

•  
•  
•

## Localização de Terremotos

- Com informações das diferenças entre os tempos de chegadas das ondas S e P (S-P) podemos calcular a distância dos eventos a partir da expressão:

$$D = \frac{t_S - t_P}{R - 1} v_P \rightarrow R = \frac{v_P}{v_S} = 1,73$$

Regra geral – estimativa grosseira:

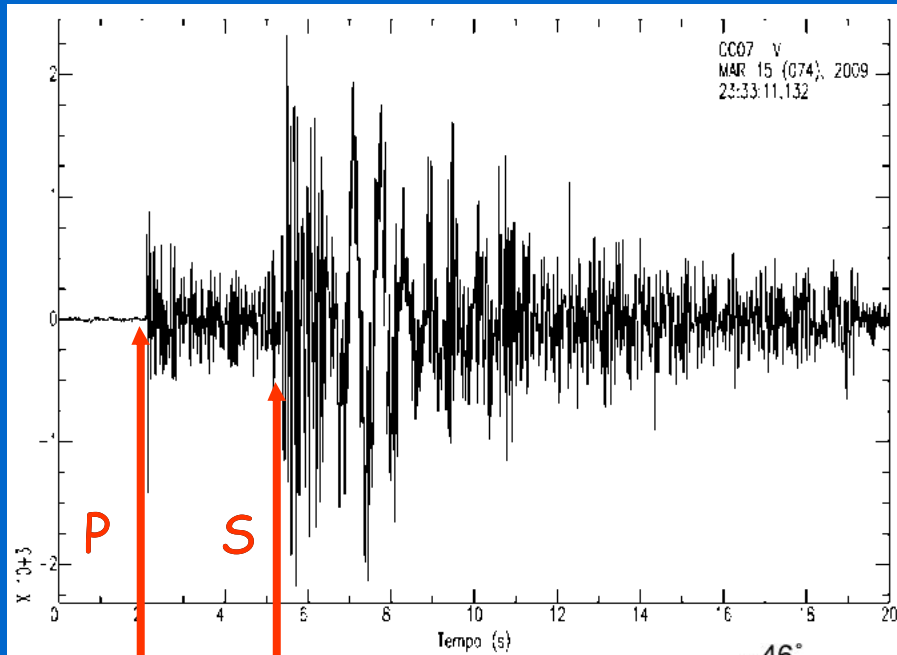
(Sg - Pg) x 8 = Δ (km) – eventos locais

(Sn - Pn) x 10 = Δ (km) – eventos regionais

# Círculo Epicentral

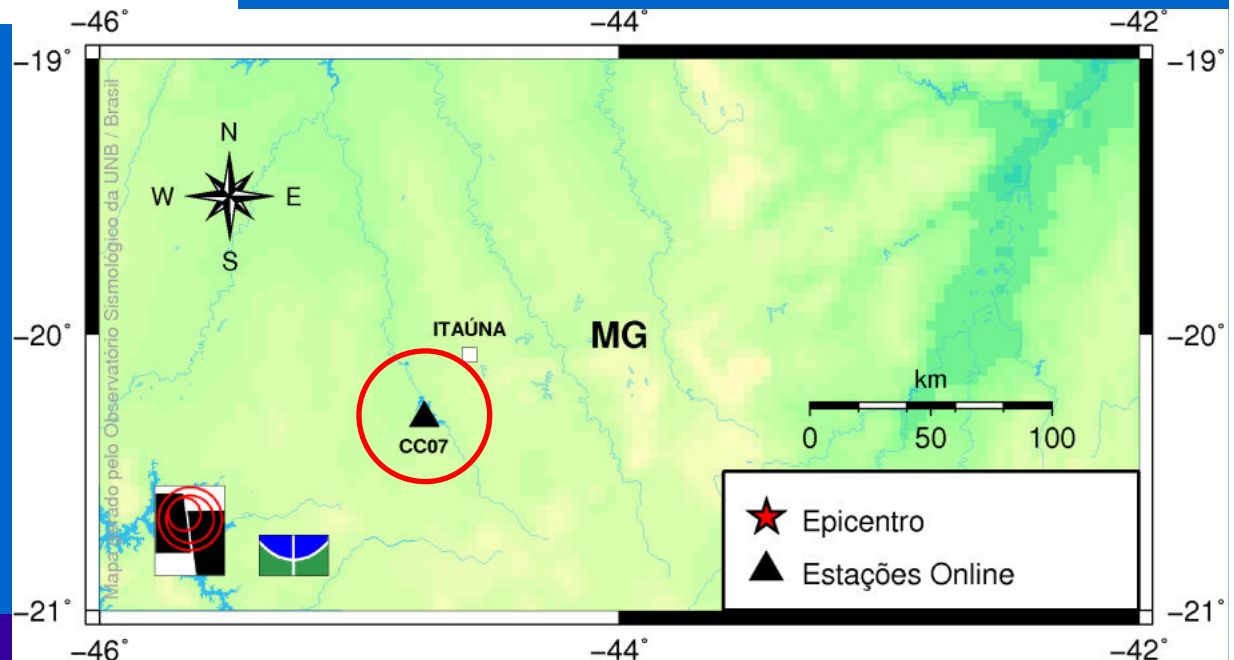
Com informações da  
(S-P) em uma estação temos  
apenas a distância epicentral.

$$(S-P) \times 8,0 = 26 \text{ km} - \text{raio epicentral}$$



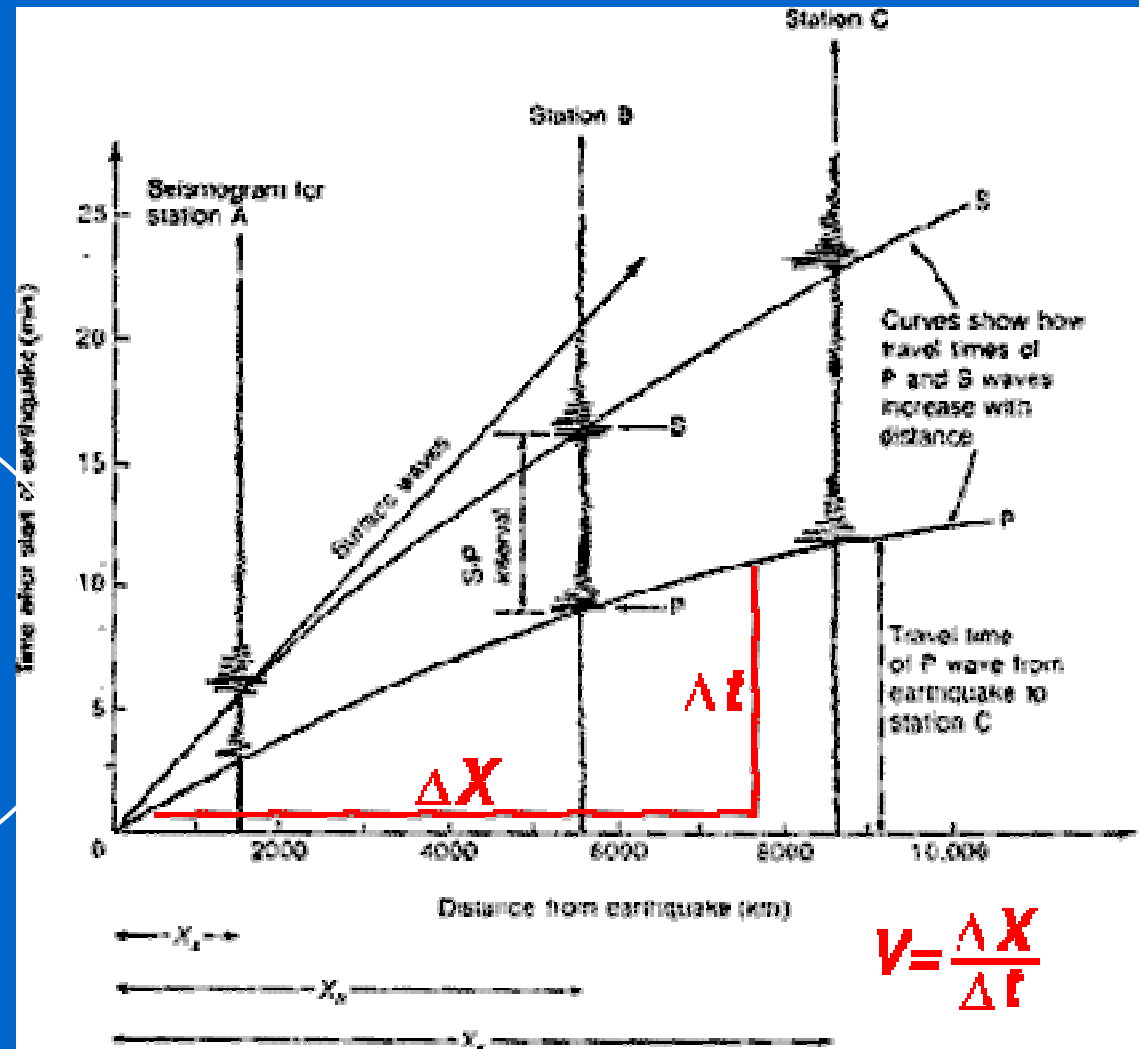
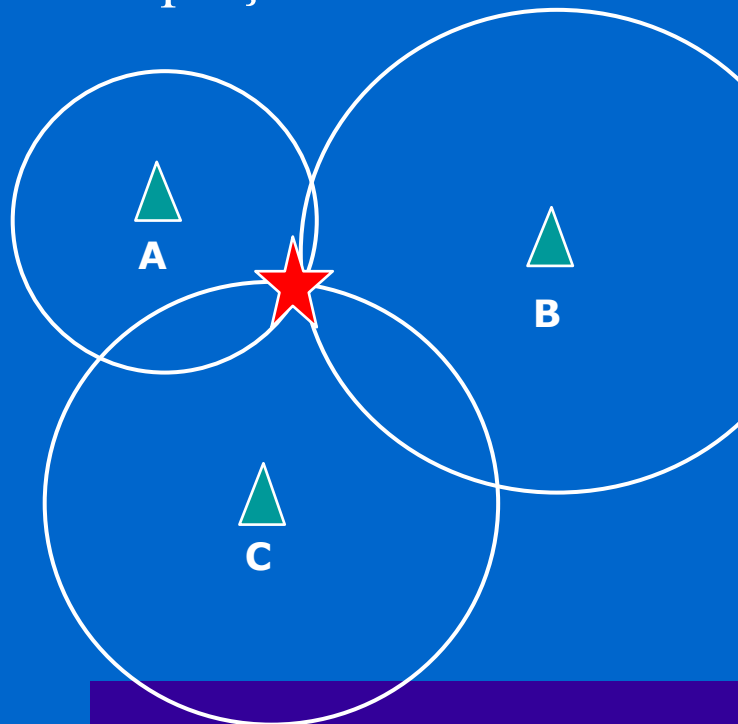
$$S - P = 3,3 \text{ s}$$

