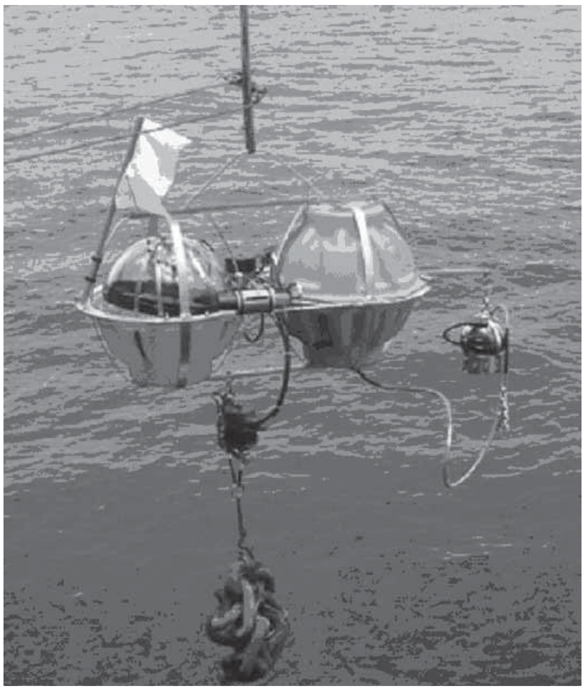
lights and radio beacons allow an easy recovery of the instrument at sea.
The development of the CMG40T sensor and the release mechanism has initiated a strong cooperation between Guralp System Ltd and Geoazur. We are pleased to announce the development of an OBS based on the Hippocampe design using a Guralp CMG-DM24/4 data (4 channel, 24bit Digitiser, 8 channels, 20bit slow rate environmental channel, IEEE 1349 (firewire) data port, Real time clock drift 0.8*10-8 drift over –3 to 14 degrees of temperature, 8 Gb Flash memory storage – accessible via firewire port.

Geoazur has a strong experience in marine operation and data interpretation. Guralp System Ltd is one of the leaders for sensor and data logger in seismology. The new OBS commercialized by GSL will be soon accessible for the whole scientific community.
More improvements will take place in this new OBS. Guralp System Ltd and Geoazur are studying also a LTOBS (Long Term OBS), which will allow continuous observation for a period of 3 years. Acoustic communication will allow checking the instrument operations and shuttles retrieving data from time to time. LTOBS is an alternative to future cabled observatories such as discussed in Esonet. This instrument would also be an answer to remote parts of the Oceans.

1 · Institut de Recherche pour le Développement
2 · Centre National de la Recherche Scientifique
3 · Université Pierre et Marie Curie (Paris)
4 · Université de Nice Sophia Antipolis



Deployment of an Hippocampe OBS . The sensor (on the right) will be released from the arm when the OBS lay at bottom of the sea.

COUPLING OF GEOPHONE IN THE OCEAN BOTTOM

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Abstract: We can obtain the performance of the geophone in the sediment to know its coupling in the bottom sea. This paper is about the parameters of coupling in order to obtain the response of geophone through the frequency and the amplitude of the vibrations. The use of the shake table permits to obtain the transfer function of coupling between the geophone and the sediment sea without using a detailed model of interaction OBS/seabed.

Introduction
The main problem when someone presents a marine geophone design is to know the performance of the geophone in the bottom sea in order to obtain good response to vibrations of seabed. This interaction between the OBS (Ocean Bottom Seismometer) and the sediment or rocks is not usually good because the geophone is deployed only by surface contact, without penetration into the bottom sea. The response to forced oscillations of OBS with the seabed is the coupling ratio.

Suppose an OBS of mass m suspended in water moving in response to a sinusoidal force F. The relation between this force and the resulting velocity vsus follows from Newton's law:

$$j\omega(m+m_{sus})v_{sus} = F$$

in which $\mathbf{m}_{sus}$ is the hydrodynamic added mass. If we now consider the OBS on the seabed the equation of motion for the bottomed OBS is:

$$j\omega(m+m_{bot})v_{bot} = -Z\cdot v_{bot} + F$$

where $\mathbf{m}_{bot}$ denotes the bottomed added mass, the $\mathbf{v}_{bot}$ is the bottomed velocity and Z is the interaction impedance between an OBS and the seabed which accounts for the seabed stiffness ***k*** and damping ***R***.

$$Z = \frac{k}{j\omega} + R \qquad (3)$$

Coupling Ratio
The geophone was placed on clayed sediment of density 2005 kg/m3 and dampness 29 %. It is characterized by a liquidity limit wL (41 %), a plastic limit wP (23%) and a plastic index IP (18%).

Laboratory studies indicate this material behaves theoretically as a non-Newtonian substance. Under low to intermediate shear stresses (2 - 121 Pa) and shear rates (0,46 – 500,2 s-1) it behaves as shear thinning (pseudo plastic), the apparent viscosity decreases when shear stresses increases. The relationships have been defined as:

$$\tau = 35{,}918.\gamma^{0{,}1955}$$

$$\eta = 8{,}62164.10^{7}.\tau^{-4{,}10498}$$

where τ is the shear stress in Pa, γ is the rate of shear strain in s^{-1}, and η is the apparent viscosity in Pa•s.

