DELIVERING CONSISTENT, RELIABLE, AND CREDIBLE MULTI-DIMENSIONAL GEOLOGICAL INFORMATION

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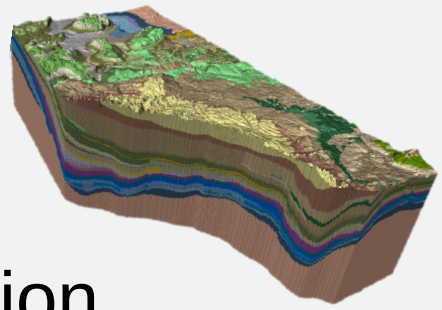
May 17th, 2019

Overview

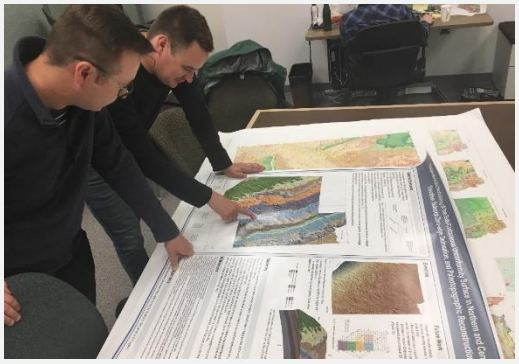
- What is the 3D Geological Framework?
- Why are we building it?
- How has it been used?
- Recent developments and innovation
  - Workflow optimization
  - Sharing our 3D models
  - Stakeholder Engagement
  - AR, VR, 360 videos
- Next Steps

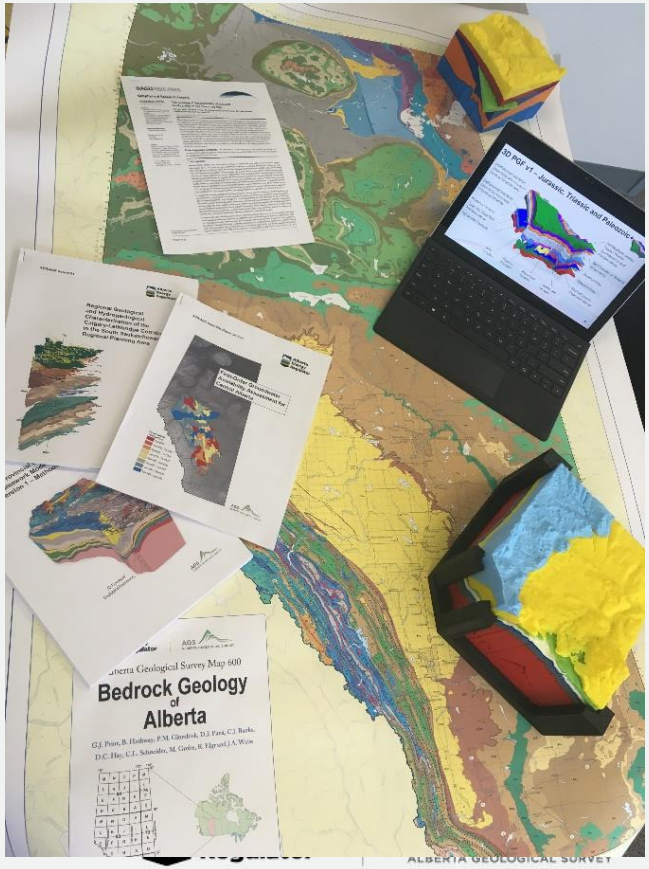


Alberta Geological Survey

Responsible for: describing the geology and resources in the province and providing information and knowledge to help resolve land-use, environmental, public health, and safety issues related to geosciences

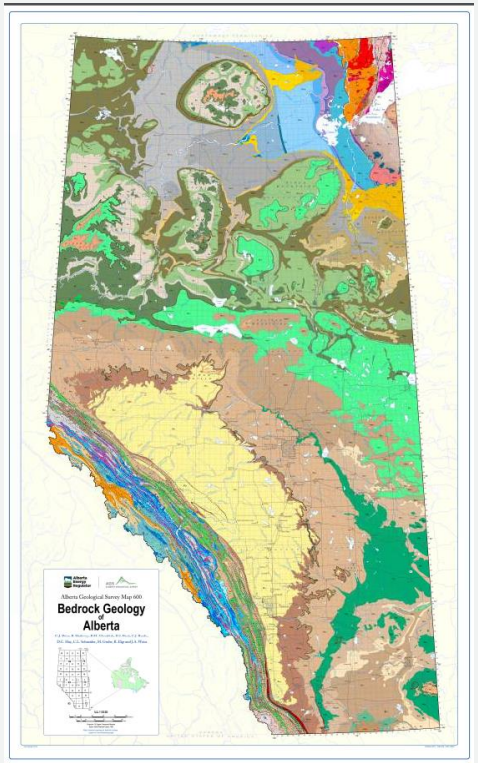
AGS Vision:
internationally **recognized** source for **credible, innovative** and **integrated** geoscience **data, information** and **knowledge** for Alberta





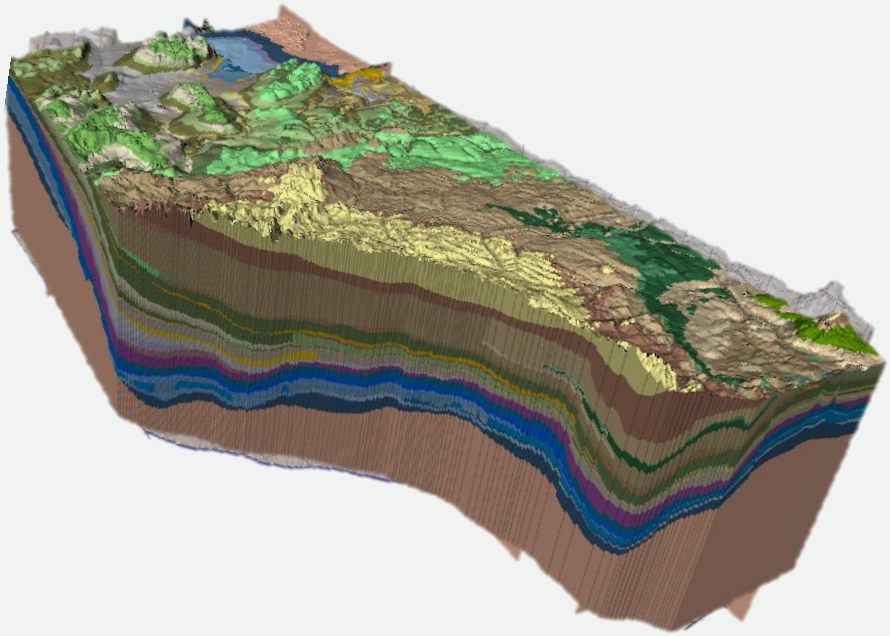
From 2D Maps to 3D Models

2D Bedrock Geology



Traditional map products

3D Geological Framework



Interactive, holistic 3D geological model

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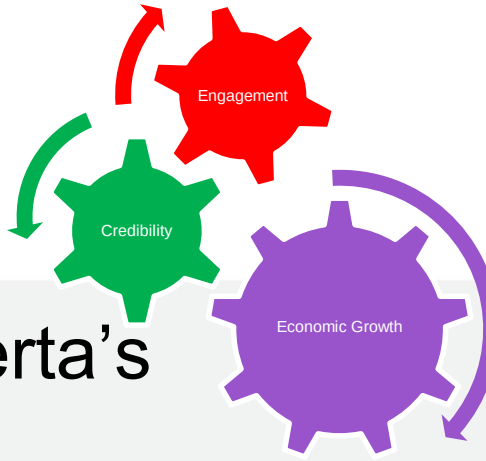
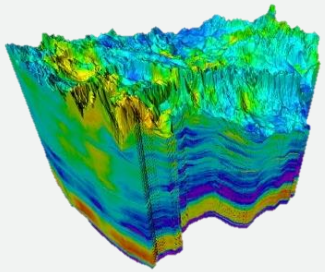
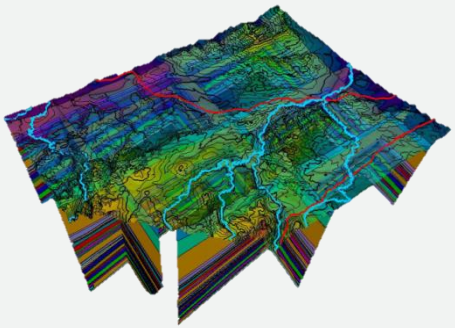
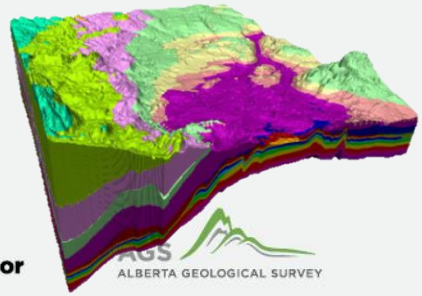
Why are we building it?



- To communicate information about Alberta's surface and subsurface for;
  - Support **safe** and **sustainable** resource development
  - **Science-based** decision making
  - Deliver **interactive and engaging** geoscience information
  - **Efficient** and **effective** evaluation and use of geospatial data







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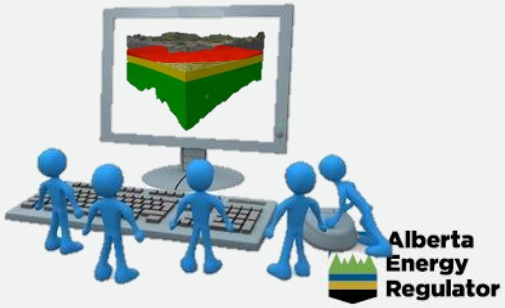
3D: Cost-Benefit

- Value of our data
  - $ 100s of Billions

- Value of our staff resources

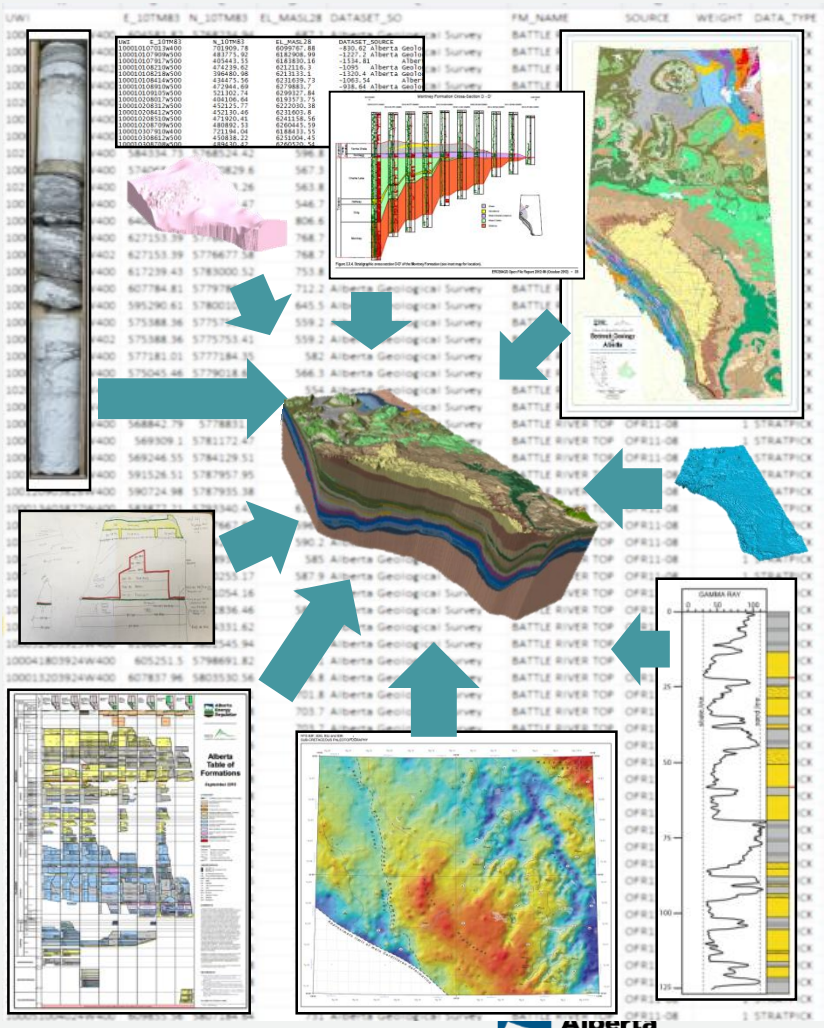
- Risk of making a bad decision



Strength: Data Integration

Integrating data from a variety of sources;

- Stratigraphic data
- Reports
- Maps
- Cross-sections
- Conceptual models
- Seismic data
- Lineament



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What can go into the model?

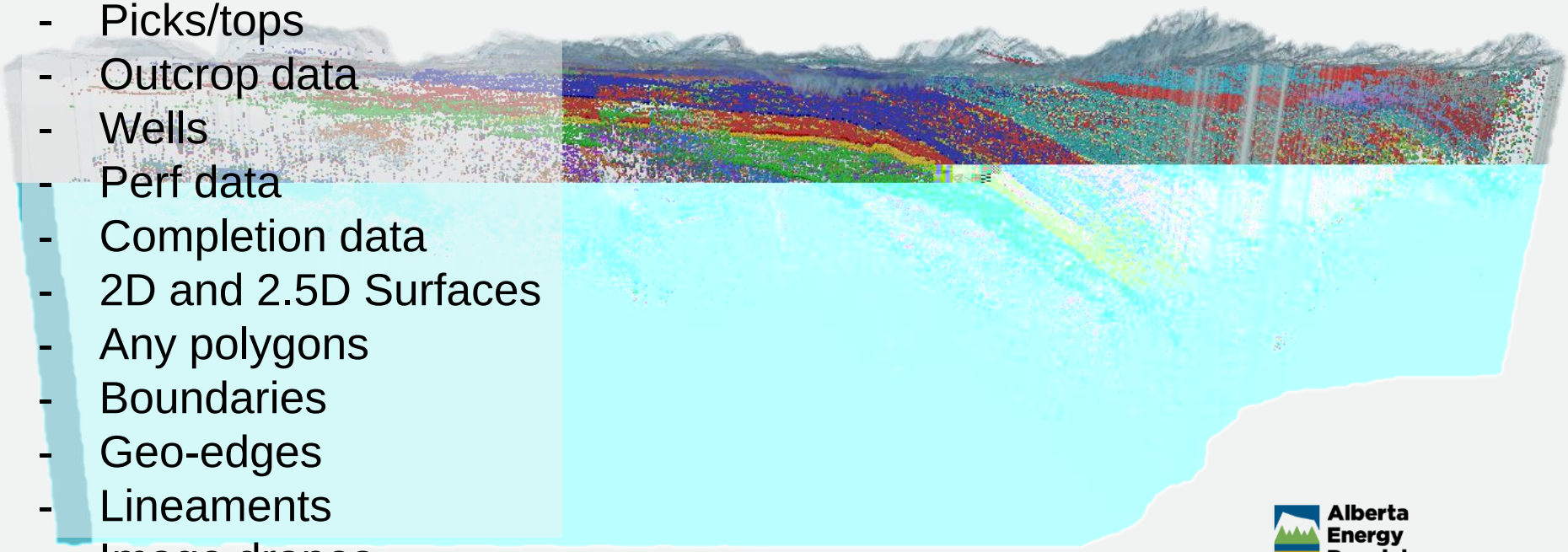
CAN

Any geospatial data:

- Any XY, XYZ, XYZt data
- Picks/tops
- Outcrop data
- Wells
- Perf data
- Completion data
- 2D and 2.5D Surfaces
- Any polygons
- Boundaries
- Geo-edges
- Lineaments
- Image drapes

