FIRST AMMONITE AND INOCERAMID DATA FROM THE UPPER CRETACEOUS OF THE TINGRI SECTION IN SE-TIBET: BIOSTRATIGRAPHICAL AND PALAEOENVIRONMENTAL IMPLICATIONS

藏南定日剖面晚白垩世菊石和叠瓦蛤类的首次发现:生物地层和古环境意义

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Abstract: A section in the Zhepure Mountains near Old Tingri in SE-Tibet, ranging from the Upper Albian to Paleogene, was described in detail by Willems et al. (1996). These authors worked on the litho-and microfacies and set up the biostratigraphical framework by planktonic foraminifera. Willems et al. (1996) established their section as a standard for southern Tibet and compared it to the Gamba area. During the 2004 Tibet-expedition of Chengdu University of Technology in China, in co-operation with Bremen and Kiel universities in Germany, the locality was revisited for the purpose of collecting invertebrate fossils. This field-work included only the Upper Cretaceous part of the Tingri section and its invertebrate faunal content. Until today almost no ammonite and inoceramid data existed for this section. This is true for most Cretaceous sections in Tibet, although the Upper Cretaceous succession was interpreted as shelf environment. which in other parts of the world contains rich faunas of these macrofossil groups. The newly discovered continuous record of rare ammonites and inoceramids is probably limited since the preservation in the wacke- and packstones is poor. In addition, sampling conditions were unfavorable and the environmental conditions disadvantageous for most groups of invertebrates, as possibly indicated by larger amounts of small bivalve debris (filaments) in the upper part of the Gamba Group. Although the collected fauna is sparse and poorly preserved, the following biostratigraphical data can be added to the hitherto described microfauna: *Calycoceras* ? from the Upper Gamba Group is Late Cenomanian in age and is accompanied by indeterminable juvenile desmoceratids. Superjacent follows a record of the ammonite *Forresteria* sp., indicating that this level in the upper part of the Gamba Group belongs to the Lower Coniacian. This supports the finding of *Inoceramus* (*Cremnoceramus*) *waltersdorfensis* ? *hannovrensis* ? from the same interval. *Anagaudryceras* ? is an individual ammonite finding from the Zhepure Shanbei or Zhepure Shanpo Formation, corre-

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sponding to the Santonian-Maastrichtian part of the succession.

Key words: ammonite; inoceramid; Upper Cretaceous; biostratigraphy; palaeoenvironment; Tingri; Maastrichtian; Tibet

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摘 要:藏南定日遮普惹山剖面主要是 Albian 晚期到古近纪海相沉积,Willems 等(1996)对岩石地层和沉积微相进行了详细研究,并通过浮游有孔虫研究建立生物地层格架。在与岗巴地区地层对比基础上,该剖面被认为是整个藏南地区白垩纪—古近纪海相地层的标准剖面。2004 年我们与中国、德国同行一道对该剖面上白垩统地层进行再考察,重点对无脊椎动物化石样品进行采集和研究。与西藏大多数白垩纪剖面一样,尽管沉积环境为陆棚环境,该剖面以前却几乎没有菊石和叠瓦蛤类化石的报道,而同样环境下的世界其他地区剖面含有大量的菊石和叠瓦蛤类化石。藏南定日剖面重新调查后发现了少量的菊石和叠瓦蛤类化石。化石数量少一方面是由于灰泥质灰岩和泥灰质灰岩内化石保存状况差,另一方面采样条件也不理想。还有,当时的环境条件可能不利于大多数无脊椎动物类群的生存,这一点或许从大量存在于岗巴群上部的小个体双壳类碎片可以得到证实。尽管获得的化石分散并且保存差,本次研究仍获得了一些有价值的生物地层数据。岗巴群上部发现的化石 *Calycoceras* ?,指示其时代为 Cenomanian 晚期,随后出现不能鉴定的 *desmoceratids* 类的幼体。之上,菊石 *Forresteria* sp. 的发现表明岗巴群顶部地层属于 Coniacian 下部,这被同一地层内发现的其他化石所支持,包括 *Inoceramus* (*Cremnoceramus*) *waltersdorfensis* ? *hannovrensis* ?。*Anagaudryceras* ?是一个发现于遮普惹山北或遮普惹山坡组的菊石,相当于 Santonian-Maastrichtian 时期地层。

