DOWNHOLE SEISMIC TOOLS

VSP & MONITORING

Sercel

Ahead of the Curve℠

DOWNHOLE TOOLS

Today's major challenges for downhole seismic acquisition include 3D and 4D imaging around deeper wells, and permanent reservoir monitoring in production/injection areas. Current major constraints include dramatic reduction in acquisition time for cost effective operation in increasingly complex and harsh environments.

Since the 70s SERCEL has accumulated considerable experience with VSP tools based on proven and successful technologies.

From 2004, following the acquisition of CREATECH INDUSTRIE, a known leader in monitoring technologies since 1987, SERCEL moved into the growing market of oil and gas hydraulic fracturing and reservoir monitoring systems.

As a result of the successful integration of CREATECH INDUSTRIE and recent advances, Sercel Downhole Division offers the most advanced technology for VSP acquisition and well monitoring.

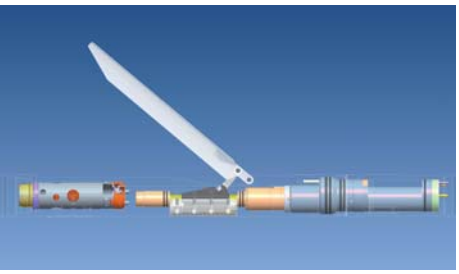
GeoWaves™, SlimWave™ and **MaxiWave** systems, all offering real time telemetry, have been designed to address the needs of large VSP downhole surveys where challenging requirements include cost efficiency, time saving, reliability, large simultaneous channels count, high quality signals and broad frequency range.

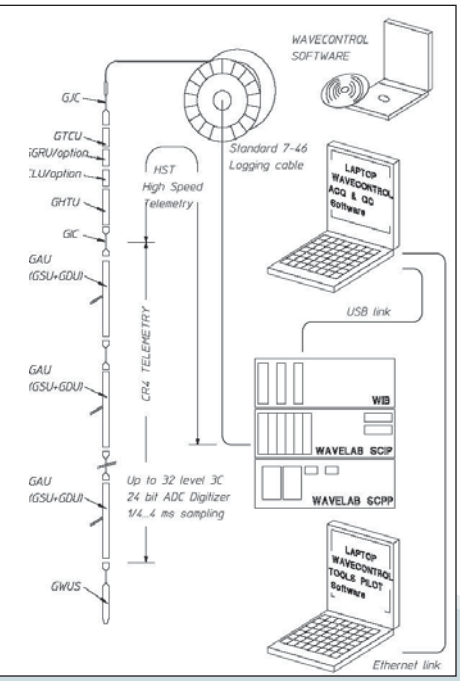
Innovative solutions for micro-seismic monitoring include a wide range of permanent tools either tubing conveyed (STPG) or behind casing (SCPG), that offer the unique advantage of allowing monitoring from flowing wells.

Furthermore, the SERCEL downhole tools offer the major advantage of being operated using a single surface acquisition and monitoring system, **WaveLab** with **WaveControl** software, providing full testing capabilities during deployment and acquisition.

To accompany the success of its customer operations, Sercel provides a dedicated VSP customer Support Service.

GeoWaves™





STANDARD DIGITAL VSP TOOL

GeoWaves™ is a digital multi-level downhole seismic array with up to 32 levels. This new reference in the VSP industry with high data rate transmission allowing real time acquisition, has been designed to fit a wide range of well diameters (4 in. to 16 in.) with the following main characteristics:

