The Biogeographic Relationships of Ordovician Strata and Fossils of Austria[1]

by

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with 6 figures

Fossiliferous rocks of Cambrian age have yet not been recognized in the Alps. All previous reports on such occurrences were misleading since they have not been based on true fossils (see H. P. SCHÖNLAUB 1979, p.11, p. 39).

Remarkably well preserved acritarchs do, however, occur in phyllitic slates near the base of the Graywacke Zone in the vicinity of Kitzbühel, Tyrol (E.REITZ & R. HÖLL 1989) and in the Innsbruck Quarzphyllite (E.REITZ & R.HÖLL 1990). They suggest an Early Ordovician age equivalent to the Tremadocian Series of the British succession. In contrast to this report the supposed occurrence of Tremadocian graptolites (E. HABERFELNER 1931) has not been confirmed; it probably represents an artifact (H. JAEGER 1969).

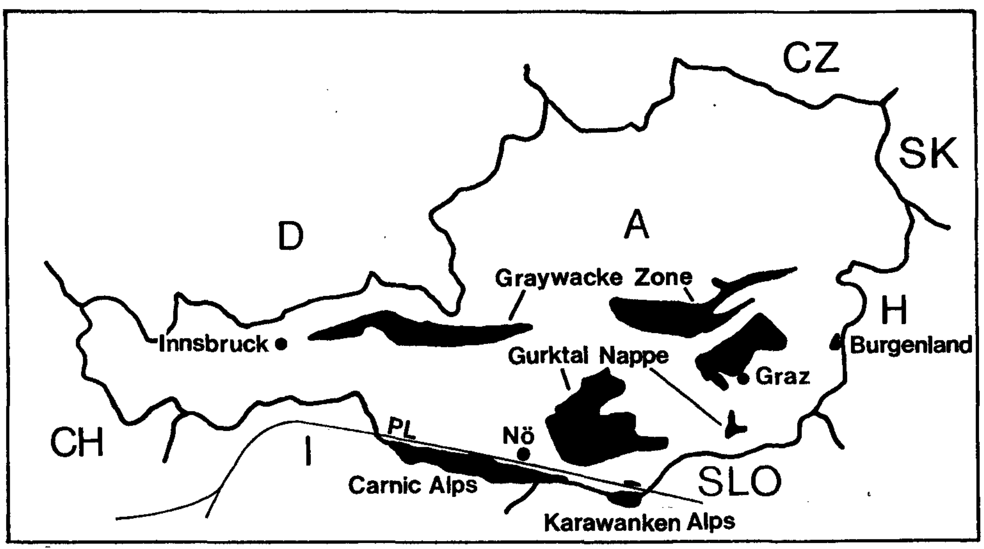

Fig. 1: Main regions with fossiliferous Paleozoic strata in the Eastern and Southern Alps (PL = Periadriatic Line, Nö = Nötsch).

The oldest megafossil assemblage of the Alps is of Upper Llandeilian age corresponding to the lower Berounian Series of Bohemia (V. HAVLICEK et al. 1987). It is derived from the locality Bruchnig on the mountain Magdalensberg north of Klagenfurt, Carinthia. The fossils comprise mostly brachiopods which occur in tuffaceous strata on top of basic metavolcanic and pyroclastic rocks. They represent mildly alkaline within-plate basalts which have been altered to spilites (J. LOESCHKE 1989a,b).

[1] Updated version of a chapter from the author's original paper of 1992 (Jb. Geol. B. - A., 135, 381 - 418).

The second important fossil assemblage was recorded from arenaceous shales in the Carnic Alps and appears to be slightly younger, i.e. Caradocian in age. The highly diversified fauna comprises brachiopods, bryozoans, trilobites, cystoids and very rare hyolithes (H.P.SCHÖNLAUB 1971, 1988, G.B.VAI 1971, L. MAREK 1976, G.B.VAI & C. SPALLETTA 1980, V. HAVLICEK et al. 1987).