Epicentro em qualquer  
ponto sobre o círculo  
com raio de 26 km !!



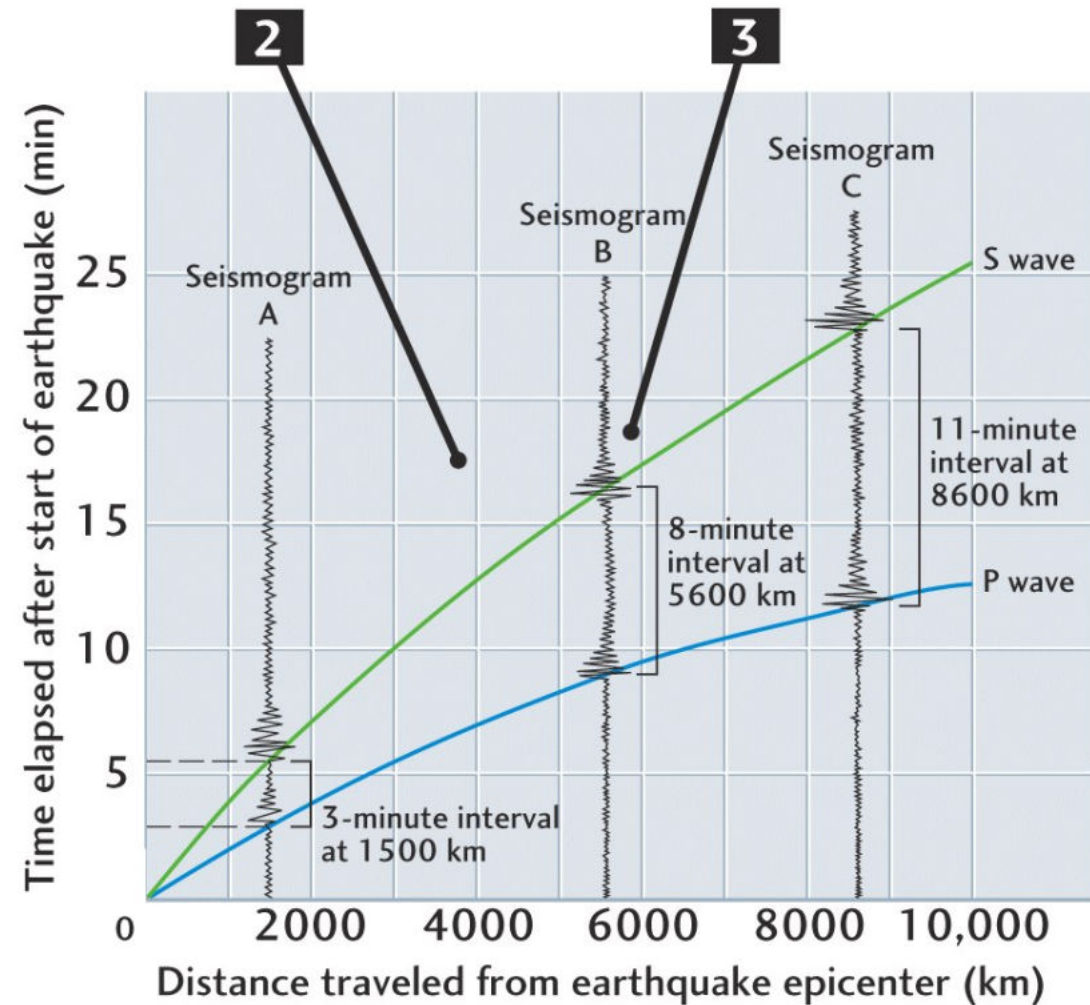
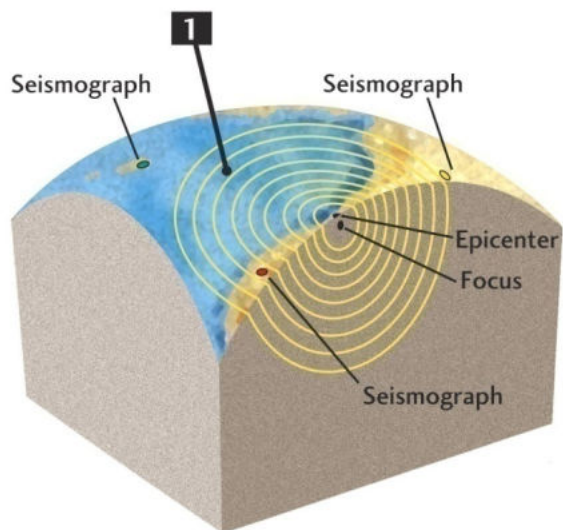
## • Várias estações - Método da Triangulação

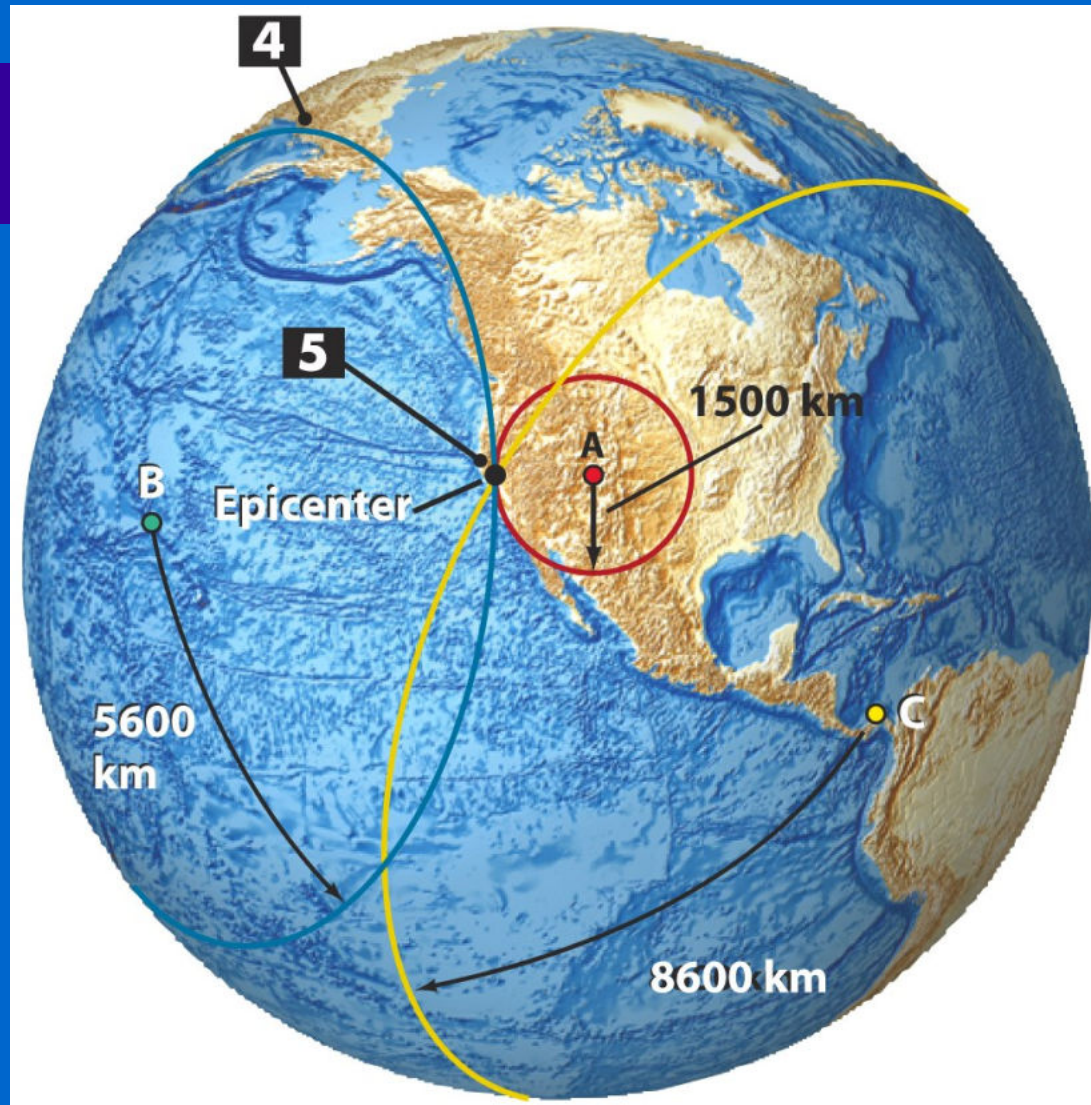
- O tempo entre as ondas P e S aumentam linearmente com a distância epicentral.
- Utilizando as diferenças dos tempos de chegadas, pode-se determinar três círculos com raios dados na equação anterior.