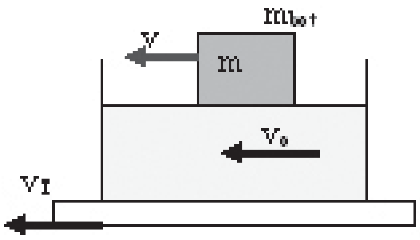

Figure 1.Response of bottomed OBS to horizontal seabed motion

The coupling ratio, r, between bottomed and suspended velocitie s is:

$$r = \frac{v_{bot}}{v_{sus}} = \frac{j\omega(m + m_{sus})}{j\omega(m + m_{bot}) + Z} \cong \frac{m + m_{sus}}{m + m_{bot}}$$

When Z/ω approaches zero as frequency increases, the high-frequency limit of the coupling ratio is simply a ratio of masses (4).

As shown in figure 1, if the seabed moves with horizontal velocity v_o and the OBS responds by moving with horizontal velocity **v** while the water remains at rest, (considering **Z**, $\mathbf{m_{sus}}$, $\mathbf{m_{bot}}$ and **r** no distinguished between vertical and horizontal motion) the transfer function for horizontal seabed motion is $\mathbf{T_h}$ (5). If the coupling ratio can be measured, the T_h can be inferred, without recourse to detailed model of the OBS/sediment interaction. Substituting the Z value (3) in the T_h expression we obtain:

$$T_h = \frac{v}{v_o} = \frac{\frac{R}{m + m_{bot}}\left(s + \frac{k}{R}\right)}{s^2 + s\frac{R}{m + m_{bot}} + \frac{k}{m + m_{bot}}} = 1 - \frac{r}{r_\infty}$$

In the expression 5 the resonance frequency ω_o and the resonance quality factor Q is:

$$\omega_o = \sqrt{\frac{k}{m + m_{bot}}} \qquad \text{g} \qquad Q = \frac{\sqrt{k(m + m_{bot})}}{R}$$

Measures in the lab

The measures in the shaker table with transducer vibration calibrator BERAN in the SARTI lab and the geophone upon the sediment basin and all together upon the shaker table figure 1, we can obtain the sensibility of the sensor under test, related to a reference sensor.

This function is the voltage output of the geophone regarding the velocity vibration of the table (7), and is equal to the sensibility of the geophone by the ratio of velocities of the geophone regarding the sediment and the ratio of velocities to the sediment regarding the table motion. Considering that the expression (7), v_o/v_T is near to the unit, the transfer function T_h can be deduced. The T_h function is the sensibility of the velocity geophone to the velocity sediment regarding the table vibrations.

$$Sens_{BERAN} = \frac{Tension_{G.S}}{v_T} = H_G \cdot \frac{v}{v_o} \cdot \frac{v_o}{v_T}$$

The figure 2 shows the sensibility of the geophone through the frequency obtained from the sediment by calibrator (squares) and the geophone sensibility from the shaker table directly (triangles).

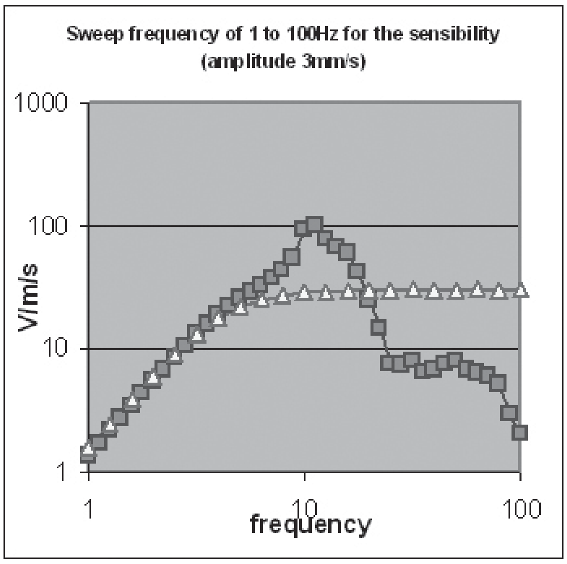

Figure 2 Sweep frequency graf for the sensibility (square points represent the geophone upon the clay and triangle points upon the shake table)

The transfer function for horizontal seabed motion T_h can be obtained from figure 2, by subtracting both graphics, with a zero and a double pole according to the expression (5) and according to the Osler reference (1). By identifying parameters the pole frequency is 11,2 Hz quality factor Q=4 and zero frequency is 44 Hz, in the present case. For low frequencies the function is practically the unity. For frequencies higher than the resonance the slope descends. The performance of the coupling is pseudo elastic due to the box walls containing the geophone.

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