

# Isoliner3D - a 3D window and volume tools for QGIS

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**What this is**

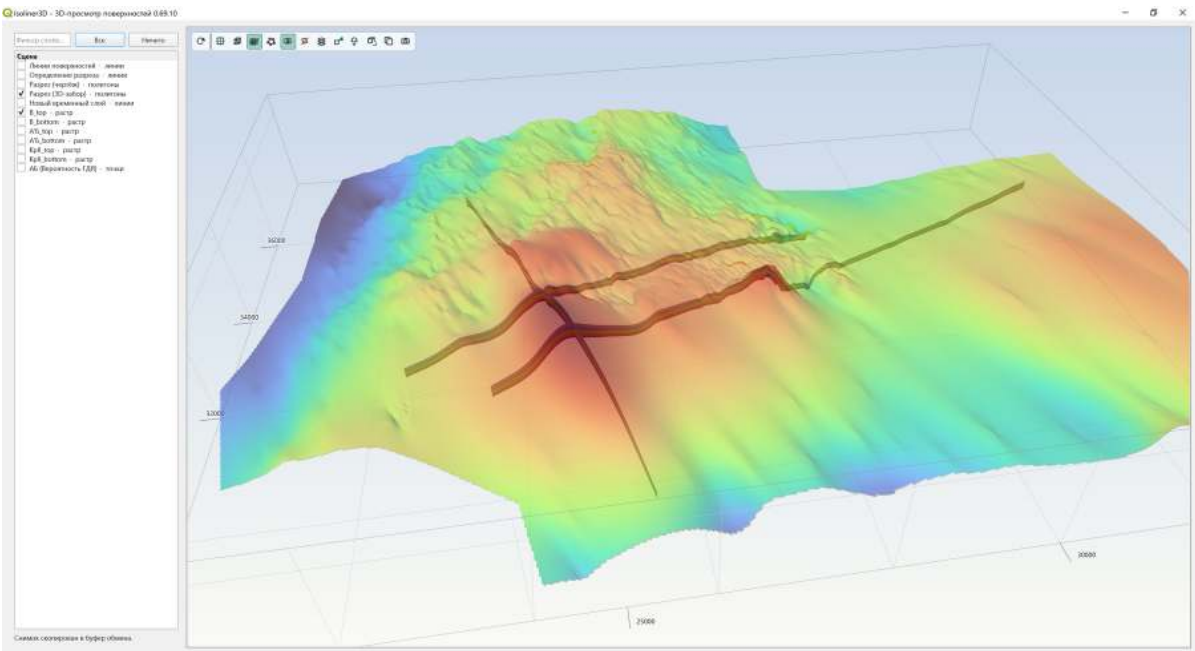


Figure 1: Relief with hillshading and three section fences across it, inside a coordinate box with elevation labels.

Isoliner3D shows the data of a project in three dimensions and computes from it. Rasters become surfaces, multiband grids become watertight beds, boreholes become coloured shafts, polygons with Z become bodies. Apart from that there is a set of tools in the Processing panel: assembling a bed grid, a block model, interpolation in volume, isosurfaces, volumes.

The module depends neither on the built-in 3D view of QGIS nor on Qt3D: the drawing goes through libraries bundled with it, nothing extra to install.

Interpolation in plan, contours, terrain and drawn sections stay with the Isoliner plugin, of which Isoliner3D is a companion.

Requirements: QGIS 3.16 or newer, Qt5 or Qt6.

**Installation**

**Plugins - Manage and Install Plugins - Install from ZIP**, choose isoliner3d.zip. QGIS need not be restarted.

## Where to start

Without your own data: the tool **2.01 Demonstration boreholes in volume** puts samples into the project, then **2.02 Interpolation of points in volume** makes a cube out of them, and the viewer shows an isosurface over that cube.

With your own: open the window from the toolbar, tick the layers in the list and press refresh. A raster shows as a surface, polygons with Z as a body.

## The viewer

The list of project layers with checkboxes is on the left, the scene on the right. A tick says what to show; the scene is built by the refresh button, not by the tick itself - on a large project a rebuild takes seconds, and doing it on every click is pointless.

Mouse: the left button rotates, the wheel zooms, the middle one pans.

## The coordinate system

The scene works in the coordinates of the project. The origin is shifted to the middle of the extent of all visible layers: without that, numbers of six digits lose precision on the graphics card and the model starts to shiver.

The vertical scale is one for the whole scene. A common origin and a common factor are computed over all visible layers at once and applied alike to rasters, polygons, lines and points. That is why a section fence lies on the surface it was built from at any exaggeration.

**Vertical exaggeration** stretches the elevations. It is a way of looking, not a property of the data.

## Scene properties

Opened by a button on the toolbar. The sections are **View**, **Clipping**, **Appearance** and **The coordinate box**. All the settings are saved into the project.

Hillshading is not decoration: a surface coloured by a ramp is drawn with vertex colours and no light at all, so the relief within one shade is lost. The gradient background is on by default.

Bodies are lit by three sources. With a single one everything turned away from it falls into shadow completely, and half of a bed body is just that - the side walls and the floor - so the scene comes out dark. The main source draws the shape, the second lights from the other side at half strength, the third from below keeps the bottom from sinking. The hillshading keeps a single source: with three it goes flatter, and the relief within one shade of the ramp reads worse.

## Layer properties

Opened by a double click on a layer in the list. Only the fields that work in the chosen mode are shown.

