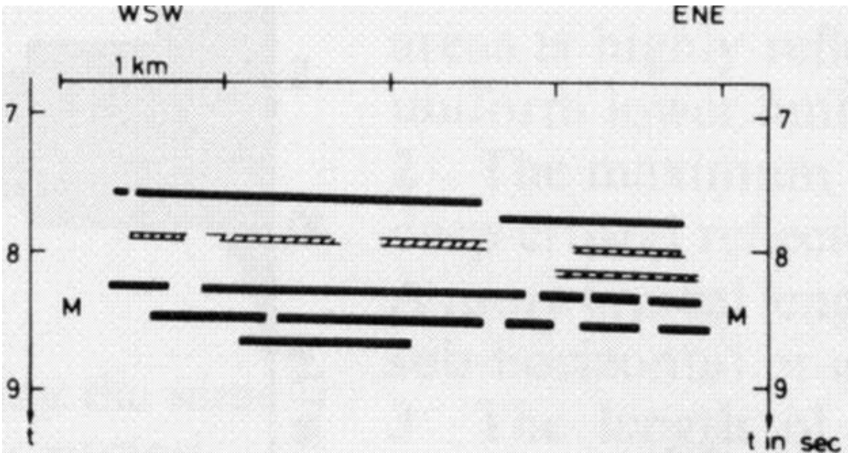
Crustal Seismic Reflection

The base of the continental crust (Moho) has been seismically defined as the surface above which the crust is characterized by an average P wave velocity equal to 6 km / sec, and values that can reach 7.6 km / sec in the deepest part. Below the Moho there is a sharp increase in the mantle velocity, equal to or greater than 8 km / sec. Conrad also demonstrated the existence of a layer inside the crust characterized by high speed (6.4 km / sec), initially interpreted as a layer with a gabbric composition.

The reflection seismic shows a very variable range of seismic responses relative to the deep crust: the seismic facies can be from transparent to variously stratified, generally characterized by non-continuous reflections on the entire profile, possibly folded.
The significance of these variations is not yet fully understood. Some of the best examples of seismic profiles across the deep crust are generally associated with extensional tectonic phases of regional nature.



One of the national projects which reached best results relatively to the crustal thickness has been the BIRPS

(*British Institutions Reflection Profiling Syndicate*)

acquired on the continental shelf

around the Great Britain.

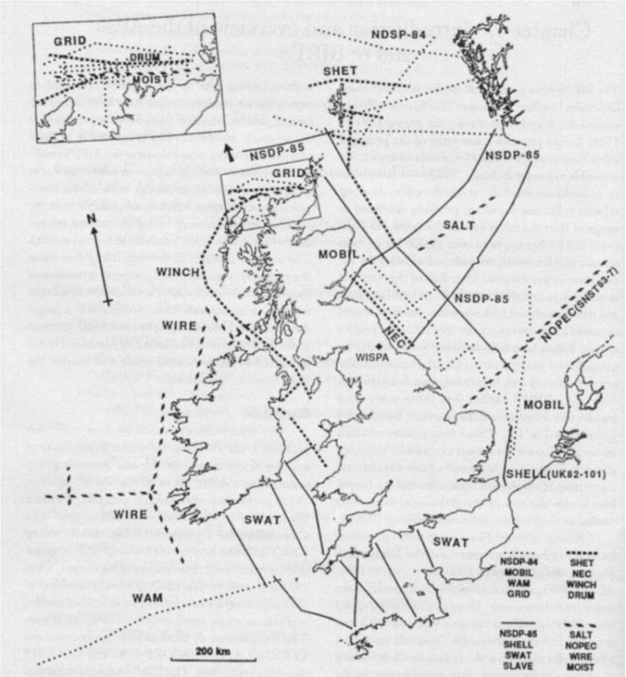
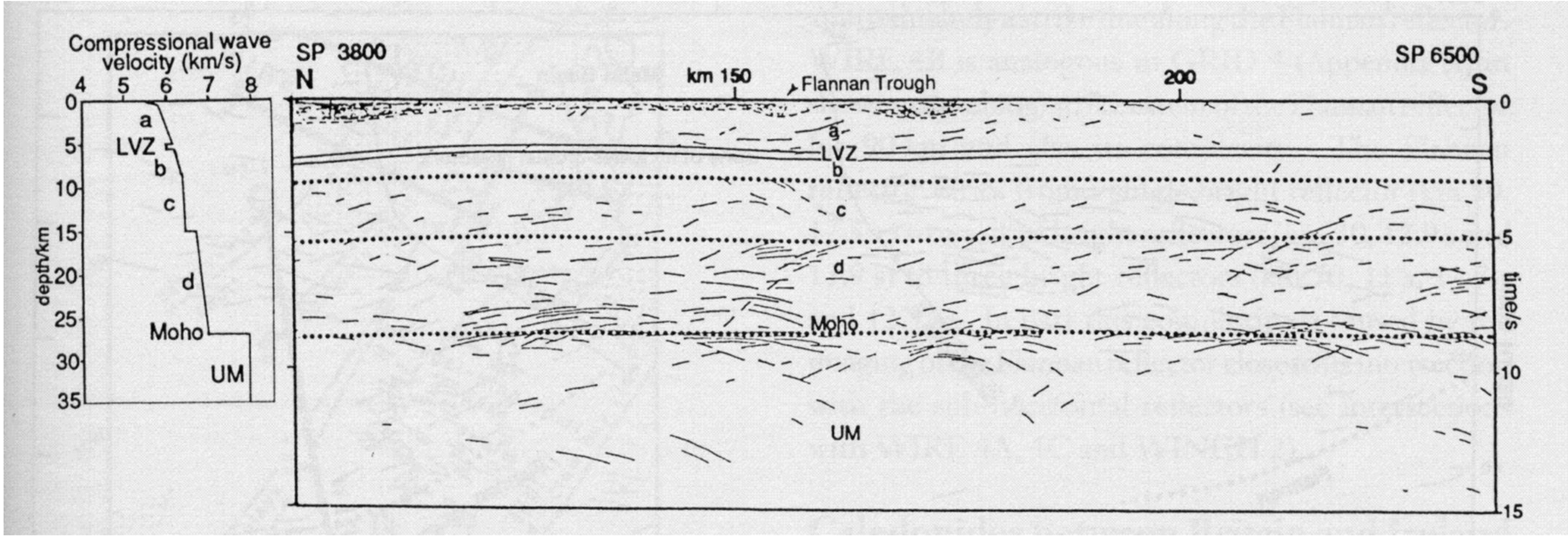
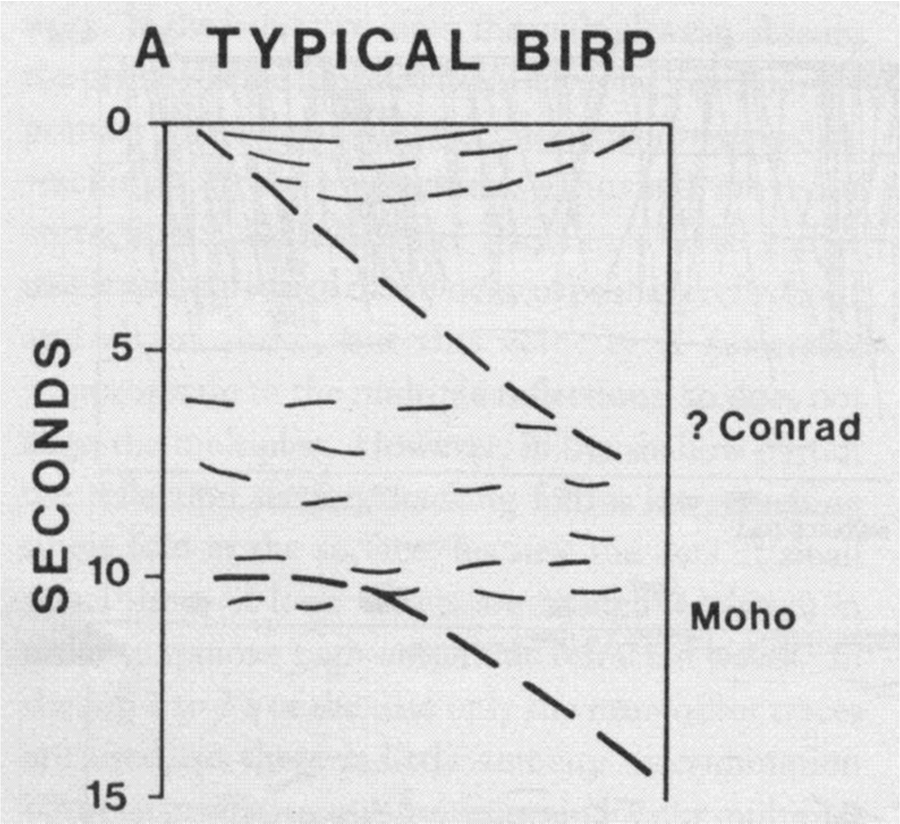


Figure 1.1. All profiles included in the Atlas. Different line patterns correspond to the different surveys.





The diagram in the figure represents the main reflections interpreted along the seismic profiles:

- the surface reflections represent the **basinal sediments** (here mainly from the Mesozoic age)
- the reflections between 6 and 10 sec refer to the **lower crust** and, for the deeper ones, to the **Moho**.
- the two oblique reflections (about 30°) can be correlated to **normal faults**, reactivated by previous Caledonian-Variscan thrusts: it should be noted that both seem to disappear within the lower crust.

