The Early Cretaceous evolution on the Morocco Atlantic Margin: establishing an integrated stratigraphic framework and depositional model for the Berriasian to early Barremian interval

PhD Candidate: Orrin Bryers

Supervisors: Prof. Jonathan Redfern, Dr. Luc Bulot, Dr. Stefan Schroeder & Prof. Giovanni Bertotti (TU Delft)

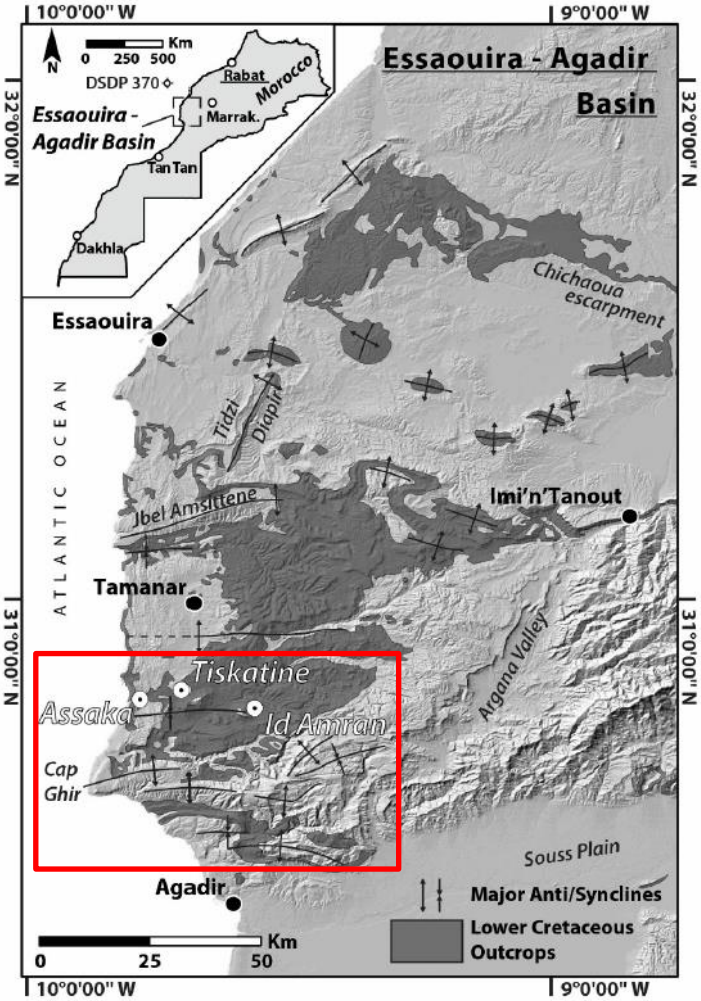
North Africa Research Group
www.narg.org.uk

PhD Overview

- New NARG multi-disciplinary project for 2018 in the Essaouira-Agadir Basin (EAB), Morocco
- Key aim is to build an integrated stratigraphic framework for the Berriasian to early Barremian intervals in the Essaouira-Agadir Basin using an integration of ammonite, calpionellid, nannofossils and smaller benthic foraminifera biostratigraphy, sequence and chemo-stratigraphy
- A second major aim is to characterise and improve our understanding of the early Hauterivian reefs in the EAB
- The project will also consider salt-tectonic movements that may be associated with hiatuses and condensed intervals in the E. Cretaceous
- Results will be tied with recent NARG studies carried out on the late Barremian to early Albian in the Agadir region and also to global type sections

