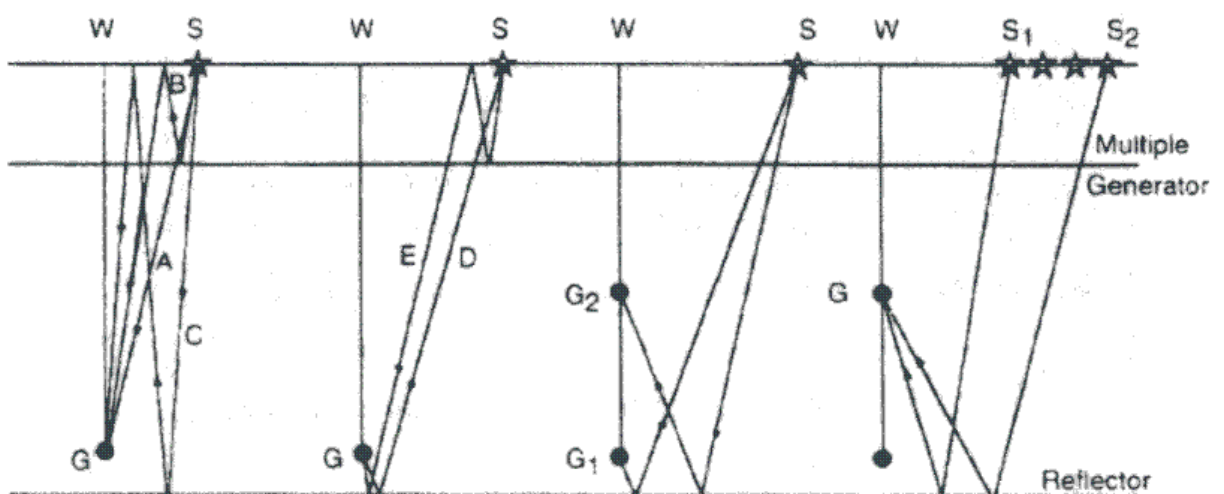


Vertical Seismic Profiling

- VSP types
- Planning and Acquisition
- Processing
- Reading:
 - › Sheriff and Geldart, Section 13.4

Types of VSP

- By placing geophones in a borehole, favourable recording conditions are achieved:
 - Shorter paths;
 - Lower attenuation, higher frequencies;
 - Less effects of weathering;
 - Receiver spread may run across the horizon of interest.



