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Condensed carbonate sedimentation in the late Devonian of the eastern Anti-Atlas (Morocco)

By Jobst Wendt[1])

RÉSUMÉ

Les plate-formes marines ouvertes et peu profondes constituent une caractéristique paléogéographique largement répandue dans plusieurs anciens milieux pélagiques à sédimentation carbonatée. Par contraste avec les zones pauvres en affleurements et hautement compliquées tectoniquement du Dévonien supérieur et du Carbonifère inférieur des Alpes, de la Pologne, de l'Allemagne de l'ouest et de la France, les séquences Paléozoïques faiblement plissées de l'Anti-Atlas oriental (Maroc) fournissent un exemple unique de condensation stratigraphique pendant le Dévonien supérieur et de plus elles affleurent sur une surface de plusieurs milliers de km^2. La condensation commence au Frasnien inférieur, elle est plus largement répandue pendant le Famennien inférieur et peut se poursuivre dans le Famennien supérieur. Ces dépôts recouvrent des carbonates néritiques ou pélagiques, généralement après une lacune de sédimentation prononcée représentant un soulèvement local au-dessus du niveau marin et/ou une submersion subséquente.

Les caractéristiques faunistiques et sédimentologiques des séries condensées sont: l'accumulation d'organismes pélagiques (principalement des Céphalopodes), le remplissage intermittent et la corrosion superficielle des coquilles, la présence de «hardgrounds» avec une faune et une flore épi- et endobenthonique éparse, l'existence de fréquentes discontinuités dans la séquence. Les taux de sédimentation qui étaient de l'ordre de 1 m/MA, pouvaient diminuer jusqu'à quelques dizaines de cm/MA. La hauteur d'eau sur les plate-formes pélagiques était probablement inférieure à cent mètres. Elles étaient flanquées de bassins peu profonds (non turbiditiques) ou plus profonds (partiellement turbiditiques) dans lesquelles les sédiments s'accumulaient avec un taux de sédimentation de 20 à 100 m/MA. Les plate-formes pélagiques à sédimentation condensée constituent une phase intermédiaire habituelle dans l'évolution sédimentaire et structurale des marges continentales passives, entre une phase antérieure à sédimentation épaisse de carbonates néritiques ou de sédiments clastiques et une phase postérieure à sédimentation de flysch. Des exemples similaires sont connus dans le Mésozoïque de la ceinture orogénique périméditerranéenne.

ABSTRACT

The weakly folded Palaeozoic sequences of the eastern Anti-Atlas (Morocco) provide a unique example of stratigraphic condensation during the late Devonian, exposed over an area of several thousand km^2. Condensation started in the early Frasnian, was most widespread during the early Famennian and may locally have continued into the late Famennian. These deposits are limited to pelagic platforms and overlie neritic or pelagic carbonates, generally after a pronounced hiatus representing local uplift above sea-level and/or subsequent drowning. Faunal and depositional characteristics of the condensed deposits include accumulation of pelagic organisms (mainly cephalopods), intermittent filling and superficial corrosion of shells, hardgrounds with a sparse epi- and endobenthonic fauna and flora, and frequent discontinuities within the sequence. Sedimentation rates were in the order of a few tens of cm to 1 m/MA. Water depth on the pelagic platforms was probably less than one hundred metres. The platforms were flanked by shallow (non-turbiditic) or deeper (partly turbiditic) basins in which sediments accumulated at a rate of 20–100 m/MA. Pelagic platforms with condensed sedimentation constitute a common inter-

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mediate stage in the depositional and structural evolution of passive continental margins between a preceding stage of thick shallow-water carbonate or clastic deposition and the final stage of flysch sedimentation. Similar examples are known from equivalent palaeogeographical settings of late Devonian/early Carboniferous age in France, West Germany, the Alps, Poland, and from the Mesozoic of the circum-Mediterranean orogenetic belts.

ZUSAMMENFASSUNG

Die schwach gefalteten paläozoischen Serien des östlichen Anti-Atlas (Marokko) bieten im Oberdevon ein einzigartiges Beispiel stratigraphischer Kondensation, das in einem Gebiet von mehreren tausend km^2 aufgeschlossen ist. Die Kondensation beginnt im unteren Frasne, ist im unteren Famenne am weitesten verbreitet und kann lokal bis ins obere Famenne anhalten. Diese Ablagerungen beschränken sich auf pelagische Plattformen und überlagern neritische oder pelagische Karbonate, im allgemeinen nach einer deutlichen Schichtlücke, die einer lokalen Auftauchphase und/oder anschliessender Absenkung entspricht. Faunistische und sedimentäre Merkmale der Kondensationshorizonte sind die Anhäufung pelagischer Organismenreste (hauptsächlich Cephalopoden), mehrfach unterbrochene Ausfüllung und oberflächliche Anlösung von Gehäusen, Hartgründe mit einer spärlichen epi- und endobenthonischen Fauna und Flora und häufige Diskontinuitäten in der Schichtfolge. Die Sedimentationsraten lagen in der Grössenordnung von wenigen dm bis 1 m/10^6 J. Die Wassertiefe auf den pelagischen Plattformen betrug wahrscheinlich weniger als 100 m. Die Plattformen waren von flachen (nichtturbiditischen) oder tieferen (teilweise turbiditischen) Becken mit Sedimentationsraten von 20 bis 100 m/10^6 J begrenzt. Pelagische Plattformen mit kondensierter Sedimentation bilden ein weit verbreitetes Zwischenglied in der sedimentären und strukturellen Entwicklung passiver Kontinentalränder zwischen der Frühphase einer Sedimentation mächtiger Karbonate oder Klastika und der abschliessenden Flysch-Phase. Vergleichsbeispiele sind aus ähnlichen paläogeographischen Milieus im Oberdevon/Unterkarbon Frankreichs, Westdeutschlands, der Alpen, Polen und dem Mesozoikum der alpidischen Faltengebirge des Mediterranraumes bekannt.

Introduction

Because of their wealth of generally well preserved invertebrate remains, palaeontologists and stratigraphers have often been attracted by condensed deposits. Such levels are not only highly reduced in thickness compared to coeval strata, but are also distinguished by various other diagnostic features. These include obvious time gaps in the sequence, caused by non-deposition, long submarine exposure, erosion and reworking. Such omission surfaces are generally encrusted by various groups of invertebrates and perforated by endolithic algae or fungi and thus represent a special environment of hardgrounds (Fürsich 1979). The net sediment input is sometimes so low that index fossils of different ages occur side by side so that the biostratigraphical zonal scheme seems to be invalidated. Condensed sequences are sometimes complicated by bedding-parallel (neptunian) sills in which younger organic remains occur below older ones, thus additionally complicating the intricate depositional history (Wendt 1971).

Occurrences of this kind are widespread throughout the geological record, but apparently they are much more common in certain periods than in others. Well-known examples have been described from the Middle Cretaceous of the northern and western Alps (Heim 1934, Heim & Seitz 1934, Gebhard 1983), the Alpine-Mediterranean Middle and Upper Jurassic (Rod 1946, Mensink 1960, Sturani 1964, Wendt 1970, 1971, Jenkyns 1971, Geyer & Hinkelbein 1971), the Middle and Upper Triassic Hallstatt facies of the Alpine fold belt (Krystyn et al. 1971, Jacobshagen 1967, Wendt 1973) and from the late Devonian/early Carboniferous of the Variscan fold belt in Europe and North Africa. The depositional history and the palaeogeographic configuration of the latter are the aim of the present study.