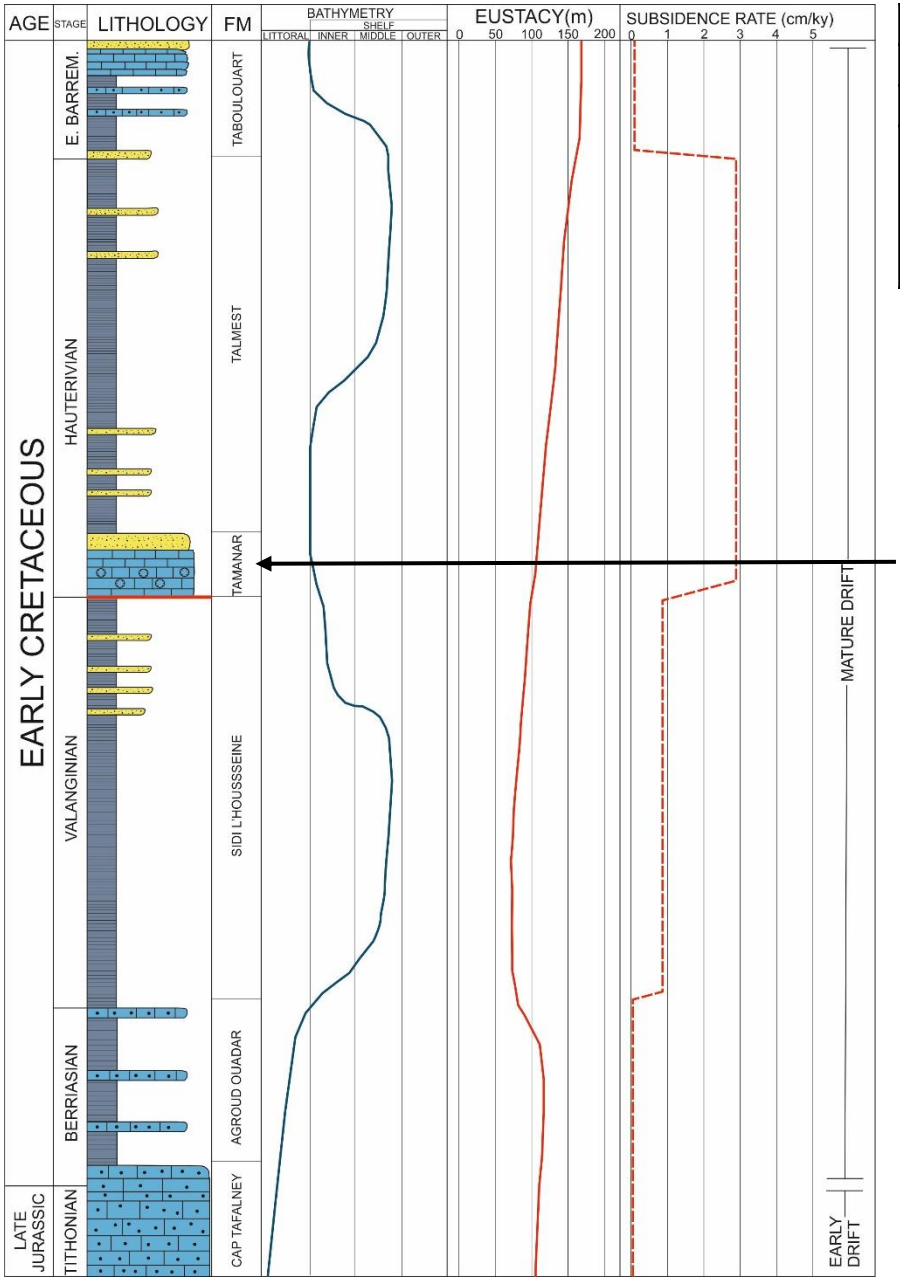
Essaouira-Agadir Basin

- Formed as a result of continental rifting in the Permo-Triassic (Duffaud et al 1966)
- Bound by highs/provenance terranes in the north by the Meseta, The Jebilet to the south and the Massif Ancien de Marrakesh to the east.
- Separated into 3 sub-basins; Essaouira, Haha and Agadir.
- Due to successes further south in the Mauritania-Senegal-Gambia-Bissau-Conakry (MSGBC), the offshore Morroco Atlantic margin is a focus for hydrocarbon exploration.



