ISSN (print): 1698-6180. ISSN (online): 1886-7995
www.ucm.es/info/estratig/journal.htm

Journal of Iberian Geology 33 (1) 2007: 31-40

Tectonic evolution from the Hercynian shortening to the Triassic extension in the Paleozoic sediments of the Western High Atlas (Morocco)

Evolución tectónica desde el acortamiento hercínico hasta la extensión triásica de los sedimentos paleozoicos del Alto Atlas Occidental (Marruecos)

H. Saber[1*], M. El Wartiti[2], D. Hmich[2] , J.W. Schneider[3]

[1]*Chouaïb Doukkali University, Faculty of Sciences, Department of Geology, B. P. 20, 24000, El-Jadida, Morocco.*
**Corresponding author: Fax: 212 23 34 21 87, e-mail : hafidsaber@yahoo.fr*
[2]*Mohammed V University, Faculty of Sciences, Department of Geology, B. P. 1014, Rabat, Morocco.*
e-mail: wartiti@fsr.ac.ma
[3]*TU Bergakademie Freiberg, Institut für Geologie, Bernhard-von-Cotta-Str.2, D-09596 Freiberg/Sa, Germany.*
e-mail: Joerg.Schneider@geo.tu-freiberg.de

Received: 10/09/05 / Accepted: 24/11/06

Abstract

In the Upper Palaeozoic (Stephanian to Upper Permian) sediments of the Western High Atlas, ancient faults trending N20°-40°, N70°-80°, E-W to N110°-120° and N160°, that is, of hercynian age, present normal, sinistral strike-slip or thrust displacements and sometimes with important throw. They were active from Stephanian (Late Carboniferous) to Late Permian times. The new biostratigraphic and chronostratigraphical data allow us to recognise the evolution of the strain ellipsoid of this sector from the Namuro-Westphalian compression stage (Hercynian orogen) to the Triassic distensive stage.

Keywords: Stephanian, late-Hercynian, tectonics, Western High Atlas, Morocco.

Resumen

En los sedimentos del Paleozoico Superior (Estefaniense-Pérmico Superior) del Alto Atlas Occidental, antiguas fallas hercínicas de dirección N20º-40º, N70º-80º, E-W a N110º-120º y N160º presentan desplazamientos de tipo normal, de desgarre o inverso, algunas veces mostrando importantes saltos. Estas fallas fueron activas desde el Estefaniense hasta el final del Pérmico. Los datos bioestratigráficos y cronoestratigráficos recientes nos permiten reconstruir el elipsoide de esfuerzos de este sector desde la etapa de compresión Namuro-Estefaniense hasta la etapa distensiva del Triásico Superior.

Palabras clave: Estefaniense, Hercínico superior, tectónica, Alto Atlas Occidental, Marruecos.

1. Introduction

This work is an approach to the study of the tectonic events and their chronology during the Late-Hercynian period in the Paleozoic of the Western High Atlas (P.W.H.A.) (Fig. 1). In the geologic literature dealing with this area, only a few papers are focused in this period of time, between the Westphalian rocks (the end of major hercynian shortening) and the deposition of the first rocks of Stephanian, Permian and Triassic ages (the rupture of Pangea and the beginning of the Atlantic rifting). During this long period, multiple events took place control-

ling the sedimentary, tectonic, paleontologic and climatic characteristics of the sediments and the subsidence, that is, the evolution and sedimentary infilling of the basins.

The Stephano-Permian deposits lie unconformably on the Palaeozoic basement and represent the culmination of the development of the hercynian chain. They are continental in origin and at the present-day they are divided into numerous disconnected basins, which are often difficult to correlate.

This work is a synthesis and an update on the chronology of the late-hercynian tectonic and geodynamic events in the Western High Atlas.

2. Lithostratigraphic units

The lithostratigraphical units of the different basins and sub-basins of the Western High Atlas are synthesized as follows:

2.1. Synthetic stratigraphic successions of Souss basin

The Souss Basin is located at the south-western corner of the Western High Atlas Mountains (Fig. 1). It consists of two subbasins, the Ida Ou Zal and Ida Ou Ziki subbasins. They represent remnants of a former larger basin, which was filled with late Pennsylvanian grey sediments (Saber, 1994, 1998; Saber *et al*., 2001). These sediments cover different parts of an older paleorelief caved into the deformed and metamorphised basement. Sedimentation starts with a basal coarsening upward mega-sequence of conglomerates and sandstones of about 400-600 m thickness in both basins (Figs. 2 and 3). They are followed by up to 1,200 m grey, alluvial sandstones (including alluvial plains and fluvial channel sediments), lacustrine black shales and occasionally coal seams up to decimetre thick.

2.2. Synthetic stratigraphic successions of Oued Zat basin

The studied sections show increasing thickness towards the south ranging from 50 to 450 m (Fig. 4). They are composed of the following sedimentary formations from base to top:

- A basal formation, the Tighadwiyn formation, composed of purplish red conglomerates subdivided in two -

