3D Models of the deeper underground – Case studies in the German North Sea

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Geo Potenzial Deutsche Nordsee

Geo-Scientific Potential of the German North Sea

Joint cooperation of project partners:

- Federal Institute for Geosciences and Natural Resources (BGR)
- State Authority for Mining, Geology and Energy (LBEG)
- Federal Maritime and Hydrographic Agency (BSH)

Aim of the project:

Acquisition and provision of basic geoscientific information supporting a sustainable development of maritime economic and natural area of the German North Sea area.

GPDN: Project structure

Geo-Potential of the German North Sea

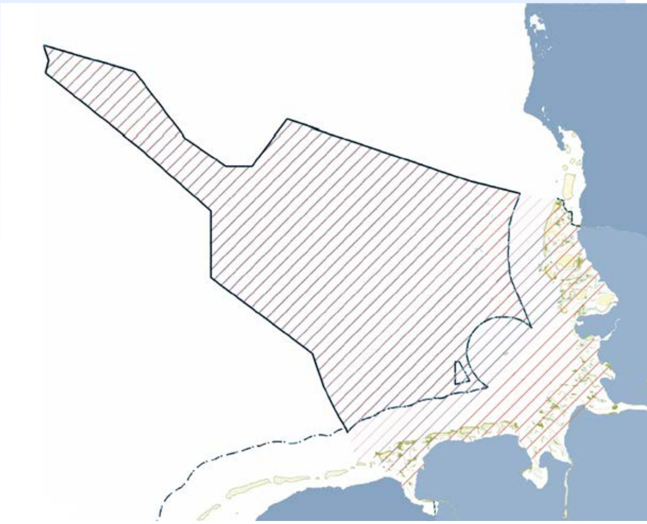
A	**Geological structural model of the North Sea area**
B	Sedimentary & mineral deposits, ground properties of the shallow subsurface
C	Sea-level development and geological framework
D	**Assessment of the hydrocarbon potential**
E	**Storage capacity of the North Sea area**
F	Geo-Information System North Sea

- The project is subdivided into **six technical modules**, all closely connected in terms of content.

- **Project duration**: 5 years (2009 until end of 2013)

- **In december**, the **results of the project** will be presented in form of web-based, user-oriented **products** and **made accessible** for the private, business and research sector, as well as for public authorities.

http://www.geopotenzial-nordsee.de



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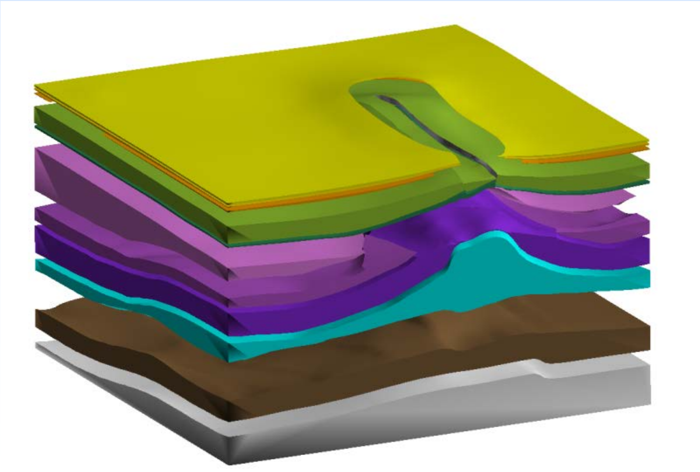
Motivation: three questions – one input model

