Geophysical Institute
University of Karlsruhe

Common-Reflection-Surface Stack

Jürgen Mann, Steffen Bergler, and Peter Hubral*

SEG San Antonio 2001

Overview

- Introduction
- 2-D examples
- Applications of the CRS attributes
  - stacking velocity
  - true amplitude analysis
  - model independent time migration
- Conclusions

Can there be
anything better than

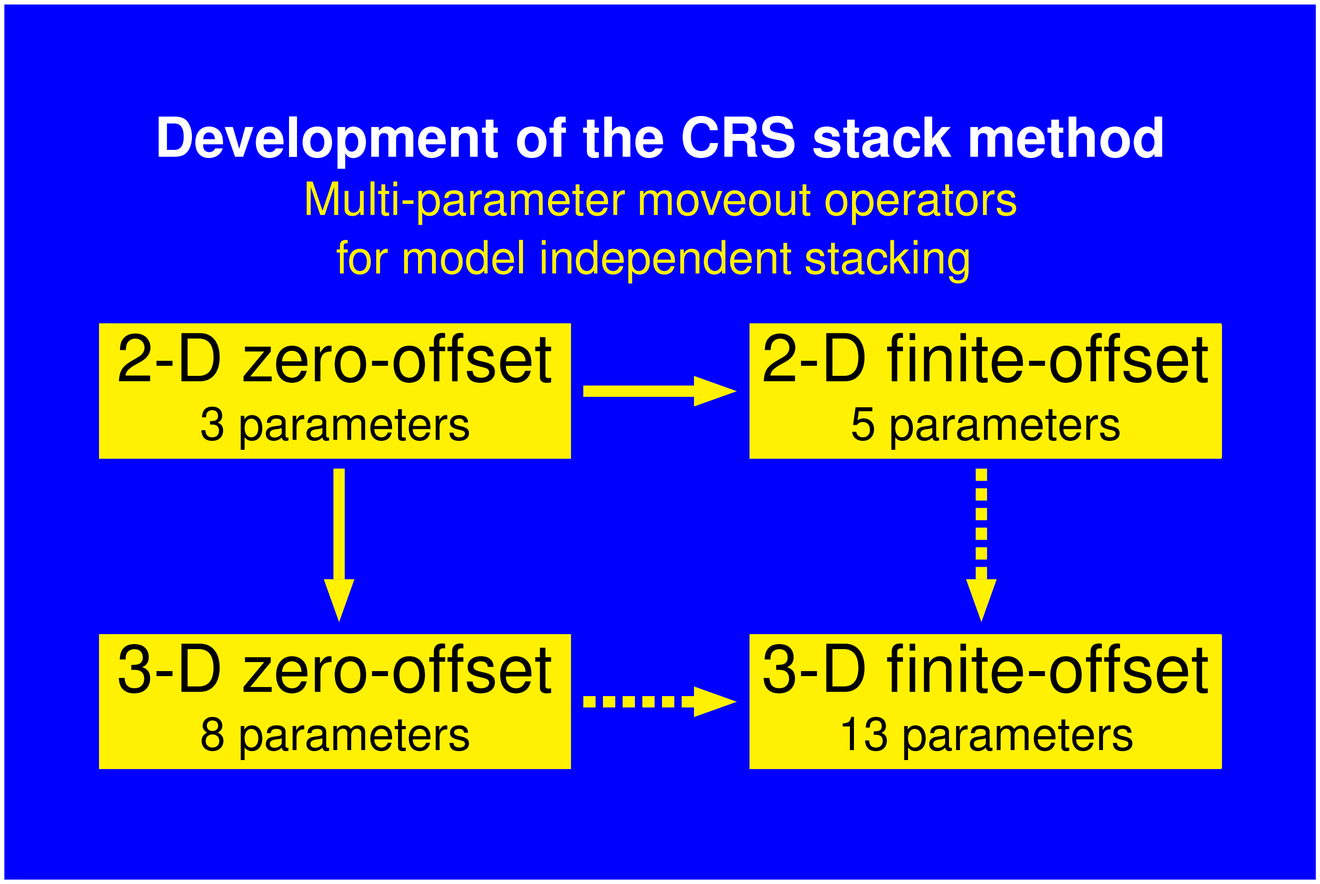
Pre-stack depth migration

or

NMO/DMO/Stack ?

Overview

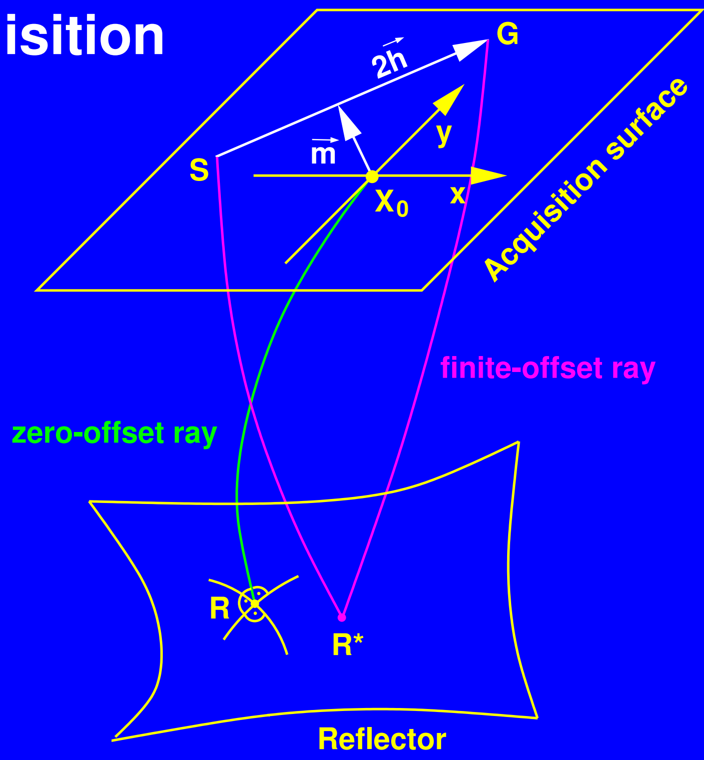
- Introduction
- 2-D examples
- Applications of the CRS attributes
  - stacking velocity
  - true amplitude analysis
  - model independent time migration
- Conclusions