Interestingly, these two fossil sites, located to the north and the south of the Periadriatic Line, differ significantly from coeval cold-water Mediterranean associations, i.e., those from Bohemia ("Perunica" according to V. HAVLICEK et al. 1994) and Morocco, although these regions and the Alps have some elements in common, for example, *Svobodaina ellipsoides, Gelidorthis meloui, Saukrodictya porosa, Aegiromena aquila aquila* and *Paterorthis paterina.* Instead, in their presence of warm water elements such as representatives of *Dolerorthis, Iberomena, Longvillia, Porambonites, Eoanastrphia* a.o. they exhibit a closer affinity to Sardinia, the British Isles and North Europe which indicates an invasion of North European warm water brachiopods as far south as the Alps, Sardinia, Montagne Noire and Spain (V.HAVLICEK 1976, V. HAVLICEK et al. 1987).

During the Hirnantian Stage the supposed relationship with Baltoscandia can still be seen in the ostracod and echinoid fauna described by R.SCHALLREUTER 1990 from the Carnic Alps. This time, corresponding roughly to the glacial maximum, is, however, also characterized by a cold water influx from Gondwana (H.JAEGER et al. 1975). On a global scale it is associated with a worldwide retreat of the sea coupled with a distinct interval of faunal extinction and the appearance of the widespread Hirnantia Fauna (A. D. WRIGHT 1968, W.B.N.BERRY & A.J. BOUCOT 1973, P.M.SHEEHAN 1973, 1975, 1979, 1988, H. JAEGER et al. 1975, P.J. BRENCHLEY & G. NEWALL 1980, N. SPJELDNAES 1981, P.J.BRENCHLEY 1984, 1994, P.J.BRENCHLEY & B. CULLEN 1984, J. RONG 1984, H.P. SCHÖNLAUB 1988, 1996, P.M. SHEEHAN & P.J. COOROUGH 1990, P. J. BRENCHLEY et al. 1994, J. D. MARSHALL et al. 1994, a.o). Its distribution is concentrated in the higher latitudes of the southern hemisphere but exceptions do occur in a tropical belt and in northern low latitudes suggesting that this unique fauna was adapted to a glacially induced cold climate and consequently cooler waters at the close of the Ordovician.

The Upper Ordovician conodont fauna of the Alps has been well known from detailed studies by O.H. WALLISER 1964, E. SERPAGLI 1967 and G. FLAJS & H.P.SCHÖNLAUB 1976 from the Uggwa Limestone of the Carnic Alps and different limestone units of the Graywacke Zone of Styria. They have been less well described from a few weakly metamorphosed occurrences in between (F. NEUBAUER 1979, M. F. BUCHROITHNER 1979, F. NEUBAUER & J. PISTOTNIK 1984). Apparently, this conodont association represents the *Hamarodus europaeus-Dapsilodus mutatus-Scabbardella altipes* (HDS)-Biofacies of W.C.SWEET & S.M.BERGSTRÖM 1984. Although their precise age within the uppermost Caradocian or early Ashgillian Series remains open the conodont bearing limestones clearly can be assigned to the *Amorphognathus ordovicicus* Zone. According to W.C.SWEET & S.M. BERGSTRÖM 1984 who tentatively revised the published conodont elements from the Carnic Alps in terms of the modern multielement taxonomy, the Late Ordovician Uggwa Limestone is dominated by *Scabbardella altipes* (43%), *Hamarodus europaeus* (17%), *Amorphognathus* cf. *ordovicicus* (8%) and *Dapsilodus mutatus* (2.4%). Less abundant are *Plectodina alpina, Belodella pseudorobusta, "Prionoidus" ethingtoni* and *Strachanognathus parvus.* The occurrence of these species and the abundance of the others, in particular *Hamarodus europaeus*, varies from coeval faunas of Thuringia, Spain and France. Yet, it seems unclear which factors are involved in these differences (J.DZIK 1989).

A comparison between this fauna from the Carnic Alps and the two others from the Graywacke Zone is difficult to assess due to probably minor differences in age and state of preservation (G.FLAJS & H.P.SCHÖNLAUB 1976). In particular, this regards the large collection derived from the limestone lenses underlying the thick acid volcanics of the so-called Blasseneck-Porphyroid in the surroundings of Eisenerz, Styria. Apparently, the revised conodont association represents the same general type as the one from the Carnic Alps in being equally dominated by *Amorphognathus* cf. *ordovicicus, Scabbardella altipes, Hamarodus europaeus, Dapsilodus mutatus* and perhaps *Plectodina alpina*; less abundant are *Belodella pseudorobusta, Panderodus* ssp. and certain elements which tentatively have been assigned to *Birkfeldia circumplicata*. Other differences between these two faunas were thoroughly reviewed by G. FLAJS & H.P.SCHÖNLAUB 1976.

