Subsurface water flow detection by time-lapse GPR data

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Outline

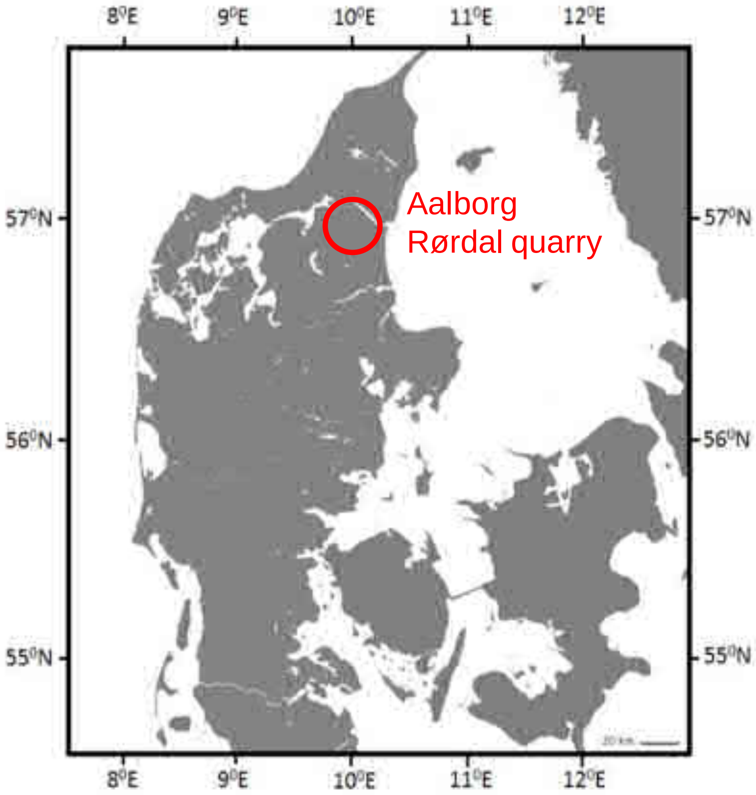
- Introduction
- Field experiment setup
- GPR Data Analysis
- Conclusions

Motivation

Using a water infiltration experiment to:

- ❑ Understand water penetration in near surface chalk
- ❑ Provide insights for fracture network mapping

Field site

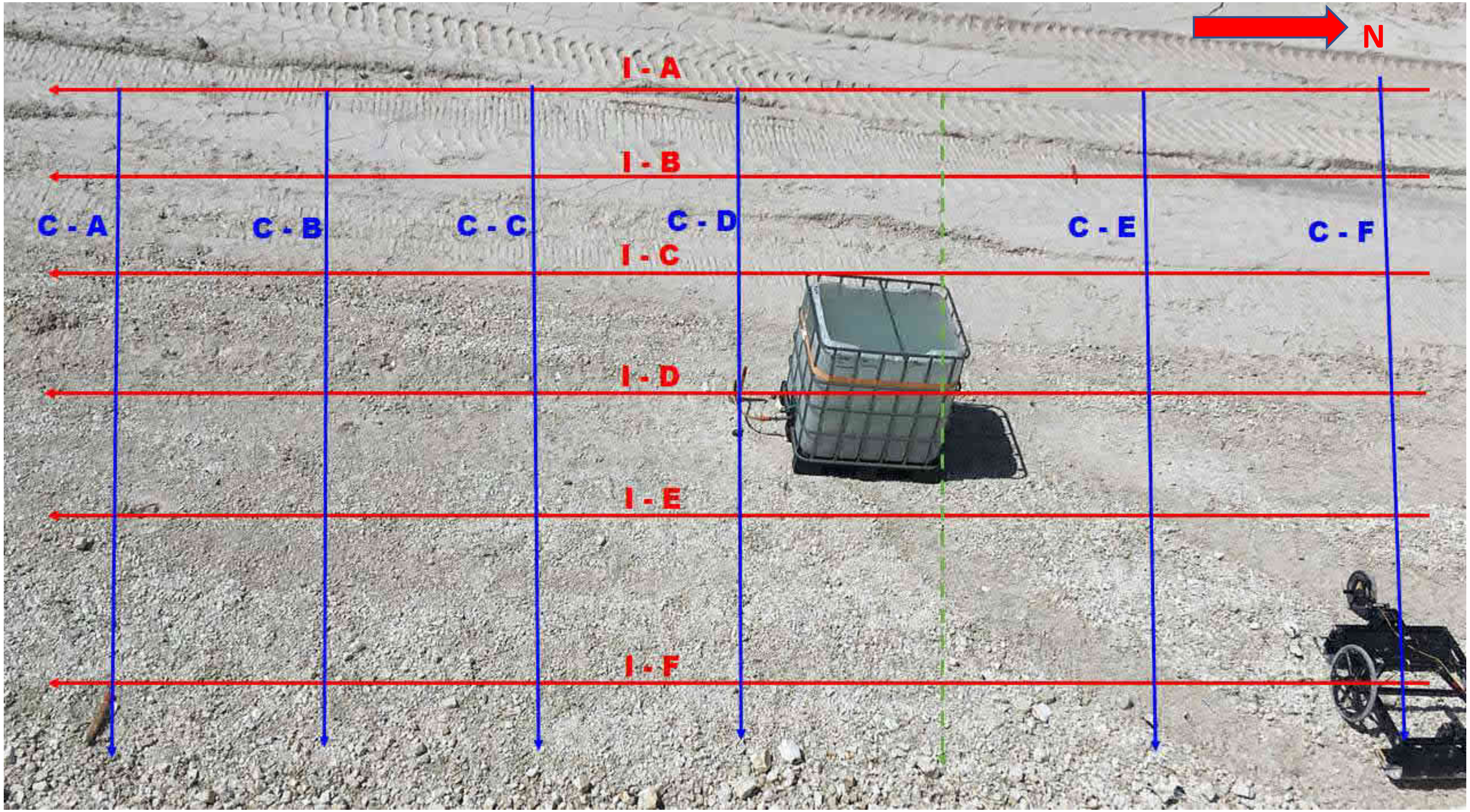


Rørdal Member

Lower maastrichtian stage

- Relatively pure chalk (carbonate content >95%) (Leth et al., 2016)
- Interbed with chalk-marl unit
- Well developed fractures
- High porosity (46%) (Nielsen et al. 2019)
- Low matrix permeability (<10 mD) (Kristensen et al. 2017)

Experiment setup



PulseEKKO GPR

100 MHz antenna

1 m offset

6 Inline

6 Crossline

1.5 m trace interval

7 measurements each line (0, 1, 2, 3, 5, 7 ,8 hr)

