Sheriff and Geldart
cap. 6.3.1

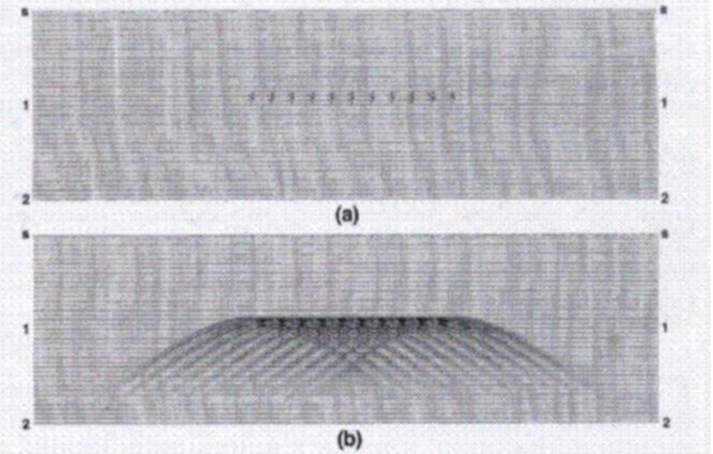
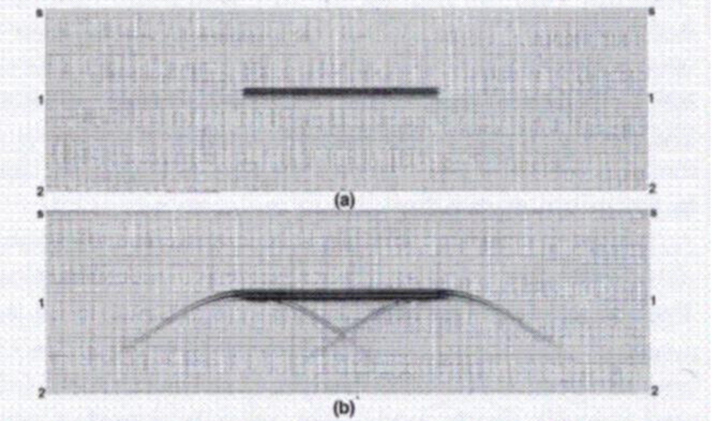
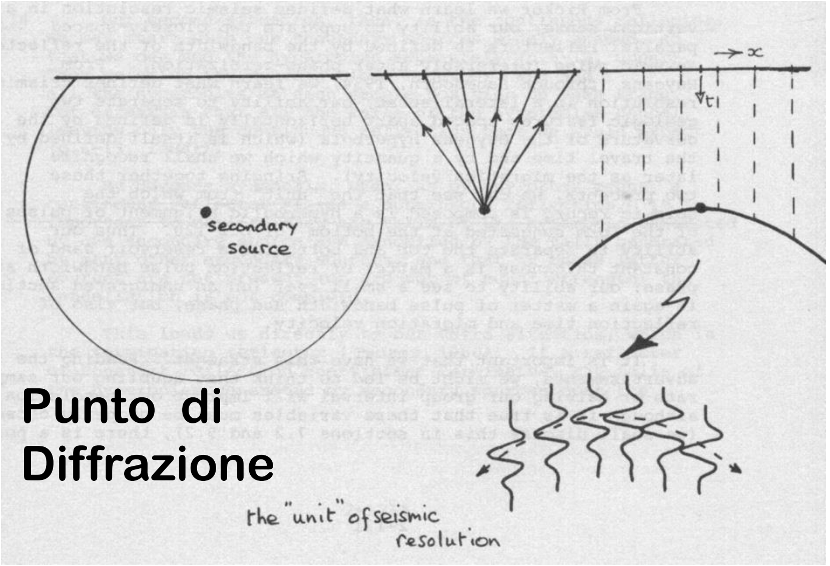



FIG. 4.1-12. Superposition of the zero-offset responses (b) of a discrete number of Huygens' secondary sources as in (a).




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

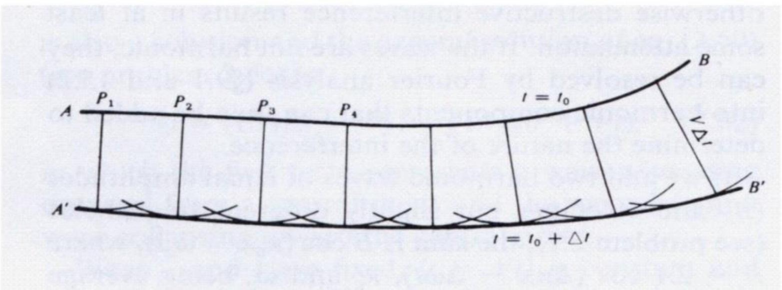


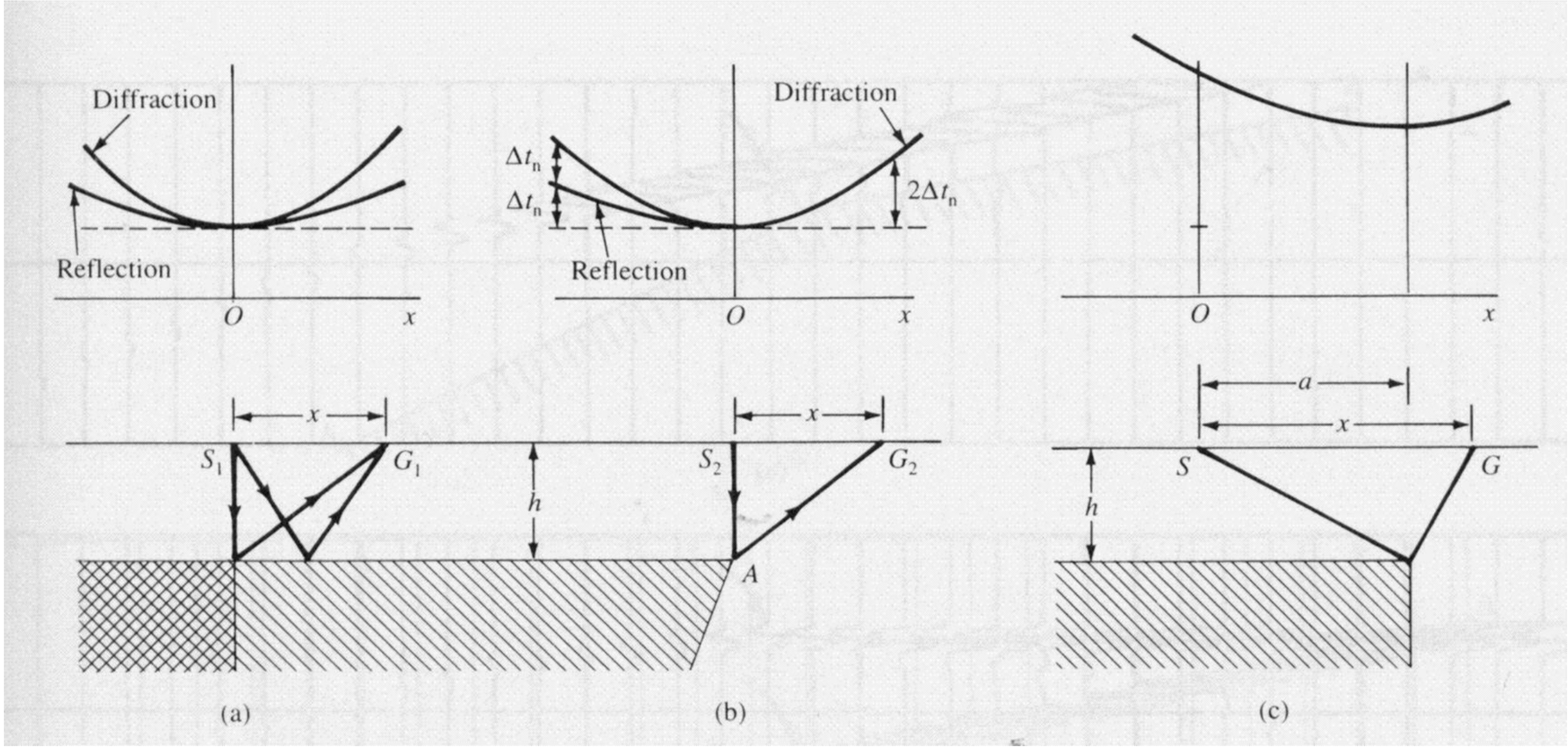

Fig. 2.8 Using Huygens' principle to locate new wavefronts.

