

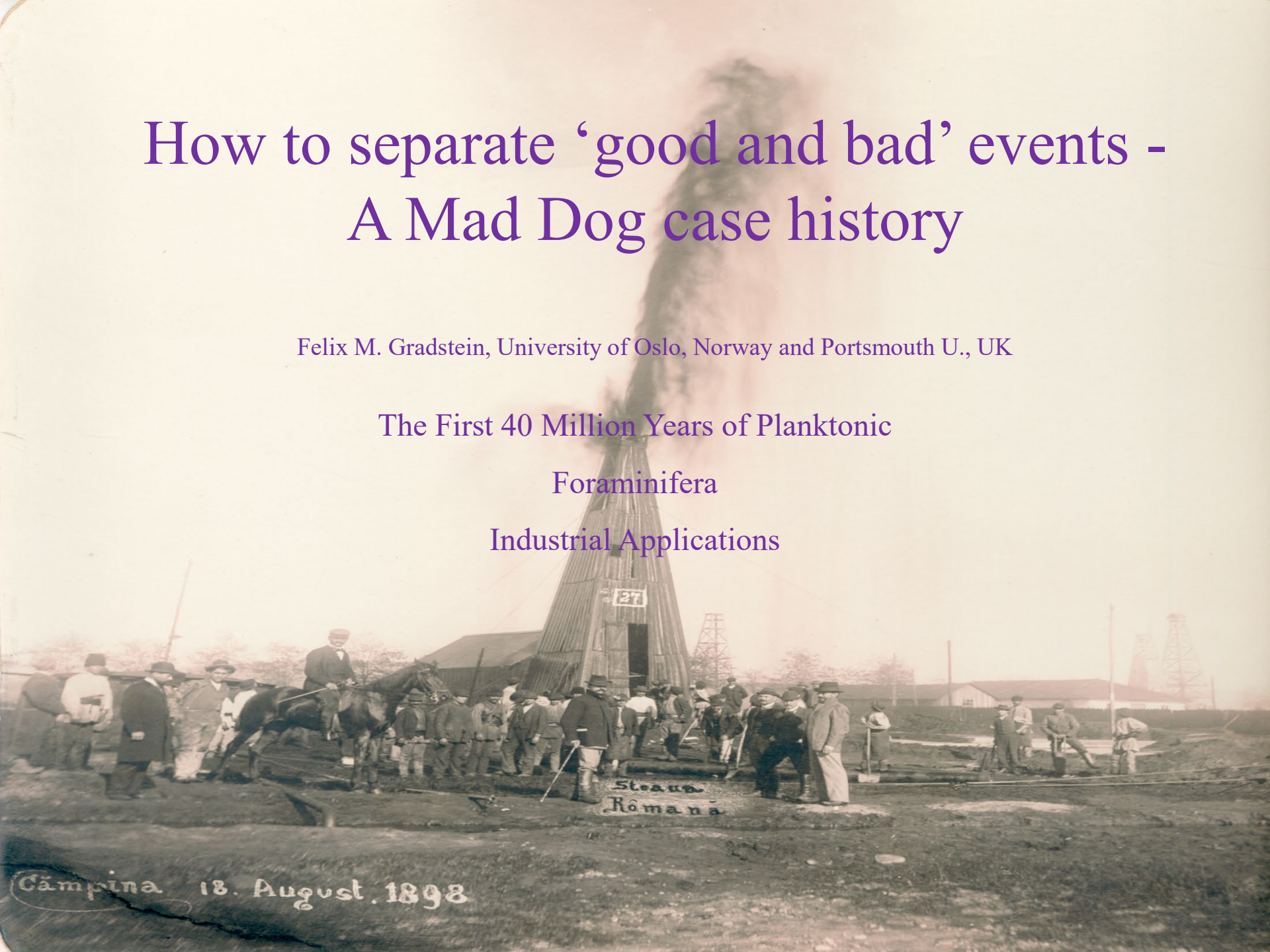
How to separate ‘good and bad’ events - A Mad Dog case history

Felix M. Gradstein, University of Oslo, Norway and Portsmouth U., UK

The First 40 Million Years of Planktonic

Foraminifera

Industrial Applications



Steaua
Romana

Cămpina 18. August 1898

Mad Dog (GOM) Miocene prospects below Jurassic evaporites

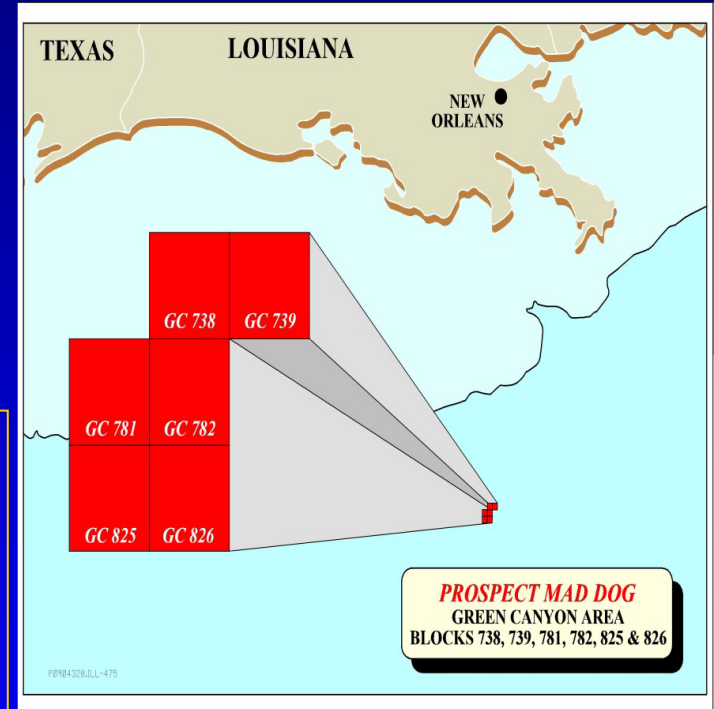


1500 – 2000m WD; 5 billion barrels OE

Deep water drilling

Ultra deep wells (> 9 km)

