تحت الرعاية السامية لصاحب الجلالة الملك محمد السادس

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SOUS LE HAUT PATRONAGE DE SA MAJESTE LE ROI MOHAMMED VI

The International Conference
The Rise of Animal Life

RALI2015

Promoting Geological Heritage:
Challenges and Issues

05-10th October 2015
Marrakesh

Supporting organizers

United Nations, Educational, Scientific and Cultural Organization (UNESCO)
The International Geoscience Programme Project (IGCP 591)
The International Commission on Stratigraphy (ICS)
The International Union of Geological Sciences (IUG)

Abstracts and program

Cadi Ayyad University, Faculty of Sciences & Technics. Marrakesh

GENERAL INFORMATION ON RALI2015

The International Conference 'Rise of Animal Life: Cambrian and Ordovician biodiversification events. Promoting geological heritage: challenges and issues' RALI 2015 is organized by the Faculty of Sciences and Technics, Marrakesh, Department of Earth and Sciences, Cadi Ayyad University, Marrakesh (Morocco).

The formal theme of the meeting are devoted to 'Cambrian and Ordovician radiations'. In conjunction with the conference, a special symposium dedicated to aspects of Geological Heritage will be held and will highlight associated educational, cultural and socio-economic issues. The captivating City of Marrakech offers an ideal setting for scientific gathering. The « Red City » boasts an exceptional cultural heritage and remarkable natural surroundings such the snow-capped High Atlas mountains, and its beautiful palm gardens.

The scientific sessions are followed by a field trip as a 'Geotraverse of Central High Atlas and Anti-Atlas'. Besides its geological importance, the southern part of Morocco is one of the most attractive touristic areas. It shows diversified landscapes, from snowy mountains to desert plains. The High Atlas (3000-4000 m above sea level) forms a major climatic barrier to the Atlantic and saharian perturbations, which account for the arid climate of the Anti-Atlas sub-saharian domain south of the chain. This field trip will also offer participants the opportunity to visit fossil localities near Zagora, where the Fezouata Biota is currently being studied by an international team of scientists. In the Ternata plain (N. of Zagora), the Lower Ordovician succession (Fezouata Shale and Zini Sandstones) lies unconformably over the middle Cambrian Tabanite Group. The Fezouata Shale corresponds to a thick monotonous series (1000 m) of siltstones deposited under shallow offshore conditions (storm-wave influence).

The Fezouata Biota provides a unique insight into one of the most critical periods in the evolution of marine life: the Cambrian-Ordovician transition.

This international conference will focus on this crucial event, especially its timing, and possible processes and causes with special emphasis on the relationships between the 'Cambrian Explosion' and the subsequent 'Great Ordovician Biodiversification Event'.

Topical sessions

-Faunas, environments, triggers and drivers of the Cambrian and Ordovician biodiversification events.
-Cambrian and Ordovician exceptional biotas: taphonomy, palaeobiology, palaeoecology.
-Geological Heritage: challenges and issues.

Organisation des Nations Unies pour l'éducation, la science et la culture

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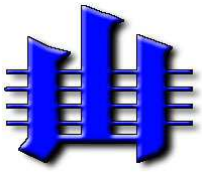
Fondation Jardin Majorelle



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CARON Jean-Bernard (Toronto, Canada)
DESTOMBES Jacques (Pessac, France)
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SOULAIMANI Abderrahmane (UCA, Morocco)

Hommage à Mr Jacques DESTOMBES

Alors que le Maroc organise un congrès sur la vie animale à l'Ordovicien, il est de toute logique de rendre un hommage à celui qui fut l'un des premiers à avoir parcouru ces contrées, M. Jacques Destombes.

J'ai eu personnellement le plaisir de rencontrer M. Destombes en 1983, alors que je venais de prendre en charge le Service d'Etudes des Gîtes Minéraux à la Direction de la Géologie. Et jusqu'à son départ de Rabat, en 1988, je n'ai pas cessé de le consulter, vu son amabilité, sa disponibilité et son expérience.

M. Destombes est né à Roubaix (dans le Nord de la France) le 21 Juin 1926. Après une Licence–es-Sciences Naturelles obtenue en 1948 (certificats de Minéralogie, Botanique, Géographie physique et Géologie) préparée et soutenue à Paris et à Lille, et une 4° année à l'Ecole Nationale Supérieure des Mines de Paris (Stage de Géologie minière), il fut recruté sur concours, après le Service militaire, au Service géologique du Maroc (Ministère des Mines et de la Géologie), à Rabat, à partir du 1° septembre 1950 et affecté à la Section d'Etude des Gîtes Minéraux (SEGM), alors dirigée par J. Agard sous la supervision d'Eugène Raguin. En plus de M. Destombes, la section comportait, entre autres, MM. Permingeat, Jouravsky et Gaudefroy. Si je cite ces éminences grises, c'est que chacune d'elles contribuera à la renommée de la géologie du Maroc. En effet, déjà à cette époque, les travaux de cette Section allaient être récompensés en 1952 par le « Prix Joseph Labbé » de l'académie des Sciences. De même, et bien tardivement, nous aurons des minéraux qui porteront leurs noms : l'agardite, la jouravskyte, la gaudefroyite, avec, à côté, un éocrinoide de l'Ordovicien inférieur du Sud marocain le Rhopalocystis destombesi n.g., n.sp., et un genre d'Echinoderme Cystoïde, le Destombesia Chauvel.

Parler de l'apport de M. Destombes en quelques phrases ne serait de toute facilité. En effet, dès que l'on parle de l'Anti-Atlas du Maroc, les noms qui viennent d'abord à l'esprit sont M. Choubert, Clariond, Hollard, Destombes et Melle Faure-Muret.

Comment alors parler de Tafilalet, au moment où le Département de l'Energie et des Mines procède à la restructuration de la zone minière de la CADETAF sans penser à M. Destombes, co-auteur des cartes géologiques couvrant cette zone (Tafilalet-Taouz)?

Comment parler des minéralisations du Maroc au moment où le département de l'Energie et des Mines relance le développement de ses ressources minérales sans penser à M. Destombes qui fut, avec certains de ses collègues, les premiers à avoir établi la carte des gîtes minéraux du Maroc et c'était en 1952. D'ailleurs, cette date fut pour M. Destombes le point de départ pour une carrière riche et diversifiée.

En effet, ce fut depuis lors qu'il allait se lancer dans l'étude des minéralisations du fer du Maroc. Et comme plusieurs gîtes se trouvaient dans le Paléozoïque, il y trouvera son terrain et son amour. On lui devra alors plusieurs études de synthèse pour le fer du Maroc.

La qualité des affleurements de l'Anti-Atlas aidant, M. Destombes s'intéressera alors à tout le domaine et dans plusieurs spécialités allant de la gîtologie à la paléontologie en passant par la cartographie géologique et la géotechnique.

En plus de sa qualité de paléontologue-stratigraphe, avec des travaux sur le Cambrien moyen, l'Ordovicien et la base du Silurien de l'Anti-Atlas, il est aussi un éminent cartographe et a levé, en collaboration avec d'autres collègues, 14 cartes géologiques au 200 000° et au 100 000°, en plus de la carte géotechnique de la meseta côtière.

Aujourd'hui, à l'occasion de ce RALI 2015, nous rendons hommage à M. Destombes qui fut parmi les premiers à avoir posé les jalons de la stratigraphie de l'Ordovicien du Maroc, lui, le membre de la sous-commission internationale sur la Stratigraphie de l'Ordovicien et à qui nous devons 116 publications géologiques et 81 rapports inédits, réalisés seul ou en collaboration avec d'autres collègues, essentiellement du Service Géologique du Maroc.

Addi AZZA

The International Conference

The Rise of AnimaL Life / RALI2015

Promoting Geological Heritage: Challenges and Issues

05-10th October 2015-Marrakesh

Schedule of events and timetable of presentations

Lectures

Monday, October 5th 2015

10h00-15h30 **Welcome of the participants**

15h30-16h00 **Opening Ceremony:**
The Minister of Culture
The Minister of Higher Education, Scientific Research and Professional Training
The Wali Marrakesh Safi
The President Cadi Ayyad University

16h00-17h00 **[Plenary 1: Derek E.G. BRIGGS]**

The remarkable Fezouata biota of Morocco compared to other exceptionally preserved Ordovician fossil assemblages
Derek E.G. BRIGGS (Department of the Geology and Geophysics, Yale University, USA)

17h00-18h30 **Reception and Stamp Exhibition by Barid Al-Maghrib dedicated to RALI2015 and Geological Heritage**

Tuesday, October 6th 2015

Session 1 (9h00-10h45) [Plenary 2: Jean Bernard CARON and Arthropods 1]

Chair: Diego C. GARCÍA-BELLIDO

09h00-10h00 **The Burgess Shale augmented: the Marble Canyon fossil deposit**
Jean-Bernard CARON (Royal Ontario Museum, Toronto, Canada)

10h00-10h15 **The Bailiella Formation, a Moroccan counterpart of the mid-Cambrian conocoryphid biofacies**
J. Javier ÁLVARO (Instituto de Geociencias CSIC – UCM, Spain)

10h15-10h30 **Disparity of the arthropod frontal-most appendage**
Cédric ARIA (Department of Ecology and Evolutionary Biology, University of Toronto AND Department of Natural History, Palaeobiology, Royal Ontario Museum, Canada)

10h30-10h45 **Anomalocaridid diversity, ecology and evolution**
Allison C. DALEY (Oxford University Museum of Natural History AND Department of Zoology, University of Oxford, UK)

10h45-11h15 **Posters and Coffee Break**

Session 2 : [Arthropods 2]

Chair : Derek BRIGGS

11h15-11h30 **Cambrian and Ordovician trends in trilobite ecdysis**
Harriet B. DRAGE (Department of Zoology, University of Oxford AND Oxford University Museum of Natural History, UK)

11h30-11h45 **A timetree for the early diversification of trilobites and implications for the Cambrian 'Explosion'**
Gregory D. EDGECOMBE (Department of Earth Sciences, The Natural History Museum, UK)

11h45-12h00 **Reappraisal on the Ordovician trilobites from the Bou Nemrou assemblage (Tafilalt Biota, Morocco)**
Juan Carlos GUTIÉRREZ-MARCO (Instituto de Geociencias CSIC – UCM, Spain)

12h00-12h15 **Trilobite assemblages of the Landeyran Formation (Floian), Montagne Noire, France: biostratigraphy and palaeoenvironmental implications**
Jean-Paul KUNDURA (France)

12h15-12h30 **Unlocking central nervous systems of Cambrian Chengjiang panarthropods and their preservation pathways**
Xiaoya MA (Department of Earth Sciences, The Natural History Museum, London AND Yunnan Key Laboratory for Palaeobiology, Yunnan University, China)

12h30-12h45 **The Fezouata arthropod fauna: an overview of current research**
Peter VAN ROY (Department of Geology and Geophysics, Yale University, USA)

12h45-13h00 **Reconstructing the diet of Cambrian arthropods**
Jean VANNIER (Université Claude Bernard Lyon 1, Laboratoire de géologie de Lyon, France) ***withdrawn***

13h00-14h30 **Posters and Lunch**

Session 3A (14h30-16h15) [plenary: David A.T. Harper and Ordovician 1]

Chair : Abderrazak EL ALBANI

14h30-15h30 **Unravelling the causes and consequences of the Great Ordovician Biodiversification Event**
David A.T. HARPER (Palaeoecosystems Group, Department of Earth Sciences, Durham University, UK)

15h30-15h45 **The significance of sponges in the Great Ordovician Biodiversification Event (GOBE)**
Joseph P. BOTTING (Chatsworth, UK AND Nanjing Institute of Geology and Palaeontology, China)

15h45-16h00 **Upper Ordovician of the Tafilalt region (eastern Anti-Atlas, Morocco): brachiopod associations, bioevents and sequence-stratigraphy.**
Jorge COLMENAR (Universidad de Zaragoza, Departamento de Ciencias de la Tierra, Área de paleontología, Spain)

16h00-16h15 **Burgess Shale-type preservation beyond the Cambrian: an example from the Middle Ordovician Llanfallteg Biota, South Wales**
Thomas W. HEARING (Geology Department, University of Leicester, UK)

Session 3B (15h30-16h15) [Geological Heritage 1]

Chair : Hasnaa CHENNAOUI

15h30-16h00 **The geological wealth of the Western High Atlas (Morocco)**

Moussa MASROUR (Université Ibn Zohr, Laboratoire de Géologie Appliquée et Géo-Environnement, Morocco)

16h00-16h15 **Ordovician geological heritage of Spain and Portugal**

Artur SA (Universidade de Trás-os-Montes e Alto Douro Portugal)

16h15-16h45 **Posters and Coffee Break**

Session 4A (16h45-18h30) [Ordovician 2]

Chair : David HARPER

16h45-17h00 **The eocrinoid Ascocystites Barrande (Echinodermata, Blastozoa) in the Upper Ordovician of Kerzaz (Ougarta, western Algeria)**

Yamouna MAKHLOUF (Laboratoire Géodynamique des Bassins Sédimentaires et des Orogènes, Université des Sciences et de la Technologie Houari Boumediene, Algeria) ***withdrawn***

17h00-17h15 **Red beds at the Cambrian-Ordovician boundary in Morocco and related NW-Gondwana domains: geodynamic inferences**

H. OUANAIMI (EGE, Ecole Normale Supérieure, Cadi Ayyad University, Morocco)

17h15-17h45 **Exceptional fossil preservation during global greenhouse crises?**

Gregory J. RETALLACK (Department of Geological Sciences, University of Oregon, USA)

17h45-18h00 **Development of the morphological diversity of attachment structures of the stalked echinoderms during the Early and Middle Ordovician of the eastern part of the Baltica basin**

Sergey ROZHNOV (Borissiak Paleontological Institute, Russian Academy of Sciences, Russia)

18h-18h15 **Lagerstätte-type preservation of fossils in siliceous deep water deposits in the Upper Cambrian and Lower Ordovician of Kazakhstan**

Tatiana TOLMACHEVA (A.P. Karpinsky Russian Research Geological Institute, Russia)

Session 4B : [Geological Heritage 2]

Chair : Moussa MASROUR

16h45-17h00 **From the inventory and assessment of sites to interpretation for tourists: current work in the M'Goun Global Geopark, central High Atlas, Morocco.**

Hanane ADARAB (Geology department, Ibn Zohr University, Morocco) ***withdrawn***

17h00-17h15 **The inventory of geoheritage sites in Draa Valley (Morocco): Contribution to tourism valorization and regional development.**

Mohamed BERAAOUZ (Laboratoire de géologie appliquée et géo-environnement, Université Ibn Zohr, Morocco) ***withdrawn***

17h15-17h30 **Paleontological heritage of Zagora region (southeastern Morocco): a tool for local sustainable development**

Abdelouahed LAGNAOUI (Department of Geology, Chouaïb Doukkali University, Morocco AND Institute of Geology and Petroleum Technologies, Russian Federation) ***withdrawn***

17h30-17h45 **Identification and classification of geomorphological geosites in the western Anti-Atlas of Morocco. An approach based on similarities and SIG for promoting geological heritage**
Lhassan M'BARKI (Géo-environment and Geoheritage Group, Ibn Zohr University, Morocco) ***withdrawn***

17h45-18h00 **Geo-tourism in the Arctic – challenges in a vulnerable environment.**
H.A. NAKREM (Natural History Museum, University of Oslo, Norway)

Gala Dinner

Wednesday, October 7th 2015

Session 5A (9h00-10h55) [Plenary 4: Ahmed BENLAKHDIM and Geological Heritage 3]

Chair 1: Mohamed BOUTAKIOUT

09h00-10h00 **Geological heritage of Morocco between its promotion and preservation**
Ahmed BENLAKHDIM (Ministry of Energy and Mining Water and Environment, Morocco)

Chair 2: Ahmed BENLAKHDIM

10h00-10h25 **Le géoparc M'Goun dans le Haut-Atlas central du Maroc**
Mohamed BOUTAKIOUT (Université Mohammed V, Faculté des Sciences, Morocco)

10h25-10h55 **Vertebrate fossils of the phosphates of Morocco, a memory of 24 million years, valorization and preservation by the OCP**
Essaïd JOURANI (OCP SA, Morocco)

Session 5B [Cambrian 1]

Chair : Jean Bernard CARON

10h00-10h15 **Sedimentary environments of the Upper Cambrian facies in the Central Anti-Atlas (Morocco): preliminary results**
Abdelfattah AZIZI (Faculté des Sciences et Techniques, Université Cadi Ayyad, Morocco)

10h15-10h30 **The Cambrian Radiation in East Gondwana: New data, new dates, new fossils**
Glenn A. BROCK (Department of Biological Sciences, Macquarie University, Australia)

10h30-10h45 **Contrasting ichnodiversity and ichnodisparity trajectories for bioturbation and bioerosion structures during the Cambrian and Ordovician radiations**
Luis A. BUATOIS (Department of Geological Sciences, University of Saskatchewan, Canada)

10h45-11h15 **Posters and Coffee Break**

Session 6A : [Cambrian 2]

Chair : Jean Bernard CARON

11h15-11h30 **An insight into the Cambro-Ordovician perireefal communities**
Jerzy DZIK (Instytut Paleobiologii PAN, AND Faculty of Biology, University of Warsaw, Poland)

11h30-11h45 **Census of exceptionally preserved fossil in Cambrian of the Barrandian area (Czech Republic)**
Oldřich FATKA (Charles University, Institute of Geology and Palaeontology, Czech Republic)

11h45-12h00 **The Emu Bay Shale biota: palaeobiogeographical relationships with other Cambrian Lagerstätten**
Diego C. GARCÍA-BELLIDO **(School** of Biological Sciences, University of Adelaide, AND Earth Sciences Section, South Australian Museum, Australia)

12h00-12h15 **Ichnology of Burgess Shale-type deposits: The interplay of ecologic, taphonomic and evolutionary constrains**
M. Gabriela MÁNGANO (Department of Geological Sciences, University of Saskatchewan, Canada)

12h15-12h30 **Cambrian stem group polychaetes resolve the origin of the annelid head and recover congruence between morphological and molecular phylogenies**
Luke PARRY (Bristol Life Sciences Building, University of Bristol, UK)

12h30-12h45 **The Emu Bay Shale Konservat-Lagerstätte: A view of Cambrian life 'Down Under'**
John R. PATERSON (Division of Earth Sciences, School of Environmental and Rural Science, University of New England, Australia)

12h45-13h00 **Exceptionally preserved Cambrian Pterobranchia from Siberian Platform (Olenek River)**
Nikolay V. SENNIKOV (Institute Petroleum Geology and Geophysics, Russia)

Session 6B : [Geological Heritage 4]

Chair : Mohamed GHAMIZI

11h15-11h45 **Some aspects of the archaeological heritage of Eastern Morocco**
Hassan AOURAGHE (Université Mohamed premier, Faculté des Sciences, Morocco)

11h45-12h15 **Meteorites from Morocco: A geoheritage to preserve and to promote**
Hasnaa CHENNAOUI AOUDJEHANE (GAIA Laboratory, Faculty of Sciences Ain Chock, Hassan II University, Morocco)

12h15-12h45 **Fossils, patrimony and knowledge: the need to protect Moroccan geoheritage. The case of the "Kem Kem beds" fossils**
Nour-Eddine JALIL (Sorbonne Universités, Muséum national d'histoire naturelle, France AND Université Cadi Ayyad, Faculté des Sciences Semlalia, Morocco)

12h45-1300 **The Fezouata Shale: a Model for Promoting Moroccan Geological Heritage. Challenges and issues**
Khadija EL HARIRI (Faculté des Sciences et Techniques-Guéliz, Université Cadi Ayyad, Morocco)

13h00-14h30 **Posters and Lunch**

Session 7A (14h30-16h15) [Plenary 5 EL ALBANI and Precambrian]

Chair : Abderrahmane SOULAIMANI

14h30-15h30 **Fossils from Gabon show early steps toward multicellularity and the oldest biodiversity 2.1 billion years ago: A new chapter of Life history**
Abderrazak EL ALBANI (Université de Poitiers, France)

15h30-15h45 **The Precambrian-Cambrian boundary in the Western Anti-Atlas (Morocco): new insight from detrital zircon ages of the Ediacaran sedimentary rocks of the Bas Drâa inlier**
Brahim KARAOUI presented by Nasrrddine YOUBI (Geology Department, Moulay Ismail University, Morocco AND Geological Institute, TU Bergakademie Freiberg, Germany)

15h45-16h00 **Multidisciplinary studies of Neoproterozoic sedimentary basin in South-western Ukraine (Ediacaran period - 553 Ma)**
Y.SOLDATENKO (Department of geological prospection, National Mining University of Ukraine, Ukraine AND IC2MP, University of Poitiers, France)

16h00-16h15 **From Snowball Earth to Greenhouse conditions and the Cambrian Bioradiation: Did the multiple pulses of the Central Iapetus Magmatic Province trigger and drive these phenomena?**
Nasrrddine YOUBI (Department of Geology, Faculty of Sciences-Semlalia, Cadi Ayyad University, Morocco AND Instituto Dom Luiz (LA), Universidade de Lisboa, Portugal)

Session 7B : [Geological Heritage 5]

Chair : Noureddine JALIL

15h30-16h00 **Moroccan Rock Art sites, a mirror of landscape and pal-ethnology of the ancient Northern Africa**
Abelkhalek LEMJIDI (Institut national des sciences de l'archéologie et du patrimoine, Rabat AND Centre national du patrimoine rupestre, Agadir, Morocco)

16h00-16h15 **The Fezouata Biota Database**
Khaoula KOURAÏSS (Département des Sciences de la Terre, Faculté des Sciences et Techniques-Guéliz, Université Cadi Ayyad, Morocco)

16h15-16h45 **Posters and Coffee Break**

Session 8A : (16h45-18h30) [Geological Heritage 6]

16h45-17h15 **Synthesis Symposium Promoting Geological heritage.**
All Chairs Geological Heritage

17h15-18h30 **Meeting APPGM**
Chair : Abdeljalil EL HASSANI SBAI

Session 8B : [Fezouata]

Chair : Peter VAN ROY

16h45-17h00 **Size matters! Ontogeny of a new palaeoscolecid worm from the Fezouata Konservat-Lagerstätte (Lower Ordovician, Morocco) and its bearing on the systematics of the group**
Emmanuel L.O. Martin (UMR CNRS 5276 LGLTPE, Université Lyon 1, France)

17h00-17h15 **Lower Ordovician graptolite biostratigraphy of the Fezouata Formation, Moroccan Anti-Atlas**
Juan Carlos GUTIÉRREZ-MARCO (Instituto de Geociencias CSIC-UCM), Spain)

17h15-17h30 **Palaeoecological aspects of the diversification of echinoderms in the Lower Ordovician of central Anti-Atlas, Morocco**
Bertrand LEFEBVRE (UMR CNRS 5276 LGLTPE, Université Lyon 1, France)

17h30-17h45 **Palynomorphs of the Lower Ordovician Fezouata Formation of Morocco**
Hendrik NOWAK (CNRS-UMR 8198 Evo-Eco-Paleo, Université Lille1, France)

17h45-18h00 **Towards new findings of Lagerstätten in the Fezouata Shales (Morocco)? A sedimentological perspective**
Bernard PITTET (Université Lyon 1, Observatoire de Lyon, UMR CNRS 5276 LGL-TPE, France)

18h00-18h15 **Palaeoenvironmental conditions and the record of the Great Ordovician Biodiversification Event in the Anti-Atlas of Morocco**
Romain VAUCHER (UMR CNRS 5276 LGLTPE, Observatoire de Lyon - Université Claude Bernard Lyon 1, France)

18h15-18h30 **A halkieriid-like aculiferan mollusc from the Early Ordovician Fezouata biota, Anti Atlas Region, Morocco**
Jakob VINTHER (Schools of Earth Sciences and Biological Sciences, Life Sciences Building, UK)

18h30-19h30 **Closing Ceremony**

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POSTERS

1. **Small shelly faunas from the Lower Cambrian (Anti-Atlas, Morocco)**
   Mohammed BENSSAOU, Abdelhkim EZAIDI, M. Belkacem KABBACHI, Nezha ELKAMALI ***withdrawn***

2. **Microbialitic diversity in the Lower Cambrian of the Anti-Atlas, Morocco. Géo-environment and Geoheritage .**
   Mohammed BENSSAOU, H. LAMBARKI, Abdelhkim EZAIDI, M. Belkacem KABBACHI, Nezha ELKAMALI ***withdrawn***

3. **The Devonian palaeontological heritage from Tafilalt: a tool for sustainable development**
   Bouchra BOUGARIANE, Larbi BOUDAD, Siham EL BOUGHABI ***withdrawn***

4. **The Rock Art of the Yagour (Moroccan High Atlas) : State of the Art, Conservation and Valorisation**
   Abdelhadi EWAGUE, Mohssine EL GRAOUI, El Hassane BOUMAGGARD ***withdrawn***

5. **The fish-like skeletal fragments from the Upper Ordovician of Tarim Basin**
   Zhikun GAI, Shitao WANG, Xianpu GUO

6. **First benthic graptolite and a possible? hydroid from the Bou Nemrou assemblage (Tafilalt Biota), Upper Ordovician of Morocco.**
   Juan Carlos GUTIÉRREZ-MARCO and Khadija EL HARIRI

7. **Ramified structures in the Upper Ordovician of Ougarta (SW Algeria); animal or sedimentary structures?**
   Rachid HAMDIDOUCHE ***withdrawn***

8. **An unusual, high-diversity assemblage in the *A. murrayi* Zone (Late Tremadocian, Early Ordovician) of the Zagora area (Central Anti-Atlas, Morocco)**
   Khaoula KOURAISS, Emmanuel MARTIN, Bertrand LEFEBVRE, Muriel VIDAL, Juan Carlos GUTIERREZ-MARCO, Khadija EL HARIRI, Ahmid HAFID, Ali BACHNOU, Abdelfattah AZIZI

9. **The ontogeny in Ellipsocephalidae (Trilobita)**
   Lukáš LAIBL, Oldřich FATKA, Petr BUDIL, Per AHLBERG

10. **New insights on the Precambrian-Cambrian Boundary of Morocco.**
    Nezha LAZREQ, Nasrrddine YOUBI, Moulay Ahmed BOUMEHDI

11. **An acercostracan marrellomorph from the Early Ordovician Fezouata Biota, Anti-Atlas region, Morocco**
    David A. Legg ***withdrawn***

12. **Protection of geological sites in an urban area of Norway :results and future issues**
    Hans Arne NAKREM, Lars E. ERIKSTAD, Jon A. MARKUSSEN

13. **Cambrian gogiid eocrinoids from the Barrandian area (Czech Republic)**
    Martina NOHEJLOVÁ, Oldřich FATKA

14. **A new skeletal-dominated reef association of stromatoporoids and bryozoans from the Middle Ordovician of Korea**
    Jae-Ryong OH, Jusun WOO, Tae-Yoon S. PARK, Suk-Joo CHOH, Dong-Jin LEE

15. **A new aglaspidid euarthropod with a six-segmented trunk from the Lower Ordovician Fezouata Konservat-Lagerstätte, Morocco.**
    Javier ORTEGA-HERNANDEZ, Peter VAN ROY, Rudy LEROSEY-AUBRIL, David A. LEGG

16. **Unusual eocrinoid (?) stem and columnals from the Late Cambrian of Northern Iran**
    Sergey ROZHNOV

17. **New echinoderm fauna from the Upper Cambrian Davis Formation (Furongian) of Southeastern Missouri, Central USA**
    James SPRINKLE, Colin D. SUMRALL, Harrell L. STRIMPLE

18. **Early Tremadocian phosphatized fossils from the Öland Island (Sweden).**
    Hubert SZANIAWSKI

19. **Asterozoan pedicellariae and ossicles revealed from the Middle Ordovician of Baltica**
    Oive TINN, Leho Ainsaar

20. **A euarthropodof uncertain affinity from the Early Ordovician Fezouata Biota, Morocco.**
    Peter VAN ROY

21. **A specialised predatory anomalocaridid from the Early Ordovician Fezouata biota, Morocco**
    Peter Van Roy, Allison C. Daley, Derek E.G. Briggs

Thursday, 0ctober 8th to Saturday, October 10th 2015

Post-conference field-trip

Thursday, 08/10/2015 at 8h00 am :Departure from the Mansour Eddahbi Congress Center

Saturday, 10/10/2015 at 18h00 pm : Arrival at Marrakesh.