## READINGS AT DIFFERENT SEISMOGRAPHIC STATIONS REVEAL THE LOCATION OF THE EARTHQUAKE EPICENTER

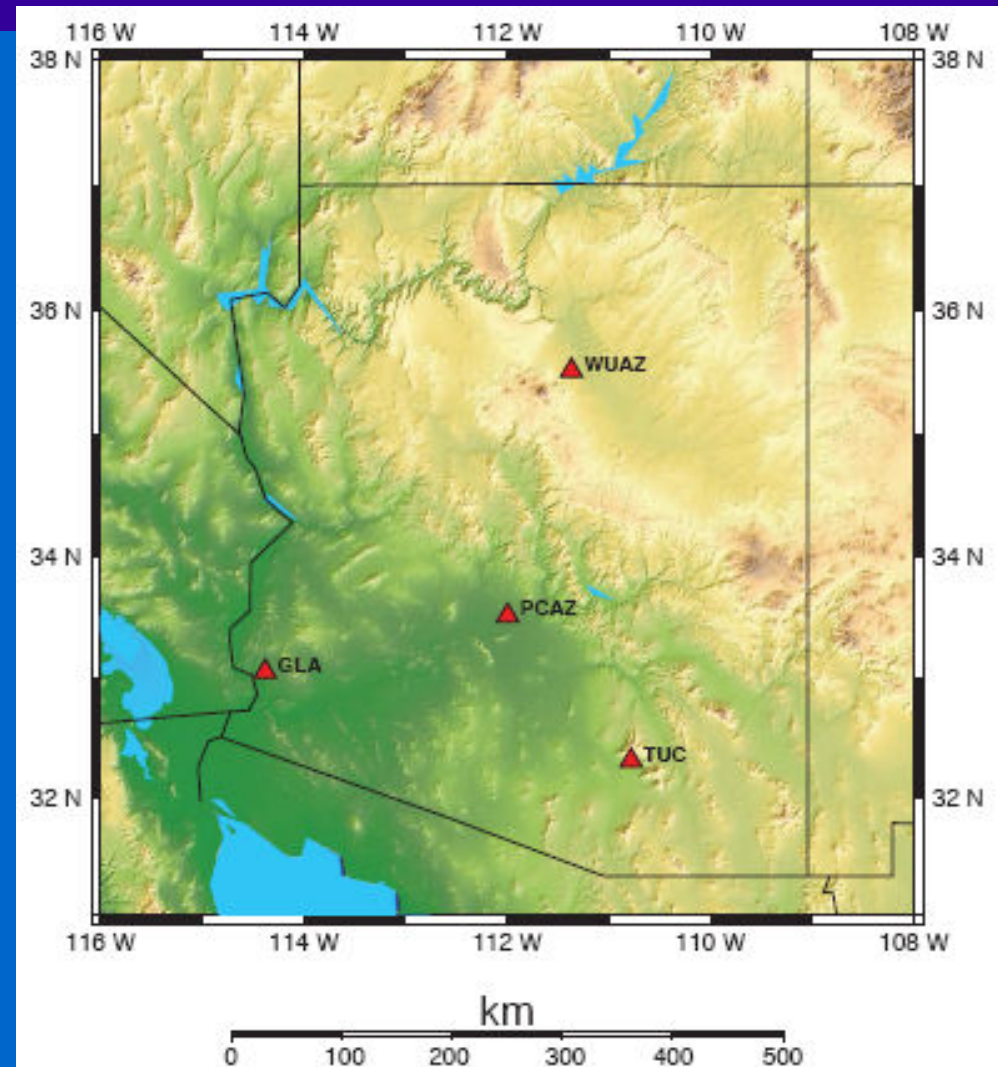
READINGS AT DIFFERENT SEISMOGRAPHIC STATIONS REVEAL THE LOCATION OF THE EARTHQUAKE EPICENTER

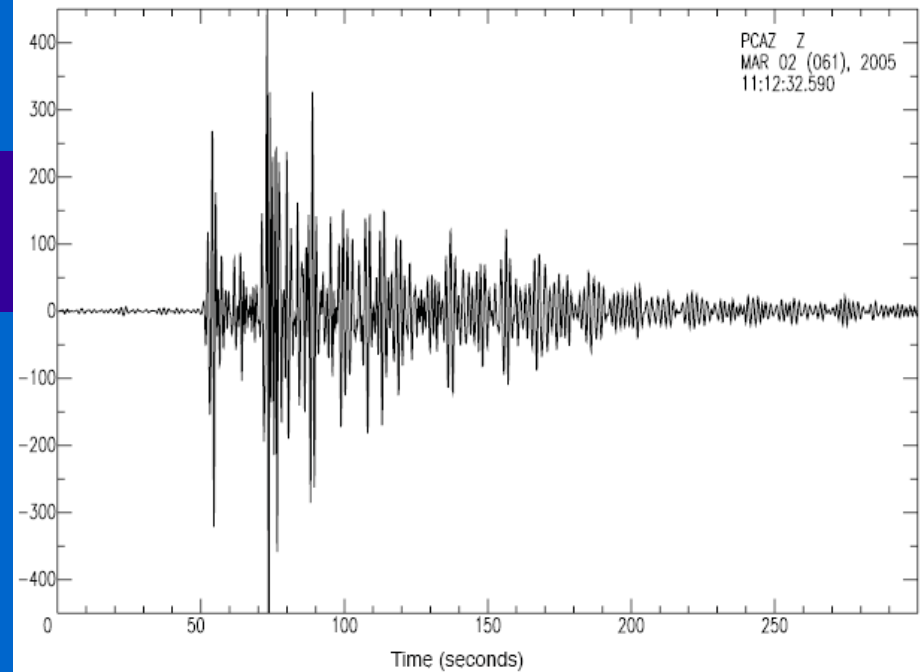
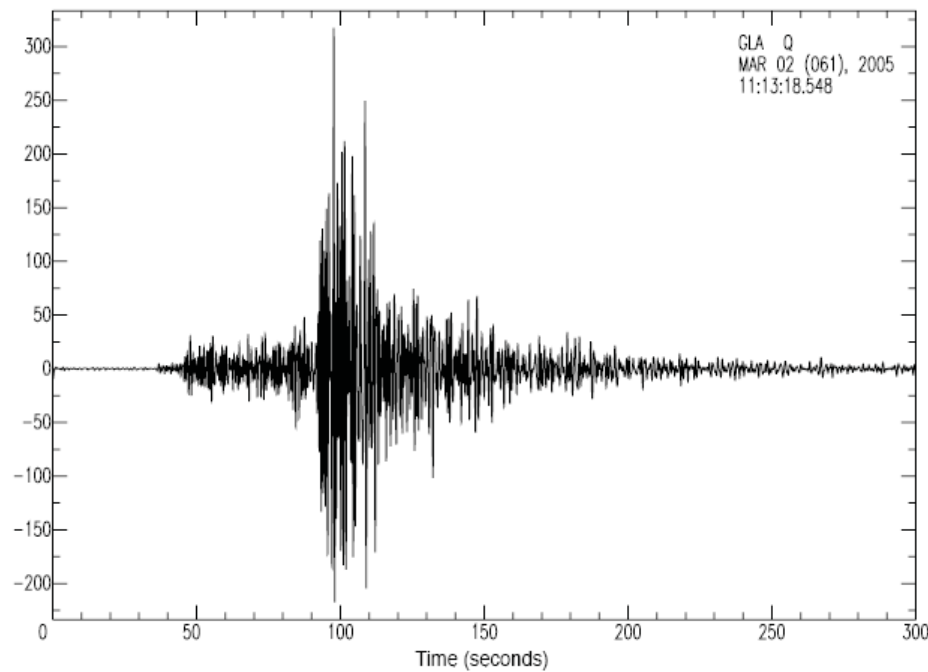




