PS

Quantifying Facies Attributes of the Caicos Platform*

By

Paul M. (Mitch) Harris[1] and Brigitte M. Vlaswinkel[2]

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Abstract

Spatial heterogeneity is a basic characteristic of carbonate depositional systems. Examining spatial depositional patterns and quantifying the facies attributes (e.g., size, shape, and facies interrelationships) in modern analogs can decrease uncertainty in a geologic model and therefore enhance the model's utility. In an attempt to gather such valuable data, the attributes for key facies of the Caicos platform are assessed from a Landsat image through facies mapping. Reef-associated facies, including fully aggraded reef, partially aggraded reef, and apron are emphasized due to their importance in many isolated platform reservoirs.

Some key findings are:

1 Platform size and reef abundance are directly related, wherein reef (fully and partially aggraded) and reef apron occupy a smaller percentage of a large platform like Caicos.

2 Reefs seem to be patchier than aprons.

3 Fully aggraded reefs become somewhat wider as their length increases; partially aggraded reefs are discontinuous along their long axis so the relation to reef width is more subtle.

4 Reef width and apron width are directly related.

5 Probabilities can be set for expected dimensions for: reef width (10% probability that reef width > 410 m, 50% probability > 270 m, and 90% probability > 145 m); and apron width (10% probability that apron width > 945 m, 50% probability > 395 m, and 90% probability > 90m).

Modern analogs like Caicos can play an important role as conceptual facies models for characterization of a reservoir, and also in providing facies attribute information to be used as input in building reservoir models.

Trend Metrics of Modern Platforms and Reef Systems & Quantifying Facies Attributes of the Caicos Platform

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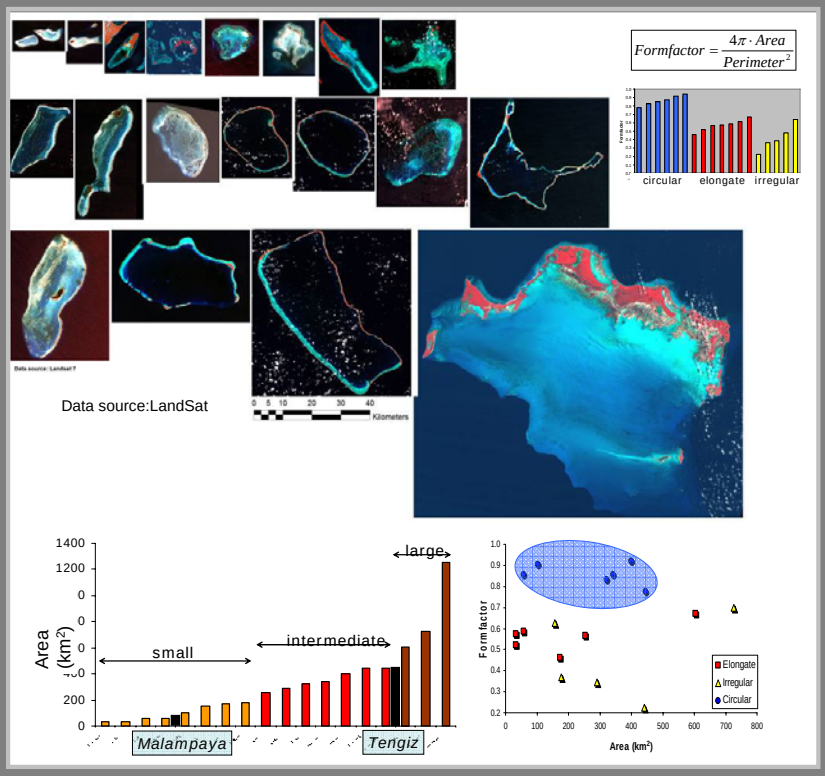
Rationale

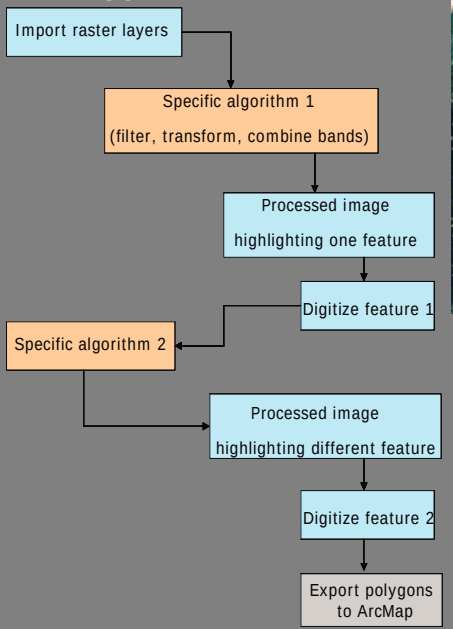
- An accurate facies model is essential for reservoir characterization and realistic reservoir modeling, as depositional facies can be a main parameter controlling heterogeneity in porosity and permeability
- Prediction of the quantitative attributes (size, shape, orientation, distribution, etc.) and variation of facies dimensions is fundamental for enhanced reservoir simulations for carbonate systems