Zero-offset

Offset

Walkaway

Objectives of VSP surveys

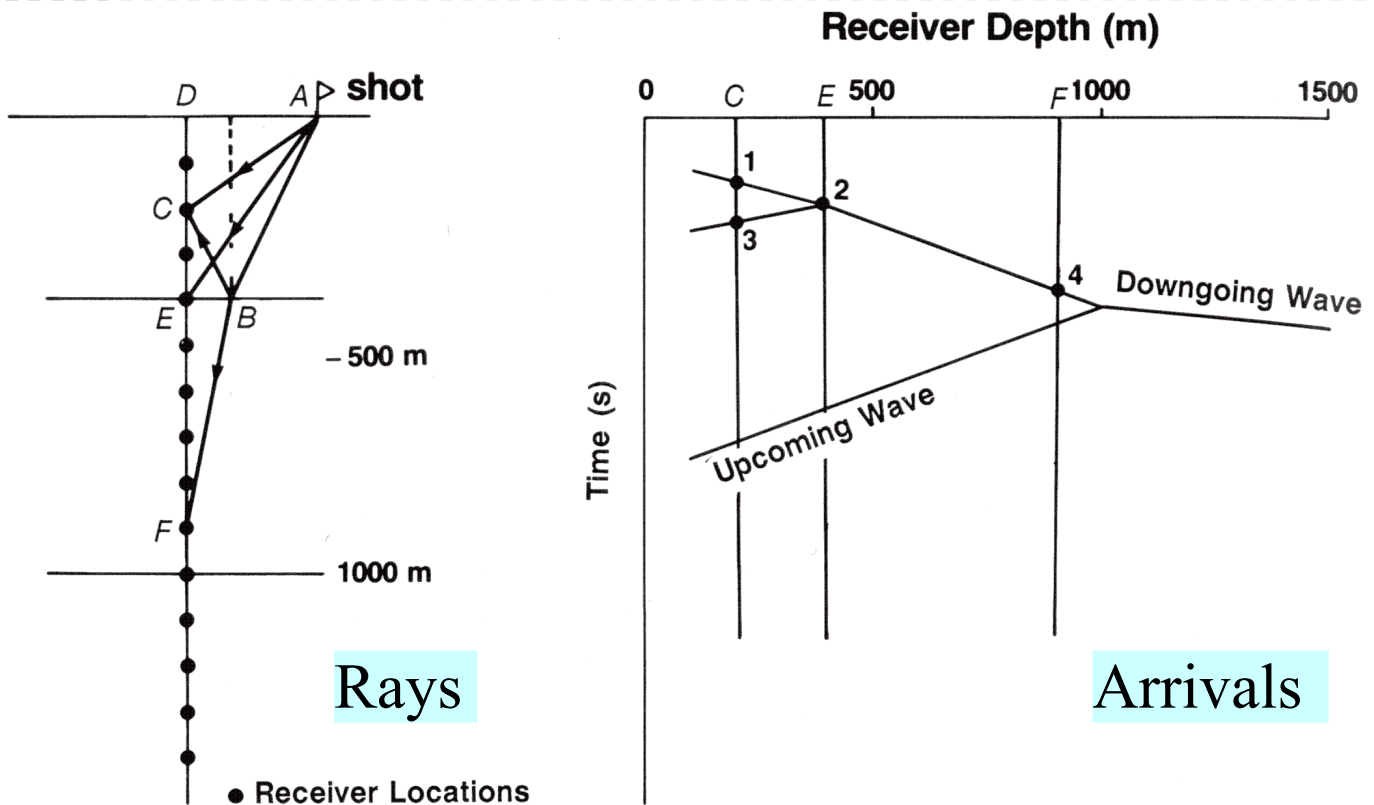
Table 13.1 *Objectives of VSP surveys*

| Objective | How achieved |
|--|--|
| Reflector identification | Upgoing wave studies on zero-offset VSP |
| Surface-to-borehole correlation | |
| Increased resolution at depth | |
| Time-depth conversion | First-break studies on zero-offset VSP |
| Enhanced velocity analysis | |
| Log calibration | |
| Multiple identification | Downgoing wave studies on zero-offset VSP |
| Deconvolution operator | |
| Improve poor data area | All types, especially offset VSP |
| Predict ahead of bit | Upgoing wave studies on zero-offset VSP |
| Structural imaging | Walkaway or offset VSP with presurvey modeling |
| Delineate salt dome | Proximity survey with source over dome |
| Seeing above/below bit on deviated wells | Zero-offset, offset, or walkaway VSP |
| Stratigraphic imaging (channels, faults, reefs, pinchouts) | Multiple-source locations with offset VSP |
| AVO studies | Research study on offset VSP with presurvey modeling |
| P/S-wave analysis | Research study on offset VSP, three-component phone |
| Polarization studies | |
| Fracture orientation | |
| Attenuation analysis | Research study on zero-offset VSP |
| Secondary recovery | Research study on offset VSP |
| Tomographic studies | Multiple wells, multiple offsets |
| Permeability studies | Tube-wave analysis research study |

After Gilpatrick and Fouquet, 1989.

VSP geometry

- *Downgoing* and *upgoing* waves can be directly observed and isolated.
- To transform reflection times into *vertical-incidence times*, 2 steps are performed:
 - "VSP static correction" - mapping of time ABC into ABC + CD;
 - For offset VSP, NMO correction maps ABCD times into DE.