Red box – outline of main study area for this PhD (map from Luber, 2018)

Essaouira-Agadir Basin – E. Cretaceous Summary



Major shallowing trend

R

T

Major deepening trend

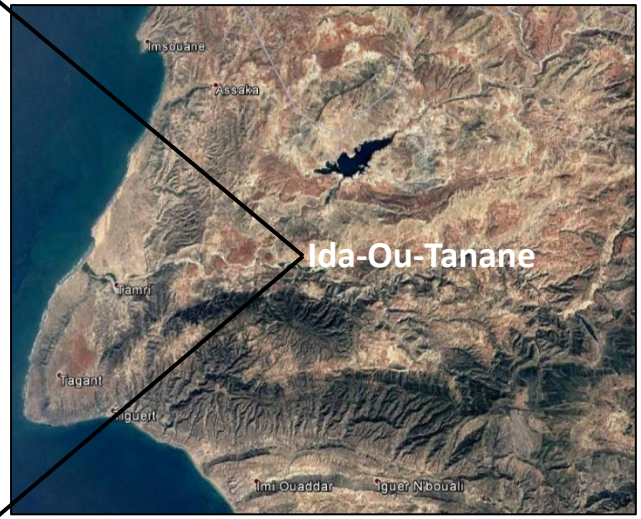
Early Hauterivian reefal facies

Formation	Thickness (m)
Cap Tafelney	15-40
Agroud Ouadar	20-70
Sidi-Lhousseine	27-70
Tamanar	35-50
Talmest	100-125
Taboulouart	50

(Modelled from Butt, 1982; Zuehlke, 2004 & Luber, 2018)

Early Hauterivian Reefs

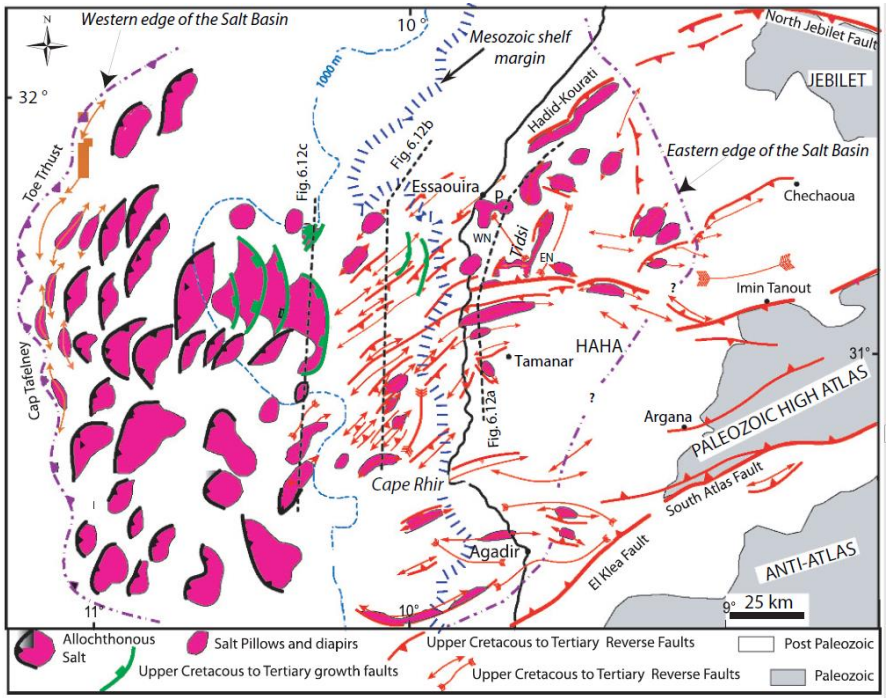
- Tamanar Formation– reefal (coral-rich) limestones, bioclastic carbonates and an upper interval with lagoonal oolitic shoals and clastic sand influxes.
- Limited knowledge exists on the architecture and extent of the reefs, requires extensive field mapping and logging.
- Useful to understand how the reef palaeotopography affected the clastic input basinward, both during and after their existence.



