan Himalayas, so the environment could also have been controlled by factors other than only depth or distance from the land. As already stated by Krishna (1981) and Olóriz (1986), an improvement of the correlations with Tethyan faunas in the course of the Tithonian is known, although endemic forms persisted; this reveals a phase of recolonization of this area by ammonites and must be interpreted as related with paleogeographical changes probably caused by interactions between tectonics and eustatism. Thus it is in this context in which the change from belemnitiferous beds in the lower member of the Spiti Shales to ammonitiferous ones in the middle member of this unit must be considered.

Systematic approach to ammonites.

Even 80 years after the appearance of Uhlig's invaluable monographic study (1903-1910), the illustrated documentation of ammonites from the Himalayan Upper Jurassic is very limited. The studies by Steiger (1914), Helmstaedt (1969) and Mouterde (1971) are contributions which demonstrate the difficulties of obtaining an exact stratigraphic record. Special mention must be made of the studies by Krishna (1981) and Krishna et al. (1982), in which the biostratigraphic analysis and characterisation of ammonite associations in the Indian subcontinent are undertaken. Although the results provide a most valuable biostratigraphic reference, we are still far from having a detailed account of the biostratigraphy at the genus and species levels.

In addition to the difficulties already mentioned, we must also take into account the high morphological diversity characterizing the ammonite associations from the Spiti Shales. This was first recognised by Uhlig (1903-1910, p. 308) and should be interpreted in terms of high intraspecific variability, according to the ecological context described above. Thus many of Uhlig's "species" must by morphotypes (ecotypes) at population level. Given the limitations of the record, we should not be surprised at the difficulties in finding a strict morphological coincidence between the forms illustrated by Uhlig and those collected since then. All of this goes to show the limited knowledge we still have today of the variability of Himalayan faunas at species level. Consequently, in our specific identification we shall omit references to the terms *group*, *confer*, and *affinis*, since their use would mean the attribution of unwarranted importance to Uhlig's types at species level. In this context, we analyze 17 ammonites from 6 samples in the interval of the last 3 m of Spiti Shales in the region examined.

Paleontological descriptions

Superfamily *Haploceratataceae* Zittel, 1884
Family *Haploceratidae* Zittel, 1884
Subfamily *Streblitinae* Spath, 1925
Genus *Uhligites* Kilian, 1907

This genus was created by Kilian (1907) for the *Streblites* from the Spiti Shales described and illustrated by Uhlig (1903-1910). Roman (1938) later proposed *Oppelia (Streblites) kraffti* Uhlig as type-species. Arkell et al. (1957) followed the proposal by Roman (1938). The generic status is accepted in accordance with the most widely accepted interpretation for Tithonian streblitoids. However, this is not a well-known genus (see Ziegler, 1974), and its wide, discontinuous, stratigraphic record (Tithonian-Valanginian) allows for more than one hypothesis regarding its significance.

Uhligites lymani (Oppel, 1863)

Pl. 22, fig. 1a, 1b

1863b *Ammonites lymani* Oppel, p. 272, pl. 76, fig. 3.
1903 *Oppelia (Streblites) lymani* - Uhlig, p. 56, pl. 2, fig. 2; pl. 7, fig. 1.

Material. One specimen (HZ 270; 6574) found in the detritus just below the tectonic contact which separates the Spiti Shales from the Giumal Sandstone.

Description. The body chamber is only partially preserved, it not being possible to observe the initial part. The whorl section is ovate with gently convex flanks. The umbilical margin is probably rounded and the umbilical wall vertical. The ribs are fine and sinuous with a gentle inflection at mid-flank which probably coincides with a gentle inflection of the peristome. Only fine striae can be observed on the lower part of the flanks, while, on the upper part, the costae are stronger, becoming concave towards the aperture. These more marked costae become smooth towards the medio-ventral line but produce in it a series of wide, gentle plicae. In the initial part of the conserved body chamber a well developed ventral crenulation can be seen which becomes obsolescent towards the aperture. These crenulations coincide with the gentle plicae produced by the ribs on the venter. Due to the weakening of the ribs on the anterior part of the body chamber the continuity with the crenulations is lost. Close to the peristome the ventral tubercles weaken sharply and the ribs cross the venter forming a marked proverse sinus whose apex coincides with a minute protuberance. The peristome cannot be described in detail, although the existence of a gentle depression in the venter and the smoothing of the ventral protuberances allow us to consider that the shell is almost adorally complete, perhaps, even, with part of the peristome preserved (ventral expansion and a

possible wide, short lappet). No remains of the suture are preserved. Remains of the siphuncule, which narrows towards the aperture, are found adhering to the dorsal zone of the body chamber, where some of the ventral area of the previous whorl is preserved.

Discussion.

Uhlig's (1903-1910) opinion that the Himalayan "*Oppelia*" are a diversified group of which we have incomplete knowledge is still valid. Taking Uhlig's observations into account (op. cit., p. 33), the structure of the suture gives cohesion to this group, but the diversity of ornamentation, development of the crenulations, whorl sections, size and peristome reveal a certain internal instability (cf. Uhlig op. cit., p. 36). On this evidence we may forecast the grouping together of several Uhlig's "species".

Our specimen shows characters also developed in *lymani* Oppel and *punctatopicta* Uhlig. There is no differentiation between stronger and weaker ribs, as in *lymani*, and so it is more similar to *punctatopicta* even in the type of crenulation on the venter. There is no great difference between these two forms in whorl section, but our specimen is somewhat closer to *lymani* with slightly convex sides and less flatty venter than to in *punctatopicta*. Also, the shell coiling is closer to *lymani*.