According to S. M. BERGSTRÖM 1990 the "Coefficient of Similarity" (CS) between conodonts from Baltoscandia and the Mediterranean area has a value of 0.30 indicating moderate similarity between the two regions. For example, they share the occurrences of specimens of *Amorphognathus, Scabbardella* and *Dapsilodus* while others appear to be restricted to continental Europe or North Africa. Obviously, the distribution of late Ordovician conodonts follows a similar pattern as inferred from megafossil assemblages and facies data. This led W.C.SWEET & S.M. BERGSTRÖM 1984 to conclude that the Mediterranean Province was a cold water realm in a polar or subpolar latitudinal setting.

In a recent conodont study of the Kalkbank Limestone of Thuringia A. FERRETTI & C. R. BARNES (1997) concluded that this fauna closely resembles coeval conodonts from Libya, Spain and France which belongs to the cold-water realm of the Mediterranean Province. Apparently less close relations exist with the Carnic Alps and Sardinia. Conodonts from these two regions seem to be closer related to temperate faunas such as those in Britain.

In the Alps, occurrences of carbonate sediments provide broad latitudinal constraints for the Upper Ordovician. Potentially useful though only of limited climatic significance is the distribution of limestones in the Carnic Alps, the Graywacke Zone and the Gurktal Nappe in between. According to W.C. DULLO 1992 the up to 20 m thick carbonate units, in the local stratigraphical schemes named Wolayer and Uggwa Lst., respectively (H.P.SCHÖNLAUB 1985a), represent grayish and whitish grainstones to rudstones and occasionally also bafflestones with abundant debris of cystoids and bryozoans and less frequently trilobites and nautiloids. Cathodoluminescence studies have revealed the rare occurrence of coated grains. Moreover, of special significance are dogtooth-cements suggesting a vadose diagenetic environment for the Wolayer Limestone in contrast to the coeval and slightly deeper Uggwa Lst. which is enriched in clay and shell fragments but decreased in the content of bryozoans and echinoderms. At about the Caradocian/Ashgillian boundary they succeed various clastic sequences which dominated the Early and Middle Ordovician interrupted by basic volcanics of presumably Llandeilian age as well as of acid volcanics in the Caradocian (M. HINDERER 1992, Fig. 2).

