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— MINING
MONITORING
INSTRUMENTATION

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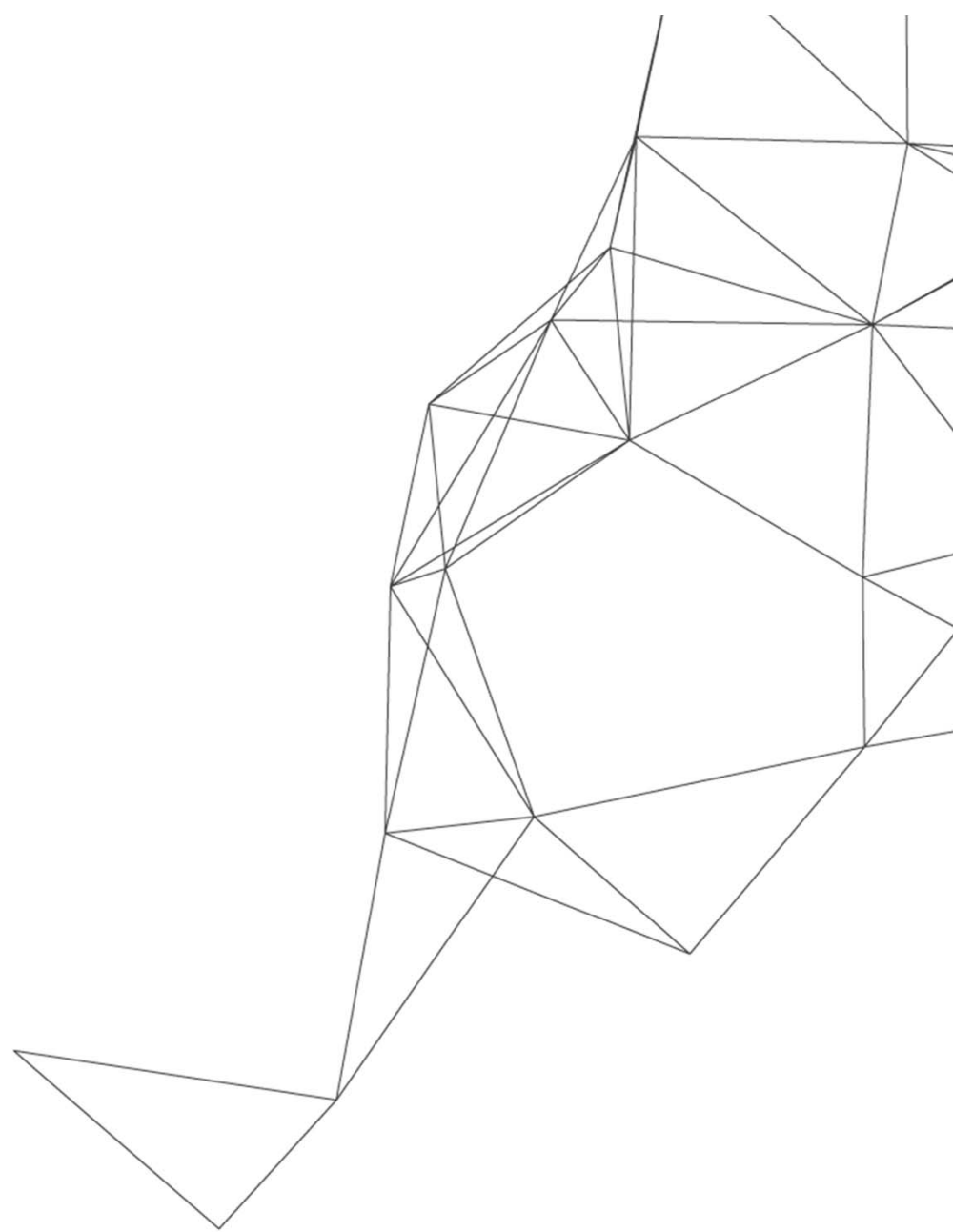
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Tel: +57 1 6368710

___ INDEX

- *Some monitoring philosophy*
- *Open-pit mine*
- *Underground mine*
- *Tailings (waste repository)*



— THE MISSION OF MONITORING

The “Mission” of Monitoring is:

*“Provide as much **information** as possible
in the **simplest** and most **complete**
form **to be used** by those
who have to make decisions”*

__ WHY MINES NEED A MONITORING SYSTEM?

- *To Improve design,*
- *To Reduce costs,*
- *To Increase safety,*
- *To Increase knowledge*
- *To Enable control of the works / operations*

— WHAT IS MONITORING?

*Collected Data +
Information =*

MONITORING



— WHAT ARE THE INFORMATION?

*“Information”
is the result of processing, gathering, manipulating
and organizing data in a way that adds to the
knowledge
of the receiver.*

*In other words,
it is the context in which data is taken.*

— WHAT IS THE “CONTROL”?

*Monitoring +
Protection works =*

CONTROL



— OPEN-PIT MINE



__ OPEN-PIT MINE



Piezometer



Multipoint piezometer



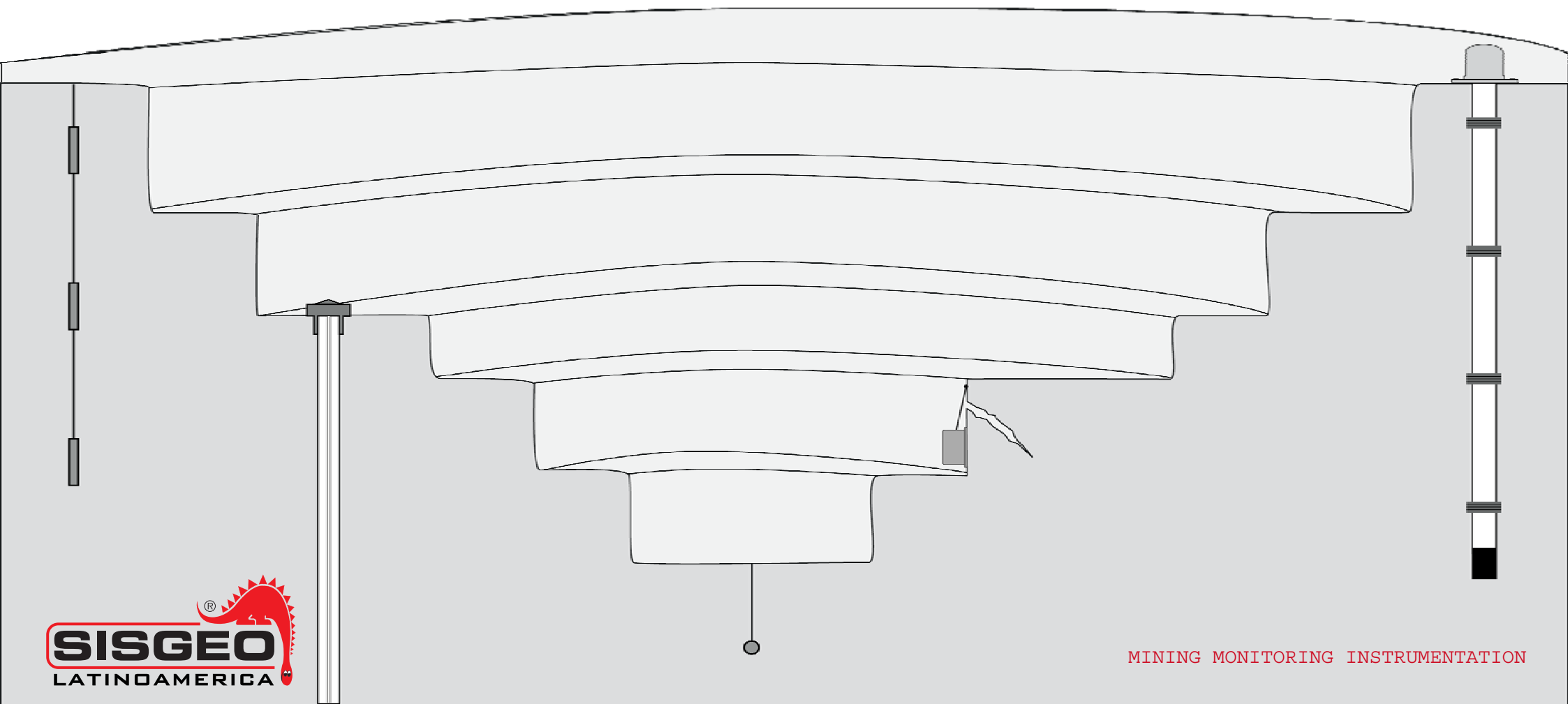
Inclinometer casing



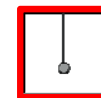
Extenso-inclinometer casing



Wire extensometer



__ PIEZOMETERS



Piezometer



Multipoint piezometer



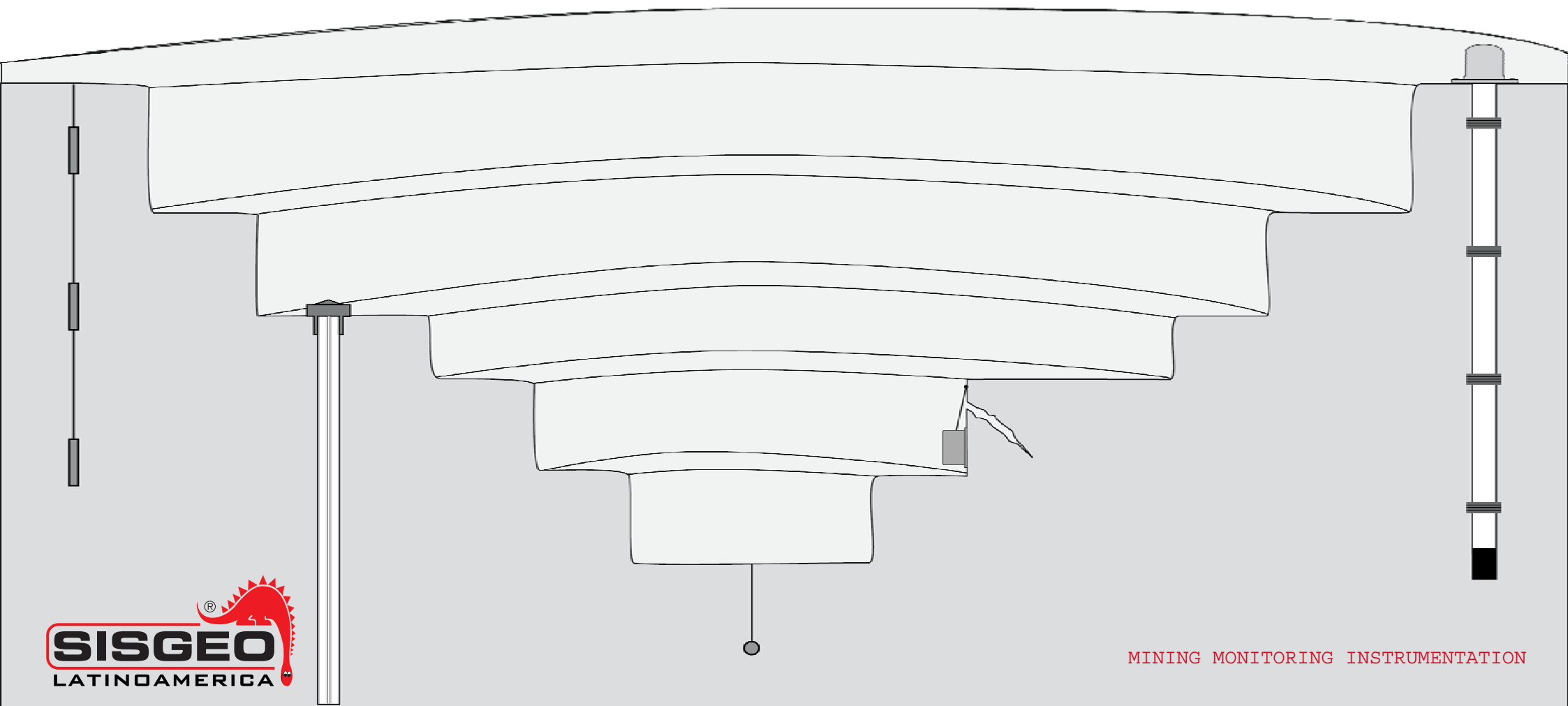
Inclinometer casing



Extensometer casing



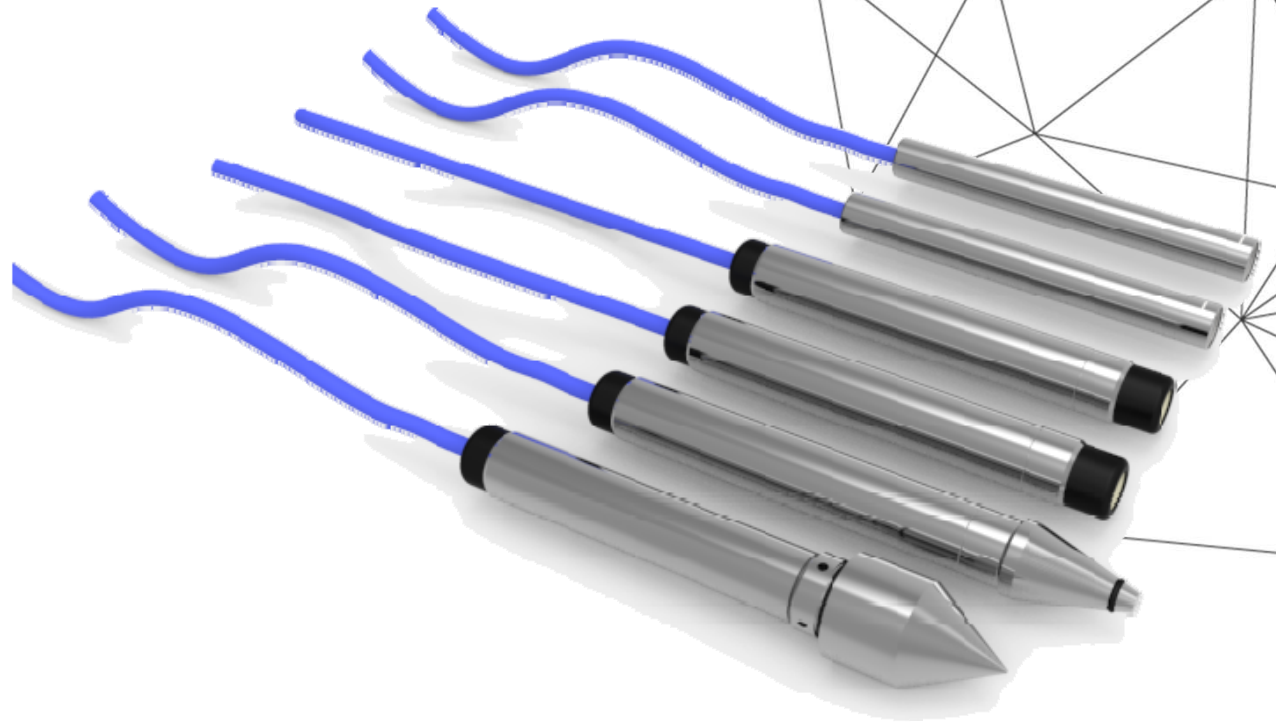
Wire extensometer



__ PIEZOMETERS FOR PORE PRESSURE

Purpose:

- *Pore pressure monitoring*



__ PORE PRESSURE: INSTALLATION PHASES



Insert the transducer in the borehole

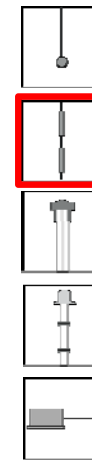


Filling with bentonite pellets (sealing)



Take zero reading

__ MULTIPOINT PIEZOMETER



Piezometer

Multipoint piezometer

Inclinometer casing

Extensor-inclinometer casing

Wire extensometer

__ PIEZOMETERS FOR PORE PRESSURE

Purpose:

- *Pore pressure monitoring in the same borehole at different depths / levels*

Installation method:
FULLY GROUTED



__ MULTIPOINT (MULTILEVEL) PIEZOMETERS



— INCLINOMETER CASING FOR HORIZONTAL DISPLACEMENTS



Piezometer



Multipoint piezometer



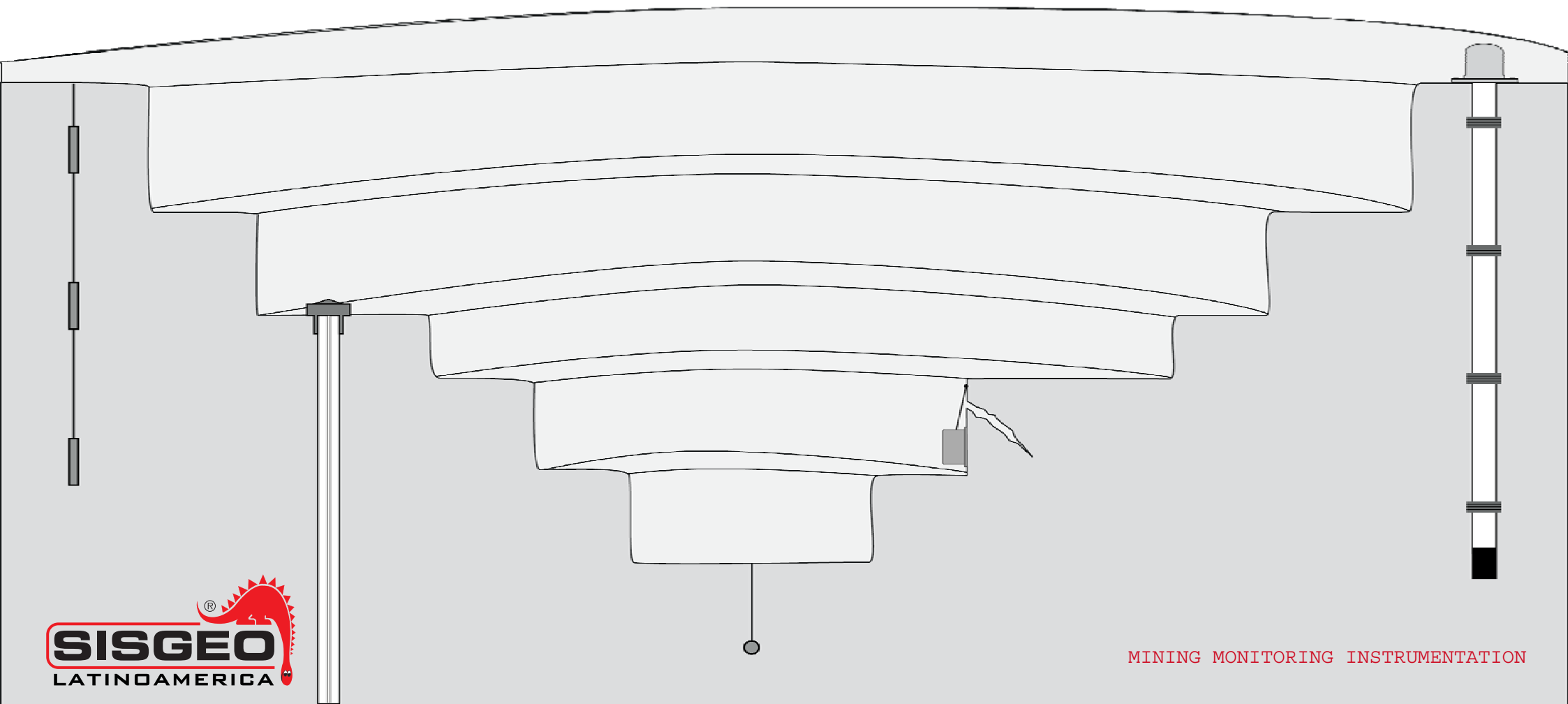
Inclinometer casing



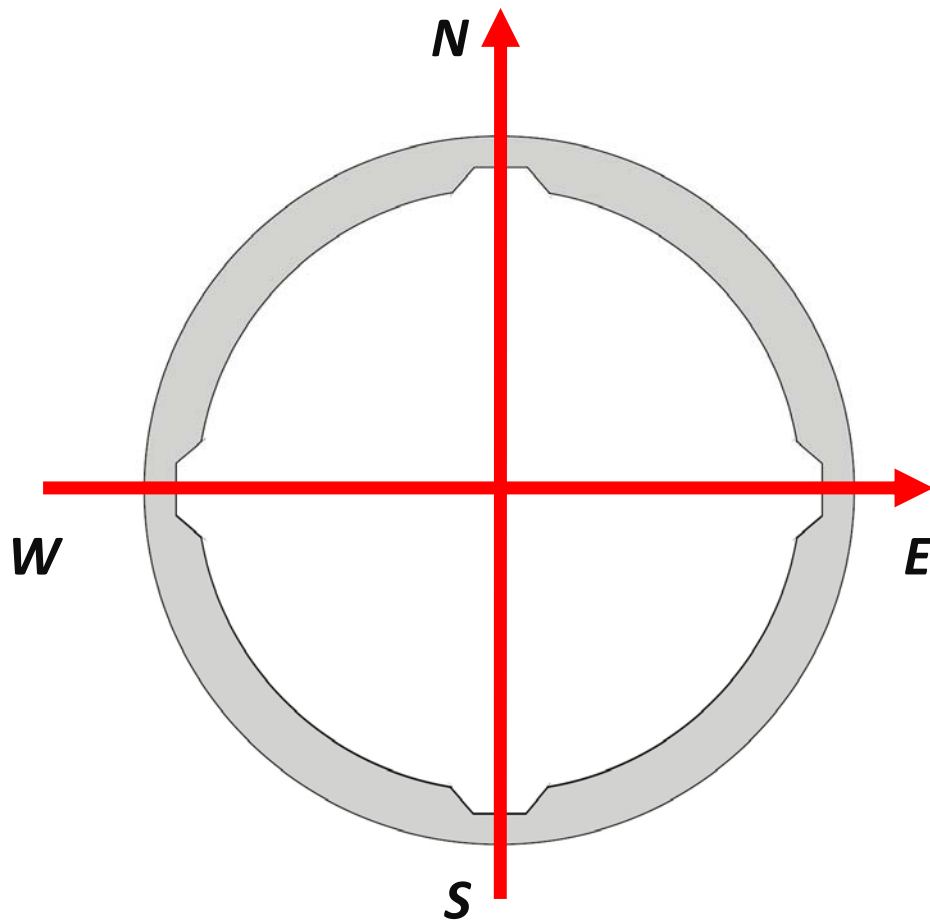
Extenso-inclinometer casing



Wire extensometer



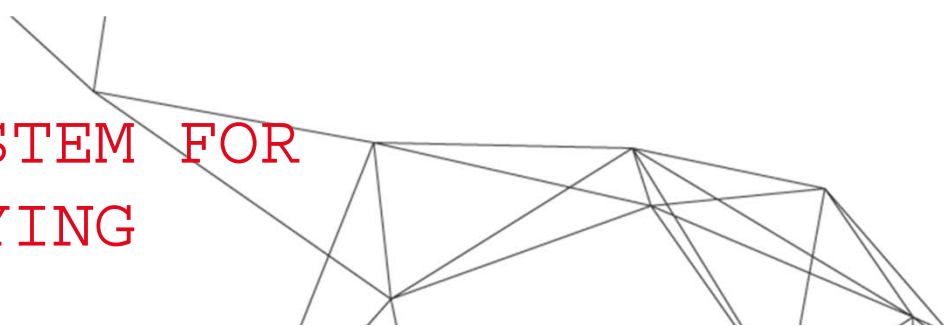
__ INCLINOMETER CASING FOR HORIZONTAL DISPLACEMENTS



***Inclinometer casing section:
4 grooves to guide the probe
in the tube without twisting***



— REMOVABLE INCLINOMETER SYSTEM FOR INCLINOMETER CASING SURVEYING



A Digital inclinometer probe

A.1 Travel bag for both inclinometer and dummy probes

B Light inclinometer cable reel

C Heavy-Duty cable

D Archimede readout

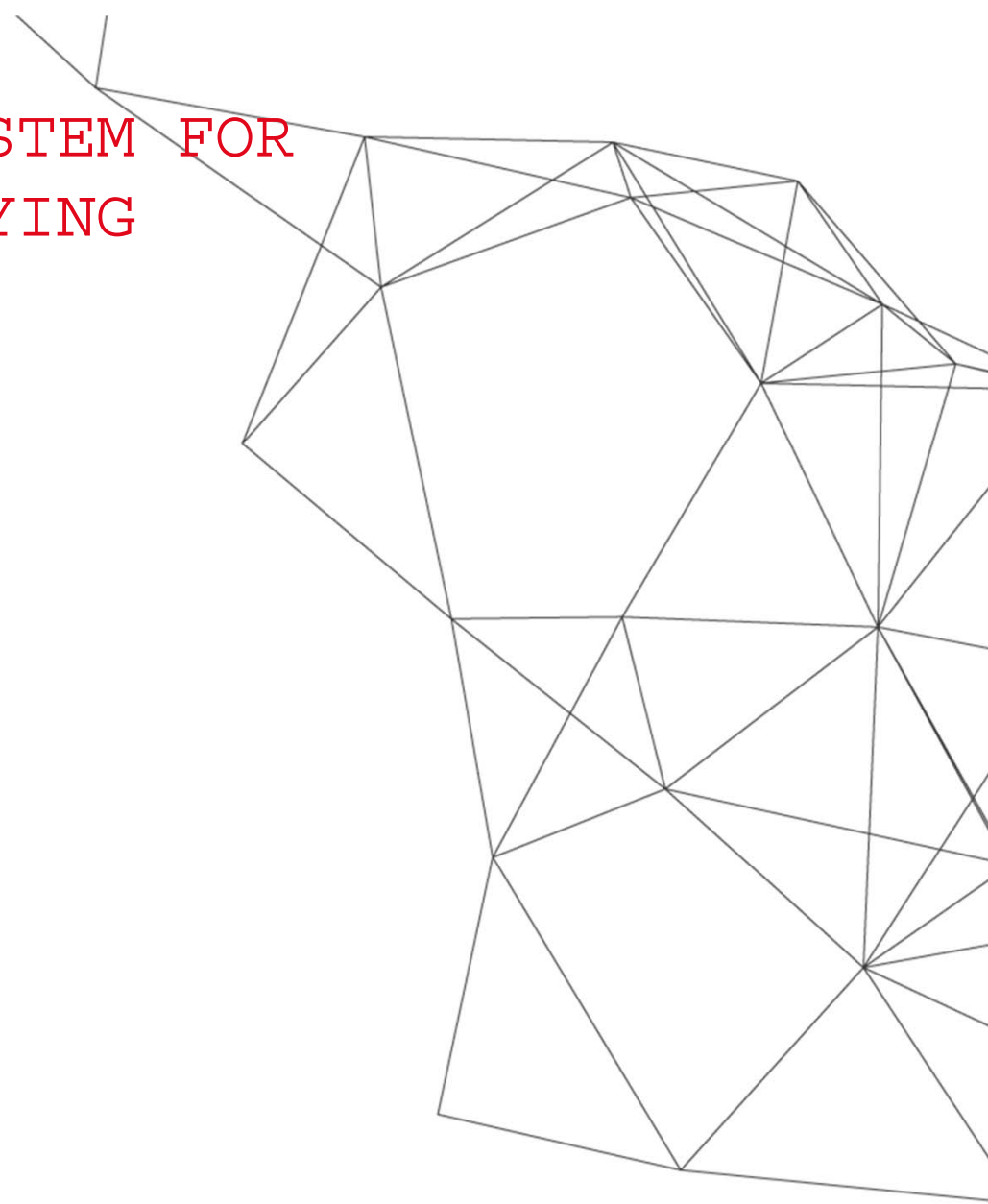
D.1 Archimede carrying case

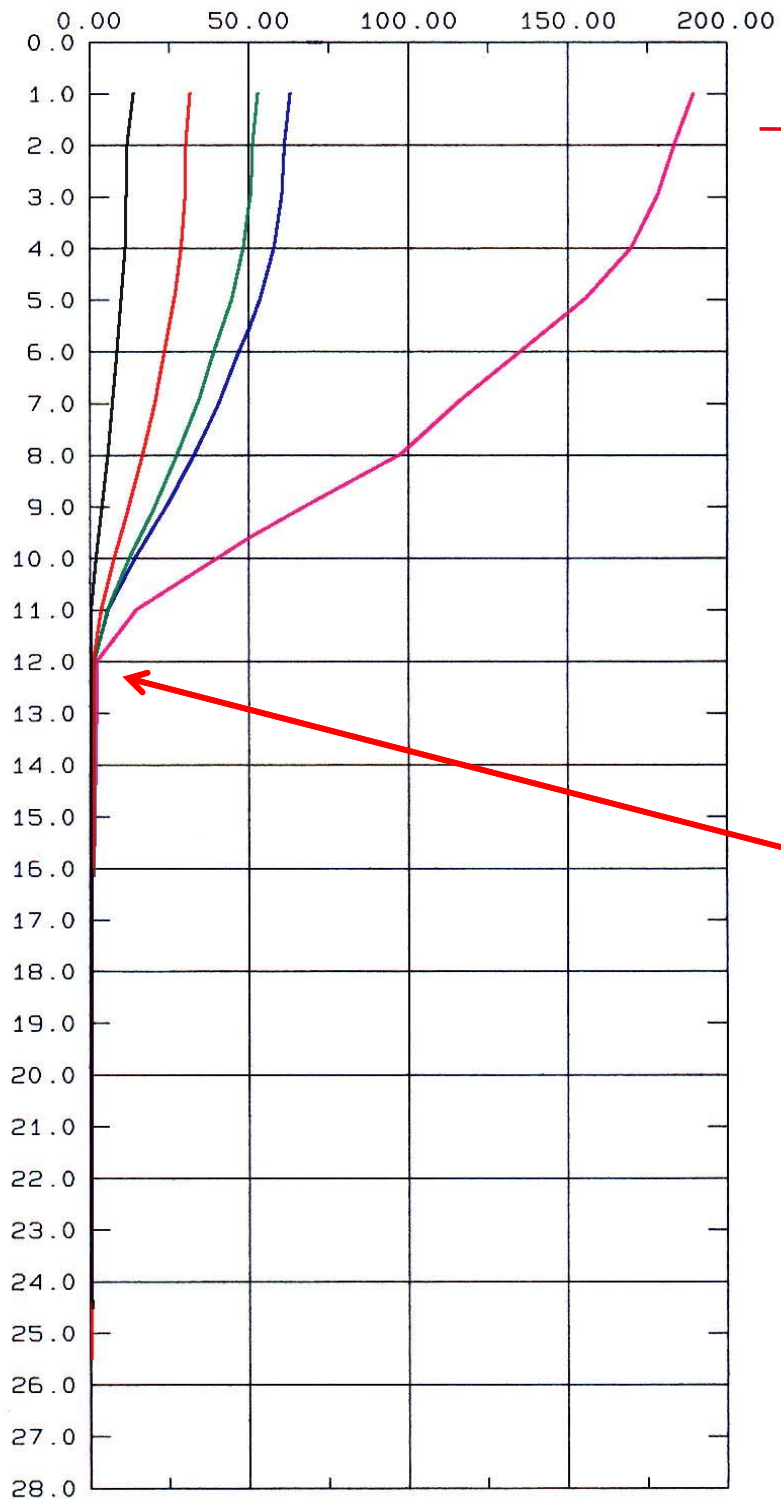
E Pulley assembly

F Dummy probe

F.1 Cable for dummy probe

— REMOVABLE INCLINOMETER SYSTEM FOR INCLINOMETER CASING SURVEYING





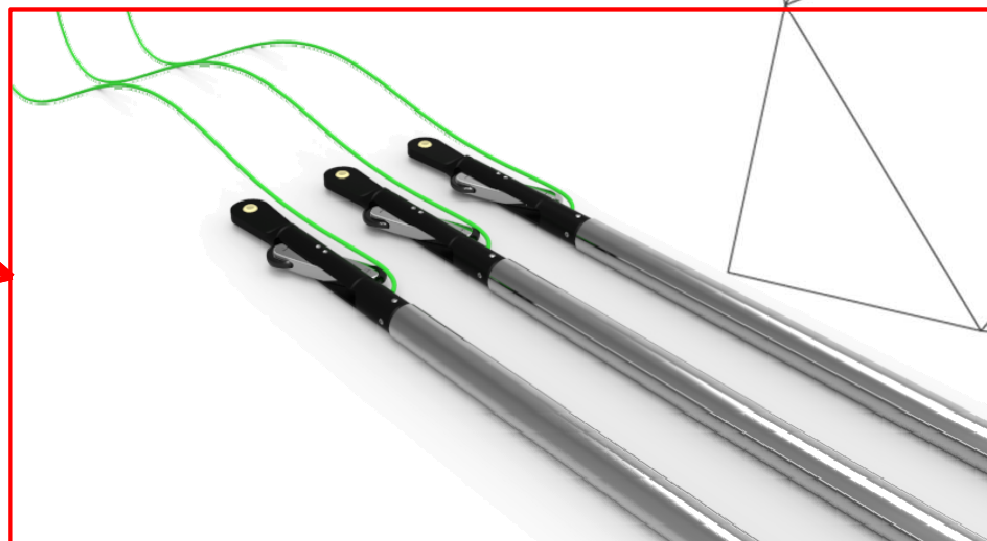
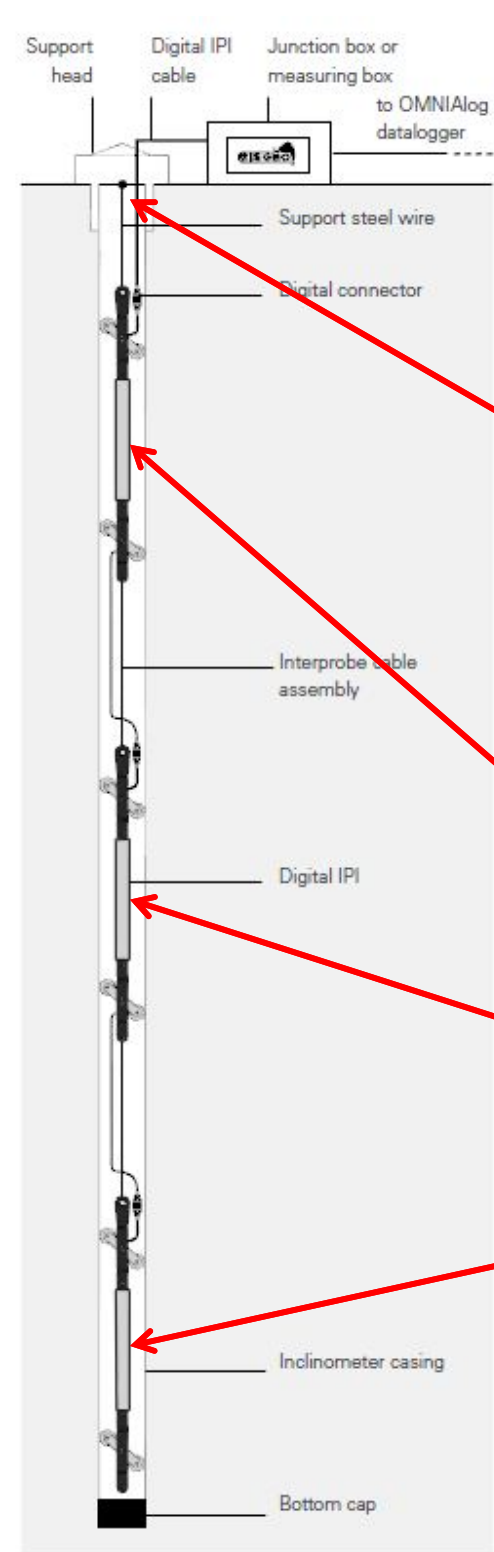
REMOVABLE INCLINOMETER SYSTEM FOR INCLINOMETER CASING SURVEYING

