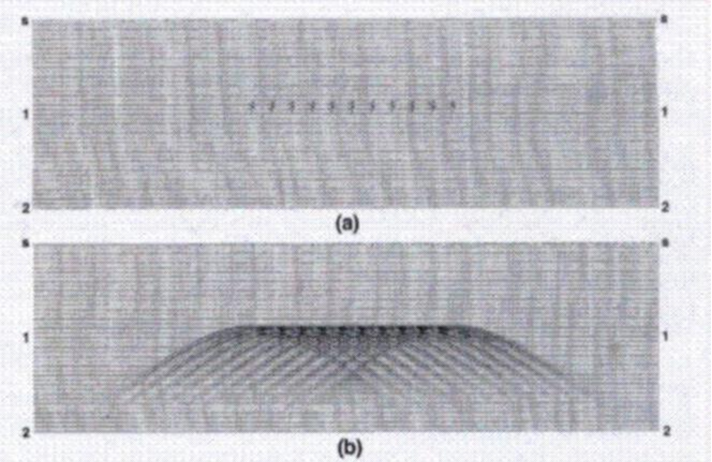
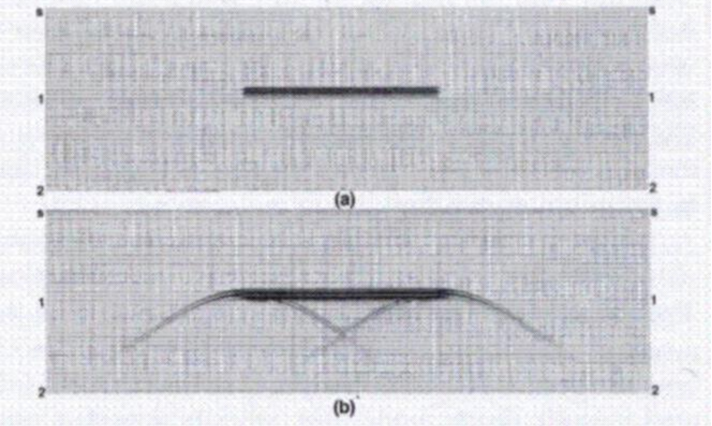
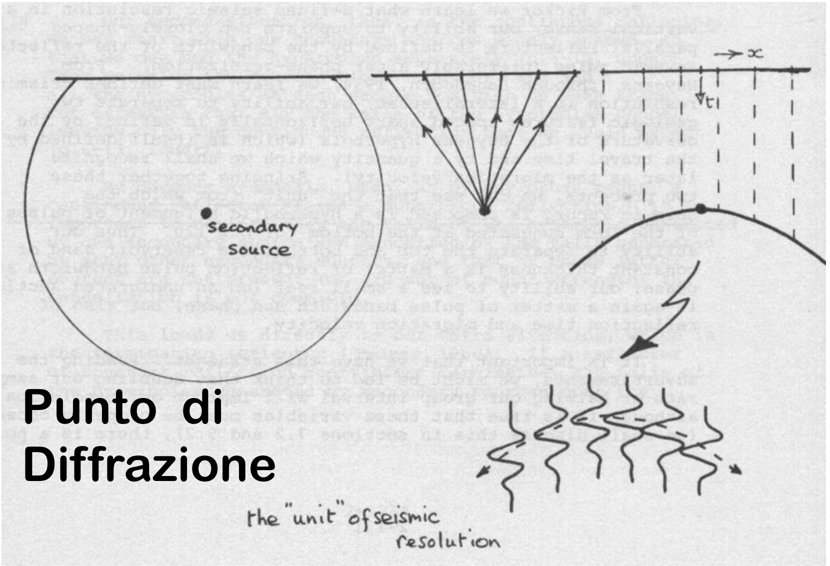
Sheriff and Geldart
cap. 6.3.1



IG. 4.1-12. Superposition of the zero-offset responses (b) f a discrete number of Huygens' secondary sources as in a).





Punto di Diffrazione

Principio di Huygens

stabilisce che ogni punto di un fronte d'onda può essere considerato come una nuova sorgente di onde

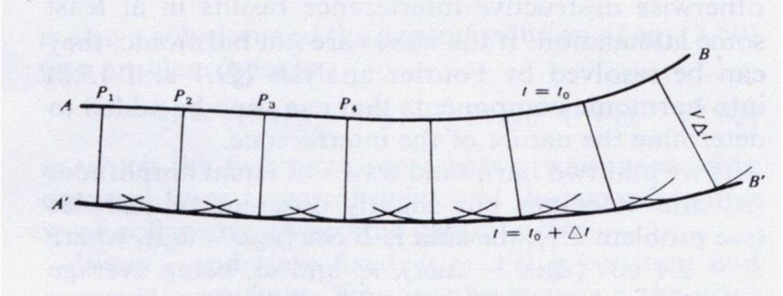
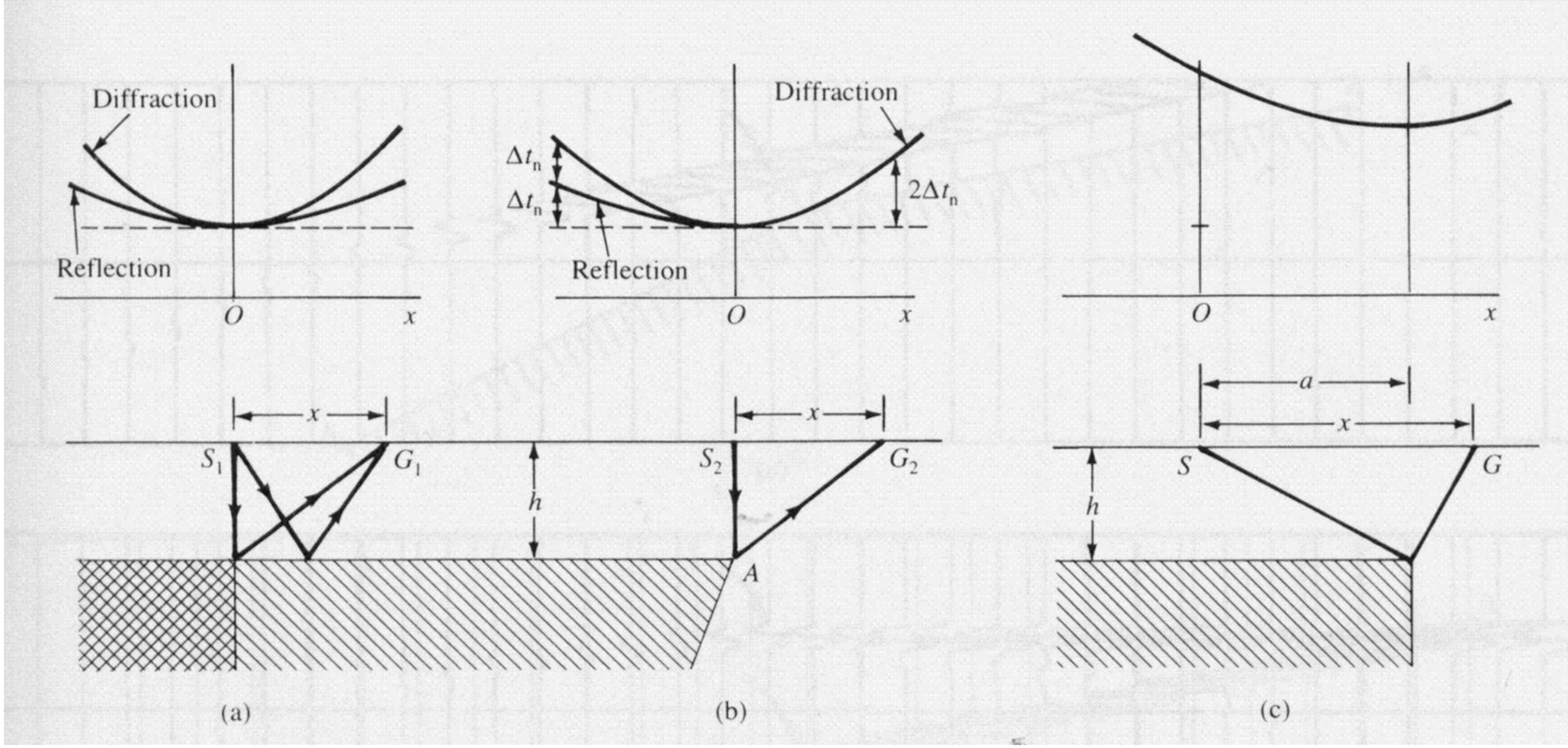


Fig. 2.8 Using Huygens' principle to locate new wavefronts.

