

Comparisons and correlations

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dence, this is by now the unique superpositional relationship available between *Mulleri* and *Caurus* Zones. It must be added that no fault that would obscure the succession was noticed from loc. HB 88 upwards, until the next overlying bedrock localities of Lower *Hyatti* age. The beds from which the float *Caurus* Zone block is derived could unfortunately not be precisely relocated, however there is no other possible provenance than from the strata bracketed between the *Mulleri* and Lower *Hyatti* Zones.

In Bloody Canyon, where the *Caurus* Zone occurs on strike about 30 to 40 m above the *Japonites welteri* beds, the *Mulleri* Zone has so far not been found in sequence. However, these apparently unfossiliferous strata leave ample room for the *Mulleri* Zone.

If not formally demonstrated by first order evidence, occurrence of the *Mulleri* Zone below the *Caurus* Zone is nevertheless the most likely. This well diversified fauna is here formally introduced at zonal rank. *Silberlingites*, *Groenlandites* and *Caucasites* are the most common forms of the *Mulleri* Zone.

Caurus Zone

Index species: *Lenotropites caurus* (McLEARN)

Type locality: East limb of anticline west of Mile Post 375, Alaska Highway, north-east British Columbia, Toad Formation (TOZER 1967).

Occurrence: USGS Mesozoic loc. M2367, M2358, M2828 (SILBERLING & WALLACE 1969); loc. HB 51, 74, 180, 201, 225, 247, 252, northern Humboldt Range (Fossil Hill Member, Prida Formation).

The *Caurus* Zone was first recognized in the northern Humboldt Range sequence by SILBERLING & WALLACE (1969). Taxonomic treatment of this low diversity assemblage was given later, by SILBERLING & NICHOLS (1982). *Japonites* cf. *J. surgriva*, *Groenlandites merriami* and *Ussurites detwilleri* are here newly reported from this zone.

4. Comparisons and correlations

Biochronologic comparisons are summarized on Table 2. This is a deliberate selection of the most relevant Lower Anisian sections. Absence of manifest condensation and vertical continuity (i.e. lower and upper limits respectively in sequence with Spathian and Middle Anisian faunas) formed the prime criteria along which data were selected. This leads to a critical examination of the available literature, followed then by acceptance of a few sections only. Data from Hallstatt-type limestone exotics (Himalayan crags, DIENER 1895; Nifoekoko block of Timor, WELTER 1915) are consequently among those that were discarded. Ammonoids collected from these exotics are interesting from the point of view of systematics but they will remain of equivocal biochronologic significance as long as the internal stratigraphy of these blocks is not adequately and cautiously reinvestigated.

When both unreliable and spotty data are taken out, the synthetic chart merely highlights the poor knowledge of the Lower Anisian substage which mainly consists of gaps and unrelated faunas. Vertical lines on Table 2 emphasize the uncertainty about the correlation of either individual or groups of biochronologic units.