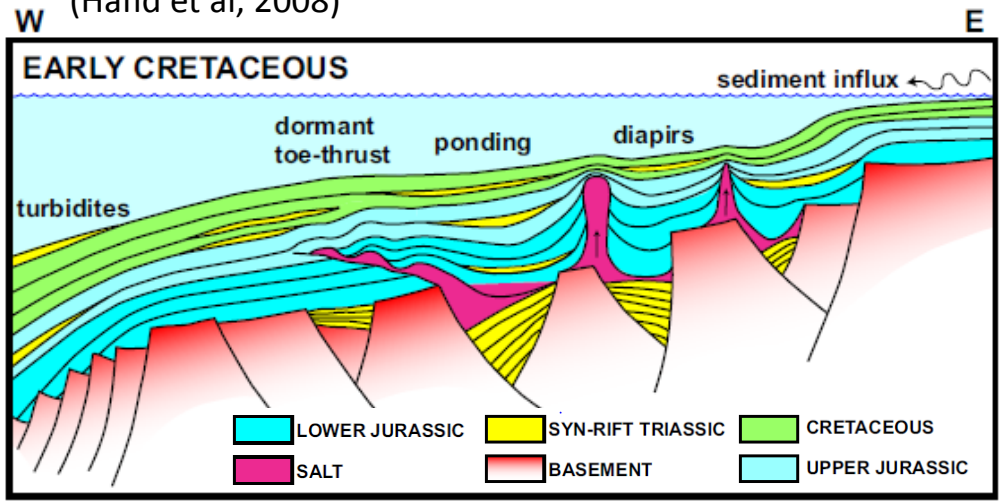
(Pictures courtesy of Tim Luber)

Salt Tectonics

- Triassic syn-rift related salt that occurs both onshore and offshore in the EAB could be linked to the notable hiatuses observed in the early Cretaceous (e.g. at Tamri)
- Also important when considering the influence of salt-tectonic movement on the behaviour of sediments flowing from the margin into the basin and therefore the deposition of potential reservoir sands



