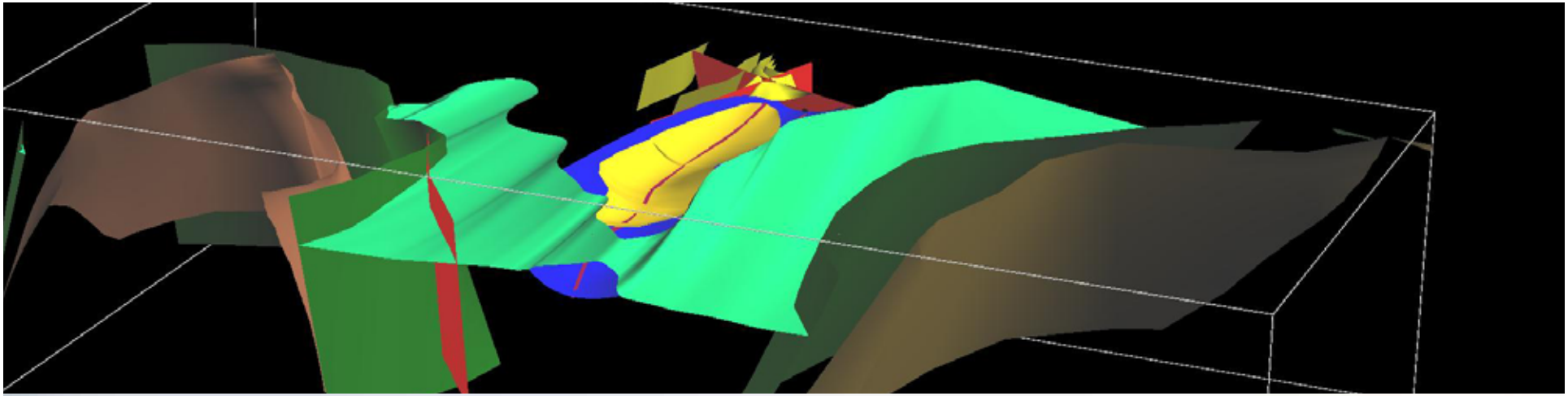

Pietari Skyttä, Tobias Bauer, Saman Tavakoli, Pär Weihed, Rodney Allen,
Mahdieh Dehghannejad, Maria Garcia Juanatey, Juliane Hübert

Bergforsk 05 May 2011

4-dimensional modelling of mineral belts

BOLIDEN
GeoVista AB
lundin mining
VINNOVA
UPPSALA UNIVERSITET

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- **Why 3D-modelling?**
  - **Earth's crust and ore deposits are 3D!**
  - **Proper integration of three-dimensional source data**
    - Surface geology
    - Geophysics (seismic, potential field IP, resistivity)
    - Drillings
    - Mine data

- **Why 4D-modelling?**
  - **Much of the near-surface deposits already discovered and exploited → deep-exploration required = expensive**
  - **Complex geological terrains and uneven source data**
    - Distribution, type and reliability → remaining uncertainties in the 3D-models

– What do we get from 4D-modelling?

- **Validation of the 3D-interpretations**
- **Improvements in understanding geological processes leading to ore deposition and their subsequent deformation = distribution and form of the deposits**

Background

- **Two currently running projects**
  - ”Vinnova 4D-modelling of the Skellefte District”
    - Luleå and Uppsala Universities, Boliden Mineral AB, GeoVista AB
    - National funding
  - ”ProMine”
    - EU-funding

VINNOVA
-Multidisciplinary
-Geology, Geophysics

ProMine
- Several Mineral Belts through Europe involved

Financial support from Boliden Mineral AB, VINNOVA and EU acknowledged!