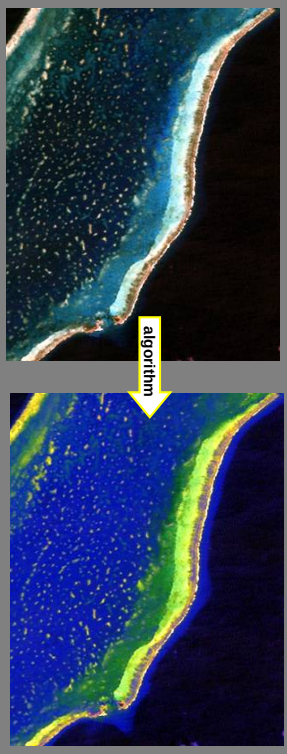
Data – Grouped by size and shape



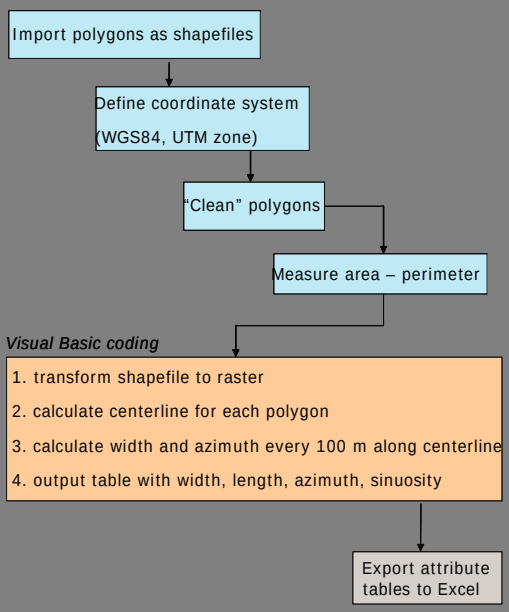
Workflow

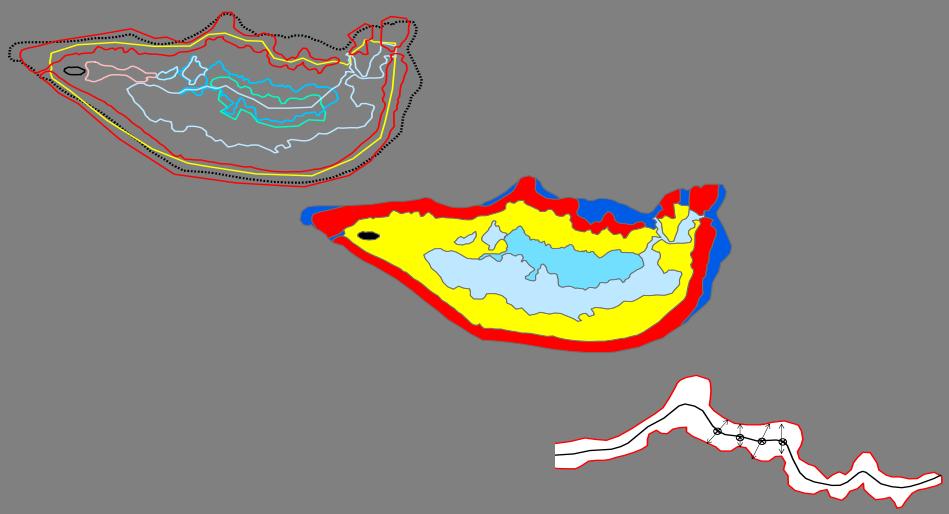
ER Mapper:





ArcGIS:

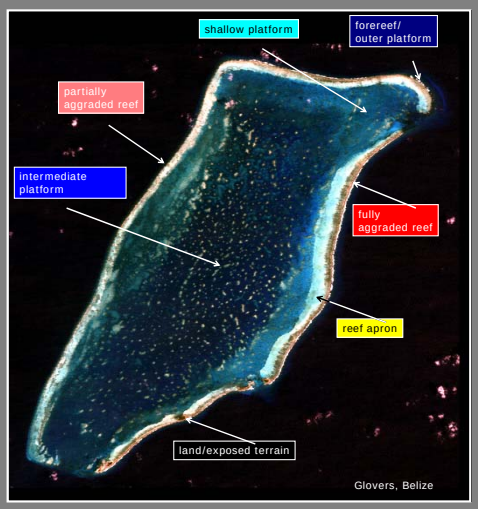




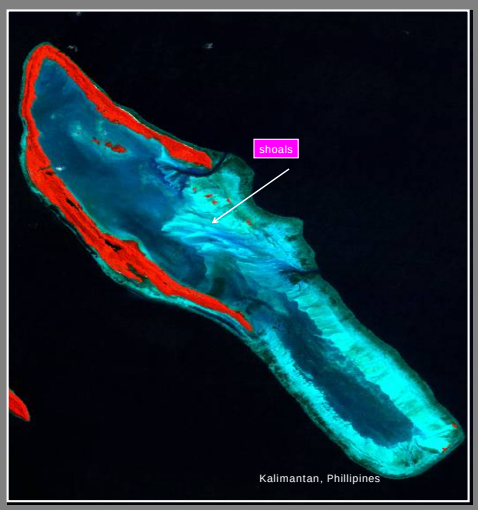
Objectives

- Provide an overview of the spectrum of facies patterns present in modern isolated carbonate systems
- Obtain quantitative data on facies dimensions, grouped by size and shape of carbonate platform
- Explore correlations and trends on landscape and facies scale