# DIFFRACTION

One of the rays starting from a diffraction point, coincides with the **reflected ray**.

"We can say that Reflection represents a particular Diffraction 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

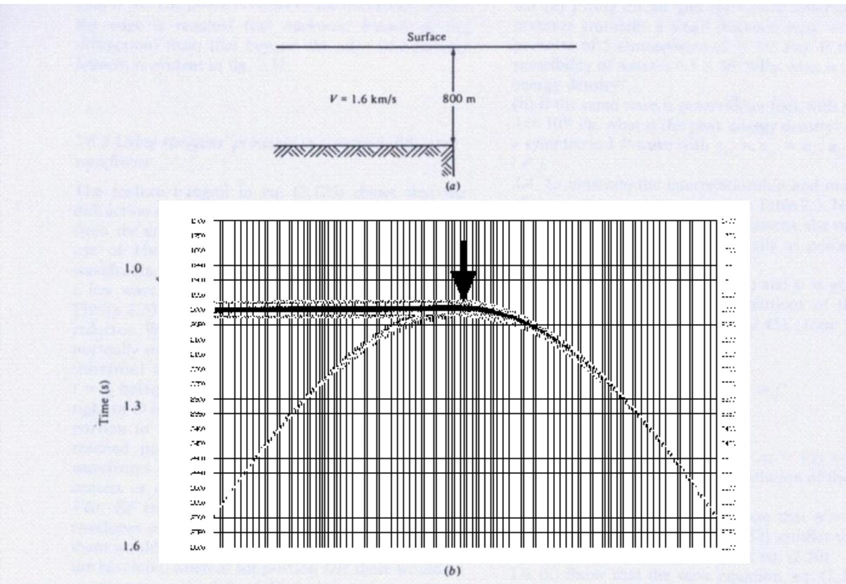
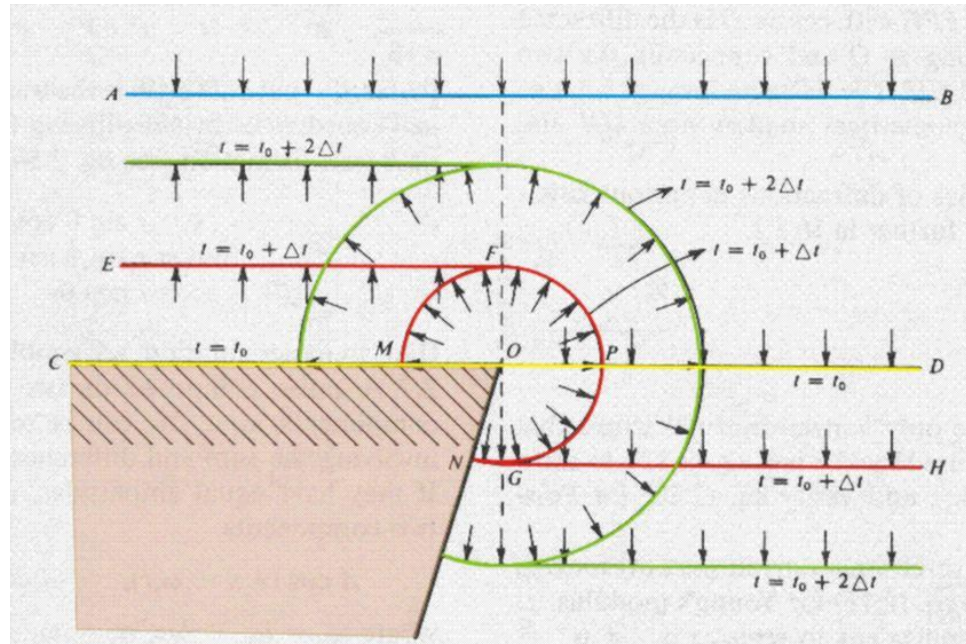



Fig. 2.32 Seismic response of a half-plane. (After Trorey, 1970.) (a) Model and (b) computed seismic record for coincident sources and geophones. The arrowhead indicates the location of the edge of the half-plane.




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 the diffraction hyperbole (figure on the left).

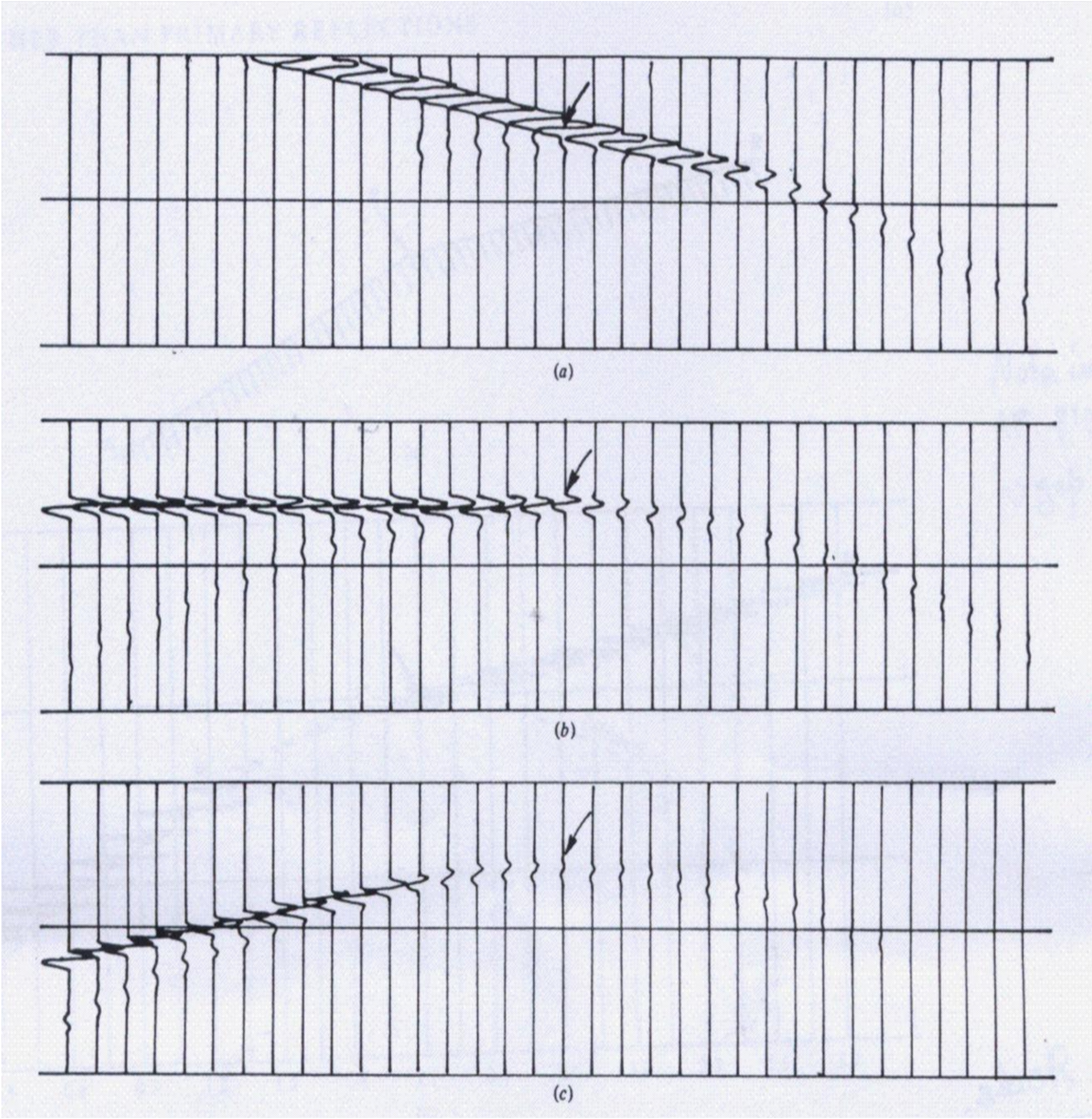
Also within the pink stratum there will be a spherical wave front (not evidenced here) with a ray t, inversely proportional to the stratum velocity.