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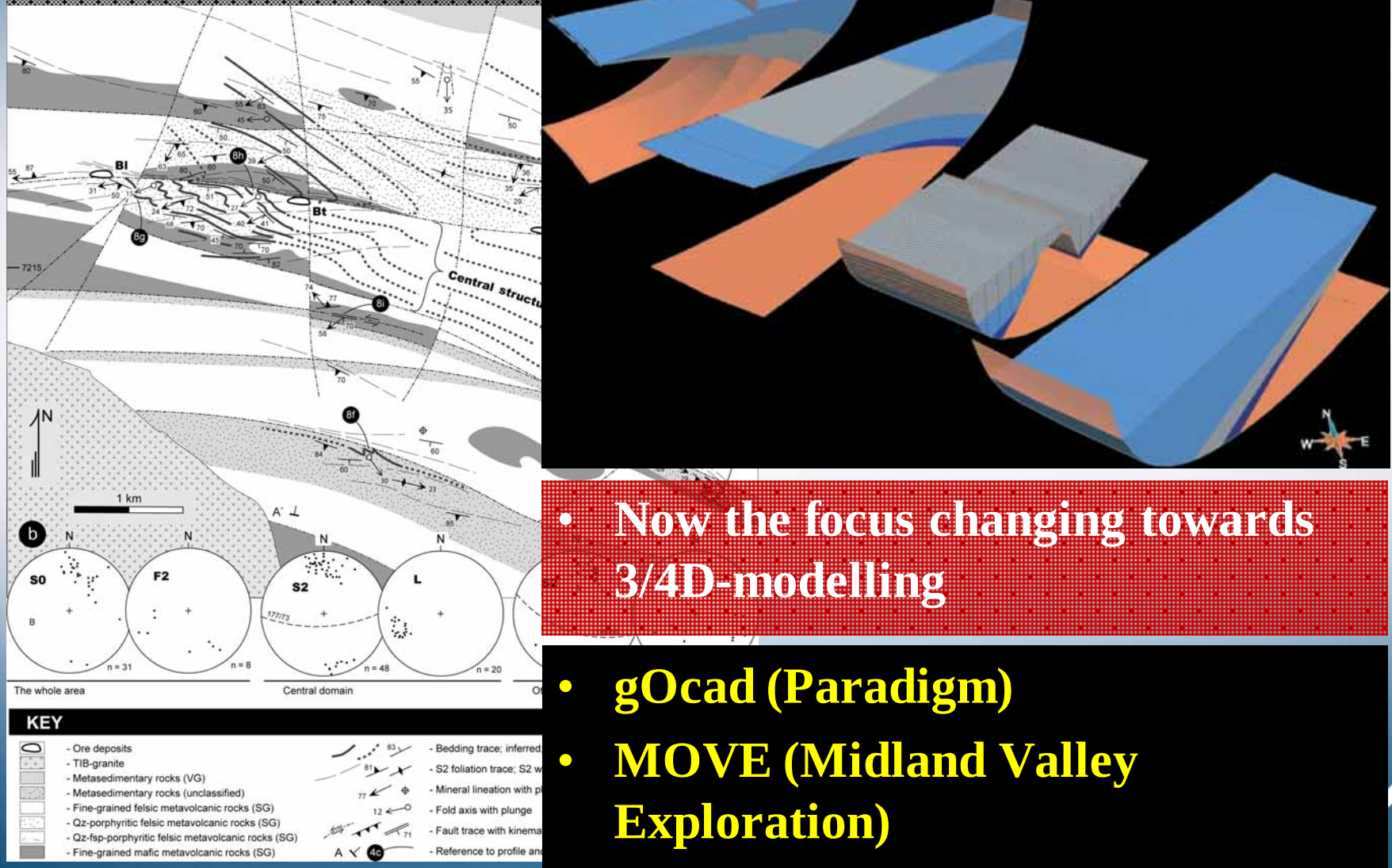
- **Much of the work so far concentrated in structural analysis & synthesis**