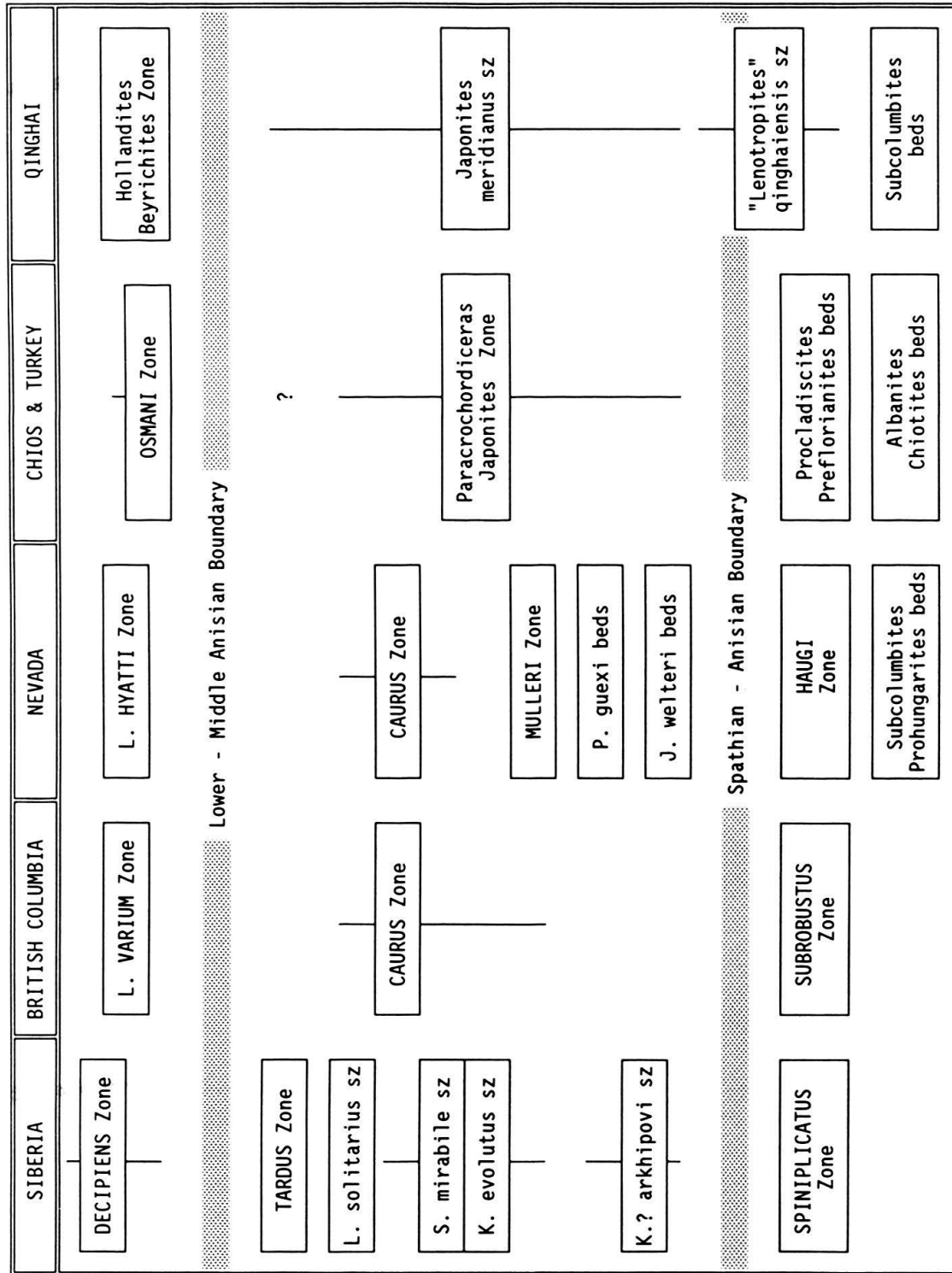


Table 2: Lower Anisian zonation and correlations, with illustration of the substage boundaries.

The history of the Lower Anisian ammonoids was surely complex enough to do without this kind of confusion that arises from forgetting the fossil record is far from complete. Especially in the present study, what one has to deal with is scarcely something other than a few snapshots scattered simultaneously over time and huge distances.

It is a truism to say that correlating several successions requires having a minimum of common elements between them – but one must face this as being an attribute not yet satisfied by the meager amount of Lower Anisian data. The use of concurrent-range-type units, an intrinsically discontinuous approach, has among its merit of faithfully reflecting the natural gaps of the record. Any other non-discrete method would inevitably discount those gaps that may eventually be found to contain new faunas. This approach equally tolerates much flexibility and adaptability in splitting or lumping biochronologic units as prompted by data currently made available.

