The Role of Strike-Slip Faulting in Fractured Reservoirs: Kizilin Fault from Southeastern Turkey as a Case Study*

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Search and Discovery Article #41492 (2014)**
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Abstract

The effects of strike-slip faulting on the formation and properties of fractured reservoirs have been not well received or considered during petroleum exploration programmes in southeast Turkey. However, we consider that strike-slip faults could play a unique role in creation of open fracture corridors and in formation of naturally fractured reservoirs with interconnected fracture networks. To investigate their individual influences on the fracture networks, we selected a site where fractured reservoir analogues outcrop and are deformed by right-lateral strike-slip faulting.

We considered the Durak and Karababa highs as appropriate sites for fracture studies, which consist mostly of Sayindere and Bozova fractured reservoir analogues and which were deformed by the Kizilin and Bozova dextral faults. In order to introduce a structural model, we carried out a combined workflow, including detailed geological and tectonic mapping in the region and collection of subsidiary fault, fracture and joint data from the damage zones of the Kizilin Fault and some other regional faults such as the left-lateral Kemerli Fault, and right-lateral Bozova Fault. We determined data collection stations located in some critical structural domains such as principal shear, contractional and extensional domains, and the domains out of central damage zones to avoid local stress variations. We recorded characteristics of the fracture sets such as linear density, spacing, filling material (i.e. calcite, asphaltite, silica, etc.) orientation and cross-cutting relationships. We also aimed to define synthetic and antithetic fracture sets such as Riedel-shears, P-Shears, R'-Shears, etc. to examine contribution of each fracture set to the anisotropic fracture porosity to determine the most favorable structural domains for fractured reservoir properties and fluid flow. Ultimately, we calculated the most profitable drilling deviation directions using linear fracture porosity, dip and azimuth data of each fracture set for the drilling programs of petroleum exploration wells which could be implemented in analogous fractured reservoir oilfields to produce oil from as many fractures and as much fracture porosity as possible. This workflow leads us to individuate the damage zone features of the Kizilin Fault and constitutes a model for further studies with similar purposes.

TPAO
TÜRKİYE PETROLLERİ A.O.

EXPLORATION

22nd WORLD PETROLEUM CONGRESS istanbul 2017

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(Turkish Petroleum Corporation)
2014

OUTLINE

- Objectives
- Location of the Study Area & Tectonic History
- Fracture Studies
    - Methodology
    - Data Analysis
- Results and Conclusions

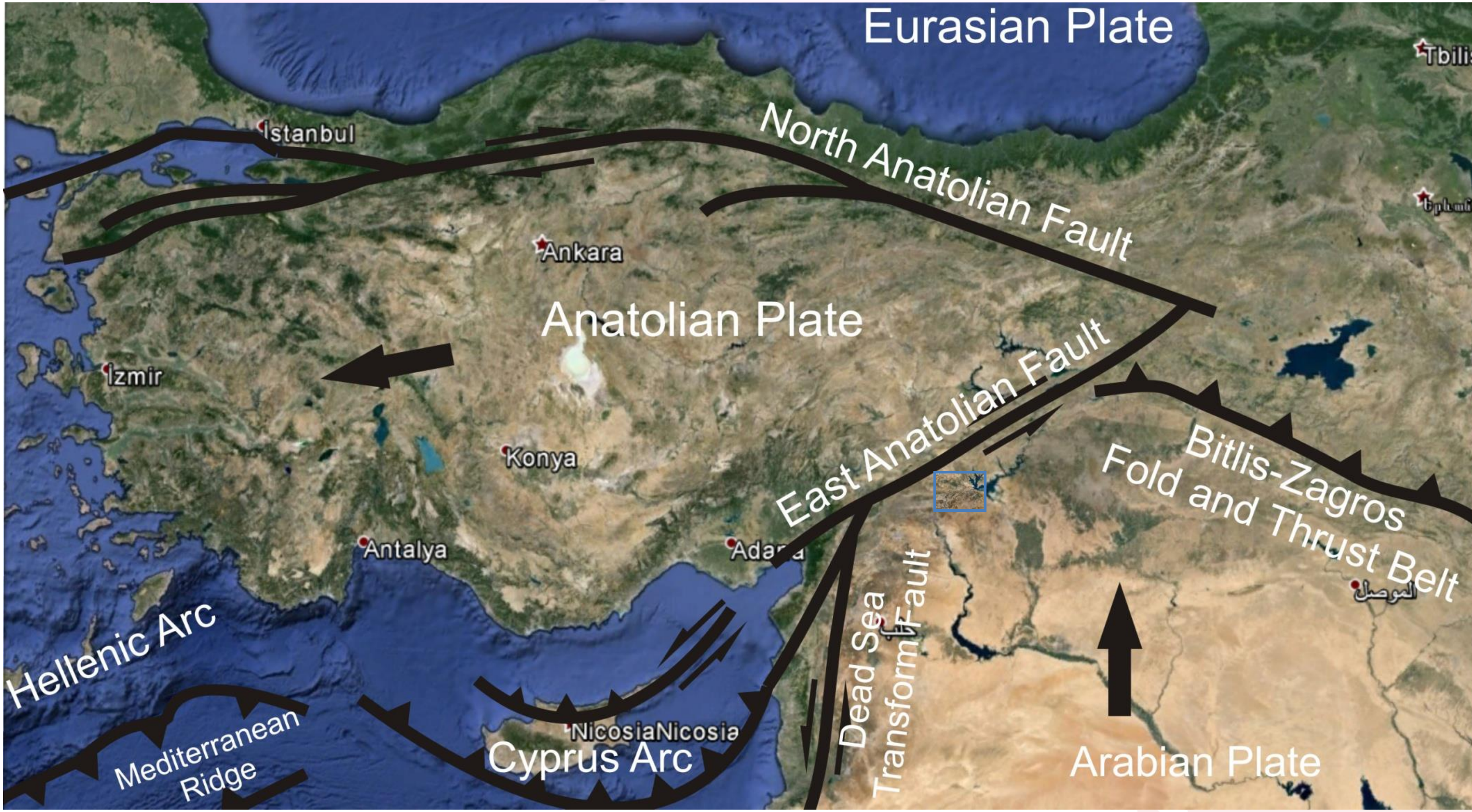
OBJECTIVES

- To make a geometrically accurate structural mapping and to define all the major faults and their relative and absolute ages.

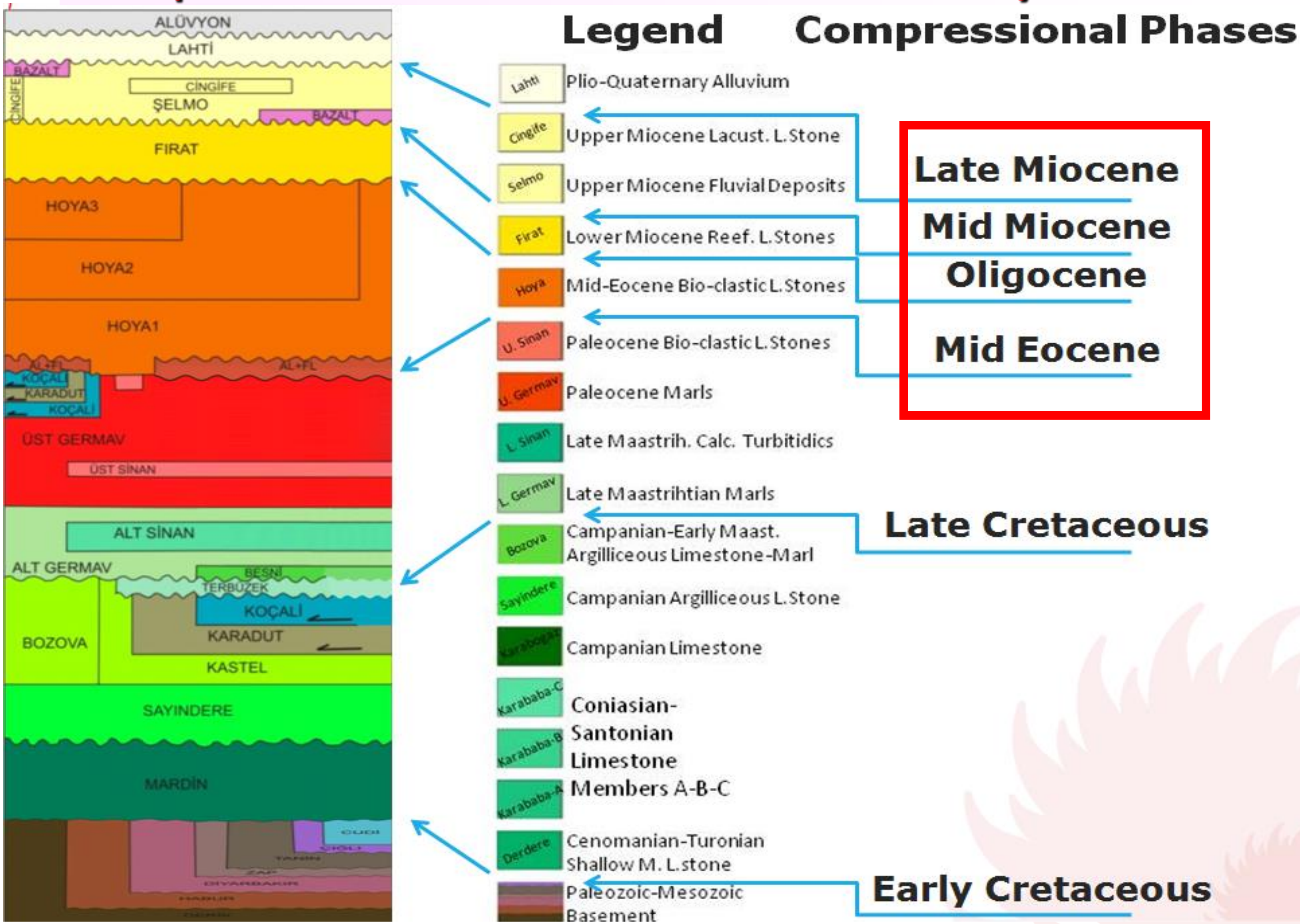
- To define structural domains along mapped strike-slip faults and explore properties of fractured reservoir analogues (e.g., preferred orientation of open fractures with respect to major strike slip fault strands (Bozova and Kızılin faults).

- Ultimately, to make inferences on determination of directional drilling trajectories to cut and produce from as many fractures as possible within analogous buried fractured reservoirs .

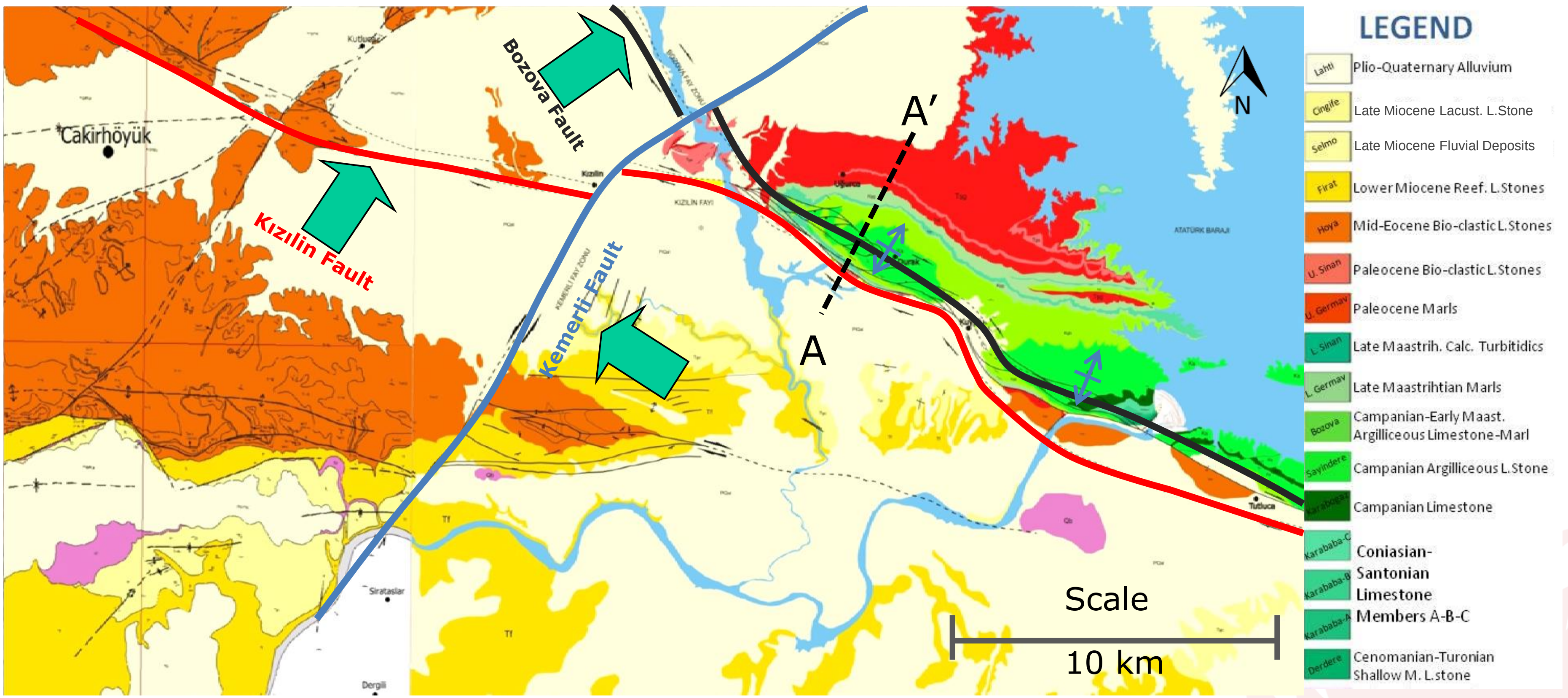
Location of the Study Area



Compressional Phases in the Tectonic History



Kızılin Fault & its' Interactions with other Regional Faults



Neogene Faultings		
Kızılin Fault	WNW-ESE Dextral Strike-Slip Faults	
Kemerli Fault	NNE-SSW Sinistral Strike-Slip fault	
Bozova Fault	NW-SE Dextral Strike-Slip Faults	

