



**Ministère de l'Industrie et des Mines**  
**Agence du Service Géologique de l'Algérie**

**Division Cartographie**  
**Département Documentation**

**Bibliothèque des Sciences de la Terre**

# **Bulletin**

# **Analytique**



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**MINISTRE DE L'INDUSTRIE ET DES MINES  
AGENCE DU SERVICE GEOLOGIQUE DE L'ALGERIE**

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## BULLETIN ANALYTIQUE / 2015

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## ENERGIE

**1: Progress in understanding the geothermal sedimentary basins in northeastern Morocco.** BARKAOUI A.E., ZARHLOULE Y., VERDOYA M.

**Keywords:** Underground temperature; Geothermal gradient; Advective heat transfer; Northeastern Morocco; Algeria.

**Abstract:** The aim of this paper is to contribute to the hydro-geothermal characterization of northeastern Morocco. This region is known by a large number of surface geothermal manifestations. Thermal waters are hosted within sedimentary rocks, and in particular the Liassic dolomitic limestones act as a reservoir. The presence of geothermal waters is closely related to important fault systems. Meteoric water infiltrates along those fractures and faults, gets heated, and then returns to surface through hydrothermal conduits. In order to improve our knowledge about the thermal regime in northeastern Morocco, a number of thermal conductivity measurements were carried out on a set of samples representative of the local stratigraphic sequence. Temperature logs were analyzed by matching thermal data with models of vertical temperature distribution. Thermo-hydraulic parameters were calculated from the coefficients of the advective models obtained by means of the least-square fitting method. Analytical modeling of heat and water transfer involved in the deep circulation was attempted along selected hydro-geological cross-sections in Oujda and Berkane region.

*In: Journal of African Earth Sciences; vol. 97, September 2014, p. 1-8.*

**2: Geothermal reservoir characteristics of Meso- and Cenozoic sedimentary rocks of Budapest (Hungary).**

GÖTZ A.E., TÖRÖK A., SASS I.

**Keywords:** Deep geothermal systems; Thermophysical rock properties; Thermofacies; Buda Hills; Hungary.

**Abstract:** The characterisation of deep geothermal reservoirs of sedimentary basins is supported by outcrop analogue studies since reservoir characteristics are strongly related to the sedimentary facies and thus influence the basic direction of geothermal field development and applied technology. Permeability and thermal conductivity are key parameters in geothermal reservoir characterisation and the data gained from outcrop samples serve to understand the reservoir system.

New thermophysical data from the Meso- and Cenozoic sedimentary rocks of Budapest include carbonates and siliciclastics of Triassic, Eocene, Oligocene and Miocene age as well as Pleistocene travertine, exposed on the western side of the river Danube in the Buda Hills. Field and laboratory analyses revealed distinct horizons of different geothermal potential and thus enable to identify and interpret corresponding exploration target horizons in geothermal prone depths in the Budapest region as well as in sub-basins of the Pannonian basins system exhibiting geothermal anomalies.

*In: Z. Dt. Ges.Geowiss. (German J. Geosci.); t. 165, n° 3, 2014, p. 487-493.*

**3: Les limites de l'exploitation des lignites.** PERRIER R.

**Mots-clés:** Lignite; Production; Exploitation; Extraction; Centrale électrique; Transition énergétique; Impasse énergétique; Environnement; Allemagne.

**Résumé:** Le gouvernement allemand a choisi de se désengager du nucléaire et s'est embarqué sur la voie du développement de l'extraction du lignite, en attendant qu'un mix énergétique d'énergies renouvelables le remplace. De fait, le lignite fournit un quart de la production d'électricité du pays. Et contrairement aux énergies renouvelables et au charbon, il n'est pas subventionné. Avec une production de lignite de 180 Mt, le pays est le premier producteur mondial, mais aussi le principal émetteur de CO<sub>2</sub> en Europe et le cinquième pollueur au monde.

Malgré les améliorations techniques apportées au traitement des fumées, le gaz carbonique est toujours émis en abondance. Or le lignite offre des réserves considérables, avec 300 ans de consommation. Mais il semble évident que l'Allemagne se dirige vers une impasse énergétique d'ici à 2050, à moins d'un changement de sa politique gouvernementale.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 216, Juillet-Août 2014, p. 29-38.*

#### **4: La filière thorium, énergie des prochains millénaires? PERRIER R.**

**Mots-clés:** Ressource; Thorium; Uranium; Energie; Electricité; Réserve; Réacteur nucléaire; Filière thorium; Filière uranium.

**Résumé:** Le thorium, faiblement radioactif, émet surtout des rayons  $\alpha$  peu pénétrants mais produit 70 fois plus d'énergie que l'uranium. Il est trois ou quatre fois plus abondant que l'uranium, et il est consommé à 99 % dans les réacteurs (contre 1% dans le cas de l'uranium). Ainsi, la filière thorium est susceptible de remplacer celle de l'uranium, si les obstacles technologiques sont surmontés. Cependant, aucun réacteur au thorium n'a encore été construit en grandeur réelle, et son coût est incertain. Voici un point sur la filière du thorium.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 210, Janvier 2014, p. 34-47.*

#### **5: André Dumont medallist lecture 2013. Crustal architecture, thermal evolution and energy resources of compressional basins. ROURE F.**

**Keywords:** Crustal architecture; Continental mantle lithosphere delamination; Foothills; Basin modelling; Reservoir appraisal; Petroleum systems.

**Abstract:** Our understanding of sedimentary basins, orogens and links between deep and surface processes has greatly benefited from recent improvement of imagery techniques, including crustal scale reflection seismic and mantle tomography. ECORS profiles across the Pyrenees, the Alps and the Paris basin for instance provide a unique control on the crustal architecture of both Cenozoic and Paleozoic orogens in Western Europe. Alternatively, mantle tomography and deep focal mechanisms in the Southeastern Carpathians and the Western and Central Mediterranean outline the progressive delamination at the Moho level of the continental lithosphere of Moesia and Adria, only its mantle part being actually recycled into the asthenosphere during the roll-back of the subduction associated with the Southeastward shift of the Carpathians and Apenninic-Maghrebian arcs. This paper describes also, using various case studies from the Apennines, Albania and Venezuela, the integrated workflow developed at IFP-EN to reconstruct the kinematic and thermal evolution of fold-and-thrust belts (foothills) and adjacent forelands, and the way numerical modelling and analytical work can improve our predictions in terms of energy resources, hydrocarbon potential and reservoir risk assessment.

Ultimately, key examples from the North America Cordillera, from the Arctic to the Gulf of Mexico, are used to document the controls of mantle dynamics on lithosphere thickness and thermicity, continental topography, post-orogenic unroofing and foreland unroofing, and the related changes observed in drainage areas and petroleum systems. Lateral changes observed in the lithosphere thickness between the Canadian Rockies and their foreland are also compared further with similar changes observed across the Tornquist-Teisseyre Line in the architecture, thermicity, rheology and deformation pattern of the European lithosphere.

*In: Geologica Belgica; vol. 17, n° 2, 2014, p. 182-194.*

#### **6: Present geothermal fields of the Dongpu Sag in the Bohai Bay basin. ZUO Y., QIU N., HAO Q.**

**Keywords:** Present geothermal field; thermal conductivity; Terrestrial heat flow; Bohai Bay basin; Dongpu sag; China.

**Abstract:** The Dongpu sag is located in the south of the Bohai Bay basin, China, and has abundant oil and gas reserves. To date, there has been no systematic documentation of its geothermal fields. This study measured the rock thermal conductivity of 324 cores from 47 wells, and calculated rock thermal conductivity for different formations. The geothermal gradient and terrestrial heat flow were calculated for 192 wells on basis of 892 formation-testing data from 523 wells. The results show that the Dongpu sag is characterized by a medium-temperature geothermal field between



stable and active tectonic areas, with an average geothermal gradient of 32.0°C/km and terrestrial heat flow of 65.6 mW/m<sup>2</sup>. The geothermal fields in the Dongpu sag is significantly controlled by the Changyuan, Yellow River, and Lanliao basement faults. They developed in the Paleogene and the Dongying movement occurred at the Dongying formation depositional period. The geothermal fields distribution has a similar characteristic to the tectonic framework of the Dongpu sag, namely two subsags, one uplift, one steep slope and one gentle slope. The oil and gas distribution is closely associated with the present geothermal fields. The work may provide constraints for reconstructing the thermal history and modeling source rock maturation evolution in the Dongpu sag.

*In: Acta Geologica Sinica; vol. 88, n° 3, 2014, p. 915-930.*

## GEOLOGIE STRUCTURALE

**7: Brittle tectonics within the Jurassic formations of the Ouarsenis culminating area, northwestern Algeria.** AÏFA T., ZAAGANE M.

**Keywords:** Polyphased tectonics; Paleostress; Rotation; Shear; Joint; Jurassic; Ouarsenis; Northwestern Algeria.

**Abstract:** Brittle structures within the Ouarsenis culminating zone were studied in order to characterize the polyphased tectonics. Field observations revealed that the dominant structures are highly tilted. They are represented by faults and joints, shears, reverse or curvilinear, locally associated with gypsum intrusions. Field data analysis shows that large scale shear faults are localized within the limits of the structural entities. Two main tectonic phases, having affected the Ouarsenis culminating zone were identified: (i) A NW-SE oriented compressive phase, represented by the contacts marked out by in-depth reverse faults and folding, mainly located in the westernmost part of Sra Abdelkader, Rokba Atba and in the western part of Batha, Fartas and Belkeiret (thrusts), respectively. This phase was also identified in reverse and sinistral faulting within Sidi Djber at the easternmost part of Sra Abdelkader, and the Grand Pic and the Southern massif of Belkeiret respectively. (ii) A NNE-SSW oriented compressive phase, characterized by dextral strike-slips, is located in the easternmost part of Sra Abdelkader and Rokba Atba.

North of the Grand Pic, a sinistral ~N120° oriented shearing occurred, with a lateral slip reaching ~2 km. The examination and the data analysis show a major N110-120° oriented fault with a sinistral signature. This movement would be responsible for block rotations and tilts. Counterclockwise rotations of the paleostress of ~38° and ~43° from west to east of the Sra Abdelkader massif and from Belkeiret to Batha, Fartas blocks were recorded, respectively. This local change of the stress field is mainly due to a deformation controlled by the regional post-Miocene geodynamic system, possibly explained by the proposed model.

*In: Journal of African Earth Sciences; vol. 96, August 2014, p. 39-50.*

**8: Neogene tectonics and fault-related folds in the Gulf of Hammamet area, Tunisian offshore.** BEN BRAHIM G., AHMADI R., BRAHIM N.

**Keywords:** Fault-propagation fold; Balanced cross-section; Thin-skinned thrusting; Subsurface geology; Gulf of Hammamet area; Tunisia.

**Abstract:** The western part of the Gulf of Hammamet area lies in the Pelagian Platform, eastward of the Atlas front. This region shows large changes in structural style compared to the Pelagian Platform. During the Neogene, the Gulf of Hammamet recorded the convergence of the Eurasia and Africa plates. During the Pliocene to early Quaternary, the area recorded an NW-SE shortening related to the Atlas contraction followed by an NNE-SSW extension linked to the Pantelleria-Malta graben opening.

Subsurface geology of the Gulf of Hammamet area allows us to propose a tectonic sketch, where the Neogene deformation is characterized by (1) Cenozoic age detachment level that located in the Mio-Pliocene and Quaternary series; (2) the growth of fault-related folds (mainly fault-propagation folds) and (3) a total shortening of about 6 km.

The thin-skinned thrusting is late Miocene age and is synchronous to the Africa-Europe collision. During the upper Miocene (Tortonian), fault-propagation folds developed above inherited normal faults.

The Pliocene age was tectonically calm period. Finally, post-Villafranchian contraction reactivated these structures. Despite the large number of hydrocarbon discoveries, the Gulf of Hammamet remains under-explored. This new interpretation of Neogene tectonic events and folding models could lead to a new play idea for the hydrocarbon prospectively in this proven oil province.

*In: Journal of African Earth Sciences; vol. 97, September 2014, p. 78-86.*

### **9: Witnesses of the Alpine deformation of small Kabylia flysch (Algeria).** BOUZEKRIA N.-E.

**Keywords:** Deformation; Flysch; Tethyan; Alpine; Small Kabylia; Algeria.

**Abstract:** Alpine flysch sediments of small Kabylia (Algeria), are two types, the first (Mauretanic et Massylien) is terrigenous material that was deposited during the upper Jurassic Cretaceous terminal period on the edge of the African and European continental stable plates; it reflects the closing of the Tethyan basin separating once the European and African plates; the second is the Numidian post-collision, it was field during the Oligo-Miocene period.

These formations are found currently in structural position in the lower and upper Kabylia basement, the analysis of structural elements (fold axes, fault planes and abnormal contacts) mounted a thrust of NW to SE, some of these were subducted as Kabylia basement and they were used during the thrust along several kilometers.

The geological map of the area as well as field observations give the impression that the small Kabylia basement is in a floating position on the flysch, this fact is reinforced by surveys carried out at the gorge of the Djen Djen river which have shown that the Kabylia basement rests on the lower parts of flysch represented mainly of basic igneous rocks.

The microstructural analysis based mainly on the stereographic projection of fold axes gave three main directions of deformation.

The first one N115 is related to the closure of the Tethyan basin and continental collision, while the second N080 is related to the thickening of the crust and thrusting of the flysch NW to SW, while the third N060 parallel to the Atlasic directions, it is related with sinistral detachment and counterclockwise rotation of Africa plate.

These three directions correspond to different constraints (N025, N330 and N350) that has suffered the Al Ka Pe Ca block during its migration to the south since Cenozoic period.

These results are connected with the different models explaining the development of the Kabylia blocks the deformations phases obtained in the Constantine pier (Marmi et al, 2006).

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 66.*

### **10: Problématique de la structure des corps triasiques de la frontière algéro-tunisienne- conséquences métallogéniques.** BOUZENOUNE A.

**Mots-clés :** Structure; Diapir; Corps triasiques; Affleurement; Métallogénie; Algérie; Tunisie.

**Résumé:** La problématique que pose la structure des corps triasiques de la frontière algéro-tunisienne soulève de nombreuses interrogations aussi bien sur le plan fondamental que sur le plan appliqué. Le mode de mise en place du matériel triasique de cette partie de l'Atlas saharien oriental et les structures qui en résultent sont diversement interprétées. En effet, plusieurs modèles interprétatifs ont été proposés pour expliquer l'anatomie de ces corps triasiques. Initialement, ils ont été considérés comme de « vrais diapirs ». Par la suite, une variante de ce modèle a été proposée dans laquelle seule une partie des affleurements de ces évaporites serait de « vrais diapirs » car effectivement enracinés ; les affleurements latéraux ou « épaulements » résulteraient de l'extravasation et de l'épanchement des formations triasiques à partir du Trias enraciné. Enfin, dans le modèle de « glacier de sel » les évaporites du Trias correspondraient à de vastes lentilles de matériel extrudé puis resédimenté, interstratifiées dans les terrains albiens. Les études sur les relations entre les dômes de sel et les concentrations métallifères aussi bien en Gulf Coast (USA) qu'en Afrique du Nord ont montré que les concentrations sont soit spatialement et génétiquement liées aux dômes de sel en se

disposant dans les formations triasiques, soit génétiquement liées à ces dômes en se disposant dans leurs couvertures sédimentaires. Cette étroite relation spatiale et génétique entre les concentrations minérales et les formations triasiques souligne l'importance de la compréhension et la définition de la structure de ces corps triasiques dont découleraient la méthodologie de recherche des gîtes minéraux et éventuellement des hydrocarbures dans la région.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 55-61.*

### **11: Intraplate deformation of the Al Qarqaf Arch and the southern sector of the Ghadames basin (SW Libya).**

CARRUBA S., PEROTTI C., RINALDI M.

**Keywords:** Intraplate deformations; Inversion structures; Remote sensing analysis; Ghadames basin; Al Qarqaf Arch; SW Libya; Algeria; Africa.

**Abstract:** The structural evolution of the Al Qarqaf Arch (Libya) and the southern sector of the Ghadames basin were reconstructed by the integration of remote sensing analysis, 2D seismic lines, well log data and geological maps. The Al Qarqaf Arch (Libya) is a wide, gentle warping of pre-Cambrian and Palaeozoic rocks that forms the southern boundary of the Ghadames basin, a large Palaeozoic intracratonic basin of the Saharan platform.

Surface and subsurface analyses revealed the presence of different phases of intracratonic deformations, related to the Al Qarqaf Arch uplift and Ghadames basin development. Extensional tectonic phases prevailed in the study area up until the Devonian, while compressional folding and structural inversion affected the region during Late Carboniferous and Mesozoic, indicating that compressional horizontal stresses affected the plate interior, giving rise to intraplate tectonics.

Three major unconformities (Intra-Silurian, Silurian-Devonian transition and Upper Carboniferous unconformities) outline these tectonic events related to the upwarping of the arch and the downwarping of the basin.

*In: Journal of African Earth Sciences; vol. 97, September 2014, p. 19-39.*

### **12: The Alboran domain in the western Mediterranean evolution: the birth of a concept.**

CASCIELLO E., FERNANDEZ M., VERGES J.

**Keywords:** Historical overview; Geodynamic evolution; Betic-Rif orogenic system; Gibraltar arc; Apennines; Western Mediterranean.

**Abstract:** Since the early 70's the majority of tectonic reconstructions of the western Mediterranean employ the Alboran domain notion as a migrating microcontinent or landmass mainly composed of Paleozoic-Triassic rocks affected by 'Alpine' HP-LT metamorphism. For nearly three decades, since the mid-80's, the Alboran domain was considered as a fragment of the Alpine chain that moved westward, colliding into Iberia and North Africa to produce the Gibraltar arc and Betic-Rif chain. In 2012, a new hypothesis for the evolution of the western Mediterranean was presented in which the Betic-Rif orogenic chain originates from rollback of an initially SE-dipping subduction of the westernmost segments of the Ligurian-Tethys under the Africa margin. This interpretation considers the metamorphic 'Alboran domain' rocks as crustal successions of the hyper-extended African and Iberian continental margins, which have undergone a complete subduction-exhumation cycle above a NW- to W-retreating subduction. A key outcome of this hypothesis is that the Alboran domain is not a fragment of the Alpine chain but a consequence of rollback dynamics.

In this contribution we try to elucidate the historical reasons behind the classical 'Alpine' interpretation of the Betic-Rif, by briefly describing key contributions, which appear linked in a logical sequence that traces the evolution of the Alboran domain concept since its original formulation by Andrieux and coauthors in 1971.

