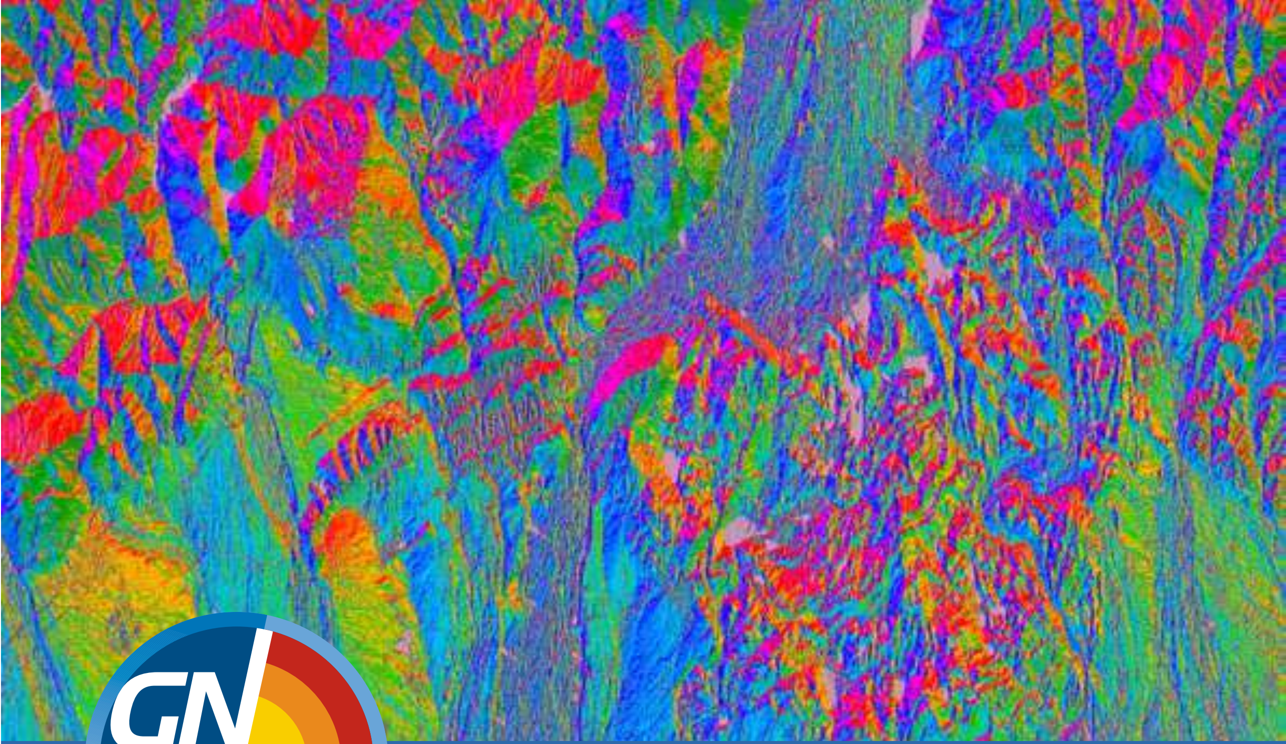

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UNDERWATER PHENOMENA DETECTION AND SEA FLOOR CHARACTERIZATION BY CHIRP DATA PROCESSING

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Introduction

Chirp recording systems provide high-resolution images of the shallow sediments below the sea floor. The obtained signal is almost saturated by multiple reflections from the water bottom and sea surface, while the propagation effects in the water layer are normally ignored, and often are even muted out as noise. Petronio *et al.* (2009, 2010) showed that amazing patterns show up in the water layer when processing properly multi-channel seismic surveys, i.e., by muting instead the signal from the sea floor downwards. Weak reflections from a few water layers with different density and temperature become visible then, opening the way for the oceanographic use of existing seismic surveys. In this paper, we carry out a comparable work for Chirp data.

