University of Texas Institute for Geophysics

Archive of Digital Chirp Subbottom Profile Data Collected Offshore of the Galveston, Texas, During Three Expeditions in 2017 and 2018: The Trinity River Paleovalley Project (TRiPP)

The University of Texas Institute for Geophysics (UTIG) conducted three surveys in 2017 and 2018 to explore the applicability of chirp subbottom profiling techniques to investigate potential sand resources on the Texas shelf. The Trinity River Paleovalley – the ancestral course of the Trinity River during the Last Glacial Maximum sea level lowstand – was chosen for the focus of this effort. Three separate surveys collected chirp data within the survey region, including two University of Texas field classes conducted in May of 2017 and 2018, and a dedicated survey aboard the R/V Trident in August of 2018. This report serves as an archive of unprocessed and processed digital chirp subbottom data, trackline maps, navigation files, and formal FGDC metadata. The unprocessed archived trace data are stored in the Edgetech JSF file format, and processed data are stored in standard Society of Exploration Geophysicists (SEG) SEG Y revision 0 format and may be downloaded and processed with commercial or public domain software. Additionally, layback navigation are written to ascii-formated, comma-separated values (csv) files. Study collaboration and funding were provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management, New Orleans, LA under Agreement Number M16AC00020

All Chirp systems use a signal of continuously varying frequency; the system used during this survey produces high-resolution, shallow-penetration (typically less than 50-ms) profile images of sub-seafloor stratigraphy. The towfish contains a transducer that transmits and receives acoustic energy and is typically towed 1 - 2 m below the sea surface. As transmitted acoustic energy intersects density boundaries, such as the seafloor or sub-surface sediment layers, some energy is reflected back toward the transducer, received, and recorded by a PC-based seismic acquisition system. This process is repeated at regular time intervals and returned energy is recorded for a specific duration. In this way, a two-dimensional (2-D) vertical image of the shallow geologic structure beneath the towfish is produced.

The seismic source utilized for the TRiPP surveys consisted of an EdgeTech SB-512i towfish running DISCOVER v. 3.51 acquisition software and towed about 5 m behind the GPS antenna. The data were acquired using a frequency sweep that 0.7-12 kHz, a 0.046 ms sample interval, and approximately 135 ms record length. Based on survey speeds of ~4.5 knots and a shot interval of 0.2 s, the shot spacing was about 0.450 m.

The binary portion of the unprocessed seismic data are stored in Edgetech's JSF file format (.jsf file extension), which includes both the full-waveform match filter output, and the envelope conversion of that record. Our processing steps are fully described in Saustrup and others (2018), and involve merging files for each line into a single file, removal of towfish heave artifacts, correcting for towfish depth, equalizing trace amplitudes, secondary deconvolution (to sharpen image) on full-waveform records, and applying a layback correction to the navigation. Processed full-waveform and envelope records are stored in SEG Y rev. 0 (Barry and others, 1975), IBM float format (.sgy file extension), which is a standard digital format that can be read and manipulated by most seismic processing software packages. The SEG Y files may be downloaded and processed with commercial or public domain.

These data are held in the public domain.

The University of Texas Institute for Geophysics (UTIG) requests to be acknowledged as originator of the data in future products or derivative research.

The validity or accuracy of marine subbottom profiles is highly qualitative and depends on equipment and operating condition variables. Visual inspection of the images rendered from the data did not show any major anomalies.

This dataset is from three field activities with consistent instrument calibrations.

These data are collected along tracklines (2-D) and are therefore inherently incomplete. Geologic details between lines must be inferred.

As the subbottom data were acquired, the position of the vessel was continuously determined by a differential GPS system with antenna mounted at the stern of the ship, near the tow point. A layback correction for the ~5 m offset between towfish and antenna has been applied to the processed data as well as the ASCII navigation files.

These data are not to be used for bathymetry. Two-way travel (TWT) times in the processed data have been corrected for assumed towfish depth and have been filtered to remove heave artifacts.

Chirp subbottom data in raw (.jsf files) and processed (.sgy) form.

Chirp processing: The following processing description is excerpted from Saustrup and others (Saustrup, S., Goff, J.A., and Gulick, S.P.S. 2019. Recommended "Best Practices" for Chirp Acquisition and Processing. Austin, TX: US Department of the Interior, Bureau of Ocean Energy Management, OCS Report BOEM 2019-039, 15 p.; doi:10.31223/osf.io/7csjh). Processing is conducted using Paradigm Echos software.

Edgetech chirp data are recorded as ".jsf"-formatted files, a native Edgetech format that includes 4 different data channels: "real," "imaginary," "envelope," and "spectrum." The two channels of interest to the following processing scheme are "real", which are the full waveform record, and "envelope", which are the envelope-processed data more commonly displayed. Following data archiving (primary recording to top-side main drive and backup to secondary external drive), and prior to processing, these records must be converted to SEGY format files, which can be done with a number of available utilities. If a single survey line consists of multiple individual files, we find it useful to first convert and then concatenate these records into a single SEGY file for processing. The Edgetech acquisition software also provides an option to record directly to SEGY format. However, this format only includes envelope records; full waveform is only retained in the .jsf files. As noted above, we highly recommend acquiring field data in .jsf or an analogous format, such as .keb files for Knudsen systems, that retains both data types.

