Integrating a Hierarchical Process and Architectural Marginal Marine Classification with a Computer Database and Expert System—Toward Improved Subsurface Predictions*

B. K. Vakarelov[1], R. B. Ainsworth[1], and R. A. Nanson[1]

Search and Discovery Article #41192 (2013)**
Posted September 9, 2013

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013

[1]WAVE Consortium, Australian School of Petroleum, University of Adelaide, Adelaide, Australia (bvakarelov@sedportal.com)

Abstract

Marginal marine classification schemes have historically not directly dealt with the different scales of geobodies that build such systems. Classifications tend to be simplistic and presented as 2-D and pseudo 3-D diagrams, based on relationships between the depositional system categories and shoreline processes (wave, tide, fluvial), and/or grain size or mode of coastal migration. While relatively straight forward and easy to apply, such a classification approach is not always effective at predicting architecture in the subsurface. The depositional system categories used are too broad and are not well related to different scales of observation. They also often refer to scales that can be much greater than the scale of an individual reservoir. Geospatial databases based on such categories also tend to display significant spread of data points.

An alternative classification approach allows for much better integration with computer database environments and sets the framework for building marginal marine expert systems by permitting an element of prediction. The process and architectural marginal marine classification uses hierarchies of architectural units that are linked through Parent-Child relationships in a Tree data structure. Each hierarchy level applies to a different scale of observation, with units covering the full spectrum of reservoir heterogeneities (entire flow units, inter-reservoir sand bodies, and intra-reservoir barriers and baffles).

The definition of Parent-Child relationships between architectural unit categories offers great advantages over traditional classification approaches. Since there is always a finite number of parent-child relationships between individual architectural categories, a unit identified on one level can be related to all possible parents to such a unit on another level. The set of potential parent categories in this case can be thought of as uncertainty. The children of predicted parent categories will have a Sibling relationship with the initially identified unit. Predicting the types of siblings that can be associated with a given architectural unit is important as these can co-exist in the same stratigraphic interval and, yet, may not be directly sampled by available data points (e.g., cores or wireline logs). The process and architectural marginal marine classification framework has been successfully integrated with a geospatial database and expert system software package that is currently under development.

References Cited

Ainsworth, R.B., B.K. Vakarelov, and R.A. Nanson, 2011, Dynamic spatial and temporal prediction of changes in depositional processes on clastic shorelines: Toward improved subsurface uncertainty reduction and management: AAPG Bulletin, v. 95, p. 267-297.

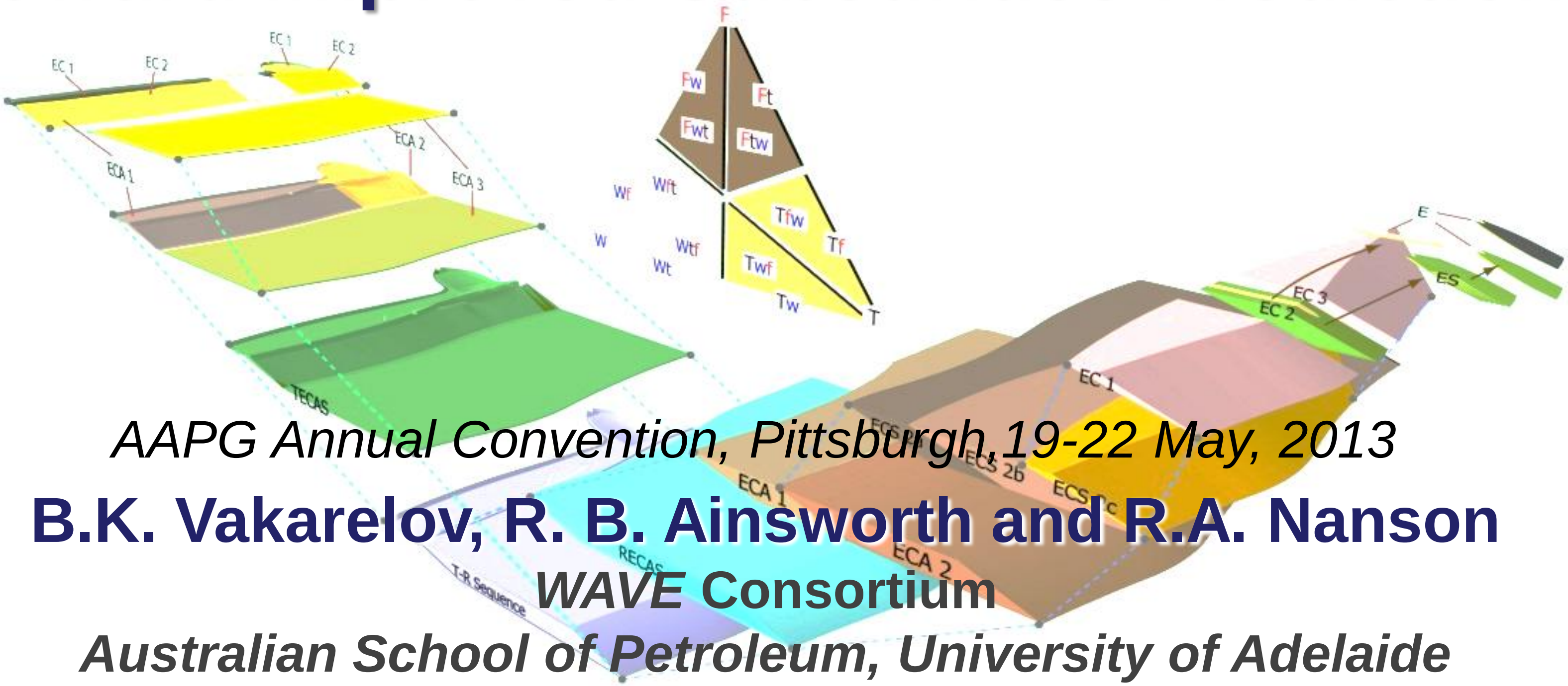
Bhattacharya, J.P., and L. Giosan, 2003, Wave-influenced deltas: geomorphological implications for facies reconstruction: Sedimentology, v. 50, p. 187-210.

Boyd, R., R.W. Dalrymple, and B.A. Zaitlin, B.A., 2006, Estuary and incised valley facies models, *in* Posamentier, H.W., and Walker, R.G., eds., Facies Models Revisited: SEPM, Special Publication 84, p. 171–234.

Galloway, W.E., 1975; Process framework for describing the morphologic and stratigraphic evolution of deltaic depositional systems, *in* Deltas: Models for Exploration: Houston Geological Society, p. 87-98.

Vakarelov B.K., and R.B. Ainsworth, 2013, A hierarchical approach to architectural classification in marginal-marine systems: Bridging the gap between sedimentology and sequence stratigraphy: AAPG Bulletin, v. 97, p. 1121-1161.

Integrating a Hierarchical Process and Architectural Marginal Marine Classification with a Computer Database and Expert System—Toward Improved Subsurface Predictions



AAPG Annual Convention, Pittsburgh,19-22 May, 2013

B.K. Vakarelov, R. B. Ainsworth and R.A. Nanson

***WAVE* Consortium**

Australian School of Petroleum, University of Adelaide

THE UNIVERSITY of ADELAIDE

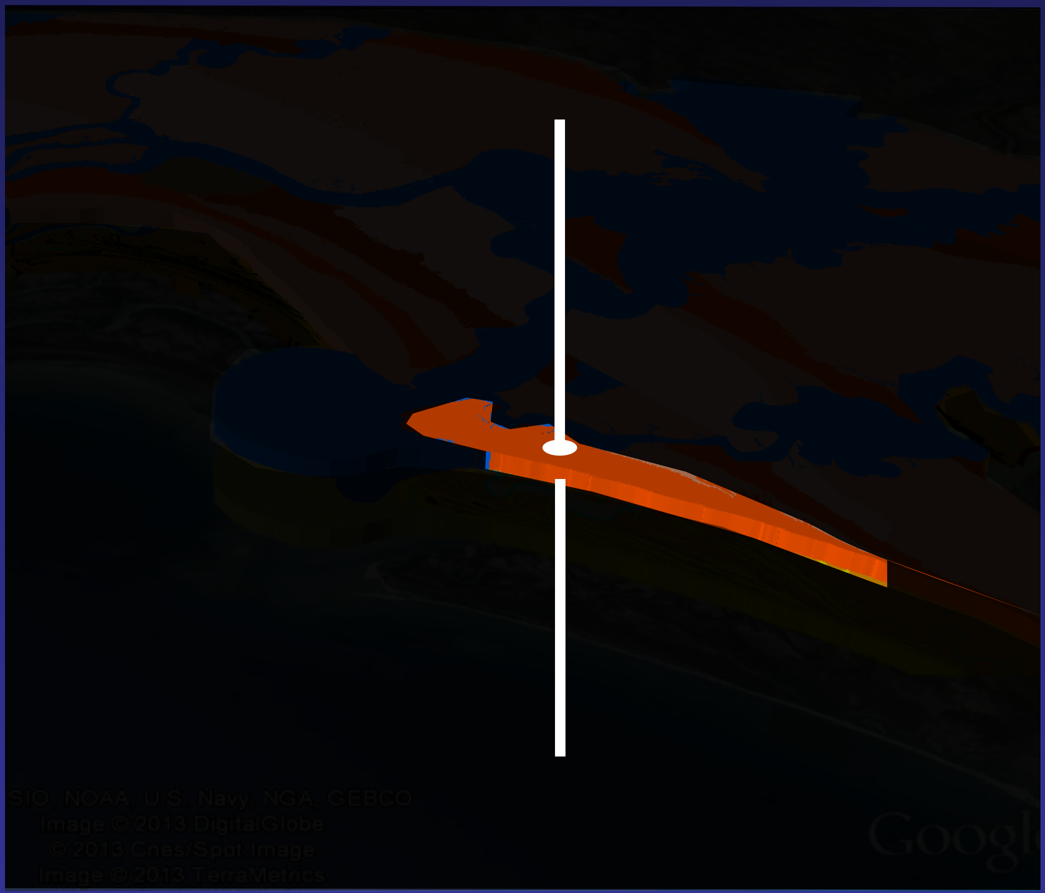
WAVE Consortium

RARG Reservoir Analogues Research Group

ASP Australian School of Petroleum

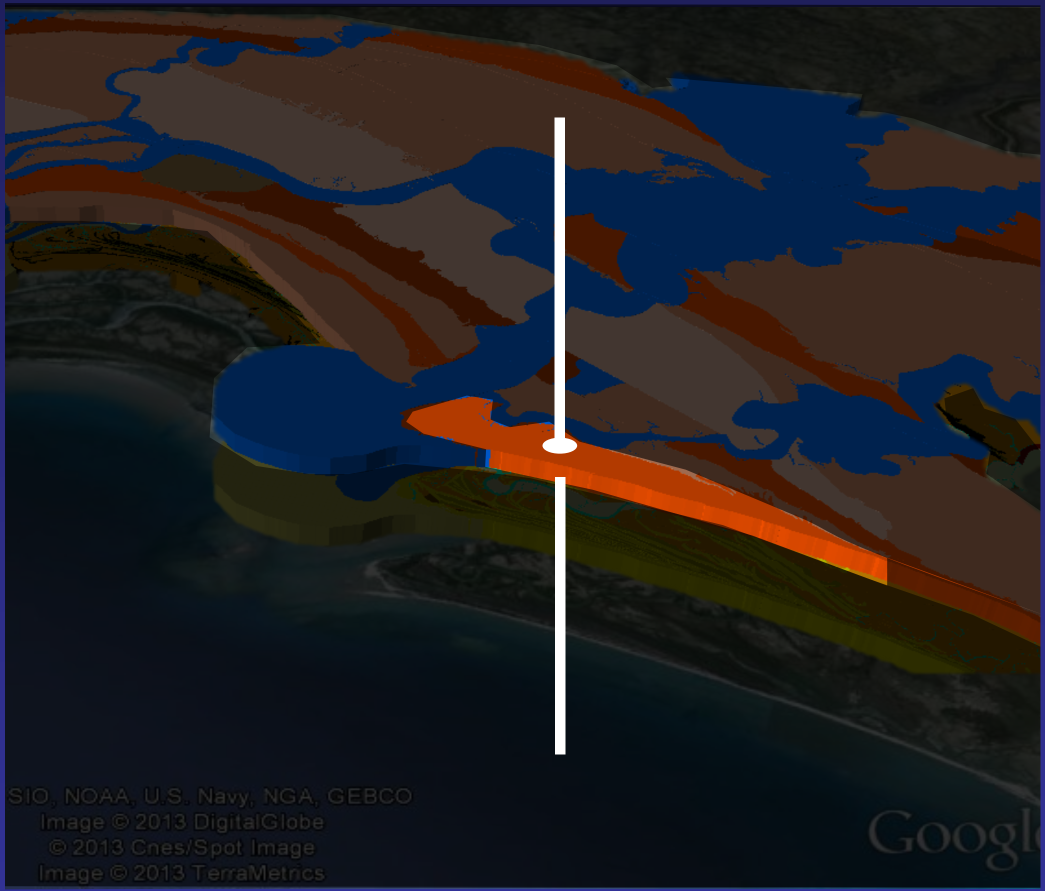
Practical subsurface requirements for depositional system classifications

- Describe subsurface stratigraphic architecture at different spatial scales
- Allow prediction of architecture and reservoir heterogeneity based on limited data
- Allow for uncertainty management in interpretation
- Computer database and geocellular model friendly



