Allied Geophysical Laboratories

UNIVERSITY of HOUSTON

Integrated near-surface geophysics: Red Lodge, Montana

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- Geophysical logs
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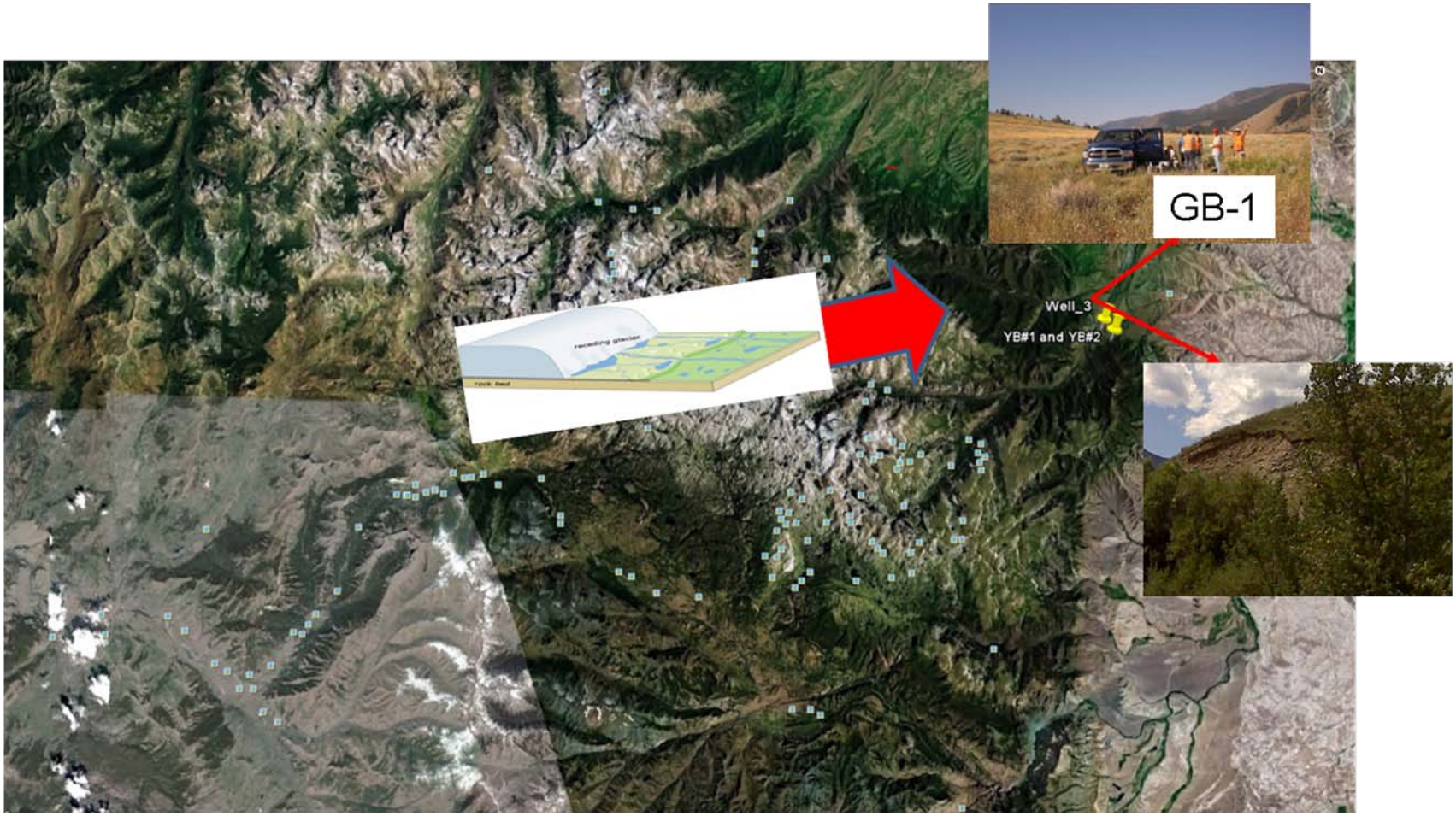
Geophysics field camp (study area)

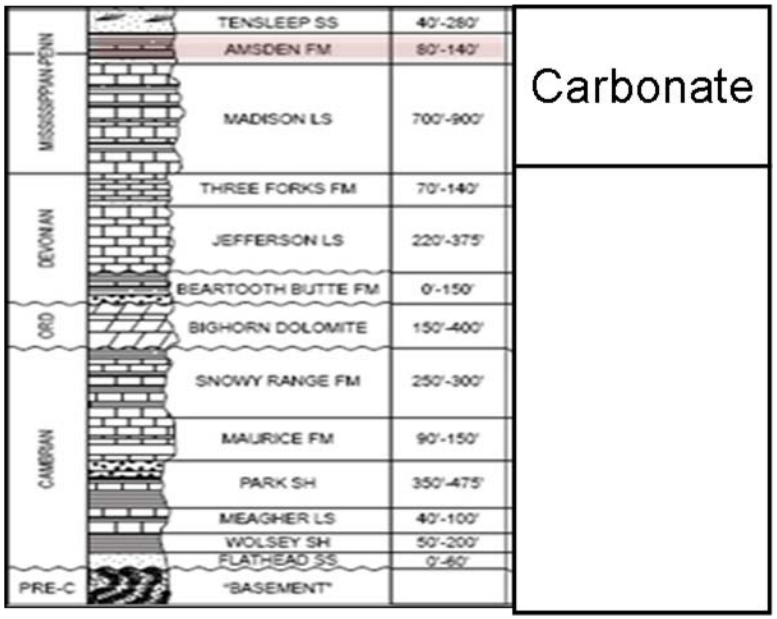
- 10 days geophysics field camp at Red Lodge, Montana.
- Every year beginning of August.
- Beartooth Mountain, Elk basin, et al.
- Logging, GPS, gravity, magnetic, surface seismic, VSP, GPR.
- Geode seismic recorder and StrataVisor stand-alone seismic recorder (from Geometrics Comp.), Vibe truck, Gravimeter, GPR, GPS, et al.