This would suggest a **ductile lower crust** (qz-feldspathic rocks), in contrast to a **fragile upper crust and upper mantle** (olivine, more refractory, therefore harder even if at higher temperatures).

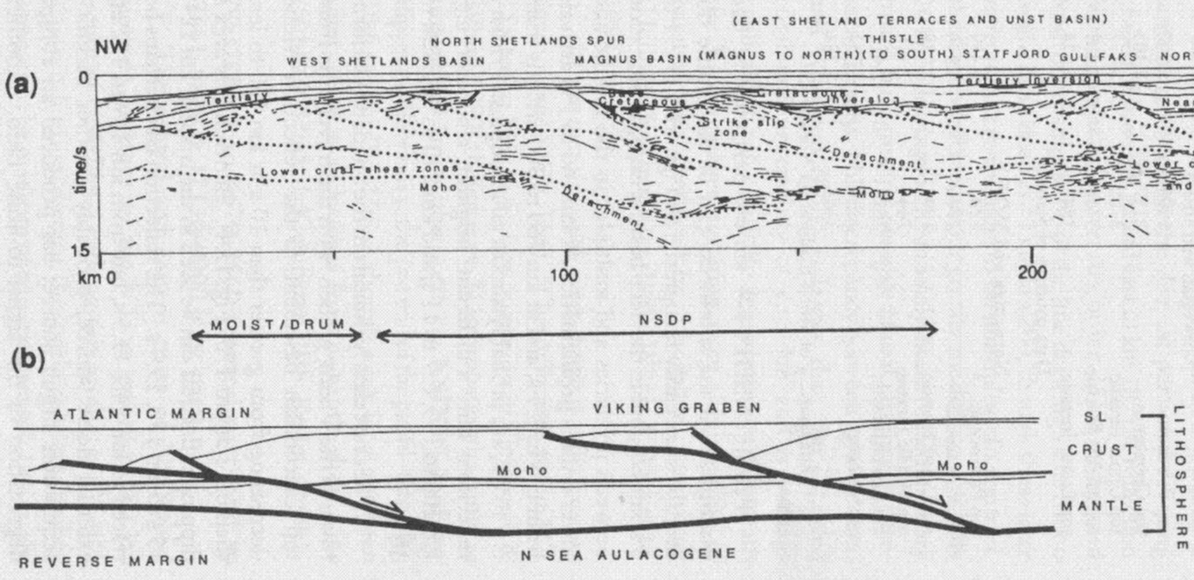


Figure D.5. (a) Interpreted detachments and shear zones superimposed on line drawing of NSDP84-1. Note the proposed asymmetry of the North Sea basin and the continental margin. Solid lines: seismic reflectors, and interpreted sedimentary horizons. Dotted lines: interpreted faults and shear zones. (b) Schematic model for lithospheric extensional duplex, based on NSDP and DRUM profiles. (a & b) reproduced, with permission, from Gibbs (1987d), *Canadian Society of Petroleum Geologists Memoir* **12**, 163-171.

The analysis of the attributes shows that the reflections from the deep crust are comparable in amplitudes to those of the sedimentary series.

It is not yet clear what is the origin of the deep reflections:

- the discontinuous presence of fluids (water, salt water, carbon dioxide, methane: it should be noted that the lower crust shows a much higher electrical conductivity than that of amphibolites or granulites from the deep crust),
- the presence of ultra-basic layers,
- the different crystallization of the rocks.

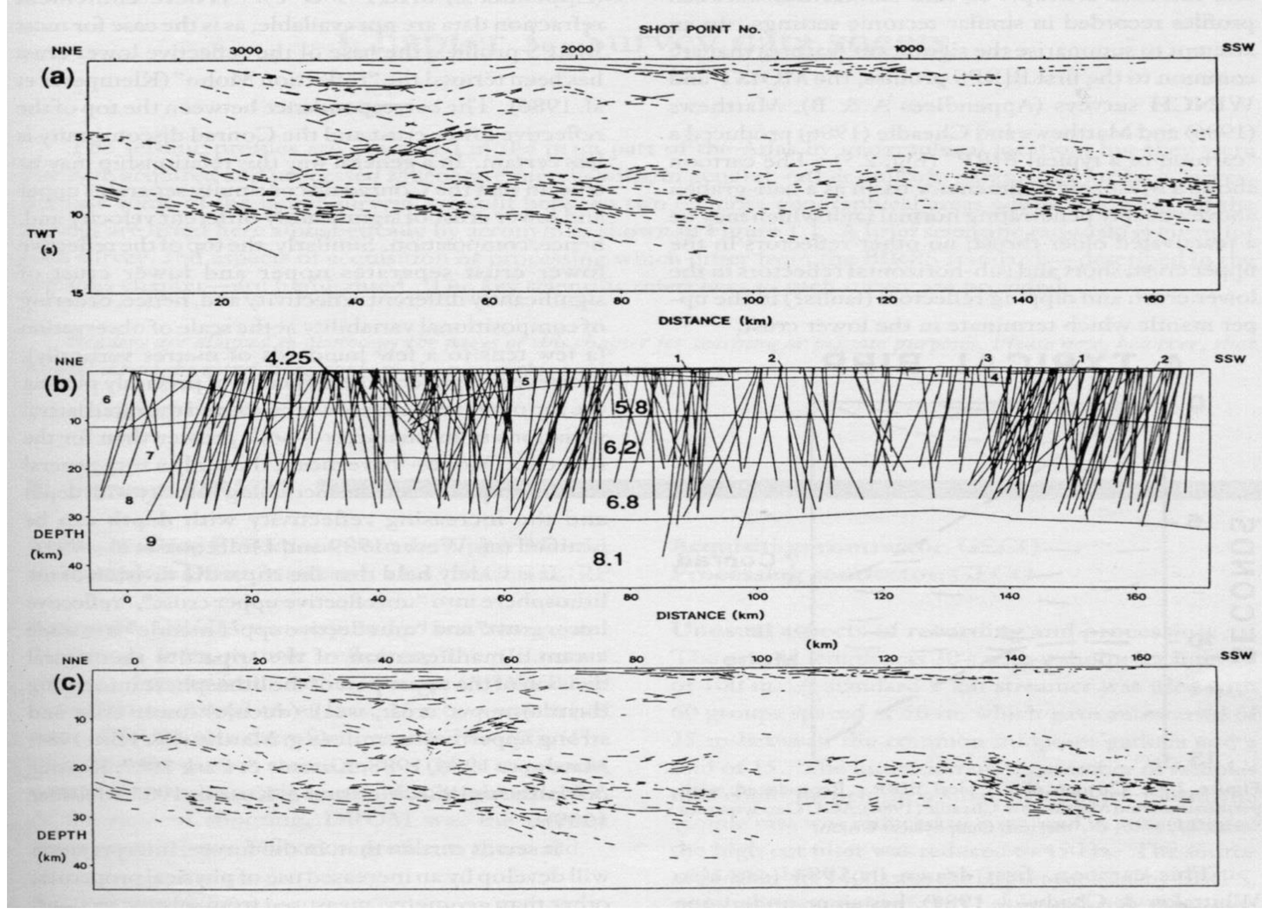
All these situations can give contrasts of acoustic impedances.

BIRPS

Line-drawing

Faults interpreted by reflectors *cut-off*

Line-drawing of the depth migrated profile.



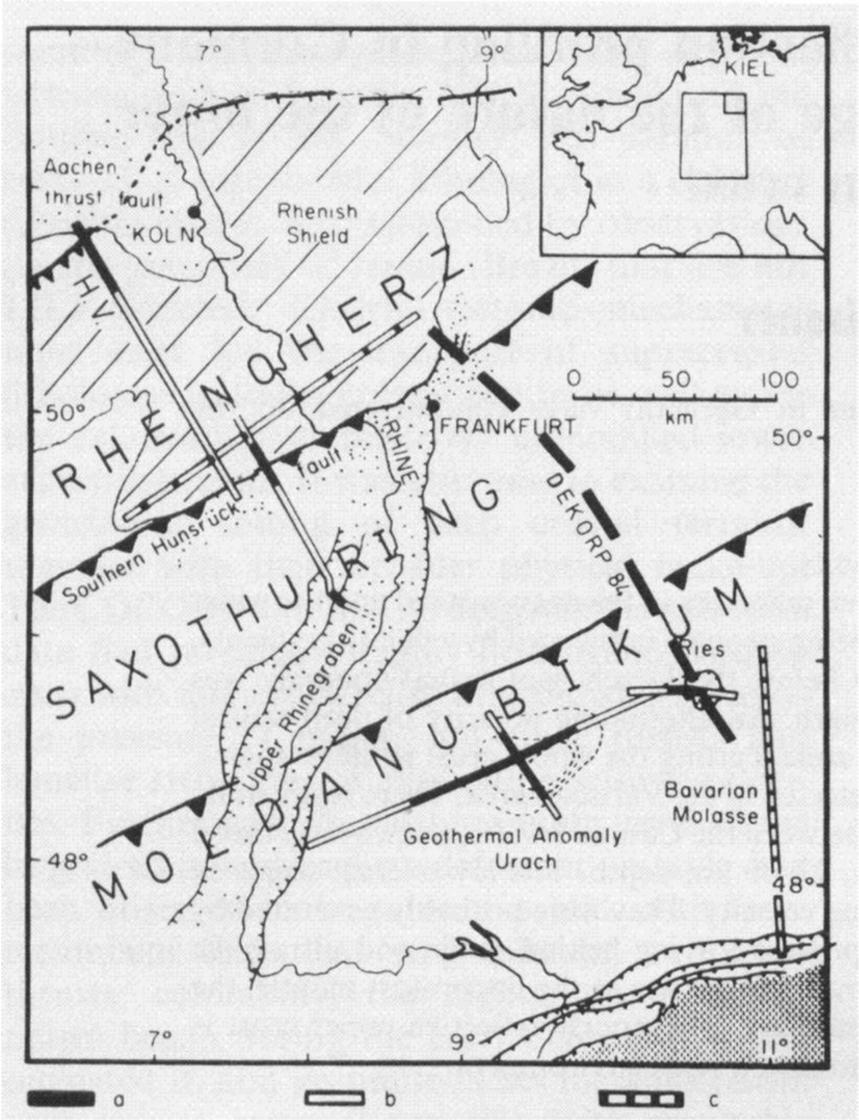
In the context of BIRPS, the lower crust can be defined as the deep reflective thickness, characterized by 8-9 reflections within a typical vertical column. These reflections are produced by lenses generally of about 4 km in length, believed to be mostly linked to layers of basic and ultra-basic rocks, but whose impedance contrast could also be amplified by the presence of fluids.