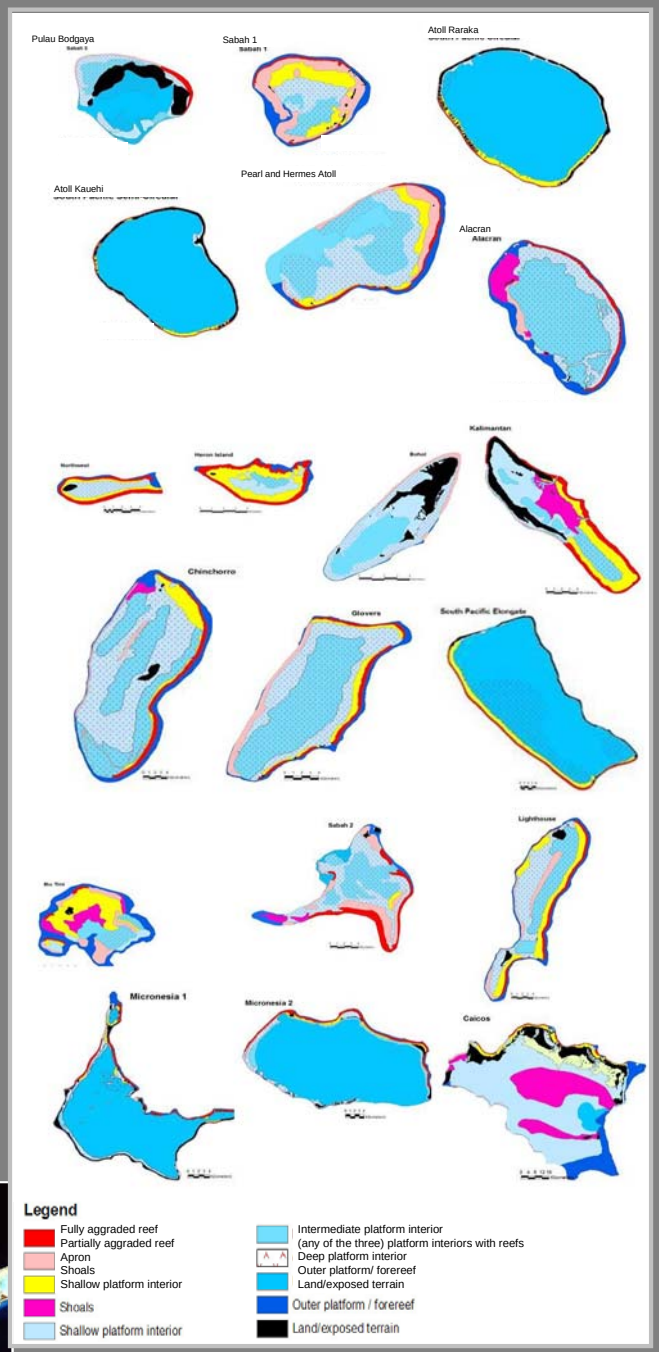
Facies



1) Fully aggraded reef
2) Partially aggraded reef
3) Reef apron
4) Shoals
5) Shallow platform interior (w or w/o isolated reefs)
6) Intermediate platform interior (w or w/o reefs)
7) Deep platform interior (w or w/o reefs)
8) Forereef/outer platform
9) Land/exposed terrain



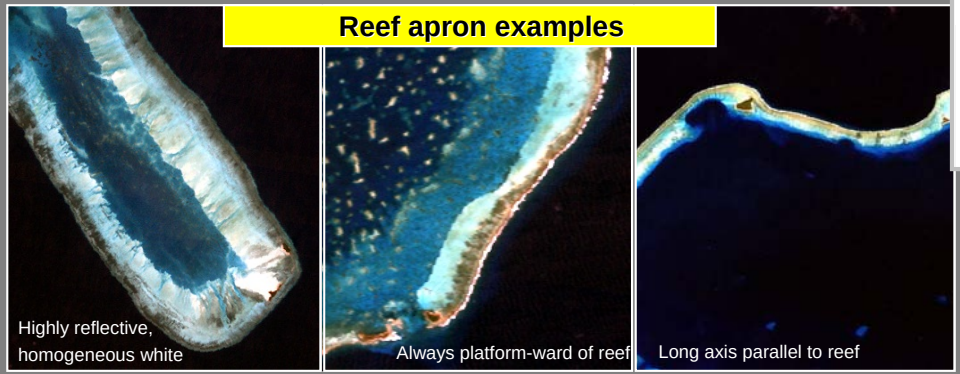
Facies maps



Objective Reproducible Criteria

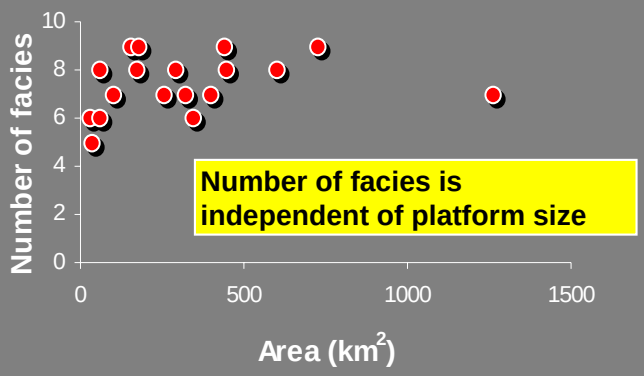
Color, context, texture and shape

Reef apron examples

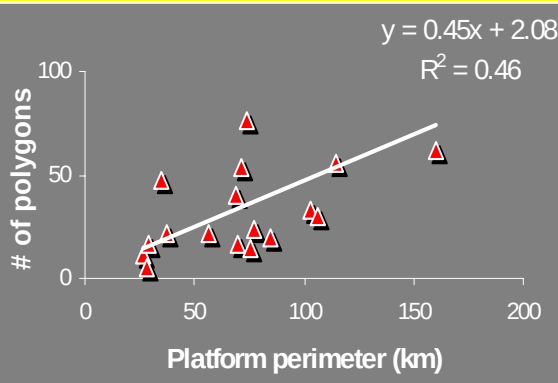


Landscape Scale 'Rules'

