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Trilobites of the Middle Wuliuan (Miaolingian) from the Kunzam La (Parahio) Formation of the Sumna River Section, Spiti, Himalaya, and Its Biostratigraphic Significance

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Abstract—A 153.48 m thick section of the Kunzam La (Parahio) Formation exposed on the right bank of the Sumna River (Spiti), Himalaya (India), yielded Cambrian trilobites from two stratigraphic intervals. The lower interval yielded the trilobites *Xingrenaspis* cf. *X. dardapurensis* and *Kunmingaspis stracheyi* with a few brachiopods. This interval falls within unzoned 4 of the Cambrian of the Himalaya. The upper stratigraphic interval yielded *Iranoleesia butes* and an undetermined ptychopariid trilobite belonging to Hayden level 13. Based on faunal elements, the entire measured section is correlated with the *Sunaspis laevis–Sunaspidella rara* biozone to *Metagraulos dolon* biozone of the southern and western marginal parts of the Ordos basin (China) and belongs to the middle Wuliuan Stage (Miaolingian Series).

Keywords: trilobites, Kunzam La (Parahio) Formation, middle Wuliuan (Miaolingian), Sumna River, Spiti, Himalaya

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INTRODUCTION

The ?*Iranoleesia butes* level (Hayden level 13) is currently known as the youngest Cambrian trilobite level in the Kunzam La (Parahio) Formation of the Spiti region, Himalaya (Hayden, 1904; Jell and Hughes, 1997; Peng et al., 2009; Reed, 1910). Peng et al. (2009, Fig. 3, p. 4) positioned this level at 1010 m above the base of the ~1360 m thick composite lithocolumn of the Kunzam La (Parahio) Formation in the Parahio Valley section, Spiti region. Biostratigraphically, lower than the ?*Iranoleesia butes* level, they recognised the *Oryctocephalus salteri* biozone (835–900 m interval). Peng et al. (2009) marked an unfossiliferous interval (unzoned 4) from 900 to 1010 m of their section (Peng et al., 2009, Fig. 3, p. 4), pending further investigation. We describe herein trilobites and a few eocrinoid plates from this interval and from the overlying *I. butes* level in a section located on the right bank of the Sumna River, just before the confluence with the Parahio River (Fig. 1). The fossiliferous section yielded *Xingrenaspis* cf. *X. dardapurensis*, *Kunmingaspis stracheyi*, *Iranoleesia butes* and an undetermined ptychopariid along with disarticulated, isolated probably blastozoan eocrinoid thecal and brachial plates. Based on faunal elements, we suggest that these strata are of middle Wuliuan (Miaolingian) age and a time-equivalent horizon of the *Sunaspis laevis–Sunaspidella rara* biozone to *Metagraulos dolon* biozone in the Ordos basin, North China (cf. Yuan et al., 2016).

GEOLOGICAL SETTING AND LITHOSTRATIGRAPHY

The Cambrian rocks in the Spiti region are exposed along a NW–SE trending belt extending from the Kunzam La Pass (in the NW) to the Baldur locality (in the SE) in the Pin Valley, in the Tethyan Himalayan Zone (THZ; tectonostratigraphic unit) which lies north of the Greater Himalayan Zone (GHZ) and located in the northernmost border of the state of Himachal Pradesh (Fig. 1a). The Parahio Valley, in the south-eastern part of the Spiti region, is a nearly NW–EW oriented valley, while the Sumna Valley (also known as Kilung *khad*) is a N–S oriented valley (Fig. 1b). These valleys and corresponding rivers merge at the Thango village, Spiti region.

The Cambrian rocks of the Spiti region have been the focus of significant recent biostratigraphic and lithostratigraphic studies (Hughes et al., 2018; Kaur et al., 2019; Myrow et al., 2006; Peng et al., 2009; Singh et al., 2016a, 2016b, 2017a, 2017b; Srikantia and Bhargava, 2018; Yin et al., 2018). The Cambrian rocks in the Spiti region belong to the Haimanta Group (Srikantia, 1981) divisible into the Batal and the Kunzam La formations (Bhargava and Bassi, 1998). Recently, Myrow et al. (2006) introduced the term Parahio For-