lithogical model of Buntsandstein for reservoir modelling

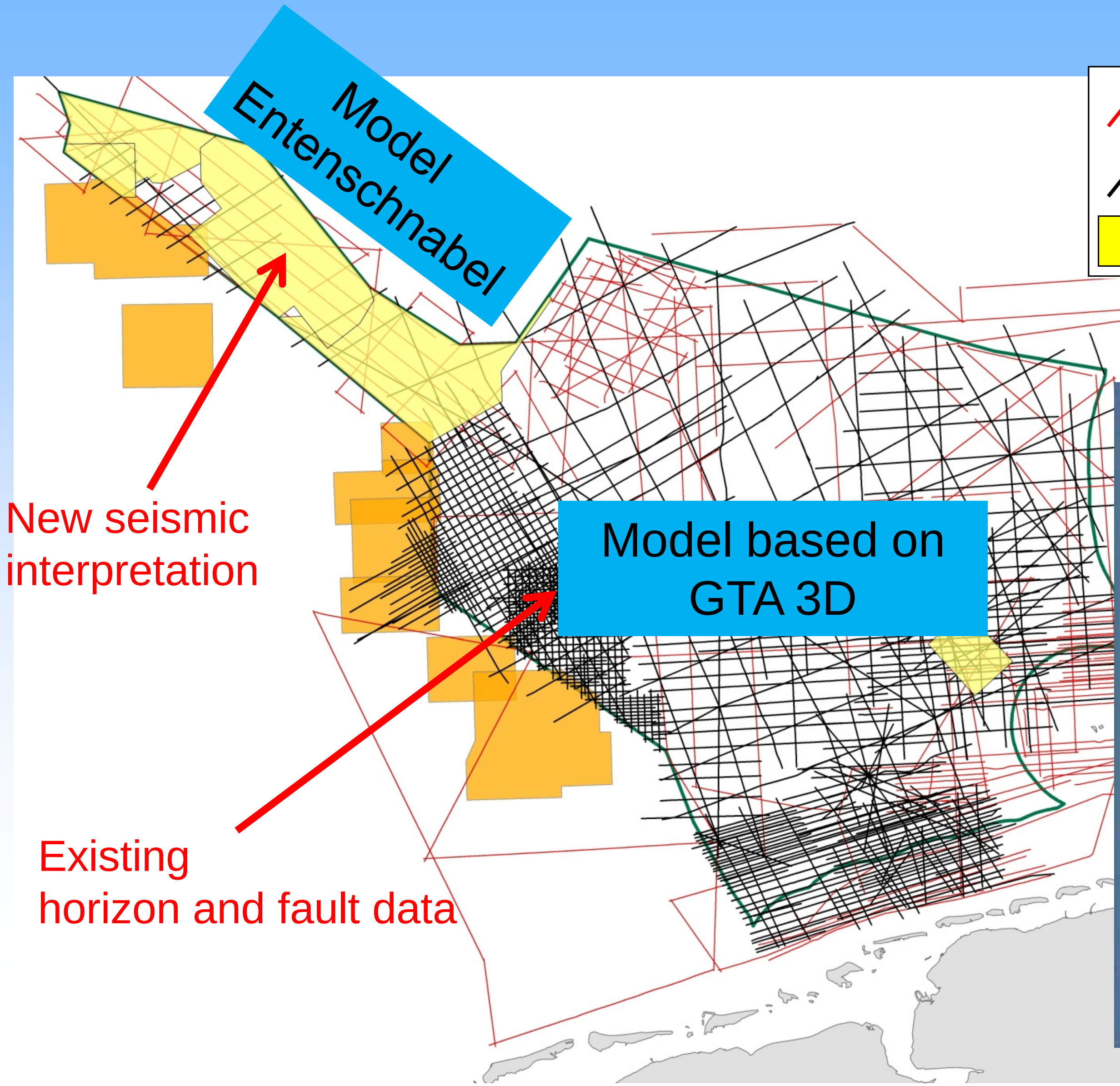
storage potential

petroleum-system-modelling



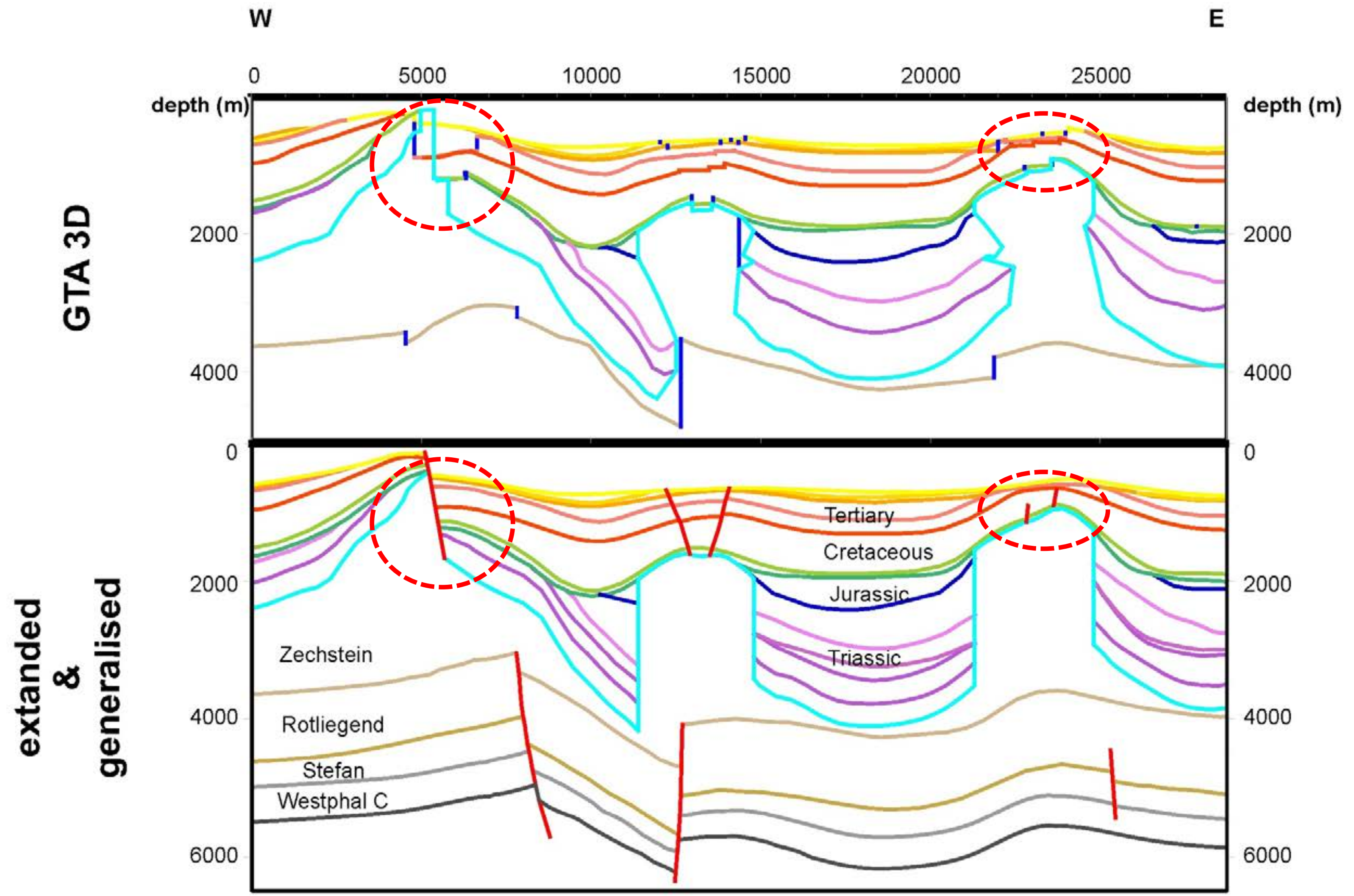
But different data coverage and data quality for model areas

Two model areas – two methodological approaches

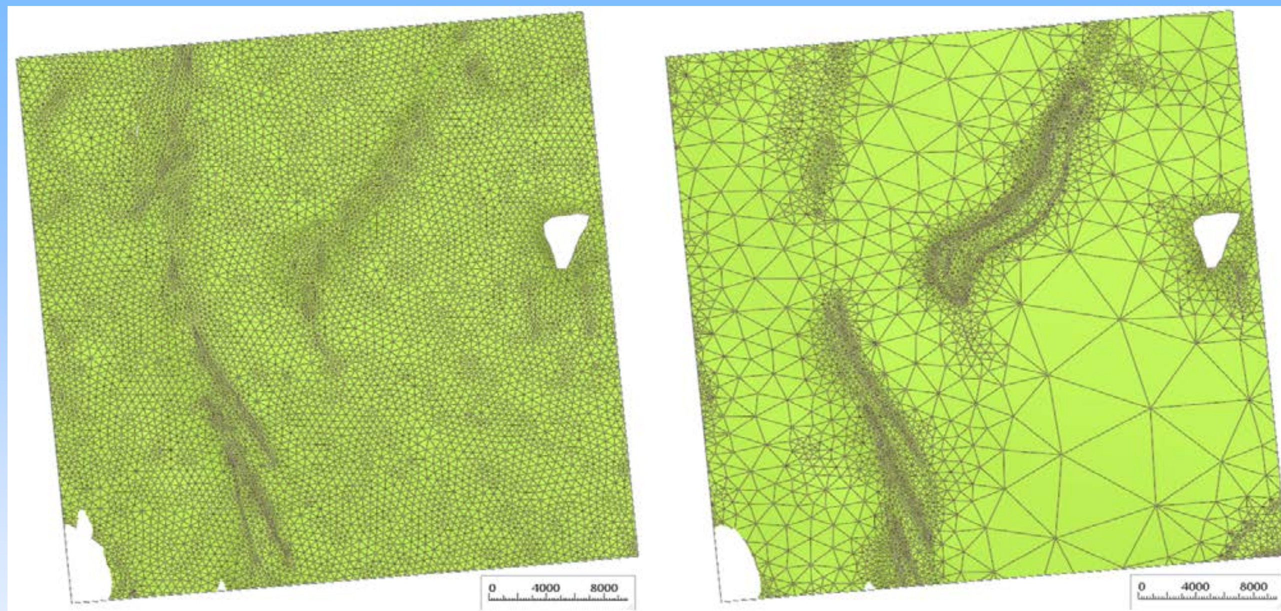


GTA-NW Deutschland (1999)

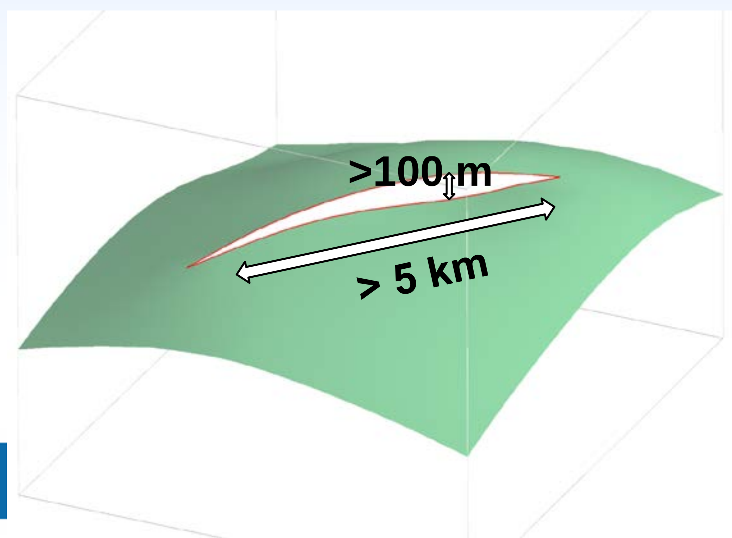
Problems with existing data => Model generalization with GOCAD

