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New records of *Diplomoceras* (Ammonoidea, Diplomoceratidae) from Koryak Upland, North-West Pacific Province: taxonomic, biostratigraphical and palaeogeographical implications

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Abstract

The geographical and stratigraphical distribution of the heteromorph ammonite genus *Diplomoceras* within the North-West Pacific Province is briefly reviewed. Although *Diplomoceras* ranks amongst the more important, globally distributed taxa during the latest Cretaceous, its precise stratigraphical range still is uncertain. Moreover, the status of the various species assigned to this genus is a matter of debate; for instance, two commonly cited forms, *Diplomoceras cylindraceum* and *D. notabile*, are considered to be conspecific by some authors, but treated as discrete taxa by others. The majority of records of species of *Diplomoceras* are from Maastrichtian strata; however, several late Campanian finds bring some discrepancy into the discussion about their biostratigraphical significance. Here we record new specimens from the upper Maastrichtian Kokuy Unit, refer them to *Diplomoceras cylindraceum* and briefly consider the geographical, biostratigraphical and taxonomic issues surrounding the genus *Diplomoceras*.

Introduction

The genus *Diplomoceras* Hyatt, 1900 ranks amongst the more important, globally distributed latest Cretaceous heteromorph ammonites and has a convoluted history with regard to aspects of its taxonomy and palaeogeographical and biostratigraphical distribution. From the very beginning, the type species, *Baculites cylindracea* Defrance, 1816, was recorded as 'foss. De Maestricht', but, as noted by Kennedy (1987, p. 183), Defrance (1816, p. 160) presented morphological characters of his *Baculites cylindracea*, while in the Supplement of volume 3 of the same publication (Defrance, 1816), this particular specimen is referred to as 'Le Baculite vertebrae, foss. De Maestricht'. Kennedy (1987) also noted specimens of the associated fauna with Defrance's *Baculites vertebralis* from Maastricht and that one of the illustrations in the volume of *Dictionnaire* plates confirmed the typical Maastricht preservation. Thus, there can be no doubt that the first specimen described by Defrance as *Baculites cylindracea* originated from the Maastricht stratotype area. Unfortunately, Defrance's originals have never been traced, which greatly complicated the situation. For this reason, Kennedy (1987, p. 181, pl. 24, Figs 1–3) designated a specimen from the upper Maastrichtian Nekum or Meerssen members (Maastricht Formation) of the Sint-Pietersberg, Maastricht, the Netherlands, neotype.

Hyatt (1900) considered *Baculites cylindracea* not to be closely related to baculitids (Baculitidae) and erected a new genus, *Diplomoceras*, to accommodate it, noting the character of the suture line, in particular. However, Hyatt's description is very brief and lacks any illustration of the specimen, yet does show the suture line; the age is indicated merely as Late Cretaceous. Wright et al. (1996) indicated the range of the genus *Diplomoceras* to be Campanian to upper Maastrichtian and illustrated *D. notabile* Whiteaves, 1903 from the Campanian of British Columbia, Canada (Usher, 1952). However, Kennedy (1987) had previously revised the genus *Diplomoceras* and species referred to it and demonstrated that, in many cases, finds of *D. notabile* should in fact be considered as *D. cylindraceum*, including the specimen illustrated by Usher (1952). Following Kennedy (1987, p. 186), the stratigraphical range of the genus *Diplomoceras* and its type species, *D. cylindraceum*, is Maastrichtian 'where these specimens are well dated'. Additionally, Kennedy (1987) noted that almost all other 'species' of *Diplomoceras* fell into the range of variation of *D. cylindraceum.* Later, Hancock & Kennedy (1993, p. 165) concluded that '*Diplomoceras cylindraceum* ranges throughout the whole of the Maastrichtian, and may appear in the upper Campanian'. Klinger & Kennedy (2003a) discussed the origination