DEKORP Project
Germany

In several regions, the alternation of the polarity of the reflectors has been observed …

Some high-angle faults cut the entire crustal thickness, while some low-angle thrusts affect the Variscan region in the upper crust.

In the same region there is strong reflectivity in the deep crust between the Conrad level at 6 sec 2wt (18 km) and the Moho at 9-10 sec (27-30 km).



DEKORP

Thin lenses with alternating velocities characterize the lower crust: they have been interpreted as the effect of widespread syn- and post-orogenic fusion processes. The poorly reflective upper crust is probably dominated by vertically oriented plutons in a rigid context.

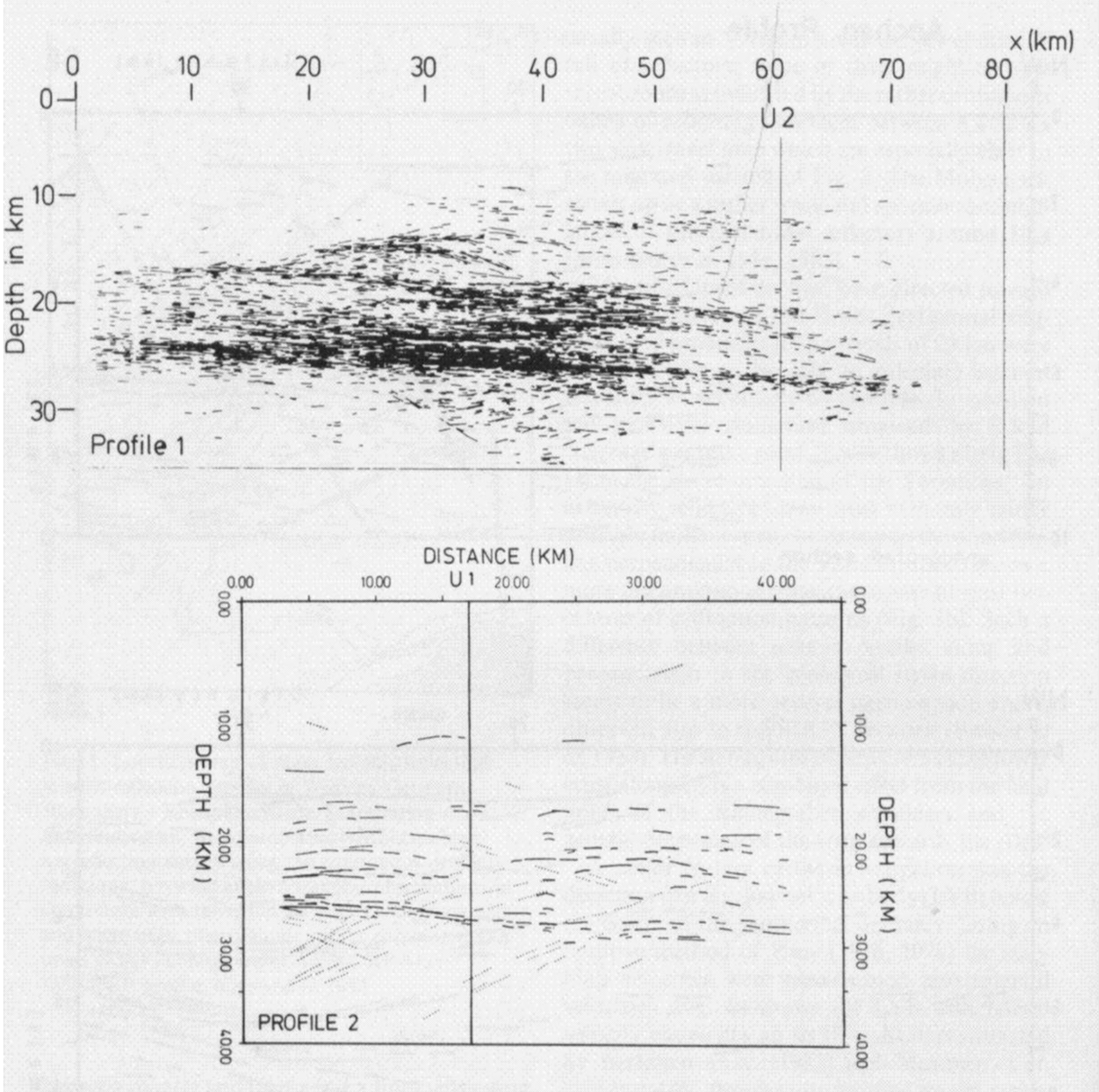
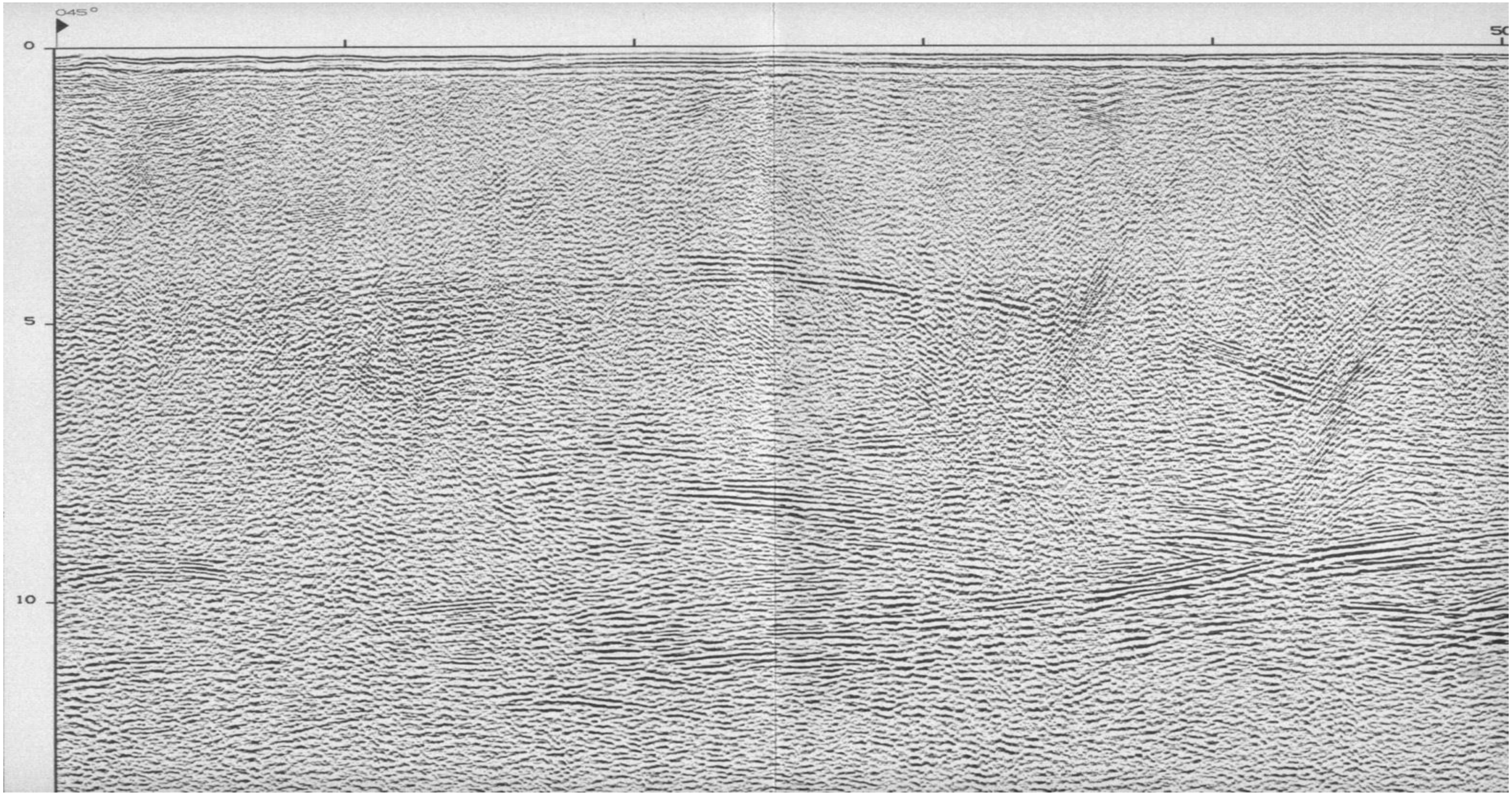


FIG. 3. Line drawings from the two Urach profiles: 3a: Line U1, composition of single records, 8-fold. 3b: Line U2, stacked version.