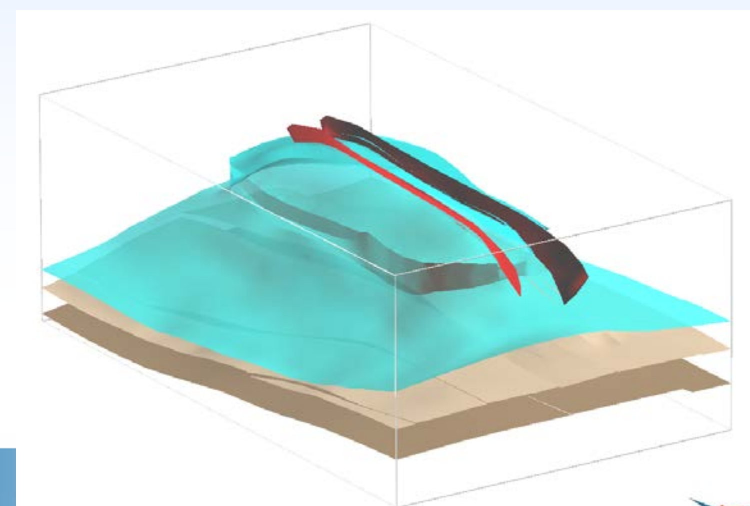


1) Horizon Modeling -> decimation and retriangulation

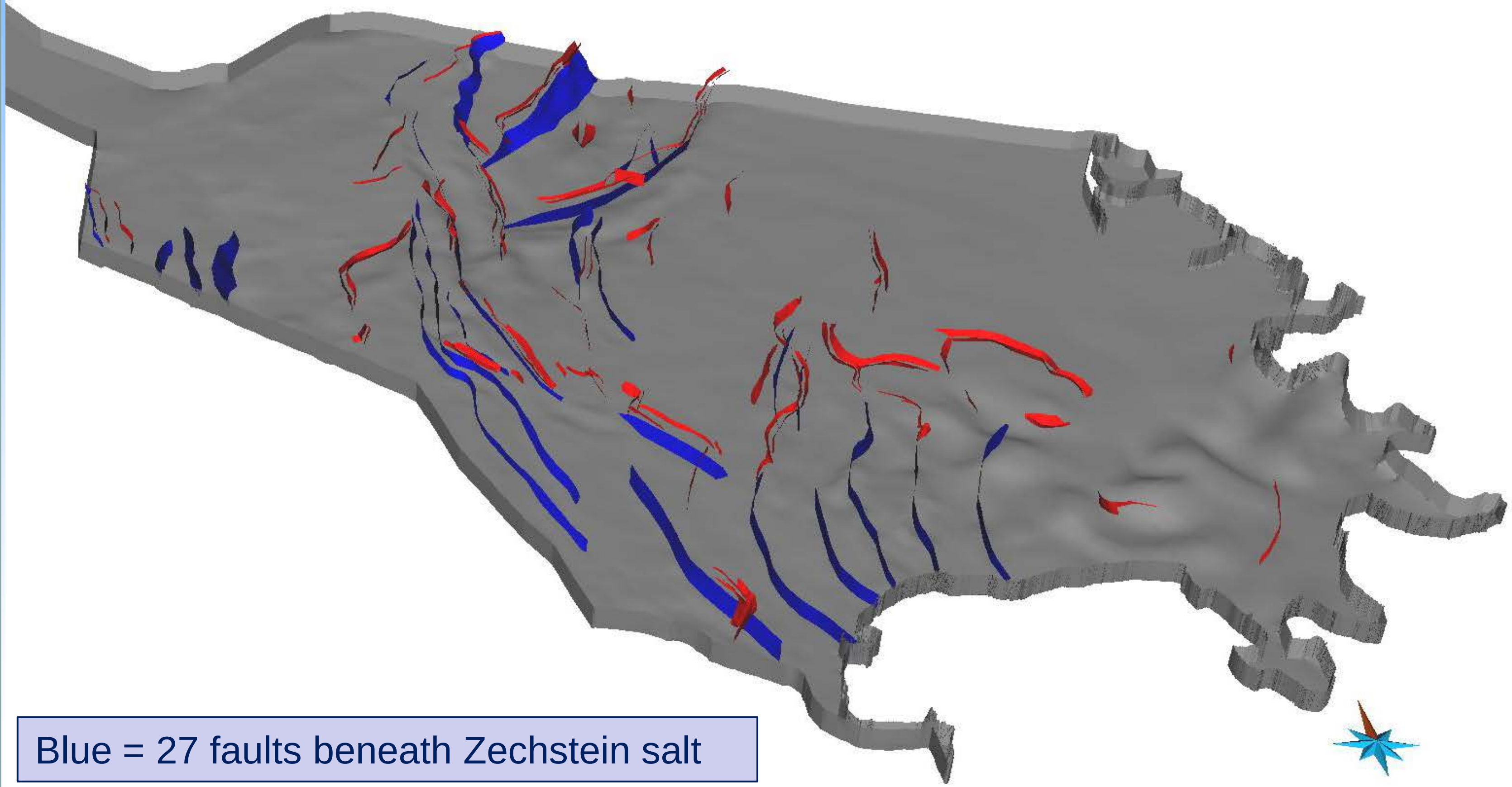


2) Fault Modeling -> criteria for vertical offset and fault length





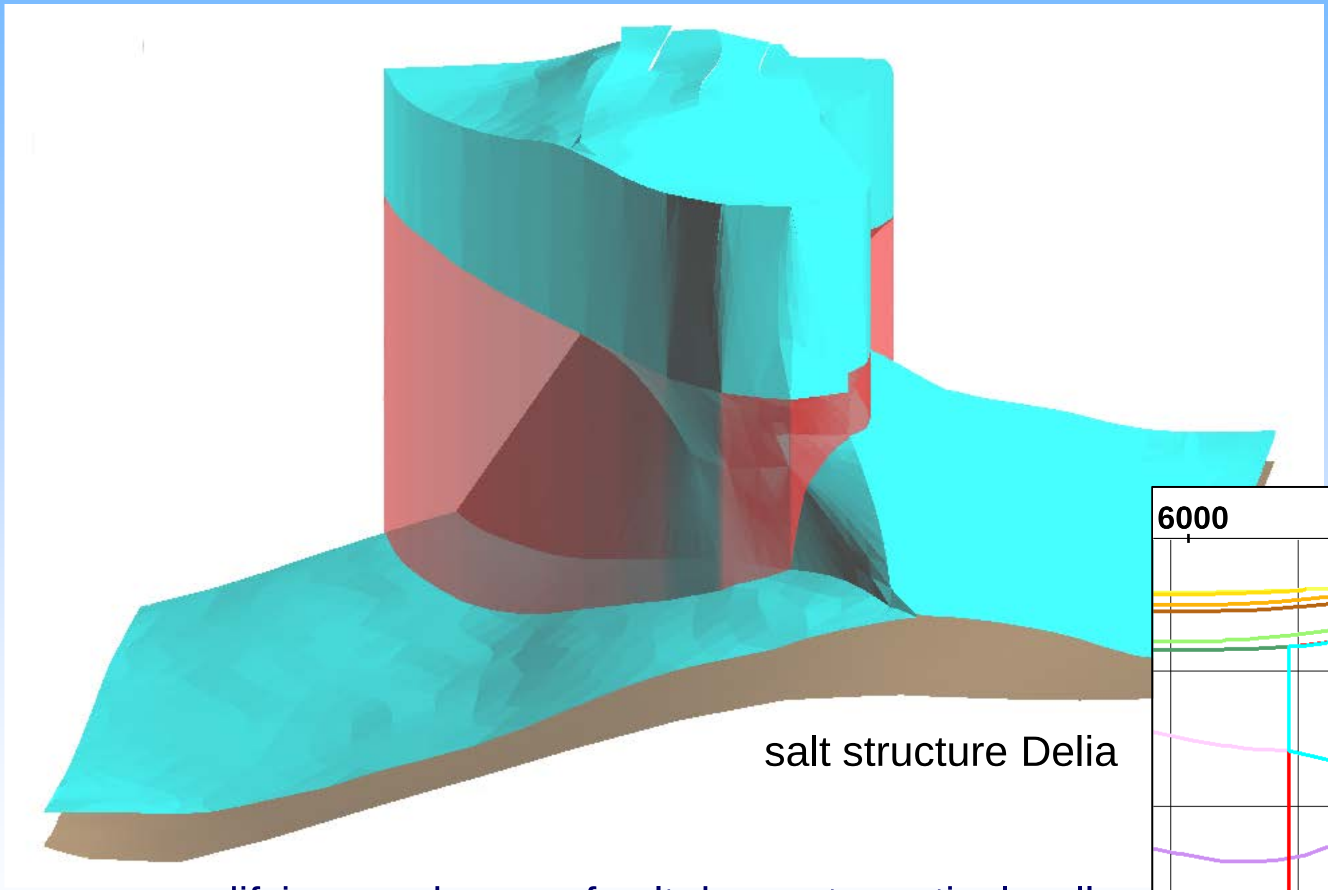
Fault Model

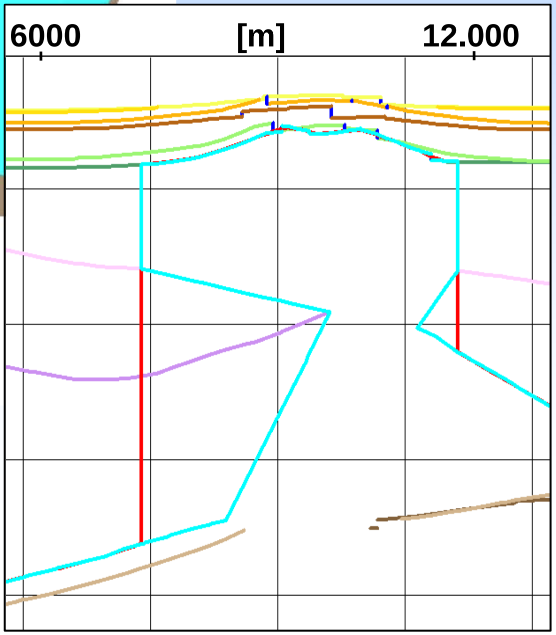


Blue = 27 faults beneath Zechstein salt

Red = 78 faults above Zechstein salt

Generalisation of salt dome geometry -> first input for Petrel model

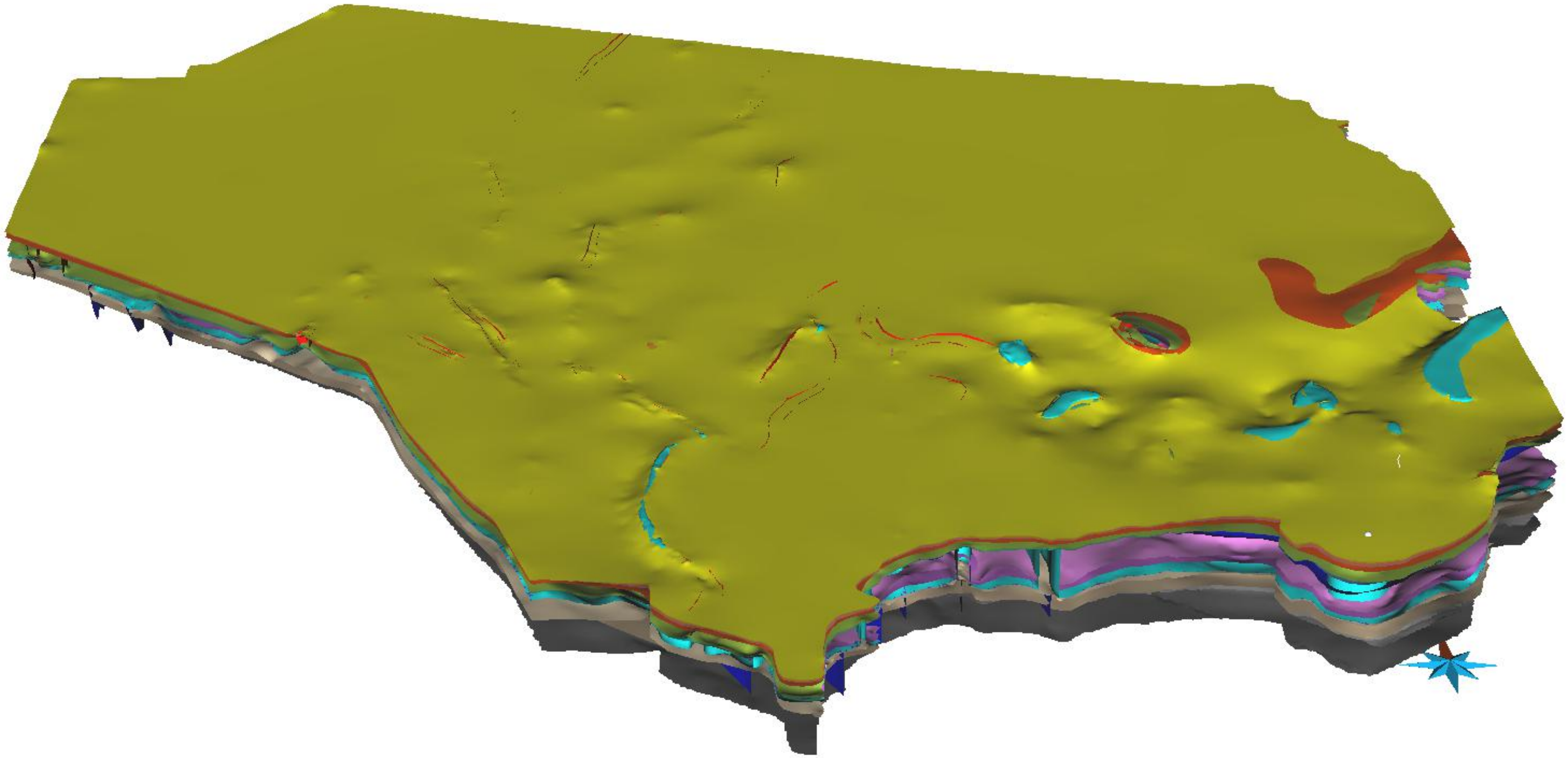




- modifying overhangs of salt domes to vertical walls
