1. INTRODUCTION

Mini-basins are well known targets for petroleum exploration as they can contain significant hydrocarbon reserves, such as in the Gulf of Mexico. But their reservoir-rock distributions remain poorly predictable, especially in cases where mini-basins are adjacent to salt-diapirs. The Donkey Bore Syncline in the Flinders Ranges, South Australia (Fig.1 A), presents an excellently exposed siliciclastic deepwater mini-basin reservoir analogue.

Detailed outcrop study, including vertical and lateral logged sections presented here, shed considerable light on the depositional system. Deciphering the commencement of siliciclastic sedimentation and the stages of basin fill from sedimentary structures and depositional style can assist in the prediction of reservoir rock distribution.

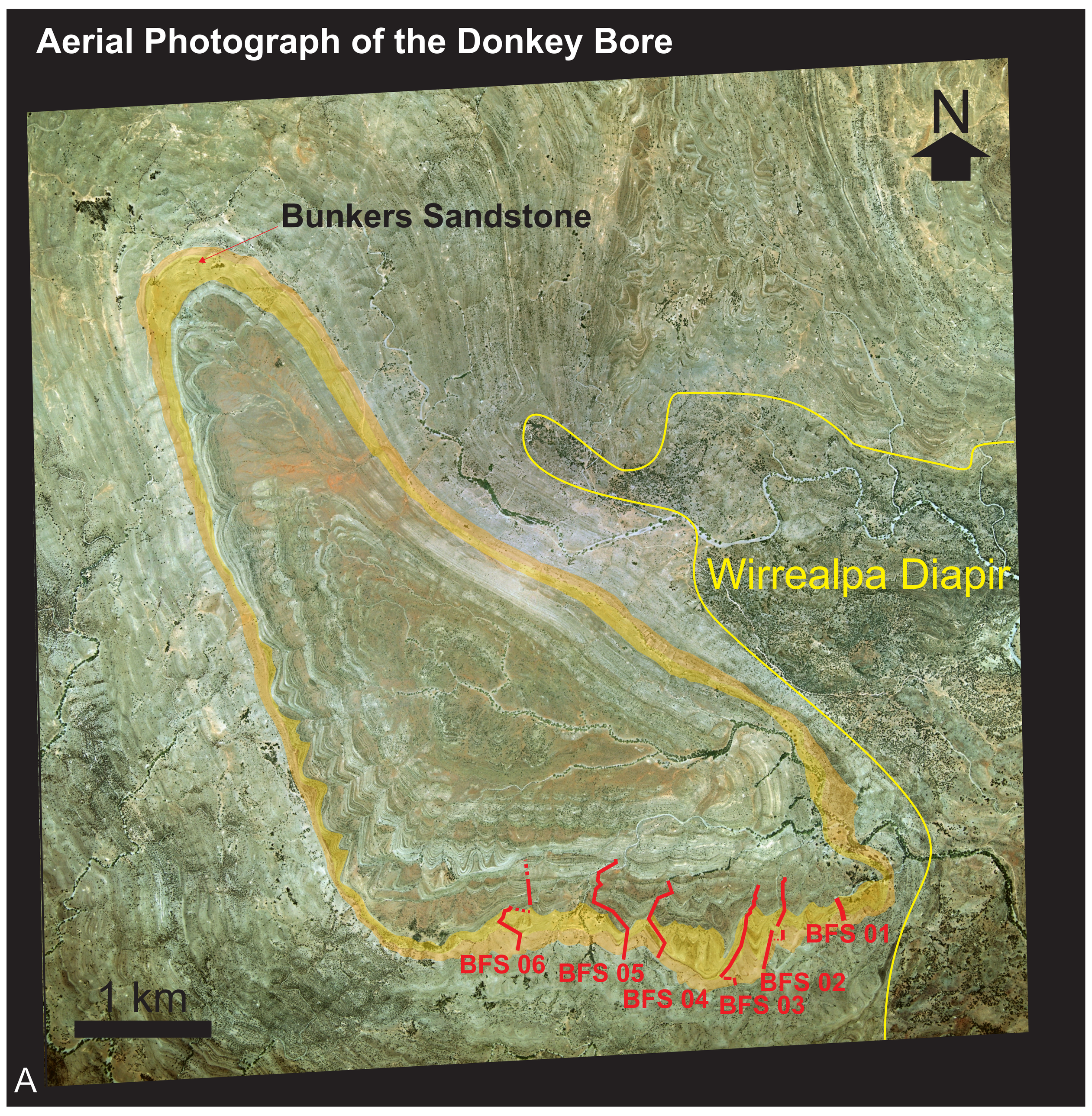

Fig. 1 A: Location of the Donkey Bore Syncline with logged section transects (Map of Australia: Free vector maps, Aerial photo: Mapland, after Payenberg et al, 2008).

