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Conodont diversification during the Ordovician: A perspective from North China and Tarim (Northwestern China)

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Review of the literature on Ordovician conodont diversification in palaeoplates of North and Western China reveals that four diversity peaks are present in North China, occurring in the middle Tremadocian, early Floian, late Floian, and late Darriwilian, with three of these peaks (excepting that in the late Floian) also being recorded in Tarim. Three diversification intervals are present in North China, during the Tremadocian, late Floian, early and middle Darriwilian; comparable intervals are observed in the early and late Tremadocian, early Floian, and the Middle Ordovician in Tarim. The main conodont diversification episode in both palaeoplates took place in the Darriwilian, at the time of the Great Ordovician Biodiversification Event. A comparison of conodont diversity patterns in different palaeoplates (North China, Tarim, and South China) demonstrates that conodont radiation events mainly occurred within the Tremadocian, Floian, and Darriwilian. Conodont diversifications in these paleoplates also display some differences. In contrasting with Tarim and South China, North China witnessed a rapid conodont diversification during late Floian time. Conodont diversity in North China and Tarim increased continually and reached a peak in the late Darriwilian, concurrent with a prominent decreasing trend in South China. Differences of conodont diversification in these three palaeoplates may be related to their palaeogeography and tectonic history. When conodont diversifications in North China and Tarim are analysed on the background of palaeoenvironments, the main episodes are seen to be partly coincident with second order sea-level changes, particularly in North China. In general, conodont radiation correlates with large scale transgressions.

conodont diversification, Ordovician, North China, Tarim

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The Ordovician biodiversification is one of the most significant macroevolutionary events in the Palaeozoic Era (Sepkoski, 1981; Harper, 2006) and its causes and timing have been the subject of many comprehensive studies (Sepkoski et al., 1983; Miller et al., 1995; Droser et al., 1997; Hammer, 2003; Servais et al., 2010). Moreover, many case studies have been conducted for different clades in the palaeoplates or terranes in existence at the time, such as Argentina (Waisfeld et al., 1999, 2003), Baltica (Rasmussen et al., 2007, 2008), northern Gondwana (Vecoli et al., 2004), and South China (Chen et al., 2006; Fang, 2006; Zhan et al., 2006a; Li et al., 2007; Zhang et al., 2007; Zhou et al., 2007; Zhen et al., 2008). Conodonts in particular experienced a dramatic diversification during the Ordovician (Sweet, 1988; Barnes et al., 1996). In their analysis of global trends in conodont biodiversity during the Early and Middle Ordovician, Albanesi et al. (2004) proposed an important radiation

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*Corresponding author (email: rcwu@nigpas.ac.cn) event in the late Early Ordovician. Hammer (2003) and Sheets et al. (2011) dissected the pattern of conodont diversification during the Ordovician in Baltica. For South China, Wu et al. (2010a, 2010b, 2012) calculated conodont biodiversity during the Ordovician and conducted case studies, showing the Floian and Darriwilian to be very important intervals for conodont diversification.

Previously, many researchers have accentuated the role of various palaeocontinents in the evolution of marine fauna (Miller et al., 1995; Waisfeld et al., 1999, 2003; Zhan et al., 2006b), which appears to reflect differences of geological dynamics (Miller, 1997). Although conodonts are normally considered as planktonic animals (Seddon et al., 1971), diversification patterns of the clade in different palaeoplates show distinct differences (Hammer, 2003; Sheets et al., 2011; Wu et al., 2010a, 2010b) that are unexpected of animals with widespread distribution. The present study aims to reveal conodont diversification trends in the North China and Tarim palaeoplates, and to compare them with biodiversity patterns recognized in South China. Based on this analysis we offer some explanations for the observed similarities and differences.

1 Material and methods

Throughout the Ordovician, the North China palaeoplate was located in the northern hemisphere (Figure 1) (Cocks et al., 2002), and was characterized by an inner epicontinental sea with several islands present, and a western marginal sea (Liu et al., 2009). During the Early Ordovician, North China moved far away from Laurentia and closer to peri-Gondwana (Fortey et al., 2003). Research on Ordovician conodonts from the North China palaeoplate began in the early 1980s (An, 1982). Subsequent works systematically described the Ordovician conodont fauna of North China and clarified its biostratigraphic framework (An et al., 1983, 1985,1990; Li et al., 1983; Lin et al., 1984; Wang et al., 1984, 1987, 1996; Zhao et al., 1984; Yu et al., 1986; Chen et al., 1988; Gao, 1990; Mei, 1995; Dong et al., 1999, 2001; Pei et al., 1987; Nicoll et al., 1999; Wang, 2001). Unlike that of South China, the Ordovician conodont fauna in North China is normally considered as a warm-water fauna, though some cooler water taxa can be found in the western North China palaeoplate within a deep water setting (An et al., 1990).

Tarim was a separate palaeoplate in the southern hemisphere of the Ordovician world (Figure 1), with a temperate environment, situated not far from the South China palaeoplate based on the trilobite fauna (Fortey et al., 2003; Zhou et al., 1992). Ordovician conodonts from the Tarim palaeoplate have been described in many papers (Qiu, 1984, 1985; Zhang et al., 1991; Zhao et al., 1991, 2000; Wang et al., 1998, 2001, 2007, 2009; Wang, 2001; Du et al., 2005; Jing et al., 2007; Zhen et al., 2011). Based on these researches, the conodont fauna in Tarim is more similar to that of South China than to that of North China (Zhao et al., 2000; Wang et al., 2007), though some intervals, such as the Floian and Katian, are characterized by warm-water taxa regarded as North China type (Wang et al., 2007).

Our analysis of conodont biodiversity trends in the North China and Tarim palaeoplates throughout the Ordovician is well-founded on these previous systematic studies. The database is precisely constrained on the basis of conodont biostratigraphy (see Appendixes 1 and 2, available at www.springer.com/scp). The Ordovician conodont biostratigraphy in North China and Tarim follows An et al. (1990) and Zhao et al. (2000), respectively. The conodont zonations are precisely tied in the Stage Slices proposed by Bergström et al. (2009) where the boundaries of those Stage

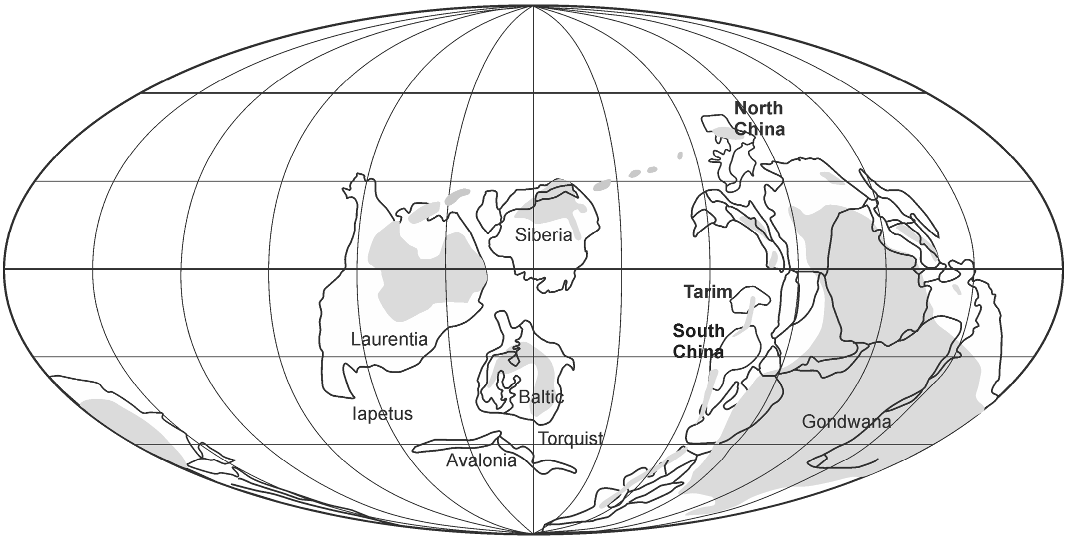

Figure 1 Palaeogeographical reconstruction showing the location of North China, Tarim, and South China palaeoplates at ca. 458 Ma (http://www.scotese.com/earth.htm).