*In this example is clear
that at depth -12.0 m
there is a slipping surface*

— IN-PLACE INCLINOMETERS (IPI) FOR AUTOMATIC INCLINOMETER MONITORING

*Support top cap after
installation*

IPI probes



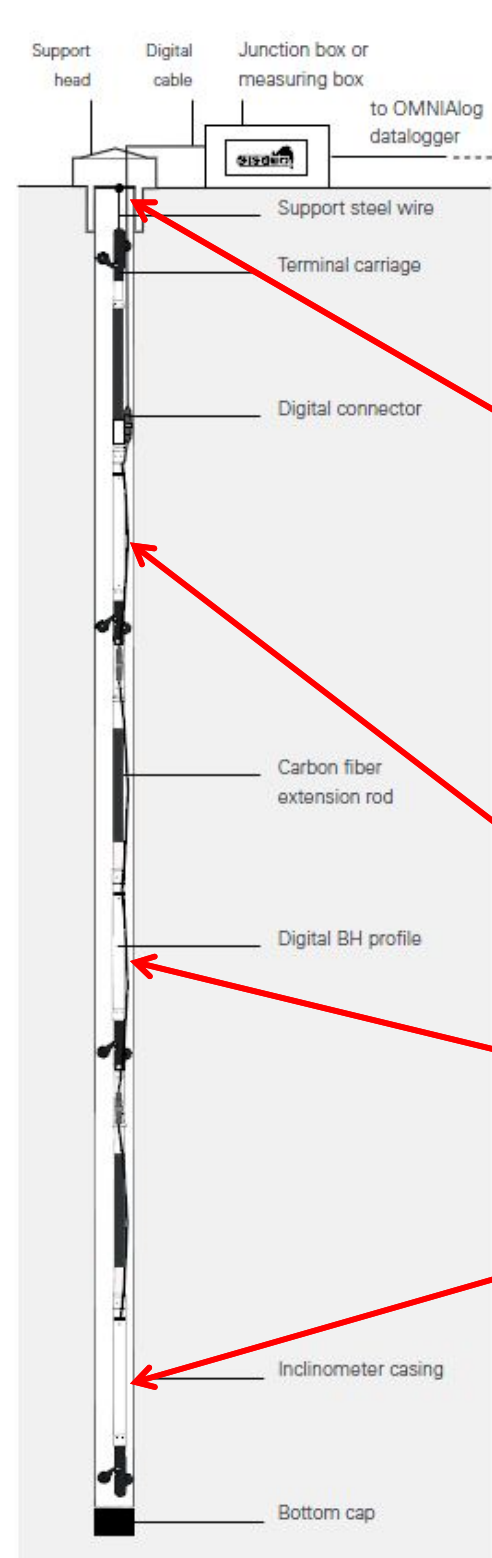
— BH PROFILE INCLINOMETERS FOR CONTINUOUS BOREHOLE PROFILING



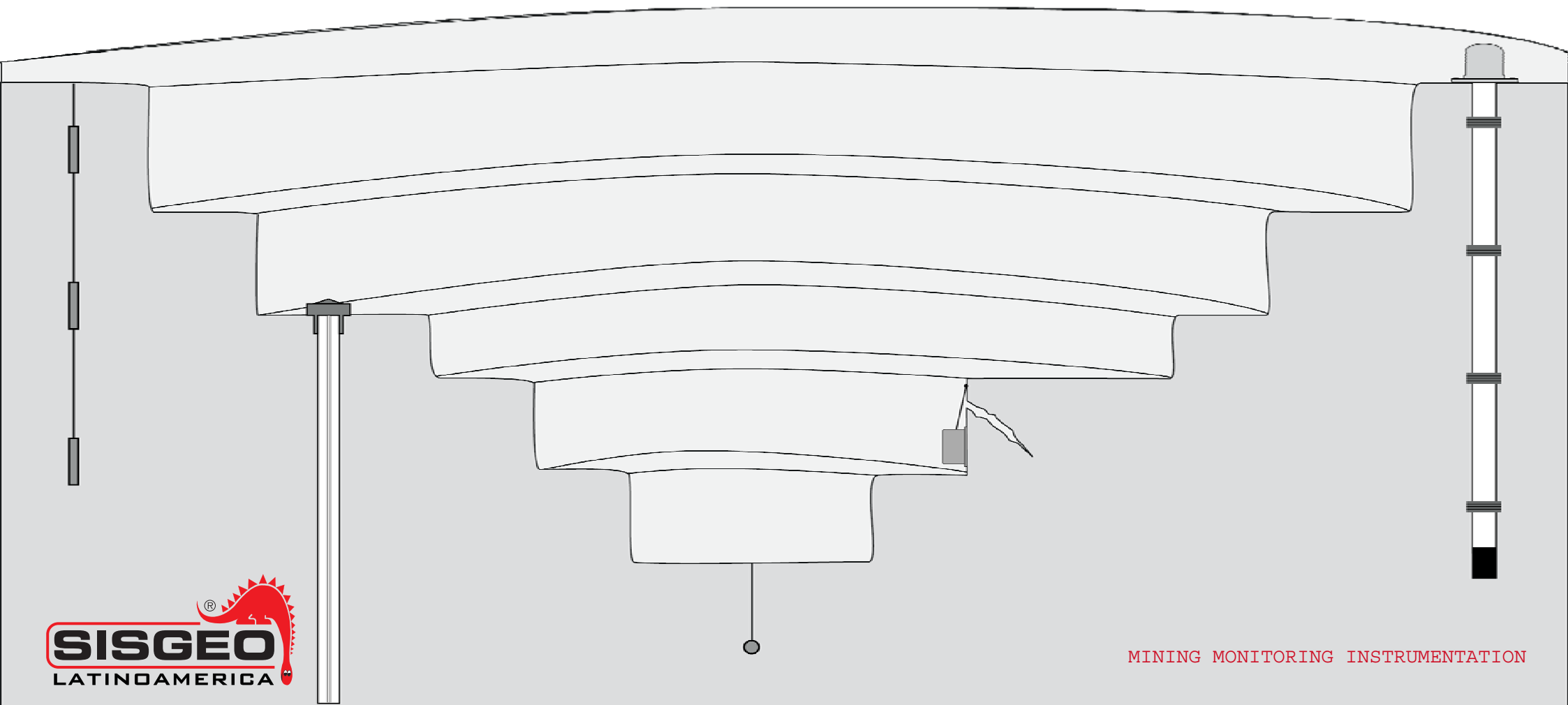
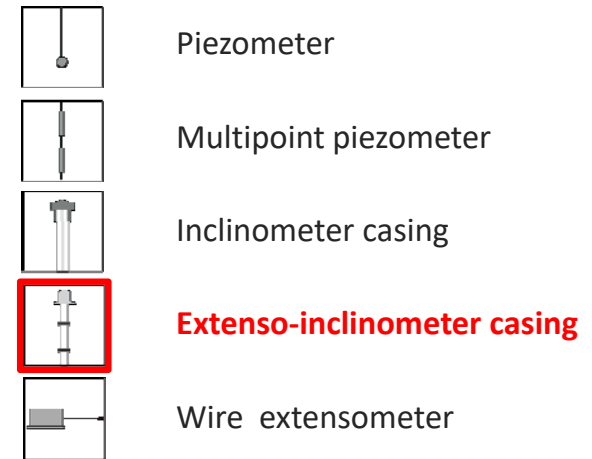
***Support top cap after
installation***



***Digital BH profile
inclinometers with
carbon fiber
extension rod***



— EXTENSO-INCLINOMETER FOR 3D BOREHOLE MONITORING



— EXTENSO-INCLINOMETER COLUMN

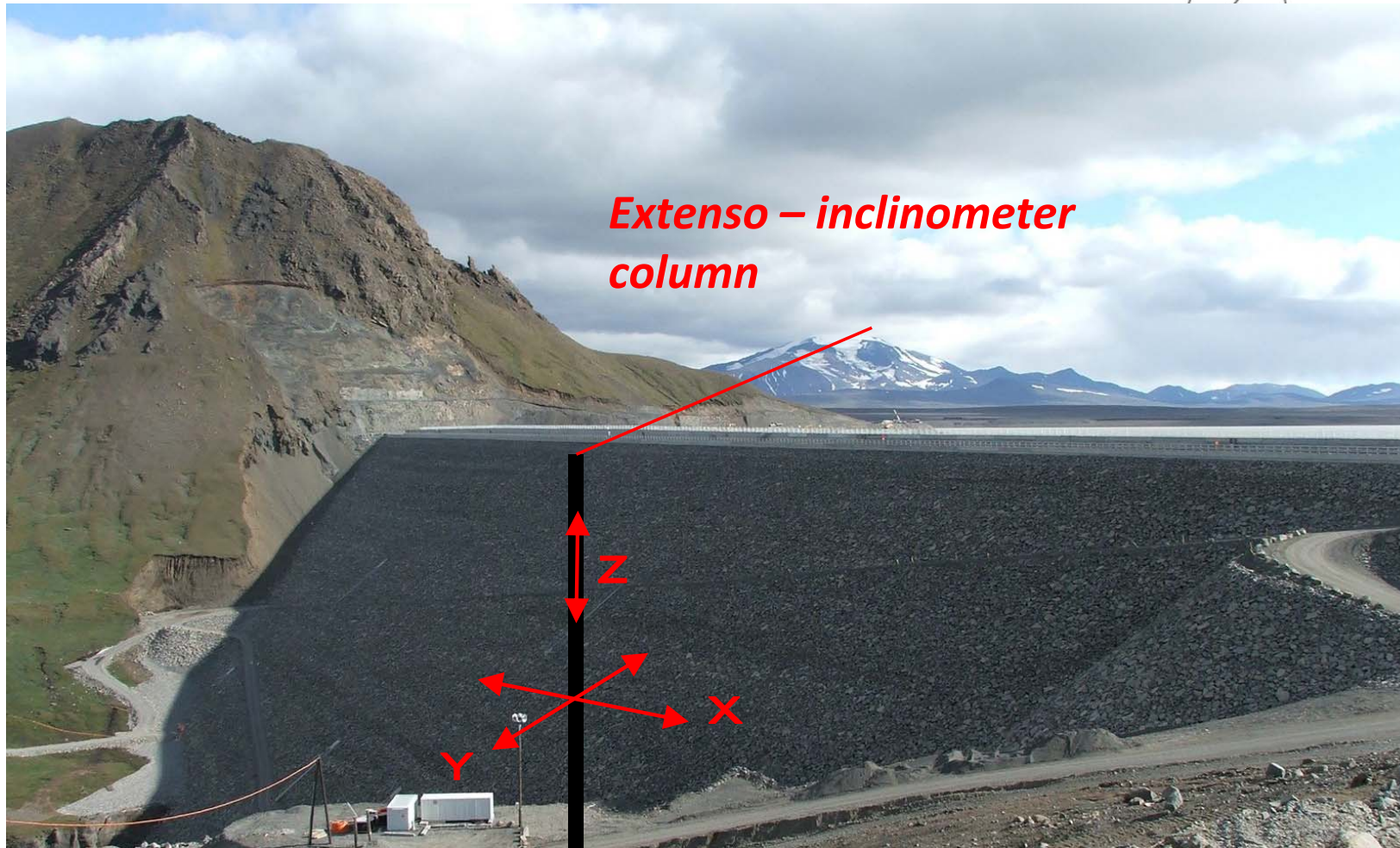
Purpose:

monitor both horizontal and vertical displacements

→ 3-D borehole monitoring



— EXTENSO-INCLINOMETER COLUMN



__ EXTENSO-INCLINOMETER - CASINGS

Casing for extenso-inclinometer column:

- *ABS inclinometer casings (Flush type)*
- *Magnet reference rings*



__ EXTENSO-INCLINOMETER - MANUAL READINGS



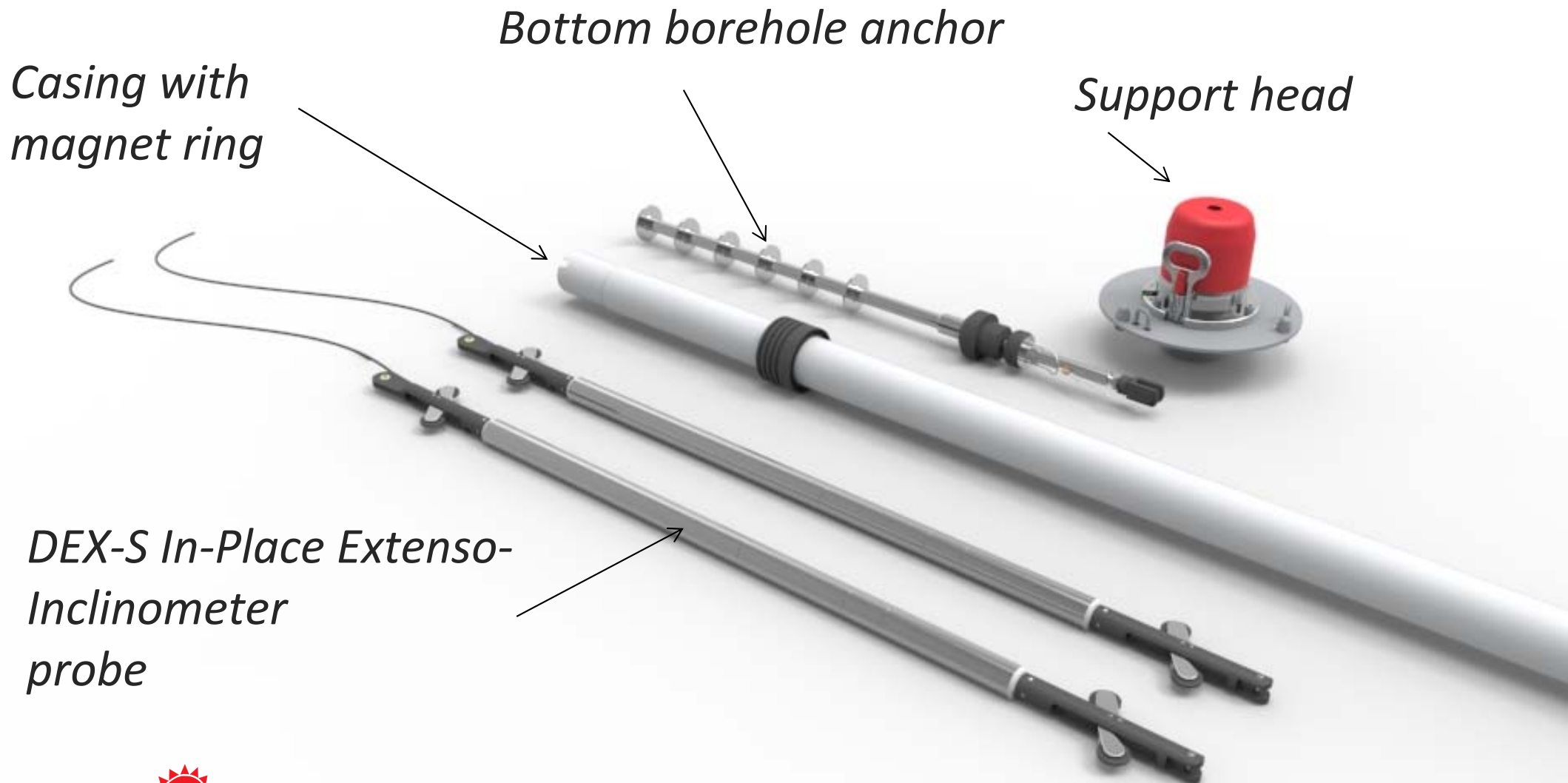
*Removable
MEMS
inclinometer*



*T-REX
incremental
extensometer*

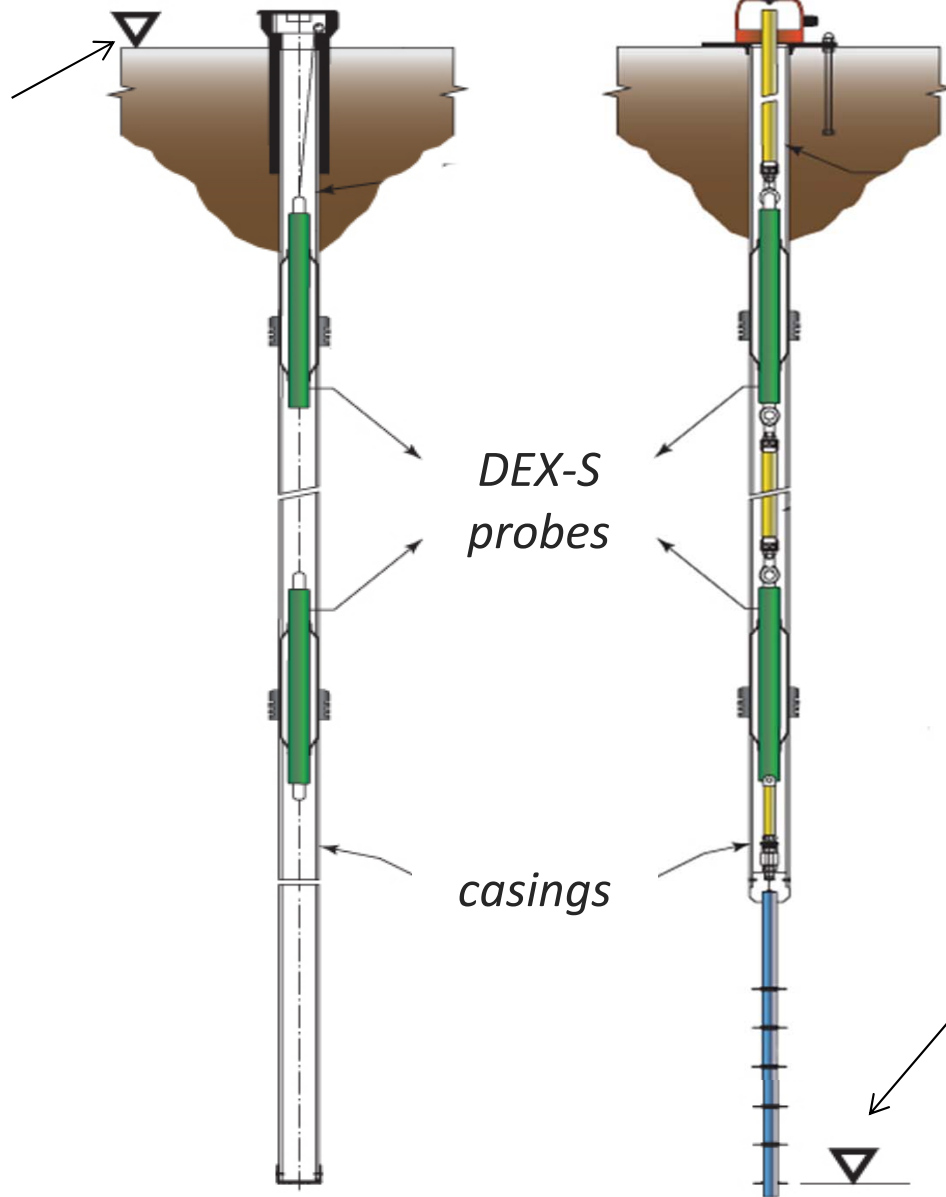


__ EXTENSO-INCLINOMETER – AUTOMATIC MONITORING:
DEX-S IN-PLACE EXTENSO INCLINOMETER



__ DEX-S IN-PLACE EXTENSO-INCLINOMETERS

*DEX-S chain
with upper
reference
(hanging from
the top)*



*DEX-S
probes*

casings

*DEX-S chain
with lower reference
(stiff chain connected
to the bottom
anchor)*

— EXTENSO-INCLINOMETER COLUMN

DEX-S probes allow:

- 3D monitoring*
- High accuracy*
- Removable probes for re-installation at different locations and maintenance (if needed)*
- Real-time monitoring in unattended location*