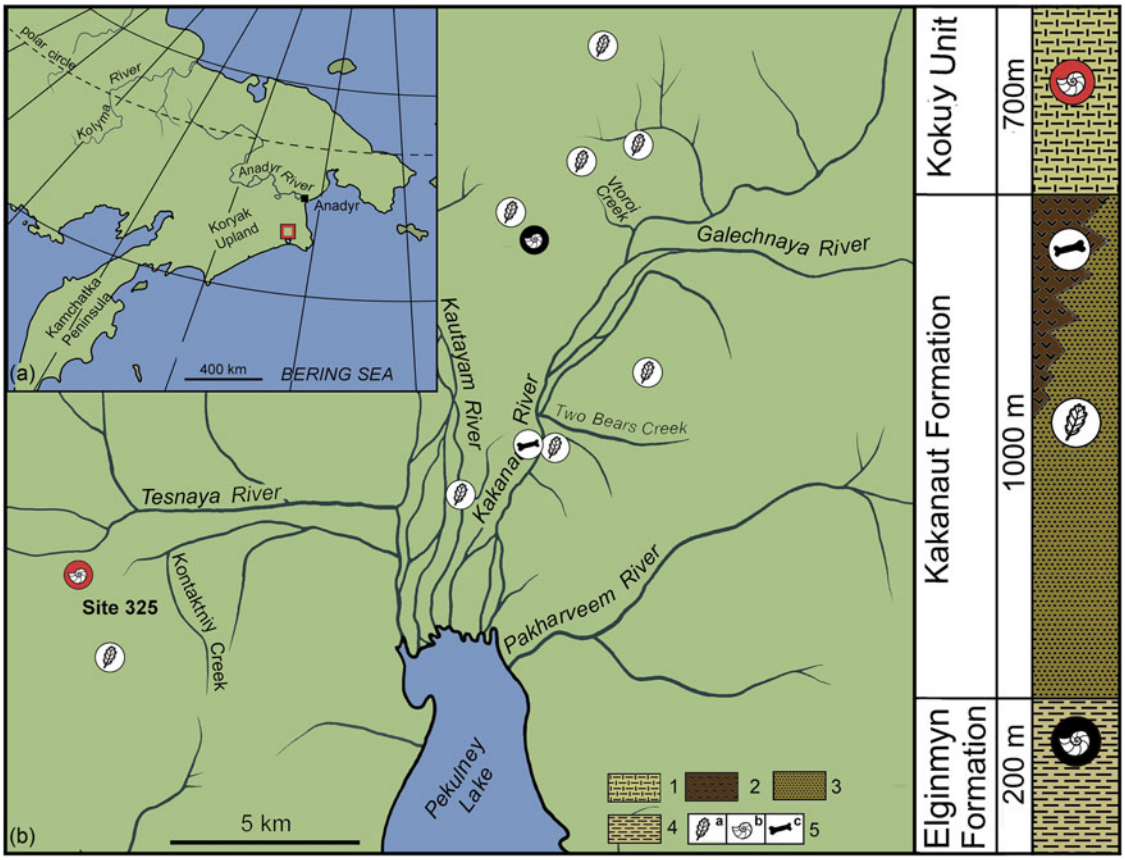

Figure 1. A. Position of the Kakanaut locality in Koryak Upland (Far East Russia). B. Map showing the locality (site 325) yielding *Diplomoceras cylindraceum*, as well as the main floral and faunal sites. Generalised stratigraphical section of the Kakanaut River Basin (modified after Golovneva & Shczepetov, 2010): 1 – marine deposits (Kokuy Unit); 2, 3 – terrestrial strata (Kakanaut Formation): 2 – effusive-pyroclastic deposits; 3 – volcanogenic-terrigenous deposits; 4 – marine Elginmyn Formation; 5 – fossil sites: (a) plant remains, (b) molluscan remains and (c) dinosaur remains.

of *D. cylindraceum* and its geographical distribution, while Dochev & Metodiev (2016, Fig. 2) have recently summarised the palaeogeographical distribution of *Diplomoceras*, adding new occurrences.

Thus, to date, there are questions surrounding both taxonomy and stratigraphical range of the genus and species. The sole conclusion that can be drawn is that *D. cylindraceum* has definitely been recorded from across the globe, but that *D. notabile* has never been found beyond the Pacific Realm.

Newly collected *Diplomoceras*: geological and stratigraphical settings

New finds of *D. cylindraceum*, described and illustrated herein, stem from the upper Maastrichtian Kokuy Unit (Fig. 1), as exposed in the Tesnaya River Basin, near Lake Pekulney in the south-eastern part of Koryak Upland. Three rather poorly preserved fragments of shafts and bends were collected in 2009 by one of us (LBG) from the right bank of the Kontaktniy Creek stream, locality 325 (Figs. 1, 2). At this site, the upper part of the Kakanaut Formation and the lower part of the Kokuy Formation are well exposed. The ammonites (Fig. 3) are kept in the collections of the CNIIGR Museum (Karpinsky Russian Geological Research Institute, Sankt-Peterburg, Russia), under registration number 13,417. The material consists of three fragmentary internal moulds of phragmocones (Fig 3). The largest specimen is a straight shaft fragment of 120 mm length and a whorl height of about 25 mm (Fig. 3 A-C). It is clearly ribbed with a rib index (following Kennedy, 1987, p.160) of 8. Two other specimens are smaller fragments of internal moulds of phragmocones with probably similar whorl heights of about 20–25 mm showing 8–10 ribs (Figs. 3D-I). There is a probability that those three fragments belong to the same individual. However, it is not possible to establish with certainty. However, the whorl height and rib index generally correspond with those recorded for *D. cylindraceum* from many previous works (e.g. Birkelund, 1993; Hancock & Kennedy, 1993).