CAN'T

Non geospatial data



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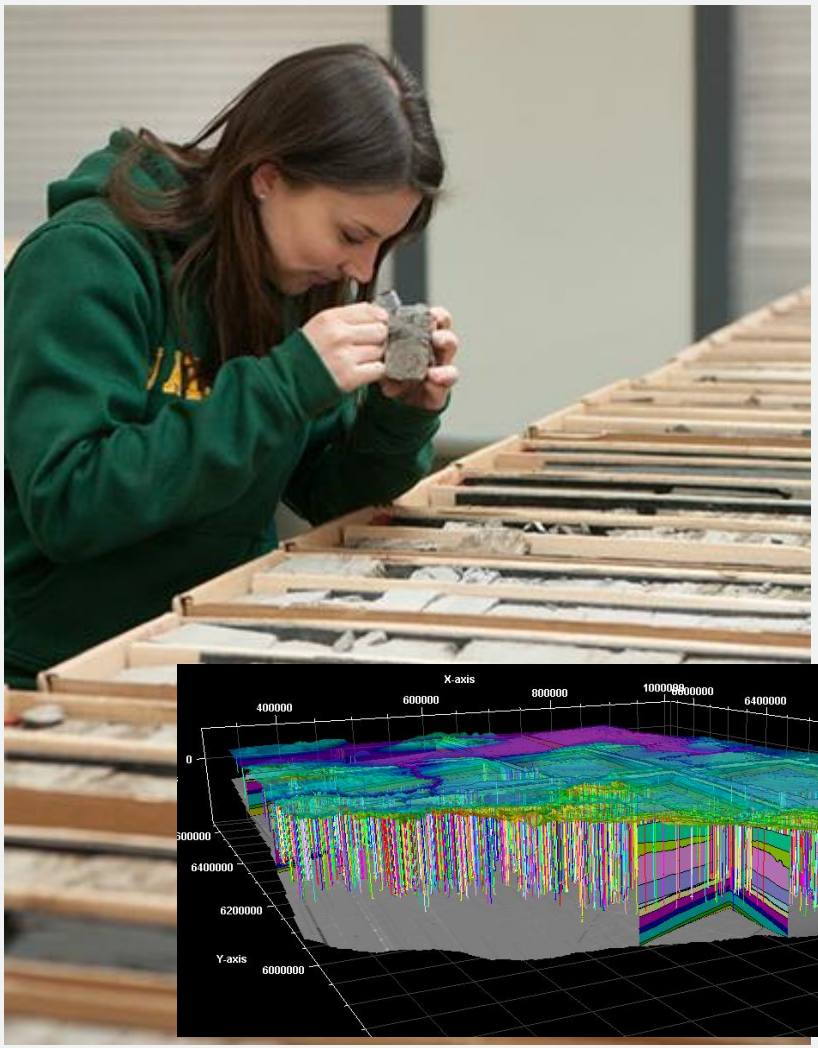
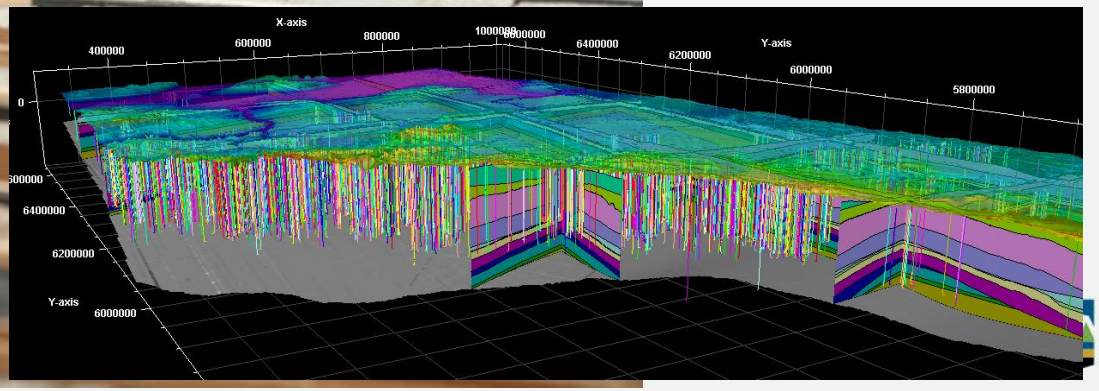
Managing and Optimizing our Data





- **450,000+ oil and gas wells** (541,000 Km total length)
- 430,000+ water wells

13.5 x

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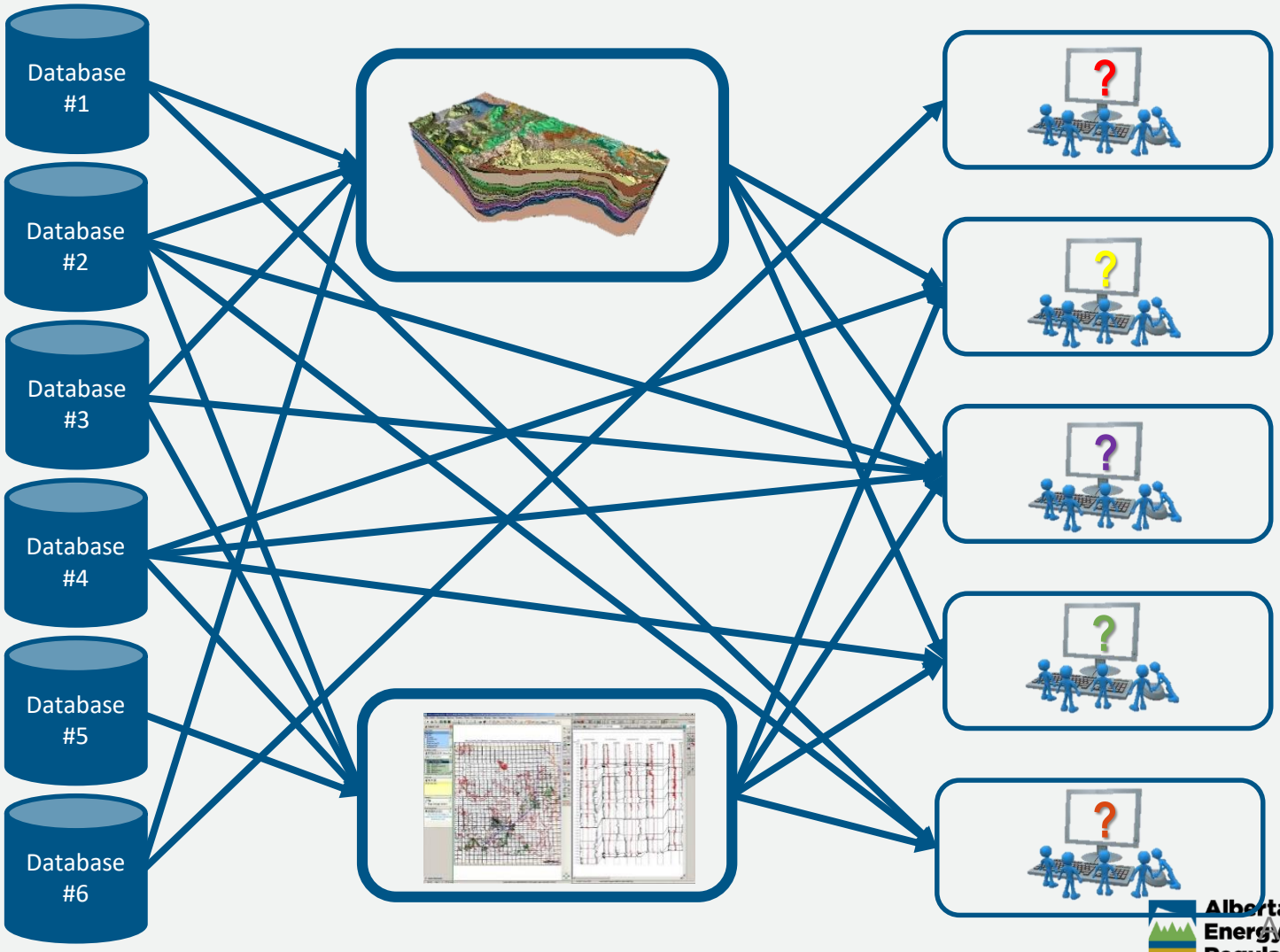
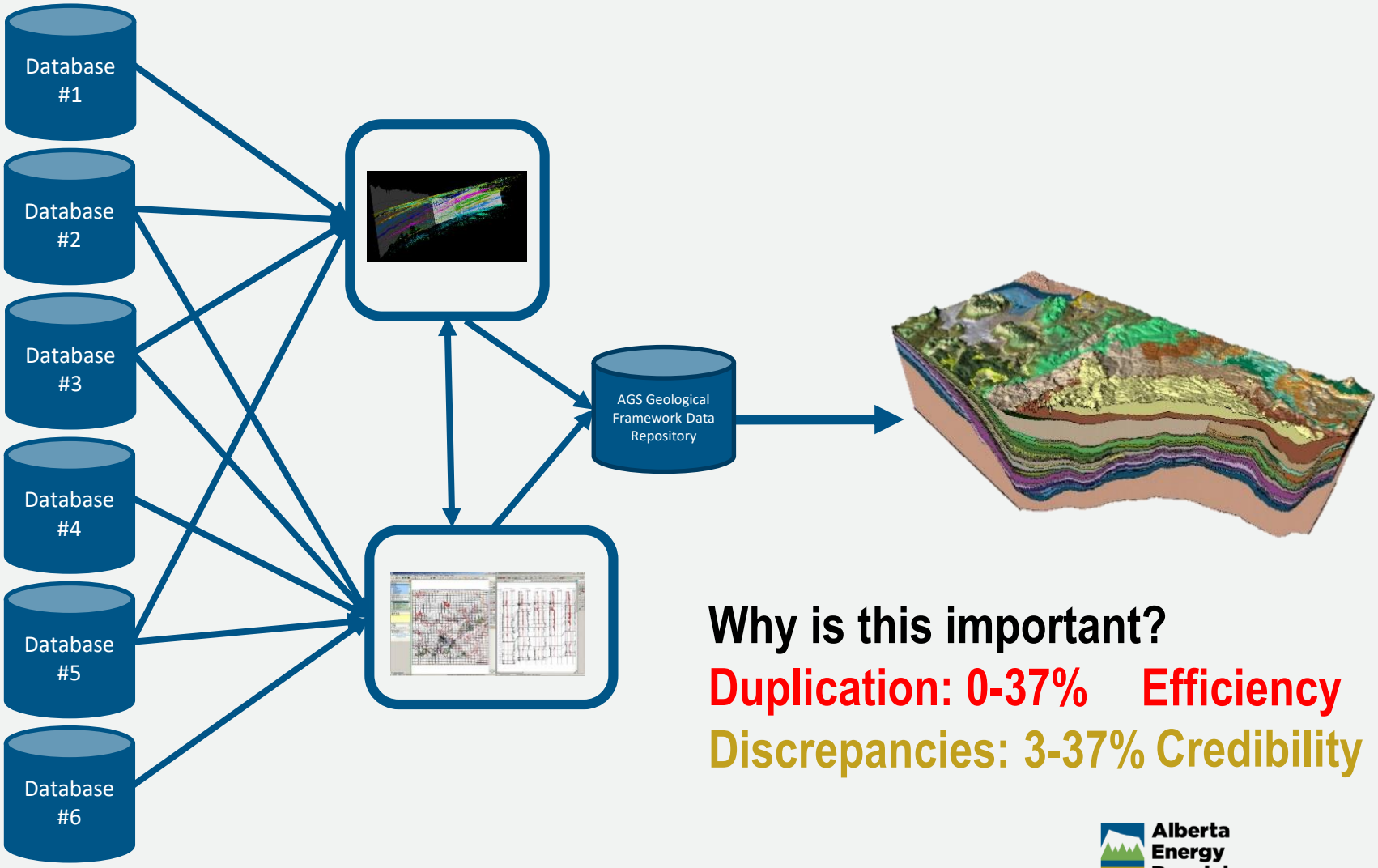
Importance of Data Management



Importance of Data Management



Why is this important?

Duplication: 0-37% Efficiency

Discrepancies: 3-37% Credibility

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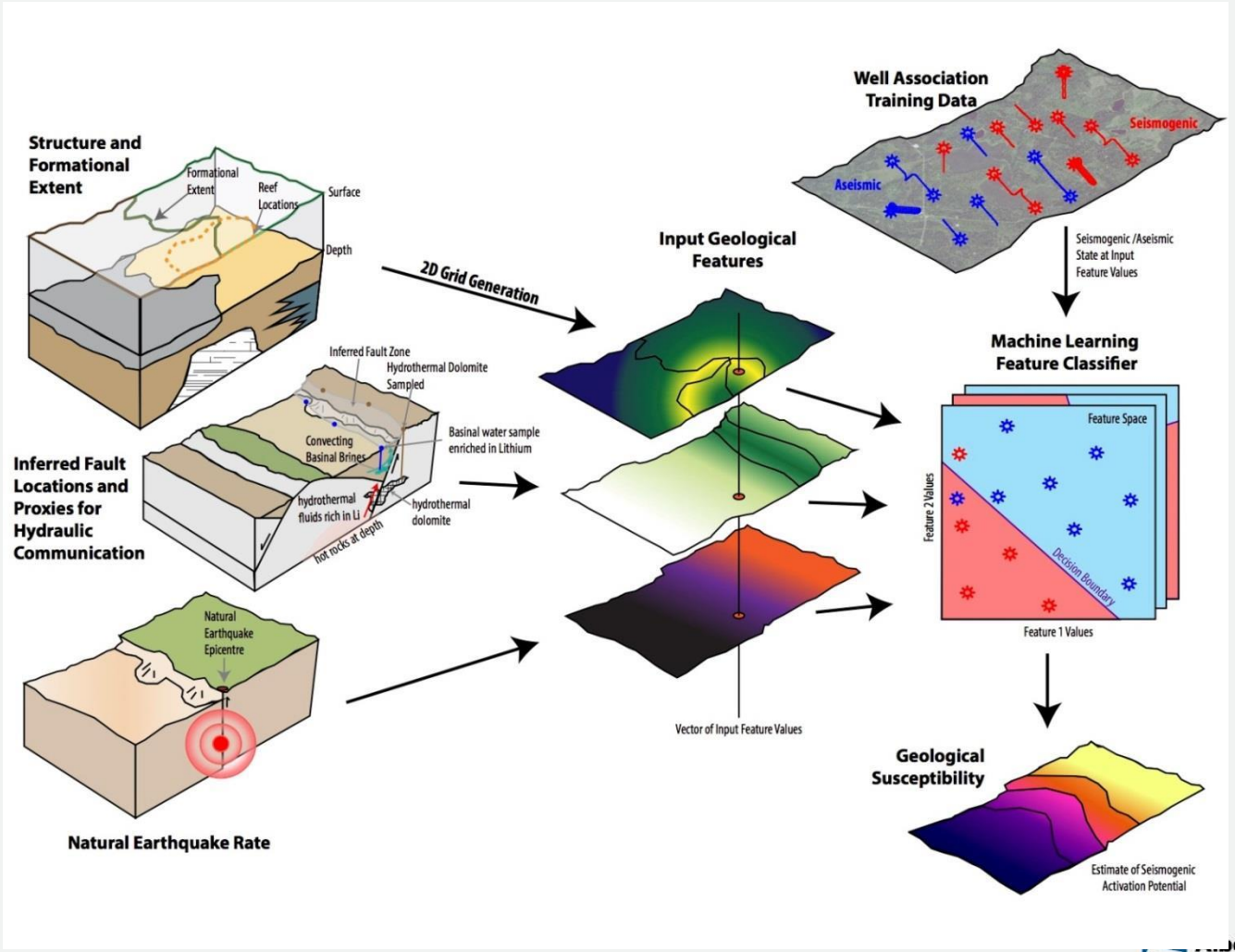
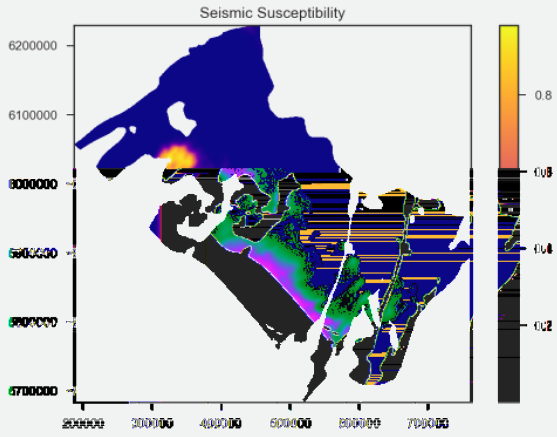
Optimizing Data: Machine Learning