Development of the CRS stack method
Multi-parameter moveout operators
for model independent stacking
2-D zero-offset
3 parameters
2-D finite-offset
5 parameters
3-D zero-offset
8 parameters
3-D finite-offset
13 parameters

Arbitrary acquisition configuration

$$\vec{h} = \frac{1}{2}\begin{pmatrix} x_G - x_S \\ y_G - y_S \end{pmatrix}$$

$$\vec{m} = \frac{1}{2}\begin{pmatrix} x_G + x_S \\ y_G + y_S \end{pmatrix}$$



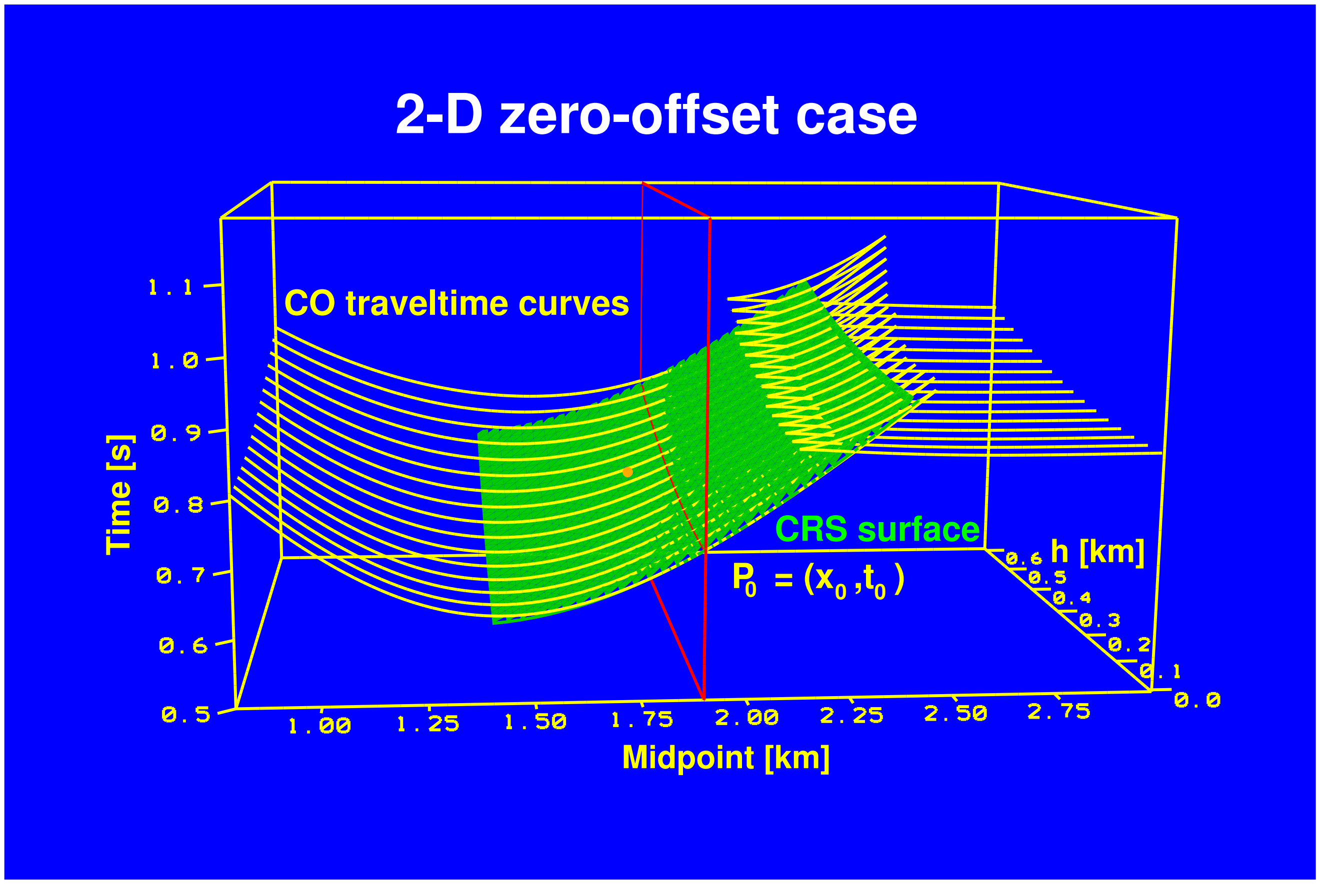
CRS stacking operators for zero-offset

3-D case:

