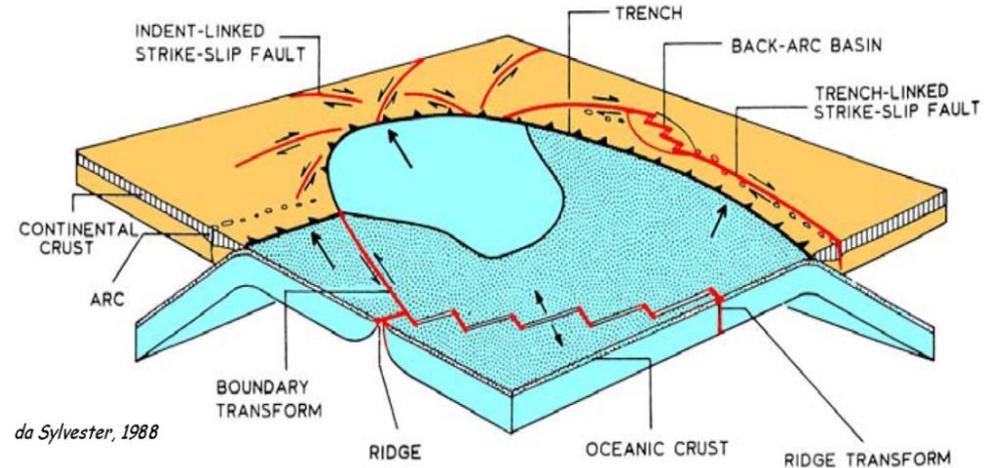
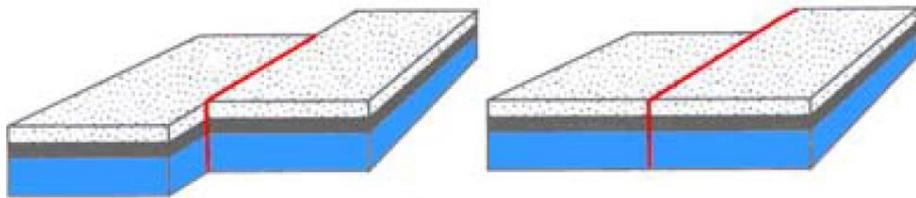


# Strike-slip Faults

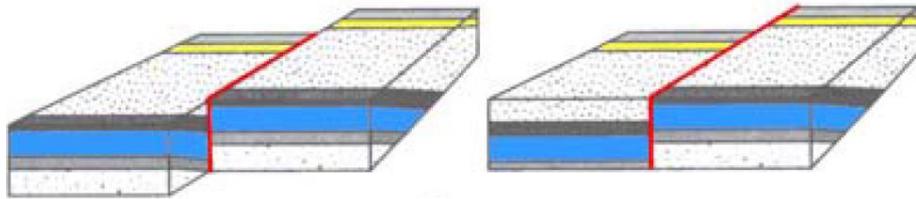


- **Transform faults**: related to plate margins, they cut the entire lithospheric thickness
- **Transcurrent faults**: limited to the crustal thicknesses, they are generally intra-continental.
- A third group of faults are the *strike-slip*, related to horizontal shift within extensional or compressional tectonic regimes. Generally, they have small throw and depth.
- The strike-slip faults generally produce second order faults and peculiar fracture systems, as that one with the *en-echelon* geometry.

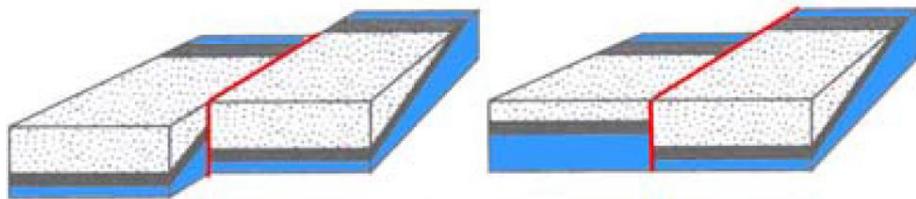
## Right and left strike-slip and apparent throw.



A.



B.



C.

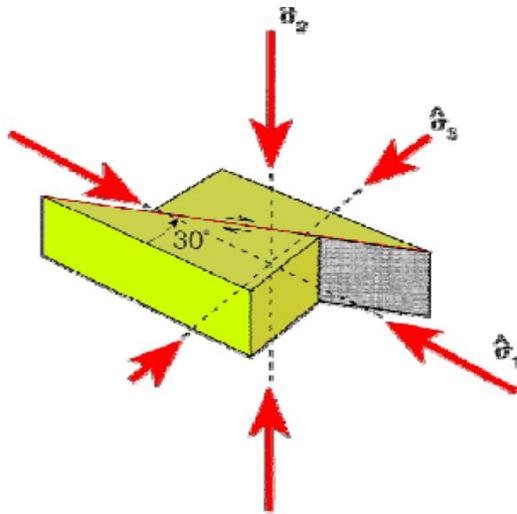
da Twiss & Moores , 1992

The right and left attribution, is unambiguous, whatever the block in which we place ourselves.

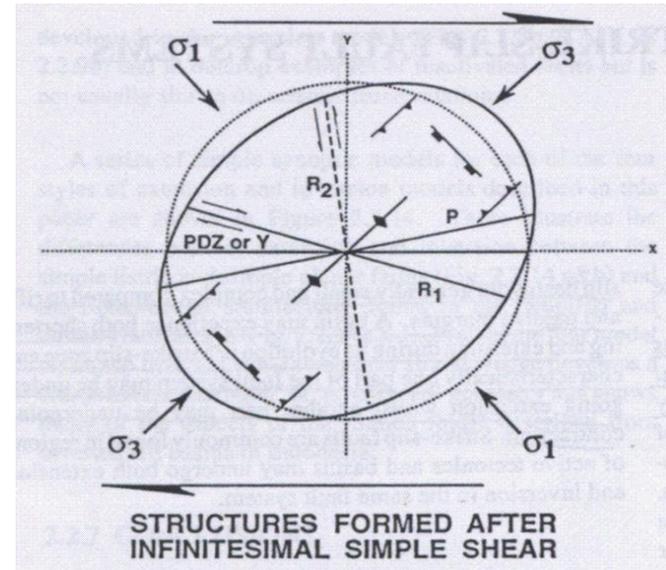
← Apparent effects

The best observation point is perpendicular to the displacement vector and therefore from above

# Strike-Slip Faults

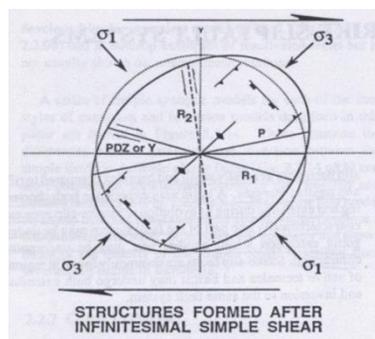


Example of right strike-slip

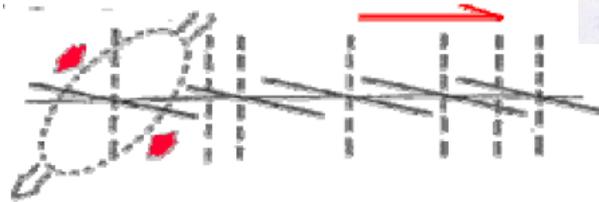


*The Strike-Slip systems are characterized by association of correlated structures, which can be interpreted in terms of the classic stress ellipsoid. With the first initial deformation along the PDZ segment, the Shears  $R_1$  (typically oriented between  $15^\circ$  and  $20^\circ$ ) and  $R_2$  (typically oriented between  $70$  and  $75^\circ$ ) and the low angle  $P$  Shear ( $10^\circ$  -  $15^\circ$ ) will develop. There will also be associated minor structures, such as extensional faults (perpendicular to  $\sigma_3$ ) and compression folds and faults (perpendicular to  $\sigma_1$ ). As the deformation evolves (increase in horizontal rejection) these structures will rotate ...*

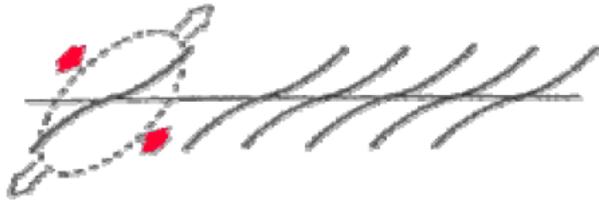
*Caratteristiche principali*



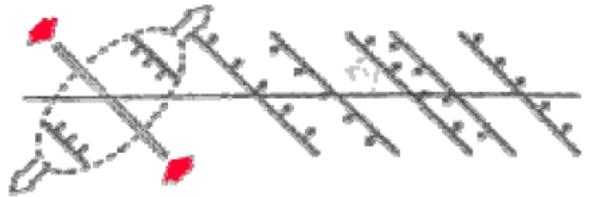
*Presenza di numerose elementi strutturali legati ad una fascia di trascorrenza (esperimento di Riedel)*



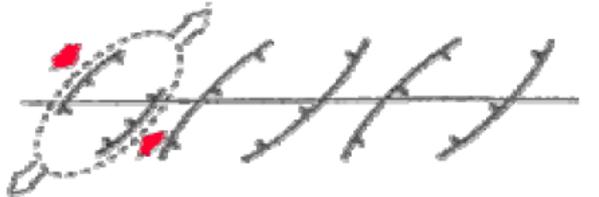
**Fratture R e R'**



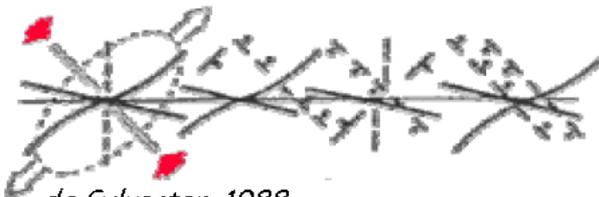
**Pieghe**



**Faglie normali**

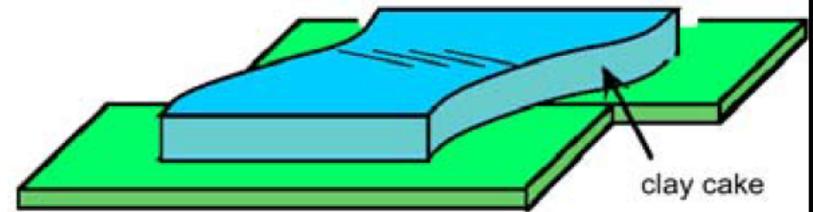


**Faglie inverse**



**Tutte le strutture insieme**

*da Sylvester, 1988*



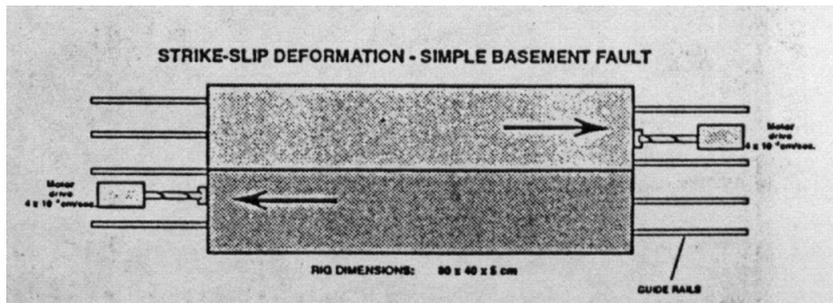
*da Allmendinger*

*Contemporaneità di strutture distensive e compressive*

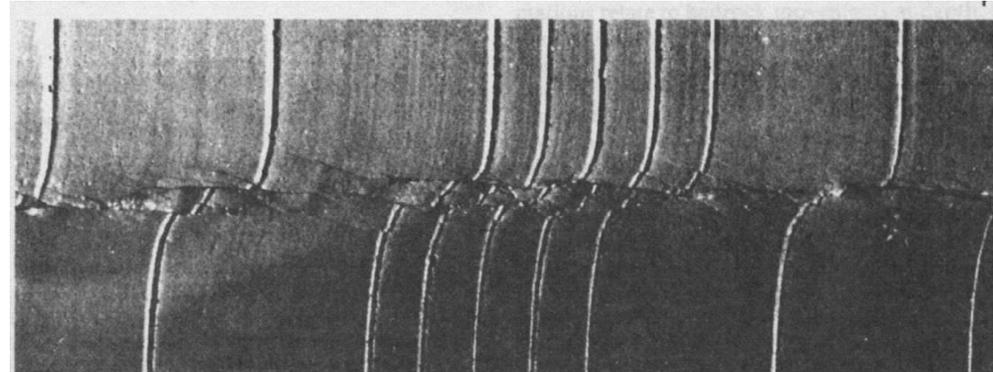
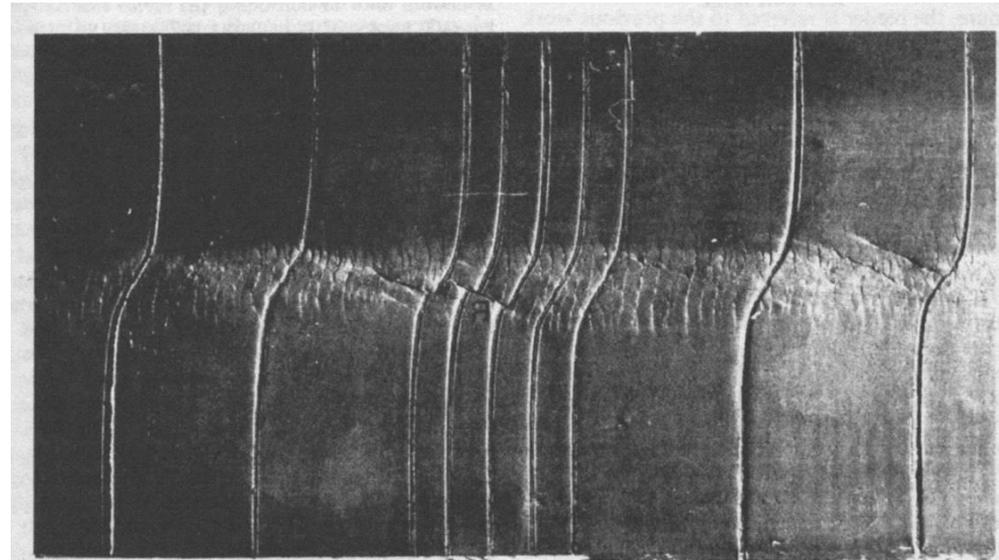
*Disposizione "en echelon" delle strutture associate*

# Strike-Slip Faults

*Shear box test:*  
to analyze the evolution of  
the structure systems related  
to a Strike-slip, a *Box Test* is  
often utilized



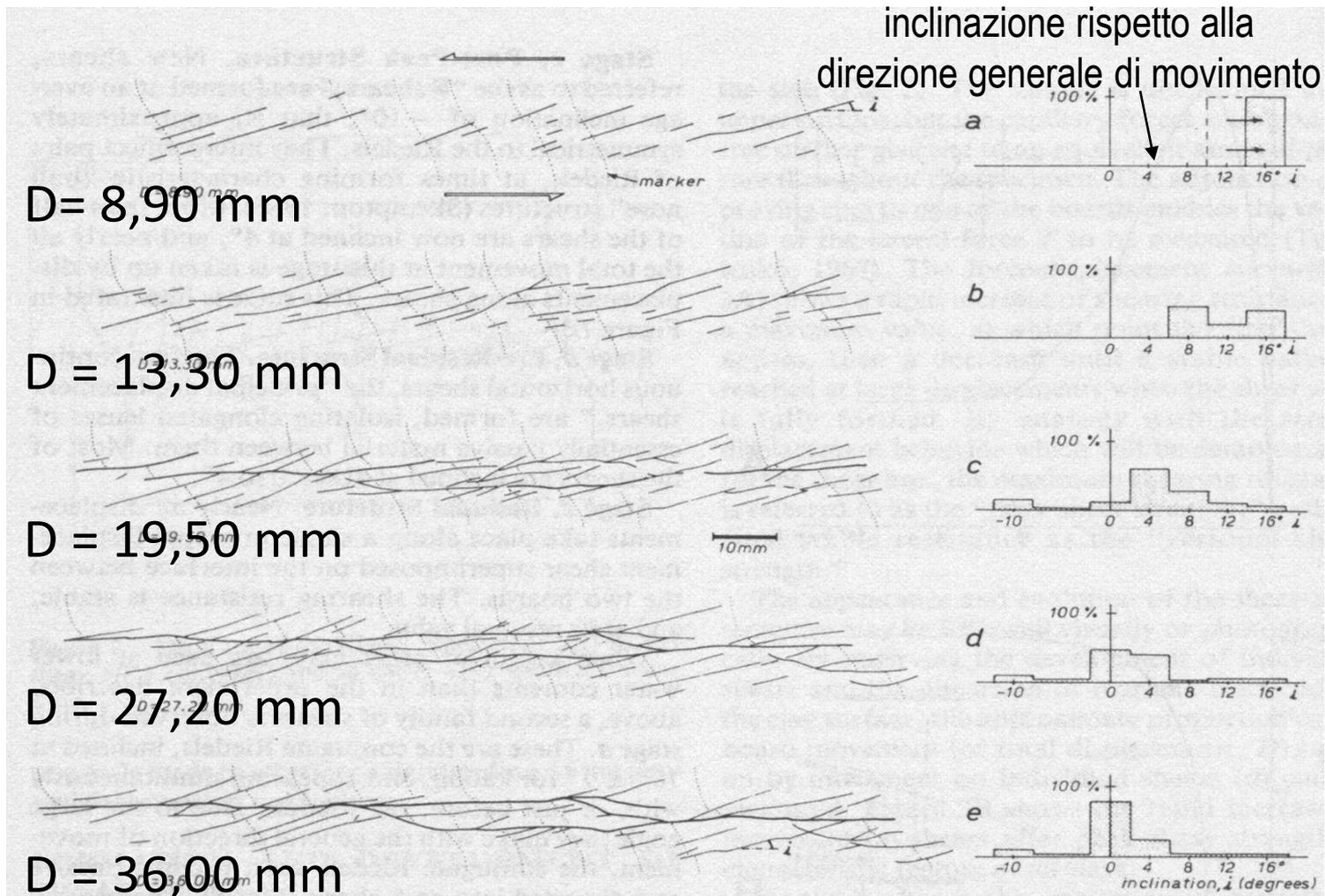
Scheme of a box-test with application of a stress field related to a **right strike-slip**.



Picture of a box-test: the effect of a **right strike-slip** can be analyzed in two different times of the deformation evolution.