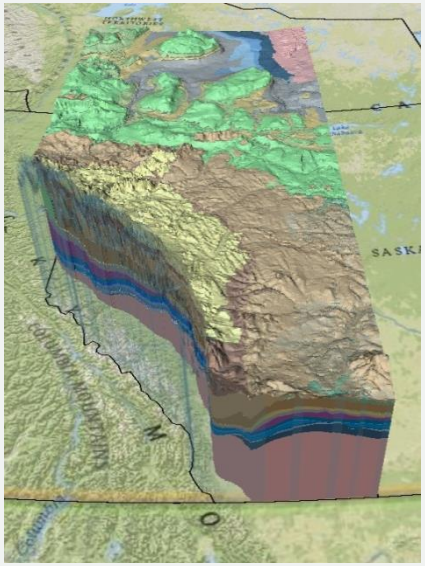




3D Provincial Geological Framework Model of Alberta

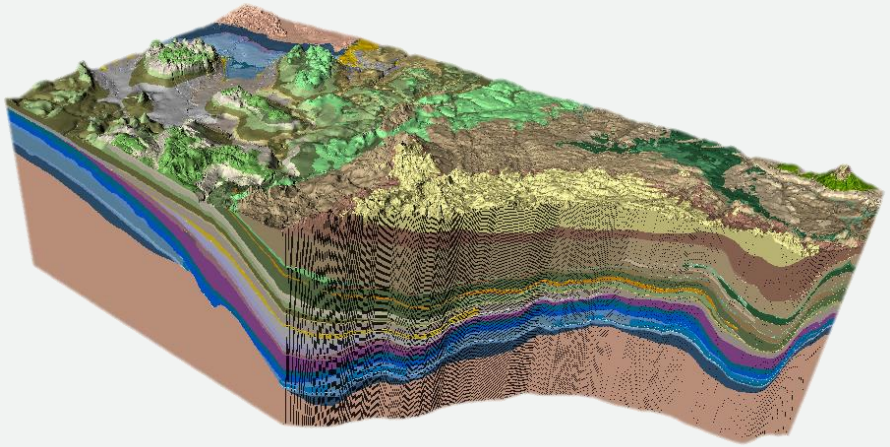
Version 1

- 32 model zones (layers)
- 620,812 data points
- 500x500m resolution



Version 2

- 62 model zones (layers)
- 1,235,761 data points
- 500x500m resolution



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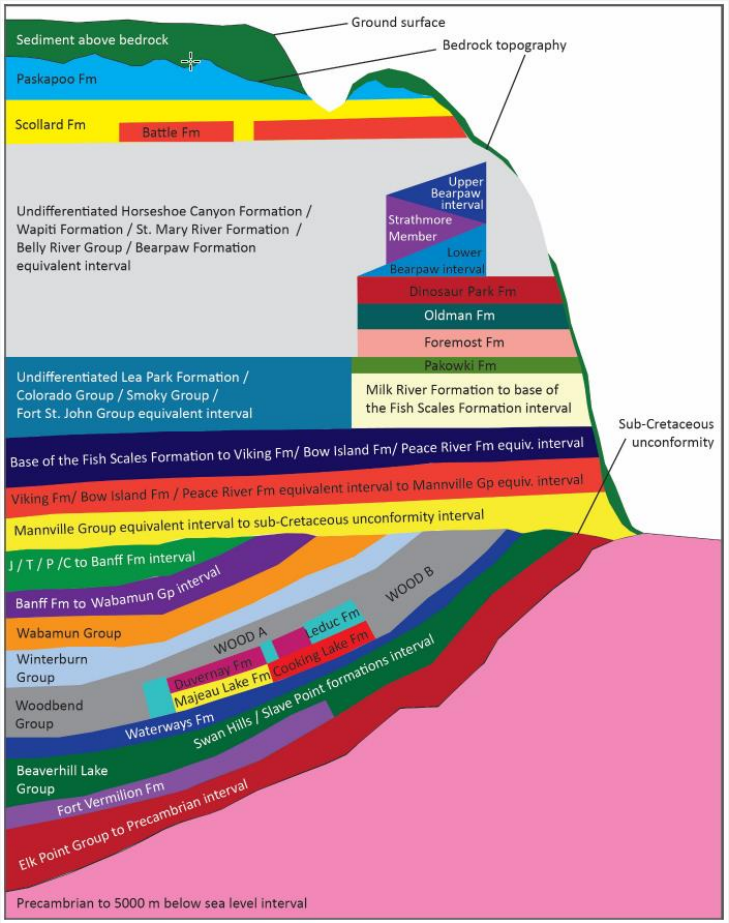
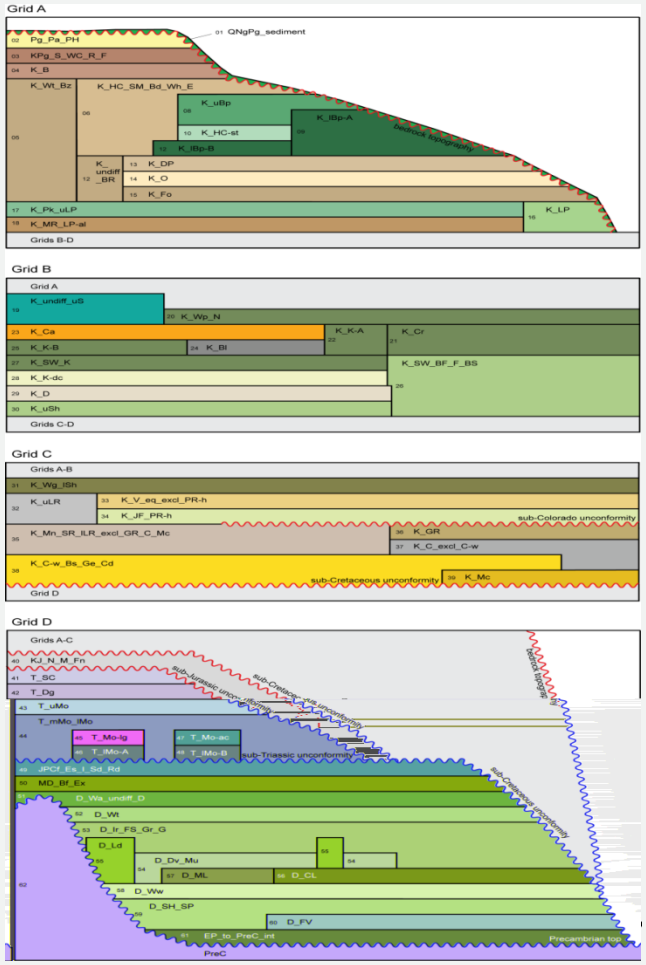
Schematic Cross-sections