Slices coincide with conodont zones. In other cases, where Stage Slices boundaries were defined on graptolite zones, we used correlations between conodont and graptolite zonations suggested by Webby et al. (2004) as illustrated in Appendixes 1 and 2 (http:link.springer.com). For the purpose of comparison with other regions or fossil groups, the Ordovician Time Slice framework employed by Webby et al. (2004) is also provided in the Figures.

Numerical evaluation of conodont biodiversity follows the measures proposed by Cooper (2004). Total diversity (D_{tot}) is the total number of species per stage slice. Normalized diversity (D_{norm}) is the sum of species ranging through the whole interval, plus half the number of species constrained within the interval, or having their FAD (first appearance datum) or LAD (last appearance datum) in the interval. In order to measure evolutionary rates, five parameters are considered, i.e., origination rates (O_d, O_{di}), extinction rates (E_d, E_{di}), and turnover rate (TR). The O_d (or conversely, extinction rate, E_d) is the percentage of species originating (or for E_d, becoming extinct) in the stage slice. The O_{di} (or conversely, E_{di}) is the number of species originating (or for E_{di}, becoming extinct) divided by the total number of species recorded in the stage slice, and divided by the duration of the stage slice. The turnover rate is the sum of O_{di} and E_{di}.

2 Results

2.1 Conodont diversity in North China

In total, 62 conodont species are recorded in the Tremadocian rocks of North China. From just 8 species known in the Late Cambrian, conodont diversity increased to 15 species in the early Tremadocian (Tr1) and reached a first peak of 45 species in the mid Tremadocian (Tr2), corresponding to relatively high values of origination and extinction rates (O_d and E_d) and turnover rate (Figure 2). Total diversity subsequently decreased to 21 species in the late Tremadocian (Tr3). Normalized diversity (D_{norm}) exhibits a similar trend, attaining a peak of 22 in the Tr2 stage slice (Figure 2). In

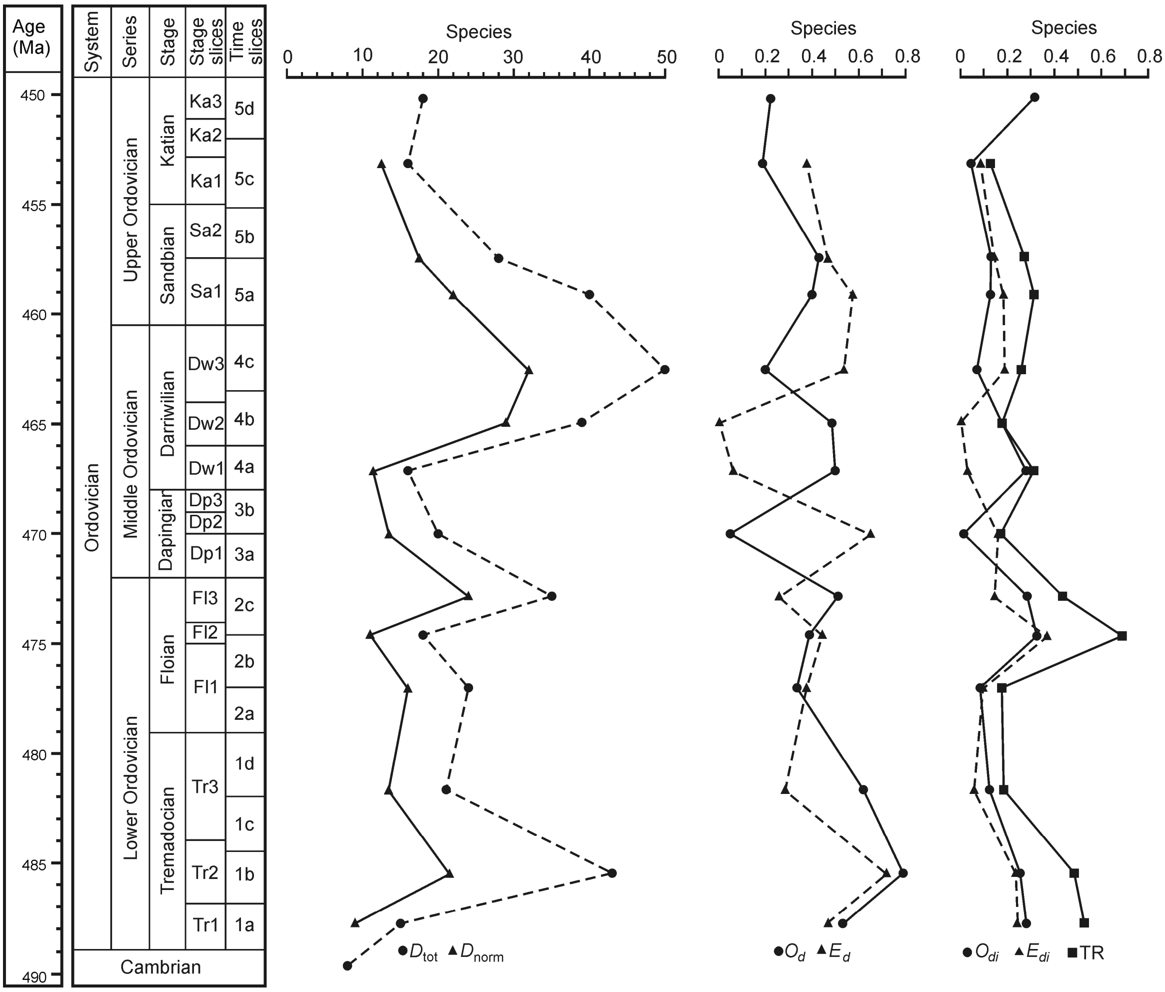

Figure 2 Ordovician conodont diversity curves of North China palaeoplate, calculated for the stage slices (Bergström et al., 2009), Ordovician time slices after Webby et al. (2004). Total diversity (D_{tot}), normalised diversity (D_{norm}), origination (O_d, O_{di}), extinction (E_d, E_{di}) and turnover (TR) rates following Cooper (2004).

the Tremadocian, O_d and E_d display similar trends to the diversity curves (D_{tot} and D_{norm}). A declining trend for O_{di} can be observed in this interval.

Conodont diversity increased slightly in the early Floian (Fl1), showing a small peak in both the D_{tot} and D_{norm} curves (Figure 2). Following a decreasing trend in the mid Floian (Fl2), another peak occurs in the late Floian (Fl3), where the total diversity increases to 35 and the D_{norm} to 24. Throughout the Floian, origination rates (O_d and O_{di}) increased slightly. In stage slice Fl3, these show a relatively high value during an interval of low extinction rates (E_d and E_{di}), coinciding with the next diversity peak of the D_{tot} and D_{norm}. Furthermore, on the basis of the turnover rate (TR), a faunal turnover event can be recognized in the middle Floian, characterized by high origination and extinction rates (O_d, O_{di}, E_d and E_{di}).

In the Dapingian, conodont diversity has a relatively low value of only 20 species (13.5 normalized), due to high extinction rates and extremely low origination rates (Figure 2).