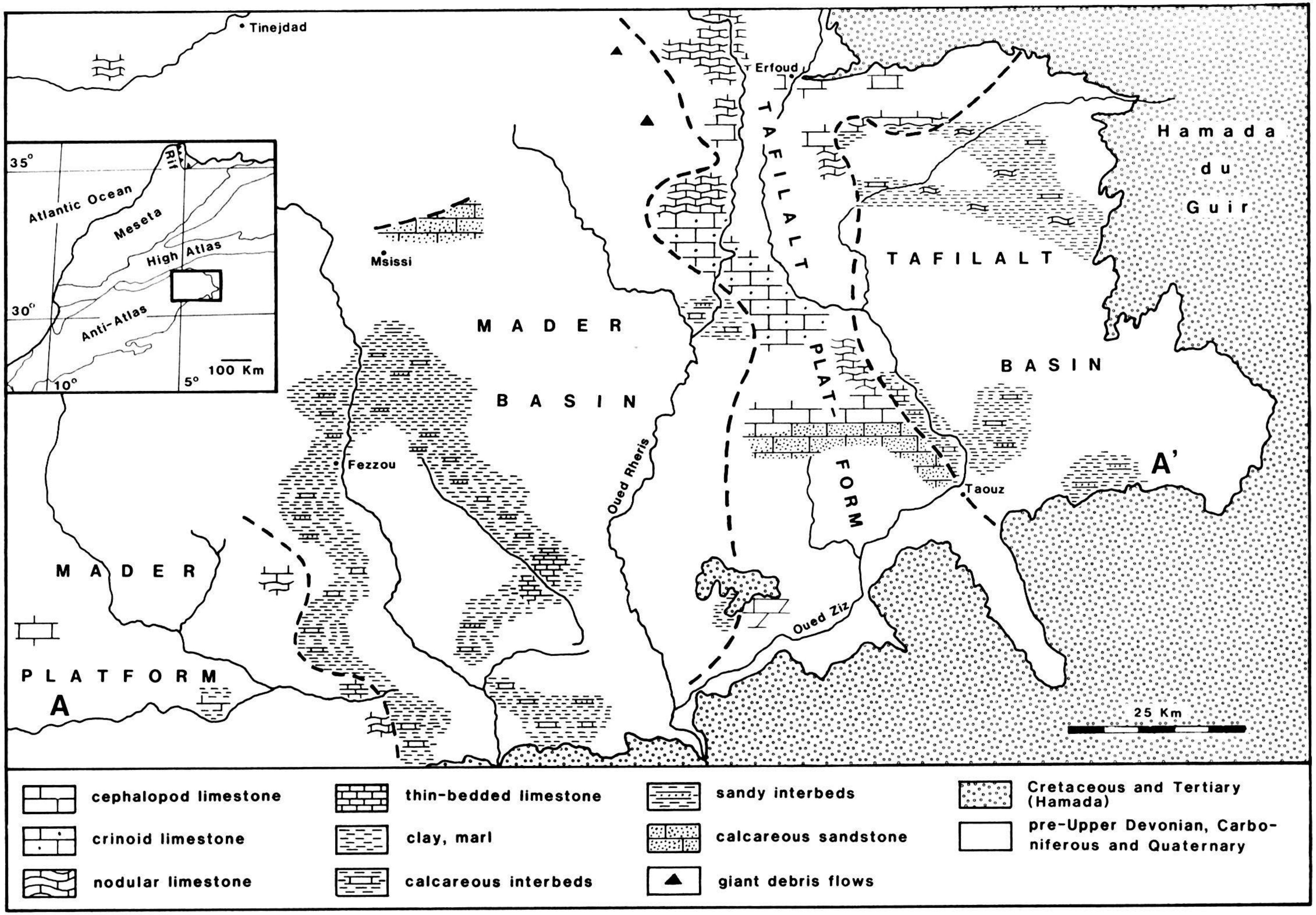

Fig. 1. Early Famennian facies pattern and palaeogeography in the eastern Anti-Atlas. A–A′ = section of facies profile of Figure 2.

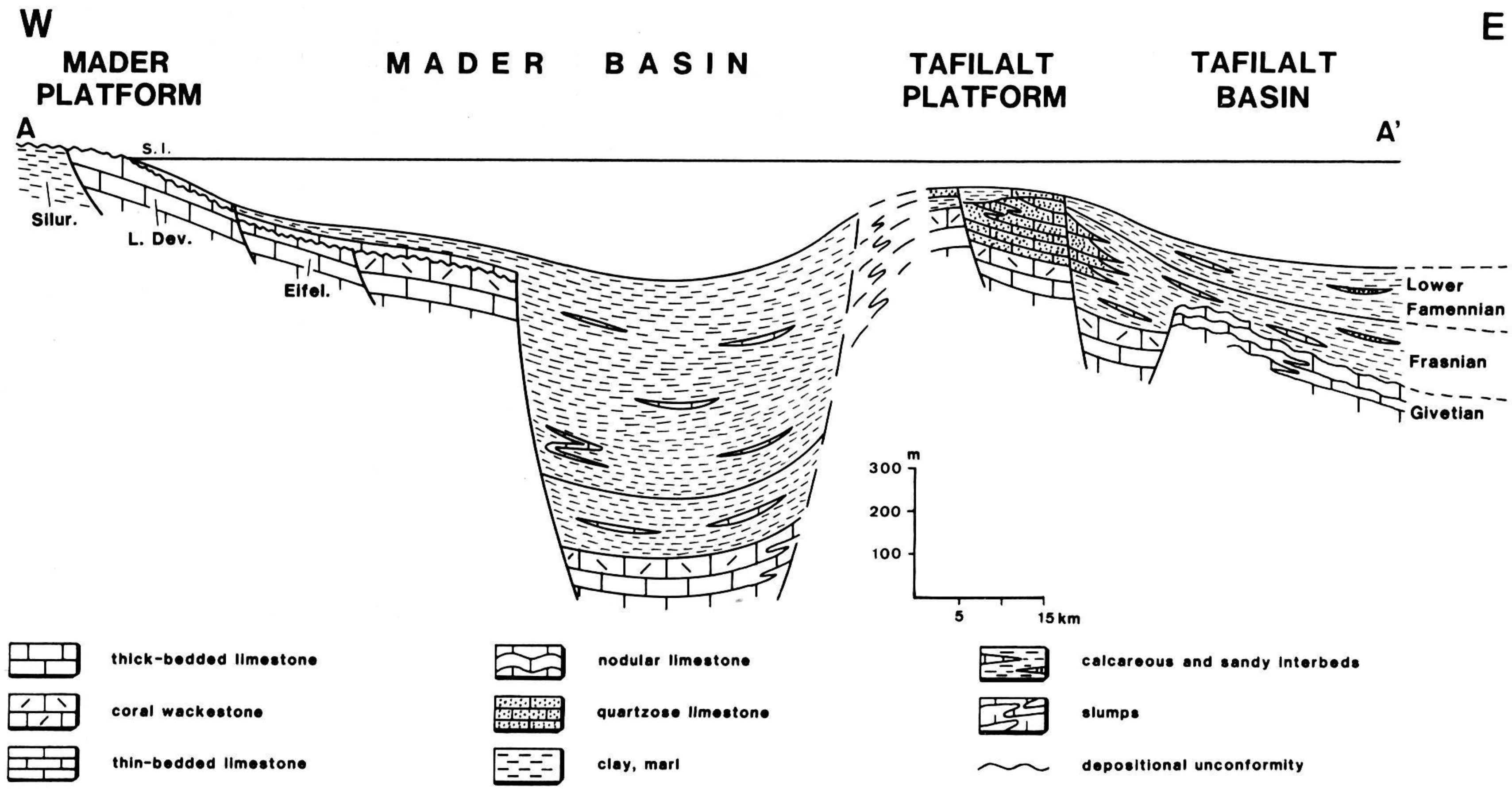

Fig. 2. Facies profile through the eastern Anti-Atlas at early Famennian times. Broken lines indicate uncertain lithological and structural boundaries due to erosional removal of Devonian rocks.