Geologic background and motivation



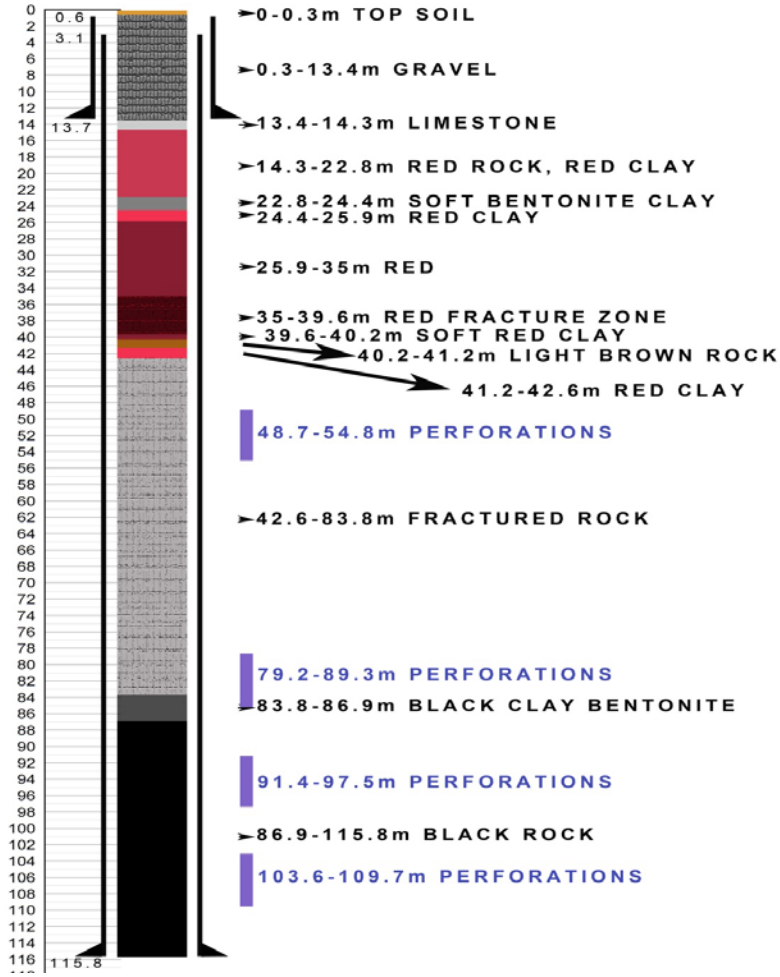
Pinedale glaciations (local name for last maximum glaciations)

Geologic background and motivation



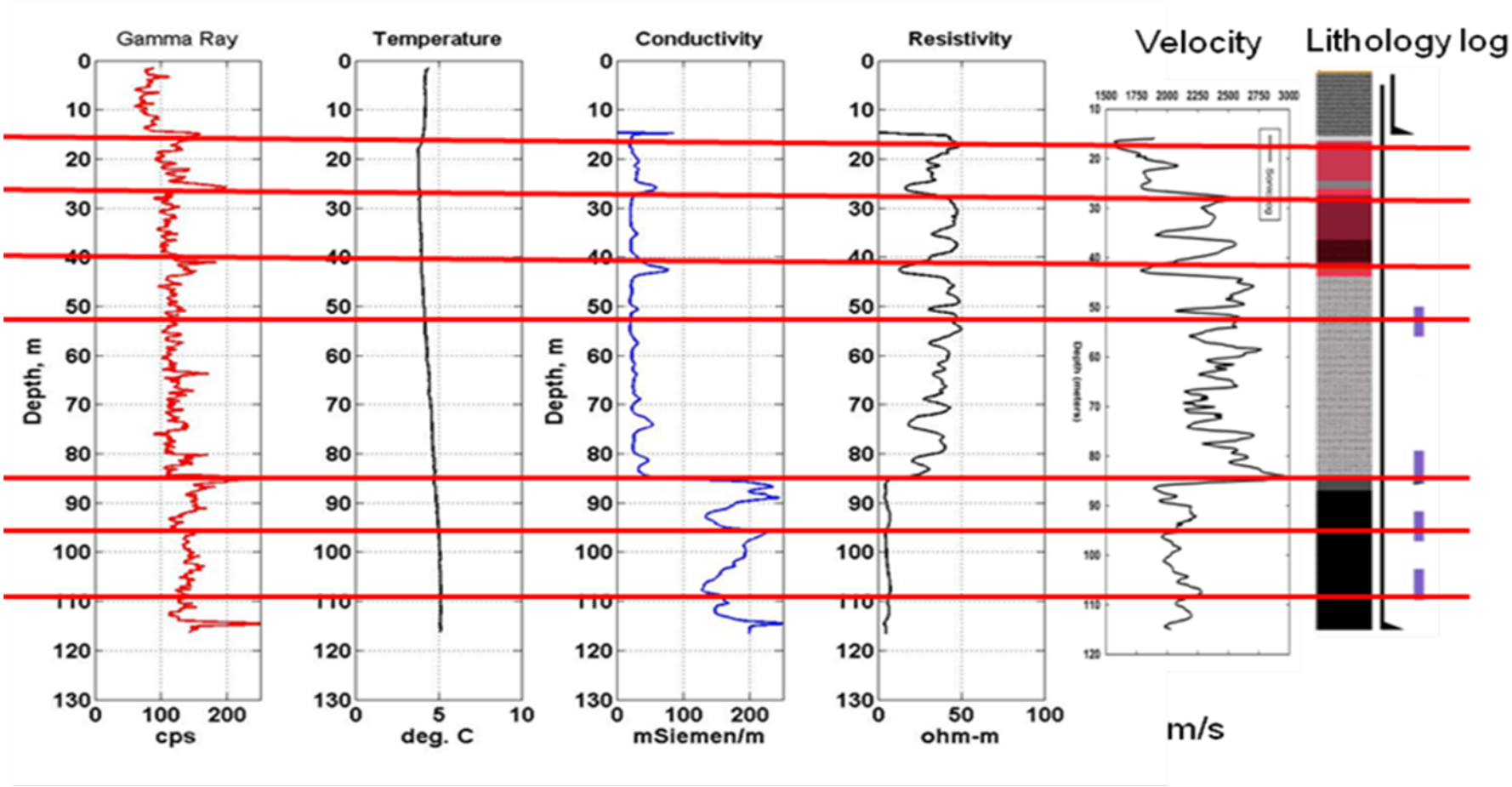
General stratigraphic column, near Red Lodge, Montana (Kauffman et al., 2008, Adopted from Mukherjee, 2010).

Depth (Meter)



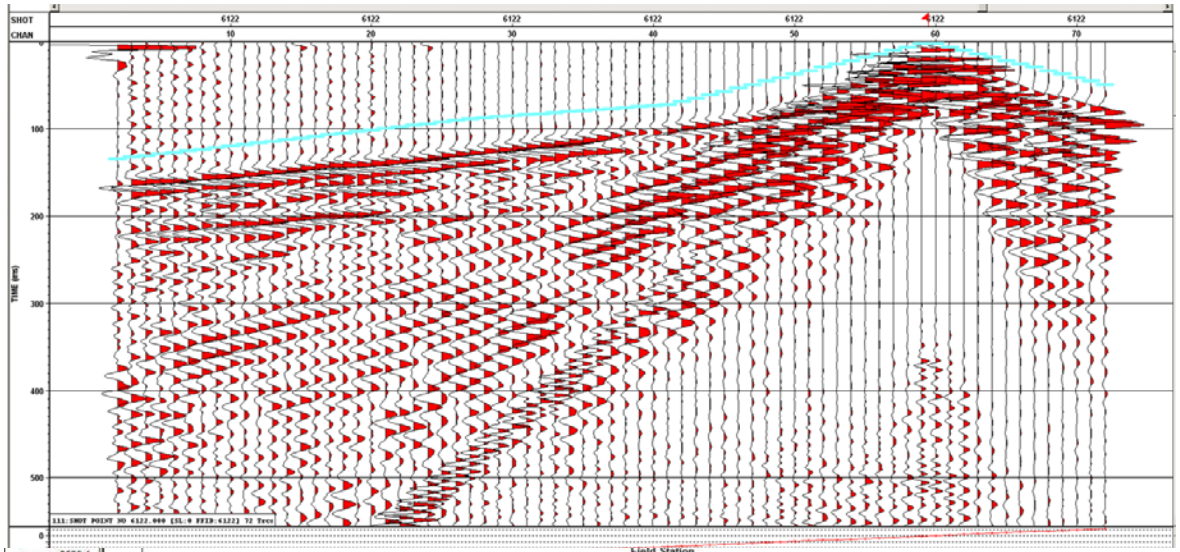
Total 115m depth, water level at 15m.