*In: Bull. Soc. Géol. France; t. 186, n° 4-5, 2015, p. 371-384.*

**13: Evolution structurale des Maghrébides: âges et styles des phases tectoniques paroxysmales tertiaires. Un nouveau modèle d'évolution de la chaîne.** DJELLIT H., MOHAMMEDI Y., LATEB T.

**Keywords:** Ductile deformation; Gravity thrust sheet; Rigid displacement; Kabylia flysch; Algerian alpine chain.

**Abstract:** The Algerian Alpine chain results from, at least, three tertiary tectonic phases whose structural styles and kinematics were not sufficiently described by the earlier studies. The aim of the present work is to precise the structural styles of each tectonic phase involved in the construction of the chain. This applies in particular to study the different compressional phases and their tertiary cumulative effects recorded by the different units present of the phases and their tertiary cumulative effects recorded by the different units present of the structural edifice. Analysis of the displacement-deformation relationship within the units allows to show that the edification of the chain took place as follows: (1) at upper Eocene, the southern margin of Kabylia basement (Kabylia dorsal in Great Kabylia or the volcanoclastic complex in Lesser Kabylia) is affected by an E-W ductile dextral transpressive strike-slip fault (D1 phase); (2) during Oligocene-Miocene a sliding tectonic phase occurred (phase D2).

During this phase, a part of Kabylia flysch slide by gravity process from North to South, over the Kabylia basement and the Kabylia dorsal; (3) a third compressional tectonic phase (D3) occurs at the end of the Oligocene-Miocene olistostromic deposits. D3 is characterized by a simple shearing with southern vergencies, on E-W plans dipping towards the North, to which are associated fault-related folds (flat and ramp). These recent results permit to propose an evolution model of the North Algeria Alpine belt. In this model, a part of Kabylia flysch have an internal paleogeographic origin, originally situated at the North part of the Kabylia basement.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 8-28.*

**14: The role of inherited structures in the evolution of the Mekkassy basin, Central Tunisia, based on geological-geophysical transects.** HAJI T., ZOUAGHI T., BOUKADI N.

**Keywords:** Folds and thrust belt; Triassic; Pull-apart basin; Mekkassy; Atlas; Tunisia.

**Abstract:** This paper uses seismic data, well data, and surface geologic data to present a detailed description of the Mekkassy basin in the Atlas fold and thrust belt of central Tunisia. These data reveal that the Mekkassy basin is bounded by major faults, along which Triassic evaporites have been intruded. The anticlines and synclines of the basin are delimited by two N-S main faults (the North-South Axis and the Sidi Ali Ben Oun fault) and are subdivided by associated N120° and N45° trending fault-related anticlines.

The Mekkassy basin is characterized by brittle structures associated with a deep asymmetric geometry that is organized into depressions and uplifts. Halokinesis of Triassic evaporites began during the Jurassic and continued during the Cretaceous period. During extensional deformation, salt movement controlled the sediment accumulation and the location of pre-compressional structures. During compressional deformation, the remobilization of evaporites accentuated the folded uplifts. A zone of decollement is located within the Triassic evaporites.

The coeval strike-slip motion along the bounding master faults suggests that the Mekkassy basin was initiated as a pull-apart basin with intrusion of Triassic evaporites. The lozenge structure of the basin was caused by synchronous movements of the Sidi Ali Ben Oun fault and the North-South Axis (sinistral wrench faults) with movement of NW-SE first-order dextral strike-slip faults. Sediment distribution and structural features indicate that a major tectonic inversion has occurred at least since Late-Cretaceous and Cenozoic. The transpressional movements are marked by reverse faults and folds associated with unconformities and with remobilization of Triassic evaporites. The formation of different structural features and the evolution of the Mekkassy basin and its neighboring uplifts have been controlled by conjugate dextral and sinistral strike-slip movements and thrust displacement.

*In: Journal of African Earth Sciences; vol. 96, August 2014, p. 51-59.*

**15: Tectonic-karstic origin of the alleged “impact crater” of Lake Isli (Imilchil district, High Atlas, Morocco).** IBOUH H., MICHARD A., CHARRIERE A.

**Keywords:** Tectonic; Karst; High Atlas; Lake Isli; Morocco.

**Abstract:** The scenic lakes Tislit and Isli of the Imilchil area in the central High Atlas of Morocco have been recently promoted to the rank of “dual impact crater” by a group of geoscientists. This was promptly denied by a group of meteorite specialists, but the first team reiterated their impact crater interpretation, now restricted to Lake Isli. This alleged 40-kyr-old impact crater would be associated with the Agoudal meteorite recognized further in the southeast.

Here, we show that the lake formed during the Lower-Middle Pleistocene in a small Pliocene (?) pull-apart basin through additional collapsing due to karst phenomena in the underlying limestones. This compares with the formation of a number of lakes of the Atlas Mountains. None of the “proofs” produced in support of a meteoritic origin of Lake Isli coincides with the geology of the area.

*In: C.R. Geoscience; vol. 346, n° 3-4, 2014, p. 82-89.*

**16: Convergence lithosphérique.** LALLEMAND S., HUCHON PH., JOLIVET L.

**Mots-clés:** Convergence; Cinématique des plaques; Géologie; Géophysique; Subduction; Lithosphère océanique; Collision; Alpes; France.

**Résumé:** Ce fascicule a pour objet de fournir aux enseignants, et aux étudiants, l’essentiel des notions actualisées sur la convergence dont ils ont besoin pour leurs cours et, au-delà des cours, pour leur culture générale.

*In: Société Géologique de France; 2005, 182 p.*

**17: Submarine allochthonous salt sheets: gravity-driven deformation of North African Cretaceous passive margin in Tunisia – Bled Dogra case study and nearby salt structures.** MASROUHI A., BELLIER O., BEN YOUSSEF M.

**Keywords:** Passive margin; Cretaceous; Allochthonous salt; Gravity deformation; Tunisia; North Africa.

**Abstract:** We used structural, stratigraphic and sedimentologic data, together with a comparison of nearby structures and a Bouguer gravity map, to evaluate the evolution of the Bled Dogra salt structure (northern Tunisia) during the Cretaceous. Triassic salt sheets are recognized in the northwestern region of the Tunisian Atlas. These salt sheets are the result of Cretaceous thick and/or thin-skinned extension along the south Tethyan margin. The Bled Dogra salt structure is one of these submarine allochthonous salt sheets, which was emplaced during the Early Cretaceous. The geologic framework, during this period, produces conditions for a predominantly gravity-driven deformation: extension has produced space for the salt to rise; vigorous differential sedimentation created differential loading that resulted in the emplacement and extrusion of a large volume of Triassic salt and formation of large submarine salt sheets. Geologic field data suggest an interlayered Triassic salt sheet within Albian sequences. Salt was extruded at the sea floor during the Early-Middle Albian and was initially buried by Middle-Late Albian strata. The Coniacian corresponds to a second transgressive cover onto the salt sheet after the gliding of the first salt cover (Late Albian-Turonian). In addition, this northwest Tunisian area exposes evidences for salt flow and abundant slump features at the base of a northward facing submarine slope, which was probably dominant from the Early Cretaceous to Santonian. Two gravity deformation processes are recognized: gravity gliding and gravity spreading. Acting concurrently, these two processes appear indistinguishable in this geologic context. Like the present-day salt-involved passive margins – such as the northern Gulf of Mexico, the Atlantic margin of Morocco, the Brazilian Santos basin, the Angola margin, Cadiz in western Iberia, and the Red Sea – the North African Cretaceous passive margin in Tunisia provides evidences that deformation in a passive-margin salt basin is predominantly gravity-driven deformation.

*In: Journal of African Earth Sciences; vol. 97, September 2014, p. 125-142.*

**18: The position of Madagascar within Gondwana and its movements during Gondwana dispersal.** REEVES C.

**Keywords:** Aeromagnetism; Dykes; Indian Ocean; Madagascar; Gondwana.

**Abstract:** A reassembly of the Precambrian fragments of central Gondwana is presented that is a refinement of a tight reassembly published earlier. Fragments are matched with conjugate sides parallel as far as possible and at a distance of 60-120 km from each other. With this amount of Precambrian crust now stretched into rifts and passive margins, a fit for all the pieces neighbouring Madagascar – East Africa, Somalia, the Seychelles, India, Sri Lanka and Mozambique – may be made without inelegant overlap or underlap. This works less well for wider de-stretched margins on such small fragments. A model of Gondwana dispersal is also developed working backwards in time from the present day, confining the relative movements of the major fragments – Africa, Antarctica and India – such that ocean fracture zones collapse back into themselves until each ridge-reorganisation is encountered. The movements of Antarctica with respect to Africa and of India with respect to Antarctica are defined in this way by a limited number of interval poles to achieve the Gondwana ‘fit’ situation described above. The ‘fit’ offers persuasive alignments of structural and lithologic features from Madagascar to its neighbours. The dispersal model helps describe the evolution of Madagascar’s passive margins and the role of the Madagascar Rise as a microplate in the India-Africa-Antarctica triple junction. Intrusions, extrusions

and dykes observed in Madagascar and its neighbours, largely from aeromagnetic survey data, are related to the outbreak of the Karoo/Bouvet mantle plume at ~182 Ma, the Marion mantle plume at ~88 Ma and the Reunion mantle at ~66 Ma. The dispersal model may be viewed and downloaded as an animation at: <http://www.reeves.nl/Gondwana>.

*In: Journal of African Earth Sciences; vol. 94, June 2014, p. 45-57.*

**19: Impact structures in Africa: a review.** REIMOLD W.U., KOEBERL CH.

**Keywords:** Impact structures; Impact crater record; Shock metamorphism; Projectile identification; Terrestrial impact record; Africa.

**Abstract:** More than 50 years of space and planetary exploration and concomitant studies of terrestrial impact structures have demonstrated that impact cratering has been a fundamental process – an essential part of planetary evolution – ever since the beginning of accretion and has played a major role in planetary evolution throughout the solar system and beyond. This not only pertains to the development of the planets but to evolution of life as well. The terrestrial impact record represents only a small fraction of the bombardment history that earth experienced throughout its evolution. While remote sensing investigations of planetary surfaces provide essential information about surface evolution and surface processes, they do not provide the information required for understanding the ultra-high strain rate, high-pressure, and high-temperature impact process. Thus, hands-on investigations of rocks from terrestrial impact craters, shock experimentation for pressure and temperature calibration of impact-related deformation of rocks and minerals, as well as parameter studies pertaining to the physics and chemistry of cratering and ejecta formation and emplacement, and laboratory studies of impact-generated lithologies are mandatory tools. These, together with numerical modeling analysis of impact physics, form the backbone of impact cratering studies.

Here, we review the current status of knowledge about impact cratering – and provide a detailed account of the African impact record, which has been expanded vastly since a first overview was published in 1994. No less than 19 confirmed impact structures, and one shatter cone occurrence without related impact crater are now known from Africa. In addition, a number of impact glass, tektite and spherule layer occurrences are known. The 49 sites with proposed, but not yet confirmed, possible impact structures contain at least a considerable number of structures that, from available information, hold the promise to be able to expand the African impact record drastically – provided the political conditions for safe ground-truthing will become available. The fact that 28 structures have also been shown to date not to be of impact origin further underpins the strong interest in impact in Africa. We hope that this review stimulates the education of students about impact cratering and the fundamental importance of this process for earth – both for its biological and geological evolution. This work may provide a reference volume for those workers who would like to search for impact craters and their ejecta in Africa.

*In: Journal of African Earth Sciences; vol. 93, May 2014, p. 57-175.*

**20: Late Ediacaran-Cambrian structures and their reactivation during the Variscan and Alpine cycles in the Anti-Atlas (Morocco).** SOULAIMANI A., MICHARD A., OUANAÏMI H.

**Keywords:** Basement faults; Reactivation; Ediacaran; Variscan orogeny; Atlas orogeny; Anti-Atlas; Morocco.

**Abstract:** The post-Pan-African evolution of the northern border of the West African Craton is largely controlled by the remobilisation of Late Neoproterozoic basement faults. The Upper Ediacaran volcanic and volcano-sedimentary sequences of the Ouarzazate Group show dramatic and rapid thickness changes, consistent with active extensional faulting associated with post-orogenic collapse and incipient continental rifting. The geometry and kinematics of these faults differ from west to east in the Anti-Atlas. N- to NE-trending faults dominate in western Anti-Atlas in response to E-W to NW-SE pure extension, while a transtensive opening regime characterizes the central (Bou Azzer) and eastern (Saghro-Ougnat) Anti Atlas.

The marine incursion in the west-central Anti-Atlas during the late Ediacaran-Early Cambrian occurred without major geodynamical break between the continental Ouarzazate Group and marine sediments of the Adoudou Fm. Extensional tectonics went on during the Early Cambrian, being concentrated in the western and central parts of the belt. From Middle Cambrian to Lower Devonian and mainly due to thermal subsidence, the Anti-Atlas basement was buried under marine sediments with dominant south-derived detrital input. Basement faults control the distribution of subsiding versus shallow areas. During the Middle-Late Devonian, the dislocation of the Saharan platform occurred, mainly in the eastern Anti-Atlas where Precambrian faults were also remobilized during the Early Carboniferous.

During the Variscan orogeny, the Paleozoic series of the Anti-Atlas basin were involved in folding tectonics, concomitant with the uplift of Proterozoic basement blocks bounded by inherited basement faults. The pre-existing rift-

related faults were variably inverted across the Anti-Atlas. In the westernmost part of the belt, Variscan shortening induced positive inversions along the remobilized basement faults, but in some cases, some faults preserved an apparently normal throw. Some hidden basement faults accommodate the Variscan shortening by strike-slip movement expressed by an echelon fold pattern in the overlying cover.

The Mesozoic-Cenozoic evolution of the Anti-Atlas is again marked by the reactivation of the basement faults. During the Triassic, the Anti-Atlas belongs to the uplifted shoulder of the Atlasic-Atlantic rift zone. Remobilisations of paleofaults again play a significant role in the weak burial of the Anti-Atlas during the Late Cretaceous-Eocene before the Neogene exhumation related to the Africa-Europe collision. Hence the structural evolution of the Anti-Atlas during the Paleozoic to present times has been heavily dependent on the fault pattern inherited from the Late Ediacaran-Cambrian rifting evolution at the northern fringe of the WAC, already deeply affected by the Pan-African orogeny.

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 94-112.*

## STRATIGRAPHIE

**21: Proposed reassessment of the Cambrian GSSP.** BABCOCK L.E., PENG SH., ZHU M.

**Keywords:** Cambrian; Terreneuvian; Paleozoic; GSSP; Chronostratigraphy; Ediacaran.

**Abstract:** Since the time of its ratification in 1992, the Cambrian GSSP, 2.3 m above the base of Member 2A (Quaco Road Member) of the Chapel Island formation, Fortune Head section, Newfoundland, Canada, has been challenged as posing an ambiguous correlation level. Difficulties have been encountered in precisely correlating the horizon coinciding with the GSSP to strata on most paleocontinents, but especially to Siberia and South China (Gondwana). The GSSP point, which was intended to coincide with the base of the *Treptichnus pedum* (formerly *Phycodes pedum* or *Trichophycus pedum*) Ichnozone at the FAD of the trace fossil *T. pedum*, occurs above the first appearance of the trace in the stratotype section. Trace fossils of other forms in the stratotype provide a means of bracketing the position of the GSSP, but are imprecise guides for correlation globally. Other chronostratigraphic guides are unavailable at the stratotype because of a dominance of coarse siliciclastic lithologies and metamorphic overprint. To facilitate global correlation of the Cambrian base and ensure nomenclatural stability to the extent possible, discussion of the merits and perceived weaknesses of the Cambrian GSSP is sought. Possible solutions to the problems surrounding the current GSSP definition are addressed in hopes that the global scientific community will actively participate in developing a well-reasoned, practical solution that will stand the test of time.

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 3-10.*

**22: Les terrains continentaux tertiaires de l'avant pays occidental en Algérie.** BENSALAH M., ADACI M., MAHBOUBI M.

**Mots-clés:** Stratigraphie; Terrains continentaux; Age Eocène; Sédimentologie; Paléogéographie; Paléo-tectonique; Sud-Ouest algérien; Algérie.

**Résumé:** Les terrains continentaux sud-tlemcénien, sud atlasique et hammadien tertiaires, occupent des surfaces considérables dans le Sud-Ouest algérien. L'étude des terrains continentaux d'âge éocène de l'avant pays tellien a montré une richesse d'enseignements au plan stratigraphique, sédimentologique, paléogéographique et paléotectonique.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 62-65.*

**23: Evolution lithostratigraphique, paléoenvironnementale et paléogéographique du flysch de Ben-Zireg (Viséen inférieur, Algérie).** BENOUCHEF M., MALTI F.-Z., ADACI M.

**Mots-clés:** Viséen inférieur; Flysch; Lithostratigraphie; Sédimentologie; Tectonique; Paléogéographie; Ben-Zireg; Algérie.

**Résumé:** La structure anticlinale de Ben-Zireg se situe sur la marge nord-occidentale de la plate-forme saharienne. Sur le flanc nord de cette structure affleure une formation silicoclastique attribuée au Viséen inférieur, dénommée « flysch

de Ben-Zireg ». Sur une épaisseur d'environ 400 m, cette formation peut être divisée en quatre grands ensembles: 1) le « pré-flyschoïde » formé d'une altérence de pélites et de bancs de grès à « HCS », dans laquelle s'intercalent des niveaux calcaires bioclastiques. Ce premier ensemble témoigne d'une sédimentation d' « offshore » à « shoreface » sous dynamique de tempêtes; 2) le « wildflysch » se caractérise par des phénomènes de résédimentation gravitaires. Il correspond à une épaisse couche de pélites vertes, slumpées, comprenant des olistolithes, avec également des intercalations gréseuses, conglomératiques ou à écoulements de débris. Ces dépôts témoignent d'une sédimentation en pied de pente (« slope apron ») et de remplissage des chenaux (« channel-fill deposits »); 3) le « flyschoidé » est composé d'une alternance régulière de pélites vertes et de bancs gréseux turbiditiques latéralement très étendus. Un niveau à olistolithes hectométriques (récif eifélien et grès cambro-ordoviciens) s'intercale au milieu de cet ensemble qui a été interprété comme la bordure d'un cône sous-marin profond (« fan fringe » ou « lobe fringe »); et 4) le « post-flyschoidé » est à alternances de pélites et de grès, intercalées de quelques niveaux calcaires à entroques et oolithes, témoignant d'un milieu de plate-forme peu profonde. L'évolution géodynamique du bassin de Ben-Zireg, pendant le Viséen inférieur, s'inscrit dans un contexte régional extensif. Elle se caractérise par l'enchaînement des stades de structuration suivants: 1) installation d'une plate-forme mixte soumise aux influences des tempêtes (pré-extension); 2) individualisation d'une fosse tectonique associée à des dépôts chaotiques et installation d'un système turbiditique riche en sable (syn-extension); et 3) au toit de ce dernier stade, la série se poursuit par une sédimentation de plate-forme mixte, puis de plate-forme carbonatée (post-extension).