Geological setting

Since the publication of SCHMIDT (1925) it is well known that condensed sequences of late Devonian and early Carboniferous age in the Rhenish Schiefergebirge (West Germany) were laid down on pelagic ridges, separated by intervening basins or furrows in which thick sequences of fine clastics accumulated. Modern studies in this area have shown that condensed cephalopod limestones occur in a wider range of environments as cappings to isolated reefs or carbonate platforms, volcanic or tectonic rises, drowned carbonate and clastic shelves (KREBS 1979, FRANKE & WALLISER 1983). Other areas of the Variscan fold belt in Europe in which Upper Devonian and/or Lower Carboniferous deposits are condensed, as well as being vertically and laterally very discontinuous, are known from the Holy Cross Mountains in Poland (SZULCZEWSKI 1971, 1978), the Moravian Karst (DVORAK 1986), the Carnic Alps (VAI 1980, CANTELLI et al. 1982), and the Montagne Noire in southern France (MAUREL 1966, TUCKER 1974, ENGEL et al. 1981). In all these regions, Variscan tectonic shortening has caused an intricate fragmentation of the depositional areas, making reliable palaeogeographic reconstructions very difficult. In the eastern Anti-Atlas of Morocco, however, Upper Devonian rocks are exposed over an area of about 20000 km^2 and are only mildly folded. The total absence of vegetation and the wealth of index fossils (cephalopods, conodonts) facilitate a detailed biostratigraphic and sedimentologic examination and the palaeogeographic reconstruction of the area.

During the late Devonian the following palaeogeographical units can be distinguished from west to east (Fig. 1, 2): the Mader Platform, the Mader Basin, the Tafilalt Platform and the Tafilalt Basin (WENDT & AIGNER 1985, WENDT 1985). The Mader Platform was exposed above sea-level and deeply eroded during most of the Devonian and became submerged during the late Frasnian, partly only during the late Famennian. Upper Devonian deposits in this area are laterally and vertically very discontinuous and in some localities reduced to a few metres only. The Upper Devonian in the northern Mader Basin is up to 1200 m thick and consists of a monotonous sequence of shales with some intercalated (partly turbiditic) sandstones. Reduction to some tens of metres and occurrence of neritic facies towards the south indicates that this basin did not continue much farther south under the Cretaceous cover. Devonian deposits in the eastern Mader Basin are completely eroded so that the boundary towards the Tafilalt Platform can be inferred only from the direction of gravitational sediment displacements (slumps and initial debris flows) along the western platform margin. The Tafilalt Platform is exposed for about 80 km in a N–S and for 15–40 km in a W–E direction. The condensed Upper Devonian cephalopod limestones of this area pass laterally into shales with intercalated nodular limestones of the shallow Tafilalt Basin which extends for several hundred kilometres farther east into Algeria.

Upper Devonian stratigraphy of the Tafilalt Platform

The Upper Devonian of the northern and central Tafilalt Platform consists mainly of grey and red cephalopod limestones which may reach a total thickness of 50 metres but are often condensed to a few metres only (Fig. 3). In the late Frasnian (*gigas*- to l. *triangularis*-zone), widespread deposition of dark grey, slightly bituminous wackestones

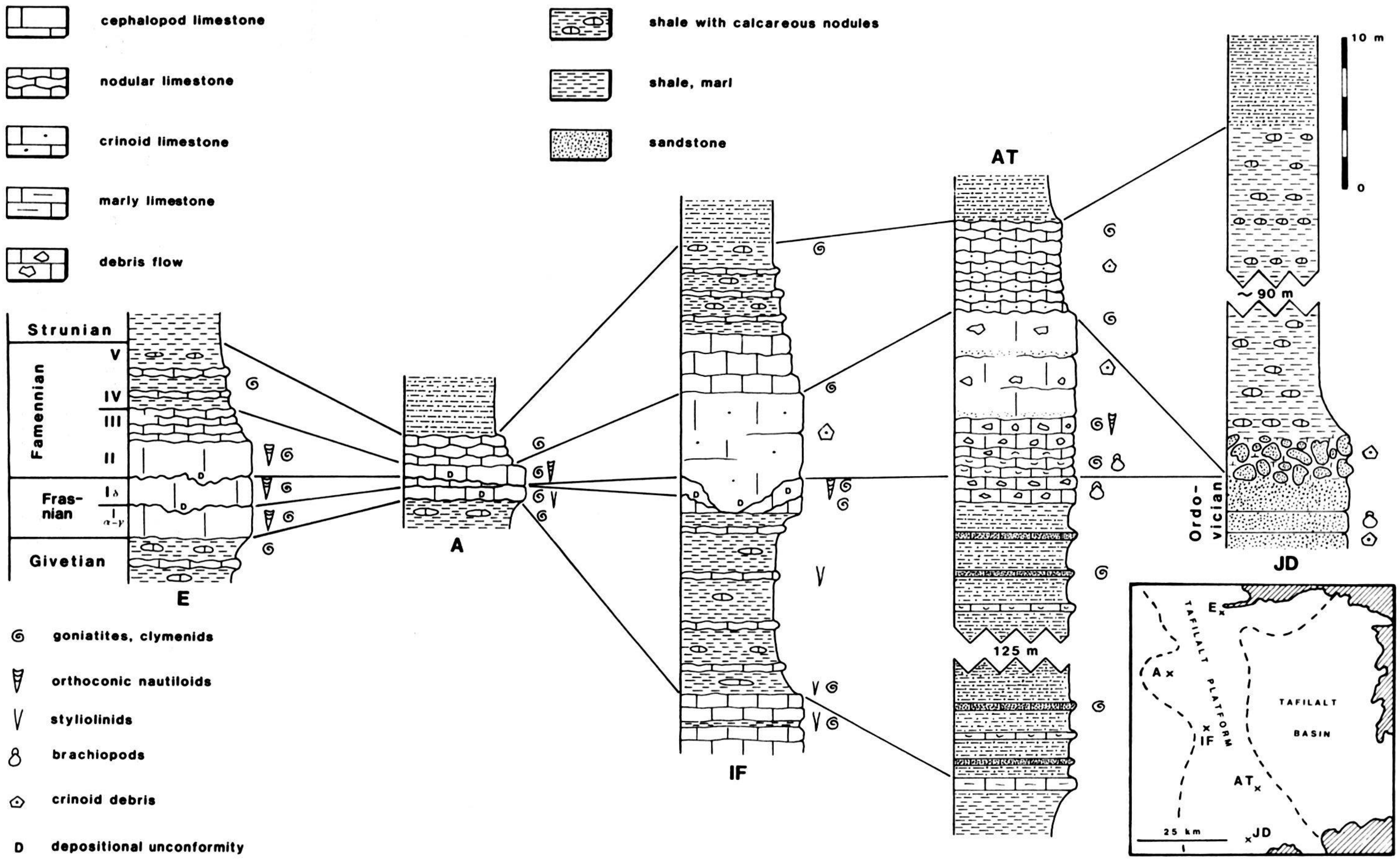

Fig. 3. Correlation of typical Upper Devonian sections of the Tafilalt Platform. E = Butte d'Erfoud, A = Jebel Amelane, IF = Jebel Bou Ifarherioun, AT = Jebel el Atrous, JD = Jdaid. (Recent conodont dating has revealed that the transgression conglomerate in section JD is of lowermost Visean instead of upper Famennian age.)

