Appendix 1: DATA ACQUISITION

The 310-km seismic reflection profile of the Daba Shan was completed in 2007. The seismic data were acquired by using French Sercel SN408XL 24-bit digital seismic recorders with 1600 channels. Dynamite sources of 40 kg nominal for normal shots and 200 kg nominal for large shots were fired with a spacing of 160 m and 5000 m, respectively. Shot spacing was reduced to 80 m across the mountainous regions of the Daba Shan (i.e., our zone 1 and zone 2 in Figs. 1 and 4). Dynamite for 40-kg sources was placed in single holes at depth of 22-24 m. Dynamite for 200-kg sources were detonated in 25-m deep 5-hole arrays. SM-24 geophones were used with a dominant frequency of 10-Hz in a group space of 40 m. Seismic data were recorded for 30s at a sampling rate of 2 million seconds. We expect imaging the crust at shallow levels (0–6s) at least 60 (in basin)/120 (in orogen) folds and at deep levels (6–30 s) at least 30 folds. The acquisition parameters are listed in **Table 1** below.

Table 1 Acquisition parameters for improved standard oil-industry

Shot interval	160 m nominal for Normal shot (Basin)
	80 m nominal for Normal shot (orogen)
	5000m nominal for Large shot
Source	Dynamite
Charge size	40 kg nominal for Normal shot
	200 kg nominal for Large shot
Shot depth	22 m ×2 for Normal shot (40 kg)
	25 m×5 for Large shot (200 kg)
Nominal fold	60 (Basin)
	120 (Orogen)
Geophone type	SM24-10Hz
Number of groups	480
Group interval	40 m
Geophone array	12 geophones in 11 m linear array
Near offset	20m (Normal shot)
	140m (Large shot)
Far offset	9580m (Normal shot)
	19300m (Large shot)
Spread	symmetric split (Normal shot)
	End-on (Large shot)
Sample rate	2 ms
Record length	30 s
Low–cut filter	15 Hz
High-cut filter	250Hz
Notch filters	out
Layout type:	9580-20-40-20-9580 (Normal shot)
	0-0-40-140-19300 (Large shot)

The quality of the recorded seismic data in field is excellent, with signal returns above ambient noise typically in excess of 20 s (TWT). We found that 40-m group space, 80/160m shot interval, and 120 folds are appropriate field parameters for acquiring high-quality seismic data. An increase in charge size for the 200-kg large shots at every 5 km greatly enhances the signal-noise ratio of the data below 6 s. The low-frequency and slow-attenuation seismic waves permit penetration of the thick crust (Jarchow 1990, Li et al., 2009). The experiment demonstrates that the multi-fold is required for imaging the deep crustal structure in regions with lower signal-to-noise ratios. The seismic section created by preliminary processing is considerably better than expected as indicated by a less reflective lower crust and a strong Moho signature characterized by a sharp increase in reflectivity at the base of the lower crust at the depth of 14-15 s TWT.

Appendix 1：DATA PROCESSING

1. Routine processing

By combining the advantages of Grisys, Omega and CGG systems, seismic data processing was first conducted following a standard procedure generally practiced in the petroleum industries (**Table 2**). These include the key steps using the following software packages: Demultiplex, Geometry Definition, Record & Trace Edition, Stacking Area Element Parameters Chosen (for crooked lines), Editing/Muting, Gain Recovery, Elevation Static, Spectral Analysis, Bandpass Filtering, Velocity Analysis, Normal Moveout Correction (NMO), Residual Static Correction, and Stacking and Migration.

Muting was accomplished by first applying a fixed amplitude recovery (spherical divergence and balance) designed to keep the trace amplitudes roughly constant with time and across the shot records. In this way, any traces contaminated by environmental noise (wind, cattle, traffic) stood out and are expressed as high-amplitude traces at depth. This is because the recorded amplitude of the noise is more or less constant with time (whereas the amplitudes of the seismic reflections decrease rapidly with time) and the spherical divergence correction (designed to even out the seismic signal) greatly amplifies the noise. Once this was done, it became straightforward to mute the noise signals from the shot records using an interactive display.

A replacement velocity of 4000 m/s and a reference elevation of 1200 m have been used to calculate the elevation and static corrections. First breaks were picked manually. Effective reflectivity has a bandwidth of 5 to 45 Hz and dominant frequency of 22 Hz. A wider pass-band was used for the pre-stack data. For the top 2.5 s TWT the filter specifications were (8-12-65-70Hz). In addition, filter specifications 2.5-5.0 s and below 5.0 s were（6,10,45,50 and（5,8,40,45）respectively.