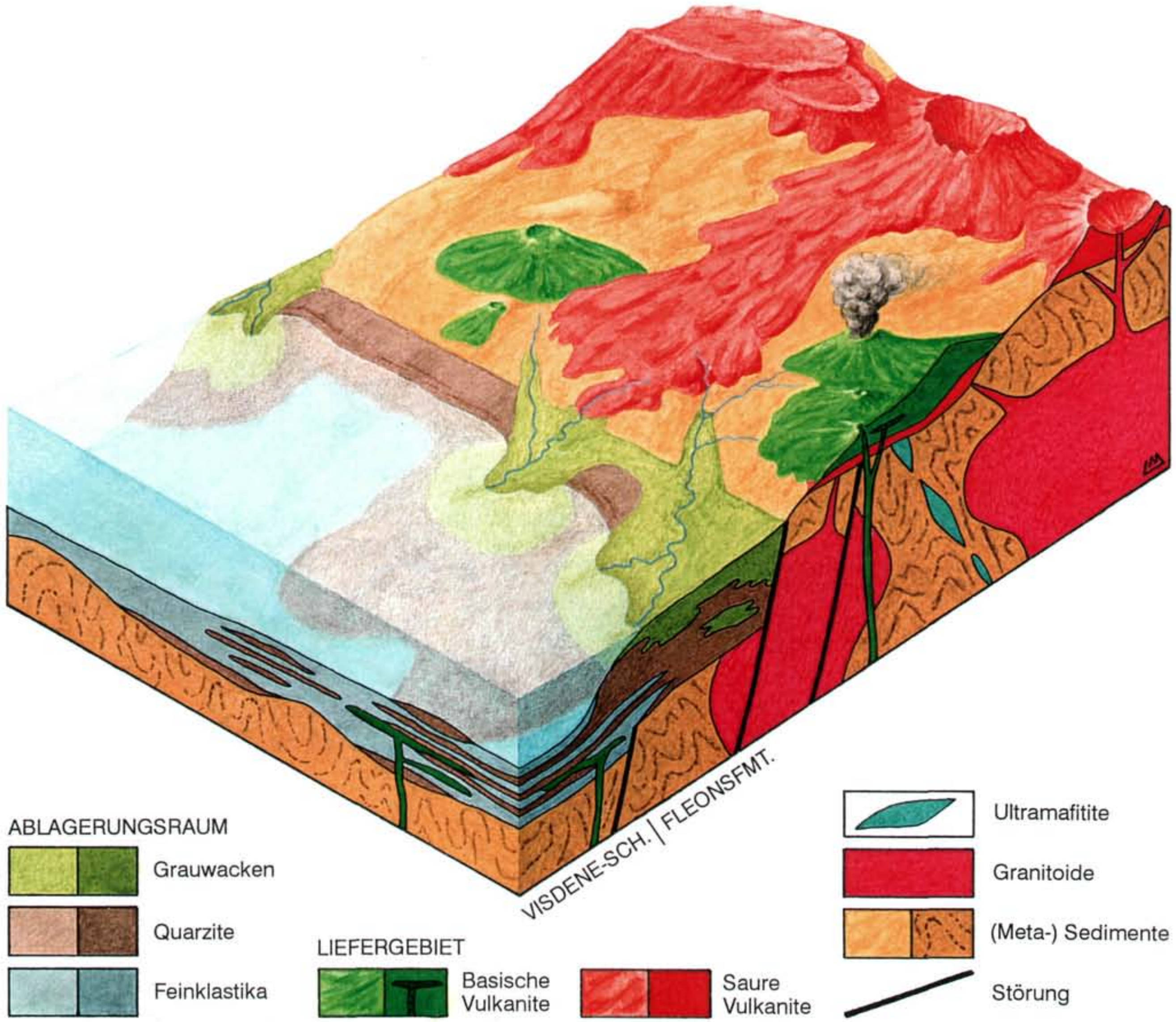

Fig. 2.
Sketch of Upper Ordovician volcanism in the Western Carnic Alps (Modified from M. HINDERER 1992).

In a general climatically based latitudinal framework these carbonate units suggest a position within the confines of the larger "carbonate belt", i.e., between latitudes of about 45° North and South where it was moderately warm and where there was adequate light penetration rather than high water temperature (A.M. ZIEGLER et al. 1984). Whether or not the late Ordovician limestones from the Alps may represent cool water carbonates analogous to modern and Cenozoic carbonates off Southern Australia (N.P. JAMES & Y.BONE 1991) is presently difficult to decide. More plausible, the nature of the corresponding sediments may have developed as the direct response to climatic changes during the Ordovician. For the Ashgillian P.D. WEBBY 1984 suggested a global climatic amelioration as the main cause for the increasing carbonate production. Alternatively, a progressive northward shift of the sedimentary basins into lower latitudes may also explain their temporal and spatial distribution (T.P.YOUNG 1990). In the Ordovician of the Mediterranean Province contemporary carbonates are widely distributed and have