Hanging reflectors and lateral variations of velocity

Hanging reflectors can heavily alter the correct interpretation of a seismic profiles.

With **time migration**, errors of position and slope of the hanging reflectors are reduced (2D) or eliminated (3D). Anyway, we have to consider that vertical scale is in TWT.

Only by applying the **depth migration** the signal distortions due to lateral variations of velocities will be corrected. Such distortions can / must be recognized and evaluated along the stack profile or the time migrated profile.

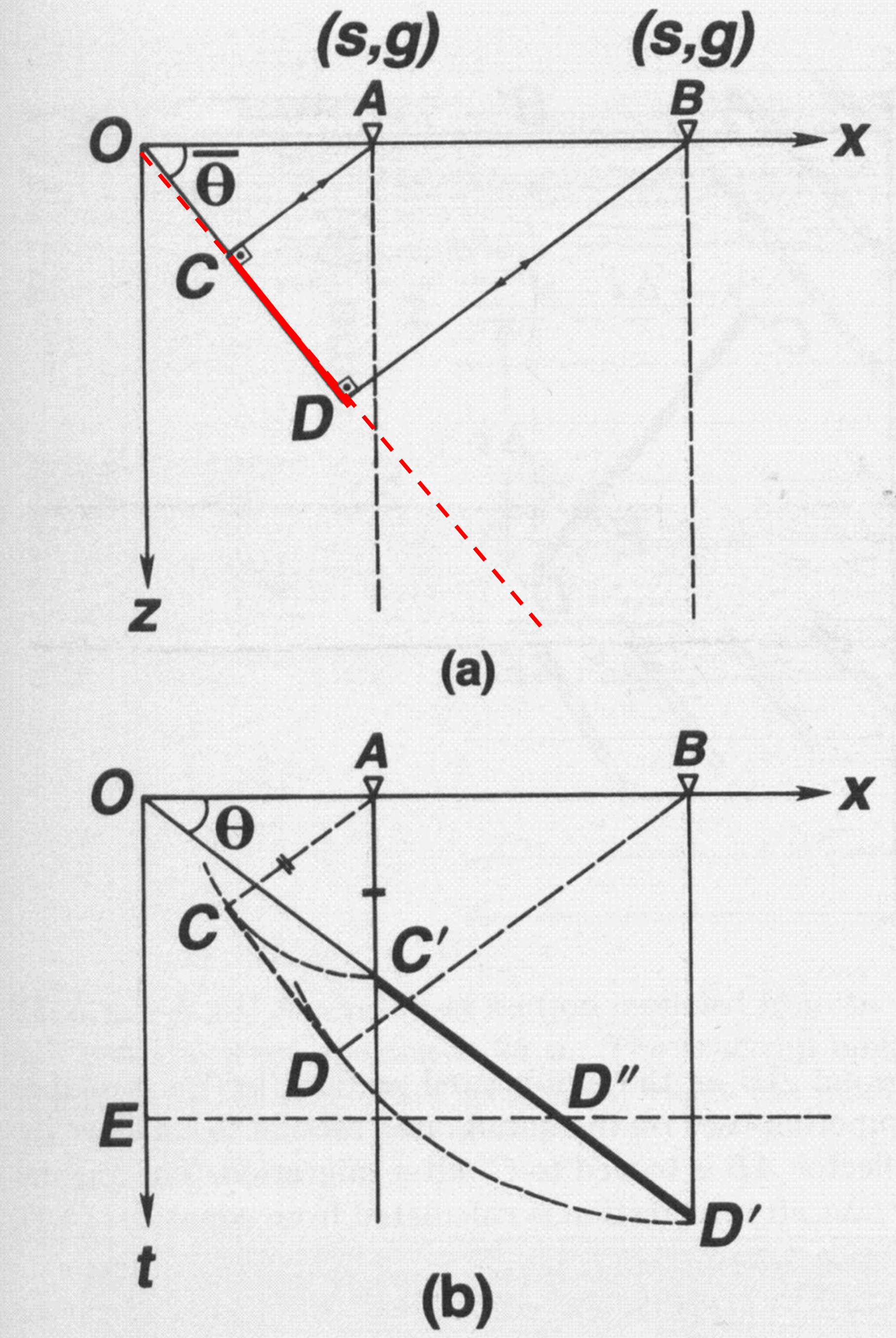
A hanging reflector will be observed by seismic reflection in a different position than its real position;

also its lenght and inclination will be different.

Along the seismic profile

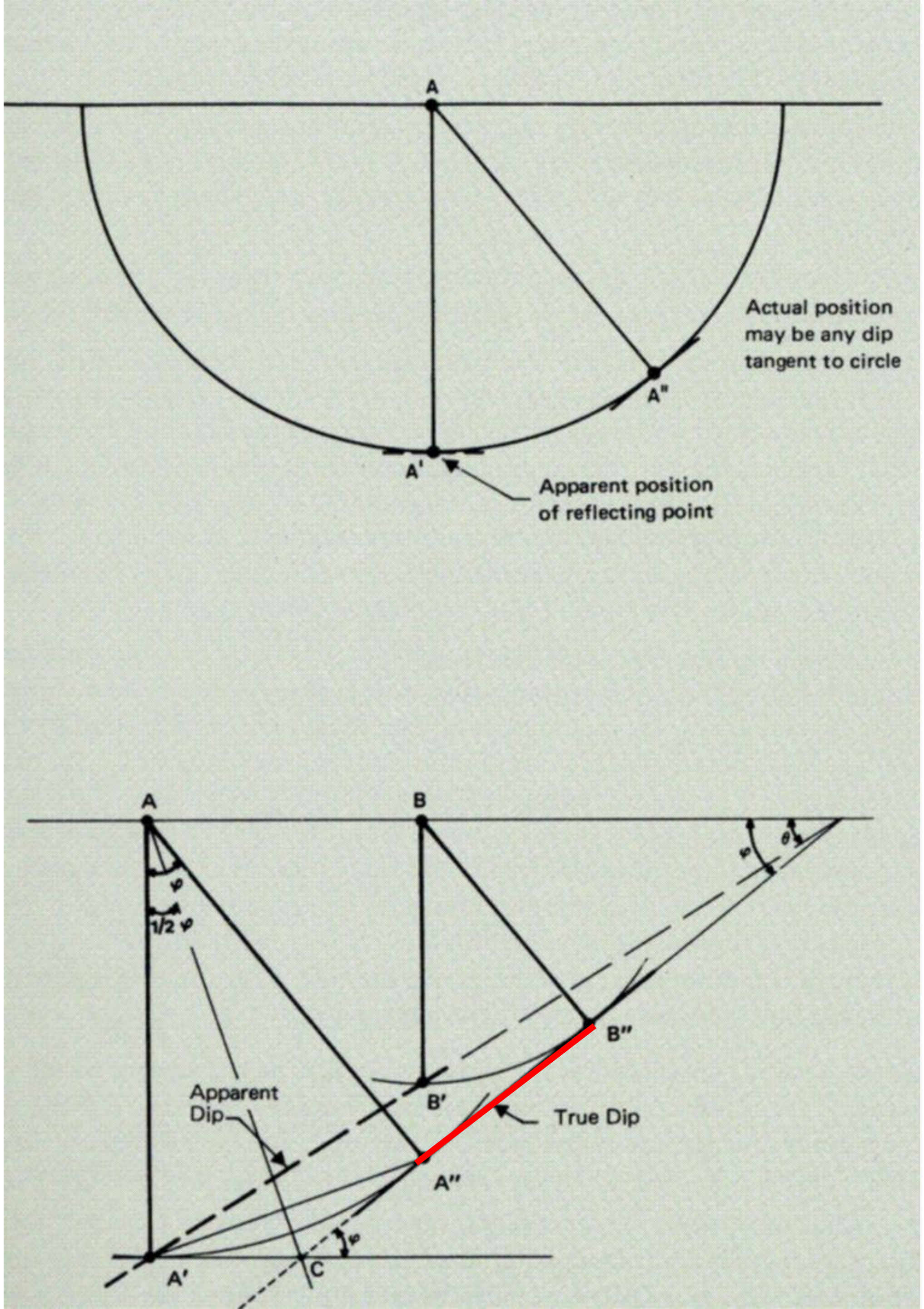
Lungo il profilo sismico

(x axis) the real reflector CD will be observed in the C'D' position and inclintion.