After band-pass filtering and a CMP gather, elevation and statics were applied. For uplifting signal-noise ratio, Pre-stack F-K filtering and Wiener deconvolution were tested but found not to improve the data significantly, and so were not applied to the data. Velocity analyses were performed, but below 6 s the normal moveout correction is almost senseless for the velocity variation. Surface-consistent residual statics were calculated by STACK-POWER method interactively with the velocity analyses. Automatic gain control, F-K filter to attenuate steeply dipping events and pre-stack time migration was performed. The sections are plotted with no vertical exaggeration for a velocity of 6 km/s.

Table 2 Processing Sequence

Data Preparation

SEG-Y Input

Line Geometry Definition
Demultiplex
Record & Trace Edition
Shot delay correction +20 ms to Header Statics

Signal Processing
Coherent Noise Attenuation
Wave Eq. Multiple Rejection
True Amplitude Recovery
Normal moveout correction (forward)
F-K Filter Power exponent
Normal moveout correction (inverse)
Surface Consistent Decon spiking mode operator length 200 ms
Bandpass Filter
Trace Equalization
Radon Filter (parabolic subtract mode)
Stacking Velocity Analysis using Velocity Spektra
NMO Correction
Trace Muting (top & bottom)
Common Offset F-K DMO
Stolt or Phase Shift 2D Migration (Stolt migrate mode)
CDP/Ensemble Stack
TV Spectral Whitening
Stolt or Phase Shift 2D Migration (Stolt inverse mode)
Implicit FD Time Migration

Post-migration Processing
F-K Filter Power exponent
Spiking/Predictive Deconvolution predictive mode
Band-pass Filter
Coherency Filter
Trace Equalization

2. Special Processing Procedures

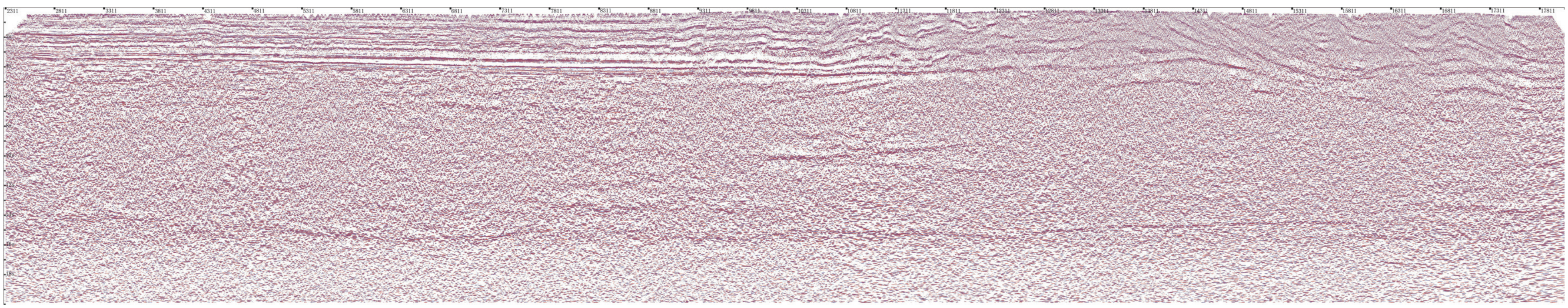
Traditional refraction methods usually provided satisfactory static correction results for simple layered structures near surface. However, the first arrivals of shot data may be highly distorted due to severe topography and rapidly variable near-surface structures. Refraction static and ray-tracing tomography methods were tested but they did not help improve the data quality. Instead, we apply the TSCWR technique that solves nonlinear wave equations using a finite-difference method. This method was combined with the first wave’s stability and the flexibility of rotary to avoid the shadow effect behind high-velocity bodies. TSCWR performance is faster and better in static correction than refraction and ray-tracing tomography for same shot data.

For data with low signal-noise ratios, velocity panels were performed to the CMP sets with

4% proportion (distance 1000 m, CMP 100 channels) in the varied-density section to find significant reflection. For the part of the seismic line with severe topography, highly variable near-surface structures, such as along CDP8000-13000 of 07-1 line across the southern front of the Daba Shan, the velocity intervals are at 50-20 m.

The common pre-stack processing of commercial software packages (e.g., CGG and PROMAX） and wave-equation and line-migration techniques were attempted on the seismic data acquired from the mountainous areas but the results show low signal-to-noise ratios. This problem was overcome by applying an improved algorithm of Kirchhoff Pre-Stack Time Migration in rough Earth surface (KPSTM), which is pending for a patent in China (Xue et al., 2006 http://www.petrosound.com/kf.asp).

Appendix for GSA Data Repository: Uninterpreted seismic reflection profile



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