(2016-03-01)

LURRIKARAK ETA SISMOTEKTONIKA

- Lurzoruaren astinaldia eta bere ondorioak edota astinaldi horrek eragiten duen uhinaren iturria → uhin sismikoen iragarpenak eragiten du lurzoruaren astinaldia.
- Oro har, uhin sismikoen iturria faila batean gertatutako batbateko mugimendutik zein desplazamendutik datorkigu.
- Uhinen iturriak:

  %90 → Failak

  %10 → Bulkanismoa, kolapsoak, antropikoak (leherketa nuklearrak, meatzaritza, mendi-maldako labainketa ...).
- Energiaren askapena

  "Errebote elastikoaren eredua" (Elastic rebound model)

  → H.F. Reid, 1906.

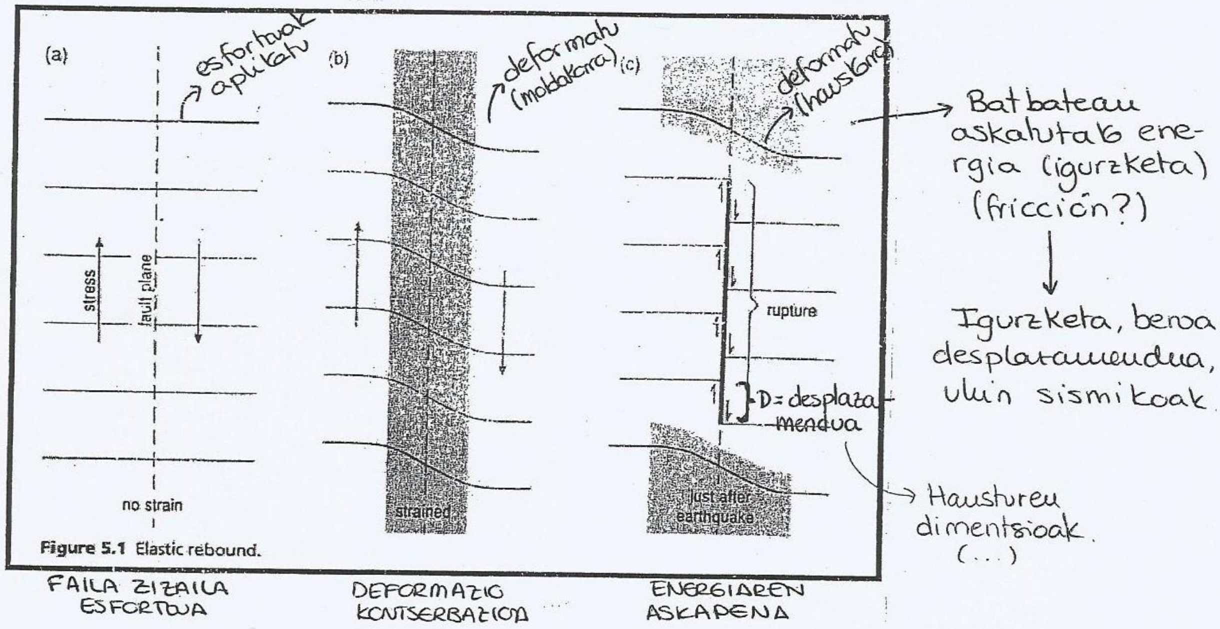


Figure 5.1 Elastic rebound.

- Atalak:
  - Hipozentro (hypocenter focus) = fokua
  - Epizentro (epicenter)
  - Atzindari lurrikarak (foreshock)
  - Erreplika (aftershock)

  sismo nagusia baino lehen/ondoren gertatzen diren sismoak intentsitate baxuagokoak

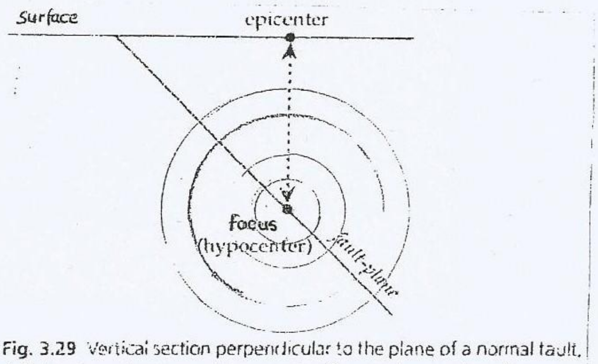
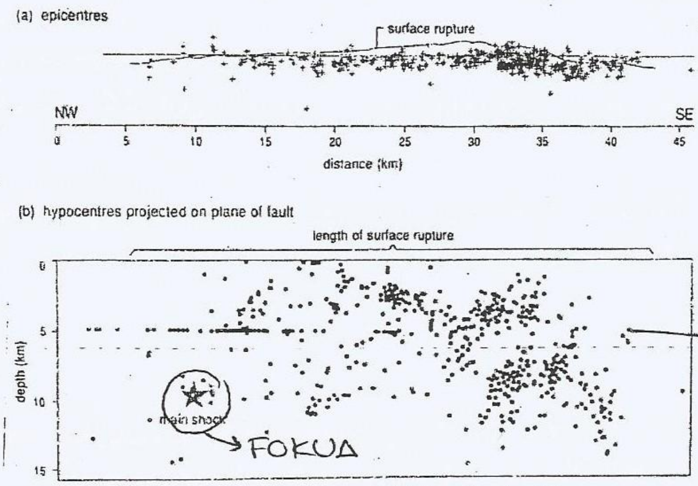


Fig. 3.29 Vertical section perpendicular to the plane of a normal fault, defining the epicenter and hypocenter (focus) of an earthquake.