**Poor seismic resolution to identify
turbidite fairways
Identify sand prone strat levels
with microfossils**



Garry Jones †

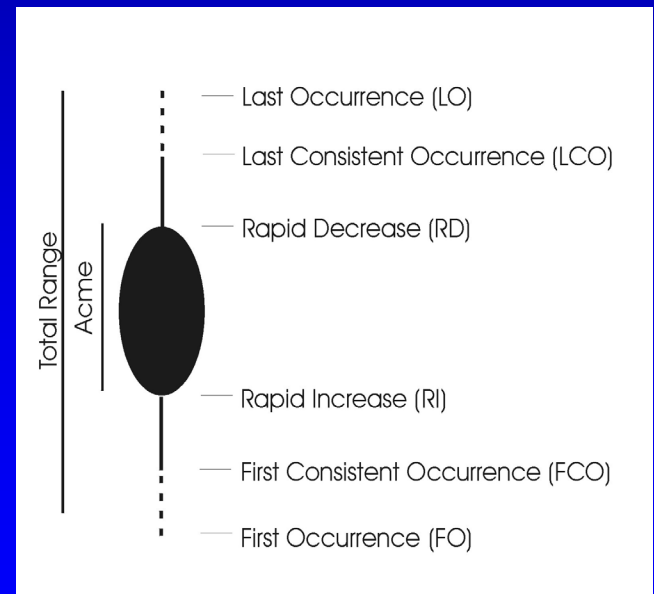


Mardi Gras 1993

Data

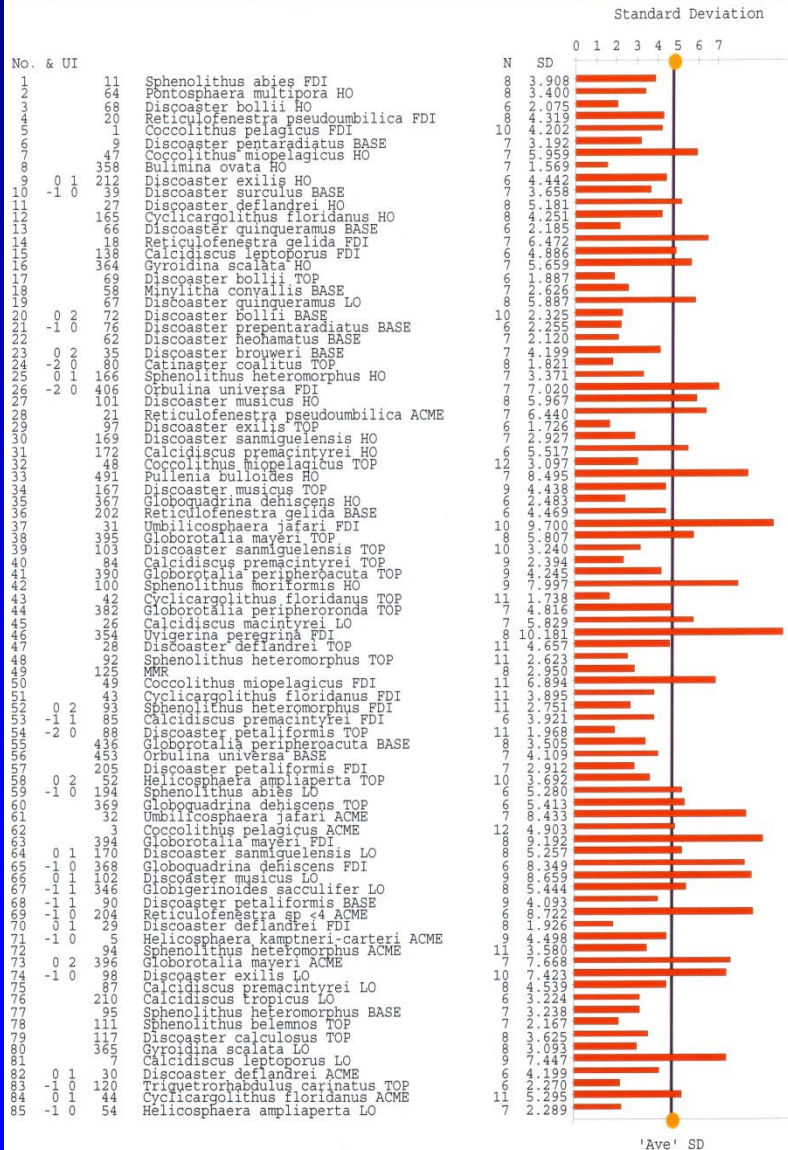
1600+ Miocene nannofossil and foraminifer occurrences in 13 wells

LO (top)
LCO
Acme
FCO
FO

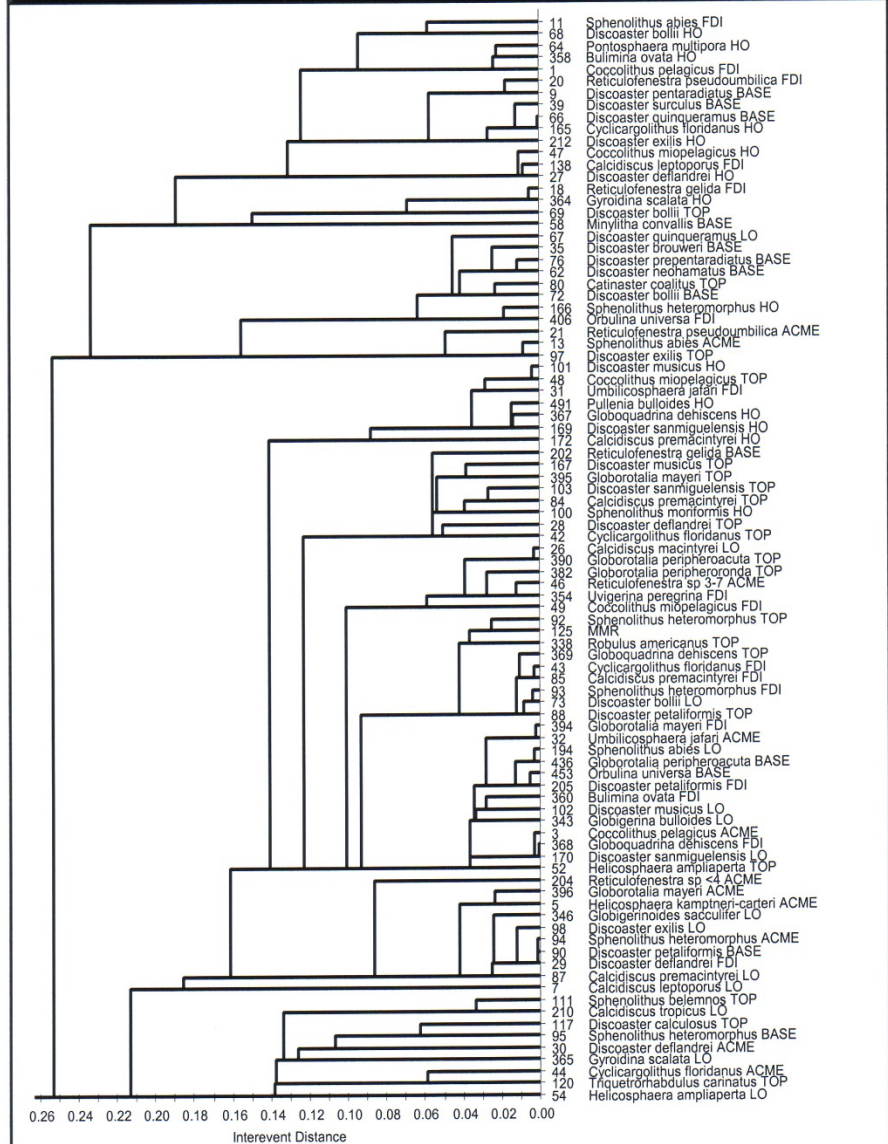


Mad Dog Miocene Optimum Sequence and Zonation

Ranked Optimum Sequence (GOM 20 jan 2004), 13 wells, 1641 records
events 13,46,73,338,343,360 with max variance deleted; 95 cycles



