

## LATEST TOURNAISIAN (EARLY CARBONIFEROUS) CONODONTS FROM THE TABAI LIMESTONE, TIRAH, NORTHWESTERN PAKISTAN

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*Abstract.* A new stratigraphic unit, the Tabai Limestone of the poorly known Tirah area of northwest Pakistan, is one of several Early Carboniferous carbonate units distributed along the North Gondwana margin, some connected with transgressive interludes. The Tabai Limestone has produced latest Tournaisian (Early Carboniferous) conodonts indicative of the middle of the *anchoralis-latus* Zone.

*Riassunto.* Il Calcarea di Tabai è una unità litostratigrafica dell'area quasi sconosciuta di Tirah in Pakistan nord occidentale. È una delle numerose unità carbonatiche – alcune delle quali associate ad eventi trasgressivi – del Carbonifero Inferiore che sono distribuite lungo il margine settentrionale di Gondwana. Nel Calcarea di Tabai sono stati ritrovati conodonti del Tournaisiano superiore (Carbonifero Inferiore) indicativi della porzione centrale dell'*anchoralis-latus* Zone.

### Introduction

Apart from information on a traverse of the Bazar Valley-Tirah region by Tahirkheli et al. (1975) and observations on igneous rocks of the Spinkai area of Tirah by Jan (1975), very little published data have been available on the geology of the Bazar Valley-Tirah area of the southern Khyber region of northwest Pakistan since a traverse by Hayden (1898) in which, while accompanying a punitive military expedition, he noted the occurrence of an unexpected and interesting Palaeozoic rocks including a Permian sequence from which he collected fossils identified with well-known forms from the Salt Range. The political inaccessibility that prevailed until comparatively recently for the Bazar Valley-Tirah area resulted in generally speculative geology for it, and indeed for most of the Khyber region. Symptomatic of this is depiction of the Bazar Val-

ley-Tirah area as consisting of Proterozoic and Mesozoic (without Palaeozoic) rocks on the recent geological map of north Pakistan (Searle & Khan 1996).

The bedrock of the Khyber region east of the Bazar Valley-Tirah area was formerly thought (Shah in Shah et al. 1971, 1980; cf. prior photo-interpretative work by Stauffer 1968) to be largely Ordovician (Landi Kotal Slate), by analogy with Ordovician clastics reported from Afghanistan, Silurian (Shagai Limestone) or Carboniferous (Khyber Limestone)—the last based on an unpublished report of arenaceous foraminifers. On the basis of extensive mapping, Ashraf Khan and Md Aslam (1989 and pers. comm. 1999) of the Geological Survey of Pakistan have concluded all these units are Precambrian and that all prior reports of fossils from them should be discounted until unequivocal documentation of precisely located material can be presented. This opinion coincides with the negative results obtained from our acid-leaching of numerous samples of all three of the above units from outcrops along and near the Khyber Highway (Molloy et al. 1997).

Unequivocal Devonian-Early Carboniferous (Tournaisian) sequences, unconformable upon the above Precambrian units and structurally preserved, nevertheless occur in limited areas, for example west of Tauda Mela (Shah et al. 1971, 1980; Molloy et al. 1997), and at Ghundai Sar (north of Jamrod) where a single sample from a thick Devonian-Carboniferous sequence (Ahmad et al. 1969; Khan et al. 1989) has produced Famennian conodonts (Pogue et al. 1992).

