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The Anisian ammonoid succession of the Nepal Himalaya*

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ABSTRACT

Anisian ammonoid sequences are well developed in central Nepal, north of the Annapurna Range, extending from the Manang district through Puchenpra Ridge, Plateau of lakes, Mesokanto Pass, to the Kali Gandaki Valley. The earliest and most significant faunules are developed in two zones, in the Kaisang, Tangje, and Thorong Members of the upper Gungdang Formation. The older zone is dominated by *Grambergia*, and also contains species of *Ananorites*, *Tienjunites*, *Qilianshanites*, *Pearylansites*, and *Sturia*? with other genera. The upper zone contains over 30 species, with *Lenotropites*, *Beyrichitids*, *Arctohungarites, Norites, Longobardites, Epiczekanowskits, Stenopopanoceras* and *Neopopanoceras*? These zones overlie a late Scythian faunule with *Keyserlingites, Dagnoceras, Prohungrites, Nordophiceras* and *Svalbardiceras* etc, placed in turn above a rich ammonoid faunule with *Subcolumbites, Dinarites, Paranoritoides, Eophyllites, Albanites* and other genera.

The Kaisang-Thorong zones are followed by a suite of ammonoids belonging to the *Paracrochordiceras* Zone; or Aegean Stage, generally regarded in recent years as indicating basal Anisian. Thus the Nepal sequence indicates the presence of a post-Scythian, pre-Aegean stage, here informally named Manasluan, after Mt. Manaslu, which is prominent west of the type section for both stratigraphic and biostratigraphic entities, on the southeast ridge of Mt. Chulu. The Manasluan stage is poorly developed world-wide, but may be represented, in part, by the so-called *Lenotropites qinghaiensis* faunule of central Qighai, and *Neopopanoceras haugi* Zone of California and Nevada.

The *paracrochordiceras* Zone of Nepal is represented by two successive faunules with some 20 species in the Phukung Menmber at the top of the Gungdang Formation and in the overlying lower Mukut Group, and includes two species of *Paracrochordiceras*. The Bithynian Stage follows, with a meagre *Gymnites depauperatus* faunule, succeeded by a rich *Paradanubites-Hollandites-Aristoptychites-Gymnites* assemblage of over 30 species. Several of the species are shared with Diener's "Lower Muschelkalk" Ammonoids from the northwest Himalaya, and some of the species are found also in Diener's "Upper Muschelkalk." *Keyserlingites* is present at this level, as reported by Diener in his "Lower Muschelkalk" Nepal evidence suggests that this genus, or species very close to this genus, range from the *Subcolumbites* level in Nepal, i.e. late Scythian, into middle Anisian, or Bithynian. North American authorities have endeavoured to impose a short range for *Keyserlingites*, as latest Scythian, but this appears to be wrong. Their interpretation of the Scythian-Anisian boundary therefore has to be substantially re-evaluated.

In the younger Mukut Group of the Annapurna region there is a possibility of having *Bulogites* and *Balatonites*, indicating the presence of Pelsonian Stage. Apart from this, Ladinian ammonoids have also been found, encouraging further study. From the Mukut of (northwest Nepal) in west Dolpo, equivalent of Diener's Upper Muschelkalk," or Illyrian Stage, with *Paraceratites* of the *trinodosus* format, and *Pseudodanubites, Hollandites, Beyrichites, Gangadharites, Bulogites, Ptyshites, Discoptydhites, Monophyllites* and other genera have been collected.

These studies indicate that Anisian of Nepal is moderately well developed, and offer sequences particularly significant for the Scythian-Anisian boundary, and lower Anisian. They also help resolve the long-standing dispute over the age of *Keyserlingites*, which has clouded understanding of the Anisian and Scythian for several decades.

