Introduction to the Fieldtrip

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Structural Overview

The fieldtrip associated with the Annual Meeting of the International Subcommission on Devonian Stratigraphy will be held in the Dra Valley which separates the Tindouf Basin from the Western Anti Atlas of Morocco. Besides the characteristic Quaternary gravel covering much of this arid area, all the sections that we will cross will be Palaeozoic in age. Cretaceous outcrops preserved along the belt borders generally lie unconformably on the Palaeozoic. Structures were developed during the late Carboniferous and levelled before the Cretaceous transgression.

The Triassic and Jurassic are missing everywhere in the Anti Atlas, but Jurassic rocks are represented by doleritic sills and dykes which penetrated into the folded and/or faulted Palaeozoic sequences. These sills are particularly numerous in the Middle and Late Devonian sequences, but are also observed locally until the early Namurian. Later deformation is represented by the Cretaceous folds of Kem-Kem and by isolated folds affecting the Hammadas Pliocene cover. They are the result of the Alpine orogenic deformation which, in the North of the Anti Atlas, produced the Rif and Atlas chains. Unconformities in the region have been used to subdivide the Atlas belt and to trace the main tectonic Atlasic events.

Summarized stratigraphy of the Palaeozoic series

The Anti Atlas chain in the Dra Valley consists of Precambrian cores belonging to the West African Craton. They are generally metamorphic, crystalline, and have recorded several tectonic phases, in particular the Pan-African Orogeny (600 Ma). At this time, erosion produced a major conglomerate lying just beneath the Adoudounian limestones (early Cambrian age in the upper part) that we will cross in the Oued Zguid Valley. These limestones crop out mainly in the area of Akhsas (near Tiznit), an area that we will see on the last day during our return from Assa towards Agadir. They are represented by massive limestones, rich in archaeocyathids of early Cambrian, and were intensively exploited in quarries for the production of decorative marble.

In the Anti Atlas, shales and sandstones, the "Grès terminaux" containing trilobites, end the early Cambrian. The Middle Cambrian (1000 to 2000 m of thickness) is represented by "*Paradoxides* shales" and by sandstones with *Conocoryphe* of Tabanite. These sandstones form very regular relief, underlining the structures and wrapping around the Anti Atlas along its southern margin. In the area of Agdz (between Ouarzazate and Zagora), exposures of Late Cambrian shales and associated beds, immediately preceding the Ordovician, were dated by trilobites for the first time by DESTOMBES & FEIST (1987).

Continuation of the Ordovician series is visible in the Zguid Valley which we will cross before the village of Foum Zguid. It is represented by an alternating sequence of shales and micaceous sandstones or quarzites. The Bani Sandstones are the most characteristic features and form the principal peaks which we will see throughout our excursion to the North of the Devonian sections (in Tata, Akka, Foum El Hassane and Torkoz). Graptolites allow dating as Tremadocian, Arenigian and Llanvirnian stages. Trilobites and brachiopods abound locally at several levels. The Ashgillian glacial-fluviatile or glacial-marine formation ends the Ordovician series. This formation places southern Morocco near the South Pole during the Ordovician.

During the Silurian, Gondwana migrated towards the north, and this is characterised by a change in the type of sedimentation and the development of warm water faunas. From the morphological side, when one leaves the Anti Atlas mountains, the facies becomes argillaceous, not giving any strong relief. Here the Silurian is characterised by black nautiloid-rich limestones intercalated with graptolite shales (we will probably see one of these outcrops on the road going from Assa to Torkoz). In the Dra Valley the total thickness of the Silurian varies from 600 to 1500 m.

The Devonian outcrops conformably overlie the Silurian, without any gap and without any notable change in the type of sedimentation. A detailed Devonian overview of research in the Dra valley is developed in the next chapter. It is important to note the morphological importance, in the Dra Valley, of the 4 successive Richs ("Groupe des Richs"). Their outcrops show the palaeogeographical situation and boundaries during the Lower Devonian and at the beginning of the Middle Devonian.

We will move into Carboniferous outcrops as we move south of the Oued Dra. We will see an example of the transition from the Devonian to the Carboniferous rocks in the South-East of Assa (at Kheneg Lakhal section) on the Zag road. This is characterised by the development of sandstones, with important brachiopod shell intercalations that now form Jbel Tazout (Tournaisian). The Dinantian facies, which forms Jbel Ouarkziz, constitutes the last marine sediments of the Palaeozoic. They belong to the early Namurian. It is overlain by 1400 m of continental Middle and Late Carboniferous facies, and covered by the horizontal beds of the Hammadas Formation.

The main goal of our trip, in addition to show the Devonian sequences exposed in the Western Anti Atlas, is to show the possibilities for correlations which exist in the "Groupe des Richs" and in the subsequent Givetian and Frasnian. In addition, the important relationships between the facies and fauna associated with pelagic and neritic zones will be examined, as well as the principal biological events found there, and their correlation with other sequences all over the world.

Reference

DESTOMBES J. & FEIST, R; (1987).- Découverte du Cambrien supérieur en Afrique (Anti Atlas central, Maroc). C ; R ; Acad. Sci. Paris, 304, II, pp : 719-724

Devonian litho- and biostratigraphy of the Dra Valley area – an overview

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INTRODUCTION

The Dra or Drâa Valley is a main valley running over a distance of almost 600 km in parallel to the overall strike direction of the Anti-Atlas Palaeozoic, from about Zagora in the NE to Tan-Tan near the Atlantic Ocean in the SW. From Zagora a significant branch of the valley cuts in northwestern direction through the Palaeozoic and Precambrian towards Ouarzazate, creating spectacular outcrops. The main Oued Dra runs over wide distance in parallel to the topmost Devonian and prominent Tournaisian Jebel Tazout, mostly very close to the Moroccan-Algerian border, and partly has become inaccessible for security reasons. However, the Dra Valley has given its name to the wide stretch of Devonian outcrops (HOLLARD & JAQUEMONT 1956, HOLLARD 1978) which forms the northern limb of the extensive Tindouf Basin (Fig. 1). This stretches into former Spanish Sahara and northern Mauritania in the SW (forming the Zemmour as an appendix) and into large parts of Algeria in its southern, central and eastern parts, including the poorly studied Menakeb in the SE. The basin has recurrently attracted interest in potential hydrocarbon reservoirs. Thermal maturation was strongly influenced by the lack of a post-Variscan cover until a late Cretaceous transgression. The Zemoul is an anticline and syncline of Palaeozoic rocks which runs from south of Tata in NW-E direction towards Tinfouchy and today mostly belongs to Algeria. Recent Devonian studies presented in this guidebook concentrate on accessible Moroccan sections, between the S of Foum Zguid and the area S of Torkoz, allowing correlations over almost 400 km on strike. The relative continuity of exposures enables an outstanding reconstruction of facies and faunal changes along the Devonian palaeoshelf of northwestern Gondwana, with little influence (only folding and some faulting) of subsequent deformation by the Variscan Orogenesis which affected all the Palaeozoic north of the South Atlas fault. The overall increasing thickness of sedimentary rocks towards the SW indicates a predominant provenance of siliciclastic supply and the presence of erosive land masses towards the SW and W. However, there are also thick clastic wedges (e.g., the Rich 3 sandstones) which fade out from NE to SW. This confirms (see cross-sections in HOLLARD 1967) that a combination of subsidence variation and changing supply directions needs to be considered in palaeogeographic reconstructions.

The scientific investigation of the Devonian of the Dra Valley area started later and led to much fewer detailed studies of faunas and sedimentology than in other parts of Morocco. Almost thirty years ago, in 1975, Henry HOLLARD led SDS members during an excursion which covered during 11 field days localities from the eastern Dra Valley to the Tafilalt. It is intriguing how few detailed section logs have been published since. Rather detailed compilations in a post-mortem publication by HOLLARD (1981b) are partly difficult to follow. Research is still in an exploration stage. The first reports of Dra Valley Devonian faunas go back to GENTIL (1929), DESCOSSY & ROCH (1934), BONDON & CLARIOND (1934), and BOURCART (1938). CHOUBERT et al. (1948) reported on the first Emsian and Famennian goniatites of the area, discovered earlier in 1938 to 1941. Recently, BULTYNCK & WALLISER (2000) gave reference to the Dra Valley in their overview of the Moroccan Anti-Atlas that otherwise is more focused on the (hemi)pelagic successions in the Tafilalt and Maider areas.

Thick, partly quartzitic sandstone units have resisted erosion and today form extensive and elevated ridges stretching along strike. As widespread marker units they provide easy landmarks for lithostratigraphical correlation and give evidence for huge open marine sandbars bordering the ancient Gondwana coastline. Starting with CHOUBERT (1948, 1951, 1956) they were named in the Lower Devonian as “Rich”. Later the term “Rich” was used for successive formations based on complete rhythothemes, numbering 1 to 4 (HOLLARD 1963a, 1981a, see Fig. 2). Late Devonian and Early Carboniferous massive sand sheets formed the Jebel Tazout and Jebel Ouarkziz, the latter also including limestones. Despite the gradual wedging out of some units over very long distances, our recent research confirmed their high correlation value and invariable stratigraphic position between well-dated pelagic levels with ammonoids and conodonts. This also applies to some thinner marker limestones which form low hills. Rich 1 to 4 sandstones represent the upper part of shallowing upwards cycles with subsequent transgressions linked to global eustatic pulses and events. The definition of formations should follow this natural division, with formation boundaries to be placed at the top of the regressive Rich sandstone units which represent late highstand system tracts and filling up successions. Sequence boundaries and paraconformities have to be sought near the very tops. Thinning and fading of Rich 4 sandstones (of the SW Dra Valley) towards the NE do not form an obstacle since the subsequent early Eifelian transgression allows an easy recognition of T-R cycles and correlation. The same applies to Rich 3 sandstones which are restricted to the NE succession, but are apparantly followed by a late Emsian transgression throughout the Dra Valley.

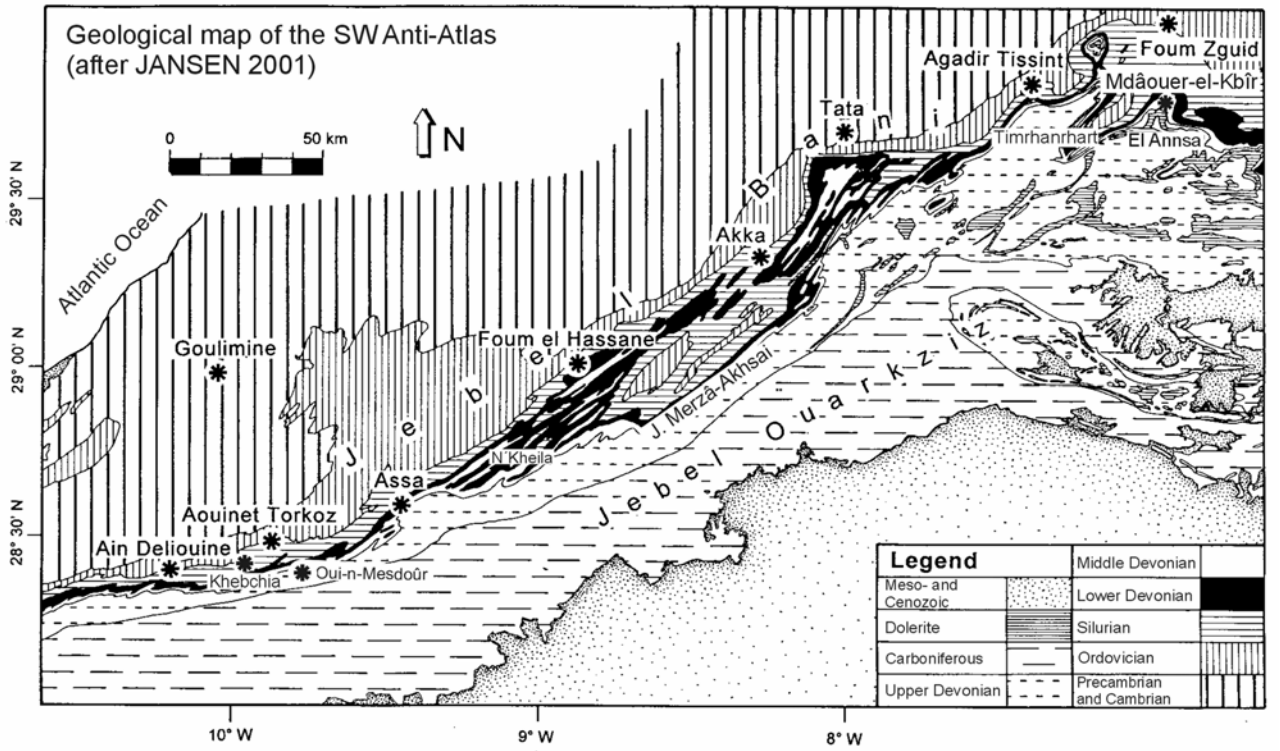


Fig. 1 : Geological map of the SW Anti Atlas (based on HOLLARD & JAQUEMONT 1956, modified after JANSEN 2001).

The Dra Valley Devonian is generally characterized by high sedimentation rates, a predominance of fine and coarse clastics and by an alternation of fossiliferous, neritic and pelagic intervals reflecting the oscillation of relative sealevel caused by basin subsidence, infilling, and/or eustatics. Successions of the Maider and Tafilalt, which SDS has visited on previous occasions, are much more condensed by comparison, up to a factor of 200 on the pelagic carbonate platforms. Due to the high input of clastic material, reefs and biostromes are mostly missing in the Dra Valley. Rare exceptions were mentioned by HOLLARD (1967). Extensive Middle and early Upper Devonian carbonate platforms re-appear towards the SW in the Western Sahara (DUMESTRE & ILLING 1967, KÖNIGSHOF et al. 2003) and at the southern margin of the Tindouf Basin. Biostratigraphy is currently based on the interfingering of faunas with ammonoids, conodonts, brachiopods, tentaculitids and trilobites but some studies have not yet left the level of preliminary identifications. The alternation of neritic and pelagic units makes the Dra Valley a significant region for the often difficult correlation of the so-called Rhenish and Hercynian facies realms (see discussion and correlations in HOLLARD 1978, JANSEN 2001). In addition, neritic faunal elements may enter assemblages gradually from NE to SW whilst pelagic taxa, such as Lower Emsian, uppermost Famennian or basal Carboniferous goniatites (e.g., *Gattendorfia* faunas, HOLLARD 1956) fade out completely. Many faunal groups are still insufficiently studied and new discoveries are to be expected in the future. Knowledge of brachiopods (HOLLARD & DROT 1958, DROT 1964, 1971 etc., BRICE & NICOLLIN 2000, NICOLLIN & BRICE 2000, AIT MALEK et al. 1999, JANSEN 1999, 2000, 2001), ammonoids (HOLLARD 1960, BENSAID 1974, KLUG 2003, and articles in this volume), trilobites (HOLLARD 1963b, ALBERTI & HOLLARD 1963, MORZADEC 1988, 2001, SCHRAUT 1998a, 1998b, 2000a, 2000b), and ostracods (G. BECKER et al. 2003, in press) is at an advanced stage, but nautiloids, pelecypods, gastropods, corals, Bryozoa, palynomorphs, fish (LEHMAN 1976) and ichnofossils have hardly been described. Work on tentaculitoids by G.K.B. ALBERTI is still mostly unpublished. This guidebook for the first time will clearly outline the regional event stratigraphy, with sometimes preliminary data on the Daleje, Chotec, *pumilio*, Taghanic, Rhinestreet, *semichatovae*, Lower and Upper Kellwasser, and Hangenberg Events. Of special interest is the discovery of "*pumilio* Beds" (EBBIGHAUSEN et al., this vol., R.T. BECKER et al., this vol.) which are much older than the two well-established Givetian *pumilio* Events.

DEVONIAN LITHOSTRATIGRAPHY

As outlined above, the Devonian can be subdivided into major transgressive-regressive cycles which led to the deposition of large sand sheets in the early Devonian and latest Famennian to Tournaisian. HOLLARD (1981a; compare JANSEN 2001) has summarized the principle sequence within Lower Devonian formations (Fig. 2). At the base there are bioclastic or micritic limestones, followed by increasingly argillaceous limestones, shales and siltstones which gradually include fine sandstones. Cross-bedded and massive sandstones alternate with siltstones and calcareous brachiopod coquinas at the top where disconformities (sometimes with phosphate nodule levels and iron crusts) may be developed. It is possible that the reversal from shallowing to initial deepening took place within the top parts of the Rich sandstones. Detailed

sequence stratigraphical studies are still lacking. The overall transgressive trend starting in the Eifelian and lasting at least until the late Famennian has obscured these cycles and led to a more crude lithostratigraphy of this interval. Some formations are here subdivided into new members and marker beds. The first often can be compared with former, mostly long descriptions of sedimentary units as used on the available geological maps. HOLLARD (1963a) was the first to provide a detailed summary of the correlation of the complete Devonian in a transsect from the Tafilalt to the westernmost Dra Valley (Tarfaya District). To a large extent, many of his sections and units have not been restudied until now. He coined several formation names which were subsequently revised, replaced and completed (HOLLARD 1978, 1981a, 1981b; BULTYNCK & HOLLARD 1980), especially since it became obvious that western and eastern successions should be separated. JANSEN (2001) mostly followed HOLLARD´s revised terminology but added considerable biostratigraphic precision and provided modern chronostratigraphic data. His results were mostly confirmed by the ammonoid dating. The correlation of lithological units (incl. marker beds) – enriched by correlations based on index fossils – is shown in Figs. 3 and 5). From old to young, the following lithostratigraphic terms will be used in the Lochkovian to Famennian (Tabs 1-2):

1. Western Dra Valley (~ Torkoz to Foum el Hassane)

I. Rich Group (HOLLARD 1981a)
Age: Lochkovian to basal Eifelian.

Lmhaifid Formation (HOLLARD 1981a, formerly "Série de Passage", HOLLARD 1963a)
Age: Lochkovian (HOLLARD 1963a,b, 1977; JANSEN 2000, 2001).
Sandy shales, sandy limestones, and calcareous sandstones; index fossils: *Latericriodus woschmidti*, *Acastella heberti* and *A. tiro*, *Eoglossinotoechia termieri*, *Lanceomyonia occidentalis*, and others. The unit has early (HOLLARD 1963a,b) been subdivided as a series into 5 formations: Ain Deliouine, Oudai Hara inférieur, Oudai Hara supérieur, Sidi M-Bark, and Talmadert. These were later (HOLLARD 1981a) reduced to units within the Lmhaifid Formation or (HOLLARD 1981b) were replaced by a different sequence of members of which not all have received names. Precise definitions and designated type-sections are still lacking; thickness > 600 m.

Assa Formation ("Assise d'Assa" or "Rich 1", HOLLARD 1963a)
Age: Upper Lochkovian (?), lower to approximately middle Pragian.
The lithostratigraphic content of the formation has changed, because the limestones above the rich sandstones were first included in the formation (HOLLARD 1963a) and later attributed to the overlying Merzâ Akhsai Formation (HOLLARD 1981a). Herein, the term is used in this modified manner.

From base to top, the following succession is present (the term "member" is currently avoided, because formal definitions are still lacking):

Basal Limestone Beds
Coarse-grained limestones and reddish sandstones; thickness 20-100 m (HOLLARD 1963a).
Middle Shales
Sandy siltstones and sandstone beds; thickness 100-180 m (HOLLARD 1963a).
Rich 1 Sandstone Beds
Massive sandstone beds with brachiopod coquinas, oolithic layers and phosphatic nodules at the top; thickness 20-50 m (HOLLARD 1963a).
Age: Lower to approximately middle Pragian; index fossils occurring at the top: e.g., *Latericriodus steinachensis*, *Platyorthis hollardi*, *Dixonella assaensis*..

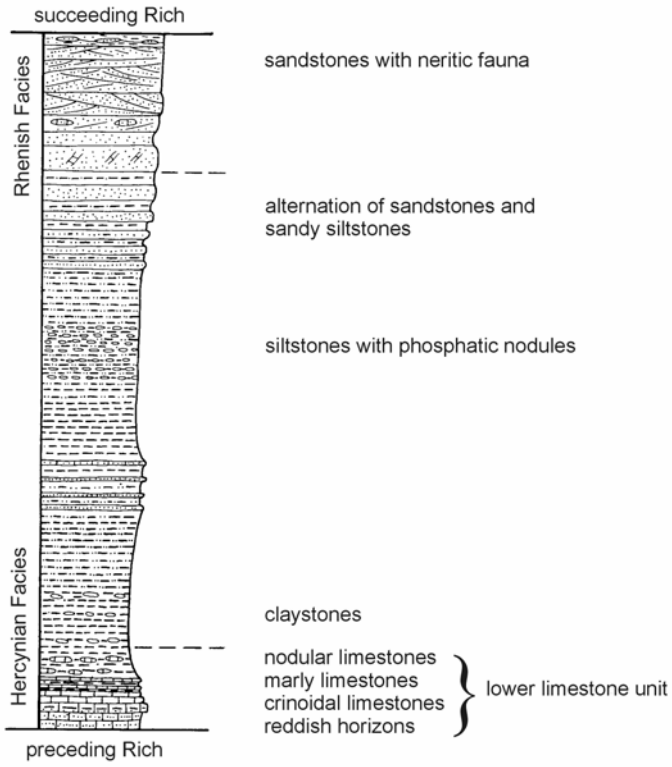


Fig. 2 : Schematic facies sketch of a typical "Rich" development (redrawn after HOLLARD 1981a).

Merzâ Akhsai Formation ("Assise du Merzakhsai" or "Rich 2", HOLLARD 1963a; sense modified by HOLLARD 1981a)
Age: Upper parts of the Pragian to ?lowermost Emsian (as defined by the current GSSP).
From base to top, the following succession is present (the term "member" is currently avoided, because formal definitions are still lacking):

Basal Limestone Beds
Massive bluish-grey crinoidal limestones, with trilobites, brachiopods, and conodonts; thickness 10-20 m.
Age: Middle to upper Pragian, zone with co-occurrence of *Latericriodus steinachensis* and *Caudicriodus curvicauda*.
Middle Shales

Shales, siltstones and some sandstone beds; thickness about 100 m.

Rich 2 Sandstone Beds

Mostly thick-bedded sandstones with siltstone interbeds and brachiopod coquinas in the upper part; thickness about 50 m.

Age: Upper parts of the Pragian to ?lowermost Emsian (= "Middle to Upper Siegenian" in terms of the "Rhenish" stratigraphy), Zone with *Filispirifer merzakhsaiensis*, *Arduspirifer maroccanicus*, and others (according to JANSEN 2001).

Oui-n-Mesdoûr Formation (HOLLARD 1978)

Formerly a part of the "Assise d'El Ansar" (HOLLARD 1963a)

Age: Lower Emsian ("Zlichovian").

Akhal Tergoua Member (new)

Definition: Black or bluish-grey, poorly fossiliferous limestones (some large-sized *Panenka* bivalves, tentaculitoids, *Odontochile*) with haematite, overlying calcareous brachiopod coquinas of the Rich 2 sandstones. The first dark, fine-grained limestones or greenish unfossiliferous shales above the last brachiopod sandstones mark the base. The thickness changes laterally and amounts to 8-9 m in the Torkoz area, but only to about 2.5 m near Assa. Recognized by HOLLARD (1981b) as "Calcaires noirs".

Type locality: Akhal Tergoua Syncline S of Foum el Hassane.

Age: *excavatus* to basal *nothoperbonus* Zone (BULTYNCK & HOLLARD 1980: faunas II to IV), Lower Devonian III-B/C.

Black Marl Member (new)

Definition: Alternation of grey, dark grey, and black shales and marls which may contain some dacryoconarid tentaculites and small brachiopods; otherwise poorly fossiliferous. The base of the member is drawn at the top of the last solid limestone of the Akhal Tergoua Member. Recognized by HOLLARD (1981b) as "Marno-calcaires à tentaculites".

WESTERN SUCCESSION (TORKOZ – FOUM EL HASSANE)	EASTERN SUCCESSION (AKKA – TATA – FOUM ZGUID)		
Yeraifa Formation	**Timrhanrhart Formation**		
Coral Marl Member (new)	Upper Member		
Grey Marls with *pumilio* Beds	Grey Marls		
Pinacites Limestone Member (new)	*Subanarcestes* Beds		Eifelian
Crinoid Marl Member (new)	*Pinacites* Beds		
Khebchia Formation			
Rich 4 Sandstone Member	Basal Shales and Marls		
Bou Tserfine Member (new)			
	Lower Member		
	Bluegrey Limestone		
Sellanarcestes Limestone Member (new)	*Achguigites* Limestone	"Upper"	
	Sellanarcestes Limestone		
Brachiopod Marl Member (new)	Trilobite Limestone		
			Emsian
Hollardops Limestone Member (new)	**Mdâouer-el-Kbîr Formation**		
	Rich 3 Sandstone Beds (Upper Member)		
Oui-n-Mesdoûr Formation		"Lower"	
Black Marl Member (new)	Middle Member		
Akhal Tergoua Member (new)	Lower Member		
Merzâ Akhsai Formation	**Merzâ Akhsai Formation**		
Rich 2 Sandstone Beds	Rich 2 Sandstone Beds		
Middle Shales	Middle Shales		
Basal Limestone Beds	Basal Limestone Beds		Pragian
Assa Formation	**Oued-el-Mdâouer Formation**		
Rich 1 Sandstone Beds			
Middle Shales			
Basal Limestone Beds			
Lmhaifid Formation	**Lmhaifid Formation**		Lochkovian

Tab. 1: Lithostratigraphy of the Dra Valley Devonian (Lochkovian to Eifelian)

WESTERN SUCCESSION (TORKOZ – FOUM EL HASSANE)	**EASTERN SUCCESSION (AKKA – TATA – FOUM ZGUID)**	
Tazout 1 Formation	**Tazout 1 Formation**	?basal Tournaisian
Kheneg Lakhal Member (new)		
Maader Talmout Member (new)		Uppermost Famennian
Lemgairinat Formation	**Lemgairinat Formation**	Upper Famennian
El Douiya Formation	**El Douiya Formation**	
shales and limestones	shales and limestones	
sandy limestones and coquinas	sandy limestones and coquinas	Middle Famennian
shales and platy sandstones	shales and platy sandstones	
Oued Amstil Formation	**Oued Amstil Formation**	Lower Famennian
	Anoû Smaira Formation	
"Schistes argileux á grandes concretions calcaires"	Upper Member (new)	
	Red Shale	
	Upper Concretion Marls	Upper Frasnian
	Red Marl	
"Calcairs noirs á tentaculites en grands gateaux á *Manticoceras*"	Lower Kellwasser Beds	
	Lower Concretion Marls	
	Carinoceras Beds	
"Schistes greseux feuilletes et quartzites fins á pistes, en plaquettes"	Lower Member (new)	
	Upper Red Griotte	
	Hexagonaria Bed	Middle Frasnian
	Naplesites Beds	
	Grey Shales	Lower Frasnian
		Upper Givetian
"Schistes gris argileux avec localement miches"	**Ahrerouch Formation**	
	Tiguisselt Member (new)	
	Juvenocostatus Beds	
"Schistes gris et calcaires noirs á Tentaculites á *Maenioceras* et Stringocephales"	Marker Siltstone	
	Afromaenioceras Beds	
	Agoniatites Beds	
	Oued Mzerreb Member (new)	Middle Givetian
	Grey Marker Limestone	
	Lower Red Griotte	
	Upper *pumilio* Bed	
	Upper *Maenioceras* Beds	
	Lower *pumilio* Bed	
	Coral Marl	
	Lower *Maenioceras* Beds	
	Ahrerich Member	
	Bensaidites Beds	
"Calcaire marneux á *Agoniatites* gr. *fulguralis*"	*vanuxemi* Beds	Lower Givetian
"Calcairs noirs à *W. crispiforme*"		upper Eifelian

Tab. 2: Lithostratigraphy of the Dra valley Devonian (Givetian to Famennian)

Type locality: Bou Tserfine, where the thickness reaches more than 50 m. According to HOLLARD (1978) the thickness increases further to the east. In the Torkoz area yellow marls of the upper part show a transition towards the next lithostratigraphic unit.
Age: Probably within the *nothoperbonus* Zone (BULTYNCK & HOLLARD 1980), Lower Devonian III-D/?E.

Khebchia Formation (HOLLARD 1978)
Formerly part of the "Assise d'El Ansar", partly equal to the N-Kheila Formation of HOLLARD (1963a).
Age: Basal Upper Emsian to ?basal Eifelian.

Hollardops Limestone Member (new)
HOLLARD (1978, 1981b) included the limestones above the dark marls of the Oui-n-Mesdoûr Formation in his "Membre inferieur" of the Khebchia Formation. However, their lower part with exclusively neritic fauna seems to represent the shallowing upwards part of a preceding cycle and in future is perhaps better re-assigned to the first unit.
Definition: Alternation of medium to light grey, bioclastic trilobite limestones and grey marls with trace fossils. The name-giving asteropygid *Hollardops* and *Phacops* occur abundantly together with other fauna. The base of the member coincides with the first light grey and bioclastic solid limestone in dark grey marls at the base of the cliff formed by the carbonate-rich alternation.
Type locality: Bou Tserfine, where the thickness is about 6 m.
Age: Basal Upper Emsian, probably *laticostatus* Zone (BULTYNCK & HOLLARD 1980) but faunas are poor in polygnathids and dominated by icriodids (e.g., *Caudicriodus culicellus culicellus, Icriodus corniger ancestralis, I. fusiformis*), more details are needed; LD III/IV transition.
Brachiopod Marl Member (new)
Formerly (HOLLARD 1978, 1981b) part of the Lower Member ("Membre inférieur") of the Khebchia Formation.
Definition: Marls and marly limestones with small-sized brachiopods, trilobites, corals and some cephalopods (*Latanarcestes*) overlying the *Hollardops* Limestone. The base of the member is drawn at the top of the last, light grey and rather nodular limestone of the *Hollardops* Limestone Member.
Type locality: Bou Tserfine where the thickness varies between 5 and 6 m. In more condensed sections (Torkoz area), the marl unit between the *Hollardops* Limestone and the next member may become very reduced.
Age: *laticostatus* Zone, perhaps ranging into the basal *serotinus* Zone; precision is still lacking since conodont faunas are dominated by icriodids, LD IV-A/B (basal Upper Emsian up to the *Latanarcestes noeggerathi* Zone). BULTYNCK & HOLLARD (1980) mention *Gyroceratites gracilis* from this level.
Sellanarcestes Limestone Member (new)
Formerly (HOLLARD 1978) part of the Lower Member ("Membre inférieur") of the Khebchia Formation.
Definition: Yellowish weathering, bioturbated nodular limestones with abundant goniatites and some other fauna (brachiopods, orthocones, corals, trilobites). There is a gradual transition between this and the preceding member. The boundary should be placed at the level where thick shale and marl units disappear.
Type locality: Bou Tserfine, where the thickness is about 4 m.
Age: Middle part of Upper Emsian, *serotinus* Zone (BULTYNCK & HOLLARD 1980: faunas VIa to VIc), but faunas are, again, dominated by icriodids; *Sellanarcestes wenkenbachi* Zone (LD IV-C) to *Anarcestes simulans* Zone (LD IV-D1).
Bou Tserfine Member (new)
Formerly (HOLLARD 1978) named as middle part ("Membre moyen") of the Khebchia Formation.
Definition: Thick package of green, fine-bedded shales and siltstones with poor fauna and with some bioturbated sandstones in the upper part. Characteristic is a seismite level in the upper part. Thickness between almost 200 m at the type locality and around 100 m near Torkoz. The base of the member is placed just above the last light grey nodular limestone of the *Sellanarcestes* Limestone Member.
Age: Probably still *serotinus* Zone, LD IV-D2.
Rich 4 Sandstone Member (HOLLARD 1963a)
Definition: Alternation of thick- and convolute bedded, often bioturbated, brownish-grey, micaceous sandstones and siltstones, mostly poor in shelly fauna, but with trace fossils. The contact with the previous member is gradational and is drawn with the first bundle of solid sandstones forming a low morphological elevation; at the top with increasingly massive sandstones forming a steep cliff; thickness 80 to 180 m. Equals roughly the Upper Member ("Membre supérieur") of the Khebchia Formation in HOLLARD (1978).
Type locality: Rich Tamelougou (= section Torkoz IIa in JANSEN 2001).
Age: Probably upper *serotinus* to *patulus* Zone, LD IV-D2/E, zone with *Arduspirifer mosellanus* ssp. (JANSEN 2001); the precise position of the Emsian/Eifelian boundary has not yet been established, but may be situated in the uppermost part.

Yeraifa Formation (HOLLARD 1978)
Age: Eifelian.

Crinoid Marl Member (new)
Definition: 3-4 m of marls and bioclastic limestone following the Rich 4 sandstones, rich in crinoid stems and with some brachiopods and trilobites. The member starts with sharp contact right above the last siltstones and thin sandstone beds of Rich 4.
Type locality: Bou Tserfine. Towards the SW (HOLLARD 1978), this unit grades into 30-35 m of irregularly bedded shales and siltstones with trace fossils but without shelly fauna (W of Torkoz).
Age: Basal Eifelian, *partitus* Zone to lower part of *costatus* Zone (not yet studied in detail), MD I-B.
Pinacites Limestone Member (new)
Formerly (HOLLARD 1963a) recognized as "Calcaires lités à *Pinacites jugleri*".
Definition: Solid and well-bedded to nodular micritic limestones with goniatites (*Pinacites, Fidelites*), orthocones, abundant ostracodes and some trilobites. The first massive and micritic limestone forms the base of the

member. Thinner and lenticular limestones may be intercalated in the marls of the preceding member.
Type locality: Bou Tserfine, where the exposed thickness is ca. 4 m (but the top part is covered). Towards the SW (HOLLARD 1978) there is an increase in neritic faunas.
Age: Upper part of *costatus* Zone with *Linguipolygnathus linguiformis* and oldest *Polygnathus pseudofoliatus* (BULTYNCK & HOLLARD 1980: faunas X and XI), MD I-C to basal I-E.
Grey Marls
Alternation of grey to black marls, styliolinites and marly, often concretionary limestones with mass occurences of "*Pumilios*" and other small brachiopods. The base of the unit should be placed just above the last solid succession of nodular limestones of the *Pinacites* Limestone Member.
Age: Middle to upper Eifelian, ca. upper part of *costatus* to *eiflius* Zones, MD I-E/F1.
Remarks: As there is only a vague (HOLLARD 1978) definition for the top of the Yeraifa Formation, the next younger, latest Eifelian transgressive episode is logically placed in the basal part of the following formation.

II. Meksem Mdarsal Group
Age: Upper Eifelian to Frasnian.
HOLLARD (1981b) drew the base of this group above the Yeraifa Formation whilst beds just above the Rich 4 sandstones were already included in it by HOLLARD (1981a: named there as "Horizon d'Ahrerich" and "Calcaires lités à goniatites").

Ahrerouch Formation (HOLLARD 1978)
Age: Upper Eifelian to top Middle Givetian.

Cabrieroceras Beds
Formerly (HOLLARD 1963a) recognized as "Calcaires noirs à *W. crispiforme*". Ca. 8 m of black marls and concretionary limestones with styliolinids and goniatites which probably correlate with the Kacak Event interval.
Age: Upper Eifelian, ca. *ensensis* Zone (details still lacking), MD I-F2.
Agoniatites aff. *vanuxemi* Beds
Formerly (HOLLARD 1963a) recognized as "Calcaire marneux à *Agoniatites* ex gr. *fulguralis*". Ca. 4 m light grey marls and nodular limestone with some goniatites (*Agoniatites*) and dark concretions near the top.
Age: Basal Givetian (MD II-A).
Coral Marl Member (new)
Definition: Thick, poorly outcropping grey or reddish shale and marl sequence with limestone nodules, some brachiopods (*Stringocephalus*) and neritic coral fauna. The base of the member lies just above a dark limestones with "*pumilios*".
Type locality: Bou Tserfine, where the thickness is more than 60 m.
Age: Givetian.

[The Frasnian to Upper Famennian, especially the **Dra Group** (**III**.) has not yet been re-studied in the western Dra Valley]

IV. Tazout Group
Age: Uppermost Famennian to Upper Tournaisian.

Tazout 1 Formation (HOLLARD 1981b)
Age: Uppermost Famennian ("Strunian").

Maader Talmout Member (new)
Definition: Alternation of thick to platy, often cross-bedded, rippled and bioturbated sandstones, calcareous brachiopod coquinas (with spiriferids, productids, rhynchonellids, and others) and of greenish to grey siltstones. The first brachiopod-bearing sandstone appearing within greenish siltstones marks the base of the member.
Type locality: Maader Talmout/Kheneg Lakhal SW of Assa, where the thickness is about 130-140 m and where there are two sandstone ridges separated by a shallow depression.
Age: ?Dasberg to Wocklum Stufe (in terms of the regional German subdivision), possibly ranging into the lowermost Carboniferous.
Kheneg Lakahal Member (new)
Definition: Alternation of unfossiliferous greenish and reddish, thin-bedded siltstones, occasionally with thin more solid fine-grained sandstone beds. The base of the member is drawn just above the last rippled, bioturbated or fossiliferous sandstone of the Maader Talmout Member.
Type locality: Kheneg Lakhal SW of Assa, where the thickness is about 150-200 m and where the member forms a valley or slope following the second Tazout ridge.
Age: ?Uppermost Famennian or Lower Tournaisian.

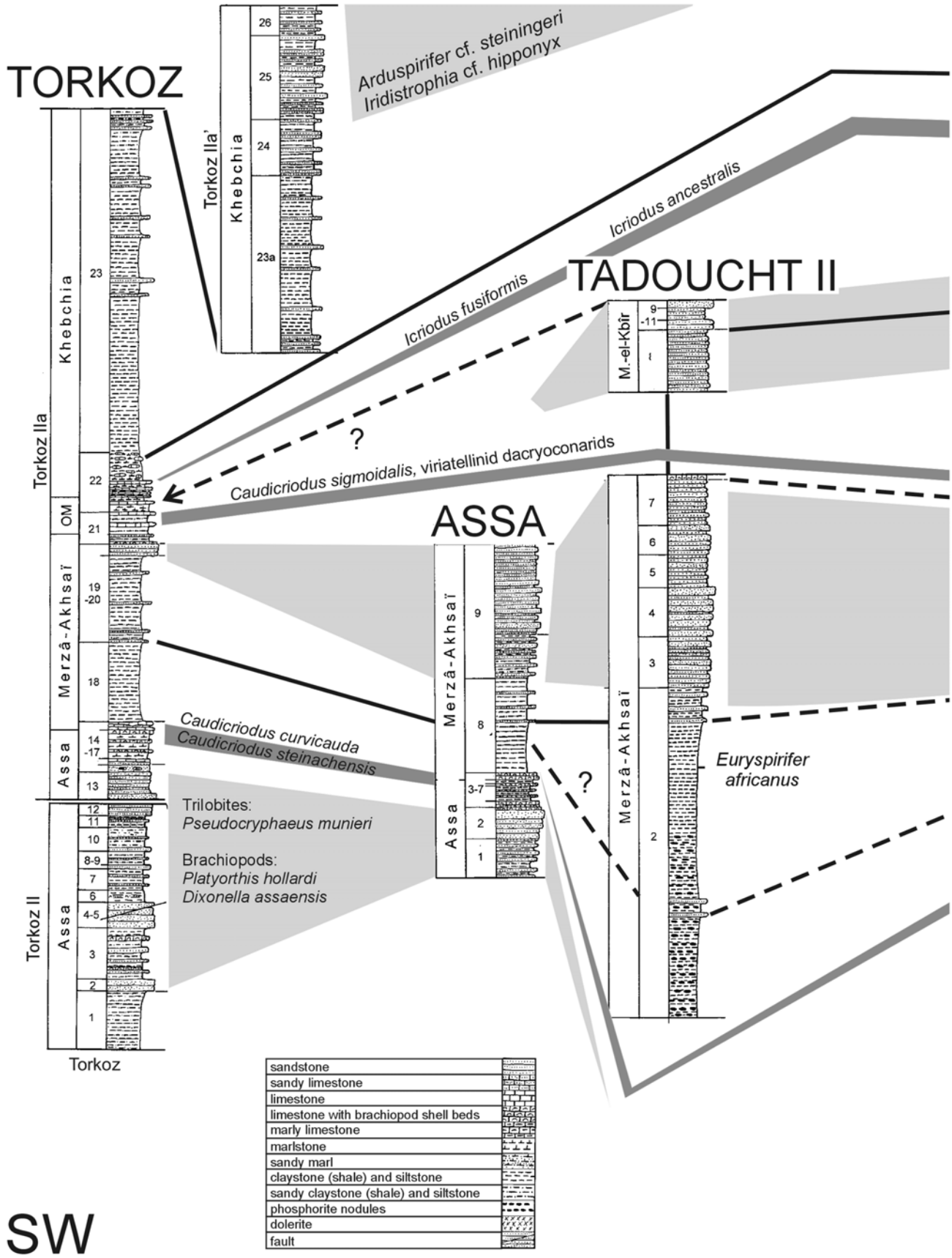
The following **Tazout 2 Formation** of HOLLARD (1981b), characterized by a third and higher sandstone ridge with poor fauna, belongs to the basal Carboniferous.

2. Eastern Dra Valey (~ Akka to Foum Zguid)

I. Rich Group (HOLLARD 1981a)
Age: Lochkovian to basal Eifelian.

Lmhaifid Formation (HOLLARD 1981a, formerly "Série de Passage", HOLLARD 1963a)
Age: *woschmidti* to *pesavis* Zones, Lochkovian (HOLLARD 1963a, 1963b, 1977, LAZREQ & OUANAIMI 1998, JANSEN 2000, 2001).
Shales, brachiopod and orthoceratid limestones; index fossils: *Caudicriodus woschmidti*, *C. postwoschmidti*, *Eoglossinotoechia termieri*, *Lanceomyonia occidentalis*, and others. The unit has early been subdivided as a series into 5 formations (see above; HOLLARD 1963b). Thickness: about 230 m (HOLLARD 1963a).

Oued-el-Mdâouer Formation (HOLLARD 1981b)
Age: Due to conodonts upper Lochkovian in the lower and upper parts (*pesavis* Zone; LAZREQ & OUANAIMI 1998, WEDDIGE in JANSEN 2001), and due to trilobites Pragian in the upper part (SCHRAUT 2000a).
Crinoidal limestones yielding corals and bryozoans, marly limestones with Pragian trilobite fauna: *Odontochile*, *Paralejurus*. Thickness: about 30-80 m near Tata (JANSEN 2001).


TORKOZ
Torkoz IIa'
Khebchia
26
25
24
23a
Arduspirifer cf. steiningeri
Iridistrophia cf. hipponyx
Icriodus ancestralis
Icriodus fusiformis
TADOUCHT II
M.-el-Kbîr
9
-11
1
?
Caudicriodus sigmoidalis, viriatellinid dacryoconarids
ASSA
Torkoz IIa
Khebchia
23
22
OM
21
Merzâ-Akhsaï
19
-20
18
Assa
14
-17
13
Caudicriodus curvicauda
Caudicriodus steinachensis
Trilobites:
Pseudocryphaeus munieri
Brachiopods:
Platyorthis hollardi
Dixonella assaensis
Merzâ-Akhsaï
9
8
Assa
3-7
2
1
?
Merzâ-Akhsaï
7
6
5
4
3
2
Euryspirifer
africanus
Torkoz II
Assa
12
11
10
8-9
7
6
4-5
3
2
1
Torkoz
sandstone
sandy limestone
limestone
limestone with brachiopod shell beds
marly limestone
marlstone
sandy marl
claystone (shale) and siltstone
sandy claystone (shale) and siltstone
phosphorite nodules
dolerite
fault
SW

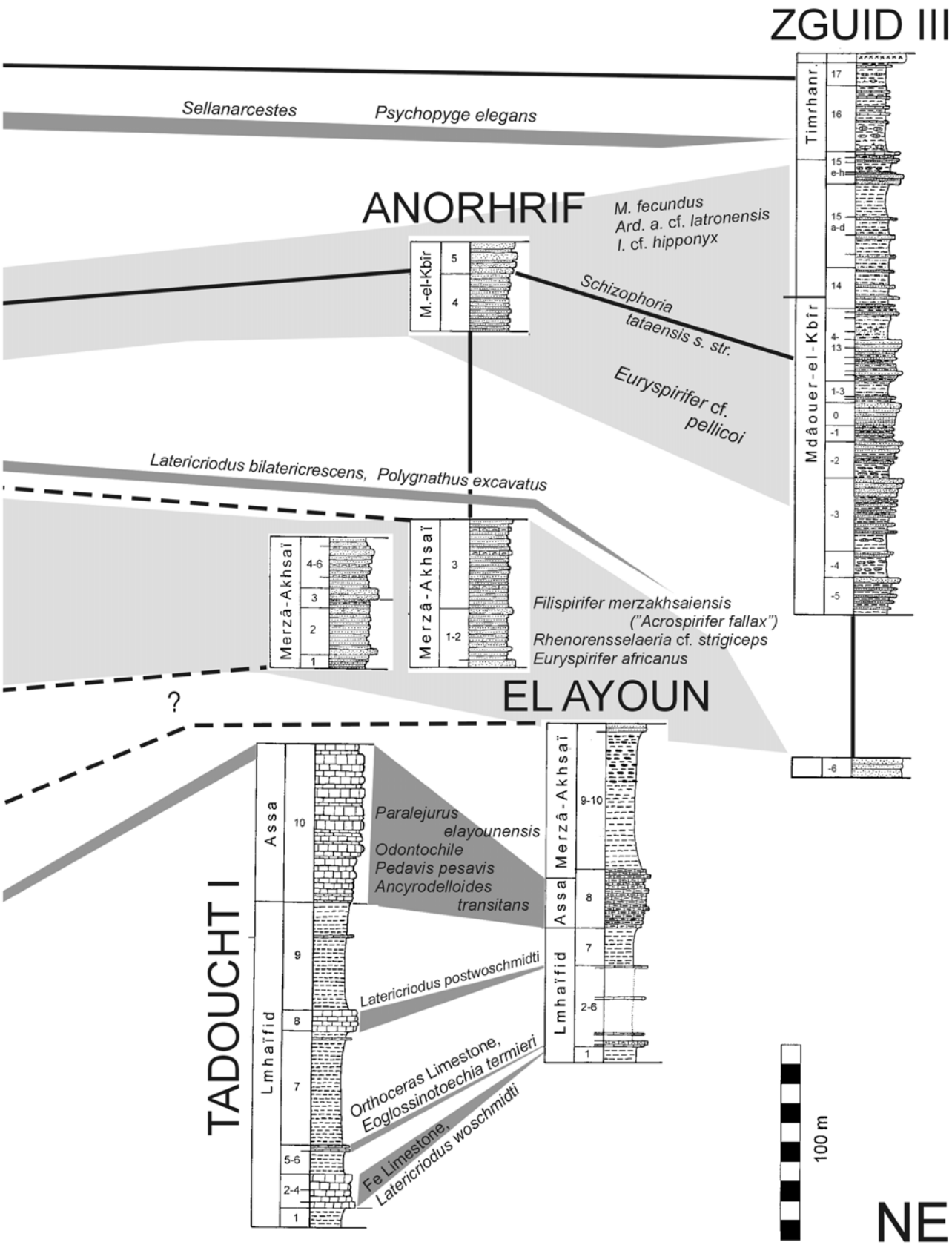


Fig. 3: Correlation of selected sections (mainly Lower Devonian) in the Dra Valley based on litho- and biostratigraphical criteria (Rich 1 to 4 successions). For location of the sections see Fig. 1.

