



BGP Vibroseis Acquisition Techniques

China National Petroleum Corporation



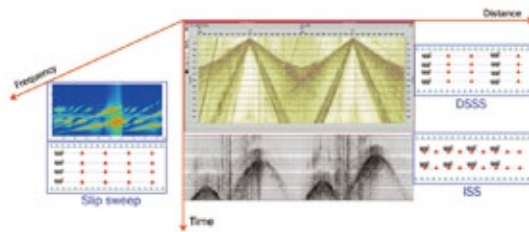
The industry has seen increasingly use of high-productivity vibroseis survey (HPVS) methods, such as slip sweep, distance separation simultaneous sweep (DSSS), and independent simultaneous sweep (ISS) in recent years. However, this brings quite a few challenges including production management, on-site QC, massive data management, and harmonics removal. Meanwhile, low frequency vibroseis acquisition is drawing great attention, with major challenges from the vibrator hydraulic and mechanic system and low frequency sweep design. As the world's largest land seismic provider, BGP, a CNPC subsidiary, makes sustained efforts in this particular field and provides PAI-Vibroseis, an integrated solution to vibroseis acquisition.



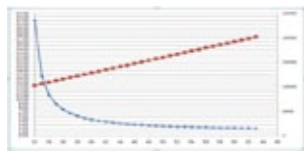
High Productivity Vibroseis (HPVS)

Technique 1: Flexible simultaneous shooting

- ✓ Customized simultaneous shooting in temporal, distance and frequency domain
- ✓ Vibrator management (Stake-less navigation, job assignment and QC)



Technique 2: Intelligent optimization of operation plan



Sources/channels ratio analysis



Equivalent 3D geometries



Spread optimization by KLSeis-II

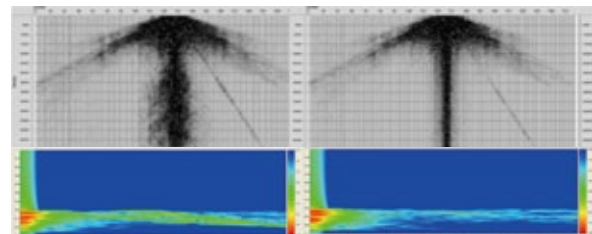
Technique 3: Massive data management and fast QC

- ✓ Fast real-time QC
- ✓ Seismic data dumping and fast QC

Technique 4: Blended noise processing

- ✓ Harmonic noise attenuation for slip-sweep
- ✓ Attenuation of interference noise by adjacent ISS shots

Harmonics removal of slip sweep data



Before

After

Low Frequency Vibroseis

LF vibrator

Index	KZ28	KZ28-LF	AHV 364	KZ28-LFV2	KZ28-LFV3
MAX. HD (kN)	275	281	276	275	280
Peak Force (kN)	276	276	275	276	280
Limited LF (Hz)	6	3	5.3	3	3
Max. Stroke (mm)	76	152	98	152	152
Areas of BP (m ²)	2.55	3.57	2.5	3.57	3.35
Mass Weights (kg)	4626	4445	4998	4650	5250
BP Weights (kg)	1450	1724	2027	1750	1920
Vibrate Pump (lpm)	483	903	504	903	903

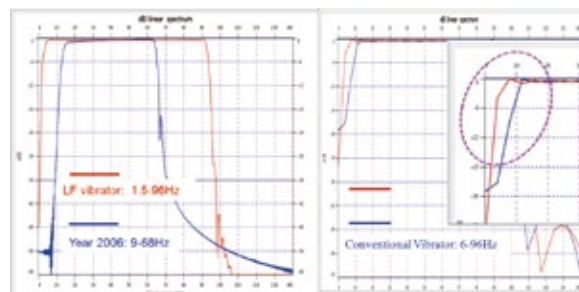


State-of-the-art LF vibrator: KZ28-LFV3

LF sweep design

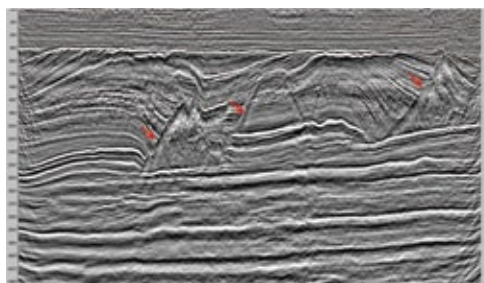
Based on the actual LF output characteristics of vibrator, optimal LF sweep can extend the capability of low frequency of vibrator on premise of protecting vibrator.

