Chapter 7

3-D Seismic Exploration
What is 3-D seismic?
- It is a group of closely spaced 2-D source and receiver lines forming a grid that covers an area.
- Receiver and source lines may or may not be orthogonal.

Why 3-D seismic?
- 3-D migration eliminates misties over dipping reflectors.
- It enhances the horizontal resolution.
- It presents a more detailed image of the subsurface.
3-D Terminology

(Cordsen et al., 2000)
3-D Terminology

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3-D Terminology

- **Inline**: direction parallel receiver lines.
- **Crossline**: direction orthogonal receiver lines.
- **CMP bin**: a small rectangle (1/2 RI x 1/2 SI) that contains all the traces which belong to the same CMP.
- **Box (unit cell)**: area bounded by two adjacent receiver lines and two adjacent source lines.
- **Patch (template)**: area of all live receivers recording from the same source.
- **Swath**: length over which sources are recorded without crossline rollover.
1. Receiver lines are laid parallel.
2. Source lines are laid parallel in a direction orthogonal to receiver lines.
3. An area of receivers (patch) is selected (e.g., 4 receiver lines with 480 receivers each).
4. Source at patch edge is shot and recorded.
5. Next source on the same source line (going inside the patch) is shot and recorded by the same current patch.
6. Keep shooting until all sources within the current patch lying on the same source line are finished. This is one salvo.
7. Roll over one source-line interval and begin recording the next salvo.
8. Keep doing this until the end of the current receiver lines. This is one swath.
9. Roll over in the crossline direction half the patch size and begin recording the next swath.
10. Keep doing this until the whole survey is finished.
Swath Shooting Method

(Continued)
Field Layouts

- Full fold
- Orthogonal
- Non-orthogonal
- Brick
- Zigzag
- Star
- Random
Factors Controlling 3-D Survey Design

1. Target depth (Z) and lateral size (B)
2. TWTT ($T_0$) and RMS velocity ($V_{RMS}$) to target
3. Interval velocity immediately above target ($V_i$)
4. Shallowest depth of interest ($Z_{\text{shallow}}$)
5. Maximum expected dip angle ($\theta$)
6. Fold of good 2-D data in the survey area ($F_{2D}$)
7. Dominant ($f_d$) and maximum usable frequency ($f_{\text{max}}$) at target
Parameters of 3-D Survey Design

1. Receiver (RI) and source (SI) intervals: controlled by B, \( f_d \), and \( V_i \)
2. Receiver line (RLI) and source line (SLI) intervals: controlled by \( Z_{\text{shallow}} \)
3. CMP Fold (\( F_{3D} \)): controlled by \( F_{2D} \)
4. Maximum Offset (\( X_{\text{max}} \)): controlled by \( Z \)
5. Minimum Offset (\( X_{\text{min}} \)): controlled by \( Z_{\text{shallow}} \)
6. Fold Taper (\( F_T \)): controlled by \( Z \)
7. Migration Aperture (\( X_{\text{MA}} \)): controlled by \( Z, \theta, V_{\text{RMS}}, T_0, \) and \( f_d \)
Parameters of 3-D Survey Design

NRL = 9

NSL = 9
Parameters of 3-D Survey Design

(Cordsen et al., 2000)
3-D Marine Surveys

- Shoot closely spaced parallel 2-D lines (Figure).
- Cable may drift with water cross currents (feathering).
- Account for feathering effect using compasses along cable to determine actual source and receiver locations.