As here considered, *Uhligites lymani* (Oppel) could include Uhlig's "species" such as *punctatopicta, platydoma* and *leptodoma*. Thus a range of variability would be established in which sutures and crenulations would be the most stable characteristics vs. variability in whorl section, size, umbilicus and certain ornamental aspects. In this interpretation Oppel's type (1863b, pl. 76, fig. 3a, b) would occupy an extreme position with regard to shell coiling and perhaps also differential development of sculpture. This hypothesis about the range of variability of *U. lymani* (Oppel) will have to be evaluated on the basis of future observations of new material collected with exact stratigraphic reference.

Apart from other references to this species in the Himalayas, *lymani* (Oppel) has been mentioned by Vetters (1905) in the Niederfellabrunn in the Western Carpathians near Vienna. However, this is a phragmocone which differs in some respects from Oppel's type *s. st.* (see Vetters op. cit., p. 242). In any case, this is the only reliable record of *Uhligites* in the European area of the Tethys, since Zeiss (1977) expresses certain doubts about the material studied by Matzka (1936) (1) from the Klentnice Beds. The interesting thing about Vetter's specimen is that it is found in association with other ammonites which have affinities with the associations from Neuburg (SW Germany), as has been pointed out by Arkell (1956) and Zeiss (1977), which indicates an age of upper Lower Tithonian to lowermost Upper Tithonian for the association studied in Niederfellabrunn by Vetters (1905). It may be possible to admit a similar age for the levels in which *Uhligites* has been found in the Spiti Shales examined in Oma Chu (Zanskar).

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(1) We have not been able to consult this study.

Mouterde (1971) mentions *Uhligites* together with *Blanfordiceras, Kossmatia, Paraboliceras, Aulacosphinctoides* and *Virgatosphinctes*, but he points out that the stratigraphic subdivision proposed for the area surrounding Chhökhor (Thakkhola) is merely tentative, probably as a result of the difficulties of sampling.

Krishna (1981) and Krishna et al. (1982) recognise *Uhligites* in the Lower and Middle Tithonian (= Lower Tithonian in the Mediterranean sense) in diverse areas of the Indian subcontinent, and its possible presence cannot be discounted in the lower Upper Tithonian, given the lack of definition of the data from Nepal.

Other mentions to *Uhligites* in the Lower Tithonian can be deduced from the commentaries by Thompson (1980), who appears to place it in the non-basal Lower Tithonian in Alexander Island, near the Antarctic Peninsula, together with *V. frequens* (Oppel) and *V. denseplicatus* (Waagen). Thompson's interpretation is consistent with the correlations of Crame (1982) for the Fossil Bluff Fm., but not for the Latady Fm., which for Crame is of Kimmeridgian age and contains a record of *Kossmatia* (this datum does not seem to concur and has yet to be confirmed). Thompson (1982) maintains his previous hypothesis, although in this case *Uhligites* also appears in the Valanginian, as recorded by Covacevich (1976) from Livingstone Island.

According to all the preceding information, *Uhligites* could be interpreted as a persistent form, apparently beginning in the non-basal Lower Tithonian and extending to the Lower Cretaceous. Another, perhaps more likely possibility is that the records of *Uhligites* are due merely to cases of convergence or, more exactly, to iterative processes.

Superfamily *Perisphinctaceae* Steinmann, 1890

Family *Ataxioceratidae* Buckmann, 1921

Subfamily *Lithacoceratinae* Zeiss, 1968 emend. Tavera, 1985

Genus uncertain (= *Virgatosphinctes* Uhlig, 1910 pars)

The ammonites under study are traditionally included in the genus *Virgatosphinctes* Uhlig, 1910 and in the subfamily *Virgatosphinctinae* Spath, 1923, and, indeed, they come from the same geological region and the same formation (the Spiti Shales) as the forms which gave rise to these taxonomic units. However, the composition of the subfamily *Virgatosphinctinae* seems unnatural ever since Spath's proposal (1923) up to Callomon's recent revision (1981) (1), which admits the dimorph pair *Virgatosphinctes M. - Aulacosphinctoides m. Virgatosphinctes* (Uhlig, 1910) is without doubt an artificial genus which should be limited to the forms of the Meridional or Austral arc of the Perigondwanian Platforms (s. Olóriz, 1986), which develop virgatipartite division (s. Geyer,

(1) J.C. Callomon has recently published an interesting revision of the systematics of the superfamily *Perisphinctaceae.*

1961), and which are morphologically close to the type-species *V. broili* (Uhlig) in their inner whorls. These virgatipartite ribs are an extreme type of division, rare among the Himalayan faunas studied by Uhlig (1903-1910), and more typically developed in those forms close to the Katrol-Group (s. Olóriz, 1976-78; Olóriz & Tavera, 1979). This group has been differentiated by Tavera (1985) as the subfamily *Torquatisphinctinae*. However, the detailed analysis of its identification and delimitation is still to be improved.

Given the lack of an analysis clarifying the status of the genus *Virgatosphinctes* Uhlig, 1910, in this paper we conceive of "*Virgatosphinctes*" in a way rather different to previously accepted treatments, which takes into account the undeniable relation of these forms to the subfamily *Lithacoceratinae* as interpreted by Tavera (1985). For the moment we may only anticipate that in the future these "*Virgatosphinctes*" will be referred to known genera from the Mediterranean Tethys and well represented in Submediterranean Europe, although they are also present in other platforms.