8.25 hrs injection

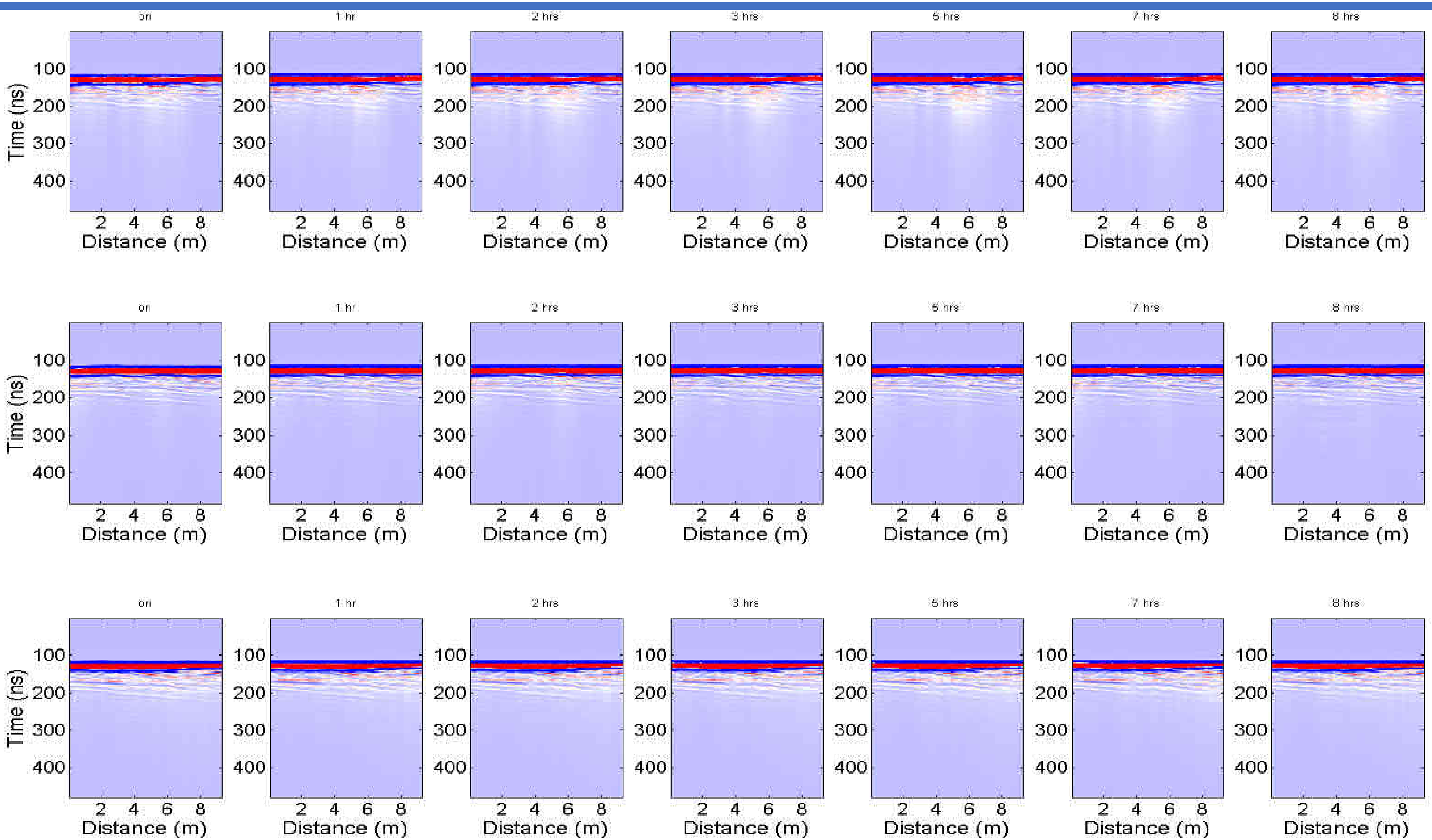
700 liters water injected

Original data

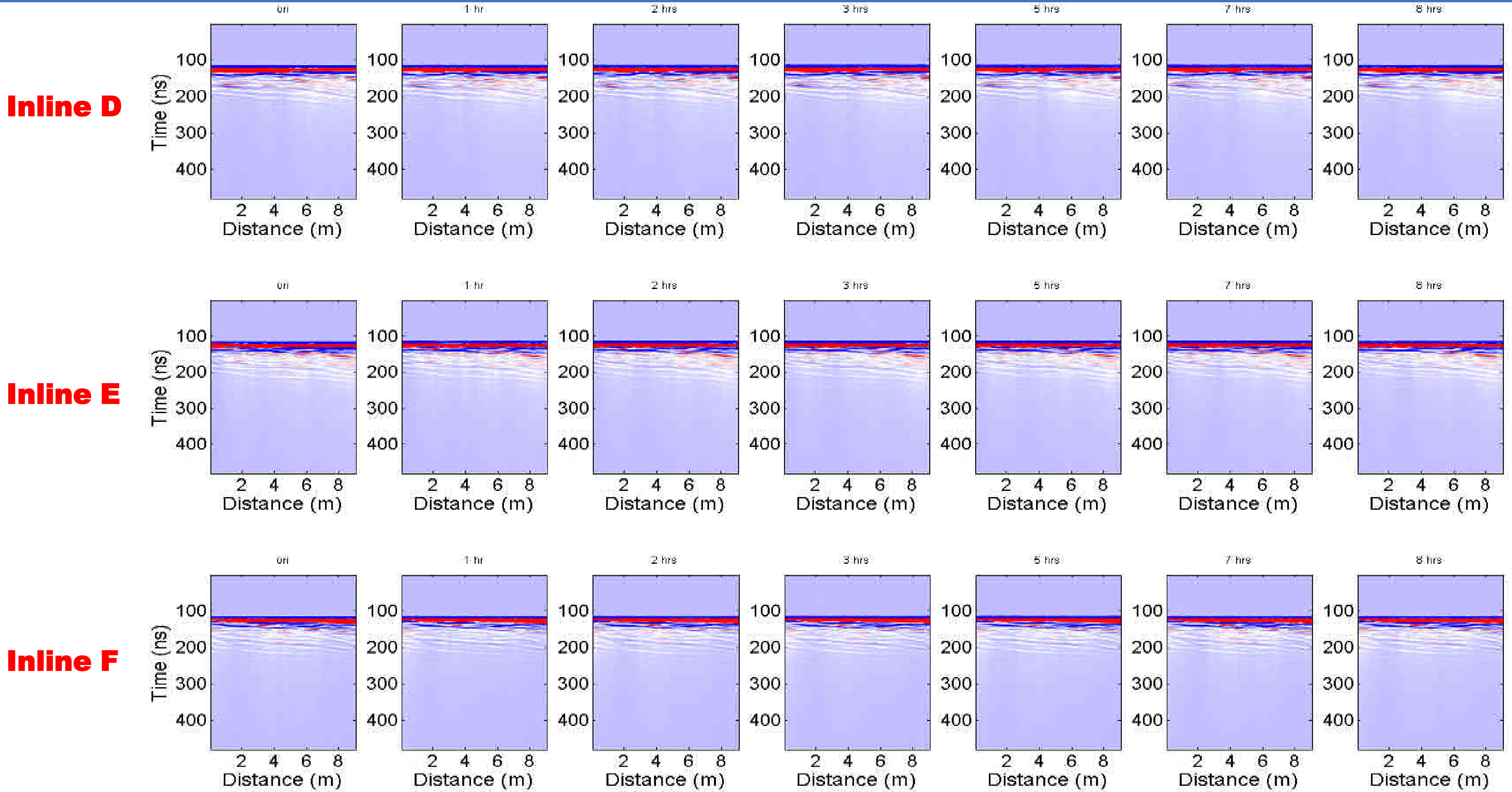
Inline A

Inline B

Inline C



Original data

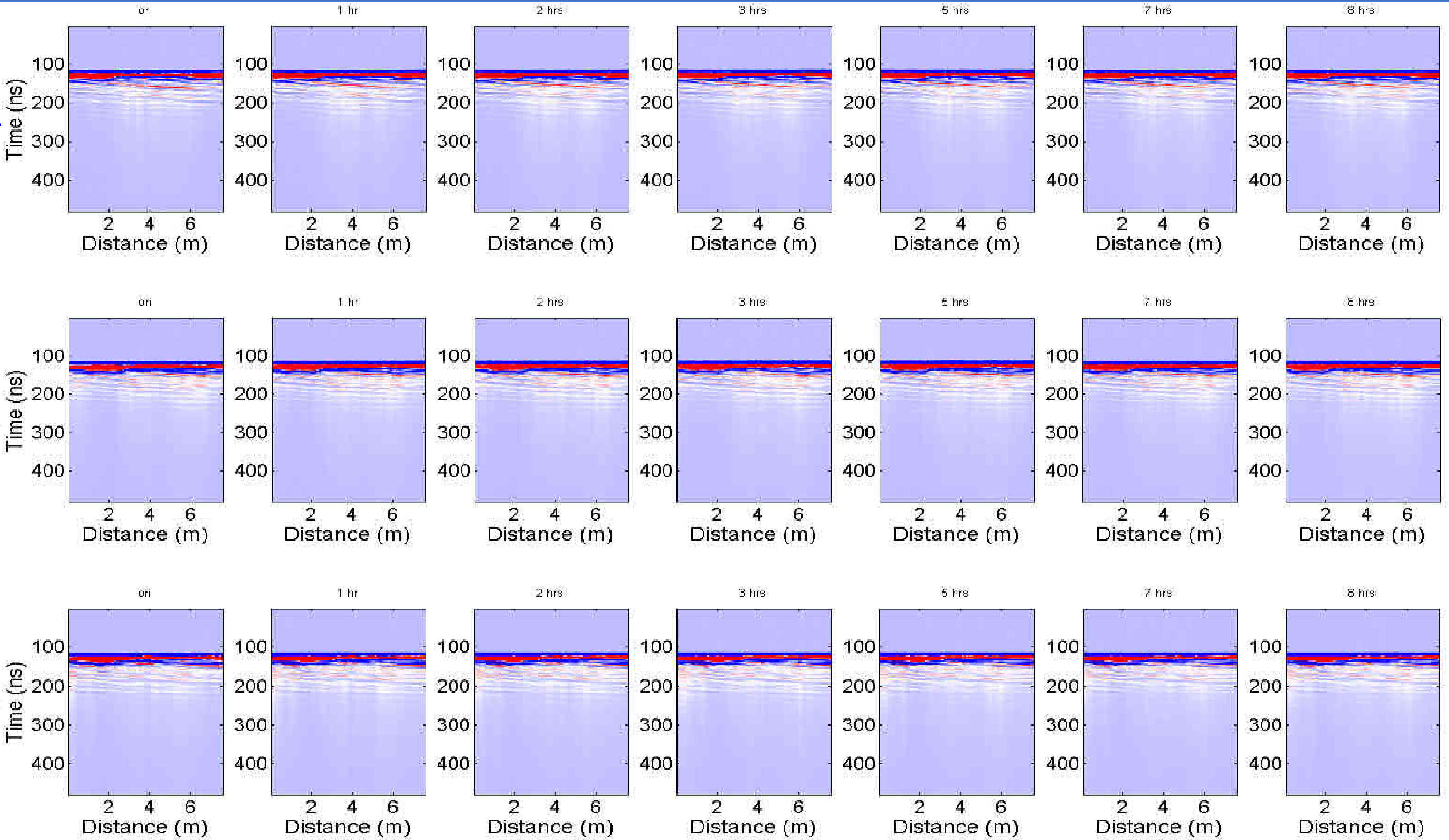


Original data

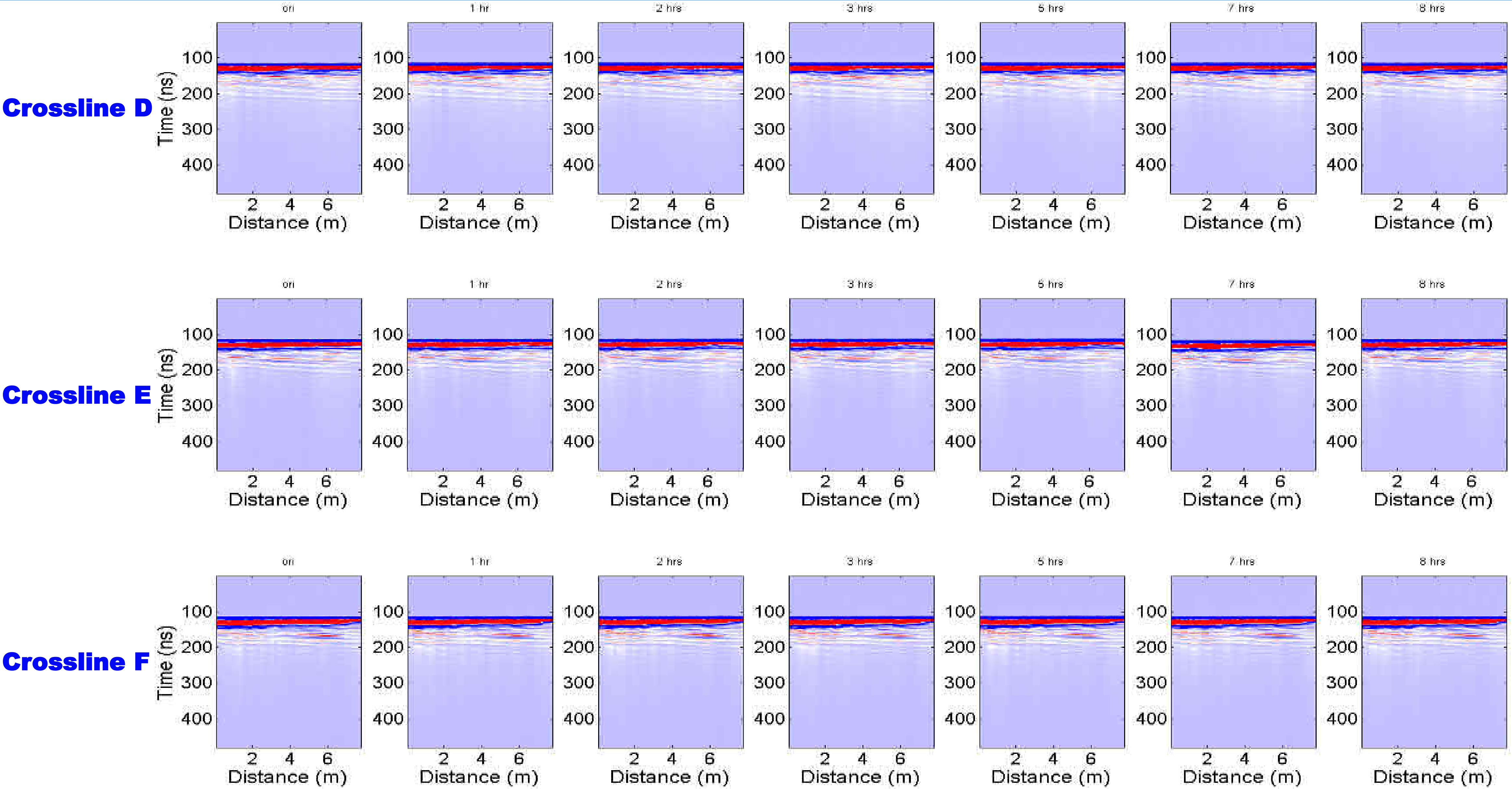
Crossline A

Crossline B

Crossline C