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INTRODUCTION

Around the beginning of the twentieth century, Diener (1895, 1907, 1913) issued a number of splendid monographs on Triassic ammonoids that had been found, principally by the Geological Survey of India, in the western Himalayas of India, and in the southern borderlands of Tibet. Building on pioneering work by Oppel (1863-5), Diener described a large array of species, from beds which he matched mostly with those of the "Muschelkalk" of Europe, and also recognised an assemblage deemed to be slightly older, which he termed "Lower Muschelkalk". Only cursory mention of Anisian ammonoids has been made in most subsequent monographs on Himalayan geology, but a few species were described by Jeannet (1959) from the Gansser-Heim expedition, and many were recorded from south Tibet by Wang and He (1976). A little beyond the Himalayas, related Anisian ammonoids have been studied in Afghanistan by Kummel and Erben (1968) and Collignon (1973), and there have been reports on Anisian ammonoids from Tibet and Qinghai, including those by Wang and He (1981) and Wang (1985), Wang et al. (1979), and He et al. (1986).

As advances proceeded in the rest of the world, interpretation of the Himalayan faunules became central to a bitter controversy, involving the boundary between Anisian and underlying Scythian, and the age of Diener's "Lower Muschelkalk" ammonoids. To North American authorities (Tozer, 1967; Silberling and Tozer, 1968; Bucher, 1989), the "Lower Muschelkalk" of the Himalaya was Scythian, not Anisian. Other authorities, including Kummel (1969), Wang(1985), and Fantini Sestini (1981) disagreed. Furthermore, Bucher (1992a, b) challenged the supposed late Anisian age for Diener's "Upper Muschelkalk" ammonoids, and stated that they were middle Anisian The Himalayan Anisian ammonoids are therefore of more than local interest. Historically, they have assumed a prominent role in the understanding of ammonoid evolution and classification, and they have impinged on correlations offered in other great sequences of the world, especially in North America.

The difficulty with the bulk of Himalayan Anisian ammonoids, apart from those from Tibet, is that most were collected long ago, and appear to belong chiefly to only two suites. The lapse in time since their collection has encouraged claims of uncertainty about their exact provenance. For this reason, the Anisian sequences in Nepal are of interest, because they have been examined and collected by the writer over the last twenty years, and go partway in elucidating matters of correlation and succession. Furthermore, the fact that the original collections examined by Diener are stored at the Geological Survey of India, Calcutta, appears to have been used by experts as an excuse for not re-examining the collections, although they are in good order. I have spent considerable time at Calcutta, rechecking Diener's collections, and have been able to add new material to help underpin Oppel's and Diener's species.

Stratigraphy

A prime area for Anisian in Nepal lies in the Manang region north of the Annapurna Range in central Nepal (Bordet et al., 1971, 1975; Fuchs et al., 1988; Waterhouse and Shi, 1991). The Anisian extends from the Nar district into the valley of the Marsyangdi River, South of Mt. Chulu, and across the Plateau of Lakes to the divide near Mesokanto Pass, and thence descends to the valley of the Kali Gandaki River (Fig 1-3). Here, Scythian ammonoid faunules are very well developed, commencing with fossils of the *Otoceras woodwardi* Zone at the base of the Panjang Formation in the Manang Group, and concluding with the *Keyserlingites costatus* Zone in the Langpo Member of the Gungdang Formation, at the top of the Manang Group. The *Keyserlingites* faunule is unquestionably Scythian in age, and contains Scythian species of genera such as *Dagnoceras*, *Preflorianites*, *Nordophiceras*, *Svalbardiceras, Prohungarites, Proptychitoides* and *Prosphingites*. It overlies a much richer ammonoid faunule in the Kone Member, with *Subcolumbites*, and many species shared with late Scythian Mediterranean faunules. The Anisian commences in the upper Gungdang Formation, in the Kaisang and Tangje Members, followed by a very diverse faunule in the Thorong Member, and meagre faunule at the top of the Gungdang, in the Phukung Member. Anisian ammonoids are less common but well preserved, in the overlying lower beds of the Mukut Group.