The *Haugi* Zone and its correlatives

First of all, let us consider the controversial status of the *Haugi* Zone, for it provides the safest link around the Lower-Middle Triassic boundary. An often debated problem is the stage assignment of this zone, which is alternatively regarded as late Spathian (TOZER 1967, 1981b; SILBERLING & TOZER 1968; SILBERLING & WALLACE 1969; GUÉX 1978; WANG 1985) or as early Anisian (SPATH 1934; SHEVYREV 1968; KUMMEL 1969; DAGYS and others 1979; ASSERETO and others 1980; JACOBSHAGEN & NICORA 1981; DAGYS 1988b).

What is of primary importance is finding the correlatives of the Upper *Haugi* Zone. Co-occurrence of *Olenikites*, *Preflorianites*, *Isculitoides* and *Keyserlingites subrobustus* warrants correlation with the *Subrobustus* and *Spiniplicatus* Zones. The first reported occurrences of *Olenekites* and *Preflorianites* support this correlation which was formerly demonstrated by GUÉX (1978).

The Siberian Lower Anisian succession was hitherto correctly thought to be more comprehensive than the Nevada *Caurus* Zone solely (DAGYS 1988b). However, to bring to the fore what was then a gap within the Nevada record does not at all imply the next underlying *Haugi* Zone correlates with the lower part of the *Taimyrensis* Zone (i.e. *Karangatites? arhipovi* and *Karangatites evolutus* Subzones) as inferred by DAGYS (op. cit.). Anyway, the three newly recognized Lower Anisian biochronologic units now fitted into the *Haugi-Caurus* interval cut short any bias of that kind.

Next, DAGYS (op. cit.) backed up his correlation with the presence of “*H. yatesi*”, “*A. inyoense*” and *Karangatites* in the *Haugi* Zone, three ammonoids allegedly of Anisian affinity. As already mentioned, such a statement does not any longer apply to “*H. yatesi*” and “*A. inyoense*”. On the other hand, *Karangatites* actually appears as the single form shared by both the Upper *Haugi* Zone and lower part of the *Taimyrensis* Zone – a somewhat tenuous tie for correlation... Various occurrences of *Karangatites* are better explained in assuming this genus ranges from the *Haugi* Zone up to the *Taimyrensis* Zone, i.e. across the Lower-Middle Triassic boundary.

In the initial proposals for the Agean substage by ASSERETO (1974, p. 37), there is absolutely no mention of the *Haugi* Zone among the correlatives of the *Paracrochordiceras-Japonites* beds of Chios. Whatever his conception of the Lower Anisian was,

this was not of accidental character because ASSERETO (op. cit.) himself placed the Nevada *Caurus* Zone as an equivalent of the *Paracrochordiceras-Japonites* beds.

Later papers dealing with the Hallstatt limestone section of Chios did not reflect Assereto's original view which became somewhat distorted after his death. Despite the condensed faunas and fissure filling problems that were known to attend Hallstatt limestones biochronology (KRYSTYN and others 1968, TOZER 1971, WENDT 1973), subsequent contribution by ASSERETO, JACOBSHAGEN, KAUFFMANN & NICORA (1980), for which the late Assereto cannot be blamed, includes an evidently unnatural fauna into the Chios Agean substage. The remaining authors already suspected locality CH 258 of being a mixed assemblage, for their section G (Fig. 4, p. 722) conspicuously shows that CH 258 comes from a fissure filling. From taking into account the Spathian-Anisian condensed locality CH 258 (*Procarnites*, *Leiophyllites*, *Eophyllites*, *Psilocladiscites*, *Cladiscitidae* n. gen. n. sp., *Preflorianites*) arose a pervasive circular argument (ASSERETO and others 1980, p. 727–728; JACOBSHAGEN & NICORA 1981). These authors managed to compel equivalence between CH 258 and the *Haugi* Zone in assuming that earliest Agean faunas are ought to contain both Spathian and Anisian forms. In the Chios context, this statement is largely biased because of condensation, nor does it apply to the *Haugi* Zone (here come "*H.* *yatesi* and "*A.* *inyoense* again!). As felt by FANTINI-SESTINI (1981, p. 46), the ultimate snag about this rigged correlation is that it leads inevitably to assign both the *Subrobustus* and *Spiniplicatus* Zones to the Anisian stage...