*In: Géodiversitas; vol. 37, n° 1, 2015, p. 5-29.*

**24: The Early Pliocene reflooding in the Western Mediterranean: new insights from the rias of the internal Rif, Morocco.** CORNEE J.-J., MÜNCH PH., MELINTE-DOBRINESCU M.

**Keywords:** Depositional geometries; Biostratigraphy; Reflooding; Zanclean; Alboran sea; Rias; Morocco; Mediterranean.

**Abstract:** New field and micropalaeontological investigations have been conducted in four of the Pliocene rias of the internal zone of the Rif in Morocco, on the southern margin of the Alboran sea. We found that marine sediments outcropping in these rias were deposited mainly during the Early Zanclean, between 5.04 and 3.8 Ma. After a transgressive episode that led to the deposition of terrestrial to marine conglomerates, dark clays deposited first at shallow palaeo-depths and then at bathyal palaeo-depths. The rias were then infilled with a shallowing upward succession comprising marine clays and sandstone and, locally, terrestrial sediments that indicate their final emersion. No Gilbert-deltas were observed in these rias. The presence of transgressive deposits at the bottom of the rias, also identified in other basins of the external zone of the Rif, and the absence of Gilbert deltas question a catastrophic reflooding after the Messinian Salinity Crisis in this area.

*In: C.R. Geoscience; vol. 346, n° 3-4, 2014, p. 90-98.*

**25: Research on the Ediacaran and Cambrian of the Anti-Atlas and High Atlas mountains, Morocco: an historical overview.** DEBRENNE F.

**Keywords:** Field explorations; Cambrian faunas; Precambrian-Cambrian boundary quest; Morocco; Gondwana.

**Abstract:** Two periods of geological research can be recognized in the Ediacaran and Cambrian of Morocco. The period 1917-1945 is represented by an exploration phase that led to numerous discoveries of Cambrian faunas overlying conformably or unconformably, thick, metamorphic, Precambrian formations. The Moroccan Geological Society (SGM) published numerous geological maps with notices and regional monographies. The second period (1948-1995) allowed erection of detailed litho- and biostratigraphic sketches for stratigraphic subdivisions, among which the proposal of alternative (radiometric and chemostratigraphic) methods to precisely locate the Precambrian-Cambrian boundary in Morocco.

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 11-18.*

**26: Architecture and composition of the Upper Burdigalian z-coral build-ups of southern Corsica (Mediterranean).** GALLONI F., CHAIX CH., CORNEE J.-J.

**Keywords:** Upper Burdigalian; Coral reefs; Biodiversity; Sedimentary architecture; Corsica; Mediterranean.

**Abstract:** In Southern Corsica, three successive Upper Burdigalian coral reef episodes (R1, R2 subdivided into R2A and R2B subunits, and R3) developed within the Cala di Labra formation. Tabular corals dominated under high water



energy and siliciclastic input conditions. The R1 reefs show the highest coral diversity with 16 species described for the first time. A coral impoverishment was recorded in the R2 and R3 reefal episodes. The reefs did not reach a climax growth stage, except the R1 ones. Analogous to North Sardinian reefs, they reflect local vanishing conditions in the Corsican-Sardinian block through Upper Burdigalian because of constant siliciclastic inputs and deepening of the Bonifacio straight.

*In: C.R. Geoscience; vol. 346, n° 1-2, 2014, p. 45-51.*

**27: Diachronism in the late Neoproterozoic-Cambrian arc-rift transition of North Gondwana: a comparison of Morocco and the Iberian Ossa-Morena zone.** JAVIER ALVARO J., BELLIDO F., GASQUET D.

**Keywords:** Volcanic geochemistry; Ediacaran-Cambrian paleogeography; Anti-Atlas; Morocco; Cadomian and Pan-African belts.

**Abstract:** In the northwestern border of the West African craton (North Gondwana), a transition from late Neoproterozoic subduction/collision to Cambrian rift processes was recorded in the Anti-Atlas (Morocco) and in the Ossa-Morena zone (Iberia). Cambrian rifting affected both Pan-African and Cadomian basements in a stepwise and diachronous way. Subsequently, both areas evolved into a syn-rift margin episodically punctuated by uplift and tilting that precluded Furongian sedimentation. A comparison of sedimentary, volcanic and geodynamic evolution is made in the late Neoproterozoic (Pan-African and Cadomian) belts and Cambrian rifts trying to solve the apparent diachronous (SW-NE trending) propagation of an early Palaeozoic rifting regime that finally led to the opening of the Rheic ocean.

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 113-132.*

**28: Neoproterozoic-Cambrian stratigraphic framework of the Anti-Atlas and Ouzellagh promontory (High Atlas), Morocco.** JAVIER ALVARO J., BENZIANE F., THOMAS R.

**Keywords:** Diamictite; Atlas rift; Morocco; West African craton; Pan-African orogeny; Gondwana

**Abstract:** In the last two decades, great progress has been made in the geochronological, chrono- and chemostratigraphic control of the Neoproterozoic and Cambrian from the Anti-Atlas Ranges and the Ouzellagh promontory (High Atlas). As a result, the Neoproterozoic is lithostratigraphically subdivided into: (i) the Lkest-Taghdout Group (broadly interpreted at c. 800-690 Ma) representative of rift-to-passive margin conditions on the northern West African craton; (ii) the iriri (c. 760-740 Ma), Bou Azzer (c.762-697 Ma) and Saghro (c. 760?-610 Ma) groups, the overlying Anezi, Bou Salda, Dadès and Tiddiline formations localized in fault-grabens, and the Ouarzazate supergroup (c. 615-548 Ma), which form a succession of volcanosedimentary complexes recording the onset of the Pan-African orogeny and its aftermath; and (iii) the Taroudant (the Ediacaran-Cambrian boundary lying in the Tifnout Member of the Adoudou formation), Tata, Feijas Internes and Tabanite groups that have recorded development of the late Ediacaran-Cambrian Atlas Rift. Recent discussions of Moroccan strata to select new global GSSPs by the International Subcommissions on Ediacaran and Cambrian Stratigraphy have raised the stratigraphic interest in this region. A revised and updated stratigraphic framework is proposed here to assist the tasks of both subcommissions and to fuel future discussions focused on different geological aspects of the Neoproterozoic-Cambrian time span.

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 19-33.*

**29: Age, internal stratigraphic architecture and structural style of the Oligocene-Miocene Numidian formation of Northern Tunisia.** RIAHI S., SOUSSI M., BEN ISMAIL K.

**Keywords:** Numidian formation; Stratigraphy; Oligocene; Miocene; Turbidites; Structural analyses; Northern Tunisia; Algeria.

**Abstract:** The stratigraphy of the Numidian formation of northern Tunisia and its internal organization are updated. Planktonic foraminifera point to a mainly Oligocene-Early Miocene age of this formation in the majority of the sections studied. Some key lithological horizons are recognized within the early Miocene succession, allowing lateral correlation between the outcrops of the Mogod and Kroumirie mountains. These include: (1) a conglomeratic interval, up to 1-2 m thick and rich in reworked glauconitic boulders, limestones fragments of the Tellian (Eocene) and pectinid bivalves; and (2) a relatively continuous glauconitic level. In the new stratigraphic scheme, the Zouza, Ben Metir and Sejnene sections represent the entire Numidian formation. A lower unit (200-700 m thick), highly pelitic with subordinate

sandstone beds was distinguished, overlain by an upper unit which is sandier, especially in its uppermost part (1,000-1,500 m thick). In the present study, these have been stratigraphically dated as Oligocene-Early Miocene p.p. (Rupelian-Chattian; P19-P21 zones) to Aquitanian (N4 zone) and Miocene (Aquitanian-early Burdigalian; N4-N5 zones), respectively. In the areas studied, the sandy succession assigned to the Kroumirie Member begins with a sandstone unit with an erosional base or a major discontinuity, locally marked by conglomerates made up of various reworked components. It rests generally on a thick shale unit that characterises the upper part of the Zouza Member. The thinner, uppermost succession of the Numidian formation represents the Babouch Member, dated a Burdigalian (N6-N7 zones).

Within the framework of the new proposal, the total stratigraphic thickness of the Numidian formation in northern Tunisia does not exceed 2,200-2,600 m.

Internally, the Numidian formation is transected by the Intra-Numidian thrust and back-thrust faults, associated with faulted folds that are recognized in outcrop on different scales and in seismic sections. Along these thrust and/or reverse faults, the middle to upper Eocene deposits have undergone uplift and are exposed at the surface (e.g., Dowar Larmel in Meloula-Tabarka, Gaâret Sejnene and Sidi M'chreg sections).

*In: Annales Societatis Geologorum Poloniae; vol. 85, n° 2, 2014, p. 345-370.*

### **30: Cretaceous basins of Central Europe: deciphering effects of global and regional processes – a short introduction.** WILMSEN M., ULICNY D., KOSTAK M.

**Keywords:** Integrated stratigraphy; Correlation; Facies analysis; Eustatic sea-level changes; Tectonic inversion; Central Europe.

**Abstract:** Cretaceous basins of Central Europe have recorded a number of global and regional processes such as long-term rise in global sea level, peak greenhouse climate and widespread Late Cretaceous tectonic inversion. Considerable recent advances in integrated stratigraphic dating now allow for major improvements in understanding of the sedimentary records in these basins. This special issue presents several case studies that document some aspects of the scientific advances of the last years, temporally focussing on the early Late Cretaceous (Cenomanian-Coniacian). Palaeogeographically, the case studies are centred on basins situated in the periphery of the Mid-European Island, comprising the Münsterland, Lower Saxony, Saxo-Bohemian and Danubian Cretaceous basins. The thematic spread includes integrated biostratigraphy, genetic and depositional sequence stratigraphy, facies analyses, detailed lithostratigraphical correlations of well-logs and outcrops as well as dating of detrital zircons.

*In: Z. Dt. Ges. Geowiss. (German J. Geosci.); vol. 165, n° 4, 2014, p. 495-499.*

## **SEDIMENTOLOGIE**

### **31: The provenance of Cretaceous to Quaternary sediments in the Tarfaya basin, SW Morocco: evidence from trace element geochemistry and radiogenic Nd-Sr isotopes.** ALI S., STATTEGGER K., GARBE-SCHÖNBERG D.

**Keywords:** Trace elements; Nd-Sr isotopes; Provenance; Tarfaya basin; SW Morocco.

**Abstract:** We present trace element compositions, rare earth elements (REEs) and radiogenic Nd-Sr isotope analyses of Cretaceous to recent sediments of the Tarfaya basin, SW Morocco, in order to identify tectonic setting, source rock composition and sediment provenance. The results suggest that the sediments originate from heterogeneous source areas of the Reguibat Shield and the Mauritanides (West African Craton), as well as the western Anti-Atlas, which probably form the basement in this area. For interpreting the analyzed trace element results, we assume that elemental ratios such as La/Sc, Th/Sc, Cr/Th, Th/Co, La/Co and Eu/Eu\* in the detrital silicate fraction of the sedimentary rocks behaved as a closed system during transport and cementation, which is justified by the consistency of all obtained results. The La/Y-Sc/Sr binary and La-Th-Sc ternary relationships suggest that the Tarfaya basin sediments were deposited in a passive margin setting. The trace element ratios of La/Sc, Th/Sc, Cr/Th and Th/Co indicate a felsic source. Moreover, chondrite-normalized REE patterns with light rare earth elements (LREE) enrichment, a flat heavy rare earth elements (HREE) and negative Eu anomalies can also be attributed to a felsic source for the Tarfaya basin sediments. The Nd isotope model ages ( $T_{DM} = 2.0-2.2$  Ga) of the Early Cretaceous sediments suggest that sediments

were derived from the Eburnean terrain (Reguibat Shield). On the other hand, Late Cretaceous to Miocene-Pliocene sediments show younger model ages ( $T_{DM} = 1.8$  Ga, on average) indicating an origin from both the Reguibat Shield and the Western Anti-Atlas. In contrast, the southernmost studied Sebkhah Aridial section (Oligocene to Miocene-Pliocene) yields older provenance ages ( $T_{DM} = 2.5-2.6$  Ga) indicating that these sediments were dominantly derived from the Archean terrain of the Reguibat Shield.

*In: Journal of African Earth Sciences; vol. 90, February 2014, p. 64-76.*

**32: Synsedimentary folding process and transtensive tectonic during Late Miocene to Quaternary in northeastern Tunisia: case of Mateur-Menzel Bourguiba region.** ALYAHYAOUÏ S., ZOUARI H.

**Keywords:** Synfolding process; Transtensive tectonic; Late Miocene; Quaternary; Northeastern Tunisia.

**Abstract:** The following paper presents an integrated approach of field observations and surface and subsurface data to precisely determine the geodynamic evolution during the Late Miocene of Mateur and Menzel Bourguiba region (northeastern Tunisia). Alternation between compressive and transtensive regime has been generated as a consequence of relative bringing of Africa and Eurasia plates. The first compressive regime controlled the Late Miocene M1 which edified folds and reverse faults. The second one during Late Miocene M2 was transtensive and remobilized E-W right lateral strike slip deep faults which generated the eastern Mateur distensional zone as a NW-SE releasing bend. The last compressive phase during Messinian and Pliocene-Early Quaternary has reactivated the E-W deep faults as right lateral strike slip movement with reverse component, the NE-SW faults were acted with reverse movement and the folding was accentuated. In this study, no deformation is observed affecting Middle Quaternary-actual series, but the compressive regime continues until the present according to the evidence existing in other regions of Tunisia.

*In: Arabian Journal of Geosciences; vol. 7, n° 11, 2014, p. 4957-4973.*

**33: Provenance, tectonic setting and geochemistry of Ahwaz sandstone member (Asmari formation, Oligo-Miocene), Marun oilfield, Zagros basin, SW Iran.** AVARJANI S., MAHBOUBI A., MOUSSAVI-HARAMI R.

**Keywords:** Provenance; Tectonic setting; Sandstone; Geochemistry; Ahwaz sandstone member; Dezful embayment; Asmari formation; SW Iran.

**Abstract:** The Asmari formation deposited in the Zagros foreland basin during the Oligocene-Miocene. Lithologically, the Asmari formation consists of limestone, dolomitic limestone, dolomite, argillaceous limestone, some anhydrite (Kalhur Member) and sandstones (Ahwaz Member). This study is based on the analysis of core samples from four subsurface sections (wells Mn-68, Mn-281, Mn-292 and Mn-312) in the Marun oilfield in the Dezful embayment subzone in order to infer their provenance and tectonic setting of the Ahwaz sandstone member. Petrographical data reveal that the Ahwaz sandstone comprises 97.5% quartz, 1.6% feldspar, and 0.9% rock fragments and all samples are classified as quartz arenites. The provenance and tectonic setting of the Ahwaz sandstone have been assessed using integrated petrographic and geochemical studies.

Petrographic analysis reveals that mono- and poly-crystalline quartz grains from metamorphic and igneous rocks of a craton interior setting were the dominant sources. Chemically, major and trace element concentrations in the rocks of the Ahwaz sandstone indicate deposition in a passive continental margin setting. As indicated by the CIW' index (chemical index of weathering) of the Ahwaz sandstone (average value of 82) their source area underwent "intense" recycling but "moderate to high" degree of chemical weathering. The petrography and geochemistry results are consistent with a tropical, humid climate and low-relief highlands.

*In: Acta Geologica Sinica; vol. 88, n° 3, 2014, p. 931-948.*

**34: Surface sediment dynamics along the eastern coast of Djerba Island (Gabes Gulf, Tunisia).** BRAHIM M., ATOUI A., SAMMARI CH.

**Keywords:** Tide; Current; Superficial sediment dynamics; Grain size; Minerals; Gabes Gulf; Tunisia.

**Abstract:** Surface sediment dynamics were studied on the eastern coast of Djerba Island (Gabes Gulf, southern Tunisia) by simultaneously assessing currents, as well as the mineralogy and grain size of bottom sediments. Harmonic analysis of time-series sea data at Ras Taguermess and El Kantara illustrated the dominance of a semi-diurnal tidal

component, with a period of 12h 42min. Orthogonal empirical functions analysis of tidal currents along the major axis at El Kantara produced a standard deviation of  $\pm 45 \text{ cm s}^{-1}$  with a main angle of  $29^\circ$ , whereas at Ras Taguermess it was  $5 \text{ cm s}^{-1}$  with a north-south direction. Analysis of grain sizes from sediment samples taken between Ras Taguermess and Ras Marmour show that the shallow bottoms (0-10 m) are composed of fine, medium and coarse sands. Mean grain size ranges between 100 and  $763 \mu\text{m}$ , a distribution attributed to a high level of wave activity. Moreover, two mean grain size gradients were evidenced: the first is alongshore from north to south, from Ras Taguermess to Aghir, and the second from south-east to north-west, between Ras Marmour and Bin El Ouediane. Quartz is abundant from Ras Taguermess to Sidi Garous along the many beaches, while it quantitatively decreased in the eroded area between Sidi Garous and Aghir. Thus, transport is from north to south. A high build-up of sediment was observed in Bin El Ouediane, resulting from a barrier island formation.