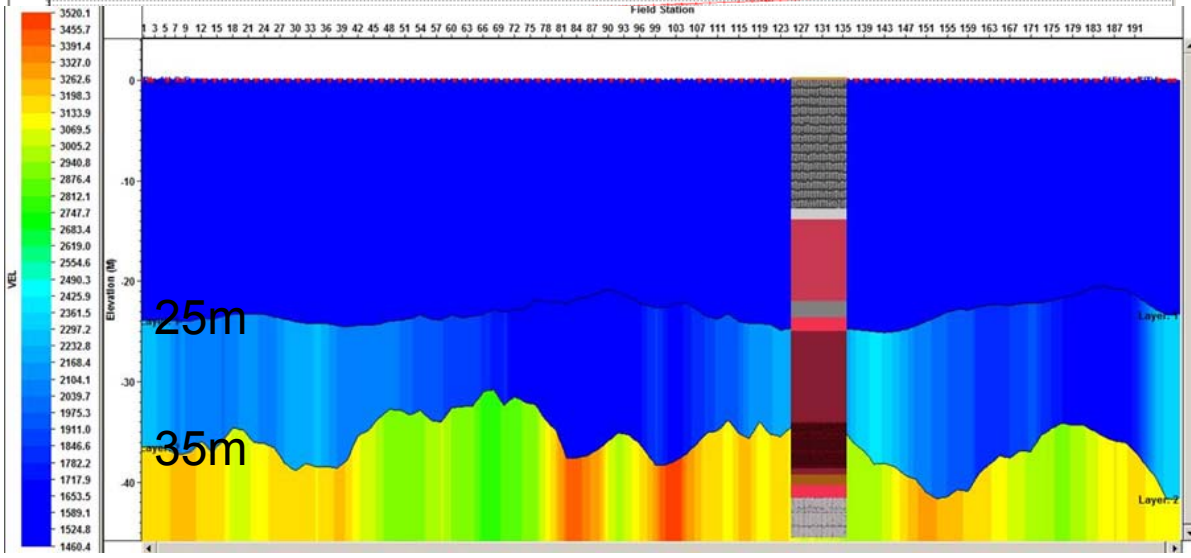
Geophysical logs



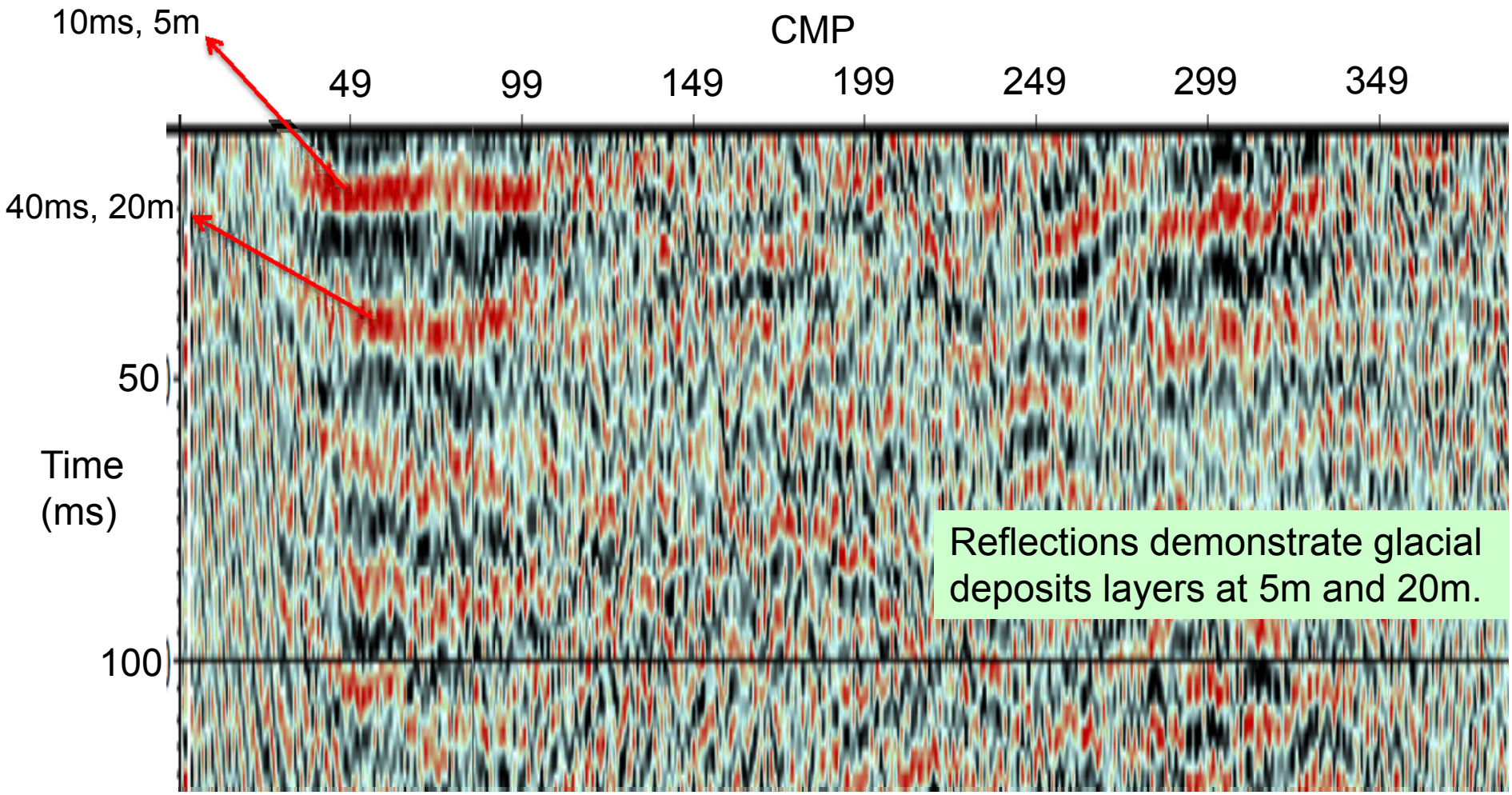
2D Seismic

- 400m long (N50E) 2D seismic was acquired near the well GB-1.
- It totally has 81 receivers with 5m spacing.
- The AWD source with 10m spacing.
- Refraction static shows two layers agree with what we expect.
- Two layer near surface velocity model shows the weathering layer has velocity 600m/s, and the glacial deposit has velocity 2100m/s, with the basement velocity is 2800m/s.