The *Haugi* Zone is regarded as Spathian by WANG (1985) but with a different significance in that it would represent the upper part of the *Subcolumbites* beds. This assertion does not hold up when confronted with the Nevada succession where the *Haugi* Zone overlies the *Subcolumbites* beds (SILBERLING & WALLACE 1969). These two units are readily distinguishable (GUEx 1978) and one can only reiterate here that it is unfounded to merge them. Such an additional misadventure of the *Haugi* Zone is merely symptomatic of the absence of any readily recognizable correlative in the Naocanjiaoguo section (Maduo, Qinghai) of HE and others (1986) and WANG (1985).

Recognition of a *Haugi* Zone equivalent at Ziyun, Guizhou (WANG 1978) is obscured by condensation, for this single level yielded ammonoids of both Spathian and Anisian ages as noticed by TOZER (1981b, p. 407–408; see also ASSERETO and others 1980, WANG 1985).

The Lower Anisian succession

The Paracrochordiceras-Japonites beds (*Ugra* Zone) of chios

Data from Nevada demonstrate the *Paracrochordiceras-Japonites* pair ranges throughout the entire succession. Among low paleolatitude faunas, this means that this couple characterizes most of what is presently known of the substage and hence is not suitable for correlations at zonal rank. Even when the *Paracrochordiceras-Japonites* faunas are found to contain the distinctive genus *Aegeiceras* (Chios, Middlemiss Crag near Chitichun #1, bed #2 of Nifoekoko block), they correlate with the whole interval from the *J. welteri* beds to the *Caurus* Zone, without further precision. Wherever *Aegeiceras* is reported from, it has either an ambiguous stratigraphic occurrence (Hallstatt-type limestones from either exotic blocks or undisturbed sequences) or is not

accurately located in the sequences (e.g. Caucasus, see SHEVYREV 1968 [= *Japonites ugra*]; also Lilang in Spiti, see DIENER 1907).

Paracrochordiceras-Japonites-Aegeiceras could possibly characterize a reproducible association (however restricted to the biochronologically suspect Hallstatt limestones i.e. Chios, Chitichun and Nifoekoko) but its biochronologic position *within* the Lower Anisian substage remains as yet unravelled.

The Himalayan "Lower Muschelkalk"

The *Paracrochordiceras-Japonites* faunas were commonly believed to correlate with the *Keyserlingites dieneri* beds of the Himalayas (Spiti and Painkhanda). This raises the question of the Himalayan "Lower Muschelkalk" of DIENER (1895, 1907, 1912) again. There are quite opposite views about the age of these *Keyserlingites* (= "*Durgaites dieneri*") beds which are classed either in the Anisian (DIENER op. cit.; SPATH 1934; KUMMEL 1969; ASSERETO and others 1980; WANG 1985) or in the Spathian (TOZER 1965, 1971, 1981b; SILBERLING & TOZER 1968). For the lack of any pertinent recent data, no definite age can be objectively drawn from DIENER's lists (1907, p. 131; 1912, p. 62–63), but there is reason to believe that his "Lower Muschelkalk" fauna from both Spiti and Painkhanda encompasses ammonoids of distinct stratigraphic occurrences. For instance, presence of an unquestionable *Hollandites* (*H. vyasa*, DIENER 1895, 1907) amidst the *Keyserlingites dieneri* beds is hardly explainable for this genera is characteristic of early Middle Anisian faunas. On the other hand, presence *Dalmatites ropini* (DIENER 1907), whose generic attribution appears correct, would indicate the *Keyserlingites dieneri* beds also contain at least one typically early Spathian form. In front of such inconsistent association, one can't help thinking that both Spiti and Painkhanda "Lower Muschelkalk" faunas as described by DIENER (1907, 1912) have an unnatural character due either to condensation or to inaccurate sampling. In view of the collecting methods that were practiced at Diener's time, it wouldn't be surprising as a matter of fact, that his composite "Lower Muschelkalk" was mistakenly based on several different horizons. The recent contribution by NICORA and others (1984) on the western continuation of the Triassic belt into the Zaskar area does not supply decisive arguments about this question.