关键词:菊石;叠瓦蛤;上白垩统;生物地层学;古环境;定日;西藏

0 Introduction

The Upper Cretaceous in the Tingri area in SE-Tibet (Fig. 1) was first described by Hao & Wan (1985). Later a section in the Zhepure Mountains near Old Tingri, ranging from the Upper Albian to Paleogene, was intensively described by Willems (1993) and Willems et al. (1996). The latter authors worked on the litho- and microfacies and set up the biostratigraphical frame by planktic foraminifera. Willems et al. (1996) established their section as a standard section for southern Tibet and compared it to the Gamba area.

Recently, Wan et al. (2000) referred to a profile near Tingri for a study on benthic foraminifera. However, none of the logs described from the Zhepure Mountains so far are identical since they refer to different sections within the area.

During the 2004 Tibet-expedition of Chengdu University of Technology in China, in co-operation with Bremen and Kiel universities in Germany, the locality of Willems et al. (1996) was revisited for collecting invertebrates. Since the latter are usually very rare in sediments of the Tethys Himalaya in Tibet these findings are described briefly in the following and their stratigraphical and palaeoenvironmental implications are discussed.

1 Locality details and conventions

The Tingri section is located at the rim of the Zhepure Mountains, about 30 km WNW of the village of Old Tingri. In this area there are quite a few exposures by erosional valleys. However, the section originally described by Willems (1993) and Willems et al. (1996) is the most comprehensive one and tectonically less complicated compared to the adjacent ones. There is no doubt that the material described in the present paper comes from the section that was established in the literature by Willems et al. (1996), since some of the colour markings made by the field-work company in the 1990 were re-discovered. These Cretaceous outcrops consist of mud-, wacke- and packstones of the Gamba Group and the Zhepure Shanbei Formation. The Gamba Group is Late Albian to Coniacian/Early Santonian in age, the latter Coniacian/Lower Santonian to Early Maastrichtian. The Middle and Late Maastrichian sediments are represented by the lower part of the Zhepure Shanpo Formation. There is a change in lithofacies from the Zhepure Shanbei to the Zhepure Shanpo Formation from pure carbonates to a regular alternation of marls, marly sandstones and calcareous sandstones that are intercalated by some limestones rich in quartz

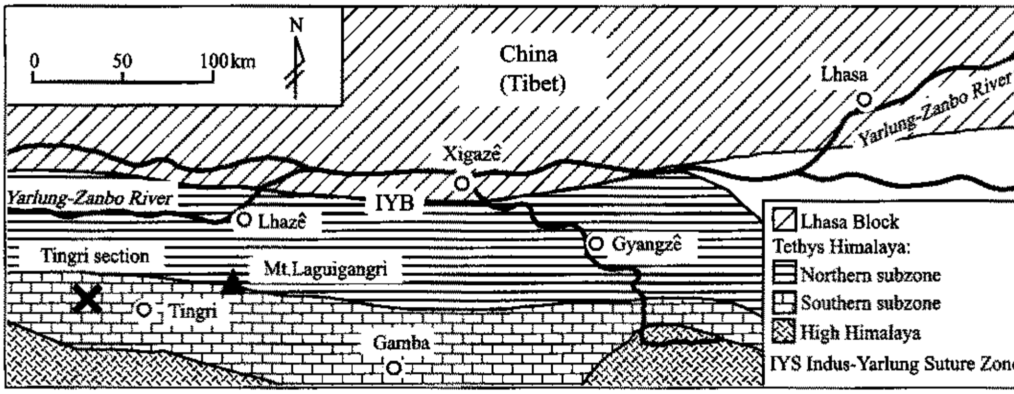

Fig. 1 Simplified geological map of the eastern Tethys Himalaya showing the location of the Tingri section in south-eastern Tibet

(Willems et al, 1996). All fossils found during field-work for the present paper in place comes from the upper part of the Gamba Group, between section meter 390 to 590. This part of the section consists mainly of wackestones with planktic foraminifera (Willems, 1993). To define the position of fossils as well of the section unequivocally for future field-work GPS data were taken in June 2004 at the places where ammonite data where obtained. The lowermost bed containing ammonites approximately corresponds to section meter 410 m of the profile and is located at N28°42. 916′ and E086°44. 878′. Section meter 465 is located at N28°42. 875′ and E086°44. 909′ and the uppermost ammonite-bearing level is section meter 515, located at N28°42. 860′, E086°44. 915′.