In the south-eastern part of Koryak Upland, Maastrichtian marine and non-marine strata are widely distributed (Terekhova, 1970; Dundo, 1971, 1974; Volobueva & Terekhova, 1974; Volobueva & Krasniy, 1979; Golovneva, 1994; Herman, 2013). One of the most interesting sections with a diverse marine fauna, plant fossils and dinosaur remains has been studied near Lake Pekulney (Fig. 1). The greatest contributions to the stratigraphy of Upper Cretaceous deposits in this region were already made several decades ago by Galina Terekhova (Terekhova, 1965; Volobueva & Terekhova, 1974; Terekhova & Dundo, 1987) and additional stratigraphical studies were carried out by Golovneva & Shczepetov (2010).

On the right shore of Lake Pekulney, Maastrichtian deposits (Fig. 1) are divided, in ascending order, into the Elginmyn Formation, Kakanaut Formation and the youngest level of the Kokuy Unit or Formation (Igumentzev & Pisorenko, 1979; Golovneva & Shczepetov, 2010).

The Coniacian–Maastrichtian Elginmyn Formation was first described by Gladenkov (1963) from the Khatyrka River Basin. On

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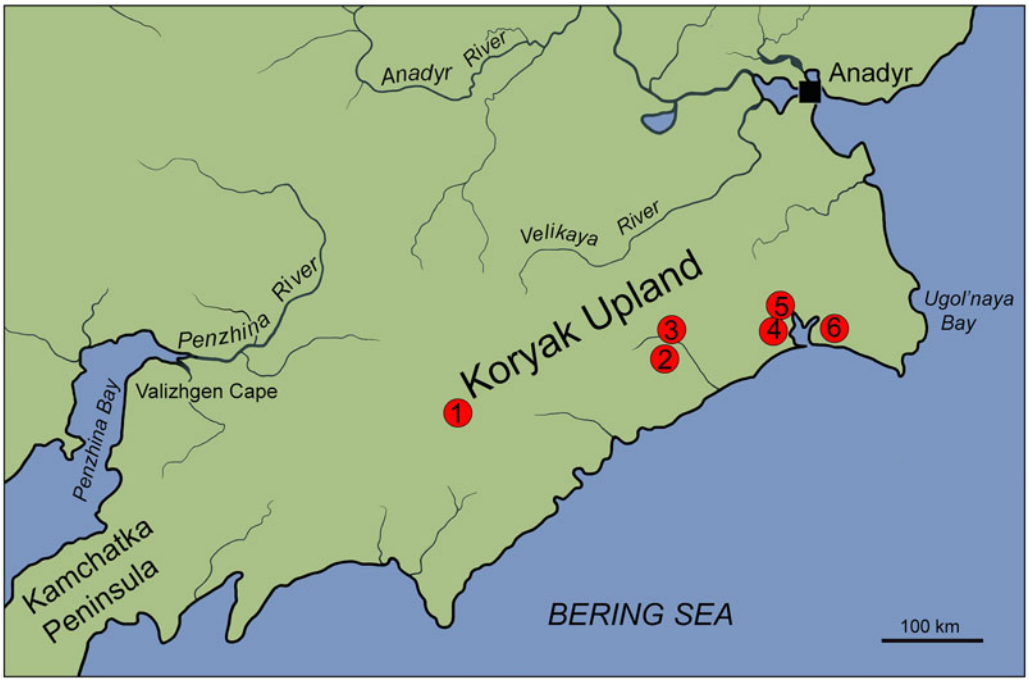

Figure 2. Localities with finds of *Diplomoceras* in Koryak Upland: 1 – Central part of Koryak Upland, Impeveem River Basin, Impeveem Formation, Maastrichtian (Dundo, 1971); 2 – interfluve of Opuka and Khatyrka rivers, Bistrorechensk Formation, upper Maastrichtian (Pochialaynen & Byalobzheskiy, 1984); 3 – interfluve of Khatyrka and Svetlaya rivers, Vysokorechensk Formation, Maastrichtian (Volobueva & Krasniy, 1979); 4 – right shore of Pekulney Lake, Rinotanmelgen River Basin, upper part of the Engilminskaya Formation, Maastrichtian (Igumentzev & Pisorenko, 1979); 5 – right shore of Pekulney Lake, Tesnaya River Basin, Kokuy unit, upper Maastrichtian (Igumentzev & Pisorenko, 1979; present study); 6 – Velkelveem River Basin, Gangut Formation, Maastrichtian (P ochialaynen, 1984).

the right shore of Lake Pekulney, this formation reaches a significant thickness of between 500 and 1,000 m. The upper part of this unit is characterised by finds of the early Maastrichtian inoceramid species, *Cataceramus pilvoensis* Sokolov, 1914 and *Schachmaticeramus shikotanensis* (Nagao & Matsumoto, 1940). The upper part of this unit has yielded the Maastrichtian ammonites, *Neophylloceras marshalli* (Shimizu, 1935), *Pachydiscus subcompressus* Matsumoto, 1959, plus the inoceramid, *Schachmaticeramus kusiroensis* (Nagao & Matsumoto, 1940), which is considered to be an early late Maastrichtian index species (Terekhova, 1965; Igumentzev & Pisorenko, 1979; Zonova et al., 1993; Toshimitsu et al., 1995).