# Strike-Slip Faults

## Evolution of the Riedel structures with the increasing horizontal throw $D$



# Strike-Slip Faults

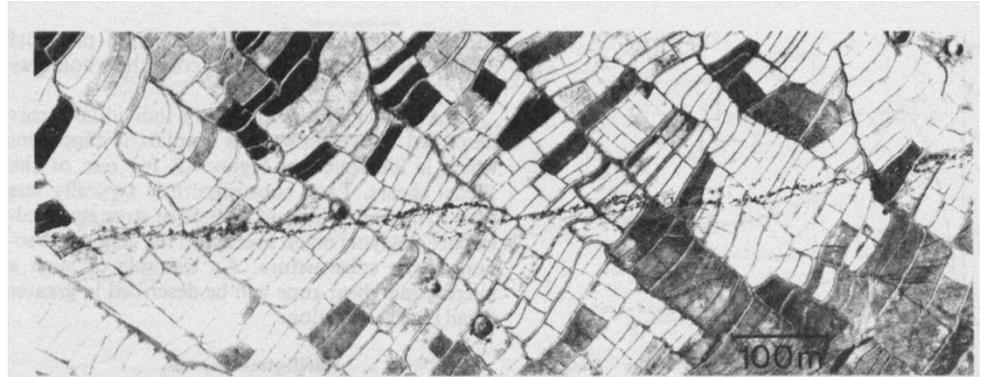
*Structures related to a strike-slip develop in a similar way at different scales.*

If  $D$  is the horizontal throw:

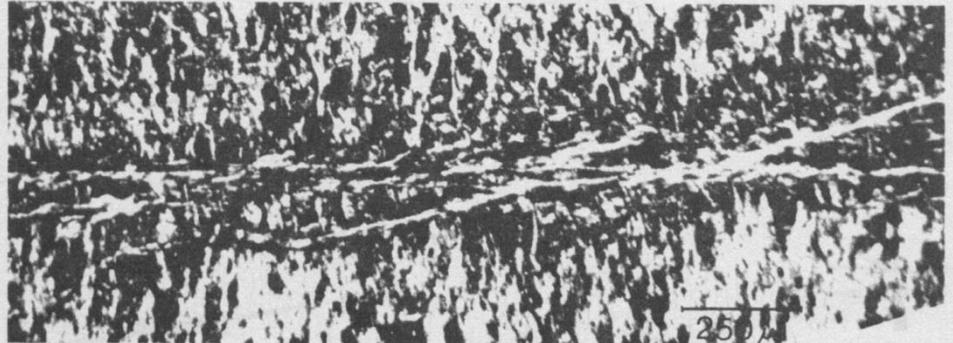
Es.: Seismic fault,  
aerial photo,  
 $D = 250$  cm

Es.: Shear Box test with kaolin,  
 $D = 8$  mm

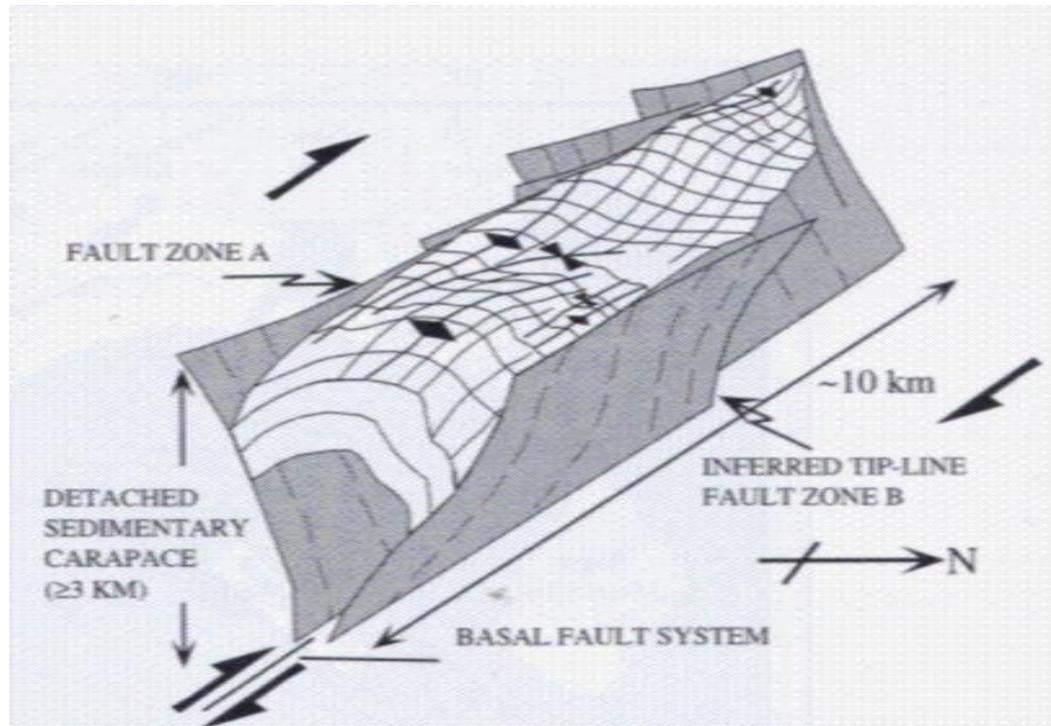
Es.: Shear Box test with kaolin,  
detail,  
 $D = 3$  mm



A



The outcropping SS faults are characterized by fracture systems, with a prevalent common direction arranged in an *en-echelon geometry*.

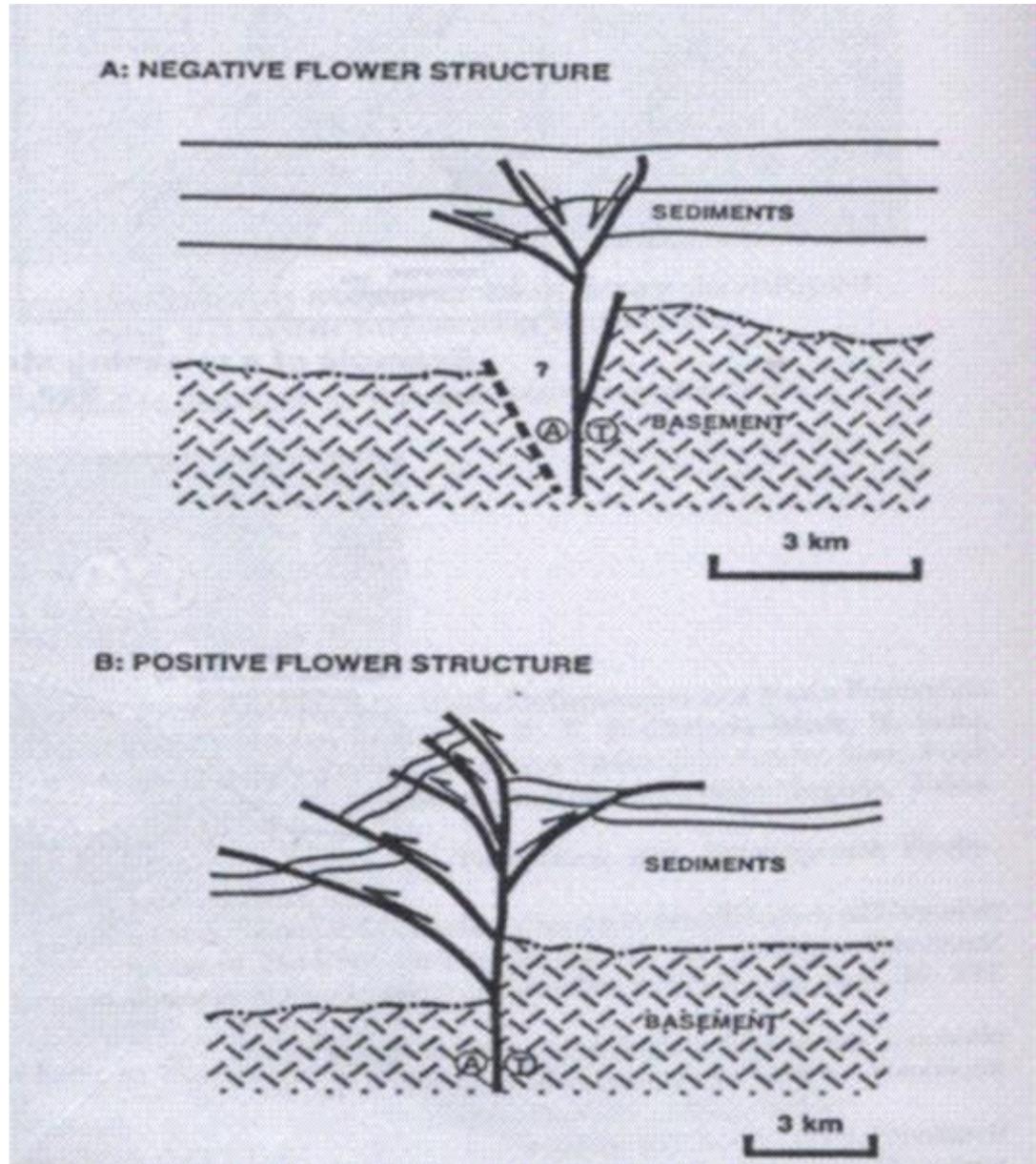


Along a seismic section these structures could be more or less complex, generally they tend to draw **flower structures**

The flower structures could be:

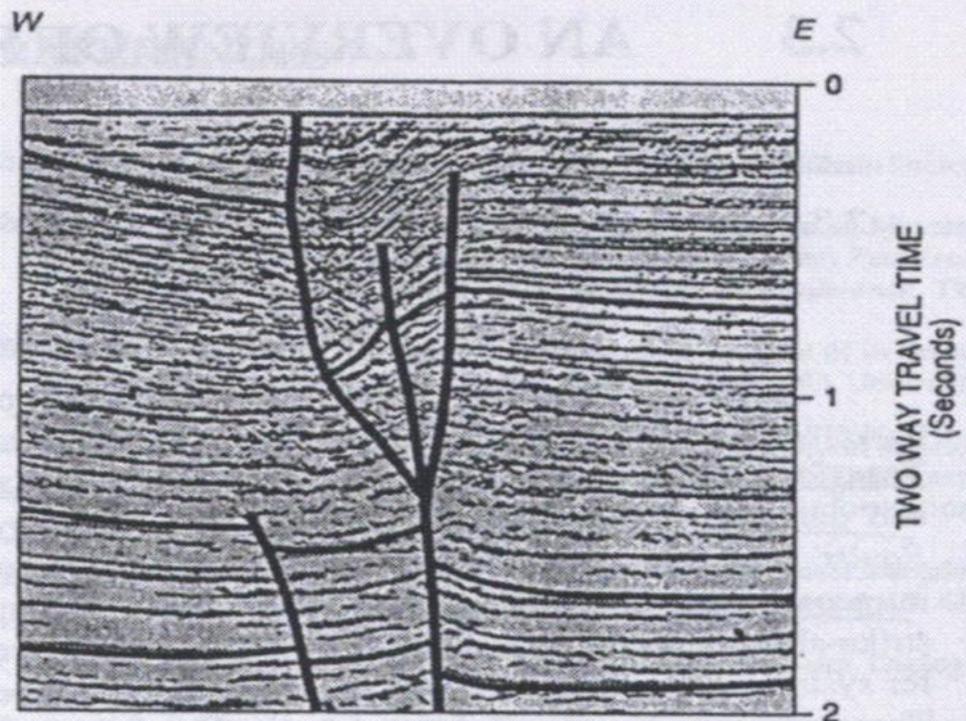
- negative when transtension is present,

- positive when traspression is present.

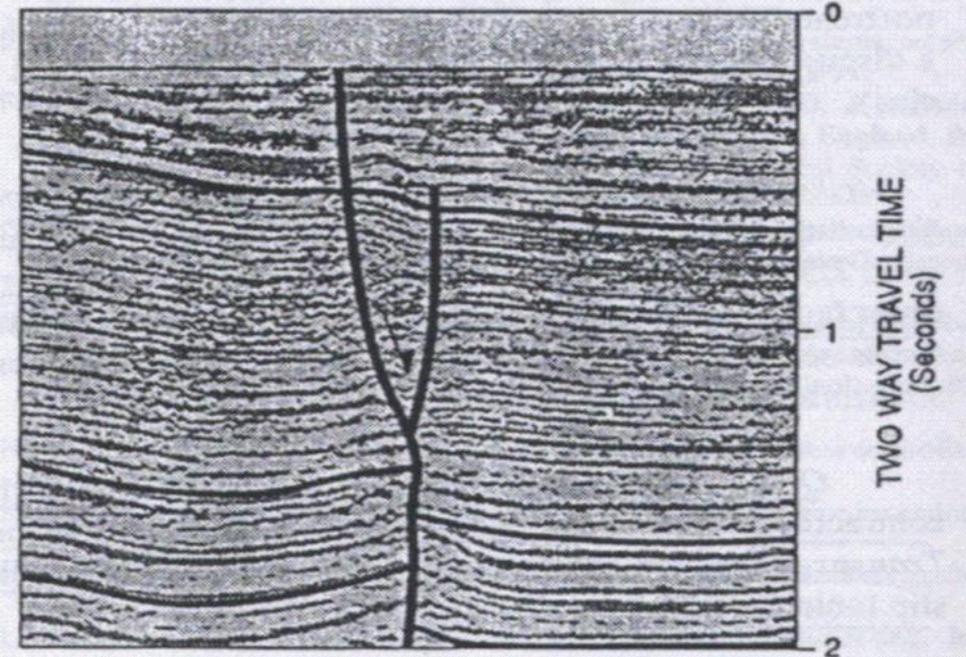


Examples along some seismic profiles crossing the same tectonic structure:

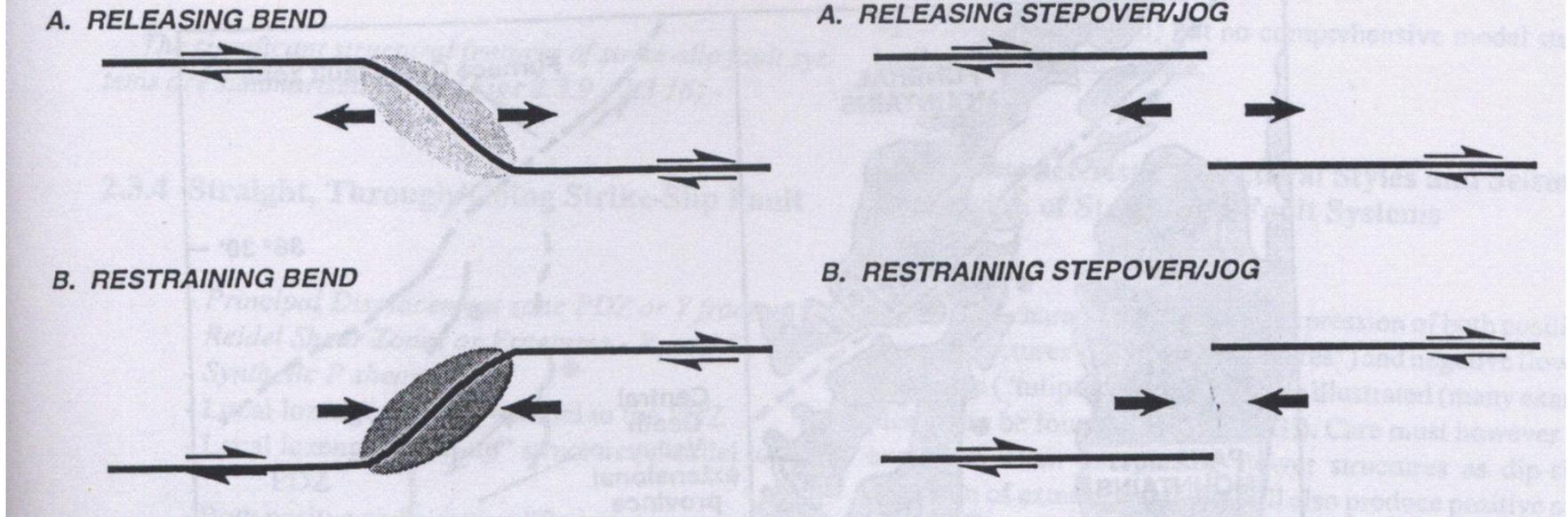
negative flower structure  
**transtension** →



positive  
flower structure  
**transpression** →



STRUCTURAL INTERPRETATION IN SEDIMENTARY BASINS



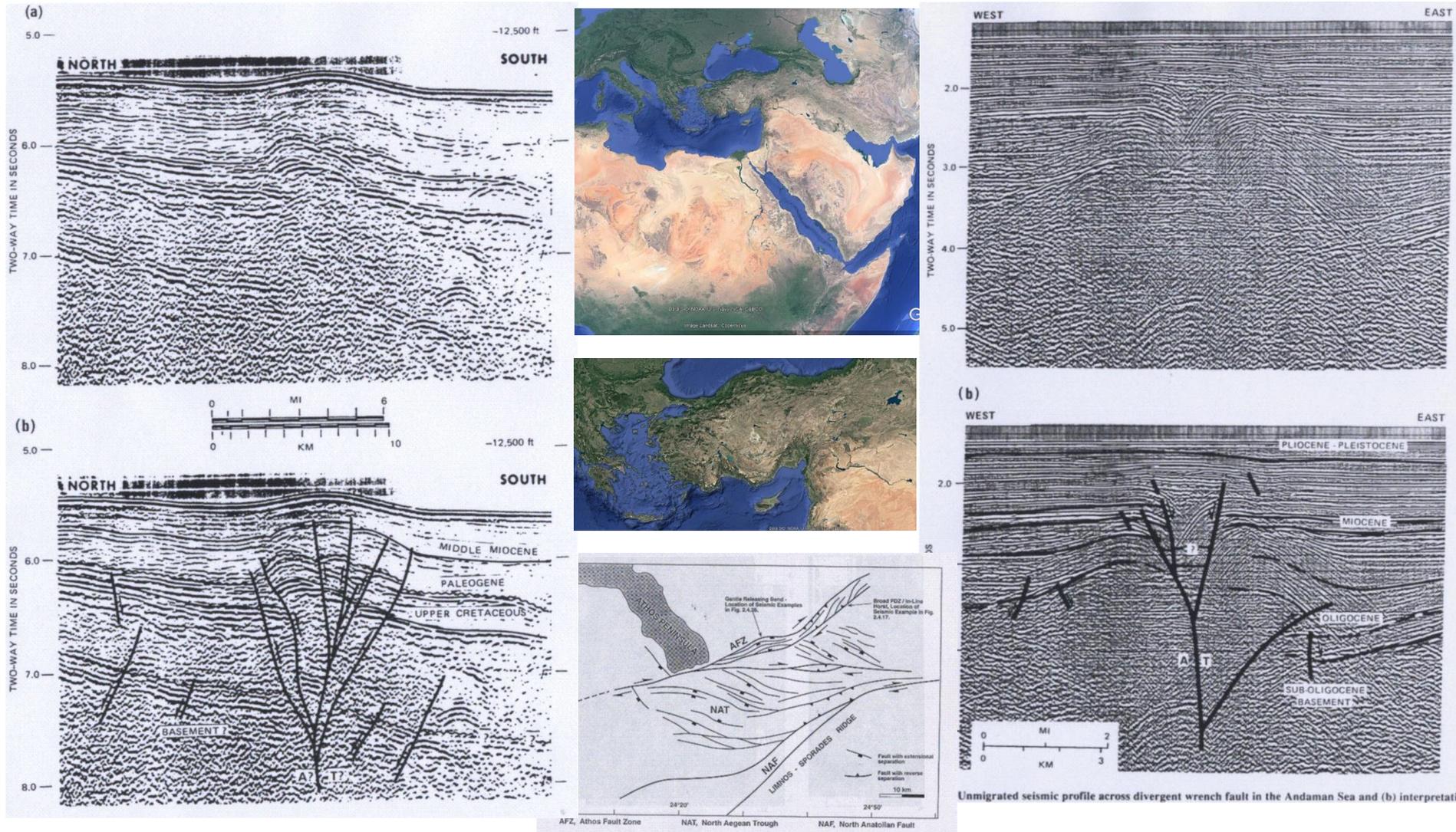
Different curvilinear shape of the SS fault:

- **Releasing Band** → possible extensional basins
- **Restraining Band**, → possible folds and *thrusts*

Similar structures may also developed with segmented faults and *en-echelon eometries*.

The shallow faults converge in a deep, single, sub-vertical fault.

