

## Triassic syn-rift reservoir architecture – linking across the Atlantic conjugate margin (Fundy Basin, Canada; Essaouira Basin and Argana Valley, Morocco)

Nadine Mader-Kayser<sup>\*/\*\*</sup> & Jonathan Redfern<sup>\*\*</sup>

<sup>\*</sup>NARG (North Africa Research Group), Manchester University & <sup>\*\*</sup>Argana Geo AS

### Summary

Since the late 1950's the offshore basins of Eastern Canada have been subject to hydrocarbon exploration, but despite this long exploration history, large areas of the shelf remain practically unexplored. The Triassic syn-rift sequences, for instance in the Scotian Basin and its' corresponding sub-basins, have been penetrated by only four exploration wells to-date. On the opposite Atlantic margin in Morocco, time equivalent Upper Triassic syn-rift sequences are proven hydrocarbon reservoirs, for example in the Essaouira Basin. Although charge can be a challenge, the Triassic has been a successful hydrocarbon play in similar settings along the northern Atlantic margin in the North Sea Basin, particularly successful where the Jurassic source rocks are directly juxtaposed against the Triassic reservoirs, or like in Morocco, where a Paleozoic petroleum system is working.

This study aims to provide a synthesis on reservoir architecture of this potentially prolific hydrocarbon play in the Eastern Canadian offshore realm, based on analogues from the onshore exposures of the Fundy Basin in Canada, and the Essaouira and Argana Basins in Morocco (figure A, B). Examples from both high-resolution outcrop studies as well as subsurface core analysis are presented, to highlight the complex facies distribution in these continental fluvio-aeolian settings (figure C-D). The climatic impact on reservoir distribution will further be addressed particularly in view of its correlation potential.

### Theory / Method / Workflow

This study of Upper Triassic (Carnian-Norian) continental fluvio-aeolian reservoirs builds on the comparison of time and facies equivalent siliciclastic deposits within geographically separate basins that developed on the super continent Pangaea (figure A-B). The Fundy, the Essaouira and the Argana Basins developed on either side of the expanding Proto-Atlantic seaway and document deposition within relatively narrow rift-basins exhibiting initial half-graben morphologies (Van Houten, 1977; Manspeizer *et al.*, 1978; Stets & Wurster, 1981; Laville & Petit, 1984; Beauchamp, 1988; Piqué & Laville, 1996; Piqué *et al.*, 1998; Labeils *et al.*, 2010; Redfern *et al.*, 2010; Baudon *et al.*, 2012; Loudon *et al.*, 2012; Leleu *et al.*, 2010; 2016). Due to their postulated proximity at time of deposition as well as their location along the same paleo-latitude, climatic overprint can be assumed to be comparable, potentially introducing an additional means of correlation in these otherwise barren sequences.

The Upper Triassic sediments (Newark Super-Group) on the Canadian margin are exposed along the coastline of the modern Fundy and Minas Basins. Detailed high-resolution mapping of architectural elements, bounding surfaces and reservoir facies was undertaken on the coarse, fluvially dominated Wolfville Formation and the overlying cyclical playa mudstones of the Blomidon Formation. Two core intervals located in the Annapolis Valley were integrated which provided valuable information regarding facies distribution and investigated cyclicities in the area towards the West. In the Argana Basin (Morocco) detailed outcrop studies focused on the Bigaoudine Formation (T6, TAGI equivalent), while core analysis was carried out on subsurface core of the Meskala field in the onshore part of the Essaouira Basin in Morocco (Mader, 2005; Mader & Redfern, 2011; Mader *et al.*, 2017).

## **Results, Observations, Conclusions**

Comparing the Fundy, Essaouira and Argana Basins on a regional scale, it can be noted that although closely located to each other during deposition, general facies trends vary. Both the Fundy and the Argana Basins show evidence for an intra-continental sedimentary sequence close to the sediment source, while Essaouira represents the more distal part of a clastic system in transition to a playa or lacustrine end-member. The study highlights that excellent reservoir facies exist in each of the basins, detailing the variable sedimentary architecture and lateral extent.

The investigated Triassic sequences show high lateral variability in sedimentary facies in all locations, often over short distances. Correlation between sections even along world-class exposures is challenging due to the lack of distinct markers or biostratigraphic control. Comparing the Moroccan and Canadian sections, reveals three to four main sedimentary units with similar sedimentary style, and it is suggested that the observed sedimentary cycles were influenced by palaeoclimatic alternations from humid to arid conditions within an overall trend of increasing aridity during the Upper Triassic. The recognition of sedimentary response in fluvial architecture to these climatic changes' aids correlation within each basin, and is applicable in both, core and outcrop studies. In addition, careful distinction of major bounding surfaces from both aeolian and fluvial strata and the use of architectural element analysis allows development of comprehensive depositional models, which can further be used to predict reservoir facies more accurately.