- the lateral dimension of every salt structure depends on the salt top surface
- potential traps near salt overhangs have been eliminated

Result: Generalised structural model

- 17 base surfaces and 2 top surfaces from Namur up to the Middle Miocene / Seafloor
- 105 fault surfaces → fault model with normal and strike-slip faults
- tringulated surfaces without multiple z-values



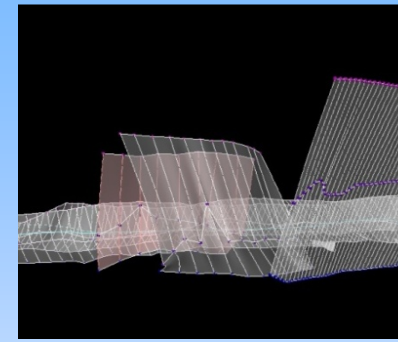
=> Consistent model ready to use for other applications (i.e. dynamic modelling)

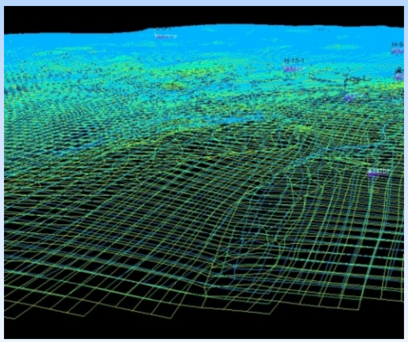
Workflow for 3D facies-modelling with Petrel