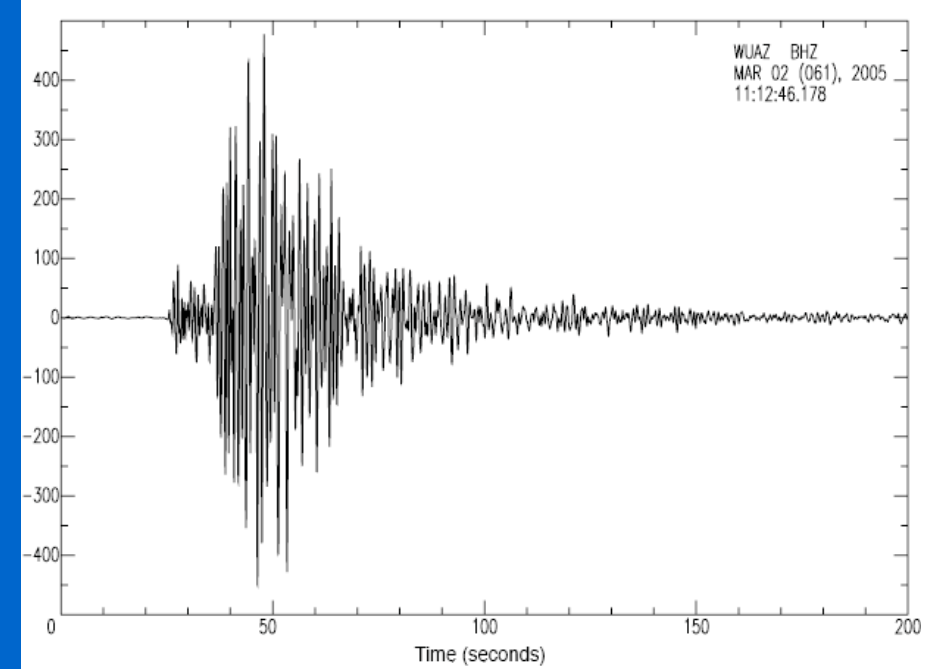
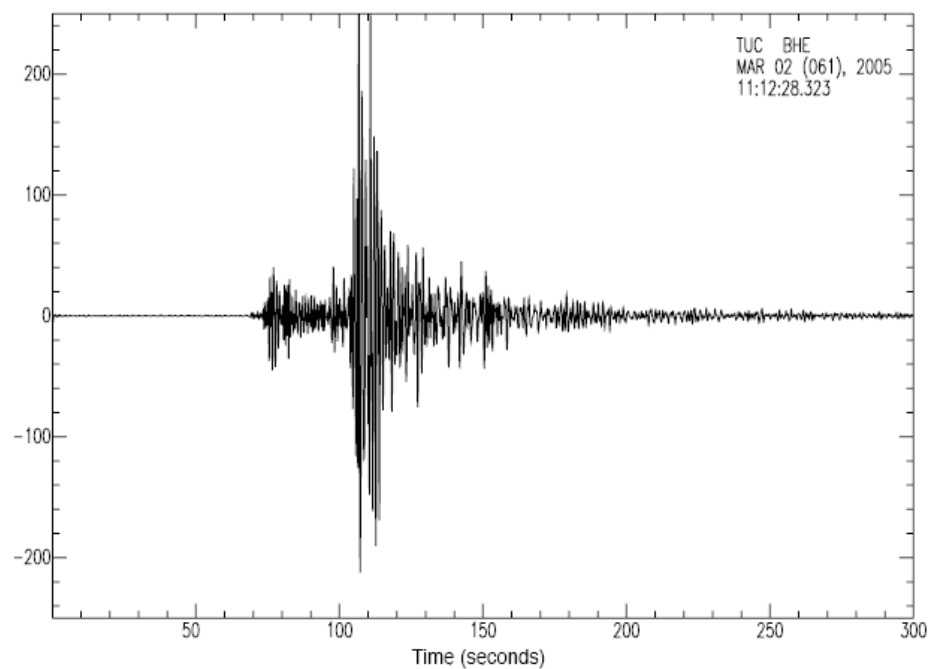


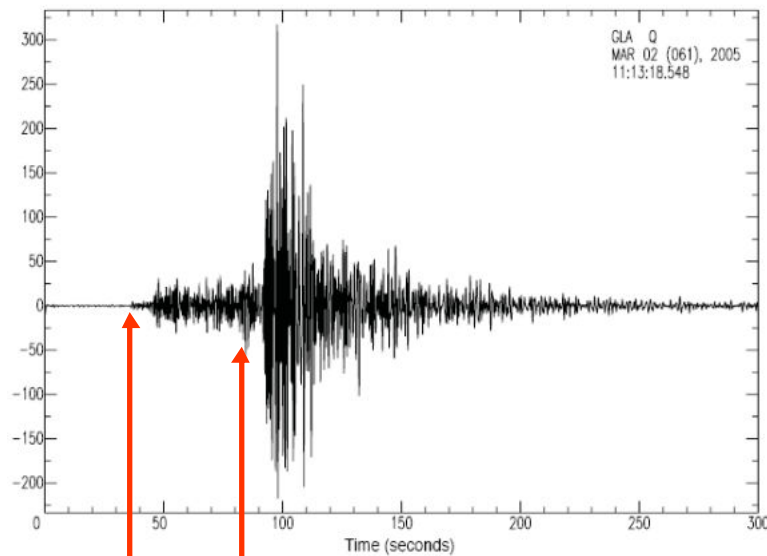
Exercício 1 - Determinar epicentro do evento utilizando os círculos epicentrais (Método da Triangulação) em cada estação, determinados usando a diferença S-P e a Tabela 1.



