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MIDDLE AND LATE SMITHIAN (EARLY TRIASSIC) AMMONOIDS FROM SPITI, INDIA

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with 42 figures and 1 table

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Abstract: The '*Parahedenstroemia*' beds in the Mikin Formation at the Mud, Guling, Lalung and Losar localities in the Spiti area (Himachal Pradesh, northern India) yield abundant and well-preserved Smithian (Early Triassic) ammonoid faunas. Our data allow the construction of a high-resolution ammonoid succession spanning the middle to latest Smithian time interval. The new biostratigraphical succession comprises the following eight distinct ammonoid faunas (in ascending order): the *Brayardites compressus* beds; the *Nammalites pilatoides* beds, subdivided into the *Escarguelites spitiensis* horizon and the *Truempyceras compressum* horizon; the *Pseudoceltites multiplicatus* beds; the *Nyalamites angustecostatus* beds; the *Wasatchites distractus* beds; the *Subvishnuites posterus* beds; and the *Glyptophiceras sinuatum* beds. This faunal succession correlates with other Tethyan successions including the Salt Range (Pakistan), Tulong (South Tibet) and Guangxi Province (South China). The new genera *Escarguelites*, *Hermannites*, *Krafficeras*, *Nuetzelia* and *Steckites* and six new species *Escarguelites spitiensis*, *Hermannites rursiradiatus*, *Nuetzelia himalayica*, *Steckites brevus*, *Subvishnuites posterus* and *Truempyceras compressum* are described.

Key words: Ammonoidea, Early Triassic, northern India, Mikin Formation, biostratigraphy.

In the aftermath of the end-Permian mass extinction that wiped out more than 90 per cent of all marine species (Raup and Sepkoski 1982), ammonoids recovered very fast in comparison with other marine clades (Brayard *et al.* 2006; Brayard *et al.* 2009). Following extremely low values in the Griesbachian (early Induan, earliest Triassic), diversity increased slowly during the Dienerian (late Induan, Early Triassic) and first peaked in the Smithian (early Olenekian, late Early Triassic). This first major evolutionary radiation was followed by a severe extinction event in the end-Smithian, after which a second major and explosive radiation took place during the Spathian (late Olenekian, Early Triassic). Our knowledge on Smithian ammonoids has significantly increased lately thanks to a number of recent studies from various basins in the Guangxi Province, South China (Brayard and Bucher 2008), South Primorye, Russia (Shigeta and Zakharov 2009; Shigeta *et al.* 2009), Tulong, South Tibet (Brühwiler *et al.* 2010*a*), Oman (Brühwiler *et al.* 2012*a*), and the Salt Range, Pakistan (Brühwiler *et al.* 2012*b*, this issue).

The Spiti area in Himachal Pradesh, northern India, has become one of the classic regions for Early Triassic ammonoids since the pioneer works of Diener (1897) and Krafft and Diener (1909) were published. However, these authors did not include precise information on the stratigraphic position of their material, and a revision of these faunas based on bedrock-controlled material is needed. Recently, a section near Mud in Spiti has been proposed as GSSP candidate for the Induan–Olenekian (Dienerian–Smithian) stage boundary (Krystyn *et al.* 2007*a*, *b*; Brühwiler *et al.* 2010*b*). While these works concentrated on this boundary, our extensive investigations in Spiti during several field seasons have also yielded abundant, well-preserved ammonoid faunas of middle-to-late Smithian age. This new material enables us to revise the taxonomy of these faunas and to establish a high-resolution biostratigraphy for the Smithian of Spiti area, India. Such data are crucial for establishing a precise and laterally reproducible biochronological subdivision of the Smithian within the Tethys and within the Early Triassic tropics.

PALAEOGEOGRAPHICAL AND GEOLOGICAL SETTING

During Early Triassic times, the Spiti area was located on the peri-Gondwanan margin, on the southern side of the Tethys Ocean (Smith *et al.* 1994; Fig. 1A). The Griesbachian to Ansisian mixed carbonate–siliciclastic rocks of the study area are referred to the Mikin Formation, which disconformably overlies the Upper Permian Kuling Shales (Bucher *et al.* 1997), and is overlain by the Upper Ladinian Kaga Formation (Bhargava *et al.* 2004). The Mikin Formation is subdivided into the following four members (from bottom to top; Figs 2, 3):

Lower Limestone Member. This member is further subdivided into a lower part consisting of brown, ferruginous limestone containing *Otoceras* (Griesbachian) and an

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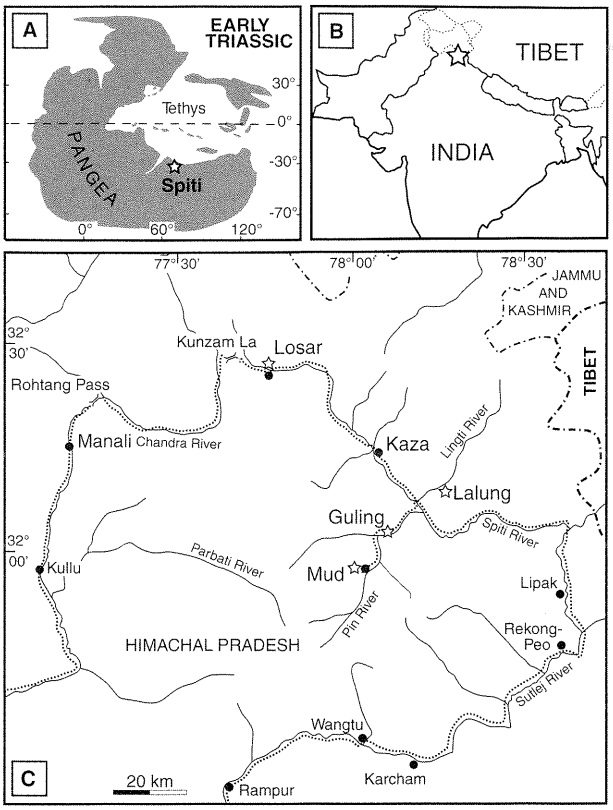


FIG. 1. A, palaeogeographical map of the Early Triassic with the palaeoposition of Spiti (modified after Brayard *et al.* 2006). B, Geographical map indicating the Spiti area in north-western India. C, location map of sampled sections.

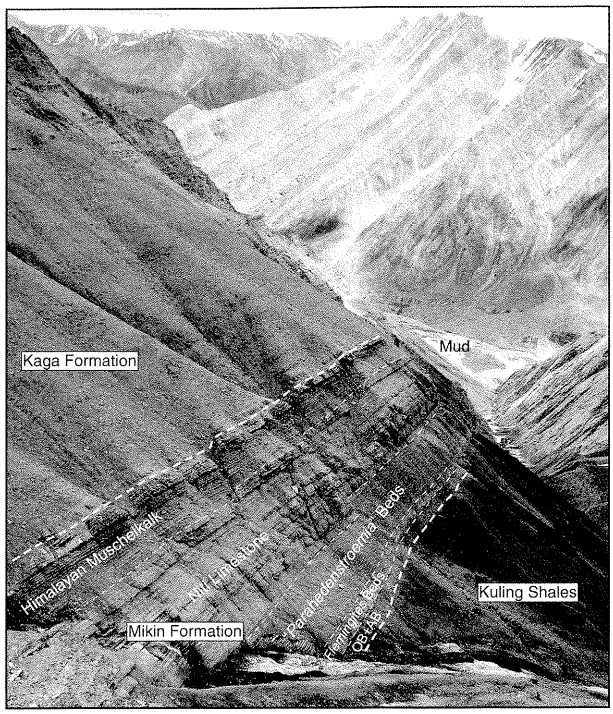


FIG. 2. Exposures of the Late Permian – Middle Triassic succession above the village of Mud in Pin Valley. Stratigraphic units after Bhargava *et al.* (2004). OB + AB: *Otoceras* beds + *Ambites* beds.

upper part consisting of grey thin-bedded limestone yielding '*Pleurogyronites*' (Dienerian). This member also contains abundant specimens of the bivalve *Claraia*.

Limestone and Shale Member. This member consists of dark shale with intercalated limestone, nodular limestone and diagenetic nodules.

The Limestone and Shale Member is subdivided into three parts (1) the *Ambites* Beds (equivalent to the *Meekoceras* Beds of Krafft and Diener 1909 and the *Gyronites* Beds of Bhargava *et al.* 2004; see also Brühwiler *et al.* 2010*b*), consisting of dark shale with intercalated limestone beds and early diagenetic nodules and are referred to the Dienerian; (2) the *Flemingites* Beds (lower Smithian), consisting of grey, slightly nodular limestone; and (3) the '*Parahedenstroemia*' Beds (=*Hedenstroemia* Beds of Krafft and Diener 1909), consisting of alternating shale and limestone beds and are referred to the middle–upper Smithian.

Niti Limestone Member. This member consists of light grey, nodular limestone of Spathian age.

Himalayan Muschelkalk Member. This member (Anisian) consists of thin limestone bands, argillaceous limestone and minor shale. Iron oxides and phosphatic preservation of fossils indicate condensed sedimentary conditions.

Comparison of the biostratigraphic data from this member with the well-established Anisian Stage of Nevada (Monnet and Bucher 2005) demonstrates that the exposures of the Himalayan Muschelkalk Member are incomplete.

The Lower Triassic mixed siliciclastic–carbonate succession of the Spiti area is very similar to the palaeogeographically distant basinal succession of the Luolou Formation in Guangxi Province, South China, which suggests a Tethys-wide control of climatic and eustatic origin on outer platform sedimentary evolution (Galfetti *et al.* 2007*a*). During the Early Triassic, the northern Indian margin was characterized by extensional tectonics related to the opening of the Neotethys (Stampfli *et al.* 1991). Therefore, successions from closely spaced localities in South Tibet (e.g. Tulong and Selong) show pronounced difference in the development of facies and thickness (Garzanti *et al.* 1998; Brühwiler *et al.* 2009).

LOCALITIES

The Spiti area is located east of the town of Manali in Himachal Pradesh, northern India (Fig. 1B). The Mud, Guling, Lalung and Losar localities have been studied

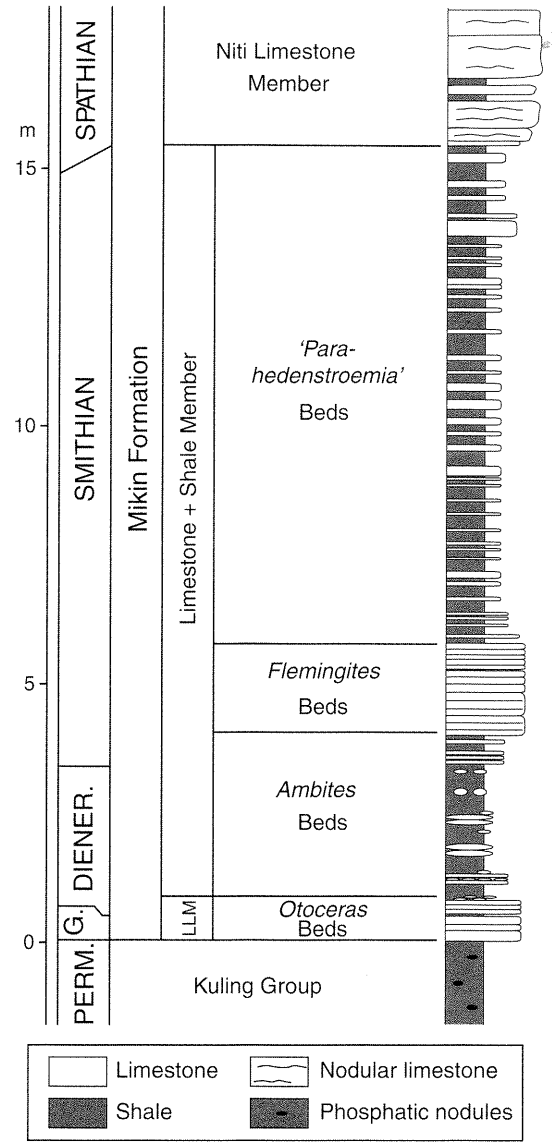


FIG. 3. Simplified stratigraphic log of the lower part of the Mikin Formation at Mud (modified after Bhargava *et al.* 2004). The lithostratigraphic units are well recognized in the other studied localities. '*Parahedenstroemia*' Beds are written with quotation marks because *Parahedenstroemia* is here regarded as a synonym of *Aspenites*.

(Fig. 1C). All the sections were sampled bed-by-bed to obtain a precise, detailed ammonoid record (Figs 4–7).

In the area near the village of Mud in Pin Valley, the Lower Triassic sediments are perfectly exposed (Fig. 2). It is one of the main localities studied by Diener (1897) and Krafft and Diener (1909), and the interval across the Induan–Olenekian (Dienerian–Smithian) stage boundary has been investigated by Krystyn *et al.* (2007*a*, *b*) and Brühwiler *et al.* (2010*b*). We extensively studied several sections at elevations ranging from 3900 to 4800 m. All sections can be correlated on a bed-by-bed basis. In the lower part of the '*Parahedenstroemia*' Beds, the ammonoids are abundant and well preserved, but fossiliferous horizons are relatively rare in their middle and upper parts. All middle to late Smithian ammonoid occurrences from Mud are shown in Figure 4.

In the Guling area, two sections were studied: one near the village in the bottom of the Pin Valley (3550 m) and one at an altitude of 3850 m, above the village. Both sections can be correlated bed-by-bed. Fossiliferous horizons are relatively rare in the '*Parahedenstroemia*' Beds, but preservation of ammonoids is sometimes excellent. All middle to late Smithian ammonoid occurrences from Guling are given in Figure 5.

Krafft and Diener (1909) described an extensive collection of Dienerian ammonoids from the area near the village of Lalung (old spelling Lilang) in Lingti Valley. Our sampling at this locality has yielded well-preserved ammonoids from the middle part of the '*Parahedenstroemia*' Beds. All middle Smithian ammonoid occurrences from Lalung are given in Figure 6.

Excellent exposures of the Mikin Formation also occur high above the village of Losar in Spiti Valley (Garzanti *et al.* 1995; Galfetti *et al.* 2007*b*). Ammonoids are abundant but mostly poorly preserved in the *Flemingites* beds. Abundant and well-preserved material was found in the lower and middle part of the '*Parahedenstroemia*' Beds. All Smithian ammonoid occurrences from Losar are given in Figure 7.

BIOSTRATIGRAPHY

Based on our bedrock-controlled sampling, we recognize a total of eight distinct ammonoid faunas of middle to latest Smithian age in the studied area (Figs 4–10). The resulting informal zonation presented herein significantly improves the preliminary versions presented earlier (Brühwiler *et al.* 2007; Krystyn *et al.* 2007*a*). A description of the ammonoid faunas as well as a discussion of their correlation with ammonoid zonations from other areas is provided, and synthetic range charts for Smithian ammonoid species and genera from Spiti are given (Figs 8–10).

No formal zone names are introduced as we prefer to use the term 'association' at the present time to describe the local faunal succession. The usage of formal zones would imply a well-established lateral reproducibility of the faunal sequence between various basins, which is still a subject of ongoing work.

Dienerian–Smithian boundary ammonoid faunas

Ammonoid faunas from the Dienerian–Smithian regional stage boundary beds at Mud have recently been

documented by Brühwiler *et al.* (2010*b*). The latest Dienerian *Prionolobus rotundatus* beds are followed by faunas containing certain ammonoids with typical early Smithian affinity (Flemingitidae, Kashmiritidae) and thus reflecting the beginning of the early Smithian evolutionary radiation. These faunas include the *Flemingites bhargavai* beds, the *Kashmiritidae* gen. nov. A beds and the *Vercherites* cf. *pulchrum* beds.

Early Smithian ammonoid faunas

Flemingites beds. In the Losar section, the species *Kashmirites nivalis*, *Kashmirites* sp. indet., *Flemingites* sp. indet., *Dieneroceras* cf. *tientungense* and *Krafficeras pseudoplanulatum* gen. nov. were found within the *Flemingites* 'beds', an assemblage that clearly demonstrates an early Smithian age for this assemblage.

Our limited sampling does not allow to significantly improve the biostratigraphy of this interval. A comprehensive study of the ammonoid fauna of the *Flemingites* beds based on abundant and well-preserved material from this interval is under progress (Krystyn *et al.* 2007*a*, *b*, in prep.).

Middle Smithian ammonoid faunas

Brayardites compressus *beds.* This subdivision was provisionally labelled 'new prionitid A beds' by Brühwiler *et al.* (2007) and is found at Mud, Guling and Losar. It is characterized by the association of *Aspenites acutus*, *Brayardites compressus*, *B. crassus*, *Jinyaceras hindostanum*, *Pseudaspenites* cf. *layeriformis*, *Tulongites xiaoqiaoi* and *Urdyceras tulongensis*. *Hermannites rursiradiatus* gen. et sp. nov. and *Xiaoqiaoceras involutus* also co-occur in this fauna.

Recently, this faunal association was also discovered at Tulong, South Tibet (Brühwiler *et al.* 2010*a*), and in the Salt Range (Pakistan; Brühwiler *et al.* 2012*b*, this issue), but a faunal equivalent is not known from South China. It probably correlates with an interval between the *Flemingites rursiratiatus* beds and the *Owenites koeneni* beds in the South China succession (Brayard and Bucher 2008).

Nammalites pilatoides *beds.* This subdivision was provisionally labelled 'new prionitid B beds' by Brühwiler *et al.* (2007) and comprises two different successive faunas in the Spiti area. *Nammalites pilatoides* and *Galfettites omani* are common to each of these. The succession consists of the following two horizons in ascending order:

1. *Escarguelites spitiensis* horizon: found at Mud and Losar. Characterized by the co-occurrence of *Escarguelites spitiensis* gen. et sp. nov., *Hanielites elegans* and *Nuetzelia himalayica* gen. et sp. nov.
2. *Truempyceras compressum* horizon: found at all studied localities. Characterized by the co-occurrence of *Truempyceras compressum* sp. nov., *Owenites* cf. *simplex*, *Paranannites* sp. indet., *Preflorianites* cf. *radians*, *Shigetaceras dunajensis* and *Steckites brevus* gen. et sp. nov.

Equivalent faunas of the upper part of the *Nammalites pilatoides* beds, that is, the *Truempyceras compressum* horizon, were also recently discovered at Tulong (Brühwiler *et al.* 2010*a*), in an exotic block of Hallstatt facies from Oman (Brühwiler *et al.* 2012*a*) and in the Salt Range (Brühwiler *et al.* 2012*b*). The *Nammalites pilatoides* beds correlate with the lower part of the middle Smithian *Owenites koeneni* beds of South China (i.e. *Ussuria* and *Hanielites* horizons; Brayard and Bucher 2008).

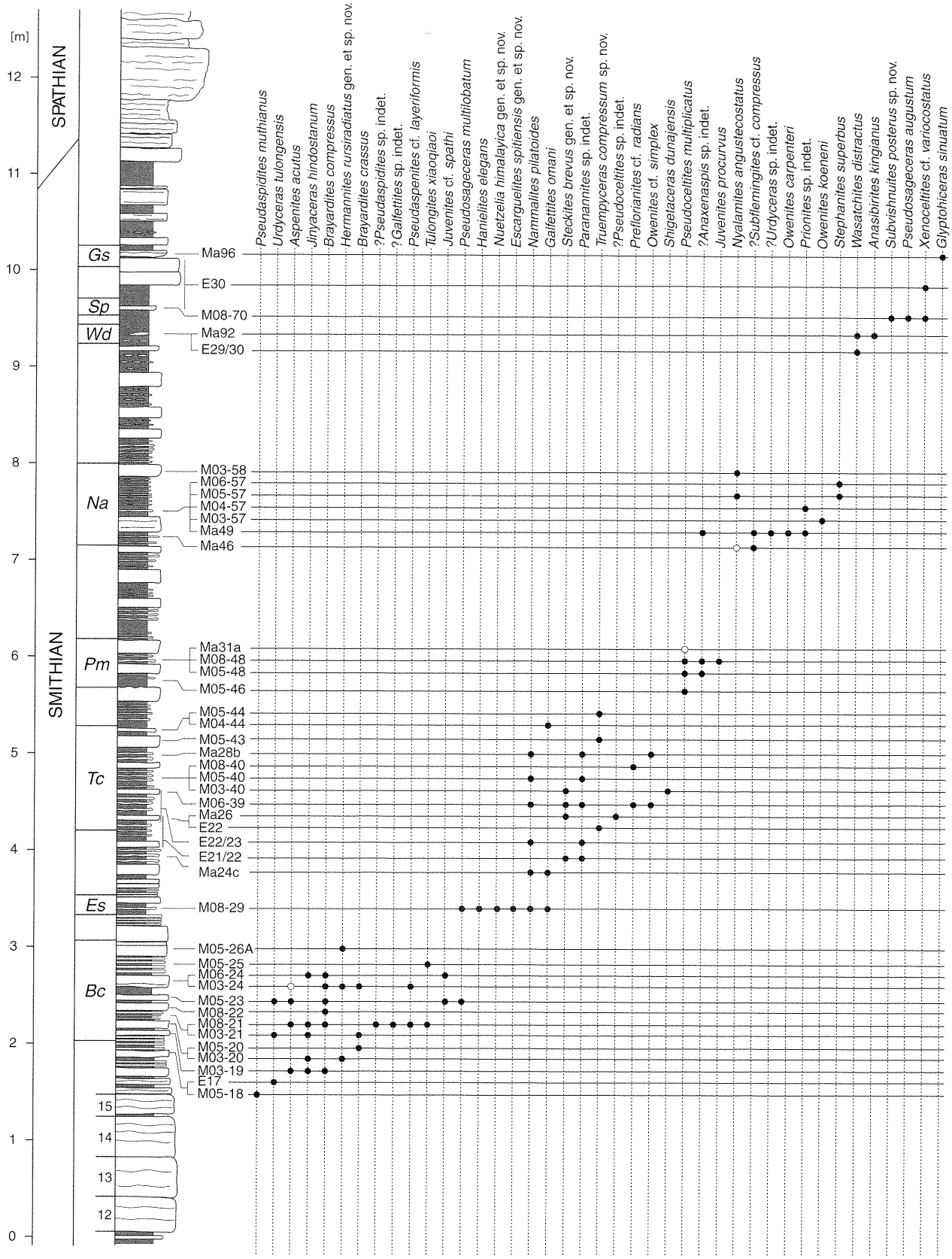
Pseudoceltites multiplicatus *beds.* This subdivision was preliminarily termed Flemingitid A beds by Brühwiler *et al.* (2007) and was found at Mud only. It is mainly characterized by the occurrence of very abundant *Pseudoceltites multiplicatus*. ?*Anaxenaspis* sp. indet. and *Juvenites procurvus* also co-occur.

This fauna occurs also at Tulong (Brühwiler *et al.* 2010*a*) and in the Salt Range (Brühwiler *et al.* 2012*b*, this issue). An exact correlative is not known from South China.

Nyalamites angustecostatus *beds.* This subdivision contains a diverse fauna and was found at Mud, Guling and Losar. It is characterized by the association of *Nyalamites angustecostatus*, *Owenites carpenteri*, *O. koeneni*, *Prionites* sp. indet., *Stephanites superbus* and ?*Subflemingites compressus* sp. nov. Rare specimens of ?*Anaxenaspis* sp. indet. and ?*Urdyceras* sp. indet. were also found in these beds.

This fauna is also known from Tulong (Brühwiler *et al.* 2010*a*), Oman (Brühwiler *et al.* 2012*a*) and the Salt Range (Brühwiler *et al.* 2012*b*), and it correlates with the *Inyoites* horizon in the upper part of the *Owenites koeneni* beds of South China, with which it shares *Owenites carpenteri*.

FIG. 4. Distribution of ammonoid taxa in the Mud section. Open dots indicate occurrences based on only fragmentary or poorly preserved material. Ammonoid faunas: *Bc* = *Brayardites compressus* beds; *Es* = *Escarguelites spitiensis* horizon; *Tc* = *Truempyceras compressum* horizon; *Pm* = *Pseudoceltites multiplicatus* beds; *Na* = *Nyalamites angustecostatus* beds; *Wd* = *Wasatchites distractus* beds; *Sp* = *Subvishnuites posterus* beds; *Gs* = *Glyptophiceras sinuatum* beds. See Figure 2 for location. Bed numbers of the lowermost part (i.e. *Flemingites* beds) after Krystyn *et al.* (2007*a*, *b*).


[m]
SPATHIAN
SMITHIAN
Gs
Sp
Wd
Na
Pm
Tc
Es
Bc
Ma96
E30
M08-70
Ma92
E29/30
M03-58
M06-57
M05-57
M04-57
M03-57
Ma49
Ma46
Ma31a
M08-48
M05-48
M05-46
M05-44
M04-44
M05-43
Ma28b
M08-40
M05-40
M03-40
M06-39
Ma26
E22
E22/23
E21/22
Ma24c
M08-29
M05-26A
M05-25
M06-24
M03-24
M05-23
M08-22
M08-21
M03-21
M05-20
M03-20
M03-19
E17
M05-18
Pseudaspidites muthianus
Urdyceras tulongensis
Aspenites acutus
Jinyaceras hindostanum
Brayardites compressus
Hermannites rursiradiatus gen. et sp. nov.
Brayardites crassus
?Pseudaspidites sp. indet.
?Galfettites sp. indet.
Pseudaspenites cf. layeriformis
Tulongites xiaoqiaoi
Juvenites cf. spathi
Pseudosageceras multilobatum
Hanielites elegans
Nuetzelia himalayica gen. et sp. nov.
Escarguelites spitiensis gen. et sp. nov.
Nammalites pilatoides
Galfettites omani
Steckites brevus gen. et sp. nov.
Paranannites sp. indet.
Truempyceras compressum sp. nov.
?Pseudocelites sp. indet.
Prefloriantes cf. radians
Owenites cf. simplex
Shigetaceras dunajensis
Pseudocelites multiplicatus
?Anaxenaspis sp. indet.
Juvenites procurvus
Nyalamites angustecostatus
?Subflemingites cf. compressus
?Urdyceras sp. indet.
Owenites carpenteri
Prionites sp. indet.
Owenites koeneni
Stephanites superbus
Wasatchites distractus
Anasibirites kingianus
Subvishnuites posterus sp. nov.
Pseudosageceras augustum
Xenocelites cf. variocostatus
Glyptohiceras sinuatum

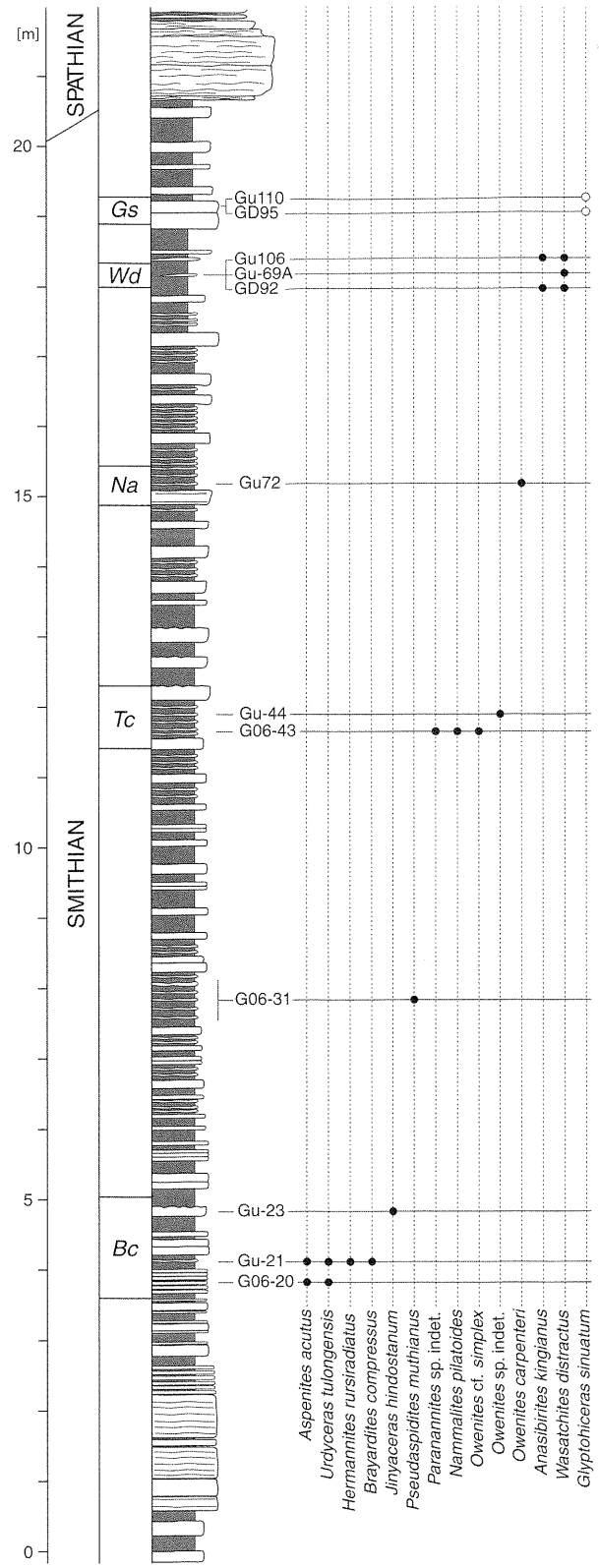


FIG. 5. Distribution of ammonoid taxa in the Guling section. Open dots indicate occurrences based on only fragmentary or poorly preserved material. Abbreviations of ammonoid faunas as in Figure 4.

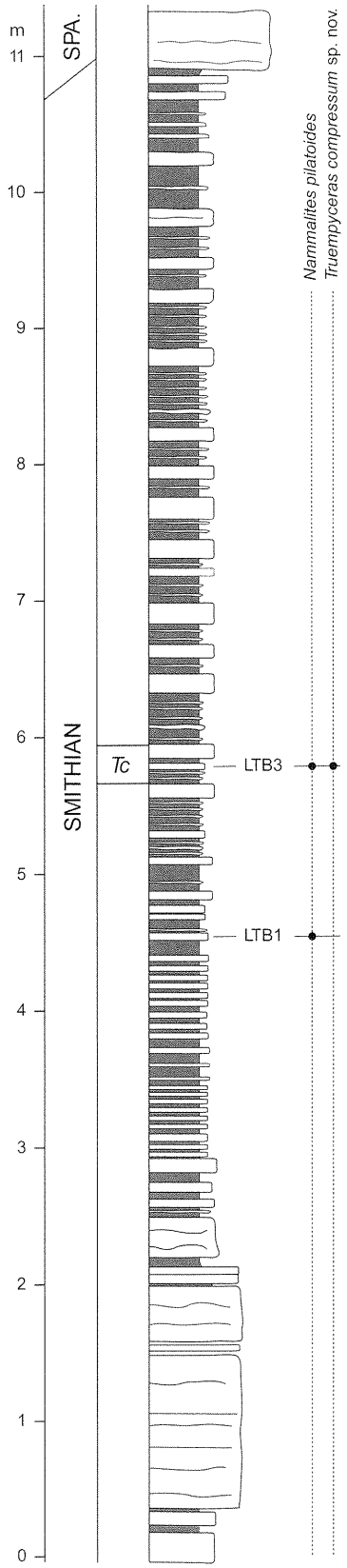


FIG. 6. Distribution of ammonoid taxa in the Lalung section. Abbreviations of ammonoid faunas as in Figure 4.

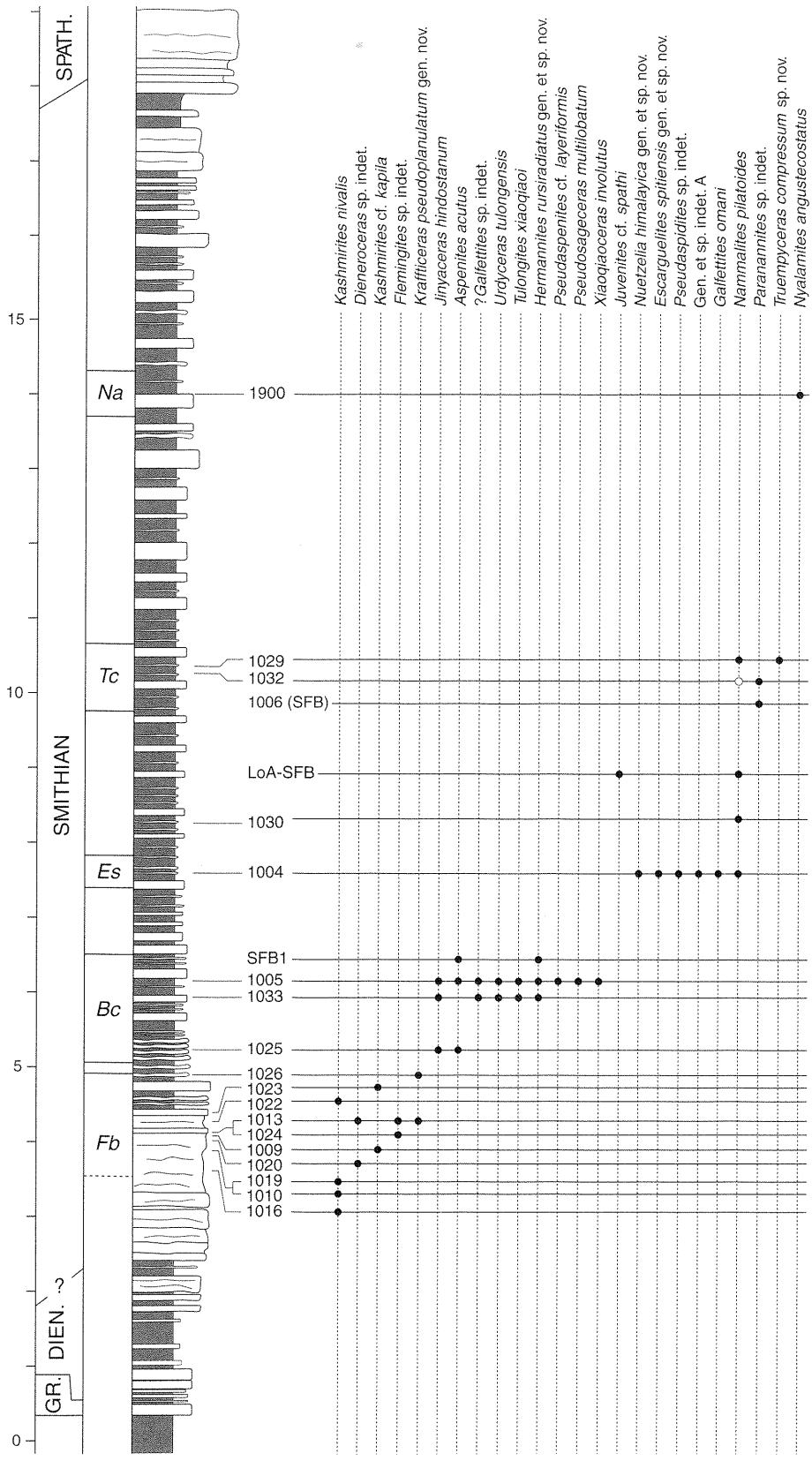


FIG. 7. Distribution of ammonoid taxa in the Losar section. Open dots indicate occurrences based on only fragmentary or poorly preserved material. Abbreviations of ammonoid faunas as in Figure 4.

