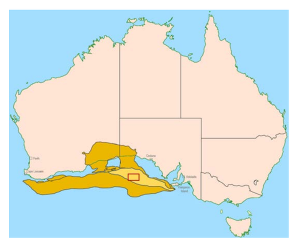
The Outer Basin High is an enigmatic feature in the outer part of the Ceduna Delta, part of the Hauterivian to Maastrichtian post-rift system and the focus of some of the recent exploration efforts in the Bight Basin. It is most likely the result of reactivation of deeper Late Jurassic rifts in the Coniacian to Santonian, and has been amplified by regional Eocene uplift.



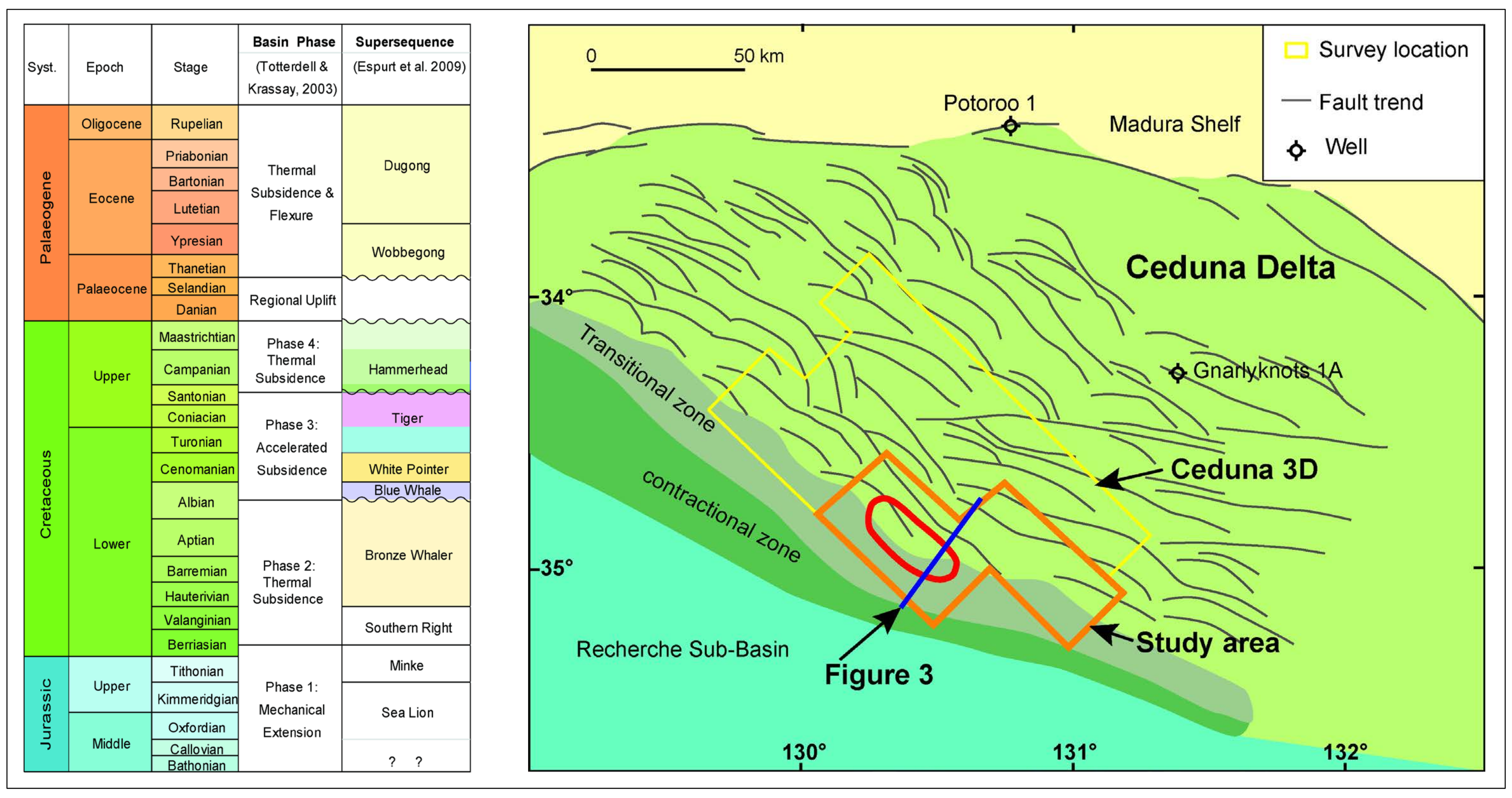


Figure 1. a) Stratigraphic column for the Ceduna Sub-basin, modified from Totterdell & Krassay (2003) and Espurt et al., (2009). b) Location of the study area (orange) and the Ceduna 3D seismic survey (yellow), overlying structural regions of the Cenomanian White Pointer Supersequence (modified from Totterdell & Bradshaw, 2004). The closest well, Gnarlyknots-1A, is 93 km NE of the study area.