The rules for open nomenclature were used after the proposals of Bengtson (1988), the abbreviations for specimens deposited in a public collection are as follows: GSUB = Geosciences Collection of the University of Bremen, Germany, after its German name "Geowissenschaftliche Sammlung der Universität Bremen".

2 Macrofauna

According to the data available up to now, invertebrate fossils are usually very rare in sediments of the Tethys Himalaya in Tibet. Since this is also true for the two groups that are excellent index-fossils in the Upper Cretaceous, ammonites and inoceramids, each single evidence is valuable for biostratigraphy. This fact encourages us to report an invertebrate fauna from the Tingri area, although it is small in number and also poorly preserved.

Concerning the ammonites there are earlier records of Cretaceous taxa from the Tingri area, Hao & Wan (1985) mentioned the Albian genera *Diploceras* and *Mortoniceras*. For Upper Cretaceous strata Willems et al. (1996) found ammonites in the Lower-Middle Cenomanian part of the Tingri section. This material was observed in thin sections only and consequently the present paper deals with the material recorded exclusively during the 2004 expedition.

Neither Willems et al. (1996) nor earlier papers recorded determinable inoceramid specimens from the Upper Cretaceous in the Zhepure Mountains. A brief description of the recently found inoceramids below is following the terminology in inoceramid shells of Matsumoto & Noda (1986) for the concentric ornament.

Additionally to ammonites and inoceramids a single test of an echinoid was found in the Upper Cretaceous part of the section that belongs to the upper part of the Gamba Group. It comes from beds at section meter 505, supposed to represent the Turonian-Coniacian boundary interval based on planktic foraminifera. The present specimen (plate 1 b) belongs to the spatangoid echinoids, an important and diverse group for that a new phylogenetic concept was established recently (Villier et al, 2004). Since it does not show features of the outer test (tubercles, fasciole), it most probably either belongs to Micrasteridae or Toxasteridae. Echinoid remains were mentioned already by Willems (1993) and Willems et al. (1996) as rare components in thin sections in the upper part of the Gamba Group.

2.1 Ammonites

(1) Section meter 410

The lowermost bed where ammonites were found correspond to a level at approximately section meter 410 (Fig. 2) that was dated as Upper Cenomanian on the base of planktic foraminifera (Willems, 1996). Both specimens found were located on one bedding plane, both are trachyostracan ammonites. However, with not more visible than a dense ribbing. Consequently, the determination is possible in open nomenclature only. Both ammonites that are *Calycoceras* ? were observed in the field. The genus *Calycoceras sensulato* occurs in Middle- and Upper Cenomanian strata (see Wright 1996).

(2) Section meter 465

A second bed containing poorly preserved ammonites corresponds to a level at about 465 m (Fig. 2). It is also dated as Upper Cenomanian on the basis of planktic foraminifera (Willems, 1996). GSUB C3116 is also determined as *Calycoceras* ?, that fits to the former micropalaeontological dating of these beds as Upper Cenomanian as well. A negative imprint of a *Calycoceras* ?, with dense and partly alternating ribs, was observed in the field and figured here on Plate 1g. The third specimen is smooth with a narrow umbilicus. This is probably a juvenile desmoceratid (GSUB C3117).

(3) Section meter 515

A single specimen (GSUB C3117; Plate 1c) is recorded at this level, belonging to an interval dated as Coniacian-Lower Santonian by planktic foraminifera (Willems et al, 1996). Although it is also strongly distorted and poorly preserved, it can be referred to as *Forresteria* sp.. On the penultimate whorl there is a row of tubercles visible on the inner flank near or at the umbilicus, whereas the rest of the shell is smooth. *Forresteria* is a genus restricted to the Lower Coniacian (see Wright, 1996). The micropalaeontological classification places level 515 m to the lowermost part of the interval, ranging from Coniacian to the Lower Santonian. Actually, this part of the section can now be accurately dated by the ammonite finding as Lower Coniacian.