been reported from Sardinia (G.B.VAI & T.COCOZZA 1986, A. FERRETTI & E. SERPAGLI 1991), Montagne Noire, the Massifs of Mouthoumet and Agly of Southern France (W.ENGEL et al.1981), the Armorican Massif (F. PARIS et al. 1981, F.PARIS & M.ROBARDET 1990, M.ROBARDET et al.1990, M.MELOU 1990), the Pyrenees (J.J.A.HARTEFELT 1970, H. DURAN et al. 1984), Catalonia and other areas in Spain (W. HAMMAN 1976, M. HAFENRICHTER 1980, H.DURAN et al. 1984, R.W. OWENS & W. HAMANN 1990, A. FERRETTI 1992), Portugal (T.P.YOUNG 1985, 1988, 1990), Libya (S. M. BERGSTRÖM & D. MASSA 1979, 1987, 1992) and the Anti-Atlas of Morocco (J.DESTOMBES et al. 1985). Consequently, the Alpine occurrences of Upper Ordovician rocks suggest a position at considerably lower and more temperate latitudes than has been shown in the revised World maps of C. R. SCOTESE & W. S. McKERROW 1990. More precisely, available faunal and lithic data from the Upper Ordovician of the Alps rather indicate a position between approximately 40 and 50° southern latitude instead of being placed around 60 degrees South. This setting, still beyond the present day Darwin Point of some 35° (R.W. GRIGG 1982), is consistent with the paleogeography of the West European Platform as proposed by T.P. YOUNG 1990.