Composition

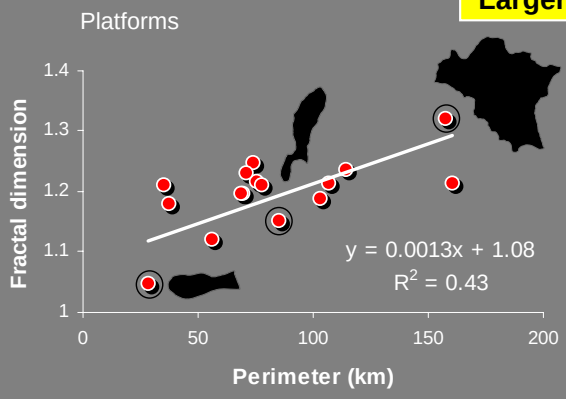


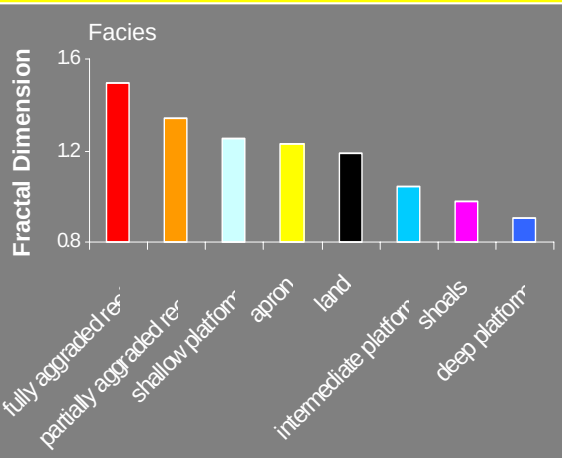
Larger platform perimeter → more facies polygons



Shape complexity

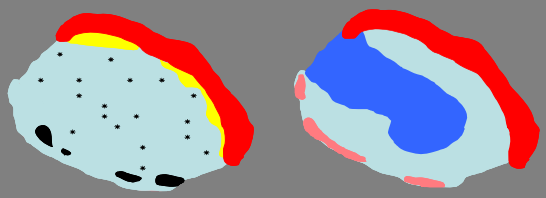
Larger platform perimeter → more complex facies shapes within platform

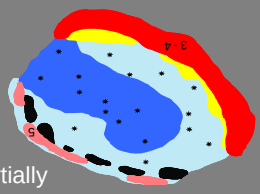




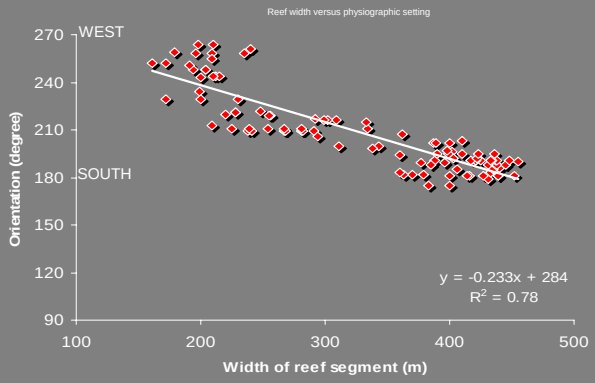
Platform configuration

Side A: fully aggraded reef
(w or w/o apron)





Side B: land / partially aggraded reef/platform

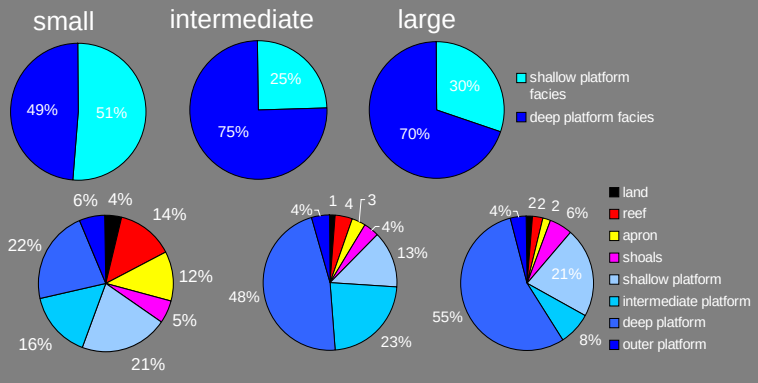


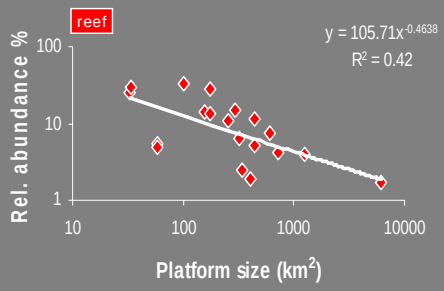
Asymmetric facies configuration leads to variability of facies characteristics within the platform.