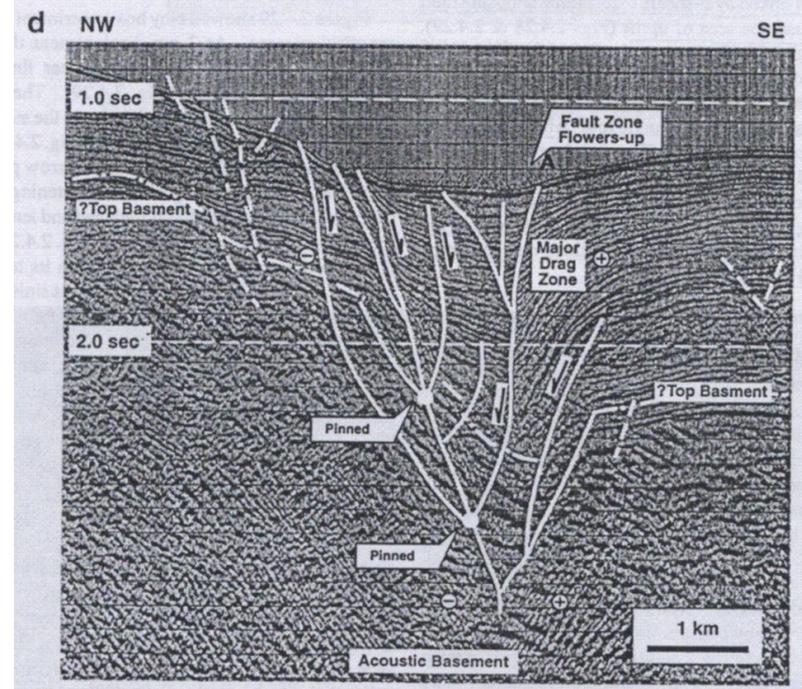
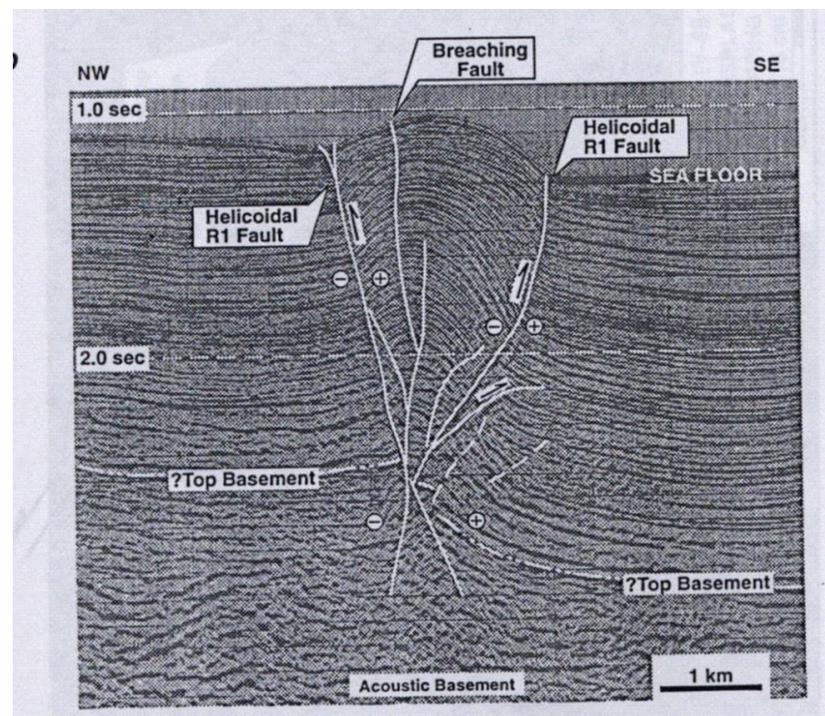
# Example of flower structures along a stack profile in the Aegean Sea, western prosecution of the North-Anatolian SS fault



# North-Anatolian System:

transpression evidence →

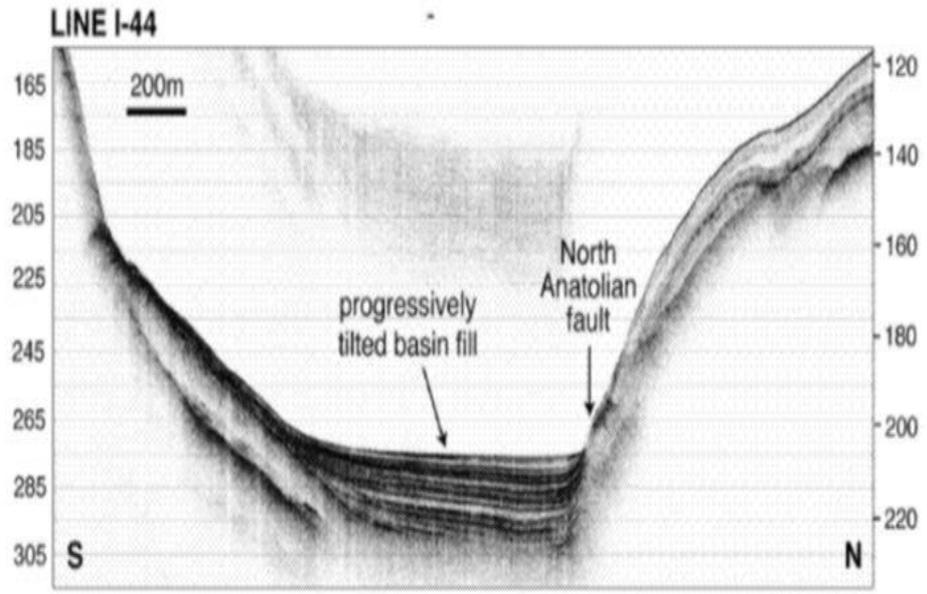
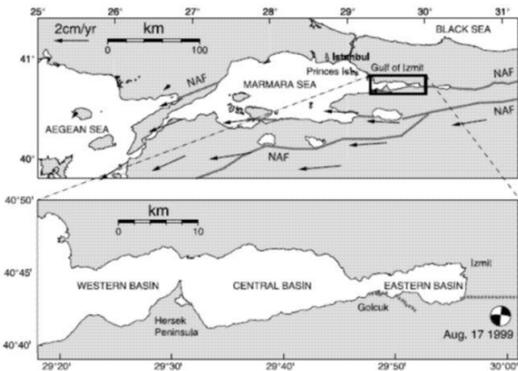
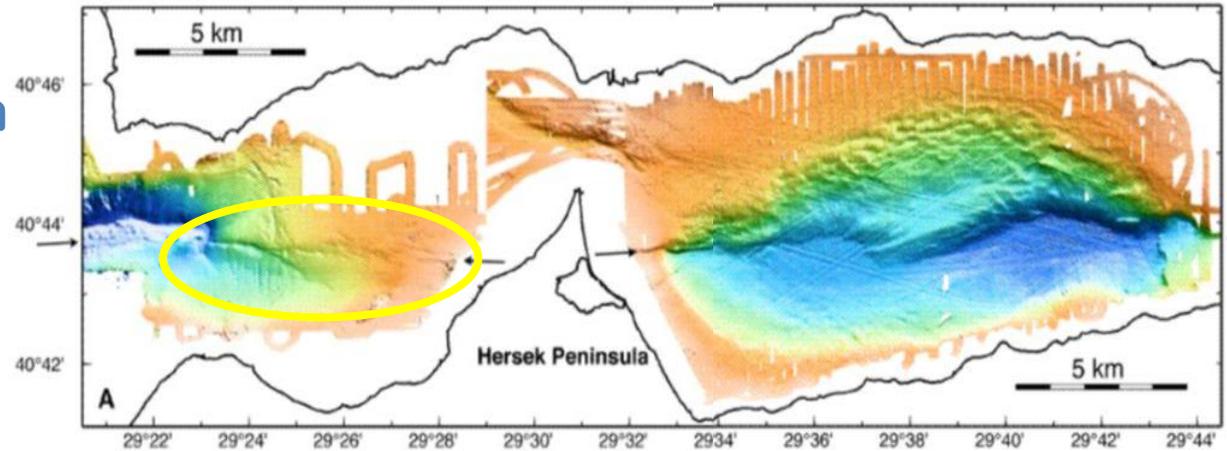
transtension evidence →



# Example of regional SS

## North-Anatolian System

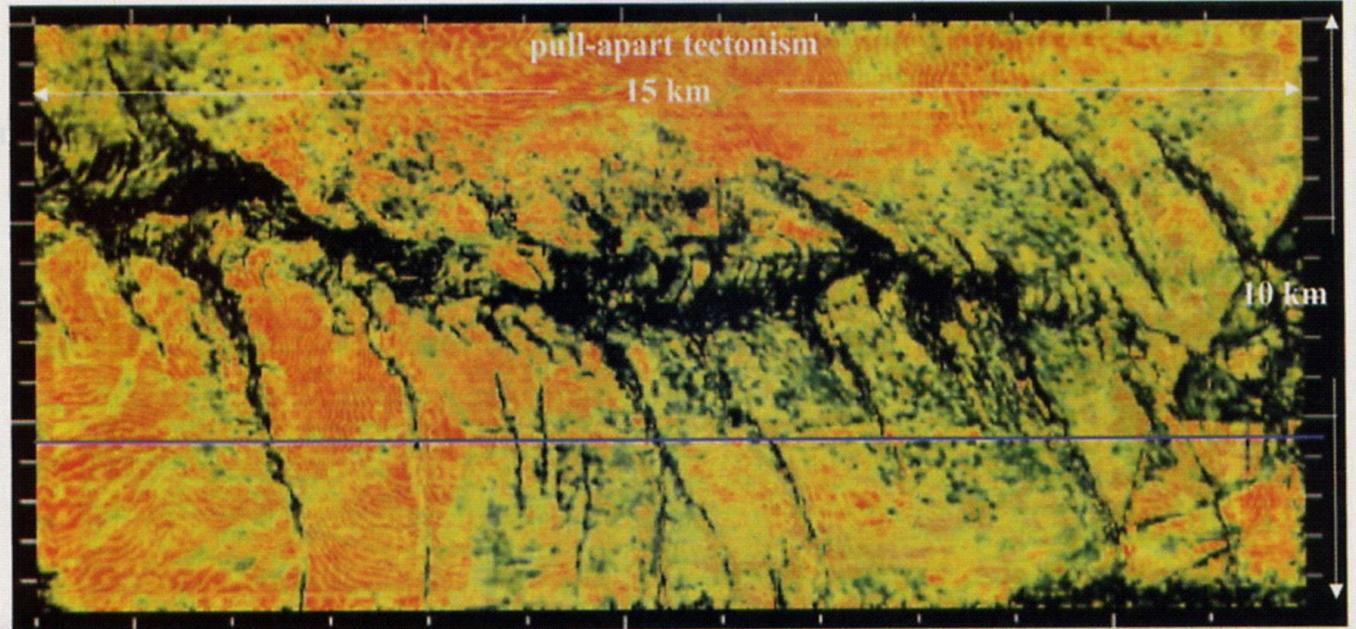
## Gulf of Izmit



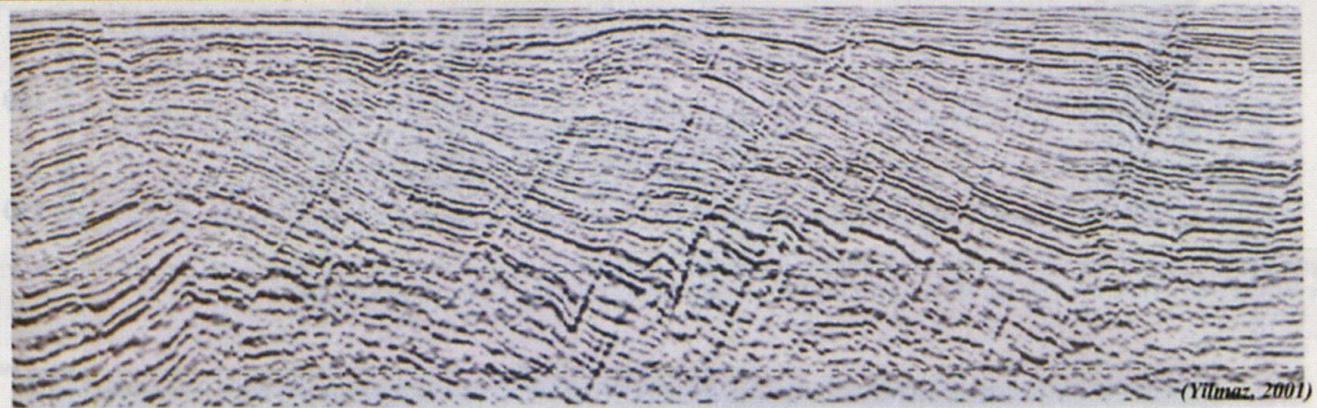
*Multibeam*: it evidences the *en-echelon* faults which cut the sea bottom.  
*CHIRP* profile: it evidences *growth strata*  
 Shallow growth stratum depicts the recent deformation and tectonic activity.

# Regional Strike-slip and related *Riedel* structures

*Time  
slice*

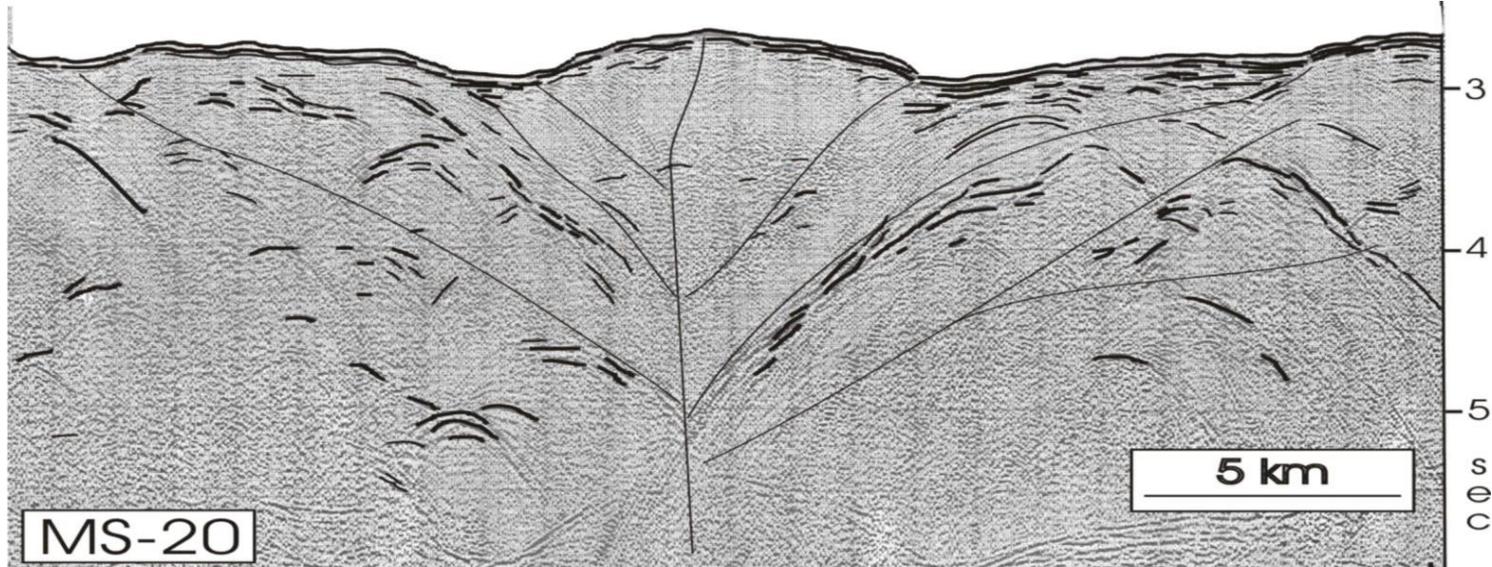


**Seismic  
profile**

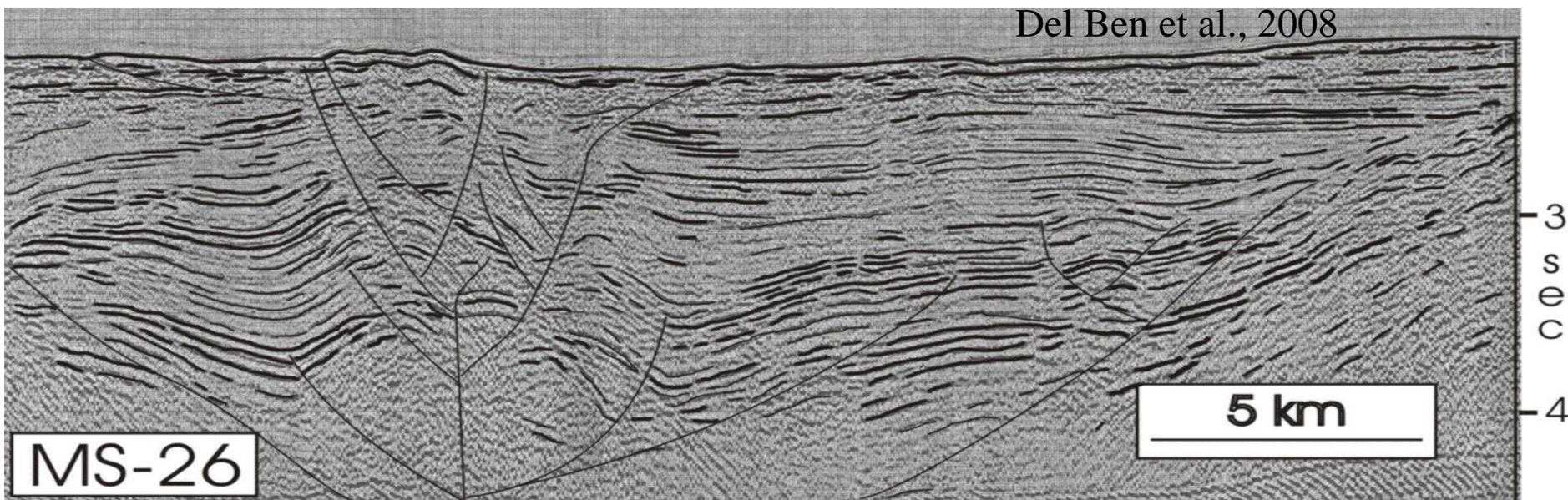


(Yilmaz, 2001)

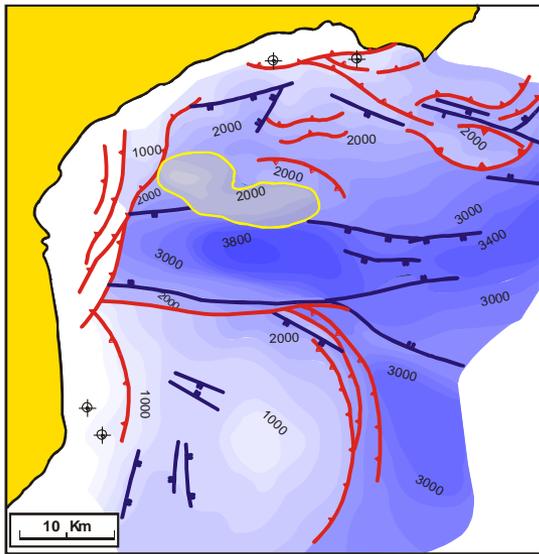
SS in the  
Calabrian Arc:  
transpression



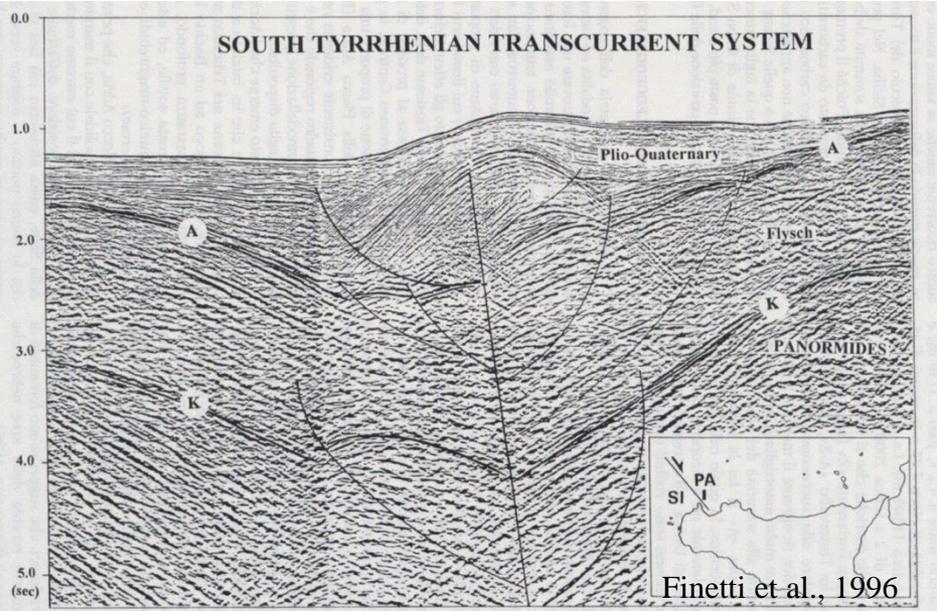
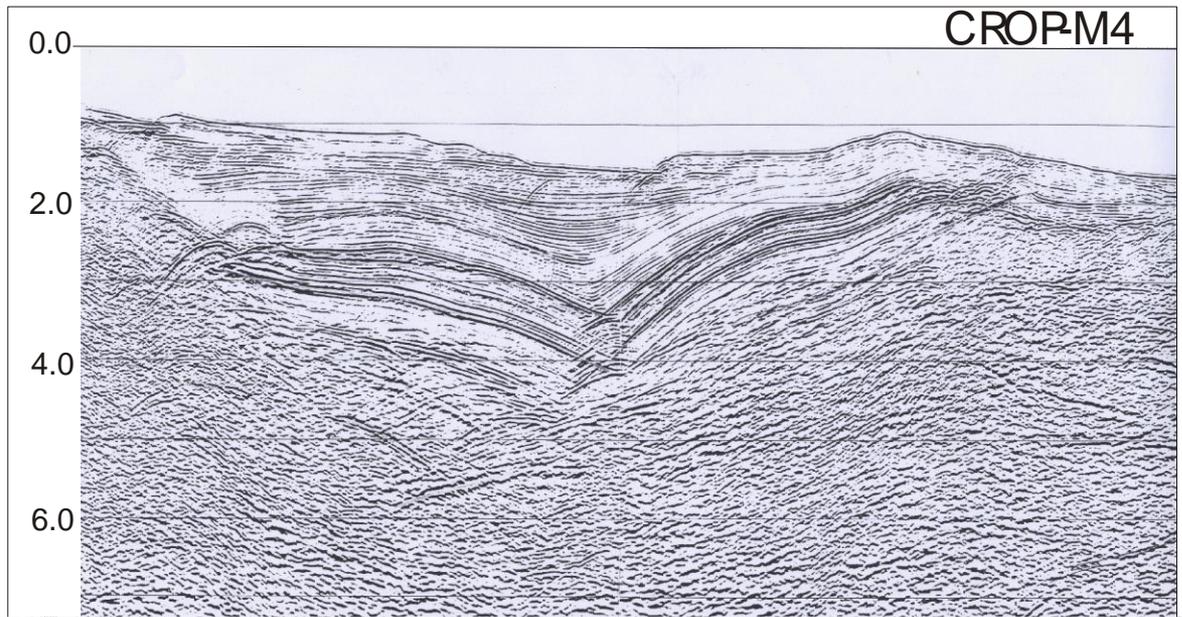
Del Ben et al., 2008