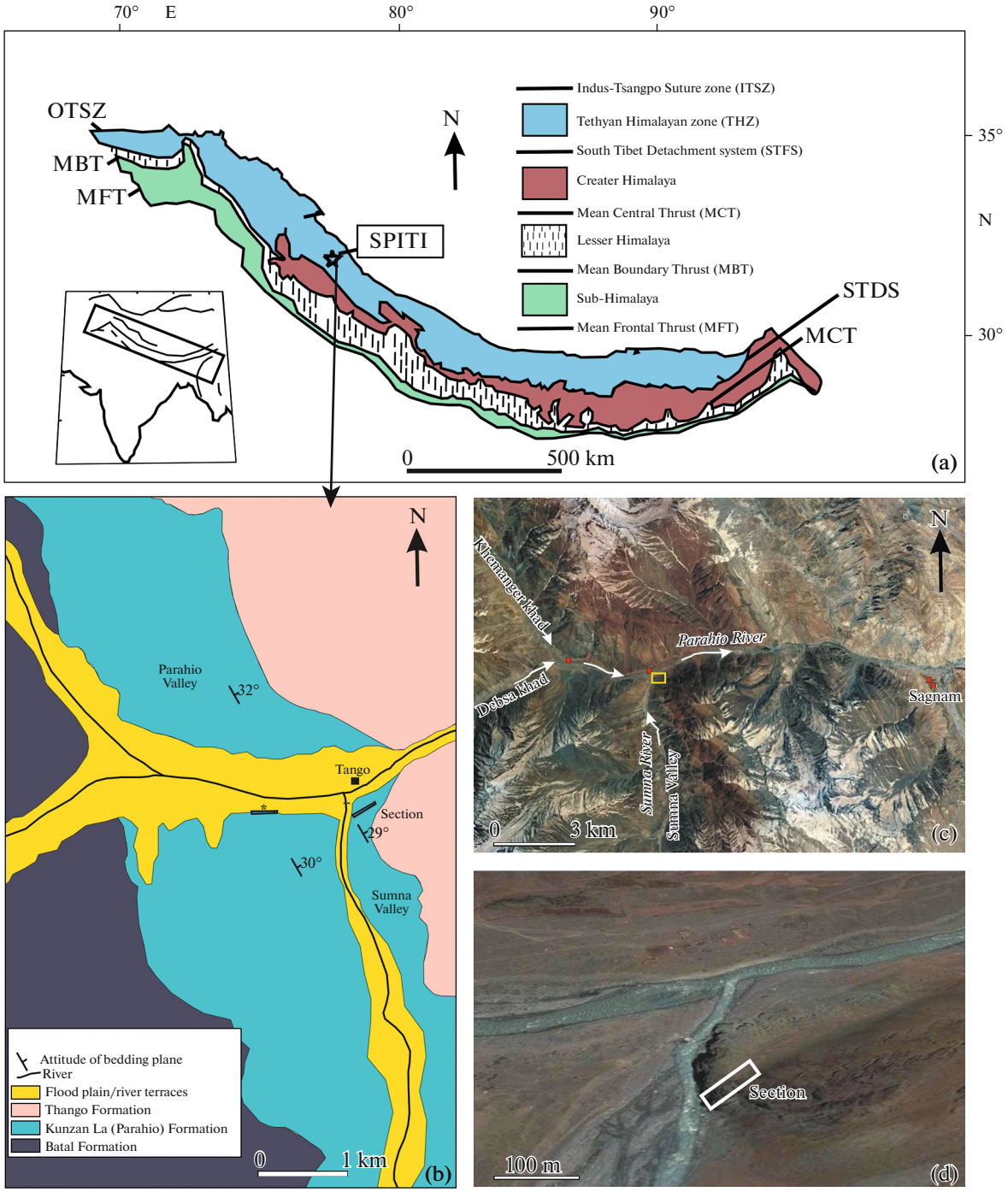


Fig. 1. Location and geological map of the Spiti region. (a) Litho-tectonic subdivisions of the Himalaya, (b) geological map of the south-eastern part of the Spiti region showing the distribution of rocks in the Parahio and Sumna valleys, (c) Google-earth image of the location of section (yellow box), (d) close-up view of the Google-earth image showing the southwest facing outcrops of the studied section above the right bank of the Sumna River before the confluence with Parahio River.

mation for the Cambrian rocks in the Parahio Valley (Spiti). The term Parahio Formation was contested by Bhargava (2008, 2011) and Srikantia and Bhargava (2018), who retain the status of the Kunzam La Formation, because the former does not follow the stratigraphic nomenclature code of India (Anon, 1971). The term Kunzam La (Parahio) Formation has also been introduced to avoid confusion among readers (Chaubey et al., 2018; Singh et al., 2014, 2015, 2016a, 2016b, 2017a, 2017b). As the nomenclature controversy still persists (Hughes et al., 2018, 2019; Srikantia and Bhargava, 2018, in press), in the present work we use the term Kunzam La (Parahio) Formation (Singh et al., 2014). The Cambrian rocks of the Spiti region

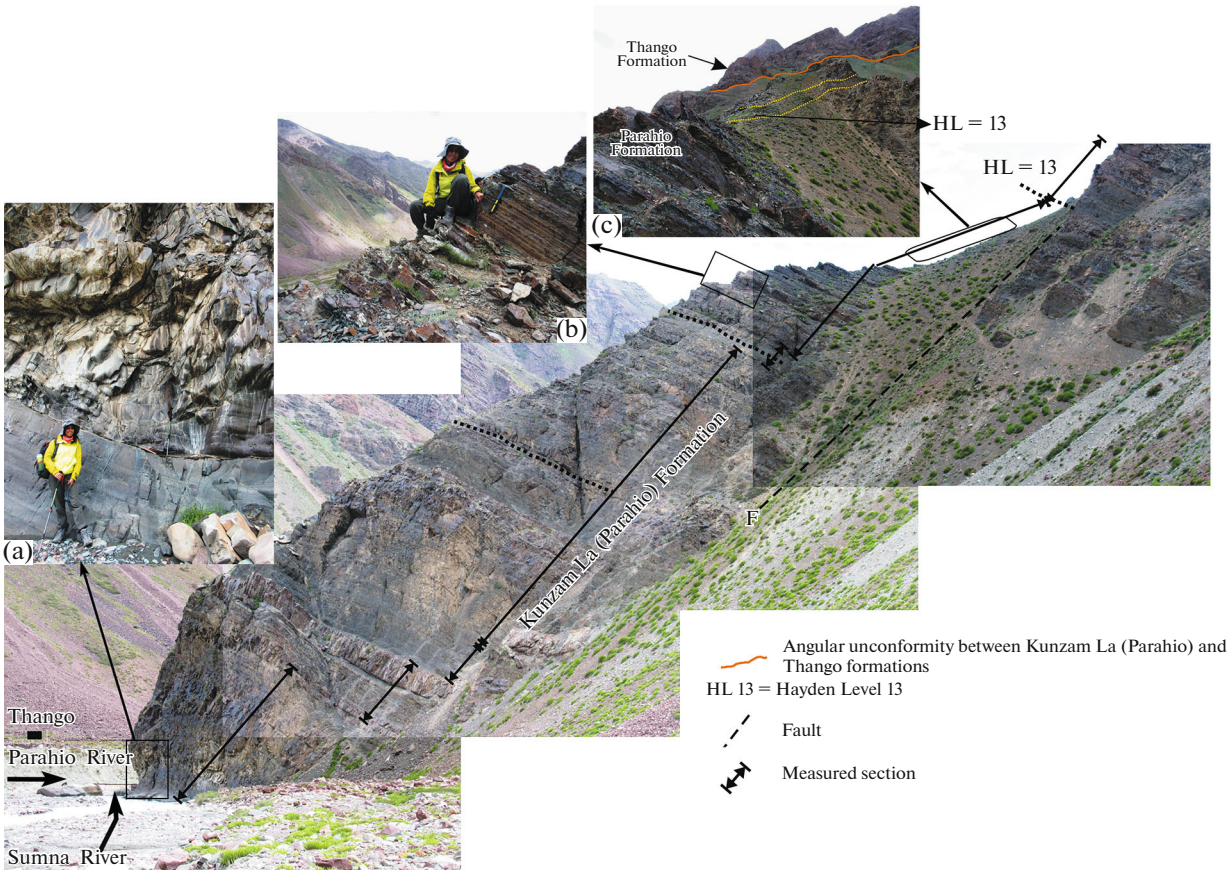


Fig. 2. Field photographs of the studied section of the Kunzam La (Parahio) Formation on the right bank of the Sumna River before confluence with the Parahio River near the Thango locality. The fossiliferous Hayden level 13 (HL = 13) lies on top of this section, (a) ball and pillow structures in thick sandstone unit at the base of the section, (b) rippled beds, (c) close- up view of the Hayden level 13 (yellow dotted line).

have yielded trilobites, brachiopods, an eldoniid, small shelly fossils, and acritarchs (Gilbert et al., 2016; Hayden, 1904; Hughes, 2016a, 2016b, 2017; Jell and Hughes, 1997; Kaur et al., 2019; Peng et al., 2009; Popov et al., 2015; Reed, 1910; Sahni and Sudan, 1996; Shah and Paul, 1987; Shah et al., 1988, 1991; Singh et al., 2014, 2015, 2016a, 2016b, 2017a, 2017b; Yin et al., 2018).