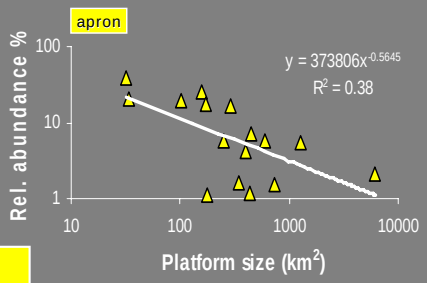
Windward side of platform is expected to show higher standard deviation of reef width than leeward side.

Facies Metrics

Facies proportions





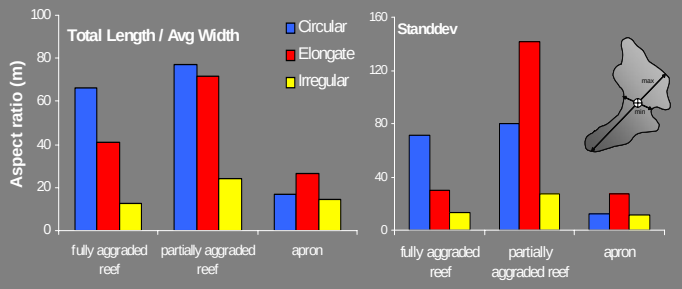


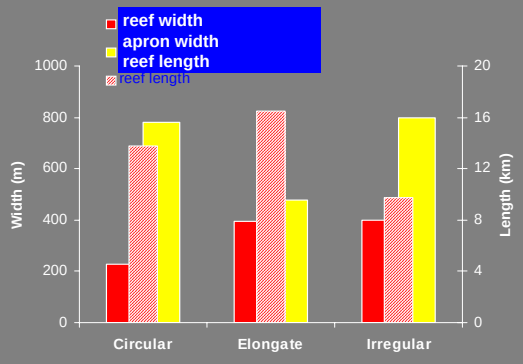
'Large' platforms contain proportionally less potential reservoir (reef, apron, shoals, shallow lagoon) than 'small' platforms

Power law relationships

Reef belt metrics

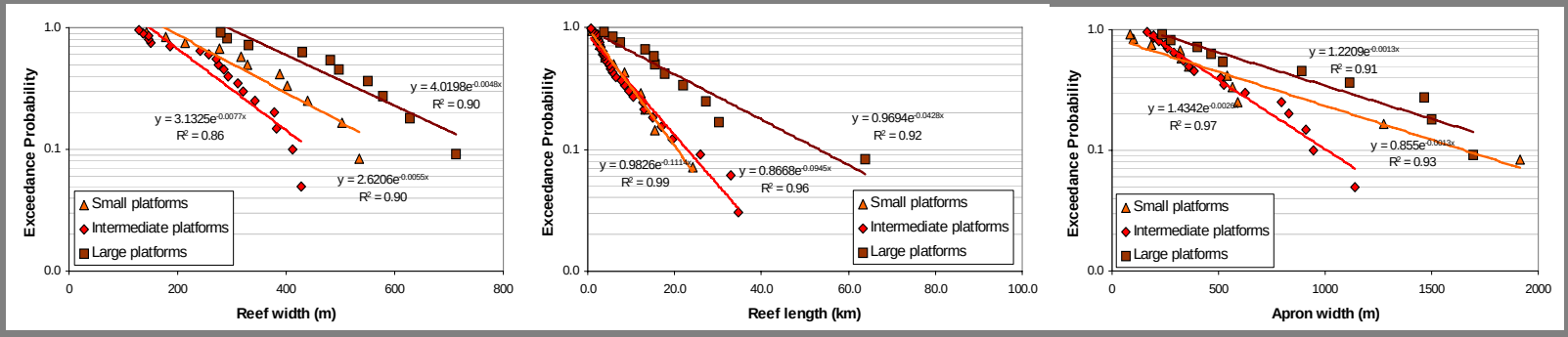
- **Circular platforms - narrowest reef**
- **Elongate platforms - narrowest apron**
- **Irregular platforms - least continuous reef**





Irregular platforms have a significantly lower aspect ratio for its reef facies.
Reefs are *consistently* shorter and wider

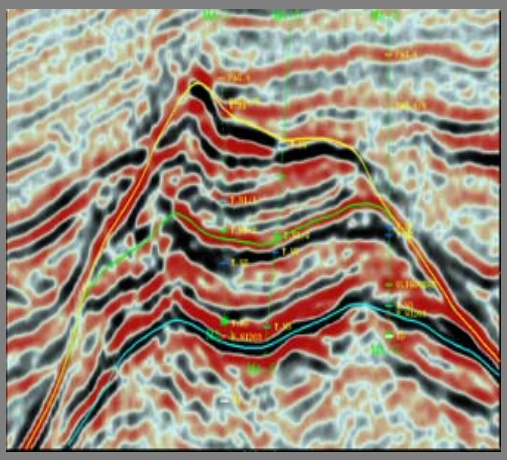
Exceedance probability

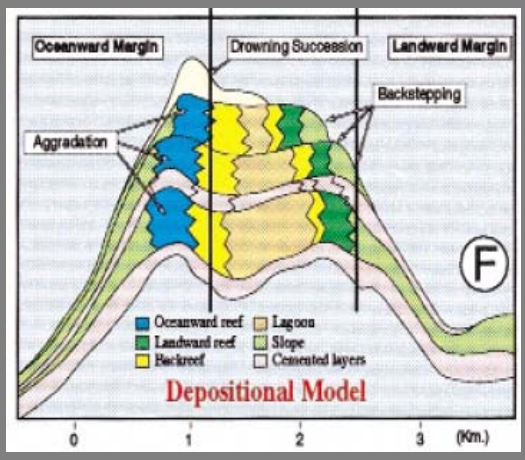


On any size platform...