*In: Journal of African Earth Sciences; vol. 92, April 2014, p. 45-54.*

**35: Depositional morphotypes and implications of the Quaternary travertine and tufa deposits from along Gafsa fault: Jebel El Mida, Southwestern Tunisia. HENCHIRI M.**

**Keywords:** Travertine; Tufa; Facies; Paleoflow; Gafsa strike-slip fault; Tunisia.

**Abstract:** The diversity of depositional morphologies of tufa and travertine in the field, which are controlled by a complex set of bio-physio-chemical parameters, can make them difficult to distinguish. In Jebel El Mida, the Late Villafranchian faulted alluvial deposits are overlain by complex lithofacies and growth patterns of spring-fed tufa and travertine. Travertine facies include travertine pinnacles, microterraces, thermal ponds, pisoids and conical structures, oncoids, microbial crusts, bacterial shrubs, microstromatolites, lithified bubbles (foam rocks) and microfans and cones. Their formation is controlled by (i) the volume of spring water and gas supplies and their respective daily, monthly or annual fluctuations, and (ii) topography and location with respect to the spring vent. The travertines highlight the predominance of physico-chemical processes over biochemical processes in their formation. In this context, water turbulence, temperature, and/or pressure changes are the dominant agents in releasing  $\text{CO}_2$ . Tufa facies include rhizcretions and cushions, plant moulds and imprints, lithified terrestrial land snails, gyttja and paleosols. Their formation is linked to the dominance of biochemical processes over physio-chemical processes. In this context the amount of  $\text{CO}_2$  in calmer waters is regulated by photosynthesis, which indirectly regulates the rate of calcium carbonate precipitation. Gafsa strike-slip fault, in addition to its tectonic role in creating fluid paths to the surface through flowing springs, acts as a major regional sill that controlled paleoflow directions, discharge locations, volume, rate and fluctuations of the water supply.

*In: Journal of African Earth Sciences; vol. 90, February 2014, p. 9-24.*

**36: SEM/EDS characterisation of dusty deposits in precipitation and assessment of their origin. MILER M.**

**Keywords:** Dusty deposits; Precipitation; Source area; Mineral composition; Chemical composition; SEM/EDS; Slovenia; Algeria; North Africa.

**Abstract:** Detailed scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) analysis of dusty material in rainfall residue, deposited and collected on February 19<sup>th</sup> 2014 in Ljubljana, was carried out with the intention to characterise it according to its chemical and mineral composition and to assess its origin. The material consists of poorly sorted and sharp-edged particles of mostly very fine-grained silt and clay fractions, which is consistent with long-range aerial transport. Particles are represented by illite, chlorite and kaolinite group clay minerals, quartz feldspars, carbonates, accessory minerals and secondary Fe-oxy-hydroxide minerals. Quantities of minerals and illite/kaolinite ratio (4.5) correspond to dusts in rainfall residues originating from Moroccan Atlas, while chlorite/kaolinite ratio (2.8) agrees better with dust from central Libya. The element ratios Al/S1, Ca/Al, K/Ca, Mg/Al, Fe/Al and (Ca+Mg)/Fe in this studied dusty deposit are in good agreement with ratios in dusts from rainfall residues originating from Morocco and northern Mauritania. This was also confirmed by the trajectories of cloud movement that caused precipitation with dusty deposit, although the back trajectory HYSPLIT simulation of air masses indicated northern Mauritania, central Niger, Southern Algeria, southwestern and central Libya as the most possible source regions.

*In: Geologija; vol. 57, n° 1, 2014, p. 5-14.*

**37: Composition, provenance and source weathering of Mesozoic sandstones from Western-Central Mediterranean Alpine chains.** PERRI F.

**Keywords:** Sandstone; Source area; Chemical composition; Weathering; Mesozoic; Western-Central Mediterranean Alpine chains.

**Abstract:** Forty-two Mesozoic sandstone samples from three different sedimentary successions of the Internal Domains along the Western-Central Mediterranean Alpine Chains (Betic Cordillera, Rif Chain and Calabria-Peloritani Arc) were chemically analyzed to characterize their composition and the degree of weathering in the source area(s). The Rif Chain sandstones have SiO<sub>2</sub> contents higher than those of the Calabria-Peloritani Arc and Betic Cordillera sandstones, whereas Al<sub>2</sub>O<sub>3</sub> contents are higher in the Calabria-Peloritani Arc sandstones rather than in the Rif Chain and Betic Cordillera sandstones. The indices of compositional variability (ICV) of the studied samples are generally less than 1, suggesting that the samples are compositionally mature and were likely dominated by recycling. Recycling processes are also shown by the Al-Zr-Ti diagram indicating zircon addition and, thus, recycling processes. The chemical index of alteration (CIA) values are quite homogeneous for the Calabria-Peloritani Arc (mean = 76) and Betic Cordillera sandstones (mean = 55), whereas the Rif Chain sandstones are characterized by CIA values ranging from 54 to 76. The CIW and PIA values are high for all the studied sandstones indicating intense weathering at the source areas. The different values of weathering rates among the studied sandstones may be related to variations of paleoclimatic conditions during the Mesozoic, that further favored recycling processes. Thus, these differences among the studied samples, may be related to an increase in continental palaeoweathering conditions and sediment recycling effects from the Middle Triassic to the earliest Jurassic due to rising humidity. In addition, regional tectonic movements promoted structural changes that allowed sedimentary recycling and subsidence, which in turn caused diagenetic k-metasomatism. These processes could significantly affect the CIW and PIA weathering indices, which likely monitor a cumulative effect, including several cycles of weathering at the source. The source areas are mainly composed of intermediate-felsic rocks with minor, but not negligible, mafic supply, as suggested by provenance proxies.

*In: Journal of African Earth Sciences; vol. 91, March 2014, p. 32-43.*

**38: Re-assessment of the northern Guinean “Koubia-Lessere unconformity” (KLU): consequences on the geological correlations throughout West Africa.** VILLENEUVE M., THEVENIAUT H., NDIAYE P.M.

**Keywords:** Regional unconformity; Neoproterozoic; Palaeozoic; Tillite; Mauritanides and rokelides belts; Panafrican orogen; West Africa; Algeria.

**Abstract:** New radiometric data from recent cartographic projects (2007, 2010) lead to a reinterpretation of the “Koubia-Lessere Unconformity” (KLU). This unconformity is evidenced in the Bassaride Ranges (northern Guinea) and in two western inliers (Tominé and Kemberra). The KLU was previously correlated with the main unconformity (Jbeliat unconformity [JU]) separating the lower “super group 1” from the middle “super group 2” of the large Taoudeni basin. Consequently, the brecciated level (partly glaciogenic) that underlines the “KLU” was correlated with the “tillitic” level located at the base of the super group 2. The latter is linked to the worldwide “Marinhoan” glacial event (650-635 Ma).

However, 32 recently published U/Pb age data on detrital or new formed zircons show clearly that the Bassarides groups (ante KLU), deformed and slightly metamorphosed by the Panafrican-II orogen, belong to the super group 2 of the Taoudeni basin. Consequently, the overlying “Koubia-Lessere unconformity” (KLU) cannot be linked to the “Jbeliat unconformity” (JU) that separates the groups 1 and 2 in the Taoudeni basin. The KLU is younger than the Panafrican-II orogen and probably younger than the last volcanic basaltic flows (492 Ma) outcropping in the Bassaride belt. Consequently, the glaciogenic levels that outcrop in the KLU should be distinguished from the numerous “Marinhoan” glacial levels of West Africa. The new KLU interpretation implies some important changes in the stratigraphic correlations and interpretations all over the West African domain.

*In: C.R. Geoscience; vol. 346, n° 9-10, 2014, p. 262-272.*

### **39: La Franche-Comté: une mosaïque de paysages façonnés par la géologie.** CAMPY M.

**Mots-clés:** Histoire géologique; Genèse; Ere primaire; Ere secondaire; Ere tertiaire; Ere Quaternaire; Tectonique; Géodynamique; Erosion; Paysage; Franche-Comté; France.

**Résumé:** Chacun des paysages de Franche-Comté est le produit d'une histoire géologique qui comporte trois étapes majeures. D'abord, la genèse des terrains constitutifs, en profondeur pour les formations du socle hercynien (ère primaire, avant -250 Ma) puis en milieu marin pour les roches sédimentaires de l'ère secondaire (-250 à -65 Ma). Ensuite, au cours de l'ère tertiaire (-65 à -2 Ma), sous la pression des forces tectoniques provoquées par la poussée alpine, les terrains ont émergé puis se sont déformés en formant des plis et des failles. Enfin, c'est au cours de la troisième étape, durant l'ère quaternaire (depuis 2 Ma), que l'érosion des terrains a progressivement sculpté les paysages que nous offre actuellement la Franche-Comté.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 214 Hors-série, Mai 2014, p. 33-43.*

### **40: Analyse spatiale de l'information géographique.** CALOZ R., COLLET C.

**Mots-clés:** Système d'information géographique; Modélisation spatiale; Géomatique; Modèles numériques; Relief.

**Résumé :** Les systèmes d'information géographique (SIG) caractérisent à la fois un modèle numérisé de l'espace géographique, mais aussi l'ensemble des outils de traitement de l'information associés. Combinant informations géographiques et statistiques, ils permettent un suivi cartographié et quantifié des dynamiques territoriales. La plupart des collectivités publiques ont aujourd'hui achevé l'acquisition et la structuration de ce type de données. Les bases résultantes sont mises à disposition du public et des praticiens, mais la richesse et la diversité des informations qu'elles proposent rendent leur exploitation complexe, dans la mesure où elles requièrent des connaissances développées en analyse spatiale.

Cet ouvrage se propose de procurer au lecteur l'ensemble des outils nécessaires à la maîtrise et à l'exploitation de ces méthodes, notamment dans le cadre de la géostatistique appliquée aux phénomènes discrets et continus, de l'analyse du relief, de la formulation de requêtes spatiales, des aptitudes des réseaux (accessibilité et zones d'influence) et des objets zonaux (analyse multivariée associée à l'aide à la décision), de la dynamique spatiale ou de la propagation des incertitudes.

*In: Ed. Presses Polytechniques et Universitaires Romandes, 2011, 383 p.*

### **41: Livret-guide des excursions.** DJELLIT H.

**Mots-clés:** Géologie; Stratigraphie; Structure; Jijel; Texenna; Tamentout; Petite Kabylie; Algérie.

**Résumé:** La région de Jijel/Texenna/Tamentout, où se situe la transversale de la coupe I, est localisée sur la terminaison occidentale des massifs de la Petite Kabylie. Sur le plan géologique, cette zone est directement située sur plusieurs contacts tectoniques, d'âge alpin, ayant servi à l'édification des reliefs telliens qui longent d'Est en Ouest la côte algérienne, depuis Jijel jusqu'aux confins algéro-tunisiens. Ces contacts tectoniques représentent en fait des accidents ayant servi aux transports puis à la superposition anormale des différentes unités tectoniques qui composent ces reliefs. Le plus important d'entre eux ou contact frontal sud kabyle, sépare les unités profondes métamorphiques du socle kabyle de celles des zones externes alpines. A ce titre on peut d'emblée énoncer que la région recèle, en conséquence, les accidents géologiques les plus importants de la chaîne alpine nord algérienne. L'organisation tectonique des unités de cette région témoigne en effet, de façon remarquable, des longs et complexes processus tectoniques ayant conduit au rapprochement entre les deux plaques: africaine, au sud, et eurasiennne, au nord.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, 52 p.*

### **42: La carte géologique à 1/50 000 de la Corse alpine.** LAHONDERE J.-C.

**Mots-clés:** Carte géologique; Schiste lustré; Unité sédimentaire; Structure; Géologie; Corse alpine.

**Résumé:** La Corse alpine comprend un empilement d'unités à matériel mésozoïque à paléogène et d'écaillés de socle hercynien qui ont subi une évolution tectono-métamorphique polyphasée. Le dispositif paléogéographique général de la Corse alpine, sur la marge entre continent européen et océan liguro-piémontais, s'est précisé des années 1970 à 2000, au fur et à mesure des travaux thématiques et de ceux du lever de la carte géologique à 1/50 000. Il est classiquement décrit selon la terminologie alpine.

*In: Géochronique; n° 132, 2014, p. 16-18.*

**43: Processus de la production cartographique à l'INCT. 4<sup>ème</sup> partie: stéréopréparation pour la grande échelle.** MEBARKI R., REDJEM F.

**Mots-clés:** Cartographie; Stéréopréparation; Processus d'aérotriangulation; Photogrammétrie numérique; Topographie.

**Résumé:** La stéréopréparation est une étape cruciale dans la chaîne de production cartographique à l'INCT. A petite échelle, le procédé d'équipement d'un chantier de photographies aériennes analogiques, en points de terrain, est entièrement pris en charge par les topographes tandis qu'en grande échelle, les travaux sont conjointement réalisés par les topographes et les photogrammètres de l'INCT en particulier pour les prises de vues aériennes issues de la DMC, essentiellement en matière de préparation des projets. Une gamme de produits à grande échelle: 1/10 000, 1/5000, 1/2000, 1/1000, est donc réalisée par l'institut afin de répondre aux demandes de certains clients nationaux ou étrangers.

*In: INCT Magazine; n° 63, 2014, p. 19-22.*

**44: Geological cartography in Poland in the 19<sup>th</sup> century.** WOLKOWICZ S., WOLKOWICZ K.

**Keywords:** Old geological maps; History of geology; Poland; Central Europe.

**Résumé:** The history of modern geological mapping in Poland began with the *Carta Geologica totius Poloniae, Moldaviae, Transylvaniae, Hungariae et Valachiae* by S. Staszic, often called the "father of Polish geology". Before Staszic, a general map of Poland had been published by J.-E. Guettard (1764a); ones of the Sudety Mts. by J. Jirasek (1791). L. von Buch (1797), and Raumer (1813); and that of the Tatra Mts. by Hacquet (1796). In times of the partition of Poland (1772 to 1918), areas annexed by Prussia were covered by systematic geological surveys. These cartographic projects resulted in the compilation of two geological atlases comprising maps of the standard sheet type, in the period from 1826 to 1836. These atlases were compiled by teams of outstanding geologists, under the leadership of L. von Buch and F. Hoffmann. Another outstanding contribution to the geology of Poland was made by G.G Pusch, the author of the excellent *Geognostische Beschreibung von Polen* (1833-1836), subsequently supplemented by *Geognostischer Atlas von Polen*. One of the greatest achievements of L. Zejszner was the geological map of the Tatra Mts., *Carte de la chaîne du Tatra*, published anonymously in Berlin in 1844, and a series of geological maps prepared as drafts of Geognostic maps of the Eastern District of the Polish Kingdom. Special attention should be also paid to two extensive studies which covered areas of Upper and Lower Silesia. The first of these, *Geognostische Karte von Oberschlesien und den Angrenzenden Gebieten*, was completed by a team led by F. Roemer, and published in 1870. The second, *Geologische Karte von dem Niederschlesischen Gebirge und den angrenzende gegenden*, was compiled by a team led by R. von Carnall, and published in the same year. Out of all the studies carried out by Austrian geologists, it is necessary to mention those of E. Tietze, as they produced excellent geological maps of the Carpathians and vicinities of Krakow and Lviv. It is also worth mentioning the contributions made by the Physiographic Commission, active from 1866 until the beginning of the First World War. Its members decided to prepare the Geological Atlas of Galicia. The final product of works of this commission was a set of 25 booklets, with over a hundred geological maps at a scale 1:75000, issued in the years 1885-1912. From 1881, the commission was also publishing its famous Physiographic Diaries, which include papers on the geology of areas annexed by Russia, written by famous Polish geologists such as J. Siemiradzki, A. Michalski, and E. Habdank-Dunikowski, illustrated with relevant geological maps prepared by them.

*In: Geological Quarterly; vol. 58, n°3, 2014, p. 623-658.*

**45: Le « Continental Intercalaire » dans la région du Guir (Algérie): nouvelles données paléontologiques, ichnologiques et sédimentologiques.** BENYOUSSEF M., ADACI M., MEISTER CH.

**Mots-clés:** Cénomaniens; Vertébrés; Ichnofaciès; « Continental intercalaire »; Sédimentologie; Bassin du Guir; Algérie.

**Résumé:** L'objet de cette note est de réviser l'âge et l'interprétation des termes détritiques qui jalonnent la série crétacée dans la région de Béchar (Bassin du Guir, Algérie). Appelés systématiquement « Continental intercalaire », ceux-ci sont attribués à l'Infracénomaniens sans arguments paléontologiques et considérés comme faciès d'origine fluviatile par de précédents auteurs.

La présence de vertébrés tels que *Spinosaurus aegyptiacus*, *Onchopristis numidus*, *Neoceratodus africanus*, cf. *Bawitius*, *Lepidotes* sp., crocodiliens et chéloniens, a permis d'attribuer ces niveaux détritiques au Cénomaniens inférieur. Cette étude basée sur les faciès et les ichnofaciès suggère que cet épandage détritique s'est principalement déposé dans un milieu de plate-forme détritique littorale soumise à une influence des marées, ou même des tempêtes. Cet environnement sédimentaire s'exprimerait par une association de traces fossiles comprenant *Skolithos*, *Altichnus*, *Monocraterion*, *Thalassinoides* et *Arenicolites*. La dynamique tidale est attestée par la fréquence des surfaces de réactivation, des structures de drapage argileux, des mégarides, des rides de courant, des stratifications entrecroisées en arêtes de poisson et des fentes de synérèse. L'influence des tempêtes est attestée par la présence de plusieurs niveaux gréseux à laminations entrecroisées en mamelon (*hummocky cross stratification*).

*In: Revue de Paléobiologie (Genève); vol. 33, n°1, 2014, p. 281-297.*

**46: Les Aulacostephanidae du Kimméridgien supérieur: systématique, évolution et biochronologie.** BORRELLI L.

**Mots-clés:** Ammonoidea; Aulacostephanoides; Aulacostephanus; Aulacostephanoceras; Pararasenia; Kimméridgien supérieur; Biochronologie; Evolution.

**Résumé:** La famille des Aulacostephanidae du Kimméridgien supérieur a fait l'objet d'une première révision depuis Ziegler (1962), à partir d'un matériel nouveau et inédit du Quercy et des Charentes rigoureusement repéré d'un point de vue stratigraphique, et sur la base des nombreuses découvertes et actualisations effectuées ces dernières années à travers l'Europe.

Une simplification taxinomique importante est réalisée par cette révision, en l'abordant selon des concepts actuels s'appuyant sur une approche ontogénétique des espèces et sur la reconnaissance des dimorphes. L'échelle biochronologique et les corrélations stratigraphiques en Europe sont affinées par le repositionnement de la sous-zone à *Orthocera* dans la zone à *Mutabilis*, par la création d'un nouvel horizon à *Eudoxux*, et par la nouvelle appellation de « zone à *Volgensis* » pour l'ancienne zone à *Autissiodorensis*. Une biochronologie exclusivement fondée sur les Aulacostephanidae est proposée pour le haut-fond ouest-européen. Les nouvelles données biogéographiques et évolutives permettent de proposer une nouvelle interprétation de la différenciation et de l'évolution des lignées, composée de lignées anagénétiques donnant successivement naissance à de courtes lignées dérivées. Cette approche fait des Aulacostephanoides, Aulacostephanus, Aulacostephanoceras et des Pararasenia des sous-genres et genres monophylétiques.

