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Tribute by the Algerian Geologists to Professor Michel Durand-Delga (1923-2012). The geological work of Michel Durand-Delga in Algeria

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ABSTRACT

Michel Durand-Delga made a success of an outstanding career in geology. His route might be considered as one of a pioneer of a new kind. He set a meticulous rhythm in this discipline of the Earth sciences, particularly in Algeria, the country he loved for its geology, landscapes and population. The first of his fructuous works was published in 1948 on the geology of the 'Petite Kabylie' and he continued, for most his life, to work very closely on this zone which he characterized, in a definitive way, as different from the African continent with at first structural then stratigraphical evidence. He highlighted the Kabylian thrust where the northern domain (internal, also called Kabyle) overlaps a southern domain (external or African). All the geological information that came later either produced by him or later by his students and opponents supported this great hypothesis which today has become a reliable paradigm.

Key words: Algeria, 'Petite Kabylie', African geology

Homenaje de los geólogos argelinos al profesor Michel Durand-Delga (1923-2012). La obra geológica de Michel Durand-Delga en Argelia.

RESUMEN

Michel Durand-Delga tuvo una carrera excepcional en geología. Su trayectoria fue la de un pionero de un género nuevo. Imprimió un ritmo particular a las Ciencias de la Tierra en Argelia, país que amaba por su geología, sus paisajes y sus habitantes. Comenzó en 1948 a publicar sobre la Pequeña Kabilia y continuó toda su vida interesándose muy de cerca en esta zona que caracterizó, de manera definitiva, diferenciándola del continente africano mediante argumentos estructurales, en primer lugar y estratigráficos, posteriormente. Durand Delga puso en evidencia el cabalgamiento de borde kabílico que permitió la superposición de un dominio septentrional (interno, denominado kabílico) sobre un dominio meridional (externo o africano). Todo lo que sucedió posteriormente, impulsado primero por él mismo y después por sus estudiantes y sus oponentes, ha apoyado esta gran hipótesis que, hoy en día, se ha convertido en un paradigma.

Palabras clave: Argelia, Geología de África, Pequeña Kabilia

VERSIÓN ABREVIADA EN CASTELLANO

Impregnado de la filosofía de los grandes geólogos, Michel Durand-Delga imprimió un ritmo particular a la Geología. En el Norte de África, prefirió afrontar la dificultad orogénica y sus secretos en vez de contentarse con describir e interpretar lo observable.

Sobre los hombros de su maestro Paul Fallot y de los grandes nombres de la geología argelina y marroquí, Durand-Delga explotó su talento y sus premoniciones para llegar a ser a su vez un incontestable maestro de la geología magrebí y del Mediterráneo Occidental. Fue él quien dio el nombre de Magrébides a los terrenos de las regiones del Tell y del Rif, en el África del Norte. Fue un especialista de esta zona orogénica del mundo, multiplicó los descubrimientos y organizó una auténtica escuela geológica.

Escribió su primer artículo sobre su zona de trabajo en la Pequeña Kabila (al oeste de la cadena numídica), titulado "Sobre la estructura del Moul-ed-Demenine", seguido de un segundo, "Sobre la estructura del Djebel Sidi Marouf y de sus alrededores (cadena numídica, Argelia)" (Durand-Delga, 1948). Y este fue el inicio de una gran aventura que aún no se ha acabado, ya que el profesor Durand-Delga se interesó a lo largo de toda su vida de geólogo por el Norte de África, hay alumnos que aún están activos y su escuela continúa, siendo la más importante de África del Norte, particularmente en la Argelia alpina (fig. 1).

Posteriormente, escribió dos contribuciones cortas o notas: "Sobre la estructura geológica de los alrededores de Texenna (Pequeña Kabilia, Argelia)" y "El Cretácico Inferior en el Oeste de la cadena numídica". Siendo todavía un doctorando, al principio de los años 50, comenzó a hacer algunos descubrimientos sobre el terreno, que se hicieron famosos, suscitando discusiones entre diversos autores y provocando controversias.

Uno de estos primeros hallazgos fue el de "la colocación del manto límite de la Pequeña Kabilia", en 1952 y del manto del "flysch Titónico-Neocomiense" denominado "flysch de Guerrouche", por oposición al flysch Albo-Aptiense de Glangeaud (1925) (fig. 1).

Las investigaciones de M. Durand-Delga en Beni Afeur (Sur de Jijel) permitieron individualizar en 1951 un Gotlandiense Inferior perfectamente datado, no metamórfico, descansando en clara discordancia sobre el zócalo cristalino con cantos en la base (fig. 2).

Durand-Delga presentó su tesis doctoral en Ciencias en 1955 sobre "la geología del Oeste de la cadena numídica" cuyo interés había sido supuesto desde hacía mucho tiempo por Paul Fallot, que le aconsejó emprenderla. G. Bétier, ingeniero general de minas, nombró al joven Durand-Delga, en 1946, a la temprana edad de 23 años, colaborador del Servicio del mapa geológico de Argelia, confiándole los levantamientos de la hoja a escala 1:50000 de Sidi Méronane, la revisión de las de Sidi Dris, y posteriormente los trabajos de Djidjeli. La tesis doctoral de Durand-Delga representa un "comentario de la cartografía detallada de alrededor de 1500 km^2, con una duración acumulada de los trabajos de 25 meses en el campo".