2. METHODS

Four vertical sections, BFS 01 to BFS 04 with a height of around 100 m, spanning over 1.3 km laterally were logged in detail. The logs were correlated on the basis of lithofacies and tracing of major bedding surfaces laterally between the sections, both on foot and from aerial photographs. Lithofacies were classified and depositional processes interpreted. The geometries of depositional units were also mapped and the depositional elements interpreted. A depositional model is presented for the initial infilling of this minibasin.

3. FACIES AND GEOMETRIES

Muddy limestone and allochtonous limestone blocks form the main background lithology in the Donkey Bore Syncline (Fig. 2A).

Unit A displays deepwater sandy lobe characteristics. It is about 7.5m thick and over 1000m long. The basal sandy limestone (FA2) occurs as very thick structureless beds with thin to medium-bedded sandstone as tail-flow tops with intervening muds (Fig. 2A and Fig. 3). FA2 may also deposit as planar laminated calcareous sandstone (Fig. 2B) before a major deposition of shale.

Units -B2 and -B1 (Fig. 3) comprise the Fa4 facies (Fig. 2C) displaying deepwater turbidite characteristics which include climbing ripples, massive bases with late-stage thin tops and normal and Bouma-type grading. Their sheet geometries are < 1 m in thickness with lengths from a few 10s of metres to over 1 km.

The Fa3 very thick calcareous facies (Fig. 2D) represent the establishment of siliciclastic sedimentation in the syncline and comprise Units B1, B2, B3 (Fig. 3). They are mainly structureless with late-stage tail flow, thin sandstone tops which may alternate with thin shales. Proximally, they are about 3 m to 6 m thick, thinning-down basinwards to sheet-like beds with a lobe like geometry.

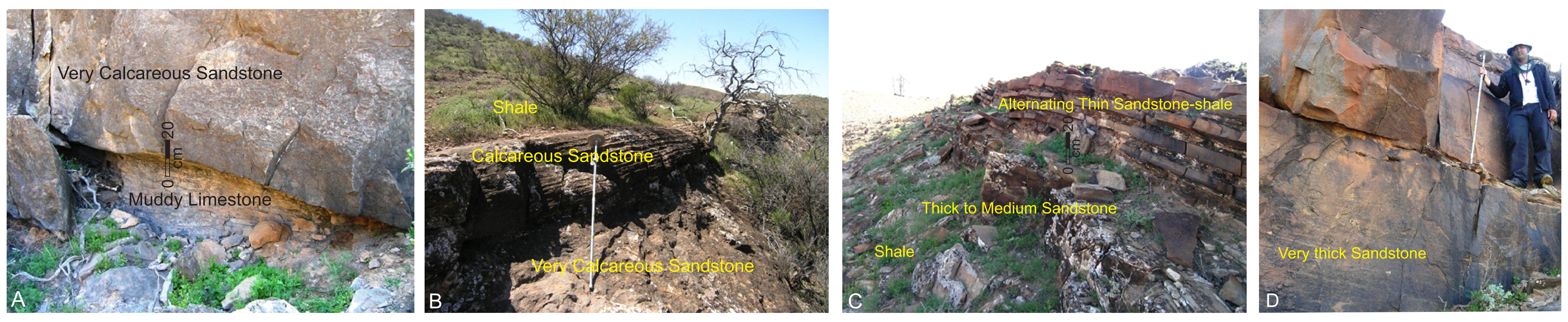

Fig. 2A: Very calcareous medium to coarse grained sandstone (Fa2) underlain by thin-bedded muddy limestone.
Fig. 2B: Very calcareous medium to coarse grained, massive sandstone overlain by planar laminated calcareous sandstone.
Fig. 2C: Shale to sandstone transition with alternating thin-bedded sandstone and shale
Fig. 2D: Very thick massive sandstone (reservoir) deposited after a major shale interval