10% probability: reef width > 400 m	**reef length > 20 km**	**apron width > 950 m**
50% probability: reef width > 240 m	**reef length > 5 km**	**apron width > 400 m**
90% probability: reef width > 120 m	**reef length > 1 km**	**apron width > 100 m**

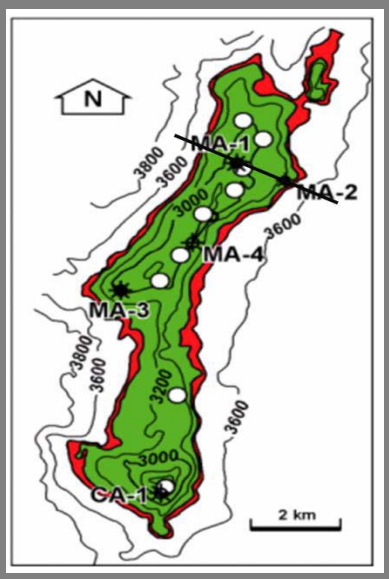
Implications for Reservoir Modeling

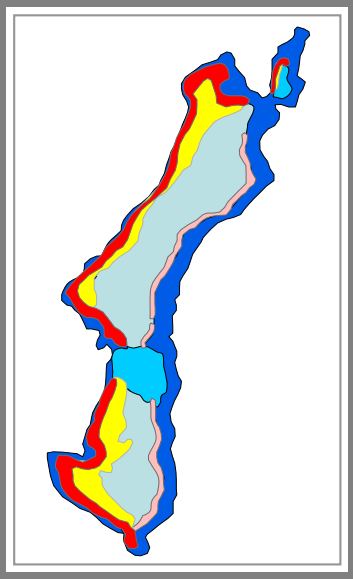




Malampaya is an isolated carbonate platform with a reef rim and an asymmetric facies distribution over the platform.

Grötsch and Mercadier, 1999

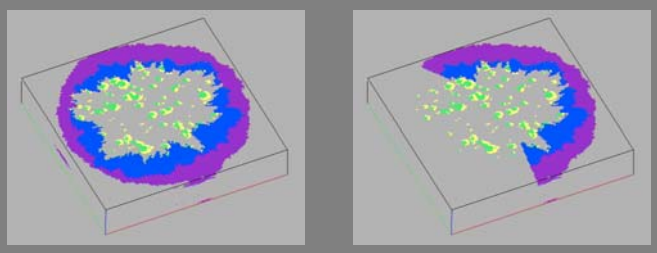




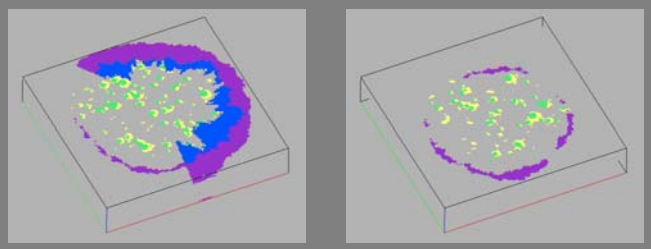
Landscape scale 'rules' explored on modern platform analogs provide information on conceptual facies depocenters

FACIES	Rock type	% Rel. Abundance	Avg width (m)	Range (m)	Avglength (km)	Aspect ratio(m)	Sinuosity
Fully aggraded reef	Boundstone Rudstone	6	387	150-625	16.5	41	0.21
Partially aggraded reef	Boundstone Rudstone Grainstone	1	196	115-300	11.3	71	0.09
Apron	Rudstone Grainstone	7	565	130-965	14.8	27	0.2
Shoals	Grainstone	3	2445	655-3395	6.8	3	
Shallow platform	Packstone	21					
Intermediate platform	Packstone Wackestone	19					
Deep/outer platform	-	41					

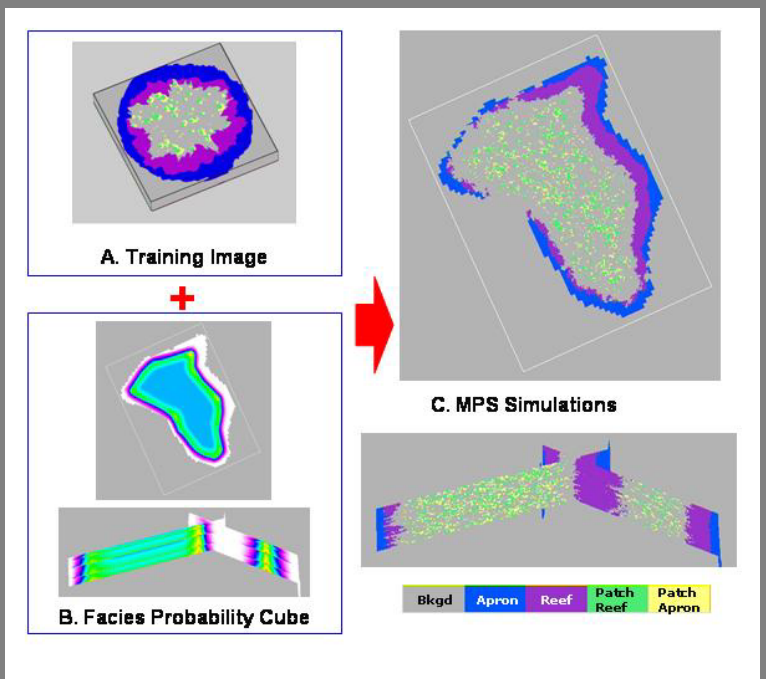
Facies metrics obtained from modern analogs also provide input parameters for training images that are used in Multiple Point Statistics (MPS) reservoir models.



