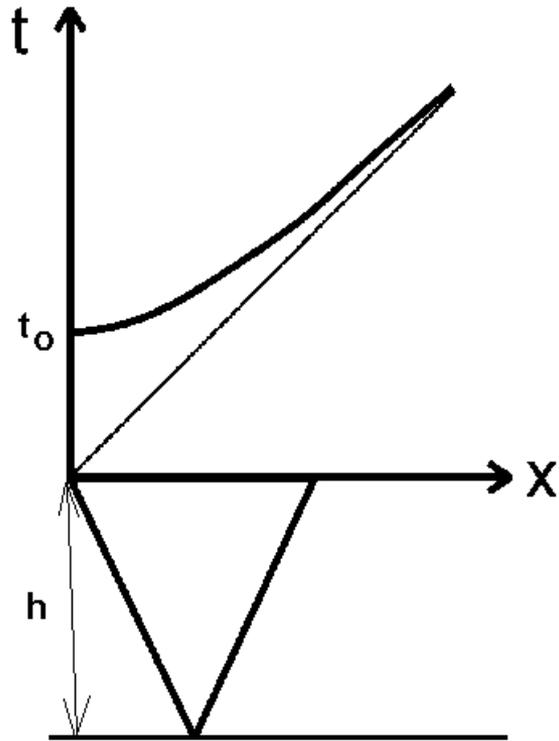


Reflexão: refletor horizontal



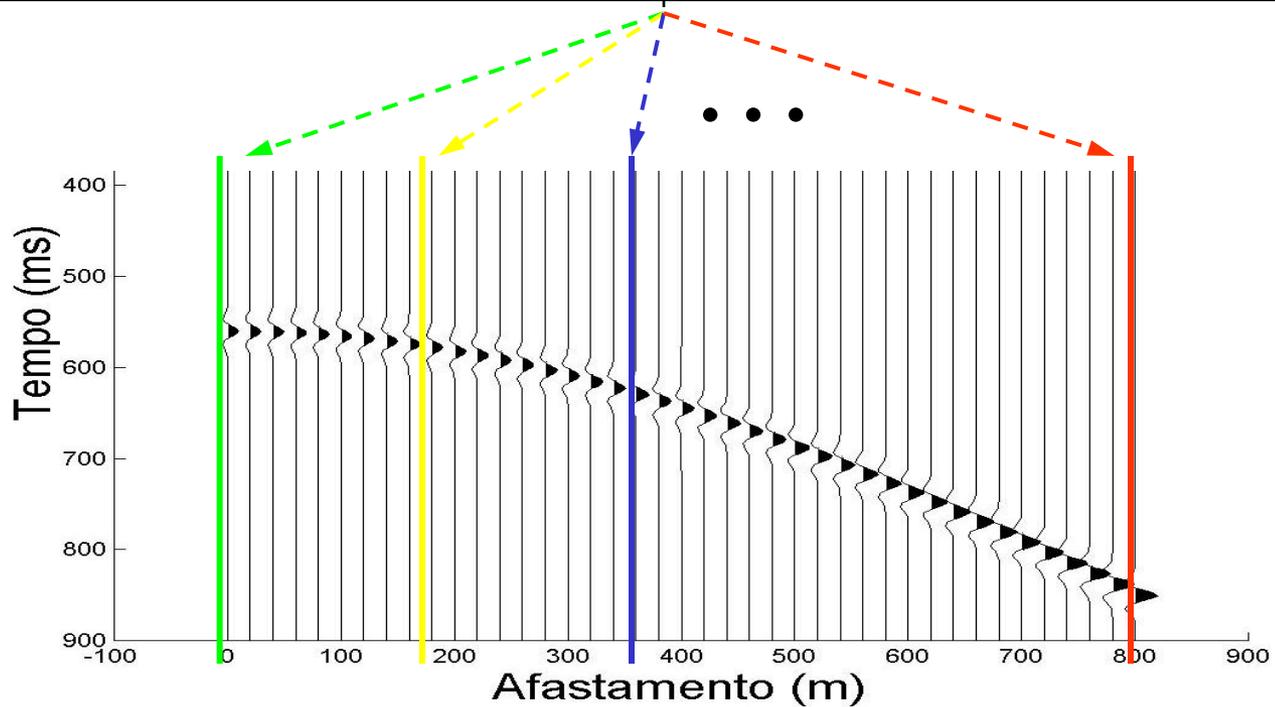
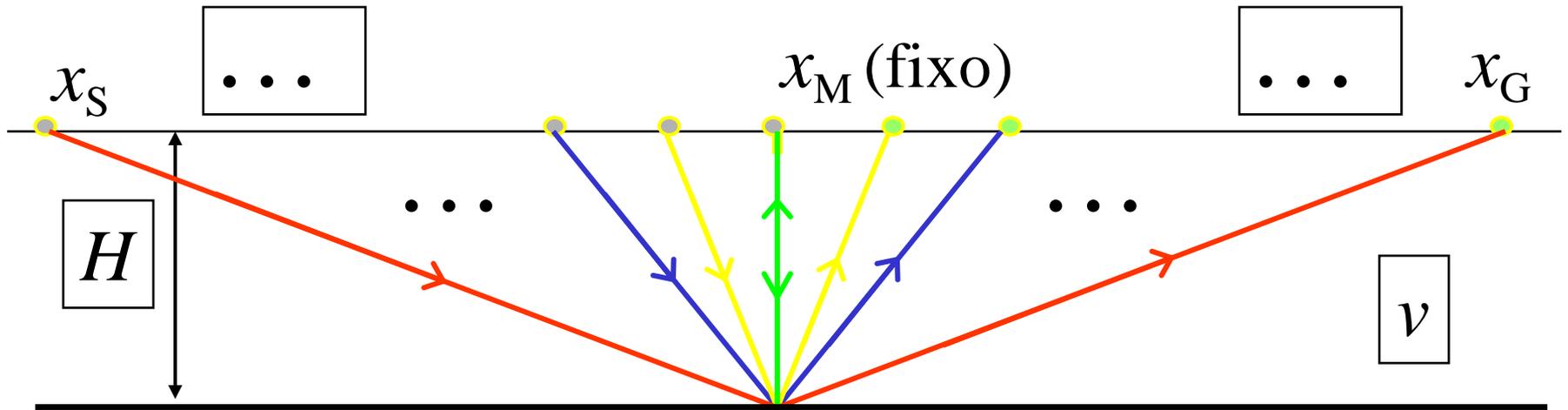
$$t^2 = t_0^2 + \frac{x^2}{V^2}$$

$$t^2 = \frac{4h^2 + x^2}{V^2}$$

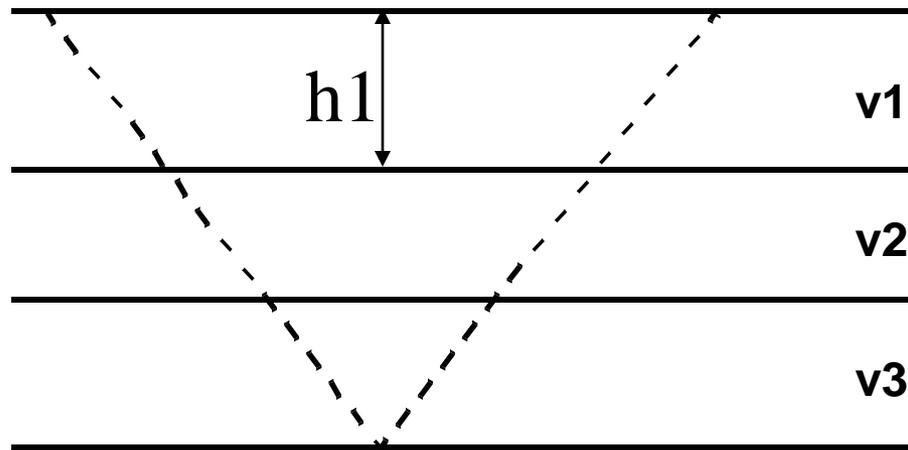
para $x=0$:

$$t_0^2 V^2 = 4h^2 \rightarrow t_0 = \frac{2h}{V}$$

Tempo de trânsito (CMP)



Diversas camadas horizontalizadas

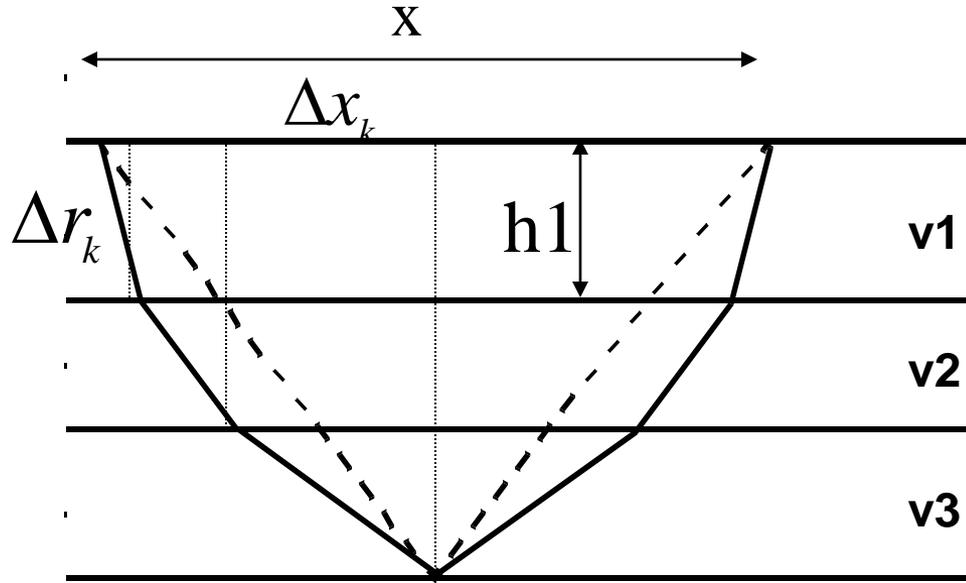


Considerando incidência normal ($x=0$)

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

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

Diversas camadas horizontalizadas



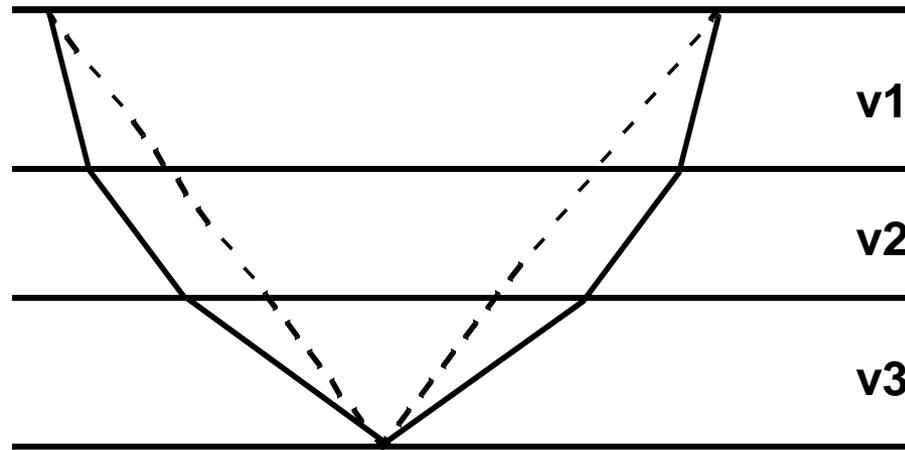
Considerando $x > 0$ e refrações nas interfaces

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

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

$$\Delta x_k = ?$$

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 da espessura da camada (h_1, h_2, \dots, h_n) e da velocidade de cada camada (v_1, v_2, v_n)

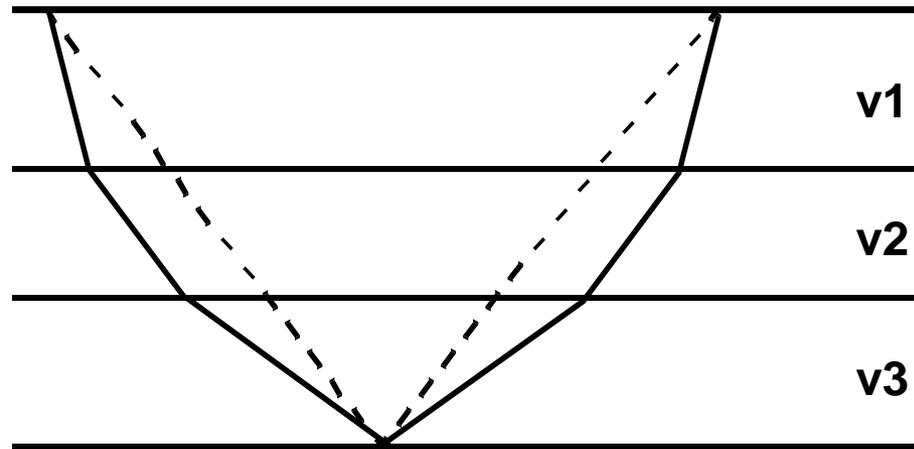
Para distâncias $x_n \sim h_n$ os 2 primeiros termos da expressão anterior permitem a precisão necessária para os propósitos da sísmica de exploração

$$t_{(x,n)}^2 = C_1 + C_2 x^2$$

$$C_1 = \left(\sum_{k=1}^{n-1} t_{(0,k)} \right) = t_{(0,n)}^2$$

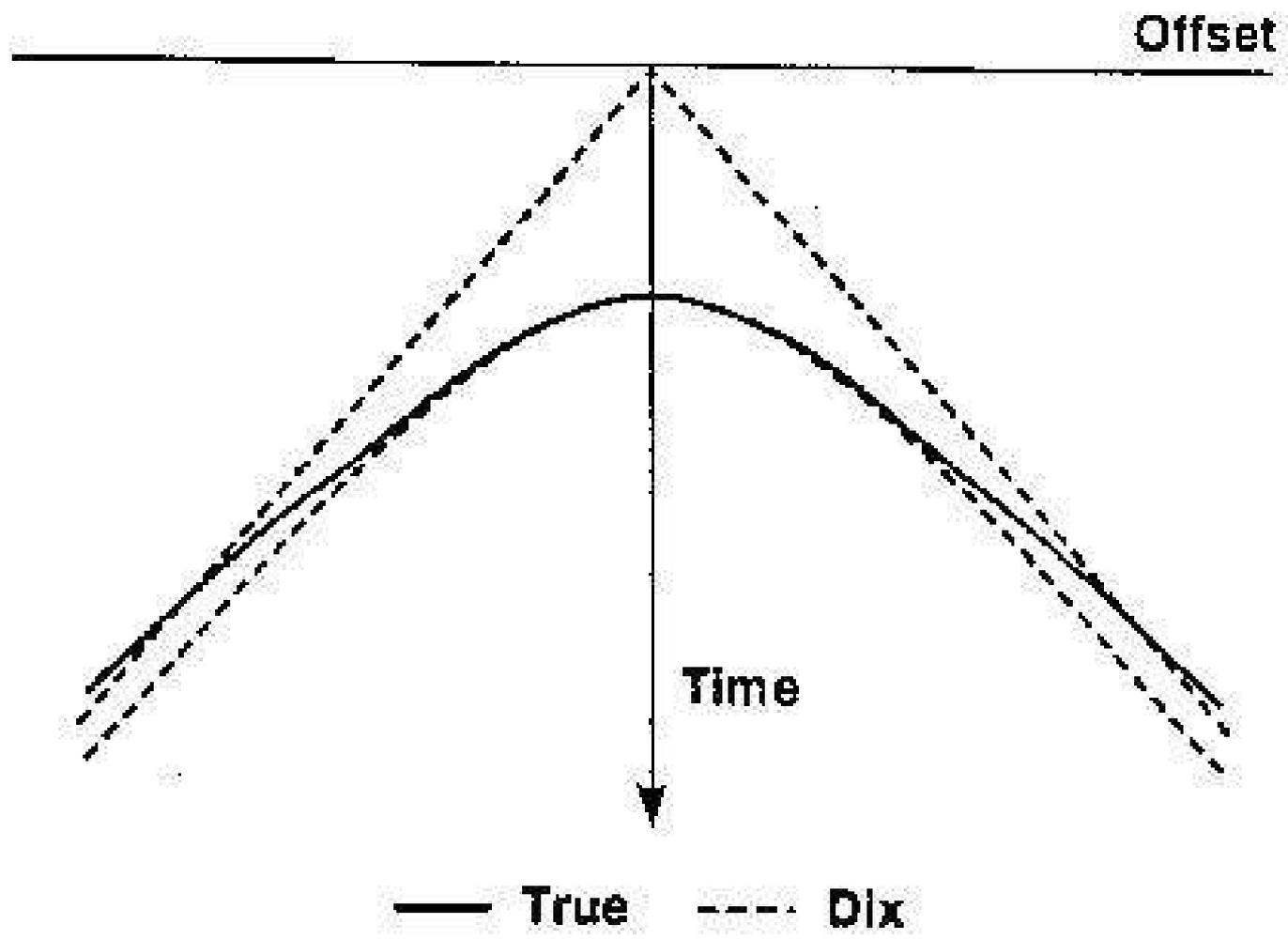
$$C_2 = \frac{\sum_{k=1}^{n-1} t_{(0,k)}}{\sum_{k=1}^{n-1} t_{(0,k)} V_k^2} = \frac{1}{\overline{V_n^2}} \quad \text{ou} \quad V_{RMS}^2 = \frac{\sum_{k=1}^{n-1} V_k^2 t_k}{t_{(0,n)}}$$