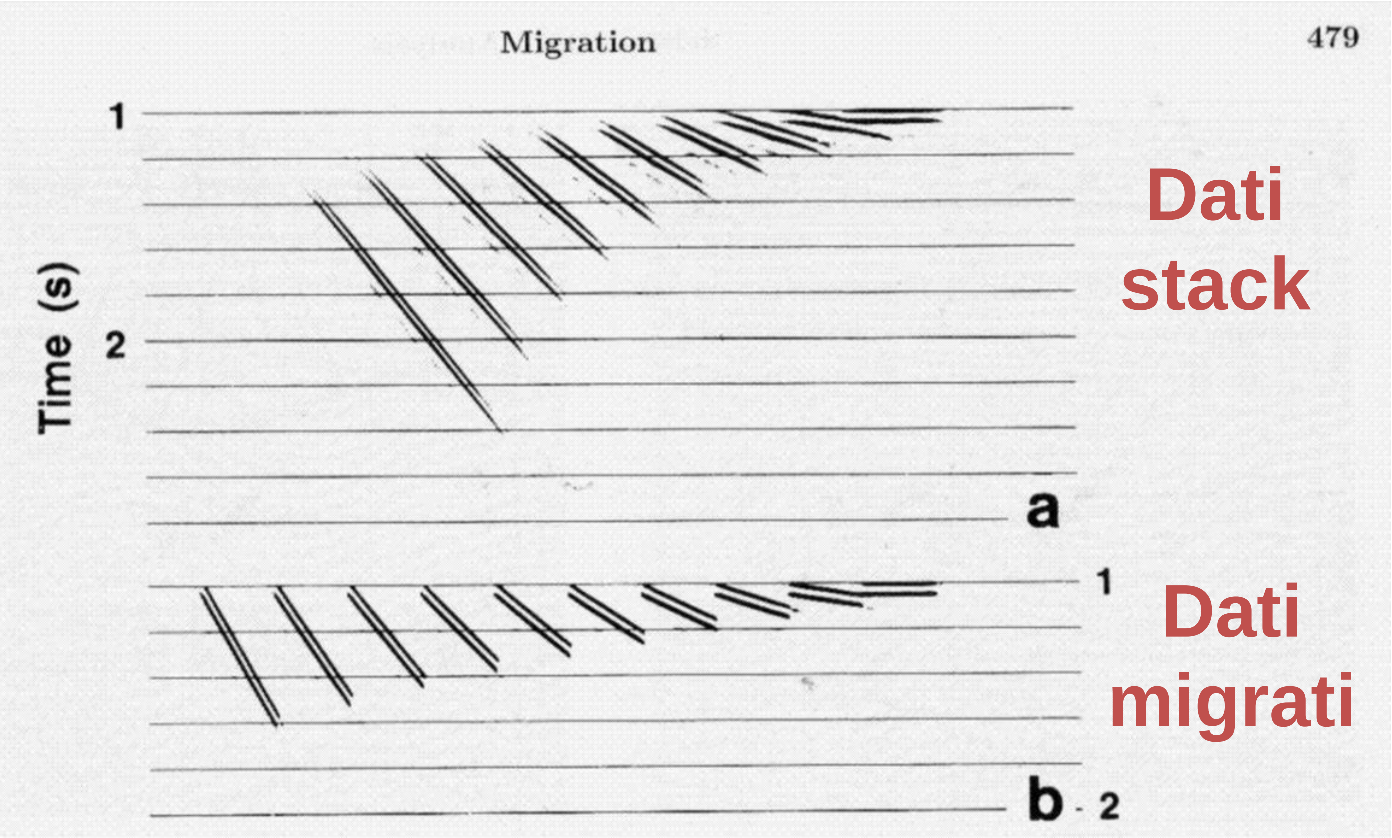


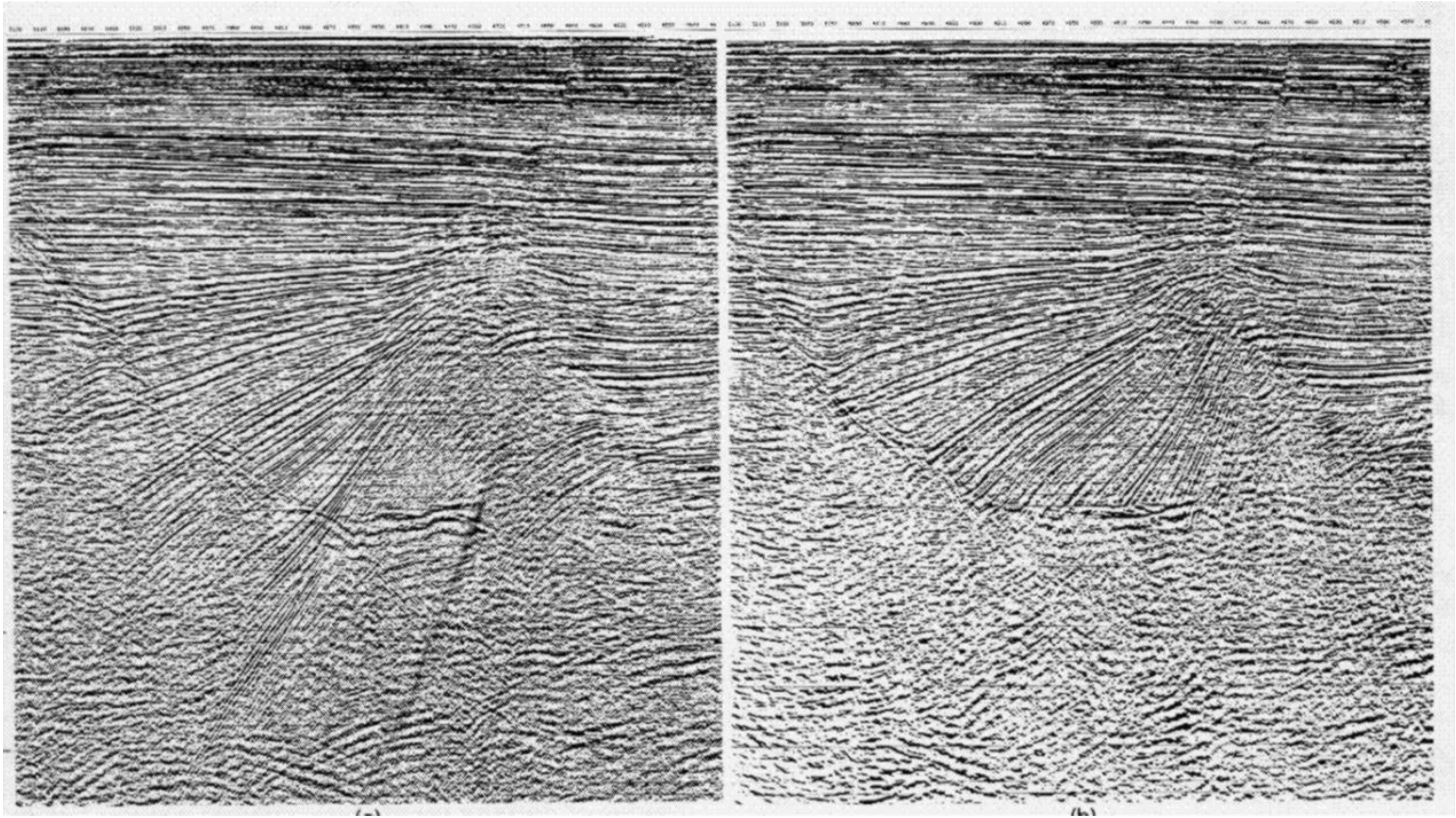
The <u>migration</u>
has the principal aim to
move the hanging reflectors
in their **real position**:

- more hanging
- further back
- less deep
- shorter



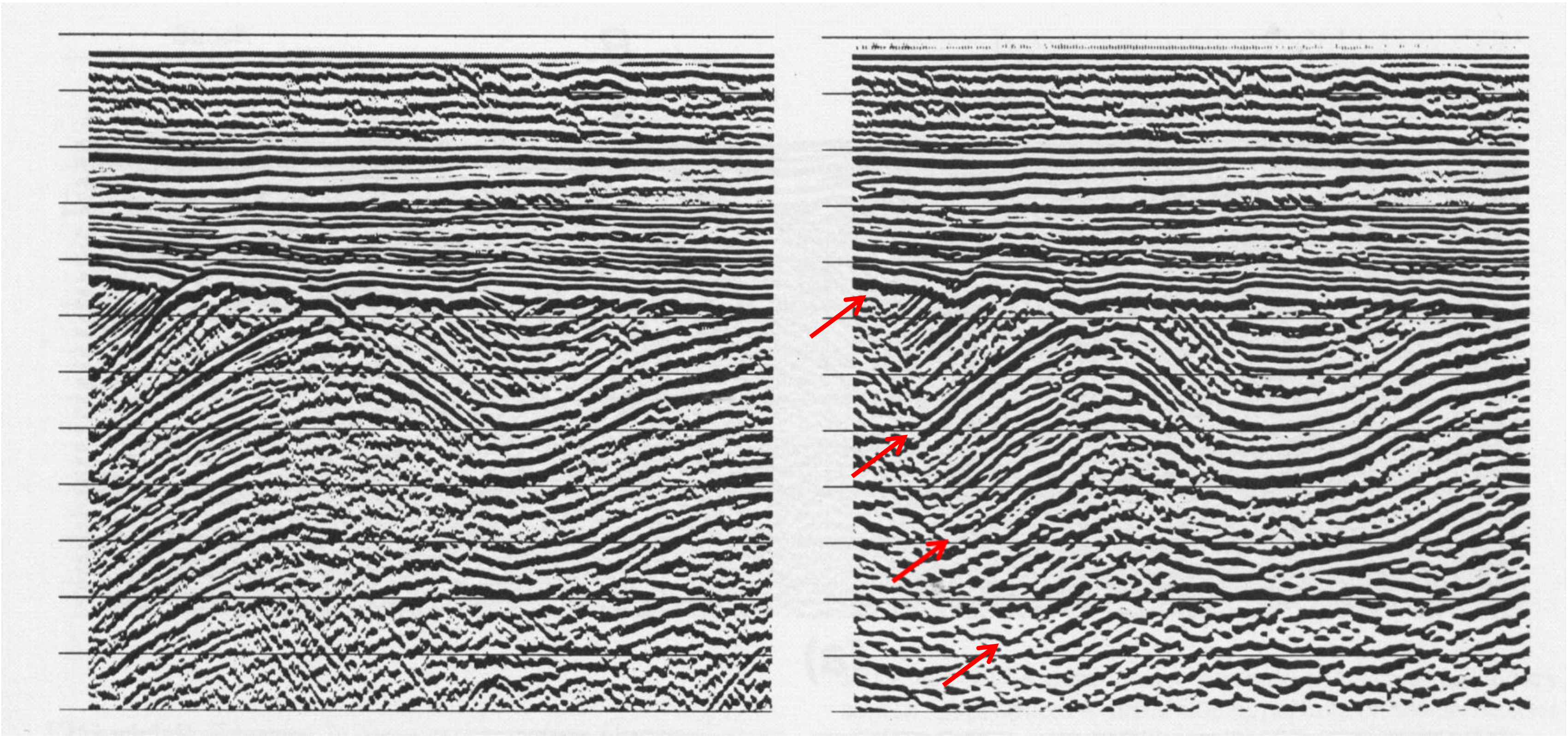
Example from a model with hanging reflectors from 0 to 45° with step of 5°





In this example the (2D) migration has moved the hanging reflectors toward their correct position.

Example of Migration



Further than the correct position of the reflectors, migration allowed to recognize (↗) the normal fault that originated the block rotation.

Fig. 2.

This is a full offset stack section of a proprietary data line, which is a dip line across a major fault. The stratigraphy is annotated to highlight the major growth intervals. Note the area of shallow gas and associated multiples between shotpoints 400 and 440.

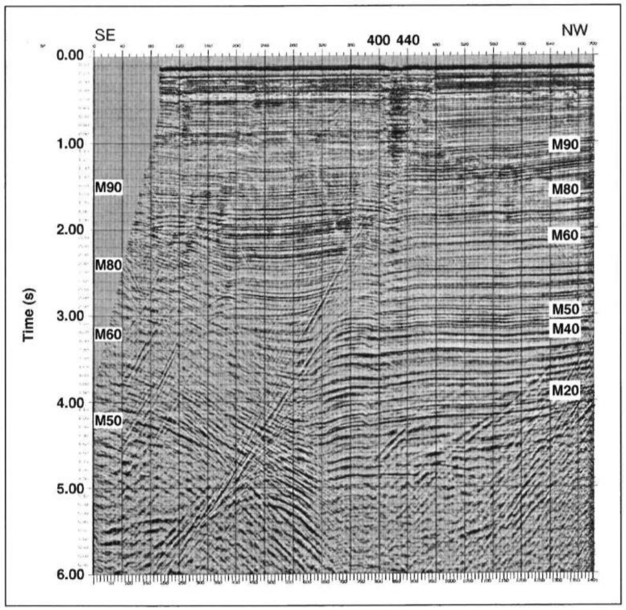
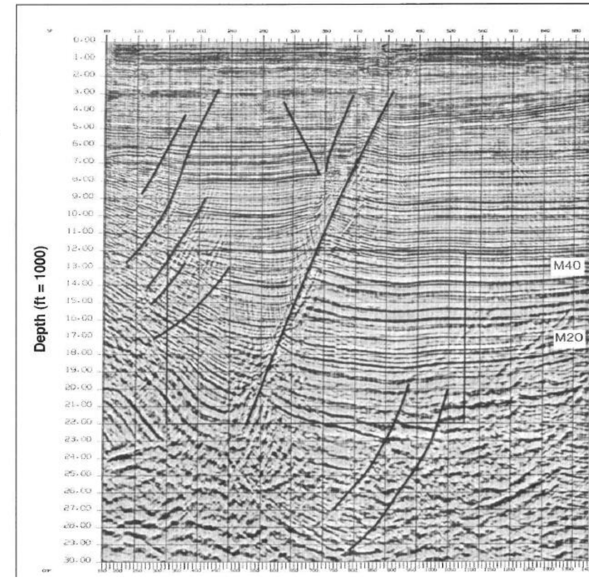
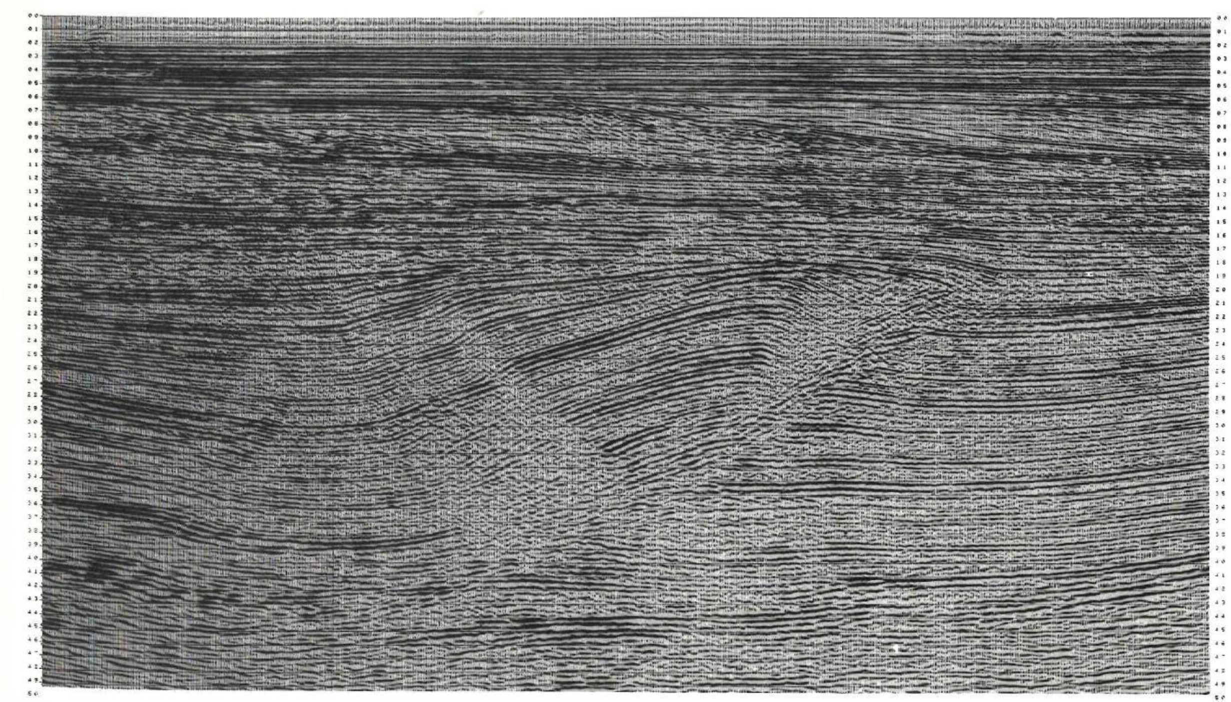


Fig. 16.

This is the poststack depth migration generated using the derived velocity model (Fig. 16). A comparison with Fig. 14 shows improved imaging of the M20 in the vicinity of the fault, and significant enhancement in imaging below M20.