Después de los estudios sobre el terreno, admitió que el metamorfismo regional era antegotlandiense e incluso de edad caledoniana antigua, desde las cordilleras béticas hasta el Edough, con algunas reservas.

El descubrimiento del Silúrico discordante sobre el zócalo metamórfico permitió resolver en aquélla época la edad del metamorfismo de los zócalos kabílides.

Recordó que las zonas paleogeográficas y estructurales esenciales argelinas están orientadas paralelamente a la costa mediterránea.

Durand Delga multiplicó los hallazgos y planteó las hipótesis más importantes sobre el orógeno alpino perimediterráneo.

Desde 1956, emitió la hipótesis del origen ultrakabílico para los flyschs y así explicar la paleogeografía de estas formaciones orogénicas. Fundó más tarde una escuela formada por excelentes observadores que trabajaron en colaboración, desde el Rif marroquí hasta los confines argelo-tunecinos, siempre bajo la sagaz mirada del profesor Durand-Delga para llegar a un esquema coherente de los magrébides. Mediante sucesivas teclas, esta escuela confeccionó un modelo que aún permanece, pese a ser criticable, pero verdaderamente a salvo del desgaste temporal. Los flyschs mauritánico y masiliense fueron la obra de sus alumnos, así como la edad de la colocación de los mantos y los olitostromas.

Sus trabajos sobre el Chenoua durante la guerra de liberación en los cuales nosotros nos hemos inspirado posteriormente (Belhai, 1987;1996 y Belhai et al., 1950), sirvieron para comprender este macizo interno del oeste de Argelia (fig. 3).

El término de "Dorsal kabílica" es debido a él, en 1965, para reemplazar el de "Cadena calcárea" de Glangeaud (1932).

Durand-Delga trató desde los años 1950 sobre el cabalgamiento del límite kabílico para distinguir dos dominios completamente diferentes desde el punto de vista paleogeográfico.

El macizo antiguo de la Pequeña Kabilia está empujado hacia el sur sobre los terrenos mesozoicos del oeste de la cadena numídica (fig. 4). El ofreció también los caracteres generales de este cabalgamiento del borde kabílico en su tesis doctoral de 1955 que resume en estos términos: "la región frontal, limitando al sur con el macizo antiguo de la Pequeña Kabilia, aparecía como formada esencialmente por un gran anticlinal tumbado hacia el sur, interesando a la vez el cristalino antiguo y su cobertura mesozoica. En el flanco inverso de este pliegue, el núcleo paleozoico ha sido cortado y ha deslizado sobre la masa plástica del flysch cretácico, siempre presente en su borde meridional".

Este cabalgamiento del borde kabílico, puesto en evidencia muy temprano por Durand-Delga (fig. 5) acabará siendo una estructura mayor que separa la Dorsal Kabílica de un dominio de flysch con sustrato de corteza adelgazada casi oceánica, separando el continente africano del dominio septentrional en el Mesozoico.

En la Pequeña Kabilia, se vuelve a encontrar el cabalgamiento al sur de las Dorsales de Chellate, del Djurdjura, de Lakhdaria, del Chenoua y del Cabo Ténès.

El profesor Michel Durand-Delga ha tenido siempre admiración y nostalgia de este país, Argelia, que él tanto amó y donde él se forjó como geólogo y sobre todo, donde hizo su equipo y tuvo sus amigos (fig. 6).

Desbordaba conocimientos geológicos, fue el hombre que mejor estuvo colocado sobre el terreno en Argelia del norte para resolver los problemas cartográficos, estratégicos y estructurales. Contribuyó a formarnos y a formar a los que nosotros hemos formado.

El profesor Durand-Delga merece ser visto como uno de los más grandes geólogos del Mediterráneo Occidental de todos los tiempos. Es el especialista indiscutible de los Magrébides y quien formó la mayoría de los especialistas en geología de esta región norteafricana.

En diciembre de 2011, la Facultad de Ciencias de la Tierra le había enviado una invitación para volver a Argelia y participar en un workshop que nosotros queríamos organizar en su honor con una excursión geológica al Chenoua, lugar que él quería mucho, además de homenajearlo en Argel.

Desgraciadamente, no pudo dar una respuesta positiva a nuestro requerimiento y nos respondió con una carta llena de humor, excusándose por el hecho de no poder asistir a dicho evento por un problema de salud. Se pensó organizar esta reunión durante el mes de abril de 2012 o al semestre siguiente, pero el destino decidió lo contrario, y Durand-Delga falleció el 19 de agosto de 2012.

Los geólogos argelinos que se interesan por los Magrébides reclaman, de alguna manera, pertenecer todos a la escuela de Durand-Delga.

Introduction

Totally convinced by the philosophy of well known geologists, Michel Durand-Delga set himself a particular rhythm in geological sciences in North Africa. Whether in Algeria, in Morocco or Tunisia, he preferred to face the difficulties and secrets of the orogenic features of this part of the African continent instead of describing and interpreting local field observations.

It was on the trail of his master Paul Fallot and the great names of the Algerian and Moroccan geologists that he showed his talent and premonitions to later become a great master himself of the geology of the Maghreb in particular and of the Western Mediterranean basin as a whole.