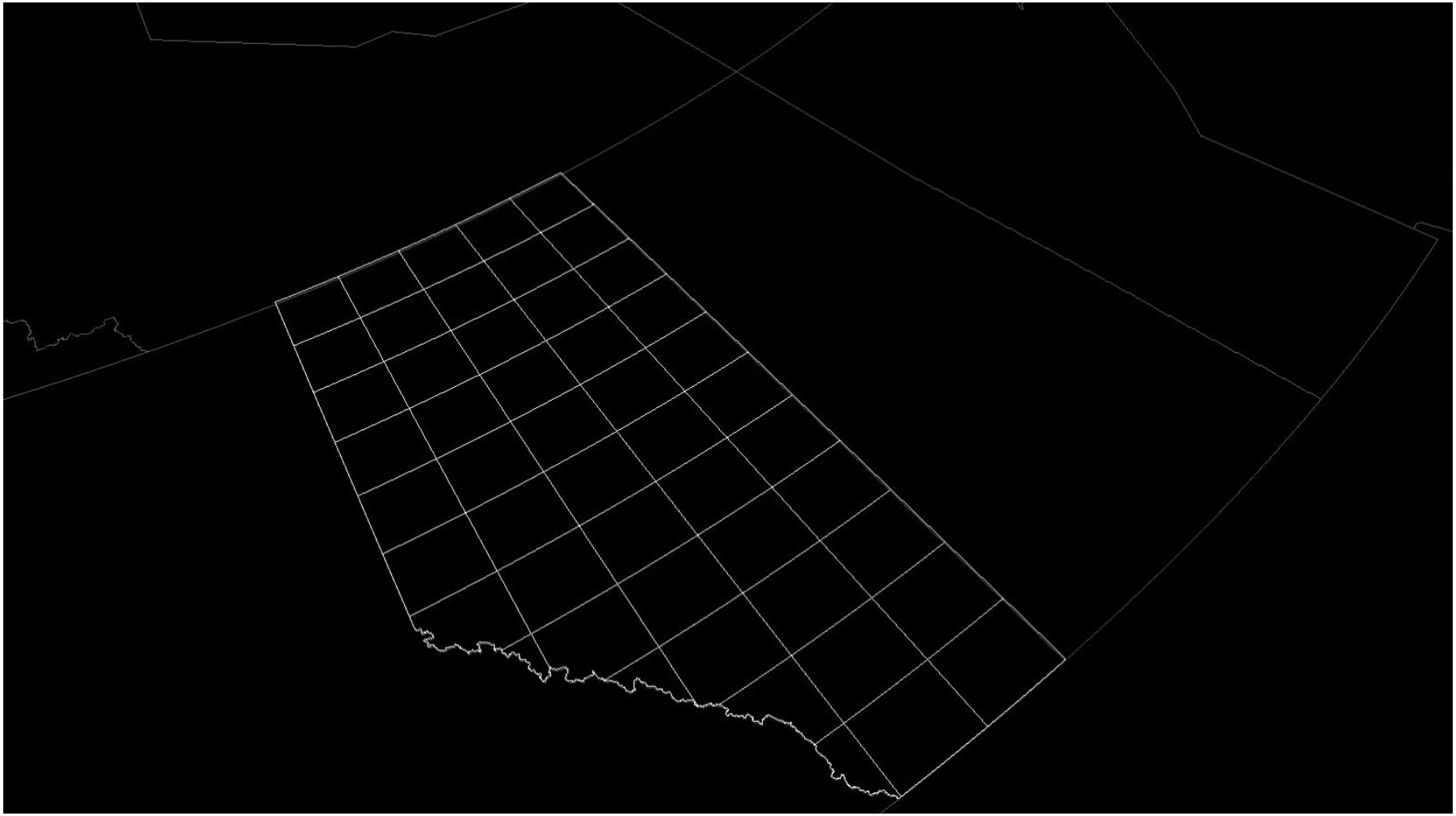
Version 1



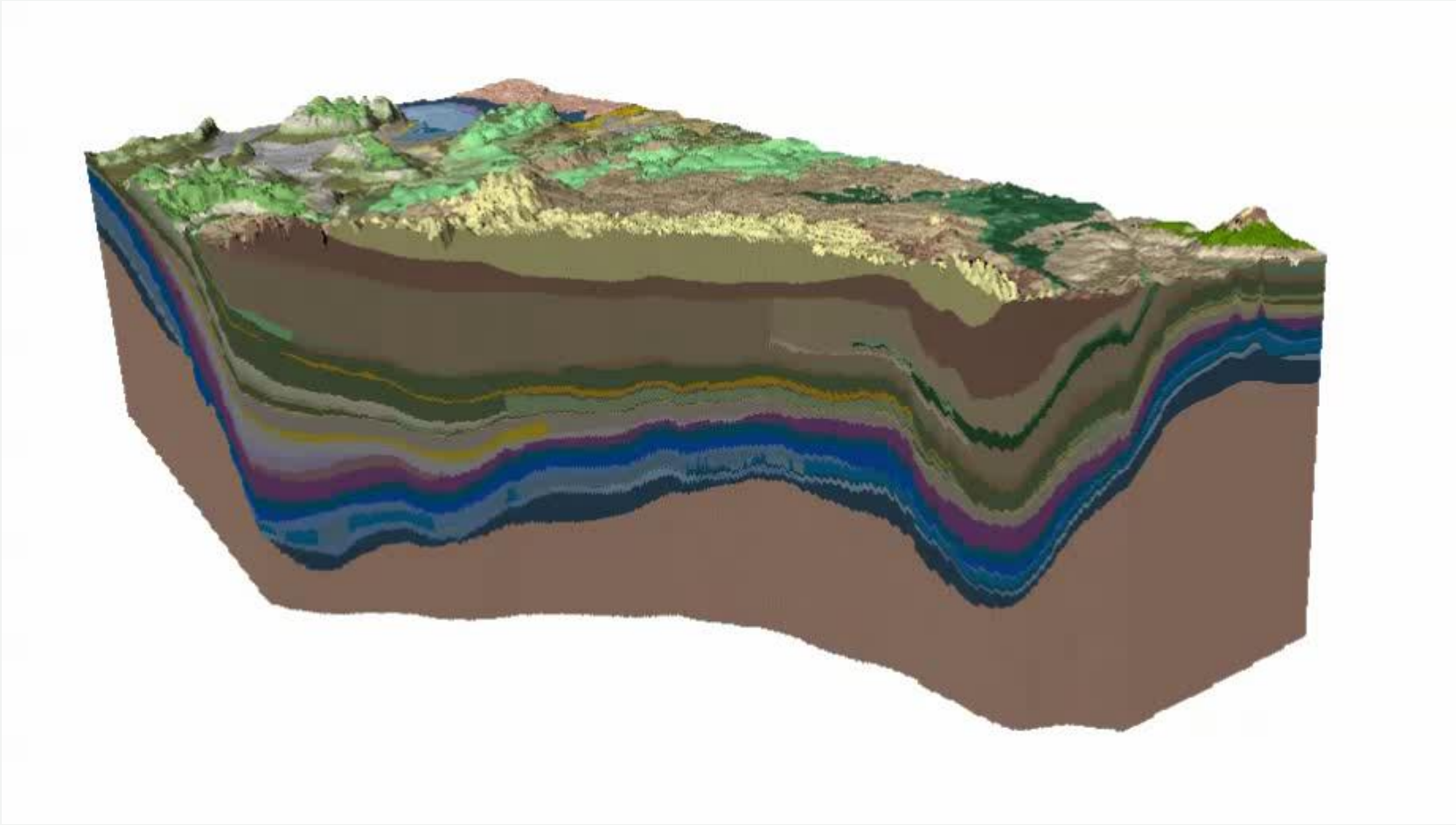
Version 2



Provincial Model - Version 2



Provincial Model Slices



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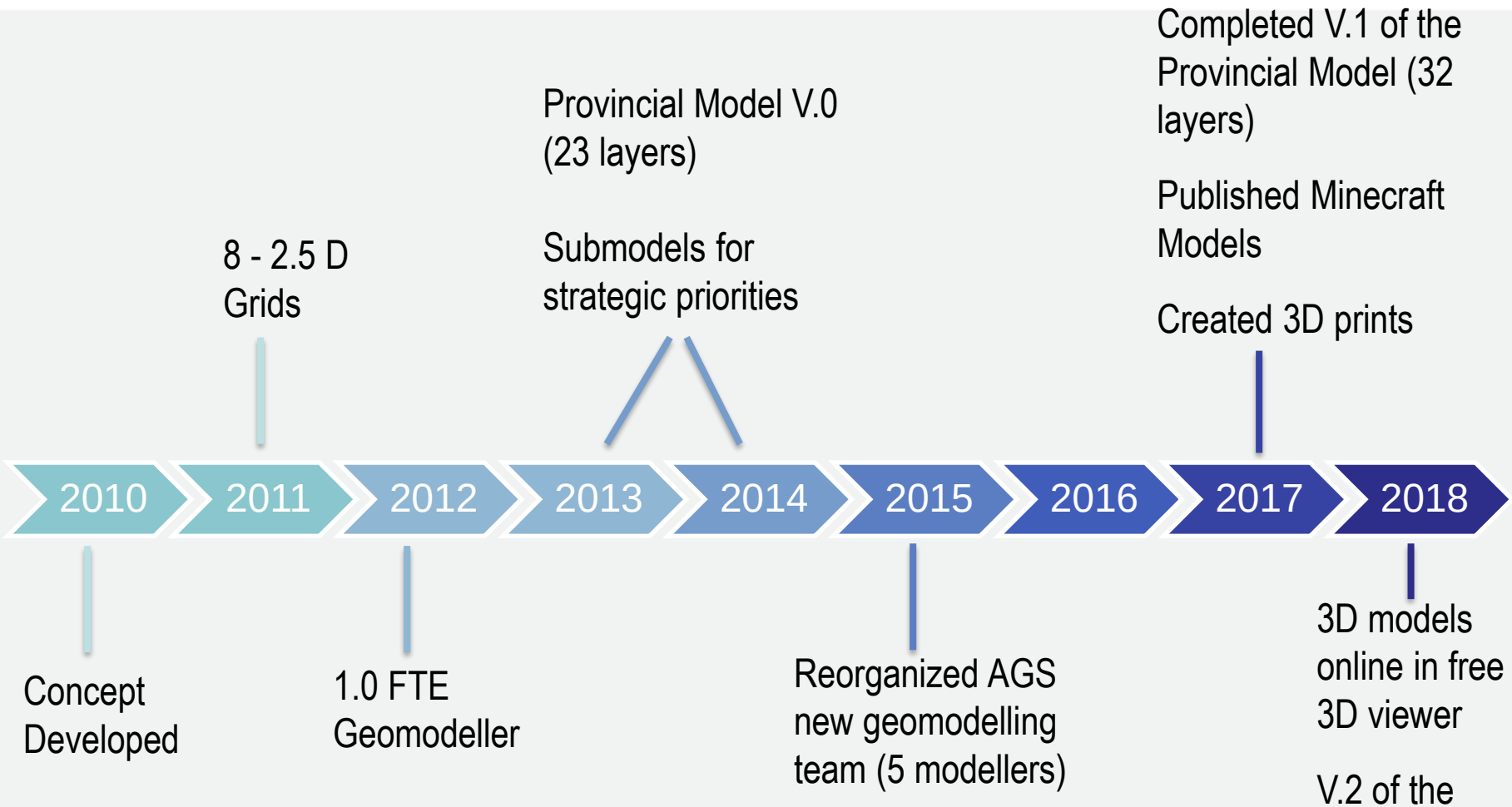
3D Geological Framework Timeline



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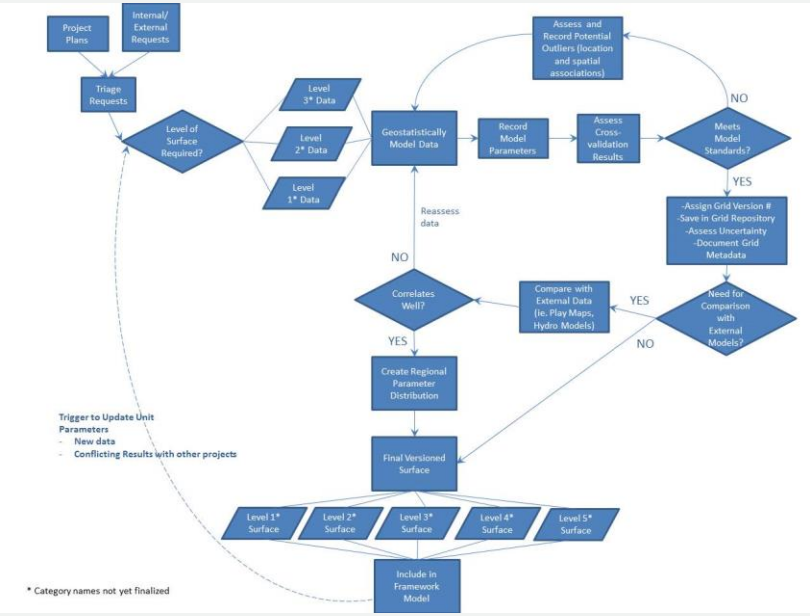
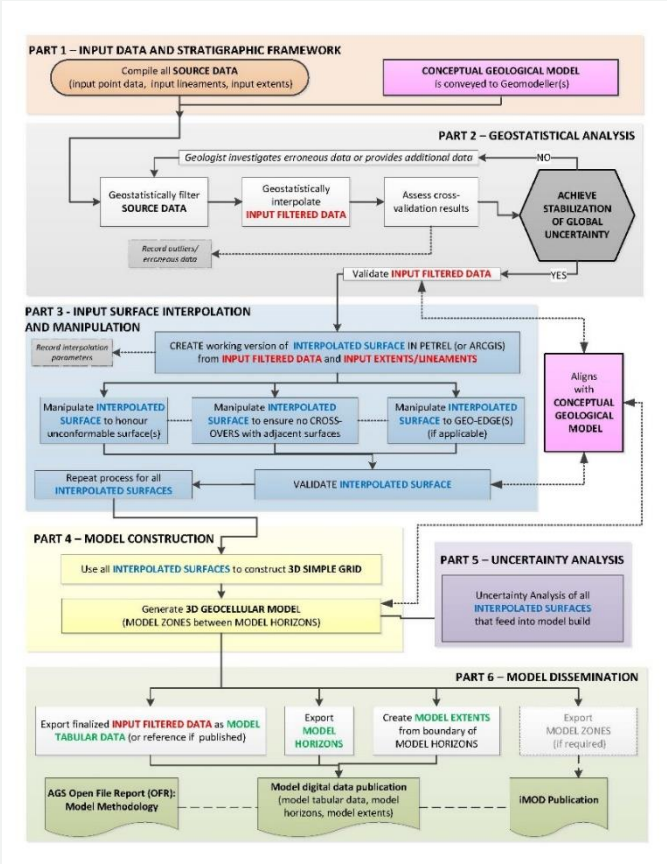
3D Modelling Workflow

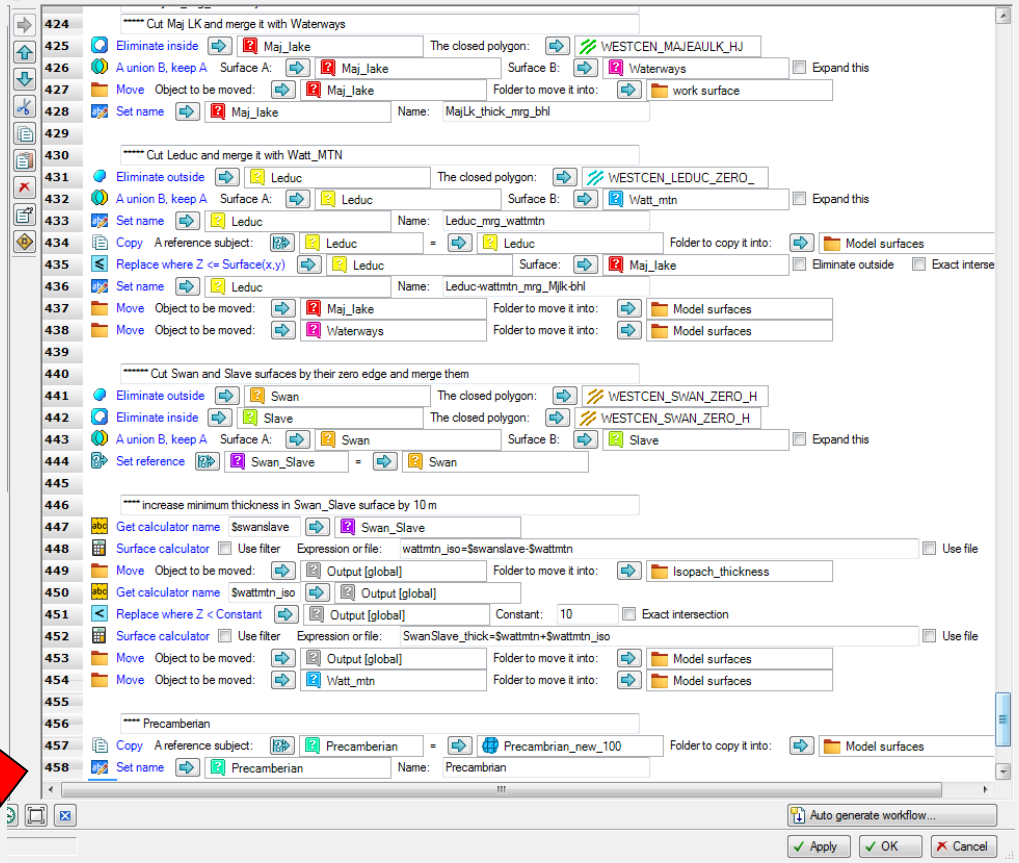




2014 **2017**

Automated Workflows

- Decrease Model build time from **2 days** to less than **2 hours**
- Increased efficiency (**87.5%**)
- Reduce chance of user error



What is the Impact?

Conceptual Model

Science and Evidence-based Model

Modern

Efficient

Credible

Decision-support

Transparent

Single-Source of Truth

Stakeholder Communication

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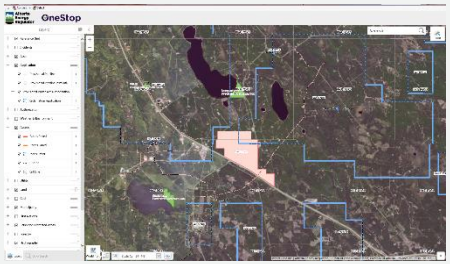
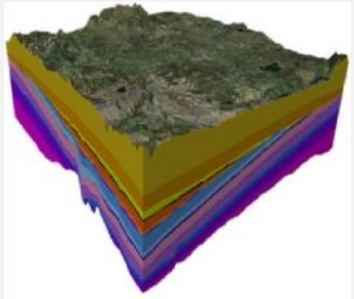
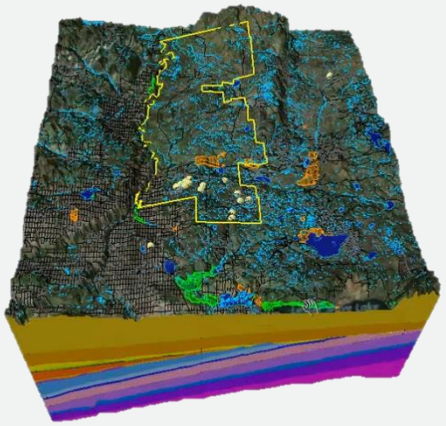
Ability to integrate Surface & Subsurface Information to Support Decision Making



Surface Data



Subsurface Model



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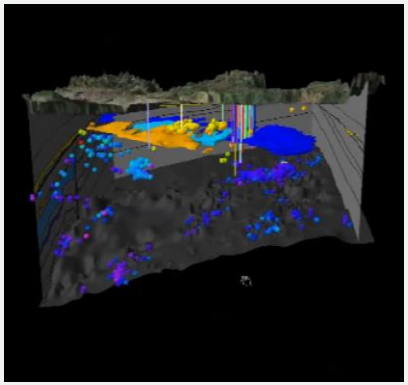

Ability to integrate surface information and subsurface geospatial data in a consistent and validated 3D geospatial environment

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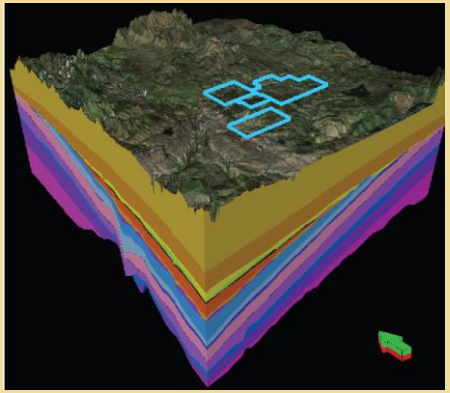
Application: Decision Support

Initial Assumption: Odours varied based on location (2D polygons)

Investigation: Hydrocarbon data and plays were evaluated in 3D

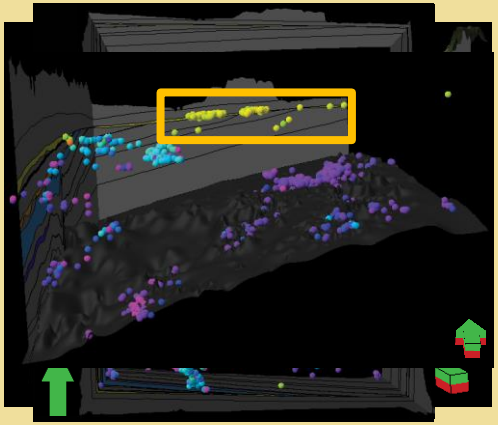
Result: Odours were related to production within subsurface zones (**Better Decision**)

3D Map of Operator Areas and subsurface



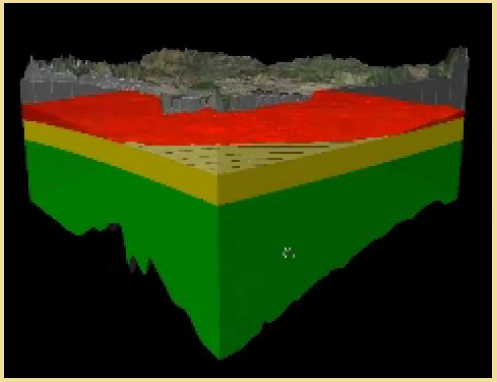
Build, Share, Integrate

Integrate and evaluate of oil geochemistry data



Evaluate

Risks characterized to support decision making



Decide

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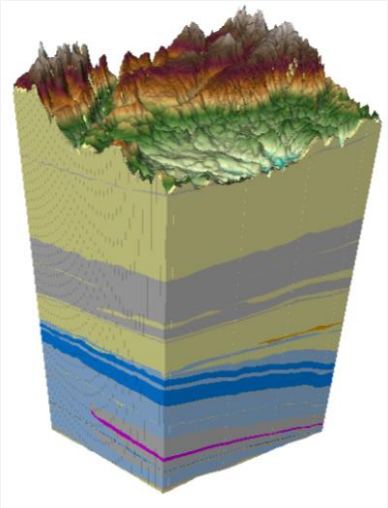
Integrate Resource Modelling