DIFFRACTION

Between all the rays leaving form a diffraction point, one of them coincides with the reflected ray.
"We can say that <u>Riflection</u> represents a particular <u>Diffraction</u> phenomenon

Reflection and Diffraction have different Moveout



The *stacking* processing phase decreases diffracted signals because they are corrected with lesser NMO velocities (longer paths/twt) than the velocity that are useful to “horizontalize” the corresponding hyperbole

Diffraction from a semi-plan

Diffraction from a faulted plan

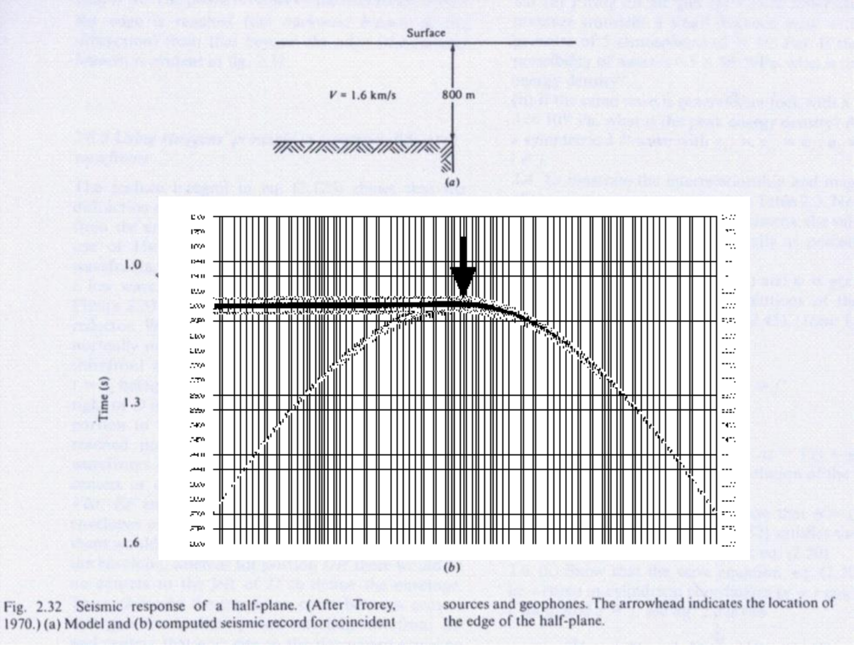
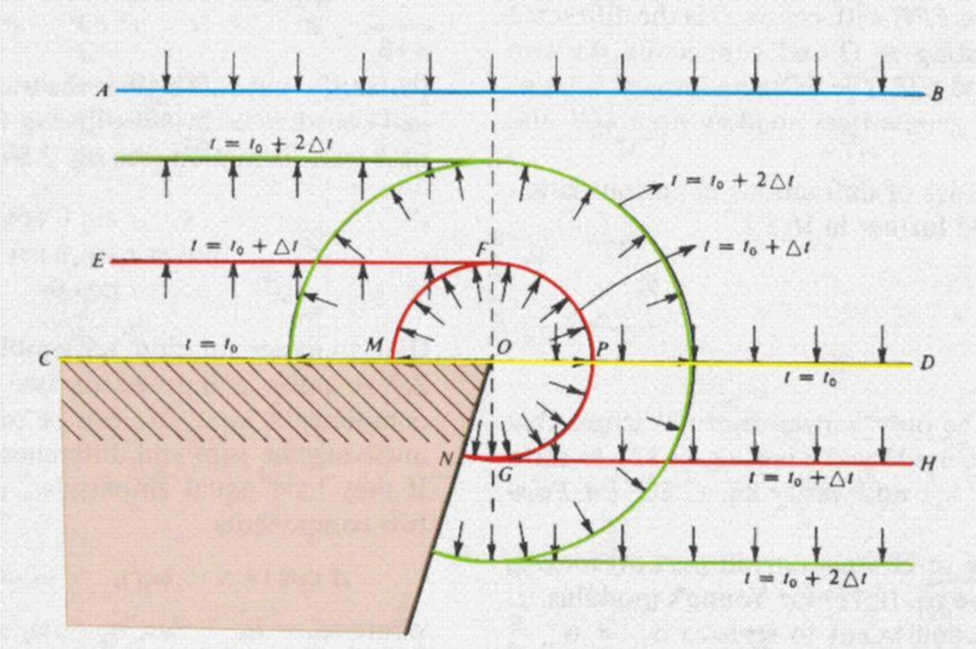


Fig. 2.32 Seismic response of a half-plane. (After Trorey, 1970.) (a) Model and (b) computed seismic record for coincident sources and geophones. The arrowhead indicates the location of the edge of the half-plane.



At t_o time, the wave front reaches the surface CO and it is reflected and diffracted; to the right, the front continues downward.

The wave front which has been diffracted at the time $t_o + \Delta t$ shall be the arc of the circle MFPGN, which is centered in O, point of diffraction.

The recorded diffracted wave will be MFP, which on the seismic profile, produces <u>the diffraction hyperbole (figure on the left)</u>.

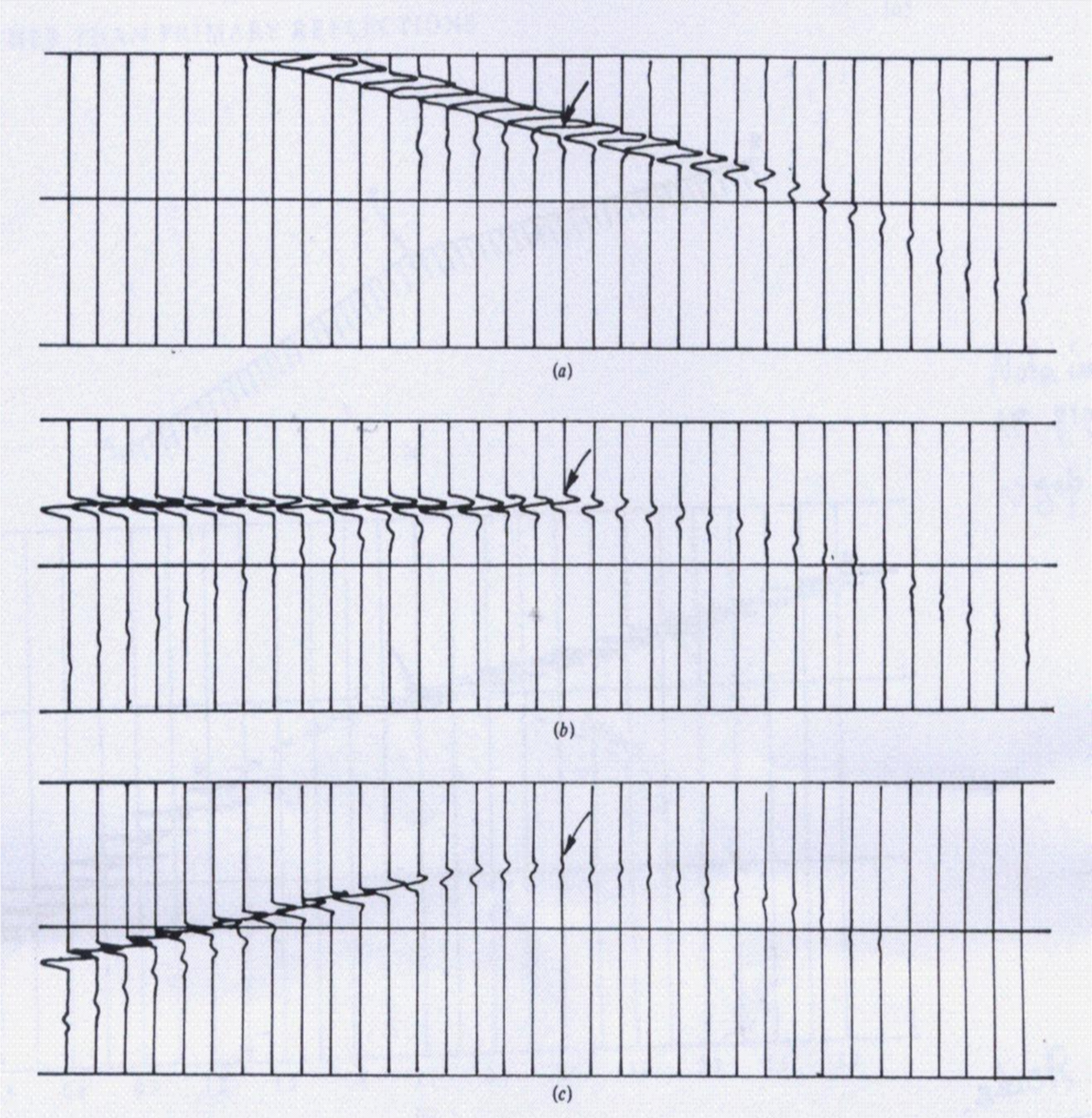
Alaso within the pink stratum there will be a spherical wave front (not evidenced here) with a ray t, inversely proportional to the stratum velocity.