During the Darriwilian, the conodont diversity recovered again, with high origination rates (O_d and O_{di}) recorded in the early Darriwilian (Dw1), subsequently decreasing in both the middle and late Darriwilian, whereas the extinction rates have opposite trends through this stage (Figure 2). Consequently, from a low value in the early Darriwilian (Dw1), conodont diversity increased continuously in the mid and late Darriwilian (Dw2 and Dw3), and reached the fourth acme in Dw3 with 52 species (D_{tot}) and 32 (D_{norm}) representing the maximum conodont diversity per stage in the Ordovician.

A gradual decline in both D_{tot} and D_{norm} occurs from the early Sandbian to mid Katian (Ka2) (Figure 2). In the Sandbian, high O_d and E_d are recorded. In contrast, low values of O_d and E_d are associated with low diversity in the early Katian (Ka1 and Ka2). Despite this, there is a slightly increasing trend in total diversity during the late Middle Katian (Ka3) with a high O_{di}.

In summary, the data-set from North China shows four diversity peaks, occurring in the Tr2, Fl1, Fl3, and Dw3 stage slices. Fluctuations in O_d, E_d, O_{di} and E_{di} indicate that the Tremadocian, Floian and Darriwilian are important intervals for conodont evolution. Three diversification intervals can be observed, corresponding to the Tremadocian, late Floian (Fl3), early and mid Darriwilian (Dw1, Dw2). These intervals are characterised by higher values of O_d and O_{di} compared to E_d and E_{di}.

2.2 Conodont diversity in Tarim

Data from the Tarim palaeoplate reveal four peaks to be present in total diversity during the Ordovician, with three peaks recognized in normalized diversity (Figure 3).

In the Tremadocian, 33 species are reported. The first diversity peak appeared in Tr2, with 26 species (D_{tot}) and 14 (D_{norm}). Conodont diversity decreased markedly in Tr3, with only 7 species recorded (D_{tot}) and a value of D_{norm} of just 4.5. This occurs despite high O_d (more than 0.5) during the Tremadocian. However, O_{di} shows a decreasing trend in this interval. A high faunal turnover can be observed in Tr2 with high values of both O_{di} and E_{di} (Figure 3).

Conodont diversity increased dramatically during the early Floian (Fl1). The second conodont diversity peak is present in this interval, when D_{tot} extends to 28 species and D_{norm} reaches 16.5 (Figure 3). Simultaneously, a high value of O_d is recorded. Subsequently, conodont diversity displays a continuously decreasing trend till the end of Floian. Another faunal turnover event is recorded in Fl2, when the maximum TR for this region in the Ordovician is present. In the late Floian (Fl3), a peak in both E_d and E_{di} is observed.

During the Dapingian, conodont diversity rises slightly, with 16 species (D_{tot}) and 11 (D_{norm}). Following this relatively low diversity interval, conodonts again diversified during the Darriwilian, when 56 species are recorded with continuous increases in both D_{tot} and D_{norm}, culminating in a third diversity peak in Dw3. High values of O_d and O_{di} in Dw1 are followed by a slight decreasing trend to the end of the Darriwilian.

Total diversity slightly declines in the early Sandbian (Sa1), then increases again in the late Sandbian (Sa2), when the fourth diversity peak occurs (Figure 3). However, after normalization, the fourth peak disappears. Even though there are relatively high values of conodont diversity in the Sandbian, a slightly decreasing trend can be observed in D_{norm}. Both the O_d (O_{di}) and E_d (E_{di}) increased during the Sandbian, driving an increasing trend in the faunal turnover rate that results in an obvious faunal turnover event in Sa2.

Conodont diversity decreased throughout the Katian (Ka1-Ka3) with 37 species recorded. Compared with the late Sandbian, diversity in Ka1 is markedly reduced, with a value of 25 species (D_{tot}) (D_{norm}=20). Through Ka2, both D_{tot} and D_{norm} increased slightly. But total conodont diversity continued to decline in Ka3 with a low O_d. Generally in the early and mid to late Katian (Ka1, Ka2 and Ka3) there are low values of both O_d and O_{di}, but relatively higher values of E_d and E_{di}. In addition, the TR shows a decreasing trend in this interval.

In summary, three biodiversification intervals are recognized in Tarim during the Ordovician. These are (1) early Tremadocian (Tr1), (2) late Tremadocian (Tr3) to early Floian (Fl1), and (3) Middle Ordovician, representing much higher O_d and O_{di}, but lower E_d and E_{di} (Figure 3).

3 Discussion

3.1 Comparison with conodont biodiversity in South China

Conodont biodiversification trends in South China (Wu et al., 2012) are here compared with the conodont biodiversity data from North China and Tarim.

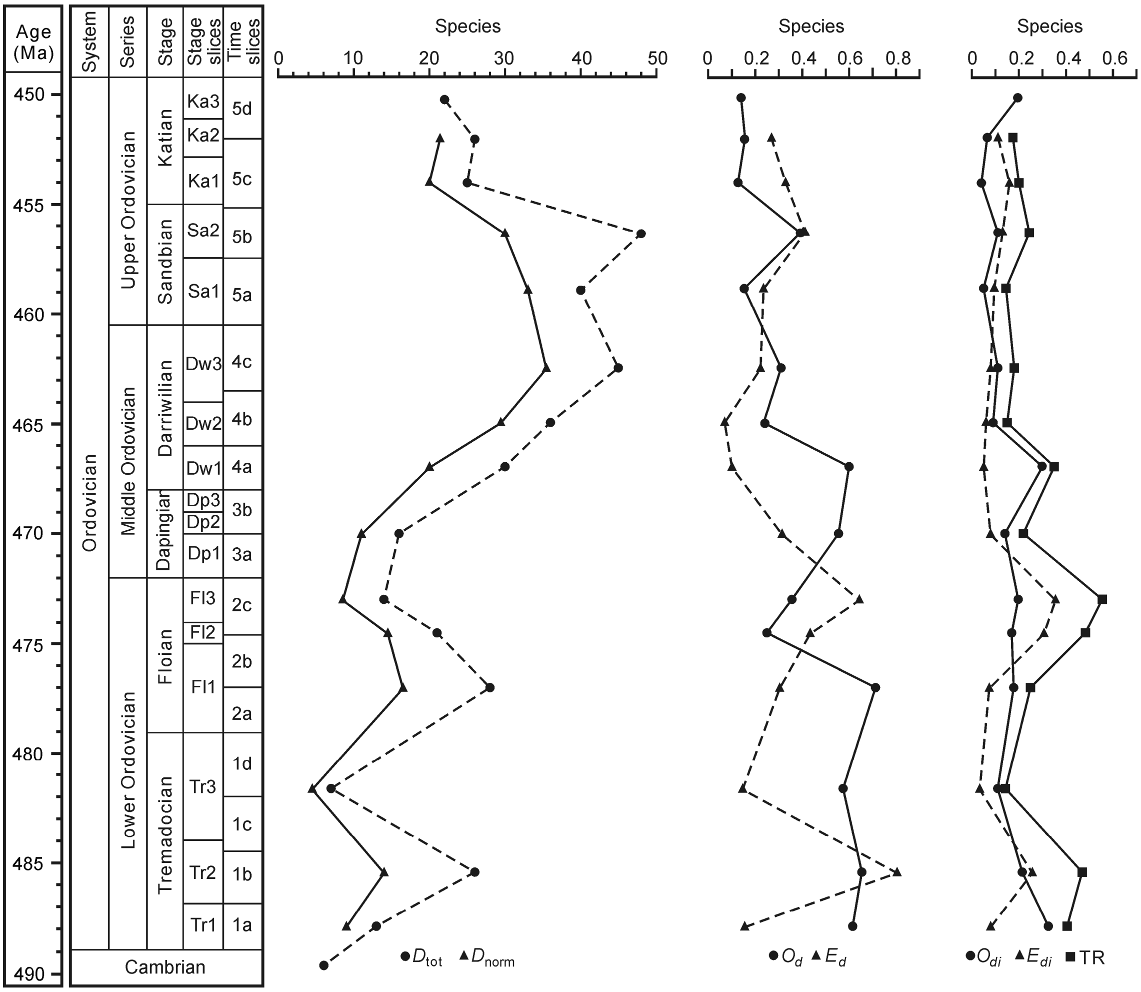

Figure 3 Ordovician conodont diversity curves of Tarim palaeoplate, calculated for the stage slices (Bergström et al., 2009), Ordovician time slices after Webby et al. (2004). Total diversity (D_{tot}), Normalised diversity (D_{norm}), origination (O_d, O_{di}), extinction (E_d, E_{di}) and turnover (TR) rates following Cooper (2004).

