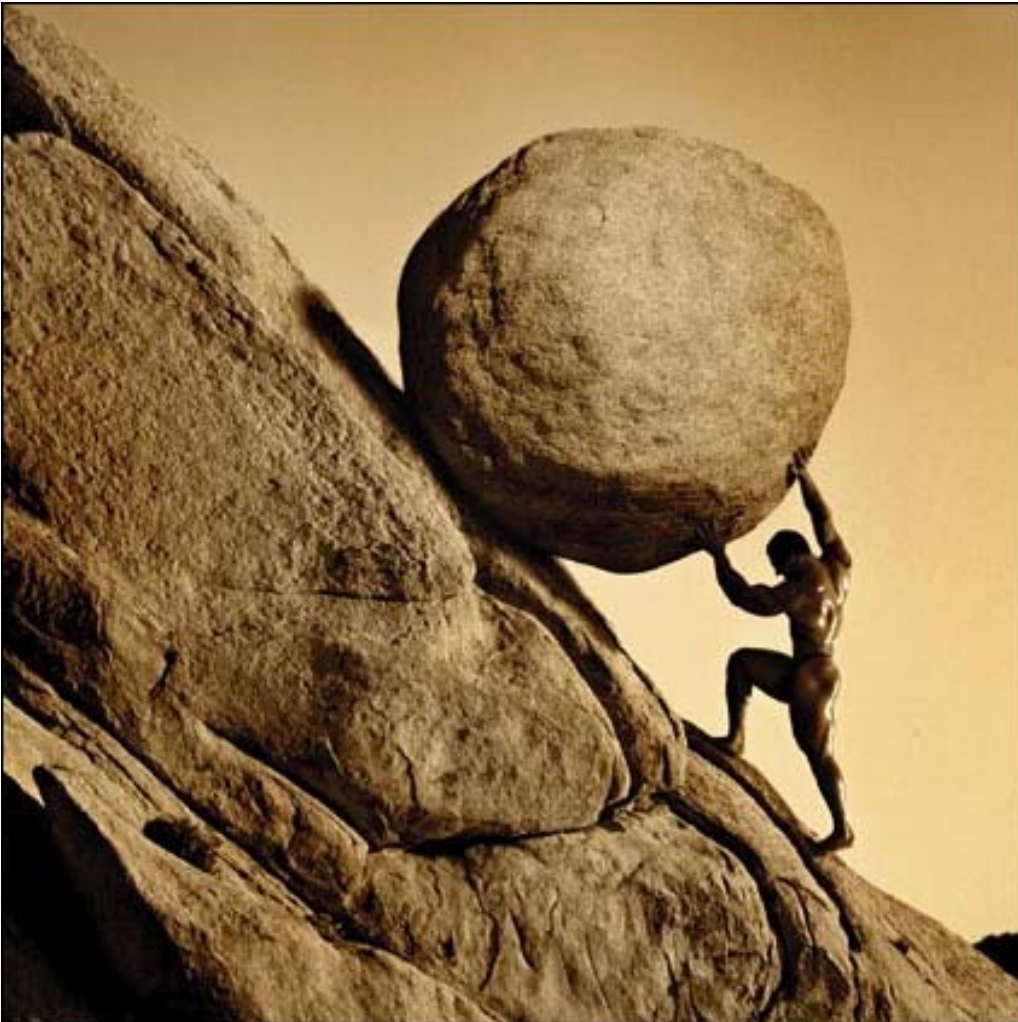


# Geological Data Management (Nailing Jelly To A Tree)



**Jim Reed**

Director of Research &  
Development

RockWare Incorporated  
Golden, Colorado



# Outline

- Conference Overview
- Refining The Topic
- Design Philosophy & Considerations
- Examples of Downhole Data
- A Simplified Borehole Data Model
- A Complex Borehole Data Model



# Outline

- **Conference Overview**
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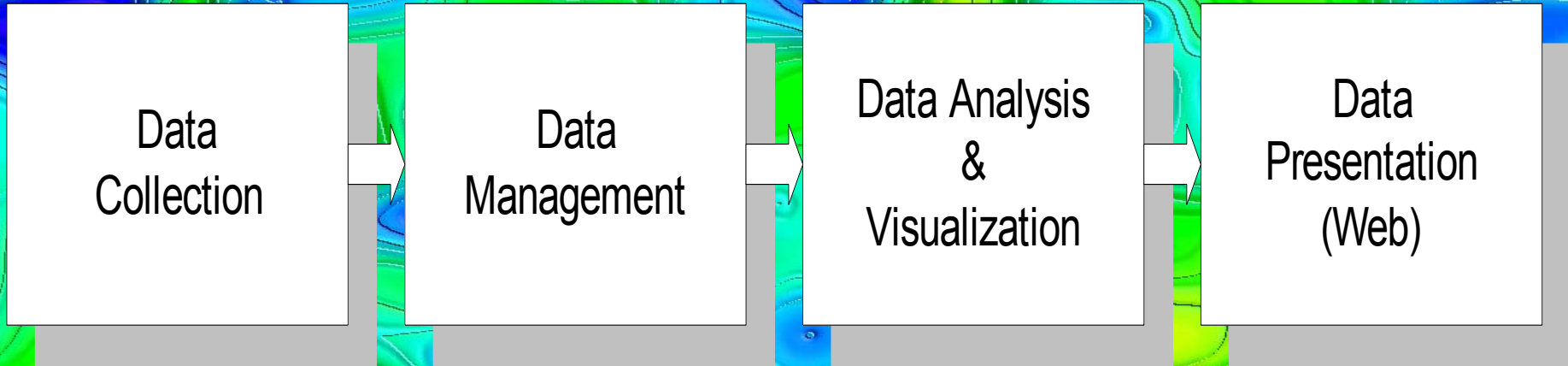
# Conference Topics

Data  
Collection

Data  
Management

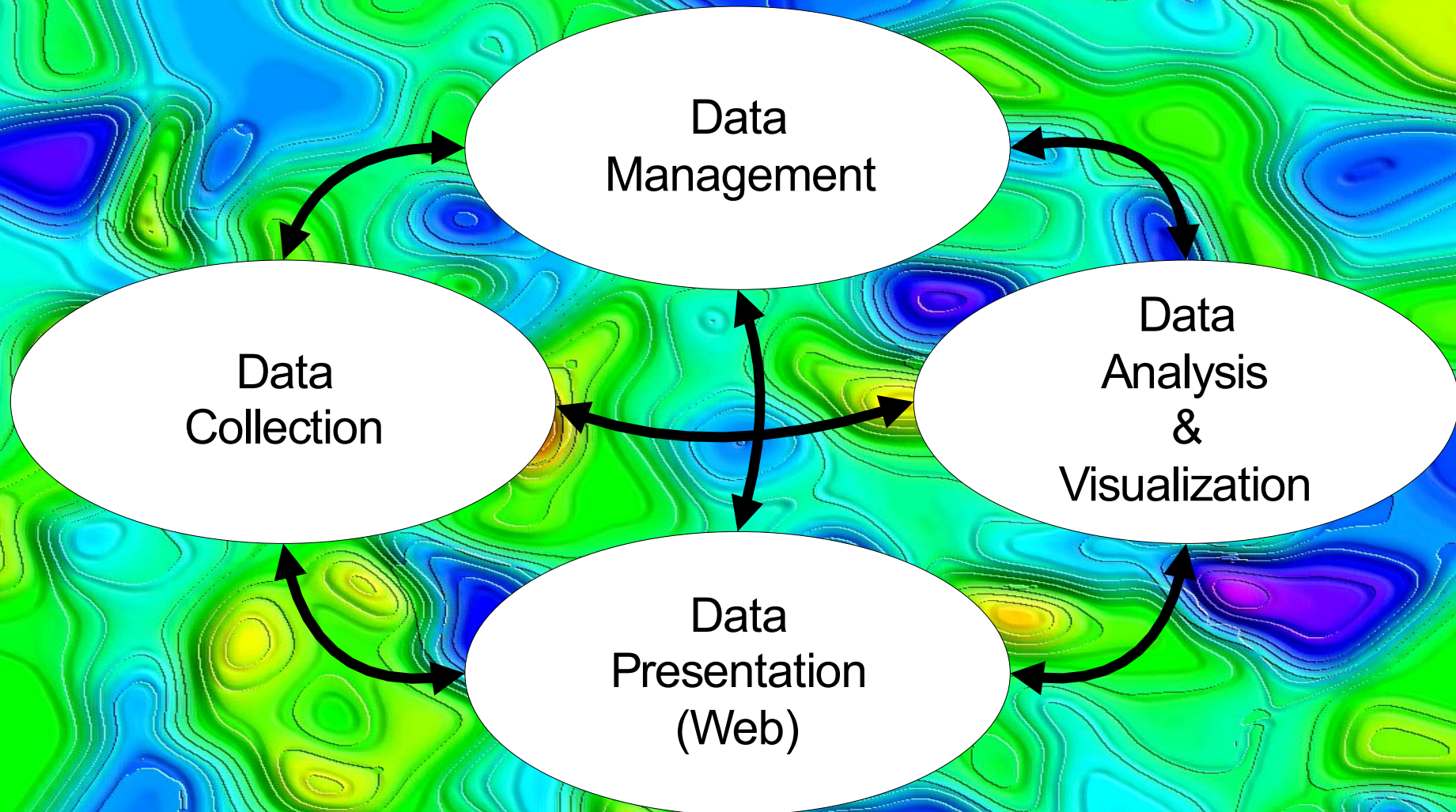
Data Analysis  
&  
Visualization

Data  
Presentation  
(Web)





# Conference Topics



## Management and Analysis of Ground Water Data

November 16, 2004, 8 am - 4:30 pm  
Continuing Education and Conference Center  
University of Minnesota, St Paul

|                                                                                                                                                     | Data Collection | Data Management | Data Analysis & Visualization | Data Presentation (Web) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|-------------------------------|-------------------------|
| <b>Jim Reed</b> , RockWare Inc.: <i>Overview of Geologic Data Management - Nailing Jelly to a Tree</i>                                              |                 |                 |                               |                         |
| <b>Geoff Delin</b> , US Geological Survey: <i>Real-Time Water Level and Stream Flow Data Acquisition</i>                                            |                 |                 |                               |                         |
| <b>John Dustman</b> , Summit EnviroSolutions Inc.: <i>Management and Analysis of Groundwater Data</i>                                               |                 |                 |                               |                         |
| <b>David Odd</b> , Campbell Scientific: <i>Wireless and PDA Telemetry for Remote Data Collection</i>                                                |                 |                 |                               |                         |
| <b>Melinda Erickson</b> , University of Minnesota: <i>Beyond the Minimum: Purposefully Designing (or Redesigning) Ground Water Sampling Schemes</i> |                 |                 |                               |                         |
| <b>Brian Johnson</b> , MN Department of Health: <i>Minnesota's County Well Index: current status and future plans</i>                               |                 |                 |                               |                         |
| <b>Jim Reed</b> , RockWare Inc.: <i>Three-Dimensional Visualization of Geologic Data - Eye Candy or Scientific Tool?</i>                            |                 |                 |                               |                         |
| <b>Harvey Thorleifson</b> , MN Geological Survey: <i>Implementation of 3D Geologic Mapping</i>                                                      |                 |                 |                               |                         |
| <b>Rich Soule</b> , MN Department of Health: <i>Arsenic Data Presentation and Analysis</i>                                                          |                 |                 |                               |                         |
| <b>Robert Tipping</b> , MN Geological Survey: <i>Bringing the data together: improved characterization of the Prairie du Chien Group</i>            |                 |                 |                               |                         |
| <b>Tina Pint</b> , Barr Engineering: <i>Incorporating Public Databases into the development of distributed parameter ground water models</i>        |                 |                 |                               |                         |
| <b>Laurel Reeves</b> , MN Department of Natural Resources: <i>Online Data Retrieval and GIS Data Deli</i>                                           |                 |                 |                               |                         |

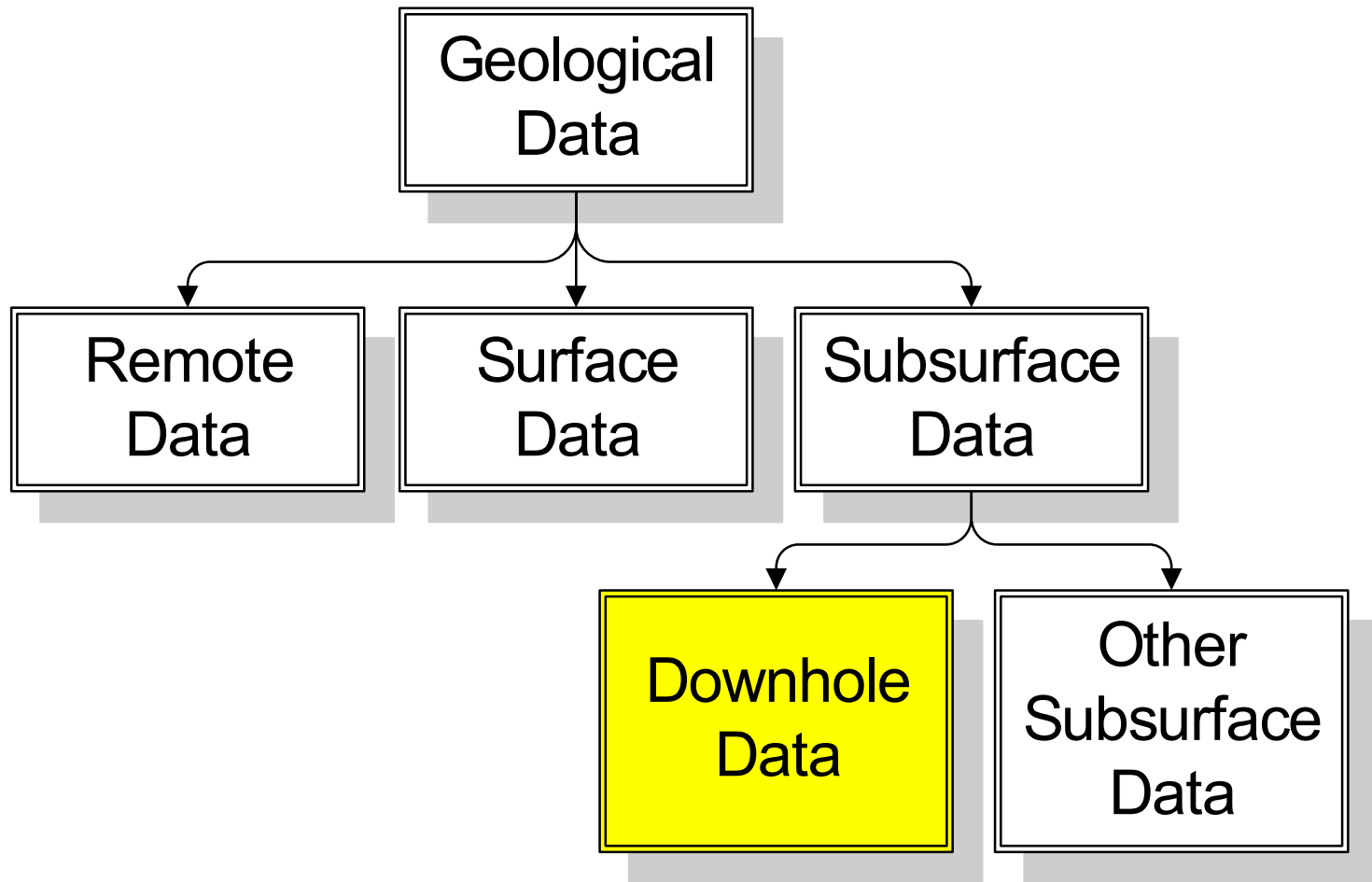


# Outline

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- A Complex Borehole Data Model



# Refining The Topic





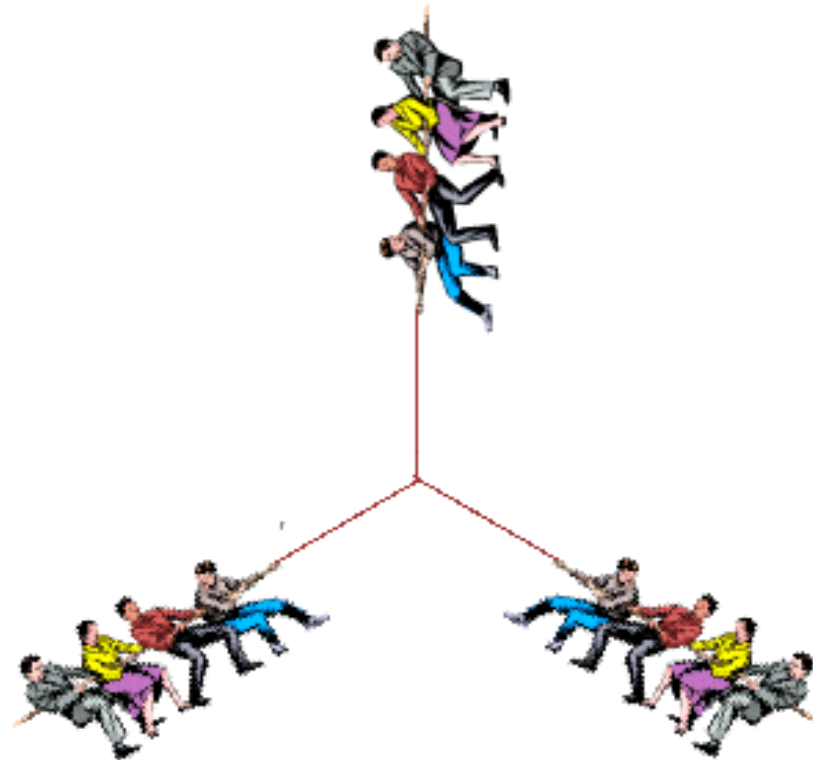
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# Primary Design Considerations