	DATA QUALITY	PRODUC-TIVITY	EASE OF MAINTENANCE	RELIA-BILITY	SAFETY
24 bits delta sigma converters	✓				
Light, compact & simple		✓		✓	✓
Easy access to geophone or electronic cartridge			✓		
Maintenance-free design (fewer seals and connectors)				✓	
Cooling system free			✓		
Easy handling when rig up & down		✓			✓
Gear Motor with built-in clutch for safer operations		✓			✓
Automatic arm closing in case of power shut down					✓
Sacrificial arm					✓
Operating temperature up to 170°C, (peak up to 180°C)	✓	✓			
Operating pressure 22,000 psi (1,500 bar)	✓	✓			
Coax inter-tool cable (fewer parts)			✓	✓	
Titanium tool housing				✓	
Accommodates fixed or gimbaled geophone cartridges	✓				
Operates using standard 7-conductor wireline cable		✓	✓		
Auxiliary measurement modules such as GR, CCL, tension/compression, and active weight unit for safe deployment	✓				
Automatic downhole electronic tests	✓				

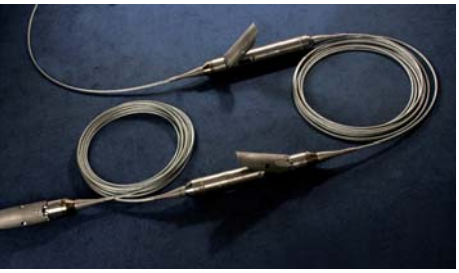
SlimWave™

SMALL DIAMETER DIGITAL VSP & MONITORING TOOL

SlimWave™ is a small diameter digital multi-level downhole seismic array for up to 12 levels. It benefits from the same technological advances as GeoWaves™ with the additional benefit of being usable in very small diameter wells or through any completion restriction thanks to its reduced diameter (1 in. 11/16, standard for production logging tools).
It has the following main characteristics:

	DATA QUALITY	PRODUC-TIVITY	EASE OF MAINTENANCE	RELIA-BILITY	SAFETY
24 bits delta sigma converters	✓				
Light, compact & simple		✓		✓	✓
Maintenance-free design (fewer seals and connectors)				✓	
Easy handling when rig up & down		✓			✓
Gear Motor with built-in clutch for safer operations		✓			✓
Automatic arm anchoring force release in case of power shut down, for safe retrieval					✓
Sacrificial arm					✓
Operating temperature up to 135 °C, (peak up to 150 °C)	✓	✓			
Operating pressure 14,500 psi (1,000 bar)	✓	✓			
Coax inter-tool cable (fewer parts)			✓	✓	
Titanium tool housing				✓	
Accommodates fixed geophone cartridges	✓				
Operates on a wide range of wireline cables (standard heptacable, 3 or 4 conductors cable, coax, or monocable)		✓	✓		
Automatic downhole electronic tests	✓				

MaxiWave



100-LEVEL DIGITAL VSP TOOL

MaxiWave is the most efficient digital multi-level downhole seismic array available on the market for very large size downhole seismic surveys.

With 100 digital 3-component levels, MaxiWave benefits from the most advanced developments in terms of real time telemetry and mechanical reliability, that make this system the optimal solution to address today's challenges for the cost effective acquisition of high volumes of quality data.

MaxiWave features an innovative optimized deployment system to cut down operationing costs:

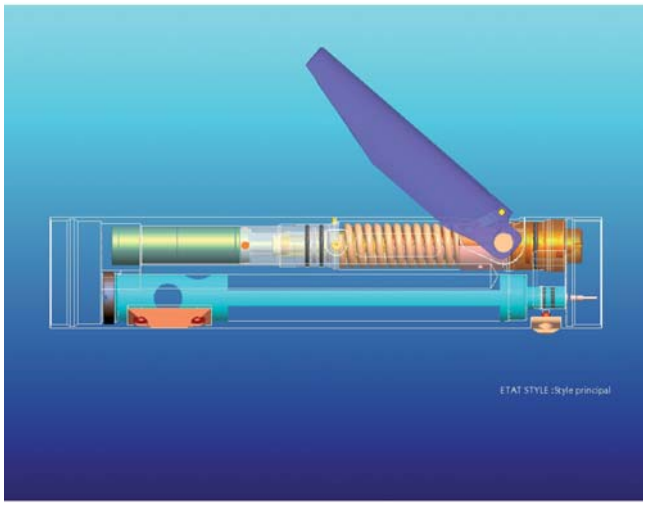
- minimum deployment and retrieval rig-time,
- maximum operational safety and reliability,
- minimum acquisition time

