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Triassic Conodonts from Ladakh and Spiti

V. J. Gupta*)

With 6 plates

Introduction

The present paper records the occurrence of Triassic conodonts from different stratigraphic horizons exposed near Lilang, along Lingti River, Spiti valley and similar succession exposed in the Zanskar valley of Ladakh. The conodonts recorded from both the regions have close similarity with the conodonts recorded earlier from within the Tethys Realm. The similarity in fauna facilitates a direct comparison of biostratigraphic zones based on conodonts with the sections rich in ammonites, bivalves and brachiopods. A general analysis of the conodont fauna from Spiti and Ladakh suggests a typical Mediterranean character. This is in particular supported by the predominance of multielements of *Gladigondolella tethydis* and occurrence of taxa characteristic of the Alps and the Balkans in the Himalayan material.

A. Spiti

Triassic rocks are well developed in different parts of Spiti and these have yielded rich assemblage of ammonites, bivalves, brachiopods and other fossil groups. This sequence has been subdivided into several biostratigraphic zones and stages on the basis of different group of fossils found therein. The best known succession of Triassic rocks in the Spiti valley is exposed near Lilang (32°09′00″N: 78°14′20″E) along the Lingti River where these rocks are generally classified as part of the Lilang Group (Hayden, 1904; Gupta, 1975). Similar rocks crop out also at Muth, Kaga and Thanam.

Sampling for conodonts along the Lilang section yielded conodonts within several lithostratigraphical levels, and similar conodonts assemblages have also been found in other parts of the Spiti valley (Table 1).

Table 1

Triassic Succession near Lilang, Spiti
(After Hayden, 1904 and Gupta, 1975)

Rhaetian

Kioto (= Megalodon) Limestone —

Massive limestones and dolomites with *Spiriferina noetlingi*, *Megalodon ladakhensis* . . . . . 380 m

*) Centre of Advanced Study in Geology, Panjab University, Chandigarh-160014, India

Norian

Quartzite Beds —
White and brown limestones with subordinate quartzites and black shales with *Spirigera maniensis* . . . . . 110 m

Monotis Beds —
Sandy and shaly limestones with brown weathering shales and sandstones containing *Monotis salinaria* . . . . . 100 m

Coral Limestone —
Limestones with *Spiriferina griesbachi* etc. . . . . 30.4 m

Juvavites Beds —
Brown weathering shales, limestones and sandstones, with *Indojuvavites angulatus*: (Sample Gu 7 with *Neogondolella hallstattensis* Mosher) . 152.2 m

Carnian

Tropites Beds —
(a) Shales and dark limestones with *Tropites subbullatus* . . . . . 182 m
(b) Dolomitic limestones with *Dielasma julicum* . . . . . 100 m

Grey Beds —
Grey shales and shaly limestones with *Spiriferina shalshalensis* and *Joannites cymbiformis* . . . . . 152 m

Halobia Beds —
Dark splintery limestones with *Halobia* cf. *comata* and *Joannites thanamensis* bed at the base . . . . . 42.7 m

Ladinian

Daonella Limestone —
Hard dark limestones with *Daonella indica* . . . . . 45.7 m

Daonella Shales —
Black limestones, shaly limestones and shales with *Daonella lommeli* and *Aristoptychites gerardi* . . . . . 48.7 m
(Sample no. Gu 6 with *Neogondolella mombergensis* (Tatge)) . . . . 48.7 m

Anisian

Upper Muschelkalk —
Passage beds at Kaga and Mafu; concretionary limestones with shale bands containing *Ptychites rugifer* . . . . . 2 m

Lower Muschelkalk —
Dark shales and grey limestones with *Keyserlingites dieneri, Sibirites prahlada, Spiriferina stracheyi*, etc.
(Sample Gu 5 with *Neogondolella cornuta* Budurov & Stefanov; *Paragondolella bifurcata* Budurov & Stefanov; *P. hanbulogi* Sudar & Budurov; *Gladigondolella tethydis* (Huckriede)
Sample Gu 4 with *Gladigondolella tethydis multielement* . . . . . 1.8 m