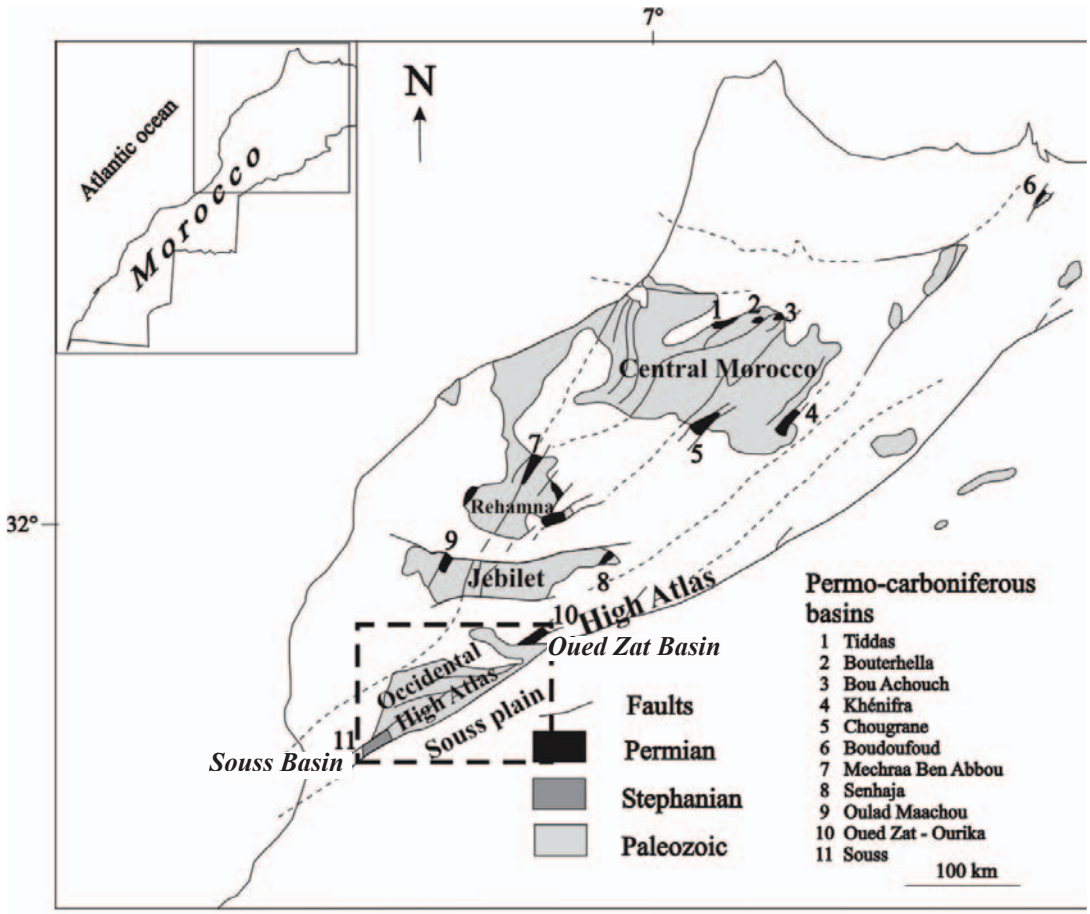

Fig. 1.- Localization of the Paleozoic of the Western High Atlas (P.W.H.A.) the in Moroccan Meseta.
Fig. 1.- Localización de los afloramientos paleozoicos del Alto Atlas Occidental (P.W.H.A.) en la Meseta de Marruecos.

three layers of variable thickness ranging from 1 to 10 m. These conglomerates are mainly composed of rounded quarzite pebbles. The base is erosive and is overlain by red sandy clays, sometimes grey or yellowish.

- An upper formation, the Mçtour formation, composed of clays and silts containing greenish grey levels with carbonaceous lenses, native sulphur and remains of flora.

In the Oued Zat area, the basal conglomeratic unit corresponds to a proximal braided river deposits. The upper unit corresponds to distal fluvial systems, which mainly consists of flood plain deposits dominated by overflow facies.

2.3. Synthetic stratigraphic successions of the Upper Permian of Argana basin

The Argana Basin is located at the western edge of the High Atlas Mountain between Marrakech and Agadir (Fig. 5). The Permian to Early Jurassic continental basin fill is well exposed in an elongated area of about 70 x 15 km. The first lithostratigraphical subdivision goes back to Tixeront (1974). The T1 unit or the Ait Driss Member and the T2 unit or the Tourbihine Member form together the Permian Ikakern Formation.

The Ikakern Formation is restricted to the Argana graben, in the central part of the Argana valley (Brown, 1980). Maximum thickness is found in the SE, of about 2,000 m. The basal conglomerates of the Ait Driss Member rest unconformably on Cambrian to Devonian folded metasediments, and locally, with an angular unconformity on Late Carboniferous sediments (Hmich *et al*., 2006).

3. Biostratigraphic and chronostratigraphic data

Many biostratigraphic studies have been published in the last years on the formations of these Stephanian, Permian and Triassic basins. These studies are of a great interest because they provide a precise chronology of the different sedimentary and tectonic events that occurred between the last major compressive hercynian phase and the Upper Permian extensional period.

3.1. The Souss basin

The beds containing macroflora are abundant in this basin, specially in the greenish-grey fluvio-lacustrine levels, above the Ikhourba and Tajgaline conglomeratic Fms. (Figs. 2 and 3). They consist of imprints of different parts of plants (leaves, stems, trunks). A microflora was discovered in the argillaceous levels by H. Saber and was recently studied by Aassoumi *et al.* (2003).

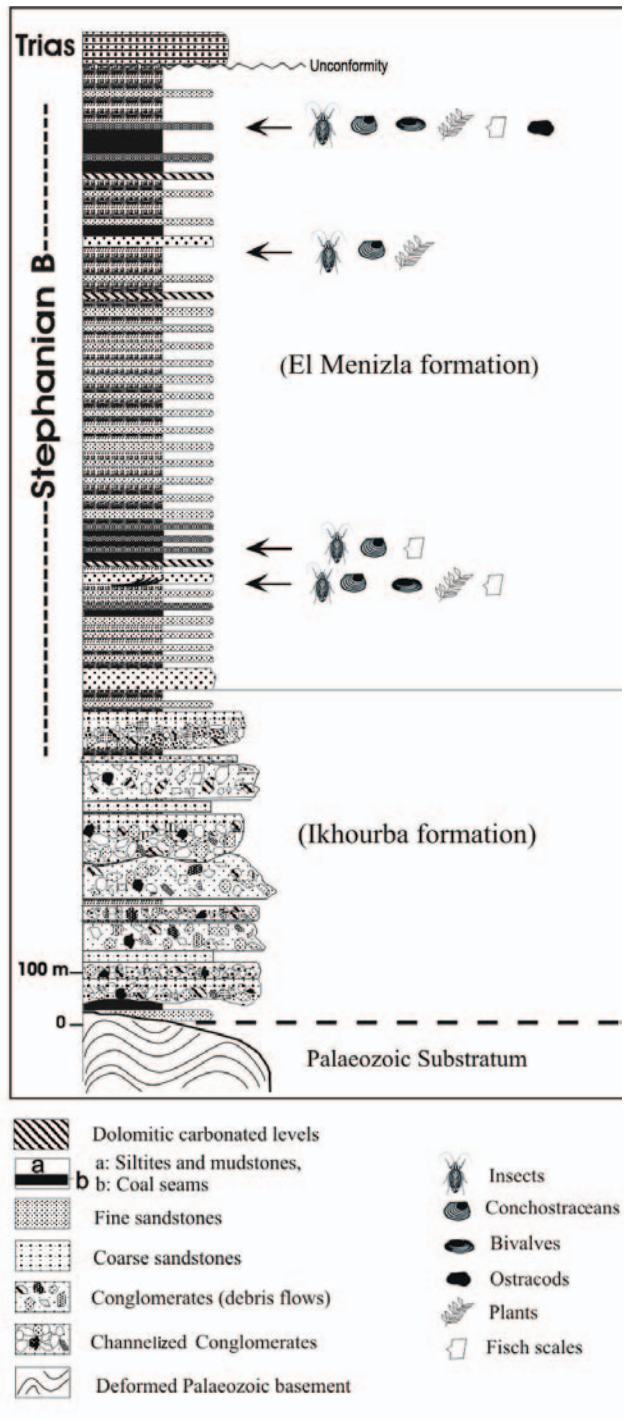

Fig. 2.- Synthetic lithostratigraphic section of the Ida Ou Zal sub-basin (after Saber *et al*., 2001).

Fig. 2.- Columna estratigráfica sintética de la subcuenca de Ida Ou Zal (basado en Saber *et al*., 2001).