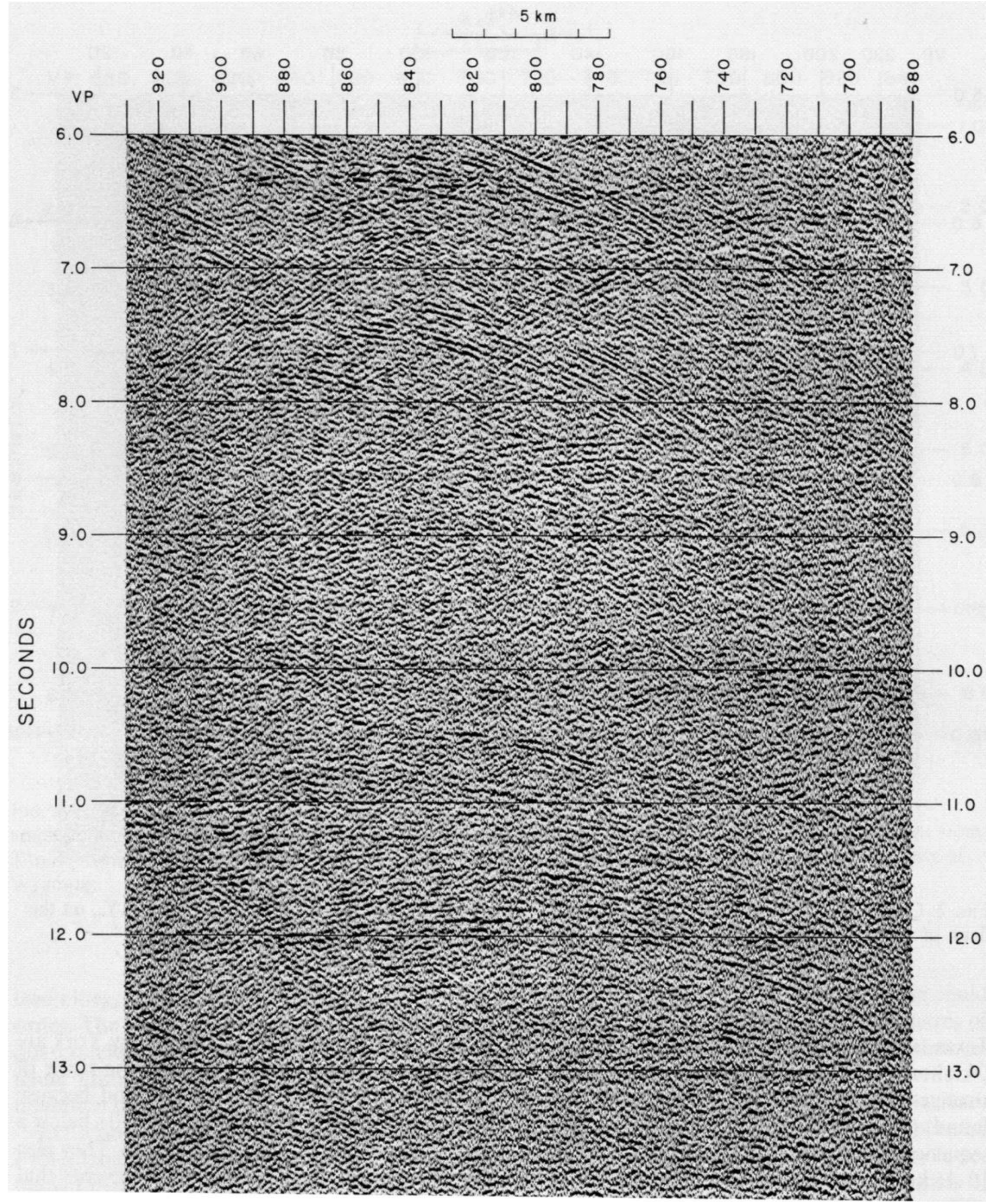
Example of regional compression that produced a massive thrust within the lower crust



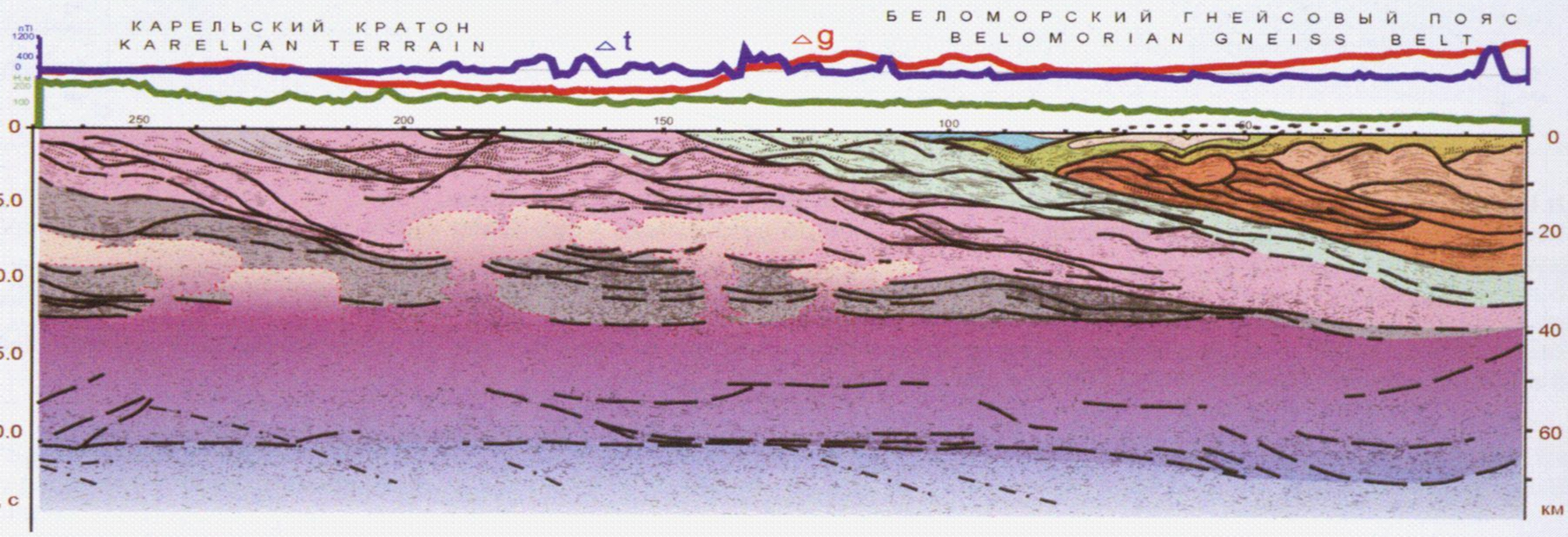
COCORP project: USA

The numerous profiles acquired for crustal-type studies in USA, show that the best deep reflections are found mainly in regions affected by recent extension.

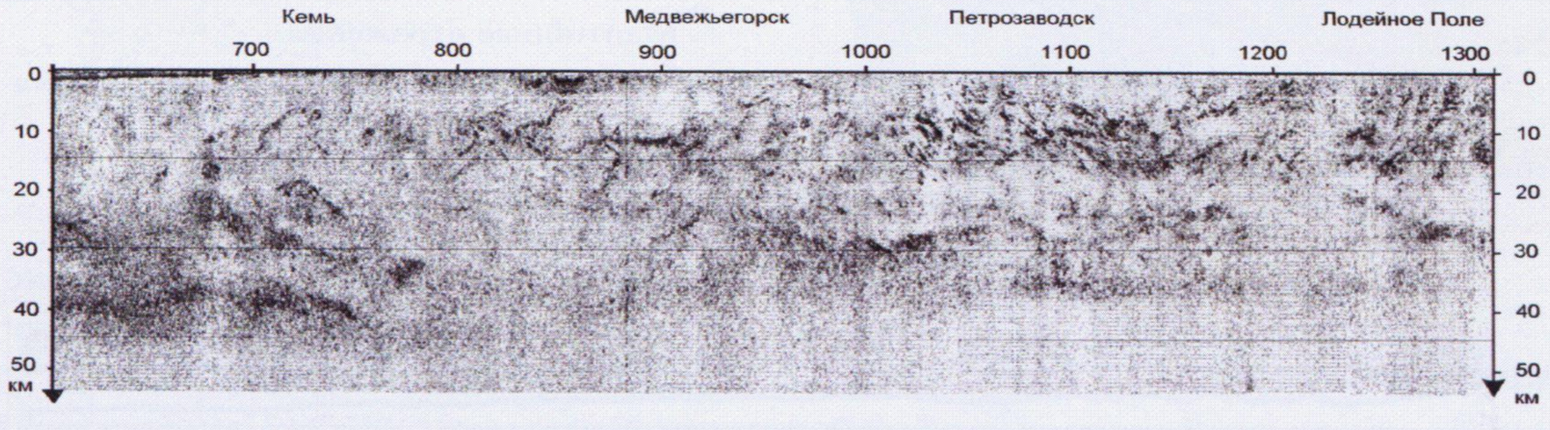
In the example, probable metamorphic rocks are folded and affected by intrusions.