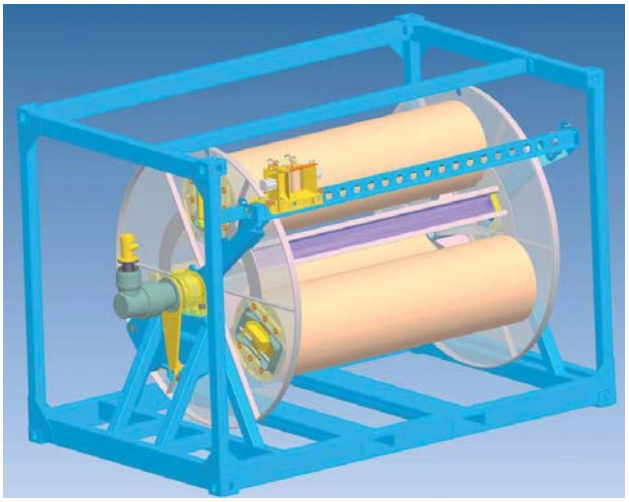
MaxiWave has the following main characteristics and benefits:

	DATA QUALITY	PRODUC-TIVITY	EASE OF MAINTENANCE	RELIA-BILITY	SAFETY
24 bits delta sigma converters	✓				
Light, compact & simple		✓		✓	✓
Easy access to geophone or electronic cartridge			✓		
Each tool can be separated as an individual level			✓		
Rackable electronics and seismic cartridge (geophone) as one unit for fast and easy handling		✓			
Supplied on a drum for easy handling and deployment		✓			✓
All tools are interchangeable			✓		
Maintenance-free design (fewer seals and connectors)				✓	
Cooling system free			✓		
Easy handling when rig up & down		✓			✓
Gear Motor with built-in clutch for safer operations		✓			✓
Spring loaded anchoring maintains permanent coupling and allows safe retrieval					✓
Sacrificial arm					✓
Operating temperature up to 135°C (150° peak)	✓	✓			
Operating pressure 17,400 psi (1,200 bar)	✓	✓			
Coax inter-tool cable (fewer parts)			✓	✓	
Titanium tool housing				✓	
Accommodates fixed geophone cartridges	✓				
Operates using standard 7-conductor wireline cable		✓	✓		
Auxiliary measurement modules such as GR, CCL, tension/compression, and weight unit	✓				
Automatic downhole electronic tests	✓				

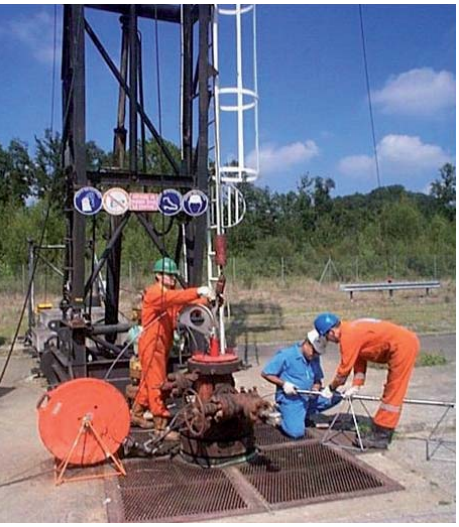
MaxiWave Benefits:

- Avoids repetitive shooting and down-hole tool movements.
- Significantly reduces well downtime & survey cost and allows combined 3D surface seismic & VSP.
- Allows wide aperture acquisition and repeat surveys from a single array position
- Offers a unique way to deploy a long array taking into account the wave field aliasing constraints.
- Capturing the down-going wave-field on a long array allows improved S/N ratio and wave-field separation.
- Recording 3D-VSP with a long array eliminates the depth and coupling function variation.
- Provides high quality data with broad frequency bandwidth and high sensitivity acquisition.