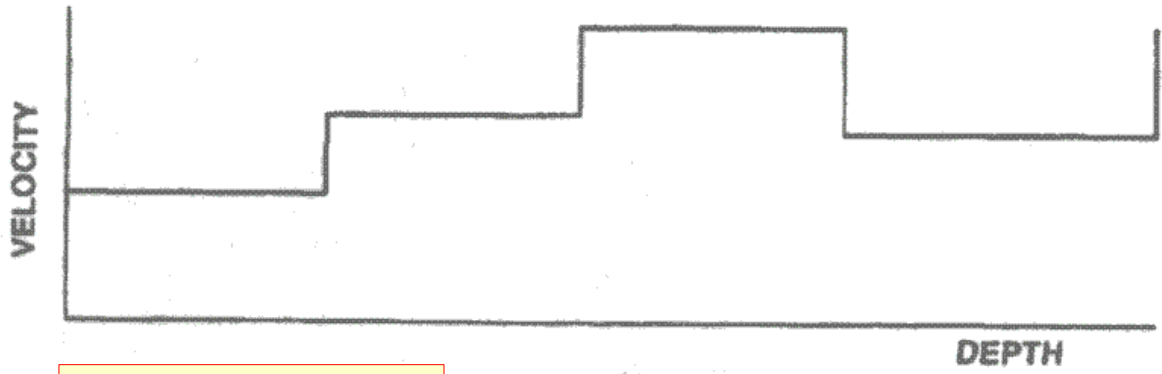


Rays

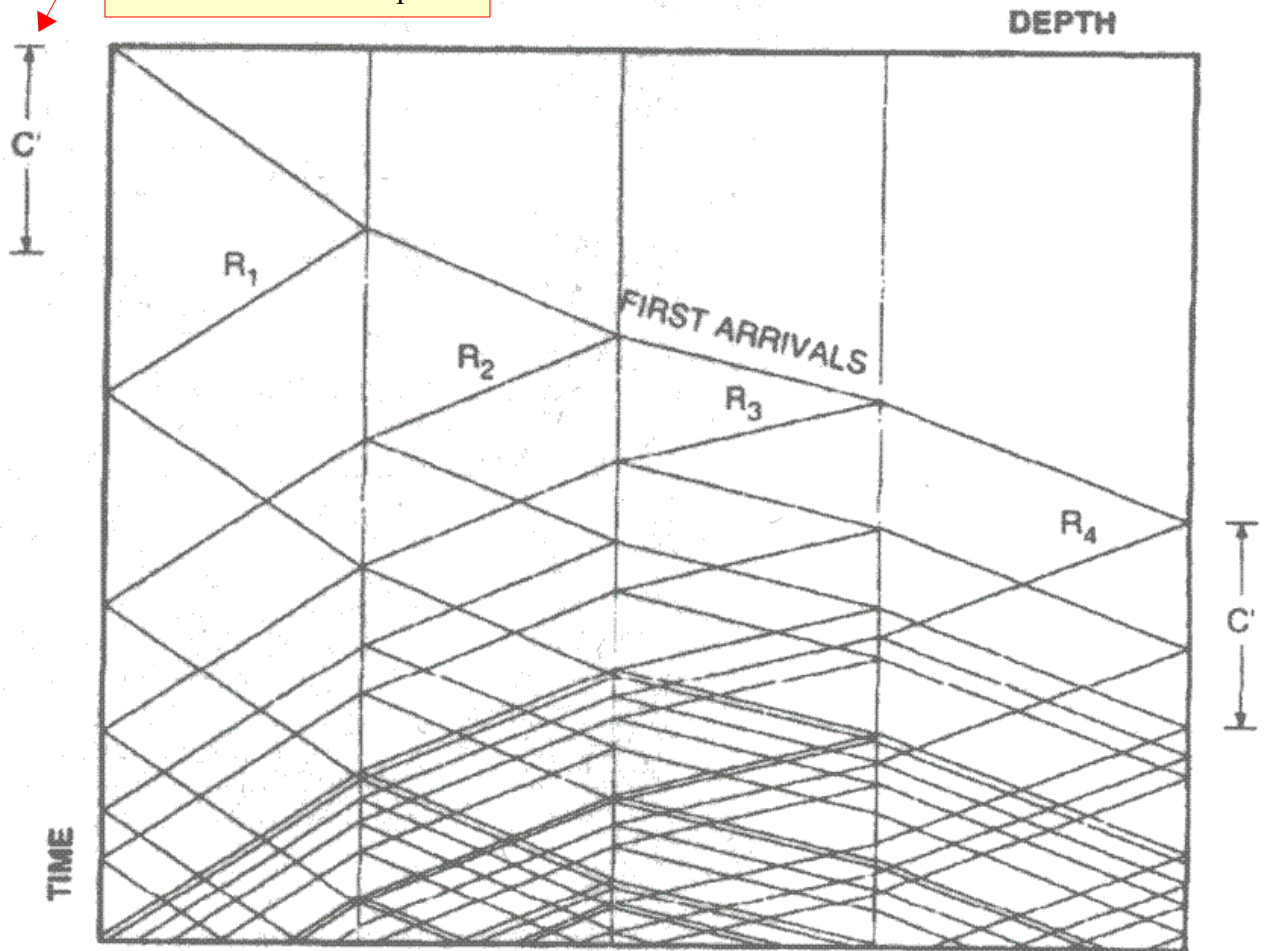
Arrivals

● Receiver Locations