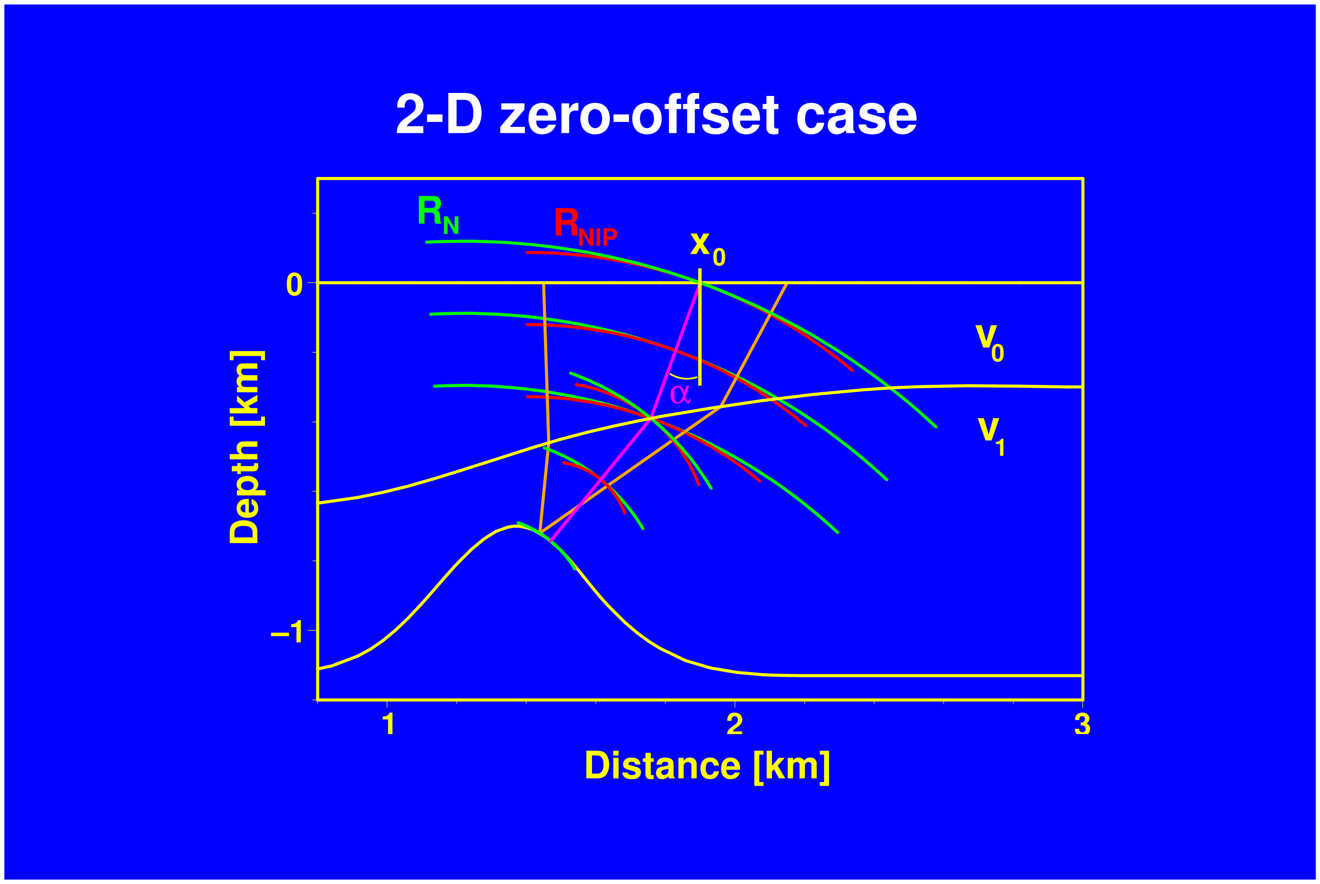
$$t_{hyp}^2 = \left(t_0 - \frac{2}{v_0}\vec{c}\cdot\vec{m}\right)^2 + \frac{2t_0}{v_0}\left(\vec{m}^T \underline{A}\,\vec{m} + \vec{h}^T \underline{B}\,\vec{h}\right)$$

2-D case:

$$t_{hyp}^2 = \left(t_0 - \frac{2\sin\alpha}{v_0} m\right)^2 + \frac{2t_0\cos^2\alpha}{v_0}\left(\frac{m^2}{R_N} + \frac{h^2}{R_{NIP}}\right)$$

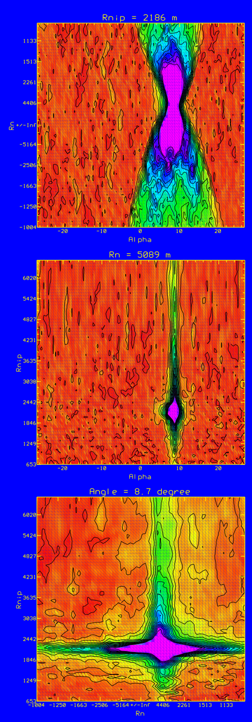


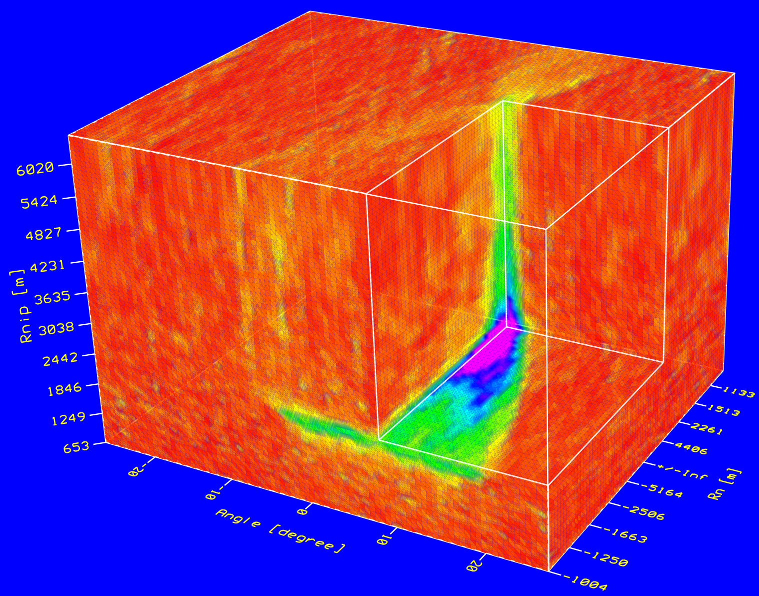
2-D zero-offset case
CO traveltime curves
CRS surface
$P_0 = (x_0, t_0)$
Time [s]
Midpoint [km]
h [km]
1.1
1.0
0.9
0.8
0.7
0.6
0.5
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
0.6
0.5
0.4
0.3
0.2
0.1
0.0



2-D zero-offset case
R_N
R_{NIP}
x_0
0
v_0
α
v_1
Depth [km]
–1
1
2
3
Distance [km]