Practical subsurface requirements for depositional system classifications

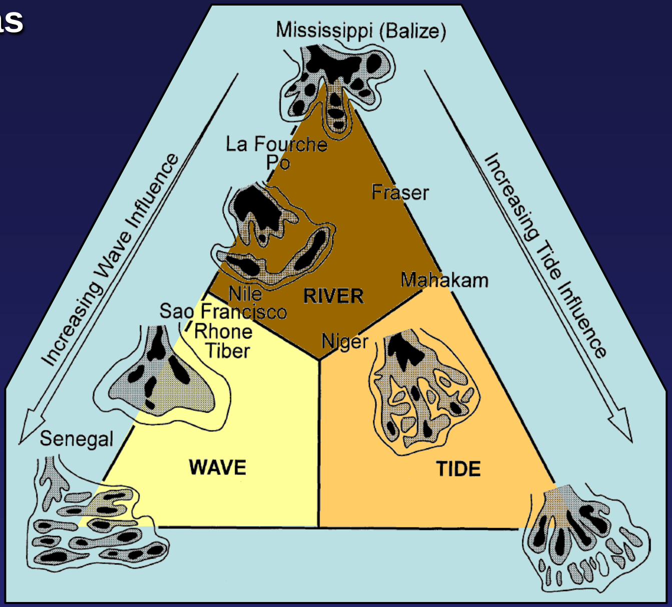
- Describe subsurface stratigraphic architecture at different spatial scales
- Allow prediction of architecture and reservoir heterogeneity based on limited data
- Allow for uncertainty management in interpretation
- Computer database and geocellular model friendly



Weaknesses of existing marginal marine classifications

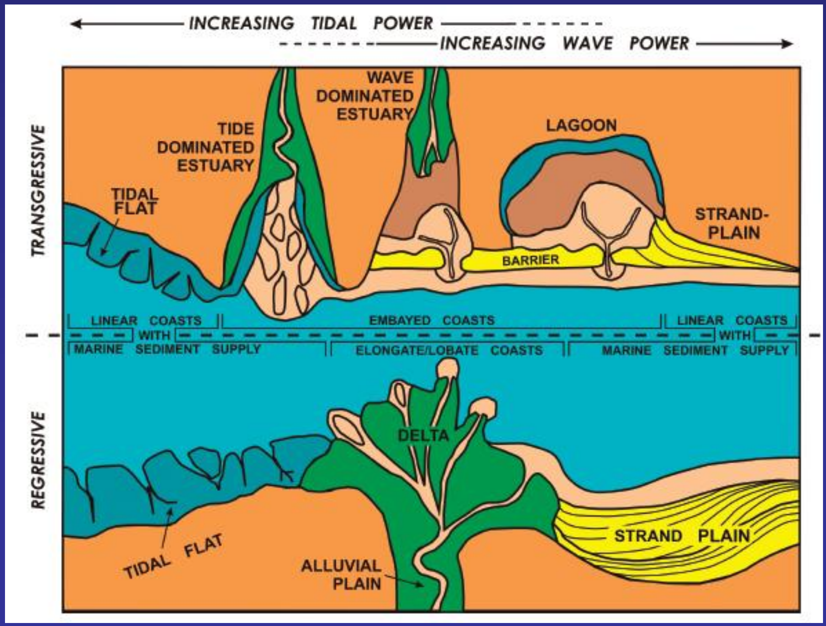
- Do not address different scales of deposition
- Are not three dimensional
- Classification category scales greater than field size
- Do not easily integrate with databases

Deltas



(Galloway, 1975; modified by Bhattacharya & Giosan, 2003)

Coastal Systems



Boyd et al. (2006)

An Opportunity

We can design a new classification from the ground up that addresses these issues.

PRACTICAL REQUIREMENTS:

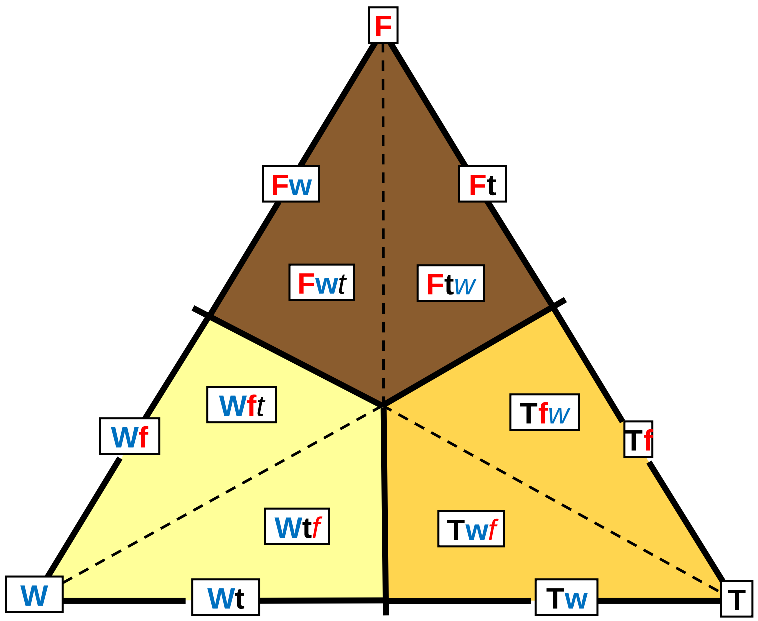
1) Handles different scales of architecture

2) Meets geocellular model requirements (*flow units -> sand bodies -> heterogeneities*)

3) Fully integrates with computer database environments

4) Allows for building rule-based, computer expert systems

A new marginal marine process classification



BOLD UPPER CASE = Dominant process
bold lower case = Secondary process
italic lower case = Tertiary process

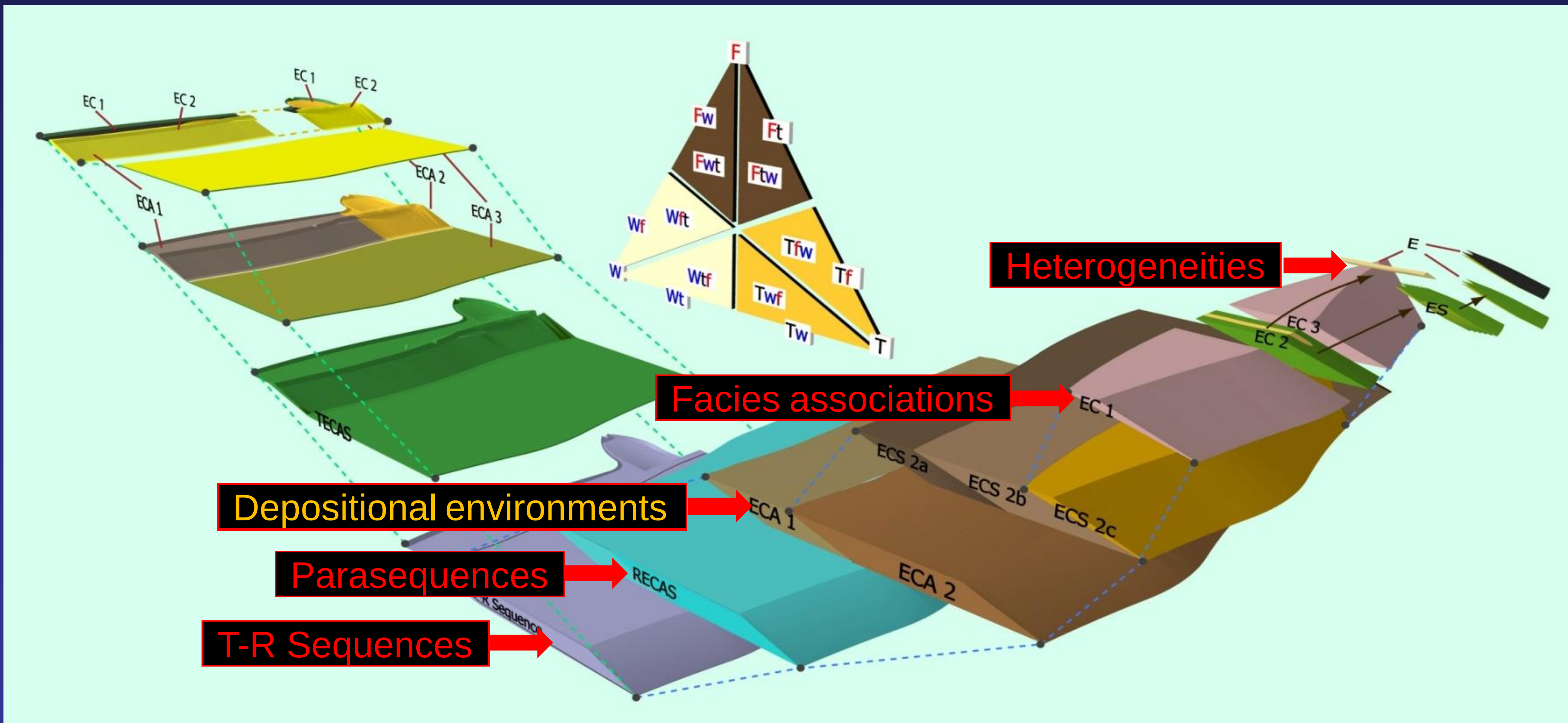
F, f, *f* = Fluvial
W, w, *w* = Wave
T, t, *t* = Tidal

Classification Categories

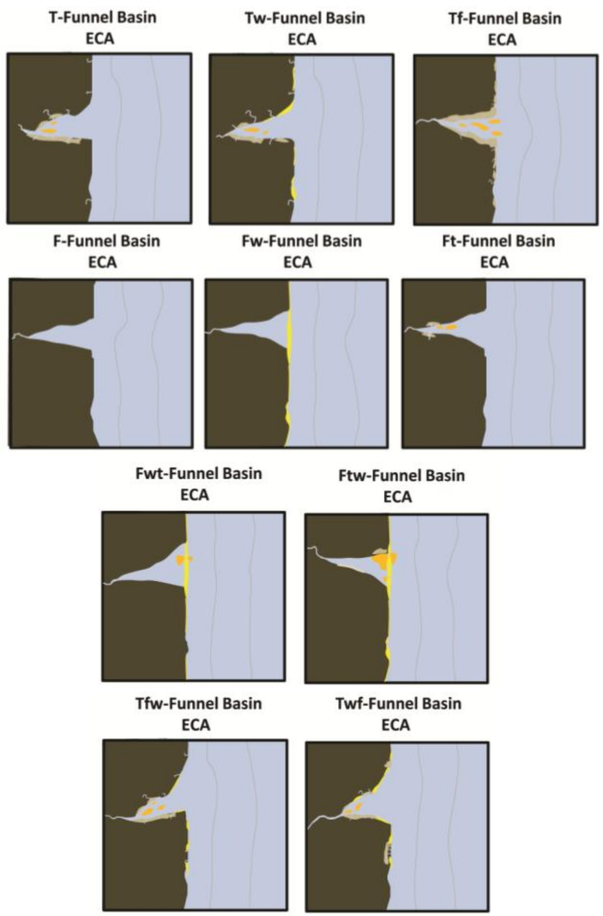
F – Fluvial dominated
Fw – Fluvial dominated, wave influenced
Ft – Fluvial dominated, tide influenced
Fw*t* – Fluvial dominated, wave influenced, tide affected
Ft*w* – Fluvial dominated, tide influenced, wave affected
W – Wave dominated
Wf – Wave dominated, fluvial influenced
Wt – Wave dominated, tide influenced
Wf*t* – Wave dominated, fluvial influenced, tide affected
Wt*f* – Wave dominated, tide influenced, fluvial affected
T – Tide dominated
Tf – Tide dominated, fluvial influenced
Tw – Tide dominated, wave influenced
Tf*w* – Tide dominated, fluvial influenced, wave affected
Tw*f* – Tide dominated, wave influenced, fluvial affected

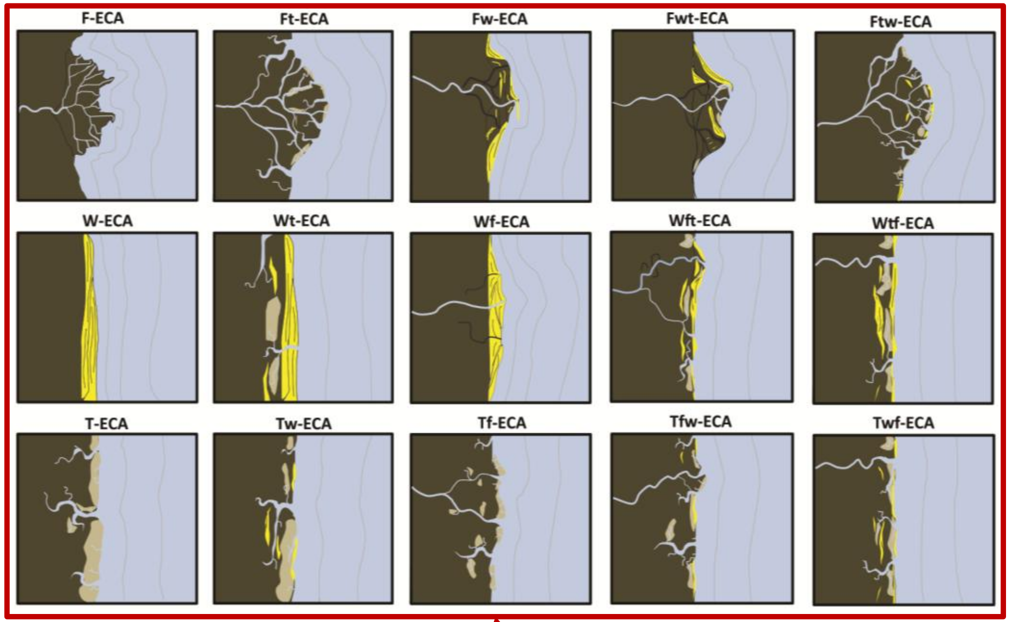
(Ainsworth et al., AAPG Bulletin, Feb 2011)