Multiples in a VSP section



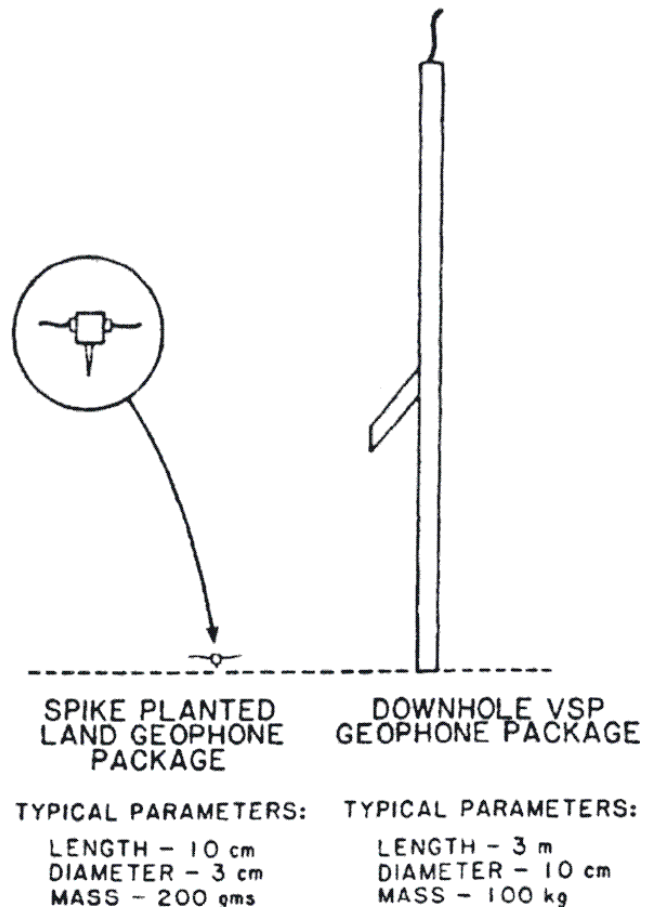
This region is relatively free from intrabed multiples



(b)