Mid Eocene Foldings

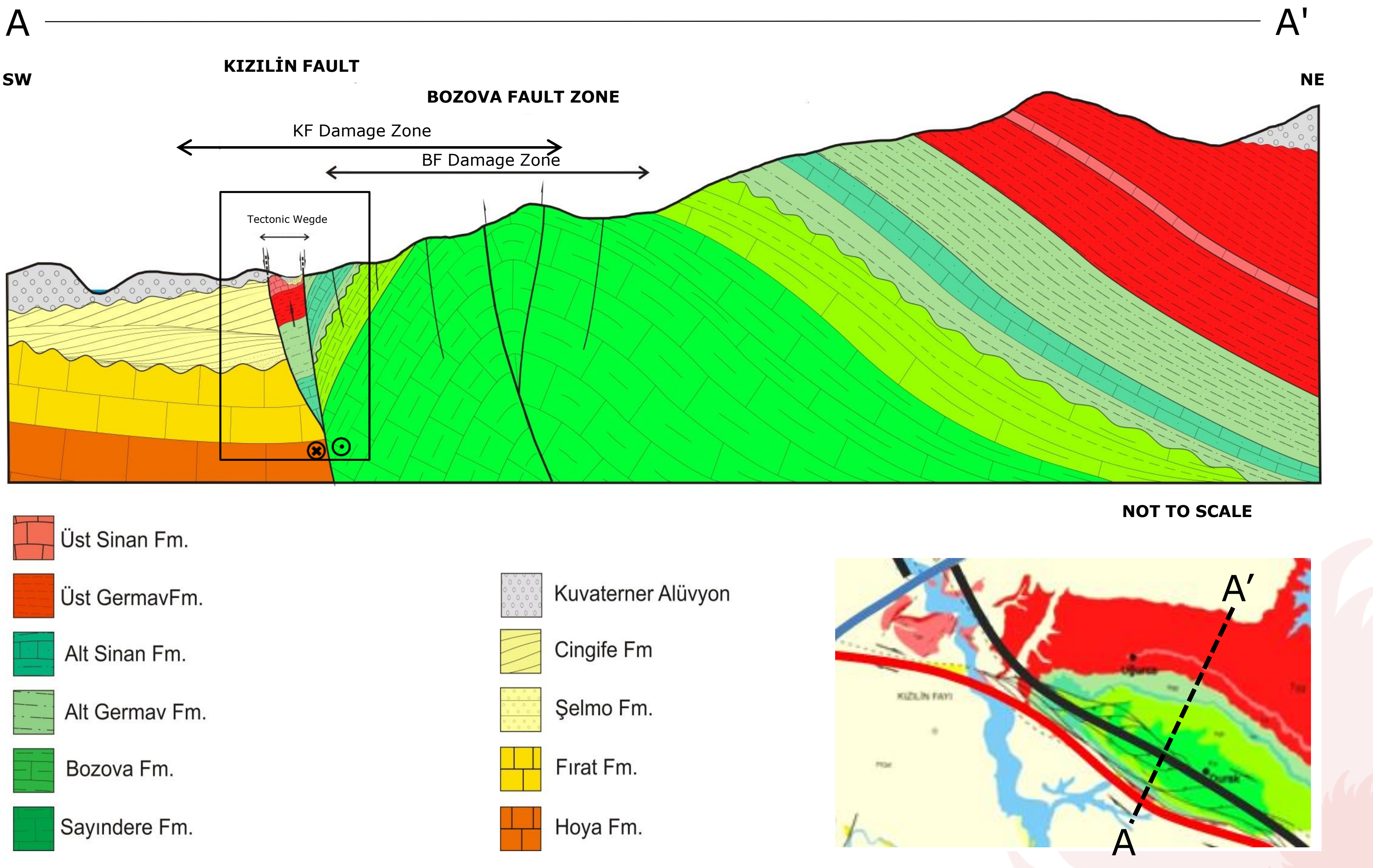
WNW-ESE anticlines and synclines

Folded youngest: Mid Eocene

Unfolded oldest: Mid Eocene

Geological Cross-Section from the Durak Hill

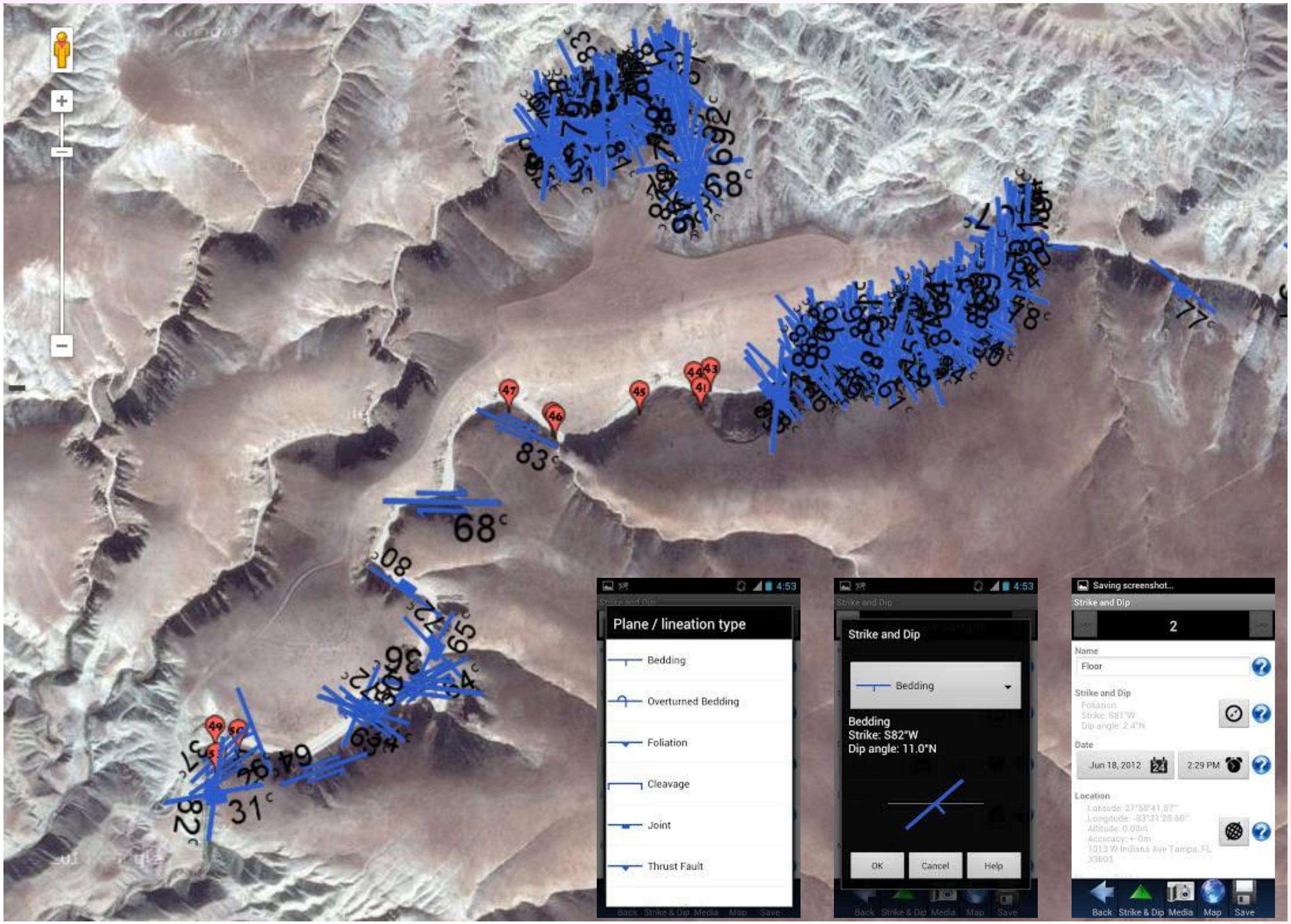
DURAK HILL/ GEMRİK ANTICLINE



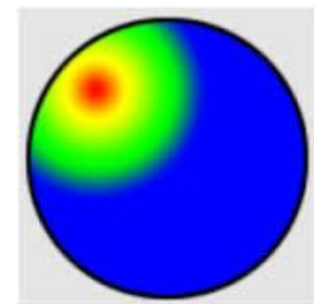
FRACTURE STUDIES

METHODOLOGY

Georeferenced Data Collection & Data Analysis



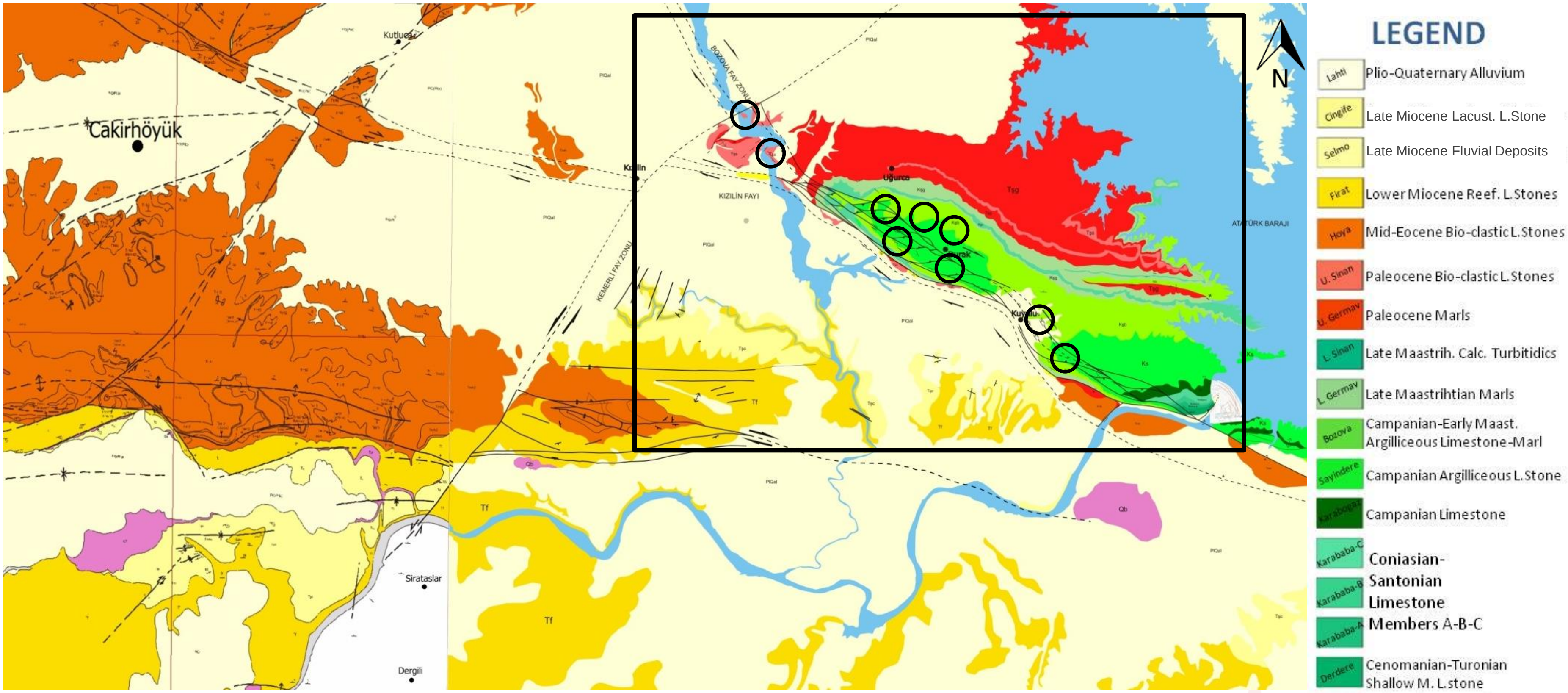
Petrel (Schlumberger)



Dips (Rocscience Inc®)