## Where the colour comes from

The scene asks the data itself, in this order: the **color** field if the layer has one, then the layer symbology asked per feature, then a single colour for the whole layer.

## Isosurfaces and voxels

A cube of values is a multiband grid where a band is a horizontal level. Tools 2.02, 2.06 and 2.07 write such grids.

Shells are set in a table: a row per level with its colour and opacity. **Cap where the body meets the cube edge** closes the shell where the body runs into the boundary; without it no volume can be computed.

The button on the toolbar puts the shells into a project layer, splitting them into connected bodies and computing the volume of each. The volume is computed by an exact formula over a watertight shell, not by summing cells: the shell cuts the edge cells in half.

The button takes two modes: an isosurface over a cube and a bed body. For a bed body every pair of bands gives its own body, and the level field holds the number of the roof band. The body is built afresh rather than taken from the scene: what is shown has its vertical stretched by the exaggeration, the layers spaced down Z and the mesh thinned to a vertex budget, so the volume of such a body is wrong by exactly the factor the vertical is stretched by. The clipping, however, is the one set in the scene.

The **holes** field counts torn edges - with them the volume is meaningless. The **pinch** field counts self-touches, which do not affect the volume.

## Exporting the scene

A button on the toolbar writes the scene to a file, the format chosen by the extension. **GLB** carries colour and transparency and is good for viewing; **STL** and **OBJ** are for CAD, where a watertight shell is needed to make a solid from.

The spin button walks the camera around the model; the capture button writes a full turn as PNG frames.

## The tools

All of them live in the Processing panel, in the groups **1. Bed and block model** and **2. 3D interpolation**.

### 1.01 Assemble a bed grid

| Field                                        | What it sets                                                                                                                                 |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Roof (raster)</b>                         | The grid of the bed roof. Elevations in metres; the step and extent must match the floor, or there is nothing to compute the thickness from. |
| <b>Bottom (raster)</b>                       | The grid of the floor. Where the floor is above the roof the thickness comes out negative and the cell becomes a gap.                        |
| <b>Parameters (rasters, band 1 is taken)</b> | Extra grids that will become separate bands: grade, density, domain. The first band of each is taken.                                        |
| <b>Bed grid</b>                              | A multiband grid: band 1 the roof, band 2 the floor, then the parameters. Every other tool and the viewer read this order.                   |

| Field              | What it sets                                                                                                  |
|--------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Roof band</b>   | The roof band in the source grid. Needed when the roof is not the first band but sits inside a multiband one. |
| <b>Bottom band</b> | The floor band in the source grid. Needed when the floor sits inside a multiband one.                         |

## 1.02 Bed calculator

| Field                                        | What it sets                                                                                                              |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>Bed grid (band 1 roof, band 2 bottom)</b> | The bed grid from 1.01. The first band is the roof, the second the floor, and the thickness follows from them.            |
| <b>Content band (empty - no content)</b>     | The grade band. Empty means computing only volume and thickness, without reserves.                                        |
| <b>Ore density, t/m<sup>3</sup></b>          | The ore density. The volume is multiplied by it to get mass: without it the report is in cubic metres rather than tonnes. |
| <b>Reserve contour (polygons, optional)</b>  | Polygons outside which cells do not enter the computation: a computation block, a licence area.                           |
| <b>Bed grid with thickness and reserves</b>  | The same bed grid with added bands of thickness and reserves per cell.                                                    |
| <b>Report (HTML)</b>                         | A summary over the contour: area, volume, mass, mean grade. Opens in a browser.                                           |

## 1.03 Bed grid to a block model

| Field                                             | What it sets                                                                                                                                                    |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Bed grid (band 1 roof, band 2 bottom)</b>      | The bed grid from 1.01. The column between the roof and the floor is split into blocks.                                                                         |
| <b>Ore density, t/m<sup>3</sup></b>               | The ore density, when there is no band for it. The block volume is multiplied by it.                                                                            |
| <b>Reserve contour (polygons, optional)</b>       | Polygons outside which blocks are not written out: a computation block, a licence area.                                                                         |
| <b>Block model (centroids)</b>                    | A centroid point per block with its size, volume and mass. The usual QGIS vector machinery works from there.                                                    |
| <b>Density band (empty - use the value above)</b> | The density band in the grid. Empty means taking the single value set above for the whole bed.                                                                  |
| <b>Vertical layers (column split)</b>             | How many blocks to split the column into vertically. One block gives a model without vertical division, and the whole thickness then falls into a single layer. |

## 1.04 Surfaces to 3D (meshes)

| Field                                  | What it sets                                                                                                                               |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Surface grids</b>                   | The grids to be given out as meshes. Each becomes a separate 2DM file.                                                                     |
| <b>Z scale (vertical exaggeration)</b> | Vertical exaggeration. A bed of one metre over a kilometre cannot be seen without it, but volume can no longer be computed on such a mesh. |
| <b>Z offset</b>                        | A shift of all elevations along the vertical. Needed to separate the beds of a pile and see them apart.                                    |
| <b>Z spacing (step per next grid)</b>  | The spread of surfaces along the vertical. Otherwise the beds of a pile lie flush and fight for depth.                                     |
| <b>Folder for meshes (2DM)</b>         | Where to put the files. The file name is taken from the grid name.                                                                         |
| <b>Node thinning (every Nth)</b>       | Thinning of the nodes. Every second node is four times fewer triangles, and the shape of the bed looks the same.                           |
| <b>Elevation band (Z)</b>              | The elevation band in the grid. For a bed grid it is the roof or the floor, depending on what to show.                                     |