With the integration of KZ28LF low-frequency vibrators, G3i cable recording system, and Digital-Seis System (DSS), BGP has conducted the first large-scale 3D low-frequency (1.5-86Hz) seismic survey in the industry. The KZ28LF with excellent performance in the low frequency band can create novel data.

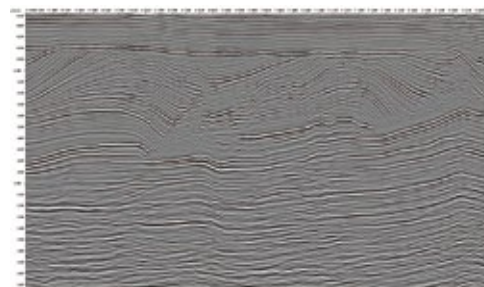


Spectrum of sweep signals

Application in Kazakhstan



New 3D PSTM based on low frequency vibroseis data



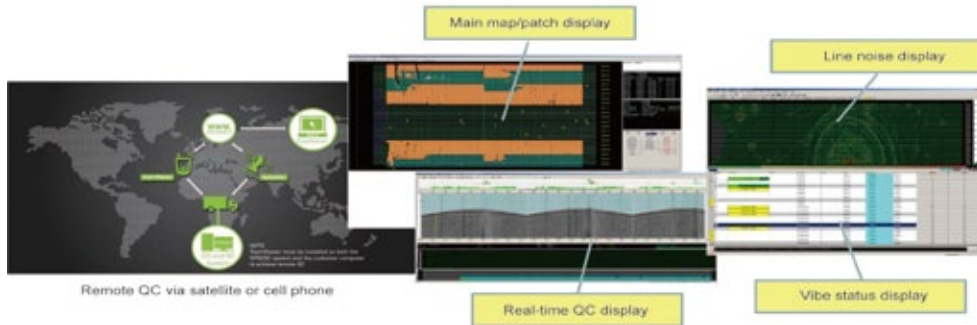
Legacy 3D PSTM based on conventional vibroseis data

The abundance of low-frequency components can reduce the ambiguity and improve accuracy of FWI and inversion, which lays a foundation for reservoir characterization and hydrocarbon prediction.



G3i Cable Recording System

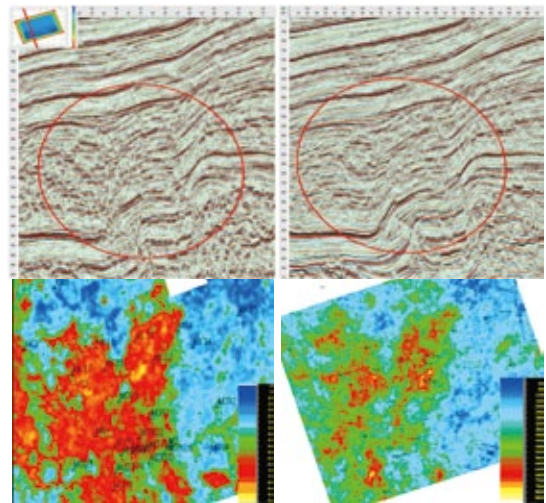
- ✓ Most rugged cabled seismic system available
- ✓ Outstanding reliability
- ✓ High channel capacity
- ✓ Analog geophone, digital 1C and 3C sensor support
- ✓ All advanced vibroseis methods supported
- ✓ Integrated QC packages



Case study: 60K G3i channels HPVS 3D Survey in China

- ✓ Full fold area: 388km²
- ✓ A total of 290,772VPs
- ✓ Full fold: 1,260
- ✓ CDP size: 12.5m*12.5m
- ✓ Trace density: 806 traces per km²
- ✓ Aspect ratio: 1.0
- ✓ A total of 63,284 channels G3i recording system
- ✓ Largest alive channel count operated in China: 54K
- ✓ DS4 operation of 16 vibrators with separated distance of 14km
- ✓ Average daily production 7,269VPs
- ✓ Peak daily production 12,316VPs
- ✓ 250Gb per hour recorded data

The result of new 3D survey



Legacy

New

Summary

1. DSS and relevant processing techniques provide an integrated technical solution for HPVS.
2. The KZ-28LF vibrator is capable of performing 3Hz of start sweep frequency with full force, which breaks the limitation of conventional vibrator for the first time in the industry.
3. The combination of HPVS and low frequency vibrator will bring more opportunities for wide azimuth, broadband, and high density 3D survey on land in the future.