Strike&Dip

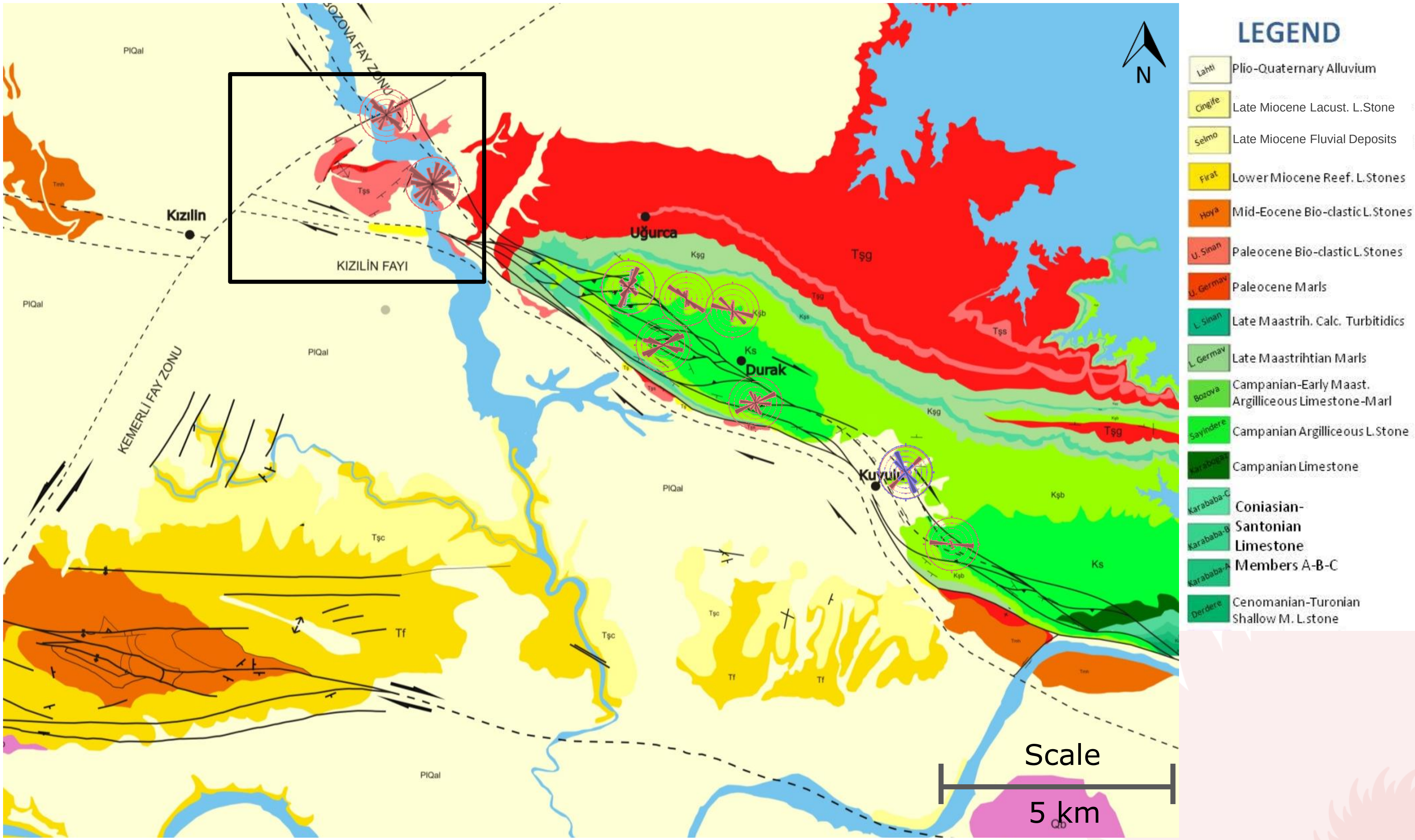
LOCATION OF DOMAINS
STRUCTURAL DATA COLLECTION STATIONS



Totally 1632 Fracture measurements

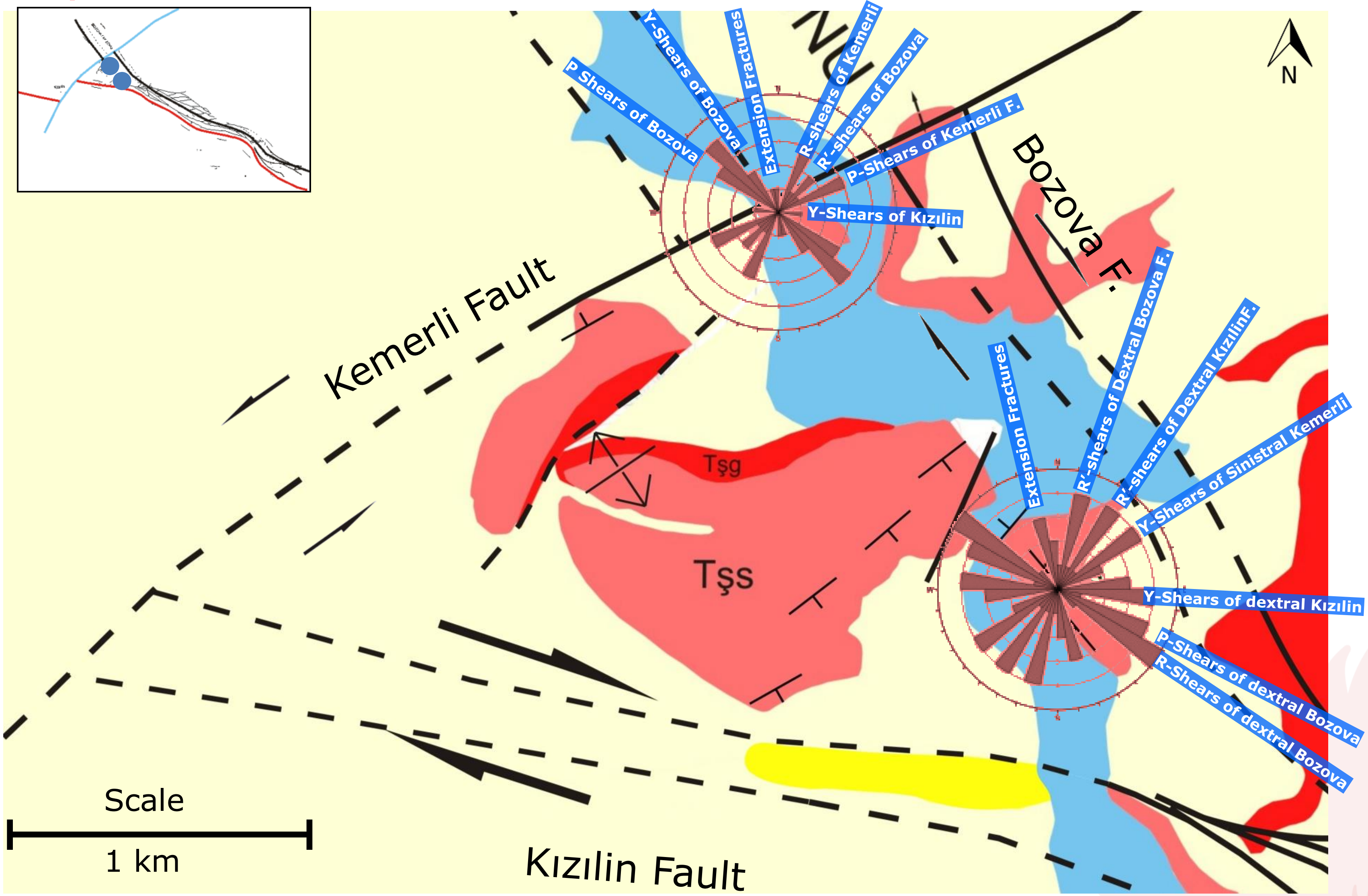
Scale

10 km

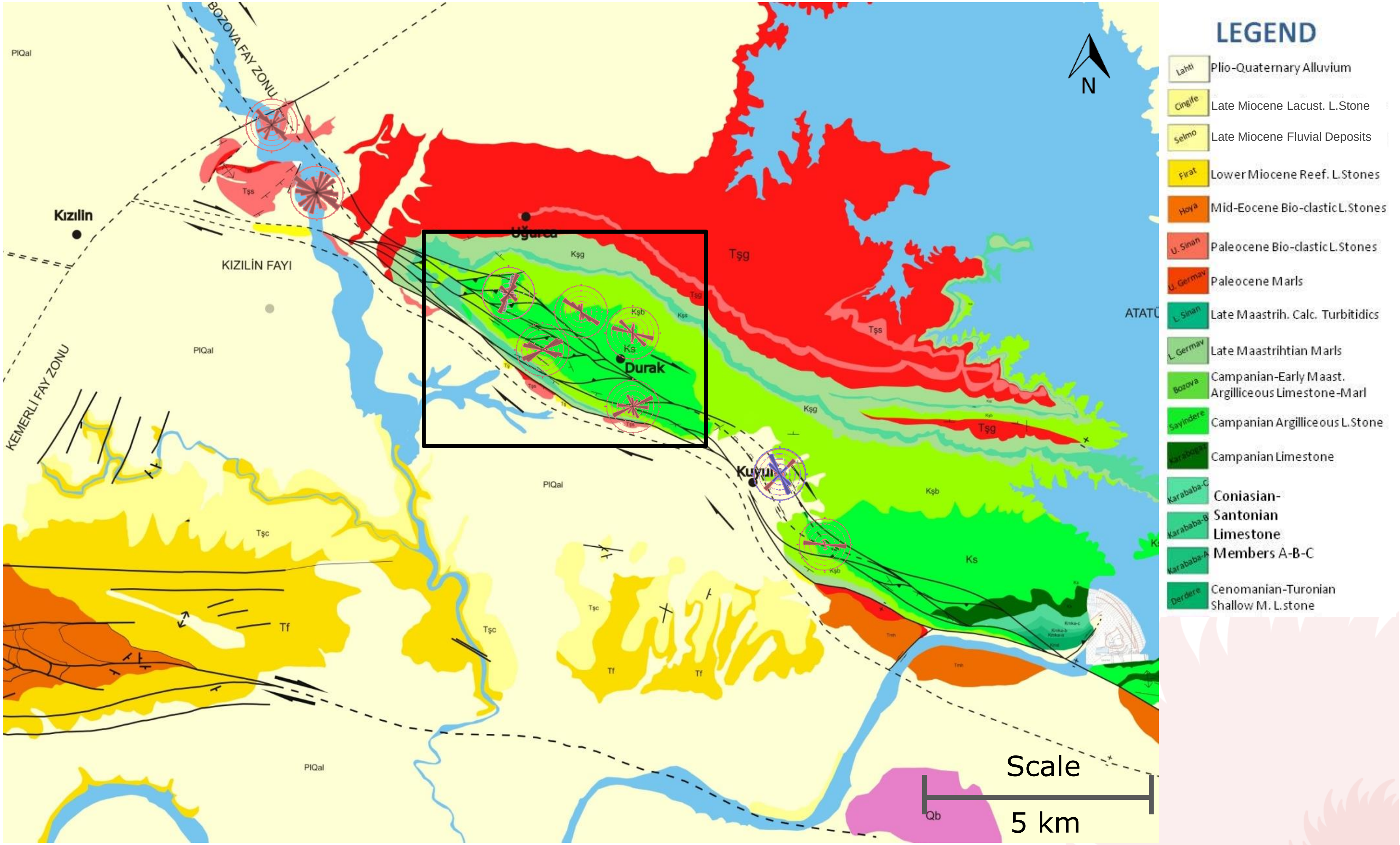


LEGEND
Plio-Quaternary Alluvium
Late Miocene Lacust. L.Stone
Late Miocene Fluvial Deposits
Lower Miocene Reef. L.Stones
Mid-Eocene Bio-clastic L.Stones
Paleocene Bio-clastic L.Stones
Paleocene Marls
Late Maastrih. Calc. Turbitidics
Late Maastrihtian Marls
Campanian-Early Maast. Argilliceous Limestone-Marl
Campanian Argilliceous L.Stone
Campanian Limestone
Coniasian-Santonian Limestone Members A-B-C
Cenomanian-Turonian Shallow M. L.stone
N
BOZOVA FAY ZONU
Kızılin
KIZILİN FAYI
Uğurca
Durak
KEMERLI FAY ZONU
PlQal
Tşg
Tşs
Ksg
Ks
Ksb
Tşc
Tf
Scale
5 km