Ceduna Sub-basin

- The main depocentre of the Bight Basin, on Australia's southern margin (Figure 1)
- Contains at least 15 km of Middle Jurassic to Cenozoic sedimentary rocks
- Frontier basin with only 6 wells
- Current exploration focused on the outer basin high on the southwest flank of the basin

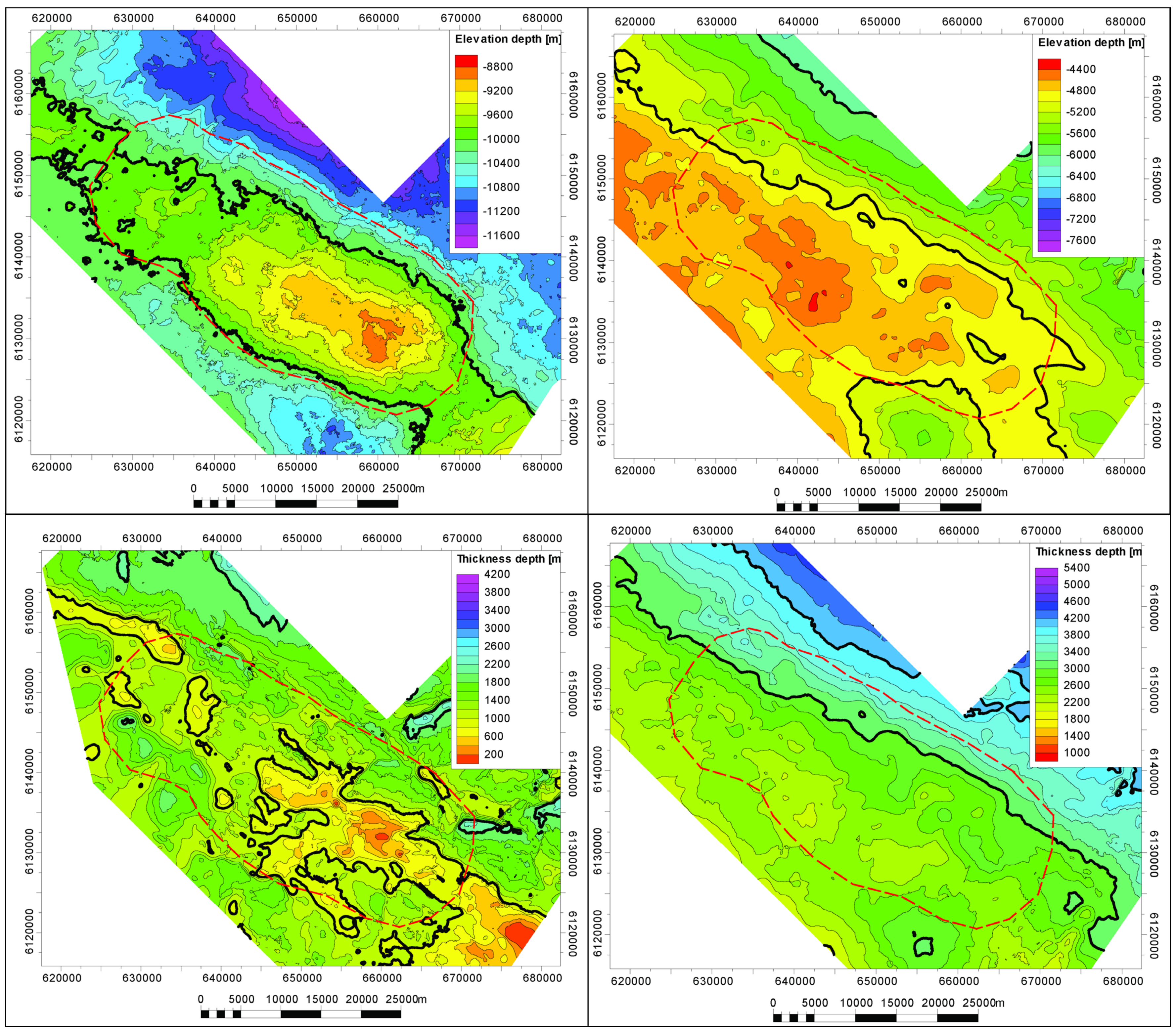


Figure 2. a) Surface map of the Top Bronze Whaler Supersequence, showing the expression of the outer basin high. b) Surface map of the Top Tiger Supersequence. c) Sediment thickness map of the Tiger Supersequence, showing thinning of the supersequence over the