Velocity Analysis

Velocity Analysis is an interactive tool used to interpret stacking (NMO) velocities or residual moveout on 2D and 3D prestack seismic datasets.

Theory

There are many methods for determining correct velocities for the NMO equation. Typically, the analysis procedure involves comparing a series of stacked traces in which a range of velocities were applied in NMO. This procedure uses prestack data with varying velocities in displays representing the amplitudes after stack. A typical analysis involves picking a velocity in a panel, varying as a function of time to properly correct prestack data. The correction removes the time delay caused by the separation of the source and receiver on the surface.

Another NMO available is for mode converted P-Sv data. This option allows for a non-hyperbolic NMO travel time computation. A method published by Slotboom et al, (1990) is used to compute the travel time instead of the familiar two-term NMO equation. This equation is:

$$ T_x = \frac{t_0}{2} + \sqrt{\frac{0.25 \cdot t_0^2 + \frac{x^2}{2 \cdot v^2}}{2}} $$

Where $T_x$ is the time at offset $x$, $t_0$ is the zero-offset time, and $v$ is the moveout velocity.

Jianhua Pan, of Absolute Imaging, has derived a modification of this equation, appropriate for when the shot and receiver are at different elevations. His equation adds a third term to the original Slotboom equation:

$$ T_x = \frac{t_0}{2} + \sqrt{\frac{0.25 \cdot t_0^2 + \frac{x^2}{2 \cdot v^2}}{2}} + \frac{(t_0 \cdot d\tau \cdot 0.25)}{\sqrt{0.25 \cdot t_0^2 + \frac{x^2}{4 \cdot v^2}}} $$

Where $d\tau$ is the vertical p-wave time difference between the source and receiver elevations, computed using the replacement velocity. Since this requires a datum elevation and replacement velocity, it is required that these be stored in the LIN database in order to use this option. This third term is non-zero only when there is an elevation difference between the source and receiver.

Velocity Analysis offers the following display panels for interpreting NMO velocities:

- The **Semblance** panel displays the stack response as a function of time and velocity in a contour plot. Semblances are computed by performing hyperbolic scans at a specified number of constant velocities between a minimum and maximum stacking velocity on prestack data. Semblance is a measurement of the similarity of one trace to the next and a maximum semblance represents the hyperbolic trajectory representing the most similar data. Given that data is the most similar along this trajectory, the stack response should be a maximum. This panel is used to pick velocities on maximum semblance peaks.

- The **Gather** panel displays a common offset stacked supergather of a specified number of CDPs. You can interactively apply NMO and a time offset mute during this analysis. Applying NMO allows you to check the time correction applied to traces. If the velocity is correct, the events on the supergather appear flat in time. To ensure the highest fidelity semblance calculations on this supergather, partial moveout and differential CDP mean statics are applied. This panel is used to aid in the analysis procedure and for quality control the NMO. This panel is also used for picking your top and/or bottom mutes for the **Interactive Mute Analysis** capabilities.

- The **Velocity Function Stacks** (VFS) panel displays a series of side-by-side stacked traces for a set of CDPs. These traces are corrected for NMO with a series of different velocities. The velocities can be a series of constant velocities or a series of time variant velocity functions as a function of time. Typically, the velocity test range is small at shallow times and larger at deep times due to the nature of the NMO effect. In order to help with the analysis, the differential CDP mean static is applied to ensure that the dip of the events matches the same data on a stacked section. This panel is used to pick velocities by visually locating the maximum stacked response.
• The **Flip Stack** panel displays the same stacked data as the VFS panel. This panel animates in a manner similar to flipping through a deck of cards. One stack panel is displayed at a time. The display animates when the mouse is horizontally moved in the semblance or the VFS panels. This panel is used to compare the stacks at the different velocities velocity functions as they are picked on the Semblance or VFS panels.

• The **Dynamic Stack** panel displays an approximation of a stack generated with the current velocity pick. This stack is an interpolation of the existing VFS panel. This panel is used as a quality control of the picked function.

**Velocity Analysis** now handles the special case of **Residual Moveout**. Residual moveout is used on gathers which have been output from a pre-stack migration imaging program. If the velocity model and migration program were completely correct, events on the gather would have been flattened. However, they may have been under corrected or over-corrected by a too high or low migration velocity. The remaining moveout can be analyzed by Velocity Analysis to generate a residual moveout parameter. These residual parameters can be input to the **Residual Moveout Correction** tool to flatten and stack the migrated gathers. Or they can be run through **2D/3D Migration Tomography** to generate a corrected velocity model.

Residual moveout analysis operates the same way as conventional velocity analysis with the following changes:

• The velocity parameter is replaced by the residual parameter \( R \) in the hyperbolic moveout equation

\[
\begin{align*}
t &= \sqrt{t_0^2 + R \tau^2} \\
Z &= \sqrt{Z_0^2 + R \tau^2}
\end{align*}
\]

\( R \) has the dimensions of inverse velocity squared in time or is dimensionless in depth. \( R \) can be either positive or negative representing under-correction or over-correction. Because \( R \) is a very small number when using ProMAX® units of feet, meters, and milliseconds, it is multiplied by a billion (10E9) to keep it in the range of 1 to 1000.
• The two kinds of R are stored in their own ProMAX®
tables: RSL for time $R_T$ and RSD for depth $R_D$.

