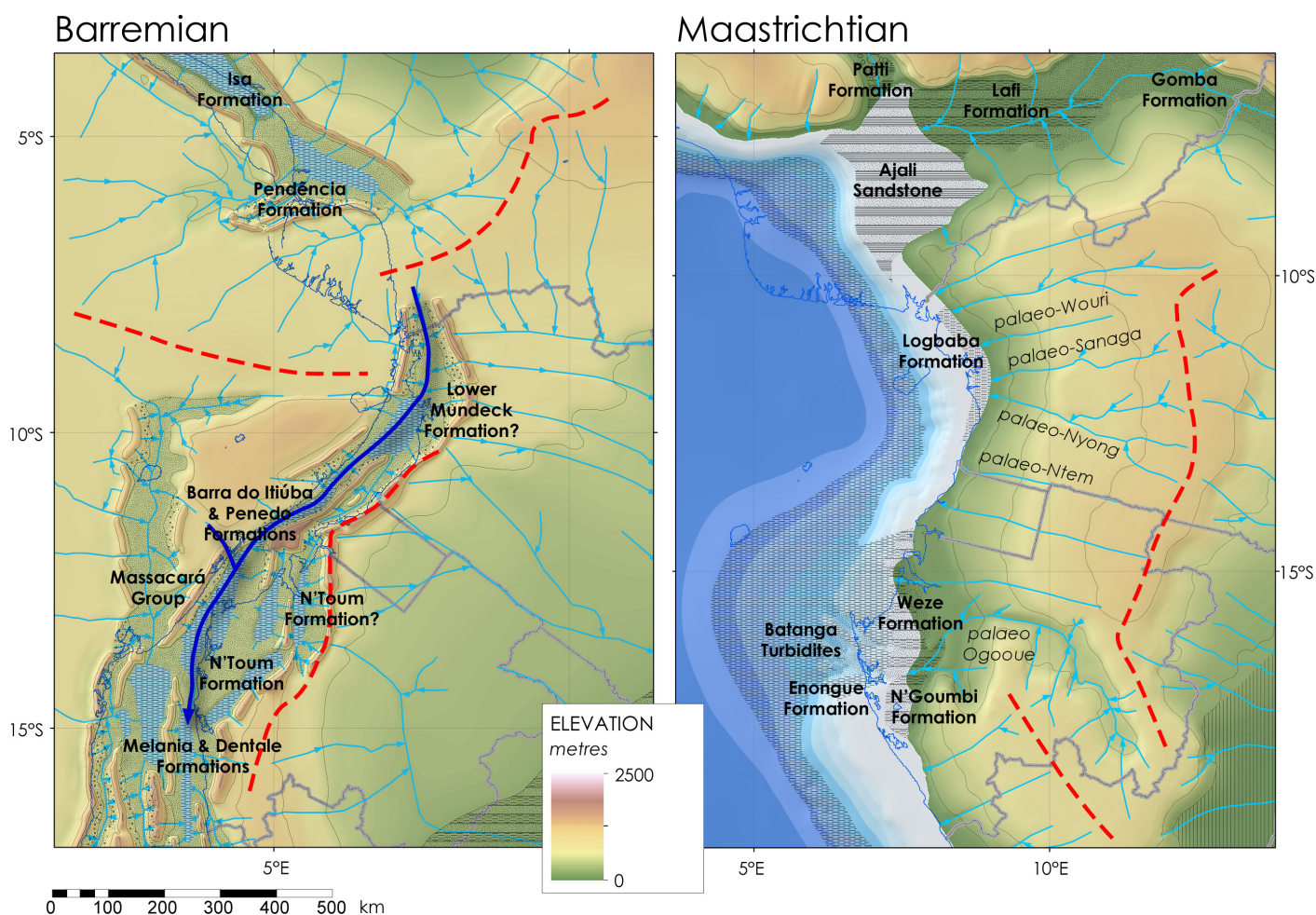


Palaeogeography in Exploration. A new Publication

Posted on January 7th 2019



Paleogeographic maps are common throughout the Earth sciences. There seem to be few geological presentations today, in either Academia or Industry, that do not include at least one paleogeography, some of which have become aesthetically quite beautiful. But, despite this, the full power of paleogeography as a tool in geological problem solving remains underutilized. In many, if not most cases, maps are used simply as a backdrop image for locating data. That is a great shame.

When Thomas Sterry Hunt first coined the phrase 'paleogeography' in 1873 (Hunt, 1873), it was not just as a 'pretty' picture for a presentation, but as a way to bring together diverse geological information to better understand the Earth system.

Hunt was one of the first petroleum geologists, and by the time of his paper, he was faced with the problem of a rapidly expanding library of geological observations and ideas that needed to be managed. A situation that is all the more applicable today.

Earlier geologists had used land-sea maps as one means of managing and visualizing this wealth of information. But, it was

Hunt who applied these maps to exploration and who established the first systematic workflow for building paleogeography by stressing the importance of the underlying crustal architecture. This workflow was expanded and developed by Charles Schuchert in the early 20th century (Schuchert, 1910, 1928) and later by Fred Ziegler (Ziegler et al., 1985) and the Paleogeographic Atlas Project (the subjects of future blogs).

Paleogeography has long been a passion with me ever since I was an intern at BP's research center in Sunbury-on-Thames back in

the mid-1980s. The first atlases of global plate reconstructions had been published 10 years before (Briden et al., 1974; Smith and Briden, 1977; Smith et al., 1973) and by the 1980s were becoming much more widely used. In Chicago, Fred Ziegler's Paleogeographic Atlas Project was developing new methods for mapping and applying the results directly to exploration problems (Ziegler et al., 1985), including the use of paleogeography with paleoclimatology to retrodict (predict the past state) the distribution of source rocks. This had demonstrated to the oil and gas exploration industry that there might be a better and cheaper way to do preliminary basin screening.