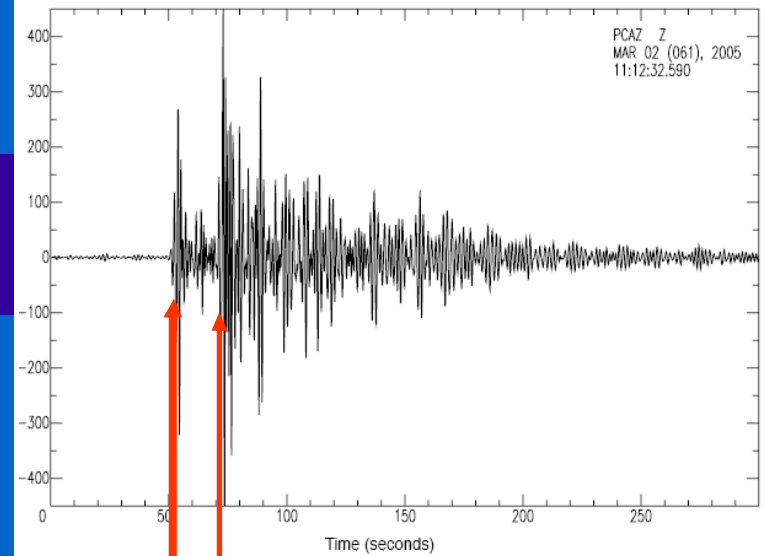


*Science Education Solutions, 2005*

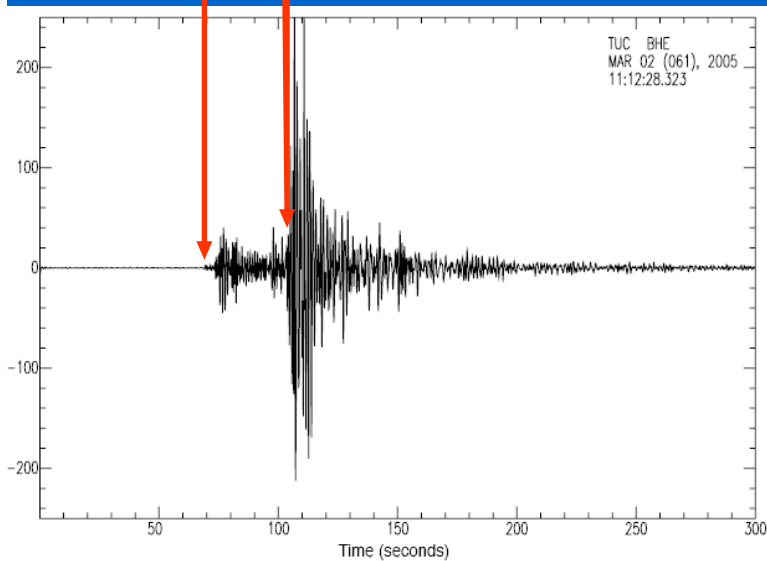




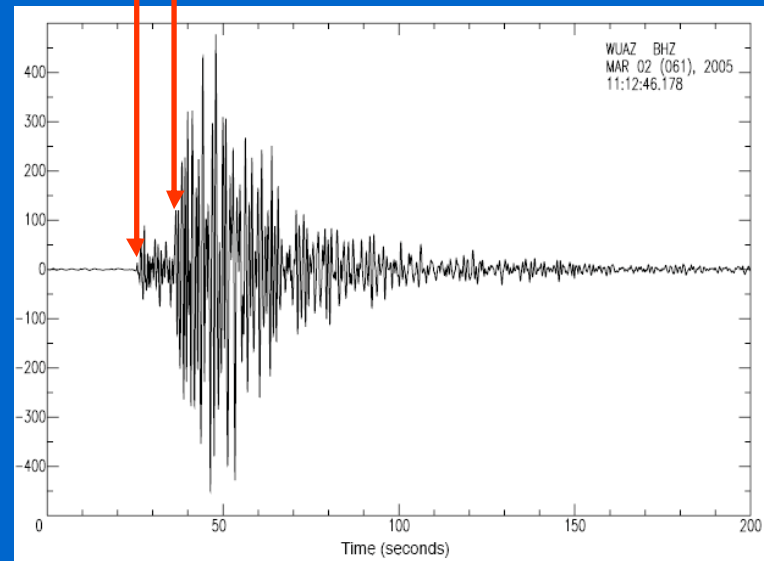
45 s - 360 km



20 s - 160 km

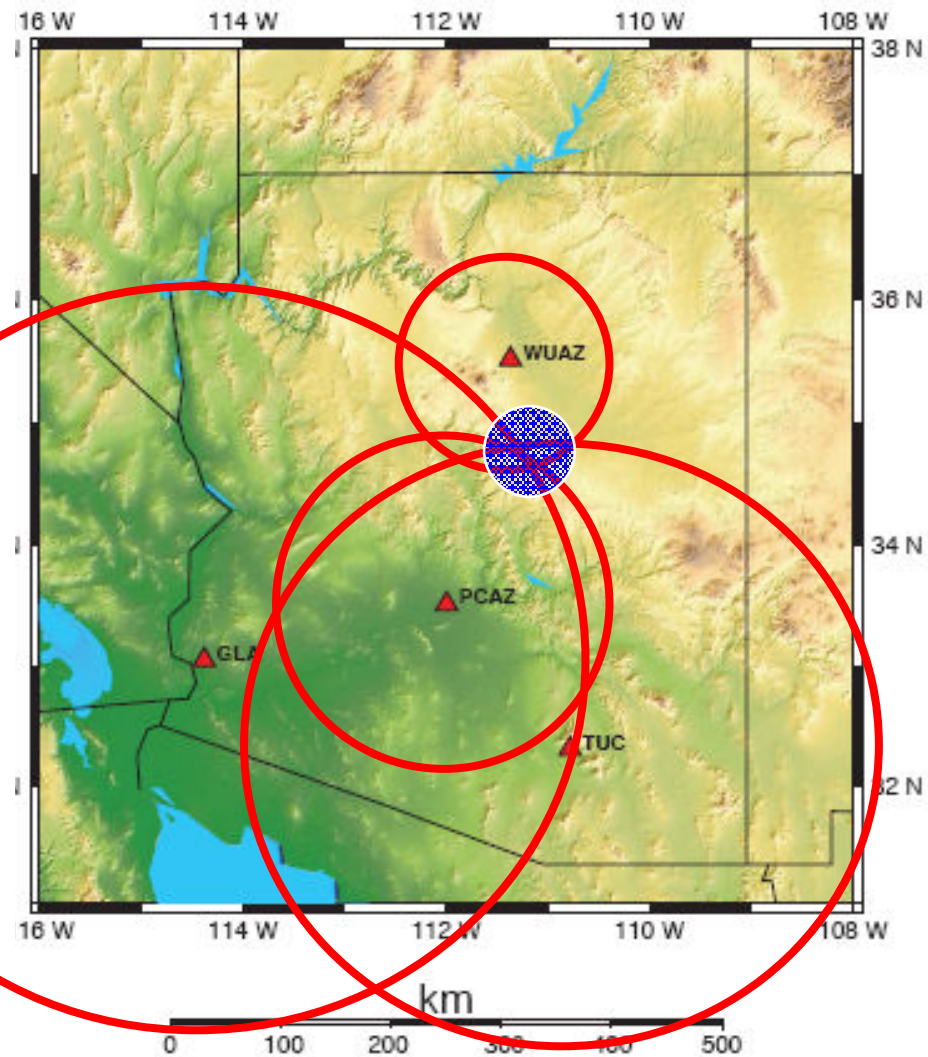
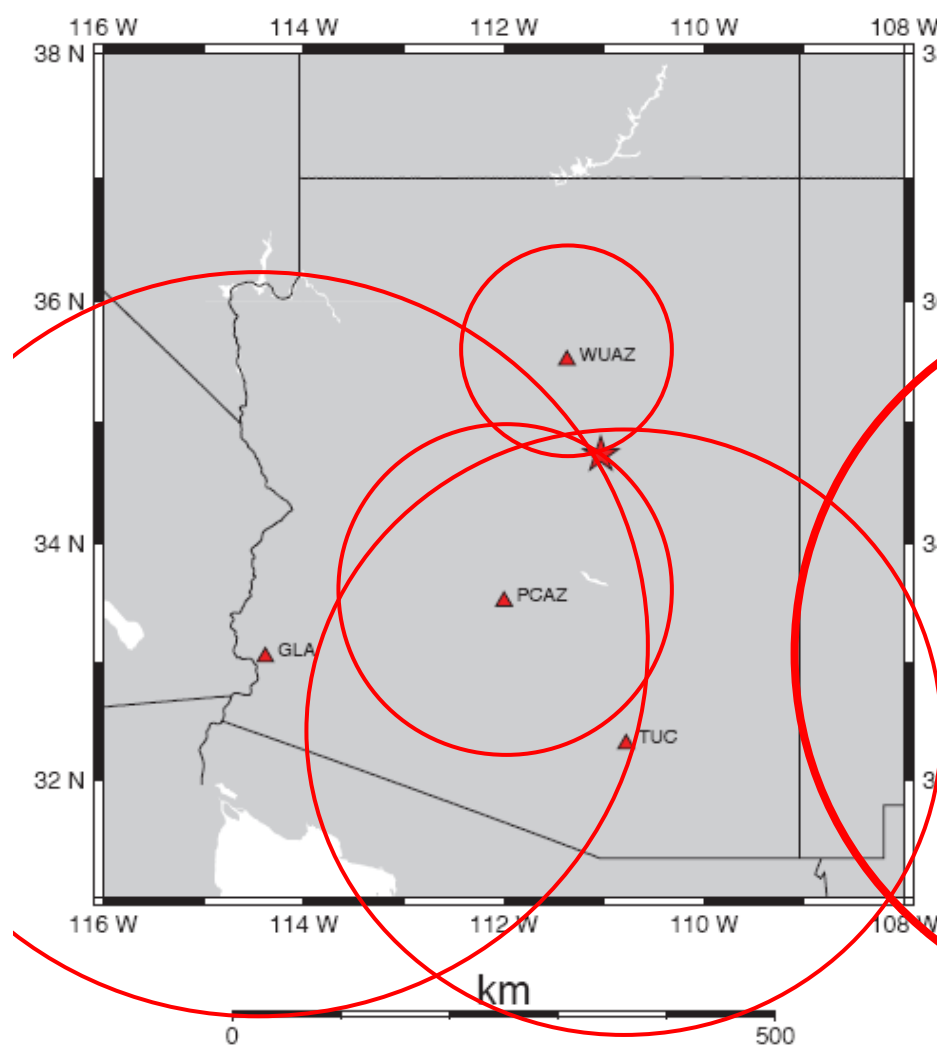


