Balancing between simplicity and reality: The Earth Sciences way to cope with natural phenomena

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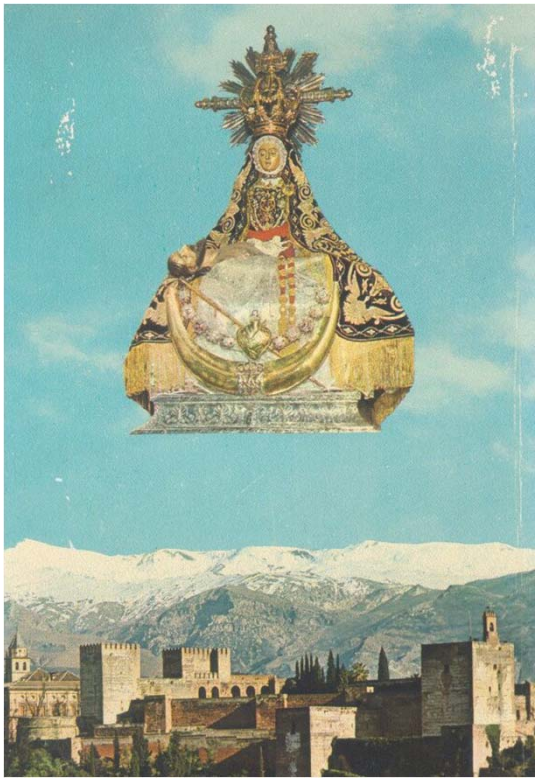
Because geology has a strong historical component, good geologists can balance between reality and simplicity

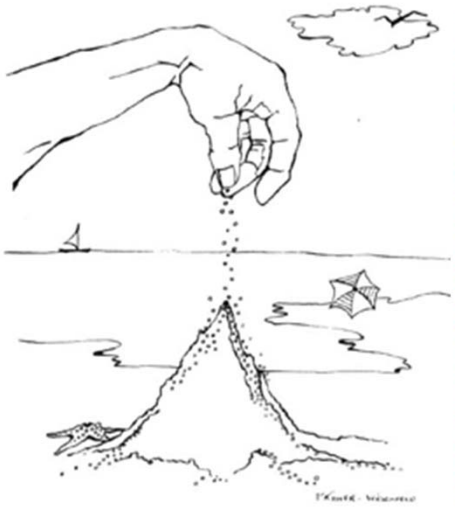
They can make useful predictions

(good) Earth Sciences help living on a stressed Earth

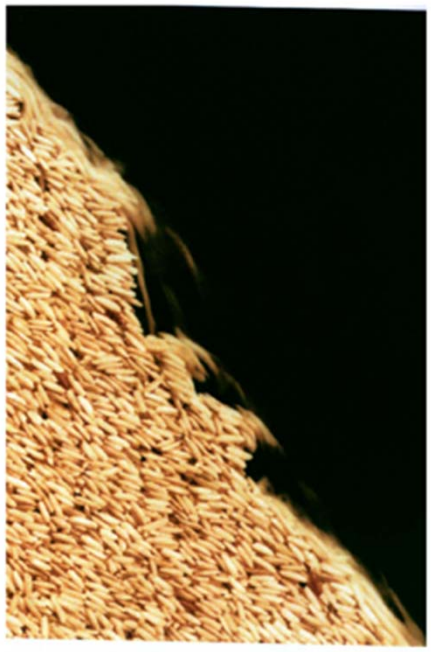
Earth Sciences are particularly necessary at the Delft University of Technology

complexity is more than something we do not understand, something absurd



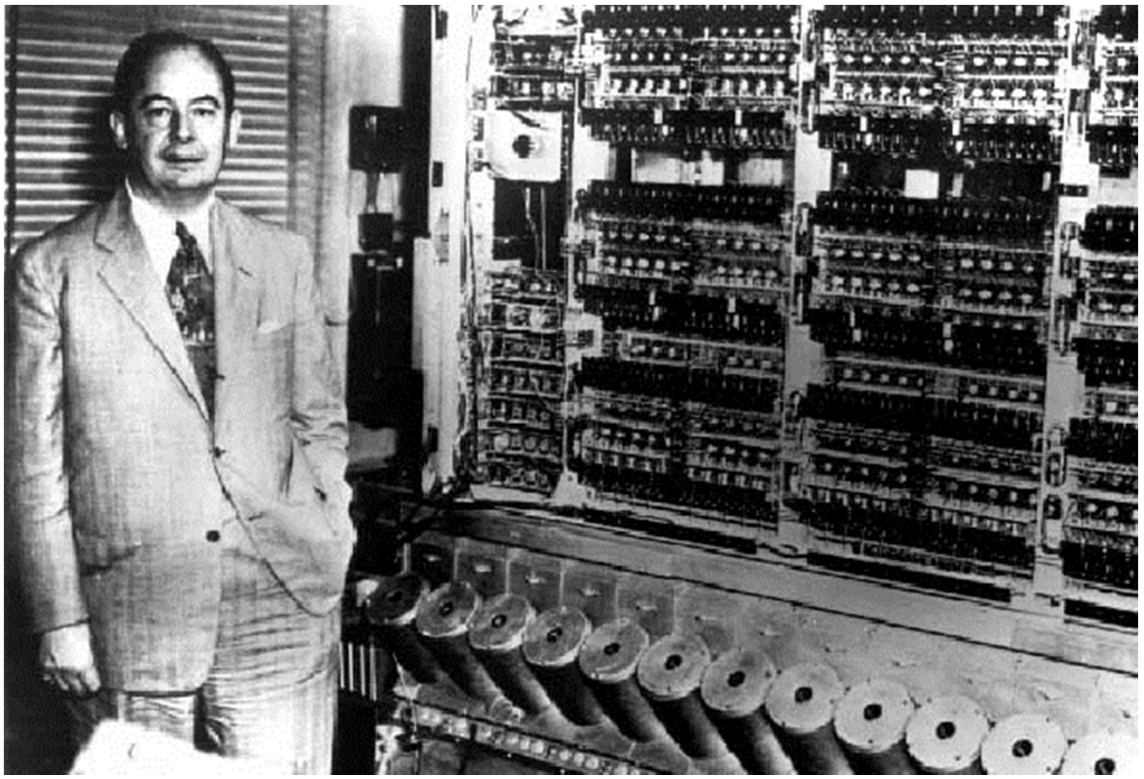


Per Bak's sand pile



complexity is more than something we cannot predict deterministically

Reality is not only complex, it is probably intrinsically contradictory



If people do not believe that mathematics is simple,
it is only because they do not realize how complicated life is

(Louis von Neumann)

Option 1: Glorious retreat

Following years of discussions on how to classify back-pain, scientists tend now to call everything simply …back-pain and refrain from further categories

(Ilic, family doctor, personal communication 2010)

the result: statements are so general that they are as true as useless

Option 2: Full power ahead

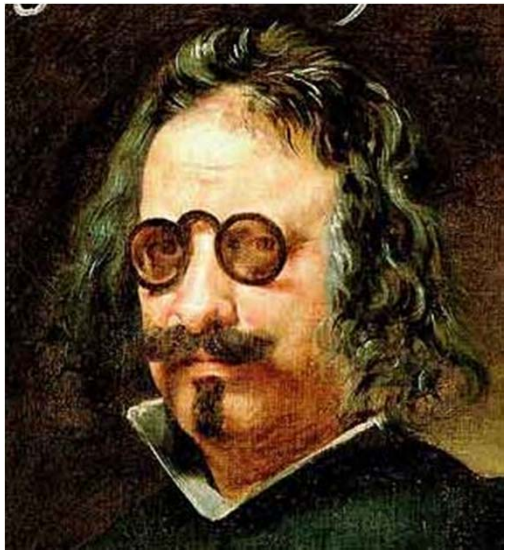
*complex phenomena require the highest **precision** and the most **complex** models*

=

*things go wrong because **precision** and **planning** are insufficient*

when the going gets tough,
the toughs get going!