## 1.05 Domains to a bed band

| Field                                        | What it sets                                                                                                  |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <b>Bed grid</b>                              | The bed grid a domain band will be added to.                                                                  |
| <b>Domain polygons</b>                       | Domain polygons: ore types, sites, zones. A cell takes the code of the domain it falls into.                  |
| <b>Bed grid with a domain band</b>           | The same grid with an added domain band. Filters for the computation and colouring of the scene work from it. |
| <b>Domain code field (numeric, optional)</b> | The numeric field with the domain code. Empty means numbering the polygons in order.                          |

## 1.06 Reserve difference (write-off)

| Field                                 | What it sets                                                                                                              |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <b>The “before” model (centroids)</b> | The block model at the start of the period. Comparison goes by matching blocks, so both models must be built on one grid. |
| <b>The “after” model (centroids)</b>  | The block model at the end of the period. A block absent from it counts as mined out entirely.                            |
| <b>Difference (centroids)</b>         | Centroids with the difference per block. The sum of the field over the layer is the write-off for the period.             |
| <b>Reserve field</b>                  | The reserve field whose difference is computed: mass, volume, metal.                                                      |

## 1.07 Create sample data (demo)

| Field                                         | What it sets                                                                                                                                   |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Example</b>                                | What exactly to create: a bed body, a pile of folded beds, a cube or a tetrahedron. The map for a texture has moved to the separate tool 1.08. |
| <b>Extent (map view) - placement and size</b> | Where to put the example and of what size. Empty means taking the extent of the view window.                                                   |
| <b>Thickness, map units</b>                   | The bed thickness in map units. Whether the body is visible at the usual vertical scale depends on it.                                         |
| <b>Bed body resolution (cells per side)</b>   | How many cells the side of the body is split into. Finer means a smoother shape and more triangles.                                            |
| <b>Output as TIN (triangulate)</b>            | Triangulate the body. Without it the faces come out quadrilateral, and not every viewer shows those.                                           |
| <b>Body (demo)</b>                            | A layer with bodies: polygons with Z, fit for the scene and for volume computation.                                                            |
| <b>Base elevation (floor), map units</b>      | The elevation of the floor. The pile is built upwards from it.                                                                                 |
| <b>Beds in the suite</b>                      | How many beds in the pile. Each lies as its own body with its own grade.                                                                       |

## 1.08 A map for a texture (demo)

| Field                                        | What it sets                                                                                         |
|----------------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Extent (when no grid is set)</b>          | The bounds of the map when no grid is set. Empty means taking the extent of the view window.         |
| <b>Map: by the extent of a grid (raster)</b> | The raster whose extent the map is made to. Needed so the texture lands exactly on an existing grid. |
| <b>Map (demo)</b>                            | A picture for a texture: it can be stretched over a surface in the viewer.                           |
| <b>Map: image side, pixels</b>               | The side of the picture in pixels. Larger means a sharper texture and a heavier file.                |
| <b>Map: graticule cells</b>                  | How many cells of the coordinate grid to draw on the map.                                            |
| <b>Map: bed fields</b>                       | How many bed fields to draw on the map.                                                              |

## 2.01 Demonstration boreholes in three dimensions

| Field               | What it sets                                                                                                                                             |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Deposit type</b> | A folded and dipping bed shows the main point: cube levels cut the deposit across. A lens is isotropic and the simplest, a vein is the opposite extreme. |

| Field                               | What it sets                                                                                                                                      |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Holes</b>                        | The grid is jittered rather than regular: a regular one gives interpolation too easy a task.                                                      |
| <b>Sample length, m</b>             | A sample longer than the thickness of the deposit will miss it between the readings. On a bed of twenty six metres, ten metres is already a lot.  |
| <b>Site extent</b>                  | The site the boreholes are placed on. Empty means a kilometre from the origin, which is written to the log.                                       |
| <b>Surface elevation, m</b>         | The mean elevation of the ground surface.                                                                                                         |
| <b>Drilling depth, m</b>            | Collars are placed on a gentle relief around it. The drilling depth down from the surface. The proportions of the body are taken from it as well. |
| <b>Sampling noise, a share</b>      | The share of lognormal sampling noise. Zero gives data without noise, where the model itself is visible.                                          |
| <b>The random seed</b>              | The same seed gives the same data: with it methods can be compared on an unchanged sample set.                                                    |
| <b>Samples with grades</b>          | Samples with the fields hole, from_m, to_m, grade, truth, zone.                                                                                   |
| <b>Core grade above background</b>  | The core grade above background. The boundary of the body is where the grade falls to half of it.                                                 |
| <b>Background in the host rock</b>  | The background in the host rock. The cutoff that separates the body is computed from it and from the core grade.                                  |
| <b>Overall grade trend, a share</b> | The overall grade trend across the site. It is there so the data does not reduce to a single body.                                                |
| <b>Share of holes stopped short</b> | The share of holes stopped short. It is there so the cube has places without data, as on real exploration.                                        |
| <b>Hole inclination, degrees</b>    | The tilt of the holes from the vertical. Zero gives vertical boreholes.                                                                           |

## 2.02 Interpolating points in 3D

Computes a value at the nodes of a volume grid from points with elevation.