Nodular Limestone —
Hard nodular limestones with few fossils;
Sample Gu 3 with *Neogondolella regale* Mosher, and *Gladigondolella tethydis multielement* . . . . . 18.0 m

Basal Muschelkalk —

Shaly limestones with *Rhynchonella griesbachi*;

Sample Gu 2 with *Enantiognathus ziegleri* (DIEBEL); *Hindeodella suevica* (TATGE) . . . . . 1.0 m

Hedenstroemia Beds —

limestones with *Pseudomonotis himaica* and *Tirolites*

Sample Gu 1 with *Neospathodus homeri* BENDER, *N. triangularis* BENDER, *Hindeodella triassica* MUELLER, *Prioniodina muelleri* TATGE

and unfossiliferous shaly limestone and shales alternating with thinly bedded limestones and shales with *Hedenstroemia mojsisovicsi*, *Flemingites rohilla*, etc. . . . . 10 m

Meekoceras Zones —

Thin bedded limestones and shales with *Meekoceras varaha*, *M. lilangensis* . . . . . 1.0 m

Ophiceras Zones —

Grey limestones with *Ophiceras sakuntala* and *Pseudomonotis griesbachi* 0.3 m

Otoceras Beds —

Brown limestones with *Otoceras woodwardi* . . . . . 0.6 m

(1) Scythian (Smithian and Spathian):

The conodonts recovered from the Lower Triassic sequence of Lilang are similar to those described earlier by SWEET (1970 a, b) and SWEET *et al.* (1971). SWEET (1970 a, b) and SWEET *et al.* (1971) proposed 5 conodont zones (Zones 3 to 7) characterised by the presence of characteristic conodonts (Fig. 1). In his subsequent publication SWEET (1973) placed the *Neospathodus cristagalli* Zone above the *Neospathodus dieneri* Zone (Fig. 2). As is clear in Table 1, SWEET (1970a) had placed *Neospathodus cristagalli* Zone (Zone 5) as occupying the stratigraphic position just in the middle of *Neospathodus dieneri* Zone. GOEL (1977) and BHATT & JOSHI while working on the Lower Triassic conodonts from Guling, Khar, etc. have followed the stratigraphic zonation proposed by SWEET (1970 a, b) and SWEET *et al.* (1971).

GUPTA & BUDUROV (1981) and AHLUWALIA *et al.* (1981) on the basis of their work on the Lower Triassic rocks have come across some samples yielding four different species of *Neospathodus* occuring together. These results are in contradiction to the conodont zonation proposed by SWEET (1970 a) and this puts doubt in our mind regarding the validity of the biostratigraphic zonation proposed by SWEET (1970 a, b) and SWEET *et al.* (1971).

Conodonts corresponding to the *Neospathodus homeri* Zone from Lilang (Sample Gu 1) are characterised by a multitude of specimens of *Neospathodus homeri* and *Neospathodus triangularis* (Pl. 1, figs. 6, 7, 9). The beds yielding these correspond to Spathian age.

(2) Anisian:

The shaly limestone (Sample Gu 2) with *Rhynchonella griesbachi* forming base of the Anisian have yielded the conodonts *Enantiognathus ziegleri*, *Hindeodella suevica* and *Neogondolella timorensis* (Pl. 1, figs. 1—5, 8).

The hard nodular limestone (Sample Gu 3) corresponding to the lower part of the Bythinian has yielded *Neogondolella regale* (Plate 1, figs. 10—13).

The grey limestone forming the upper part of the Anisian has yielded conodonts at two stratigraphic levels. The sample from the lower part (Sample Gu4) has yielded representatives of *Gladigondolella tethydis* (Plate 2, figs. 1—2) multielements whereas the conodonts from the upper part (Sample no. Gu5) include *Neogondolella cornuta* (Pl. 2, figs. 7, 8, 12, 13), *Paragondolella bifurcata* (Pl. 2, figs. 3—6, 9). *P. hanbulogi* (Pl. 2, figs. 10, 11), *Gladigondolella tethydis*. *Paragondolella bifurcata* is a characteristic form occurring at the base of Illyrian whereas *Neogondolella cornuta* has been recorded from the upper part of Illyrian in the Balkan mountains. *Paragondolella excelsa* occurs within the beds forming transition between *P. bifurcata* and *N. cornuta* bearing beds.