• Menu parameters have custom defaults for the cases of
Residual Analysis menu item is NONE, TIME or DEPTH.

Usage

A typical flow for 2D or 3D Velocity Analysis is:

SuperGather Formation*
Apply Residual Statics
Bandpass Filter
Automatic Gain Control
Velocity Analysis Precompute
Disk Data Output > precompute
Disk Data Input < precompute
Velocity Analysis
Volume Viewer / Editor

Supergathers are sets of adjacent CDPs used in velocity
analysis to:

• increase signal-to-noise

• study stacking power variability of nearby CDPs
You can create supergathers before Velocity Analysis with **Supergather Formation**, **3D Supergather Formation** or **3D Supergather Select**. In Velocity Analysis, the nearest CDPs to the central supergather CDP are used. Nearness is calculated by the root-squared distance between CDP_X and CDP_Y coordinates, or INLINE_NO and XLINE_NO or CDP bin if coordinates are not in the header. If distances are equal, the smaller CDP bin number is considered nearer. Velocity Analysis applies a differential static correction relative to the central CDP to align the supergather CDPs.

Velocity Analysis allows you to move forward, backward, or randomly through the supergathers if you use Velocity Analysis in conjunction with **Interactive Data Access** (IDA), **Volume Viewer/Editor**, or **DBTools**.

When panels are computed, the following tools become available to help with interactive velocity picking:

- NMO animation to examine quality of event flattening.
- Guide functions to show recent or nearby velocity picks.
- Continuously updating interval velocity graph to constrain the geologic reasonableness of the picks.
- Horizon display to identify important picking zones.

**Tips**

You can increase the speed of interactive velocity picking by using the following optional tips:

- Use **Velocity Analysis Precompute** to calculate semblance values, and create VFS and supergathers. If you use this process, you must select **Yes** to **Is Data Precomputed**.

- Use **Pick Copy and Automatic Snap** to copy picks from one location to the next, and to automatically snap the copied picks to the nearest semblance peak.

If you do not use Velocity Analysis Precompute, most parameters can be dynamically entered in the interactive dialog boxes.

You can simultaneously use the **Volume Viewer/Editor** with Velocity Analysis to display the entire velocity field as information is added to it for quality control purposes. The
velocity field can be viewed as a color vertical cross section or for 3D adding a color horizontal time slice.

Interactive selection of analysis locations is also available by using the communication between Volume Viewer/Editor and Velocity Analysis using Pointing Dispatcher and IDA.

If you use the Volume Viewer/Editor with the ProMAX® 3D Viewer, we recommend the following tips:

- Select **Yes** to the **Interact with other processes using PD** parameter in both Velocity Analysis and in the Volume Viewer/Editor.
- Use the same velocity table name in both Velocity Analysis and Volume Viewer/Editor.
- Inform the Volume Viewer/Editor of new or modified picks by clicking the **PD** icon in Velocity Analysis.

References

Al-Chalabi’s third term (Geophysical Prospecting, 1973).

Tvankin and Thomsen’s correction (Geophysics 59:1290, 1994) and discussed extensively in the Colorado School of Mines Center for Wave Phenomena literature.


Parameters

**Select display DEVICE**

Select **This Screen** as the display default. Enter a display name to override the current display default.

**Table to store velocity picks**

Select a database table to store velocities picks from the menu. If the current CDP exists, picks are overwritten. If **Perform Residual Velocity Analysis?** is set to **None**, the database table is type **VEL**; if set to **Time**, the table is type **RSL**; if set to **Depth**, the table is type **RSD**.
**Is the incoming data precomputed?**

Select **Yes** if the incoming dataset is precomputed by **Velocity Analysis Precompute**.

**Perform residual velocity analysis?**

Configure velocity analysis for residual velocity analysis in one of three modes:

- **None** - conventional Velocity Analysis.
- **Time** - Time Residual Analysis
- **Depth** - Depth Residual Analysis

**Calculation Parameters**

**Set the values for the computation variables**

This appears if **No** to **Is the incoming data precomputed**. Select **Yes** to enter computation variable parameters. This parameter is used to display the computation variable parameters.

**Note**

Selecting **Yes** opens the **Calculation Parameters** menu. Once you have made changes, select **No** to close the menu.

**Number of CDPs to sum into gather**

Enter the number of CDPs to sum in the gather and semblance panels. This value should be equal to or less than the number of CDPs in the supergather. Large numbers of CDPs increase signal to noise and lower numbers increase the horizontal and vertical precision of the velocity peaks. A lower number is sometimes preferred on marine data.

**Apply partial NMO-to-binning**

Select **Yes** to apply partial NMO to bin center for supergather smash and semblance calculation. This parameter does not appear if **Perform residual velocity analysis?** is set to **Time**
or **Depth**) Partial NMO has its greatest effect at shallow times and wide offset bins where the differential moveout is greatest.

**Apply differential CDP mean statics**

Select **Yes** to apply differential statics during supergather smash, semblance and VFSs calculation. The difference between FNL_STAT of the center CDP and the other CDPs is applied. The center CDP is not shifted. Differential statics has its greatest effect in complex structure areas, wide offset bins, and deep times.