Anisotropy is the ratio of the vertical scale to the horizontal one. Without it the nearest point turns out to be the neighbouring borehole rather than the neighbouring sample at the same place in plan.

Nodes with fewer points within the radius than needed stay a gap: emptiness beats an invented value.

Neighbours are gathered by sectors: the circle around the node is split into equal parts and each gives its share of the nearest points. Without this, under anisotropy all the neighbours land in one borehole, because a sample in the hole is hundreds of times closer than the neighbouring hole, and inverse distances degenerate into nearest neighbour. One sector switches the split off.

The elevation source is set separately. A flat layer gives a zero Z at every point, so taking it from the geometry will not do: all the samples would land in one plane. An elevation field suits a

computed elevation, and depth below a surface suits samples that record a depth rather than an elevation. A point whose elevation could not be obtained is left out, and the number of those is written to the log.

| Field                                                   | What it sets                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Points with an elevation</b>                         | The layer of samples. The elevation comes from the geometry, from a field or from a surface, which is set below.                                                                                                                                                                  |
| <b>The value field</b>                                  | The numeric field whose value is spread through the cube: grade, concentration, moisture. On the demonstration data from 2.01 it is grade rather than hole: otherwise the cube comes out of borehole numbers.                                                                     |
| <b>Elevation source</b>                                 | A flat layer gives a zero Z at every point. Taking it from the geometry would put every sample in one plane and the cube would be meaningless.                                                                                                                                    |
| <b>Elevation or depth field</b>                         | For elevation from a field this is the elevation itself, for depth it is the depth measured down from the surface.                                                                                                                                                                |
| <b>Surface the depth is measured from</b>               | The grid the depth is measured from. Needed by soil and similar samples, which record a depth rather than an elevation.                                                                                                                                                           |
| <b>The method</b>                                       | Nearest neighbour gives steps and suits checking the data. Inverse distances give a smoothed field.                                                                                                                                                                               |
| <b>Step in plan, m (0 means from the data)</b>          | Zero takes a fifth of the distance between places in plan. Finer is pointless: there is no data in between anyway, and the node count grows as a square.                                                                                                                          |
| <b>Vertical step, m (0 means from the data)</b>         | Zero takes half the sampling step. Coarser means merging neighbouring samples and losing the difference with depth.                                                                                                                                                               |
| <b>Largest number of points (0 means from the data)</b> | Zero takes one more than the number of samples at one place in plan. More means mixing all the levels at once and smoothing an anomaly with depth away.                                                                                                                           |
| <b>A cube of values</b>                                 | A multiband grid: a band is a horizontal level, and the elevation of the first level and the step go into the metadata.                                                                                                                                                           |
| <b>Anisotropy (0 means from the data)</b>               | Zero measures the variogram on the data and takes the ratio of the vertical range to the plan one. This is the case where no guessing is needed. A value of your own sets the scale by hand: a large one smooths along the vertical, a small one keeps the difference with depth. |
| <b>The search radius, m (0 is automatic)</b>            | Zero takes a quarter of the data extent. A node with too few points within the radius stays a gap.                                                                                                                                                                                |
| <b>The power of the inverse distances</b>               | The larger the power, the more a near point outweighs the far ones. Two is the usual choice.                                                                                                                                                                                      |
| <b>The smallest number of points</b>                    | A node with fewer points within the radius than this stays a gap: emptiness beats an invented value.                                                                                                                                                                              |

| Field                                         | What it sets                                                                                                                                                                                                                                                                             |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Search sectors (0 means from the data)</b> | Zero takes it from the data: boreholes need the split, or all the neighbours land in one hole, while for samples in plan it only tears the field. A sector boundary runs as a ray from the node, and the set of neighbours changes across it in a jump: hence the stars on soil samples. |

## 2.03 Cube to a block model

| Field                                        | What it sets                                                                                                                   |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Cube of values (bands are levels)</b>     | A cube of values from 2.02: bands are levels, the elevation of the first level and the step live in the metadata.              |
| <b>Apply the cutoff</b>                      | Without a cutoff every cell with data is written out, with one only those not below it.                                        |
| <b>Cutoff</b>                                | The value below which a cell does not reach the model.                                                                         |
| <b>Computation contour</b>                   | Polygons outside which cells are not written out: a computation block, a licence area.                                         |
| <b>Clip above (surface)</b>                  | The surface above: the points below it stay. That is how everything above the ground surface or above the bed roof is cut off. |
| <b>Clip below (surface)</b>                  | The surface below: the points above it stay. Together with the upper one only the bed is left.                                 |
| <b>Block model</b>                           | A centroid point per occupied cell with the block size, volume and value.                                                      |
| <b>Colour intervals (0 means no classes)</b> | How many intervals to split the value into. The interval number goes into the cls field and suits colouring.                   |
| <b>Density, t/m3 (0 means no conversion)</b> | With a density given, mass is added to every block in the dens and ore_t fields.                                               |

