Seismic Reflection Data Processing

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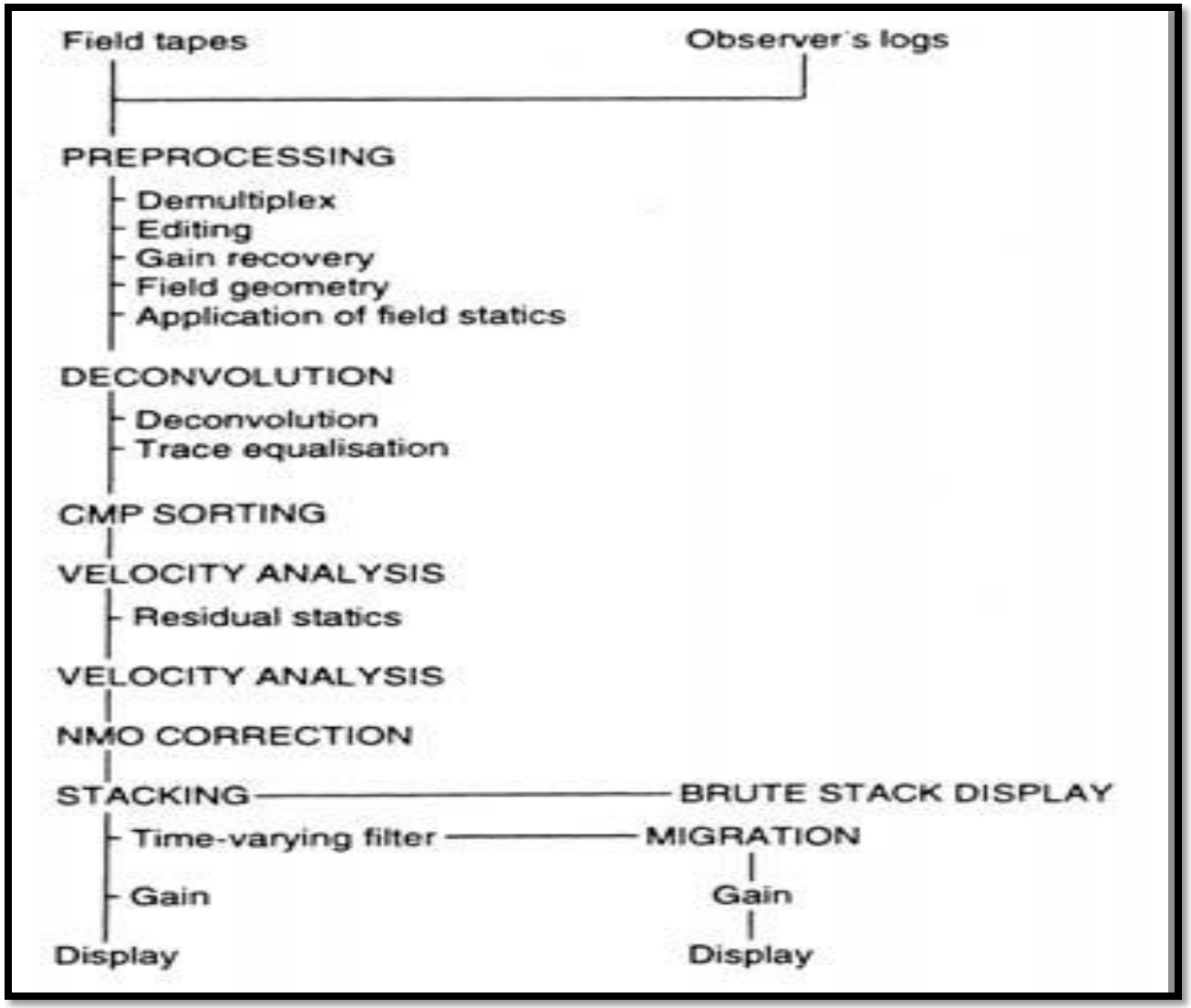
Seismic processing

- Alteration of seismic data to suppress noise, enhance signal and migrate seismic events to the appropriate location in space.