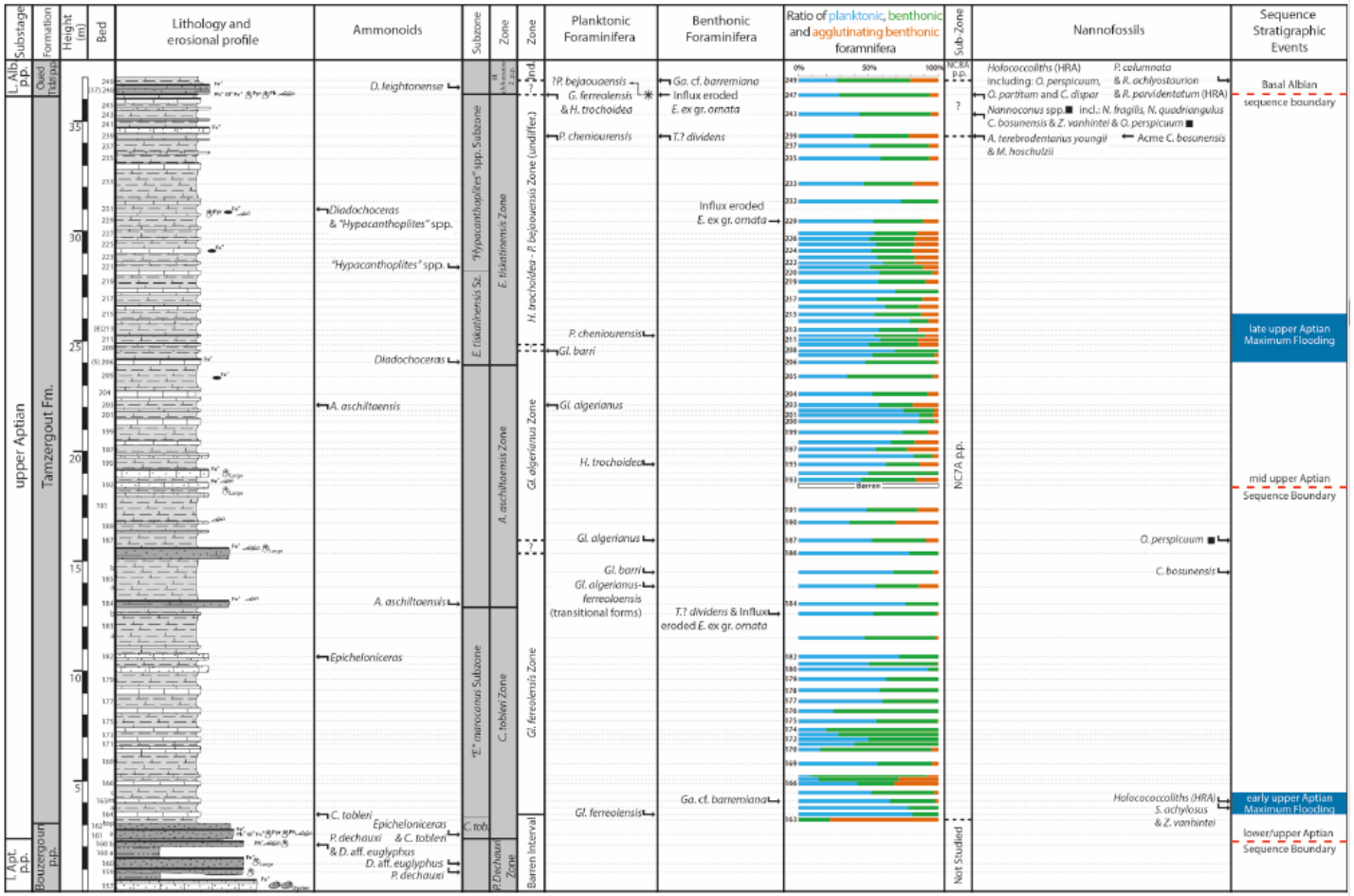
(Hafid et al, 2008)



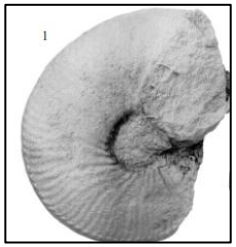
(Tari & Jabour, 2013)

Project Methods - Biostratigraphy

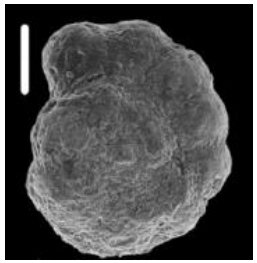
- Biostratigraphic field techniques: bed-by-bed high resolution sampling of chosen sections from Berriasian to early Barremian and subsequent analysis of samples collected to build reference framework by age-correlating these sections



(Luber, 2018)



Ammonite (Wippich, 2001)