3.1.1 Conodont biodiversity in South China

Conodonts in South China underwent a pulsed diversification during the Ordovician (Wu et al., 2012). The diversity curves (D_{tot}, D_{norm}) are characterized by two dramatic increases, which occur in early Floian (Fl1) and early Darriwilian (Dw1) time (Figure 4). Conodont diversity increased steadily in the early and middle Tremadocian, followed by a decline in the late Tremadocian. In the early Floian, conodont diversity increased dramatically. Simultaneously, D_{tot} recorded a maximum peak in diversity, prior to a gradual decrease in Fl2 and Fl3 stage slices. D_{norm} continued to increase and reached its second peak in Fl2, followed by a decreasing trend in Fl3. In the early Dapingian (Dp1), conodont diversity recovered slightly with a peak for both D_{tot} and D_{norm}. A continuous decrease in D_{tot} and D_{norm} occurred in the middle and late Dapingian. The Darriwilian commences with another expansion in diversity. The fourth diversity peak is observed in Dw1 for D_{tot}, but in Dw2 for D_{norm}. After this fourth diversity acme, both the D_{norm} and D_{tot} curves display a decreasing trend. During the Late Ordovician, there is a gradual decreasing trend for conodont diversity, though a slight recovery can be observed in D_{tot} during the early Katian (Ka1 and Ka2).

The O_{di}, E_{di} and TR curves fluctuated during the Ordovician (Figure 5). Conodonts had high O_{di}, E_{di} and TR in the early Tremadoc, succeeded by a decreasing trend through the remainder of this stage. Moreover, high O_{di} was recorded in the mid Floian and early Darriwilian. High E_{di} was present during the mid Floian, mid Dapingian and late Darriwilian. During the Late Ordovician, there was a relatively high E_{di}, displaying a rising trend. On the basis of the origination and extinction rates, three biodiversification intervals can be observed, namely (1) from the Tremadocian to mid Floian, (2) early Dapingian, and (3) late Dapingian to early Darriwilian (Dw1). Each interval is characterized by low E_{di} and relatively high O_{di}.

3.1.2 Comparison of conodont biodiversity in Chinese palaeoplates

During the Tremadocian, the conodont diversity curves

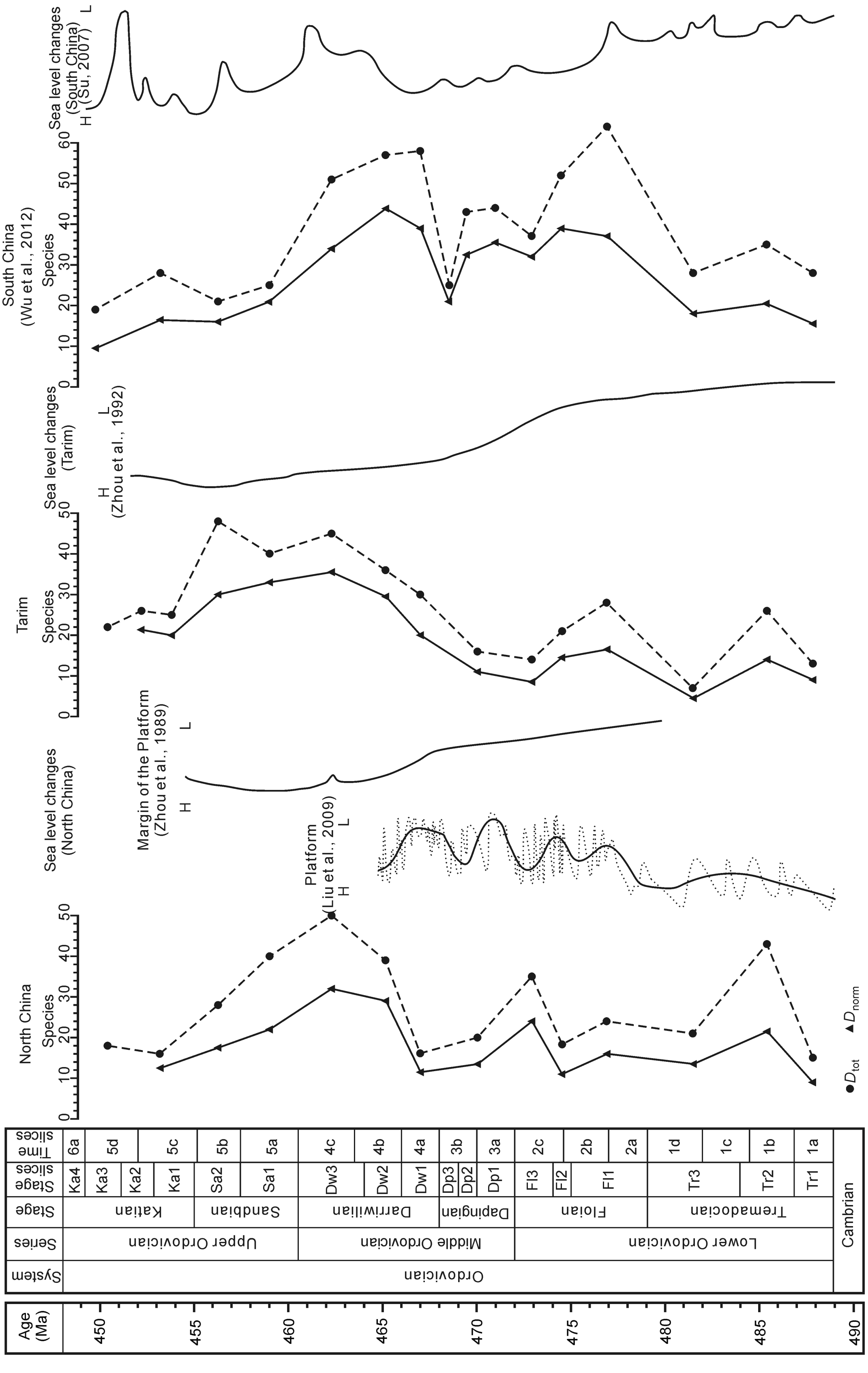

Figure 4 Ordovician conodont diversity changes in North China, Tarim, and South China palaeoplates compared with sea-level changes. D_{tot}, total diversity. D_{norm}, normalised diversity. H, highstand. L, lowstand.