Dendrogram for Scaled Optimum Sequence (GOM 20 jan 2004) in 13 wells
1641 records minus highest variance events 13,46,73,338,343,360; 88 cycles



GOM – Foraminifera and Nannofossil Events

RASC Optimum Sequence

Ranked Optimum Sequence (GOM 20 jan 2004) in 13 wells
1688 records, 153 cycles, 60 out of 90 opt seq events sd < av sd

Lower – Middle Miocene

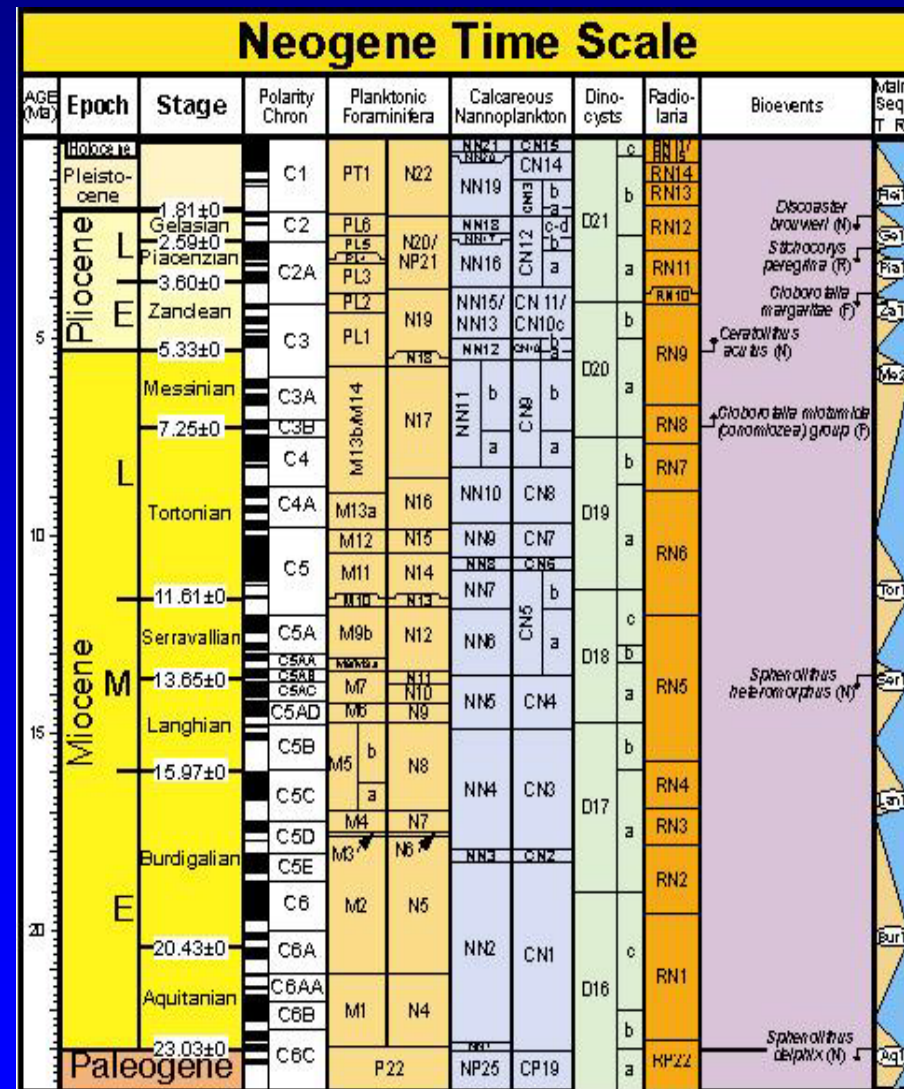
Predicts order of events in next well to be drilled!

MM65	C. FLORIDANUS		13.19
MM68	C. FLORIDANUS INCREASE		13.30
MM70	S. HETEROMORPHUS		13.59
MM80	G. FOHSI PERIPHERORONDA		14.61
MM90	D. PETALIFORMIS		14.69
MM94	RARE, SMALL H. AMPLIAPERTA		14.74
MM98	RARE, SMALL H. AMPLIAPERTA INCREASE		14.78
MM100	H. AMPLIAPERTA		14.80
MM103	VERY LARGE H. AMPLIAPERTA		14.90
MM105	GLOB. KUGLERI		14.94
MM120	D. DELANDREI ACME	CIB. 58	15.76
Middle / Early Miocene Boundary			
ME10		ROB. MAYER	17.31
ME15		ROB CHAMBERS	17.28
ME19	NANNOS INCR. W/ RETICULO. SPP.		18.60
ME20	S. BELENNOS		18.71
ME23	H. MEDITERRANEA		18.75
ME40		DISCORBIS B	18.92
ME50	D. CALCULOSUS	MARG. A	19.35
ME55	S. DISSIMILIS		19.78
ME59	D. SAUNDERSI		20.15
ME60		SIPH. DAVISI	20.21
ME61	T. CARINATUS		20.25
ME70		PLAN. PALM.	20.43
ME80		LENTIC. HAN.	20.86
ME81	S. CAPRICORNUTUS		20.91
ME90	C. ABISECTUS INCREASE	LENTIC. JEFF.	21.07
ME100	GLOB. KUGLERI	ABBEVILLE FAUNA	21.68
ME110		DISC. RESTRICTED / ROB. A	22.01
	H. RECTA / S. DISSIMILIS ACME / REWK		
ME120	K NANNOS ACME	D. GRAVELLI/GYR. HANNAI	22.52
ME130	T. CARINATUS ACME	HET SP/CIB. JEFF.	22.9
ME 140	S. DELPHIX	BOL. PERC.	23.2



Astronomically Tuned Neogene Time Scale 2004 Applied to GOM

Langhian - Serravallian		13.654 Ma	
<i>top Sphenolithus heteromorphus</i>	CN4-CN5a, NN5-NN6, MNN5b-MNN6	13.53	
<i>top Helicosphaera ampliaperta</i>	CN3-CN4, NN4-NN5	14.91	
<i>top abundant Discoaster deflandrei</i>		15.80	
Burdigalian – Langhian		15.974 Ma	
<i>bottom (common) Sphenolithus heteromorphus</i>		17.71	
<i>top (common) Sphenolithus belemnus</i>	CN2-CN3, NN3-NN4	17.95	
<i>top Triquetrorhabdulus carinatus</i>	CN1-CN2, NN2-NN3	18.28	
<i>bottom Sphenolithus belemnus</i>		19.03	
Aquitanian – Burdigalian		20.428 Ma	
<i>bottom Helicopontosphaera ampliaperta</i>		20.43	
<i>bottom common Helicosphaera carteri</i>		22.03	
<i>bottom Sphenolithus disbelemnus</i>		22.76	
<i>bottom Discoaster druggi</i>	NN1-NN2		
OLIGOCENE - MIOCENE / Chattian – Aquitanian		23.030 Ma	
<i>top Sphenolithus delphix</i>		23.11	
<i>bottom Sphenolithus delphix</i>		23.21	