## **Novel/Additive Information**

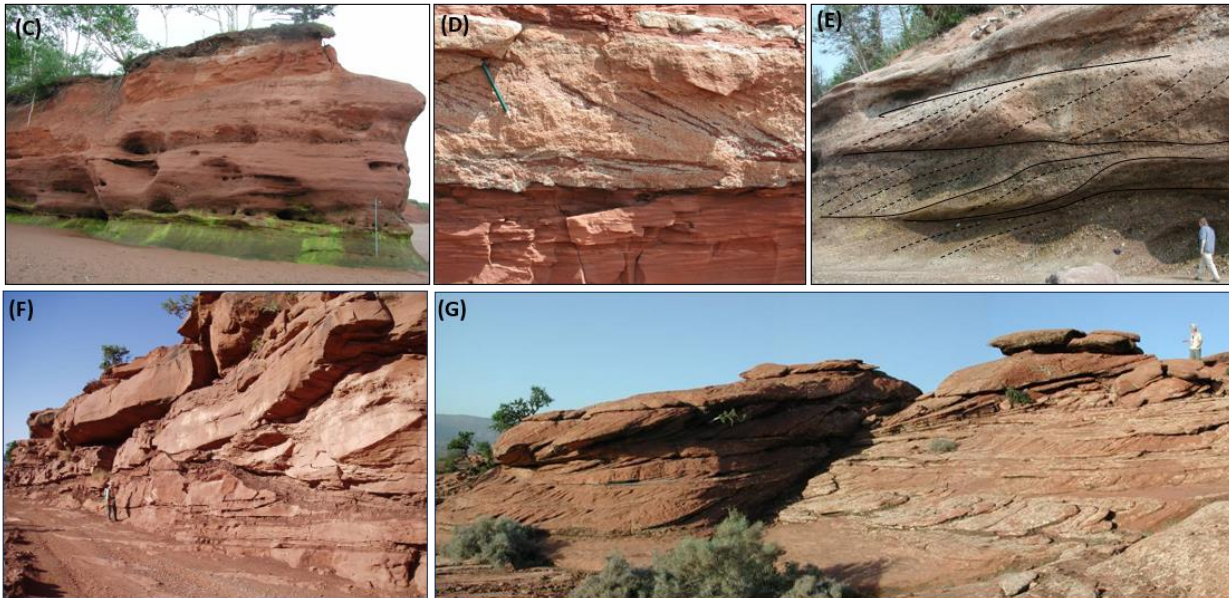
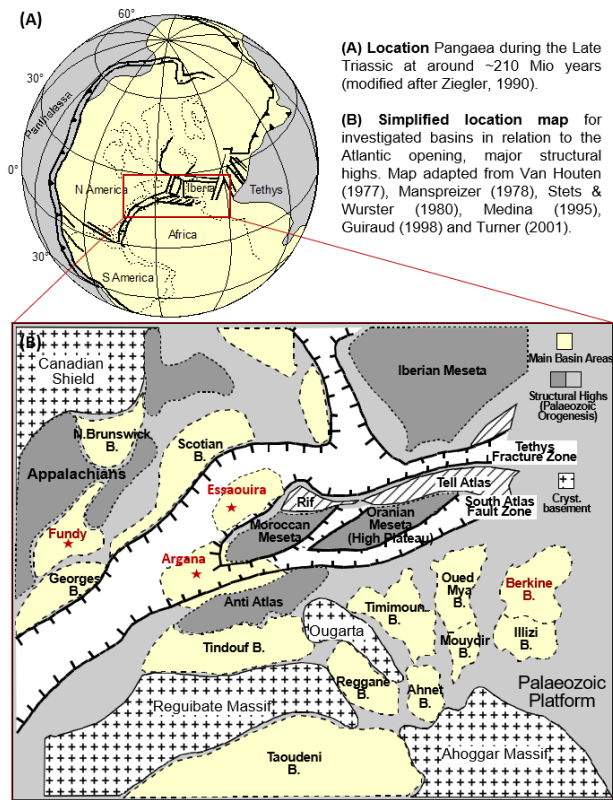
Cross-Atlantic comparison; 3D outcrop studies; core studies; architectural element analysis; fluvial bounding surfaces; climatic cyclicities.

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Images (C) to (E) display **outcrop examples** of different Upper Triassic reservoir facies from the Bay of Fundy exposures in Nova Scotia, Canada. From shallow braided fluvial channels, capped by small aeolian dune sets (C), to floodplain and playafines with crevasse deposits (B) to very coarse conglomeratic fluvial channel bars with dunes-scale cross-bed sets (D). Images (F) and (G) show examples from the Argana Valley in Morocco, exhibiting broad fluvial channels incise into floodplain and playa fines, and in (G) beautifully exposed three dimensional aeolian dune cross-bed sets.