Plant remains from these outcrops and the siltstone intercalations of the Tirkou Formation have been described by Bertrand (in Clariond, 1932), Jongmans (1950), Feys and Greber (1963) and Broutin *et al.* (1989) and mainly consist of: *Annularia stellata*, *A. sphenophylloides*, *Pecopteris candolleana*, *P. hemitelioides*, *P. cyathea*, *P.*

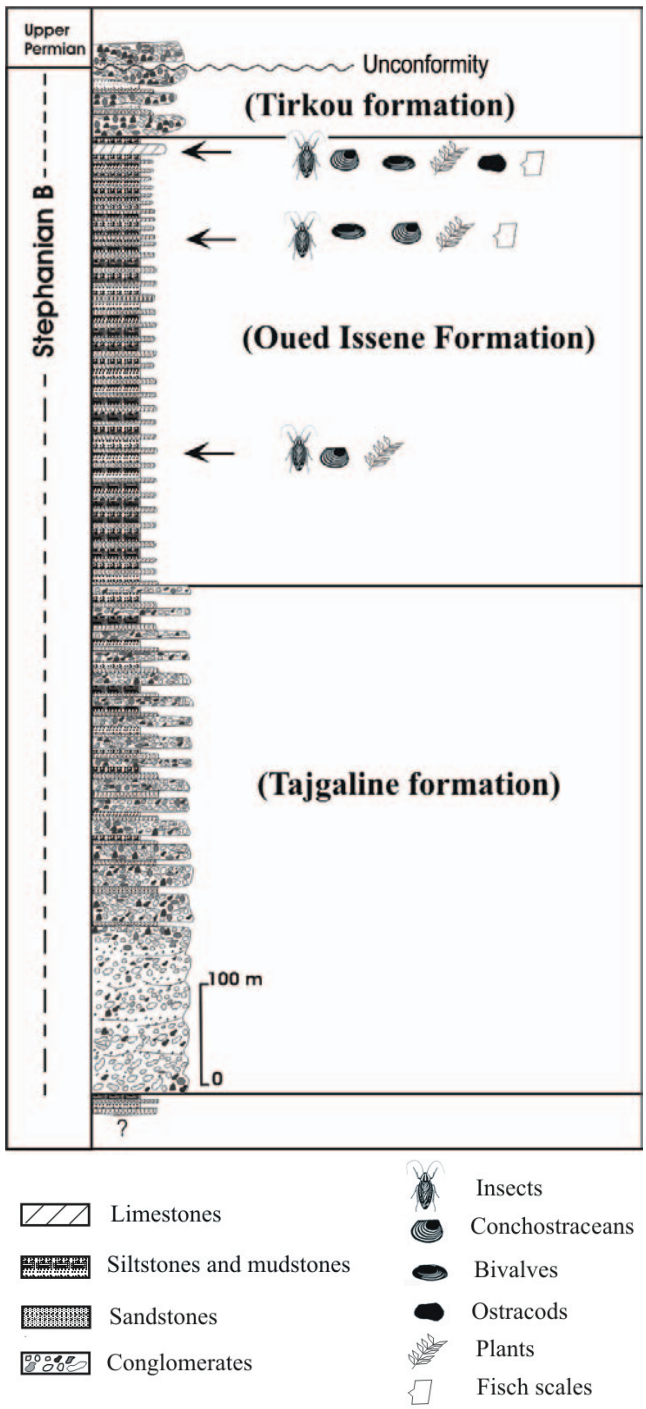

Fig. 3.- Synthetic lithostratigraphic section of the Ida Ou Ziki sub-basin (after Saber *et al*., 1994).

Fig. 3.- Columna estratigráfica sintética de la subcuenca de Ida Ou Ziki (basado en Saber *et al*., 1994).

monyi, *P. pinnatifida*, *Sphenopteris matheti*, *Odontopteris obtusa*, *Mixoneura neuropteropteroides*, *Stigmaria* (roots), *Sphenophyllum oblongifolium*, *Alethopteris subelegans*, *Odontopteris* cf. *subcrenulata*, *Taeniopteris* gr. *jejunata*, *Neuropteris cordata*, *N. neuropteroides*, *Poacordaites*, *Walchia piniformis*, *Otovicia hypnoides*, some *Culmitzschia* species as well as *Sphenobaiera* sp.

Aassoumi *et al.* (2003) briefly reported a microflora from the middle part of the Oued Issène Formation (Fig. 3) dominated by trilete and monolete spores as *Laevigatosporites*, *Calamospora*, *Lycospora* and *Reticulatisporites*, among others. Monosaccate and bisaccate pollen are very rare. Further samples from the top of the Oued Issène Formation, just below the conglomerates of the Tirkou Formation contain *Reticulatisporites*, *Lycospora* and *Thymospora*, *Leiotriletes* among others; monosaccate pollen of a *Potonieisporites* type are less abundant.

The outcrops along the El Menizla river at El Menizla village, near the southern border of the Ida Ou Zal Subbasin, are the type section of the El Menizla Formation (Fig. 2). From this area, Saber *et al.* (1995) and Saber (1998) described de following flora: *Calamites*, *Asterophyllites equisetiformis*, *Annularia*, *Macrostachya*, *Sphenophyllum oblongifolium*, *Lepidodendron*, *Pecopteris arborescens*, *P. hemitelioides*, *P. unita*, *P. paleacea*, *Asterotheca* and *Odontopteris*. *Walchia* was reported as rare.

The macroflora of the lacustrine laminated to varved black claystones is clearly dominated by conifers, as *Otovicia hypnoides* and *Ernestiodendron filiciforme*. Similarly common is cf. *Lepidostrobophyllum*, rarer are *Odontopteris subcrenulata* and *Autunia* cf. *conferta*. This association indicates xeric conditions around the lakes.

Rich assemblages of fossil insects were found close to Taghzout, Agadir-Ou-Anzizen and El Menizla. Four Families of insects were described by Hmich *et al*. (2003a,b) and Hmich *et al*. (2005; 2006). They belong to the Families: Spiloblattinidae, Mylacridae, Phyloblattidae and Poroblattinidae, all of them to the Order of Blattoidea. The Mylacridae family is only represented by the species *Opsiomylacris thevenini* (Meunier), and is the most abundant. Previous studies on these species were only made in the upper Stephanian of the Commentry Basin (Massif Central, France). These fossil insects, found for the first time in Morocco, are considered as the oldest in the African continent. They are Stephanian (Pennsylvanian) in age, which can be correlated with the upper Kasimovian/lower Gzhelian (303-302 My) of the Russian platform scale.

3.2. The Oued Zat basin

Eighteen species of macroflora found in this area were studied by Doubinger and Roy-Dias (1985). This paleofloristic association is composed by *Odontopteris dufresnoyi*, *O. subcrenulata, Pecopteris densifolia*, *P. rarinervosa, P. polypodioides, Scolecopteris, Cordaites lingulatus*, *Sphenophyllum costa, S. thoni*, *Sphenopteris sp., Aulacopteris, Calamites suckowi* and *Lebachia parv-*

ifolia (hygrophitic type). This association could be attributed to Stephanian B-C age.

