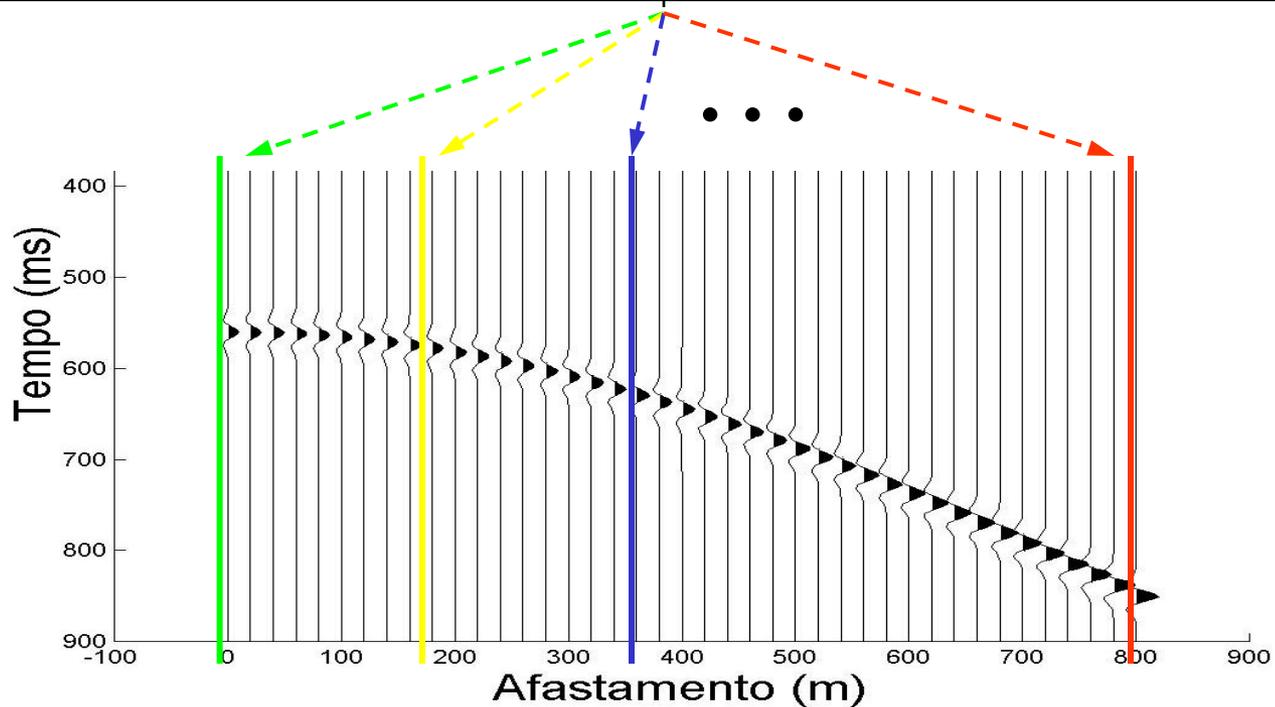
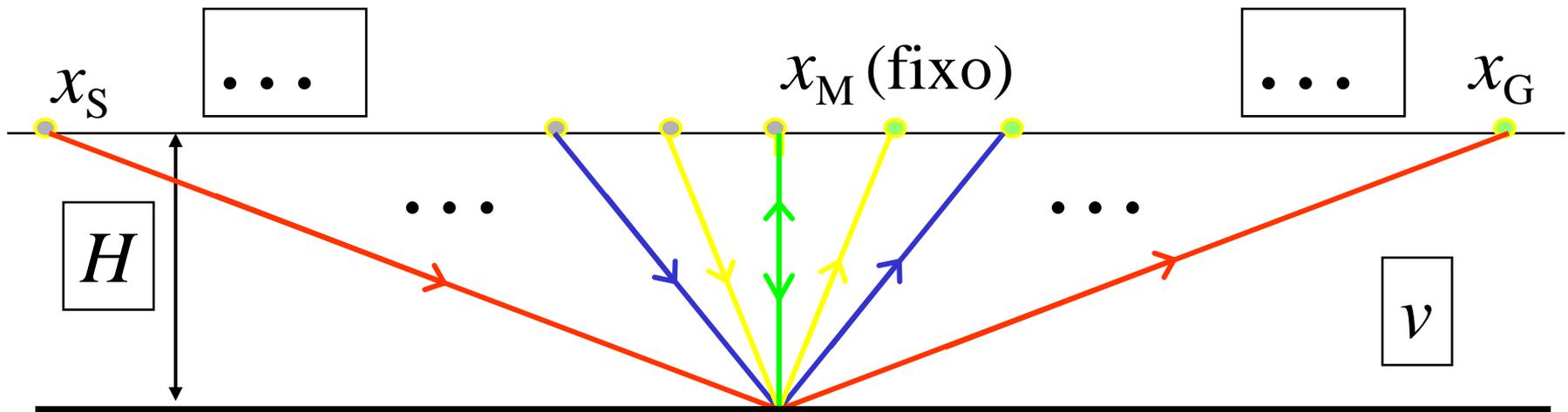
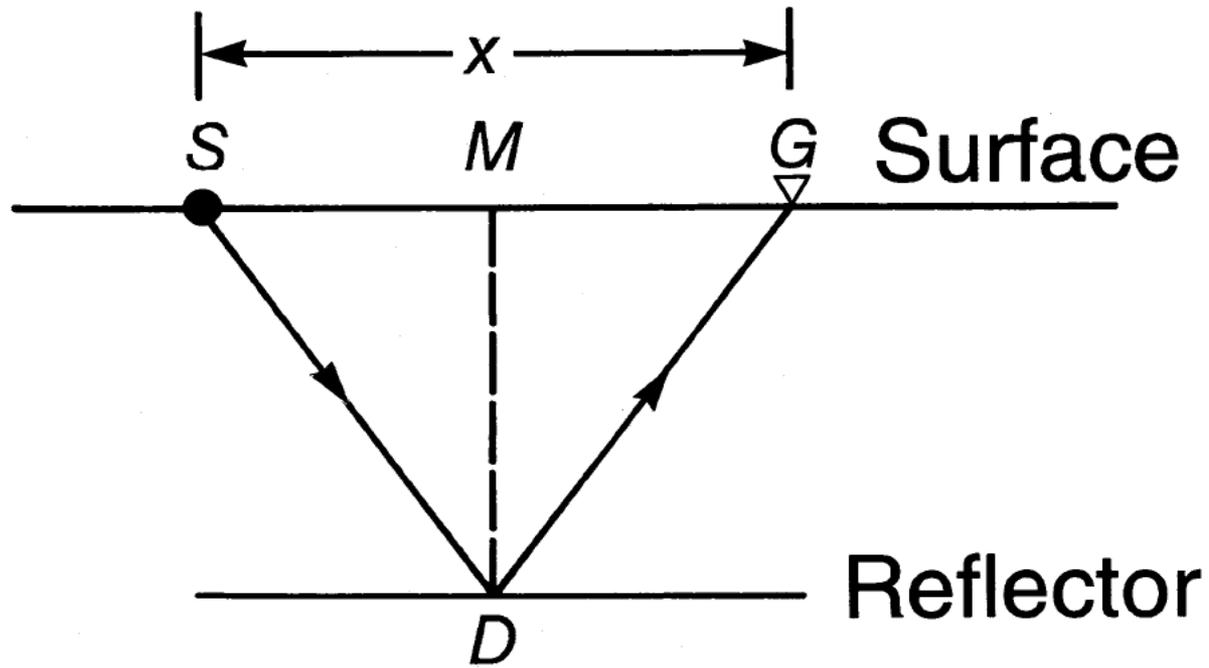


Tempo de trânsito (CMP ou CDP)





$$t^2 = t_0^2 + \frac{x^2}{v^2}$$

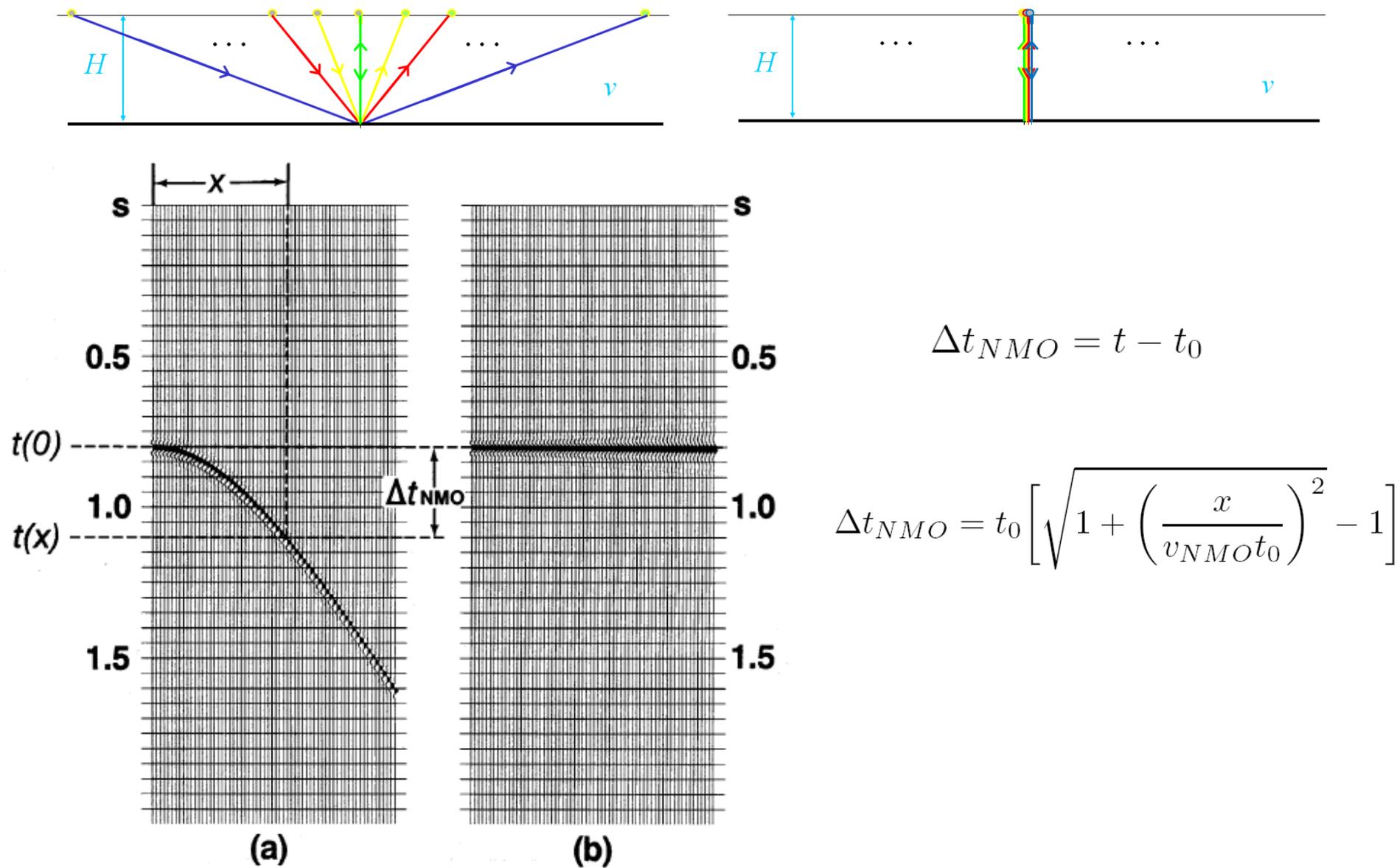
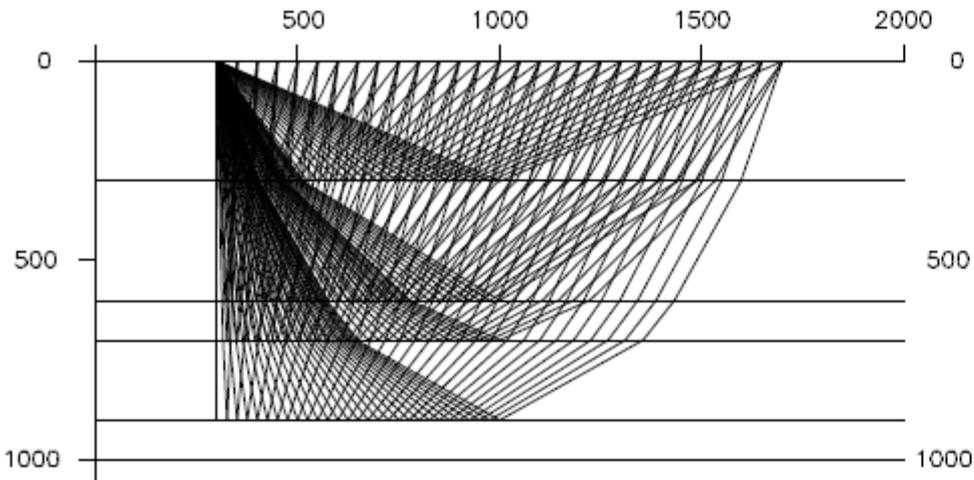
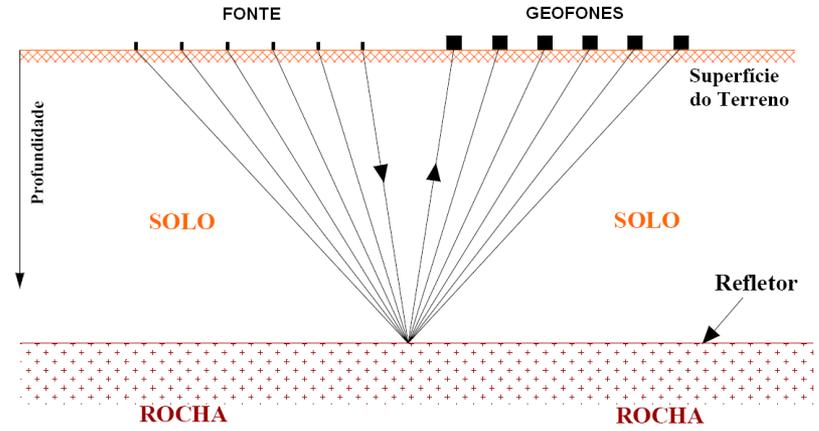
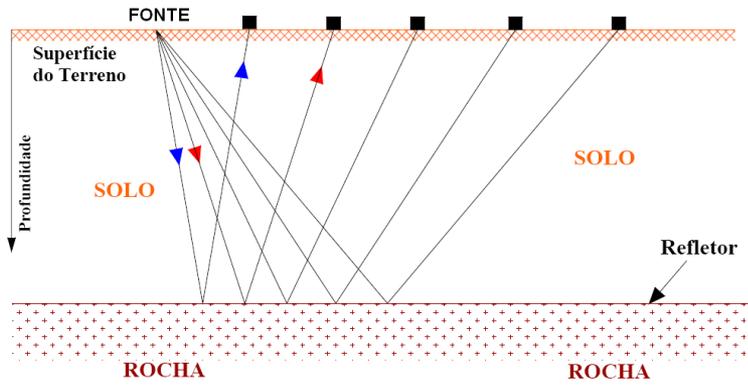
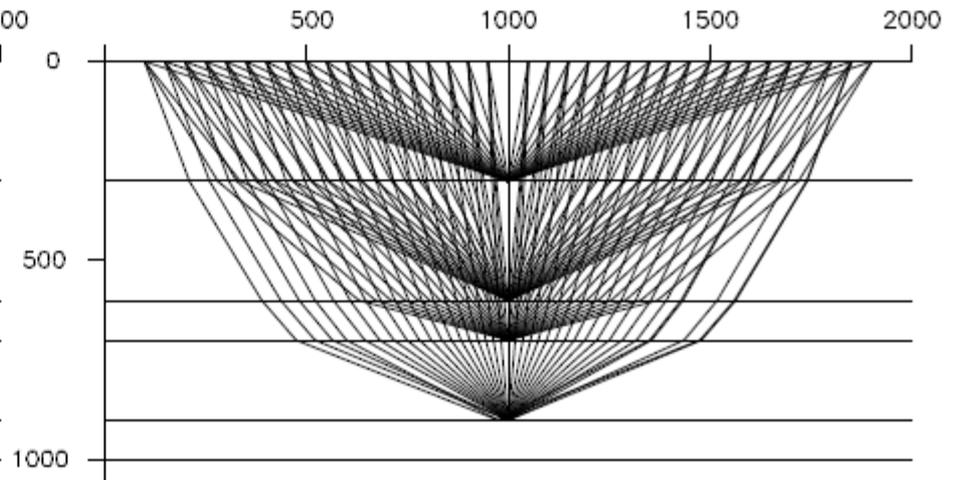


FIG. 3.1-3. NMO correction (equation 3-2a) involves mapping nonzero-offset traveltime t onto zero-offset traveltime t_0 . (a) Before and (b) after NMO correction.



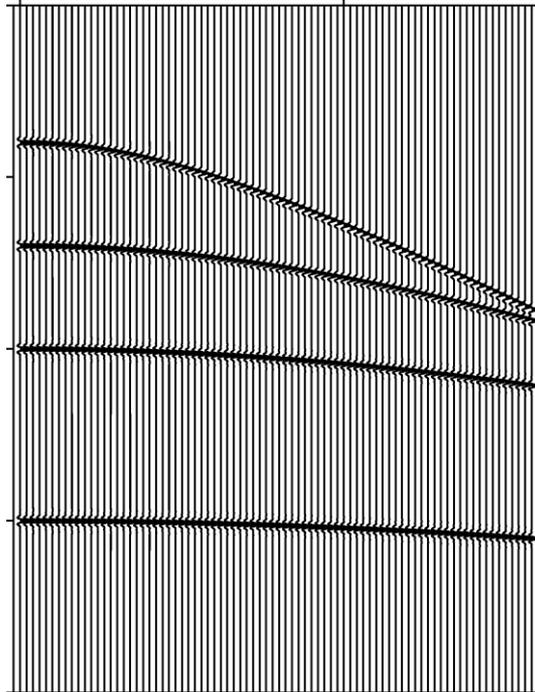
shotflat



cmpflat

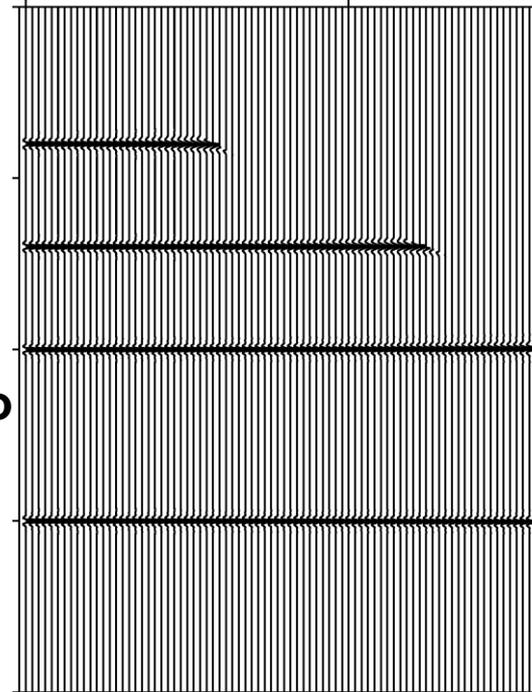
$$t^2 = t_0^2 + \frac{x^2}{v_{rms}^2}$$

Objetivo da análise de velocidades



Hipérbole de reflexão

→
correção
NMO



horizontalizadas

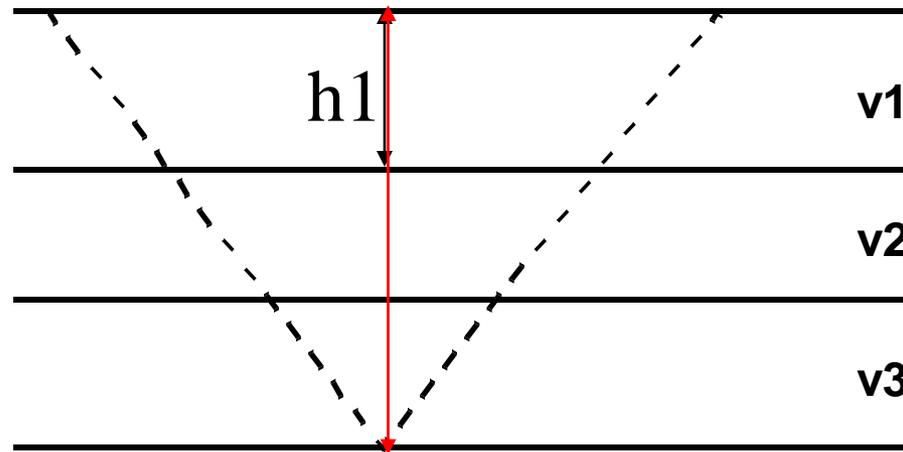
→



empilhamento

correção Normal Moveout

Diversas camadas horizontalizadas

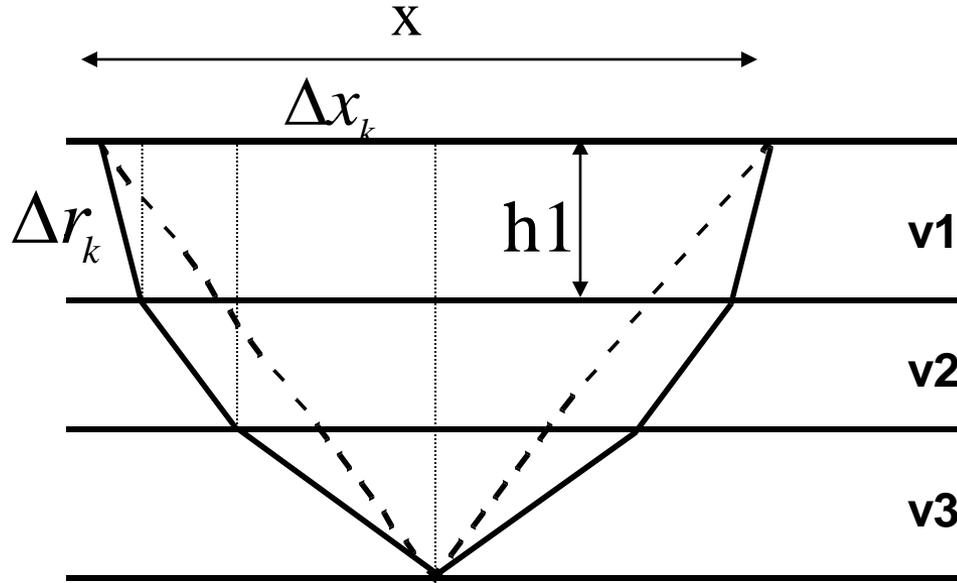


Considerando incidência normal ($x=0$)

$$t_{(0,n)} = \sum_{k=1}^{n-1} t_k = 2 \sum_{k=1}^{n-1} \frac{h_k}{V_k}$$

$$V_{a,n} = \frac{\sum_{k=1}^{n-1} V_k t_k}{t_{(0,n)}} = \frac{2 \sum_{k=1}^{n-1} h_k}{t_{(0,n)}}$$