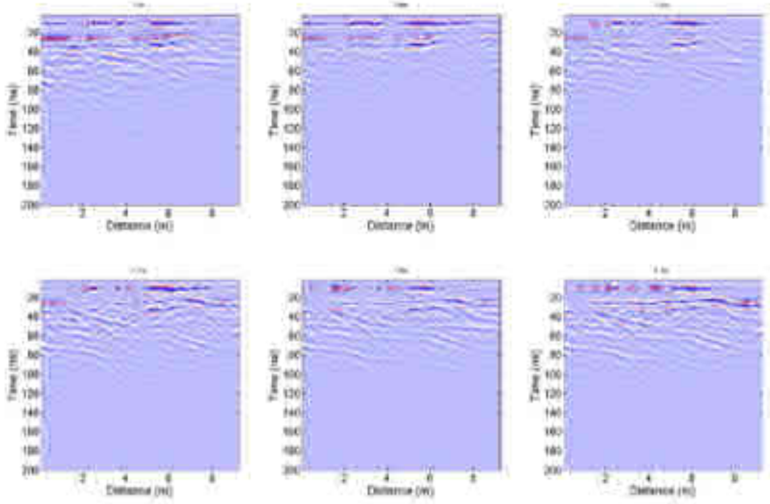


Original data

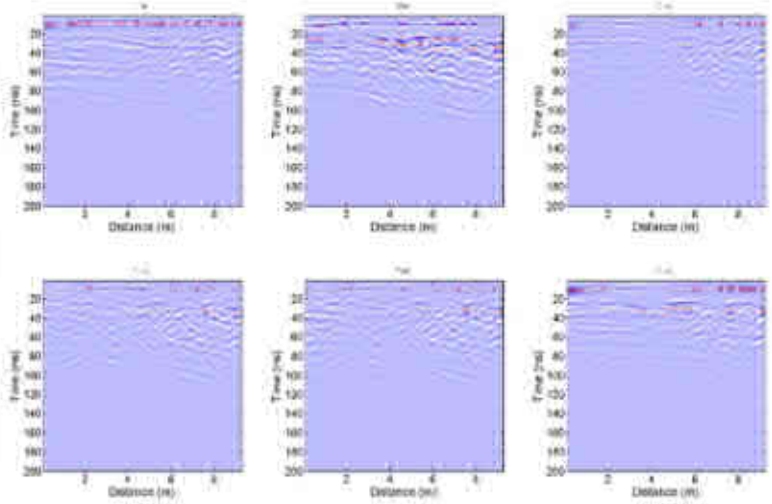


Direct subtraction

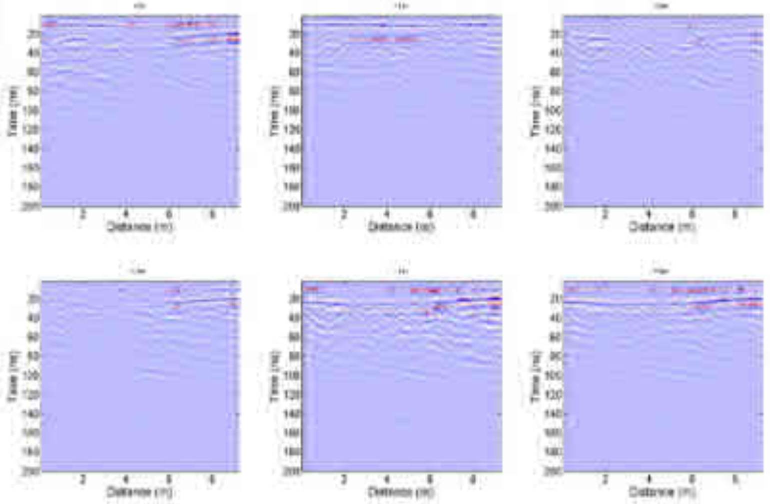
I - A



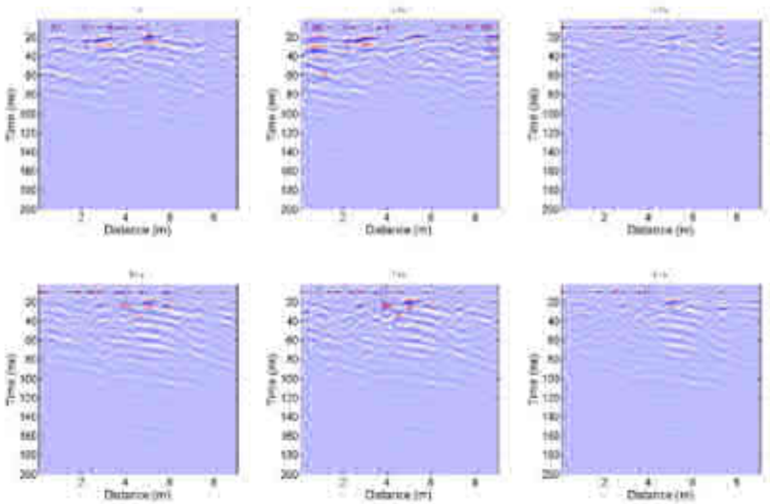
I - B



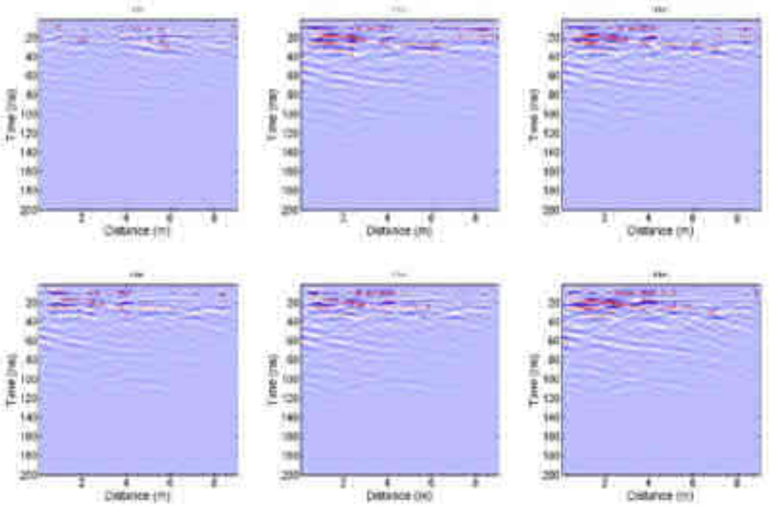
I - C



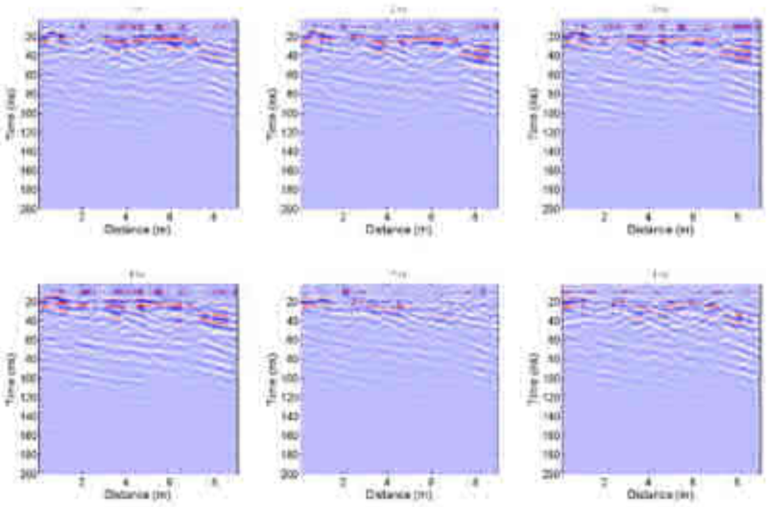
I - D



I - E

