Towards a 3D model of the Calcari Grigi Carbonate Platform (Early Jurassic, Southern Alps, Italy)*

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Abstract

3D modeling represents a standard procedure in the characterization of large-scale buried geologic bodies. While seismic provides important information about geometries at depth, facies characterization is often less definitive. That is one of the reasons for which outcrop analogues turn out to be useful, although they normally do not match the scale of subsurface bodies.

We present preliminary results in the 3D modeling of the Early Jurassic Calcari Grigi carbonate platform. The platform (size ~100km x 100km, up to 400m thick) consists of several subenvironments (tidal flats, deep lagoons, oolitic shoals), now exhumed in the Southern Alps (Italy), a poorly deformed portion of the Mesozoic passive margin of Adria. Despite some alpine faulting and folding, lateral relationships between Jurassic units are still preserved.

During Early Jurassic, the platform was affected by synsedimentary tectonics, testified by exposed structures, controlling sharp variations in the thickness of its units. Excellent outcrop continuity, extensive geological mapping, and previous studies provide a great wealth of field data that give the opportunity to produce a 3D model of a seismic-scale carbonate platform. Data were collected in a GIS database and were fed into geomodeling software.

Main stratigraphic horizons and geometries of the sedimentary prisms were modeled and lateral continuity of extensional faults estimated. This permits us to have a synthesis-picture of how synsedimentary tectonics governed the depositional processes. Spatial variability of thickness values collected in various localities was studied with geostatistics. This helped us highlight the main Jurassic faults and revealed an extensive orthorhombic fault network. The 3D model can now be populated with facies and other sedimentological and petrophysical parameters to evaluate the influence of tectonics on the depositional and diagenetic environments.

The model of a carbonate platform of this size potentially represents a useful analogue for carbonate reservoirs and could help in the understanding of similar buried sedimentary bodies.

Selected References

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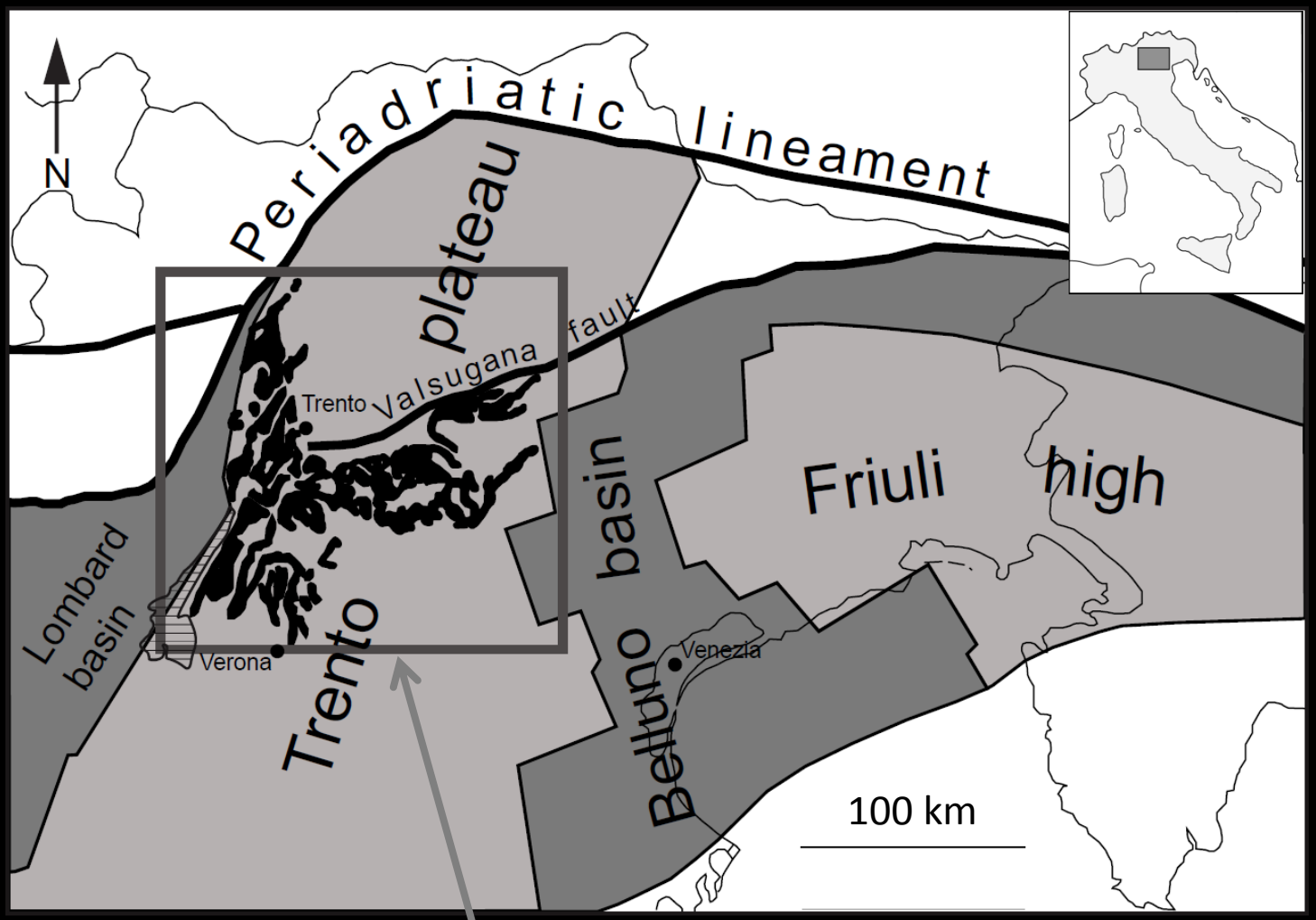
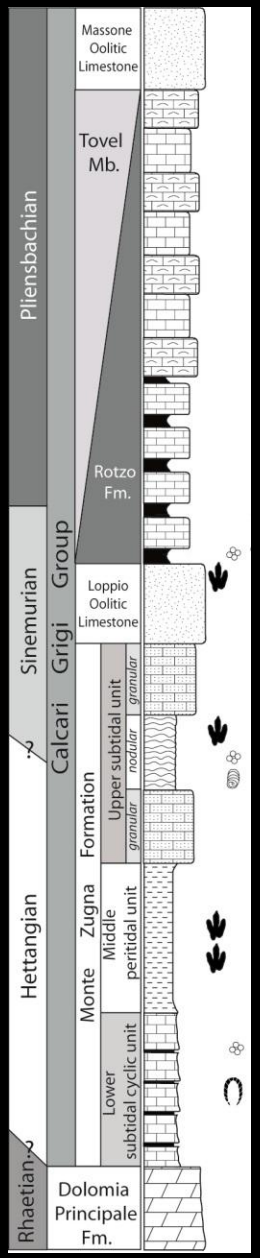
Marie Curie Actions - COFUND

Geographical setting and main Early Jurassic paleogeographic domains



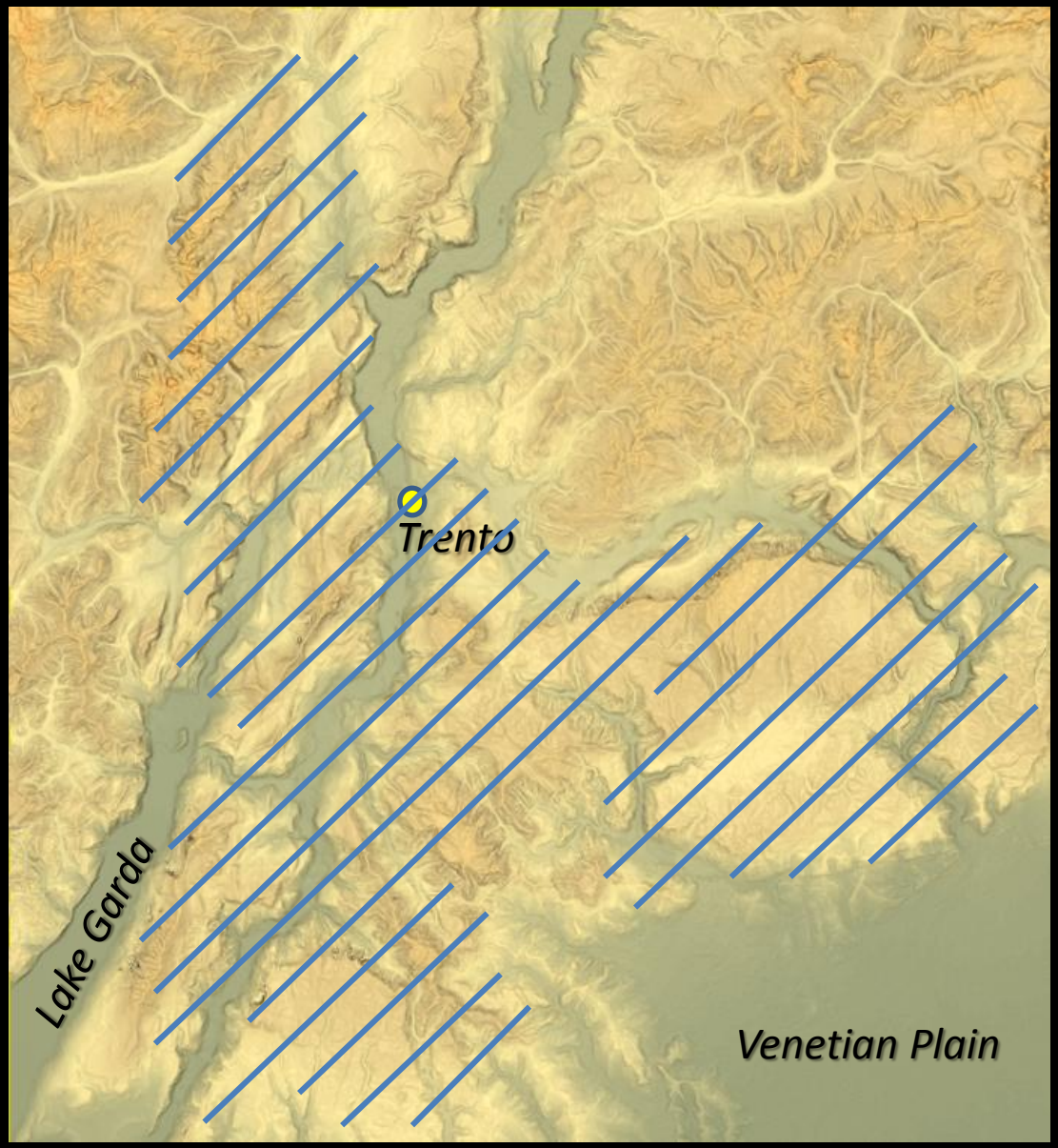


modified from Avanzini et al., 2006

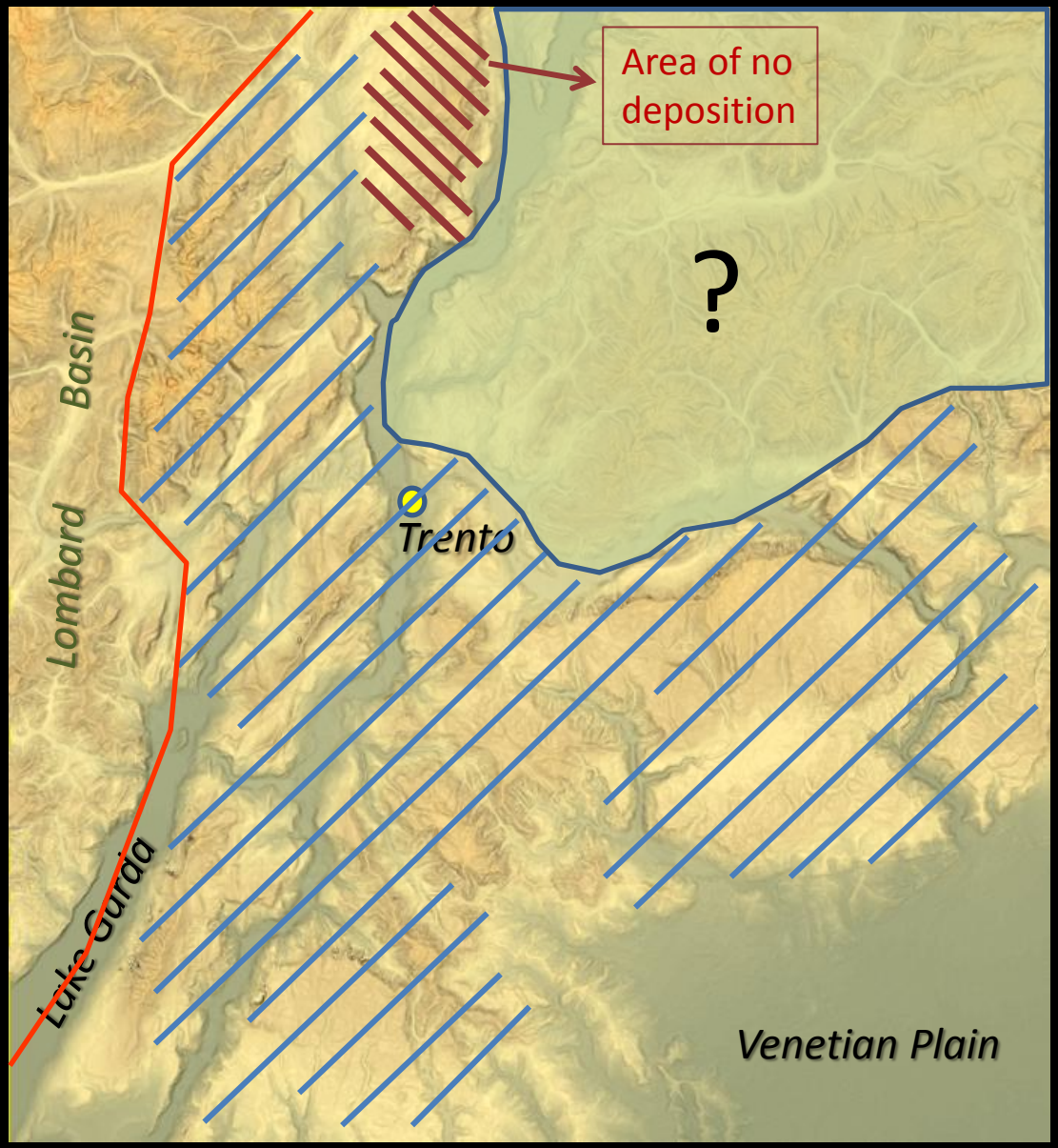
The Calcari Grigi platform consists of several facies associations--expression of shallow water subenvironments (tidal flats, deep lagoons, oolitic shoals)

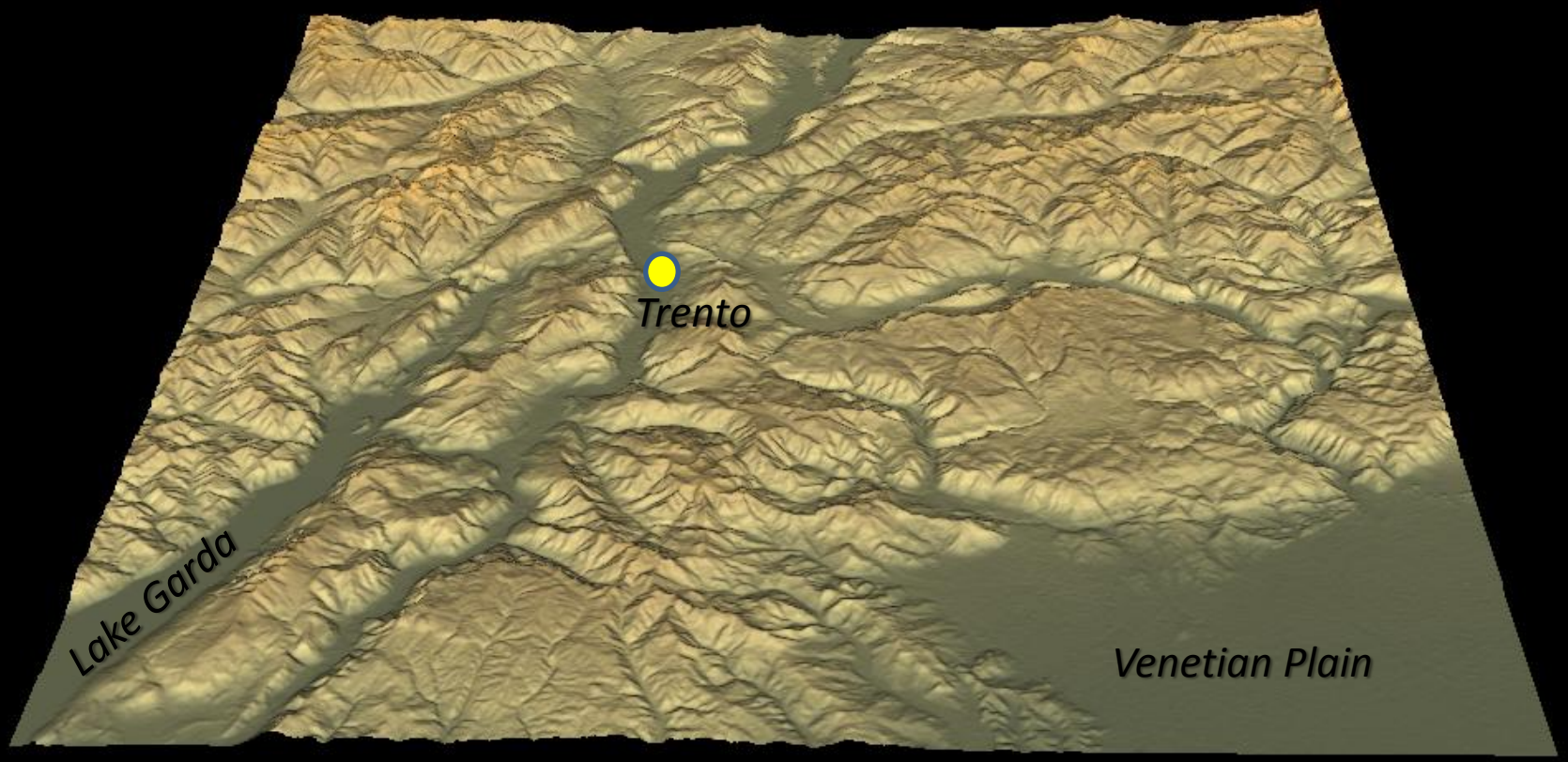
elaboration from NASA-JPL SRTM

Outcropping area of the Calcari Grigi platform



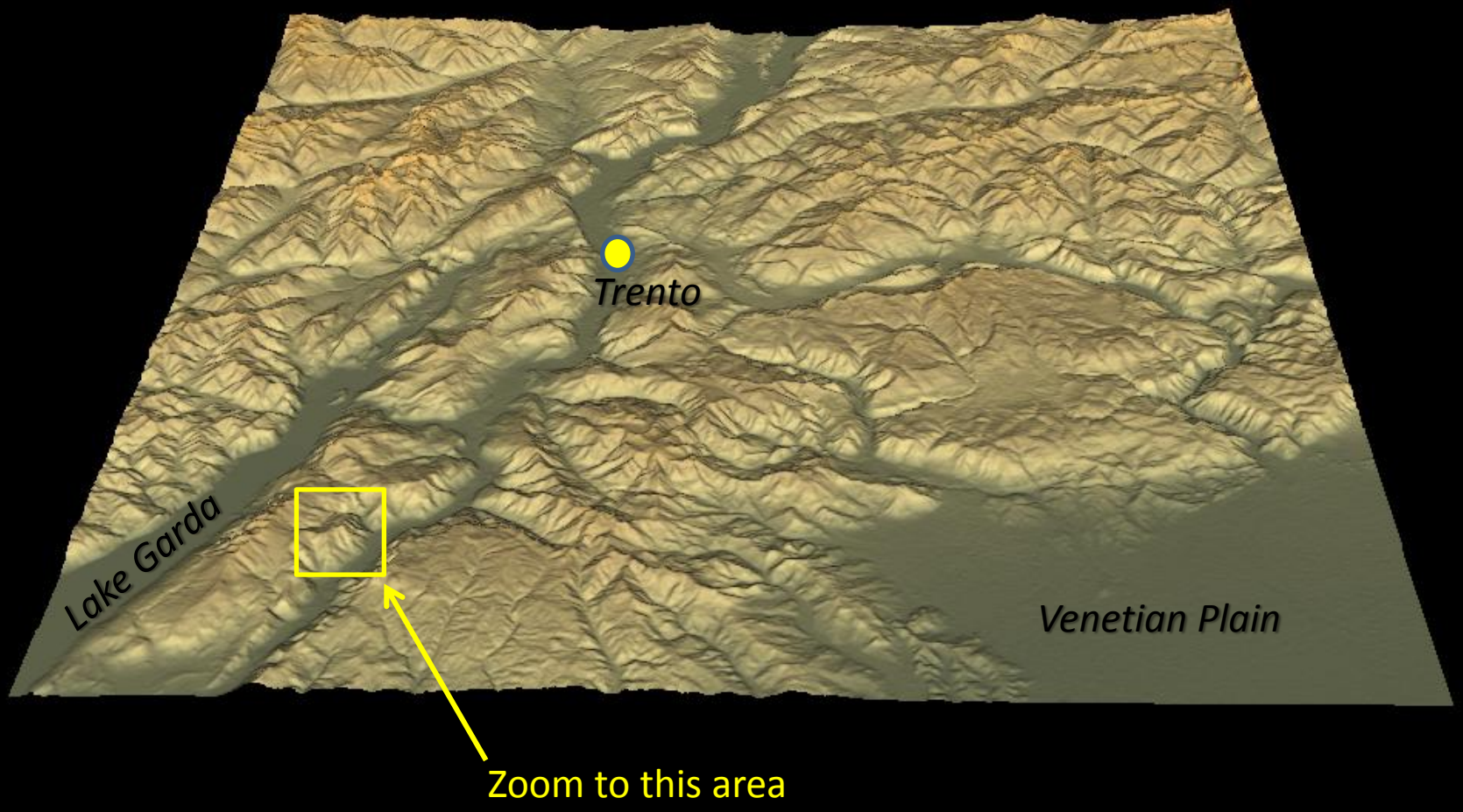
Outcropping area of the Calcari Grigi platform