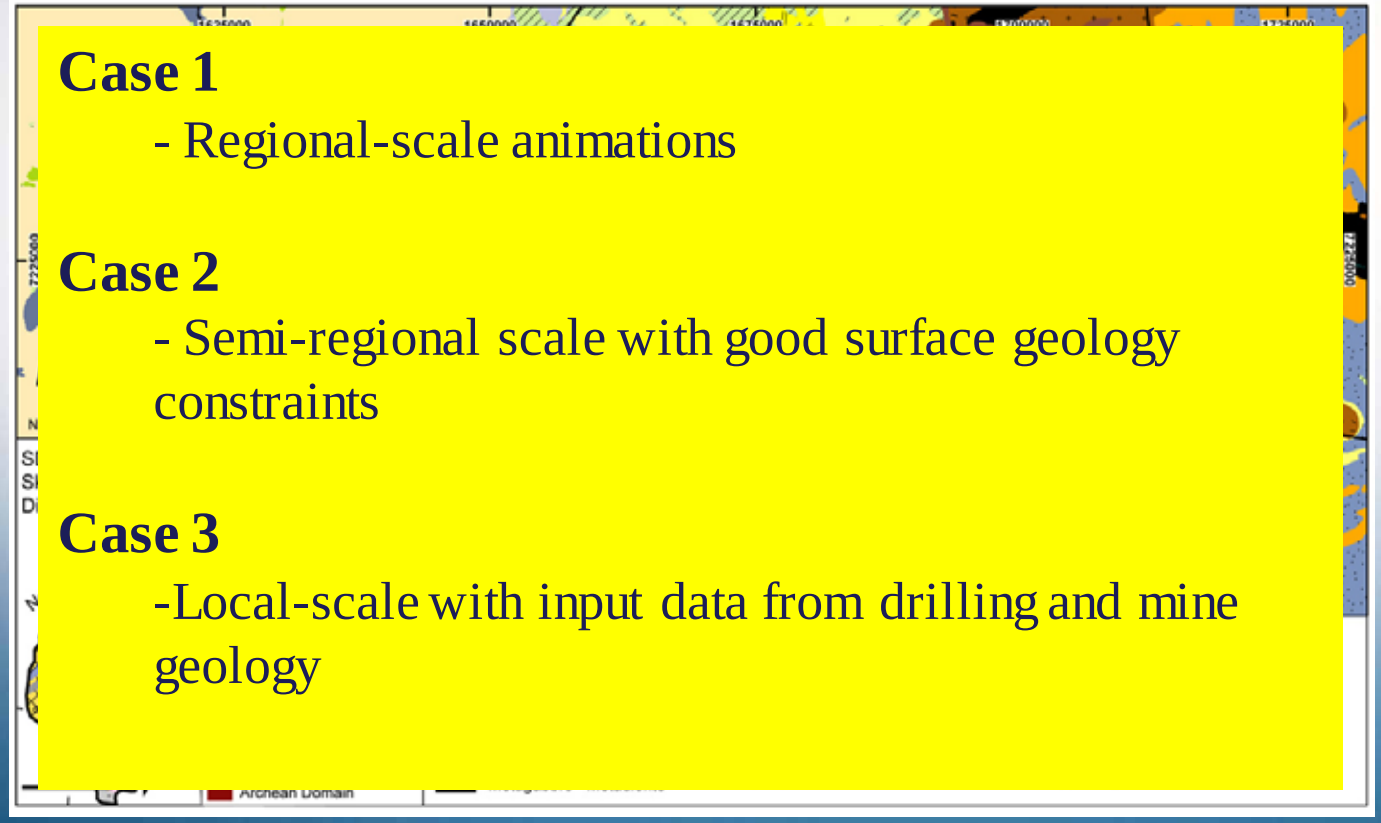


- **Now the focus changing towards 3/4D-modelling**

- **gOcad (Paradigm)**
- **MOVE (Midland Valley Exploration)**

Aim of the talk

- **Provide an overview of the possibilities and challenges of 3/4D-modelling within the Skellefte District**
  - Two geographical focus areas and three modelling scales



Case 1

- Regional-scale animations

Case 2

- Semi-regional scale with good surface geology constraints

Case 3

-Local-scale with input data from drilling and mine geology

• Case 1: Simplified crustal evolution models

– **Goals**

- A regional 3D context for activities in the district
- Aid in understanding large-scale tectonic processes
- Visualizations & presentations for decision-makers
- Teaching material

– **Input**

- *Concept:* Inversion tectonics in a segmented crust
- Geophysical and geological constraints acquired in the smaller-scale sub-projects

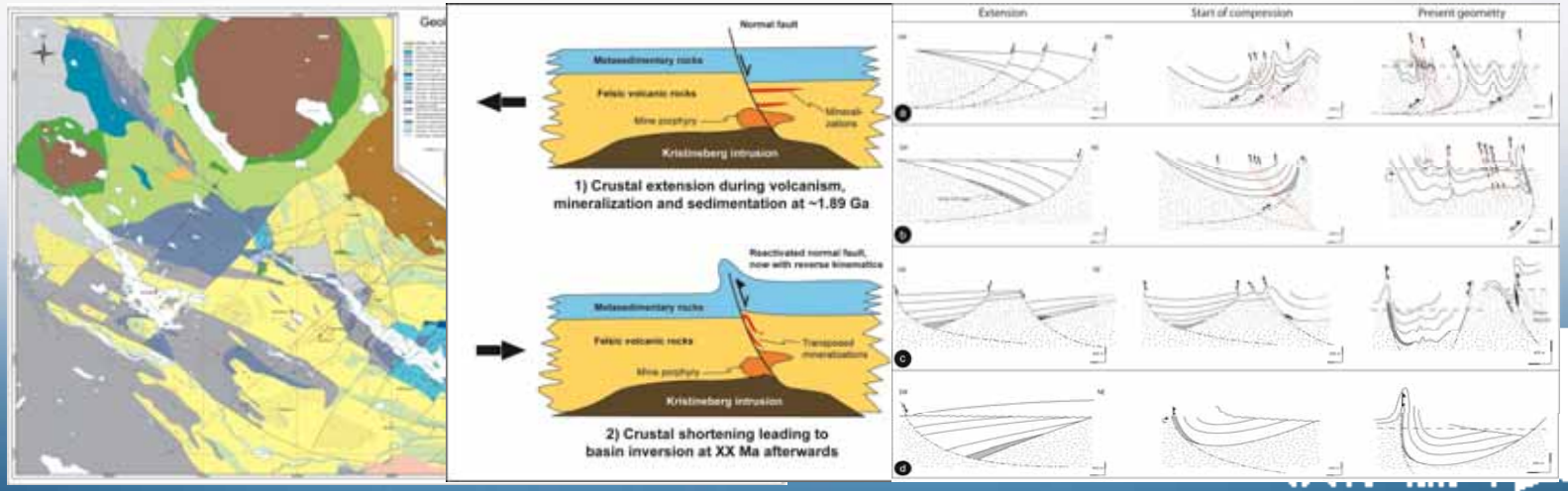
• Case 1: Simplified crustal evolution models