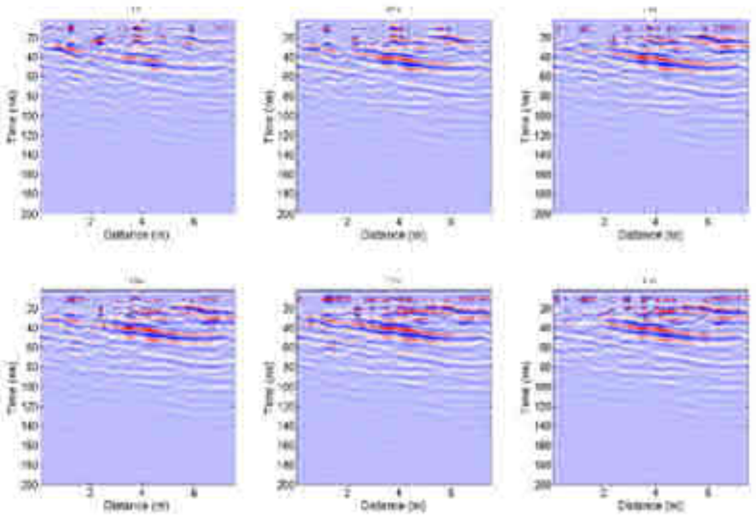


I - F

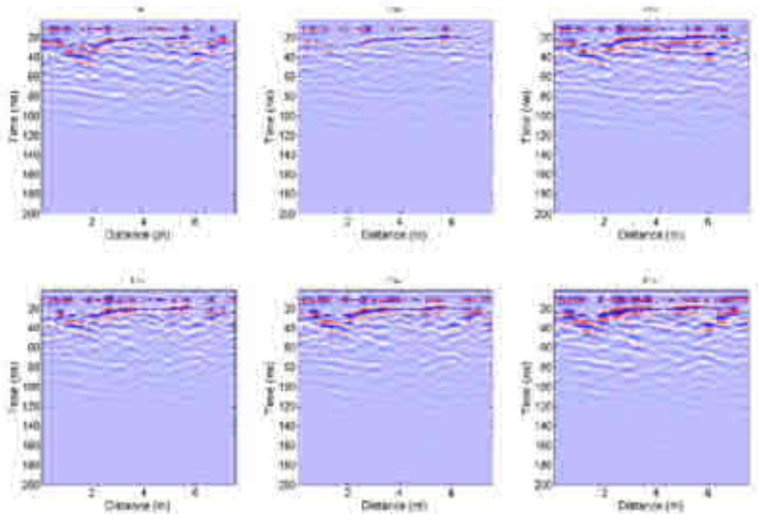


Direct subtraction

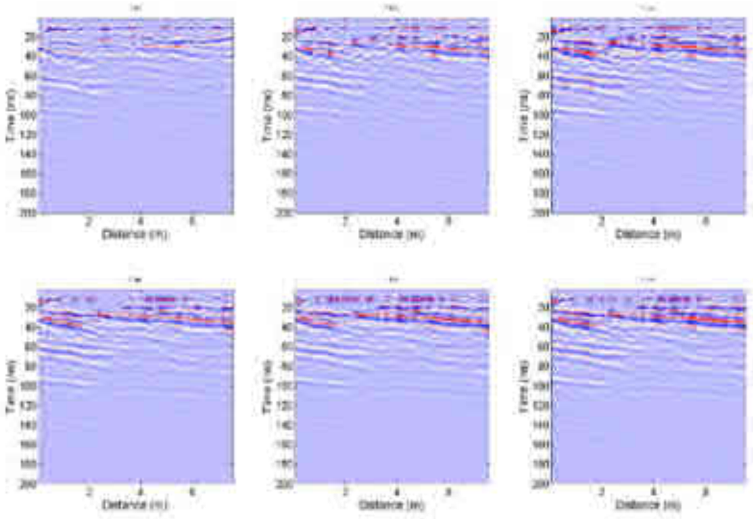
C - A



C - B



C - C



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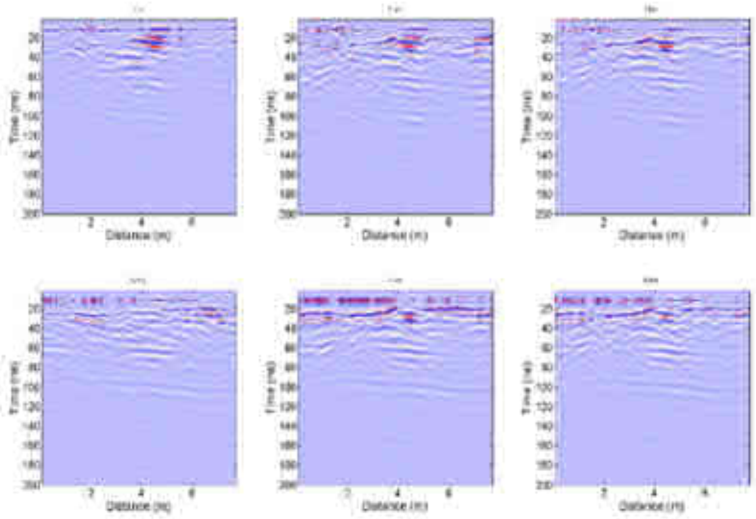
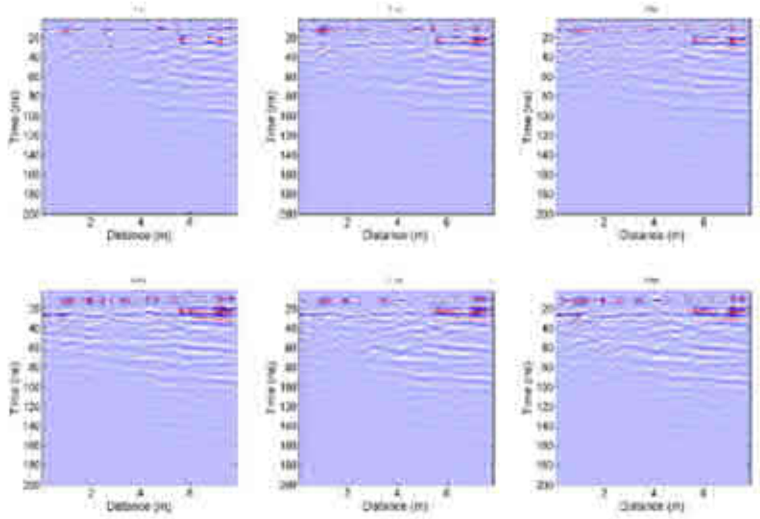
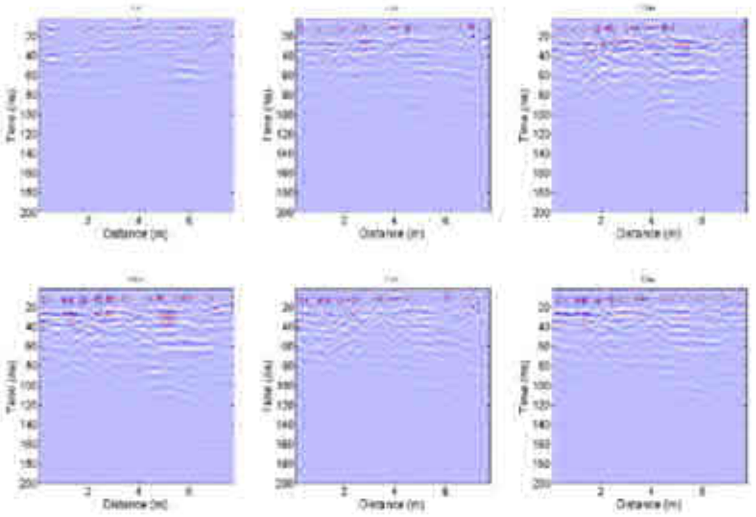