Incidentally, "*Stacheites webbianus*" (DIENER 1907, p. 91, Pl. 5, Fig. 6) which is reported from the same beds is here regarded as a khvalinitid instead of a dinaritid. "*S. webbianus*" is evidently allied to *Metadagnoceras* and *Alanites* but is distinguished from both by its less indented suture line, absence of ribs nor folds and early acquisition of tabulate venter.

The Lenotropites-Japonites Zone of Qinghai (China)

Valuable information on the Guizhou Lower Anisian was obtained by WANG (1985) and HE and others (1986). Their Naocangjiangou section (Maduo County) records what is termed the *Lenotropites-Japonites* Zone in sequence with the Spathian *Subcolumbites* beds and Middle Anisian faunas (*Beyrichites-Hollandites* Zone). This *Lenotropites-Japonites* Zone is subdivided in ascending order into the *Lenotropites qinghaiensis* and *Japonites meridianus* Subzones.

As quoted HE and others (1986, p. 262) "the lower subzone is characterized by the abundance of *Longobarditidae*". From the illustrations given by these authors, there is no convincing evidence that neither *Lenotropites*, nor *Grambergia*, *Groenlandites*, *Pearylandites* and *Arctohungarites* occur in the "*Lenotropites*" qinghaiensis Subzone. The alleged *Lenotropites*, *Arctohungarites* and *Groenlandites* should preferably be assigned to *Qilianshanites* WU. Furthermore, recognition of *Arctohungarites* should be substantiated by illustration of its diagnostic tabulate body chamber. The specimens attributed to *Pearylandites* do not have the coronate innermost whorls diagnostic of that genus but have more affinity with *Tienjunites* WU, a possible junior synonym for *Subolenites* ZAKHAROV which is of Spathian age. *Qilianshanites* and *Tienjunites* are both described from the lower part of the Qierma Member of the Junzihe Formation in the Qilian Mountains (WU, in YANG and others 1983). The beds with *Qilianshanites* and *Tienjunites* are only known to occur in sequence above beds with *Tirolites* and are therefore very weakly age-constrained, especially at their upper limit. They are regarded as Pelsonian (latest Middle Anisian) in age by WU (in YANG and others 1983), a statement which apparently has no sound foundation. With the exception of *Norites*, there is no one unequivocal Lower Anisian ammonoid reported from the "*Lenotropites*" qinghaiensis Subzone.

Conversely, a Lower Anisian age assignment of the *Japonites meridianus* Subzone is not ambiguous for it contains *Megaphyllites*, *Japonites*, *Psilosturia*, *Paradanubites*, and true *Grambergia*. Presence of *Paracrochordiceras* in the *Japonites meridianus* Subzone cannot be ruled out for "*Paradanubites*" phyllus HE has an acrochordiceratid-like suture line and apparently tuberculated inner whorls (HE and others 1986, Text-Fig. 26 d-e; Pl. 6, Fig. 28). *Paracrochordiceras* is quite often hardly distinguishable from the approximately coeval *Paradanubites* but the latter distinctively lacks the tuberculated inner whorls.