Application: Induced Seismicity

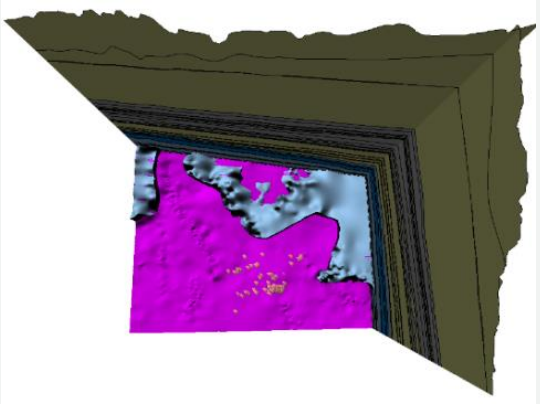
Initial Assumption: Seismicity was related to faults within the Duvernay

Investigation: Seismic events were related to underlying Swan Hills Reef

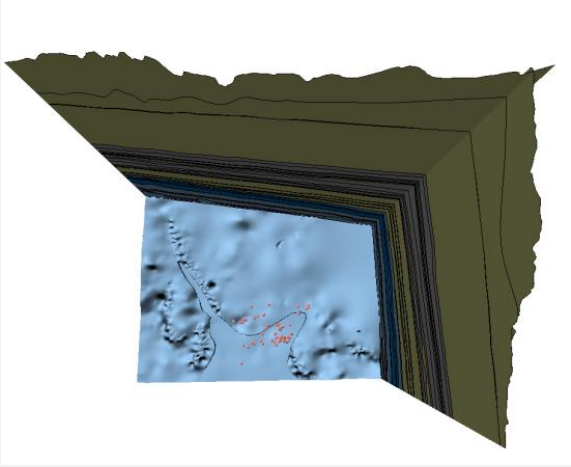
Result: Better decision and understanding of IS risk factors



3D geological model of Fox Creek area



3D evaluation of seismic event data showed little spatial correlation with the Duvernay Formation



However had strong spatial correlation with Swan Hills Reef edge

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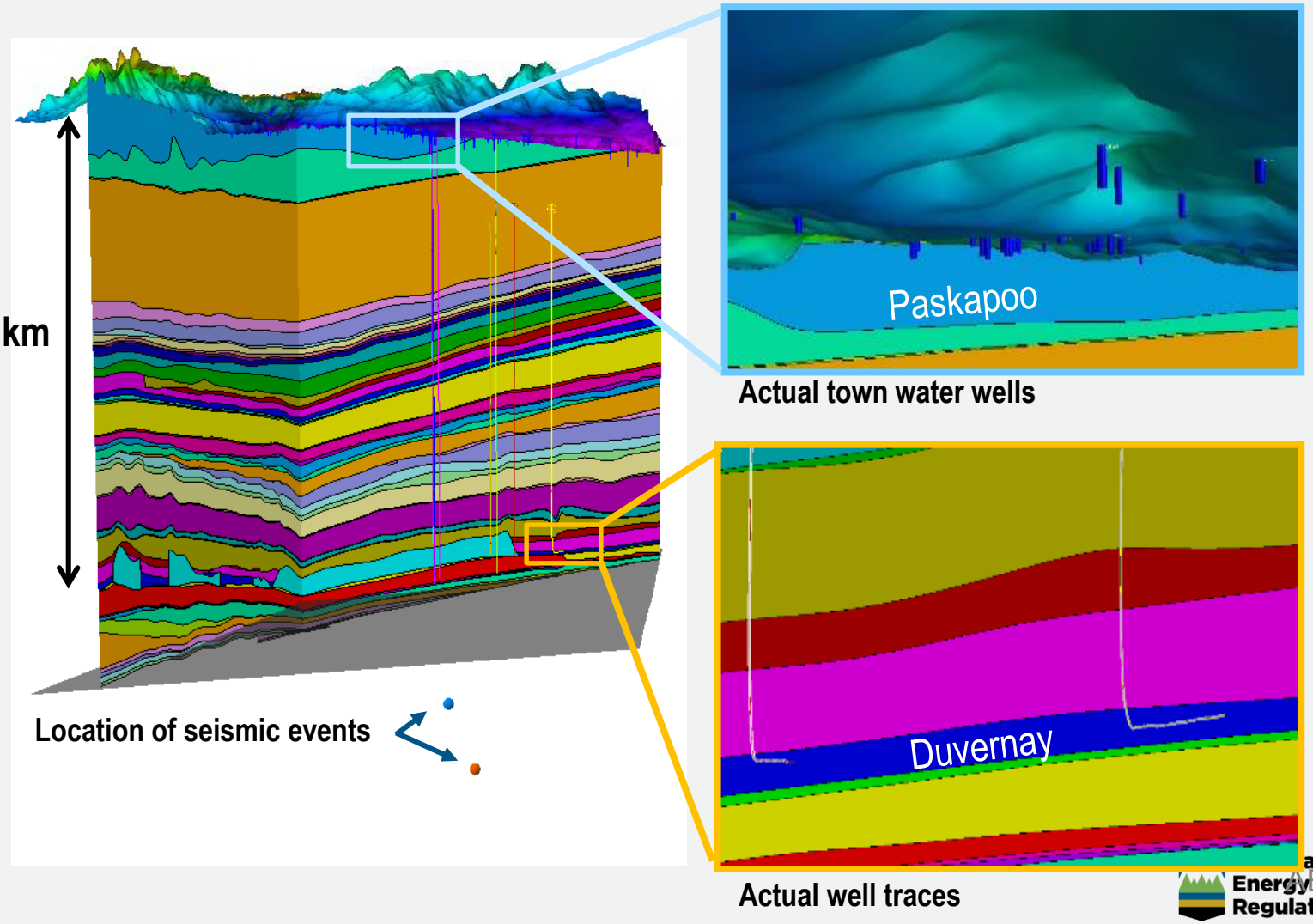
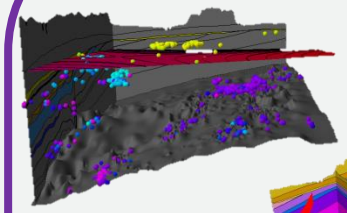
3D Visualizations to Enhance Stakeholder Communication and Engagement



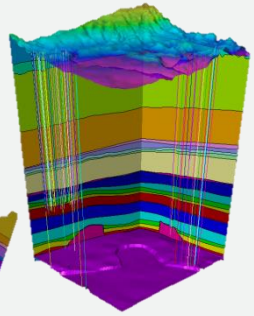
Feedback: Decision-makers

Data Integration

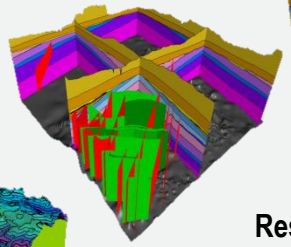
Geochemical Data



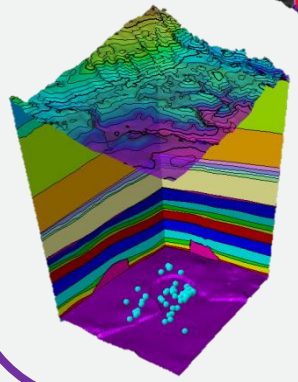
Well Data



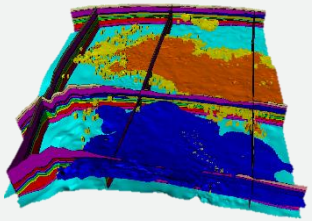
Faults



Event Data

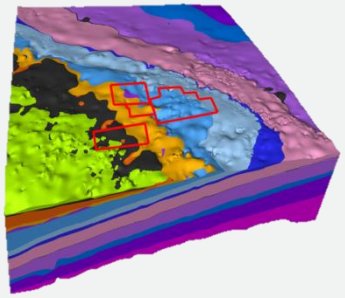


Resource Volumes

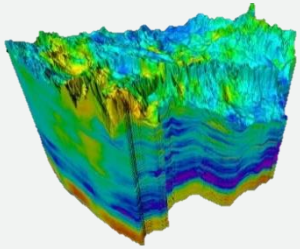


Geospatial Context

Formation Extents

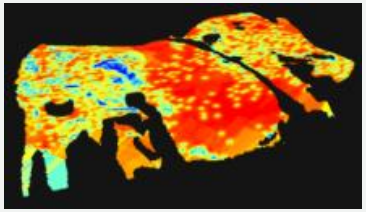


Internal Characterization

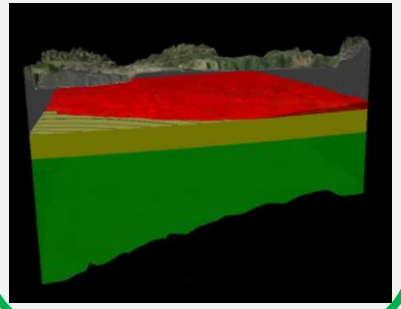


Decision Support

Uncertainty Analysis



Risk Analysis



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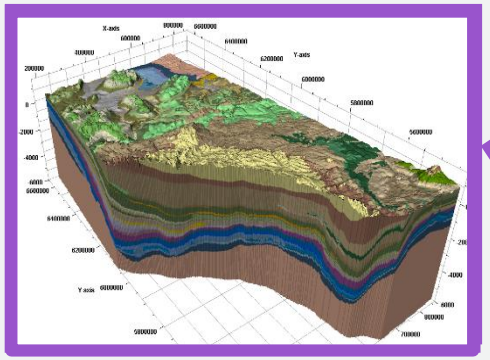
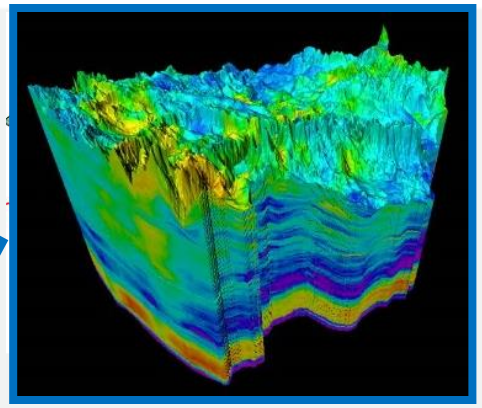
Developments and Innovation





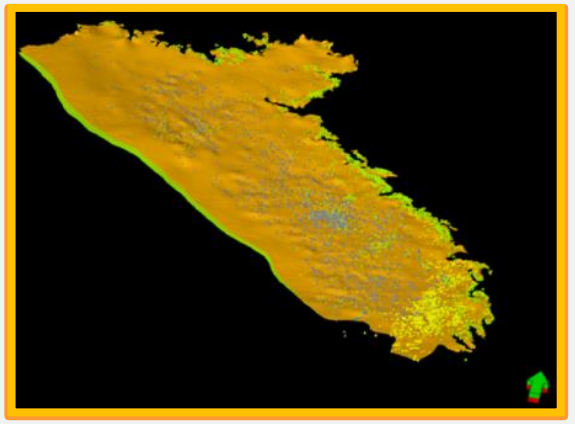
3D PROVINCIAL MODEL

PROPERTY MODELLING

INTEGRATED RESOURCES

Virtual and Augmented Reality

MINECRAFT OUTREACH



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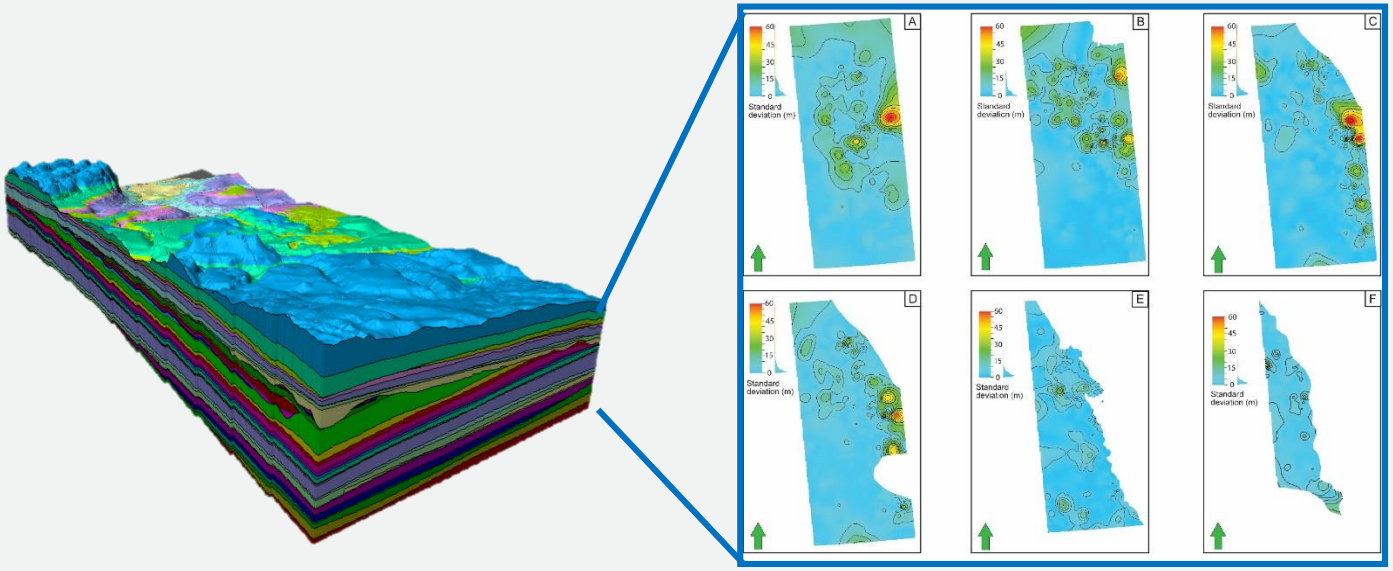
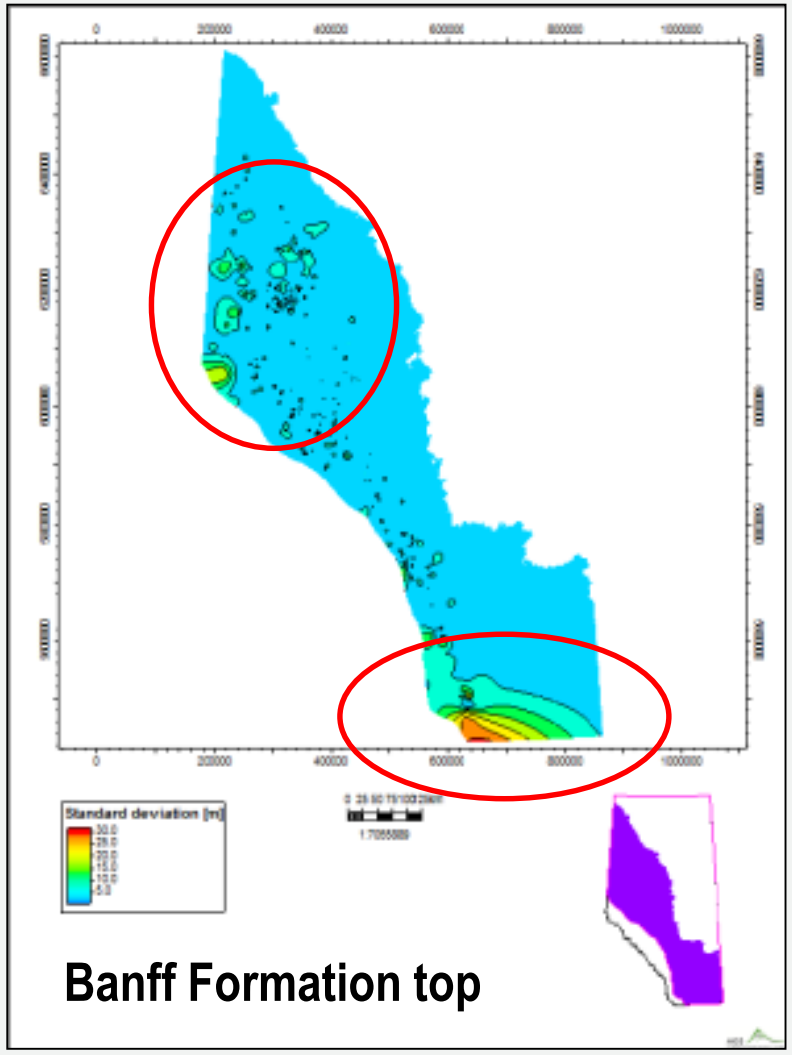
Communicating Uncertainty



