T-squared gain for deep marine seismograms

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SEP progress report 149
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SETTING

Those of us with even a modest background in seismic theory feel annoyed every time we see somebody using AGC.

At SEP, Kjartansson's t-squared gain has held back the pressure somewhat, but there are constant irritants. For example, t can be taken to another power (no theory for that). People are constantly playing with the clip percentile. Even worse, people display their area of interest (such as a shadow zone) far below clip threshold.

It's an example of "tragedy of the commons" that it's hard to get any help in building a plot scaling utility that we'd all benefit from.

PROBLEM

Kjartansson's t-squared gain was not designed for deep marine data where waves take a lot of time in water (high Q medium)

GOALS

Scale seismic data display so it is visible at all times and offsets.

Want a scaling function, like Kjartansson's t-squared, independent of parameters (except easily known parameters like offset and water-depth)

A general purpose scaling function of time and space
not tailored to a particular data set,
but useful for most data sets.

Reduce need for AGC, for clip, and for mute.

Potentially a default weighting function for inverse problems.

Kjartansson t-squared review

Spherical divergence ---> one power of t

Constant Q absorption ---> another power of t

$$e^{-|\omega|(z/v)/Q}$$

$$\begin{aligned} .05 &\approx e^{-3} = e^{-|\omega|_{\text{cutoff}}(z/v)/Q} \\ \omega_{\text{cutoff}} &= 3Qv/z = 3Q/t \end{aligned}$$

Signal strength proportional to cutoff frequency.

Jon's first guess for deep marine data

Let t_e be the "first earth arrival."

$$G(t) = \begin{cases} t & \text{for } t < t_e \\ t^2/t_e & \text{for } t > t_e \end{cases}$$

Second guess

$$G(t) = \begin{cases} 0 \times t & \text{for } t < t_e \\ (t - t_e)t & \text{for } t > t_e \end{cases}$$

Need the "$0\times$" for gain continuity.

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Best in theory. Worst in practice.

A gain of zero at the water bottom!

Any suggestions?

Decon friendly gain (first friend suggestion)

$$G(t) = \begin{cases} 1 & \text{for } t < t_e \\ t^2/t_e^2 & \text{for } t > t_e \end{cases}$$

Where water depth increase on a traverse,

water bottom arrivals do not get their needed geometrical t gain.

Continuity gain (2nd friend suggestion)

$$G(t) \;=\; \begin{cases} t & \text{for } t < t_e \\ t + (t - t_e)^2/t_e & \text{for } t > t_e \end{cases}$$

Linear before $t = t_e$ and quadratic after.
Continuous in value and derivative at $t = t_e$.

Nice but we don't need derivative continuity.

How are we going to fix this?

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The problem is the infinite bandwidth assumption.