Ease-of-Use

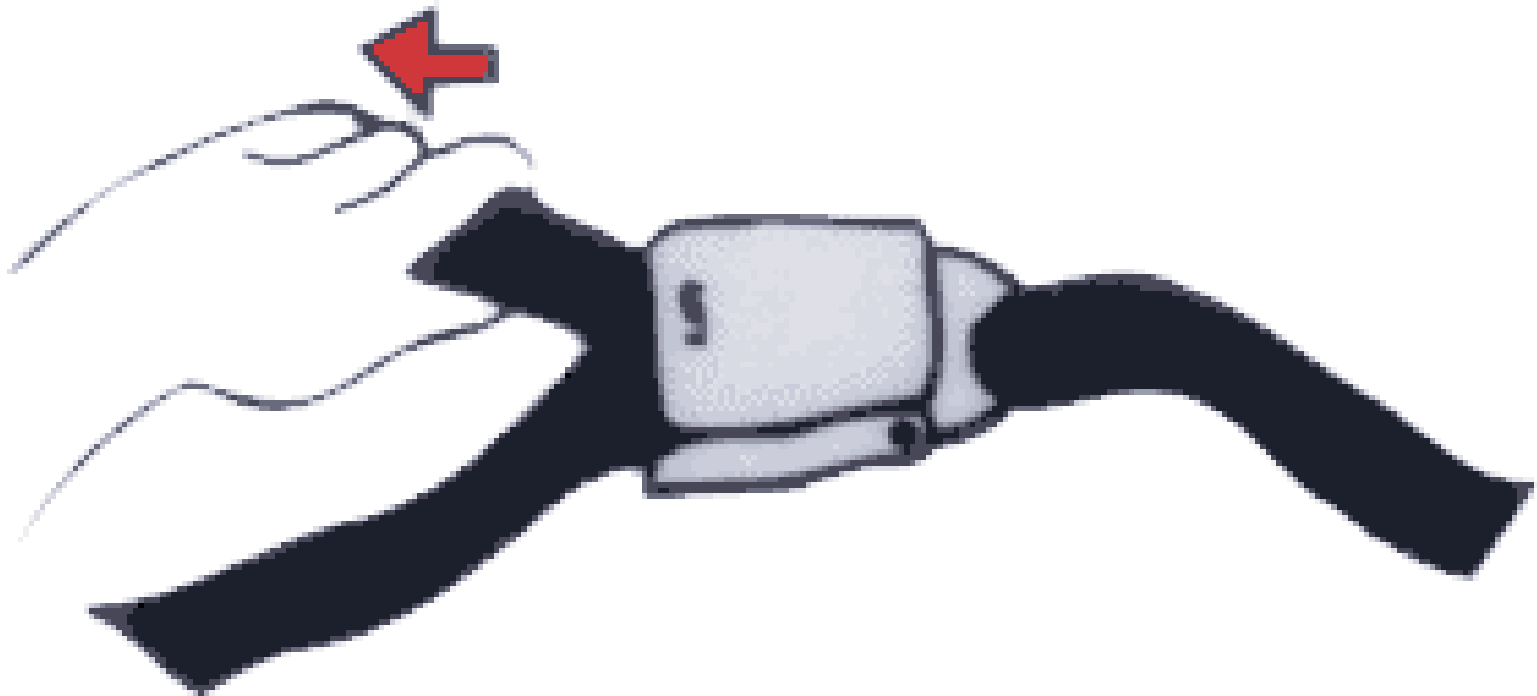


Speed

Flexibility



# Ease of Use





# The Ultimately Easy-to-Use Product

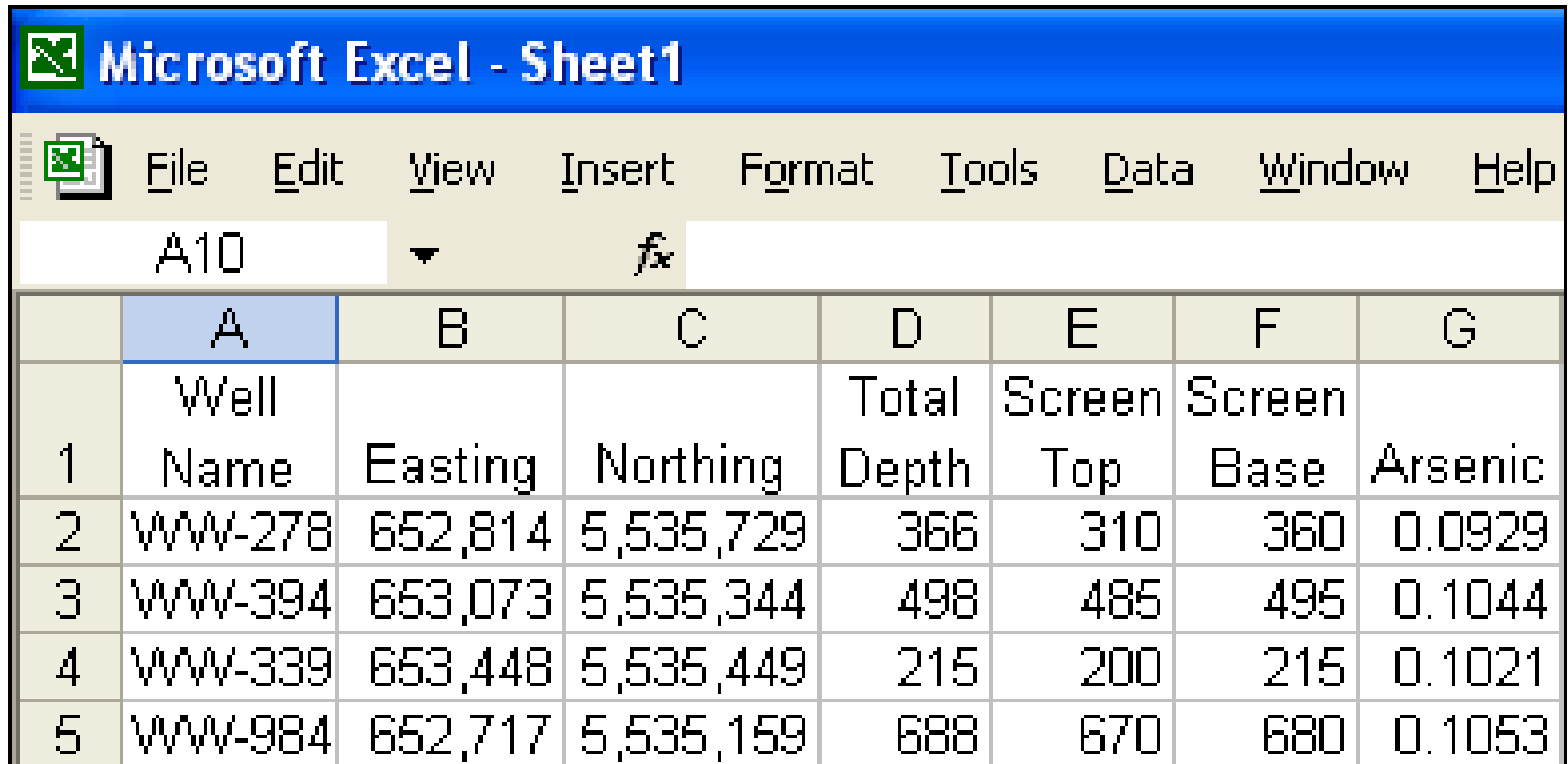


(Does nothing - Nothing to learn)



# The Excel (Flat File) Corner

## Typical Scenario



Microsoft Excel - Sheet1

File Edit View Insert Format Tools Data Window Help

A10 *fx*

|   | A         | B       | C         | D           | E          | F           | G       |
|---|-----------|---------|-----------|-------------|------------|-------------|---------|
|   | Well Name | Easting | Northing  | Total Depth | Screen Top | Screen Base | Arsenic |
| 1 | WW-278    | 652,814 | 5,535,729 | 366         | 310        | 360         | 0.0929  |
| 2 | WW-394    | 653,073 | 5,535,344 | 498         | 485        | 495         | 0.1044  |
| 3 | WW-339    | 653,448 | 5,535,449 | 215         | 200        | 215         | 0.1021  |
| 4 | WW-984    | 652,717 | 5,535,159 | 688         | 670        | 680         | 0.1053  |

Initial Phase



# The Excel (Flat File) Corner

## Typical Scenario

(Continued)

| Microsoft Excel - Sheet1                            |         |         |           |       |       |        |         |        |         |         |         |         |         |         |
|-----------------------------------------------------|---------|---------|-----------|-------|-------|--------|---------|--------|---------|---------|---------|---------|---------|---------|
| File Edit View Insert Format Tools Data Window Help |         |         |           |       |       |        |         |        |         |         |         |         |         |         |
| A8 fx                                               |         |         |           |       |       |        |         |        |         |         |         |         |         |         |
|                                                     | A       | B       | C         | D     | E     | F      | G       | H      | I       | J       | K       | L       | M       | N       |
|                                                     | Well    |         |           |       | Total | Screen | Screen  | Screen | Screen  |         |         | Oak     | Los     | Hanford |
| 1                                                   | Name    | Easting | Northing  | Elev. | Depth | #1 Top | #1 Base | #2 Top | #2 Base | Arsenic | Benzene | Fm. Top | Fm. Top | Fm. Top |
| 2                                                   | WWW-278 | 652,814 | 5,535,729 | 658   | 366   | 310    | 360     |        |         | 0.0929  | 0.003   | 67      | 132     | 211     |
| 3                                                   | WWW-394 | 653,073 | 5,535,344 | 722   | 498   | 485    | 495     |        |         | 0.1044  | 0.029   | 85      | 178     | 276     |
| 4                                                   | WWW-339 | 653,448 | 5,535,449 | 631   | 215   | 200    | 215     |        |         | 0.1021  | 0.001   | 46      | 187     | 214     |
| 5                                                   | WWW-984 | 652,717 | 5,535,159 | 595   | 688   | 670    | 680     |        |         | 0.1053  | 0.001   | 13      | 96      | 146     |
| 6                                                   | WWW-394 | 649,439 | 5,394,342 | 816   | 515   | 204    | 215     | 460    | 480     | 0.0011  | 0.025   | 112     | 205     | 255     |

The “HEY-THIS-IS-COOL” Phase



# The Excel (Flat File) Corner Typical Scenario

(Continued)

| Microsoft Excel - Sheet1                            |              |         |           |       |                |                  |                   |                  |                   |         |         |                         |                          |                    |      |         |         |
|-----------------------------------------------------|--------------|---------|-----------|-------|----------------|------------------|-------------------|------------------|-------------------|---------|---------|-------------------------|--------------------------|--------------------|------|---------|---------|
| File Edit View Insert Format Tools Data Window Help |              |         |           |       |                |                  |                   |                  |                   |         |         |                         |                          |                    |      |         |         |
| R7 fx                                               |              |         |           |       |                |                  |                   |                  |                   |         |         |                         |                          |                    |      |         |         |
|                                                     | A            | B       | C         | D     | E              | F                | G                 | H                | I                 | J       | K       | L                       | M                        | N                  | O    | P       | Q       |
|                                                     | Well<br>Name | Easting | Northing  | Elev. | Total<br>Depth | Screen<br>#1 Top | Screen<br>#1 Base | Screen<br>#2 Top | Screen<br>#2 Base | Arsenic | Benzene | Oak<br>Ridge<br>Fm. Top | Los<br>Alamos<br>Fm. Top | Hanford<br>Fm. Top | 0-5  | 5-10    | 10-15   |
| 2                                                   | WW-278       | 652,814 | 5,535,729 | 658   | 366            | 310              | 360               |                  |                   | 0.0929  | 0.003   | 67                      | 132                      | 211                | SOIL | BRN.CLA | GRN.SHA |
| 3                                                   | WW-394       | 653,073 | 5,535,344 | 722   | 498            | 485              | 495               |                  |                   | 0.1044  | 0.029   | 85                      | 178                      | 276                | SOIL | SOIL    | BRN.CLA |
| 4                                                   | WW-339       | 653,448 | 5,535,449 | 631   | 215            | 200              | 215               |                  |                   | 0.1021  | 0.001   | 46                      | 187                      | 214                | SOIL | RED CLA | GRN.SHA |
| 5                                                   | WW-984       | 652,717 | 5,535,159 | 595   | 688            | 670              | 680               |                  |                   | 0.1053  | 0.001   | 13                      | 96                       | 146                | SOIL | SOIL    | SOIL    |
| 6                                                   | WW-394       | 649,439 | 5,394,342 | 816   | 515            | 204              | 215               | 460              | 480               | 0.0011  | 0.025   | 112                     | 205                      | 255                | SOIL | BRN.CLA | BRN.CLA |

The “UH-OH” Phase

# The Excel (Flat File) Corner Typical Scenario

(Continued)



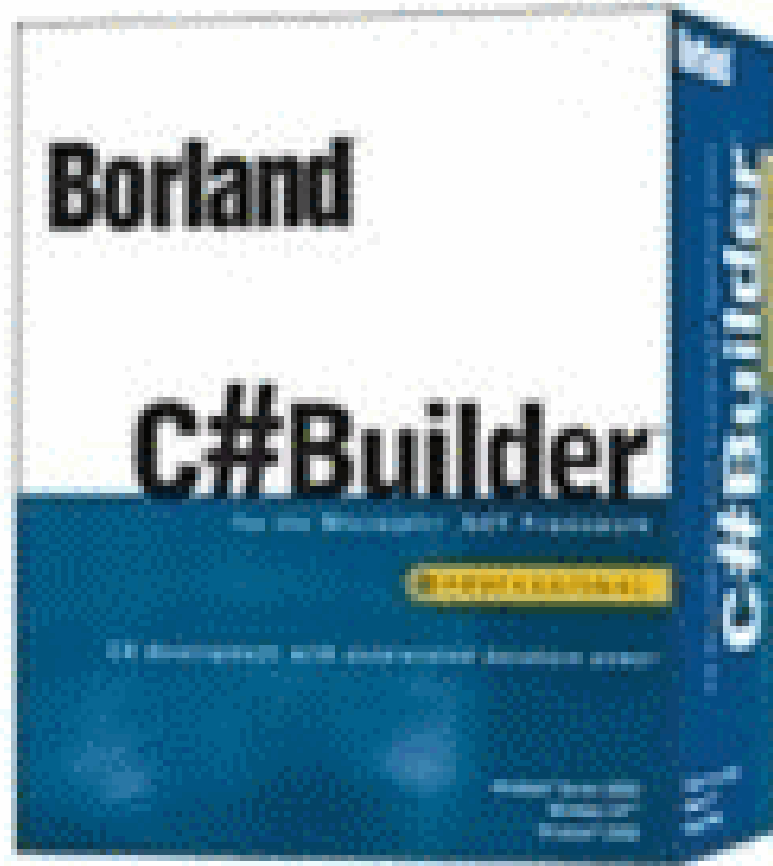
The “Wander-Around-The-Office-Asking-For-Help” Phase



# Flexibility



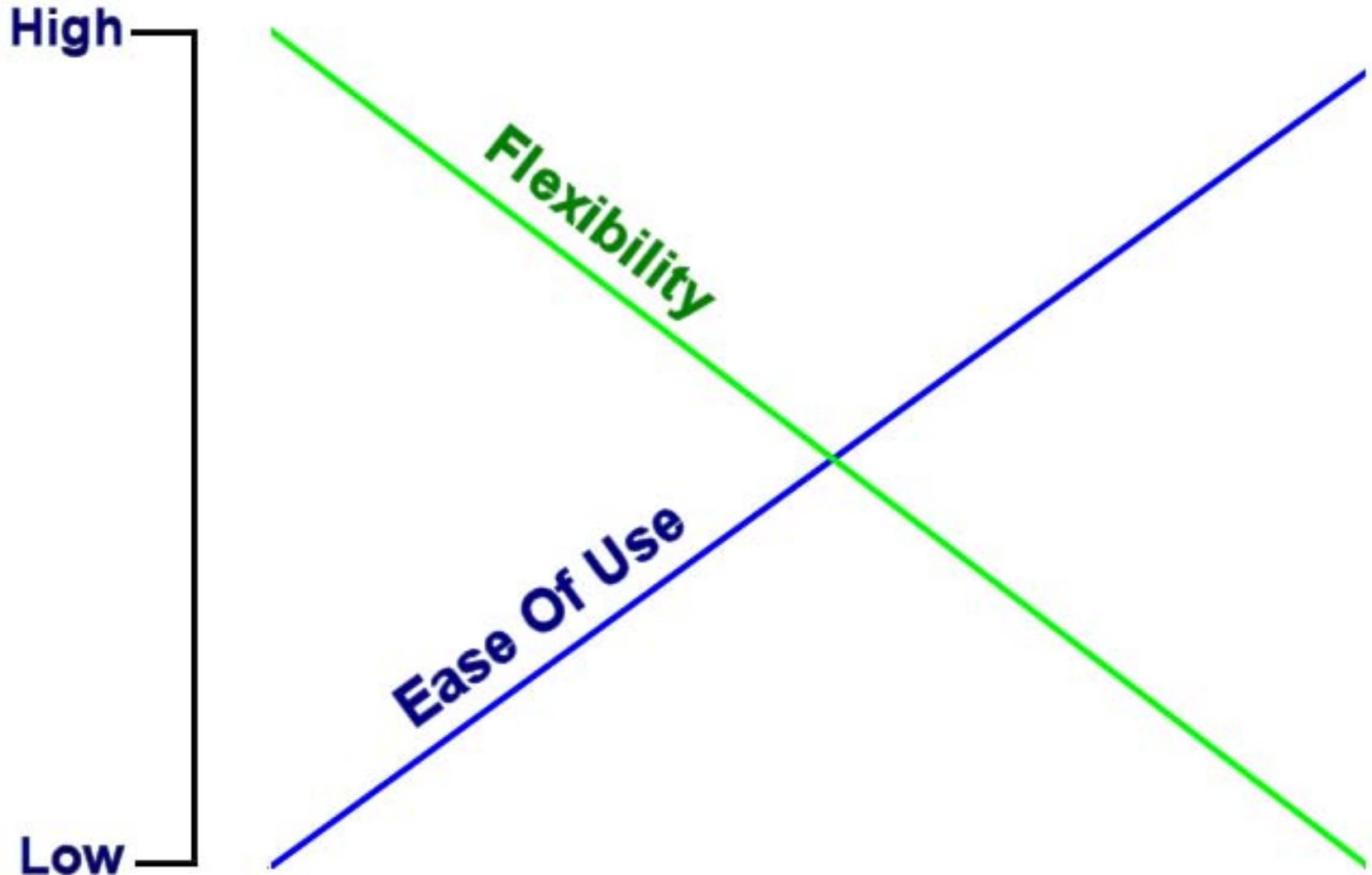
# The Ultimately Flexible Program



(Low-Level Language Compiler)



# Flexibility is Inversely Proportional to Ease-of-Use



# Feature Creep



Version 1.0



# Feature Creep

(Continued)



Version 2.0

# Feature Creep

(Continued)

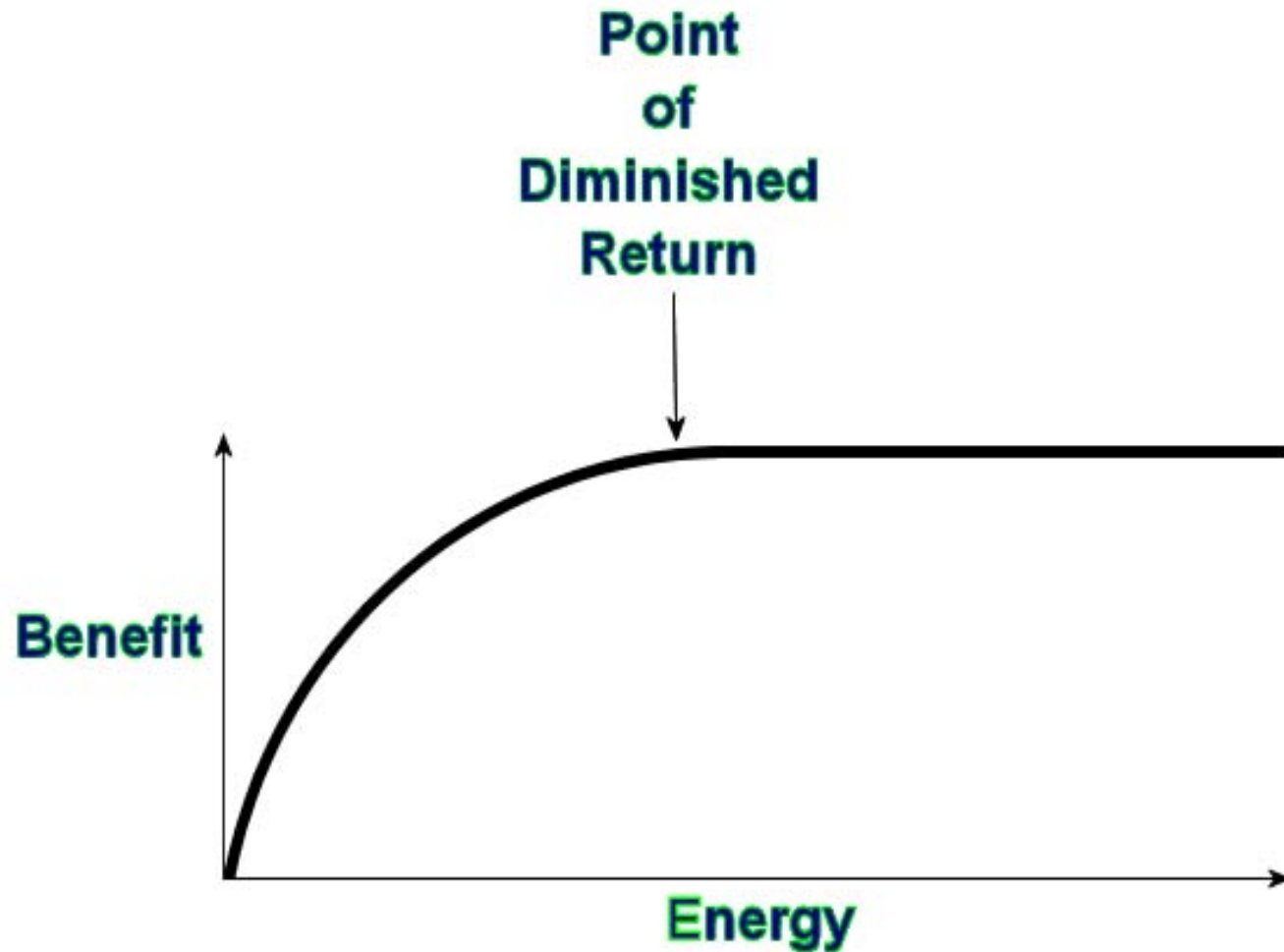


Version “N”