-The hyperbole vertex represents the diffraction point (extremity of the reflector)

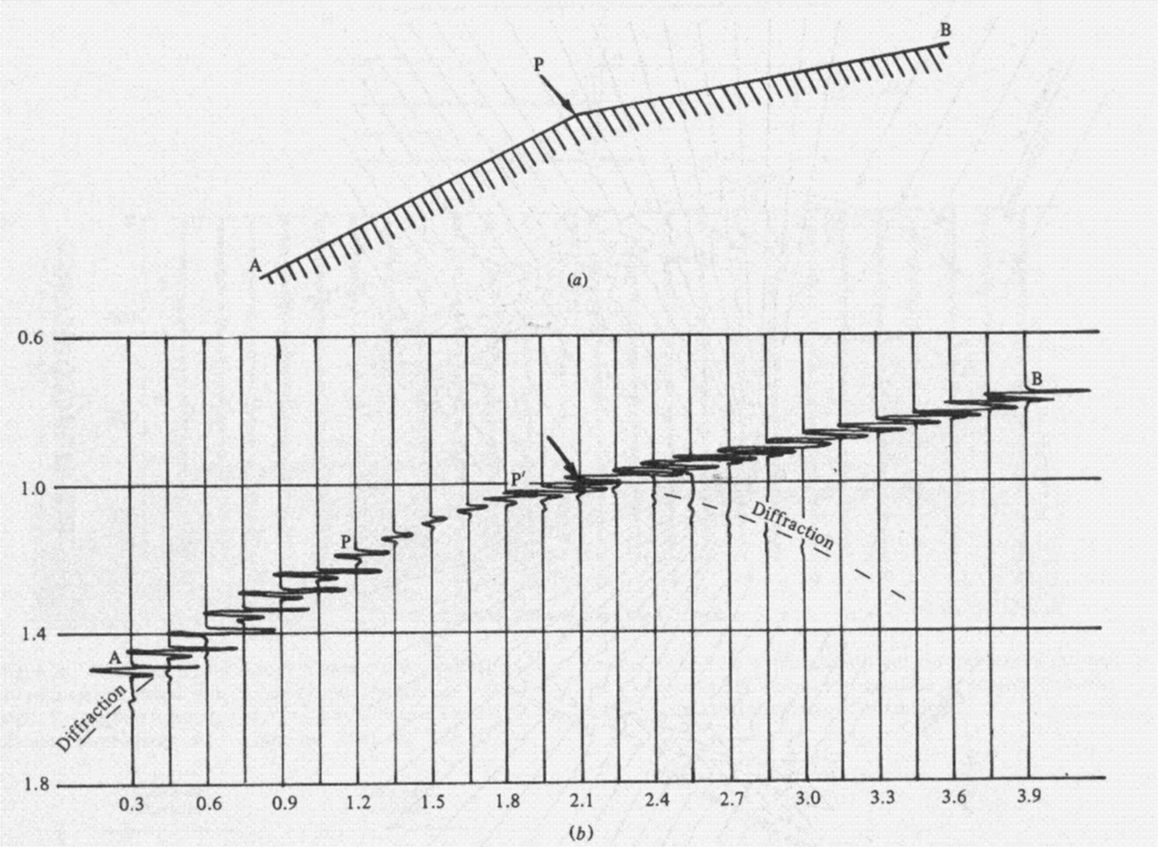
-The diffraction hyperbole is tangent to the reflector

-The curvature of the diffraction hyperbole depends on depth and velocity of the strata

- The maximum amplitude of the diffraction occurs in the tangent point. Laterally amplitude gradually decreases.

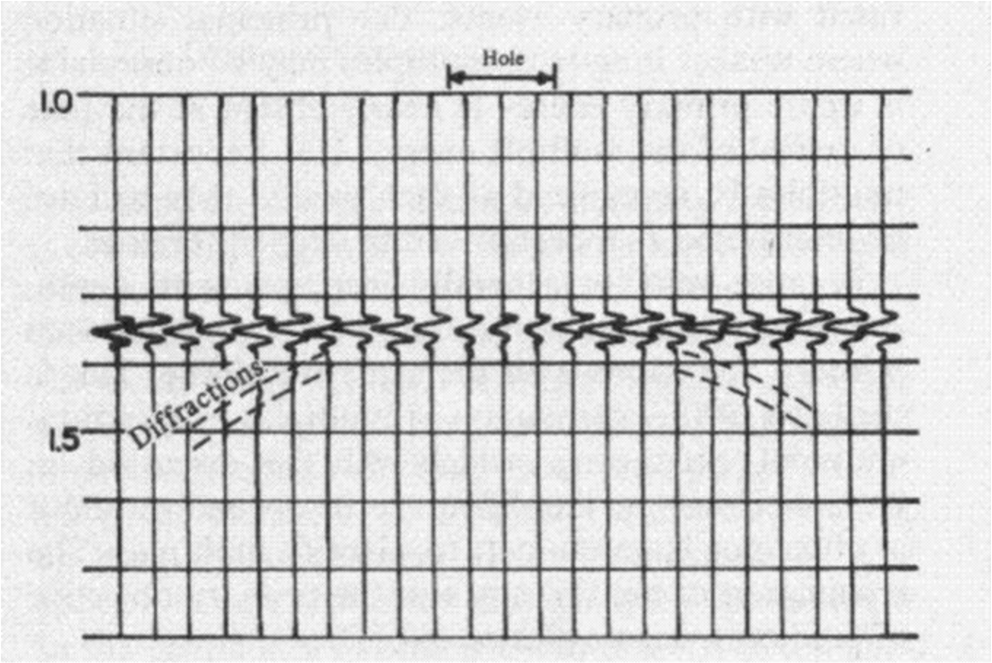


Example with abrupt slope change



The two reflectors, that are not migrated, will be interpreted on the left and with less deepening then the correct position (migrated).
There will be two different positions for the point P, which could be seen as the right extremity of the AP segment, or left extremity of the PB segment.
In the intermediate space, the reflector will apear continue due to the diffraction effect.

Example with *hole* (local absence of the Riflector)



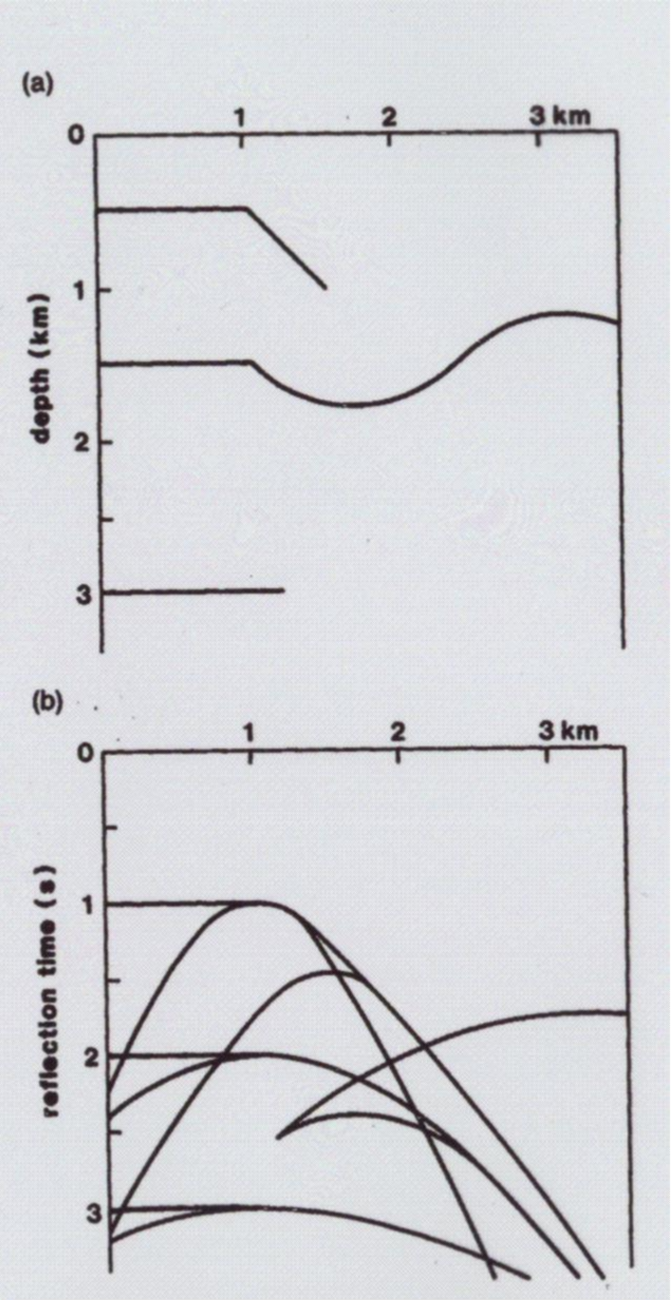
In the stacked profile the absence of the reflector is masked by the presence of diffractions which do it as a continuous reflector.