2D Seismic brute stack



Data are stacked with constant velocity 2500m/s (Pers. Comm. C. Montana, 2010).

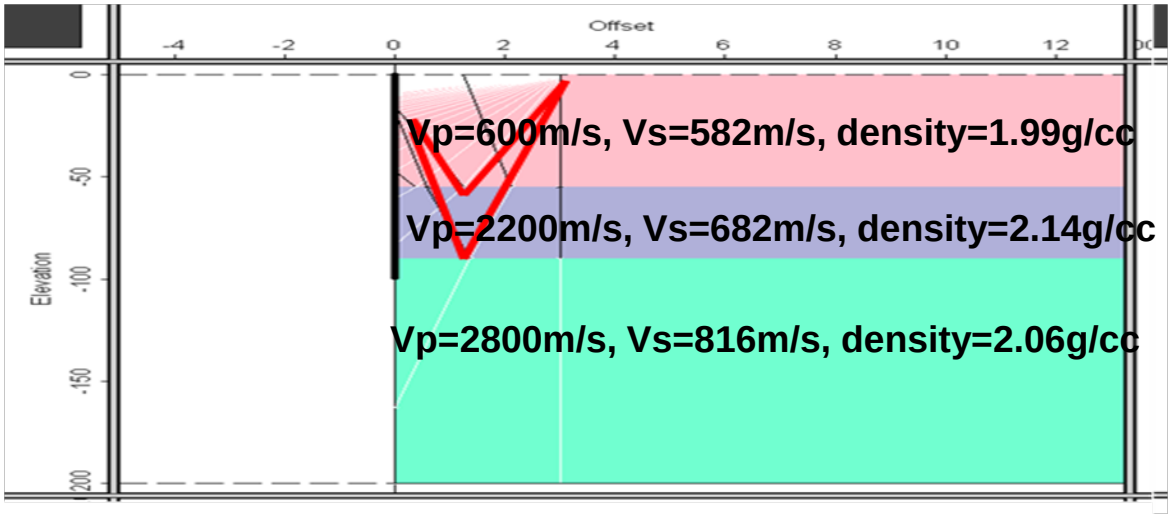
Forward modeling and synthetic VSP

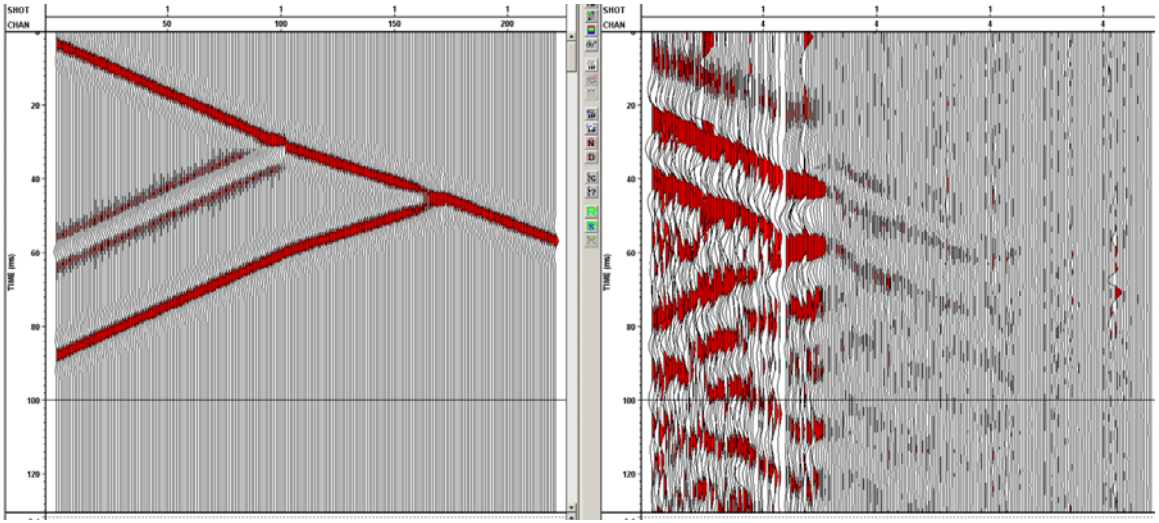
• Three layers model idea from 2D seismic near surface velocity model.

• Vp is from sonic log reading.

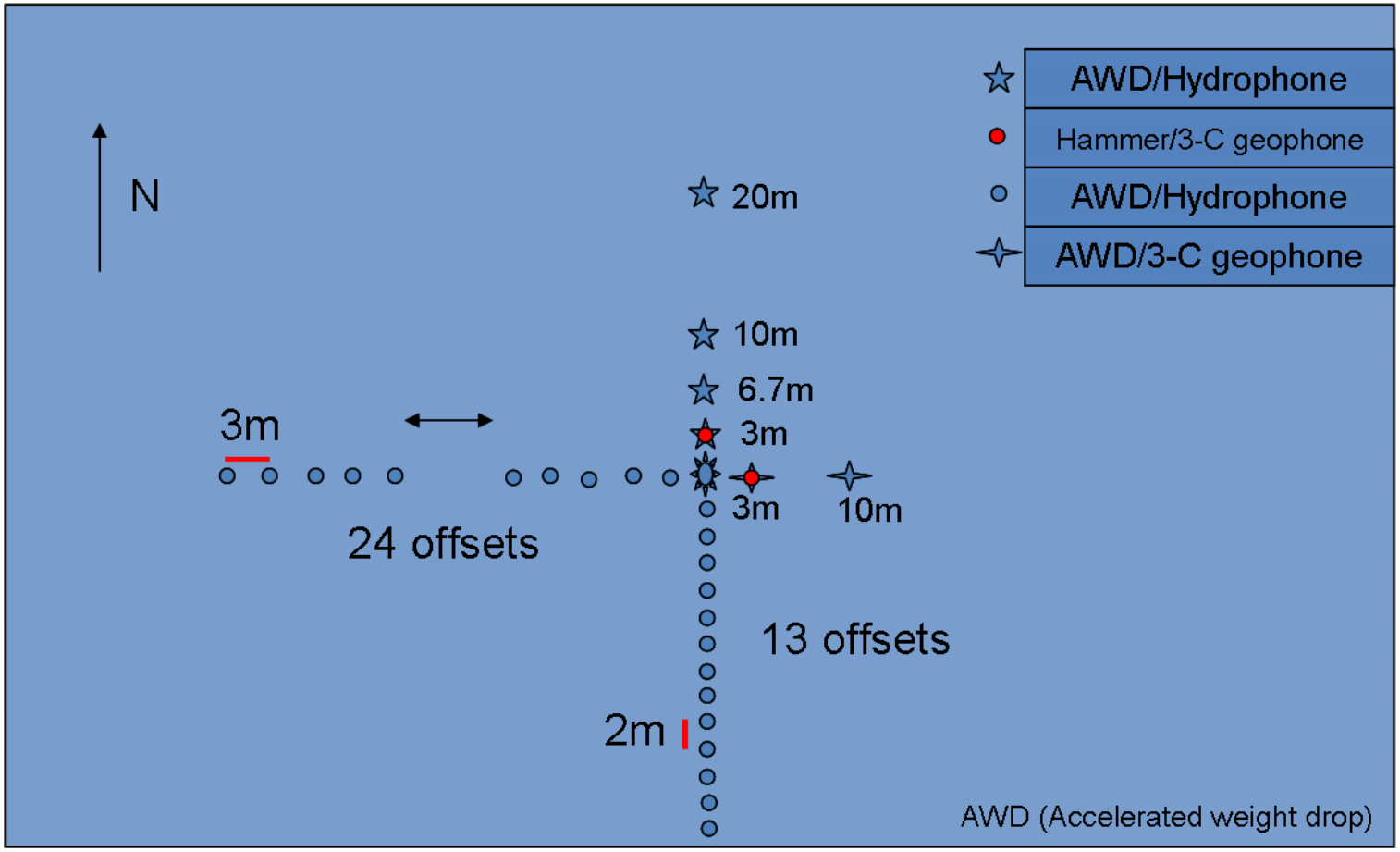
• Vs is calculated from G. Nottis's equation.
$V_s = 626.38*D^{0.2239}$
D is depth in ft, Vs in ft/s