**Absolute offset of first bin center**

Enter the absolute offset of the center of the first offset bin.

**Bin size for vertically summing offsets**

Enter the bin size of the offsets for forming supergathers. A reasonable value is the receiver group spacing.

**Maximum offset**

Enter the maximum offset for creating supergathers. The default is the maximum offset value in the database.

**Use absolute value of offset for stacking?**

Select **Yes** to use the absolute value of offset to stack gathers for 2D data. 3D always uses absolute offset. This parameter affects the supergather display in 2D. Select **No** to separately see both sides of a split spread.

**Minimum semblance analysis value**

Enter the minimum expected stacking velocity (or residual parameter). This value is the lowest used in the generation of the semblance panel and to scale all other velocity data on the screen.

**Maximum semblance analysis value**

Enter the maximum expected stacking velocity (or residual parameter). This value is the highest used in the generation of the semblance panel to scale all other velocity data on the screen.
Number of semblance calculations

Enter the number of semblance scans to perform between the minimum and maximum velocity (or residual parameter) range. More velocities increase the lateral semblance resolution and time to compute semblance.

Semblance sample rate

Enter the spacing, in ms, between semblance analysis window centers. The recommended default is about five times the sample rate.

Semblance calculation window

Enter the size of the semblance calculation window. The temporal smoothing increases as the semblance calculation window gets larger and/or the semblance sample rate gets smaller. The recommended default is twice the semblance sample rate.

Number of stack velocity functions

Enter the number of stack velocity (or residual parameter) functions.

Number of CDPs per stack strip

Enter the number of CDPs to display in the stack panels. It should be equal to or less than the number of CDPs in the supergather.

Scale stacks by number of live samples summed

Select Yes to divide the stacks by the count of traces summed. Normalization increases the display gain of shallow data with respect to deep data.

Method of computing velocity functions

Select one of the following methods for computing stack velocity functions:

- **Top-base range** interpolates velocity functions between minimum time velocity range and maximum time velocity range about a central guide function.
• **Delta-delta-t** uses a delta-t moveout at maximum offset with respect to the guide function to specify a stack velocity function. Older versions of Velocity Analysis used this method to compute fan functions.

• **Percentage** is a percentage of the central guide function.

• **Constant Velocity** evenly interpolates constant velocities between the minimum and maximum semblance velocity.

If **Perform residual velocity analysis?** is **Time** or **Depth** then this option is not display and set to Constant Velocity.

**Velocity variation at time 0**

This appears if **Top-base range** to **Method of computing stack velocity functions**. Enter the minimum time range of velocity variation in the stack velocity functions.

**Velocity variation at maximum time**

This appears if **Top-base range** to **Method of computing stack velocity functions**. Enter the maximum time range of velocity variation in the stack velocity function.

**Velocity function time increment**

This appears if **Delta-delta-t** to **Method of computing stack velocity**. Enter the velocity function time increment in ms.

**Velocity function percent maximum**

This appears if **Percentage** to **Method of computing stack velocity functions**. Enter the percentage for interpolating stack velocity functions.
Display Parameters

Set which items are visible

Select Yes to display panels, guide functions, contours, and horizons. Various attributes of the visible items, such as line color, can be set in the XWindows default files.

Note
Selecting Yes opens the Display Parameters menu. Once you have made changes, select No to close the menu.

Display semblance panel

Select Yes to display and calculate semblance and gather panels.

Display stack velocity functions

Select Yes to display the stack velocity functions on the semblance panel. This parameter does not appear if Perform residual velocity analysis? is set to Time or Depth.

Display semblance contours

Select Yes to overlay contours on the semblance panel.

Display interval velocity function

Select Yes to display the interval velocity function on the semblance panel. Interval velocities are recalculated whenever a pick is added, deleted or moved; this option will slow interactivity. This parameter does not appear if Perform residual velocity analysis? is set to Time or Depth, because no interval velocity is computed.

Display guide function

Select Yes to display the guide function on the semblance panel. The guide function often overlies the central stacking velocity (or residual parameter) function, depending on how the later have been calculated.
**Display gather panel**

Select **Yes** to display and calculate the gather panel.

**Seismic trace plotted as?**

Plot seismic traces in gather panel, function velocity stack panel, dynamic stack panel, and flip stack panel as **Wiggles** or **Grayscale**.

**Apply NMO on gather panel**

Select **Yes** to automatically apply NMO on the gather panel using the current pick velocity (or residual parameter) function. The NMO is updated every time a pick is changed. Selecting **Yes** enables mute picking.

**Animate NMO on gather panel**

Select **Yes** to apply NMO within a narrow time window on the gather panel for the current time-velocity coordinate (or time-residual parameter coordinate).

**Display dynamic stack panel**

Select **Yes** to display and calculate dynamic stack and VFS panels. Dynamic stacks are recomputed when a new pick is added, deleted or moved; this option will slow interactivity.

**Display flip stacks panel**

Select **Yes** to display and calculate the flip stack and VFS panels. This option will slow interactivity.

**Display velocity function stacks panel**

Select **Yes** to display and calculate the VFS panel.

**Display velocity color background**

Select **Yes** to display the velocity color background beneath the VFS, dynamic stacks, and flip stacks panels. The velocity color background changes as velocity picks are modified. This option will slow interactivity.
**Display velocity color key**
Select Yes to display a velocity color key.