Plenary lectures

The remarkable Fezouata biota of Morocco compared to other exceptionally preserved Ordovician fossil assemblages

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Exceptional fossil preservations (Fossil-Lagerstätten) yield fundamental information on the history of life. The Cambrian is replete with soft-bodied fossil assemblages which provide important evidence of the early radiation of metazoans, when the major body plans were established. The Great Ordovician Biodiversification Event (GOBE), which involved diversification at lower taxonomic levels, is less well served in this regard. Fortunately, however, the conditions that favored Burgess Shale-type preservation persisted at least into the Tremadocian yielding a rich and, so far, uniquely informative fauna in the Fezouata formations. This suggests that global controls still favored soft-tissue preservation at this time. The setting and nature of the Fezouata biota will be explored and compared to other soft-bodied Ordovician biotas which represent different environments. Most important of these are the Winneshiek biota (Dariwillian of Iowa), Beecher's Trilobite Bed (Katian of New York State), William Lake and Airport Cove (Katian of Manitoba, Canada) and the Soom Shale (Hirnantian of South Africa). All of these exceptional preservations, however, yield much less diverse faunal assemblages from more restricted environmental settings than the Fezouata formations. This emphasizes the importance of the Fezouata Lagerstätte and its fully marine assemblage in revealing the transition from Cambrian to post-Cambrian faunas and documenting the evolution of life after the Cambrian explosion.

The Burgess Shale augmented: the Marble Canyon fossil deposit

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The Marble Canyon fossil sitein northern Kootenay National Park, British Columbia,yields one of the most important Burgess Shale fossil assemblages yet discovered in the Canadian Rockies.Discovered in the summer of 2012 by an international team led by the Royal Ontario Museum, more than 10 000 specimens representing around 75 soft-bodied taxa have now been collected from this deposit in just two field seasons. Thanks to its exceptional diversity, density of fossils, and quality of preservation,this site promises to offer critical new clues about the early evolution, ecology and diversification of animals during the Cambrian period.

Similar tothe Walcott Quarry 40 km to thenorthwest, this siliciclasticfossiliferous unit lies along thebasinal edge of a submarine cliff known as the Cathedral Escarpment, but is locatedstratigraphically higher up in the upper part of the "thick" Stephen Formation.Arthropods are dominant at Marble Canyon in terms of the number of species and specimens present. Abouta third ofthe species—mostly arthropods—are also new. So far, only twonew arthropodshave been described:the leanchoillid*Yawunik* and the isoxyid*Surusicaris*. Both forms provide fresh new insightsintothe evolution of Cambrianstem group arthropods.A number of previously rare arthropods are also present in the assemblage, including *Molaria* and *Mollisonia*. The latterexhibitsexceptionally preserved softparts,including limbs and eyes with preservedneuropils and possible brain tissues.The presence of other forms, such as *Misszhouia* and *Primicaris*, previously known only from the early Cambrian of China, suggests that the palaeogeographic ranges and longevity of Burgess Shale taxa may have been underestimated.Compared to the Walcott Quarry and Chengjiangassemblages, arguably the two richest Burgess Shale-type deposits known to this day, arthropods at Marble Canyon are at least as diverse,if not more diverse, based on rarefaction methods.The steepness of the rarefaction curves clearly suggests that further collecting should yield many additional species in the future. In addition to arthropods, the Marble Canyonassemblage includes several taxa, which, prior to this find, were very rare and considered unique to the Walcott Quarry, such as the polychaete*Burgessochaeta* and the putative hemichordate *Oesia*. *Metaspriggina*, an enigmatic chordateoriginally described from two fragments from the Walcott Quarry,is now known from more than 100 specimens, many of which are preserved in large clusters, suggesting potential schooling behaviour prior to burial.The presence of exquisitely well-preserved features, such as paired eyes, nostrils and a series of gill branches,anchors this animal firmly within an early vertebrateclade of primitive fishes, which includes*Haikouichthys* from the lower Cambrian Chengjiang biota in China.Brachiopods and sponges are almost absent, suggesting that the environment was not ideal for sessile suspension feeders to thrive, unlike in most other Burgess Shale assemblages known from

the Canadian Rockies.The Marble Canyon site also preserves a distinct shallow-tier, low-diversity trace fossil assemblage that includes arthropod trackways preserved in close vertical proximity to body fossils, suggesting periodic oxygenated conditions.

Additional fieldwork activities,including quarrying operations during the summer of 2014, recovered thousands of fossilswithin at least 5 meters of strata. The collected data will permit detailed quantitative community analyses including a study of how the community changed through time throughthe quarried interval. The discovery of new outcrops several kilometers away from the main site, in the same rock unit suggests that the depositional environment and conditions responsible for the burial and preservation of the fossils is quite extensive compared to the type area in Yoho National Park.Although the full potential of this site has yet to be determined by additional field research, paleontological and geological work on the Marble Canyon fauna offers great prospects for future discoveries.

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Unravelling the causes and consequences of the Great Ordovician Biodiversification Event

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The 'Great Ordovician Biodiversification Event' (GOBE) was the most rapid and sustained increase of marine biodiversity in the Phanerozoic. During a geologically short time interval of some 40 myr, diversity escalated at family, genus and species levels within the context of some fundamental climatic and environmental changes. Not only a sharp increase in taxonomic diversity is obvious, but also very significant changes within the palaeoecological context of the biotas (Droser and Sheehan 1997), as the 'Paleozoic Evolutionary Fauna' progressively replaced the 'Cambrian Evolutionary Fauna' with suspension-feeding organisms, dominated by the Brachiopoda (Harper, 2006, 2010). The GOBE has been linked to a variety of possible drivers, intrinsic and extrinsic, regional and global, many of which were interconnected, and segue into each other (Harper et al. 2015). These data provide tests of a whole variety of biological and environmental hypotheses, framed to explain the event (Miller, 2012). The abundant Ordovician Brachiopoda provides a key proxy for the benthos and its role in the event. During this expansion, the phylum participated in large increases in alpha, beta and gamma diversity (Harper 2010), with, for example, the simple, archetypal 'orthide' body plan modified by a number of key adaptations: the development of biplanar to concavoconvex shells, introducing a recumbent mode of life in the strophomenides, cyrtomatodont rather than deltidiodont dentition, and a variety of more elaborate lophophore support structures (Harper *et al.* 2004). Nevertheless despite these critical architectural and functional constraints, the main Ordovician orders continued to innovate, evolving a huge variety of shell morphologies, promoting taxonomic variety (some 300 genera at the peak of the event) and a spectrum of life styles, defining narrower niches in more packed communities and occupying much of the predictable morphospace. The phylum migrated into deeper-water and towards the end of the period occupied a variety of niches associated with carbonate buildups. Whilst external factors enabled and facilitated a favourable environment for biodiversification more intrinsic factors associated with community interactions, particularly relationships with nutrients and predators, were possibly key drivers of the GOBE.

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Geological heritage of Morocco between its promotion and preservation

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Morocco is a geologically rich country as well as by its minerals or fossils outcrops.
At first, we can mention mineralogy where Morocco is renowned both for quality and for the diversity of its mineral specimens. Similarly, and in another way, we think of stromatolites, trilobites, ammonites and dinosaurs.
Regarding outcrops, several geological sites of interest were counted and described throughout the country.
Finally, we will not forget that Morocco is known for its deserts and meteorites.
This wealth certainly has its advantages but also disadvantages. Indeed, the boundaries between recovery and dilapidation are not always obvious.
We will see the lines of thought to promote this heritage in a spirit of sustainable development.

Fossils from Gabon show early steps toward multicellularity and the oldest biodiversity 2.1 billion years ago :

A new chapter of Life history

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Animals appeared a little more than half a billion years ago, changing the Earth's biosphere forever. Predation, burrowing, and all other modes of life available to animals pushed evolution in numerous directions. This was the "Cambrian explosion".

Animals were not the first, nor the only, multicellular macro-organisms, however. Scattered fossil occurrences show that large individuals using cells as building blocks appeared a number of times during the latter part of the Proterozoic Eon (2.5 to 0.54 billion years ago). Some of these early lineages (such as red or green algae) still exist.

Reported in *Nature* Magazine in 2010 and in *Plos One* in June 2014 is the recent discovery of centimeter-sized fossils from black shales in Gabon represented bu more than 450 specimens. These macro-fossils reveal that large organisms growing in a coordinated manner (a prerequisite for multicellularity) go back to at least 2.1 billion years ago, almost to the beginning of the Proterozoic Eon. The fossils were investigated by an international team of scientists, led by Pr. A. El Albani of the University of Poitiers, France.

On the surface, the fossils resemble irregularly shaped cookies with split edges and a lumpy interior. Viewed in a high-resolution X-ray tomograph (a kind of CAT scan) they reveal different shape and size exhibiting elongate, circular and a sheet-like structure with a pervading radial fabric and a neat pattern of central folds.

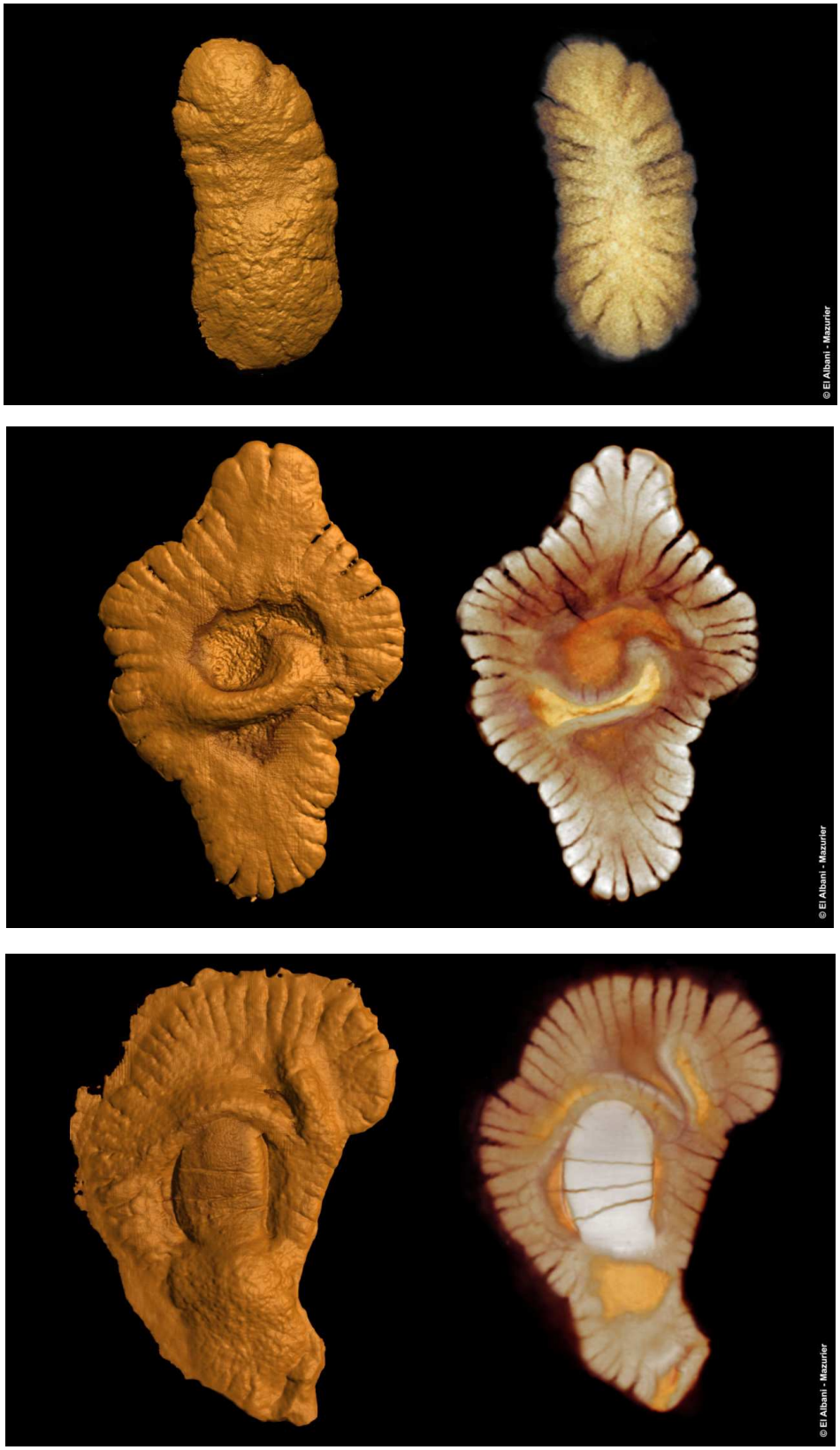
This structure is too complex to be a product of inorganic processes, and further analyses confirmed that the carbon in the fossilized tissue was assembled by biological processes, also that the iron-sulfide mineral pyrite replacing most of the tissue had been formed by bacteria "breathing" sulfate, rather than oxygen, when decomposing the organisms in the sediment. Finally, the organisms were shown to have lived in shallow marine waters with free oxygen.

Large size generally signifies an energy-demanding way of life. Breathing oxygen, as we do, is a much more efficient way of obtaining energy than other physiological processes. The Proterozoic Eon saw two major events of oxygen build-up in the atmosphere (and, thereby, in the oceans); the first near the beginning of the Eon, 2.45–2.2 billion years ago, and the second at the end, 0.8–0.54 billion years ago. The evolution of the Gabon fossils, representing an early step toward large-sized multicellularity, may have become possible by the first boost in oxygen*****, whereas the "Cambrian explosion" could have been fuelled by the second. Why it took around 1.5 billion years for the multicellular organisms to take over is currently one of the great unsolved mysteries in the history of the biosphere.

***** D. E. Canfield…..& A. El Albani "Oxygen dynamics in the aftermath of the Great Oxidation of the Earth's atmosphere" (PNAS 2013)

The site bearing the 2.1 Ga macrofossils outcropping near Franceville, in Gabon (© *El Albani*)

The fossil remains of the Gabonese colonial macro-organisms (© *El Albani*)



Virtual reconstruction (via microtomography) of the outer (left) and inner morphology (right) of three fossil specimens from the Gabonese site

Talks

From the inventory and assessment of sites to interpretation for tourists: current work in the M'Goun Global Geopark, central High Atlas, Morocco

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M'Goun Geopark, the first Global Geopark in Africa, is located in the Central High Atlas Mountains in Morocco, between Beni Mellal in the north and the crest of M'Goun Mountain in the south (Azilal), where its 5730 km^2 contain a wealth of outstanding natural and cultural sites. The sparse population is engaged in traditional agriculture, including transhumance.

The geopark, protected by law, joined the Global Geoparks Network, which is assisted by UNESCO (United Nations Educational, Scientific & Cultural Organisation), in 2014. Global Geoparks, by definition, use their geological heritage for sustainable development. The formal admittance of M'Goun took place at the 6th Global Geoparks Conference, held in Stonehammer Global Geopark, Canada, in September 2014 in the presence of representatives of most of the other 100-plus Global Geoparks.

The history of M'Goun Geopark is closely related to that of the High Atlas Mountains, documented by exceptional exposures of Mesozoic shallow marine and continental sediments, with several dinosaur trackway sites, plus some minor volcanics. But in addition to the geological and geomorphological heritage there is important ecological heritage and the human history ranges from protohistoric rock art to inhabited Amazigh villages, kasbah and granaries made of local stone and rammed earth. Elements of this rich and diverse heritage have an importance ranging from regional to international.

International recognition afforded by admittance to the Global Geoparks Network (GGN) creates an imperative to develop a dynamic and evolving site inventory, refine qualitative and quantitative site assessment, and improve management. An interpretive strategy is also needed so local people are more aware of their heritage and so value and work to conserve it, and also to attract tourists to promote sustainable development of the whole geopark. The interpretation for local people and tourists will include Azilal Museum and a range of geotrails. In addition to geotourism, education and research will be promoted as part of the management of the geopark.

The Bailiella Formation, a Moroccan counterpart of the mid-Cambrian conocoryphid biofacies

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The conocoryphidbiofacies was defined by Álvaro and Vizcaïno (2003) as a parauthochtonousassemblage of normal-eyed and blind benthic trilobites. This co-occurrence was interpreted as the result of specific environmental conditions related to turbidwaters on clayey substrates. The biofacies was recurrent on middle Cambrian formations of West Gondwana, such as the Coulouma, Val d'Homs and La Gardie formations in the Montagne Noire (southern France), the Murero, Borobia and Valtorres formations in the Iberian Chains (NE Spain), and the Genestosa Member in the Cantabrian Mountains (northern Spain). Its apparent lack in Morocco was related to the onset of diachronous regressions (progradational trends of sandy coastal plains and shoal complexes) across the middle Cambrian. However, the finding of shelly carbonate tempestites embedded in monotonous green shales of the Bailiella Formation has yielded a key opportunity to check the character of this biofacies in a Cambrian rifting branch of the Atlas Rift.

The interplay of rifting tectonics and transgression in the late mid Cambrian (~ Guzhangian times) allowed immigration of conocoryphid and paradoxidid trilobites into rifting axes of the then mid-latitude Atlas Rift. They coexisted with colonization by cinctan echinoderms, whose disarticulated ossicles infest their shell accumulations. Offshore conditions ended with the progradation of coastal and shoal deposits of the Azlag Formation, which represents the end of Cambrian sedimentation, except in a reduced area of the El Graara massif where the overlying JbelLmgaysmat Formation has yielded Furongian trilobites (Destombes and Feist, 1987; Álvaro et al., 2014).

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Some aspects of the archaeological heritage of Eastern Morocco

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The Eastern Morocco region is considered one of the richest regions of Morocco in archaeological record. In fact, thanks to the high number of archaeological surveys realized in this region and the important number of national and international projects of cooperation, more than five hundred archaeological sites were identified by Moroccan and foreign researchers during the last ten years. However, this heritage remains unknown and, far from being valued, it is also sometimes endangered.

The key archaeological sites, mainly prehistoric sites such as Tafoughalt, Zegzel, Rhafas, Ifri n'Ammar, Hassi Ouenzga, Guenfouda, Aïn Béni Mathar, the rock art of Figuig or the mortuary monuments (tumuli…) have been discovered. Some of these sites by their scientific contributions (such as the Cave of Pigeons in Tafoughalt) or speleological interest (like the cave of Chameau in Zegzel), the rock engravings of the Figuig province, were classified as National Heritage. They become a world reference for the understanding of the Prehistory of the Maghreb and of the whole Humanity.

The preservation and enhancement of the Cultural and Natural Heritage constitute firstly an important base for the knowledge and the understanding of the archaeological science and heritage and also a way of cultural and economic development for the region.

Disparity of the arthropod frontal-most appendage

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Based largely on the morphology of Burgess Shale arthropods as redescribed by Harry B. Whittington and the "Cambridge group," Stephen J. Gould once defended the view that only studies of disparity could capture the patterns underlying the very peculiar nature of the Cambrian Explosion. Since, high rates of molecular evolution have been found at the base of extant arthropod phyla, and high levels of homoplasy continue to challenge phylogenetic reconstructions, but disparity seems to have lost its appeal for arthropod workers, while at the same time gaining popularity in other animal groups and areas of macroevolutionary research. Considering the modular nature of the arthropod body plan, disparity has here been studied in the specific context of the frontal-most appendage, renowned for its wide range of morphologies in early arthropods, but also for being at the center of controversies on homology. It is shown that, among extinct and extant genera, dinocaridid and "bivalved" arthropods exhibit greater disparity of the frontal-most appendage, but also that evolutionary interpretations dramatically differ between systematic and phylogenetic viewpoints. "Bivalved" forms occupy a unique, central position in morphospace, with important macroevolutionary implications for both scenarios of topological transition of the frontal-most appendage. As is now well understood outside of the context of the Cambrian Explosion, this case study stresses that disparity patterns in the early evolution of arthropods provides necessary but insufficient information, requiring a phylogenetic framework to be thoroughly interpreted.

Sedimentary environments of the Upper Cambrian facies in the Central Anti-Atlas (Morocco): preliminary results

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Preliminary results on the sedimentological analysis of Furongian formations in the Anti-Atlas (Morocco) are presented here. In the Jebel Lamgaysmat (Foum Zguid area), four sedimentological sections show that the Jebel Lamgasymat Formation is composed principally by two sedimentary units, above the *Skolithos* ichnofacies of the Middle Cambrian sandstones (Azlag Formation).

The first unit contains silty-clay deposits (15 m) with sandy HCS and an intercalated, thin, condensed, lenticular limestone yielding Furongian fossils [1]. The upper part of this unit exhibits metric, thick, cross-bedded and bioturbated sandstones with frequent wave and current ripples indicating E-W palaeocurrents.

The second unit (17 m thick) corresponds to argillaceous-dominated facies, with sandy tidal sequences (7 m thick) showing both herringbone stratifications and reworked clay pebbles at the top.

The Tremadocian cycle (Fezouata Shale) begins with an erosional basal surface followed by microconglomeratic ferruginous sandstones containing wave ripples and herringbone stratifications. They are surmounted by the classical glauconitic claystones containing the graptolite *Rhabdinopora flabelliforme*.

The marine sedimentation of the Jbel Lamgaysmat Formation corresponds to two depositional parasequences, as in the Bourbiaa section [2], but it indicates a storm and tide-dominated inner shelf context. Both parasequences are part of a transgressive-regressive sequence, in which fossiliferous lenses may correspond to condensed intervals. This is contrasting with the high-stand deposits of the Ougarta [3] and distal facies of the Western High Atlas [4]. Our future study will focus on the Anti-Atlas areas between these two extreme localities.

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The inventory of geoheritage sites in Draa Valley (Morocco): Contribution to tourism valorization and regional development.

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This study describes the geoheritage sites in the Draa valley from Ouarzazate to Mhamid. This central-eastern area of Morocco is remarkable, because of its large variety of landscapes and very interesting geological, geomorphological and archaeological sites that help explaining the history of the earth, as well as regional climate changes to tourists and to the broad public.

The interpretation of geosites is a very important tool for the management of geological heritage as a part of a tourism development policy. The explanation of the geological, geomorphological and archaeological significance of these geosites helps visitors to understand and appreciate their significance to our heritage and the importance of their protection for future generations. The geological heritage of the Ouarzazate - Zagora region is poorly known by tourists who visit this area. It is therefore necessary to stimulate interest and attract the attention of curious visitors to this heritage.

The educational aspects of these sites are highlighted, in order to emphasize both their magnificence and their scientific interest. The information can be provided in various forms, as geological and archeological booklets, guidebooks or explanatory panels at the geosites. The approach presented here can serve as a model for a regional development of geotourism, for preservation of geological and archaeological heritage, and contributes to the project of establishing a geopark in the Central East provinces of Morocco.

The significance of sponges in the Great Ordovician Biodiversification Event (GOBE)

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Sponges were one of the major groups of suspension-feeding organisms during the Ordovician Period. Their fossil record, however, is intermittent due to their delicate skeletons. Diverse, well preserved faunas are restricted to sites of exceptional preservation, or consist of more robust, reef-building taxa (lithistids and stromatoporoids). In Cambrian Burgess Shale-type faunas, sponges were usually a major component of the communities, and were often second to arthropods in diversity and abundance. Ordovician Konservat-Lagerstätten are more varied in their preserved communities, palaeoenvironments and taphonomy, and sponges are less significant in many of these faunas.

A review of sponges in exceptionally preserved Ordovician assemblages shows that their role in these communities was more varied than in Cambrian faunas, but in some environments they were more important than expected. In the Afon Gam Biota[1] (Tremadocian, Wales) sponges dominated the community, and the same is true of several faunas from the Builth Inlier (Middle to Late Ordovician, Wales), from both offshore[2,3] and inshore environments[4]. Only a few sponge species are found in the deep-water, arthropod-dominated Llanfallteg Biota (Middle Ordovician, Wales), and the same is true of Beecher's Trilobite Bed. In the Fezouata Biota, sponges are locally dominant but show low-diversity mass occurrences that suggest temporary colonisation events in a disturbed environment. Other Ordovician Lagerstätten were formed in shallow-water or marginal environments, where sponges were either very rare or were not preserved.

The sponges occurring in Ordovician Konservat-Lagerstätten are a mixture of surviving Cambrian lineages and new morphologies. Most of the derived structures and architectures evolved in shallow-water environments, with Cambrian lineages mainly surviving in offshore habitats. Of these, protomonaxonids were mainly present above storm wave base, and reticulosans were dominant below it; both these groups show some modification from the Cambrian taxa, although most protomonaxonid genera are still recognisable.

Based on the Afon Gam and Fezouata biotas, sponge diversification appears to have begun in the earliest Ordovician, contemporaneous with the phytoplankton revolution that has been suggested as a trigger for biodiversification[5]. This was prior to the rapid increase in suspension-feeding groups such as bryozoans and brachiopods, and suggests that the nutritive potential of the developing microplankton community was first exploited by Porifera in most or all shelf-depth marine environments. Although sponges have not been as intensively studied as certain other fossil groups, they are becoming an important group for documenting and understanding the ecological transitions of the GOBE.

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Le géoparc M'Goun dans le Haut-Atlas central du Maroc

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Le Maroc est réputé par la présence de couches géologiques recouvrant la majorité du calendrier des temps géologiques allant du Précambrien jusqu'au Quaternaire. Les fossiles sont nombreux et bien conservés. Ils constituent un important patrimoine paléontologique avec des groupes fauniques très diversifiés (paléodiversité). Le grand inconvénient, c'est que ce patrimoine géologique se trouve actuellement victime de pillage, marchandage, vente et exportation illicites. L'absence d'une réglementation et la pauvreté des populations locales poussent à une exploitation alarmante et de plus en plus abusive. Le concept des géoparc, lancé dans les années 2000 par l'UNESCO, constitue un cadre important pour la protection du patrimoine géologique et sa valorisation pour un géotourisme et un développement durables.

Le géoparc M'Goun, récemment labellisé en Septembre 2014 par l'UNESCO et intégré dans le « global Geopark » est situé en plein milieu de la chaîne du Haut-Atlas central d'Azilal-Demnate. Le territoire du géoparc M'Goun renferme un patrimoine géologique, naturel, architectural et culturel de grande valeur. Leur protection et valorisation constituent un vecteur de développement géotouristique à retombées socioéconomiques fort appréciables pour les populations locales de montagne, généralement pauvres et enclavées.

Le Géoparc M'Goun se présente en une suite de reliefs à altitude souvent élevée, les principaux massifs sont Ighil M'Goun (4.068 m) et Azourki (3.690 m). L'histoire géologique du territoire du géoparc M'Goun s'intègre dans l'évolution géologique du Haut Atlas central qui remonte à l'époque du rifting triasique, mais les principales phases de remplissages bio-sédimentaires se sont déroulées durant la période jurassique, les alternances de dépôts carbonatés marins et de couches rouges continentales témoignent de fortes oscillations eustatiques. Au Crétacé, la sédimentation laguno-continentale généralisée est momentanément interrompue par deux brusques incursions marines, l'une à l'Aptien, l'autre au Cénomano-Turonien, avant le retrait de la mer de ces régions haut-atlasiques à la fin du Crétacé. La structuration en rides anticlinales et cuvettes synclinales est réalisée au cours du serrage et la compression du Néogène.

Le géoparc M'Goun constitue un territoire privilégié en raison :

- des structures géologiques inscrites dans une chaîne intra-continentale NE-SW résultant d'une inversion structurale d'un bassin essentiellement jurassique liée au rapprochement des deux plaques Afrique et Europe ;
- de la qualité des affleurements, des paysages et de la diversité des faciès sédimentaires ;
- des célèbres et spectaculaires traces de pas de dinosaures sauropodes et théropodes et des nombreux gisements d'ossements, en particulier, celui qui fourni le squelette presque complet du célèbre sauropode brachiosauridé dénommé *Atlasaurus imlakei* ;

- de la présence de cartes géologiques au 1/100.000 et d'un guide géologique « La route des dinosaures » qui couvrent la quasi totalité du géoparc du M'Goun et qui permettent de suivre et d'apprécier la géologie, le long des divers itinéraires et circuits régionaux.

Les actions réalisées sont nombreuses : implication des autorités administratives et représentatives (Conseil Régional de Tadla-Azilal, municipalités et communes), structures de gestion, monographie régionale, étude et restauration des gisements dinosauriens, construction de musée du géoparc M'goun, restauration de grenier… Des efforts sont encore nécessaires pour renforcer la structure de gestion, l'aménagement des géosites, le montage du musée d'Azilal, l'inventaire, le diagnostic et la cartographie des différents sites d'intérêts géologiques, biologiques, architectural et culturel.

The Cambrian Radiation in East Gondwana:

New data, new dates, new fossils

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The continents of Antarctica and Australia have a long and intimate geological history. They were joined together in a complex plate tectonic dance for more than 3 billion years, initially as juxtaposed cratonic elements forming the Mawson Continent. This later became an integral part of the assembly of the supercontinent Rodinia, around 1 billion years ago, and emerged unscathed through the opening of the proto Pacific Ocean as part of the *Terra Australis* Orogen around 800 Ma. During the critical period of expansive biotic radiation in the early Cambrian, Antarctica and southern Australia were sutured together near the equator forming East Gondwana. The sediments deposited during this interval are now incorporated as parts of the Transantarctic Mountains in Antarctica and the Stansbury, Officer and Arrowie Basins in South Australia and Todd River and Red Heart Dolostones in the Northern Territory provide ample evidence of a shared geological, palaeontological and palaeogeographic heritage.