– **Challenges**

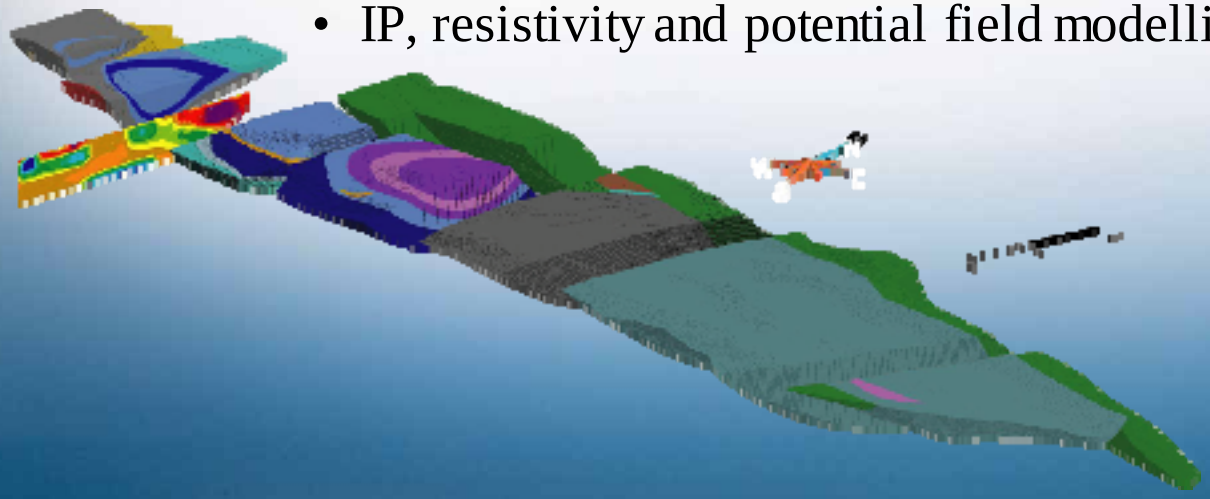
- Complexity → a suitable degree of simplification needed
- Correct conceptual model (may though hopefully evolve further)

– **Advantages**

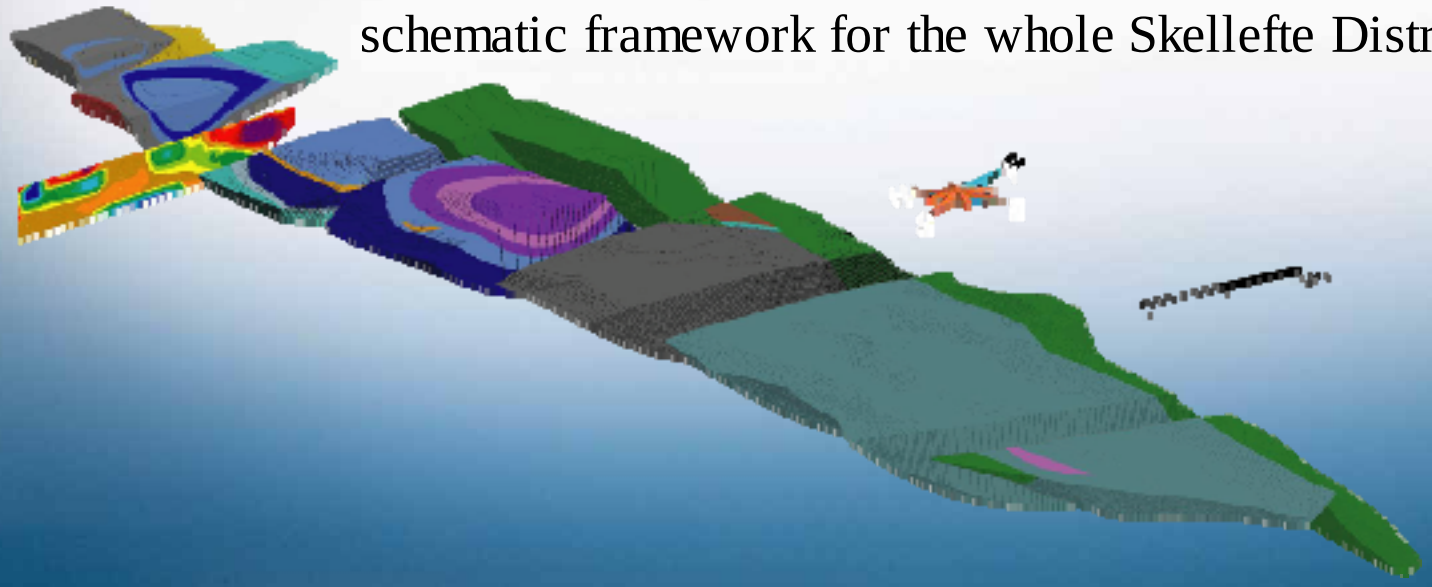
- Possibility to present the sometimes ”so-hard-to-understand” geological stories in an easier way



- **Case 2: Semi-regional scale model with good surface geology constraints**
  - **Goals**
    - Understanding the structural control on sedimentation, volcanism and mineralization + subsequent deformation patterns
    - Input into district-scale models
  - **Input**
    - Geological mapping, structural analysis
    - IP, resistivity and potential field modelling



- **Case 2: Semi-regional scale model with good surface geology constraints**
  - **Challenges**
    - Complex interplay between sedimentation and deformation
    - Correlation with the larger-scale seismics
  - **Advantages**
    - Good exposure and relatively low strain → possible to define a schematic framework for the whole Skellefte District