**Show horizons on gather panel**
Select Yes to display horizons on the gather panel.

**Show horizons on velocity function stacks panel**
Select Yes to display horizons on the VFS panel.

**Show horizons on dynamic stack panel**
Select Yes to display horizons on the dynamic stack panel.

**Show horizons on flip stack panels**
Select Yes to display horizons on the flip stacks panel.

**Show current CDP guide function**
Select Yes to display the current CDP velocity function from the Table to Store Velocity Picks on the semblance and function velocity stack panels.

**Show average CDP guide function**
Select Yes to display the average of all CDP velocity (or residual parameter) functions in the Table to Store Velocity Picks on the semblance and function velocity stack panels.

**Show previous CDP guide function**
Select Yes to display the previous CDP velocity (or residual parameter) function from the Table to Store Velocity Picks on the semblance and function velocity stack panels.

**Show next CDP guide function**
Select Yes to display the next CDP velocity (or residual parameter) function from the Table to Store Velocity Picks on the semblance and function velocity stack panels.
**Show last-viewed CDP guide function**

Select **Yes** to display the last-viewed CDP velocity (or residual parameter) function from the **Table to Store Velocity Picks** on the semblance and function velocity stack panels.

**Equalize displayed trace width**

Select **Yes** to adjust the width of the gather panel and three stack panels to equalize the width of displayed traces.

**Relative width of semblance panel**

Enter a value for the initial width of the semblance panel display. The default value is **100**. The displayed width is this width with respect to the sum of relative widths of all visible panels.

**Relative width of gather panel**

Enter a value for the initial width of the gather panel display. The menu default value is **75**. The displayed width is this width with respect to the sum of the relative widths of all visible panels.

**Relative width of dynamic stack panel**

Enter a value for the initial width of the dynamic stack panel display. The menu default value is **30**. The displayed width is this width with respect to the sum of the relative widths of all visible panels.

**Relative width of flip stacks panel**

Enter in a value for the initial width of the flip stacks panel display. The menu default value is **30**. The displayed width is this width with respect to the sum of the relative widths of all visible panels.

**Relative width of velocity function stack panel**

Enter a value for the initial width of the VFS panel display. The menu default value is **200**. The displayed width is this width with respect to the sum of the relative widths of all visible panels.
Semblance Parameters

*Set semblance scaling and autosnap parameters*

Select **Yes** to set semblance scaling and autosnapping.

**Note**

Selecting **Yes** opens the **Semblance Parameters** menu. Once you have made changes, select **No** to close the menu.

Semblance normalization mode

Select the semblance normalization mode from the following choices:

- **Scale Time Slice** divides time slice of semblance values by the maximum in time slice. Scaling in this manner will help bring up the very weak reflections that are often pickable, but lost in the background.

- **Scale panel** divide all semblance values by the maximum semblance in panel. Prior to division, a noise factor can be added to the maximum semblance.

- **No Scaling** does not normalize.

The purpose of scaling semblance values is to elevate the weak semblances resulting from marginal signal to noise ratio data to a level that yields consistent quality screen displays.

**Contrast noise factor**

This appears if **Scale Time Slice** or **Panel** to **Semblance normalization mode**. Enter a bias factor to add to maximum semblance before scaling. Values between 0.0 and 0.4 are recommended. A small bit of noise decreases the number of semblance peaks, especially when applying the **Semblance Power Contrast Factor**.

**Contrast power factor**

Enter a number from zero to ten to change the contrast of the semblance appearance. Mathematically, each semblance
sample is raised to that power. A value larger than one enhances the high semblance values, hence increasing the contrast and narrowing the semblance peaks. A value less than one enhances the weaker semblance values, hence discoursing the contrast and broadening the semblance peaks.

**Automatically snap**

Select **Yes** to automatically snap the peaks of a velocity (or residual parameter) function. A function is automatically snapped only once to prevent unintentional repicking. You can manually resnap a location by using the **Snap once** option from the Semblance menu. An automatically snapped pick is depicted by a small triangle instead the usual small circle.

The following are the automatic snap options:

- **Off** does not automatically snap. Use the **Snap once** option in the Semblance menu for manual snapping.

- **After copy only** automatically snaps picks at a new location after the previous function is copied. This option is used to fill in new and empty velocity tables by copying and modifying the previous picks.

- **Snap existing functions** automatically snaps existing functions in the output table. This option is for updating velocity tables from a previous implementation of this process.

- **Always** automatically snaps copied or previously existing functions.

**Maximum velocity% change for snapping**

Enter how far the nearest peak can be horizontally, in percentage of velocity (or residual parameter), from the current pick position. For example, if the pick is at velocity 10,000 and the maximum horizontal distance for snapping is 10%, the peak is searched between the velocities 9,000 and 11,000.

**Maximum vertical change for snapping**

Enter how far the nearest peak can be vertically, in ms, from the current pick position.
Mute Parameters

**Pick/apply a mute?**

Select an option for picking, editing, and applying a time mute as a function of offset on the gather panel. The five options are:

- **None** does not pick or apply a mute
- **Top** mutes above the line. It is useful for erasing direct arrivals, refracted and converted events.
- **Base** mutes below the line. It is useful erasing new offset multiple energy.
- **Both** mutes with both the top and bottom editing enabled. To interactively change between editing the top and the bottom mutes, use the **Swap Edit** icon.