SS in the Calabrian Arc: recent/active transpression (positive flower deforms the sea bottom), following an older transtension (deeper negative flower)

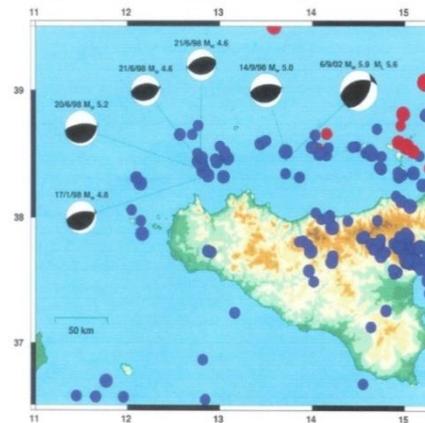


Calabrian Arc: transtension →



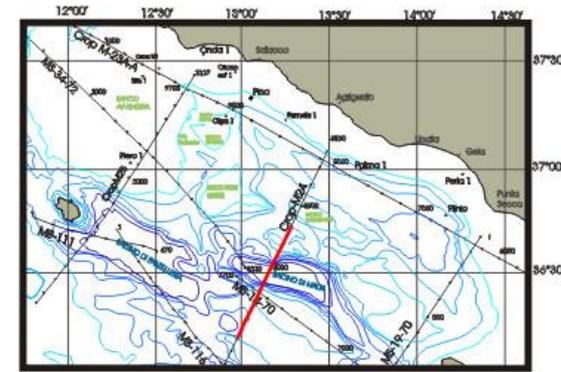
← SS in the south Tyrrhenian Sea:  
active transpression (?!).

The focal mechanism  
evidence a regional  
compressive regime  
after a prevalent  
SS tectonics



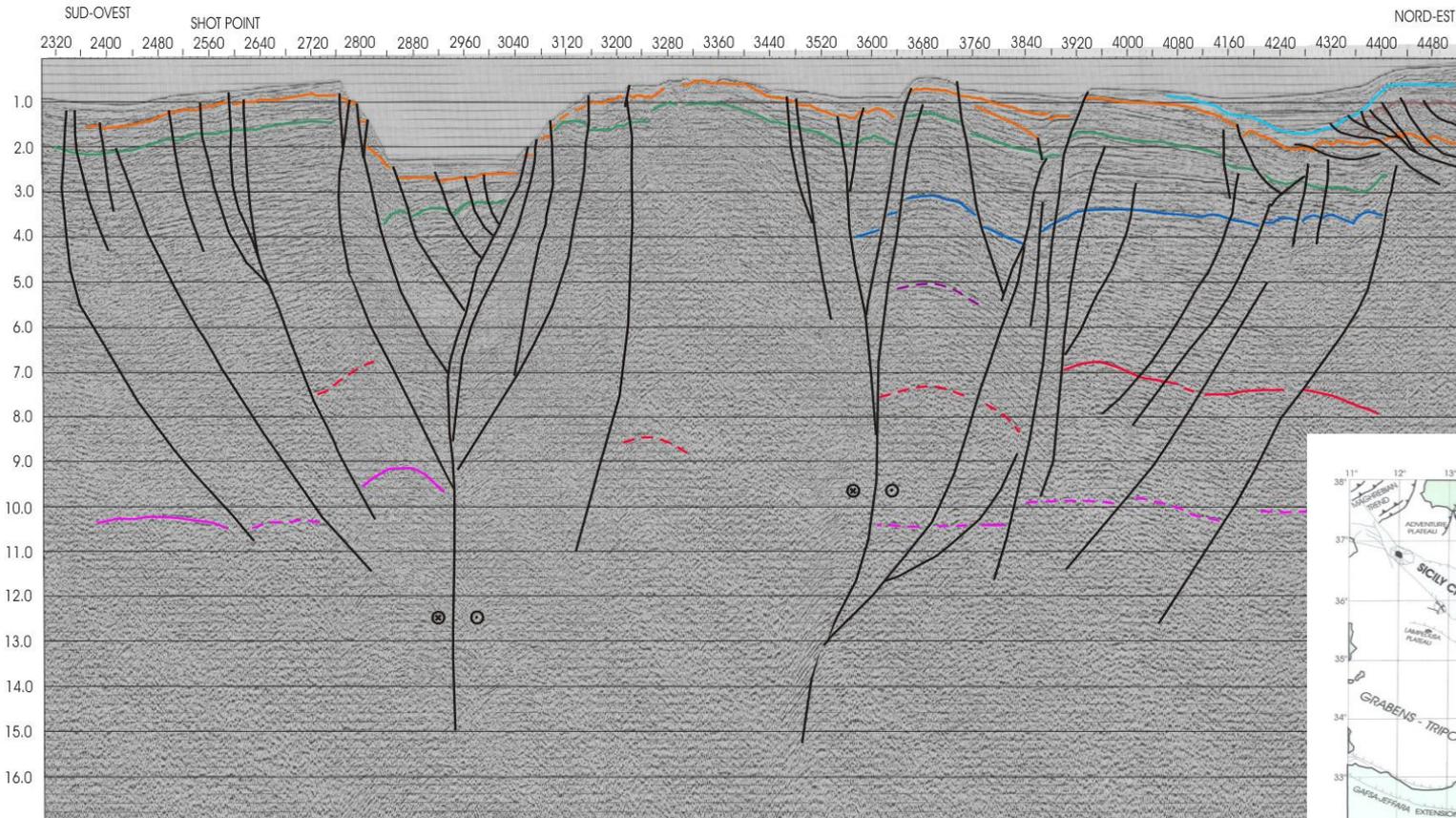
# Right SS System in the Sicily Channel: example of regional transtension

SEZIONE SISMICA CROP M 24 S.P. 2320-4480



GRABEN DI MALTA

FALDA DI GELA



Top Middle Pliocene  
Ms

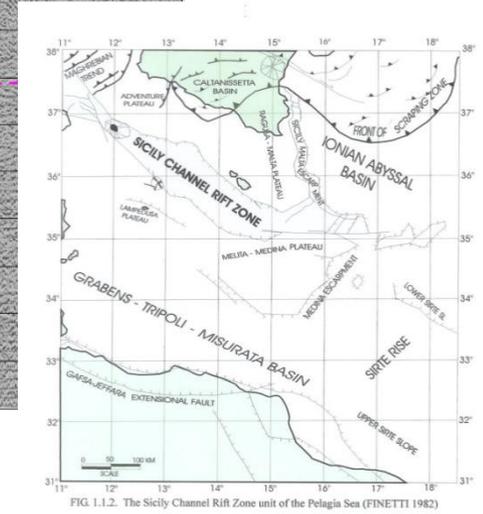
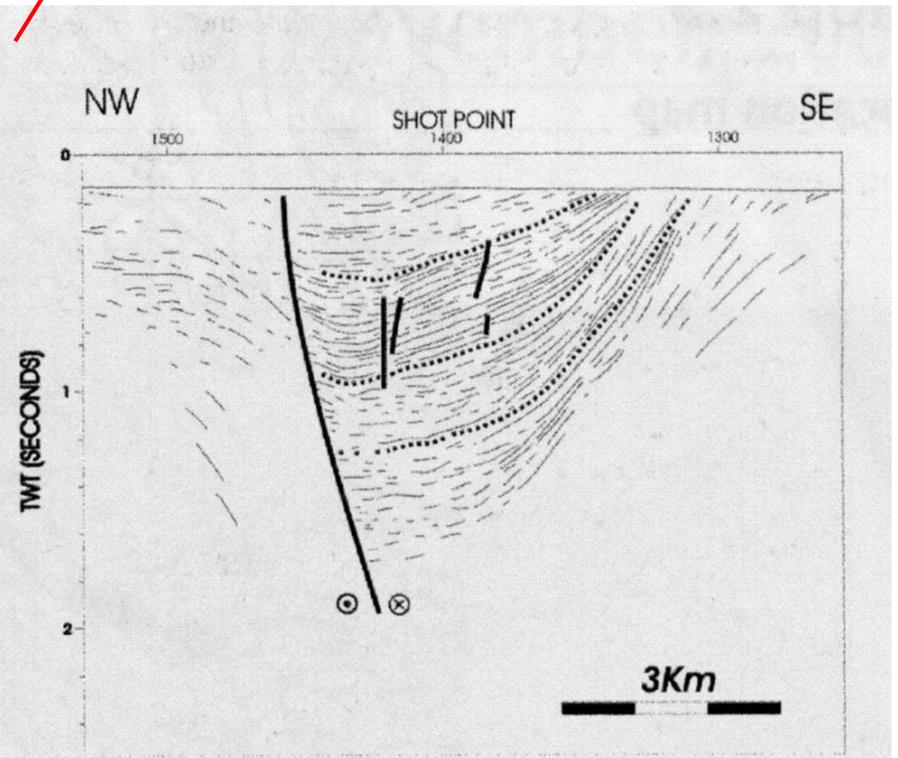
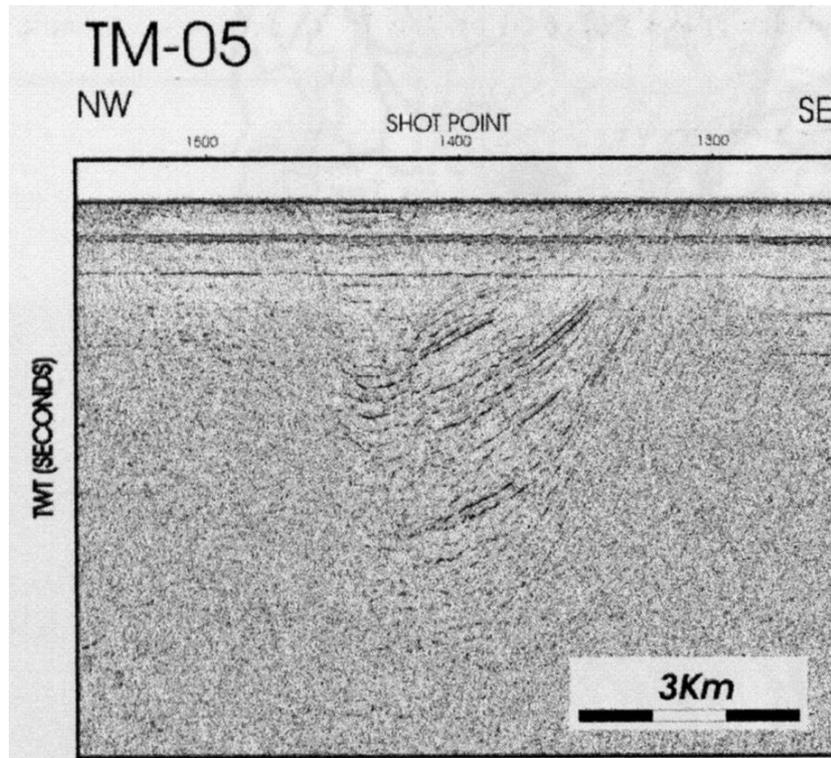
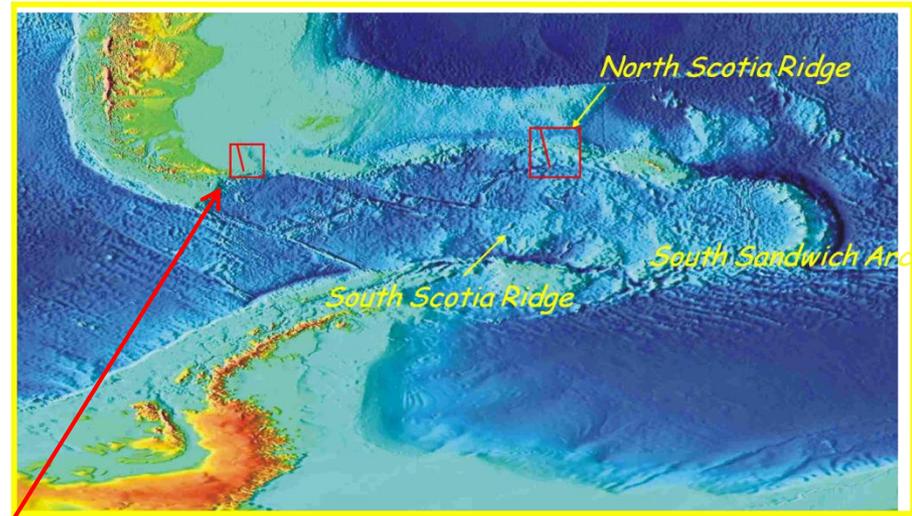


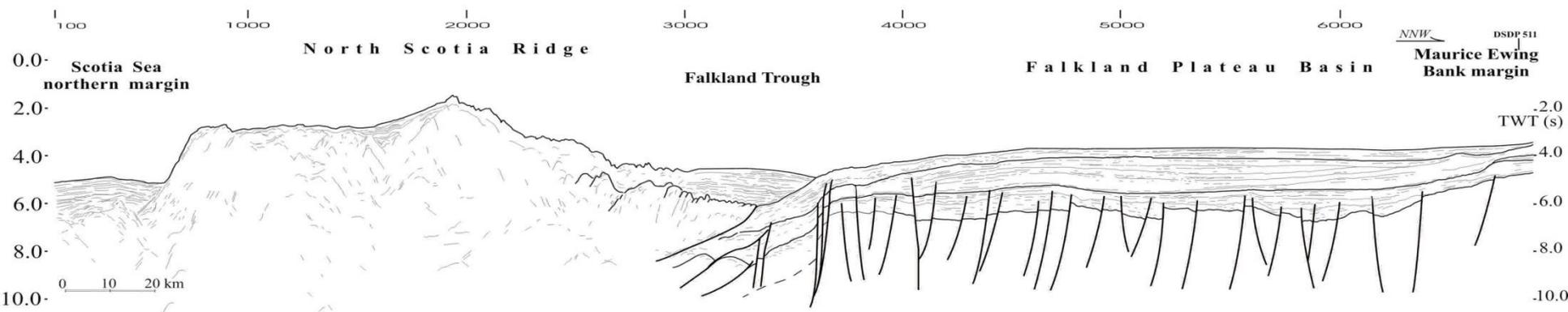
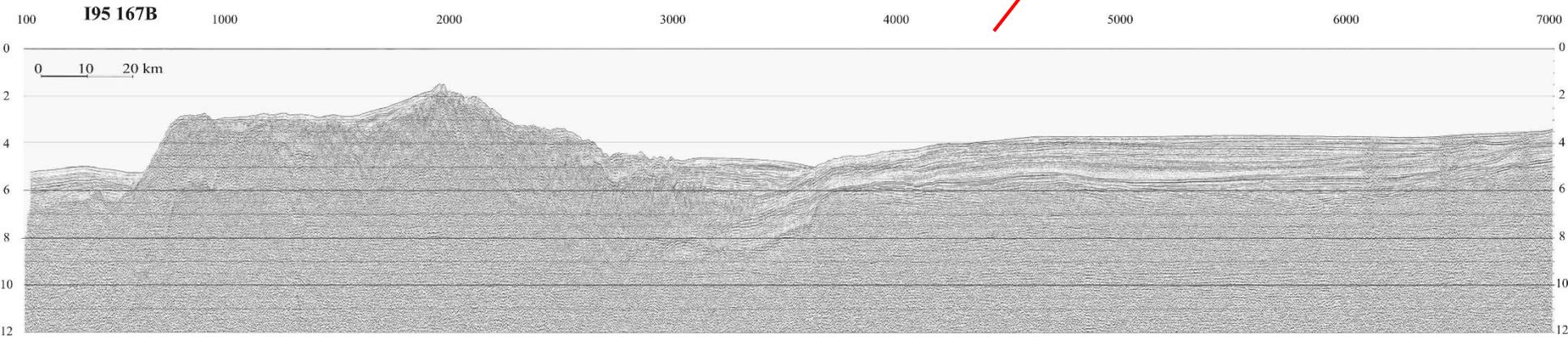
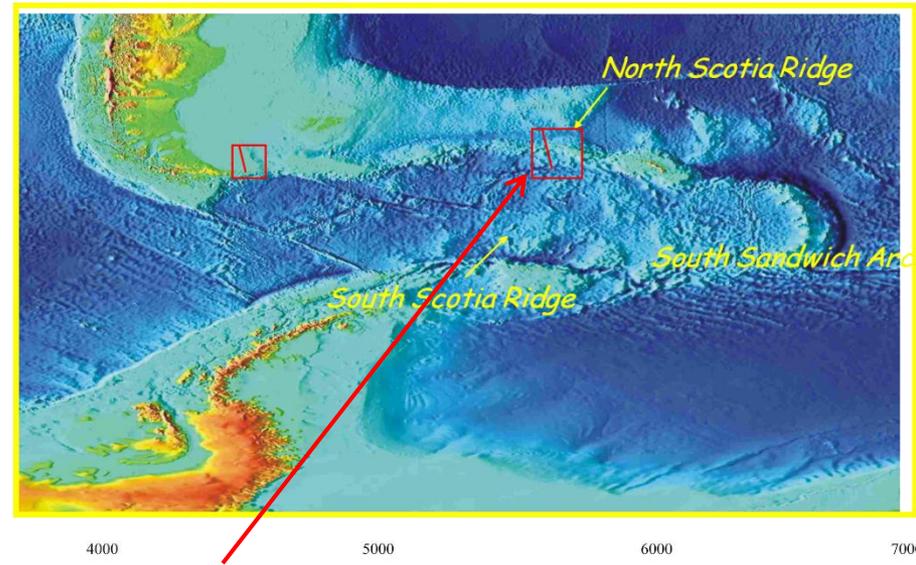
FIG. 1.1.2. The Sicily Channel Rift Zone unit of the Pelagia Sea (FINETTI 1982)