MIGRATED STACK

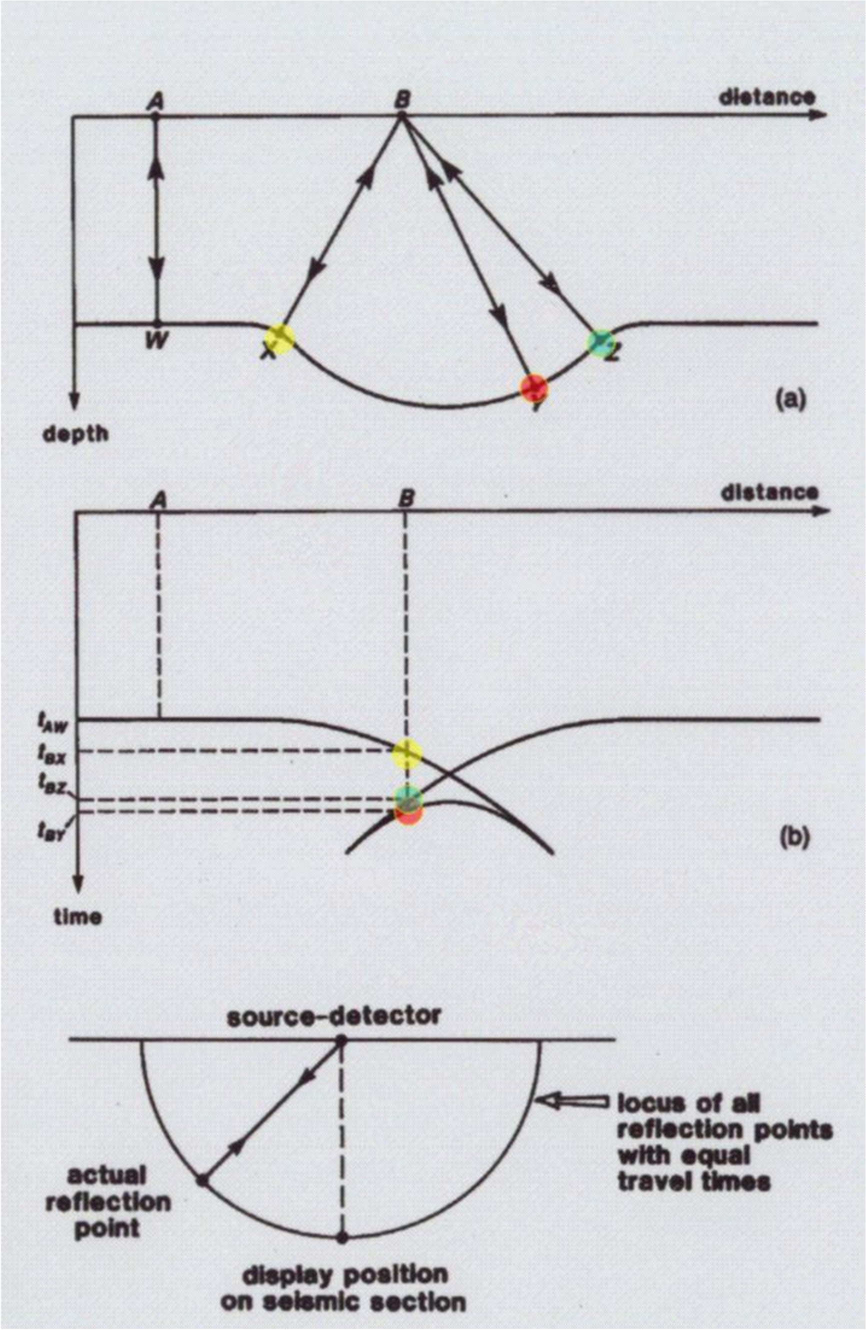


Absence of diffraction and "smudging" of the inclined reflectors testifies that it is a migrated profile. The absence of the unit of measurement of the vertical scale (s TWT or m?) does not allow to establish whether it is time- or depth-migration.

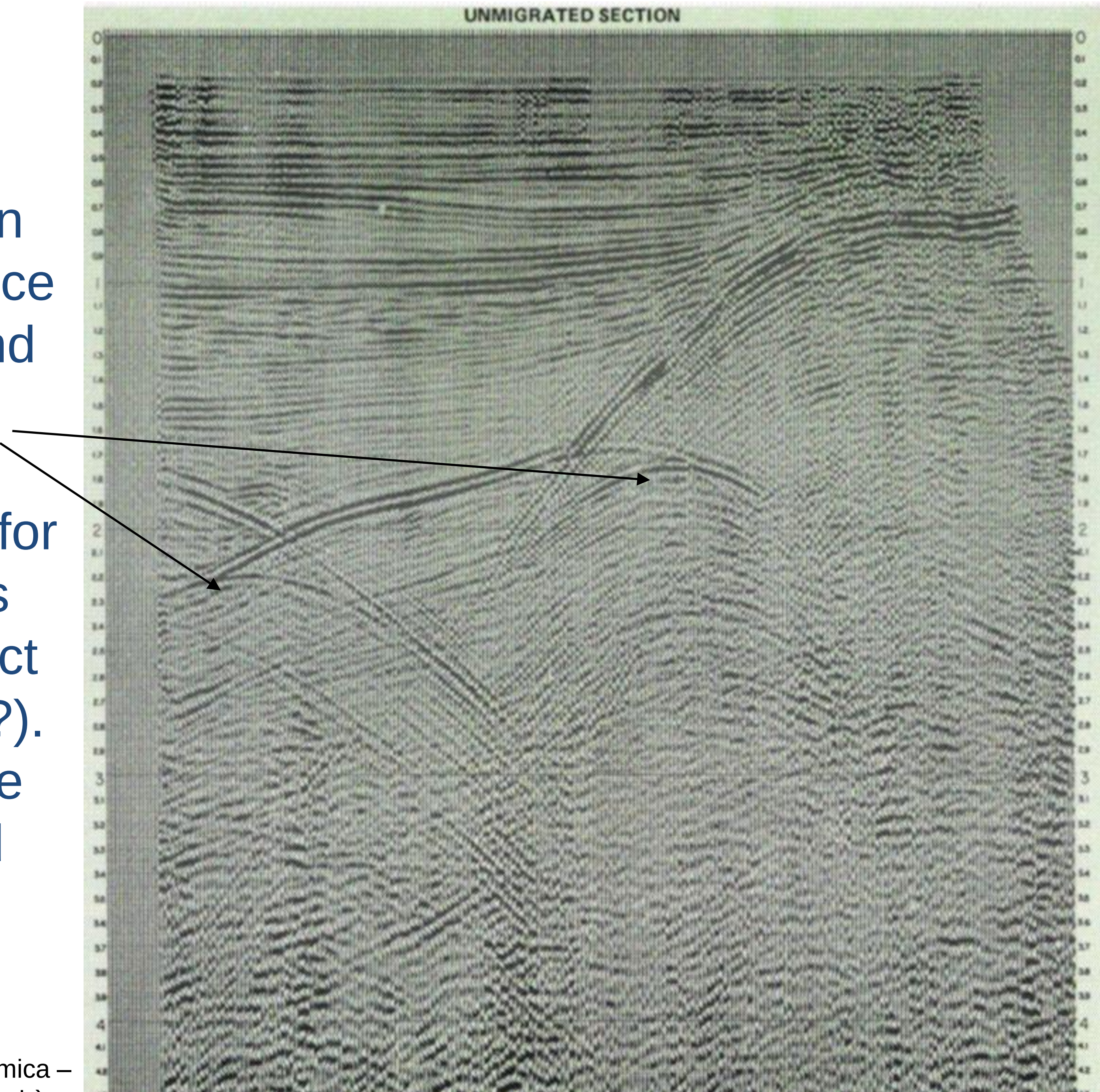
Reflector with syncline:

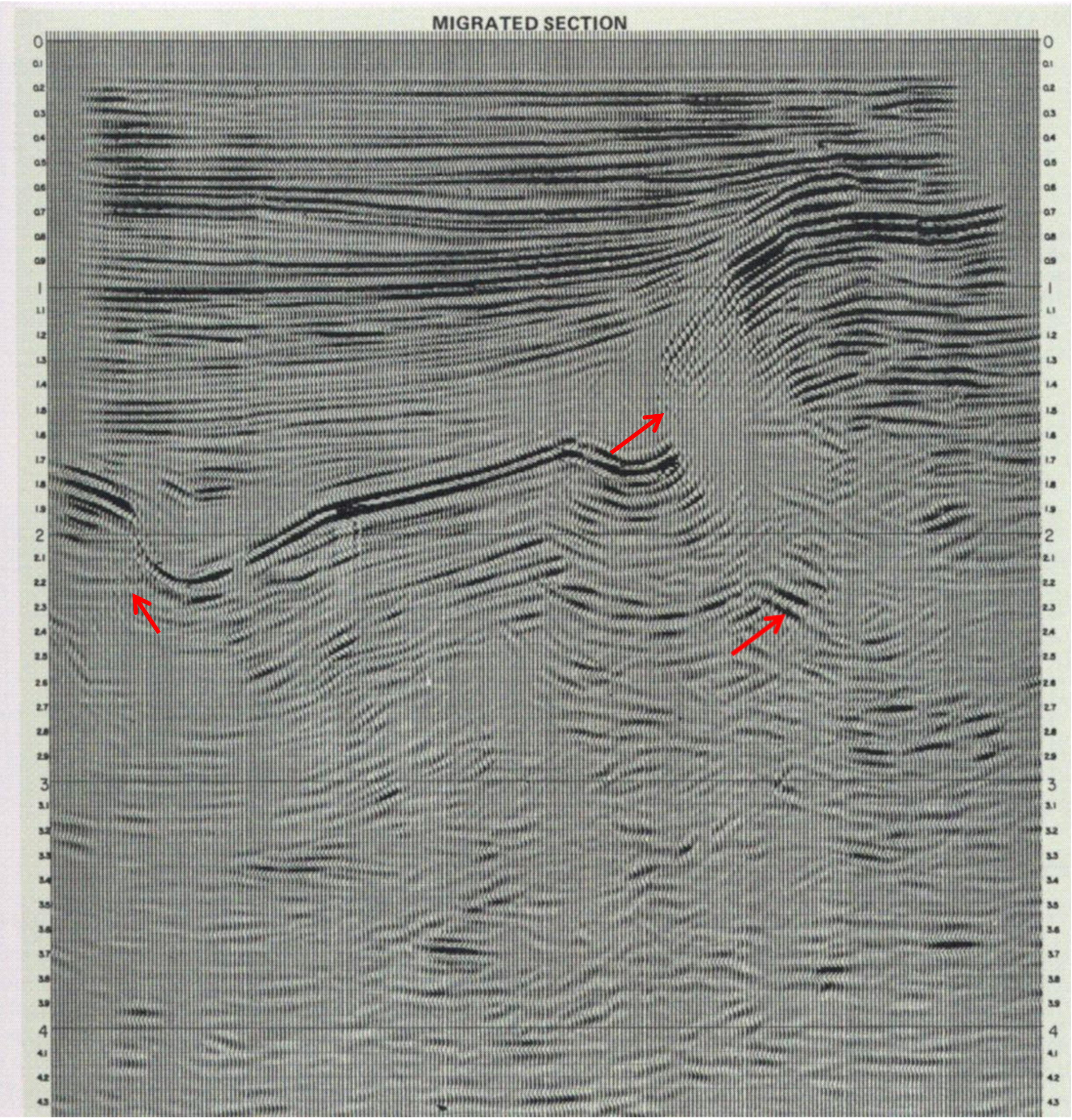
SR (source and recorder) can be in different positions above X and Z, => reflection from different points of the syncline.

These reflections will depict a continuous apparent reflector simuating an anticline.