• Density is calculated from O. Uyanik's equation.
$\rho = 16 + 0.002Vp$
ρ in g/cc, Vp in ft/s





Base map of the well GB-1 VSP survey



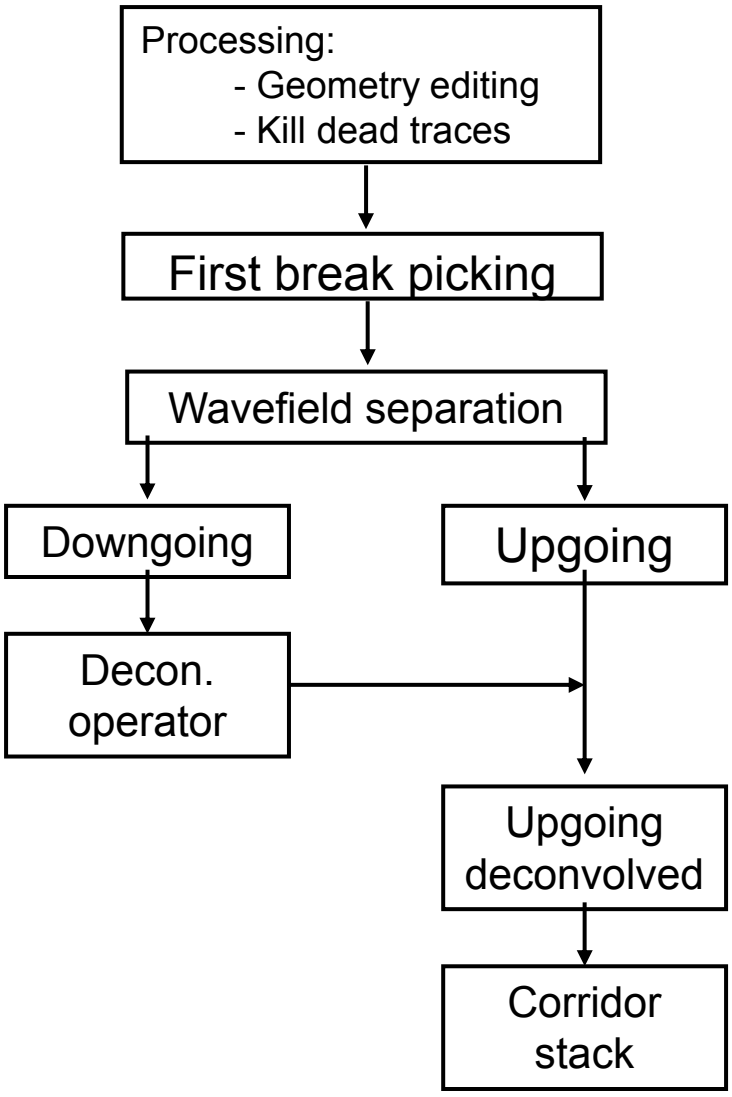
VSP processing workflow

- The first break pick for the downgoing wavefield is used to get the travel time, which can be inverted to get the interval velocity.

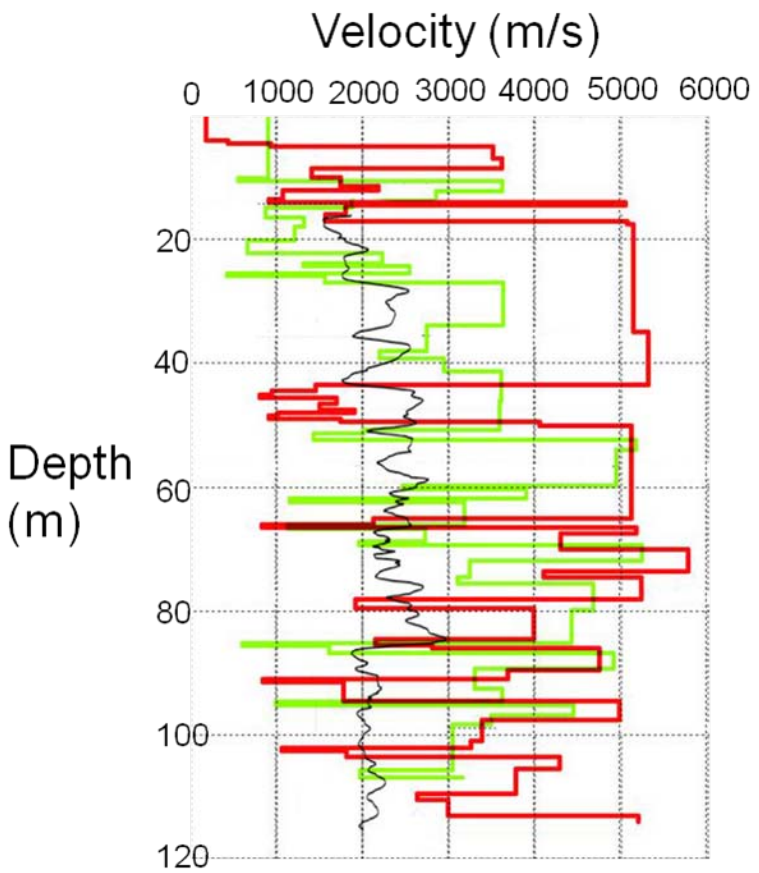
- Wavefield separation is achieved by applying a median filter to subtract the downgoing wavefield from the total traces.