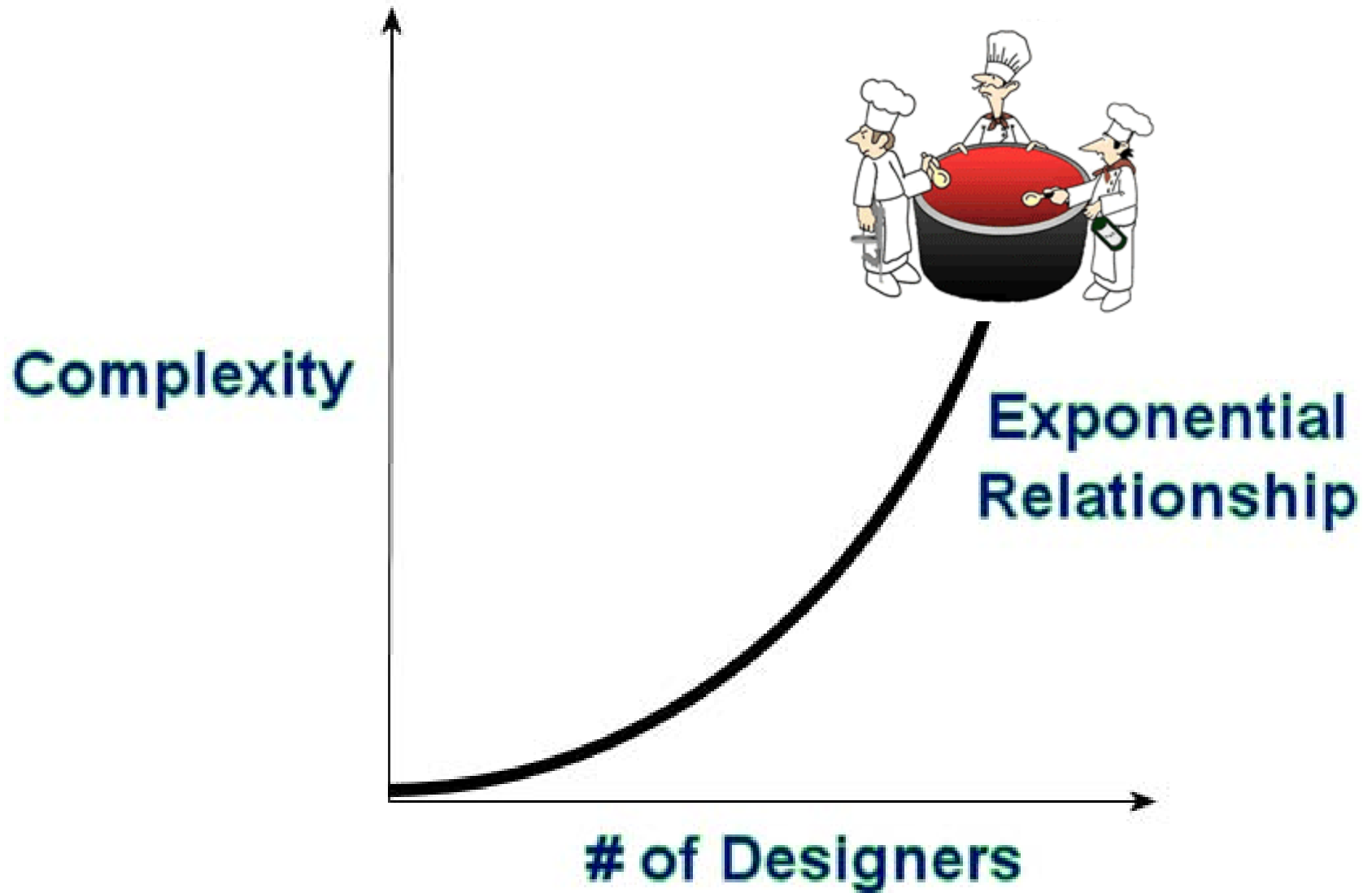
# Feature Creep

(Continued)



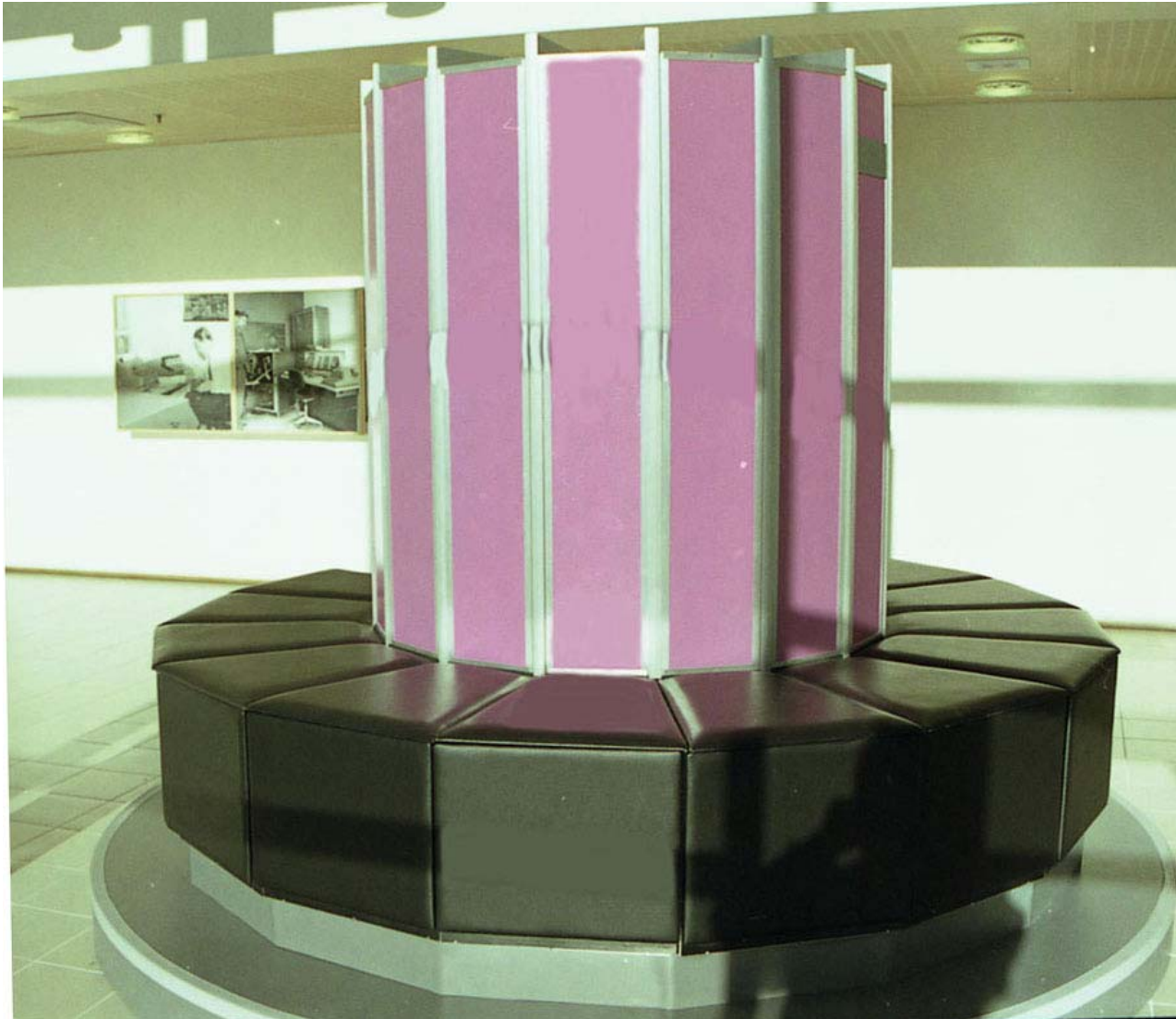
# Feature Creep

(Continued)