__ WIRE EXTENSOMETER



Piezometer



Multipoint piezometer



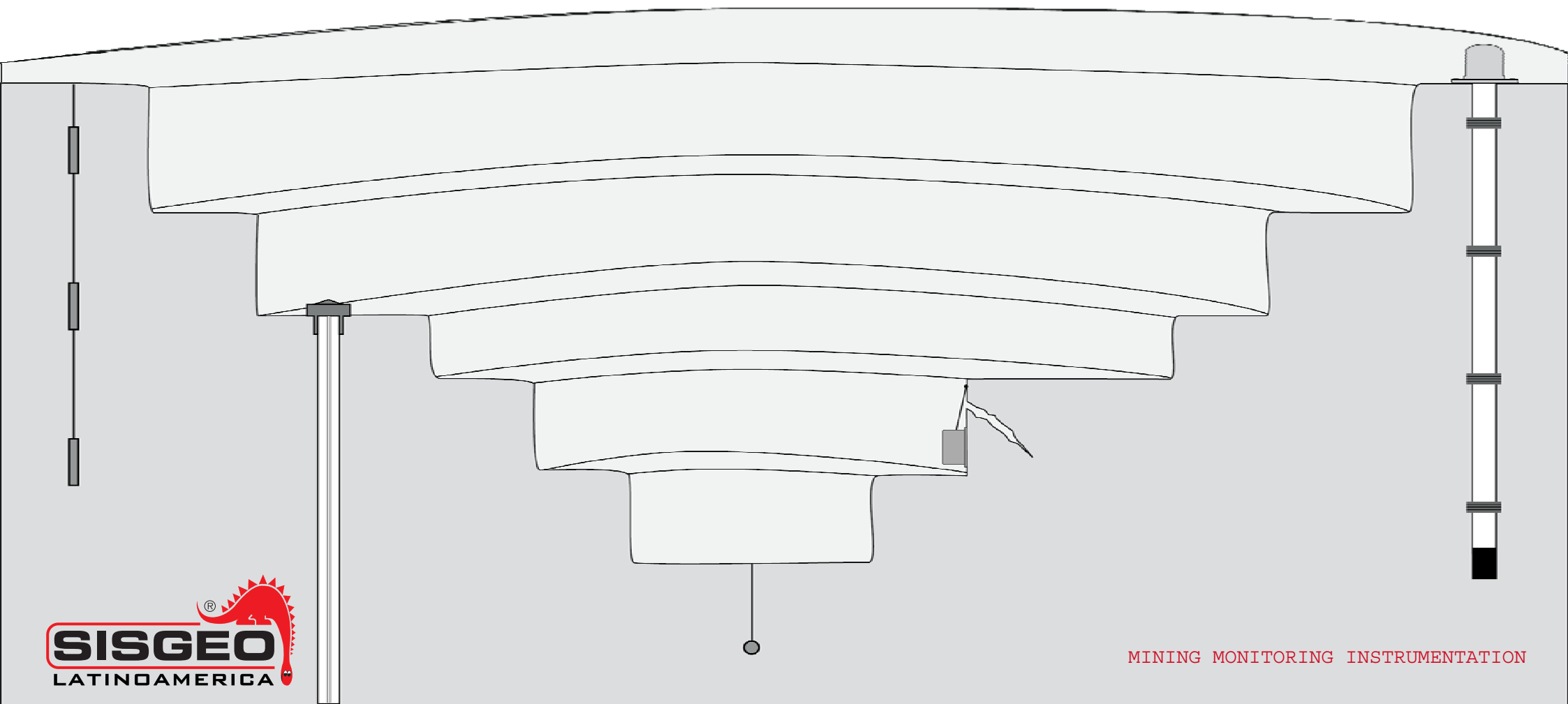
Inclinometer casing



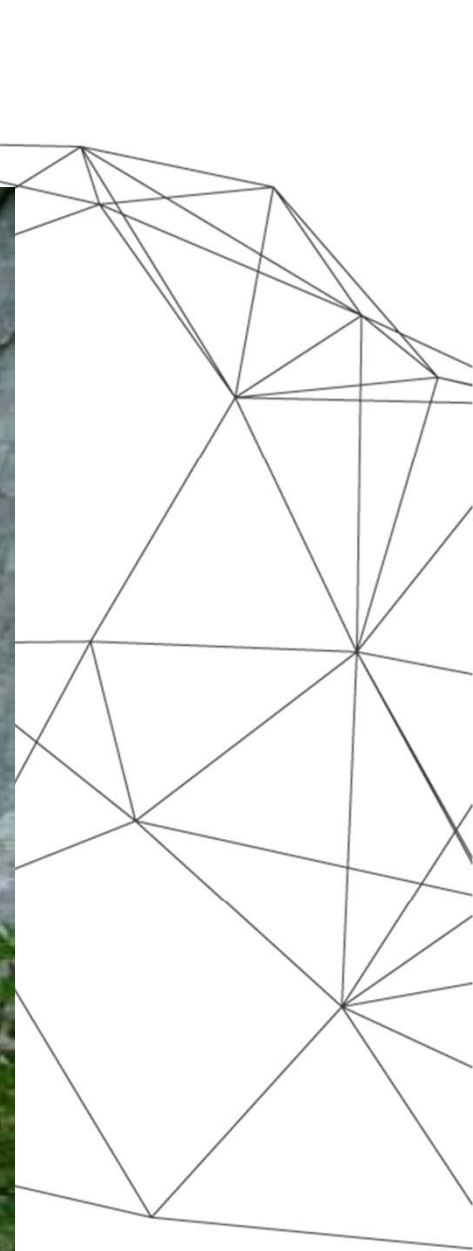
Extenso-inclinometer casing



Wire extensometer



__ WIRE CRACKMETER ON TOPPLE LANDSLIDE



__ UNDERGROUND MINE



__ UNDERGROUND MINE



MEXID miniaturized MPBXs



Anchor load cells



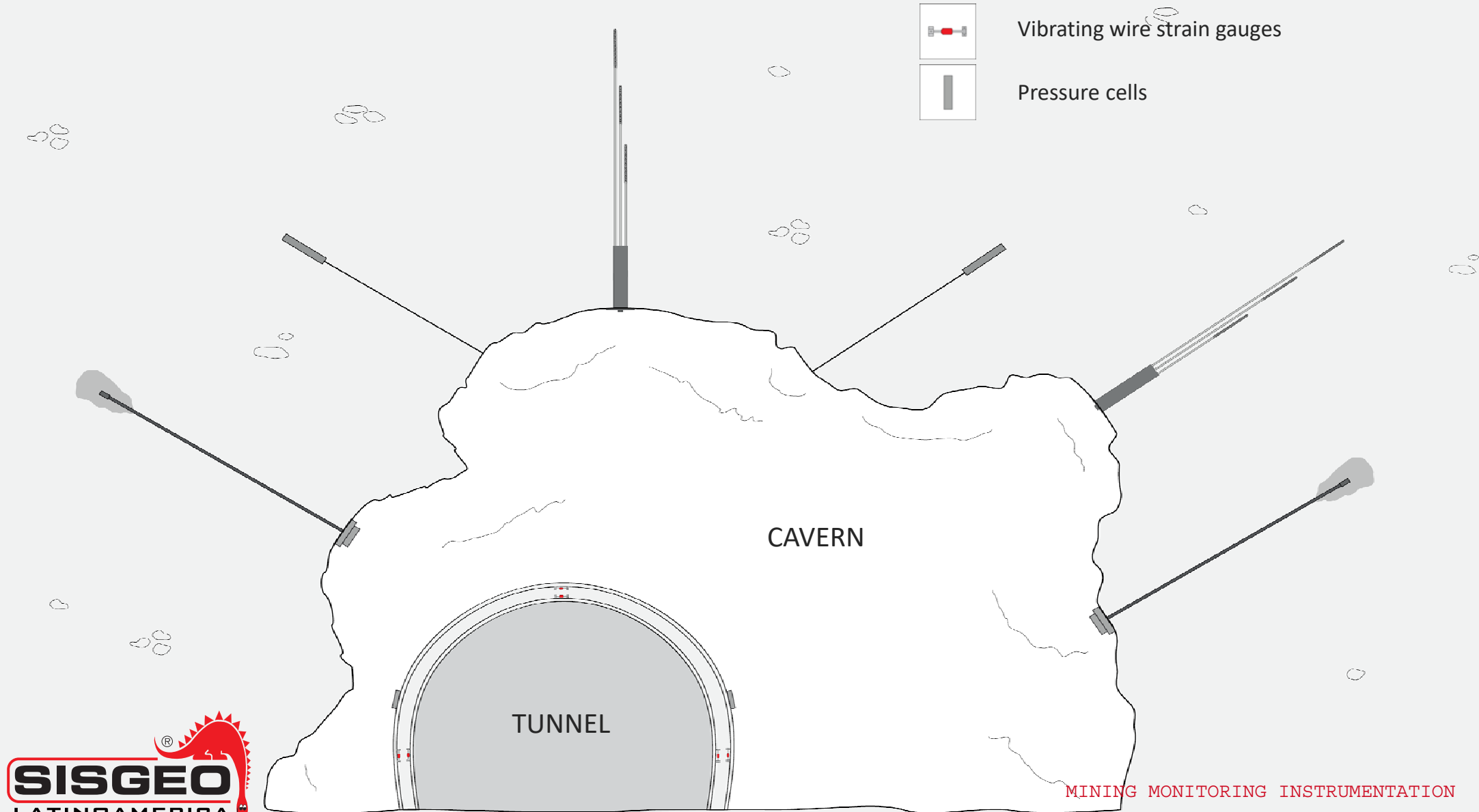
Piezometers



Vibrating wire strain gauges



Pressure cells



__ MEXID MINIATURIZED MPBX



MEXID miniaturized MPBXs



Anchor load cells



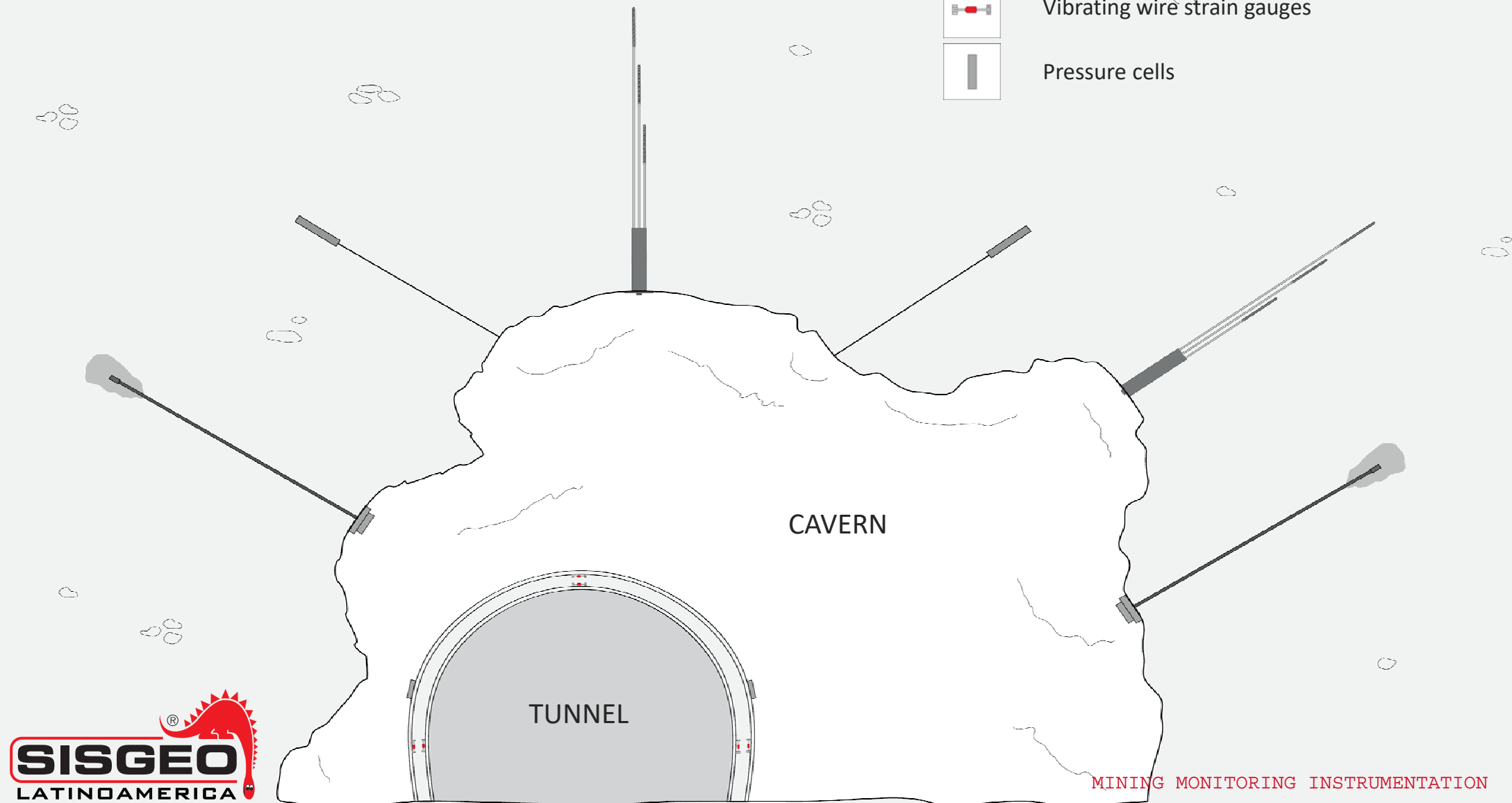
Piezometers



Vibrating wire strain gauges

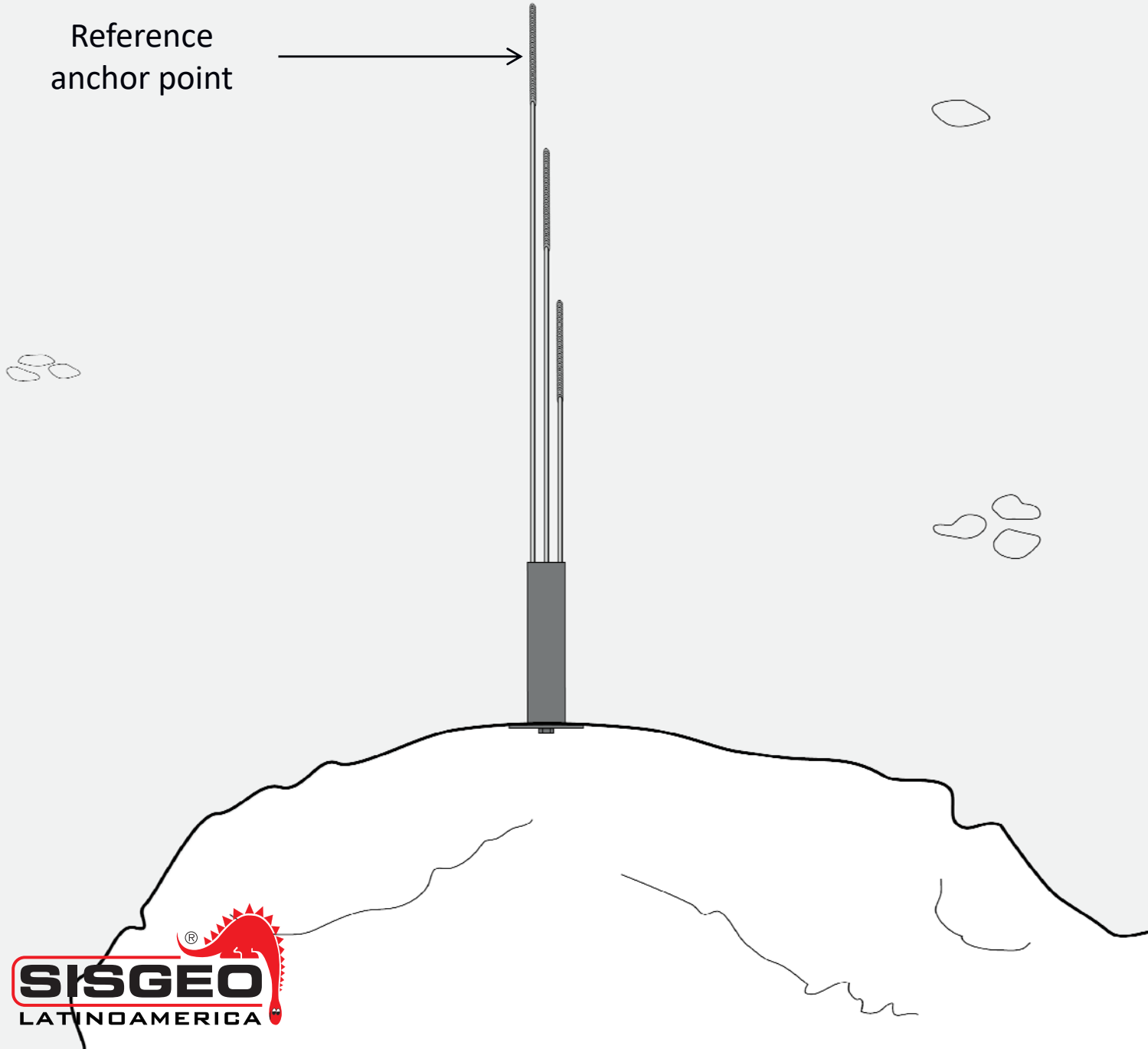
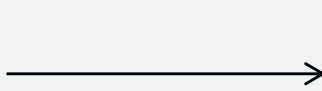


Pressure cells



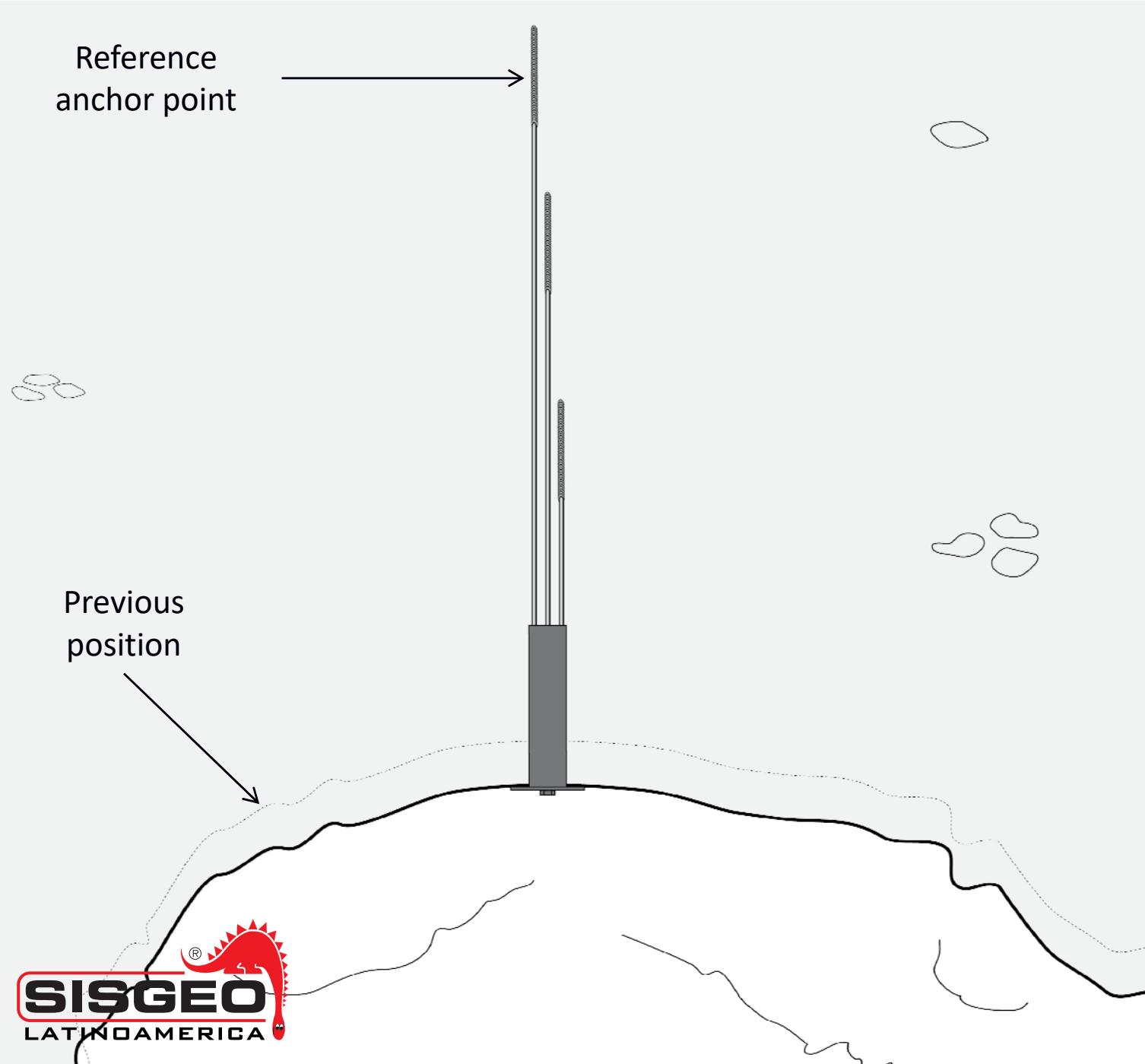
__ MEXID MINIATURIZED MPBX – HOW IT WORKS

Reference
anchor point



*The groutable anchor
installation points
can give information
of internal rock
displacement
at different depths*

__ MEXID MINIATURIZED MPBX – HOW IT WORKS



The groutable anchor installation points can give information of internal rock displacement at different depths