"Erreplikek bat egiten dute haustura planoarekin"



→ errepliken hipozentroak

Figure 5.15 Distribution of the aftershocks of the Parkfield earthquake, 1966.

→ poorly consolidated sedimentuak / Unable to accumulate strain

→ Rocks too ductile to support the elastic strain

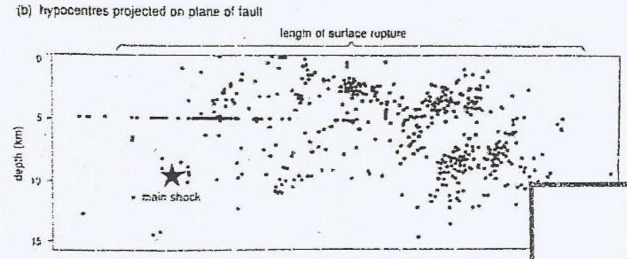
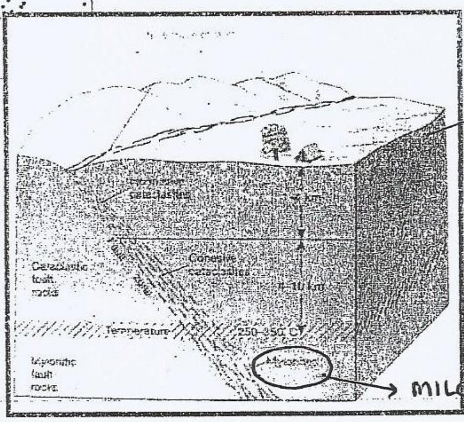


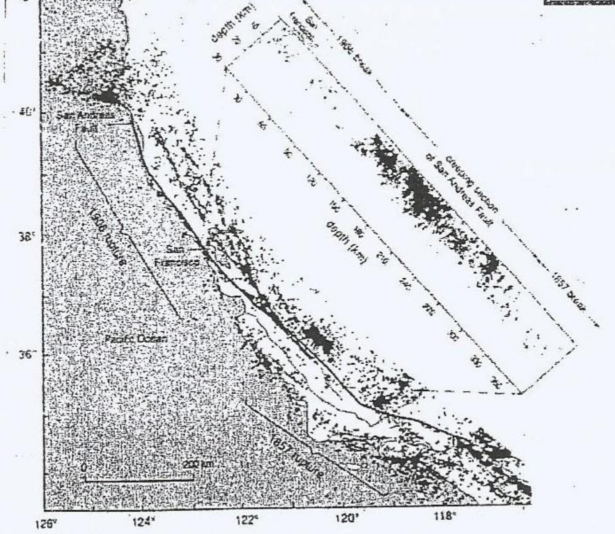
Figure 5.15 Distribution of the aftershocks of the Parkfield earthquake, 1966.



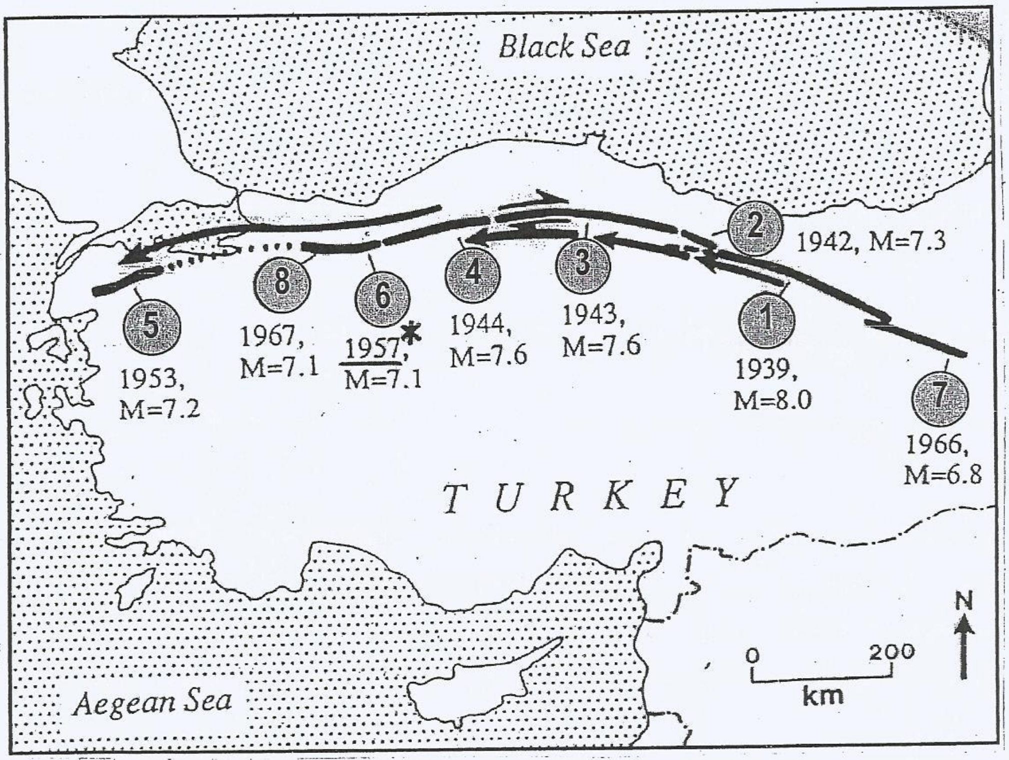
→ lehenengo Km-tan arrokak kontsolidatu gabe daude.
↳ ezin apurtu!