(4) Section meter >710

An ammonite specimen loosely collected from the river beds comes from a horizon above the 710 m level, dated Santonian to Maastrichtian by planktic foraminifera (Willems et al, 1996). This specimen is strongly worn and was observed in the field (Plate 1, Fig. 1), but shows strikingly broad, simple ribs and only very small intercostal spaces. These features likely places it into the lytoceratids, in particular the family Gaudryceratidae, e. g. some mid-growth and mature specimens of *Anagaudryceras* show a similar ribbing pattern (compare e. g. Kennedy & Klinger, 1979). The Gaudryceratidae and *Anagaudryceras* ranges throughout the Upper Cretaceous (Wright, 1996).

2.2 Inoceramids

(1) Section meter 390

The oldest inoceramids recorded from the section studied are derived from section meter 390 m in the Upper Cenomanian part of the section, but are too fragmentary preserved for determination.

(2) Section meter 512

There is an acme of inoceramids at about 512 m height; however, most specimens are fragmentary only. Plate 1 d & e are specimens investigated in the field and GSUB L8711 is an inoceramid in the collection from the same bed. This horizon lies only five meters below the level containing the Lower Coniacian ammonite *Forresteria* (see above).

Plate 1e shows *Inoceramus* (*Cremnoceramus*) *waltersdorfensis* ? *hannovrensis* ? Heinz, 1932. This Upper Turonian and Lower Coniacian taxon is already known from Japan within the East Asian faunal realm (Matsumoto & Noda, 1985, Noda & Matsumoto, 1998). The present specimen is flattened by diagenesis; however, it shows fairly regular and closely spaced concentric ribs that are low like undulations, even considering distortion. In some parts of the valve the ribs are broad, in general the ribbing is obliquely-oval. Additionally, there are well-preserved concentric ribblets visible, except for the juvenile part of the valve. The angle between hinge line and anterior line can not be determined. The present material is an adult shell and can be distinguished from the typical subspecies *Inoceramus* (*Cremnoceramus*) *waltersdorfensis waltersdorfensis* mainly by the occurrence of fairly distinctly developed rugae on the mature stage (Tröger, 1967, Keller, 1982, Walaszczyk & Wood, 1998). It is determined in open-nomenclature as *I.* (*C.*) *waltersdorfensis* ? *hannovrensis* ?, since it is not unequivocally possible to determine it on the basis of the poor material present. *I.* (*C.*) *waltersdorfensis hannovrensis* is distinguished from *Inoceramus* (*Cremnoceramus*) *rotundatus* (Fiege, 1930) by a less inflated shell with lower ribblets and it displays a smaller angle between hinge line and anterior line as well as it shows more obliquely-oval ribs (Keller, 1982). Consequently, our material fits better to the features of *I.* (*C.*) *waltersdorfensis hannovrensis*. Nevertheless, there are transitional forms between both taxa that make a determination of poorly preserved single specimens difficult (Noda & Matsumoto, 1998). A distinction of the present material from *Inoceramus* (*Cremnoceramus*) *crassus inconstans* (Woods, 1912) is even more difficult, since the latter is probably the descendant of *I.* (*C.*) *waltersdorfensis hannovrensis* and both forms are identical in their general characteristics. Transitional forms exist and both might be only distinguished by details in ornamentation (Walaszczyk, 1992; Walaszczyk & Wood, 1998).