Diversas camadas horizontalizadas



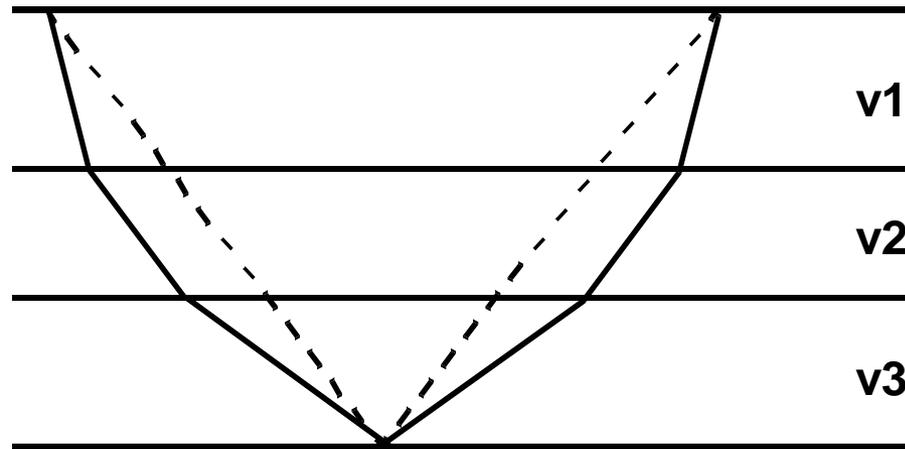
Considerando $x > 0$ e refrações nas interfaces

$$t_{(x,n)} = 2 \sum_{k=1}^n \frac{\Delta r_k}{V_k} = 2 \sum_{k=1}^n \frac{(\Delta x_k^2 + h_k^2)^{1/2}}{V_k}$$

$$x = 2 \sum_{k=1}^n \Delta x_k$$

$$\Delta x_k = ?$$

Diversas camadas horizontalizadas



$$t_{(x,n)}^2 = c_1 + c_2 x^2 + c_3 x^4 + \dots + c_j x^{2j-2} + \dots$$

onde os coeficientes c_1, c_2, \dots dependem das espessuras (h_1, h_2, \dots, h_n) e das velocidades (v_1, v_2, \dots, v_n) das camadas

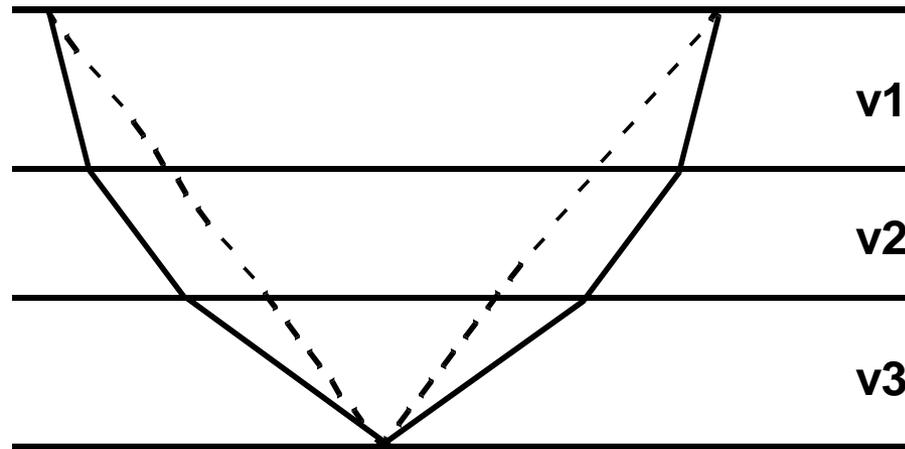
Para distâncias $x_n \sim h_n$ os 2 primeiros termos da expressão anterior permitem a precisão necessária para os propósitos da sísmica de exploração

$$t_{(x,n)}^2 = c_1 + c_2 x^2$$

$$c_1 = \left(\sum_{k=1}^{n-1} t_{(0,k)}^2 \right) = t_{(0,n)}^2$$

$$c_2 = \frac{\sum_{k=1}^{n-1} t_{(0,k)}}{\sum_{k=1}^{n-1} t_{(0,k)} V_k^2} = \frac{1}{\overline{V_n^2}} \quad \text{ou} \quad V_{RMS}^2 = \frac{\sum_{k=1}^{n-1} V_k^2 t_k}{t_{(0,n)}}$$

Diversas camadas horizontalizadas



$$V_{rms}^2 = \frac{\sum_{i=1}^n v_i^2 t_i}{\sum_{i=1}^n t_i}$$

rms = root-mean-square

V_i = velocidade intervalar

V_{rms} = velocidade média quadrática
ou velocidade de empilhamento
ou velocidade NMO

$$t_i = \frac{2h_i}{v_i}$$

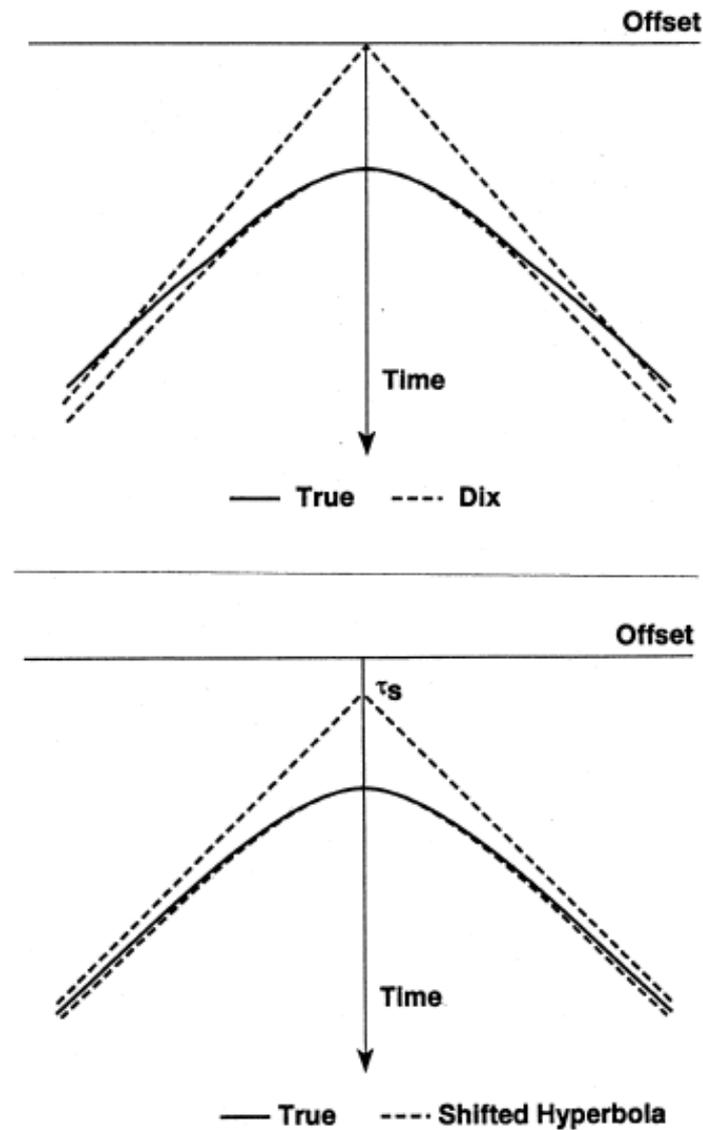
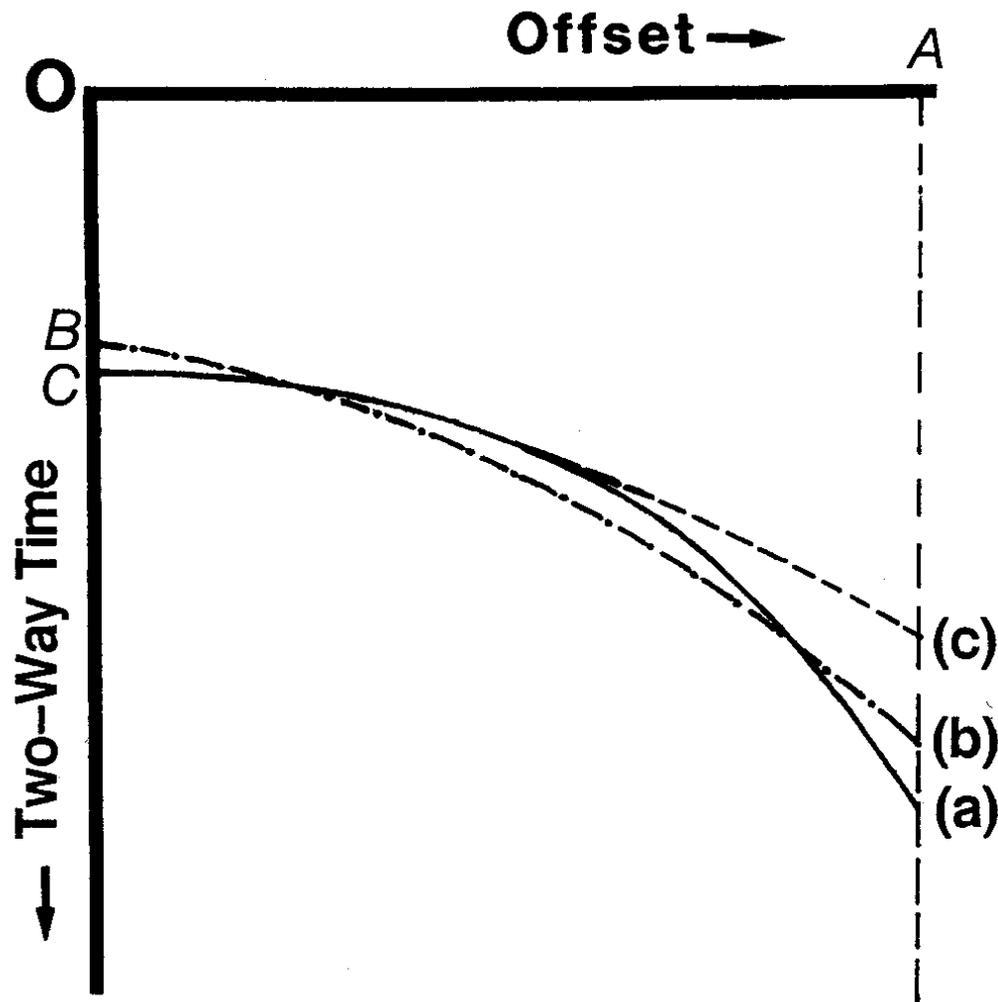


FIG. C-1. Traveltime trajectories based on (top) the hyperbolic equation (C-23) and (bottom) the time-shifted hyperbolic equation (C-14). Compare with the true traveltime trajectory associated with a layered model (Castle, 1994).



The equation for moveout velocity is derived by assuming a small-spread hyperbola. On the other hand, stacking velocity is derived from the best-fit hyperbola over the entire spread length. Here, (a) is the actual traveltime, (b) is best-fit hyperbola over the offset range OA , and (c) is small-spread hyperbola. (Adapted from Hubral and Krey, 1980.)

$$\mathbf{V}_{\text{RMS}} \quad \mathbf{X} \quad \mathbf{V}_{\text{NMO}} \quad \mathbf{X} \quad \mathbf{V}_{\text{STK}}$$

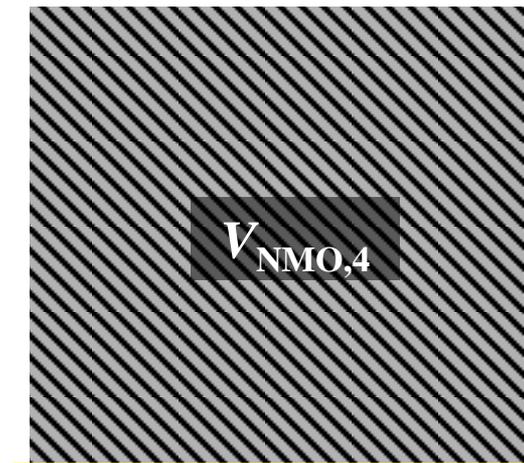
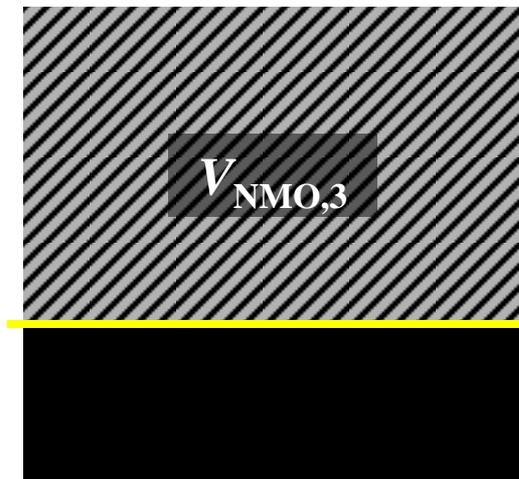
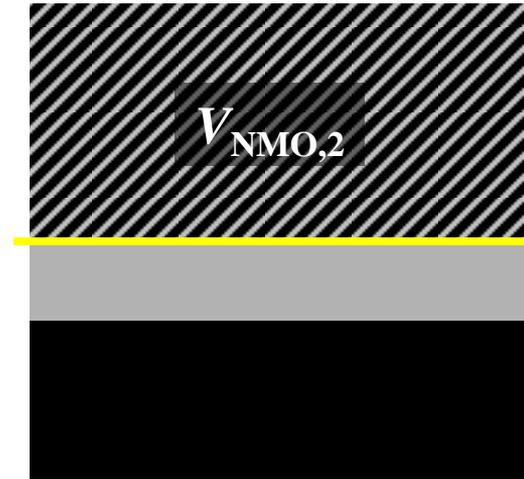
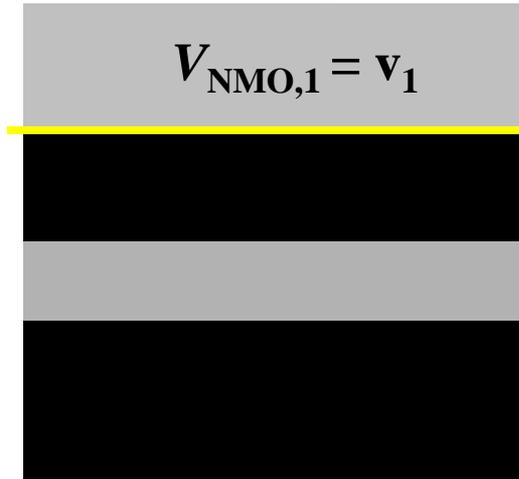
STK = stacking = empilhamento

Correção NMO - multicamadas

No problema de multicamadas a “velocidade NMO” representa a velocidade de uma camada representativa das camadas acima do refletor:



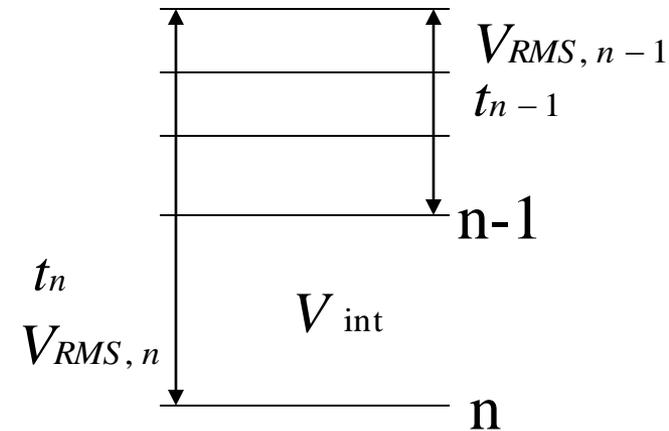
Correção NMO - multicamadas



Fórmula de Dix

Conversão da v_{rms} em velocidade intervalar

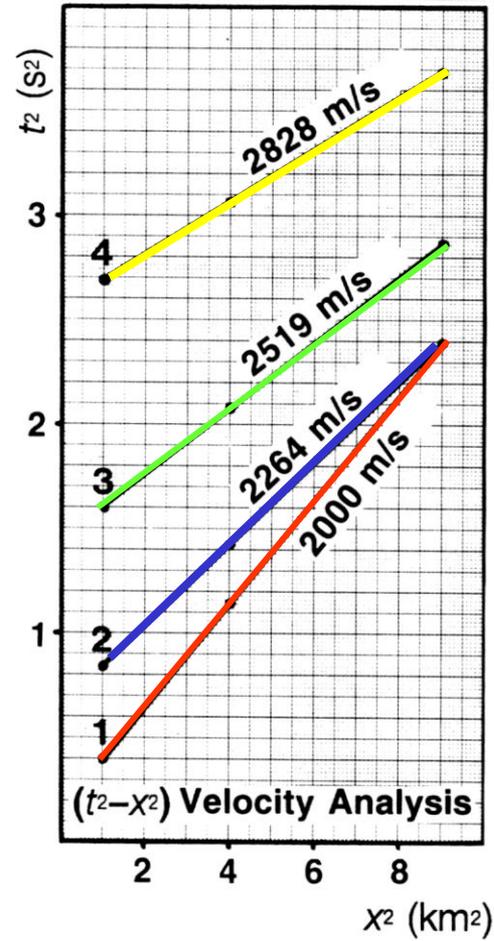
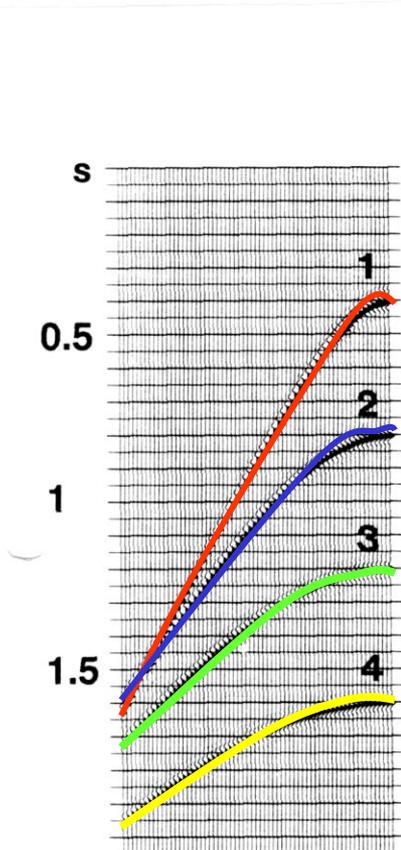
$$V_{int} = \sqrt{\left[\frac{(V_{RMS,n})^2 t_n - (V_{RMS,n-1})^2 t_{n-1}}{t_n - t_{n-1}} \right]}$$



Métodos para análise de velocidades

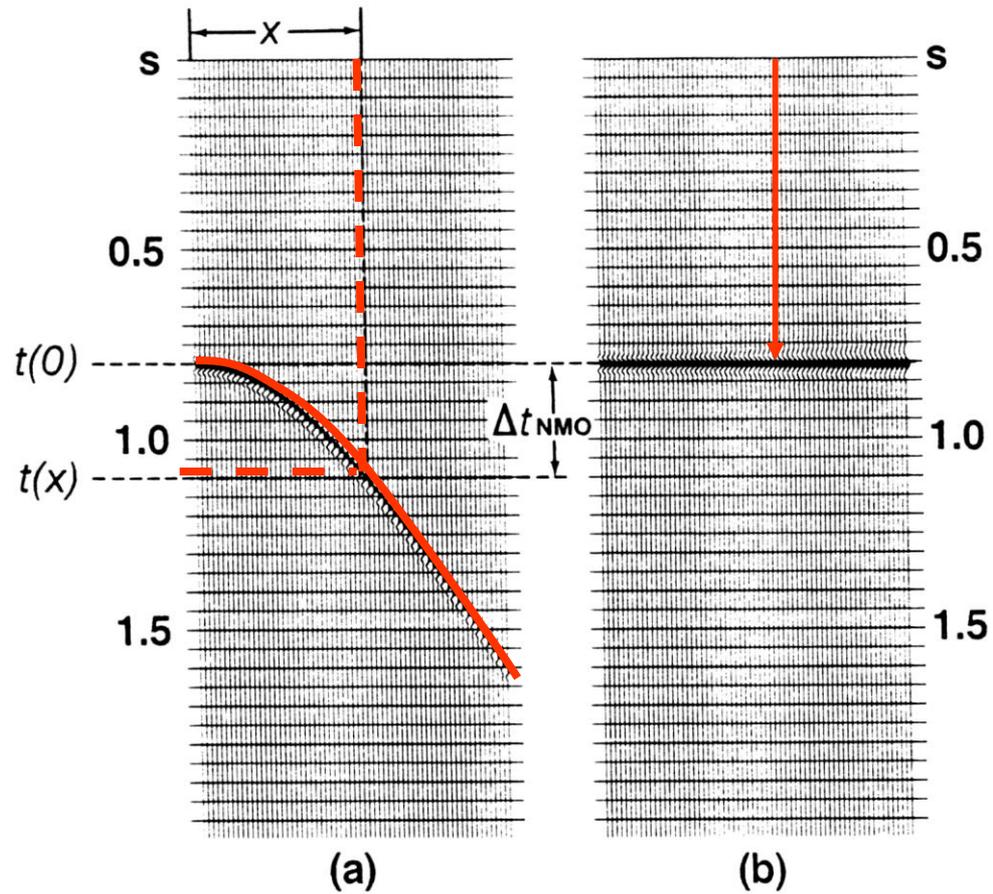
- **Análise x^2-t^2**
- **Métodos que usam a correção NMO:**
 - **CVP - constant velocity panels**
 - **CVS - constant velocity stacks**
- **Análise do espectro de velocidades (semblance)**