**Gather offset Top mute table**

This appears if **Top** or **Both** to **Pick/Apply a mute**. Select a mute table (MUT) containing top mute picks and for storing newly edited top mute picks.

**Note:** The primary key of the mute table MUST be CDP or the job will fail or produce incorrect results.

**Gather offset Base mute table**

This appears if **Base** or **Both** to **Pick/Apply a mute**. Select a mute table (MUT) containing top mute picks and for storing newly edited base mute picks.

**Note:** The primary key of the mute table MUST be CDP or the job will fail or produce incorrect results.

**Mute taper length**

This appears for all options except **None** to **Pick/Apply a mute**. Enter the mute taper length in ms. The default is **20**.

Horizon Parameters

**Select/Display horizons**

Select one of two ways to select displayed horizons:
• **None** does not display horizons.

• **Pop-menu** uses the **Horizon tables** menu to add and delete an arbitrary number of horizons. You cannot explicitly color horizons with this method.

• **Explicit** sets up to 20 horizons and colors explicitly.

• **Reset-Explicit** erases all of the horizons you entered under **Explicit** and resets the menu.

**To which datum are the horizons referenced?**

Select whether horizons are from surface or datum:

• **Final Datum** is the default; references horizons picked from a stack to final datum (F_DATUM). Stacks are shifted to final datum by **CDP/Ensemble Stack**. Use this option if horizons were picked on such a stack. Velocity Analysis will shift the horizon times by the CDP mean static value so that horizons picked on a conventionally stacked section can be used in the Velocity Analysis.

• **Floating Datum** references horizons picked on a stack to floating datum (N_DATUM).

**Horizon tables**

This appears if **Pop-menu** to **Select/Display horizons**. Select or deselect horizons from a list of available horizon parameter tables.

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**Note**

Due to a limitation in the menu, one horizon remains after trying to deselect all horizons. Set **Display horizons** to **No** to remove horizon.

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**Note**

Selecting **Yes** opens the **Horizon Parameters** menu. Once you have made changes, select **No** to close the menu.
Select horizon \( N \)

This appears if Explicit to Select/Display horizons. Select a horizon table (HOR) to display. This option is an alternative to the Horizon table parameter allowing an explicit color choice. You can select that up to 20 horizons.

Color

Select the color of the horizon select for Select horizon \( N \). You have a palette of ten choices.

Another horizon?

Select Yes to another horizon table and color pair.

Interact with other ProMAX® Modules

Interact with other processes using PD

Select Yes to communicate with the Volume Viewer/Editor or the ProMAX® 3D viewer. A change in Velocity Analysis is reflected in the Volume Viewer/Editor and the ProMAX® 3D Viewer when the PD icon is used.

Guide Function Parameters

Get guide function from existing parameter table

Select Yes to select a guide function from an existing parameter table. A guide function is used for the differential moveout in constructing the Gather panel for all methods of computing the velocity (or residual parameter) function, even for constant velocity.

Velocity guide function table name

This appears if Yes to Get guide function from existing parameter table. Select a velocity table to use as a guide function. If Perform Residual Velocity Analysis? is set to None, the database table is type VEL; if set to Time, table type is RSL; if set to Depth, table type is RSD.

Guide minimum time velocity

This appears if No to Get guide function from existing parameter table. Enter the velocity (or residual parameter)
at the top of the guide function. The guide function is a linear ramp between the top and base values.

**Guide maximum time velocity**

This appears if No to Get guide function from existing parameter table. Enter the velocity (or residual parameter) at the base of the guide function. The guide function is a linear ramp between the top and base values.

**Main Parameters**

**Apply P-Sv converted wave NMO?**

Applies what is sometimes referred to as "Slotboom NMO". Applicable for converted wave data.

Using this option requires that two fields be set in the LIN database, EXDATUM and VXDATUM. EXDATUM is the elevation of the processing datum and VXDATUM is the replacement velocity. If either of these fields is a NULL value, the tool will fail in the init phase.

Several trace headers are also required for this option to be able to compute the correction for source-receiver elevation differences. The following headers are required: FNL_STAT, SOU_ELEV, REC_ELEV, DEPTH, UPHOLE. If the UPHOLE header value is NULL, it will be set to zero.

**Maximum stretch percentage for NMO**

Enter the maximum percentage of sample-to-sample stretch for NMO. The default is 30. This mute is applied at low times and high offsets. The larger the percentage value, the smaller the mute region. Enter 0.0 for no stretch mute.

**Long offset moveout correction**

This parameter does not appear if Perform residual velocity analysis? is set to Time or Depth or if Apply P-Sv converted wave NMO is set to yes. Select an option for increasing the accuracy of the NMO at long offsets. The standard two-term hyperbolic equation used in NMO becomes less accurate as the vertical velocity gradient increases, as offset becomes greater than depth, or as anisotropy increases. The following options add a third term to the conventional NMO equation using higher powers of offset, velocity, and eta:
• **None** applies only the two-term NMO equation. This is the normal application.

• **Alchalabi** uses the simplest third term and should be the most efficient long offset correction method.