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

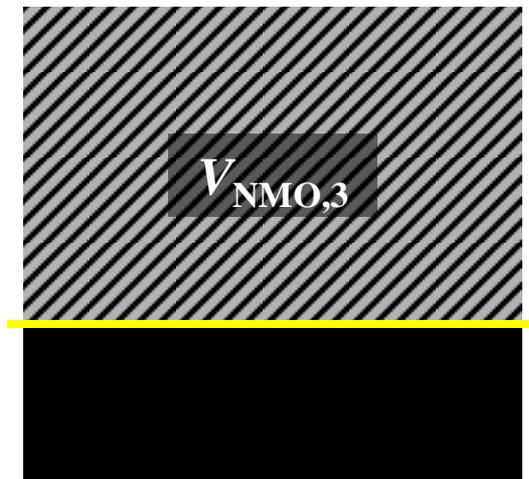
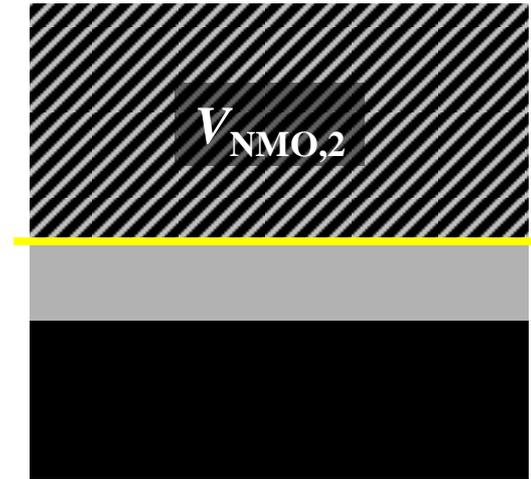
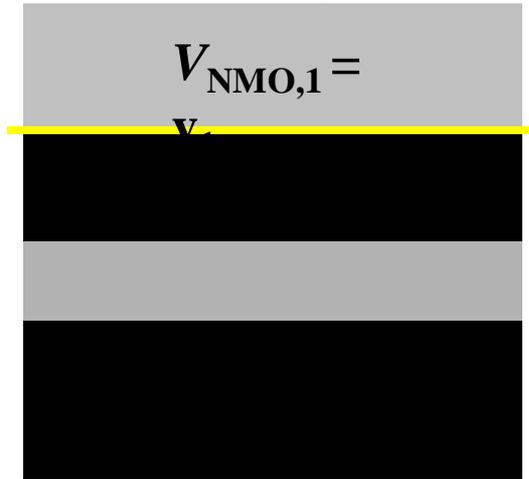


Correção NMO - multicamadas

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



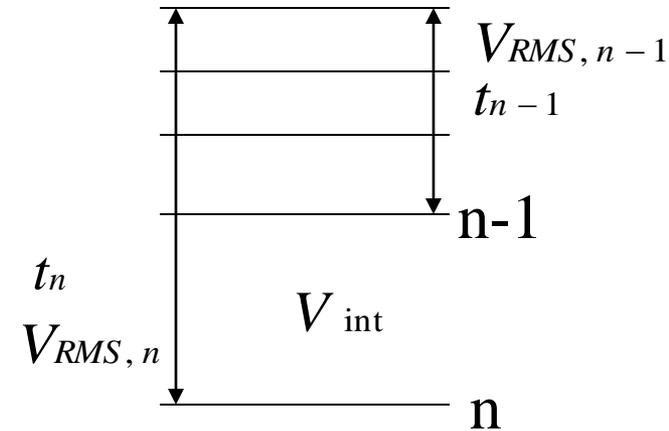
Correção NMO - multicamadas



Fórmula de Dix

Conversão da v_{rms} em velocidade intervalar

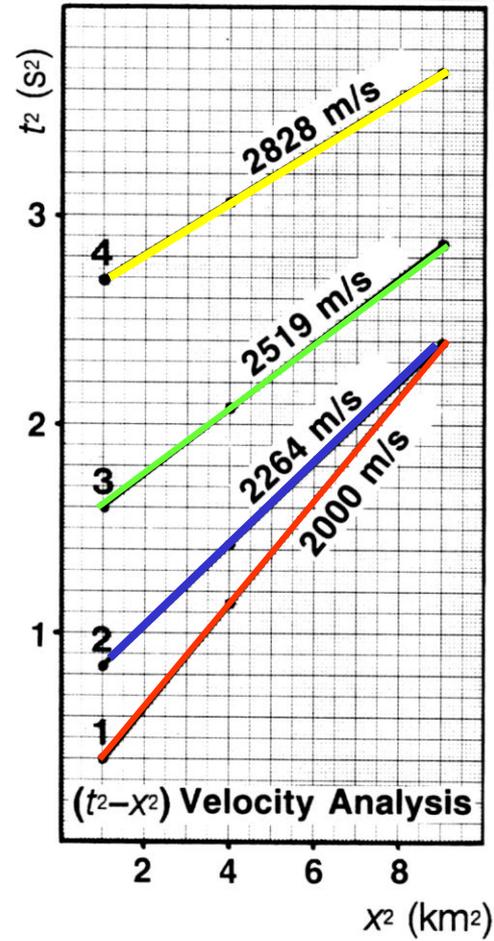
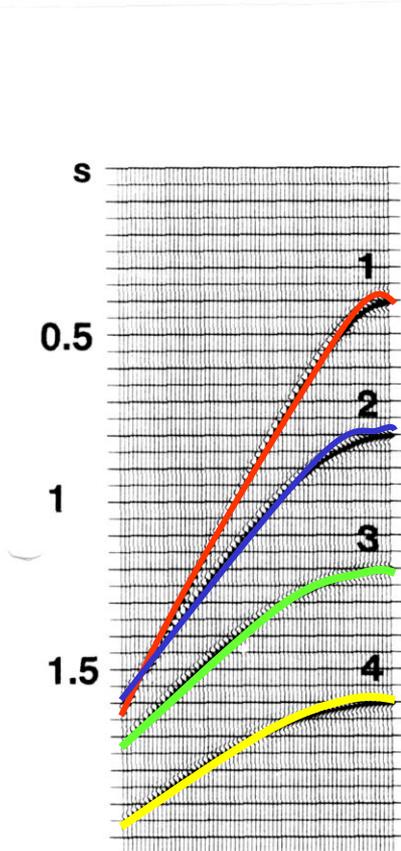
$$V_{int} = \sqrt{\left[\frac{(V_{RMS,n})^2 t_n - (V_{RMS,n-1})^2 t_{n-1}}{t_n - t_{n-1}} \right]}$$



Métodos para análise de velocidades

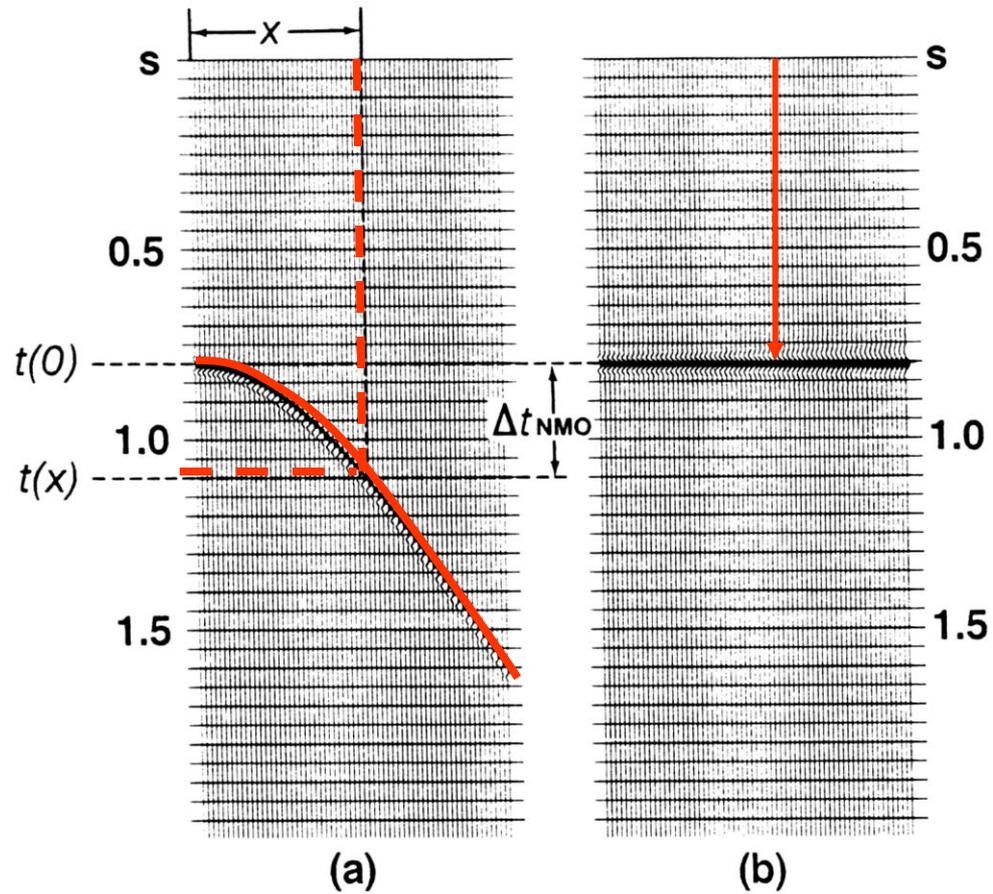
- **Análise x^2-t^2**
- **Métodos que usam a correção NMO:**
 - **CVP - constant velocity panels**
 - **CVS - constant velocity stacks**
 - **Análise do espectro de velocidades (semblance)**

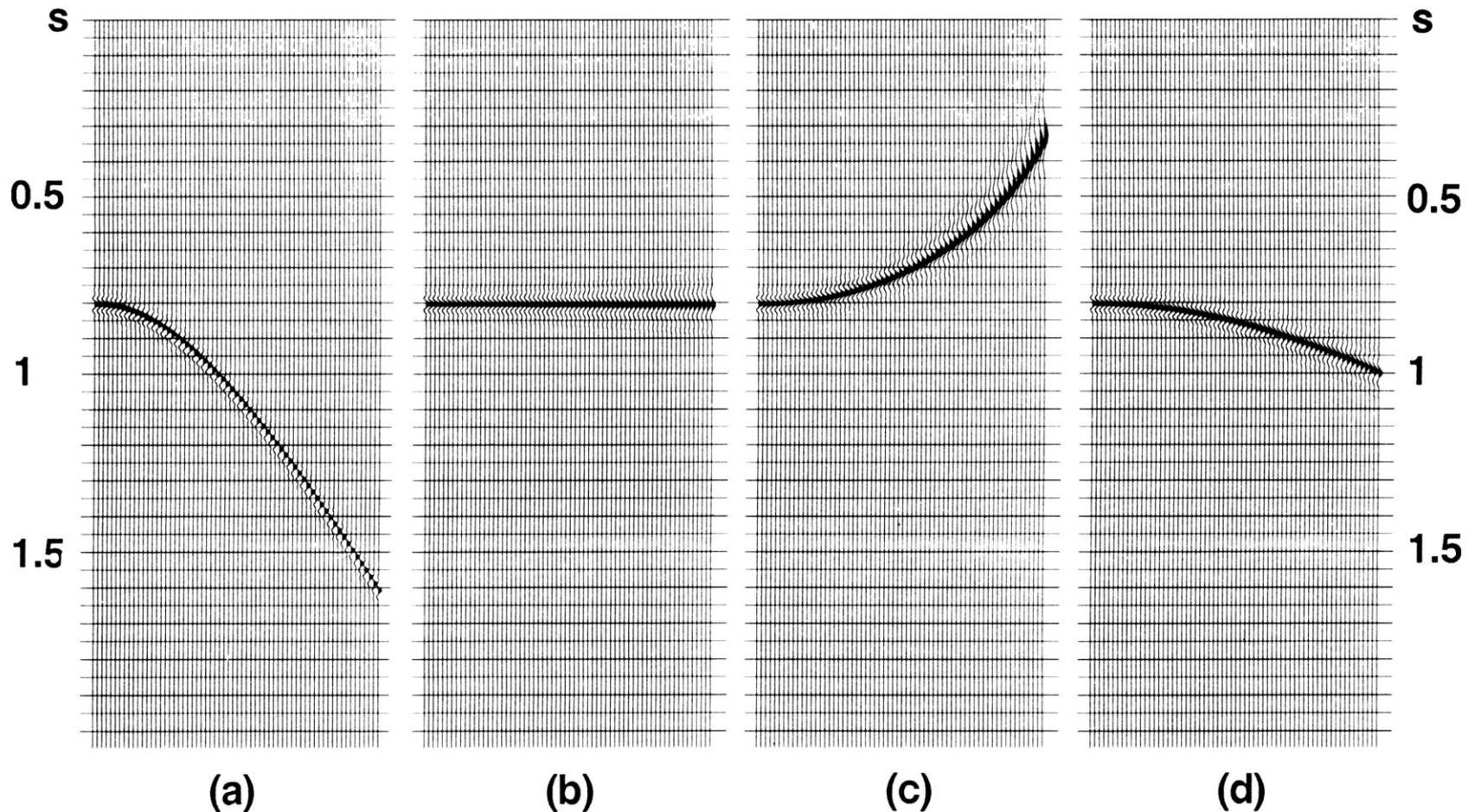
Análise x^2-t^2



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

Métodos que usam a correção NMO





(a) Reflexão não corrigida

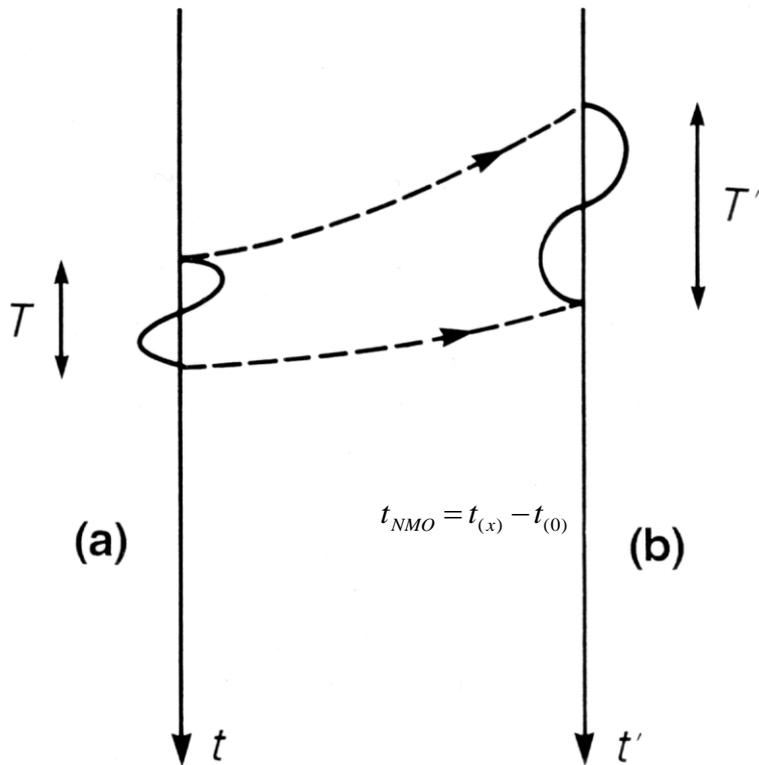
(b) Corrigida com velocidade correta

(c) Velocidade muito baixa

(d) Velocidade muito alta

Yilmaz, 1987

Stretching (estiramento)