3.3. The Argana basin and T1 and T2 Formations (Fig. 5).

Spectacular tetrapod skeleton remains have been discovered in the seventies of the last century by Dutuit (1988) in the Tourbihine Member. They were determinate as diplocaulid nectrideans *(Diplocaulus minimus)*, the captorhinid *Acrodonta* and a moradisaurine (Jalil and Dutuit, 1996).

Studies on vertebrate fossils carried out by Jalil and Dutuit (1996) and Jalil (2001) in the T2 formation, indicate an Upper Permian (Tatarian) age. This dating is of great importance, as these formations overlie the crystalline Palaeozoic basement in some areas of the basin and the continental deposits of upper Stephanian in some others by means of an angular unconformity and are not affected by previous deformation events.

4. Chronology of the tectonic phases

The structural development of the Western High Atlas, since the end of the Hercynian orogeny until Triassic times, was dominated by strike-slip faults of metric to kilometric scale, as result of a succession of several tectonic phases. These regional phases can be summarized chronologically as follows:

1- The major compressive Hercynian cycle (Namuro-Westphalian) was mainly originated by the formation of tectonic ductile structures and micro-structures characterized by syn-schistous folds with axes trending N20°-N30° and kilometric scale asymmetric shear zones trending N60°-N70° (e.g.: Imin-Tannout and Tizi n'Test faults) and N90°–N110° (Tizi Maâchou fault) (Fig. 5). They subdivide the Paleozoic of the Western High Atlas into different blocks whose kinematics is registered by the virgations of the paths of schistosity. The Hercynian deformations fit well with the dextral strike-slip tectonics trending N60°-80° in the High Atlas. The regional shortening (sub-horizontal) N100° is reoriented N120°-130° at the end of orogenesis (Cornée *et al*., 1987; Ferrandini *et al*., 1987).

2- During the Stephanian B (upper Kasimovian/lower Gzhelian) a NW-SE to NNW-SSE extension started (Fig. 6). The result of this extension is clearly shown in the Western High Atlas, particularly in the Souss (Ida Ou Ziki and Ida Ou Zal) Basin, Oued Zat Basin, Rhojdama Basin, and Haouz Basin. This phase of deformation corresponds to the relaxation, immediately after the last compressive ductile deformations of the Hercynian orogenesis. It is characterised by synsedimentary deformations (normal

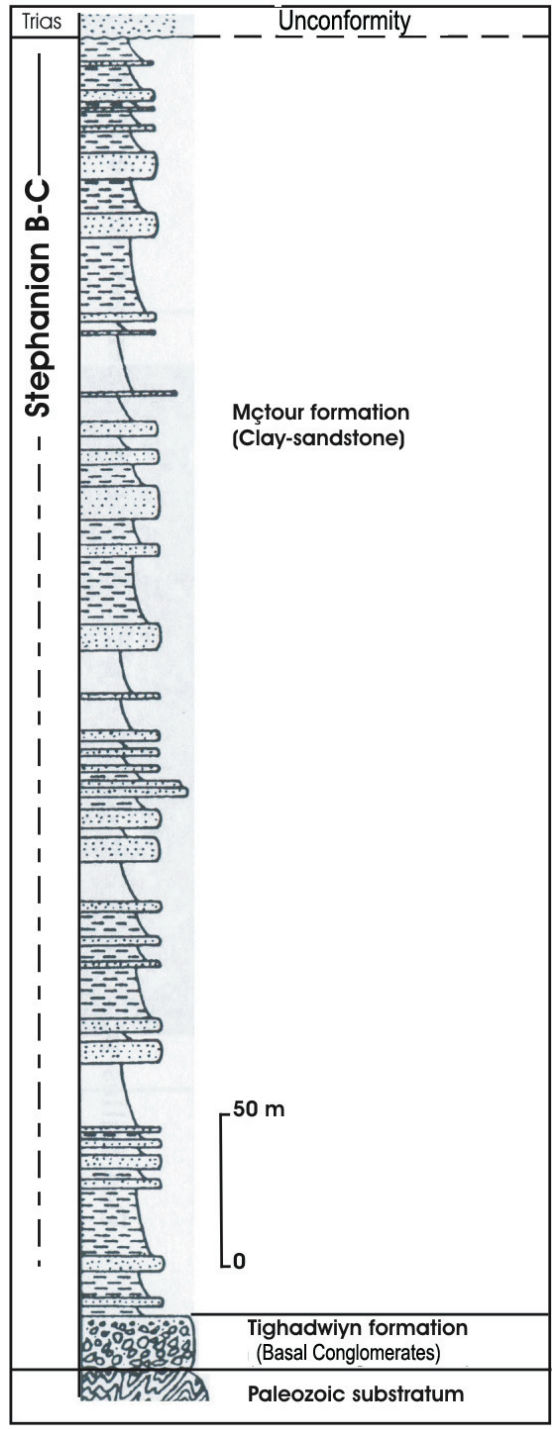

Fig. 4.- Synthetic lithostratigraphic section of the Oued Zat basin (after Saber and El Wartiti, 1996).

Fig. 4.- Columna estratigráfica sintética de la subcuenca Oued Zat (Basado en Saber y El Wartiti, 1996).

listric faults, micrograbens, slumps and progressive unconformities) along the reactivated inherited major faults, that resulted in the development of the Stephanian limnic basins. A new Stephanian age for this tectonic event has been proposed by means of the new fossil insect fauna found in the Souss Basin (Hmich *et al*., 2002) and macroflora in the Oued Zat Basin (Doubinger and Roy-Dias, 1985).

