Chapter 1

Introduction

- Seismic data is acquired in the form of common shot gathers (CSG) which do not represent the subsurface geology directly.
- Seismic data processing aims at starting with these CSGs and producing ultimately a seismic image that represents the subsurface geology.
- This ultimate seismic image is given to the interpreter to extract useful subsurface geological information.
- The raw CSGs have generally low resolution and low signal-to-noise (S/N) ratio.
- Therefore, the main objectives of seismic data processing are:
  - Improving the seismic resolution.
  - Increasing the S/N ratio.
  - Producing a seismic image that represents the subsurface geology accurately.
- There are three primary stages in processing seismic data. In their usual order of application, they are:
  - Deconvolution: It increases the vertical (time) resolution.
  - Stacking: It increases the S/N ratio and produces an initial subsurface image.
  - Migration: It increases the horizontal resolution and produces the final (more accurate) subsurface image.
- Secondary processes are implemented at certain stages to condition the data and improve the performance of these three processes.

1. **Preprocessing** involves the following processes:
   a) Reformatting: The data is converted into a convenient format that is used throughout processing (e.g., from SEG-Y format to SU format).
   b) Trace editing: Bad traces, or parts of traces, are muted (zeroed) or killed (deleted) from the data and polarity problems are fixed.
   c) Gain application: Corrections are applied to account for amplitude loss due to spherical divergence and absorption.
   d) Setup of field geometry: The geometry of the field is written into the data (trace headers) in order to associate each trace with its respective shot, offset, channel, and CMP.
2. **Deconvolution** is performed along the time axis to increase vertical resolution by compressing the source wavelet to approximately a spike and attenuating multiples.
3. **CMP sorting** transforms the data from shot-receiver (shot gather) to midpoint-offset (CMP gather) coordinates using the field geometry information.
4. **Velocity analysis** is performed on selected CMP gathers to estimate the stacking velocities to each reflector.
5. **Static corrections**
   a) Field statics correction: In land surveys, elevation statics are applied to account for topography by bringing the traveltimes to a common datum level.
   b) Residual statics correction accounts for lateral variations in the velocity and thickness of the weathering layer.
6. **NMO correction and muting**: The stacking velocities are used to flatten the reflections in each CMP gather (NMO correction). Muting zeros out the parts of NMO-corrected traces that have been excessively stretched due to NMO correction.

7. **Stacking**: The NMO-corrected and muted traces in each CMP gather are summed over the offset (stacked) to produce a single trace. Stacking M traces in a CMP increases the S/N ratio of this CMP by $\sqrt{M}$.
8. **Migration**: Dipping reflections are moved to their true subsurface positions and diffractions are collapsed by migrating the stacked section.

- Figure below shows a conventional seismic data processing flow while this Figure shows an example of applying this conventional flow on a marine data set (Yilmaz, 2001).

Field Tapes (Amplitudes)

Observer's Log (Geometry)

1. Preprocessing
    - Reformatting
    - Editing
    - Geometrical spreading correction
    - Setup of field geometry
    - Application of field statics
2. Deconvolution
3. CMP sorting
4. Velocity analysis

(Loop)

5. Residual statics correction
6. NMO correction and muting
7. Stacking
8. Migration

Conventional seismic data processing flow (after Yilmaz, 2001).

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