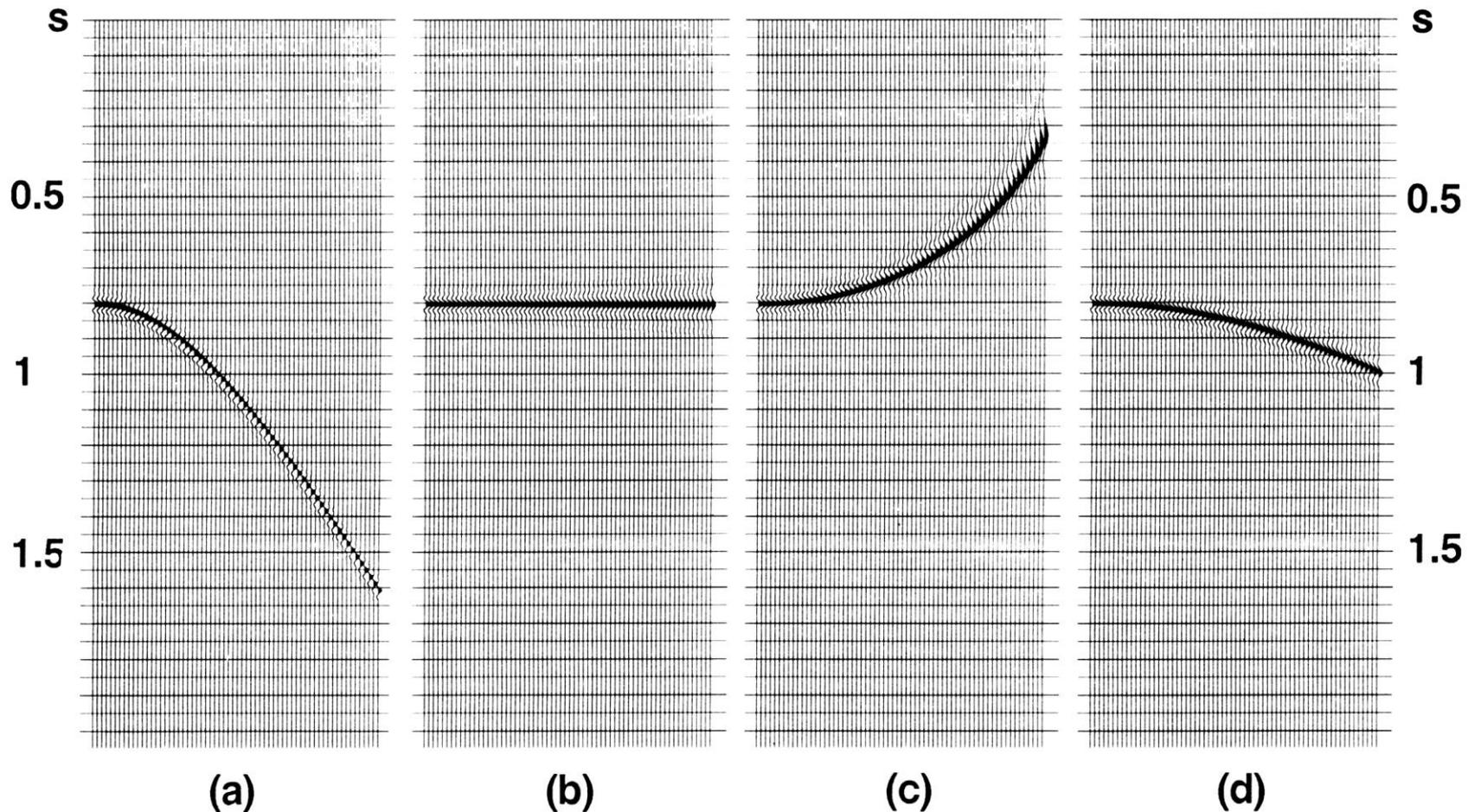
Análise x^2-t^2



$$t^2 = t_0^2 + \frac{x^2}{v_{stack}^2}$$

Métodos que usam a correção NMO





(a) Reflexão não corrigida

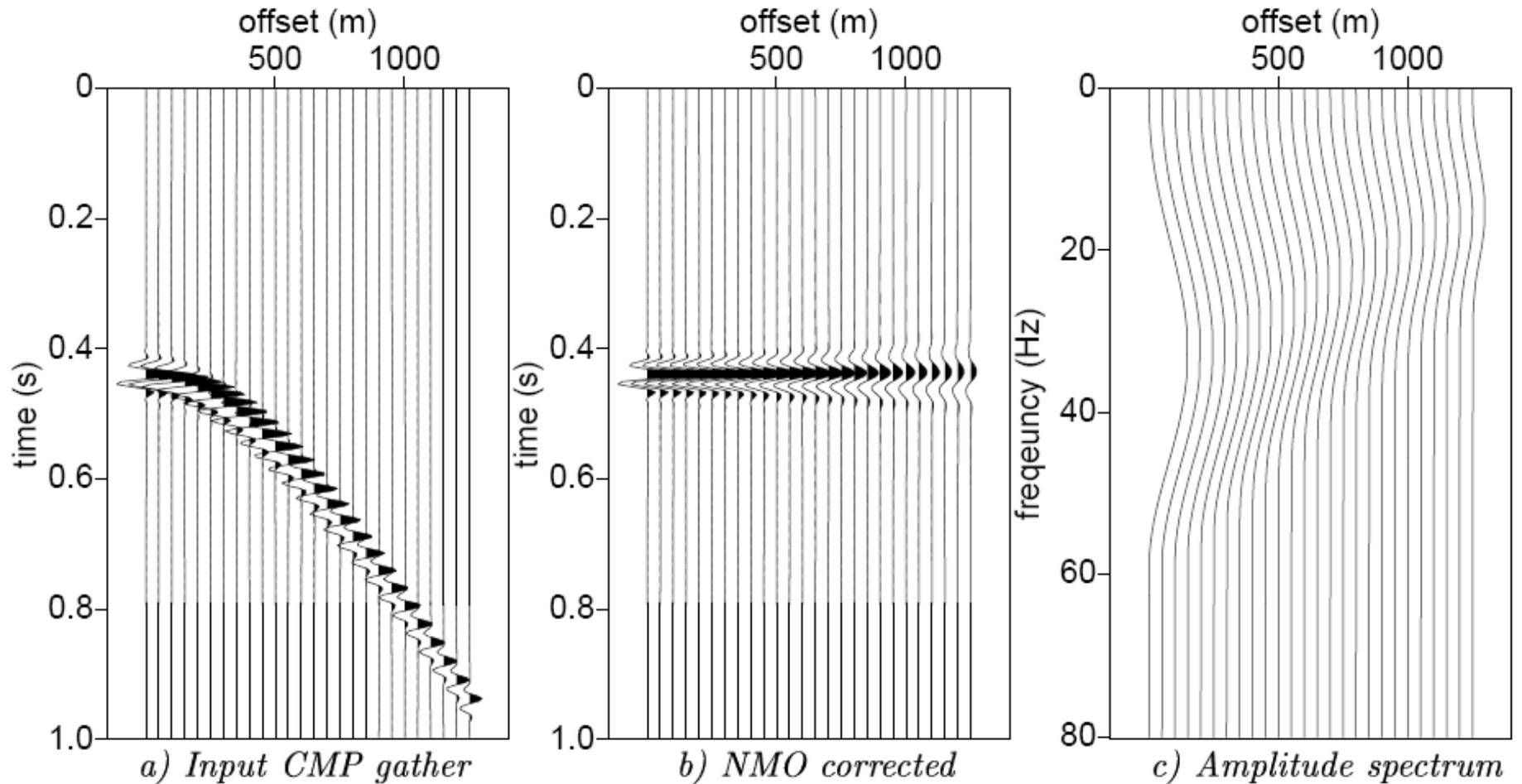
(b) Corrigida com velocidade correta

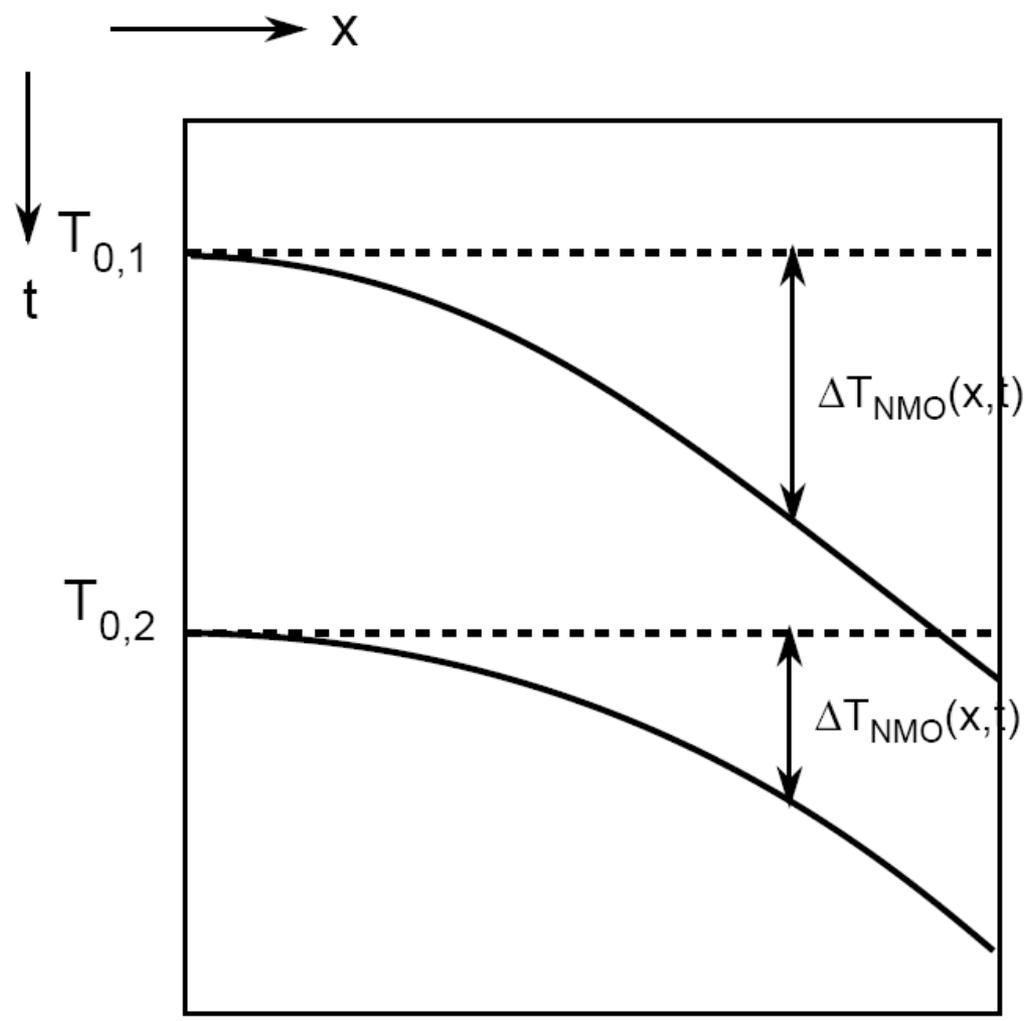
(c) Velocidade muito baixa

(d) Velocidade muito alta

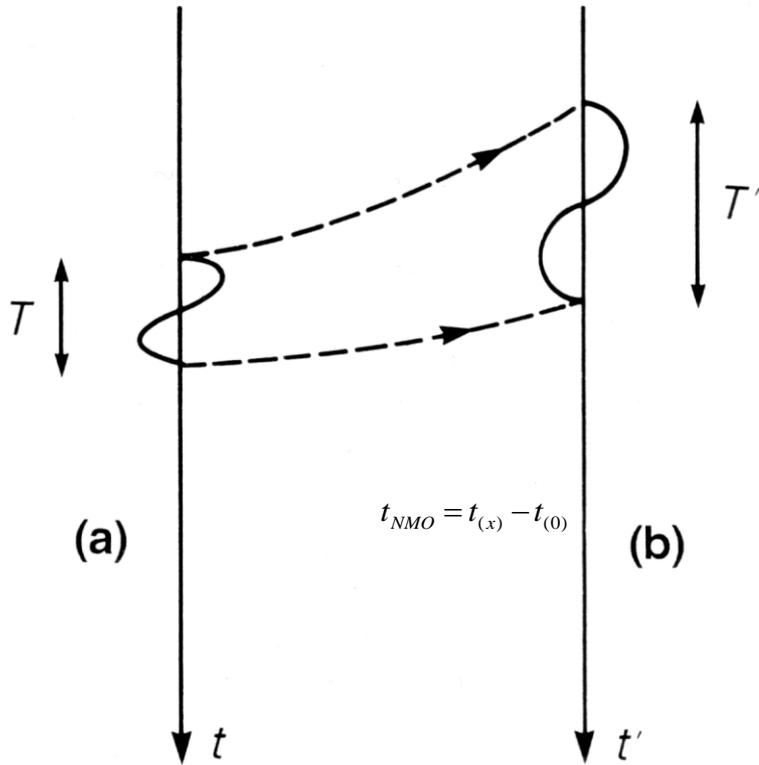
$$\Delta t_{NMO} = t_0 \left[\sqrt{1 + \left(\frac{x}{v_{NMO} t_0} \right)^2} - 1 \right]$$

Stretching (estiramento)





Stretching (estiramento)



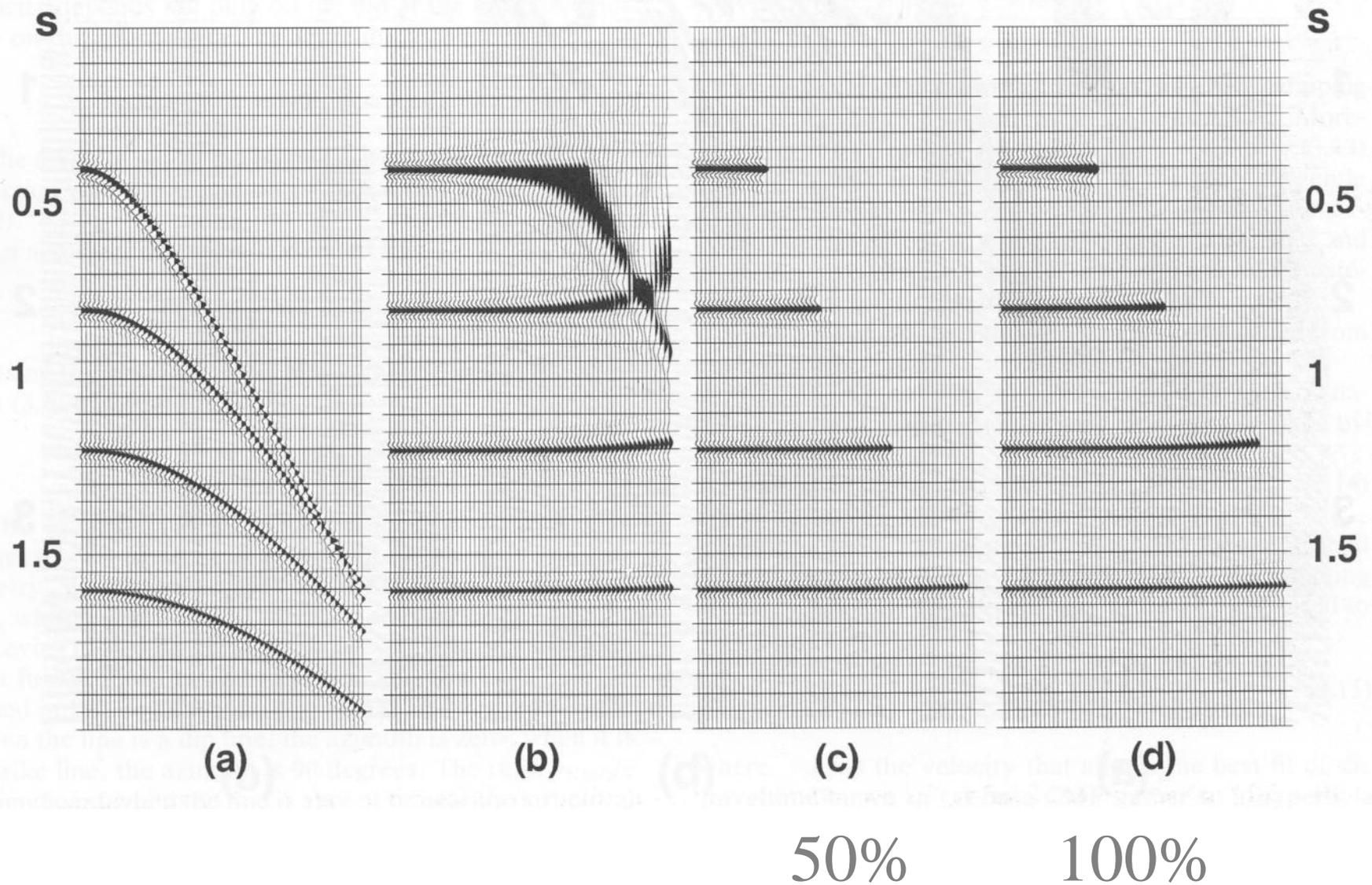
$$t_{NMO} = t(x) - t(0)$$

$$t(0) = \left(t^2(x) - \frac{x^2}{V^2} \right)^{1/2}$$

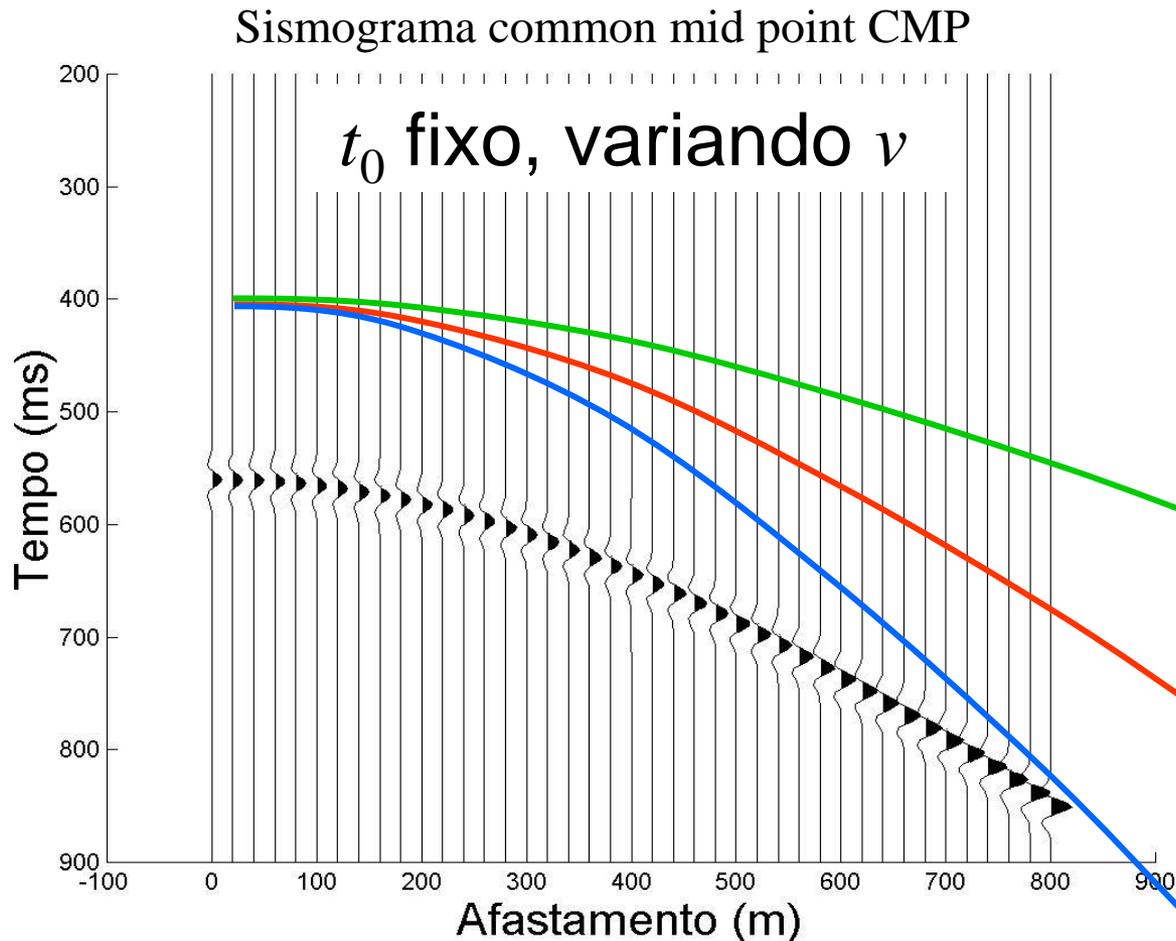
$$t_{NMO(1)} = t(x) - \left(t^2(x) - \frac{x^2}{V^2} \right)^{1/2}$$

$$t_{NMO(2)} = t(x) + dt - \left((t(x) + dt)^2 - \frac{x^2}{V^2} \right)^{1/2}$$

Efeito “stretch” (estiramento do traço)