The quest for the highest precision…



...In that Empire, the craft of Cartography attained such Perfection that the Map of a Single province covered the space of an entire City, and the Map of the Empire itself an entire Province. In the course of Time, these Extensive maps were found somehow wanting, and so the College of Cartographers evolved a Map of the Empire that was of the same Scale as the Empire and that coincided with it point for point. Less attentive to the Study of Cartography, succeeding Generations came to judge a map of such Magnitude cumbersome, and, not without Irreverence, they abandoned it to the Rigours of sun and Rain. In the western Deserts, tattered Fragments of the Map are still to be found, Sheltering an occasional Beast or beggar; in the whole Nation, no other relic is left of the Discipline of Geography.

From *Travels of Praiseworthy Men* (1658) by J. A. Suarez Miranda

In the underground parking of the Barcelona Cathedral they know exactly what we are talking about

Full Power Ahead (2)

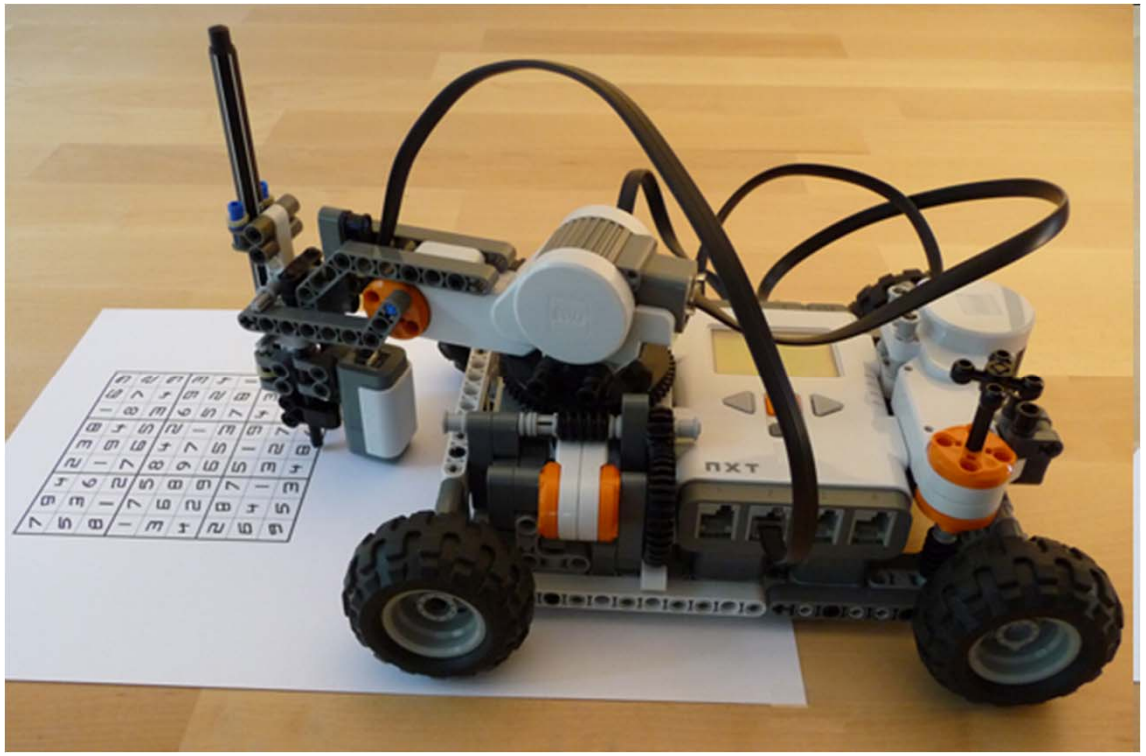
Models should include more parameters, describe more processes, should be more realistic

FPAers assumes we live in a Sudoku world

9			8		2			6
			9		3			
3		7				4		8
		2	5		7	8		
	4						3	
		6	1		4	2		
2		8				1		3
			3		9			
6			4		8			2

- the rules are defined
- the game has a clear-cut objective
- rules and goals are not influenced by the outside world
- the problem has one solution and when we find it, we know it

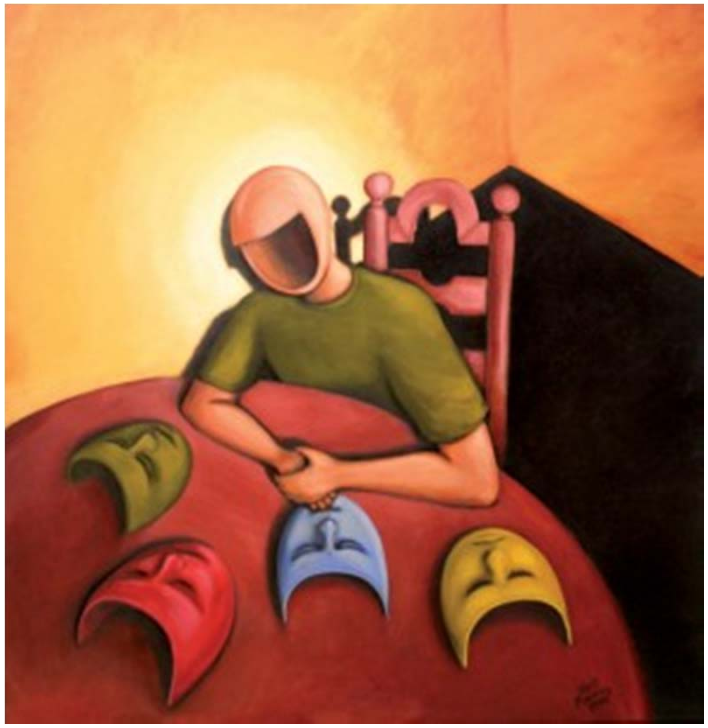
I am afraid there are no Sudoku-solvers for Earth Sciences



http://tiltedtwister.com/sudokusolver.html

Evidence suggests that perfect models can be problematic

at the personal level:



- identity crisis
- abundance of models making useless predictions

at a general level:

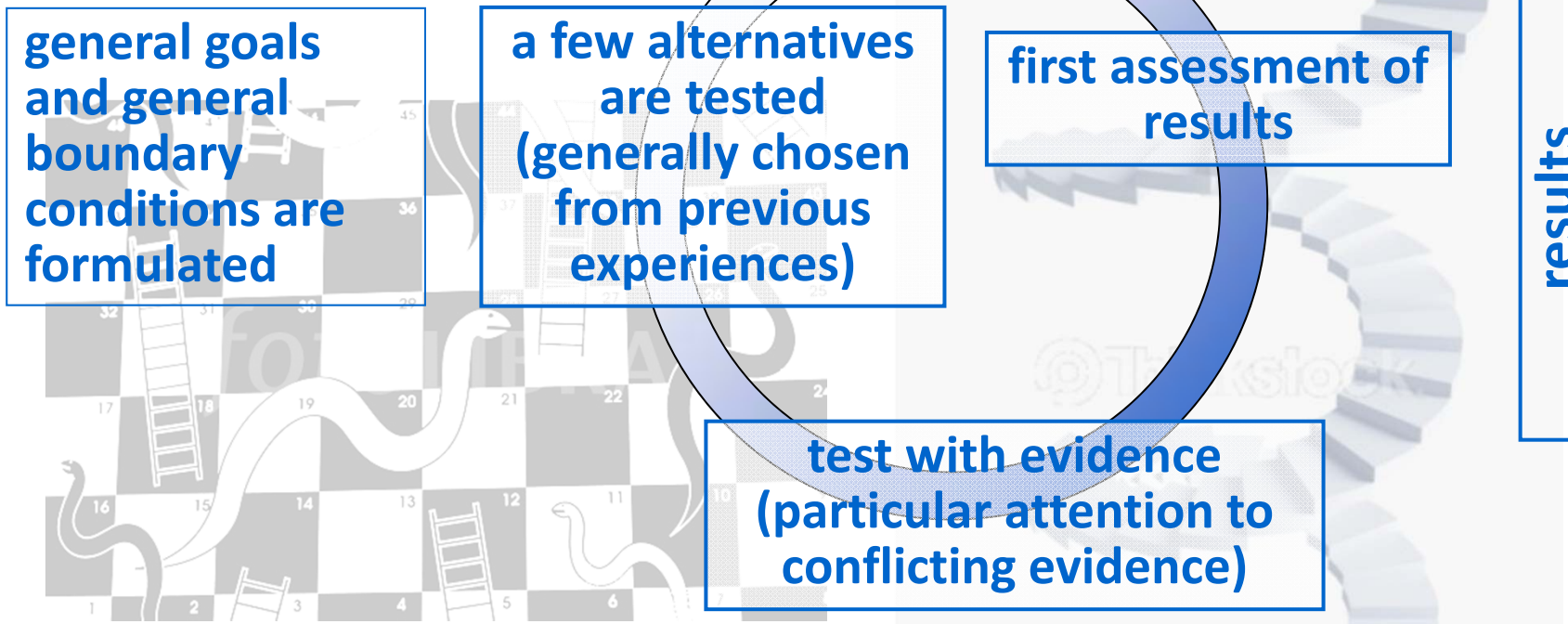
- the abundance of failed grand visions

http://www.soc.iastate.edu/sapp/Pruittigoe.html

Option 3: muddling through (German: sich durchwursteln)

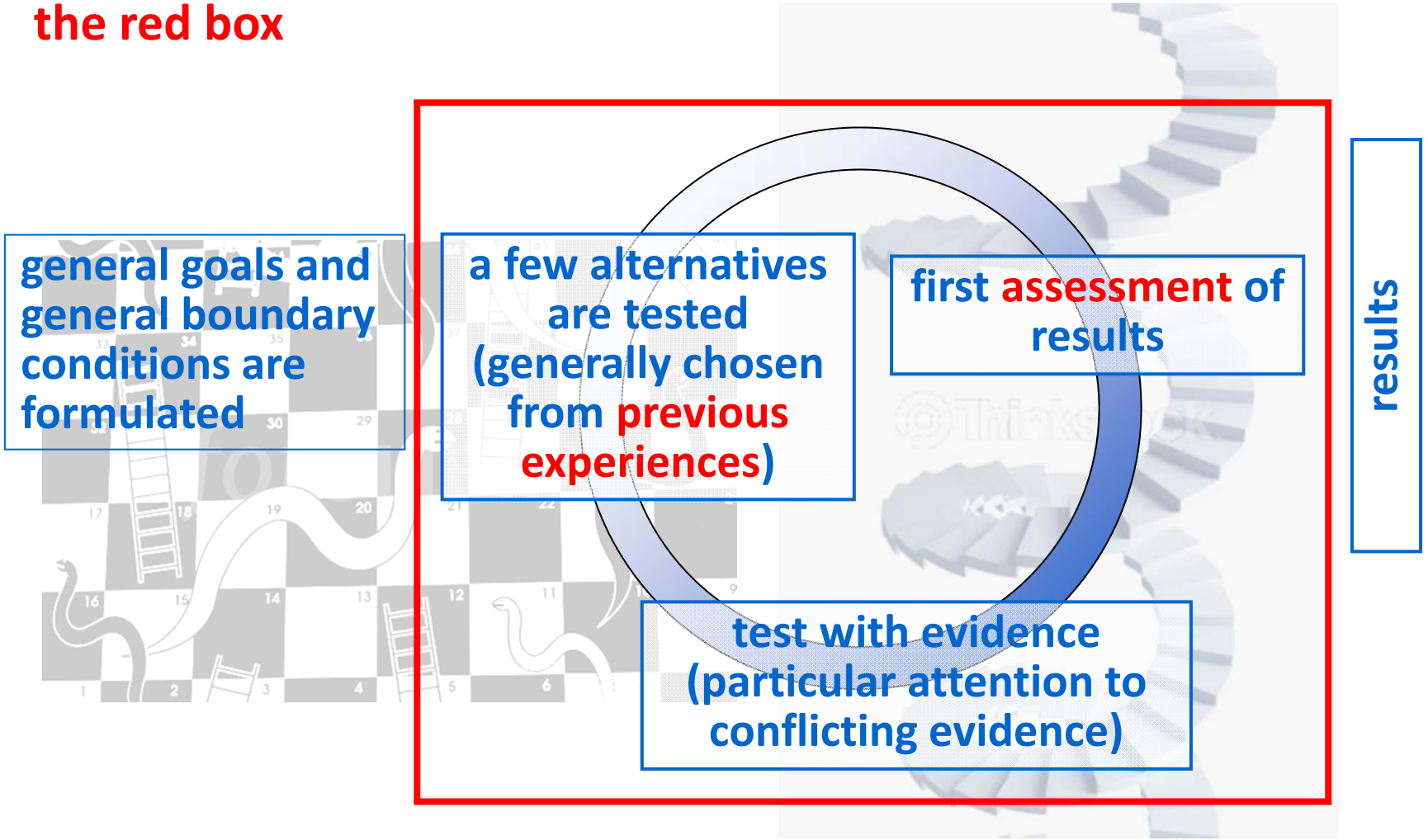
- goals in complex systems can only be defined at a general level
- selection of goals and analysis are not detached from another
- strategies are decided on the basis of comparisons with present state rather than by searching among "all possibilities"
- a succession of comparisons greatly reduces or eliminates reliance on theory

