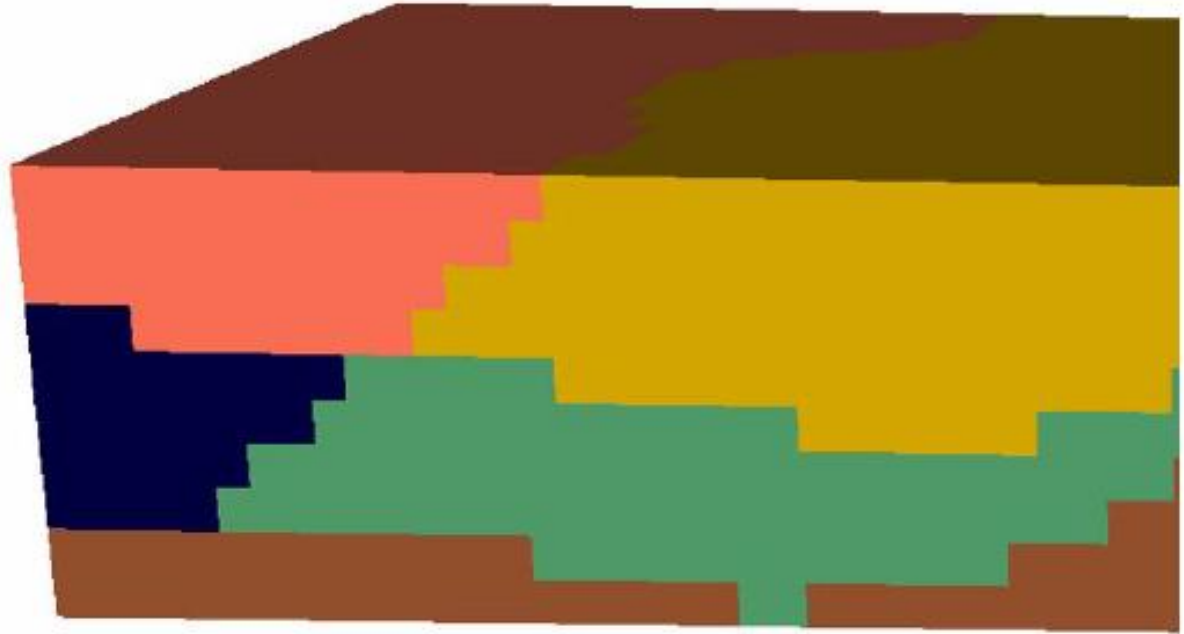


# 7. Übung

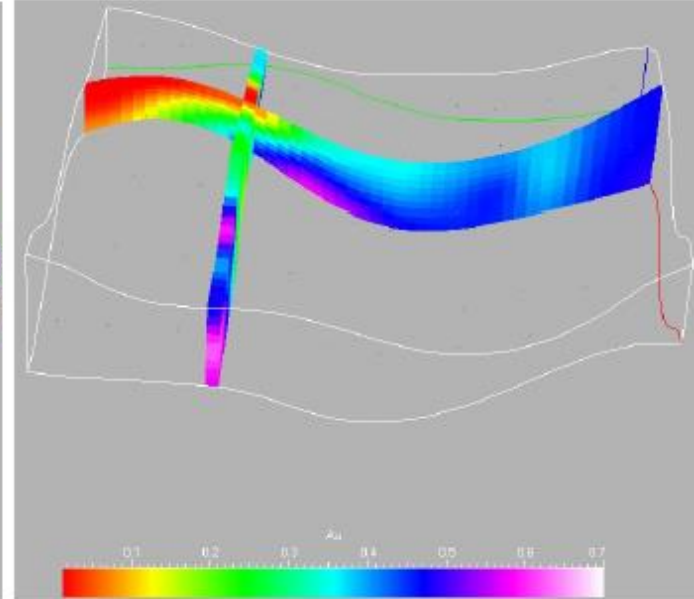
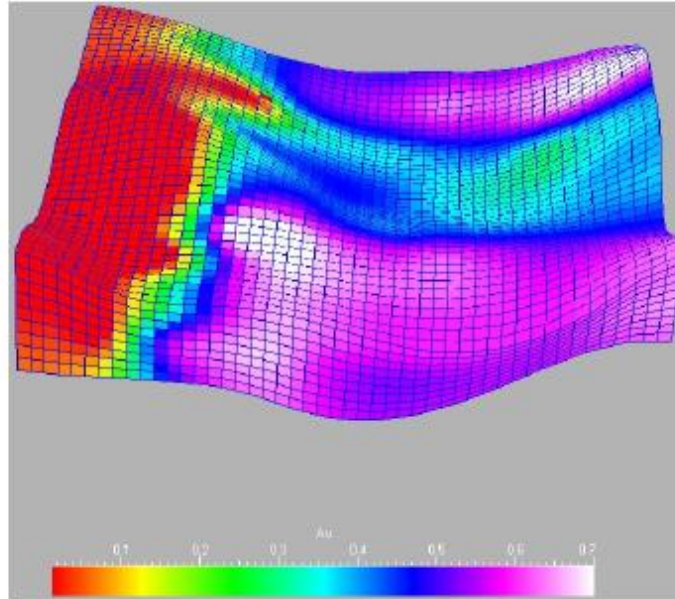


## Volumenobjekte

# Volumenobjekte in Skua-Gocad

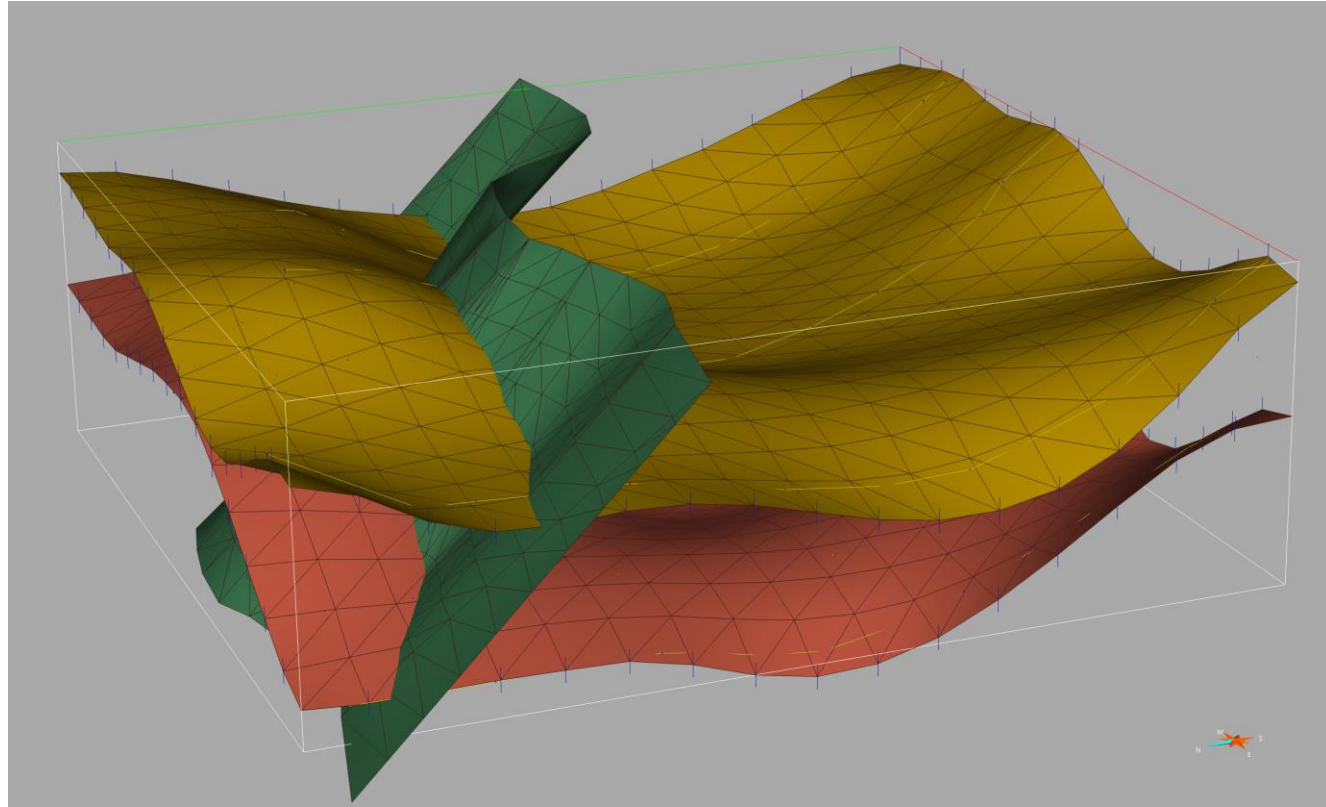
Erstellung von Volumenobjekten in Skua-Gocad. (Kapitel 10/11 im Tutorial)

1. Voxel
2. Model3D
3. Solid
4. SGrid



## Vorarbeiten

Laden Sie die Datei *sgrid.zip* aus OPAL. Entpacken Sie sie in ein lokales Verzeichnis und starten Sie das beinhaltete Projekt.





## Vorarbeiten

Erstellen Sie jetzt ein neues Projekt, im welchem Sie das Add-On *Finite Element Mesh Constructor* laden.

Importieren Sie alle Objekte aus dem vorherigen Projekt.

The 'Choose Objects to Import' dialog box shows a table of objects from a previous project. The 'Imported' column is highlighted in blue for all objects, indicating they are selected for import. Below the table, the 'Import Options' section is visible, with the radio button for 'Copy into project selected objects and all linked objects' selected.

	Name	Type	Imported	User	Domain	Scenario
4	GOGrid	QDOMDocum...	No			
5	hangingwall	Curve	No			
6	bottomwall	Curve	No			
7	fault	Curve	No			
8	fault_0	Surface	No			
9	DataAnalysis...	DataAnalysis...	No			
10	hanging	Surface	No			
11	box	Voxel	No			
12	PDA_Load_Pro...	QDOMDocum...	No			
13	bottom	Surface	No			
14	Camera#0	XMDrawingWi...	No			
15	Views2D	QDOMDocum...	No			
16	MapWell	QDOMDocum...	No			

The 'Product Selection' dialog box shows a list of products and bundles. The 'Add-ons' section is expanded, and the 'Finite Element Mesh Constructor' checkbox is checked. Other add-ons like 'LGR and Upscaler' and 'Reservoir Simulation Link' are also checked.

**Products and Bundles**

- SKUA® Architecture
- SKUA® Exploration Modeling Essentials
- SKUA® Exploration Modeling Pro
- SKUA® Reservoir Modeling Essentials

**Add-ons**

- Production and Engineering
  - SKUA® Flow Simulation Grids
  - SKUA® Hybrid Simulation Grids
  - SKUA® 2D Extruded Simulation Grids
  - Finite Element Mesh Constructor**
  - LGR and Upscaler
    - Fracture Modeling (FracMV™)
  - Reservoir Simulation Link
  - Production Data Analysis
  - Production Data Uncertainty
    - Production Risk Assessment Jacta® -3DSL Co...
    - Production Risk Assessment Jacta® -FrontSi...

Show Product Selection Summary

Buttons: OK, Cancel, Help

## Voxet

- Regelmäßiges Parallelepipet-Gitter
  - Ursprung  $\vec{X}_0 = (x_0, y_0, z_0)$
  - Kathesisches Gitterkoordinaten-System mit u-, v- und w-Achse
  - Zellenanzahl pro Gitterachse:  $n_u, n_v, n_w$
  - Schrittvektoren:  $\vec{u}_{step} = (x_u, y_u, z_u), \vec{v}_{step} = (x_v, y_v, z_v), \vec{w}_{step} = (x_w, y_w, z_w)$
  - Relevante Punkte sind immer die Zellmittelpunkte
  - $\vec{x}_{i,j,k} = \vec{X}_0 + i * \vec{u}_{step} + j * \vec{v}_{step} + k * \vec{w}_{step}$

# Voxet

- Regelmä
  - Urs
  - Kat
  - Zel
  - Sch
  - Rel
  - $\vec{x}_{i,j}$

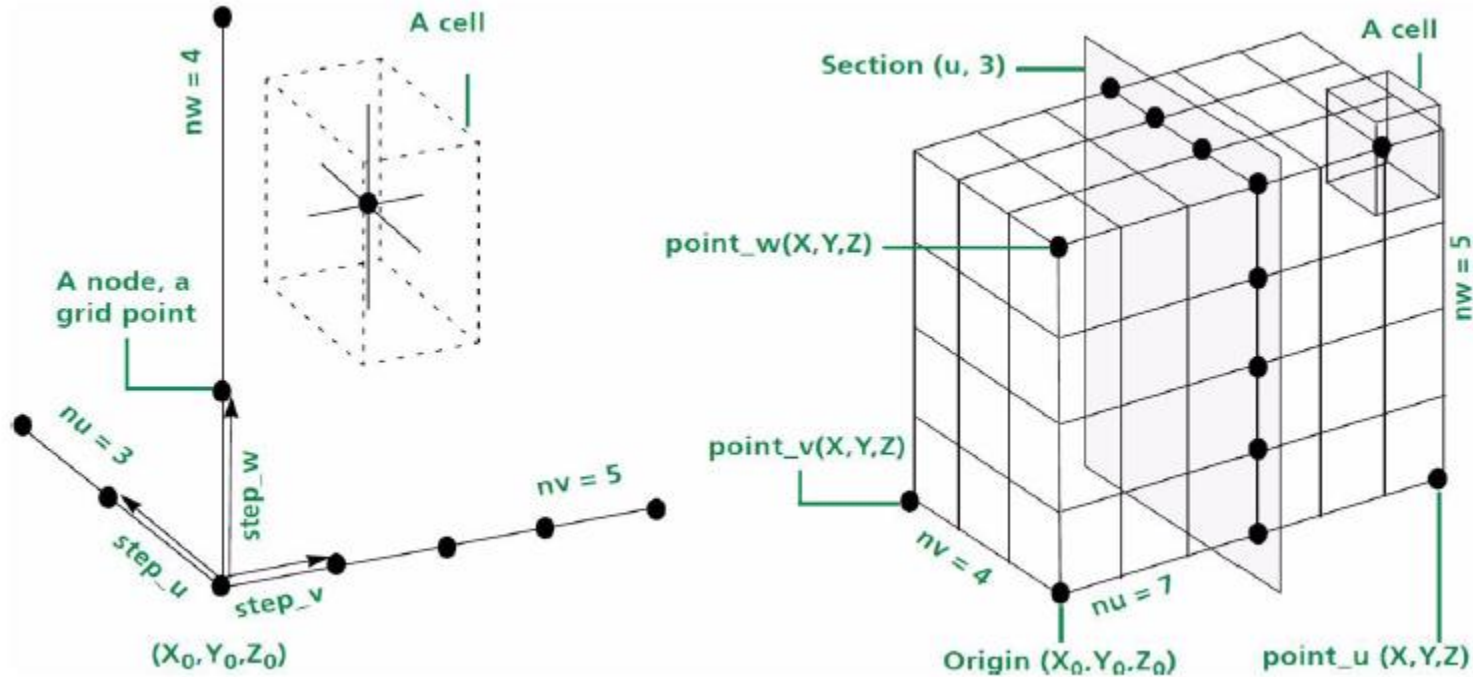


Fig. 10.a: Components of a voxel.