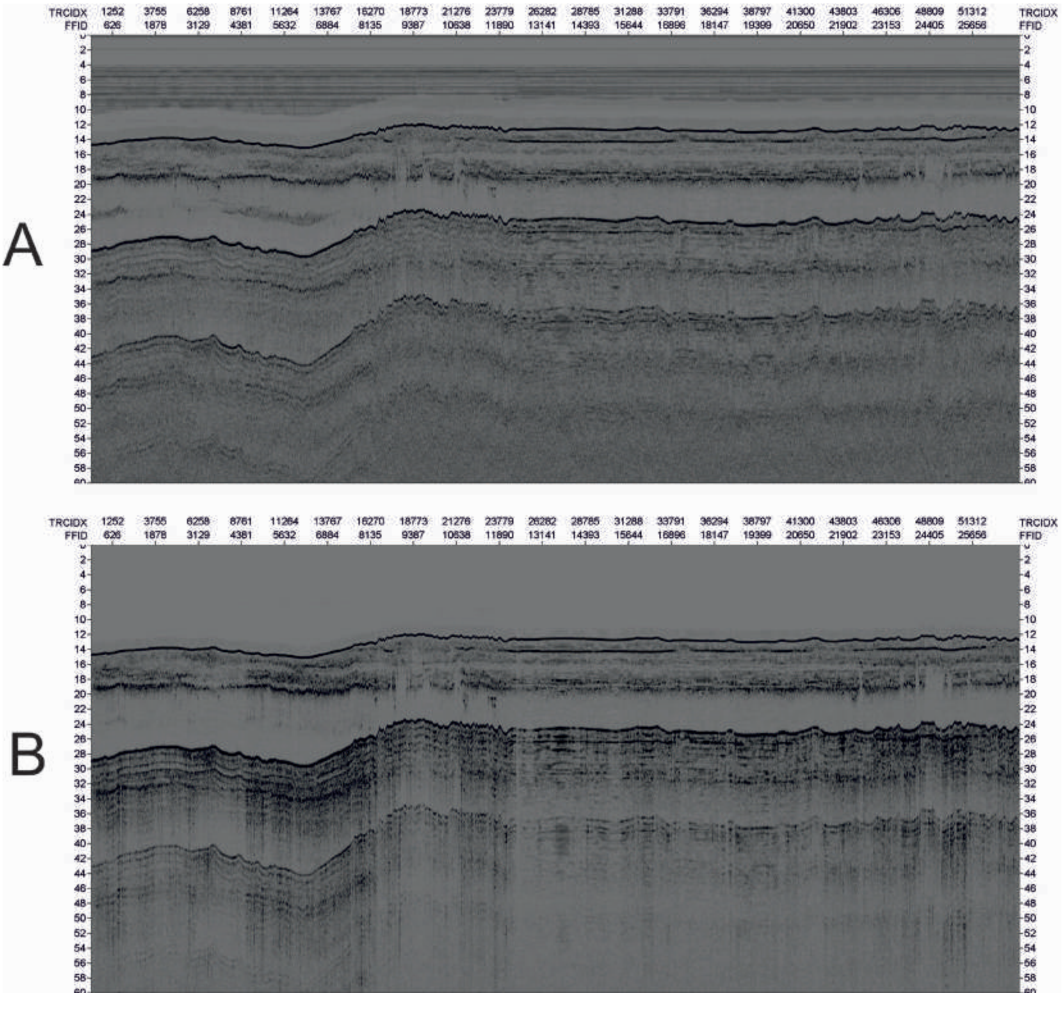

Fig.1 - Gain recovery by a 4 ms window AGC (A) and by a t^2 function (B).

Chirp data processing, however, is quite challenging for two reasons. First, being mono-channel, they cannot distinguishing multiples and primaries based of offset, nor estimating the wave propagation velocities. Second, the standard acquisition systems provide the signal envelope, and not the actual waveform that is physically propagating in the rocks. Therefore, wave-equation methods cannot be applied either for enhancing the signal. For these reasons, we adopted other methods for the amplitude decay compensation and multiple subtraction, and applied them to a few profiles acquired by OGS in the Gulf of Trieste (Italy).