simplified from Lindblom 1955

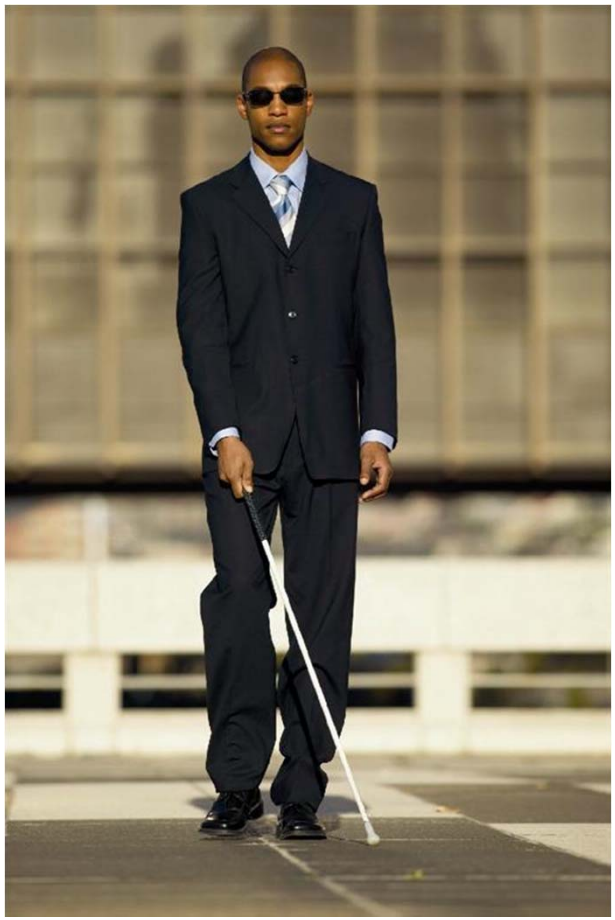


Because we know from the beginning that the process is imperfect, we know that we will need iterations: learning by doing

the red box


general goals and general boundary conditions are formulated
a few alternatives are tested (generally chosen from previous experiences)
first assessment of results
test with evidence (particular attention to conflicting evidence)
results

The red box is what brings you from the parts to the system

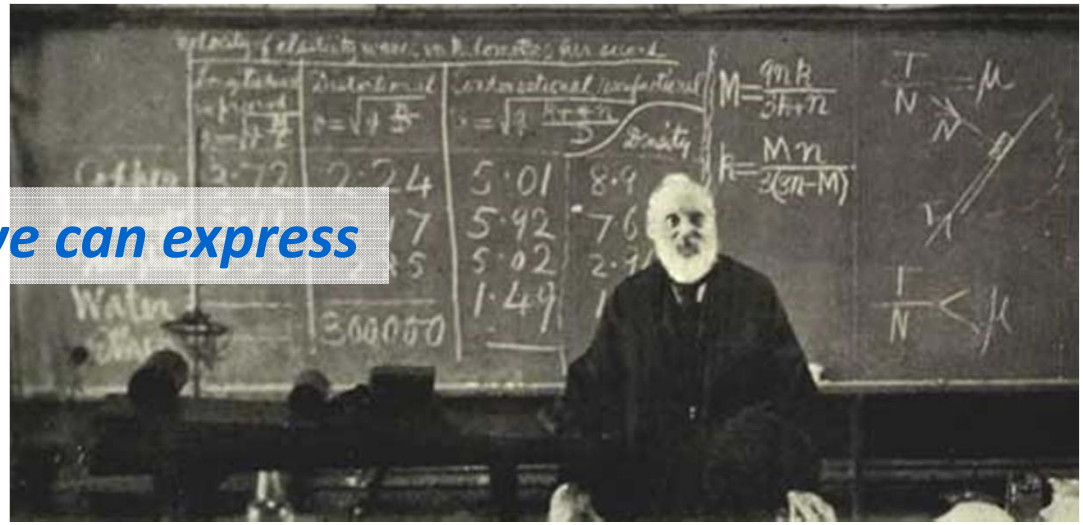


It allows the translation of physical observations into results and decisions

It is fed by evidence (especially the conflicting ones)

It is driven by tacit knowledge

tacit knowledge



We much more than we can express

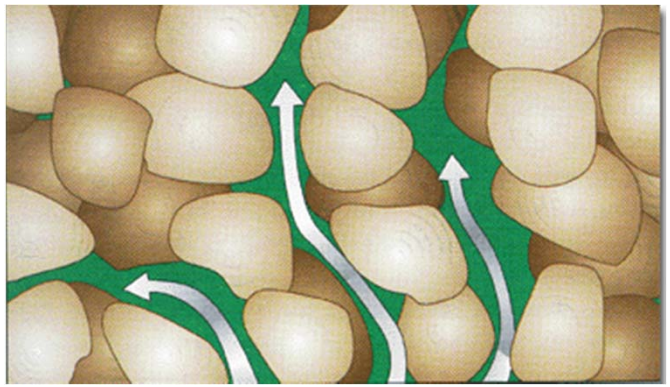
- processes the ingredients and devises a strategy using, background knowledge, life, preliminary results..
- is an efficient machinery because it updates continuously (especially if it is kept flexible)
- tacit knowledge is an essential to handle complex problems typical in Earth Sciences

The combination of well functioning tacit knowledge and sharp data gathering and interpretation are key in Earth Sciences

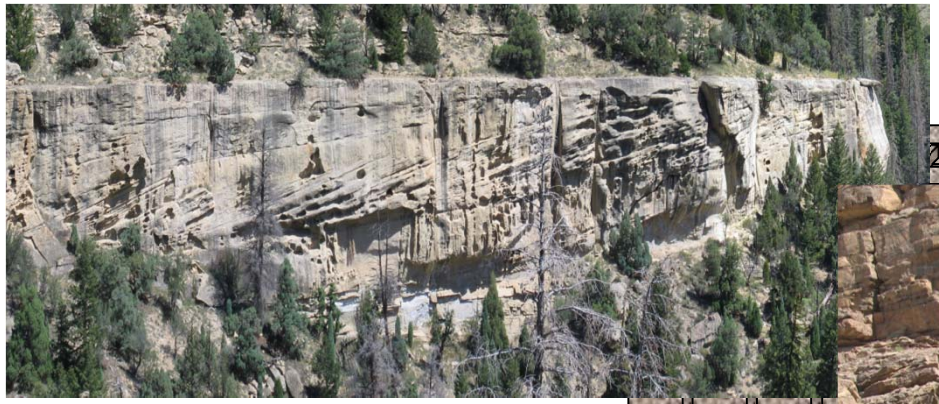
The right approach to:

Make detailed predictions making full use of knowledge of processes at the large scale

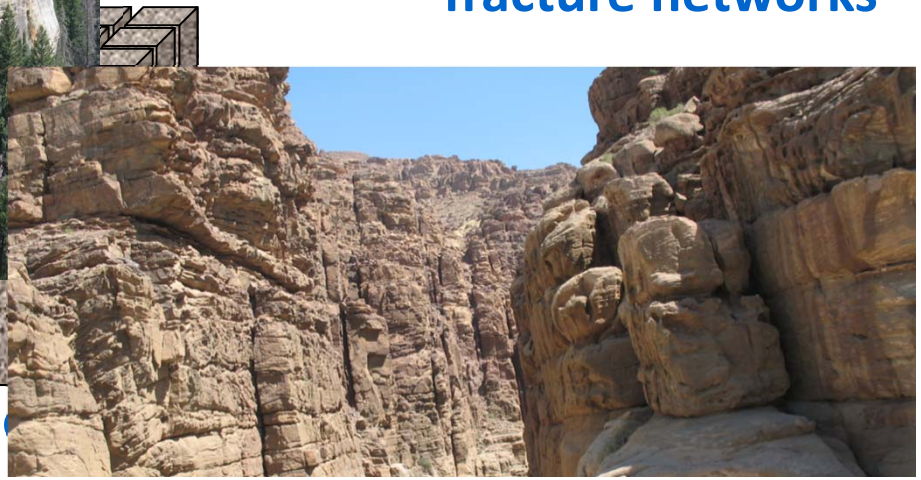
Predicting permeabilities of large bodies (100sm) at large depths (hydrocarbons, water, geothermal energy…)



