PS Paleo-Strait Clastic Carbonate Sandbodies, Bonifacio Basin, Corsica*

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Abstract

Excellent coastal exposures (5 km long) of the Miocene mixed carbonate-siliciclastic succession of the Bonifacio Basin (South Corsica) allow correlation of stratigraphic surfaces and evaluation of lateral variability in a paleo-strait/paleo-gulf setting. Coastal cliff photo-mosaic panels were interpreted, measured sections digitized and correlated and over 1000 paleocurrents measured. The succession consists of three depositional sequences. During low sea level, siliciclastic systems prevailed, fed by gilbert-type deltas; during relative sea level rise, fringing reefs developed, passing basinwards to bioclastic facies evolving upward and basinward from bryomol to molechfor and rhodalgal associations.

Cross-bed dip and geometric analyses suggest forward accretion of the sediment bodies. Cross-bed sets preferentially developed during late Lowstand (LST) and Transgressive Systems Tracts (TST) as unidirectional dune fields. Late LST cross-bed sets display higher siliciclastic content, wedge-shaped geometry and thickening- thinning-upward trends. TST cross strata are bioclastic and alternate with upper flow regime plane-parallel beds, owing to current strength fluctuations or to the migration of transition slope. Unidirectional currents are interpreted to have been induced by relative sea level oscillations able to control hydraulic cross section of the basin and current strength, accomplished on an irregular topography: the basin morphology, widening to SW and narrowing to NE, suggests an evolution from gulf (closed to the North during low sea level stands) to strait (connecting the Liguro-Provençal and Thyrrhenian Basins during TST), when currents would have been accelerated. Currents were generally unidirectional, possibly due to the forcing of dominant winds. Strongly cyclic late LST deposits sometimes show lateral accretion, probably an indication of a tidal origin.

The Bonifacio Basin is a useful outcrop analog for reservoirs of palaeostrait/palaeogulf origin. The stratigraphic relationships between sandstone

bodies, marginal reefs and bioclastic facies produce strong reservoir heterogeneity; there is also remarkable variability of geometry and orientation of high-porosity cross strata.

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PALEO-STRAIT CLASTIC CARBONATE SANDBODIES, BONIFACIO BASIN, CORSICA

Location and Geological setting

Geodynamic Setting

The Lower Miocene succession of the Bonifacio Basin (Corsica Island, red box in Fig. 1, Western Mediterranean Basin) was deposited in a structurally controlled basin associated with the opening of the Ligurian - Provençal back-arc basin.

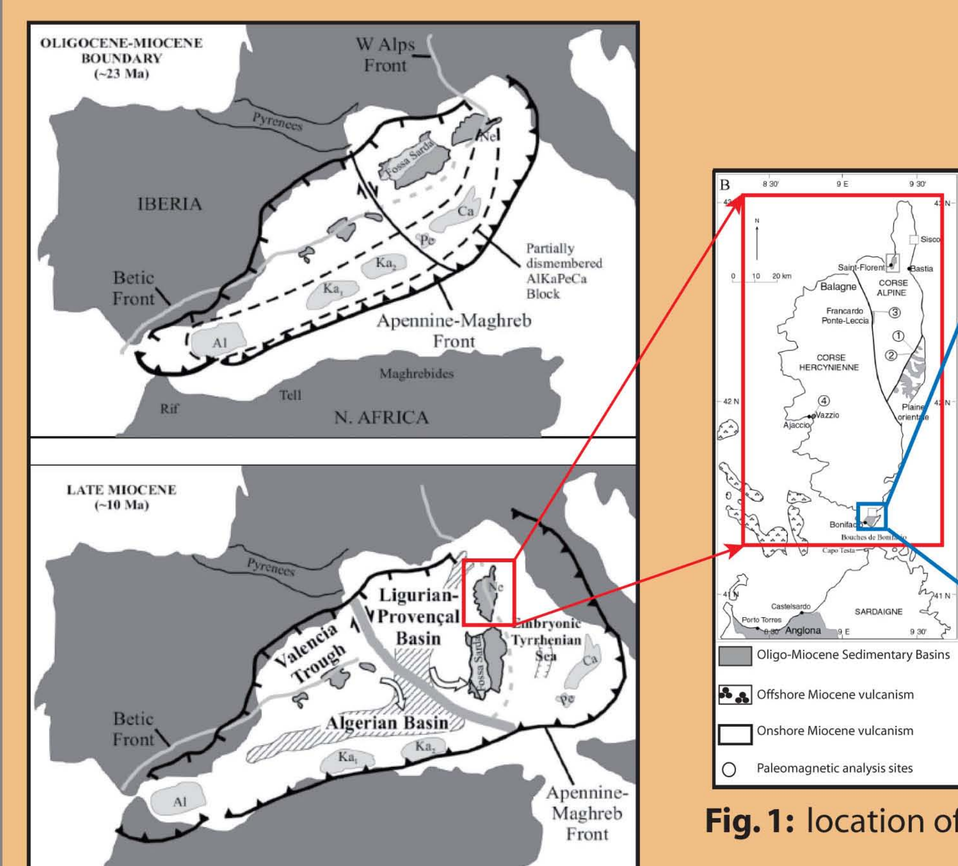

Fig. 1: location of the Bonifacio Basin.

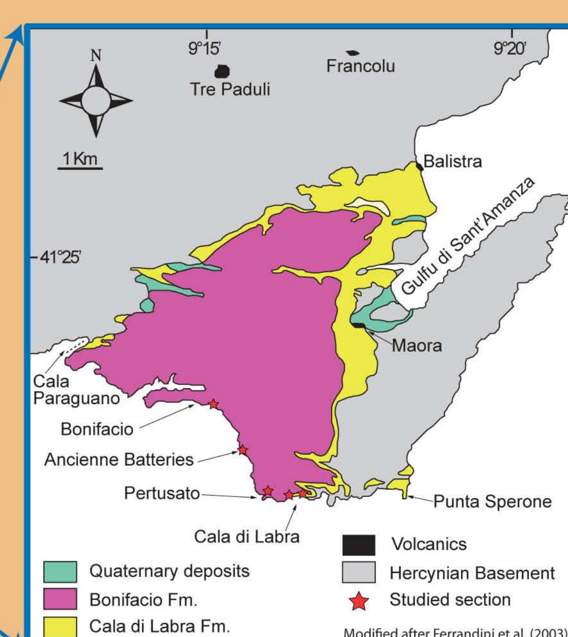

Fig. 2: geological map of the Bonifacio Basin.