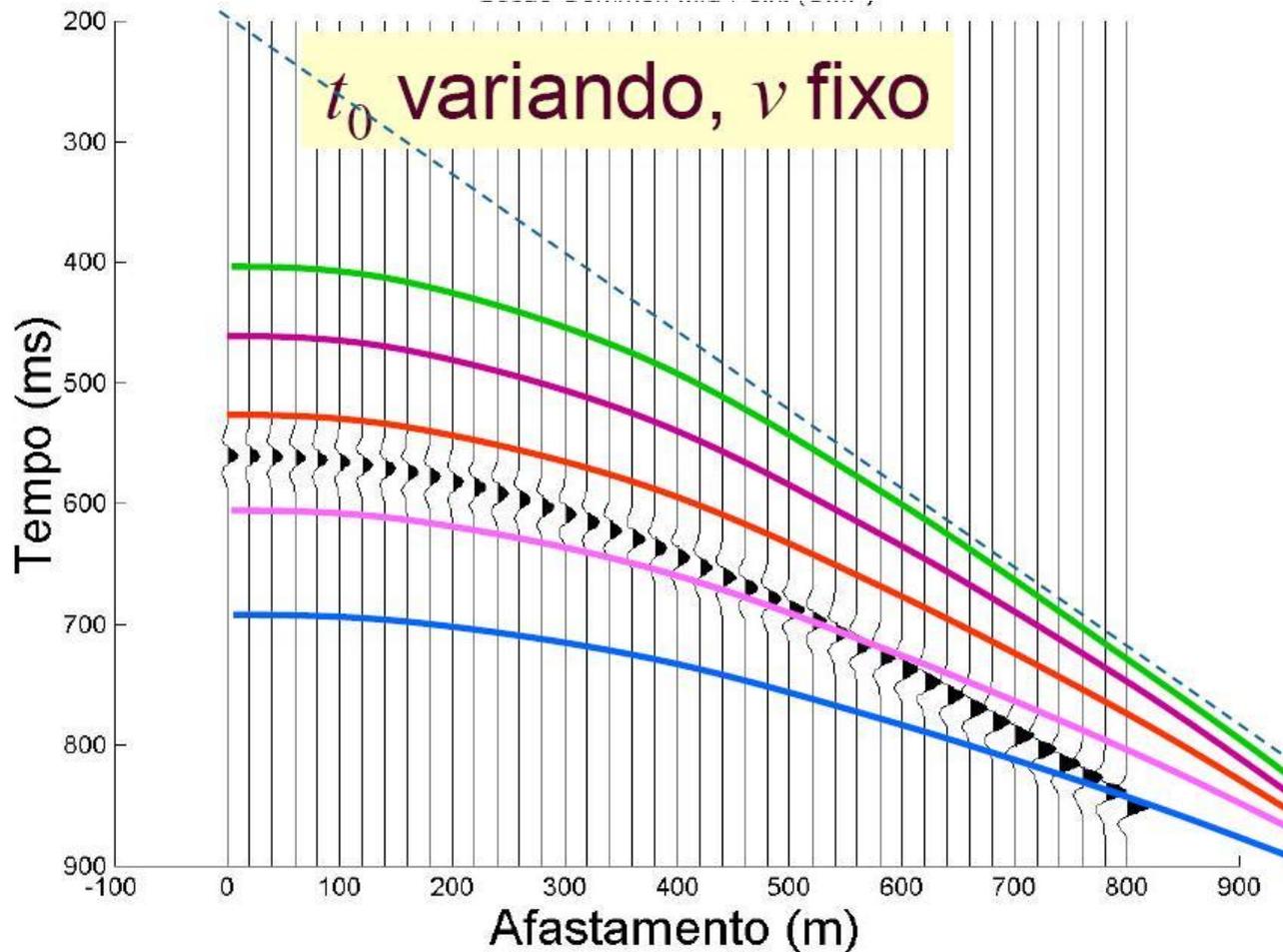


Tempo de trânsito (CMP)

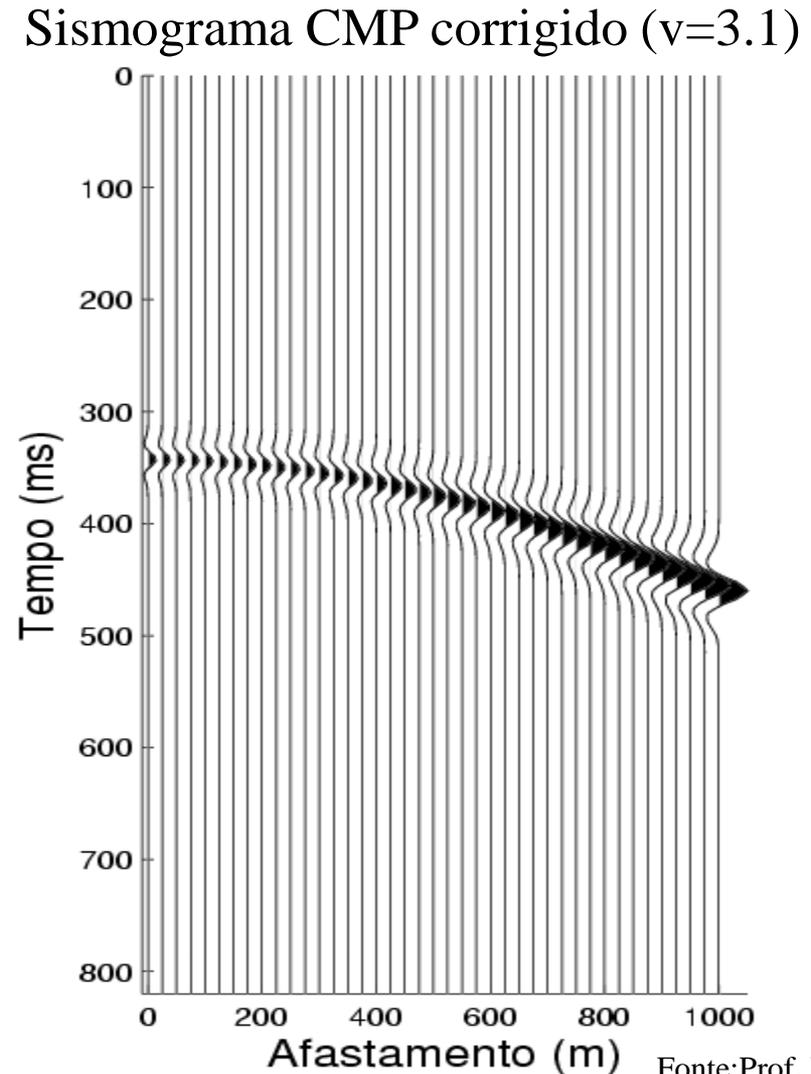
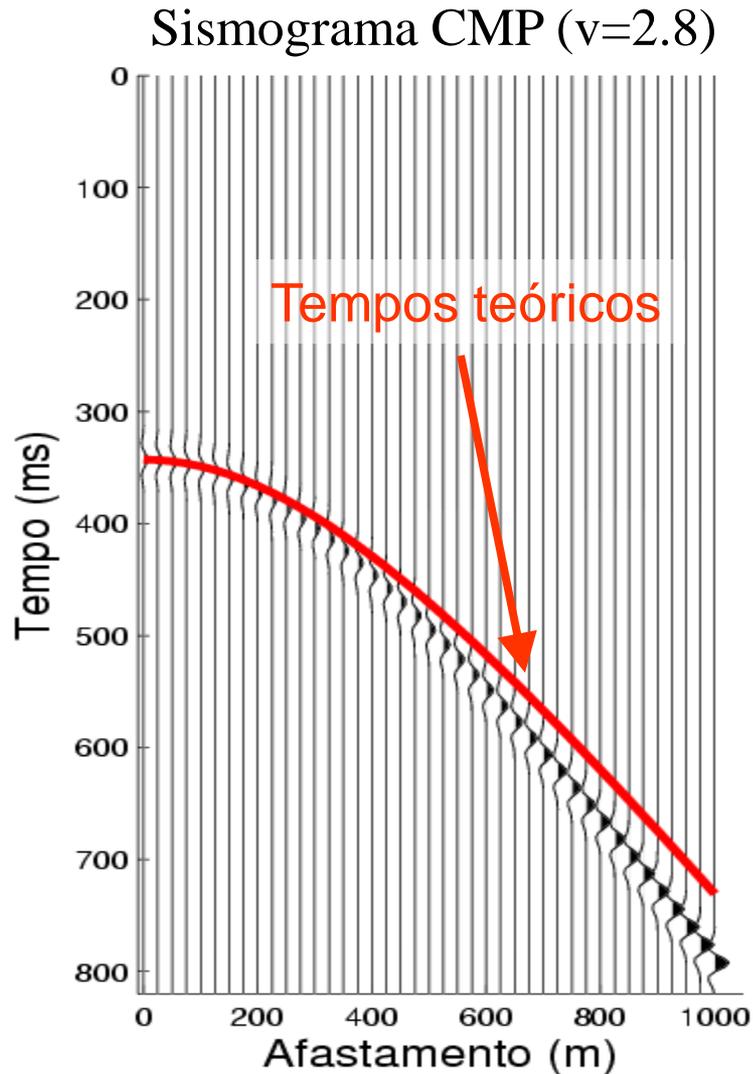


Tempo de trânsito (CMP)

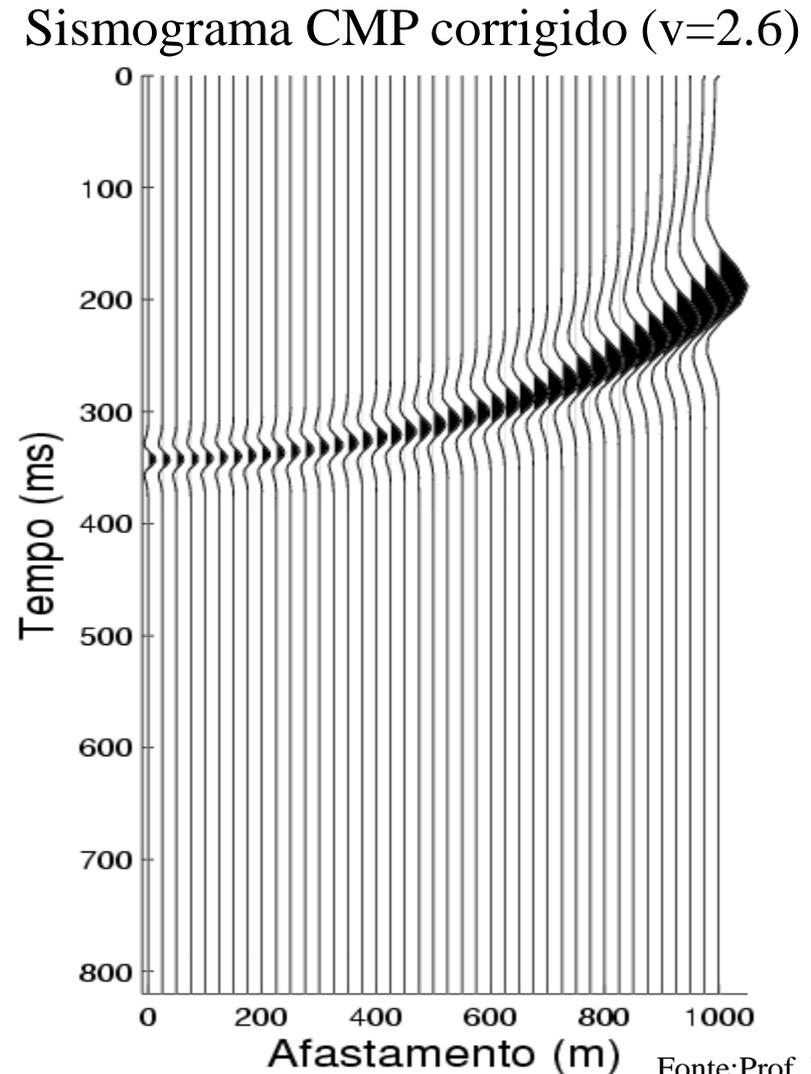
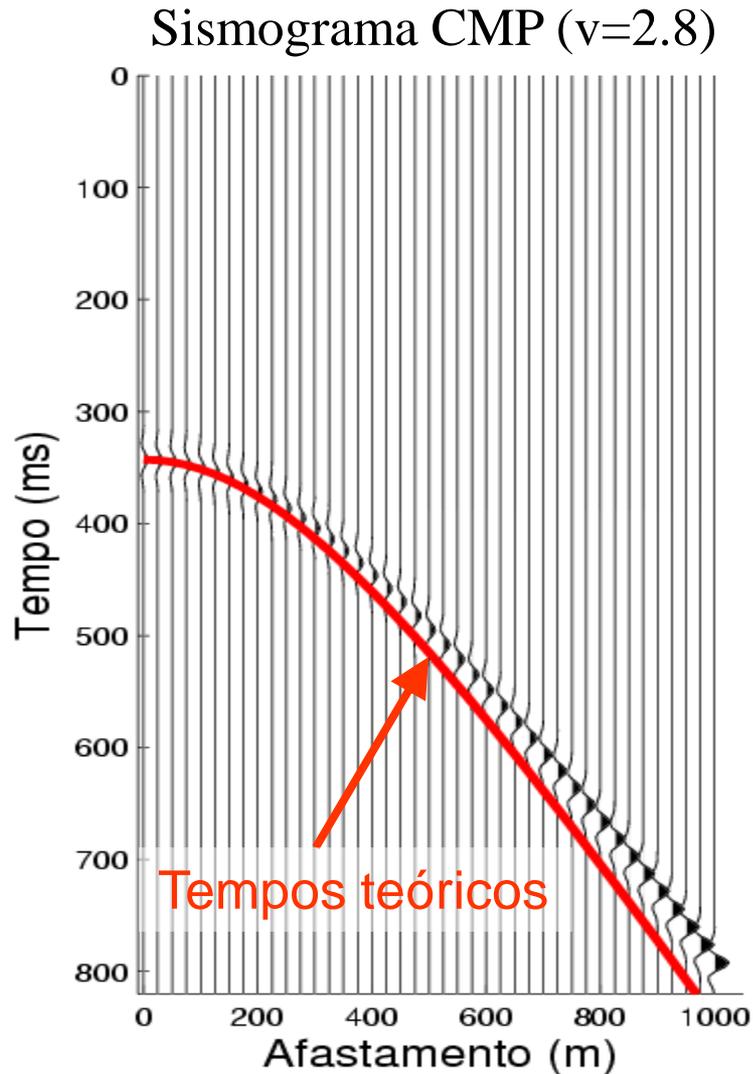
Sismograma common mid point CMP

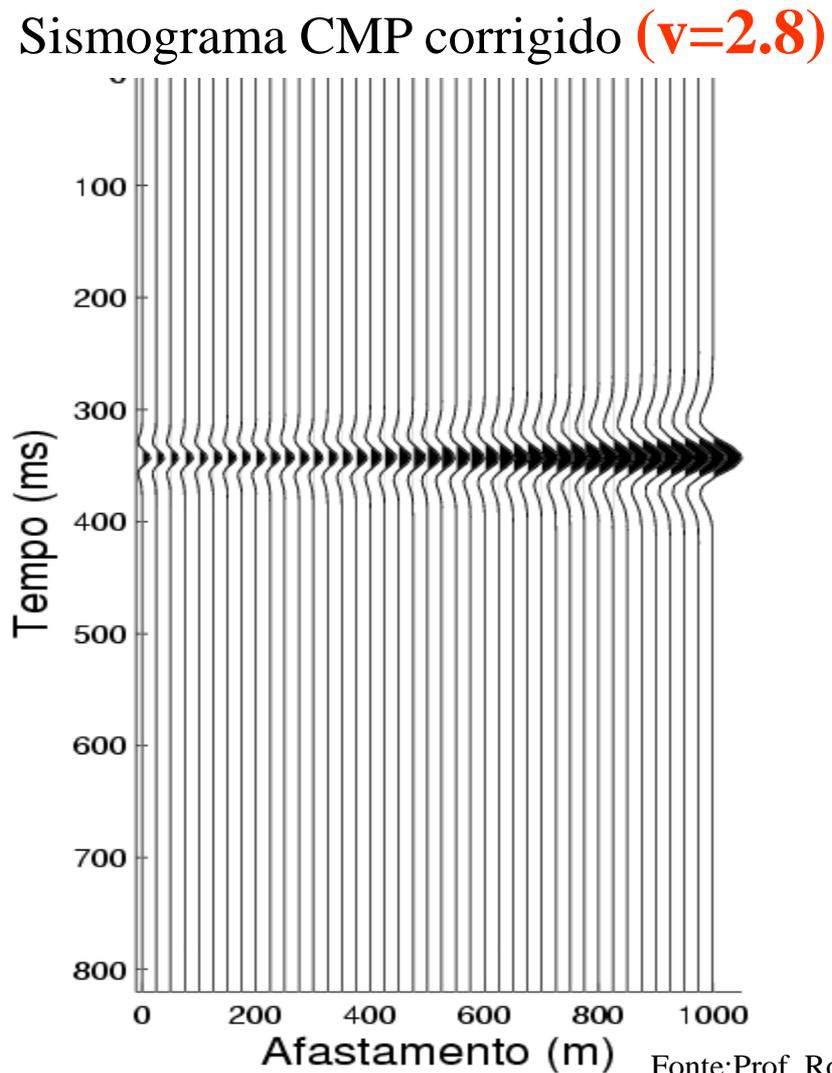
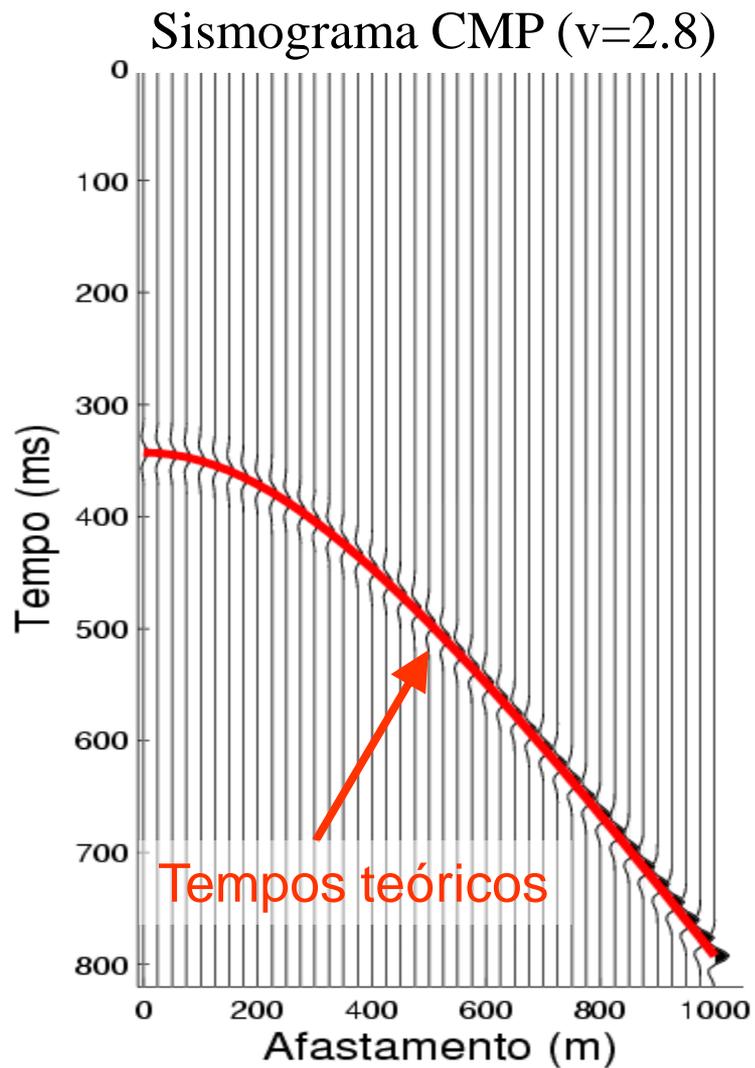


Correção NMO



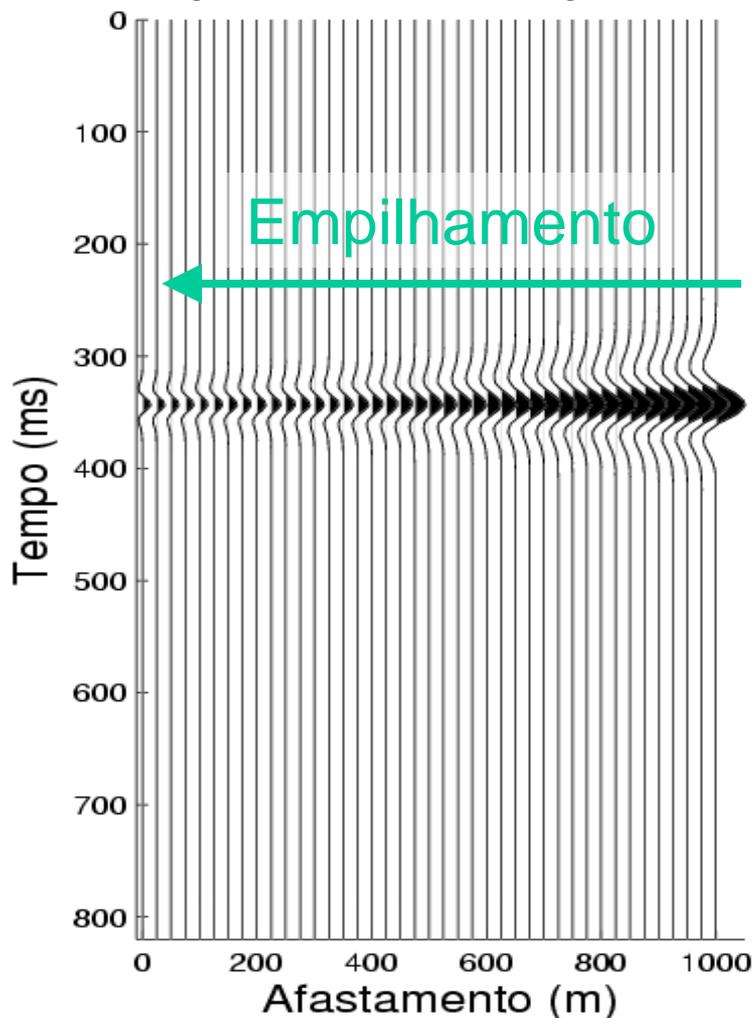
Correção NMO





Empilhamento NMO

Sismograma CMP corrigido ($v=2.8$)