Processing flow

The compensation of the amplitude decay due to geometrical spreading and anelastic absorption is very difficult for Chirp data, as conventional methods used for multi-channel seismic data cannot be applied. A common way out is choosing a window length for an Automatic Gain Control (AGC) based on the graphic taste of the interpreter. However, a significant personal bias is so introduced, and major artifacts may show up. Furthermore, the information from the relative amplitude of reflections is so lost. A heuristic approach to overcome these drawbacks was proposed by Claerbout (1997). He showed that we get interpretable images, in most cases, by multiplying each sample in the traces by the square of its arrival time. This t^2 function allows for the spherical spreading of the wavefront in a homogeneous elastic medium, proportional to the time t, and for the anelastic absorption, which adds a further factor t. Figure 1 allows comparing the gain recovery by an AGC with a window length of 4 ms and a t^2 gain function. In Fig. 1B we see a better imaging of the stratigraphy and of the blanking areas related to fluid occurrences with respect to Fig. 1A. We notice also that AGC introduces artefacts both in the sea water and around the first multiple, introducing spurious signals in the area that shows us as “blanked” by the t^2 gain recovery. This difference may induce to different geological interpretations.

Figure 1 shows strong multiples, which may hide weaker underlying reflections. A classical predictive deconvolution can help for attenuating them, but the theoretical assumptions underlying it are only partially met. The first assumption is that the reflectivity spectrum must be white: this happens (or not) in the same way as for conventional seismic surveys, where this method works mostly well. Instead, the other assumption may not hold, i.e., the minimum-phase of the signal wavelet. For Chirp data, after the envelope is taken, this is not guaranteed. A third assumption is the stationarity of the signal, which is approximately achieved by the t^2 gain recovery. Figure 2 shows that, after a t^2 correction (A), a gapped deconvolution with a prediction distance equal to the sea floor is quite successful for reducing the multiple contribution (B). A slight improvement is obtained by subtracting a scaled version of the primaries comprised between the sea floor and the first multiple (C), especially between 50 and 60 ms. Details about the related procedure are presented by Vesnaver *et al*. (2001).

Underwater plumes

Figure 3 displays an interesting feature in the water layer obtained after the t^2 gain recovery. The enlarged detail in the upper part shows one of the plumes, extended from the sea floor up to about 12 ms, where a clear reflection from a water layer is visible too. A few other acoustic discontinuities are visible between 5 and 10 ms. We remark that these events have a real physical origin, and are visible also in other profiles in the area: they are not artefacts due to gain recovery methods as AGC. When looking at the underlying part, we notice that the plumes are present in areas where gas deposits are revealed by the blanking of seismic signals between 30 and 36 ms, overlaid by strong, discontinuous reflectors. This contemporary presence validates our interpretation of these signals as due to gas release in the sea water.