- Provide information to decision-makers to determine acceptable tolerances
- Support strategic planning

Alberta Energy Regulator

Communicating Uncertainty



High uncertainty can be ok in;

- areas of non-interest with poor data distribution
- areas of high geological complexity or structure
- data poor areas with little variation in geological complexity

flag areas that need further evaluation or more data

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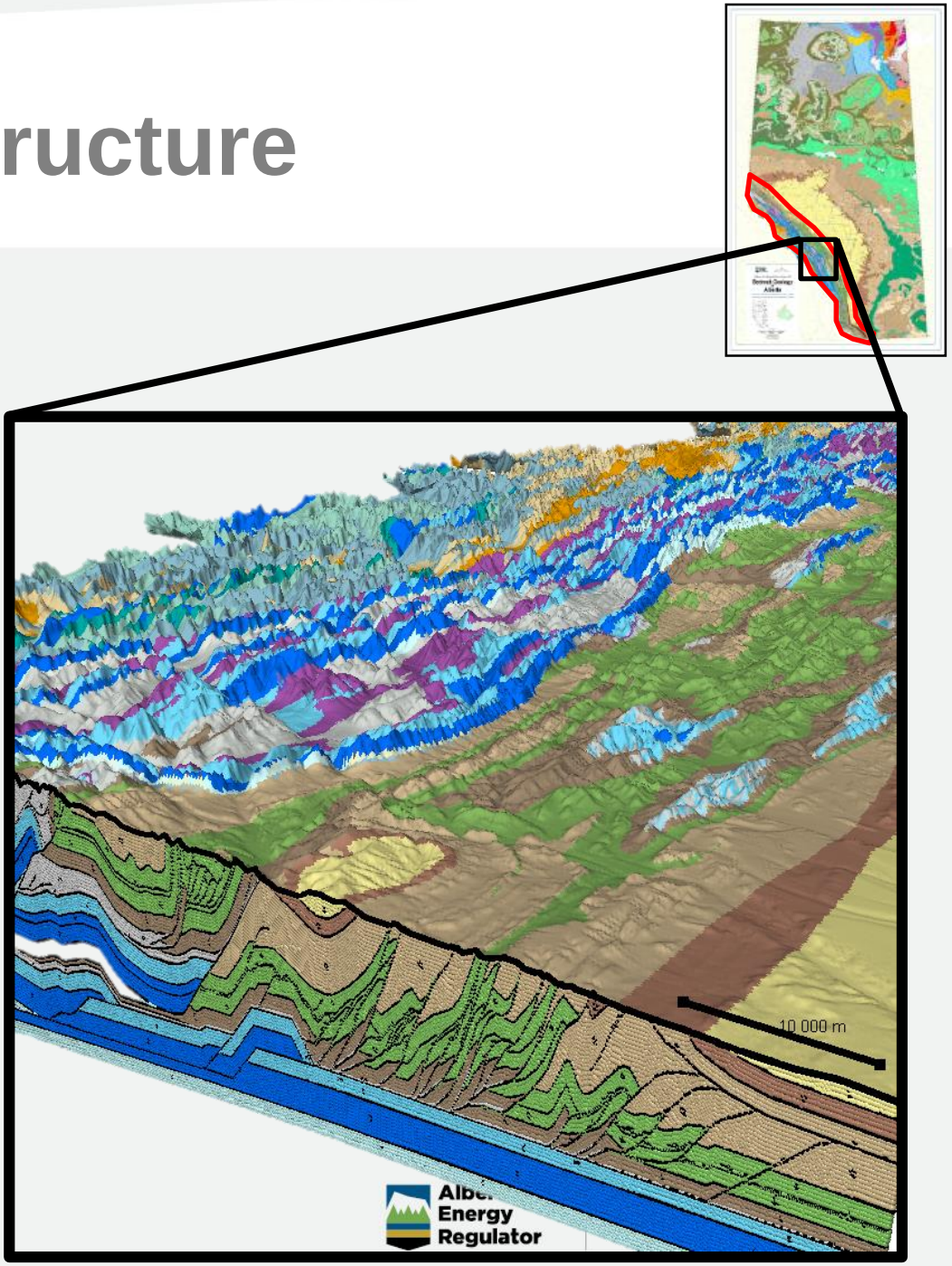
Incorporating Structure

Modelling the highly deformed region of the Rocky Mountains

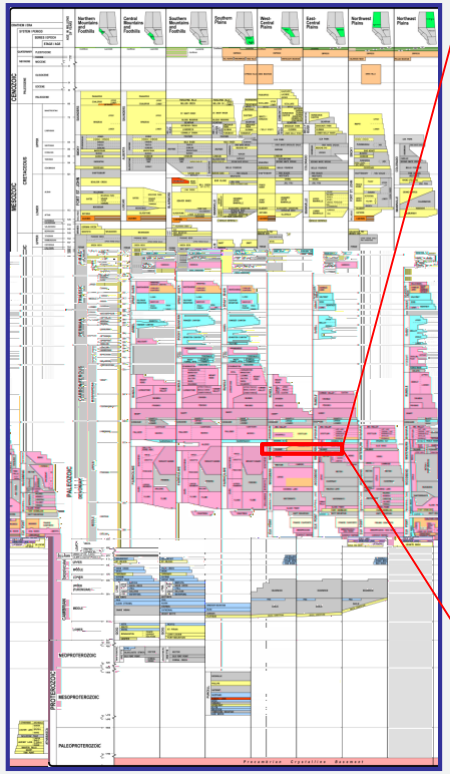
Computing Requirements

Availability of subject matter experts

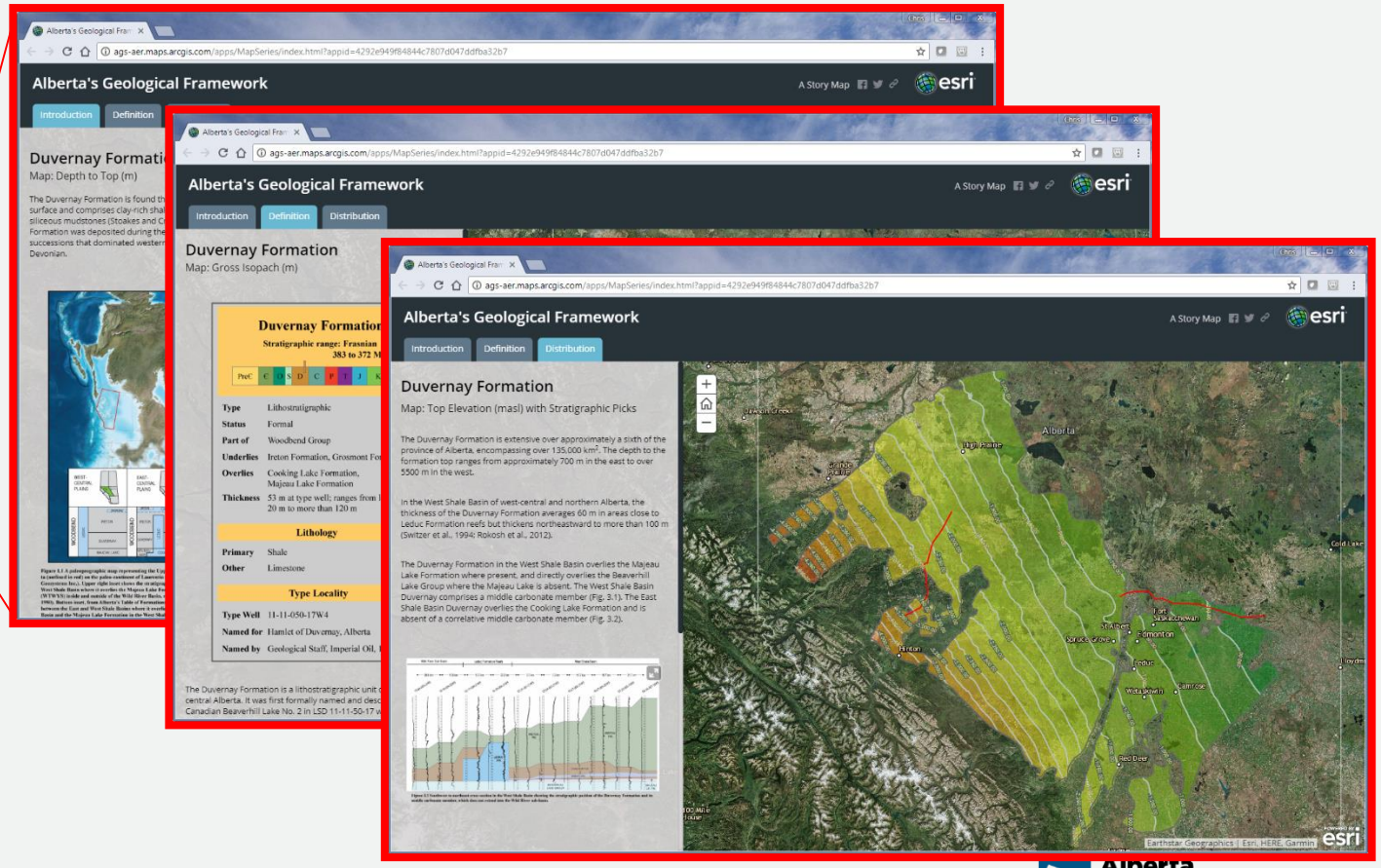


Integrated and Interactive Geological Information

Table of Formations



Online Stratigraphic Unit Summaries



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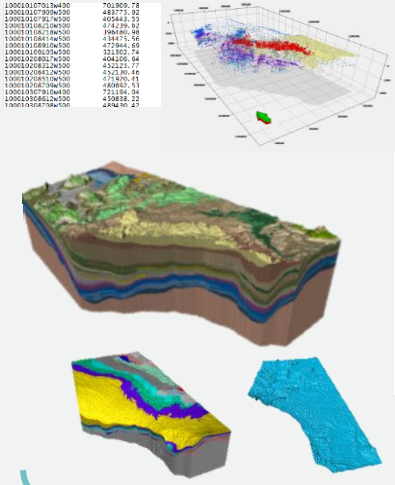
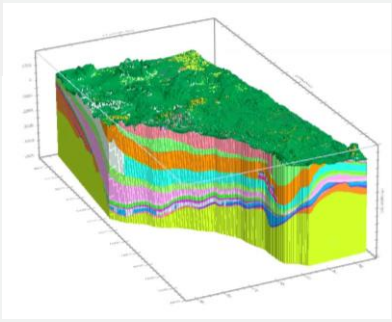
Disseminating Geological Information in 3D Models

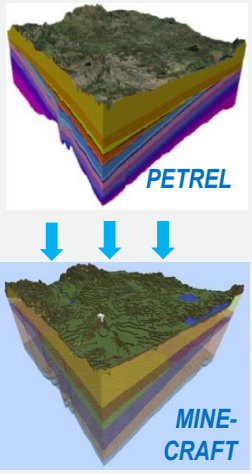
MODEL DATA
- top/pick datasets
- geological extents
- 2.5D surfaces



IMOD
Entire 3D model available via free IMOD software

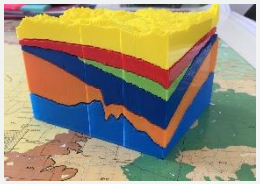


MINECRAFT
Transformation of Petrel models into Minecraft worlds



VIRTUAL REALITY
360 video tours of 3D Models and Minecraft models

3D PRINTS
Tactile representations of the geology



SUPPORT **SCIENCE-BASED** DECISION MAKING AT THE AER

SUPPORT **INTERACTIVE ENGAGEMENT** WITH A WIDE VARIETY OF **STAKEHOLDERS**

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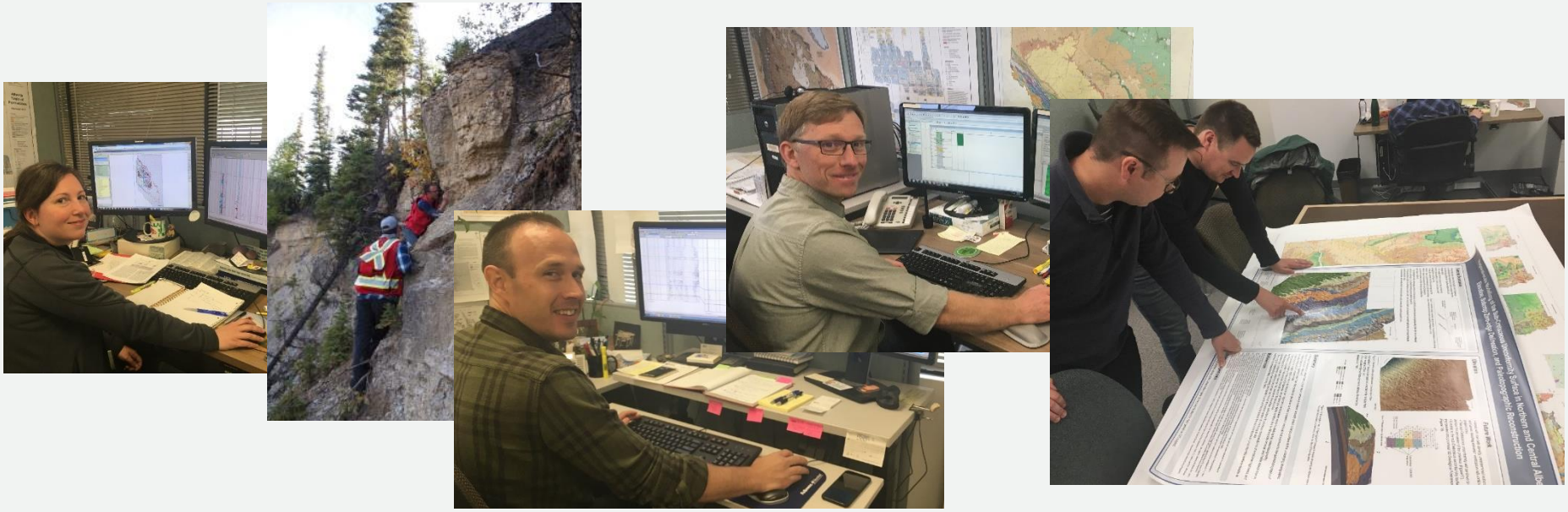
Feedback: Geoscientists



Industry

3rd time in 8 years!!