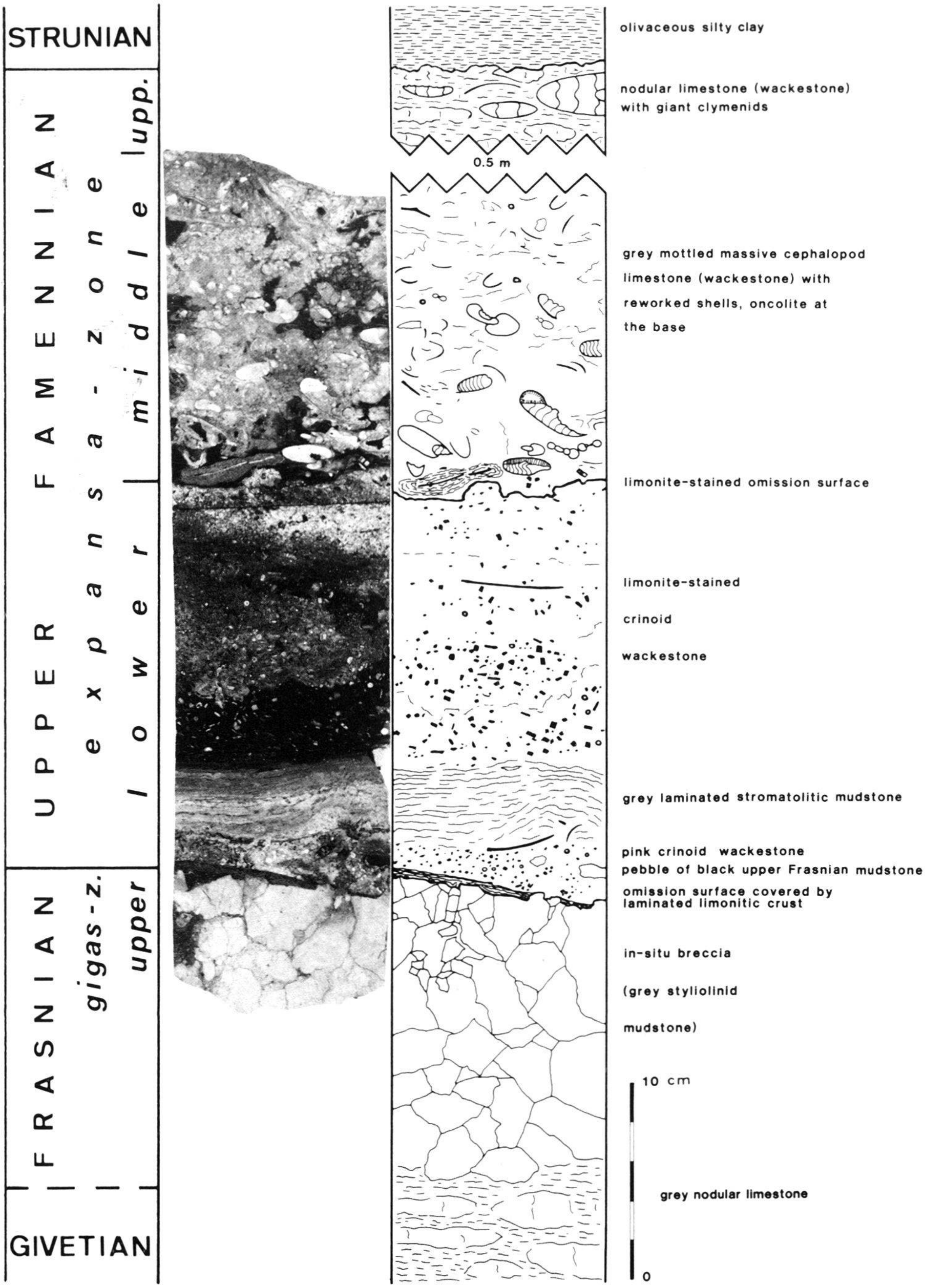

Fig. 4. Condensed Upper Devonian section 2 km south of Amelane road pass, Tafilalt Platform.

crowded with orthoconic nautiloids (Fig. 10), goniatites, brachiopods, pelecypods, crinoids, styliolinids, and the occurrence of teepees, birdseyes and storm layers suggest deposition in shallow subtidal to supratidal environments (WENDT et al. 1984). The occurrence of this lithology indicates that the platform environment had a much larger extension in the late Frasnian than during the early Famennian (Fig. 9, 11). After a distinct break in sedimentation on the northern and central Tafilalt Platform, caused by a short uplift above sea-level and erosion, lower Famennian (IIβ) cephalopod limestones transgressed over a karstified surface, locally with an angular unconformity of up to 30°. Red and pink biomicrites of this age fill solution cavities and karst crevices of the uppermost Frasnian/lowermost Famennian land surface. The subaerial interval is best documented by vadose cements lining the roofs of the cavities (WENDT et al. 1984, Fig. 7). In some areas the lower Famennian starts with a transgression conglomerate composed of rounded to subangular clasts of uppermost Frasnian limestone. The facies pattern of the lower Famennian consists of nodular limestones deposited along deeper platform margins in the north, passing laterally into cephalopod and crinoid limestones on the central platform areas and finally into quartzose brachiopod coquinas towards the south (Fig. 1). Condensation is strongest in the cephalopod and crinoid limestone facies of those platform areas which were previously emerged. Locally the whole Upper Devonian is reduced to one metre of thickness (Fig. 4) from which an average sedimentation rate of approximately 10 cm/MA can be inferred. Most of this time span is, of course, included in gaps in the sequence. In the section of Figure 4 the topmost Frasnian and the lower Famennian are missing. The only testimony of the presence of uppermost Frasnian rocks are reworked limestone pebbles of this age at the base of the upper Famennian. Only 1 km farther north, the uppermost Frasnian and lower Famennian (IIβ) are again represented by strongly condensed cephalopod limestones (Fig. 3, section A). The gap in the section of Fig. 4 is therefore probably caused by non-deposition rather than by late Famennian uplift and transgression as was argued by HOLLARD (1960). Though the upper portion of this section seems biostratigraphically complete (the presence of lower, middle and upper *expansa*-zone is demonstrated by conodonts), there is an obvious break in sedimentation between the lower and middle *expansa*-zone, documented by a limonite-stained omission surface. The presence of such minor intervals of non-deposition which cannot be detected by accurate conodont sampling, is a widespread phenomenon in condensed sequences.