The volcanogenic-terrigenous strata of the Kakanaut Formation attain a thickness of about 1,000 m (Fig 1) and comprise tuffaceous sandstones, siltstones, tuffs and basalts (Volobueva & Terekhova, 1974; Golovneva & Shczepetov, 2010). On the left shore of Lake Pekulney, deposits assigned to the Kakanaut Formation are predominantly non-marine and contain remains of plants and dinosaurs (Golovneva, 1994; Godefroit et al., 2009). The Kakanaut floral assemblage includes more than 40 species, representing such groups as Marchantiophyta (liverworts), Equisetidae (horsetails), Polypodiophyta (ferns), Cycadophyta (cycadophytes), Ginkgoaceae (ginkgos), Gymnospermae (conifers) and flowering plants (Angiospermae) (see Golovneva, 1994; Gnilovskaya & Golovneva, 2016, 2018; Zolina et al., 2020). The dinosaur fauna from the Kakanaut Formation comprises representatives of the families Hadrosauridae, Ankylosauridae, Ceratopsidae, Hypsilophodontidae, Troodontidae, Dromaeosauridae and Tyrannosauridae, inclusive of eggshell fragments, belonging to hadrosaurids and theropods (Godefroit et al., 2009).

On the right shore of Lake Pekulney, deposits of the Kakanaut Formation are more volcanogenic than on the left shore and contain just a few plant remains. On some occasions, these levels have previously been mapped as Vysokorechensk Formation (Fig. 4), as established to the west of Lake Pekulney, in the Khatyrka River valley (Bogidaeva & Gladenkov, 1963). The Vysokorechensk Formation is coeval with the Kakanaut Formation and yields similar plant fossils, yet is distinguished by the presence of marine levels with a late Maastrichtian fauna, such as the inoceramid *Schachmaticeramus kusiroensis* and ammonites (*Pachydiscus subcompressus* and *Diplomoceras* sp.) (Volobueva & Krasniy, 1979; Golovneva & Gnilovskaya, 2015).

The Kakanaut Formation is overlain by coastal-marine deposits of the Kokuy Unit, which comprises siltstones with interlayers of sandstones (Golovneva & Shczepetov, 2010) and attains a thickness in the study area of over 700 m. This unit contains remains of molluscs, brachiopods, decapod crustaceans and corals, as well as poorly preserved wood and leaves. The fragments of *D. cylindraceum* described herein (Fig. 3) have been collected from locality 325 along the Kontaktniy Creek stream, Tesnaya River valley (Figs. 1, 2).

Brief review of previous finds of *Diplomoceras*

All previous mentions and descriptions, with or without illustrations, of *Diplomoceras* (Fig. 4) are listed below and briefly compared with those from Japan, Alaska and Canada.

Late Cretaceous ammonites of the Pacific Realm are highly endemic and provincial, as demonstrated in numerous papers (e.g. Toshimitsu et al., 1995; Jagt-Yazykova & Zonova, 2012 and others). However, a number of extensive transgressive episodes have been documented from the region; these correspond to the appearance of several cosmopolitan ammonites. One of these episodes occurred in the late Campanian–early Maastrichtian. During the Campanian, ammonite diversity reached its maximum (acme) in

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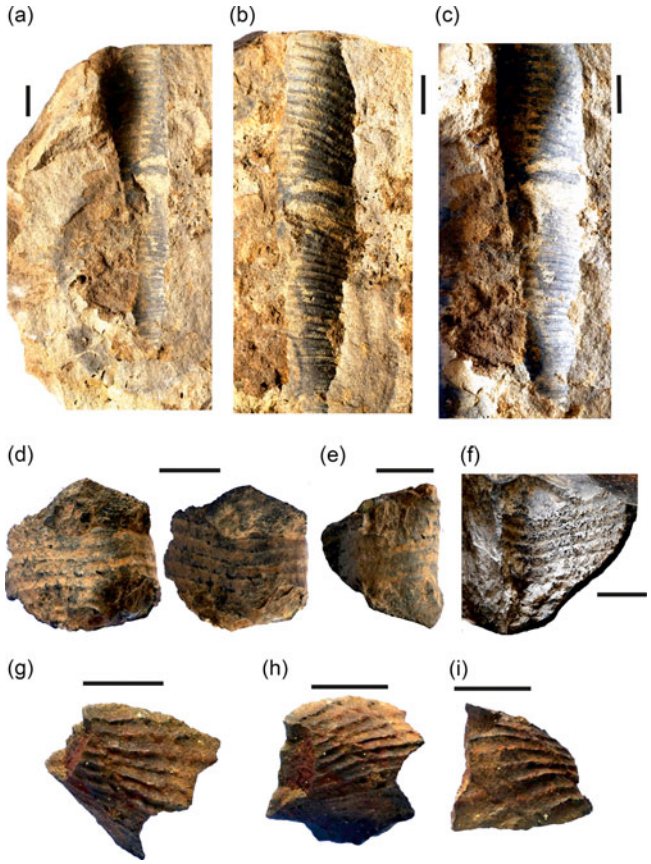