• **Castle** is normally applied as a shifted hyperbola before applying two-term NMO. This correction has been incorporated directly into ProMAX® NMO. This method does not appear to be as accurate as Al-Chalabi’s, when compared to exact results for a linear velocity gradient, and requires more computation time.

• **Tsvankin** allows for the greatest accuracy and the inclusion of anisotropic corrections, at the expense of the longest run time.

• **Harlan** is an alternative anisotropic correction. It accounts from anisotropy, but not \(v(z)\).

If you use this long-offset correction, then stack your data using the same correction in the **NMO** tool.

The long-offset moveout corrections are more accurate on the moved-out gather and VFS panels than the semblance panel because they use variable velocity functions instead of constant velocity functions. The reason is that long-offset moveout calculations use velocity gradient information. Otherwise, with ordinary NMO they are equally accurate.

**Anisotropy correction parameter \(\eta\)**

This appears for conventional NMO and if **Tsvankin** or **Harlan** to Long offset correction. Enter the anisotropy correction parameter, \(\eta\). \(\eta\) is defined in

\[
\eta = (\varepsilon - \delta)/(1.0 + 2.0 \times \delta).
\]

Small positive values between 0.0 and 0.5 are most physically likely.

**Interval velocity below last knee**

Enter an interval velocity as the deepest velocity. This parameter does not appear if **Perform residual velocity analysis?** is set to **Time** or **Depth**. Picks above this maximum are set to this value. Velocity Analysis adds a phantom pick to obtain this interval velocity. It also moves this phantom pick as other picks are moved or deleted so that the interval velocity retains the desired value. Enter **0.0** to turn off this option.
Copy picks to next location

Select Yes to have the current picks copied into the next-viewed ensemble when there are no velocity picks at that location. Copied picks are indicated by a small diamond rather than a small circle for picks loaded from a velocity table. This is useful for iterating modest velocity changes across the line. Copied velocity functions are automatically snapped by setting Automatically snap to Always, Existing, or After Copy Only.

Interactive Display

After running this process, the following interactive display window appears:

Panels

Data display in Velocity Analysis is divided into sections called panels. From left-to-right are the Semblance, Gather, Dynamic Stack, Flip Stacks and Velocity Function Stack (VFS) panels. The vertical axis of all the panels is time in ms. Each panel has its own horizontal axis depending upon the its contents.
Velocities are picked on semblance and VFS panels. Pick changes in one panel are reflected in the other panel. Changing a pick alters the gather panel moveout and recomputes the dynamic stack.

When the mouse is moved in each panel, the time, velocity, and velocity function number, and interval velocity coordinates are displayed at the bottom of the screen.

Semblance Panel

The semblance panel shows the semblance plot, the picked velocity function, the velocity guide functions, the stack velocity functions, and the interval velocity of the picked function.

Gather Panel

The gather panel displays the offset-binned supergather, the NMO moveout curve, NMO flattening, and guide horizons.

NMO flattening is turned on via the Apply NMO option in the Gather menu. It is automatically updated whenever a pick is
Velocity Analysis now has **Interactive Mute Analysis** capabilities. You can pick mutes on this panel and save them to the database. There are two mute lines: the *top mute* erases above the line and is useful for erasing direct arrivals, refracted and converted events. The *base mute* erases below the line and is useful erasing new offset multiple energy. **Apply NMO** must be on and there must be at least one velocity pick to display to pick a mute function. If there are mute picks at this supergather CDP location, the mute function is drawn as a red or blue solid line with the mute picks shown as dots. The red line can be edited. If there are no mute picks, a dotted blue line of an interpolated mute line is drawn on the gather.

*Note:* The primary key of the mute table MUST be CDP or the job will fail or produce incorrect results.

You edit the gather panel doing the following:

For incoming data = precomputed:

changed. The NMO moveout curve is not drawn when NMO flattening is on.

A more interactive version of NMO flattening is turned on via the **NMO Animation** option in the Gather menu. This option creates a window around the pick time and displays the effect of NMO in real time as the mouse is dragged in the semblance or VFS panels. You must hold down **MB1** to make a new pick or **MB3** while moving an existing pick to enable the NMO Animation. You can change the size of the window by setting **NMO Animation Window Size** in the Gather parameters dialog box.
1. Activate **Apply NMO** from the **Gather** menu pulldown
2. MB1 adds a pick
3. MB2 deletes the nearest pick
4. MB3 moves the nearest pick to the deleted pick’s location
5. For **Pick/apply mute = Both**, use the **Swap Edit** icon to switch between picking your top or bottom mute.
6. Use the **Paint Brush** icon to graphically apply your mute to the gather
7. Use the **Clear Edits** icon to clear the picks you have made
8. The mute(s) will be saved in the file that was specified in the menu

For incoming data = Non precomputed:

1. Use the same steps as with precomputed
2. Use the **Apply mute to semblance and stacks (slow)** icon to recompute the semblance and stack displays.

Pick lines are interpolated linearly between picks, between CDPs, to the edge offsets.

Mute picks are applied to data in the following manner:

1. Existing mutes are applied to the Semblance and VFS panels during initial calculation for the CDP. If the data has been precomputed, then the mute is also applied.