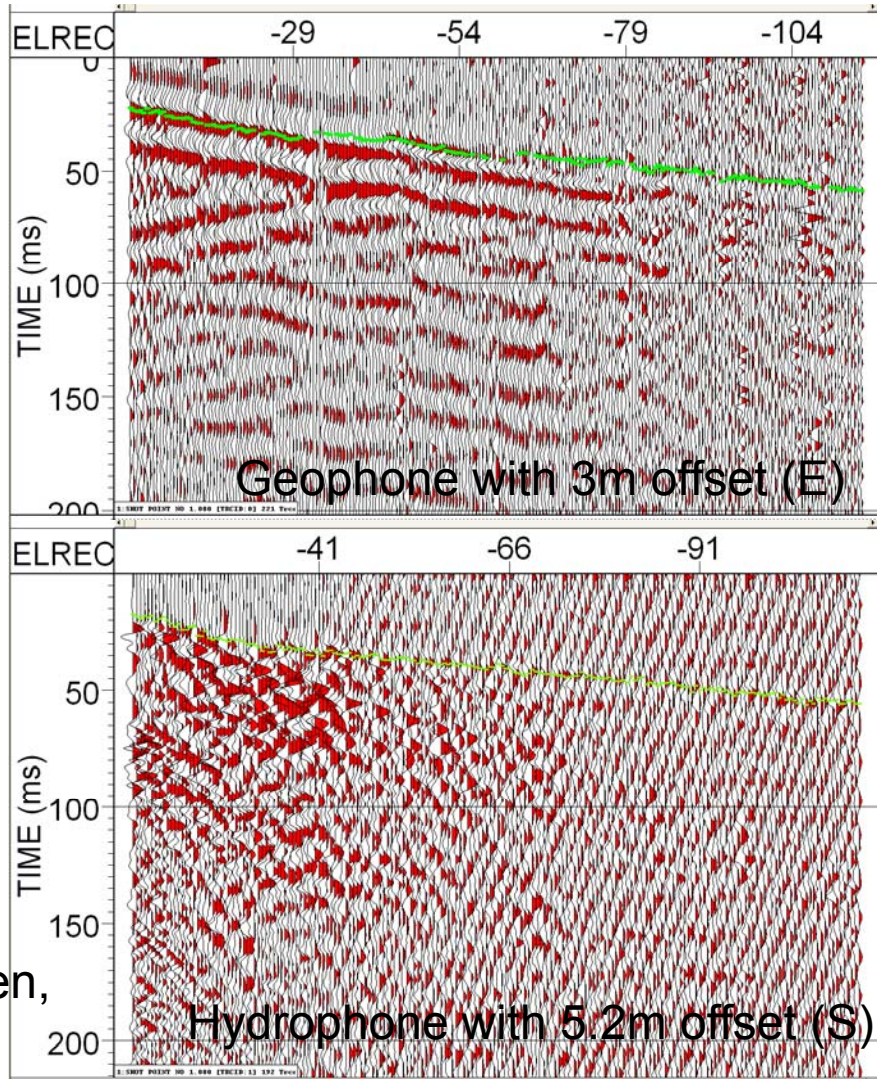
- The VSP deconvolution operator is designed from downgoing wavefield and applied to the upgoing wavefiled. This is done by removing the source signature and downgoing multiples.

- The corridor stack is the window along the edge to get the final VSP reflections to avoid noise.



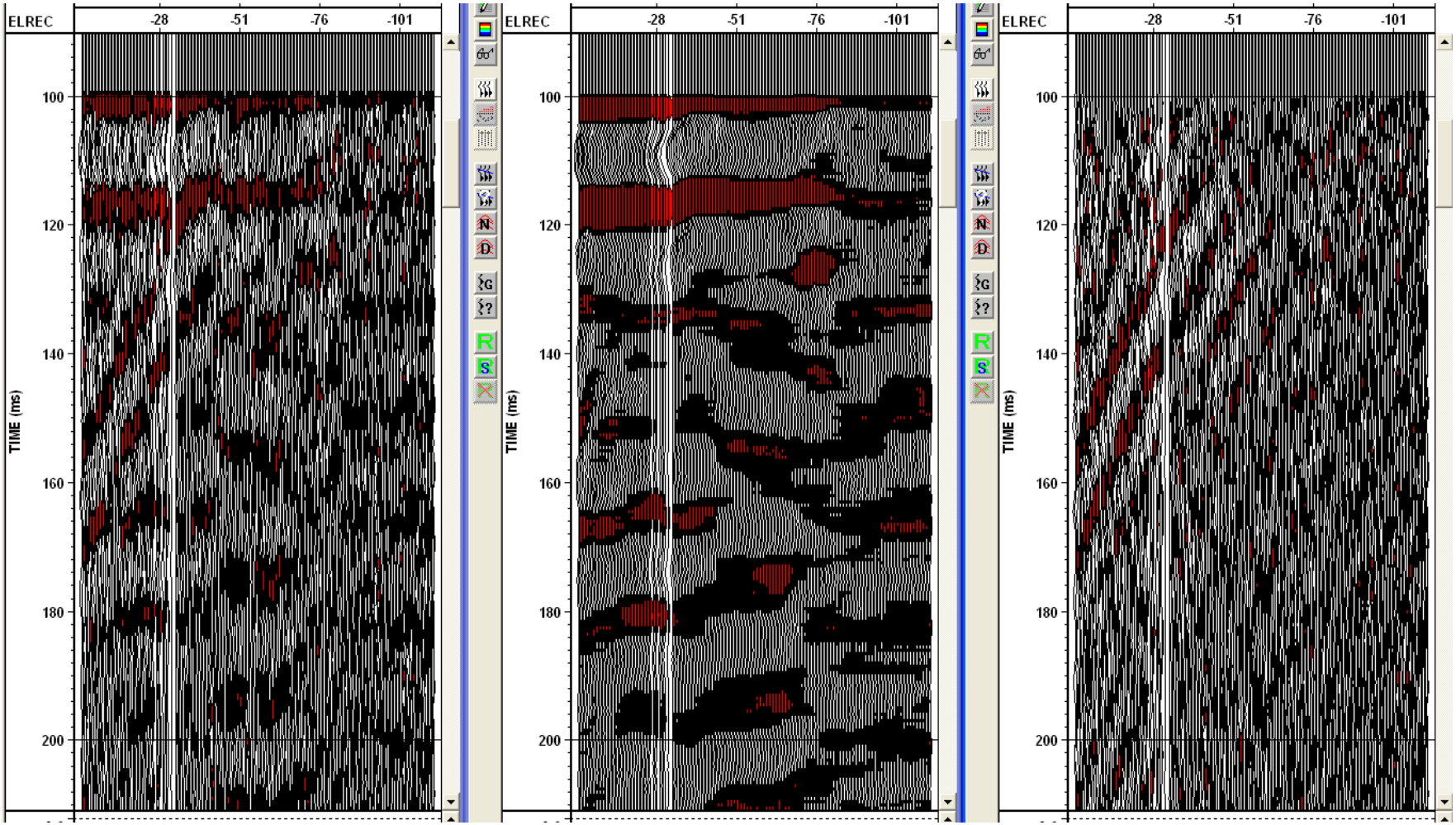
VSP geometry edit and first break pick





Geophone interval velocity shows in red,
Hydrophone interval velocity shows in green,
Sonic log shows in black.