outer basin high. d) Sediment thickness map of the Hammerhead Supersequence showing thinning of the supersequence over the outer basin high.

Outer Basin High

- 15-40 km wide with an amplitude of up to 2 km (Figures 2 and 3)
- Trends NW-SE
- Underlies transitional zone of deformation between extensional faulting and outer fold and thrust regions of the overlying White Pointer and Hammerhead delta systems (Figure 1)
- Overlies a prominent NW-trending gravity high (Figure 4)

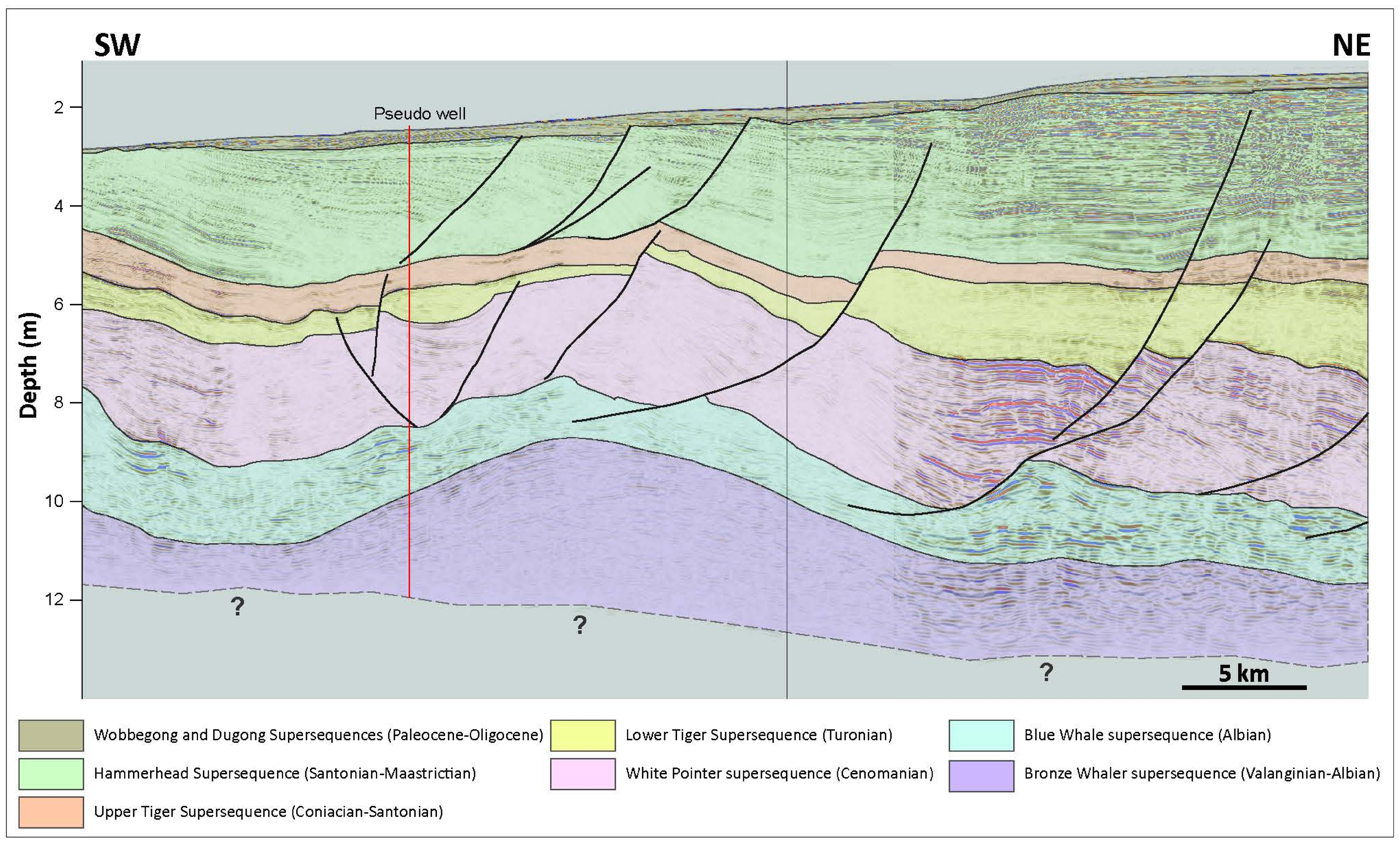


Figure 3. Seismic cross section over the outer basin high (see Figure 1 for location).