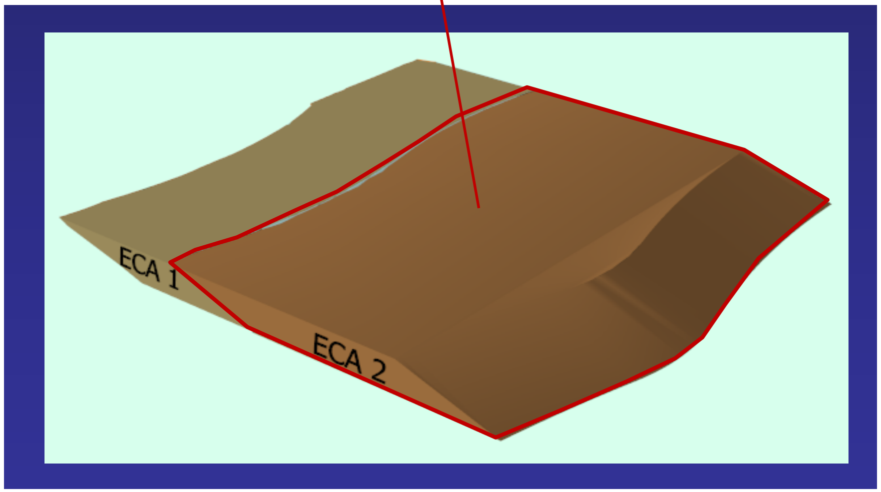
Combined with a new marginal marine architectural classification



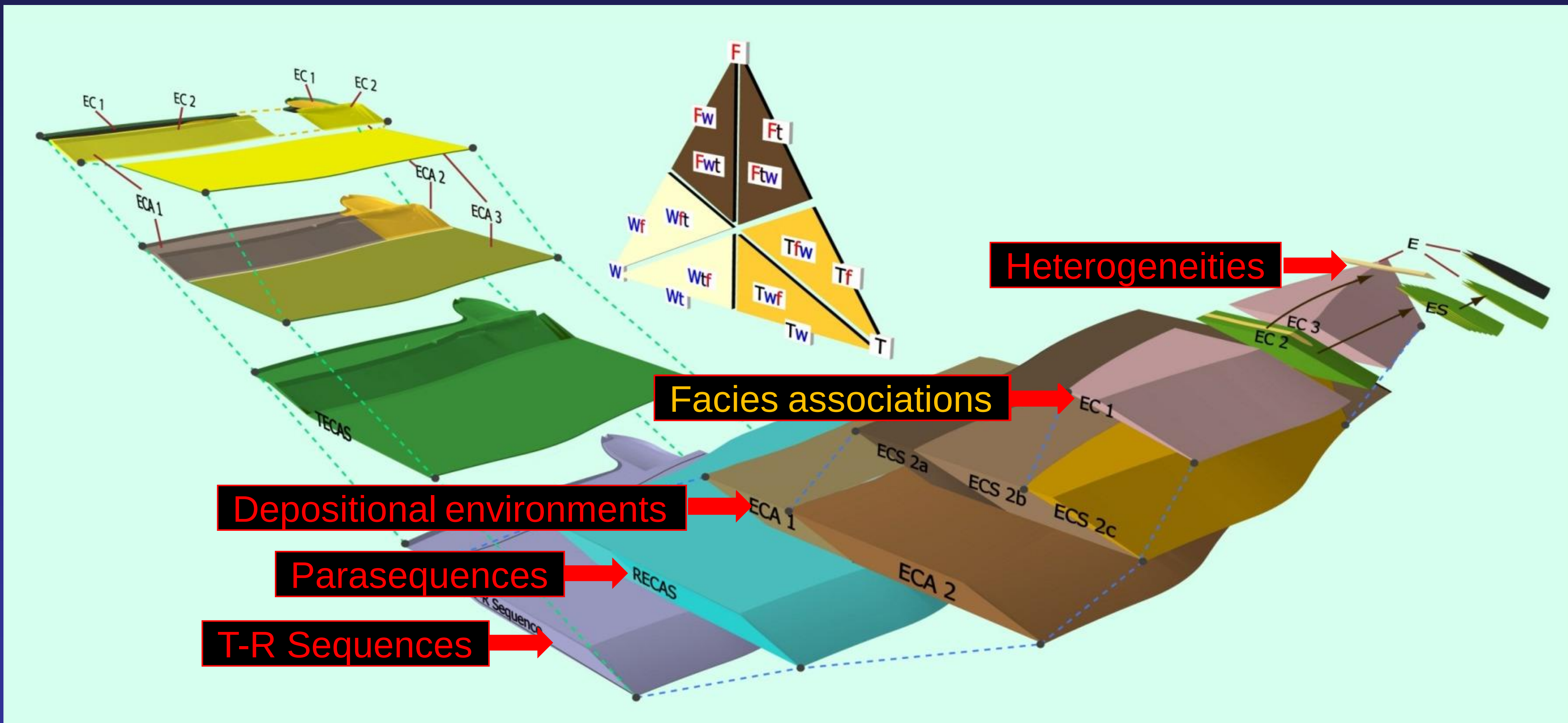
Named Element Complex Assemblages (ECA)



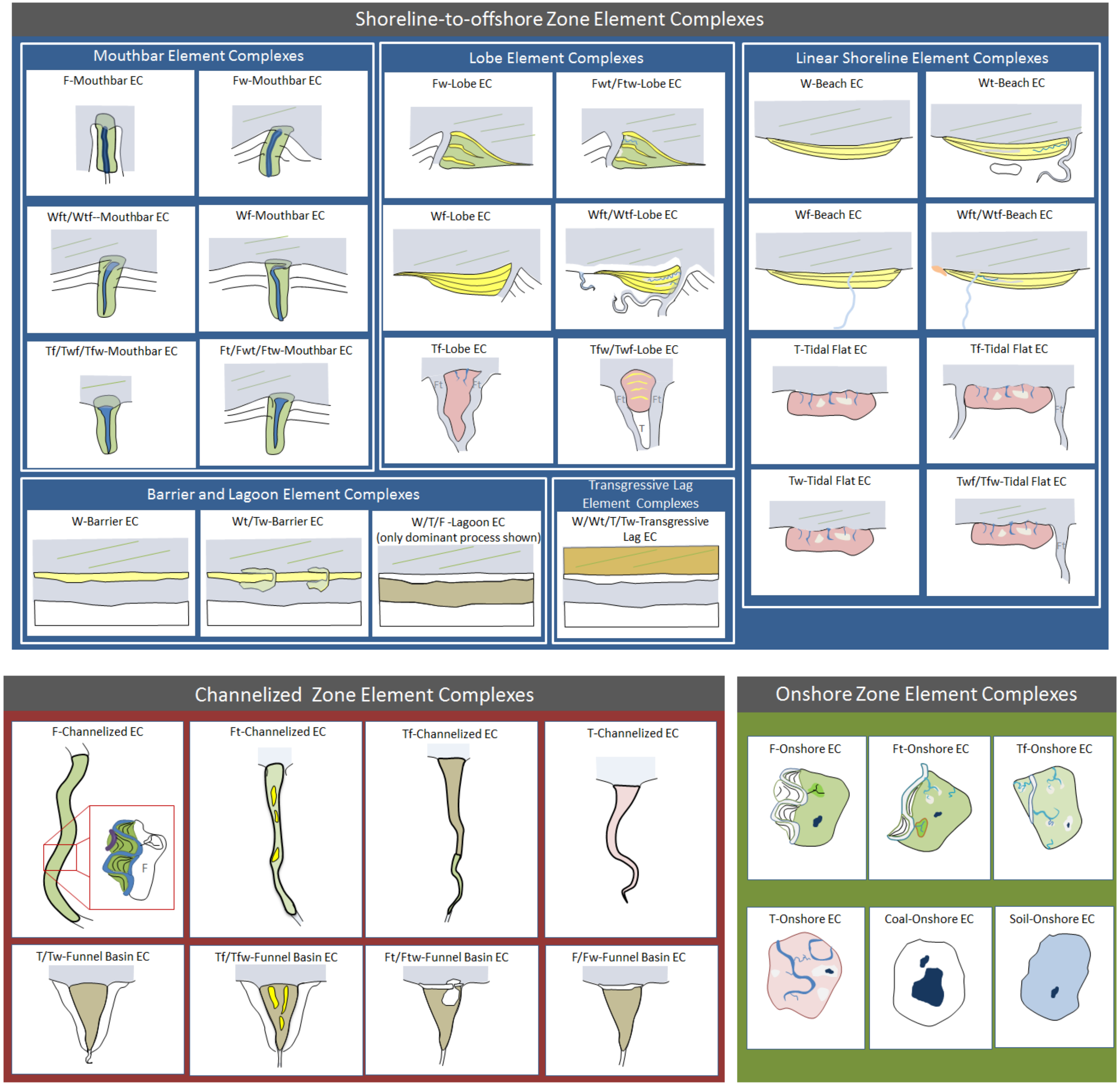


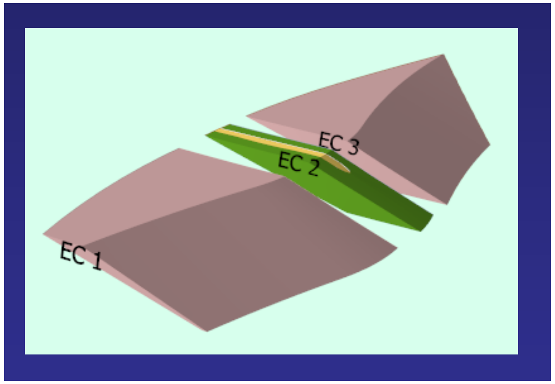


Combined with a new marginal marine architectural classification



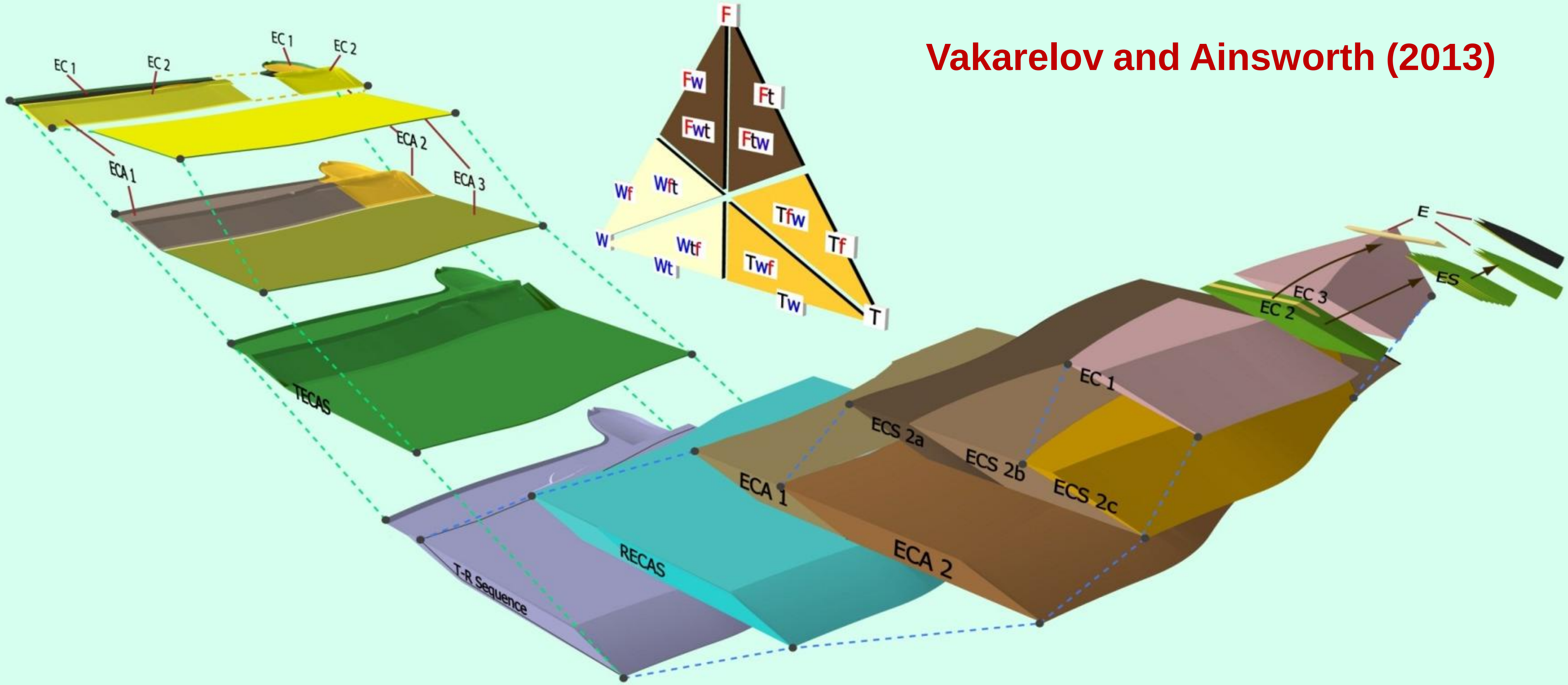
Named Element Complexes (EC)