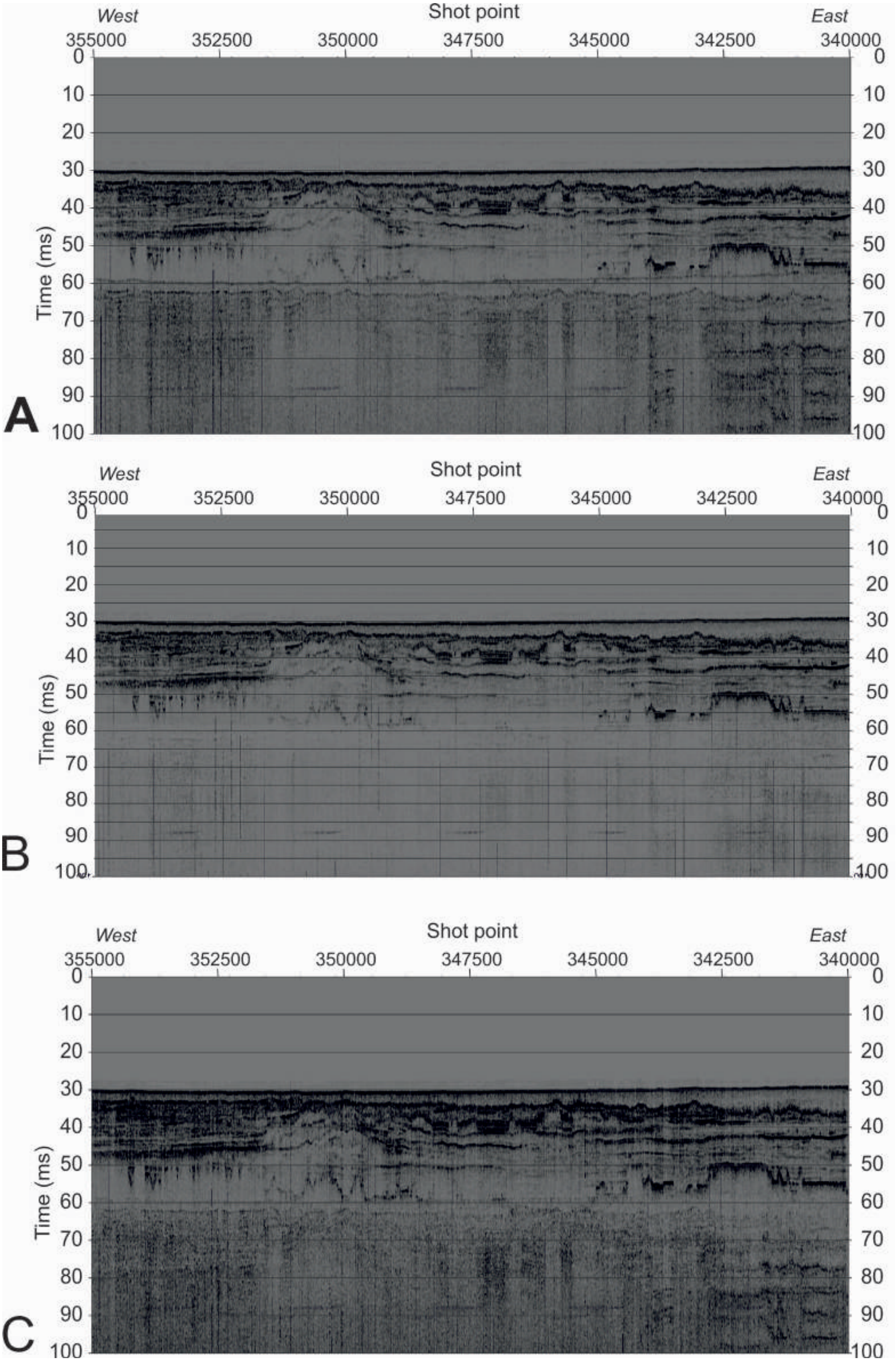

Fig. 2 – Section after a t^2 gain recovery (A), followed by a multiple attenuation by a predictive deconvolution (B) or by a multiple subtraction (C).

