Università di Trieste
Corso di Laurea in Geologia
Anno accademico 2018-2019

Geologia Marina

Parte I

Modulo 2.1 Sub Bottom Profiler

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OFFSHORE SURVEYS

SEAFLOOR INVESTIGATION

SUBSURFACE SENSING

ECHOSOUNDING

SIDE SCAN SONAR

SEISMIC METHODS
SBP systems are used for fine-scale (decimetric) imaging of shallow subsurface sediments.

A chirp system transmits selectable Frequency modulated (FM) pulses, "sweeping" through a range of frequencies, anywhere between about 400 Hz and 20 kHz. The sweep gives the source function a wide bandwidth, but also a long pulse length. To achieve the theoretical temporal resolution, the FM pulse is compressed using a digital compression filter, thus creating a “Klauder” wavelet.
APPLICATIONS

ENVIRONMENT AND SOCIETY
- Geohazard surveys
- Buried object location
- Bridge/Shoreline scour surveys
- Mining/Dredging surveys
- Archaeological surveys

ACADEMIC
Marine Geology and Biology
- Geological/Geophysical surveys
- Fluid escapes
- Neotectonic related surface expressions
- Sediment Classification

INDUSTRY
Foundation studies for offshore infrastructures
- Cable surveys
- Well site surveys
**BASIC CONCEPTS**

1. "chirp" signal (vibroseis)
2. Reflection coefficients (depend on acoustic impedance of layers)
3. = Seismic signal recorded by geophones (in this case, a synthetic seismogram)
4. To recover the reflection coefficients, cross-correlate with the identical chirp
5. Yields an approximation of the original reflection coefficients
RESOLUTION

DEFINITION
The resolution of an imaging system is measured by its ability to separate closely spaced objects. A sonar system with a 20 cm resolution will resolve layers that are at least 20 cm apart.

MULTY-FREQUENCY SYSTEM
In a multi-frequency system, it is the bandwidth of the transmitted pulse that sets the system's theoretical resolution. The theoretical sonar range resolution, either cross-track in the case of side scan sonar or vertical in the case of sub-bottom profiling, is calculated by multiplying the length of the compressed pulse by the speed of sound, and dividing the product by two to account for the ping's round trip travel time. The frequency modulated signal is less sensitive to reverberations.

Pulse length = \( \frac{1}{\text{Bandwidth}} \)

Resolution = \( \frac{1}{2} \) * velocity * pulse length

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Figure 3. (A) is a chirp sonar 1.5-7.5 kHz swept outgoing pulse and (B) same source function after match-filtering (data compliments of M. Jakobsson). (C) is an example of a chirp profile from Lake Huron collected with a Datasonics CA9000 profiler with a 100 ms pulse length swept from 4-10 kHz (image compliments of L. Mayer).
### EXAMPLE

<table>
<thead>
<tr>
<th></th>
<th>1-10 kHz</th>
<th>2-7 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Band Range:</strong></td>
<td>1-10 kHz</td>
<td>2-7 kHz</td>
</tr>
<tr>
<td><strong>Bandwidth:</strong></td>
<td>9 kHz</td>
<td>5 kHz</td>
</tr>
<tr>
<td><strong>Pulse length:</strong></td>
<td>1/9 kHz = 0.0001 s</td>
<td>1/5 kHz = 0.0002 s</td>
</tr>
<tr>
<td><strong>$V_{H2O}$:</strong></td>
<td>1540 m/s</td>
<td>1540 m/s</td>
</tr>
<tr>
<td><strong>$\Delta H$:</strong></td>
<td>0.0001 s * 1540 m/s = 0.154 m</td>
<td>0.0002 s * 1540 m/s = 0.308 m</td>
</tr>
<tr>
<td><strong>Range Resolution:</strong></td>
<td>½ * 0.0001 s * 1540 m/s = 0.077 m</td>
<td>½ * 0.0002 s * 1540 m/s = 0.154 m</td>
</tr>
</tbody>
</table>

**Power Spectrum:**

SUB BOTTOM PROFILER

INSTALLATION

Hull mounted

- NUMBER OF ELEMENTS: 16
- PING RATE: ¼, ½, 1, 2 (S)
- FREQ. RANGE: 2-7 KHZ
- BANDWIDTH: 5 KHZ
- PULSE LENGTH: 0.2 ms
- RESOLUTION: 15.4 cm
- PENETRATION: 10s of m

Portable (towed)

- INSTALLATION SUB BOTTOM PROFILER
  - FREQ. RANGE: 2-7 KHZ
  - RESOLUTION: 15.4 cm
  - PENETRATION: 10s of m
SUB BOTTOM PROFILER OVERVIEW
Sub-bottom profiler CHIRP investigations of Tagliamento River delta (northern Adriatic Sea).

Tridimensional model of the Tagliamento River delta system from sub bottom chirp analyses. Courtesy of R. Romeo
SOUTH ADRIATIC SEA
Integration of MBES and SBP data.
After Geletti et al (200...)

Eastern MAD
Late Quaternary Low Stand Wedge
Pockmarks
Mass Transport Deposits

TWT (ms)

Pockmarks?
Mounds
Mounds
faults
Mound
Salt Dome
Gas?
Zgur et al., 2011. Bios Submarine Cable System TEL AVIV To BARI Survey Report For Alcatel-lucent Submarine Networks