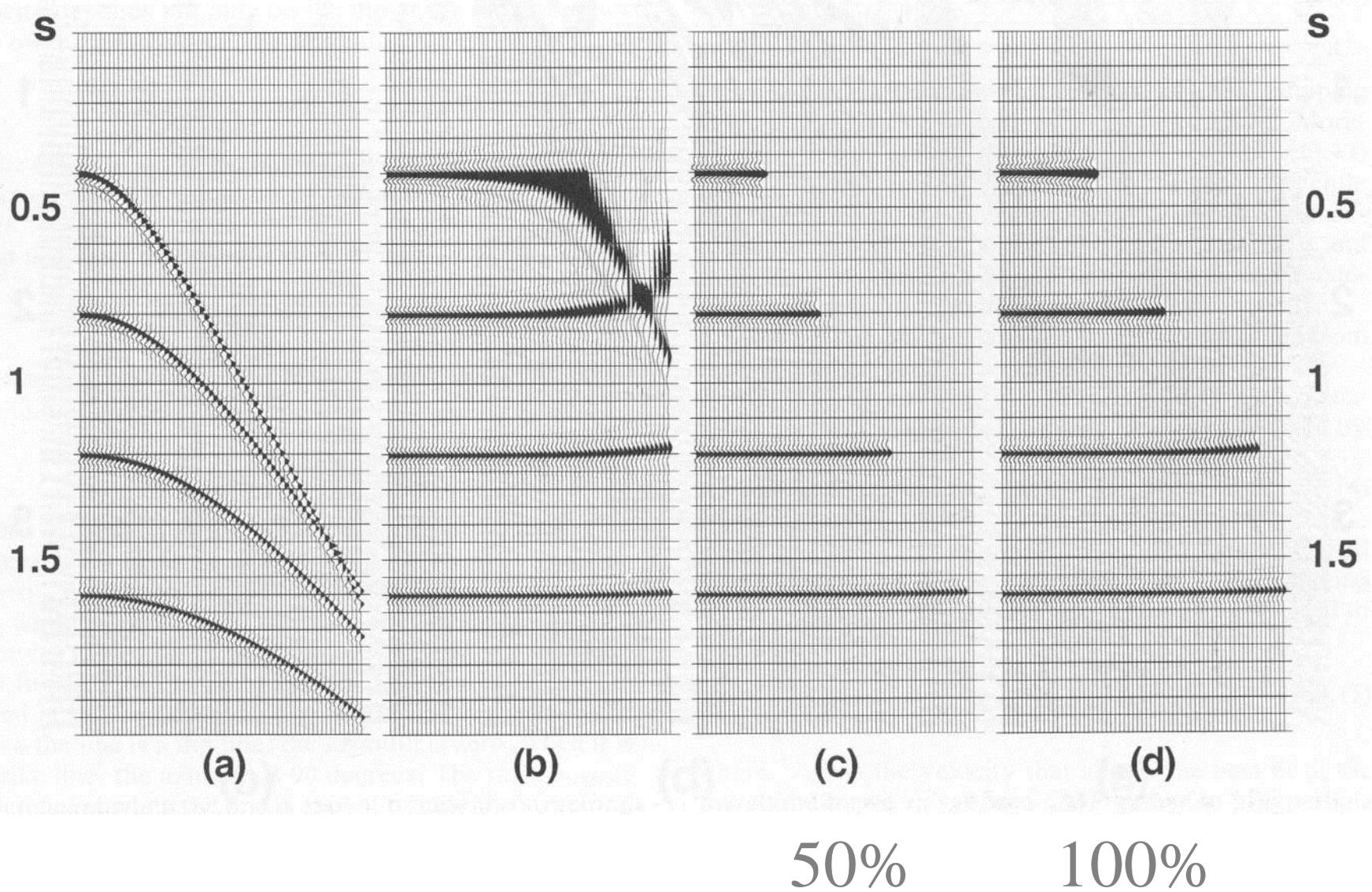
$$t_{NMO} = t(x) - t(0)$$

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

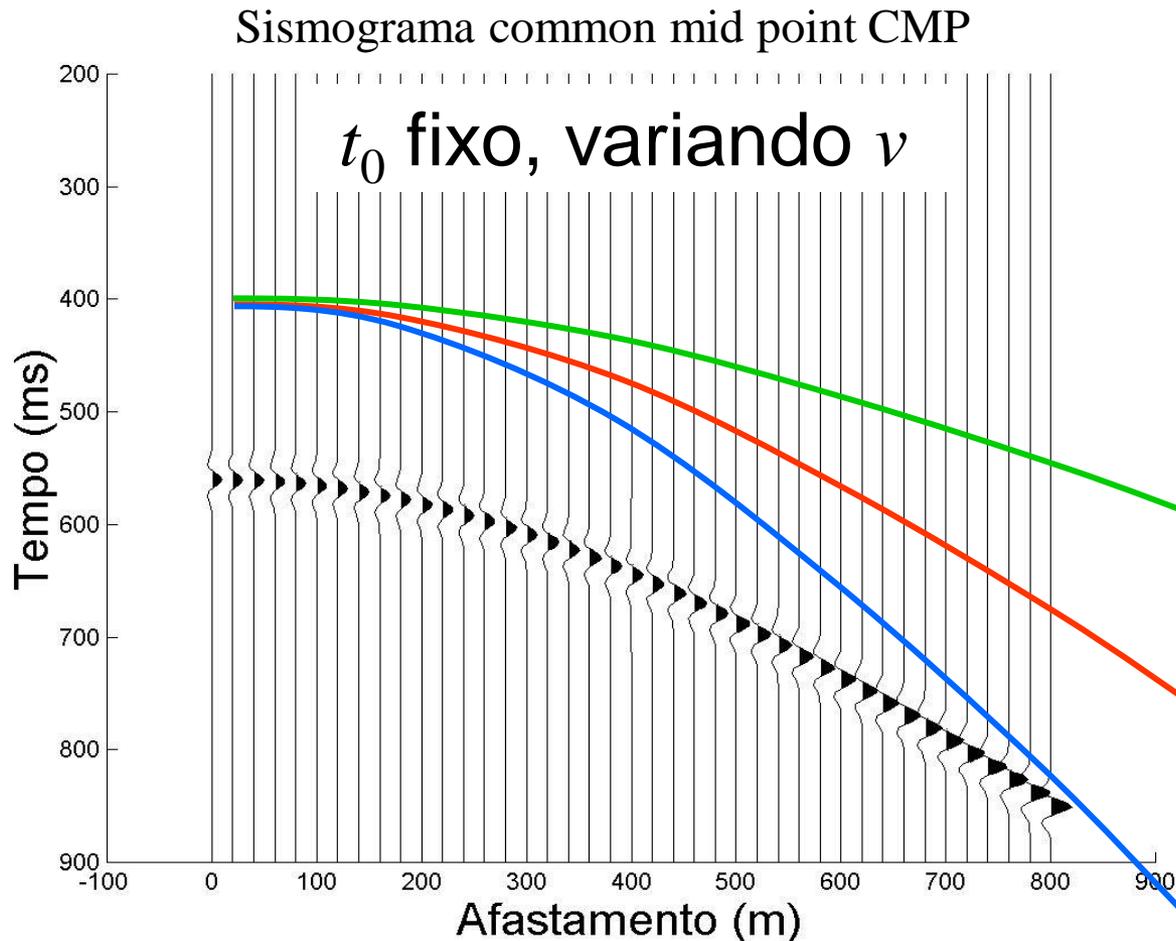
$$t_{NMO(1)} = t(x) - \left(t^2(x) - \frac{x^2}{V^2} \right)^{1/2}$$

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

Efeito “stretch” (estiramento do traço)

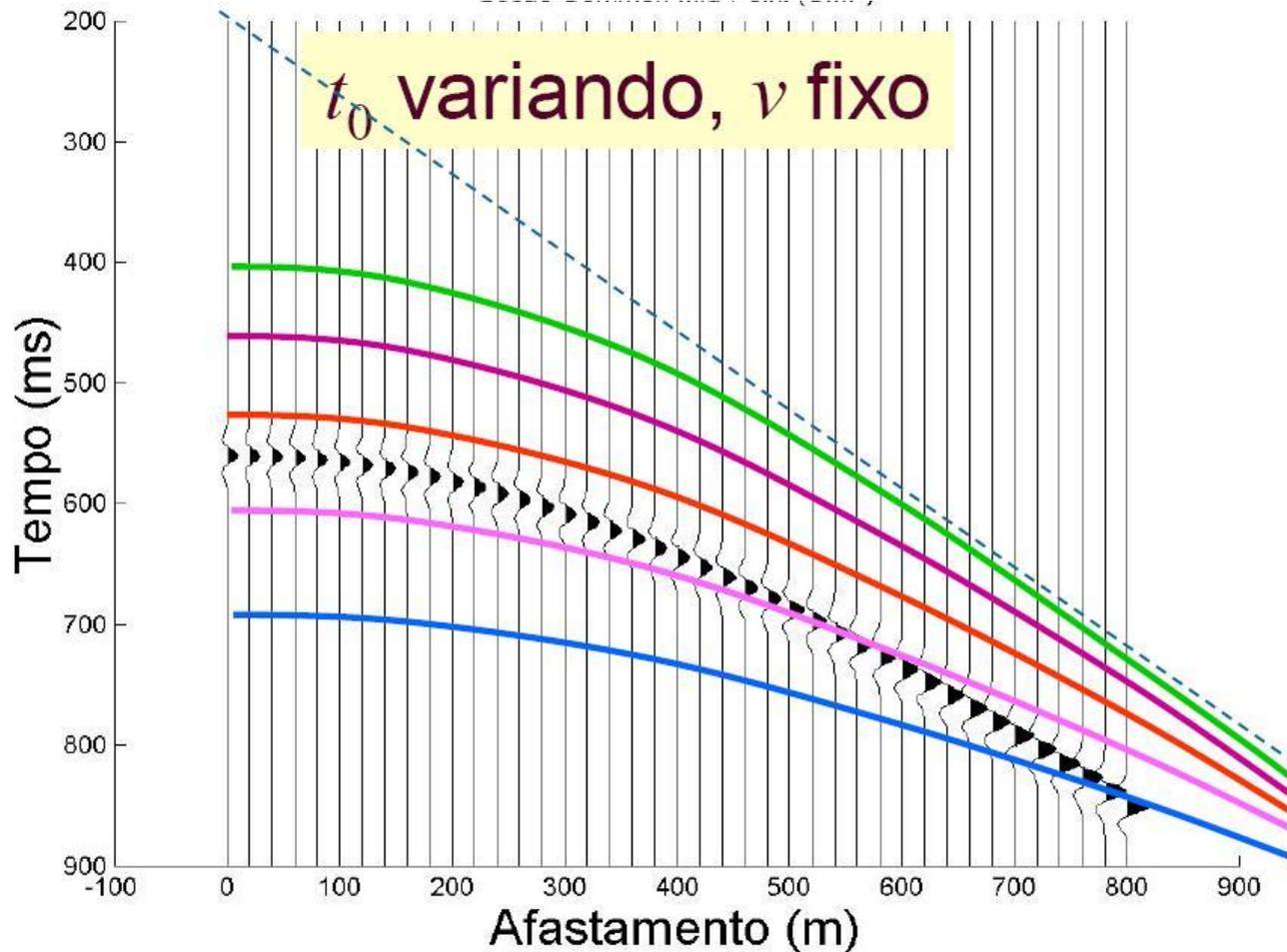


Tempo de trânsito (CMP)

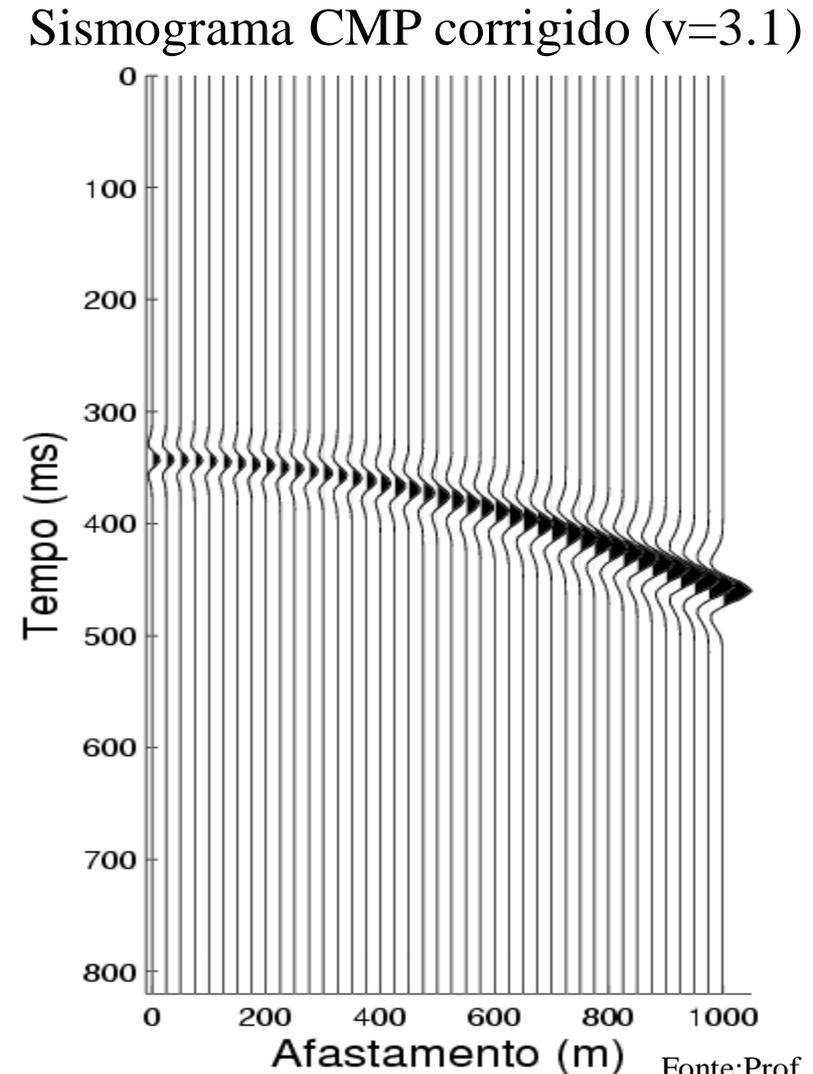
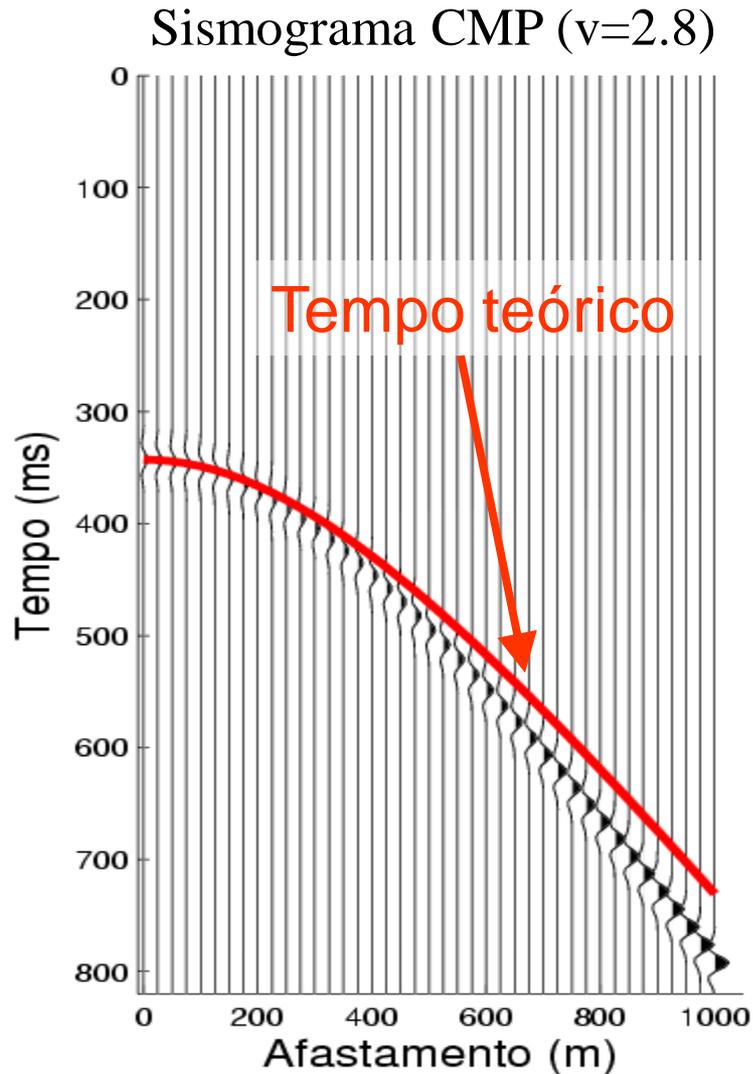


Tempo de trânsito (CMP)