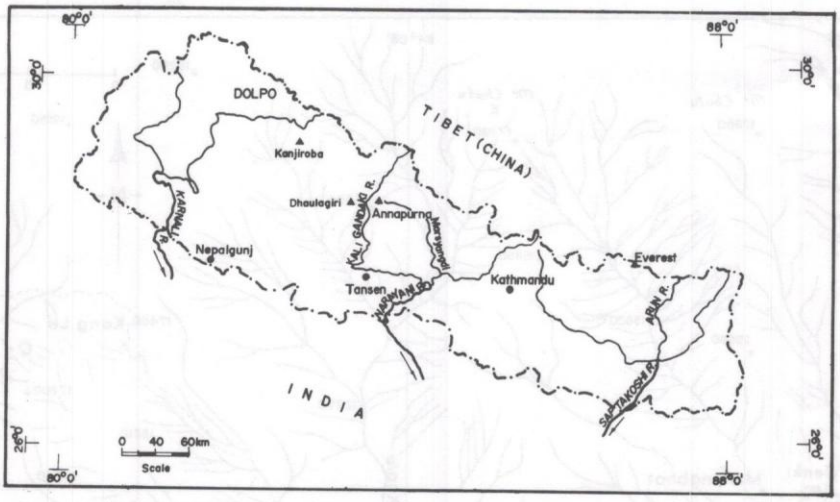

Fig 1: The Kingdom of Nepal, with Tibet to the north, showing some major rivers. The Anisian ammonoids described in this study come from Dolpo, north of Kanijiroba, and also from the Kali Gandaki valley north of Annapurna and along the north side of the Marsyangdi River.

In western Dolpo, Scythian is moderately well developed, as the Kalkya Group, with Scythian found in the Panjang and Yangar Formations, and most of the Sungjar Formation. Some early Anisian ammonoids occur at the top of the Sungjar Formation (Table 1). The overlying Mukut Group (=Mukut-Kalk of Fuchs, 1967) has scattered Anisian ammonoids, and faunules have been collected from black shale and nodular limestone.

Table 1. Lithostratigraphic units with Anisian ammonoids, indicated by asterisk or query.

International Stage	Group Manang	Member Manang	Group Dolpo
Illyrian		?	Mukut*
Pelsonian	Mukut	?	
Bithynian		*	
Aegean		*	
		Phukung*	
Manasluan	Manang	Thorong*	Kalkya*
		Tangje*	
		Kaisang*	

Faunal Succession

Manasluan Stage

The Kaisang Member above the *Keyserlingites costatus* Zone contains a new species of *Grambergia*, with *Ananorites, Tienjunites*, and new forms, followed by another faunule in the Tangje Member, with the same *Grambergia*, and also *Qilianshanites*, *Pearylandites*, *Sturia*? and other species, the two suites forming a distinctive *Grambergia* zone. The overlying Thorong Member has a very diverse ammonoid assemblage, including species *of Leiophyllitids, Qilianshanites, Tienjunites, Lenotropites, Gangadharites, Arctohungarites, Smithoceras, Norites, Epiczekanowskites, Longobardites, Stenopopanoceras* and probable *Neopopanoceras*, with primitive allies of *Beyrichites* and *Hollandites*. These faunules are clearly Anisian, but are older than the Aegean Stage, hitherto regarded as basal Anisian. The Nepal ammonoids and beds are therefore provisionally assigned to a new "Manasluan Stage", named after the Manaslu (8000 m), visible to the east from the type section on the south-east rib of Mt. Chulu (fig. 4).

A few species in the Sungjar Formation of western Dolpo are correlative, and include *Stenopopanoceras* and *Neopopanoceras*? Further afield, likely correlates include the early faunules described as the *Lenotropites qinghaiensis* Subzone 1 a by Wang (1985) and He et al. (1986) from the