LOCATION OF THE STUDIED SECTION

The 153.48 m thick studied section of the Kunzam La (Parahio) Formation (Figs. 2, 3) is exposed on the southwest facing slope above the right bank of the Sumna River, before the confluence of the Sumna and the Parahio rivers (Figs. 2, 3). The GPS coordinates for the base and the top of the section are N 32°01′53.51″, E 077°56′53.94″ and N 32°1′51.80″, E 077°56′59.51″, respectively. The section is broadly correlated to the 875–1040 m interval of the composite Parahio Valley section of Peng et al. (2009, Fig. 3, p. 4) based on (i) the first appearance datum (FAD) of *Iranoleesia butes* (Peng et al., 2009) at 121.68 m of the studied section and at 1010 m in the composite Parahio Valley section of Peng et al. (2009, Fig. 3, p. 4); (ii) the presence of a ~10 m thick ball and pillow bearing sandstone horizon, a lithological marker found in the 875–885 m interval of the composite Parahio Valley section of Peng et al. (2009) and Myrow et al. (2006) (this correlation is based on the detailed log particularly for this interval provided by Prof. Paul M. Myrow to BPS; personal communication, 2018). The Kunzam La (Parahio) Formation along this section comprises thinly to thickly bedded, fine- to medium-grained sandstone, silty shale intervals (black to bluish and dull to green), micaceous siltstone (contains brachiopods) and few thin calcareous sandstone beds. Sedimentary structures observed along this section include ball and pillow structures, gutter casts, wavy, parallel and low angle inclined laminations, flat rip-up mud clasts, hummocky cross stratification and few storm beds (tempestite).

BIOSTRATIGRAPHIC SIGNIFICANCE

The illustrated trilobites were collected from two intervals, one at 34.28–62.48 m and the second at

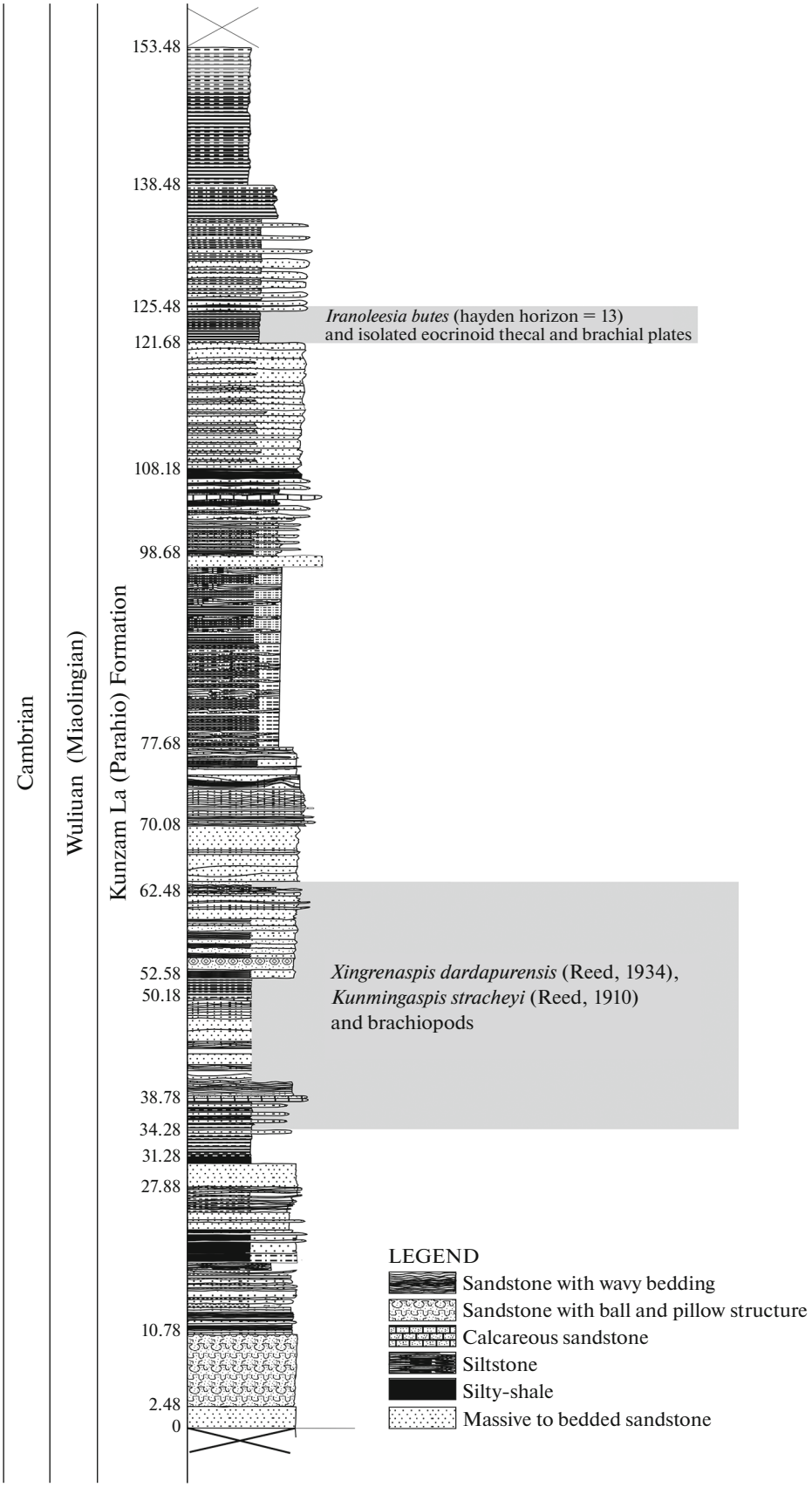


Fig. 3. Lithocolumn of the measured section of the Kunzam La (Parahio) Formation at southwest facing slope on the right bank of the Sumna River.