Our chirp processing scheme involves three primary data streams. The first of these streams includes the critical step of picking the seafloor (to within a fraction of a wavelength at ~5000 Hz, or about 0.1ms), which provides the basis for the other two data streams: real and envelope processing. Processing of real and envelope data in turn involves 3 steps: static corrections (heave compensation, towfish depth and tides), signal processing to improved image clarity, and layback correction for navigation.

The key step to being able to remove heave artifacts from chirp data, as well as for some signal processing, is to generate a precise pick of the seafloor reflection. A fully-automated bottom picker is desirable for ease-of-use but, in our experience, can fail regularly in the presence of high noise, low seafloor signal, or amplitude variability. Our own bottom-picking algorithm involves an iterative process, beginning with a coarse pick using a simple threshold algorithm, and successively refining using both automated methods and, optionally, user interaction in more difficult cases. The details of this algorithm are complex and beyond the scope of this document. Once completed, the bottom pick enables the user's ability to move individual records up or down (i.e., apply a "static") in relation to the seafloor arrival. Heave filtering, described below, is one such application. It is also possible to flatten record to the seafloor, which is useful for quality control; i.e., enhance both the user's ability to visually identify bad bottom picks and the algorithm's ability to iteratively refine the picks. Flattening is also a prerequisite for some of the processing steps described below. The seafloor flattening step is reversed later in the processing stream to preserve true topographic features at the seafloor.

The data are corrected for any recording delay (nonzero start recording time, also called deepwater delay) that may have been used in the field. This is often the case when operating in deep water; a delayed start of the recording time (a simple option in Edgetech systems, for example) can be used skip over large quantities of potentially useless water column returns and thereby keep record lengths and file sizes to manageable values.

A time series for towfish depth is recorded in the field, and used to correct to a sea-surface datum. This depth can be estimated using a variety of methods, including cable length/angle, a pressure sensor mounted on or integrated into the towfish, or ascertained with a USBL system. For best results, this step should be performed before the seafloor picking. We use a simple time interpolation between observed or recorded points.

The seafloor picks are smoothed using a user-defined (nominally 35-75 pings) low-pass filter that is large enough to average out heave artifacts. The difference between the filtered and unfiltered seafloor picks forms a static correction to correspondingly shift the traces up or down to compensate for heave. Care must be taken during this step, if possible, to not over-smooth the seafloor and remove true topography (although this is not always possible if seafloor features are of similar wavelength to heave artifacts). Heave correction values as calculated on the full waveform data are stored in a database and applied identically to both envelope and full waveform data. An important best practice for processed data is to incorporate values for final picked seafloor time, smoothed seafloor time, and seafloor static into the trace header. This enables heave compensation filtering to be "undone" so that other correction algorithms can be applied (e.g., fitting the picked seafloor to a known bathymetric surface).

Signal processing (frequency filtering, deconvolution, gain correction and water column muting) is performed after the data have been temporarily flattened at the seafloor for best results. Some signal processing methods, such as frequency filtering and deconvolution, can only be applied to the real, full waveform data traces. Full waveform data are bandpass-filtered using a filter comparable to the source wavelet band (e.g. 700-12000 Hz Butterworth Filter, with a filter length of 91 samples). This step primarily removes low-frequency towing noise.

Full waveform data are deconvolved (multi-ping predictive deconvolution) to account for slight inconsistencies in the match-filtering process (likely owing to differences between modeled and actual outgoing pulse waveforms) and to attenuate very-short-period interbed multiples. This procedure is applied to flattened records, which is reversed after the deconvolution is performed. The net visual result is to give the data a less “ringy” quality. In practice for our data we use a deconvolution operator calculated from the chirp data (e.g. a 31-trace predictive deconvolution with a filter length of 15 samples and a prediction distance of 4 samples); this is not to collapse the original outgoing pulse but rather the remnant of the outgoing pulse not removed by the match filtering in the towfish. Doing this step on temporarily seafloor-flattened data allows use of a constant design window of 10ms starting at the seafloor which saves having to define a design window that moves up and down with the seafloor.

Processed full-waveform and envelope records are stored in SEG Y rev. 0, IBM float format (.sgy file extension), which is a standard digital format that can be read and manipulated by most seismic processing software packages. Navigation in Edgetech SEGY files is stored in two places. Header bytes 73-76 (lon) and 77-80 (lat) are the standard SEGY locations containing low-resolution navigation in integer arcseconds. Edgetech then stores a high-resolution (integer miliarcsecond; divide by 600000) in trace header locations 81-84 (lon) and 85-88 (lat). These original navigation points are preserved. In addition, we place a high-resolution, filtered, layback-corrected navigation in trace header locations 181-184 (lon) and 185-188 (lat).

Layback-corrected navigation are also exported to ascii-formated, comma-separated values (csv) files, where each line indicates line name, ping number, fish latitude, and fish longitude.

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