Coherence in the attribute domain

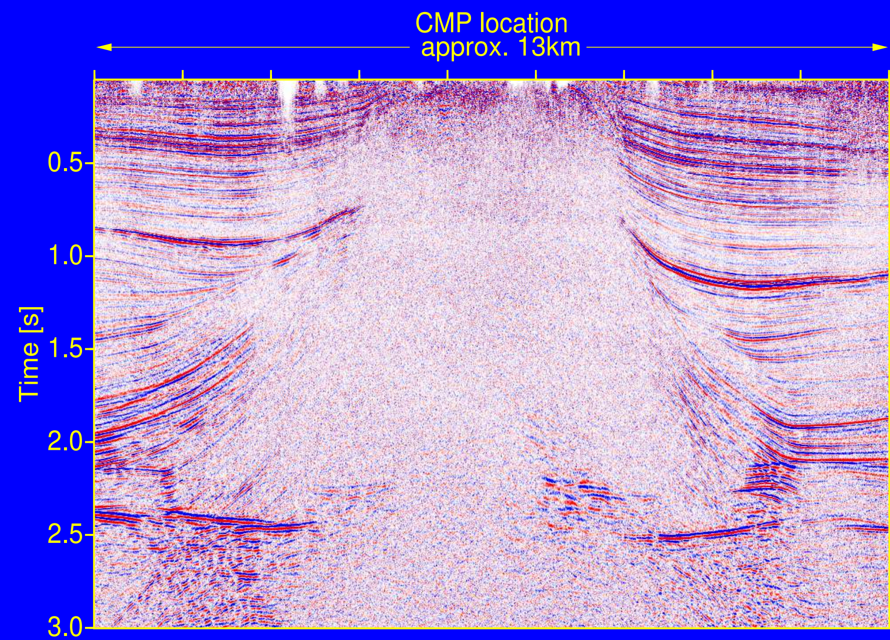




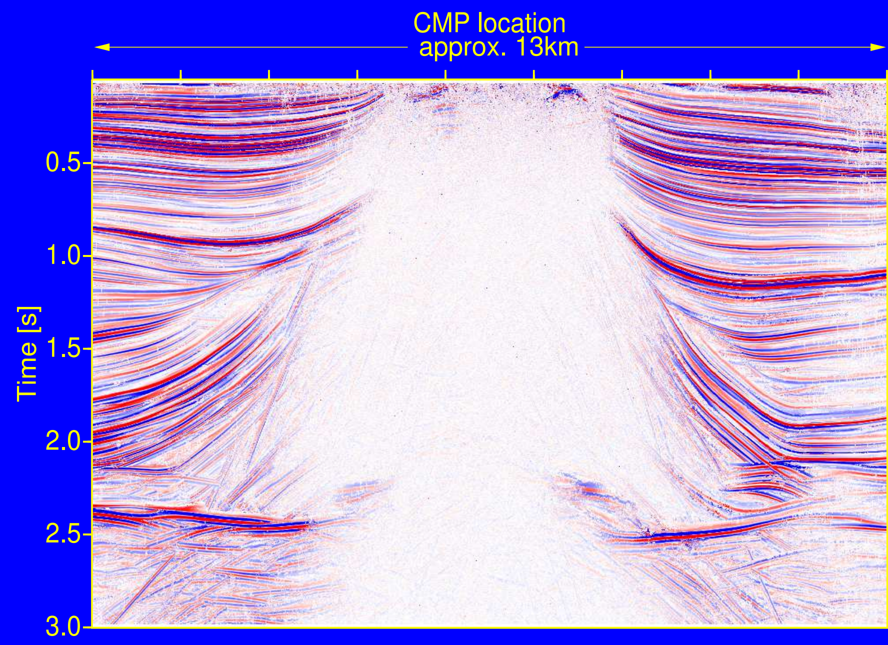
Overview

- Introduction
- 2-D examples
- Applications of the CRS attributes
  - stacking velocity
  - true amplitude analysis
  - model independent time migration
- Conclusions