Australia is perhaps unique in that all major modes of exceptional preservation are available for study: Burgess Shale-type soft bodied preservation in the Emu Bay Shale, South Australia; three-dimensional phosphatic preservation (known as Orsten-type preservation) in the Monastery Creek Formation, Queensland and superb complete or partially complete skeletal forms from a wide range of carbonate environments in South Australia and Antarctica.

This paper will utilize published and unpublished data from carbonate derived shelly fossil assemblages to review progress made over the last 15 years in documenting the remarkable early Cambrian marine life from East Gondwana. This review will outline the dramatic increase in knowledge about the diversity, abundance, ecology, phylogeny, and biostratigraphy of stem and crown group animals from this region. These include lophotrochozoans such a tommotiids, brachiopods, micro- and macromolluscs and halkieriids. We have also revealed important stem group ecdysozoans amongst the earliest Cambrian shelly fossil assemblages including unexpectedly abundant, diverse and exquisitely preserved bradoriid (bivalved) arthropods and rare, but well preserved palaeoscolecid worms and lobopods.

A new high resolution biostratigraphic scheme for lower Cambrian sequence packages in the Arrowie Basin and new IDTIMS geochronological dates from parts of the succession provide an enhanced temporal framework to bracket events associated with the main phase of the Cambrian radiation in East Gondwana. Preliminary results derived from acetic acid dissolution of carbonate samples collected from the Shackleton Limestone in the Holyoake Range, Antarctica has produced a moderately diverse assemblage of shelly fossils that can be correlated closely, and with some precision, to the new biostratigraphic scheme proposed for South Australia.

Contrasting ichnodiversity and ichnodisparity trajectories for bioturbation and bioerosion structures during the Cambrian and Ordovician radiations

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The different natures of the Cambrian and Ordovician radiations have long been recognized. Whereas the vast majority of body plans were established as a result of the Cambrian explosion, taxonomic increases during the Ordovician radiation were manifest at lower taxonomic levels. Assessing changes of ichnodiversity and ichnodisparity levels as a result of these two evolutionary events may shed light on the contrasting nature of both radiations. The early Cambrian (Series 1 and 2) displayed a dramatic increase in ichnodiversity and ichnodisparity of bioturbation structures. Whereas a maximum of ten ichnogenera have been recorded in the Ediacaran, seventy two ichnogenera are known from the early Cambrian. The rapid increase in behavioral patterns of bioturbation structures is also displayed at the scale of ichnodisparity, with a maximum of seven categories of architectural designs in the Ediacaran in contrast to thirty one in the early Cambrian. Contrasting with this evolutionary explosion in bioturbation structures, Cambrian bioerosion structures are only represented by two categories of architectural design with one ichnogenera each (*Trypanites* and *Sedilichnus*), the latter already present in the Ediacaran.

The uniqueness of the Cambrian explosion is evident when this evolutionary event is compared with the Great Ordovician Biodiversification Event. The latter shows an increase in ichnodiversity of bioturbation structures, but roughly Cambrian levels of ichnodisparity. Our analysis indicates a continuous increase in ichnogeneric diversity through the Ordovician in both shallow- and deep-marine environments. In the case of shallow-marine settings, the number of ichnogenera doubled from the Tremadocian to the Hirnantian. The ichnodiversity increase in deep-marine environments seems to be less pronounced. However, the picture for bioerosion structures is significantly different, with an increase not only in ichnodiversity, but also in ichnodisparity through the Ordovician. Nine macroboring ichnogenera are known from the Ordovician, involving six categories of architectural designs.

This study points to contrasting ichnodiversity and ichnodisparity trajectories of bioturbation and bioerosion structures during the Cambrian and Ordovician radiations, with innovations in macrobioerosion lagging behind animal-substrate interactions in unconsolidated sediment. The underlying causes of these contrasting trajectories are unclear. Whereas the trend towards infaunalization in unconsolidated substrates started well before a marked increase in predation pressures, penetration of infaunal organisms into cemented substrates during the Ordovician radiation were likely driven by increased predation.

Meteorites from Morocco: A geoheritage to preserve and to promote

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Meteorites are extra-terrestrial rocks. During the last decades, their study became a fundamental science playing a leading role on the knowledge of the formation and differentiation of the Earth and the planetary bodies of the solar system. Scientific research topics such as apparition of life on Earth, massive extinctions, origin of water on Earth, presence of water on Mars, nucleo-synthesis of chemical elements then minerals during the evolution of the solar system has been drastically improved by Meteoritics. The Meteoritical Society was founded in 1933. It is a scientific organisation dedicated to the promotion of research and education on planetary sciences, focusing on meteorites, extraterrestrial material and impact cratering. This society organises every year an annual meeting. The 77th Meteoritical Society meeting was organised in Casablanca, Morocco, on September 2014 for the first time in an Arabic and Muslim country. This organisation was granted to Morocco according to the huge number of meteorites coming from Morocco and Sahara and the dynamic of research on Meteoritics in this country.

Morocco is one of the most important countries in the word for meteorites collection with many ordinary chondrites and many rare and valuable meteorites, such as Martian meteorites (e.g., NWA7034, Rabt Sbayta), lunar meteorites, angrites, carbonaceous chondrites, etc.… The number of official meteorites coming from Morocco is more than 1.000, and more than 8.200 are known as originating from North West African countries, including Morocco. Most meteorites from Morocco and surrounding countries are not official; they are collected and sold without classification and submission to the Nomenclature Committee (NomCom) of the Meteoritical Society (MetSoc). These rocks are collected by nomads and/or hunters without a careful documentation and coordinates of the find sites. This situation causes a big confusion on the origin of these samples and a big problem on their nomenclature. We are trying for more than 15 years to educate hunters to document as well as possible their finds and try to give it a proper locality name instead of NWA (North West Africa) followed by a number, an acronym that does not reflect the country and place of origin. One consequence of this situation is a loss of Moroccan meteorites geoheritage, which do not have the privilege to bear a locality name and are totally sold out of Morocco without letting any specimen in the country of origin.

The strategy developed by our team is to try to document all falls and at least all valuable and rare specimen of meteorites collected in Morocco, then classifying and submitting them to the NomCom with a proper name, and not an NWA acronym. By doing the classification, the type specimen can be deposed in a Moroccan institution, increasing the type specimen repositories in Morocco and providing samples for Moroccan researchers to work on.

We succeeded in submitting all falls from 2004 (Benguerir, Tamdakht, Tissint, Tirhert, Tinajdad); some others are still under submission and/or classification. Many finds have also been submitted, such as Al Haggounia.

All meteorites collected in Morocco are sold and exported; no samples are preserved in Morocco. This is a big issue as this geoheritage is totally lost for future generations in our country. A smart regulation is an important part of the solution of this big problem. It should be accompanied by the creation of museums for the preservation and promotion of this heritage and the scientific development on planetary sciences in Morocco. National foundations and individuals able to finance the purchase of specimens should be encouraged by taxes reductions. Legislation concerning meteorites is very different from a country to another; it varies from the total prohibition of commerce and export, to a possible total export of all specimens.

It is very important and urgent to find a solution to this haemorrhage affecting Moroccan geoheritage and particularly meteorites, that are not renewed by the creation and the vote of law protecting and promoting them.

Upper Ordovician of the Tafilalt region (eastern Anti-Atlas, Morocco): brachiopod associations, bioevents and sequence-stratigraphy.

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The Upper Ordovician (Katian–Hirnantian) brachiopods of Tafilalt, eastern Anti-Atlas, are locally abundant, diverse and well preserved, providing a near-continuous record of faunal change on a high-latitude siliciclastic-dominated platform. A chronostratigraphic framework, based on brachiopod distribution and preservation in shell accumulation events and integrated with sequence stratigraphy, has been generated for the Katian interval (Fig. 1), which has allowed correlation with the chitinozoan-based chronostratigraphic and sequence-stratigraphic framework erected for the central Anti-Atlas.

Complete and fragmented brachiopod valves comprise up to 50% in volume of the skeletal coarse fraction from the sandy shoal complexes of the Lower Ktaoua and Upper Tiouririne formations. High-density brachiopod banks formed in sandy shorelines and shoreface complexes, where about 20 taxa have been recorded. Most of the shell accumulations are composed of parautochthonous taxa, so none of them experienced high transport rates from their living substrate. Taking into account the nature of the biofacies, in terms of skeletal constituents and relative abundance, and the stratigraphic arrangement of the studied logs, six brachiopod associations have been distinguished: the *Tafilaltia destombesi* association (lower and middle part of the Lower Ktaoua Formation), the *Drabovinella* sp. A association (upper part of the Lower Ktaoua Formation), the *Svobodaina feisti* association (uppermost Lower Ktaoua Formation), the *Heterorthis alternata* association (Upper Tiouririne Formation), the *Destombesium akkaensis* association (lower member of the Hirnantian Upper Formation of the Second Bani Group, the Alnif Member) and the *Eostropheodonta jebiletensis* association (lower member of the Hirnantian Upper Formation of the Second Bani Group, the Amouktir Member).

Because the composition and preservation potential of brachiopod communities is controlled by environmental factors, which are predominantly depth- and substrate-related, a strong correlation exists between brachiopod appearances and disappearances and the onset of sequence-stratigraphic cycles.

In Tafilalt, two Katian (transgressive–regressive) composite depositional sequences, c. 60 and 170 m thick and related to third-order fluctuations in sea level, were unaffected by Hirnantian glaciogenic erosion. They were deposited on a mixed platform with a bryonoderm association dominated by brachiopods, bryozoans and echinoderms. Brachiopods developed in high-energy inner shelf areas, whereas bryozoans (mainly trepostomates and fenestrates) and pelmatozoans (cystoids and crinoids) dominated in low-energy outer shelf areas. Brachiopod accumulations mark distinct event surfaces, such as lag and event concentrations, hydraulic simple and composite concentrations related to transgressive surfaces, and hiatal condensed concentrations marking maximum flooding surfaces. The taphonomic condensation displayed by the Hirnantian Alnif Member, which onlaps the erosive base of glaciogenic tunnel channels, is explained as reworking and resedimentation of allochthonous, robust, biogenic hard parts sourced from the underlying (Katian) Ktaoua Group.

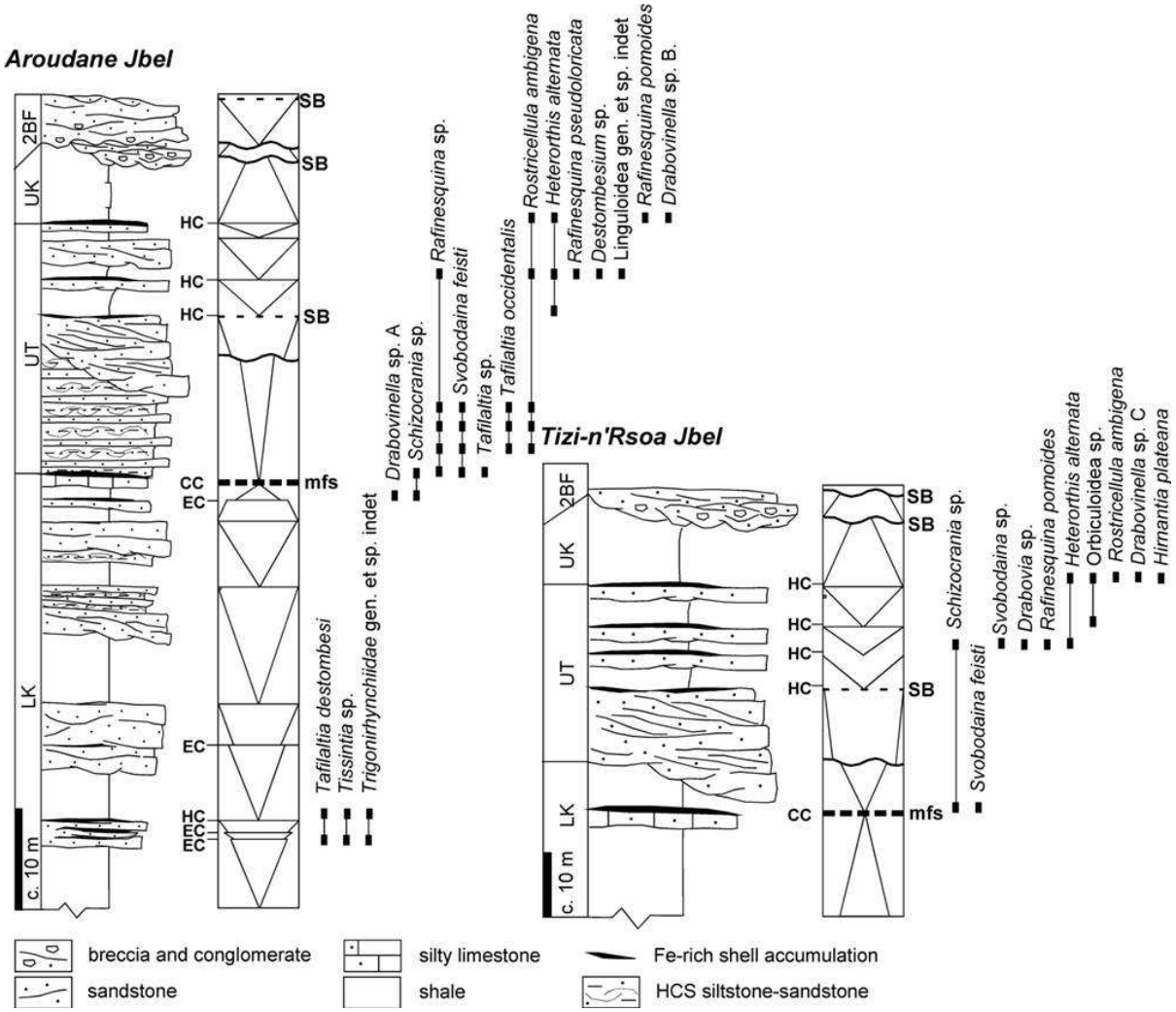

Figure 1. Stratigraphic ranges of brachiopod species in the Aroudane and Tizi-n'Rsoa jbels with sequence framework and surfaces.LK – Lower Ktaoua Formation; UT – Upper Tiouririne Formation; UK – Upper Ktaoua Formation; SB – sequence boundary;mfs – maximum flooding surface, EC – event concentration; HC – hydraulic concentration; CC – hiatal condensed concentration;2BF – Lower Second Bani Formation.

Anomalocaridid diversity, ecology and evolution

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The anomalocaridids are Cambro-Ordovician stem-lineage arthropods (Daley et al. 2009; Van Roy et al. 2015) remarkable for their large size, supposed predatory ecology, and complicated history of description. Their first body parts were discovered over 100 years ago but it was only in the mid-1980s that their morphology was more completely described (Whittington and Briggs 1985). Since then, the anomalocaridids have been the focus of much research based on fossils from Cambrian and early Ordovician Lagerstätten, culminating in a particularly intense flurry of publications in the last five years. Originally known from two taxa in the Burgess Shale, the diversity of anomalocaridids now includes at least 14 genera and 21 species from Cambrian sites in Canada (Whittington & Briggs 1985; Daley et al. 2009; Daley & Edgecombe 2013), China (Chen et al. 1994; Hou et al. 1995; Cong et al. 2014), Australia (Nedin 1995; Daley et al. 2013), the USA (Briggs et al. 2008; Lieberman 2003), Poland (Dzik & Lendzion, 1988), and Greenland (Vinther et al. 2014), as well as the Ordovician of Morocco (Van Roy & Briggs 2011; Van Roy et al. 2015) and probably the Devonian of Germany (Kühl et al 2009). Here, I present a review of anomalocaridid diversity, ecology, and evolution, summarizing and evaluating recent discoveries and placing them in a phylogenetic and biogeographic context. This work necessitated the re-examination of well-known anomalocaridid taxa (Daley & Edgecombe 2013; Daley et al. 2013) and description of new taxa (Daley et al. 2009; Van Roy et al. 2015). Phylogenetic analyses now recognise two clades within the anomalocaridids, one characterised by taxa with frontal appendages bearing long ventral spines (e.g. *Hurdia*) and the other by taxa with frontal appendages bearing short ventral spines (e.g. *Anomalocaris*) (Vinther et al. 2014; Daley & Edgecombe, in prep.). The ecology of taxa within each clade varies between highly specialized predation, more generalized predation, and filter feeding, with subgroupings within the two main clades reflecting neither ecological nor geographic similarity. Enough information now exists to apply quantitative ecological, evolutionary and palaeobiogeographic analyses to examine the evolution of anomalocaridids throughout the Cambrian Explosion.

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Cambrian and Ordovician trends in trilobite ecdysis

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Ecdysis is the process of shedding an exoskeleton during moulting. Periodic ecdysis is necessary for development, growth, and repair in organisms with a restrictive exoskeleton, but represents a time of extreme vulnerability to predation. This key life history strategy unites the most taxonomically diverse group of animals, Ecdysozoa (first identified using molecular data by Aguinaldo *et al*., 1997). As such, the evolution of ecdysial characteristics must have been central to shaping ecdysozoan diversity, morphology, development, and ecology.

Modern ecdysozoans ecdyse using a range of methods, but these are usually canonised within clades of extant taxa. However, this may not be the case for extinct taxa. The uniquely high level of within- and between-group variation in the ecdysial methods of Trilobita has been sporadically described in the literature (Whittington, 1990; Budil & Bruthánsova, 2005). Trilobites exhibit at least six distinct moulting behaviours, producing exoskeleton fragment configurations that are recognisable in the fossil record.

Here I present results from a study exploring broad trends in trilobite ecdysial patterns from the Cambrian and Ordovician, time periods from which all named trilobite Orders can be found. Substantial collections of trilobite moulted exoskeletons, housed in museums across the UK (London, Oxford, Birmingham, Cardiff) and Sweden (Uppsala), have been examined and combined with information from the descriptive literature to produce a data set consisting of information on moulting behaviour, measures of morphology and complexity, and growth data.

Due to its variability, no clear evolutionary patterns in trilobite ecdysis had yet been identified, or interpreted in light of their admittedly poorly constrained phylogeny. However, preliminary results from the data set suggest that at least two ecdysial behaviours show significant differences in the proportion of taxa exhibiting them, both between taxonomic Orders and through geological time. This indicates phylogenetic signal in the data set. Measurement data have also been used to statistically test a range of hypotheses about the causes and correlations of ecdysial variation. Trends in the evolution of ecdysis relate to morphology and development (Brandt, 2002). These results warrant further research into ecdysis in the fossil record, including the future expansion of these methods to investigate the life histories and affinities of other enigmatic Cambrian animals.

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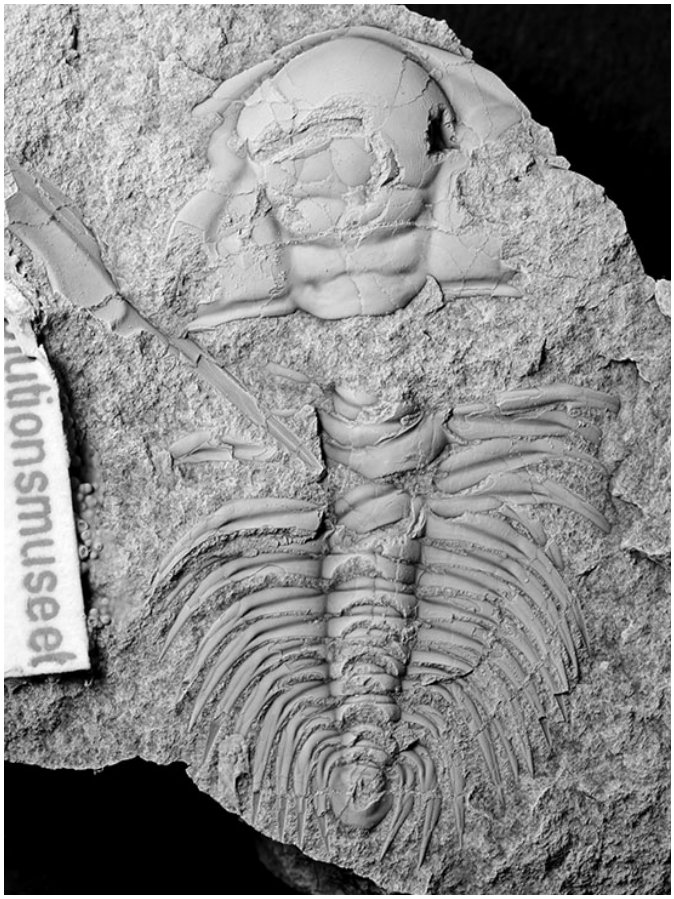

Figure 1: *Accadoparadoxides* moult from Östnär, Berg, Jämtland (Cambrian) in Sweden, exhibiting possible ecdysis through opening of the librigenal sutures (right free cheek missing, left free cheek flipped) and separation of the cranidium from the thorax. The middle thoracic segments have also been disrupted. PMU 25690 (Uppsala University Museum). Image 23mm across.

An insight into the Cambro-Ordovician perireefal communities

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Hard bottom marine environments with intense water flow host diverse communities of passive suspension feeders. In the present-day seas of relatively high primary productivity but low temporal stability such communities are dominated with colonies of erect hydroids and bryozoans. In environments with relatively low energy input but long-term temporal stability hydroids and bryozoans are replaced with gorgonian octocorals or antipatharians (black corals), with lower metabolic rate but much longer life span. Both the bryozoans (trepostomes and cryptostomes) and corals (tabulates and rugosans) contribute significantly to such reefal and perireefal ecosystems since the Mid Ordovician. In the Cambrian, pterobranch hemichordates and extinct organisms with obscure zoological affinities are the only confidently identified clonal organisms. Therefore the Early Ordovician seems to be of crucial importance in understanding how the composition of such communities approached their present day status.

Somewhat surprisingly, communities of passive suspension feeders dominated by black corals and hydroids have been recently recognized in the early Arenigian (early Floian) Fenxiang Formation at Tianjialing in the Hubei Province of China, in proximity of the most ancient bryozoans reefs developed on elevations.

Secondarily phosphatised remains of antipatharian coralla occur abundantly in the Fenxiang Formation, both on the shale and in acid-resistant residues from limy intercalations. They settled on various hard objects, including bryozoan colonies and *Sphenothallus* tubes. Probably four species are represented there. Their range of morphologies may be extended to include the alleged Late Cambrian 'bryozoan' *Pywackia* and the 'colonial ascidian' *Palaeobotryllus*. Such age of the oldest black corals is consistent with their basal phylogenetic position in respect to the scleractinians (if rugosans are also included in the clade).

Soft body structures mineralised with pyrite occur in the Fenxiang Formation as well. These are represented by the linguloid brachiopod peduncle and a colonial hydroid with elongated fusiform zooids, offering the oldest reliable record of its class. Possibly, it is a thecate hydroid. So early appearance of a highly advanced hydrozoan casts some doubts on reliability of molecular clock applied to the Cnidaria. Apparently, each of the cnidarian lineages requires separate calibration.

Another enigmatic clonal organism showing a puzzling combination of characters is preserved in the shale as pyritic internal moulds of its colony branches. They are built of organic units, which merge along a zigzag suture, the status generally believed to be unique to the pterobranch hemichordates. At least some branches taper near their tips and are closed, like the termination of thecae once reliably reported in some extant pterobranch but not confirmed by more recent zoological studies nor explained in functional and developmental terms. A similar organization of branches characterizes also feathery colonies of Webbyites from the Early Ordovician Klabava Formation of Bohemia.

The fossil assemblage includes also the oldest record of activity by marine nematodes. The marine bottom environment enabling such a mode of life well exemplifies consequences of the Cambrian 'Agronomic Revolution.' Results of research on the Fenxiang Formation show that the crucial stage in formation of modern hard bottom marine communities of clonal passive suspension feeders took place during the Furongian and Tremadocian.

The Fezouata Shale: a Model for Promoting Moroccan Geological Heritage.

Challenges and issues

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Morocco is world-famous for its remarkable palaeontological heritage illustrating all major steps in the evolution of biodiversity, and covering all geological eras, from the Precambrian to the Quaternary. Each year, thousands of exquisite Moroccan fossils are sold in all major international fossil shows and exhibitions (e.g., Tucson, Munich, Sainte-Marie-aux-Mines).

In the last 15 years, a new chapter providing unique insights into one of the most critical periods in the evolution of life was open in Morocco, at the turning point between the Cambrian Explosion and the Great Ordovician Biodiversification Event (GOBE). The discovery of several localities yielding exceptionally preserved late Tremadocian (Early Ordovician) faunas in the Zagora area (central Anti-Atlas, Morocco) has dramatically altered classical evolutionary scenarios on early metazoan diversifications (Van Roy *et al*., 2010). The Fezouata Shale is the only Ordovician Konservat-Lagerstätte in the world, showing both taphonomic conditions and abundant, diverse, fully marine assemblages readily comparable to those of the numerous famous early to mid-Cambrian Lagerstätten (e.g., Burgess Shale, Chengjiang, Emu Bay Shale, Sirius Passet). The Fezouata Biota shows an unexpected mixture of Cambrian-like taxa (e.g., anomalocaridids, marrellomorphs; Van Roy & Briggs, 2011, Van Roy *et al*., in press) along with typical elements of the GOBE (e.g., crinoids, eurypterids, xiphosurans). Intense field work in the last three years evidenced that exceptional preservation is restricted to a short time interval (*A. murrayi* to base of *H. copiosus* zones, late Tremadocian) and associated to a narrow range of environmental conditions, corresponding to a relatively shallow, storm-influenced setting (Martin *et al*., in press).

Since 2002, a fruitful and continuous collaboration on Ordovician Lagerstätten from the Anti-Atlas was initiated between the universities of Marrakech and Dijon (2002-2006), Marrakech and Lyon (2007-2011), and then Agadir, Marrakech, Brest, Lille and Lyon (2012-2015), through different projects and programs (including the last two ones: the ANR project RALI and the CNRS/CNRST cooperation project VALORIZ). Several campaigns of field work have been organised to collect samples, to prospect new sites (2003-2011), to log the series (2012-2013) and finally, to organise large scientific palaeontological excavations (2014; Kouraïss *et al*., 2014, Servais *et al*., 2014). This long collaboration offered the opportunity to many Moroccan and French scholars to study several palaeontological and geological aspects of the Ordovician of the Anti-Atlas during their Master and PhD projects. In the meanwhile, collaboration with several other international projects and partners (e.g., National Geographic, NSF) largely contributed to boost the scientific efforts and synergy and to promote the Fezouata biota.

Objectives for the next years are scientific, cultural (geoheritage) and economic:

1. clearly, the scientific description of the Fezouata biota is only beginning (most taxa still need to be described), and many aspects are to be explored both *in* and *ex situ* (e.g., taphonomy, geochemistry, micropaleontology); a drill core is planned in the coming months);
2. prospecting for new sites offers exciting possibilities to discover similarly preserved assemblages in older or younger strata;
3. enhancing and reinforcing collaboration with researchers and students from many countries in the field of Earth Science and Evolution;
4. preserving and promoting the geological heritage, by creating a local museum in Zagora, as a useful tool for community development and unique learning opportunities.
5. developing *ex situ* palaeontological collections in Moroccan public institutions. Moroccan fossils will be the subject of a temporary exhibition in the Natural History Museum of Marrakech. The objectives of the NHM of Marrakech institution are to provide reliable and regularly updated information on biodiversity to the general public and to help improving the knowledge on Moroccan biodiversity heritage through scientific inventories.

In connection with the last objective, there is an assertion of a national will to identify, protect and enhance the Moroccan geological heritage. An inventory of vulnerable geological sites underway in close collaboration between the Ministry of Energy, Mines, Water and Environment and Moroccan universities. So as to protect Moroccan geological heritage, a bill is being currently finalized by the Ministry of Energy, Mines, Water and Environment.

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Census of exceptionally preserved fossil in Cambrian of the Barrandian area (Czech Republic)

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The Barrandian area, has yielded exceptionally preserved Cambrian fossils in the Jince Formation (Příbram-Jince Basin) and in the Buchava Formation (Skryje-Týřovice Basin). Both lithostratigraphical units are from Cambrian Stage 5 to Drumian.

It is possible to separate at least four major types of exceptionally preserved fossils:

(1) Burgess Shale-type preservation involving conservation of soft-bodied animals as primary carbonaceous remains (some of them preserved anatomical detail), (2) Phosphatised digestive structures of trilobites, (3) different examples of frozen behaviour *sensu* Boucot (1990) and Boucot and Poinar (2010), (4) bite marks, cololites, coprolites and other remains documenting feeding.