*In: Revue de Paléobiologie (Genève); vol. 33, n°1, 2014, p. 1-37.*

**47: Regards sur la paléobotanique.** BROUTIN J.

**Mots-clés:** Paléobotanique; Plante fossile; Naissance; Méthodologie.

**Résumé:** Dans ce dossier « regards sur la paléobotanique », nous explorons quelques-uns des axes de recherche actuels en paléobotanique témoignant de la vitalité, la curiosité et le désir des paléobotanistes de s'impliquer dans les recherches pluridisciplinaires, dans toute la mesure du possible et en fonction des opportunités offertes par les multiples avancées technologiques de la dernière période. Ceci sans perdre de mémoire les étapes historiques structurantes et les avancées conceptuelles des « anciens » qui ont fait de cette discipline scientifique ce qu'elle est aujourd'hui.

*In: Géochronique; n° 133, 2015, p. 9-51.*



**48: Evidence of titanosauriforms and rebbachisaurids (Dinosauria: Sauropoda) from the Early Cretaceous of Tunisia.** FANTI F., CAU A., HASSINE M.

**Keywords:** Titanosauriformes; Rebbachisauridae; Albian; Sauropod diversity; Paleogeography; Tunisia; Algeria.

**Abstract:** Isolated sauropod remains including vertebrae and a humerus from the Ain El Guettar formation (Albian, Early Cretaceous) of Tunisia are described. Vertebrae include a slightly procoelous anterior caudal vertebra, amphicoelous middle caudal vertebrae, and strongly procoelous distal caudal vertebrae. The humerus has an anteroposteriorly compressed shaft, robust deltopectoral crest restricted laterally and prominent condyles bounding a distinct distal fossa. The morphological characters present in the specimens suggests that isolated remains can be referred to at least two distinct sauropod taxa.

The anterior caudal vertebra is referred to Rebbachisauridae, whereas remaining caudal vertebrae show titanosauriform and titanosaurian derived features (anteriorly placed neural arches and, in the posterior vertebrae, distinctly procoelous centra); finally, the humerus may pertain to a somphospondyliian titanosauriform, perhaps the same taxon represented by the middle and posterior caudal vertebrae. This study introduces some of the oldest titanosauriform remains from Northern Africa and provides additional data on the stratigraphic and geographic distribution of this clade during the Early Cretaceous.

*In: Journal of African Earth Sciences; vol. 90, February 2014, p. 1-8.*

**49: Preservation of rodent bones from El Harhoura 2 cave (Morocco, Neolithic – Middle Palaeolithic): microstructure, mineralogy, crystallinity and composition.** FARRE B., MASSARD P., NOUET J.

**Keywords:** Rodent bone; Taphonomy; FTIR; XRD; Microstructure; El Harhoura; Morocco.

**Abstract:** Thin sections, scanning electron microscopy (SEM), diffraction X (DRX) and infrared spectrometry (FTIR) have been used to study the structure, mineralogy, crystallinity and bulk composition of fossil rodent long bones extracted from a succession of sedimentary layers in a cave from Morocco (Neolithic – Middle Palaeolithic, El Harhoura 2). The microstructure of fossil bones is well-preserved at this scale of observation, and encrusted deposits are rare. All bones are preserved in apatite, but the crystallinity is modified, as well as the crystallite shape, the organic content and the organic-mineral ratio. No fluor enrichment has been observed. Alone or together, the studied parameters do not show a regular trend from the upper to the lower layers of the cave. The preservation of the fossil bones does not confirm the sequence of arid and humid periods inferred from taphonomic analyses.

*In: Journal of African Earth Sciences; vol. 92, April 2014, p. 1-13.*

**50: Les brachiopodes du Jurassique inférieur et moyen en Tunisie centrale (Axe Nord-Sud). Un nouveau témoin du domaine paléobiogéographique ouest-téthysien.** FAURE PH., ALMERAS Y., SEKATNI N.

**Mots-clés:** Jurassique inférieur et moyen; Brachiopodes; Ammonites; Biostratigraphie; Paléoenvironnements; Paléogéographie; Téthys; Tunisie; Algérie; Maroc.

**Résumé:** Dans l'axe Nord-Sud tunisien, les coupes levées sur le Jebel Sidi Khalif (Khechem El Kelb) et le Châabet El Attaris ont fourni d'abondantes faunes de brachiopodes stratigraphiquement bien repérées dans le Toarcien inférieur-moyen (Jurassique inférieur) et le Jurassique moyen. Les espèces caractérisent, à la fois, les Marges sud et nord de la Téthys occidentale, mais aussi la Bioprovince nord-ouest européenne. Quelques formes d'affinités arabiques s'y ajoutent au Dogger. Ces brachiopodes (19 espèces appartenant à 15 genres) sont décrits et figurés pour la première fois, aucun témoin de ces faunes n'ayant été étudié à ce jour sur la Marge nord-africaine, à l'Est de l'Algérie occidentale. Au Toarcien, la Tunisie constitue un nouveau jalon du domaine biogéographique ouest-téthysien, entre Maroc et Algérie occidentale, d'une part, et la bioprovince arabe, d'autre part. Le Jurassique moyen correspond à une période de non différenciation des provinces fauniques et ce n'est qu'à partir du Callovien que les brachiopodes d'influence arabe ou arabo-malgache coloniseront les plates-formes ouest téthysiennes. Les résultats de cette publication concernent la biostratigraphie des brachiopodes de l'Axe Nord-Sud, les paléoenvironnements dans lesquels ils se sont développés, ainsi que d'intéressantes indications sur la paléogéographie de la Tunisie

*In: Géodiversitas; vol. 37, n° 1, 2015, p. 31-57.*

**51: Nouvelles données sédimentologiques et paléontologiques (charophytes, ostracodes, coquille d'œuf de dinosaure) sur la formation du Tigri (Sénonien des Hauts méridionaux, Maroc oriental); paléoenvironnements et évolution paléogéographique.** HADDOUMI H., MEBROUK F., ANDREU B.

**Mots-clés:** Charophytes; Ostracodes; Coquille d'œuf de dinosaurien; Sénonien; Hauts Plateaux méridionaux; Maroc oriental; Algérie.

**Résumé:** Dans les Hauts Plateaux méridionaux (Maroc oriental), des études stratigraphiques, paléontologiques et sédimentologiques ont été réalisées dans la série détritique rouge (grès et conglomérats de la formation du Tigri) qui succède aux dépôts marins du Cénomano-Turonien. La partie inférieure de la formation du Tigri comporte cinq incursions marines ou laguno-marines avec des faunes oligospécifiques de petits foraminifères benthiques et d'ostracodes marins. La partie supérieure continentale de la formation a livré deux gisements de microfossiles: i) le premier contient des ostracodes dulçaquicoles à oligohalins, des charophytes (*Mesochara* sp.), un fragment de coquille d'œuf de dinosaurien (*Pseudomegaloolithus atlas*), mais également un niveau riche en radioles d'oursins marquant une ultime incursion marine crétacée; ii) le second renferme uniquement des charophytes (*Mesochara ameghinoi* et *Stephanochara* sp.).

D'importantes déformations synsédimentaires enregistrées dans la partie inférieure de la série témoignent de l'instabilité régionale associée à la création des premiers bassins sénoniens dans un contexte de tectonique extensive.

La synthèse des données obtenues, confrontée à celles connues dans d'autres régions du Maroc, permet de préciser le contexte paléogéographique en montrant que les influences de l'Atlantique, même ténues, se sont manifestées fréquemment sur les Hauts Plateaux méridionaux au cours du Sénonien.

*In: Revue de Paléobiologie (Genève); vol. 34, n° 1, 2015, p. 85-111.*

**52: Foraminiferal assemblages and geochemistry for interpreting the incidence of Early Toarcian environmental changes in North Gondwana palaeomargin (Traras Mountains, Algeria).** REOLID M., MAROK A., SEBANE A.

**Keywords:** Foraminiferal morphogroups; Geochemical proxies; T-OAE; Jurassic; Tlemcen domain; Algeria; Western Tethys.

**Abstract:** The Early Toarcian was characterised by important environmental changes and a mass extinction event usually related to a global oceanic anoxic event. The analysis of ecostratigraphic fluctuations of foraminiferal morphogroups, elemental geochemical proxies and C and O stable isotopes of the Mellala section (Tlemcen domain, North Algeria) makes it possible to determine the incidence of the anoxic event in this sector of the north Gondwana palaeomargin. The end of the Pliensbachian is characterised by a diverse foraminiferal assemblage with equilibrium species suggesting good oxygen and nutrient availability. The beginning of the Toarcian (polymorphum zone) evidences major changes in foraminifera with the disappearance of species, decreasing proportions of epifauna and shallow infauna, and fluctuations in diversity and dominance of *Lenticulina toarcense* and *Lingulina tenera* confirming a perturbation in the palaeoecological conditions in the sea-bottom. Redox proxies (Co/Al, Cr/Al and V/Al) with local maximum values suggest a decrease in oxygenation degree. A negative excursion of  $\delta^{13}\text{C}$  is recorded right at the polymorphum/Levisoni zone boundary, and the subsequent disappearance of epifauna, decreasing diversity and abundance of foraminifera (foram/100 g) would be related to the accentuation of stressing conditions. Also at the polymorphum/Levisoni zone boundary, suboxic waters at the sea-bottom indicate the maximum values of redox proxies (Co/A, Cu/Al, Cr/Al and V/Al). The upper part of the Levisoni zone is more calcareous, with increasing diversity of shallow infauna and a decrease in potentially deep infauna related to more favourable conditions. The incidence of the Toarcian oceanic anoxic event in this context was very low in comparison with the Saharan basin (Raknet El Kahla section, Saharan Atlas), where a benthic barren interval, higher total organic carbon and redox proxies are recorded. The low incidence of the biotic crisis and the rapid recovery of assemblages in the Tlemcen domain is compared with the high incidence and delayed recovery in the Saharan basin, where the palaeogeography determined restricted water circulation between the Saharan craton and the Oran massif.

*In: Journal of African Earth Sciences; vol. 95, July 2014, p. 105-122.*

**53: Etude des paléoenvironnements du Paléocène au Miocène du sud du bassin sédimentaire sénégalais (Casamance, Afrique de l'Ouest) par analyse factorielle des populations de foraminifères benthiques.** THIAM M., SARR R.

**Mots-Clés:** Paléocène supérieur; Eocène; Oligocène; Miocène; Analyse factorielle des composantes redressées; Biodiversité; Casamance; Afrique de l'Ouest.

**Résumé:** L'étude des paléoenvironnements du Paléocène au Miocène inférieur de Casamance met en évidence des milieux marins et lagunaires de profondeur et de température variables. Les transgressions paléocène et éocène favorisent des apports nutritifs et une baisse de l'oxygénation du milieu. L'analyse factorielle des composantes redressées (AFCR) réalisée sur les foraminifères benthiques de trois sondages montre une diversification des genres Cibicides et Cibicoides dans les eaux chaudes du Paléocène supérieur. A l'Yprésien, les genres Lenticulina, Eponides, Cibicoides, Uvigerina et Baggina prolifèrent sur la plateforme carbonatée. L'association s'enrichit en Nonion et Operculina dans les eaux chaudes du Lutétien. La régression survenue à l'Oligocène installe à l'ouest une mer épicontinentale froide hyposaline où se diversifient les genres Ammonia, Textularia, Spiroplectammina, Elphidium et Planulina. Au Miocène, la faune benthique est dominée par les genres Cibicides, Hopkinsina, Bolivina, Nonion, Uvigerina et Bulimina qui évoluent dans une mer épicontinentale hyposaline à normale.

*In: Revue de Paléobiologie (Genève); vol. 33, n°1, 2014, p. 143-157.*

**54: Principes de paléontologie. Cours.** TORTOSA TH., ADNET S., AMIOT R.

**Mots-clés:** Fossile; Espèce; Evolution des organismes; Phylogénie; Diversification; Extinction de masse; Paléobiogéographie; Paléoenvironnement; Géochimie; Paléoécologie; Imagerie de 3D.

**Résumé:** Ce manuel présente les méthodes et les apports de la paléontologie dans les sciences de la terre ainsi que dans les sciences de la vie. Chaque chapitre, écrit par un enseignant ou chercheur spécialiste du sujet, présente un contenu reflétant l'état d'avancement de sa discipline et des programmes d'enseignement tout en permettant une ouverture sur des points plus poussés.

Cette démarche explique le découpage du livre qui, après une brève introduction à la paléontologie (chapitre 1), abordera des concepts fondamentaux comme les fossiles et le registre fossile (chapitre 2), les espèces et les populations fossiles (chapitre 3), le développement et l'évolution des organismes (chapitre 4), la systématique et la phylogénie (chapitre 5), les notions de diversification et d'extinction (chapitre 6), des reconstitutions paléobiogéographiques, paléoécologiques et paléoenvironnementales (chapitre 7) et les apports de deux nouveaux champs disciplinaires que sont la biochimie et l'imagerie 3D (chapitre 8).

*In: Ed. Dunod; 2013, 329 p.*

**55: "Devil horned" Cyphasps (Trilobita, Otarioninae): examples from the Middle Devonian of the Ardennes (Belgium), Eifel (Germany) and Ma'der (Morocco).** VAN VIERSEN A.P., PRESCHER H.

**Keywords:** Systematic paleontology; Heterochrony; Devonian; Trilobita; Aulacopleuridae; Belgium; Germany; Morocco.

**Abstract:** Three new species of Middle Devonian otarionine trilobites are described: *Cyphasps walteri* sp. nov. from the Bou Dib formation in Morocco, *Cyphasps rommersheimensis* sp. nov. from the Freilingen formation in Germany, and *Cyphasps heissae* sp. nov. from the Ahabach formation in Germany. *Cyphasps* cf. *heissae* sp. nov. is described from the Hanonet formation in Belgium. All four taxa demonstrate a number of features linked to heterochronic processes, with in particular the long paired plabellar spines. Their designation to *Cyphasps* is discussed.

*In: Geologica Belgica; vol. 17, n° 3-4, 2014, p. 268-275.*

**56: Le skarn Mo-W-Cu à grenat, wollastonite, pyroxène et vésuvianite d'Azegour (Haut-Atlas, Maroc).** BERRADA HMIMA S., MARCOUX E., HAFID A.

**Mots-clés:** Skarn; Grenatite; Wollastonite; Métasomatisme; Azegour; Maroc.

**Résumé:** Le skarn minéralisé en Mo, W et Cu d'Azegour se forme aux dépens d'une série cambrienne essentiellement sédimentaire carbonatée dans l'aurole de métamorphisme d'un granite permien. Les bancs métasomatés plurimétriques du skarn sont pour l'essentiel des grenatites et wollastonites massives, plus rarement des pyroxénites. L'étude minéralogique montre que les grenatites sont composées pour l'essentiel d'andradite (grenat vert-noir et grenat brun-noir zoné) plus rarement de grossulaire (grenat orangé). Le pourcentage de spessartite est toujours faible (maximum 4%). La wollastonite est légèrement manganésifère, la vésuvianite fluorée (jusqu'à 3,3%) et chlorée (1, 2%). Les paragenèses permettent d'établir les conditions de formation du skarn aux alentours de 620-650°C pour une pression de 1,7 à 2 kbar, avec une  $f\text{CO}_2$  de 31 mole %, en contexte réducteur ( $f\text{O}_2$  de  $10^{-18}$  et  $10^{-17}$  atm.). Le skarn d'Azegour est un marqueur de la fin de l'orogénèse hercynienne, et dénote la persistance de conditions réductrices, un environnement très favorable à la cristallisation de sulfures. Le skarn d'Azegour semble ainsi se former à des températures plus élevées que d'autres skarns à tungstène hercyniens comme Salau (Ariège, France).

**In:** *Bull. Soc. Géol. France*; t. 186, n° 1, 2015, p. 21-34.

**57: Magmatic context of Bou Skour copper deposit (Eastern Anti-Atlas, Morocco): petrography, geochemistry and alterations.** EL AZMI D., AISSA M., OUGUIR H.

**Keywords:** Magmatic rock; Petrography; Geochemistry; Hydrothermal alteration; Bou Skour; Eastern Anti-Atlas; Morocco.

**Abstract:** The Bou Skour copper deposit is located in the western part of the Saghro massif (Eastern Anti-Atlas), about 50 km East of the City of Ouarzazate. It is subdivided into several areas that are, from North to South: "Panthère", "Chaigne", "Anne Marie", "Chapeau de fer" and "Patte d'Oie". The latter is economically the most important and is the object of this study. The "Patte d'Oie" district consists mainly of extrusive and intrusive igneous rocks. The extrusive rocks are represented by andesites spatially associated with pyroclastic terms (ignimbrites and pyroclastic breccias). This volcanic unit is intruded by a pink granite pluton and a I-type granodiorite with equigranular texture (Bou Skour granodiorite) showing to the border a microgranular facies (microgranodiorite). All these magmatic formations are intersected by rhyolitic dykes (NNE-SSW) and doleritic dykes (WNW-ESE to NW-SE). The granodiorite and andesite have undergone a polyphase hydrothermal alteration: (i) potassic alteration, (ii) phyllic alteration, (iii) silicification, (iv) argillic alteration and (v) propylitic alteration. The analysis of geochemical data of granodiorite, granite, andesite and dolerite confirmed: (i) their petrographic natures, (ii) the medium-K-calc-alkaline affiliation of andesite and granodiorite, which would have been set up into an active geotectonic environment, probably of island arc or collision, during the Pan-African orogeny, (iii) the high-K-calc-alkaline character of granite indicating a post-collision development during the Pan-African orogeny and (iv) the alkaline affinity of the dolerite which is linked to an extensive post-orogenic setting (post-Pan-African). The copper mineralization of "Patte d'Oie" area is hosted, exclusively, in the andesitic and granodioritic facies. It is represented, essentially, by chalcopyrite and bornite minerals and is, probably, related to a porphyry system (disseminated and stockwork mineralization) remobilized late, in Hercynian structures (vein mineralization).

**In:** *Journal of African Earth Sciences*; vol. 97, September 2014, p. 40-55.

**58: First African diamonds discovered in Algeria by the ancient Arabo-Berbers: history and insight into the source rocks.** GODARD G., CHARAF CHABOU M., ADJERID Z.