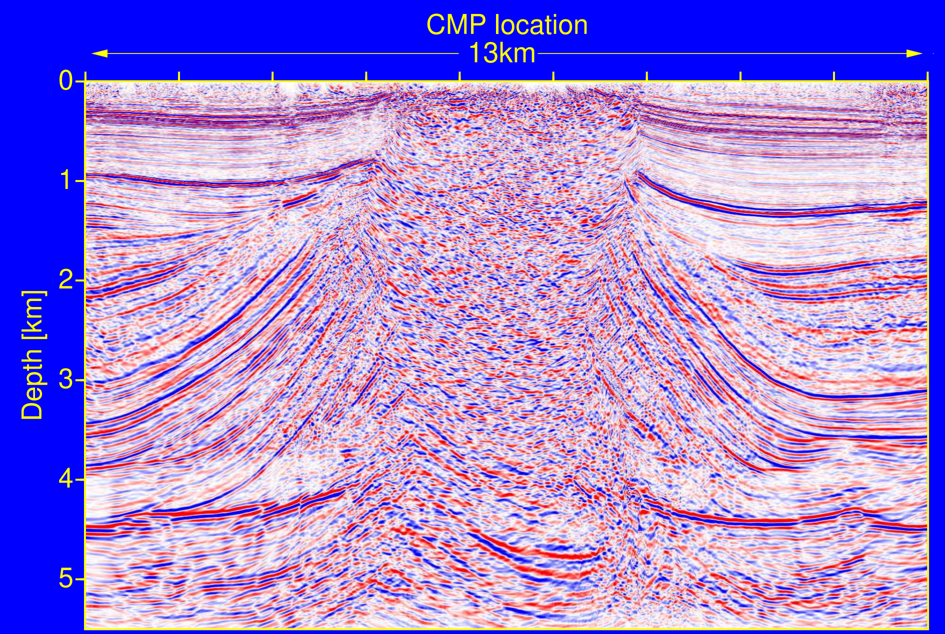
Result of NMO/DMO/Stack



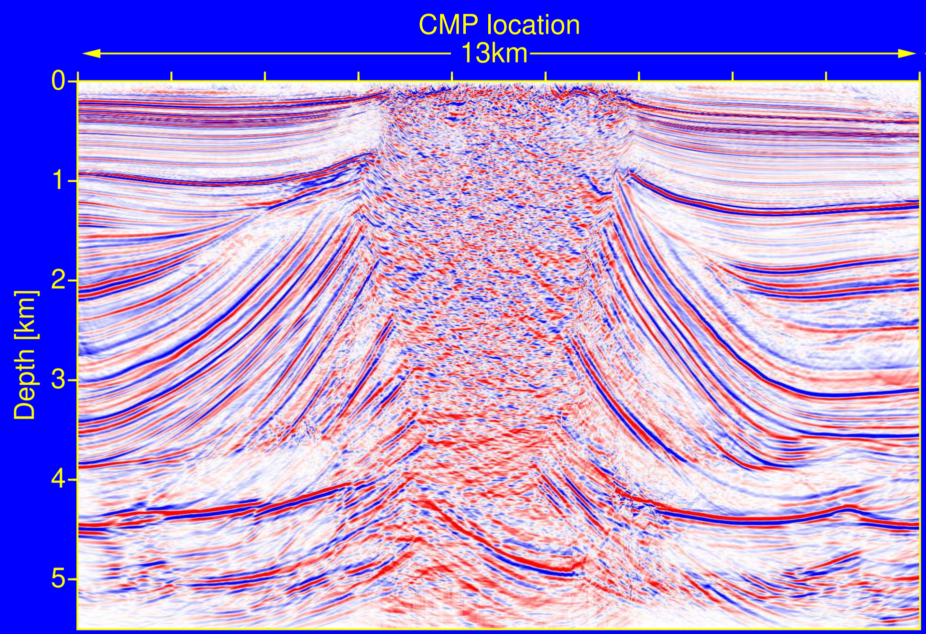
Result of CRS stack



Depth migration of NMO/DMO/Stack

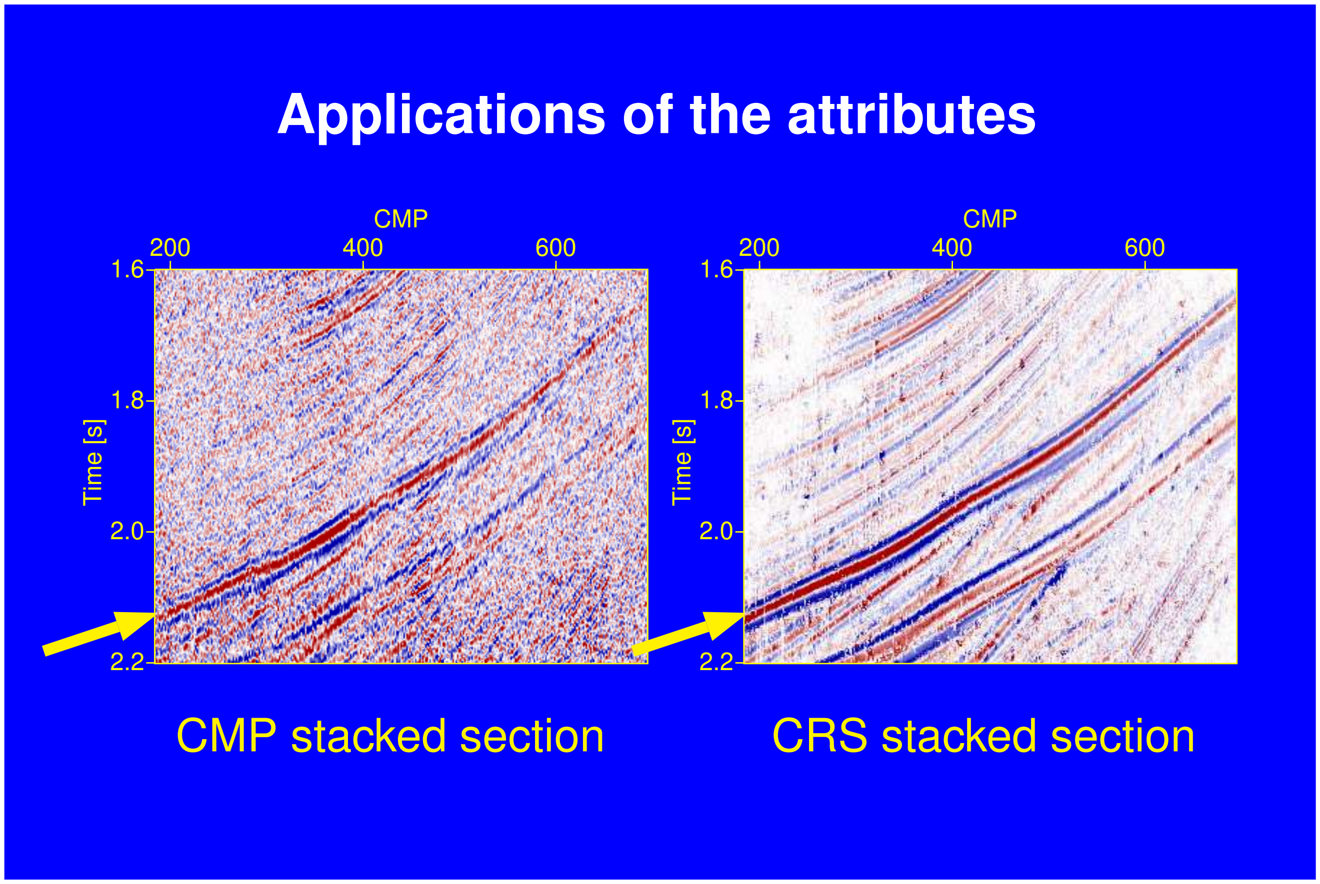


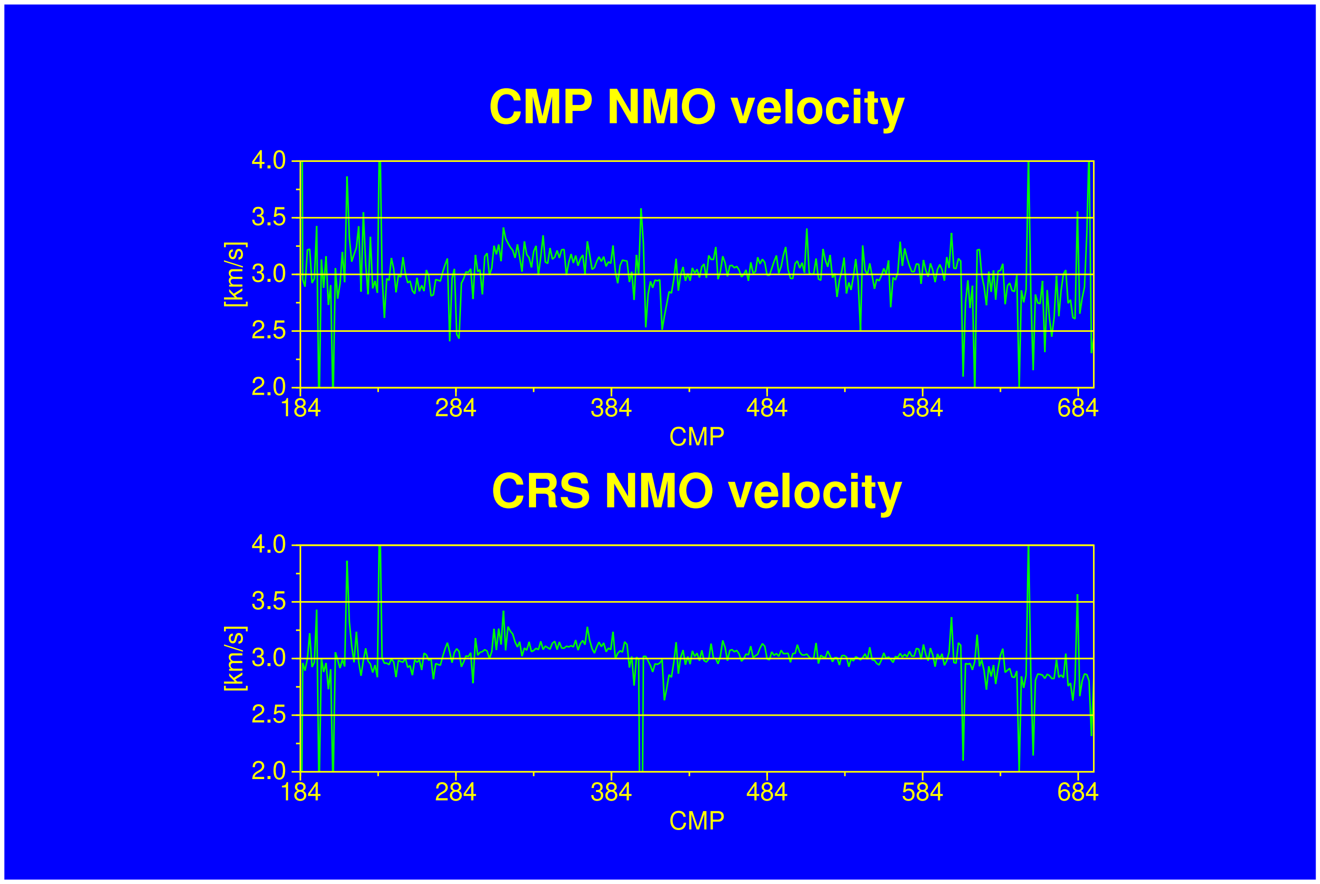