Representatives of the *Keyserlingites dieneri* group are seemingly a prominent feature of the *Japonites meridianus* Subzone. Granted that data of HE and others (1986) are reliable, it would so far provide the unique record of *Keyserlingites* from strata of undoubted Anisian age. In this view, it implies *Keyserlingites* ranges across the Lower-Middle Triassic boundary (WANG 1985). Another side of the question would equally demand some more clarification. As previously seen, the northern Humboldt Range record reveals *Keyserlingitinae* might range across the Lower-Middle Triassic boundary. They are represented there by *Pseudokeyserlingites*, a distinctive genus which was described from Qinghai as "*Gymnotoceras*" sp. (WANG and others 1979, p. 31, Pl. 7, Figs. 27–34, see also systematic descriptions). In addition to the fact that the *Pseudokeyserlingites guexi* beds might inevitably have some correlatives in the Qinghai sequence, the exact occurrence and its superpositional relationship with (or within) the *Japonites meridianus* Subzone would probably give some clues about the *Keyserlingites* question.

Interpretation of Qinghai section still remains very conjectural but the previous remarks lead us to speculate that the "*Lenotropites*" qinghaiensis fauna might be included in the time interval bounded by the *Subcolumbites* beds and the *Japonites welteri* beds. Whether the "*Lenotropites*" qinghaiensis beds should be assigned to earliest Lower Anisian or to latest Spathian cannot be definitively answered at the present state of knowledge. The *Japonites meridianus* Subzone solely can be roughly correlated with other Lower Anisian faunas.

British Columbia

In its original definition (TOZER 1967, McLEARN 1969), the *Caurus* Zone is probably more comprehensive than the *Caurus* Zone as recognized by SILBERLING & WALLACE (1969) and SILBERLING & NICHOLS (1982) in the northern Humboldt Range. The Canadian *Caurus* Zone may presumably include equivalents of the *Mulleri* Zone (*Grambergia*, *Paracrochordiceras* cf. *P. americanum*) but do not overlap the time interval covered by the *Japonites welteri* and *Pseudokeyserlingites guexi* beds.

Further refinements in correlating the British Columbia succession with that of Nevada should await publication of significant progress made by TOZER (in prep.). According to the latter (oral com., 1988), "*Arctohungarites*" *bufonis* (McLEARN 1969, p. 45, Pl. 7, Figs. 9–11) is more closely allied to *Azarianites* (DAGYS 1987) than to *Arctohungarites*. This view is endorsed here and consequently, occurrence of *Arctohungarites* in the *Caurus* Zone is no longer considered valid.

Siberia

The biochronology of Siberia Lower Anisian has been summarized by DAGYS (1988b). A more detailed faunal inventory is available through the contributions by DAGYS and others (1979) and DAGYS & KAZAKOV (1984).

Subzonal scheme of the *Taimyrensis* Zone is partly based on differences at the species level that may perfectly well have regional significance but these subzonal subdivisions are somewhat altered when based on genera only. For instance, the *Karangatites? arkipovi*, *K. evolutus* and *Stenopopanoceras mirabile* Subzones could thus be merged into a single unit.

On the other hand, the *Lenotropites solitarius* subzone of the *Taimyrensis* Zone and *Tardus* Zone remain essentially unchanged. According to VAVILOV & ARKADIEV (1986), *Taimyrites* is to be added to the *Tardus* Zone. Next, occurrence of acrochordiceratids in the *Taimyrensis* Zone (DAGYS and others 1979, p. 39; DAGYS 1988b, Tabl. 1) may not be taken for granted in that they have hitherto never been illustrated. As suggested by VAVILOV & ARKADIEV (1986), the specimens discovered by DAGYS may possibly be referred to danubitids. Indeed, *Danubites tozeri*, which was first described from the Spitsbergen *Caurus* Zone (KORCHINSKAYA 1982), has been found to occur in the *Stenopopanoceras mirabile* subzone of Cape Tsvetkova.