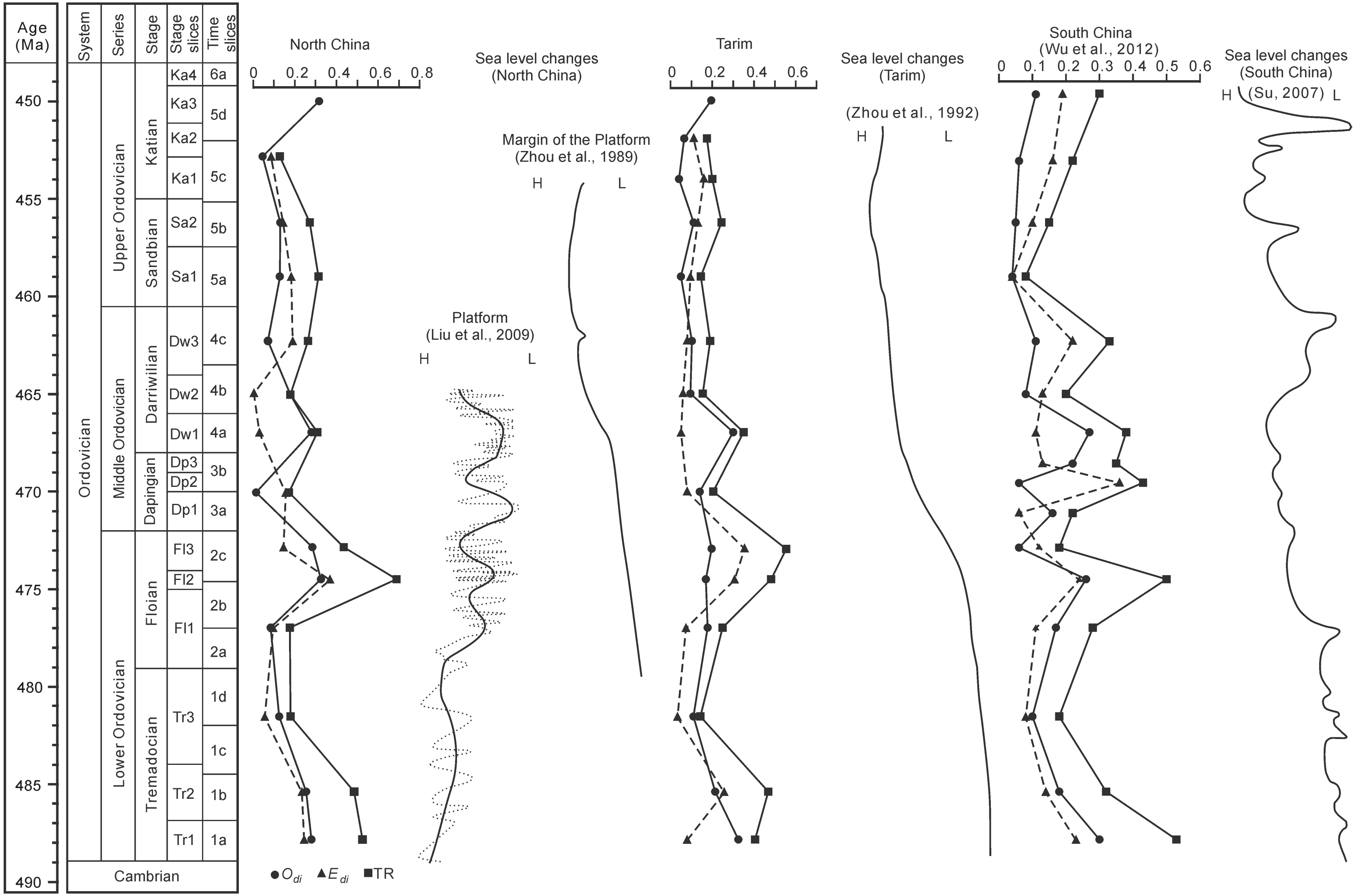

Figure 5 Origination (O_d, O_{di}), extinction (E_d, E_{di}) and turnover (TR) rates changes in North China, Tarim, and South China palaeoplates compared with sea-level changes. H, highstand; L, lowstand.

from North China, Tarim, and South China generally match each other well. In all regions the first conodont diversity peak occurred in Tr2 (Figure 4). Moreover, the conodonts display high turnover rates (TR) in Tr1 and Tr2, and O_{di} decreased gradually in the Tremadocian (Figure 5).

Some differences in conodont diversity become apparent in the Floian (Figure 4). In South China, the second peak of D_{norm} appeared in Fl2 (Wu et al., 2012). This contrasts with Tarim, where this peak was recorded in Fl1, whereas North China has two diversity peaks, a small one in Fl1 and a higher peak in Fl3. Otherwise, a prominent faunal turnover event that occurred in both South China (Wu et al., 2012) and North China palaeoplates during Fl2 time is delayed in Tarim until Fl3.

Conodont diversity is relatively low during the Dapingian in both North China and Tarim. Diversity is much higher in South China with 59 species recorded, which is double or triple that of North China and Tarim. Conodonts suffered an extinction event during the Dapingian in North China, whereas during this time they were diversifying in Tarim. Based on the data from South China (Wu et al., 2012), an extinction event is also observed in Dp2.

During the Darriwilian, conodont diversity underwent an expansion in all three palaeoplates, with a major radiation event observed in Dw1 characterised by a higher O_{di} and an extremely low E_{di} (Figure 5). The highest normalized diversity in North China and Tarim occurs in Dw3, whereas conodont diversity of South China reaches its acme slightly earlier, in Dw2, and decreases in Dw3 (Figure 4). In North China and South China, the pattern of extinction rate has an increasing trend; otherwise, there is a low value of extinction (E_{di}) in the Tarim block.

Conodont diversity throughout the North China, South China, and Tarim palaeoplates decreased during the Late Ordovician, when the E_{di} is higher than O_{di}. In the Sandbian, there was a dramatic decrease in conodont diversity in North China and South China but only a relatively slight decline in Tarim, which still had a relatively high diversity.

3.2 Relation to sea level changes

Many case studies have demonstrated that sea level fluctuation had an important impact on the GOBE (Barnes et al., 1996; Zhou et al., 2007; Zhang et al., 2008; Yan et al., 2011). Barnes et al. (1996) demonstrated that there were four faunal turnover events affecting conodonts during the Ordovician, related to sea level oscillation. Zhou et al. (2007) related Ordovician trilobite biodiversification to the two major transgressive-regressive cycles in the Tremadoc/Floian and Floian/Dapingian and the increase of oxygen in the early Middle Ordovician. Zhang et al. (2008) correlated graptolite diversification with sea level rises. Moreover, the biodiversity pattern of acritarchs corresponds well with sea level fluctuations in the Yangtze Platform of South China (Li et al., 2007; Yan et al., 2011). Wu et al. (2010a, 2010b, 2012) also argued that conodont biodiversification in South China was related to sea-level change.

In North China, Liu et al. (2009) presented a sea level change curve for the Early and Middle Ordovician on the North China Platform. During the Tremadocian, there is a highstand for sea level in North China, though the sea level change appears to fall gradually in the early and mid Tremadocian. As observed in Figure 5, a diversification event is recorded in Tremadocian times, when higher values of O_{di} and TR are present. In the early and mid Floian, the slight diversity decrease trend is correlated with a regression, which is also concurrent with a small extinction event with high E_{di}, but relatively low O_{di} (Figure 5). A regression occurred in Fl2 concurrently with high O_{di}, E_{di} and TR (Figure 5). This may indicate that the prominent faunal turnover event together with a small extinction is related to the regression at this time. Furthermore, an abrupt transgression event that was recorded in Fl3 corresponds to a diversification event with a prominent diversity peak, due to high O_{di} but low E_{di}. One strong regression event is recorded in the early Dapingian. In contrast to this diversification in Fl3, conodont diversity decreased during the Dapingian with high E_{di} but low O_{di}. Additionally, a low diversity for conodonts is present in Dw1. This can be related to the regression and low stand that occurred in early Dw1. However, an obvious transgression event is observed in late Dw1 and early Dw2, which is correlated with one important diversification with high O_{di}, but low E_{di}.

Zhou et al. (1989) outlined the sea level changes in North China during the Ordovician on the basis of the trilobite biofacies. A prominent transgression observed in the Darriwilian coincides with an increase in conodont diversity (Figure 4), though Liu et al. (1998) argued this transgression may be induced by the regional tectonic activity. However, a high stand in the Sandbian and early Katian was coincident with a continued decrease of conodont diversity.