Large geological bodies have multiscale heterogeneities

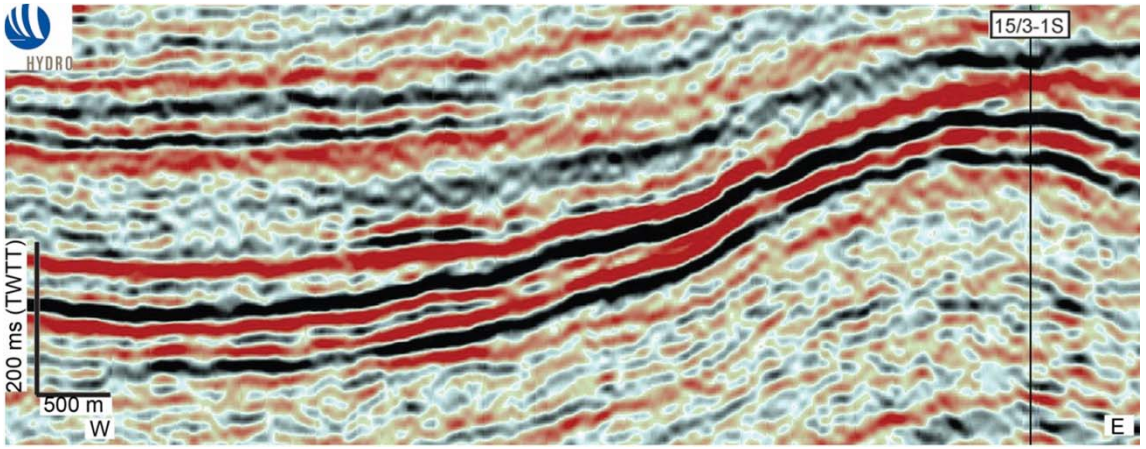


sedimentary architecture



fracture networks

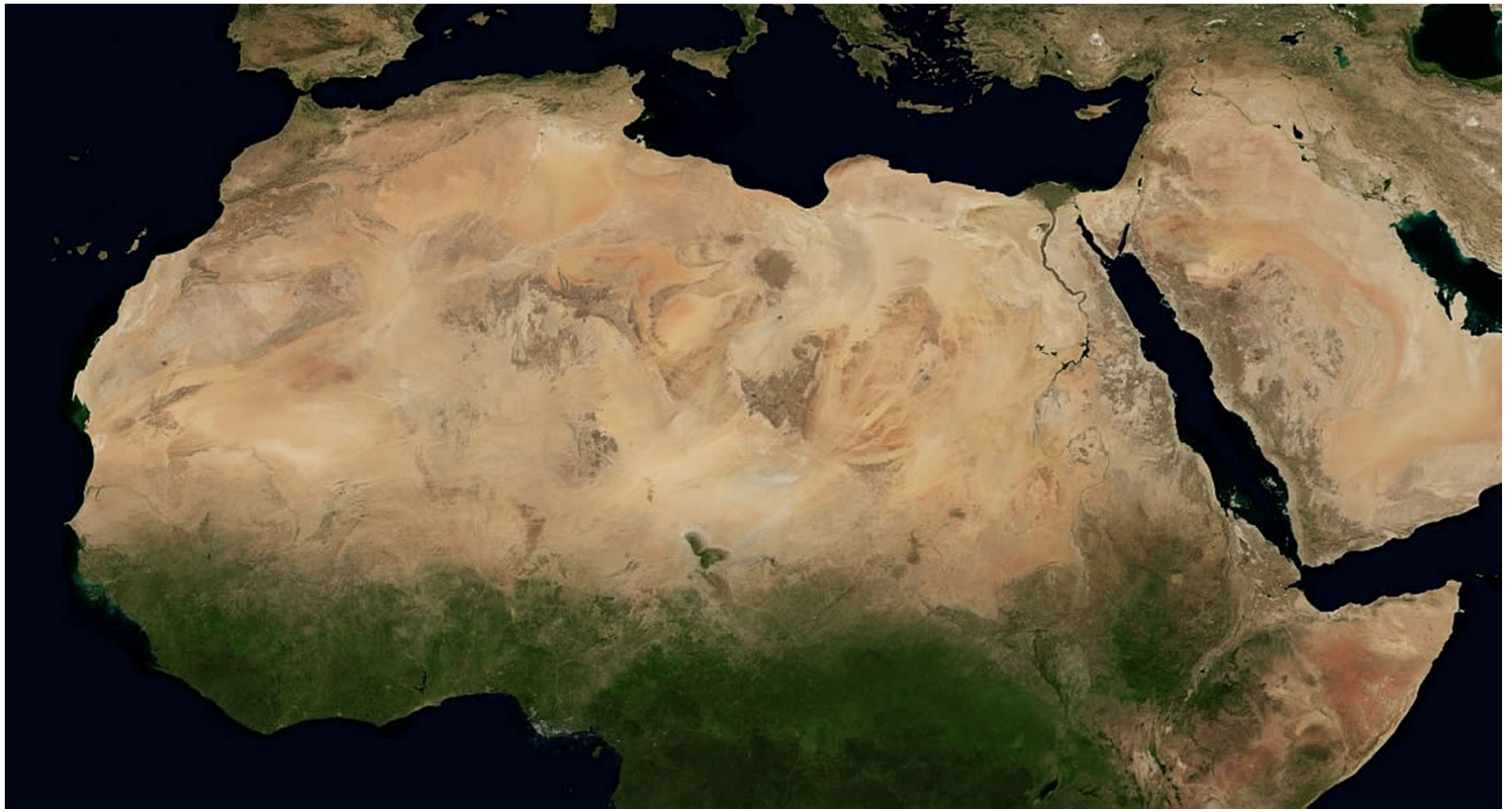
the engine



TUDelft geophysicists produce beautiful images of the subsurface

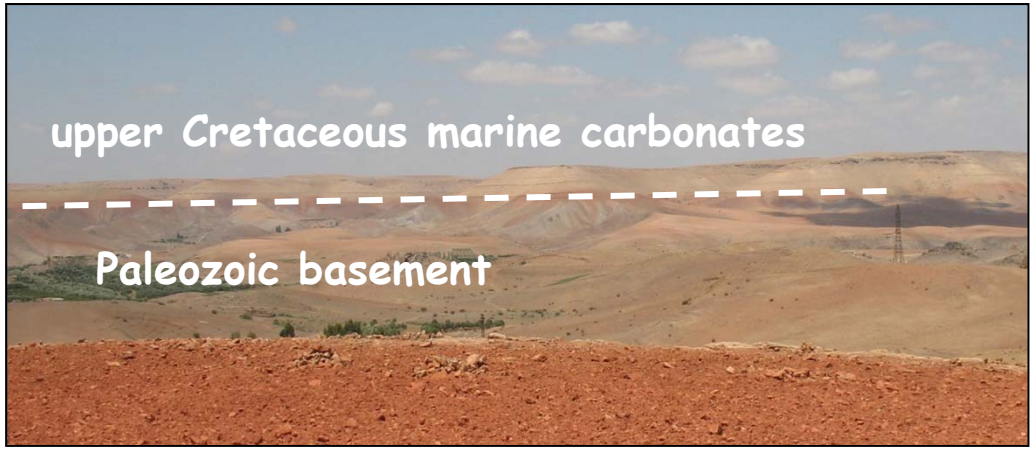
Too complicated to handle with “perfect” models: geological intuition (muddling through) is required