35 s - 280 km



12 s - 96 km



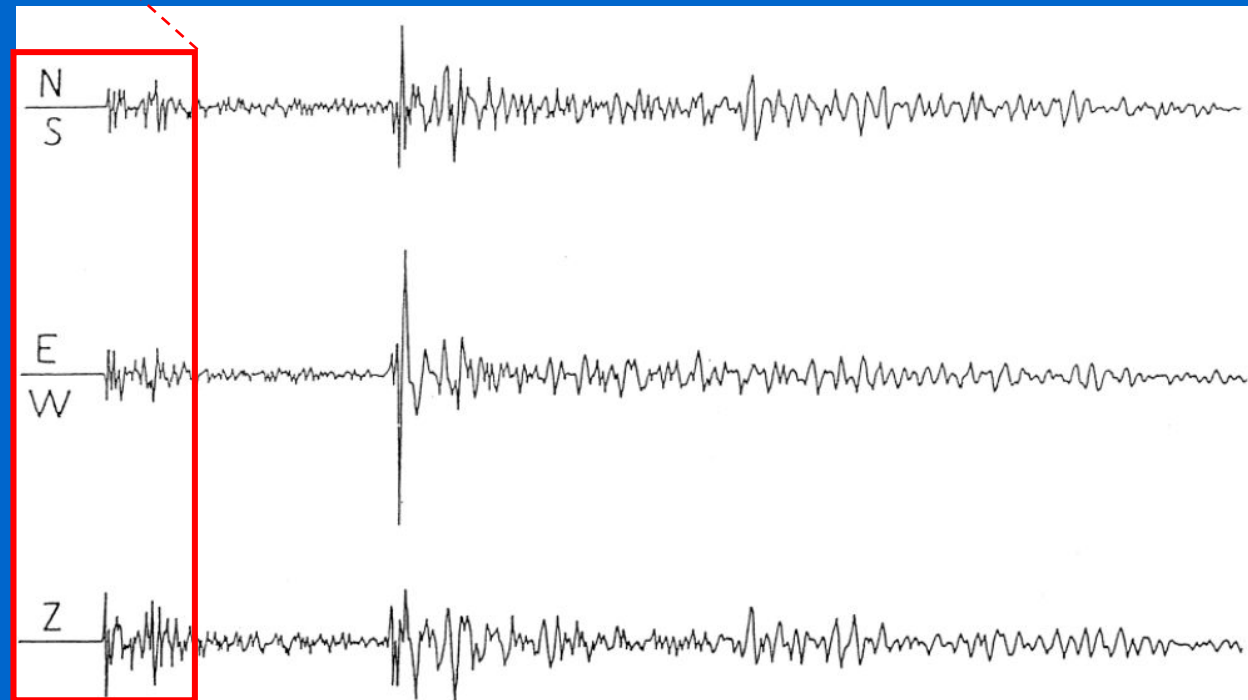
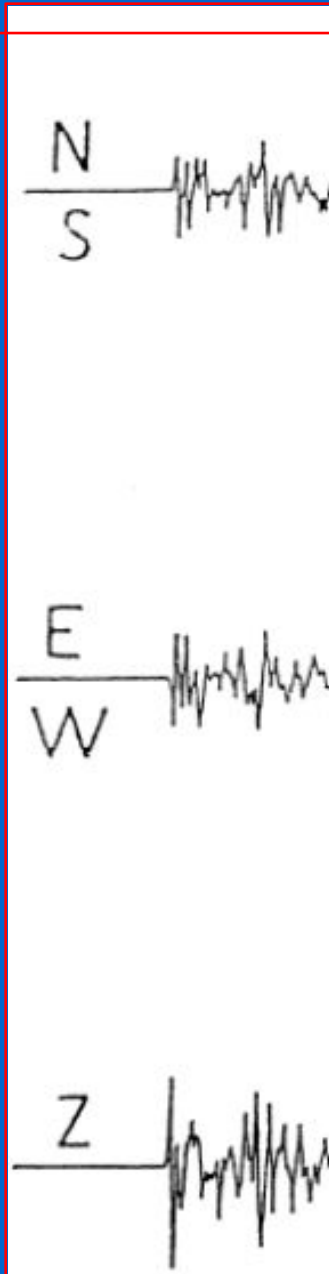


# Localização com 1 Estação

Método do azimuth reverso (*backazimute*)

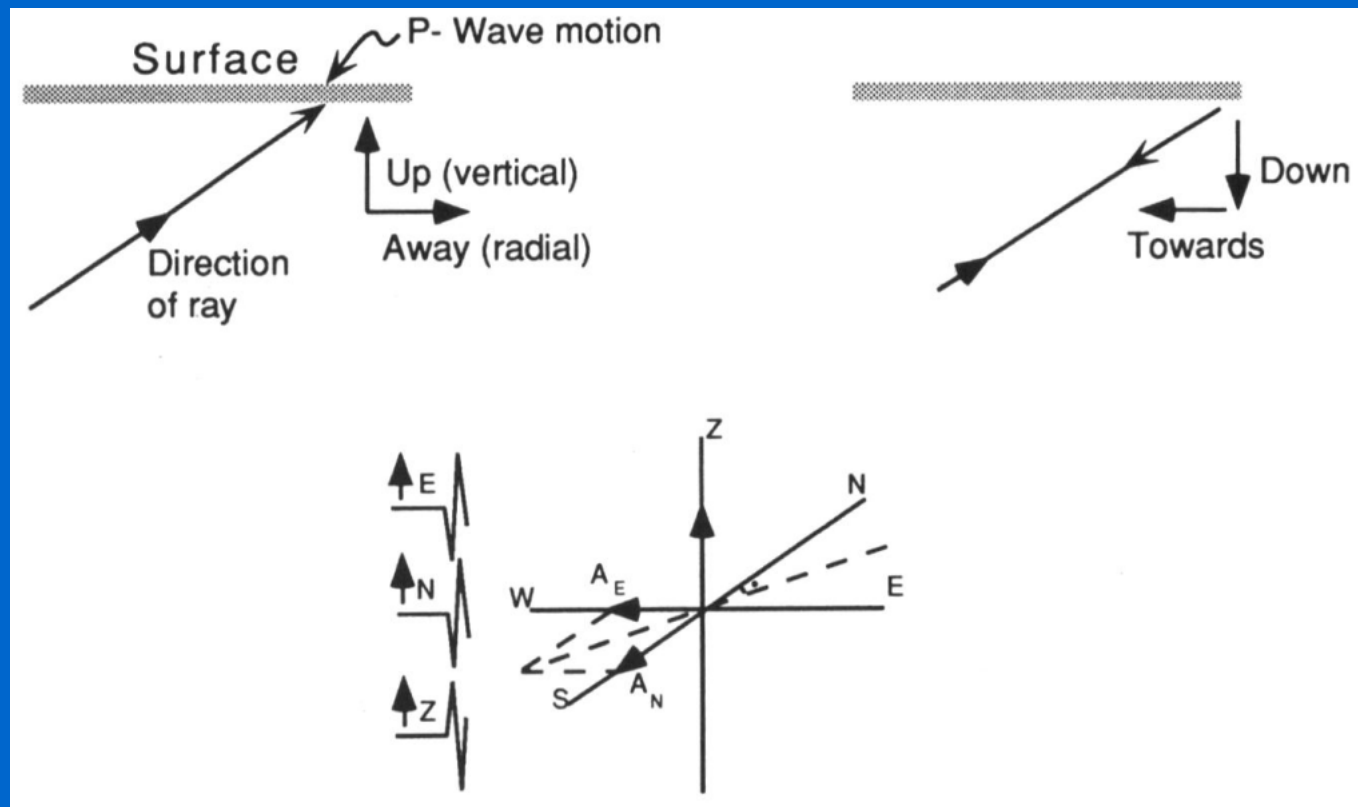
*estação tri-axial*

*onda P bem registrada*



Bormann, 2002

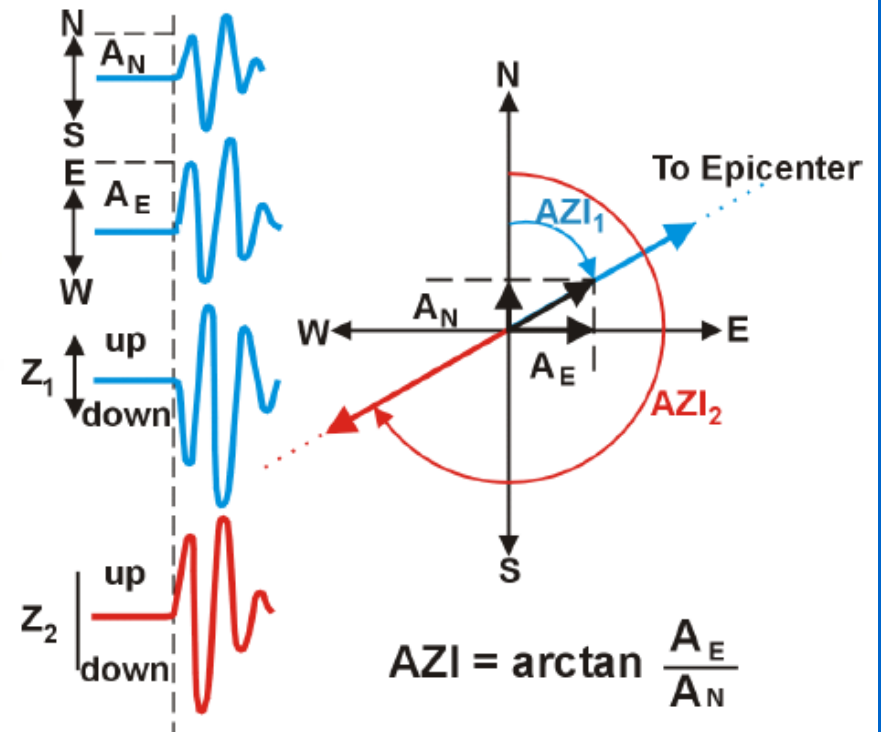
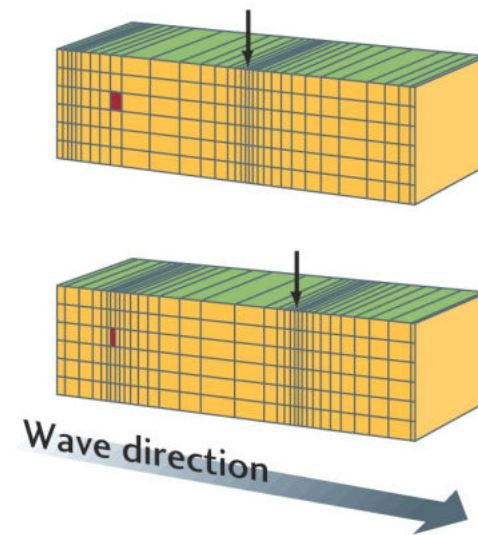
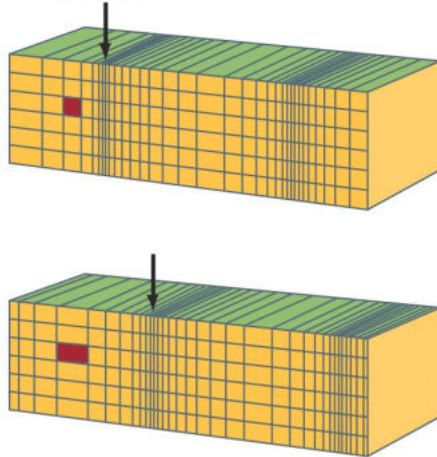
- 
- – A onda P é polarizada na direção de propagação, portanto o vetor deslocamento produzido pela onda P pode ser usado para estimar o Azimute do epicentro (azimute reverso).
- 