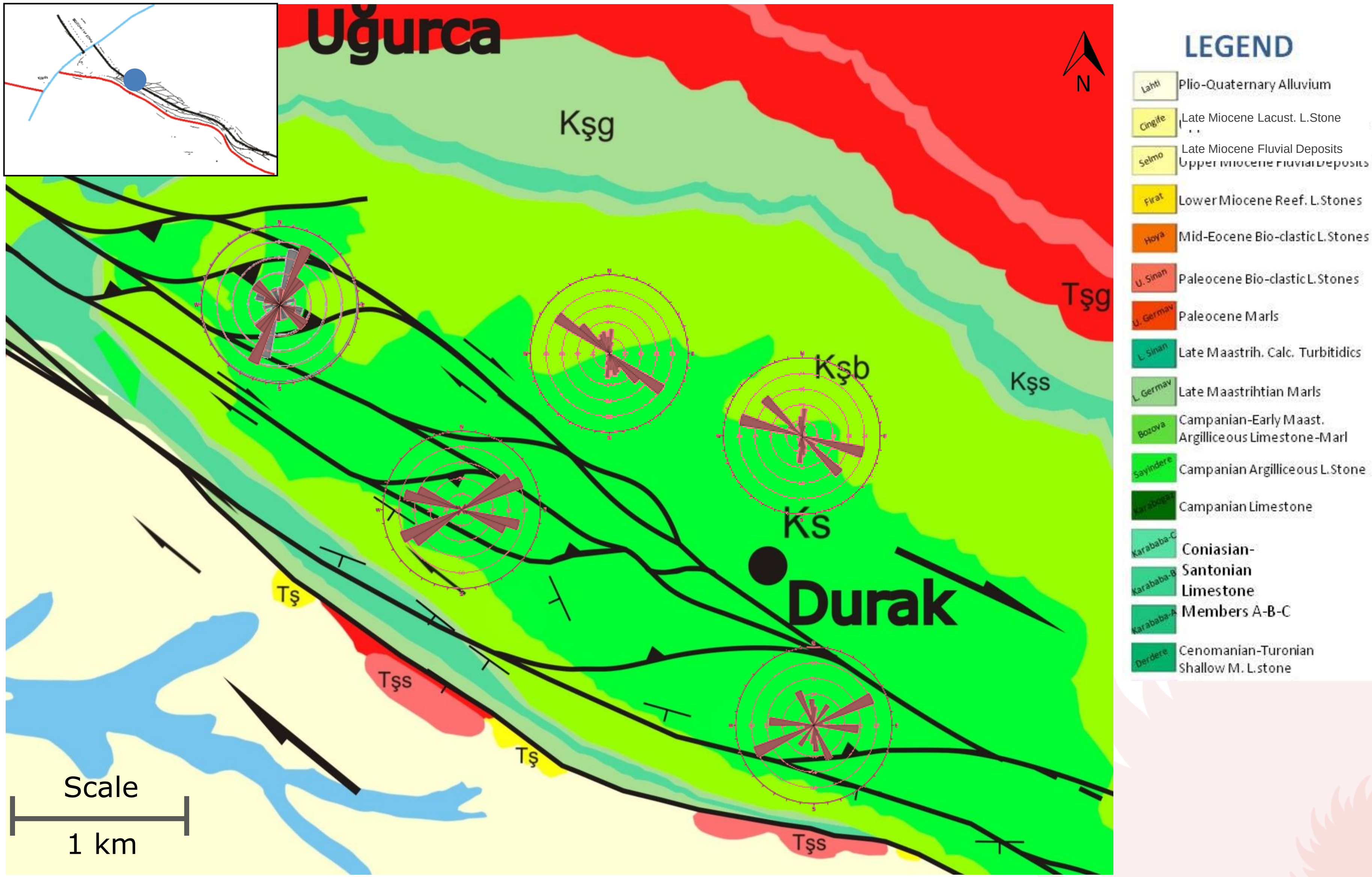
Kemerli, Bozova and Kizilin Faults



Bozova and Kızılin Faults

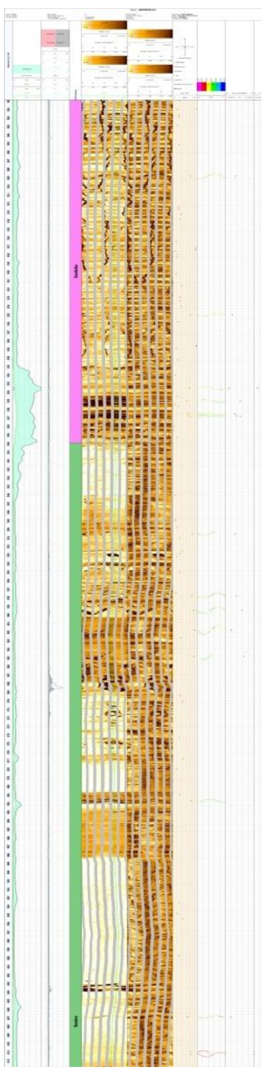


Y-Shear Domain

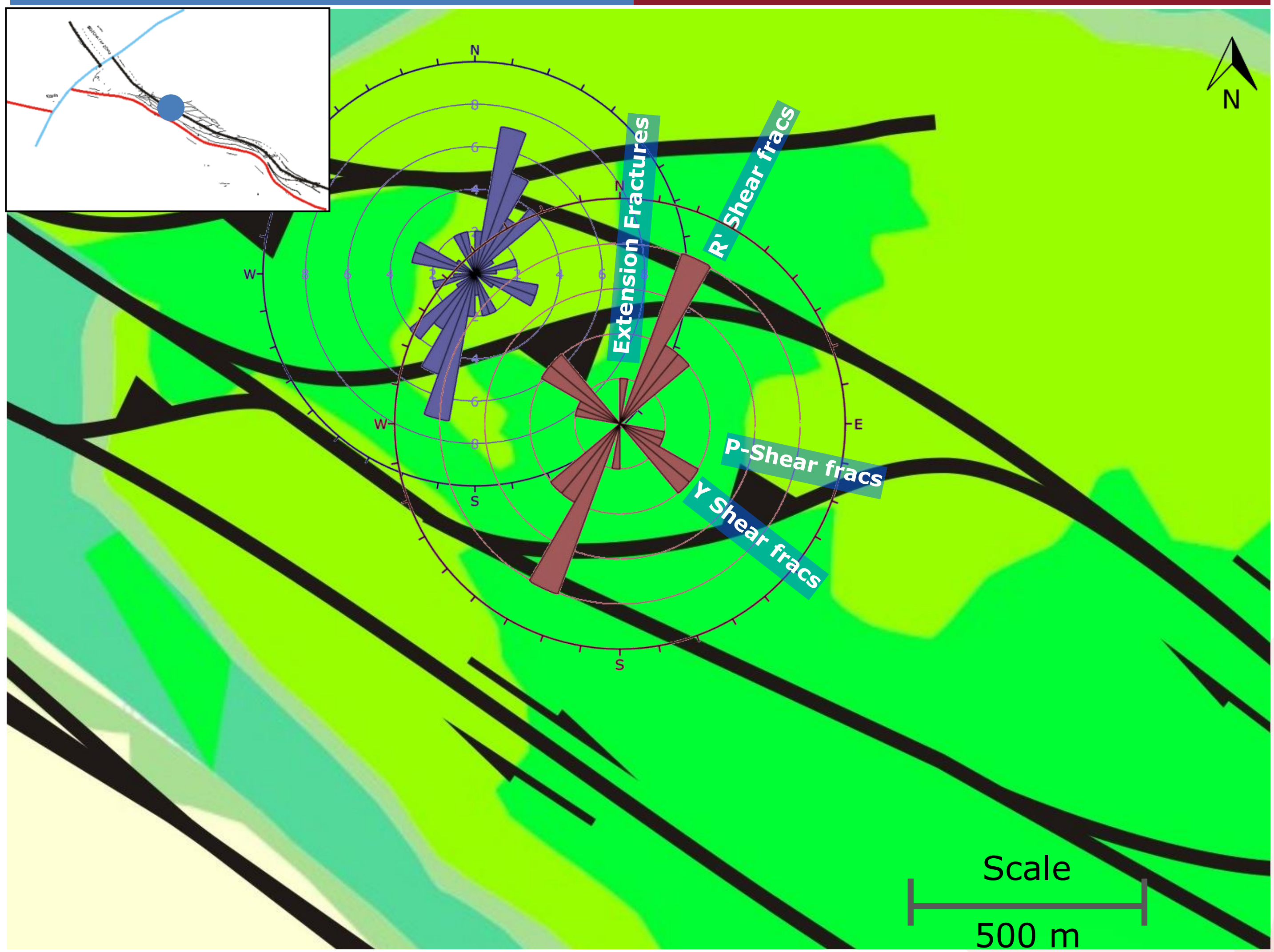


Y-Shear Domain

XRMI Log of the Well in this domain

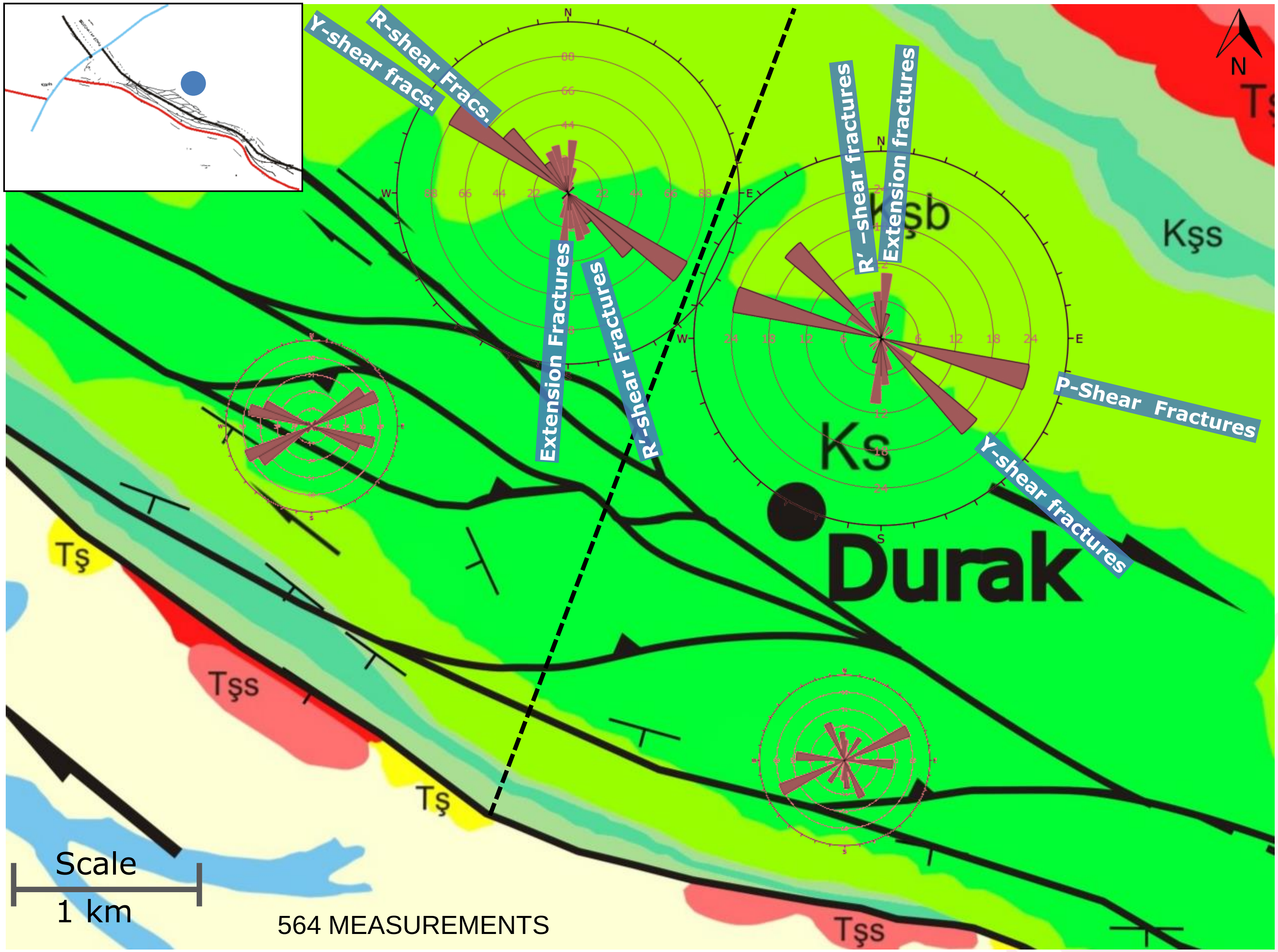


Fractures interpreted from XRMI log | **Fractures measured from nearest outcrop**

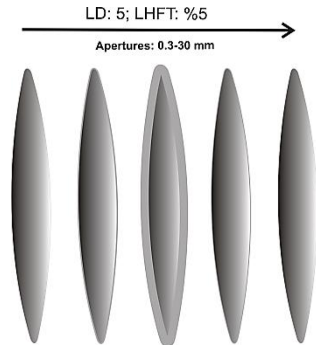


Number of measurements : 37 from the log, 42 from outcrop

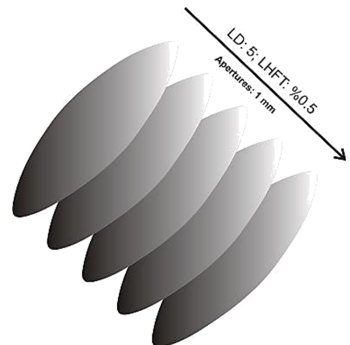
Distant Y-Shear Domain



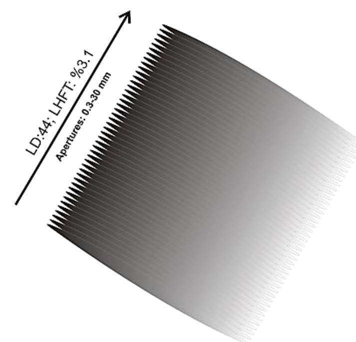
Distant Y-Shear Domain Fractures



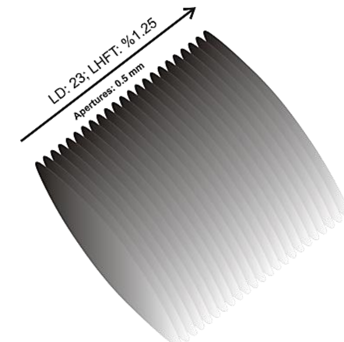
Extension Fractures



R'-Shear Fractures



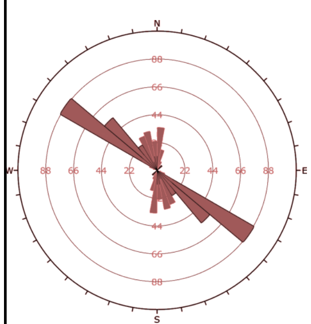
Y-Shear Fractures

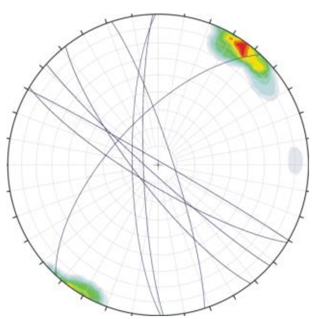


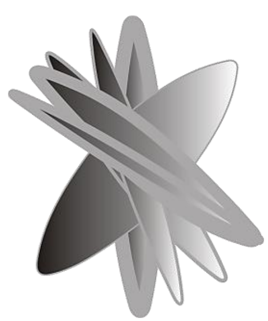
R-Shear Fractures

Disc shape visualization of fractures in a 1 meter diameter sphere. Spacing and aperture values for each fracture sets visually represented with scale for 1 meter long scan lines.