Deep seismic in Russia



SVEKALAPKO GEOTRANSECT 4B



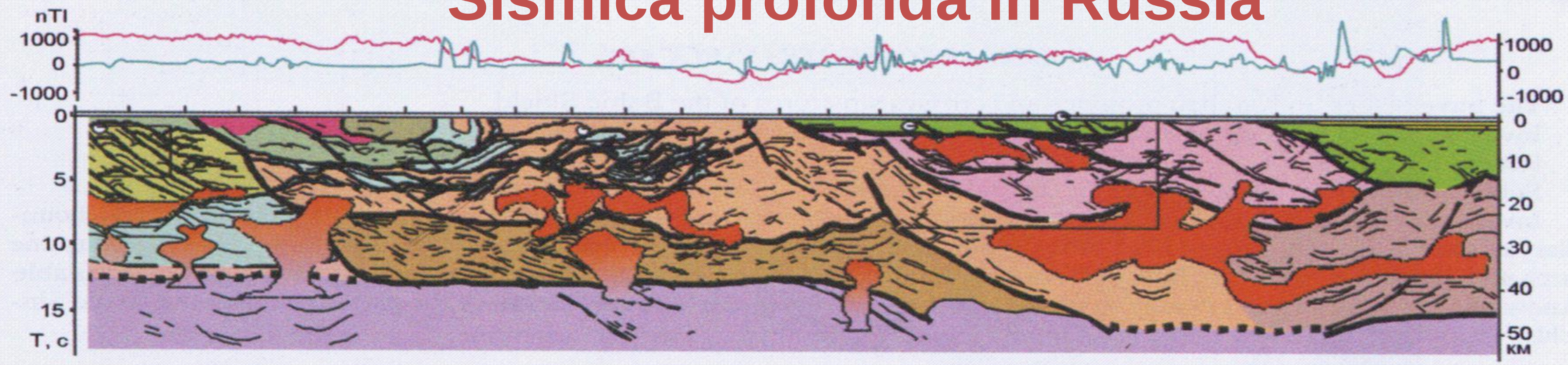
It lies in European part of Russia and crosses structures of the East-European platform.

Investigation technology is the combined seismics including reflection, vibro-CMP, refraction methods and deep seismic sounding (explosion).

Subject of inquiry: study of deep structure of the Earth's crust and upper mantle, inner structure of large tectonic units in connection with their different mineragenetic nature.

Investigation result: unique seismogeologic information is obtained characterized by reliable tracking of reflected and refracted waves from intracrustal features and Moho-boundary.

Sismica profonda in Russia



SPETSGEOFIZIKA
Tel: (095) 539-23-18
Fax: (095) 539-67-13
СПЕЦГЕОФИЗИКА
E-mail: geodptm@telcomnet.ru
E-mail: spetsgeo@telcomnet.ru

Lithoprobe Alberta Transect - Canada

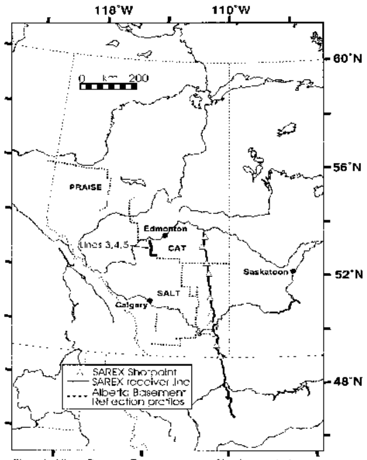


Figure 1. Alberta Basement Transect seismic profiles showing the location of lines 3, 4 and 5.

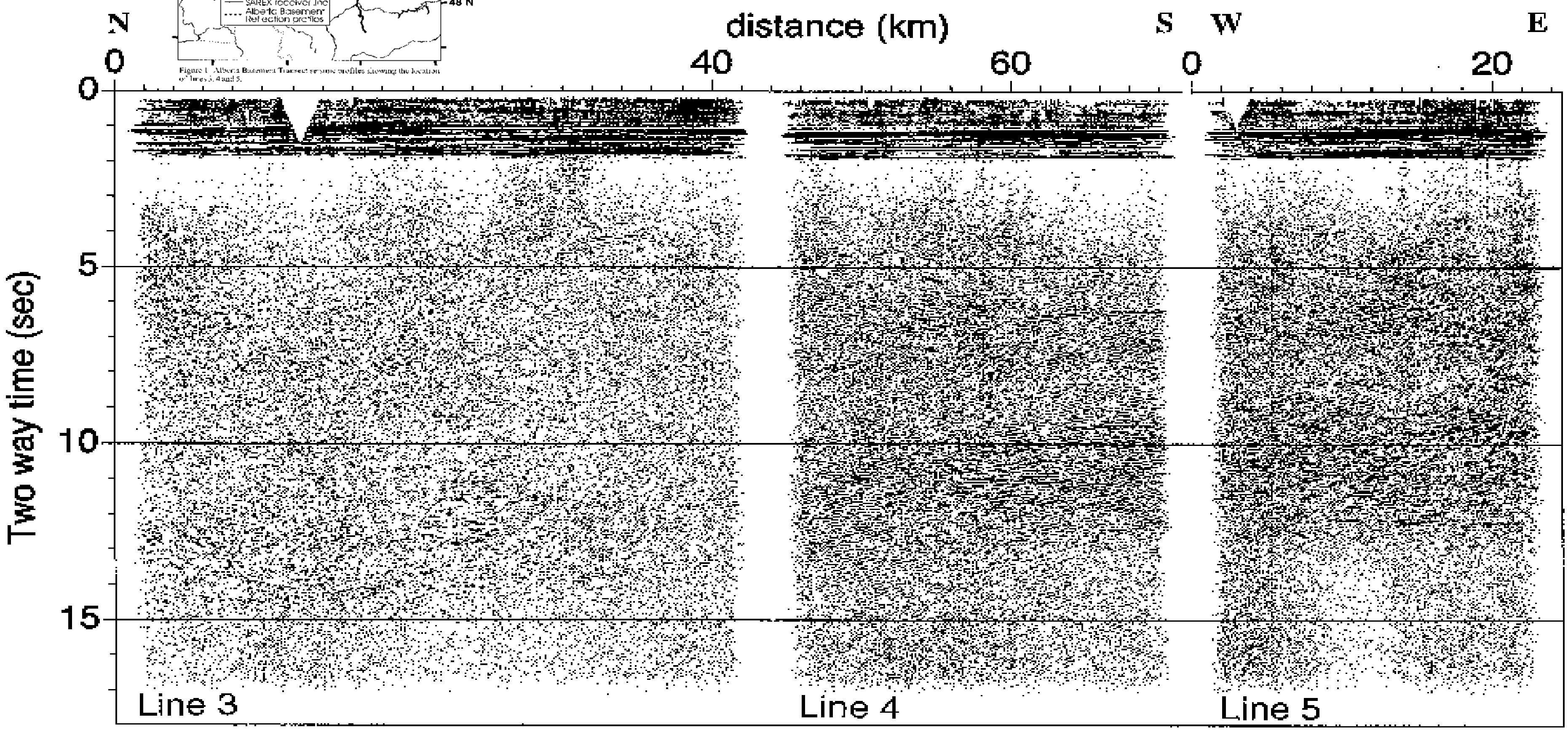


Figure 2. Lines 3, 4, and 5 from the Lithoprobe Alberta Transect as prepared for input to the migration. A negative bias is applied to each trace.