Silurian-Triassic sequences, identified from conodont data, are known from the northeast margin of the Peshawar Basin and from the Nowshera region (Pogue et al. 1992; Mawson et al. 2003), though Latif's (1970) re-

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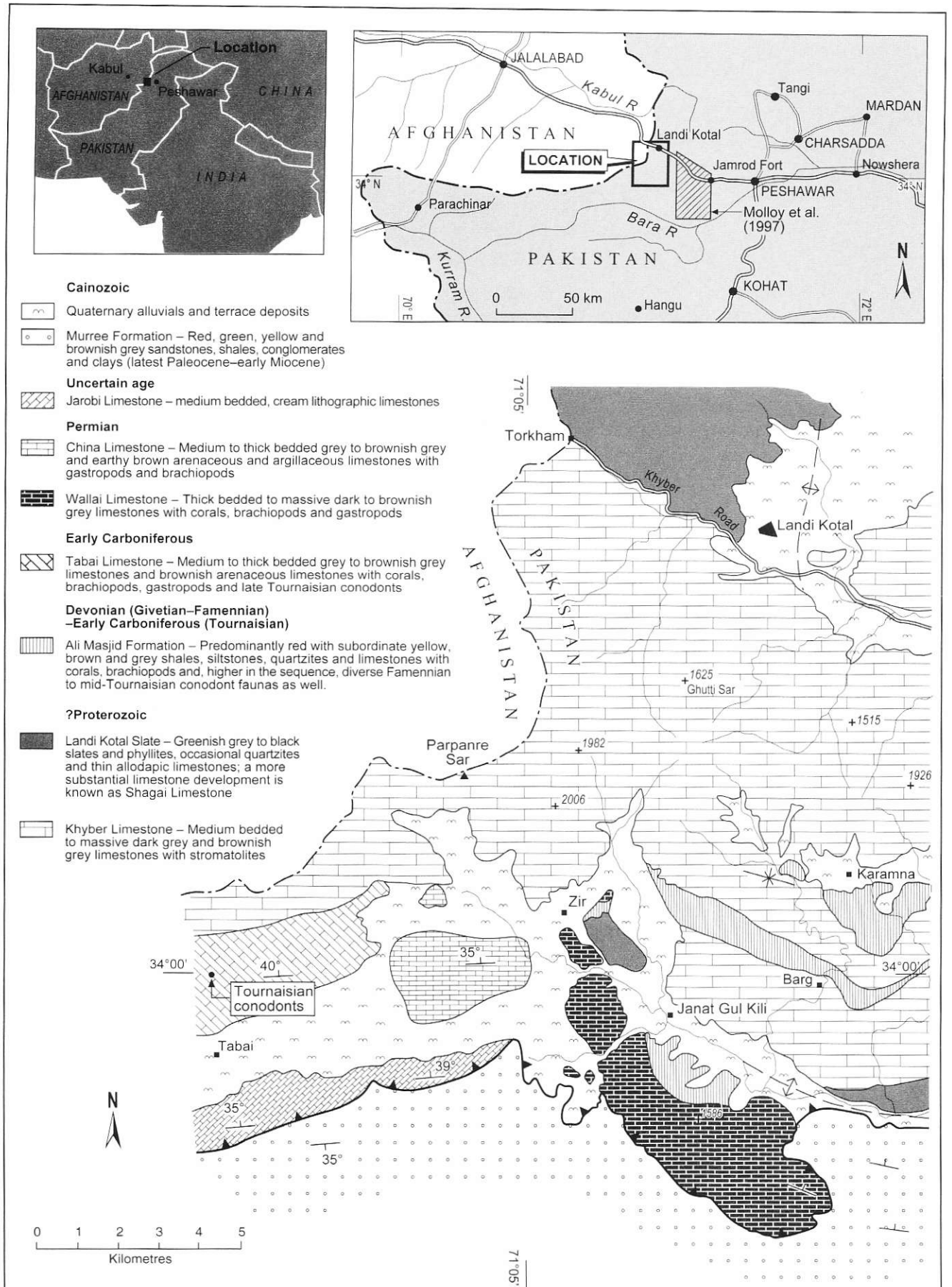


Fig. 1 - Geology of portion of Tirah, North West Frontier Province, Pakistan, based on mapping by Pakistani co-authors of this paper west of longitude 71°05', and photo-interpretation by Shah (in Shah et al. 1982) east of that longitude. Note that Shah's interpretation of Ali Masjid Formation extending into the area of this map has not been ground checked.

port of Early Carboniferous rocks at Nowshera does not accord with the Silurian-Early Devonian (Emsian) conodont data from that particular area (Pogue et al. 1992; Mawson et al. 2003). Unsuspected Ordovician-Triassic sequences have recently been identified from many areas of northernmost Pakistan, especially in Chitral (Talent et al. 1999; Gaetani et al. 2004; Perri et al. 2004; Mawson, unpub. data; Gaetani, Zanchi et al., unpub. mapping), but no occurrences of pre-Permian rocks have been discriminated previously in the poorly known southwest Khyber region.