Figure 3. *Diplomoceras* cf. *cylindraceum* (Defrance, 1816), locality 325, Kokuy Unit, lower upper Maastrichtian; Tesnaya River in Kakanaut River valley, Koryak Upland, North-West Pacific Province (Far East Russia). A–C: CNIGRI 1/13417; D–F: CNIGRI 2/13417; G–I: CNIGRI 3/13417. Scale bar equals 10 mm.

the North-West Pacific Province (Yazykova, 2002, 2004; Jagt-Yazykova, 2012; Jagt-Yazykova & Zonova, 2012) and the level of endemism decreased. One of cosmopolitan taxa that made its first appearance in this interval is the genus *Diplomoceras*.

The first find of *Diplomoceras*, identified as *D.* cf. *notabile*, was illustrated by Dundo (1971), who failed to provide a description. The specimen came from the lower part of the Maastrichtian Impenveem Formation (Figs. 2, 4), in the central part of Koryak Upland. However, Kennedy (1987, p. 182) included this record in the synonymy of *D. cylindraceum*. The Impenveem Formation has been divided into three subformations; Dundo (1971) mentioned that fragments of *Diplomoceras* have been found in every one of these (Fig. 4), but failed to provide illustrations of this material. It co-occurred with inoceramid bivalves, such as the early Maastrichtian index, *Sch. shikotanensis*, and the late Maastrichtian index, *Sch. kusiroensis*.

From the interfluve of the Khatyrka and Svetlaya rivers (Fig. 4) comes another fragment of *Diplomoceras*, originating from the Vysokorechensk Formation (Volobueva & Krasniy, 1979) and, more precisely, from the lower upper Maastrichtian *Sch. kusiroensis* inoceramid Zone (Fig. 4). A few kilometres south of Lake Pekulney, in the Rinotanmelgen River Basin (Fig. 2), *Diplomoceras* sp. has been noted from the Engilminskaya Formation, co-occurring with the late Maastrichtian index, *Sch. kuziroensis* (Igumentzev & Pisorenko, 1979).

From the right shore of Lake Pekulney Lake, in the Tesnaya River valley (Figs. 1, 2), we have now collected fragments of shaft and bend of *Diplomoceras* from the Kokuy Unit, or lower upper Maastrichtian *Sch. kuziroensis* inoceramid Zone (Fig. 4). This material we here identify as *D.* cf. *cylindraceum* (Fig. 3). Previous finds from this site were noted as *Diplomoceras* sp. (Igumentzev & Pisorenko, 1979). It is worth noting that, apart from ammonites, we have recovered representatives of other molluscan groups such as inoceramid and non-inoceramid bivalves, gastropods and baculitid ammonites. This collection is under study now and will be the subject of a forthcoming paper (Jagt-Yazykova et al., in prep.). For the moment, we wish to indicate that amongst the inoceramid bivalves from this locality, a specimen of *Korjakia kociubinskii* Pochialaynen, 1980 has been recognised. This species indicates the late Maastrichtian age of our finds. When describing his new genus and species, Pochialaynen (1980) mentioned that it had been collected from the upper part of the Maastrichtian section, together with *Pachydiscus* aff. *gollevillensis* d'Orbigny, 1850, which probably is a misidentification of *Pachydiscus* (*P.*) *flexuosus* Matsumoto, 1979, a species typical of the upper Maastrichtian in Korjaka, Sakhalin and Japan (Yazykova, 2004; Jagt-Yazykova & Zonova, 2012). Although, recently Shigeta & Tsutsumi (2019) published the results of radiometric age dating of zircons (238U/206Pb ratios, using the LA-ICP-MS method) from a tuff sample obtained from the middle part of the *Pachydiscus flexuosus* Zone (taxon-range zone) of the Yezo Group in the Nakatonbetsu area, Hokkaido, northern Japan, correlated with Member 4 of the Krasnoyarka Formation in Sakhalin. This yielded a date of 69.8 ± 0.8 Ma, 95% confidence, which suggests late early to early mid-Maastrichtian under the threefold-subdivision scheme for the Maastrichtian. In twofold-subdivisions it would to the latest early Maastrichtian. It is possible that these data will need to be corrected in light of the zonal subdivision of the *Pachydiscus flexuosus* zone which is either early late Maastrichtian or late early Maastrichtian. In any case, it is definitively Maastrichtian.