Flow overview

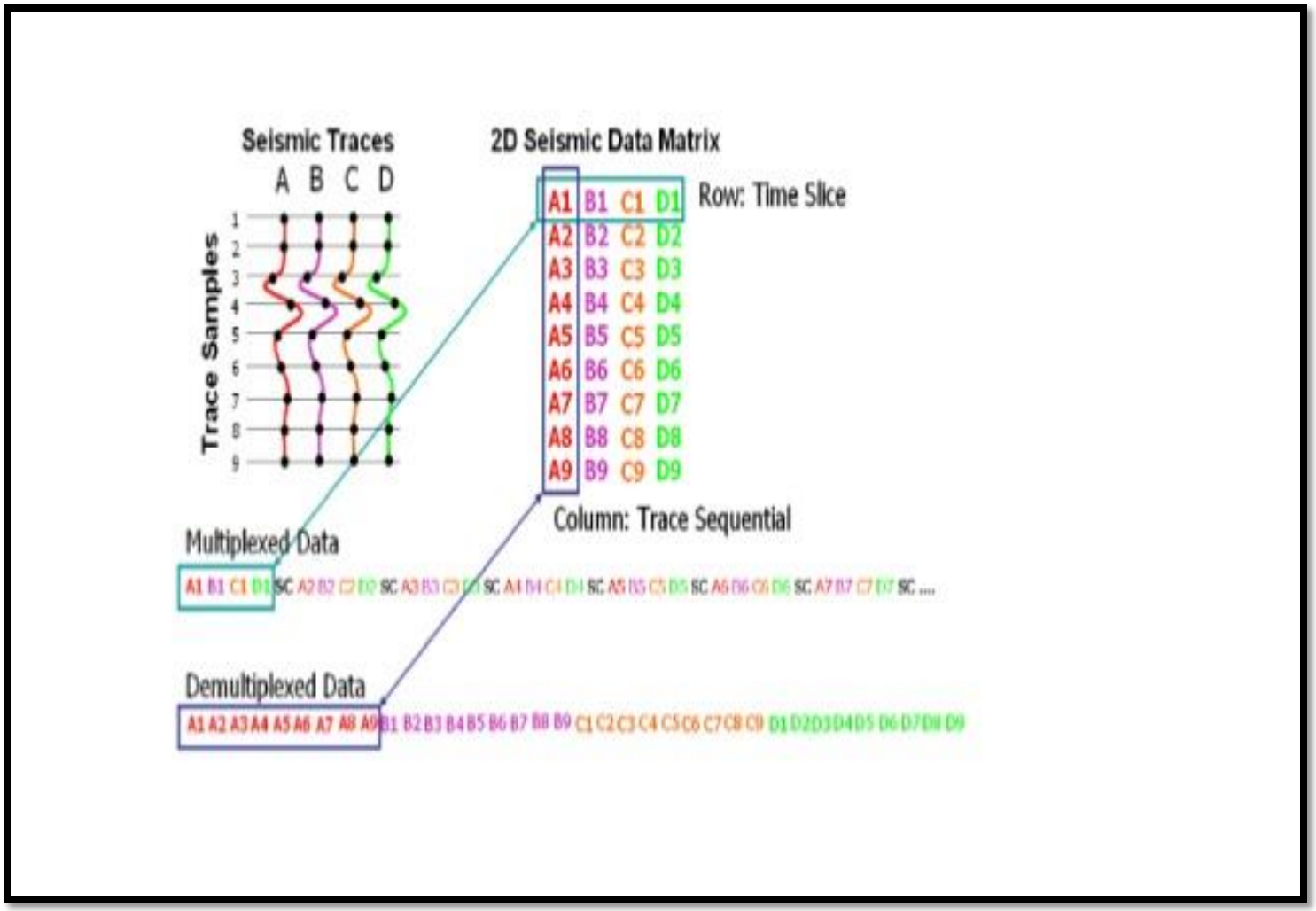
Preprocessing

Preprocessing includes the following steps:

- *Demultiplex*
- *Editing*
- *Gain recovery*
- *Field geometry*
- *Application of field statics*