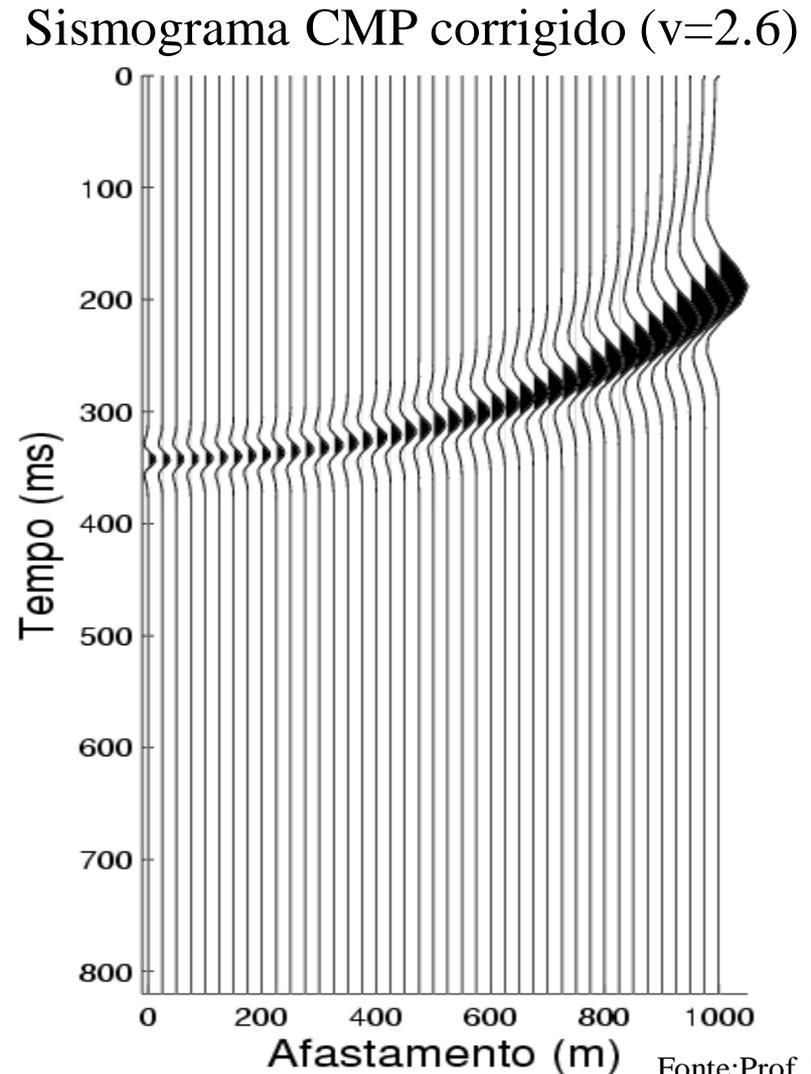
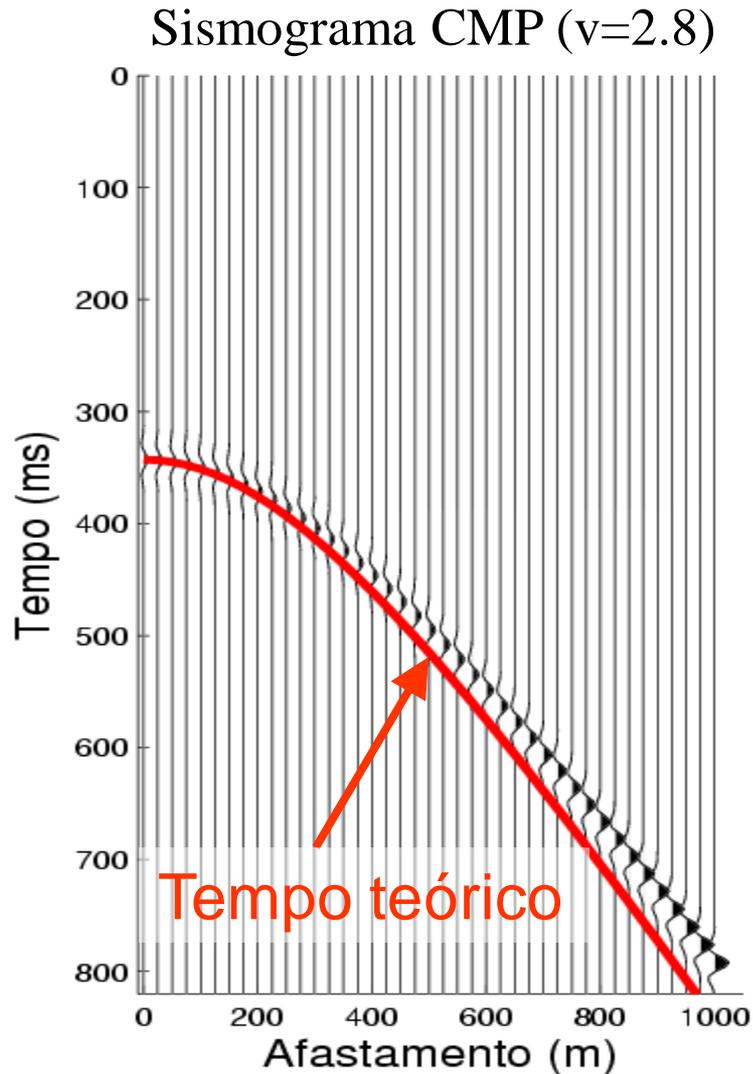
Sismograma common mid point CMP

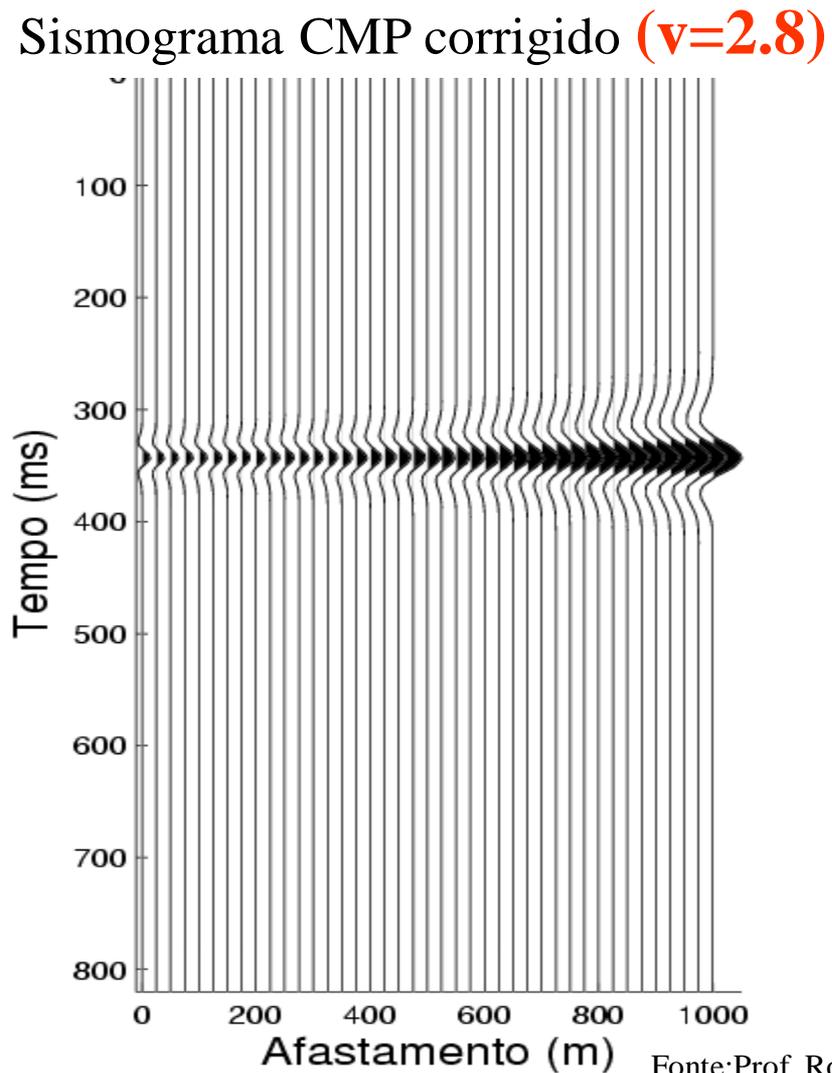
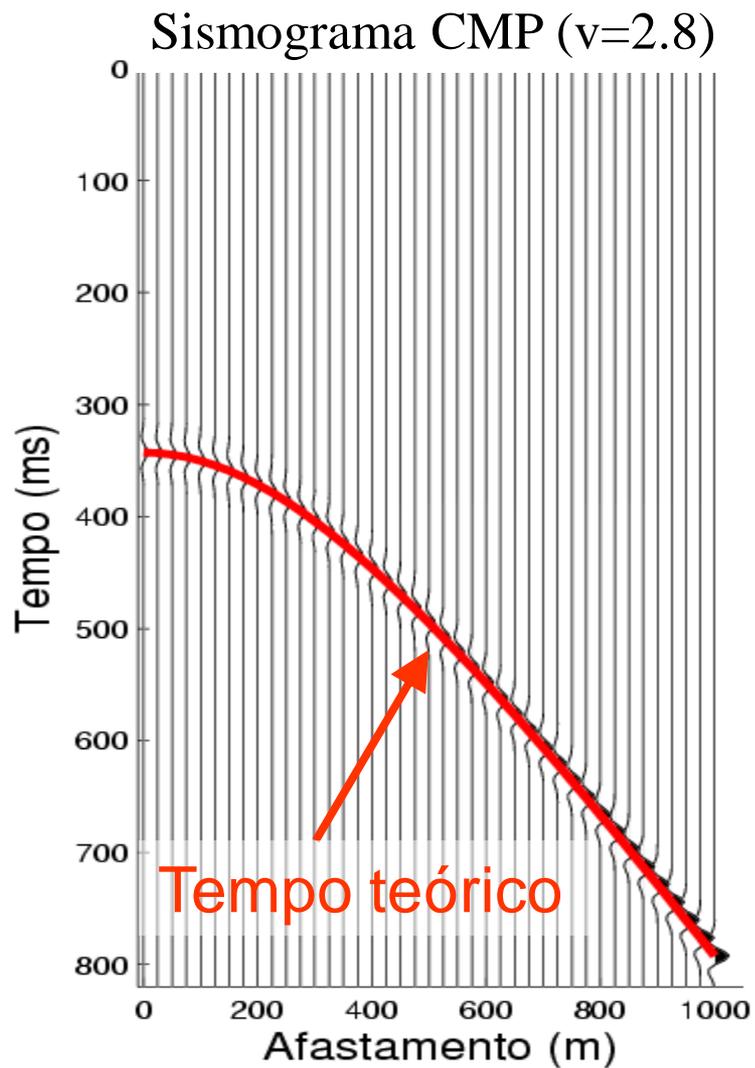


Correção NMO



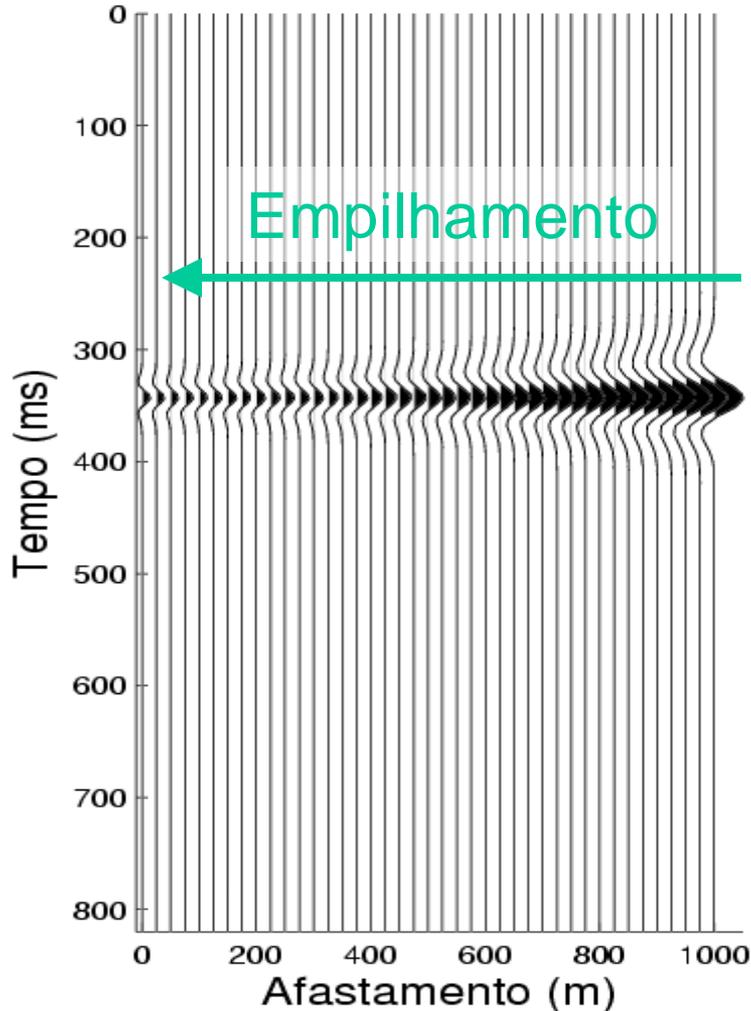
Correção NMO





Empilhamento NMO

Sismograma CMP corrigido ($v=2.8$)



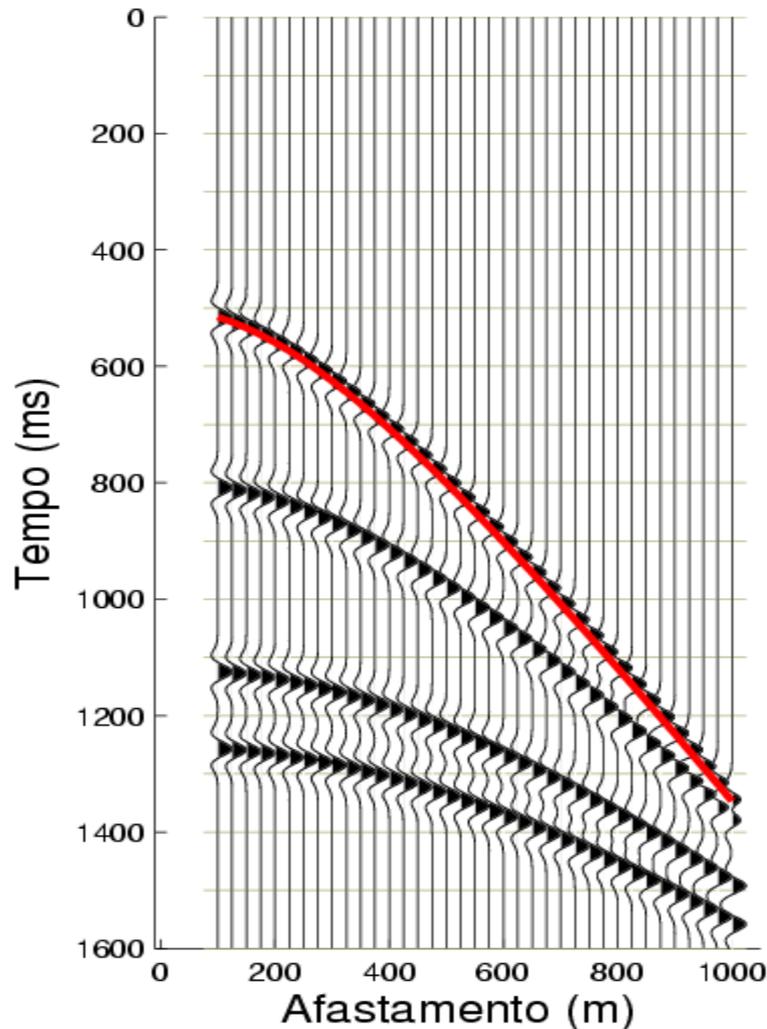
Empilhamento

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

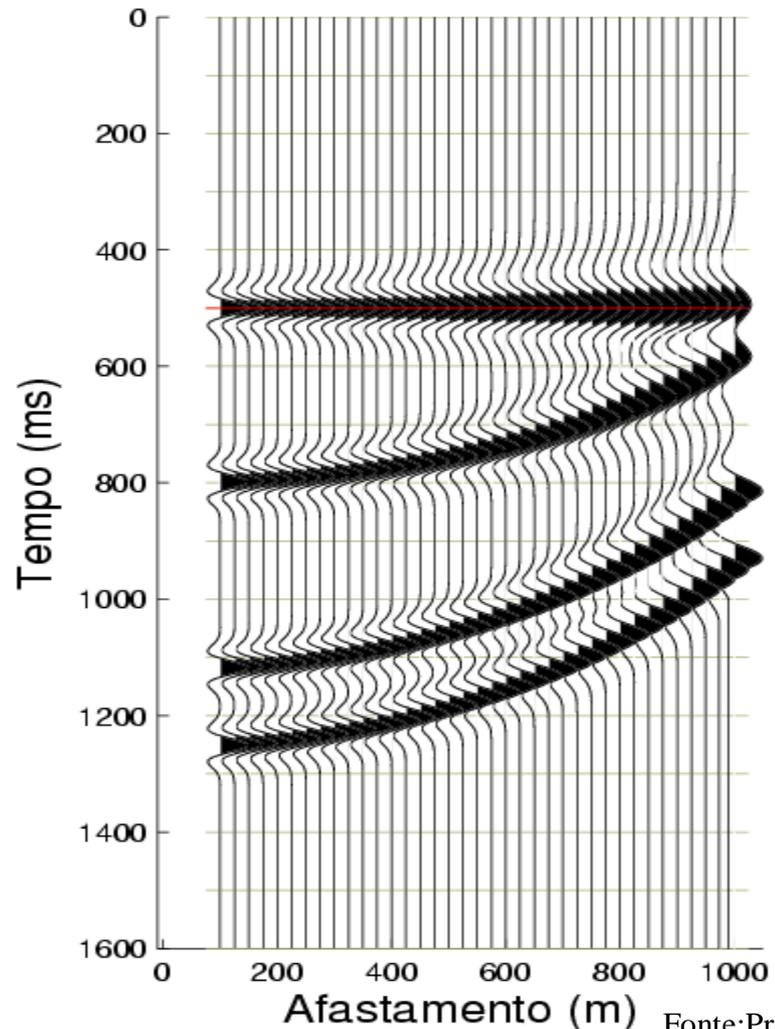
Cada conjunto CMP dá origem a um traço empilhado