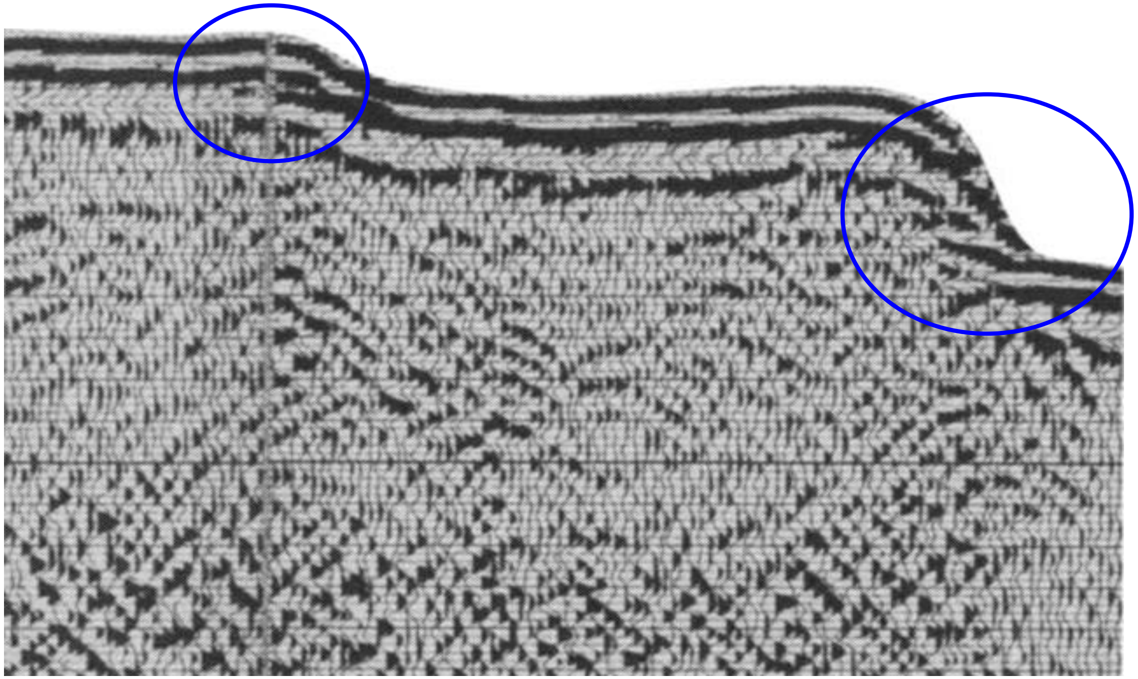
Geological meaning: erosion or non-deposition ...

What geological conditions favor the presence of diffracions?

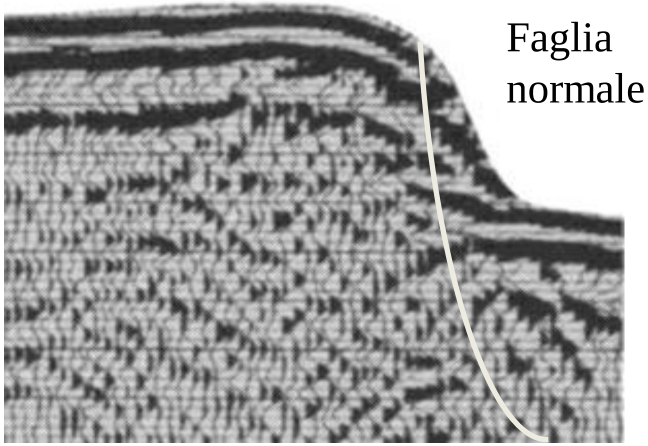
Generally, the different depositional/erosional and tectonic events that occur during the geological evolution of a basin, produce several irregularities along the stratigraphic horizons (reflectors) due to fractures, eroded surface, sediments accumulation, etc.

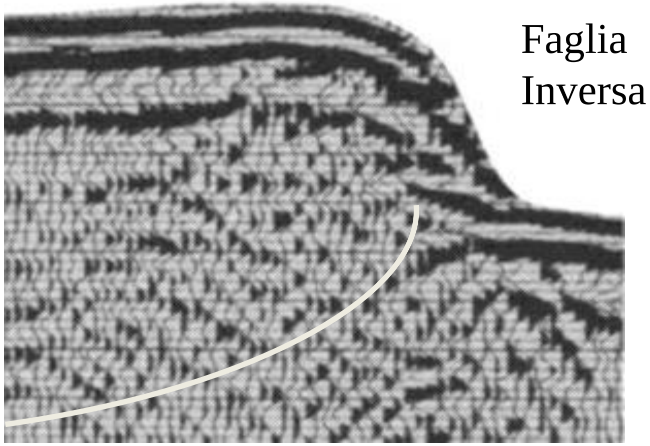
These irregularities represent points of inhomogeneity that produce diffractions.





La presenza di diffrazioni può talvolta creare difficoltà di interpretazione: il punto di rottura del riflettore non è facilmente individuabile e ciò può generare dubbi sul fatto che la frattura sia da attribuirsi a faglia normale o inversa...





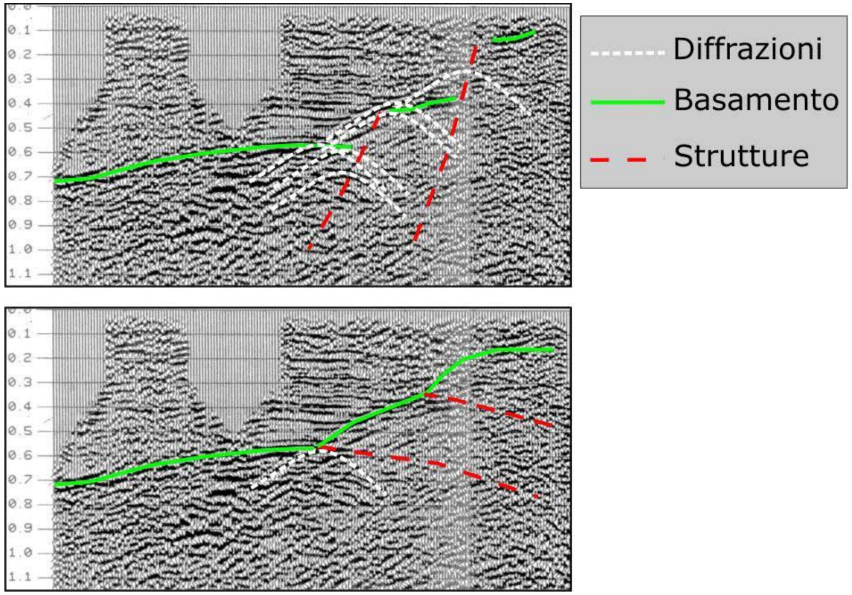
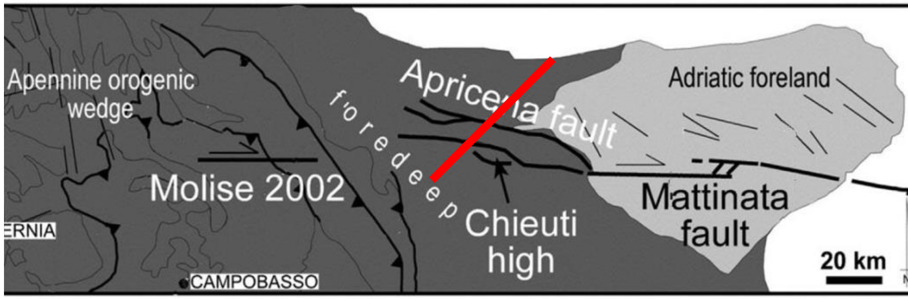


Figura **:** porzione di una linea ENI-AGIP.
In alto a sn: interpretazione in chiave **distensiva** in cui sono evidenziate possibili diffrazioni (tratteggio bianco).
In basso a sn: interpretazione in chiave **compressiva** (faglie in rosso).