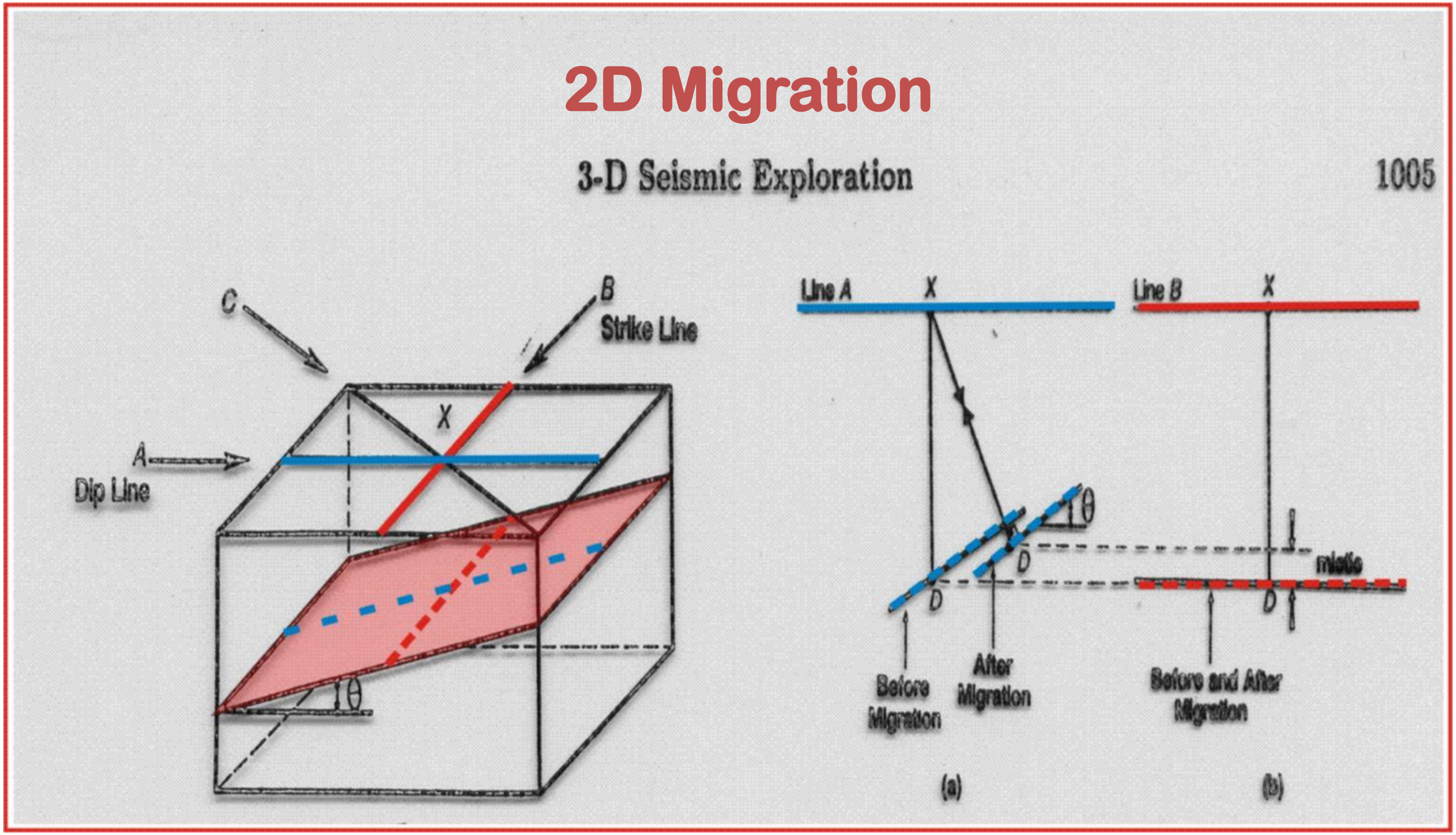
Example of a seismic profile in which the presence of diffractions and two anticlines located in a "critical" position for interpretation is recognized (direct or inverse faults?). Migration, where possible, could resolve many ambiguities.





Migration revealed the presence of two synclines produced by deformation in a probable compressive tectonic regime (inverse faults ↗)

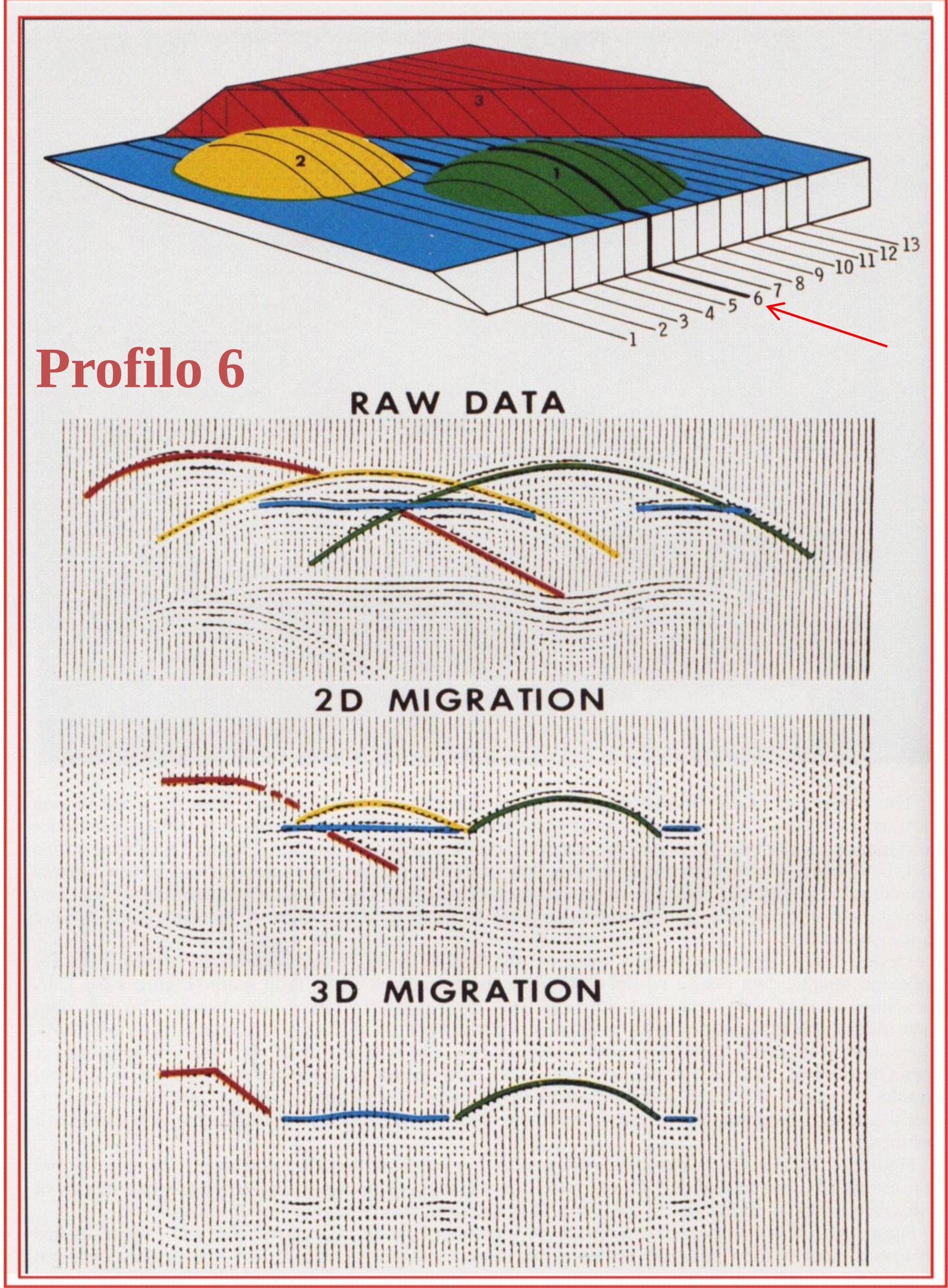
Hanging reflectors and related position of the seismic profile

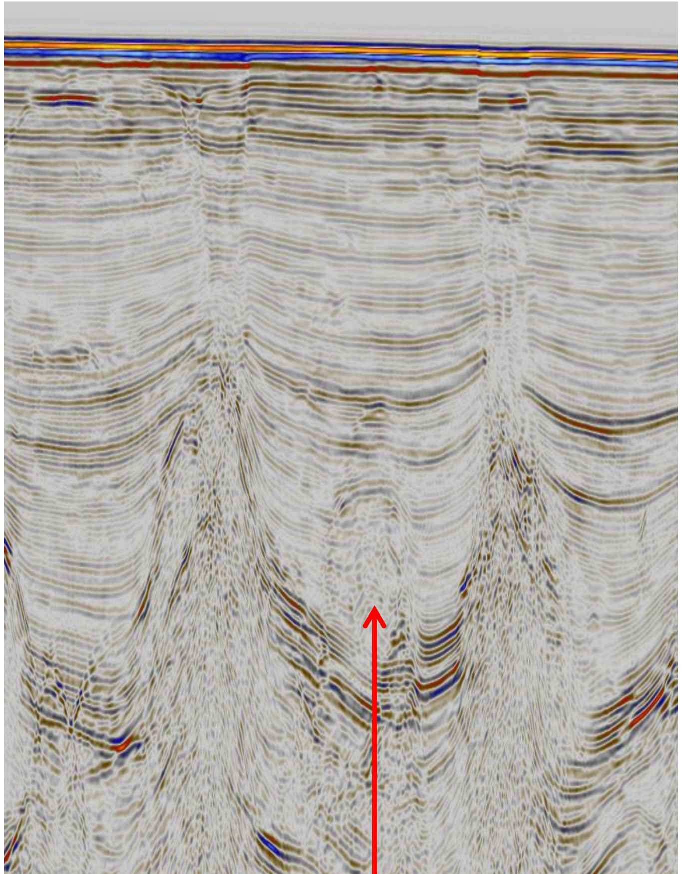


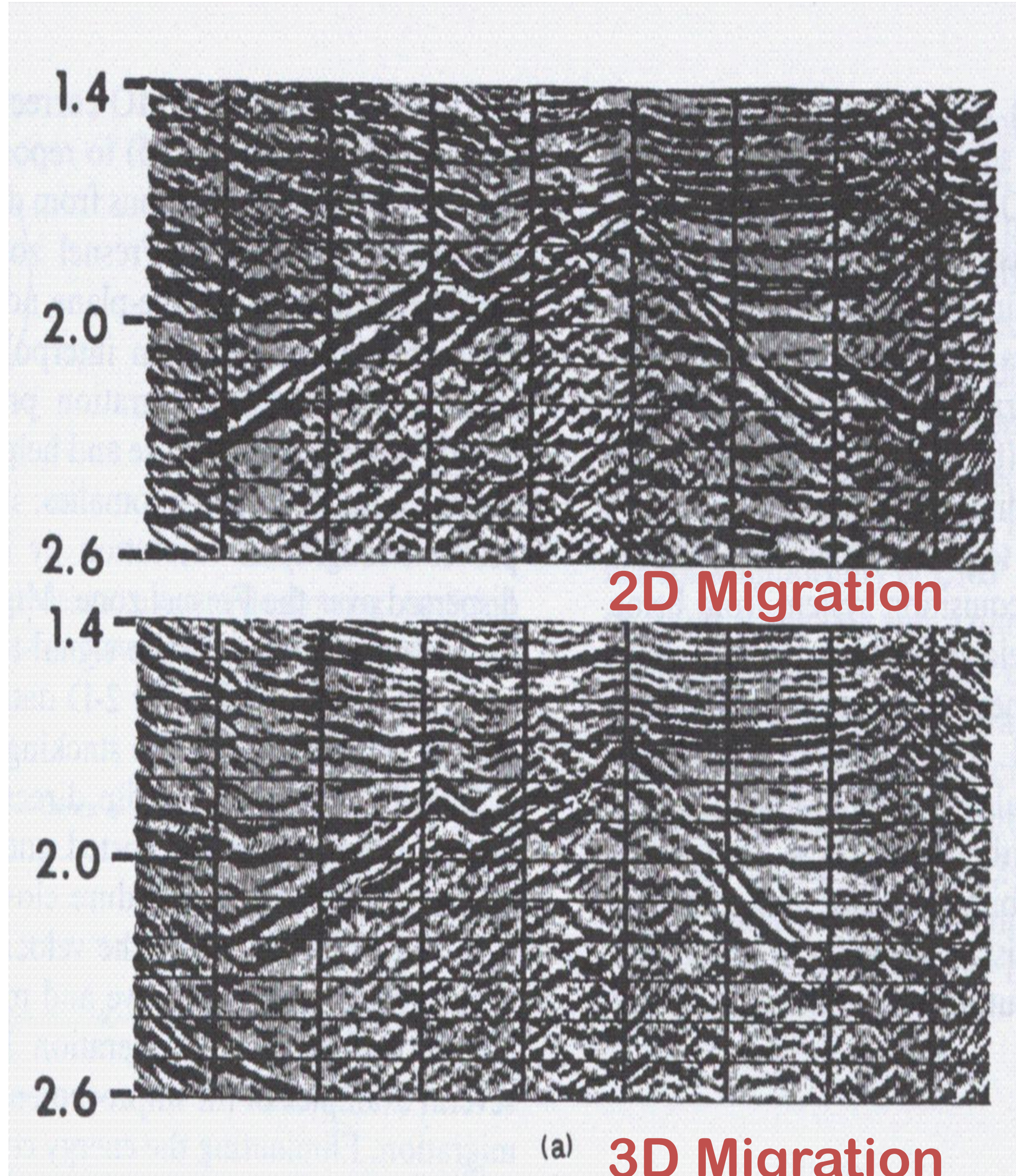
Along profile X the reflector in section A with the migration moves to the right and becomes more pending.

In section B it appears, correctly, not pending. However, his position is not correct.

Hanging reflectors with oblique or external direction with respect to the vertical plane of the seismic profile: only the 3-D migration is able to provide a seismic profile faithful to the real situation of hanging strata. 2-D migration, however, often provides a satisfactory result for interpretation.