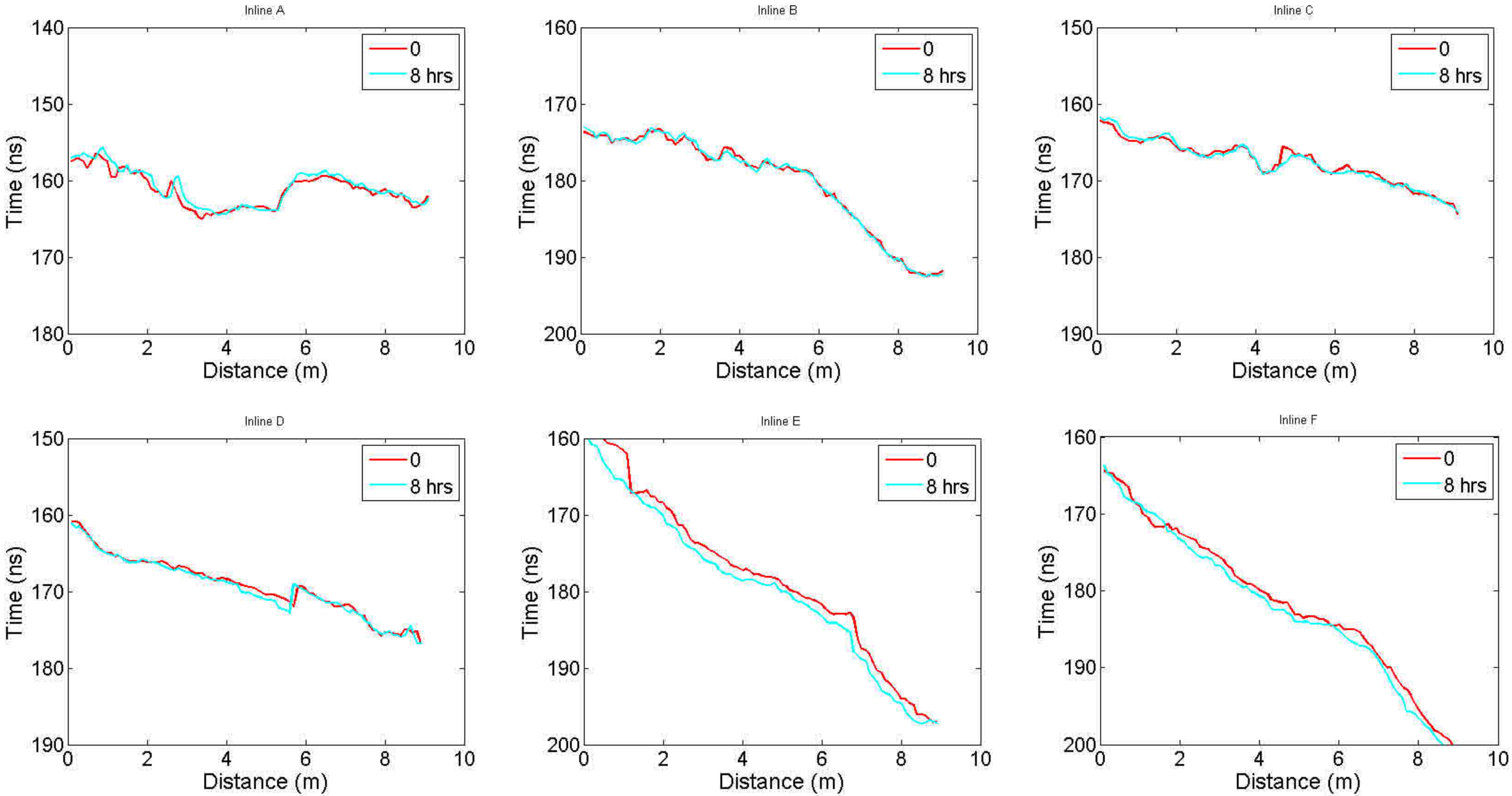
C - E



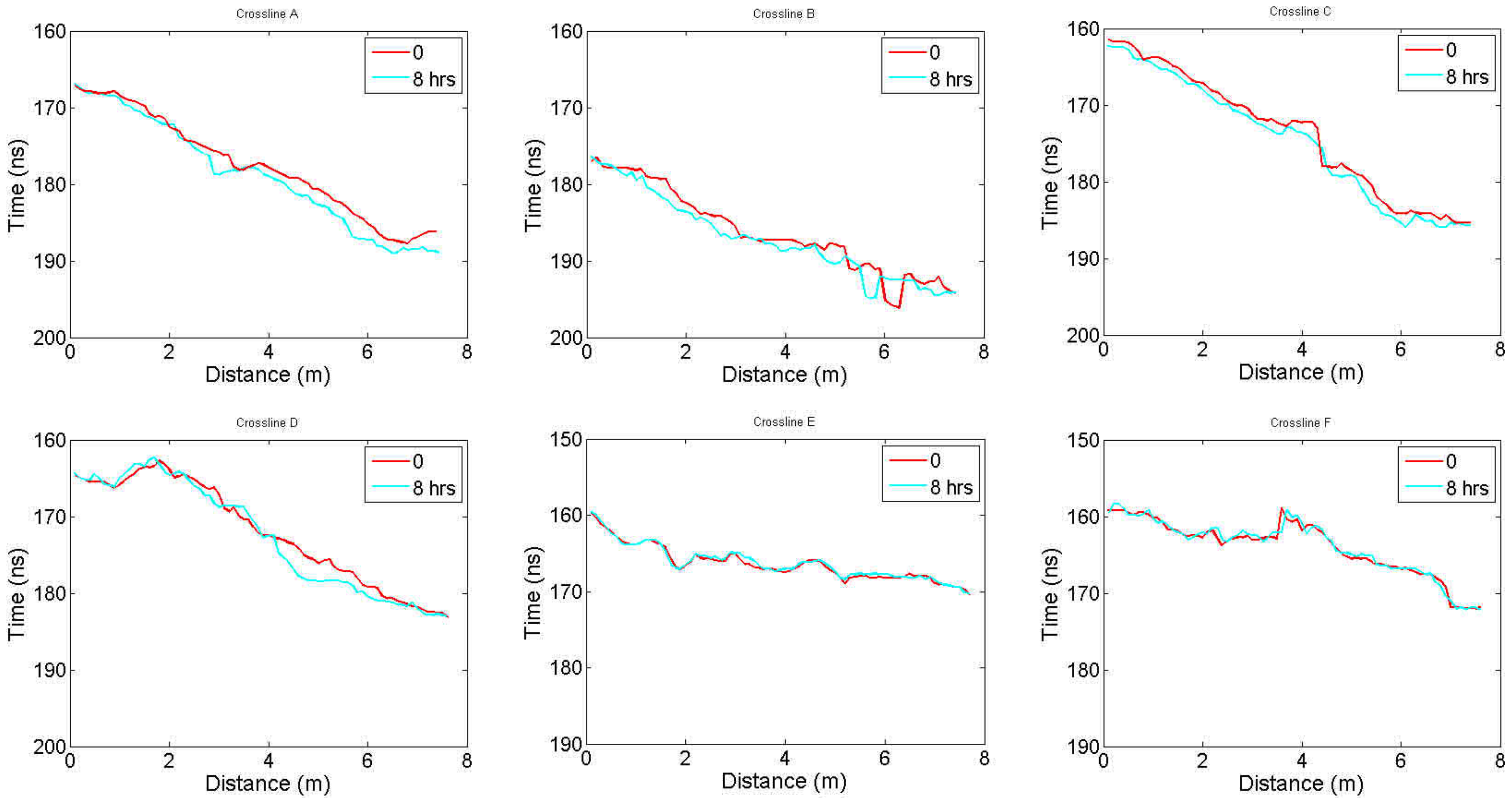
C - F



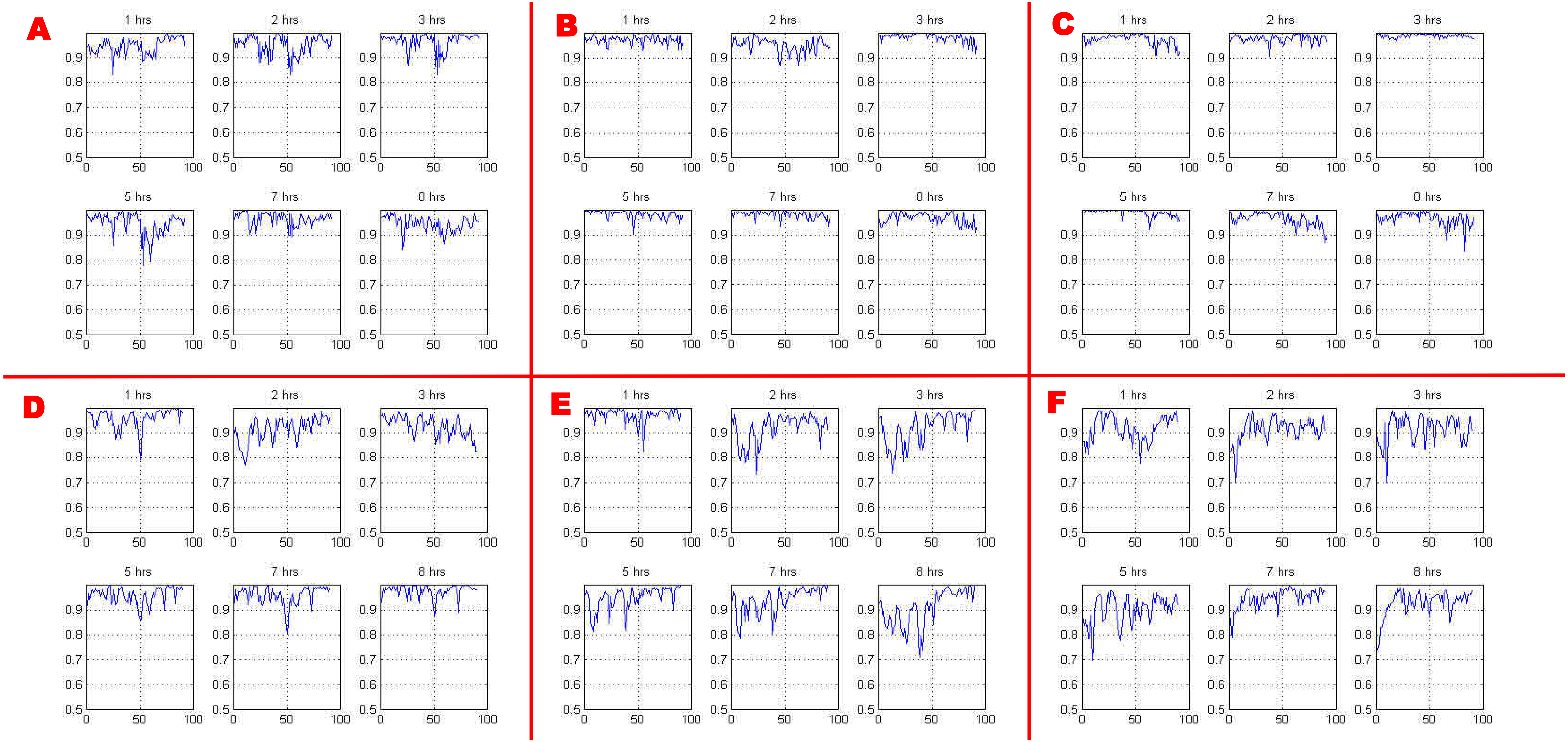
Travel time comparison - Inline



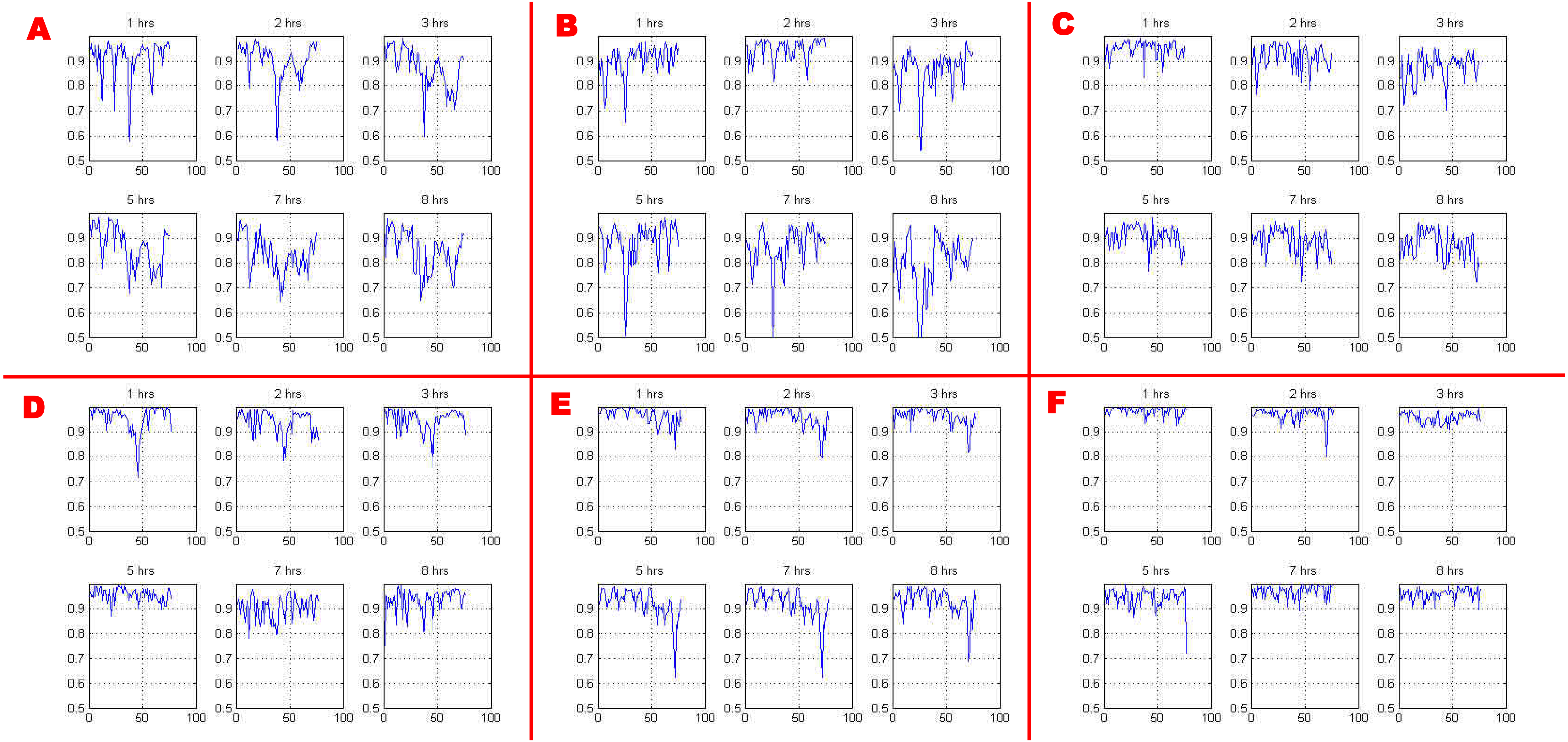
Travel time comparison- Crossline



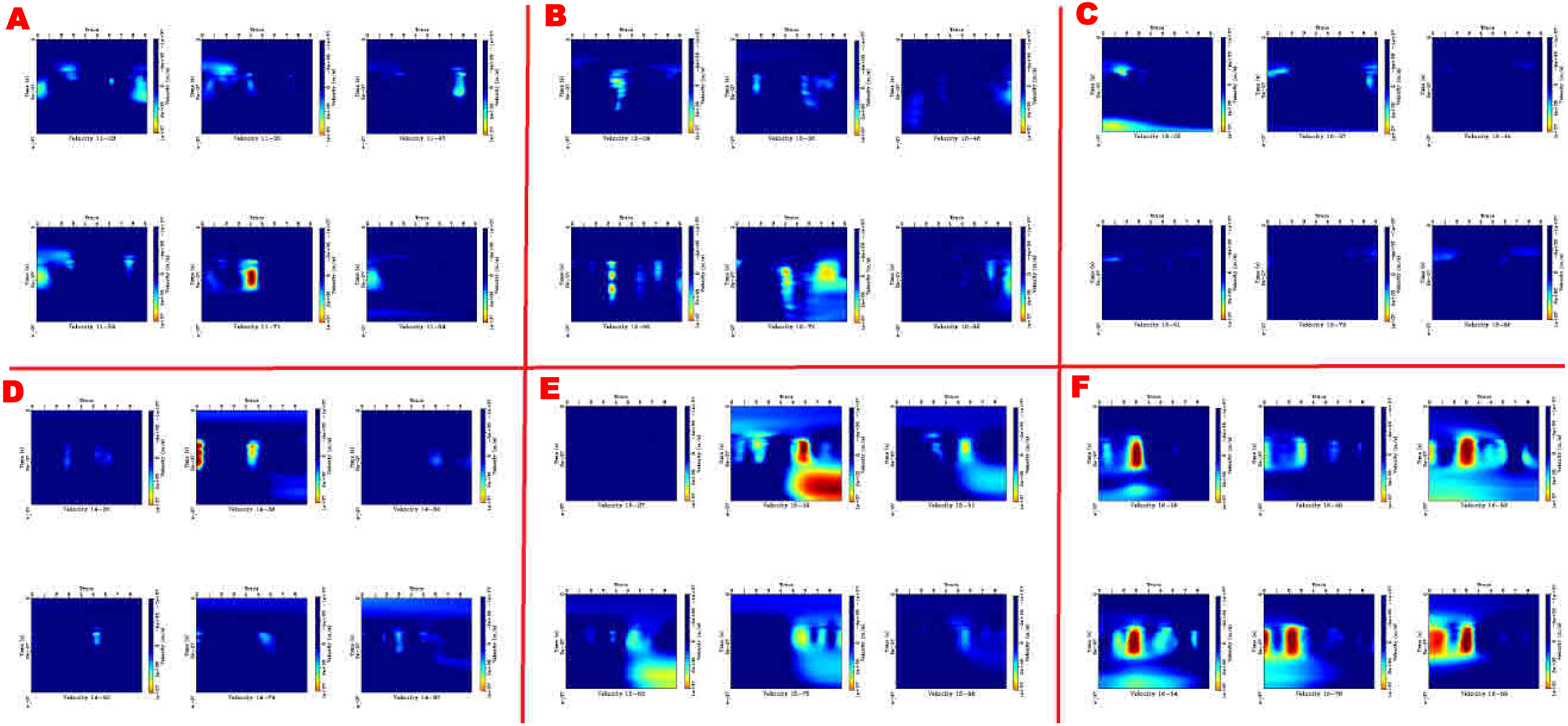