} sismoak hemen eragiten dute batez ere.

→ MILONITAK: def. moldakorra, urtze partziala.



? Adibidea



{ ①
M = magnitudea
1939 = urtea } ⇒ Ezin da predikziorik egin, irudian ageri den moduan, lurrikarak edonon eta edozein denboran gerta daitezkeelako. Faila irregularra izanik, energia toki desberdinetan akumulatzen da.

• SISMOGRAFOA (Seismograph): 3 norabidetan neurtzen dute uhinei dagokien pasoa, (nondik igarotzen diren).

(SISMOGRAFO HORIZONTALA) X edo Y → 90°-6 diferentziaz

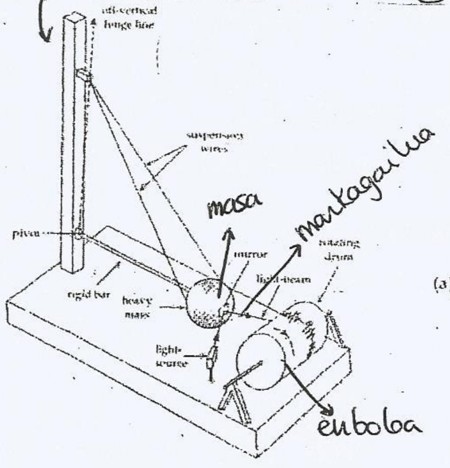
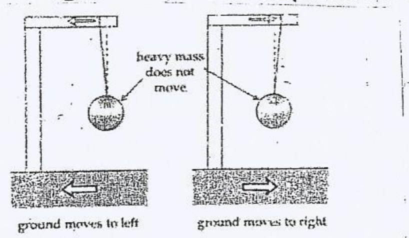
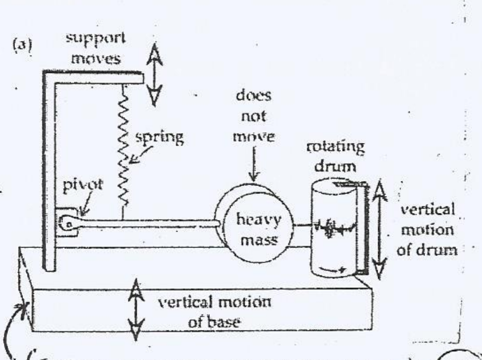


Fig. 3.23 Schematic design of the pendulum type of horizontal-motion seismometer (after Strahler, 1963).

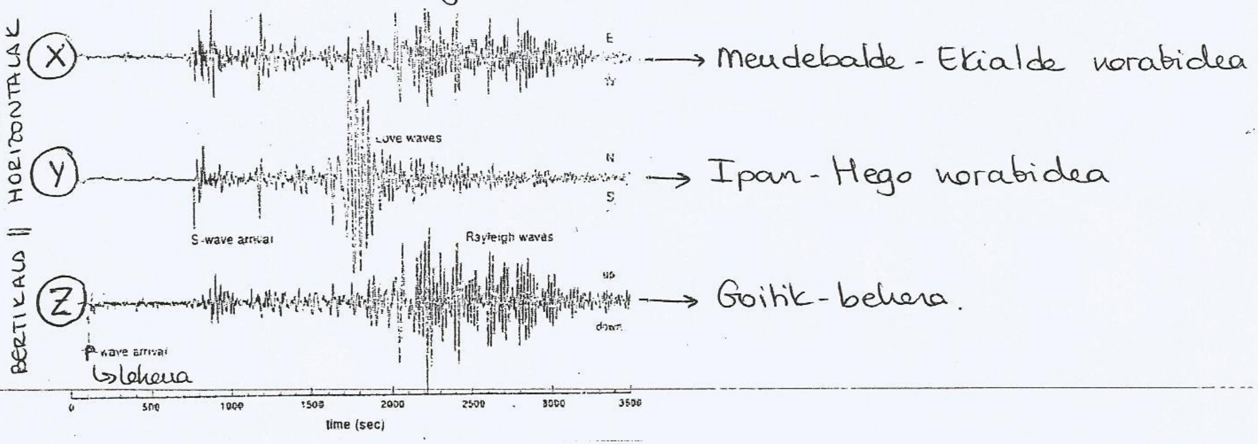




(SISMOGRAFO BERTIKALA) Z

* Enboloak, denbora eta mugimendua erregistratzen ditu, lenoak horizontalean zein goitik behera indikatzen ditu, segun eta posizioa zein den.