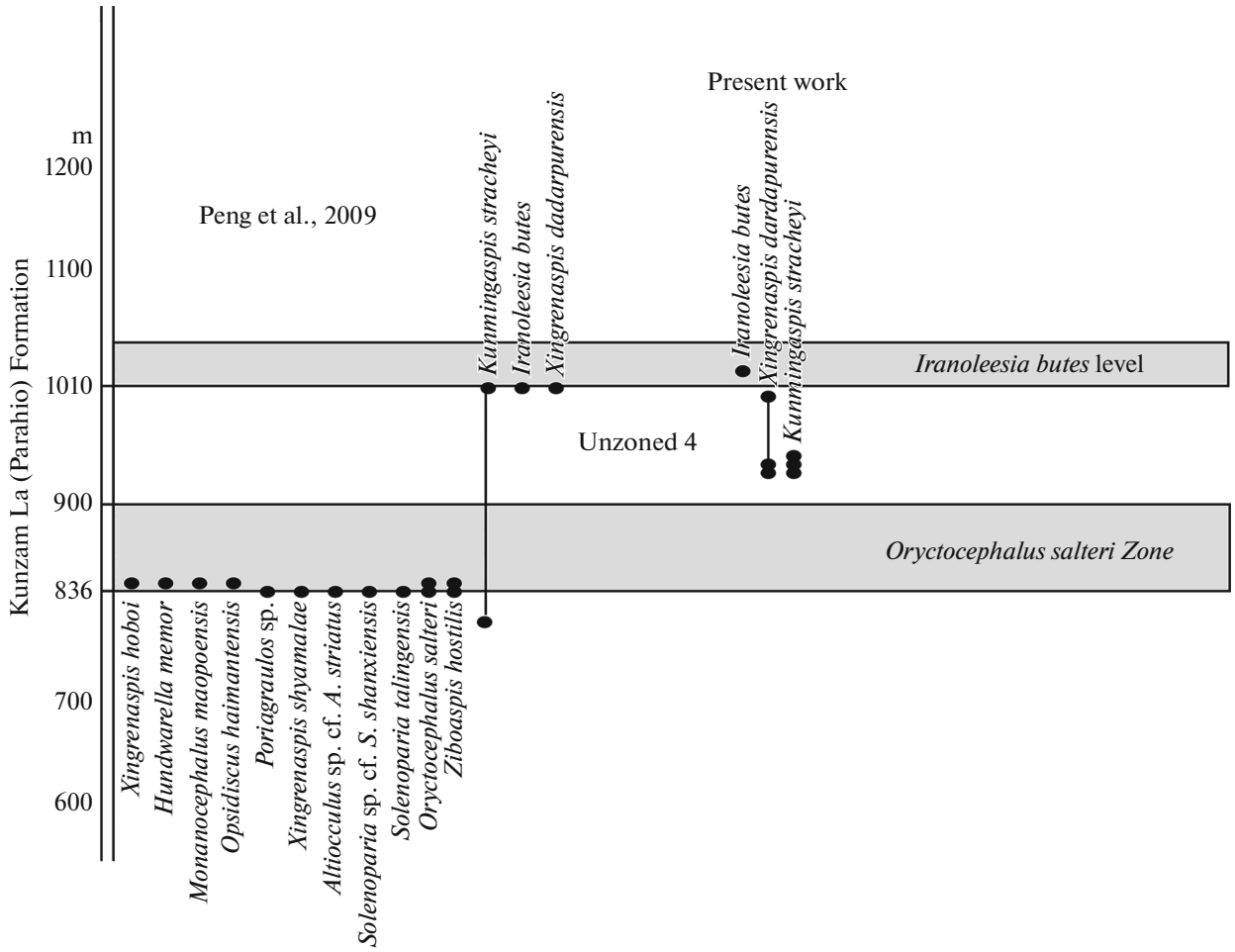


Fig. 4. A plot showing the range of trilobites known from 835–1010 m interval in the Kunzam La (Parahio) Formation, Spiti (after Peng et al., 2009 and the present work).

121.68–125.48 m, above the base of the studied section. The GPS coordinates of the fossiliferous first and second intervals are N 32°01′53.67″, E 077°56′54.16″ and N 32°1′51.70″, E 077°56′58.71″, respectively. Singh et al. (in review) recorded *Pagetia* cf. *jinnanensis* immediately below the currently discussed lowest trilobite bearing interval and correlated it with the *Sinopagetia jinnanensis* Zone (Yuan et al., 2016) of the Ordos basin (North China). The lower trilobite bearing interval falls within the unzoned 4 interval from ~900–930 m of Peng et al. (2009) and lies between the *O. salteri* biozone (870–900 m) and *I. butes* level (1010 m) (Fig. 4). In the present work, we recorded the trilobites *Xingrenaspis* cf. *X. dardapurensis*, *Kunmingaspis stracheyi* and *Iranoleesia butes* (Figs. 5–7). *Xingrenaspis* cf. *X. dardapurensis* and *Kunmingaspis stracheyi* are recorded from the 34.28–64.48 m interval. *Iranoleesia butes* and an undetermined ptychoparid trilobite along with disarticulated, isolated thecal and brachial plates of blastozoan echinoderm (Fig. 8) are recorded from the 121.68–125.48 m interval. An abundant brachiopod fauna was also collected at the 52.58–108.18 m interval from various lithologies but dominantly from the micaceous siltstone. In the studied section, we observed that *Xingrenaspis* cf. *X. dardapurensis* and *Kunmingaspis stracheyi* rich strata (34.28–64.48 m interval) are followed upwards by a succession (64.48–121 m interval) containing wavy and rippled bedded siltstone and sandstone with raindrop structures in the uppermost part. Above this is a dark grey silty shale and thin siltstone interval (121.68–125.48 m interval) which is highly fossiliferous and yielded *Iranoleesia butes*. This interval is correlated to the Hayden horizon 13 (Reed, 1910) and *Iranoleesia butes* level (Peng et al., 2009).

Hughes (2016a, Figs. 2B, 2C–2E) illustrated a few isolated and disarticulated thecal and brachial plates of a gogiid eocrinoid which are known from the *Paramecephalus defossus* biozone (Hayden level 6) of the Spiti region and from the *Xingrenaspis dardapurensis* (Reed, 1934) bearing Dardapur locality (Kashmir) in the Pohru Valley, Kashmir (Reed, 1934). Hughes (2016a) correlated the latter record with the ?*Iranoleesia butes* level (Hayden level 13) in the Spiti region. We