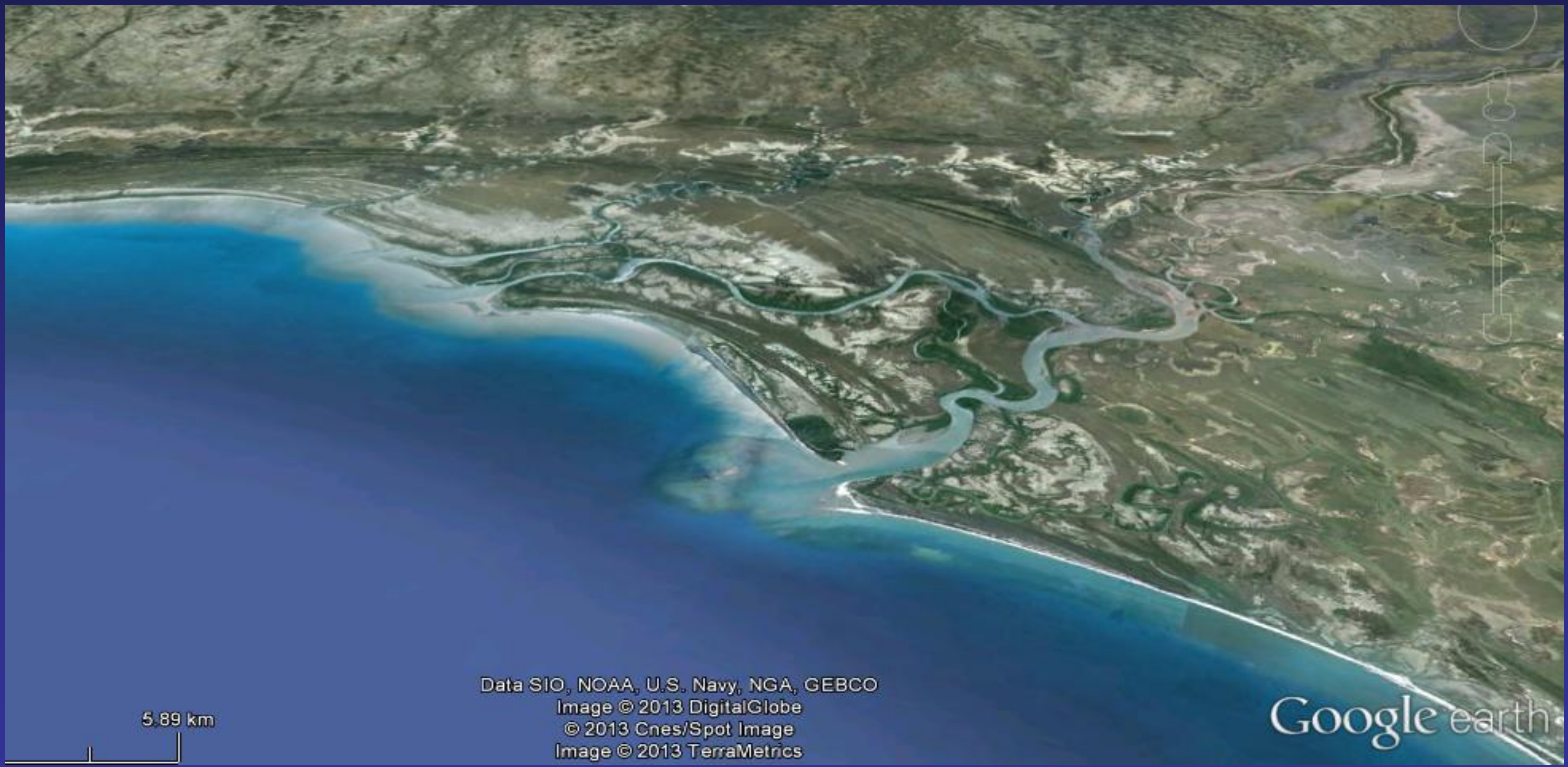


Combined with a new marginal marine architectural classification

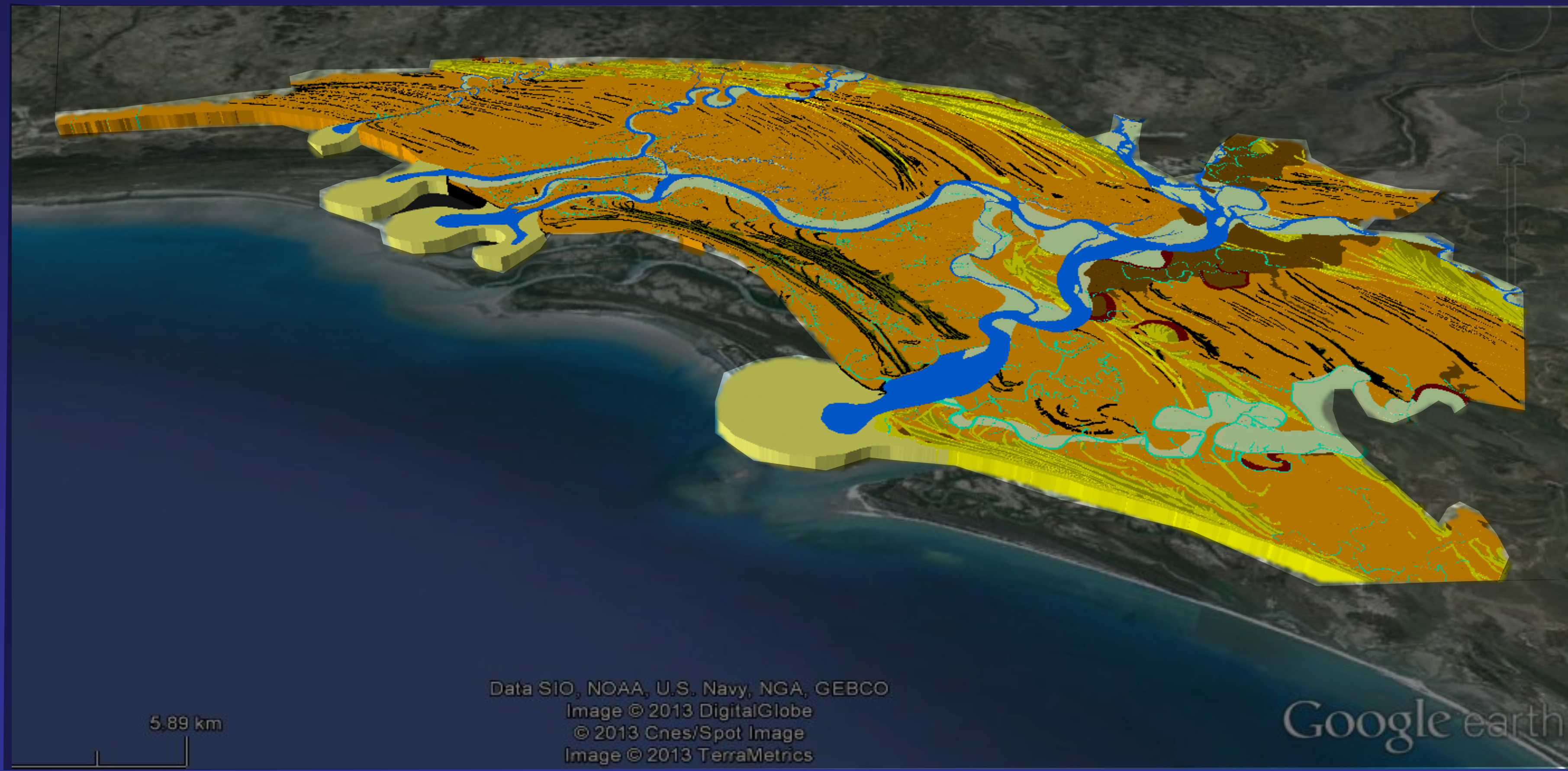
Vakarelov and Ainsworth (2013)



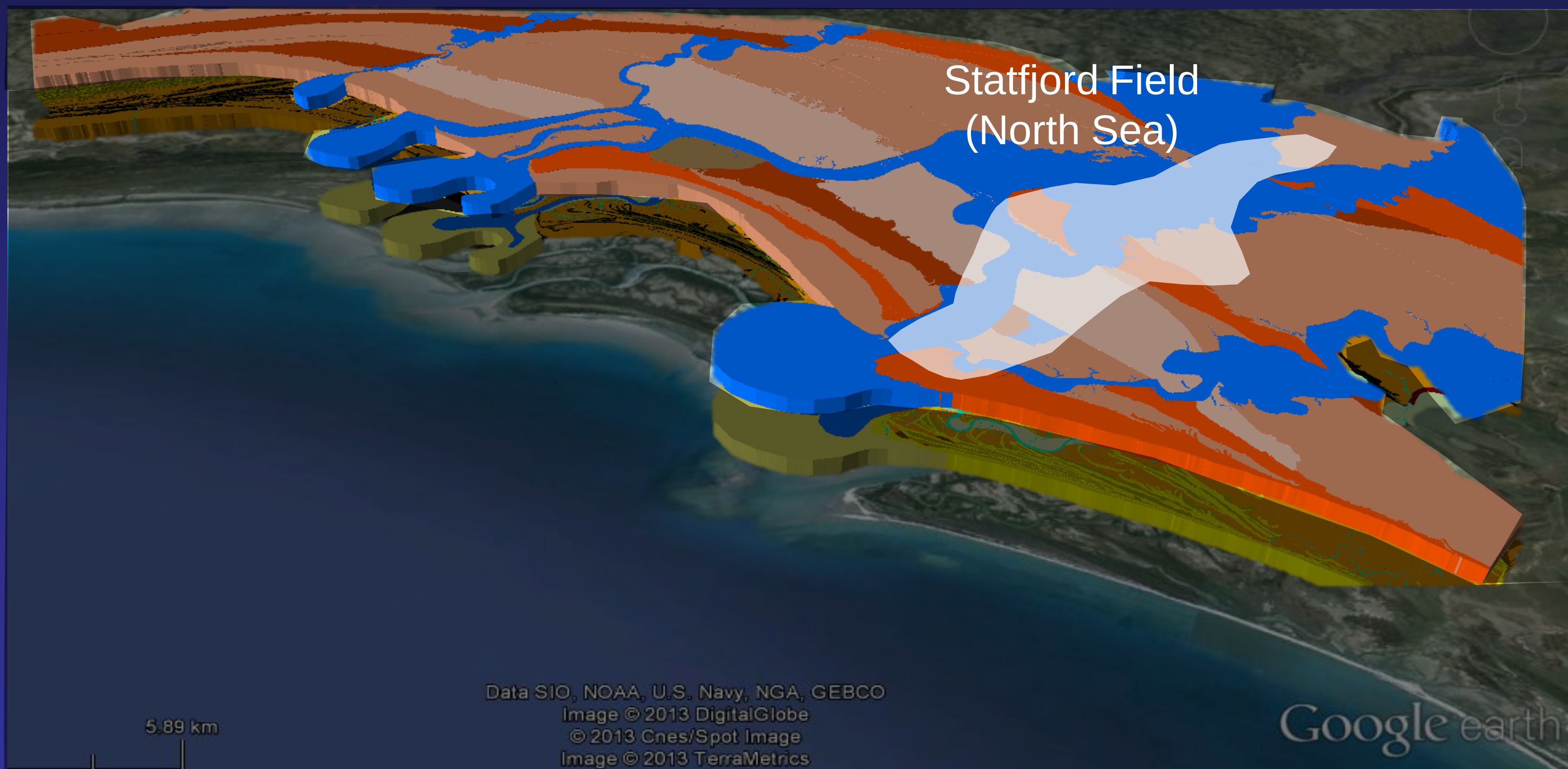
Predicting reservoir architecture away from known data points?



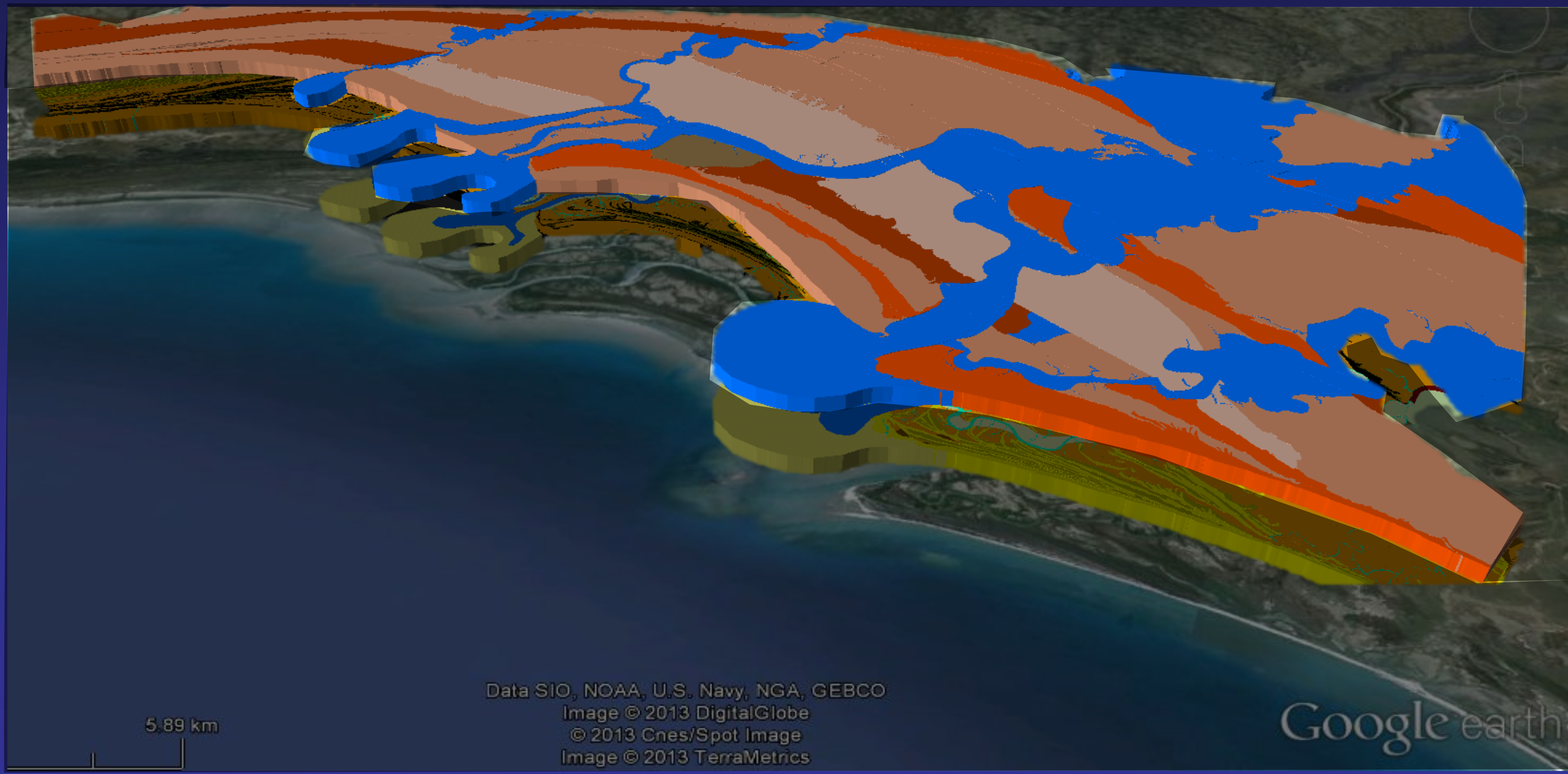
Predicting reservoir architecture away from known data points?