— MEXID MINIATURIZED MPBX

*Installation of MEXID
extensometer
into the cavern's ceiling*

— MEXID MINIATURIZED MPBX



*MEXID extensometer
after installation:
flush-mount
→ maximum clearance*

__ ANCHOR LOAD CELL



MEXID miniaturized MPBXs



Anchor load cells



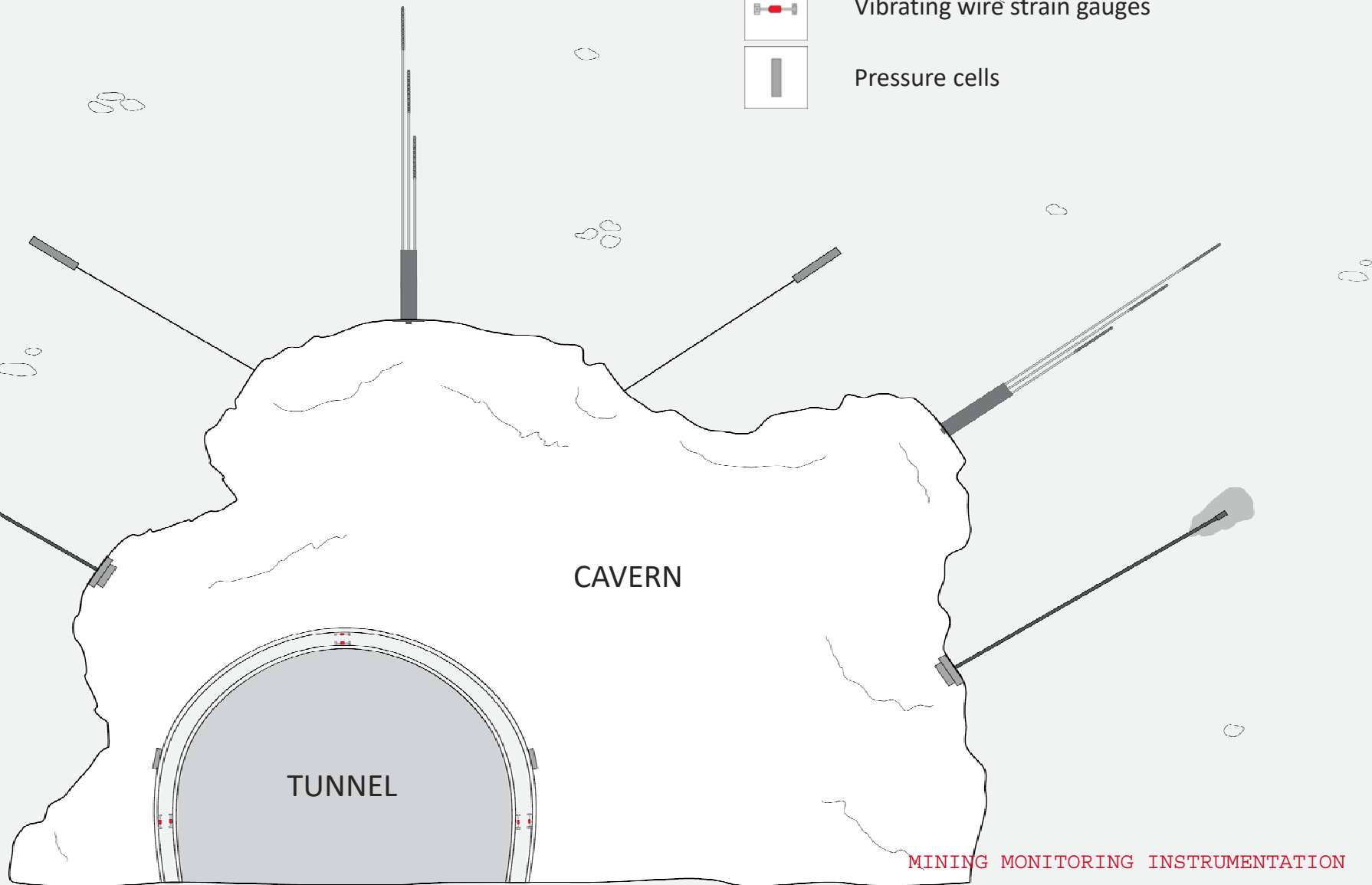
Piezometers



Vibrating wire strain gauges



Pressure cells



__ ANCHOR LOAD CELLS IN CHUQUICAMATA MINE (CHILE)



__ PIEZOMETERS



MEXID miniaturized MPBXs



Anchor load cells



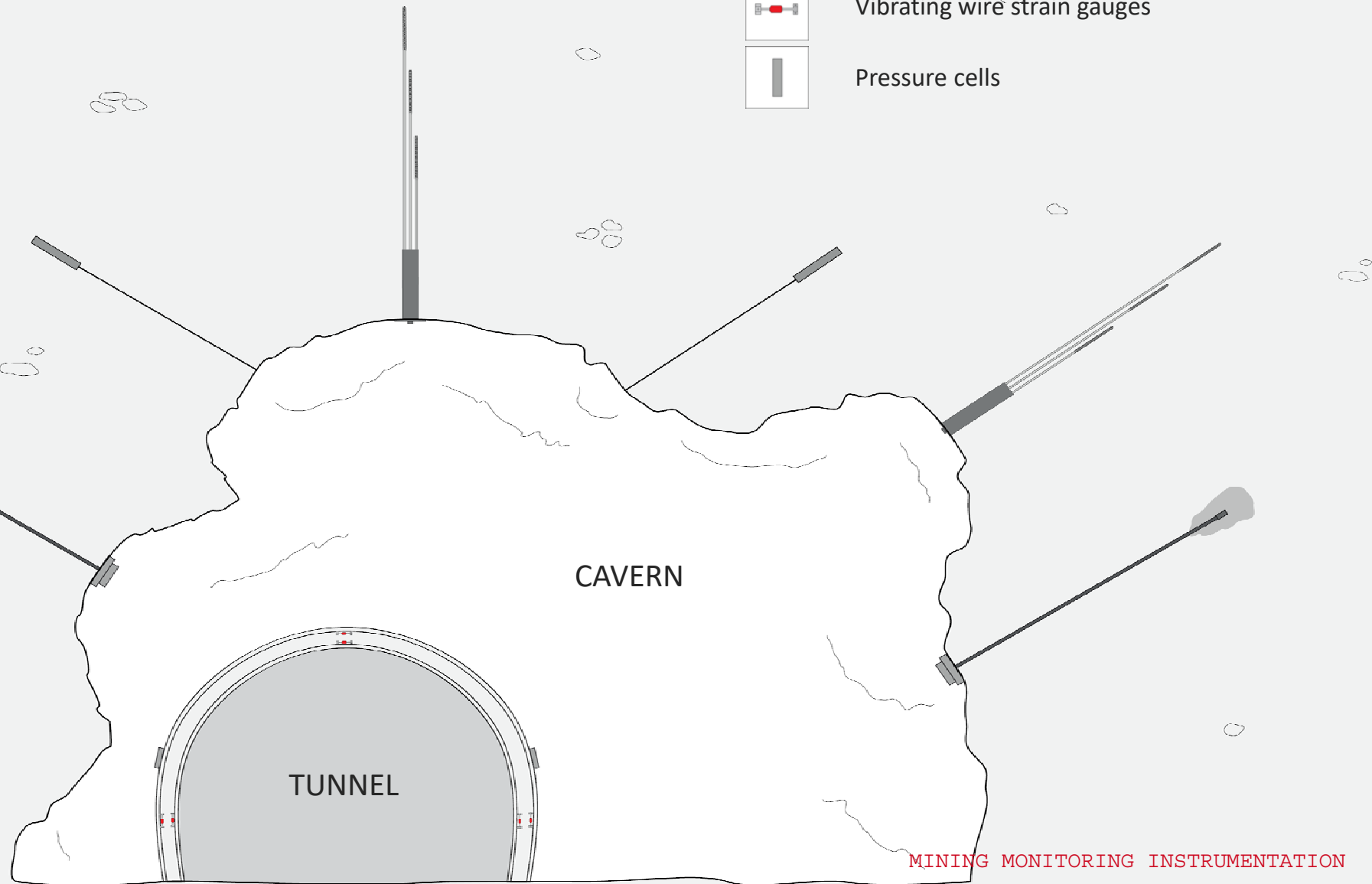
Piezometers



Vibrating wire strain gauges



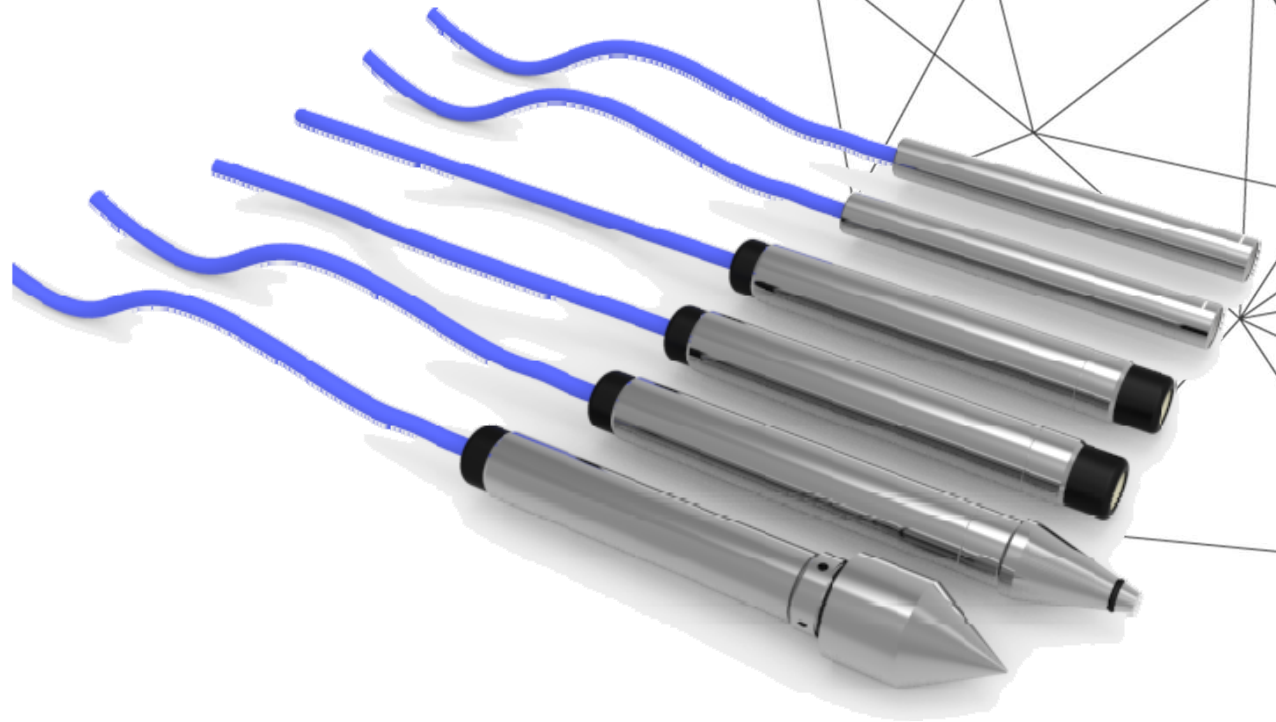
Pressure cells



— PIEZOMETERS FOR PORE PRESSURE

Purpose:

- *Pore pressure monitoring*



__ VW STRAIN GAUGES



MEXID miniaturized MPBXs



Anchor load cells



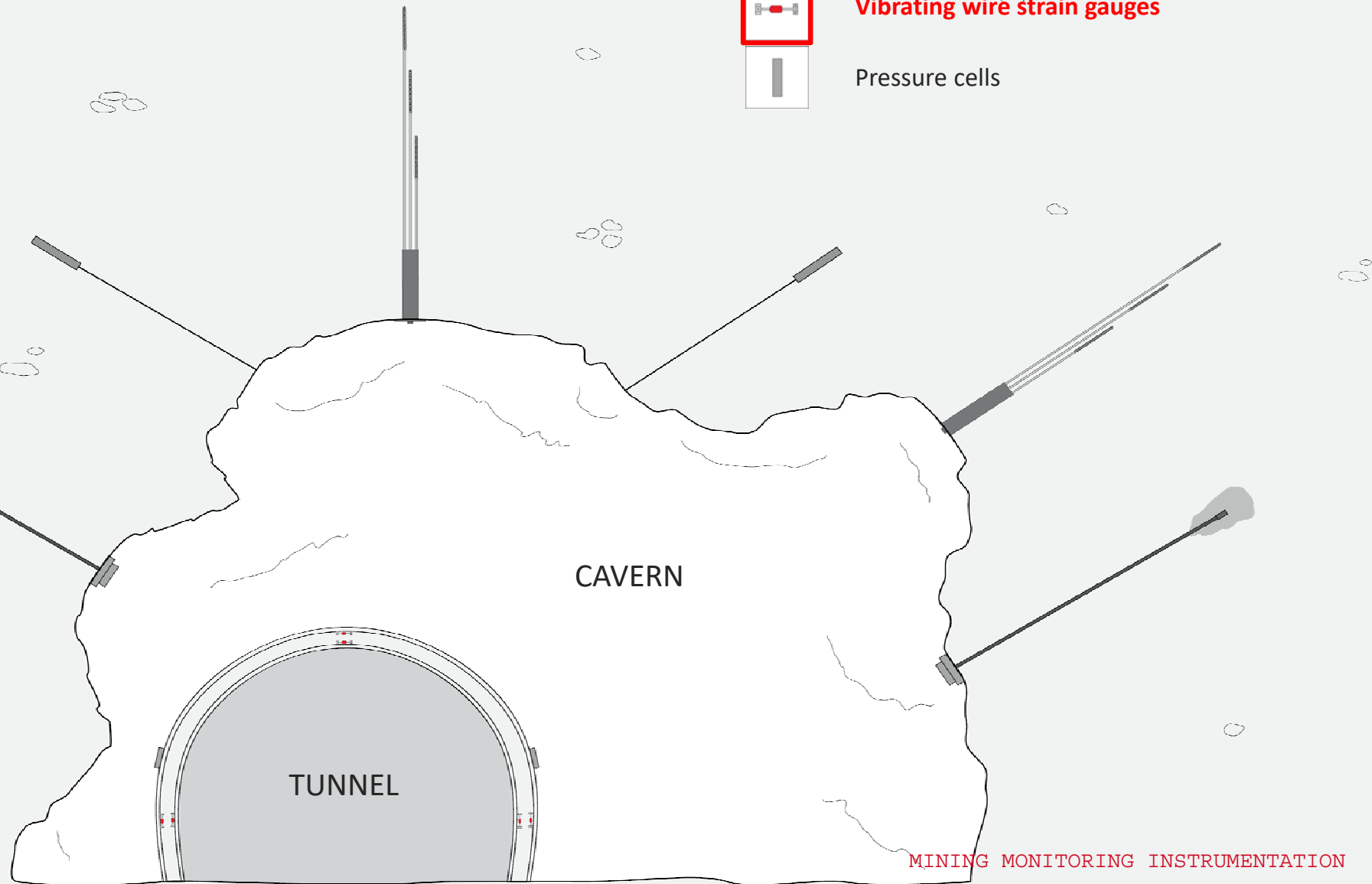
Piezometers



Vibrating wire strain gauges



Pressure cells



— VW STRAIN GAUGES



MEXID miniaturized MPBXs



Anchor load cells



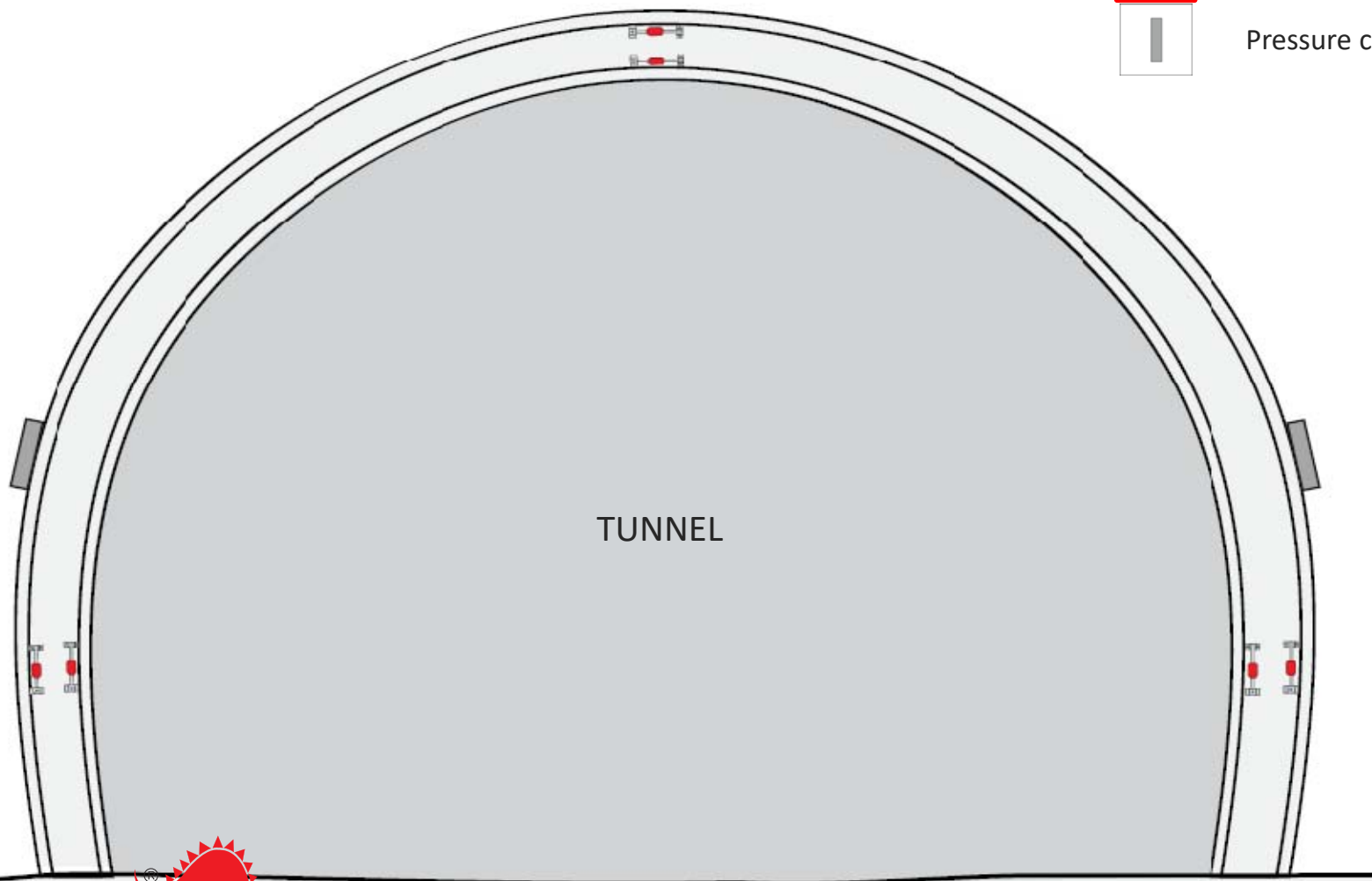
Piezometers



Vibrating wire strain gauges



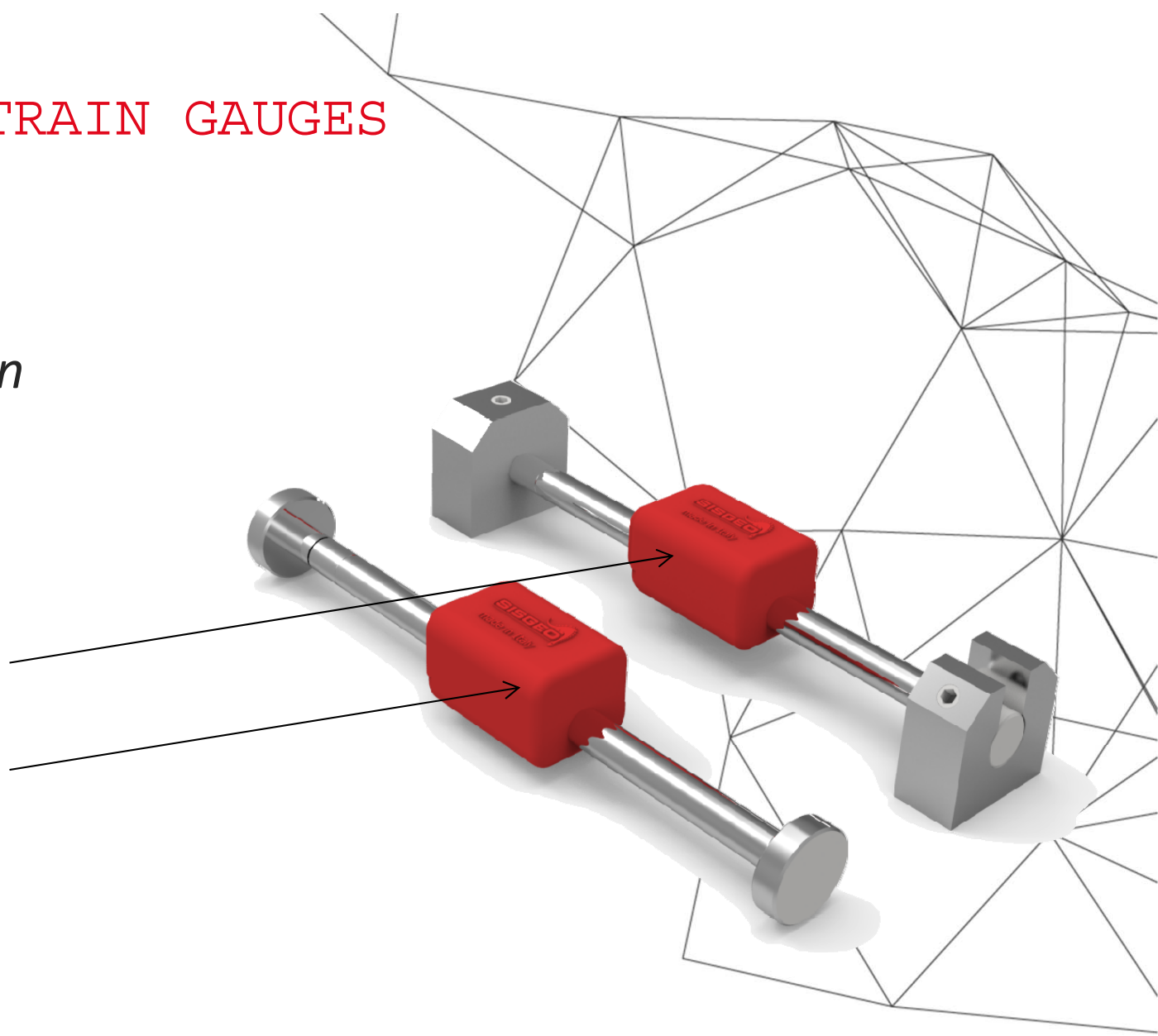
Pressure cells



— VIBRATING WIRE STRAIN GAUGES

Stress monitoring into concrete structures or on metal supports.