(1) Burgess Shale-type preservation involves: *Tuzoia* and other bivalved arthropods, e.g. *Forfexicaris* and bradoriids *Linagshanella*, *Emeiella*, *Konicekion* (see Chlupáč and Kordule 2002, Fatka et al. 2014); anomalocaridid *Hurdia* (Daley et al. 2013, unpublished); *Hallucigenia* and *Onychodictyon* (unpublished); problematic *Wiwaxia*, *Selkirkia* and *Eldonia* (see Fatka et al. 2011, unpublished); biomeralized *Spenothallus* (Fatka et al. 2012, Fatka and Kraft 2013), graptoloids (Maletz et al. 2005).

(2) Phosphatised digestive has been established in *Ptychoparia* (Pompeckj 1901), *Ptychopariodes*, *Conocoryphe*, *Ctenocephalus* (unpublished)

(3) Frozen behaviour has been documented in the following assemblages: articulated agnostids entombed in hyolithid conch and in exoskeletons of trilobite carcasses (Fatka and Szabad 2011a, Fatka and Kozák 2014); articulated trilobites entombed in hyolithid conch, under disarticulated parts of trilobite exoskeletons and feeding on fungal-bacterial mats developed around large trilobite carcasses (unpublished); bradoriids feeding on edrioasteroid echinoderms (unpublished); trilobites and agnostids feeding on fungal-bacterial mats developed around echinoderms carcasses (unpublished); mortichnia - ichnofossils with their in situ preserved producer (Fatka and Szabad 2011a).

(4) Bite marks, cololites and coprolites and other remains documenting feeding include: coprolites of durophagous animal filled by broken parts of trilobite exoskeletons (unpublished); coprolites containing numerous ossicles of cinctan, edrioasteroid and eocrinoid echinoderms (unpublished); cololites containing small complete thecae of the ctenonystoid echinoderm *Etoctenocystis* (unpublished); schools of *in situ* preserved early ontogenetic stages of trilobites and agnostids (unpublished).

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The Emu Bay Shale biota: palaeobiogeographical relationships with other Cambrian Lagerstätten

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Cambrian *Konservat-Lagerstätten* are known from most continents and provide a window into the diversification of early animal life. The early Cambrian (Series 2) Emu Bay Shale biota from Kangaroo Island (South Australia) represents the most important and diverse Burgess Shale-type (BST) assemblage in the Southern Hemisphere, and is comprised of sponges, brachiopods, hyoliths, polychaetes, priapulids, lobopodians, anomalocaridids and other non-mineralised arthropods, trilobites and vetulicolians. A close biogeographic association between Emu Bay and South China is suggested by previous recognition of co-generic occurrences of the trilobites *Redlichia* and *Estaingia* with Chinese localities, and more recently arthropods such as *Kangacaris* (Paterson et al. 2010), *Squamacula* (Paterson et al. 2012) and *Tanglangia* (Paterson et al. 2015) known also from the Chengjiang biota.

In order to examine biogeographical links between BST localities we have compiled a dataset containing presence/absence information for over 600 genera at 21 *Konservat-Lagerstätten* from around the world, ranging in time from early Cambrian Series 2 through Series 3, and including sites from Laurentia, Siberia, South China and East Gondwana. Examples include the Burgess Shale (Canada), Chengjiang (China) and Sirius Passet (Greenland) assemblages. Data was collected both from original sources and from recent summaries of taxa present for certain localities, e.g. Caron and Jackson (2008). The dataset was analysed using various statistical techniques including Parsimony Analysis of Endemicity (PAE), in a manner similar to Alvaro (2013) and Waggoner (2003) to examine the palaeobiogeographical patterns of global Cambrian trilobite and Ediacaran genera respectively. Q and R-mode cluster analysis and ordination methods were applied to the matrix, as used by Haley and Paterson (2014) to examine Cambrian trilobite distributions of East Gondwana. We have also tested the application of Bayesian analysis to this dataset.

Preliminary results support links between sites within the major continental units (e.g. Laurentia and Gondwana); however, stratigraphic age and/or palaeoenvironmental factors probably also play an important role in determining the faunal composition of BST assemblages. One example is the tendency for the Kaili biota to group with Laurentian faunas of similar age (e.g. Burgess Shale) rather than with other South China localities.

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Ordovician geological heritage of Spain and Portugal

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The Iberian Peninsula is home to the most extensive outcrops of Ordovician rocks in Europe. Both in Spain and in Portugal, geological-palaeontological studies carried out the last decade involved several attempts and actions to disseminate the knowledge related with the rich and diverse Ordovician geological heritage. Among this, several occurrences received important media attention, specially those related with the discovery and rescue of important paleontological localities, the inauguration of geological viewpoints in Ordovician geosites with geomorphological or tectonic value, or the creation of geotouristic routes along Palaeozoic sections within natural protected areas, Global Geoparks, natural monuments and on-site museums.

We here present a summary report of the main Ordovician geosites of the Iberian Peninsula, spread over five Global Geoparks (Arouca, Naturtejo, Villuercas-Ibores-Jara, Molina-Alto Tajo, Sierra Norte of Seville), one National Park (Cabañeros) and seven protected natural areas (Sueve, Luna, O Courel, Montesinho, Douro Internacional, Despeñaperros-La Cimbarra, Sierra de Aracena), all of them included in the inventories of the Global Geosites project, as well as in the respective national geological heritage inventories. Some of the places and geological routes have significant value for nature tourism and are visited by tens of thousands of visitors per year. Ordovician geosites constitute an additional value to the territories, and their potential as a geotouristic and educational resource is being implemented, for example, through fixed information-signs, geotouristic trails, guided visits, tourist information-guides and/or leaflets.

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Reappraisal on the Ordovician trilobites from the Bou Nemrou assemblage (Tafilalt Biota, Morocco)

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The Late Ordovician Tafilalt Biota of Morocco is a recently discovered Konservat-Lagerstätte that provides diverse shelly fossils like echinoderms and trilobites, associated with a number of soft-bodied metazoans preserved in medium- to coarse-grained sandstones, in a style reminiscent of the Ediacaran fossils of the Flinders Ranges in Australia. These mainly correspond to large paropsonemid eldonioids and discoidal ?holdfasts, non-biomineralised cheloniellid arthropods, and rare palaeoscolecid worms, the latter preserved as compression fossils with phosphatised cuticular structures with a resolution down to micron-scale.

One of the most prominent fossil sites of the Tafilalt Konservat-Lagerstätten is the quarry at the Bou Nemrou site, made for commercial exploitation of fossils. This is located in the Jbel Tijarfaïouine area of the eastern Anti-Atlas, halfway between the town of Mecissi (Msissi) and the city of Erfoud, and east of the El Qaid Erami (El Caïd Rami) valley. The locality lies at the upper part of the First Bani sandstone group, and belongs to the latest Dobrotivian regional stage (= Sandbian 1 *stage slice* of the global scale). It has been labelled as KR-1, CRF-4 or ECR-F4 in published papers on echinoderms, which indicate a rich assemblage of articulated skeletons with about fourteen genera of eocrinoids, ophiuroids, stylophorans, edrioasteroids, crinoids and a single cyclocystoid.

The trilobite assemblage includes single representatives of odontopleuroid, lichoid, asaphoid, dalmanitoid, cheiruroid, cyclopygoid, trinucleoid and illaenoid genera. A total of five new species have been proposed by amateur palaeontologists and remain restricted to this locality: *Uralichas hispanicus tardus* Vela & Corbacho 2009 (a poorly characterized species, regarded by us not to be a true subspecies of *U. hispanicus*), *Selenopeltis longispinus* Vela & Corbacho 2009 (species name should be rectified to *longispina*); *Basilicus calzadai* Corbacho 2011 (which would be more properly placed in the genus *Birmanites*); *Degamella sendinoae* Corbacho 2011 (a junior synonym of *D. princeps* (Barrande 1872)) and *Zeliszkella (Z.) velai* Corbacho 2011 (better placed in *Mytocephala*). Besides these, indeterminate species of *Placoparia* sp., *Eoharpes* sp., *Ectillaenus* sp., and additional illaenoid and trinucleoid also occur. Diagnostic characters for the majority of the so far endemic species are poorly selected and their published descriptions are deficient and incomplete, using purely preservational characteristics, and occasionally based on crudely reconstructed specimens. Nevertheless, some trilobites from the Bou Nemrou assemblage also show exceptional preservation that includes, in three different genera, evidence of phosphatisation of the digestive structures.

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Lower Ordovician graptolite biostratigraphy of the Fezouata Formation, Moroccan Anti-Atlas

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The occurrence of Lower Ordovician graptolites in the Anti-Atlas was repeatedly cited during the elaboration of nine sheets for the Geological Map of Morocco to 1:200,000 scale in the 1950s/80s. This lead the French geologist Jacques Destombes to the discovery of about 90 localities or horizons with Tremadocian to middle Arenigian graptolites in the Feijas External Group, which proves the existence of an unconformably and regionally diachronic deposition of the Fezouata Formation upon the middle Cambrian sandstone of the Tabanite Group.

Early Tremadocian (Tr1) graptolites from the Fezouata Shale compose a low-diversity assemblage of quadriradiate pendent *Rhabdinopora* (*R. flabelliformis* and its ecological subspecies *R. f. anglica*, *R. f. norvegica* or *R. f. socialis*, adapted to shallow and mid-shelf environments), with a few specimens assigned to *Anisograptus*? (a triradiate genus) and without *Staurograptus*. Representatives of the early biradiate development (*Adelograptus* or *Aorograptus* Biozone) have been rarely recognized and are pending revision. The same occurs with the scattered records of the distinct pendent triradiate genus *Bryograptus* which still need to be substanciated. Probably coeval with Middle Tremadocian beds (Tr2), we present here the first occurrence of *Choristograptus louai* in the Anti-Atlas, an enigmatic anisograptid so far known from a single Algerian borehole in Central Sahara. In contrast with the few graptolite records from those older Tremadocian beds, Late Tremadocian (Tr3) green shales bear rather abundant graptolites of the *Araneograptus murrayi* plus *Hunnegraptus copiosus* biozones in the Zagora area. Besides the large conical rhabdosomes of *A. murrayi*, that locally occur in massive monospecific concentrations (maybe reflecting mass mortality caused by toxic events?), the zonal assemblage yielded other anisograptids (*Kiaerograptus, Paratemnograptus*), sigmagraptids (*Paradelograptus*), early dichograptines (*Clonograptus, Tetragraptus* s.l., *Didymograptus* s.l.), plus remains of five benthic dendroid genera.

Floian graptolite assemblages are scarcely recorded in the widespread "Upper" Fezouata Formation, being mostly representative of the ?*Cymatograptus protobalticus* to *Baltograptus minutus* graptolite biozones. The highest occurrences of recognizable graptolites are about 40 m below the top of formation. The record here of *Azygograptus suecicus* may be translated to an age not older than those equivalent to the earliest part of the *Isograptus victoriae* (s.l.) Biozone (Fl3) for this upper part of the Fezouata Formation.

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Burgess Shale-type preservation beyond the Cambrian: an example from the Middle Ordovician Llanfallteg Biota, South Wales

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Non-biomineralising animals comprise the majority of modern metazoan communities but a much smaller fraction of ancient fossil assemblages. This is because taphonomic processes rarely capture organic biomolecules which, after death, are rapidly destroyed by macro-scavengers or bacterial decomposition. Instances of exceptional preservation of organic remains do occur, particularly in the Cambrian Period. The term Burgess Shale-type (BST) preservation has been applied to deposits with carbonaceous compressions as their preservation mode: examples include the Chengjiang and Burgess Shale biotas. However, this taphonomic mode appears to be concentrated in rocks of the lower and middle Cambrian System, occurring only sparsely in and above the upper Cambrian, with one example (the Fezouata Biota) in the Lower Ordovician.

The newly discovered Llanfallteg Biota, South Wales, has been collected from a deep-water siliciclastic sequence deposited during the Middle Ordovician (Darriwilian Stage). It records a biota that lived during the Great Ordovician Biodiversification Event (GOBE) and comprises a mixed assemblage of exogenous and indigenous taxa. Amongst the mostly benthic indigenous fauna are rare non-biomineralised arthropods (including a putative xenopod arthropod and specimens resembling the marrellomorph *Furca*) and other organisms, such as a low-diversity sponge fauna and several vermiform taxa. The new xenopod arthropod (Figure 1) is postulated to belong to the clade containing the Burgess Shale taxa *Emeraldella* and *Sidneyia*. The non-biomineralised taxa are predominantly preserved as a combination of carbonaceous compressions with framboidal (~1 μm diameter) pyrite. Fossils preserved as pyritic and carbonaceous compressions are sparse throughout the deposit, implying a low-diversity, low-abundance community similar to modern deep-water environments.The discovery of the Llanfallteg Biota extends the range of BST preservation ~18 million years beyond the Cambrian. This occurrence demonstrates that, even at the height of the GOBE, both BST taxa and preservation occurred in the deep-water siliciclastic environments of offshore Avalonia, continuing the offshore retreat of BST deposits throughout the Cambrian [1]. Detailed studies of similar deep-water sites in Avalonia and elsewhere may reveal as yet undiscovered sites withexceptional fossil preservation.

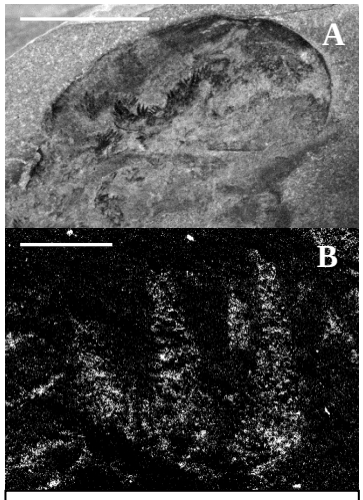

Figure 1. (A) Cephalic region of an exceptionally preserved arthropod of the Llanfallteg Biota, scale = 5 mm. (B) Carbon EDS map of the arthropod's oral

[1] Butterfield, N. J., 1995. Secular distribution of Burgess Shale-type preservation. Lethaia, v. 28, p. 1–13.

Fossils, patrimony and knowledge: the need to protect Moroccan geoheritage. The case of the "Kem Kem beds" fossils

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The early Late Cretaceous (Cenomanian) "Kem Kem beds" outcrop in the southeast of Morocco to the East of Taouz and extend southward over 250 km along the Algerian border. They comprise two formations: the continental and deltaic Ifezouane and Aoufous Formations, and are renowned worldwide for their exceptional abundance of fossils. Different types of fossiliferous sites are known: bone-bearing sites (known since 1930), track-bearing sites ('ichnosites') and sites that yield exceptional soft-tissue preservations, or *Lagerstätten*. They represent one of the richest and most diverse continental faunal and floral assemblages of this age, since they yield plants, insects, crustaceans, and more than 53 taxa belonging to the major vertebrate groups (elasmobranchs, actinopterygians, dipnoans, actinistians, amphibians (sirenids and anurans), snakes, turtles, stem crocodylomorphs, pterosaurs, non-avian dinosaurs and birds) (Garassino et al. 2006; Guinot et al. 2008; Cavin et al. 2010, Murray and Wilson, 2014). The "Kem Kem beds" fauna and flora not only document the North African terrestrial paleobiodiversity and ecosystems during early Upper Cretaceous (about 100 Million years ago), but also illustrate the influence of continental fragmentation on the evolution of dinosaurs (Sereno et al. 1996). Moreover, the *Lagerstätten* recently discovered within the "Kem Kem beds" give them a new scientific and patrimonial dimension.

Two of these sites with exceptional preservation were the subject of recent field work: a marine deposit in the lithographic limestone of GaraSbaa (GS, Cenomanian-Turonian) and an older one, named OT1 (Cenomanian), which is a fresh- to brackish water deposit with fine-grained clay in a detrital sequence. Currently, no other freshwater *Lagerstätten* of similar age is known elsewhere in the world. Their study will allow better understanding of the biodiversity, taphonomy, sedimentology and palaeoecology of this period, and these sites undoubtedly become a major milestone in the paleontological history of Morocco.

Except for the OT1 site, which remains unknown to local prospectors, and thus protected from looting, the KemKem area, including the lithographic limestone of GS, are the subject of intense and illegal excavations that have recently reached dramatic proportions, like in several other regions of Morocco. Even when they end up in foreign museums, the scientific exploitation of these fossils is hampered by the lack of data (geographical location, stratigraphic level, taphonomic data etc.). Once out of its natural context, a fossil loses much of its 'memory'.

Unfortunately, *in situ* sustainability of such deposits is currently difficult, because of the remoteness and isolation of this region. Pending the implementation of a rehabilitation policy and enhancement of natural resources, balancing between conservation, economic and social development needs, a short-term solution to limit this hemorrhage that gnaws the Moroccan geoheritage is the constitution of institutional reference collections.

In the medium term, the 2008 Law on the protection of nature that recognizes the concept of natural heritage should be applied to geoheritage (Law nr 07- 22 relating to protected areas

published on 24/10/2008, « Article Premier : *Au sens de la présente loi, on entend par aire protégée tout espace terrestre et/ou marin, géographiquement délimité et spécialement aménagé et géré aux fins d'assurer la protection, le maintien et l'amélioration de la diversité biologique, la conservation du patrimoine naturel et culturel, sa mise en valeur pour un développement durable, ainsi que la prévention de sa dégradation »*). On the basis of a scientific and well supported argumentation, this law could lead to the creation of geologically important nature reserve. This is a strong legal tool for the conservation of the natural (geological) heritage, firstly through the precise regulation expressed in the creating decree, and secondly by the means it can generate and the obligation to protect the geosites.

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Vertebrate fossils of the phosphates of Morocco, a memory of 24 million years, valorization and preservation by the OCP

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Oulad Abdoun, Gantour, Meskala and Oued Eddahab Basins contain major phosphate deposits known in Morocco.

These phosphatic sediments deposited on the margin of the African craton within one or more gulfs between Mediterranean and Atlantic "phosphogenic Provinces", range over a period of about 24 million years, from the end of the Cretaceous (Maastrichtian) up to the base of the Middle Eocene (Lutetian). These deposits of great economic importance (about 75% of world reserves) are also characterized by their remarkable richness in fossil vertebrates and they document a key period in vertebrate history, including two major biological crises: the Cretaceous/Tertiary (K/Pg) and Palaeocene/Eocene (P/E) boundaries.

The first detailed palaeontological studies of Moroccan phosphates date back to the 1930s with the pioneer works of the French palaeontologist Camille Arambourg.

The discovery of the remains of the first continental mammal in the Oulad Abdoun basin marked an important turning point in the palaeontological study of the Phosphates of Morocco (Gheerbrant *et al*., 1996). The importance of this discovery revived the interest of palaeontologists and lead to the signature of conventions between OCP, the Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement, the Muséum National d'Histoire Naturelle (MNHN) (France), the CNRS (France) and Moroccan Universities (Cadi Ayyad of Marrakesh and Chouaîb Doukkali of El Jadida).

All of these works allowed considerable progress in our knowledge of the fossil vertebrates occurring in phosphates, with the establishment of a faunal list containing at least 334 species, 192 genera and 86 families (Bardet et al., *in press*). This palaeofauna comprises not only marine taxa, but also a large number of terrestrial forms (non-avian dinosaurs, pterosaurs and mammals).

Except amphibians, all major groups of vertebrates are represented: cartilaginous "fishes" (elasmobranchs), actinopteygian fishes, reptiles (including birds) and mammals.

The palaeontological collection of OCP is the largest collection of vertebrate fossils of Morocco and is rapidly becoming one of the richest one in the world for the Maastrichtian-Ypresian time interval. Beyond its scientific importance (paleobiodiversity, paleoenvironment, biostratigraphy), it has an undeniable heritage value, which exceeds the national interest.

Recognizing the heritage value of these palaeontological collections and anxious for their preservation, OCP has always encouraged scientific research on the palaeontology of phosphates. As part of its citizen policy, OCP envisages measures of valorization by creating a palaeontological museum. In addition to the conservation and enhancement of natural and industrial heritage of the OCP, the museum will allow knowledge sharing, addressing to all Moroccan public, especially students, and also to foreign tourists.

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The Precambrian-Cambrian boundary in the Western Anti-Atlas (Morocco): new insight from detrital zircon ages of the Ediacaran sedimentary rocks of the Bas Drâa inlier

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The Ediacaran successions of the Bas Drâa inlier in the Western Anti-Atlas (here refer to BDS), consists of four units including (i) rhyolitic ignimbrite sheets; (ii) high-silica andesitic and rhyolitic lavas; (iii) silica-poor lava and pyroclastics; and (iv) rhyolitic lava dome complexes. The third unit contains basaltic and andesitic lava with at least three sandstone lenses intercalation. The BDS is capped by an angular unconformity, which is defined by sedimentary rocks of the Adoudou Formation (Fm.) of the Taroudant Group. U-Pb LA-ICP-MS analyses on zircon extracted from BDS sandstones were applied and suggest a substantial shift of the Precambrian-Cambrian boundary. The U-Pb data set (345 zircon grains with 90-110% concordance) from three sandstone samples show strong age peaks of 552 Ma and of 541 Ma placing the maximum deposition age for the BDS at the uppermost Ediacaran (Upper Ouarzazate Supergroup). The maximum depositional age of sandstone lens at 541 Ma is described for the first time from the Ouarzazate Supergroup in the Western Anti-Atlas. This age lined up with the Precambrian-Cambrian boundary according to the International Commission on Stratigraphy (ICS, 541.0 ± 1.0 Ma). Based on chemostratigraphic analysis, Alvaro et al., (2008) and Maloof et al., (2010) placed the Precambrian–Cambrian boundary into the lower part of the Adoudou Fm. of the Anti-Atlas. However, our maximum detrital ages from BDS suggest that the lowermost part of the Adoudou Fm. is Lower Cambrian in age. Consequently, in the Anti-Atlas, the Precambrian-Cambrian boundary is presumably located in a lower lithostratigraphic position, in the uppermost Ouarzazate Supergroup or in the hiatus between it and the overlying Adoudou Fm. (Karaoui et al., 2015), Precambrian Research, 263, 43–58). Thus, the time span for the strong $\delta^{13}C$ variation observed in the Adoudou Fm. was probably 20 Ma longer than assumed by Alvaro et al., (2008) and Maloof et al., (2010).

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The Fezouata Biota Database

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In southern Morocco (Central Anti-Atlas, Zagora area), the Fezouata Shale (Lower Ordovician) has yielded several levels with exceptionally preserved assemblages (the Fezouata Biota). The Fezouata Biota offers unexpected insights into the first animal biodiversifications in Early Palaeozoic times, as it represents, so far, the only Lagerstätte in the world documenting the transition between the Cambrian Explosion and the Great Ordovician Biodiversification, The Fezouata Biota is largely bridging the gap between the numerous, world-famous early to mid Cambrian Konservat-Lagerstätten (e.g., Burgess Shale, Chengjiang, Emu Bay, Sirius Passett) and the few ones described in Middle to Late Ordovician deposits (e.g., Beecher's trilobite bed, Llanfawr, Soom Shale).

Since its discovery, in the early 2000s, the Fezouata Biota has yielded thousands of spectacular specimens, some of them helping to elucidate long-standing palaeontological conundrums (e.g., the biological affinities of machaeridians). Since 2003, the Cadi-Ayyad University is strongly involved with French partners (e.g., the universities of Brest, Dijon, Lille and Lyon) in both the preservation and the scientific analysis of these exceptional fossil sites. Consequently, successive campaigns of prospection and excavation were organized in Zagora area, so as to collect samples *in situ*, on clearly identified sections. The latest excavation (four weeks in January and February 2014) focused on three horizons with exceptional preservation in the site of Bou Izargane.

At Bou Izargane, specimens were carefully oriented and their precise position noted both spatially (using a metric grid) and stratigraphically. All specimens are then registered, identified and added into the Fezouata Biota Database (FDB), which is build with the curation software FileMakerPro. In the FDB, each specimen is described by a number of items related not only to its systematics, stratigraphy and locality information, but also to its study (date and name of collection, loans, publications, ...). Once entirely registered and its study completed, the material will be deposited in the future Natural History Museum of Marrakech.

This work is part of the CNRS/CNRST cooperation project VALORIZ (grant number 52943) and the ANR (Agence Nationale de la Recherche) research project entitled “The Rise of Animal Life (Cambrian–Ordovician): organisation and tempo” (grant number RALI 197).

Trilobite assemblages of the Landeyran Formation (Floian), Montagne Noire, France: biostratigraphy and palaeoenvironmental implications

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In the Saint-Chinian area (southern Montagne Noire, France), the Tremadocian and Floian series have been studied for decades. Local biostratigraphy was originally established on trilobite FAD. The Floian succession is well exposed in both the Orb and Landeyran valley, north of Cessenon-sur-Orb. This area is the type-locality of the Landeyran Formation, a thick (200 to 400 m) lithostratigraphic unit consisting of brown to green shales. The Landeyran Formation is overlying the sandstone-dominated Le Foulon Formation. The shales of the Landeyran Formation are the youngest Ordovician deposits in this area. They are unconformably overlain by Devonian limestone. Two biozones have been defined within the Landeyran Formation: the lower one is defined on the FAD of *Apatokephalus incisus*; the upper one is based on the FAD of *Hangchungolithus primitivus*.

In this well-established biostratigraphic scheme, a detailed logging and faunal sampling were both made in the three classical sections of Le Foulon, Les Rocs Nègres, and Pont-Supérieur. This resulted in three logs (each about 10 m high), along which was plotted the faunal content collected within arbitrarily defined 30 cm-thick "layers" of shales. The resulting distribution pattern of trilobites per “layer” shows variations in the frequency of some species that might be used to define assemblages within the *Apatokephalus incisus* and *Hangchungolithus primitivus* Biozones. *Colpocoryphe* and *Asaphellus* are the most common genera in these two biozones. However, *Apatokephalus incisus* is virtually absent in about half of the Le Foulon section studied. The occurrence of *Toletanaspis* is restricted to specific “layers”, where it can reach 20% of the total trilobite diversity. In other “layers”, *Toletanaspis* is absent or very rare (less than 1% of trilobite diversity). *Neseuretus* is frequent at the top of the Le Foulon Formation, then disappears in the overlying *Apatokephalus incisus* Biozone, and reappears in the *Hangchungolithus primitivus* Biozone. *Parabathycheilus gallicus* mainly occurs within the *Apatokephalus incisus* Biozone, where its frequency is variable, but can reach up than 20% in some “layers”. A “*Parabathycheilus* layer” has been observed at the top of the Landeyran Formation. In this "layer", *Parabathycheilus* is associated with *Pradoella antetristani*, but *Hangchungolithus primitivus* is apparently absent. This layer is also characterized by the reappearance of both *Ampyx* and *Euloma*, two genera relatively common in the underlying *Apatokephalus incisus* Biozone, but previously unrecorded in the next Biozones. The observed variations in trilobite assemblages are suggestive of rapid environmental changes in the middle/late middle-late Floian of the southern Montagne Noire.

Paleontological heritage of Zagora region (southeastern Morocco): a tool for local sustainable development

Le patrimoine paléontologique de la région de Zagora (Sud-Est du Maroc) : un outil pour un développement durable local

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La province de Zagora est située au Sud-est du Maroc. Elle fait partie de la zone centrale de l'Anti-Atlas. Administrativement, elle appartient à la Région Souss Massa Drâa. Dans l'optique de la création d'un Géoparc national, la récolte des fossiles devrait être réglementée, contrôlée et mieux gérée. Elle pourrait aussi s'avérer très utile pour la création d'un musée régional exposant les exemplaires les plus spectaculaires. L'obligation de la conservation d'un tel patrimoine et la vulgarisation de son importance aussi bien scientifique que touristique seraient facilement assurées dans ce cadre. L'installation d'un musée en plein air permettrait de regrouper tous les géosites facilement accessibles, scientifiquement intéressants et pouvant être facilement intégrés à des activités touristiques à la fois éducatives et ludiques. Ce musée pourrait accueillir et valoriser les restes paléontologiques provenant de la zone ou des régions limitrophes. La constitution d'un « réseau » de points d'intérêt paléontologique et paléobiogéographique pourrait susciter des itinéraires géotouristiques-culturels, avec la finalité d'instaurer un tourisme éducatif de qualité, et surtout, de favoriser la reconversion professionnelle d'une partie des personnes actuellement impliquées dans le commerce des fossiles.

La valorisation sur le terrain de ce patrimoine paléontologique par la création d'un Géoparc passe par un certain nombre d'actions qui peuvent prendre différentes formes:

1. Des aménagements didactiques (circuit avec panneaux ou brochures…);
2. Des équipements muséographiques ou sites d'interprétation;
3. Développement de la communication envers les différentes composantes: scientifiques, culturelles, éducatives, institutionnelles et tissu associatif;
4. Des activités d'encadrement (formation, visites guidées, conférences, ateliers d'animation, reconstitution, tables rondes…);
5. L'organisation au niveau national et inter-régional de réseaux d'hébergements agréés et qualifiés parfaitement implantés sur les circuits thématiques pour que les populations soient parfaitement intégrées dans cette forme de développement socio-économique d'une manière équilibrée ;
6. Des publications, catalogues d'expositions, brochures, carnets, monographies, etc.