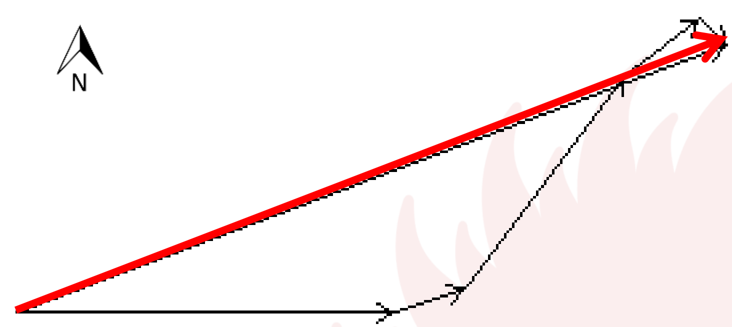
Max LHFT: 10%, Optimal well Trajectory azimuth :69





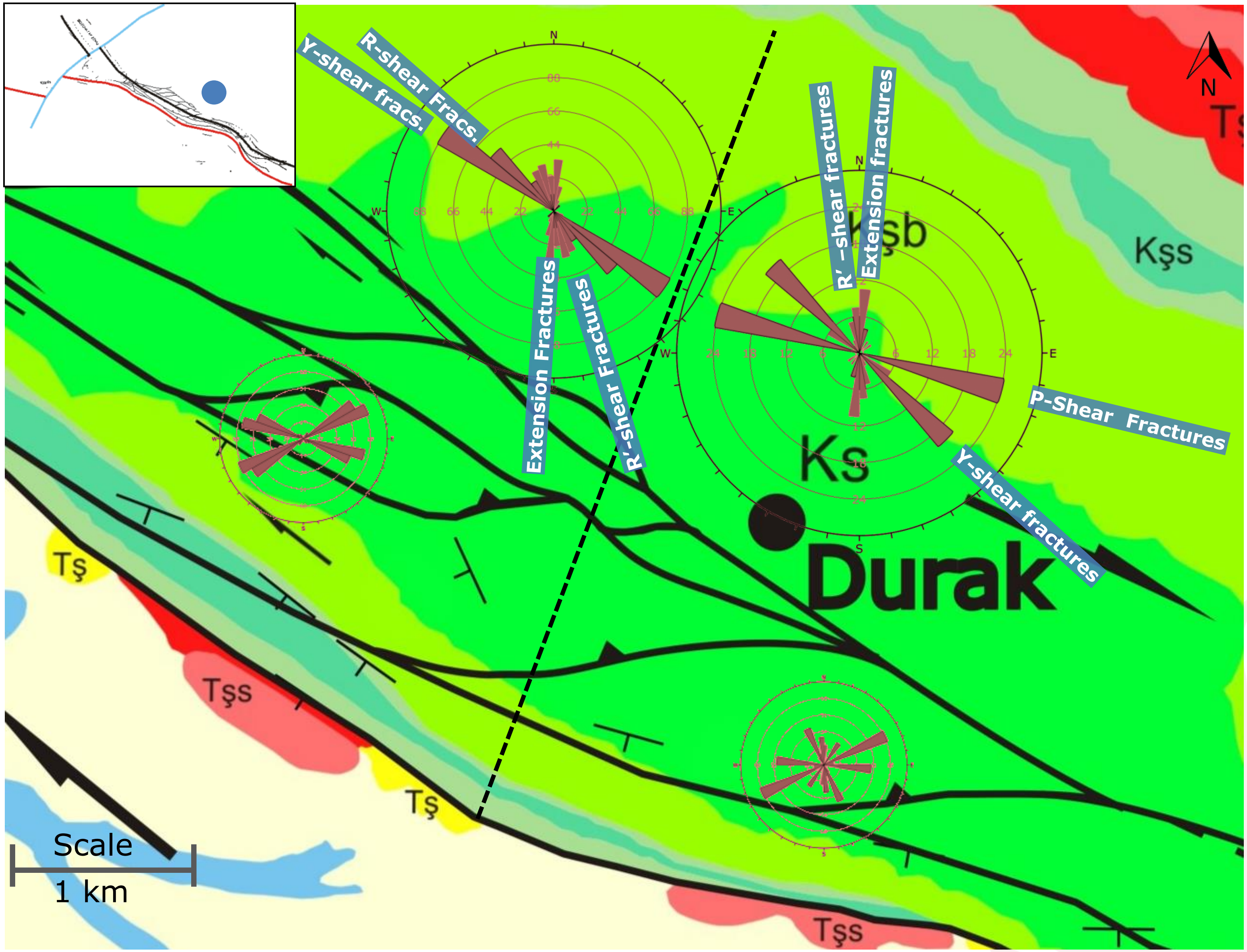


* Rose diagram and mean circles in stereographic plot of 440 fracture measurements. Intersected discs represent total thicknesses of each sets in a 1 meter diameter sphere.

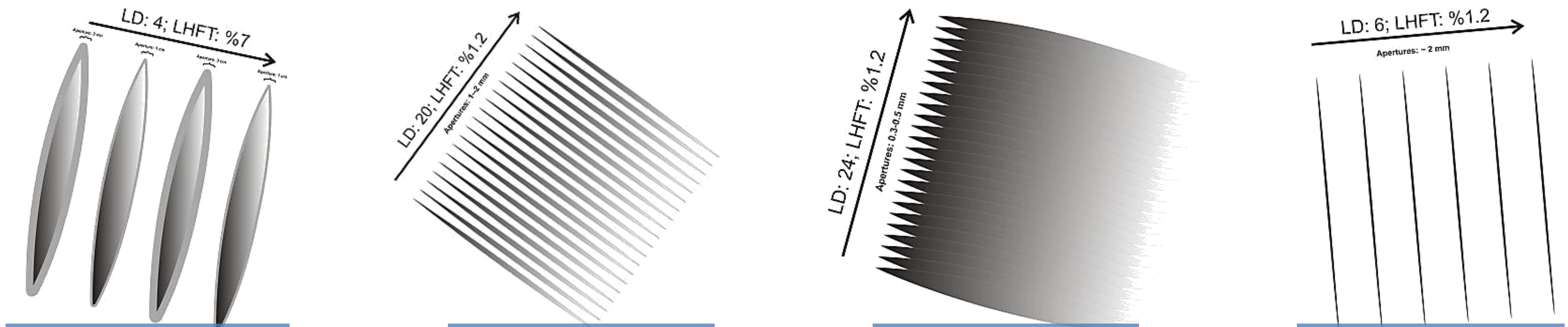


* Resultant vector of the most favorable drilling deviation azimuth.

Distant P-Shear Domain



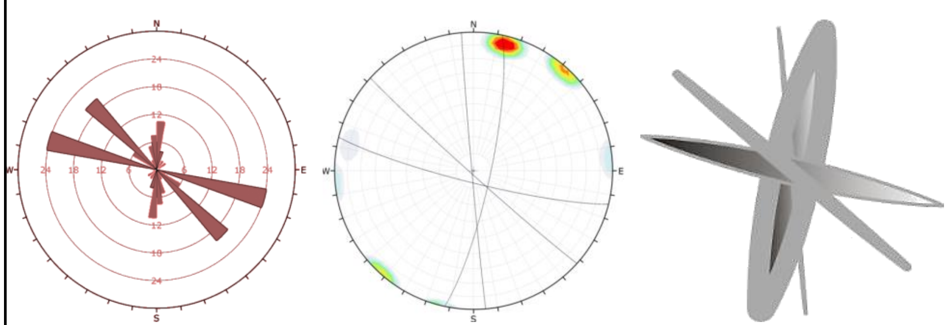
Distant P-Shear Domain Fractures



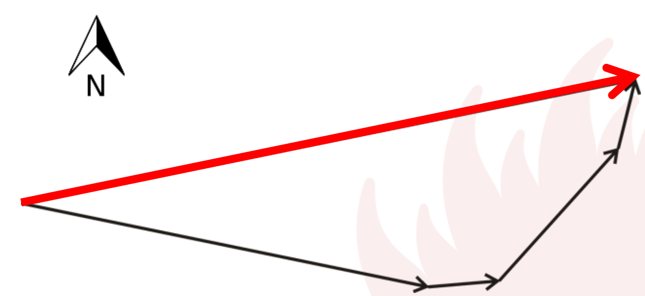
Extension Fractures **Y-Shear Fractures** **P-Shear Fractures** **R'-Shear Fractures**

Disc shape visualization of fractures in a 1 meter diameter sphere. Spacing and aperture values for each fracture sets visually represented with scale for 1 meter long scan lines.

Max. LHFT: 10.3%, Optimal well Trajectory azimuth :79

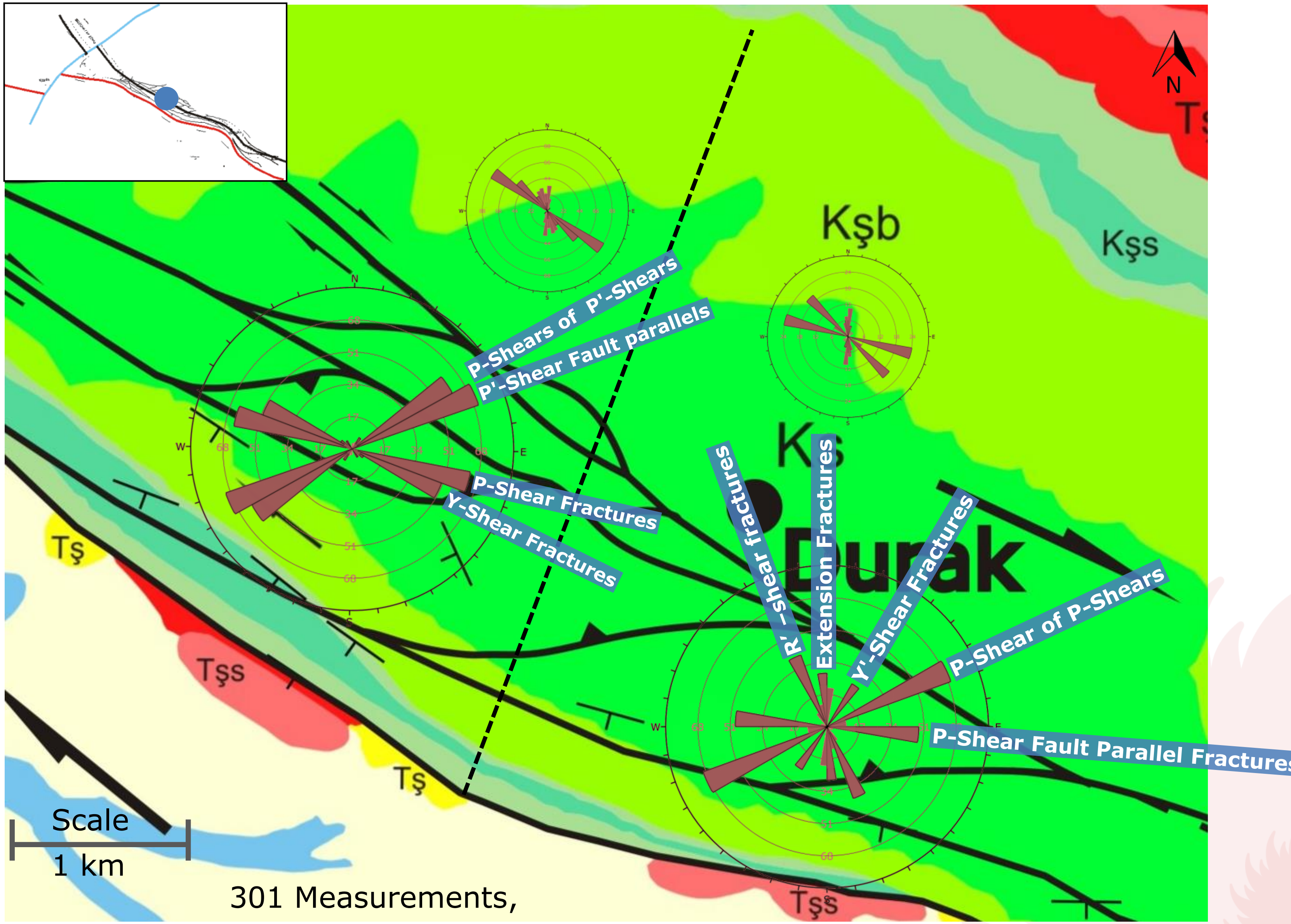


* Rose diagram and mean circles in stereographic plot of 124 fracture measurements. Intersected discs represent total thicknesses of each sets in a 1 meter diameter sphere.