★ 3 norabideetan sismografo batek neurturiko seinaleak:



↳ P eta S uhinak BARNE UHINAK direnez, anplitude erlatiboki txikiagoak dituzte, P-ak lehen erregistratzen dira eta S-ak geroago. Love eta Rayleigh uhinak AZALEKO UHINAK direnez, anplitude handienak dituzte, Love azkarrenak direlarik.

Rayleigh uhinak eliptikoki higatzen direnez up-down Z sismografoak erregistratuko ditu.

(segiratu urrutiko gaietan)

Love uhinak uhinaren norabidearekiko perpendikularki higatzen dira; Kasu honetan Love uhinak N-S Y sismografoak erregistratu ditu, ondorioz uhinaren norabidean, W-E X dela badakigu.

(2016-03-02)

- LURRIKAREN KOKAPENA (Locating a earthquake)
  - Sismografoetara heltzen diren lehenengo uhinak (P).

    ARAZOAK:
    - P uhinen bidaia denbora (desberdinak?)
    - Lurraren abiadura ez da guztiz konstantea

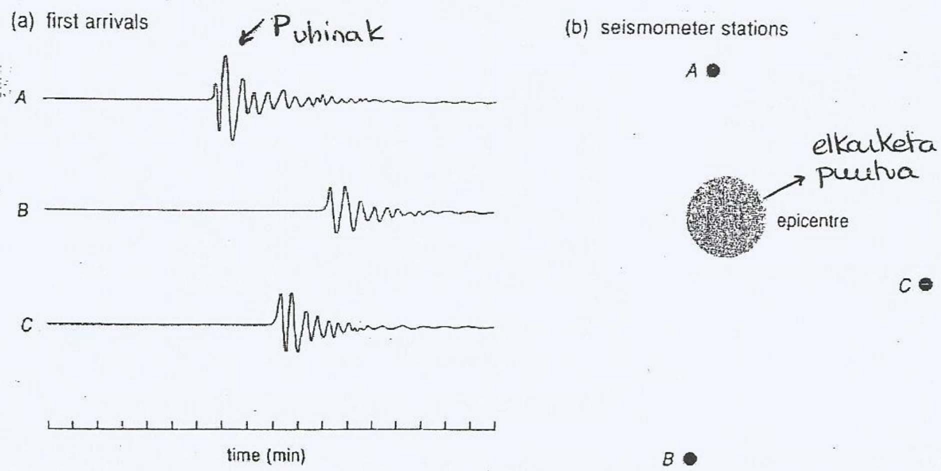


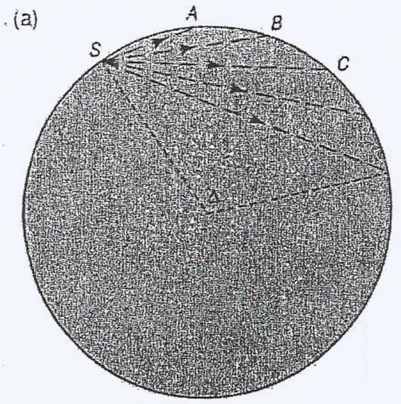
Figure 5.2 Locating an earthquake using first arrivals.

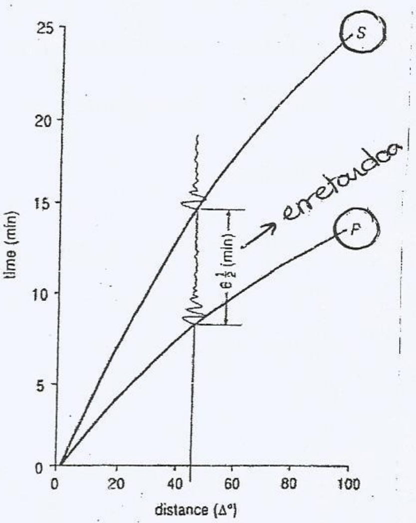
- Epizentro distantzia:
  a) kilometrotan Δkm
  b) Angelutan Δ° (angelu epizentralak)

$40.000\ km = 360\ \Delta^\circ$
$10.000\ km = 90\ \Delta^\circ$

- Sismografoetara heltzen diren P uhinen eta S uhinen bidaia denbora diferentzia

(*) Distantzia eta erretardoa erlazionatuta daude; Distantzia luzeagoa denean erretardoa ere handitzen da eta Laburragoa denean txikitu.