Surface vs. VSP geophone

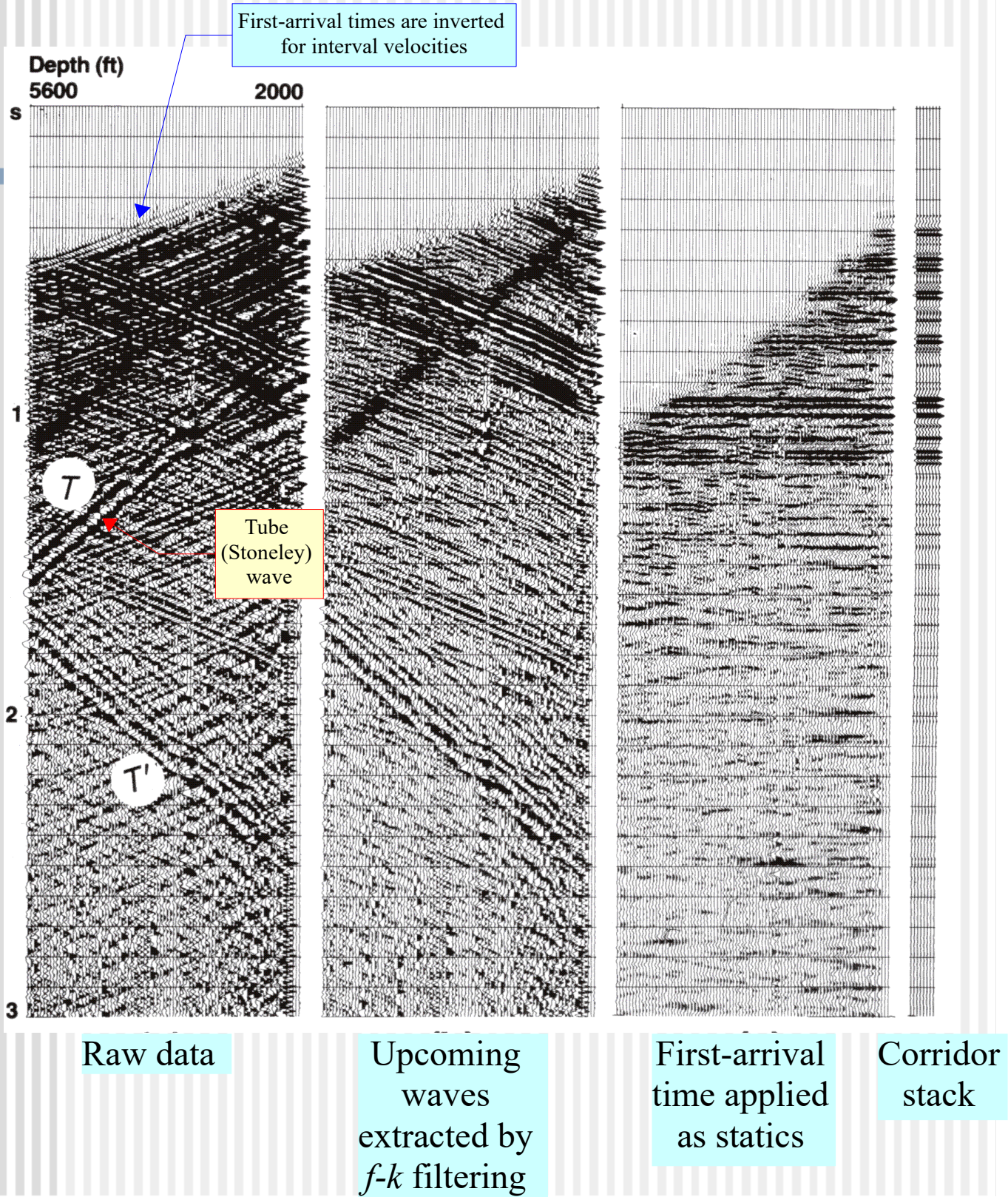
- VSP sonde should:
 - be 3-component; contain several levels;
 - include a retractable anchoring device;
 - contain orientation gear (a gyro);
 - withstand temperatures, pressures and fluids.