Clastic influence, nearly absent in the northern and central parts of the Tafilalt Platform, increases towards the south. This influx was derived from a land area farther south where lowermost Visean shales transgress over Ordovician sandstones (Fig. 3, section JD) to lower Devonian carbonates. Condensation phenomena decreased during the late Famennian when over large areas of the platform nodular limestones and shales were laid down prior to a sudden onset of a thick deltaic sequence which covered both the platform and basinal deposits of the whole area. Towards the north, these sandstones and shales of Strunian/lower Tournaisian age pass into turbidites and occasional olistostromes.

Fauna and flora

The invertebrate fauna of the condensed pelagic carbonates is dominated by nectonic organisms such as goniatites, clymenids and orthoconic nautiloids (Fig. 5). In some places, fragments of huge (up to several metres long) placoderms occur. Vagile benthos (gastropods, pelecypods, trilobites) is generally very rare. Sessile benthos is restricted to the hardgrounds intercalated in the cephalopod and crinoid limestones and mainly composed of crinoids whose ossicles were transported far into the adjacent basins. On the central Tafilalt Platform, the hardground at the Frasnian/Famennian boundary is encrusted by thick massive crinoid holdfasts which after decay of the stem and crown of the organism served as substrates for subsequent holdfasts, thus forming peculiar dome-shaped or branched encrustations (Fig. 6). Less common are Tabulata (mainly *Cladochonus*) and small solitary Rugosa, and thin (1–10 cm) stromatolitic crusts rich in iron oxide (Fig. 7). Small, simple or branched, up to several cm high shrubs of *Frutexites* (compare PLAYFORD et al. 1976) encrust hardgrounds and reworked shell fragments and occur only in the condensed sequences (Fig. 8). Hardgrounds are generally encrusted by laminated limonite crusts with scattered attached organisms (sessile foraminifera?). Skeletal remains within the condensed levels are mostly fragmentary, superficially corroded and show different sedimentary fillings documenting the slow intermittent deposition of

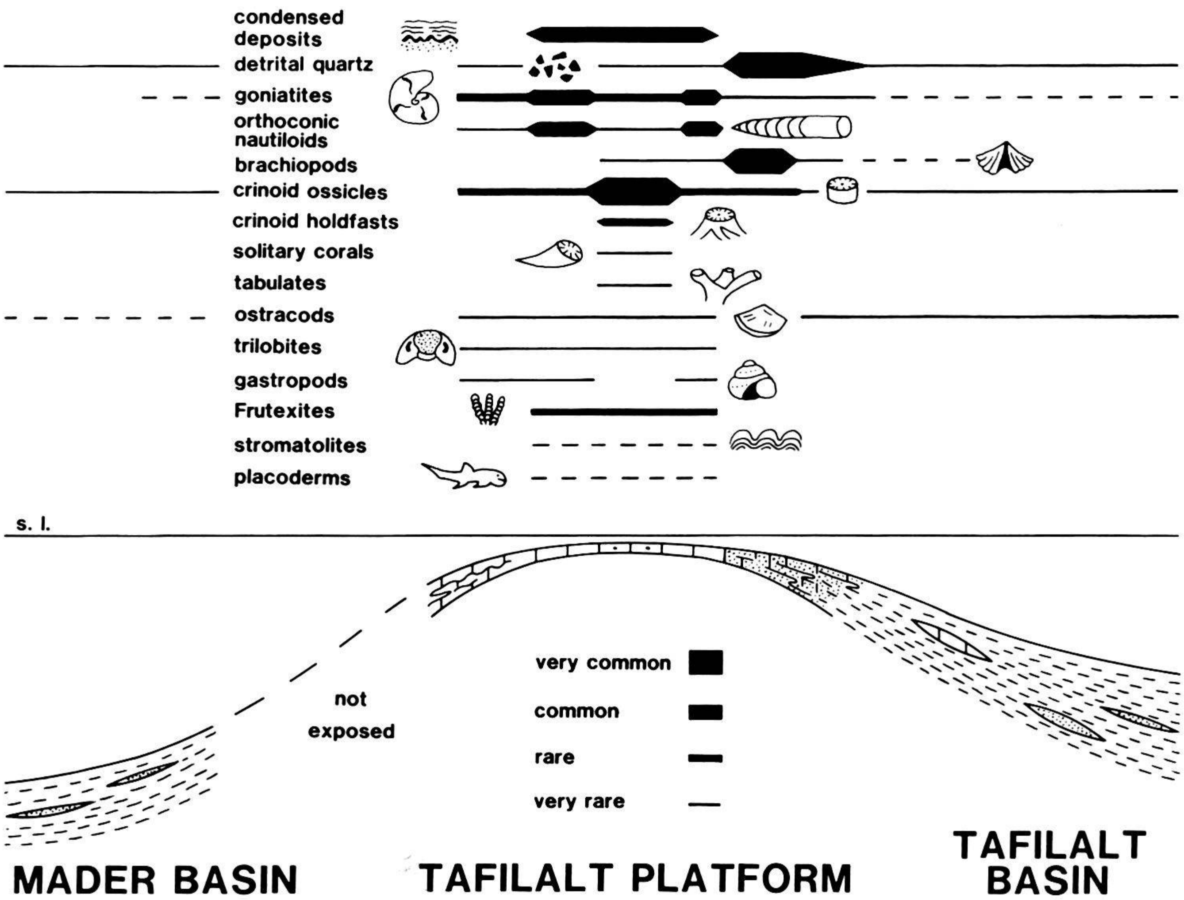

Fig. 5. Lower Famennian facies pattern and faunal spectrum from the Mader Basin across the Tafilalt Platform into the Tafilalt Basin. Lithologic symbols as in Figures 2 and 3. Not to scale.

Fig. 6. Encrusting crinoid holdfasts attached to hardground (arrowed) at the base of Famennian crinoid wackestone. Note irregular, partly branched shape of holdfasts formed by repeated encrustation. Jebel Mech Irdane, Tafilalt Platform. Polished slab. Scale in cm.

Fig. 7. "Deep water" stromatolite from condensed iron-stained cephalopod limestone. Upper Famennian, Tizi Bou Kerzia, Mader Platform. Polished slab.

Fig. 8. Iron-stained laminated shrubs (*Frutexites*), growing on lower Famennian hardground with encrusting crinoid holdfasts. Jebel Bou Ifarherioun, Tafilalt Platform. Polished slab. Scale in cm.

carbonate mud within the shells. Larger shell fragments are sometimes perforated by tiny limonite-filled borings of uncertain affinity (algae or fungi). The same preservation of shells is typical of condensed deposits in the Alpine and Mediterranean Triassic and Jurassic (WENDT 1970). Most of the above groups of organisms become extremely rare or disappear when passing from the platforms into the adjacent basins (Fig. 5). This is especially surprising with respect to the cephalopods which are totally lacking in the Frasnian/lower Famennian of the northern Mader Basin and restricted to some shale and limestone levels in the shallower areas of the Tafilalt and southern Mader Basins.