- Surfaces
- Fault modelling process

1

Structural Workflow





Corner point gridding

2

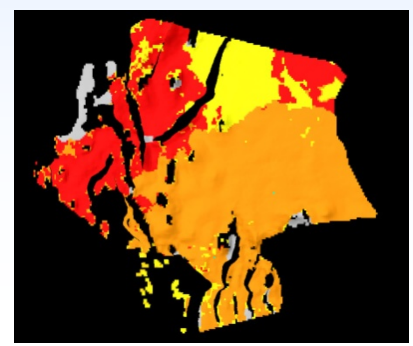
- Pillar gridding process

Input data:

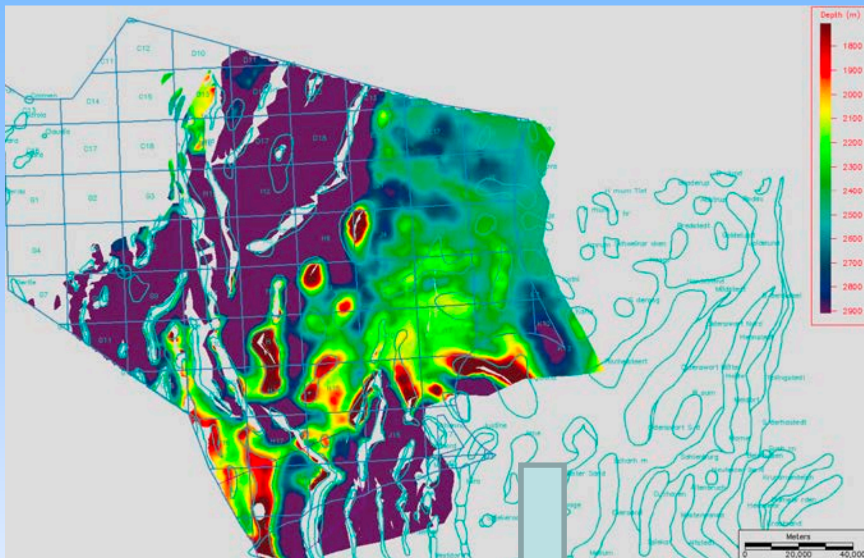
3

- Well data / maps
- geophysical logs
- lithological descriptions
- faciesinterpretation

Property Modelling

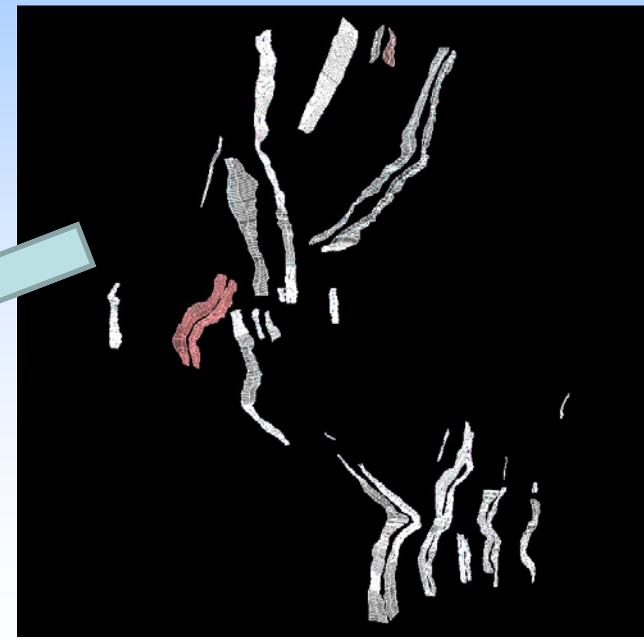


1 Structural workflow

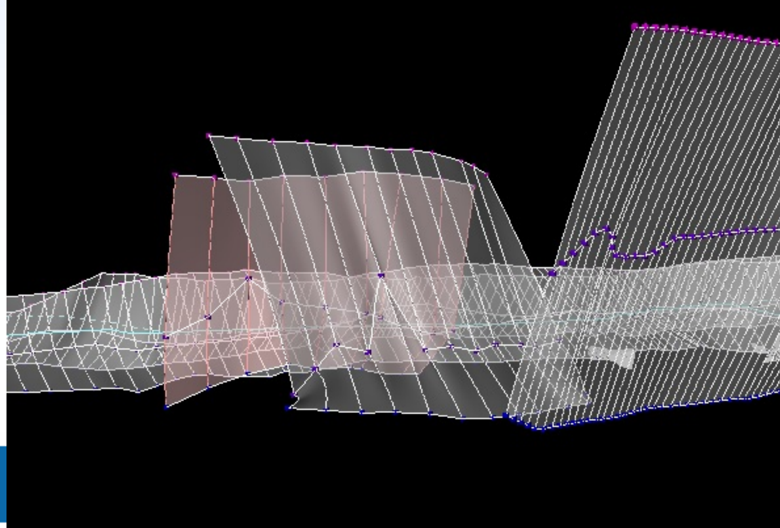


Surfaces taken from GOCAD grids together with new interpretation

faults from GOCAD as fault surfaces



=> Structural model in Petrel



2 Pillar gridding

1) Huge problems in the grid around salt structures

- Grid cells dependent on horizon parametres (conformable, discontinous etc)
=> solution: creation of faults around saltstructures

Is it only Petrel problem?