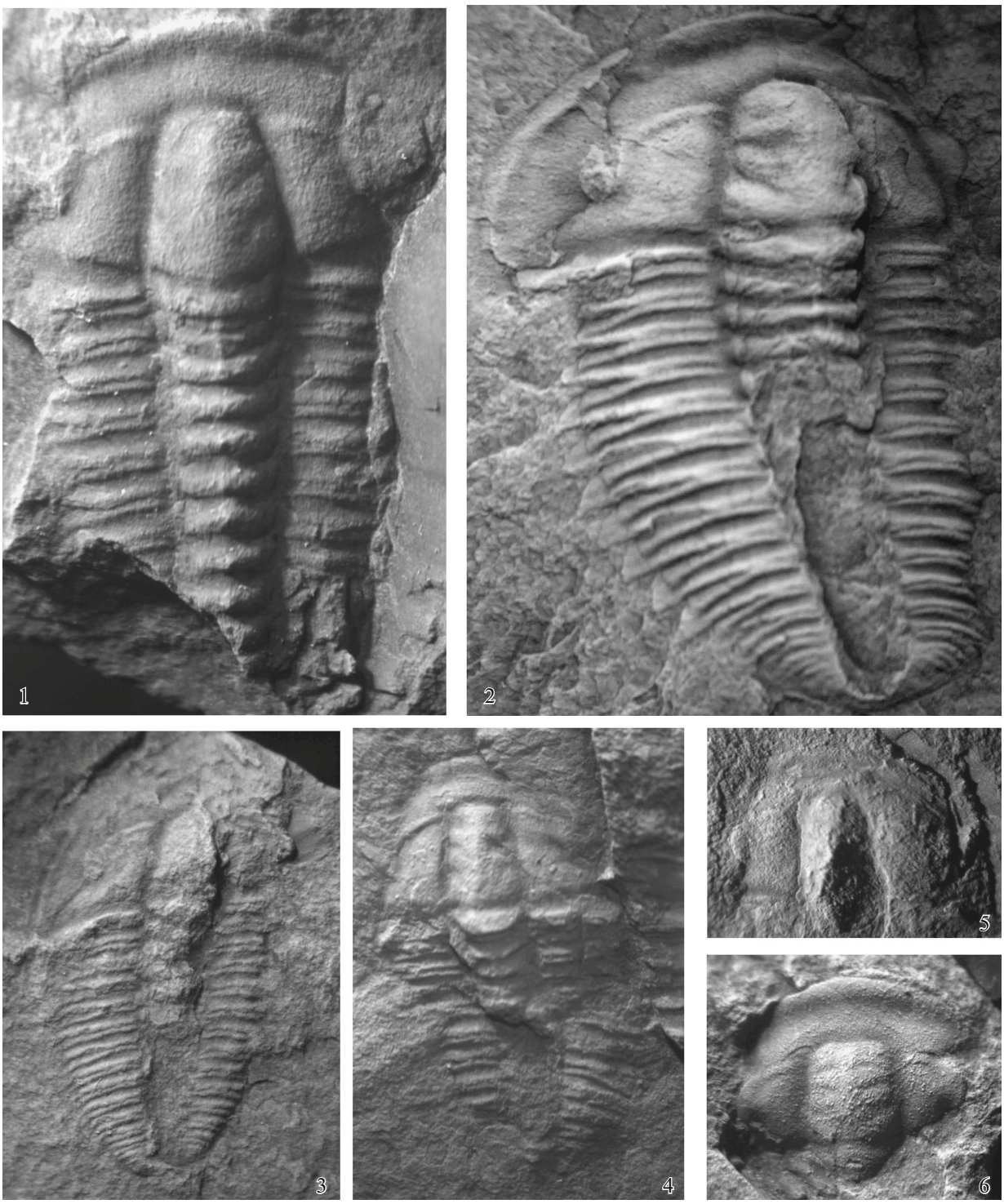


Fig. 5. Trilobites from 34.28 to 62.48 m interval in the section of Kunzam La (Parahio) Formation exposed on right bank of the Sumna River, Spiti, Himalaya. (1–6) *Xingrenaspis dardapurensis* (Reed, 1934), partially preserved exoskeleton and cranidium: (1) CAS/2017/S12-01, 7×; (2) CAS/2017/S11-03a, 7×; (3) CAS/2017/S11-06, 7×; (4) CAS/2017/S12-06a, 8×; (5–6) poorly preserved cranidium, (5) CAS/2017/S12-06, 13×; (6) CAS/2017/S12-02, 9×.

Table 1. The current status of the trilobite fauna from the Hayden level 13 (compiled after Jell and Hughes, 1997; Kobayashi, 1967; Peng et al., 2009; Reed, 1910; Shah et al., 1988, 1991; Yuan et al., 2002, and present work)

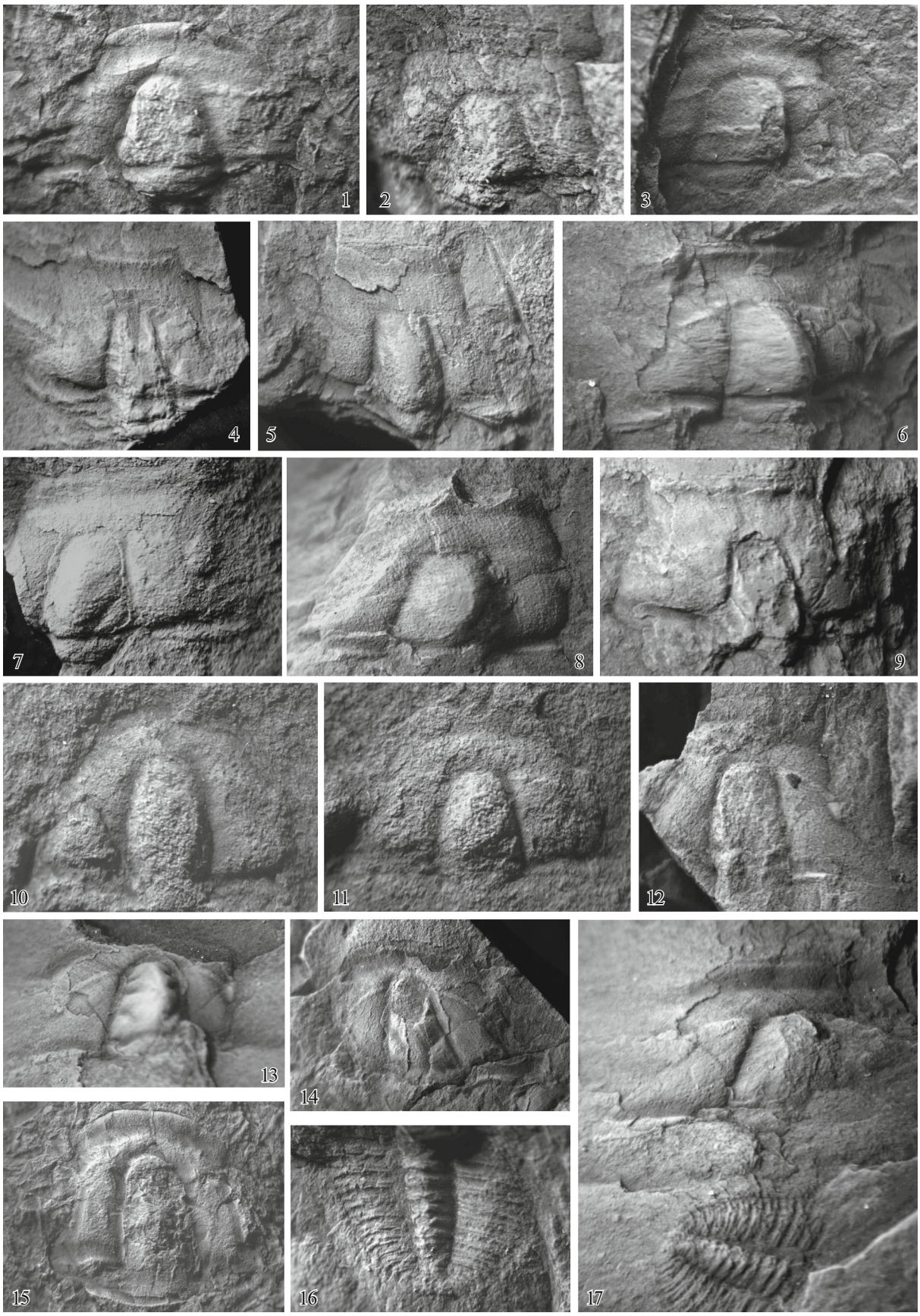
Reed (1910)	Kobayashi (1967)	Shah et al. (1988, 1991)	Jell and Hughes (1997)	Yuan et al. (2002)	Peng et al. (2009)	Present work
Olenus? Haimentensis Reed, 1910	*Hundwarella haimentensis* (Reed, 1910)	*Olenus? Haimentensis* Reed, 1910	*Iranoleesia butes* (Walcott, 1905)		? *Iranoleesia butes* (Walcott, 1905)	*Iranoleesia butes*
Dicellocephalus? Interpres Reed, 1910		*Hundwarella interpres* (Reed, 1910)				
Bathyuriscus? stoliczkai Reed, 1910						
		Hundwarella rushtoni (Shah et al., 1988)				
		Tsinania sp (Shah et al., 1991).				
		Spitella barachuensis (Shah et al., 1991)	*Iranoleesia butes* (Walcott, 1905)			
			Xingrenaspis dardapurensis (Reed, 1934) (Type specimen of *S. Barachuensis*)	*Ehmaniella* (Resser, 1937)	*Xingrenaspis dardapurensis* (Reed, 1934)	*Xingrenaspis dardapurensis*