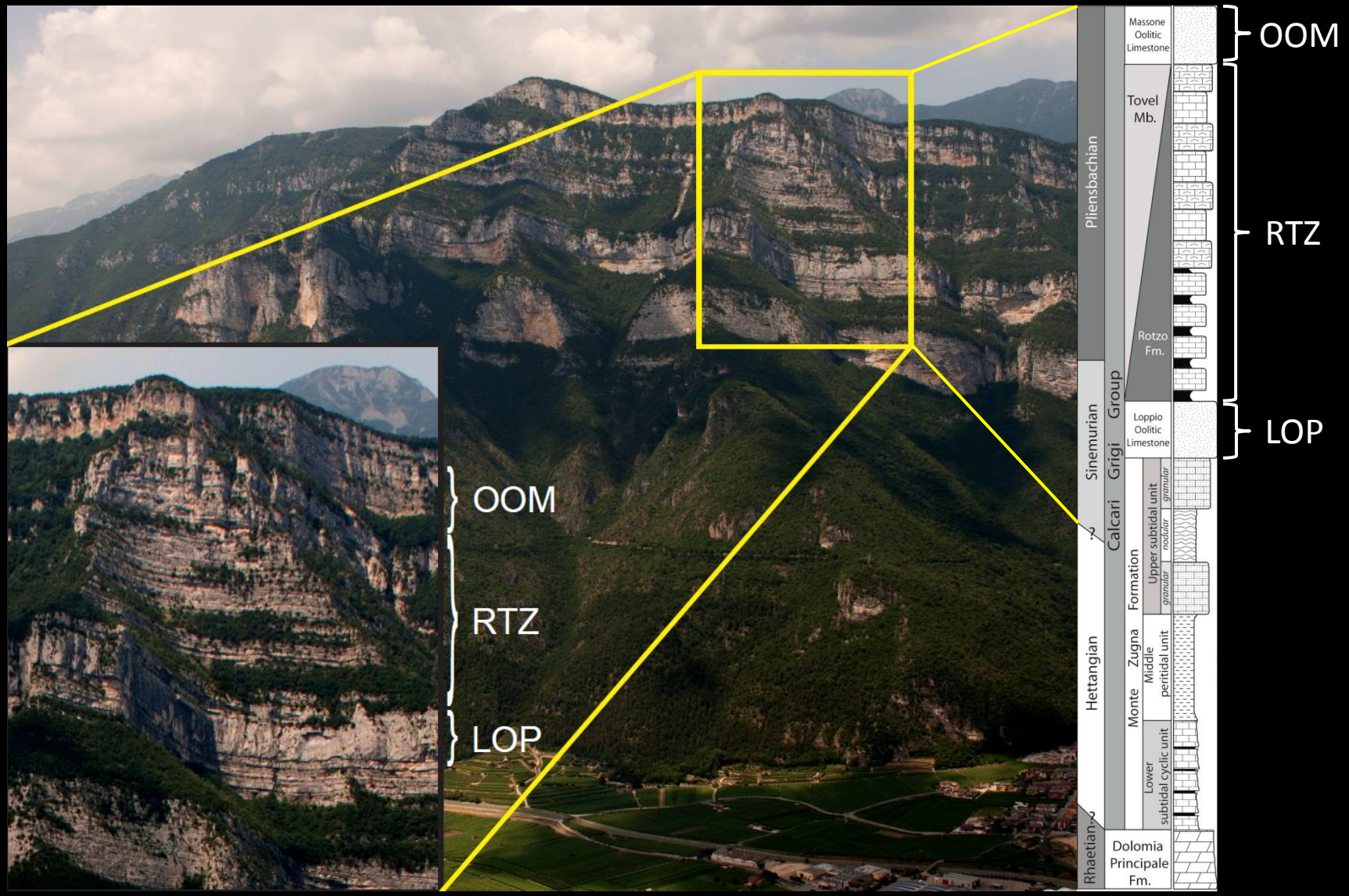


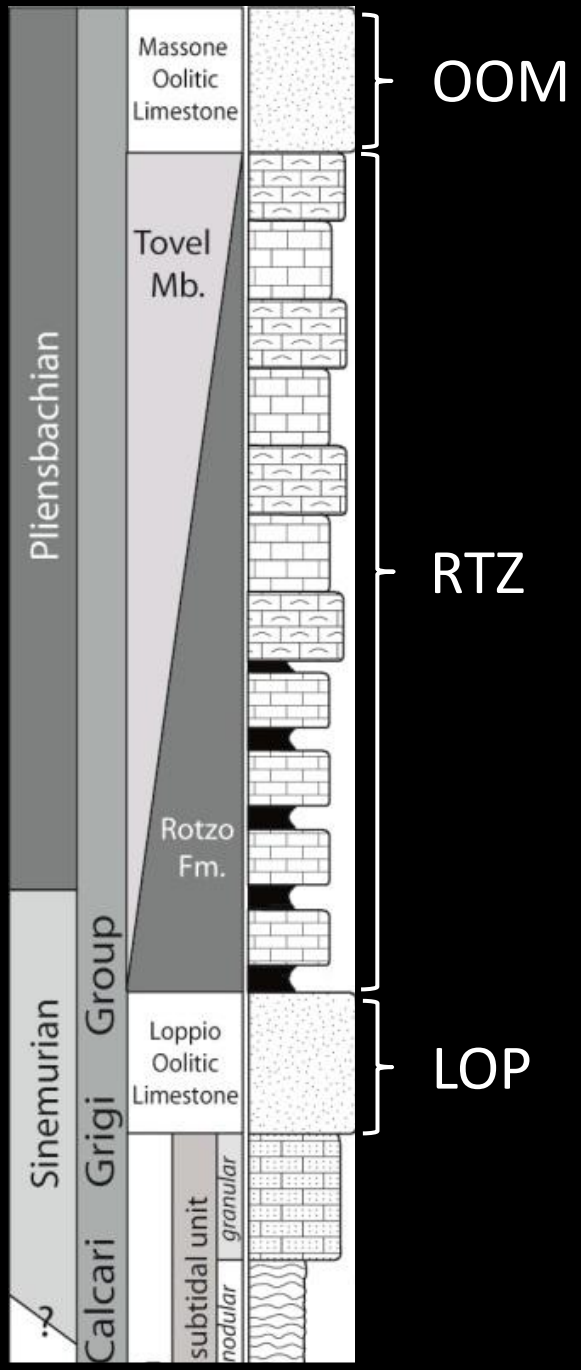
3D modeling realized using Paradigm SKUA[R]

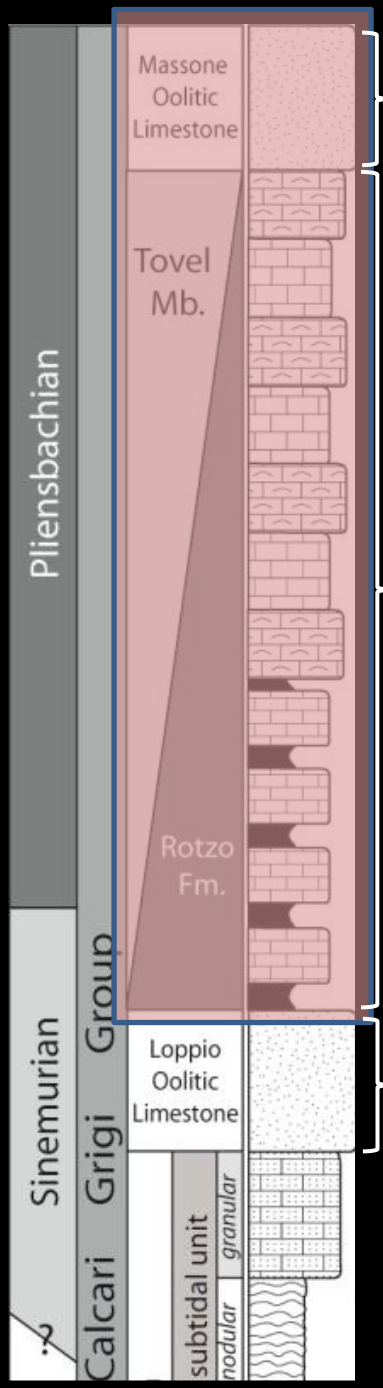
How do the Calcari Grigi look like in outcrop?



Calcari Grigi outcropping along the Adige river valley




Pliensbachian
Sinemurian
Calcari Grigi Group
Massone Oolitic Limestone
Tovel Mb.
Rotzo Fm.
Loppio Oolitic Limestone
subtidal unit
granular
nodular
OOM
RTZ
LOP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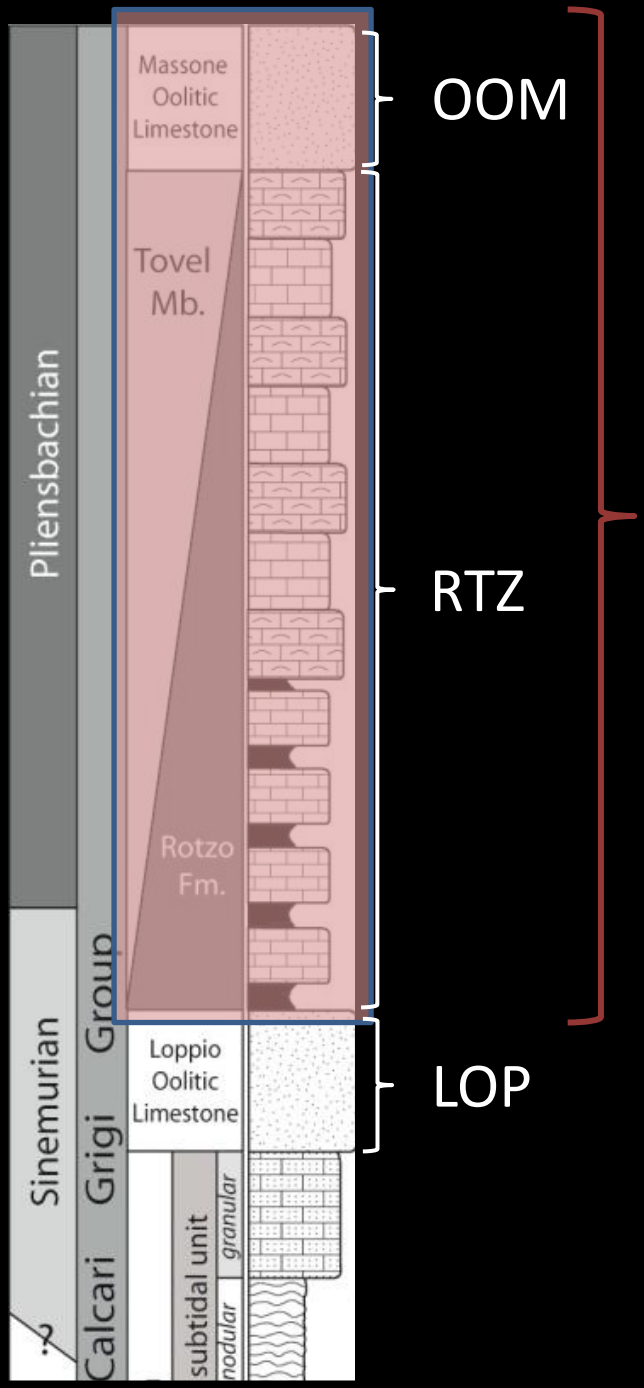
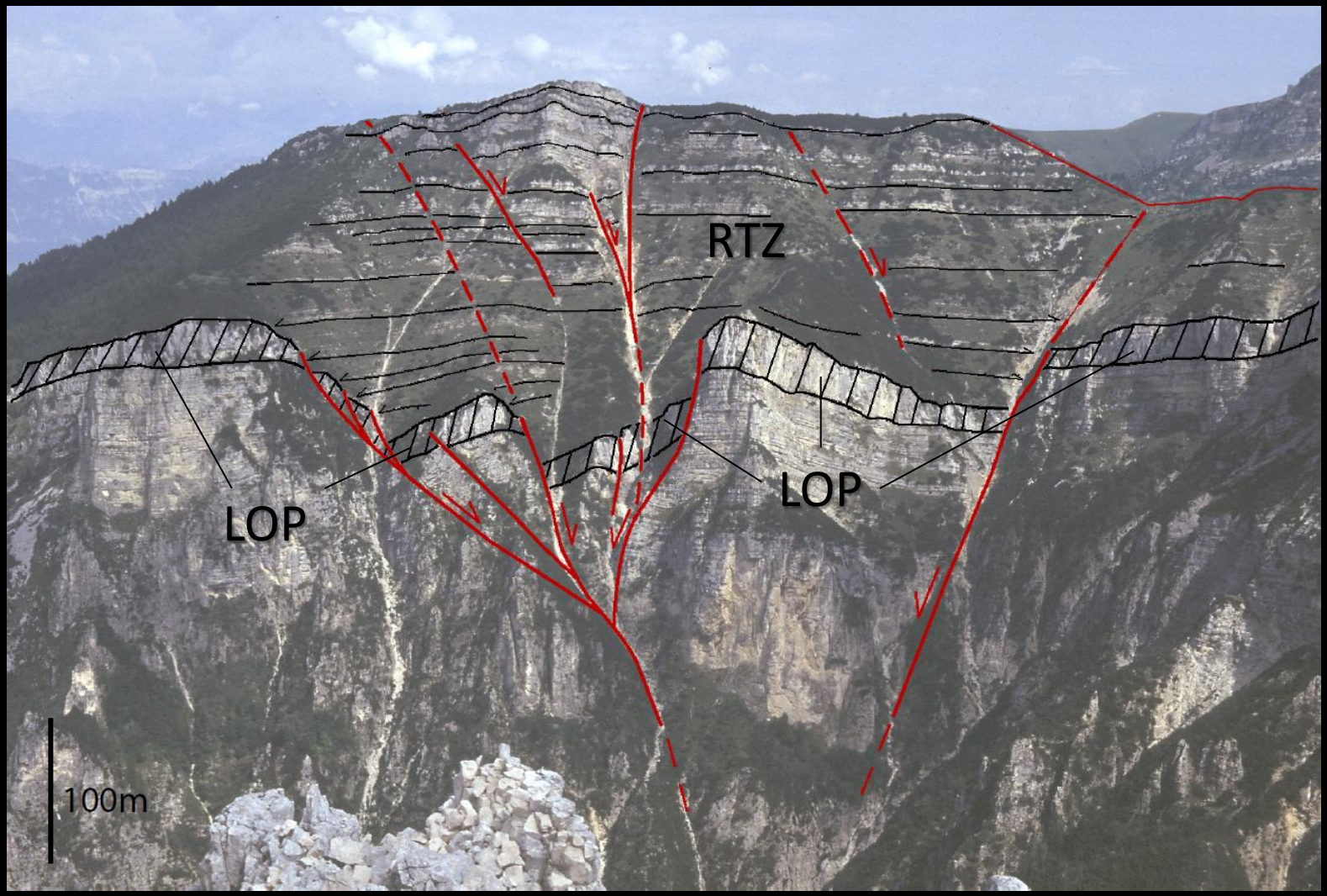