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

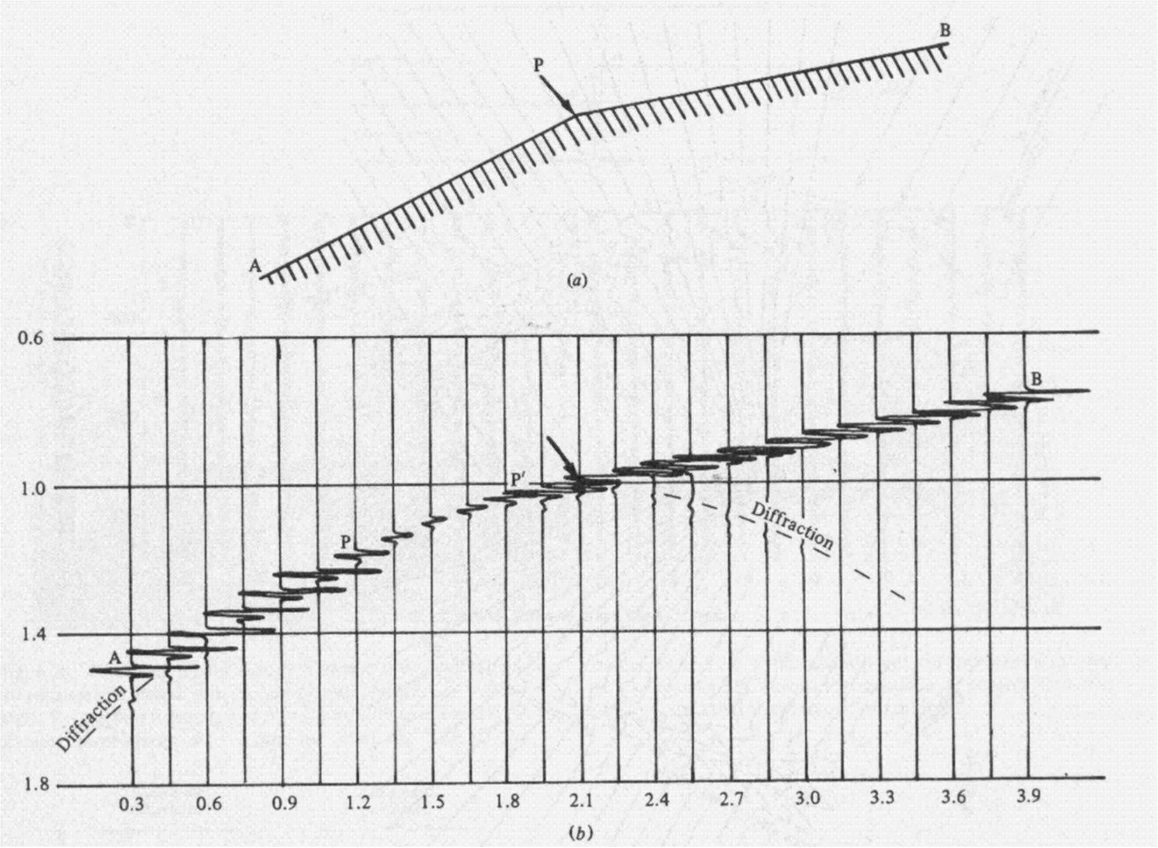
-The diffraction hyperbole is tangent to the reflector

-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.

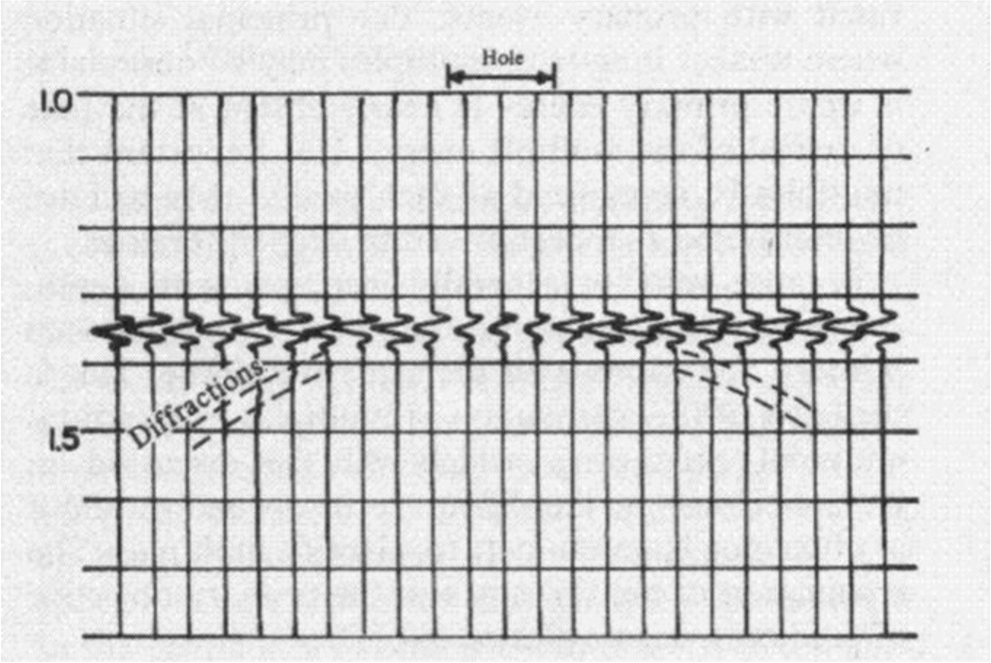


# Example with abrupt slope change




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

# Example with *hole* (local absence of Reflector)



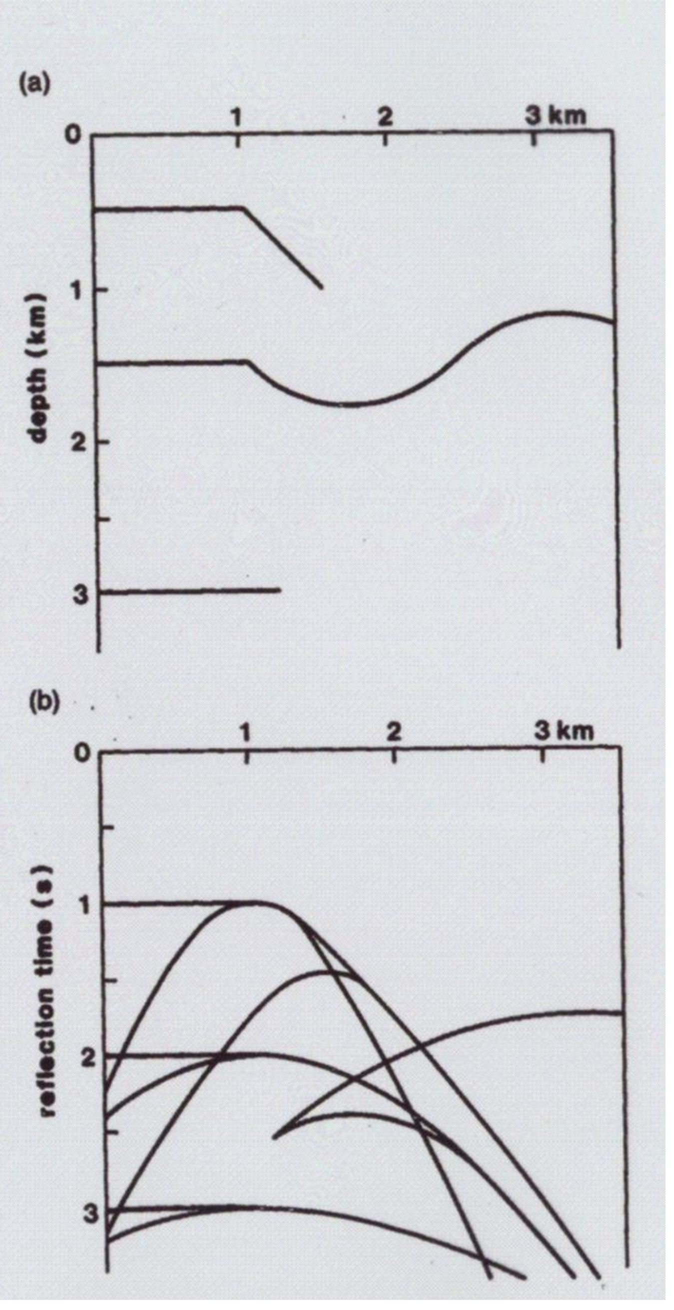

In the stacked profile, the absence of reflector is masked by presence of diffractions which shows an apparent continuous reflector.