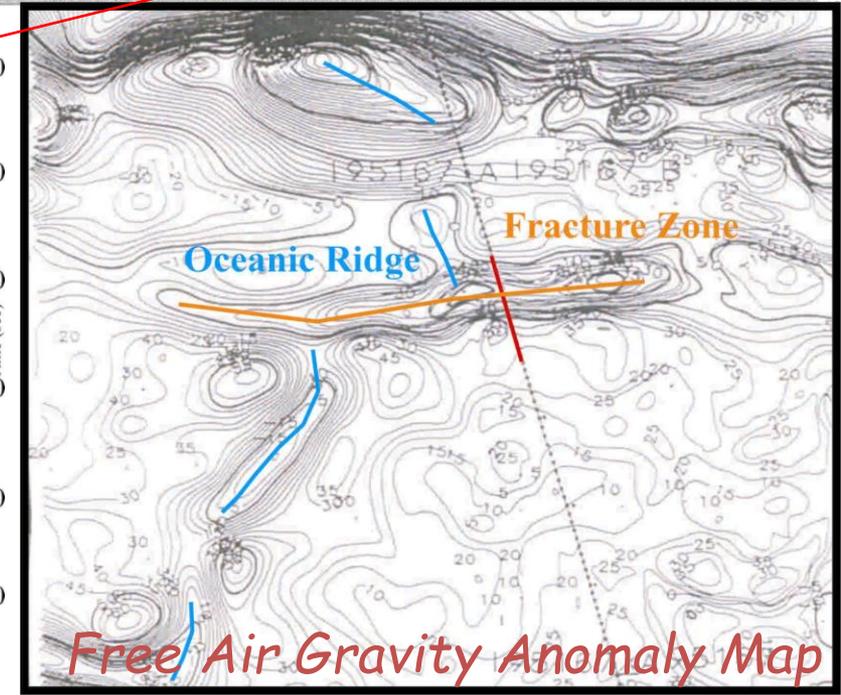
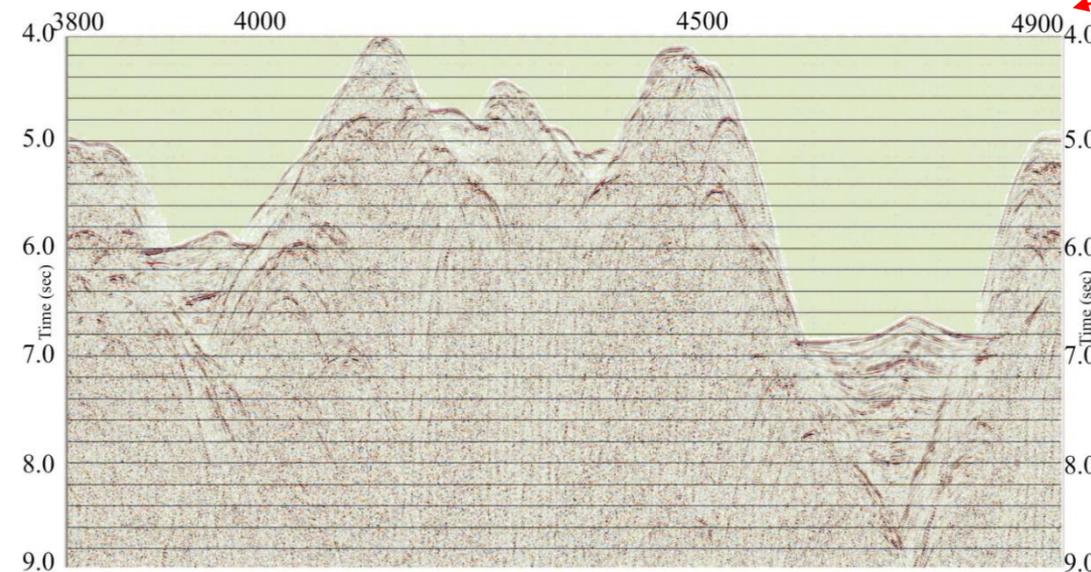
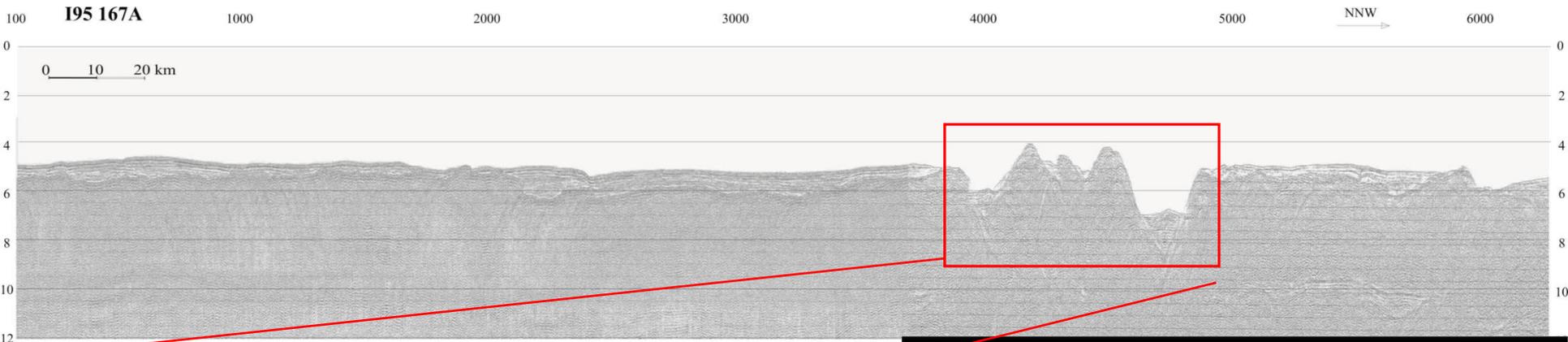
Trasforme sinistra del  
*North Scotia Ridge*  
in cui si ipotizza  
tettonica di transtensione:  
evidenze sismiche



# Trasforme sinistra del North Scotia Ridge: evidenze sismiche di transpressione

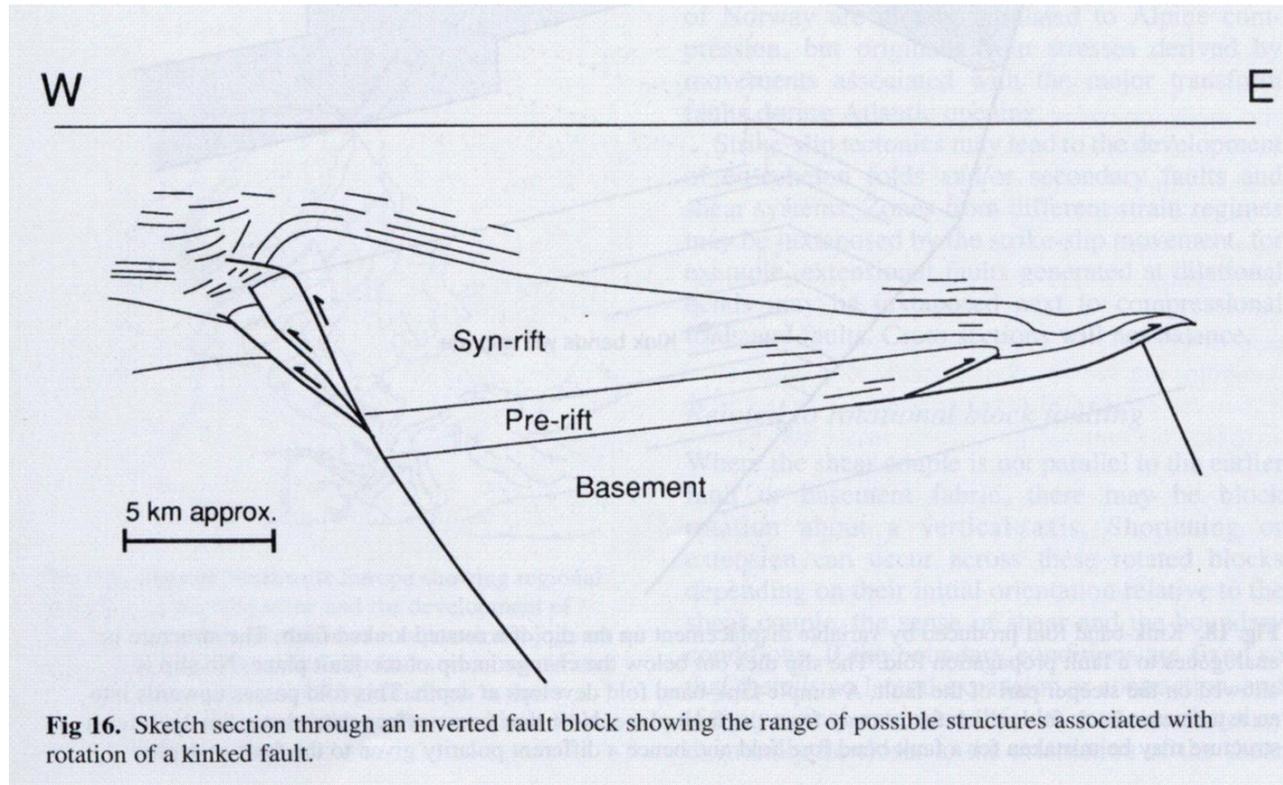


# Trasforme trasversale al *ridge* non più attivo nella Placca dello *Scotia Sea*



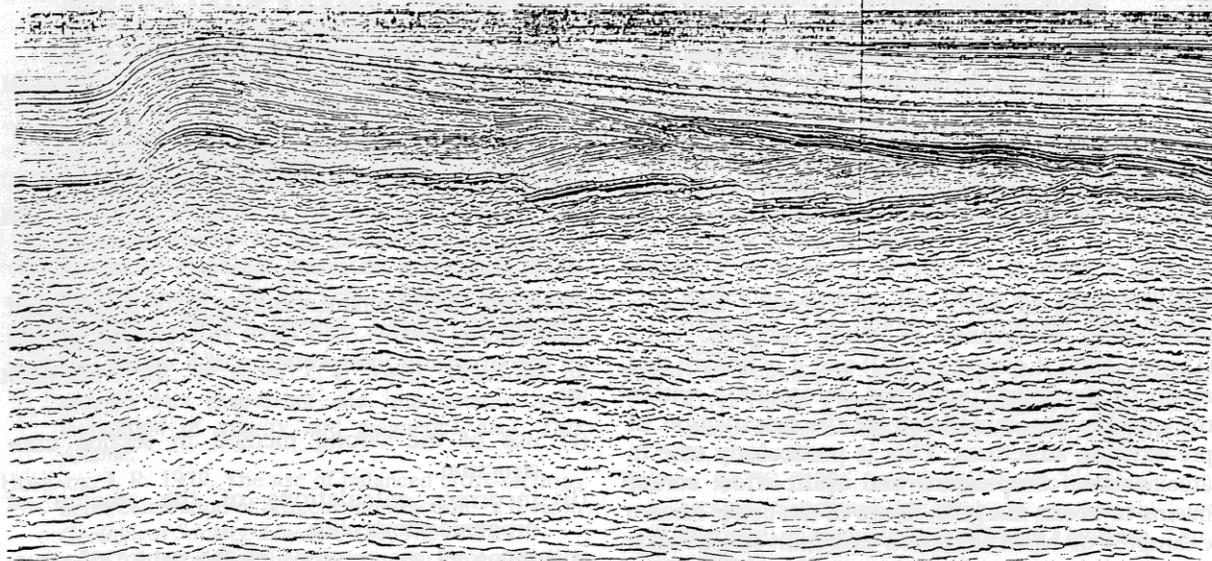
# **INVERSION TECTONICS**

# Inversione tettonica

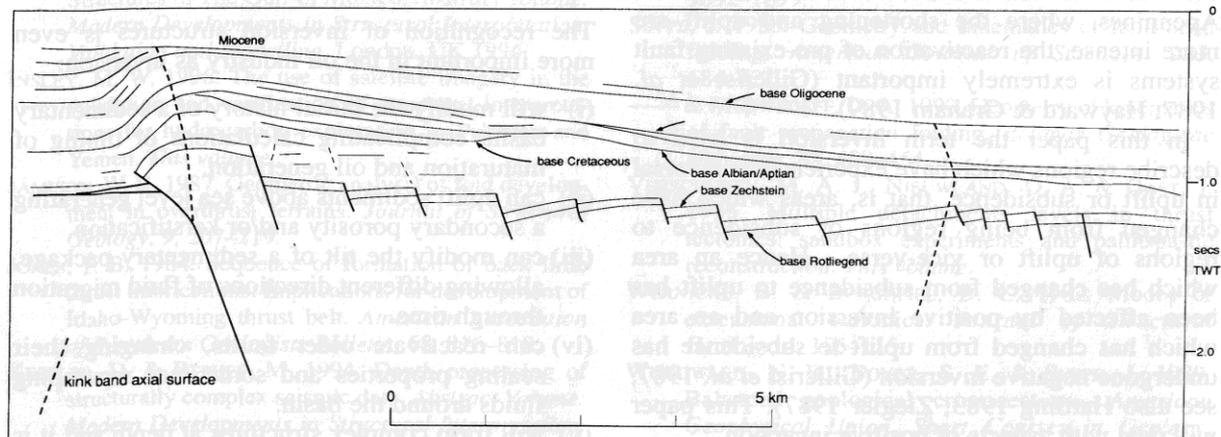


Il concetto di inversione tettonica prevede la riattivazione di

- una faglia distensiva attraverso una deformazione compressiva: si parla in tal caso di Inversione Tettonica Positiva (es. in figura)
- o di una faglia compressiva attraverso una deformazione distensiva: si parla in tal caso di Inversione Tettonica Negativa



(b) **es. di Inversione Tettonica Positiva** W E



**Fig. 1.** An example of a fold produced by rotational faulting from the southern part of the North Sea. (a) Uninterpreted seismic data. (b) Line drawing showing the major stratigraphic picks. Note the long, gently-dipping back limb and the short hooked forelimb. (From the South Hewett Fault Zone. Drawn from Badley *et al.* 1989).

Le situazioni in cui più facilmente si hanno Inversioni Tettoniche sono:

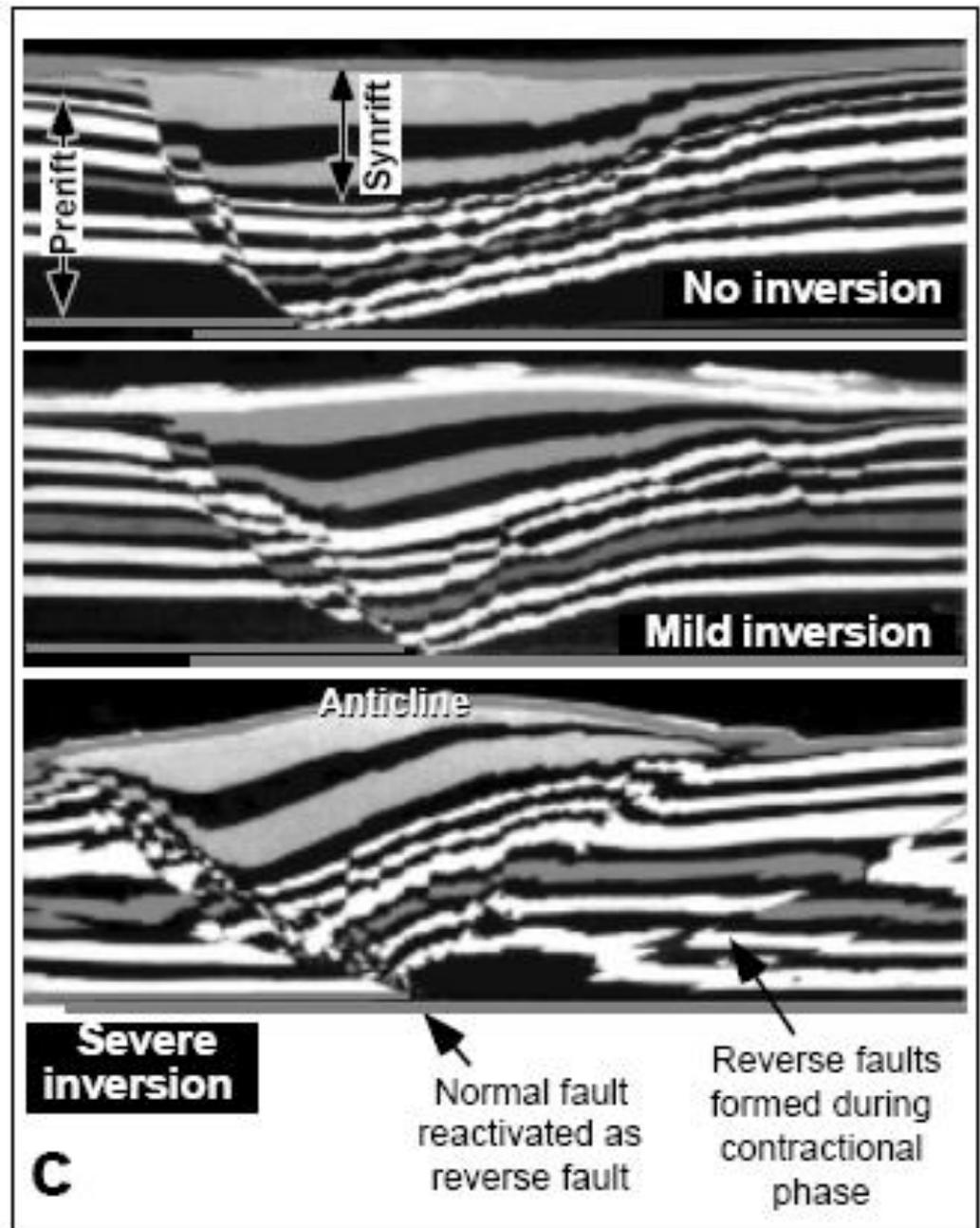
-Variazione del campo di sforzi in seguito a variazione del moto delle placche; →

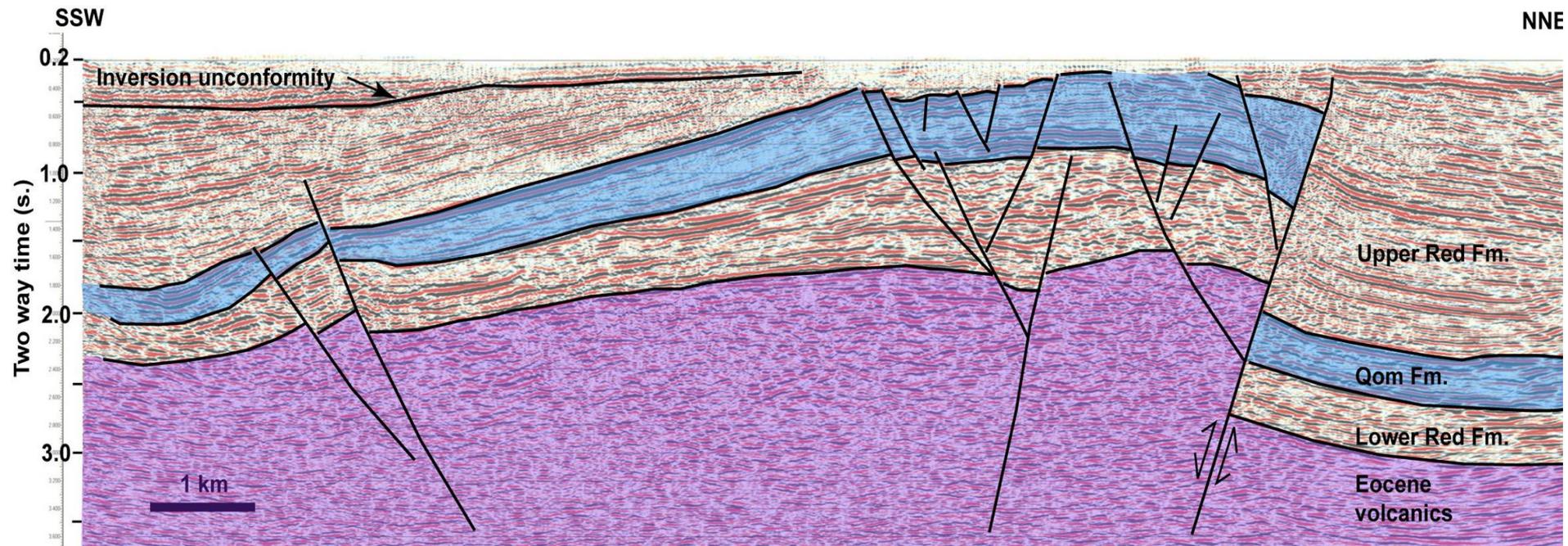
-Inversione derivante da subduzione (faglie distensive dell'avampaese invertite in compressione quando l'avampaese venga coinvolto nelle compressioni);

-Inversione derivante da sollevamento isostatico;

-Inversione dovuta ad halocinesi;

-Inversione dovuta a *slumping*.