The RASC and CONOP methods yield results that complement each other

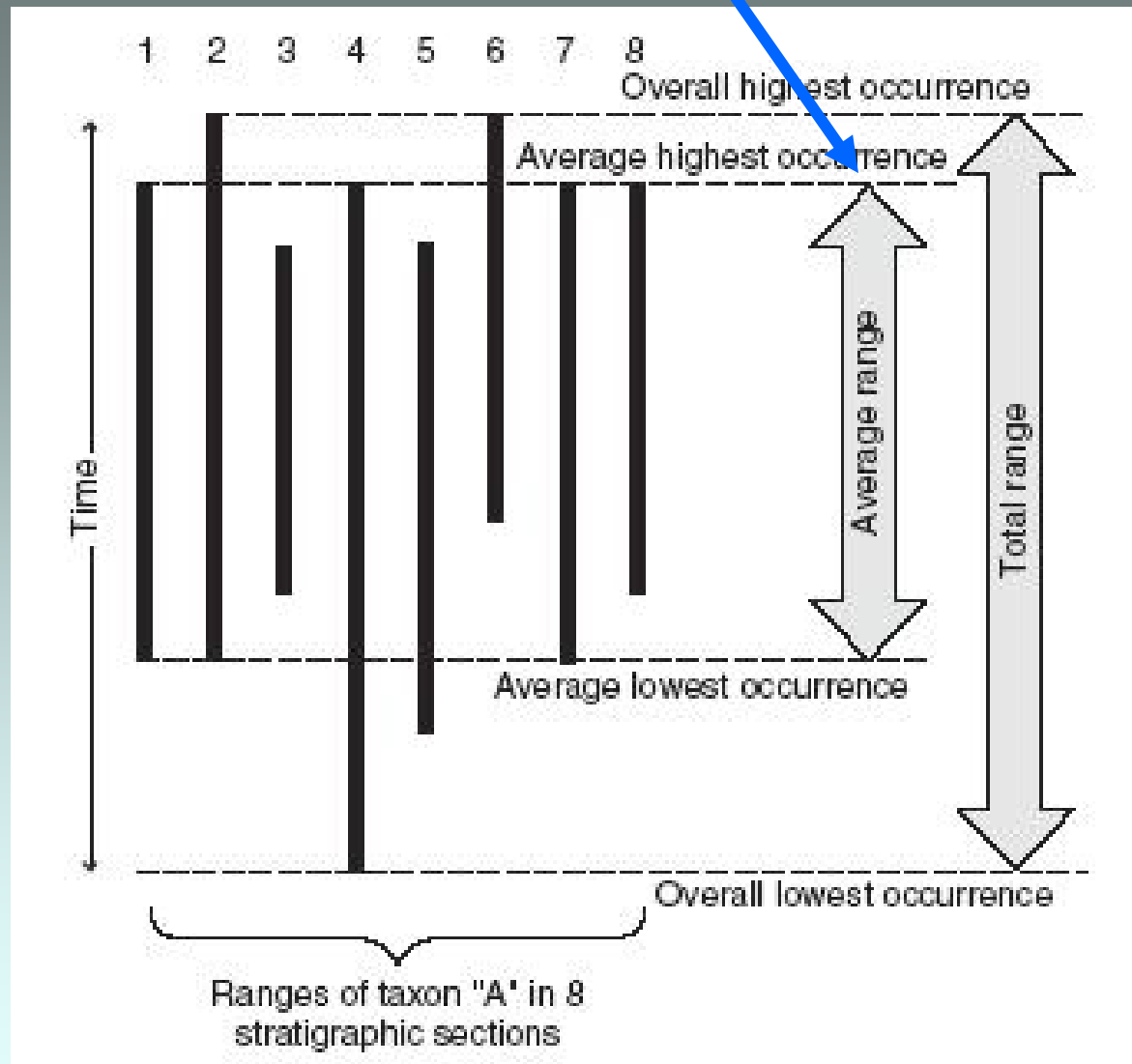
RASC - Optimum sequence of events with event variances

CONOP - Composite standard with penalty (misfit) of events

CONOP allows three strategies:

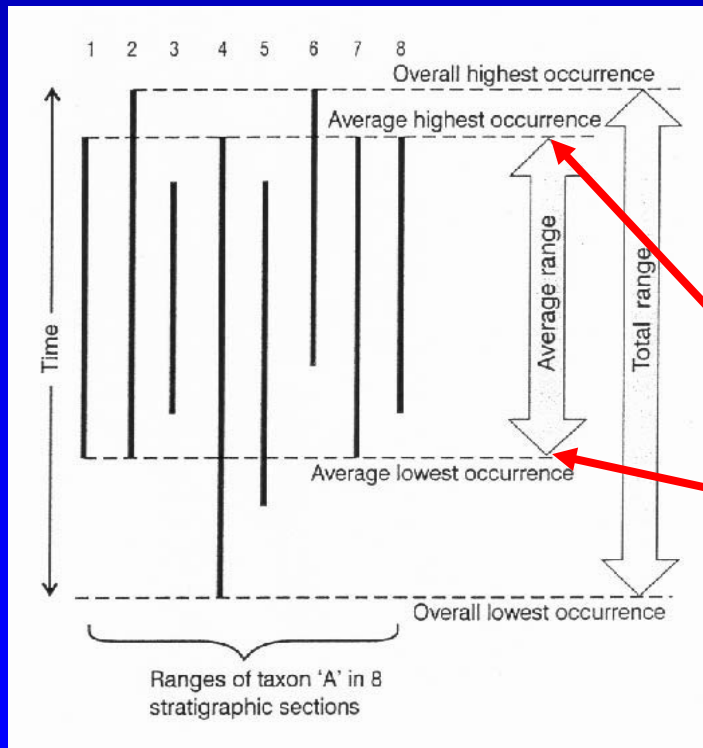
- 1. Event positions in the composite are unconstrained
and can move either up or down, not unlike RASC**
- 2. Event positions in the composite are maximized,
= stratigraphically upwards (for tops) or downwards (for bases)**
- 3. Event positions do not move (= Unique Events in RASC)**

RASC generates average tops and average bases



The average 'top' may seem 'non-biological',
but it certainly has attractive stratigraphic properties.