Merzâ Akhsai Formation ("Assise du Merzakhsai" or "Rich 2", HOLLARD 1963a; sense modified by HOLLARD 1981a)
Age: Pragian to ?lowermost Emsian.
The lithological development in the eastern Dra Valley is somewhat different from that of the western Dra Valley (see above):

Basal Limestone Beds
Nodular limestones with trilobites. Thickness: about 20 m (HOLLARD 1963a).
Age: Pragian according to trilobites (SCHRAUT 2000a).
Middle Shales
Shales with phosphatic nodules. Thickness: about 120 m (HOLLARD 1963a).
Age: Upper parts of the Pragian to ?lowermost Emsian ("Middle to Upper Siegenian" in terms of the "Rhenish" stratigraphy), Zone with *Euryspirifer africanus* (JANSEN 2001).
Rich 2 Sandstone Beds
Mostly thick-bedded sandstones with siltstone interbeds and brachiopod coquinas in the upper part. Thickness: about 125 m (HOLLARD 1963a).
Age: Upper parts of the Pragian to ?lowermost Emsian ("Middle to Upper Siegenian" in terms of the "Rhenish" stratigraphy), Zone with *Filispirifer merzakhsaiensis*, *Arduspirifer maroccanicus*, and others (JANSEN 2001).

Mdâouer-el-Kbîr Formation (HOLLARD 1978)
Age: Lower Emsian to basal Upper Emsian (formerly placed in the El Ansar Formation or "Rich 3", HOLLARD 1963a). The term "member" is used here following HOLLARD (1978), although a formal definition is still lacking:

Lower Member ("Membre inférieur", HOLLARD 1978)
SW of Foum Zguid developed as dark limestone with "*Anetoceras* Fauna" (*Erbenoceras*), nautiloids, bivalves, tentaculites and trilobites. HOLLARD (1978) recognized three limestone intercalations. Thickness: about 65 m.
Age: Lower Emsian, e*xcavatus* Zone (WEDDIGE in JANSEN 2001), LD III-B/C.
Middle Member ("Membre moyen", HOLLARD 1978)
About 100 m mostly unfossiliferous siltstones and fine-grained sandstones.
Age: Probably within the *nothoperbonus* Zone (no detailed data).
Upper Member ("Membre supérieur", HOLLARD 1963a) = Rich 3 Sandstone Beds
In the lower part with alternating siltstones and brachiopod sandstones, followed by more massive, thick-bedded sandstones. At the top with calcareous brachiopod coquinas. Thickness: up to 130 m.
Age: Zone with *Arduspirifer arduennensis* cf. *latronensis* and others (JANSEN 2001), about *laticostatus/inversus* Zone but details are lacking, LD III/IV transition with alleged *Mimagoniatites fecundus* (see JANSEN 2001: 45).

Timrhanrhart Formation (HOLLARD 1978)
Age: Upper Emsian to Eifelian.

Lower Member ("Membre inférieur", HOLLARD 1978).
Definition: At the sharp base solid and locally oolithic trilobite limestones overly massive brachiopod sandstones. These are followed by a solid *Sellanarcestes* Limestone, by yellowish-grey to brownish and nodular *Achguigites* Limestone, and, finally, by a bluish grey micrite with *Anarcestes* which may be laterally discontinuous. The last two ammonoid levels are known from the Tata region but do not occur SW of Foum Zguid where nodular and marly limestones prevail in the upper part
Proposed type locality: Oufrane, where the thickness is about 14 m.
Age: Upper Emsian, *laticostatus* to *serotinus* Zone (BULTYNCK & HOLLARD 1980: faunas V to VII), perhaps also *patulus* Zone (details are still lacking), LD IV-B (*Latanarcestes noeggerathi* Zone) to IV-D1 (*Anarcestes simulans* Zone).
Remarks: Previously (sheet Akka-Tafagount-Tata, HOLLARD 1963a) the *Sellanarcestes* Limestone was still included in the "Assise d'El Ansar" or "Rich 3". This violates the consistent cyclic subdivision employed here. The *Anarcestes* level was formerly placed as basal unit in "dm1" since the Middle Devonian base was placed much higher than now in old publications
Upper Member ("Membre supérieur", HOLLARD 1978)
Definition: In the Tata region, the Upper Member begins with grey, sometimes reddish or dark-grey shales and marls, followed by haematite-rich *Pinacites* Beds with goniatites and *pumilio* Beds, and, finally by an upper haematitic interval with *Subanarcestes* and other goniatites. The higher part of the Eifelian is poorly fossiliferous and contains shales and grey marl beds. At Foum Zguid, the succession is built up by alternating nodular limestone beds and marls grading into greenish shales with goniatites (*Pinacites, Fidelites*) and trilobites.
Proposed type locality: Oufrane, where the thickness is roughly between 60 and 80 meters. In the Foum Zguid area the basal part of the member is more calcareous and transitional to the Lower Member.
Age: Uppermost Emsian to middle Eifelian, about *patulus* to *kockelianus* Zones (?LD IV-D2 to MD I-E; further details needed, MD I-B to I-D recorded by new faunas). HOLLARD (1978) recorded joint occurrences of *Pinacites* and *Paraspirifer cultrijugatus* which need modern revision.

II. Megsem Mdarsal Group

Ahrerouch Formation (HOLLARD 1978)
Age: Topmost Eifelian to top Middle Givetian.

Ahrerich Member (HOLLARD 1978)
The member is not yet strictly defined and there is no designated type section. Lithology: Dark grey to bluish-grey nodular limestones with goniatites (*Cabrieroceras*, *Agoniatites*), alternating with grey marls and shales. In the upper part with *Tornoceras* and *Bensaidites* faunas. At Oued Mzerreb the exposed thickness of the upper part is about 10 m. HOLLARD (1978) emphasized a solid limestone with *Wernerоceras, Subanarcestes* and others at the base of the formation and member near Ahrerich. These faunas have not yet been re-collected or revised.
Age: *Agoniatites vanuxemi* Zone (MD I-F), perhaps even older (MD I-E), to lower Middle Givetian (MD II-B1,

regional *Bensaidites* n. sp. Zone), about *kockelianus*/*ensensis* to basal part of *rhenanus* Zone (approximately middle part of former Lower *varcus* Zone).

Oued Mzerreb Member (new)

Definition: At the base with cyclic shales and marls which may or may not be rich in haematitic ammonoids (Lower *Maenioceras* Beds, "Niveau pyriteux" in HOLLARD 1981b), followed by a distinctive Coral Marl, by the prominent Lower *pumilio* Bed (which may lack brachiopods in some sections), by an upper cyclic sequence, partly with rich *Maenioceras* faunas and some solid or concretionary limestones (Upper *Maenioceras* Beds), by the laminated Upper *pumilio* Bed, and by a locally distinctive red nodular limestone (Lower Red Griotte). At the top there is a grey marker limestone which allows easy correlation (ABOUSSALAM 2003) in the Tata region and further east to the Middle *Sellagoniatites* Bed of the Tafilalt.

Type locality: Oued Mzerreb, where the thickness is about 50 m.

Age: Lower to middle part of the Middle Givetian, MD II-B2 (regional *Maenioceras* n. sp. III Zone) to II-C2 (*Maenioceras decheni* Subzone), middle part of the *rhenanus* Zone to the basal *ansatus* Zone.

Tiguisselt Member (new)

Definition: Alternation of fossiliferous, haematitic shales, sometimes rich in gastropods, and of nodular, marly limestones (*Agoniatites* and *Afromaenioceras* Beds), followed by a thin, laminated marker siltstone, and then, by fossiliferous, haematic shales with nodular marl interbeds (*Juvenocostatus* Beds). The base of the member is drawn immediately above the widespread marker limestone of the topmost Oued Mzerreb Member. The thickness varies between 11 m (Oufrane) and about 30 m (type section).

Type locality: Tiguisselt, SW of Tata.

Age: Middle part of *ansatus* to *semialternans* Zone, regional "*Trevoneites*" n. sp. Subzone (MD II-D1, regionally lacking early *Afromaenioceras*) to *Mzerrebites juvenocostatus* Zone with oldest *Pharciceras* (MD III-A).

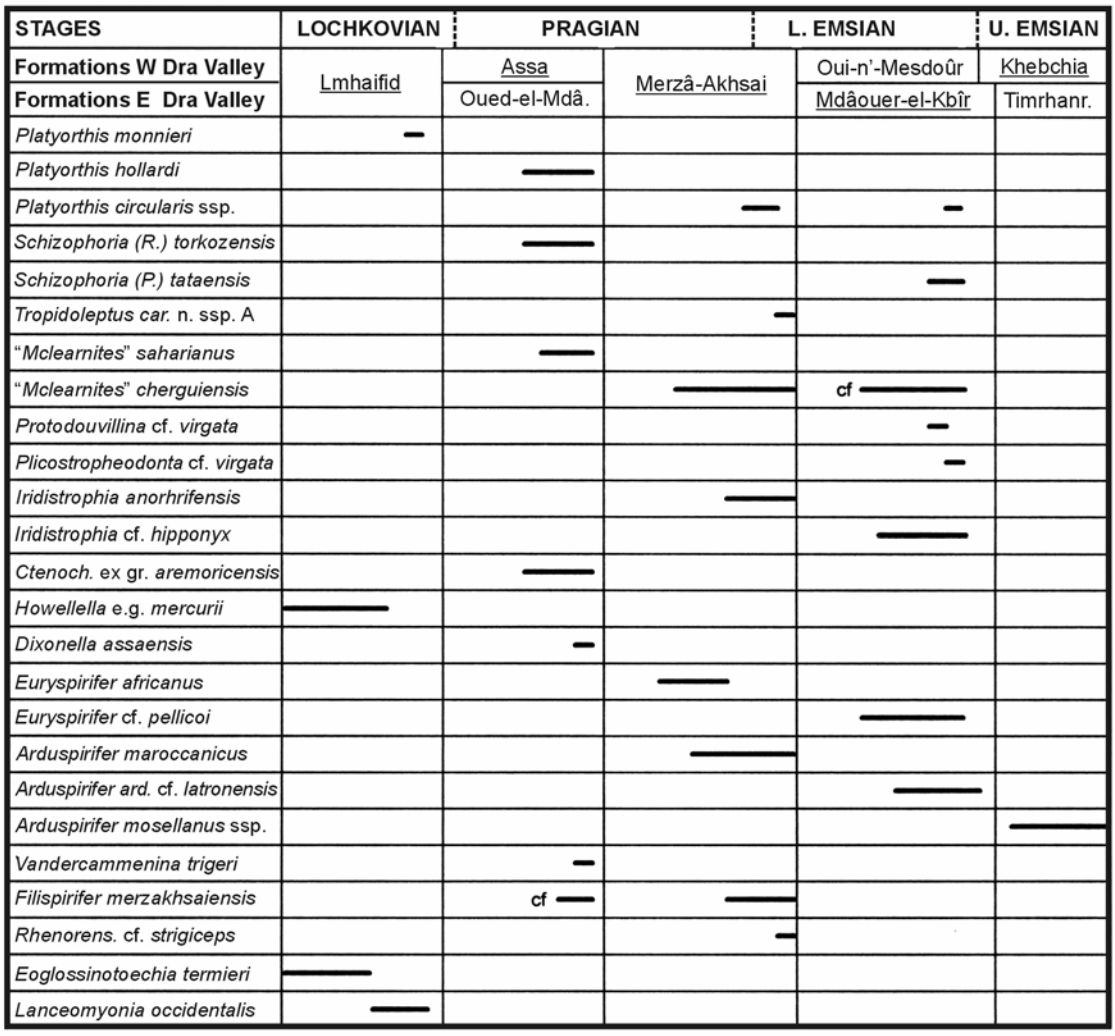


Fig. 4: Stratigraphical distribution of selected brachiopod taxa in the Lower Devonian of the Dra Valley (from JANSEN 2001, modified).

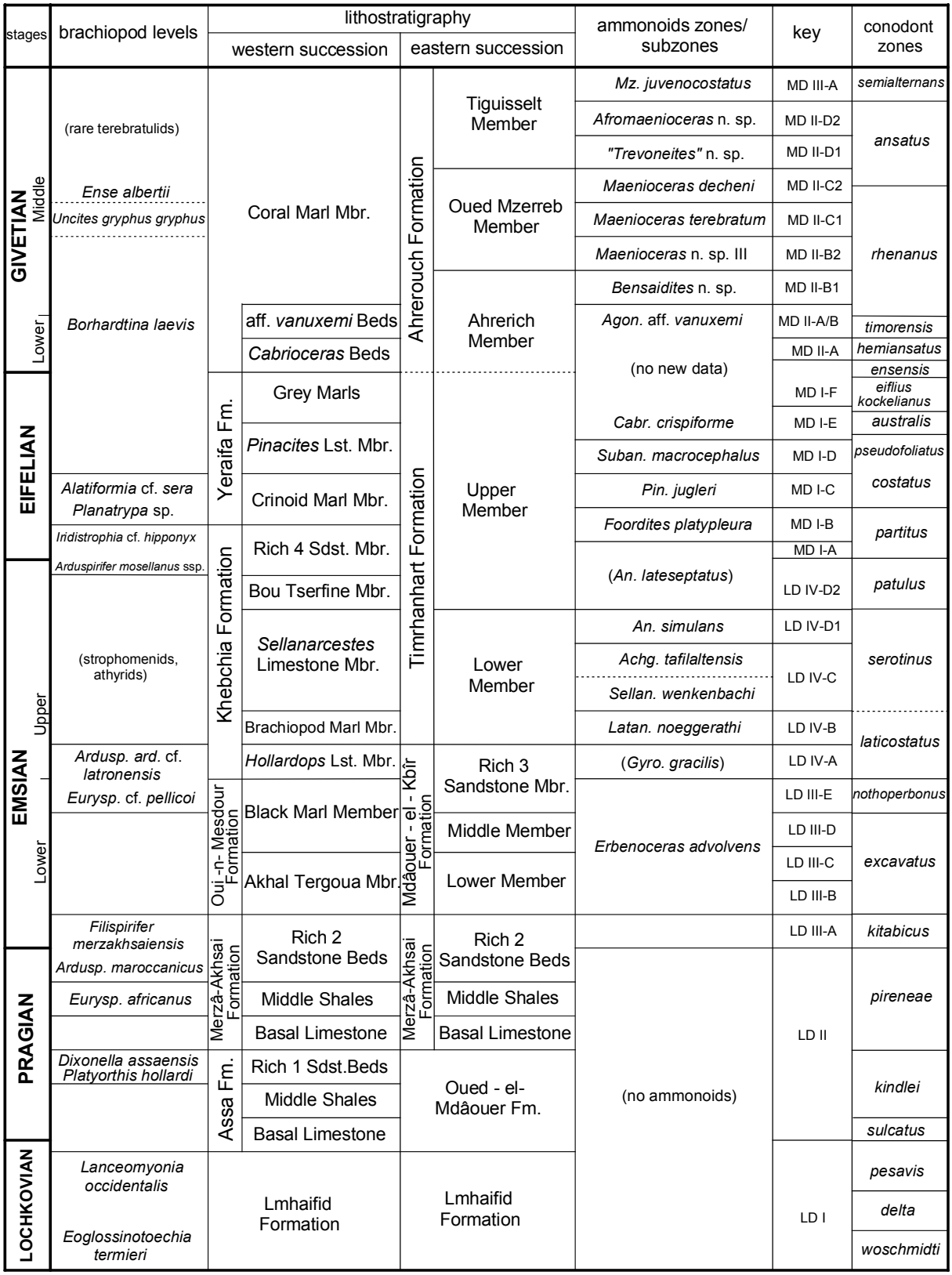


Fig. 5: Lochkovian (Gedinnian) to Givetian correlation of chrono-, cyclo- conodont and lithostratigraphy with Dra Valley ammonoid and brachiopod zones.

Anoû Smaira Formation (HOLLARD 1981b)
Age: Upper Givetian to topmost Frasnian.

Lower Member (new)
Definition: Thick package of unfossiliferous shales above the fossiliferous *Juvenocostatus* Beds, sometimes enriched in haematite (leading to readish weathering), and alternating with more prominent, partly bioclastic grey marls. At the base sometimes with black shales. The disappearance of haematized faunas is used for definition. In the uppermost part haematitic faunas re-commence (*Naplesites* Beds), followed by shales and marls with rare colonial Rugosa (*Hexagonaria* Bed). At the top there is a second red nodular limestone (Upper Red Griotte) with pelecypods.
Type section: Oued Mzerreb, where the thickness for the lower main part is still to be estimated.
Age: Upper Givetian (approximately *hermanni* Zone) to late Middle Frasnian (*Beloceras tenuistriatum* Zone, UD I-H, about MN Zone 10, details are still lacking).
Upper Member (new)
Definition: At the base, just above the red nodular limestones of the preceding member, with an alternation of fossiliferous, haematitic, goniatite-rich shales and crinoid-rich marls (*Carinoceras* Beds), followed by cyclic bluish-grey, laminated limestone concretions with few goniatites and poorly fossiliferous marls, by the fossiliferous Lower Kellwasser Beds (dark grey limestones and shales with *Manticoceras, Buchiola*, and arthrodires), by an unfossiliferous marker unit consisting of red marls, and, eventually, by another cyclic succession of concretion layers and partly fossiliferous shales. At the top of the member and formation there is another red shale.
Type locality: Oued Mzerreb, where the thickness is about 40 m.
Age: Upper Frasnian (UD I-I, regionally characterized by *Carinoceras*) to topmost Frasnian (UD I-K/L). Conodont data are not yet available.

III. Dra Group

Oued Amstil Formation (HOLLARD 1981b)
Grey shales with nodules and siltstones. Formerly (HOLLARD 1963a) recognized as "Argilites gris clair à nodules calcaires des plaines du Dra avec deux niveaux à *Cheiloceras* et *Protornoceras planidorsatum*". The latter taxon now would fall in *Armatites*. This unit has not yet been restudied.
Age: Lower Famennian (UD II-A to at least II-D).

El Douiya Formation (HOLLARD 1981b)
Shales and platy sandstones in the lower part, sandy limestones and coquinas in the middle part, shales and limestones in the upper part. Formerly (HOLLARD 1963a) recognized as "Schistes gris foncé à nodules calcaires bordeaux à *Sporadoceras*" and "Lumachelles calcareo-grèseuses supérieurs à brachiopodes et schistes à nodules et lentilles calcaires à *Platyclymenia*". Not yet restudied.
Age: Middle to (depending on future definition) lower Upper Famennian (upper UD II to UD IV).

Lemgairinat Formation (HOLLARD 1981b)
Sandstones and sandy coquina beds. Recognized by HOLLARD (1963a) as "Schistes grèseux, grès fins quartzitiques, plaques lumachelliques grèseuses à brachiopods et schistes à goniatites et clyménies pyriteuses de l'Oued Dra et du Zemoul". Not yet restudied.
Age: Upper Famennian (UD V).

The Devonian-Carboniferous boundary beds (**Tazout Group**) are currently not accessible in the eastern Dra Valley area.

DEVONIAN CYCLOSTRATIGRAPHY (Fig. 5)

The following major sedimentary cycles can be recognized at present:

Cycle 1 Lochkovian to approximately middle Pragian
start: basal Devonian.
end: regression of the Rich 1 Sandstone Beds (top Assa Formation).

Cycle 2 middle Pragian to ?lowermost Emsian
start: transgression of crinoidal limestones at the base of the Merzâ Akhsai Formation.
end: regression of the Rich 2 Sandstone Beds (top Merzâ Akhsai Formation).

Cycle 3 Lower Emsian
start: transgressive black limestones (new Akhal Tergoua Member of the Oui-n-Mesdoûr Formation in the SW Dra Valley or limestones at the base of the Mdâouer-el-Kbîr Formation in the NE Dra Valley): **Basal Zlichov Event.**
maximum flooding: lower part of new Black Marl Member of the Oui-n-Mesdoûr Formation.
end: ?light grey marls in the upper part of the Black Marl Member to regressive *Hollardops* Limestone with rich neritic fauna (SW Dra Valley: base of Khebchia Formation) or main phase of Rich 3 Sandstone Member (NE Dra Valley: upper part of Mdâouer-el-Kbîr Formation). The reversal from shallowing to deepening seems to have taken place (at least locally) within the latter which is supported by the incoming of rare goniatites (JANSEN 2001, JANSEN et al., this vol.) in its upper part.

Cycle 4 Upper Emsian (with two subcycles) to basal Eifelian
start: transgressive marls (new Brachiopod Marl Member) at the base of the Khebchia Formation (SW Dra Valley) or within the upper Rich 3 Sandstone Member of the Mdâouer-el Kbîr Formation (E Dra Valley): different phases of the **Daleje Event.**
maximum floodings: pelagic *Latanarcestes* level (SW Dra Valley: upper phase of Daleje Transgression), the very thick new Bou Tserfine Member of the Khebchia Formation (SW Dra Valley), basal shales of the Upper Member of the Timrhanrhart Formation (NE Dra Valley).

end: regressive Rich 4 Sandstone Member (at the top of the Khebchia Formation, SW Dra Valley), not recognizable in the NE Dra Valley.

Cycle 5 Eifelian
start: transgressive marls (new Crinoid Marl Member) at the base of the Yeraifa Formation or shales with first goniatites and "*pumilio* Beds" in the Upper Member of the Timrhanrhart Formation of the Tata region: **Chotec Event**.
maximum flooding: the widespread oldest faunal level with *Pinacites* and subsequent black marls (MD I-D/lower E). This flooding obviously also allowed the only known spread of ammonoids into the SW corner of the Tindouf Basin (Zemmour noir, SOUGY 1969), southwards into the northern Taoudeni Basin (NW Mali, HOLLARD 1967) and eastwards even into the Illizi Basin at the Algerian-Libyan border (LEGRAND 1967).
end: marl with neritic fauna high in the Yeraifa Formation, alternating poorly fossiliferous grey marls and limestones in the Tata region (top of Upper Member of the Timrhanrhart Formation).

Cycle 6 topmost Eifelian to Middle Givetian (with several subcycles)
start: **Kacak Event** Beds (basal Ahrerich Member of the Ahrerouch Fm), not yet re-studied. A significant transgression of the Kacak Event level is indicated by the presence of late Eifelian goniatite faunas with *Cabrieroceras* on the southern side of the Tindouf Basin (HOLLARD 1967).
maximum floodings: in the Lower and Upper *Maenioceras* Beds of the Tata region.
end: widespread grey marker limestone above the **Upper *pumilio* Event** (top of new Oued Mzerreb Member of the Ahrerouch Fornation).

Cycle 7 late Middle Givetian to Middle Frasnian (with several subcycles)
start: *Agoniatites* Beds at the base of the new Tiguisselt Member (Ahrerouch Formation).
maximum floodings: *Afromaenioceras* Bed (middle **Taghanic Event** phase), *Juvenocostatus* Beds (upper Taghanic Event phase), black shale unit (post-Taghanic transgression); all still in the Tiguisselt Member.
end: unfossiliferous siltstone and shale package above the *Juvenocostatus* Beds (indistinctive early part of the Anoû Smaira Formation).

Cycle 8 Middle to Upper Frasnian (with several subcycles)
start: blackshales with *Naplesites* low in the Lower Member of the Anoû Smaira Formation: **Lower Rhinestreet Event**.
maximum floodings: *Naplesites* Beds, *Carinoceras* Beds, **Lower Kellwasser** Bed and Upper Concretion Marls at Oued Mzerreb (all in Anoû Smaira Formation).
end: red shales at the top of the Anoû Smaira Formation.

Cycle 9 Famennian (probably with several subcycles)
start: shales with cheiloceratids (probably the "**Nehden Event**"), Oued Amstil Formation.
maximum floodings: perhaps limestone coquinas with ammonoids in the El Douiya and Lemgairinat Formations (details still lacking).
end: unfossiliferous red and green siltstones at the top of the Tazout 1 Formation (new Kheneg Lakahal Member).

The next cycle starts with a Tournaisian transgression (Tazout 2 Formation) and ends with the massive sand sheets of the Tazout 3 Formation. The subsequent argillaceous and transgressive Betaina Formation (partly with some ammonoids) falls in the later Tournaisian and forms a pronounced valley. This second Carboniferous cycles ends with the Visean Ouarkziz Formation which is mostly not accessible on the Algerian side of the successions.

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The Givetian and Frasnian at Oued Mzerreb (Tata region, eastern Dra Valley)

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1. Introduction and location

The late Givetian at Oued Mzerreb has been first investigated by BENSAID (1974) who provided a section log of strata which were then assigned to the upper Givetian to basal Upper Devonian ("ds 1α"). With the later definition of the series boundary and according to the proposed level for a future Upper Givetian substage (ABOUSSALAM & BECKER 2002), the whole previously studied succession now falls in the Middle Givetian. BENSAID (1974) mentioned a *Manticoceras* level much higher in the sequence and these true Frasnian beds, including distinctive and important global event levels, will be described here for the first time in detail. The previously documented ammonoid taxa from Oued Mzerreb are (with revised taxonomy; identifications and figures of BENSAID in brackets) as follows:
Atlantoceras tataense (pl. 1, figs 3-3b, the holotype)
Mzerrebites juvenocostatus (pl. 3, fig. 3)
Pharciceras aff. *tridens* (*Ph. tridens*, pl. 5, fig. 11)
Afromaenioceras crassum (pl. 2, figs 11, 11a, the holotype, pl. 4, figs 6, 6a, pl. 6, fig. 9)
Afromaenioceras sulcatostriatum
Afromaenioceras n. sp. (*Maenio*. cf. *crassum*, pl. 1, figs 10, 10a)
Maenioceras n. sp. II (*Maenio. terebratum*, pl. 1, fig. 11)
Wedekindella lata (pl. 3, figs 1, 1a, the holotype)
"*Phoenixites*" n. sp. (*Tornoceras simplex*)
"*Trevoneites*" sp. (*Tornoceras westfalicum*)

Associated were solitary rugose corals of the deeper-water facies, styliolinids, tentaculites, rare conodonts (*Polygnathus varcus, Linguipo. linguiformis, Belodella triangularis*, various ramiform elements), and diverse gastropods. Our investigations fully confirm the former results and faunas but add a wealth of additional details, especially since special attention was paid to lower and higher strata. The correlation of all Tata area sections gives a rather consistent picture of regional deposition (ABOUSSALAM 2003) but there are important local sedimentological and faunal features. Currently, early Middle Givetian ammonoid faunas are exclusively known from Oued Mzerreb and represent on a global scale the best assemblages from the *rhenanus* Zone (upper part of former Lower *varcus* Zone). Conodonts, unfortunately, are very scarce and other groups are basically not yet studied.

Ca. 27 km SE of Tata, the Lower Devonian is exposed in a succession of ridges, formed by SW-NE running syn- and anticlines, named as Aguelmous. In the adjacent plain, the Middle and Upper Devonian forms a gentle and wide anticline with low topography which dives under the Quarternary towards the SE. The Oued Mzerreb is a dry valley which cuts with several branches through the extensive outcrop area. The Famennian is said to be exposed W of the adjacent Oued Toufassour, ca. 1-2 km to the East, but has not yet been studied. Our section Oued Mzerreb West transsects the center of the anticline at x = 271.4, y = 287.7 (GPS: N 29° 33´ 12´´, W 07° 46´ 19´´). It needs to be emphasized that the outcrop area is situated in a military zone and in order to gain access, permission is strictly required.

2. The Middle Givetian at Oued Mzerreb West (Figs 1-2, Tabs 1-2)

The lower part of the succession was studied in plains adjacent to a branch of the dry valley. Beds dip with an angle between 15 and 20° within a fold opening to the North. There is generally an alternation of shales and marks with slightly more solid marl interbeds or grey to reddish-grey, nodular, partly bioclastic limestones with styliolinids. Some levels have abundant haematized or goethitic ammonoid, nautiloids, gastropods, some brachiopods and subordinate other fauna.

Agoniatites aff. *vanuxemi* Beds

Bed –8b consists of 18 cm reddish limestone nodules and overlying bioclastic marls which are poor in macrofauna. There are no conodonts but few tentaculites, many styliolinids, goethite spherules, rare gastropods, and a juvenile *Buchiola*. The latter proves, in accordance with the lithology, a pelagic open marine biofacies. The absence of conodonts has to be explained by poor trophic conditions. Bed –7b is a light grey marl which produced a loose and poorly preserved *Agoniatites*, perhaps *Agon*. *costulatus*, which had a long range from the upper Eifelian (MD I-F) to the Taghanic Event level. It differs from the related *Agon. vanuxemi* in stronger ribbing and more evolute, less expanding shell form of median and adult stages. KLUG (2003) included early *Agon. costulatus* in *Agon*. *vanuxemi*. There is also a medium-sized loose *Bornhardtina* sp. which has a similar range (BRICE et al. 2000) but the presence of this widespread shallow-water brachiopod in a pelagic setting is remarkable.

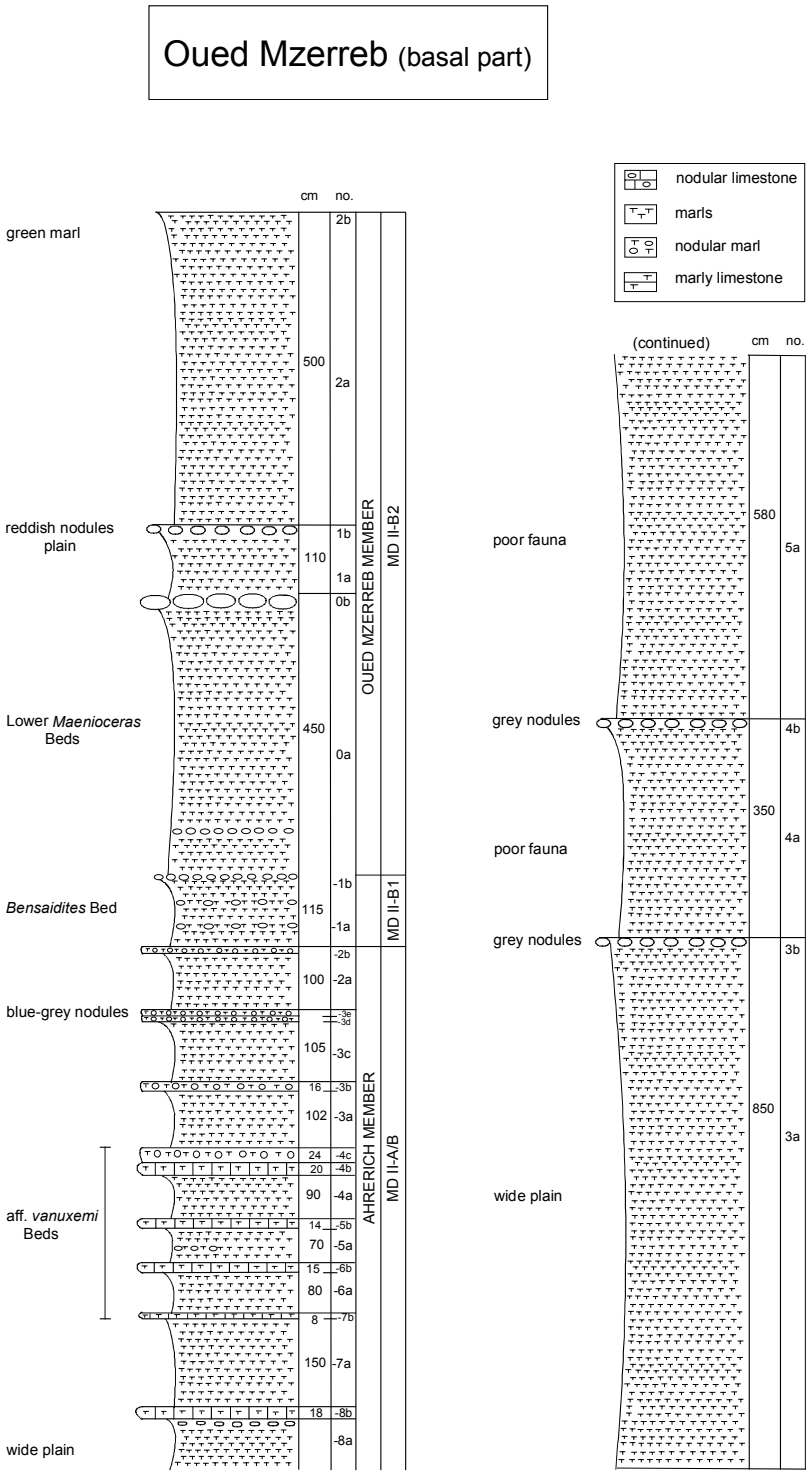

Fig. 1: Lithostratigraphy and ammonoid dating of the lower part of the Middle Givetian at Oued Mzerreb West.

Bed –6b is somewhat finer grained and yielded a more diverse goniatite fauna in association with some phacopids, crinoid fragments and rare smooth brachiopods which resemble *Crurithyris* (ambocoelids) or *martiniids.* The first is a long-ranging genus, but normally of the neritic facies. The rare haematitic fauna found in the area is clearly allochthonous and was transported during occasional flooding. There are three species of *Agoniatites* in limestone preservation, including large-sized, compressed, tegoid, unribbed forms with narrow umbilicus, lacking marginal furrows but with a flat venter at maturity. These are currently identified as *Agon.* aff. *vanuxemi*. The true *Agon. vanuxemi* of New York (unpublished data M. R. HOUSE, KLOFAK 2002) and of the eastern Anti-Atlas (Maider Platform: Ou Driss, BULTYNCK 1991) has thicker whorls and ribbing at median stages. The most common Oued Mzerreb form has been identified in HOLLARD & JAQUEMONT (1956) as *Agon. obliquus*, by HOLLARD (1963) as *Agon*. gr. *fulguralis*. Recent revision of both species by HOUSE (2003), however, showed that these younger Givetian British forms have well developed ventrolateral furrows bordering a narrower venter. This leaves the older and common North African species currently without a valid name.

The oldest beds at Oued Mzerreb can be correlated with the Lower Givetian of the Tafilalt which only has a sparse goniatite fauna consisting of some *Agon. costulatus* (BECKER & HOUSE 1994, 2000; WALLISER 1991), *Agon*. aff. *vanuxemi* (*Agon*. *obliquus* in BELKA et al. 1999 and KLUG 2003) as well as rare *Tornoceras* and *Holzapfeloceras.* The same early Givetian fauna (late MD II-A to early II-B) with "*Agon. obliquus*" and "*Agon*. aff. *costulatus*" was recognized in the Ougarta area of Algeria by PETTER (1959). *Holzapfeloceras* cf. *circumflexiferum* also occurs in Bed –6b. This form ranges in the Tafilalt from the Kacak Event beds (BECKER & HOUSE 1994) into the Lower Givetian and was used by KLUG (2003) as a marker for a *Holz. circumflexiferum* Zone straddling the Eifelian/Givetian boundary. The species is indeed a good faunal marker but latest Eifelian beds with a characteristic youngest *Cabrieroceras* fauna (MD I-F2) should not be mixed in one zone with the oldest *Bensaidites* faunas (*Bensaidites koeneni* Zone, early MD I-A) from above.

Bed -5 has basically the same assemblage as Bed –6. Bed –4 forms a very low hill and consists of a lower shale part (Bed –4a), followed by marly limestone (Bed –4b) and somewhat reddish to bluish weathering, dark grey nodular limestones (Bed –4c). Initially, and based on abundant *Agon*. aff. *vanuxemi*, this level was thought in the field to represent the Kacak Event. Sparse, small and poorly preserved conodonts, however, include forms which are best identified as *Po*. *varcus* (juvenile specimen with a large basal cavity anterior of the platform) and *Po. timorensis* (narrow form with deep adcarinal furrows, only inner anterior margin still with slight serration as in intermediate morphotypes to *Po*. *ensensis*). The association of both species gives a much younger, basal Middle Givetian age sensu BULTYNCK & GOUWY (2002: basal part of *rhenanus* Zone).

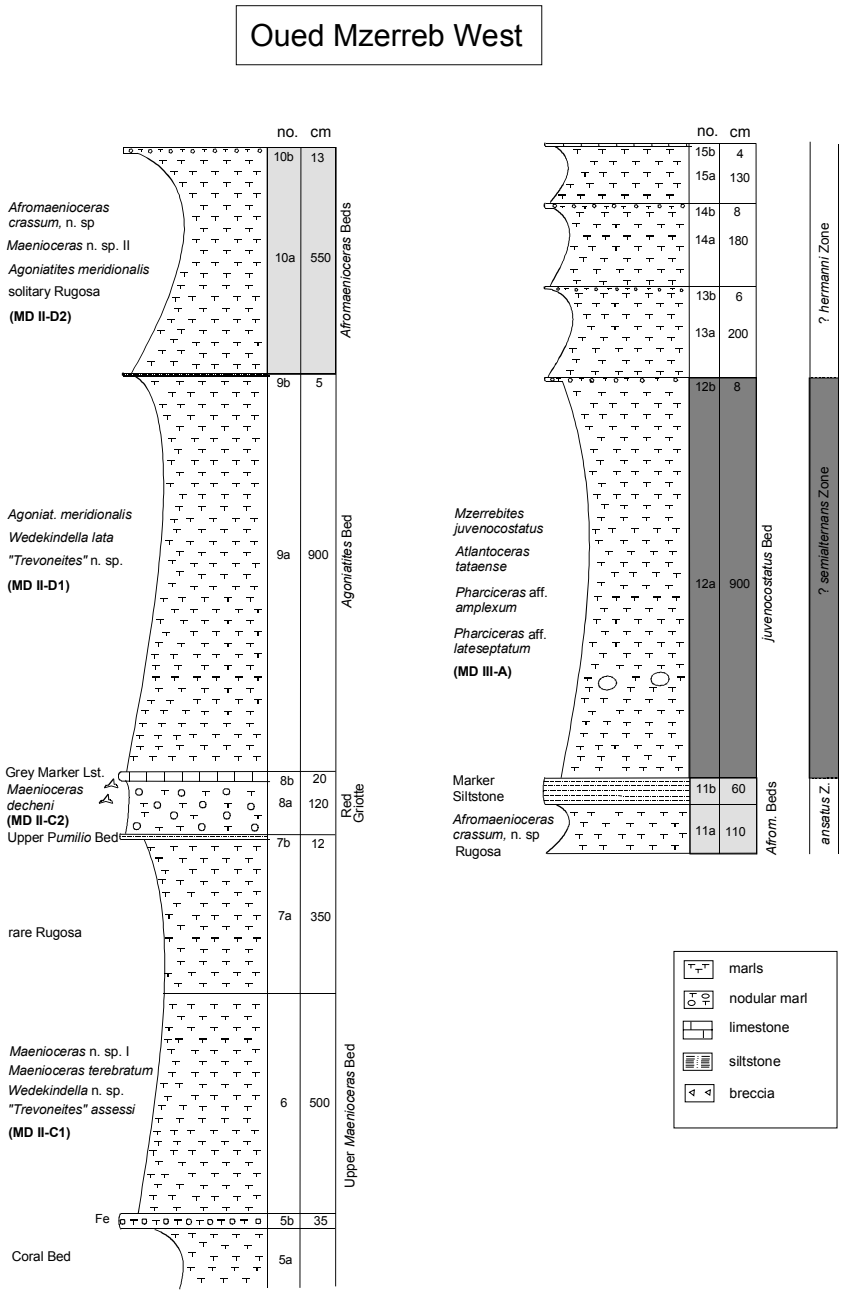

Fig. 2: Lithological and faunal succession of the upper part of the Middle Givetian (MD II-C1 to MD III-A, ca. middle part of *rhenanus* to *semialternans* Zone) at Oued Mzerreb.

There is no evidence for typical Eifelian or Lower Givetian conodonts but there are abundant dacrycoconarids, rare microvertebrate remains (teeth and vertebrae of palaeoniscids), some subspherical agglutinating foraminifers (*Thurammina*, obviously producing haematite and goethite spheres as internal moulds) and ostracods (*Polyzygia*). Support for a Givetian age comes from a single medium-sized brachiopod resembling stringocephalids which needs further study. The precise conodont level of the open umbilicate *Bensaidites molarius* Group, which defines division MD II-B, is not known within the *rhenanus* Zone in SW England. Therefore, all *Agon*. aff. *vanuxemi* Beds are currently assigned to a broader MD II-A/B interval.

The overlying Bed –3 yielded a very small-sized and mostly poorly preserved goethite fauna which first was thought to have been washed down from higher parts. However, there are some faunal elements which do not occur in the very fossiliferous subsequent units and, therefore, the assemblage should be regarded as in place. There are juvenile *Bensaidites* sp. and *Agoniatites* sp., probably juveniles both of *costulatus* (markedly ribbed) and aff. *vanuxemi* (smooth early whorls) which do not give a precise zonal age. Associated are crinoid remains, rare nuculoids, the neritic brachiopod *Pyramidalia*, gastropods, *Phacops* sp., *Buchiola*, and orthocones. Most intriguing is a minute, evolute goniatite with slight ribbing on sharp (subangular) umbilical shoulders and straight flank sutures as in *Cabrieroceras*. This single specimen seems to supports the view of HOUSE (1958, 1963) that the genus survived the global regression near the end of the Eifelian and of the Kacak Event, to become a very rare element of Givetian ammonoid faunas. Early stages of *Sobolewia* have been compared and are more involute and lack the subumbilical edges. Bed –3b resembles Bed –4b. Bed –2 is another shale-nodular limestone cycle but is unfossiliferous. Rare goethitic fauna is allochthonous.

Bensaidites Bed

A completely different Givetian goniatite fauna is abundant in the light grey nodular limestones of Bed –1 which forms a gentle slope. At the top there is a reddish weathering limestone nodule layer. The name of the bed is based on a new early maenioceratid, *Bensaidites* n. sp., which defines a new Zone and which is characterized by strong compression, closed umbilicus at maturity, and, for the genus, very advanced adventitious lobes. Even more abundant are compressed tornoceratids which are currently assigned to the North American *T. uniangulare*. Apart from a few fragments, the agoniatitids have disappeared. Gastropods, large-eyed phacopids, tabulate (*Thamnopora*) and solitary rugose corals, smooth brachiopods, nuculoid bivalves, fish teeth, foraminiferes and diverse, partly spinose ostracods point to a rather shallow pelagic biofacies with a diverse muddy ecosystem. Some of the ostracods are representatives of the "Thuringian ecotype". Conodonts are very rare. *Linguipo. linguiformis* and a single *Ctenopo*. *mucronatus* (see its range in BULTYNCK 1987) are in accordance with a dating as *rhenanus* Zone.

taxon/bed number	-8b	-7b	-6b	-5b	-4b	-4c	-3a	-1a	-1b	0a	0b	1a	3b
ZONATION	MD II-A		MD II-A/B					MD II-B1		MD II-B2			
div. gastropods	x	--	--	--	xx	--	x	x	x	x	--	xx	
styliolinids	xx	x	x	x	xxx	x	--	--	xx				
tentaculites	x	x	x	x	xx	x	--	--	x				
Buchiola sp.	x	--	--	--	--	--	x	--	--	x	--	x	
Bornhardtina laevis		x											
Agon. ?costulatus		**x**	--	--	--	--	?						
Agon. aff. *vanuxemi*			xx	x	xx	x	?						
Agon. cf. *euryomphalus*			x	--	--	--	--	--	--	x	--	xx	
Agoniatites div. sp.			x										
Agoniatites sp. indet.			x	--	x	x	xx	x	--	x	--	xx	
Holz. cf. *circumflexiferum*			x	x	--	--	--	--	--	x			
Phacops sp.			x	--	--	x	x	xx					
Crurithyris sp.			x	--	--	--	--	--	x	x	x		
crinoid remains			xx	x	x	x	xx	x	x	--	x		
encrusting Bryozoa				x									
Linguipo. linguiformis					x	--	--	--	x				
Po. timorensis					x								
Po. varcus					x								
Ctenopo. mucronatus					?	--	--	--	x				
microvertebrates					x	--	--	--	x				
Polyzygia sp.					x								
Thurammina sp.					x	--	--	--	xx				
stringocephalid						x							
Bensaidites sp.							**x**						
Pyramidialia sp.							x						
nuculoids							x	--	x	x			
orthocones indet.							x	--	--	xx	--	x	
Cabrieroceras sp. juv.							**x**						
Bensaidites n. sp.								**xx**					
"*Wedekindella*" n. sp. I								x	--	--	--	x	
Torno. uniangulare								xxx	x				
div. smooth brachiopods								x	x	x			
Thamnopora sp.									x				
Bellerophon sp.									x				
solitary Rugosa									x				
Aechmina sp.									x				
other spinose ostracods									x				
div. smooth ostracods									x				
Maenioceras n. sp. III										**xxx**	--	xxx	
Agon. aff. *costulatus*										xxx	--	xxx	
?Arkonoceras sp.										x	--	x	
Bogoslovskiya sp.										x			
"Cardiola" sp.										x			
"Torno." aff. *amuletum*										xx	--	x	
"Trevon." assessi										xx	--	x	
"Wedekindella" n. sp. II												x	
"Phoenixites" n. sp. IV												x	
"Phoenixites" n. sp. V												x	
"Trevon." aff. *assessi*												x	
Praecardium sp.												x	
Heliolites sp.													x

Tab. 1: Givetian fauna from below the Coral Bed at Oued Mzerreb West
(x = record, xx = frequent, xxx = very abundant, * = allochthonous/transported).