Normal fault activity during deposition of the Lower Red and Qom Formations. Numerous secondary normal faults are present.

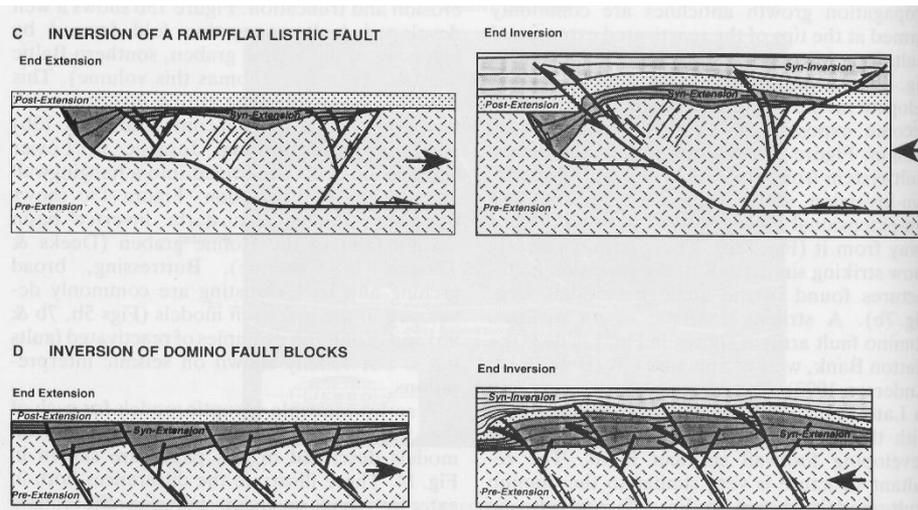
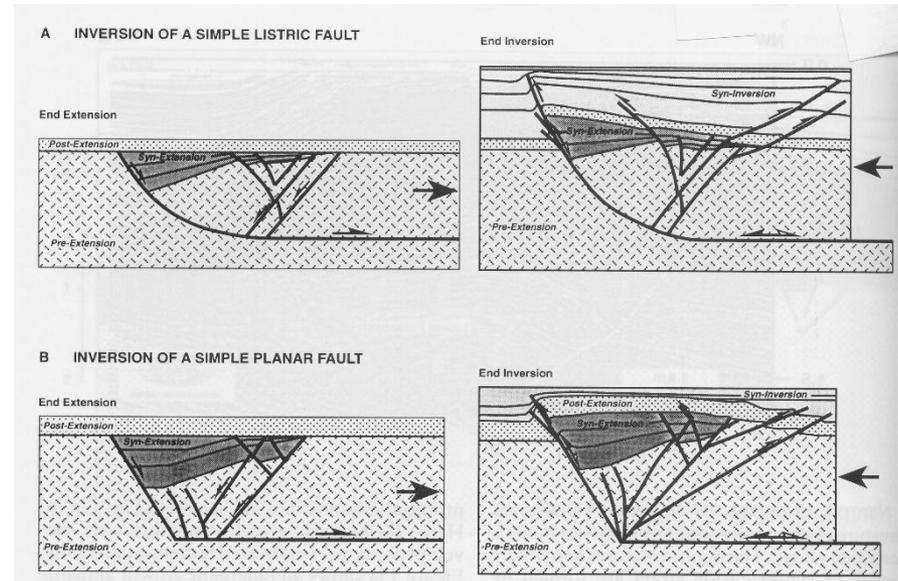
Inversion during deposition of the Upper Red Formation is clearly marked by a shallow angular unconformity present in the southern half of the seismic line.

Image from Morley et al. (2009)

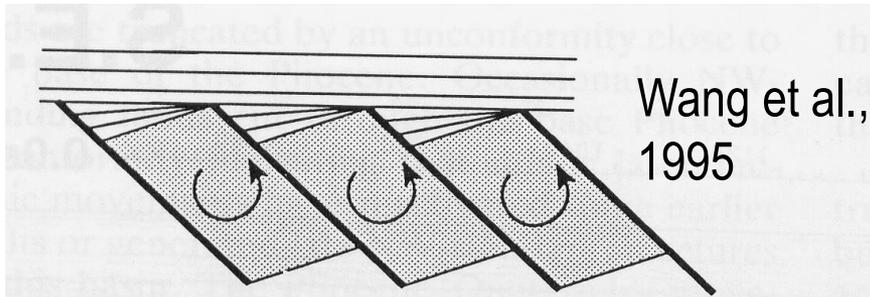
Structural development of a major Late Cenozoic basin and transpressional belt in Central Iran: the Central Basin in the Qom-Saveh area.

Virtual Seismic Atlas: [www.seismicatlas.org](http://www.seismicatlas.org)

Le geometrie prodotte dall'Inversione Tettonica dipendono direttamente dalle geometrie relative alla fase tettonica precedente

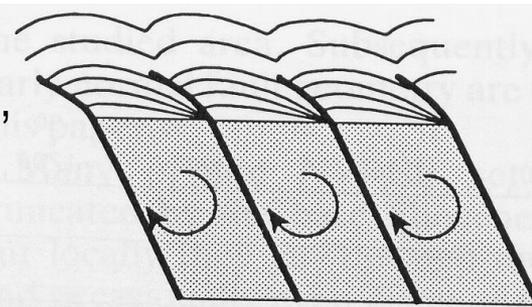


In letteratura l'inversione positiva prevale su quella negativa: ciò sarebbe dovuto, almeno in parte, alla migliore possibilità di riconoscimento di inversione positiva lungo i profili sismici.



***Rifting: Block Rotation***

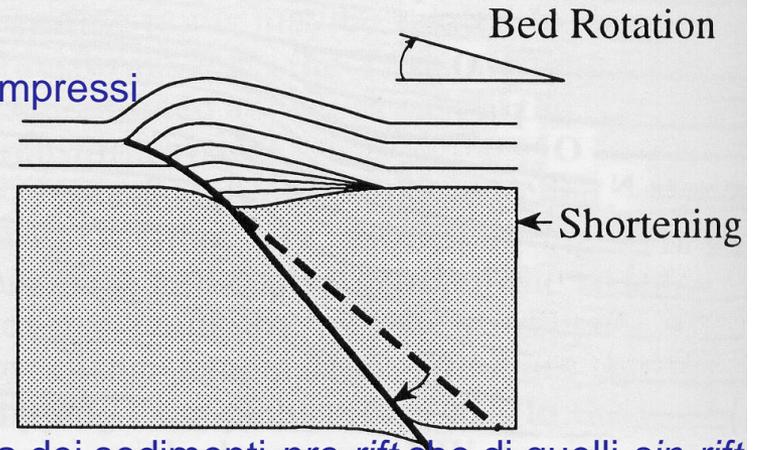
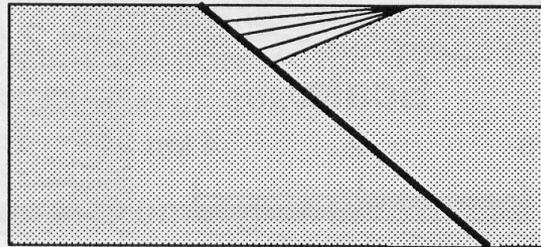
Pre-rift: block rotation and extension  
Syn-rift: growth sedimentation



***Inversion: Back Rotation***

Pre-rift: reverse block rotation & contraction  
Syn-rift: folding

Durante la *back-rotation* i sedimenti *sin-rift* saranno compressi in una serie di pieghe e faglie compressive.



Rotazione dell' *hangingwall*: comporta deformazione sia dei sedimenti *pre-rift* che di quelli *sin-rift*.

***Rifting***

Pre-rift: extension  
Syn-rift: growth sedimentation

Wang et al., 1995

***Inversion: Fault Block Flexural Cantilever***

Pre-rift: contraction & cantilever flexure  
Syn-rift: folding and rotation

# Ipotesi di inversione tettonica nell'avampaese Apulo

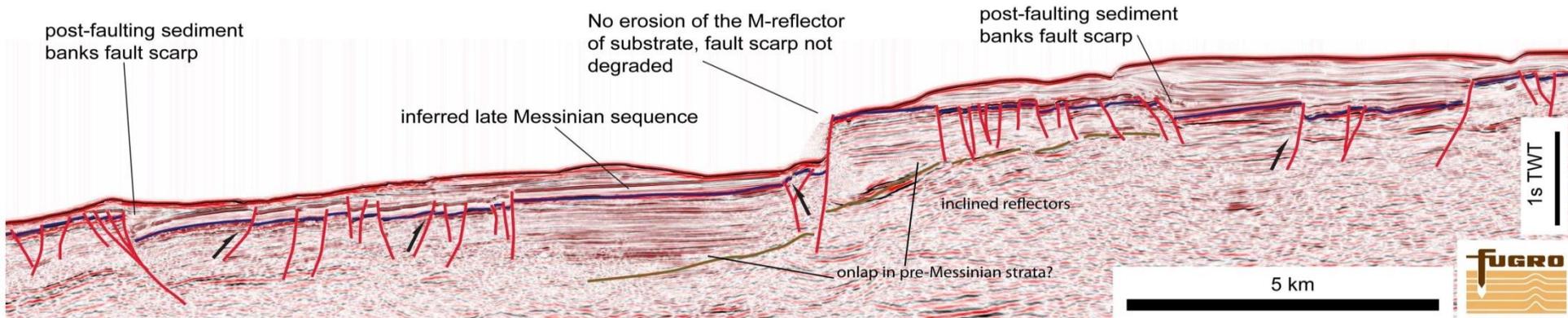
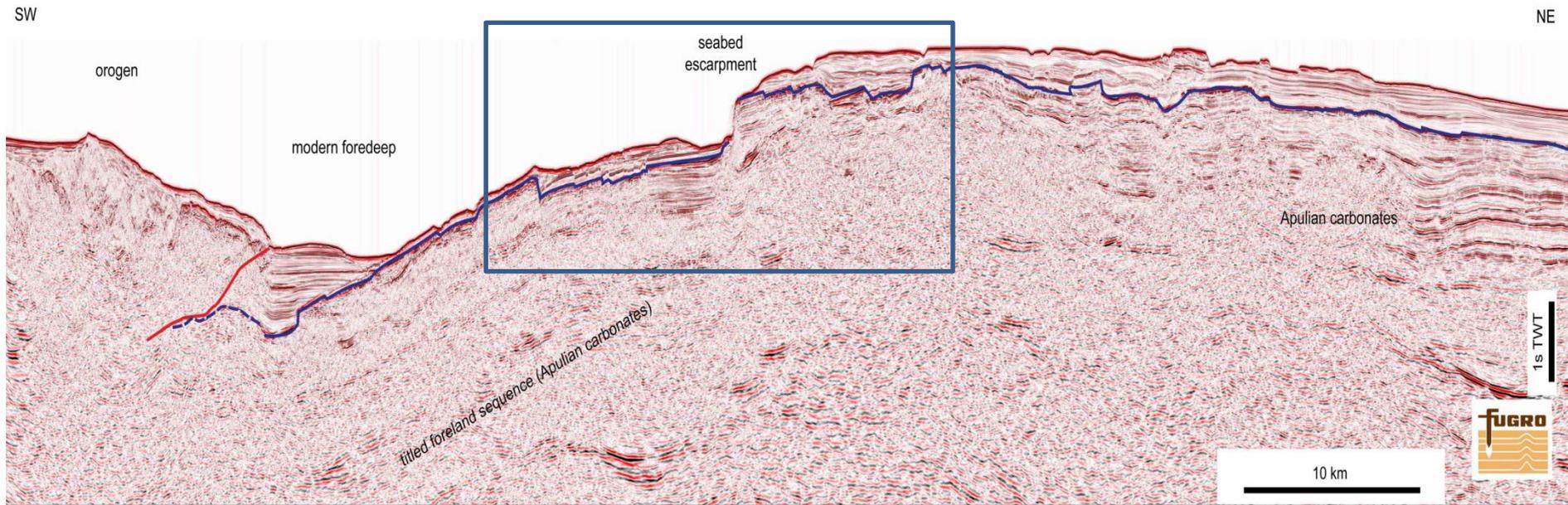
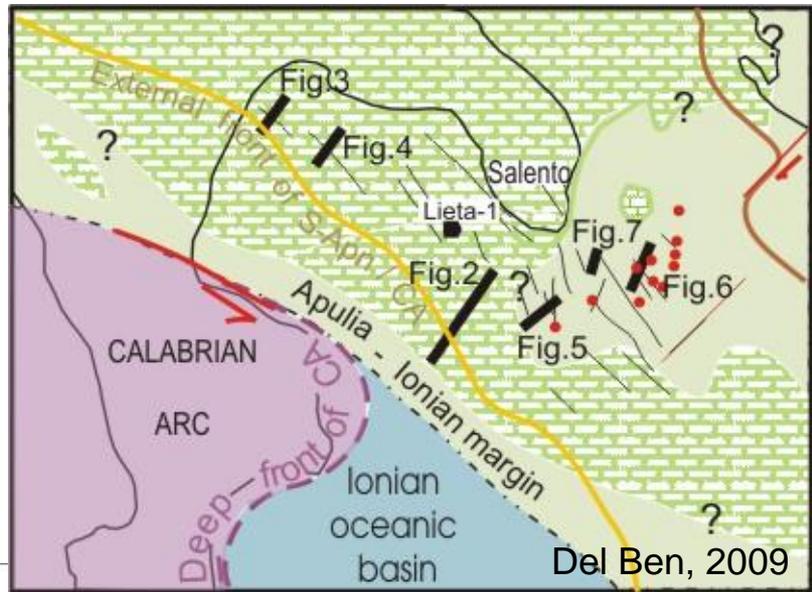
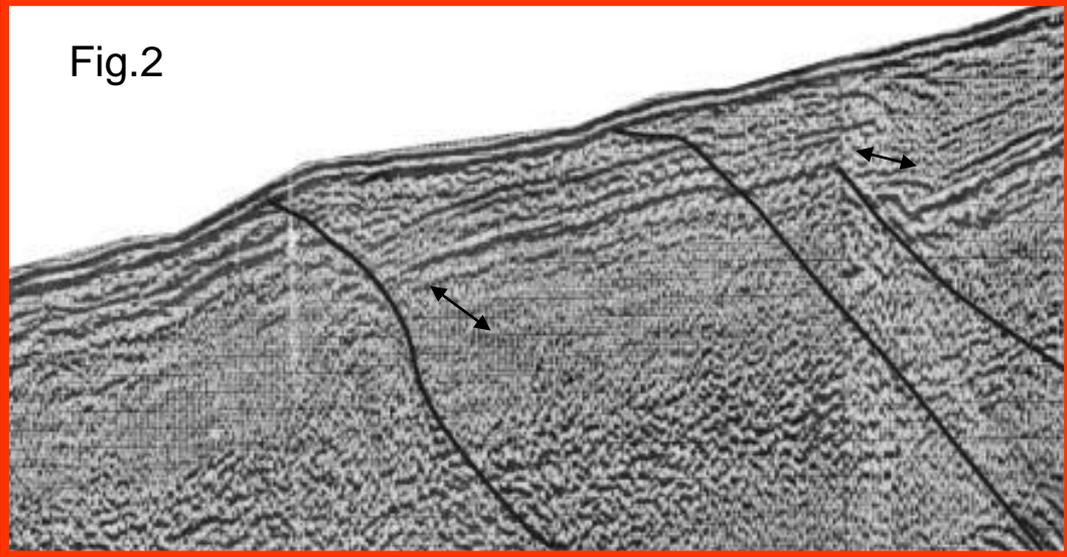


Fig.2

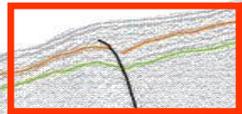


Fronte  
Arco Calabro

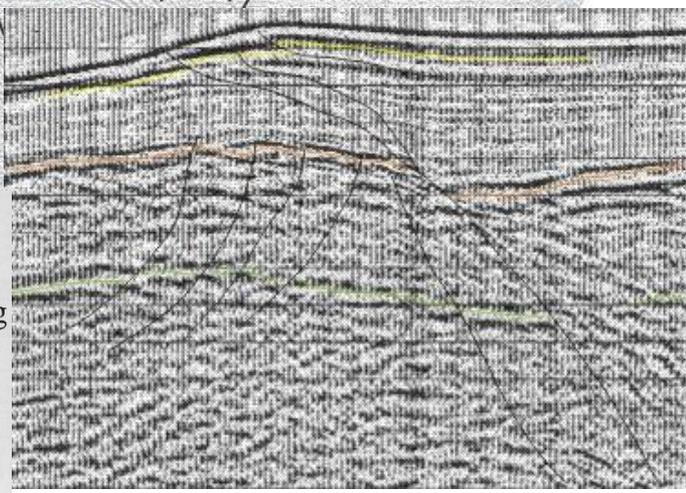
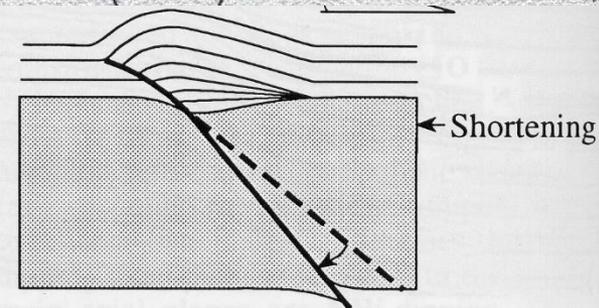
10 km