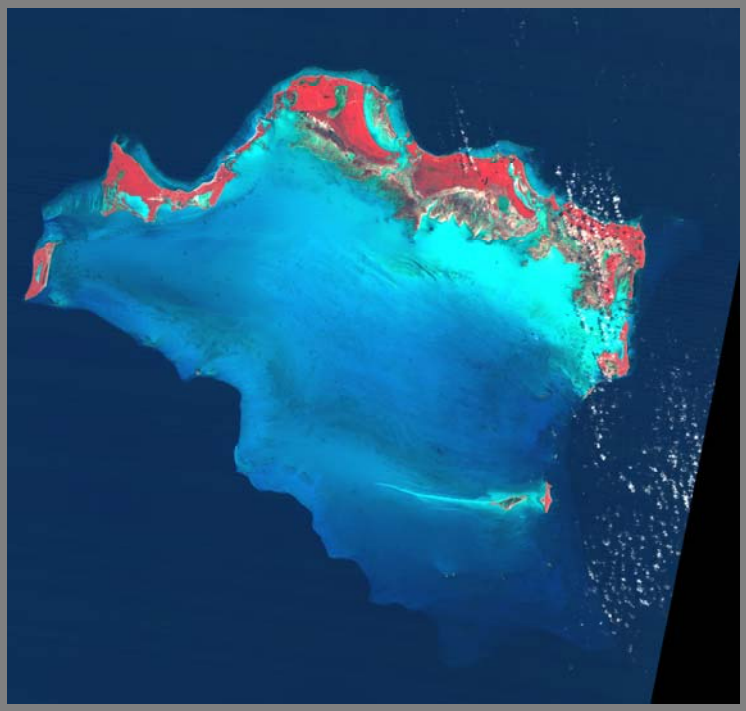
Fully aggraded reef with apron



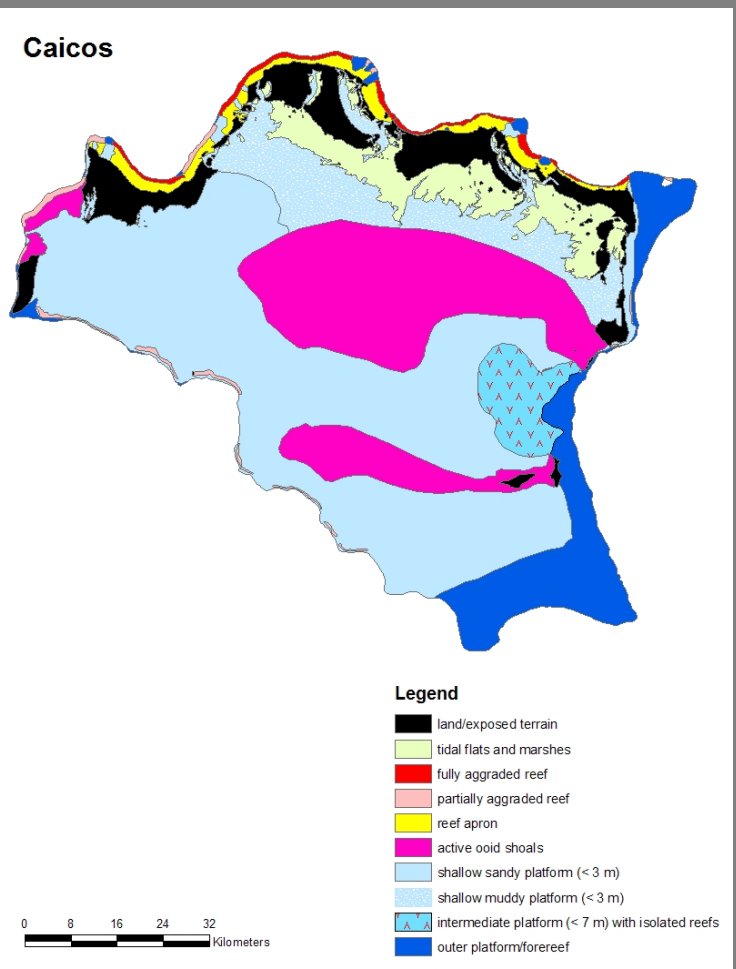
Partially aggraded reef



Quantifying Facies Attributes of the Caicos Platform

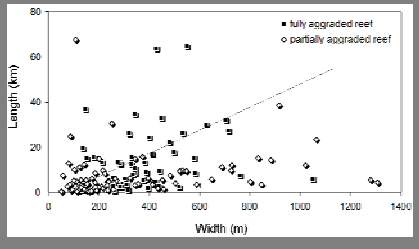


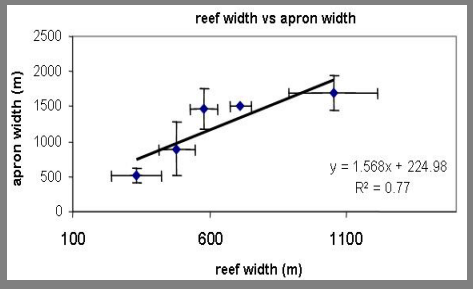
Landsat Image and facies interpretation of the Caicos Platform