A second, fairly well-preserved inoceramid from

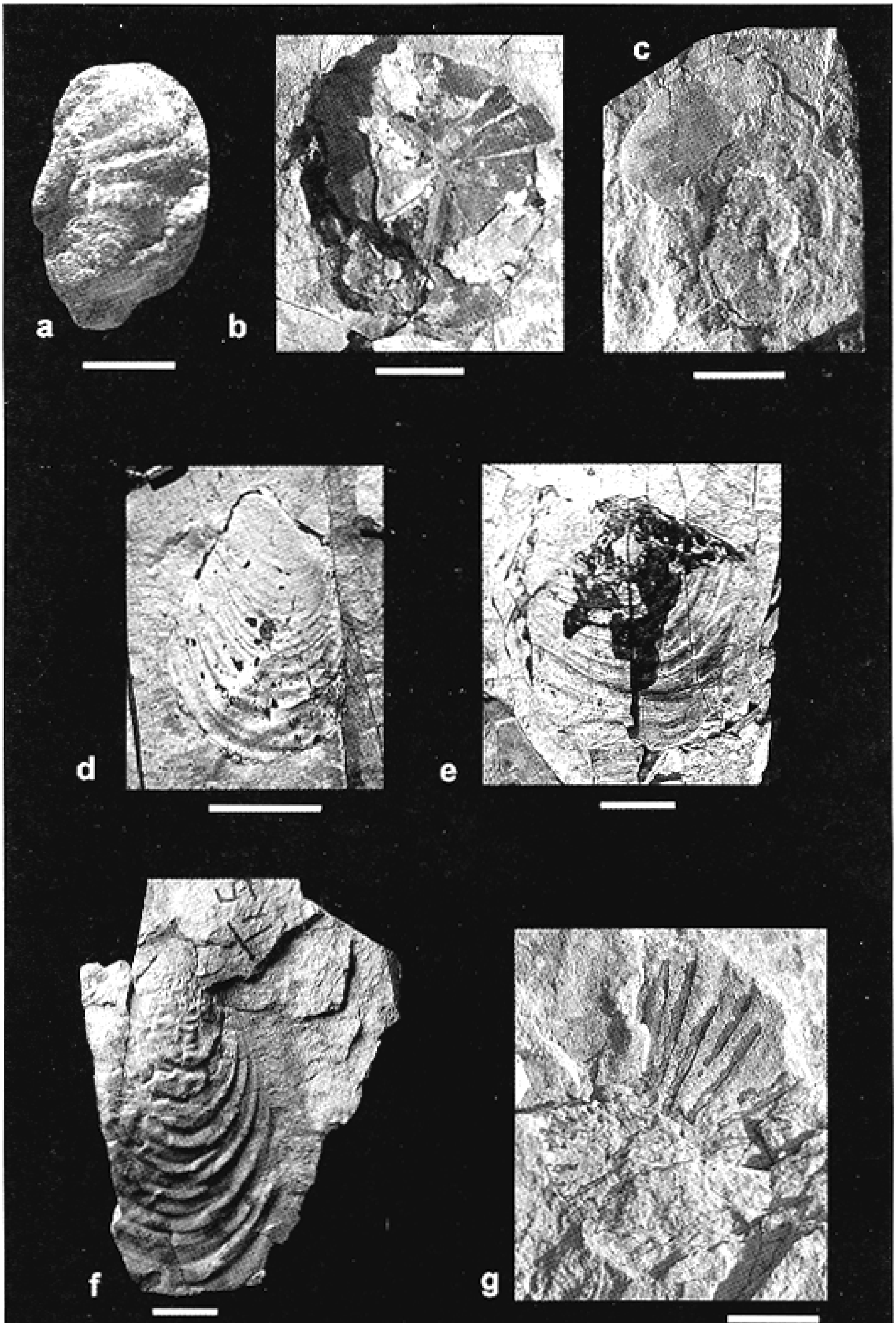

Plate 1 Invertebrate fossils from the Upper Cretaceous of the Tingri section in the Zhepure Mountain range

a—*Anagaudryceras*?, Santonian-Maastrichtian, Upper part of Zhepure Shanbei Formation or lower part of Zhepure Shanpo Formation; b—Spatangoid echinoid, indet., upper part of the Gamba Group, Turonian-Coniacian boundary interval; c—*Forresteria* sp., upper part of the Gamba Group, Lower Coniacian; GSUB C3118; d—e—*Inoceramus* (*Cremnoceramus*) *waltersdorfensis*? *hannovrensis*? Heinz, 1932; upper part of the Gamba Group, Lower Coniacian; f—*Inoceramus* sp., lowermost Zhepure Shanbei Formation, Coniacian-Lower Santonian; GSUB L8712; g—*Calycoceras*?, upper part of the Gamba Group, Upper Cenomanian. Scale bar each 20 mm