Conodonts recently discovered in the Tabai Limestone (new stratigraphic name) in the Bazar Valley-Tirah area of the South Khyber region indicate the presence of an Early Carboniferous (Tournaisian) sedimentary interval—chronologically controlled by the zonally important conodont genus *Gnathodus*—within the largely Proterozoic bedrock (Landi Kotal Slate, Khyber Limestone, Shagai Limestone) of the southern Khyber region of northwest Pakistan. The discovery is important because it, and recent discoveries of Early Carboniferous sequences (with limestones) in the eastern Khyber region, in the uppermost Yarkhun region and Turikho regions of Chitral (Gaetani et al. 2004; Mawson, unpub. data) and, though appreciably metamorphosed, among the metamorphics of the northeastern margin of the Peshawar Basin, provide evidence of a formerly widespread marine Early Carboniferous sedimentary wedge extending over much of northwestern Pakistan (Indian and Karakorum Blocks). Such sediments, and the generally associated latest Silurian-Devonian sequence (Nowshera, “Ali Masjid” and Shogrām Formations or their equivalents) extending southwestwards beneath the Mesozoic-Cainozoic blanket, may have been source rocks for petroleum. What is sobering in this regard is that rocks of similar age are widespread in central and southern Afghanistan and central Iran. In central and eastern Iran, Colour Alteration Indices (CAI) of Devonian-Permian conodonts fall within the oil and gas windows (Mawson, pers. obs.). Further investigations of all limestones are therefore desirable: for conodonts in quest of CAI data, and of associated mudstones and shales (other than obvious metamorphics) for illite crystallinity values (as proxies for CAI values), and for this to be undertaken for the entire region from Peshawar westwards to the Afghan border, from the Safed Koh mountain chain southwards to the great Mesozoic-Cainozoic sedimentary complex on which most of Pakistan’s petroleum exploration has focused until now, i.e. southwards to the Kohat Plateau and its extension westwards to the Afghan border.

Reconnaissance mapping (Fig. 1) in the Tirah-Bazar Valley area, long categorised as politically inaccessible, has confirmed the presence of the excellent Permian sequence reported by Hayden (1898), but not subsequently investigated, as well as an Early Carboniferous (Tournaisian) unit, here named the Tabai Limestone. The lithologies of the various stratigraphic units encountered are summarised on Fig. 1; a stratigraphic column for the Tabai Limestone is presented as Fig. 2.