Correção NMO - multicamadas

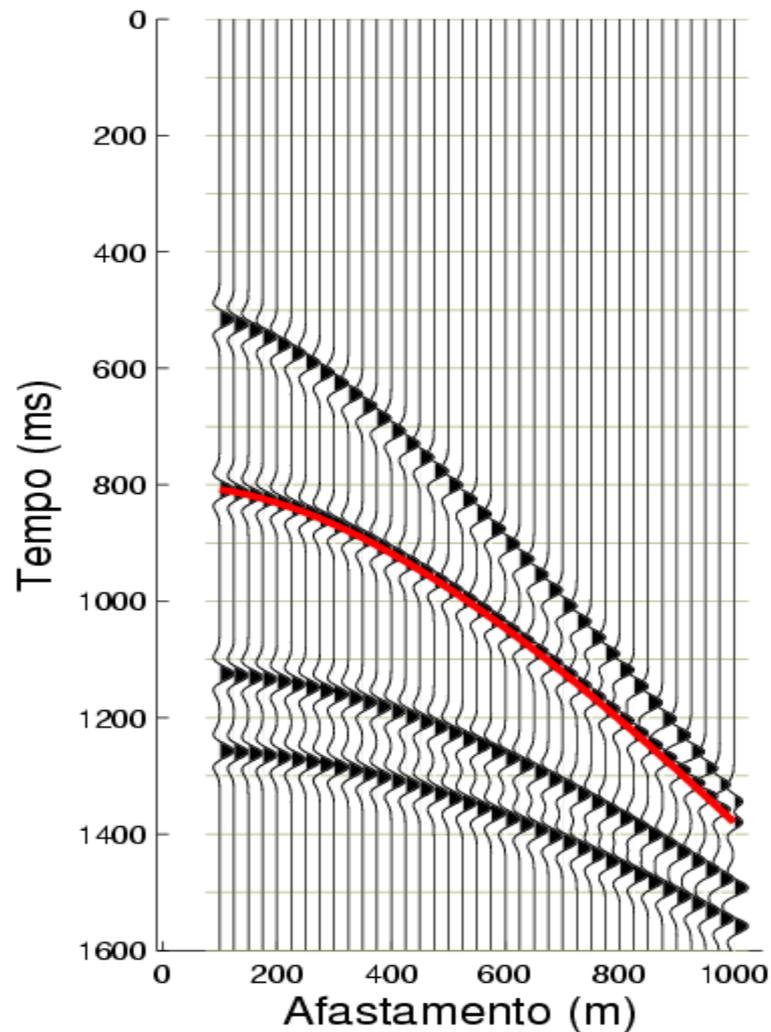
Sismograma CMP (v=2.8)



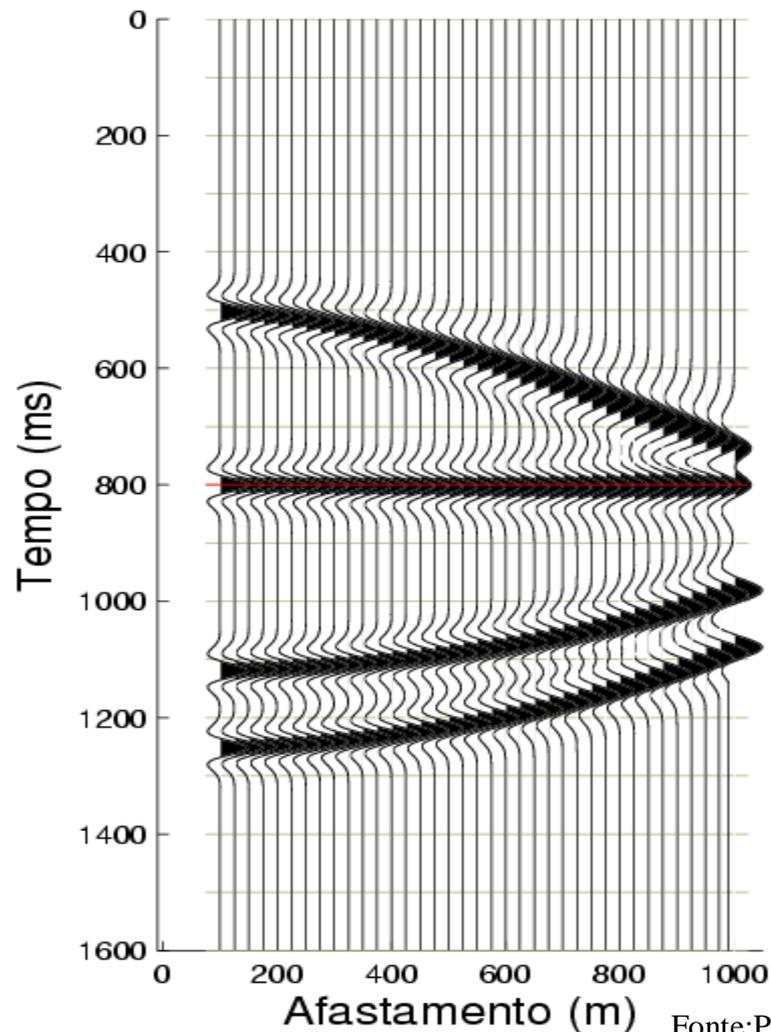
Sismograma CMP corrigido (v=1.6)



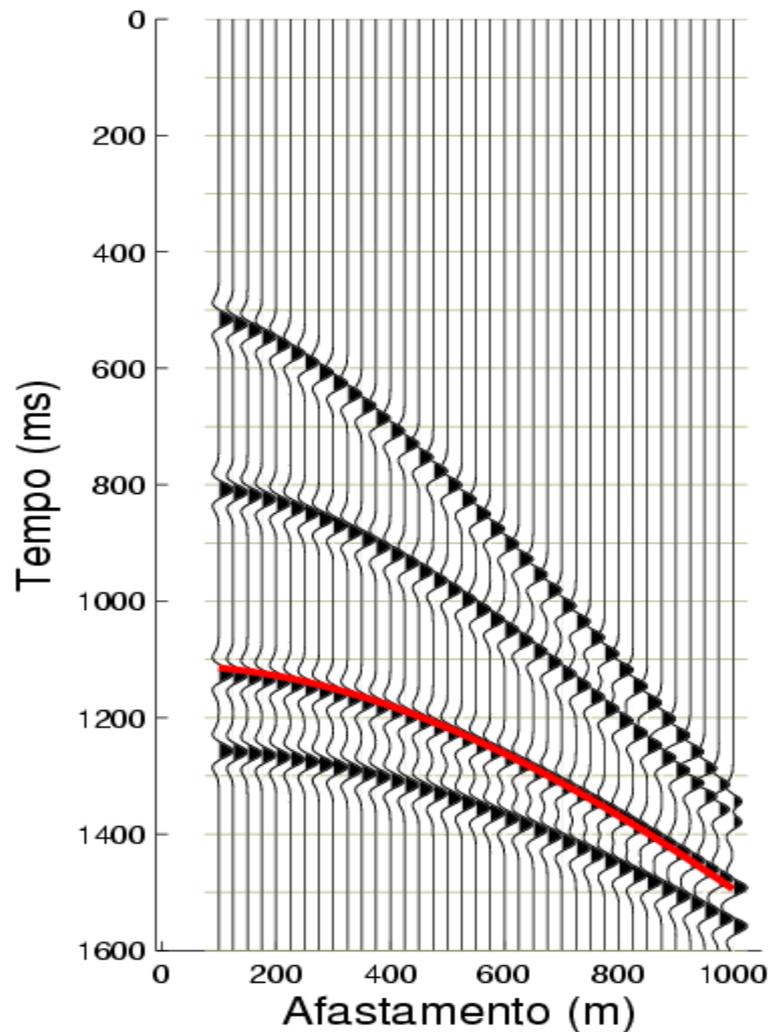
Sismograma CMP ($v=2.8$)



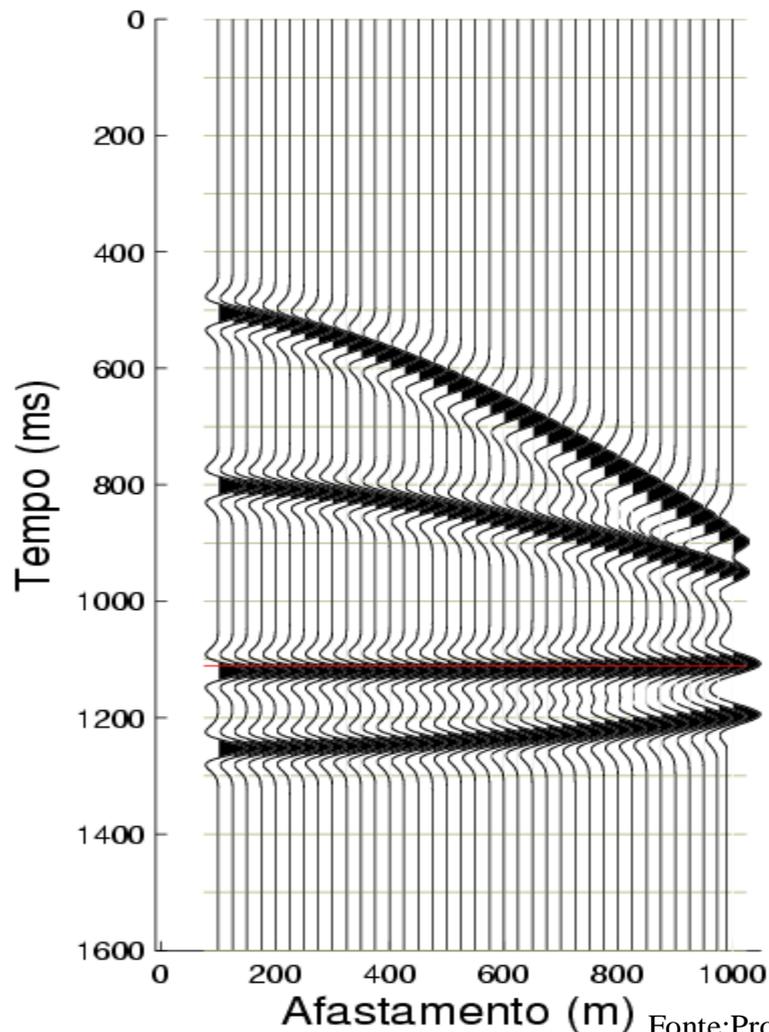
Sismograma CMP corrigido ($v=1.78$)



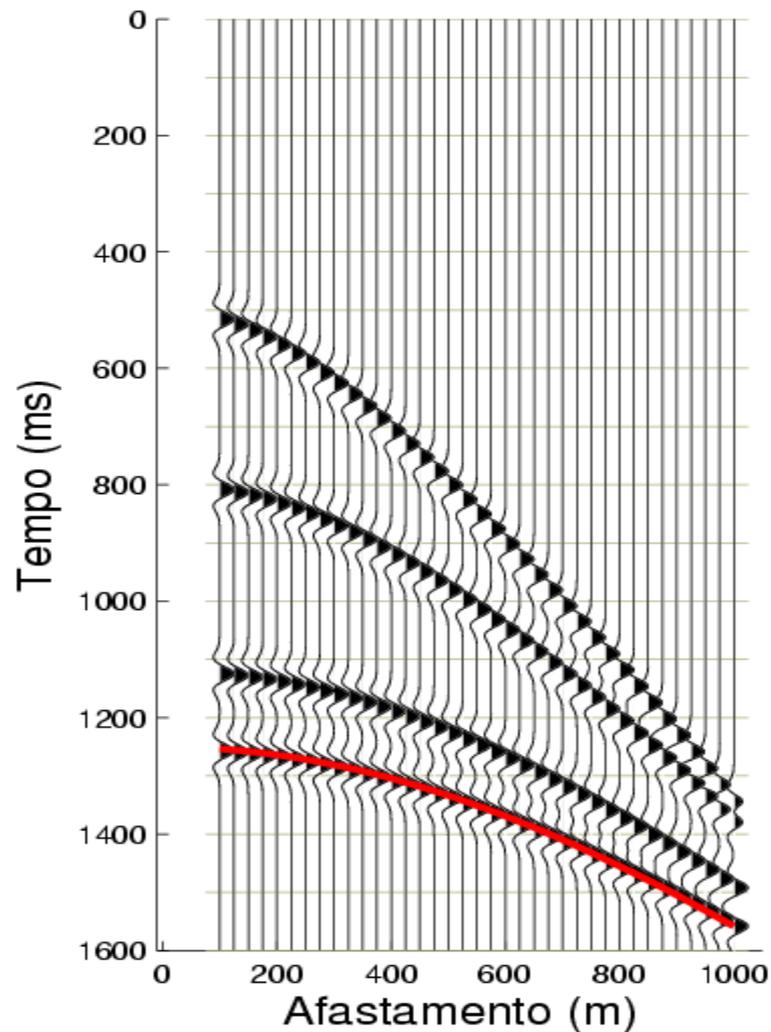
Sismograma CMP ($v=2.8$)



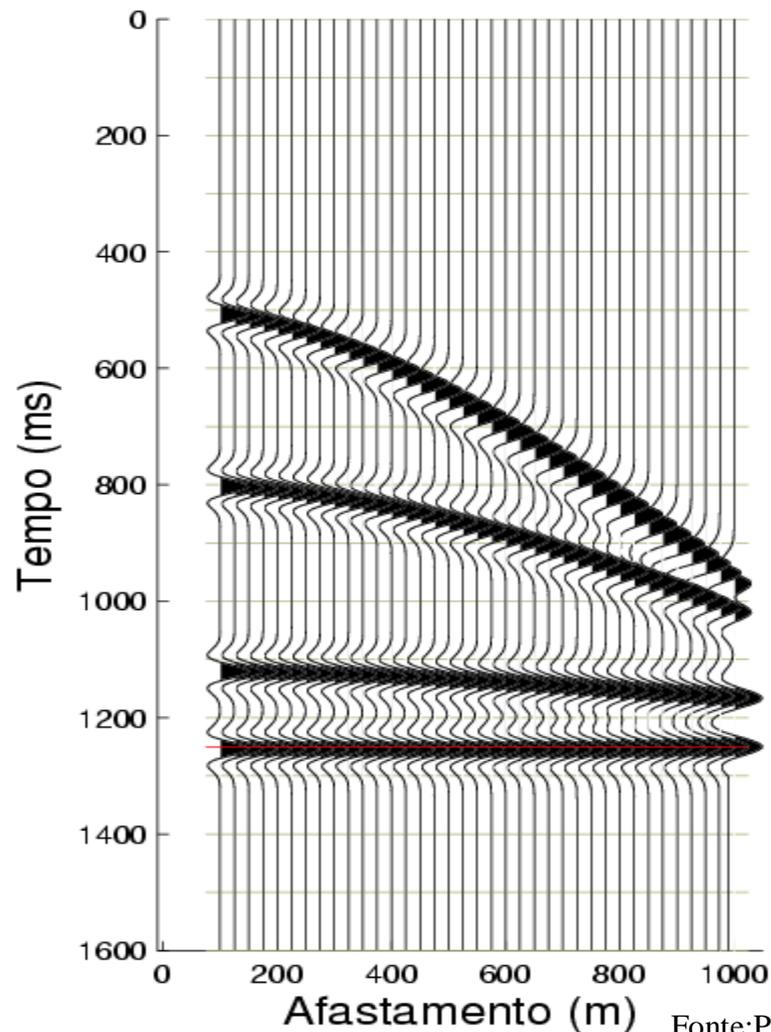
Sismograma CMP corrigido ($v=2.0$)



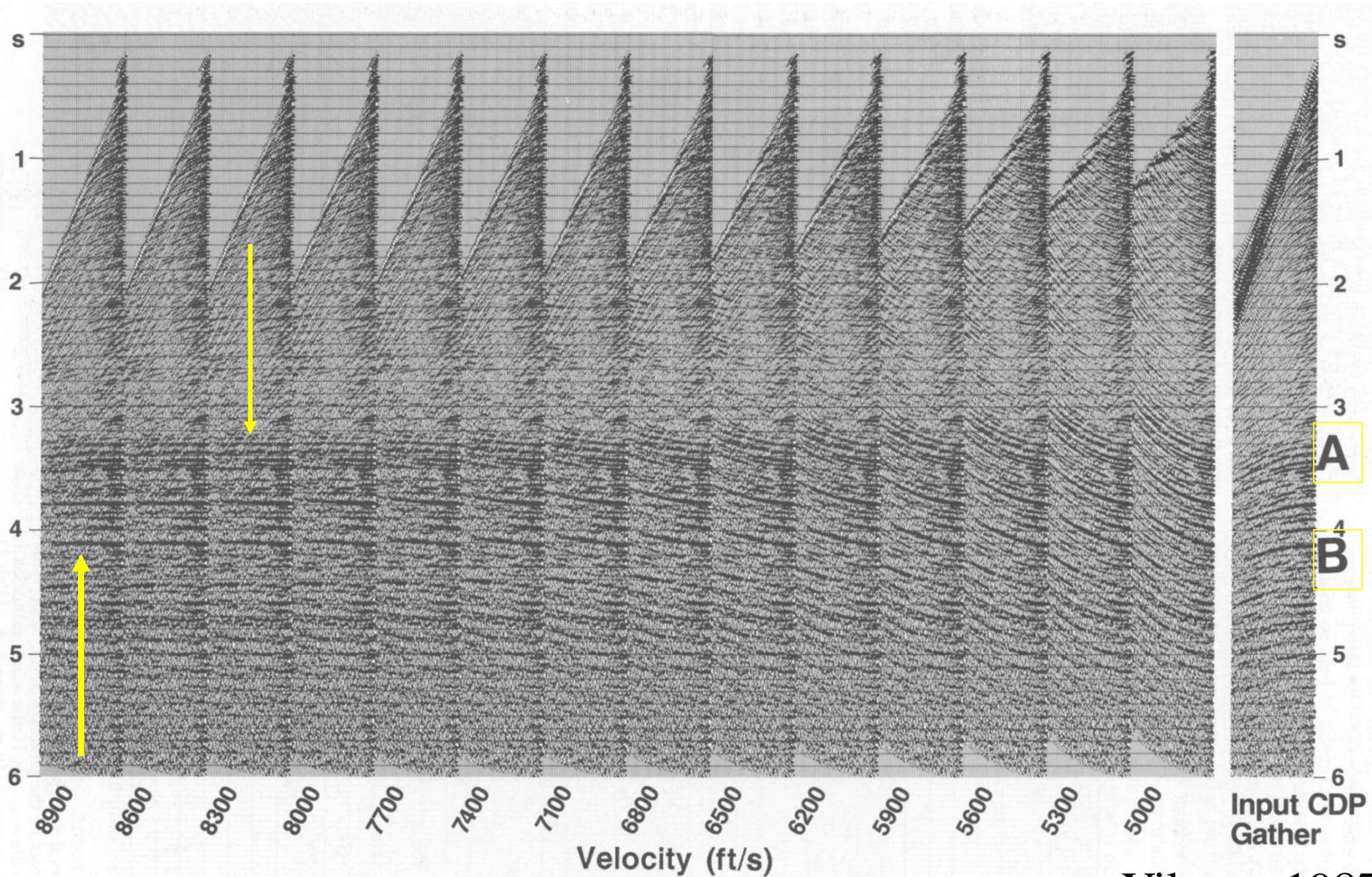
Sismograma CMP ($v=2.8$)