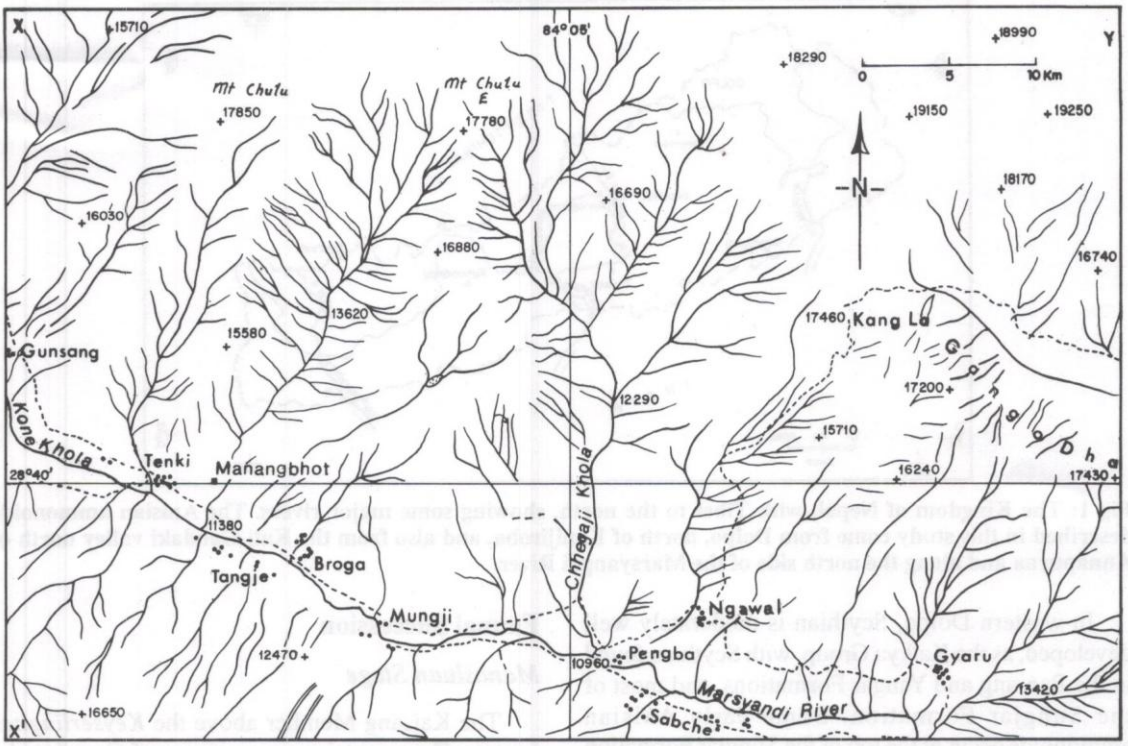

Fig. 2: General map of upper Marsyangdi valley in Manang region (spot heights in feet).

Naocangjianguo section in Maduo County, central Qinghai, sharing *Tienjunites*, *Qilanshanites*, and genera close to *Lenotropites* and other forms. The apparent presence of *Neopopanoceras* in Nepal suggests an approach to the *Neopopanoceras haugi* faunule from the Union Wash Formation of Inyo Mountains, California, with elements in the Lower Member of the Prida Formation in Nevada (Hyatt and Smith, 1905; Bucher, 1989). The *Karangatites-Grambergia taimyrensis* faunules of northeast Siberia are also likely to be correlative, in part.

Aegean Stage

The Phukung Member at the top of the Manang Group contains two species of *Paracrochordiceras*, with several other forms, including species of *Malletoptychites*, *Japonites*, *Hollandites*?, *Tienjunites* and other genera. Early levels in the Mukut Group contain allied or identical species, including the same two *Paracrochordiceras*, with species of *Arctohungarites*, *Hollandites*, *Ziyunites*, and *Leiophyllites pitamaha* (Diener). This level was not recognised in the Himalaya by Diener.

The type Aegean at Chios, Greece, is characterized by *Paracrochordiceras* (in the lower, major ammonoid level), and shares *Ziyunites* and other forms. Bed 1 in a block at Nifoekoko, Timor also has *Paracrochodiceras* (Welter, 1915). There are some strong links with the Ziyun faunule of Guizhou, China, through ammonoids that Wang (1978) ascribed to Scythian, but are mostly of early Anisian affinities. The richest *Paracrochordiceras* associations are found at four levels in the Fossil Hill Member of the Humboldt Range, Nevada (Bucher, 1989).