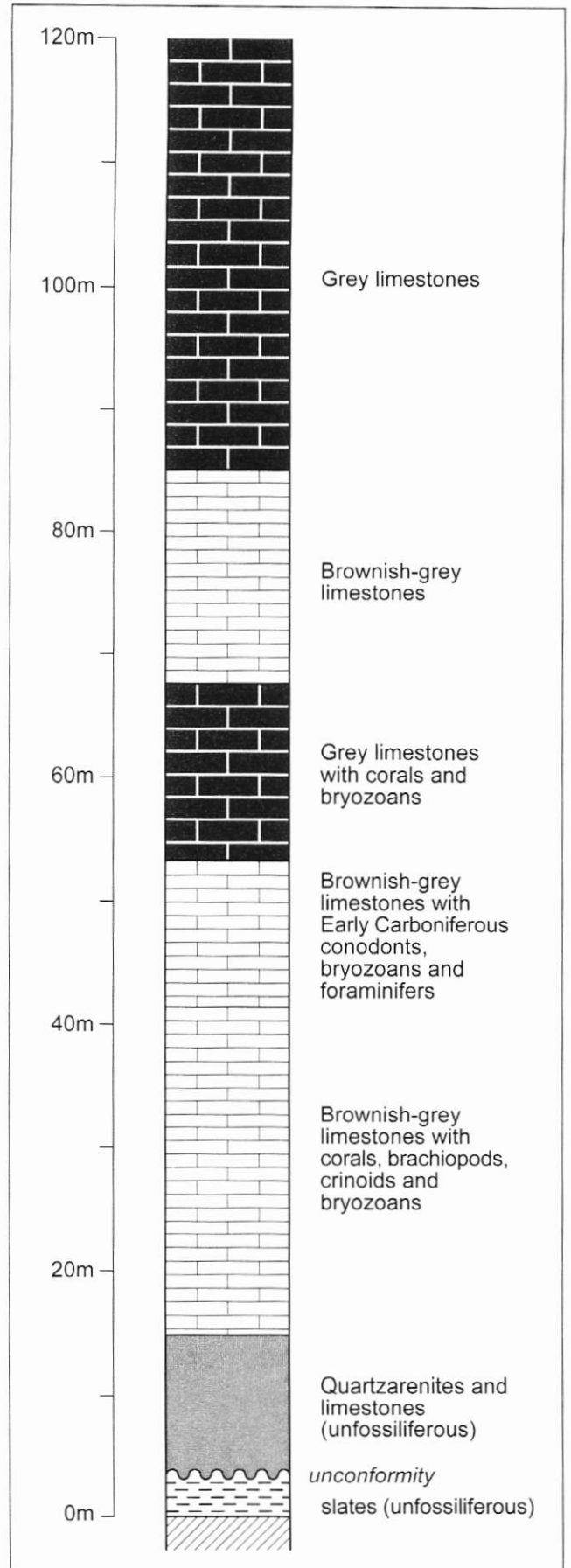


Fig. 2 - Lithologic column measured from the base of the Tabai Limestone north of Tabai village; biostratigraphically younger intervals may be present north of the measured section.

### Age of conodont fauna

Conodonts from between 41.5 m and 53 m above the base of a sampled section through the Tabai Limestone (Pl. 1) near Bazar Zakha Khel contain numerous specimens of *Gnathodus pseudosemiglaber*, *Pseudopolygnathus multistriatus* and *Cavusgnathus hudsoni*. Generic location of the last, incidentally, follows Purnell's (1992) proposal that *Clydognathus* be restricted to forms with nodose ornament and *Cavusgnathus* utilised for forms with ridged platform ornament. According to Lane et al. (1980, p. 121), the oldest occurrence of *G. pseudosemiglaber* is just below the middle of the *anchoralis-latus* Zone not quite coinciding with the topmost occurrence of *Ps. multistriatus*, however Lane et al. (1980) question this level. Perri & Spalletta (1998) in documenting the fauna from their Spinotti Section in the Carnic Alps, show the section (continuous from late in the *typicus* Zone to late in the *anchoralis-latus* Zone) to have occurrences of *G. pseudosemiglaber* in the lower half of the section and thus occurring in the lower half of the *anchoralis-latus* Zone. Considering the above, it appears that the closest approximation of age for this sample that represents 11.5 m of section, is the middle third of the *anchoralis-latus* Zone.