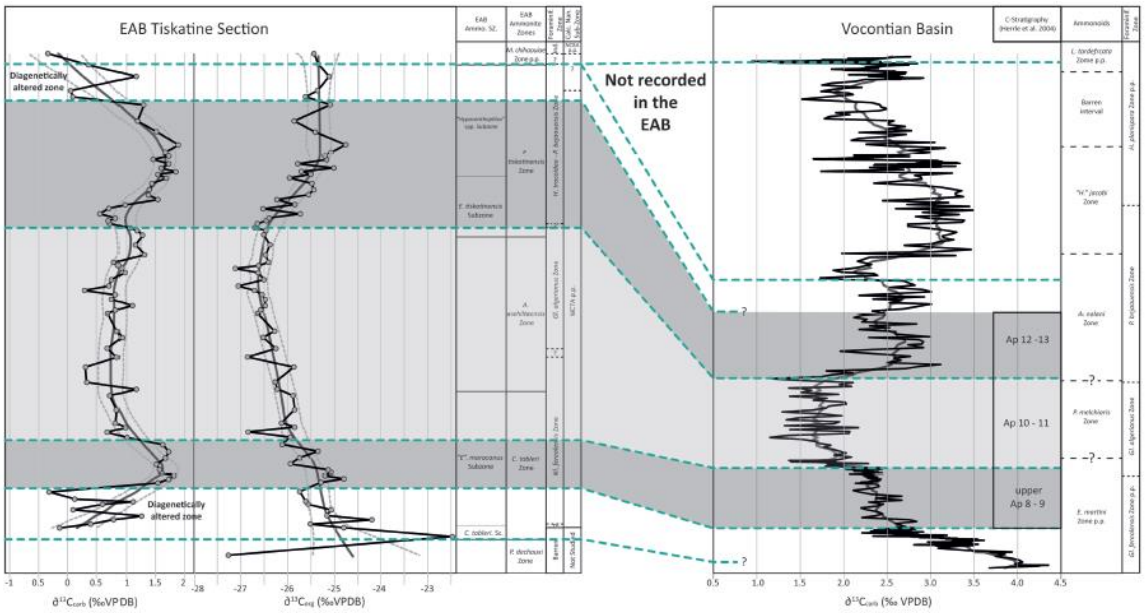


Planktonic foraminifera (Luber, 2018)

Calpionellid (Lakova et al, 1999)

Project Methods - Chemostratigraphy

- C13/O18 isotope chemostratigraphy: collect bulk rock samples and use mass-spectrometry for analyses. This will contribute towards completion of early Cretaceous isotope curves in the Essaouira-Agadir Basin and the correlation to the global curve