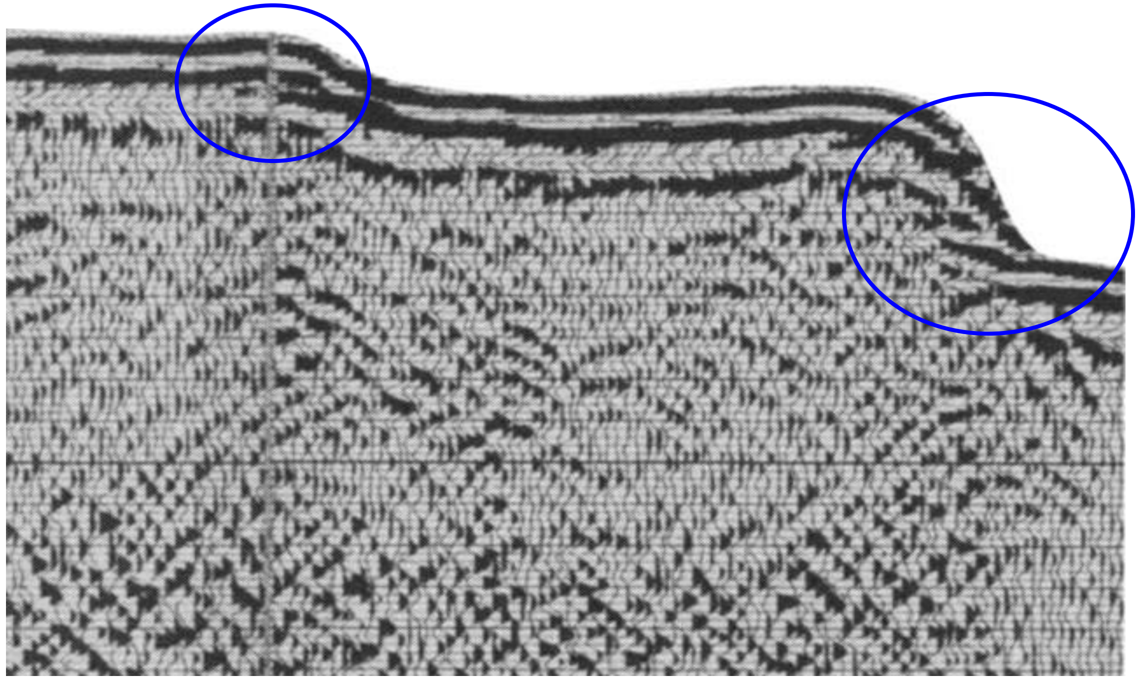
Geological meaning: erosion or non-deposition ...

What geological conditions favor the presence of diffracions?

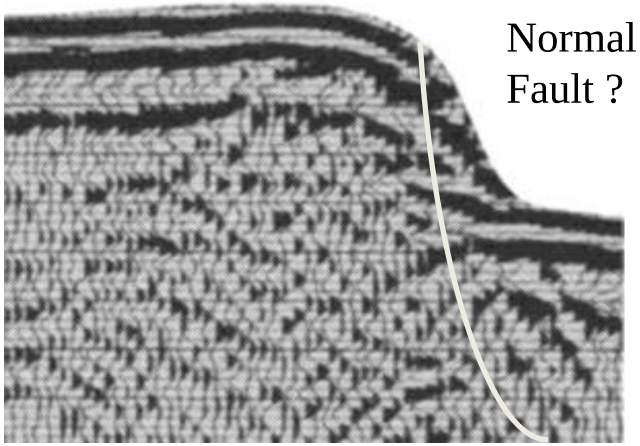
Generally, the different depositional/erosive and tectonic events that occur during the geological evolution of a basin, produce several irregularities along the stratigraphic horizons (reflectors) due to fractures, eroded surfaces, sediments accumulation, etc.

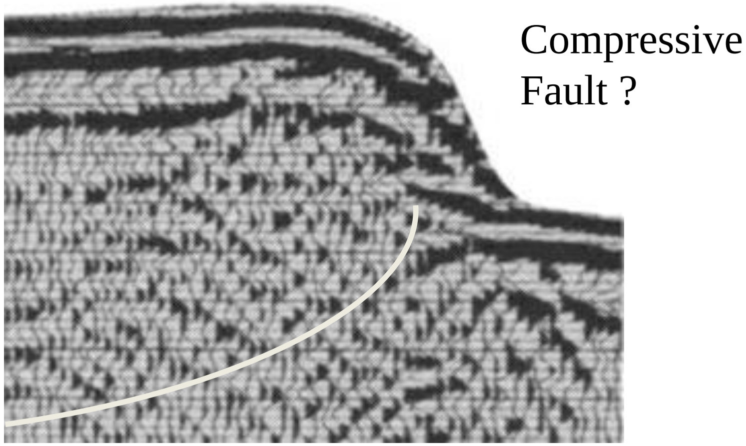
These irregularities represent points of inhomogeneity, which produce diffractions.

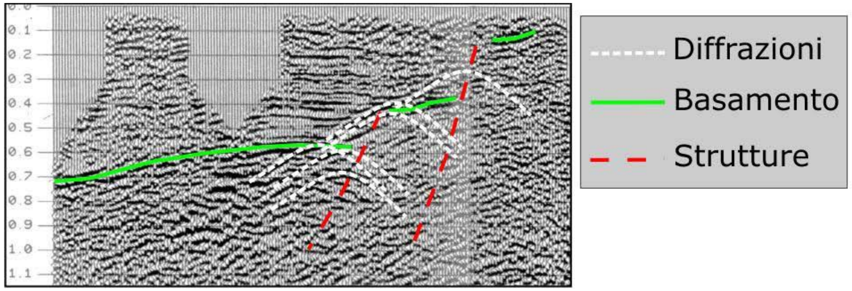


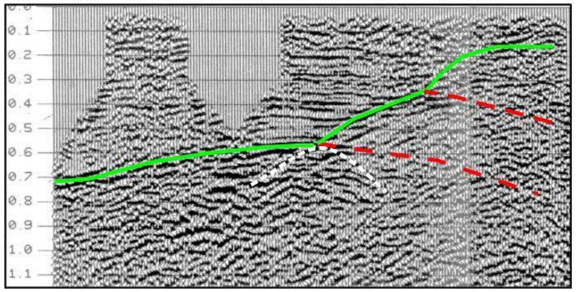


Presence of diffraction sometimes can cause some problems in interpretation: the fracture points can be not evident.
Interpretation of extensional or compressional fault could be doubtful ... ?!