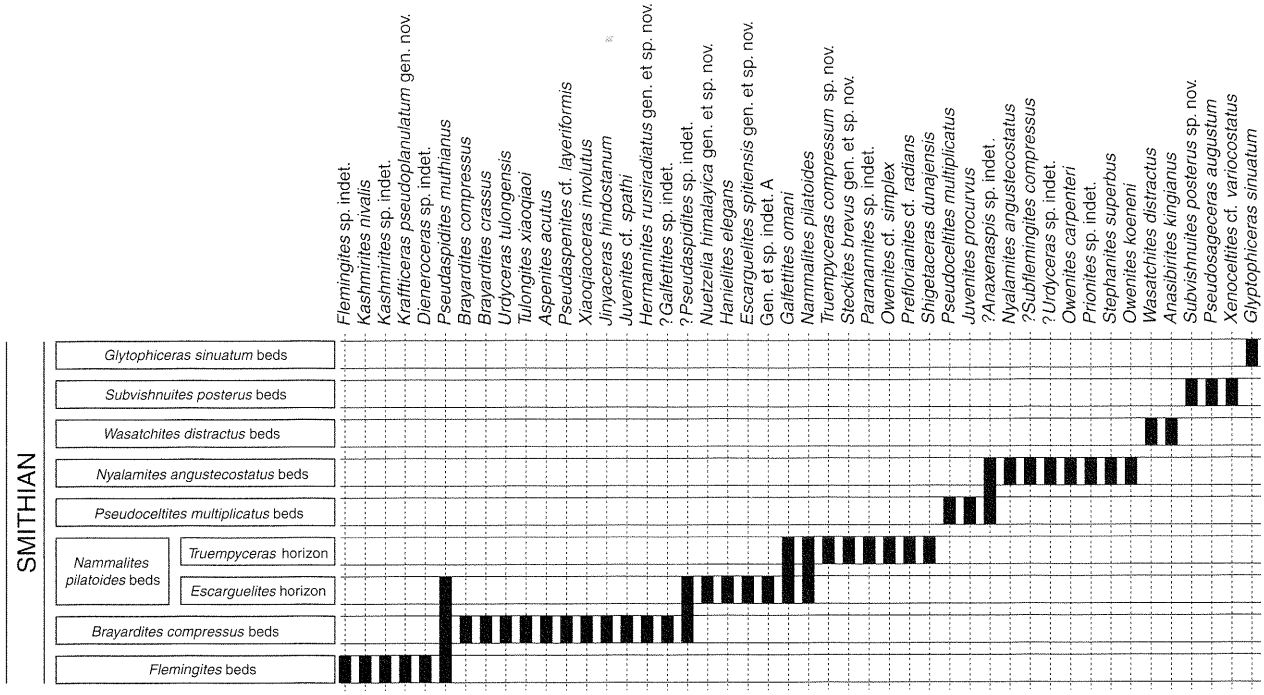


FIG. 8. Synthetic range chart showing the biostratigraphical distribution of Smithian ammonoid species in Spiti.

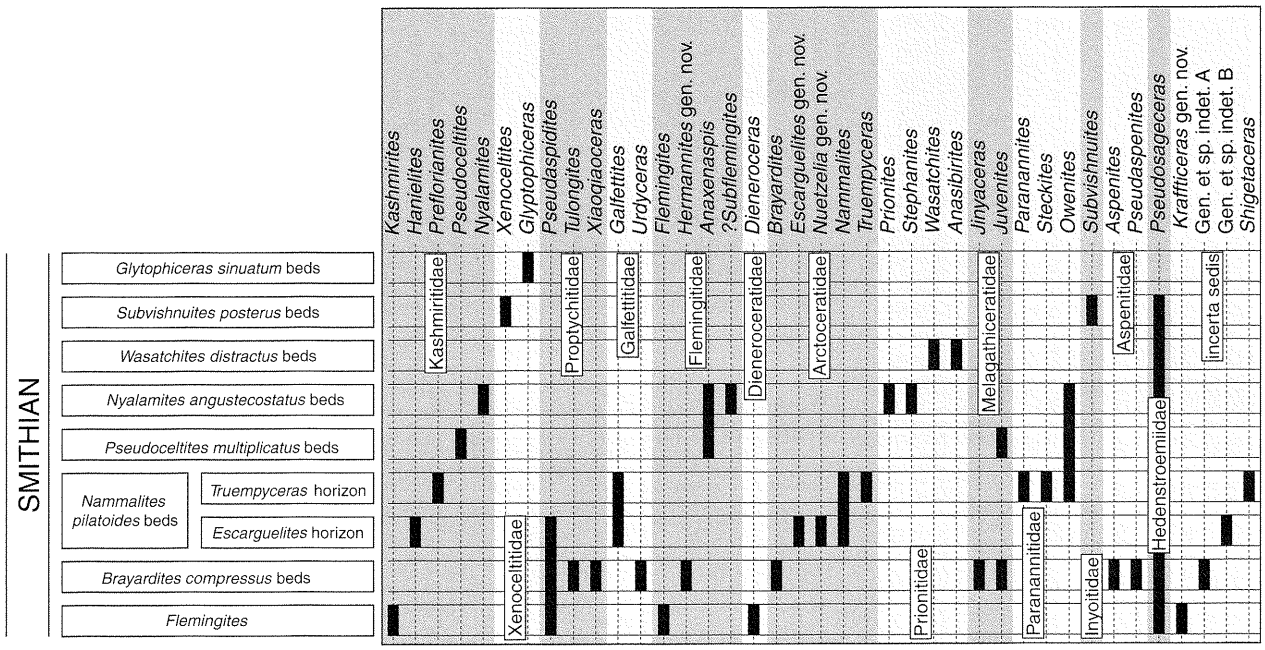


FIG. 9. Synthetic range chart showing the biostratigraphical distribution of Smithian ammonoid genera (grouped by families) in Spiti.

Late Smithian ammonoid faunas

Wasatchites distractus *beds.* This subdivision was found at Mud and Guling. It is characterized by the association of very abundant *Wasatchites distractus* and *Anasibirites kingianus*. Correlatives of this late Smithian fauna are known from many other Tethyan localities such as Timor (Welter 1922), South China (Brayard and Bucher 2008), Tulong (Brühwiler *et al.* 2010*a*), Oman (Brühwiler *et al.* 2012*a*), Salt Range (Brühwiler *et al.* 2012*b*), as well as

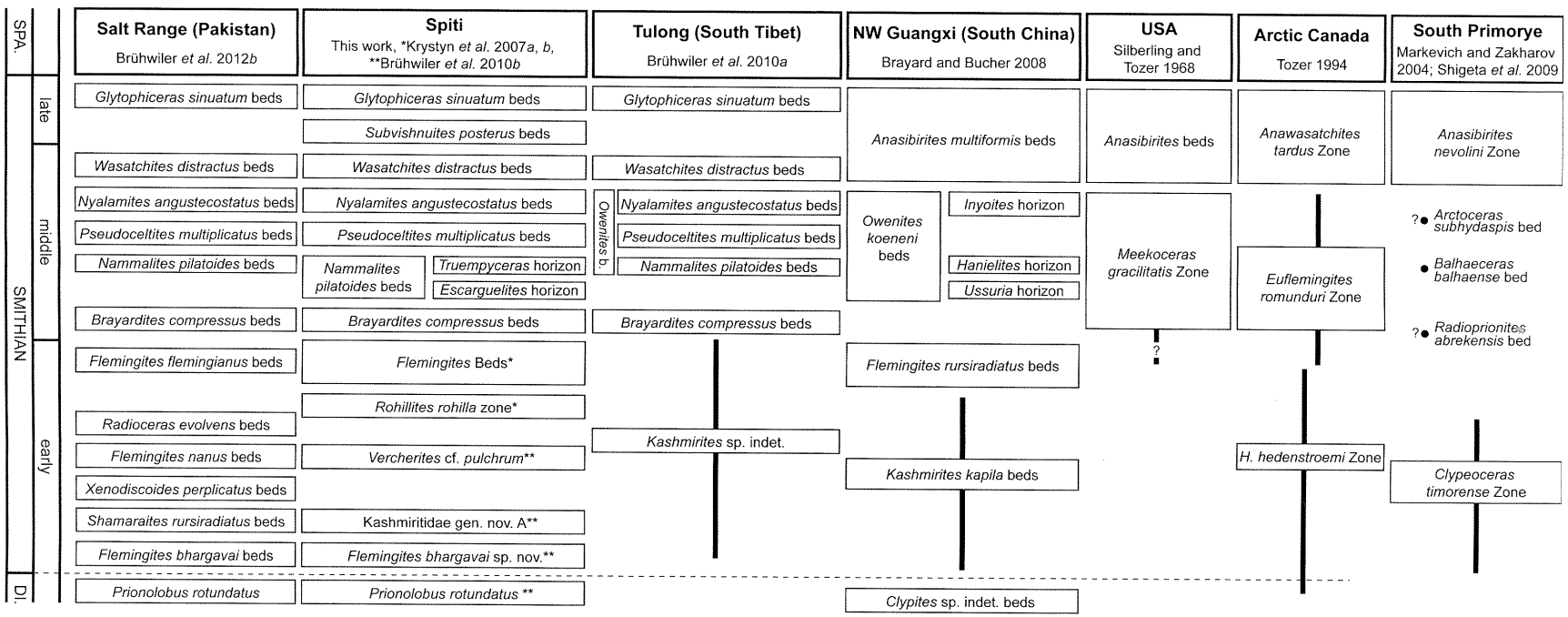


FIG. 10. Biostratigraphical subdivisions of the Smithian of Spiti and correlation with other zonations. For discussion of the biostratigraphical correlations of the Tethyan successions with those from basins outside the Tethys, see Brayard and Bucher (2008) and Brühwiler *et al.* (2010*a*). Note that the position of the Dienerian–Smithian (or Induan–Olenekian) stage boundary has not yet been formally defined (Krystyn *et al.* 2007*a*, *b*). Here, we use the ammonoid-based boundary definition as suggested earlier (Brühwiler *et al.* 2010*b*).

many other localities outside the Tethys (Markevich and Zakharov 2004; Silberling and Tozer 1968; Weitschat and Lehmann 1978; Tozer 1994).

Subvishnuites posterus *beds.* This subdivision was found at Mud only. It is characterized by the association of *Subvishnuites posterus* sp. nov., *Pseudosageceras augustum* and *Xenocelties* cf. *variocostatus*.

An exact correlative of this fauna is not known from other localities. Note that both *Pseudosageceras augustum* and *Xenoceltites* are relatively long ranging: *P. augustum* is known to cross the Smithian–Spathian boundary (Brühwiler *et al.* 2010*a*), and *Xenoceltites* co-occur with *Anasibirites* in South China (Brayard and Bucher 2008) and with *Glyptophiceras* in Tulong (Brühwiler *et al.* 2010*a*) and in the Salt Range (Brühwiler *et al.* 2012*b*).

Glyptophiceras sinuatum *beds.* The subdivision was found at Mud and Guling. It is characterized by the occurrence of *Glyptophiceras sinuatum*. This latest Smithian fauna also occurs in Tulong, South Tibet (Brühwiler *et al.* 2010*a*), and in the Salt Range (Brühwiler *et al.* 2012*b*).

CONCLUSIONS

Detailed sampling of the Smithian series at Mud, Guling, Lalung and Losar in Spiti (northern India) has yielded abundant and well-preserved ammonoid faunas of middle to late Smithian age. Our work is the first detailed description of Smithian ammonoids from this area based on bedrock-controlled material. A total of eight distinct middle to latest Smithian ammonoid associations have been found within the '*Parahedenstroemia*' Beds. In ascending order, the new local biostratigraphical sequence comprises the *Brayardites compressus* beds, the *Nammalites pilatoides* beds (subdivided into the *Escarguelites spitiensis* horizon and the *Truempyceras compressum* horizon), the *Pseudoceltites multiplicatus* beds, the *Nyalamites angustecostatus* beds, the *Wasatchites distractus* beds, the *Subvishnuites posterus* beds and the *Glyptophiceras sinnatus* beds. These biostratigraphic subdivisions of the Smithian can well be correlated with other areas on the northern Indian margin such as Tulong, South Tibet (Brühwiler *et al.* 2010*a*), Oman (Brühwiler *et al.* 2012*a*) and the Salt Range, Pakistan (Brühwiler *et al.* 2012*b*). Moreover, a detailed correlation with the well-studied record from the Guangxi Province, South China (Brayard and Bucher 2008), is facilitated by many common taxa.

SYSTEMATIC PALAEONTOLOGY

Remarks. Systematic descriptions mainly follow the classification established by Tozer (1981, 1994) and refined by Brayard and Bucher (2008), Brühwiler *et al.* (2010*a*) and Brühwiler and Bucher (2012*a*, *b*).

Provided that measurements were available for at least four specimens, the quantitative morphological range of each species is expressed utilizing the four classic geometrical parameters of the ammonoid shell: diameter (D), whorl height (H), whorl width (W) and umbilical diameter (U). The three parameters (H, W and U) are plotted in absolute values as well as in relation to diameter (H/D, W/D, and U/D). Sample numbers are reported on the stratigraphic sections (Figs 4–7).

Abbreviations. non, material not forming part of the current species; p., pars (from Latin, means that only part of the material belongs to the current species); v., *video* or *vidimus* (from Latin, means that the material was seen in person by the authors); ?, questionable; PIMUZ, Paläontologisches Institut und Museum der Universität Zürich, Switzerland.

Class CEPHALOPODA Cuvier, 1797
Subclass AMMONOIDEA Zittel, 1884
Order CERATITIDA Hyatt, 1884
Superfamily XENODISCACEAE Frech, 1902
Family KASHMIRITIDAE Spath, 1934

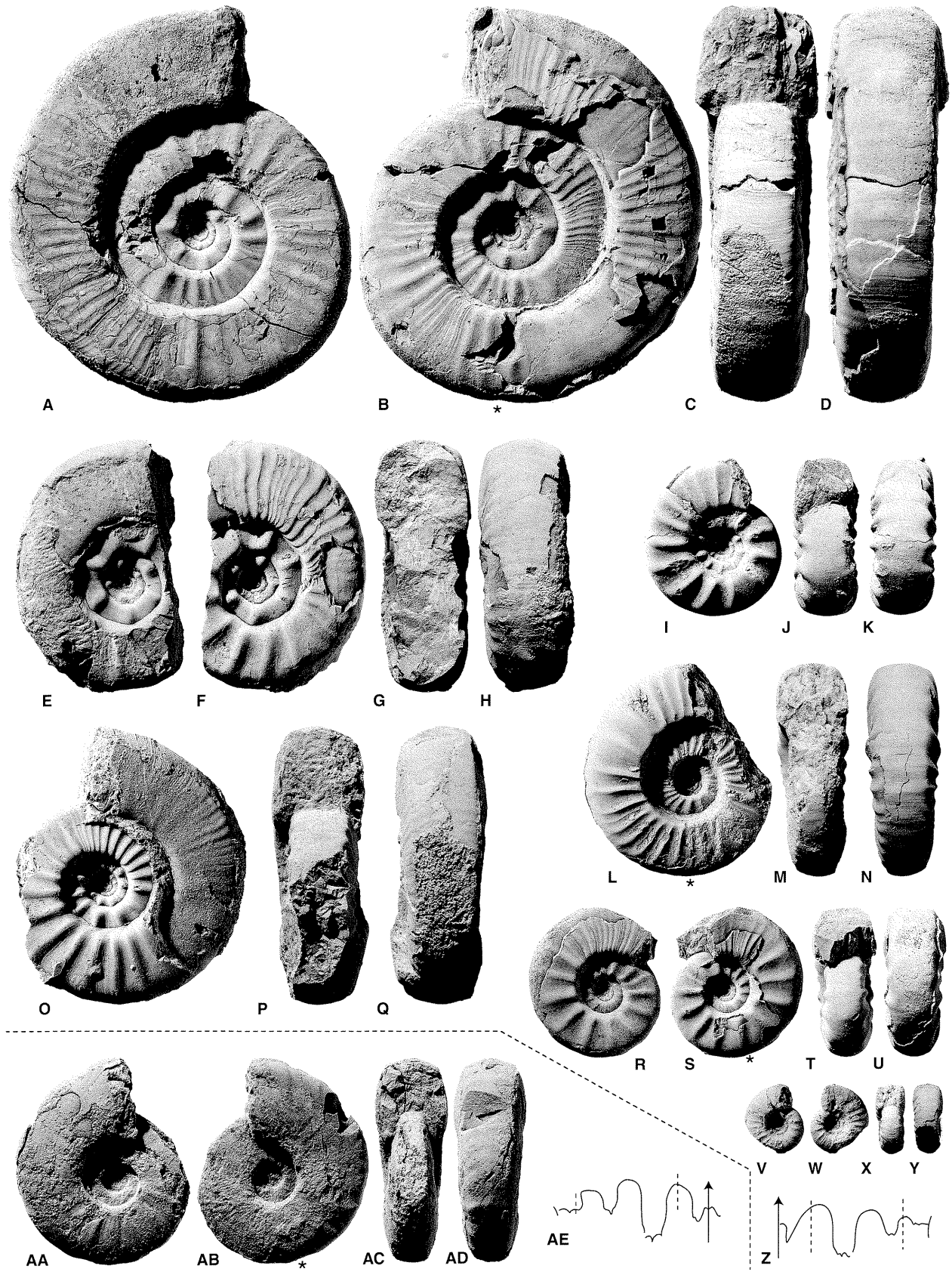
Genus PSEUDOCELTITES Hyatt, 1900

Type species. *Celtites multiplicatus* Waagen, 1895.

Pseudoceltites multiplicatus (Waagen, 1895)
Figure 11A–Z

1895 *Celtites multiplicatus* Waagen, p. 78, pl. 7, fig. 2a–c.
1895 *Celtites dimorphus* Waagen, p. 80, pl. 7, fig. 5a–c.
1976 *Psdeuodceltites multiplicatus* (Waagen); Wang and He, p. 289, pl. 6, figs 7–11.
? 1976 *Eukashmirites* cf. *blaschkei* (Diener); Wang and He, p. 290, pl. 6, fig. 12.
? 1976 *Eukashmirites* cf. *subarmatus* (Diener); Wang and He, p. 291, pl. 6, figs 13–14.
v 2010*a* *Pseudoceltites multiplicatus* (Waagen, 1895); Brühwiler *et al.*, p. 409, fig. 5: 1–7.

FIG. 11. A–Z, *Pseudoceltites multiplicatus* (Waagen, 1895). A–D, PIMUZ 28193, found as float in the *Parahedenstroemia* Beds; E–H, PIMUZ 28194, from sample M08-48; I–K, PIMUZ 28195, from sample M05-48, Mud; L–N, Z, PIMUZ 28196, Z × 2, at H = 10.8 mm, from sample M08-48; O–Q, PIMUZ 28197, found as float; R–U, PIMUZ 28198, from sample M08-48; V–Y, PIMUZ 28199, from sample Ma31a. All from the *Pseudoceltites multiplicatus* beds, Mud. AA–AE, ?*Pseudoceltites* sp. indet. PIMUZ 28200; EE ×2, at H = 11 mm; from sample Ma26, *Truempyceras compressum* horizon, Mud. All natural size unless otherwise indicated. Asterisks indicate phragmocone end where known.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v 2012*b* *Pseudoceltites multiplicatus* (Waagen, 1895); Brühwiler and Bucher, p. 27, fig. 21A–CC.

Occurrence. Samples M05-46, M05-48, M08-48, Ma31a, E24; *Pseudoceltites multiplicatus* beds.

Description. Evolute shell with a subrectangular whorl section. Flanks flat, converging very weakly. Venter broad and subtabulate, slightly arched with slightly rounded shoulders. Umbilicus with a high vertical wall and marked, slightly rounded shoulders. Ornamentation varies from strong, distant radial ribs to fine, dense and slightly sinuous ribs. Ribs usually fade out on ventral shoulders, but occasionally cross the venter as faint ridges. Suture line ceratitic with broad saddles; first and second lateral saddle tapered and large, third saddle low.

Measurements. See Figure 12.

?*Pseudoceltites* sp. indet.
Figure 11AA–AE

Occurrence. A single specimen from sample Ma26.

Description. Moderately evolute shell with a subrectangular whorl section. Flanks nearly flat, slightly convex. Venter broad and subtabulate, slightly arched with slightly rounded shoulders. Umbilicus with a high vertical wall and marked, slightly rounded shoulders. Ornamentation consists of weak, slightly sinuous ribs. Suture line ceratitic with relatively deep lobes.

Measurements. See Table 1.

Remarks. This specimen is more involute than *Pseudoceltites multiplicatus*. It also differs by its weaker ornamentation.

Genus KASHMIRITES Diener, 1913

Type species. *Celtites armatus* Waagen, 1895.

Kashmirites nivalis (Diener, 1897)
Figure 13I–R

1897 *Danubites nivalis* Diener, p. 51, pl. 15, figs 17–18.
1909 *Xenodiscus nivalis* Diener, Krafft and Diener, p. 102. pl. 24, figs 1–3, 5; pl. 25, fig. 5.
1934 *Anakashmirites nivalis* Diener; Spath, p. 237, pl. 12, fig. 4a–e.

Occurrence. Samples HB1010, HB1019, HB1016, HB1022; *Flemingites* beds, Losar.

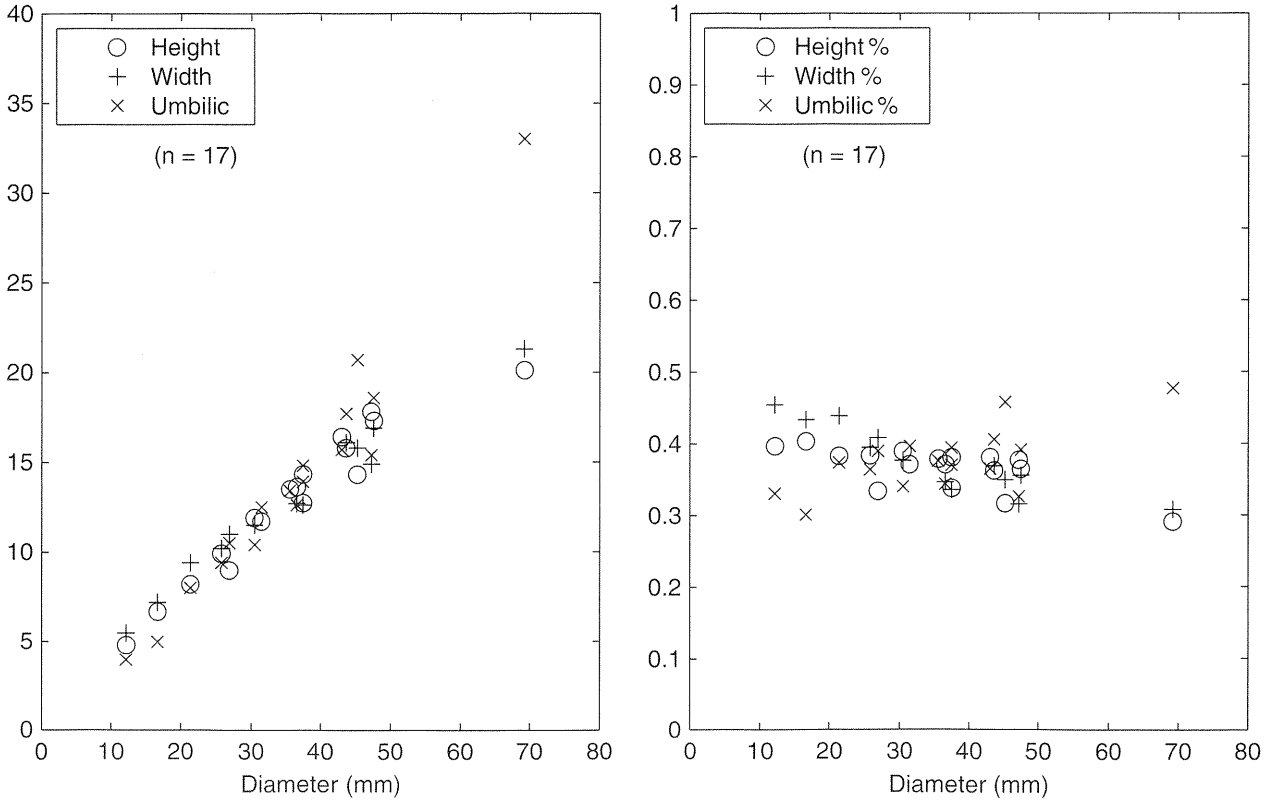


FIG. 12. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Pseudoceltites multiplicatus* (Waagen, 1895).

TABLE 1. Measurements of the classic geometrical parameters of the ammonoid shell.

Species	Specimen	D (mm)	H (mm)	W (mm)	U (mm)	Sample
?*Pseudoceltites* sp. indet.	PIMUZ 28200	36.4	15.2	13	11.2	Ma26
Kashmirites nivalis (Diener, 1897)	PIMUZ 28205	23.4	7.9	–	10.2	HB1010
	PIMUZ 28204	27.2	9.7	–	11.8	HB1010
Nyalamites angustecostatus (Welter, 1922)	PIMUZ 28209	11.1	4.1	3.8	4.5	HB1900
	PIMUZ 28208	22.7	7.9	6	9.8	M03-58
Xenoceltites cf. *variocostatus* Brayard and Bucher, 2008	PIMUZ 28214	39.5	14.4	9.1	15	M08-70
Glyptophiceras sinuatum (Waagen, 1895)	PIMUZ 28212	65.2	20.3	14.2	28.5	Ma96
	PIMUZ 28211	18.9	7.3	5.2	6.7	Ma96
Xiaoqiaoceras involutus Brayard	PIMUZ 28220	16.1	9.4	8.1	1.8	HB1005
and Bucher, 2008	PIMUZ 28221	15.7	10	9	1.4	HB1005
?*Paranorites* sp. indet.	PIMUZ 28222	161	72	41	35	Float
?*Urdyceras* sp. indet.	PIMUZ 28248	12.7	6.1	4.8	5	Ma49
Hermannites rursiradiatus gen. et sp. nov.	PIMUZ 28261	76.6	27	17.8	29.9	M03-20
?*Subflemingites compressus* Brühwiler *et al.*, 2010*a*	PIMUZ 28271	24.5	11.1	–	6.8	Ma49
	PIMUZ 28272	15.2	6.2	4.3	5	Ma46
Brayardites compressus Brühwiler *et al.*, 2010*a*	PIMUZ 28277	21.8	11.2	6.4	3.6	HB1005
	PIMUZ 28279	37	17.5	11.7	8.4	M08-21b
Brayardites crassus Brühwiler *et al.*, 2010*a*	PIMUZ 28273	35.1	14.5	20	10.6	M03-21
	PIMUZ 28274	109	42	–	42.8	M05-20
Nuetzelia himalayica gen. et sp. nov.	PIMUZ 28292	15.1	7.8	4.1	2.7	HB1004
	PIMUZ 28290	19.8	11.4	–	2.7	HB1004
	PIMUZ 28291	20.8	10.7	5.3	3.8	HB1004
Prionites sp. indet.	PIMUZ 28307	35.2	18.3	10	4.1	Ma49
	PIMUZ 28305	43.2	22.1	–	4.6	Ma49
Owenites cf. *simplex* Welter, 1922	PIMUZ 28460	21.8	11	10.3	3.2	M06-39
Steckites brevus gen. et sp. nov.	PIMUZ 28337	29.3	13.5	–	5.5	Ma26
	PIMUZ 28378	22.1	10.1	8.4	3.5	E21-22
Owenites koeneni Hyatt and Smith, 1905	PIMUZ 28461	54.8	23.9	–	12	M03-57
	PIMUZ 28335	40	19	–	6	M03-57
Owenites carpenteri Smith, 1932	PIMUZ 28339	27.5	16	11.2	0	Gu72
	PIMUZ 28340	23.6	14.7	10	0	Gu72
Juvenites procurvus Brayard and Bucher, 2008	PIMUZ 28353	24.6	8.3	13.2	9.5	Float
	PIMUZ 28354	21.5	7.9	12.7	8.2	M08-48
Aspenites acutus Hyatt and Smith, 1905	PIMUZ 28365	30.5	18.5	6.8	0	LoSFB1
	PIMUZ 28366	42.5	23.5	7.1	1.2	HB1005
Pseudaspenites cf. *layeriformis* (Welter, 1922)	PIMUZ 28369	49.1	24.5	6.5	5.5	M08-21b
Pseudosageceras augustum (Brayard and Bucher, 2008)	PIMUZ 28373	30.2	28.3	5.8	0	M08-70
	PIMUZ 28374	45.5	27.6	–	0	M08-70
Shigetaceras dunajensis (Zakharov, 1968)	PIMUZ 28375	28.5	14.8	10.3	4.9	M03-40
?*Galfettites* sp. indet.	PIMUZ 28239	24.2	10	5.9	8	HB1005
	PIMUZ 28234	11.5	5.7	2.2	3	HB1005
	PIMUZ 28238	18.2	7.8	4.5	5.4	HB1033
Gen. et sp. indet. A	PIMUZ 28308	44.5	21.6	10.5	9.3	HB1004

Diameter (D), whorl height (H), whorl width (W) and umbilical diameter (U).

Description. Evolute, slightly compressed shell with convex flanks. Venter arched with rounded shoulders. Umbilicus with rounded shoulders. Ornamentation consists of strong, distant folds. Suture line not preserved.

Measurements. See Table 1.

Remarks. Spath (1934) erected the genus *Anakashmirites* based on this species. This genus was synonymized with *Kashmirites* Diener 1913 by Tozer (1981).

Kashmirites sp. indet.
Figure 13F–H

Occurrence. Samples HB1009, HB1023; *Flemingites* beds, Losar.

Description. Evolute shell with flat, subparallel flanks. Venter subtabulate, low arched with rounded shoulders. Umbilicus wide with a steeply inclinded wall and slightly rounded shoulders. Ornamentation consists of strong, sharp ribs. Suture line is not preserved.

Remarks. The evolute coiling, the ornamentation and the subrectangular whorl section of this species favour assignment to *Kashmirites*, but the poor preservation of our material precludes an assignment at the species level.

Genus PREFLORIANITES Spath, 1930

Type species. Danubites strongi Hyatt and Smith, 1905.

Preflorianites cf. *radians* Chao, 1959
Figure 13A–E

Occurrence. Samples M06-39, M08-40; *Truempyceras compressum* horizon, Mud.

Description. Evolute shell with convex flanks. Venter rounded without any distinct shoulders. Umbilicus wide and shallow with vertical wall and rounded shoulders. Ornamentation of flanks consists of regularly spaced, strong, radial or rursiradiate rounded ribs that fade out towards lower flanks. Suture line not preserved.

Remarks. This species is very close to *Preflorianites radians* Chao (1959) from South China, which differs by its slightly more evolute coiling.

Genus NYALAMITES Brühwiler, Bucher and Goudemand, 2010*a*

Type species. Xenodiscus angustecostatus Welter, 1922.