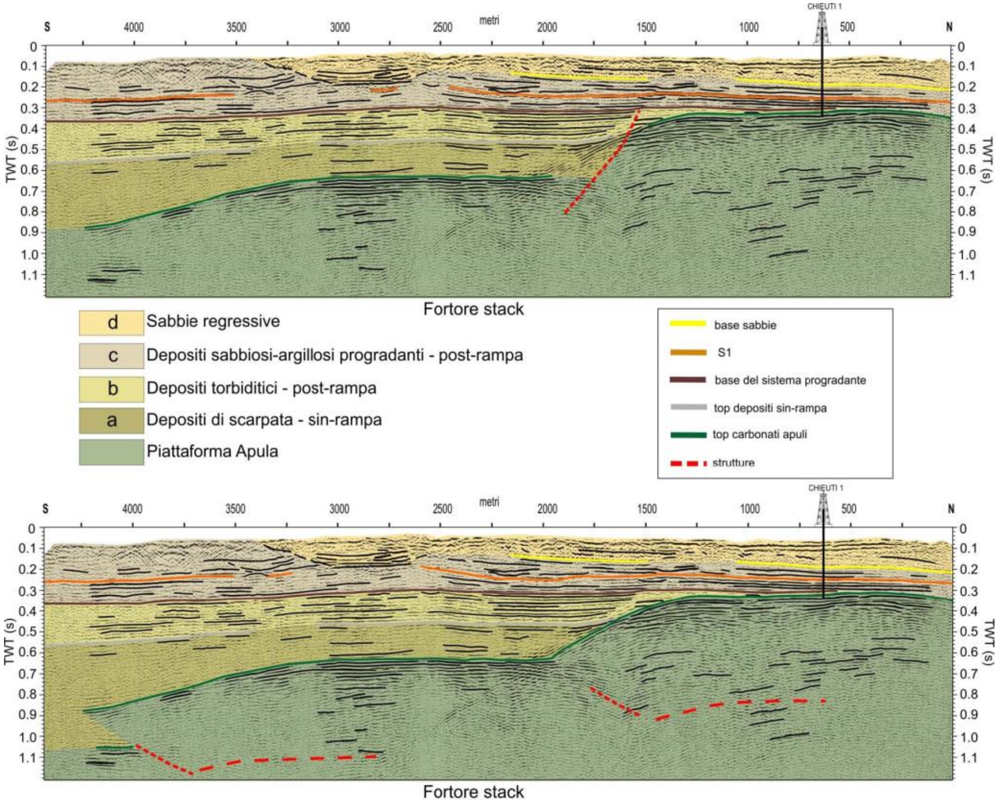


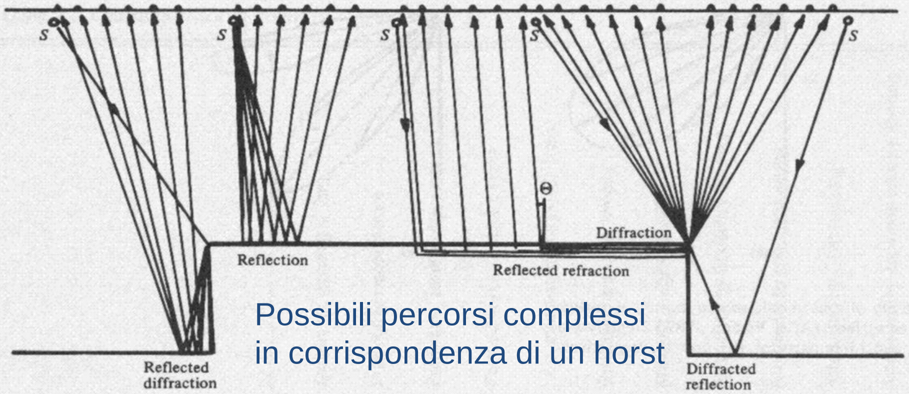
Figura : Sezione *stack* del profilo Fortore. In alto interpretazione della faglia d'Apricena come struttura **transtensiva**.
In basso interpretazione in chiave **transpressiva** della struttura.

(da Varriale, PhD Thesis 2010-11)

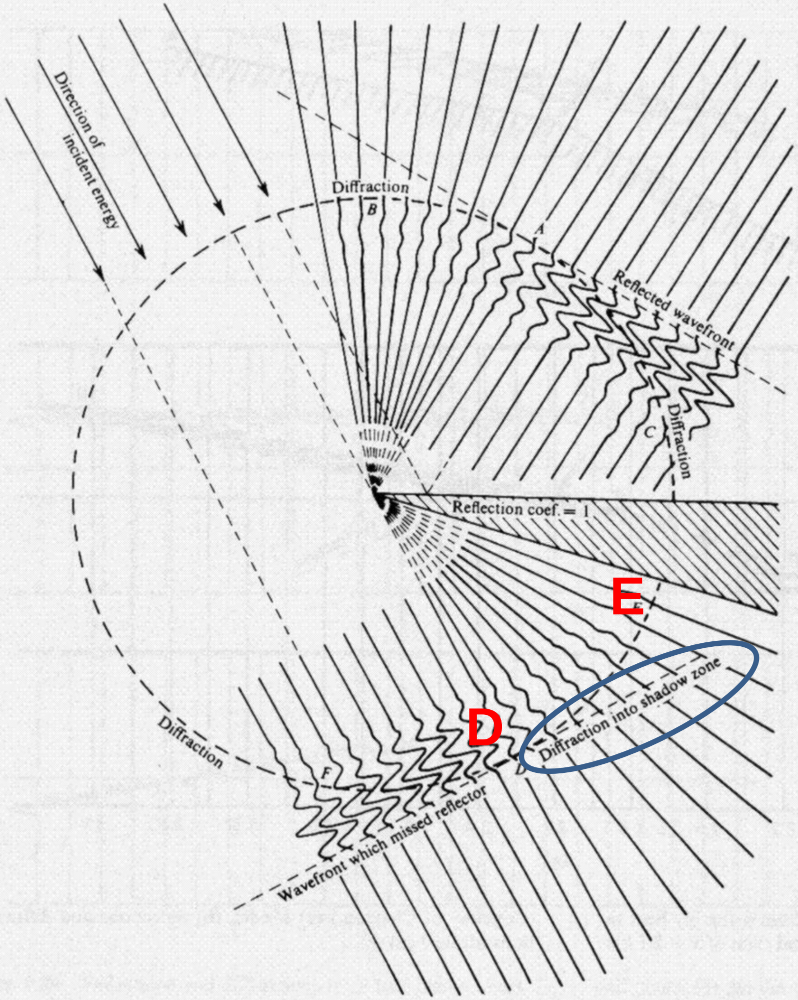
Le diffrazioni costituiscono spesso un rumore importante nei profili non migrati, che talvolta non permette il completo riconoscimento dei riflettori primari.
Maggiore è il numero di discontinuità/irregolarità presenti nella sequenza sedimentaria indagata, maggiore sarà il numero delle diffrazioni.

Si possono avere diffrazioni riflesse e riflessioni diffratte, con percorsi complessi, ma talvolta evidenziabili. In alcuni casi questi segnali sono in grado di fornire informazioni utili.

A destra: diffrazioni da cuneo sedimentario riflettente:
la diffrazione fa si che parte dell’energia sismica possa raggiungere zone che non potrebbero essere indagate dalle onde riflesse sulla base dell’ottica geometrica (fronte d’onda diffratta DE)



Possibili percorsi complessi in corrispondenza di un horst



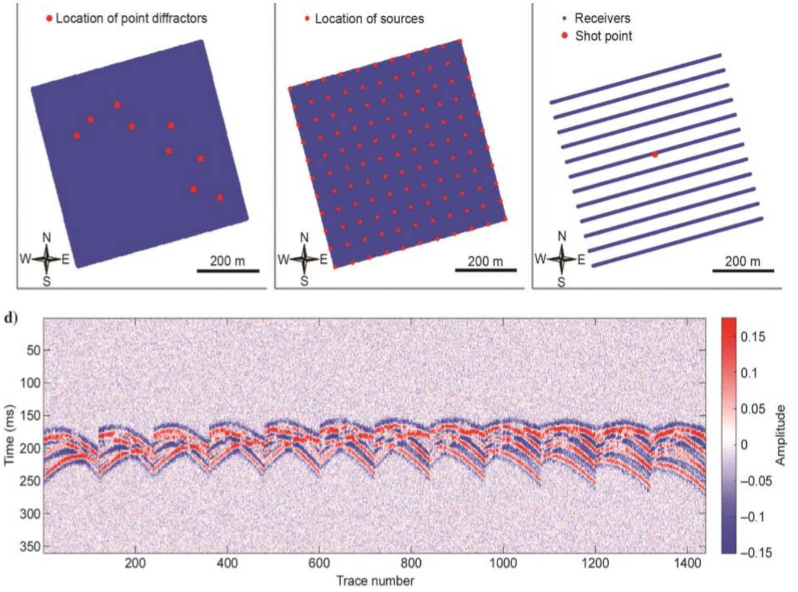
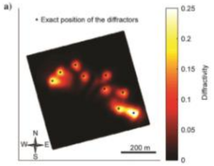


Figure 2. (a) Point diffractors (red dots) located at 400 m/0.16 s within the constant velocity cube of 5000 m/s, (b) location of sources used in the survey (red dots), (c) central shot (red dot) and some of the recording receiver lines, and (d) the corresponding seismic data.