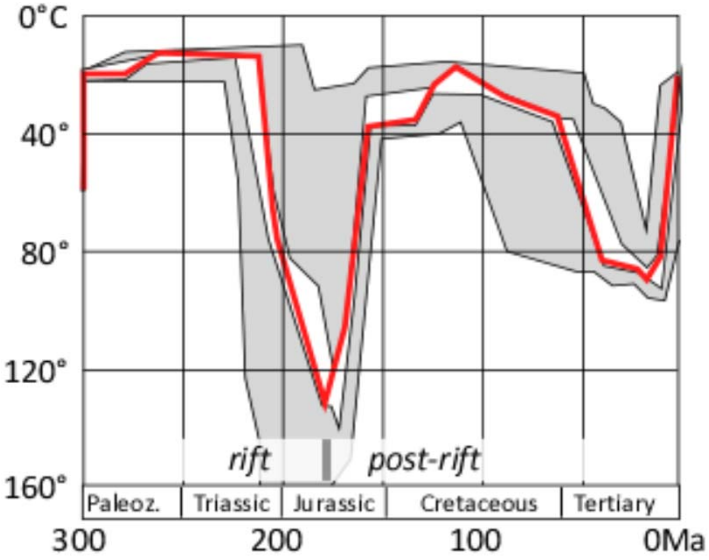
multiscale research in NW Africa:
our recent discoveries bring new perspectives to fundamental ad applied issues

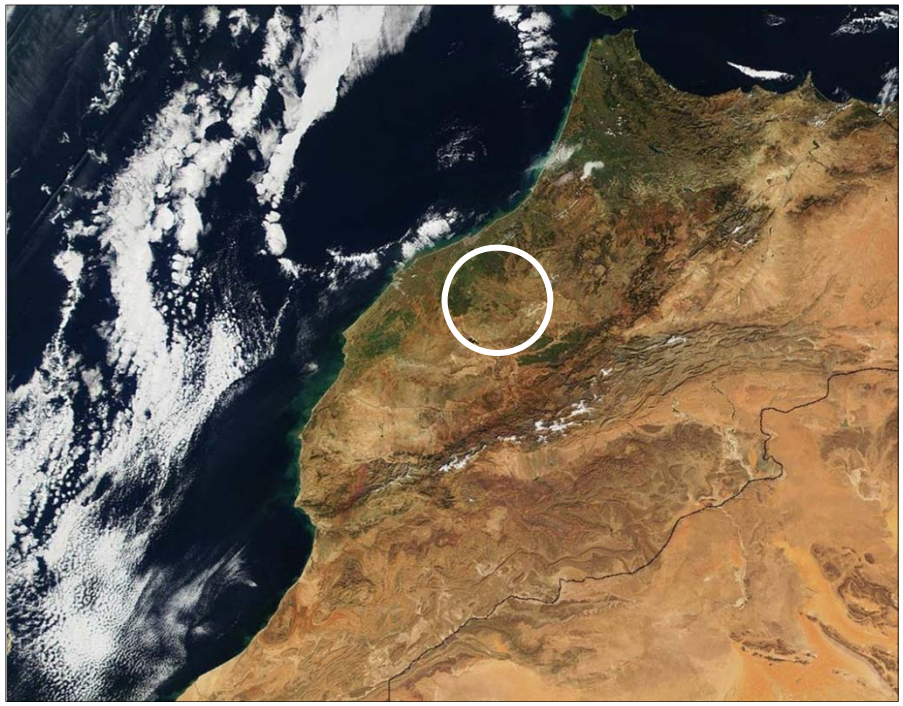


collaboration with S. Cloetingh
and P. Andriessen at VU

ISES



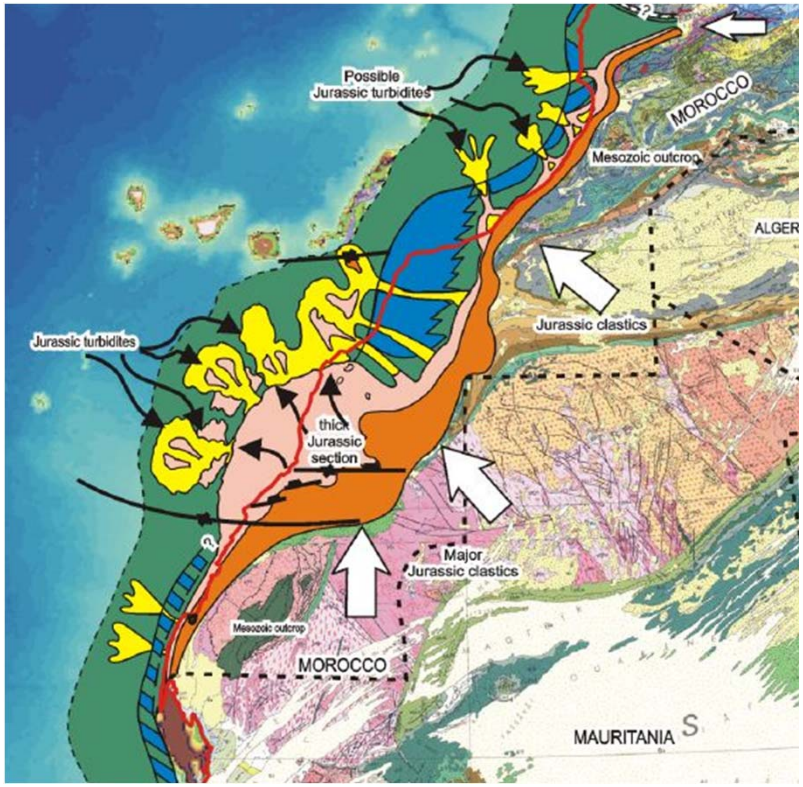




The Jurassic unconformity hides substantial vertical movements

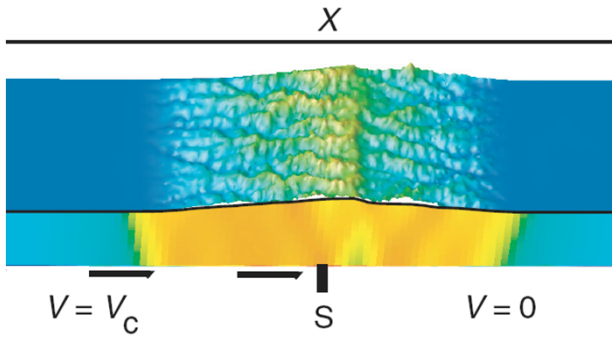
- **>2km of material has been eroded**
- **stress-strain histories are different from assumed**