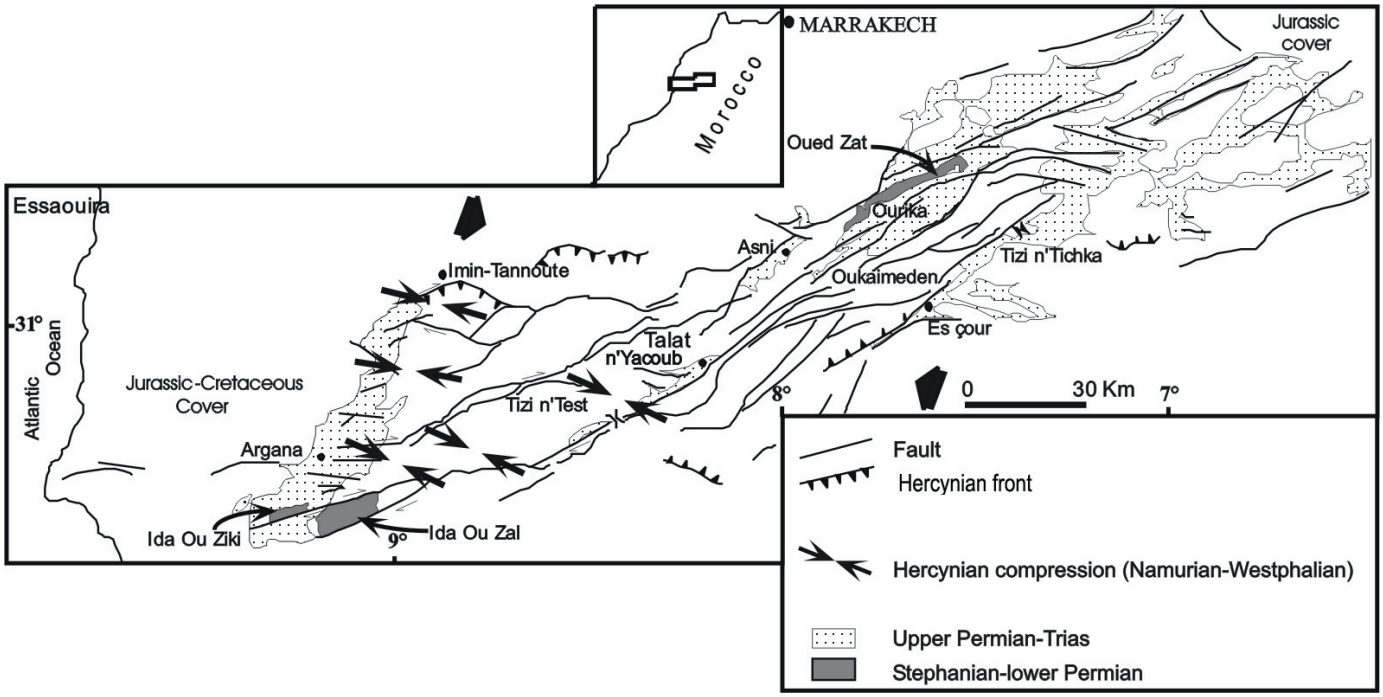

Fig. 5.- Scheme of the Hercynian (Namurian-Westphalian) main compression lineaments in the Western High Atlas.
Fig. 5.- Esquema de las principales directrices de compresión hercínica (Namuriense-Westfaliense) en el Alto Atlas Occidental.

3- The undeformed formations T1 and T2, which were recently dated as Upper Permian by Jalil and Dutuit (1996) and as Tatarian by Jalil (2001), are deposited over the deformed middle-upper Stephanian rocks by means of an angular unconformity. The direction of the compression changed from NNE-SSW to NE-SW (Fig. 7). This compression event is characterised by brittle and sub-brittle deformations (folds, kinks, flexures and frequent overlappings) localised primarily in the vicinity of the great faults, located at the border the basins. The movements along the faults are of extensional or strike-slip character, sometimes of significant amplitude.

Similar tectonic have been described in other areas of Morocco, particularly in the Kettara area, in the central Jebilet, in the Imin-Tannoute area (Ferradini *et al*., 1987), in the massif of Rehamna, in the Central Morocco (El Wartiti, 1990) and in the mountains of the SE of Oujda (Torbi and Gelard, 1994). It confirms the regional character of this phase of compressive sub-meridian post-Stephanian B and pre-Tatarian deformation (Saber *et al*., 2001).

4- After the Stephanian B compressive phase, another one, previous to the Upper Triassic phase of relaxation, began, resulting in a NS to NNW-SSE main extension (Fig. 8). The previous blocks were reactivated along pre-existent faults, acting generally as normal faults (Walgou fault in the Irohalen area, in Imin-Tannoute; Agadir-Ou-Anzizen fault in the Ida Ou Zal area) (Saber *et al*., 2001) (Fig. 8). This phase is probably related to the installation of magmatism of alkaline affinity (e.g.: granites of Azegour in the High Atlas and granites of Sebt Labrikiine in western Rehamna).

These Stephanian basins, show different size and often are of asymmetrical morphology (half-grabens).

The new discoveries of fossil remains of biostratigraphic relevance (palynoflora, invertebrates and vertebrates) allow us to make intercontinental correlations for the Stephano-Permian period in other regions of Marocco. The comparison of our observations with the available data reveal that the Moroccan late-Hercynian domains were subjected, during the lower Stephanian and the Permian, to an intense, generalised brittle tectonics. Large zones of strike-slip faults, with important displacement, subdivide the Hercynian massifs into blocks, such as the Tizi n'Test, Meltsen, Tizi M'achou and Imin-Tannoute faults. This compartmentalisation influenced surely the late-hercynian tectonics and particularly the formation of limnic stephanian basins. Often, these faults were re-activated again into normal faults during the Upper Triassic.

From the Pennsylvanian to the upper Permian, according to these structural data, the main baryte mineralization is emplaced in the High Atlas. Those mineralizations are related to the phases of deformation described above.

5- During the Upper Triassic, a general extensional regime with fault systems of a general NW-SE trend was