Well seismic applications



- **3D VSP**
  - Improved vertical & lateral resolution
  - Improved reservoir delineation
  - Faults & pinch-out detection
  - True 3D data migration in time & depth
  - True calibrated depth imaging along the array to support drilling decision
  - Possible simultaneous 3D VSP and 3D surface seismic acquisition and data integration.
  - Overcomes surface seismic limitations such as “blind” zones”
  - Application to overhangs, salt bodies, gas clouds,
- **REPEATED (4D) VSP**
  - Improved reservoir imaging resolution, statically and dynamically
  - Improved S/N ratio and optimized repeatability to quantify time-lapse changes in the reservoir
  - Monitoring of fluid interfaces variation
  - Application to water-flooding, gas injection, CO2 sequestration.
- **ZERO-OFFSET, OFFSET & MULTI-OFFSET VSP**
- **WALKABOVE**
- **WALKAWAY**
- **SALT PROXIMITY SURVEY**
- **SIMULTANEOUS 3D SURFACE SEISMIC AND 3D VSP**
- **CROSSWELL SEISMIC & TOMOGRAPHY**
- **VIRTUAL SOURCE**

PERMANENT TOOLS

STPG

SEISMIC TUBING CONVEYED PERMANENT GEOPHONES

This tool is designed for installation in a flowing well, optimizing the monitoring in injection/production areas at the reservoir level. It is particularly beneficial for hydraulic fracture monitoring from the treatment well.

The tool is attached to the tubing according to completion specifications during a workover.

The deployment is identical to that of permanent pressure gauges. It allows safe installation, in various well configurations including highly deviated wells.

SCPG

SEISMIC CASING CONVEYED PERMANENT GEOPHONES

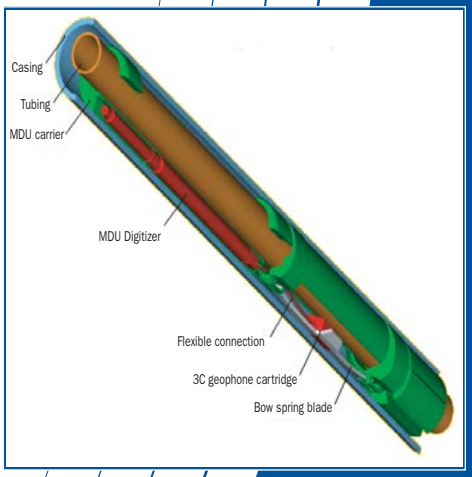
The behind Casing tool is well suited for newly drilled wells to be permanently instrumented for injection, production and compaction monitoring. Installed behind the casing and cemented in the annulus between casing and formation, it offers an optimized coupling.

Both permanent tool types share the following main features:

- Downhole digitization
- High-speed mono-conductor telemetry to the surface that allows permanent installation through tubing hanger and well-head outlet,
- Fully welded tri-axial geophone assembly and electronic cartridge,
- Surface panel including downhole string power supply, downhole commands, system tests, telemetry interface, data acquisition, permanent monitoring, and quality control.

VARIOUS APPLICATION DOMAINS

- OIL & GAS RESERVOIR ENGINEERING
- RESERVOIR STIMULATION – EOR- HYDRAULIC FRACTURING
- NATURAL & EXPLOITATION RISK MONITORING
- UNDERGROUND STORAGE MONITORING

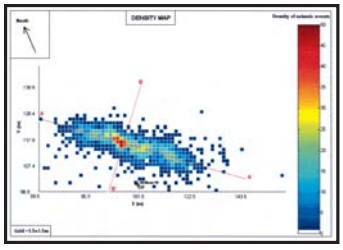


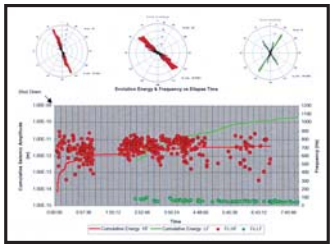
Permanent reservoir microseismic monitoring helps to identify mechanical re-adjustments and fluid movements through the analysis of induced micro-seismic event occurrences over time, throughout reservoir lifetime. Moreover, concerns such as cap-rock integrity during massive fluid injection or subsidence linked to exploitation can be assessed.