Depth migration of CRS stack



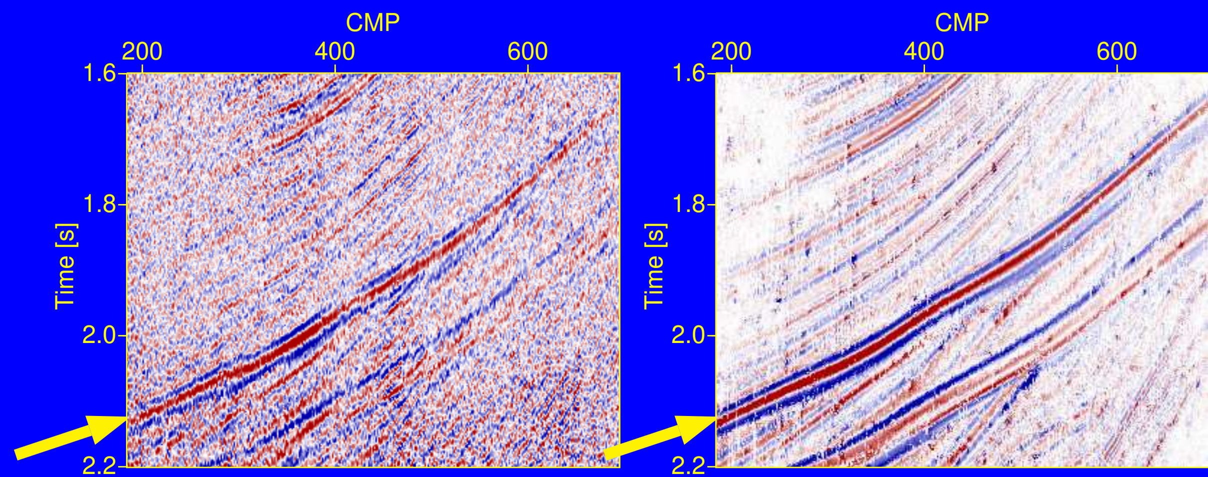
Overview

- Introduction
- 2-D examples
- Applications of the CRS attributes
  - stacking velocity
  - true amplitude analysis
  - model independent time migration
- Conclusions