## 2.04 Cube body as voxels

| Field                                           | What it sets                                                                                                                            |
|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cube of values (bands are levels)</b>        | A cube of values from 2.02: bands are levels, the elevation of the first level and the step live in the metadata.                       |
| <b>Cutoff</b>                                   | A cell not below the cutoff counts as a body. For the demonstration data the cutoff is printed by 2.01.                                 |
| <b>Computation contour</b>                      | Polygons outside which cells do not reach the body: a computation block, a licence area.                                                |
| <b>Colour intervals (0 means a single body)</b> | Zero builds one body. Several intervals give a feature each, and the body can be coloured by grade. Not read when own bounds are given. |

| Field                                       | What it sets                                                                                                                                                                                                                                                  |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Own interval bounds, space separated</b> | Own interval bounds, space separated: 0 5 10 15. They set the split instead of equal shares. A comma inside a number is a decimal mark. Order and repeats do not matter. A cell above the last bound stays in the last interval, it must not be lost.         |
| <b>Interval names, comma separated</b>      | Interval names, comma separated: low, medium, high. They go into the name field. Missing ones stay empty, extra ones are dropped.                                                                                                                             |
| <b>Merge neighbouring faces</b>             | Merging makes the layer many times lighter but tears the boundary of the body with T-junctions. Such a body can neither be measured by volume nor cut in the scene: the cut stays open, there is nothing to cap it with. For volumes and cuts clear the flag. |
| <b>Remove edge pinches</b>                  | A pinch is two cells touching along a single diagonal. It is not a hole, but its edge belongs to four faces and a watertightness check rejects such a body.                                                                                                   |
| <b>Body as voxels</b>                       | MULTIPOLYGON Z, one feature per colour interval. Fields cls, vmin, vmax, faces and shell.                                                                                                                                                                     |

## 2.05 Check of the interpolation

| Field                                                    | What it sets                                                                                                                                                                                                                                                            |
|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Points with an elevation</b>                          | The same layer of samples that goes into 2.02. The check runs on the samples themselves, no cube is needed for it.                                                                                                                                                      |
| <b>The value field</b>                                   | The value field the cube is built from. That is what we check. On the demonstration data from 2.01 it is grade.                                                                                                                                                         |
| <b>Elevation source</b>                                  | The elevation source must match the one set in 2.02, otherwise a different arrangement of points is checked.                                                                                                                                                            |
| <b>Elevation or depth field</b>                          | For elevation from a field this is the elevation itself, for depth it is the depth measured down from the surface.                                                                                                                                                      |
| <b>Surface the depth is measured from</b>                | The grid the depth is measured from. The same one as in 2.02.                                                                                                                                                                                                           |
| <b>Borehole field (empty means one sample at a time)</b> | The borehole number. With it the whole hole is removed from the set and the check measures the ability to hit between holes. Without it one sample is removed, the neighbours come from the same hole, and the error comes out several times smaller than the real one. |
| <b>The method</b>                                        | The method you intend to use in 2.02. The check is there to choose between them by numbers rather than by eye.                                                                                                                                                          |

| Field                                                   | What it sets                                                                                                                                             |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Largest number of points (0 means from the data)</b> | Zero takes one more than the number of samples at one place in plan. This is the same choice as in 2.02.                                                 |
| <b>Check residuals</b>                                  | Samples with the fields value, model, resid and aresid. They show not only how large the miss is but where it happened.                                  |
| <b>The anisotropy (vertical to horizontal)</b>          | The ratio of the vertical scale to the horizontal one. It is picked exactly by the error of this check.                                                  |
| <b>The search radius, m (0 is automatic)</b>            | Zero takes a quarter of the data extent. A sample with no points around it stays unchecked.                                                              |
| <b>The power of the inverse distances</b>               | The power of inverse distances. It is picked by the error of this check together with the anisotropy.                                                    |
| <b>The smallest number of points</b>                    | A sample with fewer points around it than this stays unchecked and does not enter the error.                                                             |
| <b>Search sectors (0 means from the data)</b>           | Zero takes it from the data: boreholes need the split, or all the neighbours land in one hole, while for single samples in plan it only tears the field. |

## 2.06 Kriging in three dimensions

| Field                                     | What it sets                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Points with an elevation</b>           | The same layer of samples that goes into 2.02. The elevation is set below in the same way.                                                                                                                                                                                                                         |
| <b>The value field</b>                    | The numeric field whose value is spread through the cube. On the demonstration data from 2.01 it is grade.                                                                                                                                                                                                         |
| <b>Elevation source</b>                   | A flat layer gives a zero Z at every point. Taking it from the geometry would put every sample in one plane and the cube would be meaningless.                                                                                                                                                                     |
| <b>Elevation or depth field</b>           | For elevation from a field this is the elevation itself, for depth it is the depth measured down from the surface.                                                                                                                                                                                                 |
| <b>Surface the depth is measured from</b> | The grid the depth is measured from. Needed by samples that record a depth rather than an elevation.                                                                                                                                                                                                               |
| <b>Reference surface (flattening)</b>     | The roof or the floor of the bed. With it the vertical is counted from the surface and the computation runs along the bedding. The variogram is measured in the flattened coordinates already: measuring it in absolute ones and computing in flattened ones would give a model that does not belong to this data. |
| <b>Floor for the thickness fraction</b>   | The second surface. With it the elevation becomes a fraction of the thickness: zero at the roof, one at the floor.                                                                                                                                                                                                 |