Nyalamites angustecostatus (Welter, 1922)
Figure 13S–AA

? 1895 *Celtites acuteplicatus* Waagen, 1895, p. 82, pl. 7a, figs 5, 5c, 6, 7.
1922 *Xenodiscus angustecostatus* Welter, p. 110, pl. 4, figs 14–17.
? 1922 *Xenodiscus oyensi* Welter, p. 111, pl. 5, figs 1, 2, 17
1968 *Anakashmirites angustecostatus* (Welter); Kummel and Erben, p. 128, pl. 19, figs 1–8.
1973 *Anakashmirites angustecostatus* (Welter); Collignon, p. 144, pl. 5, figs 7–8.
1973 *Anakashmirites oyensi* (Welter); Collignon, p. 146, pl. 5, figs 9–10.
1976 *Pseudoceltites angustecostatus* (Welter); Wang and He, p. 289, pl. 6, figs 3–6.
v 1978 *Eukashmirites angustecostatus* (Welter); Guex, pl. 7, figs 4, 9.
v non 2008 *Pseudoceltites? angustecostatus* (Welter); Brayard and Bucher, p. 18; pl. 3, figs 1–7; fig. 19 (= *Preflorianites radians*).
v 2010*a* *Nyalamites angustecostatus* (Welter); Brühwiler *et al.* p. 411, fig. 7: 3–5.
v 2012*a* *Nyalamites angustecostatus* (Welter); Brühwiler and Bucher, p. 14, pl. 1, figs 3–6.
v 2012*b* *Nyalamites angustecostatus* (Welter, 1922); Brühwiler and Bucher, p. 29, fig. 21AG–BB.

Occurrence. Samples Ma46, M03-57, M03-58, Mud; HB1900, Losar; *Nyalamites angustecostatus* beds.

Description. Small, very evolute shell with slightly convex, subparallel flanks. Venter subtabulate with narrowly rounded shoulders. Umbilicus shallow and wide with inclined wall and rounded shoulders. Ornamentation consists of regularly spaced, strong, sharp, radial ribs that fade out on ventral shoulders. Suture line ceratitic with two broad lateral saddles; third saddle reduced.

Measurements. See Table 1.

Remarks. This species is very common in the late middle Smithian of the Tethys.

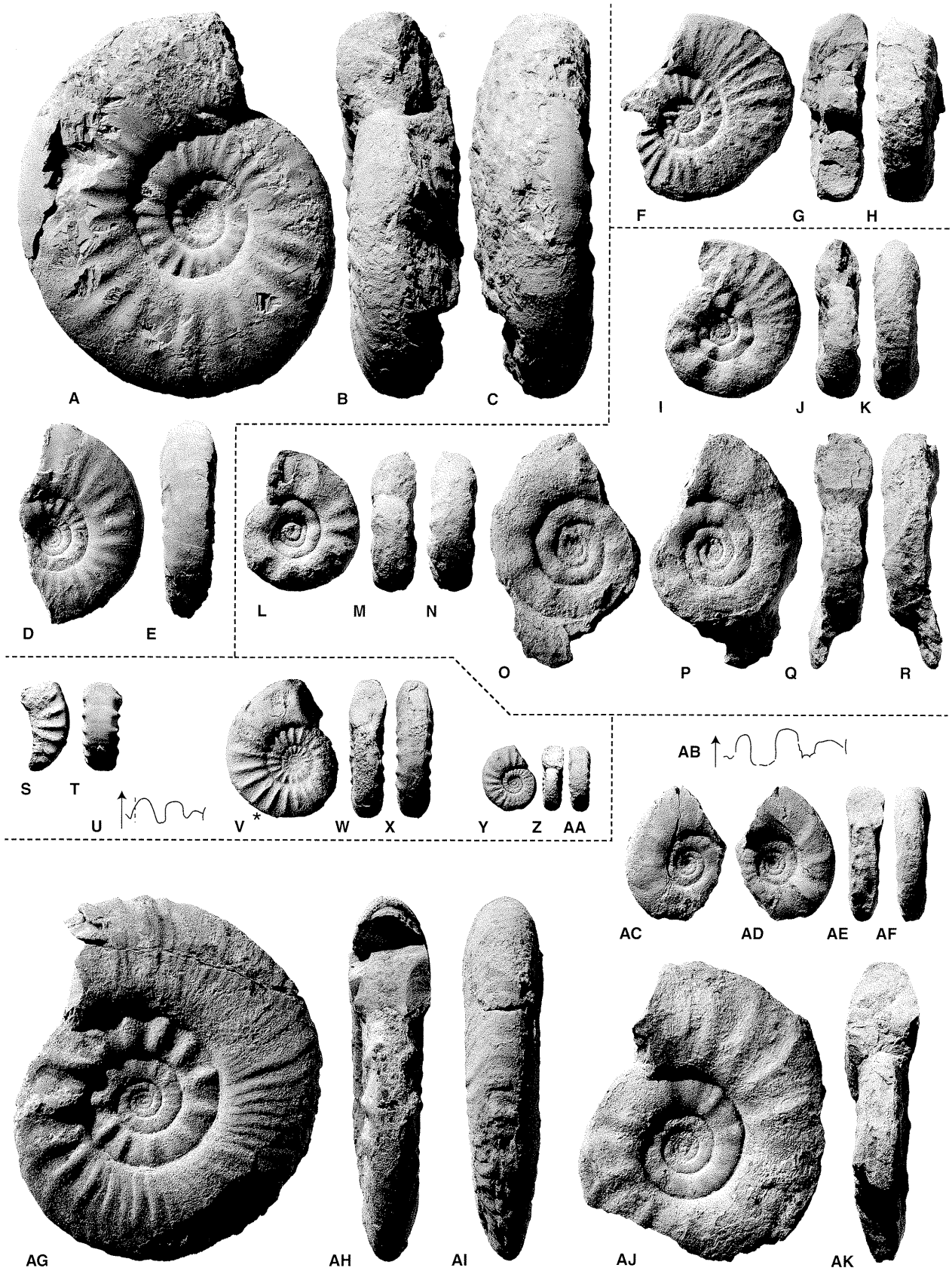
Genus HANIELITES Welter, 1922

Type species. Hanielites elegans Welter, 1922.

Hanielites elegans Welter, 1922
Figure 14J–L

1922 *Hanielites elegans* Welter, p. 145, pl. 14, figs 7–11.

FIG. 13. A–E, *Preflorianites* cf. *radians* Chao, 1959. A–C, PIMUZ 28201, from sample M06-39; D–E, PIMUZ 28202 from sample M08-40. Both specimens from the *Truempyceras compressum* horizon, Mud. F–H, ?*Kashmirites* sp. indet. PIMUZ 28203, from sample HB1006, *Flemingites* beds, Losar. I–R, *Kashmirites nivalis* (Diener, 1897). I–K, PIMUZ 28204, from sample HB1010; L–N, PIMUZ 28205, from sample HB1010; O–R, PIMUZ 28206, from sample HB1019. All from the *Flemingites* beds, Losar. S–AA, *Nyalamites angustecostatus* (Welter, 1922). S–T, PIMUZ 28207, ×2, from sample Ma46, Mud; U–X, PIMUZ 28208; U × 2, at H = 5.9 mm, from sample M03-58, Mud; Y–AA, PIMUZ 28209, from sample HB1900, *Nyalamites angustecostatus* beds, Losar. AB–AK, *Glyptophiceras sinuatum* (Waagen, 1895). AB, PIMUZ 28210, ×2, at H = 10.6 mm; AC–AF, PIMUZ 28211; AG–AI, PIMUZ 28212; AJ–AK, PIMUZ 28213. All from sample Ma96, *Glyptophiceras sinuatum* beds, Mud. All natural size unless otherwise indicated.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1934 *Hanielites elegans* Welter; Spath, p. 243, fig. 82a–d.
1959 *Hanielites elegans* Welter; Chao, p. 280, pl. 37, figs 8–12, text-fig. 36b.
1959 *Hanielites elegans* var. *involutus* Chao, p. 281, pl. 37, figs 4–6, text-fig. 36a.
1959 *Hanielites rotulus* Chao, p. 281, pl. 37, figs 12–15.
1959 *Owenites kwangiensis* Chao, p. 250, pl. 22, figs 1–2, 5–6.
v 2008 *Hanielites elegans* Welter; Brayard and Bucher, p. 19, pl. 4, figs 1–5, text-fig. 20.

Occurrence. A single fragmentary specimen from sample M08-29; *Escarguelites spitiensis* beds, Mud.

Description. Small, moderately evolute and compressed shell with flat, parallel flanks. Venter subangular. Umbilicus with low, vertical wall. Ornamentation consists of biconcave plications. Suture line is not preserved.

Family XENOCELTITIDAE Spath, 1930

Genus XENOCELTITES Spath, 1930

Type species. Xenoceltites subevolutus Spath, 1930.

Xenoceltites cf. *variocostatus* Brayard and Bucher, 2008
Figure 14A–G

1913 *Ophiceras demissum* Oppel; Diener, p. 17, pl. 1, figs 8–9.
v 2012*b* *Xenoceltites* cf. *variocostatus* Brayard and Bucher, 2008; Brühwiler and Bucher, p. 34, fig. 24A–AG.

Occurrence. Samples M08-70, E30; *Subvishnuites posterus* beds, Mud.

Description. Moderately evolute, platycone shell with nearly flat, barely convex flanks. Venter narrowly rounded with indistinct shoulders. Umbilicus shallow with moderately low, inclined wall and rounded shoulders. Inner whorls occasionally ribbed, outer whorls smooth. Growth lines prorsiradiate and biconcave. Suture line simple; fine indentations of lobes not preserved.

Measurements. See Table 1.

Remarks. Xenoceltites variocostatus from South China differs by its slightly thicker whorls, but is otherwise very similar. The specimens from the Salt Range described as *Xenoceltites* cf. *variocostatus* (Brühwiler and Bucher, 2012*b*) are identical with our specimens from Spiti.

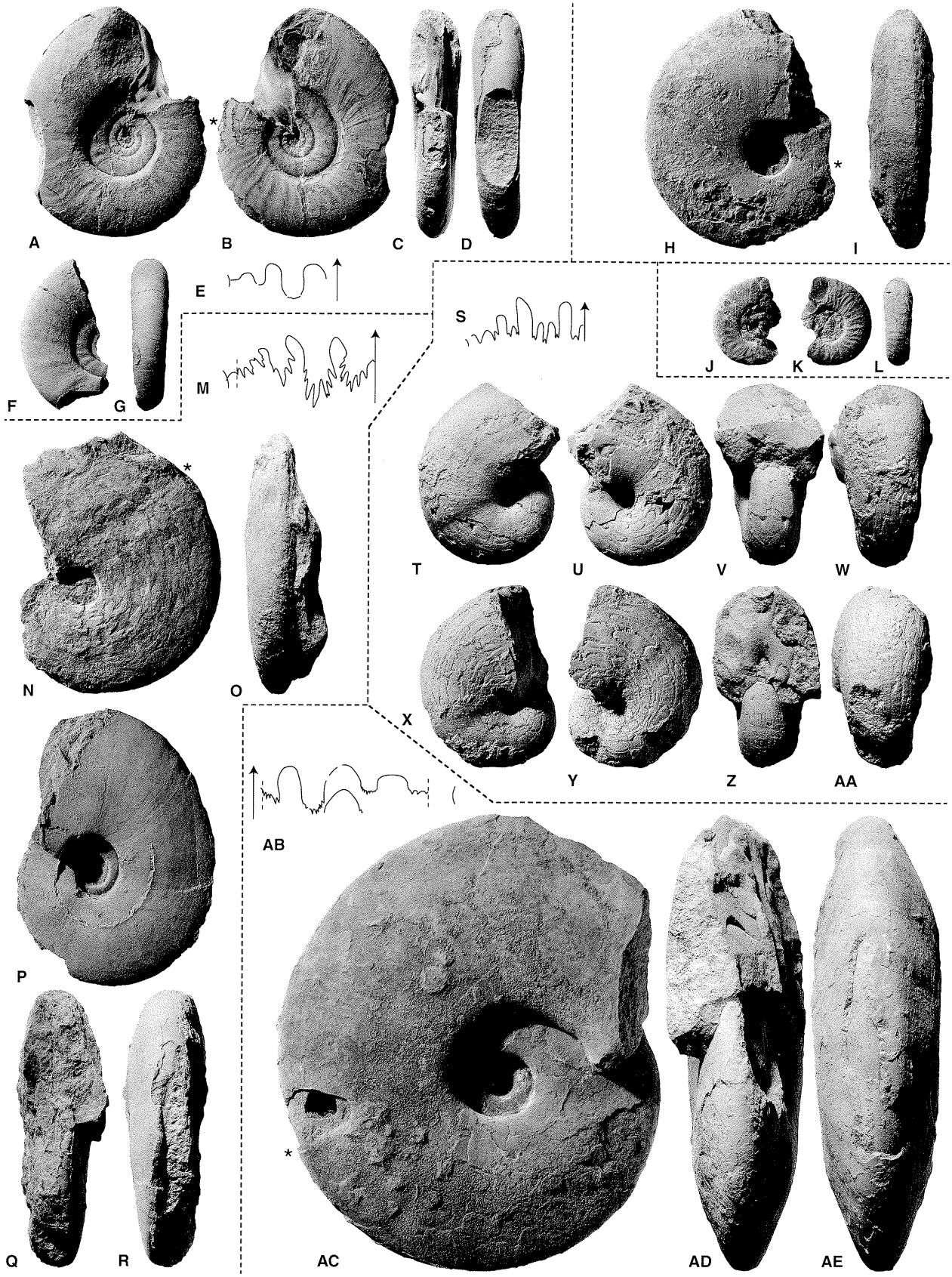
Genus GLYPTOPHICERAS Spath, 1930

Type species. Xenodiscus aequicostatus Diener, 1913 (= *Dinarites sinuatus* Waagen, 1895).

Glyptophiceras sinuatum (Waagen, 1895)
Figure 13AB–AK

1895 *Dinarites sinuatus* Waagen, p. 33, pl. 10, fig. 4.
? 1913 *Xenodiscus* cf. *lissarensis* Diener; Diener, p. 5, pl. 1, fig. 11.
1913 *Xenodiscus aequicostatus* Diener, p. 6, pl. 2, fig. 10.
1913 *Xenodiscus salomonii* Diener, p. 7, pl. 2, fig. 5.
1913 *Xenodiscus althothae* Diener, p. 8, pl. 2, figs 6, 11.
1913 *Xenodiscus* cf. *ellipticus* Diener; Diener, p. 9, pl. 3, fig. 1.
1913 *Xenodiscus comptoni* Diener, p. 10, pl. 2, fig. 7.
? 1913 *Xenodiscus* cf. *rotula* Waagen; Diener, p. 11, pl. 3, fig. 2.
1913 *Xenodiscus* cf. *ophioneus* Waagen; Diener, p. 12, pl. 2, figs 8–9.
? 1913 *Xenodiscus* cf. *sitala* Diener; Diener, p. 14, pl. 3, fig. 3.
1966 *Xenoceltites sinuatus* Waagen; Kummel, pl. 1, figs 1–2.
? 1966 *Xenoceltites sinuatus* Waagen; Kummel, pl. 1, figs 3–4.
v 1978 *Xenoceltites pulcher* Guex, p. 112, pl. 7, fig. 8.
v 2010*a* *Glyptophiceras sinuatum* (Waagen, 1895); Brühwiler *et al.* p. 409, fig. 6: 1–7.
v 2012*b* *Glyptophiceras sinuatum* (Waagen, 1895); Brühwiler and Bucher, p. 34, figs 24AH–AO, 26A–T.

FIG. 14. A–G, *Xenoceltites* cf. *variocostatus* Brayard and Bucher, 2008. A–E, PIMUZ 28214; E × 2, at H = 8.5 mm, from sample M08-70; F–G, PIMUZ 28215 from sample E30. Both specimens from the *Subvishnuites posterus* beds, Mud. H–I, *Pseudaspidites* sp. indet. PIMUZ 28218, from sample M08-21, *Brayardites compressus* beds, Mud. J–L, *Hanielites* cf. *elegans* (Welter, 1922). PIMUZ 28217, from sample M08-29, *Escarguelites spitiensis* horizon, Mud. M–R, *Pseudaspidites muthianus* (Krafft and Diener, 1909). M–O, PIMUZ 28216; M at H = 21.7 mm, from sample M05-18, just below the *Brayardites compressus* beds, Mud: P–R, PIMUZ 28219, from sample HB1004, *Escarguelites spitiensis* horizon, Losar. S–AA, *Xiaoqiaoceras involutus* Brayard and Bucher, 2008. S–W, PIMUZ 28220, S at H = 8.5 mm, D = 13.5; X–AA, PIMUZ 28221. Both specimens from sample HB1005, *Brayardites compressus* beds, Losar. All ×2. AB–AE, ?*Paranorites* sp. indet. PIMUZ 28222. Found as float in the '*Parahedenstroemia*' Beds, Mud. All ×0.5. All natural size unless otherwise indicated.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Occurrence. Sample Ma96, Mud; samples Gu110 and GD95, Guling; *Glyptophiceras sinuatum* beds.

Description. Evolute, platycone shell with convex, convergent flanks. Venter rounded with rounded shoulders. Umbilicus wide and shallow with low vertical wall and rounded shoulders. Ornamentation varies from low, dense and sinuous ribs to very strong, distant and concave ribs. Suture line ceratitic with weakly indented lobes, poorly preserved.

Measurements. See Table 1.

Superfamily MEEKOCERATACEAE Waagen, 1895
Family PROPTYCHITIDAE Waagen, 1895

Genus PSEUDASPIDITES Spath, 1934

Type species. *Aspidites muthianus* Krafft and Diener, 1909.

Pseudaspidites muthianus (Krafft and Diener, 1909)
Figure 14M–R

1909 *Aspidites muthianus* Krafft and Diener, p. 59, pl. 6, fig. 5; pl. 15, figs 1–2.
1932 *Clypeoceras muthianum* (Krafft and Diener, 1909); Smith, p. 64, pl. 27, figs 1–7.
p 1932 *Ussuria waageni* Smith, pl. 21, figs 34–36 only.
1934 *Pseudaspidites muthianus* (Krafft and Diener, 1909); Spath, p. 164.
1959 *Pseudaspidites lolouensis* Chao, p. 229, pl. 13, figs 17–21, text-figs 20a, 21a.
1959 *Pseudaspidites kwangsianus* Chao, p. 230, pl. 12, figs 6–8, text-fig. 21d.
1959 *Pseudaspidites simplex* Chao, p. 231, pl. 13, figs 6–13; pl. 45, figs 5–7, text-figs 20b, 21b.
1959 *Pseudaspidites stenosellatus* Chao, p. 231, pl. 13, figs 4–5; pl. 45, fig. 8, text-fig. 21c.
1959 *Pseudaspidites aberrans* Chao, p. 232, pl. 13, figs 14–15, text-fig. 20d.
1959 *Pseudaspidites longisellatus* Chao, p. 232, pl. 13, figs 1–3, text-fig. 20c.
1959 *Proptychites pakungensis* Chao, p. 236, pl. 18, figs 1–2.
1959 *Proptychites hemialis* var. *involutus* Chao, p. 237, pl. 15, figs 13–16, text-fig. 24d.
? 1959 *Proptychites markhami* Chao, p. 239, pl. 15, figs 3–5, text-fig. 23c.
1959 *Proptychites angusellatus* Chao, p. 240, pl. 15, figs 1–2.
1959 *Proptychites sinensis* Chao, p. 240, pl. 16, figs 5–6; pl. 17, figs 14–16, text-fig. 22c.
1959 *Proptychites latilobatus* Chao, p. 243, pl. 16, figs 1–2; pl. 19, figs 4–5.
1959 *Proptychites abnormalis* Chao, p. 243, pl. 16, figs 3–4.
1959 *Clypeoceras lenticulare* Chao, p. 225, pl. 12, figs 3–5, text-fig. 19b.
1959 *Clypeoceras tsotengense* Chao, p. 225, pl. 12, figs 1–2.
? 1959 *Clypeoceras kwangiense* Chao, p. 226, pl. 17, figs 1–2, text-fig. 19a.
1959 *Ussuriceras* sp. indet. Chao, p. 247, pl. 19, fig. 1.
1959 *Pseudohedenstroemia magna* Chao, p. 265, pl. 41, figs 13–16; pl. 45, figs 1–2, text-fig. 32b.
? 1962 *Pseudaspidites wheeleri* Kummel and Steele, p. 673, pl. 101, fig. 1; text-fig. 7c–e.
v 2008 *Pseudaspidites muthianus* (Krafft and Diener, 1909); Brayard and Bucher, p. 33, pl. 10, figs 1–10; pl. 11, figs 1–4; text-fig. 31.

Occurrence. Sample M05-18, *Brayardites compressus* beds, Mud; sample G06-31, level equivalent of the *Escarguelites spitiensis* horizon, Guling. Sample HB1004, *Escarguelites spitiensis* horizon, Losar.

Description. Involute and compressed shell with flat, slightly convex flanks. Venter rounded with indistinct shoulders. Umbilicus with high, perpendicular wall and narrow but slightly rounded shoulders. Surface smooth. Suture ceratitic with strongly indented lobes and phylloid saddles; second and third saddle curved towards umbilicus.

Pseudaspidites sp. indet.
Figure 14H–I

Occurrence. A single specimen from sample M08-21, *Brayardites compressus* beds, Mud.

Description. Moderately involute, compressed shell with slightly convex, convergent flanks. Maximum whorl width near umbilicus. Venter subtabulate with rounded shoulders. Umbilicus small and deep with high, vertical wall and marked, slightly rounded shoulders. Surface smooth. Suture line not preserved.

Remarks. This species differs from *Pseudaspidites muthianus* by its subtabulate venter. It is probably conspecific with *Pseudaspidites* sp. indet. that has recently been found in the *Brayardites compressus* beds at Tulong, South Tibet (Brühwiler *et al.* 2010*a*), and which differs from typical *Pseudaspidites* by its less complex suture line. However, as the suture line is not preserved on our specimen from Spiti, no definitive assignment can be made.

Genus XIAOQIAOCERAS Brayard and Bucher, 2008

Type species. *Xiaoqiaoceras involutus* Brayard and Bucher, 2008.

Xiaoqiaoceras involutus Brayard and Bucher, 2008
Figure 14S–AA

v 2008 *Xiaoqiaoceras involutus* Brayard and Bucher, p. 36, pl. 12, figs 12–16; text-fig. 32.

Occurrence. Sample HB1005; *Brayardites compressus* beds, Losar.

Description. Very involute shell with convex flanks and rapidly increasing whorl height and whorl width. Venter broadly arched with indistinct shoulders. Umbilicus occluded or very small and deep. Surface smooth except for sparse and weak radial folds. Suture line very distinct with narrow saddles and deeply indented lobes; first lateral lobe broad and trifid.

Measurements. See Table 1.

Remarks. The type material of this species comes from a slightly older horizon (i.e. the *Flemingites rursiradiatus* beds) of Guangxi, South China (Brayard and Bucher 2008), and is indistinguishable from our specimens.

Genus TULONGITES Brühwiler, Bucher and Goudemand, 2010*a*

Type species. *Tulongites xiaoqiaoi* Brühwiler *et al.*, 2010*a*.

Tulongites xiaoqiaoi Brühwiler, Bucher and Goudemand, 2010*a*
Fig. 15A–AN

v 2010*a* *Tulongites xiaoqiaoi* Brühwiler *et al.*, p. 413, fig. 7: 9–10.

Occurrence. Samples M08-21, M05-25, Mud; HB1033, HB1005, Losar; *Brayardites compressus* beds.

Measurements. See Figure 16.

Description. Involute, platycone shell with slightly convex flanks. Maximum whorl width near mid-flank. Venter narrow and rounded with rounded shoulders. Umbilicus small with steeply inclined wall and rounded shoulders. Shell ornamented with weak, biconcave and prorsiradiate folds. Suture line ceratitic; first and second lateral saddles tapered; third lateral saddle small.

Remarks. This species has recently been described from the *Brayardites compressus* beds of Tulong, South Tibet (Brühwiler *et al.* 2010*a*). The inner whorls of this species are superficially similar to those of *Brayardites compressus* (see below), which differs by its higher, vertical umbilical wall.

Family GALFETTITIDAE Brühwiler and Bucher, 2012*a*

Genus GALFETTITES Brayard and Bucher, 2008

Type species. *Galfettites simplicitatis* Brayard and Bucher, 2008.

Galfettites omani Brühwiler and Bucher, 2012*a*
Figure 17A–AD

v 2012*a* *Galfettites omani* Brühwiler and Bucher, p. 27, pl. 14, figs 6–8.

Occurrence. Samples M04-44, Ma24c, Mud; LoA-SFB, HB1004, Losar; *Nammalites pilatoides* beds.

Description. Moderately evolute, very compressed shell with slightly convex and converging flanks. Venter narrow and tabulate with angular shoulders. Umbilicus wide and very shallow with very low wall and rounded shoulders. Surface smooth or ornamented with weak radial folds. Suture line ceratitic with slightly phylloid saddles.

Measurements. See Figure 18.

Remarks. This species has recently been found in an exotic block of Hallstatt Limestone in Oman, associated with *Nammalites pilatoides* (Brühwiler *et al.*, 2012*a*).

?*Galfettites* sp. indet.
Figure 15AO–BI

Occurrence. Samples HB1005, HB1033, Losar; sample M08-21, Mud; *Brayardites compressus* beds.

Description. Moderately evolute, platycone shell with slightly convex flanks. Venter narrow and tabulate with slightly rounded shoulders. Umbilicus with low vertical wall and rounded shoulders. Surface smooth. Suture line ceratitic, simple.

Measurements. See Table 1.

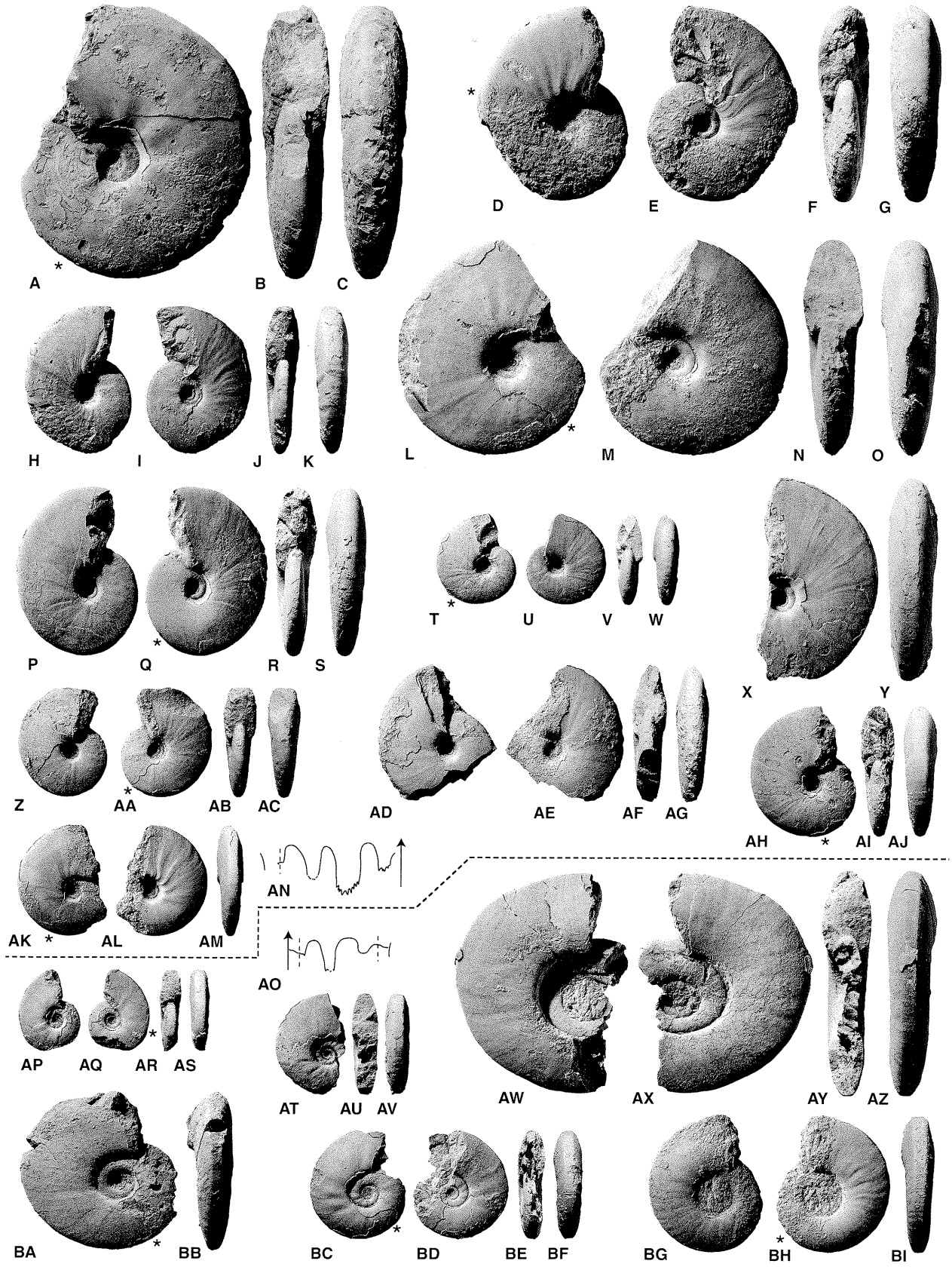
Remarks. This species is somewhat similar to *Galfettites omani* described above, but differs by its deeper umbilicus.

Genus PARANORITES Waagen, 1895

Type species. *Paranorites ambiensis* Waagen, 1895.

?*Paranorites* sp. indet.
Figure 14AB–AE

Occurrence. A single specimen, found as float in the '*Parahedenstroemia*' Beds at Mud, probably from the level of sample M04-44 or higher.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Description. Large, moderately involute, slightly compressed shell with convex, convergent flanks. Venter subtabulate with rounded shoulders. Umbilicus with high vertical wall and rounded shoulders. Surface smooth. Suture line ceratitic, second lateral saddle tapered, third lateral saddle broad and low.

Measurements. See Table 1.

Discussion. The trigonal whorl section of this species is similar to that of *Paranorites*. However, the type species *Paranorites ambiensis* differs by its more complex suture line with a slender and phylloid first lateral saddle and a higher and narrower third lateral saddle. Thus, this specimen may actually represent a new genus. However, due to our scarce material and the unknown exact stratigraphic position, we prefer not to erect a new taxon.

Genus URDYCERAS Brayard and Bucher, 2008

Type species. Urdyceras insolitus Brayard and Bucher, 2008.

Urdyceras tulongensis Brühwiler, Bucher and Goudemand, 2010*a*
Figure 17AH–BF

v 2010*a* *Urdyceras tulongensis* Brühwiler *et al.*, p. 416, fig. 10: 5–11.

Occurrence. Samples E17, M03-21, M05-23, Mud; HB1005, HB1033, Losar; G06-20, Gu21, Guling; *Brayardites compressus* beds.

Description. Compressed and moderately evolute shell. Flanks convex and convergent. Venter tabulate with very angular shoulders. Umbilicus with vertical wall and marked, but slightly rounded shoulders. Ornamentation on flanks consists of fine radial, slightly sinuous folds. One specimen (Fig. 17BE–BF) displays rather strong folds on upper flanks. Suture line ceratitic with deep lateral lobe and slightly phylloid saddles. First lateral saddle narrow; second lateral saddle slightly curved towards umbilicus.

Measurements. See Figure 19.

Remarks. This species has recently been described from the *Brayardites compressus* beds of Tulong, South Tibet (Brühwiler *et al.* 2010*a*).

?*Urdyceras* sp. indet.
Figure 17AE–AG

Occurrence. A single specimen from sample Ma49; *Nyalamites angustecostatus* beds, Mud.

Description. Compressed and moderately involute shell. Flanks convex and convergent. Venter broad and tabulate with very angular shoulders. Umbilicus with vertical wall and angular shoulders. Surface smooth. Suture line not preserved.

Measurements. See Table 1.

Remarks. This species is more involute and has broader whorls than *Urdyceras tulongensis*. Due to the small size of our specimen and the unknown suture line, no definitive assignment can be made.

Family DIENEROCERATIDAE Kummel, 1952

Genus DIENEROCERAS Spath, 1934

Type species. Ophiceras dieneri Hyatt and Smith, 1905.

Dieneroceras cf. *tientungense* Chao, 1959
Figure 17BG–BV

Occurrence. Samples HB1013, HB1020; *Flemingites* beds, Losar.

Description. Serpenticone, very evolute shell with convex flanks. Venter subtabulate with rounded shoulders. Umbilicus wide and shallow with rounded umbilical wall. Surface smooth. Suture line and simple with relatively deep lobes; indentations of lobes not preserved.

Measurements. See Figure 20.

FIG. 15. A–AN, *Tulongites xiaoqiaoi* Brühwiler *et al.*, 2010*a*. A–C, AN, PIMUZ 28223; AN ×1.5, at H = 15.8 mm, from sample M08-21, Mud; D–G, PIMUZ 28224, from sample HB1033, Losar; H–K, PIMUZ 28225, from sample HB1005, Losar; L–O, PIMUZ 28226, from sample HB1033, Losar; P–S, PIMUZ 28227, from sample HB1005, Losar; T–W, PIMUZ 28228, from sample HB1033, Losar; X–Y, PIMUZ 28229, from sample M08-21, Mud; Z–AC, PIMUZ 28230, from sample HB1033, Losar; AD–AG, PIMUZ 28231, from sample HB1005, Losar; AH–AJ, PIMUZ 28232, from sample M08-21, Mud; AK–AM, PIMUZ 28233, from sample HB1005, Losar. All from the *Brayardites compressus* beds. AO–BI, ?*Galfettites* sp. indet. AO, BC–BF, PIMUZ 28238, AO ×3, at H = 5 mm, from sample HB1033; AP–AS, PIMUZ 28234; AT–AV, PIMUZ 28235. AW–AZ, PIMUZ 28236; BA–BB, PIMUZ 28237. BG–BI, PIMUZ 28239. All from sample HB1005 except for Figures AO, BC–BF. All from the *Brayardites compressus* beds, Losar. All natural size unless otherwise indicated.