This basin formed during the counter-clockwise rotation of the Sardinian - Corsica Block of about 30° between 21 and 16 Ma which occured in relation to the southeastward subduction mrollback of the Apennines–Maghrebides subduction zone (Gailler et al., 2009).

Stratigraphic Framework

The marine mixed carbonate-siliciclastic sediments of the Bonifacio Basin (12 informal lithozones) consist of the Cala di Labra Fm. and Bonifacio Fm.

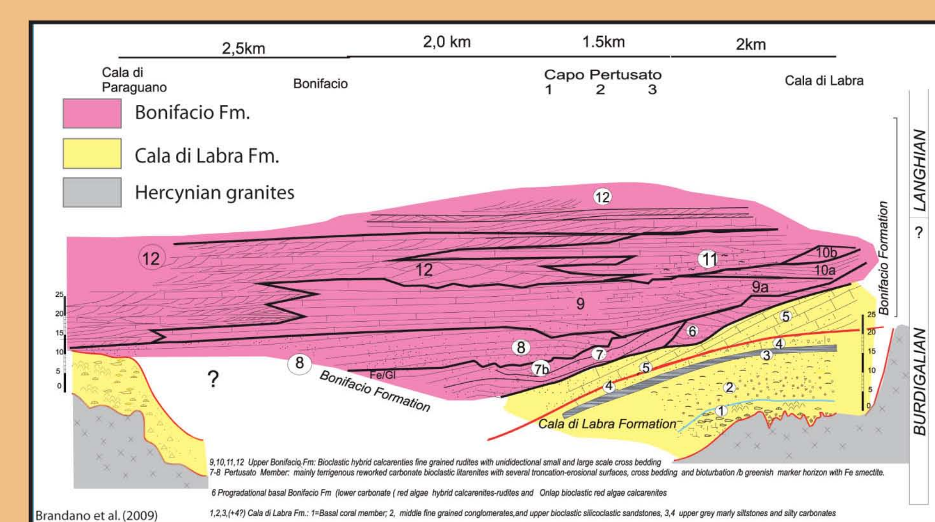

Fig. 3: stratigraphic architecture of the Bonifacio Basin (Brandano et al., 2009).

Age: Mid-Late Burdigalian

Thickness: up to 130 m

Substratum: Hercynian granites (sourcing the siliciclastic fraction)

Lower boundary: non-conformable surface

Lithostratigraphy		Age	Lithozones	T-R cycles
Bonifacio Formation	Bonifacio Member	?	12, 11, 10, 9, 8	2
	Pertusato Member	Late Burdigalian ?	7, 6	?
Cala di Labra Formation		Late/Middle Burdigalian	5, 4, 3, 2, 1	1

Fig. 4: age and stratigraphy of the Bonifacio Basin succession (modified after Brandano et al., 2009).

The Cala di Labra Fm. records a T-R cycle. It consists of a coral rich lithozone overlain by a siliciclastic lithozone. After a deepening event, a prograding clinostratified carbonate unit developed. The Bonifacio Fm. consists of a lower siliciclastic portion and an upper carbonate portion with heterozoan associations. The uppermost part shows large scale cross bedded units (Figs. 3-4).

Eastern Basin Margin

- The basal non-conformity is overlain by a carpet reef (Fig. 5a) or by shoreface deposits (Fig. 5b).

- Deepening-upward phase is recorded by a thin but laterally continuous marly interval, after which carbonate clinoforms develop (5c).

Fig. 5: carpet reef non-conformably overlying Hercynian granites (a); SCS (b); clinostratified biclastic limestones (c).

Basin Axis

- Only the Bonifacio Fm. is exposed.

- Well developed cross bedsets in mixed carbonate-siliciclastic sediments (Fig. 6).