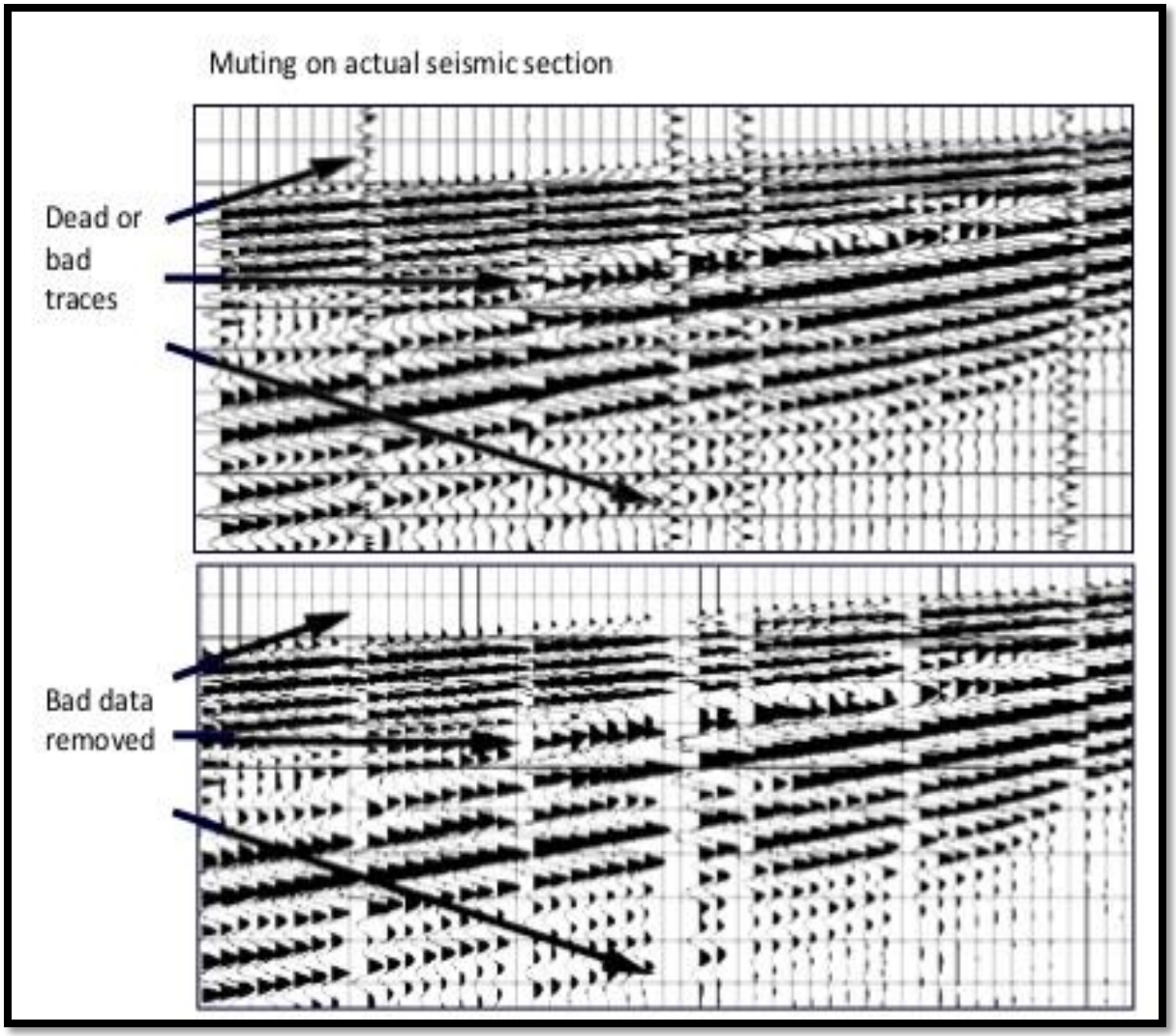
Preprocessing
Demultiplexing

- Four geophones: A, B, C, D, recording samples 1, 2, 3, 4 …
- The recording device stores samples in the order recorded.
  - Demultiplexing is separating all the samples to produce a time sequence for each geophone.


Seismic Traces
A B C D
Trace Samples
1
2
3
4
5
6
7
8
9
2D Seismic Data Matrix
A1 B1 C1 D1
A2 B2 C2 D2
A3 B3 C3 D3
A4 B4 C4 D4
A5 B5 C5 D5
A6 B6 C6 D6
A7 B7 C7 D7
A8 B8 C8 D8
A9 B9 C9 D9
Row: Time Slice
Column: Trace Sequential
Multiplexed Data
A1 B1 C1 D1 SC A2 B2 C2 D2 SC A3 B3 C3 D3 SC A4 B4 C4 D4 SC A5 B5 C5 D5 SC A6 B6 C6 D6 SC A7 B7 C7 D7 SC ...
Demultiplexed Data
A1 A2 A3 A4 A5 A6 A7 A8 A9 B1 B2 B3 B4 B5 B6 B7 B8 B9 C1 C2 C3 C4 C5 C6 C7 C8 C9 D1 D2 D3 D4 D5 D6 D7 D8 D9

