

THE TRILLIUM SERIES OF SEISMOMETERS



Trillium



nanometrics

TRILLIUM SEISMOMETERS

The Trillium product family offers the highest performance seismometers to hazard monitoring organizations and geophysics institutes to capture the highest fidelity ground motion waveforms. It features a broad range of seismometer performance and form factors to optimize seismic station designs based on the required bandwidth and magnitude of completeness while considering the limitations of the site noise and the physical constraints of the installation.



Exceptional Performance and Easy to Use

- A flat response to velocity with an exceptionally low self-noise maximizes the dynamic range over the passband and provides a more reliable data output
- Low size, weight and power (SWaP) designs to reduce station power systems and corresponding deployment logistics
- Robust designs that are resistant to harsh environments and immersible to extended depths
- Simplified workflow inherent in all seismometers with no-mass-lock design and automatic mass centering and leveling
- Easy leveling checks during or post deployment using the digital bubble level accessible from the connected Pegasus or Centaur dataloggers
- Control lines and serial communication options provide the ability to mass center and control the operating modes of the seismometer

Superior Technology

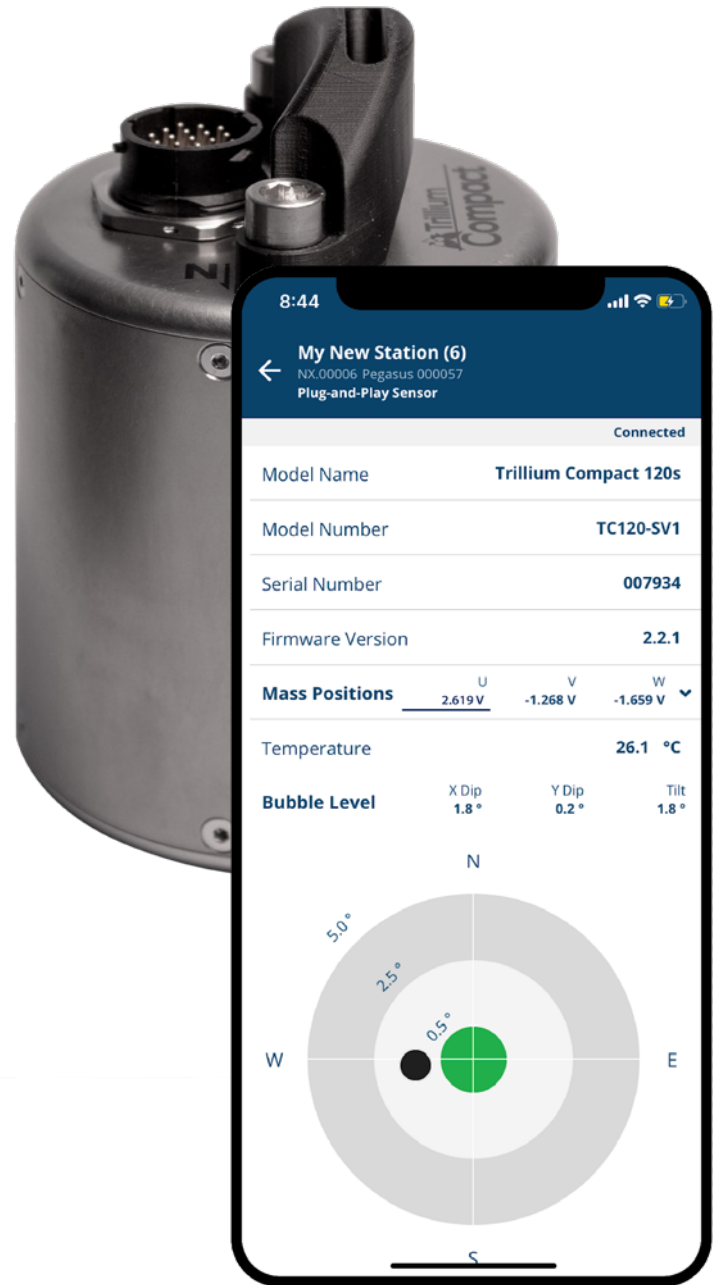
All Trillium seismometer designs provide the following unique benefits:

- Ultra-low power consumption
- High shock and vibration resistance with no-mass-lock operation
- Matched responses to nominal from axes to axes and seismometer to seismometer as they are constructed identically, including precision machining and trimming of electronics values.
- Low sensitivity to both tilt and temperature means that seismometers rarely require mass centering after the initial installation
- Higher performance in smaller packages
- More easily distinguish external noise sources from internal ones (due to symmetric triaxial arrangement of the sensing elements)
- Mass centering does not compromise mutual orthogonality of the three axes

SEISMOMETER PERFORMANCE

The Trillium seismometers are available in intermediate band, broadband, and very broadband frequency ranges for monitoring use cases in local, regional, and teleseismic seismological networks.