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Efficiently Share 3D Models

Duplication of efforts

Potential for inconsistencies

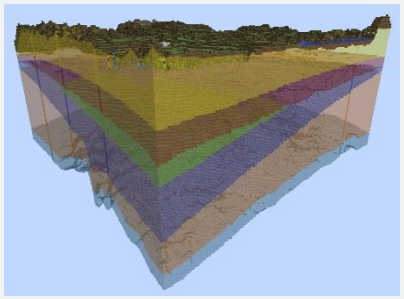
Efficient use of staff resources

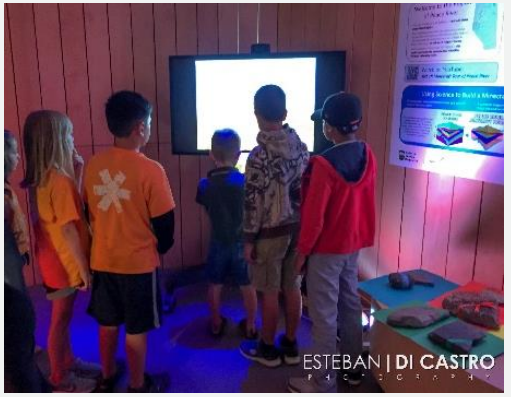
Promotes consistency and credibility

Alberta Energy Regulator

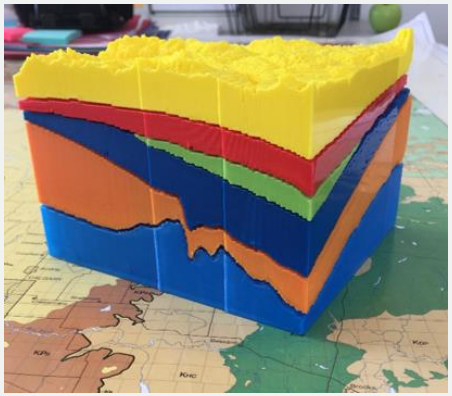
Engaging and Sharing Information with Our Stakeholders

- Minecraft





- 3D Prints



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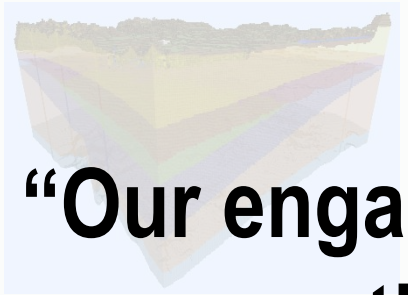
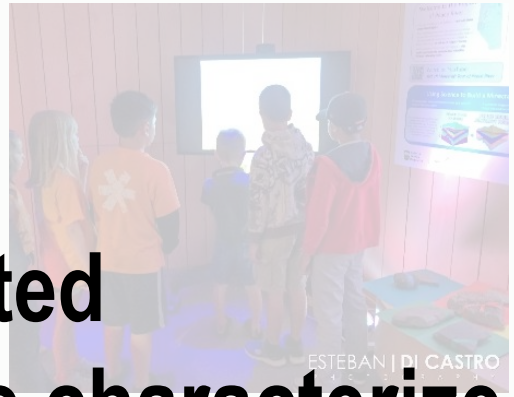
Engaging and Sharing Information with Our Stakeholders

- Minecraft





- 3D Prints

"Our engaging material started conversations about *how* we characterize the subsurface, and *why* we do it"

Elwyn Galloway - Young Global Petroleum Show (June 13, 2018)

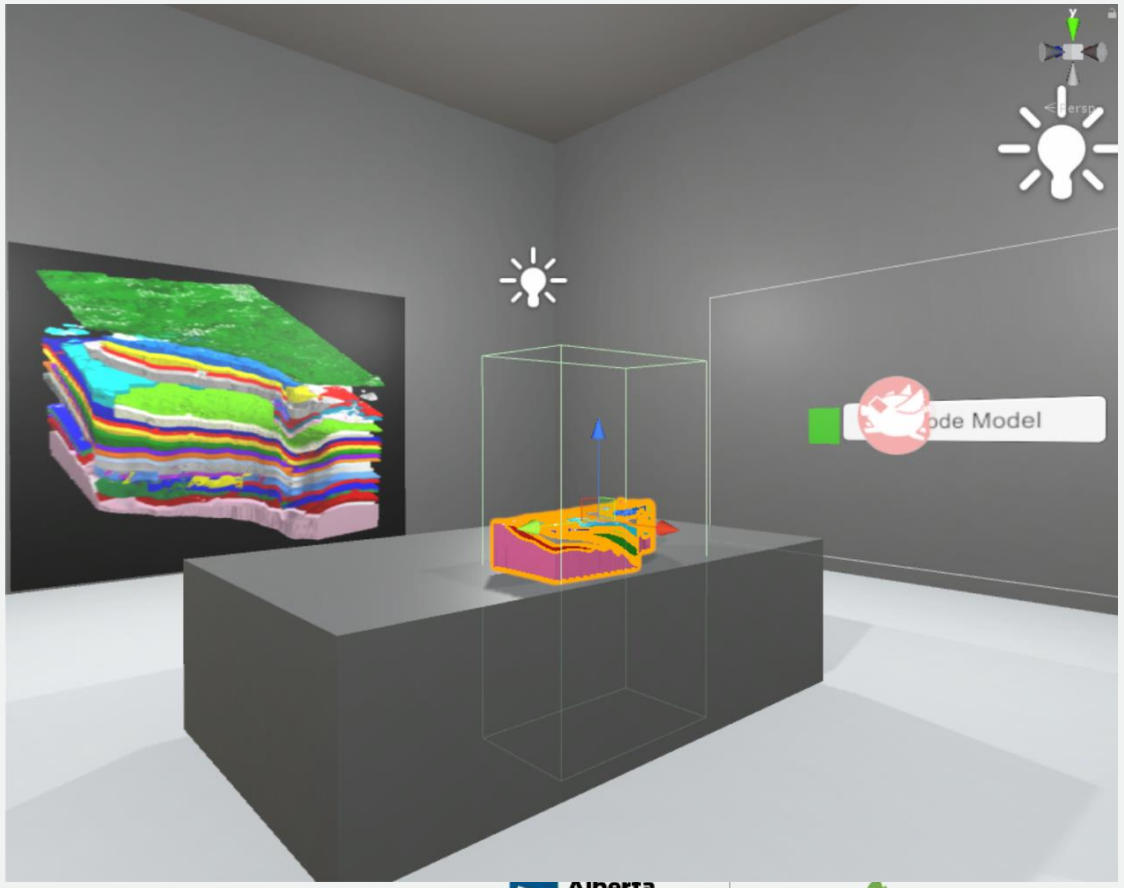
Alberta Energy Regulator | AGS ALBERTA GEOLOGICAL SURVEY

Engaging and sharing information with our Stakeholders

- 360 videos

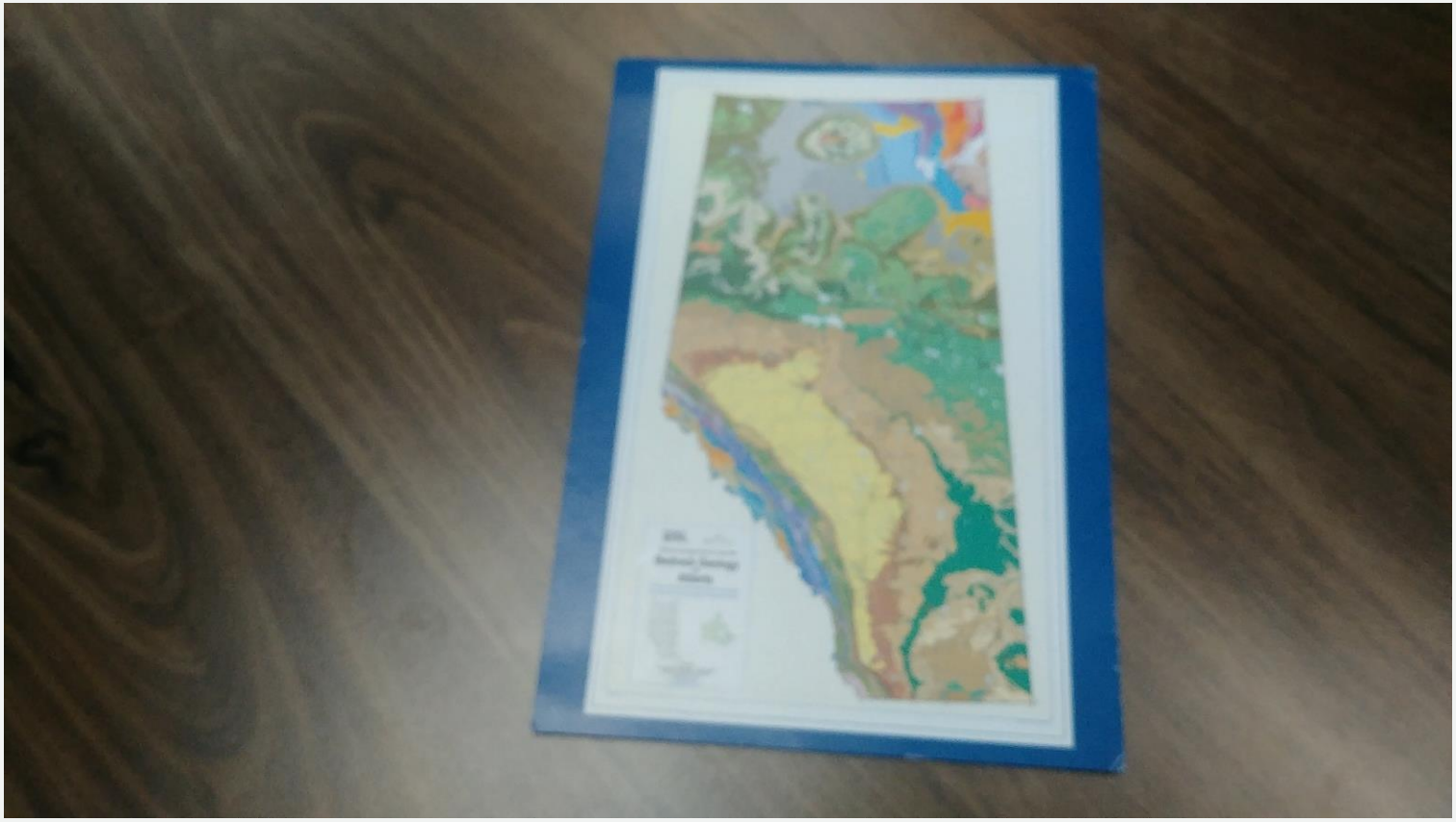
Engaging and sharing information with our Stakeholders

- Virtual Reality (VR)



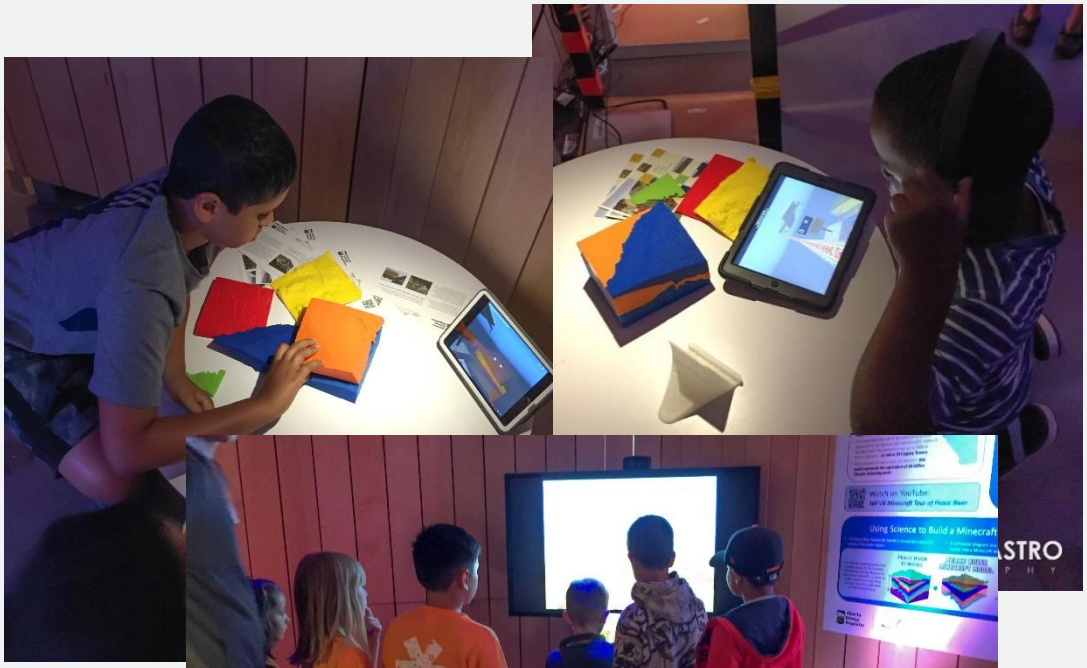
Engaging and sharing information with our Stakeholders

- Augmented Reality (AR)



Feedback: Educators and Science Centers

- Learning in Action!



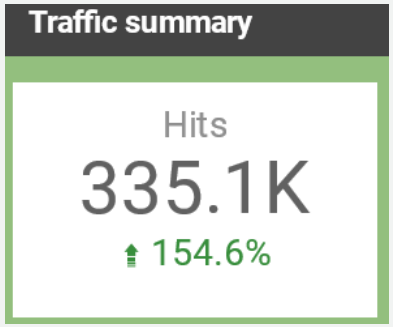
Alberta Energy Regulator

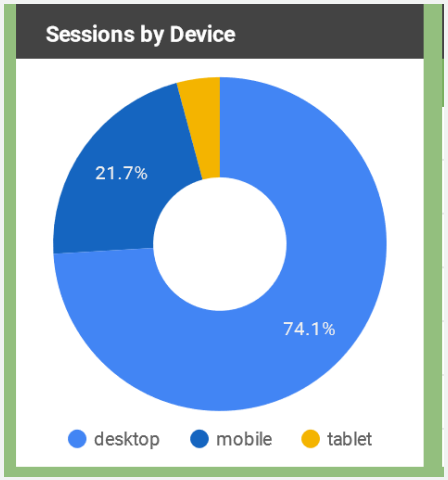
AGS ALBERTA GEOLOGICAL SURVEY

Website Stats: 30 days

- Who is visiting our website?
- Where are they from?
- How are they accessing it?
- How long do they stay?