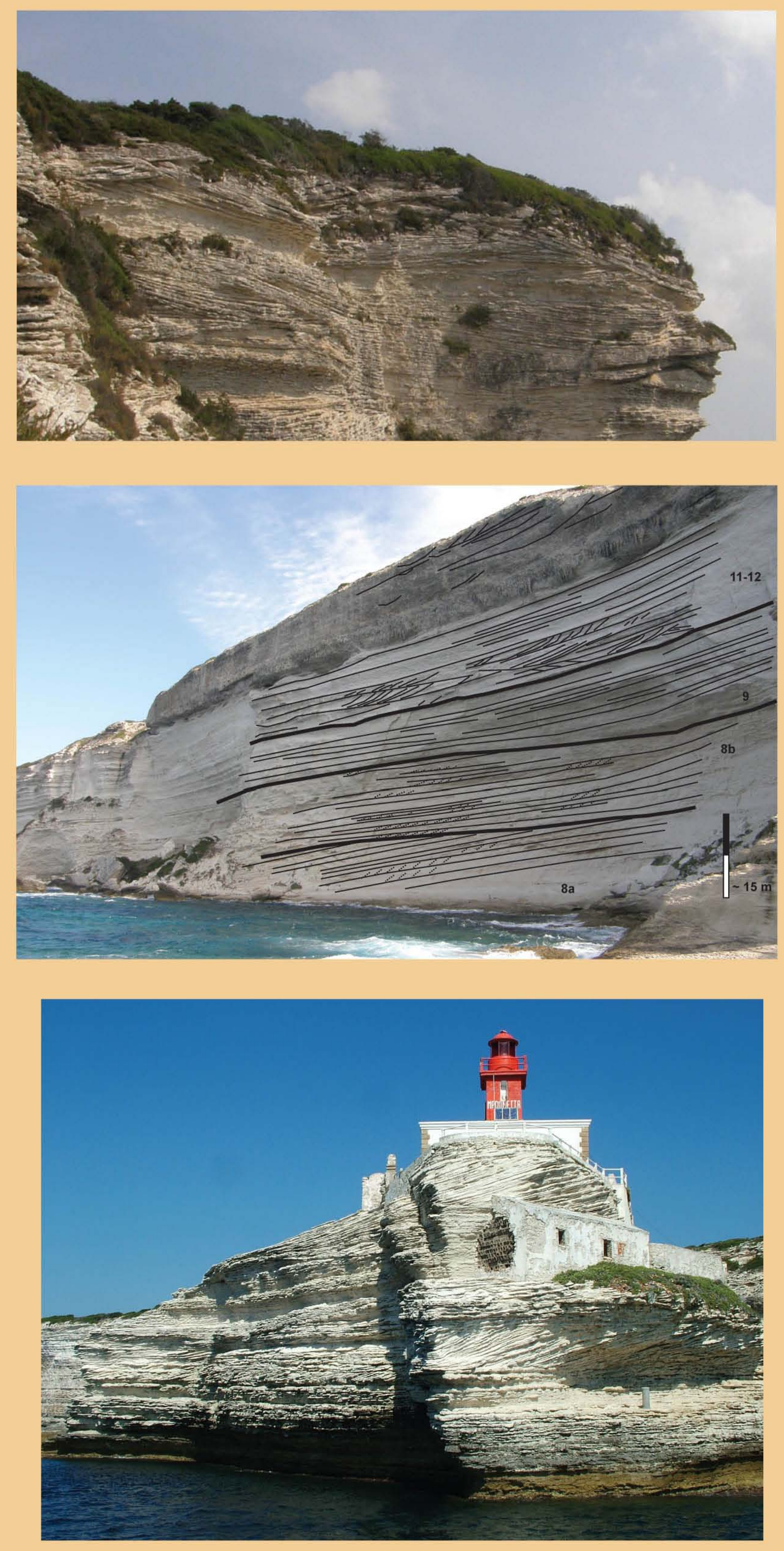

Fig. 6: widespread cross bedding (lithozones 8 and 11 -12).

North-Western Basin Margin

- Local presence of incised valleys infilled by coarse-grained gilbert deltas (Fig. 7a).

- Aggradational bioclastic deposits with large scale cross bedding (Fig. 7b) abruptly terminate northwards .

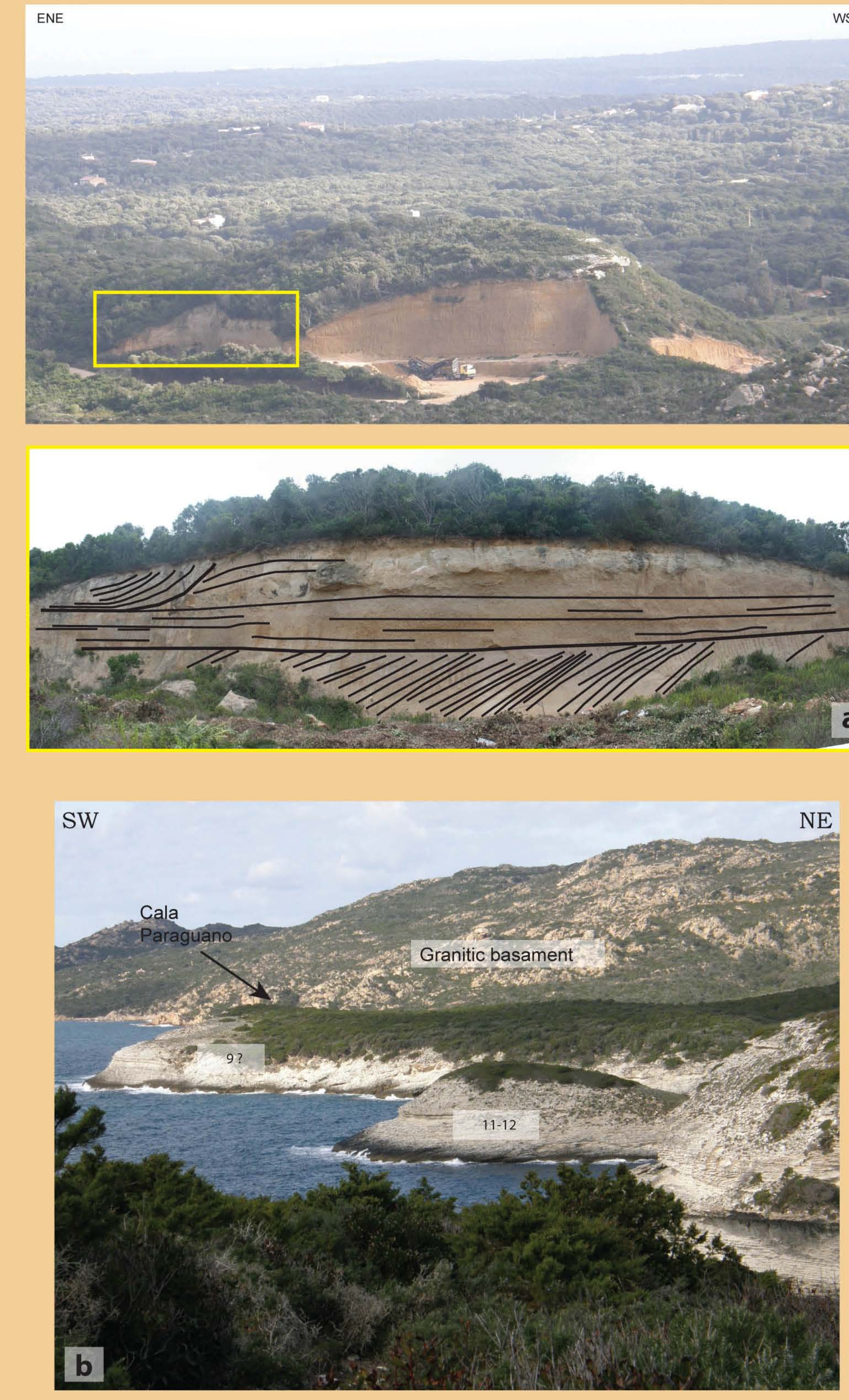

Fig. 7: gilbert deltas (a); abrupt northward termination of the cross-bedded bioclastic limestones (b).