- **Trillium Compact 20/120:** provides excellent self-noise performance and a higher clip level in a small form factor for local or regional monitoring use cases where the site noise may be elevated or where there may be stronger events
- **Trillium 120:** a very broadband seismometer ideal for local, regional and teleseismic studies, having a response flat to velocity from 120 seconds to 150 Hz and low self-noise
- **Trillium 360:** an exceptionally low self-noise seismometer with a response flat to velocity from 360 seconds to 136 Hz. Available in Horizon and OBS form factors
- **Trillium 360 GSN:** the only available seismometer that meets the USGS Class A+ requirements with a self noise below the NLNM

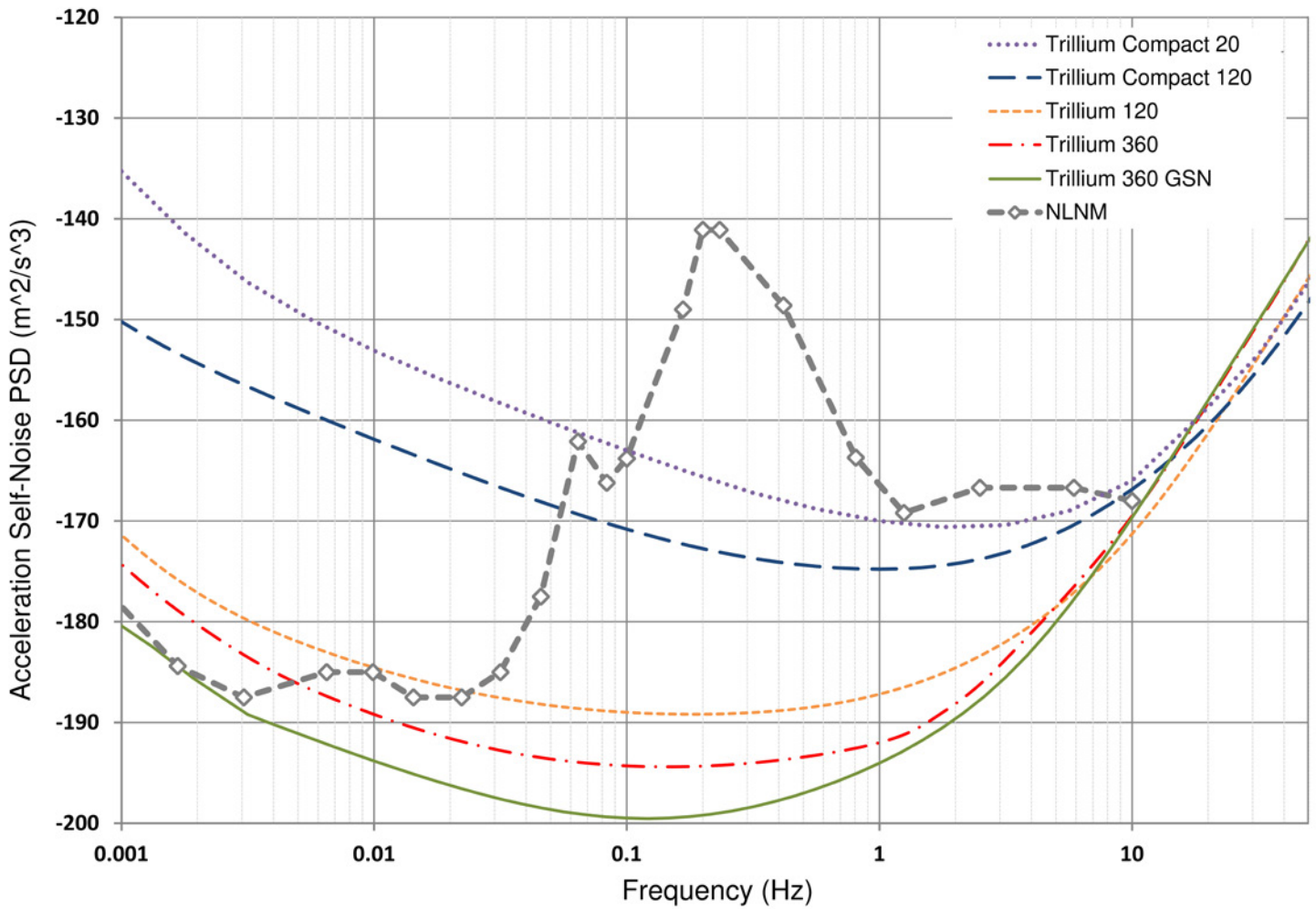


Pegasus Mobile App showing the seismometer metadata, state-of-health information and digital level bubble.