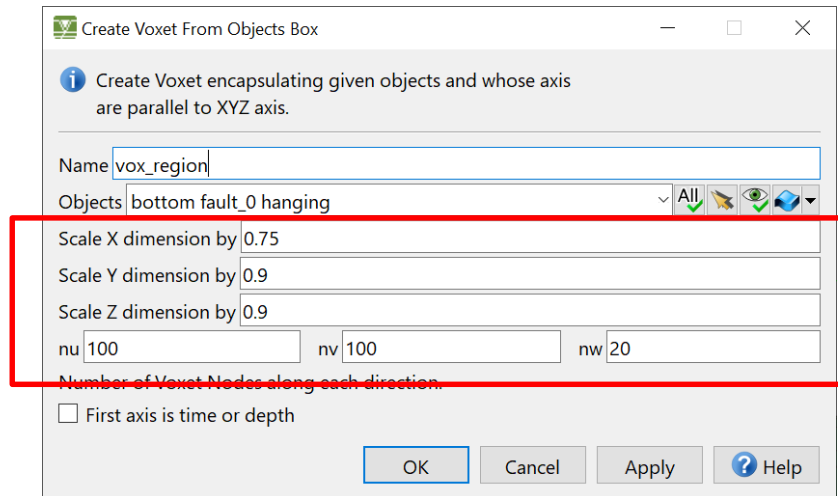
## Voxet erstellen

Ziel ist in einem ersten Schritt die Erstellung eines Voxet-Objektes, welches die stratigrafische Einheit mittels einer ID pro Zelle beinhaltet.

Das zu erstellende Voxet muss dabei kleiner sein, als die zugrundeliegenden Flächen.

### *Voxet mode*



- *New > From Object Box*



Create Voxet From Objects Box

Create Voxet encapsulating given objects and whose axis are parallel to XYZ axis.

Name

Objects  All  

Scale X dimension by

Scale Y dimension by

Scale Z dimension by

nu  nv  nw

Number of Voxet Nodes along each direction.

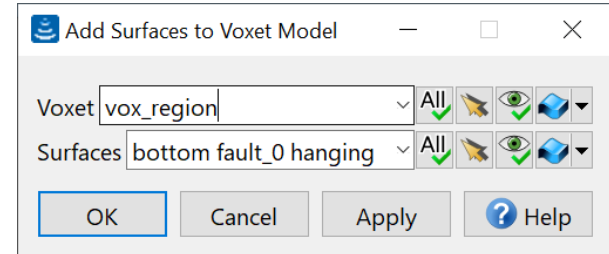
First axis is time or depth

OK Cancel Apply Help

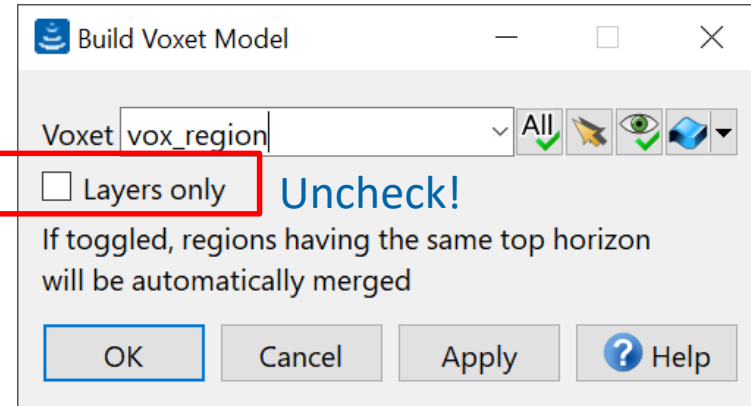
## Voxet in Regionen unterteilen

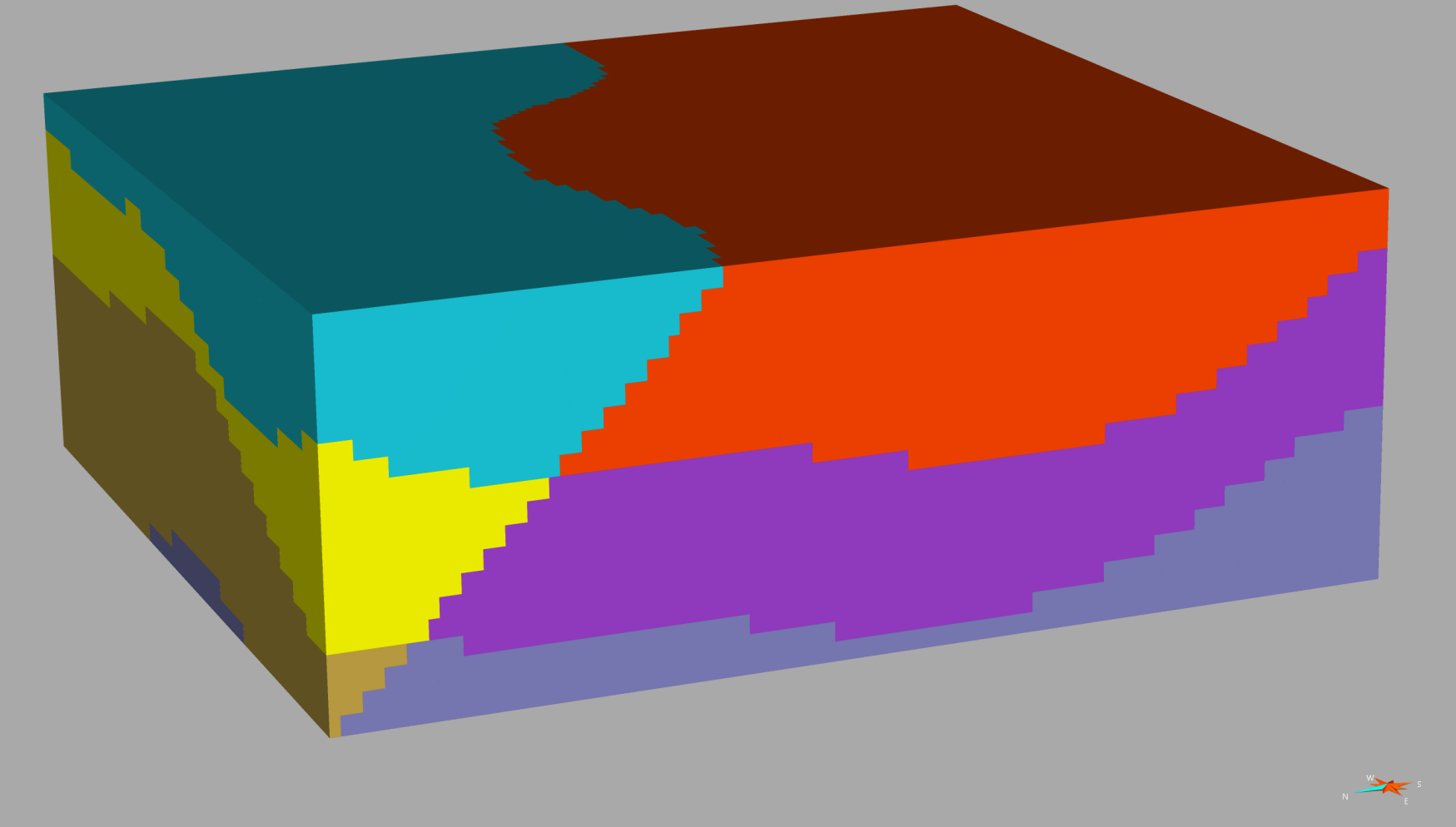
Mittels der vorhandenen Flächenobjekte soll das erstellte Voxet jetzt in Regionen unterteilt werden.

1. *Model > New > Add Surfaces*



2. *Model > New > Build*





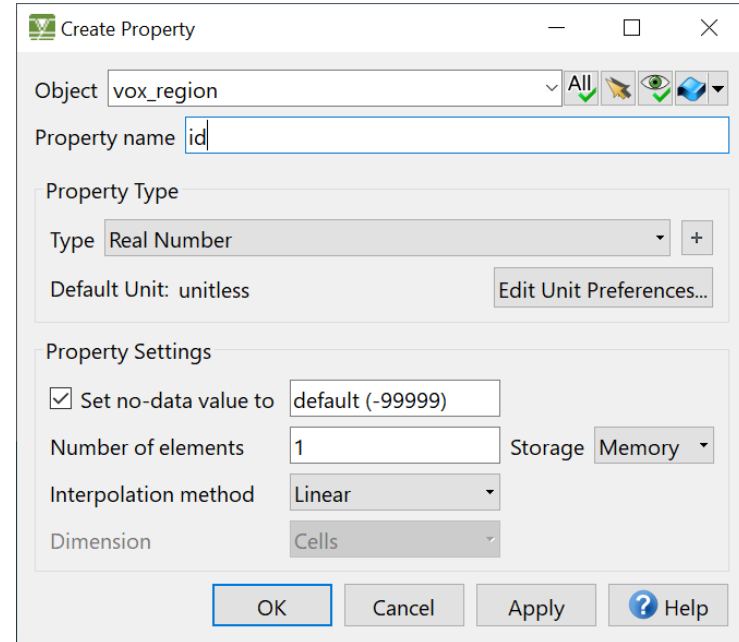
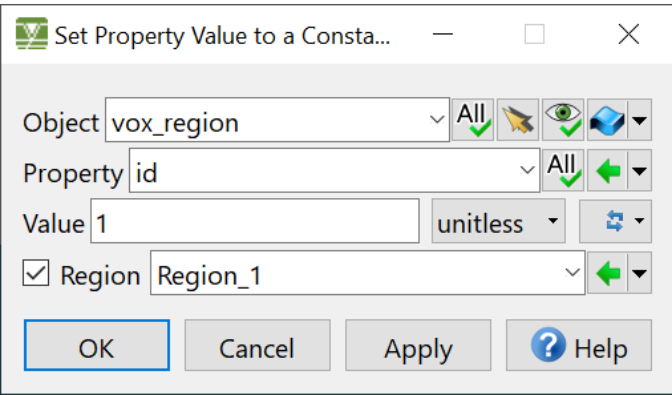


# Voxet in Regionen in Eigenschaft überführen

Die Regionen lassen sich als Property in den Zellen speichern:

1. *Property > create*

2. *Property > Set Constant*  
Wiederholung für alle Regionen!





Workflow

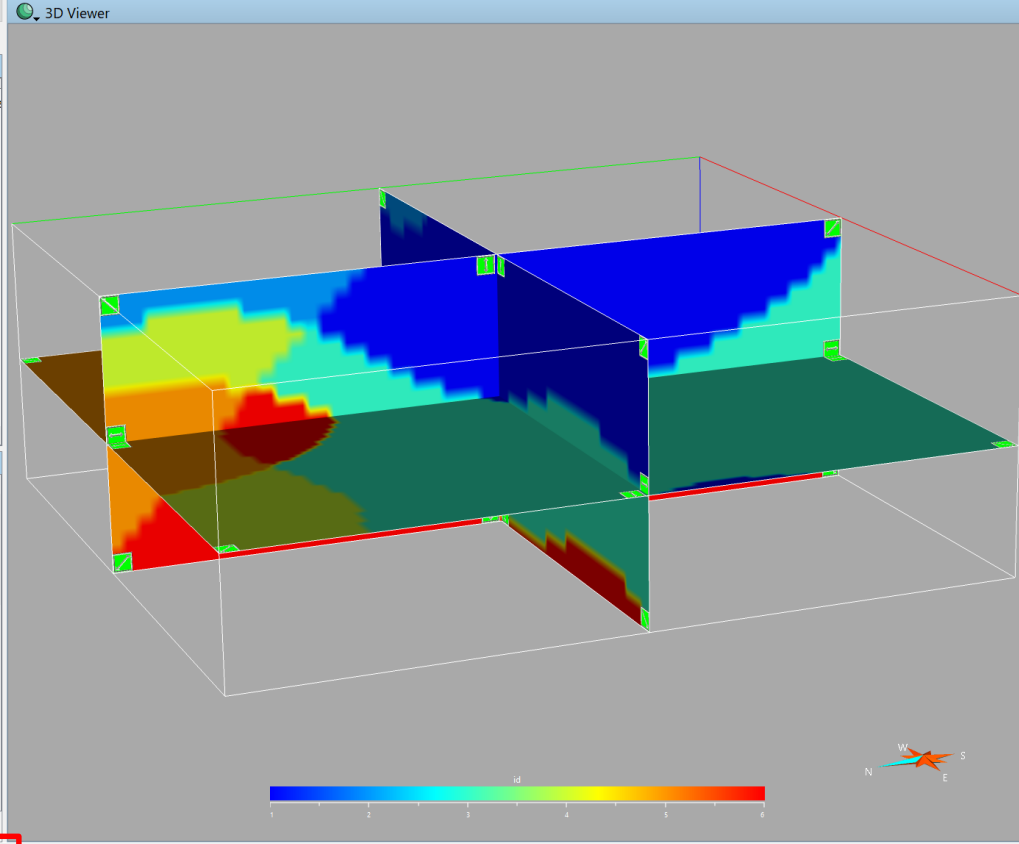
Name	User
Project (Active)	Peter Menze

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

Set Properties

- Object volume
- Property inheritance
- Value 1
- Region



Display Elements

Objects

- Seismic
  - box Depth
  - vox\_region\* Depth
  - model\* Depth
  - probes\*
  - regions\*
  - property groups\*
  - properties\*
    - IR id\*
  - sections

Unassigned Objects

- PointsSet
  - au\_grades Depth
- Curve
- Surface
  - bottom Depth
  - fault\_0 Depth
  - hanging Depth

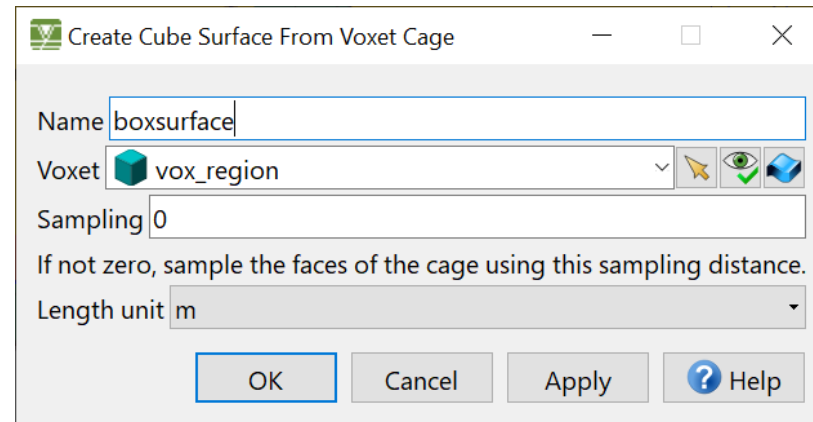
Create & Open

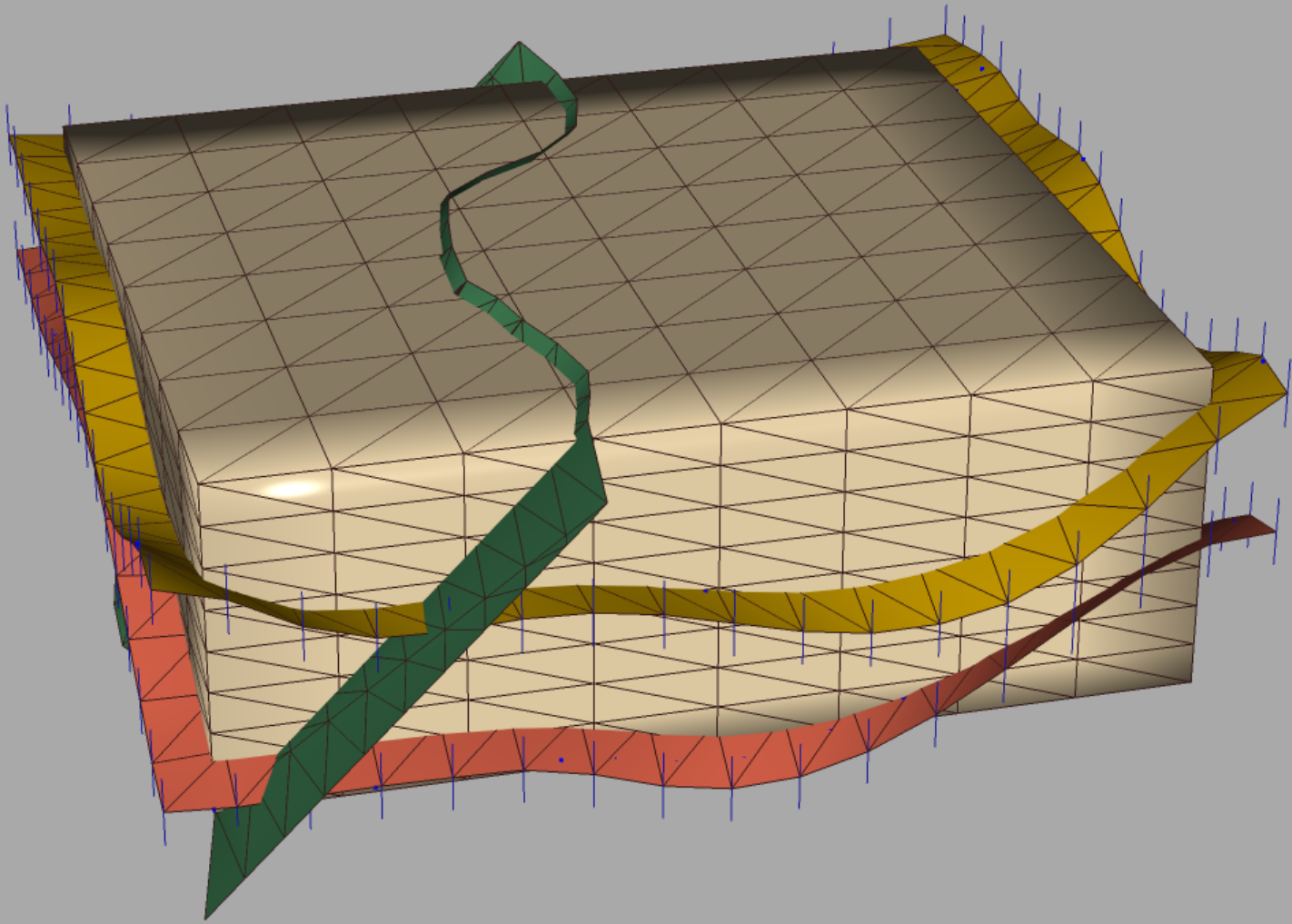
## Model3D

- Volumenrepräsentation durch konsistente Boundary Representation mittel triangulierte Flächen
  - Jede Region wird durch einen triangulierten Polyeder der Hülle repräsentiert

Erster Schritt: Erstellung einer äußeren Begrenzungsfläche -> Surface mode




1. *New > From Grid > From Voxet Cage*
2. *Tools > Parts > Merge All*
3. *Tools > Split > Split All (3x)*






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sentiert

— □ ×

▼   

s sampling distance.