**Keywords:** Diamond; Emerald of the Garamantes; Lamproite; Numidian Flysch; Radiohalos; Constantine; Sahara; Algeria.

**Abstract:** It is generally believed that the first diamonds ever found in Africa were discovered in South Africa in 1867. Actually, three diamonds had already been found in 1833 near Constantine (Algeria). One of these, still preserved, shows radiohalos that suggest an old age. It could be a Sahara diamond reworked in more recent sediments, possibly the

Oligo-Miocene Numidian flysch; however, this occurrence remains uncertain. The ancient Arabs or Berbers also knew of diamonds in the Reggane region (Algerian Sahara), at Bilād al-mās (“country of the diamond”). Since 1975, some 1500 diamonds have been collected from the alluvial deposits of this area. A manuscript written in Arabic in 1851 mentions diamonds in this region and describes their source rock, looked for in vain by modern geologists. The description is unclear, but might refer to Devonian oolitic ironstones. Modern investigations would rather suggest a kimberlitic primary source with intermediate Early Cretaceous palaeoplacers.

*In: C.R. Geoscience; vol. 346, n° 7-8, 2014, p. 179-189.*

**59: Geochemistry and petrology of metamorphosed submarine basic ashes in the Edough massif (Cap de Garde, Annaba, northeastern Algeria).** HADJ ZOBIR S., ALTENBERGER U., GÜNTER CH.

**Keywords:** Amphibolites; Submarine sediments; Basaltic ash-fall deposits; Edough; Algeria.

**Abstract:** The study presents the first evidence of metamorphosed submarine ashes in the Edough Massif, in northeastern Algeria. It occurs below the greenschist-facies Tellian units that represent the thrust Mesozoic to Eocene passive paleomargin of northern Africa deposited on thinned continental crust. The metamorphic complex consists of tectonically superposed units composed of gneisses (lower unit) and micaschists (upper unit). At the Cap de Garde, these units enclose an “intermediate unit” composed of micaschists and meter-thick layers of marbles, which are sometimes intercalated with amphibolites. The latter occur as discontinuous small lenses and layers. The amphibolites are parallel to the primary bedding of the marbles and the main foliation. Chemical markers and field observations indicate that they are metamorphic equivalents of basic igneous rocks. The lenticular character, low thickness and multiple intercalations with marine sediments and the unusual high lithium concentrations suggest subaqueous near-source basaltic ash-fall deposits in a marine environment.

*In: C.R. Geoscience; vol. 346, n° 9-10, 2014, p.244-254.*

**60: A volcanic district between the Hohhar uplift and the Tenere rifts: volcanology, geochemistry and age of the In-Ezzane lavas (Algerian Sahara).** YAHIAOUI R., DAUTRIA J.-M., ALARD O.

**Keywords:** Basalts; Mantle; Tuareg shield; Hoggar; Algeria.

**Abstract:** The In-Ezzane volcanic district (EZD), located at the triple junction of Algeria, Niger and Libya belongs to the Eastern Hoggar, covers 350 km<sup>2</sup> and includes 9 volcanic edifices that are probably aligned along NW-SE faults, parallel to the Tafassasset valley. The low volume (0.7 and 1 km<sup>3</sup>) of emitted lavas, the similar morphology of the monogenic cones and the lack of differentiated rocks indicate that the volcanic activity of the EZD was restricted in time and volume. The new K-Ar age (i.e. 2.86 ± 0.07 Ma) indicates that the EZD is contemporaneous with the last alkali volcanism paroxysm in Hoggar and with the nearby Libyan volcanics. The EZD alkali basalts (mainly basanite) show a remarkable homogeneous compositions both in major elements (44.8 ≤ SiO<sub>2</sub> ≤ 45.8 wt.%; 5.2 ≤ (Na<sub>2</sub>O + K<sub>2</sub>O) ≤ 6.2 wt.%), trace elements (4.3 ≤ Th ≤ 5.5 ppm; 34.7 ≤ La ≤ 44.7 ppm; 16.1 < La/Yb<sub>(N)</sub> < 21.6) and radiogenic isotopes (0.70285 < <sup>87</sup>Sr/<sup>86</sup>Sr < 0.70303; 0.51298 < <sup>143</sup>Nd/<sup>144</sup>Nd < 0.51301; (19.212 < <sup>206</sup>Pb/<sup>204</sup>Pb < 19.340, 15.589 < <sup>207</sup>Pb/<sup>204</sup>Pb < 15.602 and 38.834 < <sup>208</sup>Pb/<sup>204</sup>Pb < 38.903). Relative to the Hoggar alkali basalts the EZD basalts appear systematically impoverished in incompatible elements and show a depleted signature both in Sr and Nd isotopes (almost MORB-like). The Pb isotopes are relatively enriched and intermediate between tholeiites and alkali basalts of the Hoggar. This unusual geochemical signature, is uneasy to reconcile with the known characteristics of the Hoggar swell, and would rather fingerprint a circum cratonic mantle lying beneath the west border of the Murzuq craton (Libya).

*In: Journal of African Earth Sciences; vol. 92, April 2014, p. 14-20.*

## MINERALOGIE

**61: Mines ParisTech aime les gemmes.** BOUNIOL M.

**Mots-clés:** Musée de minéralogie; Minéraux; Echantillon; Mine; Pierre gemme; Cristal de roche; Calcite optique; Diamant; Roche silicatée; Continent; Paris; France.

**Résumé:** Le musée de Minéralogie de Paris est situé depuis 1770 dans l'hôtel Vendôme, qui abrite également, depuis 1783, l'École des mines de Paris (Mines ParisTech). Le musée de la Minéralogie de Paris présente plus de 4000 échantillons de minéraux collectés sur tous les continents. Les deux salles d'entrée regroupent certains des plus beaux spécimens du musée et parfois du monde, et des vitrines consacrées à la cristallographie. Le musée est ensuite réparti sur dix salles placées en enfilade, avec deux salles dédiées aux roches magmatiques et métamorphiques dans lesquelles on trouve les minéraux puis huit salles accueillant les minéraux classés par familles en fonction de leur composition chimique: éléments natifs, sulfures, halogénures, oxydes, carbonates, borates, sulfates, phosphates et silicates.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 210, Janvier 2014, p. 30-33.*

**62: Mineralogical and geochemical studies on the Gowd-e-Morad (Ni, Co, As-Cu) mineral deposit, Anarak (Central Iran).** MAZAHERI KUHANESTANI N., MOKHTARZADEH MOHAMMADI B., ALDERTON D.H.M.

**Keywords:** Mineralogy; Geochemistry; Fluid inclusion; Gowd-e-Morad; Anarak; Iran.

**Abstract:** The Ni, Co, As, and Cu deposit of Gowd-e-Morad is located 20 km northwest of Anarak in Central Iran. In this hydrothermal deposit, mineralization occurs as veins in a fault breccias zone hosted by the Chahgorbeh (schist and metabasite) complex. The main ores are made up of Ni, Co, and Cu arsenides. Petrologic studies and results obtained from geochemical analyses have indicated that the Ni, Co, As, and Cu are derived from ultramafic rocks while Pb and Zn are likely to be derived from schist. Based on the geochemical evidence, particularly the high correlation between Ni, Co, and As, it is proposed that this deposit be categorized as a "five elements" mineral deposit. Fluid inclusion studies have shown homogenization temperatures ( $T_H$ ) in the range 113-206 °C and salinity 3-13.5 % wt eq. NaCl. Therefore this "five elements" mineral deposit has been determined as a low temperature, epithermal deposit type. It is proposed that the low fluid temperatures are a result of an environment of formation which was distal to a volcanogenic source systems and the major influence of meteoric waters in the hydrothermal system.

*In: Arabian Journal of Geosciences; vol. 7, n° 11, 2014, p. 4779-4791.*

**63: Les calcaires: géologie – minéralogie & classification – formation – roches calcaires à usages industriels.** PICHON H.

**Mots-clés:** Carbonate; Calcaire; Géologie; Classification; Précipitation chimique; Roche calcaire; Industrie; Gisement; Exploitation; Contrôle qualité; Carrière Balthazard et Cotte; Sassenage; France.

**Résumé:** Le calcaire est la roche la plus présente sous les formes les plus diverses – roches massives, gisements coquilliers, etc. – à la surface du globe et donc la plus accessible sous forme de gisements à ciel ouvert, souterrains ou lacustres. Depuis les temps les plus reculés, l'homme l'a utilisé puis exploité puis transformé.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 214 Hors-série, Mai 2014, p. 5-7.*

## GEOLOGIE MINIERE

**64: Vers la caractérisation d'aires métallogéniques d'âges différents en Petite Kabylie : aperçu sur les unités géologiques minéralisées de la Petite Kabylie.** AFALFIZ A.

**Mots-clés:** Minéralisation polymétallique; Unité géologique minéralisée; Le socle métamorphique; Magmatisme miocène; Petite Kabylie; Algérie.

**Résumé:** Le Nord-Est algérien dont la Petite Kabylie fait partie, s'intègre dans la branche sud de la province alpine mésogéenne. Cette branche qui court depuis le sud de l'Espagne et jusqu'au sud de l'Italie en passant par le Nord du Maroc et de la Tunisie, montre un nombre important de minéralisations de différents types, principalement à Fe, Ba et polymétalliques. En Petite Kabylie, trois principales unités géologiques minéralisées peuvent être distinguées:

- Une unité schisto-carbonatée, métamorphisée, faisant partie d'un ensemble, réputé d'âge ancien, représenté par un socle cristallophyllien antéhercynien appartenant au domaine interne des Maghrébides. Ce socle, gneissique à la base et schisteux au sommet est le plus souvent coiffé par une couverture paléozoïque, de nature grésosarkosique et pélitique. Les principales minéralisations rencontrées dans cette unité, riche en marbre à amphibolite, sont polymétalliques (Pb/Zn, Fe, Ba, Ag ± Cu), structurées en amas stratoides, déformées et métamorphisées. Au plan model génétique, ces accumulations minérales se rapprochent beaucoup plus du type exhalatif-hydrothermal synsédimentaire. Le gisement d'Achab-Tiri (SE de Taher), reste de loin le plus représentatif des minéralisations de cette unité.
- Une deuxième unité silico-carbonatée, qui trouve place dans le domaine externe et très poche du domaine interne, bien repérée dans les niveaux d'âge essentiellement au passage Jurassique-Crétacé et au Crétacé-Eocène, bien connu dans les Babors et les cœurs des horsts du domaine des Hauts Plateaux. Les principales minéralisations typiques de cette unité sont stratiformes de type Mississippi Valley (Pb-Zn) et filoniennes polymétalliques de type épithermal, mésothermal. Cette unité peut comprendre pour le moment, les minéralisations à Cu Pb/Zn des Achaïches (sud El-Milia) et le gisement de fer de Sidi Maaouf (SE El-Milia).
- Une troisième unité principalement magmatique à post-magmatique d'âge Miocène, localisée au sein du domaine interne ou en bordure immédiate de ce dernier. Cette unité à valeur de province est composée généralement d'un ensemble de roches à caractère calco-alcalin (granitoides metalumineux et paralumineux), accompagnées d'andésites-dacites-rhyolites d'âge néogène post nappe. Juste après, cette province a connu un fort développement d'un hydrothermalisme minéralisateur qui a permis à un bon nombre de minéralisations de prendre place dont les plus importants sont de deux types :
  - Le type VMS, représenté par le gisement à Pb/Zn d'Oued Amizour (Béjaïa) et par celui de Oued El Kebir (Jijel), tous deux, situés au sein d'appareil effondré à andésite-dacite et tuffo-breches associés.
  - Le type filonien, représenté par le gisement polymétallique de Boudoukha et des filons d'Ain Kechera (Skikda), centré sur des plutons granitiques intrudant le socle métamorphique de la Petite Kabylie.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 53-54.*

**65: Positionnement de l'innovation en matière de procédés métallurgiques de traitement et de recyclage. Cas des terres rares.** GUYONNET D., TUDURI J., VAXELAIRE S.

**Mots-clés:** Minéralurgie; Matière première minérale; Terres rares; Flux; Stock; Anthroposphère; Recyclage.

**Résumé:** La complexité des produits à recycler et la tendance vers des minerais à plus faibles teneurs nécessitent le développement de procédés métallurgiques innovants. Pour bien positionner le développement de tels procédés dans le contexte global de l'économie des ressources minérales, il est important de connaître les flux et stocks de matières premières minérales dans l'anthroposphère. C'est l'objectif du projet Aster (Analyse Systématique des Terres Rares - flux et stocks), soutenu par l'Association Nationale de la Recherche (ANR), que d'identifier ces flux et stocks à l'échelle de l'UE-28, pour le cas de certaines terres rares.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 218 Hors-série 15, Octobre 2014, p. 11-16.*

**66: Les granulats suisses: caractéristiques, exigences normatives et gisements.** HAMMERSCHLAG J.-G.

**Mots-clés:** Granulat; Gisement; Normalisation; Europe; Suisse.

**Résumé:** Les granulats suisses proviennent pour une grande part de gravières exploitant des gisements fluvio-glaciaires. Ces granulats ont de ce fait été arrondis et triés au cours des processus naturels séculaires de transport et de dépôt. Ils répondent réglementairement aux normes européennes tant dans leur production que dans leur utilisation. Le principe de l'optimisation des ressources naturelles non renouvelables leur est appliqué. Quelques exemples de gisements sont présentés.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 214 Hors-série, Mai 2014, p. 55-56.*

**67: Large-scale metal zoning in a late-Precambrian skarn-type mineralization, Wadi Kid, SE Sinai, Egypt.** HELMY H.M., SHALABY I.M., ABDEL RAHMAN H.B.

**Keywords:** Metamorphic evolution; Monazite dating; Precambrian; Skarn mineralization; Wadi Kid; Sinai; Egypt.

**Abstract:** A Precambrian skarn-type mineralization is recently discovered in the Wadi Kid area in southeast Sinai, Egypt. Two sulfide ore types define large scale metal zoning; Cu-Zn-Co in calc-silicate rocks and Zn-Pb-As-Ag in metapelites. The sulfides and host rocks underwent amphibolites facies metamorphism (2.1-4.2 kbar and 500-620°C). Dating by the chemical Th-U-total Pb isochrone method yields an Th-Pb isochrone age of  $660 \pm 25$  Ma for metamorphic monazite from metapelites. Overall structural and textural relationships of silicate and sulfide minerals favor syn-tectonic formation during granitoids emplacement in a continental margin setting. Large-scale metal zoning reflects variable distances from the causative pluton(s). The Wadi Kid area is highly prospective for Cu, Zn, Pb and Ag mineralization.

*In: Journal of African Earth Sciences; vol. 90, February 2014, p. 77-86.*

**68: L'industrie de la chaux aérienne, des applications très diversifiées.** JOLY C.

**Mots-clés:** Industrie; chaux aérienne; Production; Propriété; Utilisation; Agriculture; Industrie agro-alimentaire; Industrie sucrière; Usage pharmaceutique; Industrie métallurgique; Environnement; Industrie du verre; Industrie papetière; Bâtiment; Génie civil; Construction; Union des producteurs de chaux.

**Résumé:** La multiplicité des utilisations de la chaux, toujours irremplaçable pour la plupart de celles-ci, est le reflet de ses nombreuses propriétés. Si la sidérurgie reste un important consommateur, la chaux joue un rôle capital en techniques routières, dans la stabilisation des sols, le traitement de l'eau, des gaz, des boues et des déchets, ou encore en agriculture. Les plus anciennement connues sont toujours appliquées dans le bâtiment et les matériaux de construction.

La chaux aérienne regroupe une famille de produits composés essentiellement de calcium et de magnésium dont la proportion varie suivant les gisements.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 214 Hors-série, Mai 2014, p. 21-30.*

**69: La place de la minéralurgie dans les procédés miniers et le recyclage.** JOUSSEMET R., YVON J., BLAZY P.

**Mots-clés:** Minéralurgie; Minerai; Génie minéral; Valorisation; Traitement; Recyclage.

**Résumé:** La minéralurgie, qu'on peut aussi appeler la valorisation des minerais, est un art dont l'objectif principal est de séparer des minéraux valorisables dans une application d'une autre substance non valorisable dans la même application. Il s'agit dans la majeure partie des cas d'une séparation solide-solide. On obtient alors un concentré d'une ou des espèces valorisables et un stérile composé des espèces non valorisables dans les conditions technico-économiques du lieu et du moment. La séparation solide-solide n'est évidemment pas spécifique du traitement des minerais, mais ces dernières années, les techniques de traitement des minerais ont été appliquées à la valorisation de substances résiduelles improprement appelées déchets (ressources minérales secondaires) et à certaines opérations de dépollution. Il reste que la minéralurgie est une part importante du génie minéral pris dans son ensemble.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 218 Hors-série 15, Octobre 2014, p. 17-26.*

**70: La biolixiviation des minerais sulfurés.** MORIN D.

**Mots-clés:** Minéralurgie; Ressources minérales; Biolixiviation; Minerai sulfurés; Système microbien; Procédés; Economie; Développement durable.



**Résumé:** L'oxydation des minerais sulfurés par l'oxygène de l'air produit de l'énergie au cours d'une réaction naturellement accélérée par des micro-organismes capables de se développer dans des conditions hostiles à toute autre forme de vie. La maîtrise de cette catalyse biologique a permis de concevoir des procédés industriels d'extraction de métaux comme le cuivre, l'or, le cobalt et le nickel. Ces procédés complètent les moyens actuels d'exploitation des ressources minérales primaires et ouvrent des perspectives sur le long terme dont l'économie mondiale aura besoin pour satisfaire une demande croissante.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 218 Hors-série 15, Octobre 2014, p. 27-34.*

**71: Définition d'un procédé pyrométallurgique d'élaboration d'alliages à partir d'un minerai ou d'un concentré oxydé.** NUSSBAUM G.

**Mots-clés:** Minéralurgie; Procédés pyrométallurgiques; Procédés minéralurgiques; Procédés hydrométallurgiques; Diagramme d'Ellingham; Métal; Minerai; Production; Industrie.

**Résumé:** L'application des lois de la thermodynamique aux équilibres entre oxydes métalliques et alliages métalliques en fusion permet de sélectionner le réducteur le mieux adapté et les conditions les plus favorables d'élaboration des alliages. Les exemples présentés permettent de comprendre comment les procédés pyrométallurgiques sont complémentaires des procédés minéralurgiques et hydrométallurgiques dans l'industrie d'élaboration des matériaux métalliques.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 218 Hors-série 15, Octobre 2014, p. 41-46.*

**72: Le process de préparation des calcaires de Sassenage.** POLICAND TH.

**Mots-clés:** Carbonate; Calcaire blanc; Agrégat; Structure industrielle; Procédé de production; Pierre blanche; Usine Sassenage; France.