*Lay & Wallace, 1995*

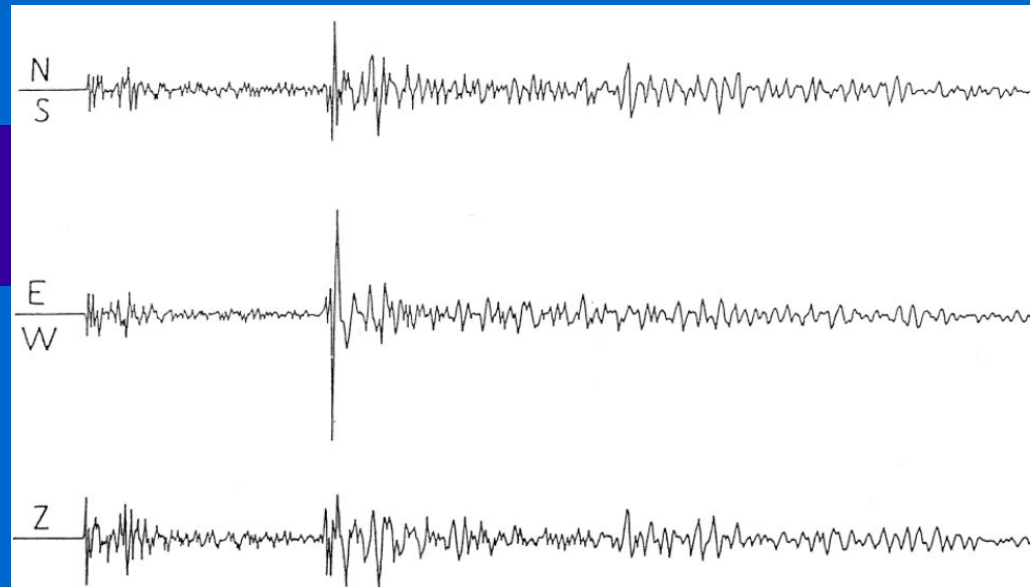
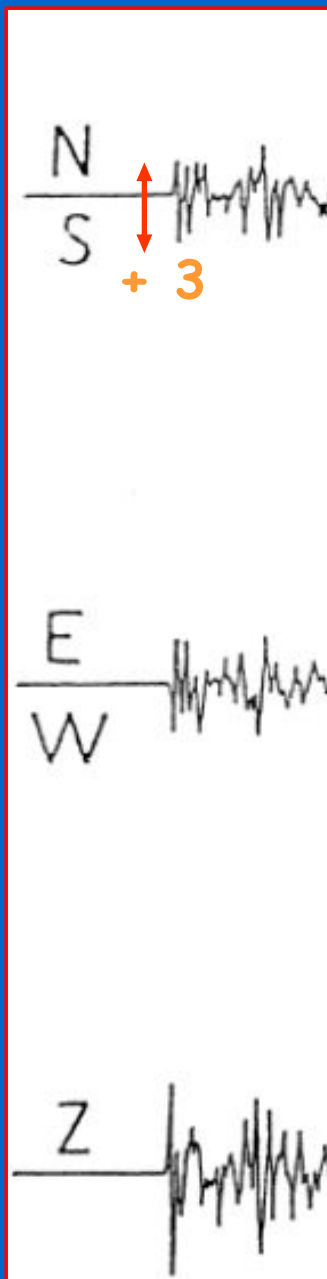
## P-wave motion

Compressional  
wave

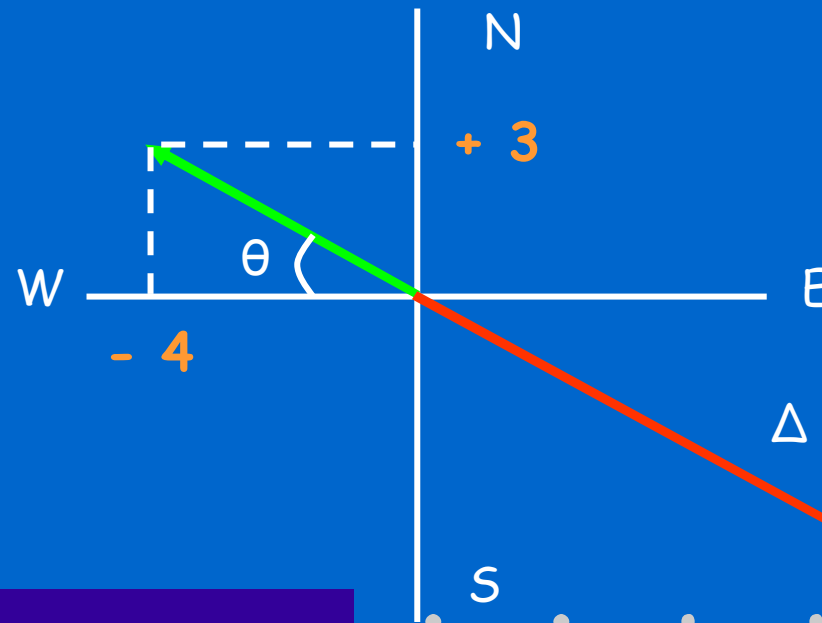


*Understanding Earth (2004)*

*Bormann, 2002*



S-P = distância epicentral ( $\Delta$ )

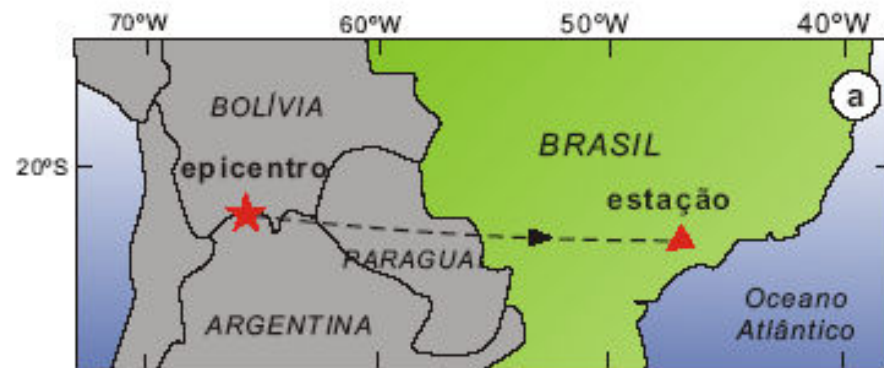


$$\operatorname{tg} \theta = \frac{3}{4} = 0,75$$

$$\operatorname{arctg} \theta = 37^\circ$$



## Argentina abala São Paulo

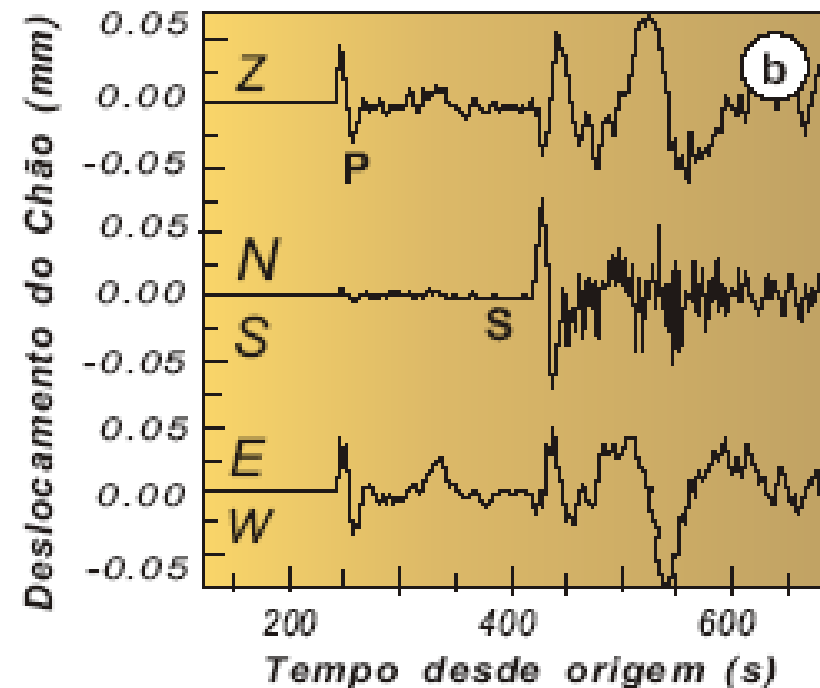
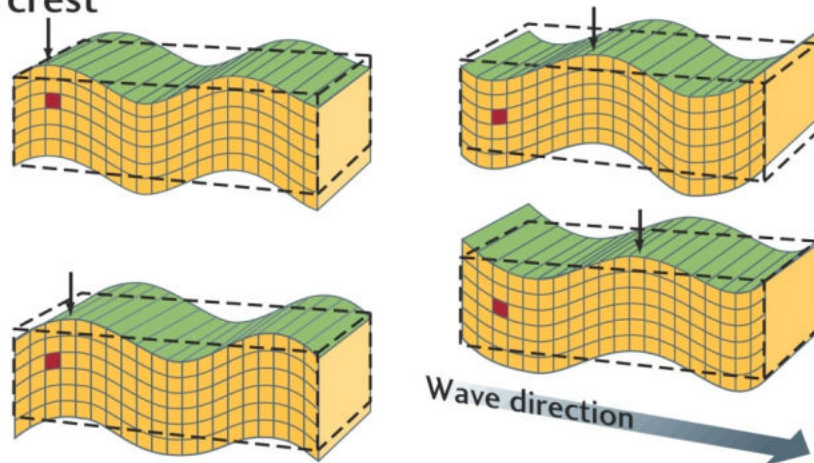


Veja que esse evento tem o azimuth compatível com sua localização na Argentina.