Acquisition procedure

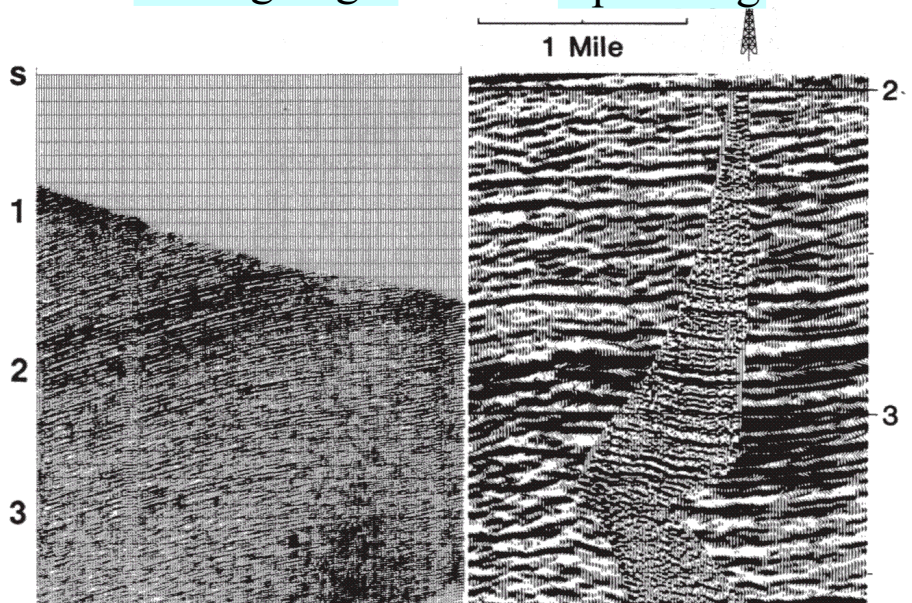
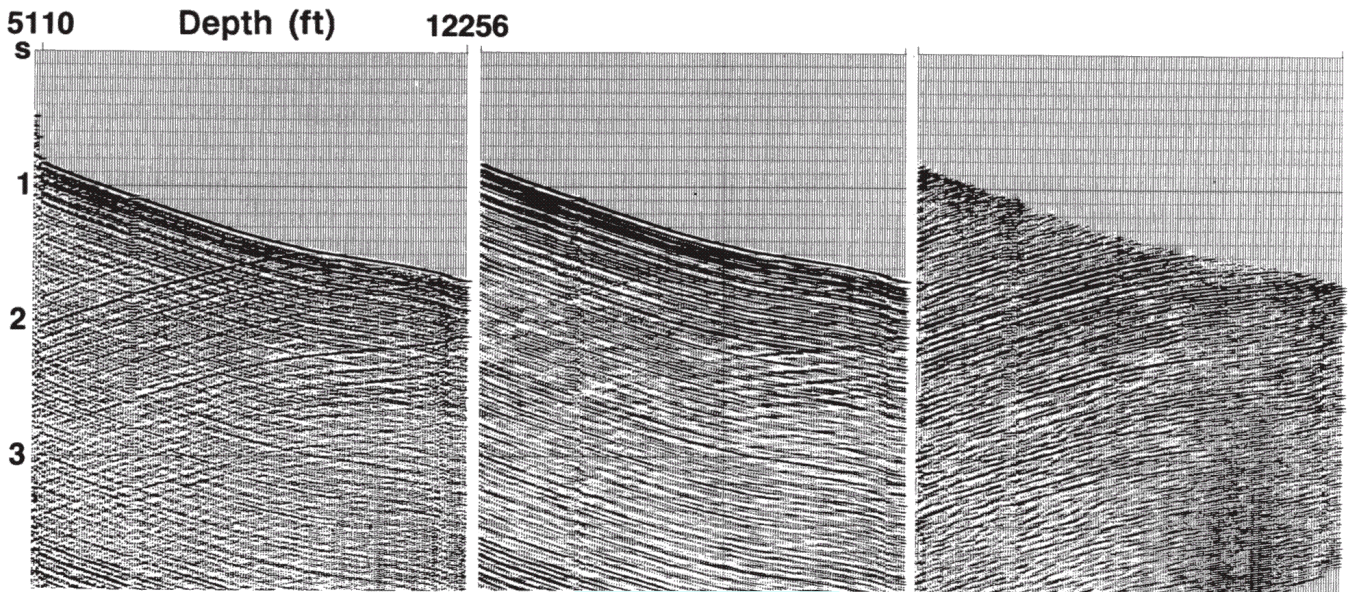
- Make sure tool depth=0 at the well head;
- Slack the cable after anchoring;
- Record 5-6 levels as the tool is being lowered;
- Determine the gain and number of records to stack for required Signal/Noise;
- Take at least 5 records and monitor quality at every level;
- Reoccupy the down levels and check the depth and waveforms;
- Avoid washed out zones;
- Recheck depth at well head.