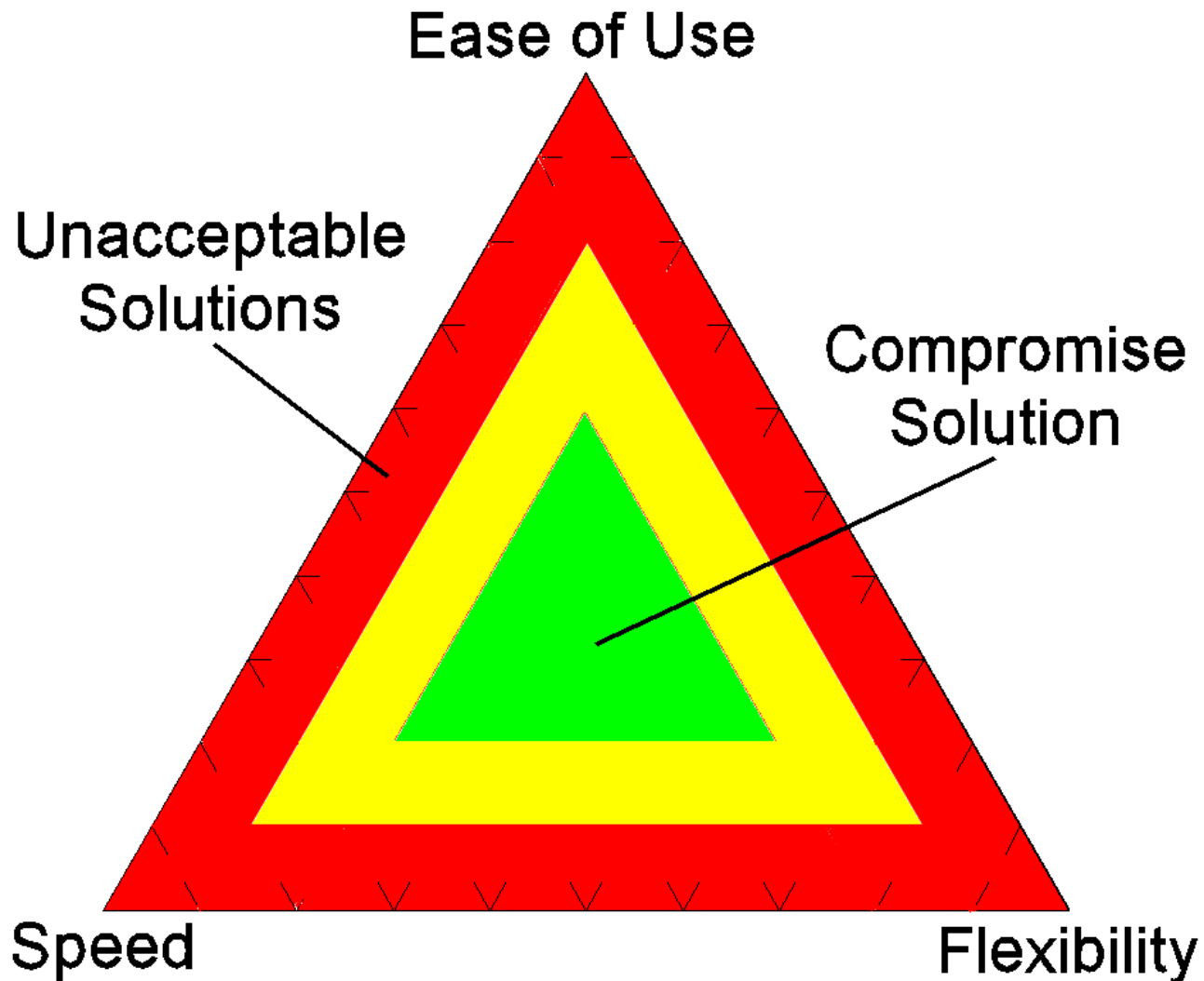




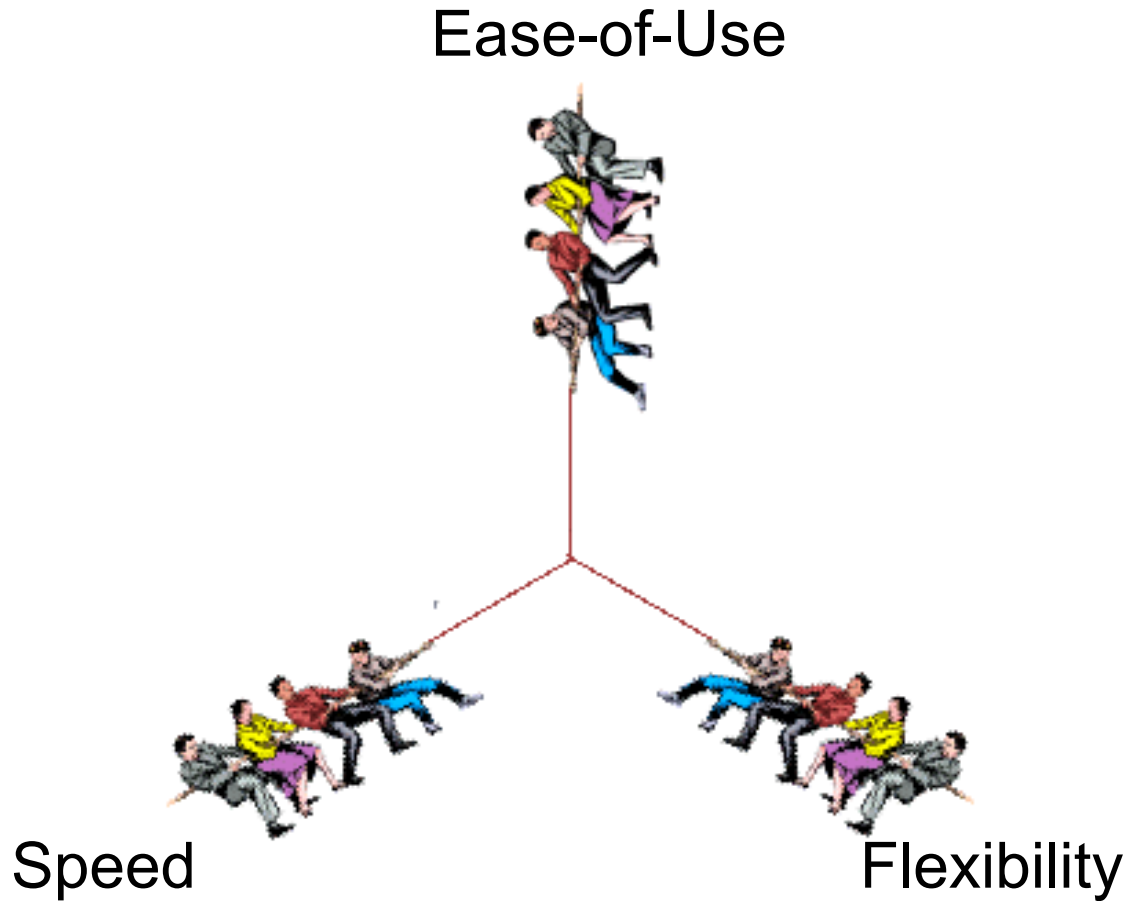
# Speed



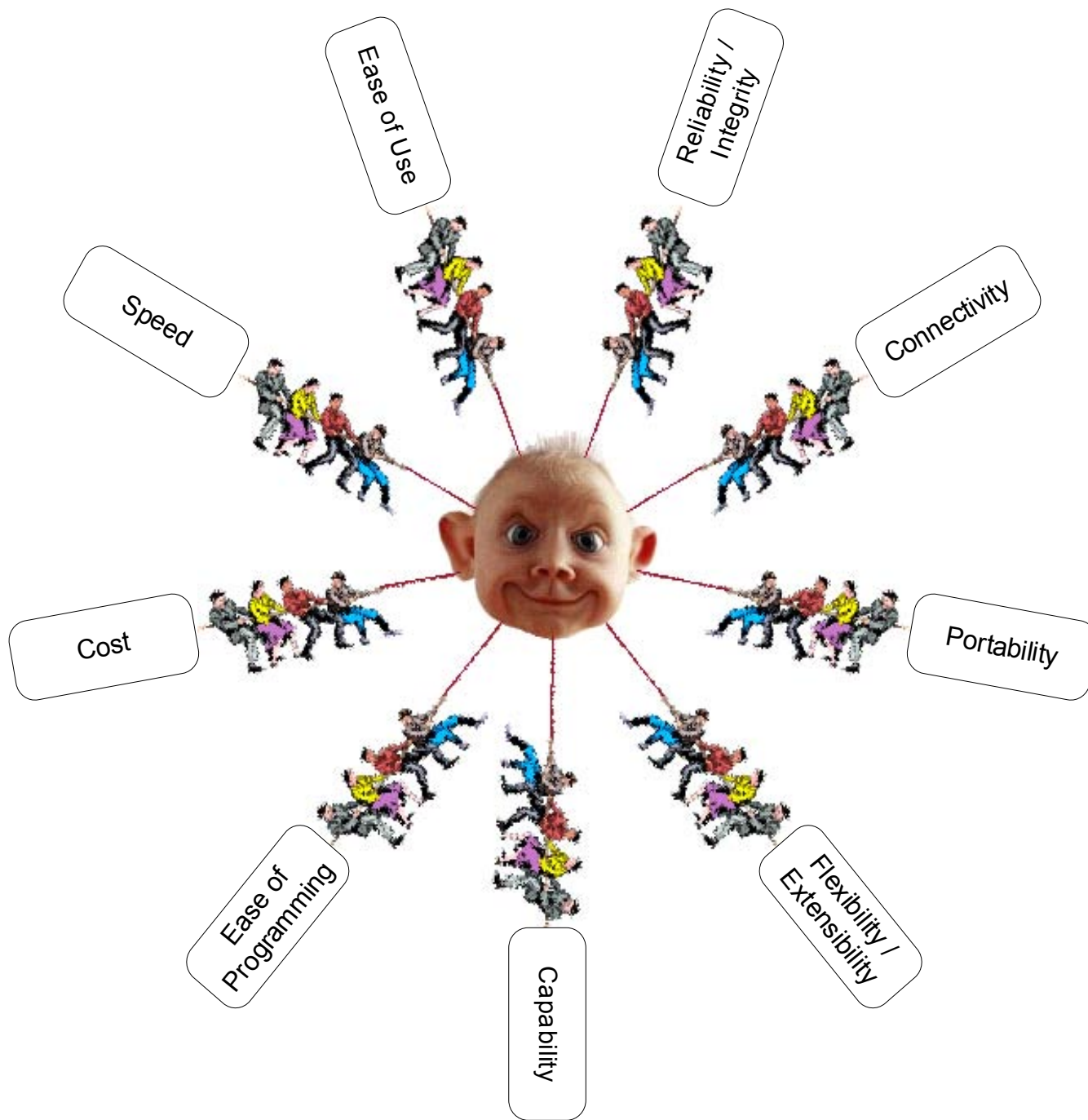
# Finding The Right Balance



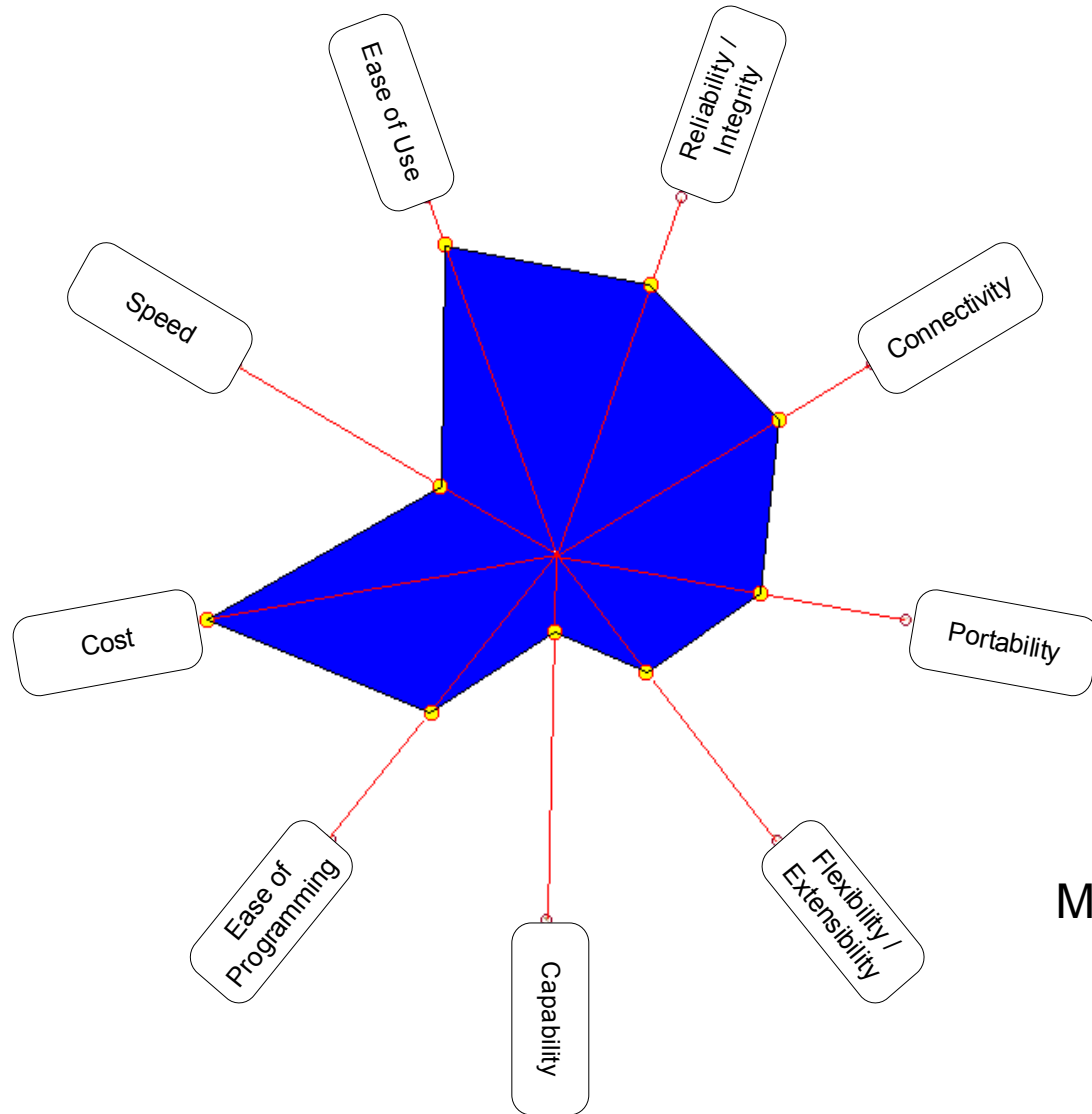
# There are more than just three considerations ..





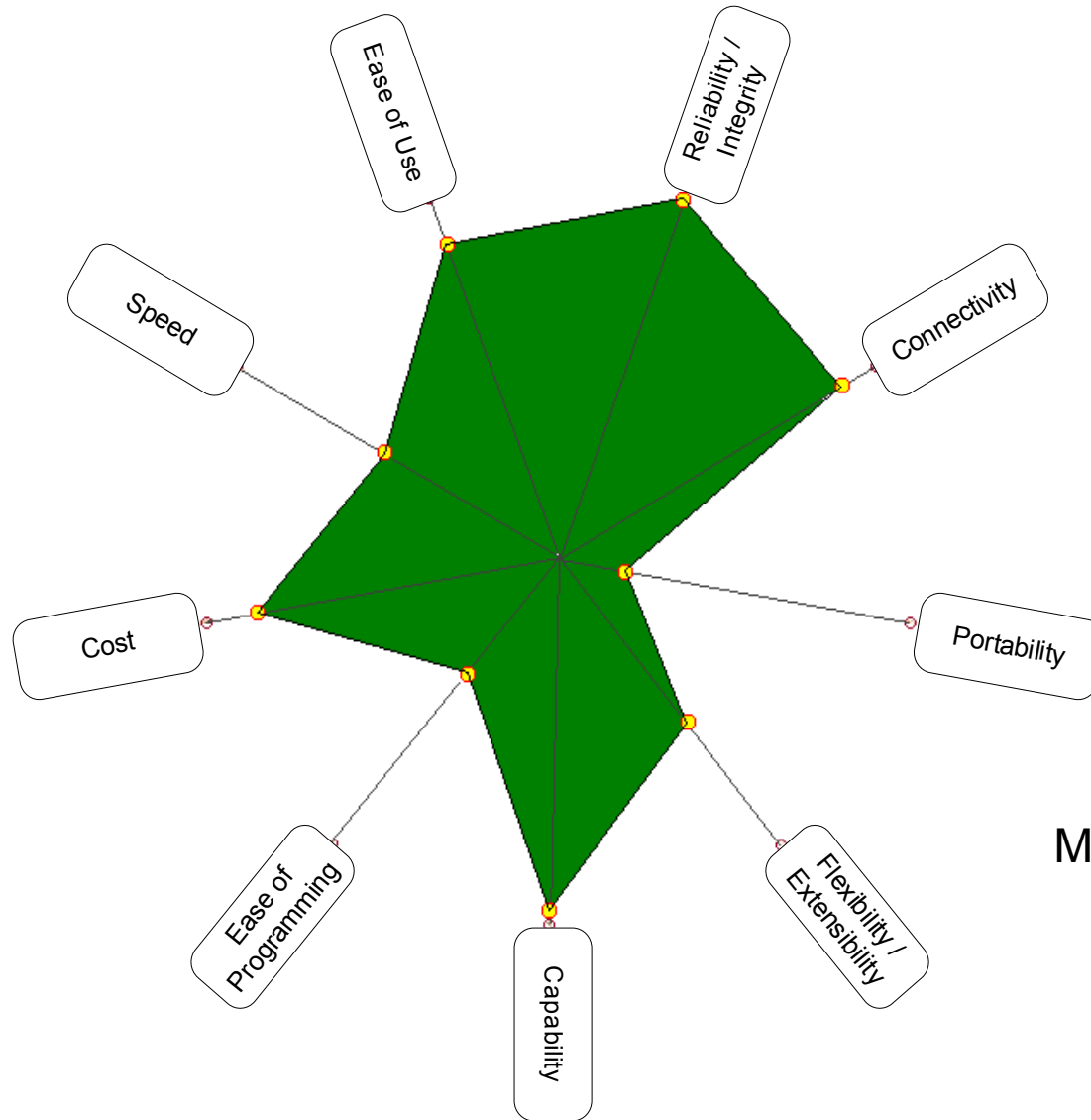


# Using Spider Diagrams To Compare & Design Data Management Systems



Microsoft Excel

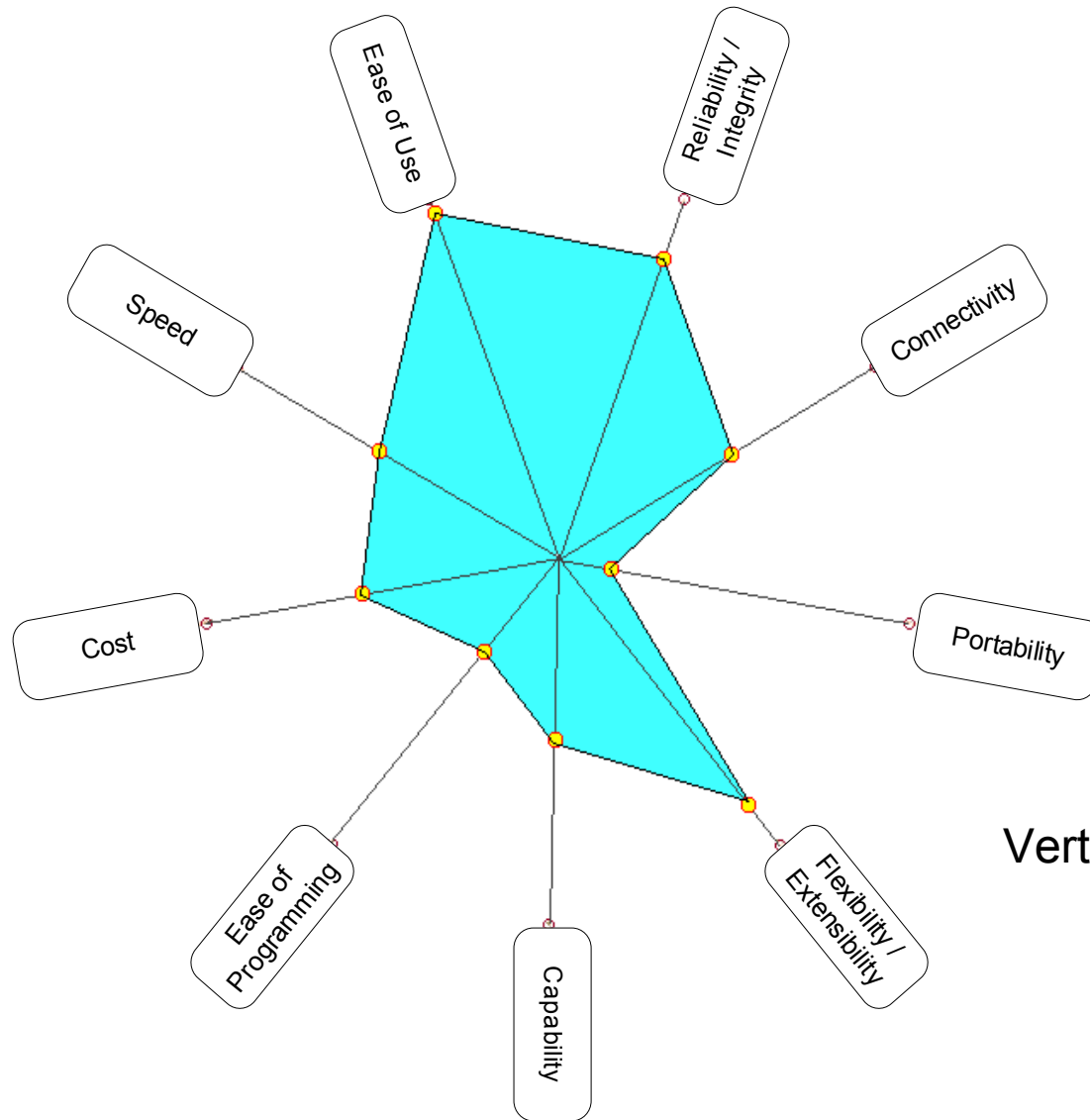
# Using Spider Diagrams To Compare & Design Data Management Systems



Microsoft Access



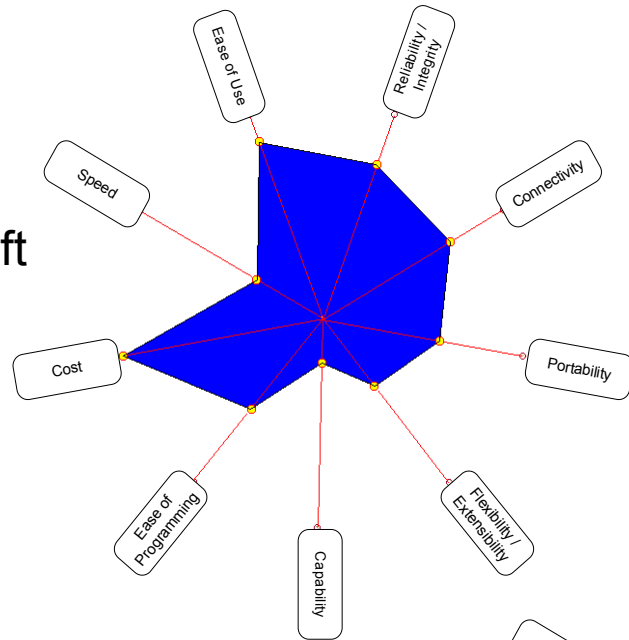
# Using Spider Diagrams To Compare & Design Data Management Systems



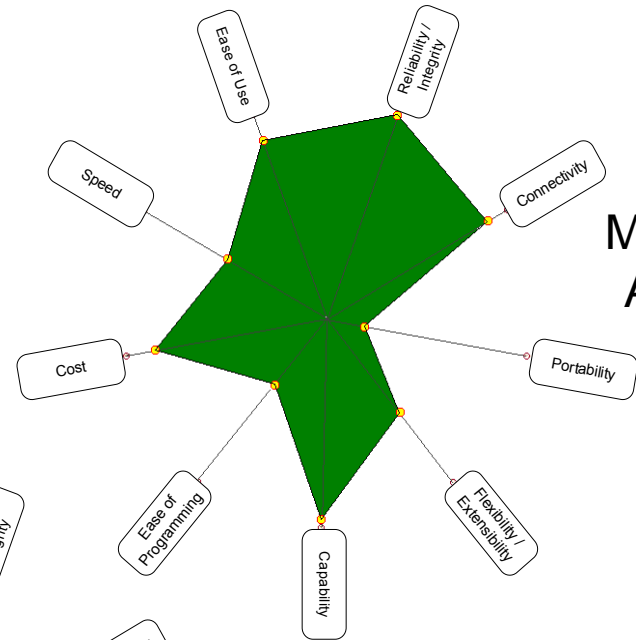
Vertical Commercial  
Product

# Using Spider Diagrams To Compare & Design Data Management Systems

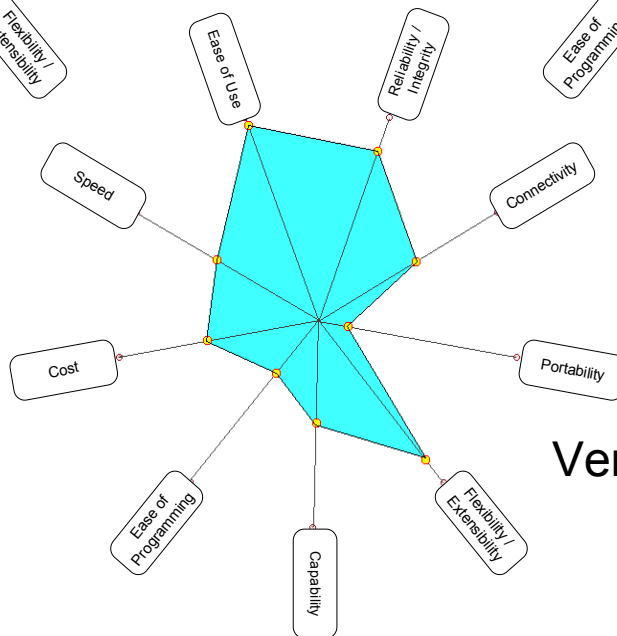
Microsoft  
Excel



Microsoft  
Access

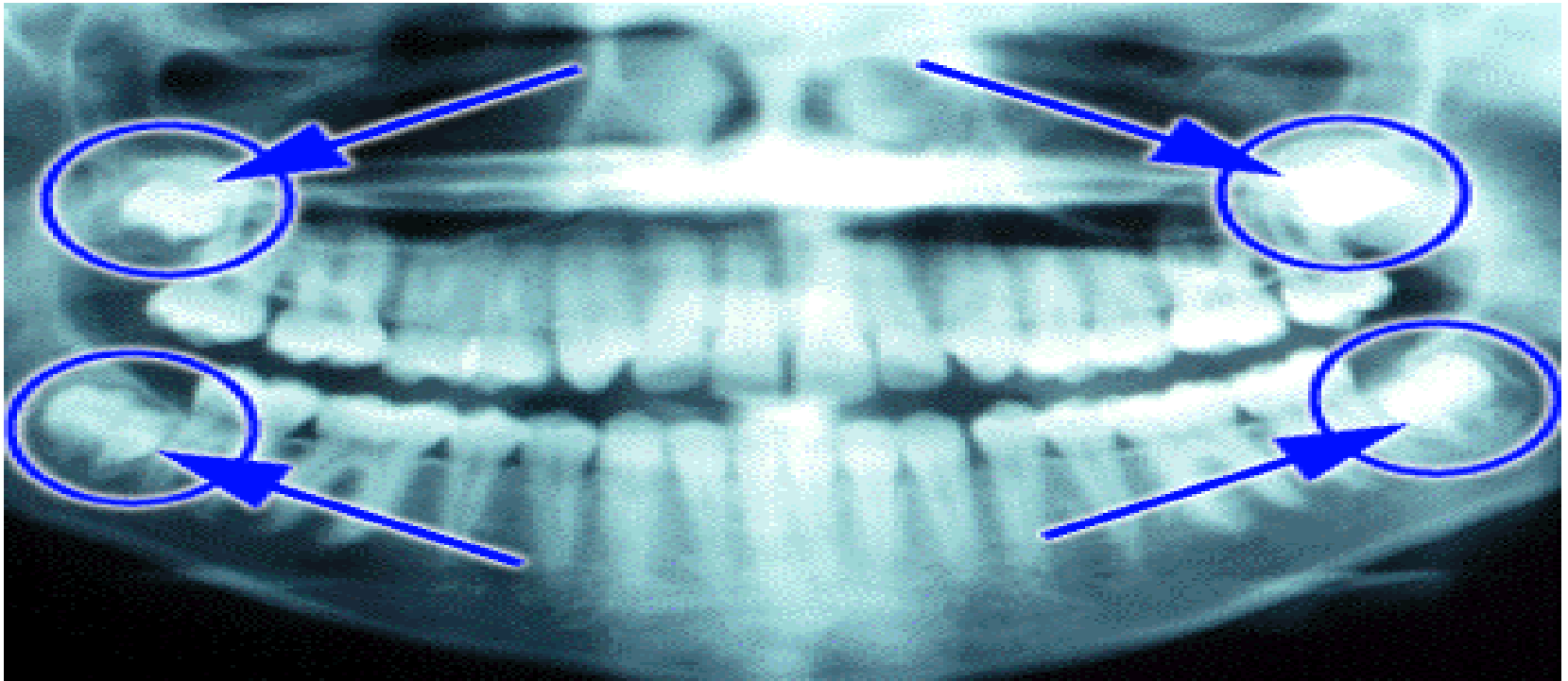


Vertical Commercial  
Product



# WISDOM:

Knowing when to stop before you start.