- *Arc-weldable model*
- *Embedment model*



__ ARC-WELDABLE VIBRATING WIRE STRAIN GAUGES



*Arc-weldable
VW strain gauges
on steel lining*

__ EMBEDMENT VIBRATING WIRE STRAIN GAUGE



__ PRESSURE CELLS



MEXID miniaturized MPBXs



Anchor load cells



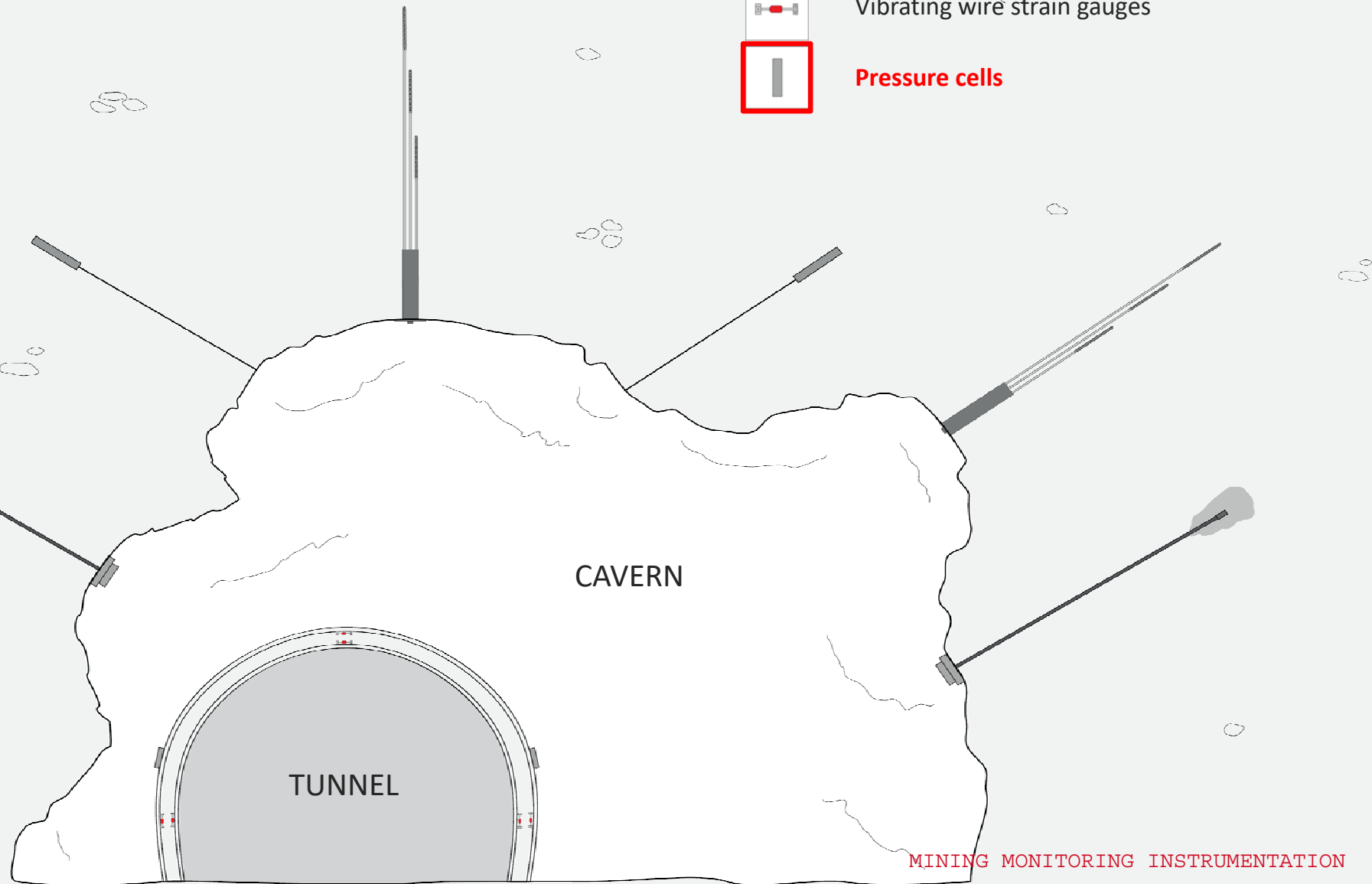
Piezometers



Vibrating wire strain gauges



Pressure cells



— PRESSURE CELLS



MEXID miniaturized MPBXs



Anchor load cells



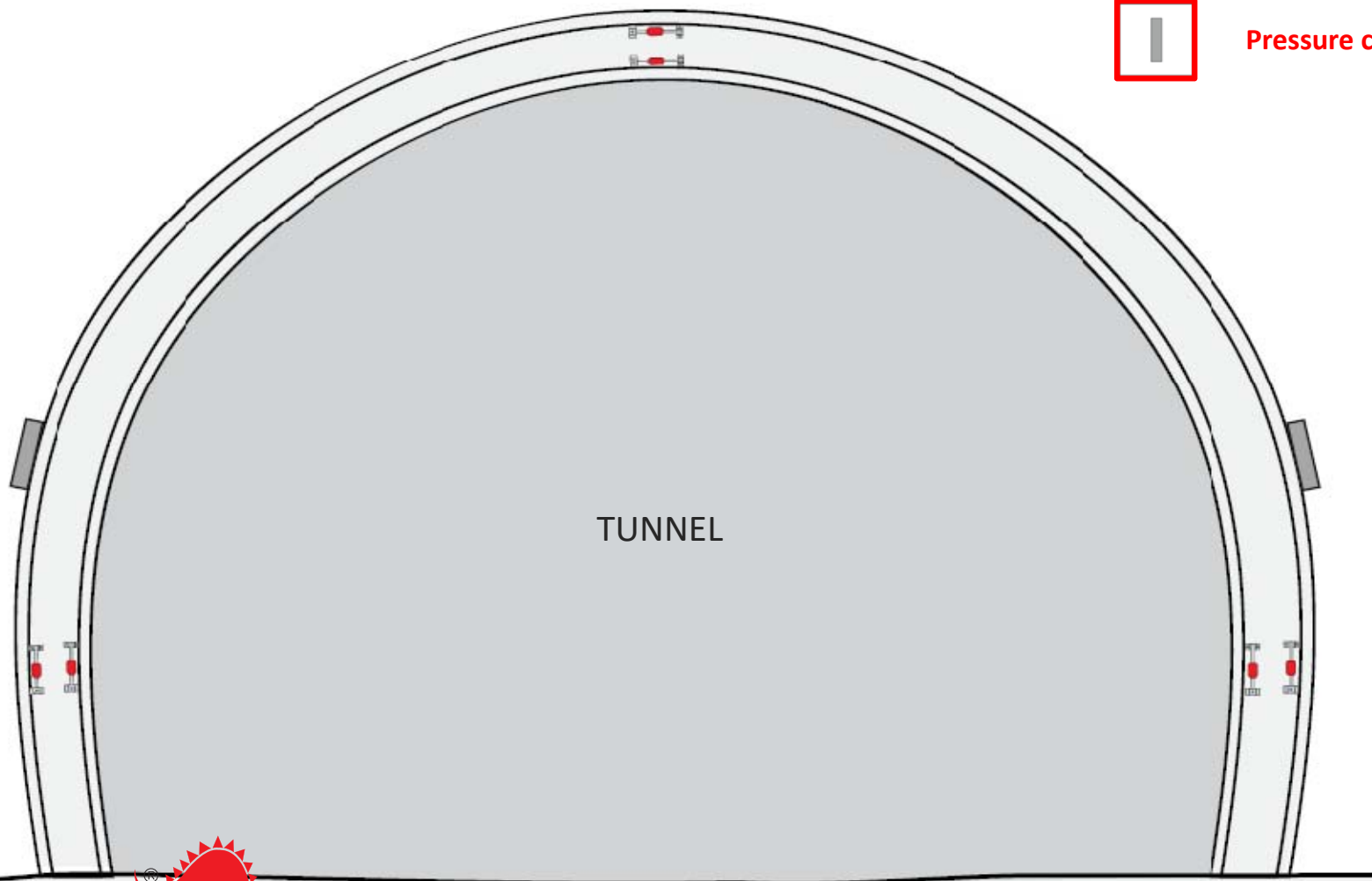
Piezometers



Vibrating wire strain gauges

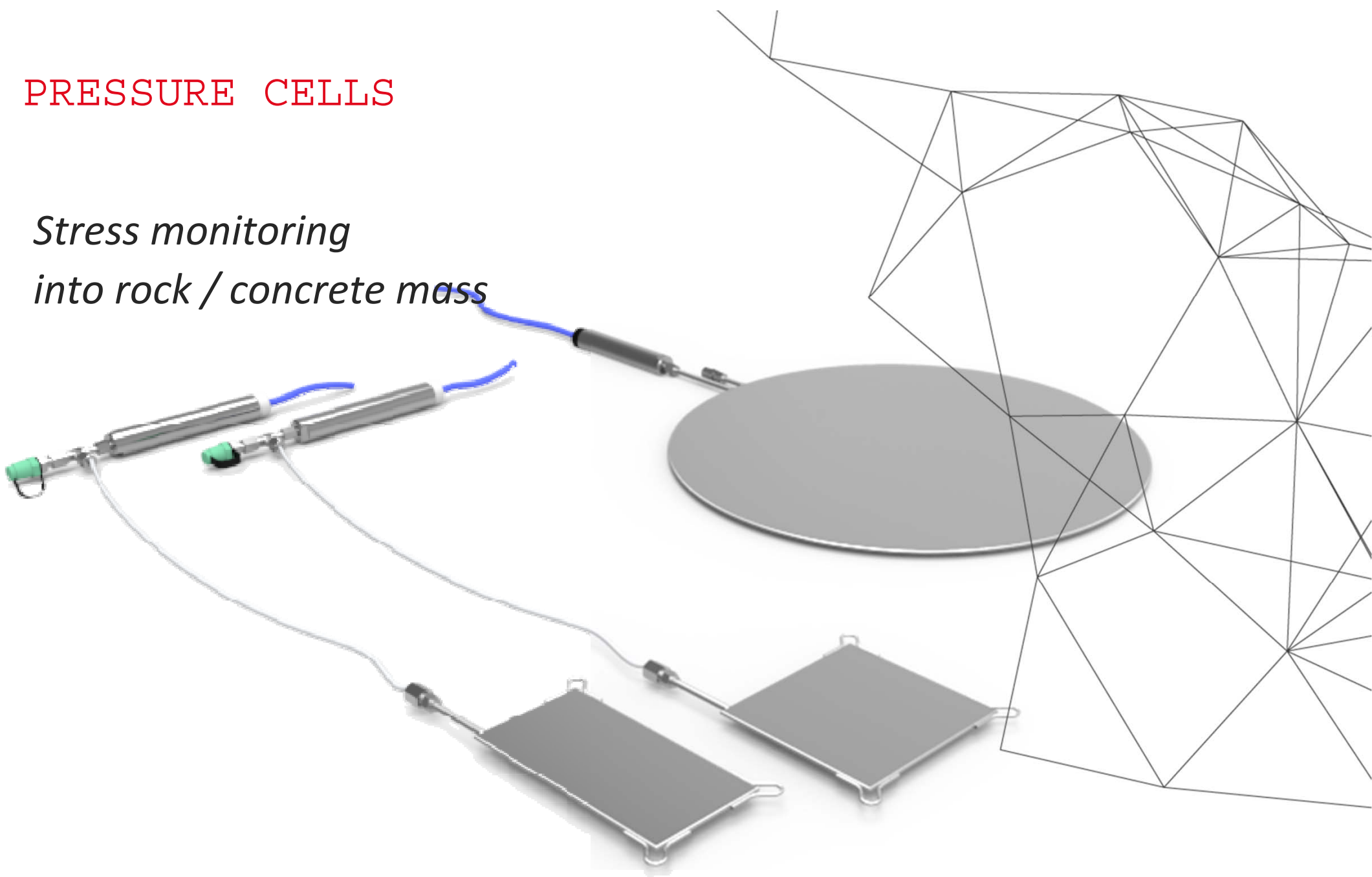


Pressure cells



— PRESSURE CELLS

*Stress monitoring
into rock / concrete mass*



— PRESSURE CELLS



__ TAILINGS (MINE WASTE REPOSITORY)



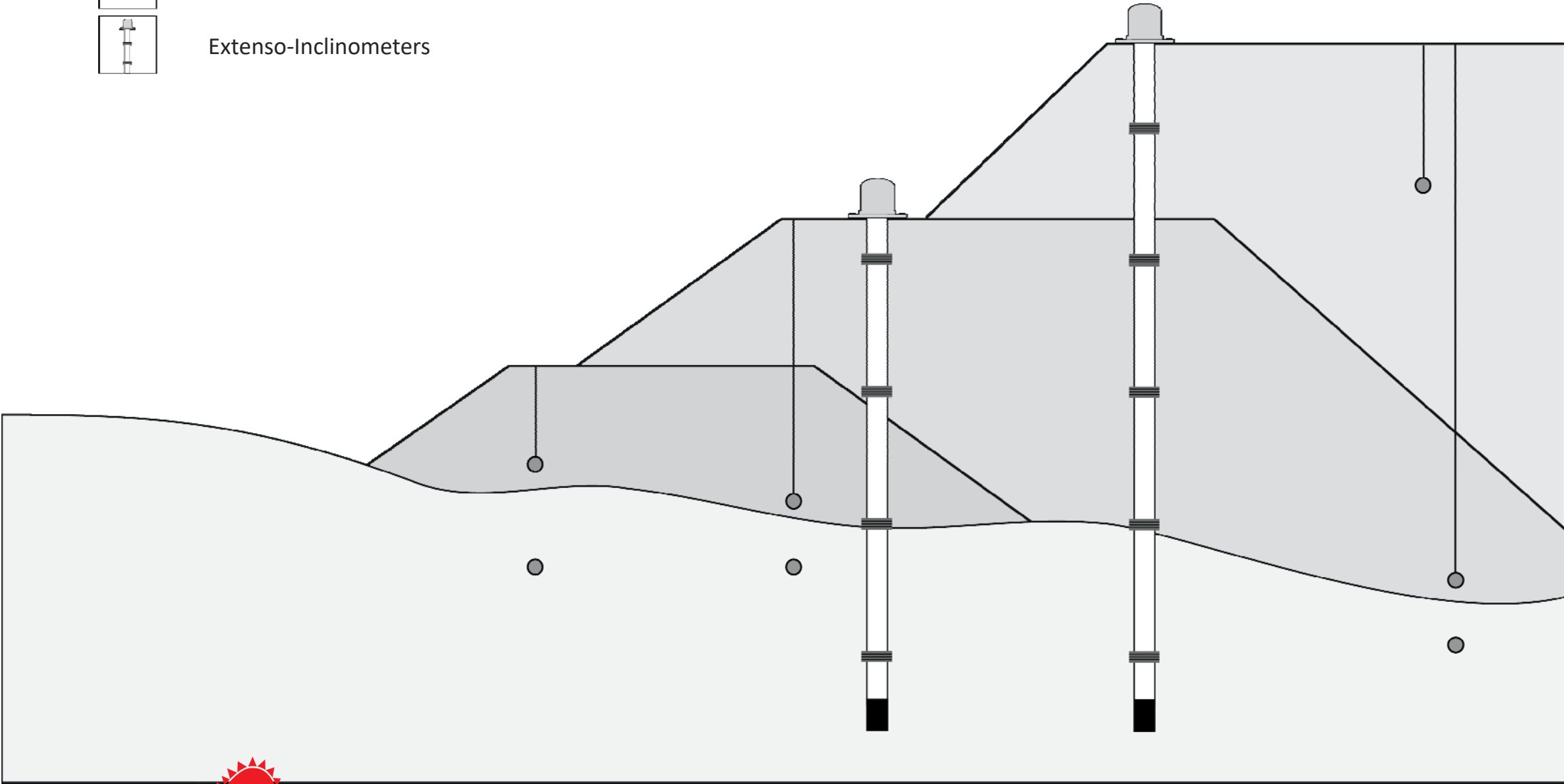
__ TAILING (MINE WASTE REPOSITORY)



Titanium Piezometers (pore pressure)



Extenso-Inclinometers



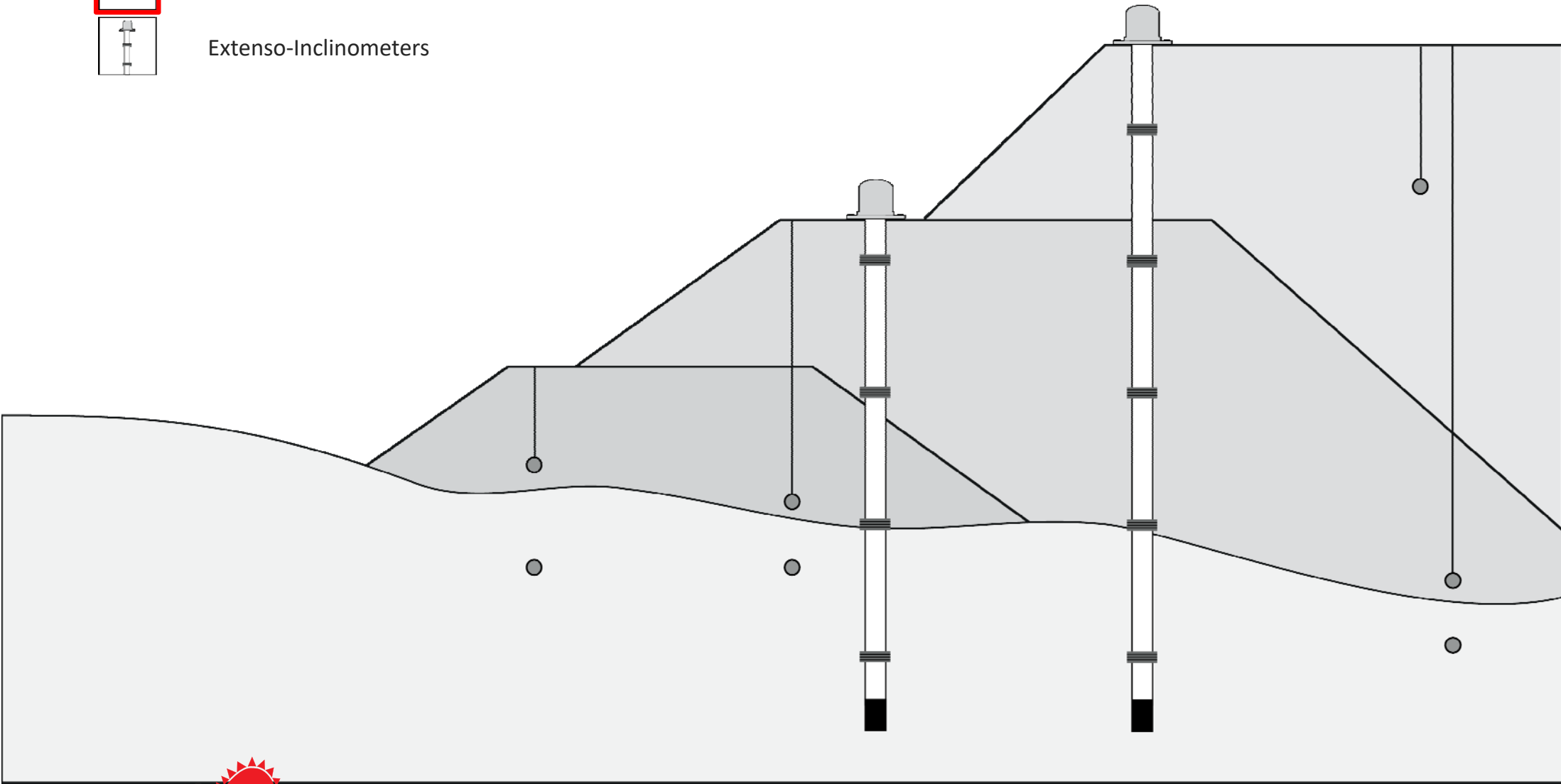
— TITANIUM PIEZOMETERS



Titanium Piezometers (pore pressure)