The following table summarizes key performance parameters for the different classes of Trillium seismometers:

Parameter	Compact 20	Compact 120	Trillium 120	Trillium 360	Trillium 360 GSN
Lower Corner Frequency	20s	120s	120s	360s	360s
Nominal Clip Level	26 mm/s	26 mm/s	16.6 mm/s	10 mm/s	10 mm/s
Nominal Sensitivity	750 V-s/m	750 V-s/m	1200 V-s/m	2000 V-s/m	2000 V-s/m

SEISMOMETER SELF NOISE



The seismometer self noise chart shows the progressively lower self-noise of the seismometers from the Trillium Compact 20 to Trillium 360 GSN



FORM FACTORS

Many seismometer form factors are offered, allowing you to select the installation method (ocean bottom, vault, direct burial, sand install in a cased hole, or locked in a cased hole) that will provide the optimal performance when considering the deployment constraints such as physical location, deployment logistics, and costs.

Ocean Bottom Seismometers (OBS)

OBS seismometers incorporate a robust and reliable leveling gimbal to auto-level from orientations of $\pm 50^\circ$ to $\pm 360^\circ$ depending on the model. Robust enclosures and proven marine connectors ensure exceptional ruggedness and resistance to corrosion in marine and freshwater environments. Our Trillium OBS seismometers are optimized for use with our purpose-built Pegasus OBS digital recorder, providing a low-power system for integration into any OBS system or as part of our turnkey Abalones¹ Ocean Bottom System.

1. Abalones is licensed from Scripps Institution of Oceanography.

Vault

Vault seismometers are well suited for installations at or below the surface where vault and seismic pier infrastructure exists or can be constructed. These form factors perform best when they are well sealed and insulated from air currents and temperature change due to the weather.

Horizon

The Horizon form factors are exceptionally versatile as they can be deployed in both shallow direct burial and vault applications, where minimal size, weight and power are essential. These ultra-portable seismometers are ideal for instrument pools as they allow for a smaller financial investment and need less storage space than is required when purchasing both vault and direct-bury instruments.

Posthole (PH)

Posthole seismometers are optimized for quiet down-hole deployments to benefit from the seismometer's exceptional self-noise. The waterproof stainless steel enclosure and high pressure marine grade connector ensures that the seismometers are protected from harsh environments making them suitable for a range of buried and cased installations. When installation at the bottom of a cased hole is not possible, for some PH models, a holelock accessory is available to lock the seismometer at a specific depth.