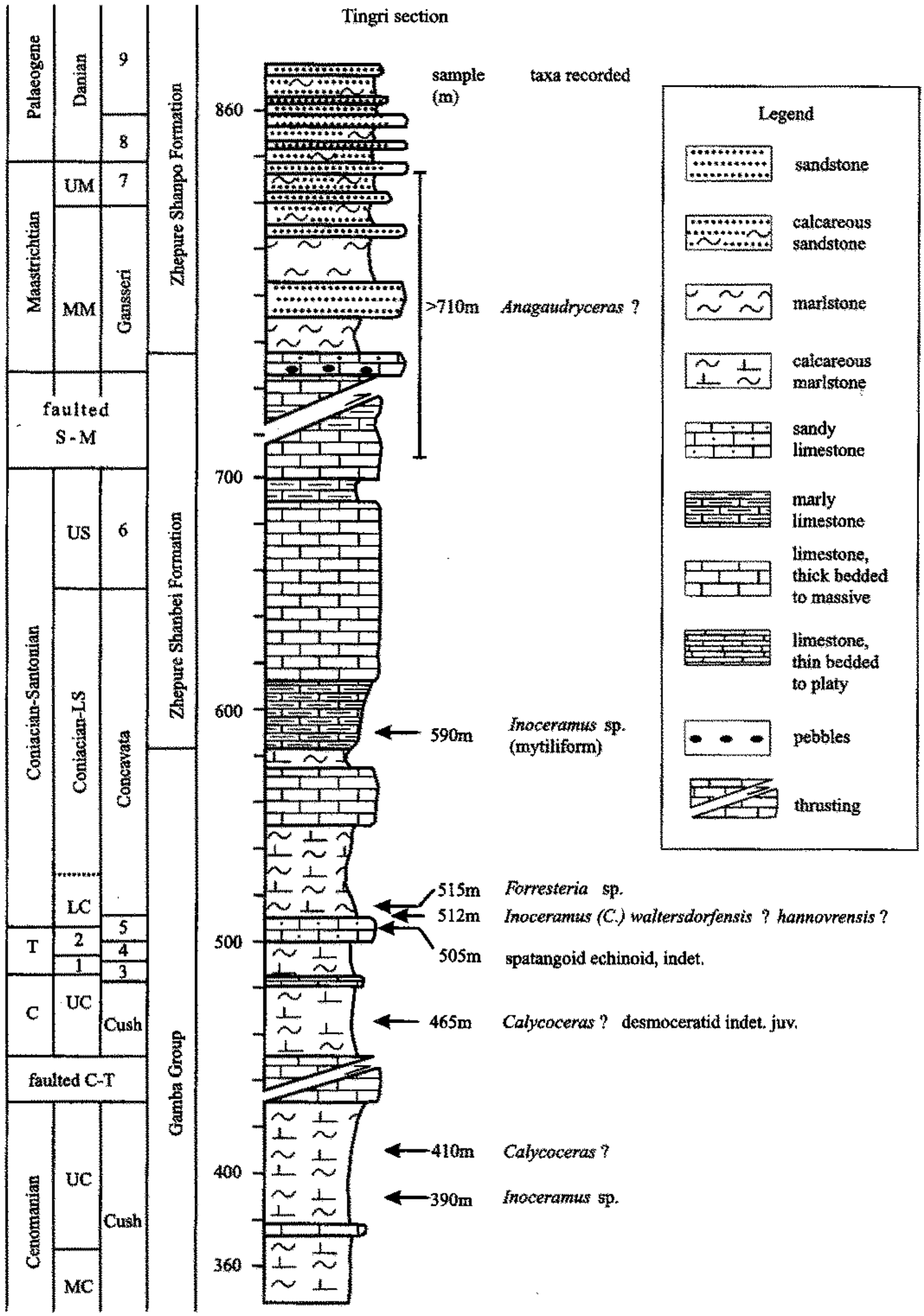

Fig. 2 Part of the Upper Cretaceous and Lower Paleogene section at Tingri and its invertebrate record

Adapted and modified after Willems et al, 1996: Figs. 7 and 8; see also for microfacies. Abbreviations: MC—Lower Turonian, MC—Middle Turonian, C-T: Cenomanian-Turonian, LC—Lower Coniacian, LS—Lower Santonian, US—Upper Santonian, S-M—Santonian-Maastrichtian; 1—Lower Turonian, 2—Middle and Upper Turonian, 3~9—Planktic foraminifera zones. 3—*Archaeocretacea*, 4—*Helvetica*, 5—*Sigali*, 6—*Asymetrica*, 7—*Mayaroensis*, 8—not zoned, 9—*Pseudobulloides*

this horizon (Plate 1 d) is also referred to *I.* (*C.*) *waltersdorfensis*? *hannovrensis*? based on the same argu specimen on Plate 1e. This is a left valve with concentric ribs that are obliquely-oval, closely spaced and regular on an early growth stage but becoming more irregular and somewhat wider on the ultimate part of the valve.