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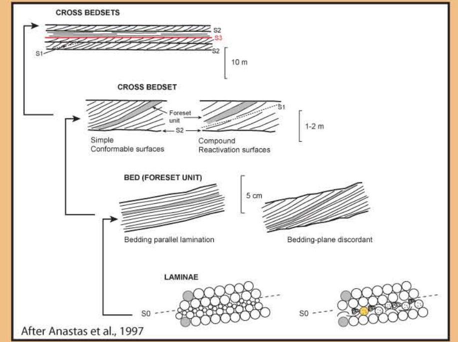
Sedimentological analysis of cross-beds



Methodology:

1) Identification of different hierarchies of cross strata;
2) Bedsets description: grain size, composition and geometry;
3) Cross beds dips measurement.

Cross bedsets lithozone 8

- Siliciclastic component prevails;
- Marginward: decimetric thickness,thickening-thinning-upward stacking patterns (Fig. 7a);
- Basinward: metric thickness, wedge-shaped geometries, local soft deformation (Fig. 7b).

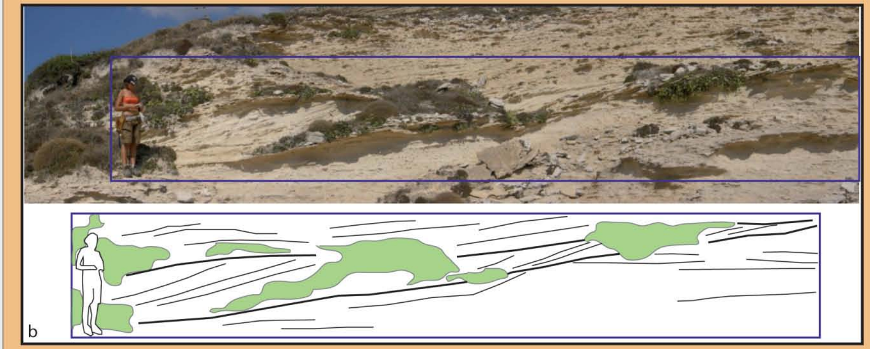


Fig. 8: thickening-thinning upward trend of cross bedsets located marginward (avarege height 30 cm; a); photograph and line drawing of a wedge-shaped cross bedset located basinward (height 1.20 m; b).

Cross bedsets lithozone 11-12

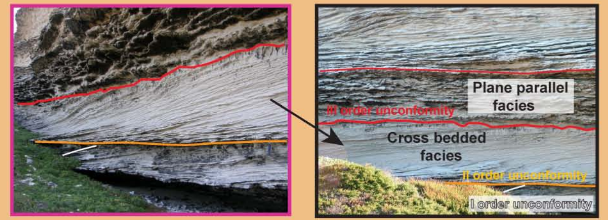
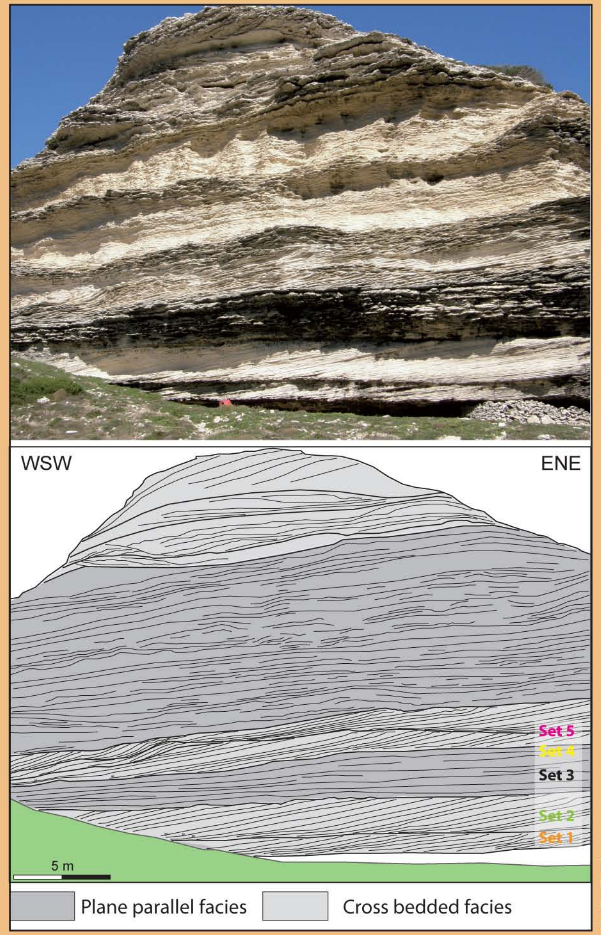


Fig. 9: example of different hierachies of surfaces.

- Biogenic component prevails;
- Relatively constant thickness;
- cross bedded facies interbedded with plane parallel facies;
- two types of discontinuity surfaces: II and III order (Fig. 9).



III order unconformities:

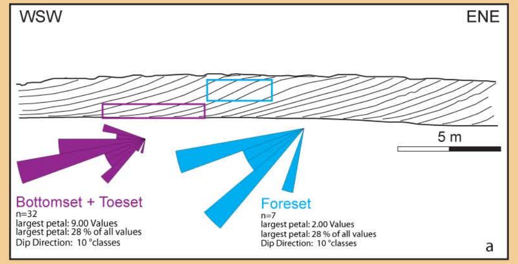
- separates cross bedded and plane parallel facies (Fig. 10);
- marked by sedimentary structures and grain-size changes, i.e. plane parallel facies are coarser grained than cross bedded facies;
- they are highly erosive surfaces;
- they can be overlain by microconglomerate layer.