Conclusions

Although the database to establish a paleobiogeographic approach during the Cambrian and Ordovician Periods of Central and Southern Europe is sparse and far from being sufficient some related trends in the interchange of past communities and in the geodynamic evolution of this area can clearly be recognized (Figs. 3 - 6):

1. During the Cambrian and Lower Ordovician thick clastic sequences are the dominating sediments in northern Africa and in the adjacent southern and central European depocenters. Though these rocks are of no or only limited climatic significance their inherited zircon population indicates Africa as source area (D. GEBAUER et al. 1993).

2. Carbonates first occur in the Lower Cambrian of Southern and Central Europe suggesting a low latitudinal position and close faunal relationships between the individual occurrences within the Mediterranean faunal realm (K.SDZUY 1962, G. FREYER 1987, P. COURJAULT-RADÉ et al. 1992, W. S. McKERROW et al. 1992). Yet, in the Alps the corresponding rocks have not been found. The oldest limestones are of Upper Ordovician age and occur in various parts of the Eastern Alps. Their

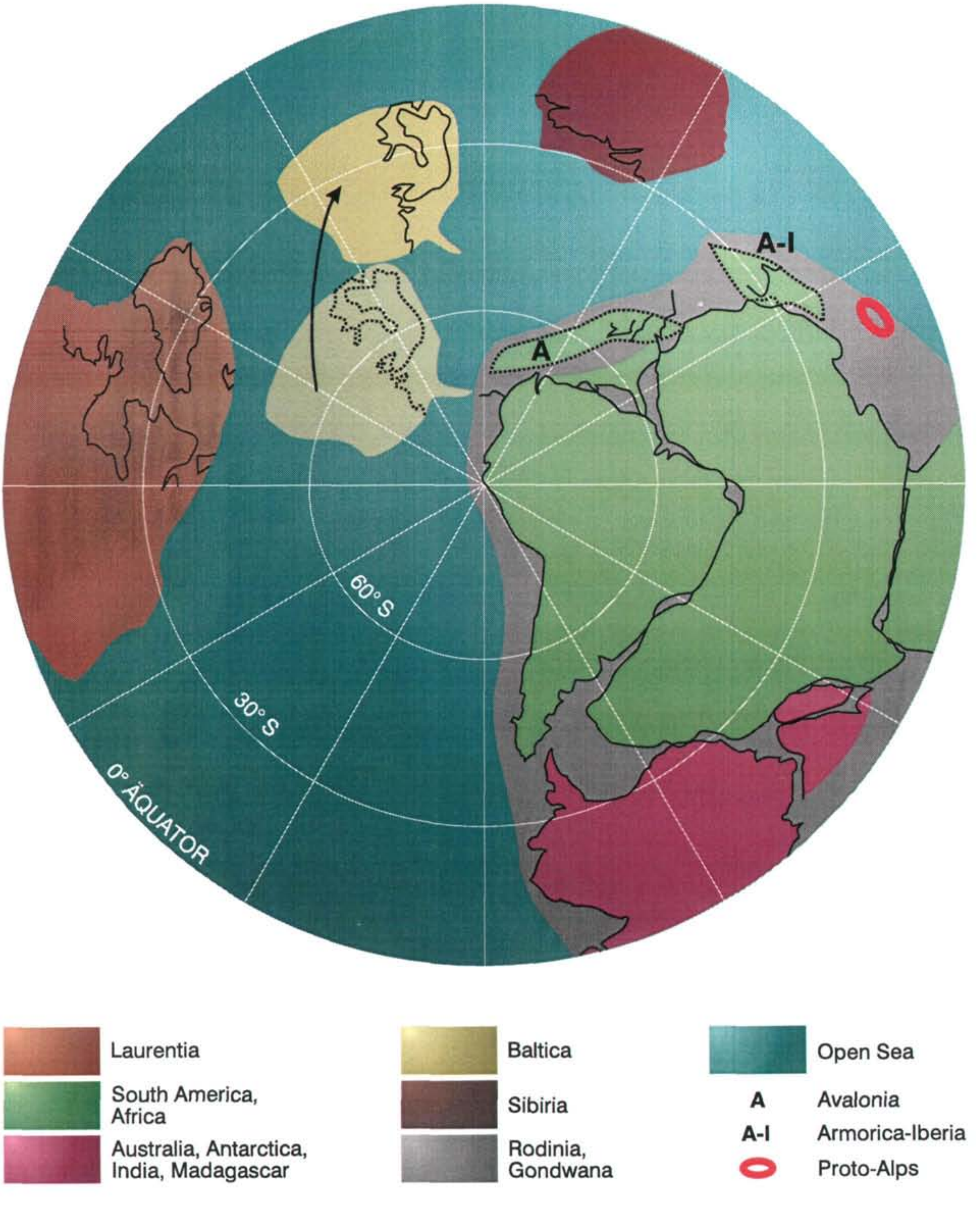

Fig. 3.
Paleogeographic reconstructions for the latest Vendian at c. 550 Ma with indication of Avalonia and and the Armorican-Iberian Massifs forming the Cadomian Arc at the northern margin of Gondwana. Also indicated is the low-latitude position of the forerunner of the Alps. Main plate configuration after T. H. TORSVIK et al. (1995).