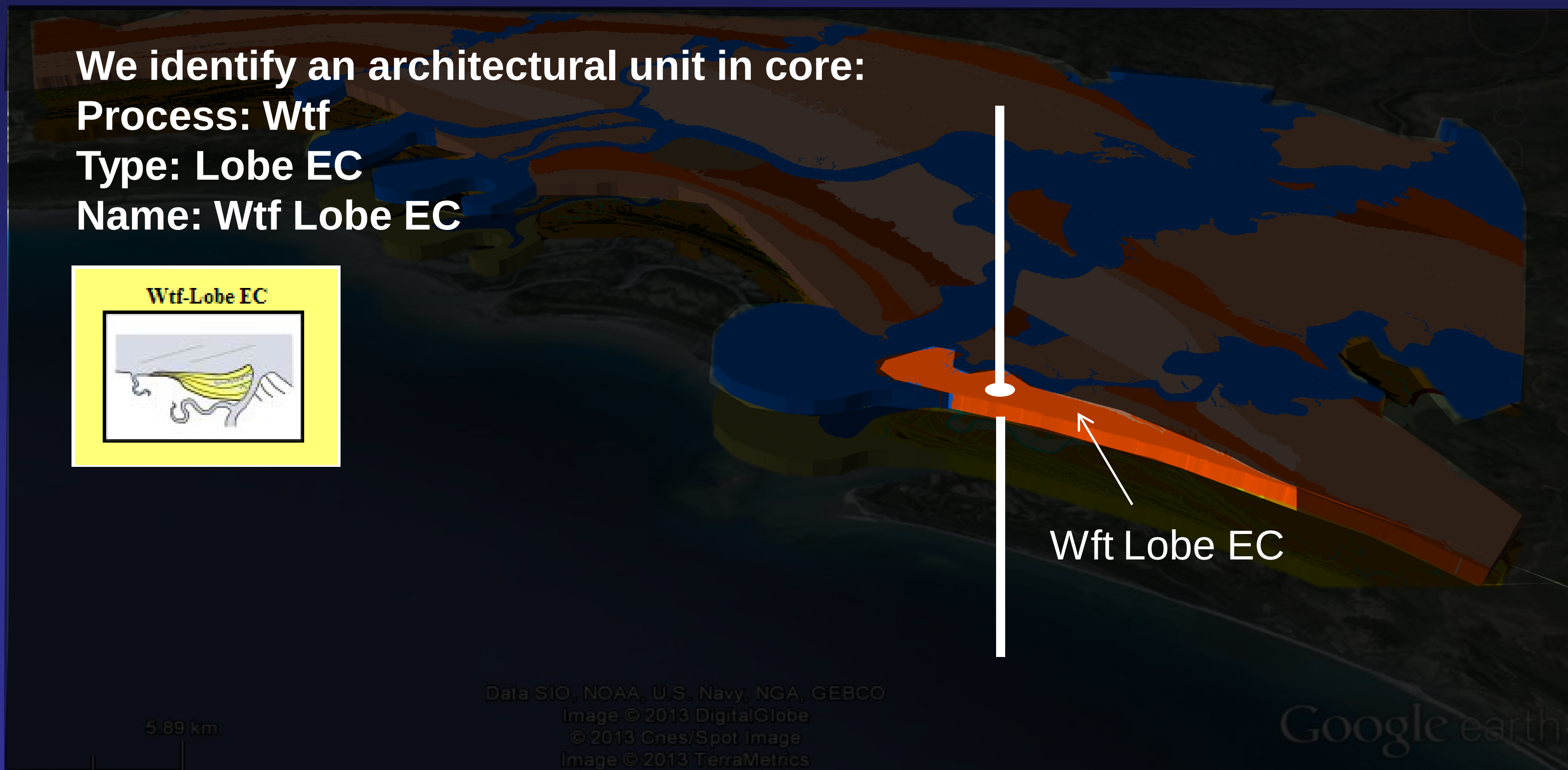
Predicting reservoir architecture away from known data points?



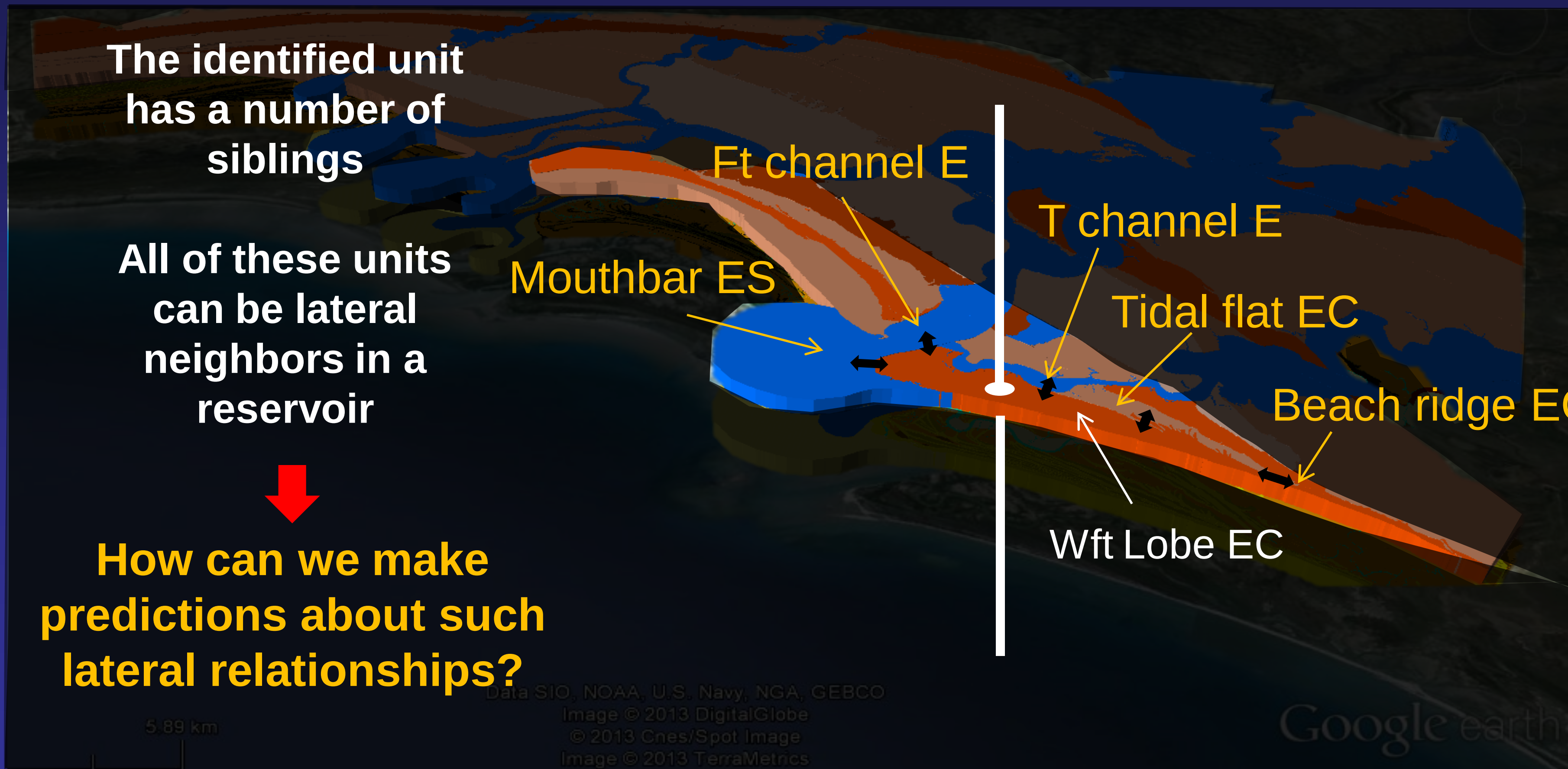
Predicting reservoir architecture away from known data points?



Predicting reservoir architecture away from known data points?



Predicting reservoir architecture away from known data points?

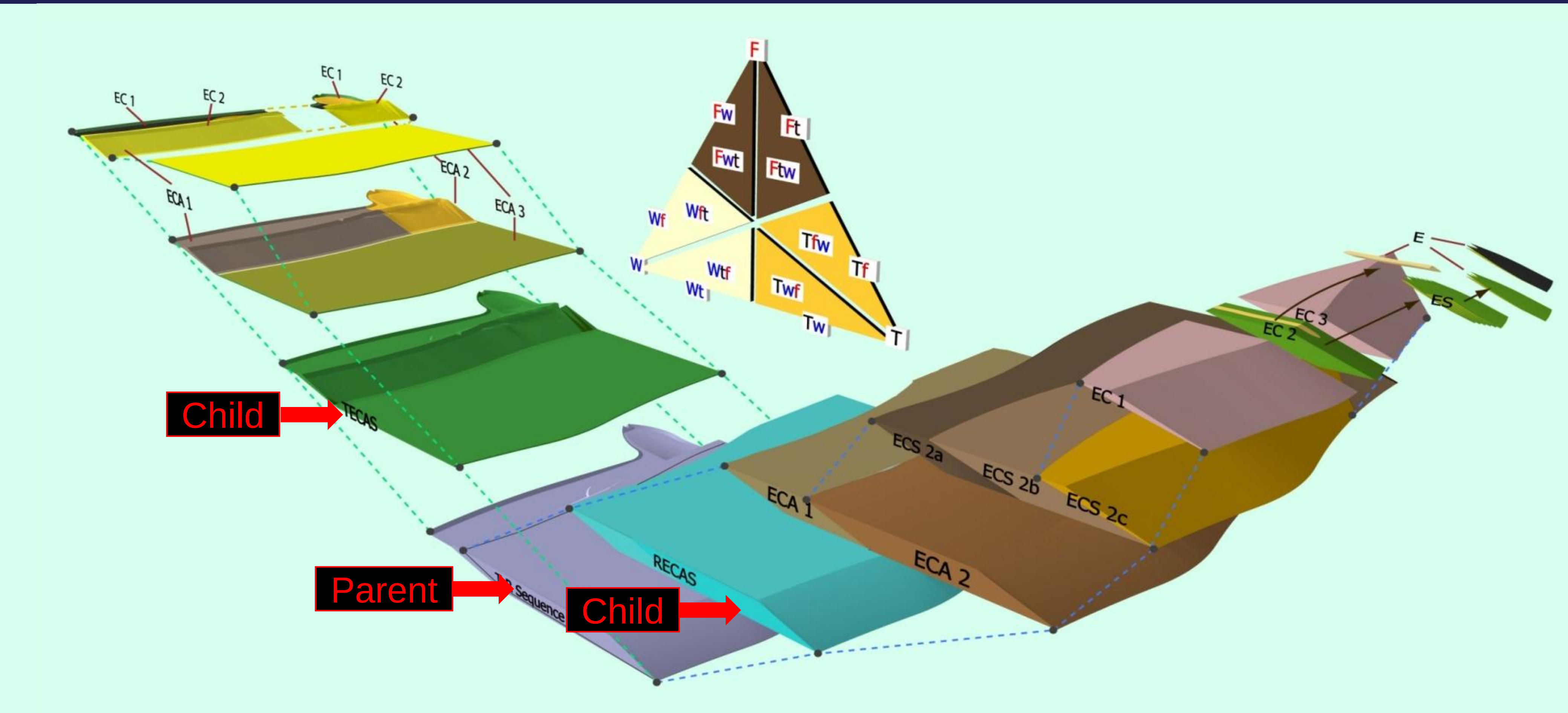


The identified unit has a number of siblings

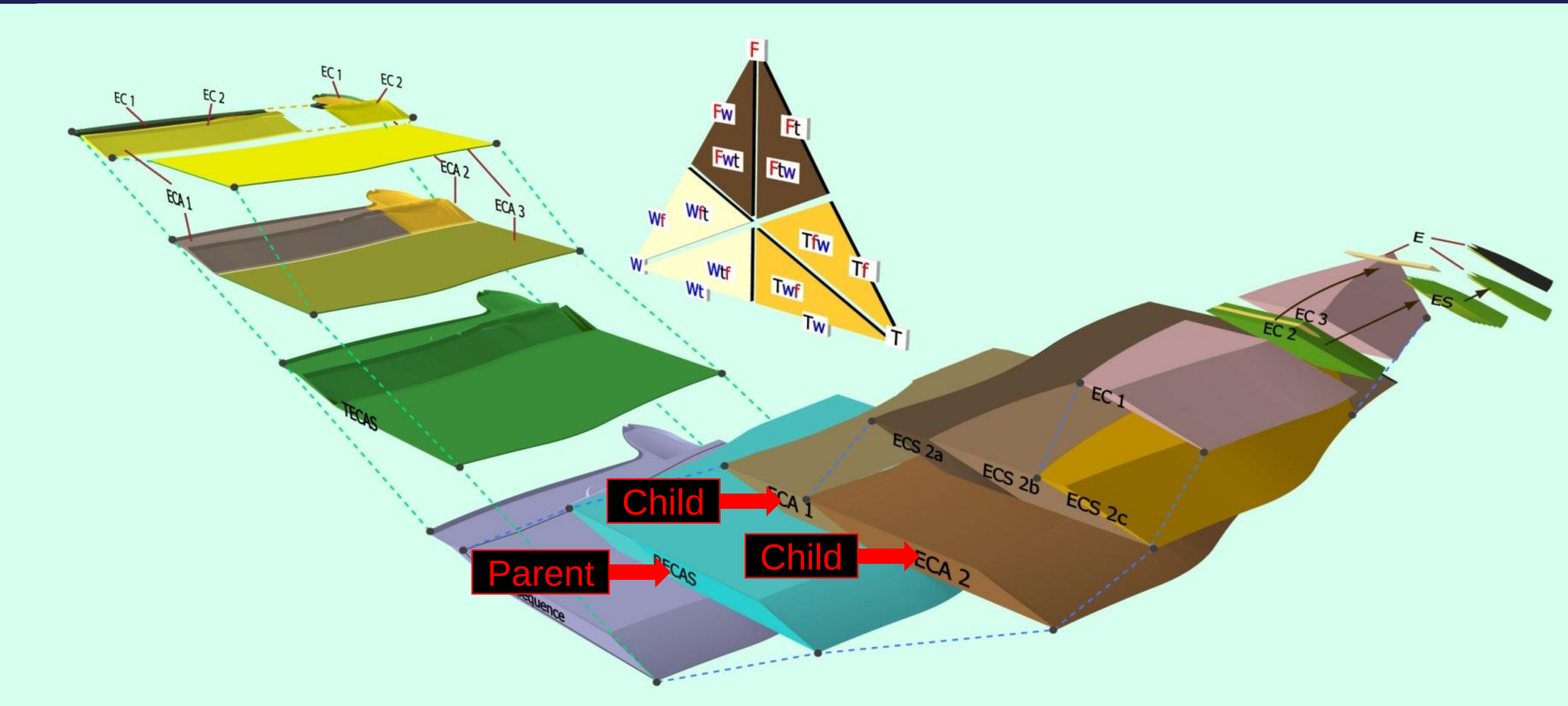
All of these units can be lateral neighbors in a reservoir