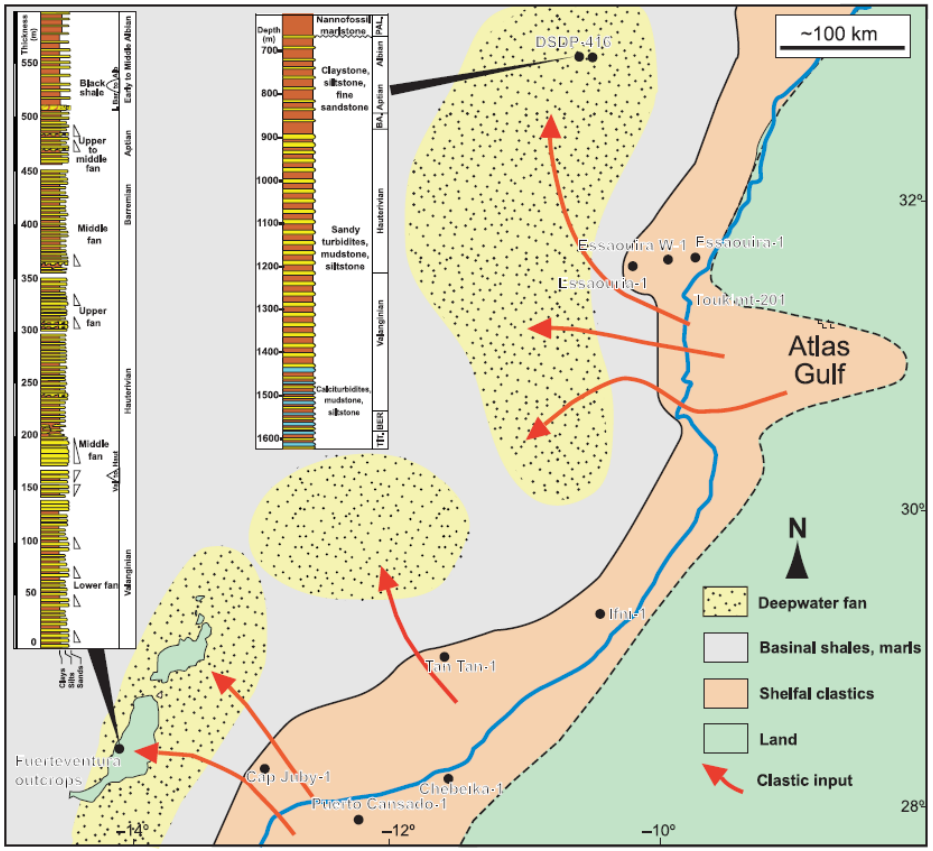


(Example of chemostratigraphic correlation based on Aptian onshore outcrops in the EAB by Luber, 2018)

Mass spectrometry lab(Google images, 2018)

Project Methods – Well Data Analysis

- Cuttings, core and wireline log analysis: accessible well logs and cuttings and/or core will provide a unique and insightful comparison of onshore and offshore stratigraphy. Stratigraphic calibration will be critical for future exploration attempts
- Methods to be integrated with sequence stratigraphic interpretation to build a comprehensive early Cretaceous framework.



(Predicted deep-water fan locations for early Cretaceous based on several offshore wells, Tarietal et al, 2012). Top pictures from Google Images.

Field Season 2018

- October 14th- 8th November 2018
- Joined by Luc Bulot (supervisor) for entirety of trip and periodic stays from Max Casson (NARG PhD), Tim Luber (Equinor), Mousa Masrour (University Ibn Zohr).
- Aim to build key biostratigraphic reference sections for the Berriasian to early Barremian in the region north of Agadir.
- Meeting with Prof. Mohssine Ettachfini at Cadi Ayyad, Marrakesh, to discuss early Cretaceous outcrops
- 16th→27th October: reconnaissance and sampling/logging of southern sections (approx. 20km north of Agadir)
- 28th Oct→07th Nov: reconnaissance and sampling/logging of northern (Tamri/Assaka) sections

Planned Study Locations

1 – Aouerga (Berriasian → Hauterivian)	**2 – Ain Hammouch (U. Jurassic→ Barremian)**	**3 –Alma (Valanginian → Hauterivian)**	**4 – Assaka (U. Berriasian→L.Hauterivian)**
5 – Tamri (Berriasian→U. Hauterivian	Key objective: create biostratigraphic reference sections		

Recent Work

- Ferry et al (2007) field excursion on the early Cretaceous has formed a good background to help this research project on choosing key reference sections
- Highlights the lateral variations in thickness between inland and coastal sections.