Based on conodont ages, the *Bensaidites* Bed correlates in the Tafilalt (Fig. 3) with a peculiar faunal level (BECKER & HOUSE 1994, 2000b) characterized by small "*Wedekindella*" cf. *psittacina*, *Sobolewia* n. sp. aff. *cancellata* (much more compressed than the true *cancellata*), agoniatitids and last *Bensaidites koeneni* (or relatives). Although there are no open umbilicate *Bensaidites* species as in SW England (see recent revision of the *Bens. molarius* Group in HOUSE 2003), this assemblage was assigned to MD II-B. This was justified by the presence of late *Bensaidites* and the *psittacina* Group in both faunas. A similar, still unpublished assemblage also occurs in the NE Maider. The latter fauna, Bed –1 at Oued Mzerreb, as well as the Tafilalt faunas all contain new "*Wedekindella*" species lacking constrictions but with concave umbilical wall. The Oued Mzerreb *Bensaidites* n. sp. Zone is consequently taken as a local lower subdivision of MD II-B.

Lower *Maenioceras* Beds

A second and previously completely unknown Givetian fauna enters in the hypoxic shales and marls of Bed 0. Loose limestone specimens of *Tornoceras*, brachiopods, corals and gastropods probably originate from Bed –1. The haematitic and goethitic association is dominated by a new species of Tab. 1. *Maenioceras* (n. sp. III) which is much more compressed than the younger *Maenio. terebratum* and in which the ventrolateral shoulders are much better rounded. There are also many *Agoniatites* which differ from *Agon. costulatus* in weaker marginal furrows. Minor faunal elements are orthoconic nautiloids, tornoceratids, bivalves, *?Crurithyris*, gastropods, and other ammonoids, such as *Sobolewia*, the *"Trevoneites" assessi* Group, and *Holz*. cf. *circumflexiferum*. A new tornoceratid with juvenile ribbing resembles to some extent the distinctive *"T." amuletum* from New York. This form, together with *Maenioceras* n. sp. III, characterizes an upper subdivision of MD II-B in the Tata region. The entry of first *Maenioceras* could be used to define internationally Givetian ammonoid division II-C but other important marker forms of the traditional *Maenio. terebratum* Zone, especially constricted *Wedekindella* s. str. and *Sellagoniatites*, are still lacking. In the eastern Anti-Atlas, corresponding associations have not yet been described from the limestone cliff of the *rhenanus* Zone.

The top of Bed 0 is formed by somewhat irregular and concretionary marls with crinoid debris and rare brachiopods. Bed 1 yielded the same fauna as Bed 0, but in addition several new and rare tornoceratid species which do not fit in currently known genera. This also applies to two new species of the Wedekindellinae without constrictions or with subdivided lobe at the umbilicus. Benthic faunal elements, such as *Buchiola, Praecardium*, and various gastropods, are typical for hypoxic, deeper and outer muddy shelf habitats. Bed 1b is a level of reddish to yellow weathering limestone nodules. The overlying Beds 2 to 4 are poorly fossiliferous. Occasional haematitic goniatites turned out to be allochthonous species derived from beds cropping out upslope. There is a single, rather large *Heliolites* colony from Bed 3b, a light grey nodular marl level.

Coral Bed

Bed 5a is a thick package of shales and marls in an area with poor outcrop. Only in the upper part, there are mass occurrences of well-preserved solitary rugose corals which, however, belong to the taxonomically difficult *Amplexus* Group, typical for outer and cool shelf facies. Their dominance suggests an episodic improvement of seafloor oxygenation due to shallowing. This mid-*rhenanus* Zone regressive phase (topmost MD II-B) can be correlated throughout the Tata region. The same Coral Marl has been found at Oufrane (see ABOUSSALAM et al., this vol.) where it directly overlies the Lower *Pumilio* Bed. The latter has not yet been recognized, however, at Oued Mzerreb West. Haematitic fauna collected together with the corals is identical with the rich fauna from Bed 6a and, therefore, was probably derived from there. Bed 5b is a marly to nodular limestone with some haematite, suggesting an end of the short oxic phase. Unfortunately, only very few ramiform conodonts have been recovered so far, together with more abundant silicified ostracods and styliolinids. Stringocephalids have been discovered around Beds 5/6 during the excursion in March 2004.

Upper *Maenioceras* Beds

Similar as Beds 0 and 1, Bed 6a has a very diverse, rich and well-preserved haematite/goethite fauna, dominated by *Maenioceras*. There are two species of the genus, *Maenio. terebratum* s. str., and the thicker and more involute *Maenioceras* n. sp. I. Together with a new species of *Wedekindella* s. str. (closely related to *Wed. lata*), these forms characterize the lower part or subzone of the *Maenioceras terebratum* Zone (MD I-C1) which is also widely known from the Montagne Noire or Germany (review in BECKER & HOUSE 2000c). In the Tafilalt, however, there are almost no ammonoids directly above the Lower *Pumilio* Bed. Characteristic associated faunal groups at Oued Mzerreb are tabulate corals (*Thamnopora* and *Heliolites*), phacopids, diverse gastropods, rare bactritids, sobolewiids, nautiloids, bivalves and plant remains. The long-ranging *"Trevoneites" assess*i is relative common. The subsequent higher part of the shale sequence (Bed 7a) is rather poor in fauna and partly covered on a gentle slope by limestone debris.

Upper *Pumilio* Bed

The Upper *Pumilio* Bed is relative thin (12 cm), platy, bioclastic, dark-grey and shows the typical facies characteristics known from the Tafilalt (LOTTMANN 1990): a lower unit with mass occurrences of styliolinids can be separated from an upper coquina of *Ense albertii*. There is no evidence that the brachiopods were swept in by a tsunami but both faunal groups obviously flourished in situ as the consequence of episodic outer shelf eutrophication.

taxon/bed number	5a	5b	5-6	6	7a	7b	8a	8-9	9a	top 10	11a	12a1	12a2	12b
ZONATION			MD II-C1				II-C2	II-C/D		MD II-D		MD III-A		
solitary Rugosa	xxx	--	--	x	x	--	xx	--	--	xx	xx			
Polyzygia sp.		x	--	--	--	--	x							
styliolinids		xx	x	--	--	xx	xx	x	--	x	--	x	x	
div. smooth ostracods		xx	--	--	--	--	xxx	x	--	--	---	--	--	xx
ramiform conodonts		x												
Heliolites sp.	x*		--	x										
Thamnopora sp.	x*		--	x	--	--	x	x						
orthocones	x*		xx	xxx	--	--	--	--	x					
breviconic nautiloids	x*		--	x	--	--	--	--	--	--	x			
Maenioceras n. sp. I	xx*		**xx**	xx										
"Trevoneites" assessi	x*		xx	xx	--	--	--	--	xx	x				
Wedekindella n. sp.	x*		xx	xx										
Phacops koeneni Gp.	x*		--	x	--	--	xx							
Cyrtolites sp.			x	x	--	--	x	x	x	--	--	--	x	
div. other gastropods			x	x	--	--	xx	x	x	--	x	--	x	
Hyolithes sp.			x											
Sobolewia virginiana			x	--	--	--	--	x						
Tornoceras sp.			x	x	--	--	x	--	--	--	--	--	x	
Maenio. terebratum			**x**	xxx										
Bac. aus. ausavensis			x	x										
Hastula subtilis			x	x	--	--	--	x						
lycopsid plant remains				x										
crinoid remains				x	--	--	xx	x						
Buchiola sp.				x	--	--	x	--	x	--	--	--	x	
Ense albertii						xx	x							
other brachiopods							xx	--	x	--	--	--	x	
Bellerophon sp.							xx							
Richteraspis sp.							x							
Maenio. decheni							**xxx**							
"Cardiola" sp.							x							
hollinellid							x							
Aechmina sp.							x							
other spinose ostracods							x	--	x					
Goniophora sp.							x							
"Phoenixites" n. sp. I							x*		x	--	--	x	x	
Agoniatites meridionalis								x	x	x				
Po. varcus								x						
Lateri. lat. latericrescens								x						
Wedekindella lata									xx					
"Trevoneites" n. sp.									**xx**	x				
Maenioceras n.sp. II										x	x	x		
tentaculites									x	--	--	--	--	xx
Afromaenio. crassum			x*	x*				x*	x*	**xx**	xx	xx		
Afromaenioceras n. sp.										**xx**	xx	x		
Mzerr. juvenocostatus				x*						x*		**x**	xxx	
Pharciceras sp.				x*							x*		x	
Atlantoceras tataense								x*				x	xxx	
"Truyolsoceras" n . sp.													x	
Mzerr. aff. *juvenocostatus*													x	

Tab. 2: Givetian fauna from the Coral Bed and above at Oued Mzerreb West
(x = record, xx = frequent, xxx = very abundant, * = allochthonous/transported).

Lower Red Griotte

Bed 8a is a marker unit consisting of reddish and bioclastic limestone nodules sitting in a marly matrix. The lithology resembles a little bit the "Vrai Griotte" of the Montagne Noire. The faunal assemblage contains many benthic and neritic taxa, such as abundant large-eyed phacopids, bellerophontids, other gastropods (e.g., *Holopella* sp.), many crinoid remains (stems and other pieces forming encrinite lenses), cornuproetids (*Richteraspis*, det. R. FEIST, first record of the subfamily for the Dra Valley Givetian), proetines, many smooth brachiopods (several taxa), rare small chonetids, solitary Rugosa (*Guerichiphyllum* und "*Amplexum*", det D. WEYER), shallow-water bivalves (*Goniophora* sp.), and thamnoporids. Abundant *Maenio. decheni* and *Tornoceras* show that the biofacies was mixed

neritic-pelagic and point to an oxic, shallow dysphotic environment, still well below any storm influences. *Maenio. decheni* defines regionally an upper subdivision (subzone) of MD II-C. Its sutures are somewhat ancestral to the younger *Afromaenioceras*. In the Tafilalt, very oligotrophic pelagic limestones just below and above the Upper *Pumilio* Bed contain only *Sellagoniatites waldschmidti* (= *Sellag. discoides* WALDSCHMIDT non TRENKNER) and rare *Tornoceras*. This Tafilalt *waldschmidti* Zone (also of MD II-C2 age) begins slightly below the base of the *ansatus* Zone (= former Middle *varcus* Zone). Bed 8a did not yield any conodonts but masses of silicified ostracods (*Aechmina*, other spinose taxa, hollinellids, *Polyzygia*, etc.), juvenile bivalves, styliolinids, crinoid and trilobite remains.

Grey Marker Limestone

Bed 8b is a solid marker limestone which shelters a small hill and which is the easiest marker level for the correlation of all Givetian sections of the Tata region (ABOUSSALAM 2003). It was also noticed by BENSAID (1974: limestones below Bed a in fig. 3). In the Tafilalt (Fig. 3), it correlates with the massive Middle *Sellagoniatites* Bed just above the Upper *Pumilio* Bed. This is supported by the local occurrence of *Latericriodus latericrescens latericrescens* which is typical in the Tafilalt for the Upper *Pumilio* level (LOTTMANN 1990). There are very few other conodonts (only *Po. varcus*), some gastropods, goethite spherules, *Buchiola*, and styliolinids. An erosive upper surface suggests shallowing upwards. There was a regressive peak low in the *ansatus* Zone.

***Agoniatites* Bed**

The subsequent return to marls with haematitic fauna (Bed 9a) indicates a subsequent transgression which is also true for the correlative and widespread *Maenioceras* Marls of the Tafilalt (e.g., BECKER & HOUSE 2000b, BULTYNCK & WALLISER 2000) which contain oldest *Afromaenioceras* (defining MD II-D1). The *Agoniatites* Bed of the Tata region is characterized by the sudden and episodic retreat of all maenioceratids whilst *Agoniatites meridionalis, Wedekindella lata* and *"Trevoneites" assessi* bloomed. BENSAID (1974) reported a corresponding fauna from his Bed B1. The reason for the palaeoecologically controlled shift in the ammonoid assemblage is still mysterious. The associated fauna, with orthocones, oxyconic bellerophontids, other gastropods, bivalves, some smooth brachiopods, ostracods, tentaculites and tornoceratids, is not peculiar. A new species of "*Trevoneites*" with much thicker whorls than *"Trev." assessi* is used as regional marker for a subdivision (lower subzone) of MD II-D.

***Afromaenioceras* Beds**

Above a thin siltstone (Bed 9b) follows another shale and marl unit (Bed 10a) which yielded fauna only near its top, a bioclastic limestone (Bed 10b, Bed B2 in BENSAID 1974). Unlike as in other Tata sections, there are again abundant solitary Rugosa (*Guerichiphyllum* sp., det D. WEYER) of the deeper/cooler water facies (*Cyathaxonia* Biofacies). Correlation of the bed with the Taghanic Onlap (ABOUSSALAM 2003, upper part of *ansatus* Zone) and with the lower cycle of the extended Taghanic Event Intervall is corrobated by the entry of various species of *Afromaenioceras*, and especially of *Afromaenioceras* n. sp. which also has been found in the argillaceous facies of the lower event interval of the SW Amessoui Syncline in the southern Tafilalt. There, and at Oued Mzerreb, it is accompanied by *Maenioceras* n. sp. II (with very advanced sutures) which, however, enters already earlier, in the *Maenioceras* Marls, in platform sections (e.g., Seheb el Rhassal, Jebel Amelane). It is intriguing that *Afro. sulcatostriatum* is locally very rare. Conodonts reported by BENSAID (1974) are consistent with a *varcus* Zone age in its very wide "superzone sense" (indicating still Middle Givetian). There are few last "*Trevoneites*" and *Agoniatites* (= *Merogoniatites*) in the *Afromaenioceras* Beds. Such a survival into the lower event interval was previously unknown and shows the complex, stepwise extinction pattern of ammonoids at the end of the Middle Givetian. Bed 11b is a significant, tripartite, 60 cm thick calcareous siltstone interval which indicates a regressive phase. The incoming of early pharciceratids above proves that it correlates with the regressive phase separating the Middle and Upper Tully Limestone (BAIRD & BRETT 2003) of New York. It is a thin marker unit which allows correlation of all studied sections of the Tata region.

***Juvenocostatus* Beds**

Bed 12a (Bed C2 in BENSAID 1974) is thought to represent the last Middle Givetian transgression which allowed a siginificant new radiation of ammonoids. Important regional newcomers are the endemic *Atlantoceras tataense*, *Mzerrebites juvenocostatus*, which also is known from the Maider (BENSAID 1974: pl. 3, fig. 6), a new related genus, and oldest species of *Pharciceras*, such as *Ph.* aff. *amplexum*, *Ph.* aff. *tridens* (thicker and more evolute) and *Ph. lateseptatum* (thicker, but more involut). By contrast to other sections of the Tata area, early pharciceratids are, however, relative rare at Oued Mzerreb. The best collecting is from the upper part of the shale and marl sequence (Bed 12a2) which is also characterized by large grey limestone concretions (Bed C3 in BENSAID 1974). Above this concretion level, faunas disappear suddenly. As in the contemporaneous bed with oldest *Pharciceras* in the Tafilalt (ABOUSSALAM & BECKER 2001: *semialternans* Zone), last Maenioceratidae are still present in the *juvenocostatus* Zone (MD III-A). There are at least three species of *Maenioceras* and *Afromaenioceras* which gradually went extinct near the end of the extended event interval. Several partly new tornoceratids are accessory faunal elements, as are gastropods, brachiopods, and bivalves.

Above the fossiliferous succession there are subsequent cycles with shales and more solid, bioclastic marls (Beds 12a3 to 15) which have not yielded any fauna. At Oufrane (ABOUSSALAM et al., this vol.) corresponding cycles still carry a typical *juvenocostatus* fauna. Therefore, the post-Taghanic Upper Givetian cannot be located precisely. It seems that there was a gradual deepening.

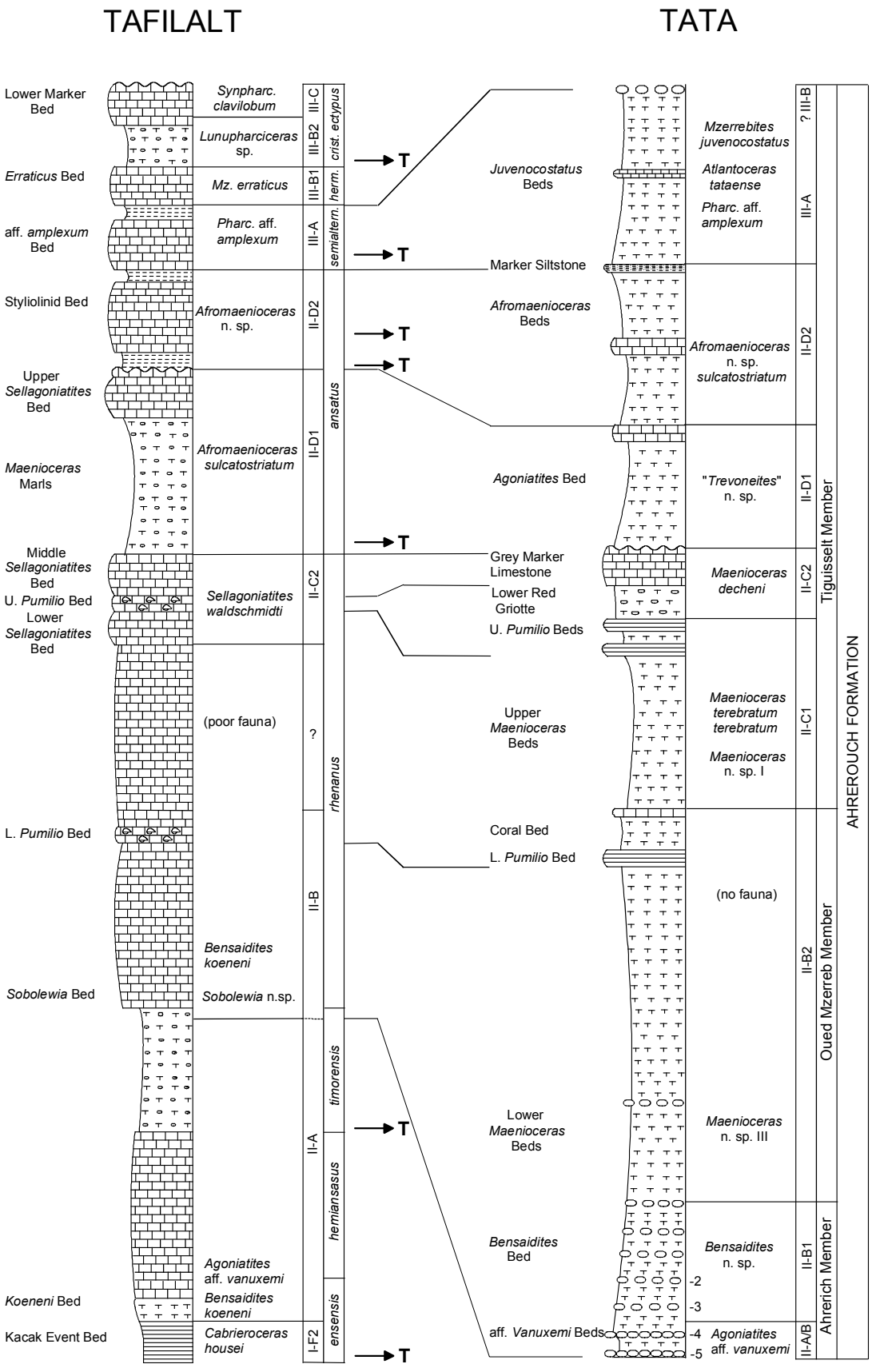

Fig. 3: Correlation of the Lower and Middle Givetian of the Tafilalt Platform
(data from BECKER & HOUSE 1994, 2000a, 2000b, ABOUSSALAM 2003, and new results) and of the Tata region.

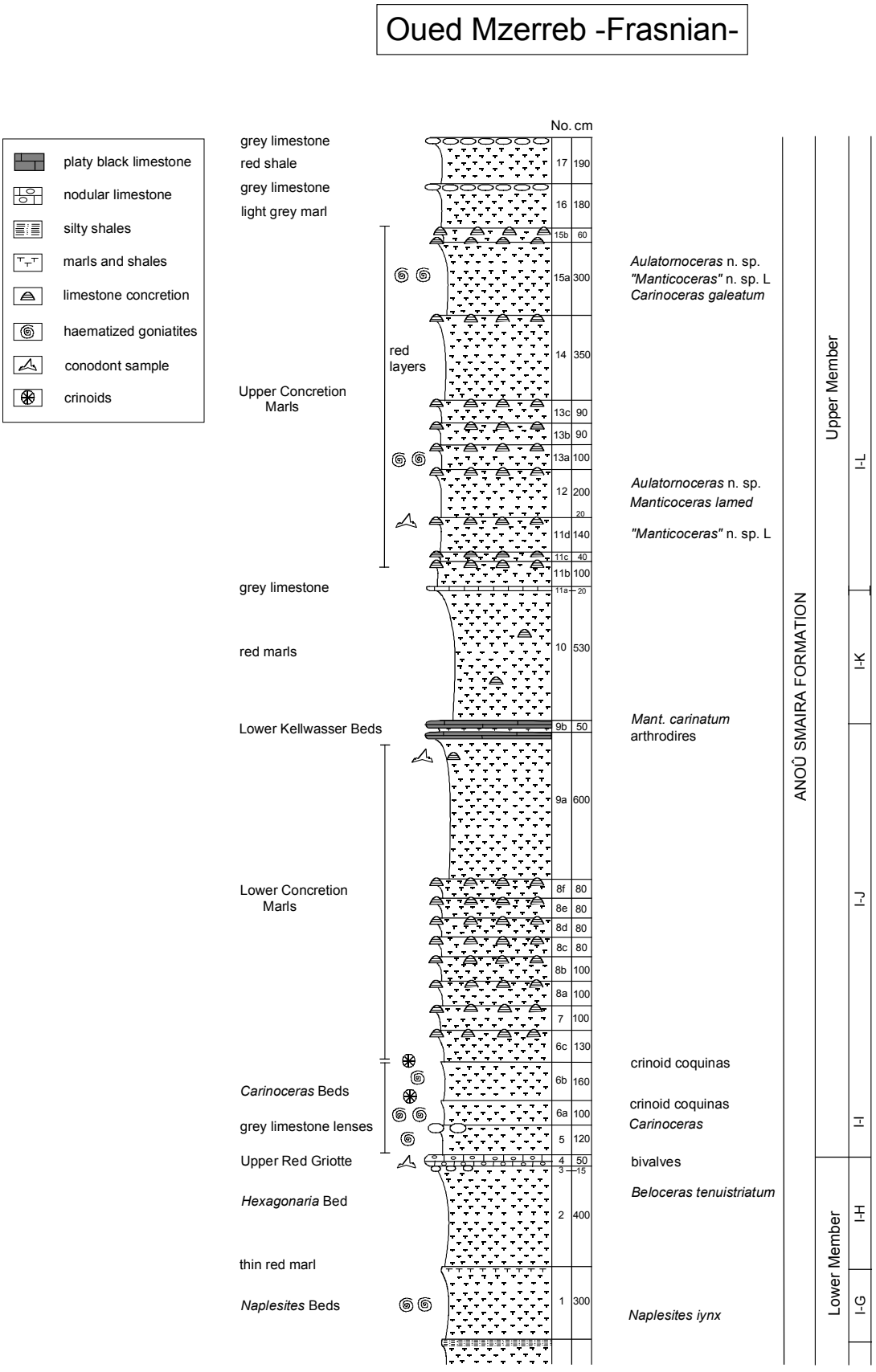

Fig. 4: Frasnian lithostratigraphy and faunas at Oued Mzerreb West.

3. The Middle and Upper Frasnian at Oued Mzerreb (Fig. 4)

The Frasnian section was measured above a gap of several hundred meters. The thickness for this Upper Givetian and Lower Frasnian interval has not yet been measured. The onset of macrofauna was used as criterion for intensive studies. The data presented here are the first precise biostratigraphical data for the Frasnian of the Dra Valley. Therefore, it is not surprising that faunas include mostly new species and several first records of faunal groups for the whole region. Preliminary data in HOLLARD & JAQUEMONT (1956) show that similar deposits with *Manticoceras* and *Beloceras* can also be found S of Akka and at the Jebel Hamsailikh S of Foum Zguid.

Naplesites Bed

Bed 0 at the base of the measured section is an unfossiliferous shale interval which ends with an inconspicuous siltstone level. The overlying deeply weathered shales and marles with a very distinctive ammonoid fauna are poorly exposed along a minor, NW running tributory to a branch of the Oued Mzerreb. The level can be found with the help of a thin red marl, Bed 1b, at its top. It was first discovered by Lieutenant Colonel BOULEHJAL who looked after us during our first visit to the locality. The assemblage indicated suddenly improved trophic conditions and consists of:

Naplesites n. sp. aff. *iynx* (with an incipient third outer umbilical lobe at maturity, common)
Lobotornoceras ausavense n. ssp. (abundant)
Lobotornoceras n. sp. (without flank constrictions)
"*Truyolsoceras*" n. sp. aff. *keyserlingi* (abundant, with rimmed umbilicus)
Truyolsoceras n. sp. N (with nodose early whorls, rare)
Phoenixites aff. *frechi* (with lower sutural relief, rare)
Phoenixites n. sp. (with higher saddles at small size, rare)
"Manticoceras" n. sp. S (rather evolute, venter flat and often furrowed, abundant)
"Manticoceras" n. sp. C (part of the *"Mant." sinuosum* Group, abundant)
Lobobactrites paucesinuatus (some specimens)
Hastula subtilis (some specimens)
Buchiola sp. (rare)
gastropods (rare)
crinoid stems (abundant, at least four different types)
Thamnopora sp. (rare)

The first listed species firmly places Bed 1a in the upper part of the *Naplesites* Genozone which is a lower subdivision of UD I-G. In New York (HOUSE & KIRCHGASSER 1993) and in the Tafilalt (BECKER & HOUSE 2000a), the genus (= *Chaoceras* and *Merzougites*, but excluding *Napl. housei* which is better placed as oldest species in *Mesobeloceras*) is restricted to levels around the MN Zone 6/7 boundary. Advanced forms, such as the new Oued Mzerreb species, indicate a basal MN 7 Zone age. This correlates the local eutrophication phase with the **Lower Rhinestreet Event** of New York and of the Tafilalt where it is characterized by a thin dark grey styliolinite (highly eutrophic facies, e.g., Bed 48 at Bou Tchrafine, BENSAID et al. 1985; also well developed at Ouidane Chebbi), followed by a regression (BECKER & HOUSE 2000a) marked by conglomerates. The reddish marl (Bed 1b) correlates with this sea level fall.

Lobotornoceras ausavense is in Germany and in the Tafilalt a younger species (of UD I-J) but closely related forms (*Lobot. strangulatum*) are known from somewhat older strata (UD I-H) of the Timan (BECKER et al. 2000). The new Oued Mzerreb subspecies extents the range of constricted lobotornoceratids downwards. "*Truyolsoceras*" n. sp. aff. *keyserlingi* is morphologically somewhat more advanced than the true *keyserlingi* from the MN 4-6 Zones of the Timan. The new manticoceratids display early juvenile flares as in *"Mant." sinuosum* or in *"Sphaeromanticoceras" rhynchostomum* (see MILLER 1938). The similar *Mant. cordatum* of Germany (Büdesheim) and NW Australia lacks such ornament of early stages.

Hexagonaria Bed

Bed 2 is rather poorly exposed in a subsequent plain and lower slope. In the upper part with occasional limestone concretions, there is some, often poorly preserved haematic fauna with *Manticoceras* sp. and others which seems to be partly or completely allochthonous. All recorded species occur in the higher *Carinoceras* Beds. Autochthonous, and in limestone preservation, there is a single fragment of *Beloceras* (probably *tenuistriatum*). The entry of the genus defines the international genozone UD I-H (BECKER & HOUSE 2000c) which correlates with the MN 9 and 10 Zones. UD I-G2 and the MN 8 Zone equivalents must be represented by the thick unfossiliferous lower part of Bed 2. Most extraordinary is the occurrence of some colonies of *Hexagonaria buxutiensis* TSIEN (det. S. SCHRÖDER) which is known from the Ardennes. The incoming of shallow-water corals, associated with rare rhynchonellids, indicates a gradual but significant shallowing episode which seems to characterize the late Middle Frasnian internationally (e.g., Vetlasyan level of the Timan, BECKER et al. 2000; rather massive *Manticoceras acutiforme* limestones of the Tafilalt, BECKER & HOUSE 2000a). It is likely that *Hexagonaria* was capable of settling rather deep and muddy substrates.

Upper Red Griotte

The shallowing continued with a second regional marker unit consisting of red, Griotte-type nodular limestones which form a very low ridge (Bed 4). Apart from medium-sized, ribbed, still unidentified bivalves, no macrofauna has been found. There are a few homoctenids in acid residues. Conodonts are very rare; there is just *Avignathus decorosus*, including the Pa and the characteristic avignathid element, as reconstructed by BOOGARD (1983). In the Frasnian composite (KLAPPER 1997), this species enters in the upper part of the MN 10 Zone which agrees perfectly with the age inferred from the goniatites found below and above. The poor macrofauna and the absence of palmatolepids

corrobates a rather oligotrophic shallow outer shelf biofacies.

***Carinoceras* Beds**

On the southern side of the Red Griotte ridge, Bed 5 consist of poorly exposed shales with some irregular and patchy, grey, unfossiliferous limestone concretions. Bed 6a in the subsequent plain is characterized by a sudden flood of diverse haematitic ammonoids, associated by some other fauna:

Carinoceras n. sp. (very abundant)
"*Manticoceras*" aff. n. sp. C (common, intermediate to *Trimanticoceras*)
Trimanticoceras n. sp. (rare)
Tornoceras contractum (abundant)
Tornoceras typum (common, intermediate to *Linguatornoceras*)
Linguatornoceras aff. *restrictum* (with juvenile flank constrictions)
Aulatornoceras auris (rare)
Lobotornoceras ausavense (rare)
Beloceras tenuistriatum glenisteri (with eight ventral lobes at median size, very rare)
Hastula subtilis (some specimens)
orthocones indet.
Buchiola sp.
other bivalves
gastropods (rare)
rhynchonellids (rare)
Thamnopora sp. (at least two species)

Trimanticoceras is a marker genus for UD I-I (*Playfordites* Genozone) of Germany (records in HOUSE & ZIEGLER 1977) and of the Canning Basin (BECKER et al. 1993, BECKER & HOUSE 2000c). *Aulatornoceras auris* first enters in UD I-I (MN 11 Zone) of New York (HOUSE & KIRCHGASSER 1993) and in the Timan (BECKER et al. 2000). The very advanced beloceratid also suggests a level above UD I-H. The new *Carinoceras* has very thick and ribbed early stages as in the New York *"Sphaeromant." rhynchostomum-"Sphaeromant." oxy* lineage which first occurs in the UD I-I fauna of Bou Tchrafine in the Tafilalt (BECKER & HOUSE 2000a). The base of I-I has been correlated at Martenberg (Germany, base of Bed q, revised conodonts in KLAPPER & BECKER 1997 and ZIEGLER & SANDBERG 2000) and in NW Australia with the global ***semichatovae* Transgression** low in the MN 11 Zone. This level has been proposed (e.g., ZIEGLER & SANDBERG 2000) to define in future the base of the Upper Frasnian. In southern Morocco, both in the Tafilalt and in the Tata region, this major sea level rise led to a significant eutrophication and enhanced organic carbon burial in hypoxic shales or limestones (oldest Kellwasser-type limestones of the Tafilalt, BECKER & HOUSE 2000a).

In the upper part of Bed 6, ammonoid collecting becomes less successful but the fauna is basically still the same. There are mass occurrences of well-preserved and diverse crinoid stems and of crown parts (mostly arms since cusps are very small in relation to the rest of the body) within Bed 6b, at the top of Bed 6b, and at the top of Bed 6c which has only very few *Carinoceras* n. sp. and *Tornoceras typum.* These crinoid blooms are rather unexpected in badly oxygenated pelagic facies but there can be no doubt that they are autochthonous.

Lower Concretion Marls

The interval from the top of Bed 6c to Bed 9a is characterized by rather irregular, discontinuous, laminated and dome-shaped marly and sometimes bioclastic limestone concretions. Rare manticoceratids have been observed at the top of Beds 8b and 8f but orthocones, *Buchiola*, and styliolinids are more common. The facies remained eutrophic but was not right for goniatites, conodonts and for the pyritization of fossils. Conodont samples (Beds 8b and 9a) only produced styliolinids, some homoctenids, lingulids, crinoid ossicles, and a few smooth ostracods. It is assumed that the Lower Concretion Marl unit represents locally UD I-J (MN 12 Zone). Similar Frasnian deposits with large septarians have been described by HOLLARD & JAQUEMONT (1956) from Akka n´Harrouch.

Lower Kellwasser Beds

Another eutrophication level is indicated by very fossiliferous, laminated, dark grey, marly limestones at the base and at the top of Bed 9b. There are many buchiolids, orthocones, crinoid stem and crown pieces and abundant manticoceratids: *Mant. lamed* and *Mant. carinatum*. The latter is most common in the Tafilalt (BECKER & HOUSE 2000a) and northern Maider in the **Lower Kellwasser** Limestone equivalents (base of UD I-K). However, elsewhere the species may enter earlier (as low as UD I-I, BECKER et al. 2000). Correlation of Bed 9b with the Lower Kellwasser level is additionally confirmed by large placoderm remains which also have been found at this level in the SW Maider (e.g., Rich Bou Kourazia), in the Tafilalt, and, occasionally, in the Lower Kellwasser Limestone of the Rhenish Massive (e.g., *Aspidichthys* of PAECKELMANN 1924). Also, all representatives of typical pre-Kellwasser goniatite genera (*Trimanticoceras, Lobotornoceras*) have disappeared. *Archoceras*, the index genus of UD I-K, has not yet been found but is known from marls just above the Lower Kellwasser Limestone in the Tafilalt (record in SCHINDEWOLF 1937, new fauna from Ouidane Chebbi).

Upper Concretion Marls

The Lower Kellwasser level is overlain by more than five meters of unfossiliferous reddish marls with some limestone concretions (Bed 10). This undated late Frasnian interval finishes with 15-20 cm grey marly limestones (Bed 11a). The subsequent units, Beds 11b to 15b, strongly resemble the Lower Concretion Marls. The concretions normally contain fauna, especially orthocones and *Buchiola*. At the top of Bed 11 (Bed 11d: reddish weathering platy limestone) there is a rich assemblage with more placoderm remains, many *Buchiola* sp., abundant *Manticoceras lamed*, some *Tornoceras typum*, a rare new

tornoceratid with chevron ribbing on the outer flank, and with a new *Aulatornoceras* which also occurs in the latest Frasnian of the eastern Tafilalt (undescribed fauna from Ouidane Chebbi) and in the Eifel Mountains. Correlation of this fourth regional major improvement of the trophic conditions in the Frasnian with the base of the **Upper Kellwasser** level is still somewhat ambiguous, especially since no conodonts were obtained (just one smooth silicified ostracod). However, the overlying shales and marls (Bed 12) yielded a new "*Manticoceras*" with very characteristic widely spaced lirae on the outer shell. The same species is known from a single Kellwasser specimen of Germany and, more typically, from the latest Frasnian (lower part of *linguiformis* Zone) transgressive *Manticoceras guppyi* Bed of the Canning Basin (see BECKER & HOUSE 1997). The absence of *Crickites* is remarkable since the genus is rather common in the eastern Anti-Atlas.

Other species collected from Beds 12 and 13 include common *Mant. lamed*, rare *Carinoceras galeatum*, very abundant *Aulatornoceras* n. sp., gastropods, *Buchiola* sp., other bivalves, orthocones (probably *Bogoslovskiya* sp.), and *Tornoceras typum*. Bed 14 is an unfossiliferous reddish interval but the same fauna re-appears in Bed 15, however, together with abundant and morphologically diverse crinoid stems. The top of the Frasnian is perhaps reached with Beds 16 and 17 which have not yet provided fauna. The alternation of light grey marls, red shales and grey marly limestones indicates an improved seafloor oxygenation, perhaps caused by the global regression at the Frasnian-Famennian boundary. Higher beds are exposed towards the dry valley but are unfossiliferous and have not yet been measured.

Oued Mzerreb/Aguelmous

At the eastern slope of the Aguelmous, there is a fine succession from the Upper Emsian limestones with *Sellanarcestes* and *Anarcestes* to the lower Eifelian with *Pinacites jugleri* (including specimens in limestone preservation), *Fidelites bicaniculatus*, *Subanarcestes marhoumensis*, and others. A significant fault cuts through, with the Lower Kellwasser level being well exposed in the plain near the base of the slope. It contains large-sized *Manticoceras lamed*, aulatornoceratids and calcified wood which is partly overgrown by large *Lunulicardium* bivalves. The Frasnian-Famennian boundary has not yet been located there.

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Plate 1

Middle Givetian goniatites from Oued Mzerreb

Fig. 1: *Atlantoceras tataense* BENSAID 1974, Bed 12a2, MD III-A, lateral view, x 3.

Fig. 2: *Mzerrebites juvenocostatus* (BENSAID 1974), Bed 12a2, MD III-A, lateral view, x 4.

Figs 3-4: *Pharciceras* aff. *amplexum* (HALL 1886), Bed 12b, MD III-A, lateral and ventral views, x 4.

Figs 5-6: *Afromaenioceras crassum* (BENSAID 1974), Bed 12a, MD III-A, lateral and ventral views, x 5.

Figs 7-8: *Afromaenioceras* n. sp., open umbilicate morphotype/subspecies lacking chevron sculpture, top Bed 10, MD II-D2, lateral and adoral views, x 2.5.

Figs 9-10: *Maenioceras decheni* (KAYSER 1873), Bed 8a, MD II-C2, lateral and adoral views showing the very narrow umbilicus and thick whorls, x 2.5.

Figs 11-12: *Maenioceras* n. sp. III, base of Bed 1, MD II-B2, lateral and adoral views, showing the strong shell compression of early whorls, x 4.

Figs 13-14: *"Trevoneites" assessi* (GÖDDERTZ 1987), Bed 6a (collection from Beds 5-6), MD II-C1, adoral and ventral views, showing the shell compression, x 2.5.

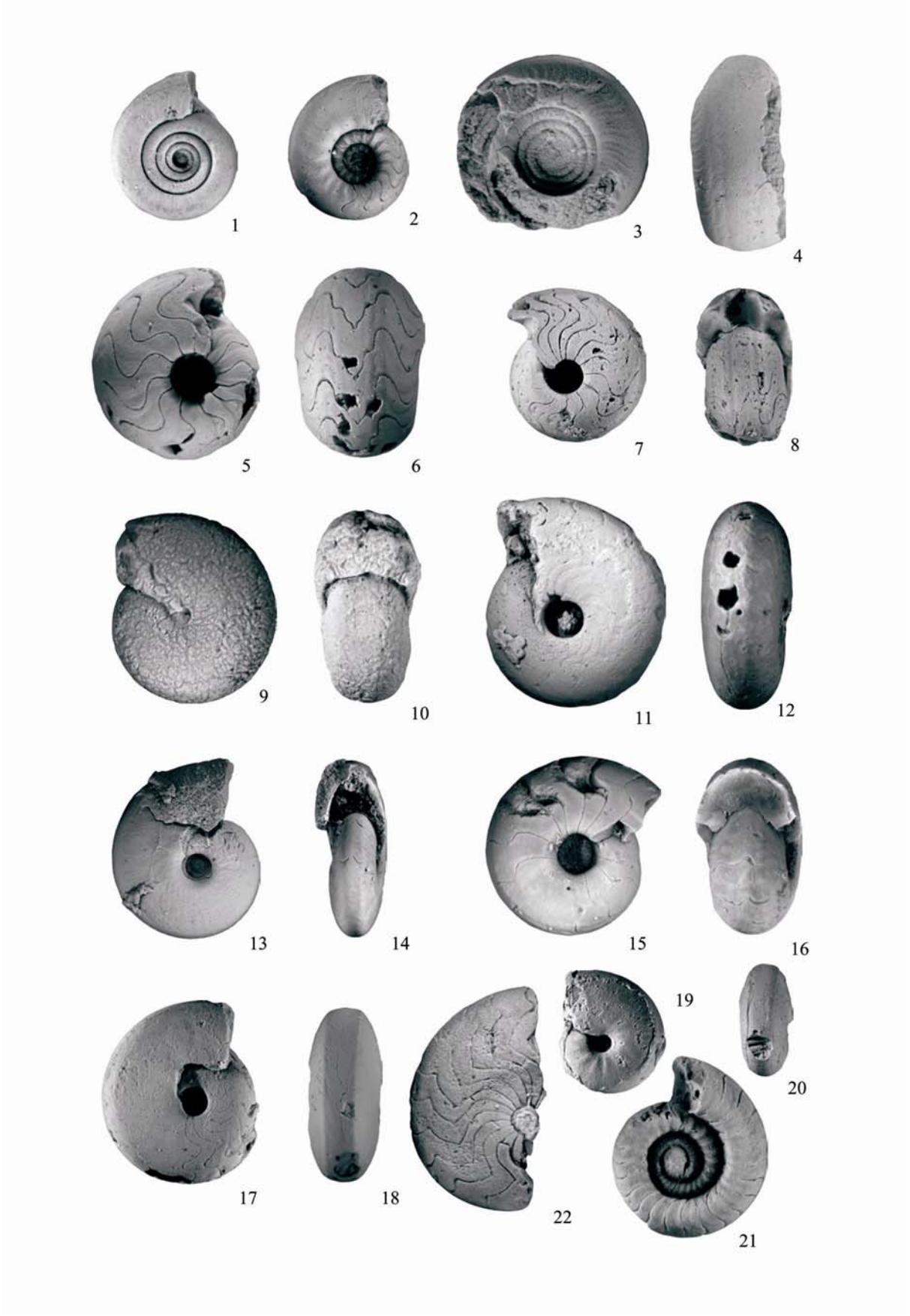
Figs 15-16: *"Trevoneites"* n. sp., Bed 9a, MD II-D1, lateral and adoral views, showing the relative thick and rounded whorls, x 5.

Figs 17-18: *Maenioceras terebratum* (SANDBERGER & SANDBERGER 1850), Bed 6a (specimen washed down into the top of Bed 5), MD II-C1, lateral and ventral views, showing shell compression and marked ventral edges, x 2.5.

Figs 19-20: *"Tornoceras"* aff. *amuletum* HOUSE 1965, base of Bed 1, MD II-B2, lateral view with juvenile ribbing, ventral view, x 4.

Fig. 21: *Agoniatites* aff. *costulatus* (d´ARCHIAC & de VERNEUIL 1842), Bed 0a, MD II-B2, lateral view, x 5.

Fig. 22: *Bensaidites* n. sp., Bed –1, MD II-B1, lateral view, showing the shallow, but well developed adventitious outer flank lobe, x 2.5.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Late Emsian and Eifelian stratigraphy at Oufrane (Tata region, eastern Dra Valley, Morocco)

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INTRODUCTION

The late Lower (above Rich 3, Upper Emsian) and early Middle Devonian (Eifelian) of the Tata region in the eastern part of the Dra Valley has not yet been the subject of any detailed stratigraphical publication although it occupies an important palaeogeographical position between the more neritic southwestern part of the Anti-Atlas and of the predominantly pelagic Maider and Tafilalt regions of the southeastern Anti-Atlas. Intercalating Emsian and Eifelian brachiopod and ammonoid faunas have been listed from the Jebel Hamsailikh S of Foum Zguid (HOLLARD & JAQUEMONT 1956), further to the NE, but have not yet been studied in detail. JANSEN (2001) concentrated on the Lochkovian to Lower Emsian sandstones and limestones with brachiopods of the Foum Zguid and Tata regions. SCHRAUT (2000) described Pragian trilobites from the same sections and localities of the Tata area. The studied succession is characterized by a rather sudden change from early Emsian shallow-water sediments and faunas to late Emsian deeper-water facies, obviously caused by the peak of the global Daleje Event. There are no significant mixed neritic-pelagic faunas as further to the SW (Assa region).

The studied sections (Fig. 1) belong to an elongated, NNE-SSW running ridge, ca. 20 km S of Tata, dipping steeply to the E, and formed by Rich 3 sandstones, the top of the Mdaour-el-Kbîr Formation. The latter forms a narrow saddle towards the W, with an elongated valley squeezed between its steep limbs. Eifelian and younger strata have reacted much more competent to the Variscan deformation which resulted in complex special folding and mostly shallower dips in the plain east of the Oufrane Rich 3 chain. To the S, the mostly shaly Middle Devonian is cut off by a second anticline.

The Oufrane Devonian has so far only been mentioned by BENSAID (1974) but his research concentrated on the late Givetian. The outcrop area is reached from Tata on the main road to Akka. It passes through the Lower Devonian sandstone ridges near Ain Oufrane where palms border the dry river. At the road marker Goulmine 261/Akka 42, a piste branches off from the main road in easterly direction and eventually leads to the western limb of the Rich 3 anticline. It can be crossed through one narrow pass and there is a subsequent easy track through the following valley. The first measured section, Oufrane NW, lies at a foot pass through the eastern anticline limb (x= 248.7, y= 287.6). This allows easy access and measurements through the Rich 3 Sandstone Member of the Mdaouer-el-Kbîr Formation and exposes the sharp contact with the overlying basal Timrhanrhart Formation. A few hundred meters to the N (GPS: N 29° 33,602´, W 07° 59,422´) the lateral section Oufrane N exposes the currently best sequence through the lower and middle parts of the Timrhanrhart Formation. Auxiliary collections of late Emsian goniatites were made in the vicitiny of the (mostly dry) waterfall at ca. x = 248,55, y = 286.55. This locality, Oufrane W, forms the base for a very fossiliferous late Givetian succession (ABOUSSALAM et al. 2004).