(3) Ladinian-Carnian:

Black limestone (Sample Gu6) intercalations within the *Daonella* Shales of Upper Ladinian have yielded conodonts of the *Neogondolella mombergensis* group. The Carnian succession has yielded only broken specimens of conodonts.

(4) Norian:

The youngest beds yielding conodonts in the Lilang section are the limestone horizons within the *Juvavites* Beds. These limestones (Sample no. Gu7) contain specimens of *Gondolella hallstattensis* (Pl. 2, figs. 14—17) which has a limited distribution in the uppermost Lacian.

The find of conodonts referred to above from different stratigraphic levels of the Lilang section is significant as these may provide an additional tool for the stratigraphic correlation of the Triassic succession were ammonites, brachiopods and bivalves are missing.

B. Ladakh

Triassic rocks are exposed in different parts of Ladakh and good sections of these are exposed in the Luneak Valley, Sarchu Plains and in the region between Sarchu and More Plains. Till date no systematic attempt has been made to work out the detailed biostratigraphy of the Triassic rocks of this region similar to the studies made by earlier workers in Kashmir, Spiti and Kumaon.

The Triassic rocks of Ladakh are poor in megafossils and this fact makes it difficult to classify them precisely and to correlate them with the corresponding horizons exposed in other parts of the Himalaya. The stratigraphy of the Triassic rocks has been further complicated due to the fact that these rocks in Ladakh are highly folded and it is difficult to work out their precise thickness on account of their being devoid of megafossils. During the course of palaeontological and stratigraphical investigations in different parts of Ladakh during several field seasons good collections of Triassic rocks were made from different stratigraphic horizons. The samples collected from Baralacha La (32°45′: 77°24′30″), Sarchu (32°48′00″N: 77°30′50″E), Uparu (32°40′30″: 77°27′), Lachlung La (33°05′30″: 77°36′30″), Tingting Khur (32°54′30″: 77°35′), Togosiru (33°10′30″: 47′30″) and Gate were macerated for the study of conodonts and other microfossils. Some of these samples have proved fruitful and have yielded good assemblage of conodonts of Dienerian-Smithian; Ladinian, Carnian and Norian age.

The following is the generalised stratigraphic succession of the Triassic rocks exposed in different parts of Ladakh. The conodonts bearing horizons along with the localities are referred to at the appropriate places in the table:

Table 2

Rhaetian	Kioto Limestone (500—700 m)	Massive limestone and dolomites with *Spirigera noetlingi*, *Megalodon ladakhensis* and *Dicerocardium ladakhense*.
Norian		Quartzite, limestone and shales with *Athyris maniensis*, *Spirigera* spp. etc. (50 m)
		Sandy and shaly limestone with *Monotis salinaria* (20 m) sample No. 1 a 20 m; sample No. 1 16 m; sample No. 2 14 m; sample No. 3 12 m
		Limestone, shale and quartzites with *Spiriferina griesbachi* (50 m)
		Coral limestone and sandstones with *Spiriferina griesbachi*, *Athyris maniensis* and *Monotis salinaria* (20 m)
Carnian		Hard, dark splintery limestone, shaly limestone (75 m)
		Dolomitic limestone with brachiopods (*Dielasma*, etc.) (80 m)
		Shaly limestone and shales with *Spiriferina*, *Rhynchonella*. (70 m)
		Dark limestone with *Halobia* cf. *comata* (sample No. 4) (40 m)
Ladinian		Dark splintery limestone with *Halobia* cf. *comata* and *Spiriferina*. (25 m) (sample No. 5)
		Black limestone and shales with *Daonella lommeli* and *Aristoptychites*. (60 m)
Anisian		Upper Muschelkalk — concretionary limestone with *Ptychites rugifer*. (4 m)
		Lower Muschelkalk — dark compact black shale and limestone with *Spiriferina stracheyi* and *Keyserlingites dieneri*. (1.00 m)
		Dark shaly nodular limestone with *Rhynchonella griesbachi*. (15 m)

Scythian	*Hedenstroemia* beds with *Tirolites*; Spathian. Grey limestone with shaly intercalations containing *Pseudomonotis* and *Flemingites rohilla* (8 m); Smithian. Thin bedded limestone with *Meekoceras varaha* (0.8 m) Grey limestone with *Ophiceras sakuntala* (0.4 m) (sample No. II) Brown limestone with *Otoceras woodwardi* (0.5 m)
Permian	Shales, limestone and interbedded quartzite.