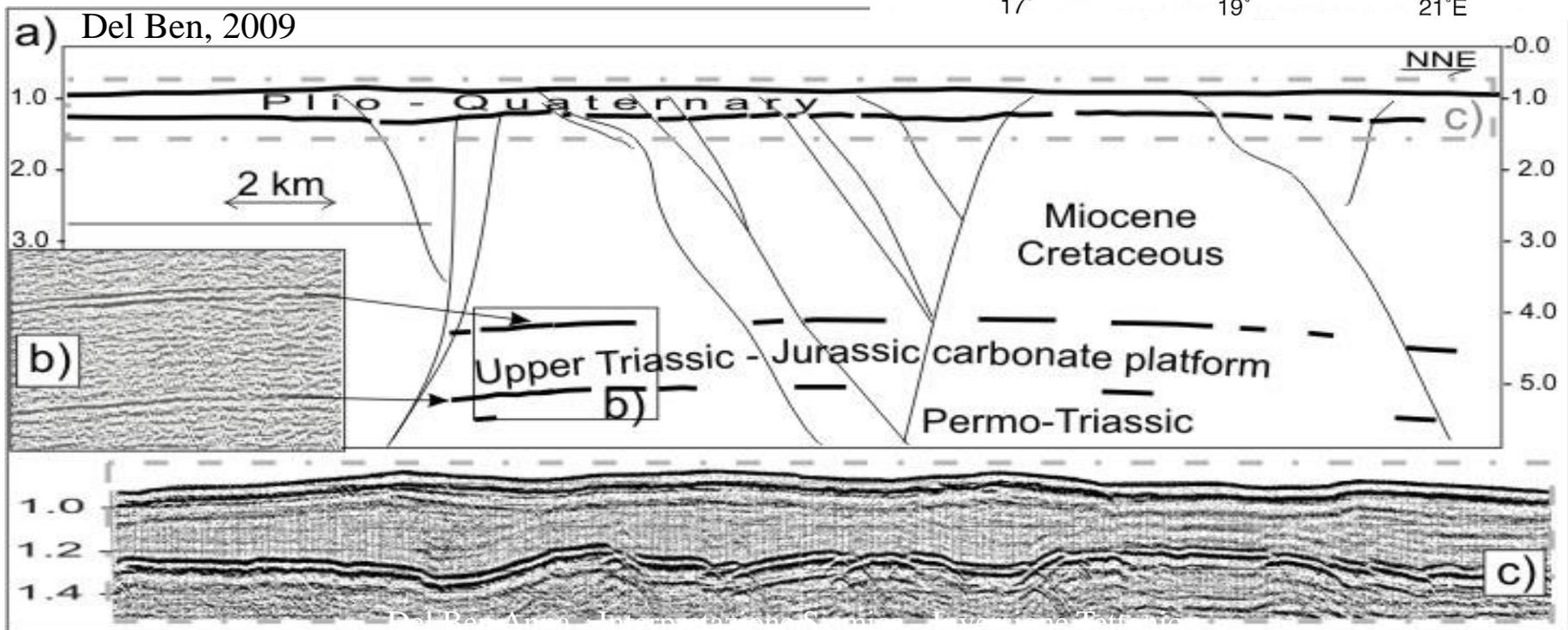
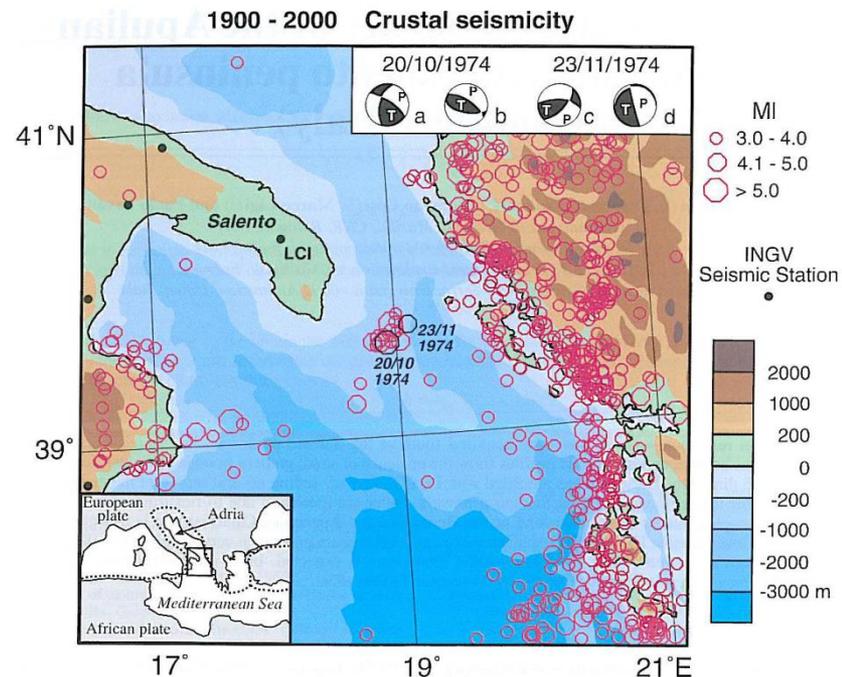
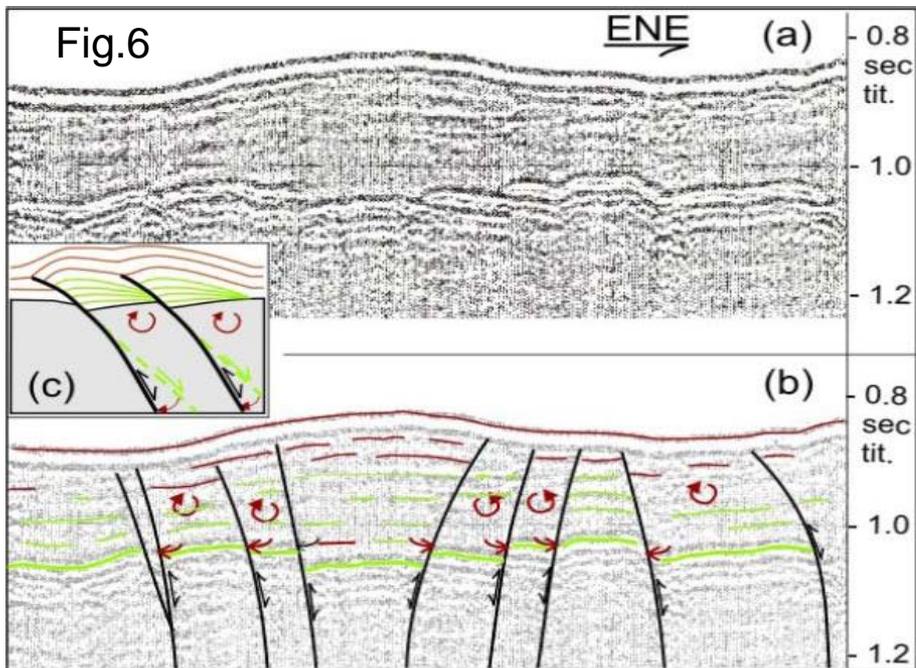
Bacino di  
foredeep  
Plio-Quat.

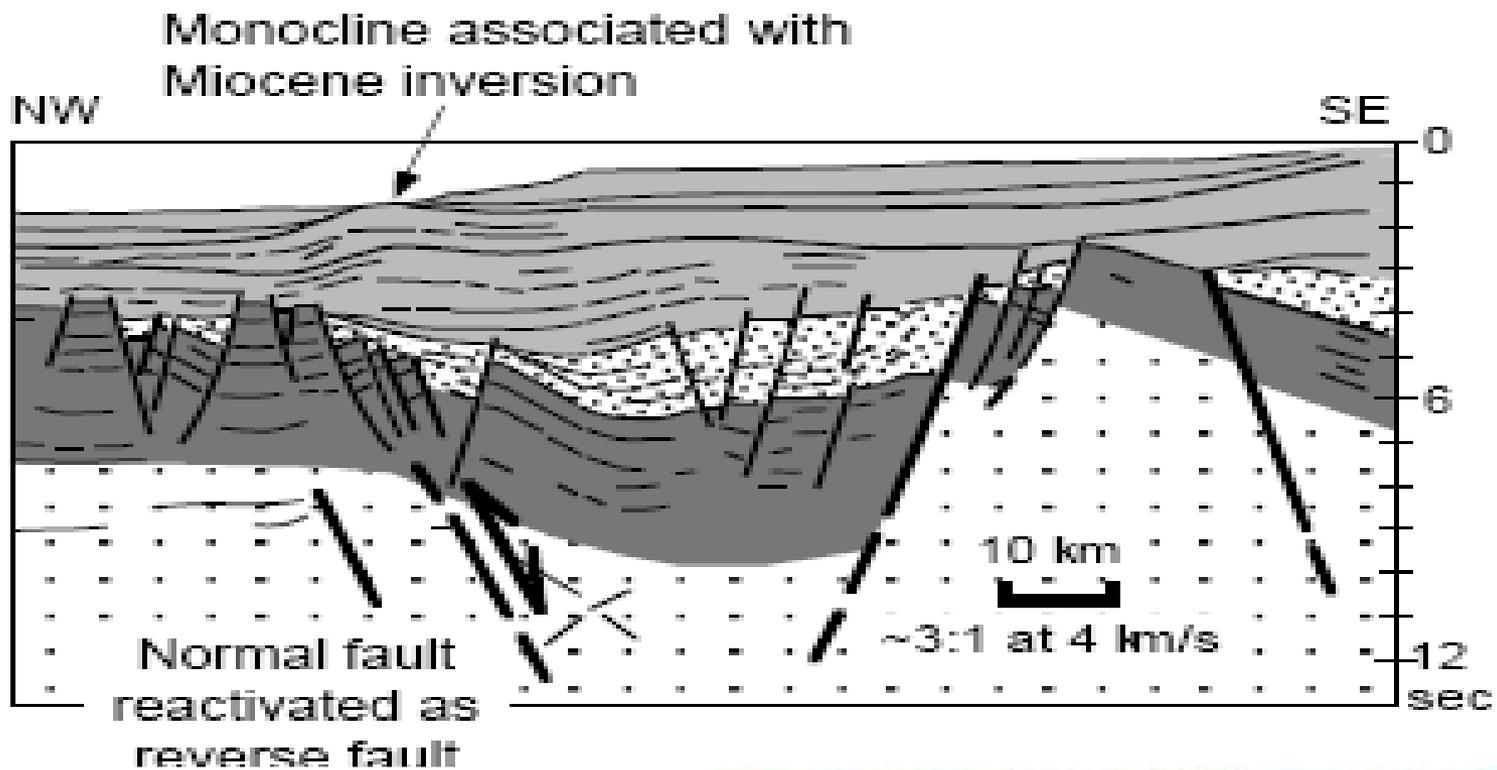
Tilting e fratturazione  
della Piattaforma Apula  
nel post-Messiniano



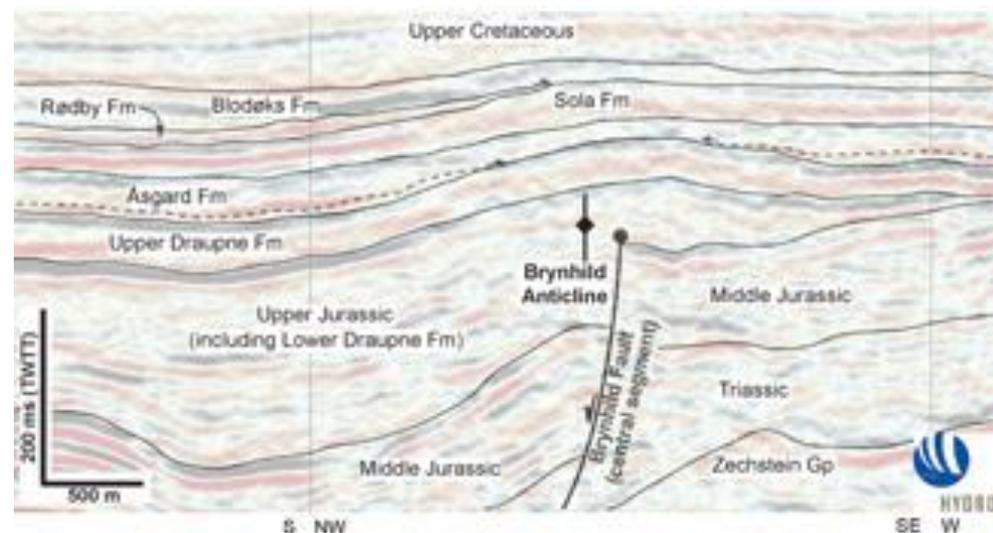
-1.0  
-2.0



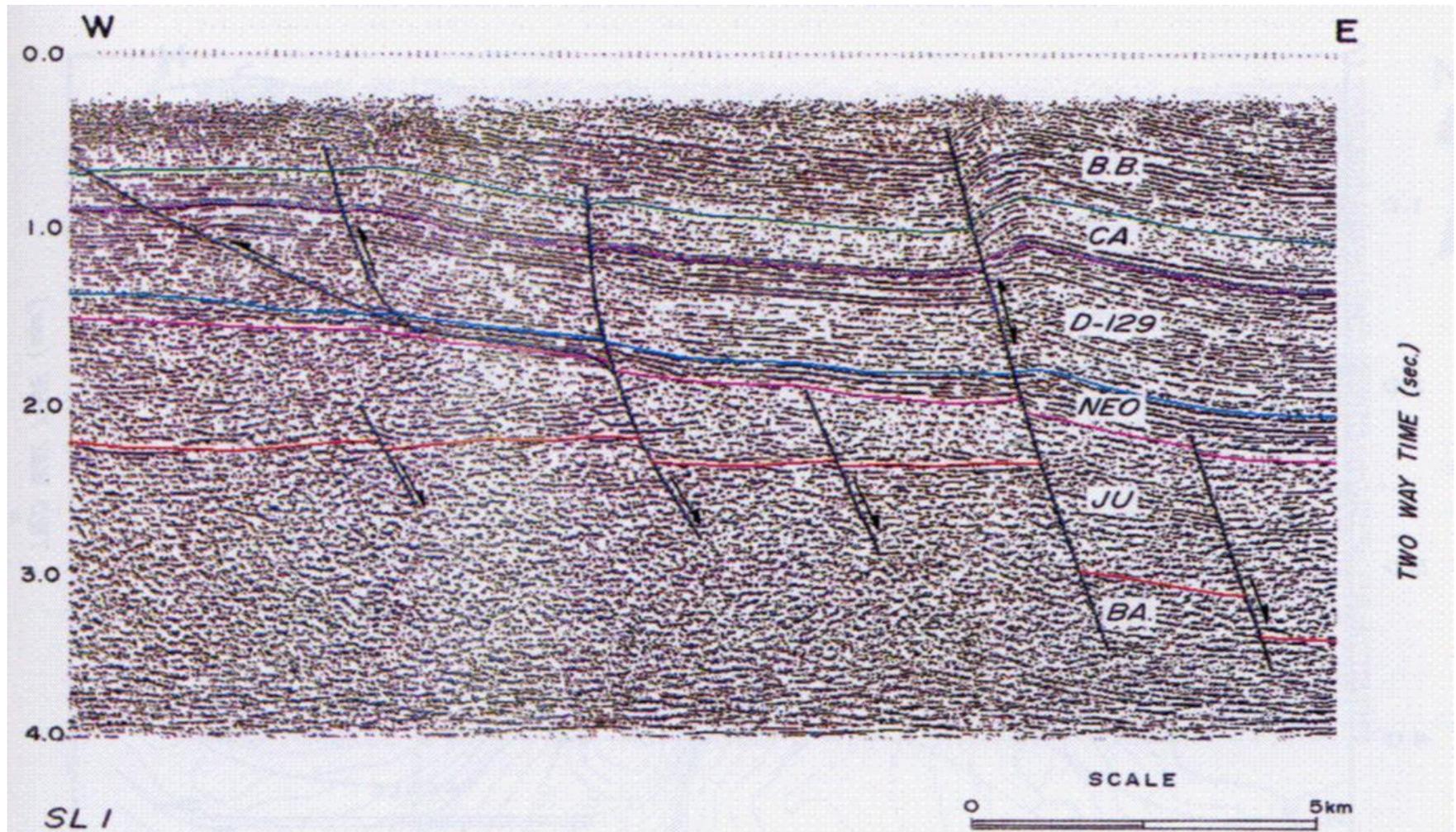




Si hanno molti esempi di riattivazioni di faglie (piani di debolezza) a tutte le scale: da faglie litosferiche a faglie o pieghe che interessano una parte ridotta della serie sedimentaria (come in figura, nella serie plastica più superficiale).

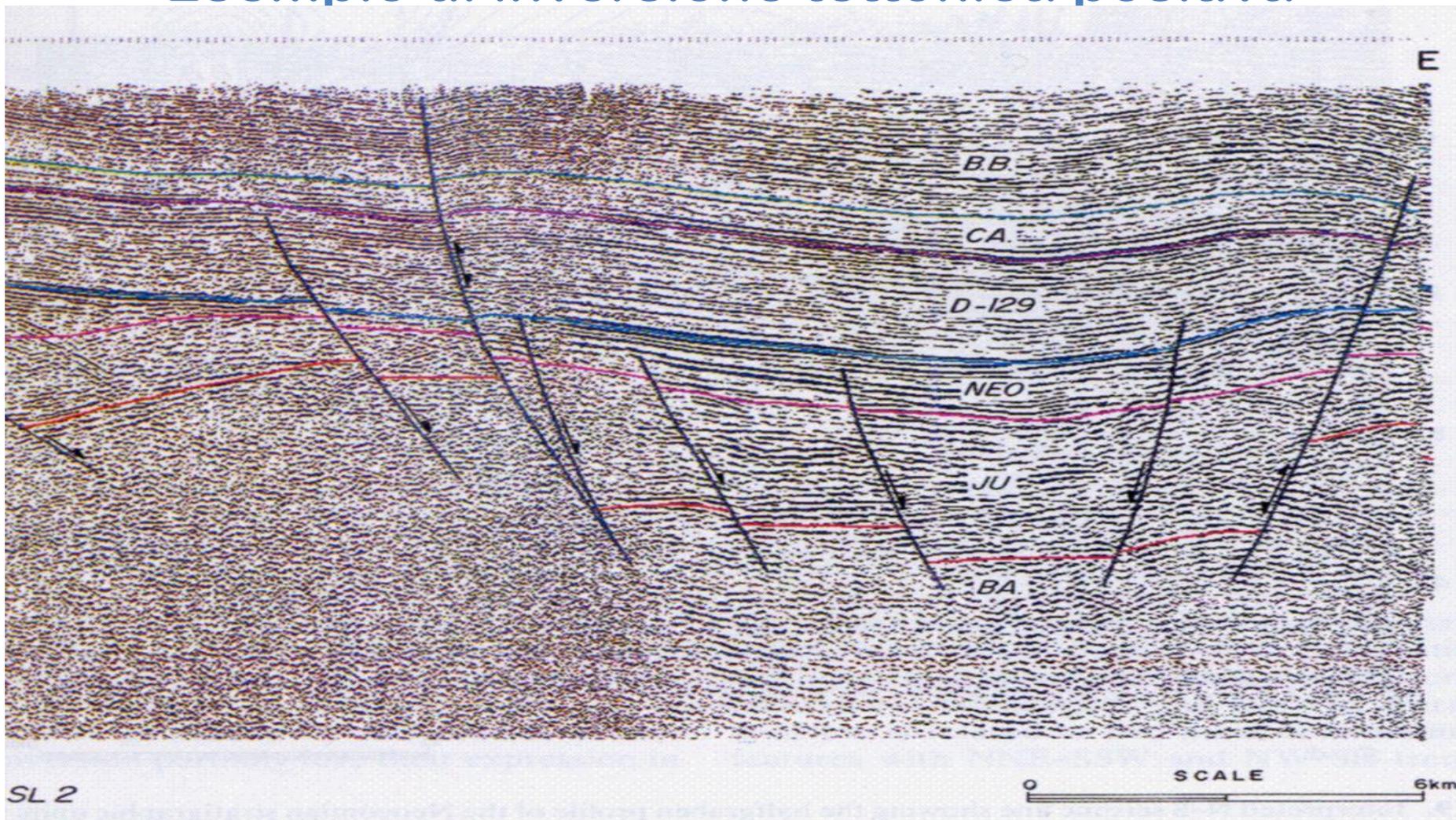


# Inversione tettonica



L'inversione tettonica è stata evidenziata soprattutto in situazioni in cui, durante le prime fasi compressive di un orogene, i bacini preesistenti vengono incorporati in sistemi di pieghe e *thrust*.

# Esempio di inversione tettonica positiva



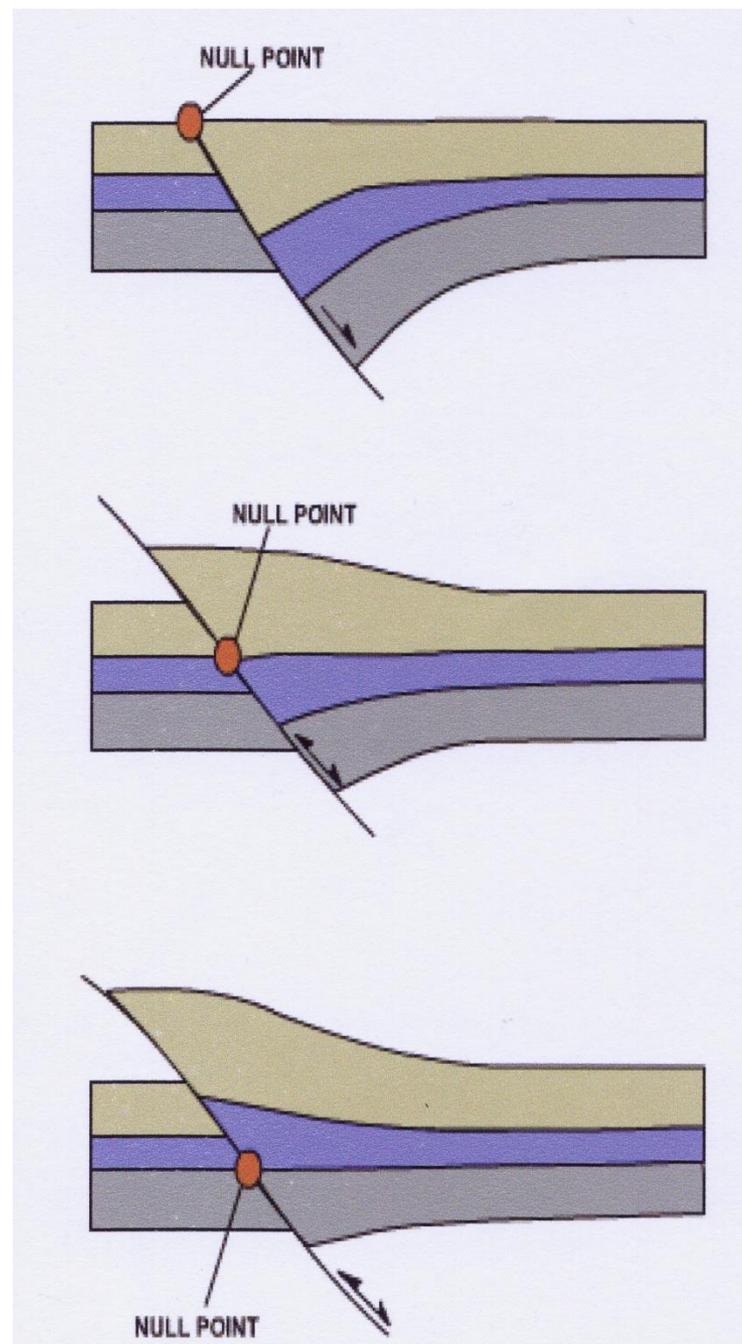
Qui, le faglie antiche, oggi disattivate, mostrano tettonica distensiva; le uniche due faglie ancora attive, originariamente di carattere distensivo, evidenziano una tettonica compressiva recente.