Ces quelques exemples soulignent la nécessité d'une gestion attentive d'un patrimoine paléontologique caractérisé par une telle perfection de conservation et d'un tel degré d'endémisme, dont l'exploitation commerciale du gisement pourrait irrémédiablement disperser des restes d'une valeur scientifique inestimable. La création d'un Géoparc permettrait un développement touristique durable, impliquant la population locale, dans un cadre décentralisé et pouvant favoriser une entente et une synergie entre différents partenaires de l'industrie touristique. Le succès ne sera assuré que par la garantie de mise en place de cette forme de développement d'une socio-économie réelle se basant sur des actions génératrices de revenus pour la population locale.

Palaeoecological aspects of the diversification of echinoderms in the Lower Ordovician of central Anti-Atlas, Morocco

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Echinoderms are one of the major components of benthic faunas in the Lower Ordovician sequence near Zagora, central Anti-Atlas, Morocco. The Fezouata Shale (Tremadocian-late Floian) has yielded numerous, exquisitely preserved echinoderm assemblages, ranging through several stratigraphic levels and palaeoenvironmental conditions. These associations offer a unique opportunity to document both evolutionary and palaeoecological aspects of echinoderm diversification in high-latitude, siliciclastic-dominated western Gondwana sediments, where rapid *in situ* burials facilitated excellent faunal census conditions. Lower shoreface deposits of the Fezouata Shale provide the most complete record of successive echinoderm faunas. These relatively shallow shelf deposits document the progressive replacement of low-diversity, Cambrian-like communities dominated by eocrinoids with higher diversity assemblages, comprising typical representatives of the Great Ordovician Biodiversification Event (e.g., asterozoans, crinoids, glyptocystitids, mitrates). However, the turnover of the Ordovician radiation was apparently less developed in both more proximal and more distal settings. Eocrinoid meadows persisted in shallower environmental conditions at least up to the end of the Tremadocian, while more distal settings yielded relatively low-diversity communities dominated by cornutes, eocrinoids and somasteroids (Fig. 1). From a palaeobiogeographic point of view, Early Ordovician echinoderm assemblages from the central Anti-Atlas display relatively strong affinities with slightly older (Furongian) to coeval faunas adapted to soft substrates from peri-Gondwanan Europe (Montagne Noire), West Gondwana (Argentina, Bolivia), South China (Guangxi), Korea and Laurentia (Nevada, Utah).

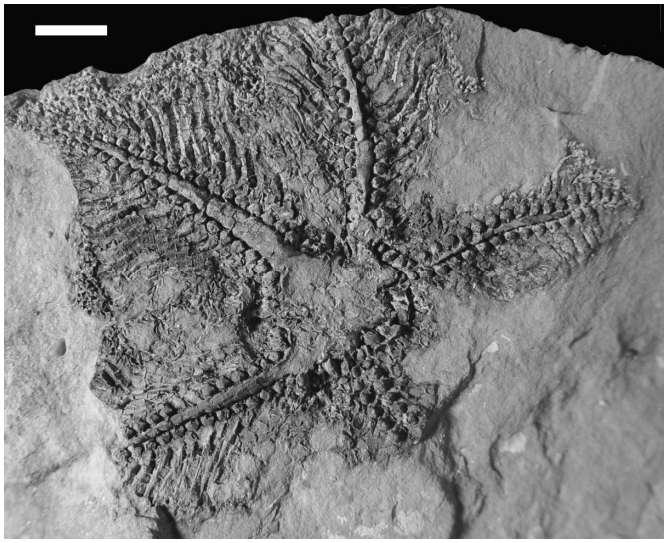

Fig. 1: Somasteroid asterozoan, Zagora area (Morocco), Fezouata Shales, late Tremadocian (*A. murrayi* biozone), FSL 424961. Scale bar: 1 cm.

Moroccan Rock Art sites, a mirror of landscape and pal-ethnology of the ancient Northern Africa

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Moroccan Rock Art is, no matter what it is palaoethnological, an alive material evidence. The geographical distribution of the engravings and paintings sites is one of the ecological reflections of the situations, in which rupestrian arts of North Africa were developed. The landscapes related to the Rock Art sites can be analyzed to reveal mechanisms leading to the metamorphoses of the material pre- and proto-historic cultures and impact to them on the Anthropisation of the pre-Sahara, Saharan and high Atlas territories.

Through the topographic analysis of the Moroccan Rock Art sites distribution, compared with the sites of the Great Sahara and those of the Western Mediterranean, we can release some specificities related to a topographic reality of crossings of corridors and ancient rivers facilitating the communications and circulations of ideas and knowledge between pre- and proto-historic communities from/to the Great Sahara and the Western Mediterranean area.

Up to what point do these landscapes, documented by the contents of the Rock Art sites, make it possible to determine the historical limits of circuits of the communities and social groups and their interactions with the environments through their modes of production, their systems of divisions of resources and their symbolic systems of the relations within a community and enter vaster historico-cultural zones?

The Rock Art sites of Morocco in particular and those of North Africa in general are, by their ecology and their geographical distribution, known for a high antiquity and especially by their long continuity in time. In some regions, however, the Rock Art expression lasted over very long periods, from probably the Upper Palaeolithic and the early Neolithic era to the Historical time. The object of this communication is to make a palaeoethnologic draft based on rupestrian arts in their temporal depth to underline a possible relation between the practices and behaviors of traditional productions, which continue today.

Unlocking central nervous systems of Cambrian Chengjiang panarthropods and their preservation pathways

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Comparative studies of nervous systems and sensory organs are fundamental for understanding the evolutionary relationships between major animal groups and their ecological adaptation throughout evolutionary history. Exceptionally preserved Cambrian panarthropod fossils provide a rich and underexploited source of data pertaining to neural and sensory organization during the early stages of their radiation.

Recent reports of the brain and other neural structures of Cambrian panarthropods demonstrate that these ancient animals had acquired complex central nervous systems (CNS) and sensory organs by 517 million years ago and that the two main configurations of the brain and eyes observed in extant arthropods (Mandibulata and Chelicerata) had already evolved. The neural structures identified in a Cambrian stem-euarthropod anomalocaridid provide direct evidence for the segmental affinity of its frontal appendages, shedding light on the origin of the euarthropod CNS. However, scarcity of fossilized neural tissue has meant that most studies to date have been based on single specimens, hindering tests of the fidelity of those structures and understanding the diagenetic processes that led to their exceptional preservation. Newly discovered specimens of the Chengjiang arthropod *Fuxianhuia protensa* with fossilized brains support the original interpretation of a tripartite brain for this animal, and revise the circuitry of its optic nerves to be innervated directly from the anterior part of the protocerebrum. Geochemical analyses on all available fossilized brains from the Chengjiang biota reveal the complexity of taphonomic pathways of these labile tissues, ranging from uniform carbon compressions to complete pyritization. We propose that neural tissues were stabilized and replicated as carbon compressions, then completely/partially pyritized through localized microbial activities. Preliminary decay experiments also support the preservation potential of neural structures and their morphological interpretation after compression.

The eocrinoid *Ascocystites* Barrande (Echinodermata, Blastozoa) in the Upper Ordovician of Kerzaz (Ougarta, western Algeria)

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In the Anti-Atlas (Morocco), the Upper Ordovician series have yielded abundant and diverse echinoderm faunas exhibiting strong affinities with coeval peri-Gondwanan assemblages from other areas of the Mediterranean Province (e.g., Bohemia, France, Spain). Two Late Ordovician eocrinoid genera have been reported in Morocco: *Ascocystites* and *Cardiocystites*. *Ascocystites* was originally described in Bohemia, and it also occurs in France and Portugal. In the eastern Anti-Atlas, the Izzeguirène Formation (early Sandbian) has yielded hundreds of exquisitely preserved specimens of *Ascocystites* (obrution deposits). *Cardiocystites* is known from Bohemia and Wales. In Morocco, it was described based on a few, exquisitely specimens collected in the Lower Ktaoua Formation (late Sandbian).

In Algeria, Ordovician echinoderms have not been studied in detail since the pionneer works of H. and G. Termier in the 1950s, based on blastozoans collected by A. Barbier and A. Lambert in the area of Stita (Great Kabylia, northern Algeria). Recent field work in the Ougarta Range (Foum Ezzeïdya, Kerzaz area, western Algeria) yielded several fully articulated individuals of the eocrinoid *Ascocystites*, associated with possible remains of cyclocystoids. All specimens are preserved as delicate imprints in Upper Ordovician sandstones. This new echinoderm assemblage from Algeria suggests relatively strong links with the eastern Anti-Atlas of Morocco.

Ichnology of Burgess Shale-type deposits: The interplay of ecologic, taphonomic and evolutionary constrains

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Although Burgess Shale-type (BS-type) faunas were originally regarded as transported from shallower water to an anoxic deeper-water setting, subsequent work have documented the presence of trace fossils in several classic BS-type deposits, providing uncontroversial evidence of an *in situ* benthic community. Biogenic structures in this type of deposits may be grouped in four major categories, based primarily on distinct preservational styles and secondarily on morphology: (1) structures directly associated to non-mineralized carapaces; (2) trace fossils with extensive distribution on bedding surfaces; (3) burrows containing their own producers; and (4) three-dimensional structures, typically pyritized burrows.

Spectacular examples of the former group are known from the lower Cambrian Sirius Passet of Greenland, where simple trails, annulated tubes, irregular polygonal networks, and thin, crenulated branching burrows occur in direct association with large, weakly mineralized *Arthroaspis* carapaces (and also present in association with other arthropod carapaces). In particular, the interconnected burrow systems have been regarded as evidence for re-use of structures, and a feeding strategy of bacterial grazing and farming has been proposed. Although it is clear that the trace fossil-carapace association is in some cases coincidental (i.e. results from taphonomic overprint), it has been postulated that at some stratigraphic levels with relatively low sedimentation rate this association reveal ecologic interactions. Carcasses and mold may have acted as attractors, favoring the establishment of a community of small invertebrates. These carapace-related communities signal an increased heterogeneity of the sea floor during the Cambrian. The second category, stratigraphic horizons covered with trace fossils, is superbly recorded at Stanley Glacier. Bedding planes with abundant and varied trace fossils seem to record improvement in oxygen content, recording colonization of the shallow infaunal ecospace. Preservation of delicate morphologic details was enhanced by early diagenetic processes (i.e. early carbonate cement) or biomat stabilization, generating firmground conditions at or very close to the sediment-water interface.

The unusual association of burrows containing their own producers deserves further investigation. Famous examples in Walcott Quarry include *Ottoia* within its J-shaped burrows. Although organic tubes locally containing their producers are not biogenic sedimentary structures, they could be considered as an extension of this category in the sense that they also provide direct paleobiologic information.

Finally, 3D burrows recording early pyritization within the sulfate reduction zone were documented at Stanley Glacier. However, these conspicuous structures are not hosted within the mudstone facies containing soft-bodied fossils, but typically within the limestone facies that capped Stanley Glacier shallowing-upward cycles.

Overall, BS-type ichnofaunas reveal a complex interplay of ecologic, taphonomic and evolutionary controls. Some general characteristics, such as dominance of minute size structures, shallow penetration depth and low diversity, support a redox discontinuity surface relatively close to or at the sediment-water interface.

In addition to oxygen as a controlling factor, early diagenetic processes and biomat development leading to substrate stabilization played a substantial role in the morphology and preservability of biogenic structures in the absence of lithologic contrast. Last, but not least, the absence of deep-tier colonization in early to middle Cambrian dysoxic settings and of a well-developed mixed layer opened a taphonomic window for the exceptional preservation of small, delicate surficial and shallow-tier trace fossils in BS-type deposits. These conditions coexisted with intensely bioturbated deposits in more oxygenated, typically shallower-water deposits, pointing to the unusual environmental and taphonomic conditions of BS-type settings. Interestingly, the recent discovery of the Marble Canyon locality in the Canadian Rockies provides evidence of medium-sized burrows, forming dense ichnofabrics that noticeably disturb the primary laminated fabric, signaling a departure from the more classical BS-type ichnofaunas.

Size matters! Ontogeny of a new palaeoscolecid worm from the Fezouata Konservat-Lagerstätte (Lower Ordovician, Morocco) and its bearing on the systematics of the group

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Palaeoscolecids are a group of Lower Palaeozoic worms closely allied to priapulids and characterized by an annulated body, covered by phosphatic(?) plates, and an eversible teeth-bearing proboscis. They occur in most Konservat-Lagerstätten of that Era, sometimes in great abundance, yet rarely diverse. This is typically the case in the Fezouata Shale, where some 68 specimens were recently recovered from the lower interval yielding exceptionally preserved fossils. These specimens all belong to a new species characterized by elongate plates, with a concave external surface surrounded by a scalloped margin (10-12 lobules) and a concave visceral surface bearing numerous pits; two rows of 32-40 plates occur on each annulus. The unusual morphology allowed neighbouring plates within a row to get imbricated during body constriction. This taxon is closely related to a contemporaneous species from Czech Republic, as was another species recently described from the Upper Ordovician of Morocco, which confirms the faunal similarities between North Gondwana and Perunica at that time. The abundant material permits the first detailed description of the ontogeny of a palaeoscolecid, including the demonstration of their discontinuous growth. Ontogenetic changes affect the size and shape of plates, their number per row, and the number of such rows per annulus. The major morphological evolution observed during the ontogeny of this taxon suggests that 39% of palaeoscolecid species might actually be invalid, having been defined on secondarily phosphatised (Orsten-type), tiny (<1.5 mm in width) fragments. The ecology of the new species will also be discussed in the light of its morphology and associated ichnofossils.

The geological wealth of the Western High Atlas (Morocco)

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The Mesozoic basin in south-western Morocco is the western end of the High Atlas, which is between the Argana corridor to the east and the Atlantic Ocean to the west. It is bounded on the north by Oued Tensift and on the south by the plain of Souss. This area offers a diverse geological wealth along with a continuous Paleo-Cenozoic sedimentary cover from the Permian to the Tertiary.

During the Jurassic and more specifically between the Middle Callovian and Lower Kimmeridgian, the Agadir Basin has seen the installation of reef and peri-reef facies characterized by a dominance of fossils such as stony corals (colonial and solitary) of sponges bryozoans, regular echinoids and large bivalves.

This is the Lower Cretaceous that offers the richest deposits of fossils. In fact, during this period the western High Atlas was covered by a shallow sea that has fostered the growth of macrofauna consisting essentially of: ammonites, echinoids, brachiopods, bivalves and gastropods.

The fossil deposits, reported for the first time in 1905 by P. Lemoine, allowed a very specific stratigraphic division and contributed to the reconstruction of the local and global paleogeography.

The ammonites

The frank marine regime which settled down at the top western Atlas during the Lower Cretaceous, allowed the deposit of a marly and marno-calcareous series rich in macrofauna (ammonites, brachiopods and echinoids). It is particularly the lower Valanginian (Campylotoxus Zone) that delivered a rich fauna of ammonites, including the Fuhriella and Karakaschiceras (Ettachfini, 1991 and Wippich, 2003).

The Upper Valanginian is marked by the association of the species *Neocomites peregrins, Olcostephanus nicklesi* and *Criosarasinella furcillata*.

The base of Hauterivian (Radiatus Zone) delivered many *Acanthodiscus, Teschenites flucticulus, T. pachydicranus, Oosterelles* of large size, *Breistroferella* and several *Leopoldia*.

During Barremian, and in some layers of the Essaouira basin, the ammonites can be massively preserved and found in strong condensation in not very thick benches. Recent studies (Company et al., 2008) showed a great diversity by quoting about sixty species of the Barremian. It is the unrolled forms (*Moutoniceras, Crioceras* (*Ancyloceras*), Barrancyloceras…) that are highly coveted by the amateurs and the fossils merchants.

Aptian is also characterized by levels of condensation of ammonites (*Cheloniceras, Epicheloniceras, Dufrenoya, Nolanicers, Tropaeum* etc).

Since the 1980s, several fossiliferous layers are left to anarchistic, unauthorized and intensive excavations and to plunderings intended to commercial speculation. The product of these excavations is resold not only locally but also in the whole world, either though Internet or in minerals and fossils stock exchanges. The latest one is the auction which took place in Paris in December 2009 where several ammonites sold came from the deposits of the High Western Atlas.

The echinoid faunas

The echinoid fauna of the lower Cretaceous of the High Atlantic Atlas is one of the richest south-tethysian fields. Echinoids are widely represented on thick and continuous sections, without important gaps,which makes it possible to follow in detail the evolution of this group since Berriasian until Aptian, with a good biostratigraphic control by the ammonites often frequent in the same levels. These conditions are particularly favorable for the study of the succession of Echinoida. Therefore, we can establish a local biostratigraphic scale based on echinoids, which will be used where ammonites are rare or absent. Among the irregular echinoids, the Toxasteridae, are by far the most abundant and the best preserved. Their fairly rapid evolution, makes them the most efficient biostratigraphic tools.

The regular Echinoida, which are generally rather rare, are of low biostratigraphic interest because of their great longevity. However, some species are rather numerous in precise levels.

The sites of dinosaurs footprints

In 2010 and 2014 two new discoveries have enriched the geological heritage of the western High Atlas.

First discovery of Lower Cretaceous dinosaurs tracks of Morocco.

Our geological prospecting in the Imi-n-Tanout region led to the discovery, for the first Lower Cretaceous Moroccan tracks of dinosaur's footprints.

The total number of prints, belonging to 8 tracks, is 72. We have also identified 30 other hollow structures that could be isolated prints. According to their shape and among the 8 tracks; three are attributed to dinosaur's theropods, two to sauropods and three tracks to an unknown bipedal (Masrour et al., 2012). It is also one of the few examples showing the transition between two models of sauropod tracks: those with hand prints and foot and those with feet "alone". In the tracks of walk, we can see that the absence of traces of hands is not due to a lack of recording, but to the obliteration by laying by superimposition of the feet.

The site of dinosaurs footprints in Anza (Agadir)

The dinosaur footprints site of Anza (age Coniacian- Santonian), in the north of Agadir city; is located on a foreshore and thereby the deposit is covered during high tides. In the 300 dinosaurs footprints of theropods counted so far, some are isolated and others are part of 56 tracks. It is important to note that this outcrop shows the presence of at least nine of Pterosaurs ichnites with only hands footprints.

Speleological site Win-Timdouine

Located at 70 km in the north-east of Agadir, under the tray of Tasroukht whose highest peak culminates at 1789 m, Win-Timdouine (the cave of lakes in Berber) is the largest cavity of the African continent with more than 19 km cumulated length.

Identification and classification of geomorphological geosites in the western Anti-Atlas of Morocco. An approach based on similarities and SIG for promoting geological heritage

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Today, in Morocco, the geotourism is one of the main segments of tourism that can increase the attractiveness of areas with high potential in geomorphological geosites and thus contribute to a sustainable local development. However, this tourism axis on the geological and geomorphological resources remains not valued by the public authorities, under-estimated by the promoters and unknown or poorly known by the indigenous populations.

Therefore, there is a real need for a serious approach towards this issue in the case of the western Anti-Atlas of Morocco. This contribution aims at contributing to the increase of the tourist attractiveness of these areas containing remarkable geomorphological geosites. A mediation approach is proposed, focusing on vulgarizing geotourism. It is based on the exploration of similarities between geomorphological landscapes and objects, animals, geometric forms...

Ten sites were classified and evaluated in the Geographic Information System. The assessment criteria adopted are: form, accessibility, infrastructure, level of risk and environmental degradation, attraction levels and local potentialities.

Geo-tourism in the Arctic - challenges in a vulnerable environment.

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The Svalbard archipelago in the Arctic comprises the islands from 74° to 81°N, and from 10° to 35°E and are under Norwegian sovereignty. The Svalbard area displays a more or less complete stratigraphical succession with fossils ranging from the late Precambrian through to the Palaeogene.

The natural environment in Svalbard is high arctic and vulnerable and 65 % of the land area is protected as national parks. Activities in these areas are subject to special regulations.

The settlements in Svalbard (pop. ca. 2300 Norwegians) were initially based on coal mining activities and today two Norwegian mines are in operation, whereas Russian mine operates in Barentsburg (pop. ca. 500 Russians and Ukrainians). Mineral exploration plays a minor role. Ongoing geomorphological processes have an important part in this high arctic landscape especially linked to the many glaciers, glacier rivers and periglacial conditions.

Since 2004, a group of scientists, students and volunteers organized from the Natural History Museum (NHM), University of Oslo, has undertaken field work in the Isfjorden area exploring for Jurassic and more recently Triassic marine reptiles and various invertebrates. The findings have caused international scientific and media interest and the Upper Jurassic black shales containing these fossils might be considered a Lagerstätte of high scientific value. The field group has been sponsored by various geological companies, as well as a local tourism agency which in return has transported tourists into the field area. The visitors, including visiting school teachers and local guides have met the scientists, they have learnt how scientific work is carried out, and they have been able to find fossils. Some work is done in co-operation with Svalbard Museum and the University Studies in Svalbard (UNIS).

Svalbard attracts an increasing number of tourists every year, and there are organized day, week and longer trips. The tourists are offered year-round activities like kayak and boat trips, glacier and mountain trekking, ice cave climbing, ski expeditions, dog sledge trips, snow mobile trips, and fossil collecting. "Hotel-nights" in Longyearbyen increased from 23.000 in 1993 to more than 82.000 in 2010. "Landed" tourists from cruise ships: 40.000 in 1996, over 100.000 in 2010.

Discussions on erecting a national geopark in the Longyearbyen area started in 2010. An initial note involving various participants discussed some aspects of such a geopark:

- A geopark's contribution to tourism, business and economic life in Svalbard
- Longyearbyen's geological, landscape and cultural history qualities
- Local geology based industry
- Sustainability and the role of national parks
- Problems related to collecting and selling fossils

These and other aspects on experiences and challenges in this remote part of the world will be discussed in the lecture.

Palynomorphs of the Lower Ordovician Fezouata Formation of Morocco

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Palynological samples of the Fezouata Formation (Tremadocian to Floian) of Morocco were analysed. The material comes from outcrops close to Zagora, including excavation sites where exceptionally well-preserved fossils of the Fezouata Biota have been found, but also from a borehole drilled at AdrarZouggar Mountain. The samples yielded acritarchs, chitinozoans, scolecodonts, and fragments of graptolites. Their abundance and preservation varies greatly, with many samples producing no palynomorphs. Acritarchs and chitinozoans are the most common constituents, but often poorly preserved. Still, they are abundant, well-preserved, and diverse in several samples, which generally indicates deposition in a low energy environment on a shelf with intermediate water depth. The most productive samples came from the lower of two intervals with exceptionally well-preserved fossils. Acritarchs in this interval can be assigned to the *messaoudensis-trifidum* assemblage. This assemblage is typical of the Tremadocian-Floian boundary interval of the Gondwanan margin in high southern palaeolatitudes. Based on the five established sub-assemblages, the acritarch taxa present here point to an upper Tremadocian age of the FezouataLagerstätte. Chitinozoans from the Fezouata Formation include *Lagenochitinadestombesi*, which defines the lowermost chitinozoanbiozone and is commonly interpreted as indicating a middle to upper Tremadocian age. *L. destombesi* and other chitinozoan species are known from several localities on the Gondwanan margin (e.g. Algeria-Tunisia and Argentina) and from other palaeocontinents (Baltica, Laurentia, and South China), providing links between those regions.

Red beds at the Cambrian-Ordovician boundary in Morocco and related NW-Gondwana domains: geodynamic inferences

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In this work we question the geodynamic framework of the Cambrian-Ordovician transition in Morocco and related northwestern Gondwana domains (Iberian Central Zone, Armorica). In Morocco, a stratigraphic dataset,between the widely transgressive sequences of the *Schistes à Paradoxides* (Middle Cambrian) and Lower Arenigian (Floian) formations,allows us emphasizing three significant points: i) Upper Cambrian (Furongian) marine deposits only show a restricted distribution[1]; ii) the extension of the fossiliferous marine deposits dated from the Tremadocian (Lower FezouataFm) does involve neither the whole Anti-Atlas nor the Atlas-Meseta domains[2]; iii) varicolored, silty/sandy iron-rich strata (red beds) develops in the central and eastern High Atlas, and the eastern parts of the Mesetadomain [this work]. Whether some other similar formations belonging to the same red beds basin or not is controversial especially in the case of the Western High Atlas, Bouznika area, Rehamna and Jebilet Massifs. Ferruginous conglomerates are frequently observed elsewhere beneath the transgressive Arenigian formations [2].

Therefore we must consider that a large scale extensional tectonics and block-faulting deformation controlled the erosion-sedimentation processes in Morocco, during the latest Cambrian-earliest Ordovician times.This is attested also by soft sediment deformations, some preserved hemigraben and the occurrence of sparse volcanic centers [3]dated from the late Middle Cambrian in the Anti-Atlas and Meseta domains.Hence the Moroccan red beds may be considered in the same way as the similar formations (Initial Red Series, SarnelhaFm …) reported for the same time span from the Iberian Central Zone and the ArmoricanMassif [4,5,6]. All these domains were belonging to NW Gondwana at that time and suffered a rifting process leading to the Rheic Ocean opening[7,8].

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Cambrian stem group polychaetes resolve the origin of the annelid head and recover congruence between morphological and molecular phylogenies

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The morphology of the annelid ancestor based on the phylogeny of living taxa remains unresolved and often conflicts with fossil evidence. Exceptionally preserved polychaete body fossils are known from several Cambrian localities (518-505 Ma), but their relationships to living annelids have been difficult to unravel. We present a reevaluation of the best-known Cambrian taxa with a particular focus on homologies of head structures and include them in a comprehensive morphology-based phylogeny of living taxa. When the data are analysed using phylogenetic methods that best accommodate complex data sets and homoplasy (Bayesian inference and Parsimony-based implied weighting), we recover topologies that are largely congruent with phylogenomics, including the recovery of clitellates and echiurans within a clade of sedentary polychaetes. The Cambrian taxa resolve as a grade in the annelid stem group and suggest that biramous parapodia, simple chaetae, paired head appendages and pygidial cirri are plesiomorphies of the crown group. Stem group annelids demonstrate that a dorsal covering of protective notochaetae is a primitive feature that was lost prior to the diversification of living annelids. Fossil evidence also raises the possibility that paired palps are derived from a modified notopodium and that the annelid head itself is derived from a modified anterior segment.

A timetree for the early diversification of trilobites and implications for the Cambrian 'Explosion'

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Trilobites are arguably the most successful, diverse and morphologically complex (i.e., character-rich) group of animals that spanned most of Cambrian time, and indeed the Palaeozoic. Yet their origin and earliest evolutionary history still pose a conundrum that gave even Darwin some considerable angst, having made specific reference to them in the *Origin*. This problem relates to their first appearance in the fossil record some 20 million years after the beginning of the Cambrian, when these readily-preservable arthropods with calcitic exoskeletons materialised with an immediate abundance, diversity and geographic provincialism – patterns that seem difficult to reconcile with Darwin's ideas of gradualism. Later workers have reiterated Darwin's presumption that the patterns in early trilobite origination would have required a lengthy evolutionary history in the Proterozoic for which fossil evidence is wholly lacking, and an inferred ancestral widespread distribution and vicariance have been suggested to date to the rifting of Pannotia (ca 600-550 Ma). Furthermore, despite several decades of phylogenetic research on trilobites using cladistic methods, there is still considerable ambiguity with regards to the interrelationships between the major clades. We have conducted a large-scale phylogenetic analysis of Cambrian trilobites using exemplar taxa from most families and a large set of morphological characters, including many that have been ascribed higher-level importance in trilobite classification, in an attempt to resolve relationships amongst all the earliest groups. Characters are preferentially sourced from fully articulated material with dorsal and ventral morphology and known ontogenies. This matrix, currently composed of 110 characters coded for 106 terminals, is analysed using parsimony, as well as with Bayesian methods that simultaneously estimate tree topology, divergence dates and morphological evolutionary rates across branches. Unique derived characters (autapomorphies) are important for the latter methods, and were scored in these datasets. The BEAST timetree infers a Terreneuvian origin of Trilobita, without the need to posit an unsampled Ediacaran history. This dating predicts that the appearance of trilobites in the shelly fossil record in Cambrian Stage 3 marks the timing of exoskeletal biomineralisation in lineages that were non-biomineralised in the Terreneuvian. The appearance of trilobite body fossils is likely a consequence of the transition from an Aragonite Sea to a Calcite Sea and is presumed to reflect largely coincident parallel events of calcification in different palaeogeographic regions. A Terreneuvian origin of trilobites coincides with evidence from the arthropod trace fossil record for a broadened repetoire of behavioural strategies in the earliest Cambrian.