confirm this correlation of rocks of Dardapur locality of the Kashmir region with the Hayden level 13 in the Spiti region.

DISCUSSION

Hayden (1904) collected trilobite and other faunal elements from seven stratigraphic levels (1, 2, 4, 6, 9, 11, and 13) from a continuous section in the Parahio Valley, Spiti region. Reed (1910) studied these collections and described the fossils from the five stratigraphic horizons (2, 4, 6, 9 and 13). From Hayden level 13, Reed (1910) described *Olenus*? *haimentensis*, *Dicellocephalus ? interpres*, and *Bathyuriscus*? *stoliczkai* and assigned an upper Cambrian age for this horizon (Table 1). Later on, Kobayashi (1967) stated that *Olenus*? *haimentensis*, *Dicellocephalus ?interpres*, and *Bathyuriscus*? *stoliczkai* are *Hundwarella haimentensis*. Subsequently, Shah et al. (1988) considered that *Dicellocephalus ?interpres* and *Bathyuriscus*? *stoliczkai* may belong to *Hundwarella interpres* and they erected a new species, *Hundwarella rushtoni,* from the Hayden level 13. Shah et al. (1988) retained *Olenus*? *haimentensis* (Reed, 1910) and assigned Hayden level 13 to the *Olenus* biozone. Furthermore, Shah et al. (1991) erected *Spitella barachuensis* and described it along with *Tsinania* sp., from the Hayden level 13. Jell and Hughes (1997) revised all these faunal elements and stated that *Olenus*? *haimentensis, Dicellocephalus ?interpres*, *Bathyuriscus*? *stoliczkai, Hundwarella interpres, Hundwarella rushtoni*, *Spitella barachuensis* (except for the holotype specimen), and *Tsinania* sp. all belong to *Iranoleesia* (Walcott, 1905) and grouped them under *Iranoleesia butes* (Walcott, 1905) and the

Fig. 6. Trilobites from 34.28 to 62.48 m interval in the section of the Kunzam La (Parahio) Formation exposed on right bank of the Sumna River, Spiti, Himalaya. (1–3) *Xingrenaspis dardapurensis*, partially preserved cranidium: (1) CAS/2018/CG-06, 7×; (2) CAS/2018/CG-11, 13×; (3) CAS/2018/CG-02, 12×; (4–17) *Kunmingaspis stracheyi*, partially preserved cranidium, thoracic segment and pygidium: (4) CAS/2018/CG-03, 9×; (5) CAS/2018/CG-04, 10×; (6) CAS/2018/CG-14F, 7×; (7) CAS/2018/CG-09, 11×; (8) CAS/2018/CG-12, 8×; (9) CAS/2018/CG-14C, 7×; (10) CAS/2018/CG-8B, 10×; (11) CAS/2018/CG-8A, 10×; (12) CAS/2018/CG-05, 8×; (13) CAS/2018/CG-14A, 9×; (14) CAS/2018/CG-14E, 7×; (15) CAS/2018/CG-01, 7×; (16) CAS/2018/CG-14D, 11×; (17) CAS/2018/CG-14B, 7×.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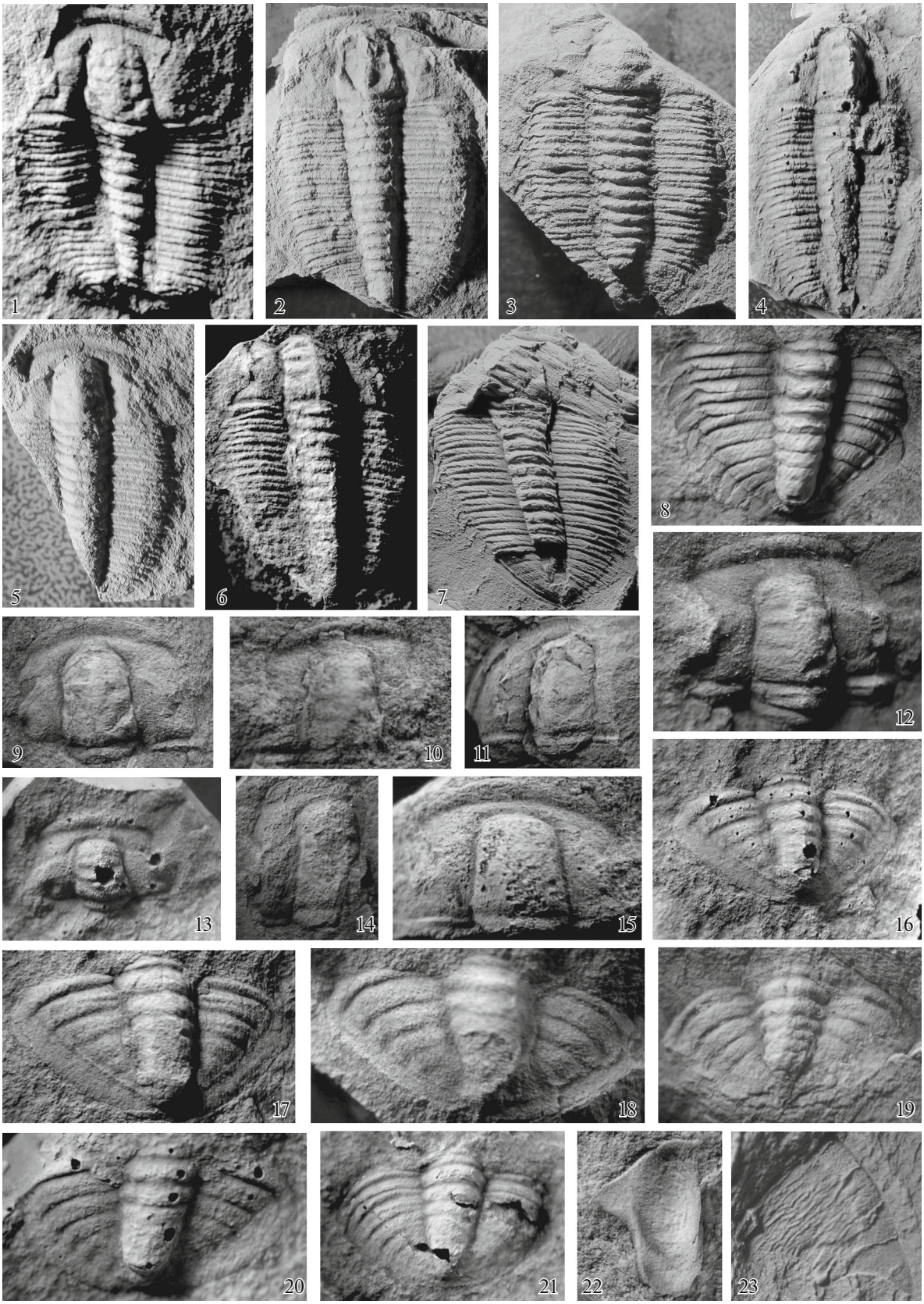
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Fig. 7. Trilobite fauna from 121.68 to 125.48 m interval (Hayden level 13) in the section of the Kunzam La (Parahio) Formation exposed on right bank of the Sumna River, Spiti, Himalaya. (1–14, 16–23): *Iranoleesia butes* (1) CAS/2017/S13-55,7x; (2) CAS/2017/S13- 27, 7x; (3) CAS/2017/S13-49, 7x; (4) Rubber cast of specimen CAS/2017/S13-05, 7x; (5) CAS/2017/S13-17, 7x; (6) CAS/2017/S13- 85, 7x; (7) CAS/2017/S13- 11, 7x; (8) CAS/2017/S13-58,8x; (9) CAS/2017/S13-99,9x; (10) CAS/2017/S13-61, 20x; (11) CAS/2017/S13- 03, 13x; (12) CAS/2017/S13- 12, 15x; (13) rubber cast of specimen CAS/2017/S13- 75, 10x; (14) CAS/2017/S13-57, 6x; (15) undetermined ptychoparid cranidium, CAS/2017/S13- 23, 12x; (16-21): pygidium, *Iranoleesia butes* (16) rubber cast of specimen CAS/2017/S13-14, 7x; (17) CAS/2017/S13- 24, 7.5x; (18) CAS/2017/S13- 66, 11x; (19) CAS/2017/S13- 20, 10x; (20) rubber cast of specimen CAS/2017/S13- 97, 13x; (21) rubber cast of specimen CAS/2017/S13-56, 8x; (22) hypostome; *Iranoleesia butes* CAS/2017/S13- 54, 14x; (23) libriginae, *Iranoleesia butes* CAS/2017/S13- 62, 14x.