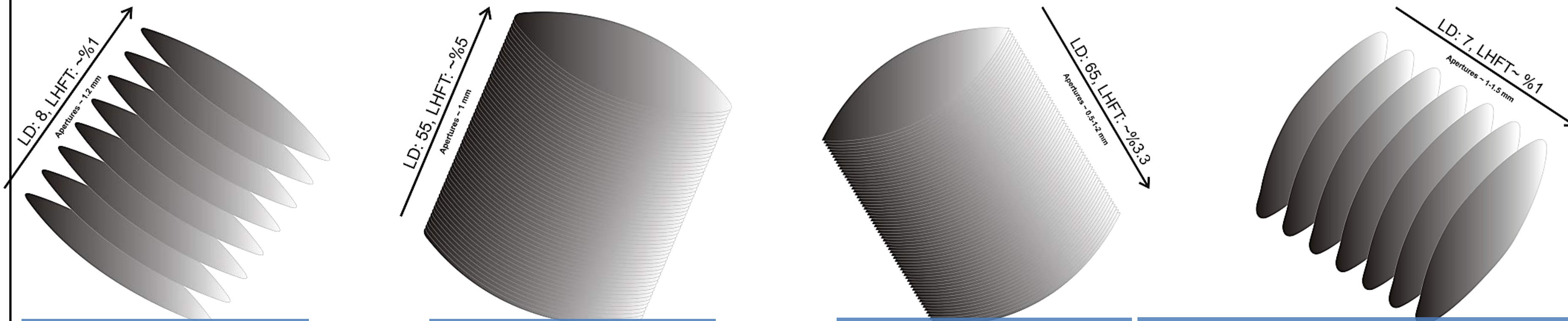


* Resultant vector of the most favorable drilling deviation azimuth.

Close to Fault Y-Shear Domain



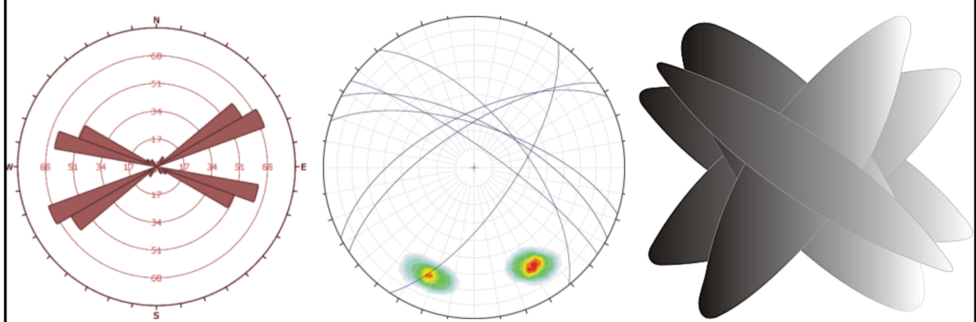
Close to Fault Y-Shear Domain



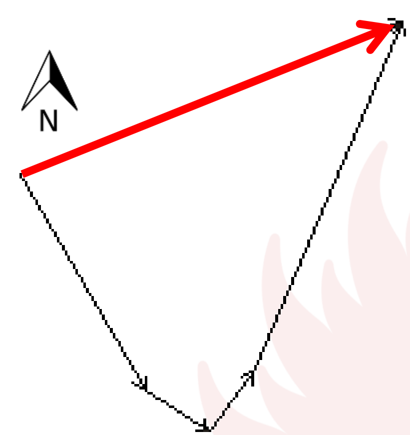
R-Shear Fractures **Y-Shear Fractures** **P'-Shear Fractures** **P-Shears of P'-Shear Fractures**

* Disc shape visualization of fractures in a 1 meter diameter sphere. Spacing and aperture values for each fracture sets visually represented with scale for 1 meter long scan lines.

Total LHFT: %5.5, Optimal well Trajectory azimuth :68.5

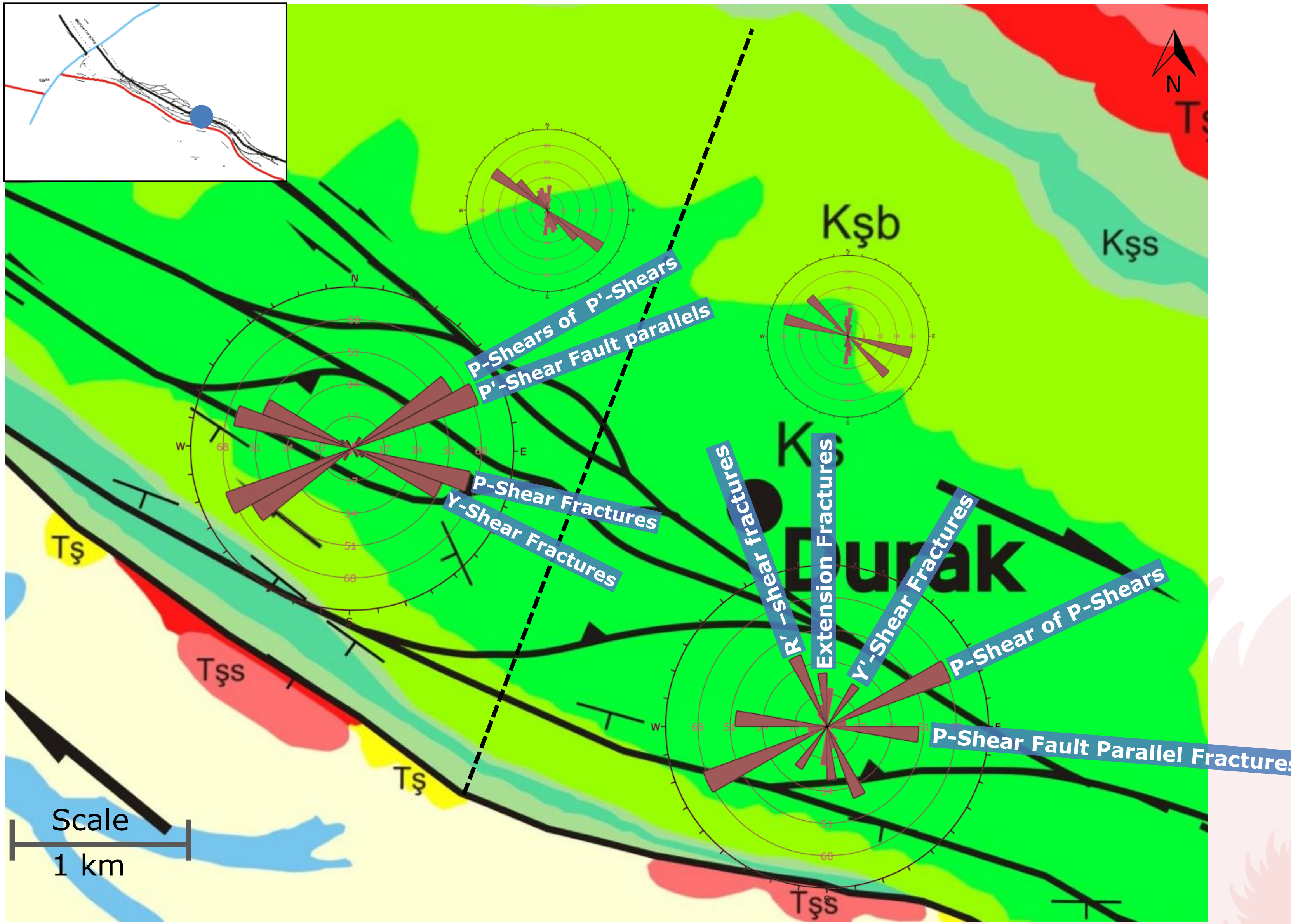


* Rose diagram and mean circles in stereographic plot of 301 fracture measurements. Intersected discs represent total thicknesses of each sets in a 1 meter diameter sphere.

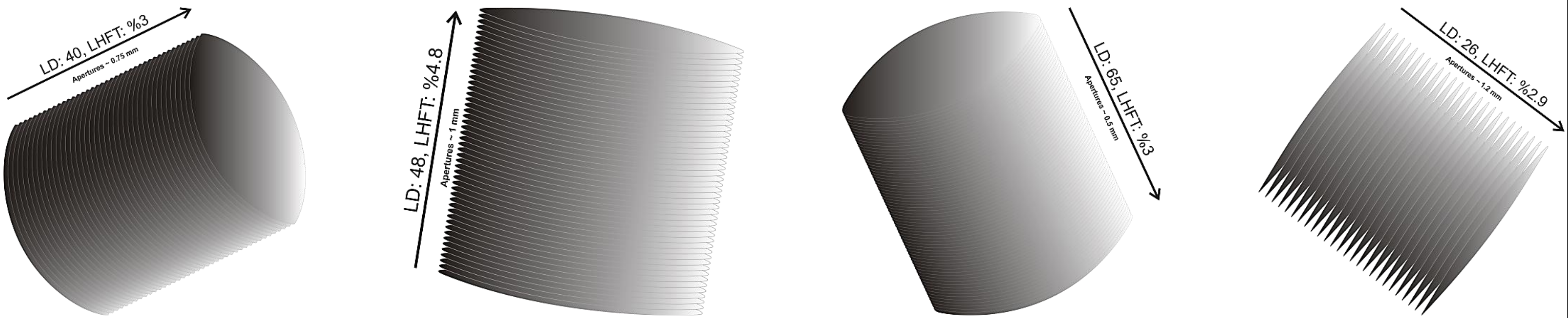


* Resultant vector of the most favorable drilling deviation azimuth.

Close to Fault P-Shear Domain



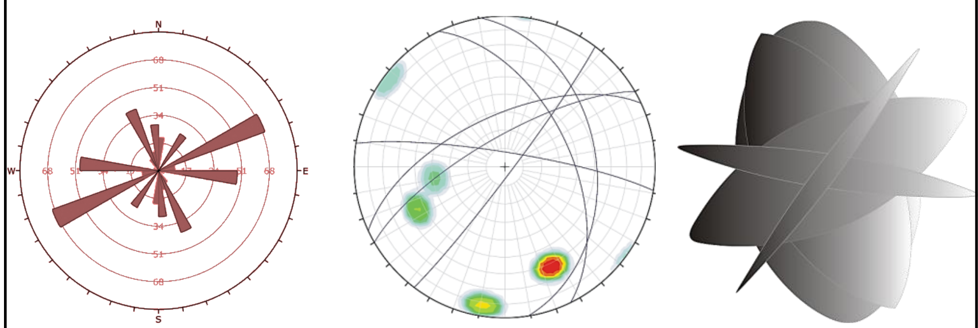
Close to Fault P-Shear Domain



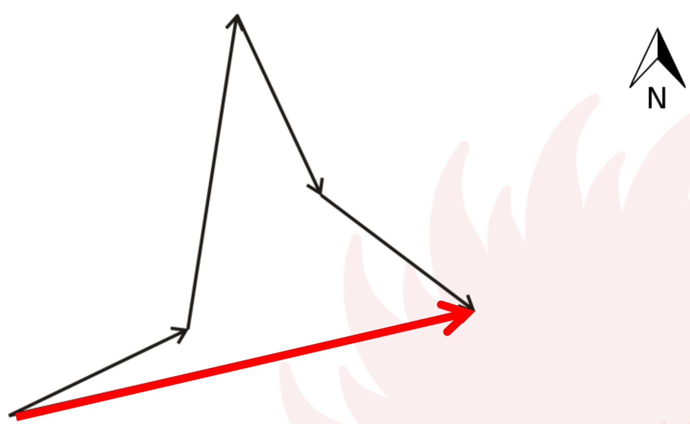
R'-Shear Fractures | **P-Shear Fault Parallel Fractures** | **P-Shear fractures of P-Shear Fault** | **Y'-Shear Fractures**

* Disc shape visualization of fractures in a 1 meter diameter sphere. Spacing and aperture values for each fracture sets visually represented with scale for 1 meter long scan lines.