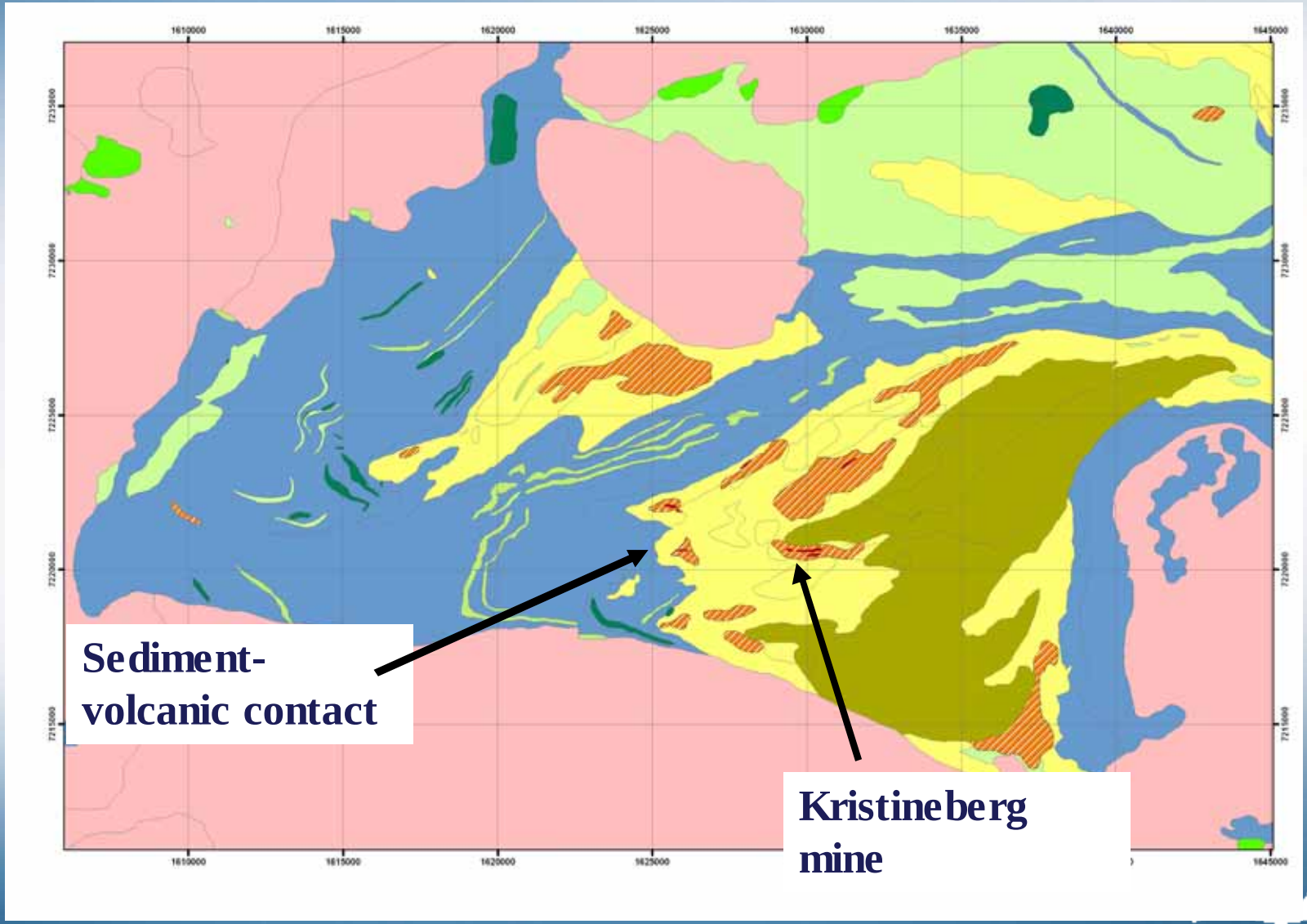
Exploring the surface geology…

- **Case 3: Local-scale with input data from drilling and mine geology**
  - **Goals**
    - Deposit/domain-scale 3D-framework for mineralizations by improved understanding on the structural evolution of the mine areas, e.g. the Kristineberg mine
      - *Fault-system geometry, kinematics and strain partitioning*
    - Input into district-scale models
  - **Input**
    - Drill core observations, triangulated ore body surfaces in 3D, profiles and plan maps from the mine
    - Geological mapping, structural analysis
    - Seismics, magnetotellurics

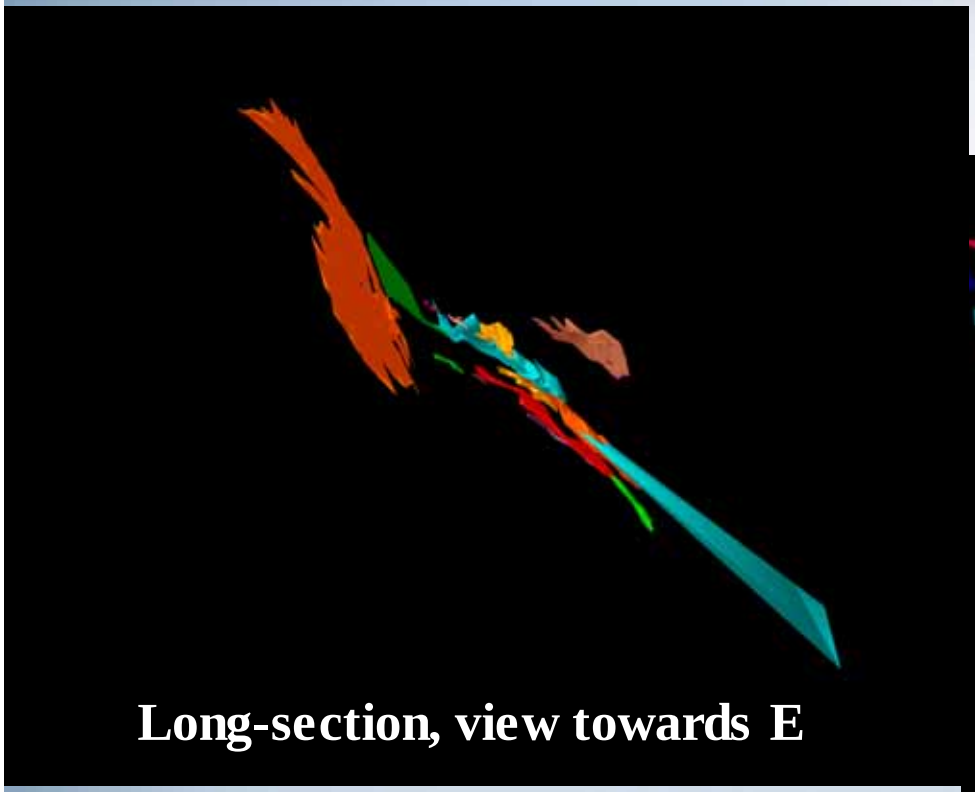
- **Case 3: Local-scale with input data from drilling and mine geology**