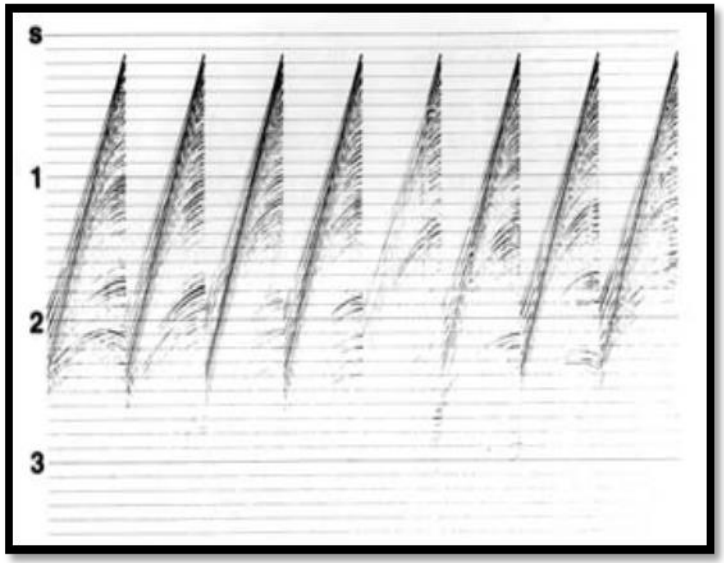
Preprocessing
Editing and muting

- The typical targets for muting are:
- To detect and kill the unwanted traces
- Remove dead traces
- Remove noisy traces
- “Cut” out unwanted signal e.g. pre-arrival noise, direct arrival, ground roll.

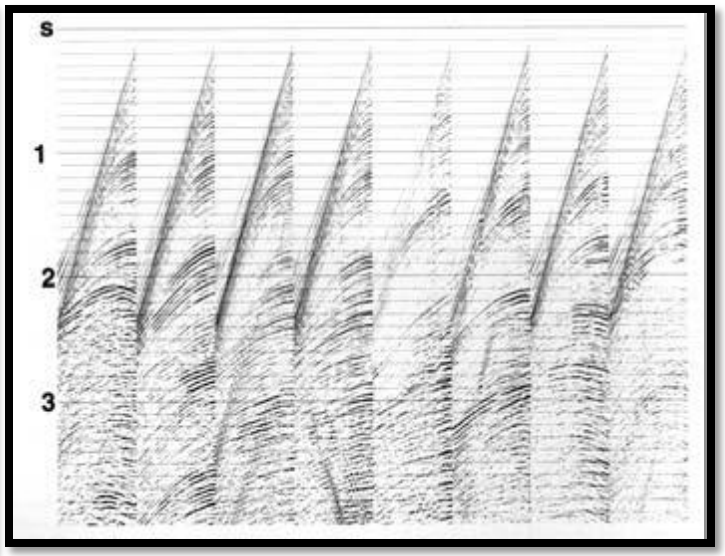

Muting on actual seismic section
Dead or bad traces
Bad data removed

Preprocessing
Gain recovery

- **Turn up the volume" to account for seismic attenuation**
- As seismic waves moves forward it experienced decay in amplitude in all direction.
- Both laterally with offset and vertically with depth.
- In processing lose amplitude, we could calculate the energy/amplitude loss using geometric spreading and apply a correction.
- Automatic gain control (AGC) apply a gain to equalize amplitude along the trace.