Diagnostic data is necessary to aid judicious decision-making especially where hydraulic fracturing is used as a stimulation technique for tight oil and gas reservoirs, water-flooding and waste fluid disposal.

Induced micro-seismic monitoring provides immediate information on the orientation and extension of generated or re-activated fractures.

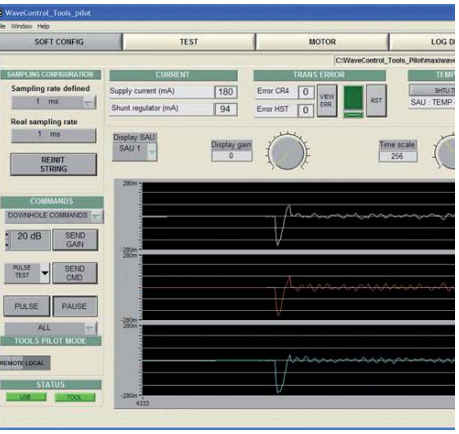
Such dynamic information helps in the delineation of reservoir structurally active features and contributes as a tracer revealing actual fluid paths for a better understanding of water breakthroughs and reservoir actual drainage.

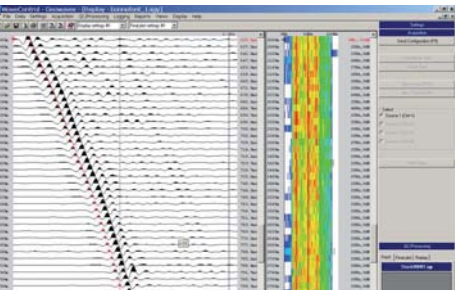


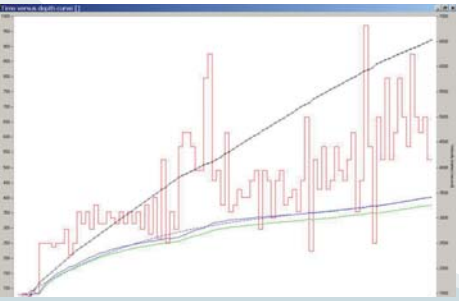


SURFACE ACQUISITION PANEL

WAVELAB







- Surface Panel common to all Sercel Digital Tools
- Used for the downhole string configuration and deployment, data acquisition and QC through **WAVECONTROL** Software.

ACQUISITION AND DATA QUALITY CONTROL

Standard acquisition

- Description of survey and well details saved in SEG Y textual file header
- Tools string configuration
- Configuration and control of multiple sources
- Telemetry set-up control
- Downhole and surface system tests:
  - Gain and distortion
  - Noise and offset
  - Cross talk
  - Bandwidth
  - Pulse test
- Anchoring motor control with arm opening indicator
- Real time display of logging auxiliary channels (Tensiometer, Gamma-ray, CCL, Active weight unit).
- Interactive stacking facilities : automatic stacking or preview before stacking
- Automatic correlation of Vibroseis data
- Real time display of all data recorded with frequency content
- Band-pass and notch display filters
- Printing and JPEG export of single shots and stack records
- Automatic generation of survey log
- Data format SEG Y and SEG 2

Monitoring features

- Continuous recording mode
- Microseismic event detection based on threshold or ratio function methods

Quality Control

- Navigation QC (Source)
- Spectral analysis of any data channel
- Memory facilities to compare spectra between receivers
- Vibroseis© similarities quality control
- Automatic, semi-automatic and manual first break picking
- Time versus depth curve with display of interval, mean and RMS velocities
- Well log data format: LAS 3.0
- Printing any record and final plot on any printers
- Display and printing of well log data on any printer
- SEG Y Viewer