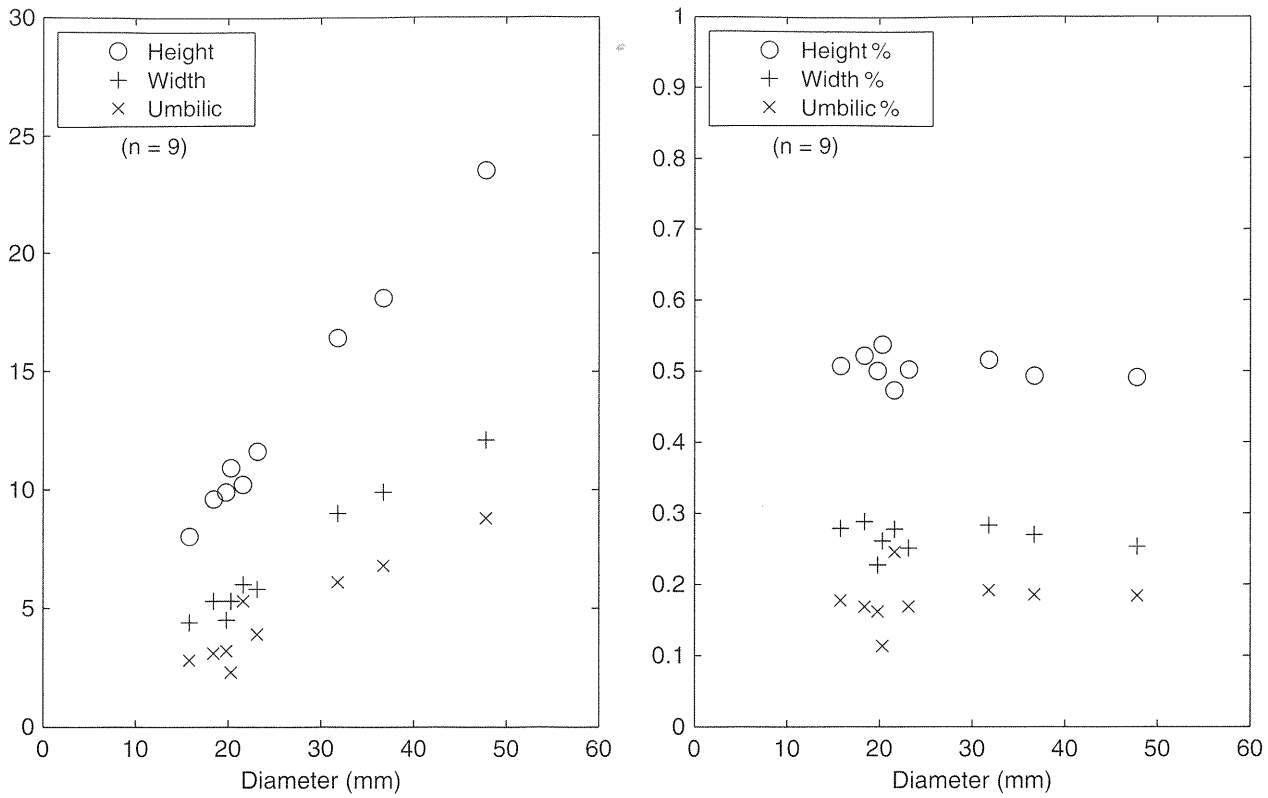


FIG. 16. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Tulongites xiaoqiaoi* (Brühwiler *et al.*, 2010*a*).

Remarks. Dieneroceras tientungense Chao, 1959 from South China differs slightly by its more rounded venter and its slightly more depressed whorls. However, it exhibits significant variation in whorl section (Brayard and Bucher 2008), and our specimens from Spiti may fall within the range of its intraspecific variation.

Family FLEMINGITIDAE Hyatt, 1900

Genus HERMANNITES gen. nov.

Derivation of name. Named after Elke Hermann (Zürich).

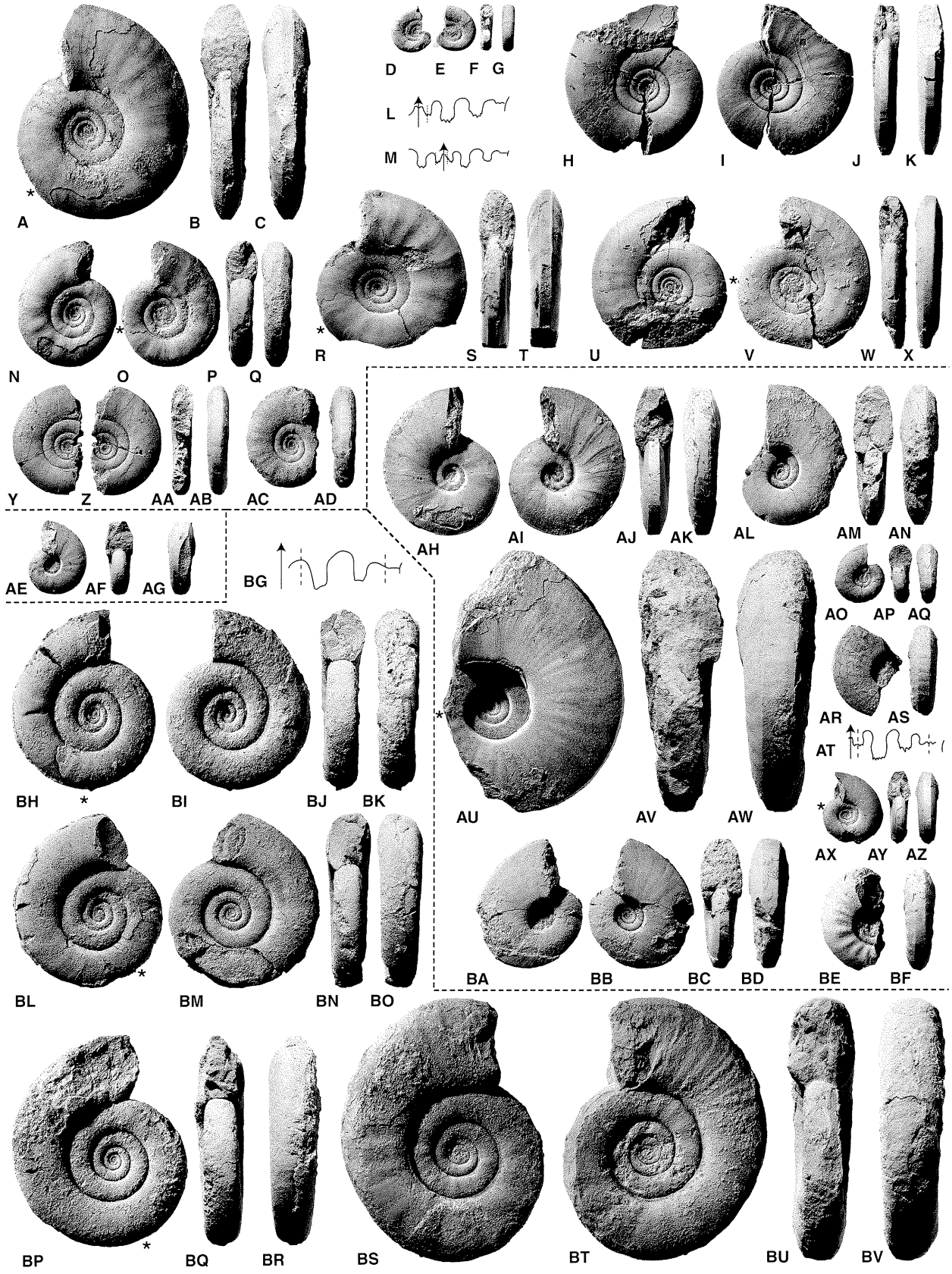
Type species. Hermannites rursiradiatus gen. et sp. nov.

Composition of the genus. Type species only.

Diagnosis. Subtabulate and evolute Flemingitidae with inclined umbilical margin. Surface without strigation, ornamentated with rursiradiate ribs that tend to thicken near the umbilical margin.

Discussion. The evolute coiling and the suture line with phylloid saddles justify the assignment of *Hermannites* to Flemingitidae. This genus differs from other Flemingitidae by its ornamentation. In its shape, it is somewhat similar to *Baidites* Brühwiler and Bucher, 2012*a*, *b* from Oman,

FIG. 17. A–AD, *Galfettites omani* Brühwiler and Bucher, 2012. A–B, PIMUZ 28240, from sample M04-44; C–G, PIMUZ 28241, from sample LoA-SFB; H–K, PIMUZ 28242, from sample LoA-SFB; L, R–T, PIMUZ 28244; L × 2, at H = 7.2 mm, from sample Ma24c; M, U–X, PIMUZ 28245; M × 2, at H = 5.7 mm, from sample LoA-SFB; N–Q, PIMUZ 28243, from sample HB1004; Y–AB, PIMUZ 28246, from sample LoA-SFB; AC–AD, PIMUZ 28247, from sample HB1004. All from the *Nammalites pilatoides* beds. AE–AG, ?*Urdyceras* sp. indet. PIMUZ 28248, from sample Ma49, *Nyalamites angustecostaus* beds, Mud. AH–BF, *Urdyceras tulongensis* Brühwiler *et al.* 2010*a*. AH–AK, PIMUZ 28249, from sample E17, Mud; AL–NN, PIMUZ 28250, from sample HB1005; AO–AQ, PIMUZ 28251, from sample HB1005; AR–AT, PIMUZ 28252; AT ×2, at H = 7.3 mm, from sample HB1005; AU–AW, PIMUZ 28253, from sample HB1033, AX–AZ, PIMUZ 28254, from sample HB1005. BA–BD, PIMUZ 28255, from sample HB1005; BE–BF, PIMUZ 28256, from sample HB1033. All from Losar except for AH–AK. All from the *Brayardites compressus* beds. BG–BV, *Dieneroceras* cf. *tientungense* Chao, 1959. BG, BL–BO, PIMUZ 28258, from sample HB1013; GGG ×3, at H = 5.8 mm. BH–BK, PIMUZ 28257, from sample HB 1013; BP–BR, PIMUZ 28259, from sample HB1013; BS–BV, PIMUZ 28260, from sample HB1020. All from the *Flemingites* beds, Losar. All natural size unless otherwise indicated.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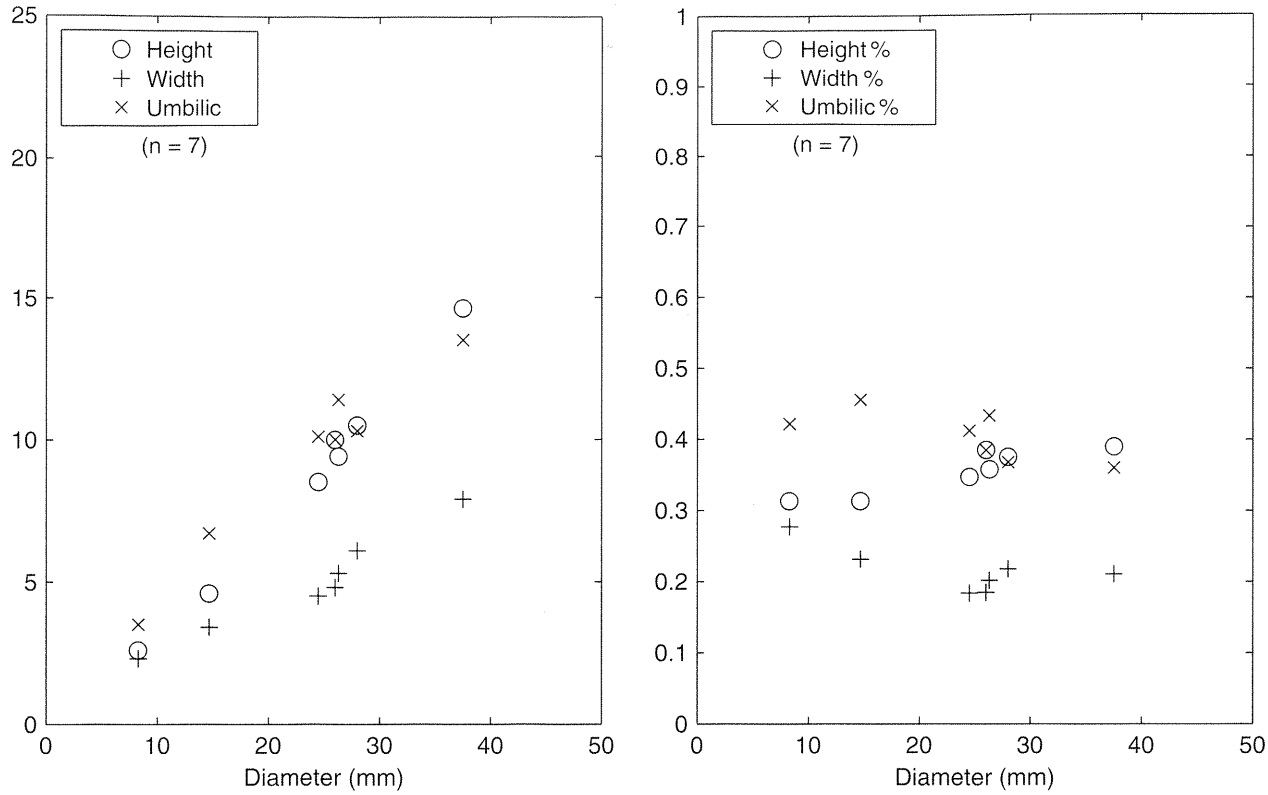


FIG. 18. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Galfettites omani* Brühwiler and Bucher, 2012*a*.

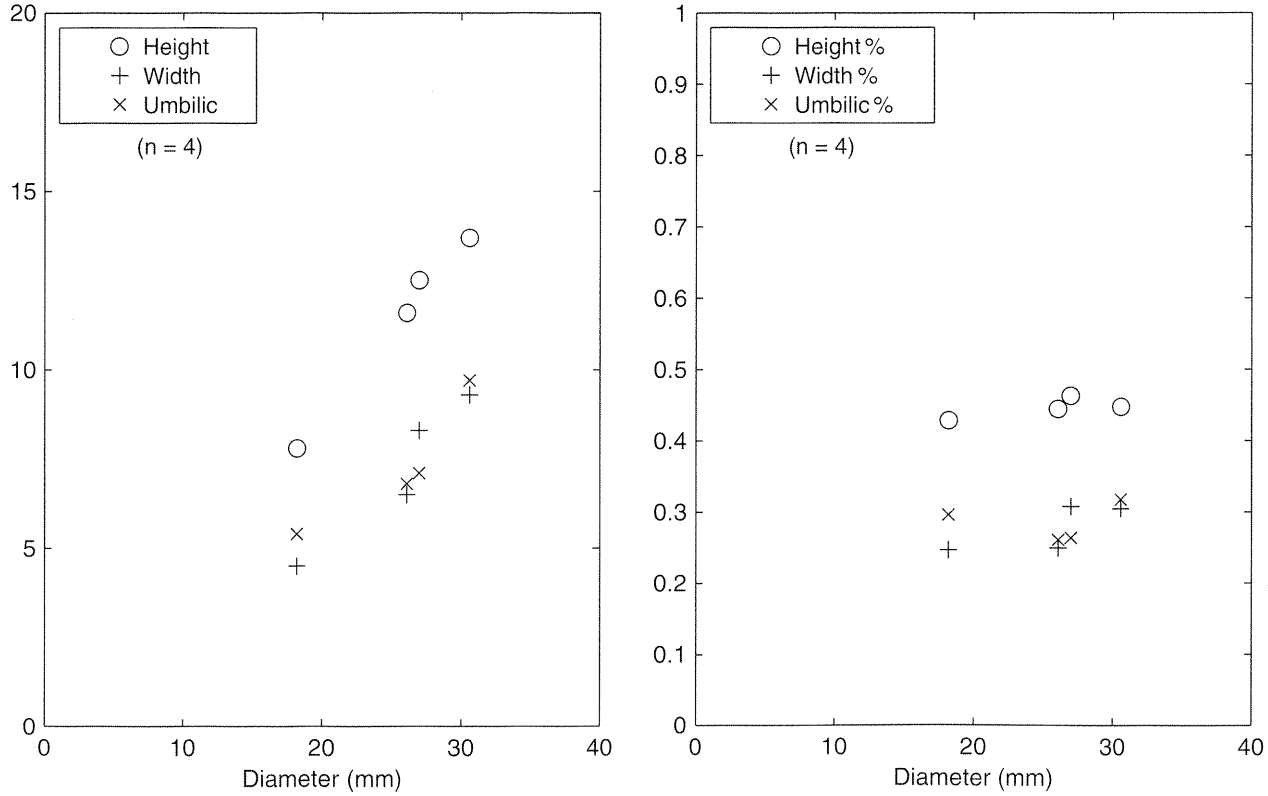


FIG. 19. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Urdyceras tulongensis* (Brühwiler *et al.*, 2010*a*).

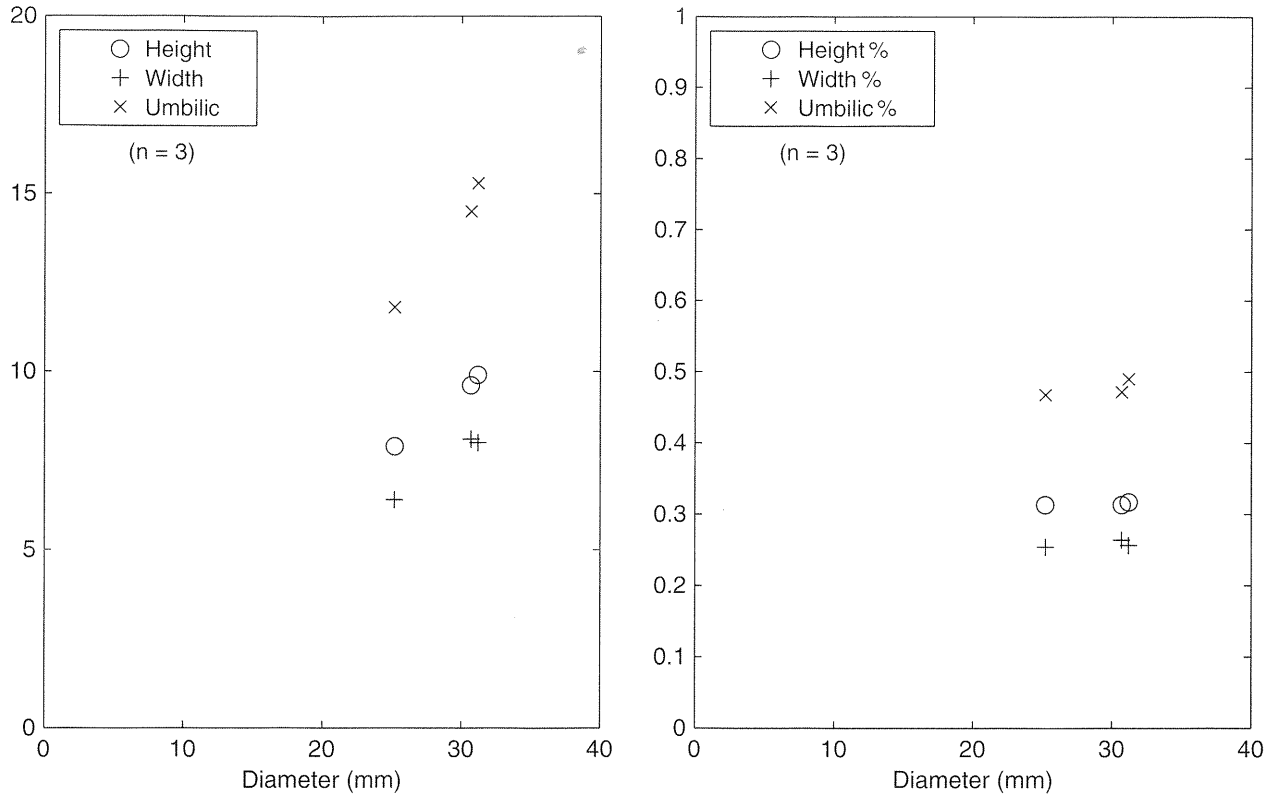


FIG. 20. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Dieneroceras* cf. *tientungense* Chao, 1959.

which differs by its suture line with a very narrow ventral lobe, its more pronounced umbilical margin and its weaker ornamentation. In its suture line, *Hermannites* is similar to *Anaxenaspis*, which differs by its elliptical whorl shape with a well-rounded venter.

Hermannites rursiradiatus sp. nov.
Figure 21A–J

Derivation of name. Refers to the rursiradate ribs.

Holotype. PIMUZ 28261 (Fig. 21A–E).

Type locality. Mud, Spiti, India.

Type horizon. Sample M03-20; *Brayardites compressus* beds.

Diagnosis. As for the genus.

Occurrence. Samples M03-20, M03-24, M05-26A, Gu21, HB1005, HB1033, Lo-SFB1; *Brayardites compressus* beds.

Description. Large, evolute and compressed shell. Upper flanks subparallel, lower flanks convergent. Venter subtabulate with rounded shoulders. Umbilicus wide with inclined wall and rounded shoulders. Ornamentated with rursiradiate ribs that tend to thicken at the umbilical margin. Ribs attenuated on outer whorls. Growth lines biconcave. Suture line ceratitic with moderately long saddles; auxiliary series relatively long.

Measurements. See Table 1.

Genus FLEMINGITES Waagen, 1895

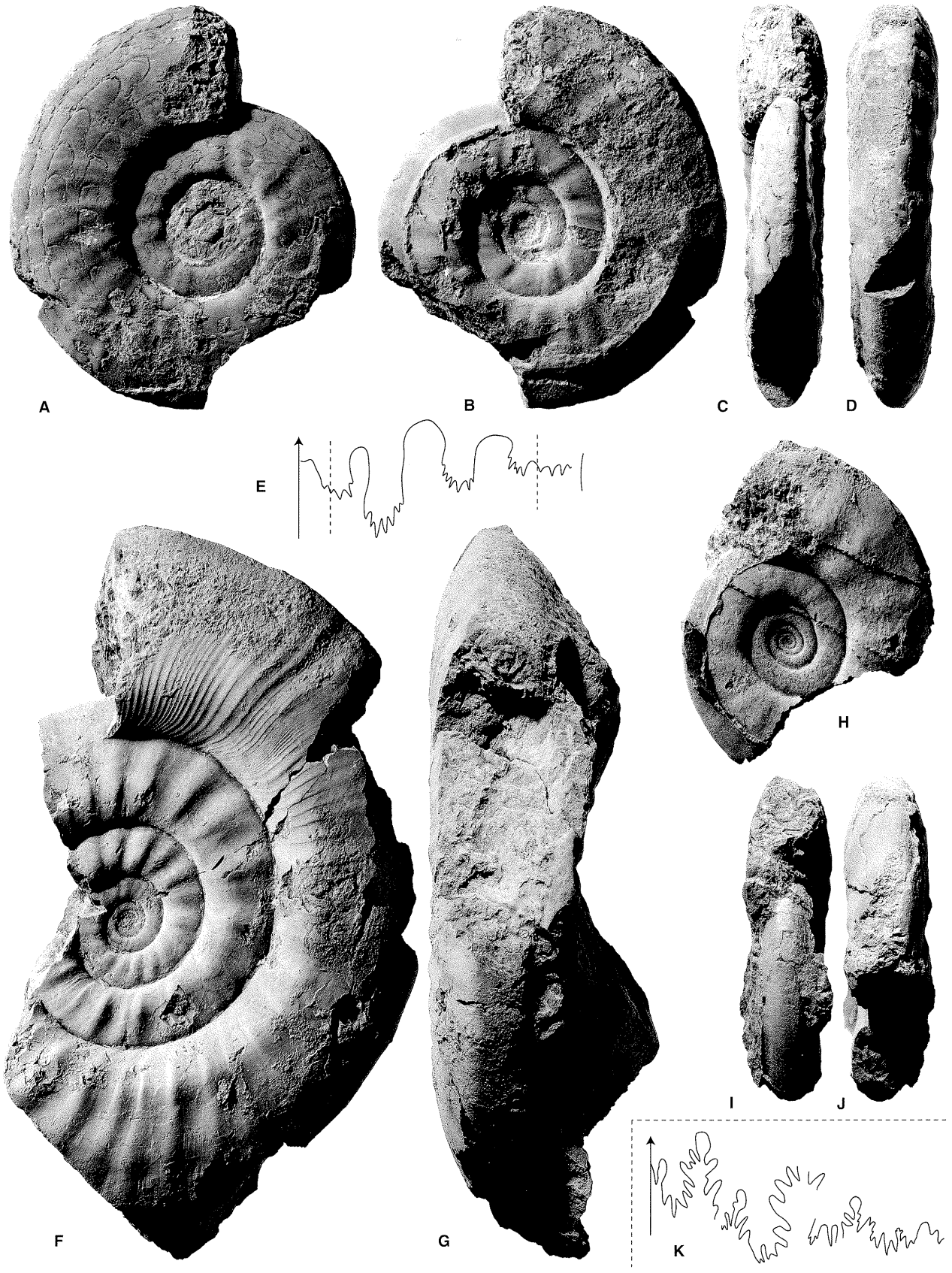
Type species. Ceratites flemingianus de Koninck, 1863.

Flemingites sp. indet.
Figure 22P–Q

Occurrence. Samples HB1013, HB1024; *Flemingites* beds, Losar.

Description. Large, evolute shell with elliptical whorl section. Venter subtabulate with rounded shoulders, but poorly preserved. Umbilicus wide with rounded wall. Flanks ornamented with coarse strigation and radial or rursiradiate, wavy ribs. Suture line not preserved.

Remarks. The poor preservation of the material precludes identification at the species level.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Genus ANAXENASPIS Kiparisova, 1956

Type species. *Xenaspis orientale* Diener, 1895.

?*Anaxenaspis* sp. indet.
Figures 22A–M, 23A–C

Occurrence. Samples M08-48, M05-48, Ma49; *Pseudoceltites multiplicatus* beds, *Nyalamites angustecostatus* beds, Mud.

Description. Moderately evolute shell with an elliptical whorl section. Venter narrowly rounded with indistinct shoulders. Umbilicus with inclined wall and rounded shoulders. Inner whorls ornamented with dense radial folds that fade out towards the venter; outer whorls smooth. Growth lines slightly biconcave. Suture line ceratitic with slightly phylloid saddles, poorly preserved.

Measurements. See Figure 24.

Discussion. The assignment of this species to *Anaxenaspis* is only provisional, as typical members of this genus differ slightly by their suture line with more elongated saddles. This species is very similar to *Hochuliites retrocostatus* Brühwiler and Bucher, 2012*b* from the Salt Range, which differs by its simpler suture line with short and nonphylloid saddles.

Genus SUBFLEMINGITES Spath, 1934

Type species. *Subflemingites involutus* Spath (= *Aspidites meridianus involutus* Welter, 1922).

?*Subflemingites compressus* Brühwiler, Bucher and Goudemand, 2010*a*
Figure 23D–J

v 2010*a* ?*Subflemingites compressus* Brühwiler *et al.*, p. 413, fig. 8: 1–6.

Occurrence. Samples Ma46, Ma49; *Nyalamites angustecostatus* beds, Mud.

Description. Moderately involute, compressed shell with flat, slightly convex flanks. Venter rounded without distinct shoulder. Umbilicus with low, inclined wall and rounded shoulders. Surface smooth or with weak radial folds on upper flanks. Suture line not preserved.

Measurements. See Table 1.

Remarks. This species has recently been described from the *Nyalamites angustecostatus* beds of Tulong, South Tibet (Brühwiler *et al.* 2010*a*).

Family ARCTOCERATIDAE Arthaber, 1911

Genus BRAYARDITES Brühwiler, Bucher and Goudemand, 2010*a*

Type species. *Brayardites crassus* Brühwiler *et al.*, 2010*a*.

Brayardites crassus Brühwiler, Bucher and Goudemand, 2010*a*
Figure 23K–Q

v 2010*a* *Brayardites crassus* Brühwiler *et al.*, p. 419, figs 11: 1–4, 12: 1–6.

Occurrence. Samples M05-20, M03-21; *Brayardites compressus* beds, Mud.

Description. Moderately evolute, shell with thick whorls and strongly convex flanks. Maximum whorl width above mid-flank. Venter broadly arched with rounded shoulders. Umbilicus with steeply inclined wall and rounded shoulders. Ornamentation consists of prorsiradiate ribs that develop elongated tubercles near umbilicus, which fade out towards mid-flank. Ornamentation strongly attenuated on adult whorls: ribs become finer and denser, tuberculation disappear. Suture line is not preseved.

Measurements. See Table 1.

Remarks. This species has recently been described from the *Brayardites compressus* beds of Tulong, South Tibet (Brühwiler *et al.* 2010*a*).

Brayardites compressus Brühwiler, Bucher and Goudemand, 2010*a*
Figures 25A–O, 26A

v 2010*a* *Brayardites compressus* Brühwiler *et al.*, p. 419, fig. 13: 1–6.
v 2012*b* *Brayardites compressus* Brühwiler *et al.*, 2012*a*; Brühwiler and Bucher, p. 82, fig. 70A–AC, ?AD–AF.

FIG. 21. A–J, *Hermannites rursiradiatus* gen. et sp. nov. A–E PIMUZ 28261, holotype; E × 1.5, at H = 26.5 mm, D = 76.6 mm, from sample M03-20, Mud; F–G, PIMUZ 28262, from sample LoSFB1, Losar; H–J, PIMUZ 28263, from sample HB1005, Losar. All from the *Brayardites compressus* beds. K, Ussuriidae gen. et sp. indet. PIMUZ 28376. Found as a float in the *Parahedenstroemia* Beds at Mud. See also Figure 22N–O. All natural size unless otherwise indicated.

Occurrence. Samples M03-19, M08-21, M08-21, M08-22, M05-23, M03-24, M06-24, Mud; Gu-21, Guling; HB1005, Losar; *Brayardites compressus* beds.

Description. Moderately evolute, compressed shell with flat, convergent flanks. Maximum whorl width near umbilical border. Venter subtabulate with rounded shoulders. Umbilicus with high, vertical wall and rounded shoulders. Ornamentation consists of prorsiradiate, biconcave ribs that develop strong tubercles near umbilicus and fade out towards mid-flank. Ribs and tubercles become finer and denser on adult whorls. Growth lines biconcave. Suture line ceratitic with relatively deep lobes.

Measurements. See Table 1.

Remarks. This species has recently been described from the *Brayardites compressus* beds of Tulong, South Tibet (Brühwiler *et al.* 2010*a*), and of the Salt Range (Brühwiler *et al.* 2012*b*).

Genus NAMMALITES Brühwiler, Bucher and Goudemand, 2010*a*

Type species. *Kazakhstanites pilatoides* Guex, 1978.

Nammalites pilatoides (Guex, 1978)
Figures 26B–Y, 27A–D

1909 *Meekoceras* sp. ind. aff. *pilato* Krafft and Diener, p. 42, pl. 28, fig. 2a–c.
1968 *Subvishnuites* cf. *enveris* (Arthaber); Kummel, p. 491, pl. 1, figs 8–9.
1968 *Wasatchites* sp. indet. Kummel, p. 500, pl. 3, figs 10–11.
1968 *Eoptychites* sp. indet. Kummel and Erben, p. 120, pl. 22, figs 10–11.
v 1978 *Kazakhstanites pilatoides* Guex, p. 109, pl. 6, figs 5, 6, 16.
v ? 1978 *Kazakhstanites pilatoides* Guex, p. 109, pl. 8, fig. 6.
v p 1978 *Anasibirites pluriformis* Guex, pl. 4, fig. 3 only.
v 2010*a* *Nammalites pilatoides* (Guex); Brühwiler *et al.* p. 416, fig. 15: 6–8.
v 2012*a* *Nammalites pilatoides* (Guex); Brühwiler and Bucher, p. 31, pl. 18, figs 1–7.
v 2012*b* *Nammalites pilatoides* (Guex, 1978); Brühwiler and Bucher, p. 85, fig. 72A–O.

Occurrence. Samples M08-29, Ma28b, E22/23, M06-39, M05-40, Mud; sample LTB1, Lalung; sample G06-43, Guling; samples HB1029, HB1030, HB1004, HB1032 (?), Losar; *Nammalites pilatoides* beds.

Description. Moderately involute, slightly compressed shell with convex, convergent flanks. Maximum whorl width at umbilical border. Venter broadly rounded to subtabulate with rounded shoulders. Umbilicus with vertical wall and rounded shoulders. Ornamentation consists of distant, rursiradiate ribs that tend to develop tubercles or elongated bullae near the umbilicus and then fade out towards the venter. A fine strigation is observed on the venter of well-preserved specimens. Suture line ceratitic with deep lobes.

Measurements. See Figure 28.

Remarks. This species has recently been described from the *Nammalites pilatoides* beds of Tulong, South Tibet (Brühwiler *et al.* 2010*a*), of Oman (Brühwiler *et al.* 2012*a*) and of the Salt Range (Brühwiler *et al.* 2012*b*).

Genus ESCARGUELITES gen. nov.

Type species. *Escarguelites spitiensis* gen. et sp. nov.

Derivation of name. Named after Gilles Escarguel (Lyon).

Type species. *Escarguelites spitiensis* gen. et sp. nov.

Composition of the genus. Type species only.

Diagnosis. Evolute member of Arctoceratidae with strong, sharp and rursiradiate ribs.