Bithynian Stage

Above the *Paracrochordiceras* beds in the lower Mukut Group of Manang, comes a small *Gymnites depauperatus* Diener faunule, with *Japonites asseretoi* Fantini Sestini, *Leophyllites pitamaha* (Diener), and a few other species. Species are much more numerous in overlying levels, *including Keyserlingites cf. parhari* (Diener), *Keyserlingites spp.*, *Ananorites*, *Leiophyllites confucii* (Diener), *Paradanubites kansa* (Diener), *Semibeyrichites* sp.,

Hollandites vyassa (Diener), *Anagymnotoceras* sp., *Aristoptychites sahadeva* (Diener), *Gymnites vasantasena* (Diener), *G. sankara* (Diener), *Japonites meridianus* (Welter), *Bukowskiites* sp., *Ussurites hara* (Diener), *U. kingi* (Diener) and *U.* cf. *arthaberi* (Welter). A number are shared with Diener's "Lower Muschelkalk" of the northwest Himalaya and Tibet, including *Keyserlingites* spp., *Paradanubites kansa, Leiophyllites confucii, Hollandites vyassa, Gymnites* aff. *sankara, Ussurites hara*, and *U. kingi*. *Gymnites depauperatus* occurs just below in Nepal. But several species at this level in Nepal are also found in Diener's "Upper Muschelkalk", suggesting that either the "Lower" and "Upper Muschelkalk" are rather close in age, or that species had a lengthy time range, or that there