GSUB L8711 is a juvenile with regular concentric ribs that are obliquely-oval. This specimen is provisorically also best placed to *I.* (*C.*) *waltersdorfensis* ?*hannovrensis*?

(3) Section meter 590

At this level that is Coniacian-Lower Santonian after the planktic foraminifera data (Willems et al, 1996) several fragments were collected. Plate 1 f (GSUB L8712) is the most complete one, showing a mytiliform inoceramid with strong, subregular concentric ribs. There are fine, slightly raised concentric ribblets in the area near the beak. The beak itself is missing. The growth axis is straight. The specimen is too fragmentary for a certain determination and is referred to as *Inoceramus* sp. herein.

3 Preservation and palaeoenvironmental implications

Inoceramids and ammonites are widely used for biostratigraphical and palaeobiogeographical studies (e. g. Matsumoto, ed., 1977; Rawson et al., ed., 1996; Wagreich, ed., 2002). Associations of these index-fossils are typical for Upper Cretaceous shelf-environments in most parts of the world. However, as a matter of fact these fossils are strikingly rare in the Tingri area of southern Tibet which is difficult to explain, because the rocks were deposited on the shelf and not in the deep-sea.

The ammonites of the Tingri section are preserved as crushed internal moulds, with their originally aragonitic shells completely dissolved. This makes it difficult to recognize them in the field, since there is no difference in color between the fossils and the surrounding carbonatic rocks. Furthermore, a calculated attempt to split the laminated wacke- and packstones for sampling ammonites is almost impossible, since the rocks are very resistant except for weathered bedding surfaces, from that almost all of the material considered here was collected. Inoceramids, on the other hand, are also strongly distorted; however, their tests are still preserved due to their original mineralogical composition of calcite. Nevertheless, the same unfavorable methodical sampling conditions described for ammonites are given for inoceramids. The rare but continuous occurrence of carbonatic invertebrate shells in the Tingri section, including ammonites, places the palaeobathymetric position of the sedimentation area on the outer shelf, as also documented by the lithofacies.

According to the carbonate microfacies interpretation of Willems (1993) and Willems et al. (1996) of the Tingri section, the profile reflects a palaeobathymetric shift from a basin or slope environment (lower part of the Gamba Group, Upper Albian to Lower Cenomanian) to an outer shelf environment (upper part of the Gamba Group, Coniacian/Lower Santonian). This coincides with an increase of planktic foraminifera and the general occurrence of benthic foraminifera in the component stock, comparing the middle part of the Gamba Group (Lower and Middle Cenomanian, 50 ~ 285 m) to the upper part of the Gamba Group (Middle Cenomanian to probably Santonian, 285 ~ about 582 m). Furthermore, the number of filaments (debris of small size shells, mainly bivalves) increases in the upper part of the Gamba Group (Willems et al, 1996), parallel to the general shallowing upward trend. It is conspicuous that the very small bivalve shells (filaments) are common in the upper part of the Gamba Group, but larger invertebrates are very rare. This biofacies of the whole profile is exceptional compared to Upper Cretaceous shelf deposits known from Europe, North America and other parts of the world because of the missing diverse and rich macrofaunas. Possibly the paleoenvironment was not very favorable for larger benthic as well as nektic invertebrates during deposition of the Gamba Group. A higher salinity might be one idea to explain the rare occurrence of inoceramids. However, in case of ammonites specimens may drift for long distances and were transported by currents from their habitats to the depositional realm (e. g. Kennedy & Cobban, 1976; Maeda & Seilacher, 1996). Consequently, it is even more difficult to explain the low number of ammonites in the section investigated for nektic organisms with phragmocone.

To summarize, we interpret the very rare occurrence of invertebrates as at least partly caused by the poor preservation in the mud-, wacke- and packstones and the unfavorable sampling conditions. Furthermore, the conditions in this outer shelf environment were exceptional compared to other regions of the world and not very favorable for a rich and diverse invertebrate fauna.

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