The Emu Bay Shale Konservat-Lagerstätte: A view of Cambrian life 'Down Under'

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The early Cambrian (Series 2, Stage 4) Emu Bay Shale (EBS) Konservat-Lagerstätte is situated on the northeast coast of Kangaroo Island in South Australia, and provides a unique source of data on the composition of animal communities, plus modes of soft tissue preservation, from the main window of the Cambrian 'explosion' in East Gondwana. Previous research on the EBS—from its initial discovery in the early 1950s through to the late 1990s—was sporadic and focused on outcrop exposures on the wave-cut platform and cliffs on the coastline, and revealed some of the more common constituents of the biota, such as the trilobites *Estaingia* and *Redlichia*, the 'bivalved' arthropods *Isoxys* and *Tuzoia*, the stem-arthropod *Anomalocaris*, the palaeoscolecid *Wronascolex*, and the problematic forms *Myoscolex* and *Vetustovermis*. Our recent excavations further inland at Buck Quarry (since 2007) and an adjacent quarry (since 2012) have divulged a much greater taxonomic diversity, with over 50 species now known. The EBS biota is dominated by arthropods (in terms of diversity and abundance), including anomalocaridids, a variety of trilobite-like artiopodans, 'bivalved' taxa, and cheliceramorphs, with the trilobite *Estaingia bilobata* being the most prevalent taxon (>75% of individuals within the biota and up to 300 per square metre). Many of the EBS arthropods have a strong biogeographic connection with taxa from South China, especially the Chengjiang Biota. The remaining species diversity comprises various other ecdysozoans (e.g., palaeoscolecids and a lobopodian), a vetulicolian (*Nesonektris*), molluscs, brachiopods, a polychaete annelid, sponges, and a variety of problematic forms. Although the constituent taxa represent a typical Burgess-Shale-type (BST) fauna, EBS fossils commonly display a range of taphonomic modes for a variety of (and often the same) tissues— particularly phosphatisation and pyritisation—a situation that is otherwise rare in most other BST deposits. For example, recently documented arthropod eyes, including those of *Anomalocaris*, show two distinct modes, preserved as iron oxide (after pyrite) and calcium phosphate, demonstrating that disparate styles of early diagenetic mineralization can replicate the same type of extracellular tissue. This contrasts with many other BST deposits wherein recalcitrant tissues such as cuticle typically preserve as featureless carbon films, or where pyritization or phosphatization is typically restricted to more labile tissues, such as mid-gut glands. This demonstrates that the prevalence of early diagenetic mineralization of soft tissues seen in EBS fossils can provide much better anatomical resolution in some instances than other Cambrian Konservat-Lagerstätten. Preservation within the EBS occurred within a local syndepositional faulted slope where small scale turbiditic events appear to have smothered both benthic and pelagic organisms transported from better oxygenated settings up slope, as evidenced by common arthropod traces in the overlying sandstones of the Boxing Bay Formation.

Towards new findings of Lagerstätten in the Fezouata Shales (Morocco)? A sedimentological perspective

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The sedimentological analysis (lithology, sedimentary structures, depositional geometries) of the Fezouata and Zini formations (Lower Ordovician, Anti-Atlas, Morocco) shows that these formations were composed of sediments deposited during a long-term (2nd-order) transgressive-regressive sequence in rather shallow environments, in the proximal offshore to shoreface for the Fezouata Shale and in the shoreface to foreshore for the overlying Zini Sandstone. Sedimentary structures (cm- to m-scale symmetrical ripples) and geometries (lobes and channel-lobes) suggest that the general depositional context was dominantly controlled by storms and waves, but that tides modulated the impact of storms and waves on the depositional mode by localizing sediment accumulation on narrow surfaces as lobes or channel-lobes. These peculiar conditions of deposition imply that localized rather thick (decimetric) accumulation occurred during storms.

The today-discovered fossil-rich beds forming the Fezouata *Lagerstätte* are all found in the same depositional environment, very close above the storm-wave base. Such an environment is highly favourable for preservation of fossils, because both storm back-current and oscillation at the sea-floor are weak, thus limiting transport of the organisms living in this environment, however bringing sediments for fossil burial. Furthermore, tide-modulation of storms, which has for consequence of locally accumulating rather thick storm deposits, could have favoured very fast burial of fossils, which is one of the most striking pre-requisite conditions for preservation of soft-tissues of animals in the fossil record.

The Fezouata Formation was deposited during a long-term (2nd-order) sequence of sea-level change. This implies that the zone favourable for exceptional preservation of fossils has moved landwards (towards the SE as reconstructed by outcrop correlation) during transgression, and seawards (towards the NW) during regression. This suggests that older *Lagerstätten* than those today discovered potentially could exist towards the SE and younger ones towards the NW if palaeoenvironmental condition is the primary factor for their formation.

Besides long-term 2nd-order sea-level changes, shorter-term (3rd- and 4th-orders) sea-level fluctuations are recognized in the Fezouata Formation. By encoding these different orders of sea-level changes by giving a value of "1" for the deepest part of the sequences (at any order) and a value of "0" for their shallowest part a reconstruction of relative sea-level changes is proposed. This reconstruction for the Fezouata in the Zagora region clearly evidences a narrow window that stratigraphically, and perfectly, contains the today discovered *Lagerstätte*. This reconstruction suggests that a 2nd stratigraphic interval is of interest for new investigations in the Zagora region because recording similar sea-level conditions than those of the known *Lagerstätte*, despite weak outcropping conditions that make the good sections rare, even existing.

Exceptional fossil preservation during global green house crises?

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Exceptional fossil preservation requires not only exceptional places, but exceptional times. In many regions of the world exceptionally preserved fish and trilobites are within thin horizons separated by great thicknesses of rock with poorly preserved, disarticulated or no fossils. The irregular stratigraphic spacing of such horizons can be correlated widely, as illustrated by horizons yielding articulated Triassic fishes in USA, Germany, Italy, and New South Wales, and Cambrian trilobites in Utah, Wales, Bohemia and Queensland (Fig. 1). The high degree of correlation of these stratigraphic spacings is a guide to additional fossil resources, and may be due to short temporal intervals of exceptional preservation globally. Compilations of ages of well-dated exceptional fossil localities show spikes of abundance which coincide with stage boundaries, mass extinctions, oceanic anoxic events, carbon isotope anomalies, spikes of high atmospheric carbon dioxide, and transient warm-wet paleoclimates. Exceptional fossil preservation may have been promoted during unusual times, comparable with the present: CO_2 greenhouse crises of expanding marine dead zones, oceanic acidification, coral bleaching, wetland eutrophication, sea level rise, ice-cap melting, and biotic invasions.

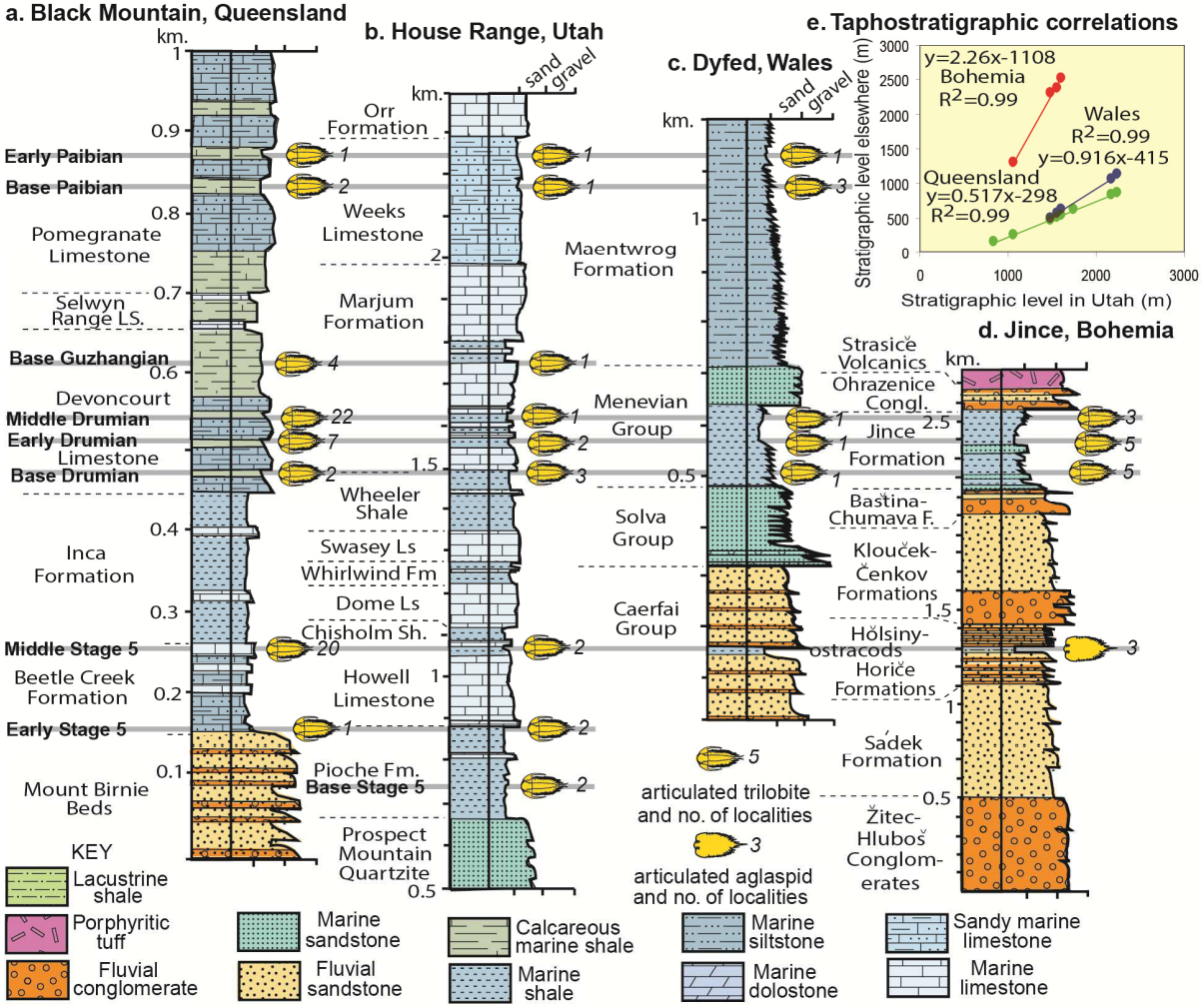

Fig.1:. International correlation of commericalquarries for articulatedCambrian trilobites.

Development of the morphological diversity of attachment structures of the stalked echinoderms during the Early and Middle Ordovician of the eastern part of the Baltica basin

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In the Ordovician there was a significant increase in the height of the shallow-water benthos tiering, especially among the stalked echinoderms. It was accomplished by increasing body size of many blastozoan echinoderms and by the appearance of crinoids with a long stem. It required the strengthening of the attachment to the ground and a corresponding development of the morphology of the attachment structures of pelmatozoan echinoderms. The known diversity of the stalked echinoderms in the Early and Middle Ordovician reaches 15 genera described from theca, cups and crowns. Stems and holdfasts of the blastozoans echinoderms are similar between each other and do not allow us to judge about the real taxonomic diversity of the group. In contrast, crinoid stems and holdfasts show much greater taxonomic diversity that is known by cups only. All holdfasts from this interval and region can be divided into five major groups. The most extensive and poorly distinguishable group is represented by solid disks with tight round axial canal. Such holdfasts are typical for eocrinoids (such structures are definitely known in *Rhipidocystis*) and diploporites (*Protocrinites*). Their sizes vary from few millimeters up to two centimeters. They appeared firstly in Upper Billingen (Floian) and often occurred in the middle Ordovician on hardgrounds and larger skeletal debris. Glyptocystitoid rhombiferans, the most common in the Ordovician of the Baltic Sea, apparently relied on the ground by coiled on the ground surface dististele with thin long columnals. The main diversity of holdfasts is observed among crinoids. There are four main morphological types, between which there are transitional forms. The most primitive morphotype has the form of a large high stub with pentagonal or five-ray axial canal and dististele with pentameric columnals. These holdfasts were among the first ones in the Volkhov regional stage, where they attached to firm carbonate grounds and hardgrounds. The second type represented by similar massive solid structures, too, is in the form of low stub, but with short flattened rhizoids, creeping along the ground. This morphotype is characteristic for hardgrounds of the Volkhov regional stage. The third type shows wide dome-shaped irregularly multiplated holdfasts and distal stem, partly constructed of alternating pentameres above. Holdfasts of this type could be different in sizes, from half a centimeter in diameter, as it known in iocrinid *Schaldichocrinus* up to 4-5 centimeter in diameter. These holdfasts are found mainly on firm grounds with numerous large carbonate detritus and hardgrounds. The fourth type is represented by the distal part of the stem, branching into many long round interweaving rhizoids. Holdfasts of this morphotype are gradually moving into a stem of pentameric columnals with a star-shaped axial canal. The axial canals in the rhizoids can be triradial, biradial or round at the distal branches. Crinoid morphotype with cirri-like branching rhizoids occurs on a soft carbonate grounds as well as on solid detritus grounds and hardgrounds of the Middle and Upper Volkhov regional stage (Dapingian). In Baltica this morphotype appears earlier than in Laurentia. Among crinoids this morphotype represents probably the initial stage in evolution to cirri-bearing morphotype, which appeared only in the upper Ordovician and became predominant in the Upper Paleozoic. The diversity of holdfasts dramatically reduced in the Kunda regional stage (Darriwilian), where they became rare, mainly in the form of small disks, adhering to solid objects. Holdfasts are rare on the Kunda hardgrounds. The study was supported by the Russian Foundation for Basic Research, project 15-04-08315-a.

Exceptionally preserved Cambrian Pterobranchia from Siberian Platform (Olenek River)

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Findings of pterobranchs from Cambrian of the Siberian Platform were reported in last century (Obut, 1964, 1974; Sennikov, 1994, 1998). First data on exceptionally preserved colonies and zooids showing soft tissue were published by Durham and Sennikov (1994), based on material from the Cambrian of Siberia. This unique locality that could be regarded as of Lagerstätte-type was found in the Green-Colored Formation aligned with lower part of the regional *Lejopyge laevigata* trilobite Zone or the uppermost part of underlying regional *Anomocarioides limbataeformis* trilobite Zone. According to modern stratification of Cambrian System the FAD of *Lejopyge laevigata* is marking the base of Guzhangian Stage of the Third Series.

The location of the Green-Colored Formation yielded exceptionally preserved rhabdopleurids is in the Olenek region of the Siberian Platform. It crops out along the Ukukit River, left tributary of the Olenek River and is composed of rhythmic alternation of grey and light-greenish-grey platy limestones, clayey limestones, marls and clayey siltstones. Numerous colonies and single tubes described as *Rhabdopleura obuti* Durman et Sennikov were found on the flattened and slightly curving surfaces of clayey limestones.
Siberian material is characterized by good state of preservation of both outer tubes of the exoskeleton - coenoecium and soft tissue of zooids. The color of Middle Cambrian coenoecium is very similar with that of the modern pterobranchs – red, orange and brown. Circle structures are observed on the initial part of colonies. Sclerotized coenoecium possess single fusellus and well distinct regular median zigzag suture. Zooids and buds are preserved in half-dimensional life state. Zooids of Siberian pterobranchs are as terminal zooids (= terminal buds) and as retracted zooids. They are characterized by almost all organs present in modern ones - pleoral disc, mouth, lophophore, and anus. Also sclerotized pectocaulus and unsclerotized soft gymnocaulus could be observed. General configuration of zooid's body and relative dimensions of organs are very similar to that of modern *Rhabdopleura* Allman. This could suggest the occurrence of morphogenetic rigidity within pterobranchs.

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The onset of the 'Ordovician Plankton Revolution' in the Late Cambrian

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The Great Ordovician Biodiversification Event comprises the diversifications of all groups of marine organisms during the Ordovician Period. It is now clear that this adaptative radiation started for some fossil groups already in the Cambrian and continued for others beyond the end of the Ordovician, making the Great Ordovician Biodiversification Event a part of a long-term Early Palaeozoic radiation, that also includes the Cambrian Explosion. It is assumed that environmental changes triggered the diversification of the phyto- and zooplankton since the Late Cambrian, permitting an increase in diversity and abundance of plankton-feeding groups during the Ordovician. In addition, molecular clock and fossil data indicate evidence for a Late Cambrian to Ordovician switch to planktotrophy in invertebrate larvae. Here we analyse in detail the onset of the diversification of the different groups of the plankton in the Late Cambrian – Early Ordovician interval, leading to the subsequent 'Ordovician Plankton Revolution'. Our analyses include the changing diversities of the phytoplankton (acritarchs), diverse groups of zooplankton (e.g. chitinozoa, graptolites, radiolarians, etc.) and the switch to a planktonic mode of life of fossil groups (e.g. arthropods, molluscs, etc.) that were part of the Cambrian benthos. The possible causes of the 'plankton revolution' are discussed. They include changes in palaeoclimate, palaeogeography or tectonic and volcanic activity, as well as a modified nutrient supply.

Multidisciplinary studies of Neoproterozoic sedimentary basin in South-western Ukraine (Ediacaran period - 553 Ma)

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Ediacaran (Vendian) system which has been dated 635-541 Ma, is a kind of "connecting" period between two crucial discoveries of multicellular life: the Paleoproterozoic (2.1 Gyrs) and the beginning of the Phanerozoic Eon (542 Ma). Currently there are more evidence that Ediacaran (Vendian) biota was not an ancestor of the Phanerozoic biota, but a completely independent group of organisms. Significant discoveries in the Ediacaran (Vendian) world were made throughout several sedimentary series in the world: e.g. Russia - Black Sea, Yorga Formation (Fedonkin, 1985), South Ural, the Ziguinskaya Formation (Grazhdankin, 2011); Canada - in the Neoproterozoic strata of the Wernecke Mountains, Twitya Formation (Narbonne and Hofmann, 1990); China - Doushantuo formation (G. Jiang et al., 2011). Different morphotypes characterise the Ediacaran (Vendian) biota: tubular (such as Plexus), discoidal (as Aspidella, Nimbia, Nemiana).

The Moguiliv-Podilska sedimentary formation (MP Formation) has been dated around 553 million years (Grazhdankin, 2011). It is unconformably overlying the Podilska Upland which corresponds to the western and south-western slope of the Ukrainian Crystalline Massif. The studied sections are located on the hillsides of the valleys of the Dniester River and tributaries. Well conserved MP Formation is ~ 255 m thick and is basically composed of fine to coarse-grained sandstones – from dark to light grey, or brown and yellowish and grey to green mudstones. The nicely preserved “Nemiana” discoidal specimens and many horizontal and sinuous tubular sections filled by fine sediments have been found in the MP Formation. These structures could be considered bioturbation-like features.

Till now, the 3D morphology of Nemiana specimens has been poorly documented. The aims of the present study is: 1) to try to determine the 3D structure of the Nemiana inside their host rocks as well as that of the tubular traces; 2) to document the microbial mats in the MP Formation throughout the Podilya basin in south-west of Ukraine; and 3) to characterise the diagenetic grade of the basin using clay mineralogical determination.

The 3D structure of the Moguiliv-Podilska biota - has been studied using X-Ray micro tomography and thin section petrography. The first results obtained show that tubes are crosscutting the host sediments before their compaction. Clay minerals are mainly chlorite, illite and mixed layer illite-smectite. This assemblage is typical of diagenetic and not metamorphic conditions.

Nemiana and the bioturbation-like are both located near the microbial mats structures. The colonization of substrates by microbial mat communities enabled the biota preservation (Gehling, 2000). This phenomenon has likely contributed to the conservation of Ediacaran (Vendian) bodies and trace fossils. The Moguiliv-Podilska sedimentary formation offered a similar environment for the conservation of these Ediacaran biota.

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Lagerstätte-type preservation of fossils in siliceous deep water deposits in the Upper Cambrian and Lower Ordovician of Kazakhstan

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In the south-west of the Balkhash Lake of Southern Kazakhstan, siliceous deposits of the Burubaital Formation rarely bear unusual accumulations of well–preserved faunas of benthic and planktonic pterobranchia, caryocaridid arthropods, ostracods, algae, acritarchs and fecal pellets. Although the primary matter of skeleton remains of the fossils in those accumulations is substituted with silica, good preservation of skeleton features as well as integrity of fecal pellets suggest that the faunas have been buried quite fast, preventing disintegration of organic matter in the siliceous sediment. These faunal accumulations occur at several stratigraphic levels within the lower part of the formation, which is constituted of c.100 m condensed unit of relatively monotonous biogenic radiolarian cherts interlayered with siliceous siltstone, and sandstone with chert debris. The formation was deposited during the Late Cambrian – Middle Darriwilian (Middle Ordovician) that was estimated by conodonts. It is assumed that chert succession was deposited in the foot of continental shelf of passive continental margin in a deep-water environment below the calcite compensation depth.

The Burubaital ribbon-banded cherts contain sparse radiolarians, sponge spicules along with rare conodonts and lingulids. Conodonts are abundant in the Lower Ordovician part of the formation only. The faunal accumulations are confined to specific siliceous facies that occur scarcely and differ significantly from the background cherts of the formation. These specific facies are represented by interbedded carbonaceous siliceous siltstone, bright-red jaspers, black and white cherts that occur only in vicinity to barite lenses in the lower part of the Burubaital Formation. Those beds also contain ostracods that are absent in background cherts as well as enormous amount of planktonic arthropods and fecal pellets. The barite bears no sulphide mineralization and is interpreted as deposited in a result of cold seep activity. More variegated lithology of the cherts, hosting the barite, was probably caused by long-lasting activity of cold seeps and different chemistry of bottom water around the seeps. Abundance of siliceous sandstones with cherty debris in the vicinity of barites, including conodont-bearing sandstones implies existence of local paleo-swells that formation was caused by the barite seeps activity. These data suggest that the barite seeps had strong impact on relatively uninhabited Late Cambrian to Early Ordovician ecosystem of open oceans. Seeps caused a severe rise of water productivity around them and formed a lateral succession of paleofacies with specific taphonomic parameters, favored preservation of faunas non-typical for siliceous deposits.

Reconstructing the diet of Cambrian arthropods

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Reconstructing the diet of 500 million year-old animals presents a scientific challenge with important implications regarding the level of interactivity within early marine communities and the construction of the very first modern-style trophic webs. The exceptional preservation of fossils from several 'early' to 'middle' Cambrian Lagerstätten has allowed scientists to reconstruct the feeding ecologies of early animals with astonishing accuracy, as exemplified by recent studies on carnivorous worms (Vannier, 2012), anomalocaridids (Vinther et al., 2014; Van Roy et al. 2015), trilobites (Lerosey-Aubril et al., 2012) and other early arthropods (Vannier et al. 2014) from the Cambrian period. Here, we focus on *Sidneyia inexpectans* Walcott, 1911 (Bruton, 1981), an iconic arthropod of the 'middle' Cambrian (Series 3, Stage 5; circa 505 Ma) Burgess Shale biota from British Columbia, Canada. Its feeding ecology is inferred using three lines of evidence: the structure of its digestive system, the analysis of its gut contents, and the functional morphology of its appendages. Comparisons with modern chelicerates (e.g. spiders, horseshoe crabs) are made to reconstruct key-aspects of its biomechanics of feeding and to elucidate the phosphatic preservation of its digestive structures. The digestive tract of *Sidneyia* was straight, tubular and relatively narrow in the trunk region. It was enlarged into a pear-shaped crop in the cephalic region and stretched notably to form a large pocket in the abdomen. Anteriorly, three pairs of glands with internal, branching tubular structures opened into the digestive tract. These glands have equivalents in various Cambrian arthropod taxa (e.g. naraoiids) and modern arthropods. Their primary function was most likely to digest and assimilate food. The mouth was ventral, posteriorly directed and led to the crop via a short tubular structure interpreted as the oesophagus. The abdominal pocket of *Sidneyia* concentrated undigested skeletal elements and various residues. It is interpreted here as the functional analogue of the stercoral pocket of some Recent terrestrial arachnids (e.g. Aranea, Solifugae), whose primary function is to store food residuals and excretory material until defecation. Analysis of the gut contents indicates that *Sidneyia* fed largely on small trilobites, brachiopods, possibly agnostids, worms and undetermined animals. *Sidneyia* was a durophagous carnivore with predatory and/or possible scavenging habits, feeding on small invertebrates that lived at the water-sediment interface. There is no evidence for selective feeding. Its living or dead prey was grasped and manipulated ventrally by its anterior appendages, then macerated into ingestible fragments and conveyed to the mouth via the converging action of strong molar-like gnathobases. Digestion probably took place within the crop via enzymes secreted in the glands. Residues were transported through the digestive tract into the abdominal pocket. The storage of faeces suggests infrequent feeding. The preservation of the digestive glands and abdominal pocket in apatite may be due to the capacity of *Sidneyia* to store Phosphorus and Calcium (e.g. spherites) in its digestive tissues and to release them into the intestinal lumen as do, for example, modern horseshoe crabs.

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The Fezouata arthropod fauna: an overview of current research

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The Early Ordovician Fezouata Biota, like most exceptionally preserved marine faunas, and faunas from normal marine environments in general, is dominated by arthropods (Van Roy *et al.* 2010; Van Roy *et al.* in press). In common with most Early Palaeozoic faunas, the Fezouata is host to a wide range of trilobite taxa, with diversity much higher than in any single Cambrian exceptionally preserved biota. However, trilobites only represent a fraction of the overall arthropod diversity when the non-biomineralised component is taken into consideration. The fauna includes a number of typical Burgess Shale taxa, extending the ranges of many iconic stem groups, e.g. armouredlobopodians and anomalocaridids (Van Roy *et al.* 2010; Van Roy & Briggs 2011; Van Roy *et al.* 2015; Van Roy *et al.* in press), into the Ordovician. These Burgess Shale forms co-occur with more advanced crown arthropods previously known exclusively from considerably younger strata, e.g.xiphosurids and other chelicerates, and cheloniellids (Van Roy 2006; Van Roy *et al.* 2010; Van Roy *et al.* in press); for these derived taxa, a Cambrian origin can now reasonably be assumed. Although so far only a few Fezouata arthropods have been systematically studied (Van Roy 2006; Van Roy &Tetlie 2006; Van Roy & Briggs 2011; Van Roy *et al.* 2015), these have provided major new insights into early arthropod evolution and the ecology of post-Cambrian Palaeozoic faunas. The high diversity of chelicerates in the Fezouata Biota is surprising, and suggests a Gondwanan origin for this clade, an idea which is also supported by the recent discovery of a eurypteroid in the Late Ordovician of southeast Turkey (Lamsdell*et al.* 2013).

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Palaeoenvironmental conditions and the record of the Great Ordovician Biodiversification Event in the Anti-Atlas of Morocco

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The Lower Ordovician succession (Tremadocian to Floian) in the central Anti-Atlas (Zagora, Morocco) consists in *ca* 900 m of fossiliferous siltstones and sandstones of the Fezouata and Zini formations. The Fezouata Formation is a unique window on the most important radiation of the Phanerozoic: the Great Ordovician Biodiversification Event (GOBE). Recorded in the lower part of Fezouata Formation (Late Tremadocian in age), the GOBE is expressed by many layers containing exceptionally preserved soft tissues of animals.

Based on facies succession and sequence analysis of ten sections, the palaeoenvironmental context of the Fezouata Biota was achieved. A model of deposition for the Fezouata and Zini formations is proposed from proximal offshore to foreshore environments. The sedimentary environment is a siliciclastic system with numerous symmetrical ripples pointing to a storm- and wave-dominance.

Peculiar sedimentary organization and sedimentary structures are observed in both the Fezouata and Zini formations: (a) cyclical changes in size of sedimentary structures in storm events; (b) an upper shoreface with characteristics of an open coast tidal flat; (c) local overdigging in swaley cross-stratifications; (d) deep internal erosion within storm deposits; (e) discontinuous sandstone layers in most depositional environments, and common deposition of sandstones as lobes or channel-lobes as well, deposition at all scale (m to kms) is discontinuous; (f) combined flow-oscillation ripples showing aggrading-prograding internal structures alternating with purely aggrading wave-ripples; and (f) foreshore environments characterized by alternating phases of deposition of parallel stratifications, small- and large-scale ripples, and frequent beach cusps. These various characteristics of deposition suggest that wave intensity during storms or fair weather conditions was continuously modulated by another controlling factor of the sedimentation, the tide. A model of deposition is provided for this wave-dominated, tide-modulated sedimentary context.

This model suggests that all layers yielding exceptionally preserved fossils are located close to the storm-wave base where distal tempestites were deposited. Distal storm deposits appear to be essential to promote exceptional preservation by fast *in situ* burial with almost no transport. Deposition of cm- to dm-thick tempestites allows instantaneous burial of animals rather deep below the seafloor, in likely oxygen-poor conditions.