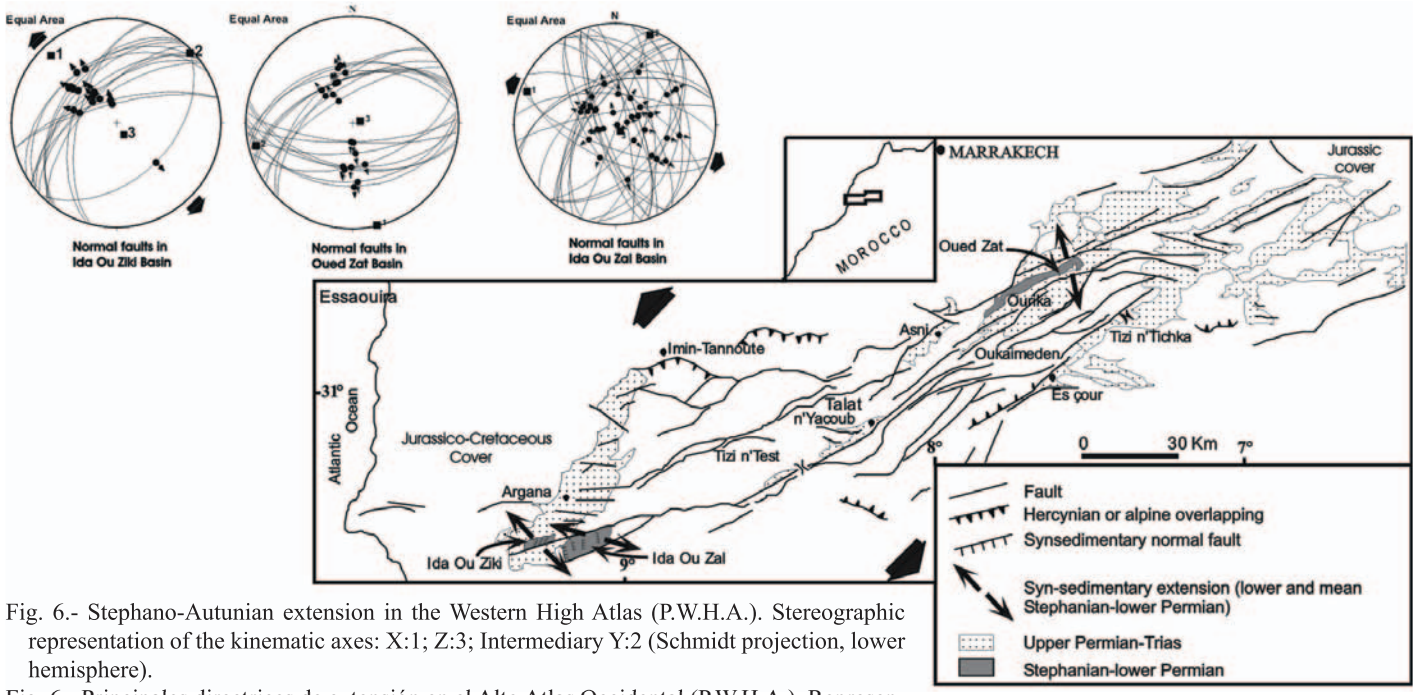

Fig. 6.- Stephano-Autunian extension in the Western High Atlas (P.W.H.A.). Stereographic representation of the kinematic axes: X:1; Z:3; Intermediary Y:2 (Schmidt projection, lower hemisphere).

Fig. 6.- Principales directrices de extensión en el Alto Atlas Occidental (P.W.H.A.). Representación estereográfica de los ejes: Extensión X:1; Y:2; Z:3 (Proyección de Schmidt para el hemisferio inferior).

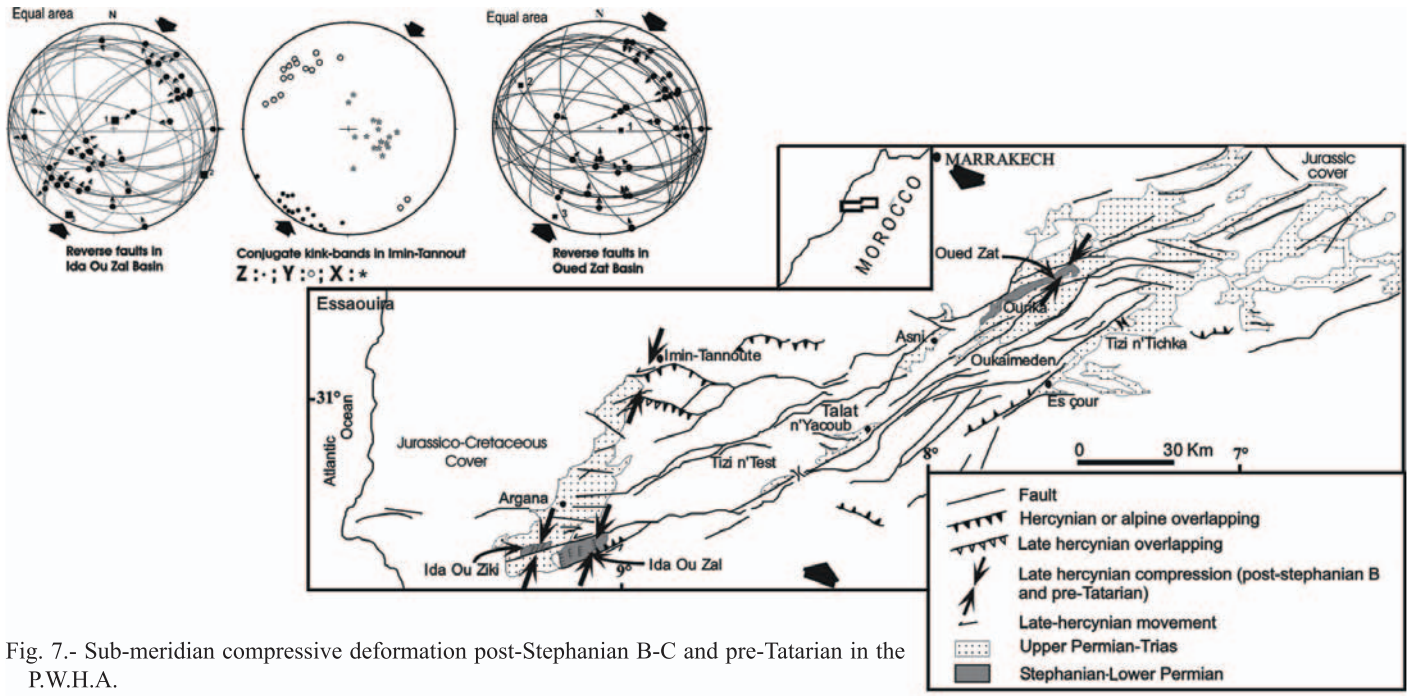

Fig. 7.- Sub-meridian compressive deformation post-Stephanian B-C and pre-Tatarian in the P.W.H.A.

Fig. 7.- Deformación compresiva submeridiana post-Estefaniense B-C y Pre-Tatariense in el Alto Atlas Occidental.

installed. It is characterized by normal faults trending from N20° to N40° controlling grabens and semi-grabens (Argana, Tizi n'Test and Oued Zat basins) and filled essentially with red conglomerates and conglomeratic sandstones at the base and silty sandstones and siltstones towards the top (Fig. 9).

5. Conclusions

The structural analysis of the Stephanian basins, the recent paleontologic discoveries and the new chronostratigraphical data allow us to define the tectonic evolution in the Paleozoic of the Western High Atlas since the Hercy-