These units display major changes in thickness

Thickness variations linked to synsedimentary tectonics

synsedimentary structure at Monte Testo

Thickness variations linked to synsedimentary tectonics

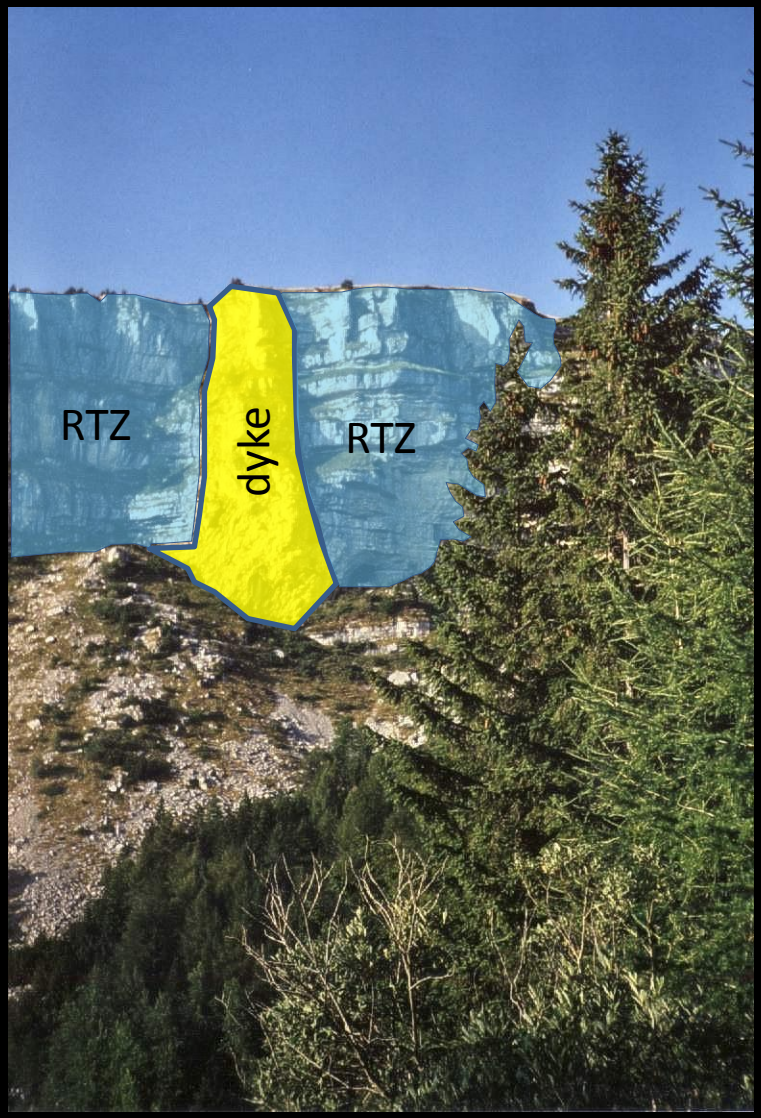


synsedimentary structure at Monte Testo

Other evidences of syndepositional tectonics

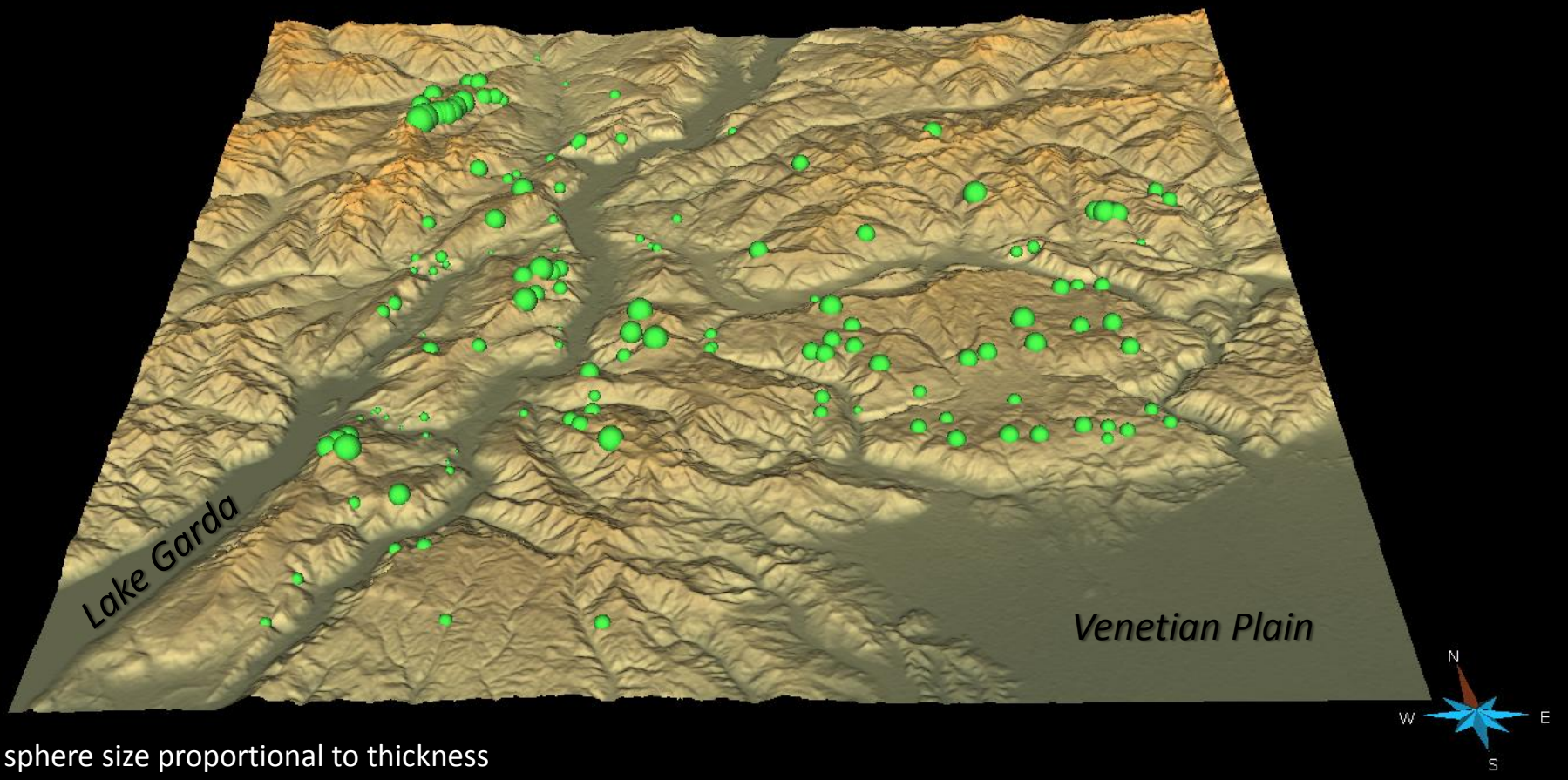
sedimentary dyke at Monte Pasubio

Other evidences of syndepositional tectonics



sedimentary dyke at Monte Pasubio

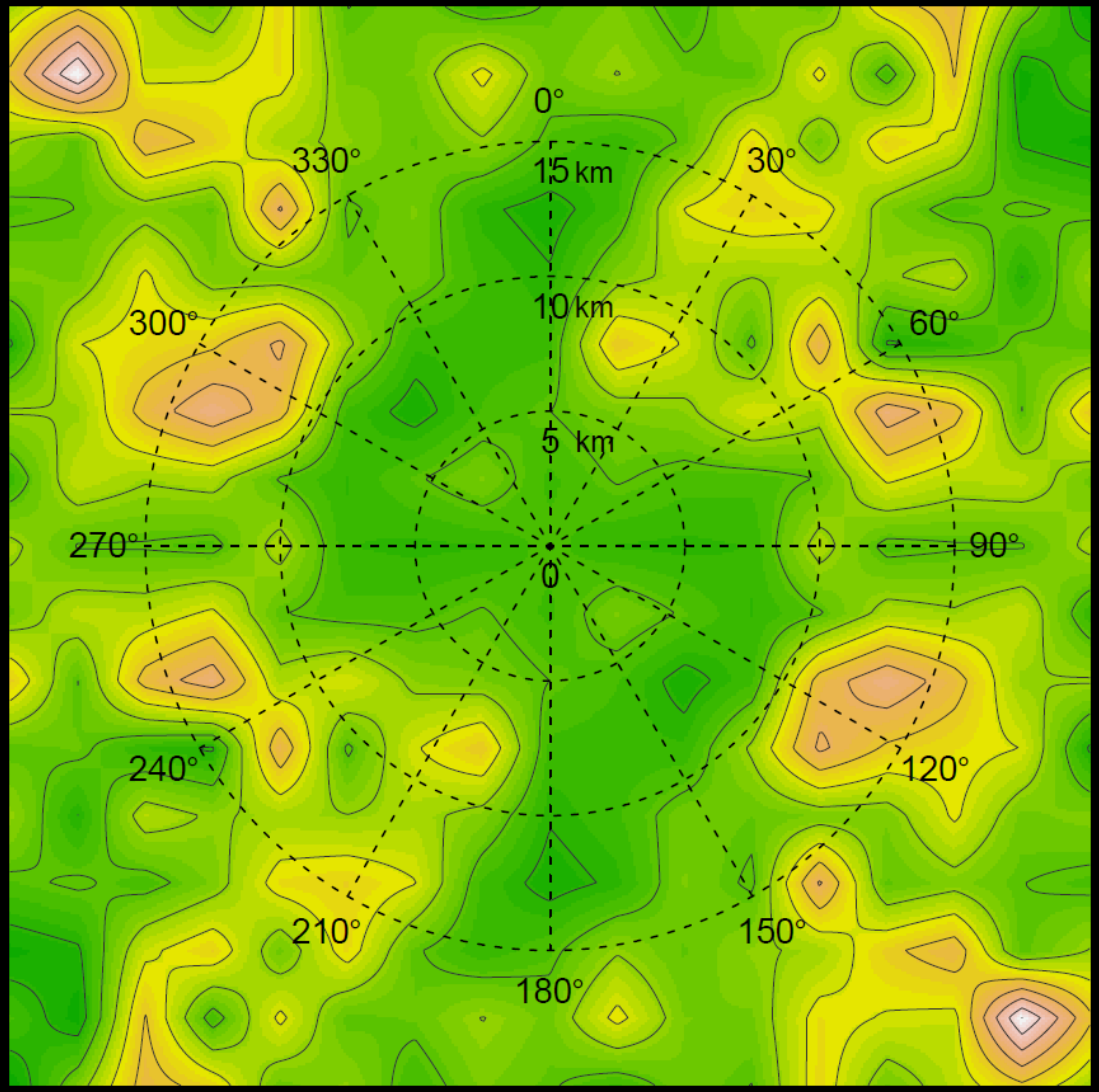
Thickness data collected in various parts of the platform



sphere size proportional to thickness

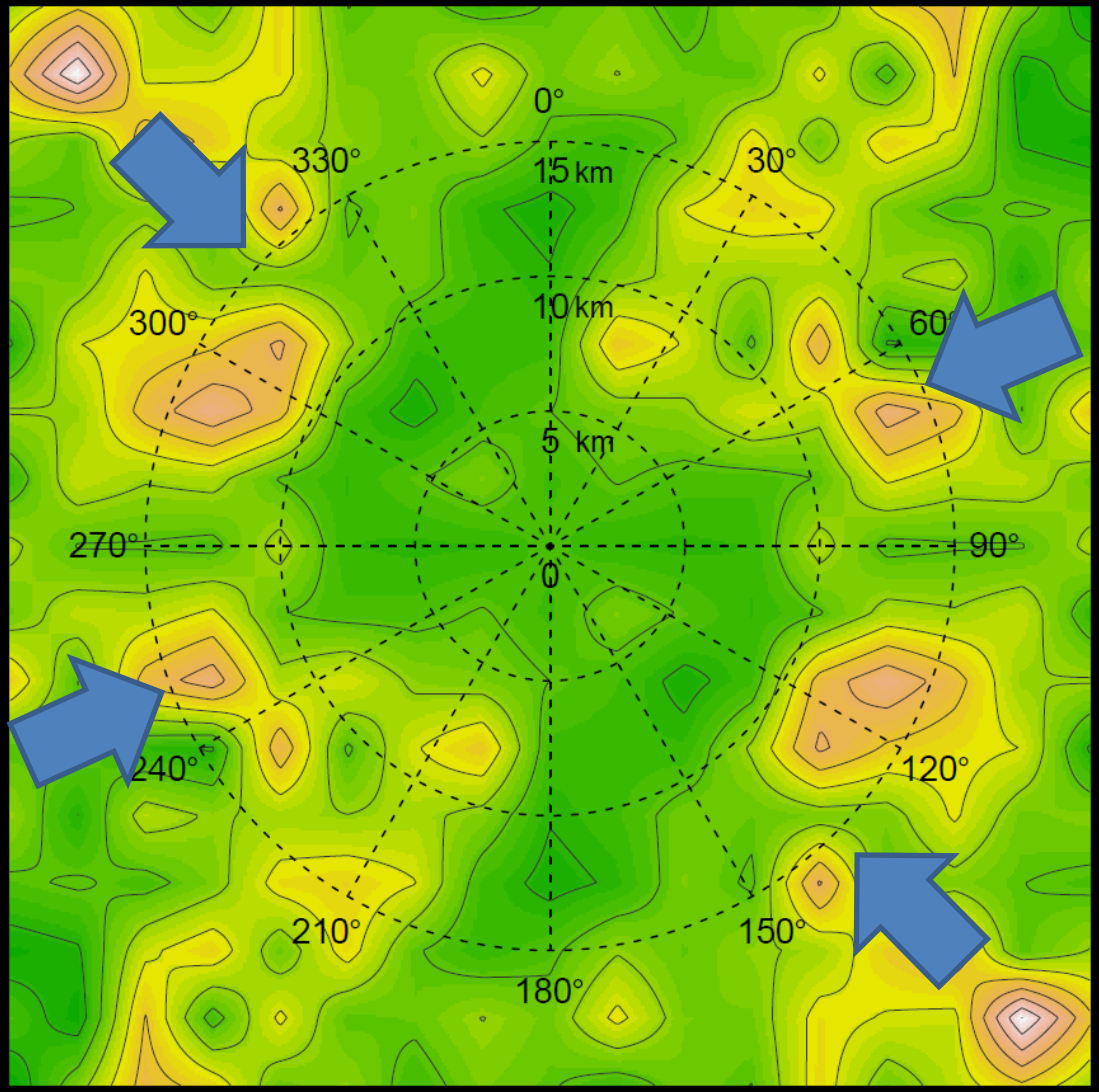
Variogram map of thickness values

Useful to enhance spatial anisotropy in the dataset

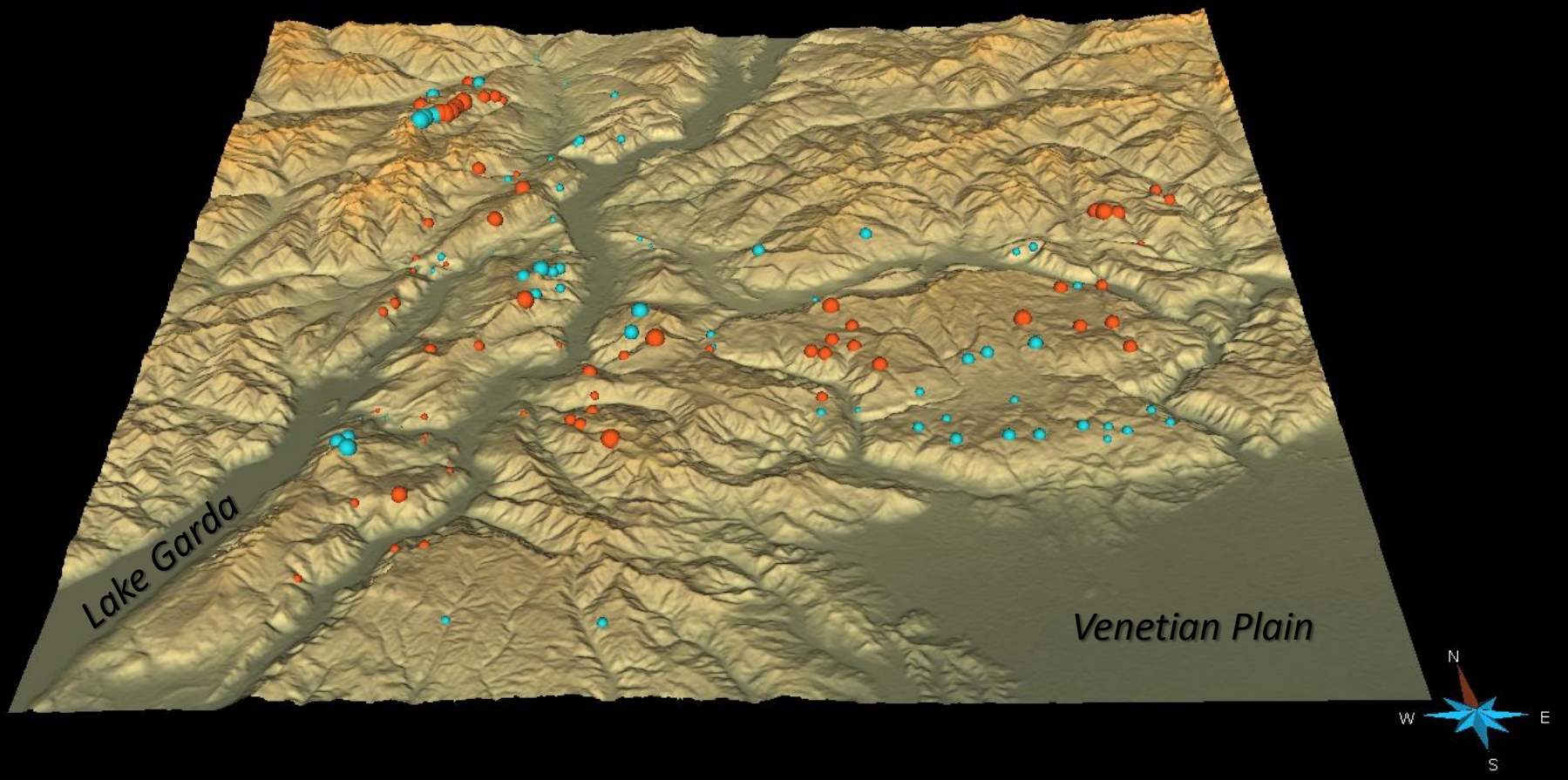


Variogram map of thickness values

Variogram map highlights two principal directions of variance in the thickness dataset



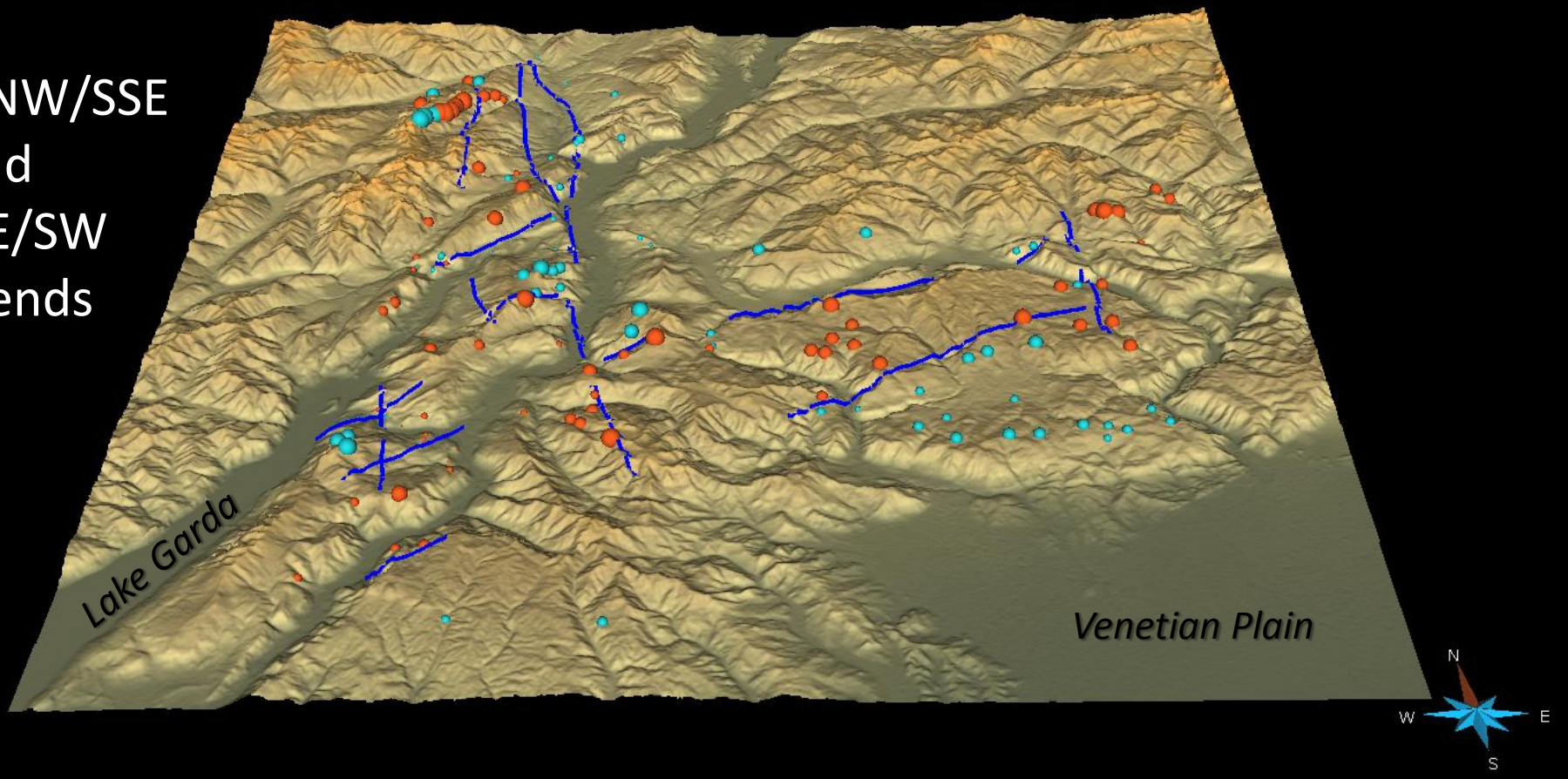
Residuals after linear detrending of thickness values