RUN 1 of RASC and CONOP



RUN 1
Ranking and Scaling
+
Unconstrained Optimization

Correlation of Run 1 Optimum Sequences with RASC and CONOP

RASC

Standard Deviation

0 1 2 3 4 5 6 7

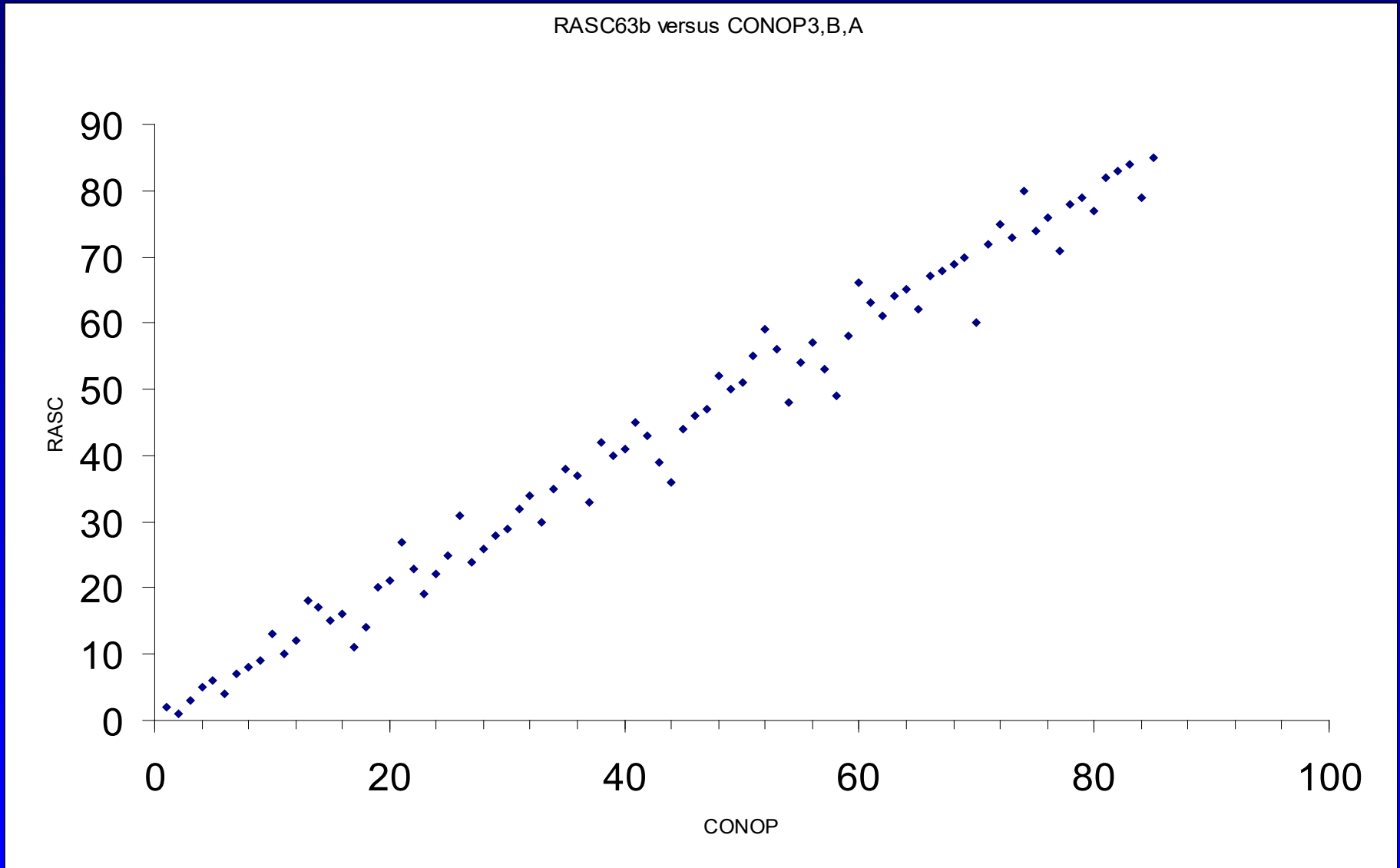
Sphenolithus abies FDI
Pontosphaera multipora HO
Discoaster bollii HO
Reticulofenestra pseudoumbilica FDI
Coccolithus pelagicus FDI
Discoaster pentaradiatus BASE
Coccolithus miopelagicus HO
Bulimina ovata HO
Discoaster exilis HO
Discoaster surculus BASE
Discoaster deflandrei HO
Cyclacargolithus floridanus HO
Discoaster quinquaramus BASE
Reticulofenestra gelida FDI
Calcidiscus leptoporus FDI
Gyrodina scalata HO
Discoaster bollii TOP
Minylitha convallis BASE
Discoaster quinquaramus LO
Discoaster bollii BASE
Discoaster prentaradiatus BASE
Discoaster neohamatus BASE
Discoaster brouweri BASE
Catinaster coalitus TOP
Sphenolithus heteromorphus HO
Orbulina universa FDI
Discoaster musicus HO
Reticulofenestra pseudoumbilica ACME
Discoaster exilis TOP
Discoaster sanmiguelensis HO
Calcidiscus premacintyreii HO
Coccolithus miopelagicus TOP
Fullenia bulloides HO
Discoaster musicus TOP
Globobulimina dehiscens HO
Reticulofenestra gelida BASE
Umbilicosphaera jafari FDI
Globorotalia mayeri TOP
Discoaster sanmiguelensis TOP
Calcidiscus premacintyreii TOP
Globorotalia peripheroacuta TOP
Sphenolithus moriformis HO
Cyclacargolithus floridanus TOP
Globorotalia peripheroronda TOP
Calcidiscus macintyreii LO
Uvigerina peregrina FDI
Discoaster deflandrei TOP
Sphenolithus heteromorphus TOP
MMR
Coccolithus miopelagicus FDI
Cyclacargolithus floridanus FDI
Sphenolithus heteromorphus FDI
Calcidiscus premacintyreii FDI
Discoaster petaliformis TOP
Globorotalia peripheroacuta BASE
Orbulina universa BASE
Discoaster petaliformis FDI
Helicosphaera ampliata TOP
Sphenolithus abies LO
Globobulimina dehiscens TOP
Umbilicosphaera jafari ACME
Coccolithus pelagicus ACME
Globorotalia mayeri FDI
Discoaster sanmiguelensis LO
Globobulimina dehiscens FDI
Discoaster musicus LO
Globigerinoides sacculifer LO
Discoaster petaliformis ACME
Reticulofenestra sp. ACME
Discoaster deflandrei FDI
Helicosphaera kamptneri-carteri ACME
Sphenolithus heteromorphus ACME
Globorotalia mayeri ACME
Discoaster exilis LO
Calcidiscus premacintyreii LO
Calcidiscus tropicus LO
Sphenolithus heteromorphus BASE
Sphenolithus belemnos TOP
Discoaster caliculosus TOP
Gyrodina scalata HO
Calcidiscus leptoporus LO
Discoaster deflandrei ACME
Triquetrabululus carinatus TOP
Cyclacargolithus floridanus ACME
Helicosphaera ampliata LO