As the undisputed specialist of this orogenic zone of the world where he multiplied geological discoveries, he created a school of Geology at the beginning of the 1960s. This school was based mainly on following his previous ideas emitted during the 1950s, when he was still a research beginner, writing his monumental thesis on the western geology of the Numidian Chain of eastern Algeria.

Professor Michel Durand-Delga enriched the Maghreb geological vocabulary with new concepts. With the contributioins from his students, he created a geological glossary of the Maghreb, naming about 50 % of the geological units, accidents and series using local names, sometimes related to the history of Maghreb. Professor Michel Durand-Delga was one of the rare survivors that stronbly contributed, after the second world war, to the exploration of the Tellian zones. "Formidable honour to keep in memory", as he, himself, wrote (letter to Belhaï in 2011).

La Petite Kabylie: the beginning of a brilliant long career

Suspected as being an interesting sector for a long time by Paul Fallot, the region of the Petite

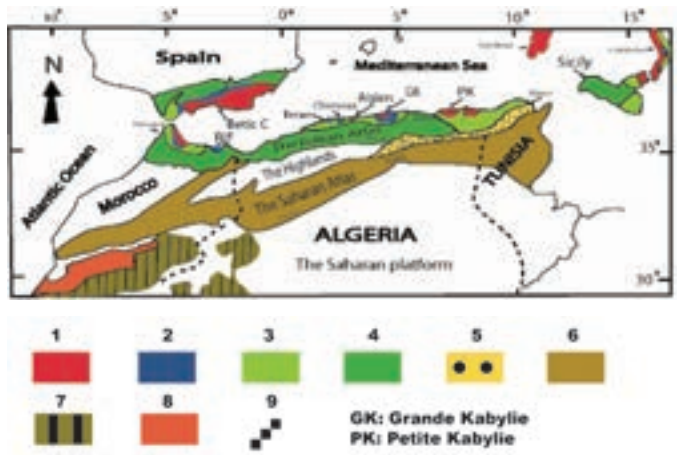

Figure 1. Structural scheme of the North of Africa showing the Altas zone, the Betic Zone and the Siculo-Calabraise zone.
1- Internal zone; 2- Kabylian dorsale; 3- Flysches; 4- Tellian Atlas; 5- Pre-Atlasic foredeep Miocene; 6- Saharan Atlas; 7- Bechar basin; 8- Anti-Atlas of Morocco; 9- Borders.
Figura 1. *Mapa de los grandes conjuntos estructurales del Mediterráneo Occidental.*

Kabylie was the first Algerian destination for Michel Durand-Delga.

In 1946, on recommendation of the supervisor Paul Fallot, G. Bétier, general engineer of Mines, named the young (23-year-old) Durand-Delga as a collaborator of the Department of the Geological Mapping of Algeria (Service de la Carte Géologique de l'Algérie). The aim was to dress the geological map (sheet) of Sidi Mérouane at 1/50 000 and the revision of Sidi Dris, then Djidjelli.

The first published work of M. Durand-Delga related to his fieldwork thesis was in 1948 and was entitled: "Sur la structure du Moul-ed-Demamène" (On the structure of Moul-ed-Demamène) followed by a second paper "Sur la structure du Djebel Sidi Marouf et de ses abords (chaîne numidique, Algérie)" (On the structure of the Djebel Sidi Marouf) and neighbourhoods (Numidian chain, Algeria). This work was the beginning of a great adventure which did not immediately end, as there was a great interest for Michel Durand-Delga in North Africa throughout his geological life. Later, he formed students who always worked in this part of the African continent and built up his own school that remains the most important in North Africa, particularly in alpine Algeria (Fig. 1).

Earlier, he had written two papers "Sur la structure géologique des environs de Texenna" (Petite Kabylie, Algérie) (On the geological structure of the Texenna neighborhoods (Petite Kabylia, Algeria), and on " Le Crétacé inférieur dans l'Ouest de la chaîne numidique" (the lower Cretaceous in the western part of the Numidian chain).

During his fieldwork when he was still a PhD student, he was able to report new geological discoveries that are still up-to-date and subject to controversy and discussion by many geologists.

In 1950, he wrote "Le Malm dans la chaîne numidique" (The Malm in the numidian chain) and "Le chevauchement bordier de Petite Kabylie" (The Petite Kabylia bordering thrust).

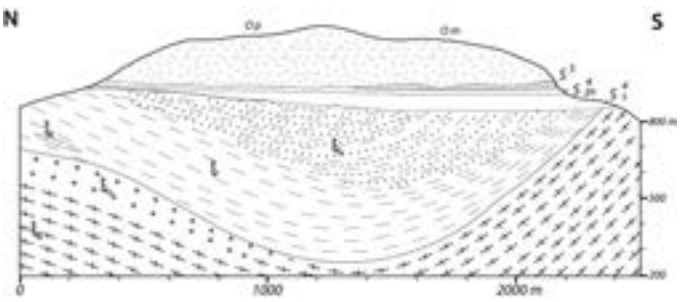

Figure 2. Beni Afeur discordance (Durand Delga, in 1955).
Figura 2. *Discordancia de Beni Afeur (Durand Delga, 1955).*

At Beni Afeur (Southern Jijel), the studies of Michel Durand-Delga (1951) ended up with a well defined and dated Lower Gothlandian formation. This is not metamorphosed and is lying on the metamorphic basement, the top of which was reduced to pebbles (Fig. 2).