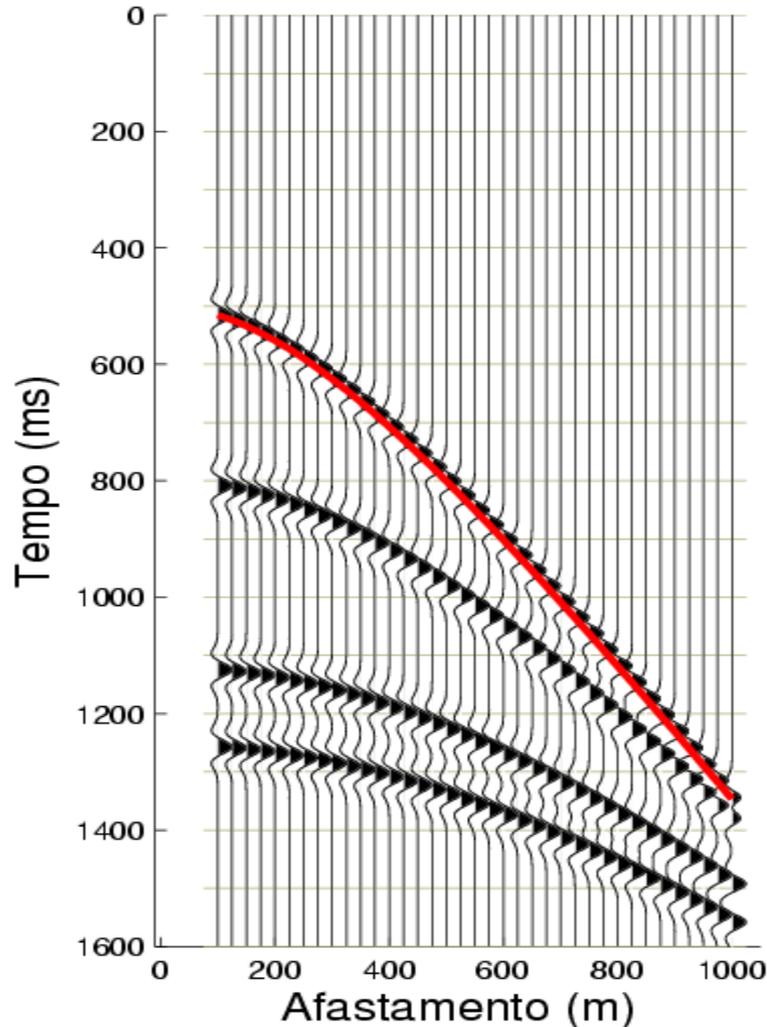
Empilhamento

Após a correção NMO todos estes traços podem ser somados, dando origem a um traço

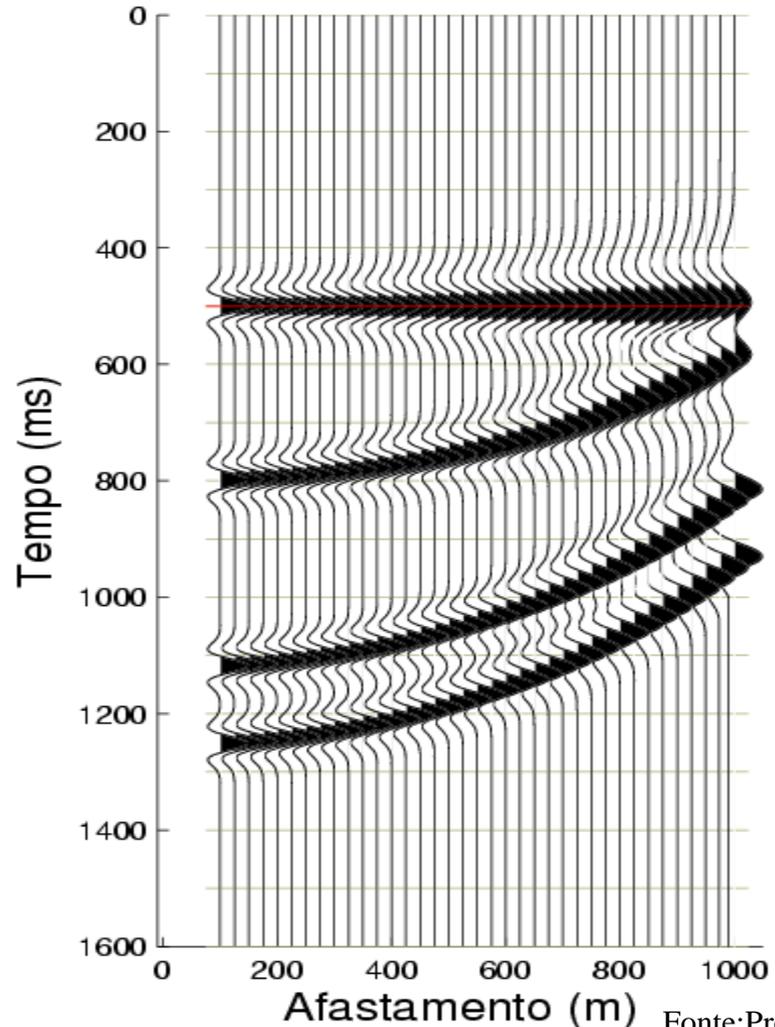
Cada conjunto CMP dá origem a um traço empilhado

Correção NMO - multicamadas

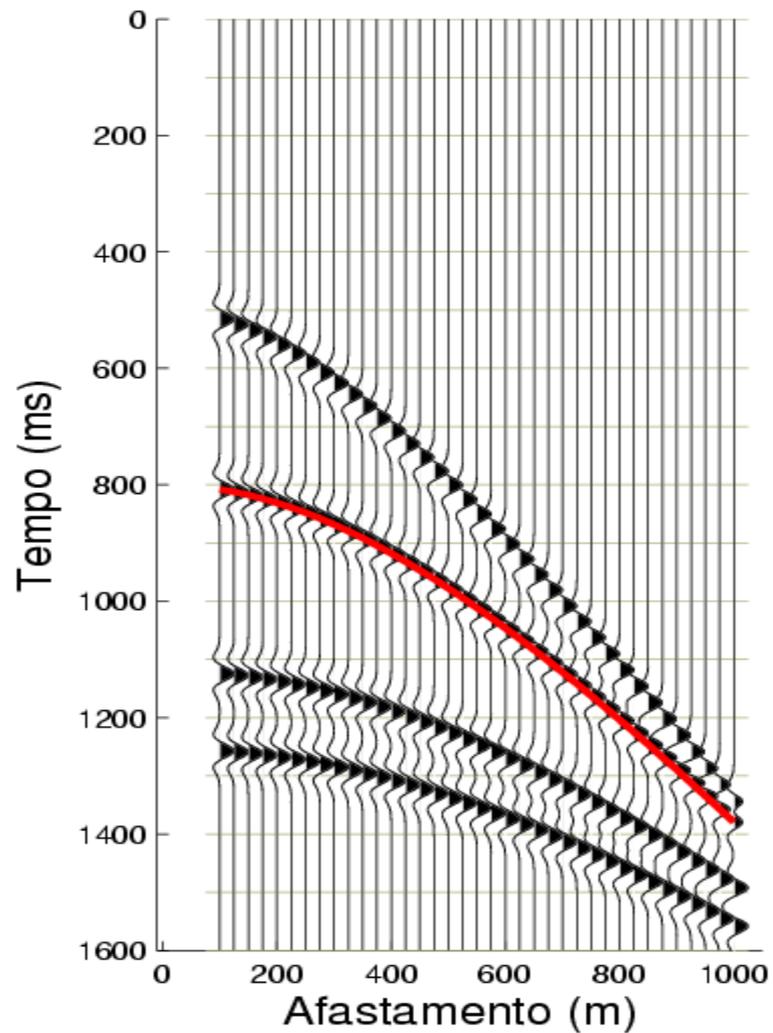
Sismograma CMP (v=2.8)



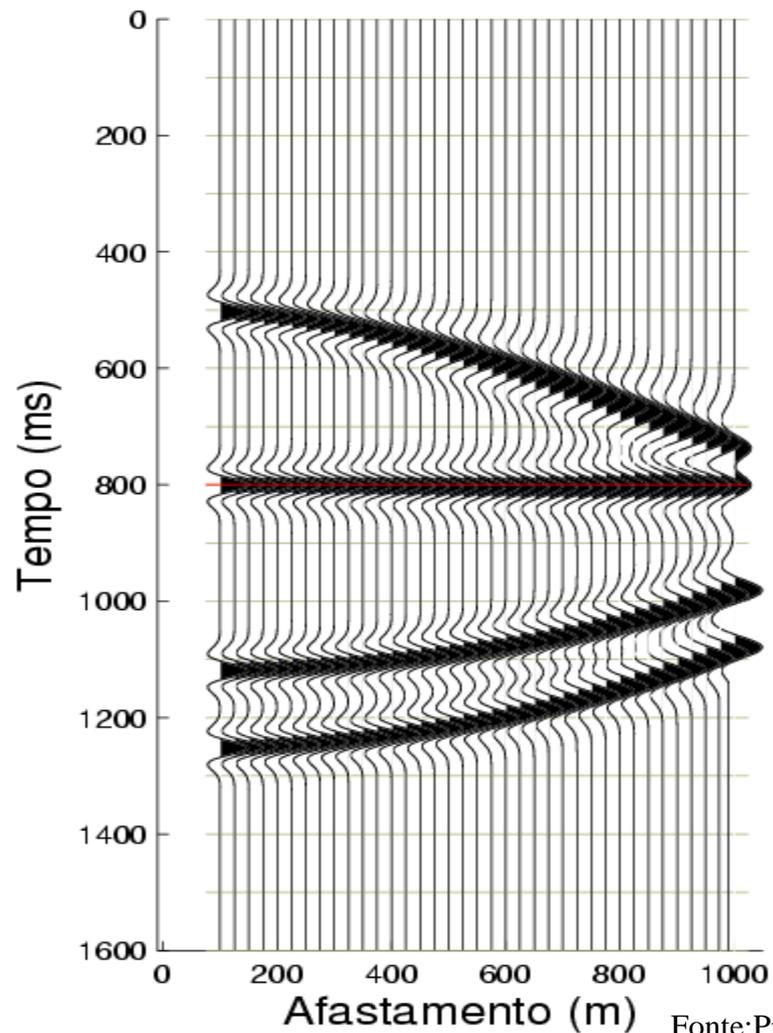
Sismograma CMP corrigido (v=1.6)



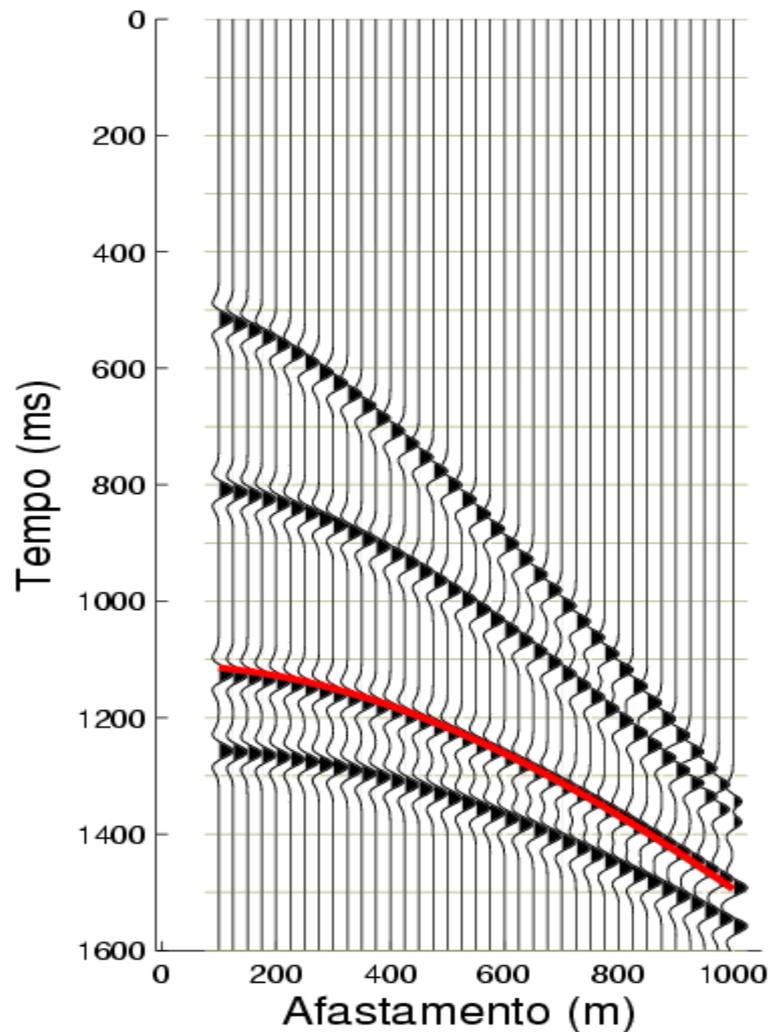
Sismograma CMP ($v=2.8$)



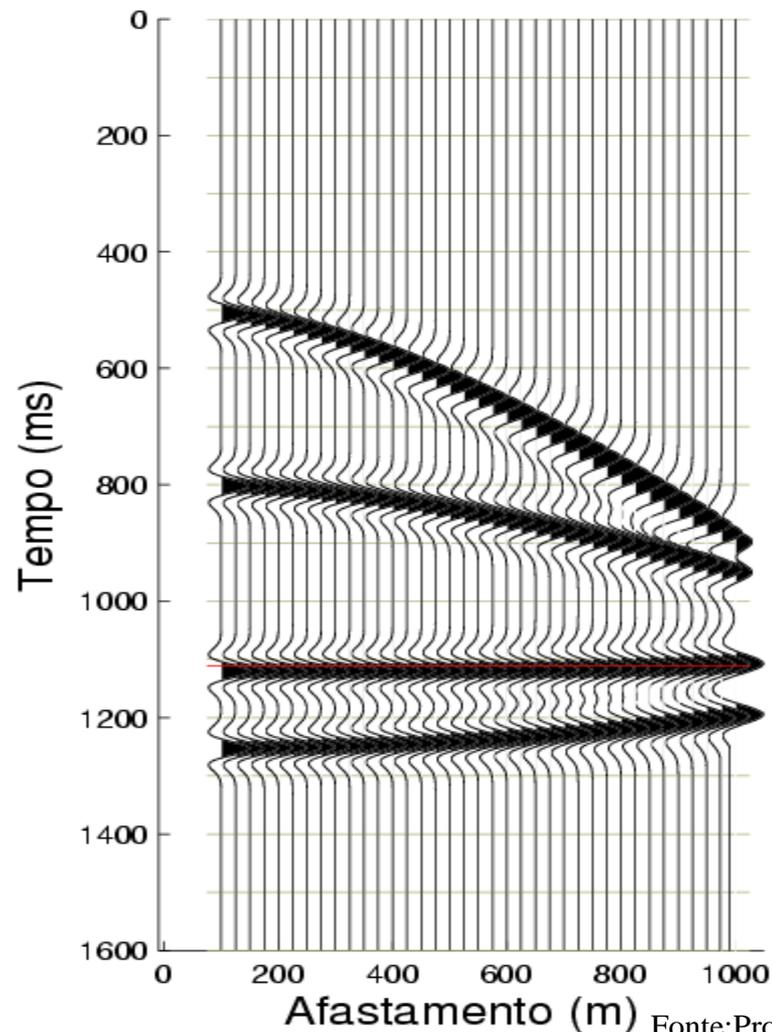
Sismograma CMP corrigido ($v=1.78$)



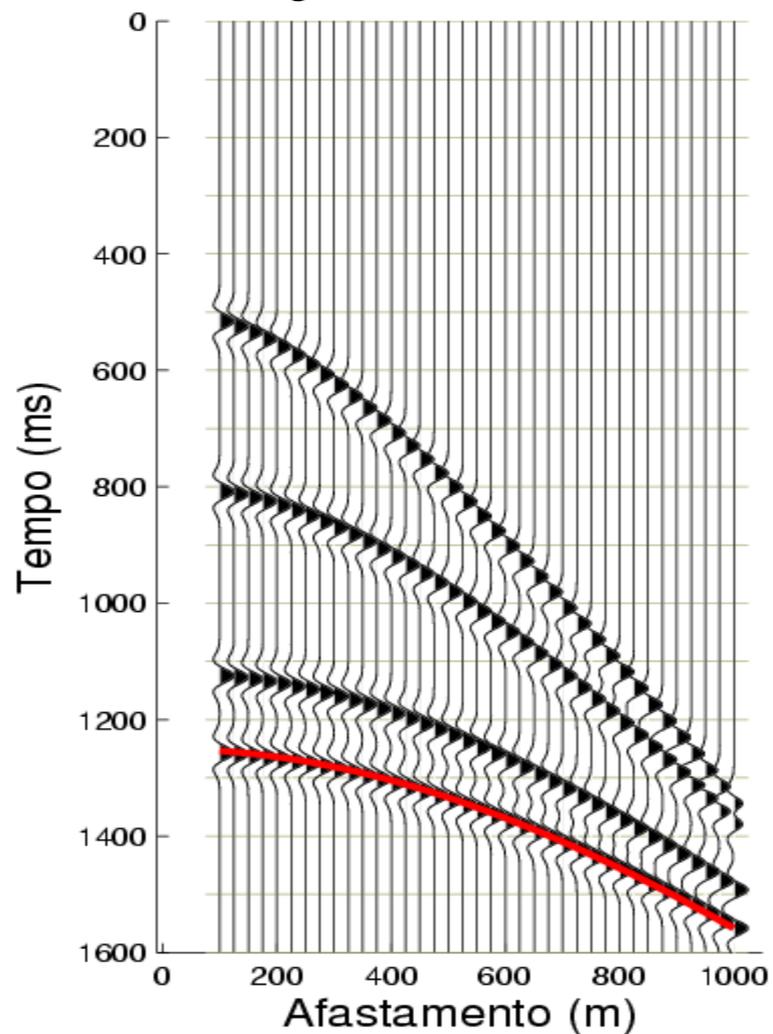
Sismograma CMP (v=2.8)



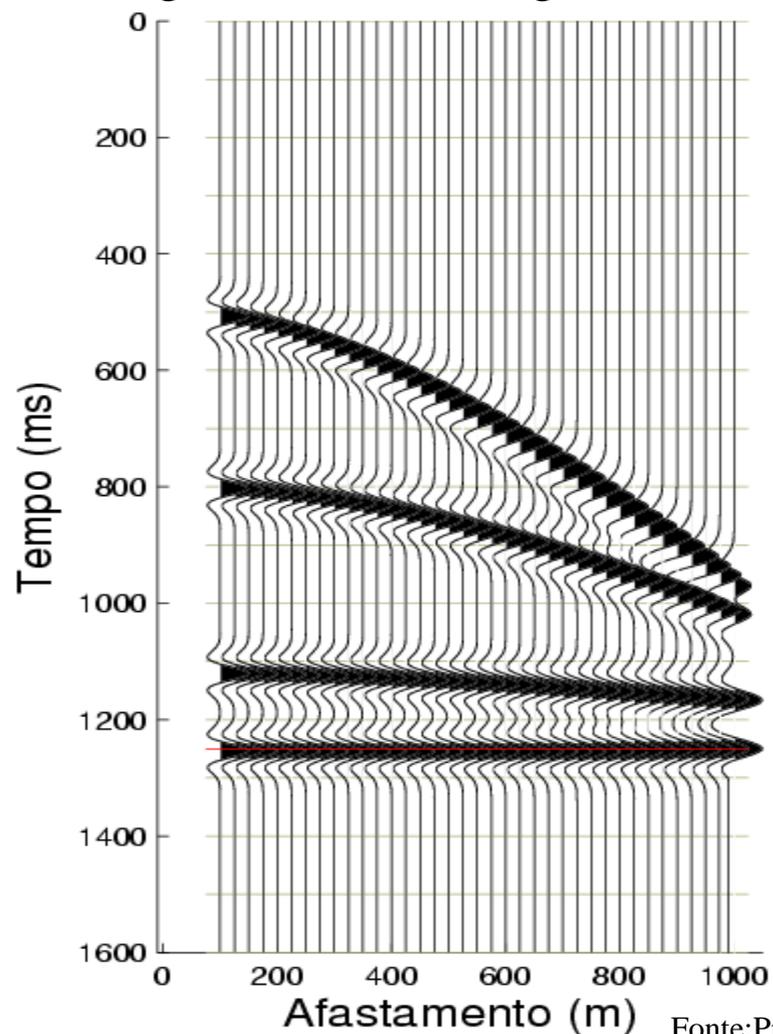
Sismograma CMP corrigido (v=2.0)



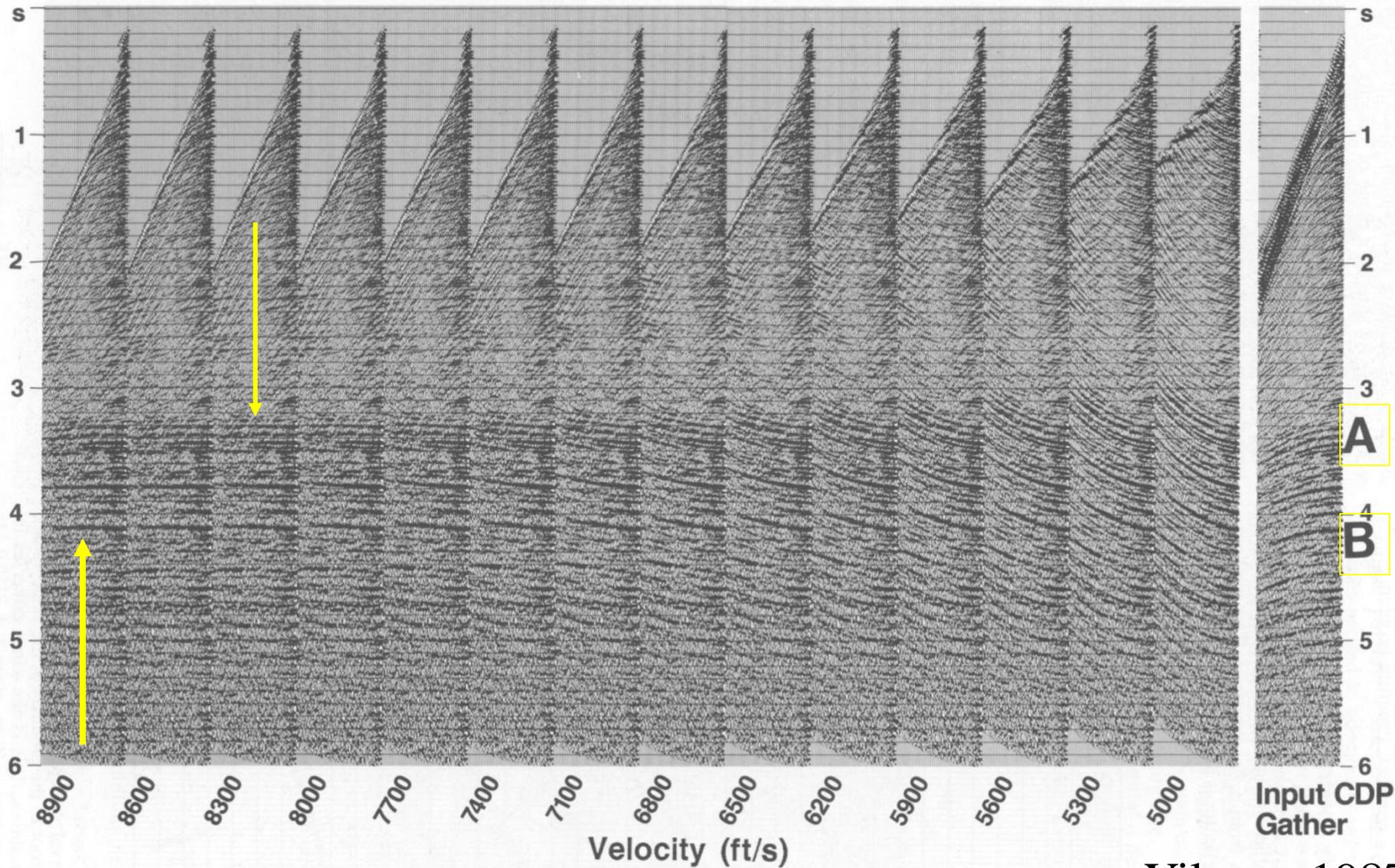
Sismograma CMP ($v=2.8$)