(1) Scythian-Ladinian:

The Permian rocks in parts of Ladakh are conformbaly overlain by about 10 m thick sequence of thinly bedded grey limestone with intercalations of shaly horizons which are well exposed in the area south and east of Sarchu. This includes a number of stratigraphic horizons which correspond to the classic sections exposed in different parts of the adjoining Spiti valley. These zones include from the basal *Otoceras* Beds of the basal Triassic age to the *Daonella* Limestone of Ladinic age.

The grey siliceous limestone at Togosiru lying immediately above the Carbonaceous shales of Permian age have yielded Dienerian-Smithian conodonts including *Neogondolella carinata* (sample No. II). The limestone yielding conodonts in the Togosiru section has also yielded specimens of *Claraia* and *Pseudomonotis*. A similar sequence is also exposed in Tingting Khar area where the limestone contains broken shells of bivalves.

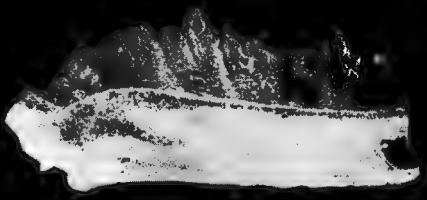
In view of the difficulties in distinguishing the sequence overlying the *Daonella* Limestone on lithological grounds the possibilities of a part of this sequence corresponding to the *Halobia* and Grey beds of Carnian age can not be ruled out.

In the Uparu section of Ladakh, the Triassic sequence is more than 300 metres thick and has yielded characteristic bivalves (*Daonella lomelli*, *D. indica*, *Pseudomonotis*) of Ladinian age. The lower part of this section exposed in the Uparu area has also yielded poorly preserved ammonites of ?Anisian age. The hard limestone containing bivalves has yielded fairly well preserved conodonts belonging to *Neogondolella mombergensis* (sample no. 5) of Ladinian age. In addition representatives of *Paragondolella* and *Gladigondolella tethydis* have also been found within this sequence.

(2) Carnian:

The Carnian succession in parts of Ladakh is represented by thickly bedded crystalline, grey, white and brown limestone corresponding to the *Tropites* Beds of Spiti. These beds are well exposed in the Umnag nala section. The lower units of these comprise grey shales with bands of limestone whereas the upper units contain grey, white or creamy white, friable limestone with intercalations of thick bands of grey calcareous shales. The grey limestone (sample no. 4) exposed near the top of Lach-lung-La has yielded *Gondolella polygnathiformis* (Pl. 3 Figs. 1, 2, 4) of Carnian age.