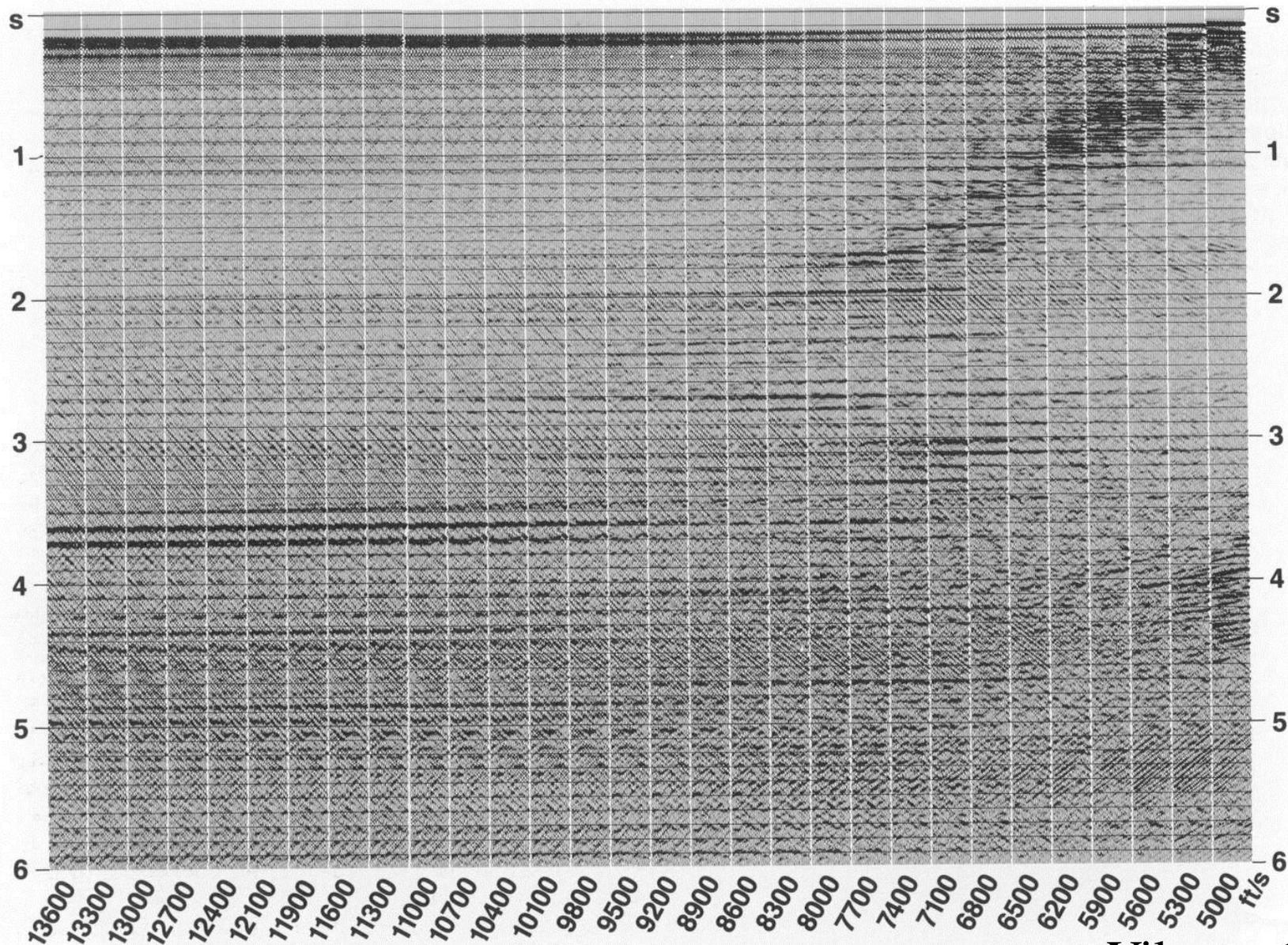
Sismograma CMP corrigido ($v=2.15$)



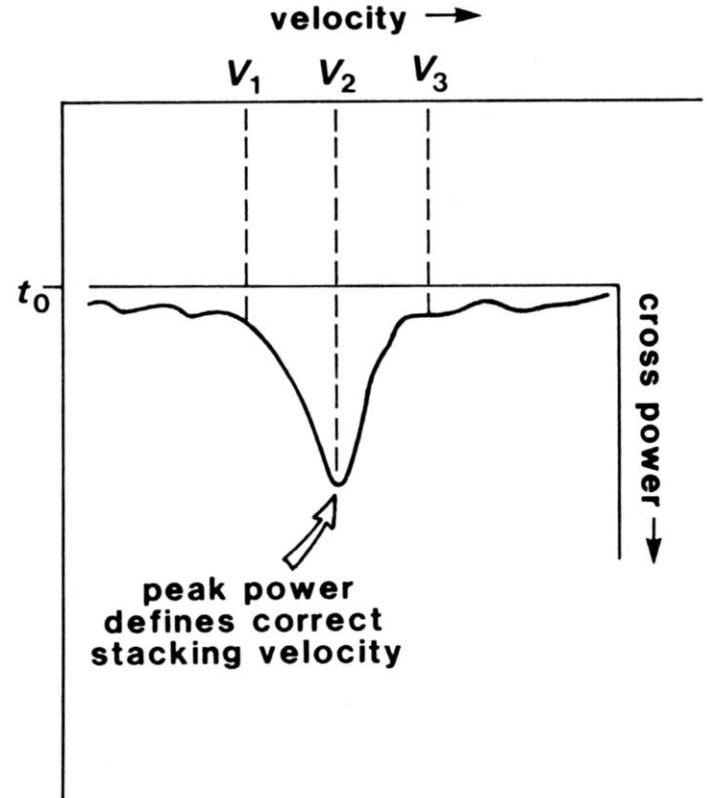
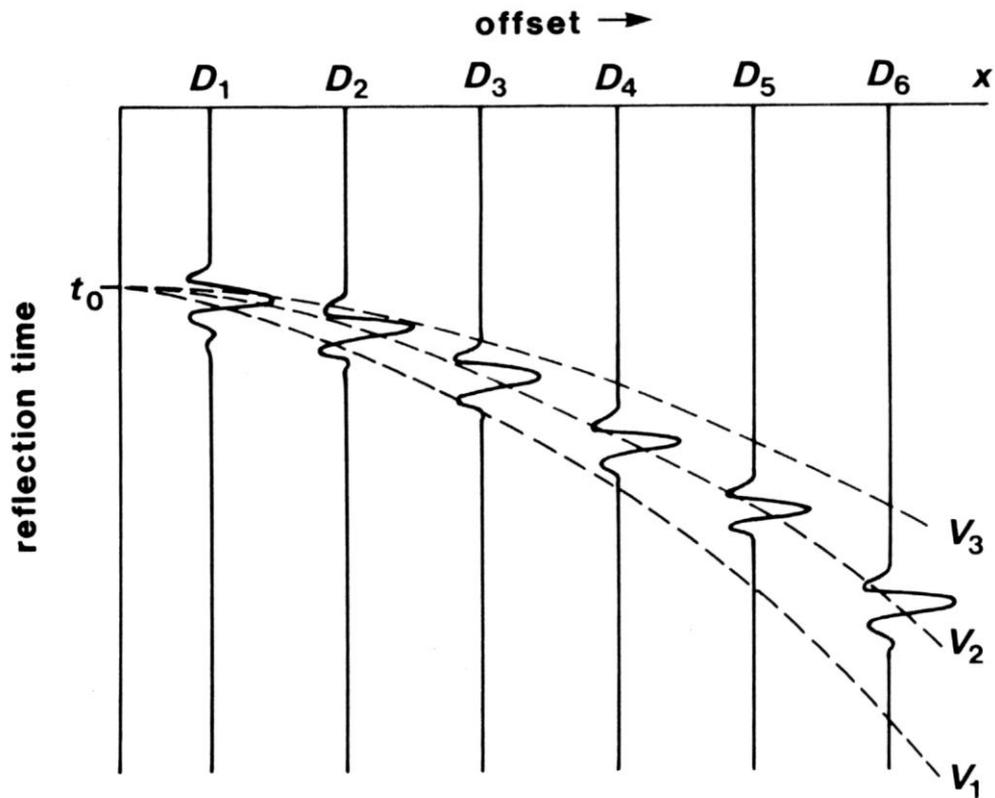
Panel NMO (1)



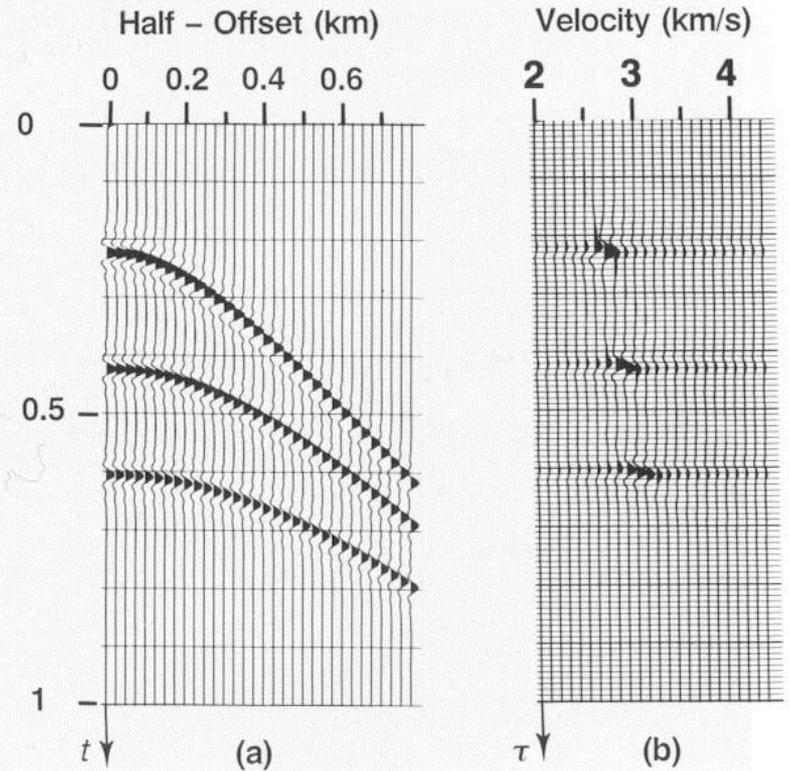
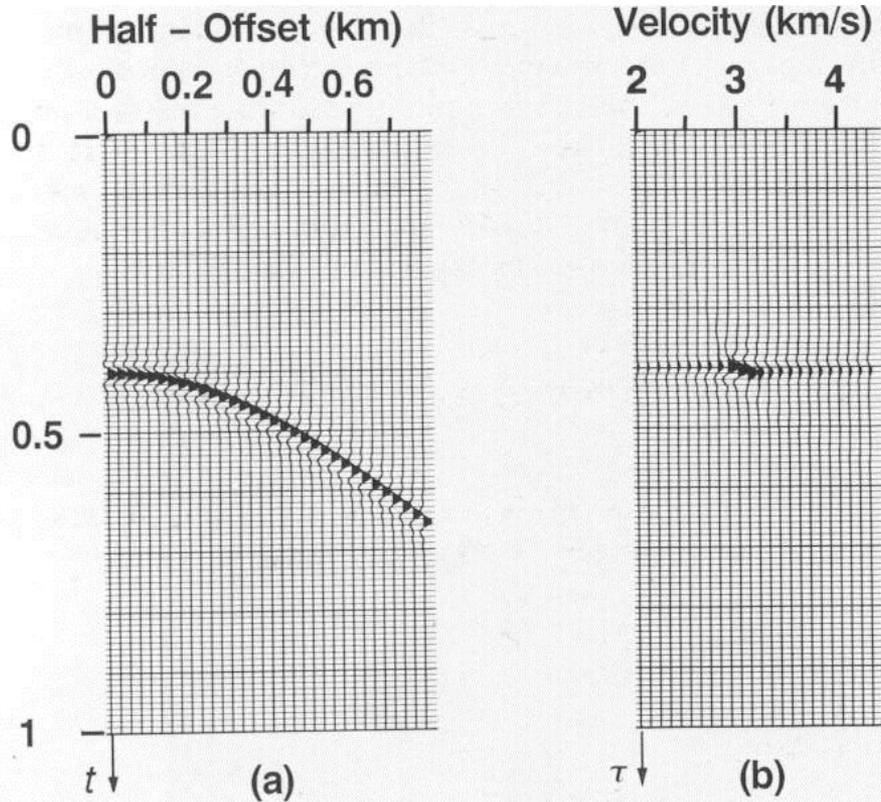
Painel CVS (empilhado) de 24 conjuntos CMP



Velocidade de empilhamento



Espectro de velocidades



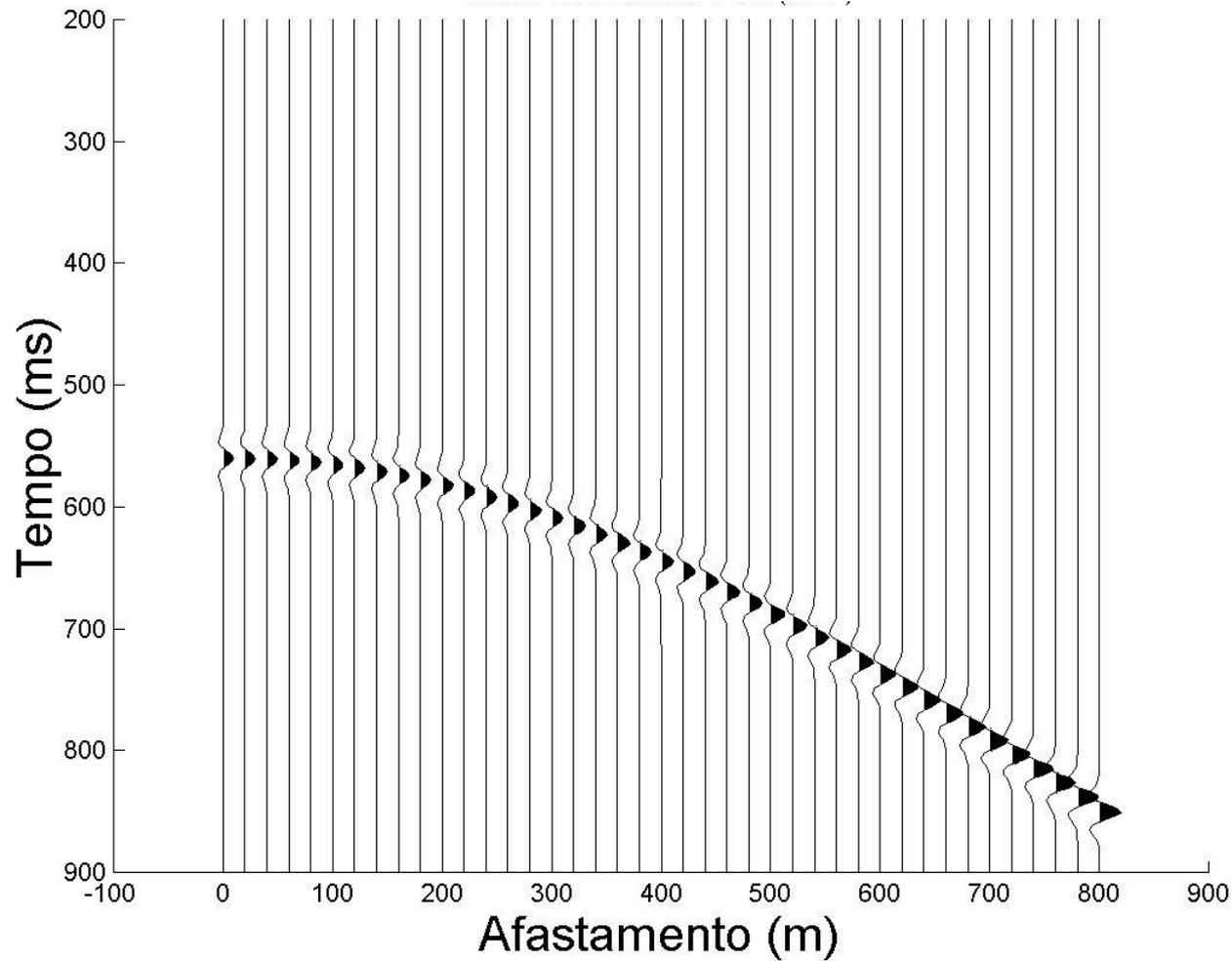
Método para calcular o espectro de velocidades