**Résumé :** La capacité de production de l'usine de Sassenage est de 450 000 t/an. On distinguera deux grandes familles de produits en raison de l'origine géologique. Ce sont le calcaire blanc broyé, avec une production annuelle de 200 000 tonnes, et les agrégats issus des autres calcaires blancs et noirs, pour 250 000 tonnes.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 214 Hors-série, Mai 2014, p. 13-15.*

**73: Les kaolins.** POULIQUEN M.

**Mots-clés:** Kaolin; Minéralogie; Pétrographie; Gisement; Extraction; Traitement; Application industrielle; Production mondiale; Marché.

**Résumé:** Le kaolin est une roche argileuse, silico-alumineuse, constituée essentiellement de kaolinite, avec une proportion de minéraux secondaires et accessoires très variable selon les gisements et le degré de concentration subi par le produit final. C'est une substance tendre, plastique, généralement blanche, avec parfois une teinte crème, ocre, jaunâtre, rosée, verdâtre ou grise. L'aspect est mat et terreux, rarement massif et nacré. Les cristallisations sont très fines, de l'ordre du micron. Elles ne sont visibles qu'au microscope électronique. La forme, la taille et la morphologie des cristallites sont des éléments déterminants pour certaines applications, autant que les caractéristiques chimiques et physiques.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 218 Hors-série 15, Octobre 2014, p. 51-93.*

**74: Carbonate de Sassenage: tour d'horizon des applications.** SANCHEZ F.

**Mots-clés:** Carbonate; Calcaire blanc; Calcaire noir; Industrie; Agriculture; Bâtiment; Eau potable; Protection de l'environnement; Industrie routière; Sassenage; France.

**Résumé:** Les utilisations des calcaires extraits et transformés dans l'usine de Sassenage sont multiples. Suivant leur origine géologique, nous avons distingué des « calcaires blancs » et des « calcaires noirs ».

Ces deux types de calcaires sont non gélifs et présentent des caractéristiques mécaniques élevées permettant des utilisations exigeantes comme dans le domaine routier et le bâtiment. La quasi absence d'éléments traces qui donne au calcaire de Sassenage sa blancheur permet son utilisation dans des applications industrielles comme le verre plat ou les mortiers industriels.

Le présent document reprend les principales utilisations des carbonates produits à l'usine de Sassenage.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 214 Hors-série, Mai 2014, p. 9-11.*

#### **75: Les procédés de lixiviation dans la production d'uranium.** THIRY J.

**Mots-clés:** Minéralurgie; Lixiviation; Uranium; Production; Exploitation; Procédés hydro-métallurgiques.

**Résumé:** Cet article présente les données et le contexte de la production d'uranium naturel et décrit de façon globale les différentes techniques de récupération d'uranium par des procédés hydro-métallurgiques avec quelques exemples issus des exploitations du Groupe Areva.

*In: Mines & Carrières - Industrie Minérale; vol. 86, n° 218 Hors-série 15, Octobre 2014, p. 35-40.*

## **GEOCHIMIE**

#### **76: New geochemical, geochronological and structural constraints on the Ediacaran evolution of the south Sirwa, Agadir-Melloul and Iguerda inliers, Anti-Atlas, Morocco.** BLEIN O., BAUDIN T., SOULAIMANI A.

**Keywords:** Ignimbrite; Silicic LIPs; Transpressive; U-Pb geochronology; Ediacaran; Anti-Atlas; Morocco.

**Abstract:** Paleoproterozoic metamorphic and igneous rocks, Tonian (?)–lower Cryogenian passive margin sedimentary rocks, Neoproterozoic dolerites, and Upper Ediacaran volcanoclastic, volcanic and pyroclastic rocks are exposed in the Agadir Melloul, Iguerda and the southern edge of the Sirwa inliers. A recent field mapping program of the Ediacaran Ouarzazate Group in these areas allow to distinguish three principal volcanic sequences. The first sequence (Adrar-n-Takoucht formation) outcrops mainly south of the Sirwa inlier, and is composed of felsic pyroclastic deposits and local basaltic lavas with ages ranging between 572 and 570 Ma. The second sequence (Anammar and Tadoughast formations) occurs primarily in the Agadir Melloul-jbel Iguiguil inlier. The Anammar formation contains essentially volcano-detrital sediments, with fine airfall pyroclastic deposits. The Tadoughast formation is composed of felsic pyroclastic deposits and rhyolitic domes with ages ranging between 567 and 564 Ma. The third sequence (Fajjoud formation) contains felsic pyroclastic deposits, with an age of 556 Ma, associated with porphyritic basalts. The magmatism of the Ouarzazate Group was not continuous between 572 and 556 Ma, but related to distinct pyroclastic pulses.

Geochemical data indicate that the pyroclastic rocks of the Ouarzazate Group have a highly potassic calc-alkaline to shoshonitic affinity. However, the basaltic facies associated with the Adrar-n-Takoucht formation demonstrate a calc-alkaline affinity whereas those associated with the Fajjoud formation have a tholeiitic affinity. Rhyolitic domes were derived from hyperaluminous leucogranites. In sum, the typology of zircons defines three poles: (i) subalkaline granites; (ii) calc-alkaline monzogranites and granodiorites frequently associated with basic rocks; and (iii) aluminous leucogranites.

In addition, the volcanoclastic deposits of the Ouarzazate Group are submitted to a syn-sedimentary tectonic. The Adrar-n-Takoucht formation is folded and unconformably overlain by the Anammar and Tadoughast formations. The Anammar and Tadoughast formations were deposited and deformed in a transtensional rift basin as indicated by basaltic lavas flows. Hence, the Upper Ediacaran Ouarzazate Group formed in a wrench tectonic regime with extensional and local compressional deformation.

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 47-71.*

**77: Lithology, mineralogy and geochemical characterizations of sediment-hosted Sr-F deposits in the eastern Neo-Tethyan region – with special reference to evaporation and halokinesis in Tunisia.** DILL H.G., NOLTE N., HANSEN B.T.

**Keywords:** Fluorite; Rare-earth-elements (REE); Sr and Nd isotopes; Evaporation; Neogene; Tunisia.

**Abstract:** The Neo-Tethyan basin is known for its sediment-hosted Sr deposits in Spain, Turkey, Cyprus, and the Gulf region. Sediment-hosted Sr-F deposits with base metals formed in the rim sinks and on top of salt domes resulting from halokinesis of Triassic evaporites near the southern edge of the Mediterranean sea in Tunisia. These evaporites delivered part of the elements, created a basin-and-swell topography and provided the local and regional unconformities to which many of the mineral deposits are related. Five mineralizing processes, each with characteristic sedimentary ore textures, are related to this subsurface salt movement: (1+2) Early- and late-stage replacement (“zebra rocks”), (3) hydraulic fracturing (“fitting breccia” sensu Dill and Weber, 2010b), (4) remobilization (“spinifex structures”), and (5) open-space filling (“caves and vein-like deposits”). Basinal brines from Mesozoic aquifers delivered Pb, Zn, Cd, REE, Y, Hg, and Se, while Sr, Cs, Be, Li, Cu and Co have been derived from Cenozoic Salinas of the Neo-Tethyan basin. Mixing of Mesozoic and Cenozoic brines between 28 and 19 Ma provoked the emplacement of Sr-F mineralization at temperatures below 200 °C under strong alkaline conditions. Epigenetic polyphase Sr-F deposits bearing base-metals which are closely related to salt domes (Tunisian-Type) may be traced into epigenetic monophase Sr deposits within bioherms (Cyprus-Type) devoid of Pb, Zn and F. Moving eastward, syndiagenetic monophase Sr deposits in biostromes (Gulf-Type) herald the beginning of Sr concentration in Miocene sabkhas of the Neo-Tethys. The current results are based upon field-related sediment petrography and on mineralogical studies, which were supplemented by chemical studies. The present studies bridge the gap between epigenetic carbonate-hosted MVT and syndiagenetic evaporite deposits, both of which developed during the same time span (Neogene) and where hosted by the same environment (near –shore marine marginal facies of the Neo-Tethys basin).

*In: Journal of African Earth Sciences; vol. 92, April 2014, p. 76-96.*

**78: Caractérisation de l'origine géogénique/anthropique des anomalies en ETM au Cap de Garde, massif de l'Edough, Annaba (NE algérien).** HADJ ZOBIR S., DAIF M., DJORFI S.

**Mots-clés:** Géogénie; Anthropie; Anomalie; ETM; Annaba; Algérie.

**Résumé:** Les éléments traces métalliques (ETM) sont naturellement présents en faibles ou très faibles concentrations dans les roches. Cependant, certains processus géologiques, tels que l'altération par l'eau, les fluides hydrothermaux et/ou l'érosion, peuvent conduire à leur accumulation. L'altération fragilise la roche, permettant ainsi la formation de minéraux argileux qui sont considérés comme pièges à éléments chimiques. Le site du Cap de Garde (Algérie) a connu, cette décennie, une importante urbanisation (construction d'hôtels, d'un centre de vacances et autres). Dans cette étude, les échantillons prélevés à proximité des constructions ont été comparés à ceux prélevés loin de celles-ci. Les premiers se caractérisent par des teneurs en Ni, Cr, Pb et Cu en dessous des normes internationales, les seconds se distinguent, contre toute attente, par de fortes concentrations. L'étude géochimique détaillée des différents faciès lithologiques et minéralogiques des zones de prélèvement a permis de mettre en évidence: (i) les fortes teneurs en ETM sont localisées dans les formations particulièrement affectées par la tectonique cassante et ayant un fort taux d'altération hydrothermale, (ii) les faibles concentrations en ETM sont particulières aux zones urbanisées géologiquement pauvres en structures cassantes et à faible taux d'altération hydrothermale. Ces résultats permettent de conclure que les fortes concentrations en ETM des zones urbanisées du Cap de Garde sont géogéniques.

*In: Trabajos de Geologia Universidad de Oviedo; n° 33, 2013, p. 231-243.*

**79: A consideration of Pan African orogenic cycle in the Anti-Atlas Mountains, Morocco.** HEFFERAN K., SOULAIMANI A., SAMSON S.D.

**Keywords:** Geochronology; Ediacaran; Anti-Atlas mountains; Morocco; Gondwana; Pan Africa.

**Abstract:** For over 50 years the Pan African orogeny has been recognized as a Neoproterozoic tectonothermal episode affecting West Africa 800-550 Ma. As such, the Pan African events are similar to the Appalachian orogenic cycle extending from ~1100 to 250 Ma and the Cordilleran orogenic cycle of 350 Ma to the present. A significant difference is that the Appalachian orogenic cycle has long been recognized as consisting of separate Grenville, Taconic, Acadian and Alleghenian orogenies. Similarly, the Cordilleran orogenic cycle consists of distinct Antler, Sonoma, Nevadan, Sevier, Laramide and ongoing Cascadian-Andean orogenies. Failure to distinguish individual tectonic events in the Anti-Atlas Mountains has been attributable to the dearth of radiometric dates in this region.

Since 2000, precision geochronologic dating in the Anti-Atlas Mountains, Morocco, has provided a means by which it is now appropriate to designate a Pan African orogenic cycle consisting of separate distinct orogenic events. We herein propose the following distinct orogenic events in the Anti-Atlas Mountains of Morocco: Iriri-Tichibanine orogeny (760-700 Ma), Bou Azzer orogeny (680-640 Ma) and the WACadomian orogeny (620-555 Ma).

*In: Journal of African Earth Sciences; vol. 98, October 2014, p. 34-46.*

## HYDROLOGIE

**80: Variations spatiales des caractéristiques physico-chimiques des eaux souterraines de la plaine alluvionnaire de Guelma, (Nord-est algérien).** BENMARCE K., CHOUABBI A., BOUABSA L.

**Mots-clés:** Eau; Aquifère; Alluvions; Faciès chimiques; Minéralisation; Pollution; Guelma; Nord-est algérien.

**Résumé :** La zone d'étude qui se situe au nord-est algérien est une dépression résultant de mouvements de compression et d'extension survenus au début du Miocène, comblée d'alluvions du même âge disposées en terrasses et alimentées en partie par la nappe des travertins située à leur amont. Cette recherche s'articule autour des variations spatiales des caractéristiques physicochimiques des eaux souterraines de la dépression. Les eaux souterraines de 7 sources ont été prélevées à la fin du mois d'Avril 2009 (saison des pluies) puis analysées. 16 paramètres ont été déterminés dans les échantillons d'eau: pH, T°C, conductivité électrique (C.E),  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ , TH (dureté totale), TAC (Titre alcalimétrique complet), ortho phosphate ( $\text{PO}_4^{3-}$ ),  $\text{Mn}^{2+}$  et  $\text{Al}^{3+}$ . La variation des valeurs du pH entre 7,7 et 10,7 montre un caractère basique de toutes les eaux analysées, celle de la conductivité électrique entre 1030  $\mu\text{S}/\text{cm}$  et 2020  $\mu\text{S}/\text{cm}$  montre un accroissement de l'amont à l'aval. Une corrélation significative a été observée entre la conductivité électrique (CE) et d'autres paramètres ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$  et  $\text{Al}^{3+}$  exceptés  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$  et  $\text{Mn}^{2+}$ . Les anions dominants sont les chlorures et les sulfates et les cations dominants sont représentés essentiellement par le calcium et le magnésium.

L'application des méthodes exploratoires multivariées (analyse factorielle) a permis d'identifier les paramètres les plus pertinents qui décrivent la qualité de ces eaux et de définir une zonation de la chimie des eaux. Le facteur I représentant la minéralisation a mis en évidence l'augmentation de ce paramètre de l'amont vers l'aval de la nappe. Le second facteur représentant la pollution anthropique a permis d'identifier un milieu réducteur dans la partie centrale de la nappe limité entre deux milieux oxydants à ses extrémités amont et aval. Les faciès chimiques chloruré et sulfaté calcique et magnésien des eaux sont liés à la nature lithologique des terrains traversés. L'accroissement des teneurs des paramètres est enregistré surtout à l'aval de l'aquifère selon le sens de l'écoulement.

*In: Bulletin des Sciences Géographiques INCT; n° 29, 2014, p. 52-62.*

**81: Application of two statistical methods for rainfall network development in northeast of Algeria.** TOURKI M., KHANCHOUL K.

**Keywords:** Physical variables; Prediction; Rainfall; Modeling; Multiple nonlinear regression; Artificial neural network; Northeast Algeria.

**Abstract:** Rainfall is an important climatic parameter and the studies on rainfall are commonly hampered due to lack of continuous data or low density of rainfall network, especially in the developing countries. In view of this problem, this study presents the methodologies used for the optimization of a rainfall observation network by predicting annual averaged rainfall. This is the prediction of rainfall using multiple nonlinear regression and artificial neural networks from 40 rainfall stations in the north-eastern Algeria. The two statistical methods are used to model relationships between a dependent variable (rainfall data) and explanatory variables (altitude, distance from the sea, latitude and longitude coordinates). The results obtained in this study indicate that Multi-Layer Perceptron Neural Network (MLP) model is able to provide more or less a better representation of rainfall prediction in comparison with the multiple nonlinear regression model. In this case, forecasting result exhibited by the proposed artificial neural network networks is the closest to actual rainfall values among the multivariate regression taken the low root mean square error of 0.129 and high efficiency factor and coefficient of correlation of respectively 0.88 and 0.94.

*In: Bulletin des Sciences Géographiques INCT; n° 29, 2014, p. 63-76.*

**82: Algerian augmentation positioning system (SAAP).** ABDELLAOUI H., ZAOURAR N.

**Keywords:** Augmentation system; Positioning; GNSS; Accuracy; Ground segment; Algeria.

**Abstract:** We present in this article the main phases of a major project that involves the realization by the National Institute of Cartography and Remote Sensing, of a network increases positioning based on GNSS permanent stations (Global Navigation Satellite System). The GNSS consist of two currently operational satellite constellations: GPS (USA) and GLONASS (Russia) and in a few years, two other; Galileo (Europe) and BEIDOU/COMPASS (China) are expected to joint them.

The architecture of the proposed network will cover the whole national territory, by receiving stations permanent GNSS multi-frequency meets the technical standards of accuracy adopted by the same systems already operational around the world.

The principle is to complete the constellations forming the GNSS, by ground segment increase or recovery, which delivers real-time corrections to increase the positioning accuracy and the provision of information to ensure the integrity of these corrections.

These augmentation systems have now become an indispensable tool for all precision applications centimeter. They are increasingly used in the work requiring high precision in the measurements, in particular for monitoring deformations of the earth's crust, auscultation structures of art, cartography, geodesy and surveying of atmosphere from the ground or space. For monitoring earthquakes, many studies focus on the exploitation of data from GNSS augmentation systems for better management of seismic risk. The geophysical research could benefit from the combination of these data with those of accurate seismic stations and tide gauges to determine the location of the epicenters and magnitudes.

*In: Bulletin des Sciences Géographiques INCT; n° 29, 2014, p. 30-37.*

**83: Neogene rotations of the Chenoua massif, northern Algeria, from remagnetizations.** AÏFA T.

**Keywords:** Paleomagnetism; Rock magnetism; Remagnetization; Neogene rotations; Volcanics; Sandstones; Chenoua massif; Northern Algeria.

**Abstract:** The tectonics of the Chenoua massif suggests block rotations of Neogene nappes associated with the African-European plate convergence. To estimate the extent of these rotations, a paleomagnetic study on rhyolites and andesites of Langhian-Serravallian age and sandstones of Burdigalian age was carried out on 23 sites (200 specimens). The sites are distributed in the northwestern, southeastern and southern Chenoua massif. One or two components of magnetization, mainly carried by magnetite, pyrrhotite and/or hematite, were isolated in sandstones and volcanics. The sandstone sites reveal magnetizations in sandstones from the Cap Blanc syncline that are post-folding. However, both polarities are found, which is consistent with data from Africa during the Upper Miocene. Clockwise and counterclockwise rotations were recorded, dating back to the Neogene times in volcanics and sediments. From the faulted Cap Blanc syncline counterclock-wise rotations of  $1\pm 4^\circ$  to  $18\pm 28^\circ$  around a vertical axis occurred in sediments since the Miocene with respect to Africa. In fact, remagnetizations occurred at several periods of time and in different sites, providing information on the evolution of post-tectonic rotations. Some volcanics record counterclock-wise rotations of about  $30^\circ$  since the Miocene, whereas others do not show any significant rotation. This can be explained by the direction of the principal compressive stress axis  $\sigma_1$  and by lateral extrusions related to an indentation model, in which we expect both clockwise and counterclockwise rotations.

