Mustagh Resources Ltd.

APPLICATION OF SEISMIC METHODS
COURSE OUTLINE

- **Introduction**
- **Basic Background Geology**

Composition of the earth and crustal rock types
Sedimentary basins – The layer cake model
Some basic structures in a sedimentary basin
Fluid migration and hydrocarbons traps
Typical hydrocarbon trap types

- **The Fundamental Seismic Principle**

Average velocity; the time distance translator
Modes of acoustic energy propagation
    Compressional wave, Shear wave
    Raleigh wave, Others
Rock properties
    Interval velocity, Density, Poisson's ratio
Propagation of a P-wave
A simple seismic experiment
    A basic reflection model
    Effect of wavelet length and signal to noise ratio

- **Basic Signal Theory**

Properties of the cosine wave
Fourier decomposition, The effect of phase
The effect of amplitude, Principles of filtering

- **Resolution and Bandwith**

Simple wedge model – variable bandwith
Simple wedge model – variable phase
Simple wedge model – variable signal/noise ratio
Bandwith

- **Energy Loss Mechanisms**

Reflection coefficients and transmission losses
Mode conversion and energy partition
Spherical divergence, Absorption

- **The Energy Source**

Desired source qualities
Dynamite
    Conventional,
Vibroseis
    Structure of a typical vibrator unit

    Ground force signal
    Correlation & basic sweep theory
        Basic correlation of a linear sweep
        Effects of sweep length and noise
Airgun
    In water, On land
Others
    P-Shooter, Hydra-Pulse, Vacu-Pulse
    Betsy, Mini-Sosie, Marthor

- **The Receiver**

Desired receiver qualities
The geophone
    Frequency, Damping, Coupling
The geophone string
    Electrical, statistical & superposition advantages
    Spatial anti-alias filter
    Determination of coherent noise

- **Convolution and Deconvolution**

The synthetic model, Convolution
The synthetic seismogram and dispersion
Deconvolution

- **CDP Method and Stacking Charts**

The superposition principle
The Multi-channel record
Calculation of nominal fold
Stacking charts, Bent lines

- **Basic Processing**

Geometry, Stacking charts, Gathers
First breaks and LVL statics, Deconvolution
Reflection and multiples, Velocity analysis
Surface consistent statistics and other algorithms
Trim statics, Stack, Migration aperture

- **Analogue, Digital and Aliasing**

Analogue signal recording, Digital signal recording
Aliasing in time

- **Seismic Instrumentation**

Earth absorption
Need for greater dynamic range
Basic structure of IFP instruments
    Successive approximation A-D converter
        Dynamic range of A-D converter
    IFP amplifier, Multiplexer
    Analogue filters
        Hi Pass filter, Low Pass filter
        Anti-Alias filter, Notch filter
    Pre-Amplifiers
Distributed telemetry systems
    Cables losses, Advantages, Disadvantages
Delta Sigma systems
    Delta Sigma and noise shaping
    2nd order modulator
    Delta Sigma and decimation filtering
    Delta Sigma and 24-bit recording
    Delta Sigma and dynamic range
ARAM 24, I/O System II, Sercel 388, Opseis Eagle
I/O Digital sensor
Instrument tests and quality control

- **Array Theory**

    Apparent wavelength and wavenumber
    Signal to noise ratio in the wave number domain
    Simple linear arrays and effective length
    Combined arrays and spatial convolution
    Vibrator arrays
Estimating signal wavelengths
    Apparent wavelength vs offset plus frequency
    3D Response In Line, Cross Line, Combined
    Ghosting in the dynamite signature

- **Trapped Mode**

- **Spatial Sampling and Aliasing**
  - The seismic record in space
  - F-K plots and geophone intervals
  - Geophone arrays as spatial anti-alias filter
  - F-K filtering

- **Dual Source Vibroseis**
  - Plus-Minus method
  - Up-Down method
  - Vari-Sweep
  - Dual sourcing (Ping-Pong)
  - Slip sweep
  - Sei-Fi Technology

- **Overview of the 3D Technique**
  - Summary of 2D
  - Swath shooting
  - 3D imaging
  - Basic statistics comparing 2D and 3D
  - Basic aspects of a 3D program and definition of terms
  - Rolling the patch and building the fold
  - Determining 3D fold
  - Geometric imprinting

- **3D Design Considerations**
  - Overall survey size and shape
    - Cover beyond the anomaly
    - Margin of poor statistics
  - Migration aperture and Fresnel zone

  - Alignment with strike/dip or land boundaries

    - Avoiding migration artifacts
  - Deciding on the desired fold
    - Signal to noise enhancement
    - 3D advantages of migration
    - 3D advantages of offset distribution
    - Is fold our most important parameter?
  - Offset considerations
    - Maximum limits
      - Interference with muted first breaks
      - Moveout stretch
      - Mode conversion
      - Energy loss due to spherical divergence
    - Minimum limits
      - Sufficient moveout for velocity analysis
      - Sufficient moveout for multiple discrimination
      - Refraction analysis
      - Amplitude vs Offset analysis)
  - Source / Receiver line spacings
  - Desired fold within offset limits (fold driven vs bin driven designs)

    - Fold at shallow events
    - Aspect ratio
    - Desired wave field sampling in all domains
    - Trade offs and compromises
  - Bin size
    - As related to surface sampling
    - Aliasing of structural dips
    - Aliasing of lateral velocity changes (diffractions)
    - Aliasing of NMO at far offsets
    - Interpretation confidence for small features

  - Advanced Techniques: Bin geometry
    - Fractionated bins
    - Bin balancing – offset intelligence
    - Fractionation of bins by mid-point scattering
  - Skidding and offsetting
  - Velocity and azimuth
  - Statistics and surface consistent algorithms

- **Basic 3D Model Types**
  - Offset grid
  - Fractionated grid
  - Double Brick grid
  - Triple Brick grid
  - Diagonal grid
  - Megabin grid
  - Random grid
  - Planned Random grid

- **Case Histories**
  - 3D Seismic and Horizontal Drilling
  - 3D Seismic Out of Plane Resolution
  - Unnecessary dry holes
  - How little we know about geology