### Implications

The late Tournaisian age of the Tabai Limestone is one of a conspicuous clustering of mid to late Tournaisian ages based on conodonts along the former North Gondwana shelf from Iran to Australia. Some of these, such as the global transgression (Lower Alum Shale Event) in the mid-Tournaisian at the base of the Early *crenulata* Zone (Becker 1993), were or may have been connected with transgressive events. Viewed globally, there were two important events during the late Tournaisian. The first was a major faunal change involving extinction of the important genus *Siphonodella* (Sandberg et al. 1978) followed by flourishing of *Gnathodus*. A dramatic decrease in conodont diversity at or about the boundary between the *isosticha*-Late *crenulata* and *typicus* zones is symptomatic of the impact of a major extinction event in at least pelagic environments; in the Arctic region of European Russia this event caused an 80% reduction in conodont diversity (Zhuravlev 2003). The second, at the end of the *anchoralis-latus* Zone, witnessed a dramatic decrease in conodont diversity (Ziegler & Lane 1987) coinciding with a major sea-level drop followed by a less dramatic sea-level rise (Hance et al. 2002). Neither has yet been subjected to intensive centimetre-by-centimetre or bed-by-bed conodont and macrofossil biostratigraphy coupled with isotope chemostratigraphy comparable to the scrutiny focused on prior global events, the Upper Kellwasser Event in the mid-Late Devonian or the Hangenberg Event

during the latest Famennian (e.g., Schindler 1990, 1993; Talent et al. 1993; Girard 1994, 1995; McGhee 1996).

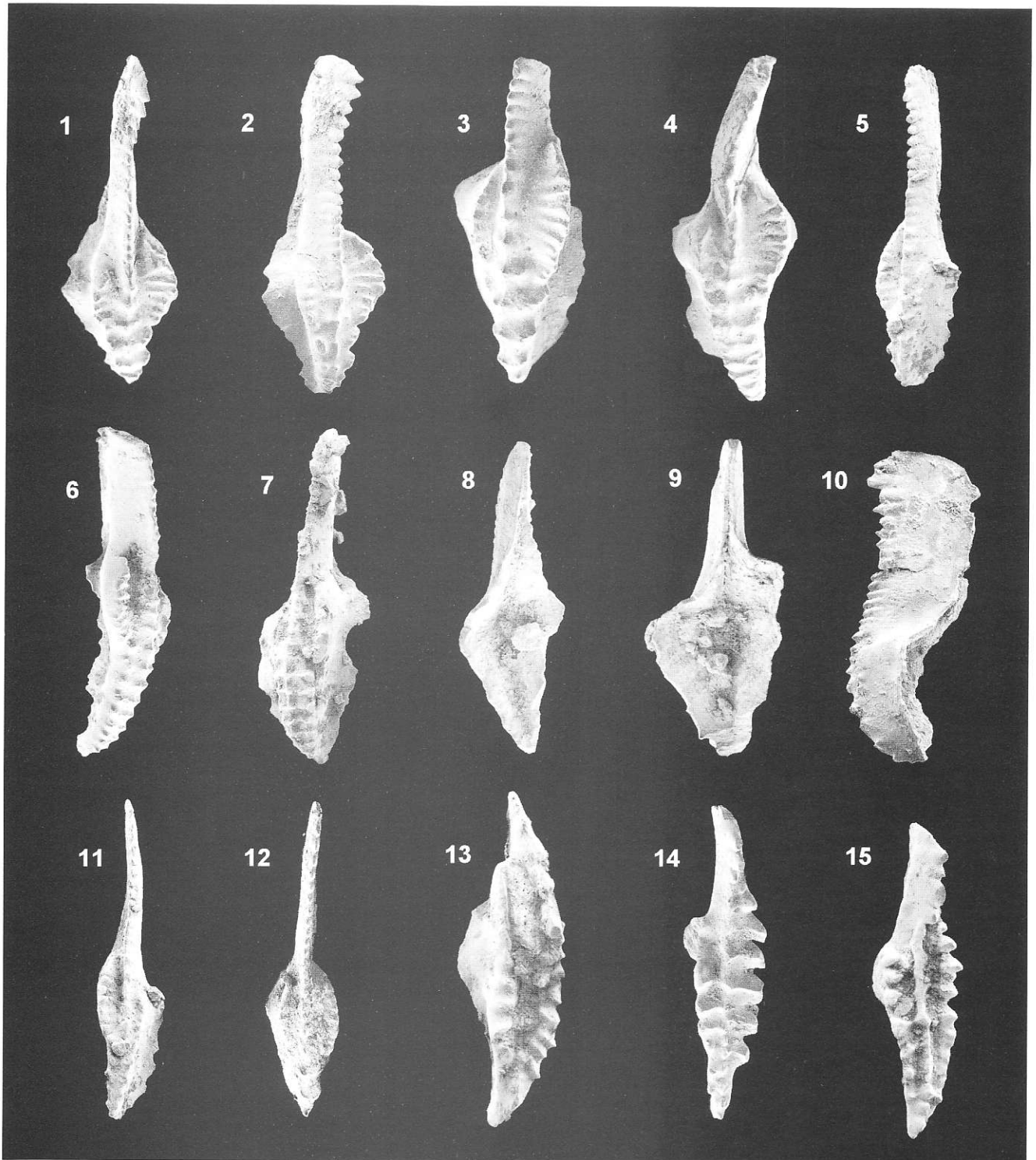
An Early *crenulata* Zone or slightly younger conodont fauna has been documented from the top of the Ali Masjid Formation about 3 km west of Misri Khel in the South Khyber region of Pakistan (Molloy et al. 1997). Conodont faunas of similar age to those of the Tabai Limestone have been documented from low in the Ribat Formation of northernmost Pakistan, but from the Karakoram rather than Indian Block. Two faunas were reported: one from somewhere between the beginning of the *typicus* Zone and mid-way through the *anchoralis-latus* Zone, the other during the later half of the *anchoralis-latus* Zone.