Pre-AGC



Post-AGC

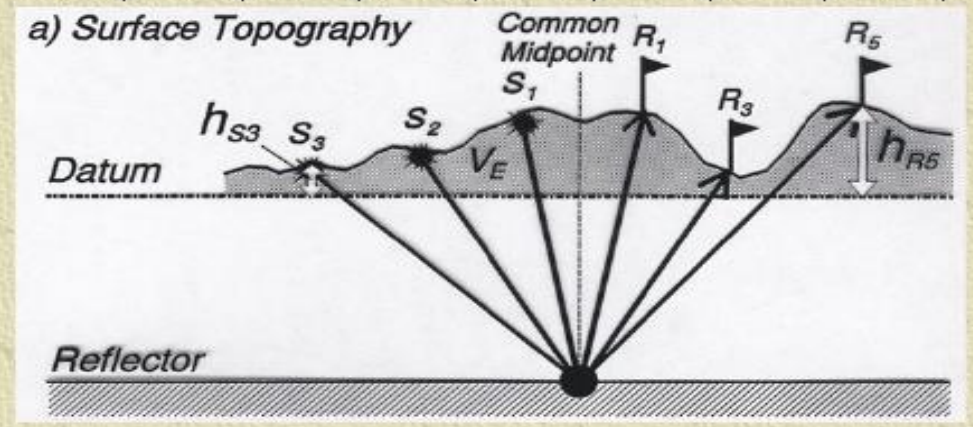
Preprocessing
Static Correction

- Often called statics, a bulk shift in time of a seismic trace during seismic processing.
- A common static correction is the ***weathering correction***, which compensates for a layer of low seismic velocity material near the surface of the Earth.

Preprocessing
Static Correction

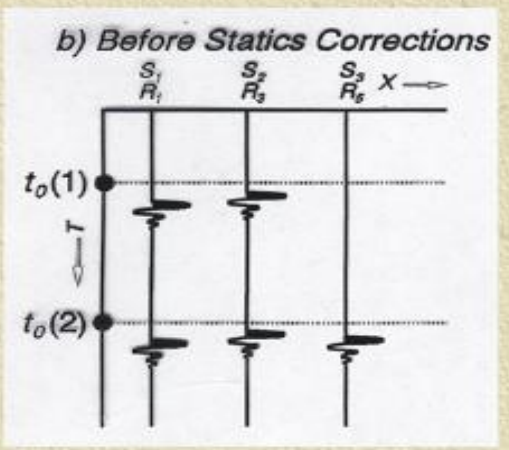
- Other correction is ***topographic correction*** which compensates for differences in topography and differences in the elevations of sources and receivers.
- Correct for surface topography and the weathered surface layer