Sismograma CMP corrigido ($v=2.15$)

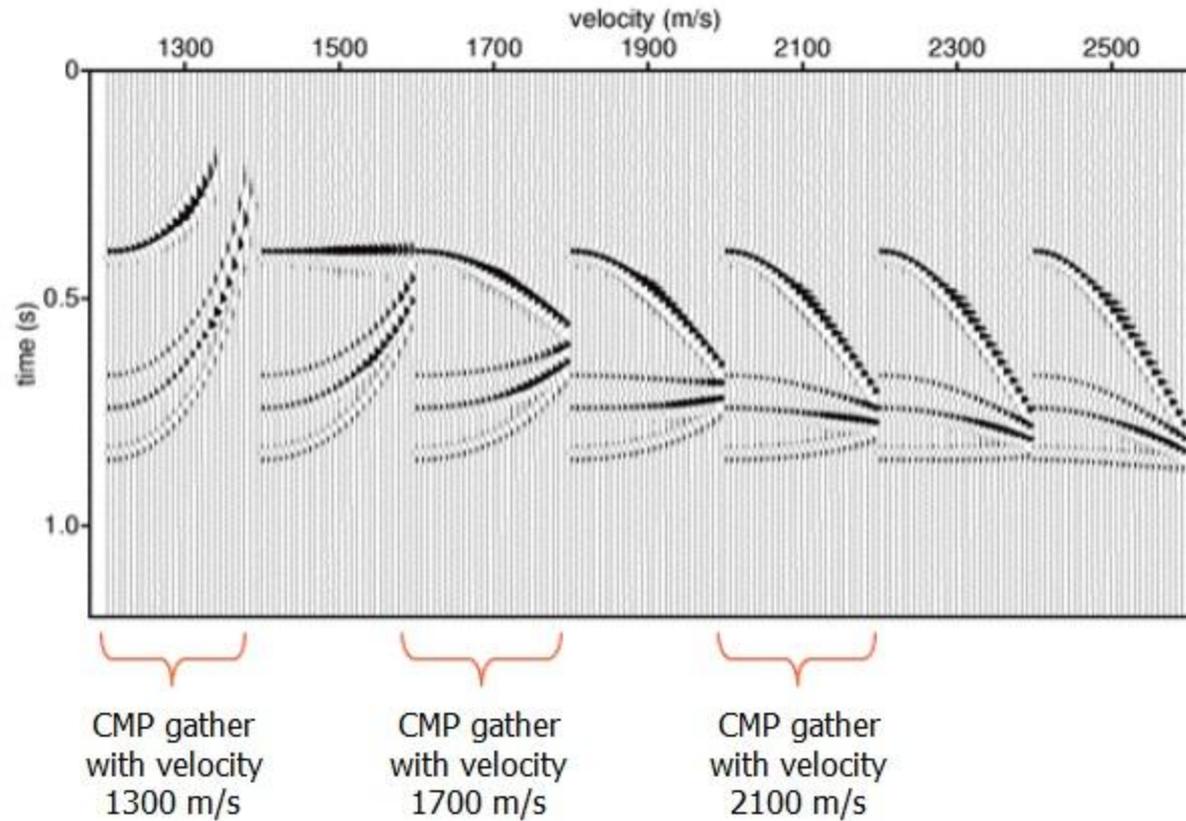


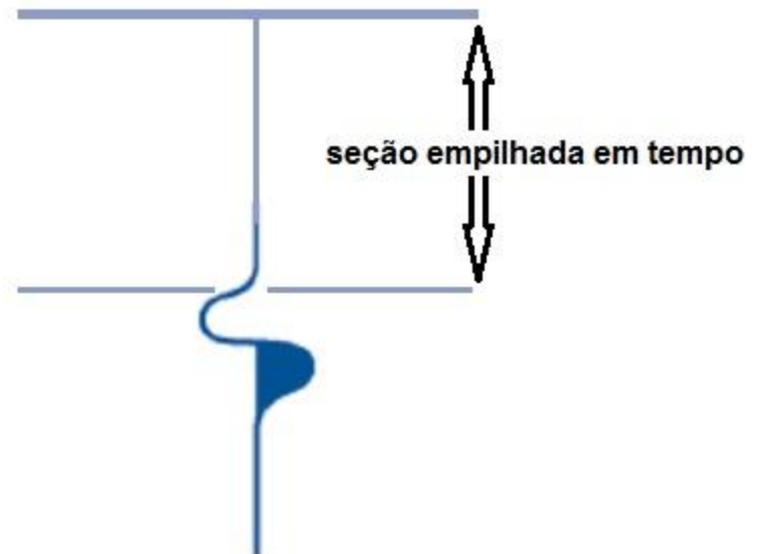
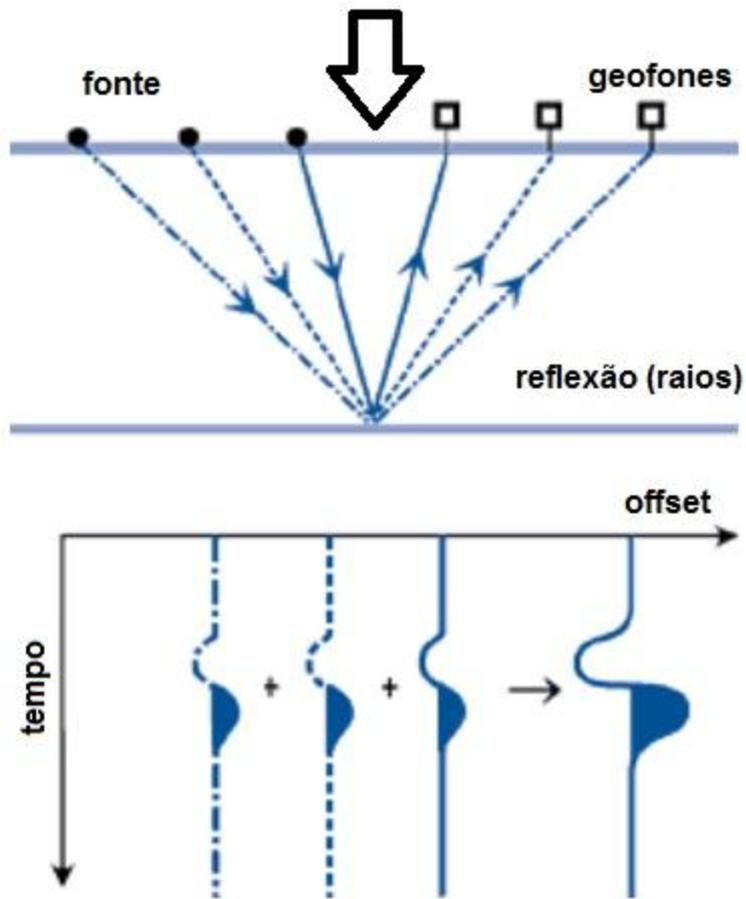
Panel NMO



Panel NMO

Velocity panels





Sismograma CMP corrigido de NMO

Seção sísmica (seção empilhada)

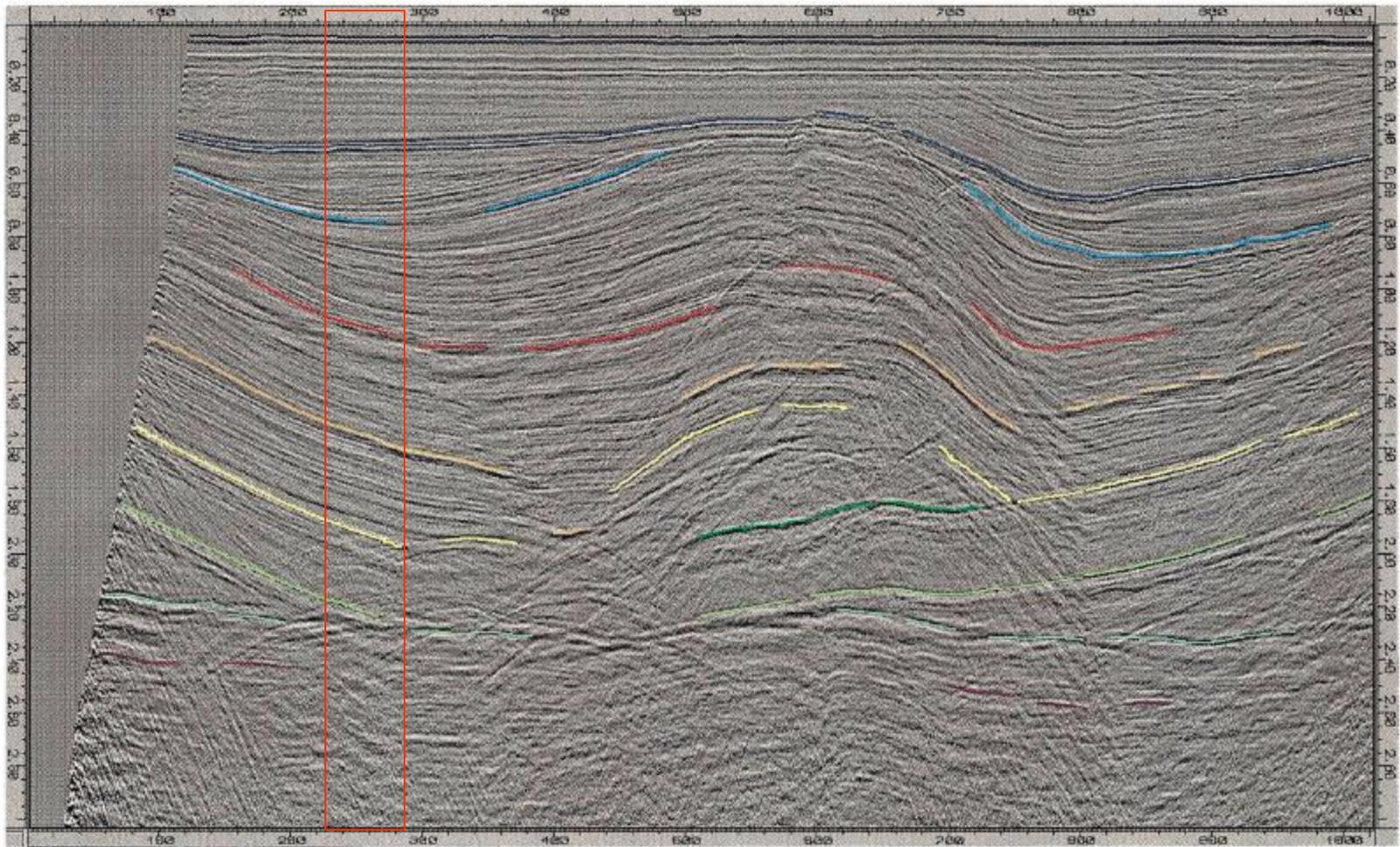
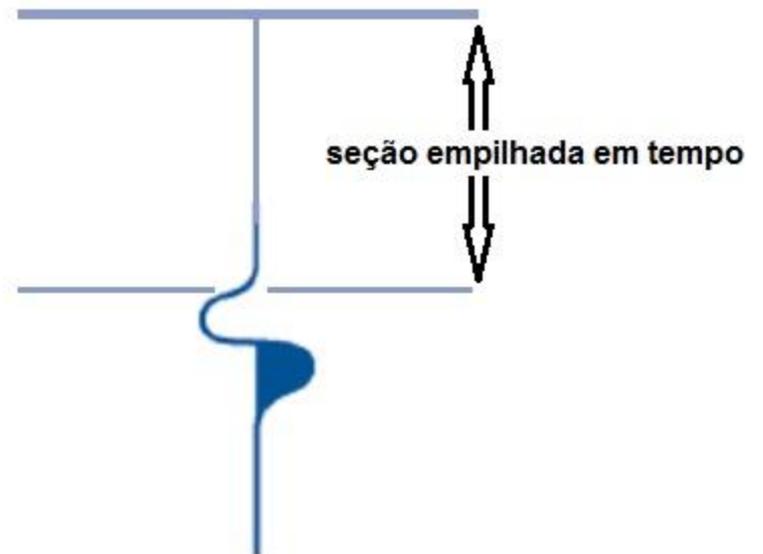
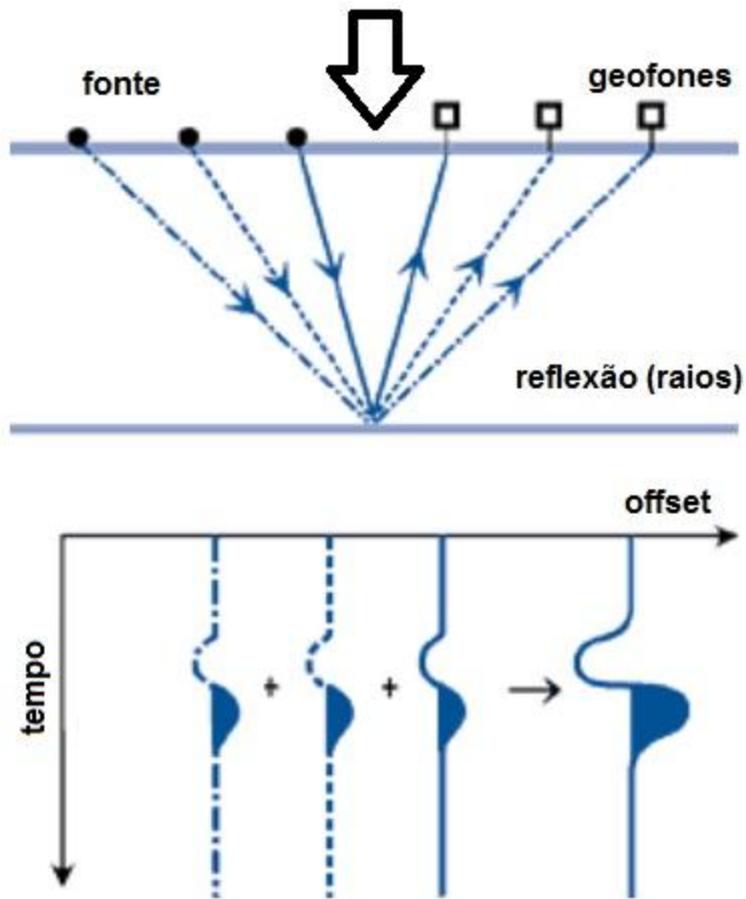
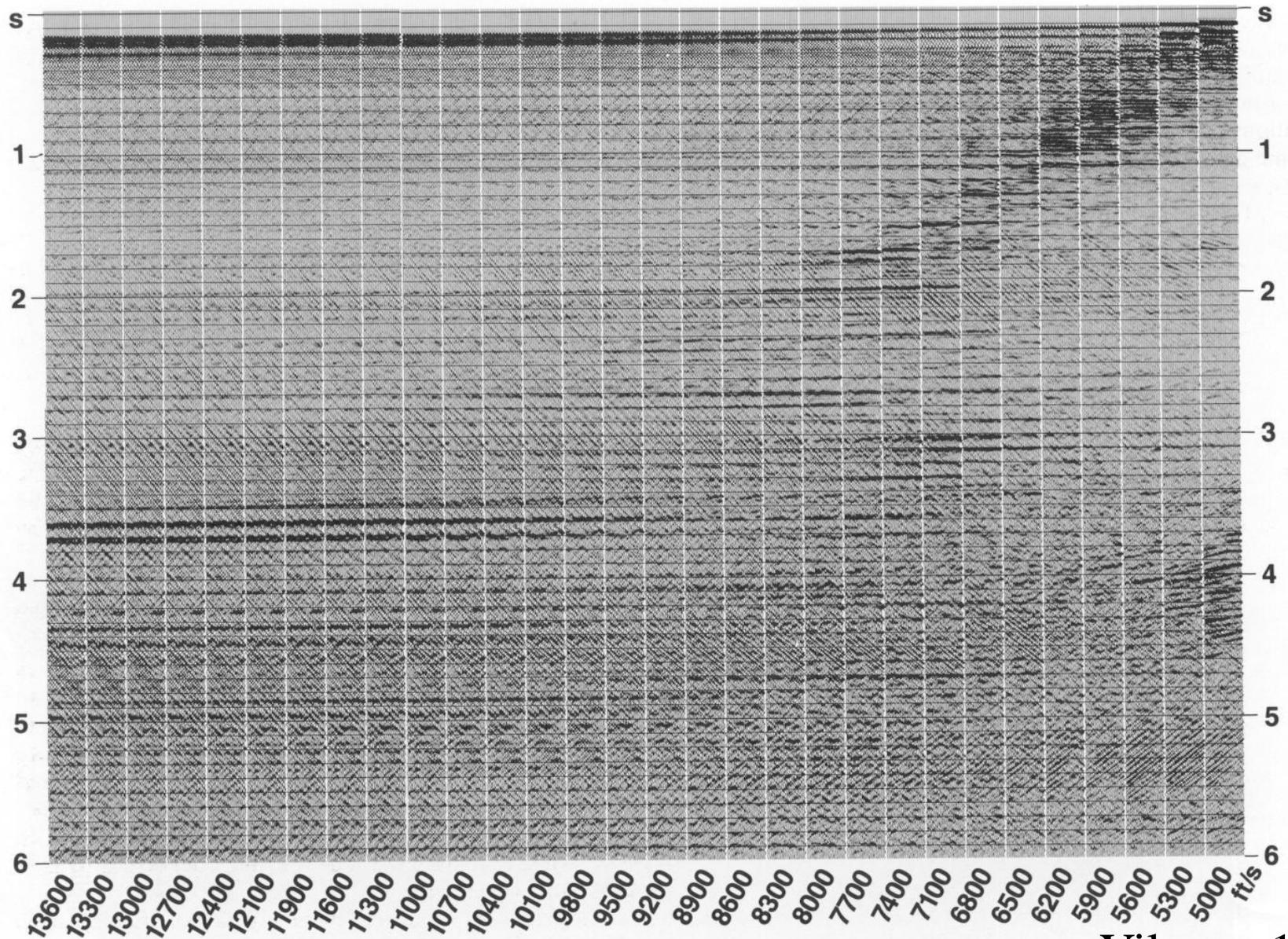


FIG. 3.2-35. A CMP-stacked section with interpreted time horizon segments associated with geological markers.