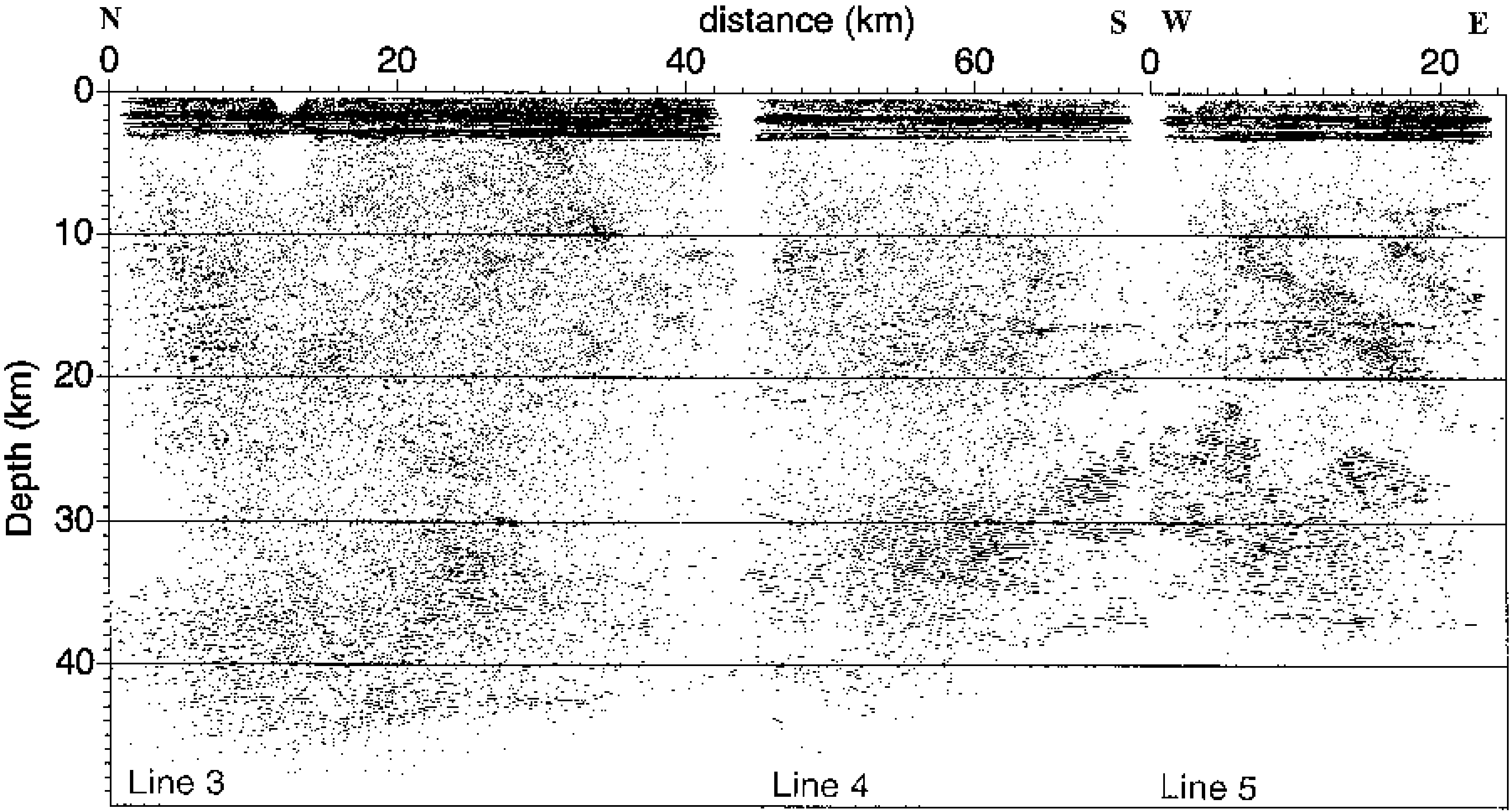
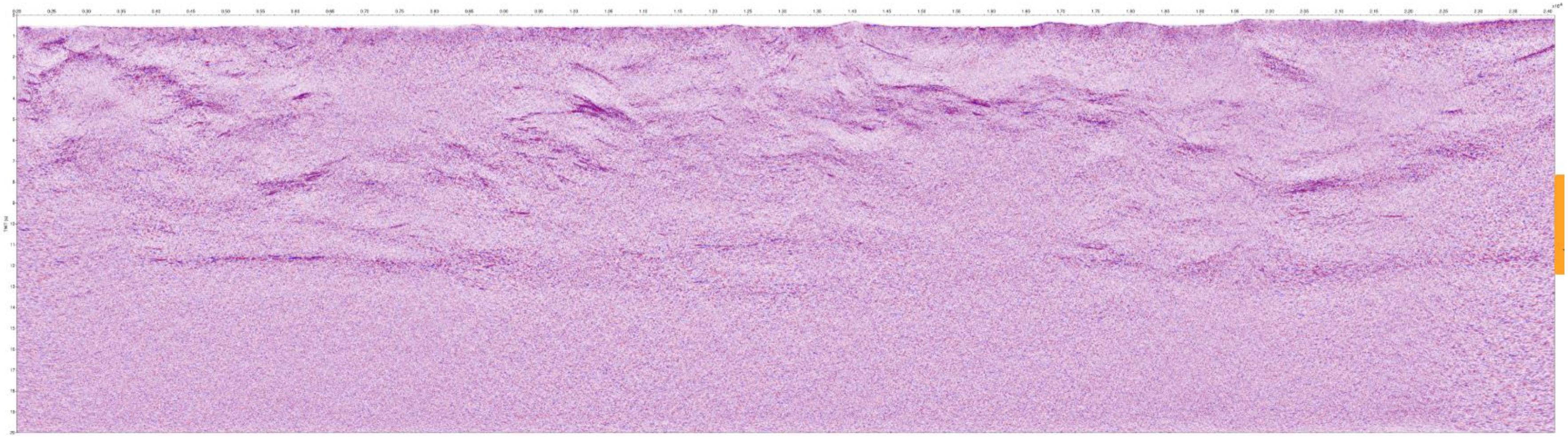
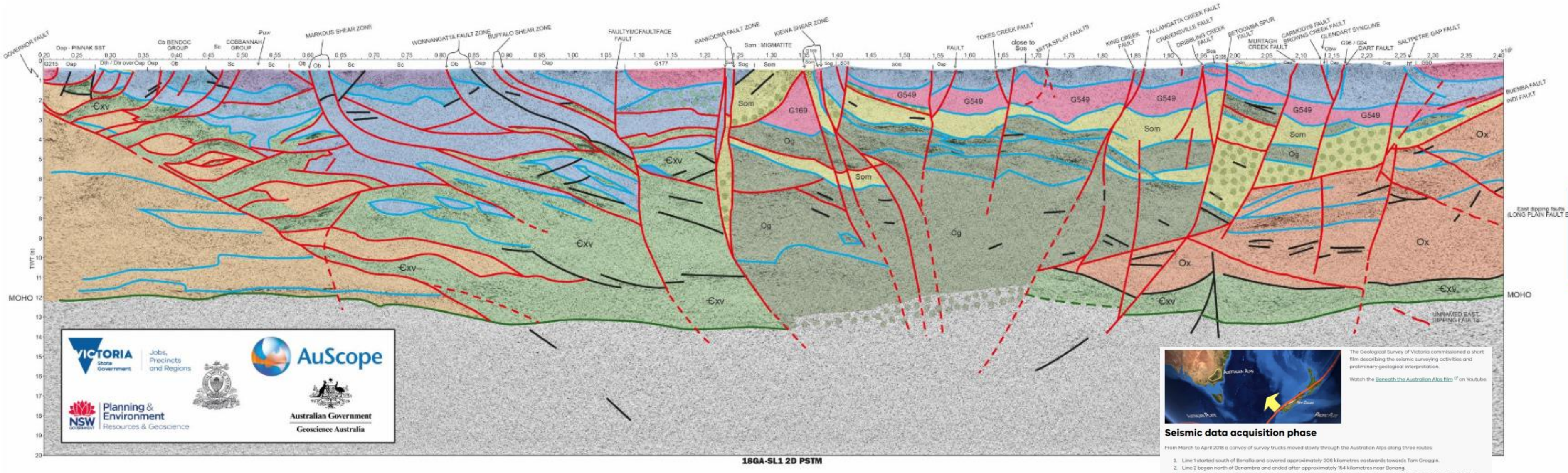
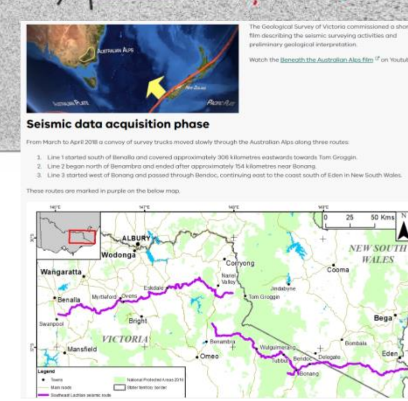


Figure 3. Lines 3, 4, and 5 after migration. No gain is applied. A negative bias is applied to each trace.

Southeast Lachlan Deep Crustal Seismic Reflection Survey (SE Australia)