Interpretation / November 2016 **B25**

Diffractivity — Another attribute for the interpretation of seismic data in hard rock environment, a case study

Mohammad Javad Khoshnavaz[1], Andrej Bóna[1], Muhammad Shahadat Hossain[1], Milovan Urosevic[1], and Kit Chambers[2]



Abstract

The primary objective of seismic exploration in a hard rock environment is the detection of heterogeneities such as fracture zones, small-scale geobodies, intrusions, and steeply dipping structures that are often associated with mineral deposits. Prospecting in such environments using seismic-reflection methods is more challenging than in sedimentary settings due to lack of continuous reflector beds and predominance of steeply dipping hard rock formations. The heterogeneities and "fractal" aspect of hard rock geologic environment produce considerable scattering of the seismic energy in the form of diffracted waves. These scatterers can be traced back to irregular and often "sharp-shaped" mineral bodies, magmatic intrusions, faults, and complex and heterogeneous shear zones. Due to the natural lack of reflectors and abundant number of diffractors, there are only a few case studies of diffraction imaging in hard rock environments. There are almost no theoretical models or field examples of diffraction imaging in prestack domain. We have filled this gap by applying a 3D prestack diffraction imaging method to image point diffractors. We calculated the diffractivity by computing the semblance of seismic data along diffraction traveltime curves in the prestack domain. The performance of the method is evaluated on a synthetic case and a field seismic data set collected over the Kevitsa mineral deposit in northern Finland. The high-resolution results obtained by the application of prestack diffraction imaging suggest that diffractivity is a robust attribute that can be used in addition to other seismic attributes for the interpretation of seismic data in hard rock environment.

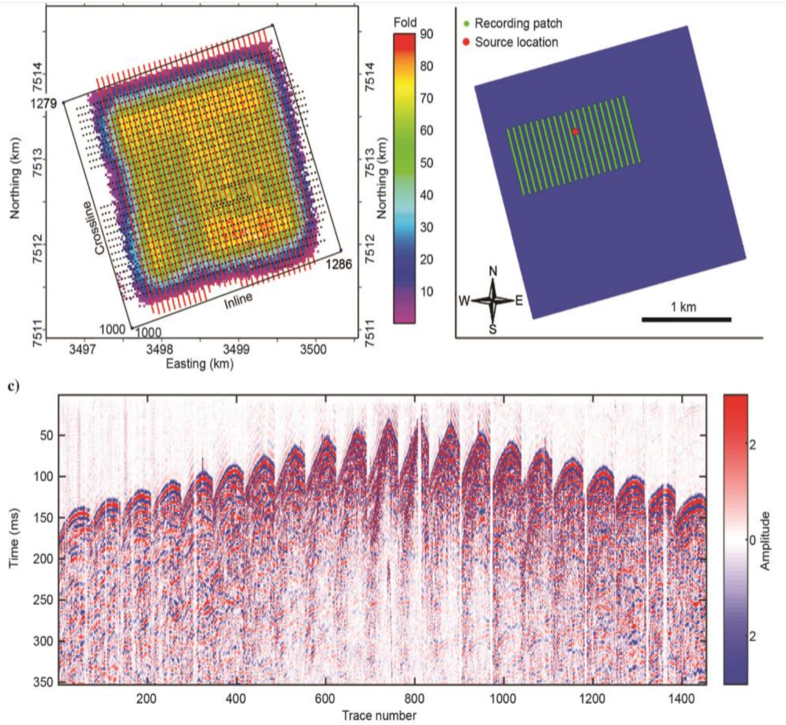
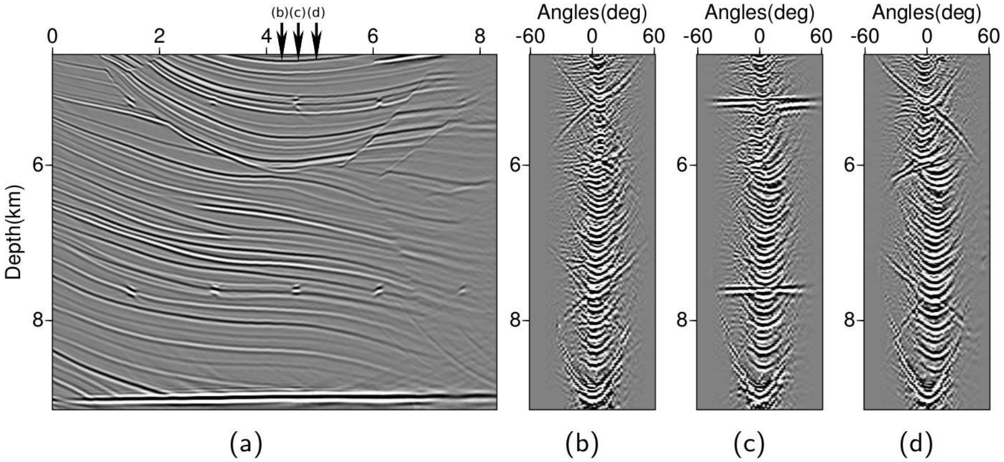
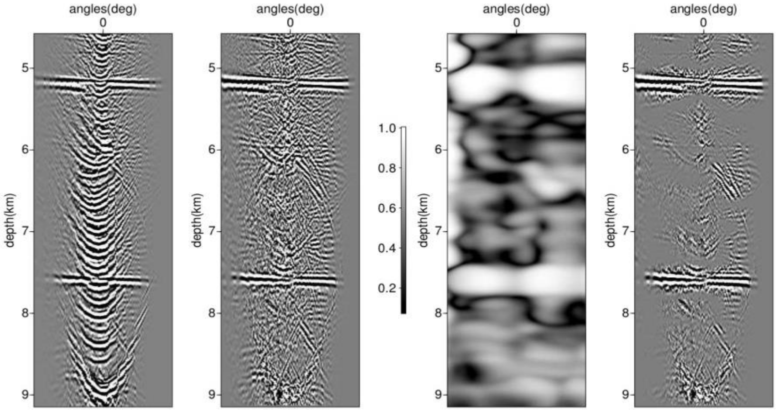


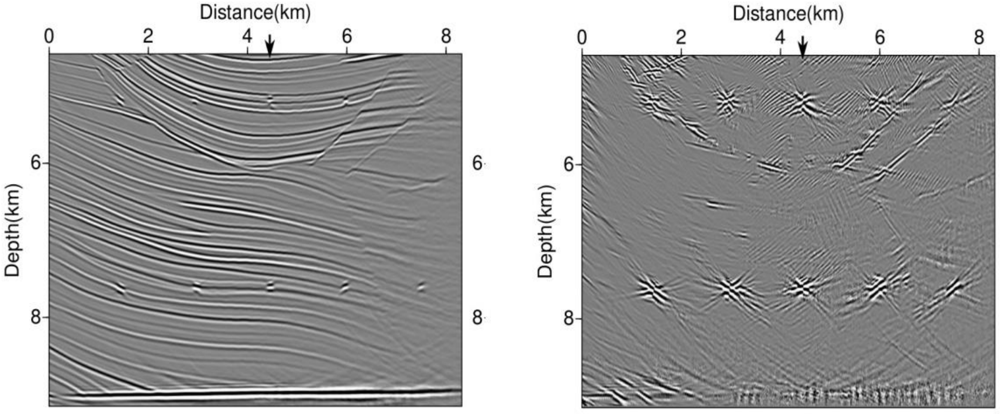
Figure 5. (a) Three-dimensional seismic survey and the corresponding fold map for the seismic data collected over Kevitsa Ni-Cu-PGE orebody, northern Finland (after Malehmir et al., 2012), (b) location of a shot and the corresponding recording patch within the acquisition area, and (c) the corresponding pre-processed seismic data (Ziramov et al., 2015) cut to 350 ms.