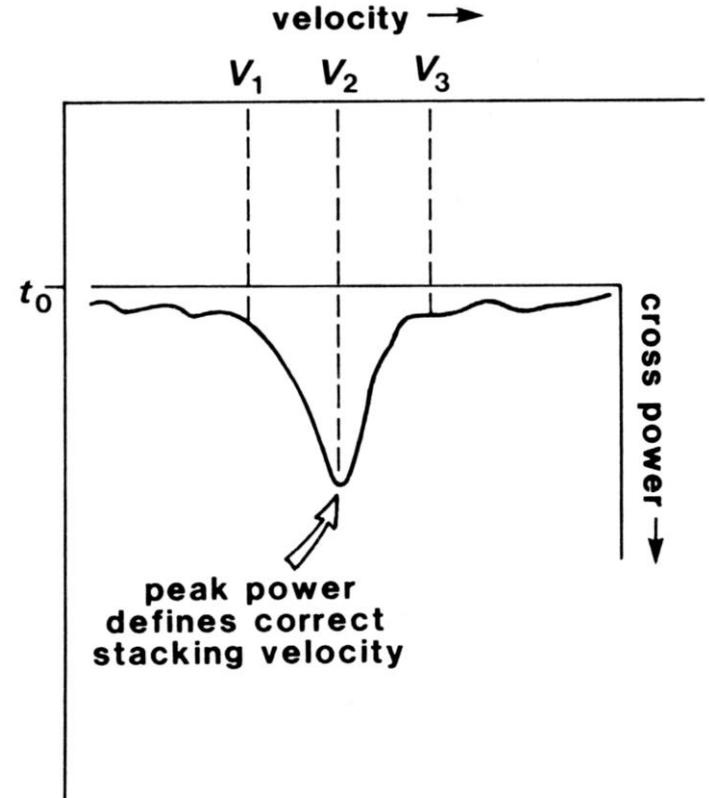
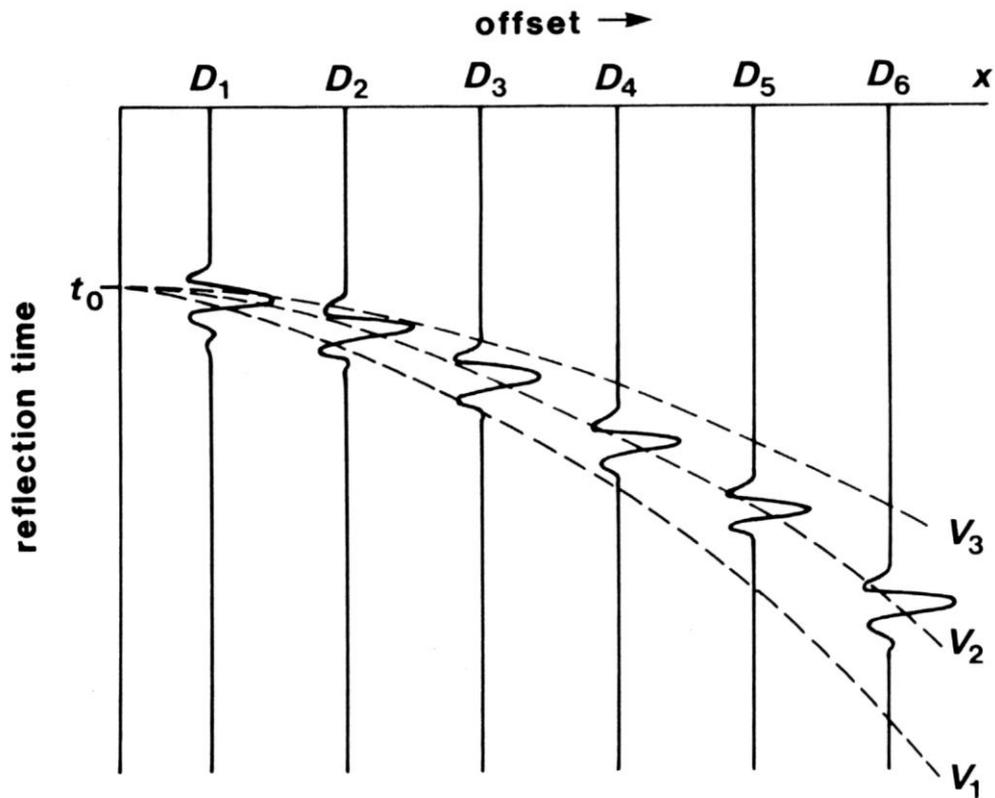


Sismograma CMP corrigido de NMO

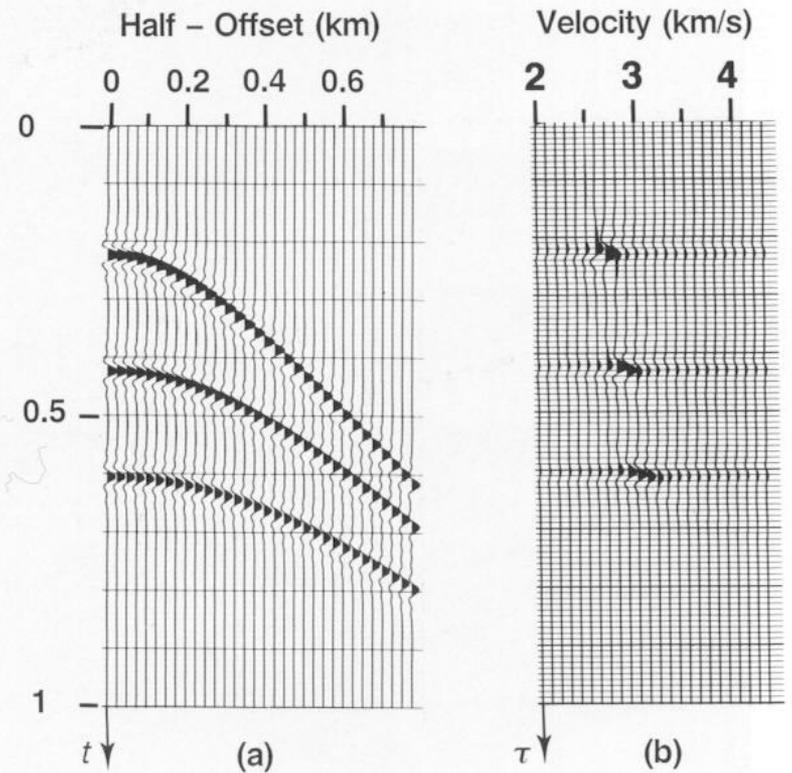
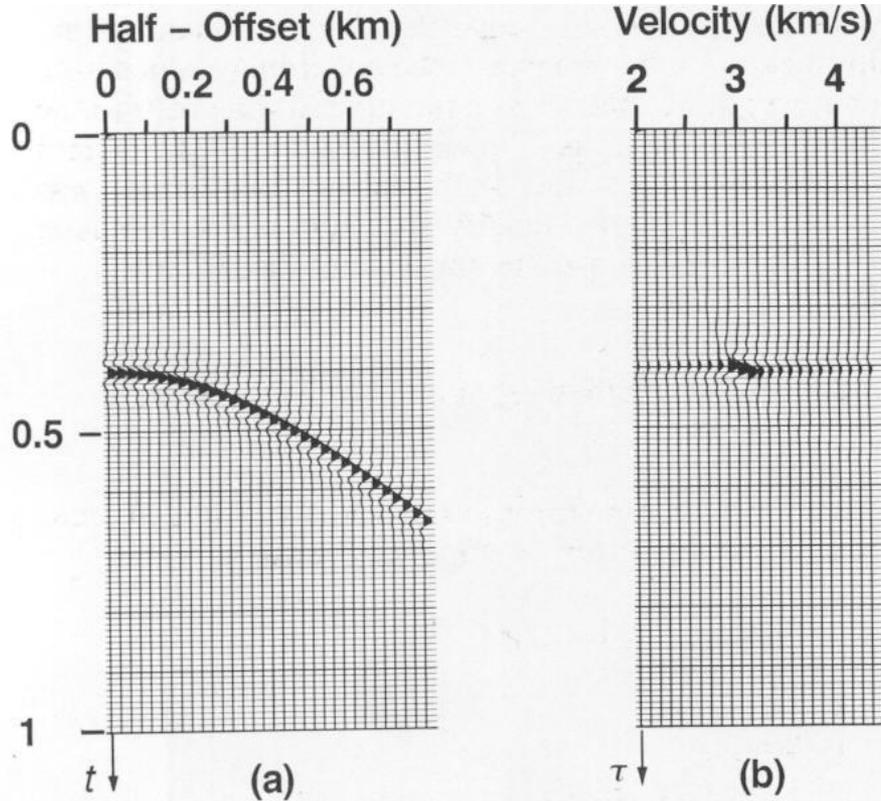
Painel CVS (empilhado) de 24 conjuntos CMP



Velocidade de empilhamento



Espectro de velocidades



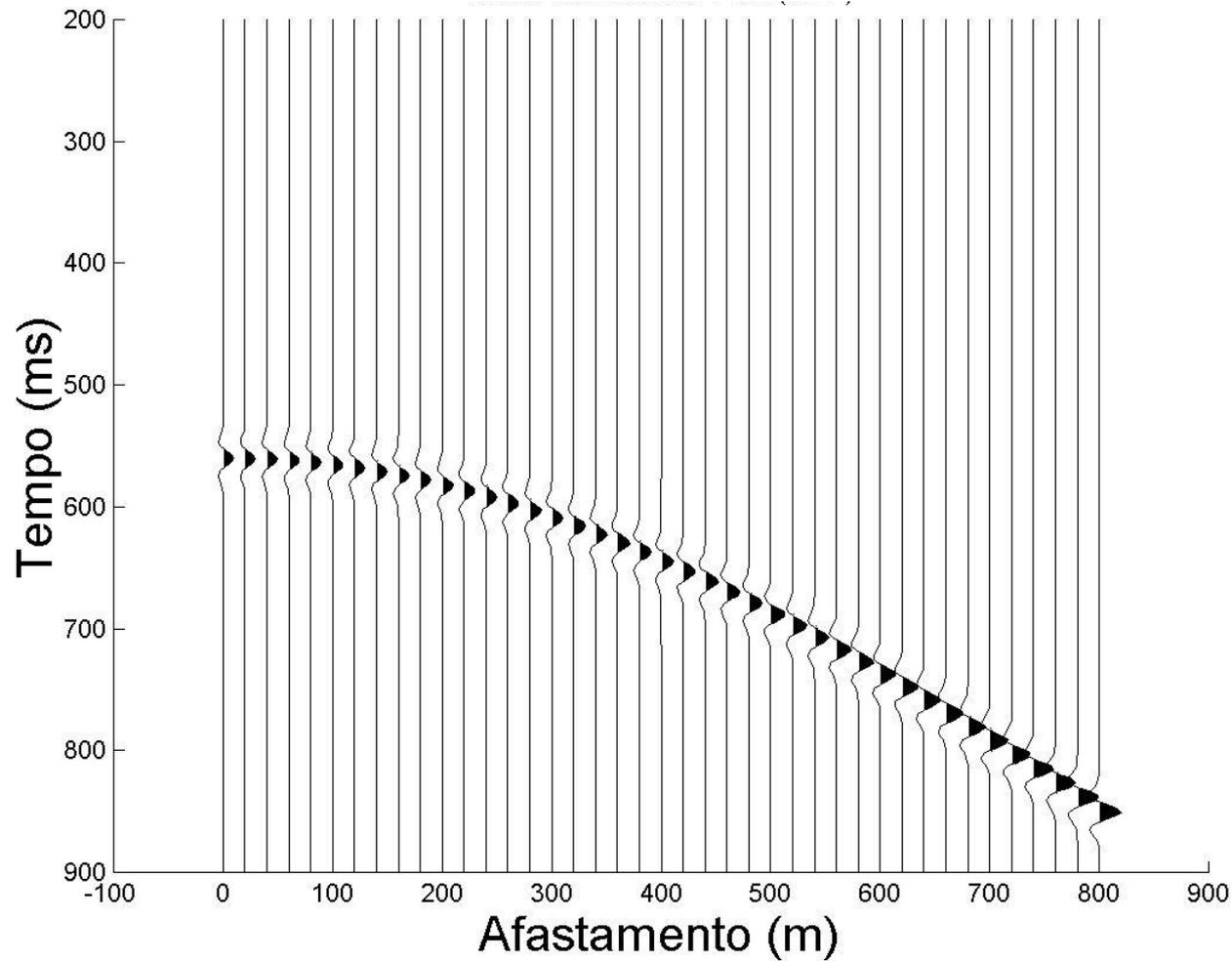
Método para calcular o espectro de velocidades

Semblance

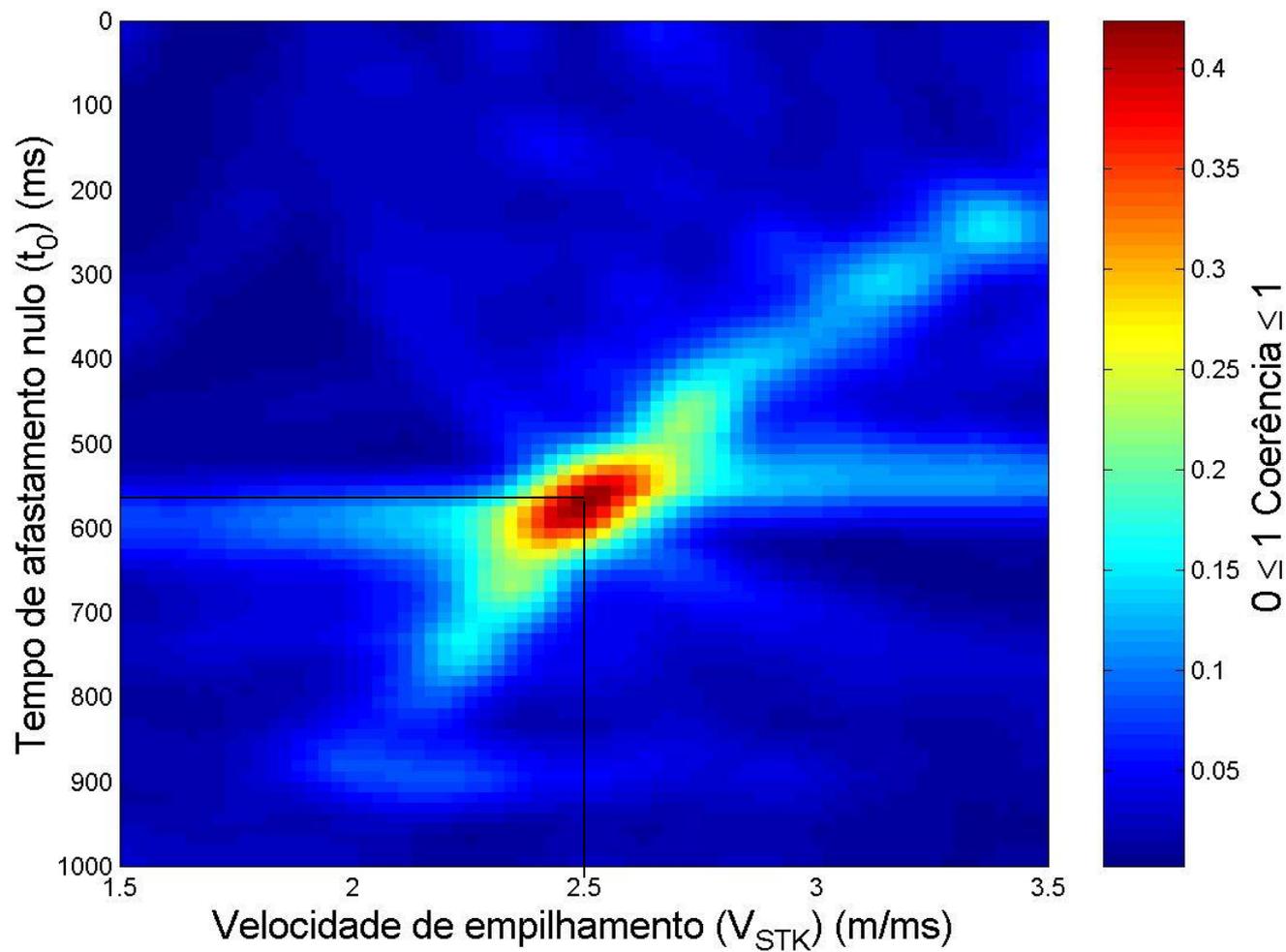
$$\frac{1}{n} \frac{\sum_t \left(\sum_i w_{i,t} \right)^2}{\sum_t \sum_i w_{i,t}^2} = \frac{1}{n} \frac{\sum_t s_t^2}{\sum_t \sum_i w_{i,t}^2}$$