SPECIFICATIONS

	GeoWaves™	SlimWave™	MaxiWave
Seismic acquisition			
Data rate optimization on cable	Fully automatic		
Bandwidth @ -3dB, 1/4 ms	1,666 Hz max		
Raw telemetry rate	2,5 Mbit/s on 23,000 ft (7,000 m) cable up to 4 Mbits/s on shorter cable		
Sample rate	1/4, 1/2, 1, 2, 4 ms		
Data transmission	True 24 bits		
Sensor type type	geophone SMC 1850 15 or 30 Hz	Omni 2400 15 Hz or SMC 1850 30 Hz	geophone SMC 1850 15 or 30 Hz
Sensor mounting	Fix or gimbal (SMC1850 10Hz)	Fix	Fix
Double sensor mounting per component	optional	no	no
Max number of levels	32	12	100
Standard tool spacing	15 m (50 ft)		
Max tool spacing	Max 640 m between GHTU (telemetry) and last GAU (level)	Max 500 m between SHTU (telemetry) and last SAU (level)	20 m with 100 levels
Surface System			
Acquisition panel	WaveLab		
Software acquisition	WaveControl		
Recording	Continuous		
Event detection	Threshold or ratio function methods		
system test	Gain and distortion Noise and offset Crosstalk Bandwidth Pulse test		
Supply voltage & Freq.	85-264 Vac / 110-330 Vdc, 47-63 Hz		
Power output	1,200 W		
Physical	rack 19'' 9U, 30 Kg (66 lbs)		
Logging cable/deployment			
Hepta cable	yes	yes	yes
Coax	optional	yes	no
Mono cable	no	yes (reduced data rate)	no
Deployment	Standard	Standard	Spooler/proprietary sheave

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	GeoWaves™	SlimWave™	MaxiWave
Electrical @25°C (Typical)			
Pre-amp gain	20 or 40 dB		
ADC	ΔΣ 24 bits		
At 20dB and 2 ms			
Full scale input signal	530 mVpp rms	400 mVpp rms	400 mVpp rms
Equivalent input noise	187 nv / rms	158 nV rms	158 nV rms
At 40dB and 2 ms			
Full scale input signal	53 mVpp rms	40 mVpp rms	40 mVpp rms
Equivalent input noise	103 nV rms	100 nV rms	100 nV rms
Instantaneous Dynamic Range	123 dB	122 dB	122 dB
Distortion	0.001%		
Crosstalk	>100 dB		
Mechanical			
Min diameter	3''1/8 (79 mm) without pads	1''11/16 (43 mm) without pads	3''1/2 (89 mm) without pads
Max diameter	16'' (408 mm)	9''5/8 (244 mm)	11'' (279 mm)
Length (level)	1262 mm (49''2/3)	1110 mm (43''5/7)	440 mm (17'')
Weight (level)	21 Kg (45,3 lbs)	6,5 Kg (14,3 lbs)	8 Kg (17,6 lbs)
Anchoring arm	Standard 7'' arm (options 9'', 13'', 16'')	Standard 7'' arm (options 5''1/2, 9''5/8)	Standard 9''5/8 arm (options 7'')
Anchoring ratio	>10:1 (7'' arm)	>10:1 (7'' arm)	>4:1 (7'' arm)
Environment			
Temperature rating	170°C (338°F) operating temp. 180°C (356°F) peak	135°C (275°F) operating temp., 150°C (302°F) peak	135°C (275°F) operating, 150°C (302°F) peak. High T. version 175°C (347°F) under development
Pressure rating	22,000 psi (1,500 bar)	14,500 psi (1,000 bar)	17,400 psi (1,200 bar)
Accessories			
Tension/compression	yes	under development	yes
Gamma ray	yes	under development	yes
CCL	yes	under development	yes

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