Timing of uplift

- Initial relative uplift of about 1.2 km in the Coniacian, during deposition of the Lower Tiger Supersequence (Figure 5)
- Lower Tiger Supersequence thins over the high
- Relative uplift continued until the Santonian
- Second stage of relative uplift in the Maastrictian to Eocene, resulting in erosion of up to 1.5 km of Hammerhead Supersequence

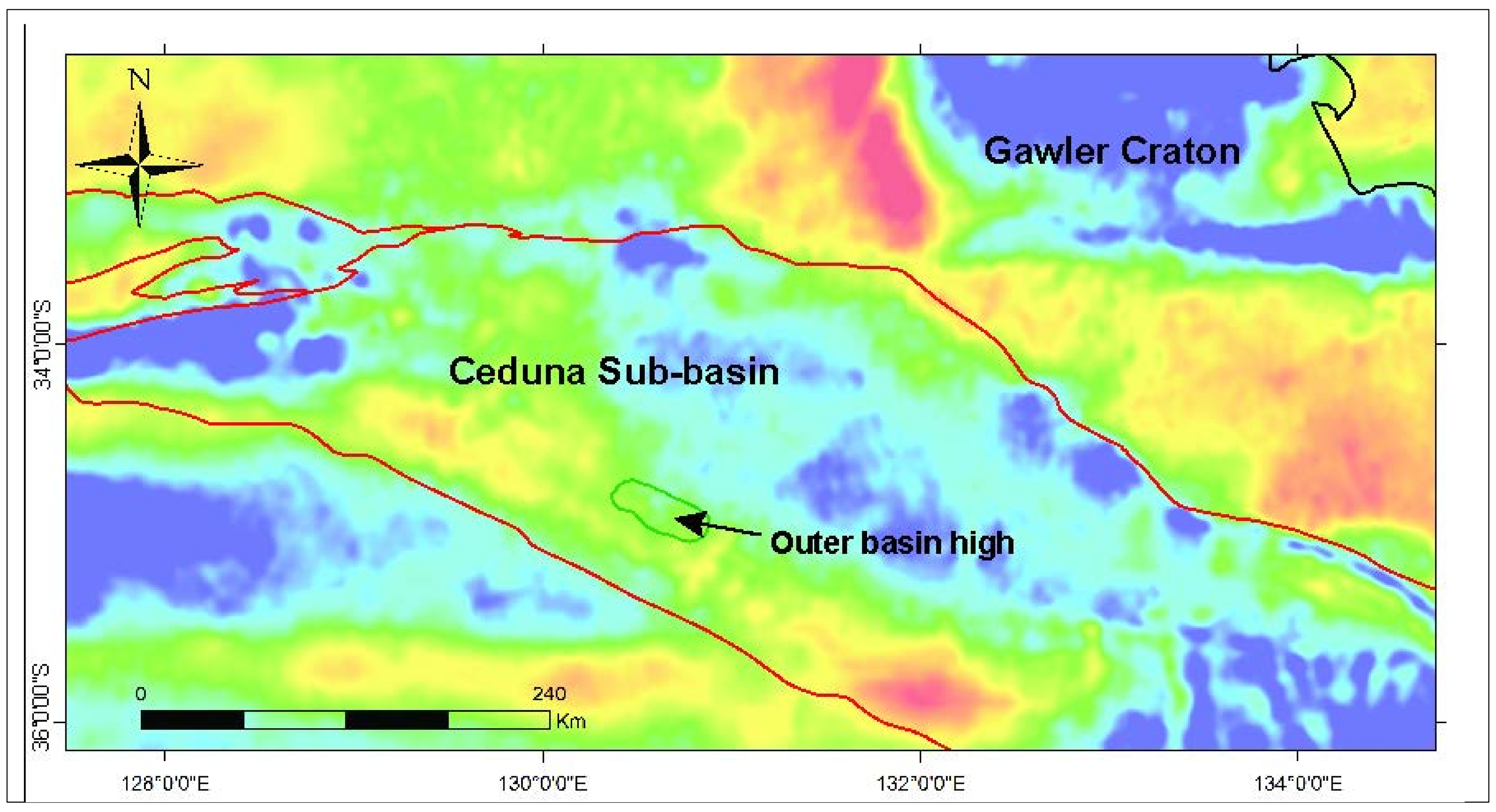


Figure 4. Isostatic residual gravity image of the Ceduna Sub-basin showing a NW-trending gravity high on the southwest flank of the sub-basin, similar to onshore trends in the Gawler Craton. Sub-basin outlines shown in red, outer basin high in green.