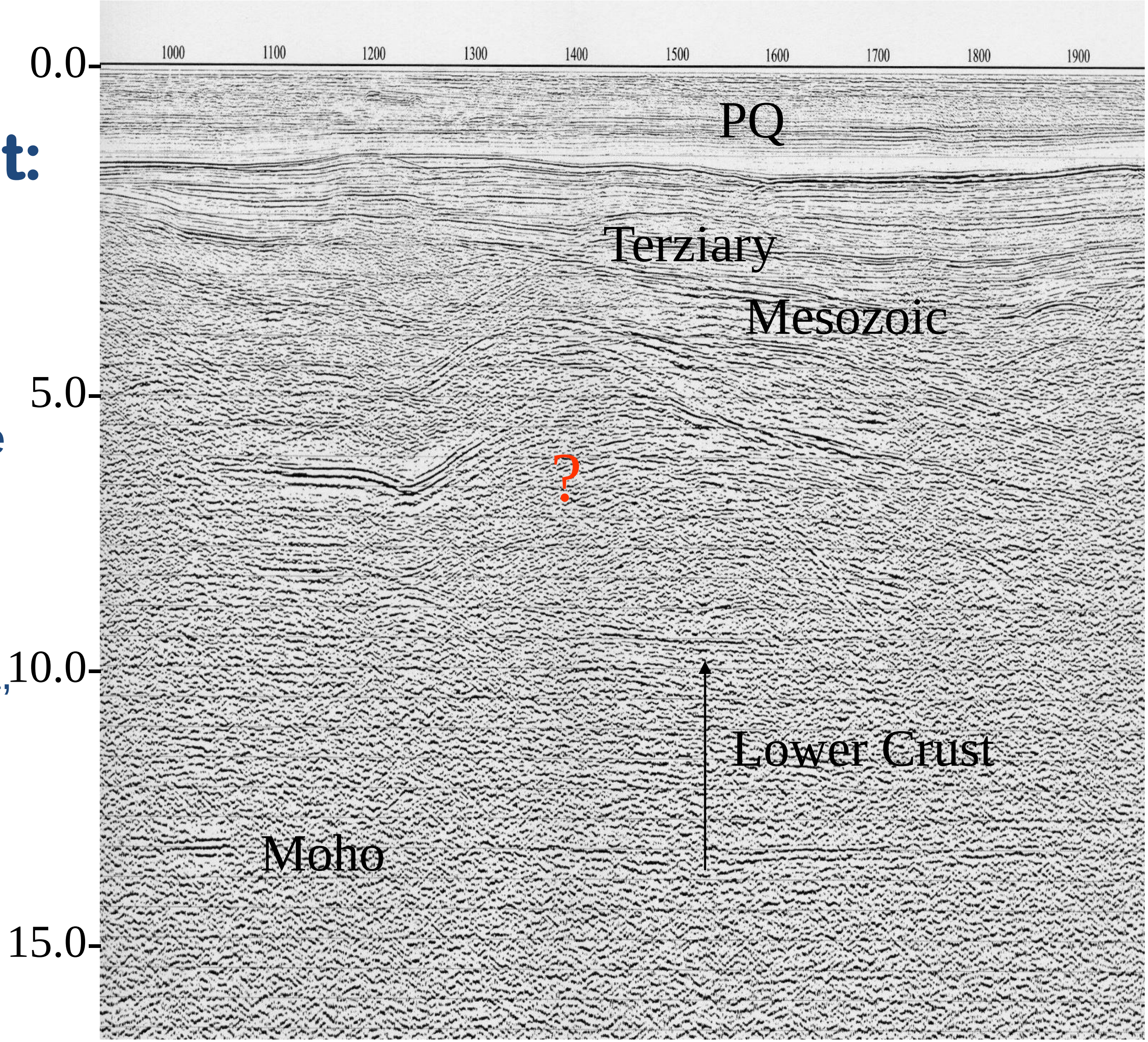




by Geoscience Australia's website

CROP project: Italia

Example of profile to study the deep crust in the Adriatic Sea, max depth of acquisition **17 sec 2wt**