This is where I came into the story, working on paleogeographic maps, paleoclimatology, source rock databases, and retrodictions. It was a great time with so many new developments and ideas about the Earth.

Many groups have developed paleogeographies over the years. Too many to mention in one blog or paper. One could mention the influential atlases of Peter Ziegler at Shell (Ziegler, 1982), the ground-breaking Russian atlases of Vinogradov (1968, 1969; 1967; 1968) and then Ronov (1989; 1984) and their teams in Moscow, the coastline maps of Smith et al., at Cambridge (and BP) (Smith and Briden, 1977; Smith et al., 1994); the maps of Doré in Statoil (Doré, 1989), and Dér court in France (Dercourt et al., 1993), and more recently the excellent work by the University of Rennes research group of Francois Guillocheau (Chaboureaud et al., 2013). Not forgetting, of course, the highly influential and widely used maps of Chris Scotese (Scotese, 2008; Scotese et al., 1979; Scotese and Golonka, 1992), who has perhaps done more than most geologists to promote plate reconstructions and paleogeography. It was on Chris's maps that Ron Blakey from Arizona first generated his beautiful 'Photoshopped' maps which many of you have seen and probably used.

But, for me, it was the developments by what I refer to as the 'Chicago School' that were the most influential, especially in the exploration Industry. It was at Chicago that Chris Scotese published his initial work as a post-doc of Fred's, where Dave Rowley and Ann Lottes published a series of papers on plate modeling, and where many of Fred's students, including Mike Hulver (now at Saudi Aramco), myself (Markwick and Valdes, 2004) and others learned and developed our understanding of geology and paleogeography, as well as methodologies for data management, auditing, and visualization.

The Paleogeographic Atlas Project is important to the story of paleogeography and its applications in two principal ways:

1. The reconstruction of paleolandscapes, not just depositional systems or facies.
2. Data management, data verification, and auditing and digital

databasing, building on the ideas of earlier workers such as Schuchert (1910) and Kay (1945)

Paleolandscapes are key because at the end of the day this is what the rock record sees. A particle weathered from the highlands in the hinterland of a basin, does not see mantle anomalies, or hyper-extended crust, at least not directly. It sees the vegetation, rivers, lakes, and sea. It sees the surface of the Earth, which is the landscape.

Data management, because without an audit trail how do you know how good the maps are? This was and is critical for the exploration industry with their need to understand exploration risk, in order to make informed decisions. Decisions that have a financial cost.

The Paleogeography Atlas Project was sponsored by the oil and gas industry and so these questions and drivers were foremost in Fred's mind. It was also this link with the Industry that stimulated the work of Judy Parrish in the early 1980s and her seminal publications on source rock retrodiction using early parametric paleoclimate models and paleogeography to reconstruct the location of ocean upwelling. These models were subsequently computerized by Scotese and Summerhayes (1986).

Over the last 18 months, I have been revisiting this story.

One result is this paper on **"Paleogeography in Exploration"** (Markwick, 2018).

This is designed to provide an introduction to the history and methodologies of paleogeography, including the latest version of Hunt's mapping workflow. Associated with this is a new mapping legend, which is available through the publication as supplemental data, as well as online as digital .style files for use with ESRI's ArcGIS. Three case studies are given which show how paleogeography can be applied at different scales to solve different exploration problems.

There is much more to add to this story and more will follow. But, for now, my aim to get the next generation of geologists, and especially explorationists, thinking about how they can use paleogeography maps more effectively in their workflows. And also, I hope, to get them excited about reconstructing the Earth system, an excitement I first discovered back in BP in the mid-1980s.

At the very least I hope that readers will see that paleogeography is so much more than just a flat image, beautiful that these may be.

"Paleogeography in Exploration" was published online in June 2018 in the Geological Magazine and will be published as part of the "Advances in Paleogeography" volume in early 2019. <https://doi.org/10.1017/S0016756818000468>

I wish to thank the volume editor, Guido Meinhold, for all his hard work in putting together a very interesting collection of papers on this important topic and for his kind inclusion of my research. I am also indebted to the reviewers, especially Tony Doré, for their perseverance in reading the original draft, which as they described it, read "more like a book..." The final version greatly benefited from their suggested changes and their dedication to the review process. They will be relieved to hear that the final version is considerably shortened. A book will be out shortly.

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About the author

Paul is currently CEO of Knowing Earth Limited, as well as a Visiting Lecturer at the University of Leeds and Visiting Research Fellow at the University of Bristol. He graduated from St. Edmund Hall, Oxford University in 1987 and received his Ph.D. from The University of Chicago in 1996.

He worked for two years at BP's Research Centre in Sunbury-on-Thames before moving to Chicago, where Paul studied with Professor Fred Zeigler's oil industry-sponsored Paleogeographic Atlas Project. This was followed by a post-doctorate at the University of Reading researching the exploration significance of the paleoclimatic and drainage evolution of southern Africa using computer-based climate models with Professor Paul Valdes. He then moved to Robertson Research International Limited, now part of CGG, as a Staff Petroleum Geologist, where he developed global predictive models of source and reservoir facies. In 2004 Paul moved to Getech Group plc, to set-up the Petroleum Systems Evaluation Group with Dr. John Jacques. From 2006 to 2017 Paul served on the Getech board overseeing the strategic technical direction, which saw the business transition and grow from an academic research group to a multi-million-pound company with four offices, 120 staff and an international client base.

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