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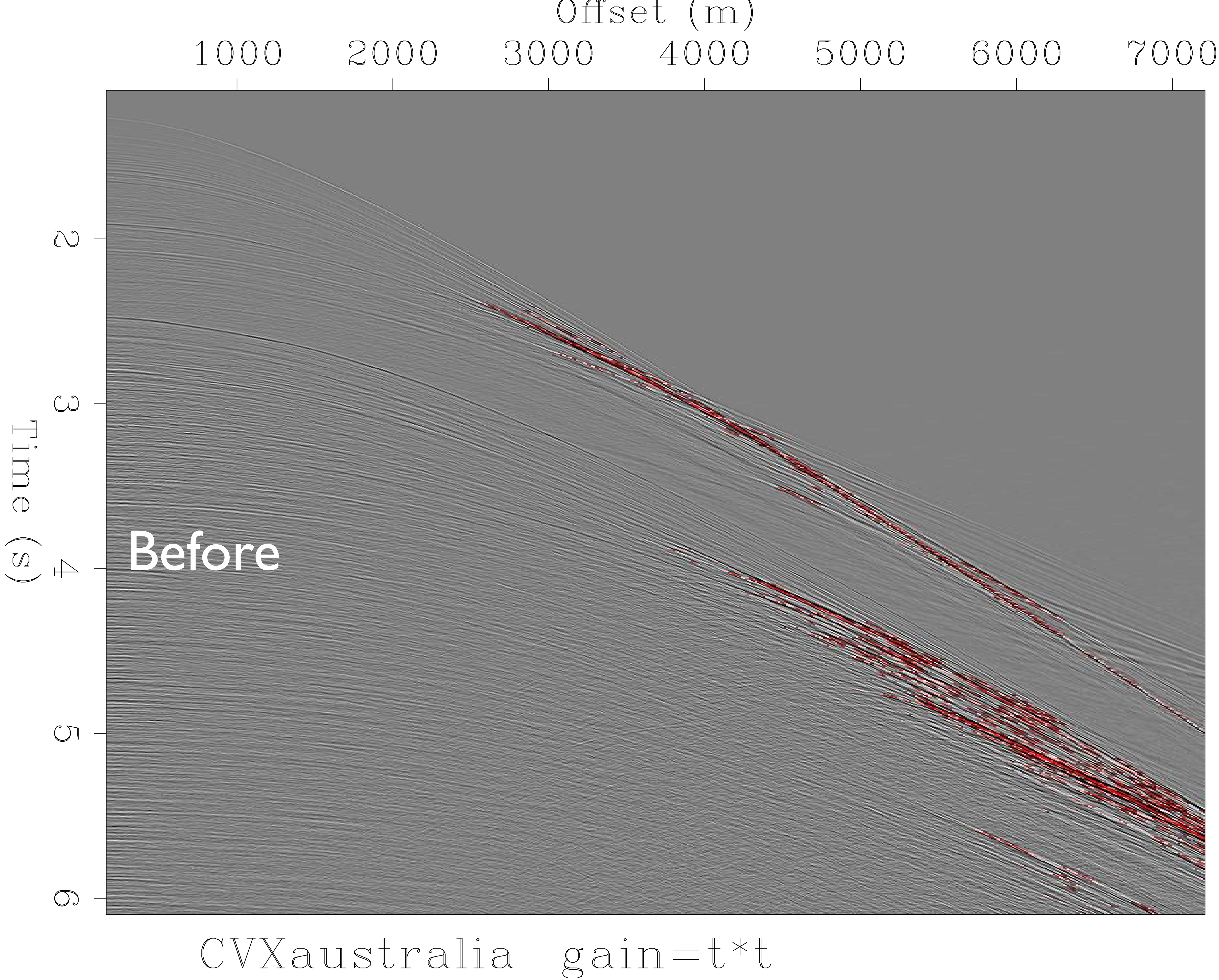
ASIDE

Hey! If we could estimate Delta t from the data itself (by asking for the most uniform output) we'd have an estimate of Q/f. Is that an estimate of Q?

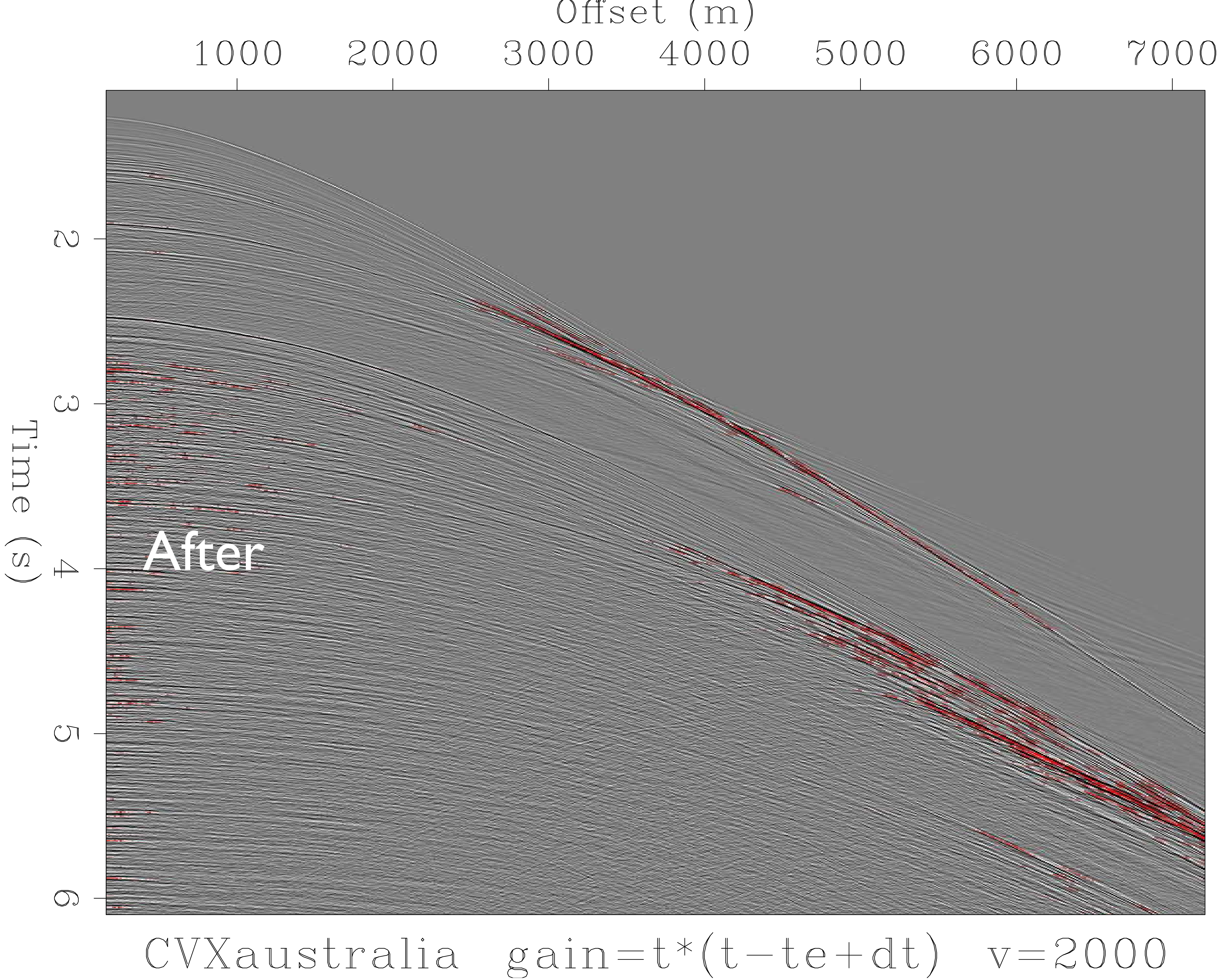
The answer!