Till now, no detailed sea level change curves for the Tarim block have been published. Therefore, it is difficult to interpret the relationship between Ordovician conodont diversity and sea level changes in this region. However, from a palaeoecological study of the trilobites, Zhou et al. (1992) briefly outlined sea level changes in Tarim (Figure 4). This shows a transgression trend in the Dapingian and a high stand in the Darriwilian, which corresponds to an increase in conodont diversity.

Thus, though the variations in conodont biodiversity curves do not always match second order sea level fluctuations in North China, sea level change in the North China and Tarim palaeoplates played an important role in conodont evolution during the Ordovician. The lack of precise correlation between conodont biodiversity curves and sea-level fluctuation may be an artifact of the present incomplete knowledge about regional seal-level curves of North China and Tarim.

3.3 Causes of the differences in biodiversification

Based on data from South China, North China, and Tarim, conodonts underwent pulsed diversifications during the Ordovician, especially in Tremadocian, Floian, and Darriwilian times. However, as illustrated by Figures 4 and 5, the diversity patterns of the three palaeoplates differ somewhat. This may be related to palaeogeographical, tectonic, and palaeoclimatic factors. Miller et al. (1995) highlighted the role of orogenic activity in the Ordovician radiation and suggested that environmental, geographic, and ecological patterns should be evaluated when investigating the radiation (Miller, 1997). Subsequently, Waisfeld et al. (1999, 2003) analyzed the Ordovician fauna in different settings from Argentina and argued that its biodiversification was strongly influenced by geodynamic history and palaeogeography. Zhan et al. (2006b) further concluded that different groups had different macroevolutionary patterns in the different terranes. As for conodonts, Bergström (1990) documented the rise in conodont provincialism starting from the Late Cambrian, subsequently increasing during the Early and Middle Ordovician with striking diversification. This provincialism and associated diversification can be interpreted in light of the distribution of palaeocontinents and epeiric seas at this time (Cocks et al., 2002).

Palaeogeographically, during the Ordovician, both South China and Tarim were located in the southern hemisphere, whereas North China was situated in the northern hemisphere and moved southward to approach peri-Gondwana (Cocks et al., 2002; Fortey et al., 2003). In general, South China, similar to Baltica, is characterized by cold and temperate conodont fauna, while North China shows similarities to Laurentia in yielding tropical fauna. Thus, Zhen et al. (2003) assigned conodonts in South China and North China to the Temperate Domain and Tropical Domain, respectively. More recently, Wang et al. (2007) analyzed the Ordovician conodont fauna in Tarim and concluded that it can be differentiated into North China and South China types. This may indicate that conodonts in Tarim were influenced by palaeocurrents circulating between these regions, or the varying palaeogeographical location of Tarim with respect to that of North and South China. The fact that South China yields some taxa (such as *Yaoxianognathus* and *Taoqupognathus*) that also are present in North China in the Late Ordovician most likely implies that South China developed similar environments to North China at this time after a long history of their tectonic movements. Therefore, different conodont faunas that characterize these three palaeoplates during the Ordovician developed as a result of their palaeogeographical and tectonic backgrounds, which may cause the differences in diversifications observed among South China, North China, and Tarim.

3.4 Conodont extinction during the Late Ordovician and its causes

Late Ordovician conodont diversity decreased in South China, North China, and Tarim, during which time a long interval with relatively higher extinction rates can be observed (Figure 5). What factors may have caused this extinction?

Shields et al. (2003) documented a sharp drop in the ^{87}Sr/^{86}Sr ratio around the Middle-Late Ordovician boundary, linked to the acceleration of hydrothermal exchange rates, but low continental weathering rates. This was coincident with, or immediately preceded, the major *gracilis* transgression, which can be recognised in South China, North China, and Tarim (Zhou et al., 1989, 1992; Su, 2007). Transgression and decreasing weathering rates may result in decreased nutrient input, thereby further influencing the conodont diversity in the early Late Ordovician. Otherwise, recent studies on palaeoclimate indicate that the beginning of the Hirnantian glaciation may be traced back to the early Katian (Saltzman et al., 2005; Trotter et al., 2008; Vandenbroucke et al., 2010; Rosenau et al., 2012). Thus climate change might have contributed to conodont extinction in the Late Ordovician.

4 Conclusions

Our research reveals that conodonts experienced a pulsed diversification pattern during the Ordovician in North China and Tarim. Three major radiation events in which the conodont diversity increased prominently are observed in both palaeoplates. These events are recorded in the mid Tremadocian, late Floian, and mid and late Darriwilian for North China, and during the mid Tremadocian, early Floian, and mid and late Darriwilian for Tarim. Three diversification intervals can be recognized with relatively higher origination rates (O_d and O_{di}), corresponding to the Tremadocian, late Floian, and early and mid Darriwilian in North China, and early Tremadocian, late Tremadocian and early Floian, and Middle Ordovician in Tarim. Diversity patterns of conodonts in South China, North China, and Tarim show some similarities, though differences exist in detail. It is noteworthy that one significant conodont radiation event is present during the Darriwilian in all three palaeoplates. Differences of conodont biodiversification in these three palaeoplates may be attributed to variations in their palaeogeographical and tectonic backgrounds.

Conodont diversity changes observed in North China and Tarim can be partly correlated with regional sea level changes. Sea level changes may play an important role in global conodont diversification during the Ordovician. However, there is little knowledge available about the regional sea-level curves in North China and Tarim, and additional research is needed.

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Appendix 1 Presence/absence of conodont species at North China [a)]

		Tremadocian					Floian				Dapingian	Darriwilian					Sandbian			Katian	
	Cambrian	Tr1	Tr2		Tr3		Fl1		Fl2	Fl3	Dp	Dw1	Dw2		Dw3		Sa1		Sa2	Ka1+Ka2	Ka3
		Rossodus beimadaoensis – Monocostodus sevierensis	*Cordylodus rotundatus – Rossodus manitouensis*	*Scolopodus opimus*	*Scalpellodus tersus*	*Serratog -nathus bilobatus*	*Serratog-nathus extensus*	*Paraserratog-nathus paltodiformis*	*Jumudomus gananda - Scolopodus sunanensis*	*Aurilobodus leptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Plectodina fragilis*	*Eoplacognathus suecicus – Acontiodus linxiensis*	*Plectodina onychodonta*	*Aurilobodus serratus*	*Scandodus handanensis*	*Tasmanog - nathus sishuiensis*	*T. shichuanhe-ensis*	*T. Gracilis – T. multidentatus*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*
Teridontus huanghuachangensis	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstromi	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus prion	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus proavus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus gracilis	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albiconus postcostatus	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirsutodontus simplex	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monocostodus sevierensis	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus lavadamensis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus erectus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus caseyi	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus beimadaoensis	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus tangshanensis	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iapetognathus jilinensis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus rotundatus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chosonodina herfurthi	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chosonodina tridentata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chosonodina fisheri	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus oneotensis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chosonodina chirodina	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus pingquanensis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus variabilis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paltodus spurius	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus primitivus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus falsioneotensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paltodus? parvus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus iowensis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acontiodus shuiyuensis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus tenuis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucharodus parallelus	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina abnormalis	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus lineatus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anodontus restrictus	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oistodus lanceolatus	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Aloxoconus staufferi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	1	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Scolopodus warendensis	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

(*To be continued on the next page*)

(*Continued*)