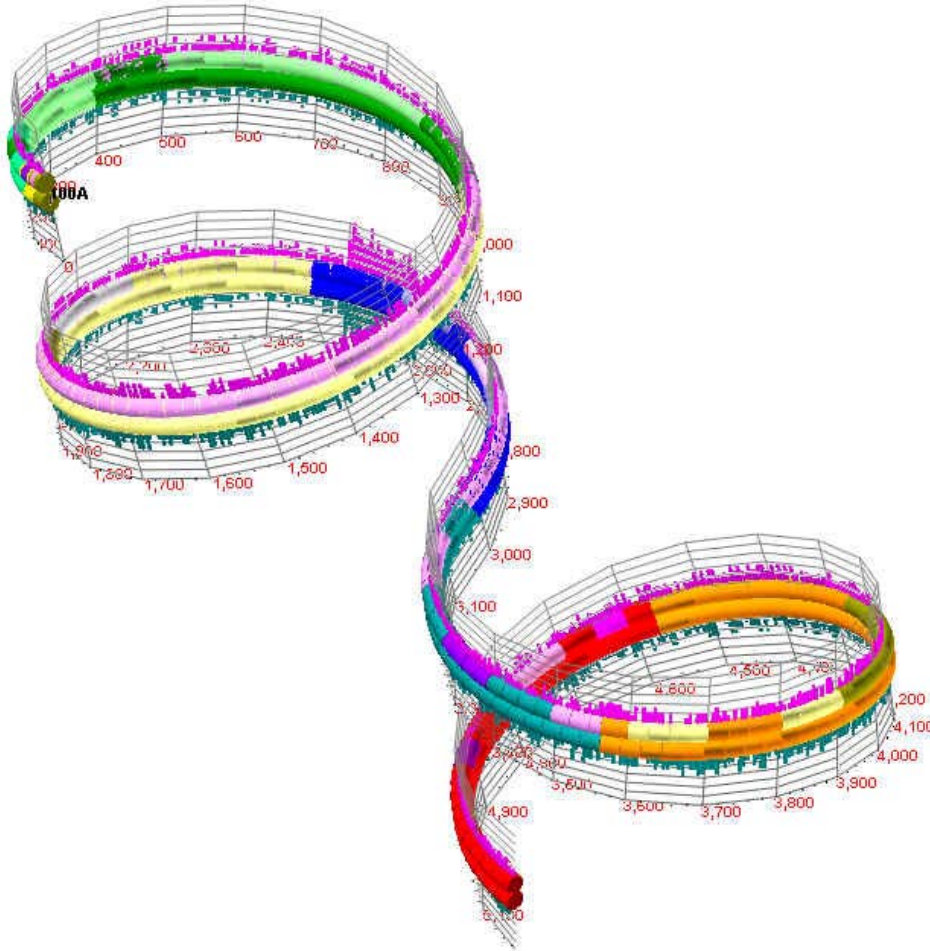


# Outline

- Conference Overview
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- **Examples of Downhole Data**
- A Simplified Borehole Data Model
- A Complex Borehole Data Model

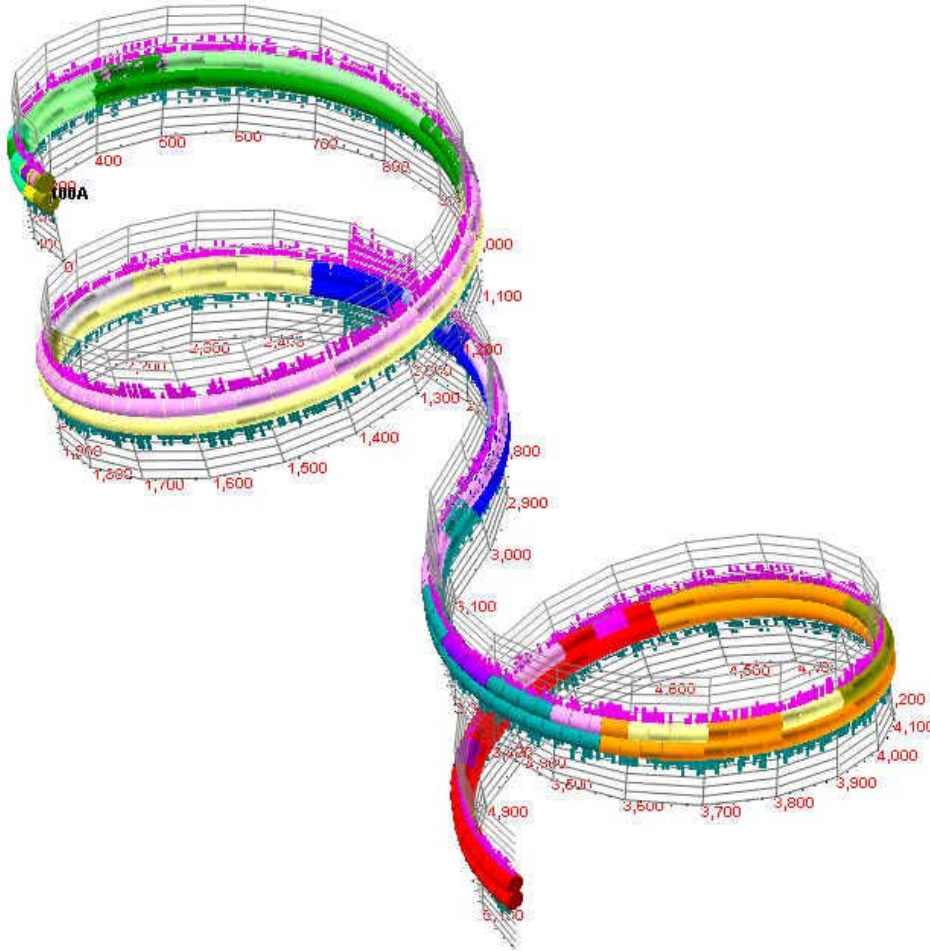


# Examples of Downhole Data



- Location
- Orientation
- Lithology
- Stratigraphy
- Interval Data
- Point Data
- Directional Data
- Imagery

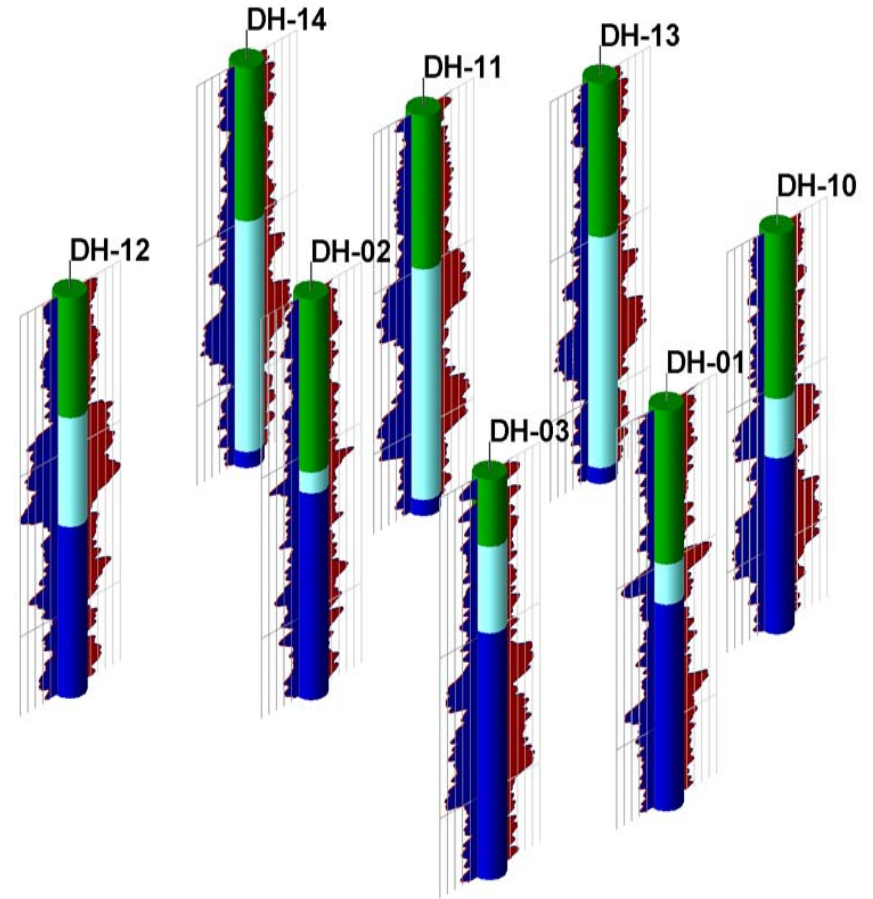
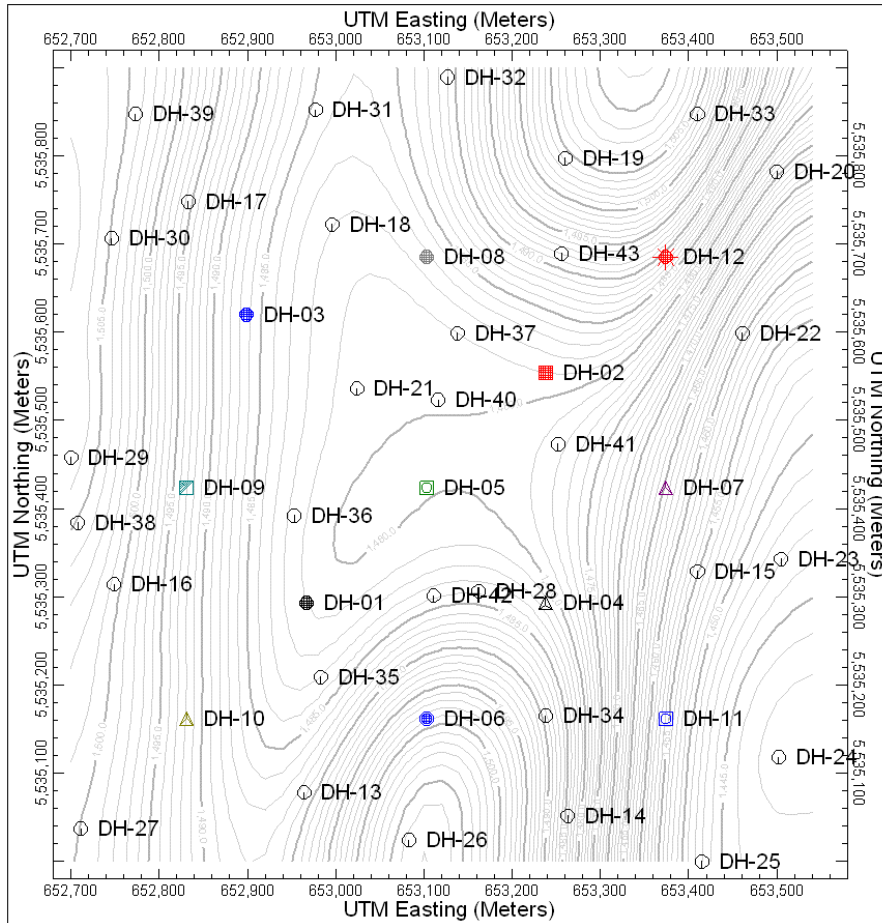
# Examples of Downhole Data



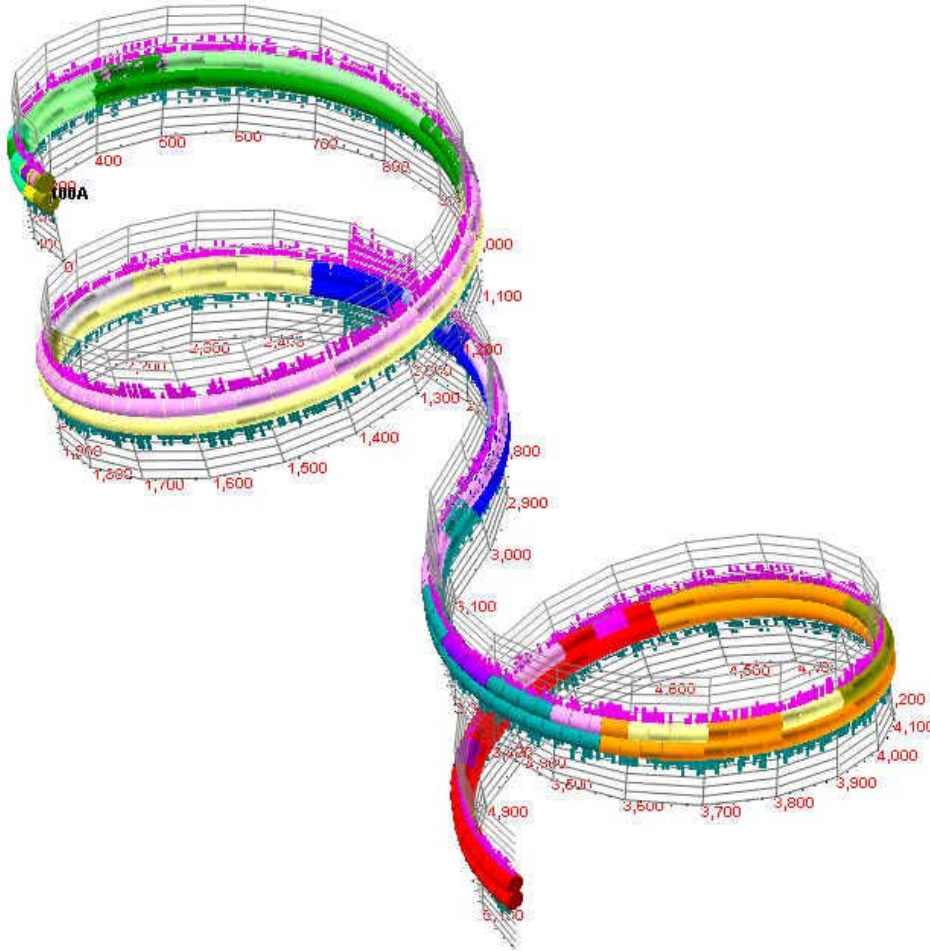
- Location
- Orientation
- Lithology
- Stratigraphy
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- Imagery



# Location

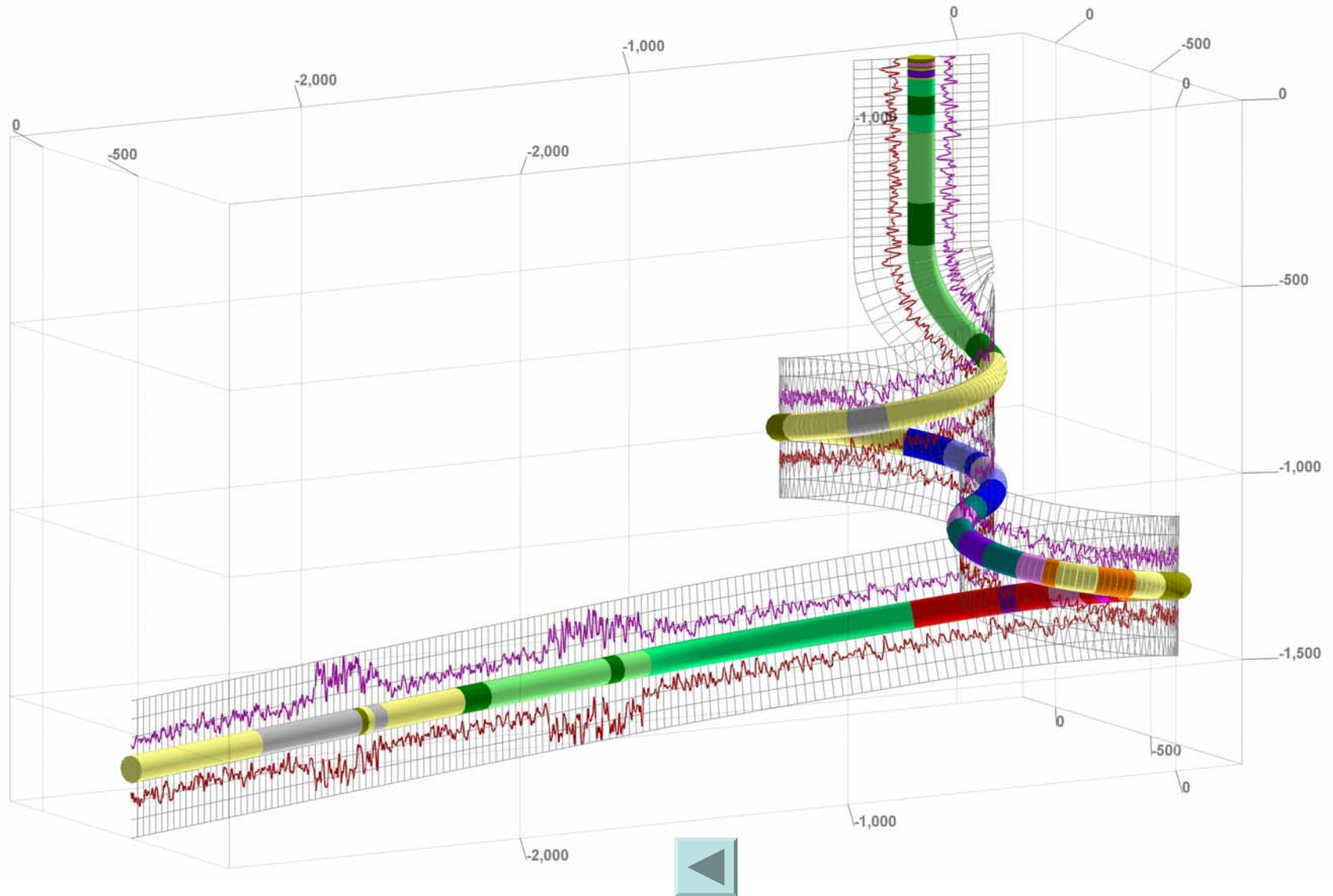


# Examples of Downhole Data



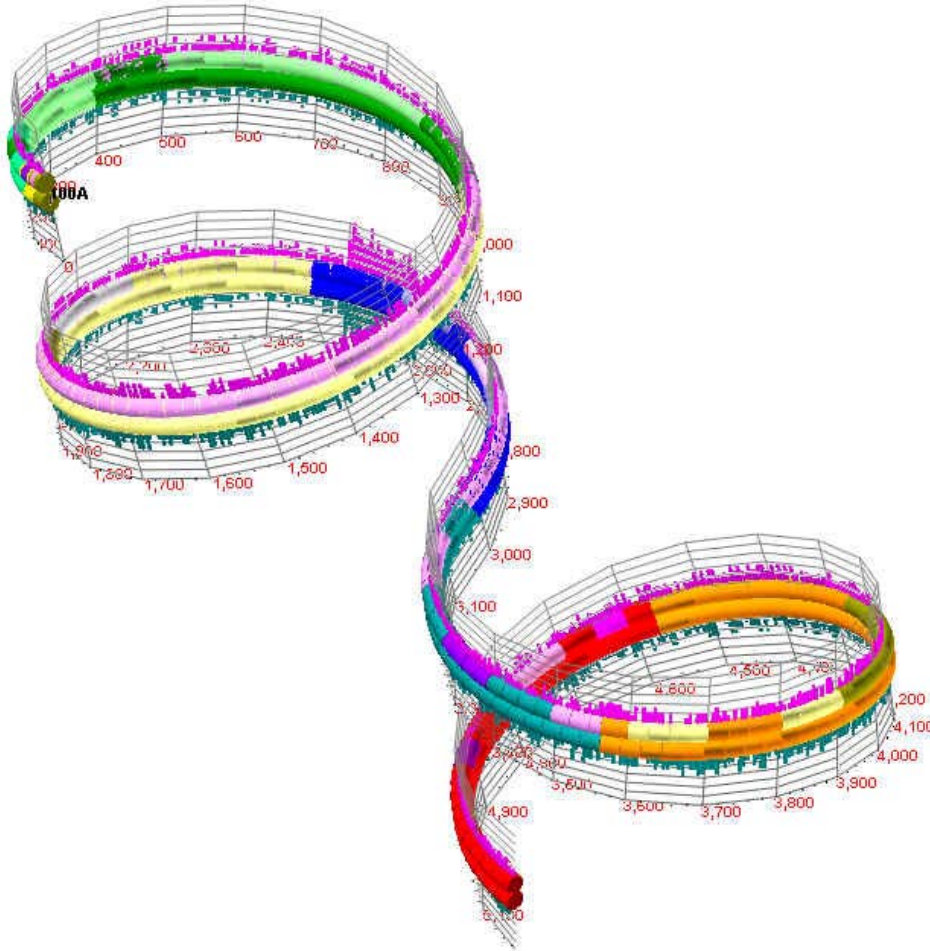
- Location
- **Orientation**
- Lithology
- Stratigraphy
- Interval Data
- Point Data
- Directional Data
- Imagery