Pochialaynen (1984) illustrated a poorly preserved ammonite fragment, described as *D. notabile*, from Maastrichtian–Danian deposits (Gangut Formation) in the Velkelveem River Basin (Figs. 2, 4). The exact stratigraphical position of this find, better indicated as *Diplomoceras* sp., within this formation is unknown. In addition, there is a record of *D. notabile* from the Bistrorechensk Formation in the interfluve of the Opuka and Khatyrka rivers (Figs. 2, 4), where *Diplomoceras* originated from a level referred to as the *Korjakia kociubinskii* Zone, as proposed by Pochialaynen & Byalobzheskiy (1984), for the uppermost Maastrichtian part of the section.

Alabushev & Wiedmann (1994) published a single specimen of *D. notabile* from the lower Campanian of southern Sakhalin. Later, the same authors (Alabushev & Wiedmann, 1997, p. 14, pl. 4, Fig. 1) recorded *D. notabile* on the basis of the same specimen which was again illustrated, and also mentioned that there were two other specimens from the lower Campanian of southern Sakhalin and even one from the lowermost Campanian of Kamchatka. Unfortunately, those specimens have never been illustrated or described in detail. However, the localisation of all specimens is so uncertain, that this age assignment appears highly questionable. Those authors compared this individual of *D. notabile* with two others (Alabushev & Wiedmann, 1997, pl. 4, Figs 2, 3) from the upper Maastrichtian of southern Sakhalin and identified as *D. cylindraceum*, noting (p. 15), that, 'The species differs from the cosmopolitan *D. cylindraceum* (Defrance) by its smaller shell with finer sculpture' . In our view, this specimen of *D. notabile* (Alabushev & Wiedmann, 1997, p. 14, pl. 4, Fig. 1) is the 7th turn of an adult individual of *D. cylindraceum*. In short, all three

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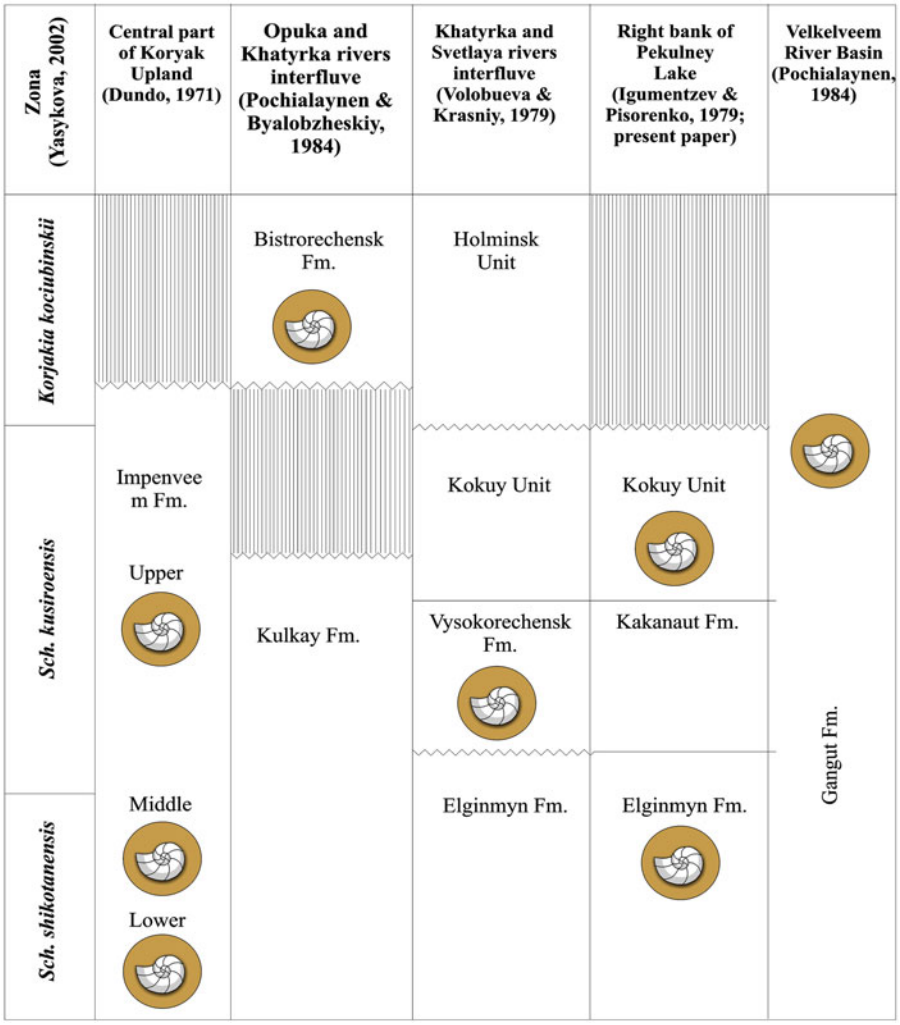

Figure 4. Distribution of finds of *Diplomoceras* in Maastrichtian deposits of Koryak Upland, North-West Pacific Province (Far East Russia).

specimens illustrated by Alabushev and Wiedmann (1997, pl. 4, Figs 1–3) belong to *D. cylinraceum*, but in view of poor photographic documentation are best treated as *D.* cf. *cylindraceum*. Unfortunately, Alabushev & Wiedmann (1994, 1997) failed to mention any lithological units as established in Sakhalin (Poyarkova, 1987). Thus, it is utterly impossible to determine from where these illustrated specimens, and all others in those two papers, originate and their age, either upper or lower Campanian or Maastrichtian, cannot be determined. In addition, we consider one specimen of the associated fauna described by Alabushev & Wiedmann (1997, pl. 4, Fig. 9) as *Ryugasella ryugasensis* Wright & Matsumoto (1954) is more closely similar to a species of *Glyptoxoceras*, and might be of Maastrichtian age.