$w_{i,t}$ valor para o traço i , tempo t

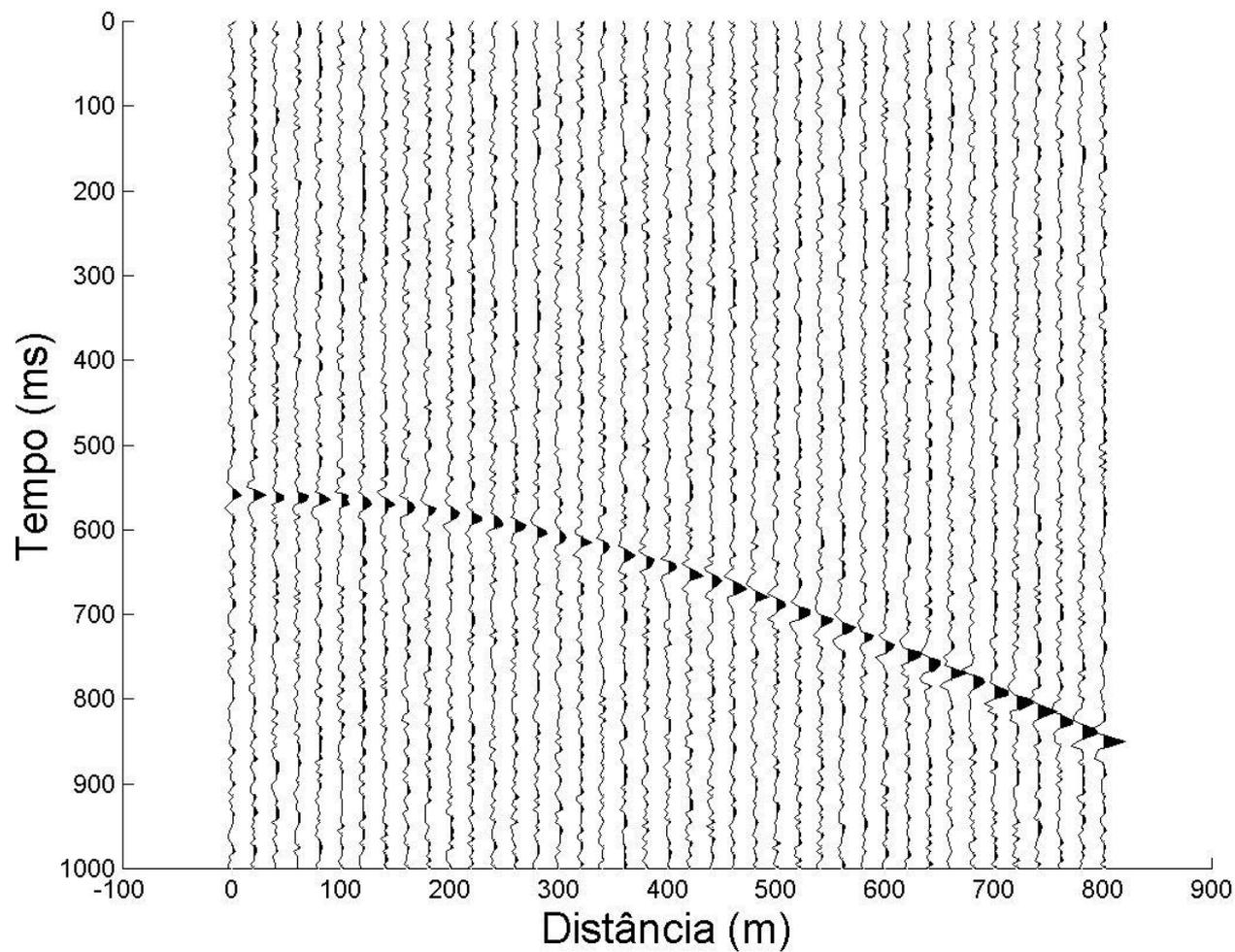
Sismograma CMP



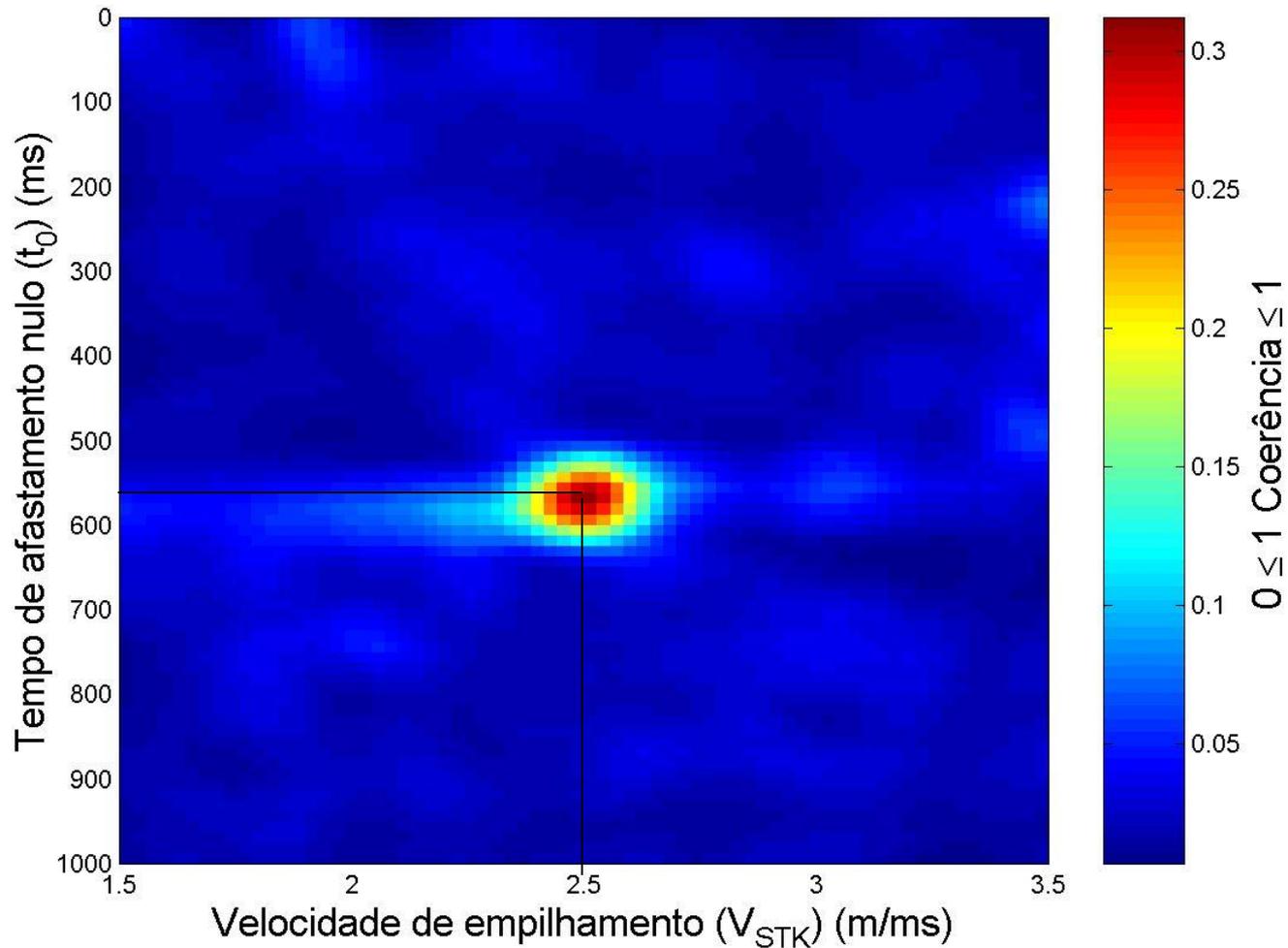
Função semblance



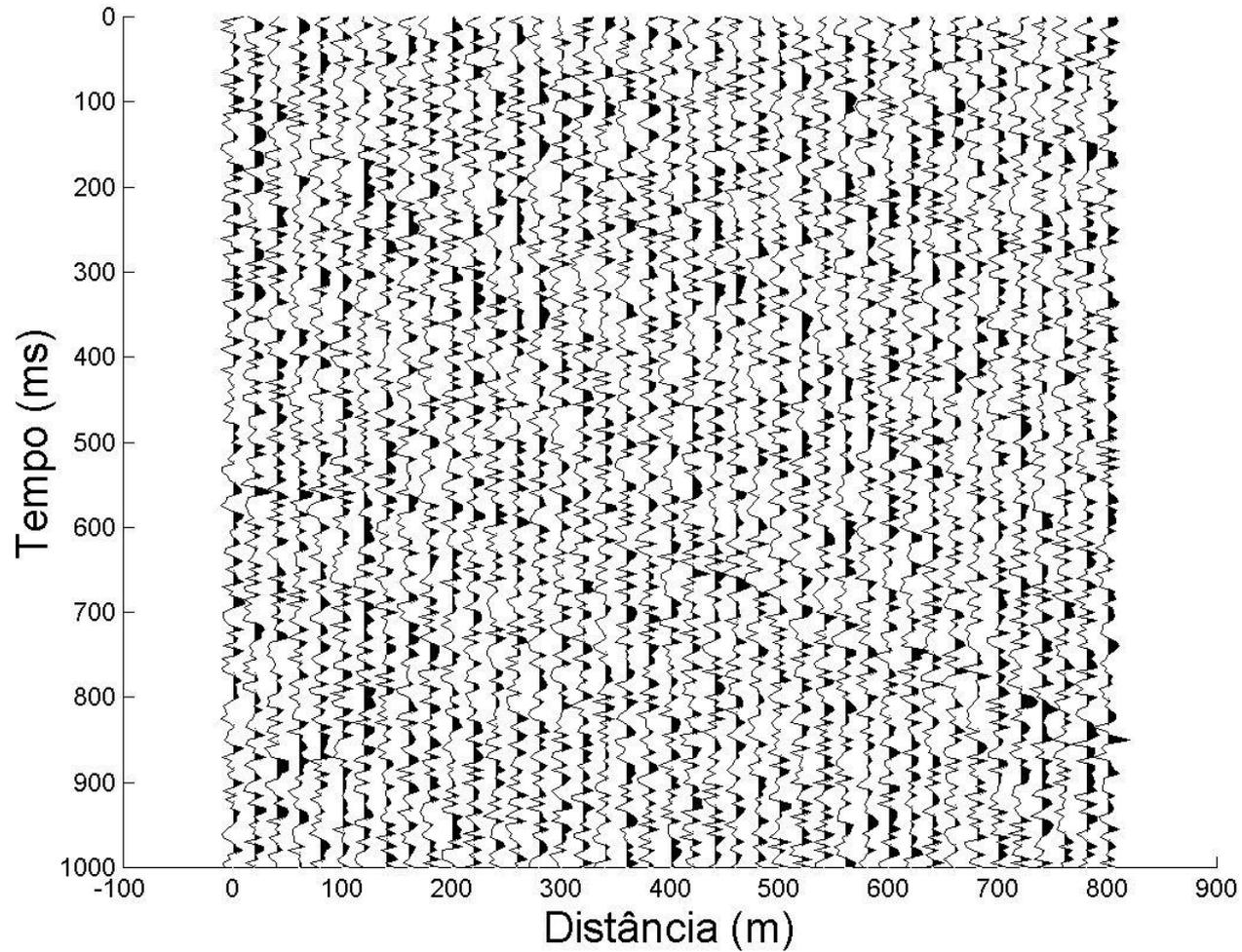
Sismograma CMP com 20% ruído



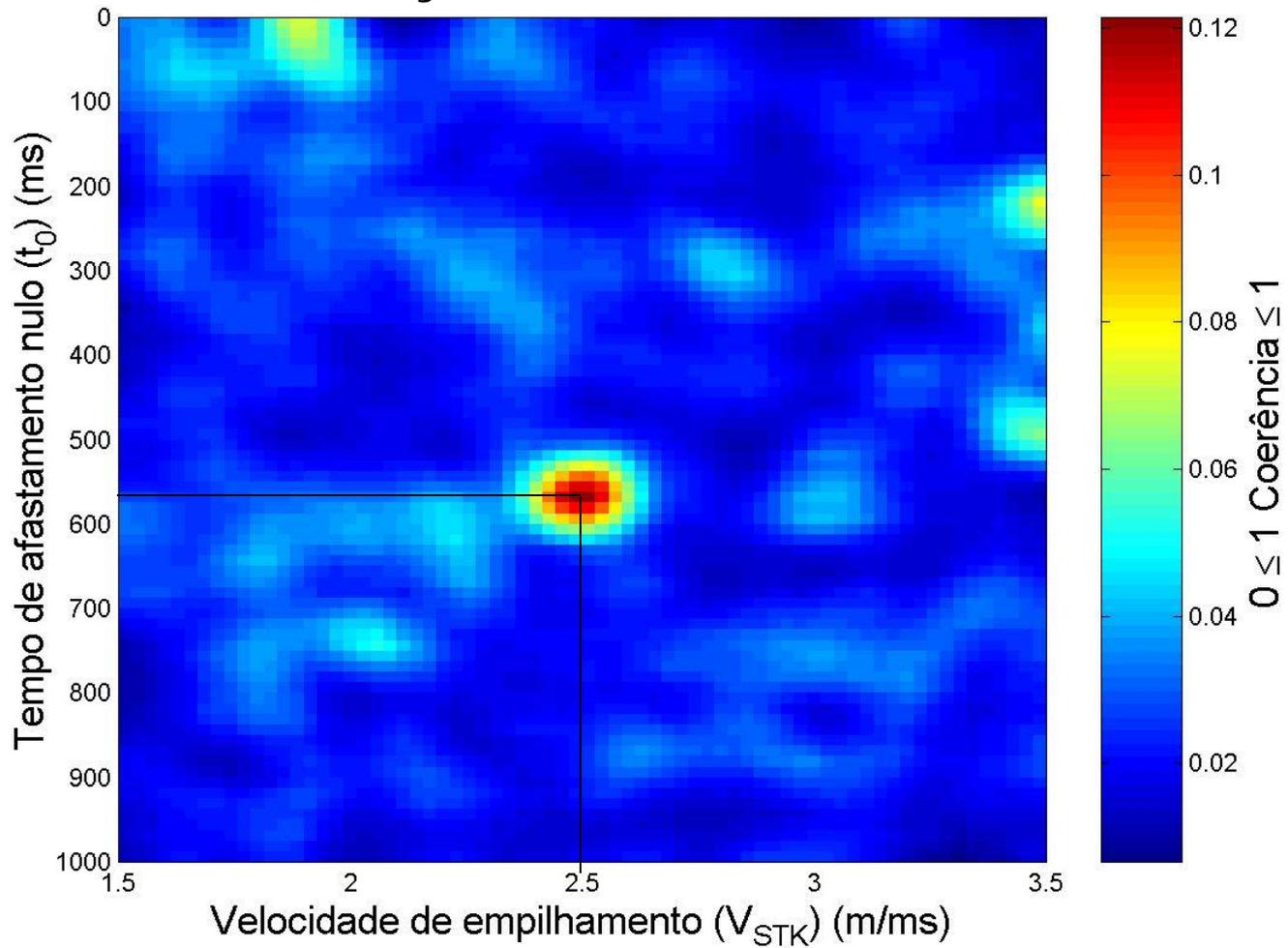
Função semblance



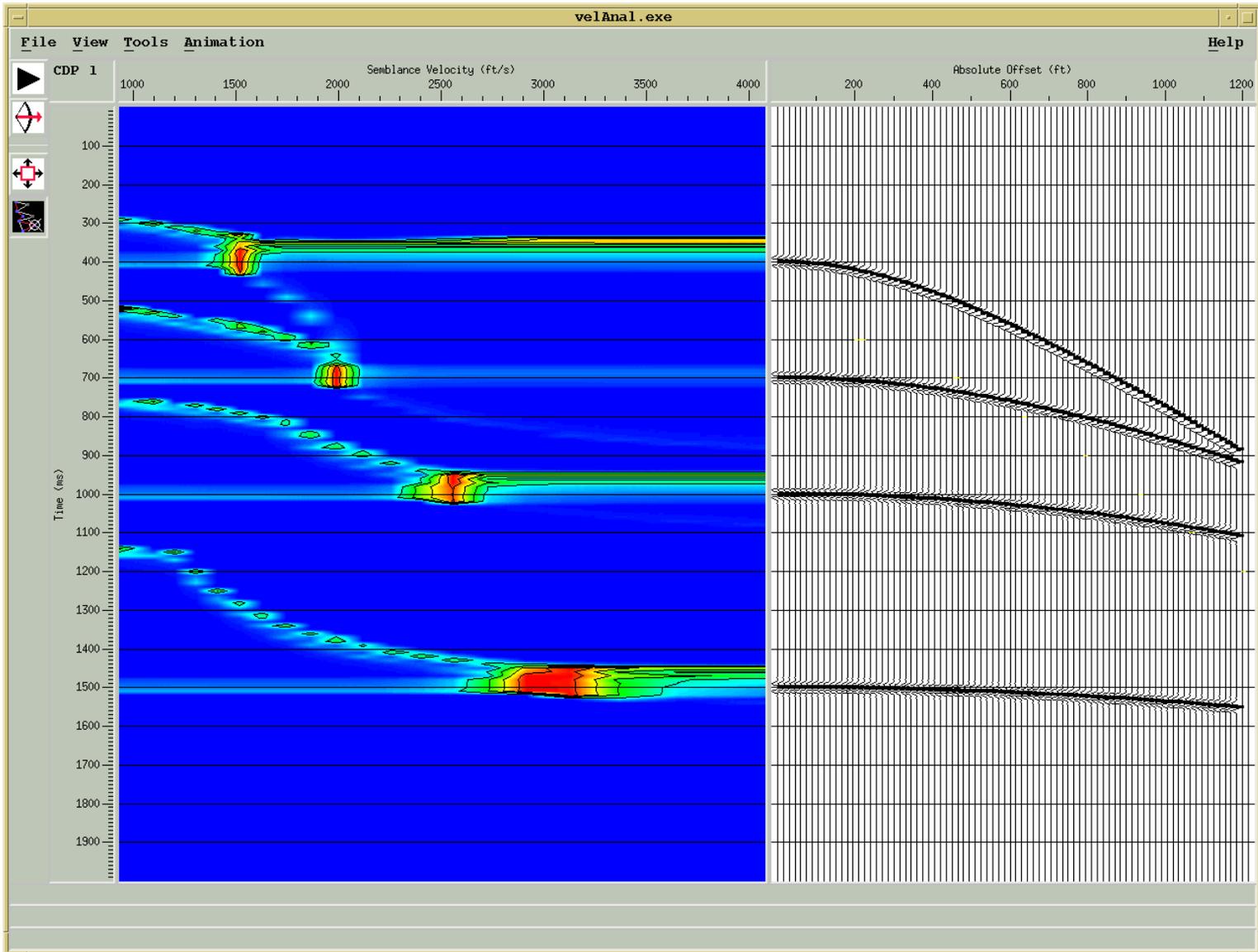
Sismograma CMP com 90% ruído

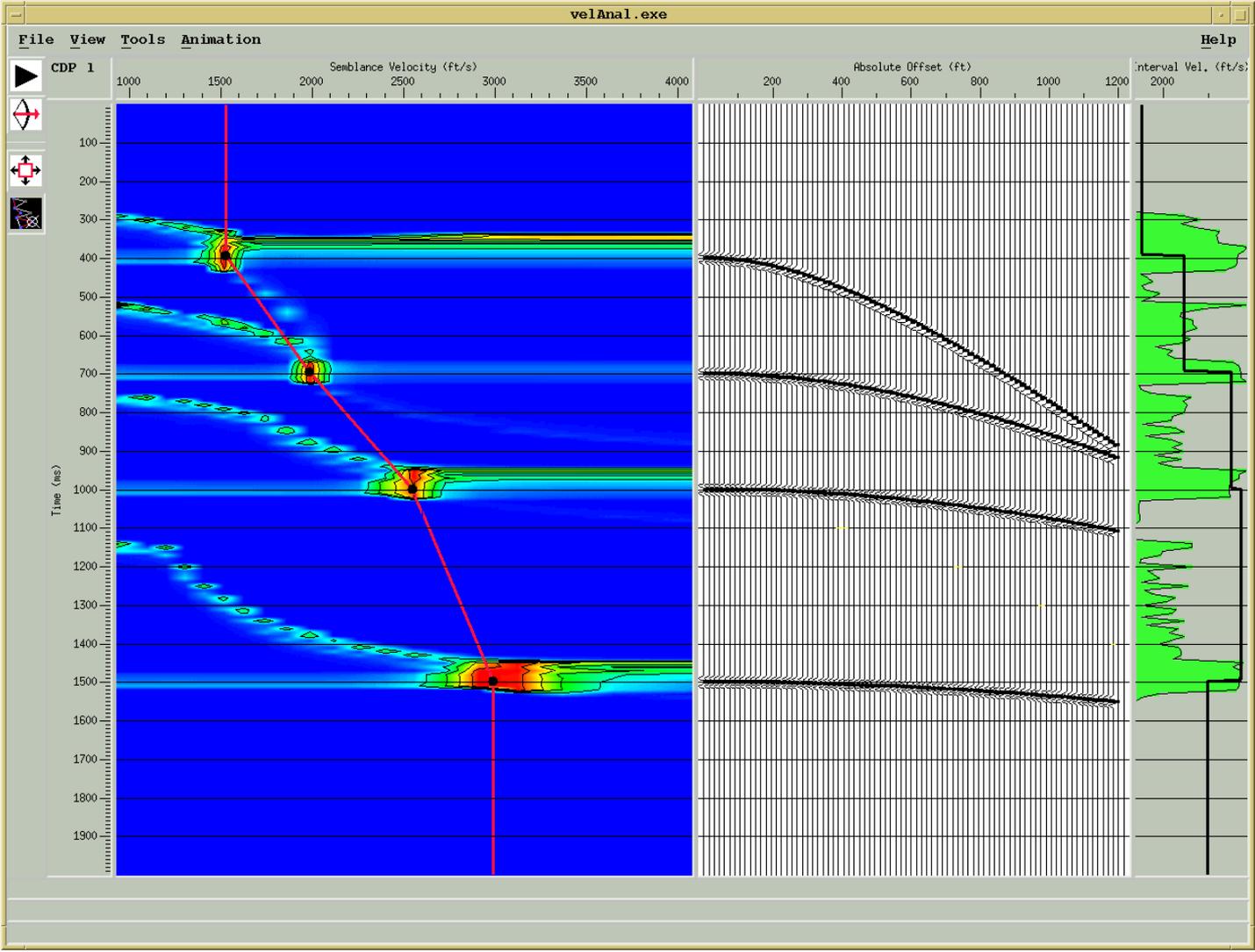


Função semblance

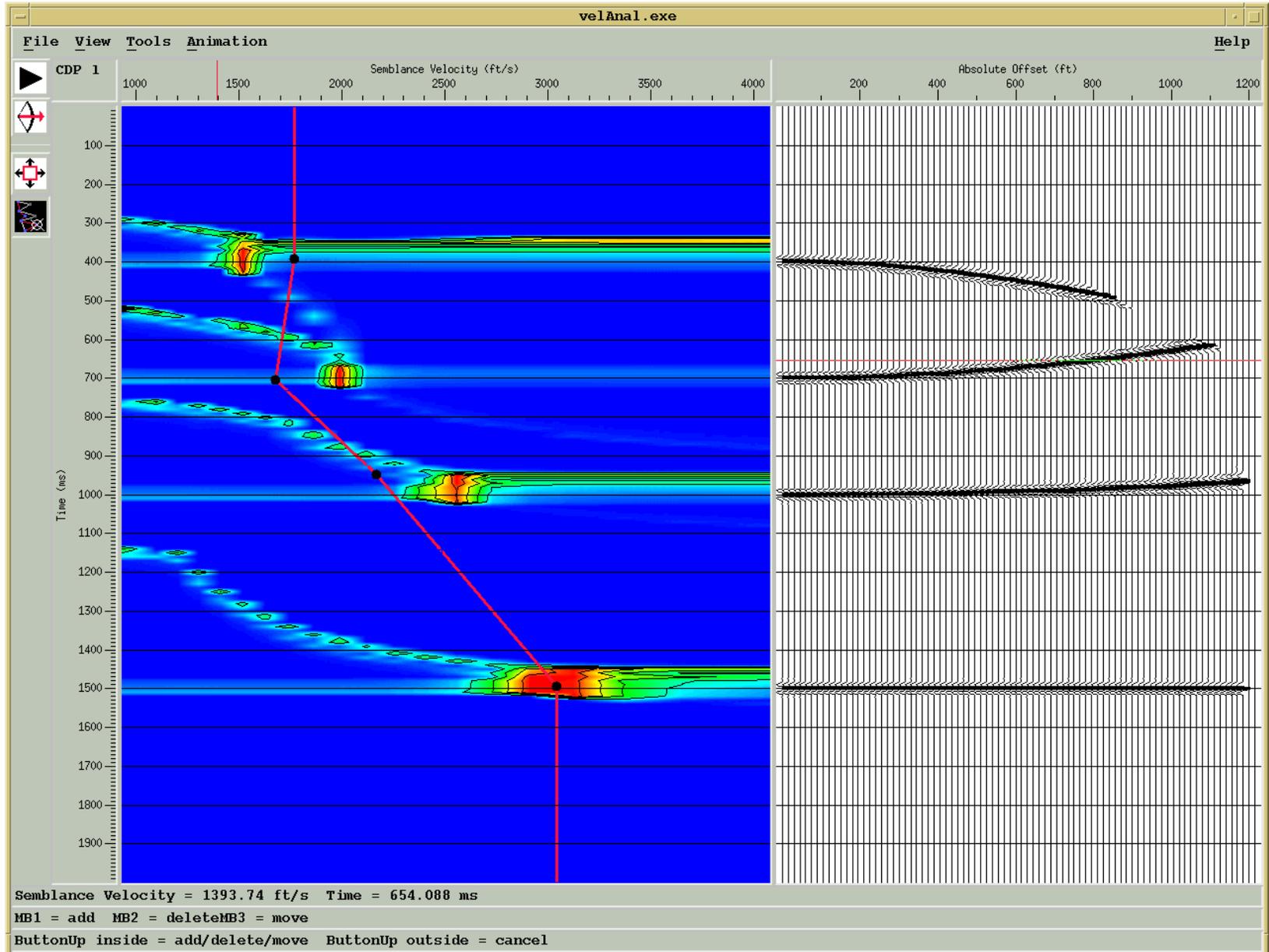


Semblance

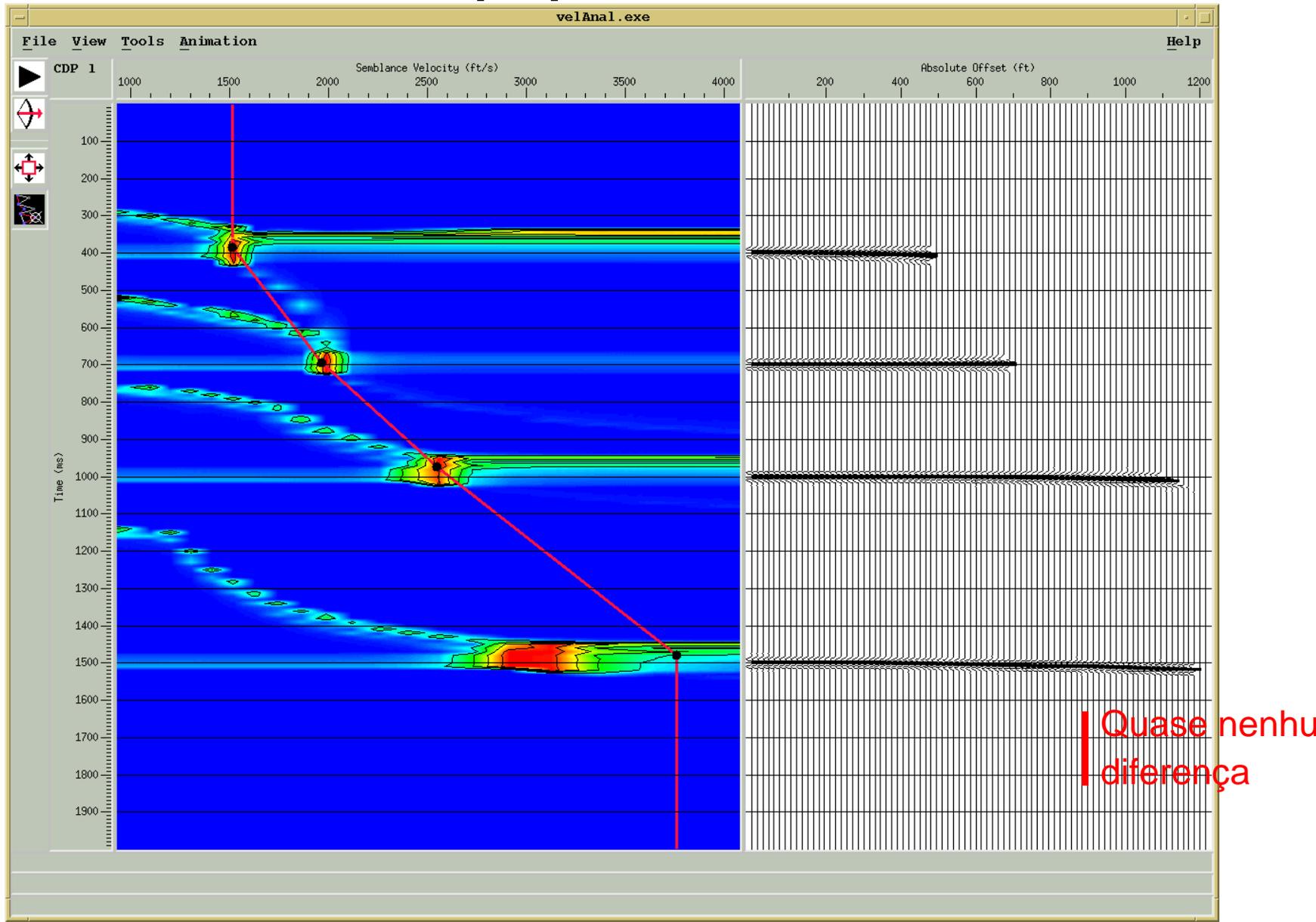




Resultado usando velocidades incorrectas



Erros para altas velocidades e tempos de trajetórias pequenos



Fatores que afetam as estimativas das velocidades

- Profundidade dos refletores
- *Move-out* da reflexão
- Comprimento do arranjo
- Razão S/R = multiplicidade