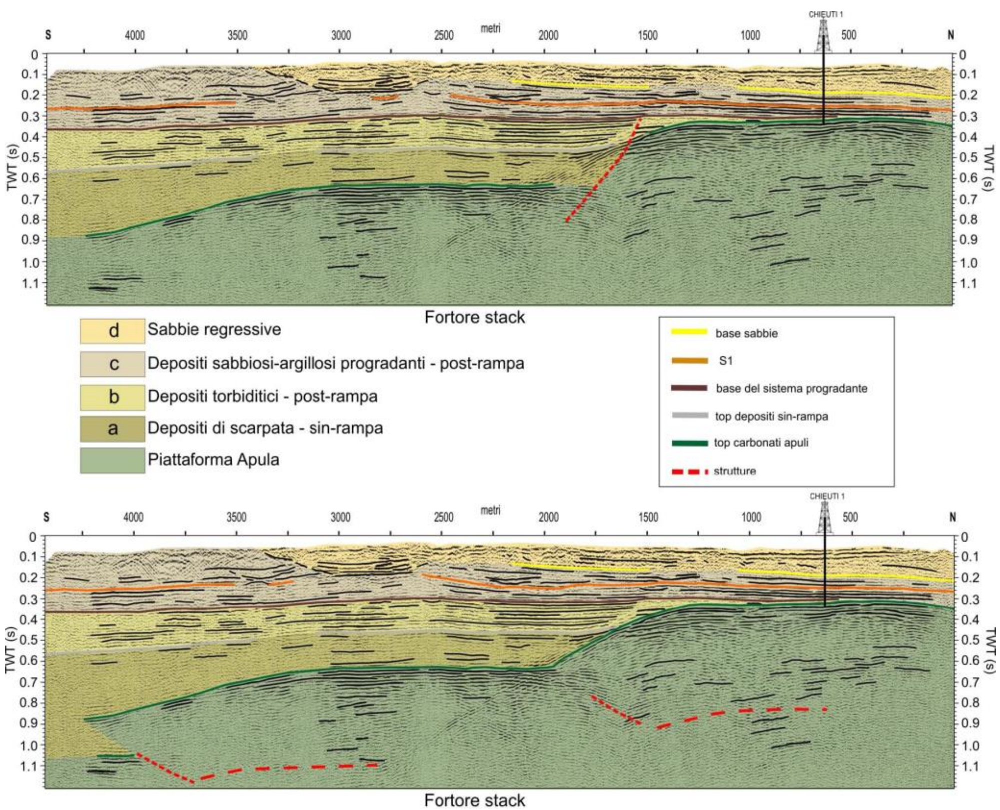




Example: part of an ENI-AGIP profile.
Top left: interpretation according to an **extensional** model, where possible diffractions are evidenced (white dashed line).
Bottom left: interpretation according to a **compressive** model (compressive faults in red).



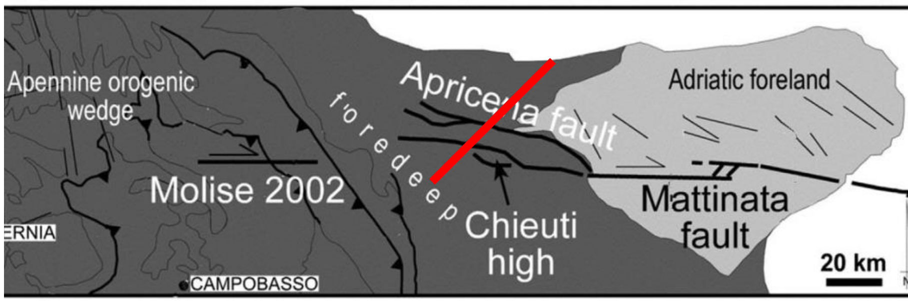




Figure on the left: *stack* profile.
Interpretation of the Apricena fault as a **transtensive** structure.

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*(by Varriale, PhD Thesis 2010-11)*

Diffractions often constitute an important noise in non-migrated profiles, which sometimes do not allow complete recognition of the primary reflectors.

The greater the number of discontinuities / irregularities in the investigated sedimentary sequence, the greater the number of diffractions.

Sometimes reflected diffractions and diffracted reflections are detectable, with complex paths. In some cases they are able to provide useful information.

Right: diffractions from reflective sedimentary wedge. The presence of diffraction means that part of the seismic energy can reach areas that could not be investigated by the reflected waves, on the basis of geometric optics (diffracted wavefront DE)

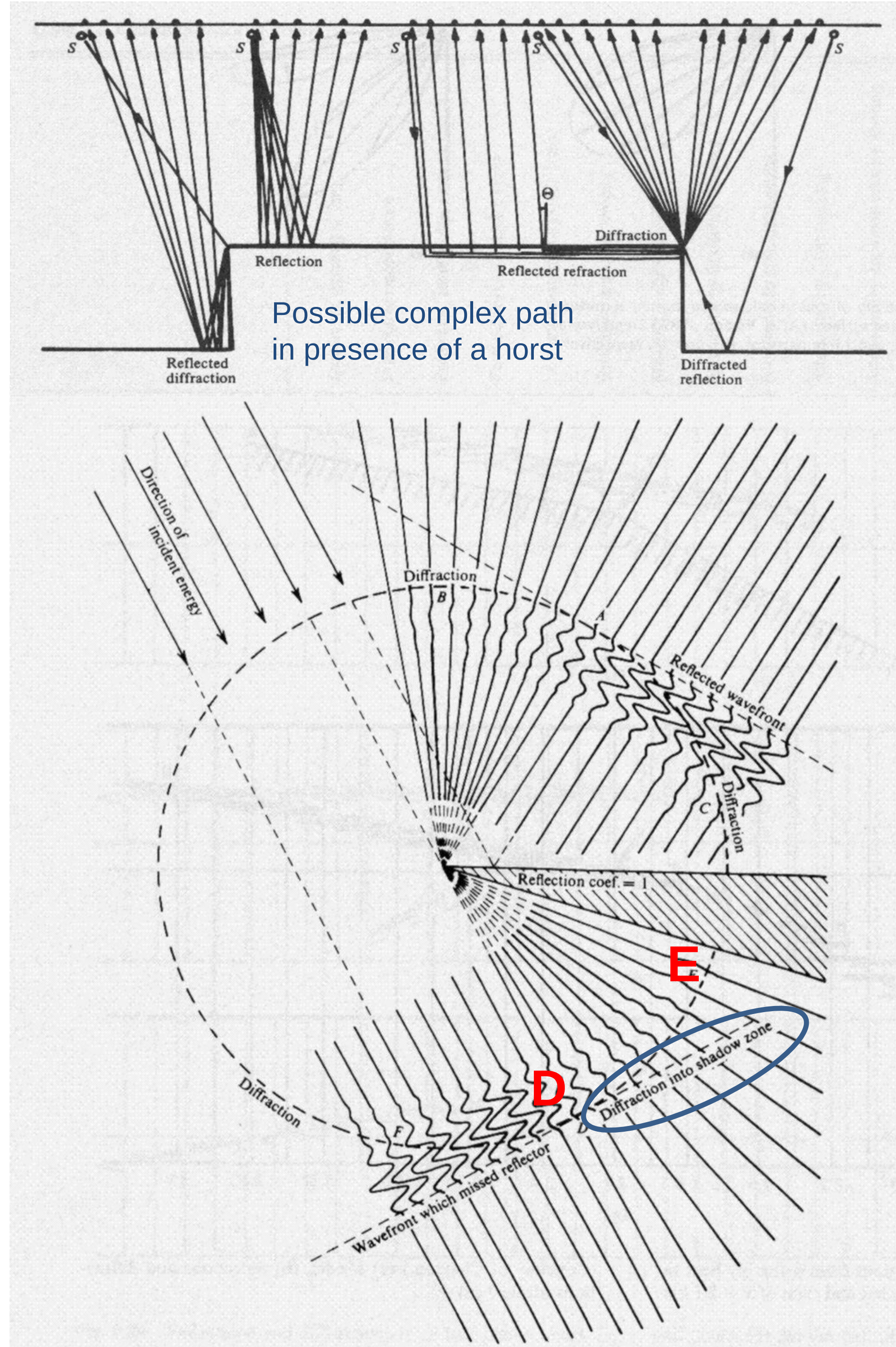
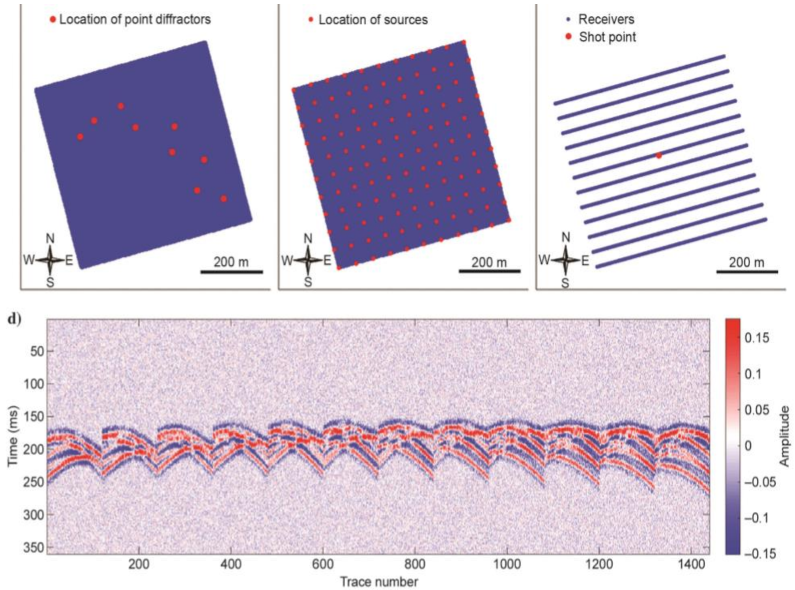


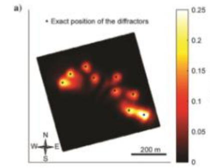
**Figure 2.** (a) Point diffractors (red dots) located at 400 m/0.16 s within the constant velocity cube of 5000 m/s, (b) location of sources used in the survey (red dots), (c) central shot (red dot) and some of the recording receiver lines, and (d) the corresponding seismic data.