Field separation (displayed with Ormsby filter & AGC)

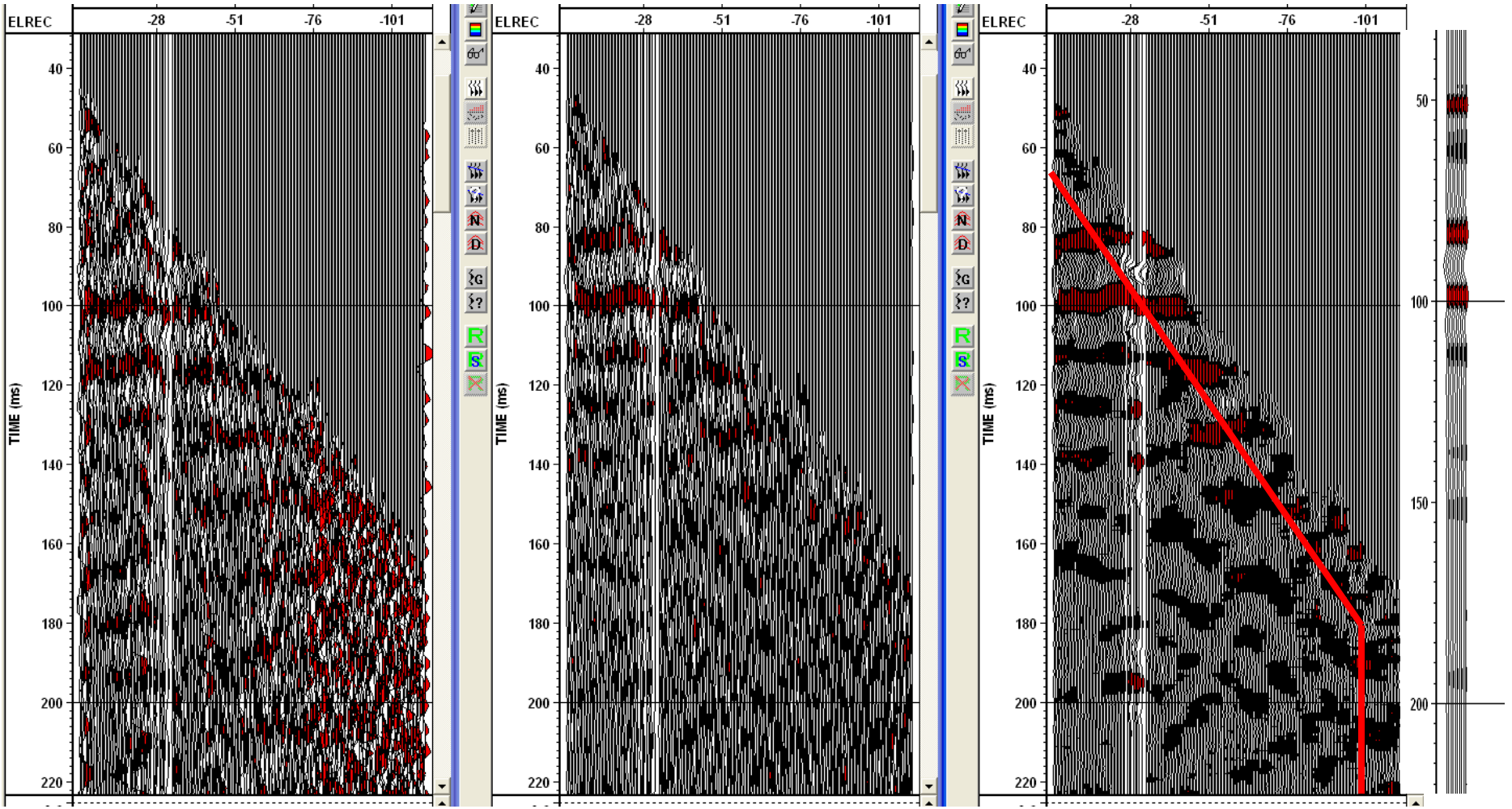


Total wavefield

Downgoing wavefield

Upgoing wavefield

Deconvolution (displayed with Ormsby filter & AGC)



Before Decon.