$$G(t) = \begin{cases} 0 & \text{for } t < t_e - \Delta t \\ (t - t_e + \Delta t)t & \text{for } t > t_e - \Delta t \end{cases}$$

$$\Delta t \approx 350\text{ms}$$



Offset (m)
1000
2000
3000
4000
5000
6000
7000
Time (s)
2
3
4
5
6
Before
CVXaustralia gain=t*t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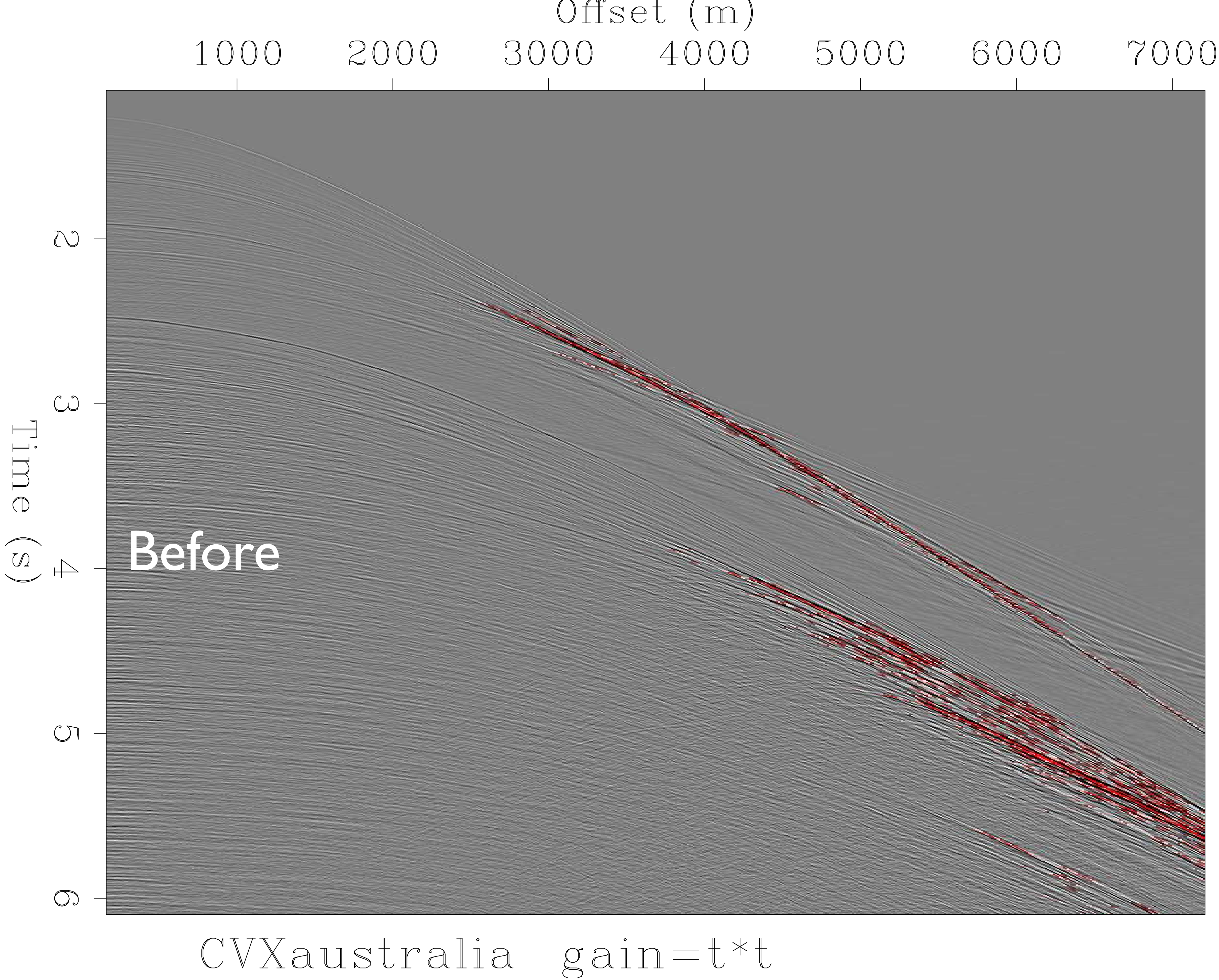