Extenso-Inclinometers

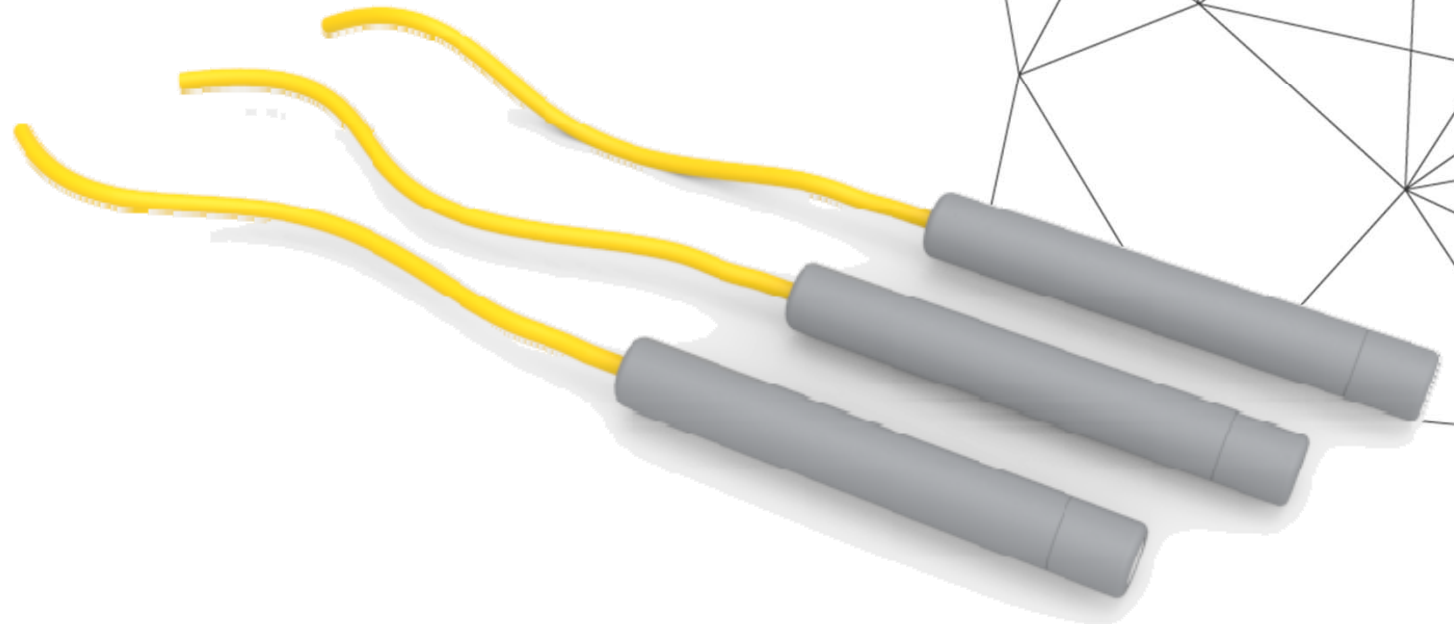


__ TITANIUM PIEZOMETERS FOR PORE PRESSURE

Purpose:

- *Pore pressure monitoring.*

They are designed for installation in highly corrosive environments and aggressive soils (up to pH = 1 @ 20°C)



__ TITANIUM PIEZOMETERS FOR PORE PRESSURE



*Installation of
titanium
piezometer under
waste repository
(before
construction)*

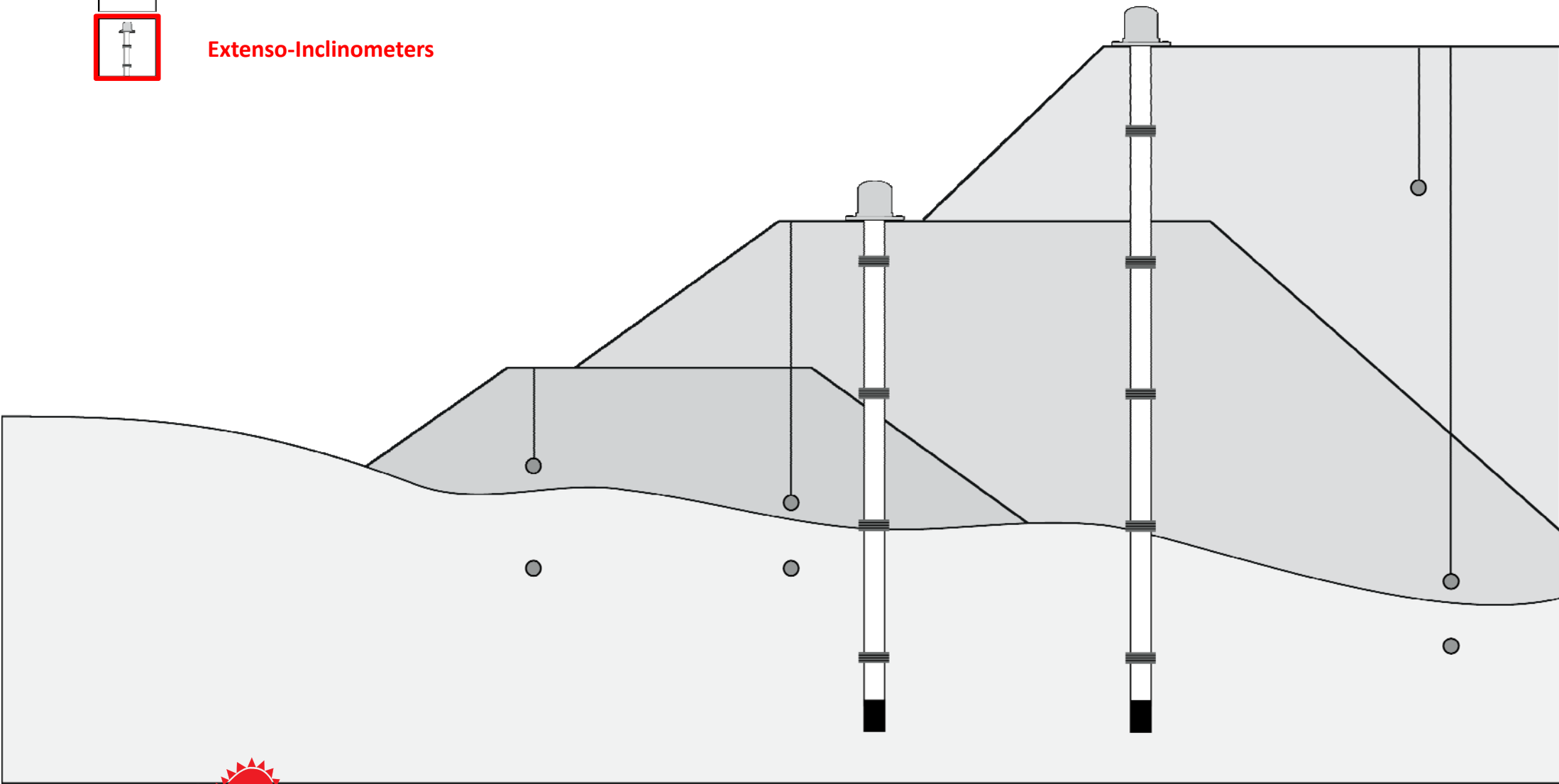
— EXTENSO-INCLINOMETERS



Titanium Piezometers (pore pressure)



Extenso-Inclinometers



__ EXTENSO-INCLINOMETER - MANUAL READINGS



*Removable
MEMS
inclinometer*

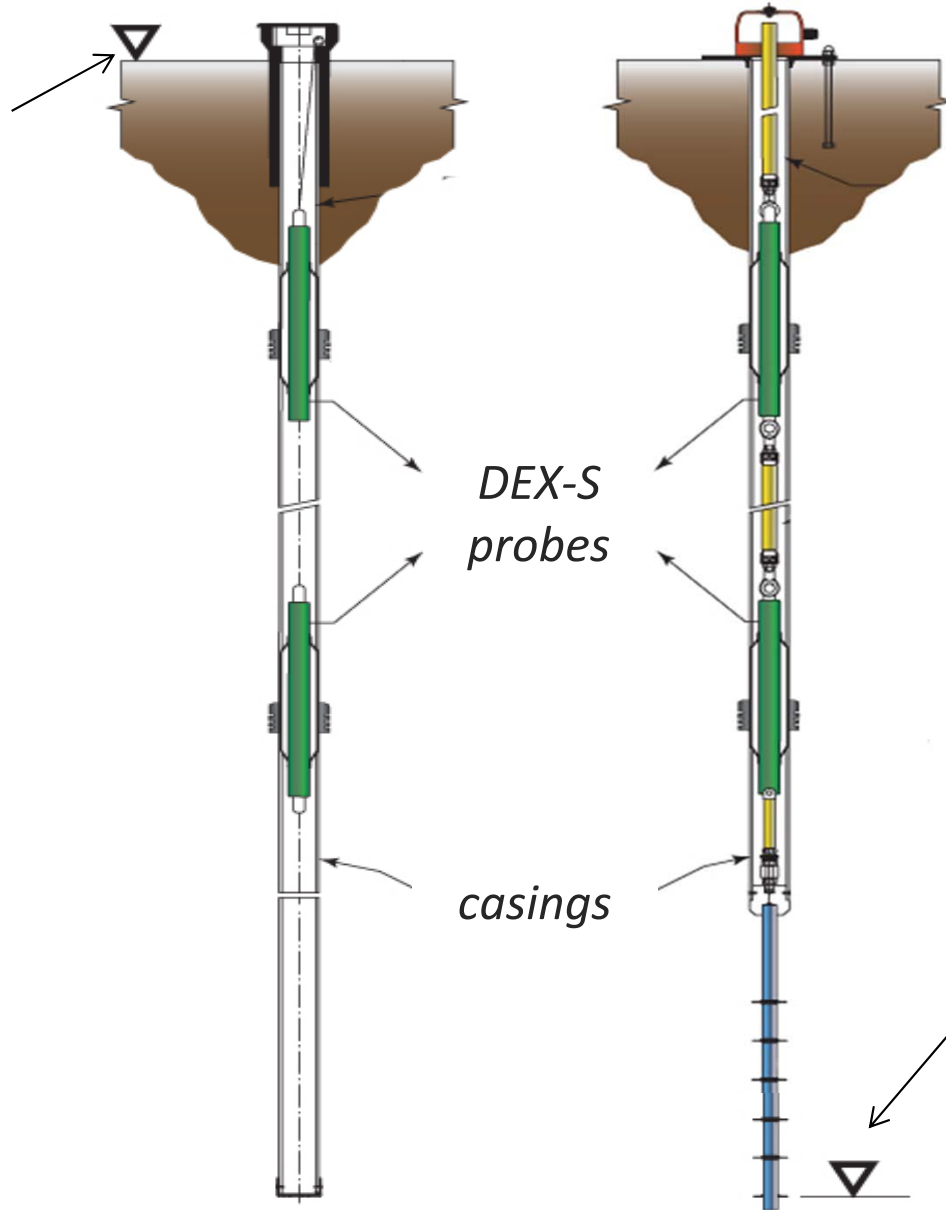


*T-REX
incremental
extensometer*



__ DEX-S IN-PLACE EXTENSO-INCLINOMETERS

*DEX-S chain
with upper
reference
(hanging from
the top)*



*DEX-S
probes*

casings

*DEX-S chain
with lower reference
(stiff chain connected
to the bottom
anchor)*

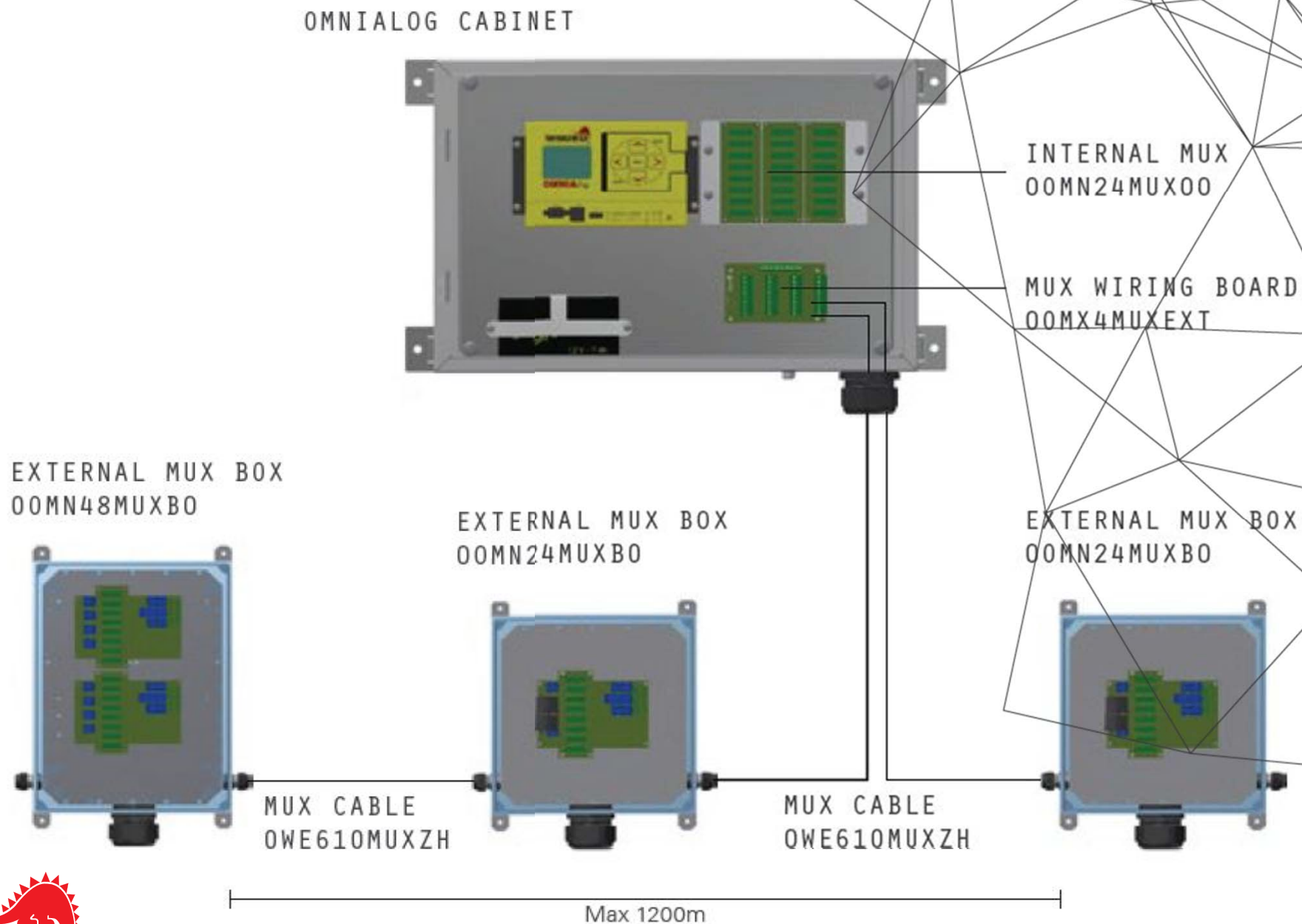
__ MINE MONITORING: DATA ACQUISITION SYSTEM

Instruments installed for mine monitoring provide automatic real-time monitoring by means of OMNIAlog datalogger.

OMNIAlog have a standard LAN port that can be connected i.e. to an industrial fiber optic interface or a GPRS modem allowing remote system management, data pushing on a server and alarms.



__ OMNIALOG DATALOGGER: EXTERNAL MULTIPLEXER



__ OMNIALOG IN PASCUA LAMA MINE - ARGENTINA





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