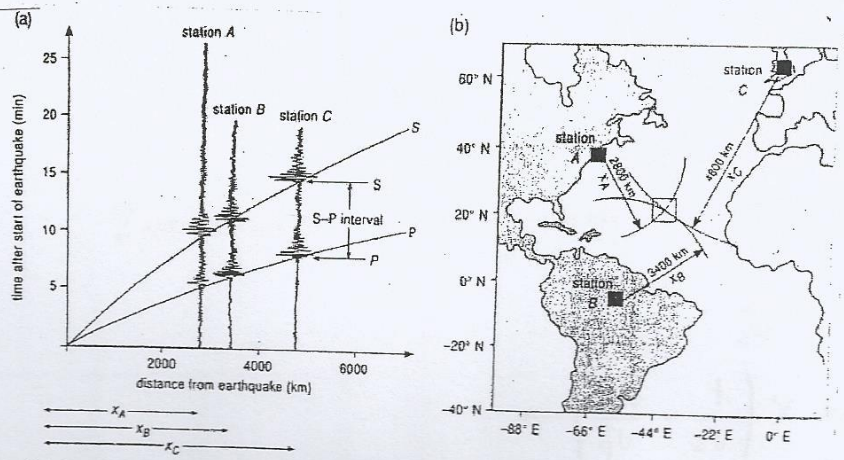
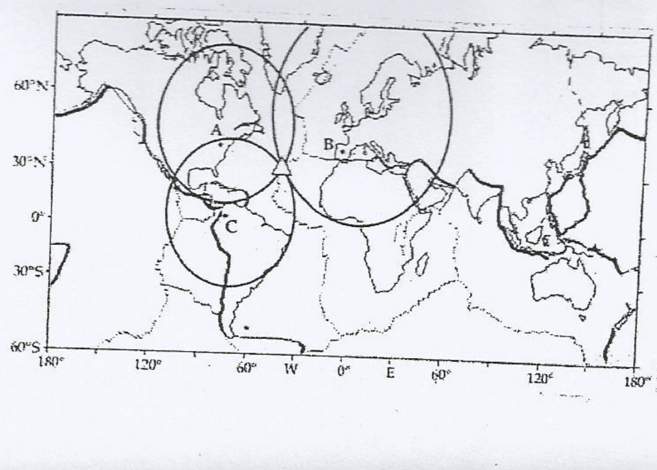


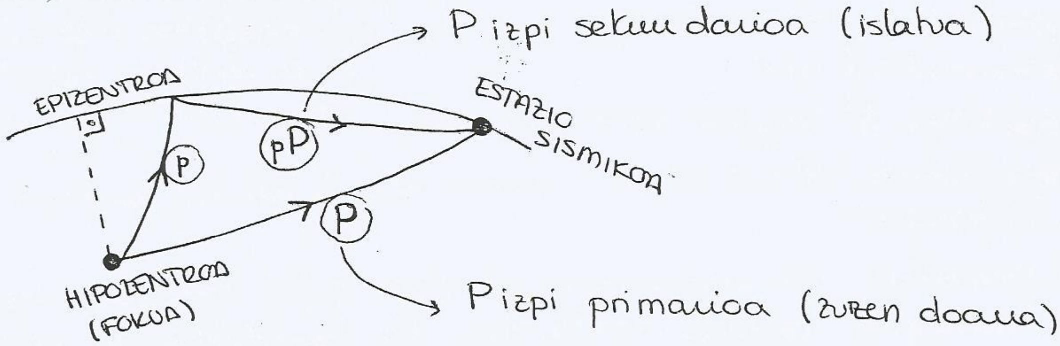
Figure 5.4 Location of an earthquake using P–S arrival-time differences.



→ Konpasarekin neurtu distantzia eta zirkulua bota.

→ Zirkuluen ebaketa puntua epizentroa izango da.

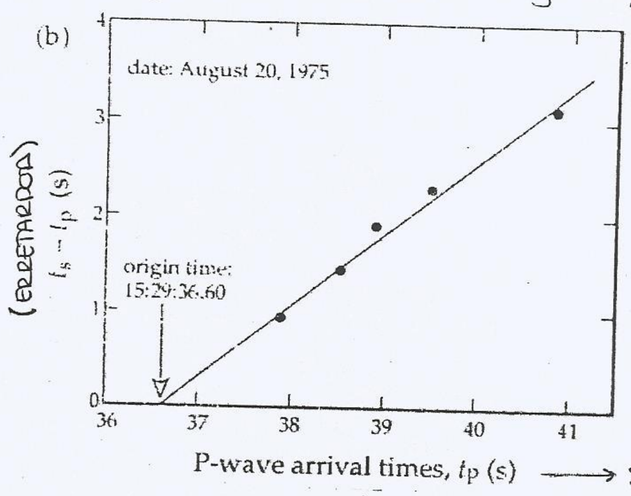
→ Geroz eta estazio sismiko gehiago izan, epizentroaren kokapena zehatzagoa!



ΔT (erretardoa), sakoneraren araberakoa da ere, geroz eta sakonago egon erretardoa geroz eta handiagoa, et badago hain sakon erretardoa txikiagoa.

- Lurrikaren hasiera:

↳ Wadati grafikoa (Wadati diagram)



→ Segundutan!

↳ erretardoa 0 denean, ateratzen dugu lurrikara gertatu den denbora, puntuak lerrokatuz.

$$t_s - t_p = \frac{X}{V_s} - \frac{X}{V_p} \rightarrow$$

$$t_s - t_p = X\left(\frac{1}{V_s} - \frac{1}{V_p}\right) \rightarrow$$

$$t_s - t_p = \frac{X}{V_p}\left(\frac{V_p}{V_s} - \frac{V_p}{V_p}\right) \rightarrow$$

$$\boxed{t_s - t_p = t_p\left(\frac{V_p}{V_s} - 1\right)}$$

- Lurrikara baten tamaina (MAGNITUDEA ≠ INTENTSITATEA)
  - INTENTSITATEA: eskala subjektiboa, neurtzen duelako seismo horrek eragindako kalteak, hau da, lurrikarak sortzen dituen efektuen araberakoa.