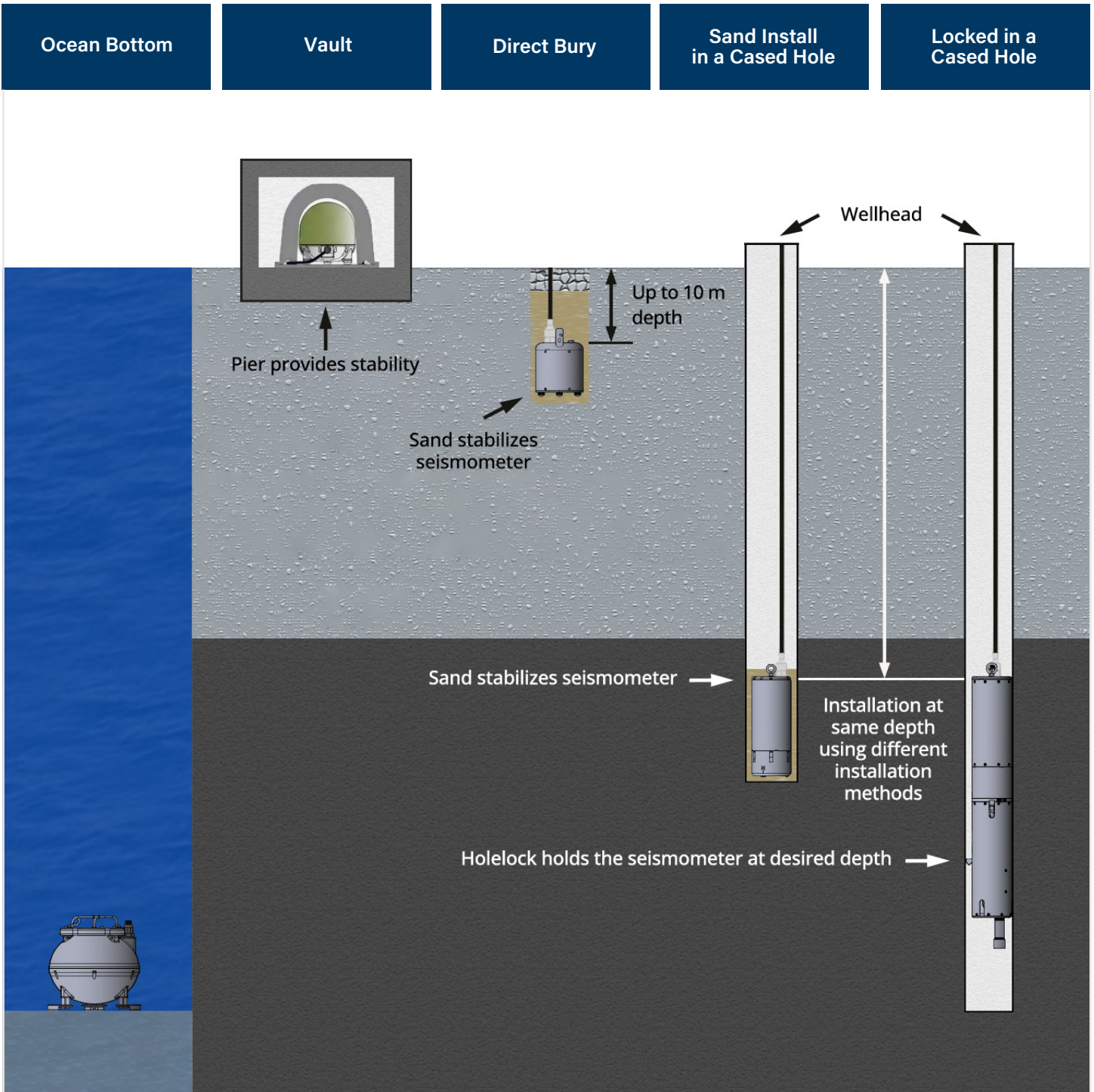
Borehole (BH)

These seismometers have an integrated robust holelock mechanism which makes it possible to position the instrument at a specific depth for quiet down-hole installations that can take advantage of the observatory class performance. This may be required if a casing bottom is not sealed and may be susceptible to flooding, or if a sand install is not possible when the casing depth exceeds the desired depth of installation.




INSTALLATION ENVIRONMENT

The following diagram illustrates the various installation methods. As part of the installation, it is important to consider the immersion specification of the seismometer and the operational tilt range if a level installation cannot be guaranteed or if there is a susceptibility to settling over time (see detailed seismometer specifications).



TRILLIUM COMPACT

The Trillium Compact is an extremely simple to deploy seismometer with no mass lock and no mass centering required. The exceptionally small size significantly reduces the time and effort required for site preparation and installation. Available with lower corner frequencies of either 20 seconds or 120 seconds, both boast ultra-low power consumption at 195 mW and 180 mW respectively.

Ocean Bottom	Vault	Direct Bury	Sand Install in a Cased Hole	Locked in a Cased Hole
 <p>Trillium Compact OBS¹</p>	 <p>Trillium Compact Horizon</p>		 <p>Trillium Compact PH²</p>	

1. Only Available in 120s configuration

2. Locked in a cased hole requires holelock accessory

Trillium Compact OBS

The Compact OBS will auto-level from any orientation thanks to its precise and reliable leveling gimbal that operates over a full 360° range.

- Titanium pressure vessel for deployments up to 6000 meters
- Aluminum-anodized enamel painted vessel for deployments up to 1800 meters
- Integrated logging of comprehensive state-of-health information for optimizing deployment techniques

Trillium Compact Horizon

The ultra-portable Trillium Compact Horizon is the smallest and lightest model ever produced by Nanometrics.

- Ultra-portable with a weight of just over 1 kg
- Corrosion proof titanium housing that can be shallow buried up to 10 m depth (2 m for polar version)
- Operates even when tilted by $\pm 2.5^\circ$ for 120s and $\pm 10^\circ$ for 20s



Trillium Compact Posthole

The Trillium Compact Posthole features a high pressure stainless steel enclosure and connector for deep deployments in buried or cased hole applications.

- Immersible up to 300 meters
- Operates even when tilted by $\pm 2.5^\circ$ for 120s and $\pm 10^\circ$ for 20s
- Available hole-lock accessory for locking in cased hole

TRILLIUM 120/360

With an extended low frequency bandwidth and noise performance useful out to beyond 1000 s and a wide dynamic range, these observatory-class seismometers are ideal for teleseismic, regional, and local studies. Ultra-low power consumption, 230mW for 120s models and 250 mW for 360s models which corresponds to less than half that of the previous generation.