Current regime

The minimum net sedimentation rate on the pelagic platforms is the result of strongly slowed subsidence and bottom currents which have transported most of the fine carbonate fraction into the adjacent basins. To a lesser extent also chemical solution and mechanical erosion have removed early lithified carbonates. The direction of currents was established by measuring the orientation of orthoconic nautiloids accumulated on some distinct bedding planes which can be traced over several thousand km^2. Figure 9 summarizes the orientation pattern in the late Frasnian, evaluating a total of about 6100 measurements from 35 localities. On the northern Tafilalt Platform orientations are clearly NW–SE. In the southern part of the platform, S–N orientations prevail, indicating offshore currents from an emerged area farther south. Currents running approximately S–N (SSW–NNE to SSE–NNW) can be observed also along the northern border of the

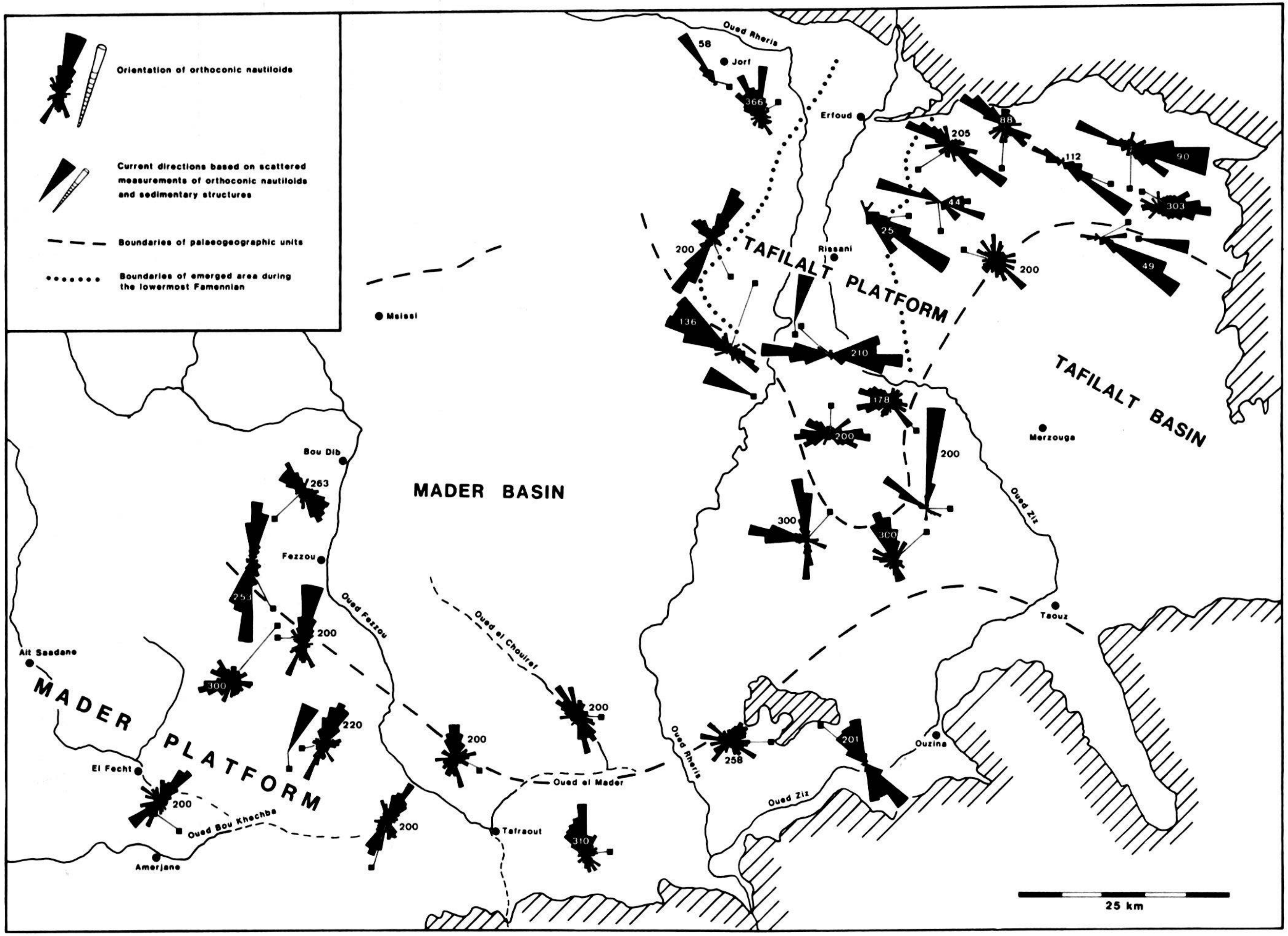

Fig. 9. Current directions, inferred from the orientation of orthoconic nautiloids, in the late Frasnian of the eastern Anti-Atlas. Black and white numbers indicate numbers of measured specimens per locality. Note NW–SE currents on the northern Tafilalt Platform and S–N currents on the southern Mader Platform, in the southern Mader Basin and on the southern Tafilalt Platform.

Mader Platform. Many of the rose diagrams show two opposite more or less equal peaks which at a first glance would indicate wave rather than current orientation (SEILACHER 1960, NAGLE 1967). But this should be transverse, i.e. parallel to the platform margins or at right angles to the inferred current directions. This is the case only in a few localities on the Tafilalt Platform. All the remaining bimodal diagrams show the same orientation as the neighbouring unimodal diagrams which clearly indicate current directions. Therefore the bimodal diagrams probably reflect current directions as well. The unexpected opposite orientation of many shells, i.e. with their apertures towards the direction of the currents, is obviously induced by their nearly parallel-sided shape and their dense packing which hampered the rotation of the slender shells during transport (Fig. 10).

The current regime on the northern Tafilalt Platform during the late Frasnian continued into the early Famennian, as is inferred from about 3850 measurements of orthoconic nautiloids from 26 localities (Fig. 11). Shells of this age are accumulated on a bedding plane which can be traced over an area of about 2000 km^2. They have all well pointed ends, are much larger and, due to their more scattered occurrence, did not hamper each other during transport (Fig. 12). Rose diagrams are all unimodal and indicate opposite bottom currents towards southeast and northwest. A similar pattern was obtained by PLAYFORD (1981) from the orientation of orthoconic nautiloids on both sides of a drowned Frasnian reef in the Canning Basin (NW Australia). Here, the opposed orientations seem to reflect the stable positions of the conical shells with their apertures downslope, i.e. in the direction of the steep (34°) slopes of the submerged ridge. The slopes of the Tafilalt Platform were certainly much more gentle (less than 5°) and the opposite