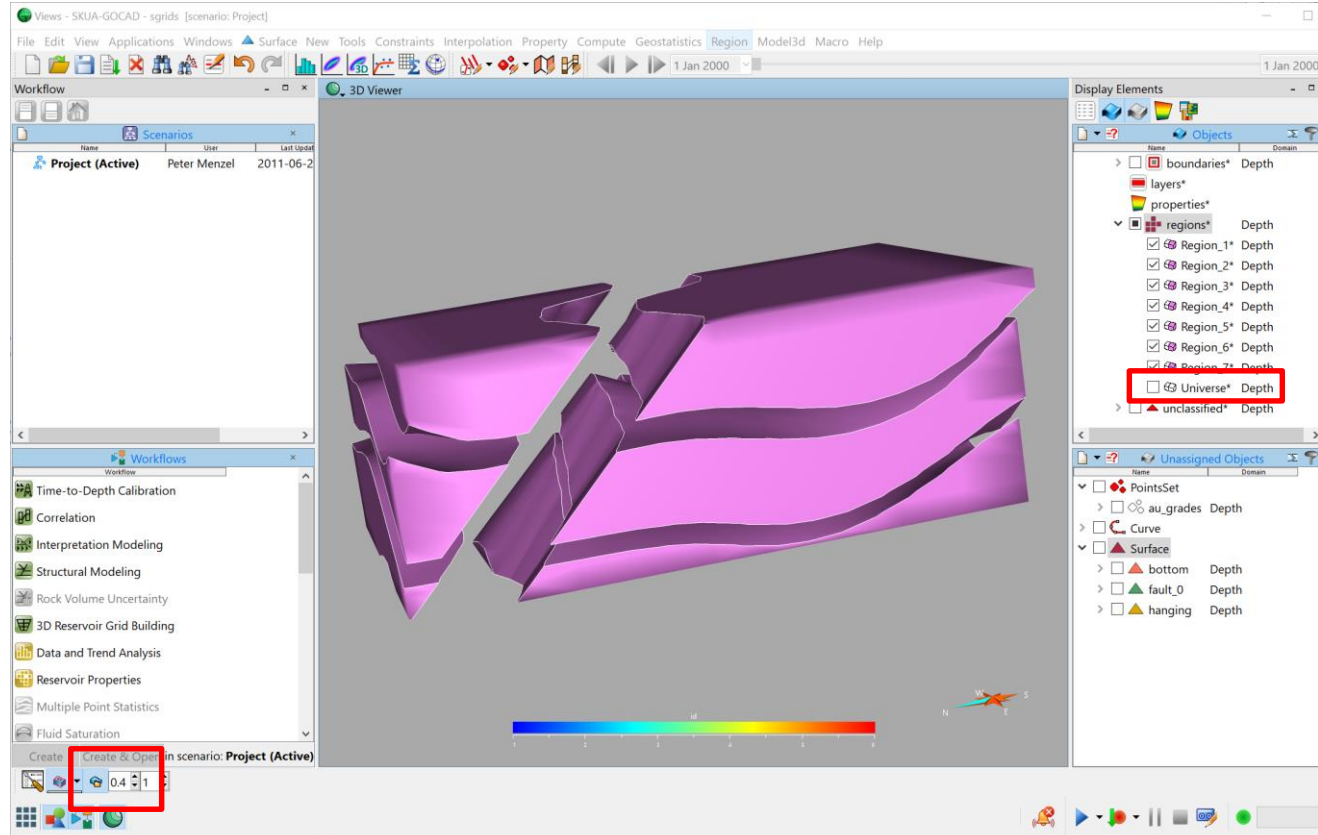
▼

Apply  Help

# Model3D

## Surface mode

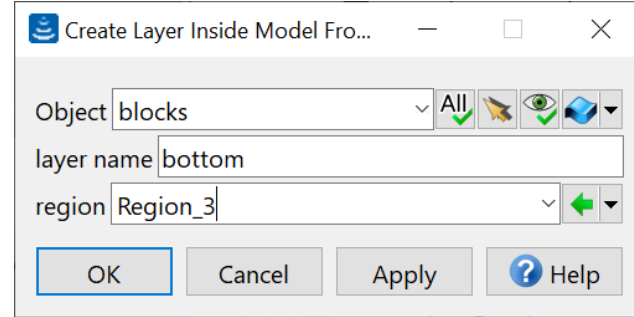
1. *Model3d > From Surfaces*
2. *Model3d > more > remove free extremities (für alle Regionen)*



# Model3D

Mehrere Blöcke zu einem Layer kombinieren:

1. *Model3d > Layers > Create one from region*
2. *Object panel > Structural Models > Rechts-Klick Region\_6 > Add to Layer*



Views - SKUA-GOCAD - sgrids [scenario: Project]

File Edit View Applications Windows Surface New Tools Constraints Interpolation Property Compute Geostatistics Region Model3d Macro Help

1 Jan 2000

Workflow

3D Viewer

Display Elements

Objects

- boxesurface\*
  - boxesurface\* Depth
- Structural Models
  - blocks\* Depth
    - skeleton\* Depth
  - boundaries\* Depth
  - layers\*
    - bottom\* Depth
      - regions\* Depth
        - Region\_3\* Depth
        - Region\_6\* Depth
- properties\*
  - regions\* Depth

Unassigned Objects

- PointsSet
  - au\_grades Depth
- Curve
- Surface
  - bottom Depth
  - fault\_0 Depth
  - hanging Depth

Time-to-Depth Calibration

Correlation

Interpretation Modeling

Structural Modeling

Rock Volume Uncertainty

3D Reservoir Grid Building

Data and Trend Analysis

Reservoir Properties

Multiple Point Statistics

Fluid Saturation

Create & Open in scenario: Project (Active)

Views Structural Data Results +

Meh  
kom

1. M

2. C



## Model3D

Regionen als triangulierte Flächen extrahieren

1. *New > From Others > Model Region*  
Erstellen Sie eine Fläche pro Region



Region

1. N  
E

Views - SKUA-GOCAD - sgrids [scenario: Project]

File Edit View Applications Windows Surface New Tools Constraints Interpolation Property Compute Geostatistics Region Model3d Macro Help

1 Jan 2000

Workflow

Name	User	Last Update
<b>Project (Active)</b>	Peter Menzel	2011-06-2

3D Viewer

Display Elements

Objects

- vox\_region Depth
- model Depth
- probes
- regions
- property groups
- properties
  - IR id
  - sections
- Boundaries
- boxsurface\*
  - boxsurface\* Depth
- Structural Models
  - blocks\* Depth

Unassigned Objects

- au\_grades Depth
- Curve
- Surface
  - block1\* Depth
  - block2\* Depth
  - block3\* Depth
  - block4\* Depth
  - block5\* Depth
  - block6\* Depth
  - block7\* Depth
  - bottom Depth
  - fault\_0 Depth
  - hanging Depth

Time-to-Depth Calibration

Correlation

Interpretation Modeling

Structural Modeling

Rock Volume Uncertainty

3D Reservoir Grid Building

Data and Trend Analysis

Reservoir Properties

Multiple Point Statistics

Fluid Saturation

Create Create & Open in scenario: Project (Active)

Show\_Selected

Views Structural Data Results +



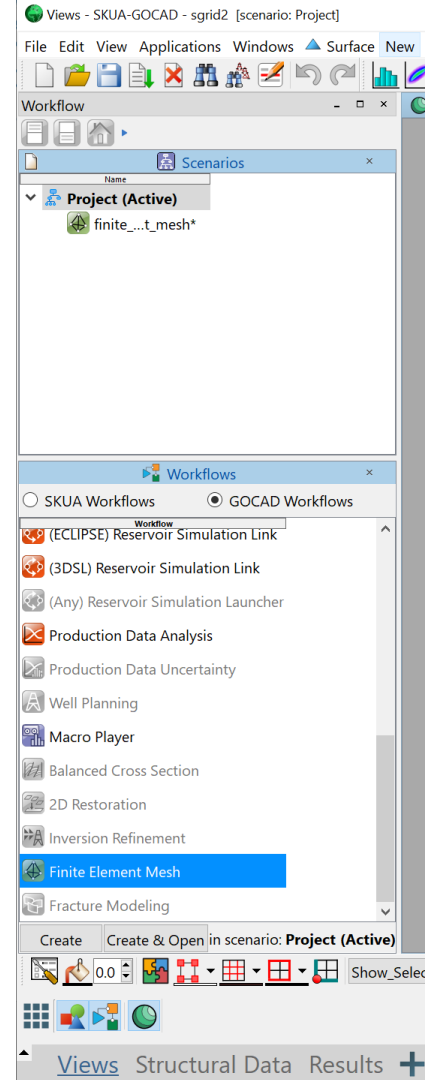
## Volumenobjekte in Skua-Gocad

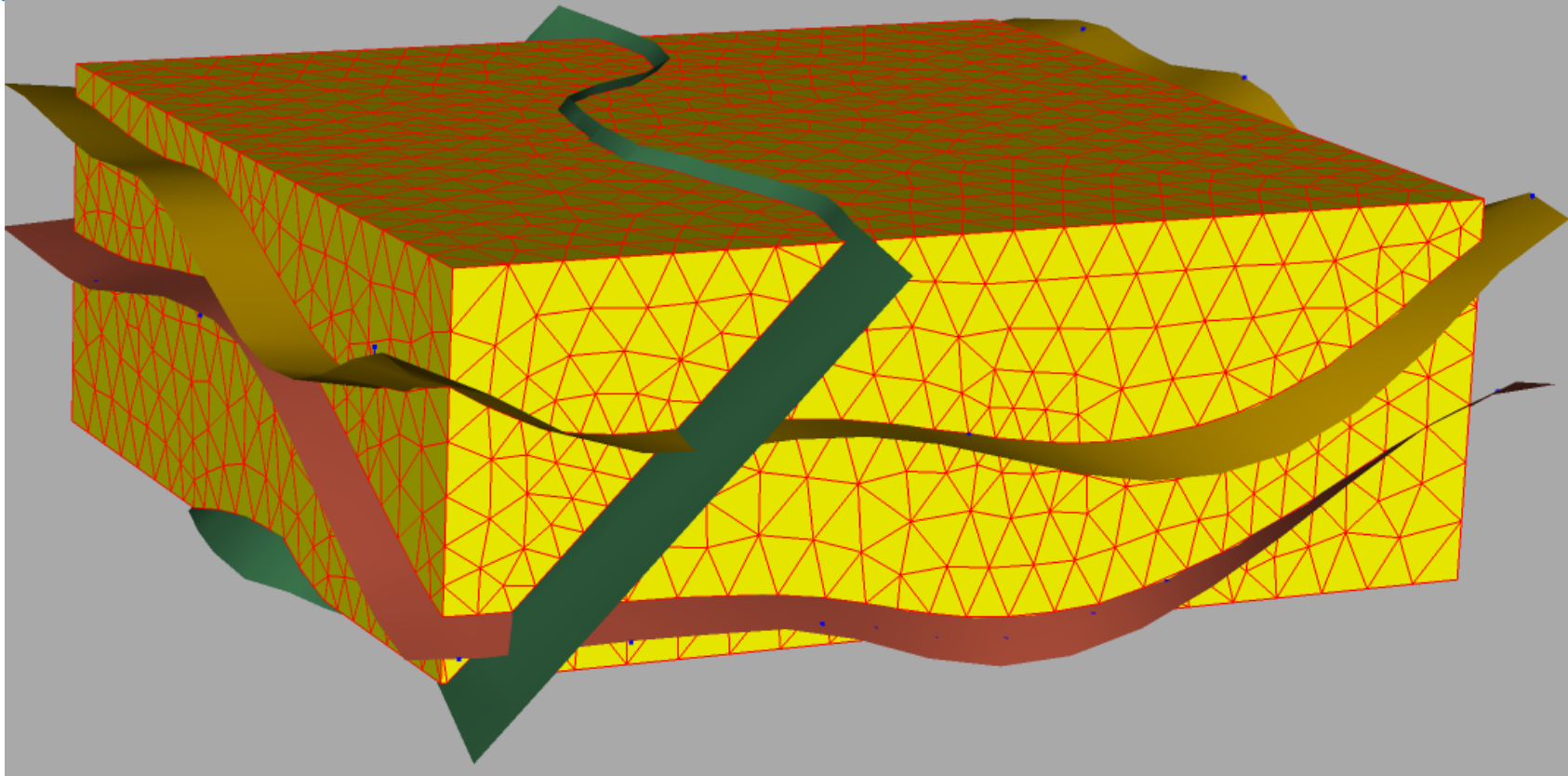
# Solid

## Tetraeder-Gitter

### *Finite Element Mesh Workflow ...*

Doppel-Klick, erstellen Sie ein Tetraedergitter basierend auf dem erstellten Model3D. Verwenden Sie für die Tetraedergröße: 20 m





## Structured Grid (SGrid)

Reguläres 3D Gitter, welches deformiert und auch geschnitten werden kann.