The Lipak Formation of the Pin valley in Spiti, northwest India, extends through the early Tournaisian to mid-Tournaisian horizons as young as the Early *crenulata* Zone (Draganits et al. 2002) — because its upper surface is erosional, it may extend elsewhere into younger Tournaisian horizons. Conodonts from the Lipak Formation in Lahaul, farther west in northwestern India (Vannay 1993), are about the same age — towards the end of the range of the genus *Siphonodella* — conceivably as young as the *isosticha*-Late *crenulata* Zone. The Lipak faunas, as well as those from transgressions in the Hardwick, Ruxton and Teddy Mountain formations of north-eastern Australia (Mawson & Talent 1997, 1999), are about three zones older than the conodont fauna from the Tabai Limestone.

In the Tabas area of eastern Iran, mid and late Tournaisian conodont faunas of inferred Early *crenulata*, *isosticha*-Late *crenulata* and *typicus* zones are represented at Howz-e-Dorah, and *anchoralis-latus* Zone at nearby Kale Sardar (Yazdi 1999). Conodont faunas from one or two zones older than the Tabai fauna, referred to the *isosticha*-Late *crenulata*, *typicus* and possibly *anchoralis-latus* zones, have been documented from the Hutk and Shams Abad areas near Kerman in southeastern Iran (Wendt et al. 2002; Webster et al. 2003).

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## PLATE 1

Conodonts from a measured stratigraphic section through the Tabai Limestone (Fig. 2) at 070° 59' 40" E, 33° 59' 52" N, NWFP, Pakistan. Specimens are housed in the Australian Museum, Sydney, with numbers prefixed by AMF.

Figs 1-12 - *Gnathodus pseudosemiglaber* Thompson & Fellow, 1970. 1, 2, upper and oblique views respectively of AMF 125836, x60. 3, upper view AMF 125837, x70. 4, upper view AMF 125838, x60. 5, 11, oblique and upper views AMF 125839, x40. 6, upper view AMF 125840, x50. 7, upper view AMF 125841, x45. 8, lower view AMF 125842, x50. 9, lower view AMF 125843, x50. 10, lateral view AMF 125844, x60. 12, upper view AMF 125845, x50.