The best-preserved specimen of *Diplomoceras* from Far East Russia is the one illustrated by Maeda et al. (2005), as *D.* cf. *notabile*, from unit K3 of the Krasnoyarka Formation in the Makarov area (Sakhalin). Those authors claimed that it was of early late Maastrichtian age, but we cannot be certain of this, because they changed the lithological subdivisions of the Krasnoyarka Formation, failing to provide correlations with the previous stratigraphical scheme (Poyarkova, 1987). However, Maeda et al. (2005) did mention finds of *Pachydiscus* (*P.*) *flexuosus* and *Glyptoxoceras* sp. from the same level; thus, it might represent the upper Maastrichtian. In stark contrast, the same authors noted the inoceramids *Schahmaticeramis shachmati* (Salnikova & Zonova in Poyarkova, 1987), *Sch. kusiroensis* and *Sphenoceramus hetonaianus* (Matsumoto, 1952) from Unit K2, which corresponds to the upper Campanian. This is highly surprising because the species listed are all considered to be late Maastrichtian indices (Zonova et al., 1993; Toshimitsu et al., 1995, and references therein). In short, we cannot be certain about the age, but, as preserved, these specimens show features which are definitively the same as *D. cylindraceum*.

In summary, it may be stated that finds of *Diplomoceras* from the Russian Pacific, described as *D. notabile*, have been noted from the upper Campanian and Maastrichtian. There are also finds of *D. cylindraceum* that have been dated as Maastrichtian. It follows that, if age assessments are correct, it could be hypothesised that *D. notabile* was the Campanian precursor of *D. cylindraceum* in the Pacific Realm, meaning that the centre of origination of *Diplomoceras* might have been in the Pacific area. However, in view of the poor state of preservation, we might equally well conclude that all specimens belong to *D. cylindraceum*. Finds from Maastrichtian deposits should also be considered to represent *D. cylindraceium*, as noted by Kennedy (1987) for the specimen published by Dundo (1971) and subsequently by Klinger & Kennedy (2003b), who included *D. notabile* of Alabushev & Wiedmann (1997) into the synonymy of *D. cylindraceum* and recorded this species from upper Campanian and Maastrichtian deposits of South Africa. Thus, the most parsimonious conclusion

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is that the cosmopolitan species, *D. cylindraceum*, is the sole representative of the genus and its stratigraphical range is upper Campanian to uppermost Maastrichtian, with the centre of origination either in South Africa or the Pacific Realm.

Finds from Japan are very important in this respect. The first late Campanian specimens of *D. notabile* were published by Tatsuo Matsumoto (Matsumoto & Morozumi, 1980; Matsumoto *in* Taira & Tashiro, 1981), who also presented a detailed review of the genus and of the species *D. notabile* (Matsumoto, 1984; Matsumoto & Miyauchi, 1984). He suggested that the existence of *D. notabile* was supported by some morphological features, such as whorl shape and character of the finest ribs, setting it apart from *D. cylindraceum*. Matsumoto (*in* Matsumoto & Miyauchi, 1984) actually proposed that every find from the Pacific area would belong to *D. notabile*, including those from the Falkland Islands (Matsumoto & Miyauchi, 1984) and that the stratigraphical range was upper Campanian. We do not agree that such features can be used to prove the occurrence of two different species, but the fact that late Campanian finds have been mostly made in Pacific or Atlantic areas support the notion of an area of origination mentioned above.

Misaki & Maeda (2009) published a single fragment of *Diplomoceras* sp. from the Toyajo Formation of south-west Japan. Although the entire assemblage of associated fauna is rather Maastrichtian in character, but the heteromorph, *Didymoceras awajiense* (Yabe, 1901) dated as late Campanian, then the position is a bit confusing. Subsequent finds from the Maastrichtian Senpohshi Formation in eastern Hokkaido (Shigeta et al., 2015) have been described as *Diplomoceras* cf. *notabile*, while Kurichara et al. (2016) recorded *D. cylindraceum* from the uppermost Maastrichtian Kawaruppu Formation (Nemuro Group) in south-east Hokkaido, having been recovered from a siltstone 15 m below the Cretaceous-Paleogene (K/Pg) boundary. The stratigraphical level of the fossil has been estimated to be ~66.8 Ma, based on the time scale for geomagnetic polarity and the K/Pg boundary. Thus, *D. cylindraceum* survived at least around 800 kyr prior to the K/Pg boundary event in the north Pacific region. Kurichara et al., (2016, p. 119) also suggested that all finds of *D. notabile* should be referred to *D. cylindraceum*.