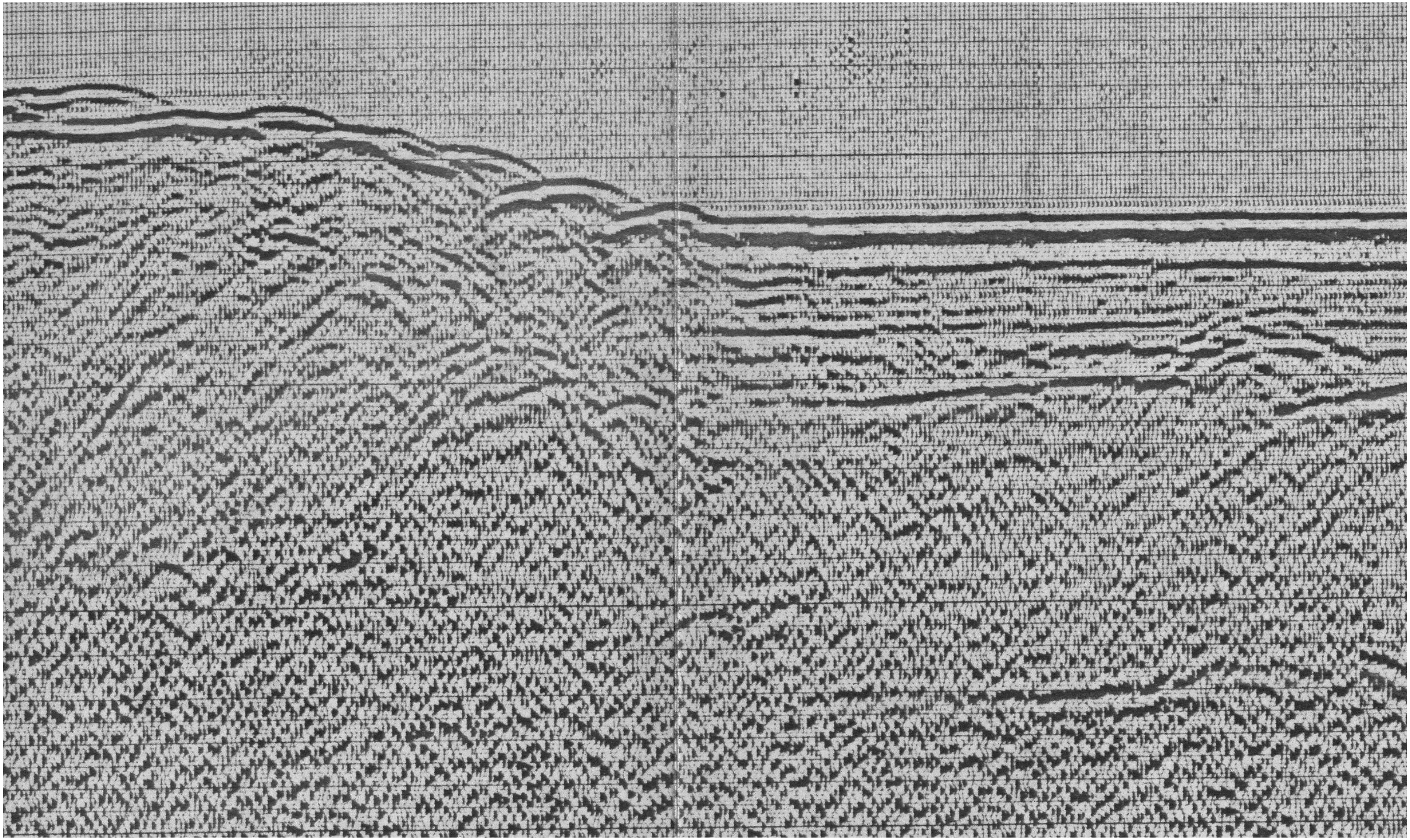
SEPARATION AND IMAGING OF SEISMIC DIFFRACTIONS Urbano, Lipari (2013)

…sometimes the goal of seismic processing consists in identifying small subsurface features (e.g. faults, fractures and rough edges of salt bodies) or small changes in reflectivity.
In all these cases diffracted waves contain the most valuable information.
Dip-filtering in the post-stack migrated domain and separation in the post-migration dip-angle gathers, where reflections always have a concave shape and diffraction have a different shape (horizontal if migration was performed with the correct velocity….)
The paper combines these methodologies.
Once the events that show clearly identifiable and slowly variable dip are removed, the remaining coherent events are interpreted as diffractions...