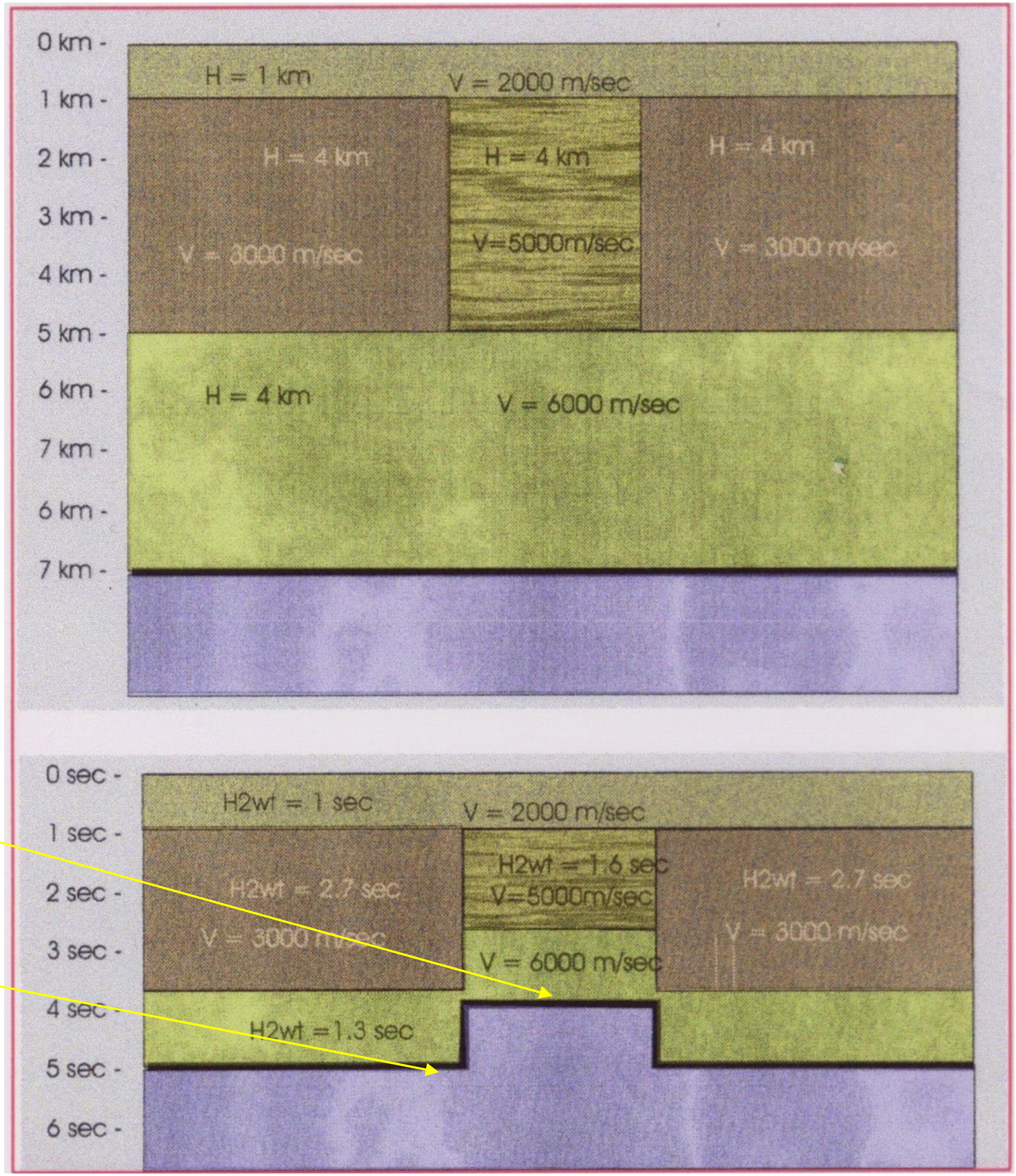
Salt diapirs:
Position along the profile or «out of plane»? …

Effects of lateral unhomogeneous velocities:

origin of

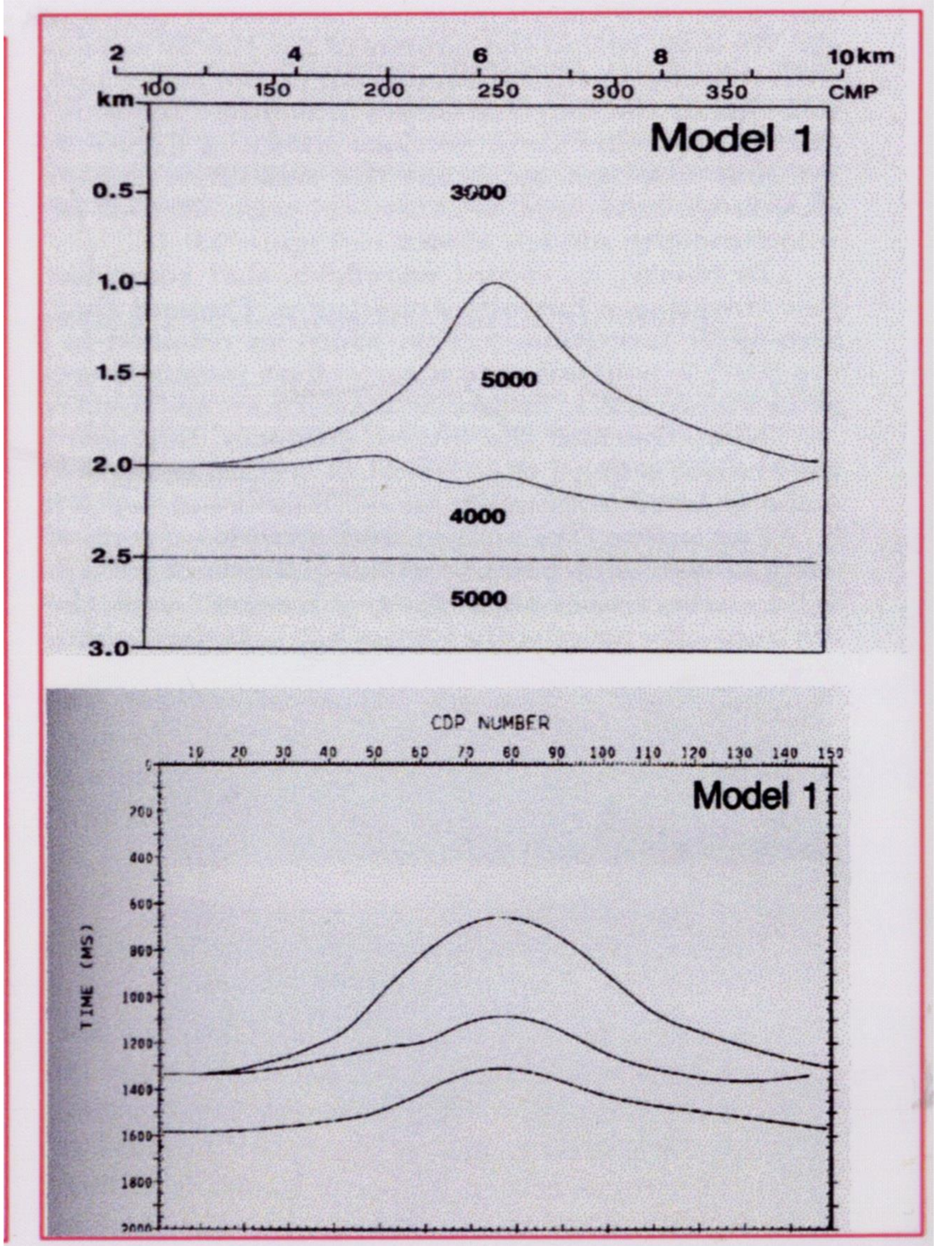
Velocity

***Pull-up* (and *Pull-down*)**

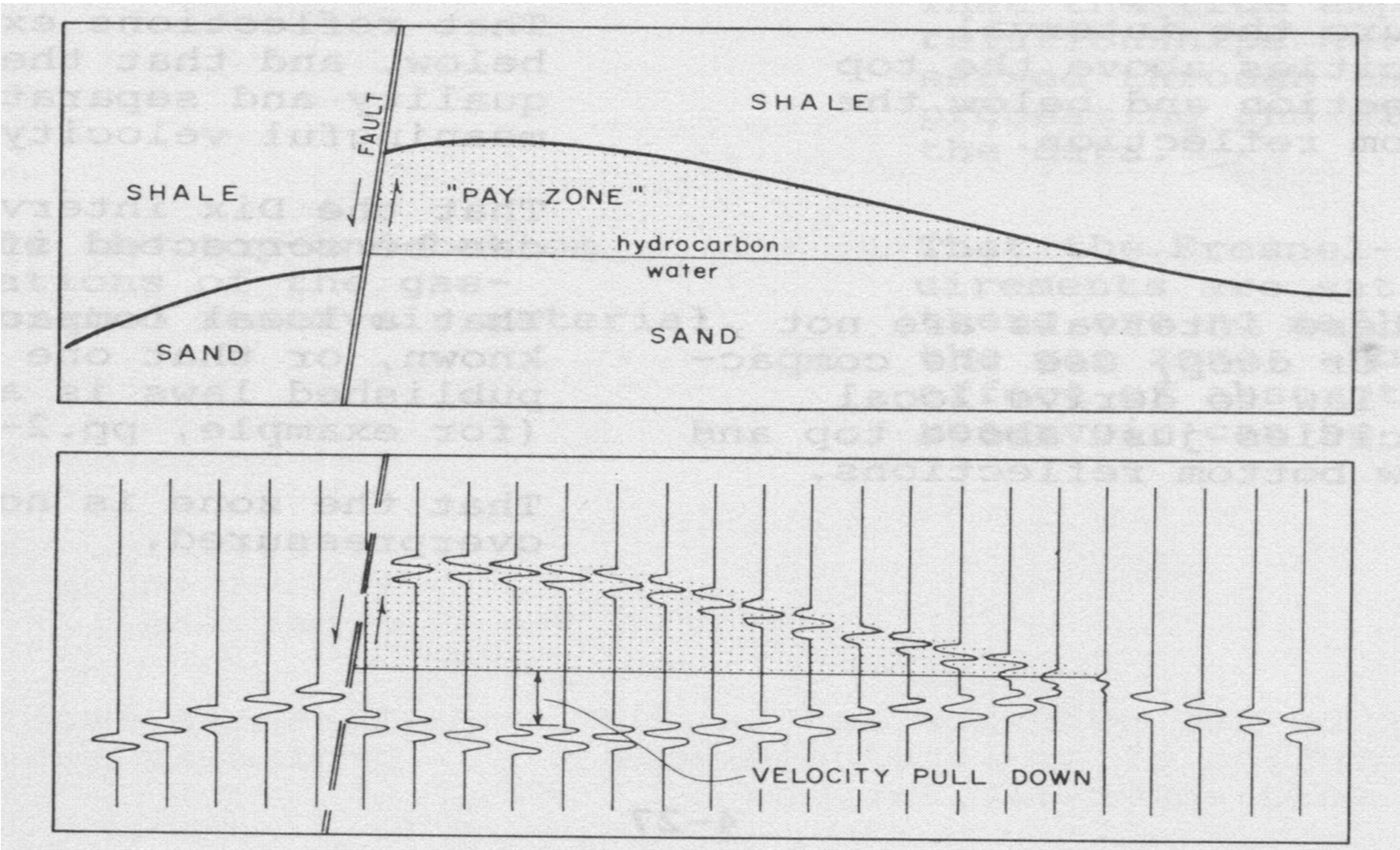


Velocity pull-up model

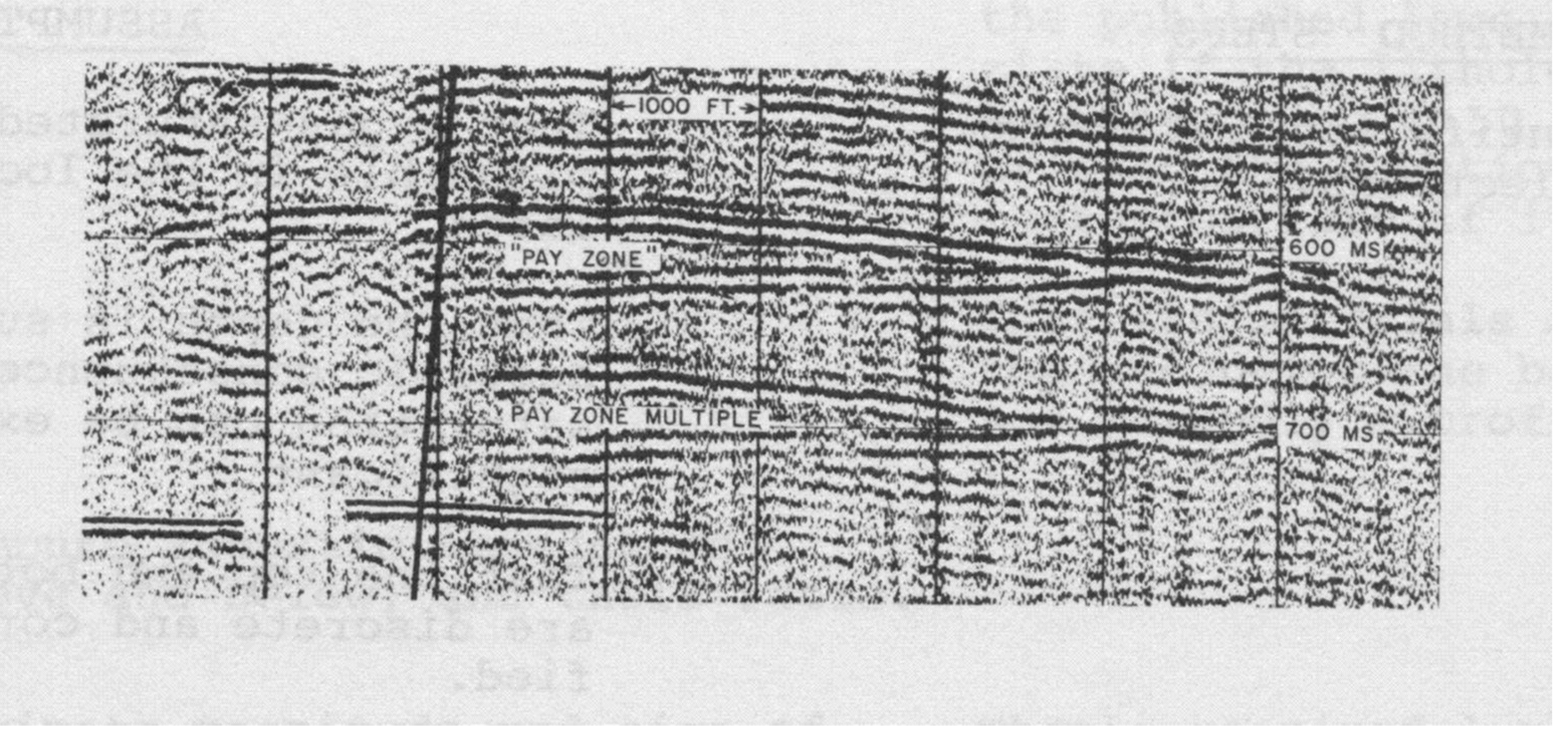
The example in figure shows the typical condition of reflectors below a salt diapir (positive structure characterized by interval high velocity)



Pull-down effect in a gas reservoir



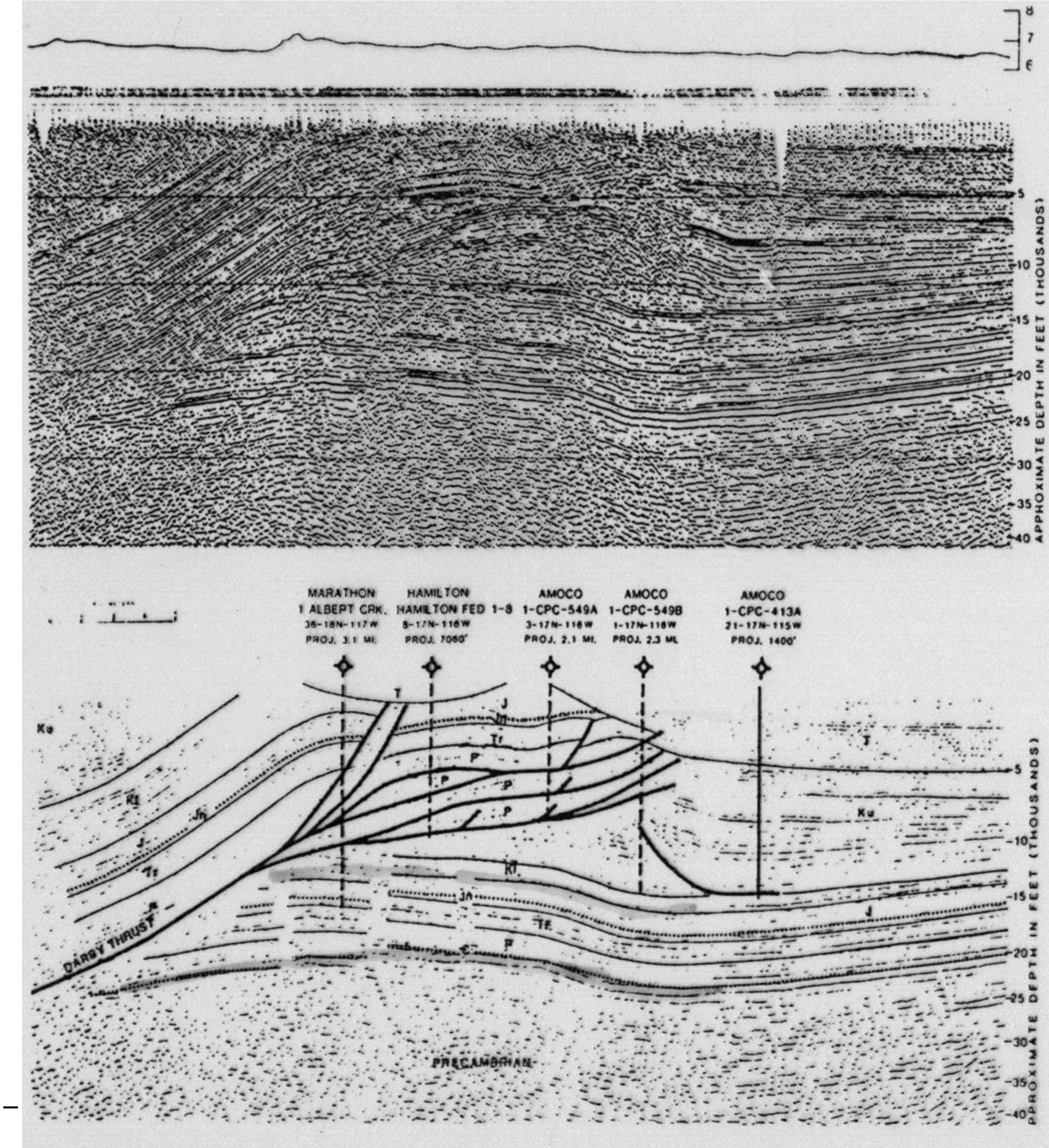
Example of *pull-down effects* below multiple *pays*: the "*flat spots*" (gas-water contact) on seismic profiles not depth-migrated are not *flat*



Pull-up velocity

below a compressive structure:

the deepest more stratified thickness below the fault is horizontal in a depth profile, while an apparent anticline has been produced b the pull-up



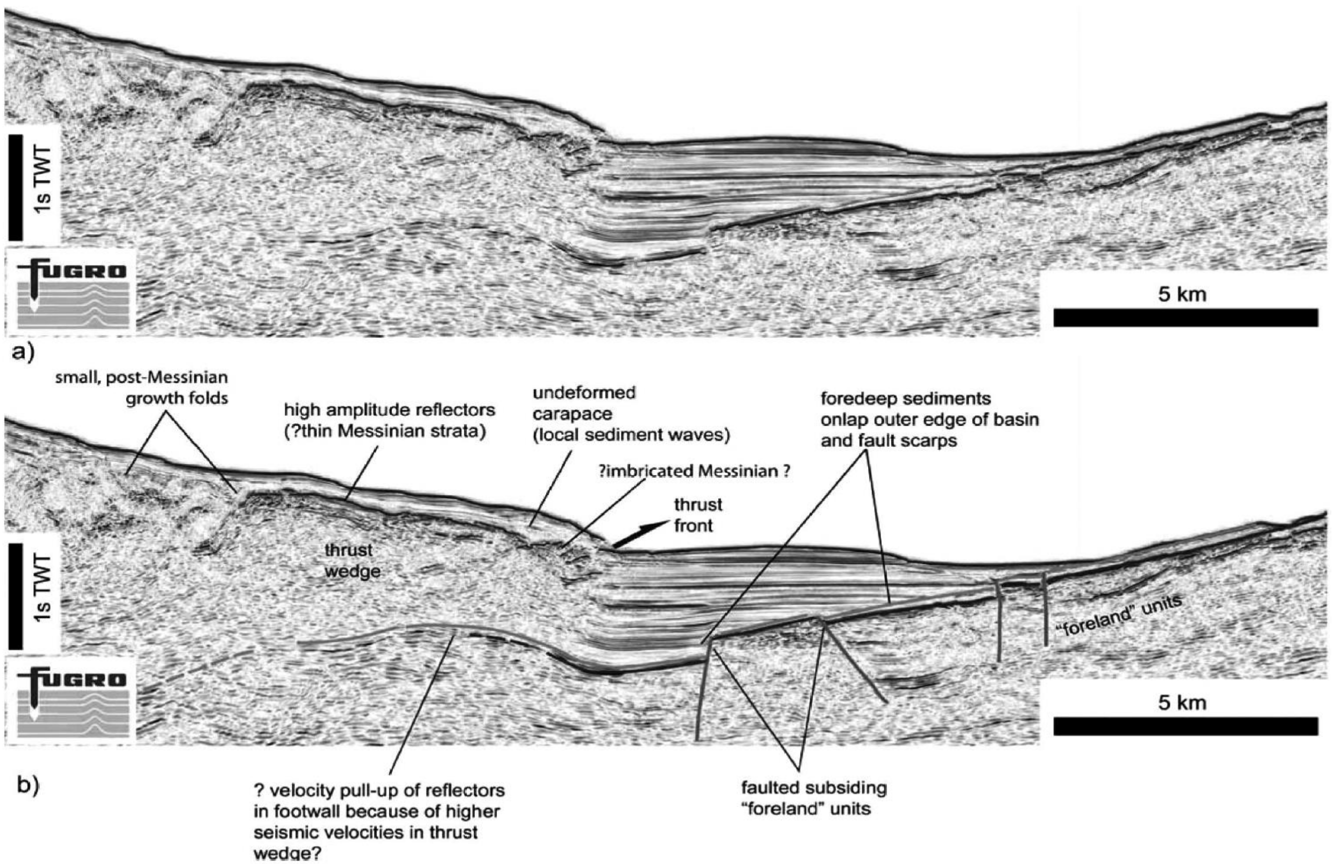


Fig. 5 - Detail of regional seismic line 1 (location on fig. 2) through the Apennine orogenic front, the leading part of the orogenic wedge, together with the adjacent foredeep basin: *a)* clean line; *b)* interpretation. High-resolution colour versions of these images are available on the Virtual Seimic Atlas: www.seismicatlas.org <http://www.seismicatlas.org>.

Calabrian Arc external thrust: Positive structure of the Apulian foreland or pull-up effect?