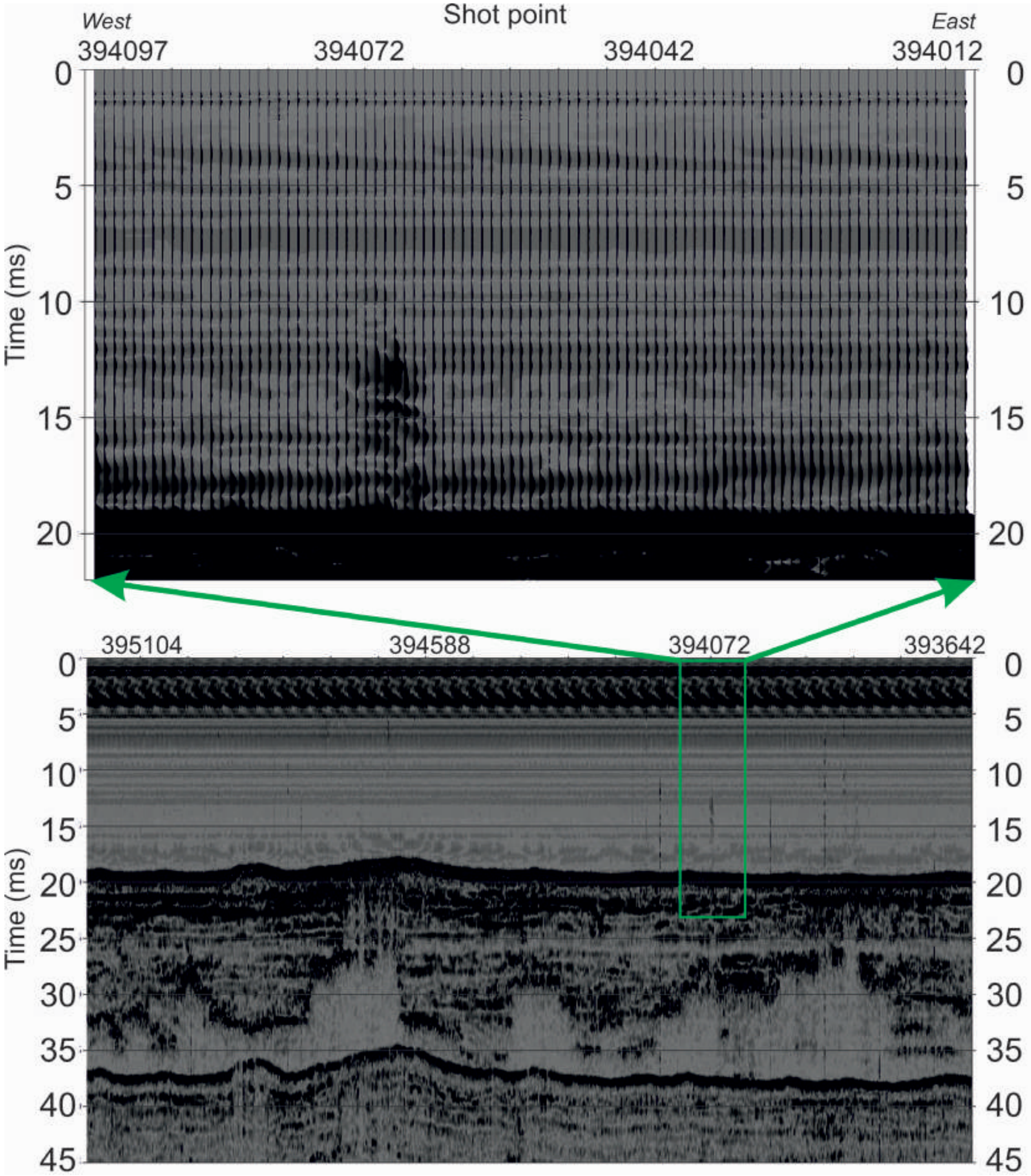

Fig. 3 – Partial section of the line GT09-C21 (upper part, raw data) and enlarged detail including an interpreted plume in the sea water (lower part, after a t^2 gain curve).

Conclusions

Processing Chirp data is limited by the lack of multiple channels and by the common practice of recording the signal envelope, instead of the original waveforms. Nevertheless, some processing can still improve the images for the shallow sediments and even interesting features in the water layer.

The occurrence of plumes due to fluid release from shallow sediments is well imaged by the analyzed data. The presented data show that a target processing of the chirp data can improve the imaging and consequently the identification of the fluid accumulation and seeps. Additional measurements, as water temperature and chemical composition, may contribute to distinguish the different fluid components (gas, groundwater, low enthalpy salty water) that are known to occur within the shallow and deep sedimentary units.

Ackowledgements

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