  - **Challenges**
    - Few if any marker horizons due to extensive ore-related alteration systems
    - Complex ore transposition pattern
  - **Advantages**
    - Dense drillings for constraints about 3D-geometry

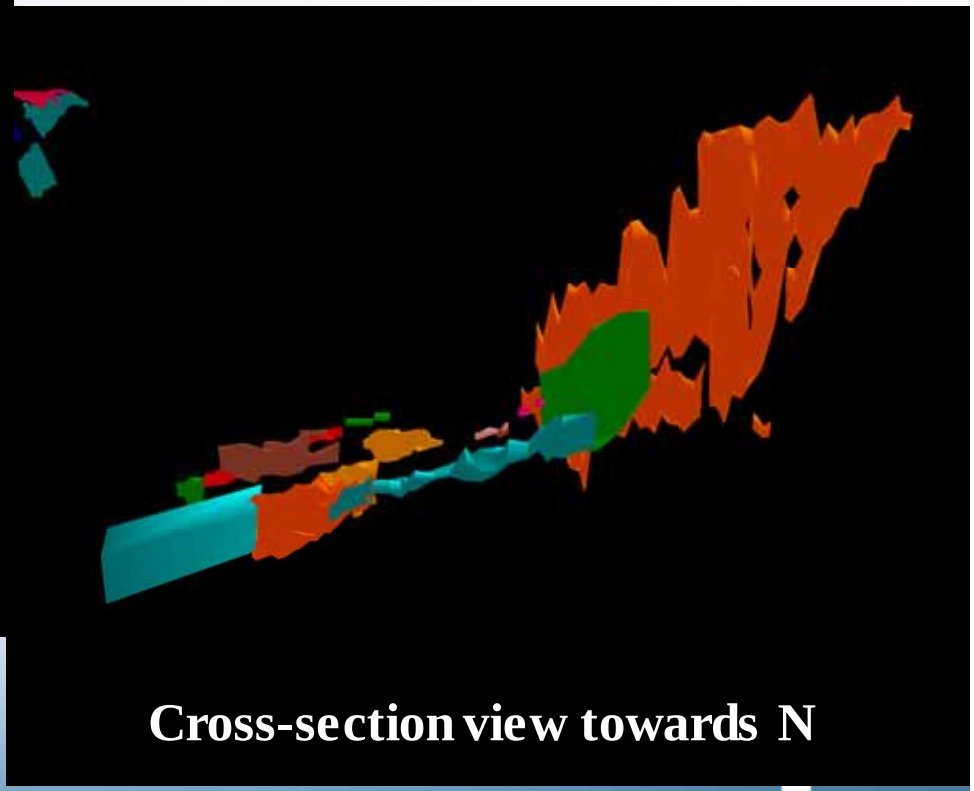
Kristineberg on map



The Kristineberg ore deposit



Long-section, view towards E



Cross-section view towards N

Source data

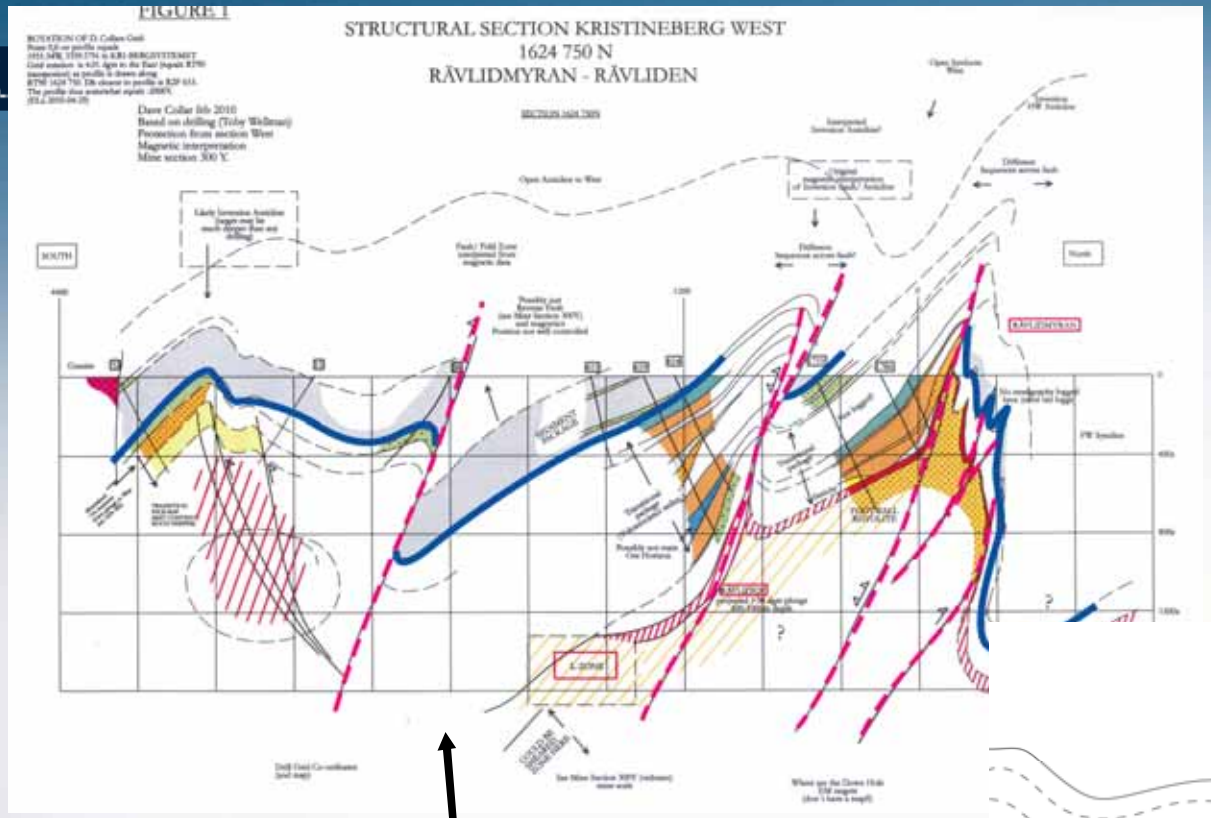