Durand-Delga concludes that the metamorphism could result from a previous Caledonian phase - the Taconic phase precisely: "l'âge du métamorphisme général du massif de Petite Kabylie" (the age of the regional metamorphism of the Small Kabylie massif). He extends this conclusion to cover the whole Small Kabylie, Great Kabylia, the Algiers massif, the Chenoua and the Betico-Rifain massifs. This age that was attributed to the Kabylian metamorphism has been accepted by the majority of the authors who worked on the Kabylian region.

"Obviously, he says, the Paleozoic age attributed to the regional metamorphism of the Kabylian massifs excludes by no means the local development of recent hydrothermal metamorphism such as that observed in the Edough massif, Djebel Filfila and Djebel Safia, where Cretaceous and Oligocene sediments and Miocene igneous rocks underwent varied modifications. Similar hydrothermal metamorphism was also known in Zaccar (Oranie) and in eastern Morocco".

The discovery of a discordant Silurian formation on the metamorphic basement allowed attributing, at that time, an age to the metamorphism of the Kabylian basement, though it is still subject to controversy (e.g., Saadallah (1992); Mahdjoub (1991); Bouillin *et al.* (1984).

The year 1952 was when the nineteenth International Geological Congress in Algiers was organized – the first and only one in colonial France and Africa. All the geologists that were present gave contributions of varied degrees of importance. Michel Durand-Delga gave a presentation on the monography n°10 relative to "the southwestern part of the Petite Kabylia".

In 1953, he discovered the Triassic formation with a Tellian character and probably 'diapiric' structure in the northeast of Aïn Kechera, which shows the great amplitude of the Kabylian basement overthrust on the external zones. At that time, Alexis Lambert established the Mansouria-Oud Djendjen map at 1/20 000 and an unpublished report on the geology of the upper Djendjen dam project. It was probably there where they met and later together published papers, particularly on the flysch formations.

In 1955, Michel Durand-Delga submitted his D.Sc. thesis, entitled "Étude géologique de l'Ouest de la chaîne numidique" (the Geological study of the Western part of the Numidian chain). This thesis represents a comment on the detailed field mapping of about 1 500 km^2. This work lasted eight years with

eight fieldwork campaigns from 1947 to 1954; that is 25 cumulative months in the field supported by family accommodation in the mining villages of Tissimiran and Sidi Marouf.

He reminds us that the main paleogeographical and structural zones of Algeria are distributed parallel to the Algerian coast. In the Constantine province, three zones can be distinguished from north to south:

- The Kabylian zone represented by the metamorphic Paleozoic massif of the Petite Kabylia, which overthrust southerly the following domains:
- The sub-Kabylian zone, which consists mainly of Mesozoic sediment outcrops that are severely disrupted, either in the Babors or at their eastern extensions, the Numidian chain;
- The Tellian zone, which is separated from the sub-Tellian zone by an alignment of more or less continuous accidents (the north Tellian front).

Michel Durand-Delga showed the importance of the Kabylian bordering thrust in his paper of 1950 and proposed later a paleogeographical separation between the Kabylian domain and Africa well before the concept of plate tectonics.

Back to Kabylia

After his fruitful experience in the Moroccan Rif, he returned back with a team to Kabylia to study the Tellian zone. This team consisted of Mohamed Téfiani to work on the Algiers ridge and flysch (Djebel Bouzegza and Palestro neighbourhoods), Daniel Raymond on the north of Grande Kabylia, Jean-Pierre Gélard on the Chellata massif, Michel Leikine on Béjaia Babors, Jean-Pierre Bouillin on the El Milia region, Jean-François Raoult on the north of the Numidian chain and finally Jean-Marie Vila on the Constantine region and the Algerian-Tunisian borders.

It was in Kabylia where Durand-Delga's students defined with him the main series of the flysch deposits and olistostromes. He also named the Kabylian Ridge 1969 to replace the previous Limestone Chain of Glangeaud, in 1932.

The Rif and western Algerian experience:

From 1956, Michel Durand-Delga emitted the ultra-Kabylian hypothesis of the flysch to explain the paleogeography of these orogenic lithologies. When studying the Moroccan Rif, he made major discoveries and completed his model with new data, which became later the foundation of his school, which is still known as "Mister Michel Durand-Delga's School". This school consists of excellent observers in geology who, from the Moroccan Rif to the Algerian-Tunisian borders, worked in collaboration under the acute eye of Professor Durand-Delga, to draw a coherent sketch map of Maghrébides; a term which he created on the occasion of an article on the Western Mediterranean Sea that was published with J. Aubouin (Aubouin and Durand-Delga, 1971).