	Country	Sessions	Pageviews
1.	United States	41,843	
2.	India	5,643	
3.	United Kingdom	3,185	
4.	Taiwan	2,871	
5.	Canada	2,725	
6.	Japan	2,270	
7.	Germany	1,992	
8.	France	1,735	
9.	Brazil	1,712	
10.	Spain	1,689	
11.	Australia	1,328	
12.	Italy	1,156	
13.	Netherlands	1,074	
14.	Mexico	1,034	
15.	South Korea	975	
16.	Poland	793	
17.	Vietnam	774	
18.	Russia	754	
19.	Thailand	747	
20.	Singapore	687	





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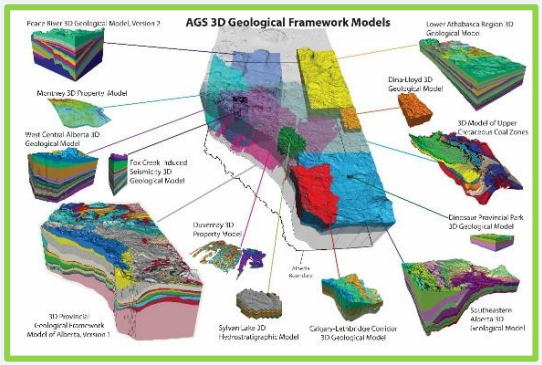
Website Stats: 30 days

Alberta Energy Regulator | AGS ALBERTA GEOLOGICAL SURVEY

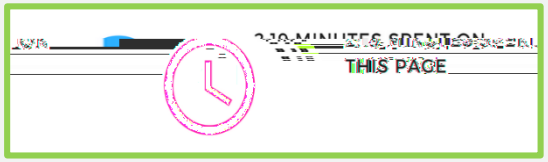
PREPARED BY JESSICA LACCETTI, PHD
WEB DEVELOPER

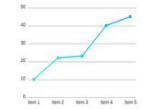


3RD MOST POPULAR LANDING PAGE

3:45

MINUTES SPENT ON PAGE





0% BOUNCE RATE; THIS IS THE PAGE USERS WANT

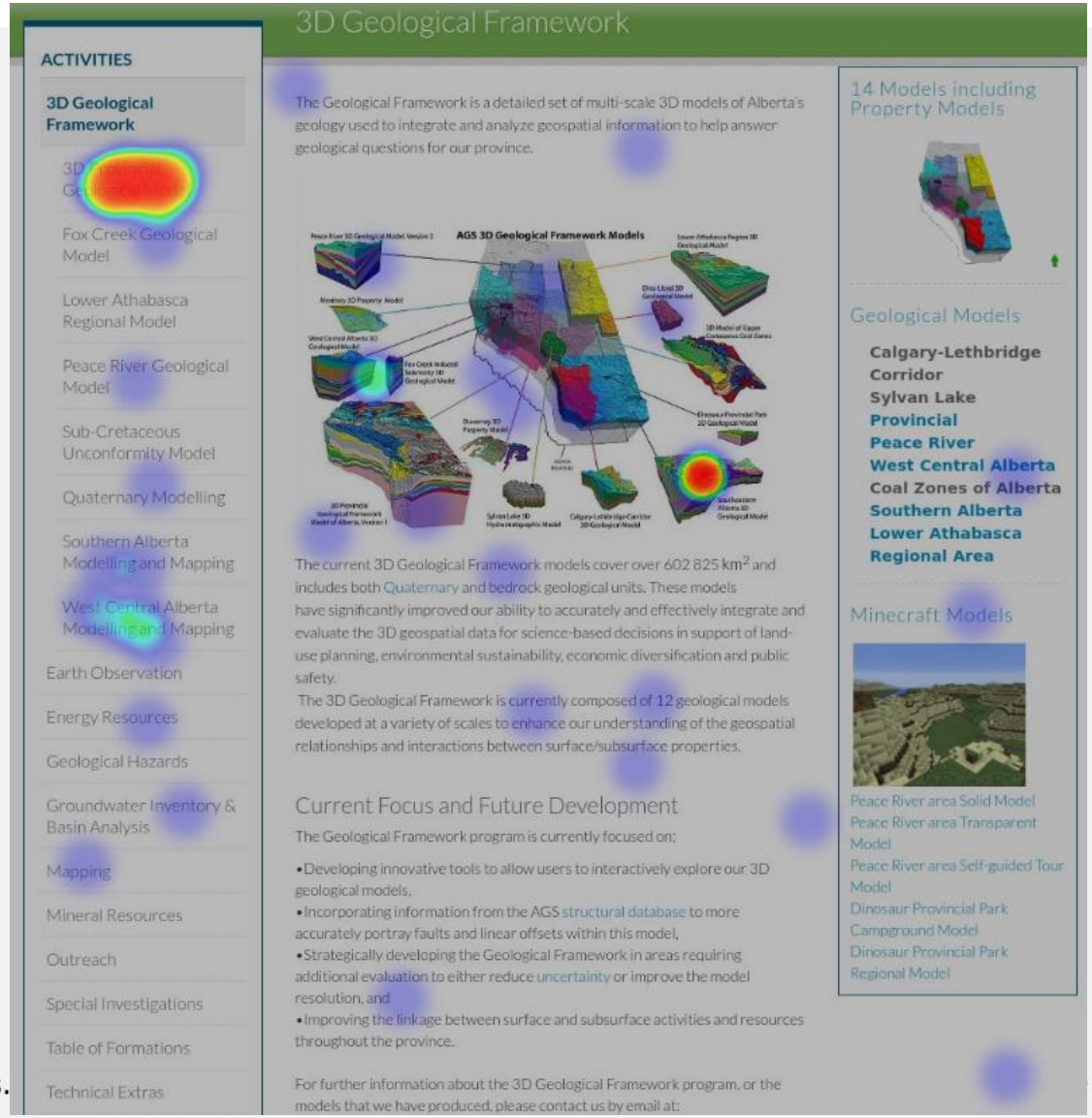
0% BOUNCE RATE; THIS IS THE PAGE USERS WANT

19 USERS CLICKED THROUGH FROM THE PEACE RIVER MINECRAFT SOLID MODEL

www.ags.aer.ca

Alberta Energy Regulator | AGS ALBERTA GEOLOGICAL SURVEY

Website: What are people looking for



3D Geological Framework

ACTIVITIES

- 3D Geological Framework
- 3D [illegible] Geological Model
- Fox Creek Geological Model
- Lower Athabasca Regional Model
- Peace River Geological Model
- Sub-Cretaceous Unconformity Model
- Quaternary Modelling
- Southern Alberta Modelling and Mapping
- West Central Alberta Modelling and Mapping
- Earth Observation
- Energy Resources
- Geological Hazards
- Groundwater Inventory & Basin Analysis
- Mapping
- Mineral Resources
- Outreach
- Special Investigations
- Table of Formations
- Technical Extras

The Geological Framework is a detailed set of multi-scale 3D models of Alberta's geology used to integrate and analyze geospatial information to help answer geological questions for our province.

AGS 3D Geological Framework Models

The current 3D Geological Framework models cover over 602 825 km^2 and includes both Quaternary and bedrock geological units. These models have significantly improved our ability to accurately and effectively integrate and evaluate the 3D geospatial data for science-based decisions in support of land-use planning, environmental sustainability, economic diversification and public safety.

The 3D Geological Framework is currently composed of 12 geological models developed at a variety of scales to enhance our understanding of the geospatial relationships and interactions between surface/subsurface properties.

Current Focus and Future Development

The Geological Framework program is currently focused on:

- Developing innovative tools to allow users to interactively explore our 3D geological models.
- Incorporating information from the AGS structural database to more accurately portray faults and linear offsets within this model.
- Strategically developing the Geological Framework in areas requiring additional evaluation to either reduce uncertainty or improve the model resolution, and
- Improving the linkage between surface and subsurface activities and resources throughout the province.

For further information about the 3D Geological Framework program, or the models that we have produced, please contact us by email at:

14 Models including Property Models

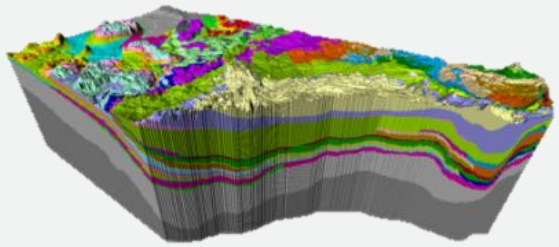
Geological Models

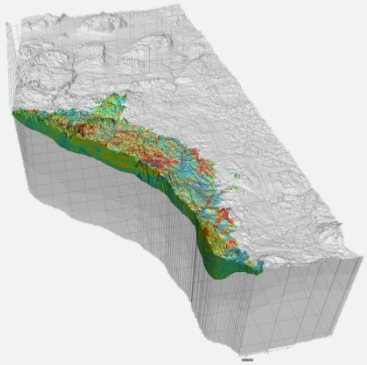
- Calgary-Lethbridge Corridor
- Sylvan Lake Provincial
- Peace River
- West Central Alberta
- Coal Zones of Alberta
- Southern Alberta
- Lower Athabasca Regional Area

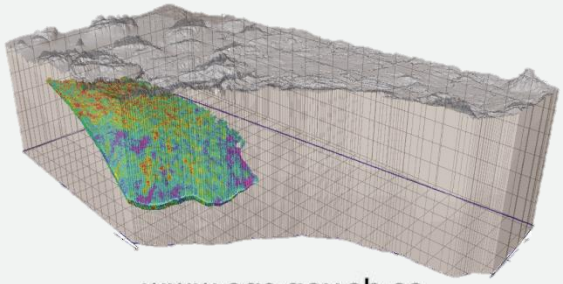
Minecraft Models

Peace River area Solid Model
Peace River area Transparent Model
Peace River area Self-guided Tour Model
Dinosaur Provincial Park Campground Model
Dinosaur Provincial Park Regional Model

Next Steps….

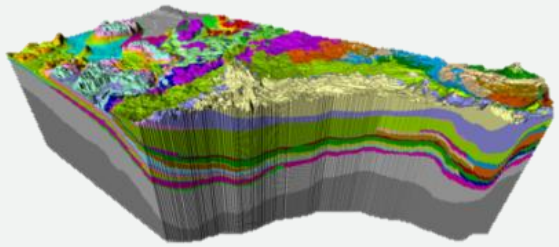


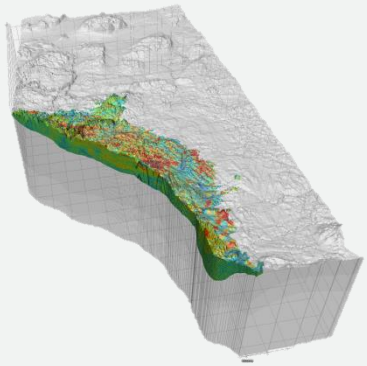


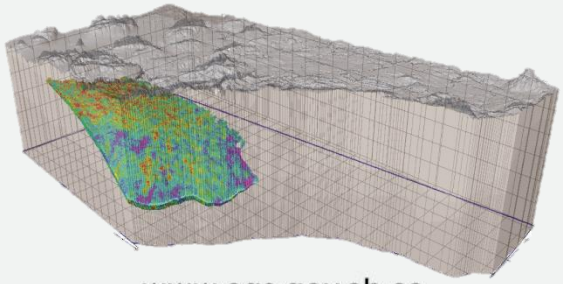


- Make 3D models more accessible (ArcPro or iMOD)
- Enable users to import and evaluated their own data within our models
- Update and refine provincial-wide geological surfaces (from 62 to 70)
- Leverage property models and geochemistry data to define 3D aquifer models

Next Steps….

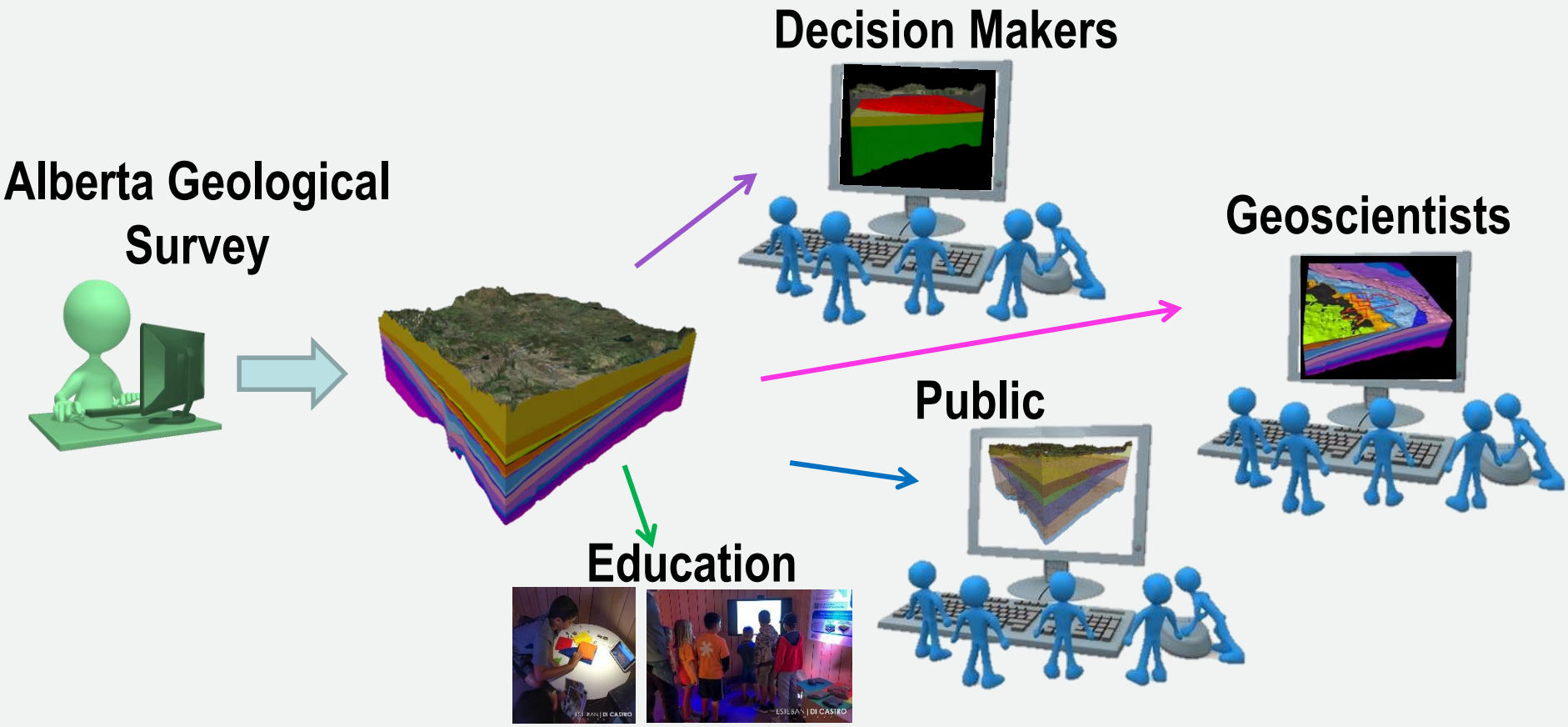






- Optimize data by leveraging machine and deep learning applications.
- Optimize our staff resources by allocating them to the areas where they can have the greatest impact.
- Further leverage our Geological Framework to support decision-making within Alberta……the **Source of Geological-Truth**
- And finally……

One Source of Geological Truth



Build 1 multi-scale model to meet the needs of a variety of stakeholders for a variety of applications

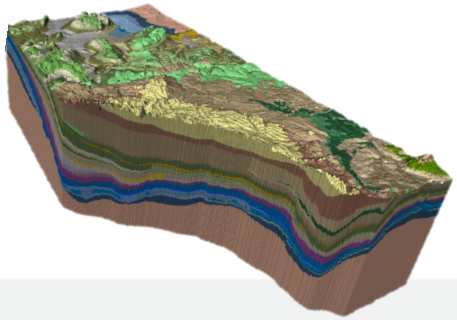
Alberta Energy Regulator

AGS ALBERTA GEOLOGICAL SURVEY

Our Vision….

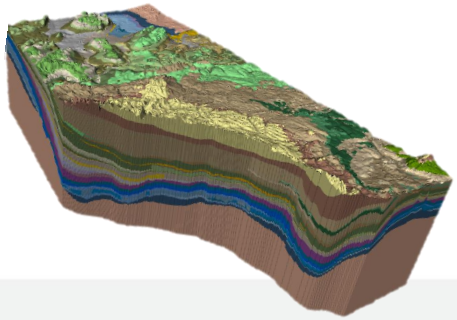
- Provide the **single-source** of **credible** geological information to Government, Regulators, Industry, and Public
- Provide a **consistent** and **reliable** 3D geological context to support **integration** of surface & subsurface geospatial information
- Ensure risk-based strategic and operational decisions are based on **sound science** and **credible evidence**
- **Reduce duplication** of work and **increase consistency** of surface/ subsurface geological, mineral, groundwater, and energy resource evaluations

Take Home Message



- Develop a *multi-dimensional*, *interdisciplinary*, *multi-scalar*, *geostatistically optimized*, *probabilistically parameterized*, *uncertainty characterized* *geocellular model* of Alberta to *effectively communicate and disseminate* geological information meeting *the needs* of a *diverse stakeholder group*.

Take Home Message



- Develop a tool to ***efficiently and effectively*** *integrate information* and *communicate* ***credible*** *geoscience knowledge* with *ANYONE*

Questions

Thank You

kelsey.maccormack@aer.ca