Examples of the relation between genera and species belonging to *Lithacoceratinae*, as considered in this study (1), and *Virgatosphinctinae* (*Virgatosphinctes* in the traditional sense), may be found in Uhlig (1910), Schneid (1915), Arkell (1937), Berckhemer & Hölder (1959) and Leanza (1980) among others. A solution will no doubt be found when an in-depth analysis is made of the status of the genus *Lithacoceras* Hyatt, 1900, and related forms, which at the moment constitute a little known group, as is recognised by Schairer (1976). This revision should not be based on isolated studies of local faunas, but on the comparison of phylogenetic sequences from diverse areas with a good biostratigraphic record (S Spain, SW Germany, Indian subcontinent and some other areas in North and South America), and taking into account the patterns of rib development as elegantly typified by Geyer (1961).

"Virgatosphinctes" denseplicatus (Waagen, 1875)

Pl. 22, fig. 2

1910 *Perisphinctes (Virgatosphinctes) denseplicatus* - Uhlig, p. 313, pl. 53, fig. 3(?); pl. 54, fig. 1; pl. 55, fig. 1-3; pl. 56, fig. 1 (?).

Material. One specimen (HZ 268B; 6575) incomplete and slightly deformed, collected 2.4 m below the contact between the Spiti Shales and the Giumal Sandstone.

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(1) Following Tavera (1985), we exclude Mediterranean- Submediterranean forms such as *Parapallasiceras s. str.*, *Danubisphinctes p.p.*, *Torquatisphinctes*, and *Dorsoplanitoides* which were included by Zeiss (1968) in *Lithacoceratinae* and *Pseudovirgatitinae* and by Callomon (1981) in *Lithacoceratinae*, i.e. are excluded from *Lithacoceratinae* those forms which present evolute whorls and subcircular whorl-sections ("colubrinoid"-type) and which, in general, do not present very complex costal divisions. These are collected under the *Torquatisphinctinae* subfamily from which the *Himalayatidae* developed in the lowermost Upper Tithonian from *Burckhardticeras* and proximate forms.

Description. The specimen is 115 mm in size and the final half whorl belongs to the body chamber. Whorl section is subrectangular to oval. Wide umbilicus. Bifurcate ribbing is dominant. A polygyrate division of "Subplanites-type" is observed towards the final part of the phragmacone. In the conserved body chamber external ribs are intercalated and polygyrates are dominant with the first division around the middle of the flank. As a result of the deformation, the part in which the polygyrate ribs develop is compressed in the direction of coiling, which produces an effect of lengthening of the ribs and closing of the interspaces. Towards the beginning of the unpreserved anterior part of the body chamber the spacing of the primary ribs can be observed, although this spacing may be accentuated by the deformation.

Discussion. The specific delimitation of this specimen is not easy as a result of the afore mentioned peculiarities of the fauna from the Spiti Shales (see also Uhlig, 1910, p. 308) and because the shell is not complete. Among the "species" illustrated by Uhlig, our specimen is closer to the morphotypes of dense and polygyrate ribbing with few external ribs (i. e. *denseplicatus* at least as far as the initial half of the body chamber). Some "species" by Uhlig (1910) with these characteristics are to be found in what we may call the "*contiguus* group" (*subfrequens*, pl. 61, fig. 1; *kutianus*, pl. 76, fig. 1; *himalayanus*, pl. 64, fig. 1; *haydeni*, pl. 61, fig. 2; *discoides*, pl. 49, fig. 2; *subquadratus*, pl. 68, fig. 1; *contiguus*, pl. 68, fig. 2). There is no doubt that this is a morphologically heterogeneous group of, in general, comparatively strong, thick ribbing, in which the forms of more globose section (*himalayanus, subquadratus*) are excluded from the comparison. The rest are definitely Subplanites-type-morphologies (1) characterised by high polygyrate divisions (exceptionally somewhat lower at mid-flank in "*contiguus*", pl. 68, fig. 2) with a lesser development of external ribs (*kutianus*, pl. 76, fig. 1; *discoides*, pl. 49, fig. 2 and to a lesser extent in *haydeni*, pl. 61, fig. 2). Amongst this group of Subplanites-type-forms precisely that denominated *contiguus* by Uhlig (1910) can be distinguished from the rest because of its spaced ribbing, while, in the others, the density of ribbing on the phragmocone is closer to the range of variability considered by Uhlig for Waagen's species. Consequently, the principal difference between the "*contiguus* group" and *denseplicatus* could be the location of the division and their evolution towards the aperture. In this sense, our specimen, despite its deformation, may be considered closer to the *denseplica-*

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(1) *Subplanites s. st.* is older (uppermost Kimmeridgian-lowermost Tithonian). A new genus will have to be created for these forms since they cannot be considered as *Virgatosphinctes s. st.* Other similar forms were described by Collignon (1960) from the Upper Tithonian (Hollandi Zone) in Madagascar (see "*V.*" *rouselli*, pl. 158, fig. 630). Olóriz (1976-78) considers some of the Tithonian "*Subplanites*" from the Indian subcontinent (morphologically convergent with *adelus* Gemmellaro and/or presented as more or less close to *contiguus s.l.*) as related to *Pachysphinctes*. This interpretation of the morphological delimitation and its origin in the Katrol-Group (s. Olóriz 1976-78) is adequate, but more information is necessary for the identification of the possible morphological recurrences even within this group, given the wide stratigraphic interval in which they are developed. The Himalayan forms are frequent in the Chidamu Beds.

tus type of pl. 54, fig. 1, if we admit that the style of the polygyrate divisions is not very affected by the deformation. The persistent character of the bifurcate ribbing, the isolated presence of polygyrate ribs towards the end of the phragmocone, and the absence of sharp ribs in specimens preserved without original shells are accepted by Uhlig (1910, p. 314). This author likewise accepts intraspecific variability in coiling (the evolute phragmocone of pl. 55, fig. 1 is very similar to our specimen, but the presence of constrictions in the inner whorls is not usual in the other specimens assigned to *denseplicatus* by Uhlig).