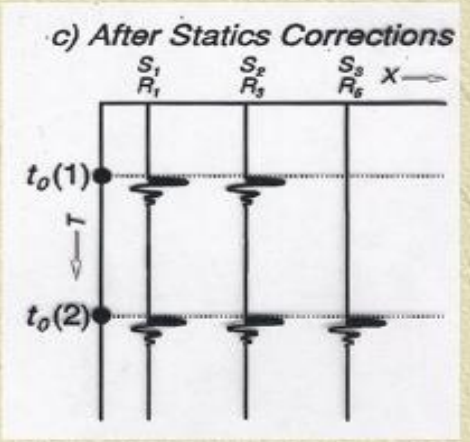
Static Corrections



$$SC = (h_{S3} + h_{R5})V_E$$

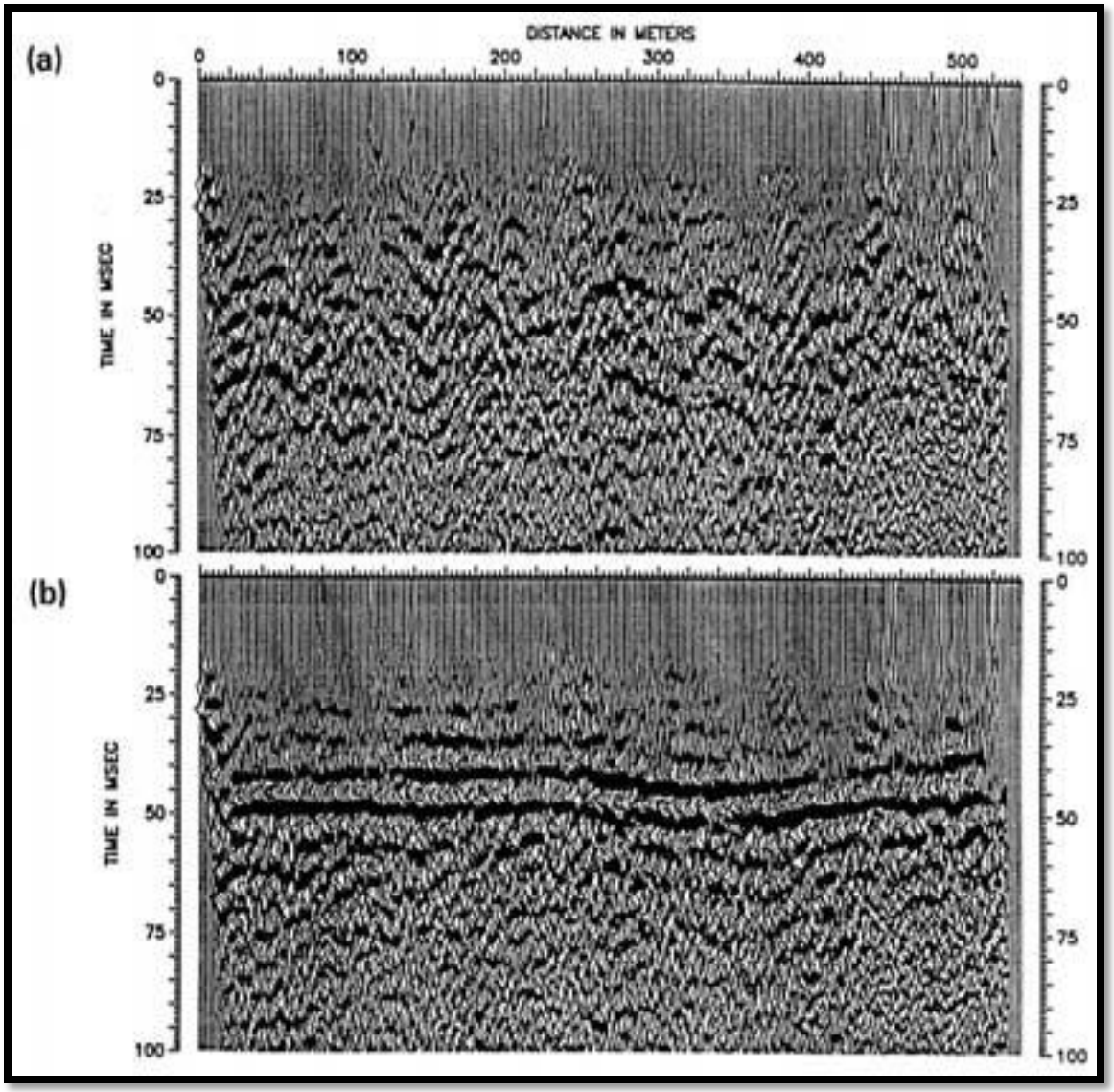
V_E: Assumed velocity of the material above





Pre-correction

Post-correction

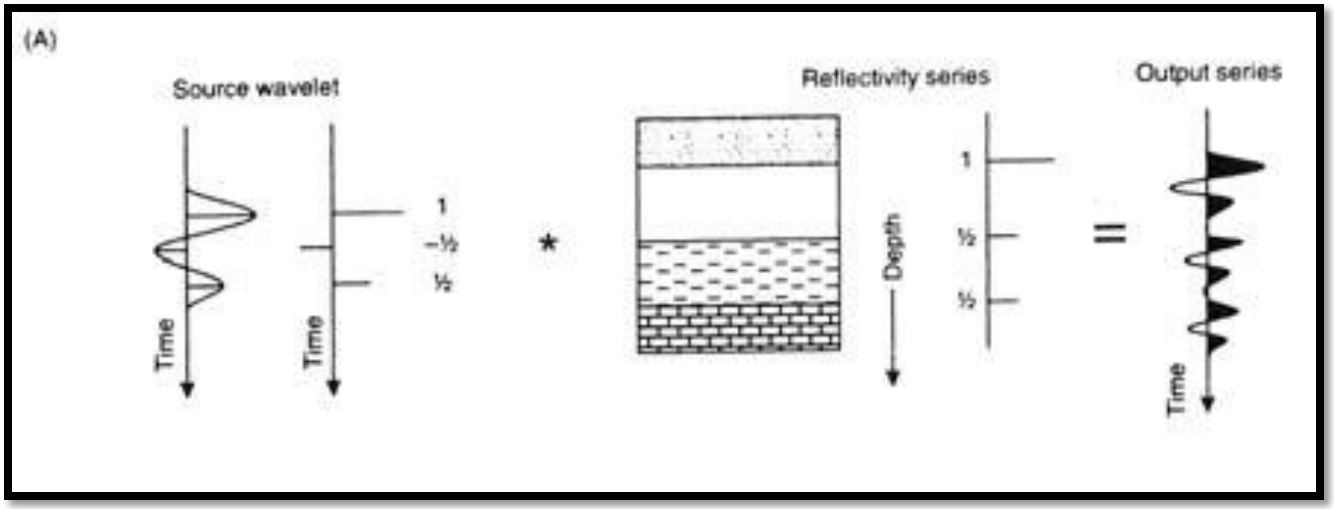


An example for static correction

Reflectivity and convolution

- The seismic wave is sensitive to the sequence of impedance contrasts.