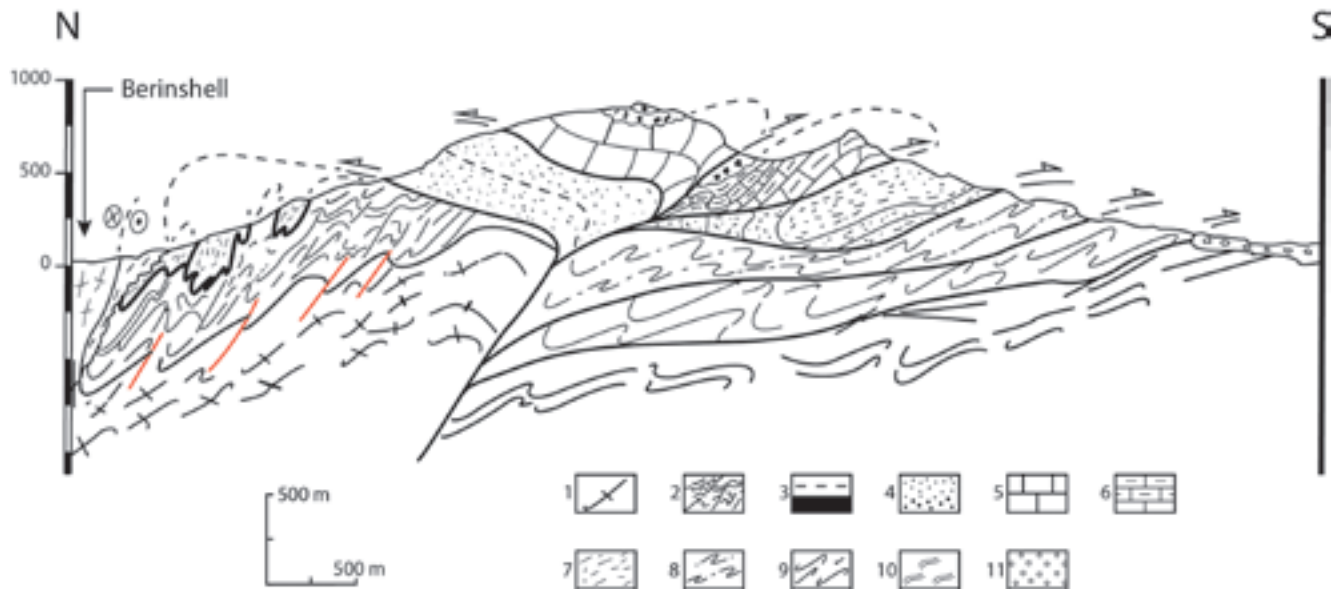

Figure 3. Cross-section through the Chenoua massif. (1. Metamorphic base of Berinshell, 2. Devonian, 3. Carboniferous period, 4. Permo-Trias 5. Internal ridge, 6. Median ridge, 7. External ridge, 8. Mauretanian flysch, 9. Massylian flysch, 10. Tellian nappes 11. Neogene post-nappes).
Figura 3. *Sección del macizo de Chenoua.*

He returned back to Algeria which was at that time in full revolution and published two articles in association with paleontologists.

In 1957, he published a paper in collaboration with Magné entitled "sur le Crétacé supérieur de la Dorsale du Chenoua" (on the upper Cretaceous of the Chenoua Ridge) where he recognized the Cenomanian-Turonian, the Senonian and the Paleogene with "scaglia" facies. In 1961, he discovered Devonian corals in the Chenoua massif which he published with Sémenoff-Tian-Chansky P. and Lafuste J.

His studies on Chenoua, either during the Algerian war or later, inspired us (Belhai, 1987; 1996; Belhai *et al.,* 1990) to understand this internal massif of western Algiers (Fig. 3).

In the same zone, Michel Durand-Delga dated precisely the Nummulitic-Cretaceous.

Internal zones of Algiers

Each of his students made fundamental geologic discoveries. We quote as an example the case of Mohamed Téfiani.

It was the young Algerian, who had just obtained his degree in geology in Paris in 1962 and he returned immediately to Algeria where he occupied the post of assistant in the Faculty. He was the Algerian student whom Michel Durand-Delga registered for his thesis, under his supervision on "Geological Study of the Southeast Algiers (area of Bouzegza)". An internal domain related to the Algiers area where very early on, he concluded the main studies which made of him one of the most brilliant alpine geologists of North Africa, in particular in the school animated by Professor Durand-Delga.

Téfiani jointly signed notes on the definitions of the mauretanian and massylian flysch deposits published in 1970 (Bouillin *et al.,* 1970) and note on olistostromes, published in 1973 (Bouillin *et al.,* 1973) but his fame was obtained when he published four brief but precursor papers on Djebel Zima (Téfiani, 1967); Tamerkennit (Téfiani, 1968); on the sandy schistose flysch of northern Kabylia (Téfiani, 1969) and the position of olistostromes at the base of the north Kabyle flysch (Téfiani, 1970). He brought a great deal to the building of the citra-Kabyle hypothesis defended by the School directed by Michel Durand-Delga.

In Great Kabylie

In the north-western Great Kabylie, Daniel Raymond (1976) analysed this complex zone by his supra-kabyles thrust sheets. He recognised a cartographic rise detailed by the flysch nappes and of the Neogene post-coat as being discordant. He resolved the problem of the tellien of Dellys as a unity which he (it) makes above kabyle, contrary to the hypothesis of a floating Kabylie defended by Alain Coutelle (1979). The work of Jean-Pierre Gélard (1979) ended in a monumental doctoral thesis in 1979, which remains a reference on the massif of Chellata in Great Kabylie. It is there that he defines the mauretanian flysch in 1969 in the Col des Chênes (Oaks Pass). He dated for the first time the Devonian in Ihamziène.

Michel Durand-Delga also had a student, Mohamed Naak, for his thesis of steady Magister supported in 1988 in Algiers in his presence.