II order unconformities:

- are erosive with respect to the underlying cross bedsets;
- don't represent a change in grain-size or sedimentary structures.

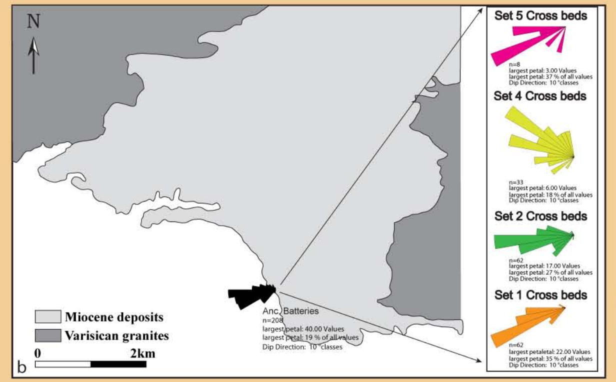
Fig. 10: photograph and line drawing of the cross bedded and plane parallel facies at Ancienne Batteries outcrop. Bedsets numbers are reffered to the paleo-curent analysis.

Paleocurrent analysis



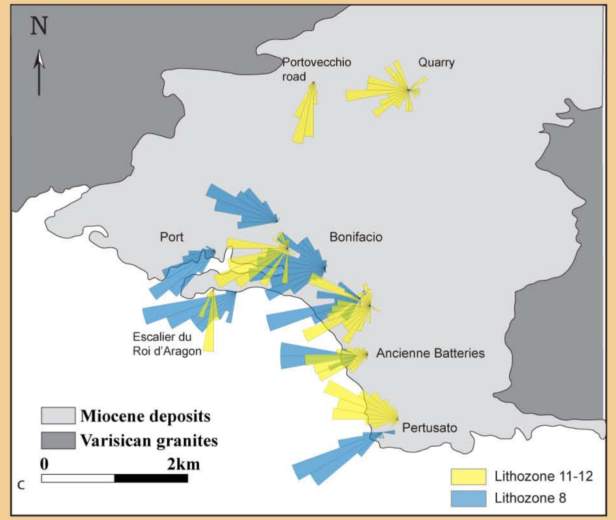
Over 1000 cross bed dip measurements have been collected.

Statistical analyses (max, min, median, standard deviation) and rose diagram elaborations have been performed.



Regardless of scale, the dips are relatively homogeneous (within each cross bedset (Fig. 11a), in vertically stacked cross bedsets (Fig. 11b), at the lithozone scale, at the basin-fill scale; Fig. 11c).

Cross bedsets dips, geometry and facies analysis suggest frontal accretion



Dune fields migration:

- mainly from the South-Eastern basin margin (Lithozone 8b and 11-12)
- sometimes (Lithozone 11-12) from the North-Western margin or along the axial zone.

Fig. 11: schematic drawing of Set 2 cross beds (Location Ancienne Batteries) highlighting bottomset and toeset beds and foreset beds (a); rose diagrams of the measured cross beds dip across vertically stacked cross bedsets from the same location (Ancienne Batteries) (b); rose diagrams of the measured cross beds dip across the Bonifacio Basin (lithozones 8 and 11-12) (c).

Interpretation

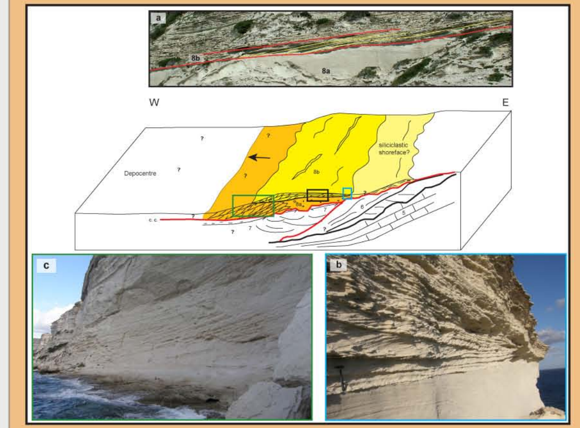
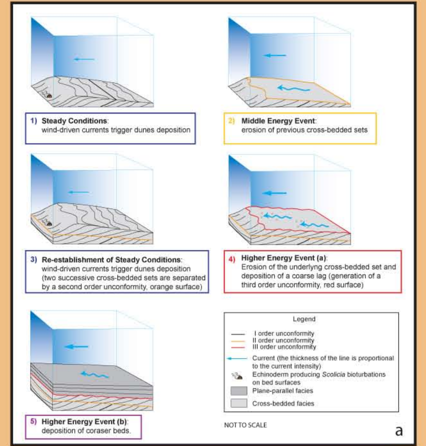


Fig. 12: depositional model for the cross bedsets of lithozone 8.

Cross bedsets lithozone 8: basinward migrating dune fields generated by unidirectional currents (Fig. 12);

- Wedge-shaped geometries related to the transition-slope;

- Thickening- thinning-upward trend related to the downcurrent migration of the dune field.



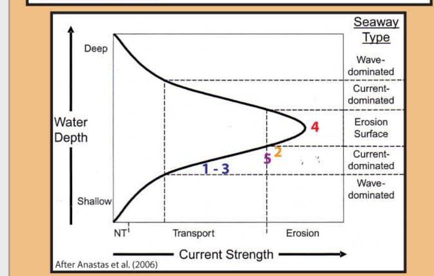


Fig. 13: depositional model for the developement of the alternating cross bedsets and plane parallel bedsets (based on the facies observed in the Ancienne Batteries outcrop; a); transition slope trajectory (b).