Observe que a onda S tem maior amplitude na componente N-S, mas a P possui pouca energia.

### S-wave motion

Shear-wave crest



Exercício 2 - Determinar epicentro do evento utilizando as polaridades e amplitudes das primeiras chegadas da onda P nas componentes Norte-Sul, Leste-Oeste e Vertical. Determinar distância epicentral usando diferença S-P e Tabela 1.

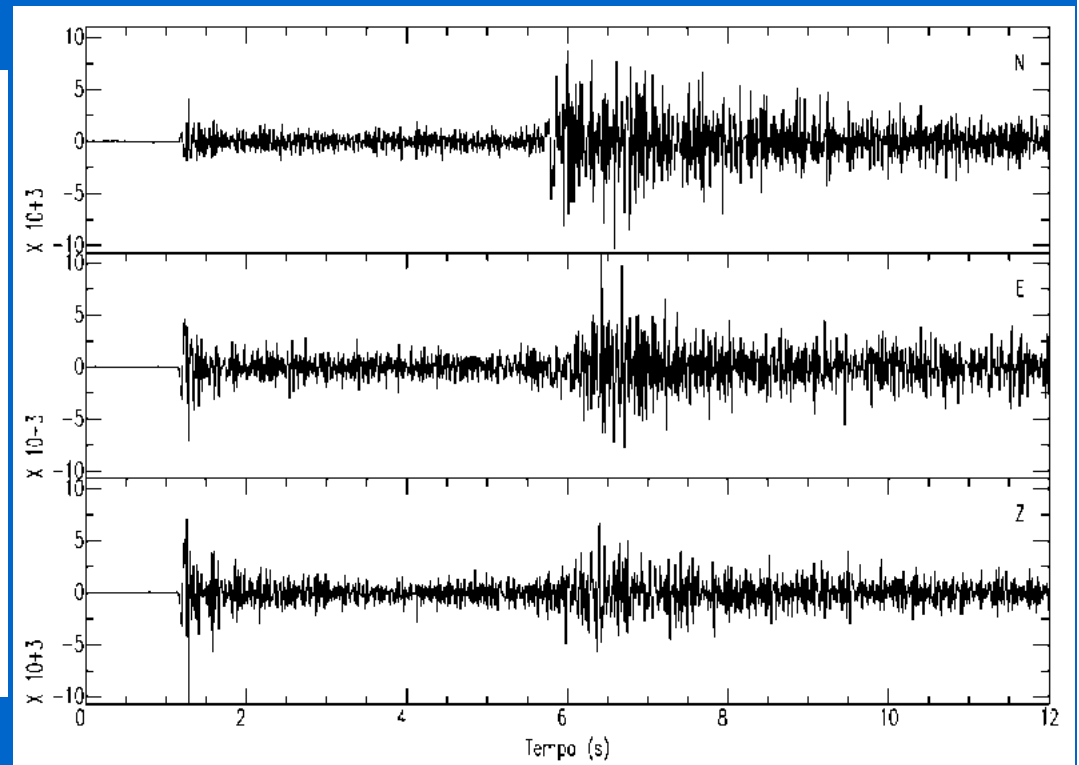
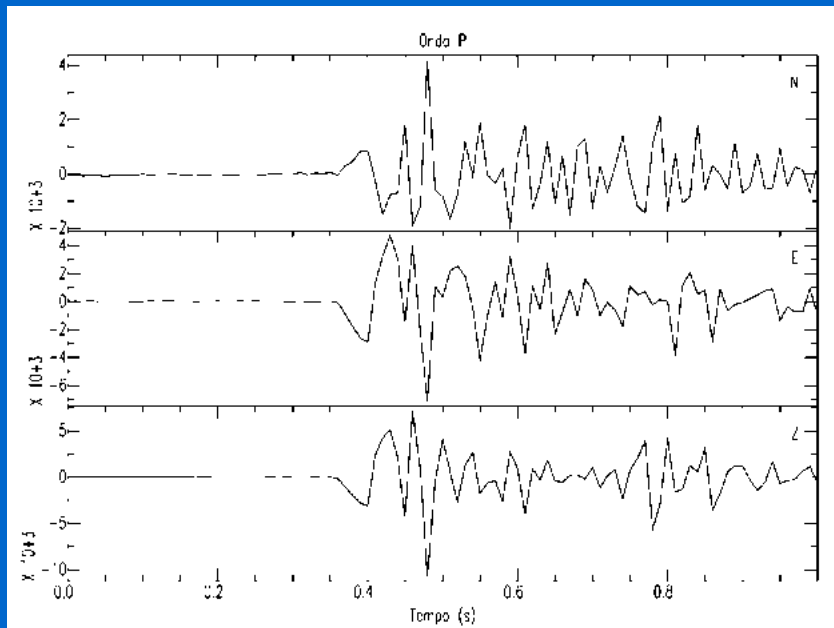


Tabela de (S-P) (s) X Distância (Km)

(S-P)	Dist.				
0,10:	0,819	0,20:	1,638	0,30:	2,457
0,50:	4,095	0,60:	4,914	0,70:	5,733
0,90:	7,371	1,00:	8,190	1,10:	9,009
1,30:	10,647	1,40:	11,466	1,50:	12,285
1,70:	13,923	1,80:	14,742	1,90:	15,561
2,10:	17,199	2,20:	18,018	2,30:	18,837
2,50:	20,475	2,60:	21,294	2,70:	22,113
2,90:	23,751	3,00:	24,570	3,10:	25,389
3,30:	27,027	3,40:	27,846	3,50:	28,665
3,70:	30,303	3,80:	31,122	3,90:	31,941
4,10:	33,579	4,20:	34,398	4,30:	35,217
4,50:	36,855	4,60:	37,674	4,70:	38,493
4,90:	40,131	5,00:	40,950	5,10:	41,769
5,30:	43,407	5,40:	44,226	5,50:	45,045
5,70:	46,683	5,80:	47,502	5,90:	48,321
6,10:	49,959	6,20:	50,778	6,30:	51,597
6,50:	53,235	6,60:	54,054	6,70:	54,873
6,90:	56,511	7,00:	57,330	7,10:	58,149
7,30:	59,787	7,40:	60,606	7,50:	61,425
7,70:	63,063	7,80:	63,882	7,90:	64,701
8,10:	66,339	8,20:	67,158	8,30:	67,977
8,50:	69,615	8,60:	70,434	8,70:	71,253
8,90:	72,891	9,00:	73,710	9,10:	74,529
9,30:	76,167	9,40:	76,986	9,50:	77,805
9,70:	79,443	9,80:	80,262	9,90:	81,081
10,10:	82,719	10,20:	83,538	10,30:	84,357
10,50:	85,995	10,60:	86,814	10,70:	87,633
10,90:	89,271	11,00:	90,090	11,10:	90,909
11,30:	92,547	11,40:	93,366	11,50:	94,185
11,70:	95,823	11,80:	96,642	11,90:	97,461
12,10:	99,099	12,20:	99,918	12,30:	100,737
12,50:	102,375	12,60:	103,194	12,70:	104,013
12,90:	105,651	13,00:	106,470	13,10:	107,289
13,30:	108,927	13,40:	109,746	13,50:	110,565
13,70:	112,203	13,80:	113,022	13,90:	113,841
14,10:	115,479	14,20:	116,298	14,30:	117,117
14,50:	118,755	14,60:	119,574	14,70:	120,393
14,90:	122,031	15,00:	122,850	15,10:	123,669
15,30:	125,307	15,40:	126,126	15,50:	126,945
15,70:	129,040	15,80:	129,970	15,90:	130,900
16,10:	132,760	16,20:	133,690	16,30:	134,620
16,50:	136,480	16,60:	137,410	16,70:	138,340
16,90:	140,200	17,00:	141,130	17,10:	142,060
17,30:	143,920	17,40:	144,850	17,50:	145,780
17,70:	147,640	17,80:	148,570	17,90:	149,500
18,10:	151,360	18,20:	152,290	18,30:	153,220
18,50:	155,080	18,60:	156,010	18,70:	156,940
18,90:	158,800	19,00:	159,730	19,10:	160,660
19,30:	162,520	19,40:	163,450	19,50:	164,380
				19,60:	165,310