Red = positive residuals Blue = negative residuals

Change in sign in the residuals defines alignments with trends consistent with the directions identified by variogram maps

NNW/SSE and NE/SW trends



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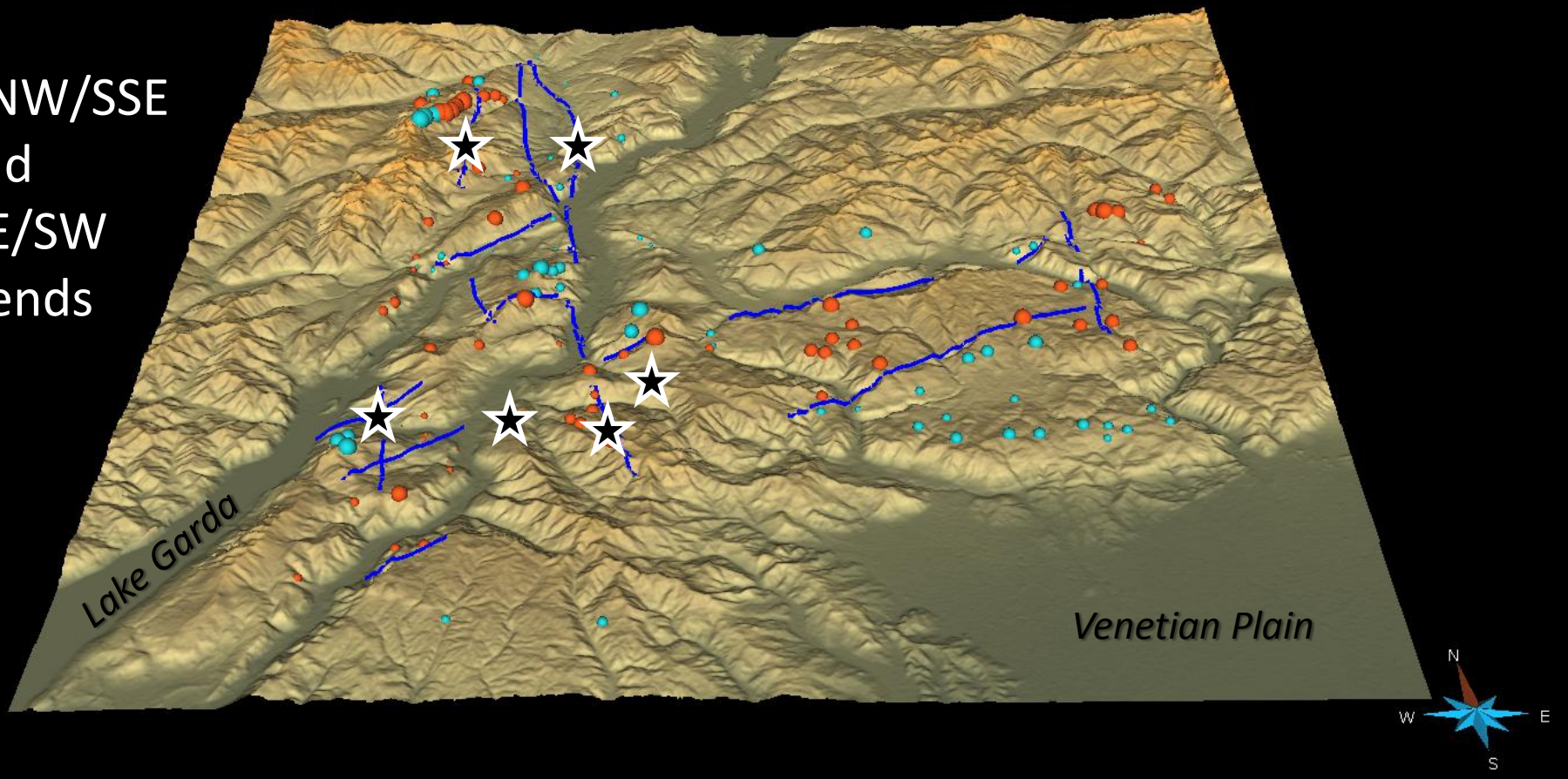
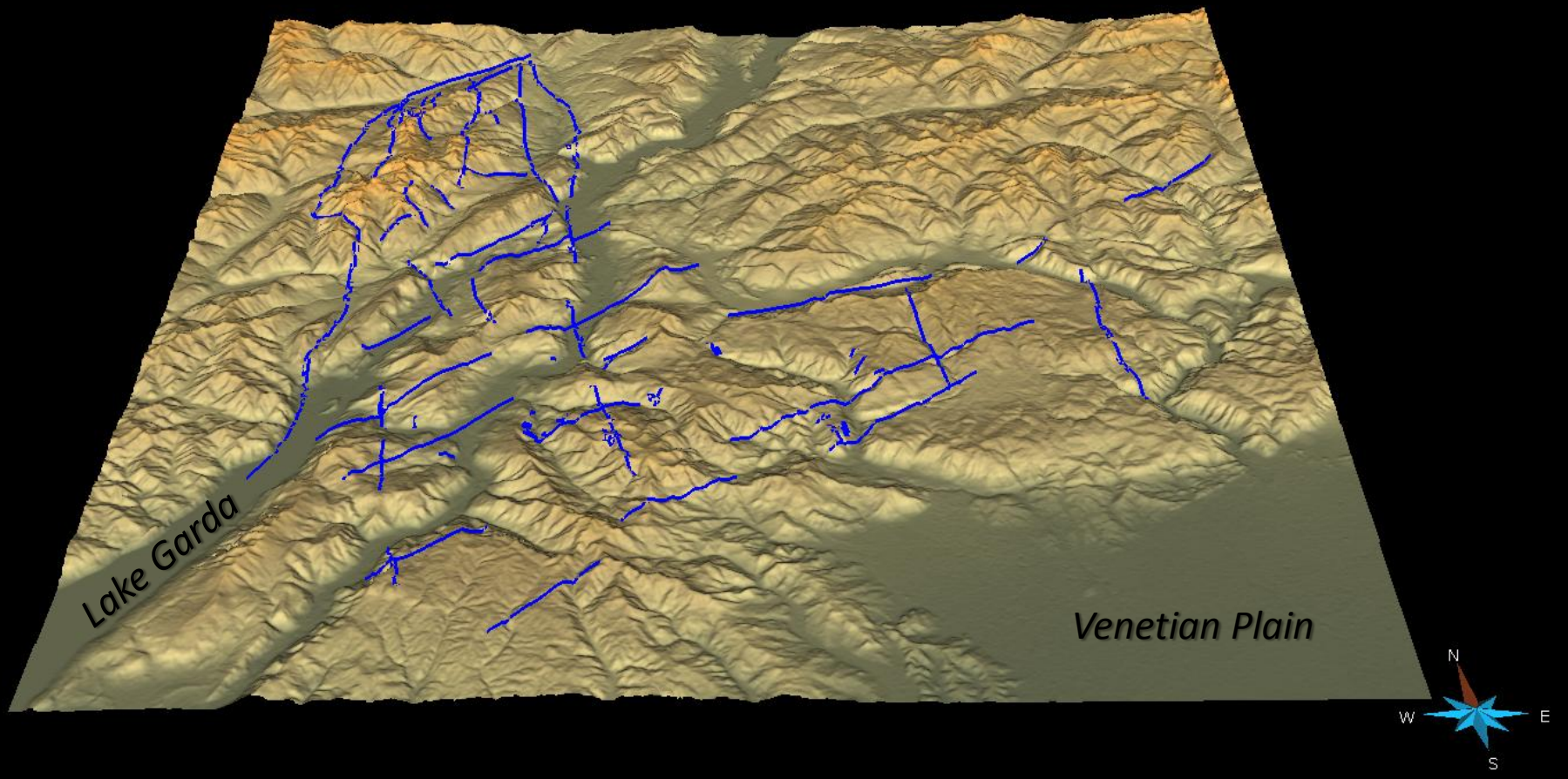


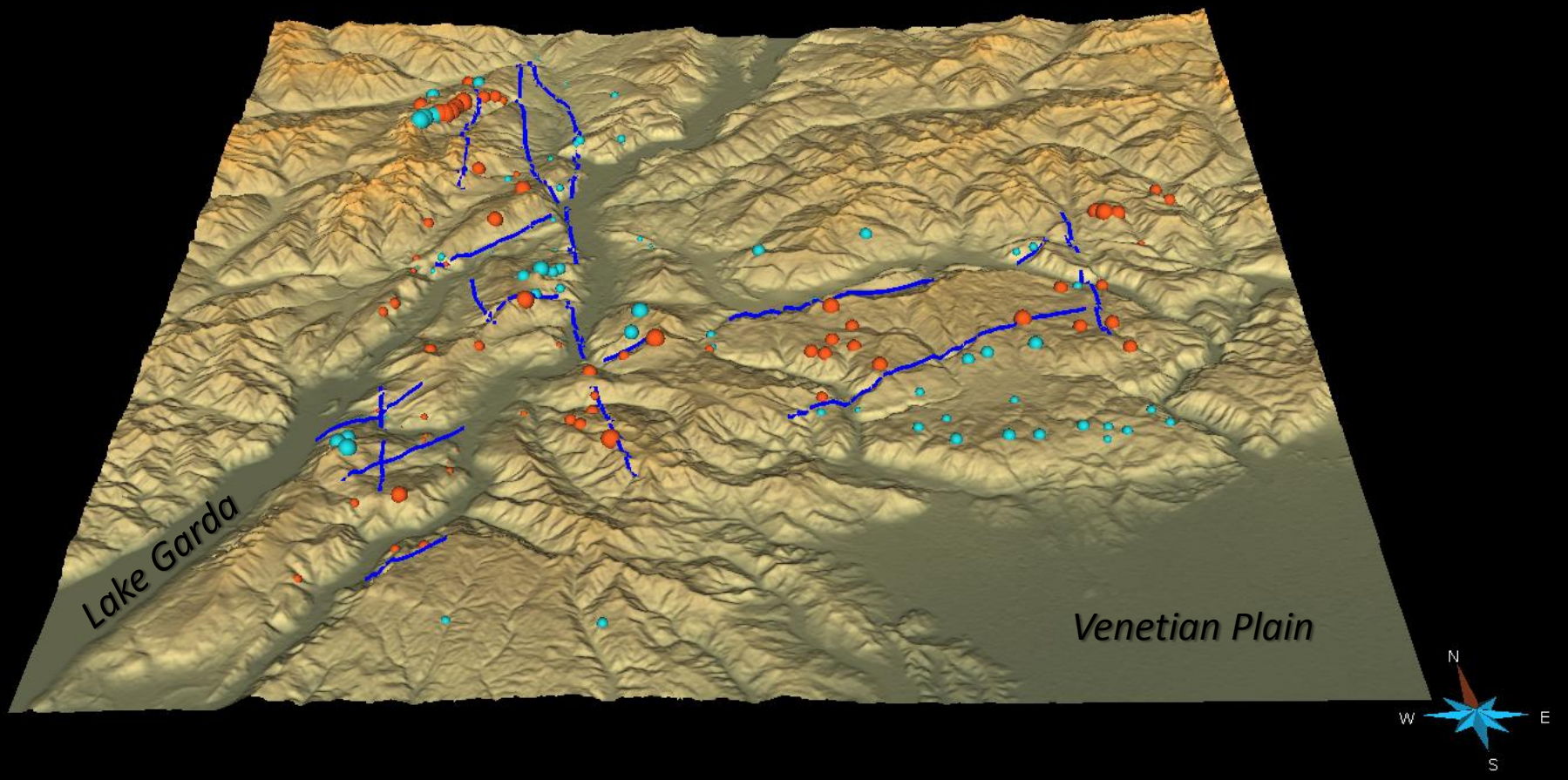
Moreover: synsedimentary structures (stars) with consistent kinematics have been found along the identified fault belts

Putting together field data and spatial-analysis results, it is possible to propose a reconstruction of the Early Jurassic fault network



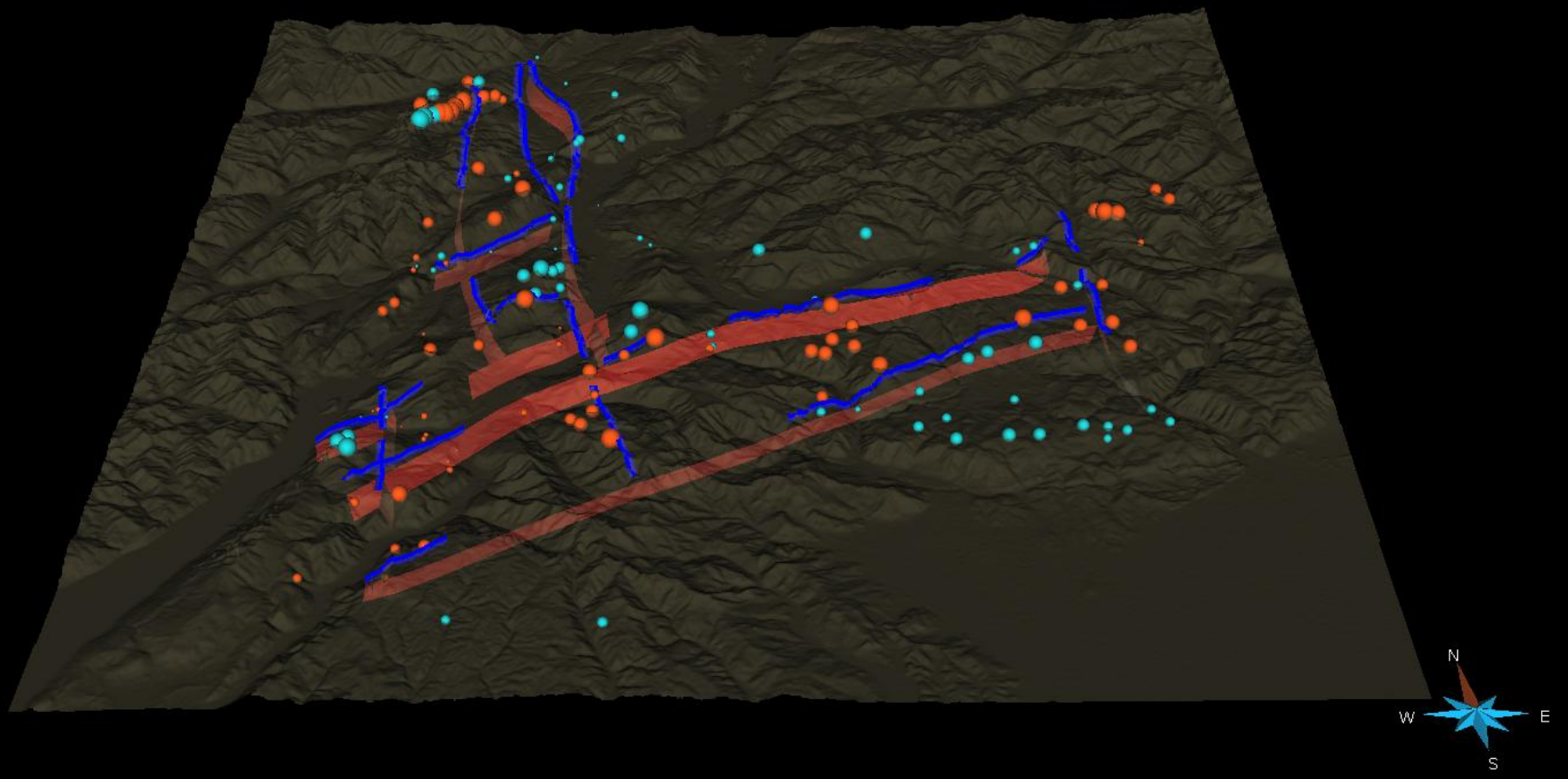
Early Jurassic fault network

Modeling faults



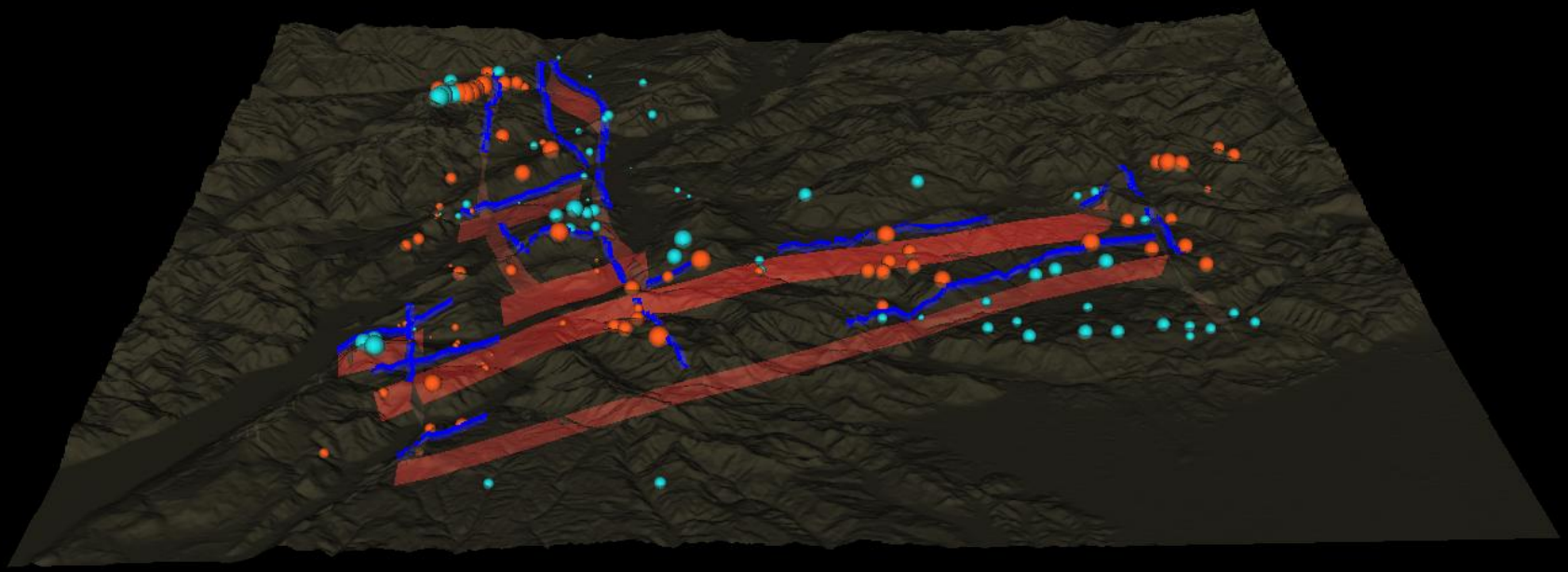
Paradigm SKUA[R]