# Orientation





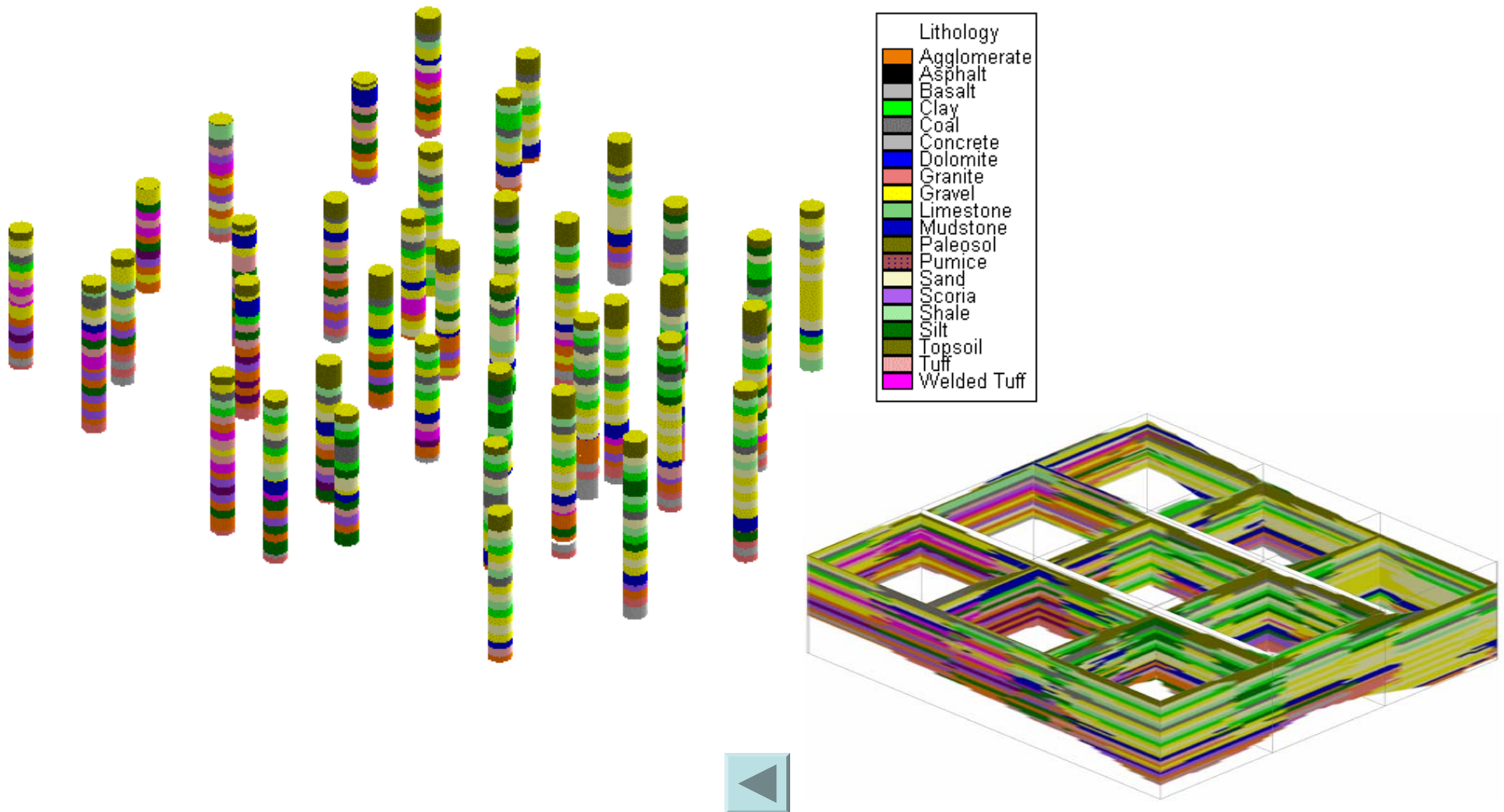
# Examples of Downhole Data



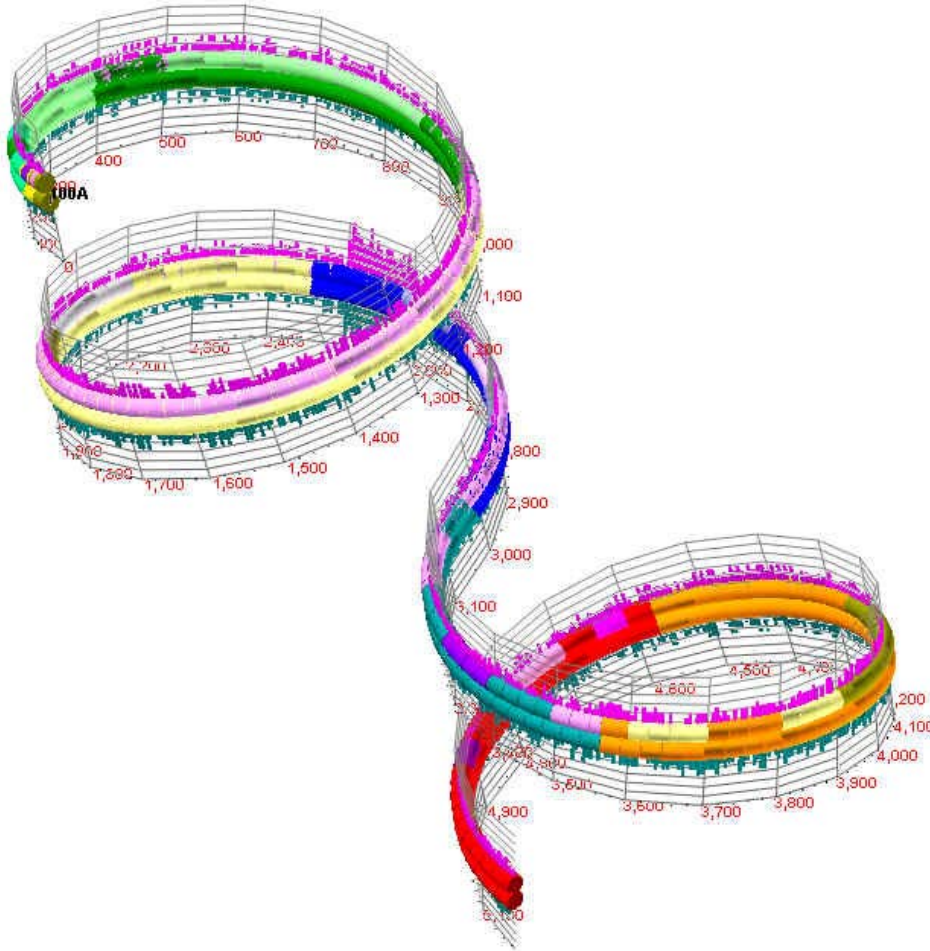
- Location
- Orientation
- **Lithology**
- Stratigraphy
- Interval Data
- Point Data
- Directional Data
- Imagery

# Lithology

(Interval-based, laterally discontinuous, qualitative data.)



# Examples of Downhole Data

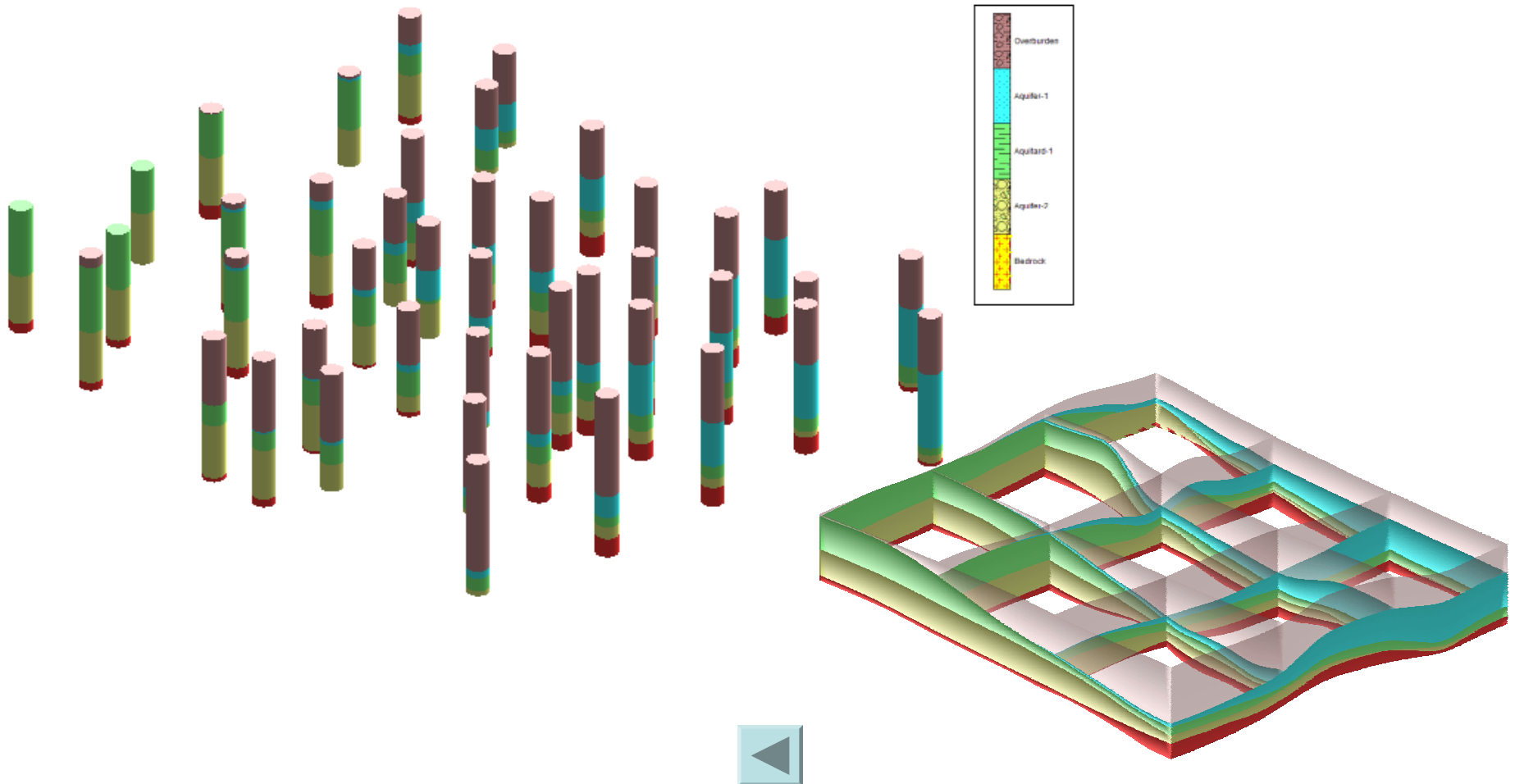


- Location
- Orientation
- Lithology
- **Stratigraphy**
- Interval Data
- Point Data
- Directional Data
- Imagery

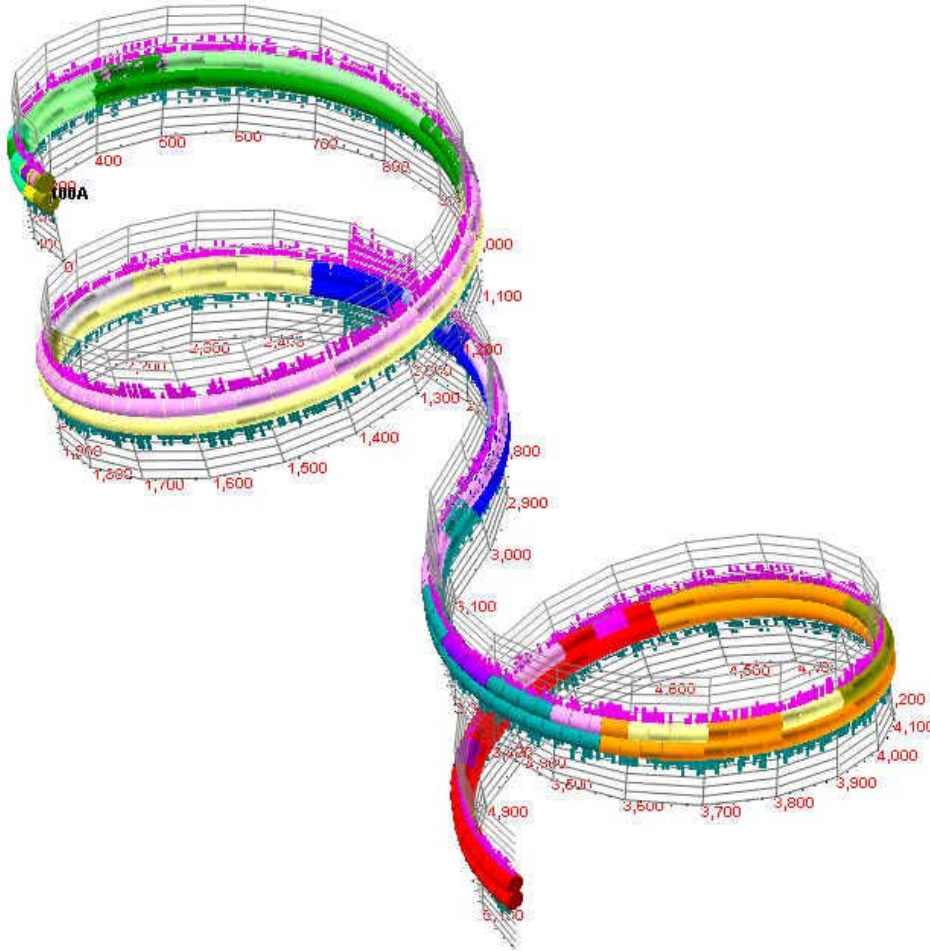


# Stratigraphy

(Interval-based, laterally contiguous, qualitative data.)



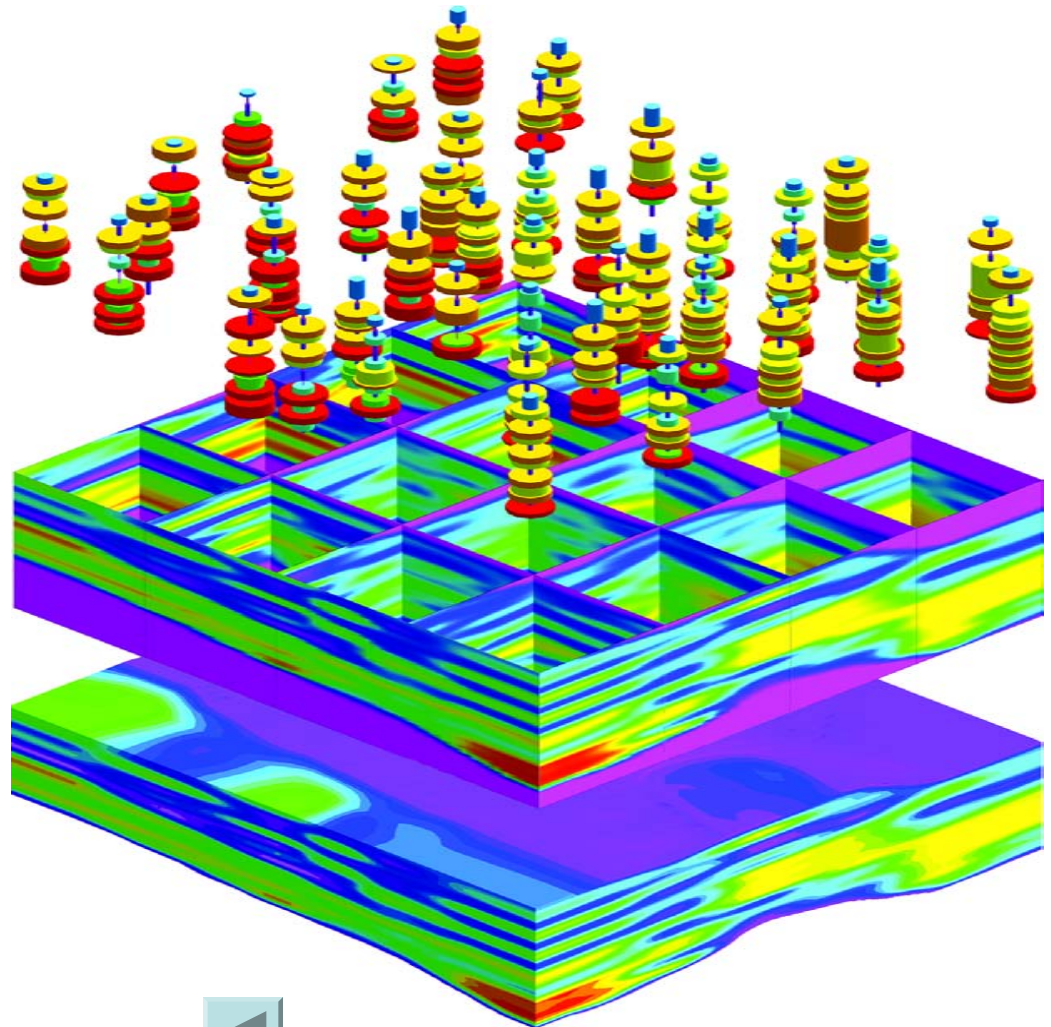
# Examples of Downhole Data



- Location
- Orientation
- Lithology
- Stratigraphy
- **Interval Data**
- Point Data
- Directional Data
- Imagery