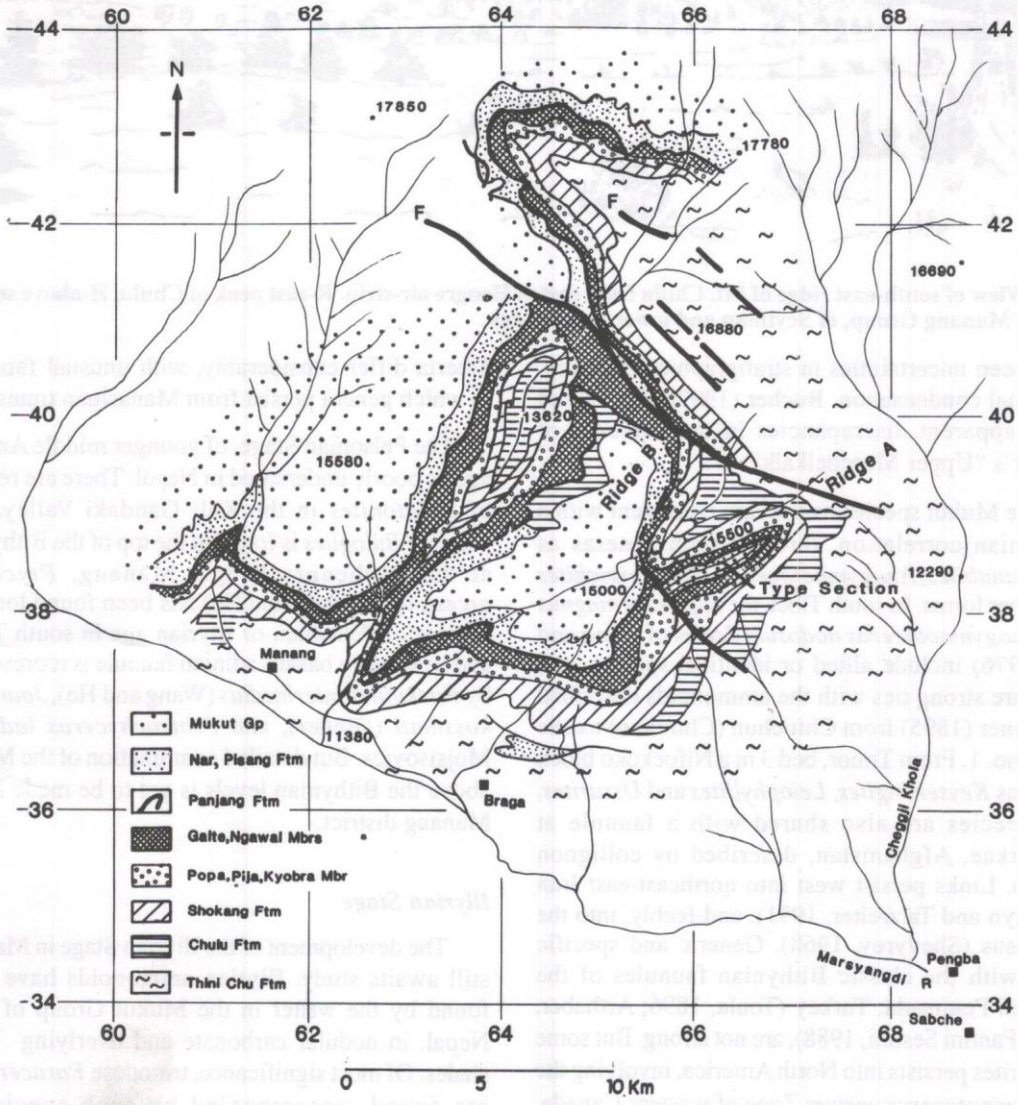

Fig 3: Geological map of the area north of Manang and Braga, by the writer, based on survey in 1981 with input from Mandala Trekking Map. The Popa to Ngawal Members (Mbr) are in the Senja Formation, and include the late Permian Marsyangdi Formation. Within the Triassic Manang Group, the Panjang Formation includes the Khangsar Formation and the Nar, and Pisang Formations include the Gungdang Formation. Spot heights (in feet) 17850 and 17780 indicate Peaks of the Chulu massif.

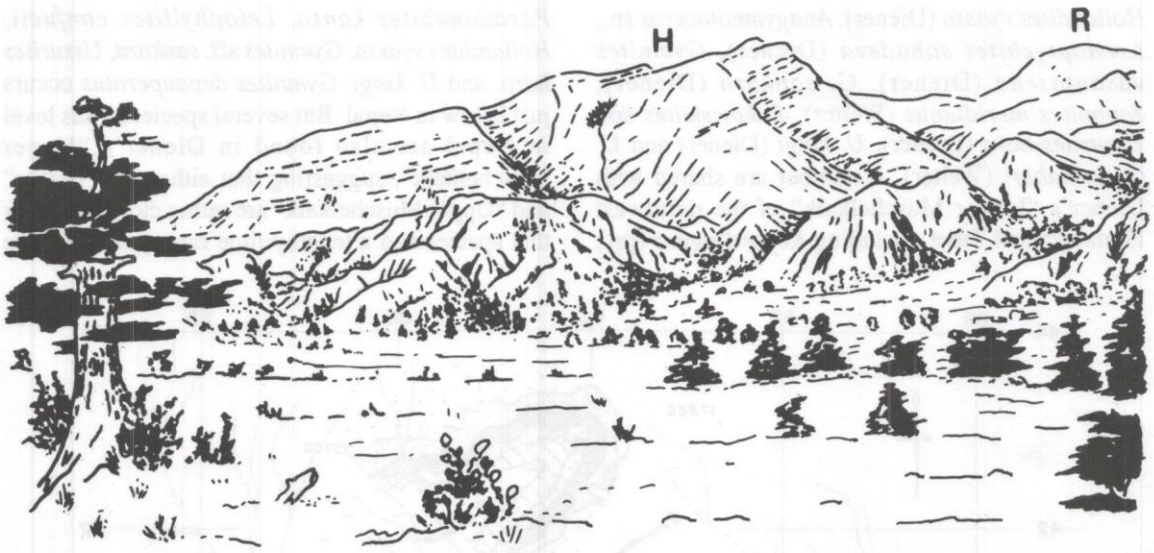

Fig 4: View of south-east ridge of Mt. Chulu from east of Hongre air-strip. R-east peak of Chulu, H-above section for the Manang Group, of Scythian and lower Anisian age.

have been uncertainties in stratigraphic collecting, or faunal condensation. Bucher (1992b) also noted some apparent discrepancies in the make-up of Diener's "Upper Muschelkalk".