Modeling faults



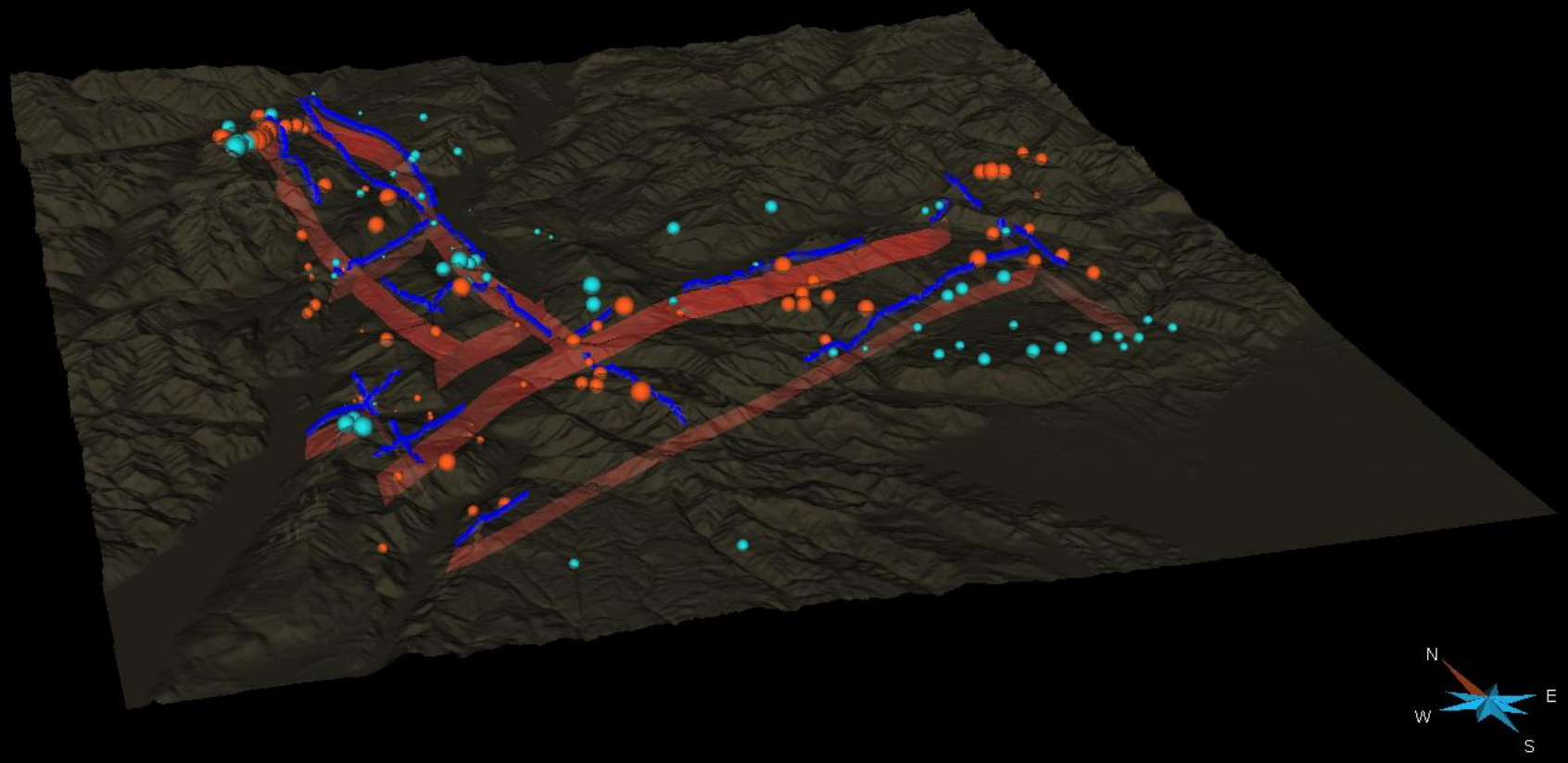
Paradigm SKUA[R]

Modeling faults



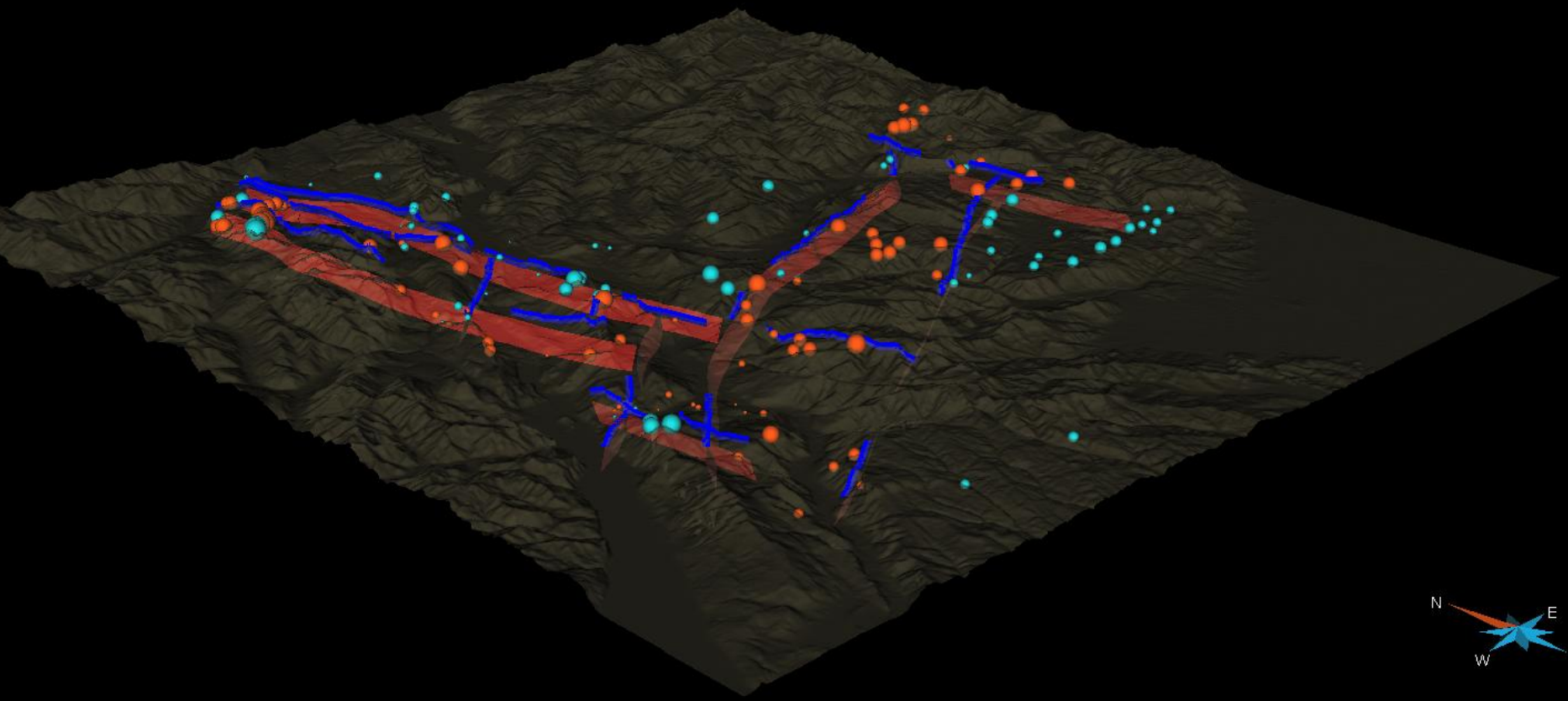
Paradigm SKUA[R]

Modeling faults



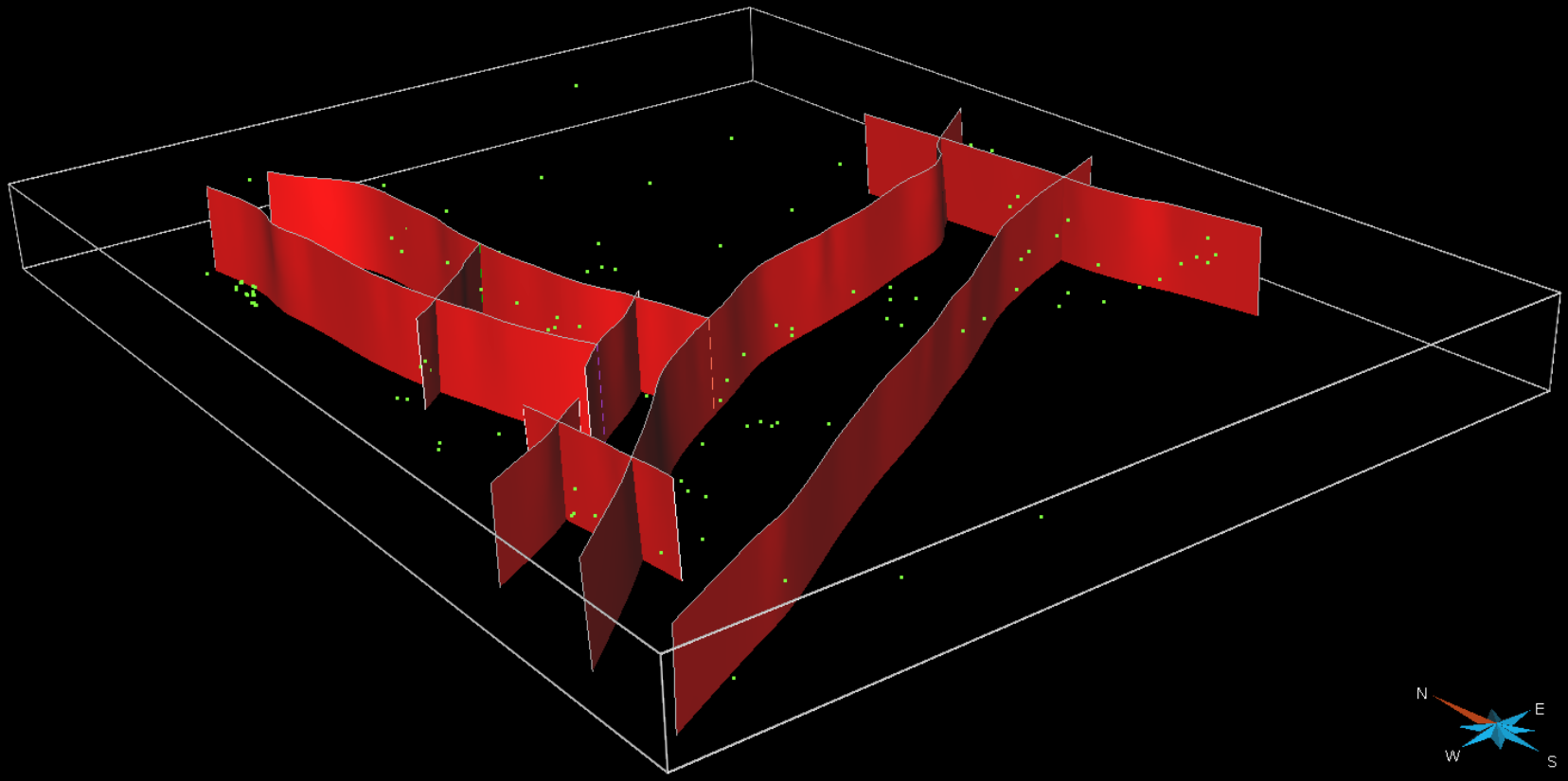
Paradigm SKUA[R]

Modeling faults



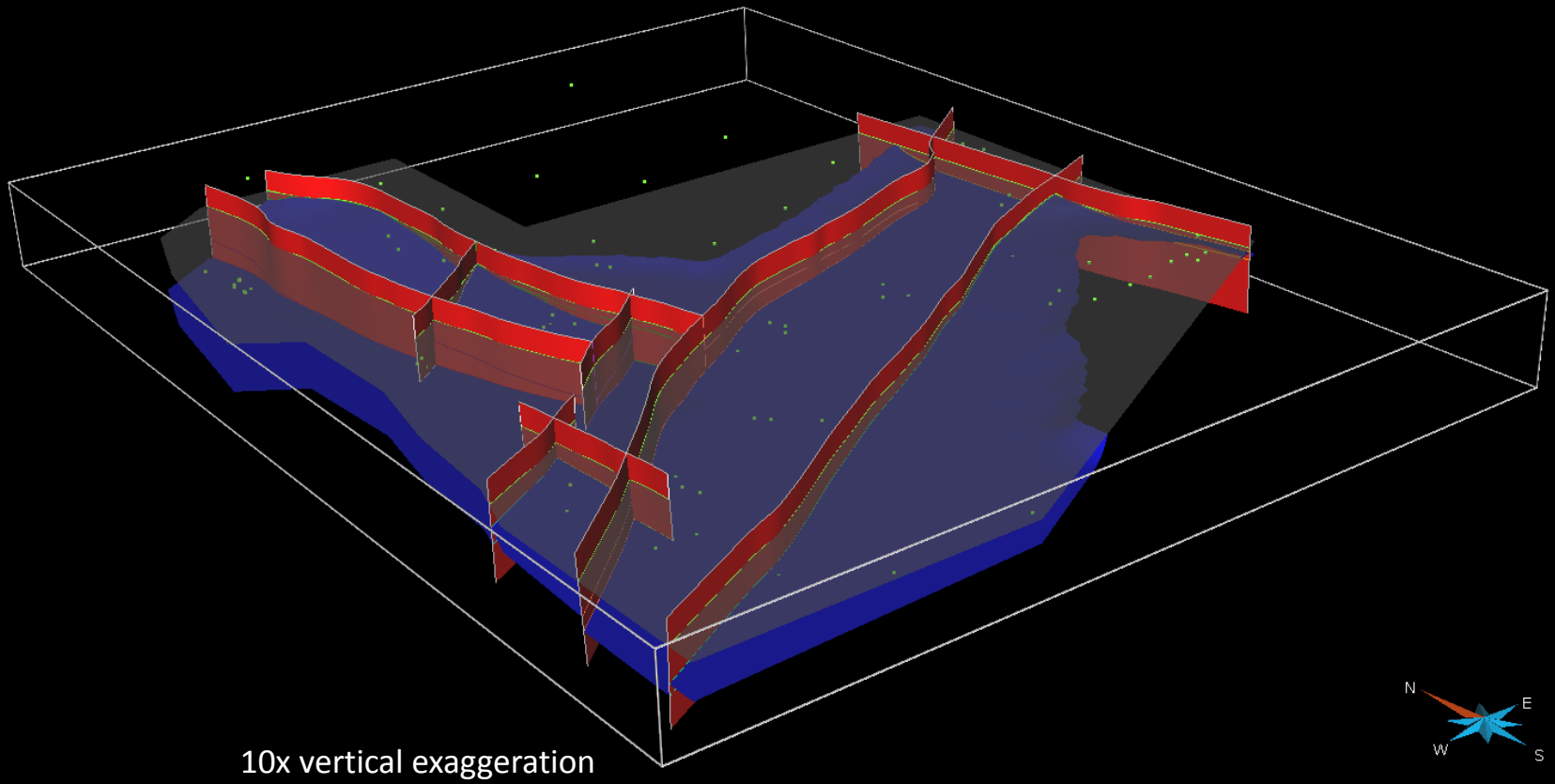
Paradigm SKUA[R]

Modeling horizons



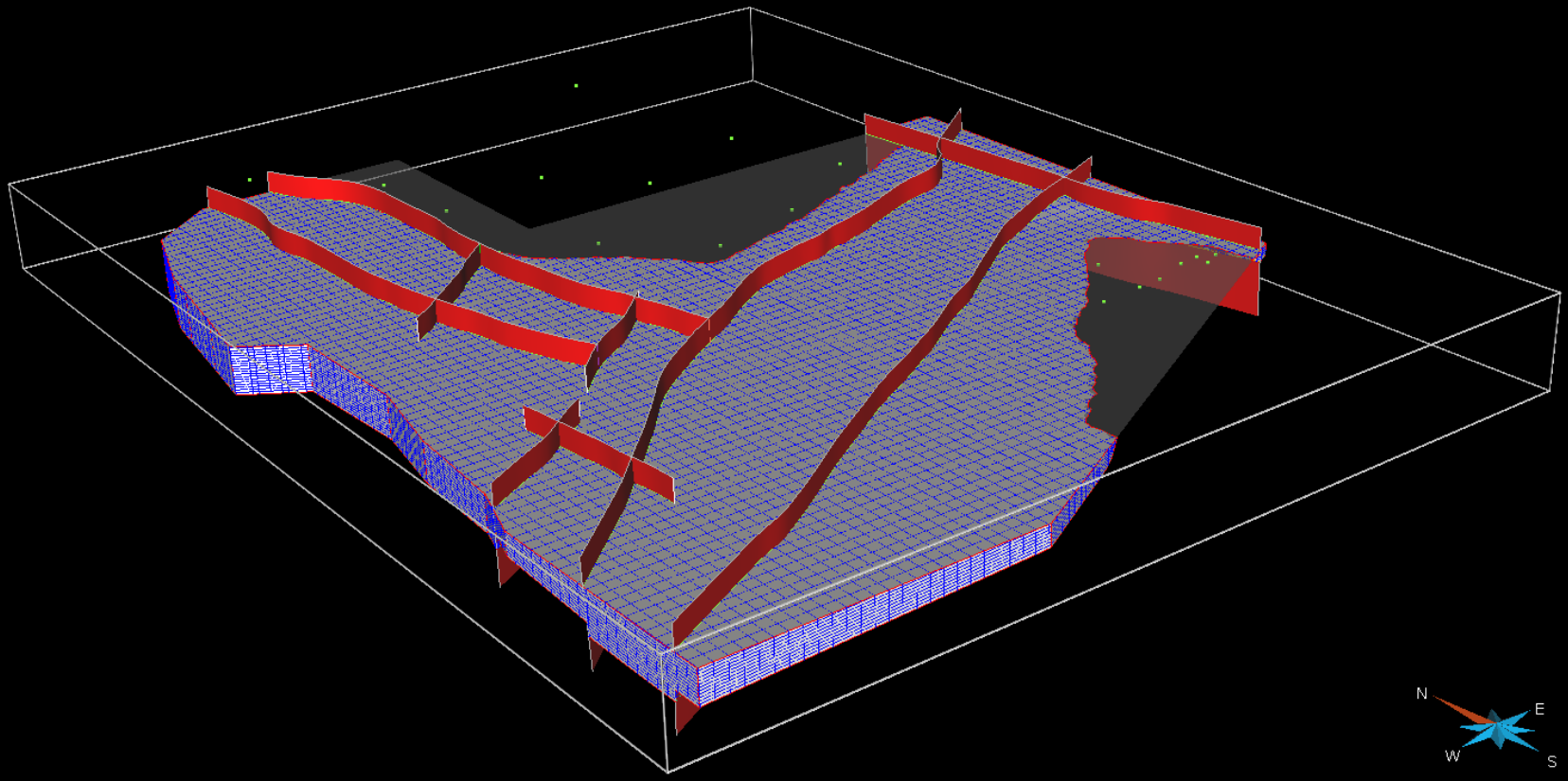
Paradigm SKUA[R]