PLATE I



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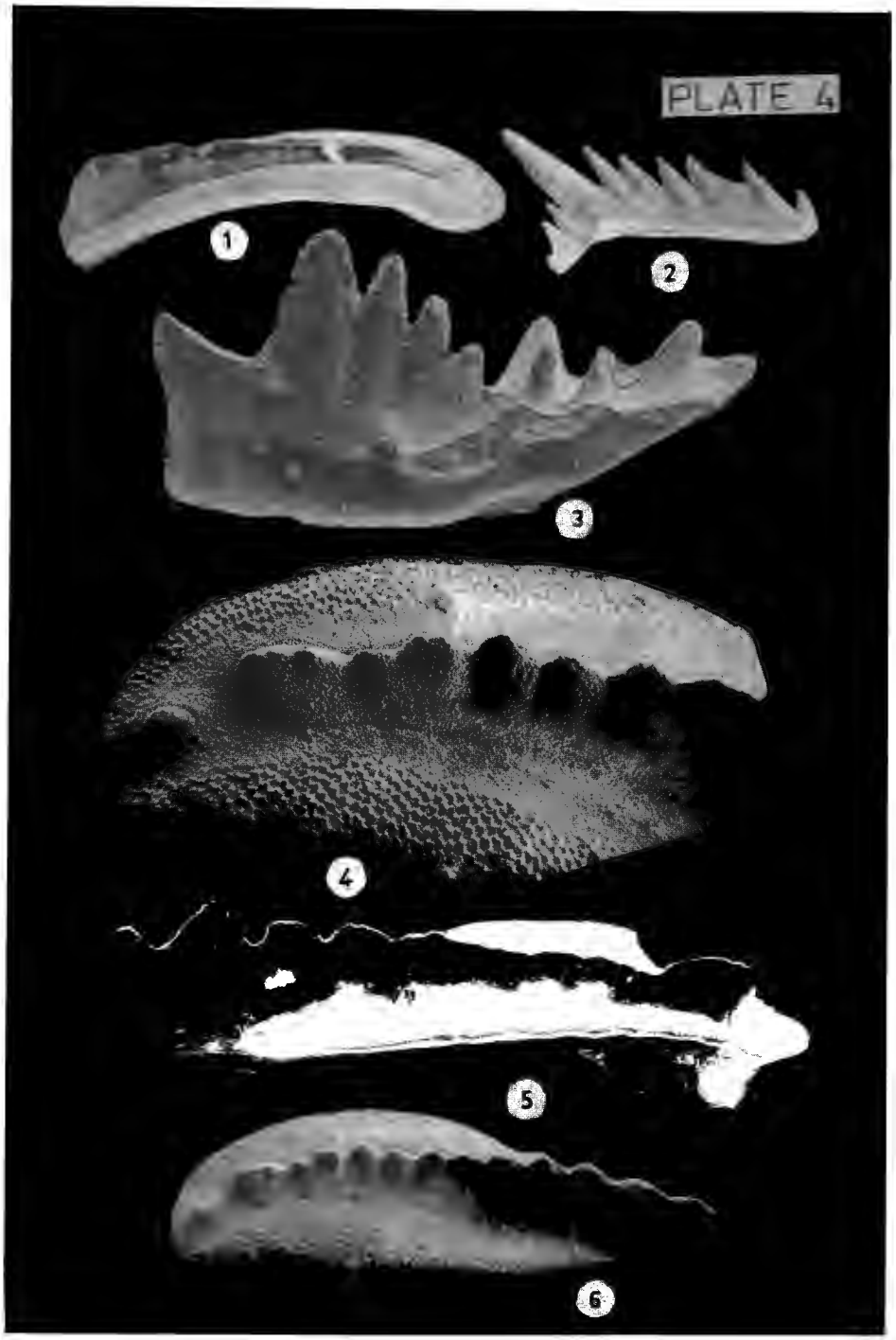
PLATE 4