| Field                                           | What it sets                                                                                                                                                                                                                                                                             |
|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step in plan, m (0 means from the data)</b>  | Zero takes a fifth of the distance between places in plan. Finer is pointless: there is no data in between anyway, and the node count grows as a square.                                                                                                                                 |
| <b>Vertical step, m (0 means from the data)</b> | Zero takes half the sampling step. Coarser means merging neighbouring samples and losing the difference with depth.                                                                                                                                                                      |
| <b>Neighbours per node</b>                      | Neighbours per node. Kriging solves a system the size of their number, so the cost grows as a cube: sixteen is the usual choice, thirty two is already noticeably dearer.                                                                                                                |
| <b>Measure the variogram on the data</b>        | The variogram is measured on the data itself: the range from the plan measurement, the nugget from the vertical one. Setting three numbers by eye is pointless, measuring them was the whole idea.                                                                                       |
| <b>A cube of values</b>                         | A cube of values: a band is a horizontal level.                                                                                                                                                                                                                                          |
| <b>Cube of the estimation variance</b>          | A cube of the estimation variance, of the same size. Zero at a sample, growing away from the data. It is a map of trust, and it is the one thing kriging always gives, whatever the density of the grid.                                                                                 |
| <b>Variogram model</b>                          | The kind of model. The difference between them is small, what matters more is the behaviour near zero: the gaussian one gives too smooth a field where the data is noisy.                                                                                                                |
| <b>Nugget effect</b>                            | The scatter that does not fall even between neighbouring samples: sampling error and variability finer than the grid. Read only when the automatic measurement is off.                                                                                                                   |
| <b>Sill</b>                                     | The overall scatter of the data the variogram reaches at large distances.                                                                                                                                                                                                                |
| <b>Range, m</b>                                 | The distance beyond which samples know nothing about each other.                                                                                                                                                                                                                         |
| <b>Anisotropy (0 means from the data)</b>       | Zero takes the ratio of the vertical range to the plan one, measured on the data. This is the case where no guessing is needed.                                                                                                                                                          |
| <b>The search radius, m (0 is automatic)</b>    | Zero takes a quarter of the data extent. A node with too few points within the radius stays a gap.                                                                                                                                                                                       |
| <b>Search sectors (0 means from the data)</b>   | Zero takes it from the data: boreholes need the split, or all the neighbours land in one hole, while for samples in plan it only tears the field. A sector boundary runs as a ray from the node, and the set of neighbours changes across it in a jump: hence the stars on soil samples. |

## 2.07 MBA in volume

Builds a cube of values from scattered points with multilevel B-splines.

A coarse lattice approximates the data, the residual is approximated by a lattice twice as fine, and so on level by level. No system of equations is solved: the work is linear in the number of points, and on hundreds of thousands of measurements the method computes where kriging stalls.

The method approximates rather than estimates. It does not hit the measured values exactly and gives no estimation error. Next to kriging it is good as a trend, which is then refined by kriging the residuals.

Beyond the cloud of points the surface goes anywhere: the edge coefficients have no data. Clip the result by a contour or by surfaces.

| Field                                                      | What it sets                                                                                                                                                                                                                                                |
|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Points with an elevation</b>                            | Measured points: borehole samples, intervals, anything with an elevation and a value.                                                                                                                                                                       |
| <b>The value field</b>                                     | The field with the value spread through the volume.                                                                                                                                                                                                         |
| <b>Elevation source</b>                                    | Where the elevation of a sample comes from: the geometry height, a field, or a depth below a surface.                                                                                                                                                       |
| <b>Elevation or depth field</b>                            | The field of elevation or depth, when it is not in the geometry.                                                                                                                                                                                            |
| <b>Surface the depth is measured from</b>                  | The surface the depth is measured from.                                                                                                                                                                                                                     |
| <b>Initial lattice in plan</b>                             | The initial lattice in plan: the method starts from it and doubles it at every level. A finer start gives a better first approximation but takes more memory.                                                                                               |
| <b>Initial lattice down the vertical</b>                   | The initial lattice down the vertical. Exploration data is elongated and the lattice need not be cubic: kilometres in plan and metres in thickness are different things. A smaller number here both stretches the influence along the bed and saves memory. |
| <b>Levels</b>                                              | How many times to double the lattice. Every level picks up what the previous one could not: the residual falls fast, while the memory of the last level grows as a cube.                                                                                    |
| <b>Cube step in plan (0 means from the data)</b>           | The cube step in plan. Zero takes it from the sampling net.                                                                                                                                                                                                 |
| <b>Cube step down the vertical (0 means from the data)</b> | The cube step down the vertical. Zero takes it from the net.                                                                                                                                                                                                |
| <b>A cube of values</b>                                    | A multiband grid: a band is a horizontal level of the cube. It is read by 2.03, 2.04 and the scene.                                                                                                                                                         |
| <b>Stop by residual (0 means all levels)</b>               | Stopping by residual: once the largest deviation from the measured values falls below it, no further levels are built. Zero means build them all.                                                                                                           |
| <b>Smallest value (empty means no bound)</b>               | The smallest possible value: a grade is never below zero, while the method does leave the range. What leaves is pressed to the bound, and a plateau appears where the overshoot was - the shape is lost there. Leave it empty if there is no bound.         |
| <b>Largest value (empty means no bound)</b>                | The largest possible value. The number of clamped nodes goes to the log: it shows whether the model is any good.                                                                                                                                            |

## 2.08 Beds from sections

Builds a grid of beds from the outlines drawn on sections.

Every ring runs along the roof one way and along the floor back, so two surfaces are taken from it. They are interpolated over the area with multilevel B-splines, and the space between the sections is filled.