4	FACIES ASSOCIATION	ARCHITECTURAL ELEMENT/ DEPOSITIONAL ENVIRONMENT		FACIES ASSOCIATION	ARCHITECTURAL ELEMENT/ DEPOSITIONAL ENVIRONMENT
Fa1	Conglomerate-Shale	Slope or high velocity flows, lobe axis, basin plain, proximal/confined	Fa7	Thin-bedded Sandstone-Shale heterolithics	Lobe fringe, Basin floor, distal lobe/fringe
Fa2	Basal Sandstone (turbidite)-Muddy Limestone	Proximal, carbonate-siliciclastic transition, Early Low-stand lobe Deepwater basin floor	Fa8	Thin-bedded transitional Sandstone-Shale	Distal lobe to Basin
Fa3	Very Thick Sandstone-Thick Sandstone-Thin bedded	Lobe axis or channel to lateral	Fa9	Shale	Quiescence of system due to sediment starvation or sea level increase
Fa4	Thick to Medium Sandstone-Thin bedded sandstone-Shale	Lobe axis or off- axis, less confined, Lobe lateral, proximal	Fa10	Isolated beds	Sporadic influx or flow diversion, Intermittent clastic activity
Fa5	Discordant Sandstone-Shale	Interchannel or mid lobe, slope or obstructed flow, topographic high, tectonic	Fa11	Contorted beds	Allocyclic: change in basin floor slope: proximal-mid basin
Fa6	Poorly-sorted muddy thick/ thin Sandstone-Shale	Slope or obstructed flow, basin margin, reactivated flow paths in lobe axis/lateral			Autocyclic: over-steepened slope

Table 1: Facies associations, architectural elements and their depositional environment interpretations.