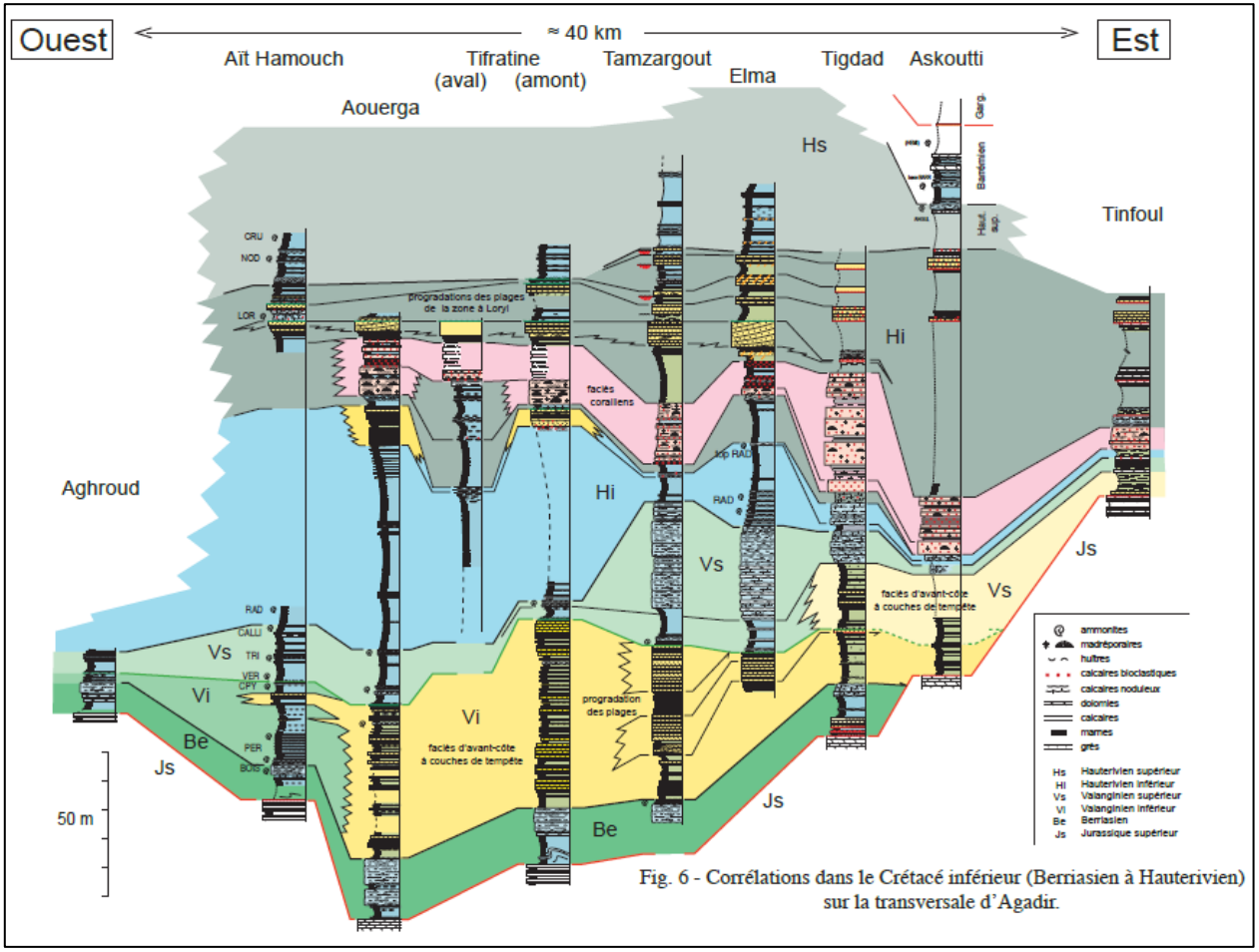
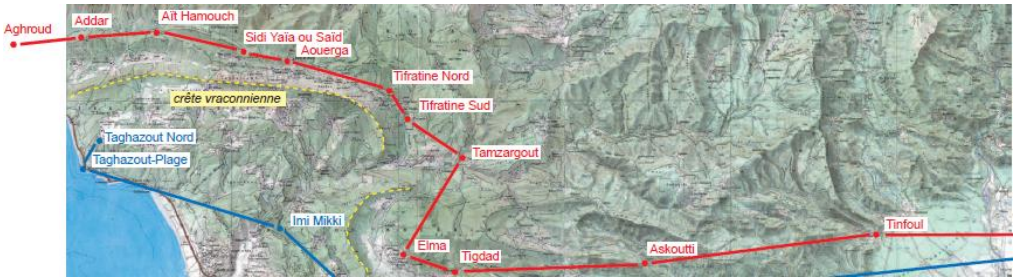


Fig. 6 - Corrélations dans le Crétacé inférieur (Berriasien à Hauterivien) sur la transversale d'Agadir.



The University of Manchester

North Africa Research Group
www.narg.org.uk

Thank you

Questions?