"*V.*" *denseplicatus* characterises the Middle Tithonian (s. Krishna et al., 1982). According to Krishna (1981) *denseplicatus* characterises this time interval (= upper Lower Tithonian in the Mediterranean Tethys) in a large part of the Indian subcontinent (Spiti-Malla, Nepal, Kachchh, Salt Range).

"Virgatosphinctes" frequens (Oppel, 1865)

Pl. 23, fig. 1, 2

1865 *Ammonites frequens* Oppel, p. 295, pl. 87, fig. 1a-c.
1910 *Perisphinctes (Virgatosphinctes) frequens* - Uhlig, p. 325, pl. 63, fig. 1-3; pl. 75, fig. 1; pl. 75A, fig. 1.

Material. Two specimens (HZ 269B; 6577 and HZ 268A; 6576) collected 1 m and 2.4 m respectively from the contact between the Spiti Shales and the Giumal Sandstone.

Description. Specimen HZ 268A in Pl. 23, fig. 2, is a rather compressed fragment of a specimen of not less than 150 mm in diameter. The ribbing is noteworthy, with the primary ribs reinforced on the lower third of the flank and a ratio between the ventral and primary ribs of 4.1-4.3. Given that the points of division cannot be observed as a result of erosion, we may deduce that the preserved part of the shell represents the stage of isocostate-polygyrate ribs with more than one external rib and that the development of fasciculate ribbing would soon have taken place.

HZ 269B (Pl. 23, fig. 1) is an incomplete phragmocone of a specimen of more than 160-170 mm in size. The whorl section is oval, flanks flattened and maximum width close to the umbilical margin. Sculpture on the flanks is vigorous, rigid and proverse, developing a small periumbilical arch. The preceding phase probably developed only bifurcate ribbing. Some external ribs are intercalated on the preserved part of the shell. There are polygyrates. The points of division are progressively inner on the flank and appear reinforced on the body chamber. The ratio between ventral and primary ribs is 3.3-3.6, which indicates that the phase of fasciculate ribbing has hardly been reached and that only the phase of polygyrate ribbing with external intercalated ribs is present.

Discussion. Our specimens can be assigned to forms with comparatively strong ornamentation and thick ribbing of the "very variable *V. frequens* (Oppel)", as considered by Uhlig (1910, p. 326, pl. 63, fig. 1). Variants of finer and denser ribbing are excluded (op. cit., pl. 75 and pl. 75A). Because of its rigidity of ribbing, HZ 269B is strikingly sim-

ilar to forms from Neuburg (SW Germany) such as *Danubisphinctes subdanubiensis* (Schneid, 1915, pl. 17 (1), fig. 2) and related forms, although without the development of *dischizotom* divisions (s. Geyer, 1961). *"V." subfrequens* Uhlig (pl. 49, fig. 1; non pl. 61, fig. 1) is smaller and has sinuous ribbing with more external divisions; *burckhardti* Uhlig (pl. 62, fig. 3) develops a similarly vigorous ornamentation, although with a more arched anterior secondary rib, is smaller and its shell is more globose; *kraffti* (pl. 53, fig. 4; pl. 62, fig. 1 and 2) is of a much smaller size, presents constrictions and its shell is also more globose. *"V." denseplicatus* (Waagen) has more delicate ornamentation. *"V." subquadratus* (pl. 68, fig. 1) and *"V." contiguus* (pl. 68, fig. 2) develop vigorous ornamentation with strong periumbilical arching and the known types from the Spiti Shales are comparatively smaller.

This species has been recognised in the Shangra, Kuling, Laptal and Spiti areas of the Himalayas (cf. Oppel, 1865; Uhlig, 1910). The latter author also located it in Chidamu. Krishna (1981, p. 55) recognises it among the fauna characteristic of the *Hildoglochiceras-Virgatosphinctes* assemblage (Middle Tithonian = upper Lower Tithonian in the Mediterranean Tethys) in the Salt Range-Attock-Hazara region.

Subfamily *Torquatisphinctinae* Tavera, 1985

This subfamily has been proposed in order to bring together forms which present "colubrinoid" inner whorls, and later bifurcate and polygyrate ribbing with few external intercalatory ribs. The composition foreseen in Tavera (1985) is subject to the revision of not clearly defined genera such as *Torquatisphinctes, Parapallasiceras* and *Danubisphinctes.*

Genus *Parapallasiceras* Spath, 1925 emend. Tavera, 1985

This genus has undergone a remarkable number of different interpretations as a result of Spath's very brief diagnosis. Here we basically follow Olóriz (1976-78), excluding the *pseudocontiguus* group as later indicated by Tavera (1985). The type-species, *Berriasella (Aulacosphinctes ?) praecox* Schneid, 1915, is a good example of how this genus is interpreted here. Schneid's (1915) imprecise reference to *Aulacosphinctes* reveals the proximity which can exist between both taxa, as has already been pointed out by Olóriz (1976-78, pp. 546 and 631-632). Tavera (1985, p. 144) later includes in *Parapallasiceras* those *Aulacosphinctes* which present polygyrate ribs. The difference, therefore, between the related forms of both taxa would be the presence or absence of polygyrate ribs. The inclusion in *Torquatisphinctinae* concurs with the origin proposed by Uhlig (1910, p. 349) for his polyphyletic subgenus *Aulacosphinctes*, following the hypotheses of Neumayr (1873).