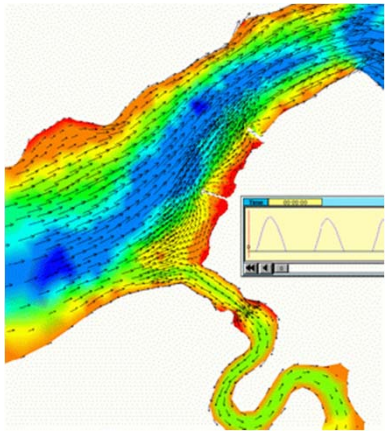
PhD B. Ghorbal and M. Gouiza

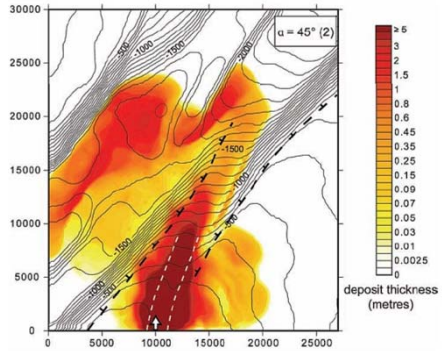


Eroded terrigenous sands form a major clastic sediment offshore Morocco

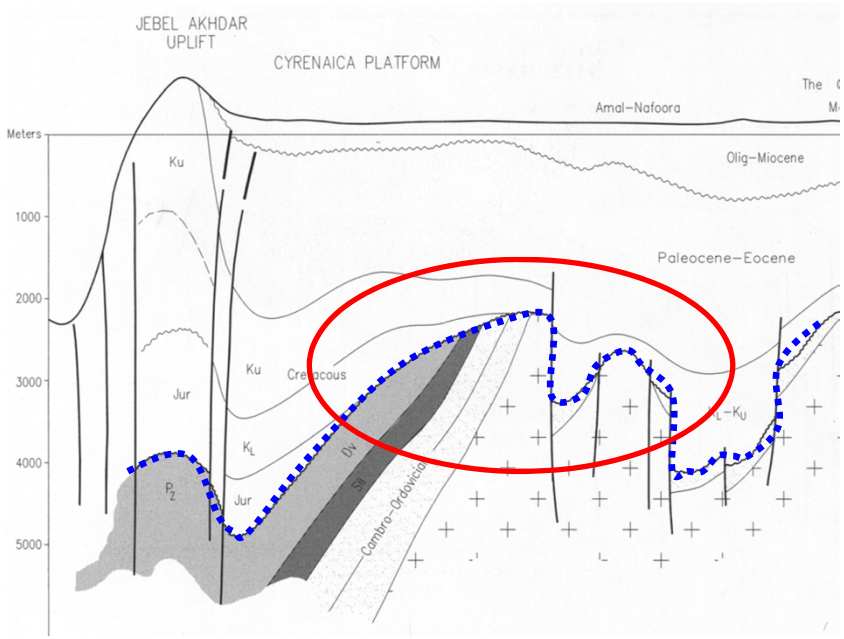
Its origin and composition was unknown







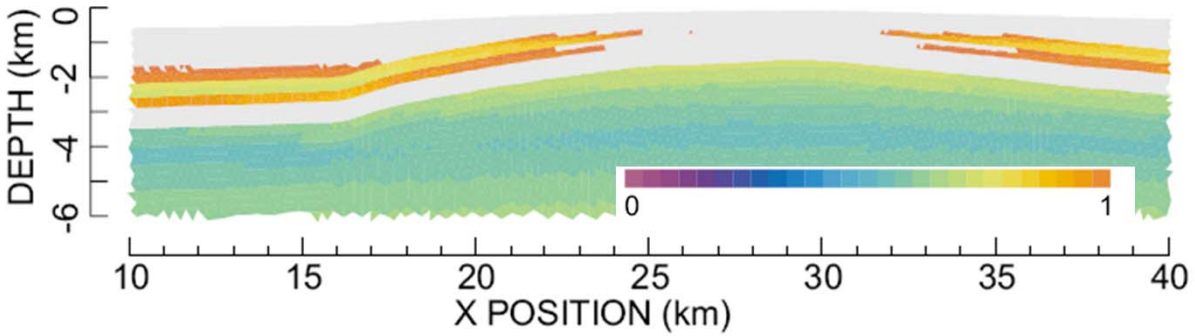
The TUD Applied geology section

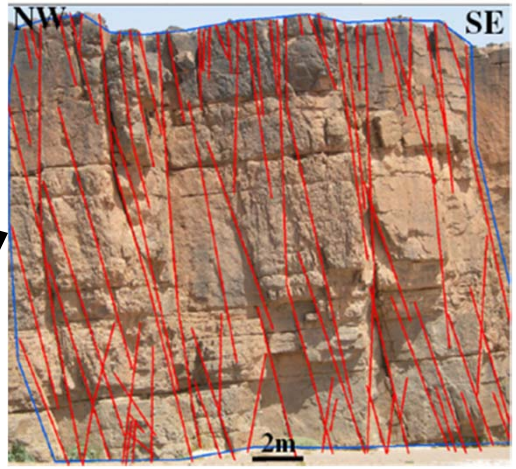


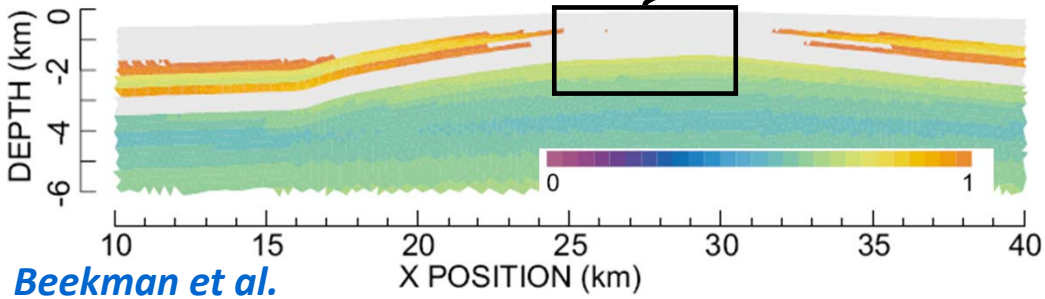
The Late Jurassic-Early Cretaceous unconformity is widespread in NW Africa