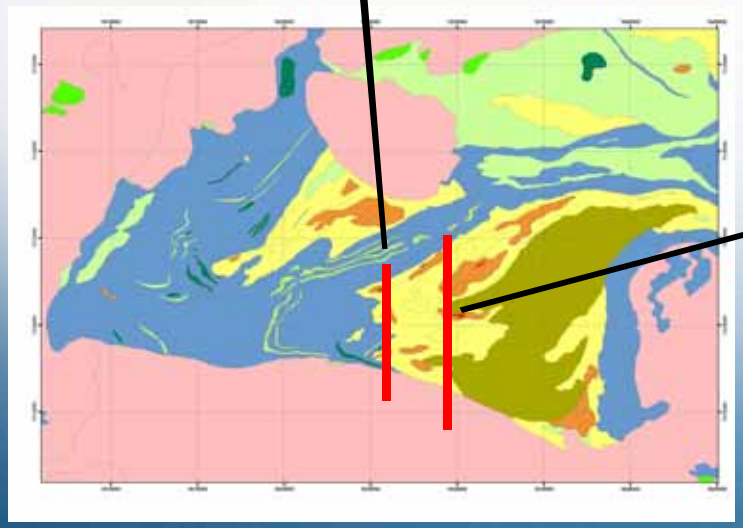
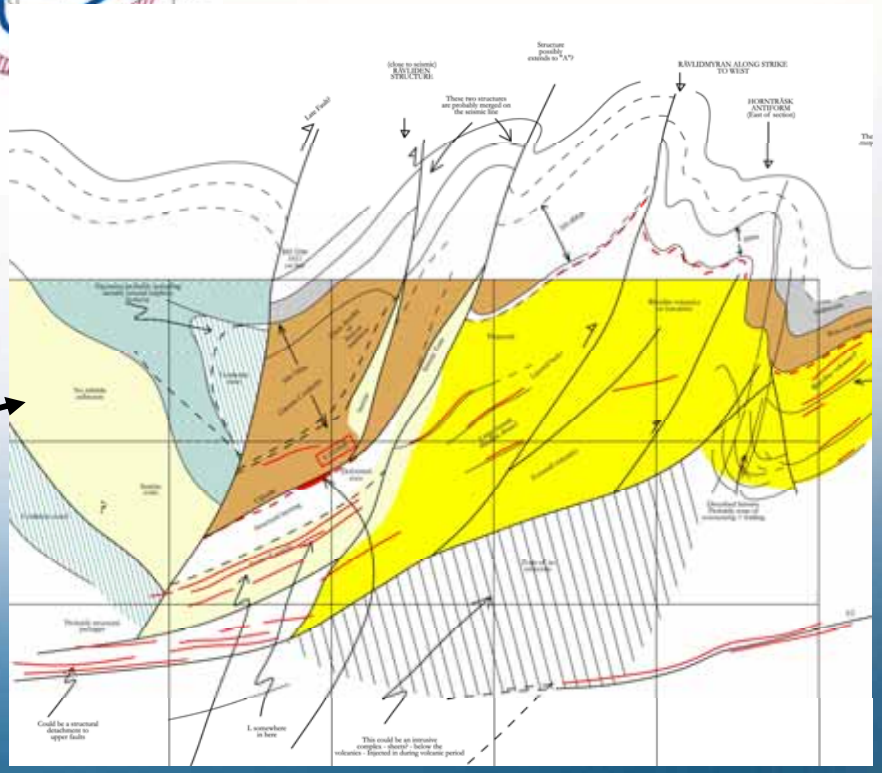
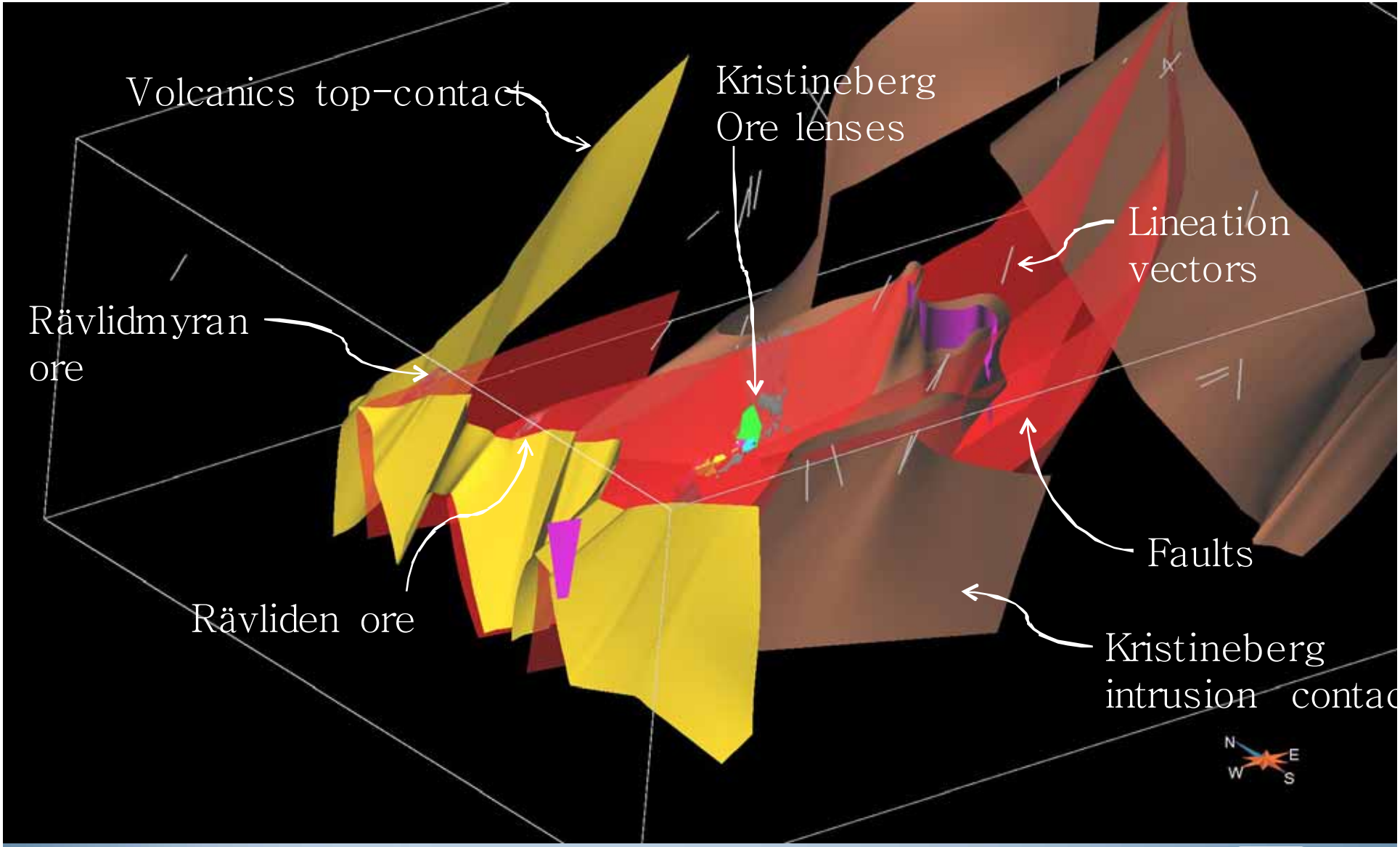


FIGURE 1
STRUCTURAL SECTION KRISTINEBERG WEST
1624 750 N
RÄVLIDMYRAN - RÄVLIDEN
Dave Collar feb 2010
Based on drilling (Toby Wellman)
Projection from section West
Magnetic interpretation
Mine section 300 °E
SOUTH
North
RÄVLIDMYRAN




RÄVLIDMYRAN ALONG STRIKE TO WEST
HORNTRÄSK ANTIFORM (East of section)



A 3D-sketch of the same

- view towards NE

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Outcomes

MODELLING

1) Feedback between the models in different scales and with different types of source data

2) Possibilities in defining deformation styles >> better interpretations on geometry and dynamics

3) Difficulties in quantifying deformation

Thank you!