The position of the sections is taken from the geometry itself, from the vertices of the outlines. The lines of the sections need not be given separately. A flat drawn section is no good: it has no real elevations.

The output is a multiband grid: a roof and a floor per bed. The scene shows such a grid as a bed body, and 1.02 and 1.03 compute the thickness, the blocks and the volumes from it.

The floor of the upper bed and the roof of the lower one are one and the same boundary if the geologist drew them as one line. Such a boundary is built once from both sets of points: built separately, they drift apart between the sections, and the model gets a gap or an overlap that the section does not have. The threshold of the gluing is set by the tolerance.

The area mask clips the result: between the sections there is no data, and the mask says how far to trust the surfaces.

Between the sections the surface goes where the interpolation put it: there is no data there. Where the sections cross, the elevations on them must agree. The disagreements are counted and go to the log together with the coordinates of the place where they are largest: with a number alone there is nowhere to look for the vertex that slipped.

| Field                                         | What it sets                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Outlines on sections (polygons with Z)</b> | A layer of outlines on sections: polygons with real Z. The position of the sections is taken from the geometry itself, from the vertices of the outline, and is never asked for. A flat drawn section is no good: its X and Y are coordinates on the sheet and there are no elevations at all. The geometry type must be PolygonZ or MultiPolygonZ. |
| <b>The field of the bed number</b>            | The field of the bed number. Every bed gives two bands in the grid: a roof and a floor.                                                                                                                                                                                                                                                             |
| <b>This bed only (empty means all)</b>        | The number of the bed, if only one is wanted. Empty means all.                                                                                                                                                                                                                                                                                      |
| <b>Grid step, m (0 means from the data)</b>   | The step of the grid over the area. Zero takes a two-hundredth of the extent.                                                                                                                                                                                                                                                                       |
| <b>Area mask (polygons, optional)</b>         | A polygon layer the result is clipped by. Outside it there is no grid at all. Between the sections there are no data, and the surface goes where the interpolation drew it: the mask says how far to trust that. Usually it is the outline of a working, a pit or a block. Empty - the grid covers the whole extent of the contours.                |
| <b>Grid of the beds</b>                       | A multiband grid: a roof and a floor per bed, in order of the numbers. The scene shows such a grid as a bed body, 1.02 computes the thickness from it and 1.03 the blocks and the volumes.                                                                                                                                                          |

| Field                                   | What it sets                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Levels</b>                           | Levels in the multilevel approximation. Few levels give a smooth surface, many bring it closer to the elevations on the sections.                                                                                                                                                                                                   |
| <b>Contact gluing tolerance, m</b>      | The tolerance within which the floor of the upper bed and the roof of the lower one count as one surface and are built once. Two surfaces built independently drift apart between the sections, and the model gets a gap or an overlap that the section does not have. Zero switches the gluing off: then every surface is its own. |
| <b>Margin outwards from the mask, m</b> | A margin outwards from the mask. The bed usually continues beyond the outline of a working, and clipping exactly along it would cut away what the data do hold.                                                                                                                                                                     |

## From drawings on sections to a body

The tool **2.08 Beds from sections**, for when the holes are few and the sections are drawn.

### Where the coordinates come from

From the geometry of the outlines, and from nowhere else. An outline on a three-dimensional section is a polygon whose every vertex has X, Y and Z. X and Y run along the line of the section, Z is the elevation. The tool works out the plane of the outline from those vertices, taking the direction from the largest spread of the points in plan. The lines of the sections need not be given separately: they are already in the data.

A flat drawn section is no good: its X and Y are coordinates on the sheet, not on the ground, and there are no elevations at all. The geometry type must be PolygonZ or MultiPolygonZ.

### How the roof and the floor are taken

The ring of the outline is sampled across, along the line of the section: at every step the upper point of the ring and the lower one. Splitting the ring in half is not allowed - only a fence is built that way, with the top running forward and the bottom back, while a hand-drawn outline has its vertices in any order.

It is these two surfaces that are interpolated, not the body as a whole. A roof and a floor are ordinary surfaces, and the problem about them has a solution for any layout of sections.

Before the fitting a flat trend is removed from the elevations. Without that the error of the method grows with the elevation itself rather than with its spread: on a roof around minus two hundred and fifty metres with a spread of eighty centimetres the surface went off by fourteen metres, and no number of levels mended it.

### The contact of neighbouring beds

The floor of the upper bed and the roof of the lower one are one and the same boundary if the geologist drew them as one line. Built separately, they drift apart between the sections, and the model gets a gap or an overlap that the section does not have.

The tool brings the samples of neighbouring beds together and measures the spread of the elevations. If it is within the **contact gluing tolerance**, the boundary is built once from both sets of

points and put into both bands: the gap is then zero by construction. If it is larger, the surfaces are built separately and a warning goes to the log with the coordinates of the place where the disagreement is largest. Go there and look in your own layer of outlines: usually one vertex has slipped.

For this the beds are ordered by their bedding, from the top down, rather than by the name of the field: numbers come as text, and then “10” stands between “1” and “2”.

## A lens inside a bed

The outlines of one section plane are taken together, by their outer boundary: the roof follows the topmost of them, the floor the lowest. A lens or a parting drawn inside a bed under the same number therefore does not touch the boundary of the body. Their samples used to be pooled together, and the cloud of the roof held both the real roof and the top of the lens: the interpolation got two answers in one place and ran the surface between them.