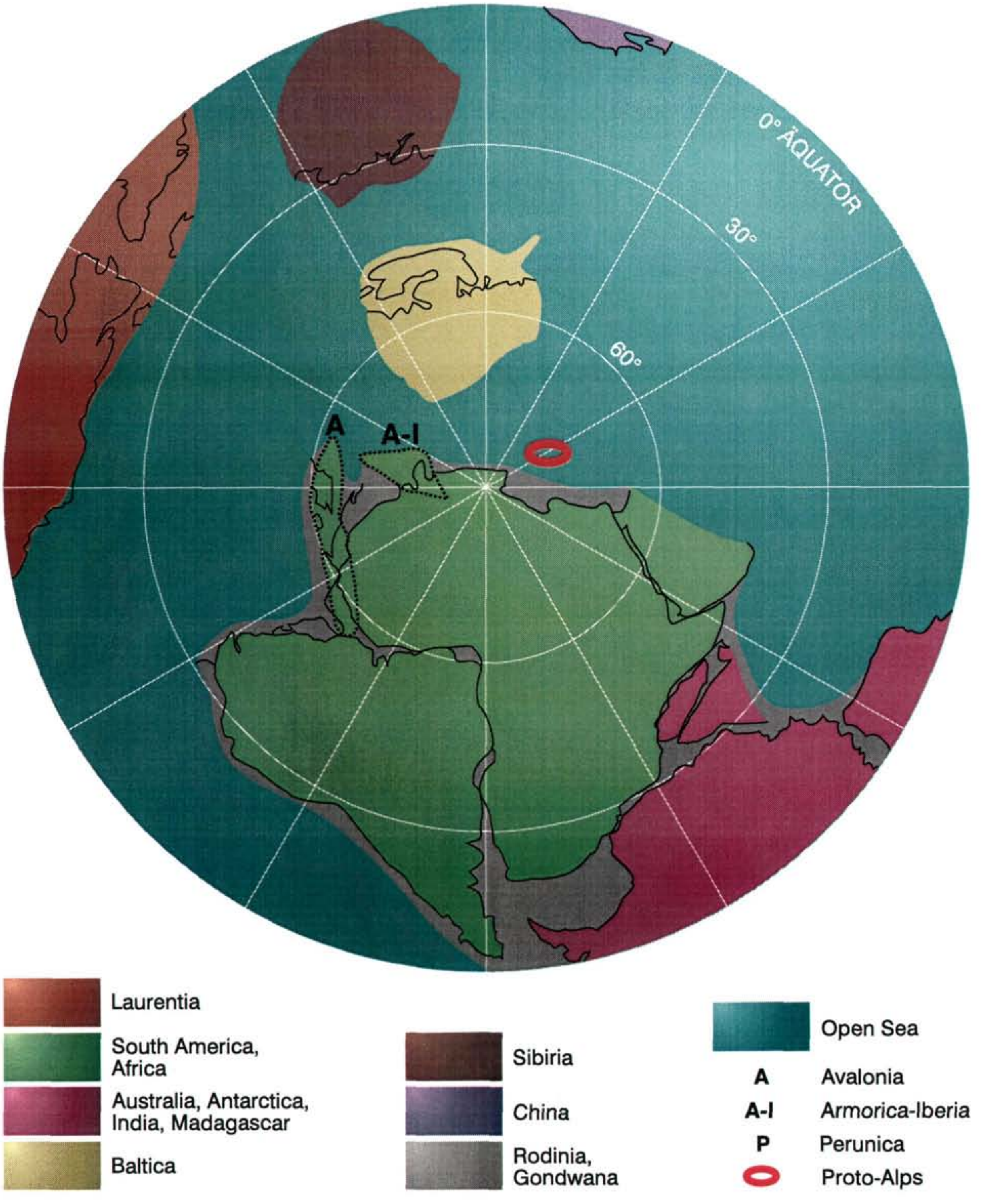

Fig. 4.
Paleogeographic reconstructions for the lowermost Ordovician at c. 490 Ma (after T. H. TORSVIK et al. 1995, modified). Note early to mid-Ordovician break-up of Gondwana including rifting of Avalonia, the Armorican-Iberian Massifs, Perunica and the ancestral Alps. The latter are located in high latitudes.