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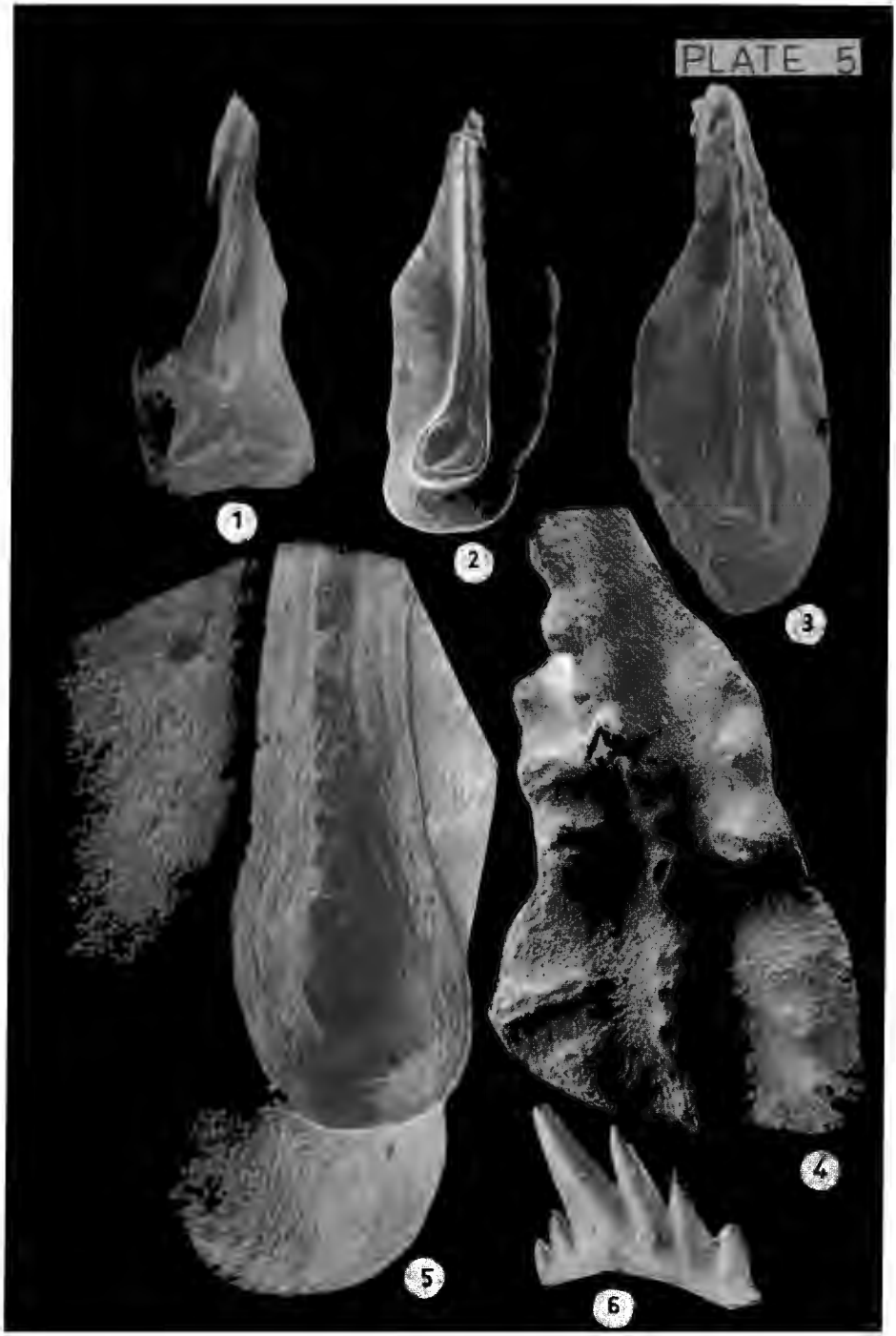
PLATE 5
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