Remarks. The assignment of *Escarguelites* to Arctoceratidae is based on its similarity with *Nammalites*. Especially, the ornamentation of the inner whorls of *Escarguelites* is very similar to that of *Nammalites*.

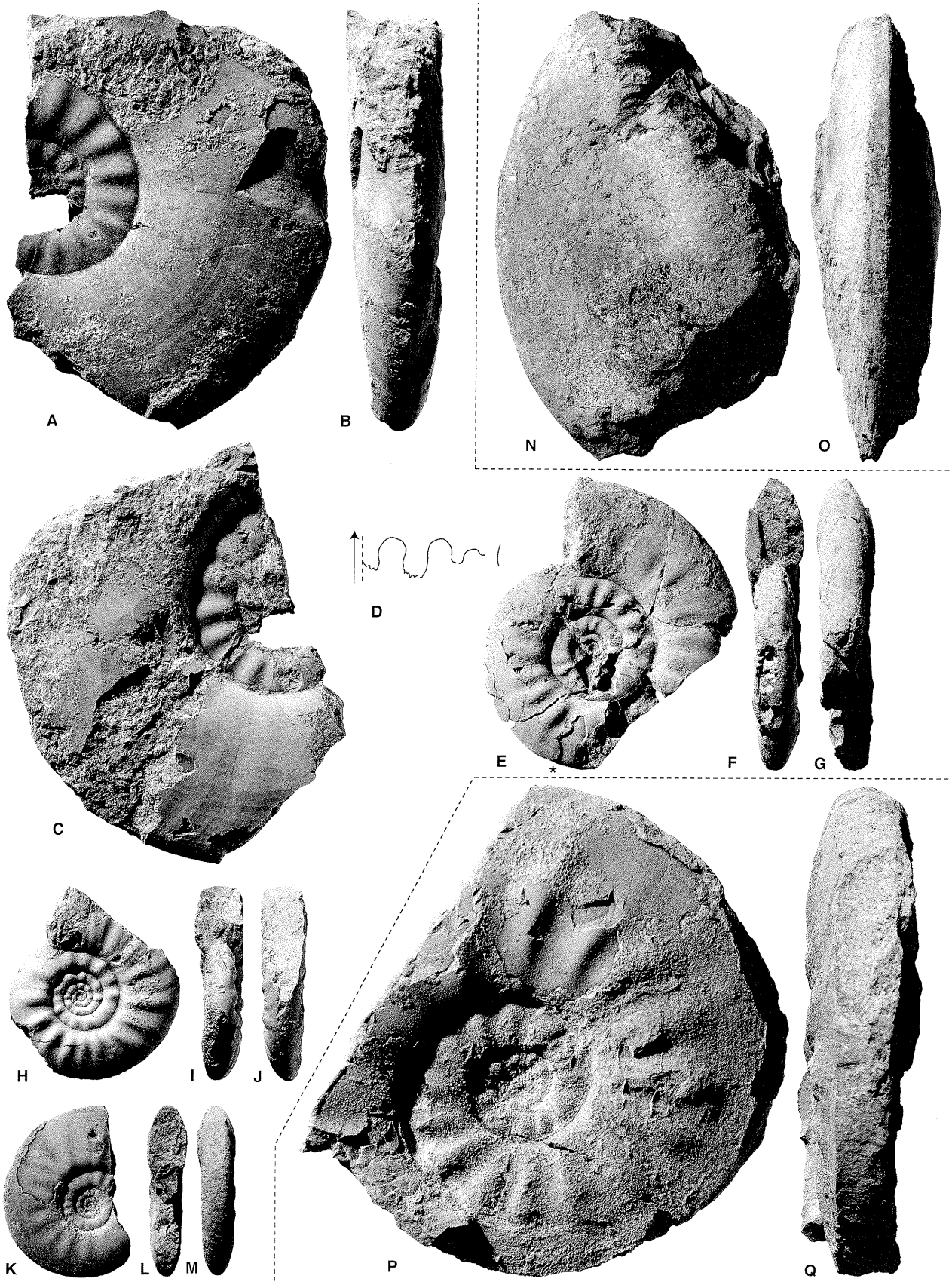
Escarguelites spitiensis sp. nov.
Figure 27E–O

Derivation of name. Named derived from the Spiti region.

Holotype. Specimen PIMUZ 28294 (Fig. 27E–I).

Type locality. Mud, Spiti, India.

FIG. 22. A–M, ?*Anaxenaspis* sp. indet. A–C, PIMUZ 28266, from sample M08-48; D–G, PIMUZ 28267; D × 2, at H = 12.5 mm, from sample M05-48; H–J, PIMUZ 28268, from sample Ma49; K–M, PIMUZ 28269, from sample M08-48; all from Mud. 8–10 from the *Nyalamites angustecostatus* beds; all others from the *Pseudoceltites multiplicatus* beds. N–O, Ussuriidae gen. et sp. indet. PIMUZ 28376. Found as a float in the '*Parahedenstroemia*' Beds at Mud. See also Figure 21K. P–Q, *Flemingites* sp. indet. PIMUZ 28264, from sample HB1013. From the *Flemingites* beds of Losar. All natural size unless otherwise indicated.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Type horizon. Sample M08-29; *Escarguelites spitiensis* horizon.

Diagnosis. As for the genus.

Occurrence. Sample M08-29, Mud; sample HB1004, Losar; *Escarguelites spitiensis* horizon.

Description. Moderately evolute shell with convex flanks. Venter broad and subtabulate with rounded shoulders. Umbilicus with vertical wall and rounded shoulders. Ornamentation consists of strong, sharp and rursiradiate ribs. On inner whorls, ribs are strongest near umbilicus. Ribs cross the venter. Suture line ceratitic; first lateral lobe deep, second lateral saddle very broad and third lateral saddle very small.

Measurements. See Table 1.

Genus NUETZELIA gen. nov.

Type species. *Nuetzelia himalayica* gen. et sp. nov.

Derivation of name. Named after Alex Nützel (Munich).

Type species. *Nuetzelia himalayica* gen. et sp. nov.

Composition of the genus. Type species only.

Diagnosis. Strongly compressed, involute Arctoceratidae with a narrow, tabulate venter.

Discussion. The assignment to Arctoceratidae is mainly based on the overall similarity with *Arctoceras*, which differs, however, by its rounded venter and less compressed whorls. *Nuetzelia* differs from other arctoceratids by its involute coiling and its overhanging umbilical wall. Proptychitidae generally differ by a more complex suture line.

Nuetzelia himalayica sp. nov.
Figure 26Z–AJ

Derivation of name. Named derived from the Himalayas.

Holotype. Specimen PIMUZ 28291, Fig. 26CC–EE.

Type locality. Losar, Spiti, India.

Type horizon. Sample HB1004; *Escarguelites spitiensis* horizon.

Diagnosis. As for the genus.

Occurrence. Samples HB1004; *Escarguelites spitiensis* horizon, Losar.

Description. Small, involute and strongly compressed shell with convergent flanks. Venter narrow and tabulate with angular shoulders. Umbilicus small and deep with an overhanging wall and angular shoulders. Surface smooth except for biconcave growth lines. Suture line ceratitic; first and second lateral saddle long and very narrow, lobes broad.

Measurements. See Table 1.

Genus TRUEMPYCERAS Brühwiler and Bucher, 2012*b*

Type species. *Anasibirites pluriformis* Guex 1978.

Truempyceras compressum sp. nov.
Figure 29A–AA

Derivation of name. Refers to the more compressed whorls with respect to the type species.

Holotype. Specimen PIMUZ 28304 (Fig. 29O, W–AA).

Type locality. Lalung, Spiti, India.

Type horizon. Sample LTB3; *Truempyceras compressum* horizon.

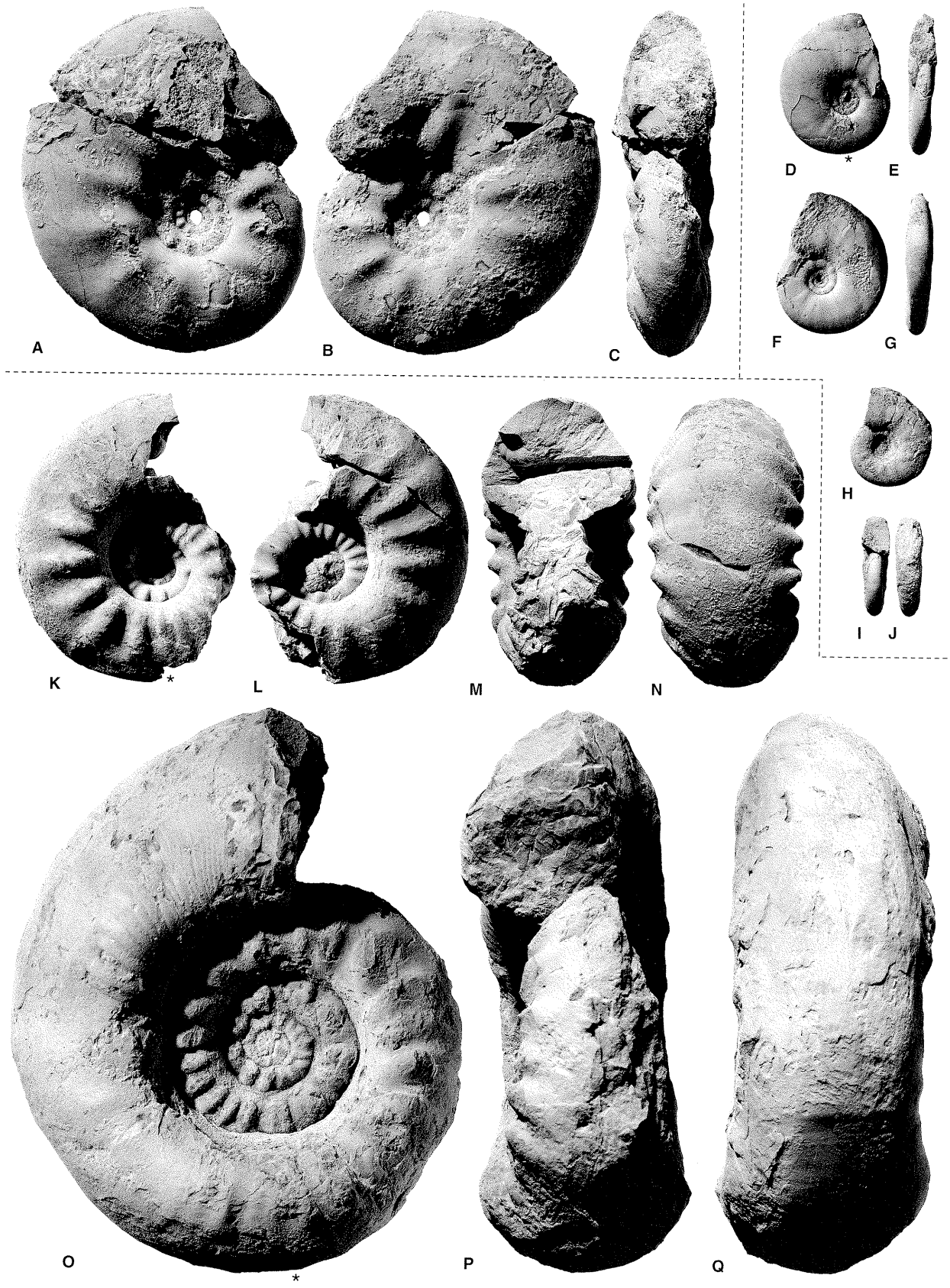
Diagnosis. Relatively compressed *Truempyceras* with weak ornamentation.

Occurrence. Samples M05-43, M05-44, E22, Mud; sample LTB3, Lalung; sample HB1029, Losar; *Truempyceras compressum* horizon.

Description. Moderately involute, compressed shell with flat, slightly convergent flanks. Venter subtabulate with angular to slightly rounded shoulders. Umbilicus with a high, vertical wall and marked, slightly rounded shoulders. Ornamentation consists of weak, slightly biconcave ribs that strengthen and form indistinct nodes on ventral and umbilical shoulders. Strongest ribs may cross the venter. Suture line ceratitic with relatively deep lobes.

Measurements. See Fig. 30.

FIG. 23. A–C, ?*Anaxenaspis* sp. indet. PIMUZ 28270, from sample M08-48, *Pseudoceltites multiplicatus* beds, Mud. D–J, ?*Subflemingites compressus* Brühwiler *et al.*, 2010*a*. D–G, PIMUZ 28271, from sample Ma49; H–J, PIMUZ 28272, from sample Ma46. Both specimens from the *Nylamites angustecostatus* beds, Mud. K–Q, *Brayardites crassus* Brühwiler *et al.*, 2010*a*; K–N, PIMUZ 28273, from sample M03-21; O–Q, PIMUZ 28274, from sample M05-20. Both specimens from the *Brayardites compressus* beds, Mud. All natural size unless otherwise indicated.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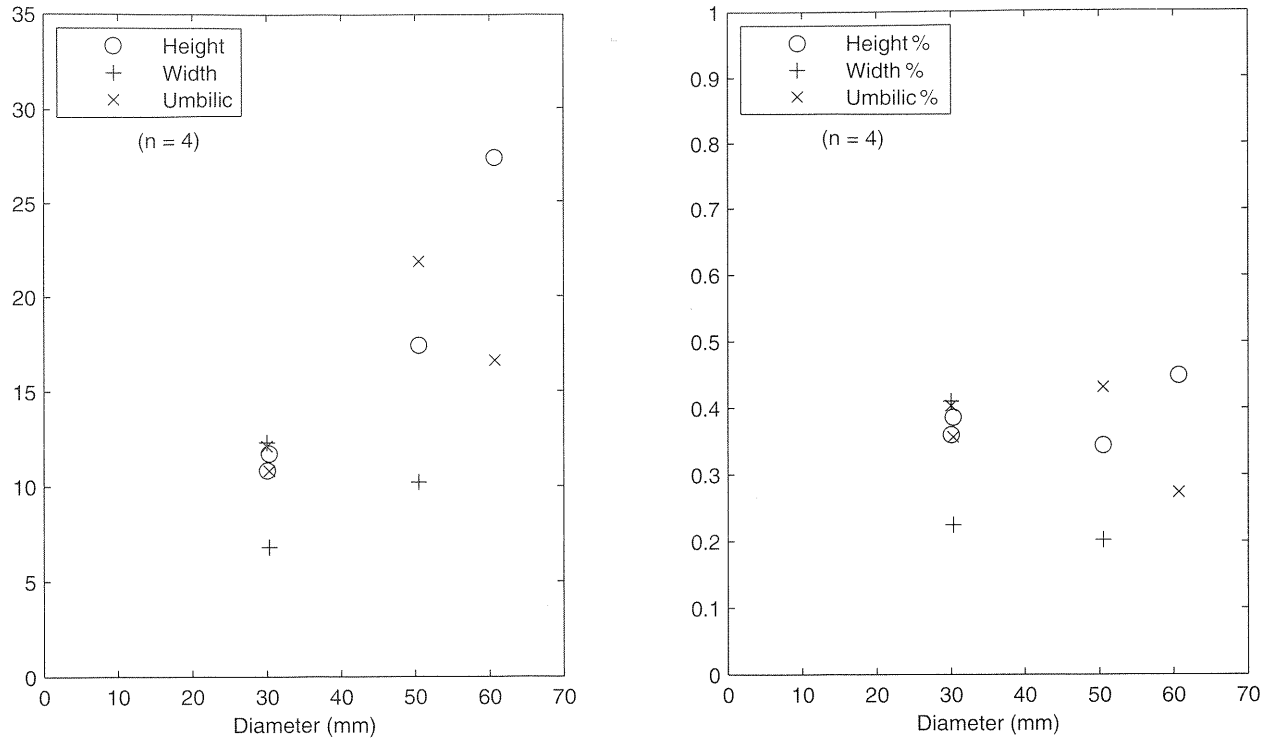


FIG. 24. Scatter diagram of H, W and U and of H/D, W/C and U/D for ?*Anaxenaspis* sp. indet.

Remarks. This species is very similar to the type species from the *Nammalites pilatoides* beds of the Salt Range (Brühwiler and Bucher in press) but differs by its more compressed whorl section and its weaker ornamentation.

Familiy USSURIIDAE Spath 1930

Ussuriidae gen. et sp. indet.
Figures 21K, 22N–O

Occurrence. A single, incomplete specimen found as a float in the '*Parahedenstroemia*' Beds, probably from the horizon of sample M03-40 or higher.

Description. Very involute, compressed oxycone with slightly convex flanks. Maximum thickness near umbilicus. Venter narrowly rounded. Surface poorly preserved. Suture line ammonitic.

Remarks. The ammonitic suture line and the shape of our specimen favour assignment to *Metussuria* Spath, 1934 or *Parussuria* Spath, 1934. *Parussuria* differs from *Metussuria* by its strigation, but otherwise, these two genera are very similar and may in fact be synonyms. The poor preservation of our single specimen precludes identification at the species level.

Family PRIONITIDAE Hyatt, 1900

Genus PRIONITES Waagen, 1895

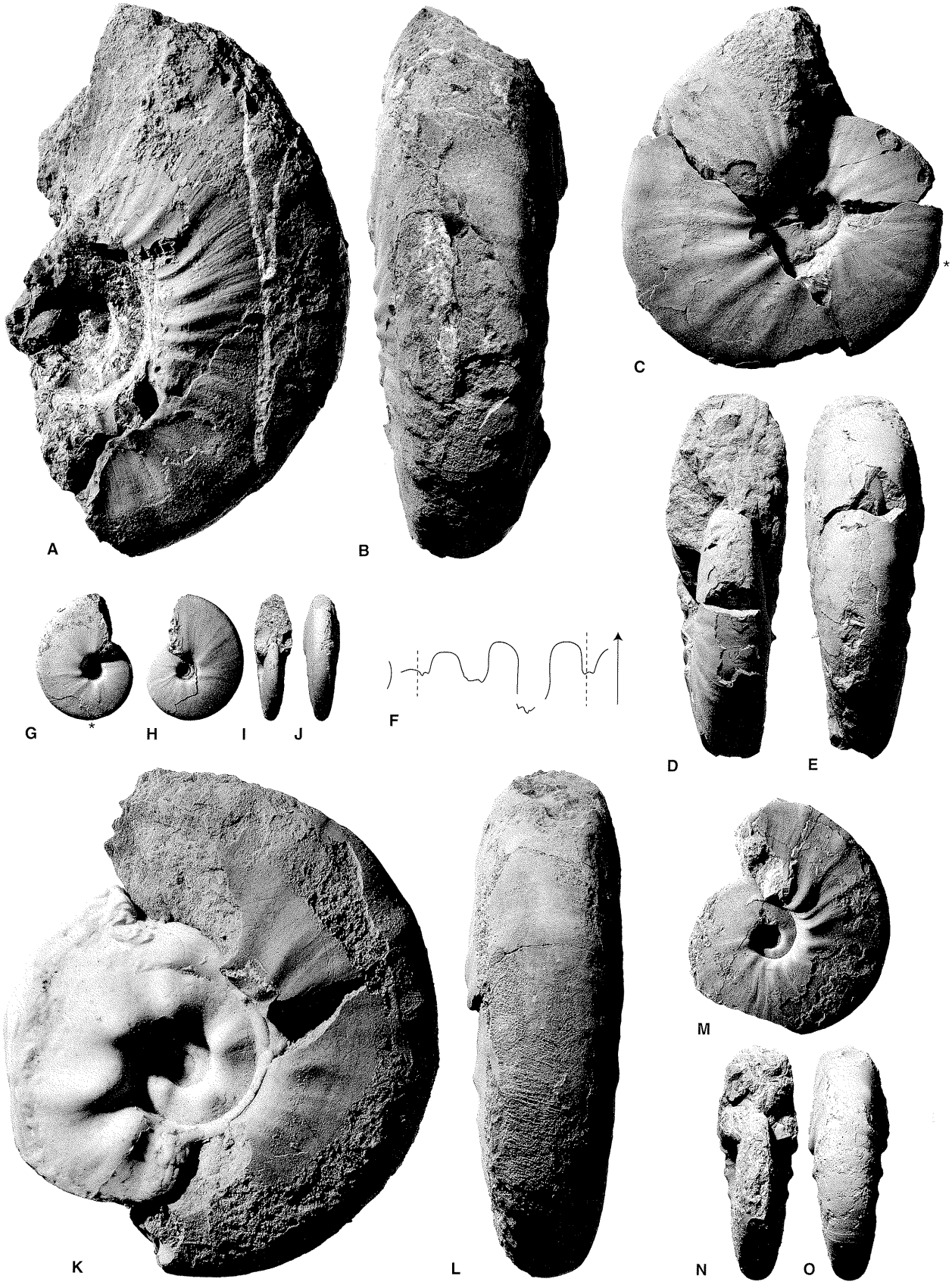
Type species. Prionites tuberculatus Waagen, 1895.

Prionites sp. indet.
Figures 31A–J

Occurrence. Sample Ma49; *Nyalamites angustecostatus* beds, Mud.

Description. Very involute, compressed shell with convergent flanks. Maximum whorl width at upper third of flanks. Venter tabulate with angular shoulders on inner whorls, subtabulate with rounded shoulders on outer whorls. Umbilicus deep and

FIG. 25. A–O, *Brayardites compressus* Brühwiler *et al.*, 2010*a*. A–B, PIMUZ 28275, from sample M03-24, Mud; C–F, PIMUZ 28276; F × 2, at H = 18 mm, from sample HB1005, Losar; G–J, PIMUZ 28277, from sample HB1005, Losar; K–L, PIMUZ 28278, from sample M08-21, Mud; M–O, PIMUZ 28279, from sample M08-21, Mud. All from the *Brayardites compressus* beds. All natural size unless otherwise indicated.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funnel shaped with steeply inclined wall and rounded shoulders. Inner whorls smooth, outer whorls with prorsiradiate, distant swellings on upper flanks. Growth lines biconcave and slightly prorsiradiate. Suture line ceratitic with broad saddles and narrow lobes.

Measurements. See Table 1.

Remarks. This species is somewhat intermediate between *Prionites tuberculatus* Waagen, 1895 from the Salt Range and *P. involutus* Brühwiler *et al.*, 2010*a* from South Tibet. The former differs by its less steep umbilical wall and the latter by its steeper umbilical wall. *P. laevis*, *P. armatus* and *P. elegans* Welter, 1922 from Timor are here considered as synonyms of *P. tuberculatus* (Brühwiler and Bucher, 2012*b*).

Genus STEPHANITES Waagen, 1895

Type species. *Stephanites superbus* Waagen, 1895.

Stephanites superbus Waagen, 1895
Figure 31P–S

1895 *Stephanites superbus* Waagen, p. 101, pl. 2, fig. 2a–c.
1895 *Stephanites corona* Waagen, p. 102, pl. 3, fig. 1a–b.
1905 *Stephanites corona* Waagen; Frech, pl. 28, fig. 1.
v non 1978 *Stephanites corona* Waagen; Guex, pl. 5, fig. 2 (= *Wastatchites distractus*).
v 2010*a* *Stephanites superbus* Waagen; Brühwiler *et al.* p. 423, fig. 14: 7–12.
v 2012*b* *Stephanites superbus* Waagen, 1895; Brühwiler and Bucher, p. 94, fig. 81A–H.

Occurrence. Samples M05-57, M06-57; *Nyalamites angustecostatus* beds, Mud.

Description. Large, moderately evolute shell with strongly convex flanks. Maximum whorl width near mid-flank. Venter broad and subtabulate with rounded shoulders. Umbilicus deep with well-rounded, inclined wall without distinct shoulders. Ornamentation consists of strong, distant tubercles on flanks, coincinding with maximum whorl width. Suture line ceratitic with very broad first lateral saddle and very low third lateral saddle.

Measurements. See Table 1.

Genus WASATCHITES Mathews, 1929

Type species. *Wasatchites perrini* Mathews, 1929.

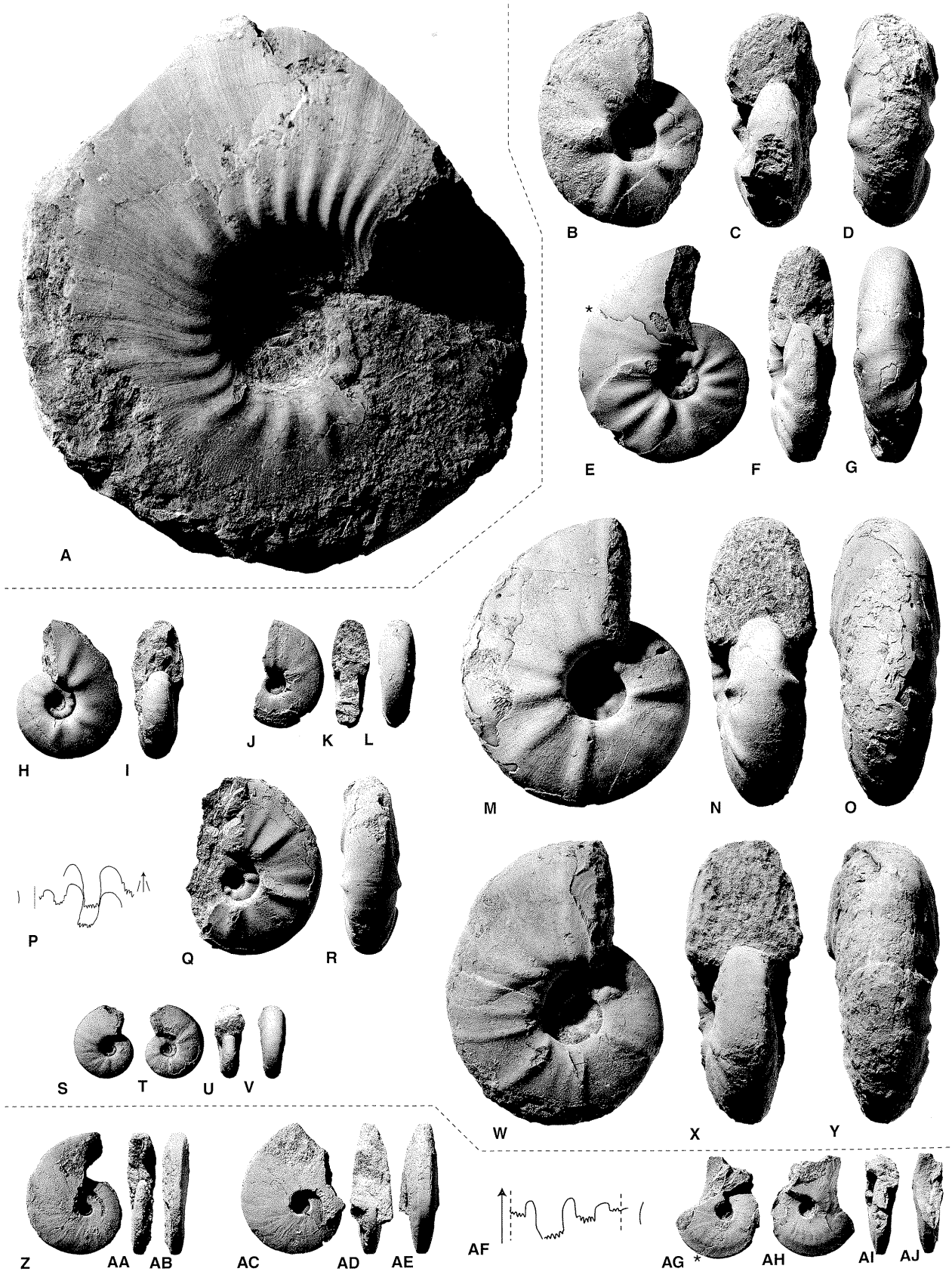
Wasatchites distractus (Waagen, 1895)
Figure 32A–Z

1895 *Acrochordiceras distractum* Waagen, p. 94, pl. 3, fig. 4a–c.
1895 *Acrochordiceras coronatum* Waagen, p. 96, pl. 3, fig. 5a–c.
1895 *Acrochordiceras* cf. *damesi* Noetling; Waagen, p. 97, pl. 4, fig. 5a–b.
1895 *Acrochordiceras compressum* Waagen, p. 98, pl. 4, fig. 4a–c.
p 1909 *Sibirites* sp. indet. Krafft and Diener, p. 138, pl. 28, fig. 4a–c.
v ? 1978 *Stephanites corona* Waagen; Guex, pl. 5, fig. 2.
v 2010*a* *Wasatchites distractus* (Waagen); Brühwiler *et al.* p. 423, fig. 15: 1.
v 2012*b* *Wasatchites distractus* (Waagen, 1895); Brühwiler and Bucher, p. 97, figs 81M–U, 82A–X.

Occurrence. Samples Ma92, E29/30, Mud; samples Gu-69A, Gu106, GD92, Guling; *Wasatchites distractus* beds.

Description. Moderately involute shell with egressive coiling at maturity. Flanks nearly flat, slightly convex and convergent on inner whorls; strongly convex on outer whorls. Maximum whorl width at mid-flank. Venter tabulate with slightly angular shoulders on inner whorls; broadly rounded with indistinct shoulders on outer whorls. Umbilicus deep with well-rounded, inclined wall and indistinct shoulders. Ornamentation consists of spiny tubercles at mid-flank as well as strong radial ribs whose strength increases when crossing the venter. Transition to maturity shows attenuation of ribbing but persistence of lateral spines. Suture line poorly preserved; first and second lateral saddles broad and tapered.

FIG. 26. A, *Brayardites compressus* Brühwiler *et al.*, 2010*a*. PIMUZ 28280, from sample M05-23, *Brayardites compressus* beds, Mud. B–Y, *Nammalites pilatoides* (Guex, 1978). B–D, PIMUZ 28281, from sample Ma28b, Mud; E–G, PIMUZ 28282, from sample HB1004, Losar; H–I, PIMUZ 28283, from sample HB1004, Losar; J–L, PIMUZ 28284, from sample Ma28b; N–O, PIMUZ 28285, from sample E22/23, Mud; P, PIMUZ 28286; at H = 17.7 mm, from sample HB1004, Losar; Q–R, PIMUZ 28287, from sample Ma28b, Mud; S–V, PIMUZ 28288, from sample HB1029, Losar; W–Y, PIMUZ 28289, from sample Ma28b, Mud. All from the *Nammalites pilatoides* beds. Z–AJ, *Nuetzelia himalayica* gen. et sp. nov. Z–AB, PIMUZ 28290; AC–AE, PIMUZ 28291, holotype; AF–AJ, PIMUZ 28292; AF ×3, at H = 7.4 mm. All from sample HB 1004, *Escarguelites spitiensis* horizon, Losar. All natural size unless otherwise indicated.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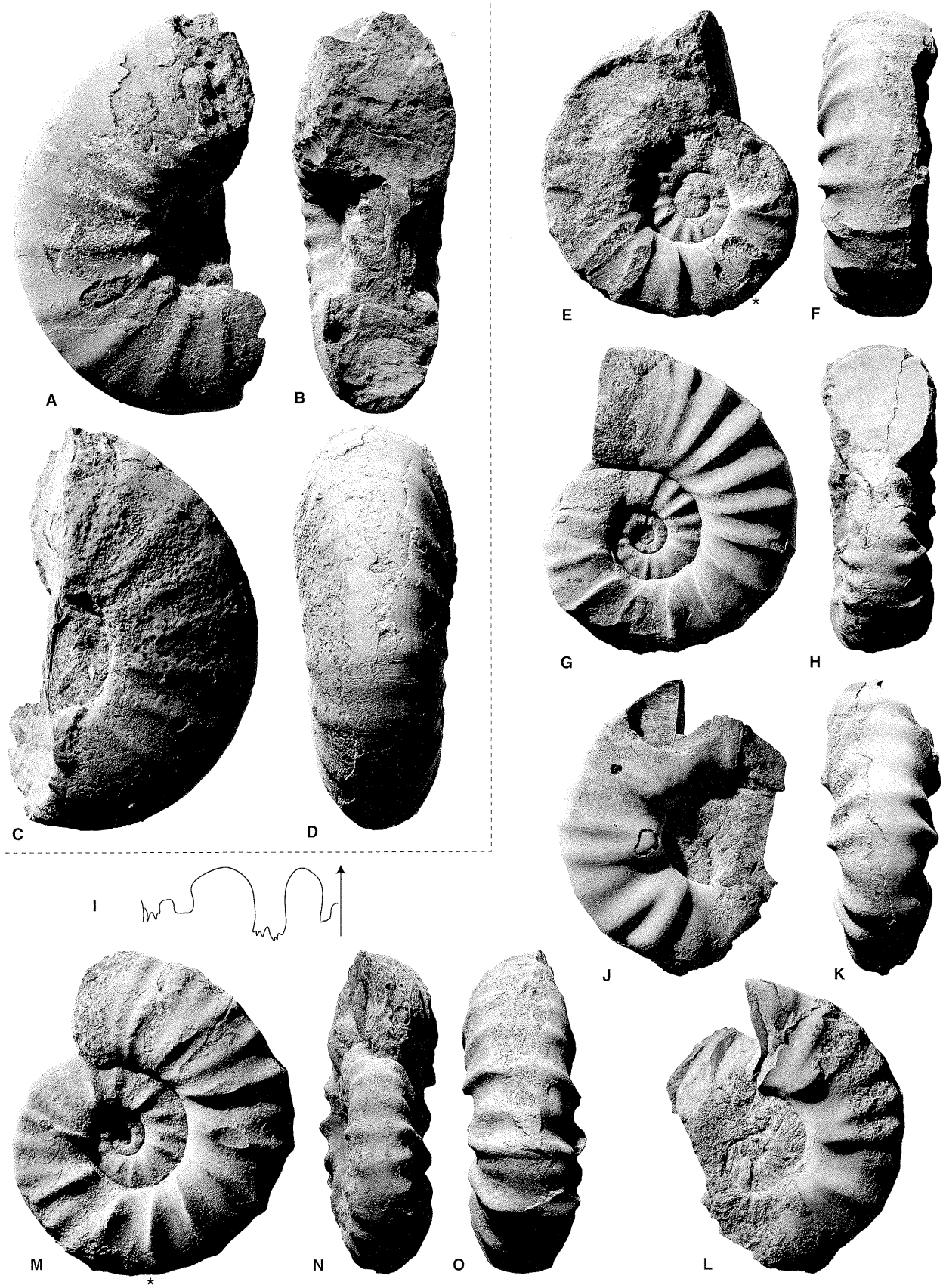
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Measurements. See Figure 33.