In Petite Kabylie

One year later, 1971, the term Maghrebides by Michel Durand-Delga appears in the Encyclopédia Universalis. The same year (1971), the concept of plate tectonics is applied to this part of the Western Mediterranean alpine chain: the idea of an Alboran microplate is proposed by Andrieux, Fontboté and Mattauer "on an explanatory model of the bow of Gibraltar ".

One of the first pupils of Mr Durand-Delga, Jean-François Raoult began a thesis in Algeria in 1964, in the Sorbonne general Geology laboratory where he was named as an assistant. He presented his thesis in 1974 and then continued to study the geology of the Small Kabylie for some years. Jean-François Raoult, as a good cartographer and thanks to his rigour and his perspicacity, succeeded in defining geologic sets, based on a tectonic study and fine stratigraphic and precise paleontological datings.

This zone is known for its calco-alkaline granite studied in the detail by Ouabadi (1994) who showed that its geochemical signature is of subduction type.

From 1956, Michel Durand-Delga's work began to be dedicated to this question of the position of the so-called Tithonique-Néocomien flysch of the Guerrouch formation he had discovered in the forest of the same name (Jijel) in 1952. This northerly margin corresponds to a patch or a sub-patch different from the African patch, called the domain AlKaPeCa (Bouillin *et al.,* 1986).

In 1980, Professor Michel Durand-Delga presented two successive topics, the first entitled "The Western Mediterranean Sea: stages of its genesis and structural problems bound to this one" in the jubilee book of the Geological Society of France, 1830-1980 published in the report series of the Geological Society of France, n° 10.

He takes a number of concepts and ideas that had already been developed, but tries to better justify them. And so, among others, he justifies the notion of Maghrebides as follows: "under this name (proposed by J. Aubouin and Michel Durand-Delga, 1971) are grouped orogenic segments of Rif, Tell, North-Sicily and Calabria. This chain is lengthened tomore than 2000 km, between the Strait of Gibraltar and the Apennines". The consciousness of the unity of this set has become recently, he recalls basically "The unity of Maghrebides is assured so especially by two particular zones, paleogeographic and tectonic in the same time: the ridge and the flysch zone ".

The second (Michel Durand-Delga and Fontboté, on 1980) is entitled "The structural frame of the Western Mediterranean Sea".

Professor Michel Durand-Delga continued to be interested in Algerian geology and published an article on the Triassic internal zones with Mr Téfiani in 1993.

The solution of 1969

Michel's proposal for the geology of the northeast of Berberie remains an inescapable reference on the internal domain and the Tellian to this day. This article published in the Bulletin of the Geologic Service of Algeria (N° 39) redraws the big structural features and raises the problems connected to this key zone of the Western Mediterranean Sea. He writes: "the object of this article is to review the structure of the coastal areas of Algeria, especially eastern Algeria and Tunisia", because the author masters the eastern part of Algeria better than its western part, which always remained the domain of competence of L. Glangeaud and of his school.

The still observable elements show the opposition of internal zones, situated inside an east-west lengthened ring around the Western Mediterranean Sea, and the external zones, situated in the periphery of this ring. These elements are the following ones:

The cristallophyllian basement: "the older massifs (named cristallophyllian essentially) nowhere contain a Mesozoic coverage from which we can guarantee the transgressif character. The first layer of this basement is a discordant Upper Oligocene (Aquitanian) (OMK)". Michel Durand-Delga defends the idea of a stable basement, being affected during Mesozoic and during the Cenozoic "only by moderate folds ... ".

" ... In Grande and in Petite Kabylia, we observe that transgressif Aquitanian in its angular base lay with an angular discordance on the upper part of the phyllades: a conflict with a very weak angle, which translates the relative tectonic stability of the Kabyle basement, from a very old time". The idea defended by Michel Durand-Delga is clear, "the Kabyle basement formed itself, and metamorphosed before the Hercynian cycle, even the Cadeomian or more".

The Kabylian "dorsale": Ficheur (1901) had qualified it as a "liasic chain" and Glangeaud (1932) a "limestone range". In the eastern regions of Algiers, all the land qualified as a"limestone range" by Glangeaud is effectively calcareous links, but Tellian membership. Besides, this unity contains, by way of limestone, only that of Lias and of Eocene ages, which determine high reliefs, but in terms of volume and surface, dolomites, primary schist, Permian stoneware and detrital layers of the upper Nummulitic. To abolish any confusion, Michel Durand-Delga suggests replacing the term dedicated to that of "limestone range", a continuation and homologue of the rifaine "Ridge" of Paul Fallot, a real backbone limiting formally the internal zones, in the exact contact of the external zones of the perimediterranean orogenesis".

In an article in 1969, he summarizes perfectly both flysch series recognized in the same year by his students J.-P.Gélard and J-F.Raoult respectively for the Mauretanian flysch in Great Kabylie and the Massylian flysch in Small Kabylie. Indeed, in these hypothetical stratigraphic columns, he clearly distinguishes four flysches but for the Lower Cretaceous, he distinguishes a fine sandstone flysch at the end of Guerrouch of a schisto-quartziteux flysch surmounted from the microbreach flysch (Massylian flysch of J-F. Raoult, 1969).