LITHOLOGICAL AND FAUNAL SUCCESSION AT OUFRANE NW (Fig. 2)

The start of the measured part of the succession lies at the base of the Rich 3 ridge, where thin, greenish-grey, often calcareous fine-grained sandstones alternate with siltstones. Only some of them (e.g., Bed 0) contain disarticulated valves of schizophoriid and spiriferid brachiopods. The ca. 50 cm thick sandstone unit 1b yielded a well-preserved and, due to its endobenthonic life style, bivalved *Grammysioidea* which strongly resembles forms which are currently only known from the Frasnian of New York. It is remarkable that similar species are completely lacking in the thick Lower and Middle Devonian clastics (Rhenish Facies) of the Rhenish Slate Mountains or Ardennes where the genus *Grammysia* occurs sporadically. This gives interesting clues for Lower Devonian bivalve biogeography.

From Bed 1b to Bed 4b (4.3 m) the thickness of sandstones units increases strongly upslope. Within the bluish weathering Bed 4b there are layers with brachiopods, including spiriferids. The following Bed 5 consists mostly of siltstones, with ca. 3.2 m silty sandstones in the upper part (Beds 5b-c). More massive sandstone beds forming the main ridge and up to 40 cm thick commence in Bed 6b but seem to be rather unfossiliferous. Beds 7c and 7c form a rather prominent, 2 meter thick cliff near the top of the ridge, followed by a thin silty intercalation (Bed 7e). At the top of the Rich 3 Sandstone Member (Bed 8, 4.15 m) there are calcareous sandstones with several brachiopod shell layers which represent storm accumulations. There are abundant spiriferids, strophomenids and rhynchonellids

(*Uncinulus*, resembling *U. pila*, see BULTYNCK & HOLLARD 1980). The upslope transition from predominant siltstones to coarse tempestites reflects a shallowing upwards cycle during a highstand system tract. Regional basin infill probably contributed significantly to the relative fall of sea level. The age of the upper, sandy part of the Mdaouer-el-Kbîr Formation has been discussed by JANSEN (2001). Brachiopods, especially species of *Iridostrophia, Schizophoria (Pachyschizophoria)* and *Arduspirifer* show both affinities with the latest Lower and early Upper Emsian. In the area S of Foum Zguid (JANSEN et al., this vol.), the Lower/Upper Emsian boundary has been identified within the fossiliferous sandstones. A *Mimagoniatites fecundus* record indicates increasing pelagic influences and a gradual transgressive trend but is stratigraphically not helpful since the species straddles the Zlichovian-Dalejan boundary (CHLUPAC & TUREK 1982). Records of *Latanarcestes* in Interval 2 of HOLLARD (1978: tab. 2) should not be used as evidence for the genus in Rich 3 Sandstone levels but refer to HOLLARD´s correlation with the western Dra Valley, where *Latanarcestes* underlies *Sellanarcestes* (BECKER et al., this vol.). HOLLARD summarized in his table the geographically different units underlying the *Sellanarcestes* Limestones but did not distinguish between successive neritic and pelagic limestones of different age in the Akka and Torkoz areas. It is not yet clear whether the basalmost Upper Emsian (Dalejan) can be recognized within the sandstones at Oufrane.

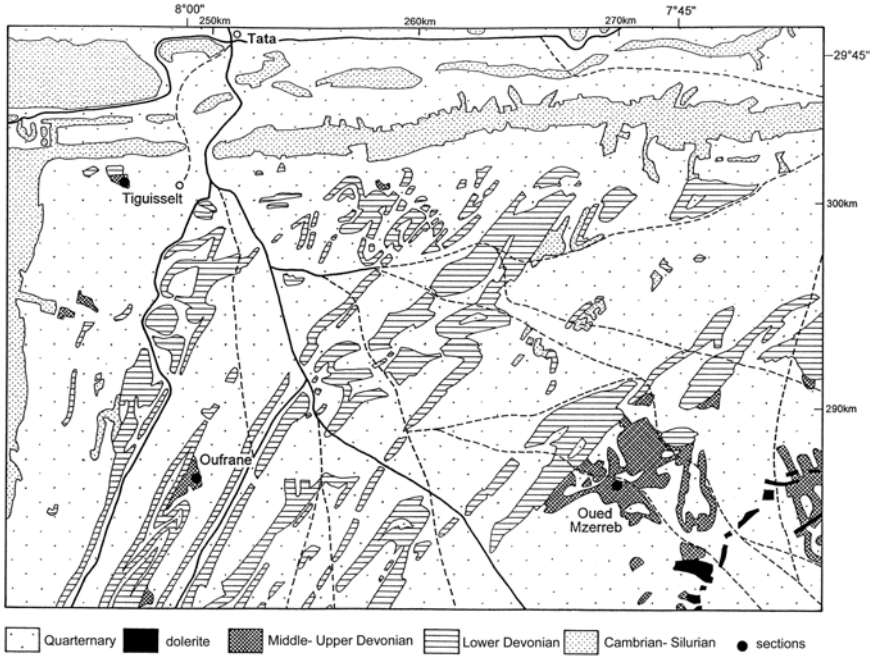

Fig. 1: Geological overview of the Devonian outcrop area S of Tata, showing the position of studied sections at Tiguisselt, Oufrane, and Oued Mzerreb (drawing by J.-P. MENDAU, Museum für Naturkunde, Berlin).

The contact between the Mdaouer-el-Kbîr and Timrhanrhart Formations is locally marked by a 1.2 meter thick breccia bed. It weathers yellow to brown, contains haematite in lenses, is microcristalline, unfossiliferous and monomict. This unit may reflect a sedimentary hiatus, submarine reworking and a sequence boundary but there was possibly also some diagenetic overprint, caused by the strong lithological contrast between both formations. It is followed by ca. 2.75 meters of light bluish-grey, solid limestone with numerous phacopids, orthoconic cephalopods and rare goniatite cross-sections. This unit is here named as Trilobite Limestone and proves a significant deepening, resulting in the depositional setting of an offshore neritic carbonate platform. The interval has been included in the Assisse d´El Ansar and Rich 3 by HOLLARD (1963) and was still included in Rich 3 and the Mdaour-el-Kbîr Formation in BULTYNCK & HOLLARD (1980) which led to uncertainties concerning the age of the latter (see JANSEN 2001: p. 45). HOLLARD (1978), however, stated clearly that the calcareous brachiopod coquinas form the top of the formation and this definition follows strictly the cyclic nature of regional deposition. Conodonts collected by P. BULTYNCK from the lower meter (locality OHW 526) of limestones above the last Rich 3 sandstone include *Caudicriodus culicellus, Icriodus fusiformis, I. homorectus*, and *I. corniger ancestralis*. This shallow-water fauna is typical for Fauna Vb of BULTYNCK & HOLLARD (1980) and probably correlates with a level in the upper part of the *laticostatus* Zone, above the Lower/Upper Emsian boundary. A second sample from the subsequent 30 cm yielded arthrodire remains and only *I. rectirostratus* and *Caudi. culicellus*. At Oufrane W, a loose specimen of *Latanarcestes noeggerathi* was collected which indicates that Bed 10 falls in the *noeggerathi* Zone (LD IV-B). This is supported by identical conodont-goniatite associations in the western Dra Valley (Torkoz, JANSEN et al. 2004b; see discussion in BECKER et al. 2004) and even in the Cantabrian Mountains (Lezna Member of Palencia, HENN 1985). However, KLUG (2003) claims that last and rare *Latanarcestes* may occur much higher, even together with first *Anarcestes*. Sequence stratigraphy and conodont data anyway suggest correlation of the Trilobite Limestone with the trilobite-bearing new Brachiopod Marl Member of the Khebchia Formation in the Assa area and with the main phase of the Daleje Transgression of the early Upper Emsian. More detailed work is necessary to clarify whether the oldest Upper Emsian strata are present at the base of the Timrhanrhart Formation or not.

The Trilobite Limestone is overlain by a 25 cm thick, light grey, brownish weathering solid marker limestone with very abundant *Sellanarcestes* and orthocones. The predominace of pelagic fauna proves a further deepening and drowning of the carbonate platform, leading also to strong condensation. This is supported by the appearance of polygnathids (*Linguipolygnathus cooperi cooperi,*

Linguipo. bultyncki), in association with *I. corniger corniger* and *I. rectirostratus*. Despite the absence of the index species, this fauna VI of BULTYNCK & HOLLARD (1980) is thought to correlate with the Upper Emsian *serotinus* Zone (see BULTYNCK 1985).

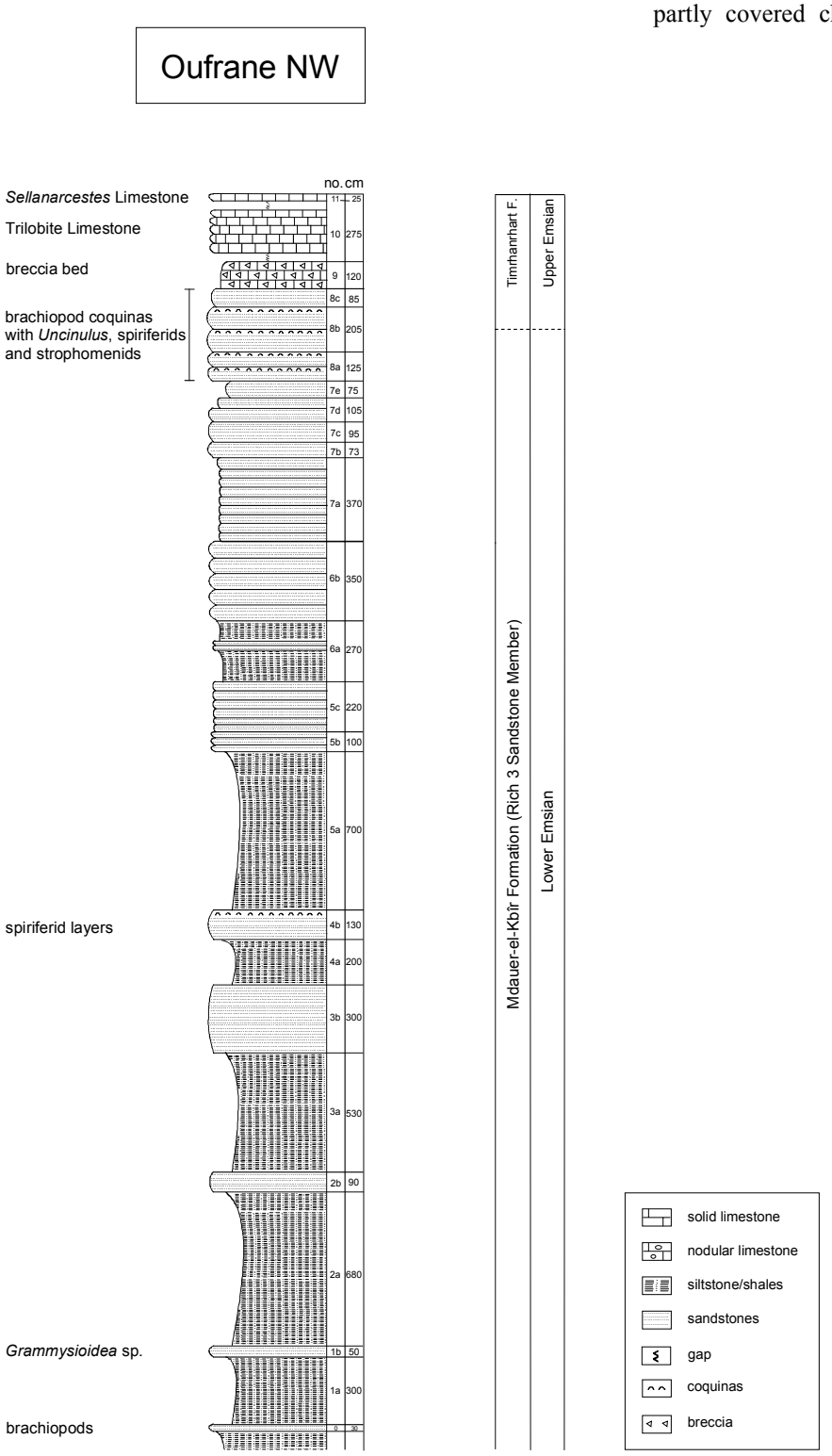

Fig. 2: Sedimentary succession and faunal layers through the Rich 3 Sandstone Member and basal Timrhanrhart Formation at Oufrane NW.

The goniatites support this interpretation and fall in the *Sellanarcestes wenkenbachi* Zone (LD IV-C) in the terminology of BECKER & HOUSE (1994). The same level is well represented towards the East in the Foum Zguid area (HOLLARD 1960, JANSEN et al. 2004a) but an older species of *Sellanarcestes* has been found in the upper part of the Daleje Shale equivalents in the Tafilalt (KLUG 2003). Above the *Sellanarcestes* Marker Limestone, there is a partly covered change to nodular limestones (maximum flooding phase) which also contain *Sellanarcestes*. Several conodont samples at section OHW 526 included basically the same fauna with *Linguipo. bultyncki, I. corniger corniger*, and *I. rectirostratus*.

LITHOLOGICAL AND FAUNAL SUCCESSION AT OUFRANE N.

Section Oufrane N (Fig. 3) begins with the topmost part of the Rich 3 Sandstone Member (Bed 8) which contains brachiopod coquinas at the top of individual beds. The second last bed also contains crinoid ossicles, asteropygids and the tabulate *Pleurodictyum problematicum*. The last bed shows an upper iron crust and yielded abundant spiriferids and rhynchonellids (*Uncinulus* sp.).

The contact between the Mdaouer-el-Kbîr and Timrhanrhart Formation is obscured in a 1 m covered interval. The following Trilobite Limestone (ca. 2.8 m) consists of light grey, fine-grained beds with many *Phacops* and large orthocones. The bipartite and prominent *Sellanarcestes* Marker Limestone (Beds 11a-b, LD IV-C, dip 108°/45°) is 32 cm thick and contains two species: the thick *Sellan. wenkenbachi* and the compressed *Sellan*. aff. *neglectus* (*neglectus* sensu KLUG 2003). The first species includes a morphotype with adult low whorls (Bed 11a) and a morphotype with higher whorl expansion at maturity (Bed 11b). A single specimen from Bed 11b resembles a new *Sellanarcestes* species which is better known from younger strata.

Bed 12 shows a sudden change to light grey and marly nodular limestones, often weathering brownish, with large orthocones and goniatites. Characteristic is the compressed *Achguigites tafilaltensis* (Pl. 1, Fig. I, first record for the Dra Valley) which is associated with *Sellan. wenkenbachi* (morphotype with always low whorls), *Sellan. tenuior* (according to GÖDDERTZ 1987 probably a subjective junior synonym of *Anarcestes applanatus*

FRECH) and *Sellan*. aff. *neglectus*. In the Tafilalt (KLUG 2003), *Achguigites* also enters in the *Sellan*. *wenkenbachi* Zone (e.g., at Rich Haroun, Achguig East and Jebel Ouaoufilal West) but continues into levels with oldest *Anarcestes* (e.g., at Achguig West and Hassi Tachbit, LD IV-D1). At Oufrane, Bed 12 mostly falls in LD IV-C but a possible entry of *Anarcestes* within it has not yet been clarified. By comparison with the Tafilalt, the first occurrences of *Sellanarcestes* (defining LD IV-C) and of *Anarcestes* (defining IV-D1) are separared more clearly and by thicker sediments. Currently there are no critical conodont faunas from the unit. In its upper part fossils become more abundant, especially trilobites (phacopids, asteropygids, homalonotids) and large nautiloids.

Bed 13 consists of green shales and nodular limestones (with trilobites) in the upper part but has not produced macrofauna in the measured section. Around the waterfall to the S (Oufrane W) this part of the succession yielded a rich ammonoid fauna of the *Anarcestes simulans* Zone (LD IV-D1). Bed 14 is partly covered by debris from the upper part of the ridge and consists of unfossiliferous shales with a thin greenish marl at the top. This deepening episode marks the base of the Upper Member of the Timrhanrhart Formation and correlates with a thick shale succession above *Sellanarcestes-Anarcestes* Limestones (new Bou Tserfine Member) of the western Dra Valley. There are two similar but thinner subsequent cycles (Beds 15 and 16) which may correlate with the thick Rich 4 sandstones of the western Dra Valley. The absence of a significant regressive episode at the end of the Emsian in the Tata region is remarkable and fits the rather gradual transition in the Tafilalt (BULTYNCK & WALLISER 2000). The precise position of the Emsian/Eifelian boundary is locally still unknown within the Upper Member of the Timrhanrhart Formation but has been fixed precisely in the more calcareous succession near Foum Zguid (JANSEN et al. 2004a).

Bed 17 also consists of unfossiliferous, mostly green silty shales with subordinate thin dark grey or reddish layers. At the top there is a decalcified yellow nodule layer. The thinner but similar Bed 18 is capped by a slightly more solid green marl which provided rare, squoshed and unidentifiable goniatites. Bed 19 has few nodules in its lower part and a weathered yellow marl at the top. Beds 20 to 24 consist of an alternation of green shales with slightly more prominent marls which variably contain masses or few *pumilio*-type brachiopods. They each indicate a sudden and episodic increase of the trophic level (eutrophication events) which correlate with the lower part of the global Chotec Event (early Eifelian, MD I-B/C transition). So far, *Pumilio* Events were thought to be restricted to the Givetian (LOTTMANN 1990). The new early Eifelian beds require a re-interpretation of the later events since there is no evidence for transport and allochthonous deposition. The Tsunami Model of LOTTMANN (1990) needs to be replaced by a scenario focussing on short-term fluxes in nutrient availability allowing sudden faunal blooms of very specific taxa.

Correlation of the Oufrane *Pumilio* levels with the Chotec Event is supported by the entry of *Pinacites jugleri* in Beds 23-25. *Pinacites*, the index goniatite of MD I-C, enters also in the upper part of the Chotec Event beds of the Tafilalt (BECKER & HOUSE 1994, 2000: just above black limestones at Jebel Amelane; WALLISER 2000: Jebel Mech Irdane). Although this is generally regarded as a minor global event, it allowed in NW Gondwana a maximum spread of goniatites, invading all major Devonian basins of Mauretania, Mali, Morocco, Algeria and even Libya. At Oufrane, first *Pin. jugleri* (in situ in Bed 23) are associated in the lower haematitic and limonitic fauna with well preserved goniatites and other taxa:

?*Geisonoceras* sp.
Bactrites cf. *schlotheimi* (rel. large, rare)
Bactrites declivis (rare)
Lobobactrites ellipticus
Werneroceras ruppachensis (Pl. 1, Fig. J)
Fidelites bicaniculatus (Pl. 1, Fig. H, in situ in Bed 24).
Cyrtolites sp.
euomphalid and other gastropods
nuculoid bivalves
rhynchonellid
phacopid

The three bactritid species are all recorded for the first time from the Dra Valley. The occurrence of *Pin. jugleri* is intriguing since the limestone facies of the western Dra Valley (BECKER et al. 2004) contains the related *Pin. eminens*. Both *Pinacites* species are known from the Tafilalt (KLUG & KORN 2002). It is also significant that *Anarcestes* regionally does not range into the early Eifelian *Pinacites* faunas. This differs from the Tafilalt (BULTYNCK & HOLLARD 1980: p.28), Germany (KLITSCH 1959), and Algeria (GÖDDERTZ, 1987), where both genera have been found together. However, it seems that this applies only to a younger group of *Anarcestes* species (*lateseptatus, plebeius*; with sharp umbilical edges, giving rise to *Crispoceras*) whilst typical late Emsian forms (e.g., *simulans, latissimus*) never range so high (e.g., KLUG 2003). Early Eifelian hypoxic goniatite shales with *Pinacites* fauna were previously noted by HOLLARD & JAQUEMONT (1956) at Akka n´Harrouch, further to West, but have not yet been described or re-sampled.

At the top of Bed 25 lies a marker level with isolated and large limestone concretions which contains rare *Fid. bicaniculatus* with shell. A green shale unit is rich in squashed rhynchonellids. The upper haematitic and limonitic fauna from Bed 26 is rather diverse:

?Geisonoceras sp. and other orthocones indet.
breviconic nautiloids
Lobobactrites ellipticus
Fidelites bicaniculatus (very abundant)
Foordites sp. indet. (very rare, preservation somewhat different)
Pinacites jugleri (Pl. 1, Fig. F)
Wendtia ougarta (rare, Pl. 1, Fig. C)
Subanarcestes macrocephalus (Pl. 1, Fig. B)

Subanarcestes marhoumensis (Pl. 1, Fig. D)
"Sobolewia" inflata (rare, Pl. 1, Fig. G)
Werneroceras cf. *ruppachensis*
crinoid stems and cusp pieces
nuculoid bivalves (two secies)
Cyrtolites sp.
euomphalid and various other gastropods (frequent)
rhynchonellid (rare)
terebratulids
Ense sp. and other small brachiopod
spiriferids (rare)
phacopid

The goniatite association is characteristic for the middle Eifelian *Subanarcestes macrocephalus* Zone (MD I-D, lower part of *costatus* Zone) and resembles faunas from the Tafilalt (KLUG 2003). The material is well preserved and allows new insights into the ontogeny of ammonoid species. The section is interrupted by a small dry valley but a sparse loose fauna with spiriferids, snails, *Wendtia* sp. and *Fidelites ?bicaniculatus* has been collected loose from a shale level above Bed 26. The late Eifelian is not exposed. The lateral distance between the last early Eifelian *Pumilio* Bed and the Middle Givetian Upper *Pumilio* Bed exposed much further to the East amounts to ca. 140 m, giving a thickness between 70 and 100 m.

UPPER EMSIAN GONIATITE FAUNAS FROM OUFRANE W

Late Emsian limestones with goniatites are also well exposed around the waterfall (section Oufrane W). The top of the Rich 3 Sandstone Member again has spiriferids, *Uncinulus*, a different rhynchonellid and large schizophoriids. It is overlain by the brownish weathering Trilobite Limestone. The solid and prominent *Sellanarcestes* Limestone yielded the same fauna as at Oufrane N, with *Sellan. wenkenbachi* and *Sellan*. aff. *neglectus*. There are many loose goniatites from equivalents of Bed 12 and include *Achguigites tafilaltensis, Sellan. wenkenbachi, Sellan*. *tenuior*, and *Sellan*. aff. *neglectus*, accompanied by snails, *Phacops* sp., and *Hollardops* sp. There are also loose specimens of *Anarcestes* aff. *simulans* which are more evolute than typical *simulans* but which show no development of umbilical edges as in the larger *An. lateseptatus*. The presence of *Anarcestes* shows that the base of the *simulans* Zone (LD IV-D1) must lie within the brownish weathering nodular limestones.

At the base of the steep cliff, there are many blocks of a different, bluish-grey micrite (equivalents of Bed 13a), weathering dark grey to reddish, with a different ammonoid fauna of the higher part of the *An. simulans* Zone:

Anarcestes latissimus (Pl. 1, Fig. A)
Anarcestes aff. *densistriatus* (thicker, but not as thick as in *simulans*, also more evolute than the latter)
Sellanarcestes wenkenbachi (both morphotypes)
Sellanarcestes tenuior
Sellanarcestes aff. *neglectus* (= *neglectus* sensu KLUG 2003)
Sellanarcestes n. sp. (relative involute, with flattened venter, two morphotypes with different whorl width, Pl. 1, Fig. E: compressed morphotype)
Phacops sp.
crinoid pieces

The association of *Sellanarcestes* and *Anarcestes* suggests correlation with the *serotinus* Zone (BECKER & HOUSE 1994) but conodont data are still lacking. Similar assemblages are known from the Tafilalt, Algeria (GÖDDERTZ 1987), Bohemia (CHLUPAC & TUREK 1983) and the Pyrenees (e.g., MONTESINOS & SANZ LÓPEZ 1999). The lack of *Achguigites* is significant and underlines the regional separation of three distinctive Upper Emsian goniatite levels containing *Sellanarcestes*. The Upper Member of the Timrhanrhart Formation is partly covered in the adjoining plain, but there are strongly cyclic, poorly fossiliferous latest Eifelian to early Givetian shales continuing to the East. Some solid beds have, again, *pumilio*-type brachiopods or fish remains (observations of March 2004). The Kacak Event is perhaps represented by peculiar limestone concretions.

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Plate 1

Representatives of the Upper Emsian to early Eifelian pelagic fauna at Oufrane.

A. *Anarcestes latissimus* CHLUPAC & TUREK 1983, no. 253/305, Oufrane W, Bed 13a (bluegrey *Anarcestes* Limestone), adoral and lateral views, x 1.

B. *Subanarcestes macrocephalus* SCHINDEWOLF 1933, no. 253/430, Oufrane N, Bed 26, x 5.

C. *Wendtia ougarta* (PETTER 1959), no. 253/536, Oufrane N, Bed 26, x 5.

D. *Subanarcestes marhoumensis* GÖDDERTZ 1987, no. 253/431, Oufrane N, Bed 26, x 5.

E. *Sellanarcestes* n. sp., compressed morphotype, no. 253/301, Oufrane W, Bed 13a (bluegrey *Anarcestes* Limestone), x 1.

F. *Pinacites jugleri* (ROEMER 1843), no. 253/283, Oufrane N, Bed 26, x 5.

G. *"Sobolewia" inflata* TERMIER & TERMIER 1950, no. 253/271, Oufrane N, Bed 26, x 5.

H. *Fidelites bicaniculatus* (SANDBERGER & SANDBERGER 1856), no. 253/10, Oufrane N, Beds 23-25, x 5.

I. *Achguigites tafilaltensis* KLUG 2003, no. 253/333, Oufrane W, Bed 12, x 1.

J. *Werneroceras ruppachense* (KAYSER 1879), no. 253/30, Oufrane N, Beds 23-25, x 1.

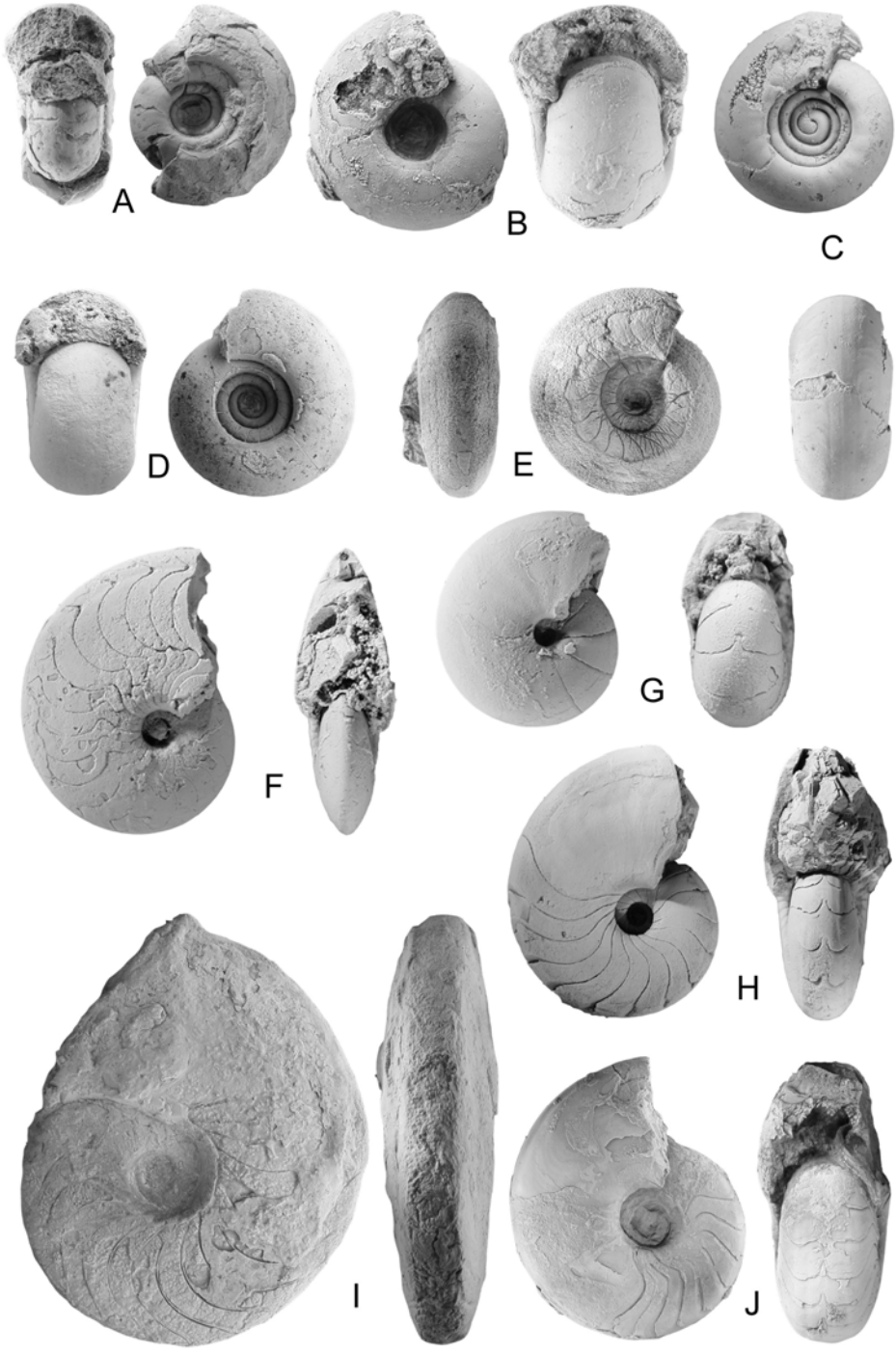
A
B
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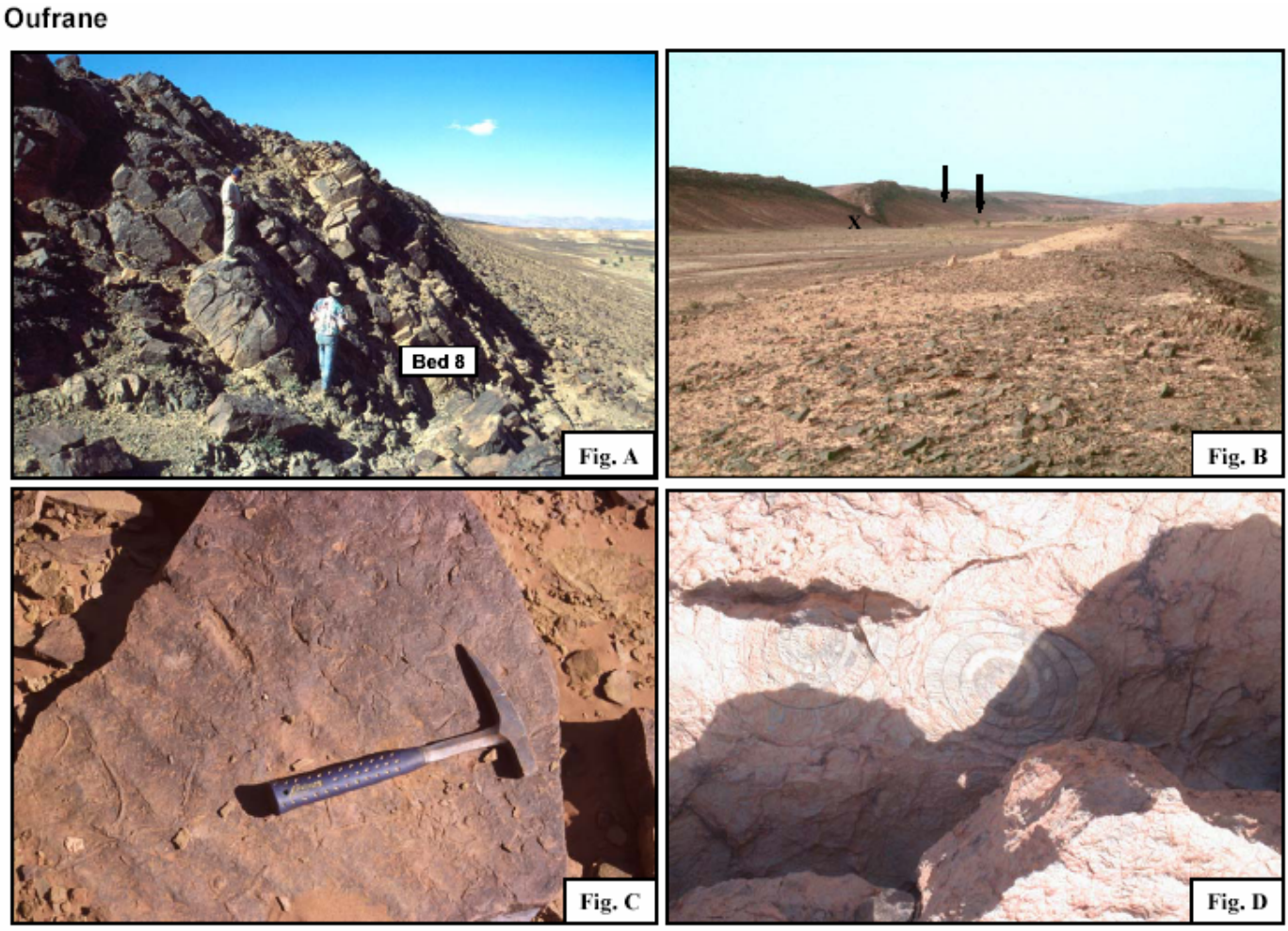
Plate 2

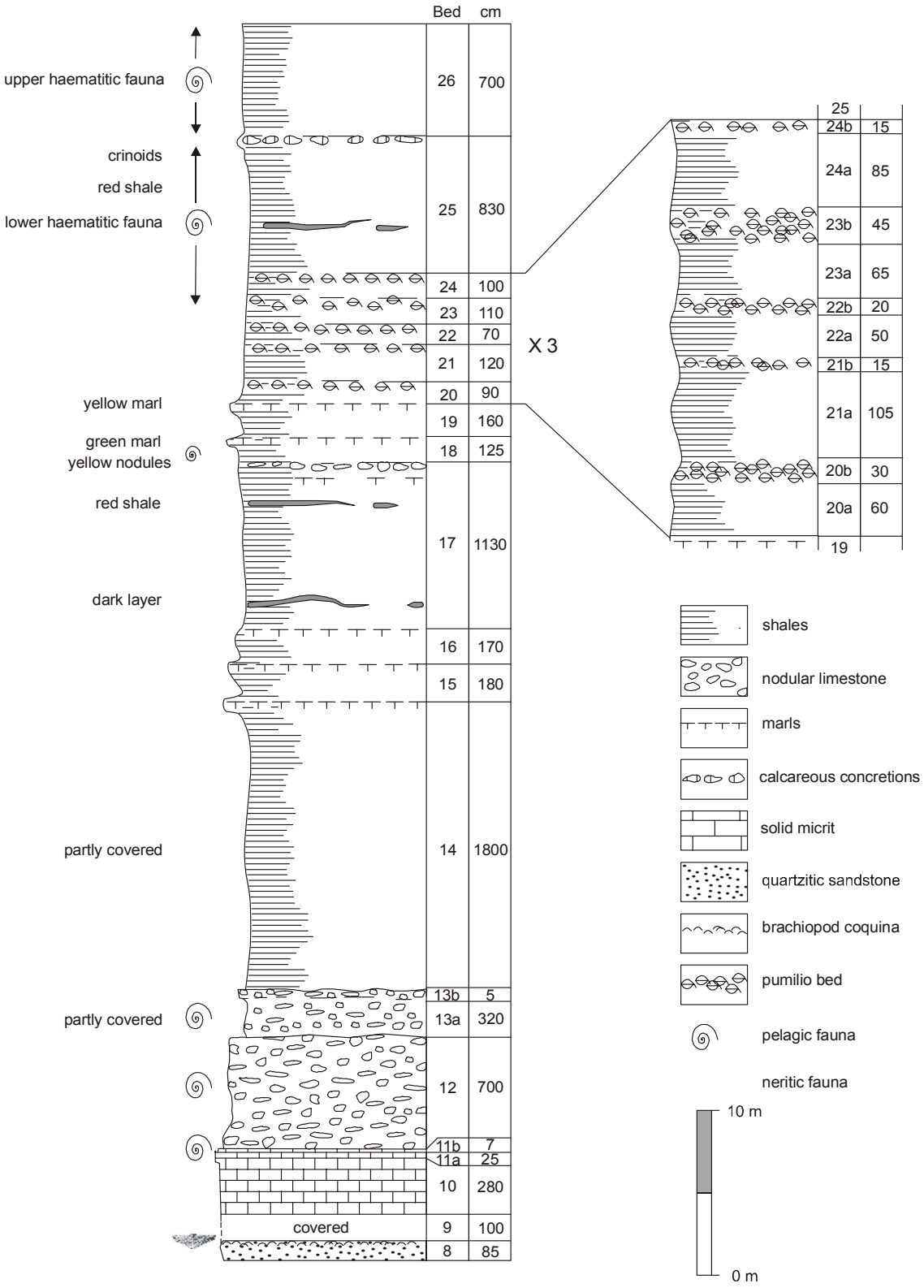


A. Topmost part of the Rich 3 Sandstone Member with thick beds containing brachiopod coquinas (Bed 8) at Oufrane NW. The Timrhanrhart Formation follows in the mostly covered slope to the right.

B. View from the SW to the dry waterfall (Oufrane W) cutting deeply into Rich 3. The bluegrey *Anarcestes* Limestone occurs as transported blocks on the lower slope (marked by X). Arrows mark the position of sections Oufrane NW and N.

C. Regular ripple marks and trace fossils in sandstones of the upper Mdâouer-el-Kbîr Formation at Oufrane NW.

D. The *Sellanarcestes* Limestone (Bed 11) at Oufrane North, showing longitudinal sections of two specimens of the marker genus with very slowly expanding whorls.



Upper Emsian - Lower Eifelian section of Oufrane
GPS: N 29° 33,602' W 07° 59,422'

Fig. 3: Stratigraphic overview of the Timrhanrhart Formation at Oufrane N, showing the position of goniatite faunas and of Eifelian *Pumilio* Beds.

Givetian biostratigraphy and facies development at Oufrane (Tata region, eastern Dra Valley, Morocco)

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INTRODUCTION

The Givetian at Oufrane, ca. 5.5 km N of Sidi-El-Mehdaoui, has been visited, as most of the Dra Valley sections, by H. HOLLARD (see charts in 1981) but no detailed stratigraphic data have ever been published. BENSAID (1974) emphasized Oufrane as an important locality for goniatites, partly as type locality for new species, but did not include a measured section. He illustrated well preserved specimens which in current taxonomy fall in the following species:

Agoniatites costulatus (his pl. 1, figs 7-8)
Wedekindella lata (his pl. 2, figs 7, 7a, the holotype)
"Phoenixites" n. sp. 1 (his pl. 5, fig. 7, figured as *Tornoceras* cf. *simplex*)
Maenioceras terebratum terebratum (his pl. 1, figs 12, 12a)
Afromaenioceras sulcatostriatum (his pl. 2, figs 2, 3, 3a, the holotype, 8, 8a, 9, 9a)
Mzerrebites juvenocostatus (his pl. 3, figs 2, 2a, figs 4-4b, figured as *Hoeninghausia (Koenenites)* cf. *lamellosa*, pl. 4, fig. 5, pl. 6, figs 1, 1a, 12)
Pharciceras aff. *amplexum* (his pl. 4, figs 8, 8a, figured as *Ph. tridens*)

These forms clearly cover the Middle and early Upper Givetian which at the time, before re-definition of the series boundary, partly fell in the basal Upper Devonian. The detailed investigation of the Oufrane Givetian since 2000 clarified the local tectonic conditions and proved that the area is globally one of the most important localities for ammonoid biostratigraphy across the Taghanic Events (ABOUSSALAM 2003). There are also important records of rare neritic faunal elements (brachiopods, tabulate corals) in the pelagic succession.

Starting from the dry waterfall of Rich 3, at the base of section Oufrane W (EBBIGHAUSEN et al., this vol.; ca. 400 m to the SE, x = 249.2, y = 286.2 on sheet Tata, GPS: N 29° 32,41´, W 07° 59,33´), the Lower and Middle Givetian (Ahrerouch Formation) is exposed around a low syncline in the adjoining plain. The axis of the narrow fold runs in SSW-NNE direction, with both gently dipping limbs lying more or less parallel to each other. A grey marker limestone at the top of the new Oued Mzerreb Member allows an easy mapping and lateral tracing of beds. The syncline deepens in NNE direction and is eventually covered by the Quartenary deposits of the dry valley which comes down from the waterfall. Towards a flat cliff consisting of Quarternary pebbles and sands in the E, a low anticline is crossed, with basal Middle Givetian shales in its core. Section Oufrane East (GPS: N 29° 32,51´, E 7° 59,07´) was measured across its eastern limb where beds dip eventually below the mentioned cliff. Again, the marker limestone at the top of the Oued Mzerreb Member allows easy mapping and precise correlation with the western section. The Middle and Upper Givetian also crops out in the plain east of the section Oufrane N (EBBIGHAUSEN et al. this vol.) but has not been measured there in detail.

FAUNAL AND SEDIMENTARY SUCCESSION AT OUFRANE WEST (Fig. 1)

The section was measured across the western syncline limb but fauna was collected from all of the outcrop area. Along strike there are several small normal faults and some very small-sized secondary folds (e.g., affecting Beds 1b to 2b). The early Givetian consists of numerous cycles of poorly fossiliferous shales. Bed 1b is an easy recognizable platy, thin-bedded, dark grey and bioclastic limestone with styliolinids and rare small squashed brachiopods ("*pumilios*") which represents the Lower *Pumilio* Bed. It is well known and more typically developed in the Tafilalt (LOTTMANN 1990) where it is dated as ca. the middle part of the *rhenanus* Zone (BULTYNCK & WALLISER 1990). BULTYNCK & GOUWY (2002) proposed to place the base of the future Middle Givetian at the base of this conodont zone. The Lower *Pumilio* Event bed is followed by ca. 120 cm greenish marls with abundant solitary rugose corals, representing a taxonomically difficult deep and cool water group of the "*Cyathaxonia* Biofacies" (oral comm. D. WEYER). This Coral Bed also occurs at Oued Mzerreb (see BECKER et al., this vol.) and indicates a minor shallowing episode with improved seafloor oxygenation. The overlying Bed 2b is a nodular marl with styliolinids and many pyrite-filled burrows which suggests decreasing oxygenation at the top of the unit.

The first rich Givetian ammonoid faunas occur in the lower part of Bed 3a which contains at least six marl cycles in its higher part. The variable carbonate input was probably controlled by Milankovitch-scale climatic oscillations. The fauna closely corresponds with the Upper *Maenioceras* Beds at Oued Mzerreb and falls in the basal *Maenioceras terebratum* Zone and Subzone (MD II-C1):

orthoconic nautiloids indet.
Hastula subtilis (first record for North Africa)
Agoniatites costulatus
Agoniatites meridionalis
Maenioceras terebratum terebratum

Maenioceras n. sp. I
Wedekindella lata
"Trevoneites" assessi
Sobolewia virginiana
Buchiola sp.
nuculoid and other bivalves
Cyrtolithes sp.
other gastropods
crinoid stem parts
brachiopods (including stringocephalids and *Uncites,* leg. March 2004)
Thamnopora sp.

Attention has to be paid to very few younger and allochthonous ammonoids which were transported in the oued and mixed with the in situ-fauna. The latter is very similar to an assemblage described by GÖDDERTZ (1987) from the Saoura Valley of Algeria whilst there are only very scarce goniatites (oldest *Sellagoniatites waldschmidti* and some *Tornoceras*) at this level in the Tafilalt. At the top of the Upper *Maenioceras* Bed lies a thin nodular marl with many styliolinids (Bed 3b), followed by ca. 6 meters of marls and shales (Bed 4a) with only very sparse fauna of the same subzone, consisting of *Agon. meridionalis*, orthocones and rare neritic faunal elements (chaetetids, stromatoporoids, colonial rugose corals, *Thamnopora*). Bed 4b is a level with lenticular, styliolinid-rich limestone concretions and nests of haematite (or goethite) at the base. Beds 5a to 6a resemble 4a and yielded a similar fauna with neritic taxa (leg. March 2004).

Bed 6b is very similar to Bed 1b, changes rapidly in thickness on strike, may have a reddish surface (due to its iron content) and is characterized by many styliolinids and squashed, often poorly preserved smooth brachiopods (*Ense* sp.). It clearly represents partly the Upper *Pumilio* Bed of LOTTMANN (1990) but a separate, identical bed (Bed 7b) follows 75 cm higher. This gives a clear distinction from the single Upper *Pumilio* Bed of Oued Mzerreb with distinctive lower tentaculite and upper brachiopod layer. BULTYNCK (1987) showed that *Polygnathus ansatus* s. str., the index of the *ansatus* Zone (formerly Middle *varcus* Zone) enters at this level in the Tafilalt but there are no conodonts yet from Oufrane. *Po. beckmanni* (= *Tortodus caelatus*), an alternative marker of the *ansatus* Zone, was recorded by LOTTMANN (1990) from the last bed just below the Upper *Pumilio* Beds at Bou Tchrafine.

The Upper *Pumilio* Beds are overlain by marls with some fossiliferous red nodules, the Lower Red Griotte, which is so characteristic at Oued Mzerreb. The index goniatite of the regional *Maenioceras decheni* Subzone (MD II-C2) has not yet been found locally, and the fauna consists only of *Phacops*, small smooth brachiopods (two species) and crinoid debris. This assemblage shows that the Upper *Pumilio* Event was followed by the most neritic interval of the overall Givetian succession at Oufrane. This regressive phase culminated in the Grey Marker Limestone (Bed 8b) at the top of the Oued Mzerreb Member of the Ahrerouch Formation which forms the top of the low cliff. Lower parts of the bed are platy and crossed by calcite veins whilst the upper part weathers more nodular. This unit correlates with the solid and massive, shallowing upwards Middle *Sellagoniatites* Limestone of the Tafilalt (e.g., BT 29 of BULTYNCK & HOLLARD 1980 and BULTYNCK 1987) which also lies just above the Upper *Pumilio* Event.