Remarks. Boreal representatives of *Wasatchites* (e.g. *W. perrini* Spath, 1934) essentially differ from *W. distractum* by the more umbilical position of their spines.

Genus ANASIBIRITES Mojsisovics, 1896

Type species. Sibirites kingianus Waagen, 1895, p. 108, pl. 8, figs 1a–c, 2a–c.

Anasibirites kingianus (Waagen, 1895)
Figures 31O, 32AA–BD

1895 *Sibirites kingianus* Waagen, p. 108, pl. 8, figs 1–2.
1895 *Sibirites chidruensis* Waagen, p. 109, pl. 8, figs 3–4.
1895 *Sibirites inaequicostatus* Waagen, p. 113, pl. 8, figs 7–8.
? 1895 *Sibirites ceratitoides* Waagen, p. 115, pl. 8, fig. 10a–c.
1929 *Anasibirites kingianus* (Waagen); Mathews, p. 8, pl. 7, figs 14–22.
1968 *Anasibirites kingianus* Waagen; Kummel and Erben, p. 135, pl. 22, figs 12–17; pl. 23, figs 1–18.
v 1978 *Anasibirites kingianus* (Waagen); Guex, pl. 3, figs 2, 9, pl. 4, fig. 6.
v 2012*b* *Anasibirites kingianus* (Waagen, 1895); Brühwiler and Bucher, p. 101, fig. 84A–U.

Occurrence. Sample Ma92, Mud; samples Gu106, GD92, Guling; *Wasatchites distractus* beds.

Description. Moderately involute shell with convex, slightly compressed flanks. Venter arched with rounded shoulders. Umbilicus with inclined wall and rounded shoulders. Ornamentation consists of straight to sinuous, projected ribs of varying strength that cross the venter. Suture line simple with tapered saddles, poorly preserved.

Measurements. See Figure 34.

Remarks. For recent discussions on the genus *Anasibirites*, see Brayard and Bucher (2008) and Brühwiler and Bucher (2012*b*).

Family PARANANNITIDAE Tozer, 1971

Genus PARANANNITES Hyatt and Smith, 1905

Type species. Paranannites aspenensis Hyatt and Smith, 1905.

Paranannites sp. indet.
Figure 35A–X

Occurrence. Samples M06-39, M05-40, Ma28b, Mud; sample G06-43, Guling; sample HB1006, HB1032, Losar; *Truempyceras compressum* horizon.

Description. Moderately involute, globose shell with convex, slightly compressed flanks. Venter arched with indistinct shoulders. Umbilicus deep with high, vertical wall and subangular, slightly rounded shoulders. Ornamentation consists of fine, radial and concave folds. Suture line ceratitic with tapered first lateral saddle, incompletely preserved.

Measurements. See Figure 36.

Remarks. This species is similar to the type species but differs by its thicker whorls and its slightly more evolute coiling.

Genus OWENITES Hyatt and Smith, 1905

Type species. Owenites koeneni Hyatt and Smith, 1905.

Owenites koeneni Hyatt and Smith, 1905
Figures 35AH–AJ

1905 *Owenites koeneni* Hyatt and Smith, p. 83, pl. 10, figs 1–22.
1932 *Owenites koeneni* Hyatt and Smith; Smith, pl. 10, figs 1–22.
1932 *Owenites egrediens* Welter; Smith, p. 100, pl. 52, figs 6–8.
1932 *Owenites zitteli* Smith, p. 101, pl. 52, figs 1–5.
1934 *Owenites koeneni* Hyatt and Smith; Spath, p. 185, figs 57a–c.
1947 *Owenites* aff. *egrediens* Welter; Kiparisova, p. 139, pl. 32, figs 1–3.
1955 *Kingites shimizui* Sakagami, p. 138, pl. 2, fig. 2.
1957 *Owenites koeneni* Hyatt and Smith; Kummel, pl. 138, fig. 171: 8a–b.

FIG. 27. A–D, *Nammalites pilatoides* (Guex, 1978). PIMUZ 28293, from sample M06-39, *Nammalites pilatoides* beds, Mud. E–O, *Escarguelites spitiensis* gen. et sp. nov. E–I, PIMUZ 28294, holotype; I × 2, at H = 12.5 mm, from sample M08-29, Mud; J–L, PIMUZ 28295, from sample HB1004, Losar; M–O, PIMUZ 28296. From sample M08-29, Mud. All from the *Escarguelites spitiensis* horizon. All natural size unless otherwise indicated.

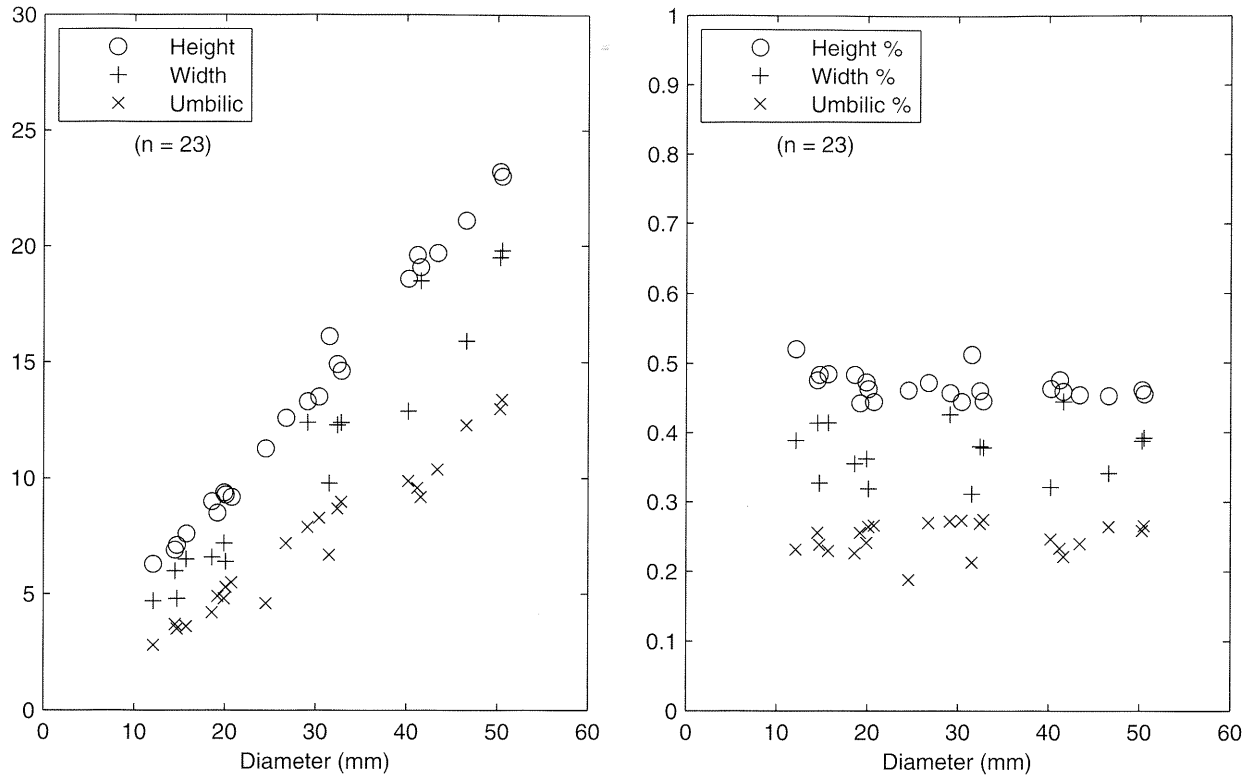
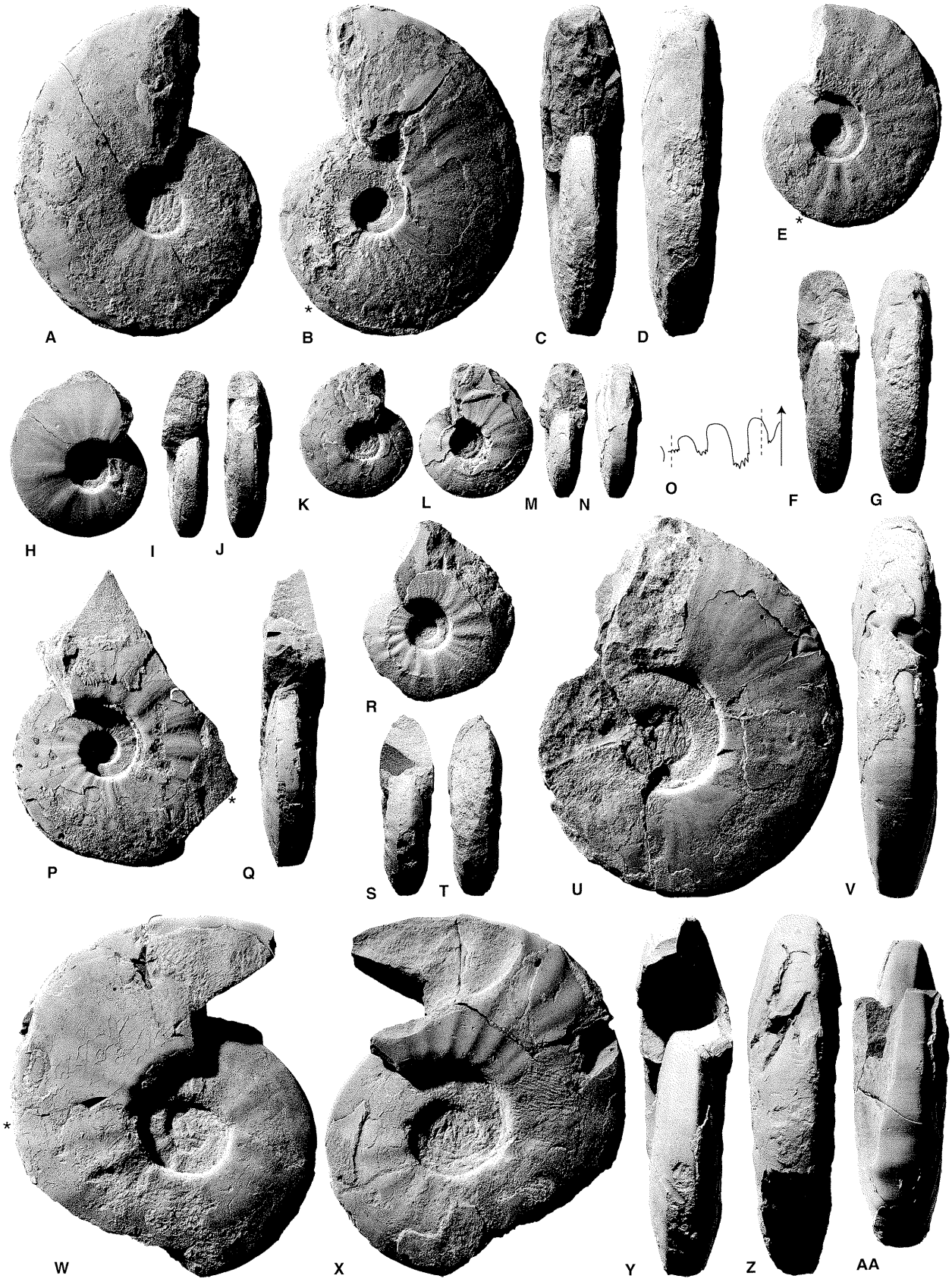


FIG. 28. Scatter diagram of H, W, and U, and of H/D, W/C, and U/D for *Nammalites pilatoides* (Guex, 1978).

1959 *Owenites costatus* Chao, p. 249, pl. 22, figs 7–18, 22, 23, fig. 26c.
1959 *Owenites pakungensis* Chao, p. 248, pl. 21, figs 6–8.
1959 *Owenites pakungensis* var. *compressus* Chao, p. 248, pl. 21, figs 4, 5, fig. 26a.
1959 *Pseudowenites oxynotus* Chao, p. 252, pl. 23, figs 1–16, figs 27a–d.
? 1959 *Owenites* cf. *koeneni* Hyatt and Smith; Kummel, p. 441, figs 2–4.
1959 *Owenites shimizui* Sakagami; Kummel, p. 430.
1960 *Owenites shimizui* Sakagami; Kummel and Sakagami, p. 6, pl. 5, figs 5–6.
1962 *Owenites koeneni* Hyatt and Smith; Kummel and Steele, p. 674, pl. 101, figs 3–7.
1962 *Owenites koeneni* Hyatt and Smith; Popov, p. 44, pl. 6, fig. 6.
1965 *Owenites koeneni* Hyatt and Smith; Kuenzi, p. 374, pl. 53, figs 1–6, figs 3d, 6.
1966 *Owenites koeneni* Hyatt and Smith; Hada, p. 112, pl. 4, figs 2–4.
1968 *Owenites koeneni* Hyatt and Smith; Kummel and Erben, p. 121, fig. 12, pl. 19, figs 10–15.
1968 *Owenites carinatus* Shevyrev, p. 189, pl. 16, fig. 1.
1968 *Owenites koeneni* Hyatt and Smith; Zakharov, p. 94, pl. 18, figs 1–3.
1973 *Owenites koeneni* Hyatt and Smith; Collignon, p. 139, pl. 4, figs 2–3.
1979 *Owenites koeneni* Hyatt and Smith; Nichols and Silberling, pl. 1, figs 17, 18.
1981 *Owenites koeneni* Hyatt and Smith; Bando, p. 158, pl. 17, fig. 7.
1984 *Owenites carinatus* Shevyrev; Vu Khuc, p. 81, pl. 6, figs 1–4.
1984 *Pseudowenites oxynotus* Chao; Vu Khuc, p. 82, pl. 7, figs 3, 4.
1990 *Owenites koeneni* Hyatt and Smith; Shevyrev, p. 118, pl. 1, fig. 5.
1995 *Owenites koeneni* Hyatt and Smith; Shevyrev, p. 51, pl. 5, figs 1–3.
2004 *Owenites pakungensis* Chao; Tong *et al.*, p. 199, pl. 2, figs 9–10, fig. 7.

FIG. 29. A–AA, *Truempyceras compressum* sp. nov. A–D, PIMUZ 28297, from sample LTB3, Lalung; E–G, PIMUZ 28298, from sample LTB3, Lalung; H–J, PIMUZ 28299, from sample M05-43, Mud; K–N, PIMUZ 28300, from sample E22, Mud; O, W–AA, PIMUZ 28304, holotype; O at H = 17.5 mm, from sample LTB3, Lalung; P–Q, PIMUZ 28301, from sample LTB3, Lalung; R–T, PIMUZ 28302, from sample HB1029, Losar; U–V, PIMUZ 28303, from sample LTB3, Lalung. All from the *Truempyceras compressum* horizon. All natural size.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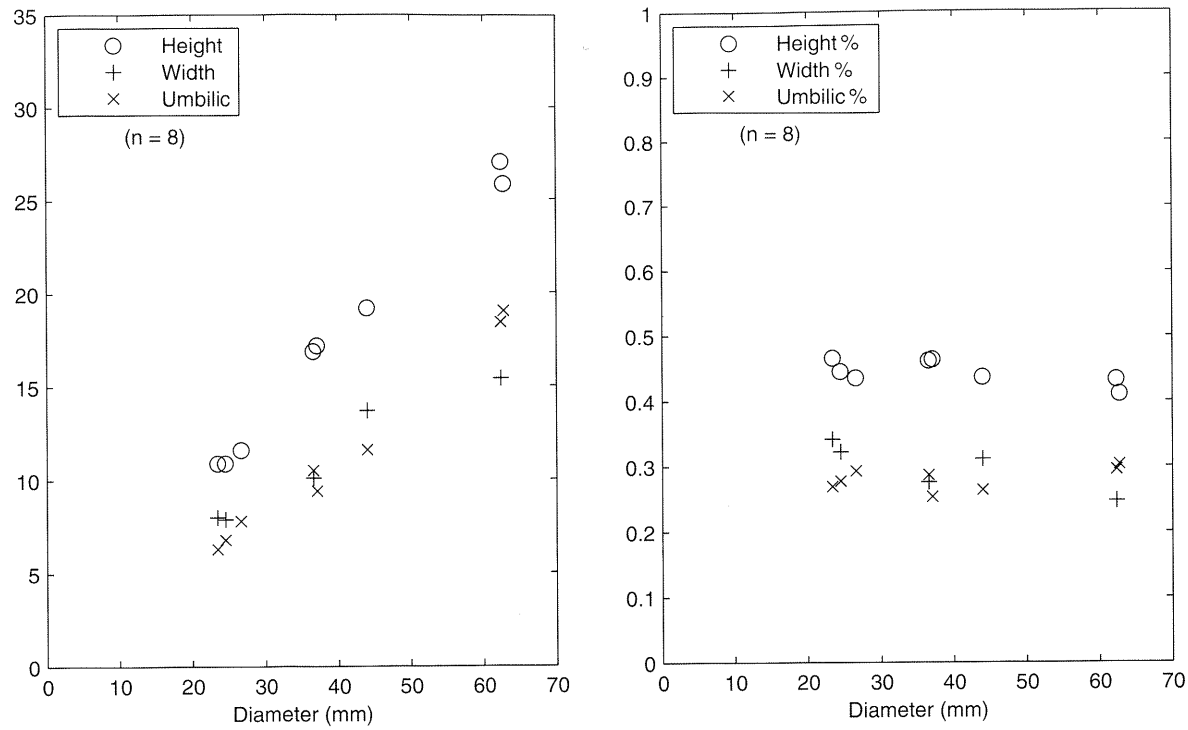


FIG. 30. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Truempyceras compressum* sp. nov.

v 2008 *Owenites koeneni* Hyatt and Smith; Brayard and Bucher, p. 67, pl. 36, figs 1–8.
v 2010*a* *Owenites koeneni* Hyatt and Smith; Brühwiler *et al.* p. 426, fig. 15: 9a–b.
v 2012*a* *Owenites koeneni* Hyatt and Smith; Brühwiler and Bucher, p. 43, pl. 25., figs 1–6.

Occurrence. Sample M03-57, Mud; *Nyalamites angustecostatus* beds.

Description. Involute, somewhat compressed shell with an inflated, lenticular whorl section. Umbilical wall inclined, imparting a conical shape to the umbilicus. Venter narrowly rounded to acute. Surface smooth. Suture line not preserved.

Measurements. See Table 1.

Owenites cf. *simplex* Welter, 1922
Figure 35Y–AC

Occurrence. Samples M06-39, Ma28b, Mud; sample G06-43, Guling; *Truempyceras compressum* horizon.

Description. Moderately involute, slightly compressed shell with convex flanks. Venter subangular with indistinct shoulders. Umbilicus deep with inclined wall and rounded shoulders. Ornamentation consists of fine, radial folds. Suture line not preserved.

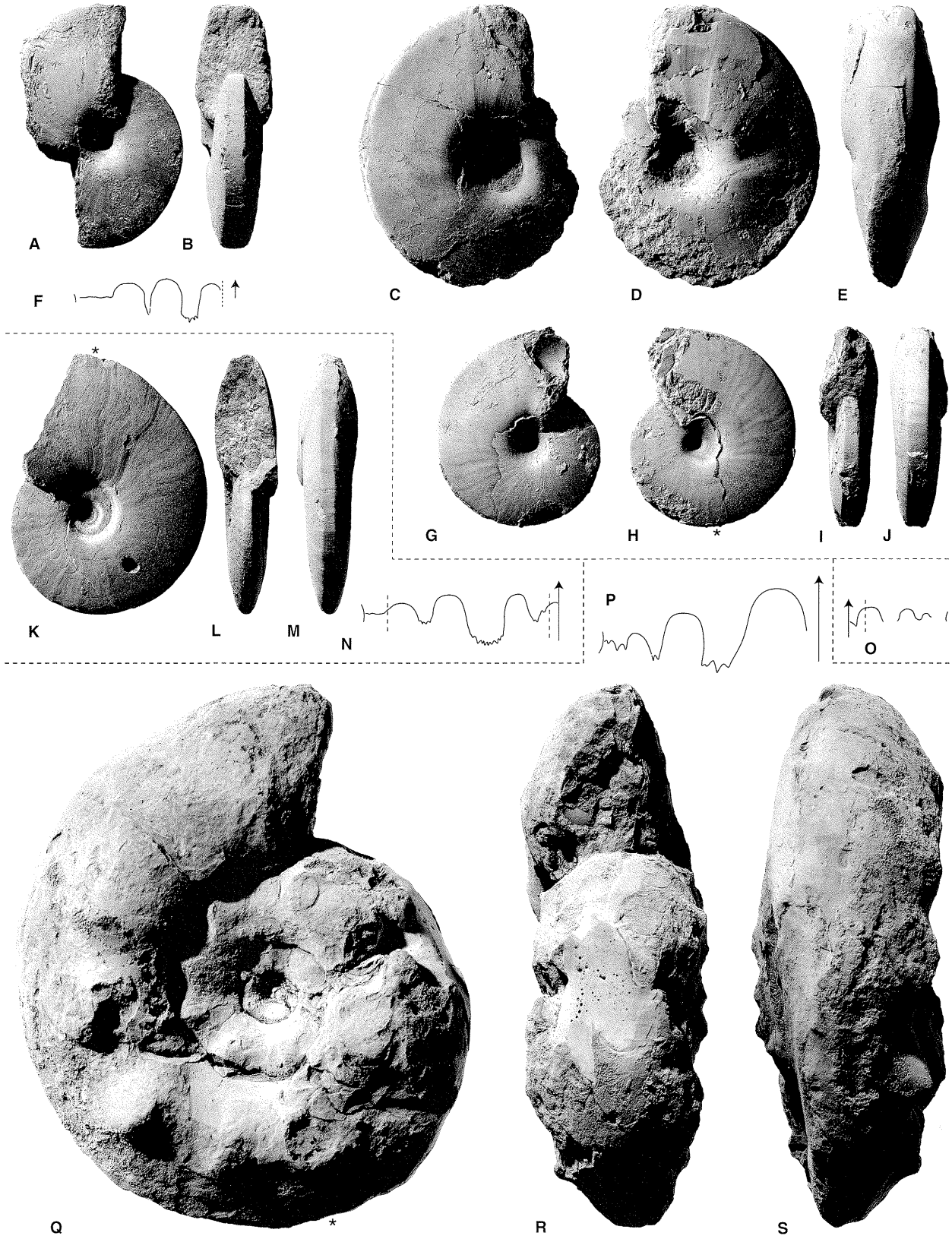
Measurements. See Table 1.

Remarks. The shape of this species is somewhat intermediate between that of *Paranannites* and *Owenites*. Typical *Paranannites* have a rounded venter; typical *Owenites* have a more acute venter. *Paranannites subangulosus* Brayard and Bucher, 2008 from South China differs by its thicker whorls.

Owenites carpenteri Smith, 1932
Figure 35AK–AU

1932 *Owenites carpenteri* Smith, p. 100, pl. 54, figs 31–34.
1966 *Owenites carpenteri* Smith; Hada, p. 112, pl. 4, fig. 1a–e.

FIG. 31. A–J, *Prionites* sp. indet. A–B, PIMUZ 28305; C–E, PIMUZ 28306; F–J, PIMUZ 28307; F × 2, at H = 13.2 mm. All from sample Ma49, *Nyalamites angustecostatus* beds, Mud. K–N, Gen. et sp. indet. A. PIMUZ 28308; N × 2, at H = 12.6 mm, from sample HB1004, *Escarguelites spitiensis* horizon, Losar. O, *Anasibirites kingianus* (Waagen, 1895). PIMUZ 28309, ×3, at H = 4.5 mm (Fig. 32AO–AR). From sample Gu106, *Wasatchites distractus* beds, Guling. P–S, *Stephanites superbus* Waagen, 1895. PIMUZ 28310; P at H = 25 mm. From sample M05-57, *Nyalamites angustecostatus* beds, Mud. All natural size unless otherwise indicated.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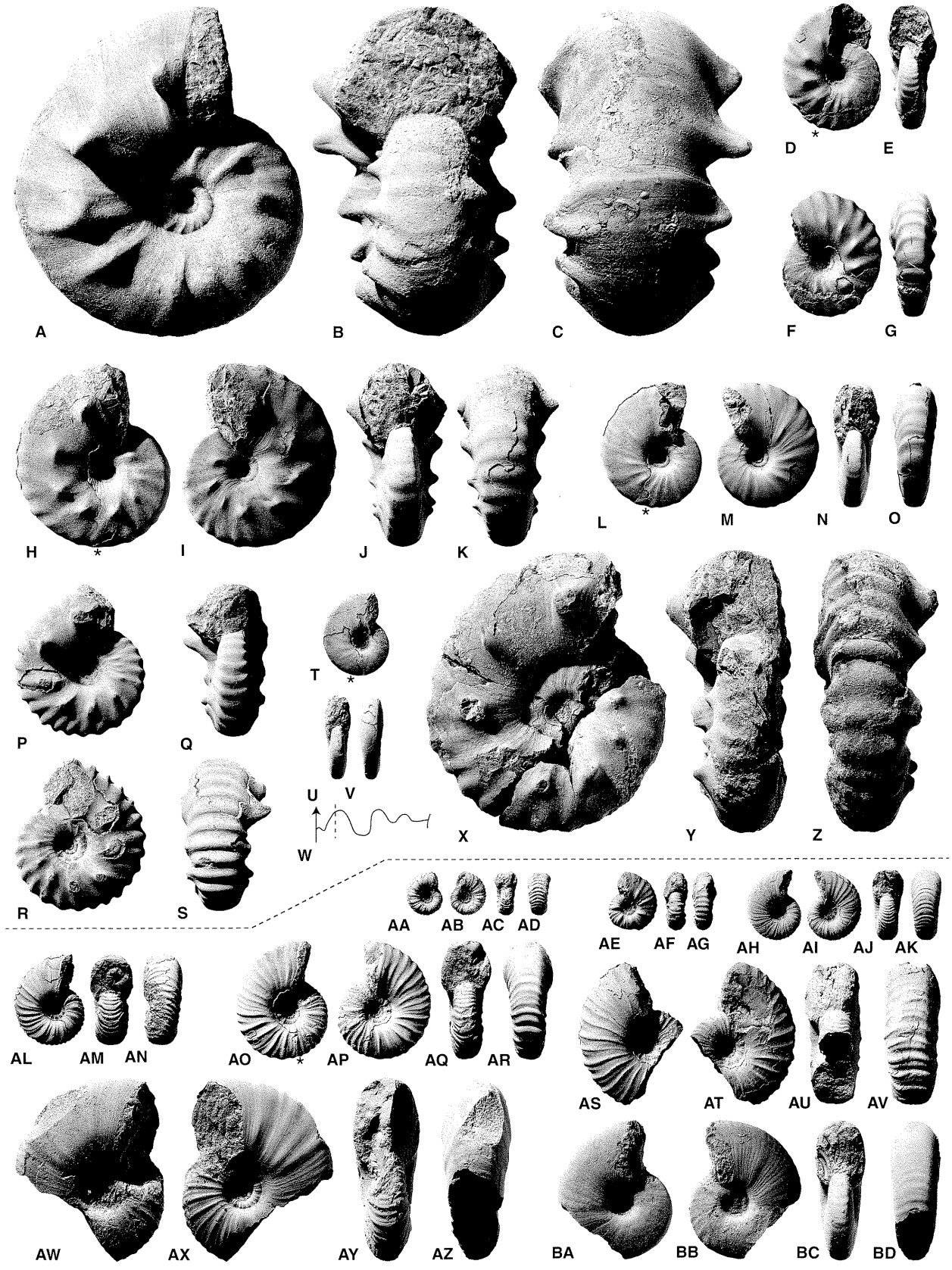
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1968 *Owenites costatus* Chao; Kummel and Erben, p. 122, fig. 12l.
1973 *Owenites carpenteri* Smith; Collignon, p. 139, pl. 4, figs 5–6.
v 2008 *Owenites carpenteri* Smith; Brayard and Bucher, p. 70, pl. 43, figs 15–16.
v 2010*a* *Owenites carpenteri* Smith; Brühwiler *et al.* p. 426, fig. 16: 7–8.
v 2012*a* *Owenites carpenteri* Smith; Brühwiler and Bucher, p. 44, pl. 25, figs 7–8.

Occurrence. Sample Ma49, Mud; sample Gu72, Guling; *Nyalamites angustecostatus* beds.

Description. Small, extremely involute shell with a subtriangular whorl section. Venter narrow and subangular. Umbilicus occluded. Maximum whorl width at umbilicus. Shell surface smooth except for deep constrictions visible on internal mould only. Suture line ceratitic with five lateral saddles; lobes weakly indented.

Measurements. See Table 1.

Owenites sp. indet.
Figure 35AD–AG

Occurrence. A single, very small specimen from sample Gu44, Guling; *Truempyceras compressum* horizon.

Description. Very small, involute shell. Venter narrow and subangular. Umbilicus small with inclined wall. Maximum whorl width at umbilical edge. Ornamentation consists of prorsiradiate, sinuous and weak plications. Suture line ceratitic with four lateral saddles; lobes weakly indented.

Remarks. Identification at the species level is not possible due to the small size of our specimen.

Genus STECKITES gen. nov.

Derivation of name. Named after Albrecht Steck (Lausanne).

Type species. *Steckites brevus* gen. et sp. nov.

Composition of the genus. Type species only.

Diagnosis. Paranannitidae with an oxyconic shape similar to that of *Owenites*, but with a suture line with a very short auxiliary series.

Remarks. This genus is very similar to *Owenites*. However, *Owenites* displays a suture line with several well-individualized auxiliary saddles.

Steckites brevus sp. nov.
Figure 35AV–BC

Derivation of name. Refers to the short auxiliary series of the suture line.

Holotype. Specimen PIMUZ 28337 (Fig. 35AV–AY).

Type locality. Mud, Spiti, India.

Type horizon. Sample Ma26; *Truempyceras compressum* horizon.

Diagnosis. As for the genus.

Occurrence. Samples Ma26, Mud-E21/22, M06-39, M06-40; *Truempyceras compressum* horizon, Mud.

Description. Moderately involute, slightly compressed shell with convex flanks. Venter subangular with indistinct shoulders. Umbilicus with inclined wall and rounded shoulders. Surface smooth except for prorsiradiate, sinuous and weak plications that cross the venter. Suture line ceratitic, with three lateral saddles and a very short auxiliary series.

Measurements. See Table 1.

Family MELAGATHICERATIDAE Tozer, 1971

Genus JUVENITES Smith, 1927

Type species. *Juvenites kraffti* Smith, 1927.

Juvenites cf. *spathi* (Frebold 1930)
Figure 37A–O

Occurrence. Sample M05-23, *Brayardites compressus* beds, Mud. A single specimen from sample LoA-SFB, *Nammalites pilatoides* beds (?), Losar.

Description. Moderately involute, globose shell with outer whorls. Flanks convex, converging to the venter from the umbilical margin. Umbilicus deep, with vertical wall and rounded

FIG. 32. A–Z, *Wasatchites distractus* (Waagen, 1895). A–B, PIMUZ 28311, from sample Ma92, Mud; D–G, PIMUZ 28312, from sample Gu106, Guling; H–K, PIMUZ 28313, from sample Gu106, Guling; L–O, PIMUZ 28314, from sample Gu106, Guling; P–S, PIMUZ 28315, from sample E29/30, Mud; T–V, PIMUZ 28316, from sample Gu106, Guling; W, PIMUZ 28317; ×2, at H = 8.9 mm, from sample Gu106, Guling; X–Z, PIMUZ 28318, from sample Gu106, Guling. All from the *Wasatchites distractus* beds. AA–BD, *Anasibirites kingianus* (Waagen, 1895). AA–AD, PIMUZ 28319; AE–AG, PIMUZ 28320. AH–AK, PIMUZ 28321; AL–AN, PIMUZ 28322; AO–AR, PIMUZ 28309 (Fig. 31O); AS–AV, PIMUZ 28323. AW–AZ, PIMUZ 28324, from sample Ma92, Mud. BA–BD, PIMUZ 28325. All from sample Gu106, Guling, except for Figures AW–AZ. All from the *Wasatchites distractus* beds. All natural size unless otherwise indicated.