The Mukut species overall are consistent with a Bithynian correlation, through such generas as *Paradanubites*, *Anagymnotoceras*, *Semibeyrichites* and other forms. In south Tibet, the *Japonites magnus* and *Anagymnotoceras nodosum* Zones of Wang and He (1976) include allied or identical species, and there are strong ties with the ammonoids described by Diener (1895) from Chitichun (Chirchun) exotic block no. 1. From Timor, bed 3 in a Nifoekoko block contains *Keyserlingites, Leiophyllites* and *Ussurites*, and species are also shared with a faunule at Kamarkae, Afghanistan, described by collignon (1973). Links persist west into northeast-east Iran (Krystyn and Tatzreiter, 1991), and feebly, into the Caucasus (Shevyrev, 1968). Generic and specific links with the classic Bithynian faunules of the Kokaeli Peninsula, Turkey (Toula, 1896; Arthaber, 1914; Fantini Sestini, 1988), are not strong. But some similarites persists into North America, involving the *Anagymnotoceras varium* Zone of western Canada, (Silberling and Tozer, 1968; Mclearn, 1969) and *Acrochordiceras hyatti* Zone, especially the *intornites mctaggarti* subzone at base, in Nevada (Bucher, 1992b). Correlative sequences in northeast Siberia differ considerably, with unusual faunules in which genera persist from Manasluan times.

The Pelsonian Stage, of younger middle Anisian age, is poorly understood in Nepal. There are reports of *Balatonites* in the Kali Gandaki Valley, and possible *Bulogites* is found at the top of the Bithynian at the Puchenpra Ridge, Manang. *Ptychites arcestoides* (Wang and He) has been found loose, a species of Pelsonian or Illyrian age in south Tibet, and a probably basal Ladinian faunule is represented by *Rimkinites intermedius* (Wang and He), *Joannites kossmati* (Diener), and *Protrachyceras ladinum* Mojsisovics. But detailed examination of the Mukut above the Bithynian levels is yet to be made in the Manang district.

Illyrian Stage

The development of the Illyrian Stage in Manang still awaits study. Illyrian ammonoids have been found by the writer in the Mukut Group of west Nepal, in nodular carbonate and overlying black shales. Of most significance, trinodose *Paraceratites* are found, accompanied by such species as *Ananorites monticola* (Diener), *Pseudodanubites dritarashtra* (Diener), *Beyrichites khanikofi* (Oppel), *Hollandites onustus* (Oppel), *Haydenites hatschetki* (Diener), *Gangadharites proximus* (Oppel),

Ptychites rugifer (Oppel), *Malletoptychites impletus* (Oppel), *Flexoptychites cochleatus* (Oppel), *Discoptychites* sp., *smithoceras* sp., *Gymnites salteri* (Beyrich), *Anagymnitoides torrensi* (Diener), and *Monophyllites sphaerophyllus* (Hauer).

The faunules are dominated by *ptychites* and *Discoptychites*, and are assigned to the *ptychites rugifer* Zone. A number of the species originally described from the Himalaya by Oppel (1863-5) have been found. The correlation originally favoured by Diener, between his "Upper Muschelkalk" and the *trinodosus* level of the Muschelkalk in Europe is strongly endorsed, but there are a few ties with the Bithynian of Manang, and a number of Diener's "Upper Muschelkalk " species have not been refound. The zone is apparently correlative with what wang and He (1976) termed the *Ptychites rugifer* Zone of south Tibet, but their *rugifer* is more accurately identified with p. *tibetanus* Mojsisovics. Species are found also in Afghanistan (eg. Kummel and Erben, 1968; Collignon, 1973).