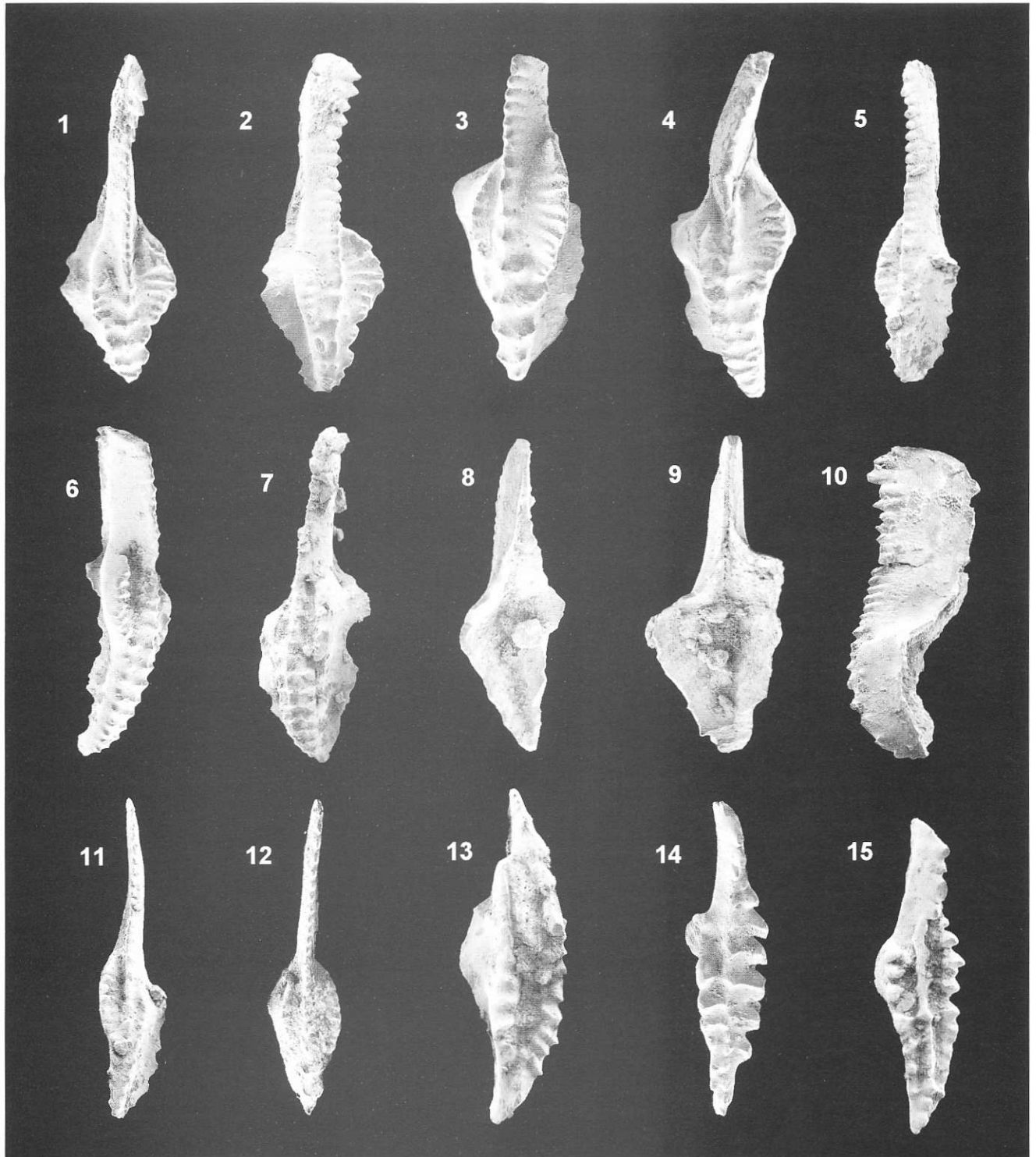
Fig. 13 - *Cavusgnathus hudsoni* (Metcalf, 1981) 13, upper view of AMF 125846, x50.

Figs 14-15 - *Pseudopolygnathus multistriatus* Mehl & Thompson, 1947. 14, upper view of AMF 12847, x40. 15, upper view of AMF 125848, x30.

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