Uplift Mechanism

- Limited seismic imaging below 10 km depth (Figure 3)
- Gravity images suggest basement faults follow a NW-SE trend (Figure 4)
- Previously described as a compressional fold attributed to ridge push (MacDonald et al., 2012)
- New model suggests outer basin high formed as an extensional fault propagation fold above a tilted basement fault block
- Fold was amplified during basin-wide uplift in the Maastrictian to Eocene, possibly due to differential compaction of the overpressured mobile shales of the Albian Blue Whale Supersequence

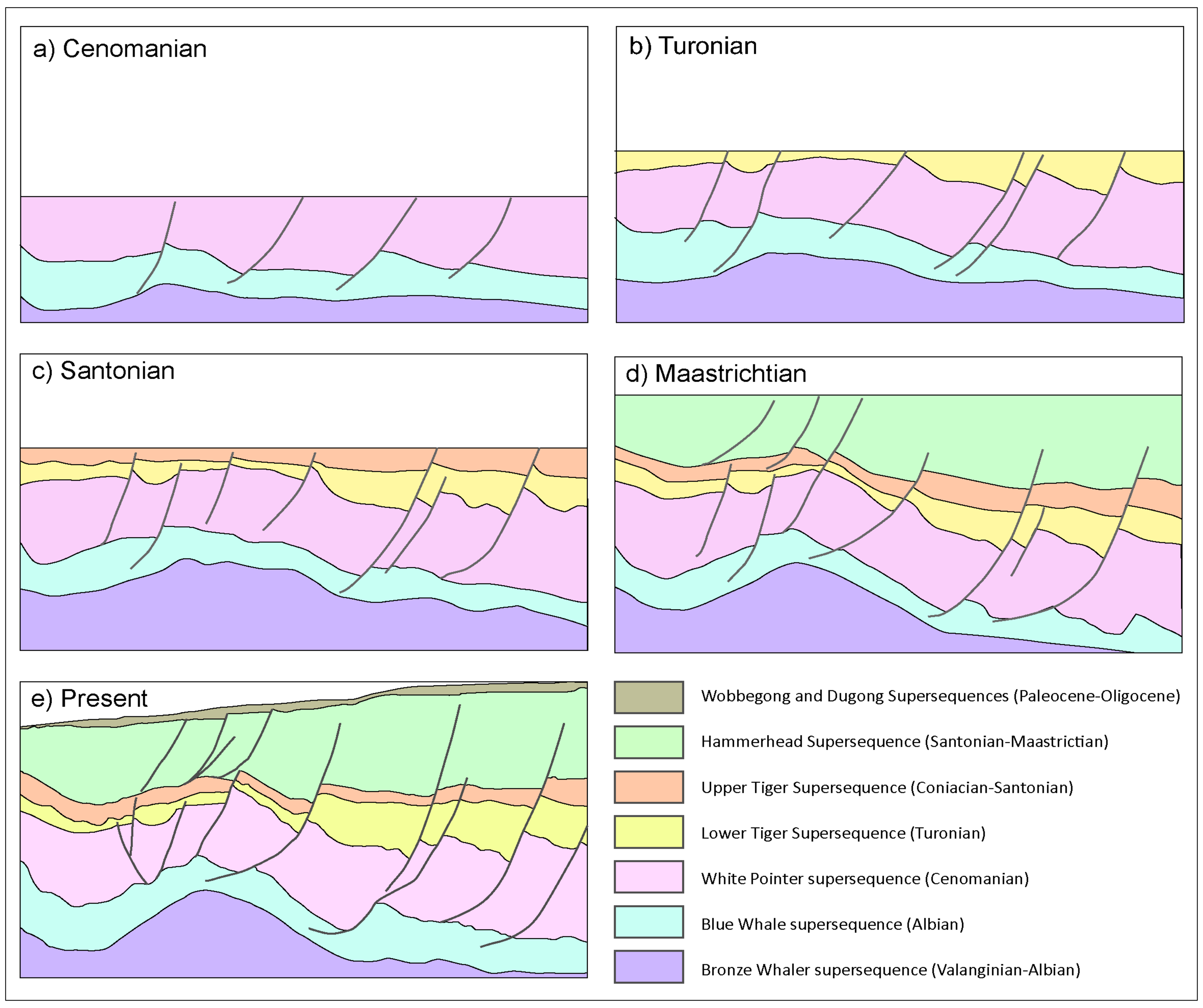
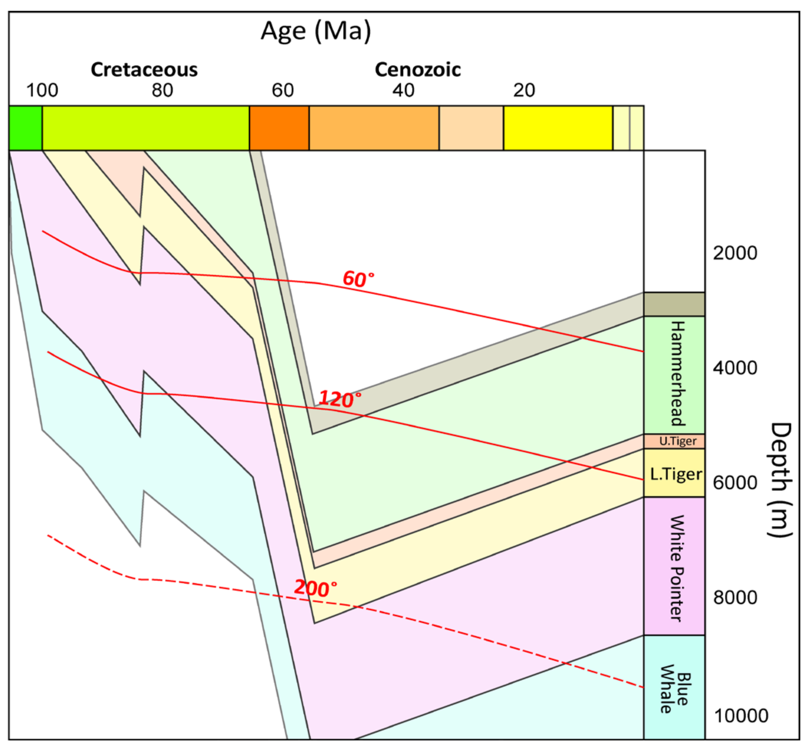