		Tremadocian					Floian				Dapingian	Darriwilian					Sandbian			Katian	
	Cambrian	Tr1	Tr2		Tr3		Fl1		Fl2	Fl3	Dp	Dw1	Dw2		Dw3		Sa1		Sa2	Ka1+Ka2	Ka3
		Rossodus beimadaoensis – Monocostodus sevierensis	*Cordylodus rotundatus – Rossodus manitouensis*	*Scolopodus opimus*	*Scalpellodus tersus*	*Serratog -nathus bilobatus*	*Serratog-nathus extensus*	*Paraserratog-nathus paltodiformis*	*Jumudomus gananda - Scolopodus sunanensis*	*Aurilobodus leptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Plectodina fragilis*	*Eoplacognathus suecicus – Acontiodus linxiensis*	*Plectodina onychodonta*	*Aurilobodus serratus*	*Scandodus handanensis*	*Tasmanog - nathus sishuiensis*	*T. shichuanhe-ensis*	*T. Gracilis – T. multidentatus*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*
Scolopodus opimus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paltodus deltifer	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Paroistodus numarcuatus	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paroistodus proteus	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Ulrichodina filiformis	0	0	0	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0
Scolopodus quadrangulatus	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracordylodus gracilis	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus huolianzaiensis	0	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Scolopodus asperus	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cornuodus longibasis	0	0	0	0	1	1	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0
Diaphorodus cortinus	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Paraserratognathus incostatus	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scalpellodus tersus	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus mancordatus	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Triangulodus brevibasis	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Serratognathus bilobatus	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Honghuayuangnathus hubeiensis	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Bergstroemognathus pectiniformis	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Oistodus multicorrugatus	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus eburnus	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
Serratognathus extensus	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Paraserratognathus problematicus	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Serratognathus diversus	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baltoniodus approximatus	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Rhipidognathus maggolensis	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Paraserratognathus paltodiformis	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus flexilis	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Triangulodus changshanensis	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Rhipidognathus laiwuensis	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Jumudontus gananda	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Scolopodus sunanensis	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Acontiodus viriosus	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
Panderodus nogamii	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0
Polycaulodus similaris	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Paroistodus parallelus	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
Scolopodus oldstockensis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Juanognathus jaanussoni	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Juanognathus variabilis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Loxodus dissectus	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Aurilobodus leptosomatus	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Histiodella holodentata	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Scolopodus mustus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

(*To be continued on the next page*)

(*Continued*)

		Tremadocian					Floian				Dapingian	Darriwilian					Sandbian			Katian	
	Cambrian	Tr1	Tr2		Tr3		Fl1		Fl2	Fl3	Dp	Dw1	Dw2		Dw3		Sa1		Sa2	Ka1+Ka2	Ka3
		Rossodus beimadaoensis – Monocostodus sevierensis	*Cordylodus rotundatus – Rossodus manitouensis*	*Scolopodus opimus*	*Scalpellodus tersus*	*Serratog-nathus bilobatus*	*Serratog-nathus extensus*	*Paraserratog-nathus paltodiformis*	*Jumudomus gananda - Scolopodus sunanensis*	*Aurilobodus leptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Plectodina fragilis*	*Eoplacognathus suecicus – Acontiodus linxiensis*	*Plectodina onychodonta*	*Aurilobodus serratus*	*Scandodus handanensis*	*Tasmanog - nathus sishuiensis*	*T. shichuanhe-ensis*	*T. Gracilis – T. multidentatus*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*
Ansella rigida	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
Filodontus filosus	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Tangshanodus tangshanensis	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Ulrichodina wisconsinensis	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Nasusgnathus dolonus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus gradatus	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0
Protopanderodus rectus	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
Triangulodus carinatus	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0
Ansella jemtlandicus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
Erraticodon tangshanensis	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0
Teridontus simplex	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Panderodus gracilis	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Spinodus spinatus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Parapaltodus flexuosus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Protopanderodus robustus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Protopanderodus arcuatus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
Periodon aculeatus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Dapsilodus mutatus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
Plectodina fragilis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Aurilobodus simplex	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Dapsilodus compressus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Eoplacognathus suecicus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Venoistodus venustus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
Oistodus sthenus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Aurilobodus aurilobus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
Eoplacognathus pseudoplanus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Acontiodus linxiensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Plectodina onychodonta	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Eoplacognathus lindstroemi	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Erismodus typus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0
Protopanderodus cooperi	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Protopanderodus varicostatus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Costiconus iniquus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Costiconus ethingtoni	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Pygodus serrus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
Erraticodon hexianensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Baltoplacognathus robustus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
Aurilobodus sp. A	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Aurilobodus sp. B	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Aurilobodus serratus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Yaoxianognathus tunguskaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1
Microcoelodus asymmetricus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Microcoelodus symmetricus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

(*To be continued on the next page*)

(*Continued*)

		Tremadocian					Floian				Dapingian	Darriwilian					Sandbian			Katian	
	Cambrian	Tr1	Tr2		Tr3		Fl1		Fl2	Fl3	Dp	Dw1	Dw2	Dw3			Sa1		Sa2	Ka1+Ka2	Ka3
		Rossodus beimadaoensis – Monocostodus sevierensis	*Cordylodus rotundatus – Rossodus manitouensis*	*Scolopodus opimus*	*Scalpellodus tersus*	*Serratog -nathus bilobatus*	*Serratog-nathus extensus*	*Paraserratog-nathus paltodiformis*	*Jumudomus ganandа - Scolopodus sunanensis*	*Aurilobodus leptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Plectodina fragilis*	*Eoplacognathus suecicus – Acontiodus linxiensis*	*Plectodina onychodonta*	*Aurilobodus serratus*	*Scandodus handanensis*	*Tasmanog - nathus sishuiensis*	*T. shichuanhe-ensis*	*T. Gracilis – T. multidentatus*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*
Protopanderodus liripipus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
Pygodus anserinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Eoplacognathus elongatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Scandodus handanensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Drepanoistodus basiovalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Scabbardella altipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Tasmanognathus sishuiensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Oulodus subundulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Tasmanognathus badouensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Belodina compressa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Panderodus recurvatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Tasmanognathus careyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Plectodina aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Belodina baiyanhuaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Pseudobelodina dispansa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
Dapsilodus variabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Pseudobelodina adentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
Scandodus furnishi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Belodella angusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Periodon grandis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Tasmanognathus shichuanheensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Belodina longxianensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Panderodus bergstroemi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Tasmanognathus multidentatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Belodina shiyangensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Phragmodus undatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Taoqupognathus blandus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Tasmanognathus gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Staufferella divisa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Paroistodus horridus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Phragmodus cognitus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Pseudooneotodus beckmanni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Yaoxianognathus lijiapoensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Ansella fenxiangensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Drepanoistodus suberectus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Yaoxianognathus neimengguensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Belodina confluens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ligonodina robusta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Yaoxianognathus yaoxianensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pseudobelodina kirki	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Aphelognathus politus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Belodina quadrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
a) 1 = present; 0 = absent																					

Appendix 2 Presence/absence of conodont species at Tarim a)