M. Durand-Delga discusses finally in the region of Dellys the problem of "the Tellian of Dellys": he concludes two possible interpretations: the first one is the one which would make retrocharried Tellian from the outh, over the northward Kabylian domain (its current position), the other interpretation is the one which would place a Tellian furrow more in the north of Kabylie and which "would mime the classic Tellian Kabyle south furrow ". Such an interpretation seems to him improbable and he opts for the first interpretation. He distinguishes in the Tellian zone two main sets (groups) which are the autochtonous and para-autochtonous Tell and the Tellian nappes (Tellian sheet thrust).

— The autochtonous and para-autochtonous Tell is formed of eight (8) different domains:

1-The pre-Kabyle scales of the northern Constantinois (the lower scales of the Moul-ed-Demamène, in the south of El Milia, and the heart of Djebel Safia, east of Skikda; 2-The sub-Kabyle zone, represented mainly by Babors; North-Tellian; 3-The

autochthon-Tellien of Algérois (Atlas of Boumaad and Blida); 4-The autochthon of the massifs of Cheliff (localized in the west); 5-The intratellien autochthon; 6-Localized in the east, the autochthon shelly and shallow of Constantinois province; 7-The parautochtone of the Oran coast (localized in the west); 8-The south autochthon-tellian.

Flysches

Louis Glangeaud, in 1925, defined the Albo-Aptian nappe of flysch in the west of Algiers. Thirty years later, Dr. Durand Delga defines, with Alexis Lambert, the flysch of Guerrouch, when in 1955 they published the article on the nappe of "Tithonic-Neocomian flysch" the so-called "flysch of Guerrouch" (Dr.Durand-Delga and Lambert, in 1955) to set it later against the flysch Albo-Aptian of Glangeaud (Glangeaud, in 1925).

In the Rif, Michel Durand Delga discovered several units of flysches which he compared with those which he had recognized in Kabylia. He discovered the nappe of Tisirène, equivalent to the Guerrouch nappe. He put in evidence the nappe of Chouamat and Meloussa when he compared it with the Albo-Aptian abd Senonian units with in microbreaches already known in Algeria.

Michel Durand-Delga (1971) was the author of a very interesting article on the oceanic cliffs of the Rekkada Metlatine, which are the ophiolites of Texenna.

This period at the beginning of the 1970s was that of the debate on the paleogeographical origin of the flyschs from the Maghreb.

It was by successive readjustments that this school made a model which remains, certainly open to criticism, but likely (certainly questionable, but likely) in spite of the passing of time.

It is the Citra-Kabyle theory elaborated from 1963 that considers that flysches settled in the south of the ridge and in the north of the African margin.

The distinction and the definition of the Mauretanian flyschs (Gélard, 1969) and Massylian (Raoult, on 1969) are the work of his (her) pupils (Bouillin *et al.,* 1970), as well as the revealing the olistostromes above Kabyle and their dating (Bouillin *et al.,* 1973).

The definition of the flysch Massylien in 1969, going from Tithonic-Neocomian to Eocan, which he rectified in 1974 to leave in the one that describes going from Albo-Aptien to Senonien, is the work of J-F. Raoult.

According to Jean-Pierre Bouillin (personal communication), Jean-François Raoult was one of the favorite followers of M.M. Durand-Delga.

Jean-Pierre Bouillin, in 1970 discovered the window of Beni Toufout established (constituted) by a mesozoïc Tellian series (with facies of Trias, of the Jurassic, the Cretaceous, still recognizable in spite of the metamorphism and the particular deformation) surrounded by gneisses and phyllades of the Kabyle, a very distant pedestal at the back of the overlapping brow.

Jean-Marie Vila confirmed the work of J.-F. Raoult and J.-P. Bouillin, and from 1967 contributed to the building of the model of flysches by providing evidence for the series of Penthièvre which is the equivalent of the unity of Djebel Zima (M. Téfiani, in 1967)

M. Durand Delga wrote, in 1956, an article where he places the pond of the Kabylian flysch and rifain in the north of the ridge and the internal domain. This said position "ultrakabyle" mimes that of the western Alps where the alpine flysch is of ligure origin, in other words "ultrabriançonnaise".

Several authors working especially in the North African sector create, besides the internal and external zones, an "extreme reactionary" zone where the internal gliding or extreme reactionary nappes were ejected.

Theses "ultra" nappes contain all the terms of the stratigraphic series from the Middle Jurassic to Aquitanian. For the "ultra" hypothesis partisans (Michel Durand-Delga, in 1956; Mattauer, in 1963; Andrieux, in 1970), these group nappes were deposited in a furrow situated in the place of the North-Algerian pond of the current Mediterranean Sea during a finished convexity-Oligocene of this furrow and would have been set up by gliding and by gravity. But it was also Delga, who proposed, in 1963, the citra-Kabyle origin of flysch.