A halkieriid-like aculiferanmollusc from the Early Ordovician Fezouata biota, Anti Atlas Region, Morocco

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The origin and evolution of molluscs have been centered on specific groups, such as the chitons, monoplacophorans and the aplacophorans. Especially the chitons and aplacophorans have been viewed as a particularly ancient grade of molluscs. This contrasts with molecular and palaeontological evidence that suggest that these two groups diversify during the Ordovician after the Cambrian Explosion. Putative stem groups are the halkieriids and other sachitids, which are common in early and mid Cambrian rocks all over the world.

Here we describe a new fossil mollusc from the Fezouata biota, which is a dorsoventrally flattened scleritome-bearing organism with an isolated anterior shell plate surrounded by minute sclerites covering the dorsum and lateral margins. The general anatomy resembles the halkieriids in several aspects, but the minute sclerites are more similar to those of chitons and aplacophorans. The molluscan affinities are demonstrated by the well preserved radula, superimposed on the anterior shell plate.

The fossil provides an important morphological link between the halkieriids and the aculiferanmolluscs (aplacophorans and chitons). This supports the notion that sachitidmolluscs and the halkieriids are stem group aculiferans, extending the group to the early Cambrian when other molluscan groups radiated.

From Snowball Earth to Greenhouse conditions and the Cambrian Bioradiation: Did the multiple pulses of the Central Iapetus Magmatic Province trigger and drive these phenomena?

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The 615-540 Ma Central Iapetus Magmatic Province (CIMP) was emplaced in multiple pulses during Ediacaran-Cambrian times, and were been linked to the disruption of the supercontinent of Rodinia (Pannotia) leading to the initial opening of the Central Iapetus Ocean (e.g., Puffer, 2002, Am. J. Sci., 302, 1-27; Ernst, 2014, Large Igneous Provinces. Cambridge University Press, 653p). In Africa, the CIMP is well represented around the West African craton, WAC (e.g., Doblas et al, 2002, Geology, 30, 839-842), in particular in the Anti-Atlas of Morocco as the volcanic and sedimentary occurrences of the 606-541 Ouarzazate Supergroup that covered a gigantic area of about 2 x 10^6 km^2 with an estimated magma volume of about 1 x 10^6 km^3 and volcanic thicknesses more than 3000 m. In some inliers (Igherm, Bou Azzer among others), the volcanic rocks (mainly felsic) of the lower unit of the Ouarzazate Supergroup present glaciogenic features such as striated pavements and structures “moutonnées” of volcanics that are well documented (Vernhet et al., 2012, Precambrian Res., 196-197, 106-112) and reinforce the idea of synchrony of the c. 590 Ma pulse of CIMP volcanism and the glaciation around 580 Ma (Gaskiers) in the WAC (Doblas et al., 2002). This glaciation is called Bou Azzer Glaciation in the Anti-Atlas (Vernhet et al., 2012). In addition, three sandstone samples show strong detrital U-Pb age peaks of 552 Ma and of 541 Ma (Karaoui et al., 2015, Precambrian Res., 263, 43-58) placing the maximum deposition age for the youngest pulse of CIMP at the uppermost Ediacaran (Upper Ouarzazate Supergroup), i.e. close to the age of the Precambrian-Cambrian transition.

In most regions, the CIMP is dominated by the eruption of huge volumes of typically basaltic magmas (mainly Continental Flood Basalts) particularly during its initial pulses; but in some regions like the African margin among others (Anti-Atlas, Sahara Metacraton, Arabian-Nubian Shield), the first occurrences of the CIMP record are plutonic bodies, and the formation of calderas with huge volume of pyroclastic flow deposits, and ash falls that covered continent-sized areas (Doblas et al., 2002). Explosive volcanism was at least partly responsible for Neoproterozoic climate change, synopsized as the "Volcanic Winter to Snowball Earth" (VW2SE) hypothesis (Stern et al., 2008, Solid Earth Series "Links between Geological Processes, Microbial Activities, and Evolution of Life", Y. Dilek, H. Furnes, K. Muehlenbachs Eds., 313-337). A protracted increase in explosive volcanism could disrupt Earth's radiative balance by continuously injecting sulfur aerosols into the stratosphere, causing cooling that could lead to glaciation. Cather et al. (2009), Geosphere, 5, 3, 315-324 suggest that iron fertilization of the oceans by great volumes of silicic volcanic ash caused a burst of biotic activity that drew down the CO_2 level in the atmosphere and led to the Cenozoic icehouse. This hypothesis is termed the icehouse-Silicic Large Igneous Province (SLIP) hypothesis. Similarly a large basaltic lava eruption like CFB can release prodigious quantities of SO_2, CO_2 and halogens (Self et al., 2005). The initial release of SO_2 and its injection into the stratosphere could trigger a global volcanic winter, akin to the models of nuclear winters, reducing photosynthesis through light occlusion and cooling. Long-term accumulation of CO_2 may lead to subsequent warming- the "Volcanic Summer" concept of (Saunders, 2005, Elements, 1, 259-263)-especially if the biologically driven carbon-capture mechanisms are compromised by the preceding "Volcanic Winter" (Saunders, 2005; Self et al., 2005, Elements, 1, 283-287). There is also the important contribution of gases released from sedimentary rocks that are 'cooked' by emplacement of dolerite sills (e.g., Svensen et al. 2009, Earth Planet. Sci. Lett., 277, 3-4, 490-500.). The various pulses of CIMP volcanism can be correlated with important events during the transition Precambrian-Cambrian: 1) link of the 590 Ma pulse (mainly felsic) as an abiotic agent involved in the triggering of Volcanic Winter and subsequent Snowball Earth conditions ("Ice House"): the Gaskiers Glaciation. The silicic portion of CIMP dominated by pyroclastic rocks (in African margin areas, especially in the Arabian-Nubian Shield) contributes to trigger and drive the Icehouse conditions. The VW2SE hypothesis of Stern et al., (2008) and/or the SLIP hypothesis of Cather et al., (2009) can be considered as a viable explanation for the late Neoproterozoic climate oscillations; 2) the liability of the last pulse of the CIMP as an abiotic agent involved in the triggering of "Volcanic Summer" and succeeding global warming conditions ("Green House") that contribute to the disappearance of ice age and the consequent expansion and diversification of the life on Earth: the Cambrian Bioradiation.

Posters

Small shelly faunas from the Lower Cambrian (Anti-Atlas, Morocco)

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Choubert (1963) assigned to the Adoudounian-Lower Cambrian time interval, the classical succession observed in the Anti-Atlas, Morocco, and comprising two carbonates series (interpreted as transgressive deposits) separated by the "Série lie-de-vin" siliciclastic series (associated with a major, glacio-eustatic regression). In the absence of classical Lower Cambrian fossil remains (archaeocyaths and trilobites), this sedimentary succession was separated into a terminal Proterozoic unit (azoic lower part) and a Lower Cambrian unit (upper fossiliferous part; Leblanc 1976, Sleeve-board & Tisserant 1977, Charlot 1978, Leblanc 1980, Hassenforder 1987). Recently, in accordance with the recommendations of the joined IUGS - IGCP 366 working group, an Early Cambrian age was assigned to this succession (Geyer & Landing 1995).

Comparison with other similar series (e.g., Siberian platform) suggests that the absence of fossils in the lower half part of the Lower Cambrian in the Anti-Atlas possibly results from the late arrival of archaeocyaths in Morocco (Debrenne 1995). Long considered as absent, subtrilobitic faunas known as “SSFs” or “small shelly fossils” are here reported from Assads Lower Cambrian mudstones facies. These deposits have yielded abundant remains of complete shells varying in size between 2 and 5 mm. The studies in progress will make it possible determine if this fauna is comparable with other “SSFs” and if it has any stratigraphic value.

Microbialitic diversity in the Lower Cambrian of the Anti-Atlas, Morocco

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Three successive main types of microbialitic buildups can be evidenced in the Lower Cambrian of the Anti-Atlas area, Morocco. The first one (stromatolitic facies) corresponds to peritidal cyanobacterial mats, which developed when the western Anti-Atlas was a marginal and irrelatively isolated platform. This facies consists in primary dolomitic planar stromatolites, equivalent in morphology to modern ones existing in the lagoon of Coorong in Australia (Einsel 1992) and the "Lagoa Vermelha" on the Atlantic coast of Brazil (Vasconcelos; McKenzie 1997). The second type of buildup is associated to the increase of the water depth from the stromatolitic peritidal zone to the subtidal thrombolitic environment. This environmental conditions change is accompanied with the first appearance of calcified and mucilaginous cyanobacteria (Latham & Riding 1990). The Anti-Atlas was then associated with more open marine conditions. During the last period, flourishing archaeocyathids and calcimicrobes formed offshore reefal build-ups. This third type of microbialitic buildup corresponds to a second episode of sea level rise. The branching archeocyathan framework contributes significantly to dendritic calcimicrobe occurrence. The basin is largely communicating with the adjacent western ocean.

The occurrence of three successive types of microbial buildups, expressed by the three types of microbialitic facies (stromatolites, thrombolites and dendrolites) recognized in the area, is indicative of a major biological diversification in the Anti-atlas during the Cambrian. This diversification is related to changing environmental conditions, controlled by the progressive opening of a basin initially confined to an oceanic domain in the west.

The Devonian palaeontological heritage from Tafilalt: a tool for sustainable development

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The Tafilalt is famous for its Palaeozoic fossils (trilobites, *Orthoceras*, *Goniatites*, *Tentaculites*, brachiopods, placoderms, conodonts ...). This wealth is remarkable mainly for the Devonian. Scientific discoveries are very numerous and publications on the Devonian faunas from the Tafilalt keep increasing each year. These deposits, mainly outdoor, are spread over large areas and indicate a palaeobiodiversity whose importance lies in great role in biostratigraphy, palaeogeography and understanding of geodynamics of the northern Gondwana margin.

The palaeontological sites of this region deserve a development associated with its environmental that would allow developing a sustainable and respectful geotourism. This is possible by the mounting of educational activities (in collaboration with local associations) and training the benefit of local populations could strengthen their membership in their area and help them to get involved in an effective way to the protection of paleontological heritage but also to promote their territory. These sites constitute a national heritage and deserve to be valorized in the frame of a regional museum, which will contribute to sustainable development and also by creating geotourism paths. However, these deposits are protected and legal status that will enable the preservation of this heritage is not yet implemented by the competent authorities.

The Rock Art of the Yagour (Moroccan High Atlas) : State of the Art, Conservation and Valorisation

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The Yagour is a plateau of the western High Atlas, lying at an altitude of 2728 m. It is about 12 km long and 5 km wide, and is dominated by the Adrar Meltsen which rises to 3535 m.

Starting in 1950, Jean Malhomme discovered hundreds of engravings on the plateau, made on the Permo-Trias sandstone slabs visible on the surface. The inventory and study he carried out on the rock art of this plateau, were produced in the form of a corpus in two volumes (Malhomme, 1959 and 1961). Twelve stations were identified. Other engravings were discovered by A. Simoneau and A. Jodin between 1964 and 1968. Later, in 1999, A. Rodrigue published a synthesis of his researches and an up-to-date inventory of the sites of the High Atlas (Rodrigue, 1999).

The recent prospections carried out from 2006 resulted in the discovery of ten new stations (Hoarou and Ewague, 2008 and Ewague *et al.*, 2013) comprising over 1 200 engravings to be added to the 1 900 already recorded. The study of the spatial distribution of the rock art stations, the tumuli, the *azibs*, the prairies and the water supply show that the engraving are closely linked to pastoral activities, a seasonal practice still continued on the plateau today.

The images engraved on the Yagour are diverse and varied in style and technique. The two techniques generally used to engrave – pecking and polishing - are present on the Yagour, as they are in Oukaimeden. The dominant theme is that of metal weapons: daggers, axes and halberds (34%); animal species are principally represented by domestic cattle (22%), followed by wild animals: elephant, rhinoceros, giraffe, ostrich and other unidentifiable animals (13%); geometrical figures: discs or circles (10%) undetermined images (9%) and human figures (8%).

The rock engravings of the Yagour cover different periods, comprising the last four millenia, as do those of the other High Atlas rock engraving sites (Oukaimeden and Jbel Rat). Certain themes can be related to the Saharan and Pre-Saharan Neolithic (Ewague, *in press*), others – such as the metal weapons – can be linked to the Bronze Age. The decorated discs, accompagnied by lances, chariots and horsemen are dated to the first millenium. Curved daggers and fibulas belong to the historical period.

The images engraved on the Yagour constitute the archives and witnesses of the cultural practices carried out on this High Plateau. They represent a heritage that should be safeguarded and valorized. At the moment it is threatened, particularly by destruction caused by humans.

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The fish-like skeletal fragments from the Upper Ordovician of Tarim Basin, Xinjiang, China

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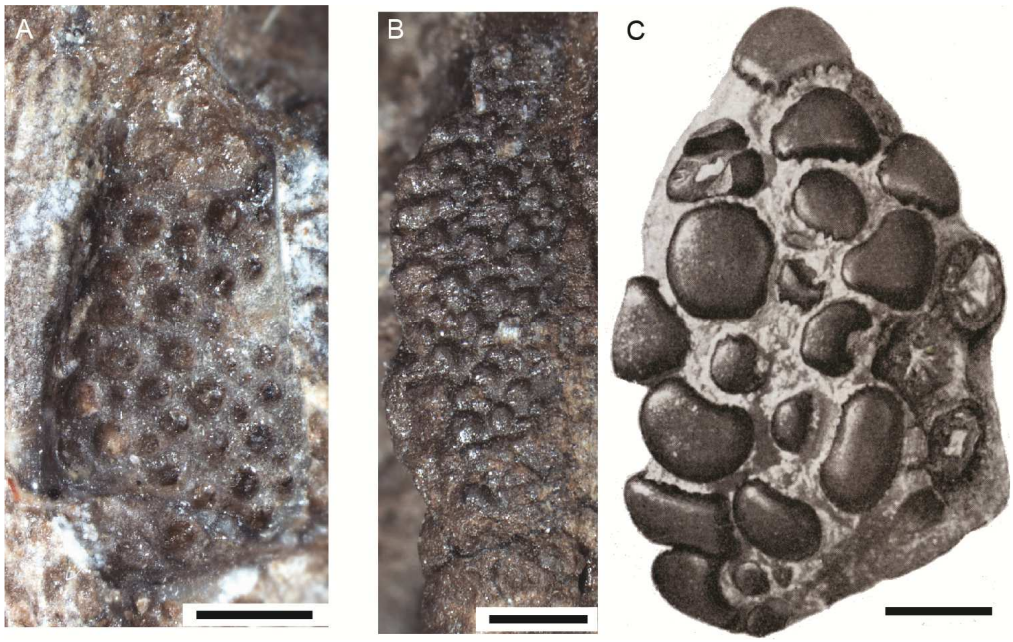
The earliest known vertebrates appeared at early Cambrian times (about 530 million years ago). However, these fish-like animals did not boom until the early Silurian times (about 435 Ma), after the glaciation at the end of the Ordovician period. The undoubted Ordovician vertebrates are very rare expect for *Arandaspis*, *Porophoraspis* from Australia, *Sacabambaspis* from Bolivia, *Astraspis*, *Eriptychius* from North America. These Ordovician vertebrates are very simple in shape, with a fusiform head covered with large bony plates ornamented with tubercles. Here, we describe some fish-like skeletal fragments from the upper Ordovician of Tarim Basin (South Xinjiang), China. The fish-like skeletal fragments were found in asscociation with the Late Ordovician conodonts *Baltoniodus alobatus*. The surface of fragments is ornamented with tiny and densely set round tubercles (Fig.1A, B), which is quite comparable to the exoskeleton of vertebrates from the Harding Sandstone of North America (Fig.1C). Further histological investigation on these fragments and more field excursion for the articulated specimen will clarify the nature of the fragments.



A, B. two fish-like skeletal fragments from the upper Ordovician of Xinjiang, China.
C. the exoskeleton of vertebrates from the Harding Sandstone of North America

First benthic graptolite and a possible? hydroid from the Bou Nemrou assemblage (Tafilalt Biota), Upper Ordovician of Morocco.

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The Late Ordovician Tafilalt Biota of the eastern Anti-Atlas preserves a number of shelly fossils and soft-bodied metazoans in shallow-water sandstones, in a style somewhat reminiscent of typical Ediacaran fossils from the Flinders Ranges of Australia. The Bou-Nemrou assemblage, occurring at the eponymous locality of the Jbel Tijarfaïouine area east of El Qaid Erami (El Caïd Rami) valley, is the oldest stratigraphic representative of the Tafilalt Biota, being located in the uppermost part of the First Bani sandstone group, in beds of early Sandbian age. Among the diverse invertebrate groups recorded at the assemblage, previous work identified diverse soft-bodied forms (large paropsonemid eldonioids, non-biomineralised cheloniellid arthropods, palaeoscolecid worms), abundant echinoderms (fourteen genera of eocrinoids, ophiuroids, stylophorans, edrioasteroids, crinoids and a single cyclocystoid), and some trilobites belonging to at least ten different genera.

Recent fieldwork in the Bou Nemrou locality has lead to the discovery of single specimens of a dendroid graptolite and a possible? hydroid cnidarian (or, alternatively, a ? Graptolithina *incertae sedis*), occurring in the micaceous medium-grained sandstone characteristic of the assemblage. The first form shows a delicate erect rhabdosome with four orders of bifurcations, bearing closely-set lateral branches alternating on opposite sides. In spite of thecal details being unknown, the alternating pinnate arrangement of lateral branches allow a confident assignment to the dendrograptid genus *Ptilograptus* Hall. Based on other characters, the specimen shows close ressemblance with the Bohemian species *Pt. glomeratus* Počta, known from Dobrotivian to middle Berounian strata. Other similar records of the genus in peri-Gondwanan Europe are in the Ordovician of Sardinia and Portugal.

Whereas the previous fossil occurs as a flattened brownish carbonaceous film, a second specimen of "pinnate" appearance consists of an external mould of a different benthic colony preserved in semi-relief (probably pyritized). At first glance, it ressembles a *Ptilograptus*-like specimen of considerable size, with a single branched erect colony with thick cortical cover and long individual tubular metathecae. These aspects are somewhat reminiscent to those of some Cambrian Dithecodendridae (Graptolitina *incertae sedis*, partially reinterpreted as hydroids). The planar and feather-like colony also ressembles the possible hydroid *Webbyites* Kraft, Kraft and Prokop, known from the Lower Ordovician of Bohemia. However, this genus differs from the Moroccan specimen in that it has a robust main stem, considerably wider than the lateral branches. Finally, another possible related form is the enigmatic (and coeval) genus *Thamnograptus* Hall (Sinograpta), with dimorphic thecae and possibly planktonic habit. In the absence of vestiges of stolon material or recognizable minute thecae both in the stem and lateral branches, it is not possible to decide with certainty whether the Moroccan specimen is a hydroid or a graptolite. However, its record opens a new line of research on the rarest fossils of the Tafilalt Fossil-Lagerstätte.

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Ramified structures in the Upper Ordovician of Ougarta (SW Algeria); animal or sedimentary structures?

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The Ougarta range forms a NW-SE direction structure, about 450 kmlong and 200 km wide. It is made up of two subdivisions: Daoura in the West, and Saourain the East. Both subdivisions are separated by Erg Erraoui.

The Ougarta range is erected perpendicularly to the Panafrican suture zone, directly above the West African craton and below the Panafrican domain of West AfricanCraton.

Considered as an “aulacogene”by some authors, a peri-cratonic basin for others or as a dissymmetric rift, the basin having given birth to this range contains sedimentary stratadated from the Cambrian to the Upper Devonian.

The infilling of the basin comprisestwo successive sedimentary series: the Cambro-Ordovician oneis essentially detrital and is extremely poor in fauna;the Siluro-Devonian one consists in afullymarine,very fossiliferroussuccession.

Two phenomena characterize the end of the first series: one is climatic and the other one is tectonic. Indeed evidence for the Hirnantian (late Ordovician) glaciation(Hirnantian) are obvious and widespread in several places of the chain and in neighbouringareas.The indications of an instabilitycorrelated to the “Taconic” phase are also numerous, and consist in sliding structures or slumps, clefts in steps, folds and plans of faults.

We report here on he occurrence of well-organized, enigmatic, ramified structuresoccurring close to the Ougarta village, a few meters below the OugartaSandstones. Their origin remains so far unclear: ice-related structures or merely animal skeletal structures?

An unusual, high-diversity assemblage in the *A. murrayi* Zone (Late Tremadocian, Early Ordovician) of the Zagora area (Central Anti-Atlas, Morocco)

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In the central Anti-Atlas (Morocco), the Lower Ordovician series corresponds to a 1000 m-thick, monotonous succession consisting of fossiliferous argillites and siltstones (Fezouata Shale), capped by the sandstones of the Zini Formation (Destombes *et al*., 1985). In the last three years, the logging of the whole Lower Ordovician succession in the Zagora area provided a detailed biostratigraphic scheme based on both graptolites and acritarchs, as well as a well-defined palaeoenvironmental framework (Martin *et al*., in press). All levels yielding exceptionally preserved assemblages (Konservat-Lagerstätten) including the soft-bodied organisms of the Fezouata biota are restricted to a relatively short time interval (*A. murrayi* Zone and base of the *H. copiosus* Zone, late Tremadocian), and they are associated to relatively shallow environmental conditions, at or above storm wave base (Martin et al., *in press*). Almost all levels with exceptional preservation have yielded low-diversity assemblages, typically dominated by one or two taxa. In contrast, well-preserved, high-diversity marine assemblages (Konzentrat-Lagerstätten) occur in the upper part of the Fezouata Shale (*H. copiosus* Zone, latest Tremadocian, and Floian). They are associated with storm deposits in slightly shallower environmental conditions. No remains of soft-bodied organisms have been observed in these levels.

We are describing here an unusual, high-diversity assemblage observed in two sections, Oued Beni Zoli [Z-F5] and Tinzouline [Z-F5(2)], within the *A. murrayi* Zone. This assemblage is dominated by trilobites (e.g., *Agerina*, *Ampyx*, *Asaphellus*, *Ekeraspis*, *Parabathycheilus*, *Selenopeltis*, *Toletanaspis*) and glyptocystitid rhombiferans (*Macrocystella bohemica*), associated with bivalves, brachiopods, cephalopods, eocrinoids, gastropods, graptolites, hyolithids, solutans, somasteroids and stylophorans. In many respects, the composition of this high-diversity assemblage shows more similarities with younger assemblages from the latest Tremadocian (*H. copiosus* Zone) or the early to mid Floian, than to most other assemblages traditionally reported from the *A. murrayi* Zone. The levels yielding the Z-F5/Z-F5(2) assemblage correspond to a sea-level low stand, and thus, to slightly shallower conditions than other fossiliferous levels of the *A. murrayi* Zone. The strong similiarities with younger, high-diversity assemblages result from their occurrence in comparable environmental conditions.

On the other hand, several taxa particularly abundant in all younger, high-diversity assemblages are absent in both Z-F5 and Z-F5(2) (e.g., the mitrate *Balanocystites primus*, the eocrinoid *Balantiocystis regnelli*, the gastropod *Carcassonnella courtessolei*). Conversely, several taxa absent in younger, high-diversity assemblages are present in both Z-F5 and Z-F5(2) (e.g., the mitrate *Anatifopsis trapeziiformis*, a new species of gastropod). These small differences probably reflect changes through time in the composition of the successive communities, rather than differences in environmental conditions.

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The ontogeny in Ellipsocephalidae (Trilobita)

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Trilobites of the family Ellipsocephalidae are significant faunal components of Cambrian Series 2 and 3 trilobite associations. Their ontogeny remains, however, poorly known. To date, early ontogeny (i.e. protaspides and meraspides) is known in about twelve genera: *Alueva*, *Bergeroniaspis*, *Bergeroniellus*, *Ellipsocephalus*, *Ellipsostrenua*, *Hamatolenus*, *Kingaspidoides*, *Latoucheia*, *Lermontovia*, *Ornamentaspis*, *Protolenus* and *Strenuaeva*. Based on these taxa, it is possible to characterize the cranidial morphology of early stages of Ellipsocephalidae, as well as ontogenetic changes in their trunk region.

The smallest cranidia of Ellipsocephalidae are sub-rectangular to sub-elliptical in outline. They are characterised by a wide (tr.) anterior border, a short preglabellar field, a bi-lobed frontal glabellar lobe, crescentic palpebral lobes, prominent eye ridges andposteriorly directed intergenal spines. During subsequent ontogeny the changes in cranidial morphology include mainly prolongation and cambering of the preglabellar field, loss of bi-lobation of the frontal glabellar lobe and disappearance of intergenal spines.

The earliest post-protaspid stages of Ellipsocephalidae bear macrospines on the first two thoracic segments. The following post-protaspid ontogeny is characterised by a disappearance of macrospinous segments in the trunk region. Later stages show macrospines only on the second thoracic segment. Finally, morphologically mature specimens do not have, with some exceptions, any macrospines. Both the morphology of early cranidia and the juvenile thoracic morphology suggest that the family Ellipsocephalidae is closely related to members of the order Redlichiida rather than to the Ptychopariida.

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New insights on the Precambrian-Cambrian Boundary of Morocco.

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The Neoproterozoic-Cambrian transition corresponds to Ouarzazate (formely "PIII" of Choubert, 1963, Notes et Mém. Serv. Géol. Maroc, n° 162) and Taroudant (Infracambrian/Adoudounian of Choubert, 1963) Groups in the Anti-Atlas of Morocco. The beginning of the Cambrian is marked by the occurrence, in most fossil sites, of many external shell bodies, called "small shelly faunas" or skeletonized small fossils (SSF). These faunas are followed by the onset of trilobites. The base of the Phanerozoic *Eon*, Paleozoic *Era* and Cambrian *System* dated to 541.0 ± 1 Ma is defined in a coastal section near the town of Fortune in southeastern Newfoundland, Canada. The Global Standard Stratotype-section and Point, GSSP (Fortunian Stage) lies 2.4m above the base of Member 2 in the Chapel Island Formation, just above the transition to storm-influenced facies. The level is marked by the first appearance datum of *Trichophycus pedum* (International Commission on Stratigraphy, ICS, 2015). In the Neoproterozoic-Cambrian volcanic and sedimentary successions of Morocco, the SSF and archaeocyaths have not been found in either the Nematik-Daldynian or in the Tommotian. However, the lithostratigraphic data coupled with chemostratigraphy and high precision U-Pb zircon geochronology from volcanics in the same carbonates units have identified these stratigraphic intervals. In the Bas Draa inlier, Karaoui et al., (2015, Precambrian Res., 263, 43-58) clarified that the Ediacaran-Nematik-Daldynian boundary is dated at ca. 541 Ma and is located in the upper part of the Ediacaran (upper Ouarzazate Group) or in the gap between the Ouarzazate Group and Adoudou Formation. The lower limit of the Cambrian should be placed at the bottom of the Adoudou Formation. Regarding the boundary (Nematik-Daldynian)-Tommotian studied in western Anti-Atlas (Tiouit-Aguerd) by Maloof et al., (2010, Geol. Soc. Am. Bull., 38, 7, 623-626), it corresponds to 524.837 ± 0.092 Ma, located at the top of Adoudou Formation. The Jellyfish (Medusa) mentioned in the Lower Limestones (Maloof et al., 2005, Can. J. Earth Sci., 42, 2195-2216), would be of Nematik-Daldynian in age. The Lower Tommotian in Morocco is identified through chemostratigraphical correlations (Megaritz et al., 1991, Geology, 19, 8, 847-850). It corresponds respectively to the biozones with gastropods N. *sunnaginicus* -D. *regularis*, identified 400 km away in the Siberian platform in the reconstruction of the time (Parkhaev et al., 2011, Museum of Northern Arizona Bull., 67, 298-300). Comparisons of carbon isotope data $\delta^{13}C$ from the Anti-Atlas and Siberia show similar results. Thus, according to the available high precision U-Pb dating and the ICS, the trilobites *Eofallotaspis* of Morocco did not characterize the base of the Cambrian; instead they appear in the "Series 2" of Cambrian (Atdabanian and equivalents). The first archaeocyaths that appeared in Morocco are Atdabanian in age (Geyer and Landing, 1995, Beringeria Special Issue, 2, 7-46.). They emerged in the upper half of the Upper Limestones and continued to be present to the top of the Schistes and Limestones Series (Choubert, 1963; Sdzuy 1978, Geol. Mag., 115, 02, 83-94). Similarly, the work of Tucker (1986, Nature, 319, 48-50.) has located two organic productivity levels of the ocean whose second interval coincides with the Tommotian Atdabanian boundary, located in Upper Limestones where there is rapid change in metazoan and a second radiation of plankton.