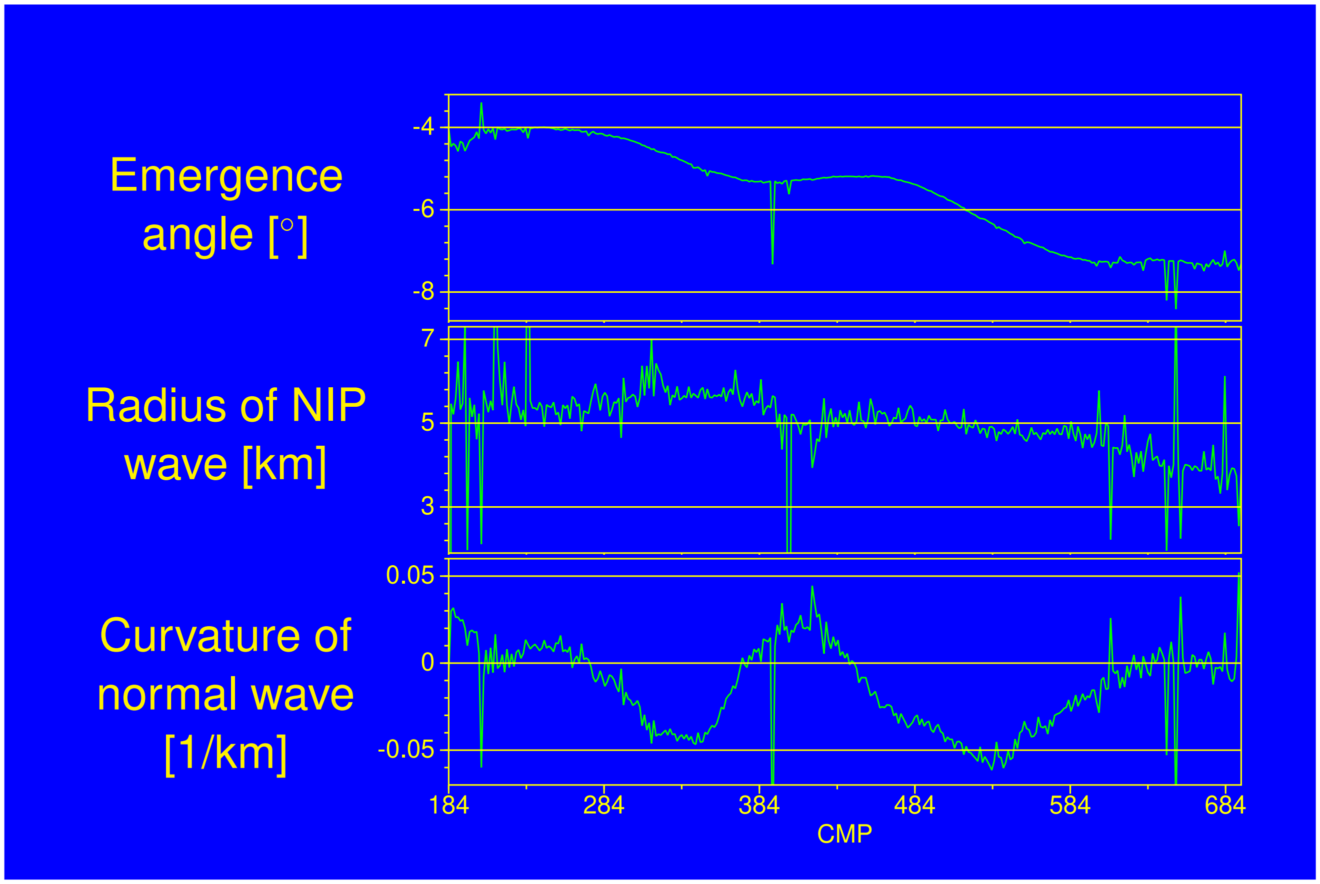

Applications of the attributes
CMP
200
400
600
1.6
1.8
2.0
2.2
Time [s]
CMP
200
400
600
1.6
1.8
2.0
2.2
Time [s]
CMP stacked section
CRS stacked section


CMP NMO velocity
4.0
3.5
3.0
2.5
2.0
[km/s]
184
284
384
484
584
684
CMP
CRS NMO velocity
4.0
3.5
3.0
2.5
2.0
[km/s]
184
284
384
484
584
684
CMP

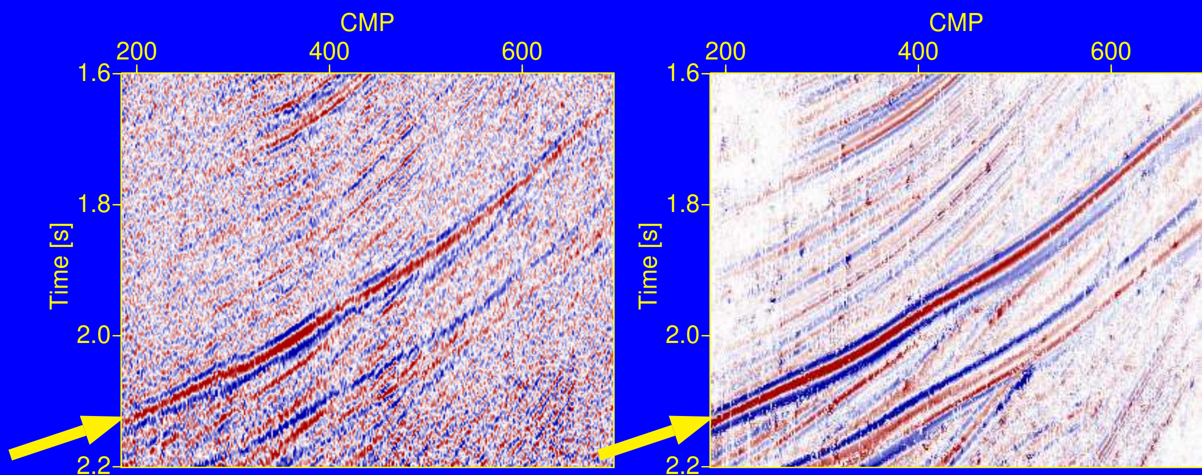
Applications of the attributes



CMP stacked section CRS stacked section

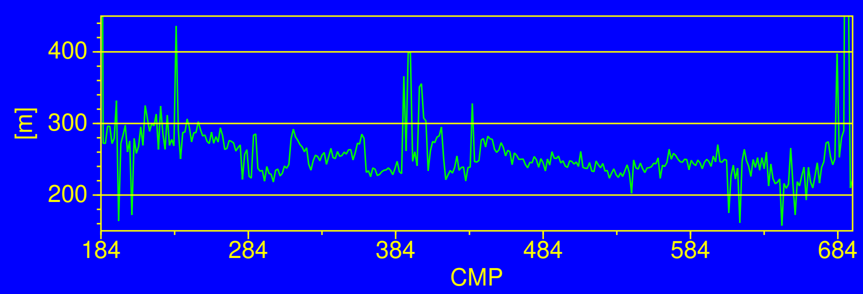

Emergence angle [°]
Radius of NIP wave [km]
Curvature of normal wave [1/km]
-4
-6
-8
7
5
3
0.05
0
-0.05
184
284
384
484
584
684
CMP