# 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.

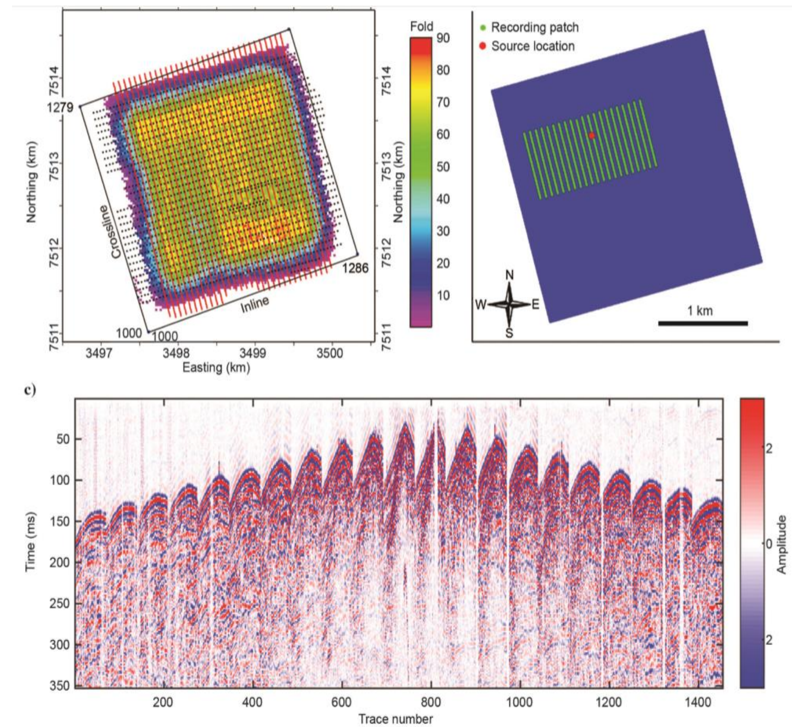
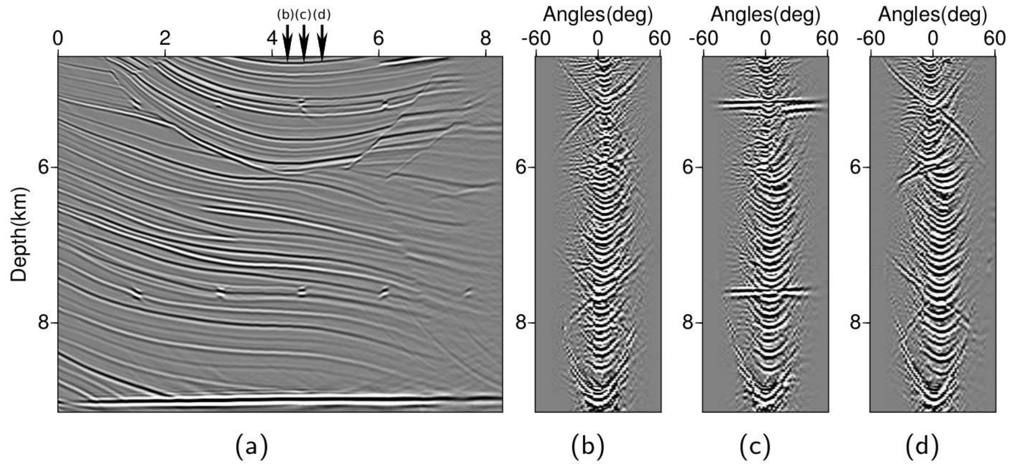
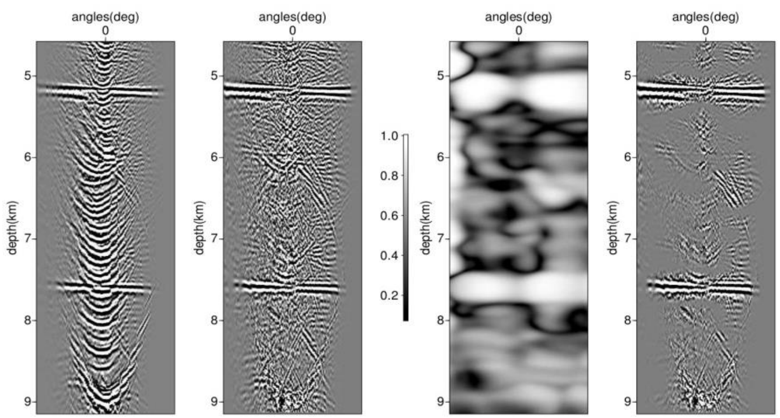



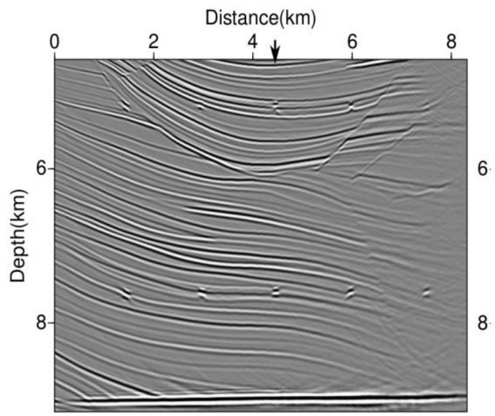

**Figure 5.** (a) Three-dimensional seismic survey and the corresponding fold map for the seismic data collected over Kevitsa Ni-Cu-PGE orebody, northern Finland (after Malehmir et al., 2012), (b) location of a shot and the corresponding recording patch within the acquisition area, and (c) the corresponding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

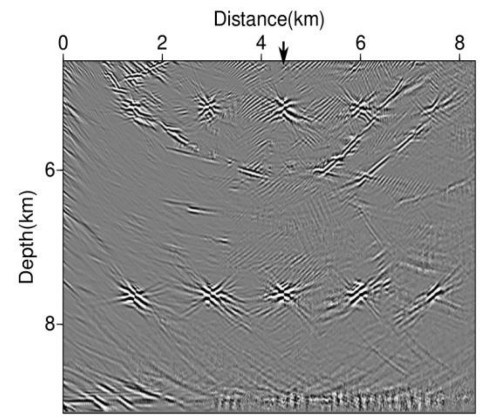
# SEPARATION AND IMAGING OF SEISMIC DIFFRACTIONS Urbano, Lipari (2013)