holotype specimen of *Spitella barachuensis* under the synonymies of *Xingrenaspis dardapurensis* (Reed, 1934). Jell and Hughes (1997) grouped various ptychopariid known from the Kashmir and the Spiti regions (Kumar and Singh, 1983; Reed, 1934; Shah et al., 1988, 1991) under *Xingrenaspis dardapurensis* (Reed, 1934). However, Yuan et al. (2002) considered *Xingrenaspis dardapurensis* (Reed, 1934) described by Jell and Hughes (1997) is probably referable to *Ehmaniella* Resser, 1937. More recently, Peng et al. (2009) stated that until more material is known they prefer to keep it as *Xingrenaspis dardapurensis*. The trilobite taxon *Xingrenaspis* is well known from the Kunzam La (Parahio) Formation and it has a long stratigraphic range. Peng et al. (2009) reported *Xingrenaspis parthiva* (from the *K. prachina* biozone), *X. shyamalae* and *X. hoboi* (from the *O. salteri* biozone), and *X. dardapurensis* (from the *I. butes* level) from the Kunzam La (Parahio) Formation. *X. dardapurensis* (Reed, 1934) is well known from the upper part of the Nutunus Formation in the Kashmir region (Jell and Hughes, 1997; Kumar and Singh, 1983; Reed, 1934; Shah et al., 1988, 1991). Jell and Hughes (1997, Fig. 4, p. 14) correlated this occurrence of *X. dardapurensis* in Kashmir with the Hayden level 13 of the Spiti region. Sundberg et al. (2011) stated that *X. dardapurensis* (Reed, 1934) illustrated by Jell and Hughes (1997) (except two specimens; Jell and Hughes, 1997, plate 19, figs. 1–2) are very similar to *X. xingrenensis*. Sundberg et al. (2011) further stated if *X. dardapurensis* is a synonym of *X. xingrenensis* known from the Kaili Formation (South China), then the former would be the senior synonym. The specimens assigned to *X. dardapurensis* in the present work lack a well preserved pygidium; therefore, we could not compare them with the *X. xingrenensis*. We follow Jell and Hughes (1997) and regard our specimens as *X. dardapurensis* until well preserved specimens are discovered from this level. Peng et al. (2009) synonymized *X. xingrenensis* with *X. hoboi,* but Sundberg et al. (2011) reassigned *X. hoboi* (Peng et al., 2009, Figs. 42.1–42.5) to *X. xingrenensis* based on longer palpebral lobes, ocular ridges that are stronger and directly nearly at 90° to the glabella; posterior facial sutures that are more divergent; and pleural lobes and pygidium with a narrower doublure and the anterior-lateral corners nearly parallel with the anterior margin of the pygidium. Sundberg et al. (2011) also stated that *X. shyamalae* and *X. hoboi* (Peng et al., 2009) are closely related but are not *Xingrenaspis* based on the pygidia having a short bluntly rounded axis with only two segments, stronger interpleural furrows and narrow margins and matching narrow doublure. Yuan et al. (2016) retained *X. xingrenensis* as a valid species. Peng et al. (2009) questioned the determination of *Iranoleesia butes* from the Indian Himalaya and considered Indian specimens are closer to *Iranoleesia pisiformis*. It is important to mention here that the Peng et al. (2009) collection site PO 11–14 (see Peng et al., 2009, Fig. 2, p. 3) which yielded trilobites *Altiocculus* sp., *Xingrenaspis shyamalae*, *Poriagraulos* sp., *Solenoparia* sp., and *Solenoparia talingensis,* all grouped under the *O. salteri* biozone in the Parahio valley section and their estimated position