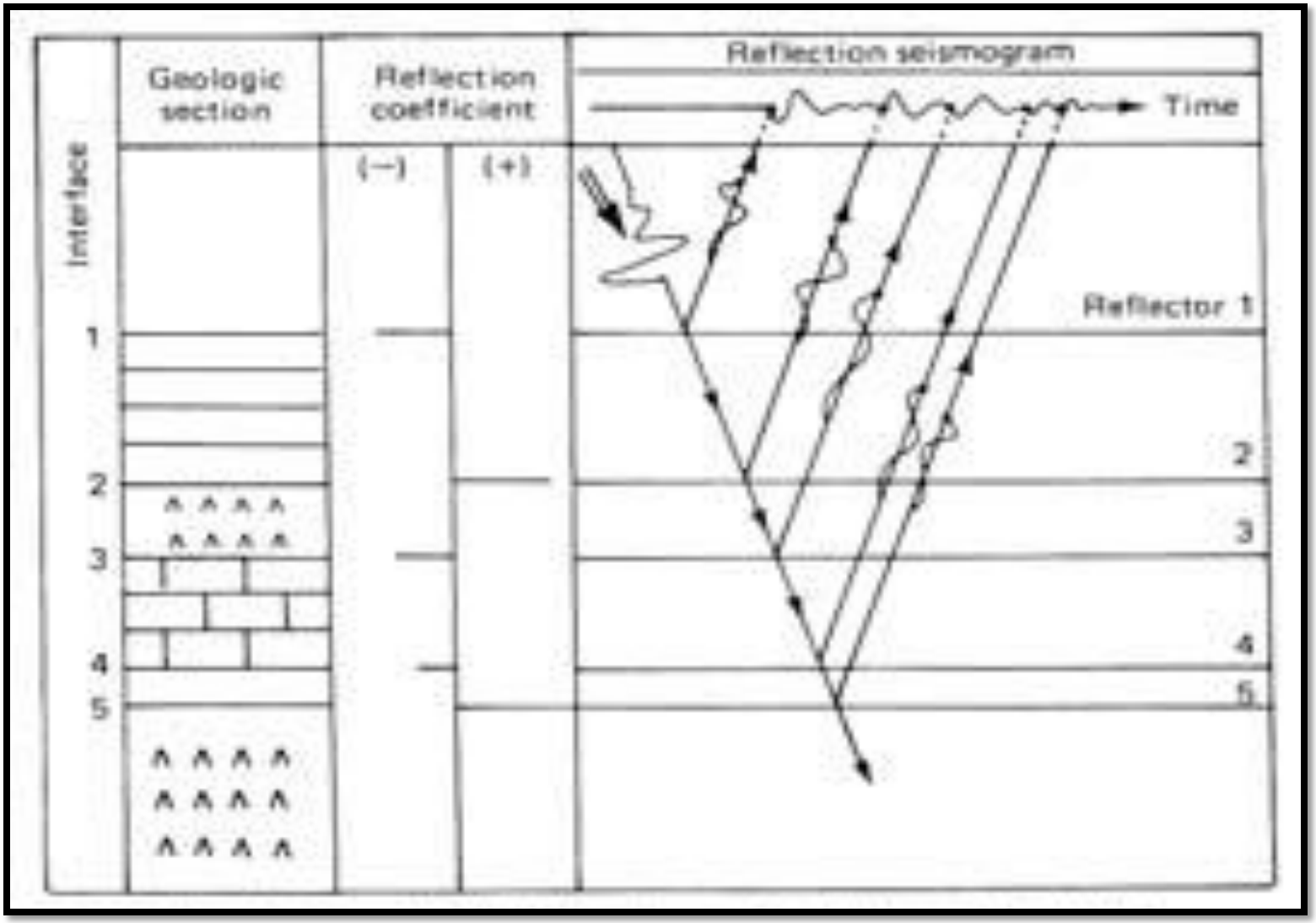
  The **reflectivity series** (R)