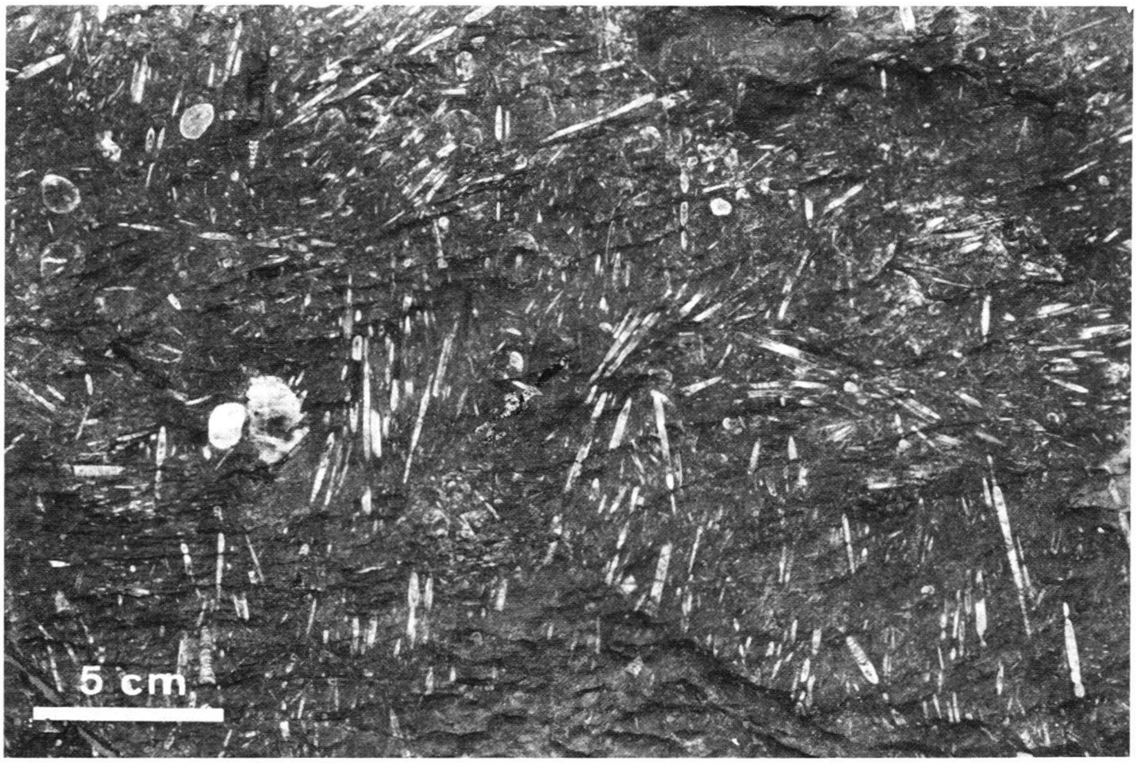

Fig. 10. Accumulation of small orthoconic nautiloids on a bedding plane of uppermost Frasnian black cephalopod limestone. Jebel Amelane, Tafilalt Platform.

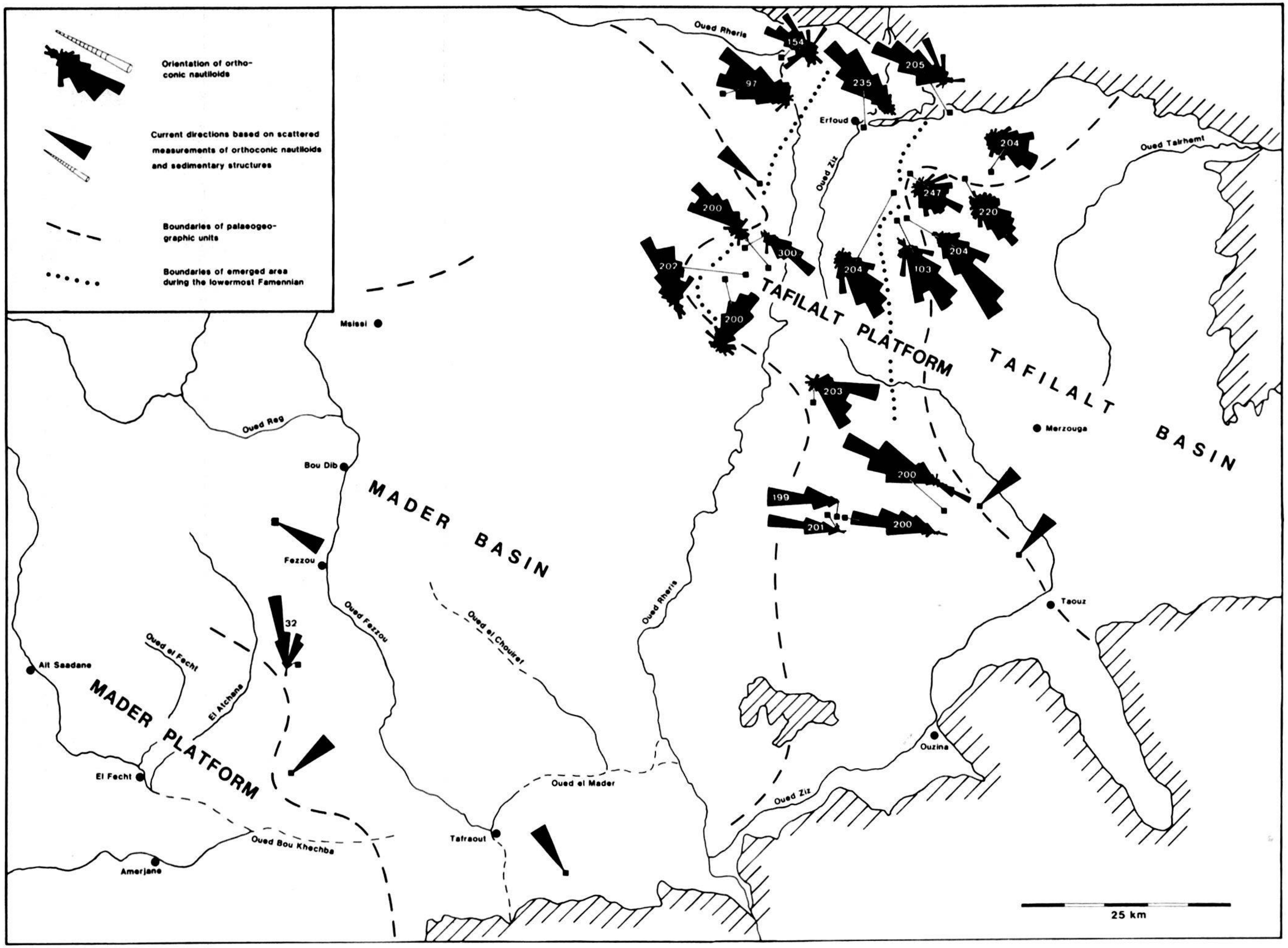

Fig. 11. Current directions, inferred from the orientation of orthoconic nautiloids, in the early Famennian (IIβ) of the eastern Anti-Atlas. Black and white numbers indicate numbers of measured specimens per locality. Note opposite (towards NW and SE) currents on the northwestern and southeastern parts of the Tafilalt Platform.

Fig. 12. Accumulation of large orthoconic nautiloids on a bedding plane of lower Famennian red cephalopod limestone. Current direction is from bottom (NW) to top (SE) of figure. Mou Keleuh, Tafilalt Platform.

orientation of the shells is probably the result of seaward returning currents from shallow platform areas into the adjacent basins.

Water depth

There has been a lengthy debate about the bathymetrical range of condensed deposits in general and the absolute water depth of some well examined occurrences in particular (summaries in WENDT 1970 and WENDT & AIGNER 1985). For the area examined in the present study the following biological and sedimentological features are relevant for palaeobathymetry:

1. Lower Famennian condensed cephalopod limestones of the Tafilalt Platform overlie upper Frasnian bioclastic wackestones which bear distinct characters of deposition in a peritidal environment. Upper Frasnian and Famennian condensed levels on the Mader Platform overlie much older rocks of Silurian to early Devonian age.
2. The lower boundary of the condensed deposits is a discontinuity surface resulting from non-deposition, early cementation and submarine or subaerial erosion. In some localities vadose cements within solution cavities document local uplift above sea-level prior to transgression and the onset of extremely slowed-down sedimentation.
3. Hardgrounds intercalated in the condensed sequences are encrusted by poorly diverse fixosessile organisms, among which crinoids with massive holdfasts seem to have preferred shallow turbulent waters (BRETT 1981).