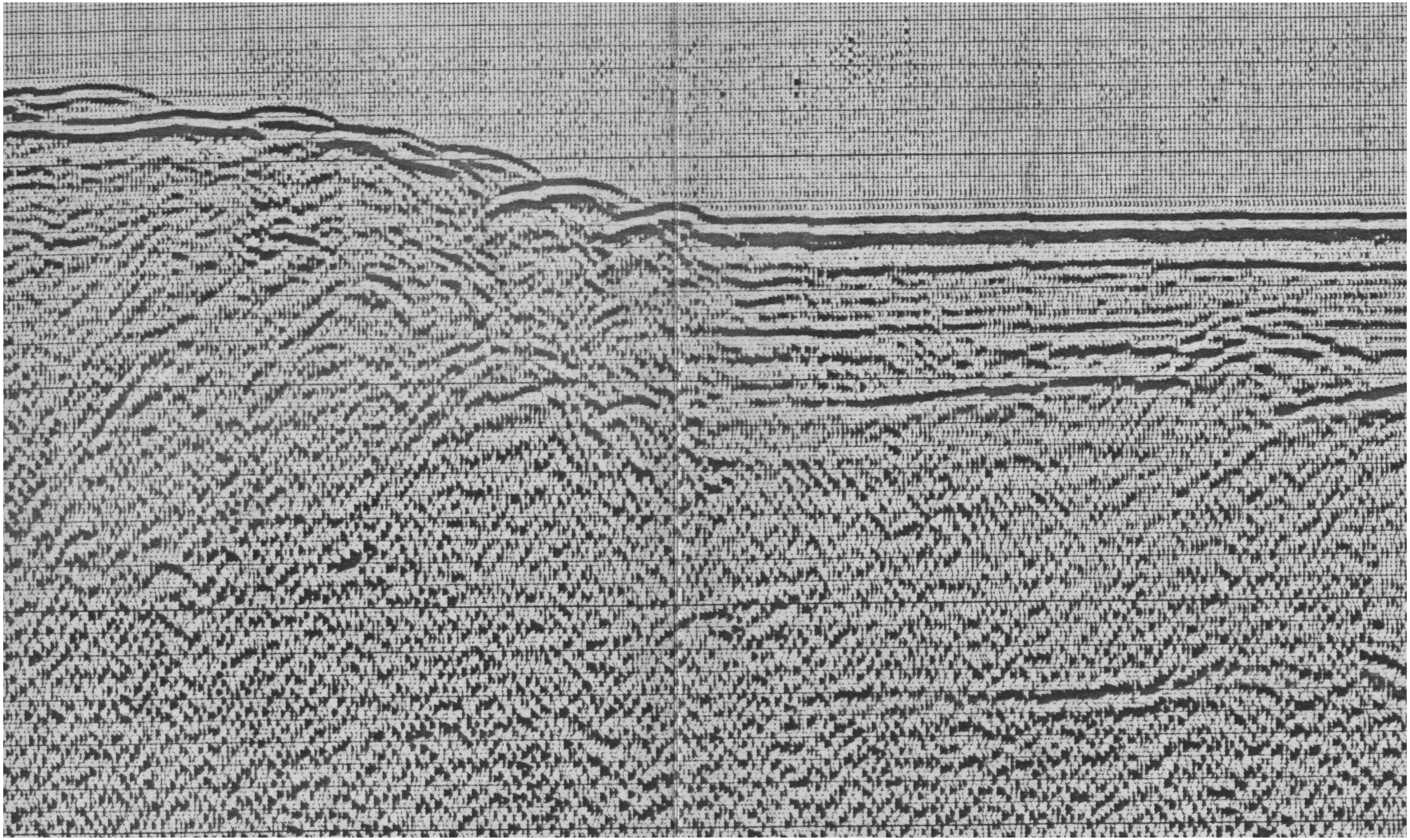
…sometimes the goal of seismic processing consists in identifying small subsurface features (e.g. faults, fractures and rough edges of salt bodies) or small changes in reflectivity.
In all these cases diffracted waves contain the most valuable information.
Dip-filtering in the post-stack migrated domain 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...





Example of seismic profile crossing the Calabria front in the central Ionian Sea; non-migrated profile, as evidenced by diffractions…

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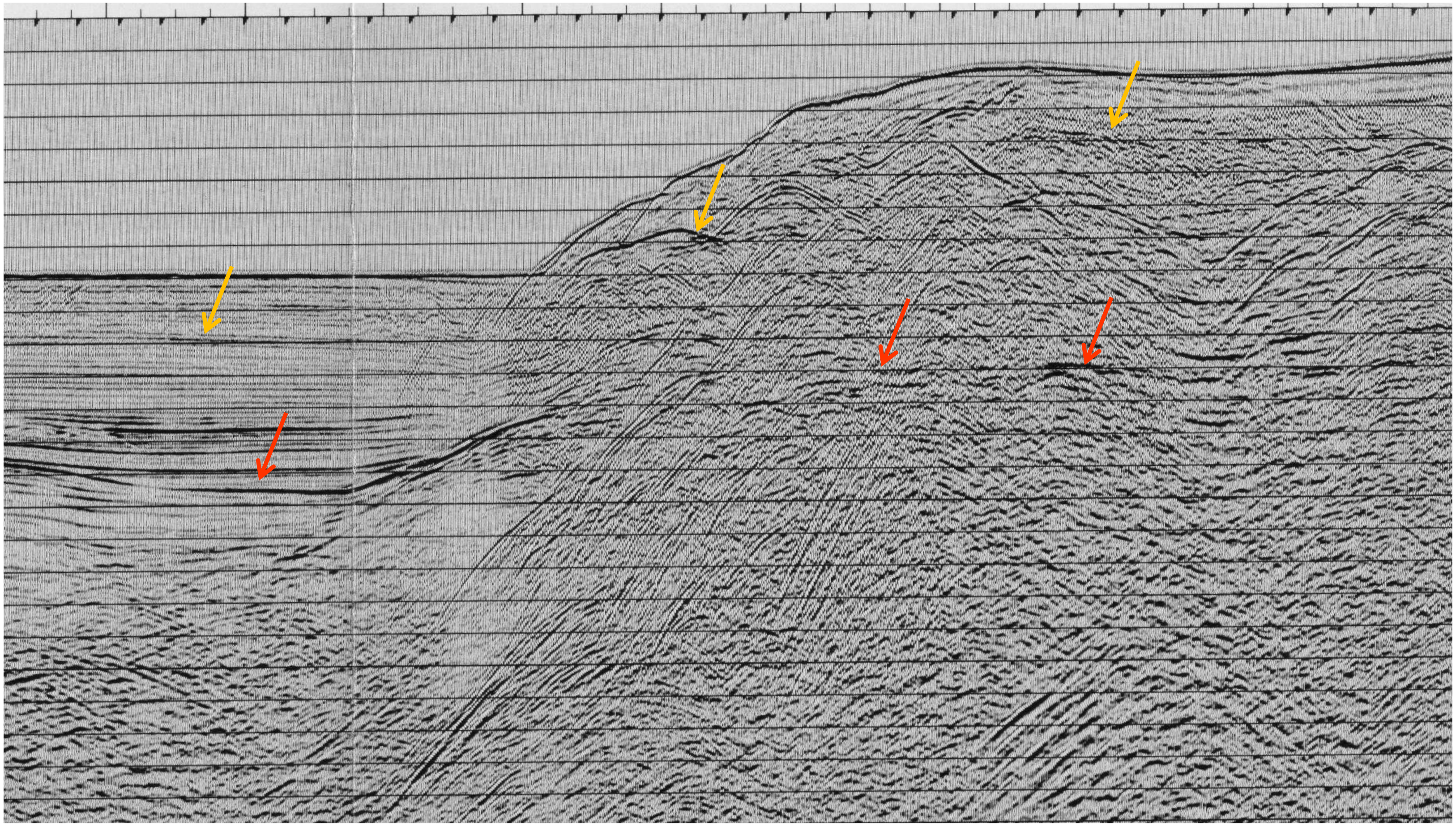
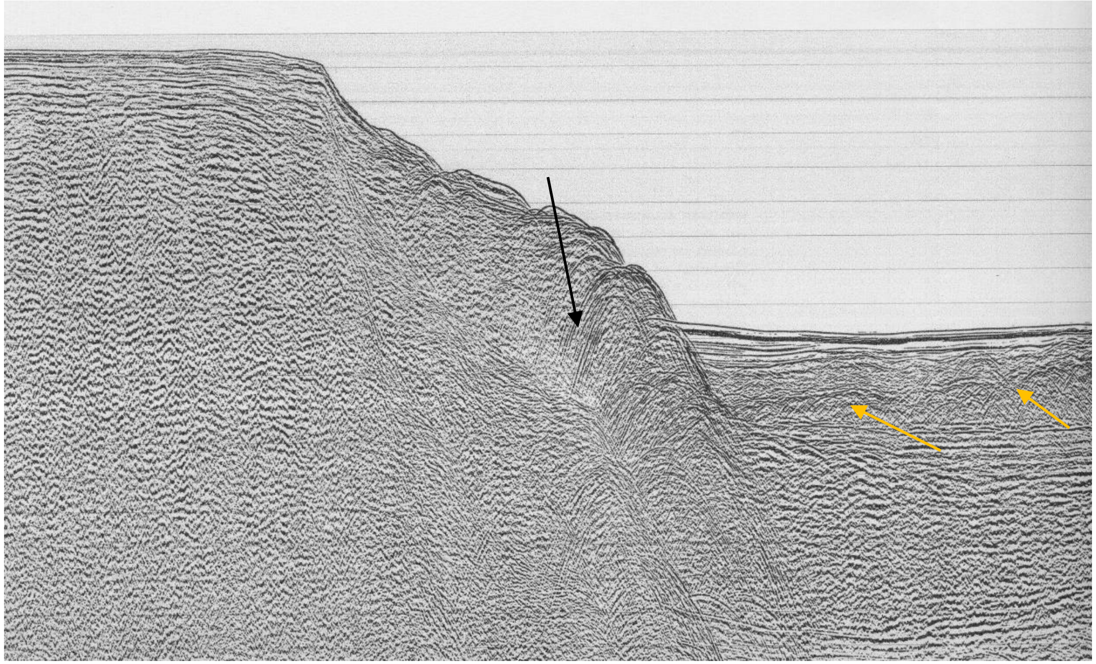
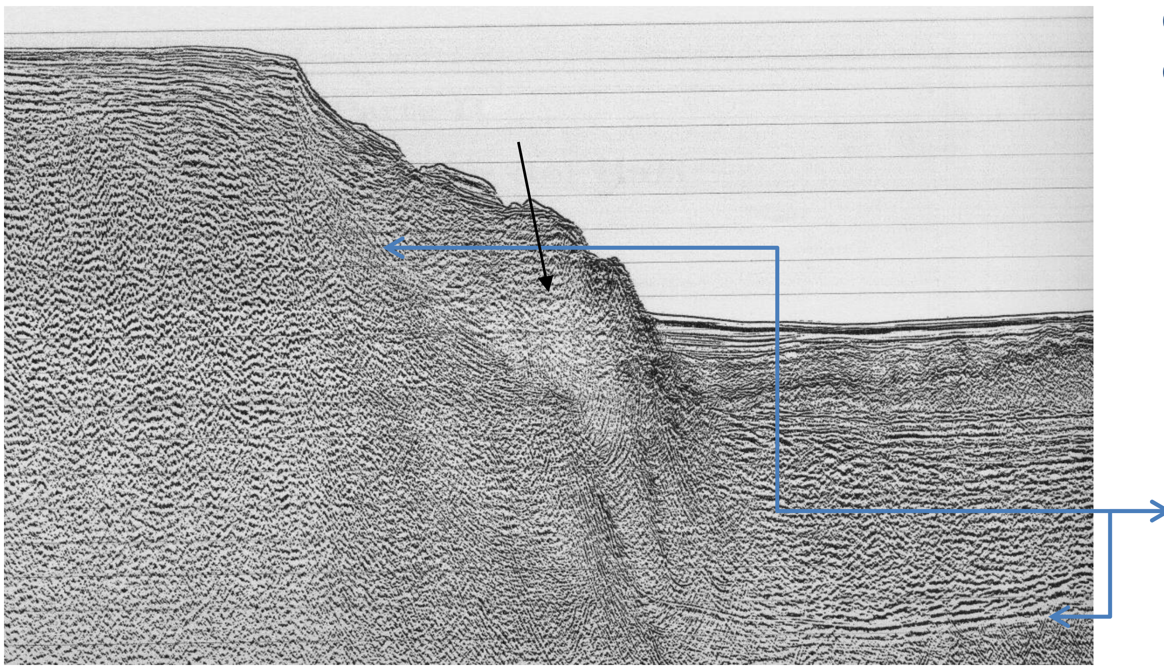