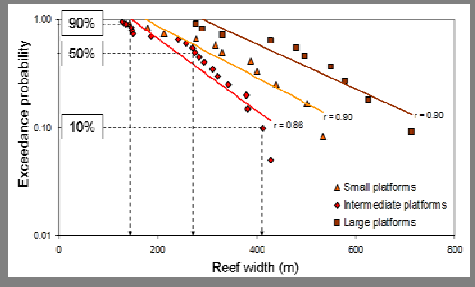
Attribute data for reef facies

Reef Facies	Mean Width (m)	Min Width (m)	Max Width (m)	Standard dev Width (m)	Length (m)	Aspect ratio (length/mean width)	Sinuosity
Fully aggraded	331	126	783	183	15443	47	0.1146
	1051	300	1676	321	5846	6	0.1327
	481	213	771	128	21928	46	0.0846
	578	269	841	101	15172	26	0.1180
	760	391	1046	162	7545	10	0.0315
	713	409	881	80	27215	38	0.1111
Partially aggraded	269	158	420	60	5254	20	0.0987
	345	15	465	90	3212	9	0.0286
	217	123	311	46	9654	45	0.0663
	323	25	510	88	6408	20	0.1333
	216	174	247	23	1653	8	0.0041
	548	270	816	132	9362	17	0.0959
	521	248	965	191	9486	18	0.0827
	263	134	350	58	5863	22	0.0093
	372	79	1306	223	15635	42	0.0410
	413	233	503	82	3439	8	0.0083
	458	324	590	93	1460	3	0.0113
	884	349	1361	175	14283	16	0.0757
	724	19	869	93	9722	13	0.0119
Apron	846	556	1043	164	3382	4	0.1109
	1115	482	2696	502	23500	21	0.0955
	2125	697	2725	506	7737	4	0.0846
	891	26	2449	764	21807	24	0.0793
	1695	443	2119	492	10928	6	0.1178
	521	149	1105	213	13814	26	0.1085
	1464	63	4478	573	24977	17	0.3925
	1500				2798	2	
	1722				1959	1	

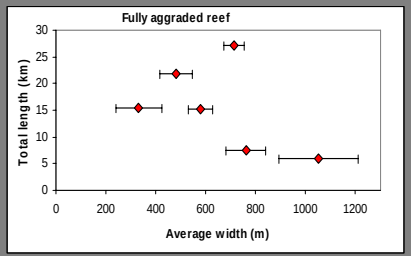


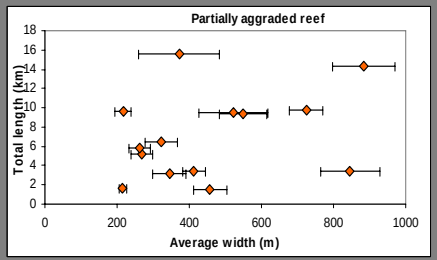


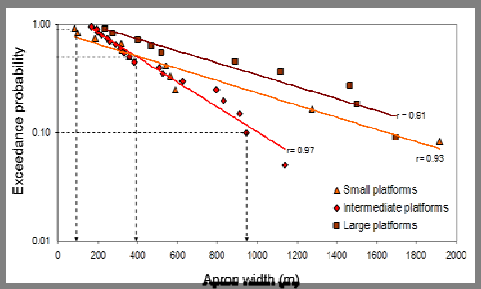
Data from all platforms above suggest that fully aggraded reefs generally become wider as their long axis increases, but the relation is more subtle for the more discontinuous partially aggraded reefs. Facies metrics specific to the Caicos platform below for fully aggraded reef and partially aggraded reef show much less distinct trends.



Data from Caicos platform (top) shows strong positive relation between width of the reef (reef is fully or partially aggraded) and the apron. Exceedance probability plots from all platforms with Caicos being the largest show size attributes for reef width and apron width.







Input for Carbonate Reservoir Models: Trend Metrics of Modern Platforms and Reef Systems*

By

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*Abstract prepared for poster presentation at 2006 AAPG International Conference and Exhibition, Perth, West Australia

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Abstract

An accurate facies model is essential for reservoir development and realistic reservoir modeling, as depositional facies can be a main parameter controlling heterogeneity in porosity and permeability. Prediction of the quantitative attributes (size, shape, orientation, distribution) and variation of facies dimensions is also required for enhanced Multiple Point Statistics simulations for carbonate systems. To address these needs, we generated quantitative data on sizes and shapes of facies within and among different sized and shaped platforms. Landsat images from 19 modern carbonate platforms from the Caribbean and Indo-Pacific regions are used as analogs to offer insights into potential facies heterogeneity of carbonate reservoirs.

The workflow for identifying and quantifying attributes of facies tracts included integrating literature and satellite images in a GIS, followed by statistical analysis. Based on objective reproducible criteria, up to 9 different facies classes were mapped and hand-digitized on all platforms using ER Mapper. Reservoir facies included fully aggraded reef, partially aggraded reef, reef apron, shoals and shallow platform interior. A GIS provided a tool for quantitative characterization, measuring for every polygon of each facies attributes such as area, perimeter, width, length, orientation, and the variability within those metrics. Subsequent statistical analyses demonstrate the existence of certain predictive “rules” between the configuration and composition of facies tracts on and among carbonate platforms (e.g. size of platform versus number/abundance of facies or size of platform versus shape complexity.) These kinds of “rules” provide both general concepts and raw data that can be used as input for enhanced carbonate models.