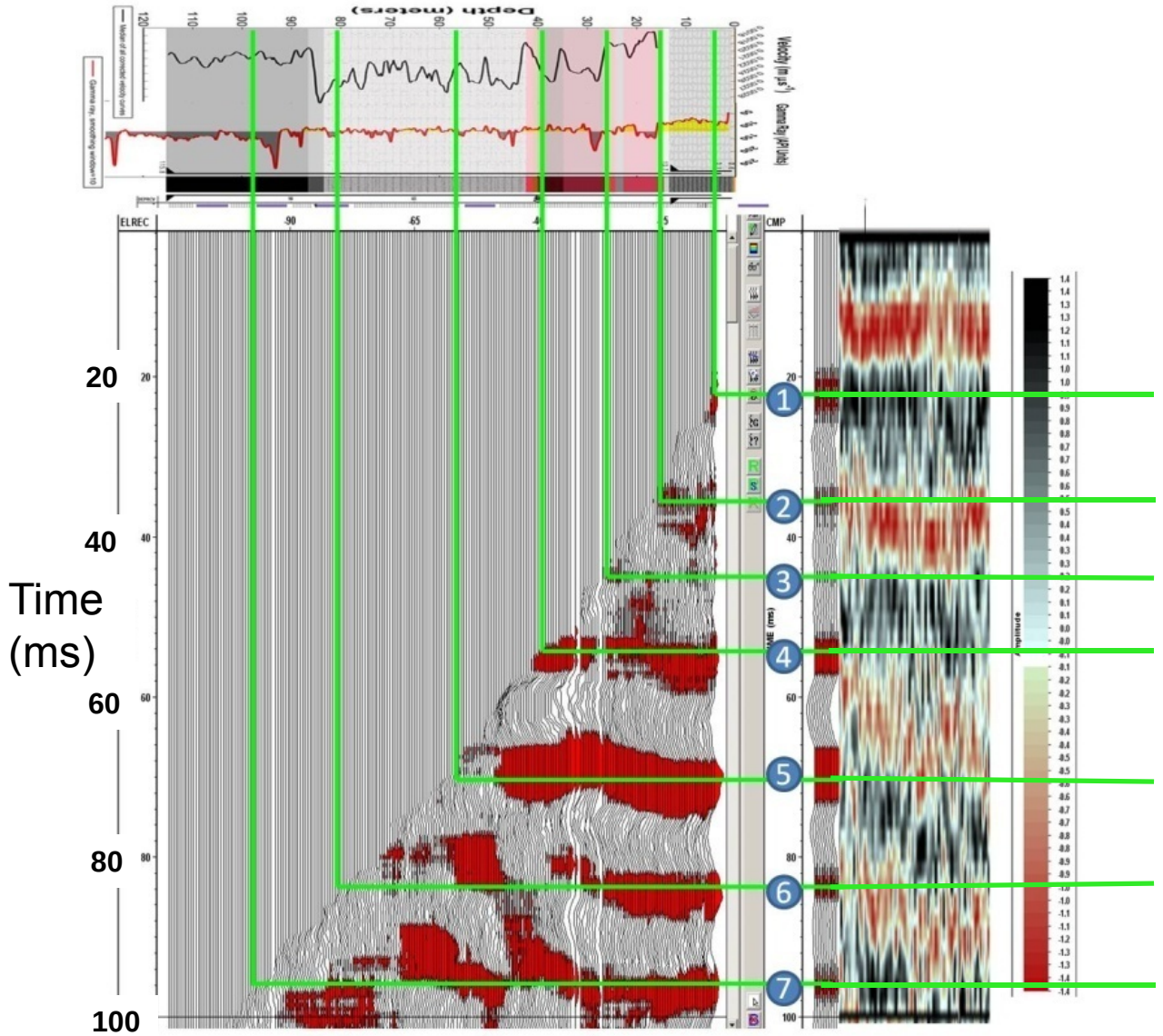
After Decon.

Flatten

Corridor stack

VSP L-plot

- Event 2 and 3 are interpreted as two glacial deposits.
- Event 1 maybe a glacial deposits, but need more geophysical data to support.
- Event 4 and 6 are interpreted as boundary of glacial to upper Madison LS, and upper Madison LS to lower Madison LS (black low velocity layer).
- Event 5 and 7 are perforation zones.



Conclusion

- Depth of glacial layers are 15m and 25m, at 5m may have another one.
- During Pinedale glaciations at least has two warm periods.
- The geophysical signatures of water is shows on VSP data as event 5 and 7.

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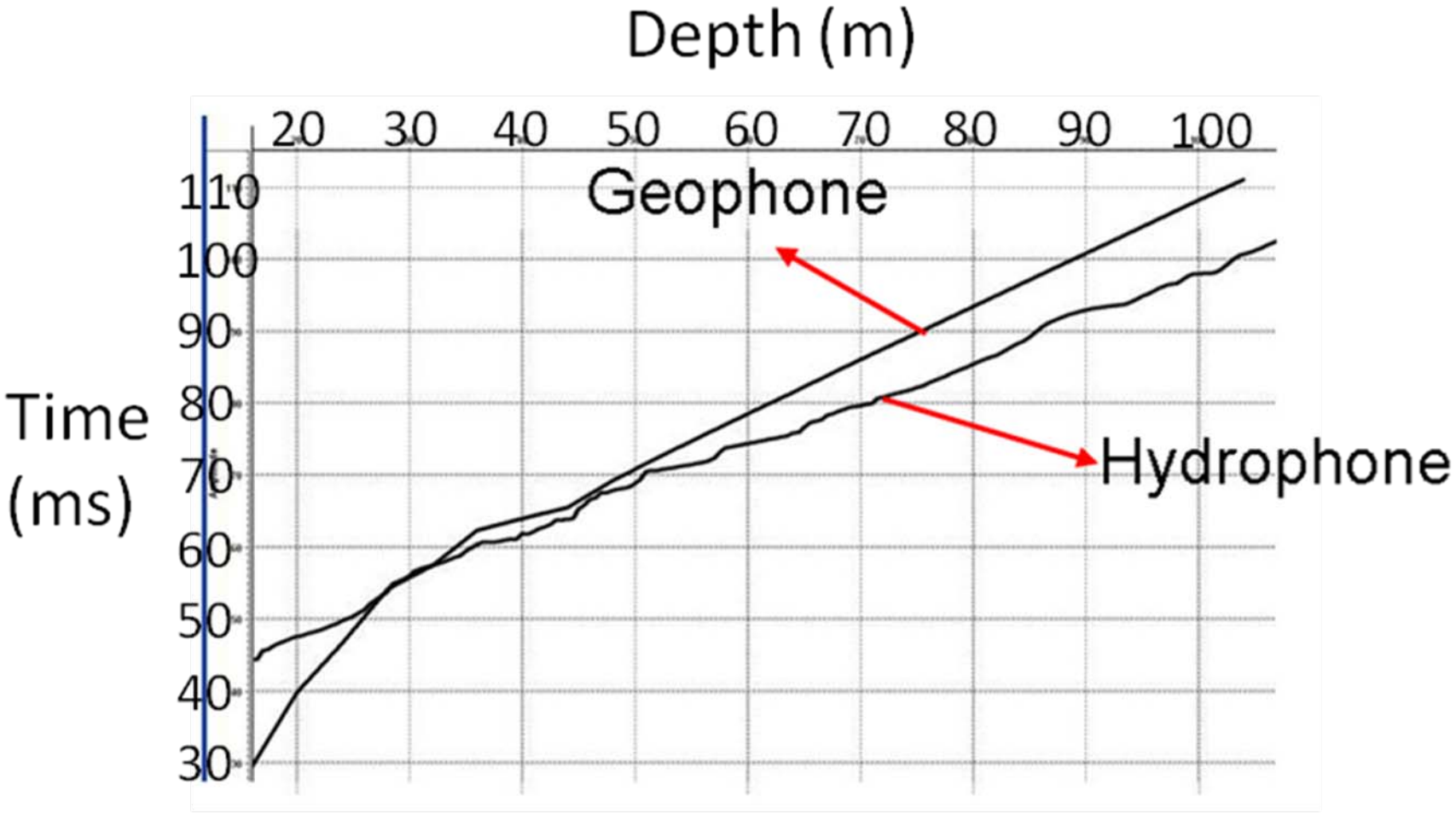
Thanks!

GEDCO

Schlumberger

Two way time to depth curve



VSP acquisition Equipment

- Geode seismic recorder (from Geometrics Comp.) is 3.6kg weight, available with 24 channels for transmitting seismic signal from 24 geophones.
- Downhole 3 component geophone to receive seismic signal.
- Accelerated weight drop (AWD) to create seismic signal.
- Hydrophone 24 level with 2m interval.