Example of a non-migrated seismic profile that crosses a compressive front: the sedimentary sequences of the Ionian Sea have been deformed by the thrusts of the Hellenic Arch. The diffractions on the right make it difficult to interpret the reflectors which are characterized by deformations and reverse faults. On the left, in the less deformed sector, the same reflectors are more evident ..

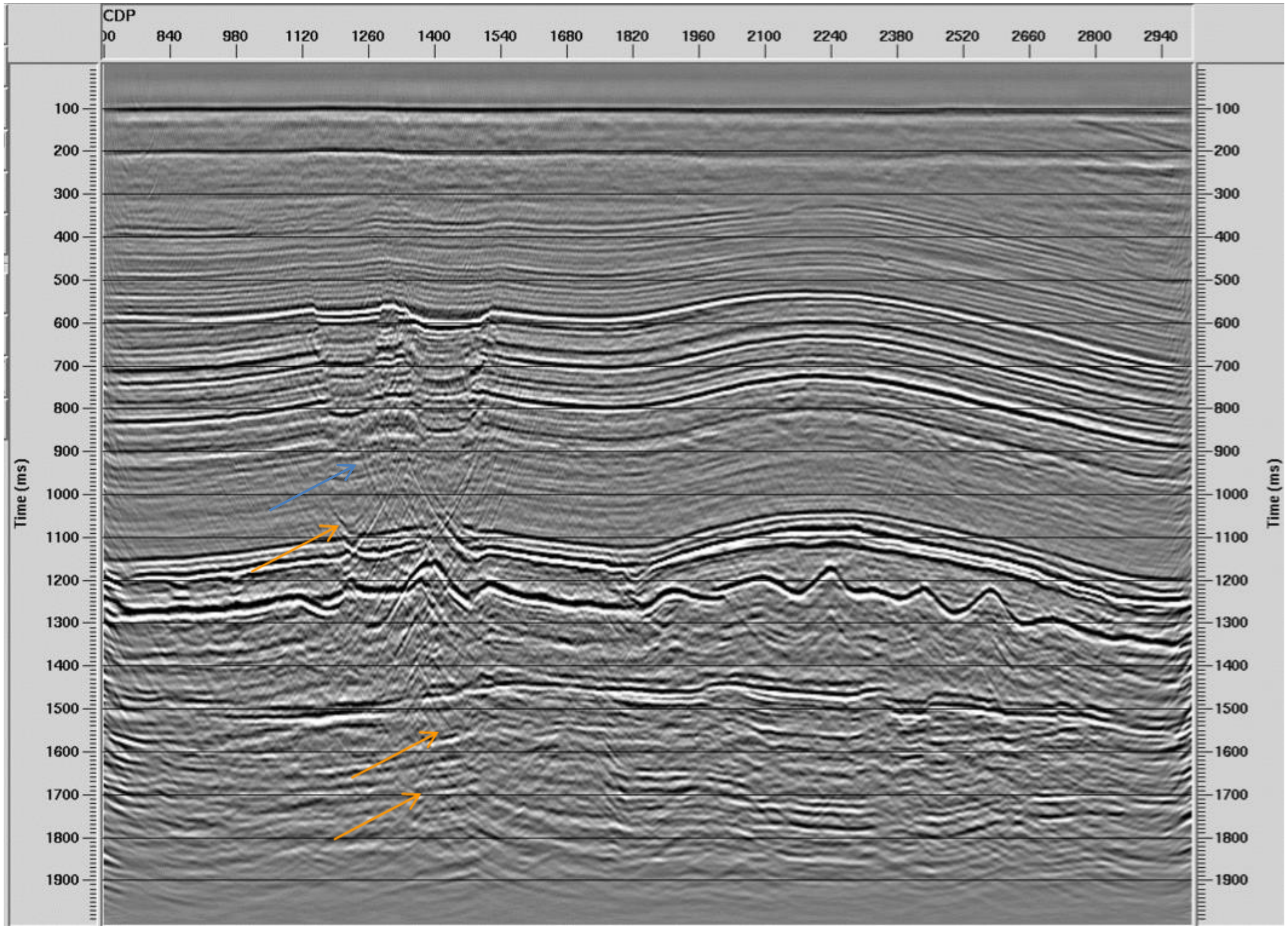




## Hyblean escarpment

Example of a seismic profile that crosses a continental margin affected by a system of normal faults that abruptly interrupts the continuity of the reflectors and separate the shallow water domain (Sicily Channel) from the oceanic domain (Ionian Sea). Numerous diffractions can be noted, including those produced by the weak deformations of the Messinian evaporites (yellow arrows).

Migration (below) has the effect of bringing the diffracted energy to its point of origin: in areas subject to fracturing, fracturing and rotation of the blocks often makes interpretation difficult even in a migrated profile. In the example of figure, even the multiple of the seabed represents a further problem.




Migration aims to :

- Move the deepening reflectors to the correct position;
- <u>«collapse» the diffractions to their points of origin.</u>

Often, «over-migration» will occur in the deepest part of the profile as inverted hyperbolas.

**Model**

**Stack synthetic profile**

**Migrated synthetic profile**