Reflectivity and convolution

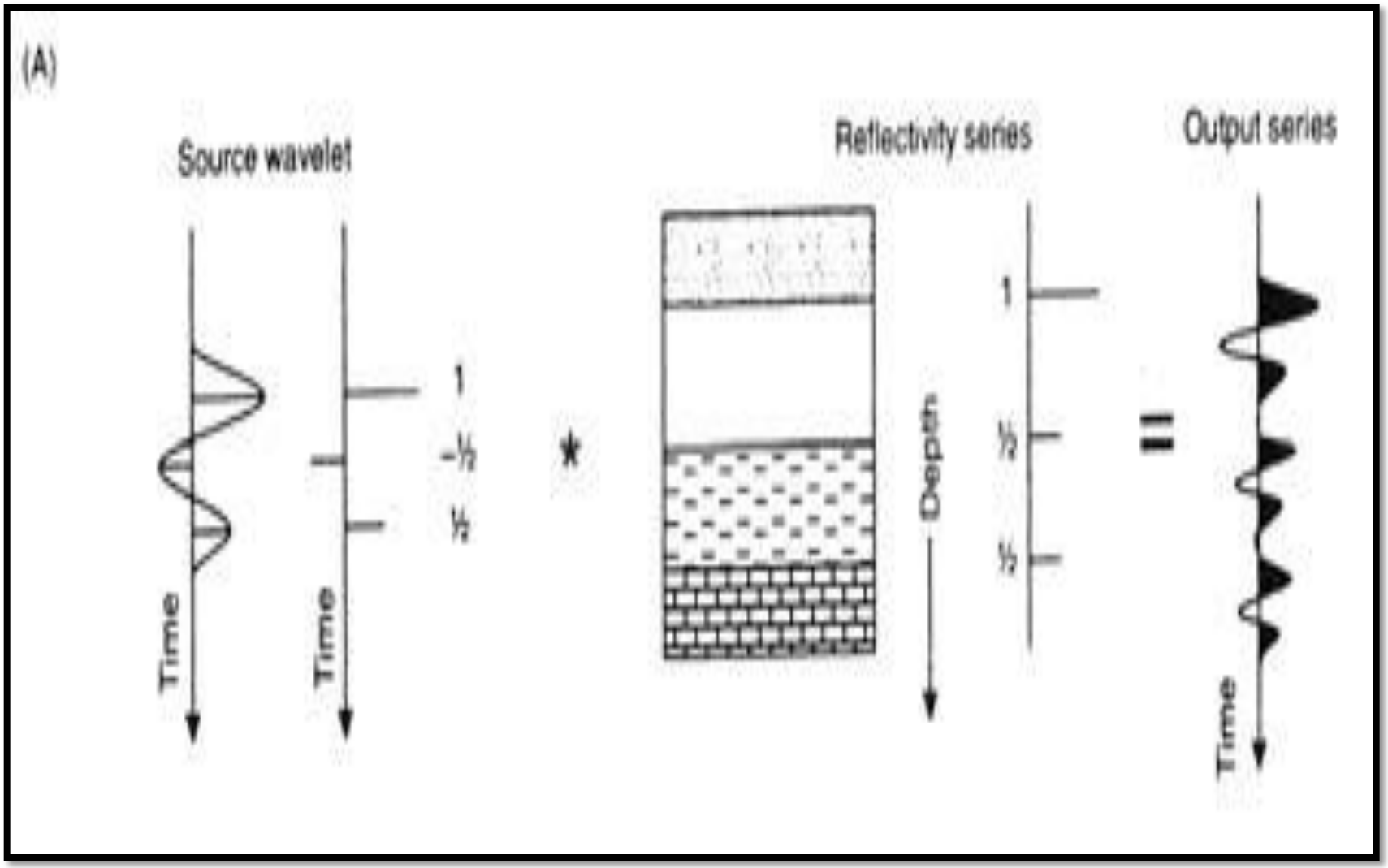
- We input a source wavelet (W) which is reflected at each impedance contrast.
- The seismogram recorded at the surface (S) is the convolution of the two

$$S = W * R$$


Interface
Geologic section
Reflection coefficient
(−)
(+)
Reflection seismogram
Time
Reflector 1
1
2
3
4
5

Convolution

- It is defined as change in the wave shape as a result of passing through a linear filter.
- It is a mathematical operation between two functions to obtain a desired function.


(A)
Source wavelet
Reflectivity series
Output series
Time
Time
1
-½
½
*
Depth
1
½
½
=
Time

Textbook

Alsadi, H.N. (2017) Seismic Hydrocarbon Exploration: 2D and 3D Techniques. Springer International Publishing, Switzerland, 331p.