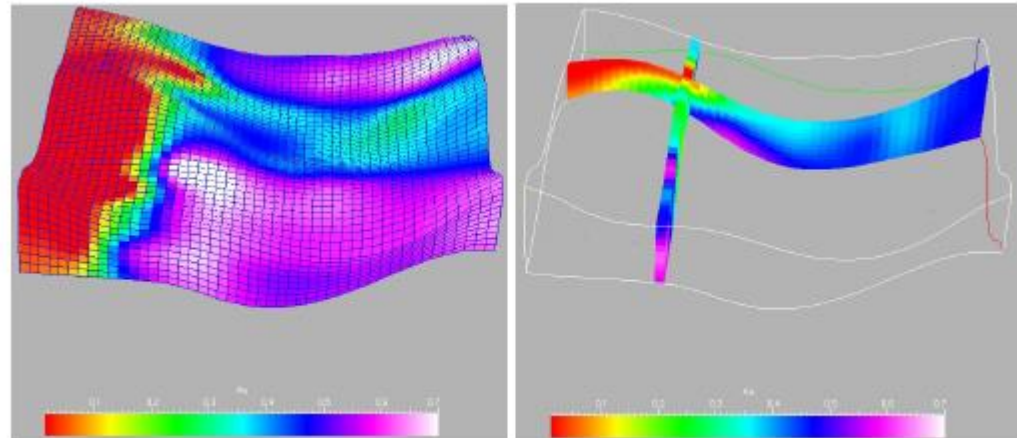


Fig. 11. a. SGrid with interpolated Au grades and sections through the SGrid.



## Structured Grid (SGrid)

Ziel dieser Übung ist die Modellierung eines gold-führenden Quarzganges.

1. Erstellung eines Flächenmodells basierend auf Kurvenobjekten.
2. Modellierung eines SGrids für innerhalb des Flächenmodells
3. Interpolation des Goldgehaltes mittels DSI.
4. Identifikation der profitablen Regionen ( $\text{Au} > 0.3 \text{ ppm}$ ).



## Structured Grid (SGrid)

Bitte erstellen Sie ein neues Skua-Gocad Projekt.

### Import der relevanten Daten

1. Importieren Sie die beiden Curve-Objekte *bottomwall* und *hangingwall* aus dem Projekt der vorherigen Übung.
2. Importieren Sie die Daten zum Goldgehalt aus der Datei *au\_grades.txt*  
*File > Import > Horizon Interpretation > Column-based File*
  - Benennen Sie das neue Objekt nach dem Dateinamen
  - Erstellen Sie für die 5. Spalte eine neue Eigenschaft *Au*



# Structured Grid (SGrid)

Column Assignment

No.	X	Y	Z	Au (ppm)
42	10015.98761	11638.97095	442.4547119	0.3
30	10015.98761	11700.37061	433.5982361	0.35
31	10015.98767	11662.95032	438.2898865	0.4
55	10015.98771	11565.38525	438.7396851	0.45

Current file X:/MAGEO/Teaching/Geomodellierung/WS\_19\_20/SKL Preloaded : 69 lines (100%) Preload all

Start at line 2 End at line 0

Property list and parameters

- X
- Y
- Z

1- Select the first line  
2- Select the last line.  
3- Select each property in the list:  
- input the column number  
- specify the null value if any.  
4- You can add or remove any additional property you want.

Column number 4

Use nodata value -99999

Advanced

Buttons: Add, Remove, OK, Cancel, Back

Column Assignment

No.	X	Y	Z	Au (ppm)
42	10015.98761	11638.97095	442.4547119	0.3
30	10015.98761	11700.37061	433.5982361	0.35
31	10015.98767	11662.95032	438.2898865	0.4
55	10015.98771	11565.38525	438.7396851	0.45

Current file X:/MAGEO/Teaching/Geomodellierung/WS\_19\_20/SKL Preloaded : 69 lines (100%) Preload all

Start at line 2 End at line 0

Property list and parameters

- X
- Y
- Z
- Au

1- Select the first line  
2- Select the last line.  
3- Select each property in the list:  
- input the column number  
- specify the null value if any.  
4- You can add or remove any additional property you want.

Column number 5

Use nodata value -99999

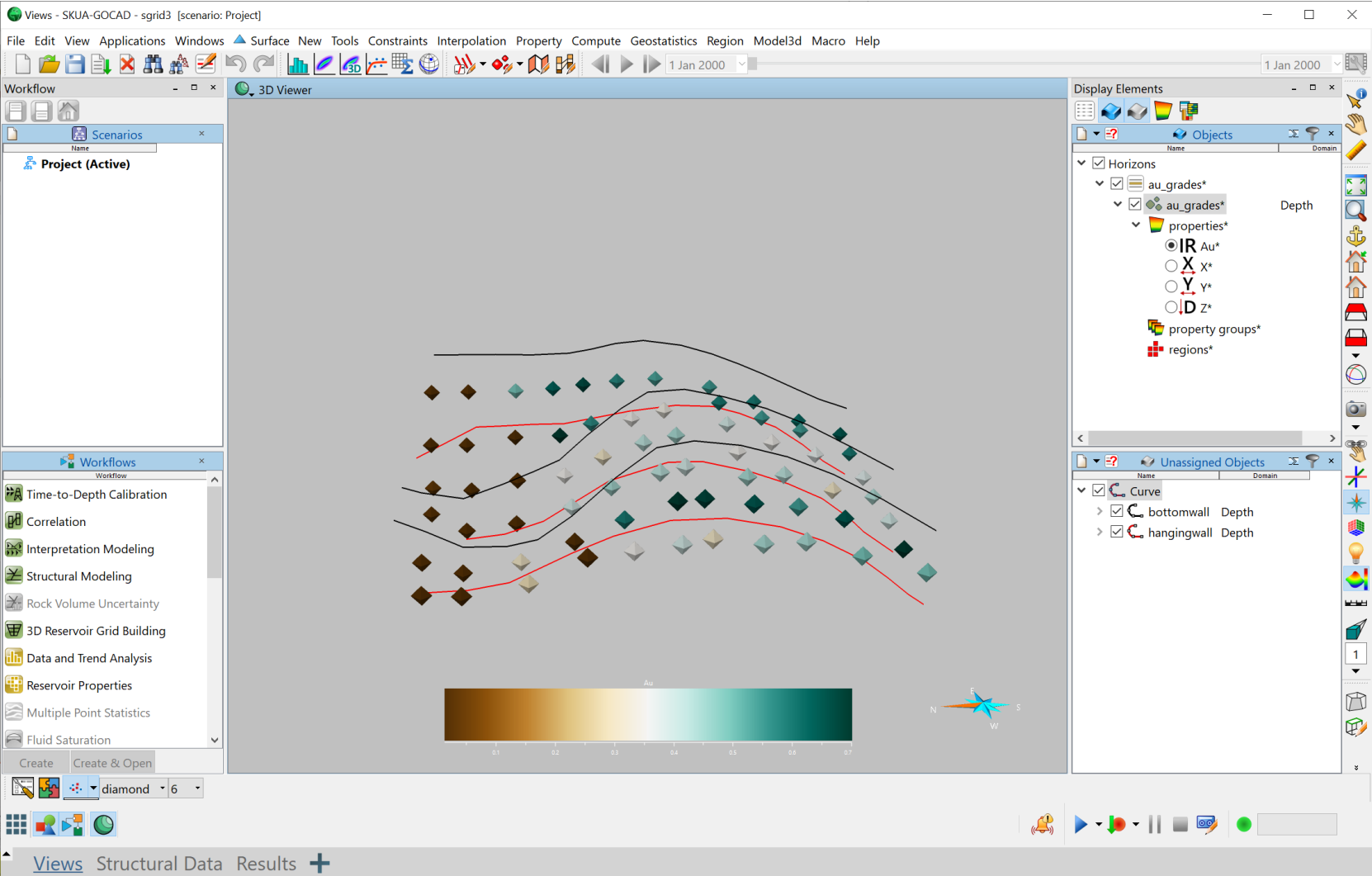
Advanced

Domain:  Time  Depth

Specify units of selected files

Area units:  Feet  Meters  Kilometers  
Depth unit:  Feet  Meters  
Depth axis positive values:  Upward  Downward

Buttons: Add, Remove, OK, Cancel, Back





# Structured Grid (SGrid)

## Erstellung des Flächenmodells

1. Erstellen Sie die Bounding Box aller Objekte als Voxet.
2. Modellieren Sie über DSI aus den Kurven-Objekten zwei Flächenobjekte innerhalb der Grenzen der Bounding Box.



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows Voxet New Tools Constraints Interpolation Property Compute Interpretation Geostatistics Region Model Macro Help

1 Jan 2000

Workflow 3D Viewer

Scenarios

Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

Create Create & Open

Show\_Selected

Display Elements

Objects

- Seismic
- Horizons
  - au\_grades
    - au\_grades Depth
      - properties
        - IR Au
        - X X
        - Y Y
        - D Z
      - property groups
      - regions

- Unassigned Objects
- Curve
- bottomwall Depth
- hangingwall Depth
- Surface
- bottomHorizon Depth
- hangingHorizon Depth

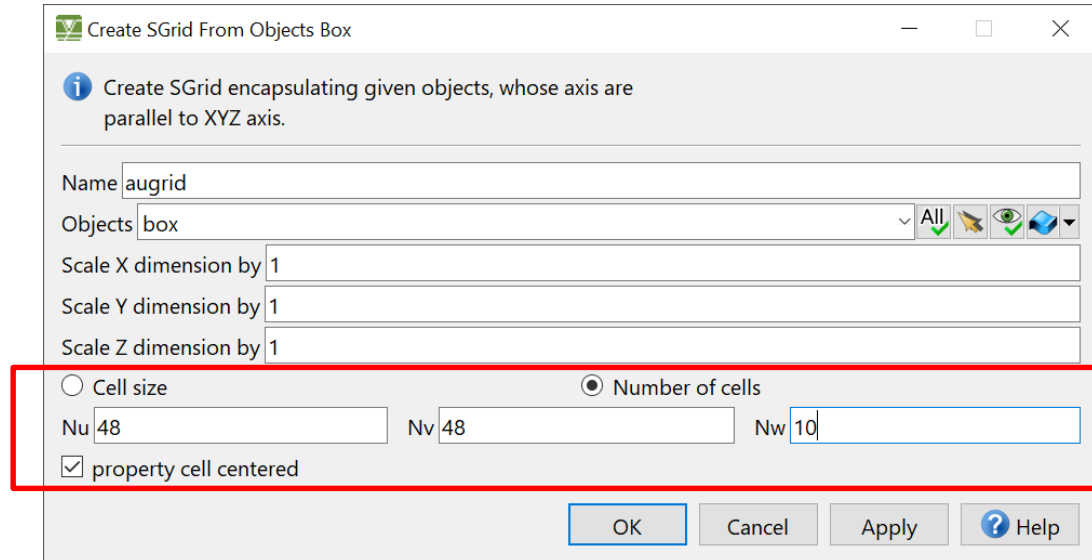
0.3

Views Structural Data Results +

# Structured Grid (SGrid)

## Erstellung des SGrid-Objektes SGrid-mode


### 1. *New > From Object Box*



Create SGrid From Objects Box

**i** Create SGrid encapsulating given objects, whose axis are parallel to XYZ axis.

Name

Objects  All 

Scale X dimension by


Scale Y dimension by

Scale Z dimension by

Cell size  Number of cells

Nu  Nv  Nw

property cell centered

OK Cancel Apply  Help



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows SGrid New Tools Constraints Interpolation Property Compute Geostatistics Region Model Rescaling Macro Help

1 Jan 2000

Workflow

3D Viewer

Scenarios

- Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

Create Save & Open

Display Elements

Objects

- Seismic
- Horizons
  - au\_grades
    - au\_grades Depth
- Geological Models
  - augrid\* Depth
    - regions\*
    - property groups\*
    - properties\*
  - sections
  - faults

Unassigned Objects

- Curve
  - bottomwall Depth
  - hangingwall Depth
- Surface
  - bottomHorizon Depth
  - hangingHorizon Depth

1

Help

Views Structural Data Results +

Close button (X)

Navigation icons: Home, Back, Forward, Search, etc.

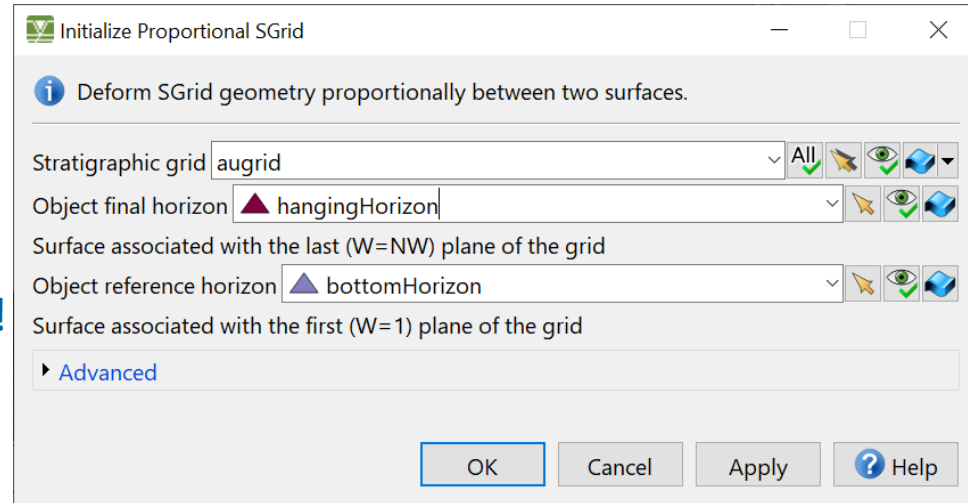
1

Help button

# Structured Grid (SGrid)

## Erstellung des SGrid-Objektes

2. *Tools > Conformable > Between Top and Bottom*
3. Erstellen Sie eine Kopie des erstellten Gitters mit dem Namen *southgrid*  
Diese Kopie wird später benötigt!



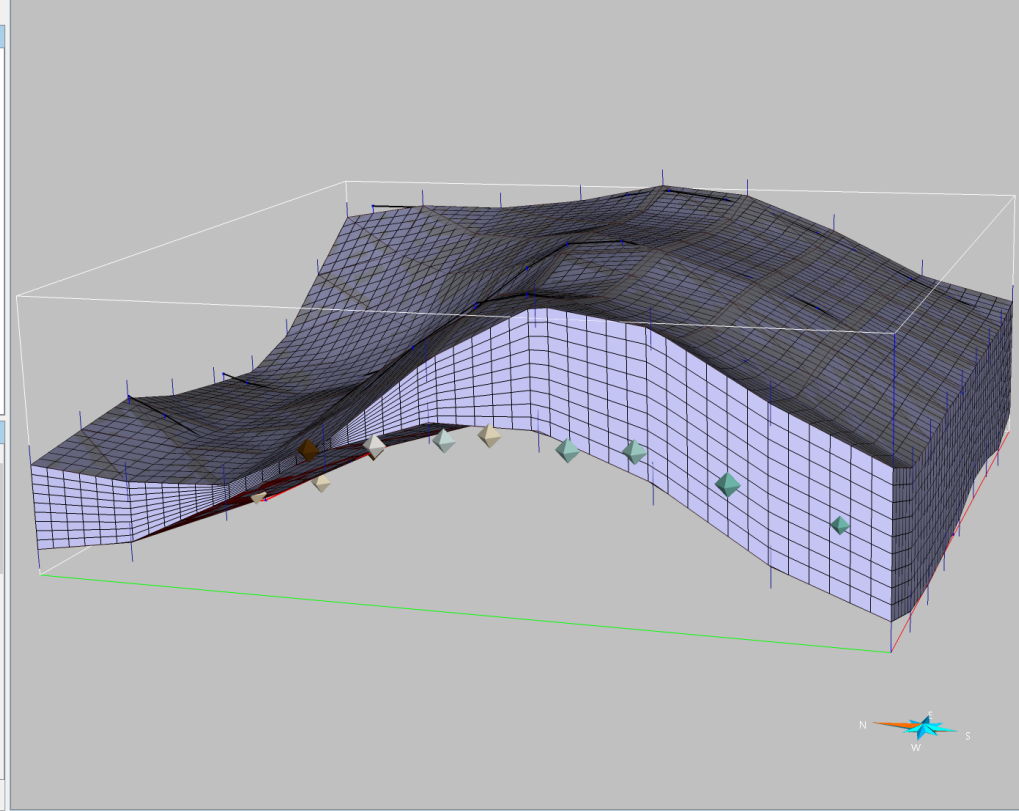


Scenarios

Name
Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation



Objects

Name	Domain
Seismic	
Horizons	
au_grades	Depth
au_grades	Depth
Geological Models	
aagrid*	Depth
regions*	
property groups*	
properties*	
sections	
faults	