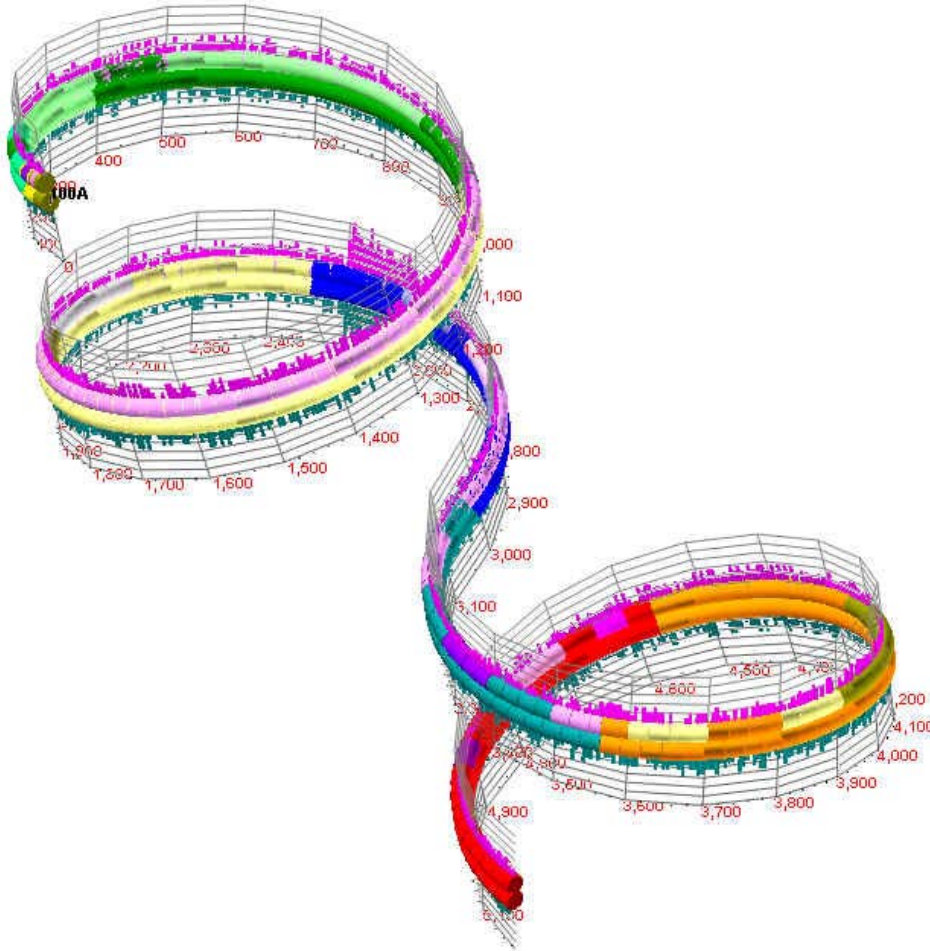
# Quantitative Interval-Based Data

- Geochemical
- Geotechnical



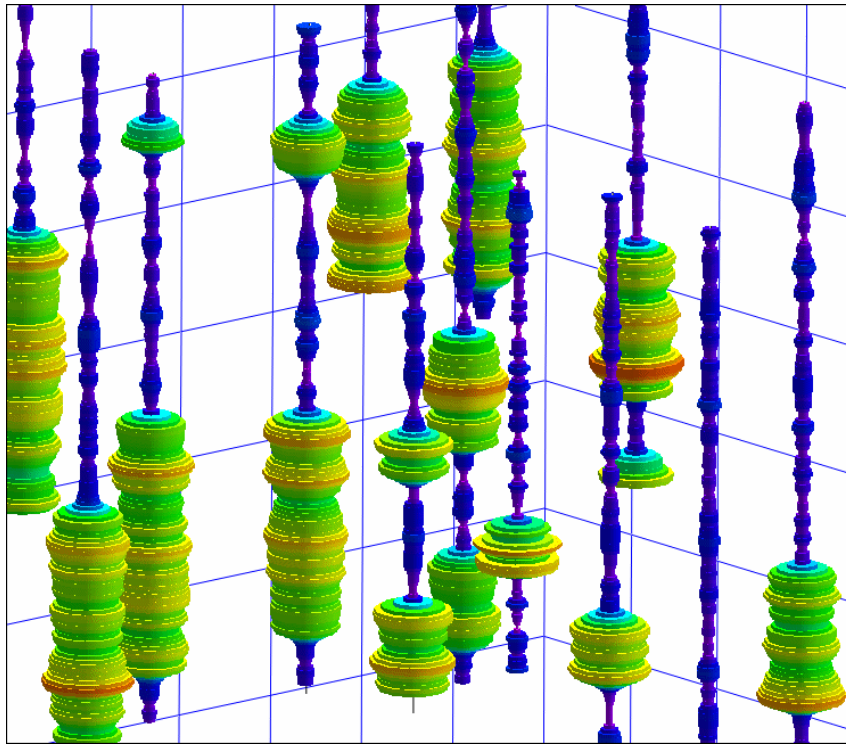


# Examples of Downhole Data

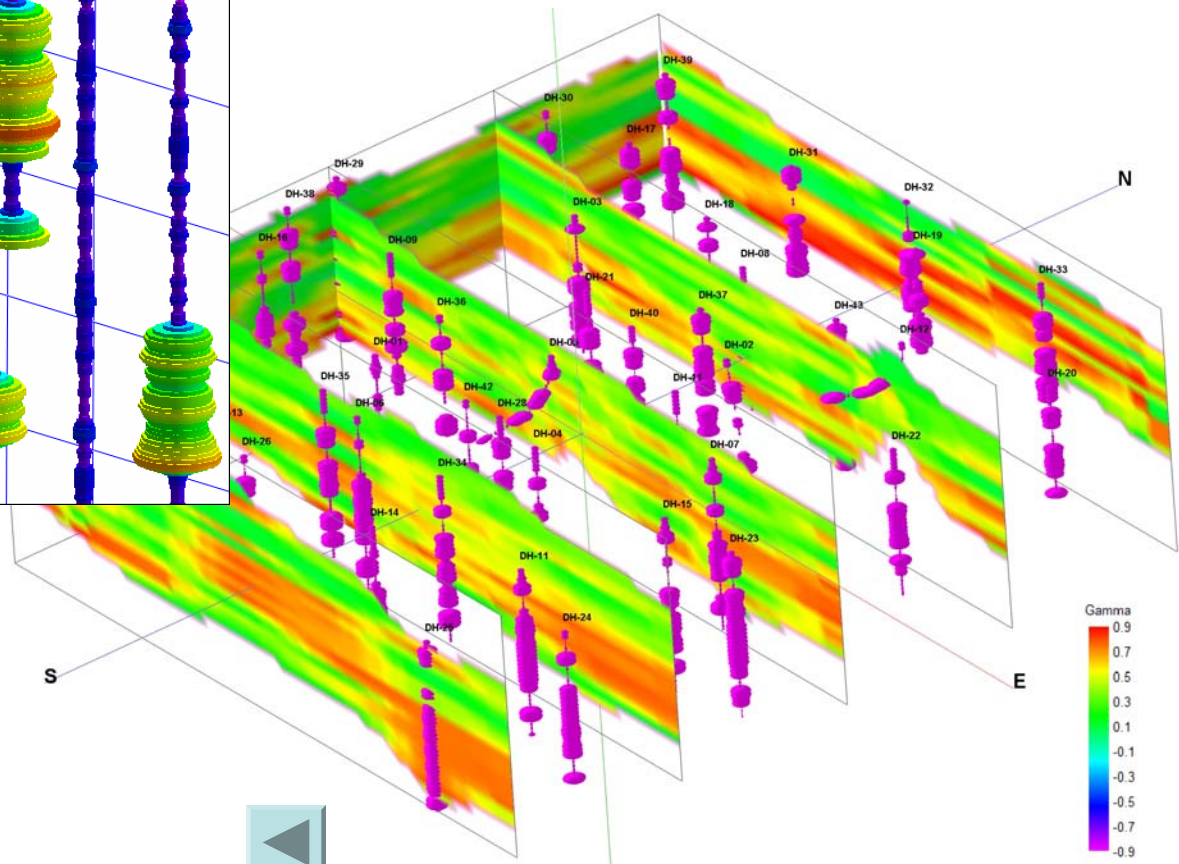


- Location
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- Stratigraphy
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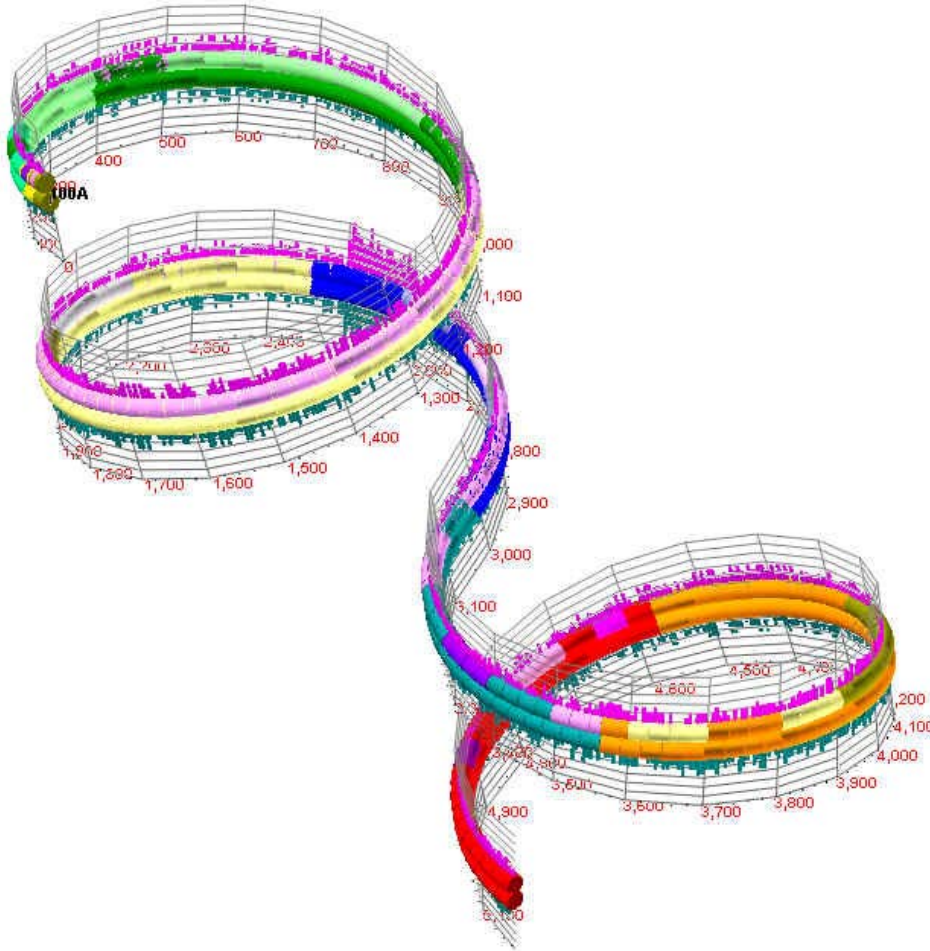
# Quantitative Point-Based Data



- Geophysics
- Point-Based Geochemistry
- Point-Based Geotechnical



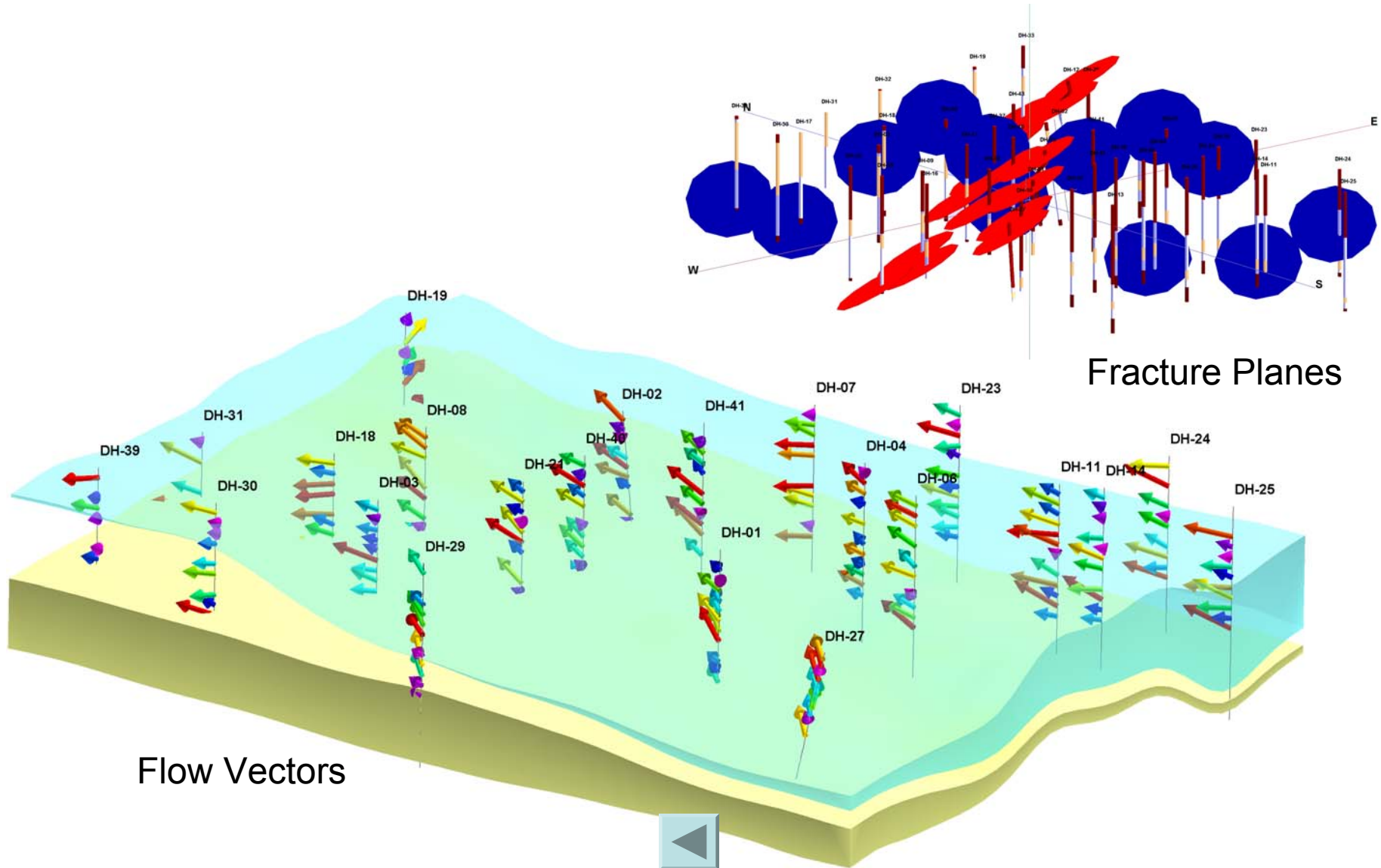
# Examples of Downhole Data



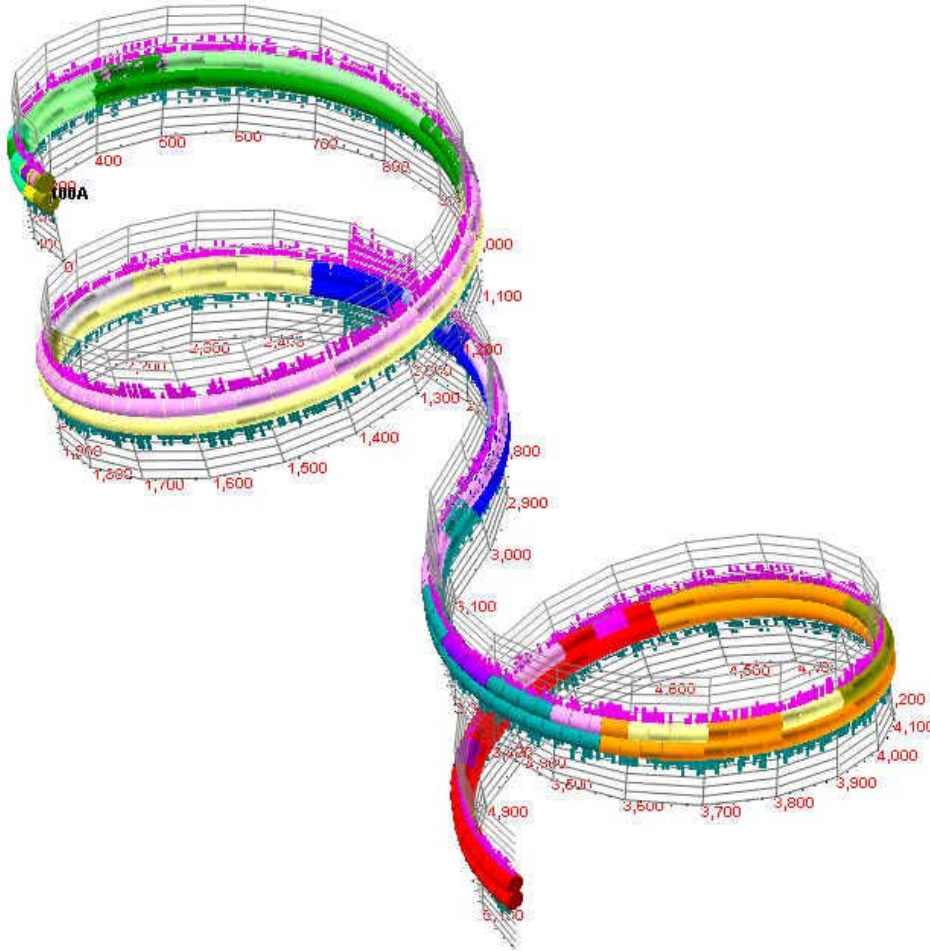
- Location
- Orientation
- Lithology
- Stratigraphy
- Interval Data
- Point Data
- **Directional Data**
- Imagery