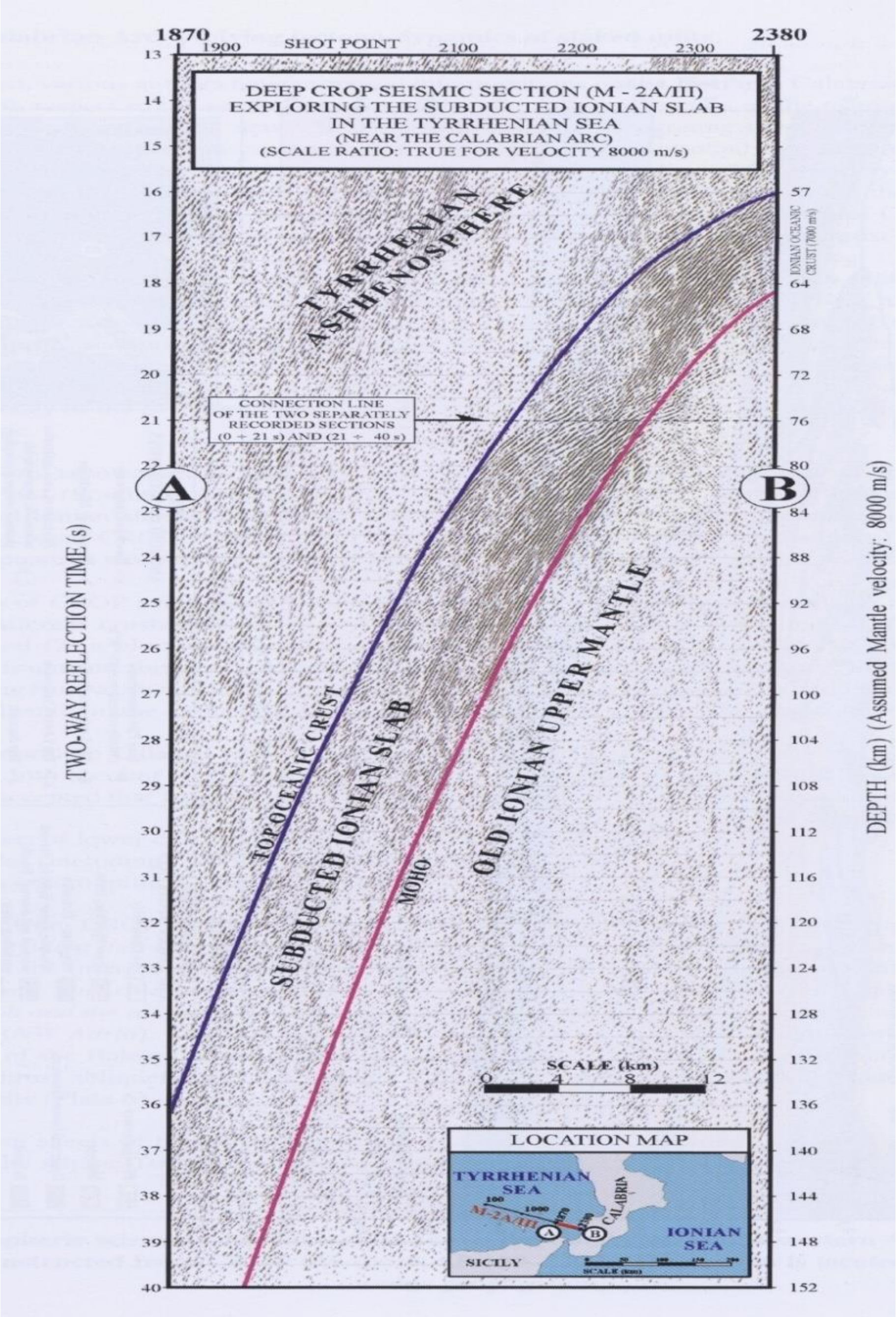


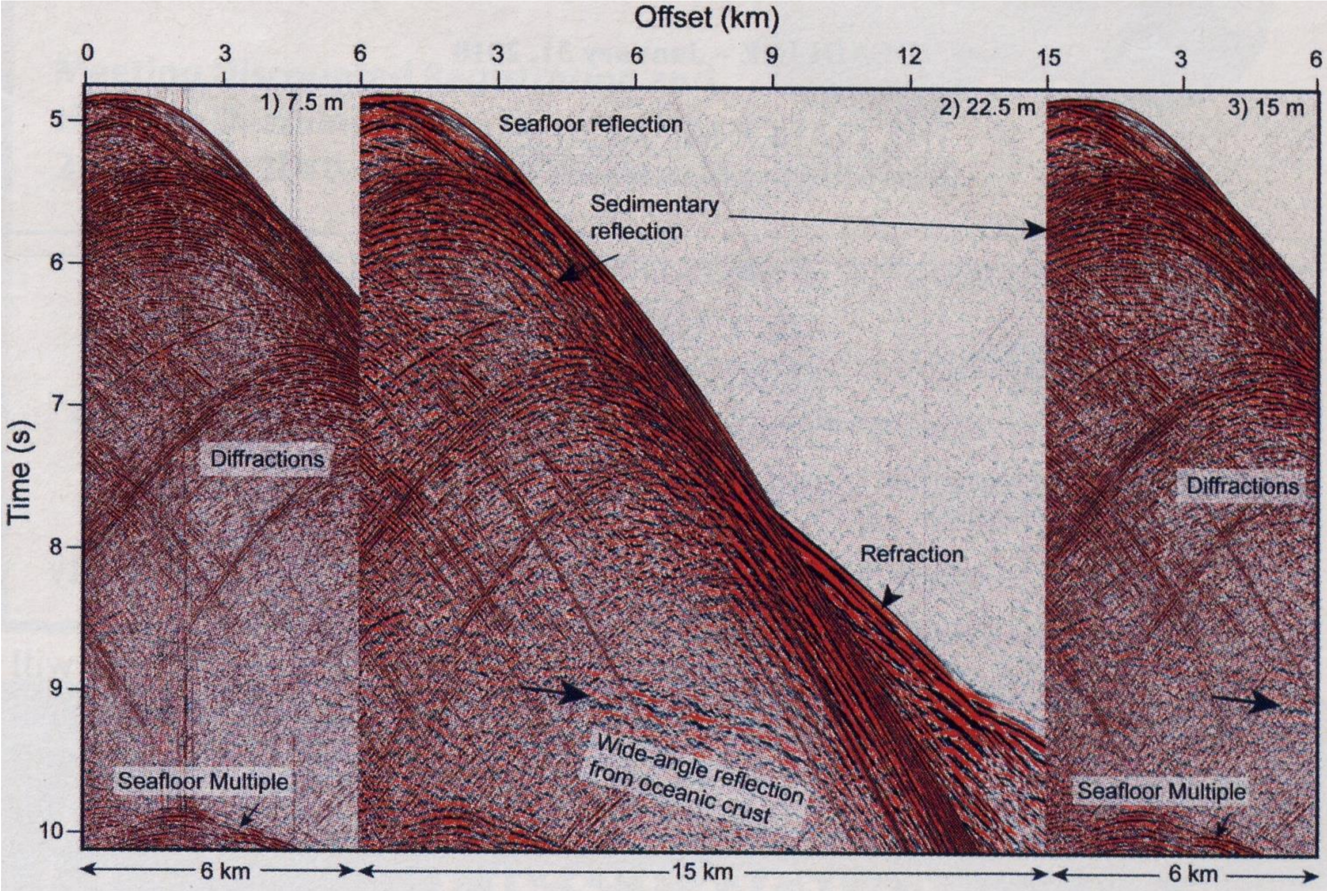
CROP prject: Italia

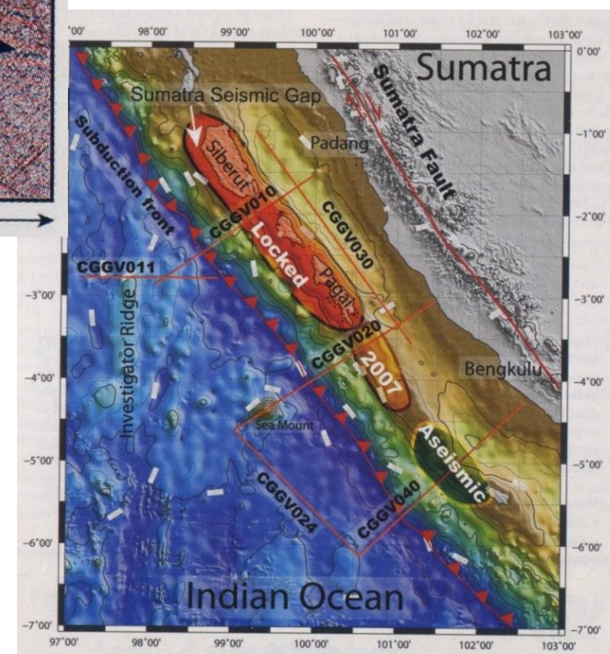
Example of a seismic profile in the south-eastern Tyrrhenian Sea (Calabrian margin).

The Ionian slab is clearly visible.

The maximum depth of acquisition is 40 sec (vertical scale on the left), on the right the estimated depth in kilometers.





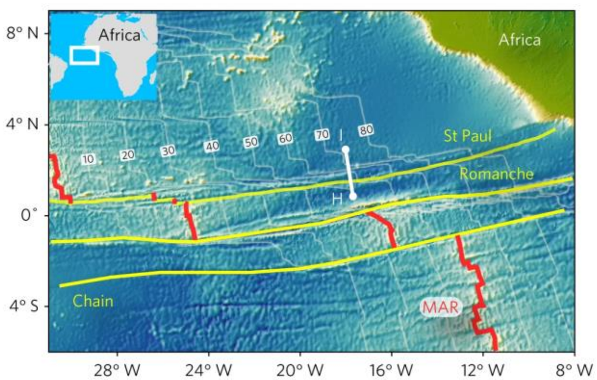


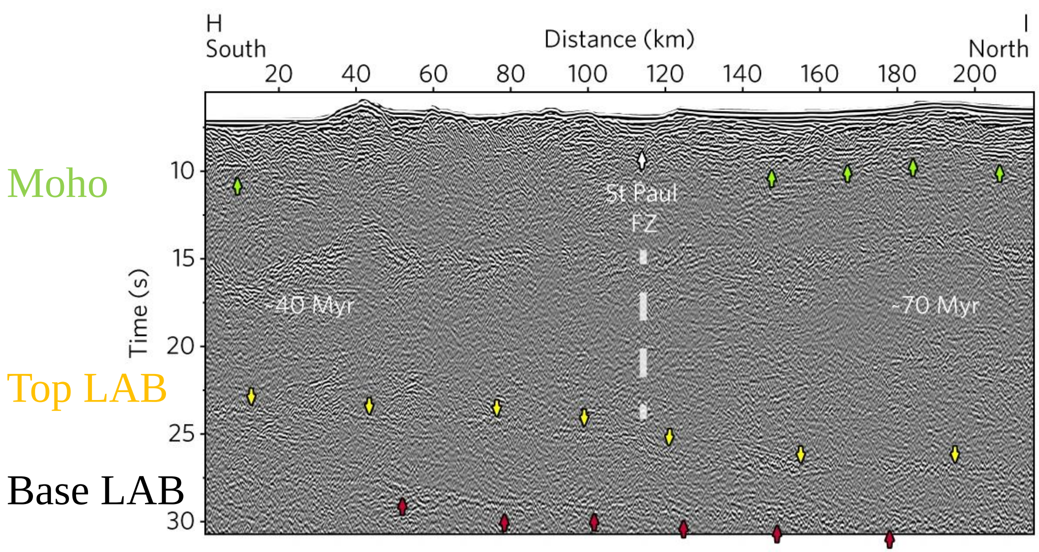
Offshore Sumatra: acquisition of seismic reflection profiles to explore the deep crust.
Only the long offset profile makes it possible to clearly detect the reflections coming from the Moho.

Seismic Reflection Image of the Lithosphere-Asthenosphere Boundary across the Equatorial Fracture Zones in the Atlantic Ocean

•Mehouachi, F. ; Singh, S. C.

The Lithosphere-Astenopshere Boundary (LAB) is one of the most extensive plate boundaries in Earth, but its detection have been very elusive because of the aseismic nature of the differential motion between the lithosphere and the underlying astenopshere. The LAB has been identified using surface waves and receiver function methods, but their vertical resolutions are of the order 30 km and 10 km, respectively. Here we **use seismic reflection method** to image the LAB. In order to image such a deep structure, we have used a **12 km long multi-component streamer** deployed at **30 m water depth**, deepest streamer ever used, and **10,000 cubic inch tuned air-gun source**, for recording and generating **low frequency energy** from deep earth, respectively. **A 800 km long seismic reflection profile** was shot across three major transform fault and fracture zones in the **equatorial Atlantic Ocean**, namely Romanche, St Paul and Chain. The age contrasts along our profile are: 25 Ma to 10 Ma across the Chain Fracture Zone (FZ), 10 Ma to 40 Ma across the Romanche Transform Fault (TF), and 40 Ma to 70 Ma across the St Paul FZ. We find that the LAB reflection across the St Paul FZ lies at 70 km (40 Ma) and 80 km (70 Ma) depth, consistent with the age-dependent depth of the LAB. We also image a second reflection at 15 km and 10 km below the LAB reflection across the FZ, possibly defining a channel above the asthenosphere. The thinning of this channel LAB across the St Paul FZ suggests that the channel thickness decreases due to the cooling of the lithosphere, indicative of the presence of hot fluid in the channel.



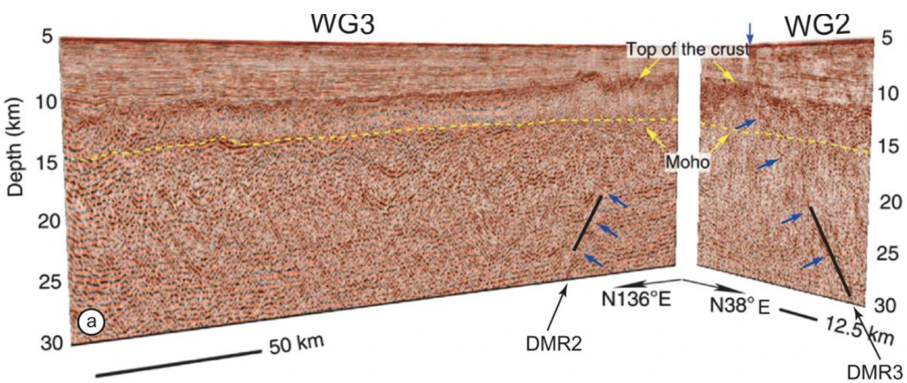


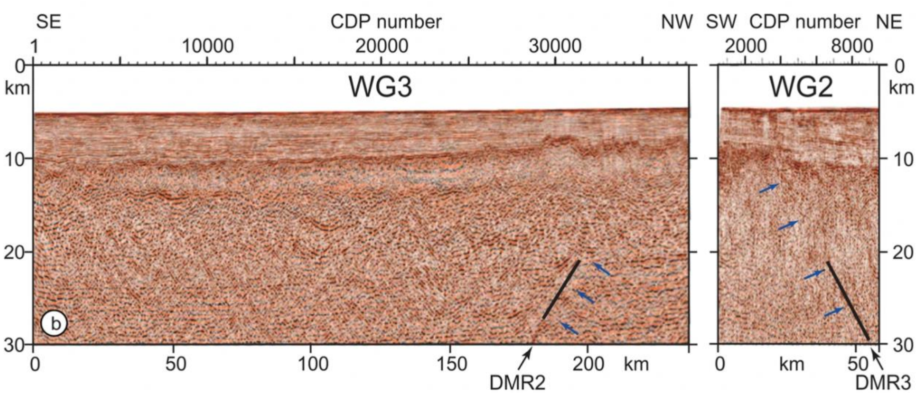
The seismic image along profile [HI]. Green arrows: Moho reflections; yellow arrows: top LAB reflections; red arrows: bottom LAB reflections. The St Paul FZ (white arrow and dashed line) lies between 100- and 120-km distance, separating 70-Myr-old oceanic lithosphere in the north from 40-Myr-old lithosphere in the south. The base of the LAB is difficult to pick beyond the 180-km distance range, as the seismic image reaches its recording limit.

Oceanic mantle reflections in deep seismic profiles offshore Sumatra are faults or fakes

Jean-Claude Sibuet, Enyuan He, Minghui Zhao, Xinming Pang & Frauke Klingelhoefer

Sci Rep **9,** 13354 (2019)





… This result confirms that most of mantle reflections observed southwest northern Sumatra are fakes rather than faults.