Modeling horizons



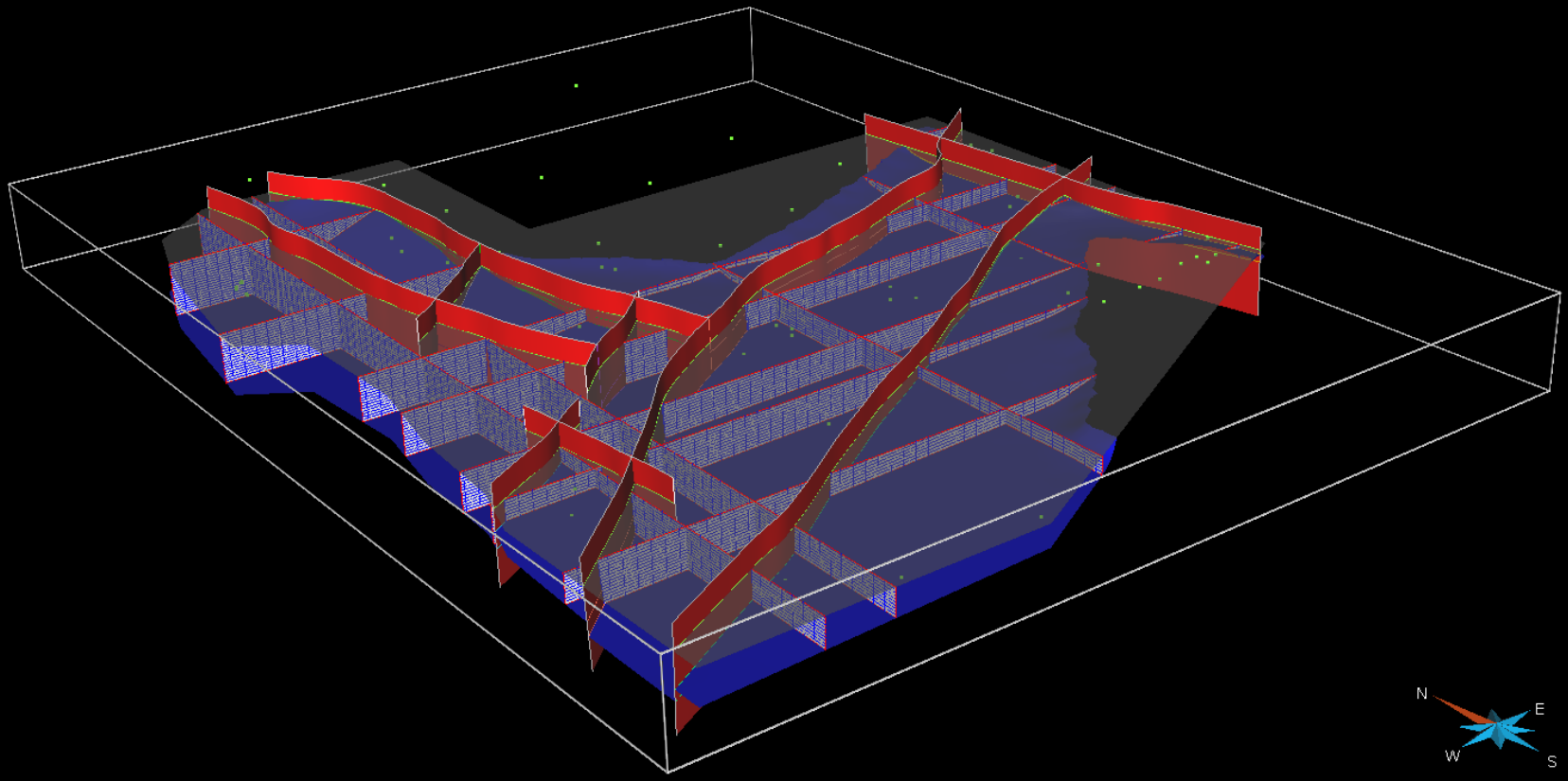
10x vertical exaggeration

Building the geologic grid



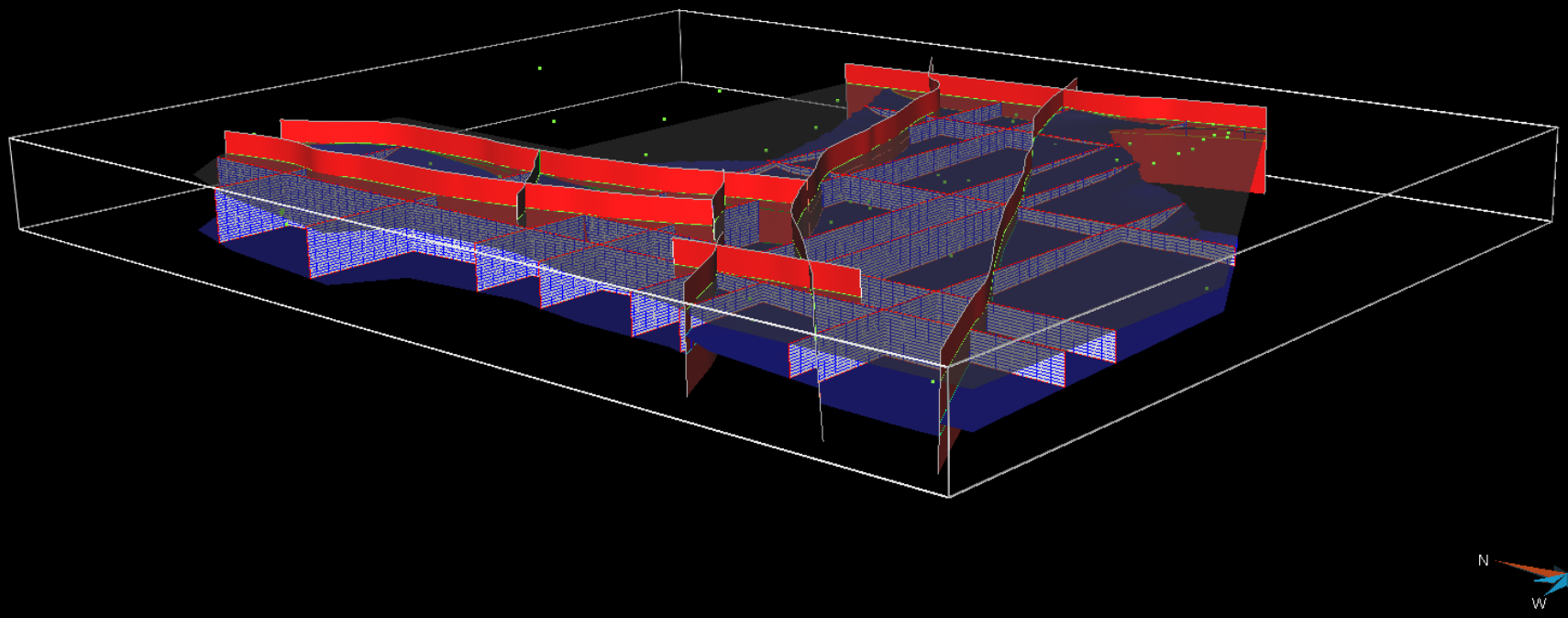
Paradigm SKUA[R]

Building the geologic grid



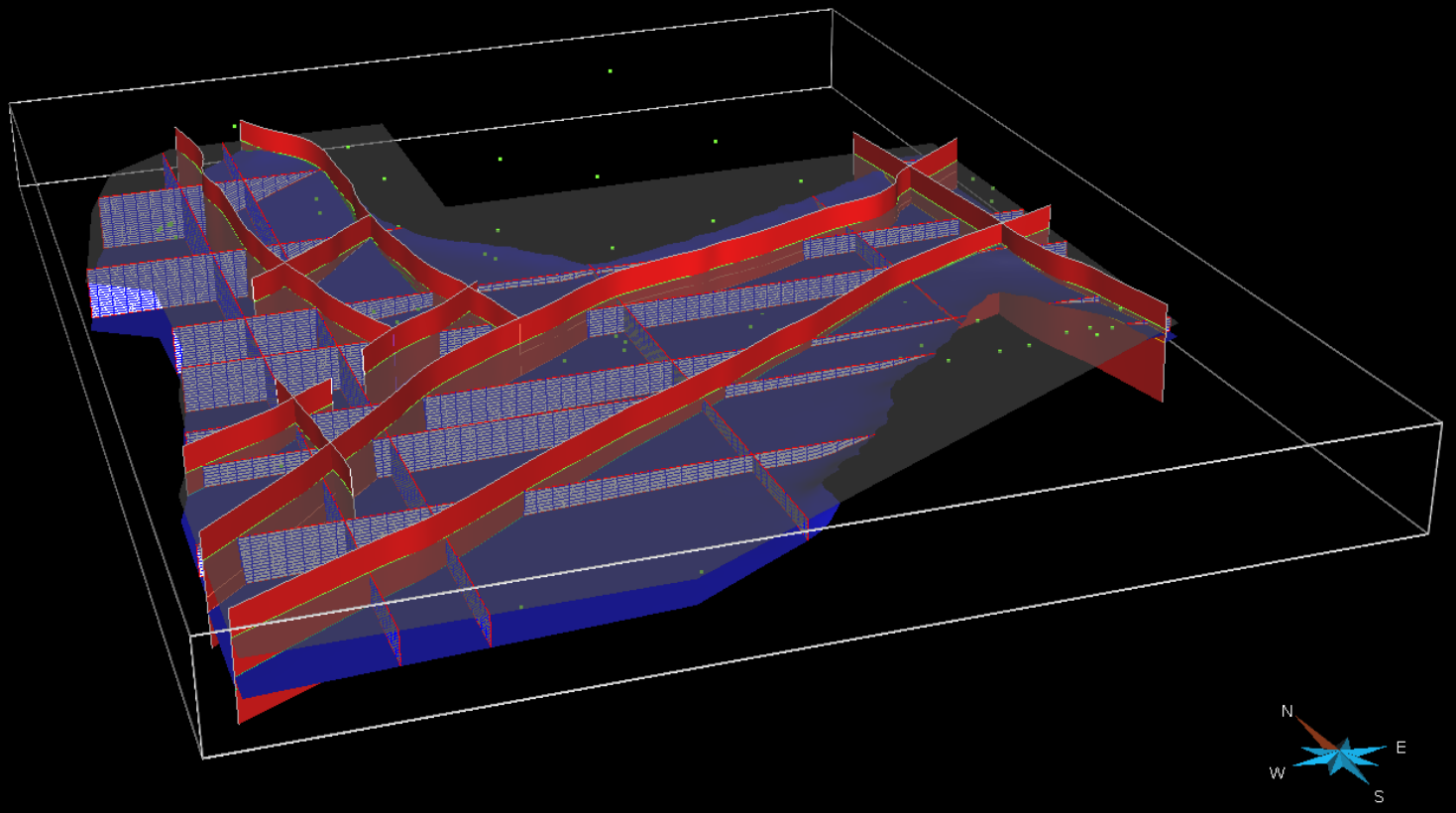
Paradigm SKUA[R]

Building the geologic grid



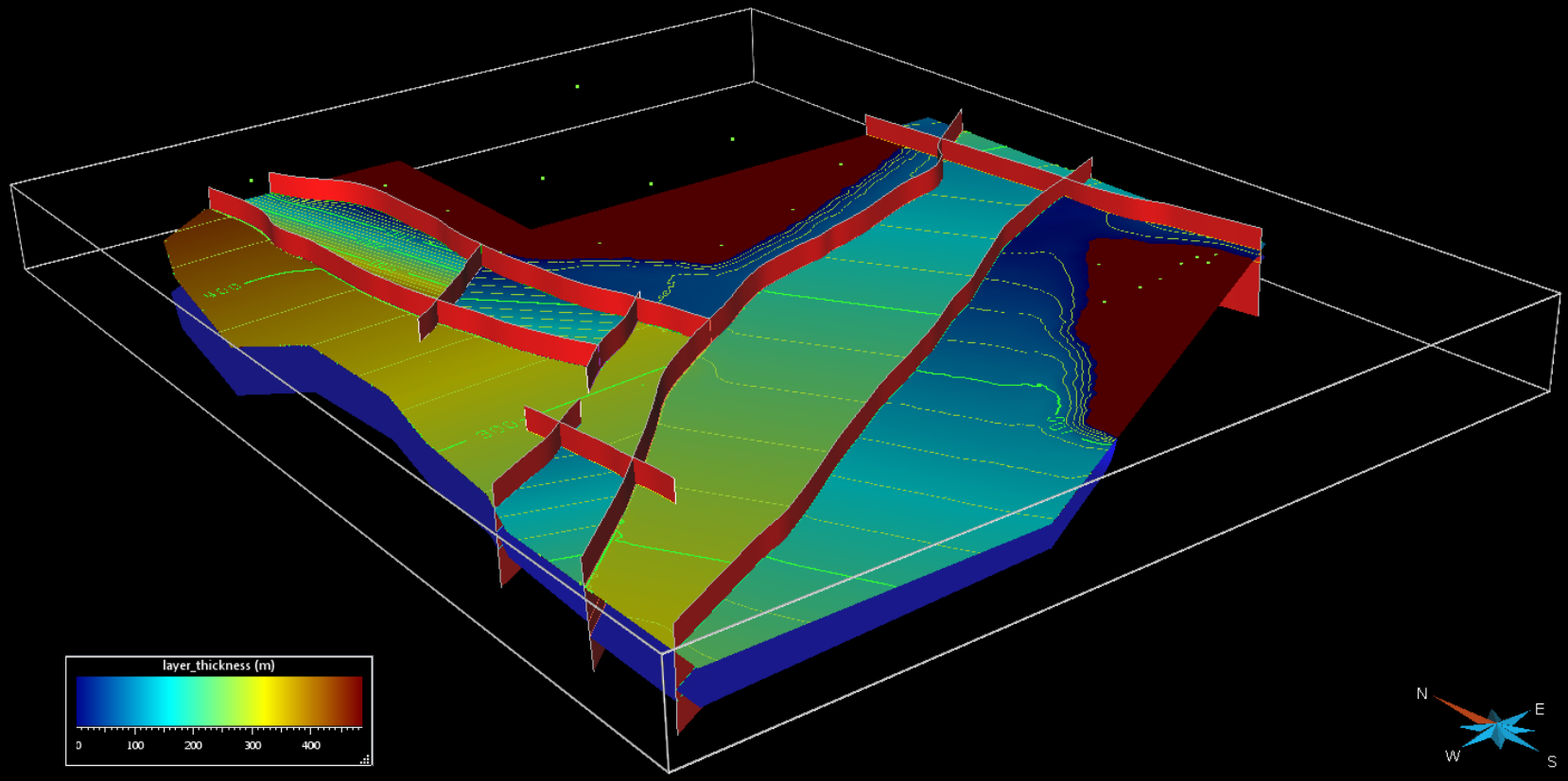
Paradigm SKUA[R]

Building the geologic grid



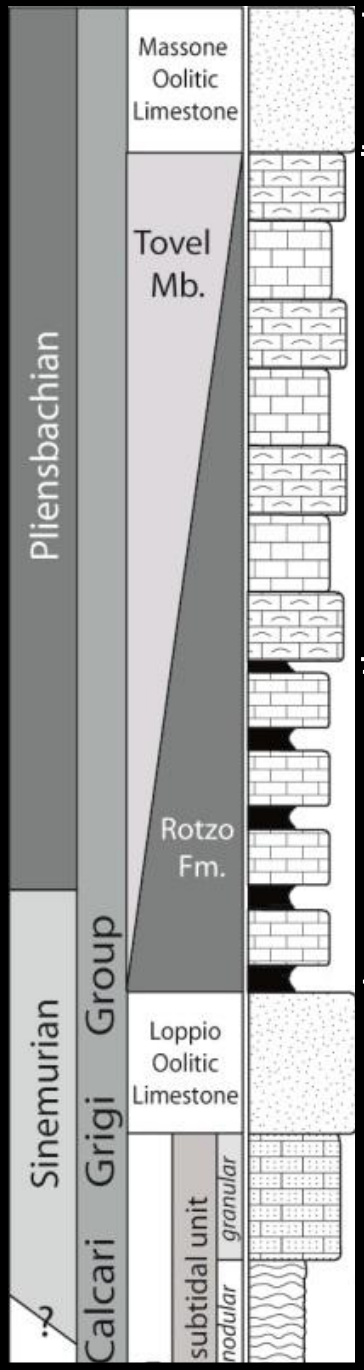
Paradigm SKUA[R]

Thickness map



Paradigm SKUA[R]