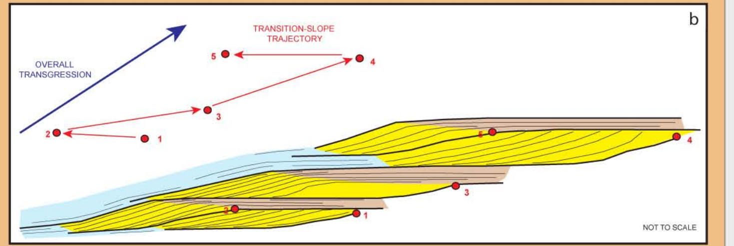
Cross bedsets lithozone 11-12: downcurrent-migrating, unidirectional dune fields.

Interbedding between cross-bedded and plane-parallel bedsets:

1) periodic-aperiodic variations in current strenght (Fig. 13a):

- Dune migration (phases 1 and 3): stationary currents
- High energy event (phase 2): erosion (II order discontinuity)
- Higher energy - greater magnitude event (phase 4): erosion (III order discontinuity)
- Deposition of upper flow regime plane-parallel facies (phase 5)

2) high-frequency variations of relative sea-level changes (i.e. transition slope trajectory; Fig. 13b).



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Sequence Stratigraphy

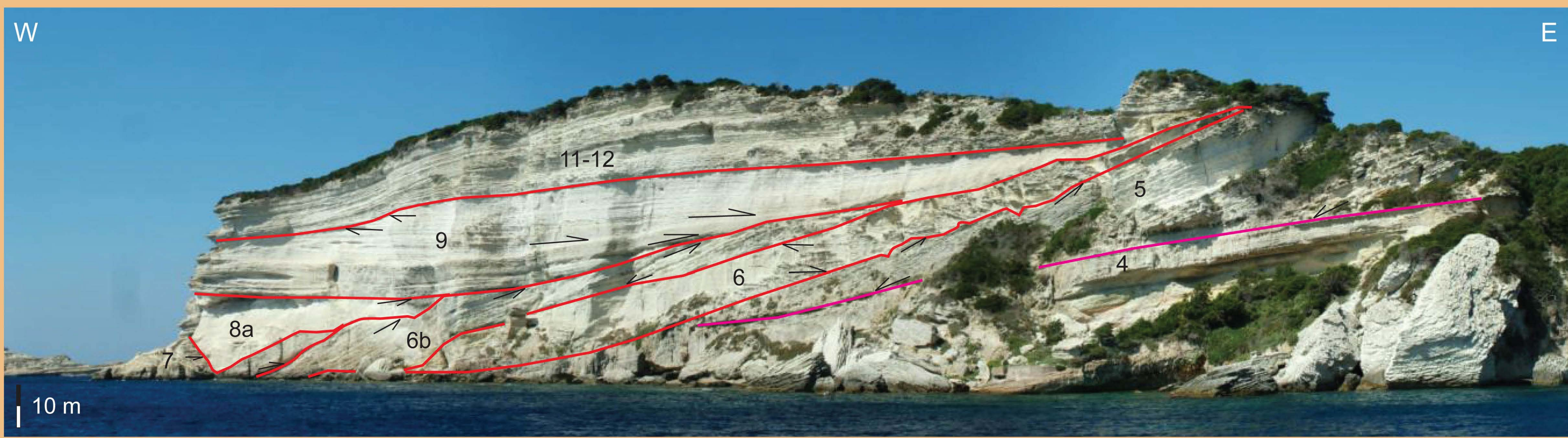
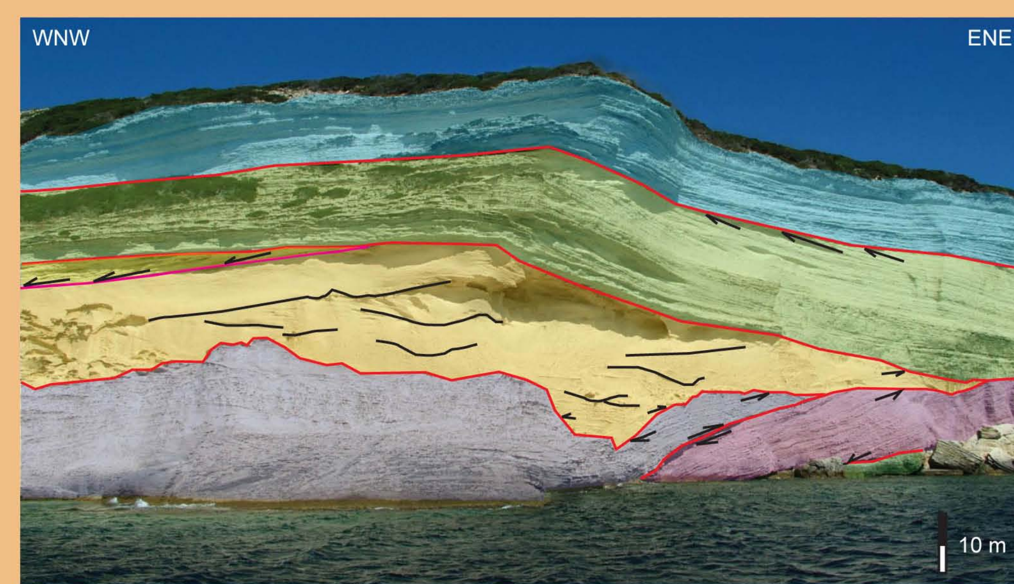


Fig 14: outcrop photograpshs highlighting important stratigraphic surfaces and cycles.



- The Bonifacio Basin succession can be divided in three III-IV order depositional sequences (Figs. 14 and 15);
- SB, TS and MFS are associated to important changes both in sediment composition and sedimentray structures;
- Realative s.l. falls recorded by an increase in siliciclastic input;
- increasing rate of relative s.l rise associated to increasing carbonate productivity;
- TST recorded locally by fringing reefs and widespread unidirectional dune fields;
- HST recorded by prograding carbonate ramps and locally by fringing reefs.