Parapallasiceras spitiensis (Uhlig, 1910)

Pl. 24, fig. 1a-1b, 2

1910 *Perisphinctes (Aulacosphinctes) spitiensis* Uhlig, p. 351, pl. 33, fig. 1, 3; pl. 41, fig. 1 (?).

Material. Two specimens (HZ 269; 6579 and HZ 268C; 6578) collected 2 and 2.4 m respectively below the contact between the Spiti Shales and the Giumal Sandstone.

Description. HZ 268C is a very incomplete fragment easily relatable to the other described here. HZ 269 is an incomplete specimen, the last preserved whorl of which belongs to the body chamber. The peristome is not preserved. The whorl section is trapezoidal with flatty flanks convergent to the venter. No ventral groove is observed but rather a slight flattening of the ventral region in which the ribs are projected slightly towards the aperture. In the inner and middle whorls the ribs are strong, radial and somewhat spaced. Presumably only bifurcate ribs are developed in the phragmocone. In the body chamber some rigid polygyrate ribs are developed and also one oblique constriction. The presence of polygyrate ribs implies the inclusion of this specimen in the genus *Parapallasiceras* rather than in *Aulacosphinctes*.

Discussion. There is some doubts about the inclusion of the incomplete phragmocone figured by Uhlig (1910, pl. 41, fig. 1) in this species, because of its greater size and ornamental development comparing with the specimens with body chamber in pl. 33, fig. 1 and 3 in the Uhlig's monography. The almost complete specimen of the Himalayan "species" *moerikeanus* figured by Uhlig (1910, pl. 33, fig. 2), is closely related to *spitiensis* Uhlig (1910, pl. 33, fig. 1 and 3), as recognised by this author (op. cit.) in his reconsideration of Oppel's species, and these two could possibly be brought together in a single species when their variability is known. Other of Uhlig's "species" such as *hollandi* (op. cit., pl. 32, fig. 1) and *rareplicatus* (pl. 32, fig. 2) are larger and have strong, spaced sculpture on inner whorls. Both "species" are clearly differentiated from the "*moerikeanus-spitiensis* group" by their whorl sections and/or by their sculptural development.

The "*moerikeanus-spitiensis* group" has been recognised in the Hymalayan Tethys in the lower Upper Tithonian (*Himalayites-Corongoceras-Aulacosphinctes* assemblage in Krishna et al., 1982); in an unspecified Middle-Upper Tithonian from Nepal in an association in which *Uhligites* is also present (Krishna, 1981); and in the Upper Tithonian (*Blandfordiceras-Himalayites* assemblages) of the Salt Range-Attock-Hazara region (Krishna, 1981). Related forms do not appear to be frequent in Madagascar (*Aulacosphinctes spitiensis* var. *multicostata* in Collignon, 1960, pl. 170, fig. 712, is a phragmocone of uncertain identification). In epicontinental Europe forms with similar ribbing characterise the Neuburg Fm. in which the type-species of the genus *Parapallasiceras* is present (Schneid, 1914-1915, 1915; Barthel, 1975).

Family *Himalayitidae* Spath, 1925

This family is here considered as proposed by Tavera (1985). Future work is necessary to understand the real significance of genera such as *Aulacospinctes*. Mediterranean ammonite genera belonging to this family are *Himalayites* Uhlig, *Aulacosphinctes* Uhlig, *Djurjuriceras* Roman, *Durangites* Burckhardt, *Micracanthoceras (Micracanthoceras)* Spath, *M. (Corongoceras)* Spath, *Protacanthodiscus* Spath, *Tithopeltoceras* Arkell, *Simplisphinctes* Tavera, and *Pseudosimplisphinctes* Tavera. According to Tavera (1985) the genera *Neocosmoceras* and *Neohoploceras* must be assigned to the family *Berriasellidae*.

Genus *Aulacosphinctes* Uhlig, 1910 emend. Tavera, 1985

Uhlig's original diagnosis is too broad and so the genus is polyphyletic. This has given rise to a variety of interpretations. Olóriz (1976-78, pp. 631-632) proposed a reinterpretation on the basis of the undeniable relation with *Parapallasiceras* and *Lemencia* of those *Aulacosphinctes* developing polygyrate ribs, and recommended the reconsideration of the excessively broad conception of this genus. Tavera (1985, p. 144) proposed the definitive exclusion of the forms with polygyrate ribs. This decision provides a clear delimitation of the genus *Aulacosphinctes* and if Uhlig's forecasts (1910, p. 350) about the immature character of the original specimen of *Ammonites moerikeanus* Oppel can be proved, another type-species will have to be found for this genus.

Aulacosphinctes parvulus Uhlig, 1910

Pl. 23, fig. 4

1910 *Perisphinctes (Aulacosphinctes) parvulus* Uhlig, p. 364, pl. 32, fig. 4.

Material. Two specimens (HZ 269 A and C; 6580) collected one meter below the contact between the Spiti Shales and the Giumal Sandstone.

Description. The incomplete juvenile specimen (HZ 269 C) is referred to this species since it is from the same level and may easily correspond to the inner whorls of *A. parvulus*. Nonetheless, it could belong to another related "species" of Uhlig, or even to a nucleus of *Parapallasiceras*.