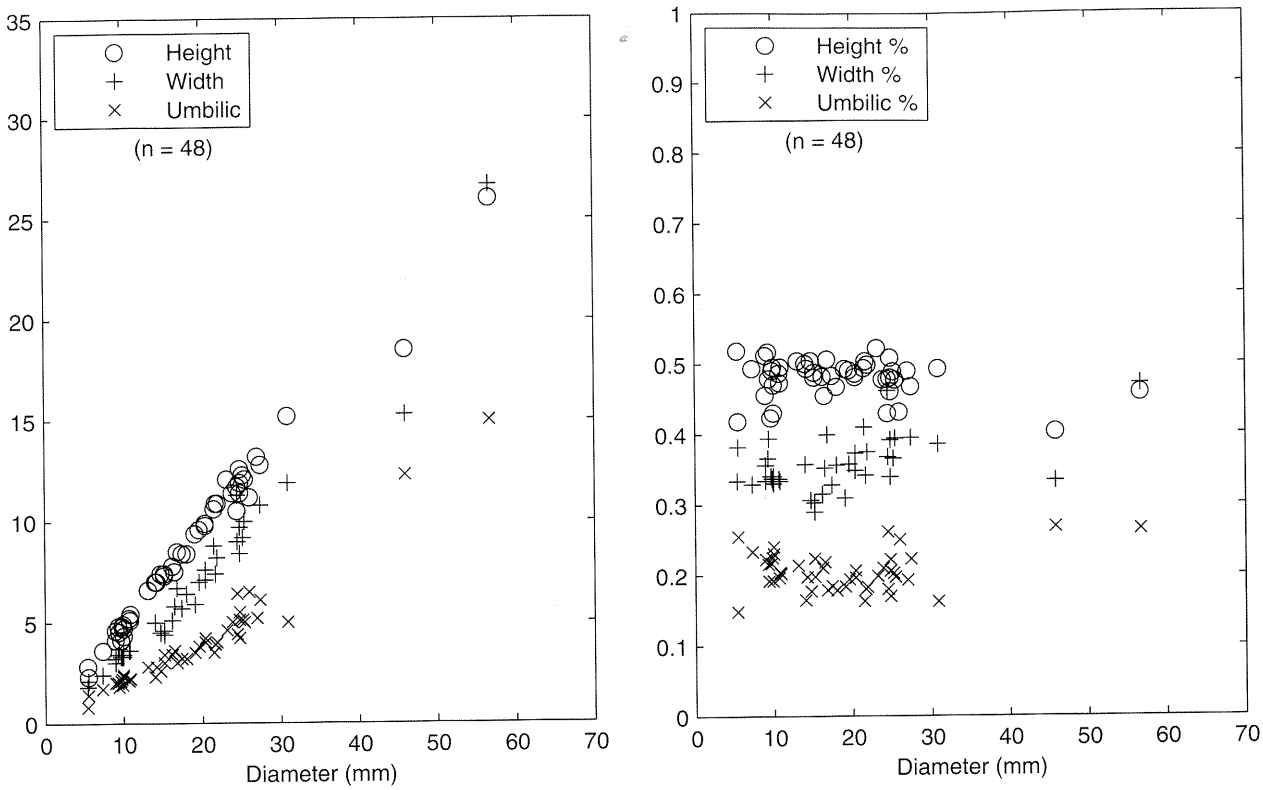


FIG. 33. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Wasatchites distractus* (Waagen, 1895).

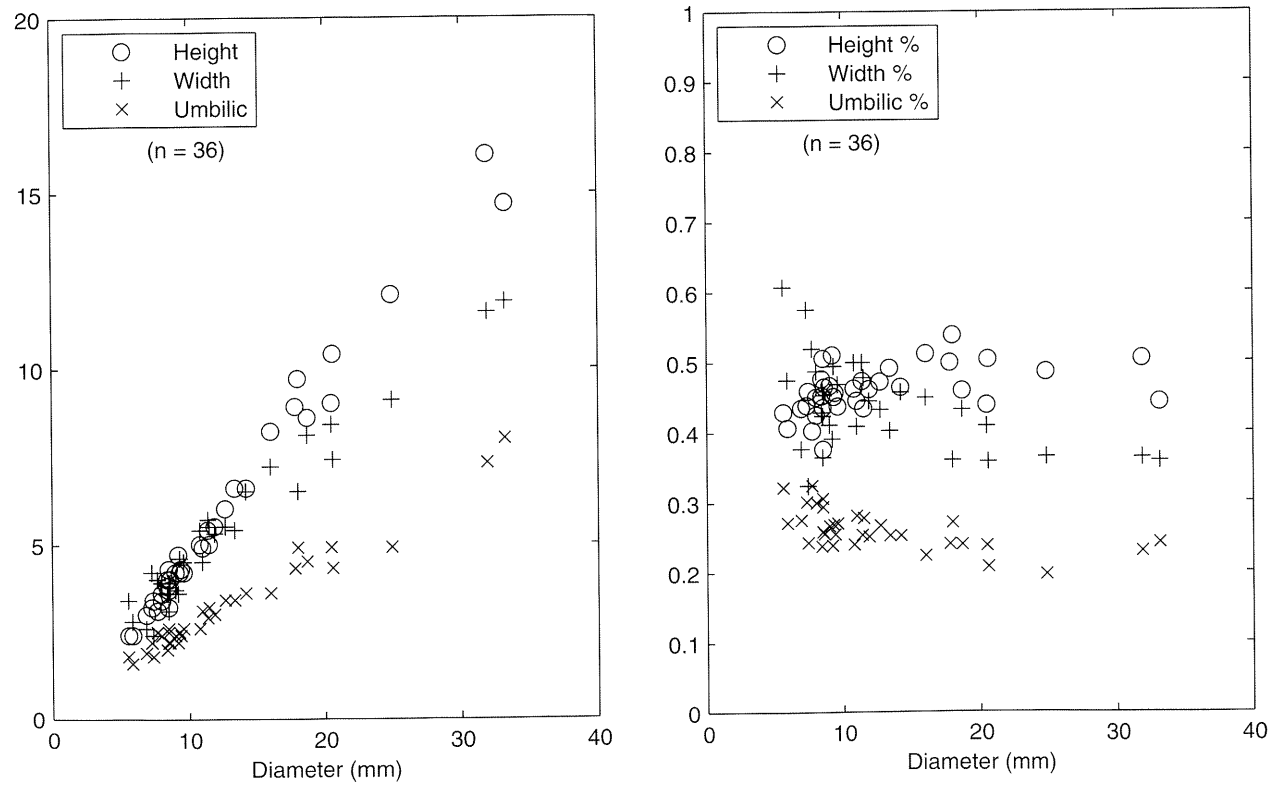


FIG. 34. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Anasibirites kingianus* (Waagen, 1895).

shoulders. Ornamentation consists of prorsiradiate constrictions that cross the venter. Suture line not preserved.

Measurements. See Figure 38.

Remarks. Typical representatives of *Juvenites spathi* display a subtrigonal whorl section, especially on outer whorls (Brayard and Bucher 2008), which is not observed on our specimens. Therefore, the assignment to *Juvenites spathi* is only tentative.

Juvenites procurvus Brayard and Bucher, 2008
Figure 37AK–AP

v 2008 *Juvenites procurvus* Brayard and Bucher, p. 32, pl. 22, figs 6–12, text-fig. 30.

Occurrence. Sample M08-48; *Pseudoceltites multiplicatus* beds, Mud.

Description. Small, subglobose and moderately involute shell with rounded venter and convex flanks. Umbilicus with vertical wall and rounded shoulders. Ornamentation consists of numerous, deep and projected constrictions. Suture line simple with only two lateral saddles, and lobes apparently smooth.

Measurements. See Table 1.

Genus JINYACERAS Brayard and Bucher, 2008

Type species. Jinyaceras bellum Brayard and Bucher, 2008.

Jinyaceras hindostanum (Diener, 1897)
Figure 37P–AJ

1897 *Nannites hindostanus* Diener, p. 68, pl. 7, figs 3, 11–12.
1897 *Nannites herberti* Diener, p. 69, pl. 7, fig. 2.
v 2010*a* *Jinyaceras hindostanum* (Diener); Brühwiler *et al.*, p. 426, fig. 16: 4–6.

Occurrence. Samples Ma24c, M03-19, M03-20, M03-21, M08-21, M06-24, Mud; sample Gu-23, Guling; samples HB1005, HB1025, HB1033, Losar; *Brayardites compressus* beds.

Description. Small, moderately involute to moderately evolute, laterally compressed shell with flat, subparallel flanks. Venter broadly arched, with rounded ventral shoulders. Umbilicus with vertical wall and subangular shoulders. Ornamentation consists of prorsiradiate constrictions that nearly disappear on venter. Constrictions are deepest on evolute variants. Suture line simple with only two lateral saddles, lobes apparently not indented.

Measurements. See Figure 39.

Family INYOITIDAE Spath, 1934

Genus SUBVISHNUITES Spath, 1930

Type species. Subvishnuites welteri Spath, 1930 (= *Vishnuites* spec. Welter, 1922).

Subvishnuites posterus sp. nov.
Figure 37AQ–BK

v 2012*a* *Subvishnuites* sp. indet. Brühwiler and Bucher, p. 36, pl. 21, fig. 14a–c.

Derivation of name. Refers to the younger age of this species with respect to the type species.

Holotype. Specimen PIMUZ 28360 (Fig. 37BH–BK).

Type locality. Mud, Spiti, India.

Type horizon. Sample M08-70; *Subvishnuites posterus* beds.

Diagnosis. Relatively involute *Subvishnuites* with flattened flanks and a relatively deep umbilicus.

Occurrence. Sample M08-70; *Subvishnuites posterus* beds, Mud.

Description. Moderately evolute, compressed shell. Flanks convex; subparallel on the upper half and strongly converging on the lower half. Venter narrowly rounded. Umbilicus with vertical wall and rounded shoulders. Surface smooth or ornamented with weak ribs that cross the venter. Suture line ceratitic with long, slightly phylloid saddles and deep lobes.

Measurements. See Figure 40.

Remarks. The type species *Subvishnuites welteri* Spath, 1930 and *S. stokesi* Kummel and Steele, 1962 have a middle Smithian age and thus are slightly older than this species (Brayard and Bucher 2008). *S. posterus* differs from these species by being more involute. Additionally, *S. welteri* has a shallower umbilicus.

Subvishnuites posterus has recently been found in an exotic block of Hallstatt facies from Oman, associated with *Anasibirites multiformis* (*Subvishnuites* sp. indet. *in* Brühwiler and Bucher 2012*a*, *b*).

Family INCERTAE SEDIS

Genus SHIGETACERAS Brühwiler, Bucher and Goudemand, 2010*a*

Type species. Hemiprionites dunajensis Zakharov, 1968.

Shigetaceras dunajensis (Zakharov, 1968)
Figure 41AJ–AM

1968 *Hemiprionites dunajensis* Zakharov, p. 125, pl. 23, figs 6–8.
? 2009 *Hemiprionites* sp. indet. Shigeta and Zakharov, p. 87, fig. 74.
v 2010*a* *Shigetaceras dunajensis* (Zakharov, 1968); Brühwiler *et al.*, p. 428, fig. 10: 1–4.

Occurrence. A single specimen from sample M03-40; *Truempyceras compressum* horizon, Mud.

Description. Compressed and involute shell with slightly convex and convergent flanks. Venter tabulate with angular shoulders. Umbilicus small and deep with vertical wall and narrow, slightly rounded shoulders. Surface smooth. Suture line not preserved.

Measurements. See Table 1.

Remarks. This species has recently been found in the *Nammalites pilatoides* beds at Tulong, South Tibet (Brühwiler *et al.* 2010*a*).

Genus KRAFFTICERAS gen. nov.

Derivation of name. Named after A.v. Krafft.

Type species. Meekoceras pseudoplanulatum Krafft and Diener, 1909.

Composition of the genus. Type species only.

Diagnosis. Platyconic and moderately involute Meekoceratoceae with a bicarinate venter and a deep umbilicus with a vertical wall.

Remarks. The bicarinate venter of *Kraffticeras* is similar to that of *Meekoceras*, which differs by its funnel-shaped umbilicus. The umbilicus and the ornamentation of *Kraffticeras* may indicate affinities with Arctoceratidae.

Kraffticeras pseudoplanulatum (Krafft and Diener, 1909)
Figure 37BL–CB

1909 *Meekoceras pseudoplanulatum* Krafft and Diener, p. 30, pl. 6, fig. 3a–c.

Occurrence. Samples HB1013, HB1026; *Flemingites* beds, Losar.

Description. Moderately involute, compressed shell. Flanks nearly flat, only slightly convex. Venter bicarinate. Umbilicus deep with vertical wall and subangular shoulders. Surface smooth or ornamented with weak plications that are most prominent near umbilical margin. Suture line ceratitic with long saddles and deep lobes.

Measurements. See Figure 42.

Genus et species indet. A
Figure 31K–N

Occurrence. A single specimen from sample HB1004; *Escarguelites spitiensis* horizon, Losar.

Description. Moderately involute, platycone shell with slightly convex flanks. Venter narrow and tabulate with angular shoulders. Umbilicus with inclined wall and rounded shoulders. Surface smooth except for distinctly biconcave growth lines. Suture line ceratitic with broad lobes.

Measurements. See Table 1.

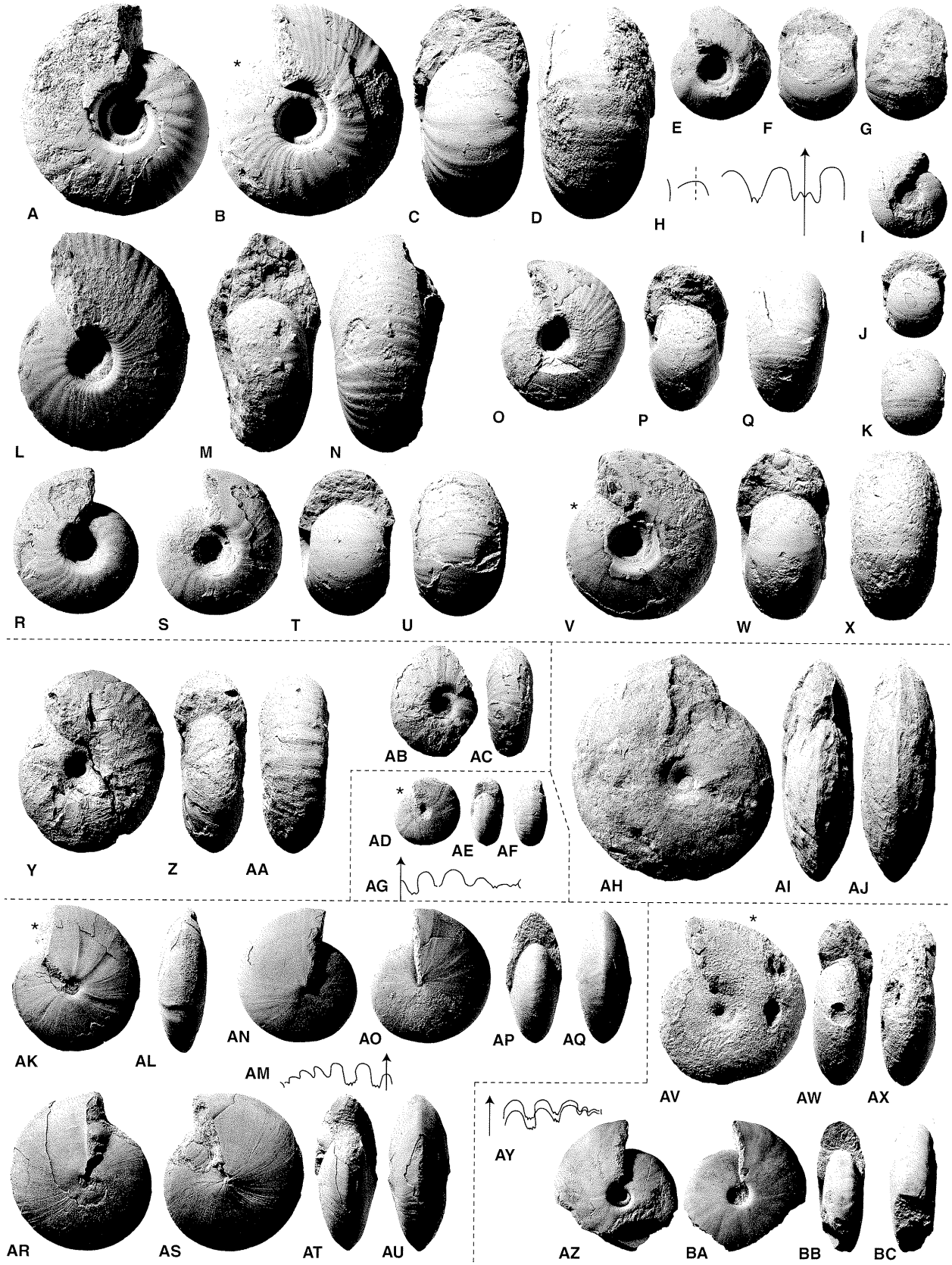
Remarks. The overall shape of this specimen is similar to that of *Meekoceras*, which differs by its bicarinate venter and its narrower umbilicus.

Superfamily SAGECERATACEAE Hyatt, 1884
Family ASPENITIDAE Spath, 1934

Genus ASPENITES Hyatt and Smith, 1905

Type species. Aspenites acutus Hyatt and Smith, 1905.

FIG. 35. A–X, *Paranannites* sp. indet. A–D, PIMUZ 28326, from sample M06-39; E–G, PIMUZ 28327, from sample M06-39; H, V–X, PIMUZ 28332; H × 2, from sample Ma28b; I–K, PIMUZ 28328, from sample M06-39; L–N, PIMUZ 28329; from sample HB1006, Losar; O–Q, PIMUZ 28330, from sample Ma28b; R–U, PIMUZ 28331, from sample M06-39. All from Mud, except for L–N. All from the *Truempyceras compressum* horizon. Y–AC, *Owenites* cf. *simplex* Welter, 1922. Y–AA, PIMUZ 28333; AB–AC, PIMUZ 28334. Both specimens from sample Ma28b, *Truempyceras compressum* horizon. AD–AG, *Owenites* sp. indet. PIMUZ 28336; AG ×5, at H = 4mm, from sample Gu44, *Truempyceras compressum* horizon, Guling. AH–AJ, *Owenites koeneni* Hyatt and Smith, 1905. PIMUZ 28335, from sample M03-57, *Nyalamites angustecostatus* beds, Mud. AK–AU, *Owenites carpenteri* Smith, 1932. AK–AM, PIMUZ 28338; AM ×2, at H = 8.5 mm, from sample Ma49, Mud; AN–AQ, PIMUZ 28340, from sample Gu72, Guling; AR–AU, PIMUZ 28339, from sample Gu72, Guling. All from the *Nyalamites angustecostatus* beds. AV–BC, *Steckites brevus* gen. et sp. nov. AV–AY, PIMUZ 28337; AY ×2, at H = 8.1 mm, from sample Ma26; AZ–BD, PIMUZ 28378, from sample Mud-E21-22. *Truempyceras compressum* horizon, Mud. All natural size unless otherwise indicated.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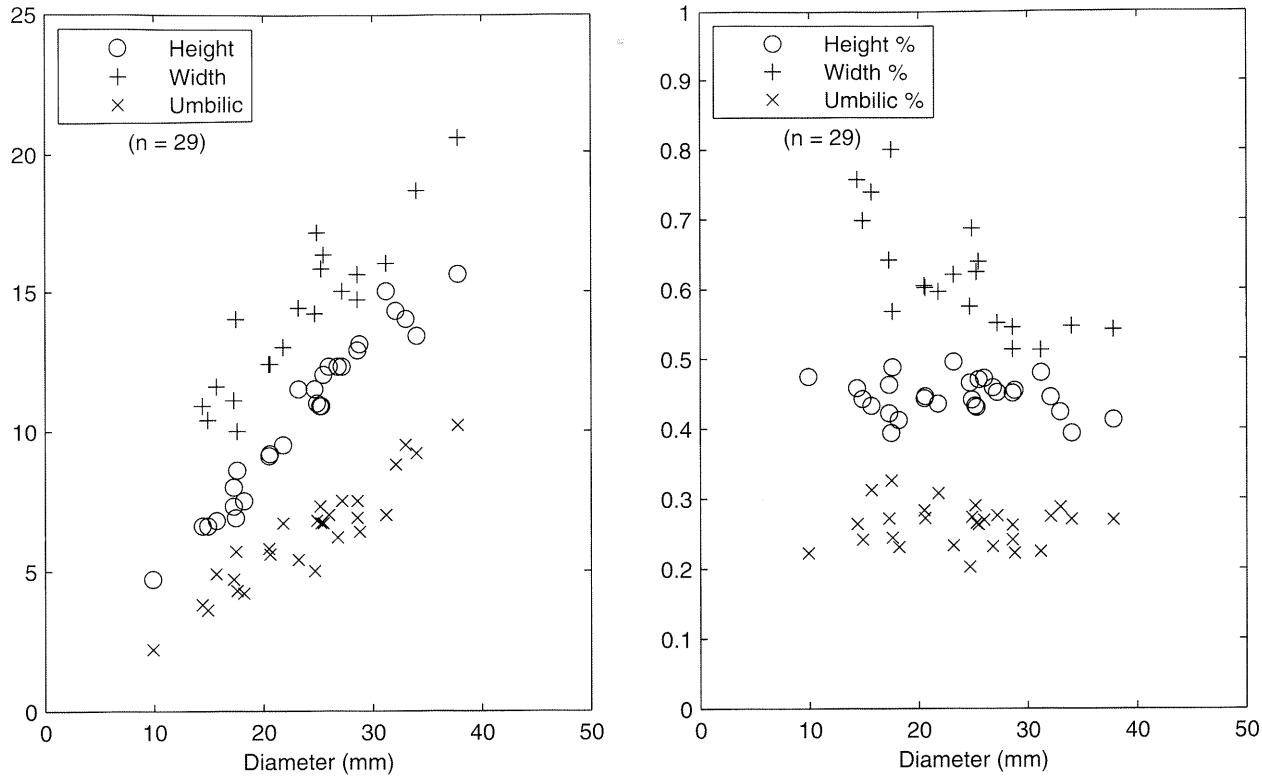
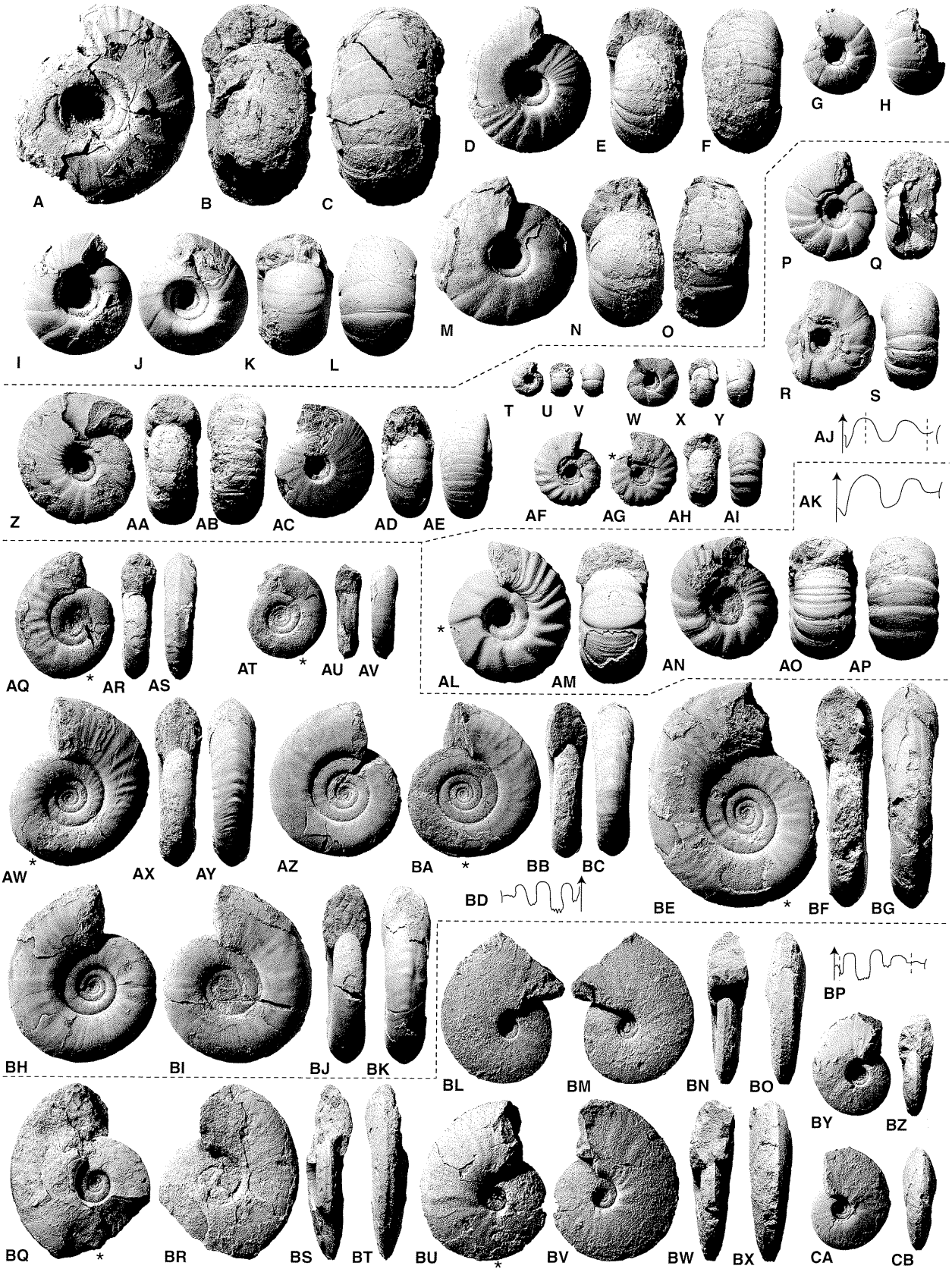


FIG. 36. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Paranannites* sp. indet.

Aspenites acutus Hyatt and Smith, 1905
Figure 41A–M

1905 *Aspenites acutus* Hyatt and Smith, 1905, p. 96, pl. 2, figs 9–13; pl. 3, figs 1–5.
? 1909 *Hedenstroemia acuta* Krafft and Diener, p. 157, pl. 9, fig. 2.
1922 *Aspenites acutus* Hyatt and Smith; Welter, p. 98, fig. 7.
1922 *Aspenites laevis* Welter, p. 99, pl. 1, figs 4–5.
1932 *Aspenites acutus* Hyatt and Smith; Smith, p. 86, pl. 2, figs 9–13, pl. 3, figs 1–5, pl. 30, figs 1–26, pl. 60, figs 4–6.
1932 *Aspenites laevis* Welter; Smith, p. 86, pl. 28, figs 28–33.
1932 *Aspenites obtusus* Smith, p. 86, pl. 31, figs 8–10.
1934 *Aspenites acutus* Hyatt and Smith; Spath, p. 229, fig. 76.
? 1934 *Parahedenstroemia acuta* Krafft and Diener; Spath, p. 221, fig. 70.
1957 *Aspenites acutus* Hyatt and Smith; Kummel, p. L142, fig. 173a–c.
1959 *Aspenites acutus* Hyatt and Smith; Chao, p. 269, pl. 35, figs 12–18, 23, fig. 34a.
1959 *Aspenites laevis* Welter; Chao, p. 270, pl. 35, figs 9–11, fig. 34b.

FIG. 37. A–O, *Juvenites* cf. *spathi* (Frebold, 1930). A–C, PIMUZ 28341; D–F, PIMUZ 28344; G–H, PIMUZ 28343; I–L, PIMUZ 28352, from sample LoA-SFB, *Nammalites pilatoides* beds (?), Losar; M–O, PIMUZ 28342. All from sample M05-23, *Brayardites compressus* beds, Mud, except for I–L. P–AJ, *Jinyaceras hindostanum* (Diener, 1897). P–S, PIMUZ 28351, from sample HB1005, Losar; T–V, PIMUZ 28349, from sample HB1005, Losar; W–Y, PIMUZ 28348, from sample HB1005, Losar; Z–AB, PIMUZ 28346, from sample HB1005, Losar; AC–AE, PIMUZ 28345, from sample M06-24, Mud; AF–AI, PIMUZ 28347, from sample HB1005, Losar; AJ, PIMUZ 28350, ×2, at H = 6.8 mm, from sample M08-21, Mud. All from the *Brayardites compressus* beds. AK–AP, *Juvenites procurvus* Brayard and Bucher, 2008. AK–AM, PIMUZ 28353; AK at H = 6.9 mm, found as float in the '*Parahedenstroemia*' Beds. AN–AP, PIMUZ 28354, from sample M08-48, *Pseudoceltites multiplicatus* beds. Both specimens from Mud. AQ–BK, *Subvishnuites posterus* sp. nov. AQ–AS, PIMUZ 28355; AT–AV, PIMUZ 28356; AW–AY, PIMUZ 28357; AZ–BD, PIMUZ 28358; BD ×2, at H = 6.1 mm; BE–BG, PIMUZ 28359; BH–BK, PIMUZ 28360, holotype. All from sample M08-70, *Subvishnuites posterus* beds, Mud. BL–CB, *Kraffticeras pseudoplanulatum* (Krafft and Diener, 1909) gen. nov. BL–BO, PIMUZ 28361, from sample HB1013; BP–BT, PIMUZ 28362; BP ×2, at H = 6.9 mm, from sample HB26; BU–BX, PIMUZ 28363, from sample HB1013; BY–CB. PIMUZ 28364, from sample HB1026. All from the *Flemingites* beds, Losar. All natural size unless otherwise indicated.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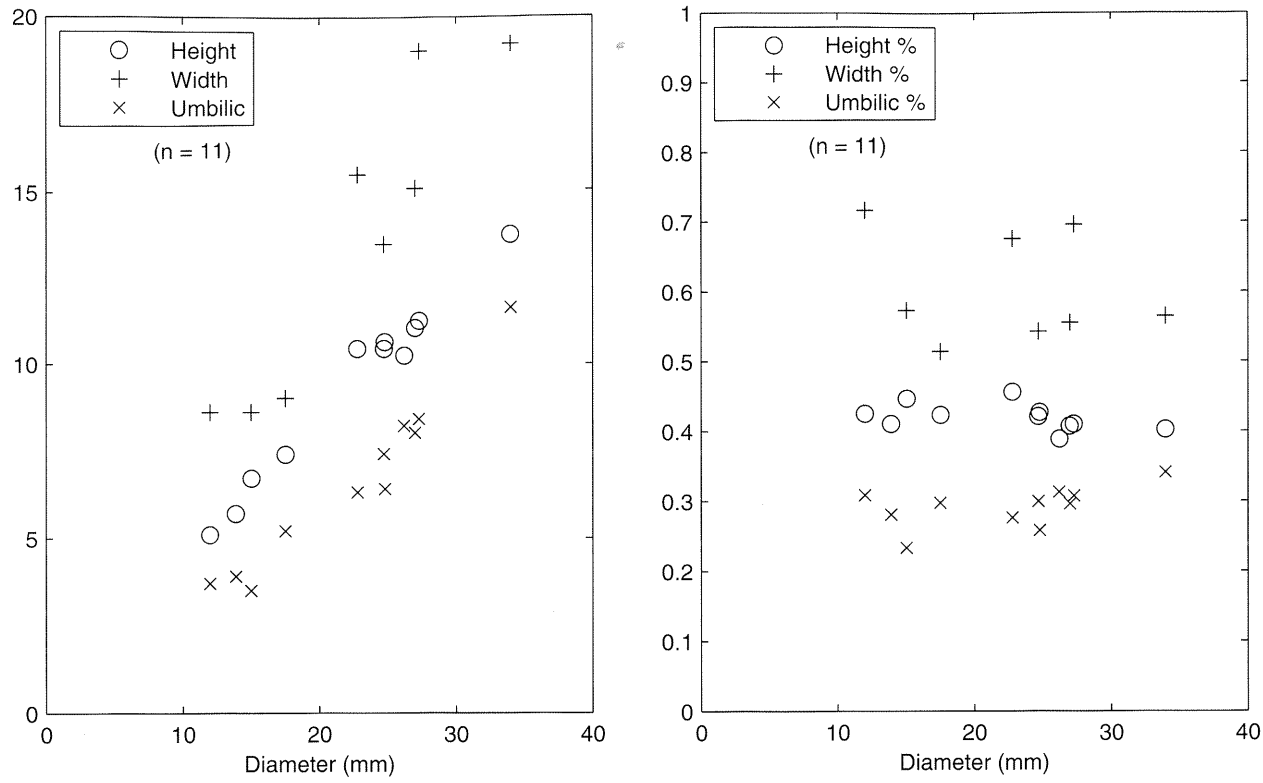


FIG. 38. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Juvenites* cf. *kraffti* (Frebold, 1930).