If the lens is wanted as a body of its own, give it its own bed number.

Outlines of different sections are never merged this way. A disagreement at one place in plan between two sections is data, and it must be seen rather than hidden by taking the outermost.

## How far to trust the surface

The grid is built over the whole extent of the outlines, and beyond the sections the surface goes where the interpolation put it. The **area mask** says how far to trust that: outside it there is no grid at all. Usually it is the outline of a working, a pit or a block. The **margin outwards from the mask** is left because the bed continues beyond the outline of a working, and clipping exactly along it would cut away what the data do hold.

## The order of the work

1. Outlines of the beds on sections: polygons with real Z.
2. **2.08 Beds from sections**. Set the field of the bed number and leave “This bed only” empty: all the beds are built in one run, on a common grid. In separate runs every bed gets its own extent and its own step, and the contacts between them no longer meet.
3. The log: the thickness over the area must lie within the thickness on the sections, and the lines about the contacts must show centimetres rather than decimetres.
4. The grid into the scene, the **Bed body** mode. The shells button puts the bodies into a project layer, with the volume in the attributes.
5. Thickness, volume and reserves come from **1.02 Bed calculator**, the block model from **1.03**.

What is worth knowing beforehand. The accuracy is decided by how often the sections are spaced, and no computation can mend that: between two sections there is no data.

The volume of a body from the shells button and the volume from 1.02 will not agree exactly. The mesh runs through the centres of the cells, 1.02 counts whole cells, and the difference is the half-cells around the perimeter: about one per cent on a grid of two hundred cells, and noticeably more on a coarse one.

## Typical tasks

Six chains that come round again and again in the work. Numbers with a dot are Isoliner3D tools, names without a number are the neighbouring Isoliner.

## From boreholes to reserves

1. Samples with grades in a point layer, the elevation in the geometry or in a field.
2. **2.05 Cross-validation** to choose the parameters. Leave out a whole hole, not a single sample: a neighbouring sample in the same hole almost repeats the one left out, and the error comes out lower than the real one.
3. **2.02 Interpolation of points in volume** or **2.07 MBA in volume** for the cube of values.
4. The cube into the scene, isosurface mode. Clipping by the terrain and by the licence outline is in the scene properties.
5. The **shells into a project layer** button: bodies with the volume of each.

## From horizons to a bed

1. In Isoliner the **roof** and the **floor** are interpolated in plan.
2. **1.01 Assemble a bed grid** - a multiband grid.
3. **1.03 Bed into a block model** - blocks with volume and mass.
4. The same grid shows in the scene as a bed body, without any conversion.

## A section on the drawing and in volume

The section fence built by Isoliner is polygons with real Z, and it goes into the scene as it is; the colour of the beds comes from the color field. The point is a check by eye: the fence lies on the surfaces it was built from.

## What has changed between surveys

Two models of the same area from different times, then **1.06 Reserve difference**.

## Showing it to someone who is not a geologist

**GLB** for a browser, Blender or Windows; PNG frames of a turn for a video; **STL** or **OBJ** for CAD. For CAD switch on the cap at the cube edge: an open shell will show as a mesh but will not become a solid.

## Checking the data before the model

**2.05** leaving out one sample, and the same leaving out a whole hole. The difference between the two errors tells what the model rests on.

Measured on the demonstration deposit, samples every five metres down the hole: with a 100 m grid of holes the ratio is 0.9, with 200 m it is 1.6, with 400 m it is 2.6. The error per sample hardly changes with the grid - a neighbour down the hole is always close by. The error per hole grows with the distance between the holes, and that one is the real one.

The figures are for the demonstration data; yours will differ. What matters is the ratio and how it changes as the grid gets denser.

## Neighbouring plugins

**Isoliner** - interpolation in plan, contours, terrain, drawn sections, borehole graphics. Isoliner3D reads what it builds.

**Topoliner** - topographic constructions.

## Licence and developer

Isoliner3D is developed by **Inform++ LLC**, Perm — [www.informpp.ru](http://www.informpp.ru).

The module is distributed under the **GNU General Public License, version 2 or, at your option, any later version** (GPL-2.0-or-later). You are free to use, study, modify and pass it on; when passing on a modified version you must keep the same licence and open the source. The full text of the licence is in the LICENSE file inside the module.

The program is distributed in the hope that it will be useful, but **with no warranty whatsoever**, including the implied warranty of fitness for a particular purpose. Responsibility for the results rests with whoever applies them: every model is an approximation, and decisions about reserves and mining are made by a specialist, not by a program.

The bundled pyqtgraph and PyOpenGL libraries carry their own licences, compatible with the GPL.

## Where to look

The **About the plugin** button on the toolbar, and the menu item of the same name, show the version and the links, open the changelog and the log of the module.

The log is started when the module loads, next to the QGIS profile, as isoliner3d.log. Every step goes into it, not only failures. The lines the tools print go there as well, not only into the Processing window: a picture of the log used to show that a run took half a second and not a single number to judge the result by.

| Where                                                | What for                                   |
|------------------------------------------------------|--------------------------------------------|
| <a href="http://www.informpp.ru">www.informpp.ru</a> | about the developer and the other products |
| <a href="#">Source code</a>                          | builds, history, texts                     |
| <a href="#">Report a bug</a>                         | if something works wrong                   |

When reporting a bug, attach the version from the window title and the lines from the log: with them the cause is found in one go.