Figure 4. Cross section between Texenna showing Beni Afeur, where the Kabyle border-overlapping enters the base.
Figura 4. *Sección entre Texenna y Beni Afeur, donde el Kabyle entra en la base metamórfica y flyschs.*

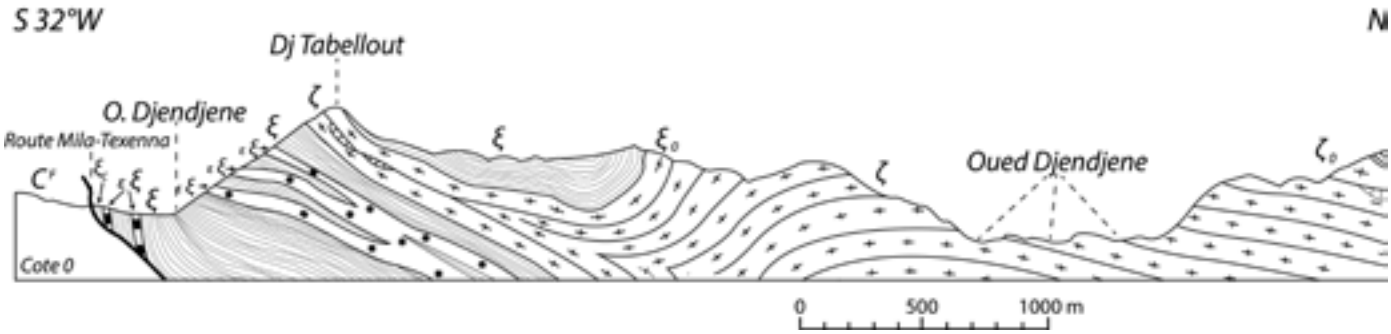

Figure 5. Oued Djendjen and Oued Rha and the Beni Afeur massif.
***Figura 5**. Oued Djendjen y Oued Rha y macizo de Beni Afeur.*

For other authors, (J.-F. Raoult, 1974, J.-P. Bouillin, in 1977, J.-M. Vila, in 1980), no form exists very far away from a («ultra») furrow». The homeland of nappes is in the calcareous south of the chain in an external position. Their implementation at the beginning of the Miocene results from an ejection from a "suction" zone situated in the contact with the internal zones and the external zones. Others (In. Cairo, 1973 or Has. Cairo 1970, Has. Coutelle, in 1979, M. Djellit, 1987) envisage a mixed origin for the alochthonous flysch.

Some would have been ejected by an external furrow in position and the others would have slid from an extreme reactionary furrow. This problem of the origin of these thrust sheets is of great importance for the elaboration of creation models of the Western Mediterranean pond.

The central idea of the school is that the flysch furrow would have differed in the base of the Cretaceous after the collapse of a zone already affected by distensions has been attested by eruptive rocks of the Rekkada-Metletine type (Durand-Delga, on 1971), and enters a northerly Kabyle margin (basement and Ridge) and a southern African margin (Tellian domain). The thesis of Jean-Pierre Bouillin (1977) almost established the coronation of Michel Durand-Delga's school for the model defended since the training of this school. The citra-Kabyle model is here explicit.

The Kabylian south accident or the brow of the Kabylian overlapping (the Kabyle thrust)

Michel Durand-Delga writes in 1950 of the border Kabyle thrust to distinguish two completely different domains on the paleogeographic plan.

The old massif of Petite Kabylia is pushed southwards on mesozoic ground west of the numidic chain (Fig. 4). He gives the general characteristics of this overlapping to border Kabyle in his thesis in 1955 when he summarizes in these terms "the frontal region limiting to the south the ancient massif of Small Kabylia appears as formed essentially by a big anticlinal slip southward, interestingly at the same moment of ancient cristallophyllian and its coverage Mesozoic. On the inverse side of this fold, the Paleozoic pit became unstuck and slid on the plastic mass of the Cretaceous flysch, always present on its southern edge ".

Metamorphic and flysch

This overlapping (Fig. 5) turned out to be a major structure which separates the Kabyle Ridge from a domain of flysch in a substratum of even oceanic thinned crust, separating the African continent from

Figure 6. Durand Delga was always happy to find himself in Algeria among these old friends and geology colleagues.
***Figura 6.** Durand Delga siempre era feliz de estar en Argelia entre sus viejos amigos y colegas.*

the northerly domain in the Mesozoic. Besides the dorsale of the Small Kabylia, we find this overlapping in the south of the Ridges of Chellata, Djurdjura, Lakhdaria, Chenoua and the Cap Ténès.

Conclusion

Professor Michel Durand-Delga always had great admiration for Algeria and felt homesick when away from it, the country he loved so much and where he forged his geologist's profession and especially built up a team and had many friends (Fig. 6).

Professor Michel Durand-Delga deserves to be considered as one of the greatest geologists of the Western Mediterranean Sea. He is the uncontested specialist of the Maghrebides and the one who formed the most specialists in the geology of this chain. He dedicated the main part of his research activity to the decoding of the structures of the mountain ranges of the alpine cycle, everything around the Western Mediterranean Sea, from Gibraltar to Corsica. In Andalusia and in Algeria, he also found Paul Fallot's tracks.

Endowed with excellent observation skills and rare perspicacity, he very early on sensed the complex mess of the geologic constituents of North Africa and he put in the time and the men necessary to decode the geology. In 1980, he became a corresponding member of the Paris Academy of Sciences. From then on, he dedicated a large part of his time to reading and to correcting papers which concerned the Mediterranean geology and especially the Maghrebides.

He was always happy to be in Algeria every time he passed there, for field trips or for conferences.

The Algerian Geologists who are interested in Maghrebides should refer to all at Dr. Durand-Delga's school.

In December 2011, the Faculty of Earth Sciences announced the desire to honour him.

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