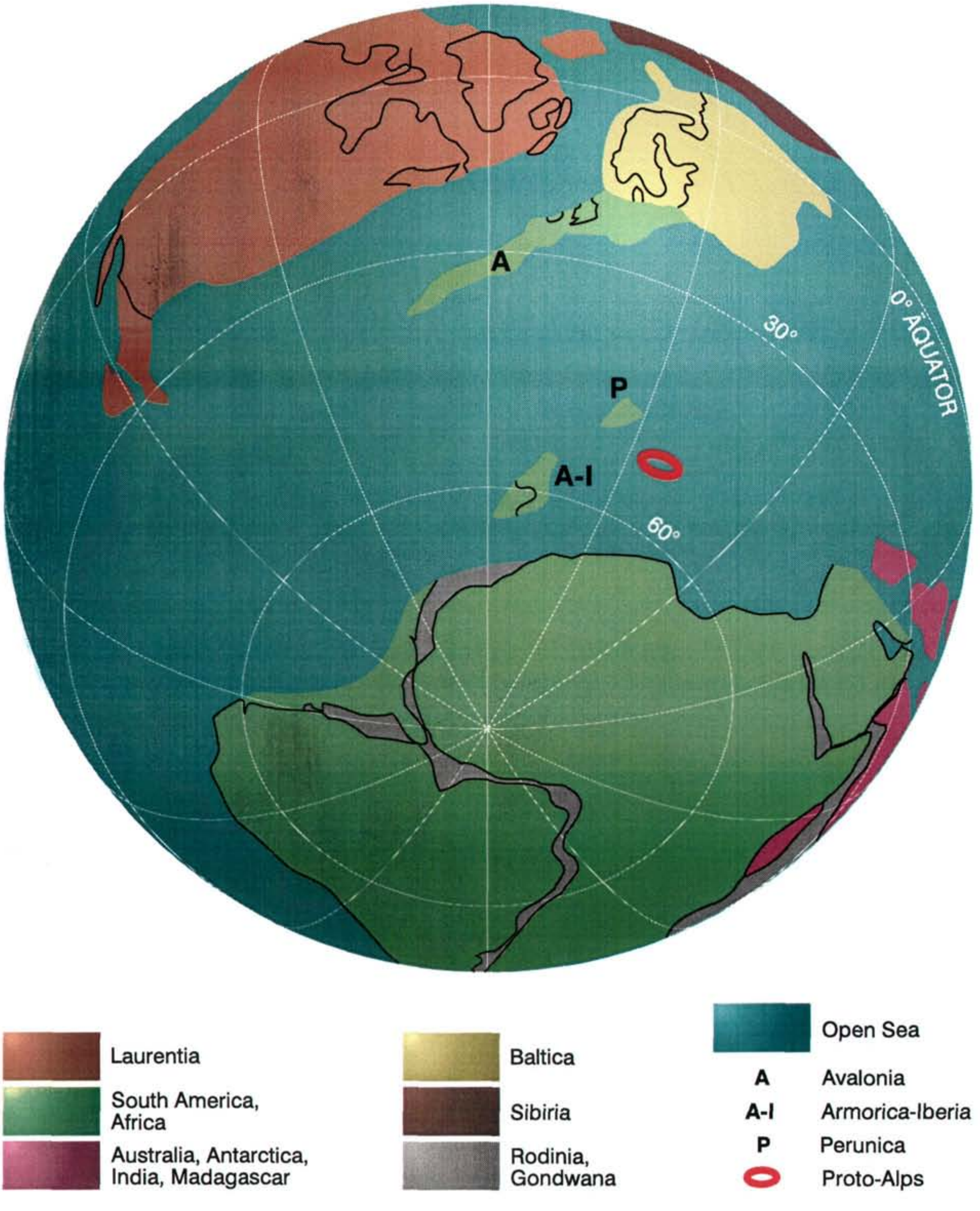

Fig. 5.
Paleogeographic reconstructions of the Atlantic bordering continents in the Upper Ordovician at c. 460 Ma (after L. R. M. COCKS & C. R. SCOTESE 1991, modified).

fossil content and microfacies indicate a moderate climate in a temperate latitudinal setting.

3. Upper Ordovician fossils, in particular most brachiopods, cystoids, ostracods and conodonts, are more closely related to coeval warm water faunas of northern Europe, Great Britain and Sardinia than to northern Africa. Exceptions are, however, the occurrences of the African brachiopod species *Paterorthis paterina* in the Caradocian, the Ashgillian Hirnantia fauna and the brachiopod *Clarkeia* sp. which indicate a temporary minor cold water influence from southern high latitudes.

4. Probably during the Llandeilian a rifting related basic volcanism occurred first recognized in Middle Carinthia but supposedly also occurring at other places of the Alps. Interestingly, this event seems to coincide with calc-alkaline igneous activity in the Ardennes, Wales and SE Ireland (B.P. KOKELAAR et al. 1984) when Avalonia started to rift off from Gondwana (L.R.M.COCKS & R.A. FORTEY 1982, W.S.McKERROW & L.R.M.COCKS 1986, K.T.PICKERING 1989, C.R. SCOTESE & W.S.MCKERROW 1990, F.PARIS & M.ROBARDET 1990 with opposing statements). An analogous plate disruption and subsequent separation might well be assumed for certain parts of the Variscan Alps (J. LOESCHKE & H. HEINISCH 1993, H. P. SCHÖNLAUB 1993).

5. A second major magmatic event occurred in the Early Ashgillian and has been regarded as a collision-subduction related process (J.LOESCHKE 1989a). In accordance with paleomagnetic data from Gondwana it seems reasonable to suggest that this event reflects the rapid northward movement of Africa (T. H. TORSVIK et al. 1996) and its final collision with an unknown microcontinent or terrane located to the north.

6. Our best estimate for the paleolatitudinal position of the late Ordovician of the Alps and its relationship with adjacent areas is illustrated on the amended map of L. R. M. COCKS & C. R. SCOTESE (1991) for this time (Fig. 1). This plate configuration is based on the data from the Alps presented in the foregoing chapters and seems well constrained by sedimentary and faunal evidence from the West and Central European Platform (M.ROBARDET et al. 1990, M.MELOU 1990, T.P.YOUNG 1990, F. PARIS & M.ROBARDET 1990).

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