Beds 9a and 10a in the basal part of the new Tiguisselt Member of the Ahrerouch Formation are, again, rather poorly fossiliferous shale intervals with some orthocones, brachiopods, *Agon. meridionalis, Wedekindella lata*, *"Trevoneites"* n. sp. (more involute and thicker than *assessi*) and poorly preserved *Maenioceras*. The first species led to the naming as *Agoniatites* Beds whilst "*Trevoneites*" n. sp. can serve to recognize the unit as a distinctive zone. Based on regional correlation and sequence stratigraphy (deepening above the Middle *Sellagoniatites* Bed), Bed 9a may correlate with the *Maenioceras* Marl (containing the oldest *Afromaenioceras,* MD II-D1) and the dark grey concretion layer Bed 9b with the Upper *Sellagoniatites* Bed of the Tafilalt (ABOUSSALAM & BECKER 2001). If this is correct, the Taghanic Onlap coincides with the base of Bed 10a and is not very conspicuous. Bed 10b would correlate with the regressive episode separating the Lower and Middle Tully of New York (BAIRD & BRETT 2003). Support comes from the youngest and rich fauna of the subsequent *Afromaenioceras* Bed (Bed 11a) which can be collected widely in the core of the syncline (Bed 12). It consists of:
orthocones indet.
Agoniatites meridionalis
Maenioceras cf. *terebratum*
Wedekindella lata
"Phoenixites" n. sp. I
Sobolewia virginiana (rare)
"Trevoneites" assessi
"*Trevoneites"* n. sp.
Afromaenioceras sulcatostriatum
Afromaenioceras crassum
Afromaenioceras n. sp. (probably with two subspecies)
Cyrtolites sp.
pleurotomariaceans and other gastropods
brachiopods
Thamnopora sp.

The new *Afromaenioceras* species suggests a high level in the *sulcatostriatum* Zone (*Afromaenioceras* n. sp. Subzone, MD II-D2) since in the Tafilalt it has not been found in the (pre-event) *Maenioceras* Marls but in the lower (Jebel Ouaoufilal) to upper (Seheb el Rhassal) parts of the Taghanic Event interval. A succession of *Afromaenioceras* faunas is also known from Algeria (GÖDDERTZ 1987). A single and probably new *Manticoceras* shows a different preservation and proves that the Frasnian must have outcropped somewhere nearby. These strata may currently be covered by the Quarternary. At the top of the section there is a thin marker siltstone (Bed 11b) with many styliolinids which correlates in all of the Tata region with the regressive-transgressive cycle at the boundary between the second and third sequence of the Taghanic Events (Middle/Upper Tully boundary). There are no younger faunas in the syncline core. Collected loose material around Bed 12 represents washed over specimens from Bed 11a.

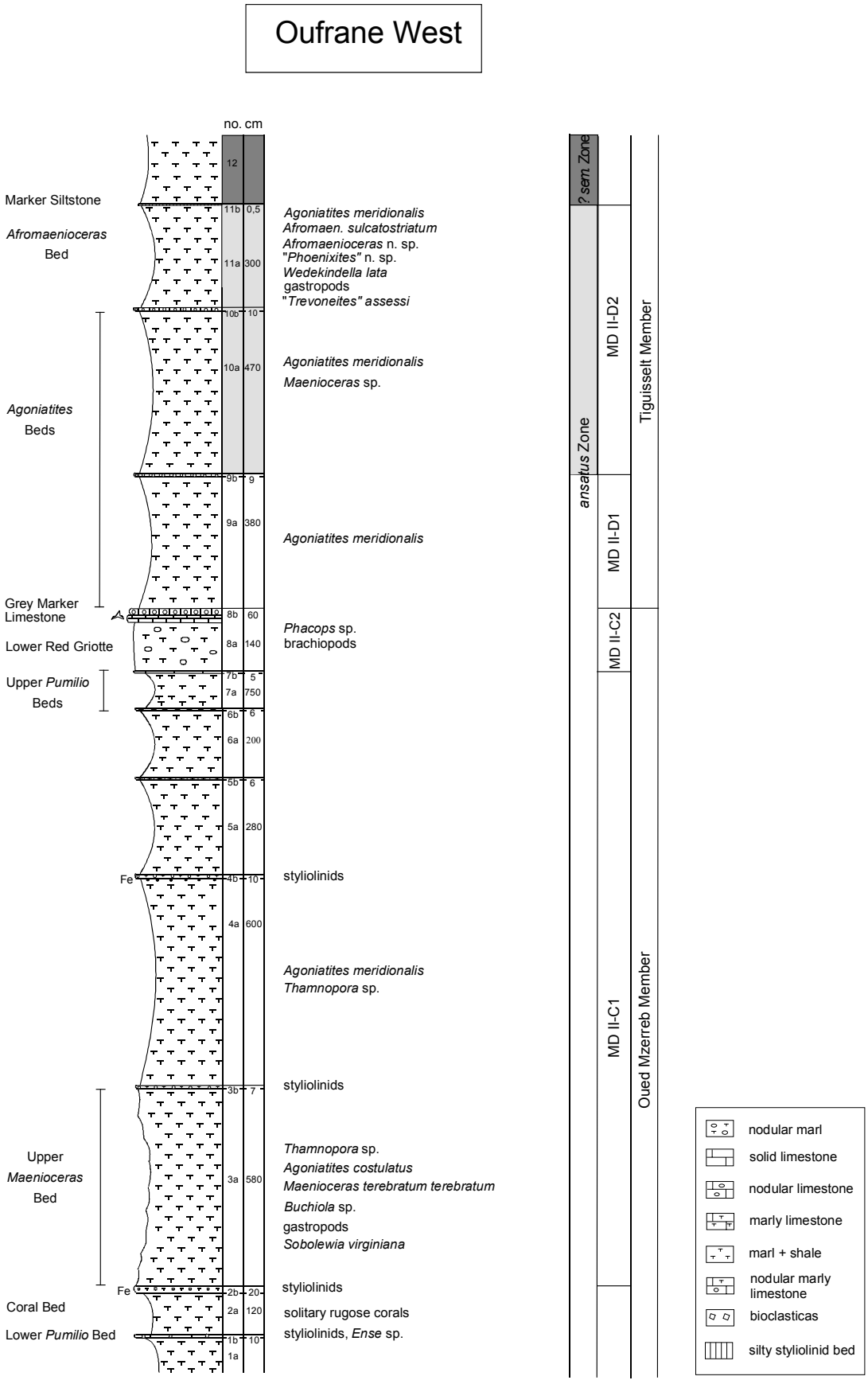

Fig. 1: Faunal, events and lithological succession of the Givetian at Oufrane West.
The Taghanic Event interval is grey shaded.

FAUNAL AND SEDIMENTARY SUCCESSION AT OUFRANE EAST (Fig. 2)

Bed 8b is used as marker to correlate the Givetian sections at Oufrane but many other beds can be identified easily based on faunas and lithology. The Lower *Pumilio* Bed, Coral Bed and the main fossiliferous part of the Upper *Maenioceras* Beds are covered by sand. Beds 2a´ to 4a´ correlate with the fossil-poor upper part of Bed 3a and with Bed 4a of Oufrane West. There is a characteristic, haematitic and goethitic, mostly not well preserved fauna with large *Agoniatites* and other goniatites in Beds 2a´and 3a´:
Agoniatites costulatus
Agoniatites cf. *meridionalis*
Sobolewia virginiana
Wedekindella n. sp.
"Trevoneites" assessi (including adults) and relatives
"Phoenixites" sp. indet.
Maenioceras terebratum terebratum
Thamnopora sp.

The goniatite assemblage is typical for the regional *Maenio. terebratum* Zone and Subzone (MD II-C1). Of special importance is a single specimen of *Uncites gryphus gryphus* (second record for North Africa) which is a shallow-water (reefal facies) marker brachiopod of the Middle Givetian of Germany and many other regions. It allows pelagic-neritic correlation over wide distances across the Proto-Tethys. The lower shale part of Bed 3b´ is much less fossiliferous and produced a few *Maenio. terebratum terebratum*, still of the same subzone. There is a small-sized, well preserved and unique new *Lobotornoceras* which must have come from higher, Frasnian beds. It may represent the oldest species of the genus which, so far, is only known from the early to middle Frasnian.

The following succession of Beds 4 to 8 closely corresponds with Oufrane West but is somewhat more condensed. The yellowish weathering lower and upper parts of the bipartite Upper *Pumilio* interval are only separated by 40 cm of shale. There are a few *Amplexum*-type deep-water corals in Bed 8a (det. D. WEYER). The Grey Marker Limestone (Bed 8b) is nodular at the base and top and consists of mudstone with styliolinids and very rare conodonts: *Polygnathus varcus* and *Latericriodus latericrescens latericrescens*. The record of the latter is remarkable since the normally long-ranging and shallow-water genus *Latericriodus* is confined in the Tafilalt (BULTYNCK 1987, LOTTMANN 1990) to the Upper *Pumilio* level of the early part of the *ansatus* Zone. The very specific palaeoecological conditions of the event obviously allowed a short-termed and opportunistic immigration into the northwestern margin of Gondwana, including the Dra Valley area, and further on to the Montagne Noire (ABOUSSALAM 2003, ABOUSSALAM & BECKER 2001).

The *Agoniatites* Bed (Bed 9a) indicates a subsequent deepening at the base of the new Tiguisselt Member. It contains the name-giving *Agon. meridionalis* together with a more diverse ammonoid, brachiopod and gastropod fauna than at Oufrane W (Tab. 1). Characteristic are the thick-whorled *"Trevoneites"* n. sp. and a second new species of *"Phoenixites"* which both characterize the new regional "*Trevoneites*" n. sp. Zone (and Subzone, MD II-D1) which correlates with the *Maenioceras* Marls of the Tafilalt. Bed 9b is a solid bluegrey limestone. The fauna of the shale and marl unit 10a is similar to that from 9a but characterized by the income of three species of *Afromaenioceras* indicating the upper part of the *sulcatostriatum* Zone (MD II-D2). The presence of *Afromaenioceras* n. sp. supports the correlation of the base of Bed 10a with the initial Taghanic Onlap (see discussion above) but there are no associated faunal changes or extinctions. Bed 10b is another styliolinid-bearing mudstone and seems to lack conodonts. With respect to the pelagic setting, their scarcity in the Givetian of the Tata region is surprising and was perhaps controlled by trophic conditions. Bed 11a is the main *Afromaenioceras* Bed with a very diverse fauna (Tab. 1), also including last *Agoniatites, Wedekindella, "Trevoneites"* and *Sobolewia*. The Oufrane Givetian is at present the best succession on a global scale to prove a sudden ammonoid extinction, including last members of three (sub)families (Agoniatitinae, Parodiceratidae, Sobolewiidae), at the boundary between the second and third phase (Middle/Upper Tully boundary) of the Taghanic Events. Some goniatites from the overlying beds were washed down and mixed with the main *Afromaenioceras* fauna (marked by an * in Tab. 1). Their allochthonous nature is clearly proven by the fact that they are completely missing in the same unit at Oufrane W.

The regional marker bed 11b is a thin silty, pyrite-rich ostracod-styliolinid packstone with alternating carbonatic and more fossiliferous clastic layers. It represents a very short but important regressive episode and lag deposit. Increased quartz input and fossil accumulation were caused by winnowing during increased bottom turbulence. There are very few conodonts, *Linguipolygnathus linguiformis* and *Ctenopolygnathus mucronatus*, which suggest dating as Middle/Upper *varcus* Zone in the old terminology. The subsequent Beds 12a to 15a contain a very different goniatite fauna, dominated by *Mzerrebites juvenocostatus*, the beautiful *Atlantoceras tataense*, and various early pharciceratids, such as *Ph*. aff. *amplexum, Ph. lateseptatum*, and *Ph*. aff. *tridens*. This oldest fauna of the *Pharciceras* Stufe (HOUSE 1985), the regional *Mz. juvenocostatus* Zone (MD III-A), was first recognized by BENSAID (1974) as his "do $I\alpha_1$". It still has some typical Middle Givetian forms, such as *Maenioceras terebratum* n. ssp. and *Maenioceras* n. sp. II (named as *Bensaidites* n. sp. in KORN & KLUG 2002; both with advanced, deep adventitious lobes) and species of *Afromaenioceras*. It correlates with *Pharciceras-Maenioceras* associations recently (ABOUSSALAM & BECKER 2001) found in the Tafilalt and in the Montagne Noire which both have been dated as *semialternans* Zone (Upper *varcus* Zone). The same conodont level, the Upper Tully Limestone of New York, is also long known to include the oldest *Pharciceras* (*Ph. amplexum*, e.g., HOUSE 1962). The great significance of an Upper Tully level ammonoid radiation is fully confirmed at Oufrane and, as in the Tafilalt (BECKER & HOUSE 2000), also introduced *Epitornoceras*.

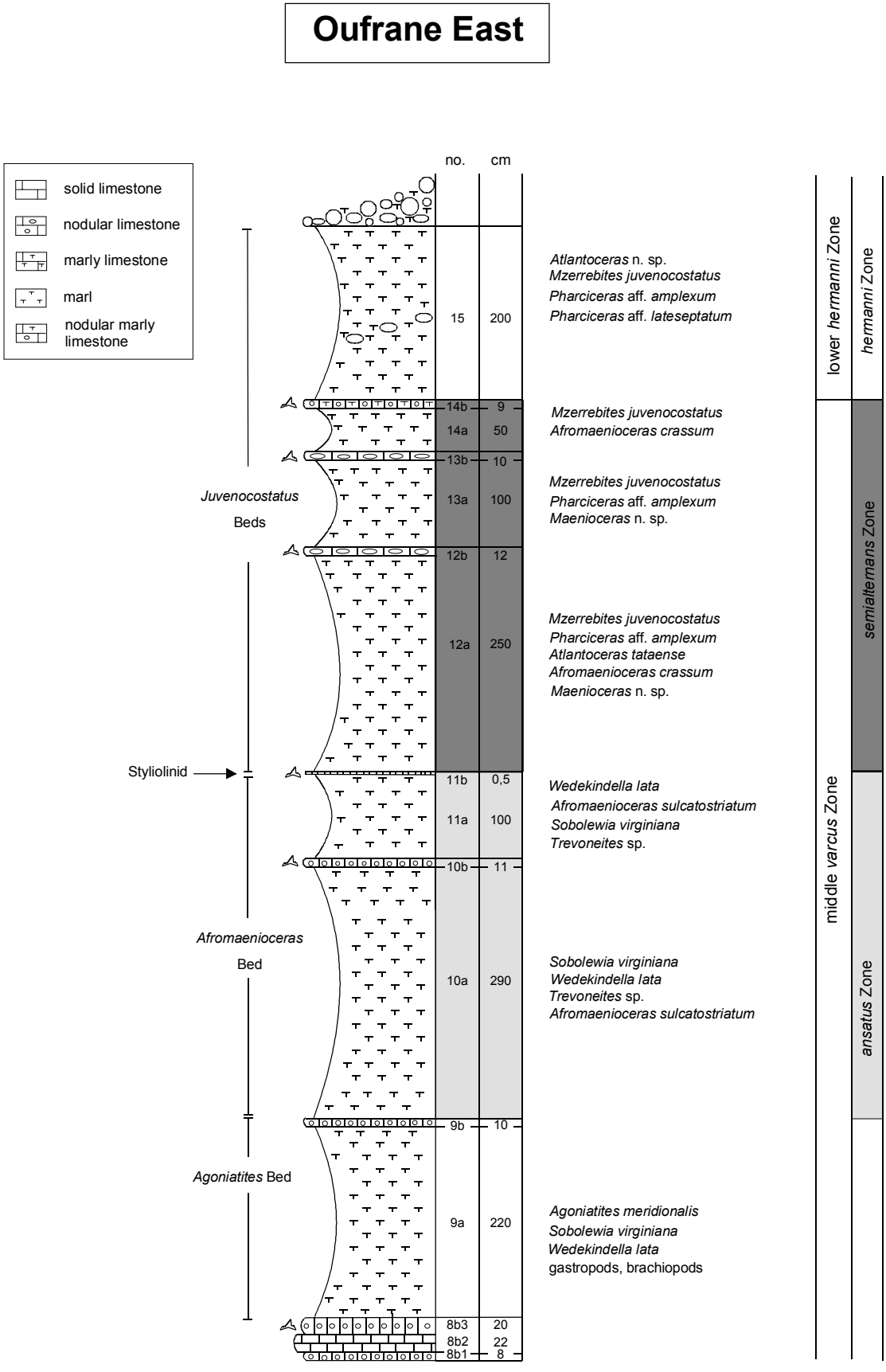

Fig. 2: Lithological and faunal succession of the Givetian at Oufrane East (for legend see Fig. 1).

Beds 12b and 13b are limestone concretions which consist of partly recrystallized mudstones with ostracods and various amounts of styliolinids. Unfortunately, there are no conodonts. Bed 14b is more marly, consists of three individual layers and shows bioturbation. The gradual disappearance of last maenioceratids (youngest record in Bed 14a) may indicate that the highest exposed beds should be assigned to the basal Upper Givetian (sensu ABOUSSALAM & BECKER 2002). Bed 15 includes brown sideritic concretions with large-sized, flattened *Mzerrebites* which beautifully display the growth ornament. In the Tafilalt, the genus is known to range into *hermanni* Zone (*Mzerrebites erraticus* Zone, MD III-B, BECKER & HOUSE 2000) where, perhaps at a slightly younger level, it may be associated with advanced pharciceratids (*Stenopharciceras* s.l. and *Lunupharciceras*). The complete disappearance of faunas in the mostly covered marls below the Quarternary cliff may indicate, as at the other Tata localities, a post-Taghanic deepening.

taxa/bed numbers	8b3	9a	10a	11a	11b	12a1	12a2	12a3	12/13	13a	14a	15	15a(1)	15a(2)
Po. varcus	1													
Lateri. lat. latericrescens	2													
haematized styiolinids	xx	x	--	x	--	x	x	x	--	x	--	--	--	x
Agoniatites meridionalis		x	--	x			x*							
"*Phoenixites*" div. sp.		**x**	x	xx	--	x	x	xx	x	x	--	--	x	x
Wedekindella lata		xx	xx	xxx										
"Trevoneites" n. sp.		**x**	x	x										
Sobolewia virginiana		x	x	x										
bellerophontids		x	--	x	--	--	x	x	--	x	x	--	x	x
other gastropods		x	x	x	x	--	x	x	x	x	x		x	x
brachiopods		x	--	--	--	--	--	--	--	x	x			
orthoconice cephalopods		x	--	--	--	x	x	--	--	--	--	--	--	x
Afro. sulcatostriatum			**xx**	xxx	--	x	x		x					
Afro. crassum			**x**	xx	--	x	x	xx	--	--	x			
Afromaenioceras n. sp.			**x**	x	--	--	x							
various bivalves			x	x										
crinoid stems			x	x										
Thamnopora sp.				x										
Buchiola sp.				x	--	x	--	x	x					
Linguipo. linguiformis					5									
Ctenopo. mucronatus					1									
Mzerrebites juvenocostatus		x*	x*	xx*		**xxx**	xx	xxx	xx	xx	xx	xx	xx	xx
Pharciceras div. sp.				x*		**x**	x	xx	x	x	x	--	x	x
Epitorno. mithracoides				x*		**x**	--	x	--	x	x	--	--	x
Atlantoceras tataense			x*	x*		**x**	--	xx	x	--	x	--	x	
Tentaculiten						x	x							
Maenioceras n. sp. II								x	--	?				
Tornoceras sp.								x	--	x				
Guerichiphyllum sp.								x		x				
zonation	MD II-D1		MD II-D2			MD III-A							?MD III-B	

Tab. 1: Macrofaunal record of the Tiguisselt Member of the Ahrerouch Formation at Oufrane East (*allochthonous/ transported, x = record, xx = moderately common, xxx = abundant, marker taxa in bold; for conodonts the number of specimens is given, showing the scarcity of material). The solitary Rugosa were identified by D. WEYER.

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Givetian stratigraphy and faunas at Tiguisselt (Tata region, Dra Valley, Morocco)

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INTRODUCTION AND LOCATION

Tiguisselt S of Tata was one of the important localities in the eastern Dra Valley which BENSAID (1974) included in his classical study of late Givetian Moroccan ammonoids which, at the time, were partly placed in the basal Upper Devonian. However, a detailed description of the ammonoid-rich succession has not been given previously. The section was also visited by H. HOLLARD who noted sample levels of late Eifelian and Givetian age in the compilation published (after his death) in 1981. Translated into modern taxonomy, the following ammonoids have been illustrated by BENSAID (1974):

Atlantoceras tataense (pl. 1, figs 4, 4b, 6)
Agoniatites meridionalis (pl. 1, figs 5, 5a, as cf. *meridionalis*, pl. 1, figs 9, 9a, the holotype)
Agoniatites costulatus (pl. 6, fig. 5)
Wedekindella lata (figs 24a-b1, pl. 5, figs 8, 8a)
"*Phoenixites*" n. sp. (figs b1-b2, 24f, as *Tornoceras simplex*)
"Trevoneites" assessi (fig. 24d, pl. 5, fig. 12, as *Tornoceras westfalicum*)

This assemblage clearly consists only of Middle Givetian taxa if the proposed definition (ABOUSSALAM & BECKER 2002, BULTYNCK & GOUWY 2002) as time span between the base of the *rhenanus* Zone and the base of the *hermanni* Zone becomes accepted. Our detailed investigations (ABOUSSALAM 2003) gave a detailed sedimentary and faunal sequence from ca. the Lower *Pumilio* level to unfossiliferous parts of the Upper Givetian. There are very rich haematized faunas which allow an easy correlation with the contemporaneous sections at Oufrane (ABOUSSALAM et al., this vol.) and Oued Mzerreb (BECKER et al., this vol.). Several levels are extraordinarily rich in small gastropods but these have not been studied in detail.

The measured section is located at a low, more or less circular hill at ca. 3 km distance from the Tiguisselt village which lies ca. 8 km S of Tata on the western side of the Oued Tata. The dry valley is best crossed at the branch from the main road to Akka at the road marker stone 52. The piste leads for a total of 4 km westwards, passes the oued after a mosque, crosses an electrical line, and continues through palms near a single white house. Just W from there, the Devonian is exposed in the centre of a flat syncline, at x = 245.6, y = 300.8 (GPS: N 29° 40´40´´, W 08° 01´40´´).

SEDIMENTARY AND FAUNAL SEQUENCE (Fig. 1)

The ca. 70 m thick succession of the Ahrerouch Formation is, similar as at the other Givetian sections of the Tata area, characterized by predominant hypoxic shales and marls with pelagic fauna with thinner limestone and siltstone interbeds. Conodonts are very rare and only few, mostly long-ranging taxa have been found. Dating and correlation, therefore, mostly relies on ammonoid and event stratigraphy. During our fieldwork we appreciated the company and logistic support of V. EBBIGHAUSEN (Odenthal) and J. BOCKWINKEL (Leverkusen) who also made ammonoid collections available for study. The downward transport of small specimens causes some disturbance (see * marks in Table 1) but, by comparison of all Tata successions, the allochthonous elements can normally be identified with confidence. In many but not in all cases show transported specimens different preservation or abrasion. The sequence is in detail:

Lower *Pumilio* Bed

15 cm of platy to laminated, bioclastic, dark grey limestone (Bed 0) with styliolinids and only few small brachiopods. The characteristic lithology allows correlation with the Lower *Pumilio* Bed at Oufrane.

Coral Marl and Upper *Maenioceras* Beds

The corals known abundantly at Oufrane from right above the Lower *Pumilio* Bed are much more rare at Tiguisselt. Bed 1a is a shale with some haematitic fauna including gastropods, *Sobolewia virginiana, "Trevoneites",* other tornoceratids, *Wedekindella*, *Agoniatites*, *Maenioceras terebratum*, and *Maenioceras* n. sp. I. The latter two characterize regionally the lower parts of the *Maenioceras terebratum* Zone (MD II-C1). It is possible that some of the fauna was washed down from the thicker marl unit Bed 2a which follows with roughly the same assemblage above a bipartite green marly, nodular limestone. The subsequent beds exposed in the main outer slope of the syncline are rather unfossiliferous. There are solid limestones (Bed 2b), platy silty limestones (Bed 3a), levels of nodular marls (Beds 3c, 3d) and styliolinitic beds (top of Bed 4b). The irregular limestone concretions and haematite nests of the lower part of Bed 4b allow straight correlation with Bed 4b at Oufrane. The limestone Bed 5b has a red marl at the base, a very even top, and a laminated lower part which suggests a distal turbiditic origin.

Laterally, to the North, a level which is thought to correlate with Bed 2a (here named as Bed 2a´) carries a different fauna (leg. BOCKWINKEL & EBBIGHAUSEN) dominated by a relative compressed relative of *Sobolewia cancellata* (probably a new species or subspecies which also occurs at older levels in the Tafilalt). Maenioceratids are lacking in this rather unique assemblage which also contained a questionable new holzapfeloceratid which resembles much

older (upper Eifelian) *Parodiceras*. A higher level (Bed 3b´) has, again, the two marker maenioceratids of MD II-C1, but various morphotypes of *"Trev." assessi* and gastropods are especially common.

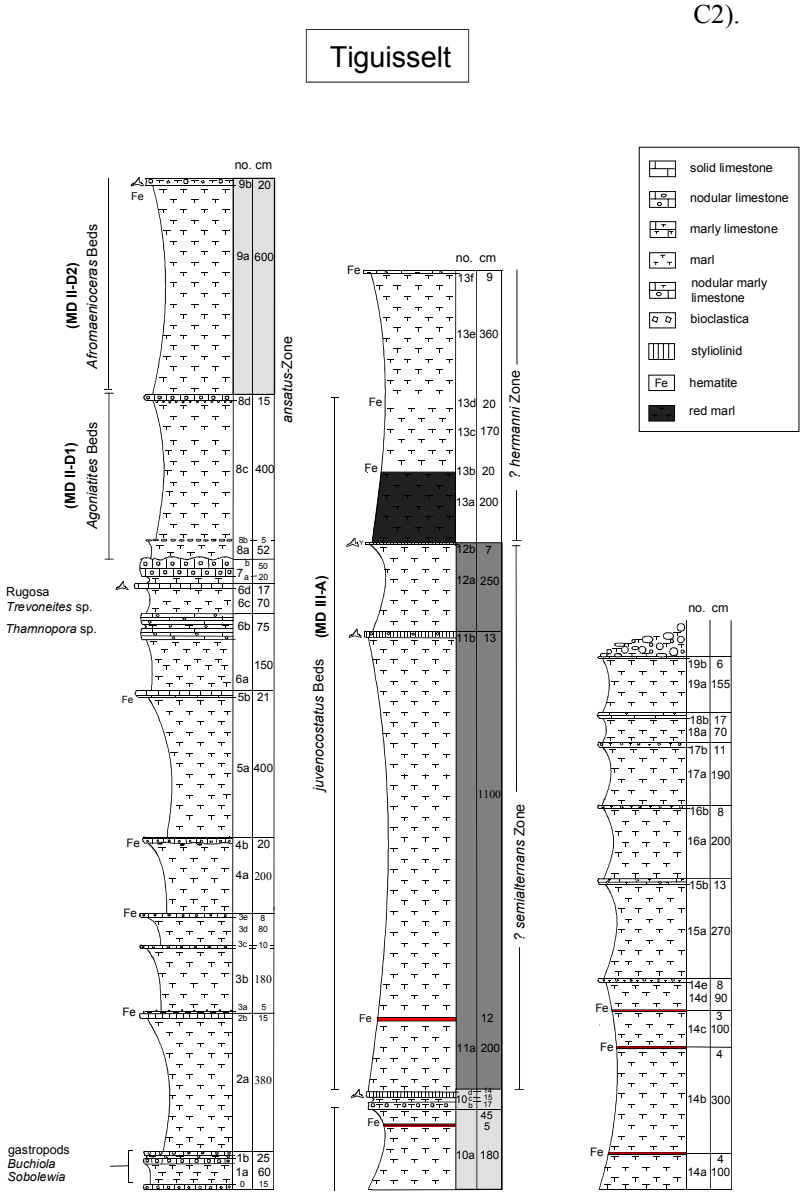

Fig. 1 : Lithostratigraphy and faunal levels in the Middle Givetian at Tiguisselt

Upper *Pumilio* Bed

The 75 cm thick, very platy and argillaceous Bed 6b of the main section correlates with the bipartite Upper *Pumilio* Bed at Oufrane. This is supported by a marl layer within the unit. *Pumilios* are not very abundant at Tiguisselt.

Lower Red Griotte (equivalents)

Above the Upper *Pumilio* Bed the regressive, red nodular unit known from Oued Mzerreb and Oufrane is locally represented by marls with some neritic faunal elements, especially with rugose and tabulate (*Thamnopora*) corals. There is also a haematitic fauna with goniatites and gastropods but the faunal composition is identical with richer faunas from higher up. Therefore, this material is regarded as probably allochthonous. Locally there is no evidence for the *Maenioceras decheni* Subzone (MD II-C2).

Grey Marker Limestone

The marker limestone unit at the top of the new Oued Mzerreb Member of the Ahrerouch Formation consists locally of two solid limestones, separated by 20 cm of marl. The lower and massive Bed 6d is a styliolinid wackestone with ostracods, some brachiopods, without conodonts, and with a sparitic matrix which suggests deposition under a current regime which washed out fine particles. The more nodular Bed 7b is also free of macrofauna and correlates with the top of Bed 8b at Oufrane.

***Agoniatites* and *Afromaenioceras* Beds**

As at Oufrane and Oued Mzerreb, there are three shale/marl-limestone cycles (Beds 8c, 9a, 10a) above the regional Grey Marker Limestone. However, *Afromaenioceras* is locally not only missing from the lower (as at Oued Mzerreb) or from the lower two units (as at Oufrane), but is lacking completely. This confirms a rather mysterious facies-controlled absence of the genus and of all other maenioceratids. Correlation with MD II-D is confirmed by very abundant haematitic "*Trevoneites*" n. sp. which is associated with even more abundant *Wedekindella lata* and with common *Agoniatites meridionalis*. Very characteristic is the mass occurrence of small *Cyrtolites* and other gastropods. This snail-ammonoid biofacies differs from the other Tata sections. The 20 cm thick grey-reddish Bed 9b is thought to correlate with the Upper *Sellagoniatites* Bed of the Tafilalt and marks the regressive phase just prior to the initial Taghanic Onlap (Bed 9a). Bed 9b is a strongly recrystallized mudstone with some styliolinids and ostracods, again without conodonts. Apart from the incoming of some rare tornoceratid species, the shale faunas do not change much from cycle to cycle. A marker red band, indicating stronger hypoxia, can be found in the upper part of Bed 10a (Middle Event Interval). The only good conodont fauna with species of the *varcus* Zone (s.l.) comes from a siliciclastic styliolinid limestone (Bed 10d). The microfacies analysis showed that it is a peloid-styliolinid wackestone to packstone with haematite/pyrite, quartz grains, crinoid debris, some brachiopods, trilobite remains, ostracods, gastropods, bivalves and calcispheres. This shallowing episode correlates with the marker siltstone of Oued Mzerreb and Oufrane, at the boundary between equivalents of the Middle and Upper Tully Limestone.

taxa/bed numbers	1	2	2a´	3b´	6b	6c	8c	9a	10a	10d	11a1	11a2	12	13a	13b	16
ZONATION	MD II-C1					C2	MD II-D				MD III-A			MD III-?B		
Sobolewia virginiana	x	--	--	x	--	--	x	--	x							
"Trevoneites" assessi	x	--	xx	xxx	--	--	--	cf.								
Maenioceras terebratum	x	x	--	x												
Maenioceras n. sp. I	x	x	--	x												
Wedekindella lata	x	--	--	-	--	x*	xxx	xx	xx		x*					
Buchiola sp.	x	--	x	x	--	x	--	--	--	--	--	--	x	--	x	
Cyrtolites sp.	x	x	--	x	--	--	xx	x	x	--	x	x	--	--	x	
other gastropods	xx	x	xx	xxx	--	xx	xxx	x	xx	--	x	x	x	x	x	
haematized styliolinids	x	--	--	--	--	--	--	--	--	--	--	--	xx	x	x	
orthocones	x	x	--	x	--	x	x	x	x	--	x	--	x	--	x	
rugose corals	x	--	--	--	--	x										
Agoniatites meridionalis	x	x	xx	x	--	--	xx	x	xx		x*					
"*Phoenixites"* n. sp. I	x	--	x	x	--	--	x	x	--	--	xx	x	x	xx	xx	
Wedekindella n. sp.		x	--	x												
"*Wedekindella*" n. sp.			x													
Agoniatites costulatus			x													
Sobolewia aff. *cancellata*			xxx													
?Holzapfeloceras n. sp.			x													
brachiopods					x	--	x	x	--	--	--	x	--	x	x	
Thamnopora sp.						x	x	x	x	--	--	--	--	x	--	x
Hastula subtilis						x*	--	x								
"Trevoneites" n. sp.	x*	x*				x*	xxx	xx	x	x*						
?Bactrites sp.							x									
Tornoceras sp.								x*	x*		x	--	x	--	x	
Atlantoceras tataense	x*							x*			xx	x	--	xx	xx	
Mzerrebites juvenocostatus							x*	x*	x*		xx	x	x	xx	xx	
Po. varcus										1						
Linguipo. klapperi										1						
Linguipo. linguiformis										20	--	--	2			
Ctenopo. mucronatus										1	--	--	3			
Po. timorensis										1						
Tortodus sp.										1						
Pharciceras aff. *amplexum*											x					
Ph. aff. *lateseptatum*											x	--	--	--	x	
Afromaenioceras crassum	x*		x*									x				
Maenioceras n. sp. II												x				
problematical fossils													x			
Epitornoceras mithracoides															x	

Tab. 1: Macro- and microfauna at Tiguisselt section west.
(x = record, xx = common, xxx = very abundant, * = allochthonous/transported)

***Juvenocostatus* Beds**

Bed 11a is characterized by a sudden change in the ammonoid fauna. *Sobolewia, Wedekindella*, *"Trevoneites",* and *Agoniatites* have suddenly disappeared and *Mzerrebites* and *Atlantoceras* become dominant. The same significant goniatite extinction has been observed at the marker siltstone and regression at Oufrane. Associated with *Mzerrebites* are some rare and oldest *Pharciceras* and rare, youngest maenioceratids, such as the advanced *Maenioceras* n. sp. II, and *Afromaenioceras crassum*. This assemblage, which also includes some tornoceratids, is characteristic for the *juvenocostatus* Zone (MD III-A, *semialternans* or Upper *varcus* Zone based on Tafilalt data, e.g., ABOUSSALAM & BECKER 2001). Gastropods remain common. A red marker unit low in Bed 11a indicates another short "oxygen crisis". Bed 12a has a much poorer but similar fauna. The calcareous beds 11b and 12b are rather unfossiliferous mudstones with styliolinids and common ostracods. Only the upper level yielded a few long-ranging conodonts which, however, suggest that they still fall in the *varcus* Zone (s.l.). The rather unique dark grey shales at the base of Bed 13a may correlate with the post-Event transgression at the base of the Upper Givetian (basal *hermanni* Zone). This is indicated by the lack of any maenioceratids in the *Mzerrebites-Atlantoceras*-tornoceratid assemblages of Beds 13a and 13b. *Pharciceras* remains very rare and advanced or multilobed species (e.g.,

Lunupharciceras), which are characteristic for MD III-B in the Tafilalt (BECKER & HOUSE 2000), have not yet been found. Higher in Beds 13 and 14, there are further red marl bands but, as at the other Tata area sections, the macrofauna has disappeared almost completely. Even younger marls and shales are exposed in a small trench in the eastern part of the syncline but yielded just a single *Thamnopora* which may have been transported.

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The Pragian at Assa (SW Dra Valley, Morocco)

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LOCATION AND INTRODUCTION

The section is situated 1 km NE of Assa in the SW Dra Valley (Fig. 1). Leaving Assa on the road to Foum el Hassane, the road runs along a conspicuous ridge formed by the Rich 1 Sandstone Beds. The section (Fig. 2) which was first described by HOLLARD & LAFUSTE (1961) forms the beginning of this ridge. It shows a typical example of the Assa Formation also known as Rich 1. In the section, the strata of the Assa Formation dip with 75°-80° towards SSE. In the overlying Merzâ Akhsai Formation the strata dip with 55° to the same direction. The beginning of the section is located at GPS N 28° 37,517' W 09° 23,987', the end at GPS N 28° 37,450' W 09° 23,918'.

The lithostratigraphic content of the Assa Formation has changed in the works of HOLLARD, because the limestones following above the Rich sandstones ("Calcaire d'Assa") have initially been included into the formation (HOLLARD 1963, 1965) and have later been attributed to the overlying Merzâ Akhsai Formation (HOLLARD 1981a,b). We use the term Assa Formation in the newer sense.

HOLLARD assigned the Assa Formation to the "Siegénien supérieur" in most of his works (1963, 1965, 1967, 1981a) not excluding that it might range downward into the "Siegénien moyen" (1965: 29) or upward into the "Emsien inférieur" (1967). According to recent brachiopod studies (JANSEN 1999, 2001), the formation has an "Early Siegenian" age in the sense of the "Rhenish" subdivision; new conodont data indicate a position within the lower to middle Pragian in terms of global chronostratigraphy (see below). The Assa Formation is typically developed in the region between Ain Deliouine in the SW and Foum el Hassane in the NE.

DESCRIPTION OF THE SECTION ASSA I

Assa Formation ("Rich 1")

Rich 1 Sandstone Beds

(1) 19.5 m sandstone beds with intercalated silty and sandy layers, widely covered by debris;

(2) 16 m grey, very hard and partly thick-bedded quartzitic sandstones with oblique stratification, in the upper part with shell beds, intercalated beds of platy sandstones; at the top 1 m thick calcareous sandstone bed with uneven surfaces and forming a ridge, subdivided by muddy and silty layers; bedding surfaces covered by brachiopods: e.g., *Platyorthis hollardi* JANSEN 1999 (very abundant), "*Mclearnites*" *saharianus* JANSEN 2001 (very abundant), *Ctenochonetes* ex gr. *aremoricensis* RACHEBOEUF 1976, *Filispirifer* n. sp. cf. *merzakhsaiensis* JANSEN 2001;

(3) 3.0 m reddish calcareous shell beds with uneven bedding surfaces resembling a conglomerate; fine-grained layers in between; brachiopods: *Schizophoria (Rhenoschizophoria) torkozensis* JANSEN 1999, *Iridistrophia* n. sp. X, *Filispirifer* n. sp. cf. *merzakhsaiensis* JANSEN 2001, *Dixonella assaensis* JANSEN 2001; additional fauna: rugose corals and bivalves;

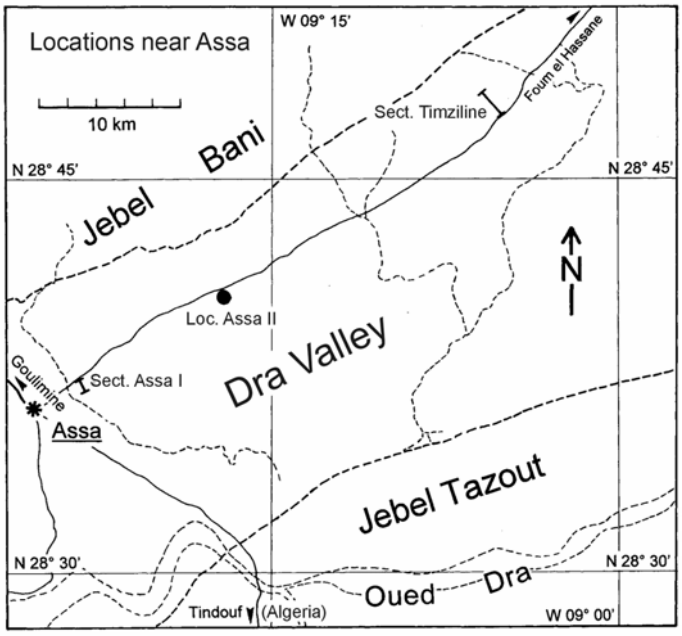

Fig. 1 - Location map of sections in the vicinity of Assa (the section Assa I is described in detail).

(4) 8.1 m silty mud shales with intercalated more silty and sandy layers; 20 cm thick calcareous shell bed at 3.2 m (= Unit 4a) like Unit 3; layers of phosphorite nodules at 4.4 m, 4.6 m and 5.35 m (= Units 4b, 4c and 4d); 20 cm thick calcareous shell bed at 5.4 m (= Unit 4e); brachiopods: *Ctenochonetes* ex gr. *aremoricensis* RACHEBOEUF 1976, *Dixonella assaensis* JANSEN 2001, *Oligoptycherhynchus daleidensis* (C.F. ROEMER 1844); trilobites (after SCHRAUT 2000): *Arduennella maillieuxi* (ASSELBERGHS 1923), *Parahomalonotus planus planus* (KOCH 1883), *Treveropyge prorotundifrons* cf. *iberica* GANDL 1972, *Metacanthina munieri* (OEHLERT 1877); pteriomorph bivalves;

(5) two massive detritic limestone beds, 28 cm and 30 cm thick, dark bluish-grey, weathered reddish; crinoid columnals; indeterminable brachiopod remains; conodonts from the lowermost limestone: *Caudicriodus angustoides castilianus* (CARLS

1969) ?, *Latericriodus steinachensis* (AL RAWI 1977);

(6) 2.0 m platy silty mudstones;

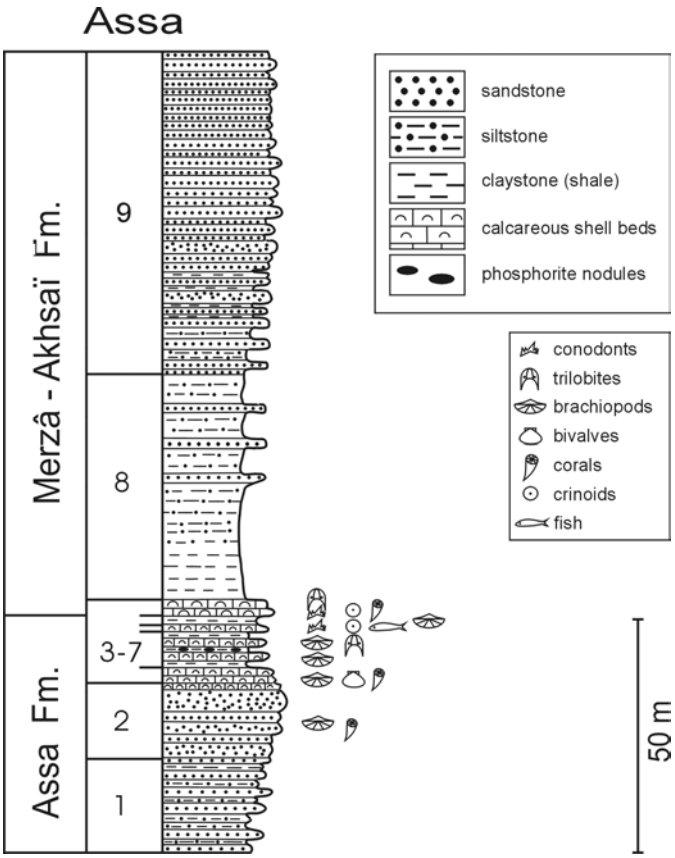

Fig. 2 - The Pragian section Assa (= Assa I in Fig. 1). Only distinct beds due to their fossil abundances and/or importance are indicated by symbols. Details are given in the text.

Merzâ Akhsai Formation ("Rich 2")

Basal Limestone Beds

(7) 2.7 m detritic limestone beds, dark bluish-grey, very hard; crinoid columnals, brachiopods: *Filispirifer* sp.; trilobite: *Odontochile* sp.; conodonts: at 30 cm *Caudicriodus curvicauda* (CARLS & GANDL 1969) ?; at 35 cm *Latericriodus steinachensis* (AL-RAWI 1977), *Caudicriodus angustoides castilianus* (CARLS 1969) ?, *Caudicriodus curvicauda* (CARLS & GANDL 1969) ?, at 75 cm *Ozarkodina excavata* (BRANSON & MEHL 1933), *Latericriodus claudiae* (KLAPPER 1980), *Latericriodus* aff. *L. beckmanni* (ZIEGLER 1956);

Middle Shales

(8) 48.4 m silty mudstones with some sandstone layers, forming a valley, only partly outcropping; directly above the base of this unit; HOLLARD & LAFUSTE (1961) described small reef bodies with *Trachypora limbata* (EATON 1832);

Rich 2 Sandstone Beds

(9) > 68 m thick succession, 21.9 m fine- to medium-grained sandstone beds with finer grained intercalations; 9.4 m platy sandstones, increasingly thin; 37 m thin platy sandstones. HOLLARD & LAFUSTE (1961) reported from the Rich 2 Sandstone Beds "*Spirifer* gr. *primaevus* (STEININGER 1853)" (probably = *Filispirifer* e.g. *merzakhsaiensis* JANSEN 2001).

BIOSTRATIGRAPHY AND PALAEOENVIRONMENT

Assa Formation

The Assa Formation has yielded a biostratigraphically significant brachiopod fauna (Plate 1) allowing correlations with sections in the Celtiberian Chains (NE Spain) and the Armoricain Massif (NW France). The fauna and its stratigraphic position are essentially the same as in the section Torkoz (for discussion see JANSEN et al., this volume). A difference is the high abundance of trilobites and the spiriferid *Dixonella assaensis* JANSEN 2001 in Unit 4. The genus is intermediate between the genera *Hysterolites* and *Euryspirifer*. Comparable forms occur in the upper part of the "Lower Siegenian" (sensu CARLS 1987) or upper part of the "lower Pragian" in the Armorican Massif (Céneré Formation, see GOURVENNEC 1989). The conodont taxon *Latericriodus steinachensis* (AL RAWI 1977) from Unit 5 is consistent with an early to middle Pragian age of the uppermost Assa Formation.

Judging from the trilobites in Unit 4, SCHRAUT (2000) assumed a late Pragian age. However, Pragian trilobite faunas of the Rhenish facies are still poorly studied. The following trilobites have been found: *Parahomalonotus planus planus* (KOCH 1883), *Arduenella maillieuxi* (ASSELBERGHS 1923), *Treveropyge prorotundifrons* cf. *iberica* GANDL 1972, *Methacanthina munieri* (OEHLERT 1877) (det. G. SCHRAUT).

The sandy sediments of the upper Assa Formation have been deposited under shallow marine conditions with strong siliciclastic supply and transport of sand and silt. From Unit 3 onwards, the sand supply apparently ceased, probably already reflecting the onset of the following transgression documented by the basal limestones of the Merzâ Akhsai Formation. The shales of Unit 4 containing phosphorite nodules point to a transgression as well.