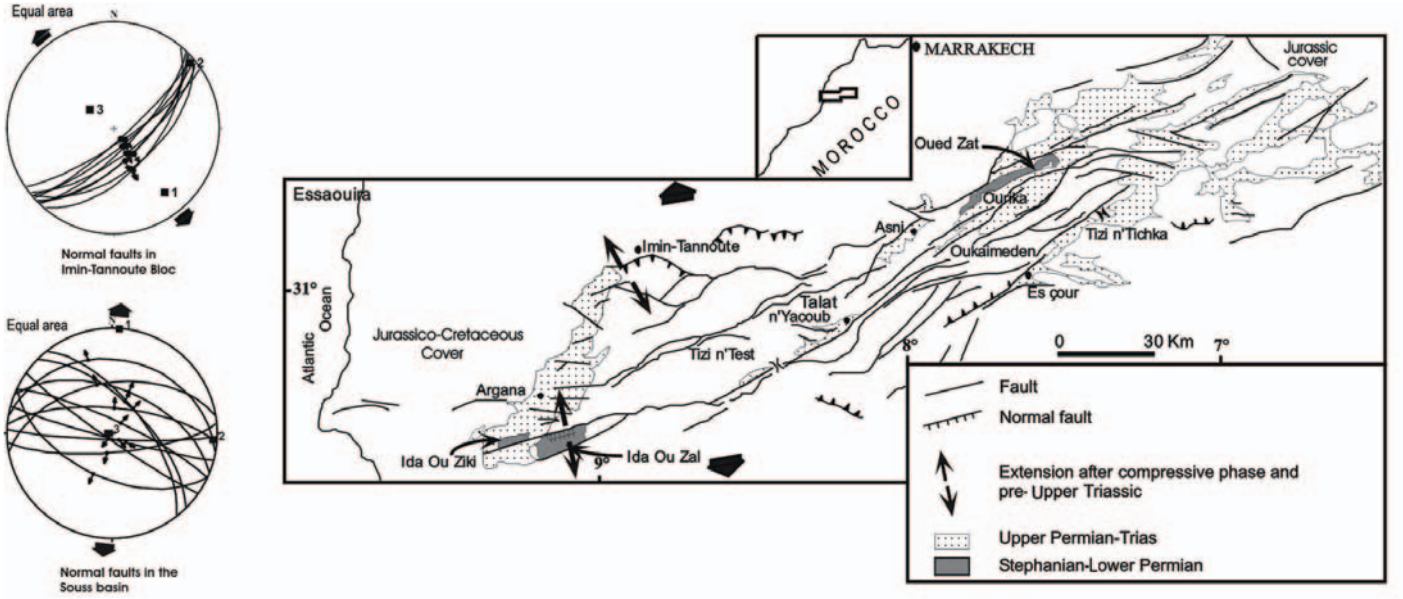

Fig. 8.- Sub-meridian extension after-compressive phase and pre-Upper-Triassic in the P.W.H.A.
Fig. 8.- Extensión localizada entre la fase de compresión y la extensiva previa al Triásico Superior en el Alto Atlas Occidental.

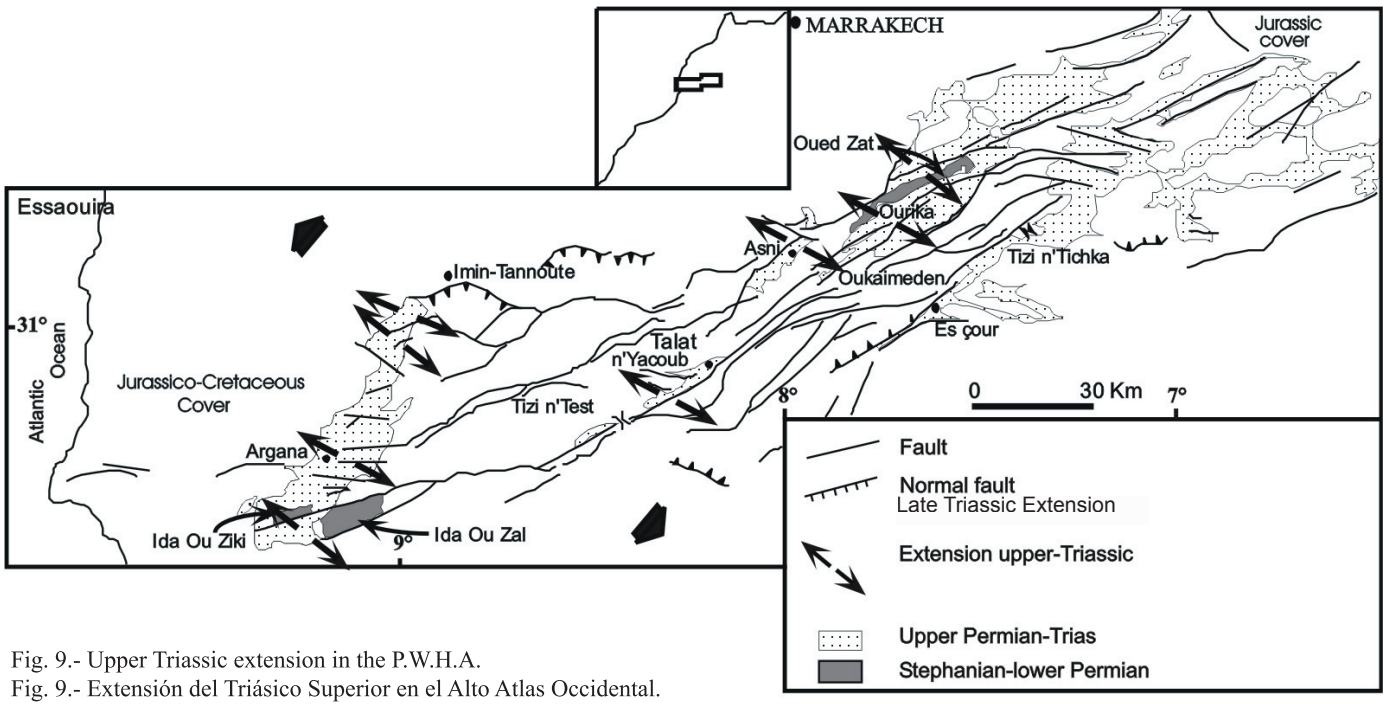

Fig. 9.- Upper Triassic extension in the P.W.H.A.
Fig. 9.- Extensión del Triásico Superior en el Alto Atlas Occidental.

nian compression until the Triassic distension. After the end of the Hercynian orogenesis Z (N120°) and X are in a sub-horizontal plane; in the Pennsylvanian (upper Kasimovian/lower Gzhelian), the extension X is installed and become NW-SE to NNW-SSE. This last extension can be local and is generated by a sub-horizontal compressive regional stress oriented N15° to N40° within a transtensive tectonics. Between the Pennsylvanian and the Tatarian, the Stephanian deposits were deformed in a transpressive regime. This N15°-N40° constraint was replaced by a sub-meridian extension (NNW-SSE to NNE-SSW) probably "pre-Upper Triassic (pre-Carnian-Norian)". During the Upper-Triassic extension, X become N110°-N130°. This distensive regional regime produced the formation of new normal faults (N20°-N40°) in the Argana, Tizi n'Test and Oued Zat Triassic basins. The orientation of the tectonic stress influenced the kinematic of the faults. Most of them are inherited from the lower Paleozoic systems.

Acknowledgements

The authors are grateful to Prof. Antonio Funedda (Department of Earth Sciences, Cagliari University-Italy), and Dr. Marco Roscher (TU Bergakademie, Freiberg-Germany), for their constructive reviews of the manuscript. We also thank Dr. Alfredo Arche and Prof. Ana M. Alonzo Zarza for their comments and suggestions who have considerably improved both the presentation and English. The authors wish to address their warmest thanks to Prof. José López-Gómez and Prof. Javier Martín-Chivelet for their collaboration and the edition of the manuscript.

References

Aassoumi, H., Saber, H., Broutin, J., El Wartiti, M. (2003): *First spore, pollen and acritarch associations in the Ida Ou Ziki basin (southern slope of the Western High Atlas, Morocco)*. XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht, The Netherlands, 10-16 August 2003. Abstract, 195: 1-2.