Semblance

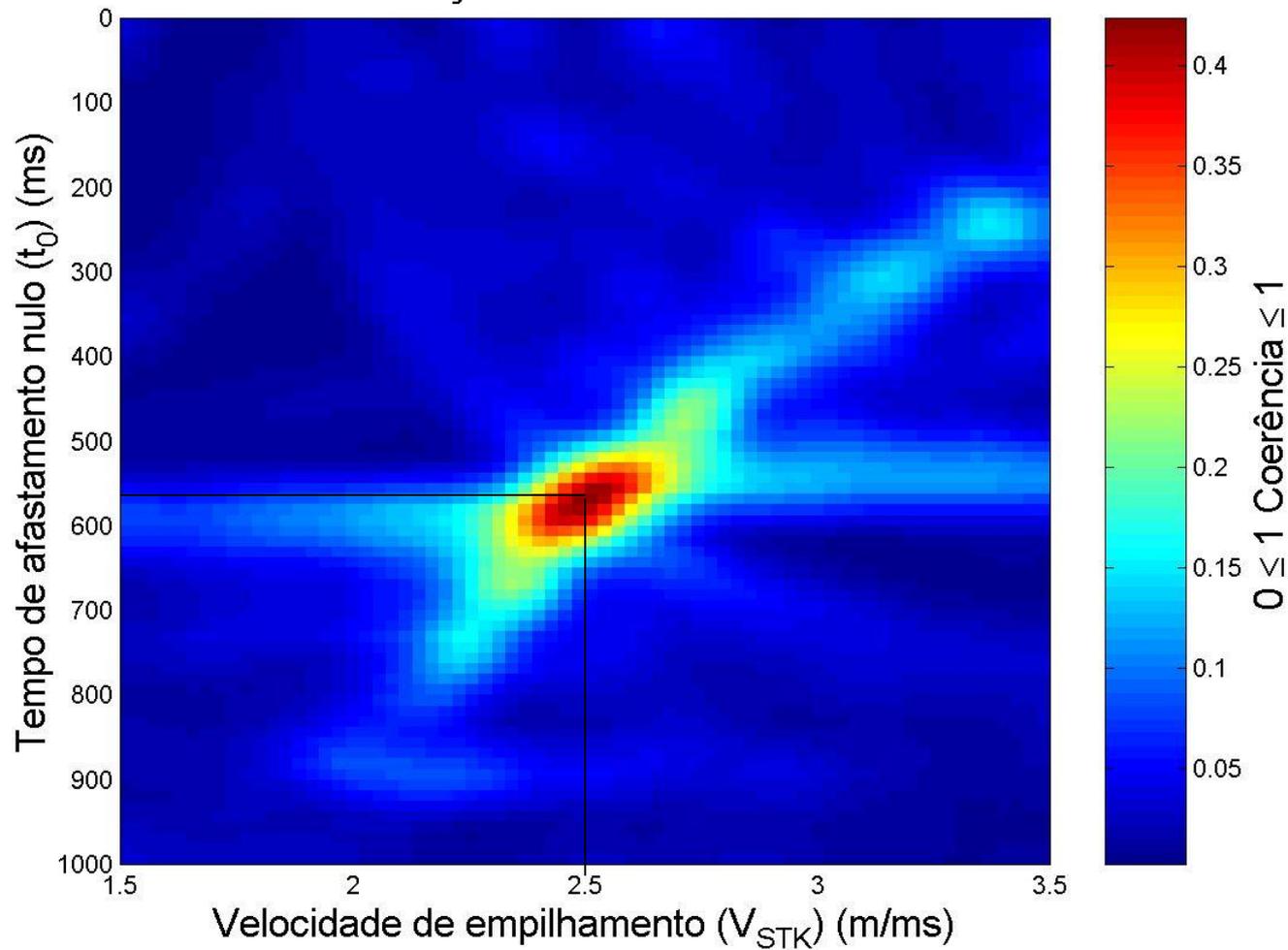
$$\frac{1}{n} \frac{\sum_t \left(\sum_i w_{i,t} \right)^2}{\sum_t \sum_i w_{i,t}^2} = \frac{1}{n} \frac{\sum_t s_t^2}{\sum_t \sum_i w_{i,t}^2}$$