How can we make predictions about such lateral relationships?

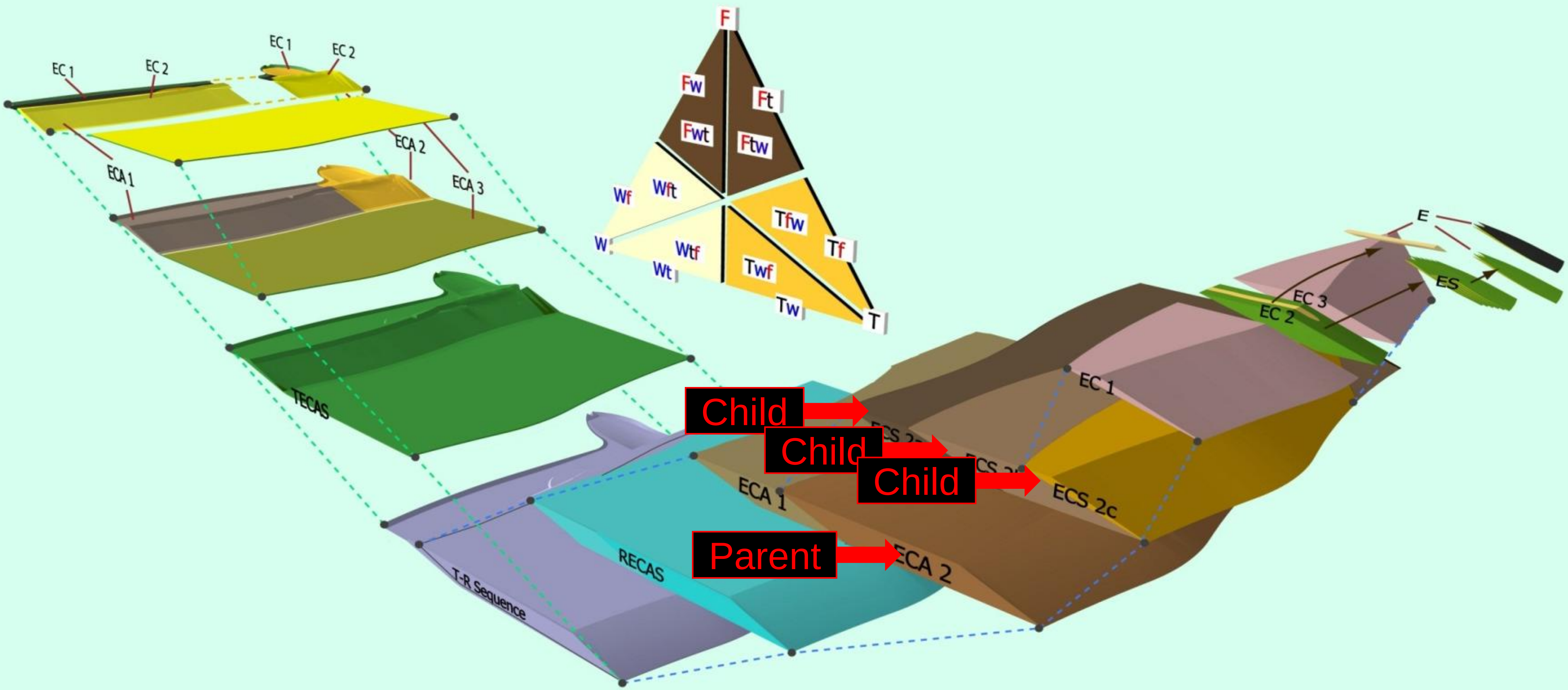
The architectural unit hierarchy can be described by a series of parent-child relationships



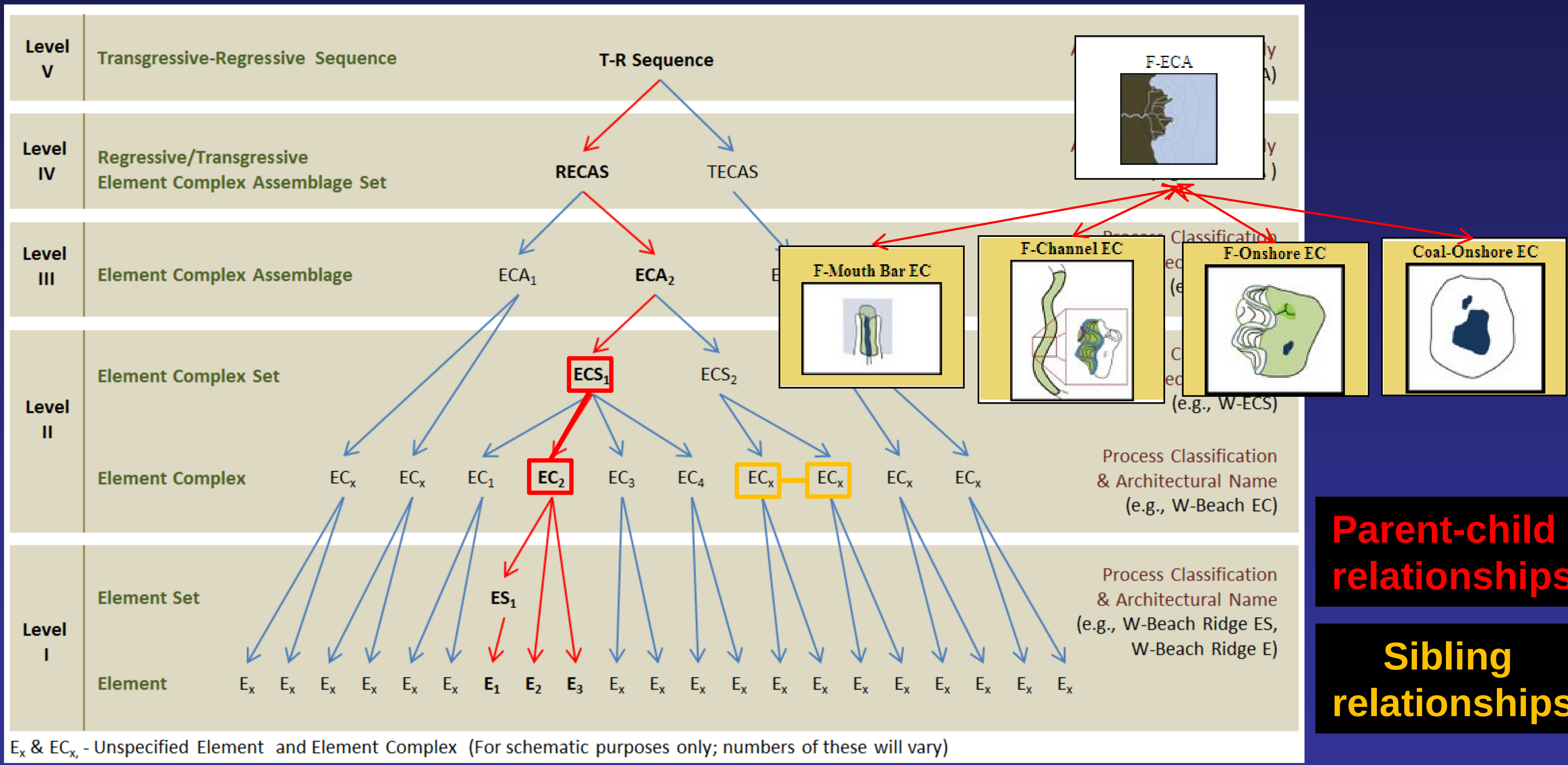
The architectural unit hierarchy can be described by a series of parent-child relationships



The architectural unit hierarchy can be described by a series of parent-child relationships



Architectural hierarchy as a tree structure



Parent-child relationships

Sibling relationships

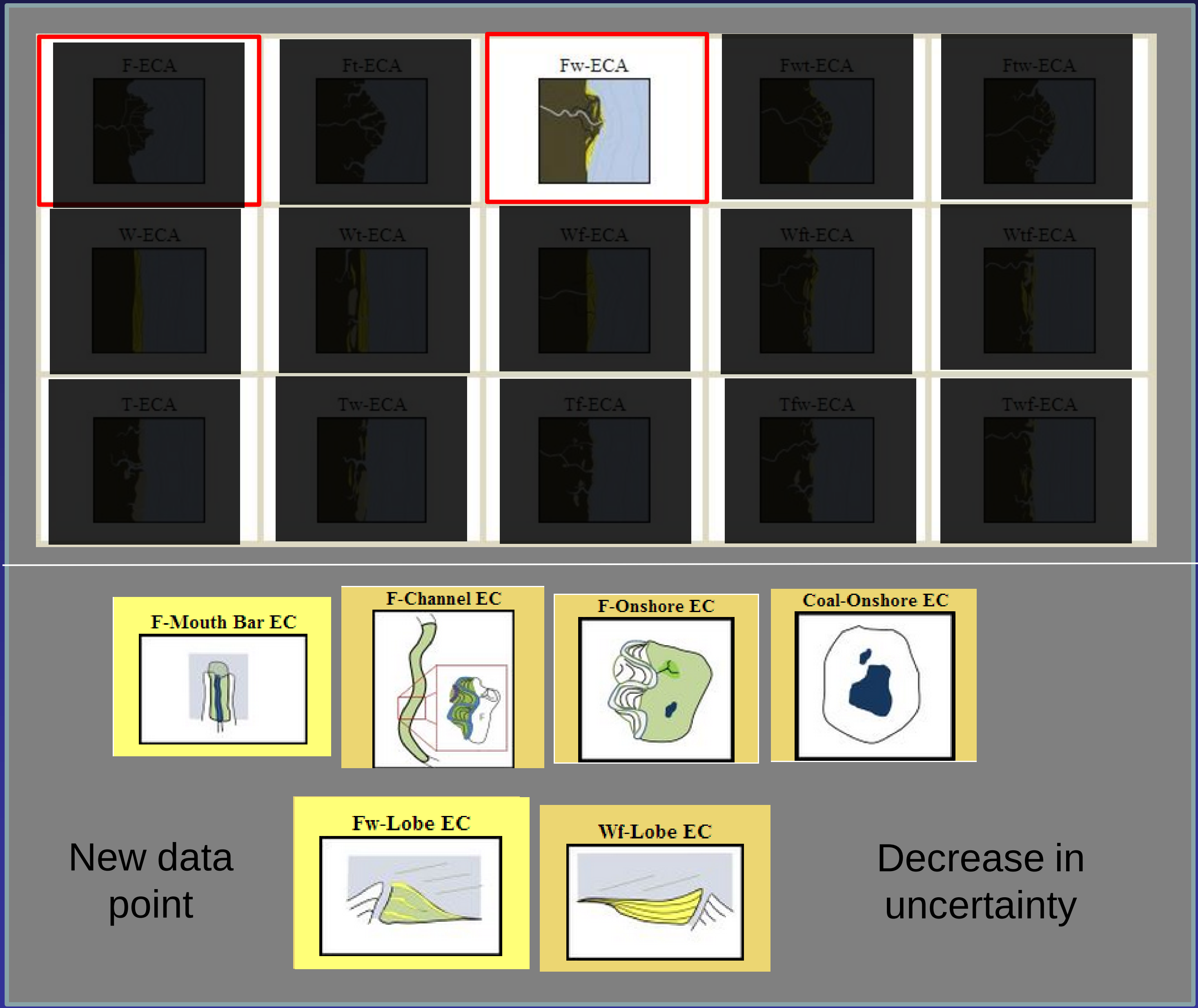
These relationships are easily described by computer code

Parent-child relationships between classification categories can be used for prediction and uncertainty management in the subsurface