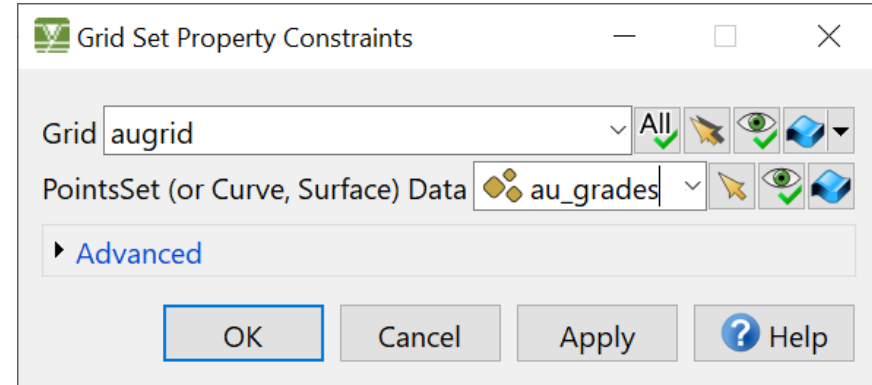
Unassigned Objects

Name	Domain
Curve	
bottomwall	Depth
hangingwall	Depth
Surface	
bottomHorizon	Depth
hangingHorizon	Depth

# Structured Grid (SGrid)

## Eigenschaftsinterpolation mittels DSI

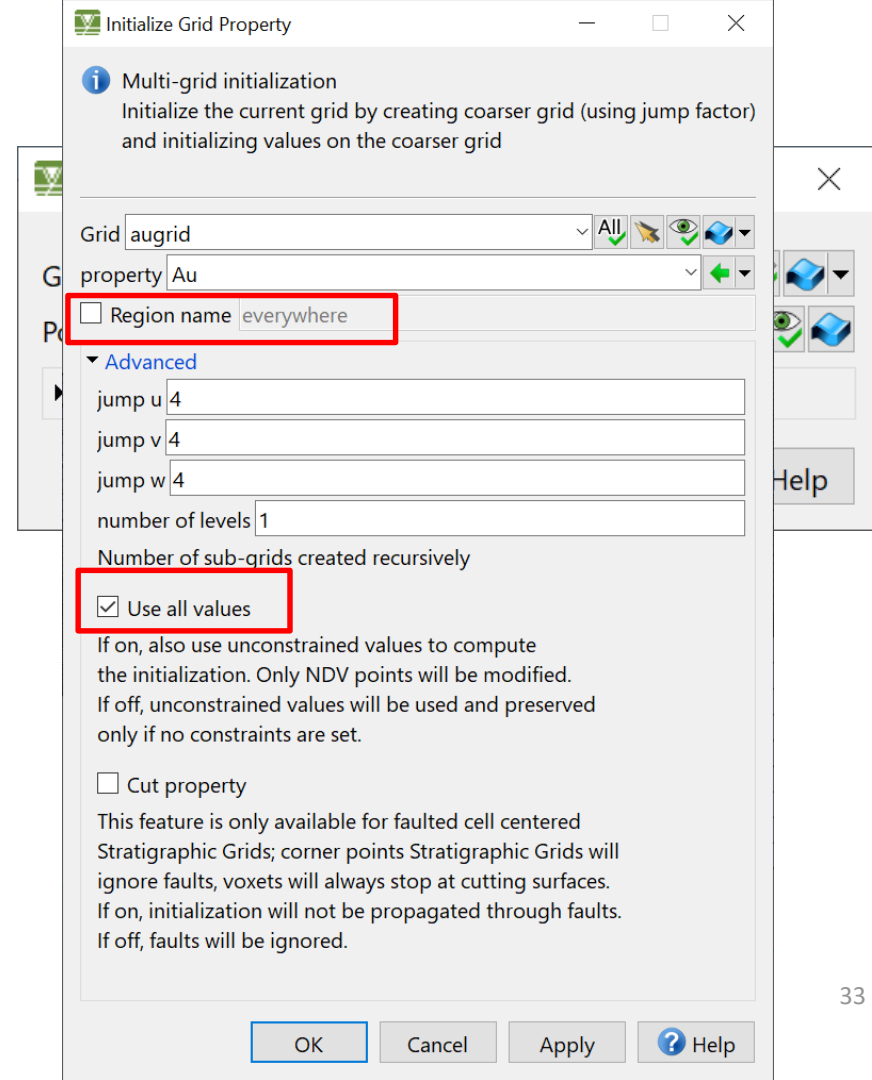
1. *Constraints > Set Property Control Points > Between Top and Bottom*



# Structured Grid (SGrid)

## Eigenschaftsinterpolation mittels DSI

1. *Constraints > Set Property Control Points > Between Top and Bottom*
2. *Interpolation > Initialize Property (Multi-Grid)*





Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows SGrid New Tools Constraints Interpolation Property Compute Geostatistics Region Model Rescaling Macro Help

1 Jan 2000

Workflow

3D Viewer

Scenarios

- Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

Display Elements

Objects

- Seismic
- Horizons
  - au\_grades
    - au\_grades Depth
- Geological Models
  - augrid\*
    - regions\* Depth
    - property groups\*
    - properties\*
      - IR Au\***
    - sections
    - faults
    - southgrid\* Depth

Unassigned Objects

- Curve
  - bottomwall Depth
  - hangingwall Depth
- Surface
  - bottomHorizon Depth
  - hangingHorizon Depth

0.1 0.2 0.3 0.4 0.5 0.6 0.7

Views Structural Data Results +

Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows SGrid New Tools Constraints Interpolation Property Compute Geostatistics Region Model Rescaling Macro Help

1 Jan 2000

Workflow

3D Viewer

Display Elements

Objects

- Seismic
- Horizons
  - au\_grades
    - au\_grades Depth
- Geological Models
  - agrid\* Depth
    - regions\*
    - property groups\*
    - properties\*
      - IR Au\*
    - sections
    - faults
  - southgrid\* Depth

Unassigned Objects

- Curve
  - bottomwall Depth
  - hangingwall Depth
- Surface
  - bottomHorizon Depth
  - hangingHorizon Depth

Time-to-Depth Calibration

Correlation

Interpretation Modeling

Structural Modeling

Rock Volume Uncertainty

3D Reservoir Grid Building

Data and Trend Analysis

Reservoir Properties

Multiple Point Statistics

Fluid Saturation

Create Create & Open

Au

0.1 0.2 0.3 0.4 0.5 0.6 0.7

N E S W

1

Views Structural Data Results +



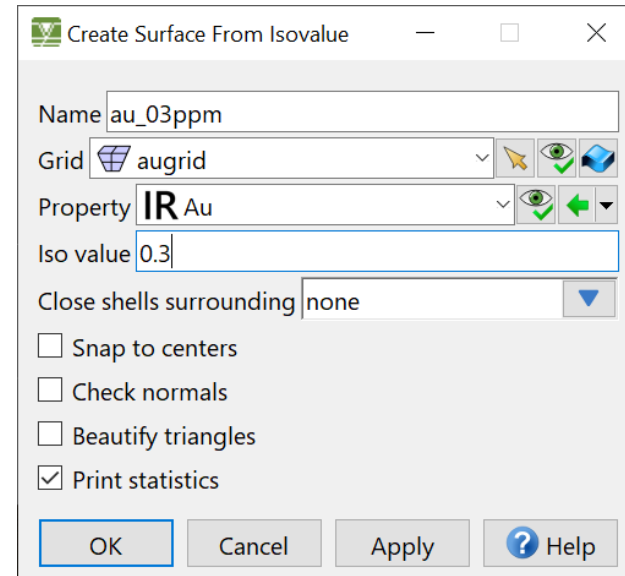
## Structured Grid (SGrid)

### Erstellen von so genannten Iso-Flächen

Das heißt Flächen, welche den Verlauf einen konstanten Eigenschaftswertes in einem Gitter abbilden.

Surface mode

*New > From Grid > Grid Iso-Property*

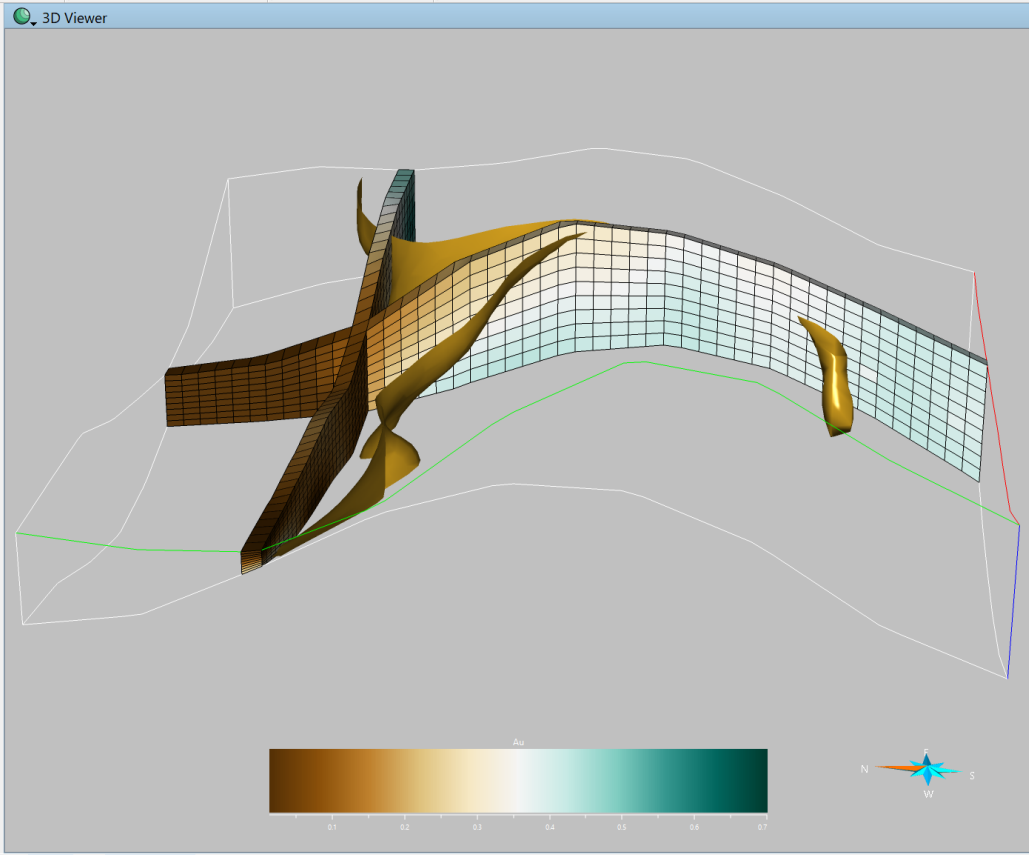




Workflow

Scenarios

Project (Active)



Display Elements

Objects

- Seismic
  - box Depth
- Horizons
  - au\_grades
    - au\_grades Depth
- Geological Models
  - augrid Depth
  - regions
  - property groups
  - properties
  - IR Au
  - sections
  - faults

Unassigned Objects

- Curve
  - bottomwall Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - hangingHorizon Depth

Workflows

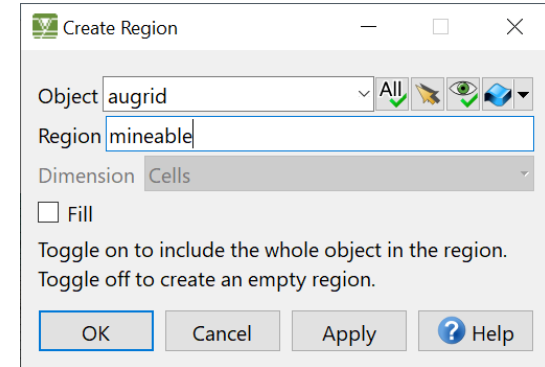
- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

# Structured Grid (SGrid)

## Unterteilung des SGrids in profitable und nicht-profitable Regionen

### SGrid mode

1. Erstellung der Region *mineable*, deren Abbau profitable wäre.  
*Region > Create*





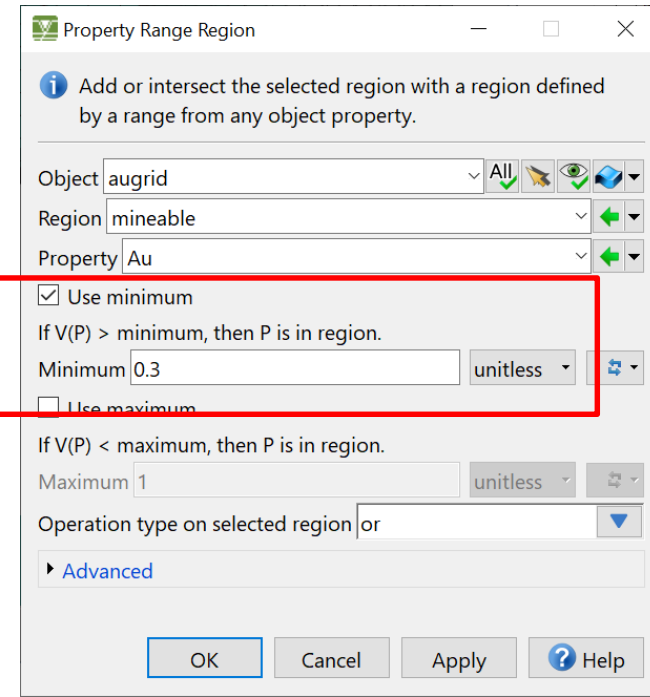
# Structured Grid (SGrid)

## Unterteilung des SGrids in profitable und nicht-profitable Regionen

### SGrid mode

1. Erstellung der Region *mineable*, deren Abbau profitable wäre.  
*Region > Create*

*Region > Initialize > From Property Range*



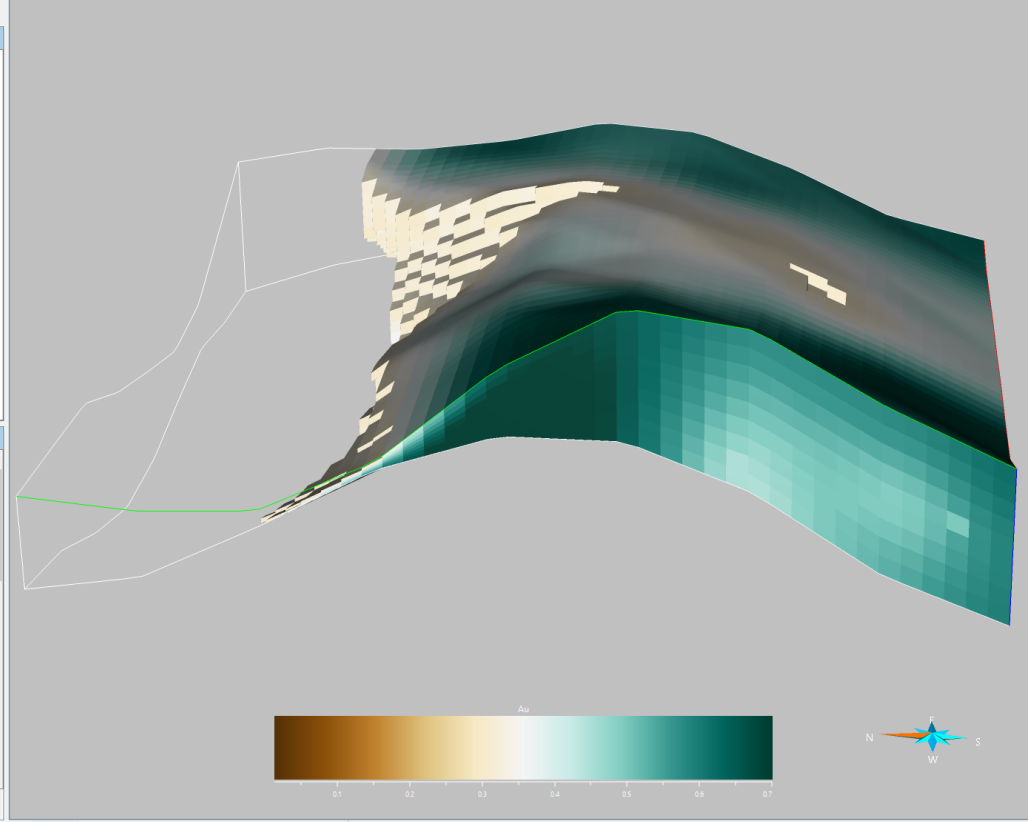


Scenarios

Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation



Display Elements

Objects

- Seismic
  - box Depth
- Horizons
  - au\_grades
    - au\_grades Depth
- Geological Models
  - augrid Depth
    - regions
      - mineable\*
    - property groups
    - properties
      - IR Au
    - sections