After
CVXaustralia gain=t*(t-te+dt) v=2000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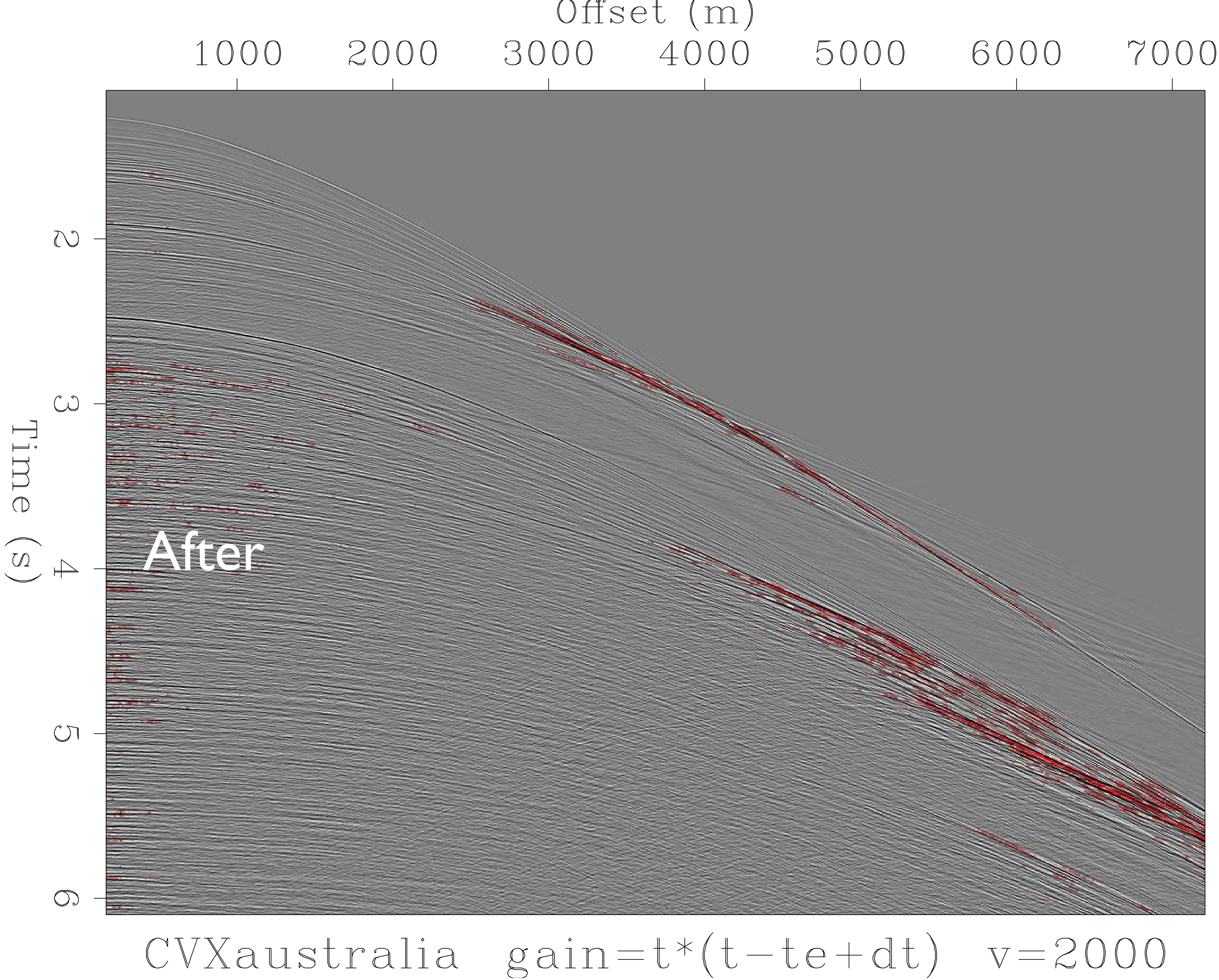
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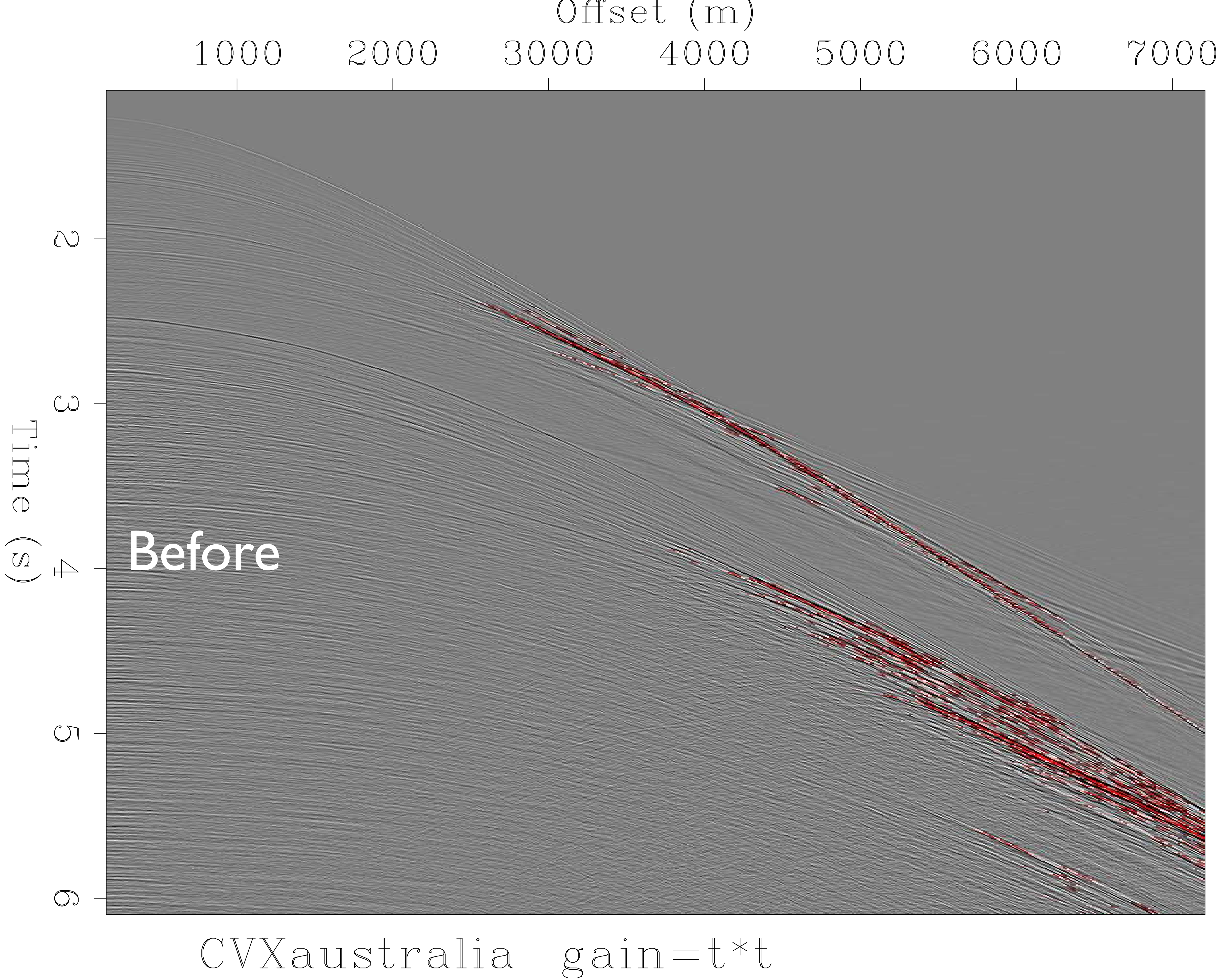
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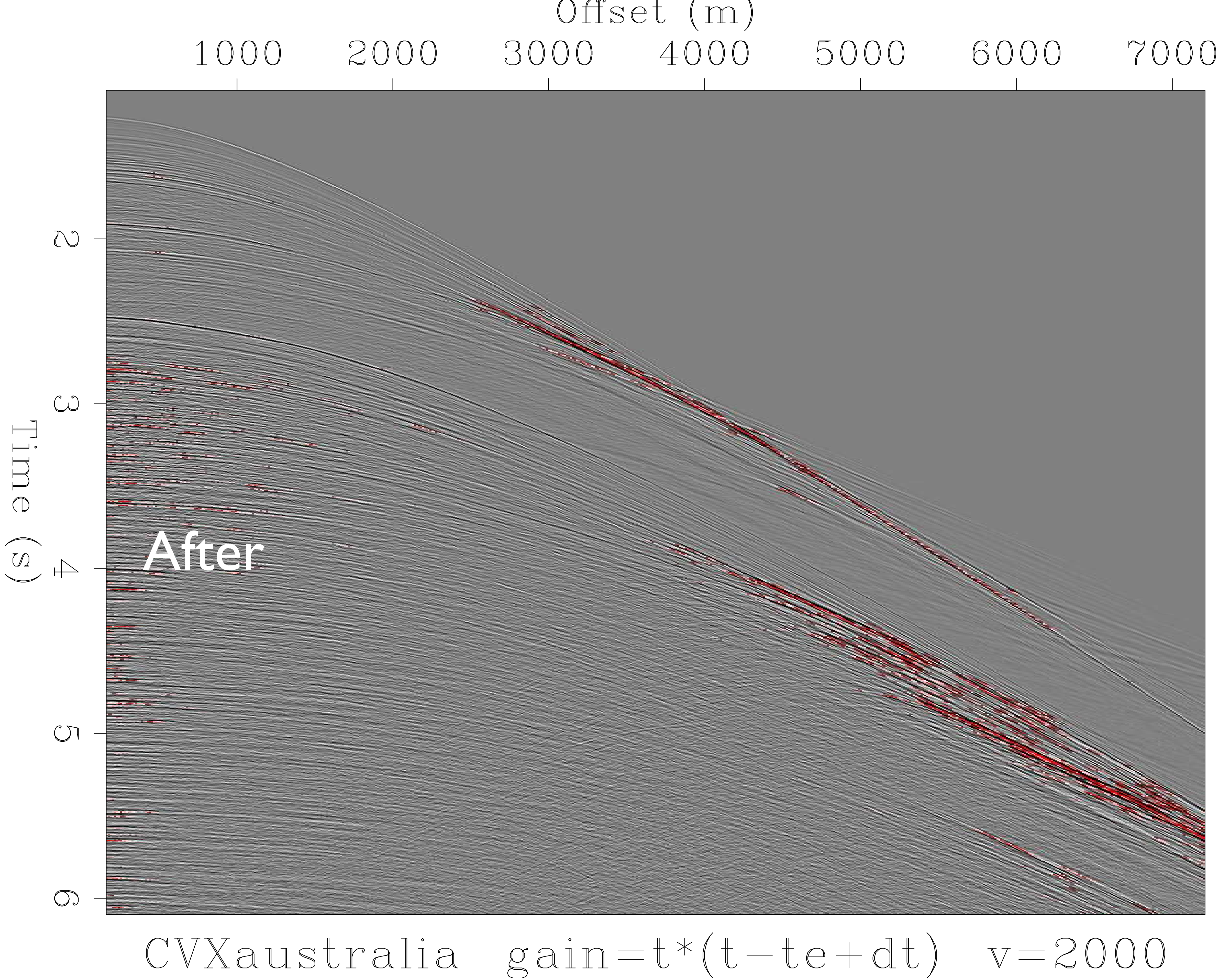
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Apologies

- Need data variety (more data) for test cases.
- Need data with less multiple energy
- Need water bottom measured instead of guessed from 1.2sec+NMO(x)
- How about code to deduce Δt from the data itself?
- Should acknowledge water-velocity critical angle

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