Total LHFT:% 7.2, Optimal well Trajectory azimuth :77.3

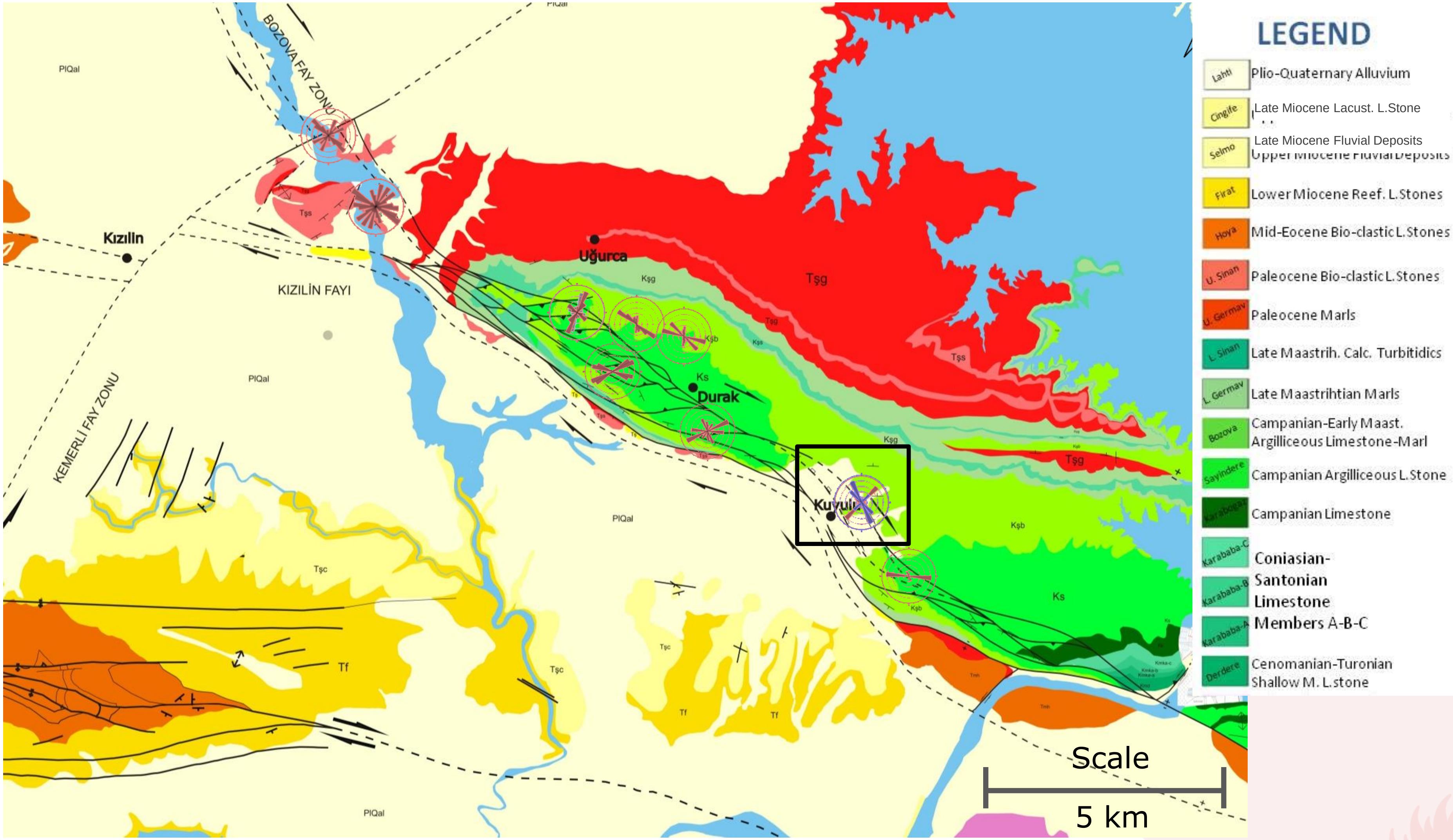


* Rose diagram and mean circles in stereographic plot of 284 fracture measurements. Intersected discs represent total thicknesses of each sets in a 1 meter diameter sphere.

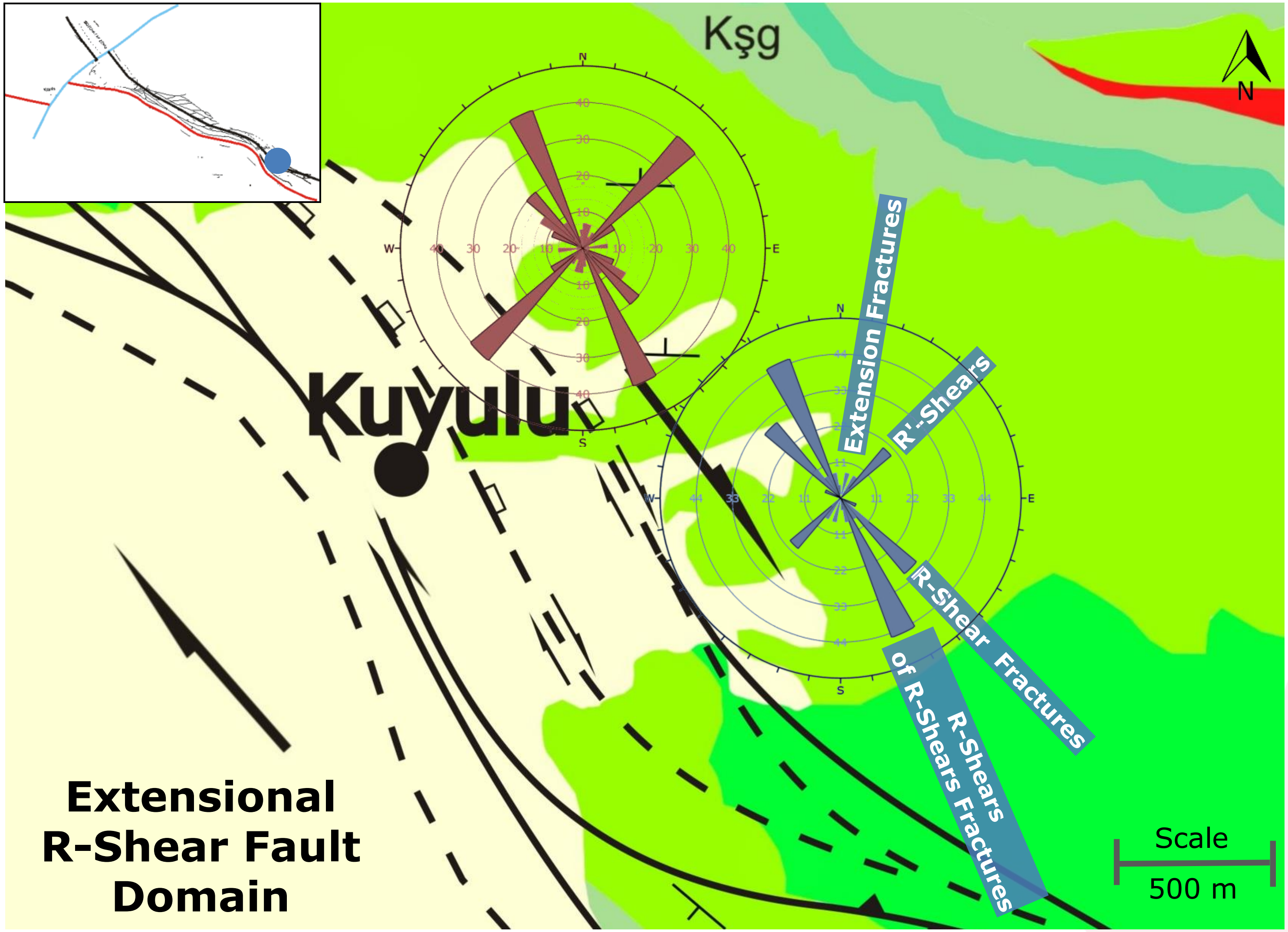


* Resultant vector of the most favorable drilling deviation azimuth.

Extensional Domain

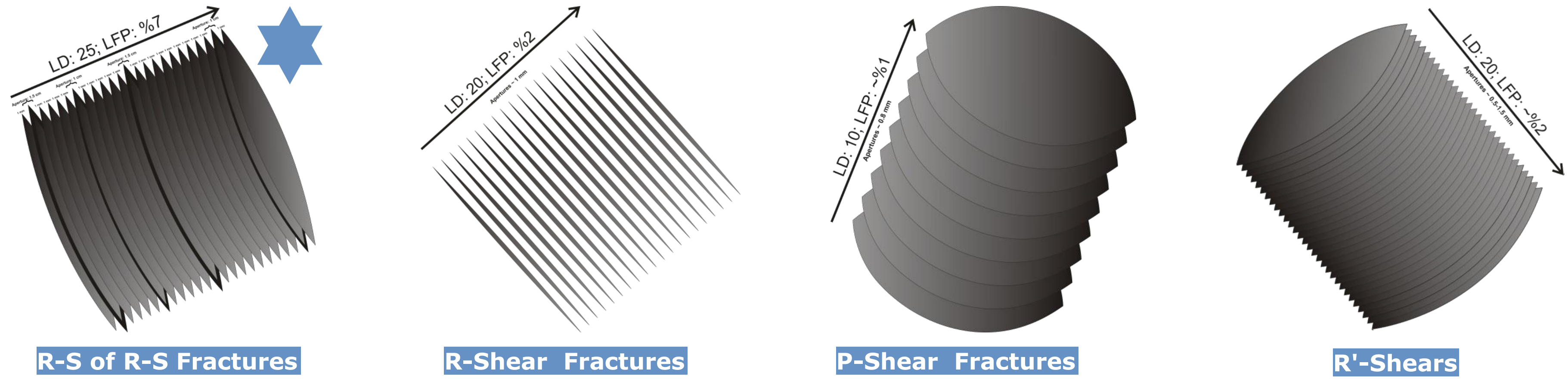


Extensional R-Shear Domain



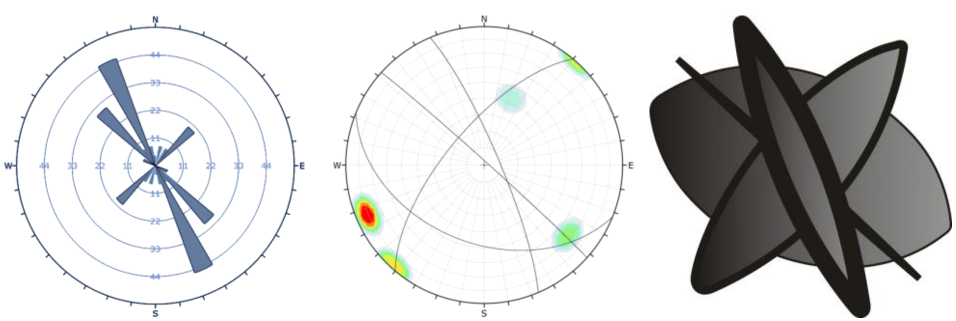
178 Measurements, 113 oil filled

Kuyulu Exhumed Fractured Reservoir

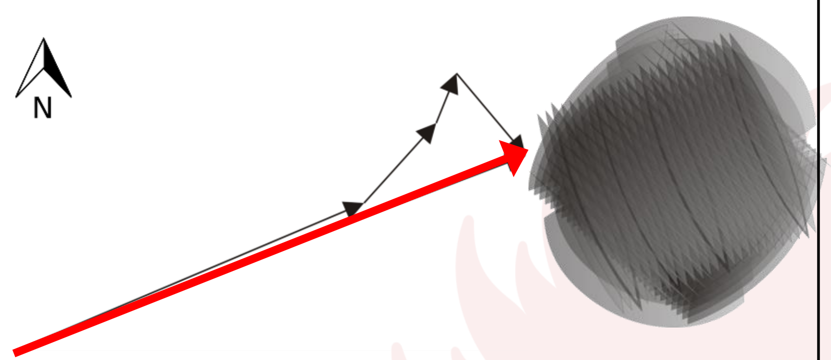


* Disc shape visualization of fractures in a 1 meter diameter sphere. Spacing and aperture values for each fracture sets visually represented with scale for 1 meter long scan lines.

Total LFP: %10.1, Optimal well Trajectory azimuth :68

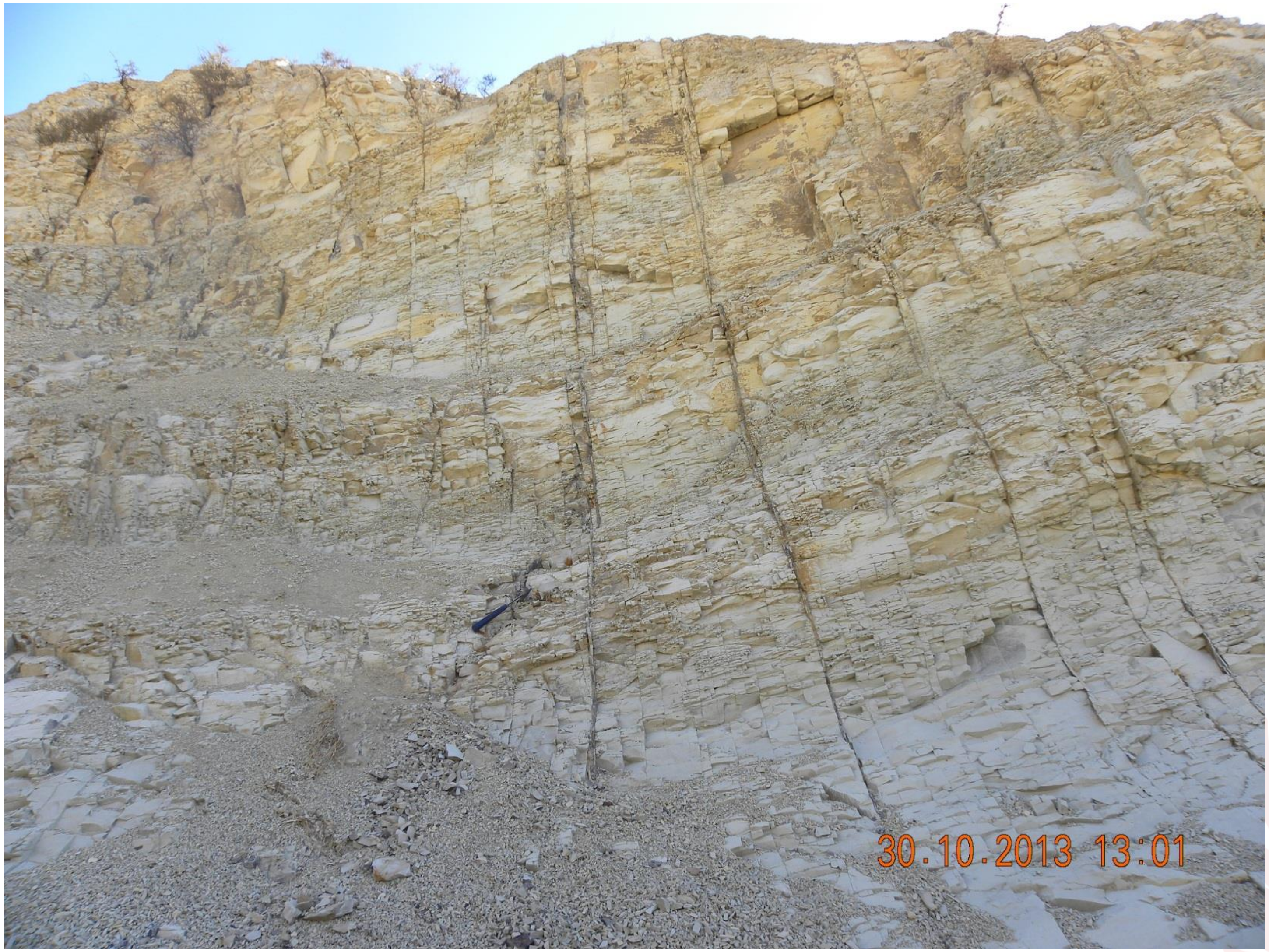


* Rose diagram and mean circles in stereographic plot of 178 fracture measurements. Intersected discs represent total thicknesses of each sets in a 1 meter diameter sphere.