- Delimiting errors from fault model by try and error in the modelling process

2) In a regional model horizons have the same properties over the whole area

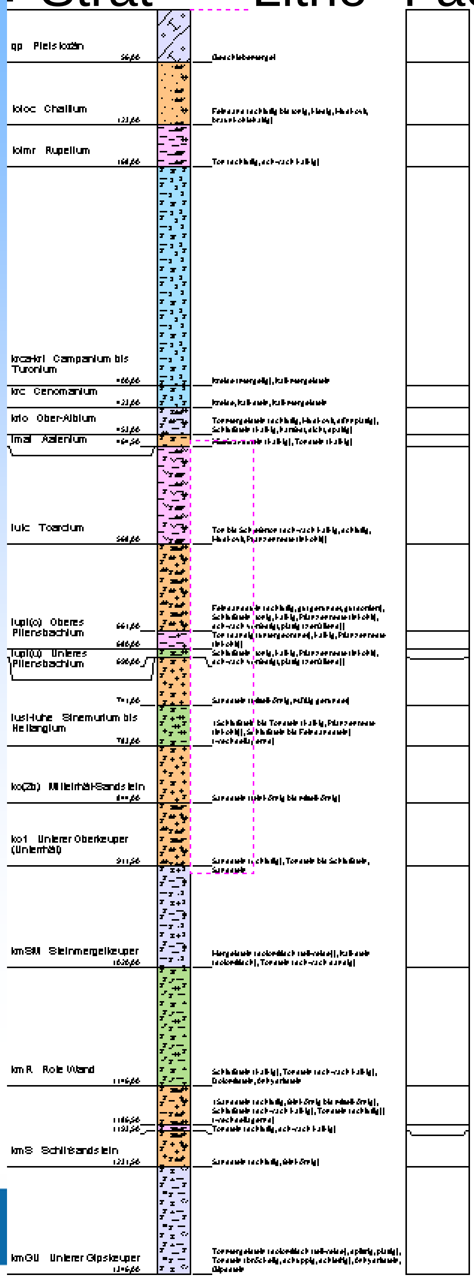
=> causes problems with gridding

Examples: conformable surface in one area vs. erosional in the other

if base Solling = erosional => cutting of saltstructures

3 Property modelling

Strat Litho Facies



GeODin – Output table as Access Database

DEPTHTO	SART	STRAT	PETRO	GENESE	FARBE	ZUSATZ	E
87		q	M(g,s)				
127		tolo	fS(u4,t,brk),T(s),gS(ml-tru,ec)		bngr,gr,dgr		
152		tolm	T(u,k2,"gk","m","py",shm,ps)		blgr,gngr		
230		krca	^kr(m),^mk(dc,mbrc,ebf)		wegr,hblgr		
355		krcc-krsa	^kr("py"),^mk(dc,rh)		wegr,blgr,hgngr		
385		krto	^kr("py"),^mk(u2,dc,rh,pg)		wegr,blgr		
520		krc	^k(kr),^mk(dc,rh,mbrc)		wegr,gr,gngr		
532		krl	^mt(u,"gl","gk",zf),^u(k,"gl",dc,"gk","ph")		gr,gngr,grbn		
583		jutc	T-^tbl(k2,u,s(wl),"gk","gl","py",pf(ik))	br	grgn,gr,swgr		
622		jupl(o)	fS(u,r4,so4),^u(t,k2,"m","py","gk",pf(ik))	br	gr,blgn,grbn,gel		
716		jusi(o)	^u(t,k,v2)	l	grbl		
743		jusi-juhe	^ms(u2,ce,(i),pf)	br	hgr,bngr,gebn		
755		jusi-juhe	^ms(u2,ce,(i),pf)	br	hgr,bngr,gebn		
425		krto	^kr("py"),^mk(u2,dc,rh,pg)		wegr,blgr		
440		krto	^kr("py"),^mk(u2,dc,rh,pg)		wegr,blgr		
703		jupl(u)	T-^tbl(k,"py","gk",pf(ik))	l	grbl		
840		ko2	^u-^t(k,"py","gk",ko,klm,brl),^u-fS(k2,"gk	l	blgr,vigr		
949		kmSM	^t(u,"py",brl),^mt(erd,lc),^m(pg,mbrc)		bu,orbn,ol,hgr,r		
1142		kmGO	^u(car,"m",erd,pg,brs,lc,p2),^t(car4,erd,s		swbn,robn,dgr,c		
1194		kmS	^s(kgf-kgm,u),^u(t,s,k2,erd),^t(u4,s4)		vibn,gr,robn,grg		
157		tolm	^u(s,(t),ce,p)		hgr		
240		krca	^u(t,"gk"4,k2,"py",brl)		gnsw		
250		krca	^kr(m),^mk(dc,mbrc,ebf)		wegr,gr,hblgr		
	idm		^md				
470		krtm	^kr("py"),^mk(u2,dc,rh,pg)		wegr,blgr		
481		krtu	^kr("py"),^mk(u2,dc,rh,pg)		wegr,blgr,ro		
642		jupl(o)	T(s2,k2,pf),^mt(s2,dc,brl)	br	grbl,grvi		
660		jupl(o)	^u-fS(t2,k,"m",v2)	br	grbn,gr		
671		jupl(o)	T(k,"gk","py",shm-klm)	br	dgr		
685		jupl(o)	^u-fS(k2,"gk",pf(ik),v2)	l	grbl,vigr		
	bas		Sk				
	ban		^k				
	lgd		^k				
	ban		^k				

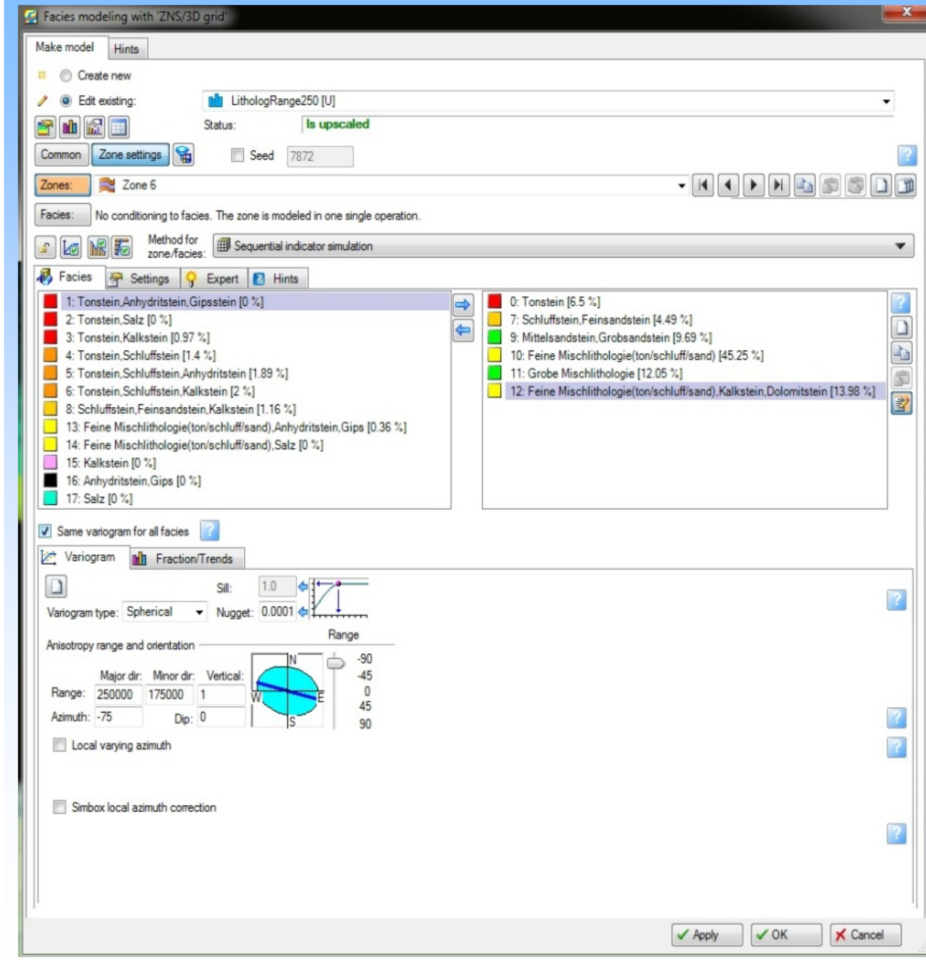
lithological description results in a lot of combitionation of ‚letter strings‘