4. The fauna of the condensed levels is dominated by nectonic organisms which do not indicate special water depths but tend to disappear towards the deeper basinal areas (Fig. 5).
5. Apart from occasional "deep water" stromatolites (MONTY 1971, PLAYFORD et al. 1976) and *Frutexites,* indicators for the photic zone such as calcareous algae and micritic envelopes are absent from the condensed deposits examined in this study.
6. Orientation patterns of conical shells reflect bottom current velocities between 0.2 and 0.7 m/sec. (NAGLE 1967, FUTTERER 1978).

These features suggest a depositional depth of the condensed levels from a few to about one hundred metres, generally above storm wave base. The occurrence of debris flows which might be related to earthquakes, would also allow one to envisage tsunamis as responsible for the orientation and reworking of large, partly sediment-filled shells.

Water depth in the basins flanking the pelagic platforms can be visualized with much less certainty. Assuming a mean slope angle of 2°, sufficient for the release of slumps and initial debris flows as are frequently observed along the margins of the Tafilalt Platform, a water depth of 300–500 m in the Tafilalt Basin can be calculated.

Sedimentation rates

Condensed deposits generally overlie thick, rapidly deposited shallow water carbonates or clastics, often after a pronounced hiatus. Their most common lithology is a cephalopod limestone; much less frequently crinoid limestones are strongly condensed. With these lithologies very often black and red cherts are associated (Fig. 13), though never condensed in a strict sense. The latter do not occur in the late Devonian/early Carboniferous of the eastern Anti-Atlas, but are well known from coeval, probably more open marine environments in the Montagne Noire (ENGEL et al. 1981), Rhenish Schiefergebirge (FRANKE & WALLISER 1983), Moravian Karst (DVORAK 1986), as well as from similar settings in the Alpine-Mediterranean Jurassic (JENKINS 1971). Sedimentation rates of these lithologies (not corrected for compaction which, however, can probably be ignored) is in the order of 1–5 m/MA, in the condensed levels less than 1 m/MA (Fig. 13). On the Tafilalt and Mader Platforms stratigraphic condensation occurs in the time span from the early Frasnian into the late Famennian (V β) and is most widespread during the early Famennian. If we include the area of Jebel Grouz (225 km ENE of Erfoud), which might represent the eastern prolongation of the Tafilalt Platform, the upper Tournaisian/lower Visean is also strongly condensed (WEYANT & PAREYN 1975). Condensation phenomena disappear with the vertical transition into nodular limestones and shales which in turn are abruptly overlain by much more rapidly (50–200 m/MA) deposited deltaic sandstones, shales and turbidites of Strunian age.

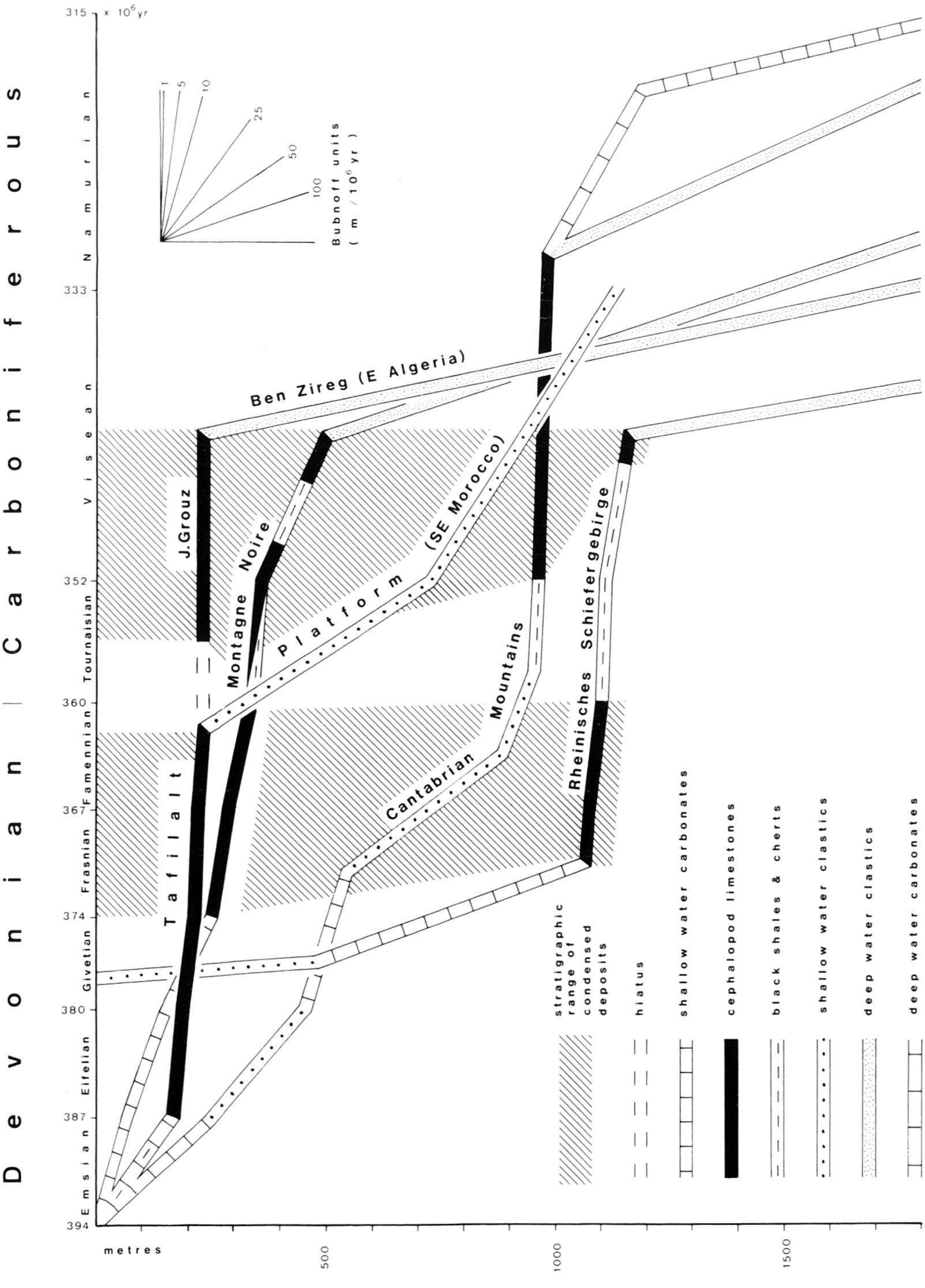

Fig. 13. Sedimentation rates (not corrected for compaction) and temporal range of stratigraphic condensation in some major Devonian/Lower Carboniferous zones in Europe and North Africa.

Conclusions

Condensed deposits comprise a great variety of organic and sedimentary features reflecting a well known interval in "geosynclinal" evolution, named the vacuity period by AUBOUIN (1962). They overlie rapidly deposited shallow water clastics and carbonates, generally after a hiatus caused by uplift and erosion or abrupt subsidence, and pass vertically into deeper water carbonates, shales and finally into flysch. Condensed levels and associated facies represent an intermediate stage of drowned platforms on a passive continental margin. Disintegration of this margin led to the formation of pelagic platforms which are separated by deeper basins or furrows. Direct evidence of the tensional tectonic activity are angular unconformities and neptunian dykes whose sedimentary fillings may represent periods of non-deposition in the normal sequence. Thus, the depositional history and the palaeogeographic setting of condensed deposits provides an important clue in deciphering an intermediate stage in the evolution of passive continental margins prior to their collisional stage.

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