The better conserved of the specimens (HZ 269 A) is incomplete, evolute (= 50%) and at 45-50 mm presents a half whorl belonging to the body chamber. The peristome is not observed. The whorl section is subquadrate with narrow venter on which a clearly marked groove develops, which becomes weaker towards the aperture. The secondary ribs are interrupted without forward projection, rising slightly at the end where the groove is least marked. The ribs bifurcate above mid-flank and there are some interca-

lated simple ribs. The angle of the divisions is wide. There are two constrictions in the last whorl. In the inner whorls the ribbing is spaced and no changes are observed.

Discussion. A related "species" in the Himalayas is *la touchei* Uhlig, which is larger and could simply represent an individual of greater size but the same species. In Madagascar, and although the size and density of ribbing is variable, the following "species" described by Collignon (1960) are related: *retrocostatus, natricoides* var. *obliqua, proximus* var. *angusta* and *lynoptychus*; *macer* and *gracilis* are also related amongst those of small size.

Exact biostratigraphic references for *A. parvulus* are not often found in the Himalayas. The related forms in Madagascar are mostly from the Upper Tithonian (Hollandi Zone) and some of them (*retrocostatus, gracilis*) are, in Collignon's opinion, related to *parvulus*. Moreover, Collignon (1960) finds *A. natricoides* in the Lower Tithonian (Kobelli Zone) together with *Uhligites*. Olóriz (1976-78) quotes related forms (*A.* gr. *parvulus-la touchei*) from the uppermost Lower Tithonian and the base of the Upper Tithonian in Southern Spain (Subbetic Zone).

Aulacosphinctes sp.

Pl. 23, fig. 3

Two incomplete juvenile specimens, HZ 268 D and E (6581 a, b), less than 45 mm, imperfectly preserved and from the same level as *Parapallasiceras spitiensis* (Uhlig). These could in fact be either *Aulacosphinctes* or *Parapallasiceras*. Their inclusion in *Aulacosphinctes* is based on the tendency to develop a slight prominence at the ventral end of the ribs (larger specimen). The less complete specimen is in a very poor state of conservation. Among the *Aulacosphinctes* these could represent forms related to the group of *A. parvulus*.

HZ 266 A and B are, respectively, an incomplete specimen and a fragment tentatively referable to *Aulacosphinctes* sp., but subject to the same considerations as mentioned above. The same could be applied to HZ 268 I, and perhaps to HZ 268 H, both being small fragments.

Forms of uncertain systematic position

HZ 267; 6582

Pl. 24, fig. 3

A phragmocone of rather more than 100 mm in size with rectangular-oval whorl section and convex venter. Coiling is moderate. Ribs are bifurcate, not very divergent, slightly higher than mid-flank. There are no simple or intercalatory ribs. Towards the end of the preserved shell the inner position of some divisions points and the somewhat more sinuous character of the ribs is reminiscent of a configuration connected with the

development of polygyrate ribs. In the inner whorls it appears that the ribbing is more spaced than in the outher whorl.

Discussion. Given the limitations due to its partial conservation, this specimen can not easily be included in any one genus of the subfamily *Lithacoceratinae*. In the Himalayas some forms which develop simple ribbing, with no periumbilical arch and presenting no changes in the body chamber, are related because of the style and density of ribbing. "*Virgatosphinctes*" *intermedius* (Uhlig, 1910, pl. 66, fig. 1) from the Chidamu Beds presents only one polygyrate rib on the body chamber; "*V.*" *pompeckji* (Uhlig, 1910, pl. 65, fig. 1) from the Sherik River presents no modification of its simple ribbing on the body chamber and is possibly the most closely related form. The systematic position of these forms is not clear as they are morphologically reminiscent of some *Torquatisphinctes* and even *Subplanitoides* Zeiss (1968) or *Pseudodiscosphinctes* Olóriz (1976-78). Other forms also from the Chidamu Beds are differentiated by the development of polygyrate ribs and more globose whorl section (*V. rotundidoma* Uhlig, 1910, pl. 52, fig. 1; pl. 53, fig. 1). Amongst the forms classified by Uhlig (1910) such as *denseplicatus* there are some related phragmocones although, in general, these present a thinner and denser ribbing, and at times also develop polygyrates and/or intercalatory external ribs (cf. pl. 53, fig. 3; pl. 54, fig. 1; pl. 55, fig. 1, 2, 3).

In Kachchh some of the forms studied by Waagen (1873-75) are similar, such as *alterneplicatus* (pl. 50, fig. 2) and *denseplicatus* (pl. 46, fig. 3; pl. 55, fig. 1), and also those identified by Spath (1927-1933) such as *denseplicatus* var. *blakei* (pl. 90, fig. 1), *denseplicatus* var. *rotunda* (pl. 96, fig. 3) and *indosphinctoides* (pl. 93, fig. 1).

In Argentina the forms recognised by Indans (1954, pl. 21, fig. 1 and 4) as *denseplicatus* var. *rotunda* and *denseplicatus* var. *blakei* have, respectively, a more subrectangular and globose whorl section according data from this author (cf. Indans, op. cit., p. 106) and at least the former may have polygyrates.

In Southern Spain Olóriz (1976-78) collected somewhat similar forms which were assigned to *Pseudodiscosphinctes geron* (Del Campana non Zittel) and *Pseudodiscosphinctes* sp. 1 (cf. Olóriz, op. cit., pp. 492-494 and 496-498, pl. 41, fig. 3 and 4).

All the forms mentioned here are from the non-basal Lower Tithonian levels.

HZ 268 F and HZ 268 G; 6583

These are two small fragments of undeterminable phragmocones belonging to perisphinctoid ammonites.

Conclusions.