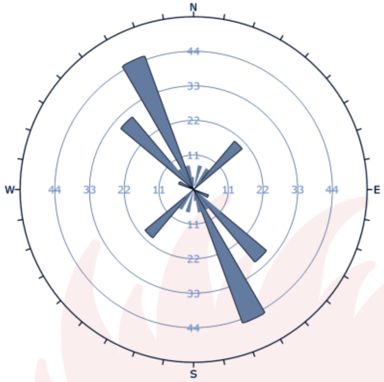


* Resultant vector of the most favorable drilling deviation azimuth and Spherical Representation of the fractured reservoir.

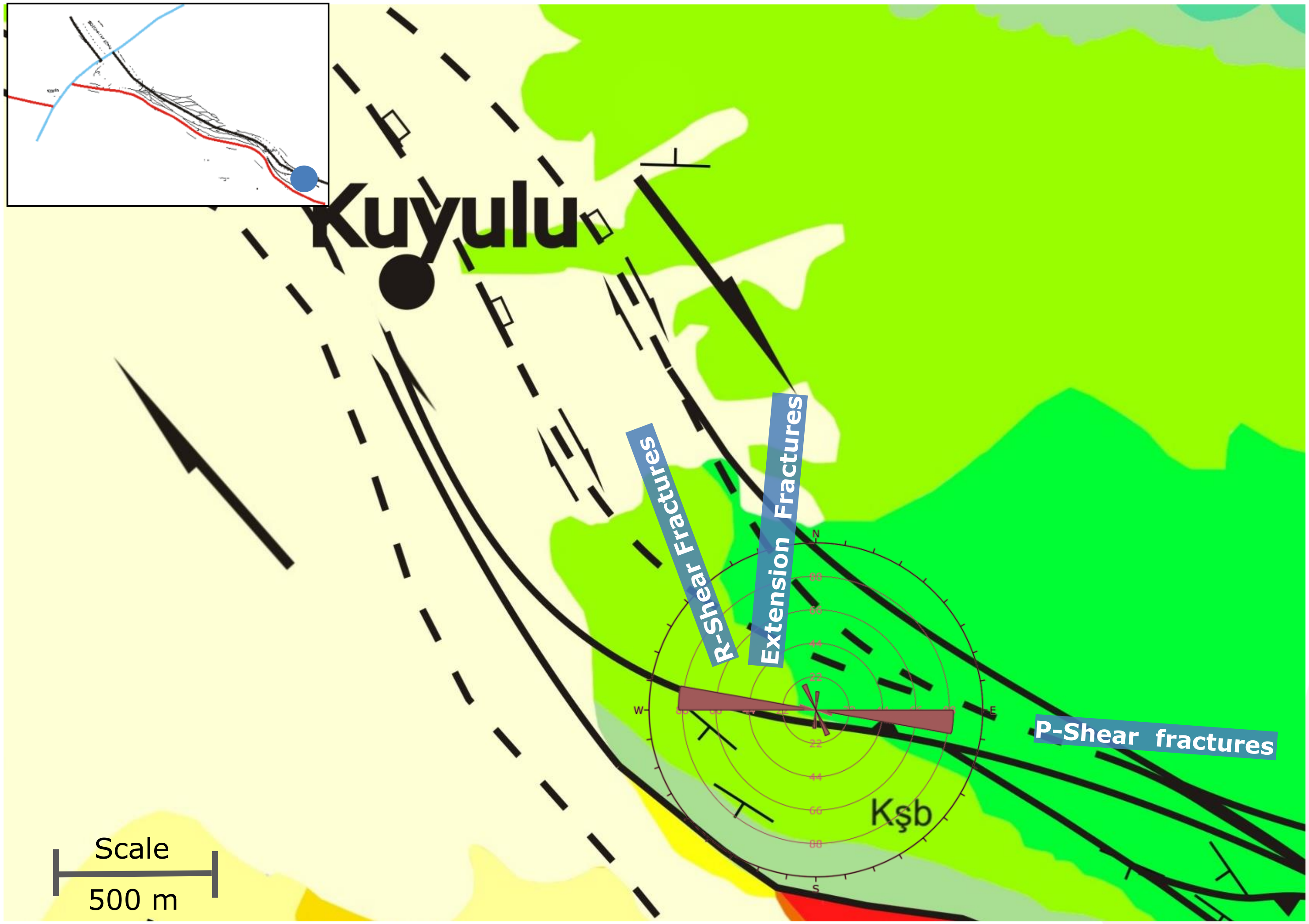
Kuyulu Exhumed Fractured Reservoir



Preferred Orientation of Conductive Fractures

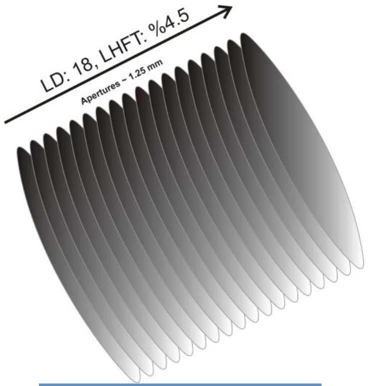


R-Shear to P–Shear Transition Domain

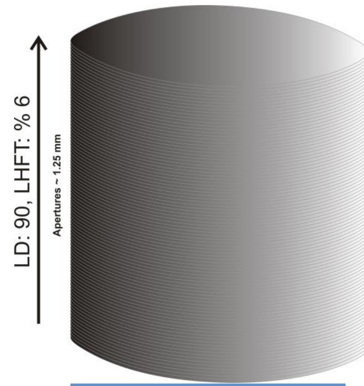


130 Measurements

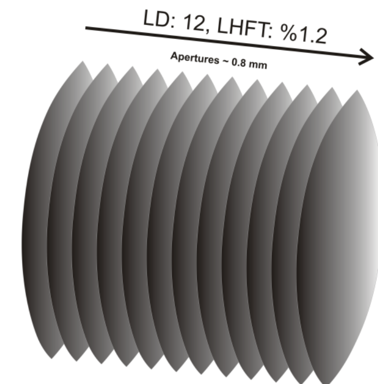
R-Shear to P–Shear Transition Domain Fractures



R-Shear Fractures



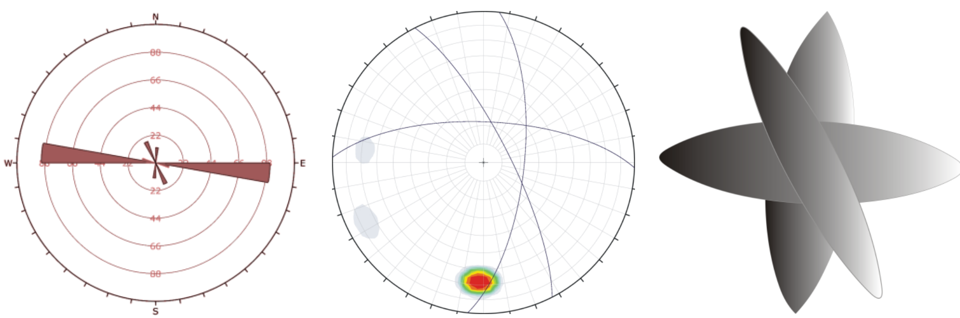
P-Shear fractures



Extension Fractures

* Disc shape visualization of fractures in a 1 meter diameter sphere. Spacing and aperture values for each fracture sets visually represented with scale for 1 meter long scan lines.

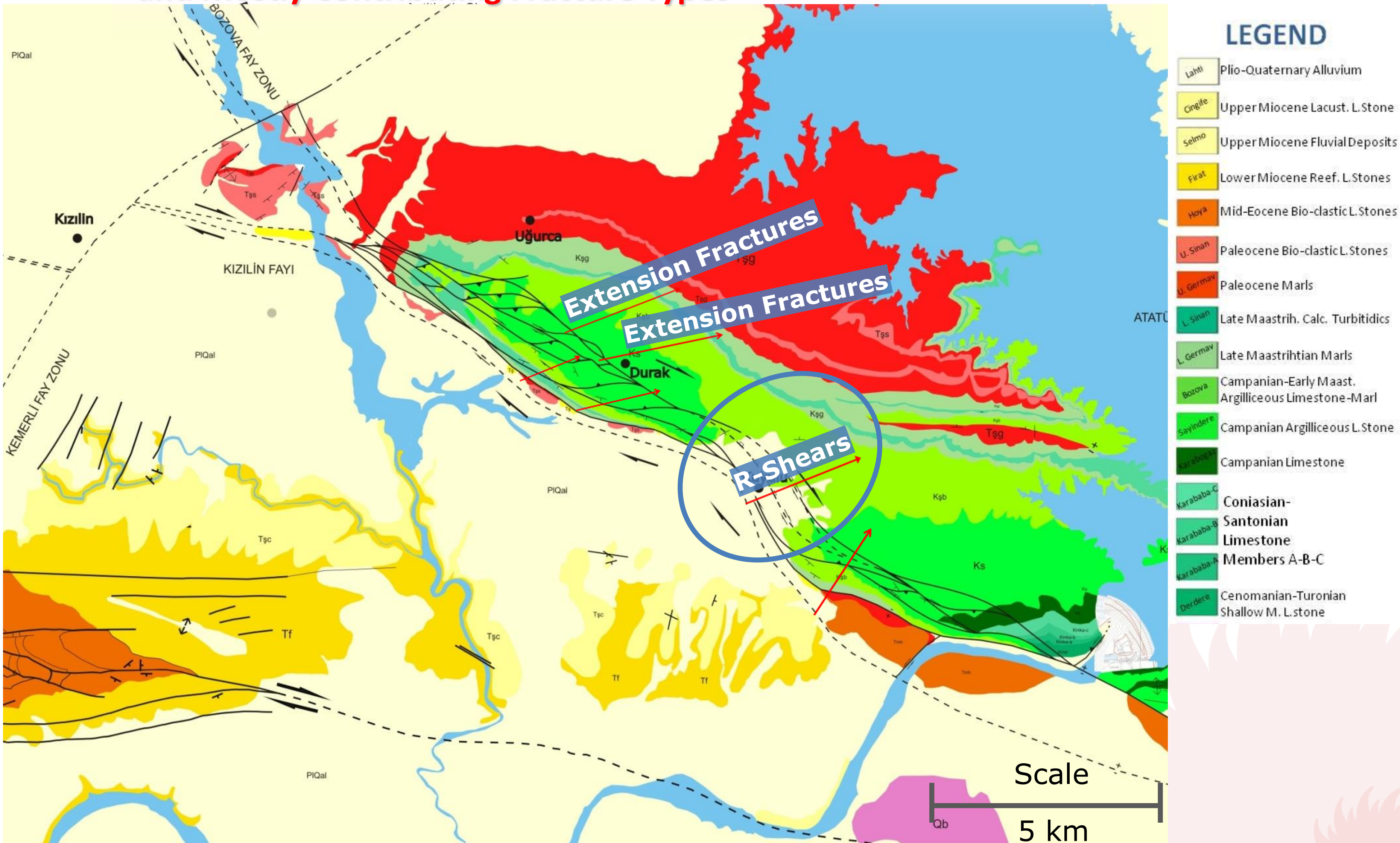
Total LHFT: %9.48, Optimal well Trajectory azimuth :33



* Rose diagram and mean circles in stereographic plot of 130 fracture measurements. Intersected discs represent total thicknesses of each sets in a 1 meter diameter sphere.

* Resultant vector of the most favorable drilling deviation azimuth.

For the Best Case Scenario* Drilling Locations, Best Trajectories and Mostly Contributing Fracture Types



*In case of all fractures would be unhealed and the domains would have been buried.

Results and Conclusions

- Discovery of Kuyulu exhumed oily fractured reservoir of Riedel-Shear structural domain signifies the importance of subsidenced (extensional) domains within the hinterland of strike-slip fault strands for naturally fractured oily reservoir explorations.
- These extensional domains are formed through Riedel of Riedel and Riedel shear fracture-fault corridors which have tensional component, and whose stress distribution favors extension fractures to remain open as well.
- This once again confirm the well-known phenomenon that prospective areas for open fracture corridors are expected to be in right stepping or bending to right domains of dextral fault zones, whereas left-stepping or bending to left domains of sinistral fault zones.
- Kuyulu exhumed oily fractured reservoir and some other producing fractured reservoir oilfields in the region are falling into R-Shear structural domains of different dextral strike slip faults. This fact may be guiding us for further exploration programmes.

- In order to encounter in the wells as many fracture and as much fracture porosity as possible, we could calculate using field data the optimal drilling deviation direction geometrically by summing up the vectors whose directions are perpendicular to the mean orientation of the fracture sets and whose magnitudes are proportional to the linear fracture porosity of each fracture set.