There are a number of more recent finds of *Diplomoceras* from Japan. Masukawa & Ando (2018) mentioned *Diplomoceras* sp. from the upper Campanian of Japan and also noted that in the north-west Pacific region, *Diplomoceras* ranged from the mid-Campanian to the uppermost Maastrichtian. They established the age of the Nakaminato Group in south-west Japan as late Campanian, because *Diplomoceras* co-occurred with *Didymoceras awajiense* and *Inoceramus* (*Endocostea*) *shikotanensis* (= *Schachmaticeramus shikotanensis* as understood here). In the upper part of the section, Masukawa & Ando (2018) mentioned the 'early' Maastrichtian inoceramid, '*Inoceramus*' *kuziroensis* (= *Schachmaticeramus kuziroensis* as understood here), which leads to a lot of confusion. In many previous papers, these two inoceramid species have been considered to be of early and late Maastrichtian age, respectively (e.g. Noda & Matsumoto, 1976; Poyarkova, 1987; Zonova et al., 1993; Toshimitsu et al., 1995; Yazykova, 2004). Yet, according to Masukawa & Ando (2018, p. xx) all previous finds of *Diplomoceras* should be dated as late Campanian. The main argument underlying these changes lies in the outcome of zircon dating. However, these data have never been formally published, but just briefly mentioned as follows, 'U_Pb age of detrital zircons indicated by Nagata and Otoh (pers. comm., May 2016)'. In short, their dating of stratigraphical levels is based on personal communication, rather than on published data. We are not in favour of this interpretation and shall provide more detailed counterarguments in our planned work on associated ammonites, inoceramid and non-inoceramid bivalves and gastropods from locality 325. The most recently published, comparatively large assemblage from Japan was identified as *Diplomoceras* sp. and originates from even older levels, mid- to upper Campanian levels (Shigeta & Tsutsumi, 2019).

One last note on finds from Alaska (Jones, 1963): *D. notabile* is known from the upper part of Member 3 of the Matanuska Formation, which could be either latest Campanian or early Maastrichtian. Kennedy (1987) included this into the synonymy of *D. cylindraceum*; we concur. The same should hold true for *D. notabile* from the Nanaimo Group (uppermost Campanian to lower Maastrichtian) of British Columbia, Canada (Haggart, 1991).

Conclusions

As noted above, Kennedy (1987) and Klinger & Kennedy (2003b) included into the synonymy of *D. cylindraceum* some Pacific finds of *D. notabile*, notably two finds from Maastrichtian strata as described by Anderson (1958) and two from New Zealand (Henderson, 1970), material from Alaska (Jones, 1963), Koryak Upland (Dundo, 1971) and Sakhalin (Alabushev & Wiedmann, 1997), but did not question any finds from Japan. We agree with Kurichara et al. (2016) that all material of *Diplomoceras* from Japan, identified as *D. notabile*, should be considered to belong to *D. cylindraceum*. The stratigraphical range of that species is mid-Campanian to uppermost Maastrichtian. Kurichara et al. (2016) even suggested that *D. cylindraceum* was the youngest Cretaceous ammonite in the Pacific Realm.

There are three ways to interpret all of the above data, as follows:

1. *Diplomoceras notabile* and *D. cylindraceum* are sibling or vicariant species, in which case all finds from the Pacific area, including Australia, should be listed as *D. notabile*, and those from European and Atlantic (African) regions as *D. cylindraceum*;
2. *Diplomoceras notabile* occurred in the Campanian, *D. cylindraceum* in the Maastrichtian, in which case the former might be the precursor of the latter and the centre of origination would be in the Pacific area;
3. *Diplomoceras notabile* is synonymous with *D. cylindraceum* and all morphological differences are those expressed by ecophenotypy or polymorphism, depending on environmental conditions. The deep-water facies of the Pacific is assumed to have led to morphological changes in comparison to the shallower-water chalk facies of Europe.

Our view is that all records of *Diplomoceras* from the North-West Pacific Province pertain to *D. cylindraceum* and that the stratigraphical range of this species is mid-Campanian to uppermost Maastrichtian. Long-lived taxa are quite common in the evolutionary history of the Ammonoidea. Klinger & Kennedy (2003b) already discussed the possibility that *D. cylindraceum* could have been amongst the longest-ranging heteromorph ammonite species of the Cretaceous Period. Material illustrated here, originating from the upper part of the Maastrichtian, provides evidence that Kurichara et al. (2016) were right in noting that *D. cylindraceum* could well have been the youngest Cretaceous ammonite in the Pacific Realm.

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