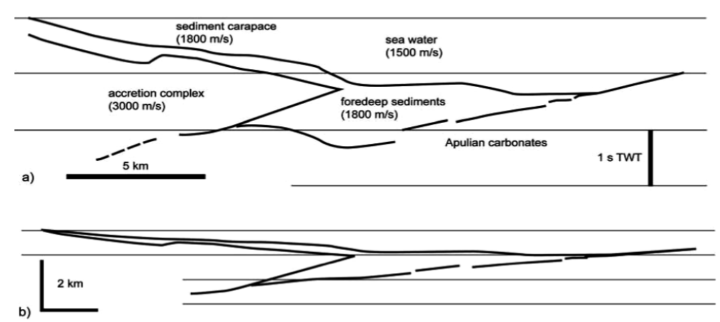
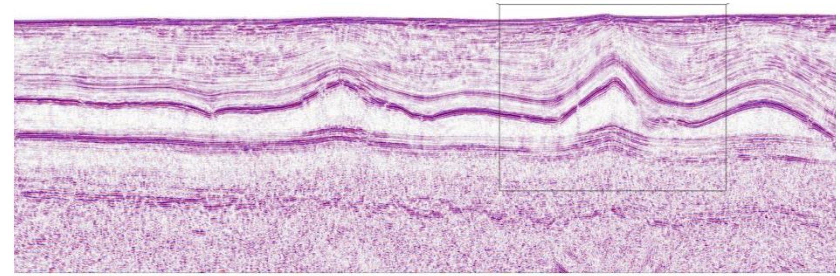
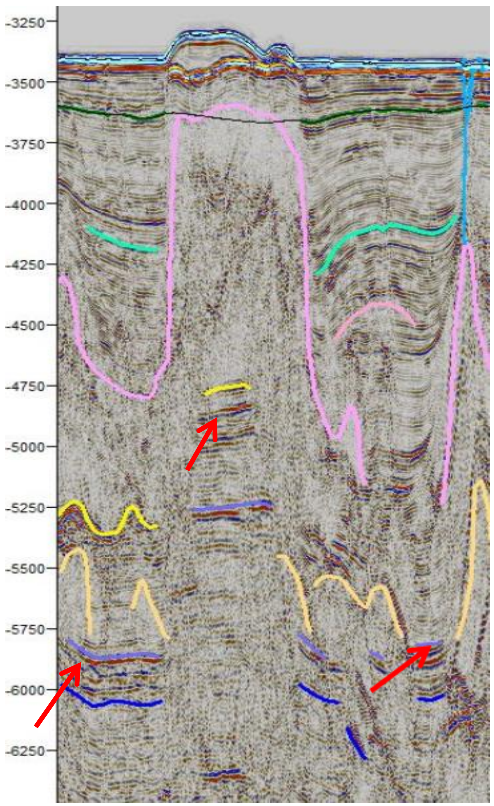
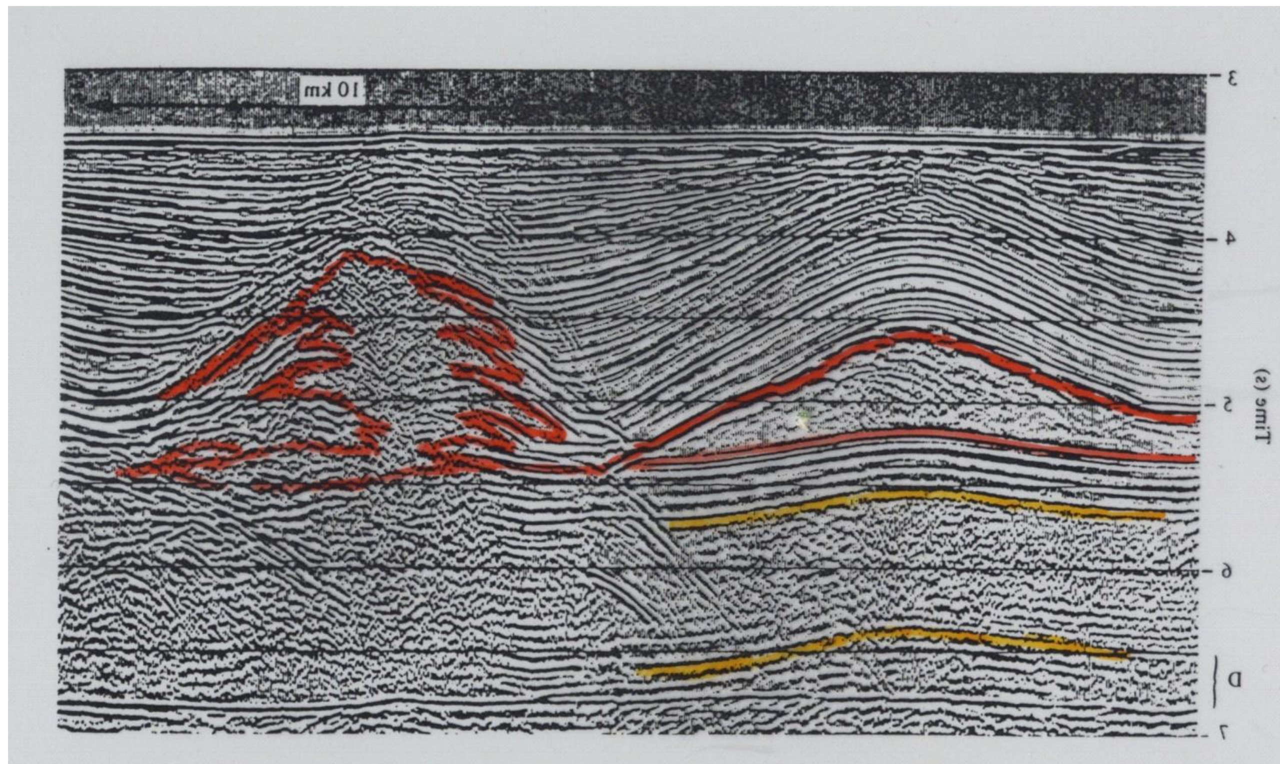


Fig. 6 - Investigation of velocity pull-up effects expected by varying water depth and seismic velocity in the shallow section: *a)* shows the geometry in time, *b)* is a simple depth conversion of the same data.

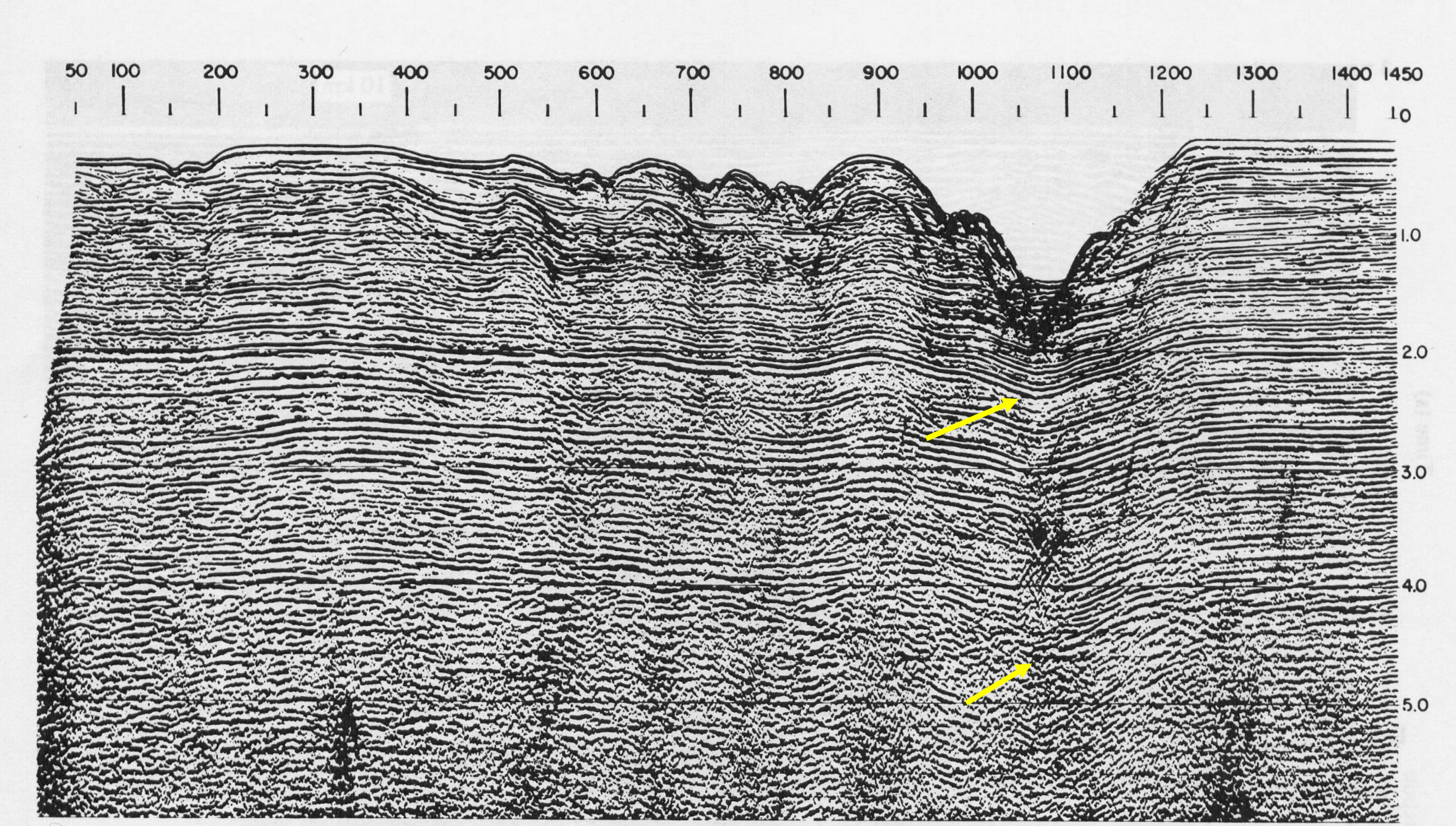
Pull-up velocity below salt diapirs (Balearic basin)







Example of *pull-down* due to a canyon



(*a*)

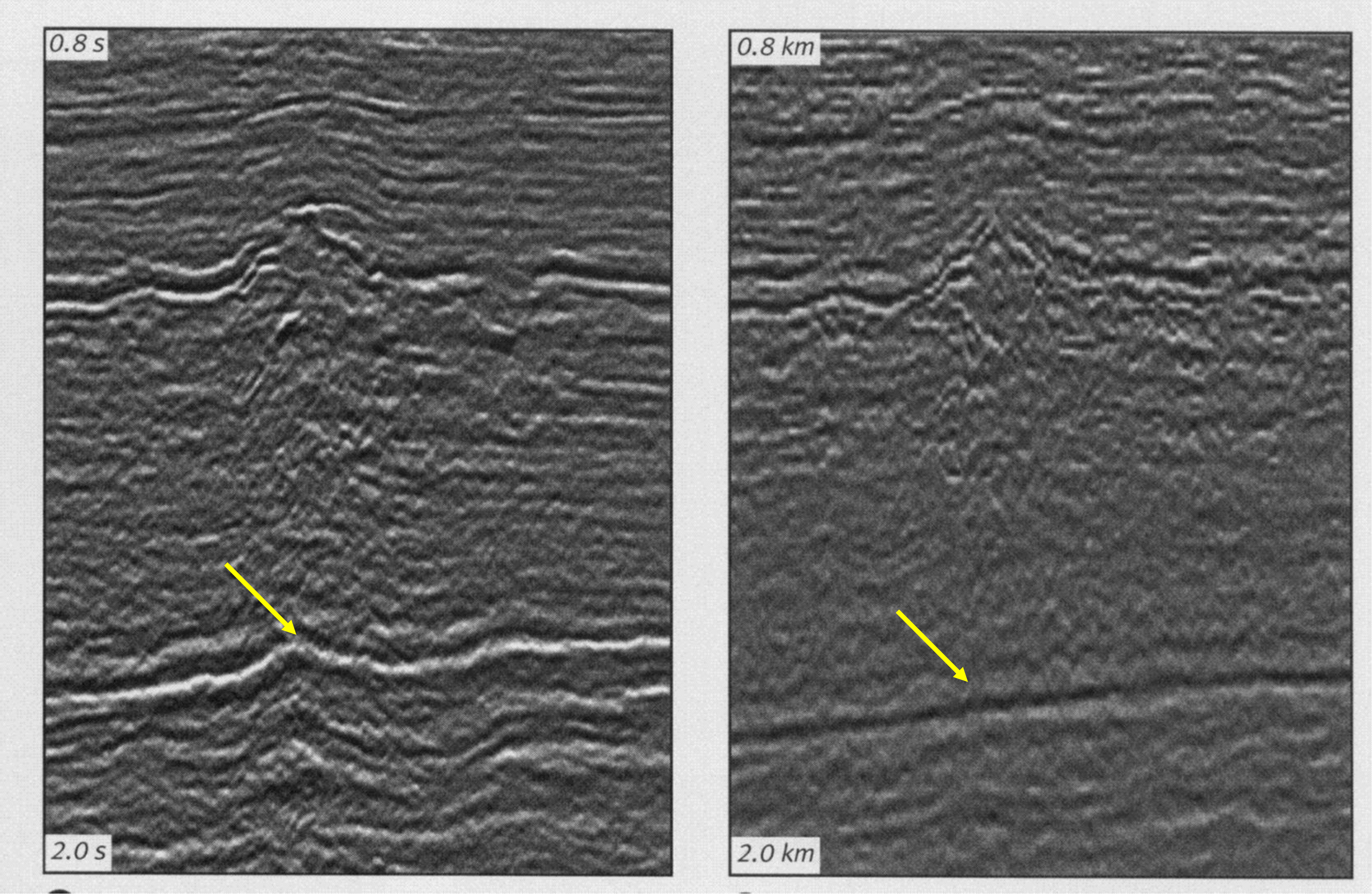
- **A seismic section, even if it has been time migrated, is alwas affected by**

pull-up e _pull-down_ effects.

Consequently, the interpretation will have to consider the effects of this type of «deformation» of the seismic markers.