CONOP

Sphenolithus abies FDI BOB
Pontosphaera multipora HO BOB
Discoaster bollii HO BOB
Reticulofenestra pseudoumbilica FDI BOB
Coccolithus pelagicus FDI BOB
Discoaster exilis HO BOB
Coccolithus miopelagicus HO BOB
Bulimina ovata HO BOB
Calcidiscus leptoporus FDI BOB
Cyclacargolithus floridanus HO BOB
Discoaster surculus BASE BOB
Discoaster pentaradiatus BASE BOB
Discoaster quinquaramus BASE BOB
Discoaster deflandrei HO BOB
Discoaster quinquaramus LO BOB
Reticulofenestra gelida FDI BOB
Gyrodina scalata HO BOB
Orbulina universa FDI BOB
Fullenia bulloides HO BOB
Umbilicosphaera jafari FDI BOB
Discoaster bollii TOP BOB
Minylitha convallis BASE BOB
Catinaster coalitus TOP BOB
Discoaster prentaradiatus BASE BOB
Discoaster neohamatus BASE BOB
Sphenolithus heteromorphus HO BOB
Discoaster bollii BASE BOB
Discoaster brouweri BASE BOB
Discoaster exilis TOP BOB
Discoaster musicus HO BOB
Discoaster sanmiguelensis HO BOB
Reticulofenestra pseudoumbilica ACME BOB
Calcidiscus premacintyreii HO BOB
Coccolithus miopelagicus TOP BOB
Globobulimina dehiscens HO BOB
Discoaster musicus TOP BOB
Reticulofenestra gelida BASE BOB
Globorotalia mayeri TOP BOB
Discoaster deflandrei TOP BOB
Discoaster sanmiguelensis TOP BOB
Calcidiscus premacintyreii TOP BOB
Sphenolithus moriformis HO BOB
Uvigerina peregrina FDI BOB
Cyclacargolithus floridanus TOP BOB
Globorotalia peripheroacuta TOP BOB
Globorotalia peripheroronda TOP BOB
Coccolithus miopelagicus FDI BOB
MMR
Sphenolithus heteromorphus TOP BOB
Cyclacargolithus floridanus FDI BOB
Orbulina universa BASE BOB
Calcidiscus macintyreii LO BOB
Sphenolithus heteromorphus FDI BOB
Discoaster petaliformis TOP BOB
Discoaster petaliformis FDI BOB
Calcidiscus premacintyreii FDI BOB
Helicosphaera ampliata TOP BOB
Globobulimina dehiscens TOP BOB
Coccolithus pelagicus ACME BOB
Globorotalia peripheroacuta BASE BOB
Umbilicosphaera jafari ACME BOB
Sphenolithus abies LO BOB
Globobulimina dehiscens FDI BOB
Globorotalia mayeri FDI BOB
Discoaster sanmiguelensis LO BOB
Globigerinoides sacculifer LO BOB
Discoaster musicus LO BOB
Helicosphaera kamptneri-carteri ACME BOB
Reticulofenestra sp. ACME BOB
Sphenolithus heteromorphus ACME BOB
Discoaster deflandrei FDI BOB
Discoaster petaliformis BASE BOB
Globorotalia mayeri ACME BOB
Discoaster exilis LO BOB
Calcidiscus premacintyreii LO BOB
Calcidiscus leptoporus LO BOB
Calcidiscus tropicus LO BOB
Discoaster deflandrei ACME BOB
Sphenolithus belemnos TOP BOB
Discoaster caliculosus TOP BOB
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Gyrodina scalata LO BOB
Triquetrabululus carinatus TOP BOB
Helicosphaera ampliata LO BOB
Cyclacargolithus floridanus ACME BOB