Lithostratigraphy		Age	Lithozones	Systems Tract
Bonifacio Formation	Bonifacio Member	Burdigalian	11-12	TST
			9-10	
	Pertusato Member		8b	Late LST?
			8a	LST
			7b	Early HST?
			7	LST - TST
Cala di Labra Formation			6b	Late HST
			6	
			5	HST
			4	
			3	TST
			2	
			1	

Fig 15: sequence stratigraphic chart of the Bonifacio Basin succession (red: SB, blue: TS; green: MFS).

Conclusions

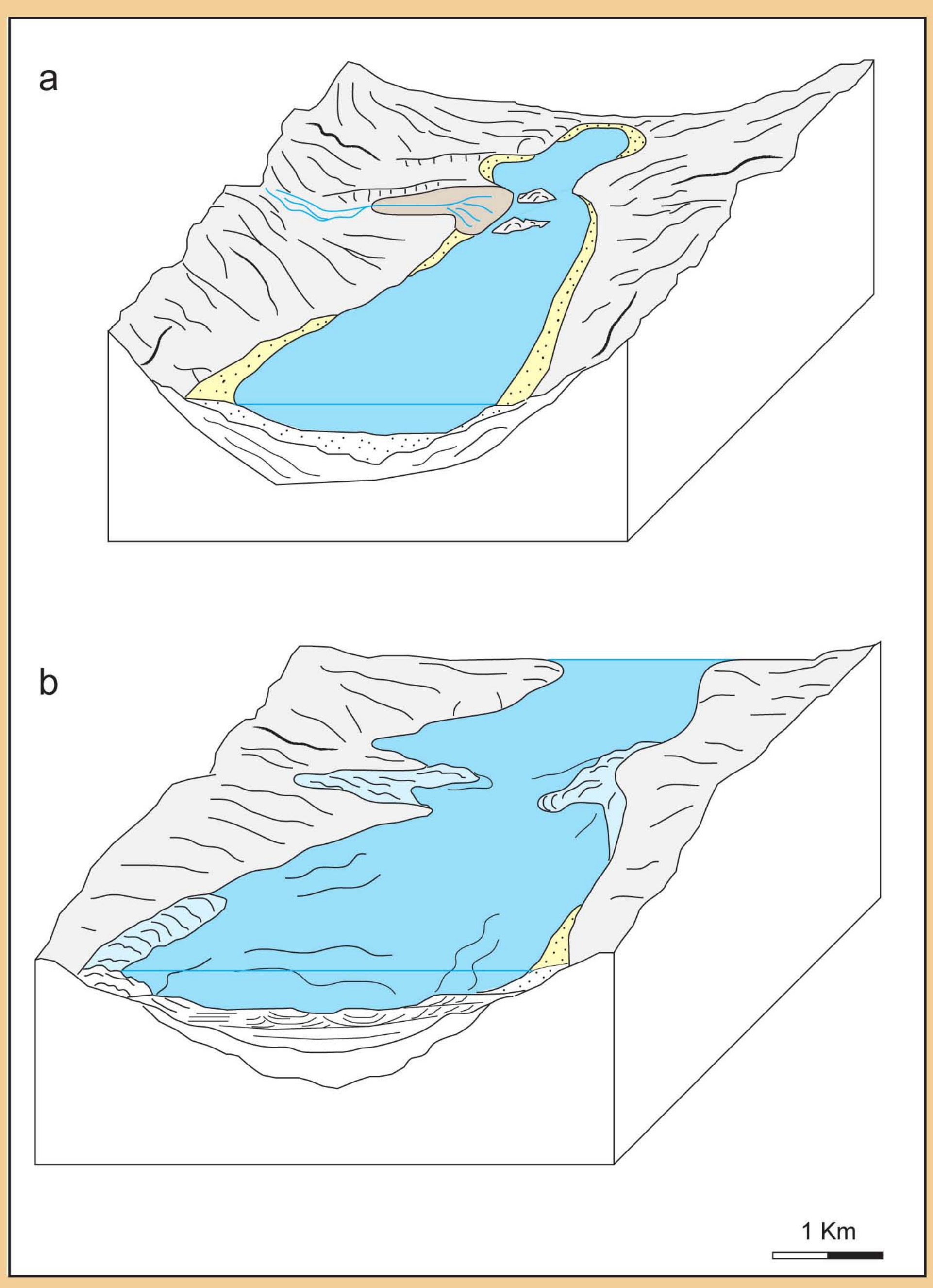


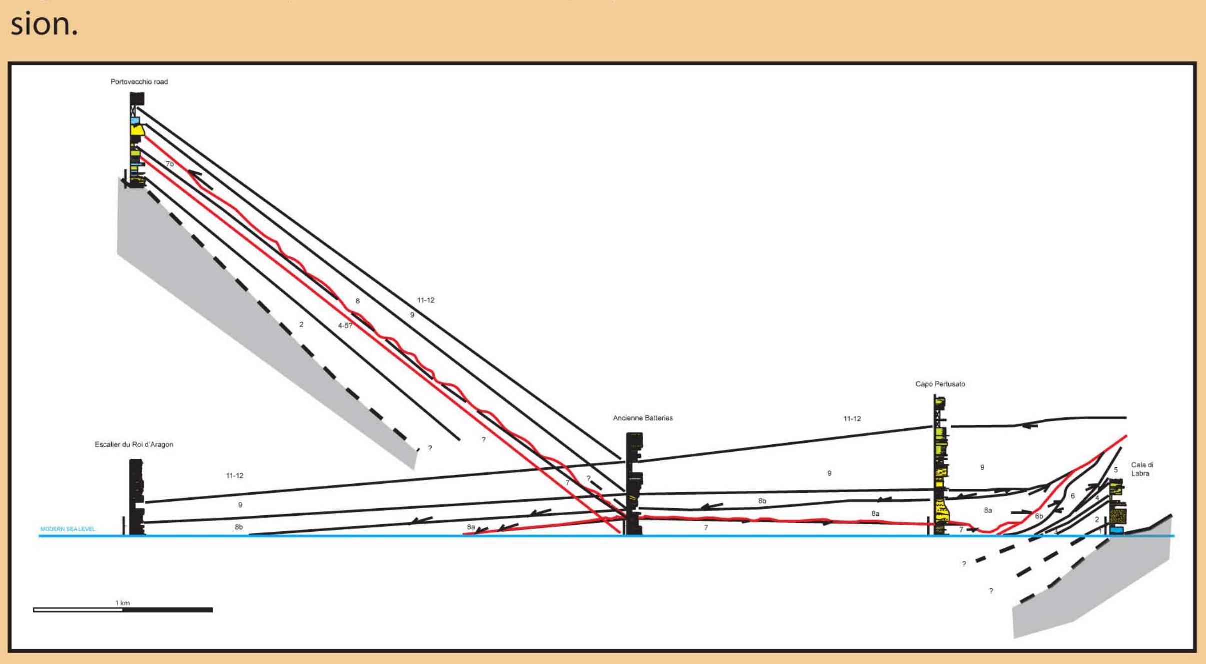
Fig 16: evolution of the basin from paleogulf to paleostrait.