An acercostracanmarrellomorph from the Early Ordovician Fezouata Biota, Anti-Atlas region, Morocco

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Marrellomorpha are a problematic group of Palaeozoic arthropods which were long believed to occupy a relatively basal position among deuteropods (Wills *et al.* 1995, 1998; Cotton &Braddy 2004; Van Roy 2006; Siveter *et al.* 2007). However, recent phylogenetic analyses (Legg *et al.* 2013; Legg in press) have resolved marrellomorphs as stem mandibulates. Within Marrellomorpha, two morphologically distinct orders can be distinguished (Rak*et al.* 2012; Legg *et al.* 2013; Legg in press): Marrellida are characterised by the possession of an elaborate spinose cephalic shield and the presence of two or three pairs of head appendages, while Acercostraca have a carapace covering the entire dorsal side of the animal, and five pairs of cephalic appendages.Acercostraca further contains two families, the Cambrian Skaniidae, and the Silurian-Devonian Vachonisiidae. Here we present anacercostracanmarrellomorph from the latest Tremadocian Fezouata Biota of southeastern Morocco (Van Roy *et al.* 2010). The new taxon is small and characterised by a cardioid dorsal carapace with a pronounced antero-median notch. The carapace has a median ridge expanding into a triangular node anteriorly, and a distinct marginal rim around its circumference. Ventrally, there is an anterior lacrimiform doublure, which is succeeded by a peculiar doublure-like structure composed of subrectangular to subtrapezoidal elements, which recall the secondary spines or serrations seen on the primary spines of the cephalic shield of marrellids. The head contains a pair of antennae and at least four additional pairs of appendages, while possibly up to 28 pairs of delicate appendages are present on the trunk. The Moroccan taxon presents a morphology which appears to be intermediate between Cambrian skaniids and Silurian-Devonian vachonisiids; in the most recent phylogenetic analysis presented here, the new Moroccan fossil resolves as the most basal vachonisiid, being sister to the Silurian *Xylokoris chledophilia*and the Devonian *Vachonisia rogeri*.

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Protection of geological sites in an urban area of Norway – results and future issues

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The two counties Oslo and Akershus cover an area of 5.372 km^2 (1.4 % of Norway) with a population of nearly 1.2 mill. (20 % of the total population). Central in these two counties is the Oslo rift structure, active from late Carboniferous and into the Permian. The Oslo fjord follows the rift fault lines. In the graben depression sedimentary rocks from the early Palaeozoic are preserved. Within the rift magmatic rocks (lavas and plutonic rocks) dominate and on both sides of the rift we find Precambrian gneisses. The last ice age has left its imprint on this landscape. Due to glacio-isostatic depression and rebound we find a marine limit of about 200-220 m above today's sea level and the occurrence of major glaciofluvial drainage has resulted in large areas with marine clays, now our main agricultural areas.
Geoconservation has been conducted here since the late parts of the 20th Century. Several protected areas have been established and can be classified as:

- Sedimentary rock sites, usually rich in Lower Palaeozoic fossils (natural monuments and nature reserves)
- Quaternary sites (gullies in marine clays, ice marginal features etc.) (nature reserves and landscape protected areas)
- General bedrock sites (lava flows, gneisses, mineral sites)

The priority in the 1970's – 80's and 90's was to establish the selected protected areas, but little effort was put into the management of them. The need for management has been given higher priority and master plans for management of protected areas are made and will guide the practical management. One project covering more than 30 protected geosites was finished in 2014, and a report was provided on how the management should be carried out. These sites are mostly stratigraphic (fossil) sites. The main problem on these sites is that they are gradually being overgrown and difficult to access and study. Most geological values are, however, intact, even if they are situated in areas with a high urban pressure and intense use as recreation areas. All sites are marked with governmental signposts, but the general level of information can be improved. The use of these areas and the urban pressure is still growing and the management faces a challenge to keep them in a good and hopefully even improved state for the future.

Cambrian gogiid eocrinoids from the Barrandian area (Czech Republic)

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Eocrinoids represent one of the main echinoderm groups in Cambrian associations (Sprinkle, 1973). It is a paraphyletic class of basal blastozoans (Sprinkle, 1973; Smith 1984). The class Eocrinoidea is characterized by the presence of brachioles, theca and stem.

Studied material is housed in the Palaeontological Department of the National Museum in Prague and in the Czech Geological Survey in Prague. These specimens have been collected from several outcrops and sections in the Jince Formation of the Příbram-Jince Basin, and from outcrops and one section in the Buchava Formation of the Skryje-Týřovice Basin. All studied material appears in siliciclastic sediments that, based on their trilobite content, are considered to be Drumian in age. Gogiid eocrinoids are usually preserved disarticulated in the Barrandian area (e.g. Prokop, 1960). Articulated specimens are rare and restricted to specific levels (Fatka et al., 2004). Some of the studied specimens are excellently preserved and provide the opportunity to study even the finest morphological details like internal and external surface of thecal plates, detailed morphology of sutural pores and brachioles.

Gogiid eocrinoids are the most diverse group of echinoderms in the Barrandian area. Three genera have been described so far: *Acanthocystites* Barrande, 1887; *Akadocrinus* Prokop, 1962 and *Luhocrinus* Prokop and Fatka, 1985. These genera share common features, like a bottle-shaped theca composed of numerous, irregularly arranged and variable in size thecal plates with our without epispires, straight brachioles with biserial plating pattern. The theca grades into proximal part of the stem which is provided by a distal attachment disc composed of polygonal plates. In addition, a new and as yet undescribed eocrinoid, with unique body plan organization has recently been found. This species represents a transitional form between lepidocystids and more derived gogiid eocrinoids.

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A new skeletal-dominated reef association of stromatoporoids and bryozoans from the Middle Ordovician of Korea

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Stromatoporoids and bryozoans are representative skeletal reef-building organisms from the Ordovician to Devonian. They began to take a reef-building role from the Early Ordovician in association with lithistid sponges, pelmatozoans, calcimicrobes, and microbialites, and flourished since the late Middle Ordovician affecting the major reef-phase transition from microbial- to skeletal-dominated reefs. Here we report a decimeter-scale patch reef primarily composed of stromatoporoids and bryozoans from the Duwibong Formation (Darriwilian, late Middle Ordovician), Taebaeksan Basin of Korea (North China Platform), eastern Gondwana. The reef is constructed by numerous centimeter-scale columns and masses made up of ragged thin laminae consisting of stromatoporoids (34%), bryozoans (16%), probable calcimicrobes and algae (4%), and siliceous sponge (<1%). The remaining portion is allocated to sediments (3%) and uncertain part (42%) due to poor preservation. Stromatoporoids (*Cystostroma* sp.) are poorly preserved in general but the skeletons composed of extraordinarily small vesicular cyst plates are recognizable in parts.

The bryozoans, identified as a *Nicholsonella* sp., are characterized by indistinct granular walls and abundant acantho- and mesozooecia. The layers of stromatoporoid and bryozoan frequently alternate, forming globular to extended-bulbous masses which are key features of the Duwibong reef. Calcimicrobes and algae sporadically occur as tiny patches or thin encrusting laminae. Siliceous sponges commonly fill the bored space on the reef frameworks, but it is not clear whether these sponges were the bioeroder responsible for these borings or mere dweller. The reef-building consortium of stromatoporoids and bryozoans has not been known from the Ordovician so far; such composition widely occurs in the mid-Paleozoic reefs. It is suggested that the Duwibong reef was a forerunner of the Siluro-Devonian reefs which were dominated by stromatoporoids, corals, and bryozoans.

A new aglaspidid euarthropod with a six-segmented trunk from the Lower Ordovician Fezouata Konservat-Lagerstätte, Morocco

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AglaspididaWalcott, 1912 (= Aglaspididas*ensustricto*[1]) represents a major and fairly diverse – yet historically problematic – group of Lower Palaeozoic euarthropods distinguished by a phosphatic cuticle, and a pair of postventral plates in the trunk. Aglaspidid fossils are remarkably rare, and the paucity of well-preserved material often makes it difficult to recognize new species that may provide additional information on the evolutionary history of these enigmatic euarthropods. Here we report a new taxon from the Lower Ordovician (BouChrebeb locality, uppermost Tremadocian *Hunnegraptus copiosus* biozone) FezouataKonservat-Lagerstätte in Morocco. The presence of postventral plates under the posteriormost trunk tergite and the base of the tailspine, indicates a clear evolutionary relationship with Aglaspidida. The overall morphology of the new taxon most closely resembles that of the 'Ordovician-type' aglaspidids [2], more specifically the late Cambrian - Early Ordovician genus *Tremaglaspis* [3]. Its prominent cephalic shield and the presence of only six trunk tergites, however, deviate from the organization of all other known aglaspidids, notably extending the known range of morphological disparity of the group. The presence of less than 11 trunk tergites in the new taxon and the Ordovician species of *Tremaglaspis* [3] suggests a trend towards reducing the number of trunk tergites in post-Cambrian aglaspidids. These findings confirm the suggestion [1] that the body plan of aglaspidideuarthropods was much more variable than previously estimated from the study of Cambrian representatives alone.

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Cambrian trilobites of northern Victoria Land, Antarctica: diversity and faunal affinity

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Antarctica was part of East Gondwana during the Cambrian, and the Transantarctic Mountains, formed during the Cambro-Ordovician Ross Orogeny, were located along the eastern margin of Antarctica. Due to limited accessibility and the relatively small number of specimens available for study, the faunal affinities of trilobites from Antarctica with other parts of the world have been less studied. Cambrian trilobites from the Transantarctic Mountains were reported from only a few spots of the Central Transantarctic Mountains (CTM) and northern Victoria Land (NVL). The Cambrian trilobites of the CTM occur from the Cambrian Series 2, and in a previous study they were compared with faunas from around the world: i.e. South China, Australia, Morocco, Spain, and Siberia. In NVL, the Cambro-Ordovician successions are distributed in the Bowers Terrane which was part of an arc-backarc system. The Cambrian trilobites of this area occurr mostly in strata ranging in age from the Cambrian Series 3 to the Furongian. Previously reported and new material acquired during the 2012–2013, 2013–2014, and 2014–2015 field seasons includes 98 species in 64 genera. Contrary to the trilobites from the Cambrian Series 2 of the CTM, these trilobites have been interpreted to show affinities only with east Gondwana, including Australia, South China, and North China, with the closest affinity with Australia. This result is seemingly contrary to the notion that the Cambrian Series 2 trilobites show a stronger provincialism than those from the Cambrian Series 3 and Furongian. However, for the trilobites from the CTM, comparisons with other trilobite faunas worldwide were based on only a limited number of available specimens and were further influenced by spot-sampling without adequate stratigraphic data; hence, a more detailed analysis using larger and better documented collections may still reveal a more-or-less strong provincialism. Interestingly, material newly collected during the 2011–2012 seasons by a joint expedition of Sweden, Australia, and U.S.A. contains components similar to the Cymbric Vale fauna of New South Wales, Australia, which was located right next to Antarctica during the Cambrian. Likewise, the trilobites from the Cambrian Series 3 and the Furongian of NVL may show a closer faunal affinity with other parts of the world, rather than Australia: e.g. *Liostracina simesi* was reported only in northern Victoria Land and Korea, and *Placosema* occurred in Antarctica, South China, and Korea.

Unusual eocrinoid (?) stem and columnals from the Late Cambrian of Northern Iran

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Limonitized echinoderm ossicles looking like small simple holdfasts from the upper Cambrian (Furongian, Mila Formation, Member 3) limestone of section Shahmirzad in North Iran, Alborz Mountains were collected firstly by A. Zhuravlev (Kruze & Zhuravlev, 2008). Small sizes (diameter 2-7 mm, height to 5 mm), low conical form, wide plain or a little concave upper (proximal) surface contrary to convex narrow lower (distal) part make these ossicles similar to the inverse typical primitive holdfasts of some Cambrian and Ordovician eocrinoids. Thus, the ossicles were first interpreted as holdfasts (Rozhnov, 2001). Zamora *et al.* (2009) described similar ossicles as columnal type A and interpreted them as possible columnals. They were found in the Furongian Valtorres Formation of Encomienda valley, Iberian Chains (NE Spain). The reconstruction of the echinoderm with such ossicles became more exact now after the new detailed study of the locality Shahmirzad, new numerous specimens of the ossicles and study of the unusual stem with theca fragment. Stereom-like microstructure of the ossicles testifies to echinoderm nature of the ossicles. Stem from this locality constructed partly by such columnals directly proves that the disarticulated holdfast-like ossicles are columnals and helps to describe some details of that unusual echinoderm. Stem is preserved almost completely excluding small distal part and consists of four nodal columnals similar to the holdfast-like disarticulated columnals from this locality. Nodal columnals of the stem are joined by the stacks of very low narrow cylindrical columnals. The sizes of the nodals diminished rapidly in the distal direction: the diameter of the upper surface of the proximal nodal columnal is 5,5 mm and diameter of distal one is 2,5 mm. The height of the proximal nodal is 3,5 mm and height of distal is 2,0 mm. The diameter of badly preserved internodal columnal stacks averages near one fifth of the nodal diameter, and height of internodal stacks is near four fifth of nodal columnal height. Proximal (upper) surface of the nodal columnals is plain or a little concave with small bordered aperture of axial canal in the center. Axial canal is narrow. Proxistele (height 6mm) starts in the center of most proximal nodal columnal. It is formed by low narrow columnals gradually enlarged to the basis of the theca. Distal diameter of the proxistele is 1,2 mm and proximal diameter near the basis of the theca is 1,8 mm. Theca has the form of a tall cone and has been arranged by large plates judging by preserved part of basal plates and some plates of the next circle. It is possible to suppose that this stemmed echinoderm during life rose above the ground not more than 6-7 cm. Thus, the animal occupied the main and the most common tier in the typical Cambrian benthic tiering. Conical form of the nodal columnals helps to hold the stem in the water column. From a morphogenetic point of view, formation of such columnals could be due to the process of the serial periodical repetition of the holdfast.

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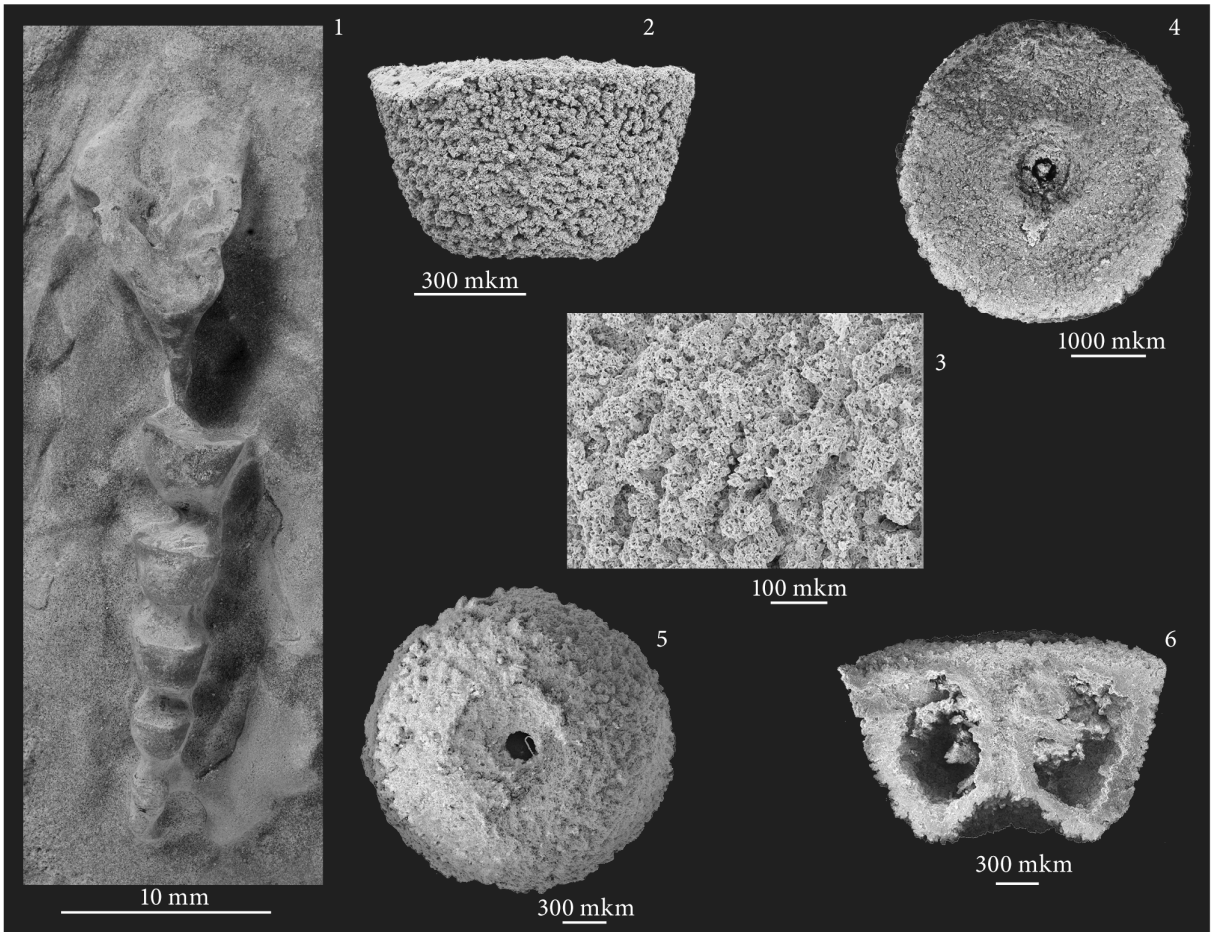
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New echinoderm fauna from the Upper Cambrian Davis Formation (Furongian) of Southeastern Missouri, Central USA

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A large echinoderm fauna has been recovered from exposures of the Upper Cambrian Davis Formation (Furongian, *Elvinia* Zone) near Bonne Terre and Elvins, Ste. Francois Mountains, southeastern Missouri, USA. The Bonne Terre locality has produced a single, large, stemmed, eocrinoid theca and over 100 one-piece, distal holdfasts attached to flat-pebble conglomerate beds and large domal stromatolites. The nearby Elvins locality has produced a larger echinoderm fauna from washed shale samples consisting of: a new stalk-bearing edrioasteroid represented by about 120 partial thecae and stalks plus numerous disarticulated ambulacral, mouth frame, and cover plates; a new stylophoran represented by over 1200 separate marginal plates, partial aulacophores, and stylocones; and seven conical stalks or partial specimens of a medium-sized, enigmatic echinoderm.

The Davis fauna is the largest Furongian echinoderm fauna now known, but has only four genera, thus resembling other Late Cambrian faunas. Echinoderms occur with trilobites, articulate and inarticulate brachiopods, small gastropods, and hyolithids in an alternating shale and limestone interval in Unit C of the Davis Formation. This fauna lived on a stable tropical shelf or platform near isolated granitic islands in a fairly quiet, shallow-water environment with alternating coarse clastics and carbonate mud.

The single eocrinoid has an ellipsoidal theca with numerous, polygonal plates, short ambulacra extending down the theca bearing several small brachioles alongside, and a slowly tapering, columnal-bearing, proximal stem slightly longer than the theca. It is preserved on a flat-pebble conglomerate bed, and was probably attached to one of the pebbles until broken off and buried with the many still-attached, distal holdfasts.

The new edrioasteroid is convergent on stalk-bearing Middle Cambrian eocrinoids such as *Gogia* with an elongate theca and conical stalk. However, its ambulacral system extended much further down the theca, and lacked their erect brachioles. This new genus has an edrioasterid ambulacral system with internal pores resembling the Middle Cambrian genus *Totiglobus*, but differs in its thecal shape, basal attachment structure, location of the anal pyramid, and number of cover plates sets protecting the ambulacra.

No complete specimens of the new stylophoran have been found in the Davis shale samples because the flattened theca bearing tiny-plated central areas easily disarticulated. However, examples of all the marginal thecal plates have been identified and used to make a reconstruction, along with a few articulated proximal aulacophores, about 600 stylocones, and over 100 distal aulacophore segments, some with articulated cover plates. It is provisionally assigned to the Family Cothurnocystidae, based on the presence of sutural pores (cothurnopores). The reconstructed thecal plating shows a modified heart-shaped theca, prominent spine on M3, zygal not connected across the theca, and only 2 adorals. This new stylophoran is probably related to the Middle Cambrian to Early Ordovician genera *Ponticulocarpus*, *Cardiocystella*, *Phyllocystis*, and *Cothurnocystis*.

The medium-sized, enigmatic echinoderm has a rounded-conical, attachment base with small, irregular plates and larger, polygonal plates in vertical attached columns at the top. The largest specimen has a higher, tegmen-like structure bearing irregular plating folded over the summit and back of the theca. This partial echinoderm resembles the wide, conical stalk and lower theca of the Middle Cambrian eocrinoid *Gogia guntheri*.

Early Tremadocian phosphatized fossils from the Öland Island (Sweden)

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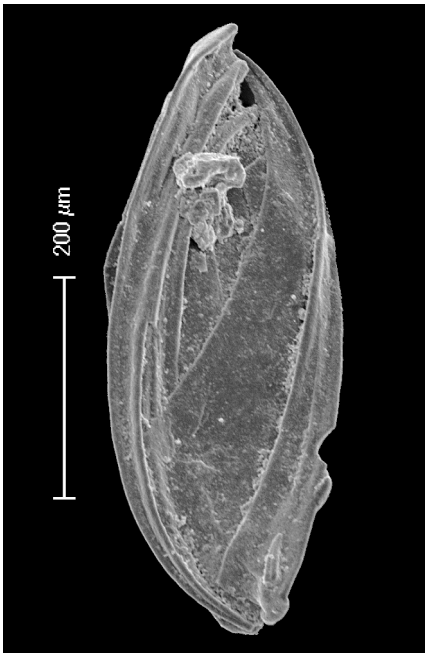
The occurrence of exceptionally well preserved early Tremadocian phosphatized fossils on the Öland Island (Äleklinta region) has been known for many years (Andres 1989). The fossils represent some different systematic groups but not all of them are well recognized yet. The cited author shortly described two groups of arthropods. One of them closely resembles the extant, soft bodied parasites Pentastomida, and most probably represent their marine ancestors. Similar pentastomids, of slightly different age, became later recognized in different localities. The second group of arthropods are very small crustaceans of unknown affinities, but certainly different from those known from the Upper Cambrian "Orsten" of Sweden. The soft bodied fossils are represented also by numerous, small, rounded and elongated forms resembling embryos and larval forms. Other phosphatized fossils occurring in the locality are the grasping apparatuses of chaetognaths and the conodont-like elements and apparatuses of "coelocerodonts" (Szaniawski 2015). The grasping spines and apparatuses of chaetognaths are common in the Cambrian and Early Ordovician deposits. They are usually treated as protoconodonts and assigned to the genus *Phakelodus* Miller. However, in the discussed locality in addition to the typical apparatuses of chaetognaths similar to them apparatuses which are more similar to those of the conodont genus *Coelocerodontus* Ethington are present (see the figure). Separate "coelocerodont" elements are very common in the locality. Similar apparatuses are known only from the Cambrian-Ordovician transitional section in Malyi Karatau (Kaazkhstan). That suggests that they can be preserved in very special conditions only. It is probable that outer layer of the elements have been composed of chitin, similarly to the grasping spines of chaetognaths and because of that became similarly phosphatized.



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Asterozoan pedicellariae and ossicles revealed from the Middle Ordovician of Baltica

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Asterozoans are an abundant and diverse group of Echinodermata, which, however, have left behind a rather poor fossil record. The main reason for that is their peculiar skeleton, which consists of thousands of mesodermally produced discrete ossicles. These ossicles, although tightly linked in the dermal layer during animal's lifetime, break up soon after disintegration of soft tissues.

Isolated asterozoan ossicles and pedicellariae were revealed in micropalaeontological samples from the Middle Ordovician (Darriwilian) of the Mishina Gora section, North-West Russia. The well-preserved *Bursulella unicornis* type fossils represent the oldest hitherto record of asterozoan pedicellariae. The accompanying ossicles do not tell the precise taxonomic position of the fossils, but allow their tentative placement within the stelleroid stem group, the Somasteroidea. The abundance of disarticulated ossicles in the samples proves that asterozoans were not as rare as they have been considered and were important members of the Ordovician ecosystems

The width of the isolated valves of pedicellariae found in the Mishina Gora section falls between 0.6 up to 2 millimeters and consist of triangular base and a single spine. On the inside the spine shows a fine groove running along its median part. The maximum height of the spines of the studied specimens is 0.6 mm, but on some specimens clear breakage scar can be seen, indicating that the maximum length might be longer. Internally, one side of the valve is lined with robust serration that extends from the lowest part of the base up to the end of the spine. Most pedicellarial valves are asymmetric. Some, mostly smaller specimens show slightly (about 10 degrees) inclined spine, while the degree of asymmetry of the others depends of the outline shape of the base. The wide base of the valve is slightly concave.

At present, before further finds of complete specimens with attached pedicellariae, it is not possible to decide with any degree of confidence, whether the described specimens represent the same asterozoan family or not. Besides pedicellariae the samples yielded also a number of disarticulated asterozoan ossicles with complicated morphology, which however, do not allow systematic arrangement neither.

The finding of asterozoan pedicellariae in the Ordovician sediments has one more aspect besides the taxonomic importance. The pedicellariae offer formidable defence against ectoparasites and other small pests that would like to colonise the spine canopy on the echinoderms. Thus the finds of pedicellariae could also be regarded as an indication of much higher faunal diversity than it is evident from the fossilizable faunal record, and perhaps also the presence of parasitic interactions in the ecosystem.

A euarthropodof uncertain affinity from the Early Ordovician Fezouata Biota, Morocco

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The latest TremadocianFezouata Biota is host to a highly diverse arthropod fauna, containing a range of Burgess Shale-type taxa together with considerably more derived, typically post-Cambrian forms (Van Roy 2006; Van Roy &Tetlie 2006; Van Roy *et al.* 2010, 2011, 2015, in press). This varied fauna also includes several arthropods of uncertain affinity. Among those is a single specimen with a strongly vaulted ovoid shield covering the entire dorsal side of the animal. The shield has a delicate dimpled ornament and shows no signs of segmentation, apart from the presence of a short, narrow, sharply delimited, annulated posterior axis. On theanteriormost margin of the shield, a pair of small eyes may be present. The virtual absence of flattening or any other kind of deformation, together with its preservational mode, suggest that the shield probably was thinly mineralised.An interpretation of the dorsal cover as a carapace, i.e. a posterior extension of the cephalon, as in acercostracans (Van Roy 2006; Legg in press) seems implausible due to the presenceof a clearly defined annulated posterior axial region.While the size of the Moroccan taxon (ca 25 mm long) would seem to militate against its interpretation as a larval stage, its peculiar morphology suggests that it may represent a highly paedomorphic form in which no free segments were released during ontogeny. The new fossil shows some similarity to the atypical burlingiid *Schmalenseeia fusilis* (Peng *et al.* 2005), in that both possess anundivided biomineralised dorsal shield covering the body. However, there are also significant morphological differences between both taxa, and in the absence of any information on the ventral anatomy of the new Moroccan arthropod, its systematic positionwithin Euarthropoda currently remains uncertain.

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A specialised predatory anomalocaridid from the Early Ordovician Fezouata biota, Morocco

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Anomalocaridids are a major clade of lower stem-euarthropods (Budd 1996; Cong *et al.* 2014; Daley *et al.* 2009; Kühl*et al.* 2009; Ortega-Hernández 2014; Van Roy *et al.* 2015; Vinther*et al.* 2014), which, until recently, were considered to have disappeared after the middle Cambrian: the Fezouata biota from the Early Ordovician of Morocco has provided the first undoubted post-middle Cambrian anomalocaridid record, and is home to at least five different taxa (Van Roy & Briggs 2011; Van Roy *et al.* 2014, 2015). While generally regarded to have been fierce apex predators, the wide morphological variation exhibited by the grasping appendages of different taxa is testimony to their ecological diversity (Daley and Budd 2010), with some forms having been filter-feeders (Vinther*et al.* 2014; Van Roy *et al.* 2015). Here we present a new large hurdiid with a highly specialised predatory morphology. The robust appendage is ca 10 cm long and consists of eightpodomeres. Uniquely, thebluntly rounded terminal podomereislargely surrounded by the expanded preceding podomere. Massive ventral spines with a strongly pro-curving tip are present on podomeres 2-8. The spines become shorter anteriorly and are wider than thepodomeres to which they attach, causing them to overlap when the appendage is contracted. Each ventral spine carries massiveauxiliary spinesmodified into robust teeth on its anterior margin, and has a thin, sharp edge alongits posterior margin. An isolated large, triangular central carapace element with a pronounced median ridge may belong to the same taxon.The overlap and sharp posterior margin of the ventral spines of the appendage would have allowed them to function like scissor blades, shredding soft-bodied and weakly sclerotized prey. This highly specialised morphology is further evidence of the ecological diversification prevalent among anomalocaridid taxa in general, and hurdiids in particular. In this respect, it is interesting to note that the Fezouataanomalocaridid fauna is dominated by ecologically diverse Hurdiidae, with fossils of Anomalocarididae being exceedingly rare (Van Roy *et al.* 2014).

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