Unassigned Objects

- Curve
  - bottomwall Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - hangingHorizon Depth

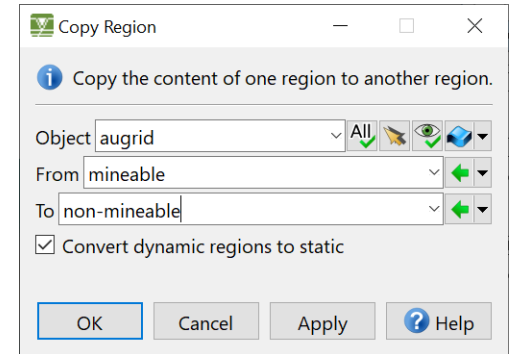
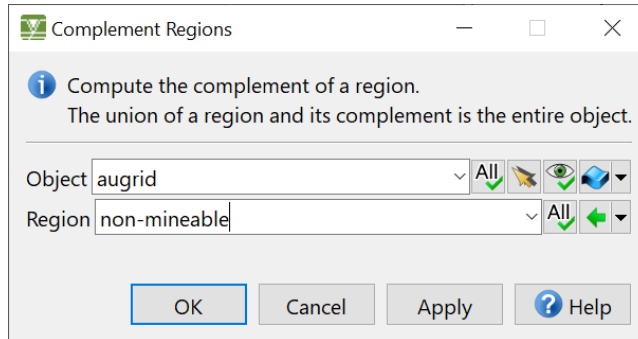
# Structured Grid (SGrid)

## Unterteilung des SGrids in profitable und nicht-profitable Regionen

- Erstellung der Region *non-mineable* als Komplement der Region *mineable*.

*Region > Copy*

*Region > Edit > Complement*





Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows Surface New Tools Constraints Interpolation Property Compute Geostatistics Region Model3d Macro Help

1 Jan 2000

Workflow

- Scenarios
- Project (Active)

3D Viewer

Display Elements

- Objects
  - Seismic
    - box Depth
  - Horizons
    - au\_grades
      - au\_grades Depth
  - Geological Models
    - augrid Depth
      - regions
        - mineable\*
        - non-m...able\*
      - property groups
      - properties
        - IR Au
- Unassigned Objects
  - Curve
    - bottomwall Depth
    - hangingwall Depth
  - Surface
    - au\_03ppm Depth
    - bottomHorizon Depth
    - hangingHorizon Depth

Colormap: BrBG, 256, 0.013, 0.7

Views Structural Data Results +

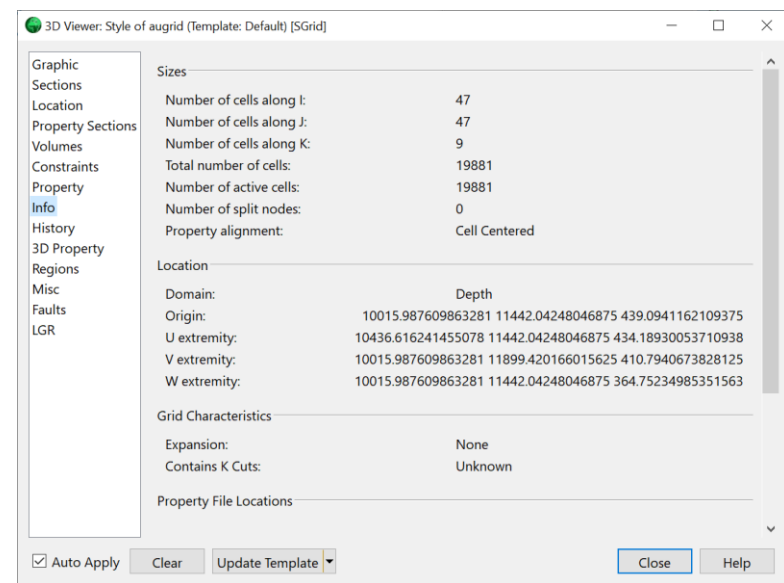
# Structured Grid (SGrid)

## Meta-Informationen und Statistiken

1. Zellenanzahl allgemein  
Style Editor > Info

2. Zellenanzahl in einer Region  
Rechts-Klick auf eine Region im Object Panel:  
*Compute > Node/Cell Count in Region*

3. Volumen einer Region  
Rechts-Klick auf eine Region im Object Panel:  
*Compute > Region Volume*



# Interpolation des Goldgehaltes ...

## ... unter Berücksichtigung der Störung

Es gibt 2 unterschiedliche Bereiche mit nicht-profitabler Vererzung:

- Großer Bereich in Norden
- Kleines „dead hole“ im südlichen Bereich

Es ist bekannt, dass der Untersuchungsbereich von einer Störung unterteilt wird. Diese wurde bisher bei der Interpolation des Goldgehaltes nicht berücksichtigt.

Ziel ist jetzt den gesamten Bereich nördlich der Störung von der Interpolation auszuschließen.

# Interpolation des Goldgehaltes ...

## ... unter Berücksichtigung der Störung

1. Importieren Sie das Kurven-Objekt *fault* auf dem Projekt der vorherigen Übung.
2. Erstellen Sie die Fläche der Störung: Surface mode  
*New > From Curves > Several Curves (number of levels: 10)*  
Selektieren Sie interaktiv die beiden Kurven  
(Achtung Strg-Taste gedrückt halten!)



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows Surface New Tools Constraints Interpolation Property Compute Geostatistics Region Model3d Macro Help

1 Jan 2000

Workflow 3D Viewer

Scenarios

- Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

Create Create & Open

Display Elements

Objects

- Seismic
  - box Depth
- Horizons
  - au\_grades
    - au\_grades Depth
- Geological Models
  - augrid Depth
  - southgrid Depth
    - regions
    - property groups
    - properties
    - sections
    - faults

Unassigned Objects

- Curve
  - bottomwall Depth
  - fault\* Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - fault\* Depth
  - hangingHorizon Depth

Views Structural Data Results +

# Interpolation des Goldgehaltes ...

... unter Berücksichtigung der Störung

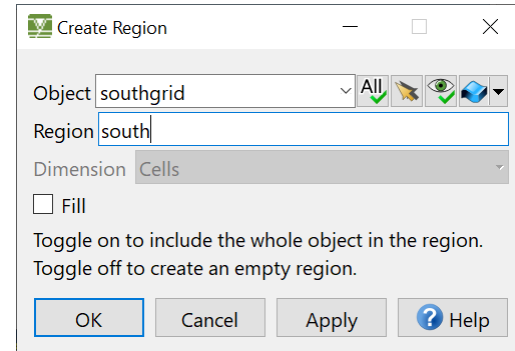
- Erstellen einer Region *south* im Objekt *southgrid* für den Bereich südlich der Störung: SGrid mode  
*Region > Create*

*Region > Initialize > From Surface*

*Region > Edit > Complement*

*Region > Edit > Filter > Manually*

Selektieren Sie den Bereich südlich der Störung





Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows SGrid New Tools Constraints Interpolation Property Compute Geostatistics Region Model Rescaling Macro Help

1 Jan 2000

Workflow

3D Viewer

Scenarios

- Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

Create Create & Open

Display Elements

Objects

- Seismic
  - box Depth
- Horizons
  - au\_grades
  - fault\*
- Geological Models
  - augrid Depth
  - southgrid Depth
  - regions
    - south\*
  - property groups
  - properties
  - sections

Unassigned Objects

- Curve
  - bottomwall Depth
  - fault\* Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - fault\* Depth
  - hangingHorizon Depth

region.

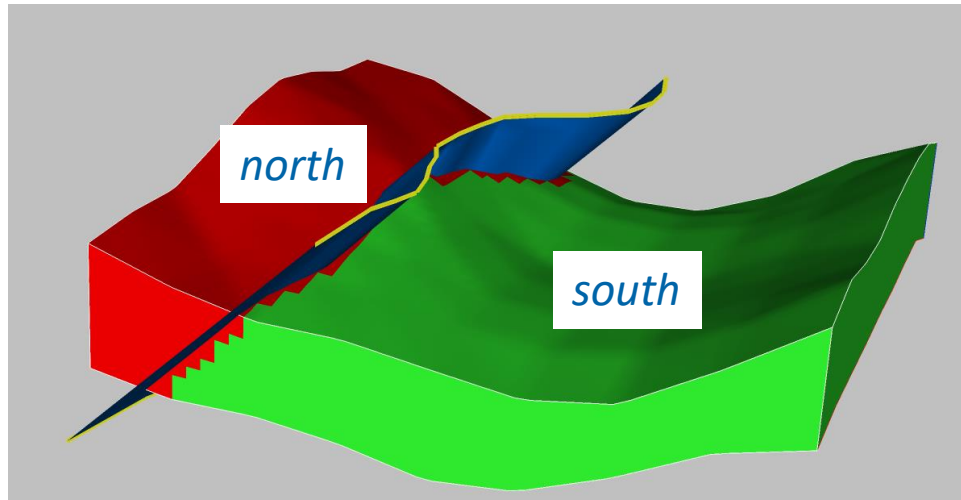
Help

Views Structural Data Results +

# Interpolation des Goldgehaltes ...

... unter Berücksichtigung der Störung

4. Erstellen Sie eine komplementäre Region *north* für den nördlichen Bereich (inkl. des Bereiches um die Störung)



# Interpolation des Goldgehaltes ...

... unter Berücksichtigung der Störung

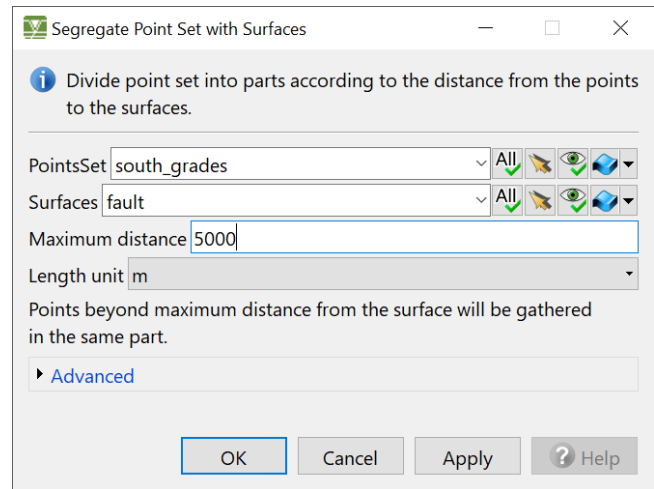
4. Kopieren Sie das PointSet *au\_grades* in ein neues Objekt *south\_grades*.  
Beachten Sie, dass alle Eigenschaft mit kopiert werden.

Löschen Sie alle Punkt nördlich der Störung.

PointSet mode

*Tools > Segregate with Surfaces*

*Tools > Part > Delete Selection*





Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows PointsSet New Tools Property Compute Geostatistics Region Macro Help

1 Jan 2000

Workflow

3D Viewer

Display Elements

Objects

- au\_grades
  - au\_grades Depth
  - south\_grades\* Depth
    - properties\*
      - IR Au\* (selected)
      - X X\*
      - Y y\*
      - D Z\*
    - property groups\*
    - regions\*
  - fault\*
- Geological Models
  - augrid Depth
  - southgrid Depth
    - regions
      - north\*
      - south\*
    - property groups

Unassigned Objects

- Curve
  - bottomwall Depth
  - fault\* Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - fault\* Depth
  - hangingHorizon Depth

Time-to-Depth Calibration  
Correlation  
Interpretation Modeling  
Structural Modeling  
Rock Volume Uncertainty  
3D Reservoir Grid Building  
Data and Trend Analysis  
Reservoir Properties  
Multiple Point Statistics  
Fluid Saturation

Create Create & Open

Au

0.1 0.2 0.3 0.4 0.5 0.6 0.7

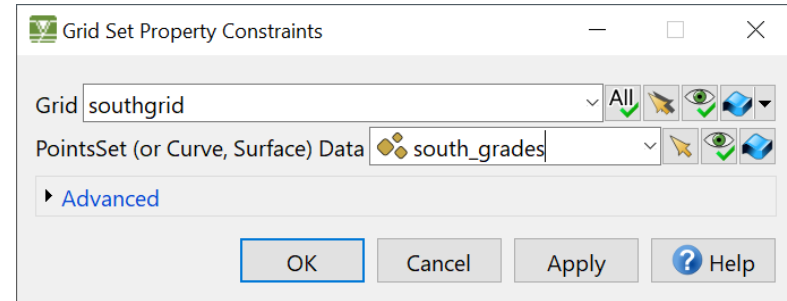
N E S

Views Structural Data Results +

# Interpolation des Goldgehaltes ...

... unter Berücksichtigung der Störung

5. Interpolation des Goldgehaltes mittels DSI.  
SGrid mode:  
*Constraints > Set Property Control Points*





# Interpolation des Goldgehaltes ...

... unter Berücksichtigung der Störung

- 5. Interpolation des Goldgehaltes mittels DSI.  
SGrid mode:  
*Constraints > Set Property Control Points*

*Interpolation > Initialize Property  
(Multi-Grid)*

**Initialize Grid Property**

**Multi-grid initialization**  
Initialize the current grid by creating coarser grid (using jump factor) and initializing values on the coarser grid

Grid: southgrid [All] [Eye] [3D]

property: Au [Left] [Right]

Region name: south [Left] [Right]

**Advanced**

jump u: 4

jump v: 4

jump w: 4

number of levels: 1

Number of sub-grids created recursively

Use all values  
If on, also use unconstrained values to compute the initialization. Only NDV points will be modified. If off, unconstrained values will be used and preserved only if no constraints are set.

Cut property  
This feature is only available for faulted cell centered Stratigraphic Grids; corner points Stratigraphic Grids will ignore faults, voxets will always stop at cutting surfaces. If on, initialization will not be propagated through faults. If off, faults will be ignored.