Fractured anticlines have a poly-phase history of vertical movements

correct boundary conditions are crucial to predict where fractures are





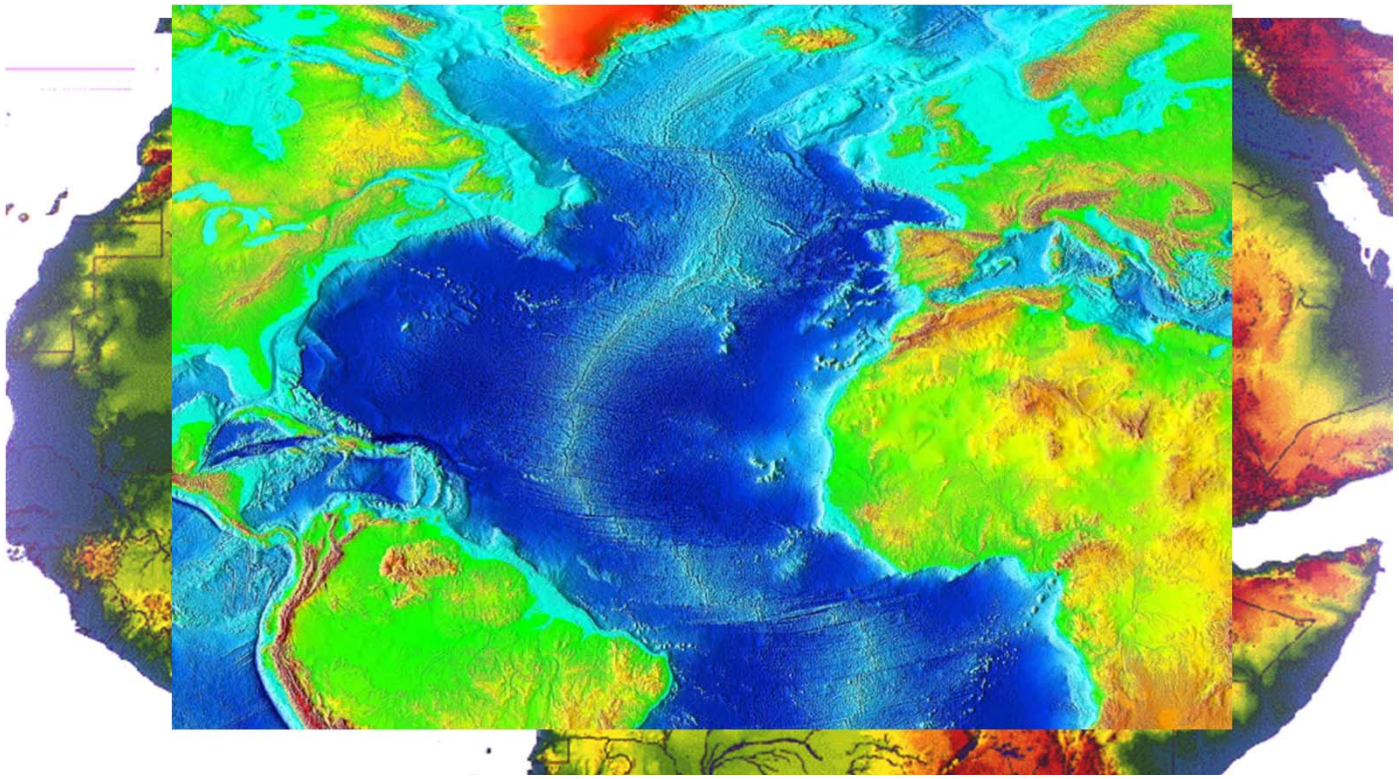


Beekman et al.

We populate the fractured areas with information from outcrops

PhD H. Boro

Comparable vertical movements found over most of NW Africa



New perspectives for the understanding of processes further south, like for instance the onset of the river Niger and of the Niger delta

The same signal found also in Canada!

A lot of interdisciplinary work

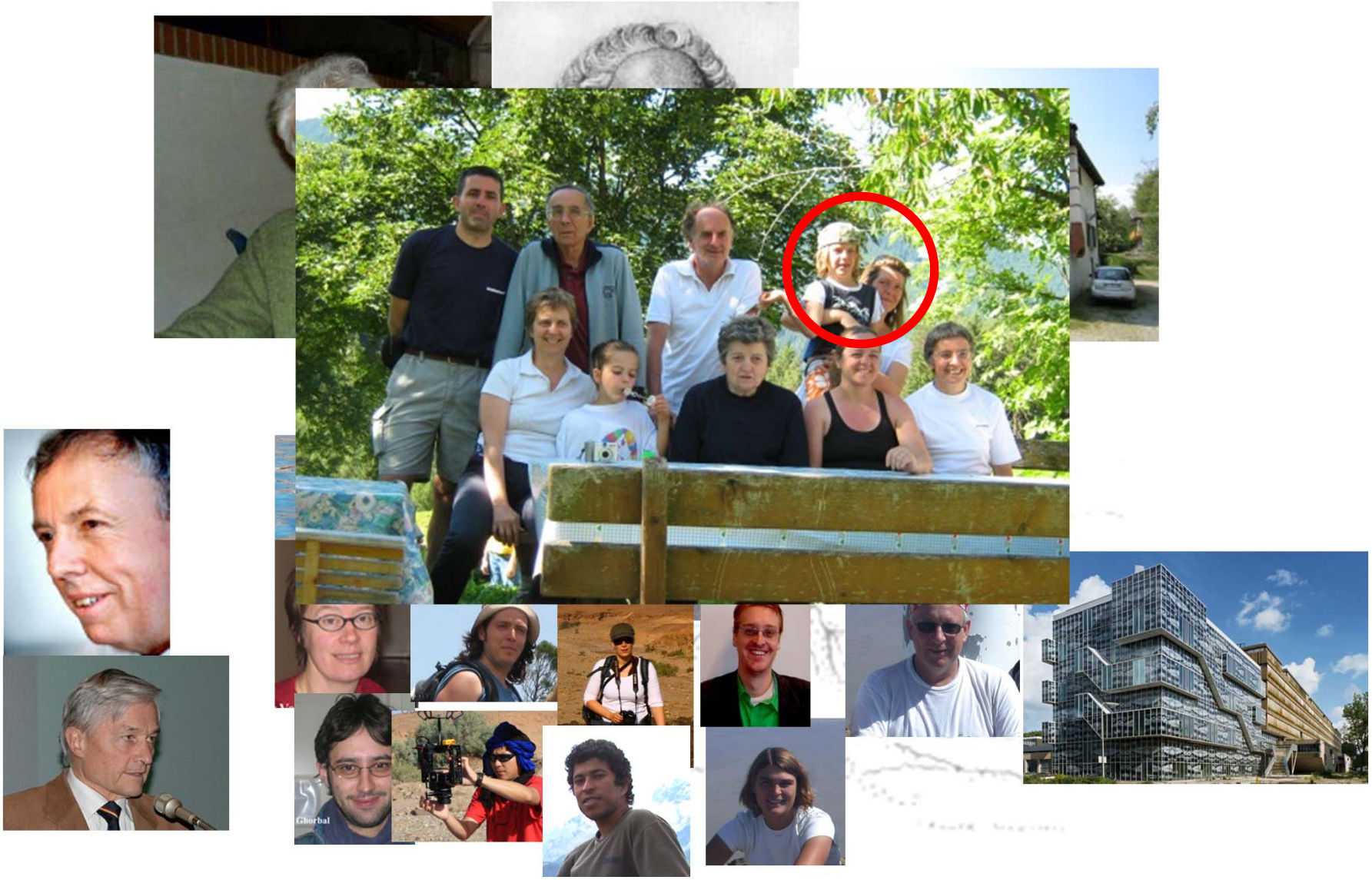
This is an excellent place for this

Great competences and great people

Strengthening collaboration with other NL Universities

Very much looking forward to the coming years

Thanks to



Ik heb gezegd