Figure 5. Schematic evolution of the outer basin high based on seismic interpretation of section shown in Figure 3. a) Cenomanian: thickening of Blue Whale Supersequence to SW suggests fault growth started in Albian. Deeper (basement) faults not visible. b) Turonian: Extension continues, subsidence to NE (Ceduna depocentre), start of outer basin high development. c) Santonian: Accelerated relative uplift of outer basin high, detached listric faults rotate. d) Maastrichtian: Regional uplift and erosion across the basin, consistent with continent-wide tilting; reactivation of outer basin high. e) Present: tilting to SW makes faults appear steeper, minor reactivation of faults and deposition of cool-water carbonates.



Implications for source rock maturity

- 1D burial history of a pseudo well on the SW flank of outer basin high incorporates removal of 1.5 km of Hammerhead Supersequence (Figure 6)
- Tiger Supersequence source rock enters oil window at 68 Ma
- Gas window at 58 Ma
- Lower Tiger Supersequence may be overmature
- Uplift and erosion estimates key to determining source rock maturity

Figure 6. 1D burial history model of a pseudo well on the southwest flank of the outer basin high (See Figure 3 for location). The thermal gradient was obtained from the burial history model of the Gnarlyknots-1A well by Struckmeyer (2009)

Conclusions

- The outer basin high of the Ceduna Sub-basin formed in two phases; the first associated with late stages of rifting (Coniacian to Santonian) and the second associated with regional uplift and erosion (Maastrictian to Eocene)
- The outer basin high follows NW-SE basement trends associated with the underlying Gawler Craton
- Formation mechanism is an extensional fault propagation fold draping a basement fault block
- The Eocene unconformity removed up to 1.5 km of Hammerhead Supersequence above the outer basin high, which has implications for source rock maturity

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