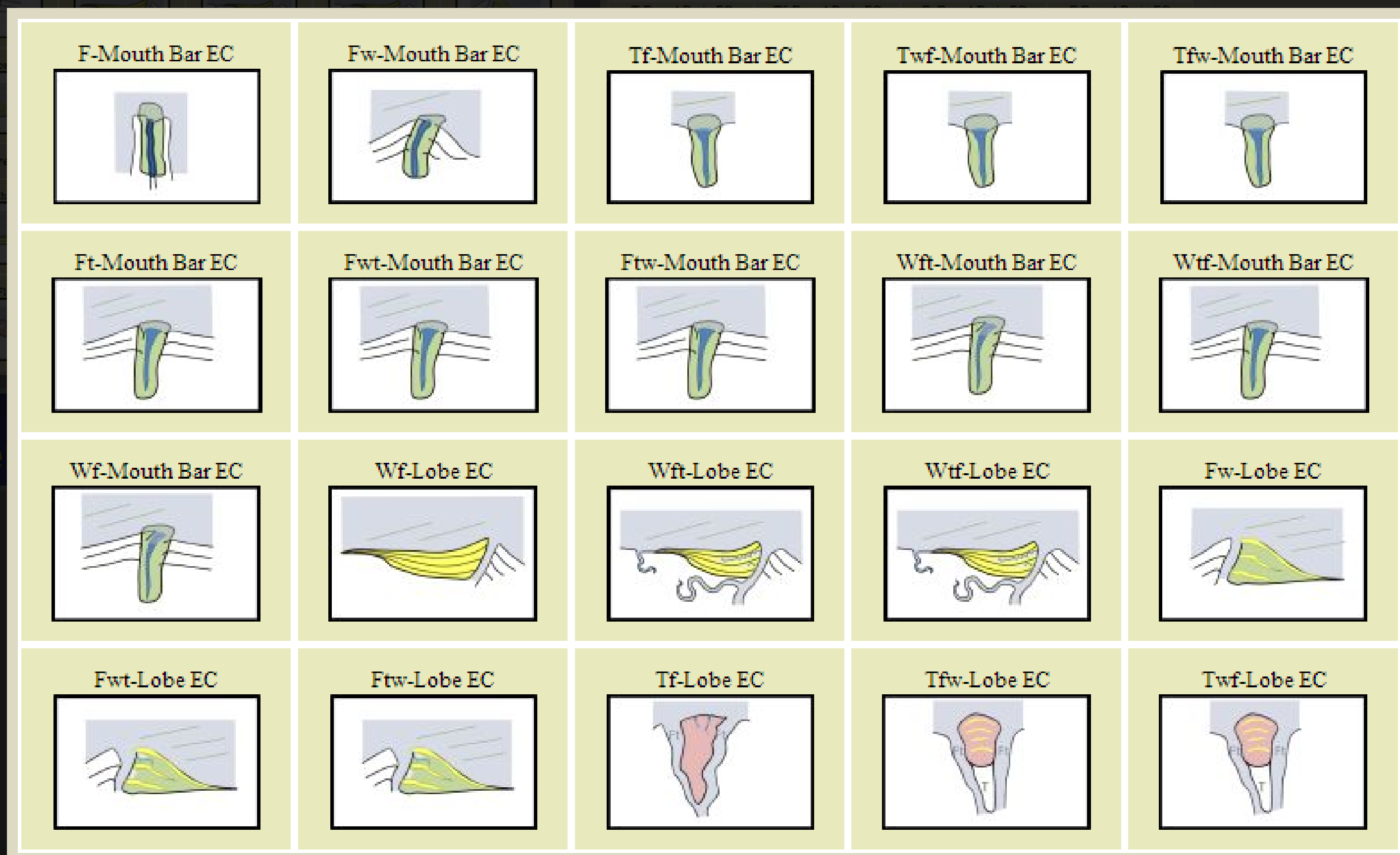
Parent-child relationships can be used for prediction

Parents

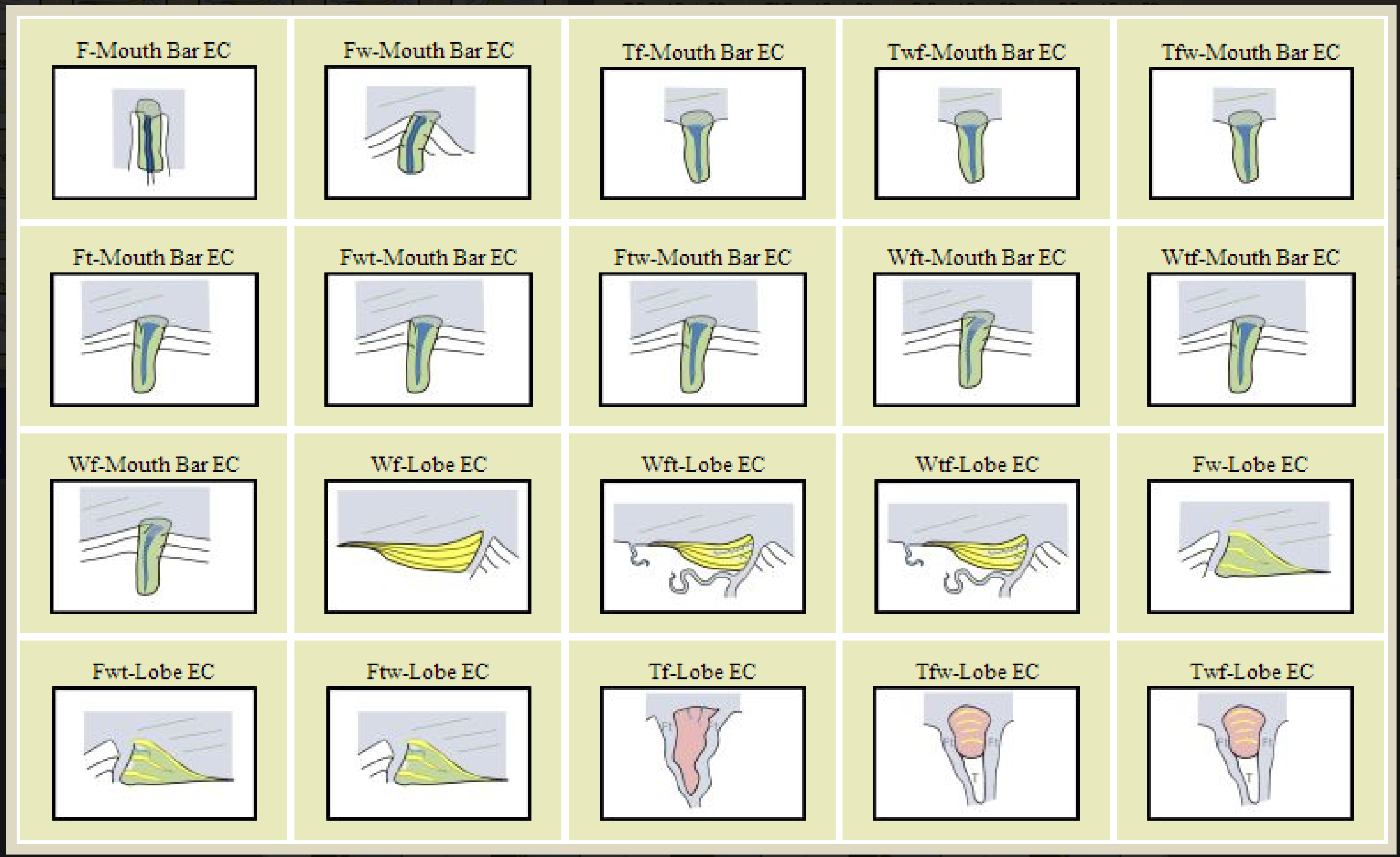
Children (Siblings)



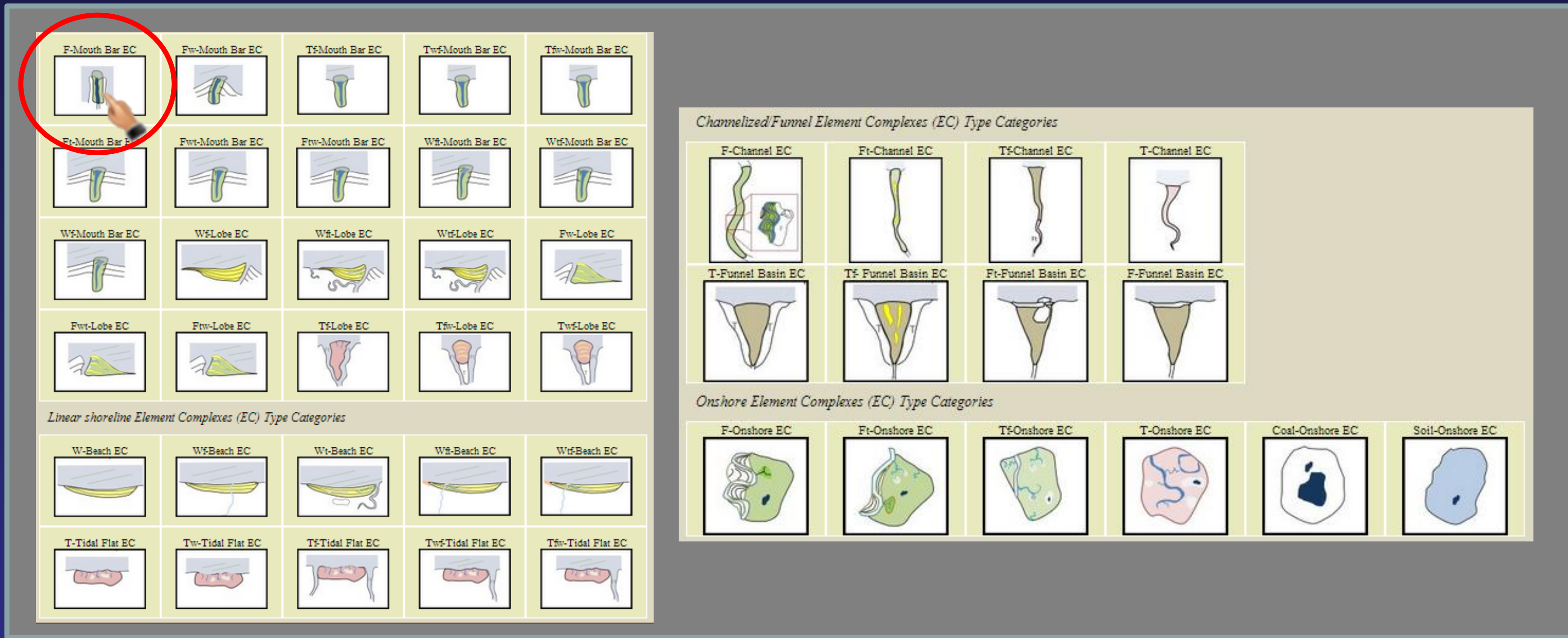
A rule-based, computer expert system for predicting lateral architectural relationships



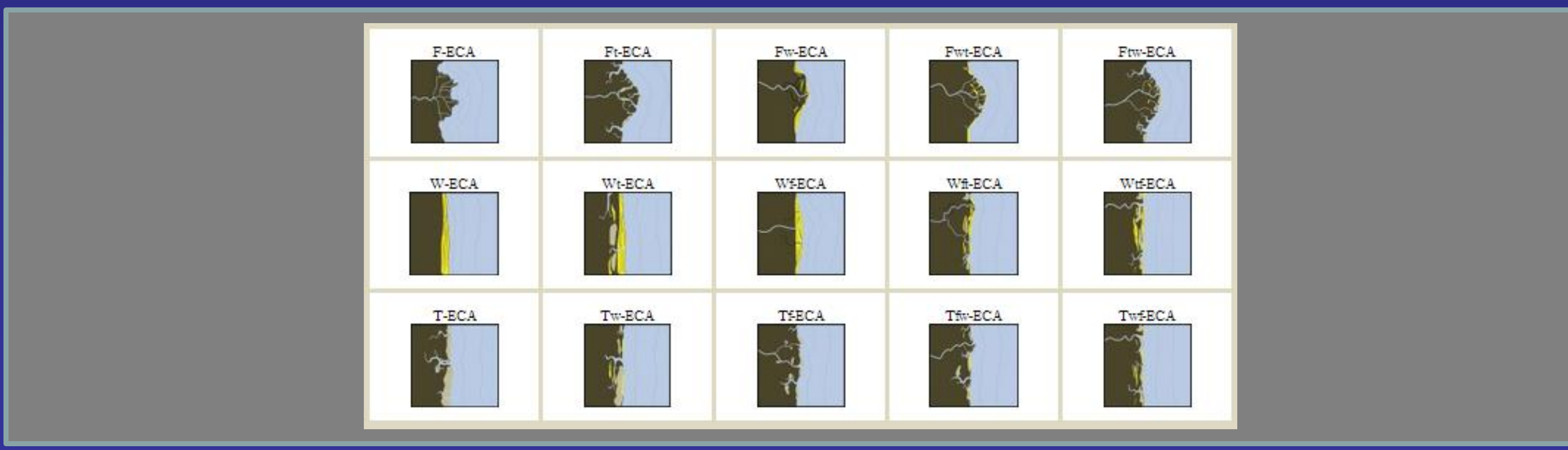
Siblings


F-Mouth Bar EC
Fw-Mouth Bar EC
Tf-Mouth Bar EC
Twf-Mouth Bar EC
Tfw-Mouth Bar EC
Ft-Mouth Bar EC
Fwt-Mouth Bar EC
Ftw-Mouth Bar EC
Wft-Mouth Bar EC
Wtf-Mouth Bar EC
Wf-Mouth Bar EC
Wf-Lobe EC
Wft-Lobe EC
Wtf-Lobe EC
Fw-Lobe EC
Fwt-Lobe EC
Ftw-Lobe EC
Tf-Lobe EC
Tfw-Lobe EC
Twf-Lobe EC