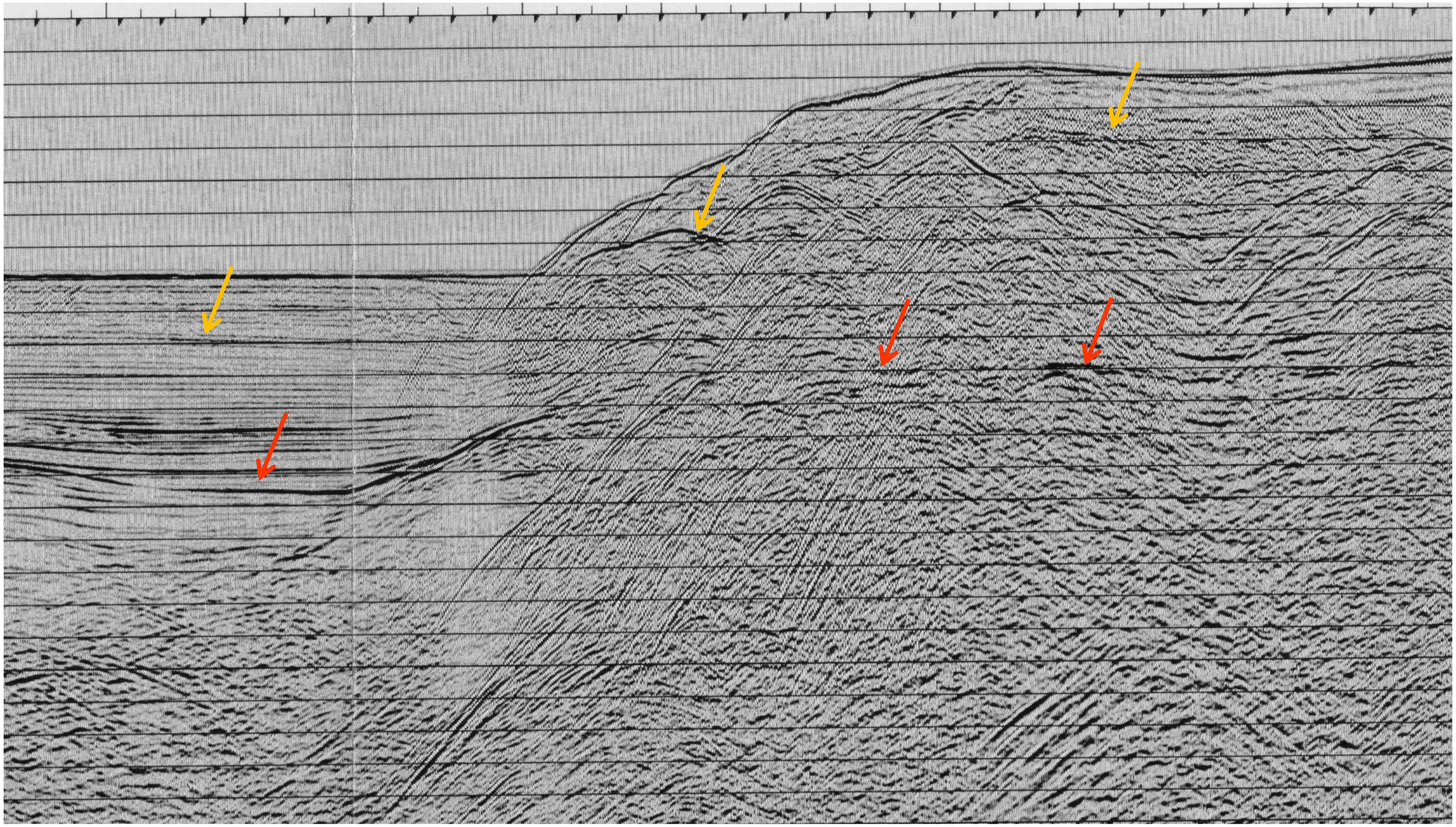




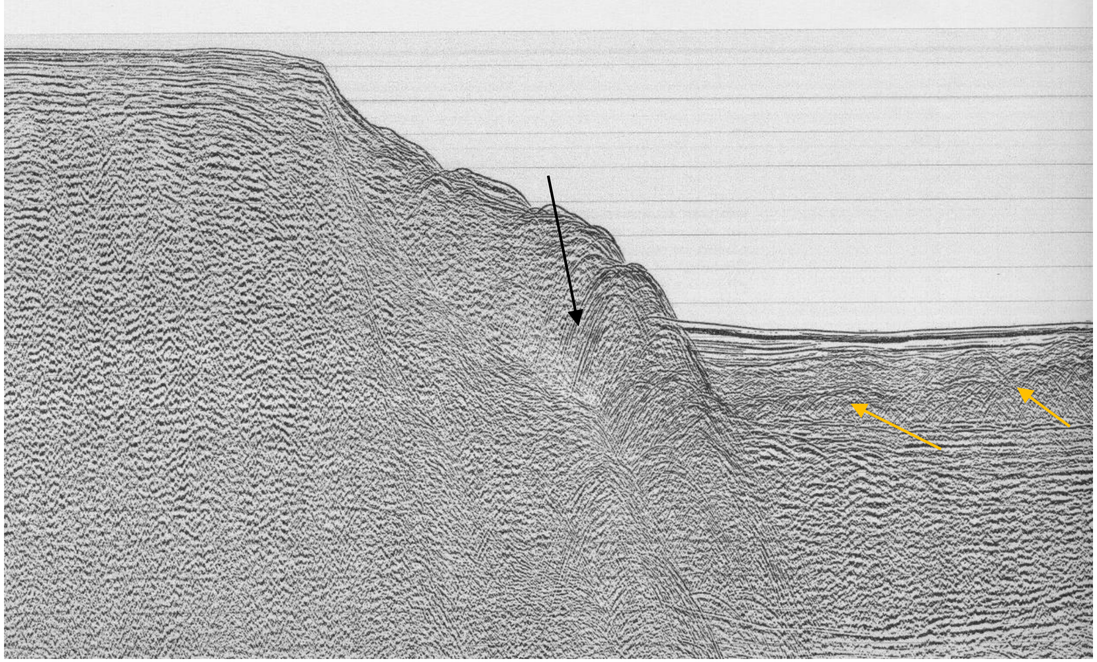


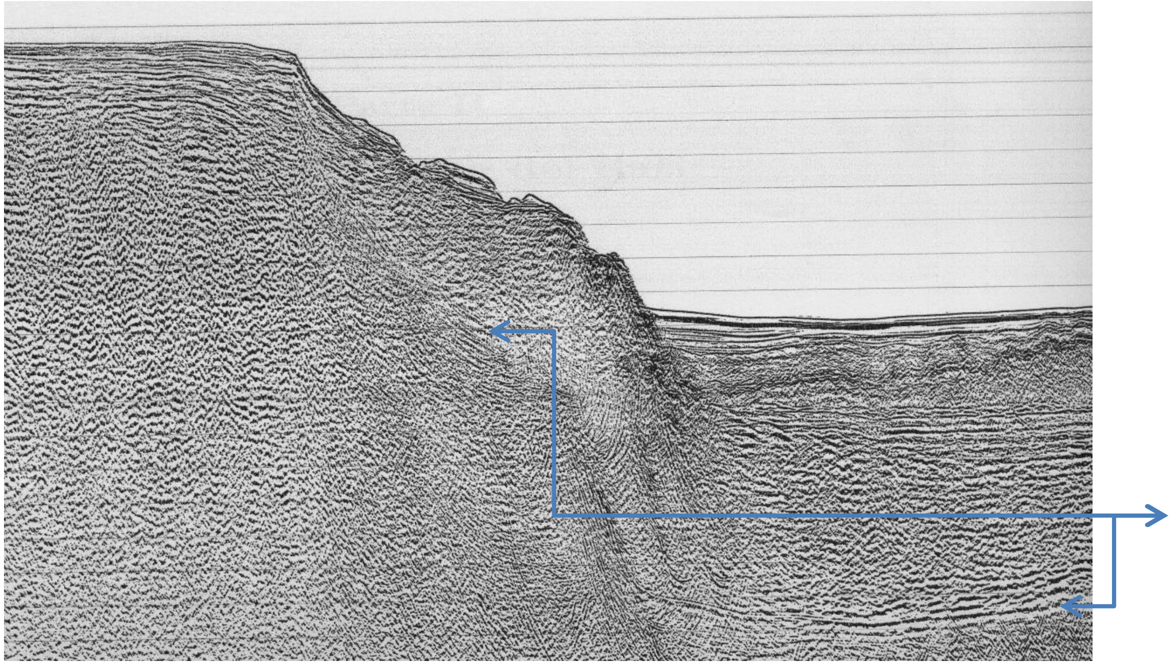


Esempio di profilo sismico attraverso il fronte della catena Calabra
nello Ionio centrale; profilo non migrato, come evidente dalle diffrazioni presenti



Esempio di profilo sismico non migrato attraverso un fronte compressivo: la sequenze sedimentaria dello Ionio è stata deformata nei *thrust* dell’Arco Ellenico. Le diffrazioni presenti a destra rendono difficile l’interpretazione dei riflettori caratterizzati da deformazioni e faglie inverse. A sinistra, nel settore meno deformato, gli stessi riflettori sono meglio evidenti..



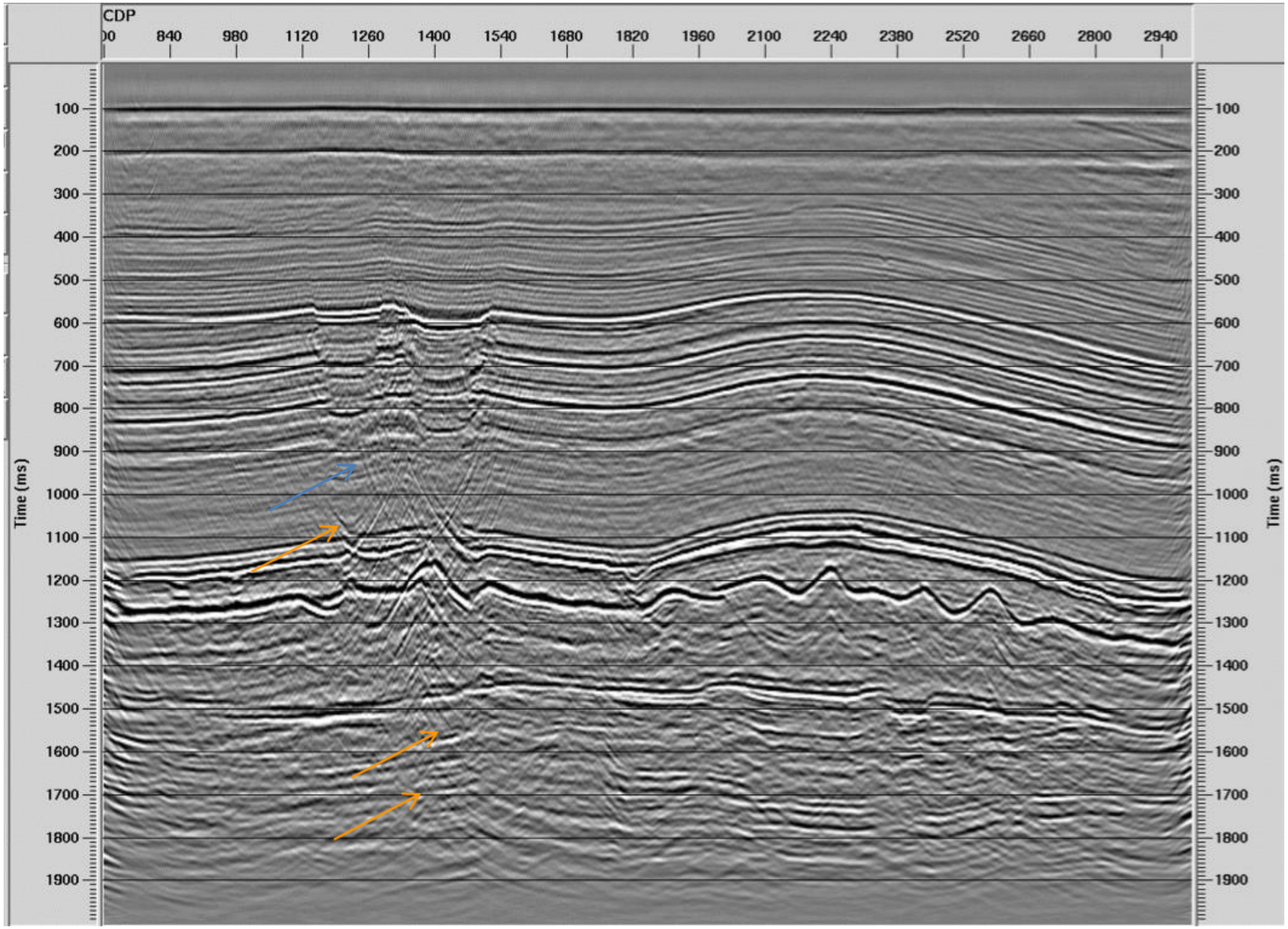


Scarpata Iblea

Esempio di profilo sismico attraverso un margine continentale interessato da un sistema di faglie normali che interrompono bruscamente la continuità dei riflettori e separano il dominio di mare basso (Canale di Sicilia) rispetto al dominio oceanico (Mar Ionio). Si possono notare numerose diffrazioni, tra cui quelle prodotte dalle deboli deformazioni delle evaporiti Messiniane.

La migrazione (sotto) ha l'effetto di portare l'energia diffratta al suo punto origine: in aree soggette a fratturazione, la frammentazione e rotazione dei blocchi spesso rende comunque ardua l'interpretazione anche in un profilo migrato.

Nell'esempio in figura anche la multipla del fondo mare rappresenta un ulteriore problema.

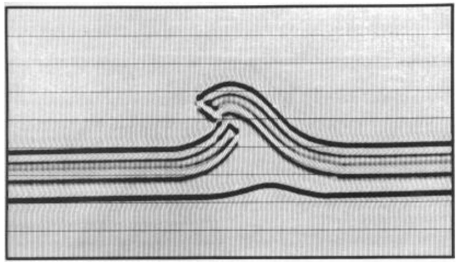


La migrazione ha lo scopo di

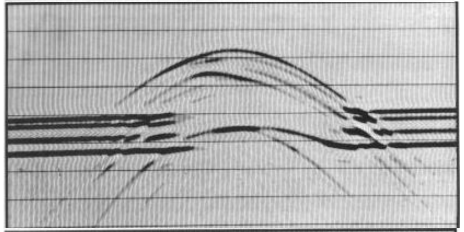
- spostare gli eventi pendenti alla loro corretta posizione
- <u>«collassare» le diffrazioni al loro punto origine</u>

Spesso si ha una «sovra-migrazione» in profondità, che origina iperboli rovesciate

Modello



Sezione sintetica stack



Sezione sintetica migrata