- **The knowledge, also qualitative, of the velocities distribution, allows to evaluate the _pull-velocity_ effects.**
- **If the original seismic field data is available, and they can be reprocessed, the DEPTH MIGRATION allow the real position of the reflecting discontinuities.**

Example of Depth Migration with correction for the *pull-up* effect

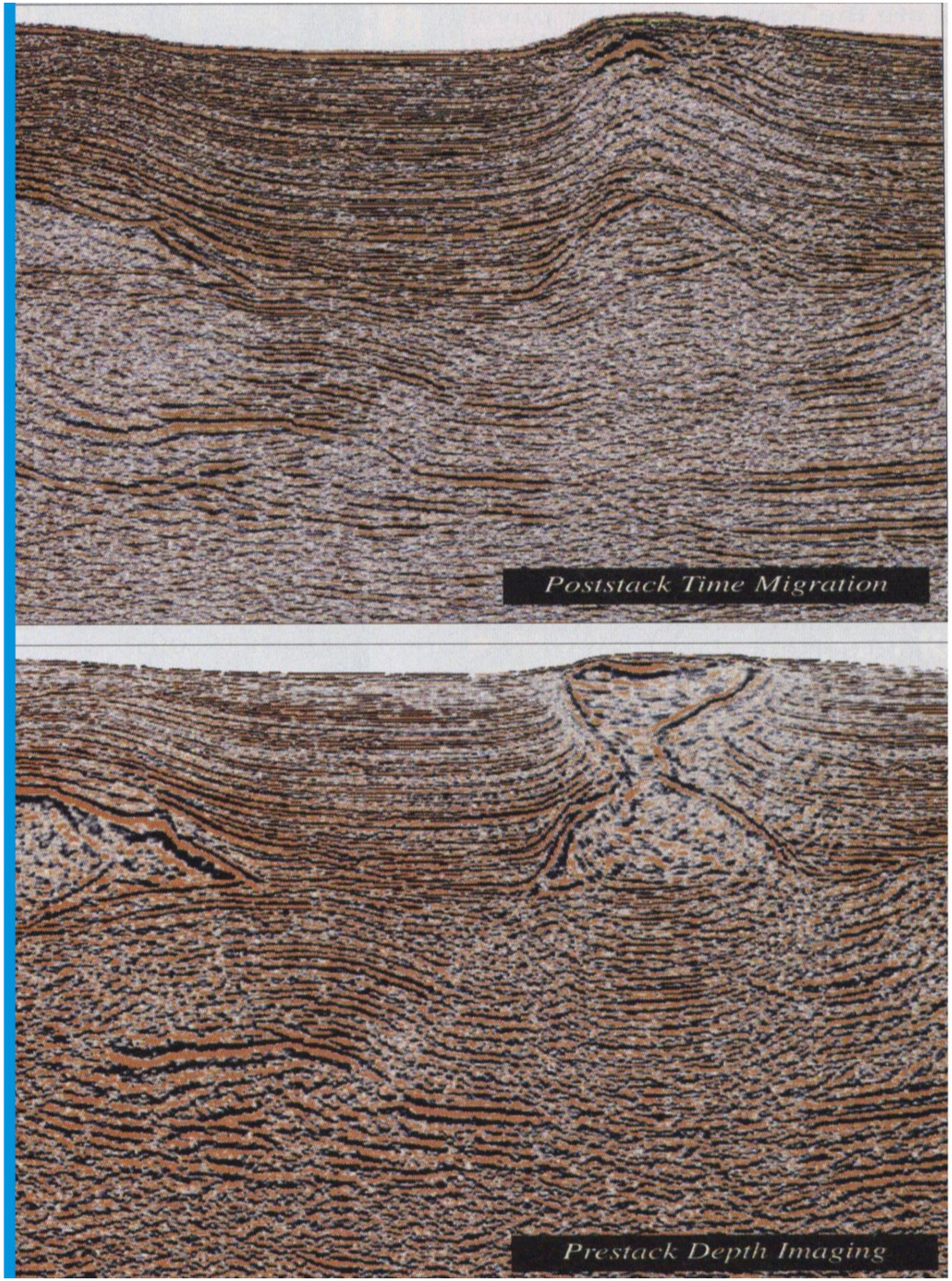


Example of a salt diapir

time migrated (*post-stack*)

depth migrated (*pre-stack*)

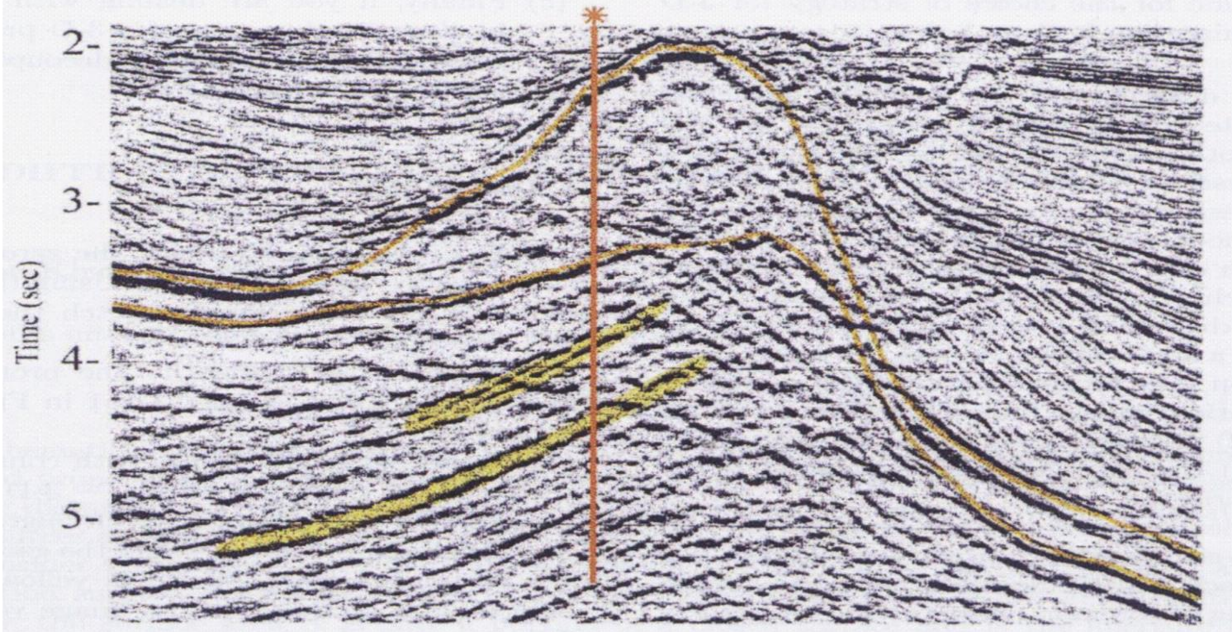
further than correction of horizons position, also the salt boundaries are now well evidenced



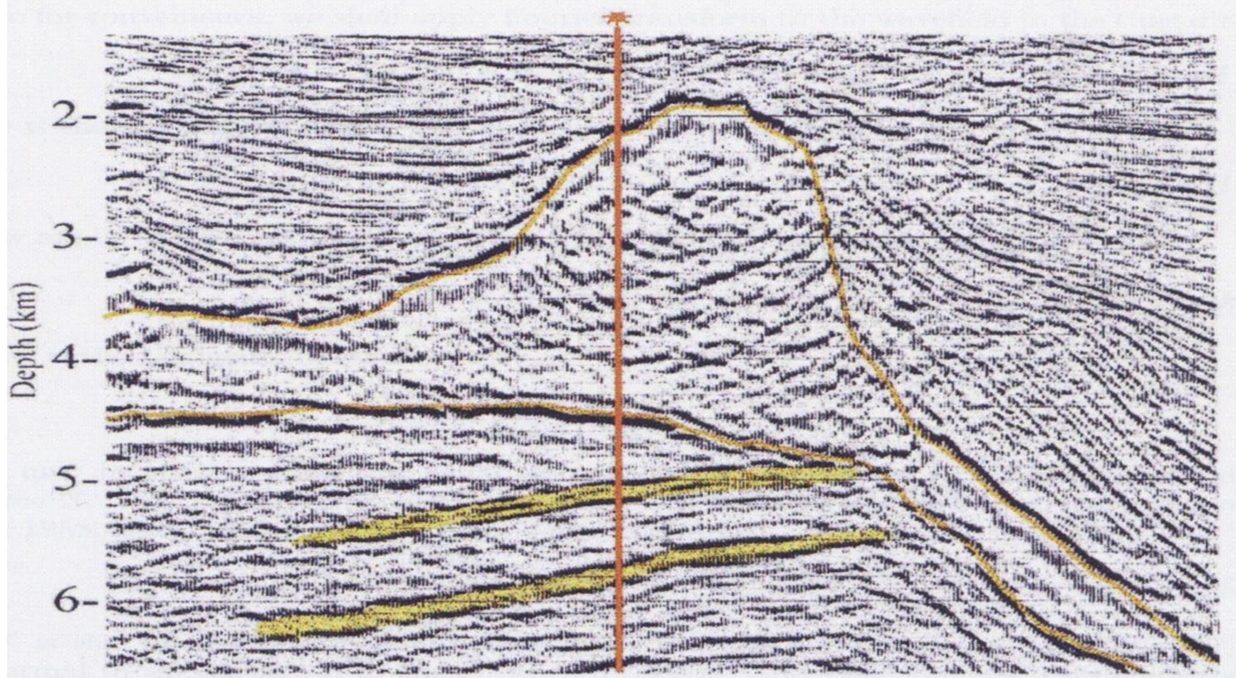
Example of a salt diapir

time migrated

depth migrated



a

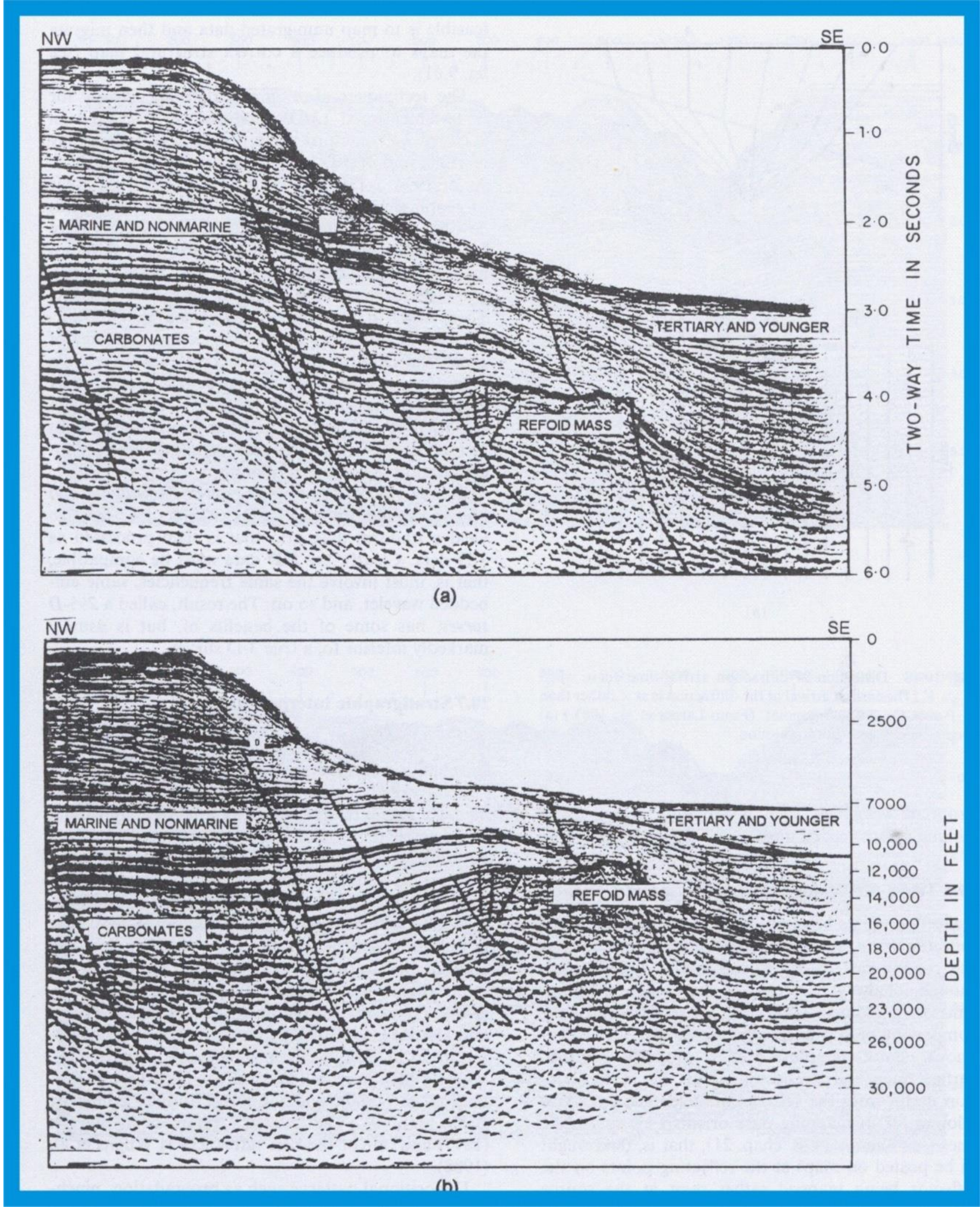


b

Example of depth migration of a profile crossing a basin margin

Note the twt depth of the carbonate sequence and coeval *reef, that* is apparently deeper.

The depth migration moves the structures to the correct position and shows the *reef* in a more superficial due to tilting of the block between the normal faults



Example of Depth Migration