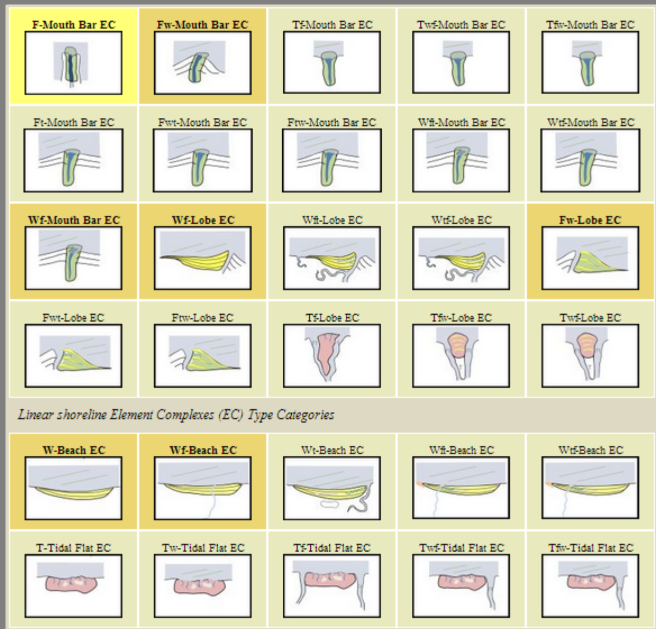
Siblings

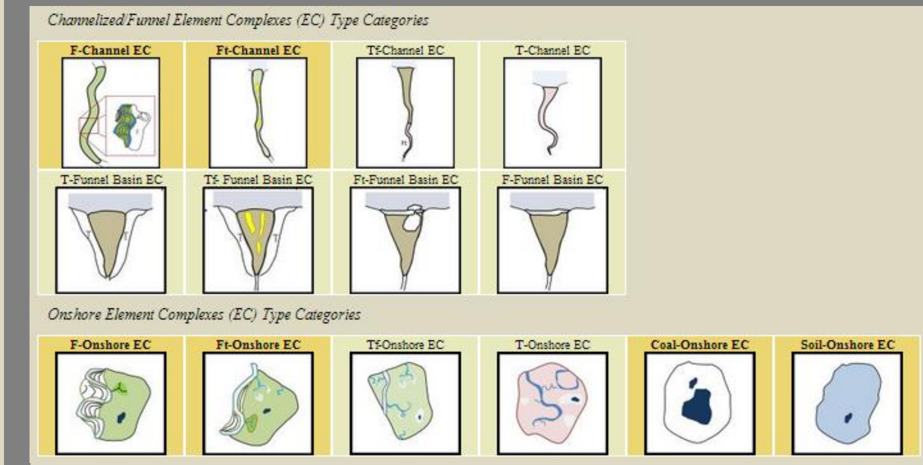


Parents

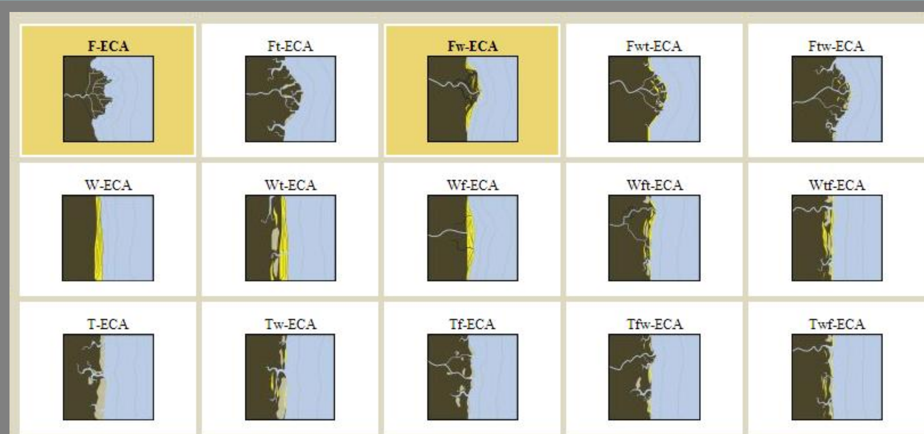


Siblings

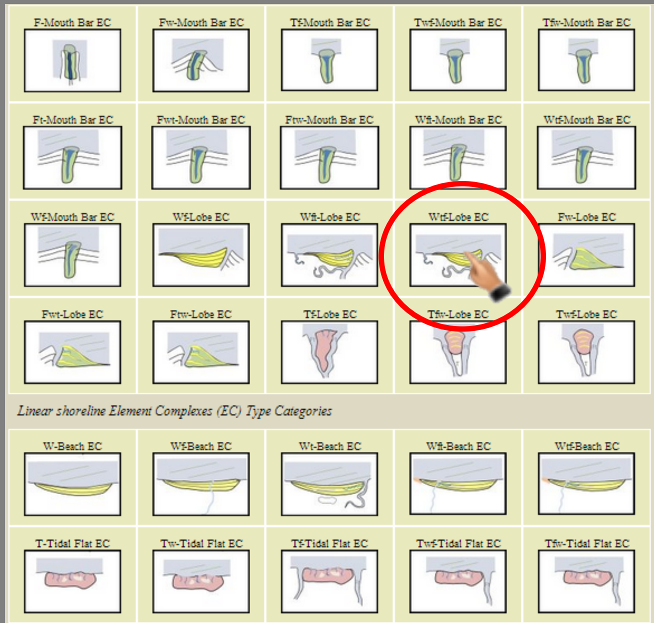


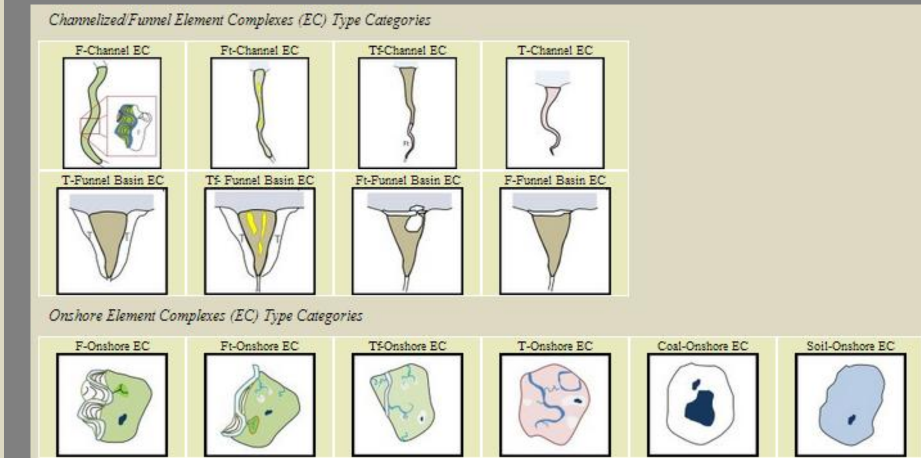


Parents

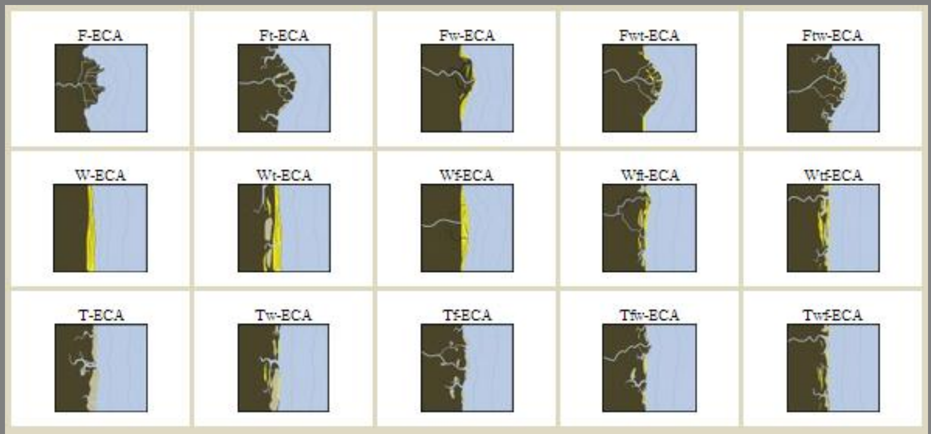


Siblings

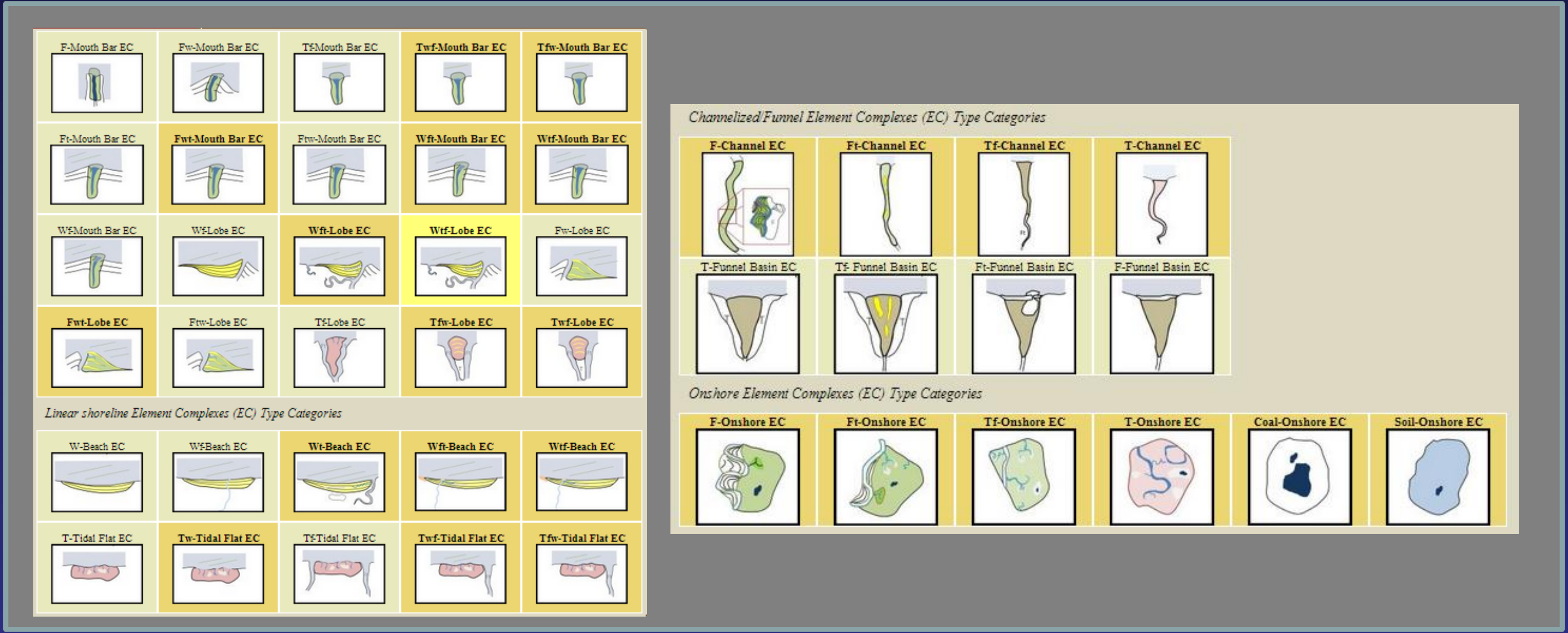




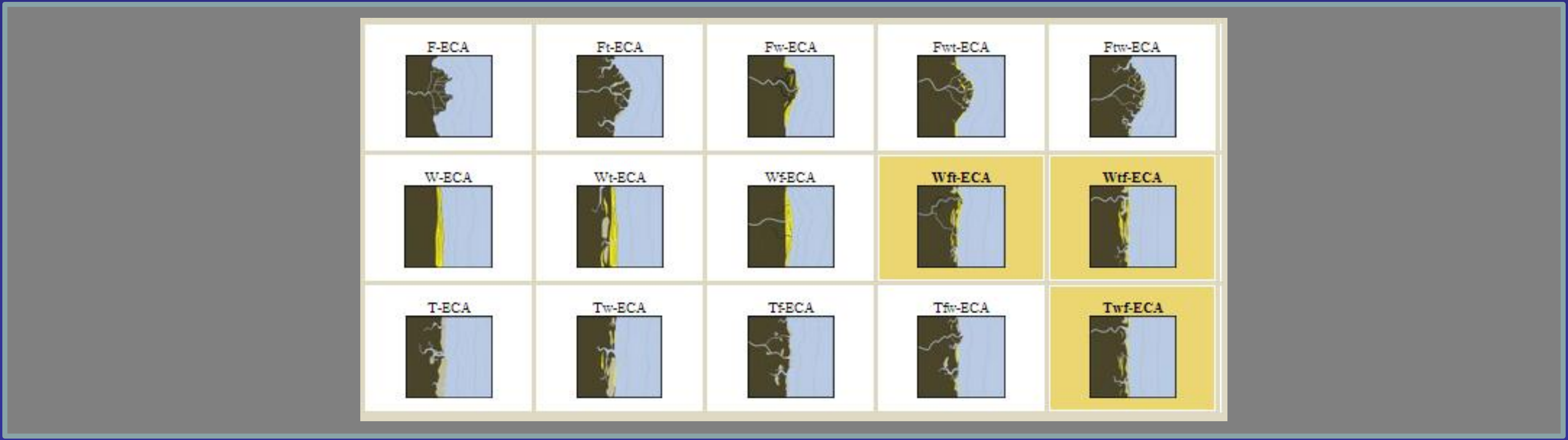
Parents



Siblings



Parents



Conclusions

- A new hierarchical, “database-friendly” marginal marine classification
- Parent-child relationships can be a powerful tool for subsurface prediction and uncertainty management

Thanks to the *WAVE* Consortium Phase I and Phase II Sponsors

Chevron

bp

Statoil

OMV

woodside

nexen

Apache

BG GROUP

bhpbilliton

Todd Energy

BADR PETROLEUM CO.

ConocoPhillips

Website: www.waveknowledgebase.net