Applications of the attributes

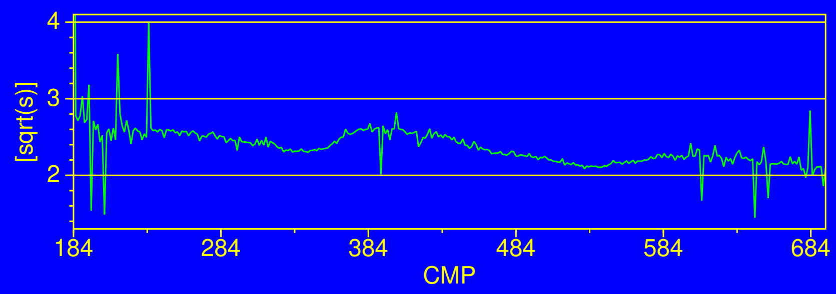


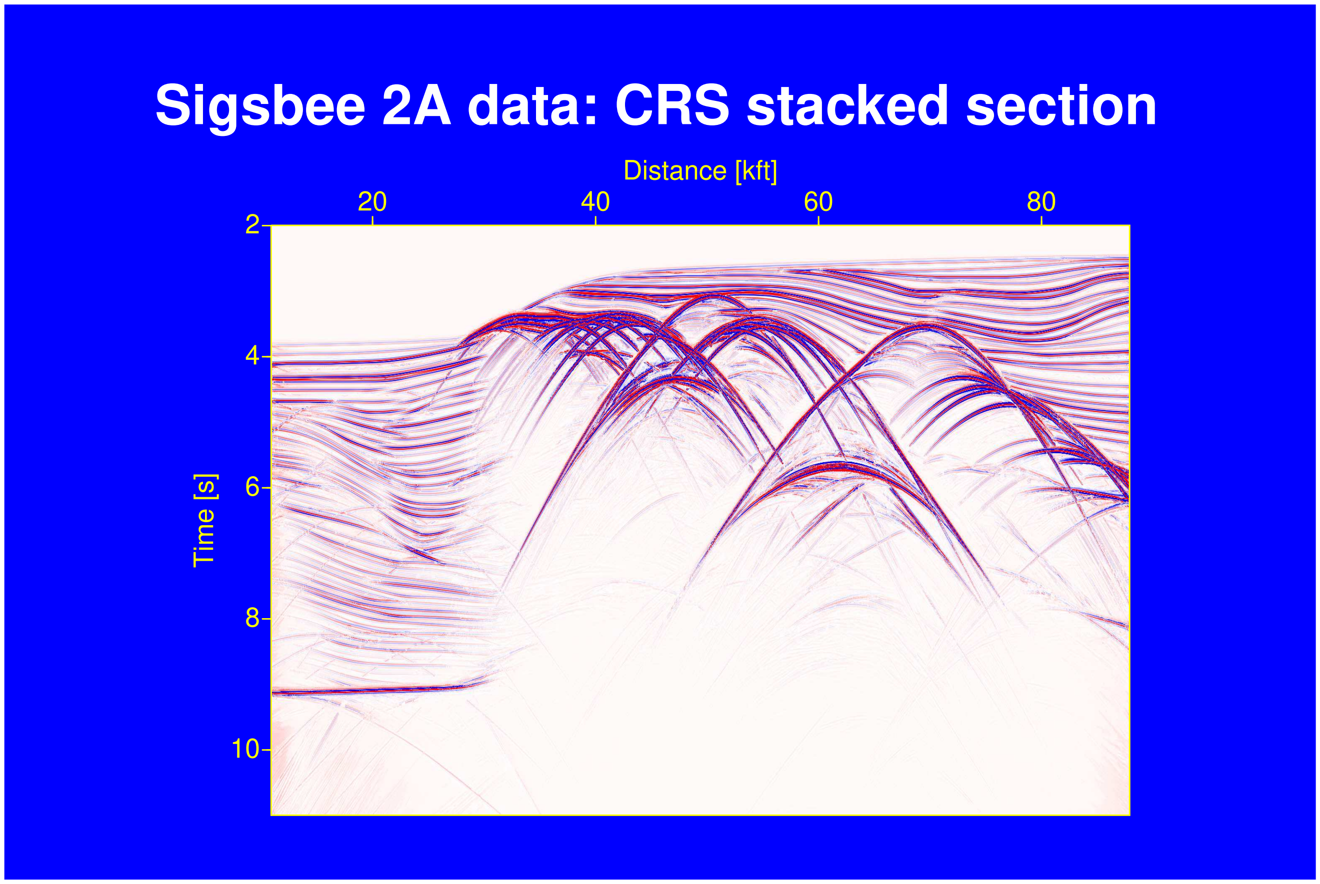
CMP stacked section CRS stacked section

Projected Fresnel zone

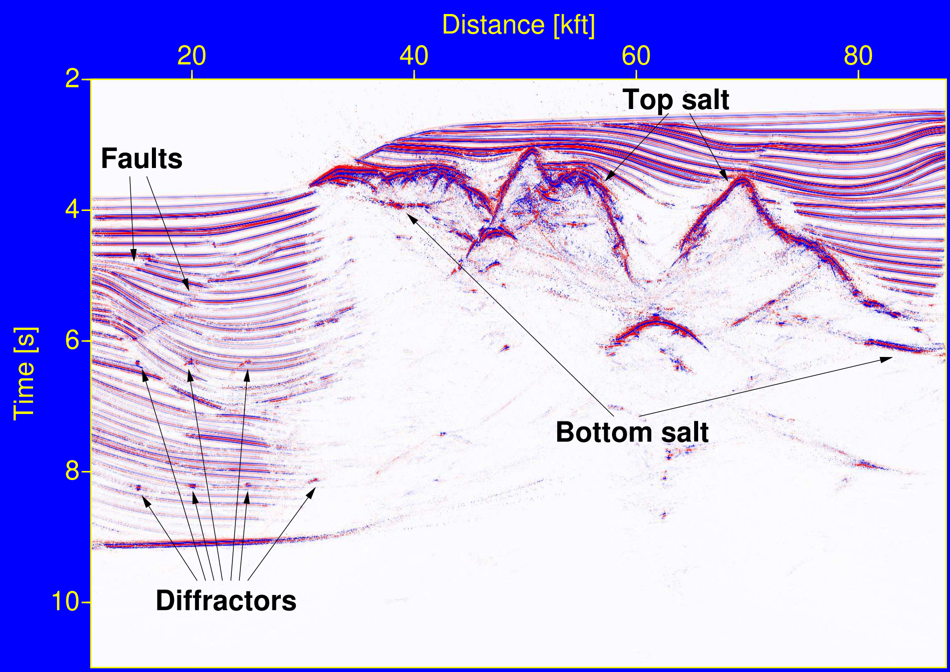


Normalized in-plane geometrical spreading




Sigsbee 2A data: CRS stacked section
Distance [kft]
20
40
60
80
Time [s]
2
4
6
8
10

Model independent time migration



Overview

- Introduction
- 2-D examples
- Applications of the CRS attributes
  - stacking velocity
  - true amplitude analysis
  - model independent time migration
- Conclusions

Conclusions (I)

CRS stacked section:

- completely data-driven method
- high signal-to-noise ratio
- high vertical resolution
- increased continuity of events

Conclusions (II)

Kinematic wavefield attributes:

- more accurate stacking velocity
- projected Fresnel zone for parsimonious migration
- geometrical spreading factor for
  - natural gain functions
  - true amplitude analysis
- model-independent time migration and inversion
- wavefield separation

Acknowledgments

This work was kindly supported by the sponsors of the *Wave Inversion Technology Consortium*, Karlsruhe, Germany.

We would like to thank the *Subsalt Multiples Attenuation and Reduction Technologies* (SMAART) oil industry joint venture, *BEB Erdgas und Erdöl GmbH*, Hannover, Germany, and *Preussag Energie GmbH*, Lingen, Germany, for the data examples.