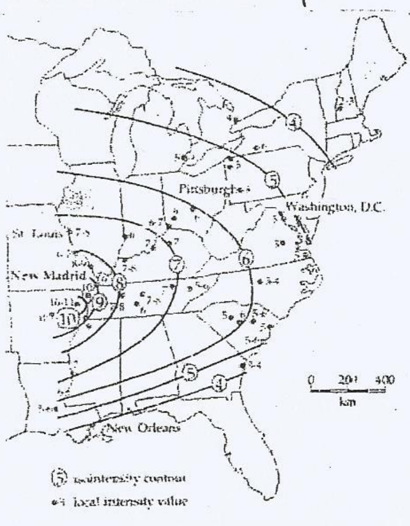
Neurtzeko <u>Mercalli</u>-ren eskala (1902) erabiltzen da, I - XII -ra dijoana. (zenbaki erromatarretan). EMS-ek (1998) berriztu zuen eskala:

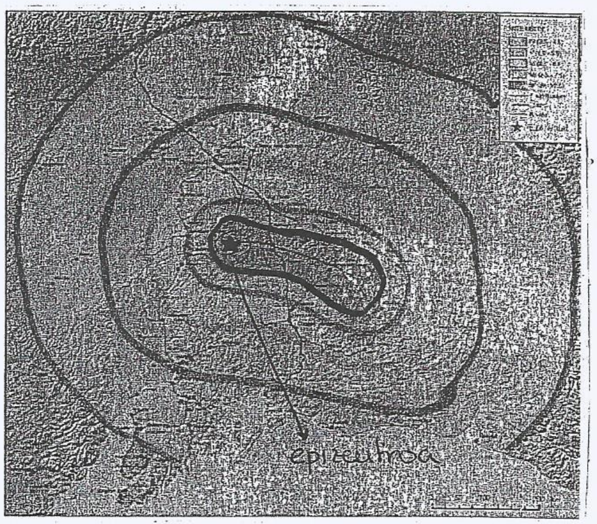
Table 3.1 *Abridged and simplified version of the European Macroseismic Scale 1998 (European Seismological Commission, 1998) for earthquake intensity*

The scale focuses especially on the effects on people and buildings. It takes into account classifications of both the vulnerability of a structure (i.e., the materials and method of construction) and the degree of damage.

Intensity	Description of effects
I–IV	*light to moderate earthquakes*
1 I	**Not felt**
2 II	**Scarcely felt** Felt only by a few individual people at rest in houses.
3 III	**Weak** Felt indoors by a few people. People at rest feel a swaying or light trembling.
4 IV	**Largely observed** Felt indoors by many people; outdoors by very few. A few people are awakened. Windows, doors and dishes rattle.
V–VIII	*moderate to severe earthquakes*
5 V	**Strong** Felt indoors by most, outdoors by few. Many sleeping people awake. A few are frightened. Buildings tremble throughout. Hanging objects swing considerably. Small objects are shifted. Doors and windows swing open or shut.
6 VI	**Slightly damaging** Many people are frightened and run outdoors. Some objects fall. Many houses suffer slight non-structural damage like hair-line cracks and fall of small pieces of plaster.
7 VII	**Damaging** Most people are frightened and run outdoors. Furniture is shifted and objects fall from shelves in large numbers. Many well built ordinary buildings suffer moderate damage: small cracks in walls, fall of plaster, parts of chimneys fall down; older buildings may show large cracks in walls and failure of fill-in walls.
8 VIII	**Heavily damaging** Many people find it difficult to stand. Many houses have large cracks in walls. A few well built ordinary buildings show serious failure of walls, while weak older structures may collapse.
IX–XII	*severe to destructive earthquakes*
9 IX	**Destructive** General panic. Many weak constructions collapse. Even well built ordinary buildings show very heavy damage: serious failure of walls and partial structural failure.
10 X	**Very destructive** Many ordinary well built buildings collapse.
11 XI	**Devastating** Most ordinary well built buildings collapse, even some with good earthquake resistant design are destroyed.
12 XII	**Completely devastating** Almost all buildings are destroyed.

Isoseismal map:

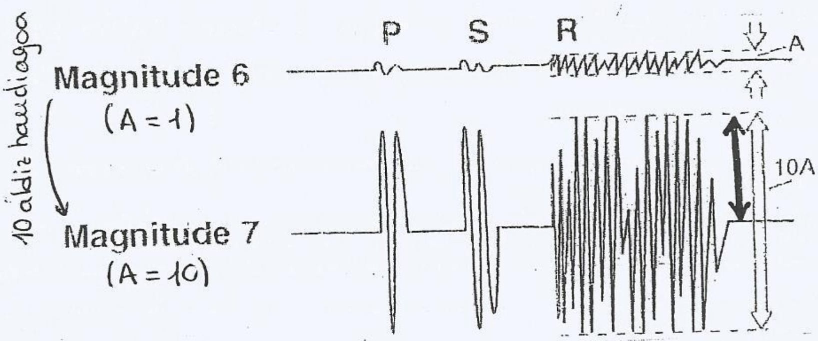




- MAGNITUDEA: eskala objetiboa, sismografoz neurtutako balioa baita. Neurtzeko...