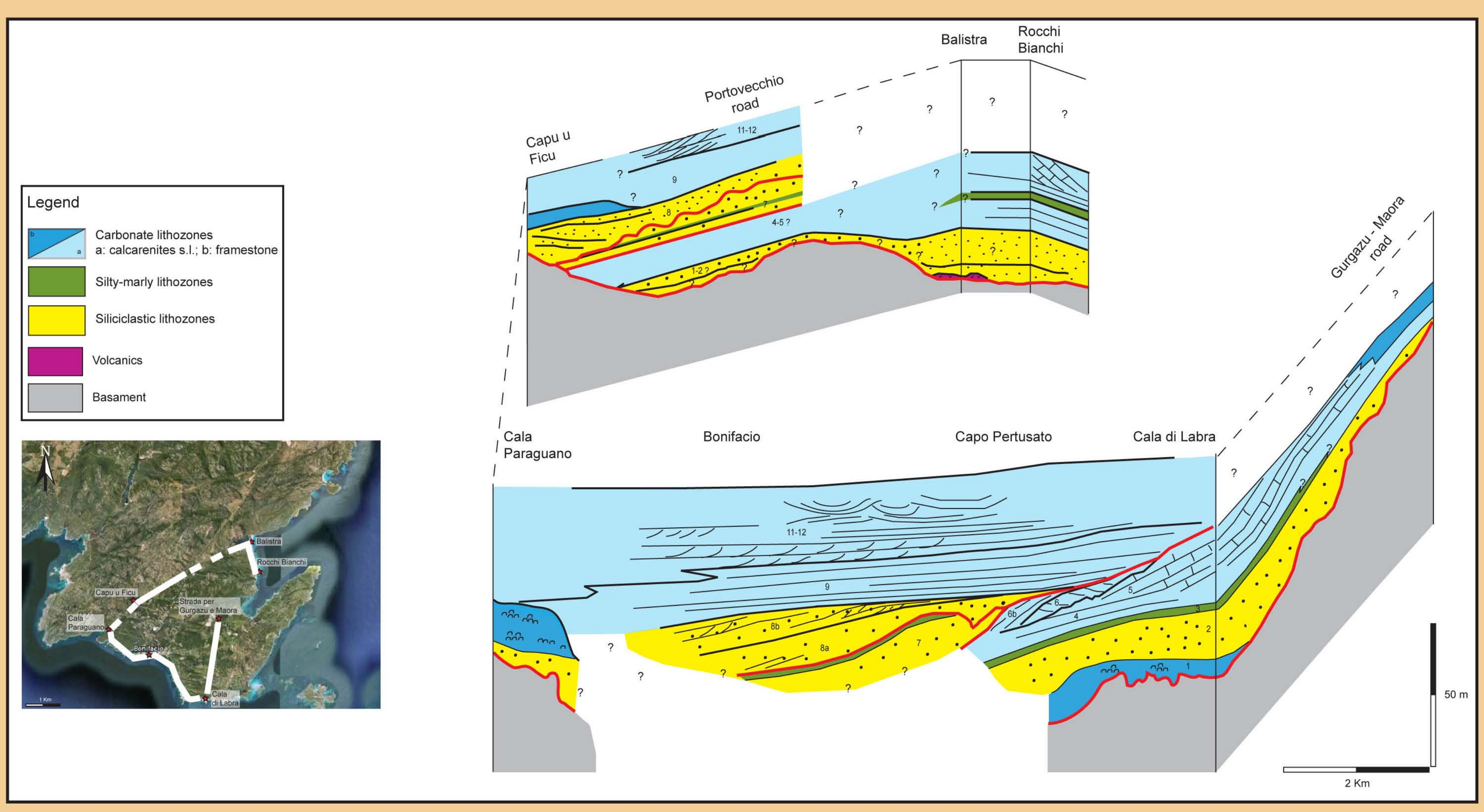
1) BASIN MORPHOLOGY: the facies distribution and basin morphology, rapidly enlarging SW-wards, suggest that during low sea -level time intervals the basin was a palaeogulf while during relative sea-level rise time intervals it behaved as a paleaeostrait connecting the Balearic and Thyrrenian basins, in which currents were accelarated (Fig. 16).

2) STRATIGRAPHIC CHART: stratigraphic reconstruction of the evolution of the Basin, based on the measured stratigraphic sections and on the vertical and lateral reletionships between the different lithozones (Fig. 17).

3) DEPOSITIONAL CONTEXT: generally high energy conditions in the Bonifacio Basin, but cross bedsets are present only in specific stratigraphic levels, i.e. when there were the appropriate conditions (relative sea level change and basin cross section variation) in order to establish and maintain relatively costant unidirectional currents.

Fig 17: correlation panel and 3D stratigraphic chart of the Bonifacio Basin succession.





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