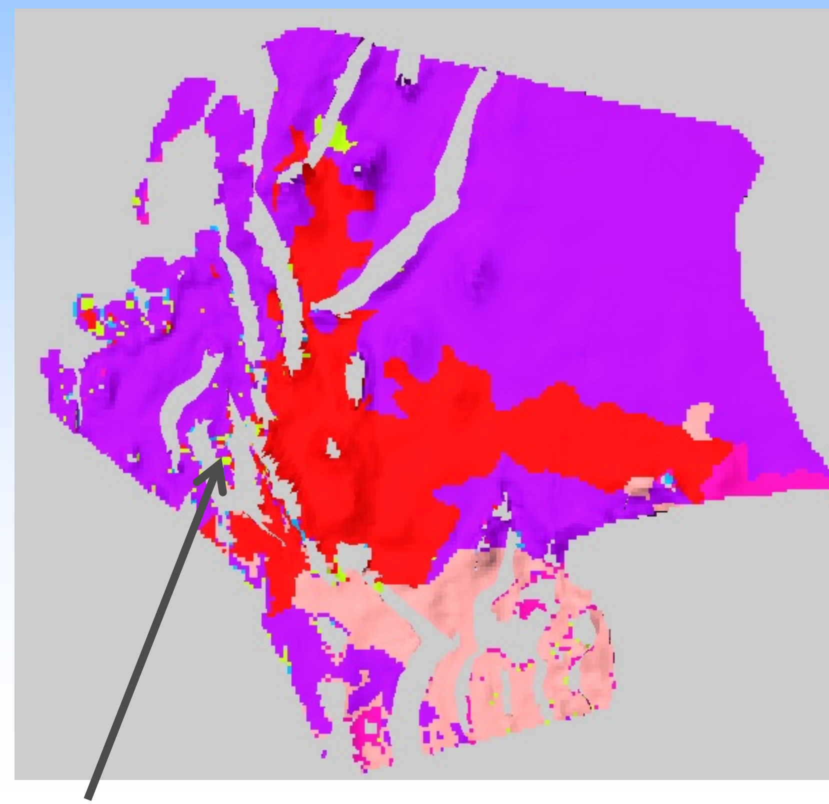
=> Making automatisation difficult

17 lithologies

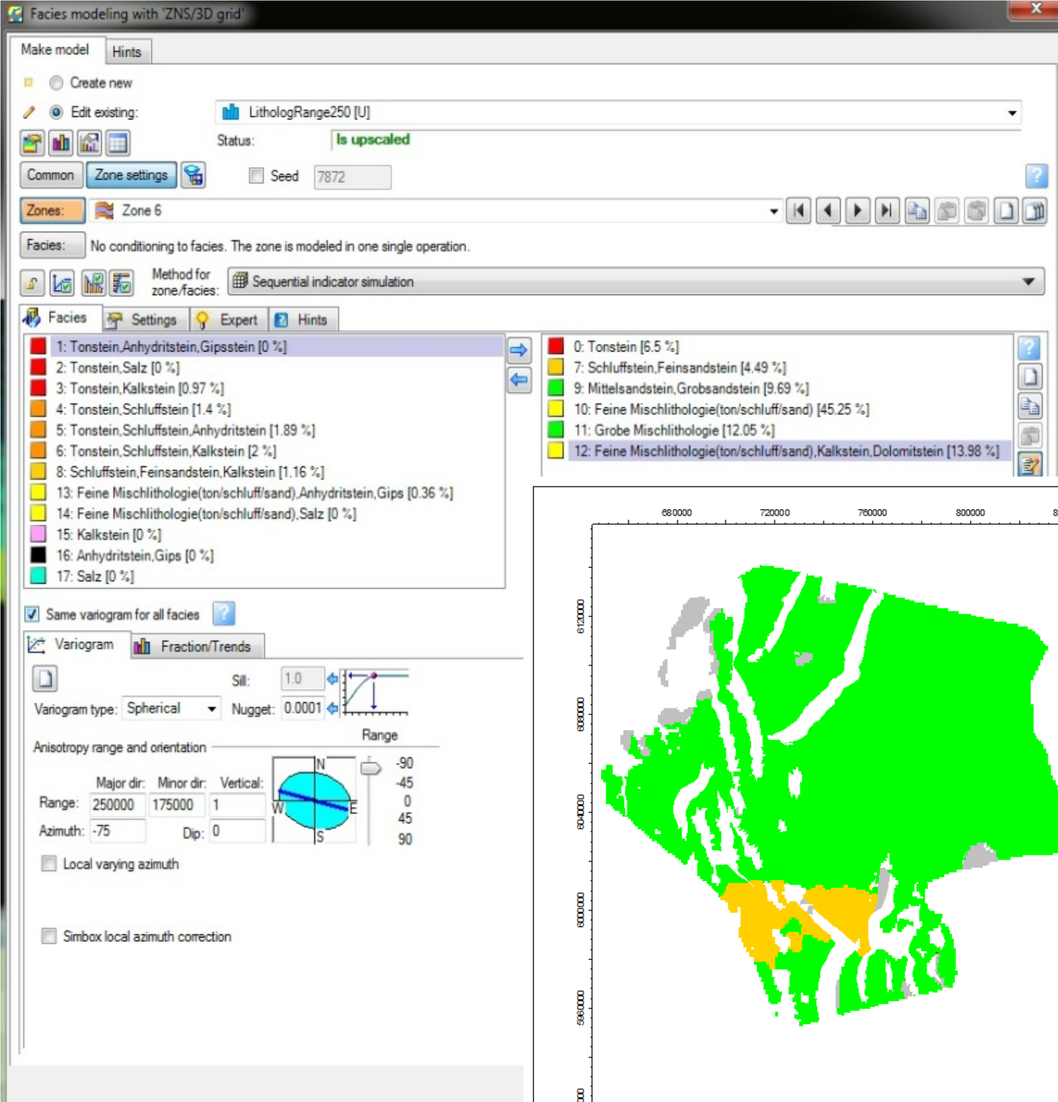
Statistics: SIS algorithm

borehole radius: 250 km





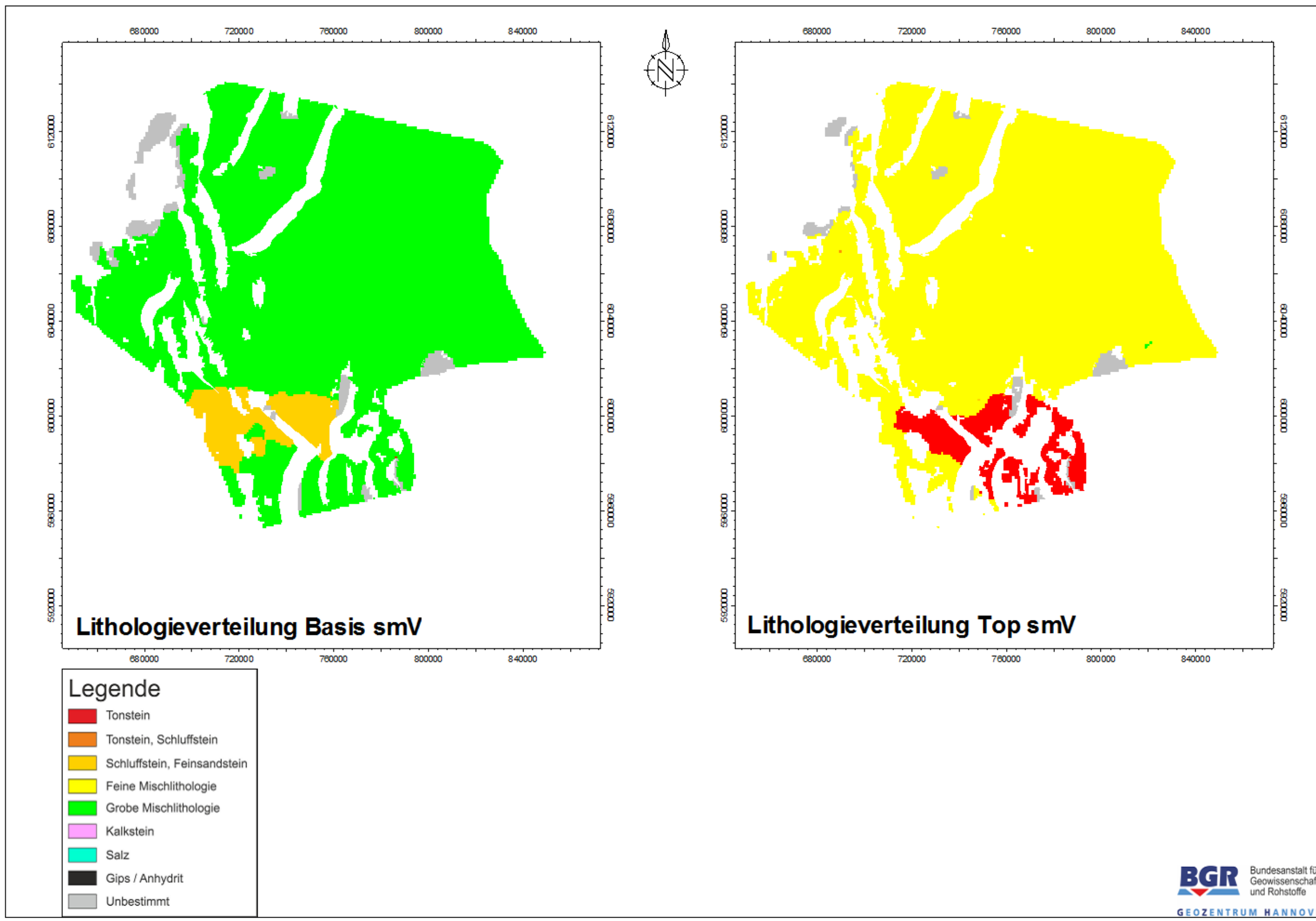
Areas with randomly filled properties



Solution:

=> Manual correction

=> Grouping of colors in the template



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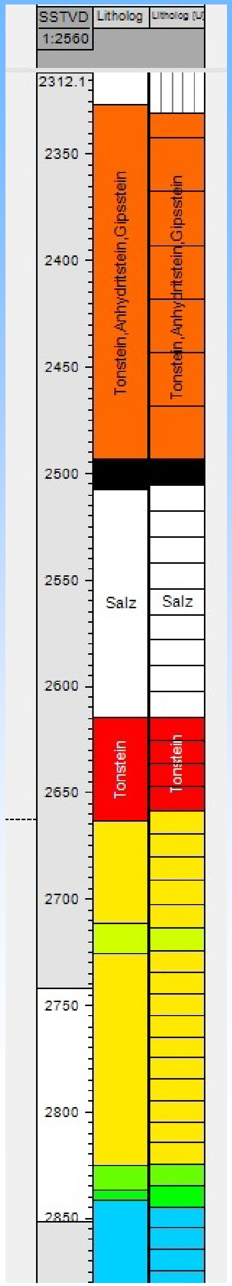
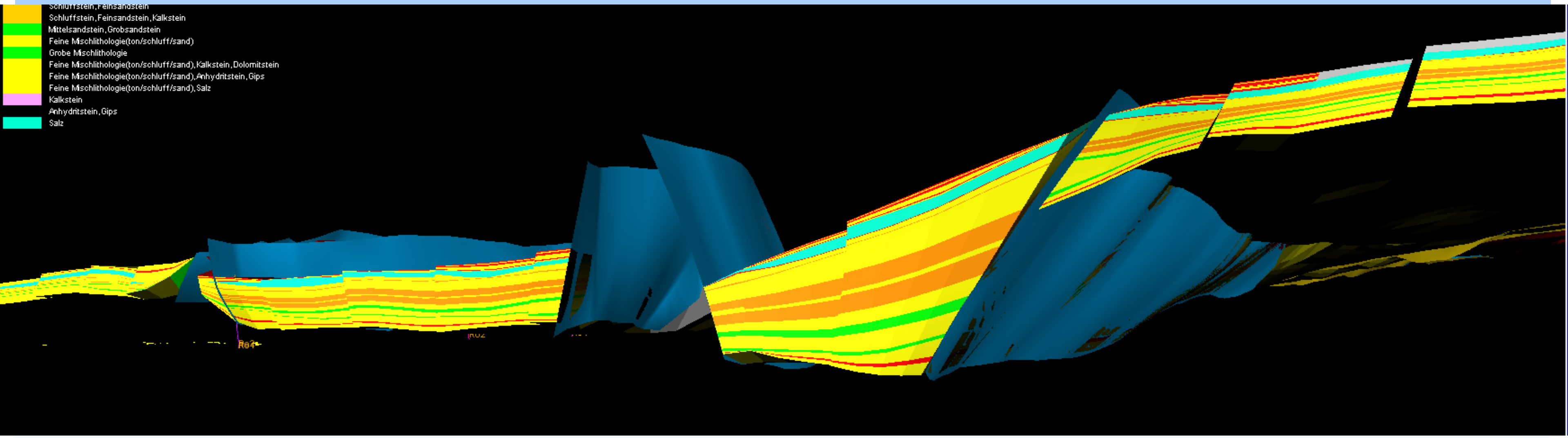
Generalisation by upscaling



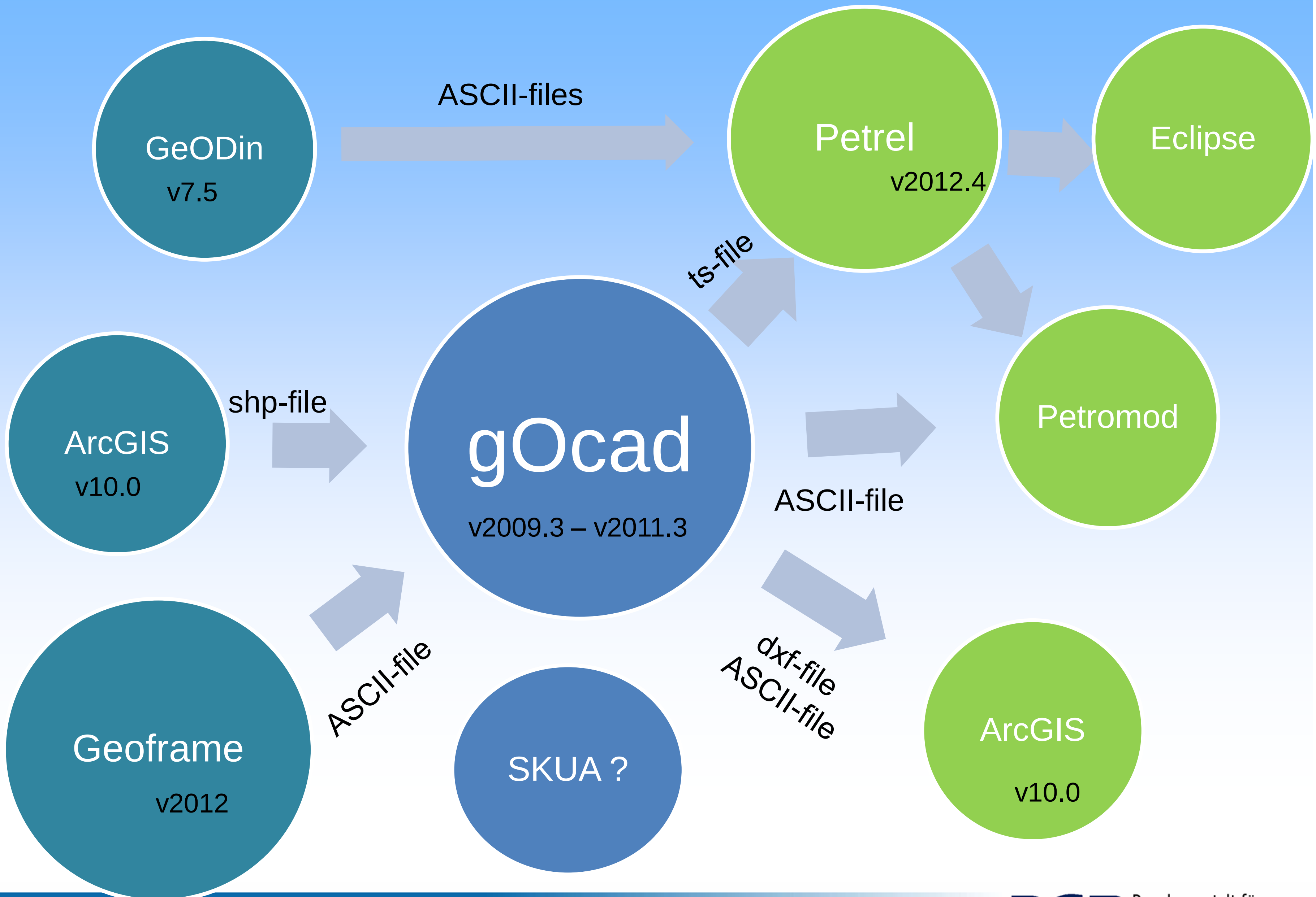
Classification of lithologies

=> What‘s the necessary grade of detail ?

Facies model ready to use for dynamic modelling



One model – different software solutions



Summary – Open Questions - Discussion

Modelling of salt structures in GOCAD and Petrel
-> consequences for gridding process

Automatisation of well parameters / lithological descriptions
-> Grade of detail / databases

Software issues
-> which software to use / best workflow ?