Merzâ Akhsai Formation

A comparatively rich conodont fauna could be isolated from the Basal Limestone Beds of the Merzâ Akhsai Formation. The fauna consisting of icriodids with *Caudicriodus curvicauda* restricts the possible age to the middle to late Pragian (K.W.). The macro-fossils of the Basal Limestone Beds do not allow biostratigraphic alignment.

Based on biostratigraphic correlations using brachiopods, the Rich 2 Sandstone Beds following above the shales has been attributed in other sections, e.g., in the Torkoz section, to the "Middle" to "Upper Siegenian" in the sense of the "Rhenish" subdivision (JANSEN 2000, 2001, JANSEN et al., this volume). In terms of global chronostratigraphy, this

unit refers to approximately the upper Pragian and lowermost Emsian.

The Basal Limestone Beds represented by Unit 7 with its crinoids point to a neritic environment with clear, agitated water. Trilobites, brachiopods, crinoids, and icriodid conodonts indicate shallow-marine conditions. The lack of sandy material supports a greater distance from the coast which may be caused by a transgression. The onset of siliciclastics above indicates an increasing terrestric influence which culminates in the Rich 2 Sandstone Beds.

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Plate 1

Brachiopods and trilobites from the upper Assa Formation

Fig. 1 "*Mcearnites*" *saharianus* JANSEN 2001.
1. Ventral valve internal mould; x 1.0. Section Timziline, Unit 1.

Fig. 2 *Iridistrophia* n. sp. X sensu JANSEN 2001.
2a. Dorsal valve internal mould; x 1.0. Section Torkoz II, Unit 6.
2b. Ventral valve internal mould; x 1.0. Locality Assa II.

Fig. 4 *Schizophoria (Rhenoschizophoria) torkozensis* JANSEN 1999.
4a. Dorsal valve internal mould; x 1.0. Section Torkoz II, Unit 9.
4b. Ventral valve internal mould; SMF 59261; x 1.0. Section Torkoz II, Unit 6.

Fig. 5 *Platyorthis hollardi* JANSEN 1999.
5a. Dorsal valve internal mould; x 1.0. Section Timziline, Unit 1.
5b. Ventral valve internal mould; x 1.0. Locality Assa II.

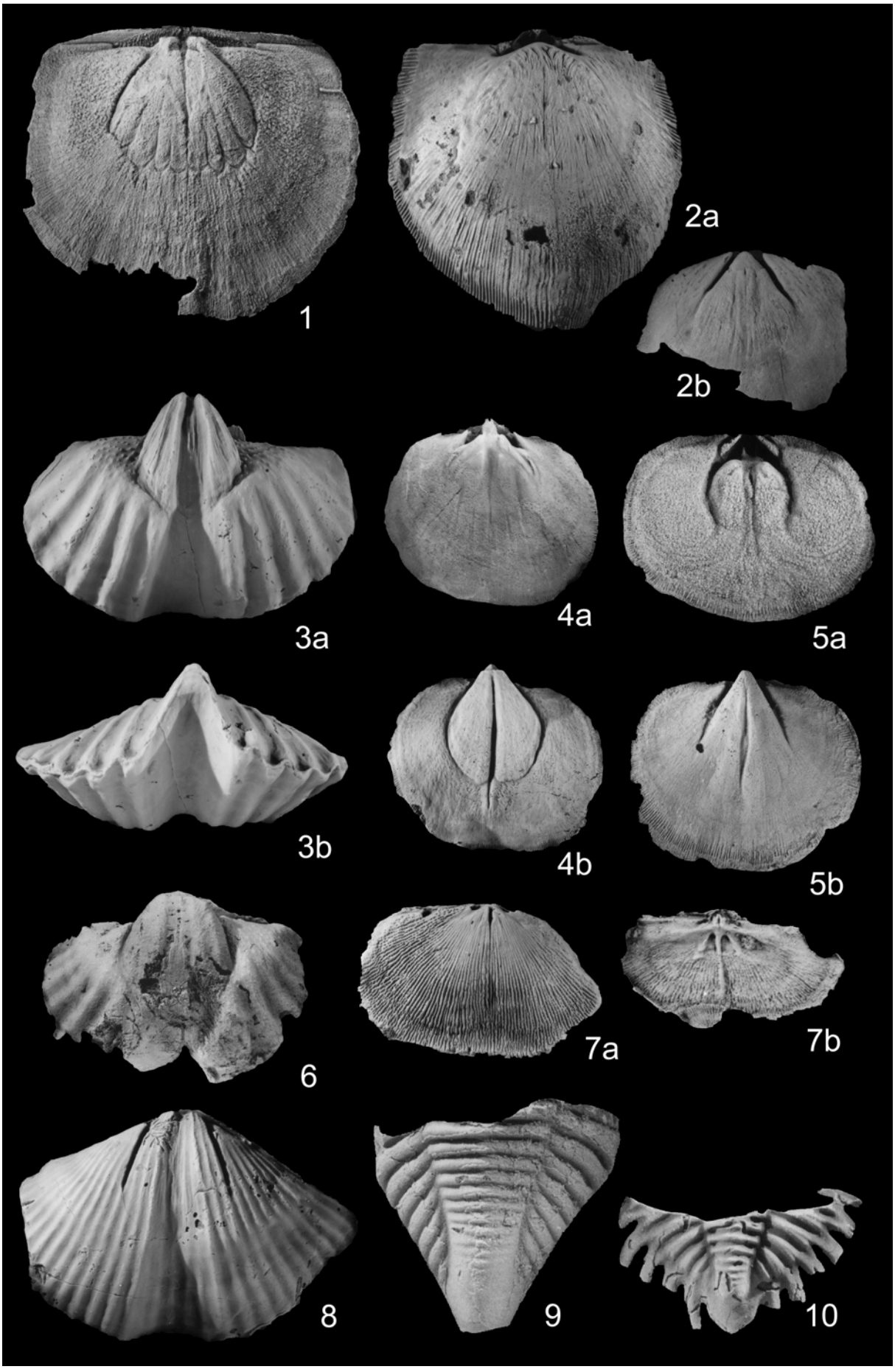
Fig. 6 *Filispirifer* cf. *merzakhsaiensis* JANSEN 2001.
6. Ventral valve internal mould; x 1.0. Section Assa I, Unit 3.

Fig. 7 *Ctenochonetes* ex gr. *aremoricensis* RACHEBOEUF 1976.
7a. Ventral valve internal mould; x 1.5. Section Assa I, Unit 2.
7b. Dorsal valve, latex cast of internal mould, x 1.5. Section Torkoz II, Unit 6.

Fig. 8 *Vandercammenina trigeri* (DE VERNEUIL 1850).
8. Ventral valve internal mould; x 1.5. Section Assa I, Unit 3.

Fig. 9 *Arduennella maillieuxi* (ASSELBERGHS 1923).
9. Pygidium; x 2.5. Section Assa I (refigured from SCHRAUT 2000: Pl. 7, Fig. 2a).

Fig. 10 *Methacanthina munieri* (OEHLERT 1877).
10. Pygidium; x 2.2. Section Assa I (refigured from SCHRAUT 2000: Pl. 14, Fig. 5a).


1
2a
2b
3a
4a
5a
3b
4b
5b
6
7a
7b
8
9
10

Sedimentary succession and neritic faunas around the Devonian-Carboniferous boundary at Kheneg Lakahal south of Assa (Dra Valley, SW Morocco)

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INTRODUCTION

From the beginning of stratigraphical research in the Anti-Atlas there has been a peculiar interest in the Devonian-Carboniferous boundary, especially since it was originally thought that this was a time of early tectonic movements (e.g., CLARIOND 1932, DELEPINE 1939). Later studies (e.g., HOLLARD & JACQUEMONT 1956a, HOLLARD 1956, 1971, ALBERTI 1972) showed that the transition between both systems is complete in NW Africa, apart from effects of sea level changes. In fact, latest Devonian and early Tournaisian sediments are often very thick in comparison with underlying condensed cephalopod limestones and marls. Uppermost Famennian ammonoid faunas with *Wocklumeria* or *Parawocklumeria* and early Carboniferous faunas with *Gattendorfia* have been found in an eastern area from the Maider (HOLLARD & JACQUEMONT 1956: footnote 7, HOLLARD 1956, 1958a, 1971, KORN 1999, BECKER et al. 2002) and Tafilalt (HOLLARD 1960, KORN 1999, unpublished new faunas) to the Gourara (MEYENDORFF 1939, CONRAD et al. 1986) and Saoura Valley areas (PETTER 1954, CONRAD et al. 1970) of SW Algeria. The western Anti-Atlas area is long (HOLLARD & JACQUEMONT 1956a) known to be characterized by thick sandstone wedges which form the dominant, elongated Tazout Ridge. HOLLARD (1956, 1963, 1971) tried to correlate the nearshore and neritic successions of the Assa area with the partly pelagic sequences to the east, mostly based on the rather intermediate region of the Zemoul (around Dfeil). Unfortunately, this important mixed neritic-pelagic sequence is currently inaccessible on the Algerian side of the area S of Foum Zguid.

The latest Devonian and basal Carboniferous lithostratigraphy of the Dra Valley has been rather imprecise since named formations where not strictly defined and no type sections were given. HOLLARD (1956) recognized SE of Assa in ascending order an interval (a) with a "Strunian" fauna, a first ridge with micaceous sandstones (b), which was correlated with the Lower Tournaisian at Dfeil, and a second sandstone ridge, the main Djebel Tazout (c), which was thought to represent younger Tournaisian levels. This gives three sandstone units. The transition from the Tazout sandstones to marls in the subsequent Betaina Valley has been dated, based on *Eoglyphioceras duponti* and *Fascipericyclus* (HOLLARD & JACQUEMONT 1956b), as latest Tournaisian to basal Viséen (*Fascipericyclus-Ammonellipsites* Genozone in current terminology, e.g., RILEY 1990; see also correlation charts in LEGRAND-BLAIN 2002). In the stratigraphic chart of HOLLARD (1963), the Tazout series (in the sense of a group) was divided into a lower "Grès de base du Tazout" of supposed latest Famennian age (= a) and into an upper "Schistes inferieur du Tazout"of Lower Tournaisian age (= b). The higher Tazout part was not discussed due to its younger age. The original tripartition was kept on the geological map, sheet Foum el Hassane-Assa (CHOUBERT et al. 1963), where lower (with "*Spirifer verneuili*" and *Productella subaculeata*), middle (with "*Sp. verneuili*" and "*tornacensis*"), and upper "Grès du Jbel Tazout" are shown. However, this time only the upper Tazout part was referred to the Tournaisian. Eventually, HOLLARD (1971,1981) introduced the terms Tazout 1, Tazout 2 and Tazout 3 Formations but there are no clear definitions. Only the Tazout 1 Formation was dated as Devonian and said to be characterized by shell beds (apart from lumachelles at the top of the Tazout 3 Formation). HOLLARD (1971) suggested a correlation of his Tazout 2 with shales below the *Gattendorfia* level of the Zemoul. This left a possible latest Famennian age (UD VI).

With respect to the 1st order mass extinction associated with the global Hangenberg Event and in relation to the suspected short-termed but major climatic changes at the Devonian-Carboniferous transition, which led to glaciations in South America, a much improved knowledge of the neritic succession S of Assa became a significant task. We have measured in 2002 and 2003 the sedimentary sequence, sampled specific carbonatic beds for conodonts and collected brachiopod faunas which identifications are still somewhat preliminary. Better preserved specimens should improve the taxonomy and more levels have to be sampled. Therefore, the presented results should be taken as data of an early stage of research and further details will have to be added.

From Assa the main road to Zag is asphalted and leads in SE direction. After ca. 13 km it crosses for more than three km at Ida ou Nguit the Idalene dry valley. Famennian shales exposed at the slope down into the oued are

unfossiliferous. The route of the main road has changed since the topographic map (sheet NH-29-III-4 Assa) was printed. It now runs through the valley of Kheneg Lakahal (Kheneg Akhal on the geological map) which cuts through all of the Tazout Ridge. Our measurements started with the first exposed beds on the eastern side of the valley, ca. at x = 120.5, y = 177.5 (main locality GPS: N 28° 27,446´ W 09° 21,643´). These are unfossiliferous siltstones which may represent the "pelites" recognized by HOLLARD (1981) at the base of the Tazout Formation. However, it seems easier to place the base of the formation and of its lower member, here named as **Maader Talmout Member** (following the name of the adjacent plain on the geological map), at the first fossiliferous sandstone bed.

DETAILED SEDIMENTARY AND FAUNAL SUCCESSION OF SECTION KHL

From old to young:

below Bed –7 green to multicoloured siltstones without fauna.

Bed –7 ca. 1 m dark quartzite, at the top with big productid brachiopods and with diverse bivalves.

Bed –6 ca. 8 m siltstones, followed by 200 cm thin-bedded siltstones, and with a 10 cm sandstone bed with ripples at the top.

Bed –5 ca. 3 m siltstone sequence which terminates with a 10 cm pink to green sandstone bed with ripples at the top.

Bed –4 ca. 4 m siltstones, with two sandstone beds at the top: 10 cm sandstone with ripples and big brachiopods (Bed –4b) and a 14 cm compact calcareous sandstone bed with brachiopod coquinas (Bed –4a).

Bed –3 270 cm siltstones, at the top a 10 cm calcareous brachiopod coquina (sandstone bed, sample 9) without conodonts:
external casts of rhynchonellids (Trigonirhynchiidae)
remains of chonetids
remains of productids
Cyrtospirifer sp.

Bed –2 180 cm siltstones, at the top with 20 cm calcareous sandstone (coquina bed) with ripples, bivalves, and brachiopods (sample 6):
Paurogastroderhynchus sp. (Rhynchonellida)
Hamlingella or *Araksalosia* sp. (Productida)
Cyrtospirifer sp.

Bed –1 ca. 8,5 m siltstones with a calcareous sandstone coquina (sample KHL-1, without conodonts) and quartzite lenses with trace fossils and brachiopods (samples 15, 4, 7):
sample 15
Mesoplica praelonga (Productida)
Sample KHL-1
Paurogastroderhynchus sp.
Cyrtospirifer sp.
Mesoplica praelonga (forming monospecific productid coquinas)
sample 4
Paurogastroderhynchus sp.
Cyrtospirifer sp.
sample 7
Paurogastroderhynchus sp. (young form)
Cyrtospirifer sp. (two species)
other spiriferid
Mesoplica cf. *praelonga*
Araksalosiidae

Bed –1b 2,5 cm thin-bedded sandstone with ripples, situated in the gentle northern slope of the first sandstone ridge.

Bed –1a ca. 2,5 m siltstones, with a 2,5 cm thin, platy, rippled sandstone at the top.

Bed -0 ca. 27,5 m unfossiliferous siltstones exposed in the southern slope of the 2nd sandstone ridge, with a 50 cm thick quartzite bed (Qz-0) at the top.

Bed 0 ca. 25 m siltstones with brachiopods in the lower part (samples 14, 10) and with a calcareous sandstone coquina (sample 1) in the middle part. The sequence terminates with a 50 cm quarzite (Qz 0):
sample 1a
crinoids
Polygnathus communis communis
Branmehla cf. *inornata*
sample 14
chonetids
external cast of rhynchonellid (Trigonirhynchiidae)
sample 10
Prospira? sp. (Spiriferida)
Schuchertellidae (orthotetid)

Bed 1 ca. 8,5 m siltstones, with brachiopods in fine sandstones in the upper part, followed by two (Qz 1: ca. 1 m and ca. 1,2m, respectively), dark grey weathering quartzite units separated by ca. 50 cm siltstones with a few more brachiopods.

Bed 2 ca. 10 m siltstones with brachiopods in the lower (sample 8) and upper part (sample 12), and with a calcareous sandstone coquina with rare fragments of bivalves, fish teeth and conodonts (sample KHL 1) in the middle part. The succession terminates with ca. 2,5 m sandstones (Qz 2), with two small quarzite beds with brachiopods (samples 2, 13) at the base, with beautiful trace fossils and cross-bedding, and with more brachiopods from the base of a rippled sandstone at the very top (sample 1).
sample 8
Spinocarinifera sp. (Productida)
sample KHL 1
Palmatolepis perlobata schindewolfi
Palmatolepis gracilis gracilis

Palmatolepis gracilis sigmoidalis
Palmatolepis gracilis expansa
Polygnathus communis communis
Polygnathus sp. (fragment)
Mehlina strigosa
?Mehlina sp.
Branmehla inornata
Branmehla cf. *bohlenana*
Bispathodus stabilis morphotype 1
Bispathodus stabilis morphotype 2
sample 12
casts of *Tylothyris?* sp. (Spiriferida)
sample 2
Eomartiniopsis sp. (Spiriferida)
Spinocarinifera sp. (Productida)
external cast of rhynchonellid (Trigonirhynchiidae)
orthoconic nautiloid indet.
sample 13
orthotetid (*Schuchertella* sp.)
Prospira? sp. (Spiriferida)
chonetid

Bed 3 ca. 7 m siltstones with calcareous sandstone coquinas with brachiopods (samples 1, 5, 3, 11). At the top (Qz 3) with two (80 cm and 40 cm) thin-bedded quartzite levels.
sample 1
Eomartiniopsis sp.
external cast of rhynchonellid (Trigonirhynchiidae)
sample 5
Voiseyella? sp. (Spiriferida)
Eobrachythyris ? sp. (Spiriferida)
sample 3
cf. *Acanthatia* sp. 2 (Productida)
Leptagonia cf. *analoga* (Strophomenida)
Tylothyris? sp.
Rhipidomellidae (Orthida)
sample 11
Eomartiniopsis sp.

Bed 4 ca. 5 m siltstones, at the top with 50 cm poorly bedded quartzite (Qz 4).

Bed 5 ca. 3 m silty shales, with a 10 cm calcareous sandstone at the top (Qz 5, sample KHL 5 without conodonts). Sandstones (leg. ABOUSSALAM 2003) from just above Qz 4 include very nice trace fossils and brachiopods:
Eomartiniopsis sp.
Voiseyella? sp.
Prospira? sp.
casts of rhynchonellids

Beds of the upper part of the Maader Talmout Member also yielded various gastropods, including some large, *Loxonema*-type forms. Crinoidal detritus is present both in the lower (e.g., Qz-1) and upper units. The member is overlain in the subsequent valley and in the northern slope of the main Tazout Ridge by very finely bedded, greenish-yellow to reddish-brown weathering siltstones with minor interbeds (1-3 cm thick) of somewhat more solid siltstones or fine sandstones. There is no fauna at all which suggests a hostile, marginal marine environment. This succession is between 150 and 200 m thick and forms the new **Kheneg Lakahal Member** of the Tazout Formation. It is unclear whether it correlates with the "Pélites à nodules conglomèrates" in the lower part of the Tazout 2 Formation of HOLLARD (1981) but conglomerates have not been observed at Kheneg Lakahal.

The upper part of the main Tazout Ridge consists of intertidal, brown, often quartzitic sandstones with well-preserved oscillation ripples. At Kheneg Lakahal the fauna is rather poor and consists of large, often poorly preserved bivalves and of some rhynchonellids. Much better brachiopod faunas can be found in the overlying Betaina Formation which yielded *Syringothyris* sp. and the productid *Keokukia? betainensis* (HOLLARD 1958b). The pericyclid level of HOLLARD & JACQUEMONT (1956b) has not been located in the lower marls of the formation.

BIOSTRATIGRAPHIC DATING AND DISCUSSION

The age of the greenish siltstones underlying the Tazout Formation is unclear. HOLLARD (1963, 1981) placed the "Schistes et grès de l´Oued Dra" or the Lemgairinat Formation in the Famennian V but this is not yet proven by fauna. The youngest known ammonoid faunas (e.g,, HOLLARD & JACQUEMONT 1956a) from S of Akka include, in modern taxonomy, *Platyclymenia, Erfoudites, Prionoceras*, and cyrtoclymenids. This assemblage is typical for the lower part of UD IV, especially for the *Annulata* Event level (lower UD IV-A). The faunas has not yet been restudied or resampled. Typical Upper Famennian pelagic faunas (*postera*/*styriacus* Zone or younger) are not yet known from the western Dra Valley.

The lower part of the Maader Talmout Member (Beds –7 to –1) correlates with the Tazout 1 Formation of HOLLARD (1971, 1981) which is said to be characterized by lumachelles. Its fauna is characterized by a brachiopod assemblage with *Cyrtospirifer*, which is restricted to the Upper Devonian, with *Mesoplica praelonga*, and with *Paurogastroderhynchus*. The second species is long known from classical outcrops of neritic facies in Western Europe (e.g., Pilton Beds, shales A1 and A2, ca. upper Famennian V to lower Famennian VI), from Algeria (Lower Kahla Sandstone), and from Middle Asia. On the Russian Platform (RZHONSNITSKAYA 2000), it is characteristic for very late parts of the Famennian (Khovanshina and Zigan Horizons) which postdate the entry of *Bispathodus costatus* within the Middle *expansa* Zone. *Paurogastroderhynchus* is the index form of a brachiopod zone of the Gortun Suite in the Transcaucasus (MAMEDOV & RHZONSNITSKAYA 1985, RHZONSNITSKAYA & MAMEDOV 2000) which predates the occurrence of *Mesoplica praelonga* in the overlying Arshakiakhpjur Suite. The Gortun Suite has conodonts which indicate an age no older than the *styriacus* or *postera* Zone which, again, correlate with the upper part of the *Platyclymenia* Stufe (UD IV-B/C). Ostracods from the Gortun Suite, however, may indicate a younger age (ARISTOV et al. 1975). The association of both brachiopod

genera roughly indicates an early to late Upper Famennian age (*postera* to *expansa* Zones), more likely Famennian V which begins in the Tafilalt near the base of the Middle *expansa* Zone. HOLLARD (1971) also considered a Famennian V age for his Tazout 1.

The thick and rather unfossiliferous beds between the low first and the higher second ridge in the lower part of the Tazout system (Beds –0 to 1) are also difficult to date. The productid *Spinocarinifera* is found, for example, in the lower, main part of the Arshakiakhpjur Suite of the Transcaucasus (RZHONSNITSKAYA & MAMEDOV 2000: regional *Sphenospira julii* Zone) which has been correlated with the *costatus* Zone (at least Middle *expansa* Zone, possibly up to the *praesulcata* Zone). The Asian form, however, is not identical with the basal Carboniferous *Spinocarinifera nigra* from France (LEGRAND-BLAIN 1991). The sparse conodonts from Bed 0 are not very helpful since they have very long ranges. *Po. communis communis* enters in the *styriacus* (*postera*) Zone but ranges right through the latest Famennian. An Uppermost Famennian age for levels up to Qz 1 is possible but not really proven.

The conodont fauna from Bed 2 is diverse, but does not give a very precise age within the Uppermost Famennian. *Bispathodus stabilis* morphotype 2 is a marker form which enters in the Upper *expansa* Zone but, as all associated taxa, it ranges to the top of the Wocklum Limestone level or to the main Hangenberg extinction level. Due to the shallow facies, the lack of *Siphonodella praesulcata* cannot be taken as reliable indication for a pre-*praesulcata* Zone age. On the other side it is surprising that the outcrop has yielded at all a conodont assemblage with palmatolepids, bispathodids, and others, as in a pelagic setting. The lower part of Bed 2 may represent a transgressive episode. Re-sampling also produced a single trilobite pygidium.

All coquina beds are here included in the Maader Talmout Member of the Tazout 1 Formation. The brachiopod assemblages starting with sample 2 (Qz 2) include the marker spiriferid *Eomartiniopsis* which is known from the Lower Carboniferous of Eurasia, North America, and Australia. *Leptagonia analoga* occurs, for example, in the Transcaucasus in the *Unispirifer praeeulbanensis* Zone of the Kyarki Beds (e.g., RZHONSNITSKAYA & MAMEDOV 2000: also together with *Spinocarinifera* and others) which has been assigned to the lowermost Tournaisian. This is mostly based on the presence of *Polygnathus longiposticus* (see range in KLAPPER 1966, CLAUSEN et al. 1989, or KORN et al. 1994: synchronous entry with *Siphonodella sulcata* at Drewer, Germany) together with other, long-ranging conodont species. In South China, however (Nanbiancun, XU & YAO in YU 1988), the species was found both below (together with clymenids) and above the Hangenberg Event level. Further associations of *Leptagonia analoga* with clymenids and even with phacopids are known from NW China (Xinjiang, Upper Hebukehe Formation, LIANG & WANG 1991). The genera *Prospira, Voiseyella*, and *Tylothyris* are also both known from the latest Famennian and early Carboniferous (review in NICOLLIN & BRICE in press). *Tylothyris clarksvillensis* from the Louisiana Limestone of Missouri, however, falls in the post-Hangenberg Upper *praesulcata* Zone with *Stockumites louisianensis*. Does the *Tylothyris?* from sample 12 (below Qz 2), therefore, indicate a post-event age?

The close superposition of a diverse pre-Hangenberg conodont fauna by a supposed basal Carboniferous *Eomartiniopsis* brachiopod fauna is rather surprising since both levels should be separated by the regressive phase of the Hangenberg Event which led in a very brief period in the Tafilalt and Maider to the deposition of very thick clastic sequences. There is currently no evidence for an unconformity or strong condensation within Bed 2. However, sediment bypassing during strong regression is a possible explanation. The Carboniferous age of the upper part of the Maader Talmout Member should be confirmed by conodont data. A sample from Bed 5, unfortunately, was barren. HOLLARD (1971) reported from a section 50 km E of Assa an ammonoid fauna with *Stockumites* cf. *intermedius* from just above the Tazout 1 Formation. This would indicate the post-Hangenberg Event Stockum level at the Devonian-Carboniferous transition which is now also known from the Maider (new fauna) and from the easternmost Tafilalt (KORN 1999, BECKER et al. 20002). Further data are needed to clarify whether the *Eomartiniopsis* fauna may enter in the latest Devonian or not.

The Kheneg Lakahal Member cannot be dated and may have been included in the Tazout 2 Formation by HOLLARD (1981) which, however, was not defined. The latter certainly includes the sandstones with restricted fauna starting below the top of the main Tazout Ridge. The new brachiopod samples (leg. EBBIGHAUSEN & BOCKWINKEL in 2002) from the much higher Betaina Formation are in perfect agreement with the old collections of HOLLARD & JACQUEMONT (1956) and HOLLARD (1958b).

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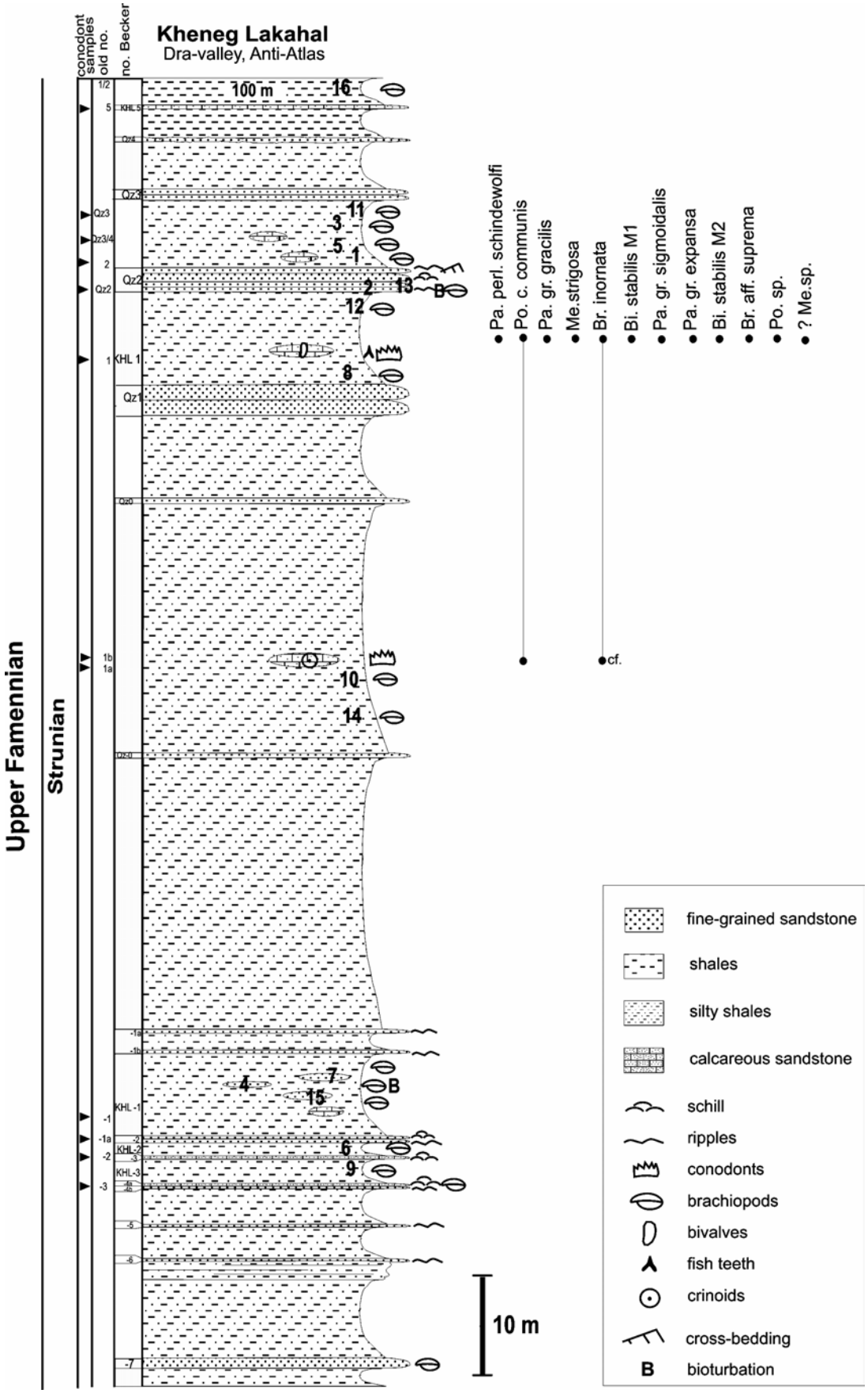

Fig. 1: Lithostratigraphy, Conodont and Brachiopod sample levels at Kheneg Lakahal.
(GPS: N 28° 27, 446 / W 09° 21, 643)

Pragian and Emsian near Aouinet Torkoz (SW Dra Valley, Morocco)

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LOCATION AND INTRODUCTION

The section is situated about 10 km S of Aouinet-Torkoz (Fig. 1). Approach: desert road from Aouinet-Torkoz towards the South until the first ridge appears; drive along its northern slope to the West until the ridge bends towards the North; the section starts at GPS N 28° 23,363'; W 09° 53,566'. The section runs from the North to the South across the ridge. In order to get a complete succession, it was necessary to subdivide the section into three parts: Torkoz II, Torkoz IIa, and Torkoz IIa' (Figs. 2-3).
The section reveals a complete succession from middle parts of the Pragian to the Upper Emsian including the upper part of the Assa Formation, the Merzâ Akhsai Formation, the Oui-n-Mesdoûr Formation and the Khebchia Formation (Fig. 3). Members as defined by R.T. BECKER et al. (this volume) could not yet be considered. Calibration with the type section at Bou Tserfine has to be provided later. The cyclic sedimentary development can be referred to the Cycles 1 to 4 defined by R.T. BECKER et al. (this volume).

SEDIMENTARY AND FAUNAL SUCCESSION

The main intervals are as follows:

Units 1 to 14: Assa Formation, upper part. The section begins at the N slope of a ridge built up by the Rich 1 Sandstone Beds. The succession from Unit 1 to 14 consists of approximately 120 m sandstones and siltstones, often with ripple marks, cross-stratification, load casts, and mud clasts. Above Unit 12, on top of the ridge, the section Torkoz II ends. The continuing section Torkoz IIa begins slightly towards the E and runs down the southern slope of the ridge.
Brachiopod shell beds and lenses occur in some units (3, 9, 14). Units 6, 9, 11, 12, 13, and 14 contain brachiopod faunas, mainly orthids and strophomenids described by JANSEN (1999, 2001; see chapter 3). Furthermore, the tabulate coral *Pleurodictyum* is rather common. Worm-like traces are present in Unit 11.
The Rich 1 Sandstone Beds can be correlated with upper parts of the "Lower Siegenian" (sensu CARLS 1987) in NE Spain and NW France (JANSEN 1999, 2001).
The sedimentary succession was – at least predominantly – deposited in a very shallow marine environment with strong siliciclastic influx, strong water currents and significant sediment transport, i.e., it represents a typical Rhenish facies.

Units 15 to 16: Uppermost parts of Rich 1 Sandstone Beds, about 18 m thick. A lithological change from more sandy to calcareous sedimentation can be observed, whereas the brachiopod fauna does not change significantly. Icriodid conodonts are present. In terms of international chronostratigraphy, the top of the Assa Formation may belong to lower to middle parts of the Pragian (see "Assa section", JANSEN et al., this volume, b).
At the base, limestone lenses intercalated in sandstones occur (Unit 15), followed by continuous limestone beds with crinoid columnals and brachiopods (Unit 16). This change indicates a changing environment with less turbid water probably introducing the following transgression.

Unit 17: Basal Limestone Beds of the Merzâ Akhsai Formation. The 4.4 m thick unit consists of massive crinoidal limestones with brachiopods (e.g., pentamerids), orthocone nautiloids and icriodid conodonts. In other sections (e.g., Assa I section), the trilobite *Odontochile* occurs. The top of the unit has yielded a diverse ostracod fauna. Age: according to conodonts from section Assa I middle to late Pragian.
The lithological change from Unit 16 to 17 reflects the transgression at the beginning of Cycle 2.

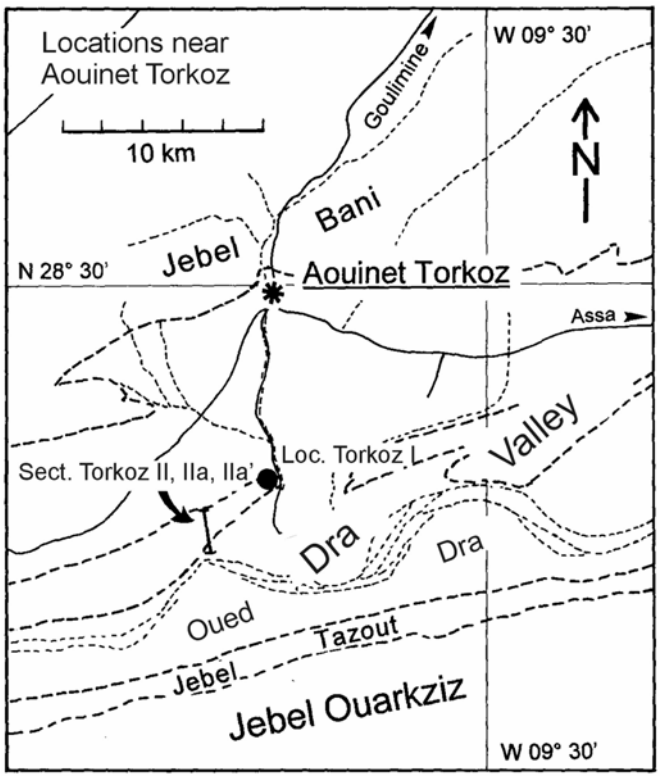

Fig. 1 - Location map of sections in the vicinity of Aouinet Torkoz (the sections Torkoz II, IIa, and IIa' are described in detail).

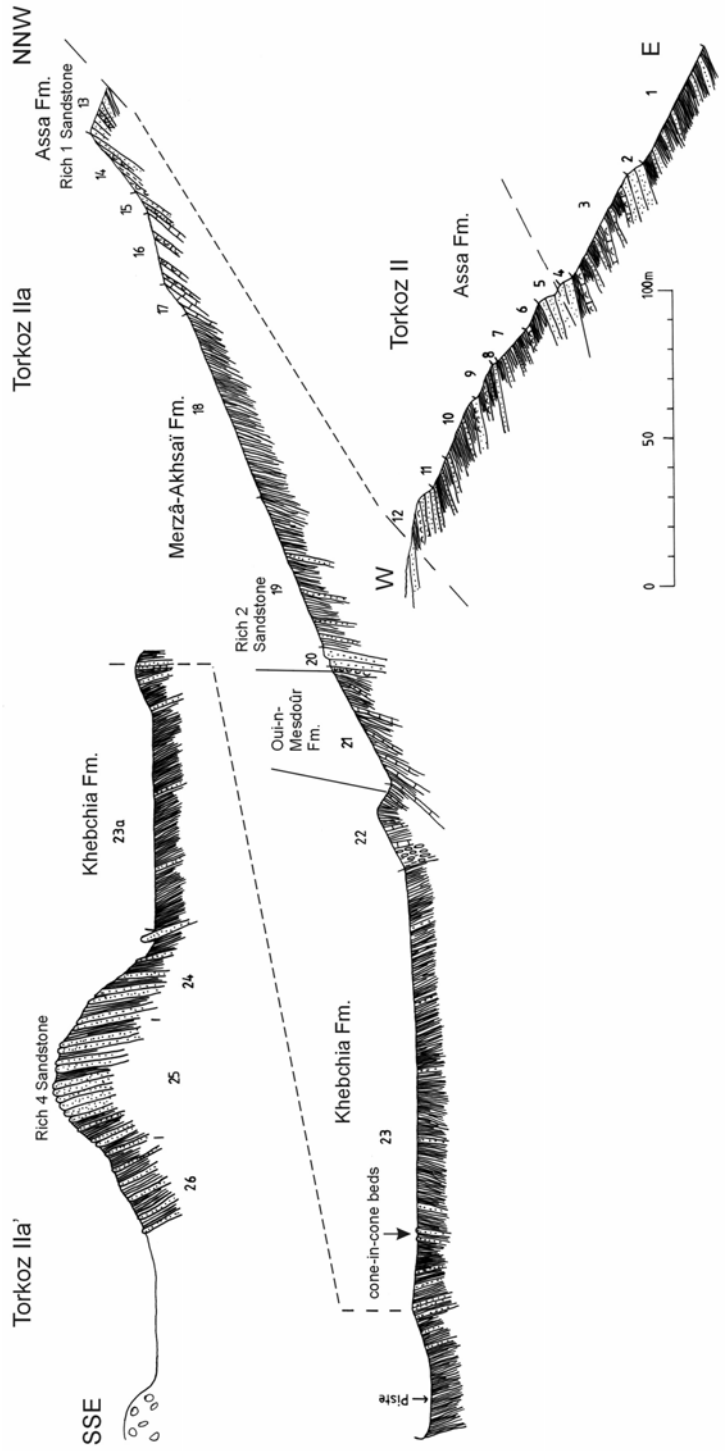

Fig. 2 - Cross-section of the middle Pragian to Upper Emsian strata South of Aouinet Torkoz (for columnar section see Fig. 3).

Units 18 to 21a: Middle Shales (thickness 84.8 m), followed by Rich 2 Sandstone Beds (thickness 10.3 m) of the Merzâ Akhsai Formation. The succession starts with 40.3 m thick, light grey to yellowish muddy and marley, unfossiliferous shales (Unit 18), which are not well exposed. Further up the section (Unit 19), some platy sandstone beds with brachiopods and *Pleurodictyum* are intercalated announcing the following regression. Units 20 and 21a, together 10.3 m thick, embody the Rich 2 Sandstone Beds, characterized by sandstones with cross-stratification, shales, and brachiopod coquinas. Unit 21a contains a typical Rich 2 brachiopod fauna (JANSEN 2001; see chapter 3) allowing a correlation with the "Middle" to "Upper Siegenian" in Western and Central Europe. In terms of global chronostratigraphy, the interval may be assigned to probably the upper Pragian and lowermost Emsian.

The strata were deposited in a shallow marine environment with strong siliciclastic input und sediment transport. The observed development corresponds to the regression at the end of Cycle 2.

Unit 21b and basal 4.2 m of Unit 22: Oui-n-Mesdoûr Formation, thickness 16.4 m, situated at the base of the ridge. A significant marker horizon characterized by dark tentaculite limestone beds with intercalated shales following above the last sandstone bed of Rich 2 with sharp boundary. The limestone beds become more distinct towards the top of the unit.

Although the conodont elements are fragmentary, from a shallow water facies and stratigraphically less significant, the formation in its lower parts can be assigned more or less to the *excavatus* Zone of the Lower Emsian ("Zlichovian"). The units 21b-5 to 21b-7, however, may include an age of the *nothoperbonus* Zone (upper "Zlichovian") and perhaps of the *inversus* Zone (lowermost "Dalejian") (see chapter 4). Dacryoconarids are very abundant in some layers (see following unit and chapter 6). At other locations, specimens of *Mimagoniatites* have been found in upper parts of the formation (BULTYNCK & HOLLARD 1980), showing a late Zlichovian to Dalejian age.

The transgression reflected by the sedimentary and faunal development at the beginning of Unit 21b marks the start of Cycle 3 which has been referred to the "Basal Zlichov Event".

Unit 22: first 26 m of the Khebchia Formation built up in the lower part by light grey and yellow limestones beds alternating with marls. They are overlain by an increasing number of layered limestone nodules that are intercalated in the marls. Further up in the section, the marls grade into claystones, and the limestone nodules disappear. The succession forms a small ridge running parallel to the base of the high ridge.

In the interval 11.2 to 13.4 m (units 22c-e), trilobites (see Plate 2) are abundant and very impressive because their dark exoskeletons remarkably contrast with the light carbonates. *Hollardops mesocristata* (LE MAÎTRE 1952), *Psychopyge elegans* (TERMIER & TERMIER 1950), and *Diademaproetus holzapfeli praecursor* G. ALBERTI 1969 occur in limestones and marls, accompanied by large arthrodire remains and corals.

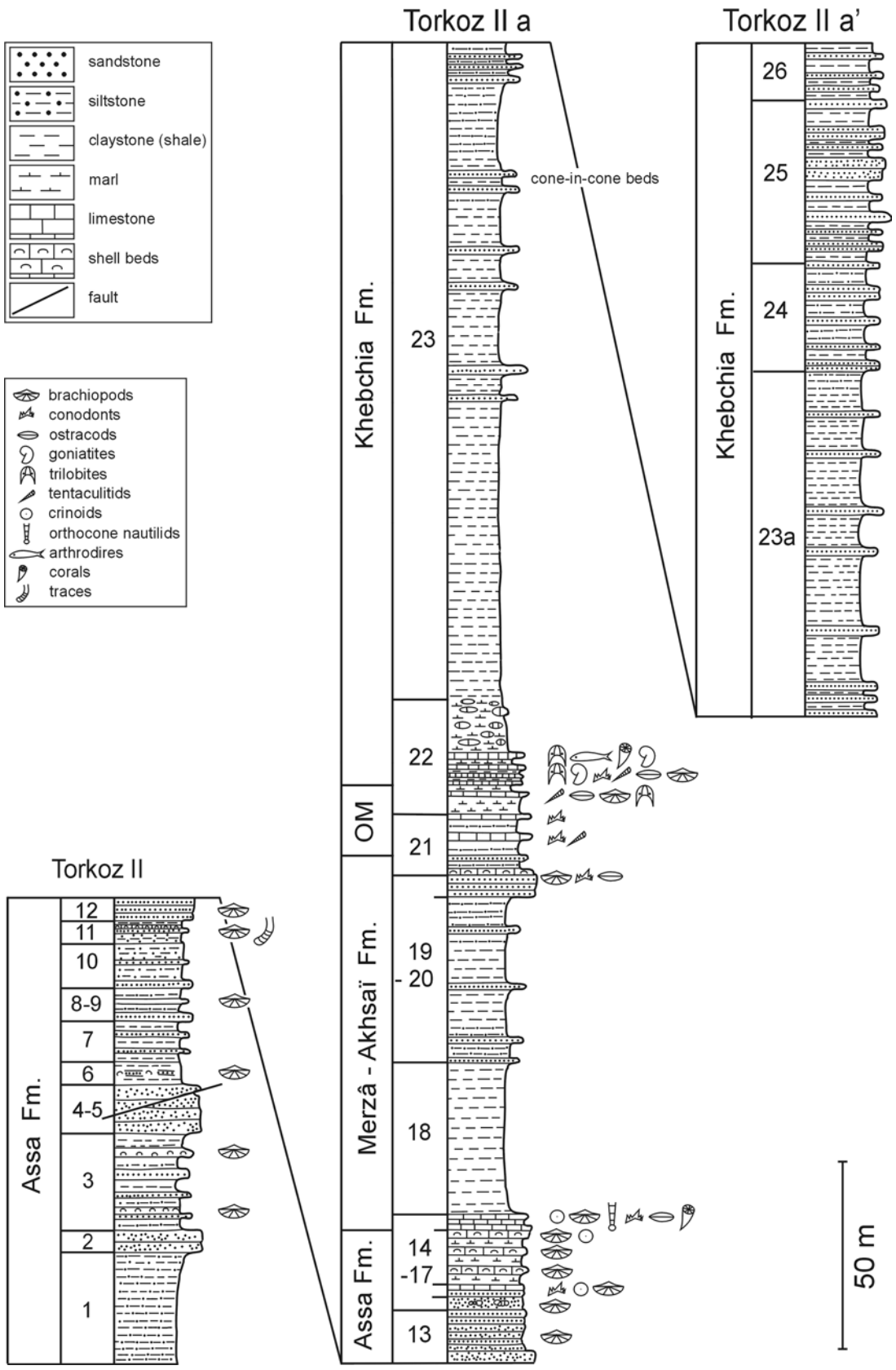

Fig. 3 - The sections Torkoz II, IIa, and IIa' (for location see Fig. 1, a cross-section is provided in Fig. 2). Only distinct beds due to their fossil abundances and/or importance are indicated by symbols; the tabulate coral *Pleurodictyum* sp. occurs in several layers. OM = Oui-n-Mesdoûr Formation. Details are given in the text.