SUMMARY OF SIGNIFICANT ASPECTS OF ANISIAN AMMONOIDS IN NEPAL

1. Substantial Nepal faunules of early Anisian age lie above late Scythian, and below Aegean, to mark a distinctive suit with two zones, named after *Grambergia* and *Stenopopanoceras*. They are provisionally referred to the new Manasluan stage, with type section for rocks and faunules on the southeast Chulu ridge, Manang. Correlative faunules are found in central Qinghai (Zone 1a "*Lenotropites*" *qinghaiensis*), Siberia (*Karangatites* etc.) and California-Nevada (*Neopopanceras haug*).

2. The controversial *Neopopanoceras haugi* Zone of Inyo Mountains, California, deemed to be Scythian by recent North American authorities, and Anisian by many others, is Anisian, i.e. Manasluan to judge from Nepal evidence.

3. The Aegean Stage is moderately well developed in Nepal, with some 20 species, including two species of the diagnostic genus *Paracrochordiceras*.

4. The faunule of Ziyun, Guizhou, China, deemed to be Scythian by Wang (1978), includes many Aegean elements, and is mostly if not entirely of Anisian age.

5. The Bithynian Stage is well developed in Manang, and includes Diener's "Lower Muschelkalk" ammonoids of northwest Himalaya, as well as some species considered by him to be of "Upper Muschelkalk".

6. *Keyserlingites* is found in the Bithynian faunules of Nepal, accompanied by species of unarguable Anisian age, such as *Paradanubites, Hollandites, Gangadharites, Anagymnotoceras, Semibeyrichites, Gymnites, Ussurites*, etc. This disproves the claims by Tozer (1967, 1971) Silberling and Tozer (1968), and Bucher (1989) that *Keyserlingites* is restricted to late Scythian, and that Diener's "Lower Muschelkalk" was Scythian, not Anisian. That is not to say that the Anisian *Keyserlingites* will never be found to show some subtle difference from Scythian *Keyserlingites*. The genus *Durgites* has long been proposed for such species. But Tozer (1967) found it impossible to distinguish the two suites, and distinction must be based on morphology, not age. Whatever the taxonomy, the Himalayan "Lower Muschelkalk" is Anisian.

7. The Pelsonian Stage is so far poorly known throughout the Himalaya, but I believe this is likely to revealed by further field work and study.

8. The Illyrian Stage is represented in the lower Mukut Group of western Dolpo, with trinodose *Paraceratites*, and various species originally described by Oppel (1863-5). A number of species recorded by Diener (1907) from the "Upper Muschelkalk" are present.

9. The full nature of Diener's "Upper Muschelkalk" is not fully clear. Nepal evidence suggests that some of Diener's "Upper Muschelkalk" species are found in the Nepal Bithynian, and more in the Nepal Illyrian. Many species have not been found in Nepal. There is clearly need for further study of these faunules, and their stratigraphic ranges in northwest India, because it seems possible that distinct biostratigraphic levels are involved in Diener's "Upper Muschelkalk".

10. Bucher (1992a,b) considered that the "Upper Muschelkalk"was correlative with the

Acrochordiceras hyatti and *Nevadisculites taylori* Zones of Nevada, that is Bithynian, of middle, not late, Anisian age. He pointed to some genera, such as *Nevadisculites, Hollandites, Favreticeras, Pseudodanubites* and others found only at middle Anisian levels in Nevada. Although there is no reason to suppose that these genera were similarly restricated in age range in othe parts of the world, and it appears likely that Diener's "Upper Muschelkalk" contains possible Bithynian and Pelsonian, as well as Illyrian ammonoids. But some of the revisions proposed by Bucher (1992a,b) for Diener's identifications, including *Haydenites*, and trinodose ammonoids cannot be sustained by first hand examination of the types, or careful scrutiny of the figures.

CONCLUSIONS

The Anisian of the Himalayas does range well beyond the circumscribed middle Anisian envisaged by some North American workers, such as Tozer and Bucher, and in some respects, the Himalayan Anisian stands proud, fuller than that of Europe or Mediterranean, or South Primoyre, more diverse than the sequences of Siberia, and more complete for basal Anisian than North America. But there are gaps in the work done, so the representation of the Pelsonian Stage, and full details of the late Anisian and basal Ladinian are still poorly understood.

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