1. Ritcher (1935): <u>Sakonera gutxiko</u> lurrikaren <u>epizentrotik 100 Km-tara</u> dagoen sismografo berezi batean (<u>Wood - Anderson sismografoa</u>) jasotako uhinen gehiegizko anplitudearen logaritmoa ematen digu.

$\boxed{M_R = \log_{10} A_s}$ (azal uhinen gehiegizko anplitudeen [mikrak])



(2016-03-03)

2. Neurketak:

- Ritcheren eskala ezin da edonon erabili (Epizentrotik 100 km-tara)

$$M_L \text{ (local magnitude)} = \log_{10} A_S + 3\log_{10} \Delta\,[\text{Km}] - 2{,}92$$

Ritcher zuzen-duta sakoneran eta distantzian

$$\boxed{M_L = \log_{10} A_S + 30 \log_{10} (8\,\Delta t_{S-P})\,[\text{seg}] - 2{,}92}$$

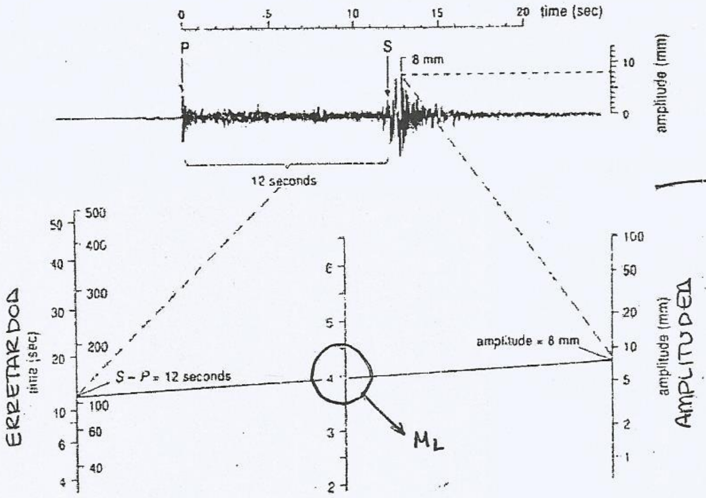


Figure 5.23 How magnitude is defined from a seismogram.

Grafikoz kalkulatzeko (M_L, erretardo eta amplitudearen ara-bera, ebakitzen direneko puntua).

- Ritcheren eskala edonon erabili (sakonera gutxiko sismoak).

$$M_S \text{ (Rayleigh surface wave magnitude)} = \log_{10} \left(A_S/T\right) + 1{,}66 \log_{10} \Delta^\circ + 3{,}3$$

$$\boxed{M_S = \log_{10} \left(A_S/T\right) + 1{,}66 \log_{10} \Delta^\circ + 3{,}3 + \text{correction (depth)}}$$

- Momentu magnitudea, M_W (moment magnitude):

$$\boxed{M_W = \frac{2}{3} \log_{10} M_0 - 10{,}7}$$

Momentu Magnitudea (M_w)

M_w = 2/3 $\log_{10} \mu_0$ + 10.7 → $\mu_0 = 2Fb$ | $F/A = \mu\gamma$ → $\gamma = tg\psi = d/2b$ | **$\mu_0 = (2\mu\ A\ d\ b) / 2\ b = \mu\ A\ d$**

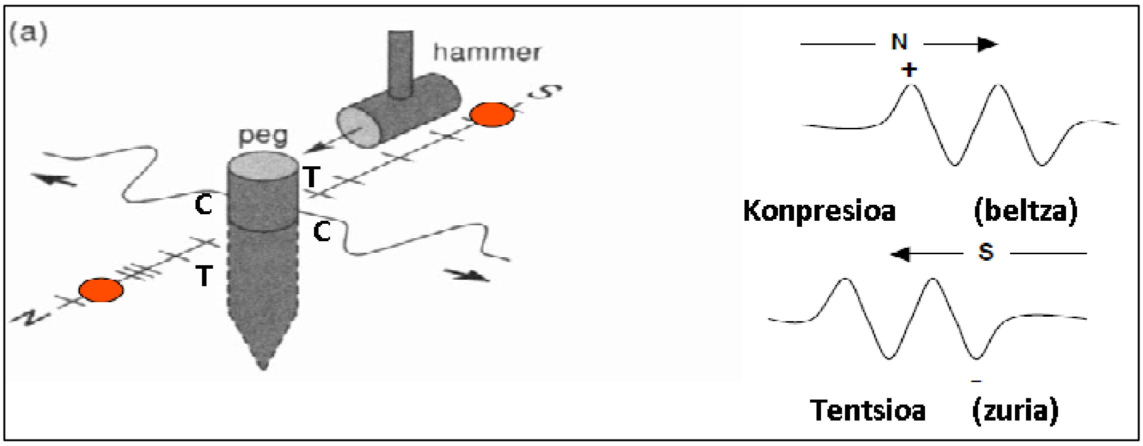
γ = Zizaila deformazioa μ = Gogortasun modulua