Brown, R.H. (1980): Triassic rocks of Argana Valley, Southern Morocco and their regional structural implications. *American Association of Petroleum Geologists Bulletin*, 64: 988-1003.

Broutin, J., Ferrandini, J., Saber, H. (1989): Implications stratigraphiques et paléogéographiques de la découverte d'une flore permienne euraméricaine dans le Haut-Atlas occidental (Maroc). *Compte Rendu de l'Académie des Sciences, Paris*, 308, II: 1509-1515.

Clariond, L. (1932): Sur le Stéphanien des Ida ou Zal (Maroc occidental). *Comptes Rendus de l'Académie des Sciences, Paris*, 195: 62-64.

Cornée, J.J., Ferrandini, J., Muller, J., Simon, B. (1987): Le Haut Atlas occidental paléozoïque: un graben cambrien moyen entre deux décrochements dextres N60°E hercyniens (Maroc). *Compte Rendu de l'Académie des Sciences, Paris*, 305: II, 499-503.

Doubinger, J., Roy-Dias, C. (1985): La paléoflore du Stéphanien de l'Oued Zat (Haut Atlas de Marrakech - versant Nord - Maroc). *Geobios,* 18: 573-586.

Dutuit, J.-M. (1988): *Diplocaulus minimus* n. sp. (Amphibia: Nectridea), Lépospondyle de la Formation d'Argana, dans l' Atlas marocain. *Comptes Rendus de l'Académie des Sciences, Paris*, 307: 851-854.

El Wartiti, M. (1990): *Le Permien du Maroc mesetien: étude géologique et implications paléogéographiques*. Thèse d'Etat, Université Mohamed V, Rabat, 458 p.

Ferrandini, J., Cornée, J.J., Saber, H. (1987): Mise en évidence d'une compression sub-méridienne d'âge permien probable dans le massif ancien du Haut-Atlas occidental (Maroc). Évolution de l'ellipsoïde de déformation depuis l'orogenèse hercynienne jusqu'à la distension triasique. *Compte Rendu de l'Académie des Sciences, Paris*, 304 II, 20: 1243-1248.

Feys, R., Greber, Ch. (1963): Le Stéphanien et l'Autunien du Souss dans les Ida ou Zal (Haut-Atlas occidental, Maroc). *Notes Mémoires Service Géologique Maroc*, 170 (22): 19–43.

Hmich, D., Schneider, J., Saber, H., El Wartiti, M., Broutin, J. (2002): *First record on Late Palaeozoic insect faunas from Morocco Biostratigraphic and biogeographic implications*. 19th Colloquium of African Geology, Chouaïb Doukkali University, El Jadida, Morocco, March 2002, Abstracts, p. 101.

Hmich, D., Schneider, J.W., Saber, H., El Wartiti, M. (2003a): *Pennsylvanian (Upper Carboniferous) insects from Morocco – biostratigraphic and biogeographic implications*. XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht, The Netherlands, August 2003. Abstract, 230: 228-229.

Hmich, D., Schneider, J.W., Saber, H., El Wartiti, M. (2003b): First Permocarboniferous insects (blattids) from North Africa (Morocco): implications on palaeobiogeography and palaeoclimatology. Freiberger Forschungshefte C 499, Freiberg. *Paläontologie, Stratigraphie, Facies* (11): 117-134.

Hmich, D., Schneider, J.W., Saber, H., El Wartiti, M., (2005): Spiloblattinidae (Insecta, Blattida) from the Carboniferous of Morocco, North Africa: implications for biostratigraphy. In: Lucas, S.G., Zeigler, K.E. (eds.): *The Nonmarine Permian. New Mexico Museum of Natural History and Science*, 30, Albuquerque, 111-114.

Hmich, D., Schneider, J.W., Saber, H., Voigt, S., El Wartiti, M., (2006): New Continental Carboniferous and Permian faunas of Morocco: implications of biostratigraphy, palaeobiogeography and palaeoclimate. In: S.G. Lucas, G. Cassinis, J.W. Schneider (eds.): *Non-Marine Permian Biostratigraphy and Biochronology*. *Geological Society, London, Special Publications,* 265:

Jalil, N.E., Dutuit, J.M. (1996): Permian Captorhinid reptiles from the Argana Formation, Morocco. *Palaeontology*, 39 (4): 907-918.

Jalil, N.E. (2001): *Les Vertébrés permiens et triasiques d'Afrique du Nord, avec une description de nouveaux pararreptiles Pareiasaures (Amniota, Parareptilia, Pareiasauria) du Permien du Maroc. Liste faunique, relations phylogénétiques et implications biostratigraphiques.* Thèse d'Etat, Univ. Cadi Ayyad, Marrakech, 210 p.

Jongmans, W.J. (1950): Notes sur la flore du Carbonifère du versant Sud du Haut-Atlas. *Notes et Mémoires du Service Géologique, Maroc*, 76: 155-172.

Saber, H. (1994): Sédimentologie et évidence d'une tectonique tardi-hercynienne d'âge Permien Inférieur dans le bassin des Ida Ou Ziki; Sud-Ouest du massif ancien du Haut-Atlas (région d'Argana, Maroc). *Journal of African Earth Sciences*, 19 (1/2): 99-108.

Saber, H., El Wartiti, M., Broutin, J., Toutin Morin, N. (1995): L'intervalle stéphano-permien (fin du cycle varisque au Maroc). *Gaia, Lisbonne*, 11: 57-71.

Saber, H., El Wartiti, M. (1996): Histoire sédimentaire et tectonique tardi-hercynienne des bassins de l'Oued Zat et Ida Ou Zal (Haut-Atlas Occidental, Maroc): bassins en transtension sur décrochements. *Journal of African Earth Sciences*, 22 (3): 301-309.

Saber, H. (1998): Le Stéphano-Permien du Haut Atlas occidental: étude géologique et évolution géodynamique (Maroc). Thèse d´Etat ès-Sciences, Chouaïb Doukkali university, El-Jadida, 212 pp.

Saber, H., El Wartiti, M., Broutin, J. (2001): Dynamique sédimentaire comparative dans les bassins stéphano-permiens des Ida Ou Zal et Ida Ou Ziki (Haut Atlas Occidental, Maroc). *Journal of African Earth Sciences*, 32 (4): 573–594.

Tixeront, M. (1974): Carte géologique et minéralogique du Couloir d'Argana, 1/100 000. *Edition du sérvice Géologique du Maro*c, *Notes et Mémoires*, 205.

Torbi, A., Gelard, J.P. (1994): Paléocontraintes enregistrées par la microfracturation, depuis l'Hercynien jusqu'à l'Actuel, dans les monts du Sud-Est d'Oujda (Meseta Orientale, Maroc). *Compte Rendu de l'Académie des Sciences, Paris*, 318 (II): 131-135.