The trilobite fauna points to a Late Emsian or even late Late Emsian age (SCHRAUT 2000). The same late Late Emsian age interval, i.e., from the *serotinus* Zone to the *patulus* Zone, is obvious by stratigraphically rather significant shallow water icriodids. Ostracods are rather common and diverse, especially in Unit 22e at 13.4 m (see chapter 5). At the same level, *Latanarcestes noeggerathi* (von BUCH 1832) indicates the *L. noeggerathi* Zone of the lower Dalejian (upper *laticostatus* Zone to basal *serotinus* Zone). Further upwards, a limestone bed with abundant goniatites, e.g., *Sellanarcestes* aff. *neglectus* (BARRANDE 1865), *Anarcestes latissimus* CHLUPÁC & TUREK 1983, and *A.* aff. *simulans* (BARRANDE 1865) is present corresponding to the *L. noeggerathi* to *A. simulans* zones, and, in terms of conodont stratigraphy, to the *serotinus* Zone in the Upper Emsian (R.T. BECKER, pers. comm.).
On both slopes of the small ridge there are some beds exposed yielding tentaculitids (except for a single specimen of probable homoctenid affinity they belong to the dacryoconarids – beds 22a,b, and e). Even when the discrimination between nowakiid and viriatellinid taxa is sometimes rather difficult, the stratigraphic position seems to be similar – a position high in the Lower to low in the Upper Emsian is most probable due to the occurrence of taxa from the viriatellinid group *Viriatellina pseudogeinitziana* BOUCEK 1964, *V. hercynica* BOUCEK 1964, and *V. gracilistriata* (HALL 1879) (see discussion in chapter 6).
From the neritic trilobite limestone up to the rather pelagic *Sellanarcestes* beds a transgressive tendency is recognizable which may be correlated to the Daleje Event, or the beginning of Cycle 4.

Units 23 to 26: Khebchia Formation (continued), beginning with 175 m thick green to greenish-greyish shales and siltstones representing the Bou Tserfine Member (Unit 23). This succession forms a plain. In the upper part, sandstone beds are increasingly intercalated into the shales showing a beginning regression (Cycle 4). A peculiar detail are two 15 cm thick sandstone beds with stromatolite-like, cone-in-cone structures at 119 and 120 m which are probably of inorganic origin (seismites ?). One of these beds has also been discovered in the section Bou Tserfine at the same stratigraphical level (BOCKWINKEL et al., this vol.). The sandstone beds become more frequent from 140 m on upwards and form a small ridge at 165 m; section Torkoz IIa ends here.
The section continues 145 m towards the West as Torkoz IIa'. The lower 90.8 m (Unit 23a) begin with the same ridge followed by greenish shales and a 15 cm thick sandstone bed at 22 m. In the following 28.5 m silty and sandy rocks alternate with up to 20 cm thick sandstone beds (Unit 24), followed by a 42.8 m thick sequence composed of thick-bedded sandstones with ripples, separated by sandy/silty intercalations (Unit 25) and further sandstones (Unit 26). This is the Rich 4 Sandstone Member forming a marked geomorphological ridge. The whole succession is poorly fossiliferous, and only a few brachiopods have been found referring to the latest Emsian and, probably, early Eifelian (chapter 3). Crinoid columnals and a tentaculite have been found as well.
The sedimentary structures point to shallow water conditions due to a regression at the end of Cycle 4. At least parts of the unit are marine as indicated by the shelly fauna.

BRACHIOPODS (U.J.)

The sandstones of the riches contain the stratigraphically most important brachiopod faunas (Plate 1; see also plates in other articles by JANSEN et al., this volume, a-b), whereas the limestones and marls of the section Torkoz II are rather poor in determinable brachiopods.

The Rich 1 Sandstone Beds include a brachiopod fauna, e.g.,

Platyorthis hollardi JANSEN 1999
Schizophoria (Rhenoschizophoria) torkozensis JANSEN 1999 (Unit 6 = type stratum and type locality)
Iridistrophia n. sp. X
Ctenochonetes ex gr. *aremoricensis* RACHEBOEUF 1976
"*Mclearnites*" *saharianus* JANSEN 2001 (very abundant)
Meganteris sp.

The brachiopod fauna is biostratigraphically significant allowing correlations with sections in the Celtiberian Chains (NE Spain) and the Armorican Massif (NW France), because very close biogeographic relationships existed. The relationships to faunas from the Ardenno-Rhenish Mountains are wider. The fauna of the Assa Formation is phylogenetically transitional between the classical "Gedinnian" and "Middle Siegenian" faunas of the Ardenno-Rhenish Mountains, where this evolutionary stage is lacking due to non-marine or brackish facies of the Lower Siegen Beds. According to CARLS (1987), the stratigraphic level falls into the upper part of the "Lower Siegenian", as defined in continuously marine sections in Western Europe. Stratigraphical equivalents are, for example, upper parts of the Nogueras Formation (d2c beta) in the Celtiberian Chains, middle parts of the Banugues and Felmín formations in the Cantabrian Mountains, or the upper Saint-Céneré Formation in the Armorican Massif (comp. CARLS 1987, 1988, 1999, GOURVENNEC 1989, GARCÍA-ALCALDE 1996).

The Rich 2 Sandstone Beds again contain a brachiopod fauna (Plate 1), e.g.,

Filispirifer merzakhsaiensis JANSEN 2001 (formerly named "*Acrospirifer* cf. *fallax*" in the works of DROT and HOLLARD)
Proschizophoria n. sp. F
"*Boucotstrophia*" cf. *gigas* (MCCOY 1852)
Chonetidina indet.
Iridistrophia anorhrifensis JANSEN 2001
Rhenorensselaeria cf. *strigiceps* (ROEMER 1844)

Remarkable is a sandstone bed, probably a tempestite, 1 m above the base of Unit 21a which is enriched in *Proschizophoria* n. sp. F (sensu JANSEN 2001).
This brachiopod fauna again allows good correlations with sections in the Celtiberian Chains and the Armorican

Massif, but also the Ardenno-Rhenish Mountains. *Proschizophoria* n. sp. F is close to "Middle" to "Upper Siegenian" *Proschizophoria personata* (ZEILER 1857) from the Ardenno-Rhenish Mountains, and *Rhenorensselaeria* cf. *strigiceps* is closely related to *R. strigiceps* occurring in the same stratigraphic level. Therefore, the interval may be assigned to the classical "Middle" to "Upper Siegenian" as defined in the Ardenno-Rhenish Mountains. Age-equivalents in Western Europe are, for example, upper parts of the Santa Cruz Formation in the Celtiberian Chains, upper parts of the Banugues and Felmín formations in the Cantabrian Mountains, or the upper Montguyon and upper Faou formations in the Armorican Massif (comp. CARLS 1987, 1988, 1999; CARLS & VALENZUELA-RÍOS 1998, GOURVENNEC 1989, GARCÍA-ALCALDE 1996).

In the Rich 4 Sandstone Member only one ventral internal mould of *Iridistrophia* cf. *hipponyx* (SCHNUR 1851) of latest Emsian or early Eifelian aspect has been discovered loosely in the section. At another locality, *Arduspirifer mosellanus* ssp. has been found in the same position referring to the latest Emsian (probably late *serotinus* to *patulus* Zone).

CONODONTS (K.W.)

Single conodont elements, which could be isolated from limestones in the section Torkoz IIa are mainly fragments, indicate a shallow water facies and thus permit only rather indistinct stratigraphic datings.

17 (lower Merzâ Akhsai Formation)

Latericriodus sp., aff. *L. beckmanni* (ZIEGLER 1956)

Age: ~ *excavatus* Zone or older.

21b (Oui-n-Mesdoûr Formation)

21b-1: *Latericriodus* sp., aff. *L. beckmanni* (ZIEGLER 1956)
21b-2: *Latericriodus* aff. *L. beckmanni* (ZIEGLER 1956), *Caudicriodus* cf. *ultimus* WEDDIGE 1985
21b-3: *Caudicriodus sigmoidalis* (CARLS & GANDL 1969), *Latericriodus beckmanni* (ZIEGLER 1956), *Latericriodus bilatericrescens* (ZIEGLER 1956)
21b-4: *Caudicriodus sigmoidalis* (CARLS & GANDL 1969), *Latericriodus beckmanni* (ZIEGLER 1956)
21b-5: ? *Eucostapolygnathus inversus* (KLAPPER & JOHNSON 1975), *Latericriodus bilatericrescens* (ZIEGLER 1956), *Criteriognathus steinhornensis miae* (BULTYNCK 1971)
21b-6: *Latericriodus beckmanni sinuatus* (KLAPPER, ZIEGLER, & MASHKOVA 1978)
21b-7: *Criteriognathus steinhornensis miae* (BULTYNCK 1971)

Ages:
21b-2 – 21b-4 (basal 0.3 m of the formation): ~ *excavatus* Zone (Zlichovian, Early Emsian)
21b-5 – 21b-7 (6.5 to 8.2 m above the base): ~ *nothoperbonus* Zone up to ? *inversus* Zone (Zlichovian, Early Emsian to ?earliest Dalejian)

22 (basal part of Khebchia Formation)

22b3: *Icriodus corniger ancestralis* WEDDIGE 1977 (*Icriodus fusiformis* CARLS & GANDL 1969)
22b top: *Caudicriodus culicellus culicellus* (BULTYNCK 1976), *Icriodus corniger rectirostratus* BULTYNCK 1970, *Icriodus fusiformis* CARLS & GANDL 1969
22c: *Icriodus corniger ancestralis* WEDDIGE 1977, *Icriodus corniger rectirostratus* BULTYNCK 1970, *Icriodus fusiformis* CARLS & GANDL 1969
22d: *Caudicriodus culicellus culicellus* (BULTYNCK 1976), *Icriodus corniger ancestralis* WEDDIGE 1977, *Icriodus corniger leptus* WEDDIGE 1977, *Icriodus* sp., aff. *I. werneri* WEDDIGE 1977
22e: *Icriodus corniger ancestralis* WEDDIGE 1977, *Icriodus fusiformis* CARLS & GANDL 1969
22f: *Icriodus fusiformis* CARLS & GANDL 1969, *Icriodus* sp., aff. *I. werneri* WEDDIGE 1977
22g: *Icriodus corniger ancestralis* WEDDIGE 1977, *Icriodus corniger leptus* WEDDIGE 1977, *Icriodus* sp., aff. *I. werneri* WEDDIGE 1977
22i: *Icriodus corniger leptus* WEDDIGE 1977 ?

Age of Unit 22: *serotinus* to *patulus* zones (Late Emsian, Dalejian).

OSTRACODS (G.B.)

Silicified ostracods are spread in the Section Torkoz IIa. First information has been presented in G. BECKER et al. (2001, 2003), systematic descriptions of species found in Units 21-22 of Oui-n-Mesdoûr and lower Khebchia formations are just provided by G. BECKER et al. (in press). Herein, additional information is given.
The top of the Unit 17 (Merzâ Akhsai Formation) as well as Unit 22e (lower part of the Khebchia Formation) have yielded diverse ostracod faunas (see Tab. 1, for provisional faunal list). The faunas from units 15 to 17 indicate a Pragian to Early Emsian age, whereas the fauna from Unit 22 indicates a Late Emsian age.
All assemblages are of Thuringian provenience, "mixed faunas" sensu G. BECKER (in BANDEL & BECKER 1975) reflecting life habitates in deeper, offshore water below the wave base.

TENTACULITIDS (E.S.)

In the section Torkoz IIa tentaculitids are present in some abundance in the upper part of the exposure (small ridge mainly built up by marly limestones of Unit 22 and from the middle part of the underlying Unit 21). The following taxa occur in this interval (transitional forms are also present):

Unit 21 (middle part, Oui-n-Mesdoûr Formation)
styliolinids
Viriatellina cf. *pseudogeinitziana* BOUCEK 1964.

Unit 22 (on both slopes of the small ridge – beds 22a,b, and e, lower Khebchia Formation)

styliolinids
Viriatellina cf. *pseudogeinitziana* BOUCEK 1964
Viriatellina cf. *pseudogeinitziana* BOUCEK 1964 —> *Viriatellina* cf. *hercynica* BOUCEK 1964
Viriatellina cf. *hercynica* BOUCEK 1964
Viriatellina cf. *hercynica* BOUCEK 1964 —> *Viriatellina* cf. *gracilistriata* (HALL 1879)
Viriatellina cf. *gracilistriata* (HALL 1879)
? *Homoctenus* sp.

Torkoz	15 Top	16 Top	17 Top	22a	22b3	22bTop	22e
Ctenoloculina cf. *disjuncta* ZAGORA 1968			x				
Parabolobina aff. *kroemmelbeini* ZAGORA 1968			x				
Parabolobina aff. *creunitziensis* ZAGORA 1967			x				x
Paralobolina? sp. sensu FEIST & GROOS-UFFENORDE 1979			x				
Tetrasacculus sp. A							x
Selebratina sp. 17			x				
Ulrichia (*Ulrichia*) sp., ex gr. *U.* (*U.*) *spinifera* CORYELL & MALKIN 1933			x				x
Ulrichia (*Subulrichia*) *fragilis* WARTHIN 1934 sensu ZAGORA 1968			x				
Pseudozygobolbina? sp. 17			x				
Aechmina aff. sp. A BECKER & SANCHEZ DE POSADA 1977			x				x
Berdanella sp. 17			x				
Healdia sp. 17			x				
Cytherellina vel *Healdianella* spp.			x	x	x		x
Bythocyproidea sp. 17			x				
Bythocyproidea sp. 22					x		
Thlipsurella rabieni ZAGORA 1968		x	x				
Polyzygia kroemmelbeini LEFÈVRE & WEYANT 1966	x						
Marginohealdia costata (ZAGORA 1968)			x				
Marginohealdia vetusta ZAGORA 1967							x
Quasillites (*Quasillites*) sp. 17			x				
Quasillites (*Quasillites*) sp. 22				x			
Quasillites (aff. *Beckmannillites*) sp. 22				x			
Menoeidina sp. 17			x				
Jenningsina planocostata JORDAN 1964 vel *arcuata* ZAGORA 1968		x		x			
Bufina europaea PRIBYL 1953			x				
Zeuschnerina sp. 17			x				
Loquitzella mesodevonica ZAGORA 1968					x		x
Microcheilinella sp., ex gr. *M. clava* (KEGEL 1932)			x	x	x	x	x
Bairdiocypris sp. 22							x
Praepilatina sp., ex gr. *P. praepilata* (POLENOVA 1960)			x		x		
"*Cytherellina*" sp., ex gr. "*C.*" *inconstans* ZAGORA 1976			x	x	x	x	x
Baschkirina? sp.							x
Bairdia (*Bairdia*) sp.							x
Acanthoscapha aff. *orthodorsalis* BLUMENSTENGEL 1962							x
Tricornina (*Tricornina*) sp. A BECKER 1975			x				x
Cryptophyllus sp. A BECKER & SANCHEZ DE POSADA 1977					x		

Tab. 1 - Vertical distribution of ostracods in parts of the Torkoz II and IIa sections (Assa to Khebchia formations); provisional list.

Besides the styliolinids which are also present in these beds and the single specimen of ? *Homoctenus* sp. (low in bed 22e), but do not allow any proper determination, dacryoconarids can be identified that belong to the viriatellinids. According to the work of LARDEUX (1969: 205) the forms listed above are even arranged in stratigraphical order in his Tab. 13. There *Viriatellina pseudogeinitziana* represents the oldest taxon followed by *Viriatellina hercynica,* and *Viriatellina gracilistriata*. In his monograph he reports them from the Emsian La Grange Limestone, an olistholitic unit in the Eastern Armorican Massif (NW France). Although that complex is rather disturbed by tectonics, it provides sections important for the definition of the Lower/Upper Emsian boundary (comp. also LARDEUX 1980, BULTYNCK et al. 2000). An assignment to "middle" Emsian strata can also be claimed

from the papers of BOUCEK (1964); ALBERTI (1998) introduces new species of *Viriatellina* in open nomenclature that are ascribed to the Emsian, too. Of prime interest with respect to correlation of units 21 and 22 is the citation of *V. pseudogeinitziana* and *V. hercynica* by BULTYNCK & HOLLARD (1980: 22) from the section Mdâouer el Kbîr SE of Foum Zguid (Eastern Dra Valley). Due to the co-occurring goniatite *Anetoceras advolvens* HOLLARD 1963, it may be correlated with a position above the Rich 2 Sandstone Beds in the basal Oui-n-Mesdoûr Formation. Moreover, HOLLARD (1978: 20,21) shows the co-occurrence of *Nowakia* cf. *praecursor* BOUCEK 1964 and *N.* cf. *zlichovensis* BOUCEK 1964 with *Anetoceras advolvens*, placing those strata close to the Lower/Upper Emsian boundary.

The presence of *Viriatellina* cf. *pseudogeinitziana* in a slab from the middle part of Unit 21 is consistent with an assignment to the Early Emsian (in accordance with other faunal groups collected from the section – see above). *V.* cf. *hercynica* (present in bed 22a) and in bed 22b (even when there are transitional forms of *V.* cf. *pseudogeinitziana* to *V.* cf. *hercynica*) fit with an assignment to the higher parts of the Lower Emsian by e.g., trilobites, goniatites and conodonts (see above). In the youngest bed that yielded tentaculitids, *V.* cf. *gracilistriata* and transitional forms of *V.* cf. *hercynica* to *V.* cf. *gracilistriata* may even indicate a position already in the Late Emsian.

TRILOBITES

Relevance of the trilobites from the section for stratigraphic purpose has already been discussed in chapter 2. Additional information on some of the forms can be obtained from SCHRAUT (2000) who also determined the first four taxa of the following list:

Hollardops mesocristata (LE MAITRE 1952)
Hollardops n. sp. aff. *Hollardops mesocristata* (LE MAITRE 1952)
Psychopyge elegans TERMIER & TERMIER 1950
Diademaproetus holzapfeli praecursor G. ALBERTI 1969
Phacops (Phacops) saberensis torkozensis SCHRAUT 2000
Phacops (Phacops) vogeli SCHRAUT 2000
Scabriscutellum sp.
Paralejurus sp.
homalonotid gen. et sp. indet.
phacopids
proetids

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Plate 1

Brachiopods and trilobite from the upper Merzâ Akhsai Formation

Fig. 1 *Filispirifer merzakhsaiensis* JANSEN 2001.
1a. Dorsal valve internal mould; x 1.0. Section Tadoucht I, Unit 1.
1b. Ventral valve internal mould; x 1.1. Locality Anorhif III.

Fig. 2 "*Mclearnites*" *cherguiensis* JANSEN 2001.
2. Ventral valve internal mould; x 1.0. Section Anorhrif II, Unit 3.

Fig. 3 *Rhenorensselaeria* cf. *strigiceps* (ROEMER 1843).
3. Dorsal valve internal mould; x 1.6. Section Anorhrif II, Unit 3.

Fig. 4 *Iridistrophia anorhrifensis* JANSEN 2001.
4. Ventral valve internal mould; x 1.0. Section Anorhrif II.

Fig. 5 *Proschizophoria* n. sp. F sensu JANSEN 2001.
5a. Ventral valve internal mould; x 1.5. Section Torkoz IIa, Unit 21a.
5b. Dorsal valve internal mould; x 1.5. Section Torkoz IIa, Unit 21a.

Fig. 6 *Euryspirifer africanus* JANSEN 2001.
6a. Ventral valve internal mould; x 1.0. Section Tadoucht II, Unit 3.
6b. Dorsal valve internal mould; x 1.0. Section Tadoucht II, Unit 3.

Fig. 7 *Parahomalonotus planus planus* (KOCH 1883).
7a. Cranidium; x 2.0. Section Tadoucht II, Unit 3 (refigured from SCHRAUT 2000: Pl. 5, Fig. 1a).
7b. Pygidium, x 1.1. Section Tadoucht II, Unit 3 (refigured from SCHRAUT 2000: Pl. 6, Fig. 4a).

Fig. 8 *Arduspirifer maroccanicus* JANSEN 2001.
8a. Ventral valve internal mould; x 1.5. Locality Anorhrif III.
8b. Dorsal valve internal mould; x 1.5. Locality Anorhrif III.

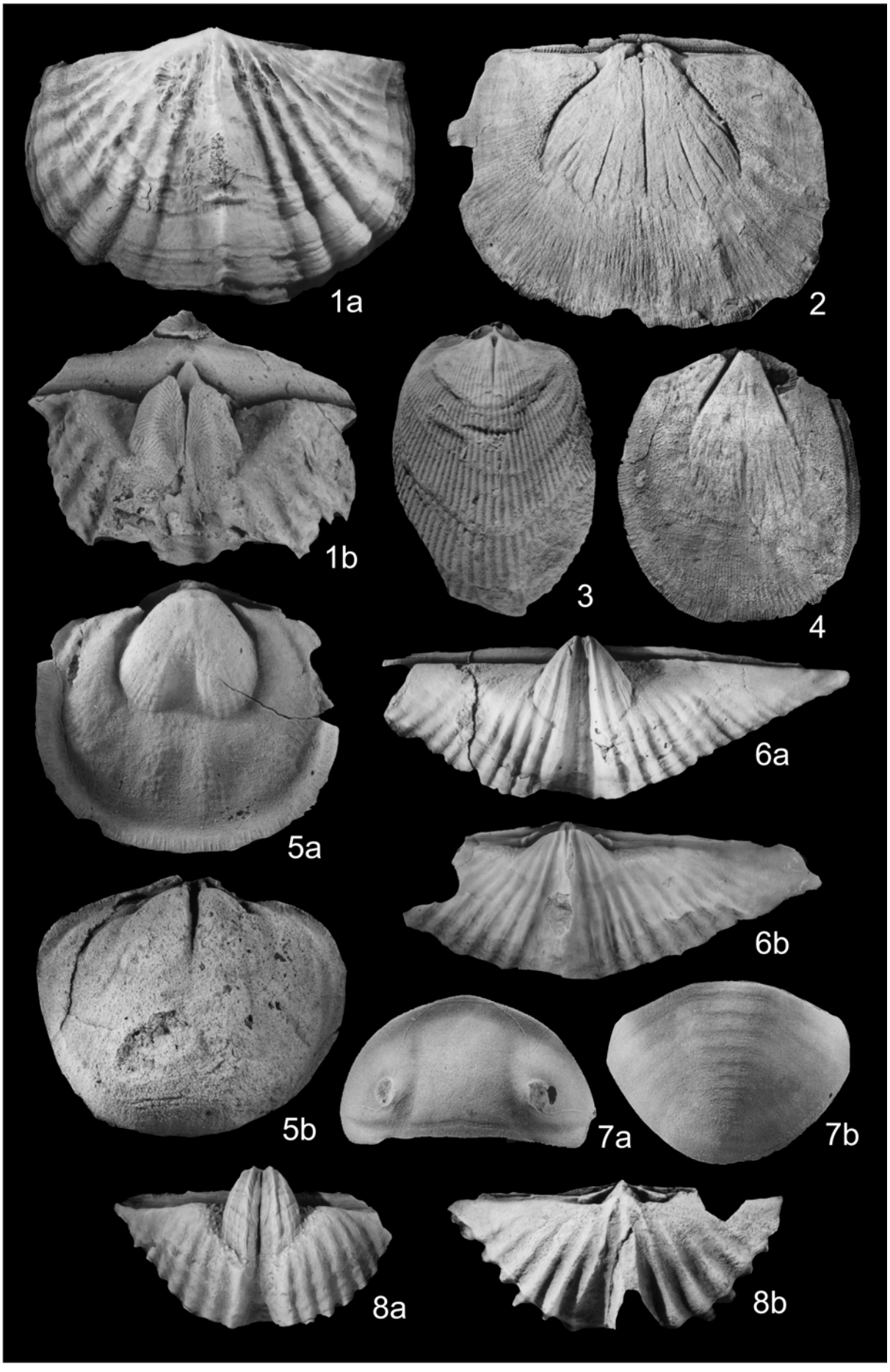

1a
2
1b
3
4
6a
5a
6b
5b
7a
7b
8a
8b

Plate 2

Trilobites from the Khebchia and Timrhanrhart formations

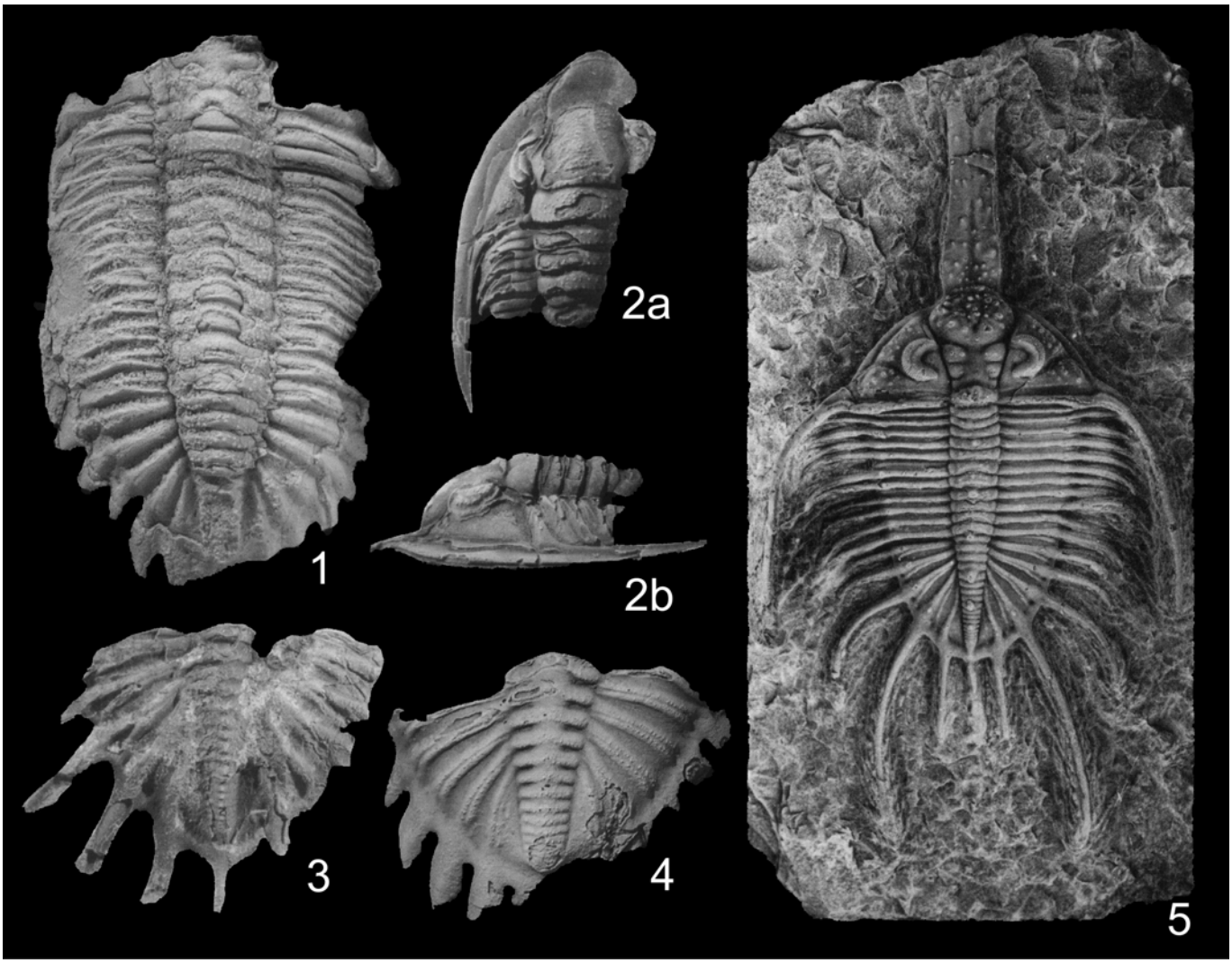
Fig. 1 *Hollardops mesocristata* (LE MAITRE 1952).
1. Dorsal view; x 1.2. Section Torkoz IIa, Khebchia Formation (refigured from SCHRAUT 2000: Pl. 13, Fig. 5).

Fig. 2 *Diademaproetus holzapfeli praecursor* G. ALBERTI 1969.
2a. Cranidium, dorsal view; x 1.8. Section Torkoz IIa, Khebchia Formation (refigured from SCHRAUT 2000: Pl. 16, Fig. 1).
2b. Cranidium, lateral view; x 1.8. Section Torkoz IIa, Khebchia Formation (refigured from SCHRAUT 2000: Pl. 16, Fig. 1).

Fig. 3 *Psychopyge elegans* TERMIER & TERMIER 1950.
3. Pygidium, dorsal view; x 1.3. Section Torkoz IIa, Khebchia Formation (refigured from SCHRAUT 2000: Pl. 15, Fig. 1).

Fig. 4 *Hollardops mesocristata* (LE MAITRE 1952).
4. Pygidium, dorsal view; x 1.2. Section Torkoz IIa, Khebchia Formation (refigured from SCHRAUT 2000: Pl. 13, Fig. 1a).

Fig. 5 *Psychopyge praestans* MORZADEC 2001.
5. Complete specimen, dorsal view; x 1.0. Jebel el Gara, SW of Foum Zguid, *Sellanarcestes* Limestone Member, Timrhanrhart Formation, (refigured from MORZADEC 2001: Pl. 13, Fig. 1a).



Upper Emsian stratigraphy at Rich Tamelougou near Torkoz (SW Dra Valley, Morocco)

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INTRODUCTION

The significance of the Lower Devonian of the Torkoz area was first highlighted by the discovery of a limestone unit with *Sellanarcestes* (HOLLARD 1960) which allowed biostratigraphic correlation over wide distances in the Dra Valley, with the area S of Akka, sections (Jebel Hamsailikh) S of Foum Zguid, and further on with the Tafilalt and Saoura Valley of Algeria. HOLLARD (1963) briefly characterized the whole Torkoz succession in a column in his stratigraphic table of the southern Anti-Atlas. Further data can be taken from his diagrams of facies development in HOLLARD (1967: figs 8-10). A detailed chart in HOLLARD (1981) mentions the Rich Tamelougou as a sampled locality but this posthumous publication does not give further explanations.

The Rich Tamelougou can be reached at ca. 10 km distance from Aouinet-Torkoz on the main track towards the S. After passing the second ridge of the ca. W-E stretching Devonian outcrop belt, the piste swings towards the W and eventually bends through a pass down into a valley between massive Rich 2 and Rich 4 sandstone cliffs. The measured section begins at GPS N 28° 23,704´ and W 09° 52,380´, in an area where there are good exposures of greenish shales on the valley floor. All beds steeply dip to the S. Sections Torkoz II, IIa, and IIa´, measured by WEDDIGE, PLODOWSKI & JANSEN in 1995 (JANSEN 2001, JANSEN et al., this vol., see also section log in SCHRAUT 2000), are situated near-by and include the same sedimentary sequence. Individual units (JANSEN numbers will be given in brackets) can be easily correlated between both studies and our rather rough thickness estimates are in general accordance with results by the Senckenberg Group. A difference lies in the fact that we have placed greater emphasis on pelagic fauna.

SEDIMENTARY AND FAUNAL SEQUENCE (Fig. 1)

Our section starts with partly cross-bedded sandstones and alternating siltstones of the upper part of the Rich 2 Sandstone Beds of the Merzâ-Akhsai Formation (unit 20). Towards the top (unit 21a, lower part of 21b), there are brachiopod coquina beds with disarticulated valves in the lower part which are embedded with their convex side upwards, suggesting tempestitic high-energy deposition. High haematite and goethite contents led to brownish to pink weathering. Shell beds are rather massive and hard. JANSEN (2001) recognized *Filispirifer merzakhsaiensis, Proschizophoria* n. sp. F, and *Rhenorensselaeria* cf. *strigiceps* in these beds.

Often covered by sandstone debris of the steep Rich 2 slope, there is a rather sharp boundary between the top of the shallowing upwards Merzâ-Akhsai and the subsequent, transgressive Oui-n-Mesdoûr Formations. The Akhal Tergoua Member consists of 8-9 m of dark, bluish weathering fine-grained limestones (main part of unit 21b) with abundant haematite (originally pyrite), suggesting an incursion of anoxia which is supported by the almost complete lack of macrofauna. This sudden change in deposition, drowning and eutrophication is correlated with the global Basal Zlichov Event (very early but not basal Emsian) but Lower Emsian conodonts (WEDDIGE in JANSEN et al., this vol.) are very sparse.

The Black Marl Member of the Oui-n-Mesdoûr Formation is characterized by a rather sudden change to 1.2 m of platy, bluish weathering marls (base of unit 22) which represent the time of maximum flooding. These are followed by 17 – 20 m of yellowish weathering shales and marls (lower part of unit 22) with minor yellow limestones, indicating a gradual filling up of the accomodation space and shallowing of the regional environment. The total thickness of the member is much reduced in comparison with the Assa area. At the top of the formation, the *Hollardops* Limestone Member consists of 5-6 m of rather solid light-grey to yellow limestones which alternate with weathered shales and marls. The underside of limestone beds may show casts of filled, simple burrows but there is no evidence of gradded bedding and the calcareous matrix between isolated bioclasts is very fine (micritic). There are abundant and large-sized, well preserved *Phacops saberensis torkozensis, Hollardops mesocristata*, rare *Psychopyge termierorum* (= *elegans* in SCHRAUT 2000: only pl. 15, fig. 3), giant-sized orthocones, large solitary Rugosa and beautiful trace fossils. SCHRAUT (2000) also found *Diademoproetus* in association with *Hollardops*. MORZADEC (2001) mentioned in the Torkoz region a section at Hassi Talah, ca. 7 km further to the SW, as an excellent trilobite locality, also yielding *Psycho. termierorum*. However, he did not realize that the main trilobite limestone and overlying goniatite beds are strictly separated. Therefore, he wrongly assumed that *Psychopyge* is restricted to the Upper Emsian *Sellanarcestes* beds. This led SCHRAUT (1998) to speculate about a Moroccan *Psychopyge elegans* Zone ca. in the middle part of the

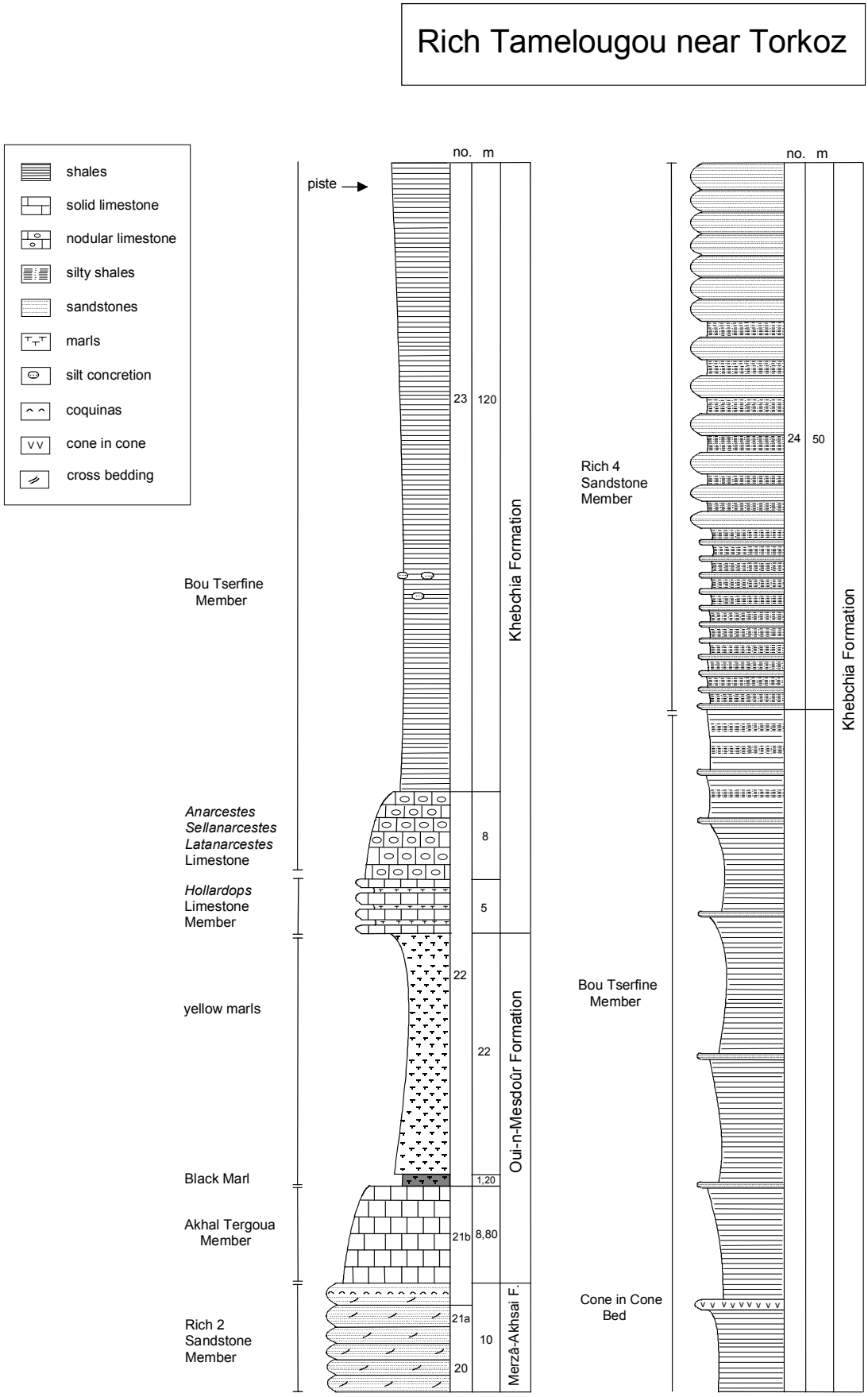

Fig. 1: Simplified lithological log of the Upper Emsian at Rich Tamelougou.

Upper Emsian (Dalejan). The new specimen suggests that a *Psychopyge* Genozone enters at the very base of the Upper Emsian and ranges into the higher part of the latter. It is possible that various species of *Psychopyge* occupy different stratigraphic positions within this interval.

The age of the *Hollardops* Limestone Member has been discussed in the chapter on Bou Tserfine (BECKER et al., this vol.). The icriodid fauna with *Caudi. culicellus, I. corniger ancestralis*, *I. fusiformis*, and some others (WEDDIGE in JANSEN et al., this vol.) is typical for early Upper Emsian strata and is also known from different regions of Spain (e.g., regional *I. culicellus* Zone of GARCIA LÓPEZ et al. 2002), the Armorican Massive (BULTYNCK & MORZADEC 1979), and from the neritic facies of the Rhenish Massive (e.g., WEDDIGE & REQUADT 1985). The conodont species range higher into the *serotinus* and *patulus* Zones (middle and late parts of the Upper Emsian) but, due to the lack of associated polygnathid in their lower range, cannot be regarded as reliable indicators of the latter. Their entry below the first anarcestids in the Dra Valley and in Spain suggests a correlation of the early *culicellus-corniger ancestralis* faunas with the upper part of the *laticostatus* Zone (see also BULTYNCK & MORZADEC 1979, GARCIA-LÓPEZ et al. 2002, and "Conodont step 22" in CARLS & VALENZUELA-RIOS 2002). SCHRAUT (1998, 2002) suggested that the Torkoz *Diademoproetus* may perhaps indicate a younger, late Upper Emsian age but the genus is also known from the early Upper Emsian of Celtiberia (CARLS 1989).

The change from neritic to pelagic sedimentation, the boundary between the Oui-n-Mesdoûr and the lower Khebchia Formations, is rather gradual (within the upper part of unit 22). The more solid trilobite limestones grade into nodular limestones with abundant goniatites, some trilobites and other fauna. This reflects the increasing influence of the global Daleje deepening of the basal Upper Emsian. The preliminary faunal list is as follows:

orthoconic cephalopods (?*Geisonoceras* sp.)
breviconic cephalopod (resembling *Lysagoraceras*)
Latanarcestes noeggerathi (abundant)
Sellanarcestes wenkenbachi
Sellanarcestes tenuior
Sellanarcestes aff. *neglectus* (= *neglectus* sensu KLUG 2003)
Anarcestes latissimus
Anarcestes simulans
Anarcestes cf. *simulans* (slightly more compressed)
Anarcestes n. sp. (compressed and rather involute form)
Phacops sp. (abundant)
Hollardops cf. *mesocristata* (rare)
Panenka div. sp.
gastropod
crinoid stem fragments
large arthrodire plate (*Antinosteus lehmanni* LELIEVRE 1984, det. H.-P. SCHULTZE, Berlin)
Oligophyllum sp. indet. (det. D. WEYER, Berlin)
different, very small-sized solitary rugose coral

The solitary rugose corals are typical for the deeper and cooler water of the *Cyathaxonia* Facies. *Oligophyllum* has a rather long range in the ?Pragian to Eifelian (oral comm. D. WEYER). The ammonoids strongly resemble late Emsian faunas from Oufrane and give a total range of three zones (*Latan. noeggerathi* Zone, LD IV-B to *Anarcestes simulans* Zone, IV-D1, see BECKER & HOUSE 1994) which indicates a strong condensation. Comparison with the thicker Bou Tserfine section and collections of the Senckenberg group (JANSEN et al., this vol.) show that closer sampling allows to separate different anarcestid levels. In the Torkoz area, the two lower members of the Khebchia Formation of the Assa region cannot yet be separated. As in the Cantabrian Mountains (HENN 1985), levels with *Latanarcestes* still fall in an interval with *I. corniger ancestralis, I. corniger leptus*, and others, which still may be slightly older than the base of the *serotinus* Zone. The subsequent *Sellanarcestes* level, however, is well correlated with the *serotinus* Zone in the Tafilalt (BULTYNCK & HOLLARD 1980) and in the eastern Dra Valley (EBBIGHAUSEN et al., this vol.). Interestingly, there is also no evidence for mixed brachiopod-ammonoid occurrences as at Bou Tserfine. The thicker successions of the Assa region formed as a consequence of a higher subsidence rate, not because of a deeper basinal setting. Laterally and episodically changing subsidence rates along the Dra Valley give evidence for synsedimentary tectonic activity.

The Bou Tserfine Member of the Khebchia Formation also is not as thick as towards the E and includes the marker seismites of Bou Tserfine as further proof of latest Emsian crustal movements. The nodular limestones quickly change into unfossiliferous green shales and siltstones, often with rounded siltstone concretions in the lower part (lower 120 m of unit 23). In its upper part, and just S of the westwards running piste, the Cone-in-Cone Marker Bed is well developed and overlain by a sandstone with rare large chonetids. With the increasing income of thin sandstones, there is a gradual transition to the Rich 4 Sandstone Member which forms the main ridge, bordering the wide plain of the Dra Valley s.str. The boundary between both members is drawn with the morphologically visible first more sequence of solid sandstones (more than 15 cm thick). This gives more than 50 m thickness for Rich 4 until the steep cliffs on its southern side which embrace a spring. Individual, brown quartzite beds near the top reach 1.5 m in thickness and are often strongly bioturbated, rippled and cross-bedded. The top of the sequence stands near vertical or is slightly (steeply) overturned. Macrofauna has not yet been collected and this suggests an extensive, inhospitable and flat nearshore sand bar environment with strong currents. Detailed sedimentological studies of this highstand system tract, however, are still lacking.

Separated by a gap in outcrop in the valley S of the Rich 4 cliffs, green, unfossiliferous siltstones and shales are exposed in low hills below Quarternary sands and gravels. These are assigned to the Givetian. Marls and sandy limestones with crinoids, brachiopods (atrypids, orthids, schizophoriids, *Leptaena*) and trilobites above the Rich 4 Sandstone Member, as well as the *Pinacites* Limestone

Member of the Yeraifa Formation, have been discovered in February 2004 to the Southeast of the measured section. The latter unit is overlain by dark grey marls with few brachiopods including *Productella*.

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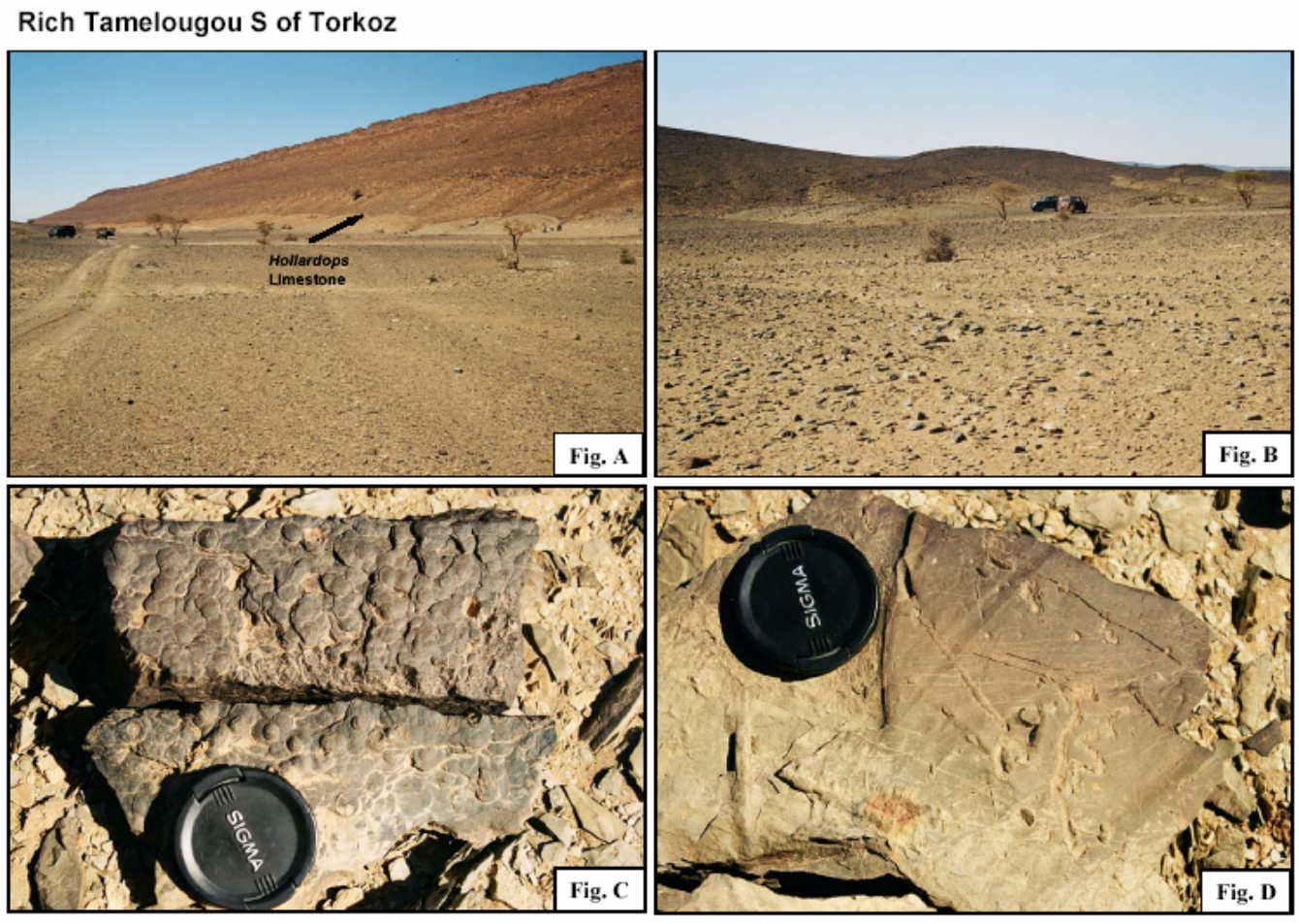
Plate 1

Fig. A: View of the steeply dipping Rich 2 Sandstone Beds of the Merzâ Akhsai Formation at Rich Tamelougou. The westwards leading track, with the cars parking next to it, runs in the higher part of the Bou Tserfine Member of the Khebchia Formation. Rubble at the base of the high cliff consist of limestones with trilobites and anarcestids from the base of the Khebchia Formation. The *Hollardops* Limestone Member (arrow) forms an extended series of low hills at the base of the ridge.