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

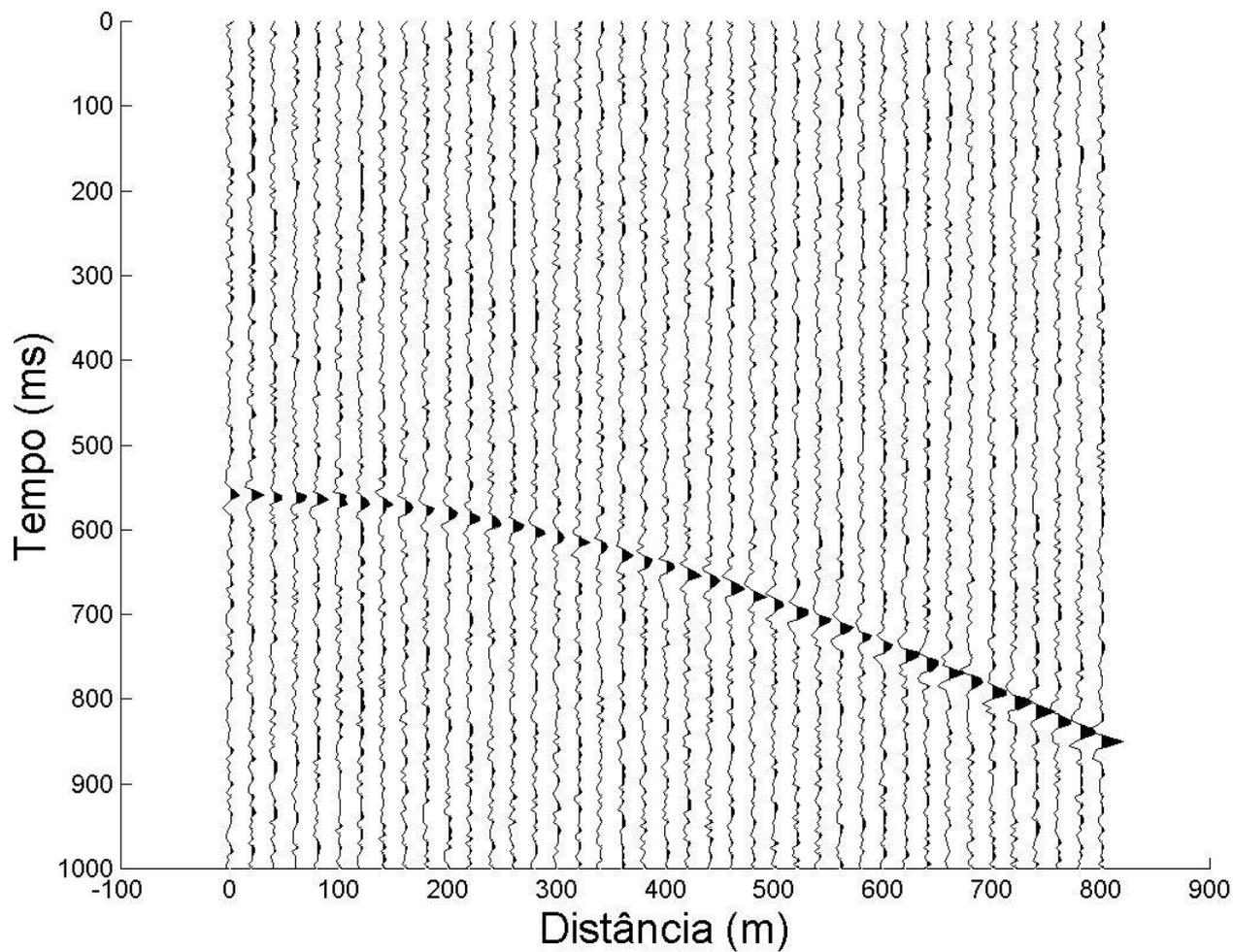
Sismograma CMP



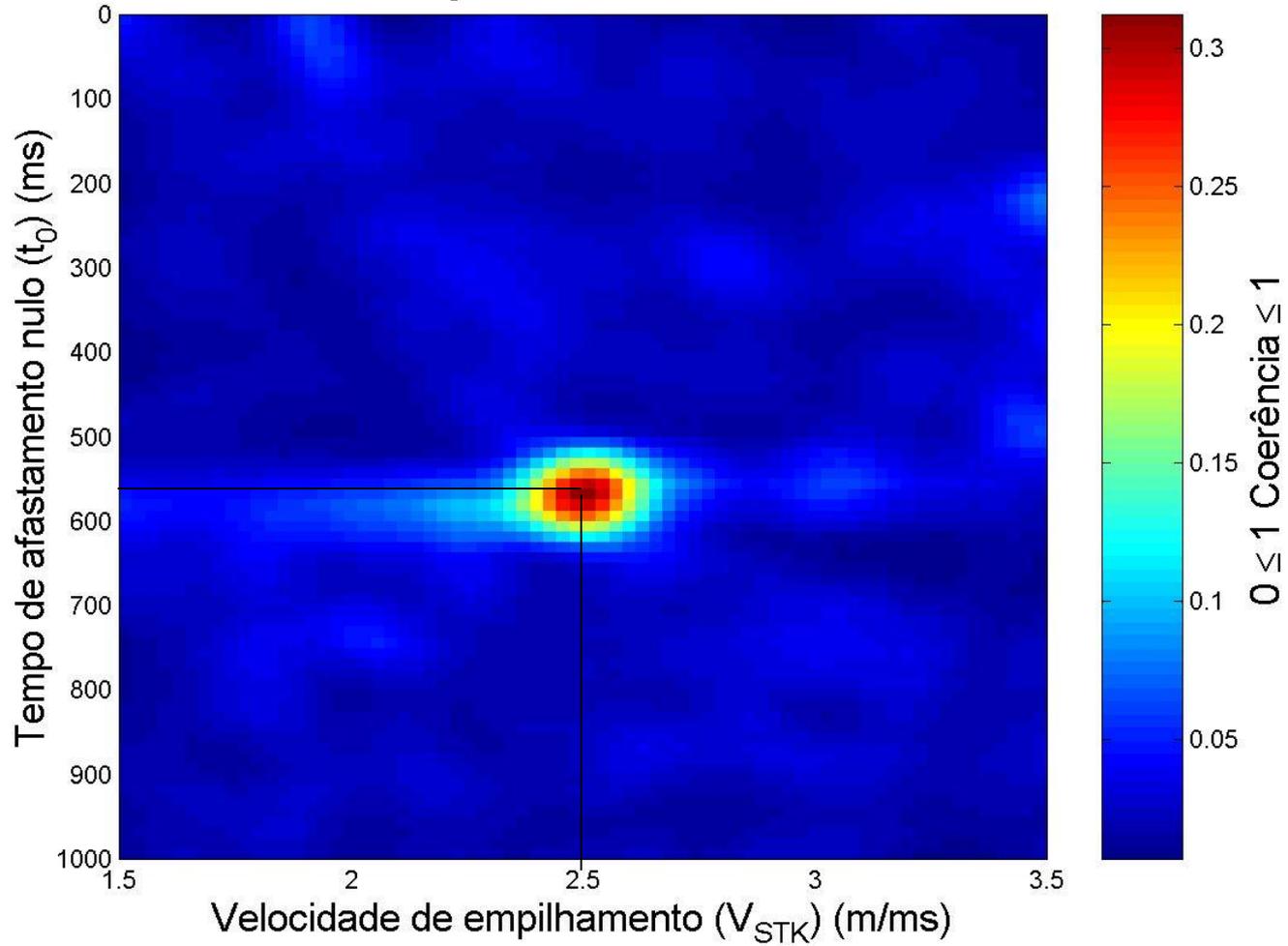
Seção de coerência



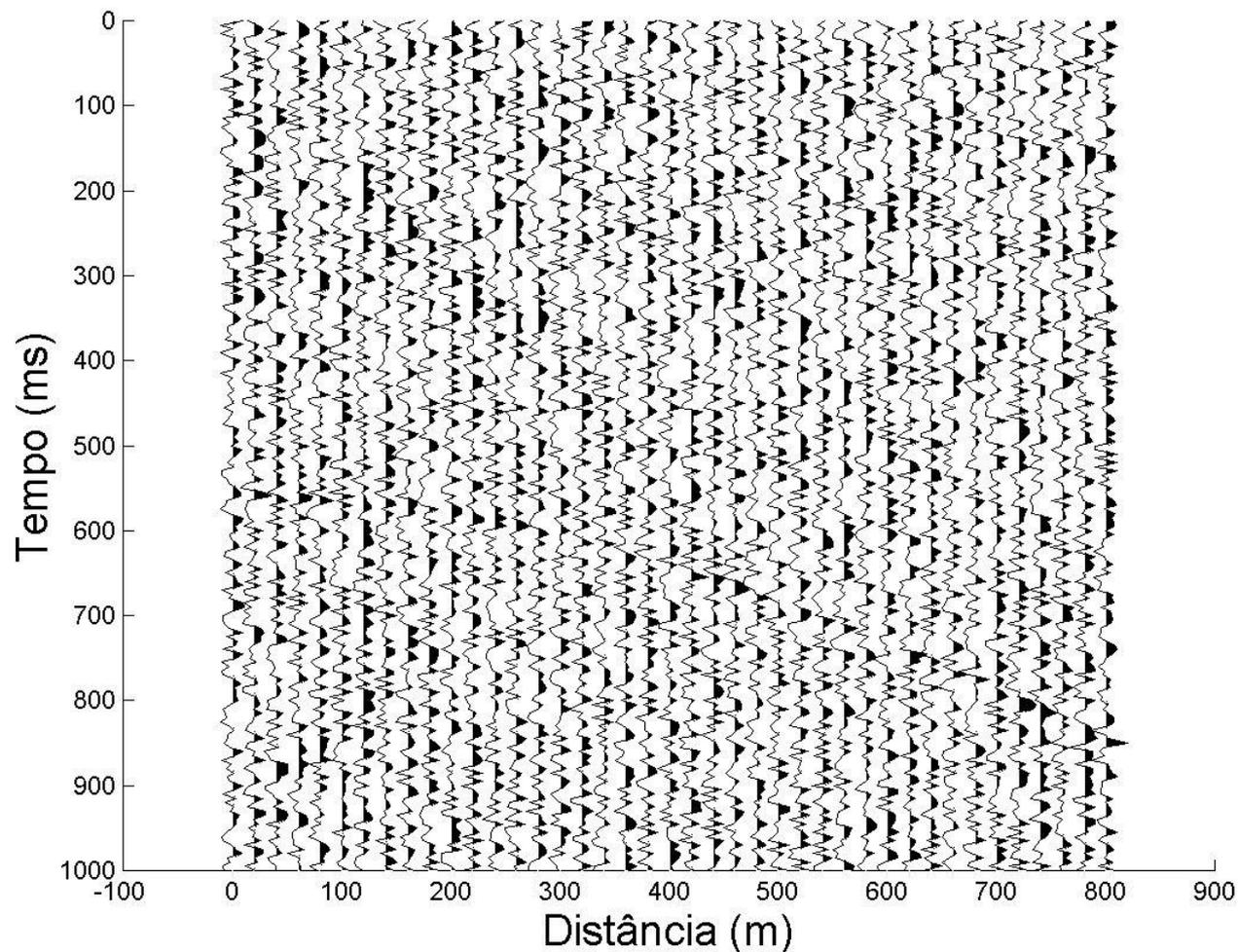
Sismograma CMP com 20% ruído



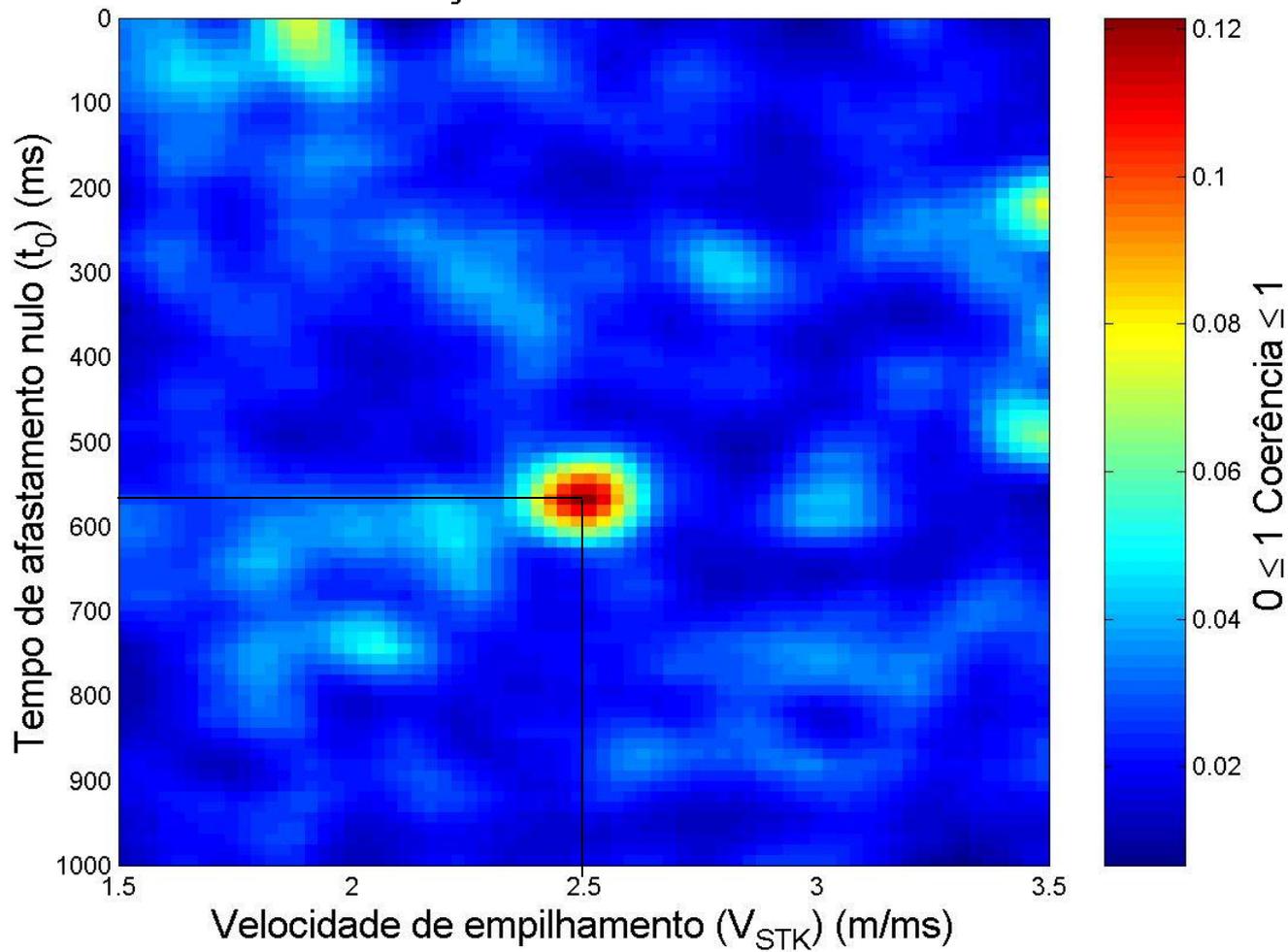
Seção de coerência



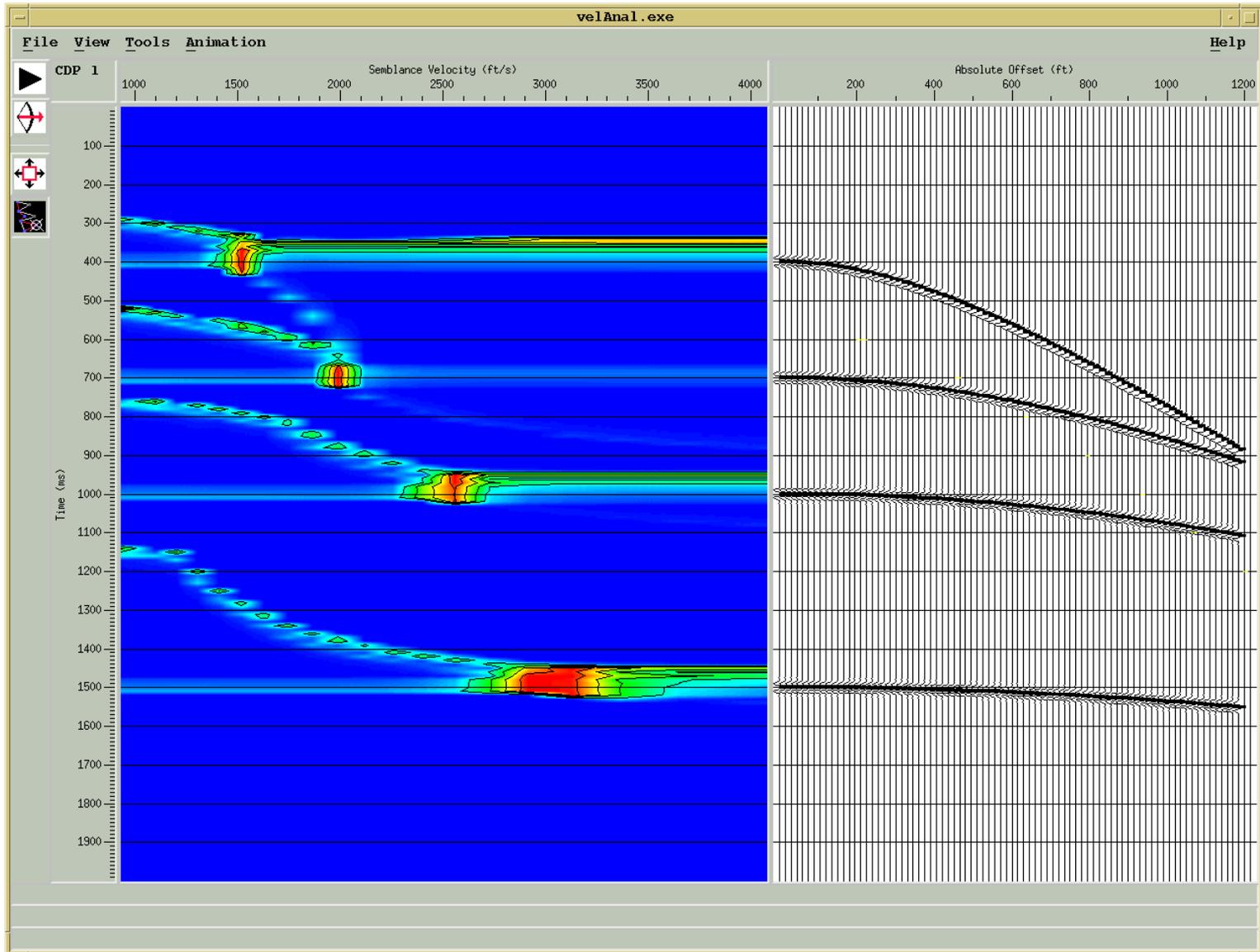
Sismograma CMP com 90% ruído

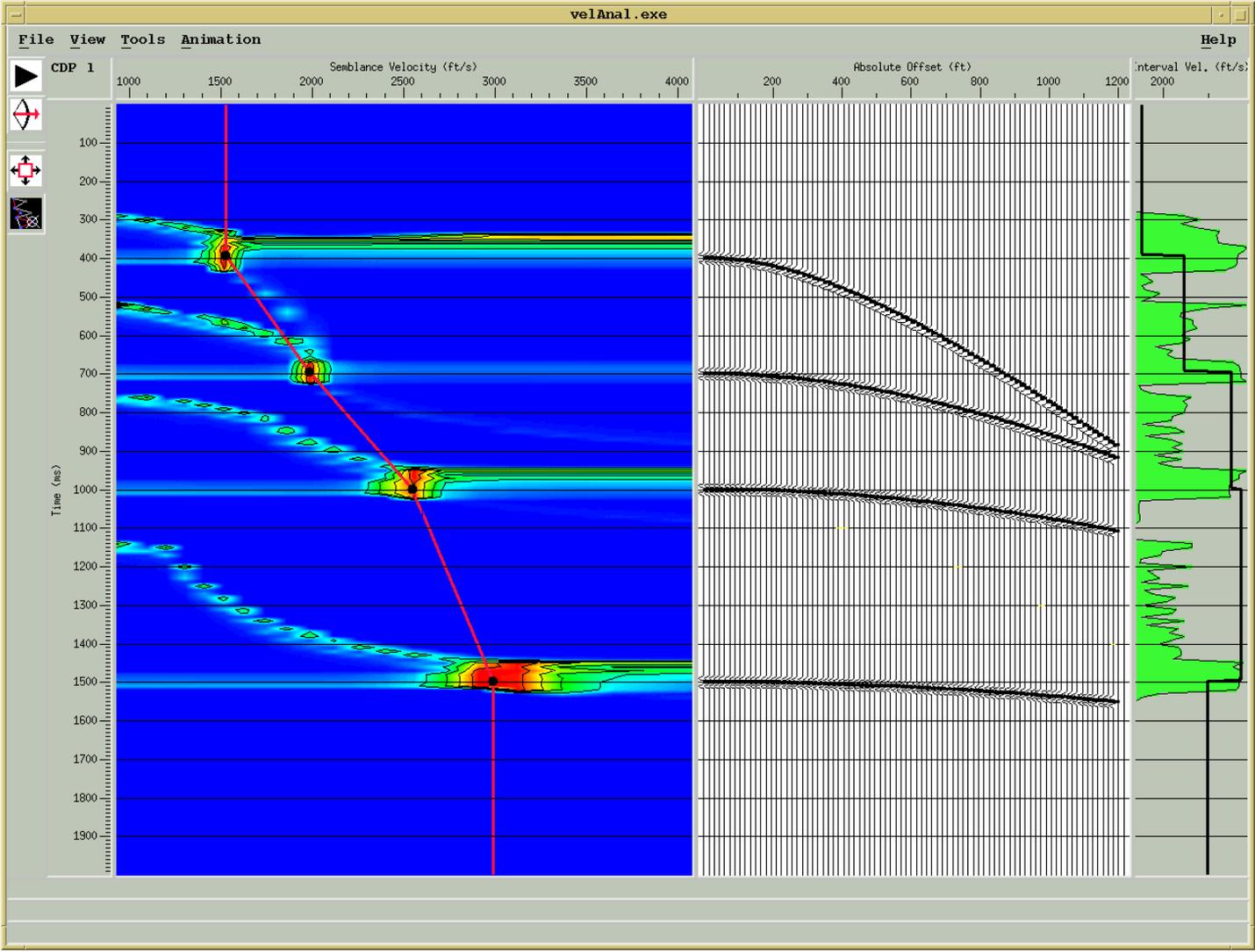


Seção de coerência

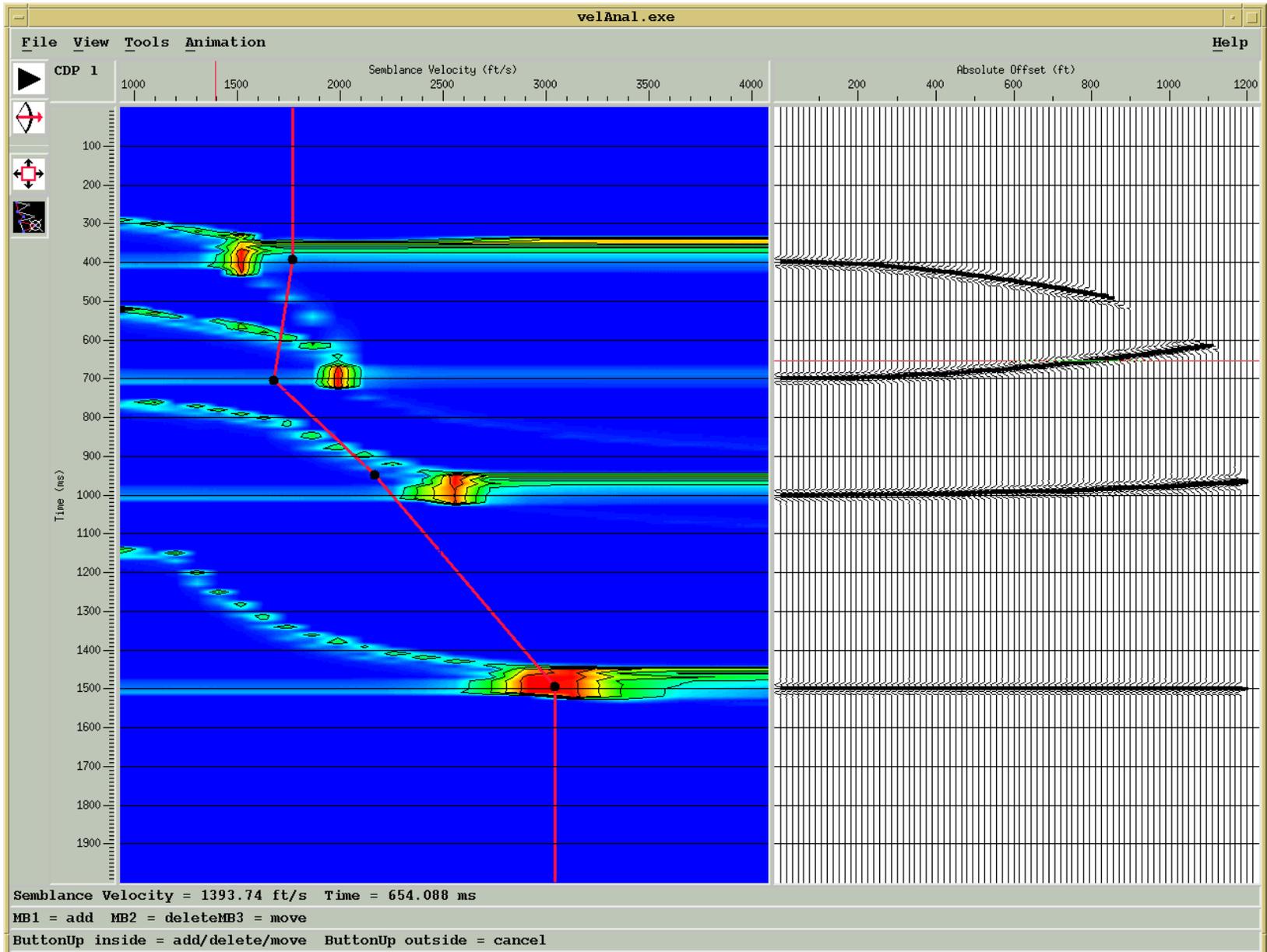


Semblance

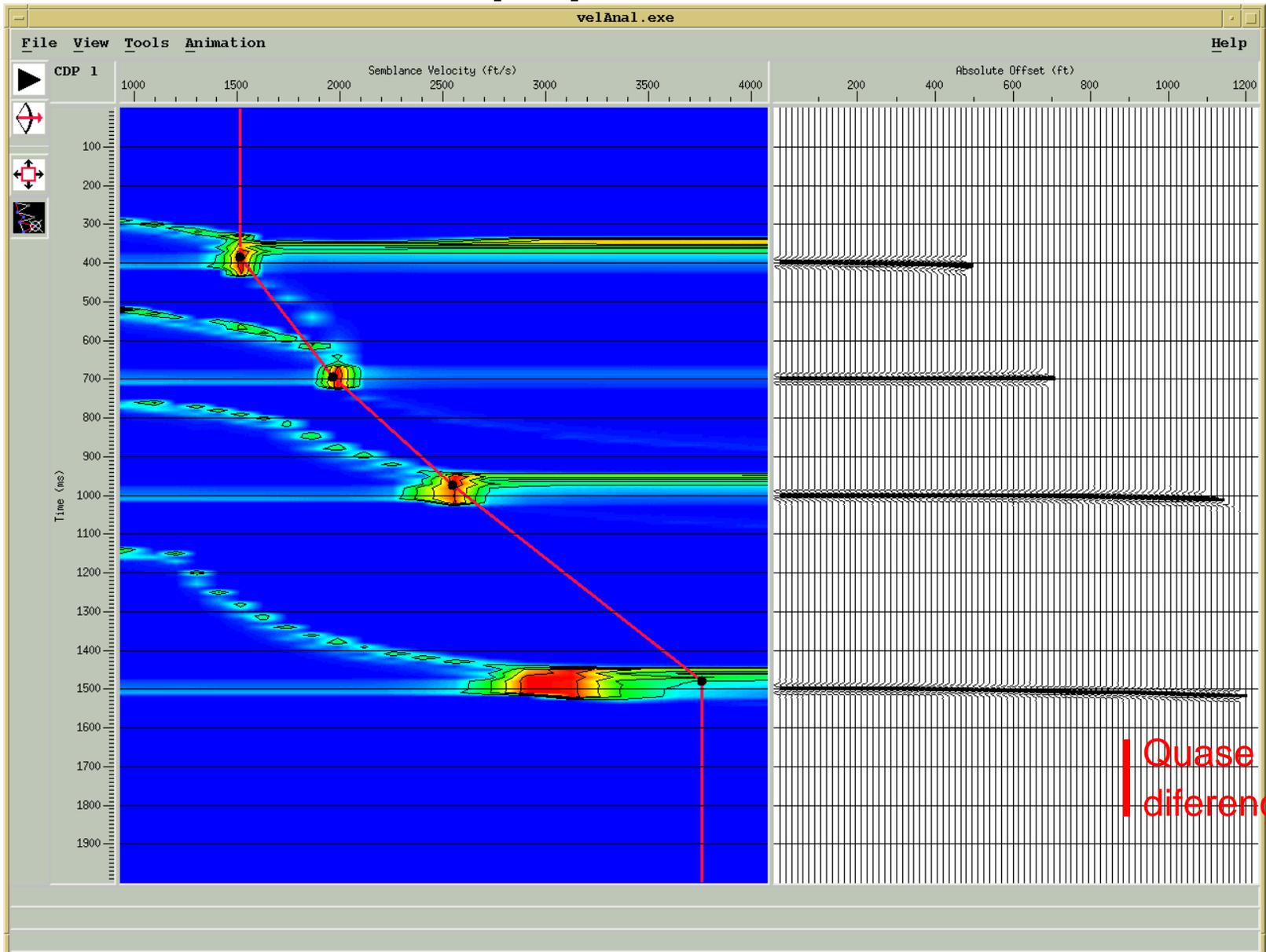




Resultado usando velocidades incorrectas



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
- Relação S/R