Ocean Bottom	Vault	Direct Bury	Sand Install in a Cased Hole	Locked in a Cased Hole
 <p>Trillium 120/360 OBS</p>	 <p>Trillium 120/360 Horizon</p>	 <p>Trillium 120 PH</p>	 <p>Trillium 120 Slim PH¹</p>	 <p>Trillium 120 BH</p>

1. Locked in a cased hole requires holelock accessory

Trillium 120/360 OBS

The Trillium 120/360 OBS delivers observatory grade performance with the ease-of-use and durability of our industry-leading land-based Trillium seismometers.

- Robust leveling gimbal that can self-level up to a $\pm 50^\circ$ tilt range
- Titanium ellipsoidal pressure vessel rated for 6000 m deployments
- Robust design does not require a mass lock or gimbal lock providing reliable, trouble-free operation

Trillium Horizon 120/360

This portable, lightweight, and easy-to-deploy seismometer can be buried at shallow depth or set on a pier.

- Stainless steel construction that is resistant to the elements
- Can be shallow buried up to 10 m depth (2 m for polar version)
- Magnetic shield included on T360 models and on Polar models

Trillium 120 PH/BH

The Trillium 120 PH/BH advanced leveling system ensures the axis stack is mechanically leveled to ensure that the vertical axis does not couple horizontal noise to ensure a successful down-hole deployment at any site.

- Automatic self-level over a tilt range of $\pm 5^\circ$
- Downhole deployments of up to 300 meters
- The borehole models come with an integrated holelock for locking in a cased hole

Trillium 120 Slim PH

The Trillium 120 class slim posthole seismometer has a diameter of just 104 mm, which makes it ideal for use in new or existing narrow cased boreholes.

- $\pm 4^\circ$ mass-centering range permits installations in downhole deployments that are up to 4° from vertical
- With the Centaur Digital Recorder, the digitizer can perform real-time tilt and azimuth correction at the source, eliminating the need for correction downstream
- The Slim Posthole can also be paired with a hole-lock accessory for locking in a cased hole

TRILLIUM 360 GSN

The Trillium 360 GSN very broadband seismometer series industry-leading performance, including low self-noise, very wide bandwidth, gives full-bandwidth coverage for monitoring global and local seismicity with a single instrument.

- Meets USGS Class A+ requirements
- Able to resolve below Peterson's new low-noise model (NLNM)
- An extended low-frequency range useful to beyond a 10,000-second time period
- Flat response from 360 seconds to 80 Hz

Ocean Bottom	Vault	Direct Bury	Sand Install in a Cased Hole	Locked in a Cased Hole
Not Available	 Trillium 360 GSN Vault	 Trillium 360 GSN PH	 Trillium 360 GSN BH	

Trillium 360 GSN Vault

The Trillium 360 GSN Vault seismometer is ideally suited for new installations or recapitalization of global seismic stations that require the best seismometer performance in a vault form factor.

- Aluminum pressure vessel rated to IP68 at 2 meters in case of a flooded vault
- Incorporates a patented thermal stability system to minimize the effect of diurnal temperature fluctuations in vaults
- Automatic mass centering

Trillium 360 GSN PH/BH

The Trillium 360 GSN PH/BH seismometer advanced leveling system to ensure the axis stack is mechanically leveled to ensure that the vertical axis does not couple horizontal noise to ensure a successful down-hole deployment at any site.

- Automatic self-leveling over a tilt range of $\pm 5^\circ$
- Downhole deployments of up to 300 meters
- The borehole model comes with an integrated holelock

USER SELECTABLE OPTIONS

The polar environment option allows for operation down to -50°C , and the magnetic shield provides the lowest magnetic sensitivity of any broadband seismometer.

	Magnetic Shield	Polar Environment
Compact 20/120	Not required	Optional for PH, BH, Horizon
Trillium 120	Included for OBS & Polar, optional on others	Optional for PH and Horizon
Trillium 360	Included	Optional for Horizon
Trillium 360 GSN	Included	Optional for Vault and PH



Polar Certified Models available for operating temperatures down to -50°C

See Also

- **Cascadia Compact and Cascadia 120 Slim Posthole:** combines a seismometer and accelerometer in a single instrument. A Cascadia Integration Kit is also available to connect Titan Posthole to Trillium 120 or 360 Posthole or Borehole.
- **Meridian Compact:** combines a compact seismometer and 24-bit data logger in a single instrument