L'**inversione** è **totale** quando la serie precedente alle due fasi tettoniche, distinte ed opposte, risulta a rigetto zero.

Lungo la faglia si avrà un **punto nullo** dove il rigetto è pari a zero.

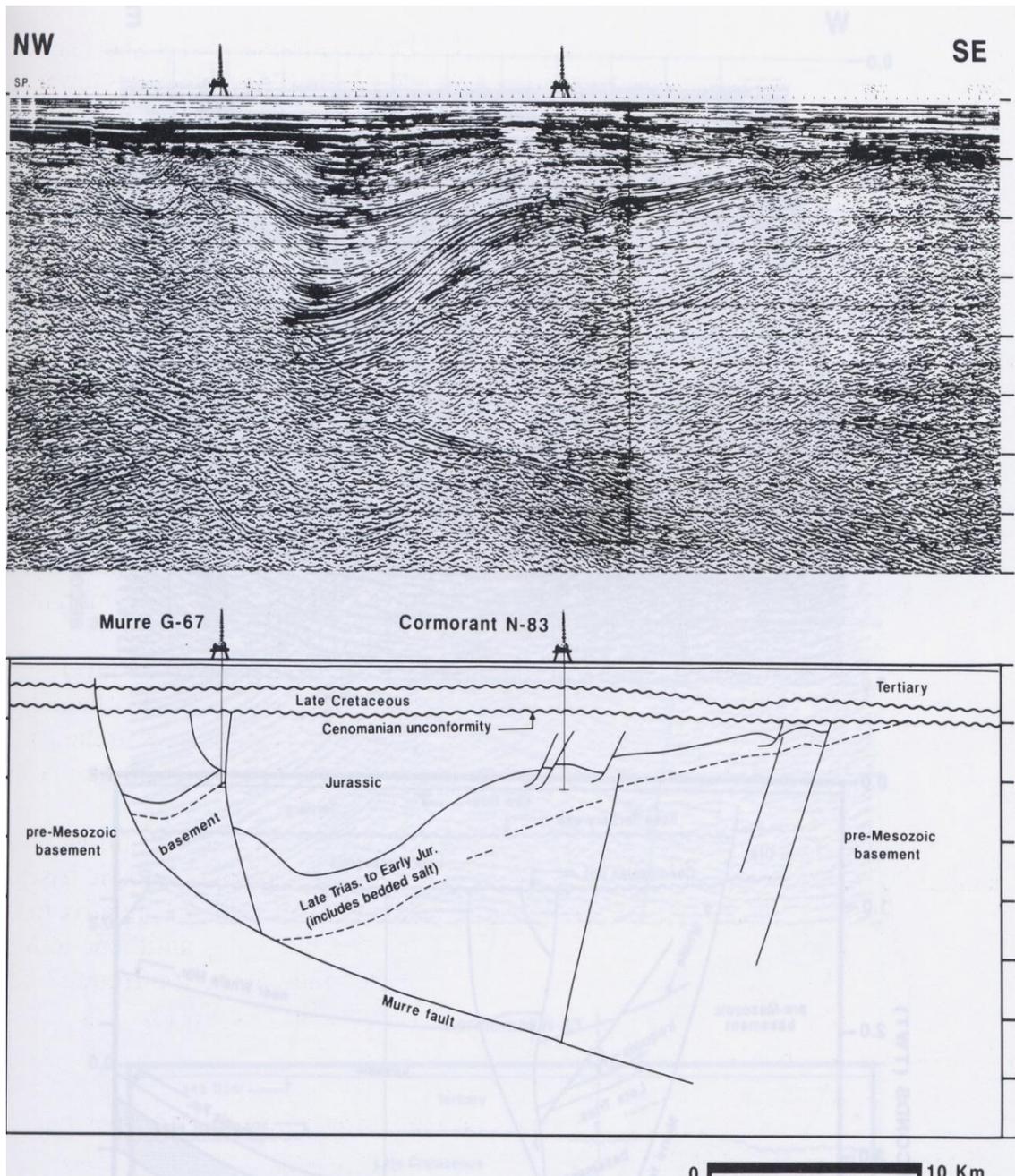
Il punto nullo separa in maniera netta una zona sottostante, dove si riconosce la distensione (componente residua della prima fase tettonica), da una soprastante, dove si riconosce la compressione

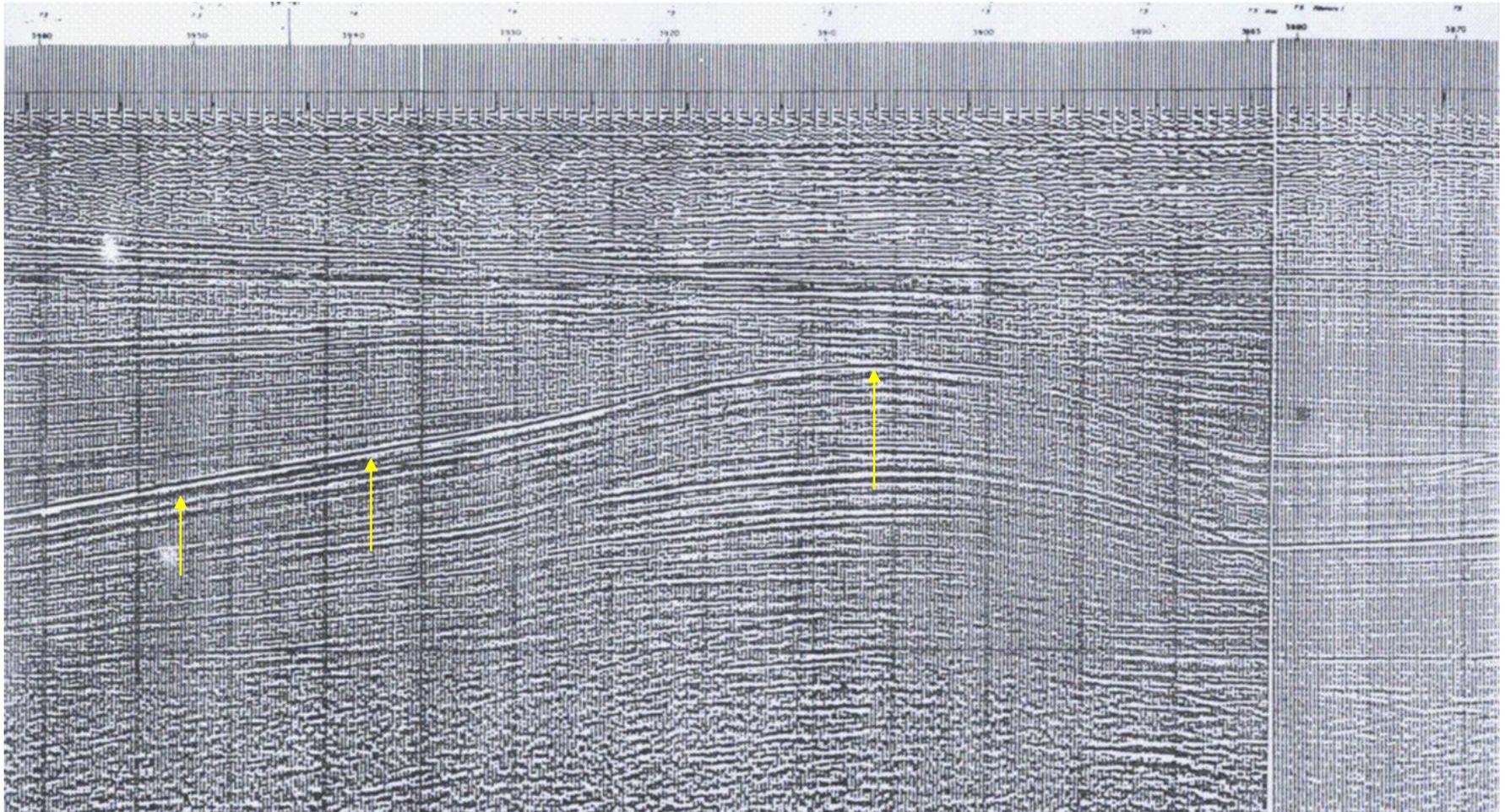
(viceversa nell'inversione negativa).



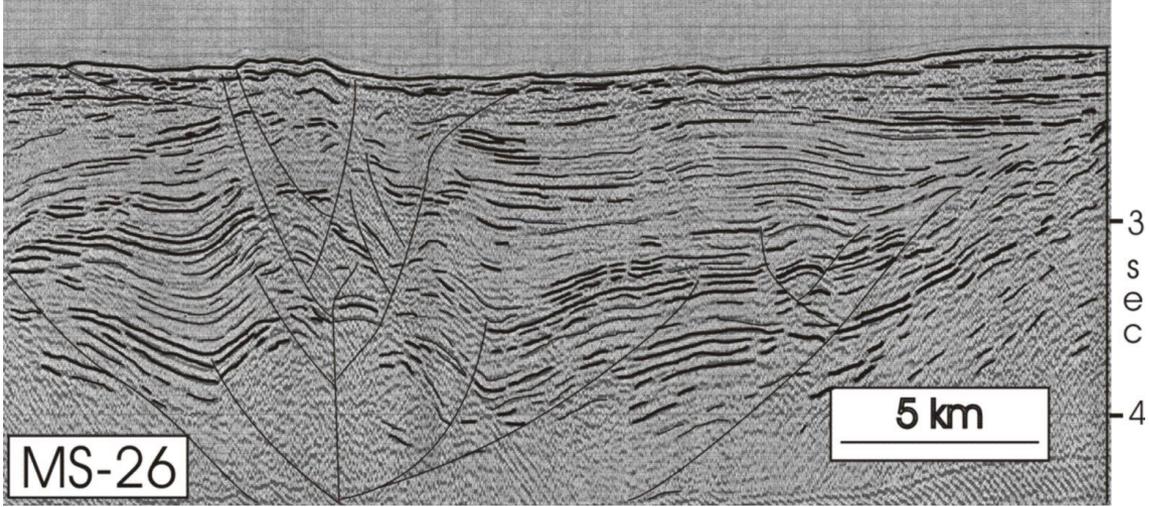
Gli elementi geometrici associati alla inversione tettonica sono:

- *Fold Growth* (anticlinale sopra la faglia riattivata)
- Spostamento del depocentro distante dalla faglia
- Ampia arcuatura e sollevamento
- Inversione del *tilting* nei blocchi fagliati
- Presenza di *back-thrust*
- Strutture di "*pop-up*" sviluppate contro la faglia distensiva

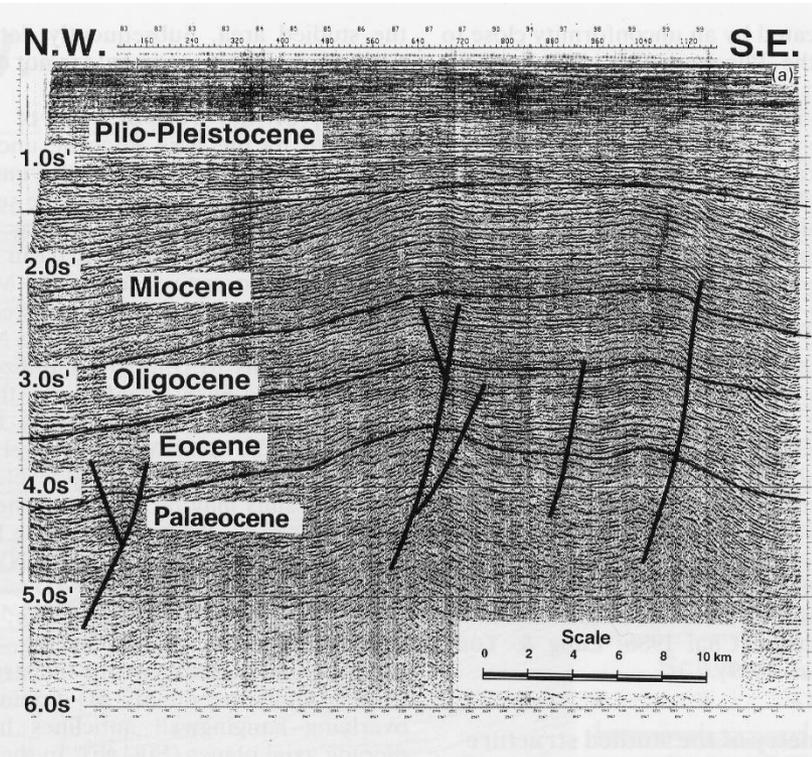
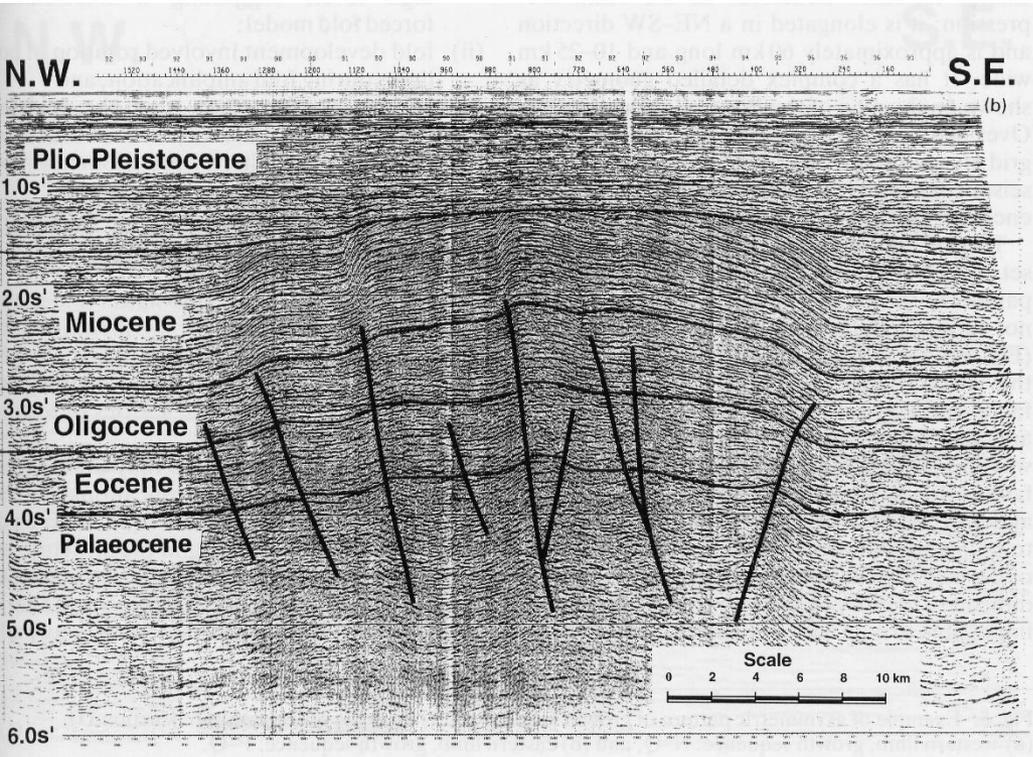




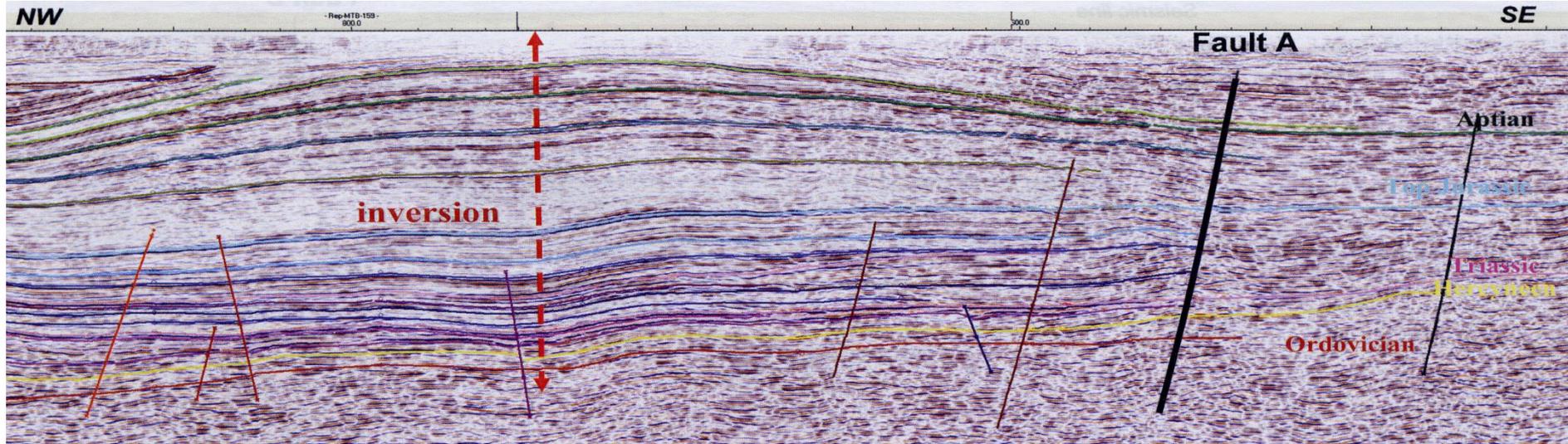
Esempio di inversione tettonica positiva in Adriatico centrale: la serie pre-Messiniana limitata dai due riflettori, risulta più spessa in corrispondenza dell'alto dell'anticlinale prodotta dalla fase tettonica compressiva, più recente rispetto alla precedente fase distensiva.



Lungo i sistemi di *strike-slip* si può assistere all'inversione tettonica della componente secondaria (distensiva o compressiva): la transtensione evolvi in transpressione (esempio in figure, a sinistra offshore dell'Arco Calabro), o viceversa.



Del Ben Anna - Interpretazione Sismica – Inversione Tettonica



# Esempio di inversione tettonica in Tunisia

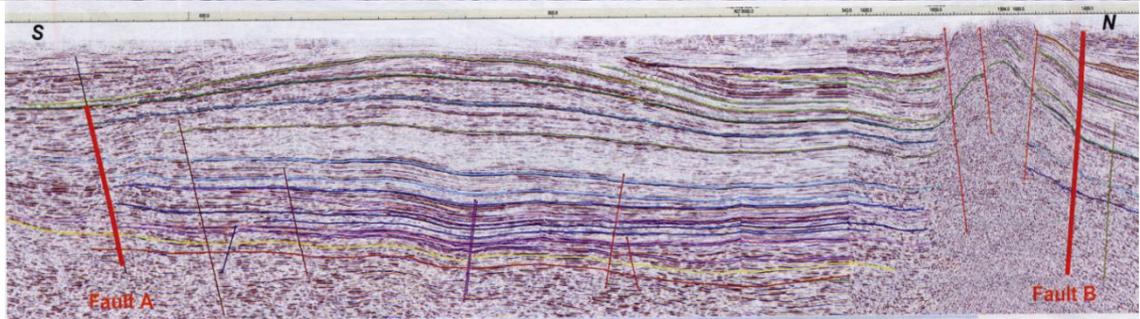


Figure 8 Composite seismic line through the Fejej Graben.