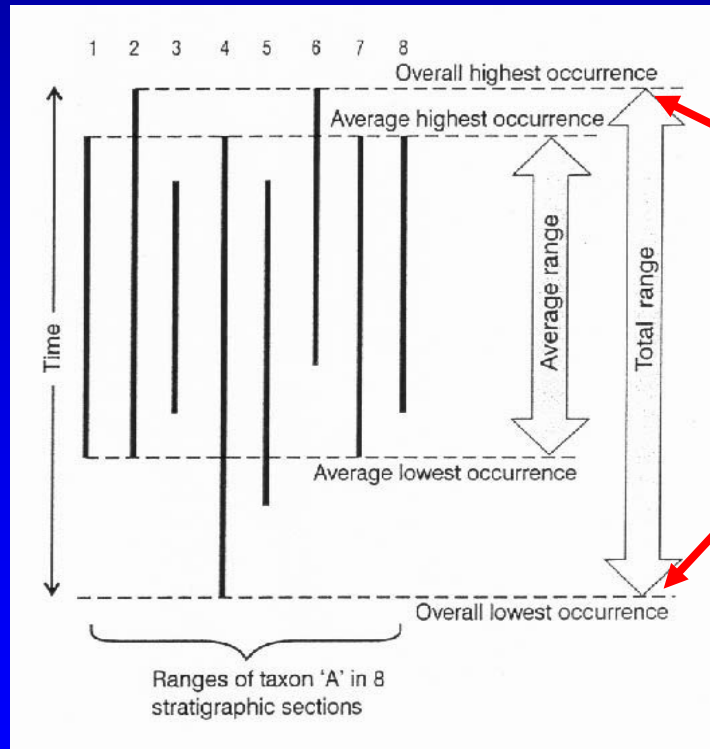
'Ave' SD

Run 1 - Average Stratigraphic Positions of Events



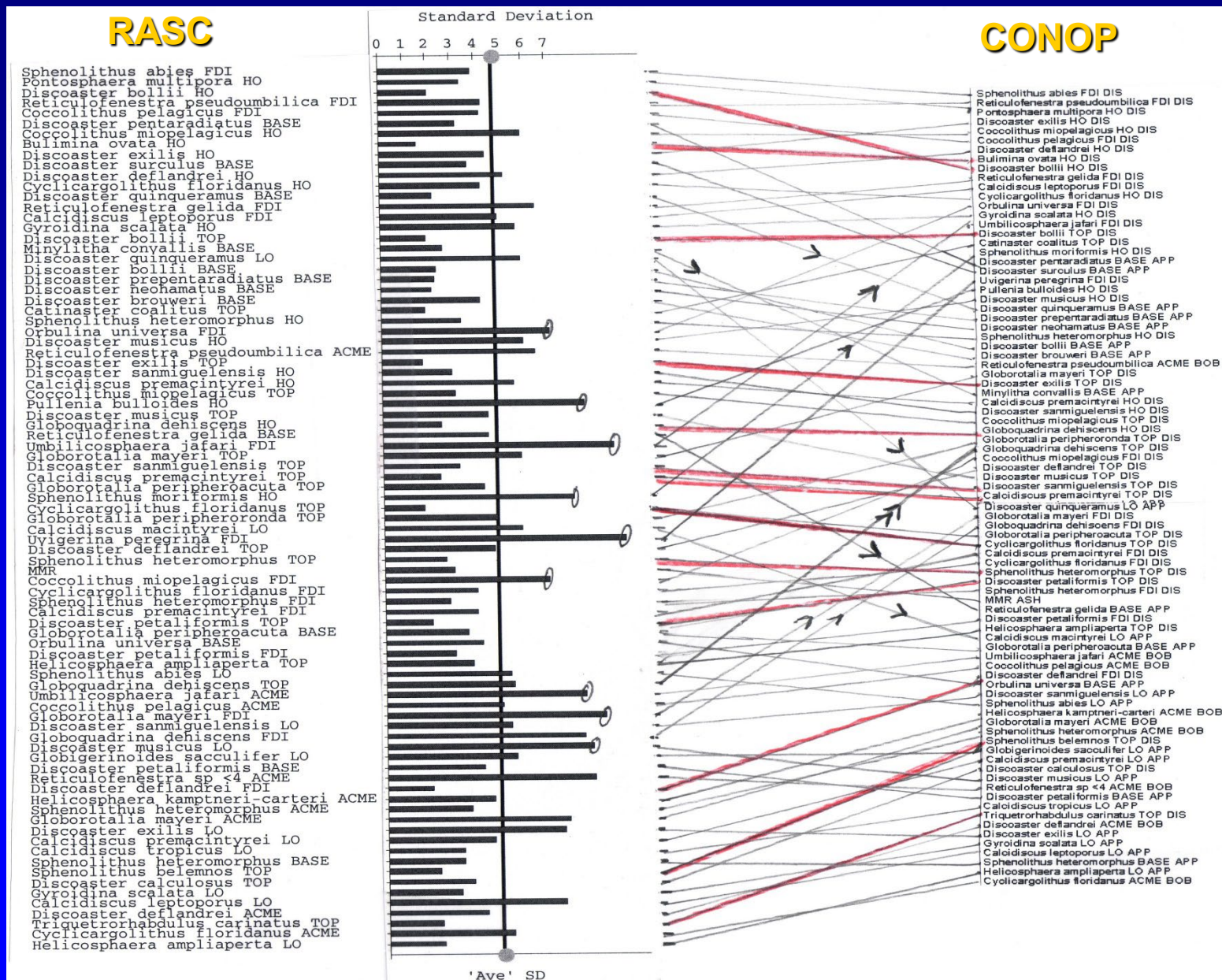
Zonal convergence of RASC and CONOP

RUN 2 of RASC and CONOP



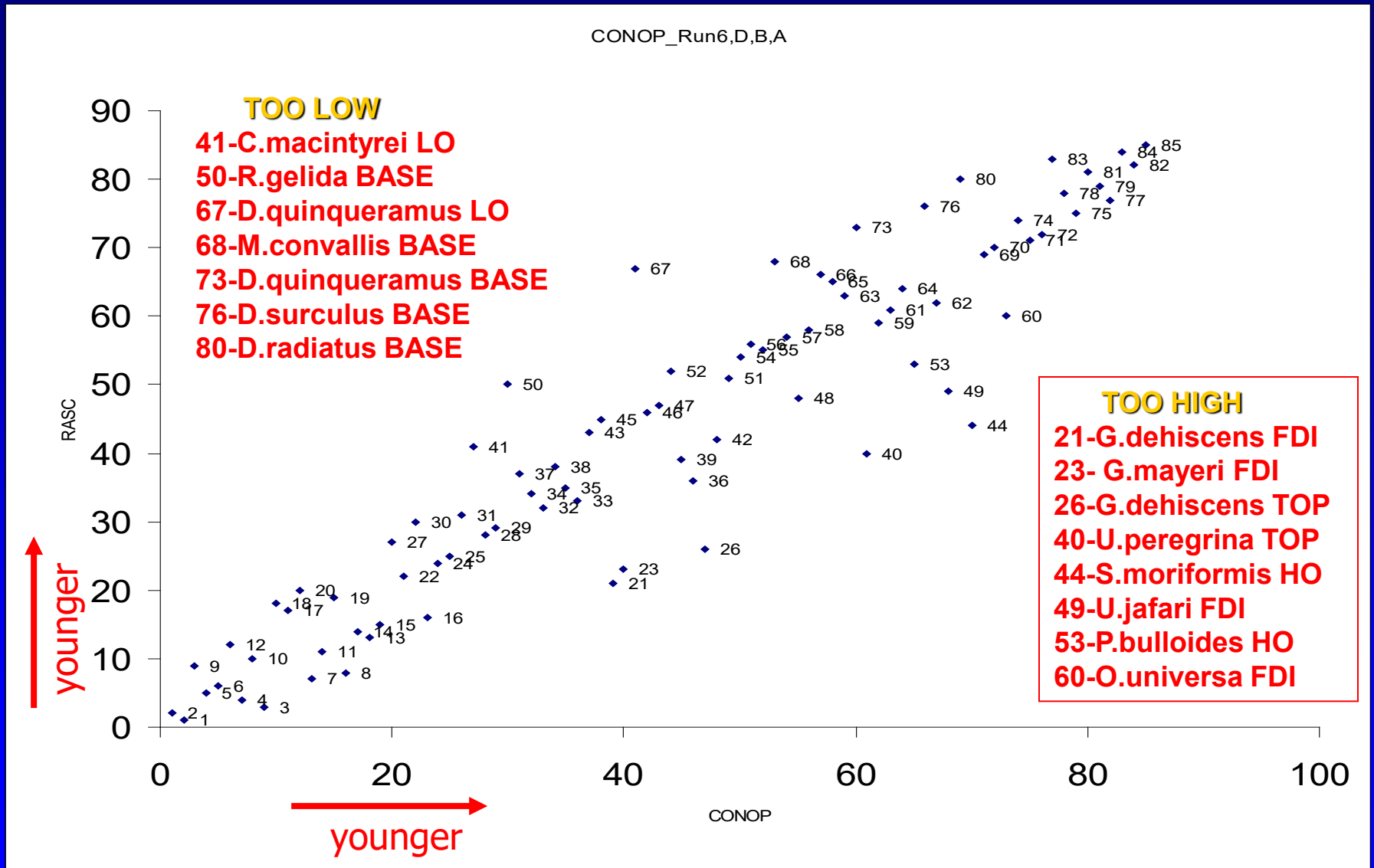
RUN 2
Constrained Optimization
+
Ranking and Scaling as Run1