# Directional Data

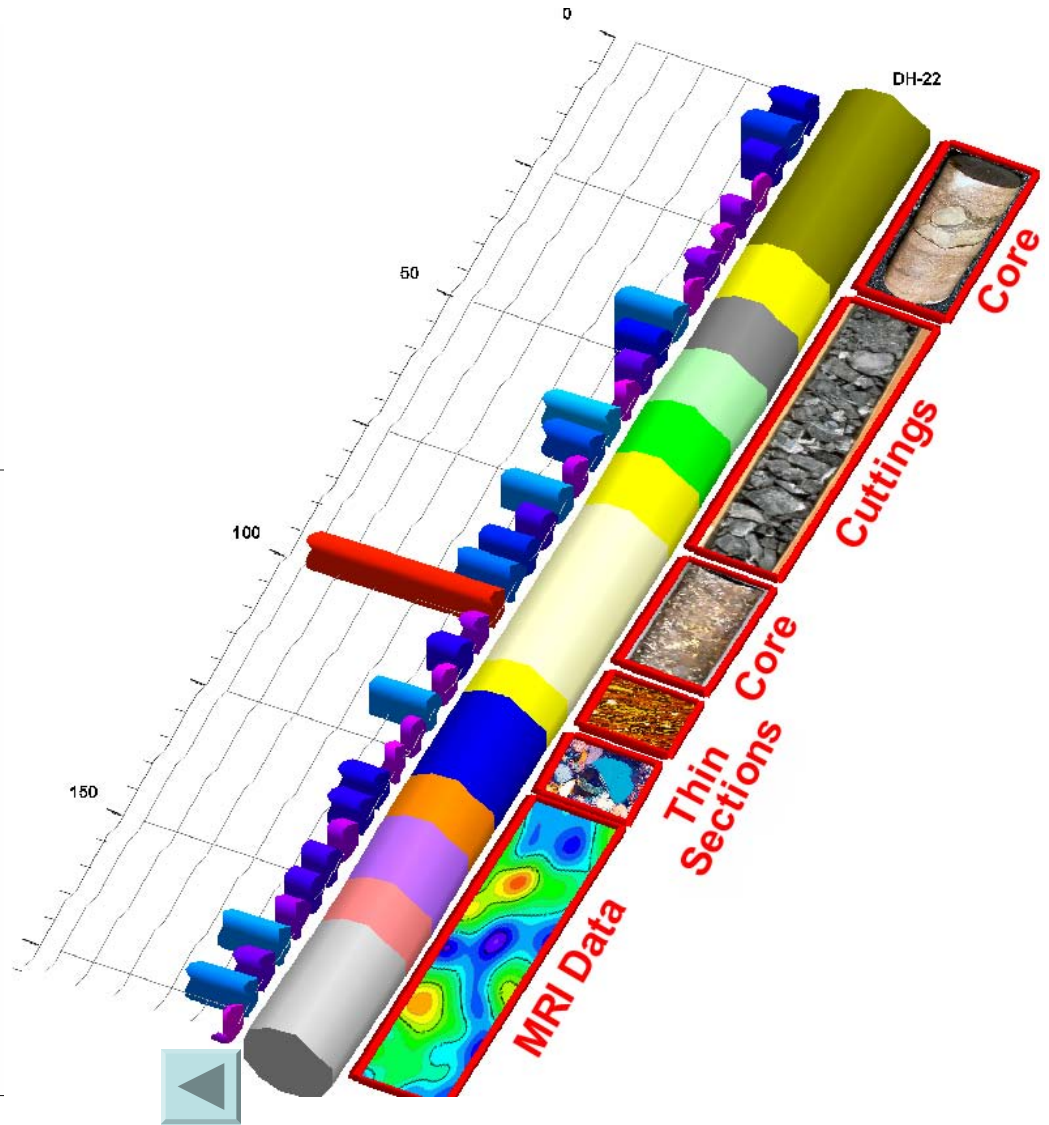
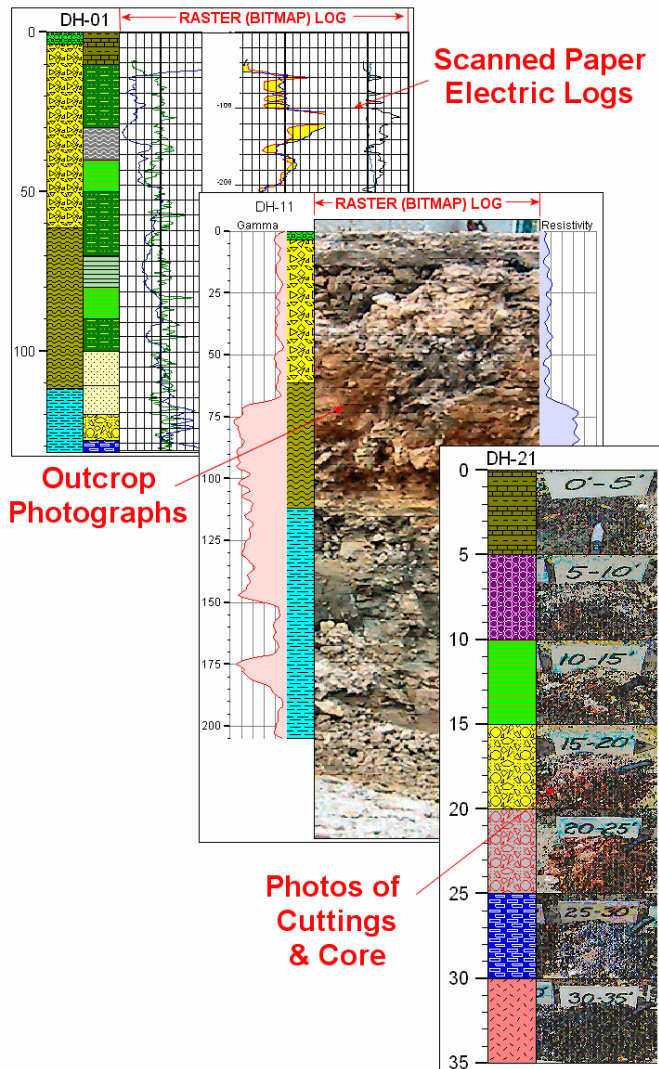


# Examples of Downhole Data



- Location
- Orientation
- Lithology
- Stratigraphy
- Interval Data
- Point Data
- Directional Data
- **Imagery**

# Downhole Imagery



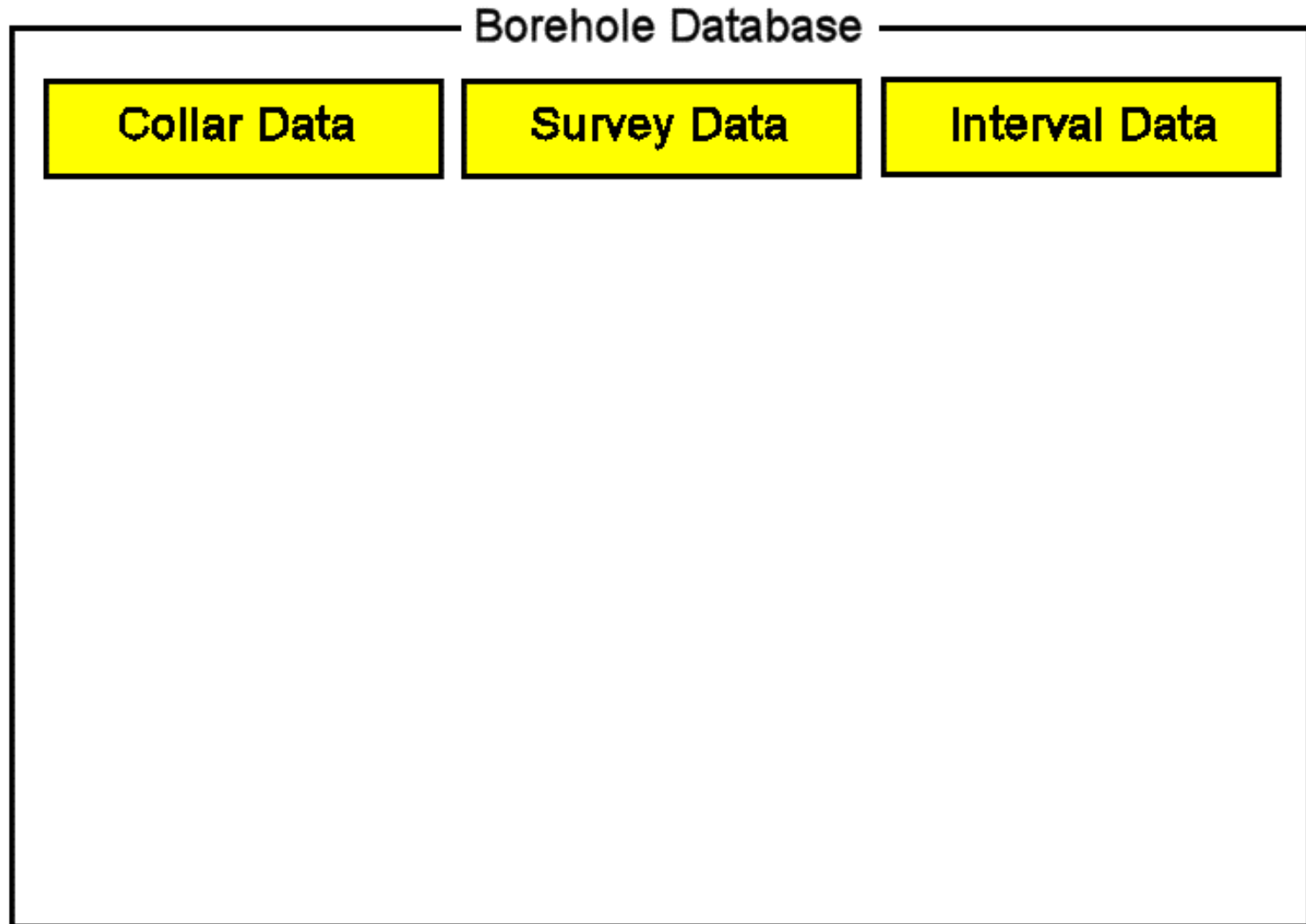


# Outline

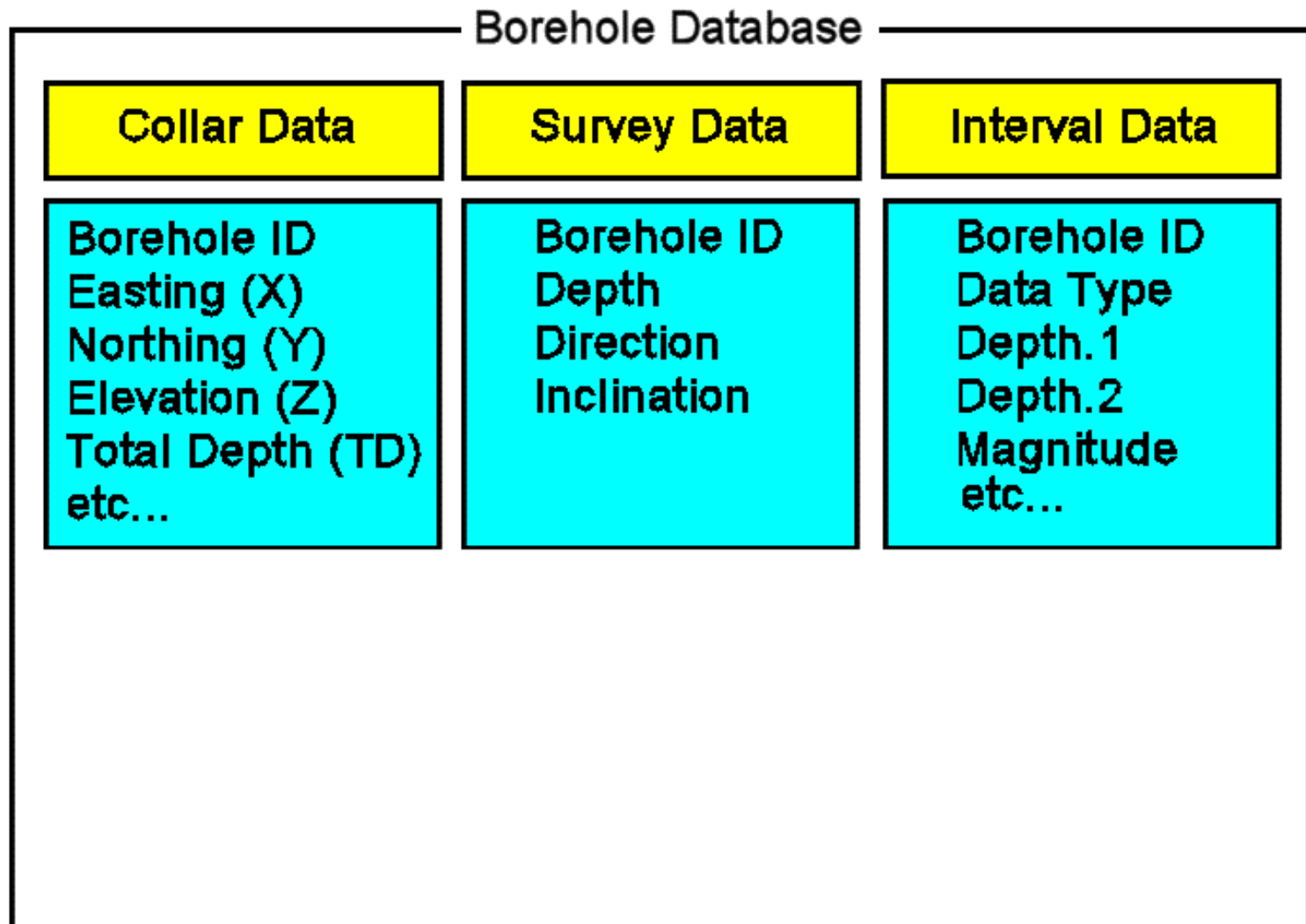
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# A Simplified Borehole Data Model (Tables)

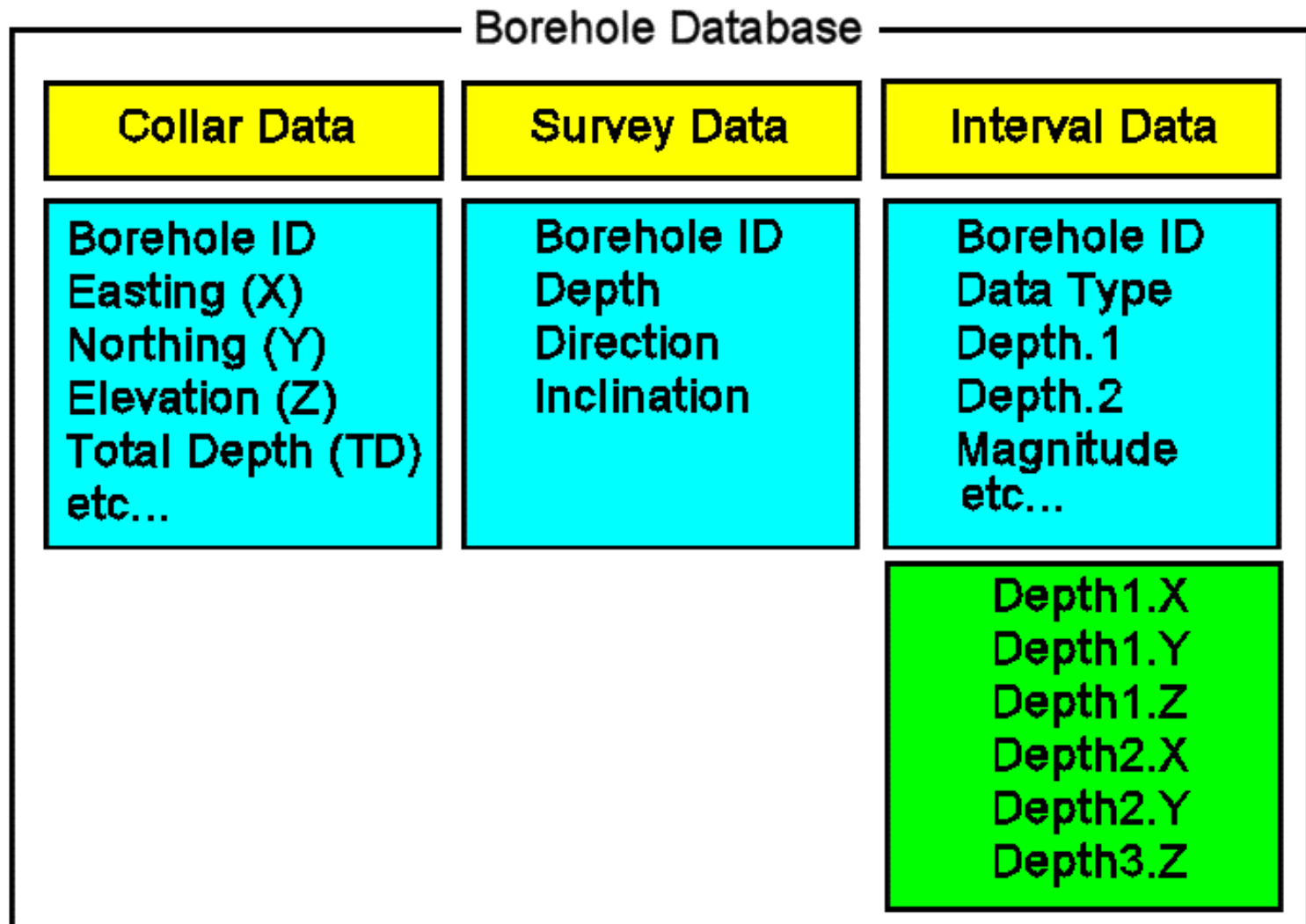


# A Simplified Borehole Data Model (Fields)





# A Simplified Borehole Data Model (Calculated Fields)





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# A Complex Borehole Data Model

| Locations     |
|---------------|
| Borehole ID   |
| Easting       |
| Northing      |
| Elevation     |
| Total Depth   |
| Symbol        |
| Symbol Thick. |
| Symbol Color  |
| Etc...        |

| Orientation |
|-------------|
| Borehole ID |
| Depth       |
| Azimuth     |
| Inclination |

↑  
Depth -> XYZ  
Computer

| Point Data  |
|-------------|
| Borehole ID |
| Depth       |
| PointType   |
| Magnitude   |
| Date        |
| Comments    |
| X,Y,Z       |

| Interval Data |
|---------------|
| Borehole ID   |
| Depth-1       |
| Depth-2       |
| IntervalType  |
| Magnitude     |
| Date          |
| Comments      |
| X1,Y1,Z1      |
| X2,Y2,Z2      |

| Lithology   |
|-------------|
| Borehole ID |
| Depth-1     |
| Depth-2     |
| LithoType   |
| Comments    |
| X1,Y1,Z1    |
| X2,Y2,Z2    |

| Stratigraphy |
|--------------|
| Borehole ID  |
| Depth-1      |
| Depth-2      |
| StrataType   |
| Comments     |
| X1,Y1,Z1     |
| X2,Y2,Z2     |

| Vectors     |
|-------------|
| Borehole ID |
| Depth       |
| Azimuth     |
| Inclination |
| Magnitude   |
| Comments    |
| X,Y,Z       |

| Aquifers    |
|-------------|
| Borehole ID |
| Depth-1     |
| Depth-2     |
| Date/Time   |
| Comments    |
| X1,Y1,Z1    |
| X2,Y2,Z2    |

| Hydro-Stratigraphy |
|--------------------|
| Borehole ID        |
| Depth-1            |
| Depth-2            |
| HydroStrat-Type    |
| Comments           |
| X1,Y1,Z1           |
| X2,Y2,Z2           |

| Symbols     |
|-------------|
| Borehole ID |
| Depth       |
| SymbolNum   |
| Color       |
| Caption     |
| X,Y,Z       |

| Bitmaps     |
|-------------|
| Borehole ID |
| Depth-1     |
| Depth-2     |
| Header Base |
| Footer Top  |
| File Name   |
| X1,Y1,Z1    |
| X2,Y2,Z2    |

| Fractures   |
|-------------|
| Borehole ID |
| Depth       |
| Azimuth     |
| Inclination |
| Radius      |
| Aperture    |
| Color       |
| Comments    |
| X,Y,Z       |

| Patterns     |
|--------------|
| Borehole ID  |
| Depth-1      |
| Depth-2      |
| Background   |
| Foreground   |
| PatternNum   |
| PatternSize  |
| PatternThick |
| Caption      |
| X1,Y1,Z1     |
| X2,Y2,Z2     |

**Bitmap Library**

| PointTypes |
|------------|
| Index      |
| Name       |
| Minimum    |
| Maximum    |
| Units      |

| IntervalTypes |
|---------------|
| Index         |
| Name          |
| Minimum       |
| Maximum       |
| Units         |

| StrataTypes  |
|--------------|
| Index        |
| Name         |
| Background   |
| Foreground   |
| PatternNum   |
| PatternSize  |
| PatternThick |
| Fill Percent |
| Density      |

| HydroStrat-Types |
|------------------|
| Index            |
| Name             |
| Background       |
| Foreground       |
| PatternNum       |
| PatternSize      |
| PatternThick     |
| Fill Percent     |
| Density          |
| LithoTypes       |
| Index            |
| Name             |
| Background       |
| Foreground       |
| PatternNum       |
| PatternSize      |
| PatternThick     |
| Fill Percent     |
| Density          |

| Symbol Library |
|----------------|
| Index          |
| Segments       |
| X1             |
| Y1             |
| X2             |
| Y2             |

| Pattern Library |
|-----------------|
| Index           |
| Segments        |
| X1              |
| Y1              |
| X2              |
| Y2              |



# A Complex Borehole Data Model (The Interface)

Borehole Files (43)

# The End