VSP data processing



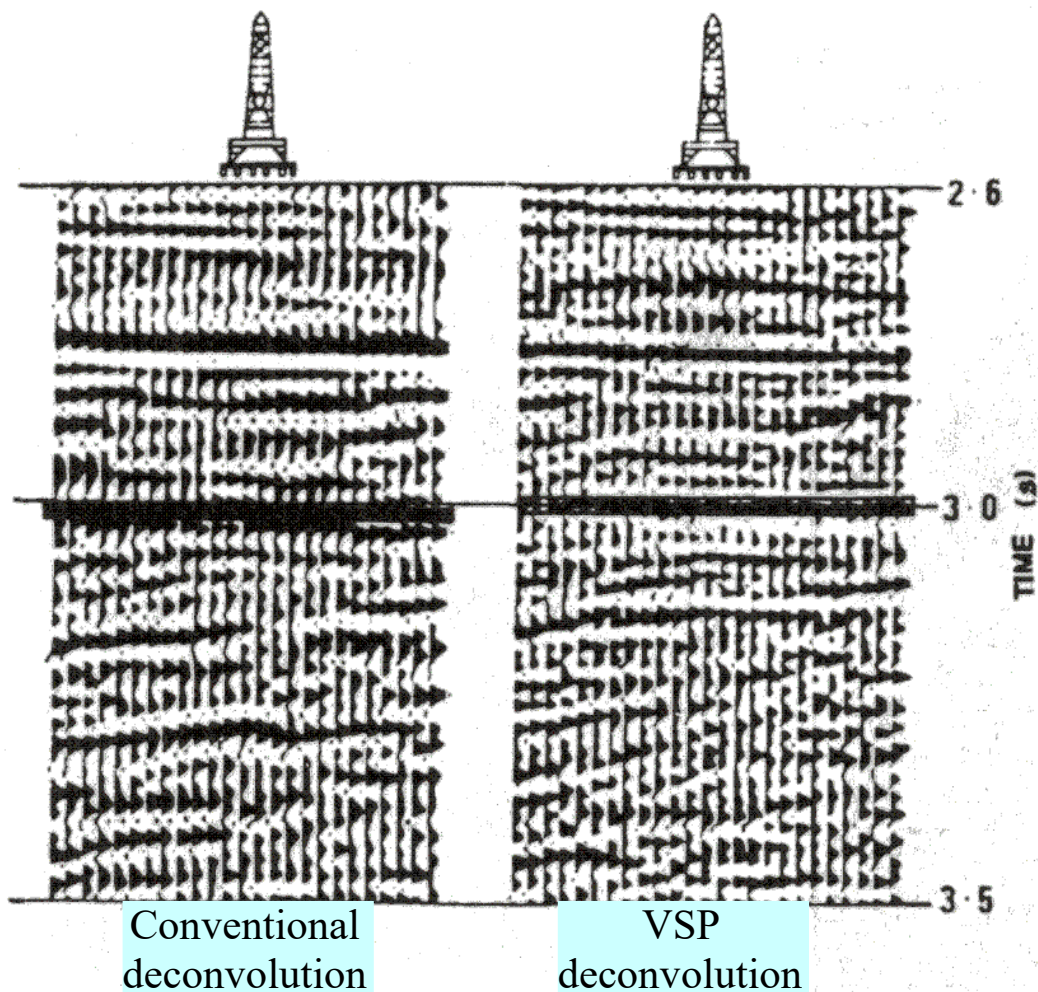
VSP data processing

another example



VSP deconvolution

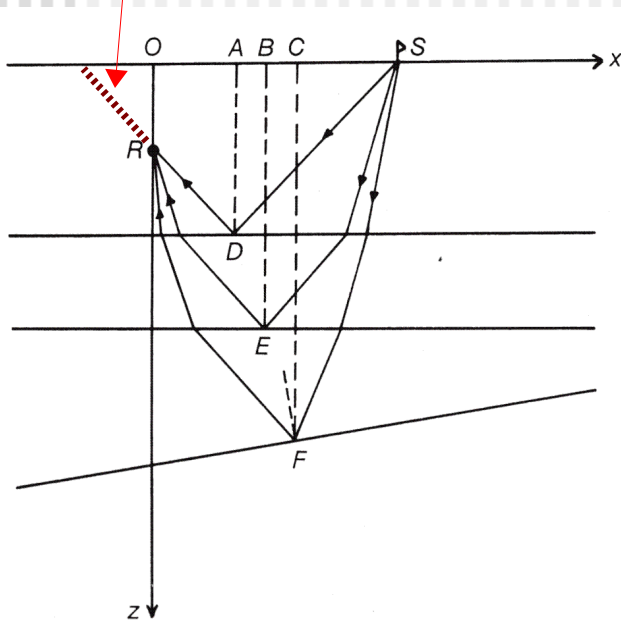
- Deconvolution filter derived from VSP could be applied to CMP data across the same area
- Because of broader frequency band and better-quality VSP recording, this deconvolution improves CMP data:



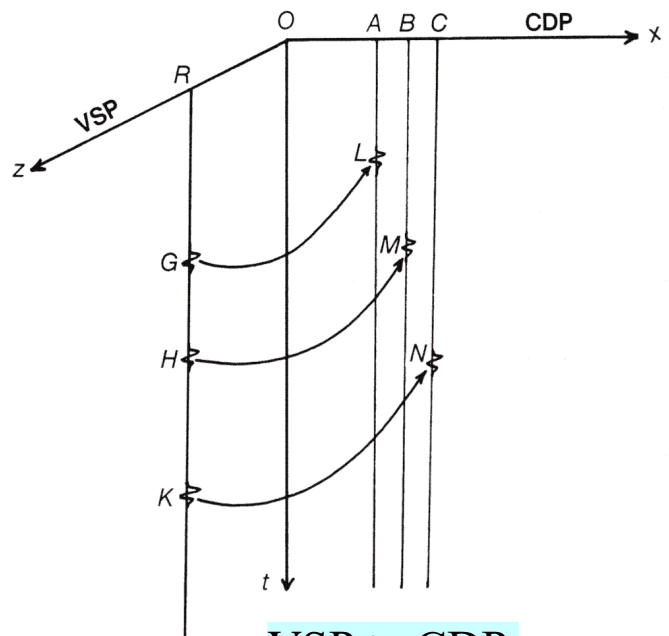
VSP migration and VSP-CMP transform

- Travel times are mapped into depth via ray tracing;
 - this is similar to “pre-stack” migration.
 - This ray tracing can also transform VSP reflection records in a surface-reflection form (VSP-CMP transform)
- VSP apertures are limited, and so we need to know the dominant dips or use other constraints

To transform a VSP to surface reflection, we need to add the time along this ray



Rays



VSP to CDP transform