Correlation of RUN 2 Optimum Sequences with RASC and CONOP



Run 2 Average Event Occurrences with RASC

Overall Lowest or Highest Occurrences with CONOP



Conclusions

Neogene Gulf of Mexico

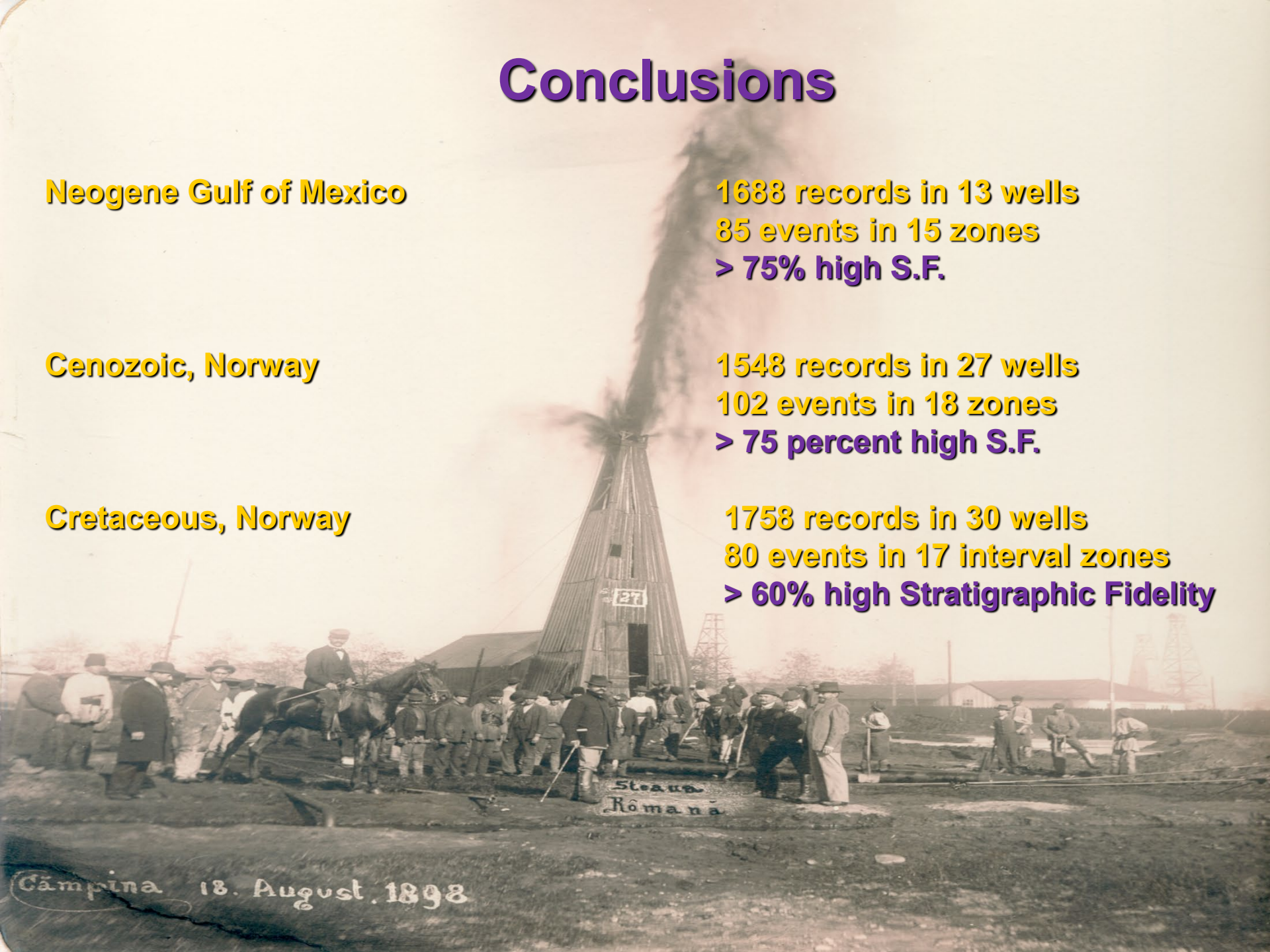
1688 records in 13 wells
85 events in 15 zones
> 75% high S.F.

Cenozoic, Norway

1548 records in 27 wells
102 events in 18 zones
> 75 percent high S.F.

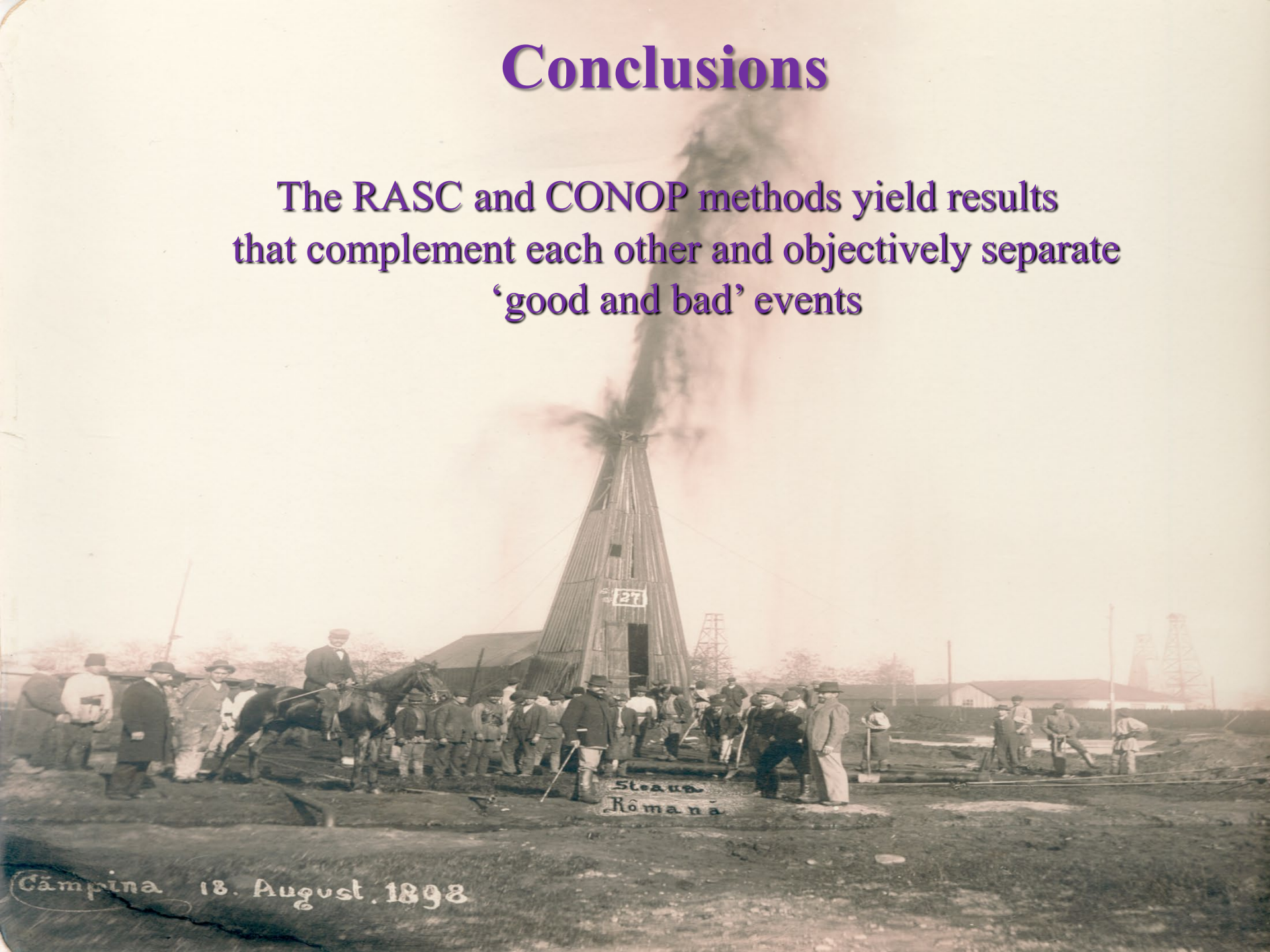
Cretaceous, Norway

1758 records in 30 wells
80 events in 17 interval zones
> 60% high Stratigraphic Fidelity



Conclusions

The RASC and CONOP methods yield results that complement each other and objectively separate 'good and bad' events



Stația
Română

Cămpina 18. August. 1898