*In: Arabian Journal of Geosciences; vol. 7, n° 11, 2014, p. 4629-4640.*

**84: Apport de la cartographie aéromagnétique à l'identification structurale du système aquifère des sources de l'oasis de Figuig (Maroc).** AMAR M., MANAR A., BOUALOUL M.

**Mots-clés:** Champ magnétique; Déconvolution Euler; Couverture mésozoïque; Source de l'oasis de Figuig; Haut Atlas oriental; Maroc.

**Résumé:** La carte du champ magnétique résiduel du Haut Atlas oriental montre d'importantes anomalies. L'application de la réduction au pôle à cette carte et l'application de la transformation de l'angle d'inclinaison puis le calcul de la déconvolution Euler pour la détection des failles, a permis d'améliorer les connaissances sur la structure du système

aquifère des sources de l'oasis de Figuig. En effet, la plus importante partie de ce système aquifère est contenue dans les terrains de la couverture mésozoïque.

*In: Bulletin de l'Institut Scientifique – Rabat. Section Sciences de la Terre; n° 34, 2012, p. 29-40.*

**85: Evidence of a Permian remagnetization in the Neoproterozoic-Cambrian Adoudounian formation (Anti-Atlas, Morocco).** BOUDZOU MOU F., VANDAMME D., AFFATON P.

**Keywords:** Paleomagnetism; Neoproterozoic; Cambrian; Adoudounian formation; Anti-Atlas; Morocco; West-African craton.

**Abstract:** A paleomagnetic study was undertaken on samples collected from seven sites of the exhumed and eroded Ait-Abdallah and Kerdous antiforms in the Moroccan Anti-Atlas of the West African craton. These sites are located in the Adoudounian formation considered as of Neoproterozoic-Cambrian age. The magnetic mineralogy is represented essentially by magnetite and titanohematite. Magnetization is carried by three components respectively of high-temperature (500-670°C), medium-temperature (350-470°C) and low-temperature (NRM-300°C). Plotted in Gondwana Apparent Polar Wander Path, the high and medium temperature components close to the Permian pole and determine Permian overprint directions. The low temperature component closes to the present day field and corresponds to the present overprint day. This study shows that Permian overprint largely affect the Anti-Atlas area.

*In: Bulletin de l'Institut Scientifique – Rabat. Section Sciences de la Terre; n° 34, 2012, p. 15-28.*

**86: Seismicity and seismic hazard in Morocco 1901-2010.** CHERKA OUI T.-E., EL HASSANI A.

**Keywords:** Seismicity; Catalogue; Intensity map; Seismic; Morocco; Algérie; Afrique; Europe.

**Abstract:** The seismic activity in Morocco is not as important as in other world areas such as Japan, California, Greece, Turkey, etc. Nevertheless, background seismicity in Morocco is not negligible and has produced a few historical and instrumental earthquakes with local magnitudes above 6. The Agadir earthquake 1960, for instance, destroyed this city with several villages and caused 12,000 deaths. Later, other remarkable earthquakes occurred: in Al Hoceima in 2004 in the North of Morocco caused 629 deaths. The mechanisms governing the spatial distribution of these earthquakes and their frequency remain poorly understood. Most probably the seismicity of northern Morocco and Atlas mountain reflects primarily deformation induced by the ongoing collision between Africa and Europe (the convergence rate being of the order of 5mm/yr at most). In this work, we presented an earthquake catalogue covering the period 1901-2010, comprising about 25,000 events for the region lying between 0°W-20°W and 21°N-38°N. It results from raw data of Morocco, Spain, Portugal and Algeria seismic networks, enabling an input consisting of origin time  $H$ , geographical coordinates (longitude  $\lambda$  and latitude  $\varphi$ ) and at least one of the following parameters: surface wave magnitude  $M_s$ , body wave magnitude  $M_b$ , epicentral intensities  $I_0$ . A first application of this catalogue allows the drawing up of an updated seismicity and maximum observed intensities map of Morocco. This map is obtained by using about 1,700 values of MSK intensity observed in 670 localities. This document may be useful in mapping the seismic hazard in Morocco. There is a similarity between this map and the seismic hazard map from the SESAME project.

*In: Bulletin de l'Institut Scientifique – Rabat. Section Sciences de la Terre; n° 34, 2012, p. 45-55.*

**87: Apport du paléomagnétisme dans l'étude de la néotectonique du Nord de l'Algérie.** DERDER M.E.M., MAOUCHE S., DJELLIT H.

**Mots-clés:** Activité sismique; Paléomagnétisme; Néotectonique ; Bassin de la Mitidja; Algérie.

**Résumé :** L'activité sismique de la Méditerranée occidentale est en partie concentrée en Afrique du Nord, et particulièrement au nord de l'Algérie. Cette sismicité est due à la convergence entre les plaques Africaine et Eurasiatique qui implique une tectonique transpressive avec une direction de raccourcissement N-S à NNW-SSE. Cette tectonique s'explique par une déformation active le long de la frontière de plaque. La déformation active dans le Nord de l'Algérie peut s'expliquer par un modèle cinématique de rotations de blocs: la transpression tectonique NNW-SSE définit des blocs orientés NE-SW qui seraient soumis à des rotations horaires (Meghraoui et al. 1996; Morel & Meghraoui; 1996). Des résultats d'études paléomagnétiques récentes effectués sur le bassin du Chelif (Derder et al., 2011) sont en accord avec ce modèle.

Nous présentons dans Cet exposé, les résultats paléomagnétiques obtenus récemment dans le bassin de la Mitidja (Centre de l'Algérie) et dans le bassin de la M'léta (Ouest de l'Algérie) qui confirment bien ce modèle de déformation en rotations de blocs.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 32*

**88: Evidence for transform motion along the South Balearic margin and implications for the kinematics of opening of the Algerian basin.** DRIUSSI O., BRIAIS A., MAILLARD A.

**Keywords:** Seismic reflexion profiles; Gravity models; Magnetic anomalies; Kinematics; Transform margin; South Balearic margin; Algerian basin.

**Abstract:** Two major types of kinematic models have been proposed to explain the opening of the western Mediterranean basins (Liguro-Provençal and Algerian basins, and Valencia trough). In one type of models, all continental blocks bounding the basins drift to the southeast, driven by the rollback of the Tethys subduction slab. In the other type of models, the Alboran domain drifts to the southwest, implying a westward rollback of the broken subducting slab and a NE-SW opening of the Algerian basin. In most models, however, the structure of the Balearic promontory was not taken into account, despite its key location at the boundary of the three major basins. We used the interpretation of a large seismic database coupled to gravity and magnetic anomaly analyses to characterize the nature and structure of the South Balearic margin. The constraints brought by the new analyses allow us to suggest a new scenario for the opening of the Algerian basin.

Seismic profiles show that the South Balearic margin is composed of four segments with different morphologies and crustal structures. Two segments, the Mazarron and the Emile Baudot escarpments, are characterized by steep scarps and sharp crustal thinning. Two other segments, the South Ibiza and South Menorca margins, have a smoother bathymetry and crustal thinning. We interpret the former in terms of transform margins, and the latter as divergent margins. The distribution of faults on the passive margin segments suggests that they have recorded at least two phases of deformation. A first phase of opening, probably in a NW-SE direction, affected the south Balearic margin, and possibly created some oceanic floor. The existence of the transform margin segments and the prominent NW-SE orientation of the magnetic lineations in the eastern Algerian basin suggest that most of this basin opened in a NE-SW direction, in different oceanic corridors. The two eastern corridors formed by the southwestward drift of the Kabylies. The western corridor, bounded by the transform segments of the South Balearic margin and the Algerian margin, results from the southwestward drift of the Alboran domain, as suggested by previous studies.

*In: Bull. Soc. Géol. France; t. 186, n° 4-5, 2015, p. 353-370.*

**89: Etude qualitative de la précision des modèles numériques de terrain globaux: cas de l'Algérie.** HADDAD M., RABEHI N., TAIBI H.

**Mots-clés:** GTOPO30; SRTM; GLOBE; ASTER; GMTED; ETOPO; Données BGI ; Algérie.

**Résumé :** L'objectif de l'article est de vérifier la qualité des différents Modèles Numériques de Terrain – MNT globaux disponibles: GTOPO30, GLOBE, SRTM (30" et 3"), ETOPO1, GMTED (30", 15" et 7,5") et ASTER.

Dans ce cadre, les altitudes des 12472 points gravimétriques, fournis par le Bureau Gravimétrique International – BGI et couvrant le territoire algérien ont été comparées à celles interpolées à partir des MNT.

Les écarts en altitude ont montré que les MNT GTOPO30 et GLOBE présentent des écarts-types très élevés (~48 m), alors que les autres modèles présentent des écarts-types modérés (de 21 à 27 m). Néanmoins, les deux modèles SRTM 3" et GMTED 7,5" sont ceux qui présentent une dispersion minimale (~72 % des points gravimétriques exposent des écarts en altitude compris dans l'intervalle de -10 à 10 m).

*In: Bulletin des Sciences Géographiques INCT; n° 29, 2014, p. 16-29.*

**90: Structure lithosphérique et modèle géodynamique de la région d'Alboran.** TIMOULALI Y.

**Mots-clés:** Tomographie sismique; Vitesse de la croûte; Blocs tectoniques; Rif central; Cordillère Bétique; Maroc.

**Résumé :** Avec les réseaux sismiques en Espagne et au Maroc, de récentes données sismiques ont été recueillies et utilisées pour l'étude de la lithosphère dans la cordillère Bétique – Rif. La présente étude a deux objectifs principaux: 1) Utiliser les données sismiques les plus récentes en arc Bétique – Rif pour l'étude de la lithosphère en appliquant les techniques de tomographie sismique locales. 2) Définir les blocs structuraux possibles et expliquer les perturbations de vitesses détectées par les GPS au niveau de la région. Les résultats des tests résolutions indiquent que les images calculées donnent des structures proches de la réalité entre 5 -60 km de profondeur. L'image tomographique obtenue montre que la présence de deux blocs représentant la croûte supérieure (vitesse 6,5 km / s) à 3 – à 13 km de profondeur entre le Bétique et le Rif marocain à l'Ouest et au milieu de la mer d'Alboran.

Les images montrent également de faibles vitesses favorisant la présence de l'état de fusion à la base de ces deux blocs. Des blocs tectoniques sont aussi présents au niveau du Rif central et le centre de la Cordillère Bétique.

*In: 1<sup>ère</sup> Ecole de Terrain sur la Géologie des Maghrébides (1<sup>ère</sup> ETGM) « en hommage au professeur Michel Durand-Delga » Université de Jijel & CRAAG 24-27 Novembre 2014, p. 35-49.*

**91: Layered lower crust and mantle reflectivity as imaged by a re-processed crustal seismic profile from Sicily in the central Mediterranean.** VALENTI V., CATALANO R., WEI P.

**Keywords:** “Layered” lower crust; Mantle reflectivity; Seismic re-processing; Central Mediterranean.

**Abstract:** Though Sicily is a key area for understanding the central Mediterranean tectonics, a number of questions on its dynamics remains open due to the lack of detailed data on the lithospheric structure.

Deep reflectivity images of the African lithosphere, beneath Sicily, have been derived from the re-processing of the crustal seismic reflection stack (SI.RI.PRO. Project).

Of specific interest was the imaging, beneath central-southern Sicily, of a thinned crust with a reflective, “layered” pattern for the lower crust that differs from the one, thicker and sub-transparent, of the northern-central sector.

Brittle deformation in the upper crystalline crust along a low-angle normal fault and sub-horizontal sub-Moho events are the main features, spatially associated with the “layered”, attenuated lower crust.

Geological implications, which are related to the above-mentioned crustal characters, that allow us to suppose two combined hypotheses (the first suggesting that the crustal features derive from the effects of Permian and Mesozoic rifting cycles, the second connecting the crustal thinning to the latest Pliocene-Pleistocene volcanic activity and tectonics), are here discussed.

The imaging of the Moho patterns and the crustal/sub-crustal reflectivity characteristics, here illustrated for the first time, could provide constraints for the geodynamic processes governing this area where an interaction between African and Tyrrhenian European plates occurs.

*In: Bull. Soc. Géol. France; t. 186, n° 4-5, 2015, p. 257-272.*

## GEOMORPHOLOGIE

**92: Etude morphologique par Sonar à balayage latéral des sédiments meubles de la plateforme interne atlantique au Sud de Tanger (Maroc).** GEAWHARI M.A., MHAMMDI N., AMMAR A.

**Mots-clés:** Sonar à balayage latéral; Dunes; Le large de Cap Spartel; Plateau continental marocain; Sud de Tanger; Maroc.

**Résumé :** Cette étude est basée sur la cartographie détaillée de la partie proximale de la plateforme atlantique marocaine au sud de Cap Spartel, menée à l'aide d'un sonar à balayage latéral (SBL) et complétée par les données sédimentologiques provenant de sources bibliographiques. Les images sonar SBL montrent une mosaïque complexe de substrats rocheux et de corps sédimentaires transversaux et longitudinaux aux courants dominants. L'analyse morphologique suggère que les courants de marée sont l'agent hydrodynamique principal qui contrôle le développement des petites structures.

*In: Bulletin de l'Institut Scientifique – Rabat. Section Sciences de la Terre; n° 34, 2012, p. 57-67.*



**93: Recent warming trends inferred from borehole temperature data in Figuig area (Eastern Morocco).** OUZZAOUIT L.A., BAKRAOUI A., BENALIOULHAJ N.

**Keywords:** Climate change; Borehole temperature; Geothermal gradient; Eastern Morocco.

**Abstract:** Ground surface temperature history (GSTH) reflecting the past climate conditions in eastern Morocco was evaluated by analyzing temperature-depth profiles measured in four boreholes at the Figuig Oasis. The temperature-depth data were inverted using the functional space inversion method in order to reconstruct the surface temperature past changes. The results reveal a recent warming in the last century with an amplitude of 1-3 °C for the four boreholes and a comparison with surface air temperature (SAT) variation from the Bouarfa and Bechar meteorological stations confirms this result. This warming trend is confirmed by other climate proxies.

*In: Journal of African Earth Sciences; vol. 96, August 2014, p. 1-7.*

**94: Le changement climatique, mythes, réalités et incertitudes.** VELLINGA P.

**Mots-clés:** Climat; Changement climatique; Réchauffement; Energie.

**Résumé :** Pourquoi le changement climatique inquiète-t-il tant les uns et laisse-t-il les autres de marbre? Peut-on vraiment parler de changement climatique alors que les hivers restent froids? 2009 et 2010 ont même été les hivers les plus froids depuis des années aux Pays-Bas et dans certains pays européens. Et si changement climatique il y a, nous, les êtres humains, en sommes-nous bien les responsables? A en croire la grande majorité des experts, le climat se réchauffe mais est-ce donc si grave – le phénomène est-il dépourvu d'avantages?

Il est parfois difficile de séparer le vrai du faux en la matière. Ce livre se propose de répondre aux questions que presque tout le monde se pose sans toujours oser les formuler tout haut. Sans éluder les incertitudes qui subsistent, nous tenterons de faire le point sur ce que nous savons et sur ce que nous ignorons de l'influence des être humains sur le climat et d'indiquer ce que nous pouvons faire. L'avenir reste toujours incertain mais nous serons plus forts pour faire face aux défis si nous en savons plus.

*In: Ed. Université de Bruxelles; 2013, 160 p.*

## GEOLOGIE DE L'INGENIEUR

**95: Principes généraux des mouvements gravitaires.** BERNARDIE S., CERDAN O.

**Mots-clés:** Mouvement de terrain; Mouvement gravitaire; Instabilité rocheuse; Glissement de terrain; Coulée boueuse ; Erosion des sols ; Effondrement; Affaissement ; France

**Résumé :** Les mouvements gravitaires désignent un déplacement de masse de terrain sous l'action de la pesanteur. Généralement, le mouvement est initié sous l'effet de sollicitations naturelles (précipitations, fonte des neiges, séismes, etc.) ou anthropiques (terrassment, déboisement, exploitation de matériaux ou de nappes aquifères, etc.).

Les instabilités gravitaires peuvent être déclinées en plusieurs types de mouvements selon la nature des sols considérés (meuble, rocheuse...), leur comportement mécanique avant et pendant le déplacement (solide, plastique, visqueux, fluide...), les volumes impliqués, la vitesse du mouvement (lent – cm/an, rapide – m/s), la forme de la trajectoire.

Ainsi, la typologie des mouvements de terrain correspond à la classification des différents phénomènes d'instabilité en fonction du mécanisme mis en jeu et des déformations observées. On peut distinguer 5 types de mouvements gravitaires: chute de blocs, glissement de terrain, érosion, coulée de boue, effondrements/affaissement.

*In: Géochronique; n° 133, 2015, p. 10-14.*

**96: Les glissements de terrain: caractérisation géophysique.** GRANDJEAN G.

**Mots-clés:** Glissement de terrain; Géophysique; Cartographie de la résistivité; Tomographie électrique; Sismicité; France.

**Résumé :** Pour comprendre la dynamique d'un glissement de terrain, il est essentiel d'en déterminer les unités structurales internes et de caractériser les principaux processus hydrogéologiques en relation avec les événements climatiques régionaux. Les méthodes géophysiques, comme l'imagerie sismique et électrique, sont bien adaptées à ce type d'études dédiées à la compréhension des mécanismes internes des versants instables. Ces méthodes d'imagerie permettent de donner une mesure directe et non intrusive des vitesses des ondes acoustiques (P) ou de cisaillement (S) ainsi que de la résistivité électrique.

*In: Géochronique; n° 133, 2015, p. 22-26.*

**97: Cartographie de l'aléa mouvement de terrain.** VANDROMME R., DESRAMAUT N., SEDAN O.

**Mots-clés:** Cartographie; Mouvement de terrain; Glissement terrain; Changement climatique; Vallée de l'Ubaye; France.

**Résumé :** Les zones montagneuses sont de plus en plus concernées par les glissements de terrain. Les causes résident dans plusieurs facteurs principalement liés aux utilisations des terrains et au changement climatique. La prise en compte de ces facteurs dans la cartographie des risques montre un intérêt croissant qui a conduit à une large variété de modèles, tous considérant la prédisposition et les facteurs environnementaux, en particulier la végétation et l'hydrographie.

Les méthodes pour caractériser le risque de glissement de terrain peuvent être classifiées dans trois groupes: inférentielles et heuristiques, statistiques, ou basées sur les approches physiques.

*In: Géochronique; n° 133, 2015, p. 15-18.*

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