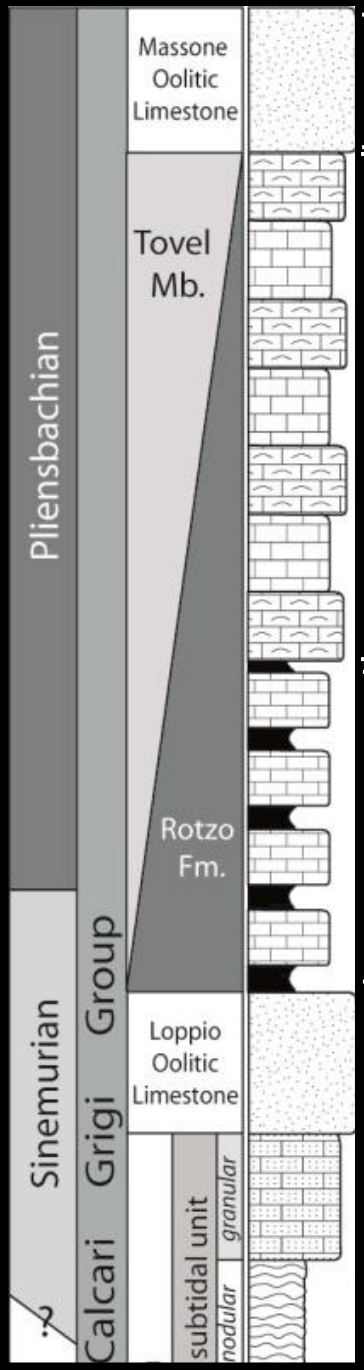
Distributing facies



OOM

RTZ_2

RTZ_1



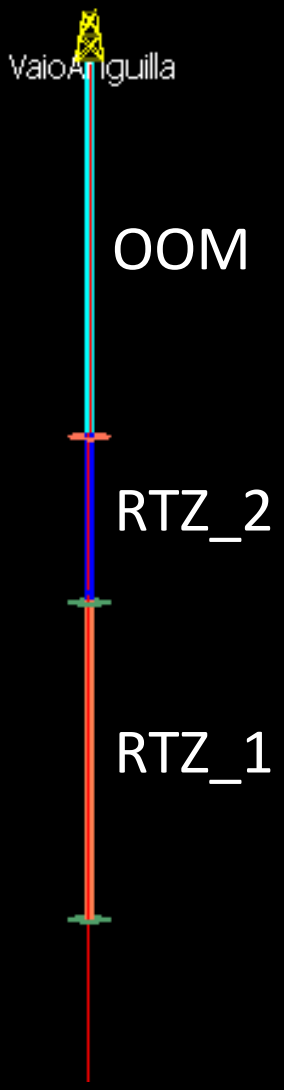
OOM

RTZ_2

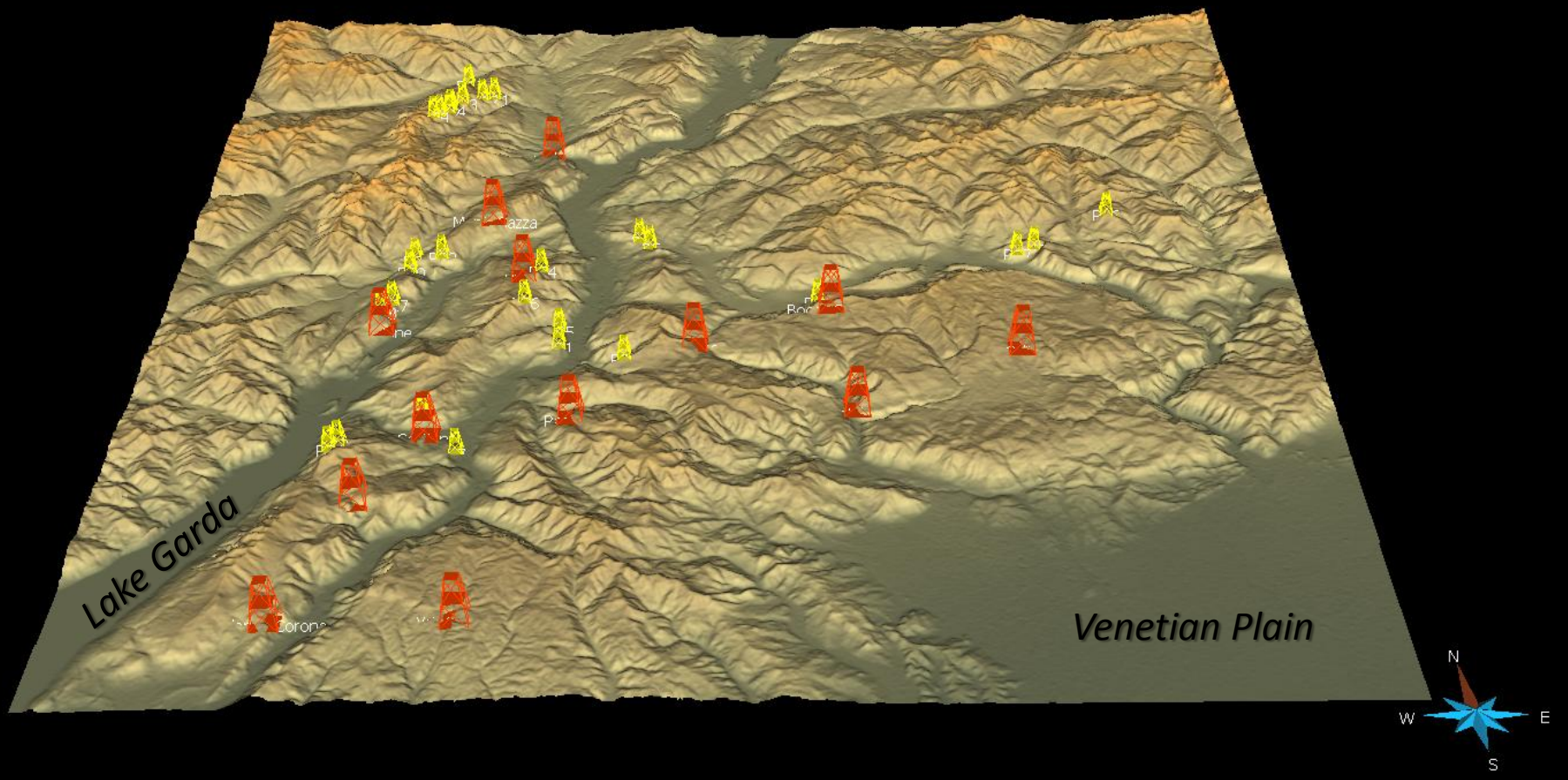
RTZ_1

Stratigraphic sections transformed into pseudo-wells

Distributing facies

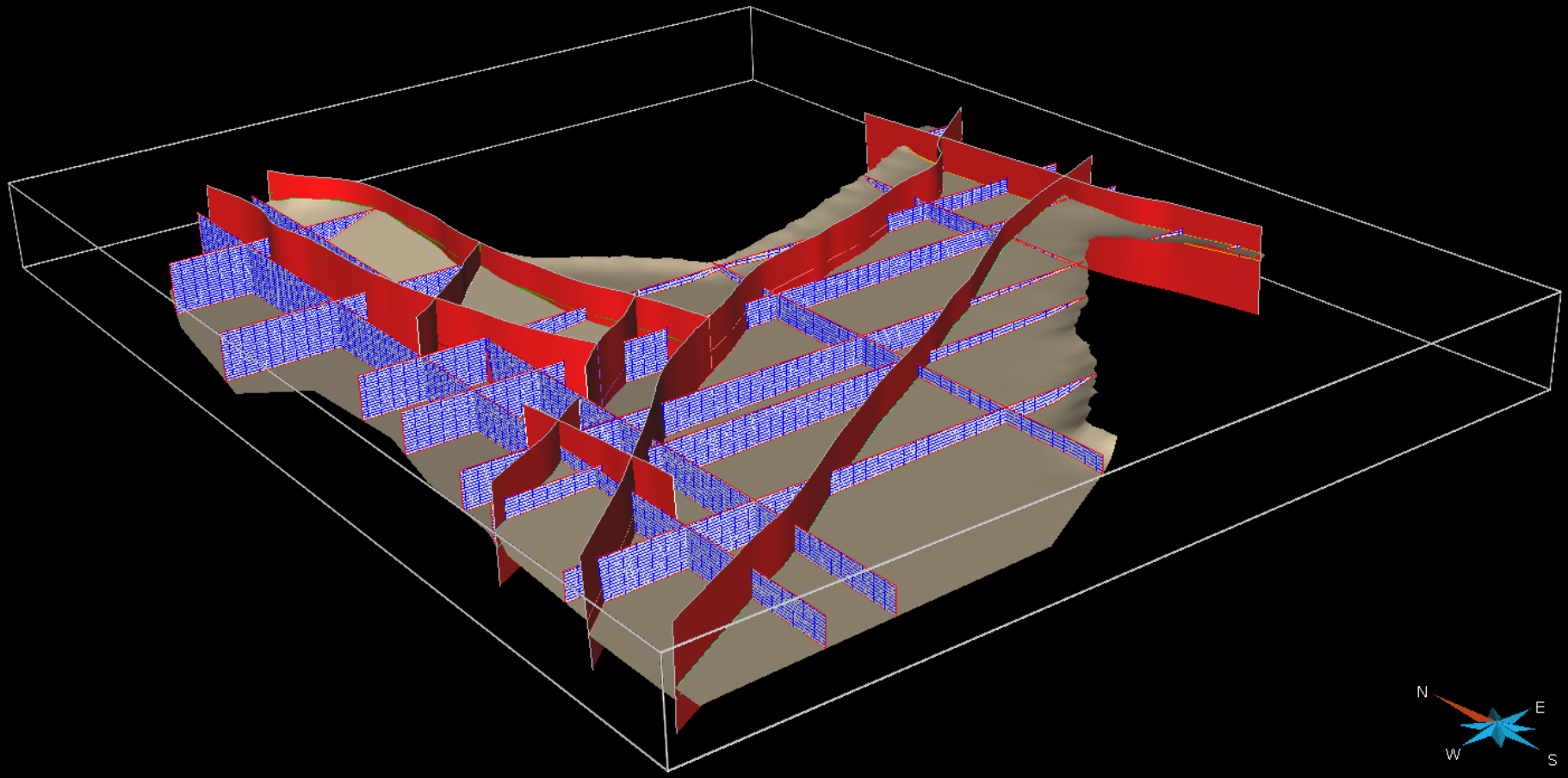


Distributing facies



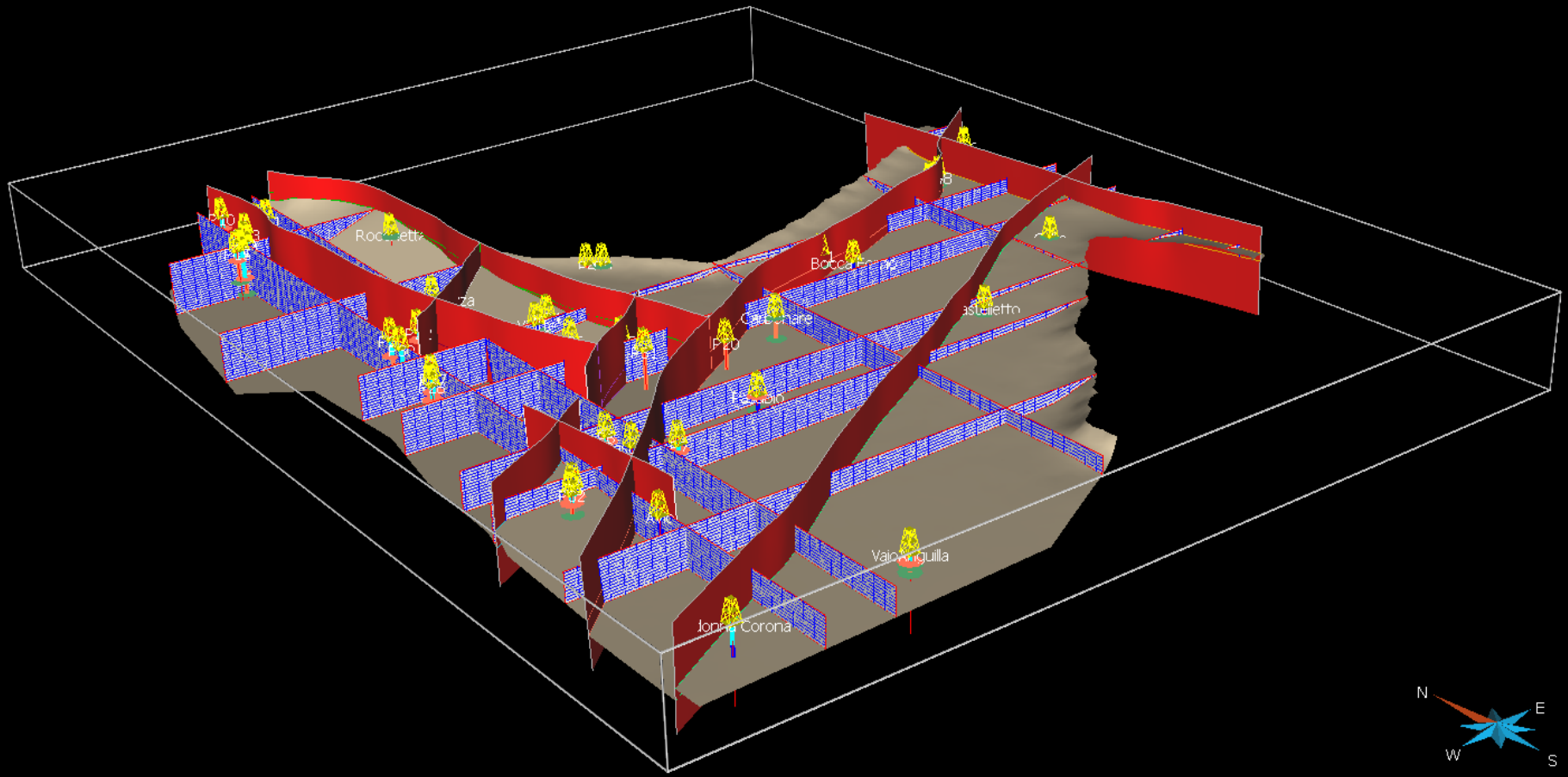
Distribution of pseudo-wells in the study area.

Distributing facies



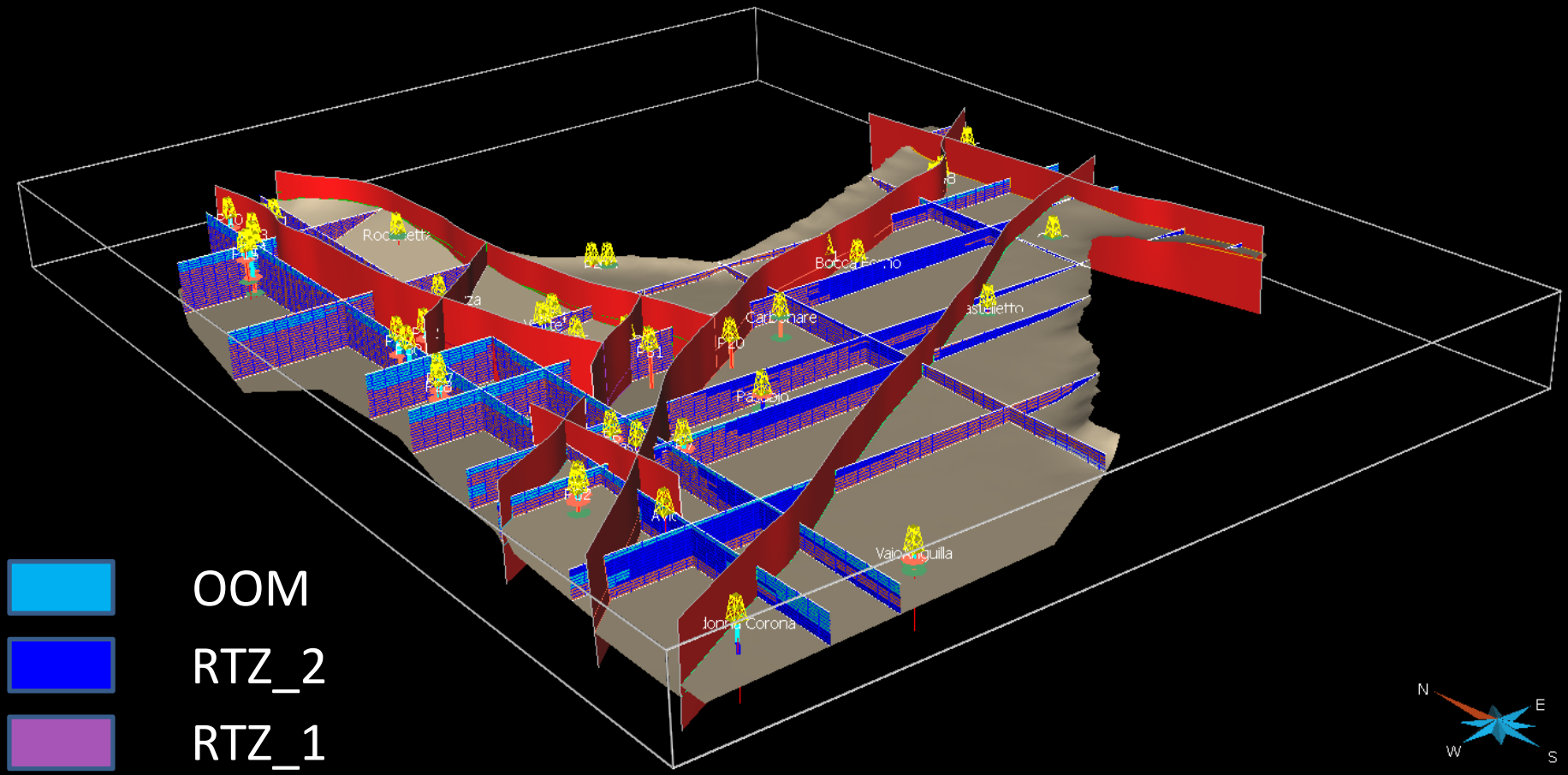
Paradigm SKUA[R]

Distributing facies



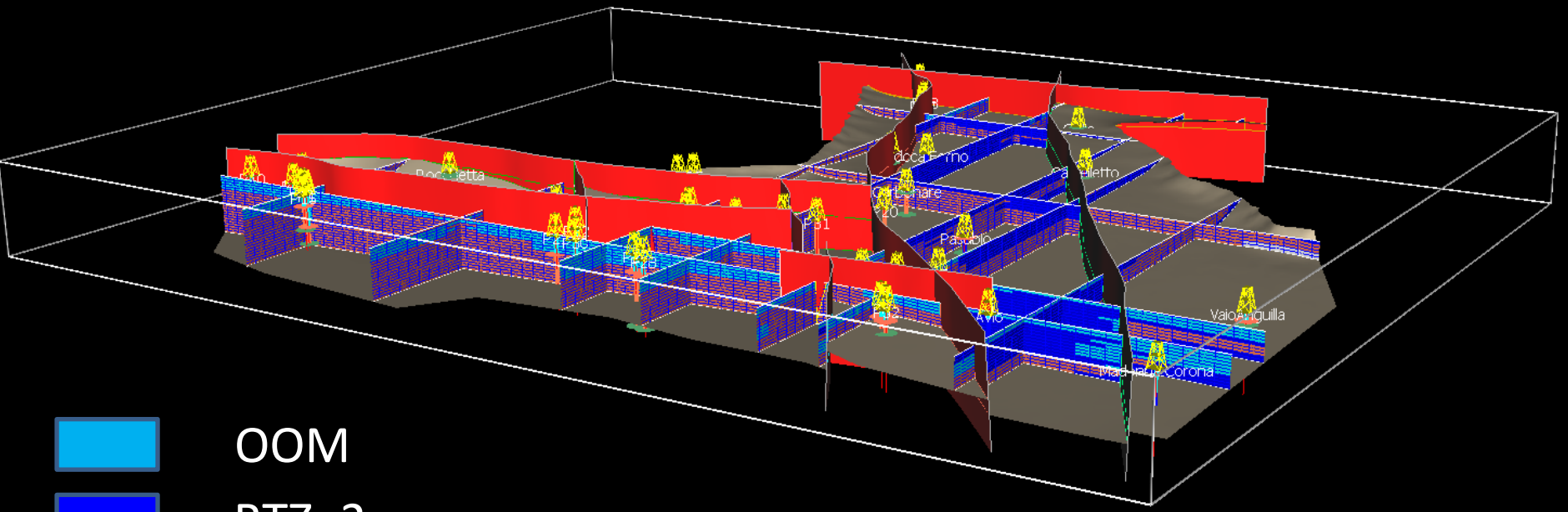
Paradigm SKUA[R]

Distributing facies



Paradigm SKUA[R]