Fig, B: View to the S at Rich Tamelougou, showing the gradual change from green shales and siltstones of the Bou Tserfine Member to the sandstone-siltstone alternations in the lower part of the Rich 4 Sandstone Member of the Khebchia Formation.

Fig. C: The Cone-in-cone Marker Bed in the upper part of the Bou Tserfine Member at Rich Tamelougou.

Fig. D: Strongly bioturbated fine sandstones near the base of the Rich 4 Sandstone Member at Rich Tanelougou.



Lower and Middle Devonian stratigraphy and faunas at Bou Tserfine near Assa (Dra Valley, SW Morocco)

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LOCATION AND INTRODUCTION

The main road from Assa to Foum El Hassane first crosses the Oued Mouf and then runs in NE direction, first N, later S of it, parallel to the marker ridge of Rich 2, for a distance of ca. 45 km. Ca. 18.5 km NE of Assa, there is a small interruption of the ridge and a piste branches off and winds through the sandstones. Subsequently it turns to SW, crosses the valley formed by the erosion of a Lower Devonian syncline, and then approaches the anticline N of Bou Tserfine (Fig. 1). The thick, measured section starts on the southern slope of the ridge formed by Rich 2 and follows the ca. N-S running oued just W of the deserted village which is marked by a conical hill with a kasbah ruin on top. The ca. W-E running ridge of Rich 4 to the south forms another marker for easy orientation. The start of the section lies in a small dry valley at GPS N28° 39,196´ and W09° 16,093´. The Upper Emsian part can be recognized by some palm trees which offer shade for resting and parking. The Bou Tserfine section previously has not been studied although it is thicker than sections to the West. Its specific importance also lies in some mixed neritic-pelagic faunas of Lower and Middle Devonian age.

SEDIMENTARY AND FAUNAL SUCCESSION (Fig.2)

Rich 2 Sandstone Beds

The sandstones of Rich 2 (Rich 2 Sandstone Member of the Mersakhsai or Merzâ Akhsai Fm., Pragian) are best exposed on the ridge but have not been studied in any detail. Only few beds seem to be fossiliferous. At the base of the measured section there is a fine exposure of the topmost sandstone beds and of the transition to the overlying Lower Emsian shales and limestones. Beds A0 to A4 are cross-bedded sandstones which change their thickness laterally. The surface of Bed A0 is visible in the dry valley and is greenish, followed by 10 cm of siltstone. At the top of Bed A1 there are shell fragments, black phosphatic nodules up to 8 cm in diameter and some reworked (burrowed) siderite clasts. Laterally, oscillation ripples are well developed which prove a very shallow, probably intertidal depositional setting. At the base of Bed A2 there is a 30 cm siltstone interval. The overlying sandstones wedge out over short distances which suggests deposition as shallow marine channel fills. This is supported by conglomeratic intercalations with some clasts reaching 10 cm in diameter. There are also more, but mostly small phosphatic nodules and mud diapirs. Higher up (Beds A2 and A3), thick-shelled brachiopods can be abundant in shell beds which may represent tempestites. There are also some crinoid ossicles (Bed A2). Another shell layer is developed at the top of Bed A4. Bed A5 represents the irregularly bedded calcareous transition between the top of the Mersâ Akhsai Formation and the overlying, still very argillaceous units of the Oui-n-Mesdoûr Formation (formerly also named as "Assisse d´El Ansar", HOLLARD 1963a). Brachiopods occur in several layers but are not yet identified. The transitional nature shows that there is no significant hiatus as proposed by HOLLARD (1978). A sequence boundary would be placed within the top of the Rich 2 sandstones, terminating the second major sedimentary cycle of the Dra Valley Devonian.

Oui-n-Mesdoûr Formation

The greenish siltstones and shales of Bed A6 indicate a further deepening (transgressive system tract) in the earliest Emsian but the lack of macrofaunas in Beds A6 and A7 makes it difficult to correlate this phase with eustatic deepening events known elsewhere. Generally, the event terminology of the basal Emsian still needs to be developed since several pulses can probably be distinguished on a global scale. Most likely, the onset of the third major regional sedimentary cycle of the Devonian correlates with the Basal Zlichov Event which postdates the base of the Emsian as defined in the Asian GSSP. Marly limestone deposition commences with Bed A8. The alternation of grey-bluish marls and limestones, unfortunately, is poor in macrofauna (few fish remains, tentaculites, trilobites, rare solitary Rugosa). On sheet Foum el Hassane-Assa, this unit or member has been named as "Calcaire noir à *Odontochile spiniferum*" but here the new name Akhal Tergoua Member is used (see introduction chapter, index trilobite collected in March 2004 from Bed A11). It is probably contemporaneous with the *Anetoceras* bearing limestones of HOLLARD (1963b), which, however, are currently only known from the NE Dra Valley around Foum Zguid. Bed A10b is a somewhat thicker marker unit which can be followed on strike. It contains well-preserved *Latericriodus beckmanni beeckmanni* which is typical for the Lower Emsian (Zlichovian) *excavatus* Zone. A continuing deepening is indicated by a change to dark grey marls and less calcareous limestone beds towards the top of Unit A (Beds A14 to A18, the latter with many tentaculites). Unit B, the next member (new Black Marl Member), comprises a cyclic sequence of deeply weathered shales and of thin black marls with some tentaculites and occasional minute

brachiopods, formerly known as "Schistes argileux à *Tentaculites*". This maximum flooding phase led to the first fully pelagic facies recognized in the Bou Tserfine section and should correlate with the global peak of the early Emsian (Zlichovian) transgression. A mostly covered subsequent interval follows above mostly yellowish weathering shales and has been named as Unit C. Towards the east, with the best locality 8 km SE of Foum El Hassane, the Black Marl Member becomes more condensed but remains rather unfossiliferous and overlies bluish weathering dark grey limestones with some large pelecypods (*Panenka* sp.) which are typically found in pelagic facies. Towards the West, around Torkoz, the black marls grade upwards into yellow weathering marls, indicating, as at Bou Tserfine, a better oxygenation due to shallowing (early highstand phase).

Hollardops Limestone Member (basal Khebchia Formation)

The next important and regionally widely distributed marker horizon (Unit D) is the *Hollardops* Limestone Member at the base of the Khebchia Formation. It consists of an alternation of light to medium grey, sometimes reddish, trilobite-rich marly limestones and of dark grey to grey, marly shales. It seems to represent the late highstand system tract of the regional Cycle 3. The rather dark shales at the base may mark a minor deepening pulse.

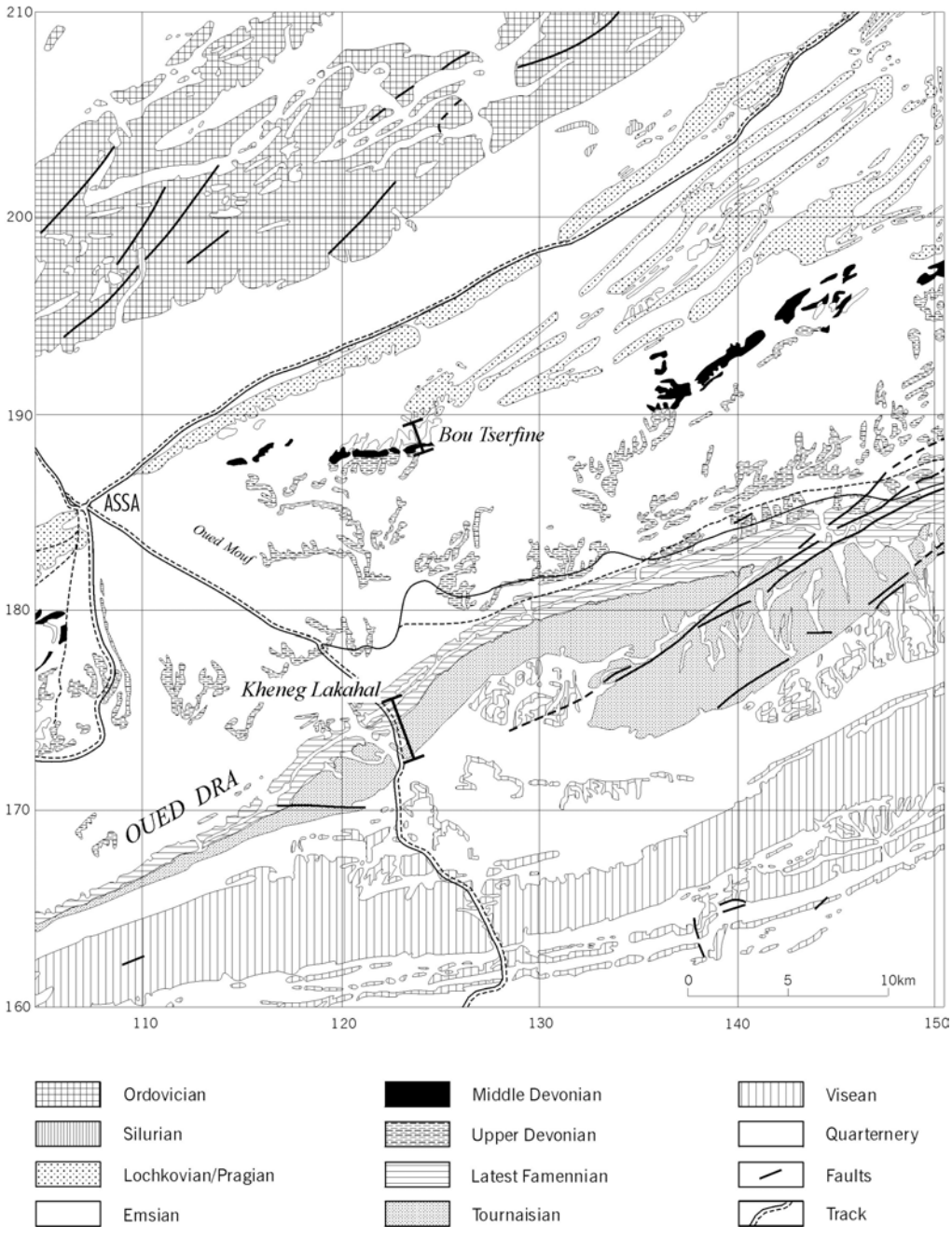

Fig. 1: Location of the Bou Tserfine section E of Assa in the western Dra Valley.

HOLLARD (1978) has aligned this marked neritic carbonate unit with the overlying nodular limestones with more pelagic assemblages. The fauna of Unit D is dominated by very abundant, well-preserved *Hollardops mesocristata* and *Phacops saberensis torkozensis*. There are both disarticulated moulting remains as well as complete, often enrolled specimens. The different enrolling modus of asteropygids and phacopids can be observed in numerous specimens. The original dark shells give a beautiful contrast to the much lighter rock colour. In addition, there are rare other trilobites (*Psychopyge*, proetids, odontopleurids), giant orthocones, coiled nautiloids (leg. I. TROTH, March 2004), small-sized solitary Rugosa (*Palaeocyathus* sp., det. D. WEYER), *Favosites* sp., other tabulate corals, some gastropods, few styliolinids, some ostracods (*Preapilatina* sp., *Polyzygia kroemmelbeini*), and rare atrypids, athyrids and other small brachiopods, including inarticulate forms (acrotetrids) in conodont residue. It is intriguing that the largest known Moroccan Devonian nautiloids come from a rather neritic facies and not from pelagic limestones. There are septate fragments of 20 cm lengths and 7 – 7.5 cm diameter, suggesting an overall shell lengths in the scale of 80 cm to 1 m, perhaps even more, depending on the original lengths of the body chamber. Haematite-filled borings increase in number toward limestone tops and point to reducing conditions in the sediment. At the very top of Unit D, more solid and thick beds grade into limestone nodule levels. This indicates that the reversal from shallowing to rising sea level, the transition from the third to the fourth Dra Valley Devonian cycle, locally occurred without a sequence boundary within the member.

The age of the *Hollardops* Limestone Member cannot be determined easily due to the absence of marker polygnathids. Samples from the base of the member at Bou Tserfine were inproductive. *Palaeocyathus* is a long-ranging deeper-water coral known from the upper Silurian to Upper Emsian (written comm. D. WEYER). Conodonts from the Torkoz area (JANSEN et al., this vol.) consist mostly of icriodids. Species such as *Caudi. culicellus, I. fusiformis*, and *I. corniger ancestralis* are not known from the Lower Emsian limestones of the Tafilalt (e.g., BULTYNCK & WALLISER 2000), Cantabrian Mountains (Requejada Member of the Abadia Formation, GARCIA-LOPEZ et al. 2002, including the "Capas de Vanes" levels of MONTESINOS 1991) or Armorican Massive (BULTYNCK 1989) and indicate a basal Upper Emsian age (ca. upper part of *laticostatus* Zone). It is probably no coincidence that giant orthoconic nautiloids also occur in the basal Upper Emsian d4bγ Member of the Mariposas Formation in Celtiberia which just follows the entry of *Caudi. culicellus* (CARLS 1989, CARLS & VALENZUELA-RIOS 2002). Similar as in the Dra Valley, the Spanish formation has mostly icriodids (*I. fusiformis*) but it shows a succession from *Now. cancellata* to *Now. richteri* as it is known from the lower part of the Dalejan in Bohemia. In the Palentinia Domain of NE Spain, *Gyroceratites pallantianus*, a marker of LD III-A (BECKER & HOUSE 1994), occurs around the level with first *I. corniger ancestralis* and with *Now. cancellata* (MONTESINOS & TRUYOLS-MASSONI 1987, conodonts in GARCIA-LÓPEZ et al. 2002). In summary, a basalmost Upper Emsian age (LD IV-A) of the *Hollardops* Limestone Member seems well established. Data from the very base of the Khebchia Formation may be helpful for the future decision on the formal substage boundary.

Brachiopod Marl Member (new)

The change from nodular limestone to calcareous shales forming Bed E1 of the lower Khebchia Formation, here defined as Brachiopod Marl Member (a transgressive system tract), is interpreted to correlate with the main deepening of the global but gradual Daleje Event above the base of the Upper Emsian. Sequence stratigraphy and the presence of typical Dalejan oldest anarcestids in higher beds contradict the assumption of JANSEN (2001) that the base of the Khebchia Formation is younger than the base of the Daleje Shales. There is a very rich but unusually small-sized fauna consisting of nice brachiopods, crinoid ossicles, edrioasteroids (leg. G. MCINTOSH, March 2004), solitary Rugosa, snails and further asteropygid and phacopid trilobites. According to preliminary identifications, the following taxa can be recognized:

Laccophyllum sp. (det. D. WEYER, Berlin)
Phacops saberensis ssp.
Hollardops mesocristata
strophomenids (several species)
athyrids (several species)

The potential of the fauna for correlation has not been exploited since brachiopod identifications are not possible without knowledge of internal features. In the higher part of Unit E (upper part of the Marl Member), well-bedded or nodular limestones re-appear. The second limestone bundle (Beds E2 and E4) yielded few rugose corals, rare ostracods, no conodonts, the nautiloid *Arthrophyllum* and mostly poorly preserved *Latanarcestes noeggerathi*. This allows a dating as second ammonoid zone of the Upper Emsian (LD IV-B, see BECKER & HOUSE 1994) and precise correlation with the main part of the Bohemian Daleje Shale. It is possible that *Gyroceratites gracilis* mentioned from elsewhere by BULTYNCK & HOLLARD (1980) came from the same level or from just below. The *Latanarcestes* level represents locally the second maximum flooding and incursion of fully pelagic facies into the predominantly neritic Lower Devonian successions of the Assa region. Conodonts associated with *Latanarcestes* in the Torkoz area (WEDDIGE in JANSEN et al., this vol.) do not differ from the basal parts of the Khebchia Formation. There are also striking similarities with the Lezna Member of the Arauz (or Abadia) Formation of Palencia (Cantabrian Mountains, HENN 1985) where *Latan. noeggerathi* is associated with the same icriodids (including oldest *I. corniger leptus*) as at Torkoz. This suggests that the *Caudi. culicellus-I. corniger ancestralis* faunas are of high correlative value in the basal Upper Emsian (LD IV-A/B), in a position between youngest Lower Emsian polygnathid faunas and polygnathid faunas indicative of the *serotinus* Zone (e.g., BULTYNCK & HOLLARD 1980, BULTYNCK 1985, including oldest *Linguipo. bultyncki*). GARCIA-LÓPEZ & SANZ-LÓPEZ (2002) consequently recognized a *culicellus* Zone in the basal Upper Emsian of the Cantabrian Mountains, followed by a zone with *I. corniger ancestralis*. The rarity of polygnathids in pelagic *Latanarcestes* assemblages does not conform with the standard models of conodont biofacies.

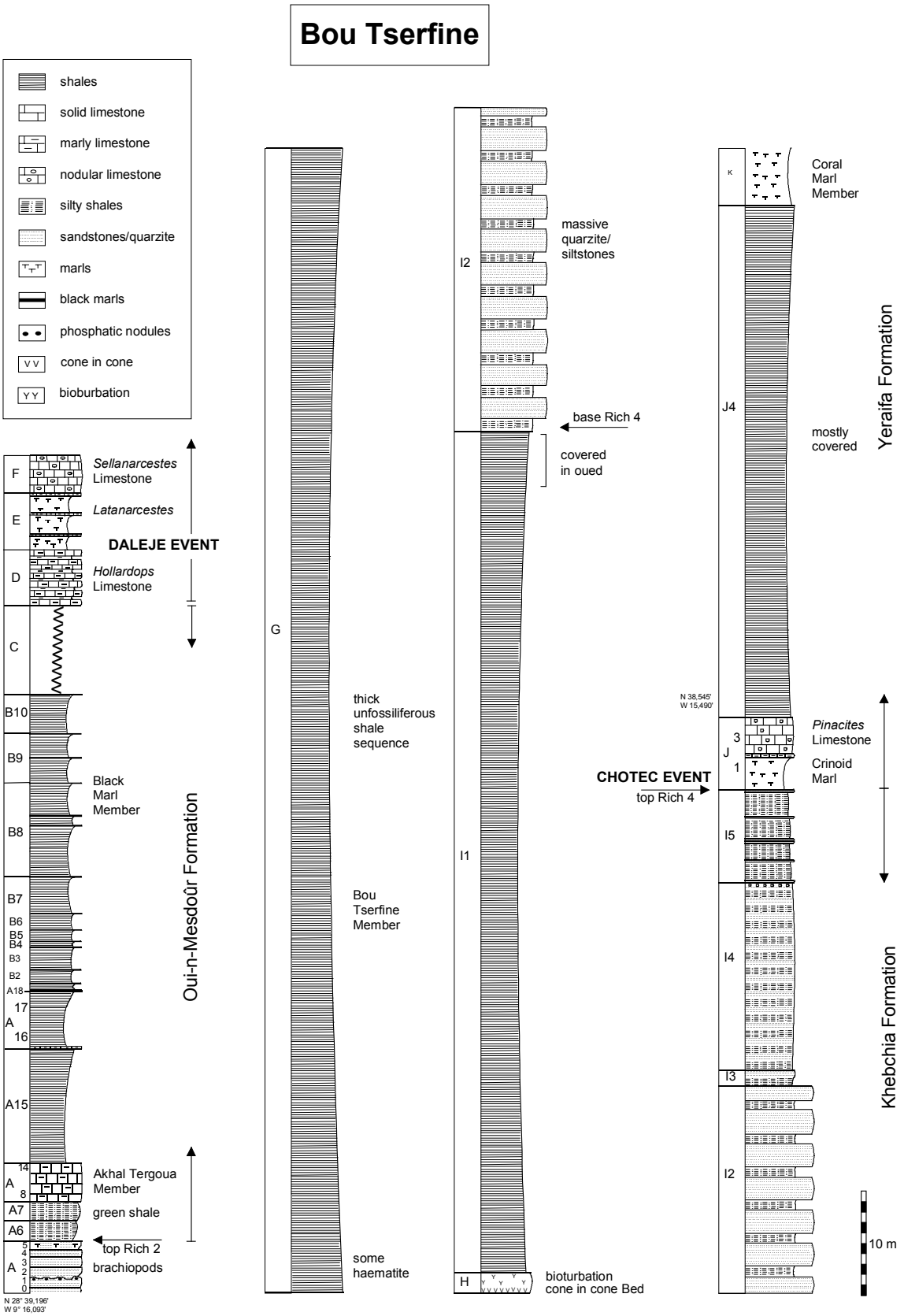

Fig. 2: Late Pragian to Eifelian lithostratigraphy and the position of the Basal Zlichov (Akhal Tergouna Mbr.), Daleje and Chotec Events at Bou Tserfine.

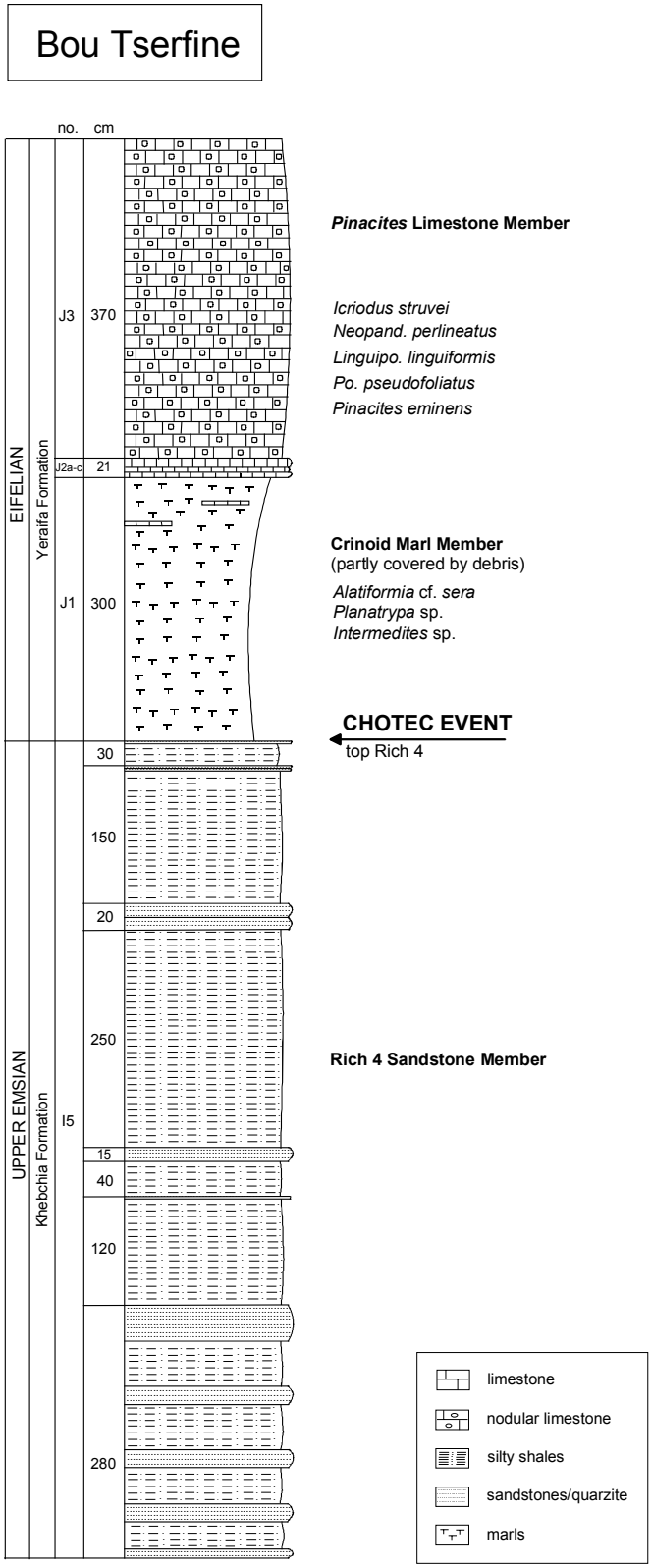

Fig. 3: More detailed lithological log of the Emsian/Eifelian boundary interval at the slope of Rich 4 at Bou Tserfine.

Sellanarcestes Limestone Member (new)

There is a gradual transition to a thicker and more fossiliferous limestone unit, the *Sellanarcestes* Limestone Member (Unit F). This slight shallowing upwards trend (highstand system tract) correlates well with the gradual transition from thick equivalents of the Daleje Shale to the overlying nodular *Sellanarcestes* Limestones in the Tafilalt and Maider (e.g., BULTYNCK & HOLLARD 1980, BECKER & HOUSE 1994). In Bohemia, the same gradual regression causes the transition from the Daleje Shales to the Trebotov Limestone. Locally, and in accordance with a more intermediate facies setting, abundant goniatites and orthoconic cephalopods are associated with neritic faunal elements, such as large-sized pelecypods, crinoid remains, gastropods, and diverse small-sized brachiopods. The complete faunal list is (preliminarily) as follows:

Phacops sp.
Hollardops sp.
Panenka sp.
Platyceras sp.
Hyolithes sp.
crinoid remains (ossicles, stem pieces, cusp parts)
solitary Rugosa
athyrids, strophomenids, plectodontids and ?terebratulids (see Pl. 1, partly the same taxa as in Bed E1)
Arthrophyllum sp.
other orthoconic cephalopods
Sellanarcestes tenuior
Sellanarcestes aff. *neglectus* (= *neglectus* sensu KLUG 2003, two morphotypes)
Sellanarcestes neglectus s.str. (sensu CHLUPAC & TUREK 1982)
Sellanarcestes n. sp. (rather thick morphotype, with flattened venter as in *Latanarcestes ventroplanus*)
Anarcestes latissimus
Anarcestes simulans
Anarcestes n. sp. (rather involut, very shallow flank lobes, thinly discoidal)

The collected faunas from the higher part of the *Sellanarcestes* Limestone Member clearly falls in LD IV-D1 of the zonation introduced by BECKER & HOUSE (1994), characterized by the association of *Sellanarcestes* and *Anarcestes* (correlating with the upper part of the *serotinus* Zone). *An. simulans* is a widespread species and regionally selected as index species. According to KLUG (2003), *An. lateseptatus* enters in the Tafilalt higher and this is supported by the current lack of this species in levels with *Sellanarcestes* in the Dra Valley. It is possible that oldest parts of the member, which have few goniatites, do not yet contain *Anarcestes* (LD IV-C). The peculiar fauna with *Achguigites*, known from Oufrane, has not yet been found in the western Dra Valley.

Bou Tserfine Member (new)

The well oxygenated nodular limestones are overlain by a very thick succession of green shales and siltstones, here named as new Bou Tserfine Member of the Khebchia Formation. As a transgressive system tract, it allows in the southwestern part of the Dra Valley a sequence

stratigraphic subdivision of the Devonian Cycle 4. Internationally, this sea level rise seems to correlate with the base of T-R-Cycle Ic of JOHNSON et al. (1985). In the lower part there is a relative poor fauna consisting of squashed and haematized orthocones (including a ribbed *Lobobactrites*), rare phacopids, and poorly preserved bivalves, suggesting reduced seafloor oxygenation (dysaerobic facies). Towards the top (and south), fossils disappear completely and the silt content increases, leading to greater resistance against weathering, and indicating a slowdown of transgression and filling of the basin. Before the main oued curves around to the west, the member is subdivided by a sandy Cone-in-Cone Marker Bed, representing a synsedimentary seismite of 15-20 cm thickness. The same bed can be followed over more than 70 km distance to the Torkoz area and is an excellent event stratigraphic marker. It is overlain by ca. 2 m of siltstones/fine sandstones with strong bioturbation. The upper part of the member is mostly covered in the oued which contains hard calcrete sheets.

Rich 4 Sandstone Member (new)

The sandstones of Rich 4 (Unit I) form the upper member of the Khebchia Formation, exposed in a high and prominent cliff with a steeper northern slope. This unit represents a significant shallowing episode (late highstand system tract) which, however, is not very distinctive in the Tata region and further on to the East. Thick quartzites alternate with finer sandstones and siltstones which show a wide array of sedimentary structures (e.g., widespread convolute bedding) and diverse trace fossils. However, other macrofauna is rather rare. Chonetids and strophomenids have been found in loose plates towards the SW but may have been transported over a long distance by the river during short-termed flooding events. The most massive quartzites with intertidal ripple marks are developed near the ridge top. The change from low sea level to the transgressive system tract of the basal Yeraifa Formation is gradational and exposed on the southern slope of the ridge (Fig. 3). The Emsian/Eifelian boundary must lie within the sandstone member.

Crinoid Marl Member (lower Yeraifa Formation, new**)**

Unit I5 consists of medium-bedded sandstones and siltstones with some brachiopods at the top of Rich 4 which are followed by the 3 m new Crinoid Marl Member (Bed J1). The latter is strongly covered by Rich 4 debris but produced abundant and diverse crinoid ossicles, edrioasteroids (leg. MCINTOSH, March 2004), phacopids, proetids, scutelluids, and an important neritic brachiopod fauna (det. EBBIGHAUSEN & JANSEN):
Intermedites sp. (Pl. 1, Figs C)
Alatiformia cf. *sera* (Pl. 1, Figs D)
Planatrypa sp. (Pl. 1, Figs F)
Isorthinae indet. (overgrown by *Spirorbis*, Pl. 1, Figs B)
plectodontid
pentamerid (*"Gypidula"* sp.)
Oligoptycherhynchus sp. (Pl. 1, Figs A)
Kransia sp.
"Leptaena" sp.

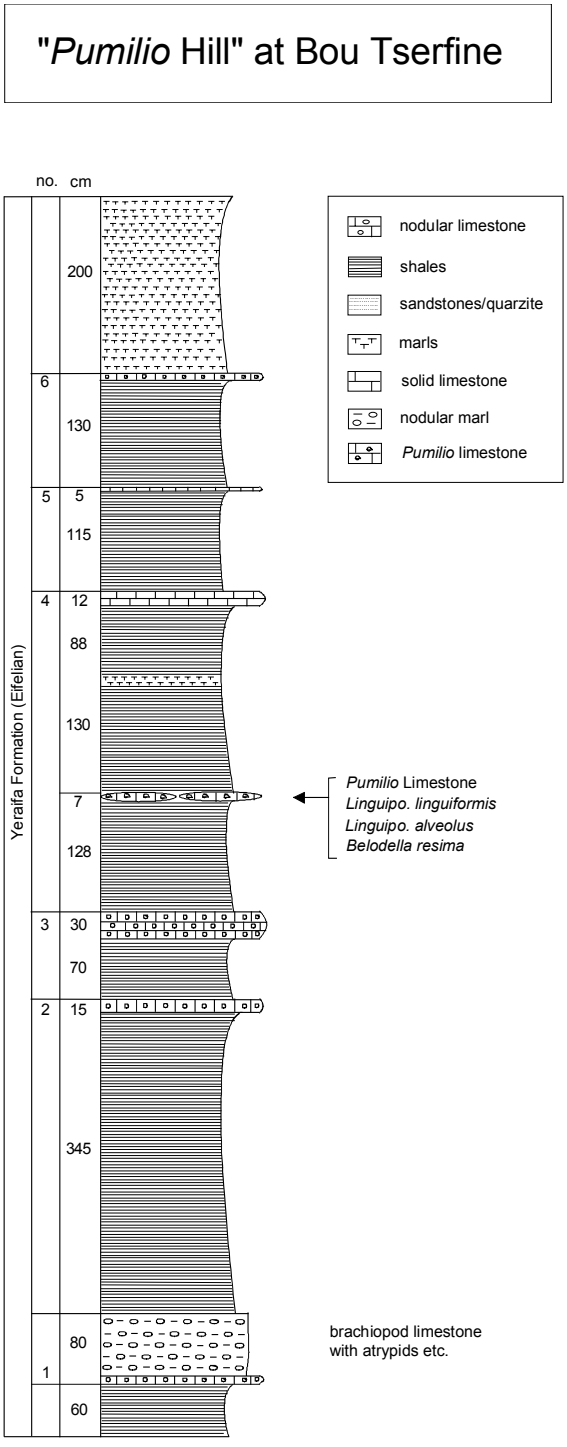

Fig. 4: Detailed lithological log of the Eifelian at *Pumilio* Hill, S of Rich 4 at Bou Tserfine.

Preservation resembles the Eifel Mountains of Germany. Precise dating requires a more detailed study of the brachiopods. Conodont results are still lacking. *Alatiformia* cf. *sera* is based on a single specimen from Gees (Ahrdorf Formation, middle Eifelian, STRUVE 1963) but the range of the rare species is not established and the Moroccan specimen is significantly smaller. *Planatrypa* enters with the small-sized and different *Plana. tirocinia* in the Eifel Mts. also in the Ahrdorf Formation but COPPER in BRICE et al. (2000: Fig. 4) gives a basal Eifelian to perhaps even

latest Emsian lower range for the genus. *Kransia* is a typical Eifelian rhynchonellid genus whilst *Oligoptycherhynchus* has a longer range (BRICE et al. 2000). From a sequence stratigraphic viewpoint, it seems possible that the transgressive Crinoid Marl Member correlates with the global Chotec Event (early Eifelian, MD IIB/C transition, uppermost *partitus* to basal part of *costatus* Zone; conodonts in BULTYNCK 1985 and KLUG et al. 2000). Since the underlying sandstones are very poor in fauna, the event was locally not associated with an extinction.

***Pinacites* Limestone Member** (new)

Unit J2 consists of three solid marker limestones with *Fidelites* sp. which may perhaps correlate with a massive marker limestone unit of the lower part of the *costatus* Zone of the Tafilalt (BULTYNCK 1985: Bed 7 at Bou Tchrafine; upper MD II-C, BECKER & HOUSE 1994; Bed 30 at the base of Unit G at Jebel Mech Irdane, WALLISER 2000, see also KLUG et al. 2000 and KLUG 2000). More diverse pelagic faunas re-immigrated into the region with Unit J3 which is characterized by well-preserved *Pinacites eminens*, in association with abundant ostracods (including various spinose species), the large bivalve *Panenka*, solitary Rugosa, so far unidentified phacopids (mass occurence of silicified debris in conodont residue), and rare proetids (the first Eifelian representatives of the family from the Dra Valley). *Pinacites* is an early Eifelian marker ammonoid (defining the thin MD I-C zone, BECKER & HOUSE 1994) which enters in the Tafilalt at the top of the transgressive Chotec Event beds but which continues into oldest beds with *Cabrieroceras* (MD II-E1, still *costatus* Zone, BECKER & HOUSE 1994, updated; KLUG et al. 2000, KLUG 2003). A conodont assemblage obtained from a dissolved *Pinacites* is distinctive and includes:
Polygnathus pseudofoliatus
Linguipolygnathus linguiformis
Belodella resima (rare)
Neopanderodus perlineatus (rather frequent)
Icriodus struvei (rare)

The abundance of *Neopanderodus* is striking since the genus normally occurs in shallow-water or even reefal facies without goniatites (WEDDIGE 1988). *Linguipo. linguiformis* enters at Bou Tchrafine (BULTYNCK & HOLLARD 1980, BULTYNCK 1985) in the Chotec Event level. *Po. pseudofoliatus* appears somewhat higher in the *costatus* Zone, above the mentioned marker limestones (near the MD II-D/E boundary, BECKER & HOUSE 1994). This constrains the age of the collected *Pinacites* level at Bou Tserfine to be in the upper range of the genus. BELKA et al. (1997) showed that the upper part of the *costatus* Zone with *Po. pseudofoliatus* is a rather thick interval in the eastern Anti-Atlas. It correlates in the sequence of the Eifel Mountains of Germany with upper members of the Nohn Formation (WEDDIGE 1977, 1988) which, however, lack the marker conodont. This leaves doubts that the famous *Pinacites* fragment of SCHMIDT (1950, refigured in BECKER & HOUSE 1994) came, as suggested by STRUVE (1992), from the Flesten oder Wasen levels of the subsequent Ahrdorf Formation near Gees which already falls in the *australis* Zone. The latter has not yielded any *Pinacites* in the Tafilalt which supports the suspicion of WEDDIGE (1977: p. 342) concerning the true level of the Eifel *Pinacites*. In the continuation of the Eifel to the W, in the Ardennes, still unpublished new specimens of *Pinacites* are only known from the early Eifelian (probably Chotec level). A *Pinacites* mentioned by STRUVE (1992: p. 512) from possibly much younger beds (Junkerberg Formation) has not been illustrated and may belong to the derived genus *Exopinacites* which also has been found (March 2004) at Bou Tserfine. In summary, Unit J3 falls in the late part of the lower Eifelian (middle to upper part of the *costatus* Zone) and should correlate with the Nohn Formation of the Eifelian type region. KLUG (2002) correlated the short transgressive phase in the upper range of *Pinacites* with the international depophase Id of JOHNSON et al. (1985) but the main pulse is that of the Union Springs Shale of New York (basal *australis* Zone) which seems to be preceded by an earlier transgression.

Grey Marls

The Rich 4 debris covers most of the subsequent Eifelian shales but there is a small outcrop in a low hill, here named as *Pumilio* Hill, several hundred meters to the SW of the main section in the wide plain formed by the dry valley. A detailed section is illustrated in Fig. 4. At the base, the deeply weathered light grey to yellowish and unfossiliferous shales are interrupted by a bioclastic limestone with some poorly preserved atrypid brachiopods. Higher, more nodular and marly limestones only yielded an orthoconic cephalopod. Of special interest is a rather thin, dark grey, lenticular limestone which is covered by small sized terebratulids which are commonly named as "*Pumilios*". Associated are rare gastropods, silicified ostracods and some styliolinids. Conodonts are very scarce and include *Linguipo. linguiformis, Linguipo. alveolus*, *Ctenopolygnathus angustipennatus* juv. and *Belodella resima*. The second species enters low in the *costatus* Zone (BELKA et al. 1997) but becomes more abundant in the late part of the zone and in the *australis* Zone (e.g., in the Eifel Mts., WEDDIGE 1997); the third is a long-ranging species in the *costatus* Zone (BULTYNCK 1985, BELKA et al. 1997). This suggests a middle Eifelian age for the exposed beds. It is likely that there are several discontinuous levels of the same brachiopod facies, as better exposed S of Torkoz. Taxonomic relationships with younger, Givetian "*Pumilios*" are still unclear but Eifelian "*Pumilio* Beds" have also been recognized at Oufrane in the Tata region (EBBIGHAUSEN et al., this vol.) and seem to be regionally characteristic. The origin of the type Lower and Upper *Pumilio* Beds needs to be re-evaluated in the light of their older counterparts.

Coral Marl Member (new)

At some 100 m walking distance and downslope Rich 4, from the *Pinacites* Limestone, very different and so far undescribed neritic faunas occur in yellowish marls above a solid, dark "*Pumilio*" Limestone. There are well-preserved solitary rugose corals (N. Gen. aff. *Catactoechus* n. sp., det. S. SCHRÖDER, Cologne; *Adradosia* sp., det. D. WEYER, Berlin), few brachiopods (including *Stringocephalus*, leg.

BECKER & SCHRÖDER, March 2004), phacopids, rare orthocones and various tabulate corals, for example *Thamnopora, Alveolites* and *Heliolites*, which all were capable to colonize very soft substrates. The age is early Givetian. Nodular limestones exposed laterally are slightly older and yielded a single agoniatitid. There are also some brachiopods and a large fragmentary rugose coral. These faunas need to be re-sampled. Much further to the south, low hills bordering the wide oued contain completely decalcified concretions of up to 10 cm diameter. They are light grey, flattened and strongly laminated which suggests quiet, basinal deposition. Their fauna consists of orthocones, pelagic-type bivalves (*Buchiola* and others), styliolinids and involute, poorly preserved goniatites. This indicates a Givetian to Frasnian age (Oued Amstil Formation s.l.).

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Plate 1

Representatives of neritic fauna from the Upper Emsian (GPS: N 28° 38,993´, W 09° 16,000´) and Lower Eifelian (GPS N 29° 38,551´, W 09° 15,950´) of Bou Tserfine.

Figs A: *Oligoptycherhynchus* sp., no. 280/86, ventral, dorsal, frontal and lateral views, Bed J1, upper part (lower Eifelian), x 2.

Figs B: Isorthinae sp., overgrown by *Spirorbis*, no. 280/81, ventral, dorsal, frontal, and lateral views, Bed J1, upper part (lower Eifelian), x 2.

Figs C: *Intermedites* sp., no. 280/91, ventral, dorsal, and frontal views, Bed J1, upper part (lower Eifelian), x 1.5.

Figs D: *Alatiformia* cf. *sera* STRUVE 1963, no. 280/93, ventral, dorsal, frontal, and apical views, Bed J1, upper part (lower Eifelian), x 4.

Figs E: Athyrid, no. 280/29, ventral and dorsal views, Bed F (Upper Emsian), x 5.

Figs F: *Planatrypa* sp., no. 280/102, ventral, dorsal, frontal, and lateral views, Bed J1, upper part (lower Eifelian), x 1.5.

Figs G: Plaectodontid, no. 280/22, ventral and dorsal views, Bed F (Upper Emsian), x 5.

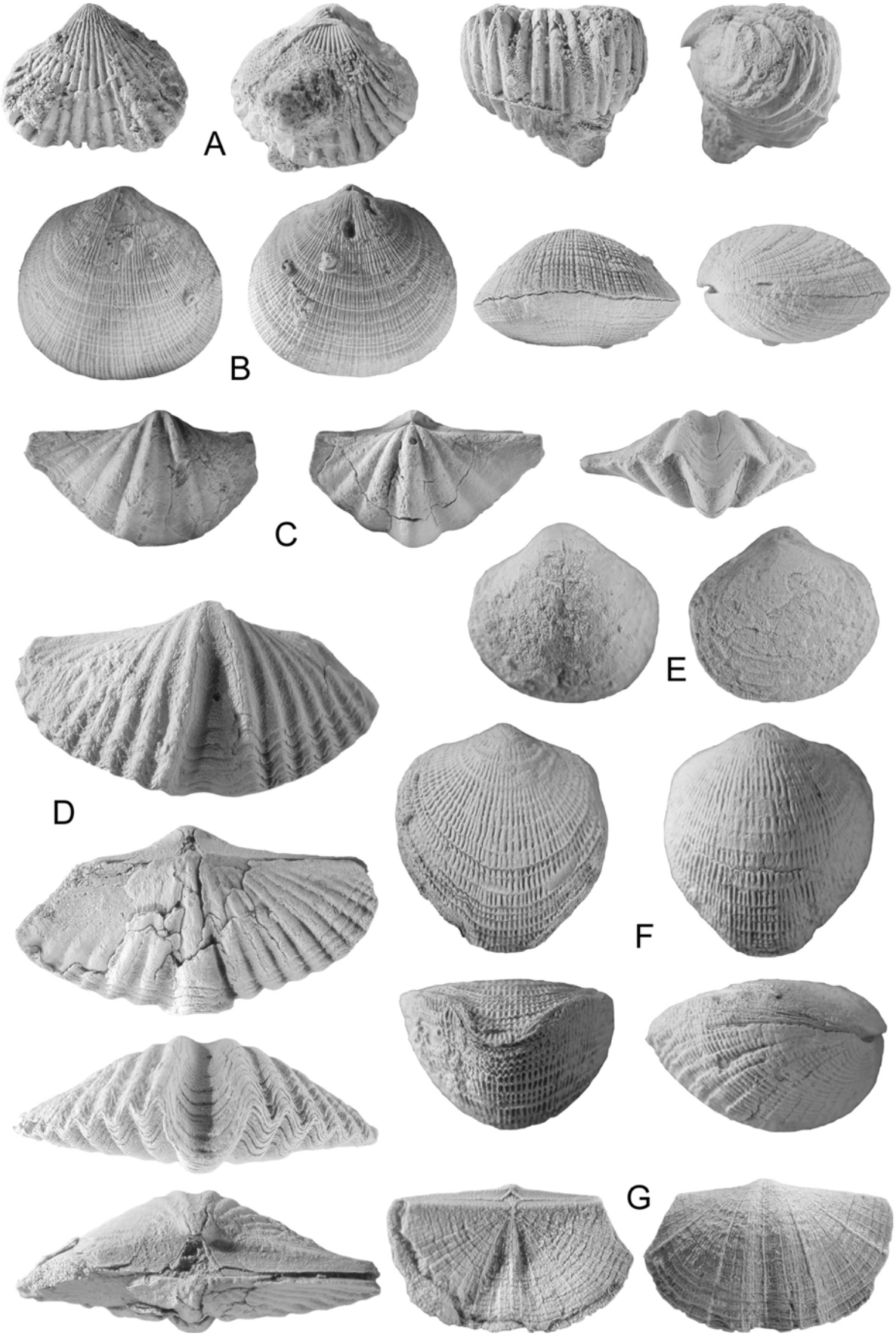
A
B
C
D
E
F
G

Plate 2

Fig. A: View from Rich 4 towards the North, with the isolated kasbah as landmark, and with Rich 2 forming the ridge in the background.

Fig. B: Ridge formed by the *Hollardops* Limestone Member. Rich 2 forms the background and it is separated by a wide plain occupied by the Oui-n-Mesdoûr Formation.

Fig. C: View from the top of Rich 4 showing the strongly covered transition from the upper Khebchia Formation to the Yeraifa Formation occupying the plain. The *Pinacites* Limestone Member forms a minor cliff in the midground.

Fig. D: Trace fossil from the Rich 4 Sandstone Member.