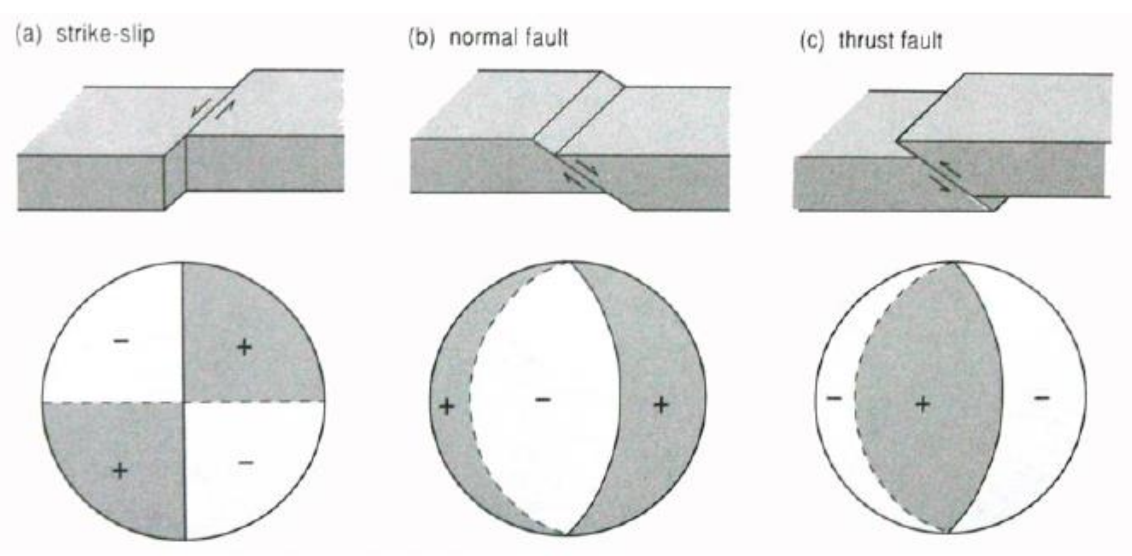
d = desplazamendua A = haustura zonaren azalera

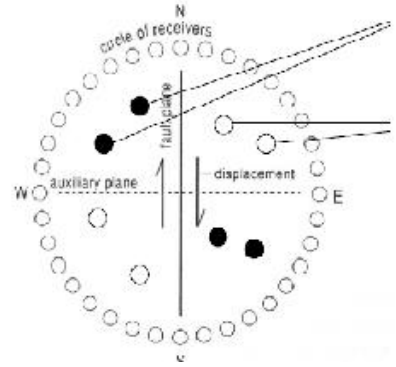
Magnitudea (Mw)	Intentsitatea
1 - 3	I
3 - 3.9	II - III
4 - 4.9	IV - V
5 - 5.9	VI - VII
6 - 6.9	VII - IX
> 7	> VIII

FOKU MEKANISMOEN SOLUZIOAK

Lurrikara eragin duen faila mota zein bere norabidea antzemateko erabiltzen den mekanismoa da. Lurrean itsatsitako eta iltzatutako makila bat dago mailu baten bitartez alde batetik jotzen zaiona. Kolaren bitartez itsatsita dagoenez ez da alde hutsik eratzen eta uhin fronte bat eratzen da. Ondorioz eremuaren inguruan, nondik jo dugun arabera, bi konpresiozko eremu eta beste bi tentsiozko eratzen dira.







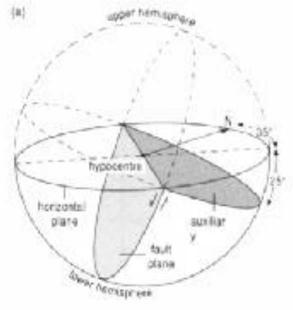
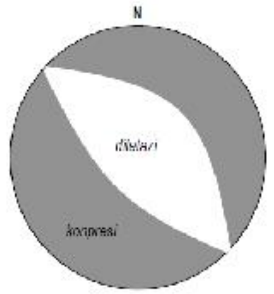


Figure 5.8 Focal sphere.



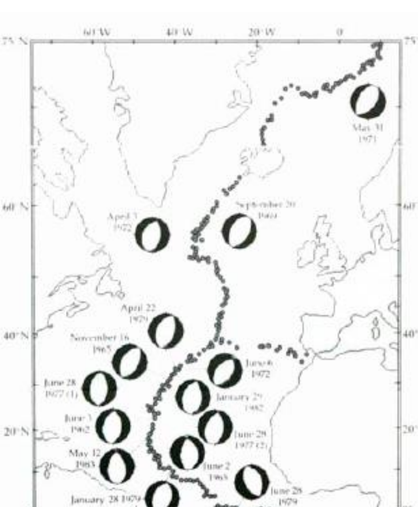


Fig. 3.39 Fault-plane solutions for earthquakes along the Mid-Atlantic Ridge, showing the prevalence of extensional tectonics with normal faulting in the axial zone of the spreading center (based on data from Huang et al., 1986).