Distributing facies

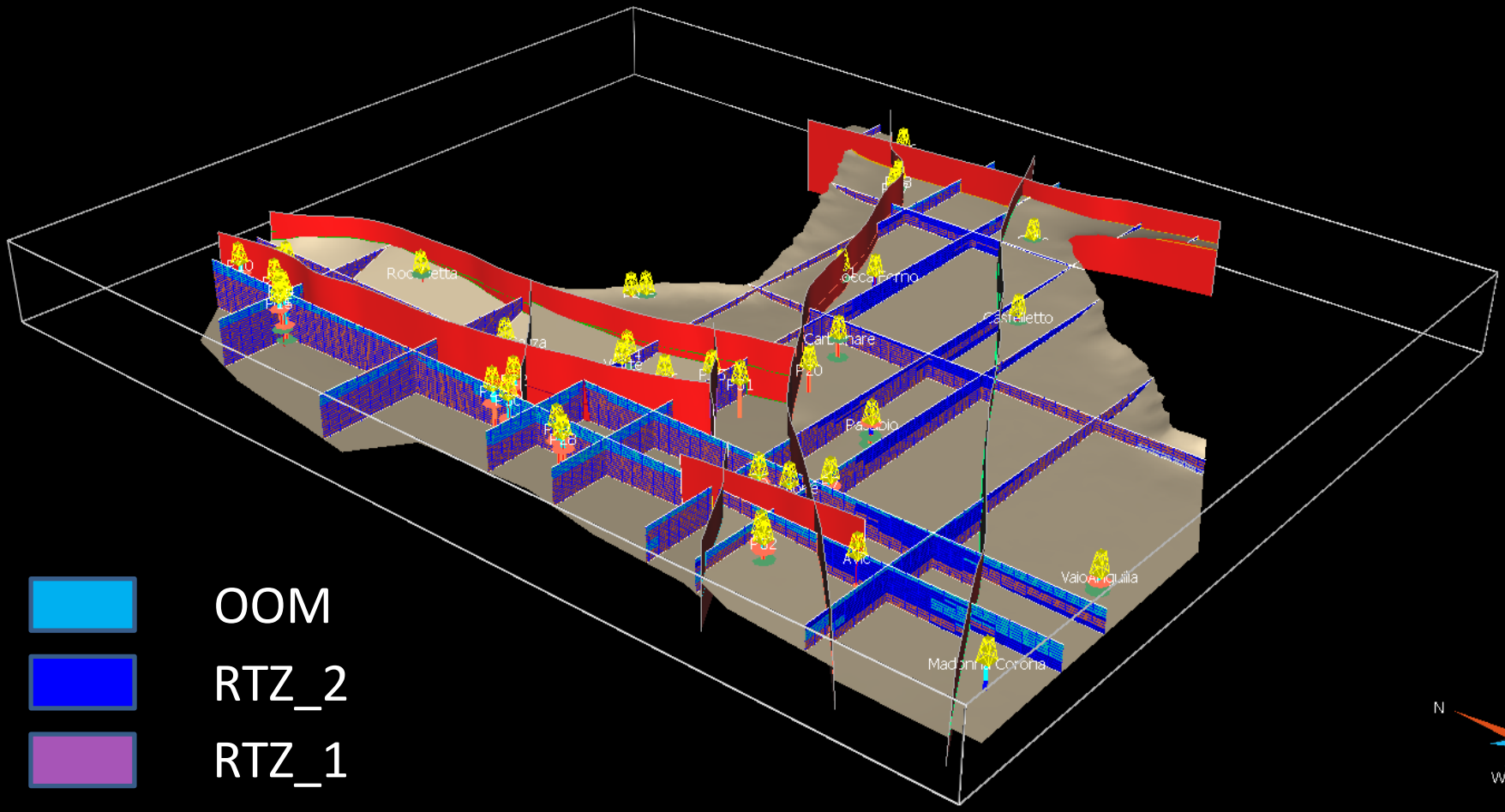


OOM

RTZ_2

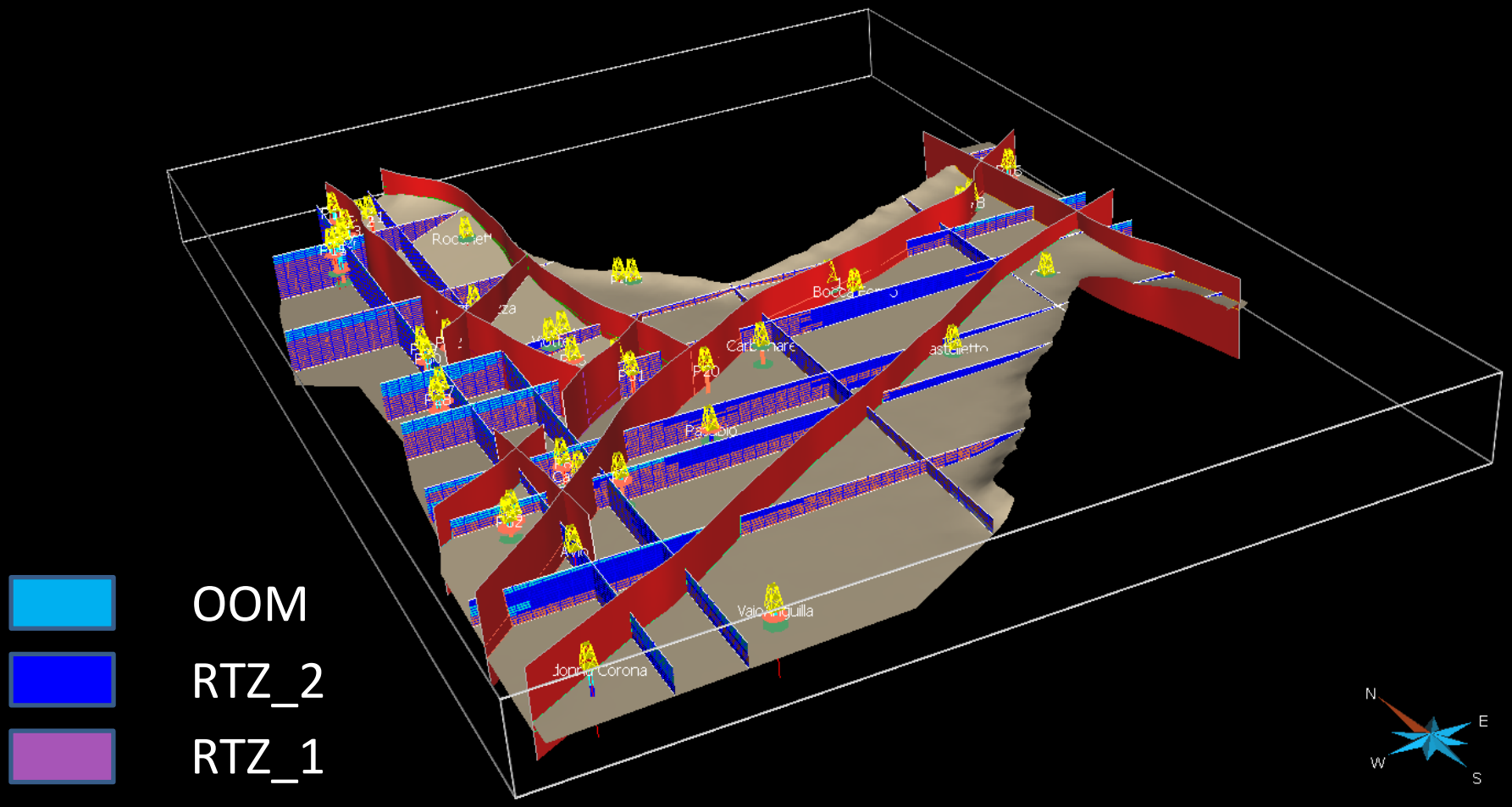
RTZ_1

Distributing facies

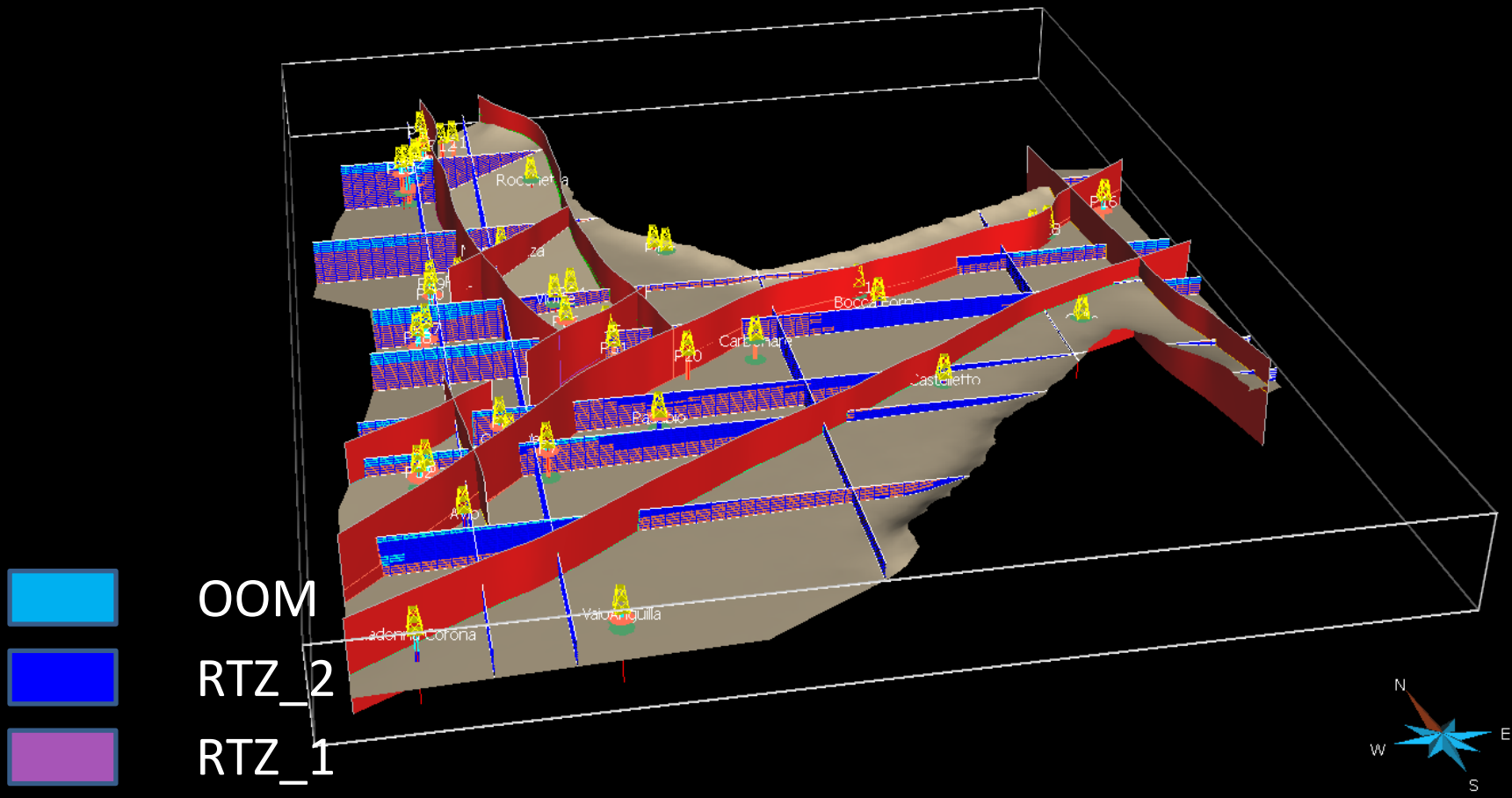


Paradigm SKUA[R]

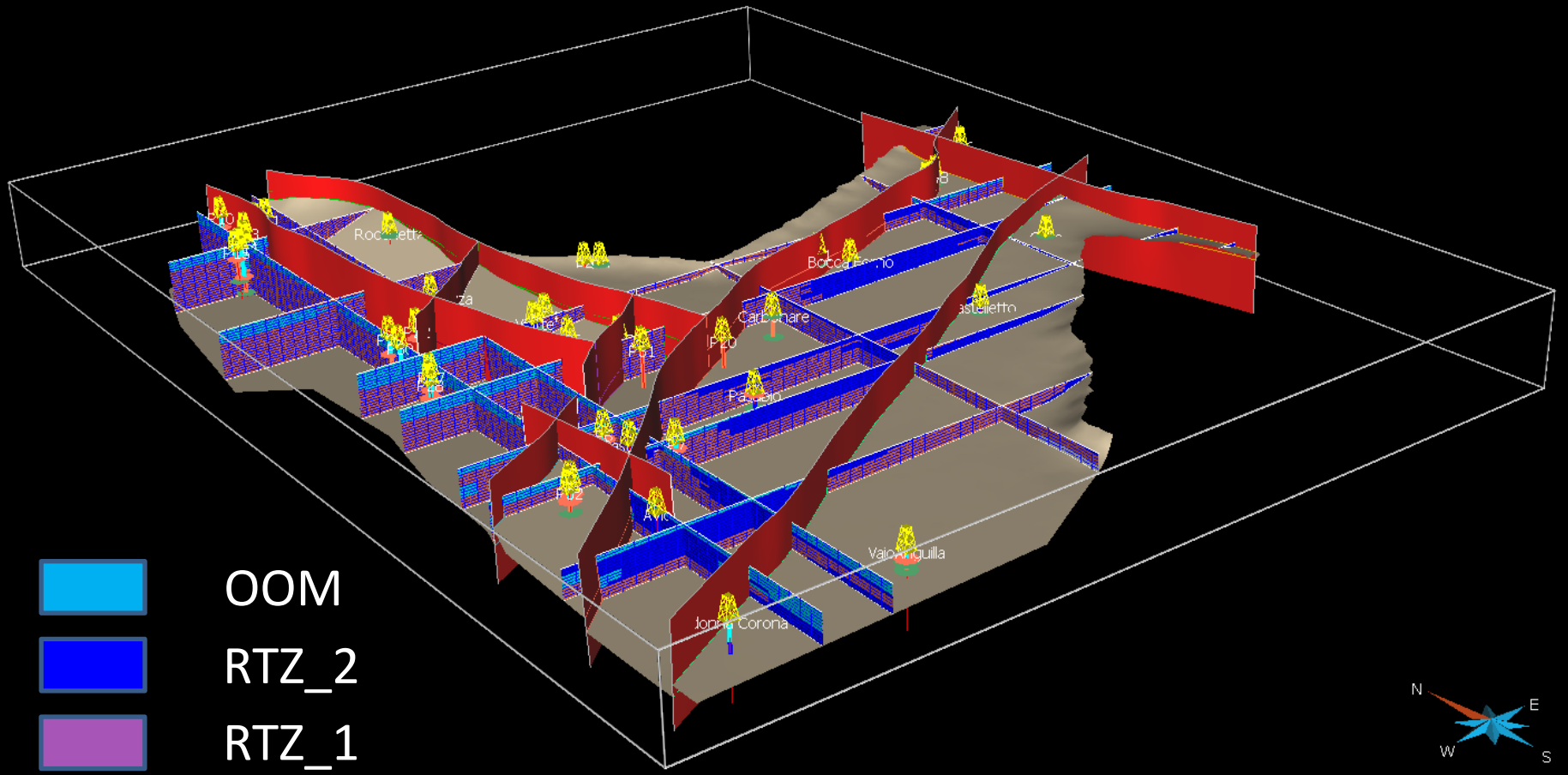
Distributing facies



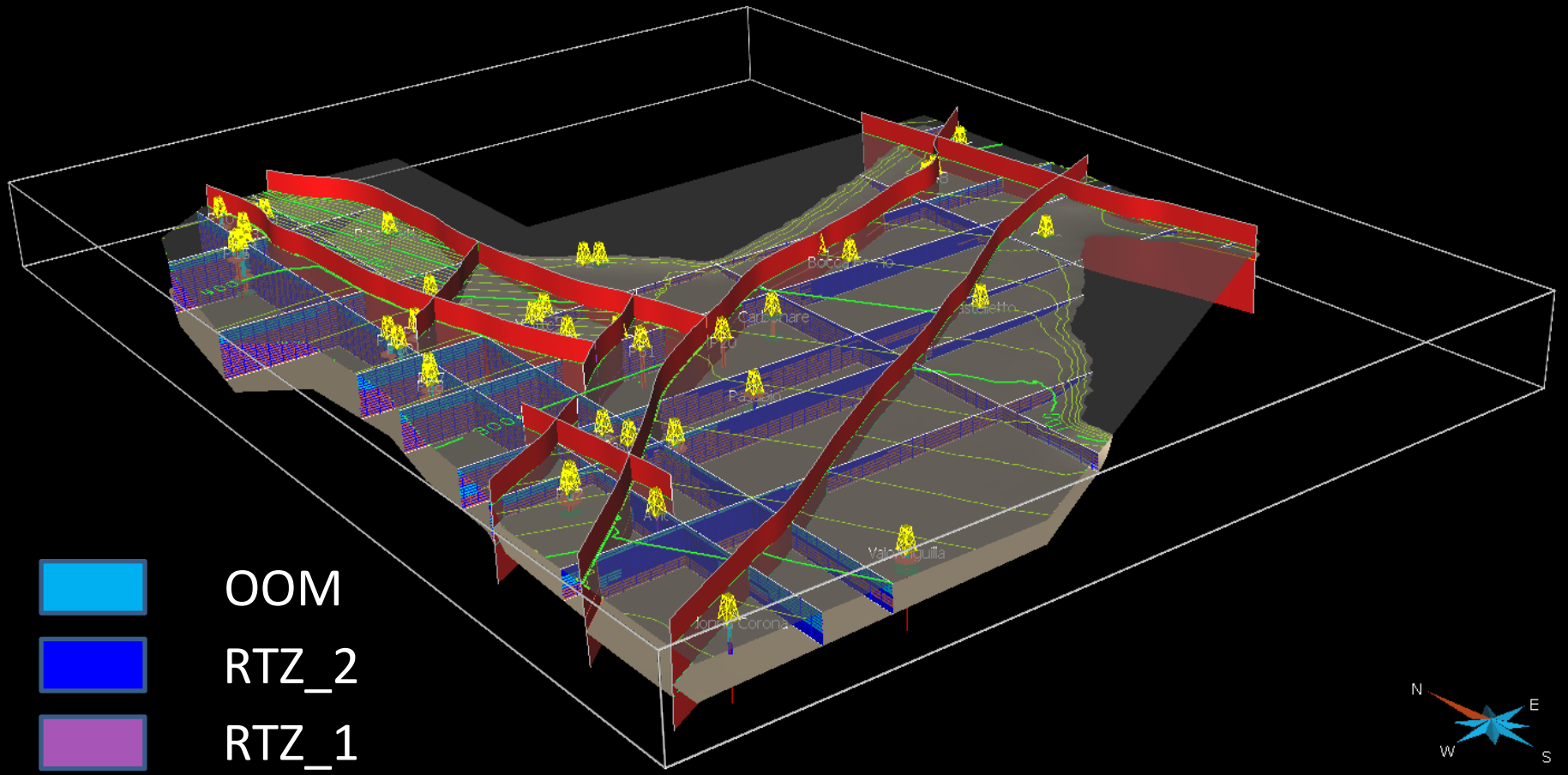
Distributing facies



Distributing facies



Distributing facies



SUMMARY

- Preliminary results of the 3D modeling of the Calcari Grigi carbonate platform have been presented. The platform is comparable in size and thickness to several buried bodies; hence it deserves to be modeled in detail.
- Analysis of spatial anisotropy in the platform's thickness variations allowed us to make reasonable hypotheses about the location of major synsedimentary fault belts.
- Results show that the platform was characterized by an extensive fault network displaying an orthorhombic symmetry in response to a true 3D strain field.
- Field data have been transformed into pseudo-wells to populate the 3D geologic model with facies information, opening to evaluate the influence of the synsedimentary tectonics in facies distribution.

FUTURE WORK

- Lots of field data still available and will be incorporated in the model to improve its complexity .
- Refinement of the facies characterization on the basis of field data.
- More advanced geostatistical approaches to populate the volume with properties.
- Validation of the model.

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