It is well known that the Siberia sequence has much in common with that of British Columbia and secondarily with these of Ellesmere Island, Peary Land (North Greenland) and Spitsbergen (TOZER 1967; KUMMEL 1953; TOZER & PARKER 1968; KORCHINSKAYA 1982), but less rough correlations necessitate refinement of the key-succession of the British Columbia Lower Anisian. However, one can surmise that the time intervals represented by the *Karangatites? arkipovi* Subzone as well as the *Japonites welteri* and *Pseudokeyserlingites guexi* beds are pre-*Caurus* in age. Though the *Tardus* Zone is the only Siberia unit from which *Lenotropites* is reported, co-occurrence of early representatives of *Czekanowskites* and *Arctohungarites* impedes correlation with the Canadian *Caurus* Zone. On the other hand, presence of *Lenotropites* precludes correlation with the Lower and Middle *Varium* Zone of British Columbia. The *Lenotropites*-*Czekanowskites*-*Arctohungarites* concurrent interval is thus inevitably post-

Caurus and pre-Middle Anisian in age and therefore has no exact correlative known from some place else. The Lower-Middle Triassic boundary has customarily been placed between the *Spiniplicatus* Zone and the *Karangatites* beds of the *Taimyrensis* Zone (DAGYS and others 1977), what is consistent with both Canada and Nevada.

Other various Lower Anisian ammonoids occurrences

Lower Anisian ammonoids have been reported from several section of lesser importance. In Central Iran, a few Lower Anisian ammonoids were found in the Alam Formation (TOZER 1972a). *Ugraites*, a genus generally thought to be of Lower Anisian age and *Caucasites* are both listed in the “second ammonoid assemblage” of SHEVYREV (1968, p. 34). This suggests that Lower Anisian may potentially be recognized in the sequence of northwestern Caucasus, for the only unquestionable available occurrence of *Caucasites* is that from the *Mulleri* Zone. Lower Anisian is possibly present in the poor faunas known from the Khabarovsk area. The *Karangatites* beds and the rather age-ambiguous *Leiophyllites pradyumna* Zone are reported from this area by OKUNEVA (1976) and OKUNEVA & JELEZNOV (1976). Co-occurrence of *Karangatites* with *Claraia* cf. *C. aranea* (TOZER) would illustrate the supposed long range of this ammonoid for *Claraia aranea* is considered as diagnostic of the late Spathian *Subrobustus* Zone (TOZER 1967; TOZER & PARKER 1968). Finally, the Primorye sequence (ZAKHAROV 1968) merely has no bearing on the problem, having no ammonoid record between its *Subcolumbites* beds and the ill-defined *Leiophyllites pradyumna* Zone.

5. Systematic descriptions¹⁾

Order *Ceratitida*

Superfamily **Xenodiscaceae** FRECH 1902

Family **Xenodiscidae** FRECH 1902

Genus *Hemilecanites* SPATH 1934

Hemilecanites cf. *H. paradiscus* KUMMEL

Plate 6, Figures 7–8, Text-Figure 3

Hemilecanites paradiscus KUMMEL 1969, p. 375, Pl. 29, Figs. 11–12; Pl. 31, Figs. 15–16 [holotype]; Pl. 35, Figs. 12.

Description. Moderately evolute, high whorled and compressed shell with an angular, nearly acute venter. Umbilical margin well defined, evenly sloping towards the umbilical suture. Outer flanks gradually converge towards the narrow venter. Surface smooth, with sinuous and slightly prorsiradiate growth striae. At D = 37 mm, H = 35%, W = 21% and U = 35%. The goniatitic suture line conforms to that of *H. paradiscus*.

Discussion. The few available specimens from the *Japonites welteri* beds are comparable to the species described by KUMMEL (1969) from the lowermost part of the Tobin Formation (*Subcolumbites* beds, USGS Mesozoic loc. M2562).

¹⁾ The systematic descriptions follow the classification by TOZER (1981a). Repository of figured specimens is abbreviated USNM (National Museum of Natural History, Washington D.C.).