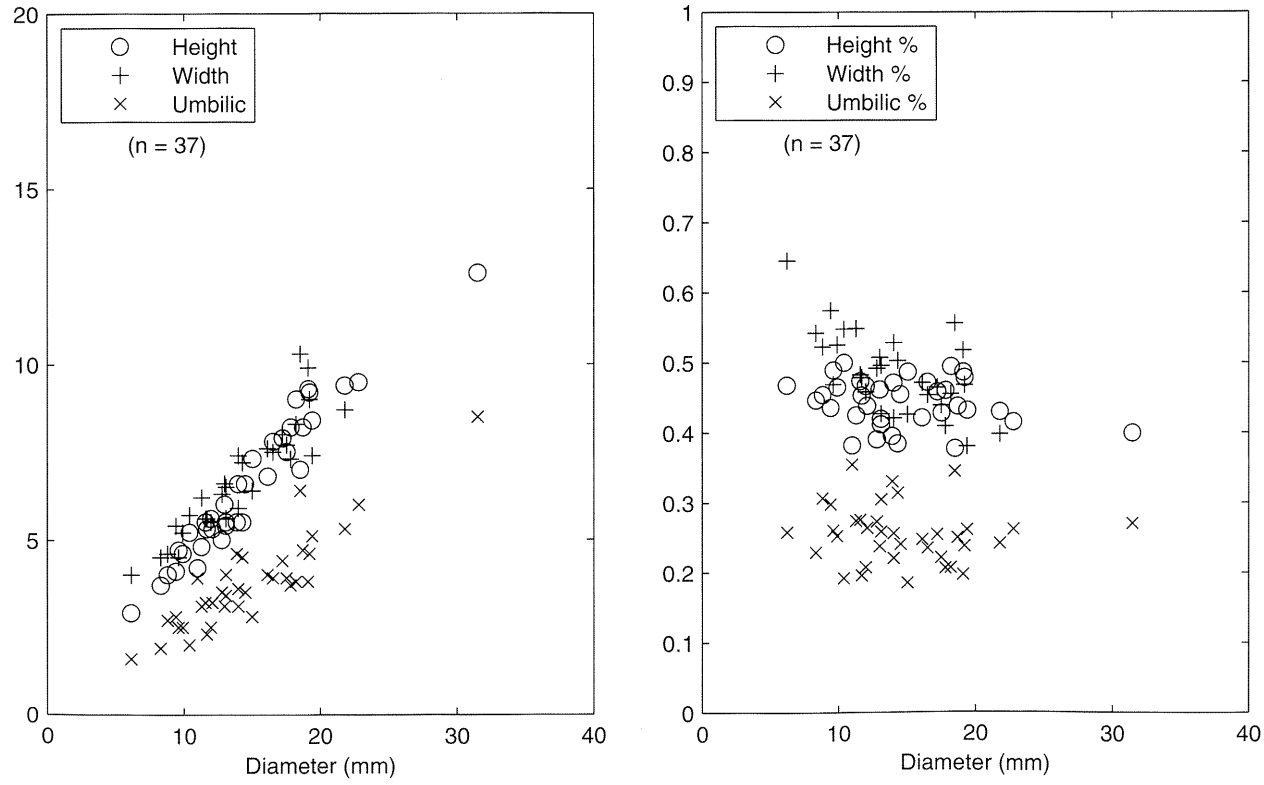


FIG. 39. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Jinyaceras hindostanum* (Diener, 1897).

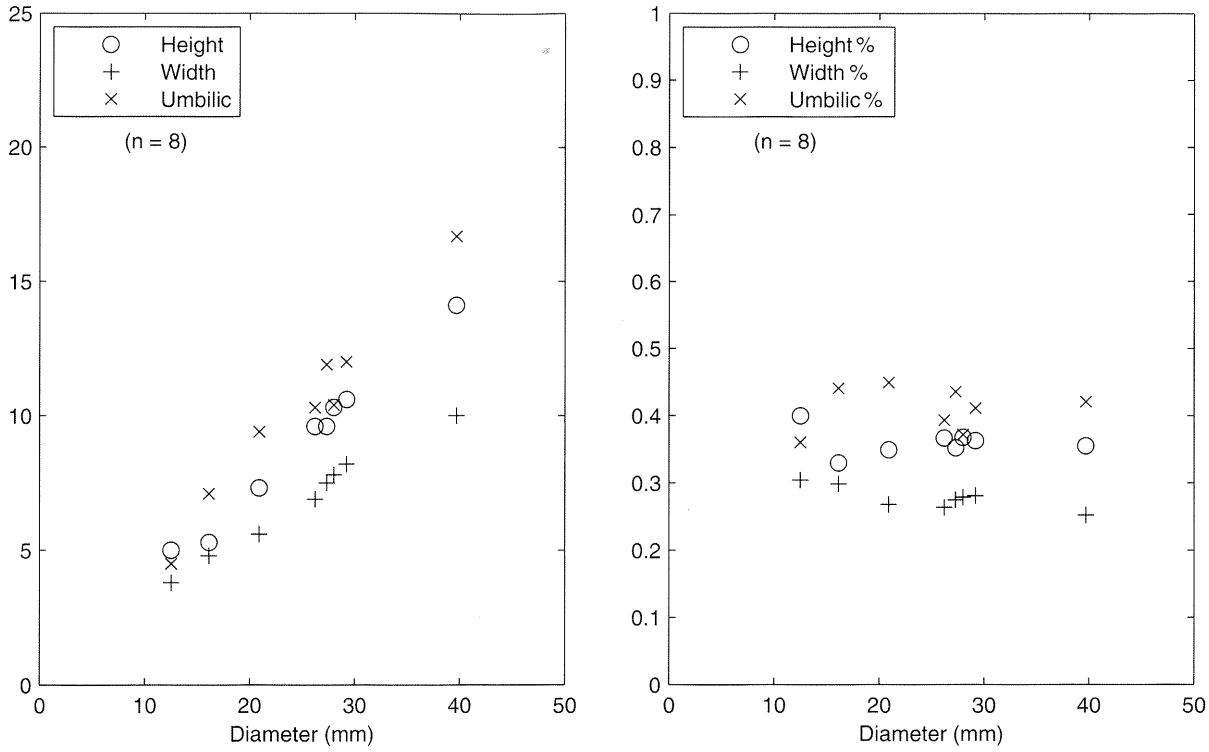


FIG. 40. Scatter diagram of H, W and U and of H/D, W/C and U/D for *Subvishnuites posterus* sp. nov.

1962 *Aspenites acutus* Hyatt and Smith; Kummel and Steele, p. 692, pl. 99, figs 16–17.
1962 *Hemiaspenites obtusus* Smith; Kummel and Steele, p. 666, pl. 99, fig. 18.
1979 *Aspenites* cf. *acutus* Hyatt and Smith; Nichols and Silberling, pl. 1, figs 10–11.
1979 *Aspenites acutus* Hyatt and Smith; Nichols and Silberling, pl. 1, figs 12–14.
v 2008 *Aspenites acutus* Hyatt and Smith; Brayard and Bucher, p. 77, pl. 42, figs 1–9.
v 2010*a* *Aspenites acutus* Hyatt and Smith; Brühwiler *et al.*, p. 429, fig. 16: 12–13.
v 2012*a* *Aspenites acutus* Hyatt and Smith; Brühwiler and Bucher, p. 48, pl. 26, figs 1–2.

Occurrence. Samples M03-19, M08-21, M05-23, M03-24(?), E18, Mud; samples G06-20, Gu-21, Guling; samples HB1005, HB1024, LoSFB1, Losar; *Brayardites compressus* beds.

Description. Extremely involute, very compressed shell with slightly convex flanks. Maximum whorl width at mid-flank. Whorl section lanceolate, with an acute keel. Umbilicus occluded. Umbilical region slightly depressed. Surface nearly smooth except for fine radial folds and falcoid growth lines. Suture line ceratitic with two adventitious saddles and a long auxiliary series.

Measurements. See Table 1.

Remarks. Aspenites acutus is a relatively long-ranging species and is known from the early to the middle Smithian (Brayard and Bucher 2008; Brühwiler *et al.* 2012*a*).

Genus PSEUDASPENITES Spath, 1934

Type species. Aspenites layeriformis Welter, 1922.

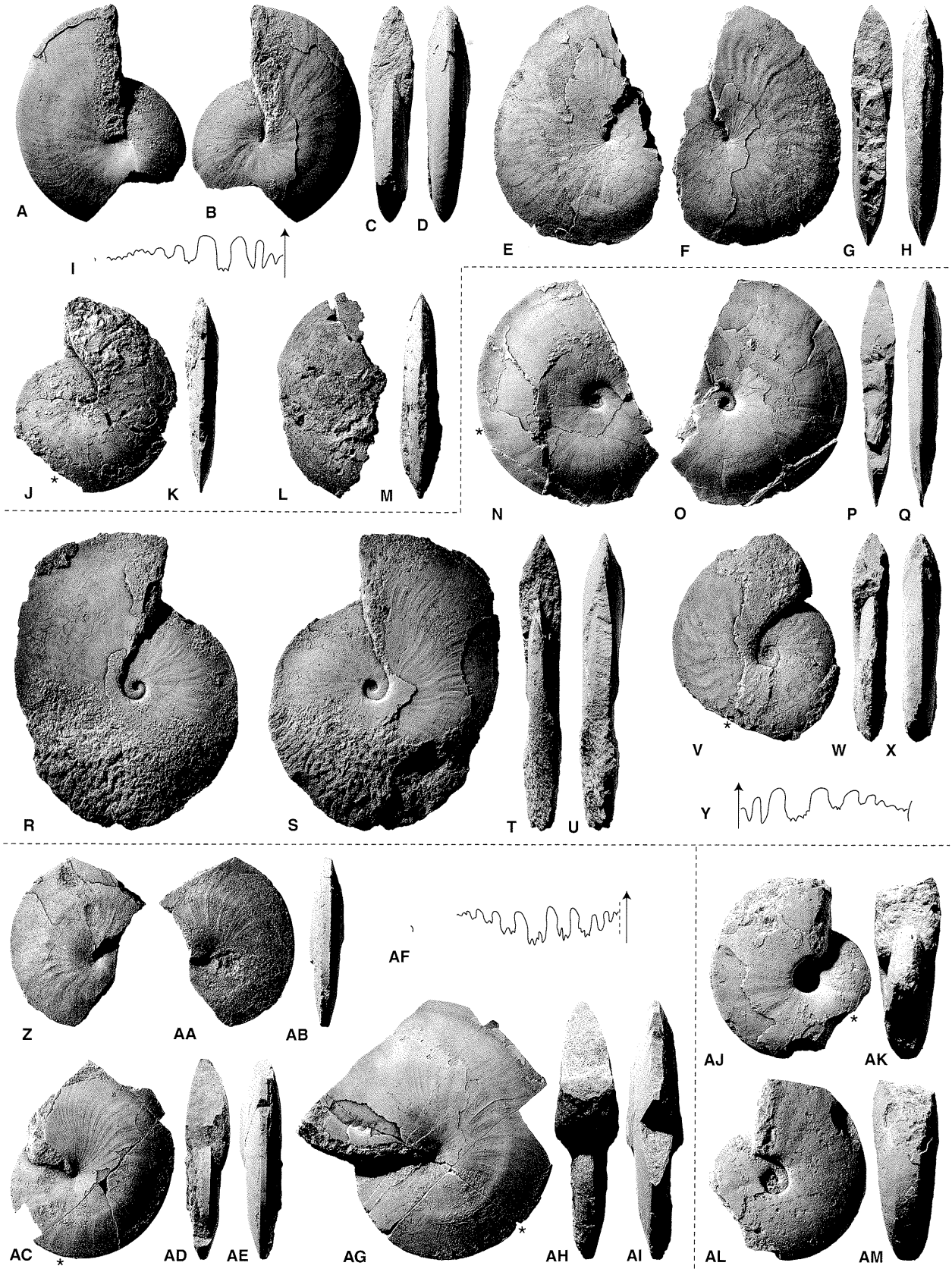
Pseudaspenites cf. *layeriformis* (Welter, 1922)
Figure 41N–Y

Occurrence. Samples M08-21, M03-24, Mud; sample HB1005, Losar; *Brayardites compressus* beds.

Description. Involute, very compressed oxycone similar to *Aspenites,* but with an egressive umbilicus. Venter acutely keeled and slightly convex flanks. Umbilicus with rounded shoulders. Surface smooth except for biconcave growth lines and very weak biconcave folds. Suture line ceratitic with an adventitious lobe and a well-individualized auxiliary series.

Measurements. See Table 1.

Remarks. The type species from Timor differs slightly by its folds but is otherwise very similar. The specimens from South China described as *Pseudaspenites layeriformis* by Brayard and Bucher (2008) are slightly more evolute than our specimens.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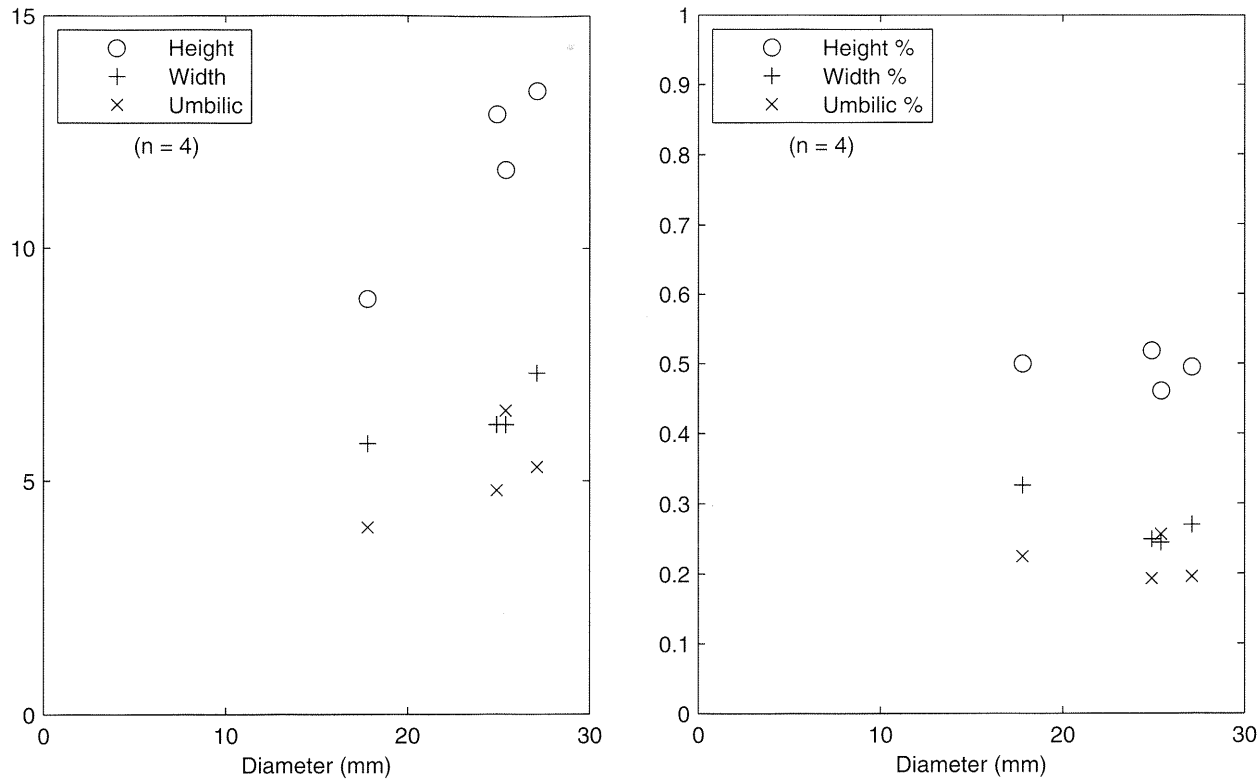

FIG. 42. Scatter diagram of H, W and U and of H/D, W/C and U/D for '*Kraffticeras*' *pseudoplanulatum* (Krafft and Diener, 1909).

Family HEDENSTROEMIIDAE Waagen, 1895

Genus PSEUDOSAGECERAS Diener, 1895

Type species. Pseudosageceras sp. indet. Diener, 1895.

Pseudosageceras augustum (Brayard and Bucher, 2008)
Figure 41Z–AI

v 2008 *Hedenstroemia augusta* Brayard and Bucher, p. 72, pl. 39, figs 1–11, text-fig. 63.
v 2010*a* *Pseudosageceras augustum* (Brayard and Bucher); Brühwiler *et al.*, p. 429, fig. 16: 10–11.

Occurrence. Sample M08-70; *Subvishnuites posterus* beds, Mud.

Description. Extremely involute, compressed oxyconic shell. Flanks with weak, but distinct longitudinal line at about mid-flank, marking a very slight change in slope between the lower and upper portions of flanks. Venter very narrow and weakly bicarinate. Umbilicus closed. Surface smooth except for strongly biconcave growth lines. Suture line ceratitic with several adventitious lobes and long auxiliary series.

Measurements. See Table 1.

Remarks. This species was originally assigned to *Hedenstroemia*, but it has been transferred to *Pseudosageceras* on the basis of its suture line, which exhibits several adventitious lobes and not only a single one like true *Hedenstroemia* (Brühwiler *et al.* 2010*a*).

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FIG. 41. A–M, *Aspenites acutus* Hyatt and Smith, 1905. A–D, PIMUZ 28365, from sample LoSFB1, Losar; E–H, PIMUZ 28366, from sample HB1005, Losar; I–K, PIMUZ 28367; I × 3, at H = 11.3 mm, from sample M08-21, Mud; L–M, PIMUZ 28368, from sample M03-19, Mud. All from the *Brayardites compressus* beds. N–Y, *Pseudaspenites* cf. *layeriformis* (Welter, 1922). N–Q, PIMUZ 28369, from sample M08-21, Mud; R–U, PIMUZ 28370, from sample HB1005, Losar; V–Y, PIMUZ 28371; Y × 3, at H = 10 mm, from sample M03-24, Mud. All from the *Brayardites compressus* beds. Z–AI, *Pseudosageceras augustum* (Brayard and Bucher, 2008). Z–AB, PIMUZ 28372; AC–EE, PIMUZ 28373; AF–AI, PIMUZ 28374; AF ×2, at H = 18.2 mm. All from sample M08-70, *Subvishnuites posterus* beds, Mud. AJ–AM, *Shigetaceras dunajensis* (Zakharov, 1968). PIMUZ 28375, from sample M03-40, *Truempyceras compressum* horizon, Mud. All natural size unless otherwise indicated.

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REFERENCES

ARTHABER, G. 1911. Die Trias von Albanien. *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients*, **24**, 169–288.

BANDO, Y. 1981. Lower Triassic ammonoids from Guryul Ravine and the spur three kilometers north of Barus. *Palaeontologia Indica, New Series*, **46**, 135–178.

BHARGAVA, O. N., KRYSTYN, L., BALINI, M., LEIN, R. and NICORA, A. 2004. Revised litho- and sequence stratigraphy of the Spiti Triassic. *Albertiana*, **30**, 21–39.

BRAYARD, A. and BUCHER, H. 2008. Smithian (Early Triassic) ammonoid faunas from northwestern Guangxi (South China): taxonomy and biochronology. *Fossils and Strata*, **55**, 1–179.

—— —— ESCARGUEL, G., FLUTEAU, F., BOURQUIN, S. and GALFETTI, T. 2006. The Early Triassic ammonoid recovery: paleoclimatic significance of diversity gradients. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **239**, 374–395.

—— —— BUCHER, H., MONNET, C., BRÜHWILER, T., GOUDEMAND, N., GALFETTI, T. and GUEX, J. 2009. Good Genes and Good Luck: ammonoid Diversity and the End-Permian Mass Extinction. *Science*, **325**, 1118–1121.

BRÜHWILER, T. and BUCHER, H. 2012*a*. Systematic palaeontology. *In* BRÜHWILER, T., BUCHER, H., GOUDEMAND, N. and GALFETTI, T., *Smithian (Early Triassic) ammonoid faunas from Exotic Blocks from Oman: taxonomy and biochronology. Palaeontographica, Abteilung A*, **296**, 3–107.

—— —— 2012*b*. Systematic palaeontology. *In* BRÜHWILER, T., BUCHER, H., WARE, D., ROOHI, G., HERMANN, E., HOCHULI, P. A., ROOHI, G., REHMAN, K. and YASEEN, A. (ed.). *Smithian (Early Triassic) ammonoids from the Salt Range, Pakistan. Special Papers in Palaeontology*, **88**, 1–114.

—— —— GOUDEMAND, N. and BRAYARD, A. 2007. Smithian (Early Triassic) ammonoid faunas of the Tethys: new preliminary results from Tibet, India, Pakistan and Oman. *New Mexico Museum of Natural History and Science Bulletin*, **41**, 25–26.

—— GOUDEMAND, N., GALFETTI, T., BUCHER, H., BAUD, A., WARE, D., HERMANN, E., HOCHULI, P. A. and MARTINI, R. 2009. The Lower Triassic sedimentary and carbon isotope records from Tulong (South Tibet) and their significance for Tethyan palaeoceanography. *Sedimentary Geology*, **222**, 314–332.

—— BUCHER, H. and GOUDEMAND, N. 2010*a*. Smithian (Early Triassic) ammonoids from Tulong, South Tibet. *Geobios*, **43**, 403–431.

—— WARE, D., BUCHER, H., KRYSTYN, L. and GOUDEMAND, N. 2010*b*. New Early Triassic ammonoid faunas from the Dienerian/Smithian boundary beds at the Induan/Olenekian GSSP candidate at Mud (Spiti, Northern India). *Journal of Asian Earth Sciences*, **39**, 724–739.

—— BUCHER, H., GAUDEMAND, N. and GALFETTI, T. 2012*a*. Smithian (Early Triassic) ammonoid faunas from Exotic Blocks from Oman: taxonomy and biochronology. *Palaeontographica, Abteilung A*, **296**, 3–107.

—— —— WARE, D., ROOHI, G., HERMANN, E., HOCHULI, P. A., ROOHI, G., REHMAN, K. and YASEEN, A. 2012*b*. Smithian (Early Triassic) ammonoids from the Salt Range, Pakistan. *Special Papers in Palaeontology*, **88**, 1–114.

BUCHER, H., NASSICHUK, W. W. and SPINOSA, C. 1997. A new occurrence of the upper Permian ammonoid *Stacheoceras trimurti* Diener from the Himalayas; Himachal Pradesh, India. *Eclogae Geologicae Helvetiae*, **90**, 599–604.

CHAO, K. 1959. Lower Triassic ammonoids from Western Kwangsi, China. *Palaeontologia Sinica, New Series B*, **9**, 355 pp.

COLLIGNON, M. 1973. Ammonites du Trias inférieur et moyen d'Afghanistan. *Annales de Paléontologie (Invertebrés)*, **59**, 127–163.

DE KONINCK, L. G. 1863. Description of some fossils from India, discovered by Dr. A. Fleming, of Edingburgh. *The Quarterly Journal of the Geological Society of London*, **19**, 1–19.

DIENER, C. 1895. Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz. *Mémoirs du Comité Géologique St. Petersburg*, **14**, 1–59.

—— 1897. The Cephalopoda of the Lower Trias. *Palaeontologia Indica, Series 15, Himalayan Fossils*, **2**, 1–181.

—— 1913. Triassic faunae of Kashmir. *Palaeontologia Indica, New Series*, **5**, 1–133.

FREBOLD, H. 1930. Die Altersstellung des Fischhorizontes, des Grippianniveaus und des unteren Saurierhorizontes in Spitzbergen. *Scrifter om Svalbard og Ishavet*, **28**, 1–36.

FRECH, F. 1905. *Lethaea geognostica. Das Mesozoicum. I, Trias.* E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 623 pp.

GALFETTI, T., BUCHER, H., BRAYARD, A., HOCHULI, P. A., WEISSERT, H., GUODUN, K., ATUDOREI, V. and GUEX, J. 2007*a*. Late Early Triassic climate change: insights from carbonate carbon isotopes, sedimentary evolution and ammonoid paleobiogeography. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **243**, 394–411.

—— HOCHULI, P. A., BRAYARD, A., BUCHER, H., WEISSERT, H. and VIGRAN, J. O. 2007*b*. Smithian–Spathian boundary event: evidence for global climatic change in the wake of the end-Permian biotic crisis. *Geology*, **35**, 291–294.

GARZANTI, E., JADOUL, F., NICORA, A. and BERRA, F. 1995. Triassic of Spiti (Tethys Himalaya, India). *Rivista Italiana di Paleontologia e Stratigrafia*, **101**, 267–300.

—— NICORA, A. and RETTORI, R. 1998. Permo–Triassic boundary and lower to middle Triassic in South Tibet. *Journal of Asian Earth Sciences*, **16**, 143–157.

GUEX, J. 1978. Le Trias inférieur des Salt Ranges, Pakistan: problèmes biochronologiques. *Eclogae Geologicae Helvetiae*, **71**, 105–141.

HADA, S. 1966. Discovery of Early Triassic ammonoids from Gua Musang, Kelantan, Malaya. *Journal of Geosciences, Osaka University*, **9**, 111–121.

HYATT, A. 1900. Cephalopoda. 502–604. *In* ZITTEL, K. A. V. (ed.). *Textbook of palaeontology*. Eastman, C. R., London, 839 pp.

—— and SMITH, J. P. 1905. Triassic cephalopod genera of America. *United States Geological Survey, Professional Paper*, **40**, 1–394.

KIPARISOVA, L. D. 1947. *Atlas of the guide forms of the fossil faunas of the USSR 7, Triassic*. All Union Scientific Geological Research Institute (VSEGEI), Leningrad (now St. Petersburg), Russia, 253 pp. [In Russian].

—— 1956. Materials on paleontology, new families and genera. *Transactions of the All Union Scientific Research Geological Institute (VSEGEI), New Series*, **12**, Paleontology, 76–79.

KRAFFT, A. V. and DIENER, C. 1909. Lower Triassic cephalopoda from Spiti, Malla Johar, and Byans. *Palaeontologia Indica, Series 15*, **6**, 1–186.

KRYSTYN, L., BHARGAVA, O. N. and RICHOZ, S. 2007*a*. A candidate GSSP for the base of the Olenekian Stage: Mud at Pin Valley; district Lahul & Spiti, Himachal Pradesh (Western Himalaya), India. *Albertiana*, **35**, 5–29.

——RICHOZ, S. and BHARGAVA, O. N. 2007*b*. The Induan–Olenekian Boundary (IOB) in Mud – an update of the candidate GSSP section M04. *Albertiana*, **36**, 33–45.

KUENZI, W. D. 1965. Early Triassic (Scythian) ammonoids from northeastern Washington. *Journal of Paleontology*, **39**, 365–378.

KUMMEL, B. 1952. A classification of the Triassic ammonoids. *Journal of Paleontology*, **26**, 847–853.

—— 1957. Systematic descriptions, L138–L139, L142–L143. *In* ARKELL, W. J., KUMMEL, B., MILLER, A. K., MOORE, R. C., SCHINDEWOLF, O., SYLVESTER-BRADLEY, P. C. and WRIGHT, C. W. (eds). *Cephalopoda Ammonoidea. Treatise on invertebrate paleontology* (MOORE, R. C. ed.). *Part L, Mollusca 4*. Geological Society of America, Boulder, Colorado and University of Kansas Press, Lawrence, Kansas, 490 pp.

—— 1959. Lower Triassic ammonoids from Western Southland, New Zealand. *New Zealand Journal of Geology and Geophysics*, **2**, 429–447.

—— 1966. The Lower Triassic formations of the Salt Range and Trans-Indus Ranges, West Pakistan. *Bulletin of the Museum of Comparative Zoology, Harvard University*, **134**, 361–429.

—— 1968. Additional Scythian Ammonoids from Afghanistan. *Bulletin of the Museum of Comparative Zoology, Harvard University*, **136**, 483–509.

—— and ERBEN, H. K. 1968. Lower and Middle Triassic cephalopods from Afghanistan. *Palaeontographica, Abteilung A*, **129**, 95–148.

—— and SAKAGAMI, S. 1960. Mid-Scythian ammonites from Iwai Formation, Japan. *Breviora*, **126**, 1–11.

—— and STEELE, G. 1962. Ammonites from the *Meekoceras gracilitatus* Zone at Crittenden Spring, Elko County, Nevada. *Journal of Paleontology*, **36**, 638–703.

MARKEVICH, P. V. and ZAKHAROV, Y. 2004. *Triassic and Jurassic of the Sikhote-Alin*. Dalnauka, Vladivostok, Russia, 420 pp. [In Russian with English summary].

MATHEWS, A. A. L. 1929. The Lower Triassic cephalopod fauna of the Fort Douglas area, Utah. *Walker Museum Memoirs*, **1**, 1–46.

MOJSISOVICS, E. 1896. Beiträge zur Kenntnis der obertriadischen Cephalopoden-Faunen des Himalaya. *Denkschriften der Akademie der Wissenschaften in Wien*, **63**, 573–701.

MONNET, C. and BUCHER, H. 2005. New Middle and Late Anisian (Middle Triassic) ammonoid faunas from northwestern Nevada (USA): taxonomy and biochronology. *Fossils and Strata*, **52**, 121 pp.

NICHOLS, K. M. and SILBERLING, N. J. 1979. Early Triassic (Smithian) ammonites of Paleoequatorial affinity from the Chulitna terrane, south central Alaska. *United States Geological Survey, Professional Paper*, **1121**, 1–5.

POPOV, Y. 1962. Some Early Triassic ammonoids of northern Caucasia. *Transactions of the Academy of Sciences of the USSR*, **127**, 176–184.

RAUP, D. M. and SEPKOSKI, J. J. 1982. Mass Extinctions in the Marine Fossil Record. *Science*, **215**, 1501–1503.

SAKAGAMI, S. 1955. Lower Triassic ammonites from Iwai, Orguno-Mura, Nishitamagun, Kwanto massif, Japan. *Science Reports Tokyo Kyoiku Diagaku, Series C*, **30**, 131–140.

SHEVYREV, A. A. 1968. *Transactions of the Palaeontological Institute 119. Triassic ammonoidea from the southern part of the USSR*. Nauka, Moscow, 272 pp.

—— 1990. Ammonoids and chronostratigraphy of the Triassic. *Trudy Paleontologicheskogo Instituta Akademii. Nauk SSSR*, **241**, 1–179.

—— 1995. Triassic ammonites of northwestern Caucasus. *Akad. Nauk SSSR, Palaeontol. Inst., Trudy*, **264**, 1–174.

SHIGETA, Y. and ZAKHAROV, Y. 2009. Systematic paleontology: cephalopods. 44–140. *In* SHIGETA, Y., ZAKHAROV, Y., MAEDA, H. and POPOV, A. M. (eds). *The Lower Triassic system in the Abrek Bay area, South Primorye, Russia. National Museum of Nature and Science Monographs*, **38**, Tokyo, 218 pp.

—— MAEDA., H. and ZAKHAROV, Y. 2009. Biostratigraphy: ammonoid succession. 24–27. *In* SHIGETA, Y., ZAKHAROV, Y., MAEDA, H. and POPOV, A. M. (eds). *The Lower Triassic system in the Abrek Bay area, South Primorye, Russia. National Museum of Nature and Science Monographs*, **38**, Tokyo, 218 pp.

SILBERLING, N. J. and TOZER, E. T. 1968. *Special Paper – Geological Society of America. Biostratigraphic classification of the marine Triassic in North America*. Geological Society of America (GSA), Boulder, Colorado, 63 pp.

SMITH, J. P. 1927. Upper Triassic marine invertebrate faunas of North America. *United States Geological Survey, Professional Paper*, **141**, 262 pp.

—— 1932. Lower Triassic ammonoids of North America. *United States Geological Survey, Professional Paper*, **167**, 1–199.

SMITH, A. G., SMITH, D. G. and FUNNELL, B. M. 1994. *Atlas of Mesozoic and Cenozoic Coastlines*. Cambridge University Press, Cambridge, 109 pp.

SPATH, L. F. 1930. The Eotriassic invertebrate fauna of East Greenland. *Meddelelser om Grønland*, **83**, 1–90.

—— 1934. *Part 4: The ammonoidea of the Trias. Catalogue of the fossil cephalopoda in the British Museum (Natural History)*. The Trustees of the British Museum, London, 521 pp.

STAMPFLI, G., MARCOUX, J. and BAUD, A. 1991. Tethyan Margins in Space and Time. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **87**, 373–409.

TONG, J. N., ZAKHAROV, Y. D. and WU, S. B. 2004. Early Triassic ammonoid succession in Chaohu, Anhui Province. *Acta Palaeontologica Sinica*, **43**, 192–204.

TOZER, E. T. 1971. Triassic time and ammonoids. *Canadian Journal of Earth Sciences*, **8**, 989–1031.

—— 1981. Triassic Ammonoidea; classification, evolution and relationship with Permian and Jurassic forms. 65–100. *In* HOUSE, M. R. and SENIOR, J. R. (eds). *The Ammonoidea*. Academic Press [for the] Systematics Association, London-New York, International, 593, pp.

—— 1994. *Canadian Triassic ammonoid faunas*. Geological Survey of Canada, Ottawa, ON, 663 pp.

VU KHUC. 1984. *Triassic ammonoids in Vietnam*. Geoinform and Geodata Institute, Hanoi, Vietnam, 134 pp.

WAAGEN, W. 1895. Salt-Range fossils. Vol. 2: Fossils from the Ceratite Formation. *Palaeontologia Indica*, **13**, 1–323.

WANG, Y. G. and HE, G. X. 1976. Triassic ammonoids from the Mount Jolmo Lungma region. *In A report of scientific expedition in the Mount Jolmo Lungma region (1966–1968)*, palaeontology, fascicule 3, 223–502. Science Press, Beijing, 545 pp. [In Chinese].

WEITSCHAT, W. and LEHMANN, U. 1978. Biostratigraphy of the uppermost part of the Smithian Stage (Lower Triassic) at the Botneheia, W-Spitsbergen. *Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg*, **54**, 27–54.

WELTER, O. A. 1922. Die Ammoniten der unteren Trias von Timor. *Paläontologie von Timor*, **11**, 83–154.

ZAKHAROV, Y. D. 1968. *Biostratigraphiya i amonoidei nizhnego triasa Yuzhnogo Primorya (Lower Triassic biostratigraphy and ammonoids of South Primorye)*. Nauka, Moskva, 175 pp. [In Russian].