Correlation coefficient of Inline



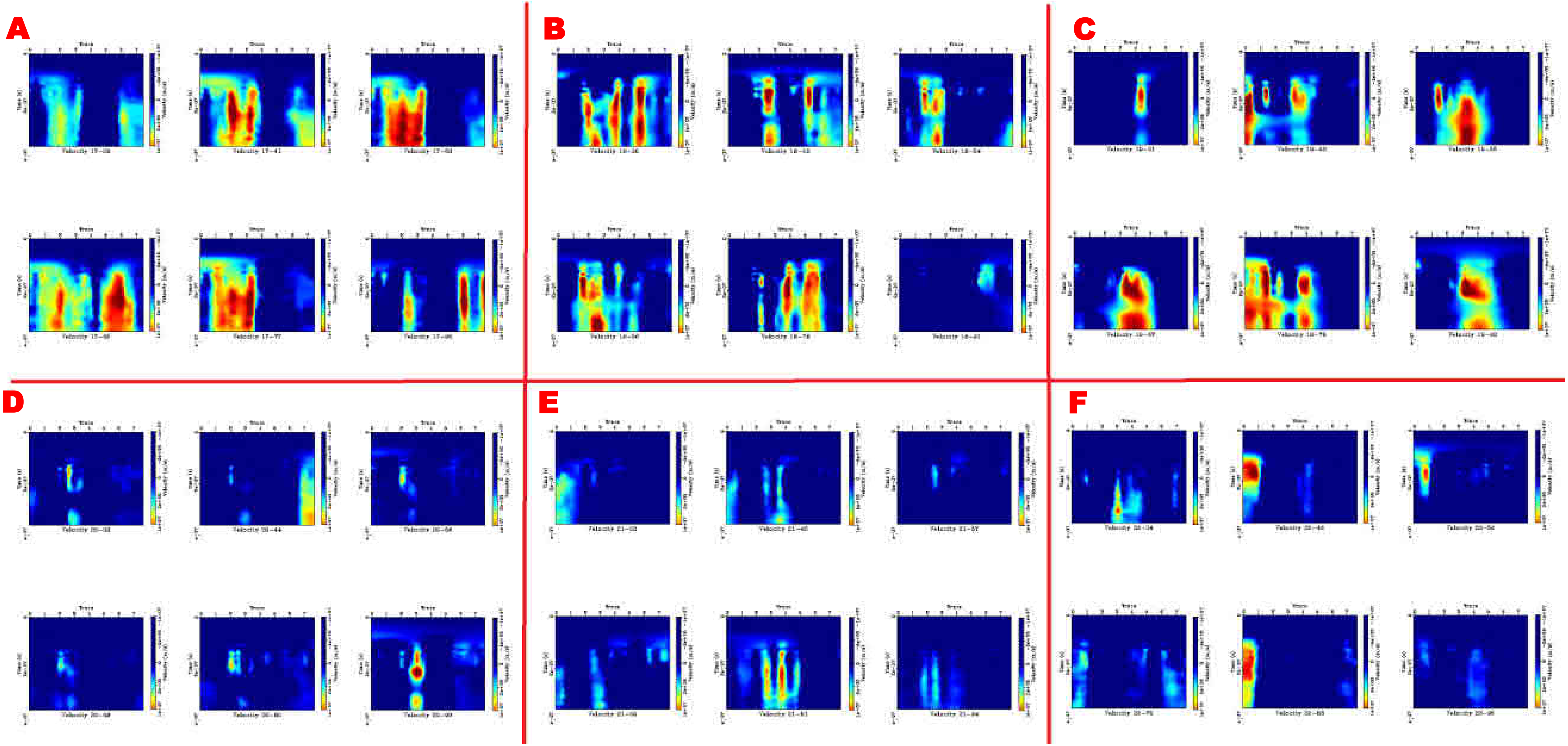
Correlation coefficient of Crossline



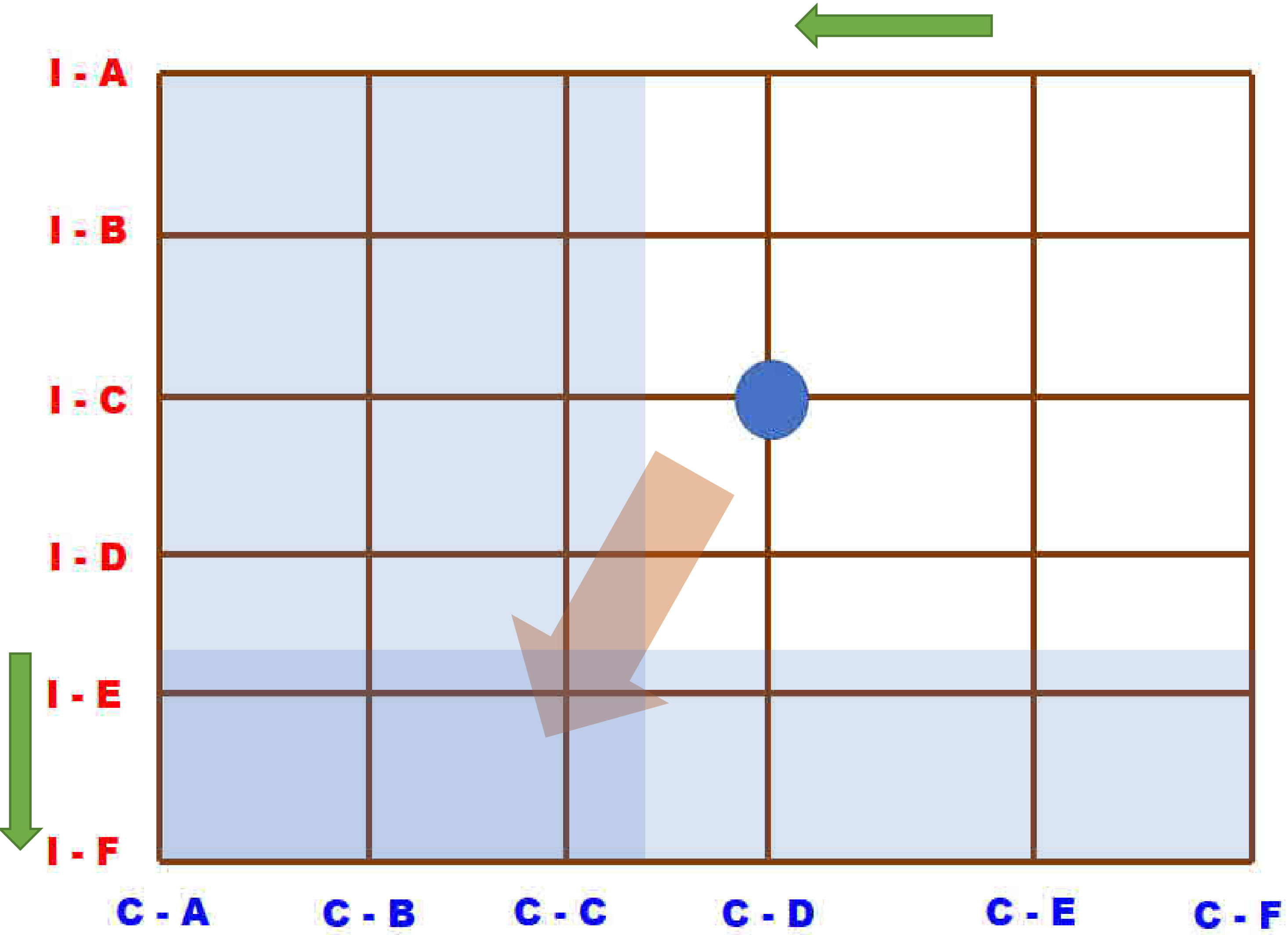
Velocity variation of inlines

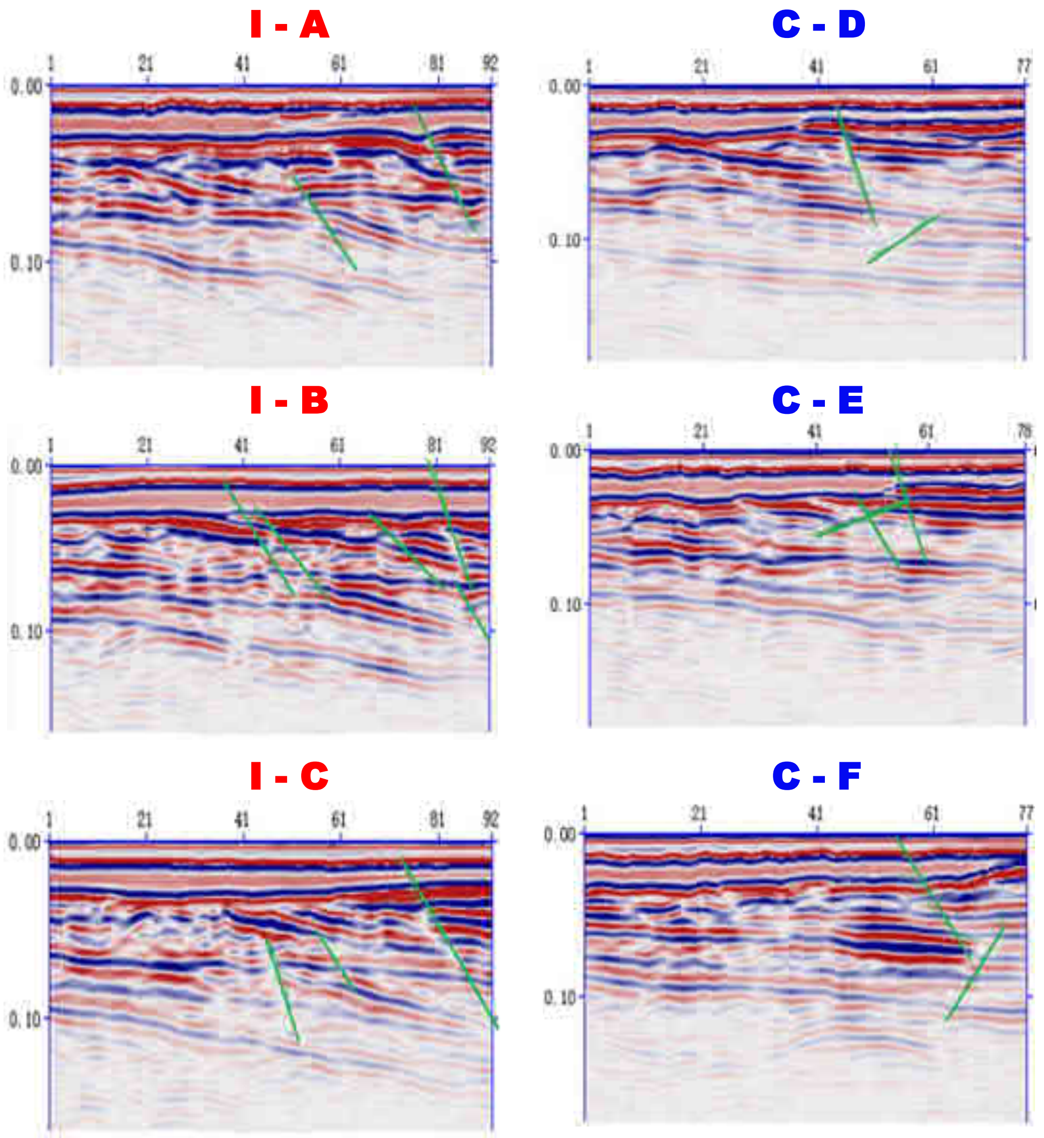


Velocity variation of crosslines