In a passive margin context, the Spiti Shales facies in the region of Oma Chu (Zanskar, NW Himalayas) were deposited on a shelf which was very probably "disconnected" from the circulation of open sea currents. The environment, rich in nutrients

and somewhat turbid, was periodically subjected to comparatively major storm events. There are some condensed and nodular levels which could be related to eustatic pulses.

Ammonite associations subject to a considerable Platform Effect (s. Olóriz, 1986) became established and developed in this environment. Ecological strategies can be recognised in the high intraspecific diversity of the ammonites and in the existence of "extreme phenotypes" (Olóriz, 1987a). Consequently, the traditionally recognised morphological instability of Himalayan ammonites was induced ecologically.

On the basis of new systematic considerations, the following genera have been recognised: *Parapallasiceras, Aulacosphinctes, "Virgatosphinctes"* and *Uhligites*. The genus *Parapallasiceras* is proposed for the first time for Himalayan faunas. The heterogeneous character of the genus *Virgatosphinctes* is recognised, as well as the fact that current interpretations of *Uhligites* conceal morphological convergences and iterative phenomena.

An upper to uppermost Lower Tithonian - lowermost Upper Tithonian age is recognised for the uppermost strata of the Spiti Shales Fm. in the sector examined. The species recognised here, or others related to them, date from the non-basal Lower and Middle Tithonian in the Indian subcontinent, but with certain reservations they are also considered to be found in the lowermost Upper Tithonian. The age proposed for the fauna analysed is coherent with that assigned to similar forms in Madagascar, in various areas of the Submediterranean and Mediterranean Tethys and in Antarctic regions.

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PLATE 22

Fig. 1 - *Uhligites lymani* (Oppel). HZ 270; 6574. a) Lateral view of the body chamber; b) ventral view of the body chamber.

Fig. 2 - *"Virgatosphinctes" denseplicatus* (Waagen). HZ 268B; 6575. Lateral view. Mark on the last septum.

All the specimens are reproduced in natural size.

PLATE 23

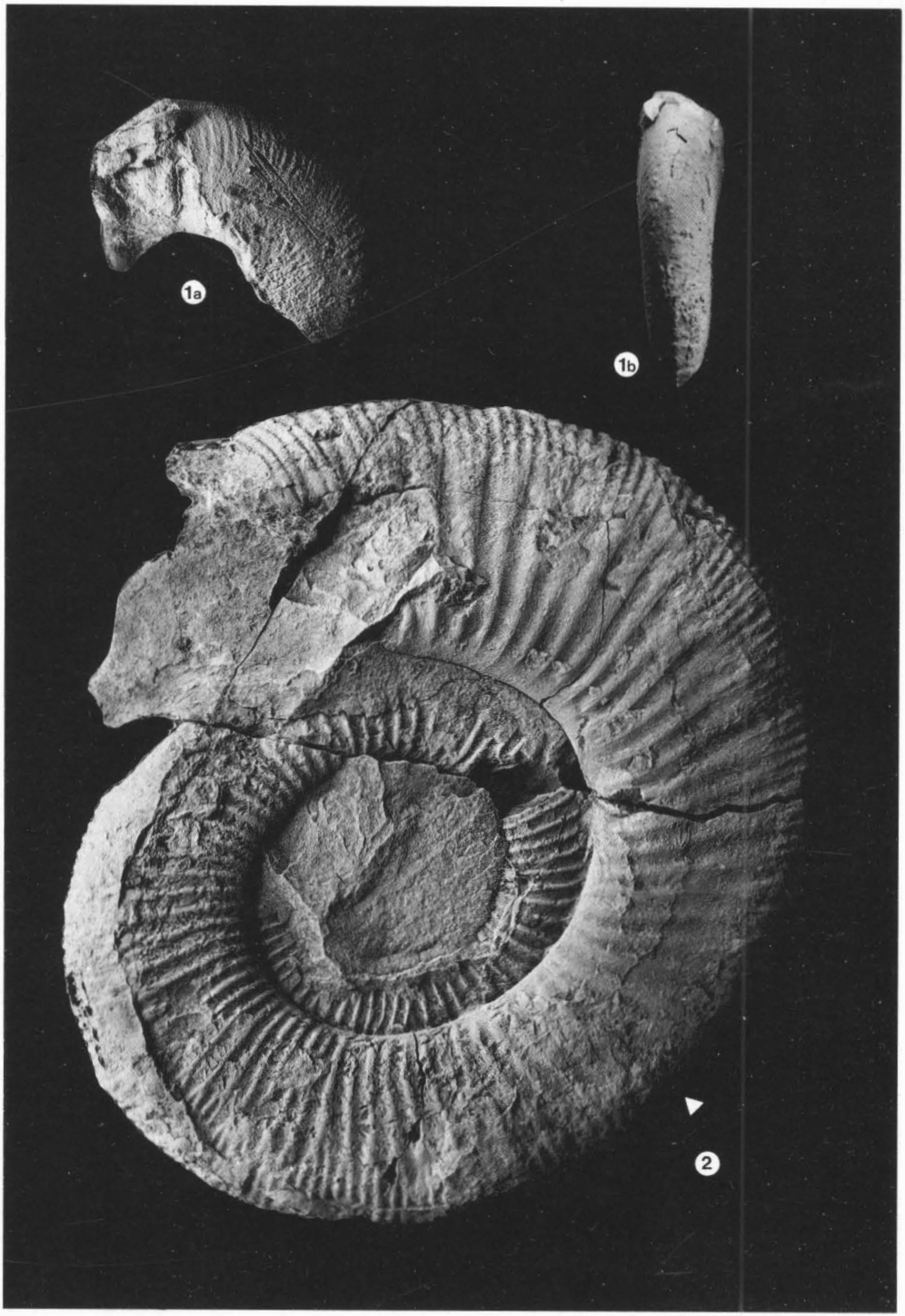
Fig. 1 - "*Virgatosphinctes*" *frequens* (Oppel). HZ 269B; 6577. Lateral view of the phragmocone.
Fig. 2 - "*Virgatosphinctes*" *frequens* (Oppel). HZ 268A; 6576. Lateral view of the phragmocone.
Fig. 3 - *Aulacosphinctes* sp. HZ 268D; 6581a. Lateral view. Last conserved whorl belonging to the body chamber.
Fig. 4 - *Aulacosphinctes parvulus* Uhlig. HZ 269A; 6580. a) Ventral view of the phragmocone; b) lateral view. Mark on the last septum.