		Tremadocian				Floian			Dapingian	Darriwilian				Sandbian					Katian			
	Cambrian	Tr1	Tr2		Tr3	Fl1	Fl2	Fl3	Dp	Dw1	Dw2	Dw3		Sa1	Sa2				Ka1	Ka2	Ka3	
		Variabilo-conus bassleri	*Rossodus manitouens – Chosonodina herfurthi*	*Ulrichodina floweri*	*Diaphorodus proteus*	*Serratog-nathus diversus*	*Serratogna-thoides chuxianensis – Tangshanodus* sp.	*Aurilobodusleptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Lenodus variabilis*	*Eoplacog-nathus suecicus*	*Pygodus serrus*	*Pygodus anserinus*	*Yangtzeplacog-nathus jianyeensis*	*Eoplacog-nathus elongatus*	*Baltoniodus alobatus*	*Belodina compressa*	*Phragmodus undatus*	*Belodina confluens*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*	*Aphelognathus pyramidalis*
Cordylodus proavus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teriodontus nakamurai	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semiacontiodus nogamii	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teridontus huanghuachangensis	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus intermedius	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teriodontus gracilis	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Variabiloconus bassleri	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rossodus manitouensis	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Striatodontus striatus	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parapanderodus carlae	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirsodontus simplex	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monocostatus sevierensis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albiconus postcostatus	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus lindstroemi	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clavohamulus bachuensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus rotundatus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chosonodina herfurthi	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina priscus	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acanthodus uncinatus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tropodus comptus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina abnormalis	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanoistodus nowlani	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scalpellodus tersus	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycostatus falsioneotensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cordylodus angulatus	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus tenuis	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina floweri	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanoistodus concavus	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paroistodus numarcuatus	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanoistodus suberectus	0	0	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Drepanoistodus angulensis	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diaphorodus proteus	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diaphorodus bifidus	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina hemisphaericus	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Honghuayuangnathus hubeiensis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serratognathus diversus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reutterodus andinus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina filiformis	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina sunanensis	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diaphorodus cortinus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergstroemognathus extensus	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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		Tremadocian				Floian			Dapingian	Darriwilian				Sandbian					Katian			
	Cambrian	Tr1	Tr2		Tr3	Fl1	Fl2	Fl3	Dp	Dw1	Dw2	Dw3		Sa1	Sa2				Ka1	Ka2	Ka3	
		Variabiloconus bassleri	*Rossodus manitouens – Chosonodina herfurthi*	*Ulrichodina floweri*	*Diaphorodus proteus*	*Serratognathus diversus*	*Serratognathoides chuxianensis – Tangshanodus* sp.	*Aurilobodusleptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Lenodus variabilis*	*Eoplacognathus suecicus*	*Pygodus serrus*	*Pygodus anserinus*	*Yangtzeplacognathus jianyeensis*	*Eoplacognathus elongatus*	*Baltoniodus alobatus*	*Belodina compressa*	*Phragmodus undatus*	*Belodina confluens*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*	*Aphelognathus pyramidalis*
Ulrichodina tarimensis	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tropodus sweeti	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteracontiodus exilis	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prioniodus elegans	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paracordylodus gracilis	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulrichodina barbatus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopodus rex	0	0	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Cornuodus longibasis	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Nasusgnathus dolonus	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus arcuatus	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0
Paroistodus proteus	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanoistodus forceps	0	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Paroistodus parallelus	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Oistodus lanceolatus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paltodus subaequalis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serratognathoides chuxianensis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus gradatus	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Panderodus nogamii	0	0	0	0	0	0	1	1	1	0	1	1	0	1	1	1	0	0	1	0	0	0
Aurilobodus leptosomatus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drepanodus perlongus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxodus dissectus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Periodon flabellum	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Paroistodus horridus	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0
Juanognathus anhuiensis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Tangshanodus tangshanensis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Paroistodus originalis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Histiodella infrequensa	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus rectus	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Drepanoistodus basiovalis	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Periodon aculeatus	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Protopanderodus varicostatus	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	1	0	0
Protopanderodus cooperi	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0
Protopanderodus calceatus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
Baltoniodus prevariabilis	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Lenodus variabilis	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
Pygodus anitae	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Erraticodon balticus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Scolopodus gracilis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Protopanderodus robustus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0
Protopanderodus graeai	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Spinodus spinatus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	0	1
Costiconus costatus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	0	0	0
1 = present; 0 = absent																						

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(*Continued*)

		Tremadocian				Floian			Dapingian	Darriwilian				Sandbian					Katian			
	Cambrian	Tr1	Tr2		Tr3	Fl1	Fl2	Fl3	Dp	Dw1	Dw2	Dw3		Sa1	Sa2				Ka1	Ka2	Ka3	
		Variabilo-conus bassleri	*Rossodus manitouens – Chosonodina herfurthi*	*Ulrichodina floweri*	*Diaphorodus proteus*	*Serratog -nathus diversus*	*Serratogna -thoides chuxianensis – Tangshanodus* sp.	*Aurilobodusle ptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Lenodus variabilis*	*Eoplacog - nathus suecicus*	*Pygodus serrus*	*Pygodus anserinus*	*Yangtzeplacog- nathus jianyeensis*	*Eoplacog -nathus elongatus*	*Baltoniodus alobatus*	*Belodina compressa*	*Phragmodus undatus*	*Belodina confluens*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*	*Aphelognathus pyramidalis*
Eoplacognathus pseudoplanus	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Dapsilodus viruensis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	0	0	0
Costiconus ethingtoni	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Dzikodus tablepointensis	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Costiconus nakholmensis	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0
Drepanoistodus venustus	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0
Parapanderodus striatus	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Ansella jemtlandica	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	1	0	0	0
Eoplacognathus suecicus	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Besselodus semisymmetricus	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	1	0	0	0
Scolopodus eburnus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Scabbardella altipes	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0
Panderodus gryphus	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0
Panderodus gracilis	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1
Yangtzeplacognathus crassus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Drepanodus reclinatus	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Histiodella holodentata	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Pygodus serrus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Yangtzeplacognathus protoramosus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Yangtzeplacognathus foliaceus	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Decoriconus costulatus	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0
Tripodus alatus	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Cahabagnathus friendsvillensis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Dapsilodus mutatus	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1
Protopanderodus procerus	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0
Histiodella kristinae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Polonodus clivosus	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Polonodus newfoundlandensis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pygodus anserinus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Cahabagnathus sweeti	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Protopanderodus liripipus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1
Yangtzeplacognathus jianyeensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Cahabagnathus chazyensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Complexodus originalis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Baltoniodus variabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ansella fenxiangensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Pseudooneotodus mitratus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1
Eoplacognathus elongatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Baltoniodus alobatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0
Periodon grandis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Strachanognathus parvus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Taoqupognathus blandus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1

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(*Continued*)

		Tremadocian				Floian			Dapingian	Darriwilian				Sandbian					Katian			
	Cambrian	Tr1	Tr2		Tr3	Fl1	Fl2	Fl3	Dp	Dw1	Dw2	Dw3		Sa1	Sa2				Ka1	Ka2	Ka3	
		Variabiloconus bassleri	*Rossodus manitouens – Chosonodina herfurthi*	*Ulrichodina floweri*	*Diaphorodus proteus*	*Serratognathus diversus*	*Serratognathoides chuxianensis – Tangshanodus sp.*	*Aurilobodusleptosomatus – Loxodus dissectus*	*Tangshanodus tangshanensis*	*Lenodus variabilis*	*Eoplacognathus suecicus*	*Pygodus serrus*	*Pygodus anserinus*	*Yangtzeplacognathus jianyeensis*	*Eoplacognathus elongatus*	*Baltoniodus alobatus*	*Belodina compressa*	*Phragmodus undatus*	*Belodina confluens*	*Yaoxianognathus neimengguensis*	*Y. yaoxianensis*	*Aphelognathus pyramidalis*
Pseudobelodina inclinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0
Belodina compressa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1
Belodina monitouensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1
Histoidella serrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Yaoxianognathus tunguskaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Chirognathus duodactylus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Belodina longxianensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
Pseudobelodina dispansa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Phragmodus undatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Belodina baiyanhuaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Plectodina tenuis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Yaoxianognathus lijiapoensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Plectodina bidentata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Yaoxianognathus dolboricus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Belodina confluens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Dichognathus brevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Yaoxianognathus neimengguensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Xingjiangculum typicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Aphelognathus politus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Yaoxianognathus yaoxianensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Aphelognathus pyramidalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Panderodus recurvatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
a) 1 = present; 0 = absent																						