2. The mute is only applied to the Gather panel if **Apply NMO** under the **Gather** menu or **Gather Parameter Dialog** is on, there is at least one velocity pick, and the **Paint Brush** icon is activated. We suggest picking and editing the mutes on the gather with the painting turned off so that you can see the bad data parts.

3. A newly picked or edited mute is only applied to the Semblance and VFS panels when the incoming data is non precomputed and is applied by the **Apply mute to semblance and stacks** icon. The mute is graphically
applied to the Gather panel with the **Paint Brush** icon for both precompute and non precomputed data.

**Velocity Function Stacks Panel**

The VFS panel shows multi-CDP stacks. It can be annotated with the color background of the stacking velocity functions and guide horizons.
Dynamic Stacks Panel

The Dynamic Stack panel shows a representation of a stack generated by the current velocity pick. The dynamic stack interpolates between the velocity function stacks. It can be annotated with color background of the stacking velocity function and the guide horizons.

Flip Stacks Panel

The Flip Stacks panel animates through the velocity function stacks when the mouse button is dragged on the semblance or VFS panels. You must use MB1 to make a new pick or MB3 with an existing pick to activate the animation.

Menu Bar

The menu bar contains the pulldown menus: File, View, Semblance, Gather, Stacks, plus Help which is located on the far right of the menu bar. When commands in the menu bar are not appropriate, they are grayed out. Commands that pop up dialog boxes end in an ellipsis(...).
Many of the options launch a dialog box to edit parameters. In all cases, you will use the following buttons for the settings.

- **OK** applies new settings and exits dialog box.
- **Apply** applies new settings.
- **Cancel** cancels dialog box.

**File**

The **File menu** contains commands to generate, read and save picks, make a copy of the screen, and exit.

- **Save Picks** saves current picks to a velocity table.
- **Save Screen Snapshot** saves the current screen image. You can save up to ten screen snapshots.
- **Animate** displays the animation control dialog box. Use this to review saved screen images, manually or automatically cycles through images. It controls the speed of playback, limits the set of displayed frames, and deletes unwanted frames.

**Animation Dialog**

![Animation Dialog](image)

**Speed Control** controls the playback speed. This control is active during an animation sequence.

**Frame Control** shows the current frame. Drag the slider
to change frames.

**Animation Tool Icons**

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Start" /></td>
<td><strong>Start Frame</strong> sets the start frame to the current frame. Animation sequences operate between the start and end frames.</td>
</tr>
<tr>
<td><img src="image" alt="End" /></td>
<td><strong>End Frame</strong> sets the end frame to the current frame.</td>
</tr>
<tr>
<td><img src="image" alt="Delete" /></td>
<td><strong>Delete</strong> deletes the current frame. Start and end frame are then updated.</td>
</tr>
<tr>
<td><img src="image" alt="Rewind" /></td>
<td><strong>Rewind</strong> steps backward to the first frame.</td>
</tr>
<tr>
<td><img src="image" alt="Back" /></td>
<td><strong>Back</strong> single steps backward by one frame.</td>
</tr>
<tr>
<td><img src="image" alt="Cycle" /></td>
<td><strong>Cycle</strong> cycles through saved frames.</td>
</tr>
<tr>
<td><img src="image" alt="Ramp" /></td>
<td><strong>Ramp</strong> ramps through saved frames.</td>
</tr>
<tr>
<td><img src="image" alt="Toggle" /></td>
<td><strong>Toggle</strong> toggles between the start and end frames.</td>
</tr>
<tr>
<td><img src="image" alt="Stop" /></td>
<td><strong>Stop</strong> stops an animation sequence started by Cycle, Ramp, or Toggle.</td>
</tr>
</tbody>
</table>
Animation Tool Icons

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward</td>
<td>single steps forward by one frame.</td>
</tr>
<tr>
<td>Cancel</td>
<td>closes the animation dialog box.</td>
</tr>
<tr>
<td>Printer Hardcopy</td>
<td>prints the screen to a printer.</td>
</tr>
<tr>
<td>Plotter Hardcopy</td>
<td>prints the screen to a plotter.</td>
</tr>
<tr>
<td>Exit and continue flow</td>
<td>exits Velocity Analysis and continues the flow.</td>
</tr>
<tr>
<td>Exit and stop flow</td>
<td>exits Velocity Analysis and stops the flow.</td>
</tr>
</tbody>
</table>

View

The View menu controls which objects are displayed on the screen, their color, and size.

- **Object Visibility Dialog** launches a dialog box to turn on or off the five panels, plot wiggle traces or grayscale, and adjust the width of the panels. You can also turn on or off horizons, color scales, NMO, and guide functions.

- **Edit ColorMap** launches the **Color Editor**. This controls the color scale of the semblance panel and velocity color backgrounds. The color scale is bounded by the minimum and maximum stacking velocities.

Semblance

The Semblance menu controls the appearance of the semblance panel.

- **Semblance parameters** launches a dialog box to change the semblance parameters. See the **Semblance and Computation Parameters** sections for a complete description.

- **Semblance panel scaling** launches a dialog boxes to scale a time slice, panel, or turn off semblance scaling. See the **Semblance Parameters** section for a complete description.
**Erase current pick function** erases a current pick function.

**Copy picks to next location (diamonds)** copies a picked to an unpicked location. The pick drawing shape is changed from a circle to a diamond to show the pick was copied instead of loaded.