OK Cancel Apply ? Help



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows SGrid New Tools Constraints Interpolation Property Compute Geostatistics Region Model Rescaling Macro Help

1 Jan 2000

Workflow

- Scenarios
  - Project (Active)

Workflows

- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structural Modeling
- Rock Volume Uncertainty
- 3D Reservoir Grid Building
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

3D Viewer

Display Elements

Objects

- IR Au\*
- X X\*
- Y Y\*
- D Z\*
- property groups\*
- regions\*
- fault\*
- Geological Models
  - augrid Depth
  - southgrid Depth
    - regions
      - north\*
      - south\*
    - property groups
    - properties
      - IR Au\*
    - sections
    - faults

Unassigned Objects

- Curve
  - bottomwall Depth
  - fault\* Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - fault\* Depth
  - hangingHorizon Depth

Colormap: BrBG, 256, 0.013, 0.7, 0.0

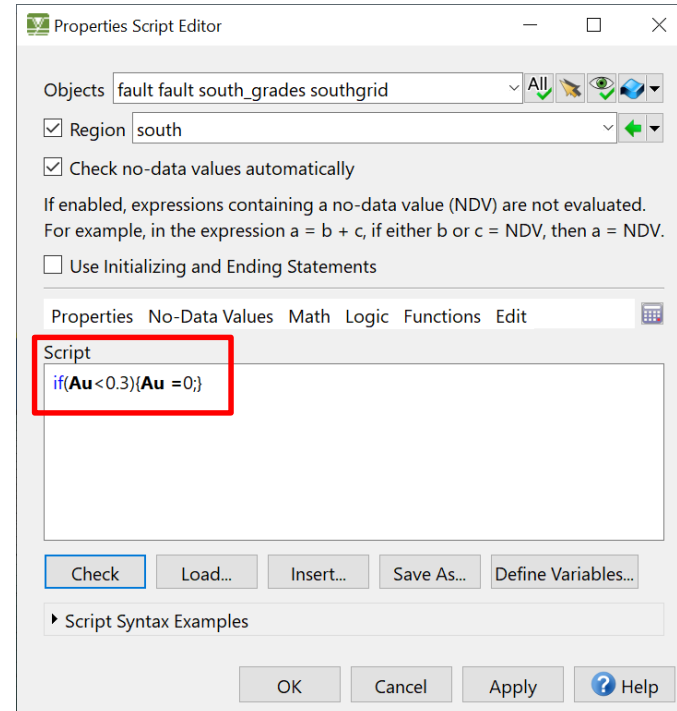
Views Structural Data Results +

Help



# Abschätzung der profitables Gold Ressource

1. Alle Zellen mit nicht-profitables Goldvererzung auf Null setzen.  
*Compute > Apply Script > on Object ...*



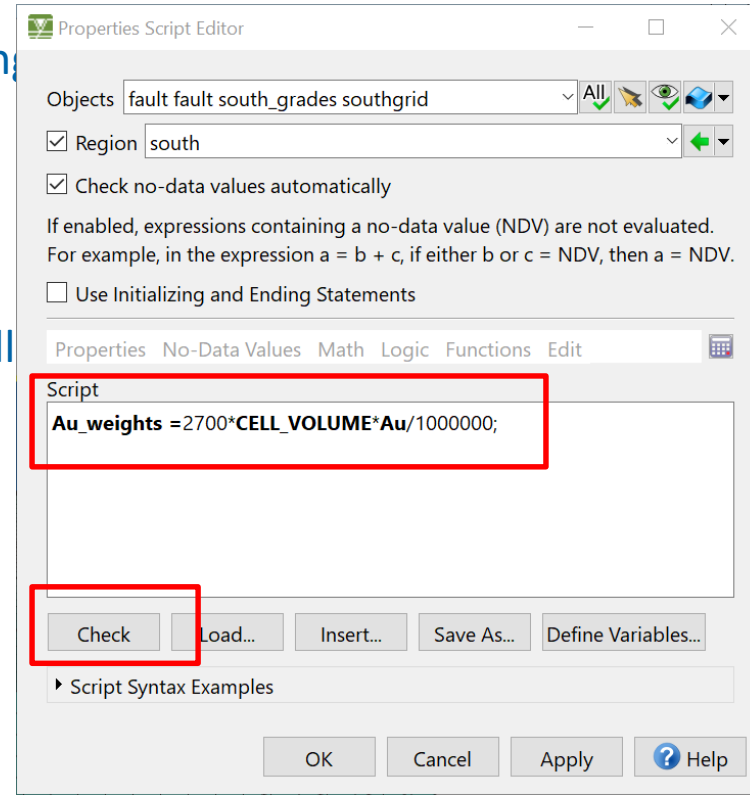


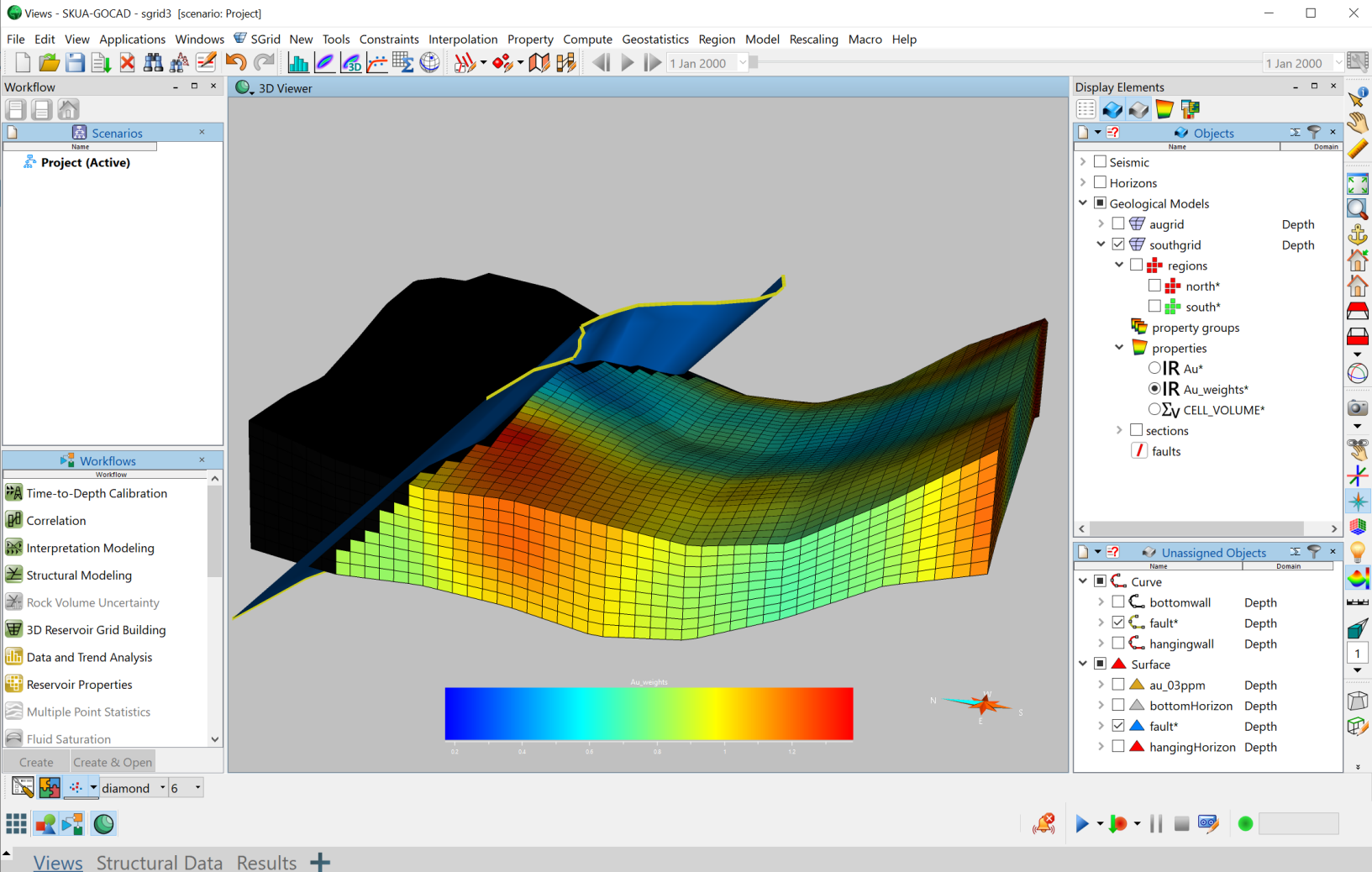
## Abschätzung der profitables Gold Ressource

1. Alle Zellen mit nicht-profitables Goldvererzung auf Null setzen.  
*Compute > Apply Script > on Object ...*
2. Erstellen Sie eine Property *Au\_weights*.
3. Erstellen Sie eine weitere Property für die Zell-Volumina:  
*Compute > Property > Compute Cell Volume*

# Abschätzung der profitables Gold Ressource

1. Alle Zellen mit nicht-profitables Goldvererzung  
*Compute > Apply Script > on Object ...*
2. Erstellen Sie eine Property *Au\_weights*.
3. Erstellen Sie eine weitere Property für die Zell  
*Compute > Property > Compute Cell Volume*
4. Berechnen Sie die Masse des verfügbaren Goldes:  
*Compute > Apply Script > on Object ...*





# Abschätzung der profitables Gold Ressource

1. Alle Zellen mit nicht-profitables Goldvererzung auf Null setzen.

*Compute > Apply Script > on Object ...*

2. Erstellen Sie eine Property *Au\_weights*.

3. Erstellen Sie eine weitere Property für die Zell-Volumina:

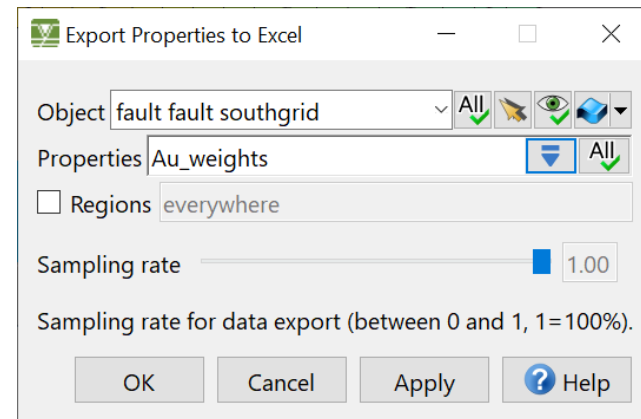
*Compute > Property > Compute Cell Volume*

4. Berechnen Sie die Masse des verfügbaren Goldes:

*Compute > Apply Script > on Object ...*

5. Export der Ergebnisse nach MS Excel

*File > Export > Sgrid > Export Properties to Excel*



Mappe1 - Excel

Start Einfügen Seitenlayout Formeln Daten Überprüfen Ansicht Was möchten Sie tun? Anmelden Freigeben

Calibri 11 A A Standard

F K U Bedingte Formatierung Als Tabelle Zellenformatvorlagen Einfügen Löschen Format Zellen Sortieren und Suchen und Filtern Auswählen Bearbeiten

Zwischenablage Schriftart Ausrichtung Zahl

A1 Data Sheet

1	<b>Data Sheet</b>		
2	<b>Object :</b>	southgrid	Compute Statistics
3	<b>Region :</b>	everywhere	
4			
5	<b>Nb Data :</b>	19881 (blank = no data)	Compute Cross-Plot
6	<b>Sampling :</b>	100 %	
7			
8			
9			
10	<b>Property :</b>	Au_weights	
11	Unit :	unitless	
12		1,22325659	
13		1,24829125	
14		1,28410327	
15		1,32007861	
16		1,34208405	
17		1,34098542	
18		1,34851933	
19		1,3596859	
20		1,35258222	
21		1,3184278	
22		1,26162505	
23		1,19113803	
24		1,11958563	
25		1,04393363	
26		0,96229273	
27		0,8870331	
28		0,83098537	
29		0,79816127	
30		0,77809954	
31		0,76594037	
32		0,7503107	

southgrid\_everywhere Tabelle1

source

setzen.

Properties to Excel

Default fault southgrid All

es Au\_weights All

ons everywhere

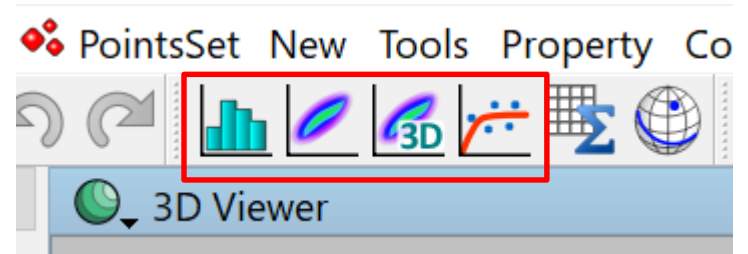
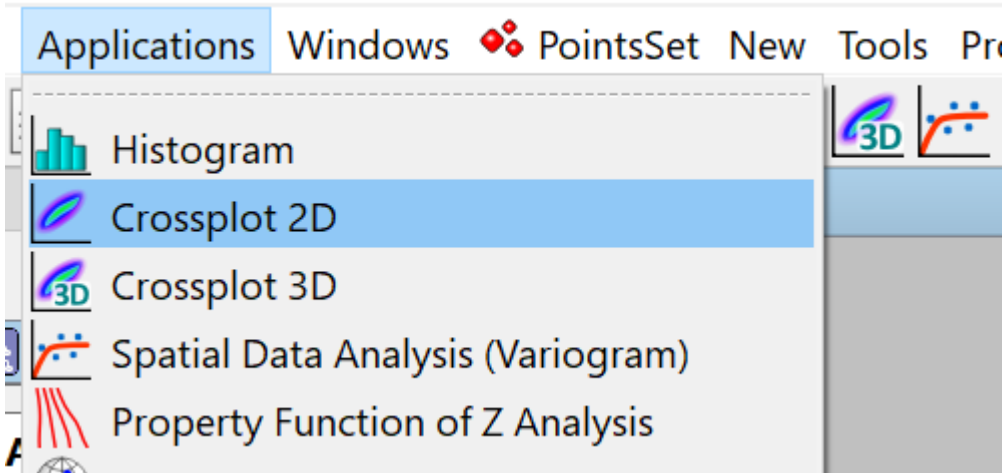
g rate 1.00

Sampling rate for data export (between 0 and 1, 1=100%).

OK Cancel Apply Help

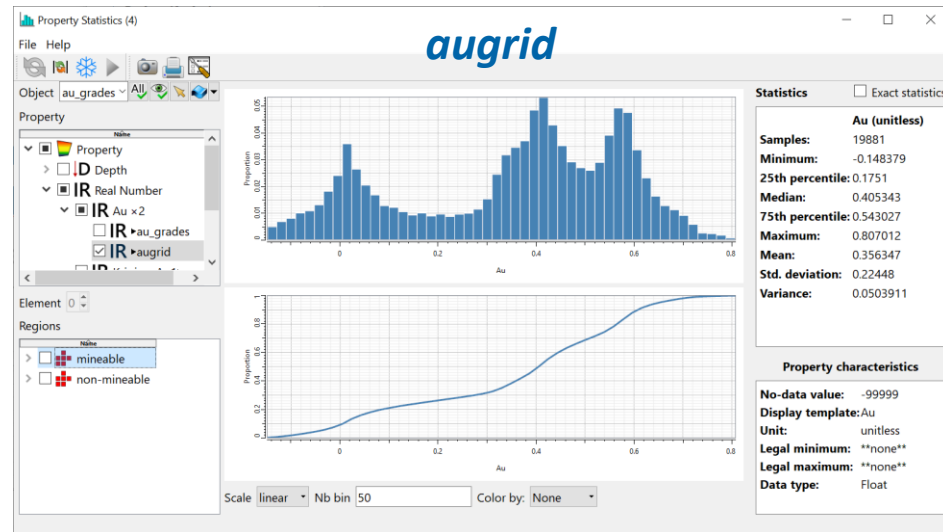
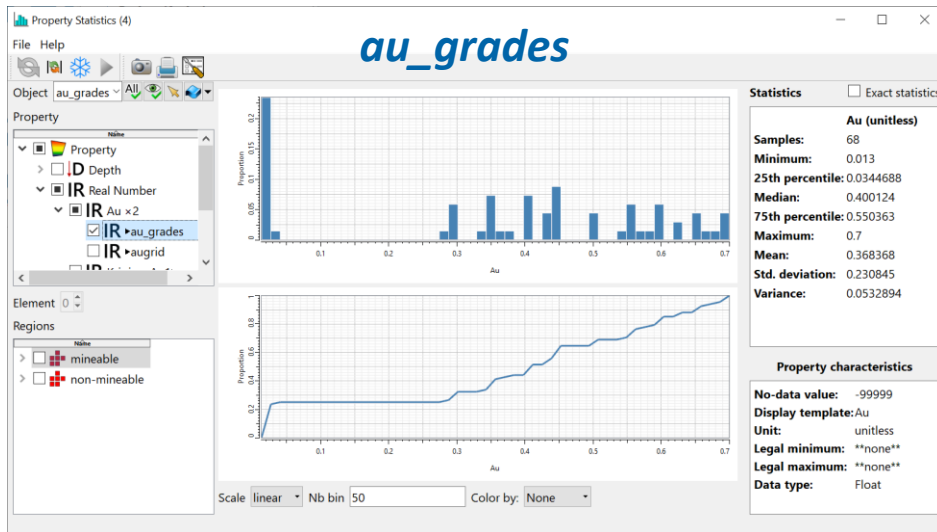
# Explorative Datenanalyse

Skua-Gocad erlaubt Ihnen, vorhandene Eigenschaften von Objekten zu analysieren



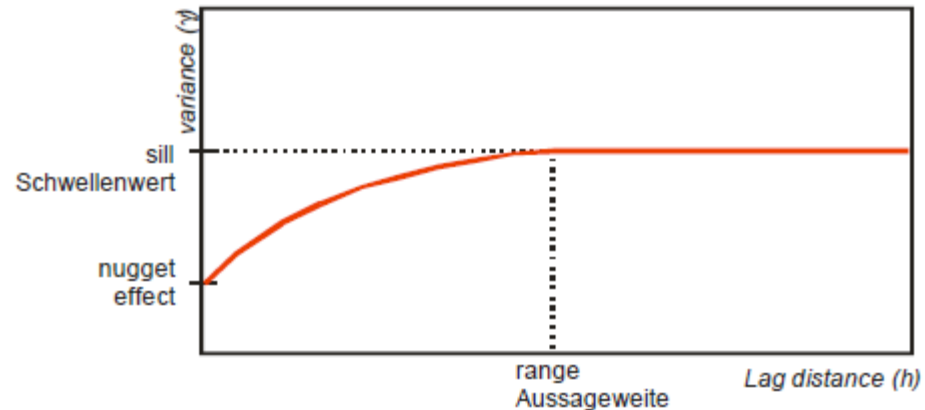
# Explorative Datenanalyse

Stellen Sie das Histogramm zur Eigenschaft *AU* des PointSets *au\_grades* sowie dar des SGrids *augrid* dar. Vergleichen Sie die beiden Eigenschaftsverteilungen. Was fällt Ihnen auf?