5. CORRELATED LOGGED VERTICAL SECTIONS BFS 01 - 04

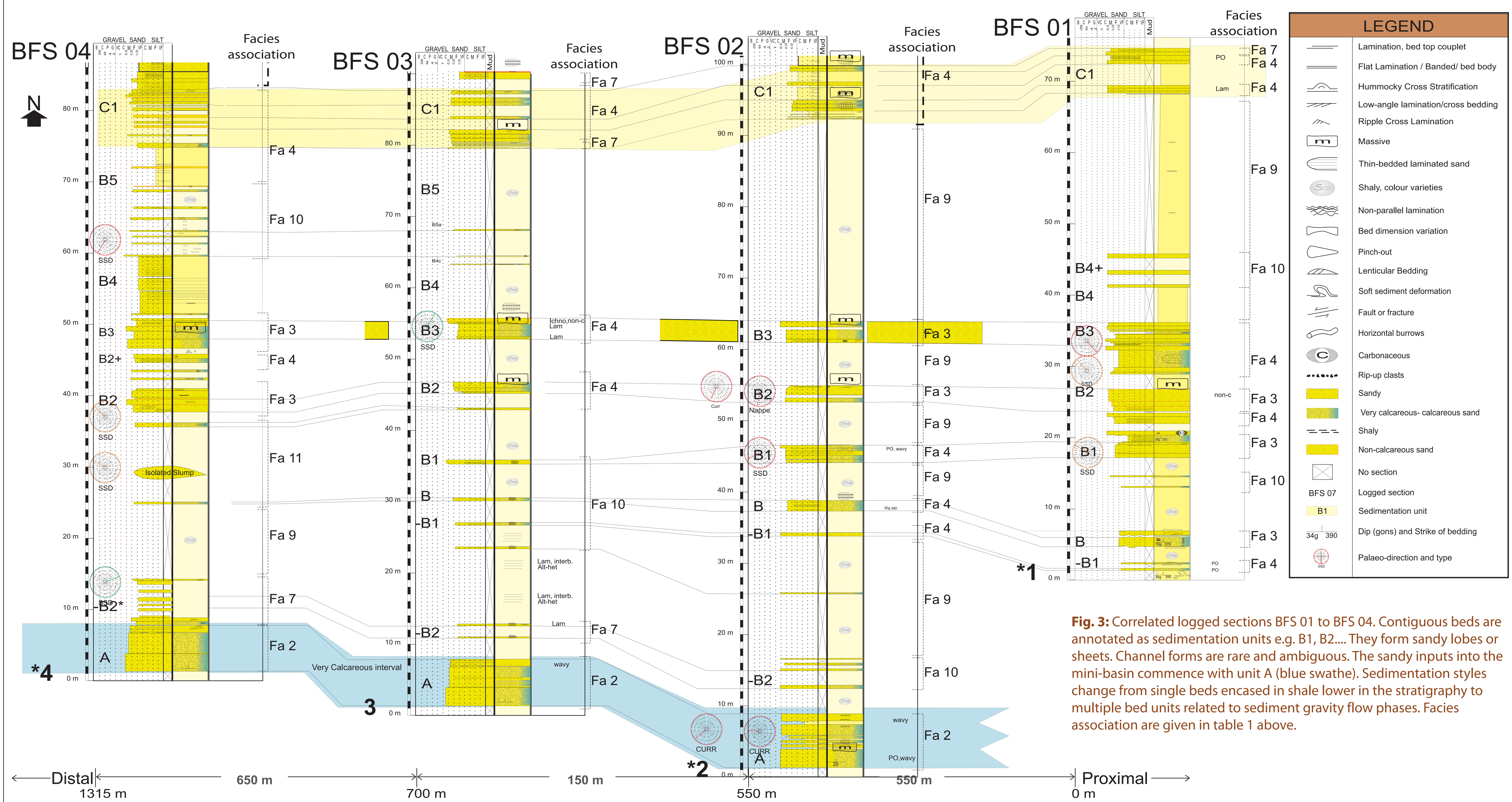

Fig. 3: Correlated logged sections BFS 01 to BFS 04. Contiguous beds are annotated as sedimentation units e.g. B1, B2.... They form sandy lobes or sheets. Channel forms are rare and ambiguous. The sandy inputs into the mini-basin commence with unit A (blue swathe). Sedimentation styles change from single beds encased in shale lower in the stratigraphy to multiple bed units related to sediment gravity flow phases. Facies association are given in table 1 above.

6.KEY FINDINGS OF THE EVOLUTION OF MINIBASIN FILL

- A change from a carbonate to a siliciclastic deposition system is detected. The siliciclastic mini-basin fill shows a distinct style of sandy units geometry and architecture during initiation and subsequent stages.
- The initial sandy deposition is characterized by thinner, commonly single beds encased in shale, sheet forming deposits. The later depositions are mostly stacked, multi-bed, sandy lobe-forming units, with a greater areal extents.
- Units B1, B2 and B3 have larger areal extents, are thicker and stack-up compensatively.
- Both, individual and multi-bed units display basinwards progradation processes.
- The thinner multistacked units (Unit C1, Fig.3) may indicate shift in depositional loci. This may be due to change in seafloor topography due to salt mobilization.
- This study represents a rare detail of sedimentologic processes, architectural elements and architecture in the evolution of a salt-withdrawal minibasin. It may find application as a reservoir analogue for salt-driven mini basins.

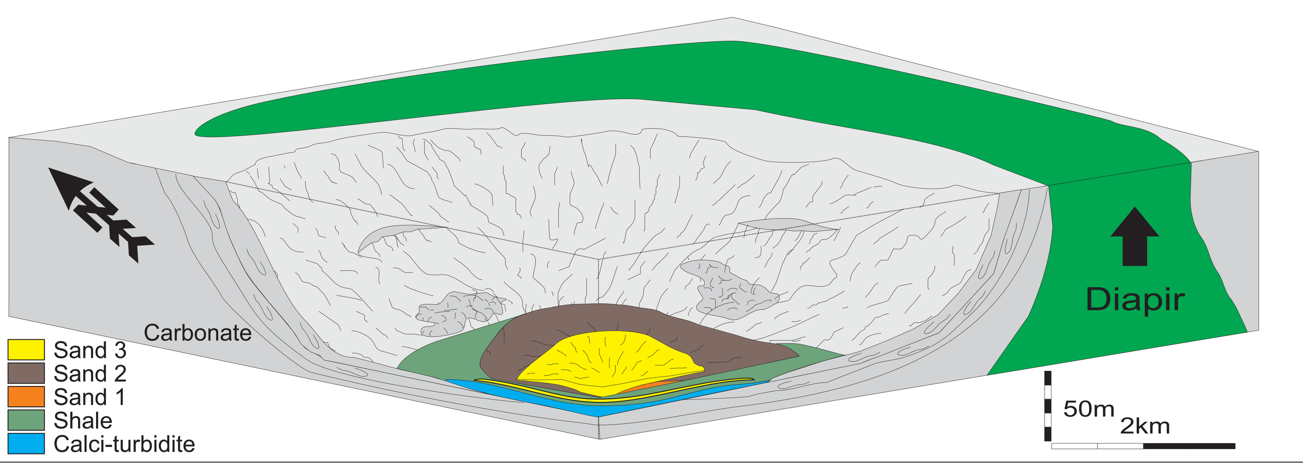

Fig. 4: Depositional model for the early phase of sandy input.
The mini-basin has several evidences of instability in the form of slides, slumps and subaqueous sediment gravity flows.
Paleoflow is from the south.

REFERENCES

see Fernandes et al. (2018), APPEA Journal Extended abstracts (this conference)

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