All specimens are reproduced in natural size.

PLATE 24

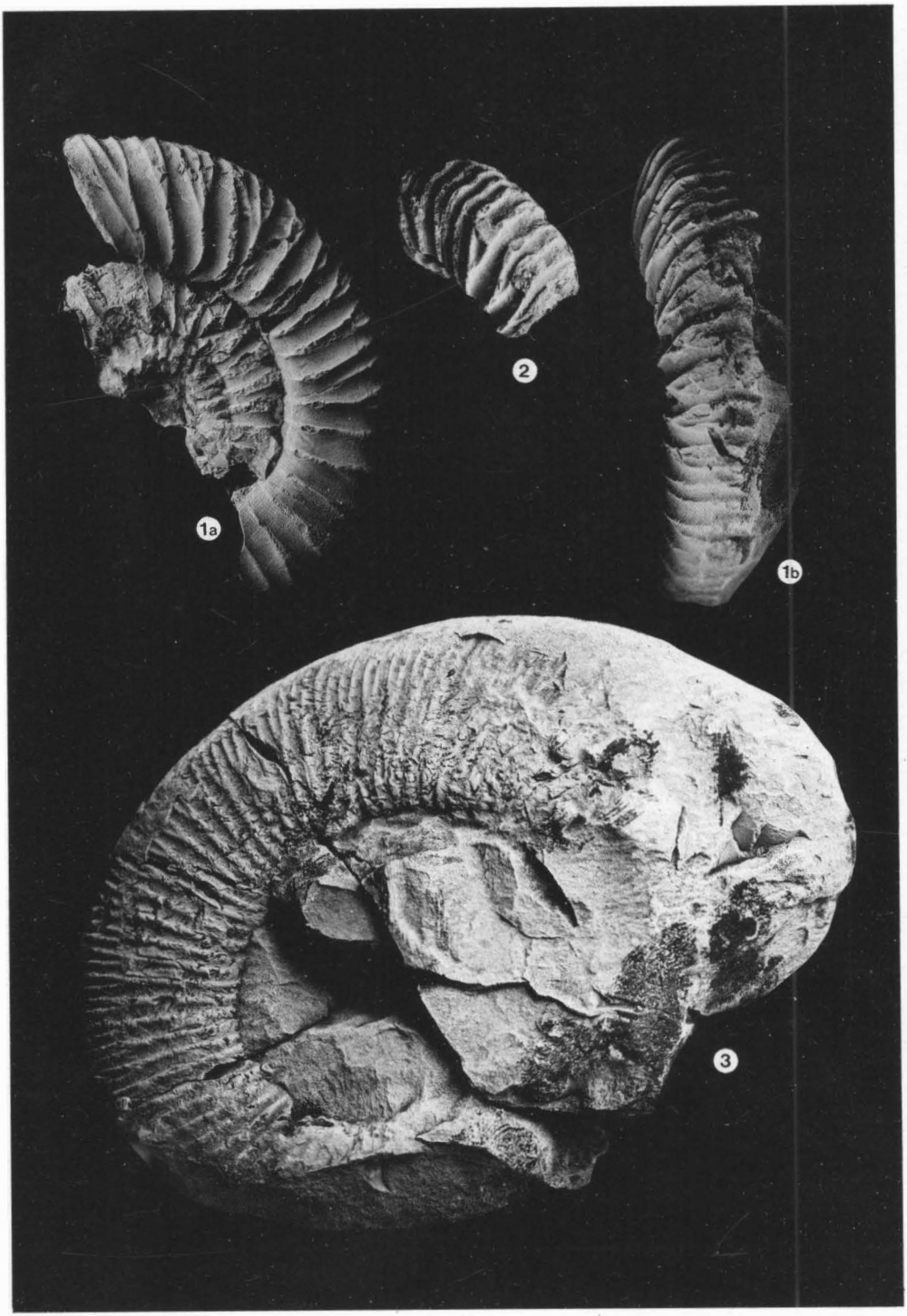
Fig. 1 - *Parapallasiceras spitiensis* (Uhlig). HZ 269; 6579. a) Lateral view. Last whorl belonging to the body chamber; b) ventral view of the body chamber.
Fig. 2 - *Parapallasiceras spitiensis* (Uhlig). HZ 268 C; 6578. Oblique view of a phragment belonging to the body chamber.
Fig. 3 - HZ 267; 6582. Lateral view of the phragmocone of an undifferentiated specimen.

All the specimens are reproduced in natural size.



1. Uhligites lymani (Opp.)
2. "Virgatosphinctes" denseplicatus (Waagen)

1,2 "Virgatosphinctes" frequens (Opp.)
3 Aulacosphinctes sp.
4 A. annulus Uhlig



1-2. Parapallasiceras spitiensis (Uhlig

3 - Form uncertain systematic position