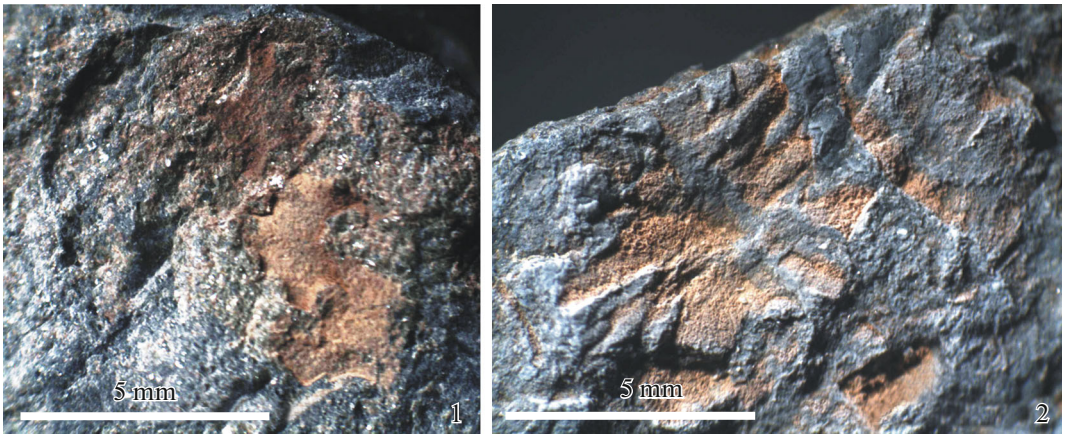

Fig. 8. Poorly preserved isolated and disarticulated thecal and brachial plates of gogiid eocrinoid from *Iranoleesia butes* level.

			North China (Yuan et al., 2016)	South China (Peng and Robison, 2000; Yuan et al., 2004)	India (Peng et al., 2009)	Present work
Cambrian	Miaolingian	Wuliuan	*Bailiella lantenoisi*	*Ptychagnostus gibbus*	*Iranoleesia butes* level	?
			Poriagraulos nanus			
			Inouyops titiana	*Oryctocephalus orientalis/ Peronopsis taijiangensis*	*O. salteri*	
			Metagraulos dolon		*Paramecephalus defossus*	*Iranoleesia butes* level
			Sunaspis laevis–Sunaspidella rara		*Katoia prachina*	*O. salteri*
			Sinopagetia jinnanensis			*Paramecephalus defossus*
			Ruichengaspis mirabilis			*Katoia prachina*
			Zhongtiaoshanaspis similis			
			Shantungaspis aclis	*Oryctocephalus indicus*	*Oryctocephalus indicus*	*Oryctocephalus indicus*
			Yaojiayuella ocellata			

Fig. 9. Correlation between the Cambrian biostratigraphy of Spiti with that of North and South China.

is ~836 m in the composite Parahio River section (see Peng et al., 2009, Fig. 3, p. 4 and Appendix 1, p. 95, and their respective figure captions). Peng et al. (2009) mentioned that collection sites PO 11–14 lie south side of the Parahio River on slopes just west of confluence of the Sumna and Parahio rivers. However, Hughes et al. (2018, Fig. 3, p. 4) re-defined the collection site PO 11–14 on the right bank of the Sumna River immediately near the confluence of Parahio and Sumna rivers. If the location provided by Hughes et al. (2018) is correct, it indicates that the collection site PO 11–14 lies somewhere within our current studied section. However, the known trilobite fauna from PO 11–14 collections indicates part of the *O. salteri* biozone (836–900 m), particularly at the estimated position of ~836 m (Peng et al., 2009, Appendix 1, p. 95); therefore, much lower than our collection levels. We consider that this estimated position must be fall in 900–1010 m interval in the composite Parahio valley section rather than ~836 m.

The GPS coordinates of the PO 10 collection [1]provided in the Peng et al. (2009), which yielded ?*Iranoleesia butes* and *Kunmingaspis stracheyi*, is same as given for their PO 11–14 collections (see Peng et al., 2009, Appendix 1, p. 95). The estimated height for the PO 10 collection in the composite Parahio Valley section is also ~836 m, but in the biostratigraphic lithocolumn of the composite Parahio Valley section (Peng et al., 2009, Fig. 3, p. 4) and in the description of ?*Iranoleesia butes*, they estimated this collection level at 1010–1050 m interval. Peng et al. (2009, Fig. 57, p. 79) indicate the ?*Iranoleesia butes* (PO 10 collection) was collected from the south side of the Parahio River on slopes above the east bank of Sumna River above the confluence with the Parahio River, which differ from PO 11–14 collection site, despite having the same GPS coordinates. However, Hughes et al. (2018, Fig. 3, p. 4) provided a different location of the PO 10 collection and this location lies along a section exposed far away from the confluence of Sumna and the Parahio rivers, in east side of the Sumna River which represent 1167–1352 m interval of the Kunzam La (Parahio) Formation (see Hughes et al. (2018, Fig. 3, p. 4)).

Jell and Hughes (1997) and Peng et al. (2009) suggested the Hayden level 13 in the Spiti region belongs to latest Wuliuan Stage (Miaolingian Series) probably in the *Ptychagnostus gibbus* Zone (Fig. 9). They also suggested that the Hayden level 13 can be correlated with a level that lies slightly lower than the *Crepicephalus* Zone in North China. However, we correlate the Hayden level 13 with the *Metagraulos dolon* Zone (middle Wuliuan age), equivalent to the upper part of the *Oryctocephalus orientalis* or *Peronopsis taijiangensis* Zone of South China (Fig. 9). This correlation is based on the fact that the trilobite taxon *Iranoleesia* is well known from the *Metagraulos dolon* Zone in southern and western marginal parts of the Ordos Platform (Yuan et al., 2016). The taxon *Sinopagetia jinnanensis*, which recently has been recorded in same section (Singh et al., *in review*), below the presently described lowest trilobite level, also occurs immediately below the *Metagraulos dolon* Zone on the Ordos Platform (Yuan et al., 2016). Therefore, we correlate the *Xingrenaspis dardapurensis* and *Kunmingaspis stracheyi* rich strata with the *Sunaspis laevis–Sunaspidella rara* Zone and *Iranoleesia butes* bearing beds with the *Metagraulos dolon* Zone of the southern and western marginal parts of the Ordos Platform, North China.

CONCLUSIONS

Present work records trilobites *Xingrenaspis* cf. *X. dardapurensis* and *Kunmingaspis stracheyi* from the unzoned 4 of the Kunzam La (Parahio) Formation (Peng et al., 2009) in the Spiti region. Based on the recognition of the *Pagetia* cf. *jinnanensis* bearing level (Singh et al., *in review*) immediately above the *O. salteri* biozone and sequence of order of appearance of trilobites in the western marginal parts of the Ordos Platform, North China, we infer that the studied interval

can be correlated to the *Sunaspis laevis–Sunaspidella rara* Zone of Ordos basin, North China. This work also suggests that the youngest known trilobite level in the Spiti region is equivalent to level of *Metagraulos dolon* Zone of the North China and belongs to middle Wuliuan (Miaolingian) which was previously considered to be late part of Wuliuan Stage.

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