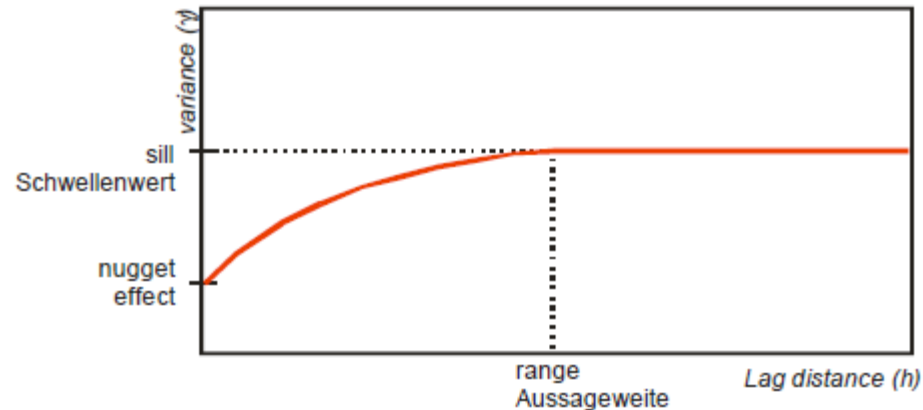
# Räumliche Datenanalyse / Variogram

- Räumliche Datenanalyse umfasst Verfahren, die es erlauben, die räumliche Verteilung einer Eigenschaft zu charakterisieren. Sie ist die grundlegende Voraussetzung für eine geostatistische Interpolation dieser Eigenschaft, da über räumliche Datenanalyse die Parameter des Vorhersagemodells bestimmt werden können.
- Das Hauptwerkzeug dafür ist das so genannte Variogram. Es beschreibt den Grad der räumlichen Abhängigkeit einer Eigenschaft.



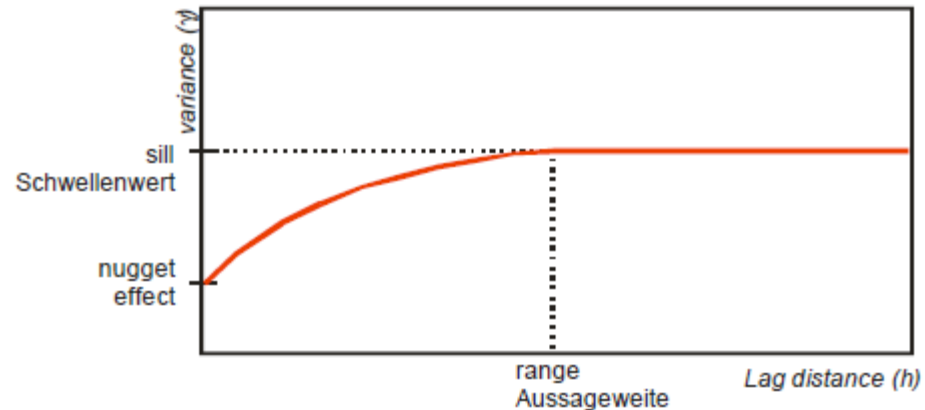
# Variogram

- Es verknüpft die Varianz von Eigenschaftsdifferenzen zwischen zwei Datenpunkten mit der Distanz zwischen den Punkten.
- Empirisches Variogram:
  - Basiert auf den gegebenen Datenpunkten
  - Die zur Bestimmung der Parameter des theoretischen Variograms
- Theoretisches Variogram:
  - Funktion, welche die räuml. Abhängigkeit über ein math. Modell beschreibt.
  - Anwendungs-/Anwender-abhängig, z.T. subjektiv



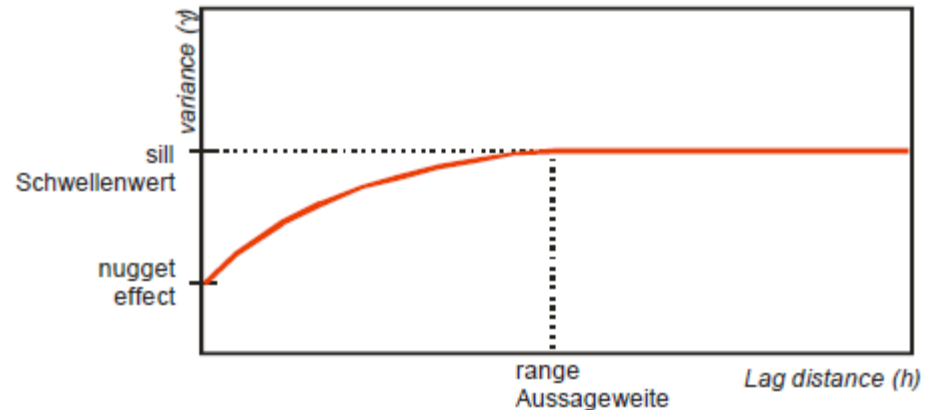
# Variogram

- Wichtige Parameter zur Bestimmung des empirischen Variogramms:
  - **Lag distance:** Stützpunkt Abstand zur Berechnung des Variogramms
  - **Lag:** Anzahl der Stützpunkte zur Berechnung des Variogramms
  - **Sampling rate:** Anteil der Daten zur Berechnung des Variogramms



# Variogram

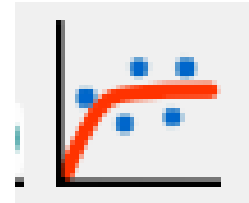
- Wichtige Parameter zur Bestimmung des theor. Variograms:
  - **Nugget Effect:** lokale Microvariabilität
  - **Range:** Max. Distanze bis zu der räuml. Abhängigkeit angenommen werden kann
  - **Sill:** Max. Varianz außerhalb des Range



## Variogram

Unterziehen Sie die Eigenschaft  $AU$  des PointSets  $au\_grades$  einer räumlichen Datenanalyse (Spatial data analysis) und erstellen Sie ein Variogrammmodell.

Verwenden Sie dafür den Skua-Gocad *Variogram Analyzer*:





Variogram Analyzer

File View Variogram Type Help

### Data and Transformations

**Select data**

Input data: au\_grades [All] [eye] [hand] [cube]

Property: Au [left] [right]

Regions:  everywhere

Automatically guess sampling (maximum number of data points used: 10 000)

Sampling rate (%):  100

**Coordinate transformation**

No transformation

Following grid stratigraphy (UVW) Grid: box [eye] [hand] [cube]

Rescaling Z between surfaces (XYW) Top horizon: [eye] [hand] [cube]

Bottom horizon: [eye] [hand] [cube]

**Property transformation**

No transformation

Normal score  Use external distribution: [dropdown]

Indicator Cut-off value: [input] unitless [dropdown] [refresh]

Back Next Guess Model

ischen  
modell.



Variogram Analyzer

File View Variogram Type Help

### Compute Experimental Variogram

**Vertical Variogram**

Number of lags: 1 Lag distance: 50.3812 m

Number of x columns: 7 Number of y columns: 7

Compute

**Areal Variogram**

Number of lags: 20 Lag distance: 64.0432 m

Number of strata: 1

Compute omni-directional Azimuths: 0 45.0 90.0 135.0 deg

Tolerance: 22.5 deg Bandwidth: 320.216 m

Enable dips (for 3D variogram) Dips: 45.0 0.0 45.0 90.0 deg

Tolerance: 22.5 deg Bandwidth: m

Compute

Y axis (North)  
azimuth  
direction vector  
lag unit distance  
bandwidth  
tolerance  
X axis (East)

Compute Variogram Map

Back Next

1.

2.

3.

chen  
bell.

Variogram Analyzer

File View Variogram Type Help

### Model Variogram

**Interactive modeling and tuning**

Nugget:  unitless^2

Cumulative sill:  unitless^2 **Recommended value:** 0.0525058 unitless^2

Variogram structures

Type	Contribution (unitless^2)	Azimuth (deg)	Rv (m)	R1 (m)	R2 (m)
1 Spherical	0.0525058	1.77099	6483.46	253.473	253.473

Structure Editing

**1.** **Fit variogram automatically**

**Fit Model**

Advanced fitting parameters

**Display Model and Create Resource**

Show in the 3D Viewer:

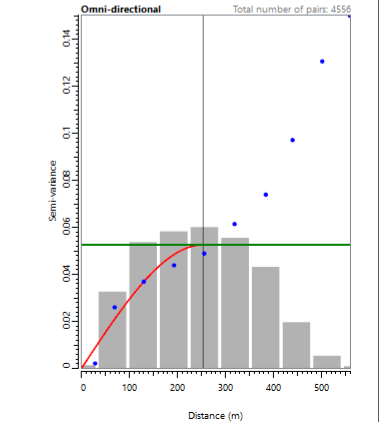
Ellipsoid center: X  m Y  m Z  m

Show surface Transparency (%)

**2.** **Create as Resource**

Back Next

lichen  
modell.



Variogram Analyzer

File View Variogram Type Help

### Model Variogram

**Interactive modeling and tuning**

Nugget:  unitless<sup>2</sup>

Cumulative sill:  unitless<sup>2</sup> Recommended value: 0.0525058 unitless<sup>2</sup>

Variogram structures

Type	Contribution (unitless <sup>2</sup> )	Azimuth (deg)	Rv (m)	R1 (m)	R2 (m)
1 Spherical	0.0525058	1.77099	6483.46	253.473	253.473

Ellipsoid center: X  m Y  m Z  m

Show surface Transparency (%)

2.

Back Next

Save Variogram Model as R... ? X

Please provide a name for the new resource:

OK Cancel

Display Elements

Objects

- Horizons
  - au\_grades
    - au\_grades Depth
    - south\_grades Depth
  - fault
- Geological Models
  - augrid Depth
  - southgrid Depth

Unassigned Objects

- Curve
  - bottomwall Depth
  - fault Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - fault Depth

Resources

- Colormap
- Macro
- Ternary Colormap
- Variogram
  - Au variogram IR Real...mber



Volumenobjekte in Skua-Gocad

# Geostatistische Interpolation / Kriging

Interpolieren Sie im SGrid *augrid* den Goldgehalt über *Simple Kriging*.

*Geostatistics > Estimation > Kriging*

Kriging

**i** Fill by kriging

**Simulation Support**

Object  All

Region name

New property prefix

Output kriging variance

**Conditioning Data**

Input data objects  All

Input data region

Input data property

Use data assignment Assignment Type  Power

**Statistics**

Variogram

**Interpolation Parameters**

Kriging method

Search Parameters Domain Coordinates Mean Varying Variogram Sequential Kriging

Use all data

Use search ellipsoid factor

Use search parameters

Use restricted vertical search

Vertical search interval

Use all data inside strata

Search stop at fault

Max nb used points

Use data outside region

OK Cancel Apply Help



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

File Edit View Applications Windows PointsSet New Tools Property Compute Geostatistics Region Macro Help

1 Jan 2000 1 Jan 2000

Workflow 3D Viewer

Scenarios

- Project (Active)

Workflows

- SKUA Workflows
- GOCAD Workflows
- Time-to-Depth Calibration
- Correlation
- Interpretation Modeling
- Structure & Stratigraphy
- Structure Uncertainty
- Data and Trend Analysis
- Reservoir Properties
- Multiple Point Statistics
- Fluid Saturation

3D Viewer

Display Elements

Objects

- augrid Depth
- regions
- property groups
- properties
  - IR Au
  - IR Krig...\_Au1
  - IR Krig...ance
- sections

Unassigned Objects

- Curve
  - bottomwall Depth
  - fault Depth
  - hangingwall Depth
- Surface
  - au\_03ppm Depth
  - bottomHorizon Depth
  - fault Depth

Resources

- Colormap
- Macro
- Ternary Colormap
- Variogram
  - Au variogram IR Real...mber

Colormap BrBG 256 0.013 0.7 0.0

Views Structural Data Results +



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

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Workflow

3D Viewer

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- Colormap
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Kriging\_AuVariance

0 0.0002 0.0004 0.0006 0.0008 0.001

0.00119386

0.0

Views Structural Data Results +



Views - SKUA-GOCAD - sgrid3 [scenario: Project]

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Workflow 3D Viewer

Display Elements

- augrid Depth
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  - property groups
  - properties
    - IR Au
    - IR Krig...\_Au1
    - IR Krig...ance
  - sections

### Property Statistics (5)

Object: d \ All

Property

- IR Real Number
  - IR Au\_augrid
  - IR Kriging\_Au
  - IR Real Number V

Element: 0

Regions

- mineable
- non-mineable

Statistics  Exact statistics

**Au (unit)**

Samples: 19881  
Minimum: -0.14837  
25th percentile: 0.1751  
Median: 0.405343  
75th percentile: 0.543027  
Maximum: 0.807012  
Mean: 0.356347  
Std. deviation: 0.22448  
Variance: 0.050391

Property characteristics

No-data value: -99999  
Display template: Au  
Unit: unitless  
Legal minimum: \*\*none\*  
Legal maximum: \*\*none\*  
Data type: Float

Scale: linear | Nb bin: 50 | Color by: None

### Property Statistics (5)

Object: d \ All

Property

- IR Real Number
  - IR Au\_augrid
  - IR Kriging\_Au1
  - IR Real Number V

Element: 0

Regions

- mineable
- non-mineable

Statistics  Exact statistics

**Kriging\_Au1**

Samples: 19881  
Minimum: -0.06784  
25th percentile: 0.137796  
Median: 0.395151  
75th percentile: 0.535987  
Maximum: 0.7  
Mean: 0.348226  
Std. deviation: 0.216005  
Variance: 0.046658

Property characteristics

No-data value: -99999  
Display template: Au  
Unit: unitless  
Legal minimum: \*\*none\*  
Legal maximum: \*\*none\*  
Data type: Float

Scale: linear | Nb bin: 50 | Color by: None



## Volumenobjekte in Skua-Gocad

Wenn Sie sich weitergehend mit räumlicher Analyse und Geostatistik befassen wollen:

- Kapitel 12 im Tutorial, der Datensatz *WellPoints.txt* befindet sich im OPAL
- Lehrveranstaltung „Multivariate- und Geostatistik“ (Prof. Gerhards)

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