**Auto snap options (triangles)** automatically snaps the peaks of a velocity function. A function is automatically snapped only once to prevent unintentional repicking.

- **Off** does not autosnap.
- **After Copy Only** snaps the pick to the current semblance after a function is copied to a new location.
- **Existing Functions** snaps the pick to the current semblance to an existing function. Useful for converting a stacking velocity field to a new RMS field after DMO or prestack migration.
- **Always** snaps the pick to a new location or after copying.

**Snap once (triangles)** snaps picks to the nearest semblance peaks. The pick drawing shape is changed from a circle to a triangle to show the pick was automatically snapped.

**Snap Parameters** launches a dialog box to modify snapping parameters.

**Gather**

The **Gather** menu controls the appearance of the gather panel.

- **Gather parameters** launches a dialog box to change the gather parameters. See the **Gather Parameters** section for a complete description.

- **NMO parameters** launches a dialog box to change the NMO parameters. See the **Main** and **Mute Parameters** sections for a complete description. This option appears when incoming data is non precomputed.

- **Apply NMO** applies NMO to the gather after each pick.

- **Animate NMO** animates the effect of NMO around the location of the pick.
• **Trace Scaling** adjusts the scaler values for scaling stacks and gathers.

**Stacks**

The **Stacks** menu controls the appearance of the VFS, Flip Stacks, and the Dynamic Stack panels.

• **Stack parameters** launches a dialog boxes to change the stack parameters. See the *Calculation Parameters* section for a complete description. This option appears when incoming data is non precomputed.

• **Stack Velocity Function** launches dialog boxes to change the following methods of computing stack velocity functions: **Top-Base Range**, **Delta-delta Time**, **Percentage**, and **Constant Velocity**. This option appears when incoming data is non precomputed.

• **Trace scaling** adjusts the intensity values for scaling stacks and gathers.

**Icon Bar**

The following commands are invoked using the icons on the left hand side of the screen.

<table>
<thead>
<tr>
<th>Velocity Analysis Icons</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="icon" alt="Next ensemble" /></td>
</tr>
<tr>
<td><img src="icon" alt="Previous ensemble" /></td>
</tr>
</tbody>
</table>
Velocity Analysis Icons

- **Rewind** rewinds the dataset to the first ensemble specified in the sort order. This button only works if **Interact with other processes using PD?** is set to **Yes**. You can also press the "r" key to rewind to the first ensemble.

- **PD** saves and sends the velocity picks in the current ensemble to the Volume Viewer/Editor or the ProMAX® 3D Viewer. This icon only appears when **Interact with other processes using PD?** is set to **Yes**.

- **Swap Edit** allows you to switch between picking your top or your bottom mute. Click on the upper line to enable your top mute and the bottom line for your bottom mute.

- **Paint Brush** applies the current mute functions to the Gather panel.

- **Clear Edit** allows you to clear your mute picks, but will not recompute.

- **Apply Mute** applies your mute picks to the semblance and stack panels.

- **Zoom** zooms on an individual panel, or on the panel axis. Since all panels share the same Y-axis, zooming a panel will zoom other panels in the vertical direction. However, since X-axis is not shared, zooming one panel does not affect the other panels. Click and drag using **MB1** to select an area to zoom. If you release **MB1** outside the window, the zoom operation is cancelled. If you just click **MB1** without dragging, this tool will unzoom.
Several Keyboard shortcuts are provided in the velocity analysis module. These are:

n - next record

p - previous record

r - rewind to the first record

Interactive Data Access must be set to "yes" to allow the p and r keyboard shortcuts to work.

**Note:** You may need to turn off "Num Lock" to get the ensemble shortcut keys to work.

### Customizing the User Interface

In addition to the controls and menu items described, there are a number of features of Velocity Analysis that can be customized using X Windows resources. The file $PROMAX_HOME/port/lib/X11/app-defaults/ VelAnal71 is the default resource file and contains a sample set of resources used to customize **Velocity Analysis**.

**Note:** The exact path of this file will depend on your installation. The resources in this file can be used to configure the screen size as well as the colors and fonts of various objects in **Trace Display**.
In order for Velocity Analysis to find this file, you must add a path to it in your XFILESEARCHPATH environment variable. A typical setting for this environment variable might be:

```
$PROMAX_HOME/port/lib/X11/%T/%N%S:/usr/lib/X11/%T/%N%S
```

There are a number of ways to customize the resource settings used by Velocity Analysis:

- Your system administrator can edit the default resource file.
- You can copy the default resource file into your own directory, edit the file, and add that directory to the XFILESEARCHPATH environment variable.
- You can copy the default resource file to your $HOME directory and edit it.
- You can copy the resources you want to change into your .Xdefaults file. If you do this, please add the word VelAnal71 to the beginning of each resource name. For example, the default resource file contains a line that looks like:

```
VelAnal71*geometry: 2000x2000
```

  This line starts up Velocity Analysis using the full screen. Suppose you wanted Velocity Analysis to start-up using an 800 by 600 pixel window. You could place the following line in your .Xdefaults file:

```
VelAnal71*geometry: 800x600
```

For a more detailed discussion on customizing ProMAX® applications, please refer to the *System Administration* guide.