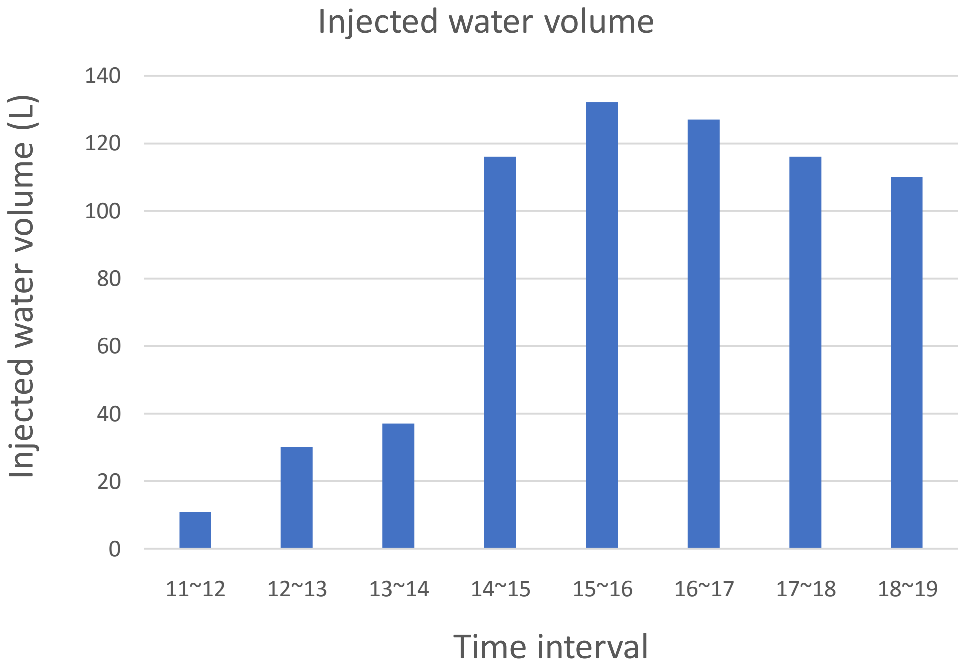
Water infiltrated zone





Water injection rate

Time interval	water injected (L)
11~12	11
12~13	30
13~14	37
14~15	116
15~16	132
16~17	127
17~18	116
18~19	110



Water injection rate increases first and then decreases

Conclusions

- Water infiltration causes obvious changes on inline E&F and crossline A&B&C

- Travel time comparison, correlation coefficient and velocity variations also confirm the changes

- Water primarily flows southeast through fractures

- Water injection rate increases first and then decreases

THANKS!