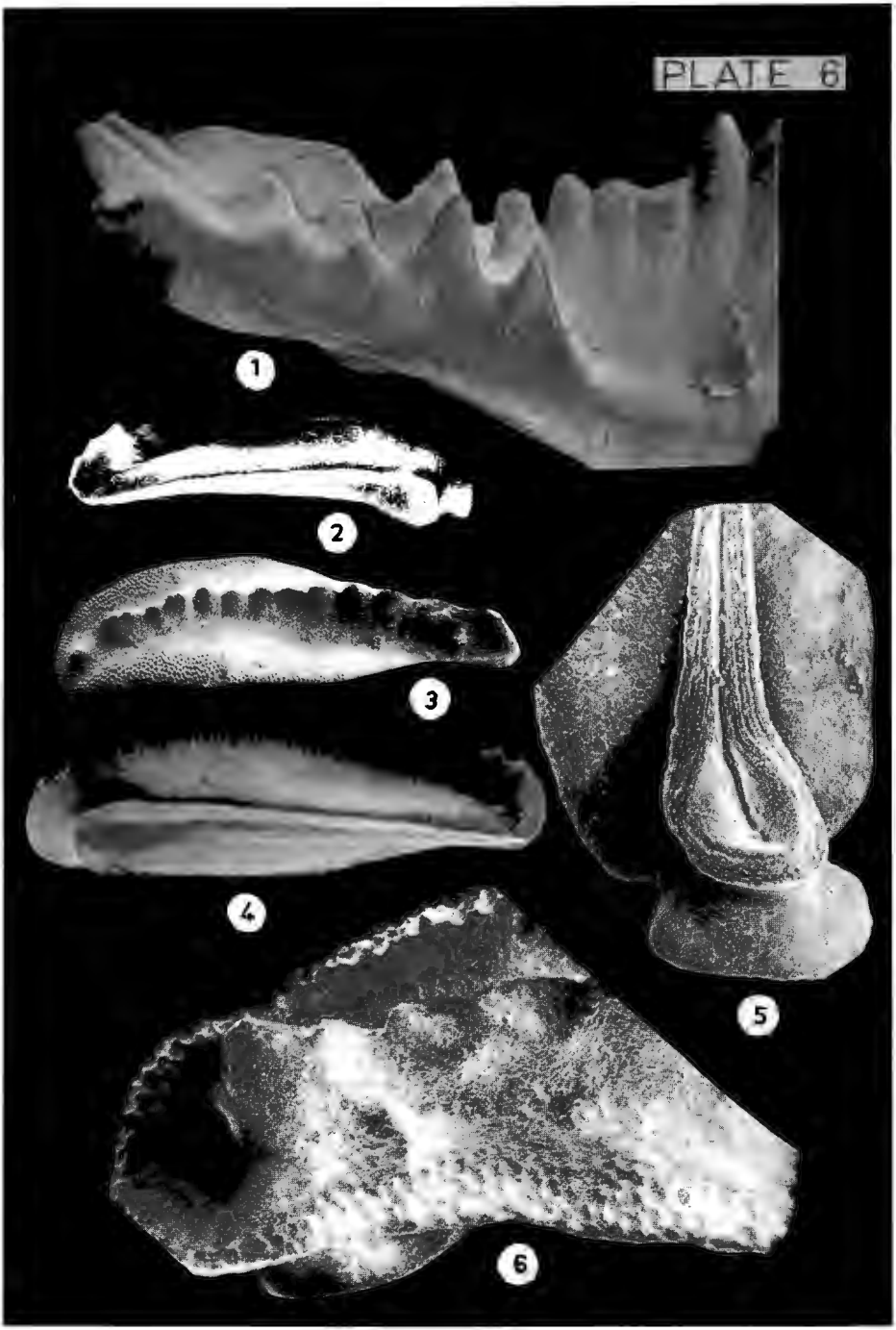
PLATE 6
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(3) Norian:

The strata corresponding to the Grey Beds of Carnic age are conformably overlain by a thick sequence which consists of grey phyllitic slates, slaty shales, dark sandy and shaly limestone, sandstone and quartzites. This succession at places is fossiliferous but it is difficult to demarcate precisely the biostratigraphic zones within this sequence. The lower units of this sequence possibly belong to the *Juvavites* Beds which are well exposed in the higher reaches of Umnag and Kurparubem nalas and in the section exposed between Lachlung La and More Plains.

The middle part of the succession is essentially argillaceous and is intercalated with limestone bands which may correspond to the Coral Limestone of Norian age. The youngest unit in the succession is essentially represented by grey platy limestone yielding at places *Monotis salinaria*. The limestone exposed in the Gata area has yielded a few corals (*Montlivaultia* sp.) and brachiopods (*Rhynchonella* sp., *Terebratula* sp.), bivalves (*Pecten* sp.), etc.

The beds referred to above are in turn followed by about 50 metres thick succession of fine to medium grained, brown, grey and white massive quartzites. In some sections, i. e., Kuparubem nala section the quartzitic horizons are interbedded with bands of limestone. In the Umnag nala section these quartzites have yielded brachiopods of probable Upper Norian age.

The greyish blue and black limestone exposed near Kangla Jar is at places oolitic in mature and contains at places fragmentary corals of probable Upper Norian age. A similar succession is also exposed at the top of Lachlung La where poorly preserved specimens of *Gondolella steinbergensis* have been found. The lower units (sample nos. 2, 3) of this succession have yielded a well preserved assemblage of Lacian conodonts (*Gondolella hallstattensis* (Pl. 4, figs. 4—6), and *Metapolygnathus abneptis abneptis* (Pl. 3, figs. 7—8; Pl. 4, fig. 3; Pl. 5, fig. 4). The upper units (sample nos. 1 & 1 a) of this succession at the top of Lachlung La have yielded the Alaunian (?) conodonts *Metapolygnathus abneptis abneptis, Metapolygnathus abneptis spatulatus* and poorly preserved pecimens of *Gondolella steinbergensis*. The conodont assemblages from the lower and upper units of Lachlung La may correspond to *Metapolygnathus abneptis abneptis* Assemblage Zone and *Metapolygnathus abneptis spatulatus* Assemblage Zone respectively (KRYSTYN, 1980). Similar fauna has also been recorded recently from the Upper Triassic succession of northeastern Kumaun (GUPTA *et al.*, 1978).

The uppermost units of the Triassic succession in Ladakh are represented by 500 to 700 metres thick sequence of massive limestone and dolomites yielding at places well preserved specimens of *Megalodon ladakhensis*. The limestone is of hard, grey and massive nature and is similar to the well known Kioto (= *Megalodon*) Limestone of the Spiti Valley.

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Explanation of Plates

Plate 1 (All specimens from Lilang Section, Spiti)
Figs. 1—5, 8. *Neogondolella timorensis* (NOGAMI) sample Gu 2; × 90
Fig. 6. *Neospathodus tringularis* BENDER sample Gu 1; × 110
Figs. 7, 9. *Neosphathodus homeri* BENDER; sample Gu 1; 7 × 90; 9 × 70
Figs. 10—13. *Neogondolella regale* MOSHER sample Gu 3; × 110

Plate 2 (All specimens from Lilang Section, Spiti)
Figs. 1—2. *Gladigondolella tethydis* (HUCKRIEDE) — sample Gu 4; × 100
Figs. 3—6, 9. *Paragondolella bifurcata* BUDUROV and STEFANOV — sample Gu 5; × 100
Figs. 7, 8, 12, 13. *Neogondolella cornuta* BUDUROV and STEFANOV — sample Gu 5; × 100
Figs. 10, 11. *Paragondolella hanbulogi* SUDAR and BUDUROV — sample Gu 5; × 100
Fig. 14—17. *Gondolella halstattensis* MOSHER — sample Gu 7; × 100

Plate 3 (All specimens from Ladakh)
Figs. 1, 2, 4. *Gondolella polygnathiformis* BUDUROV and STEFANOV — sample no. 4; × 100
Fig. 3. *Gondolella navicula* MOSHER × 240
Figs. 5—6. *Gondolella* cf. *foliata* BUDUROV; × 100
Figs. 7—8. *Metapolygnathus abneptis abneptis* HUCKRIEDE × 120

Plate 4 (All specimens from Ladakh)
Fig. 1. *Gondolella navicula* MOSHER × 60
Fig. 2. *Ozarkodina* sp. × 60
Fig. 3. *Metapolygnathus abneptis abneptis* HUCKRIEDE × 100
Figs. 4—6. *Gondolella* cf. *hallstattensis* MOSHER × 100

Plate 5 (All specimens from Ladakh)
Fig. 1. *Metapolygnathus abneptis* aff. *spatulatus* (HAYASHI) × 120
Fig. 2. *Gondolella polygnathiformis* BUDUROV and STEFANOV × 100
Fig. 3. *Gondolella* sp. × 100.
Fig. 4. *Metapolygnathus abneptis abneptis* (HUCKRIEDE × 240
Fig. 5. *Gondolella* sp. indet. × 240.
Fig. 6. *Ozarkodina* sp. × 60.

Plate 6 (All specimens from Ladakh)
Fig. 1. *Metapolygnathus abneptis spatulatus* (HAYASHI)
Fig. 2. *Gondolella* sp. indet. 1 × 240; × 120.
Figs. 3—4. *Gondolella hallstattensis* MOSHER × 120
Figs. 5—6. *Gondolella polygnathiformis* (same as pl. 3, fig. 2); × 240.