GENERATION AND MIGRATION OF PETROLEUM IN IRAQ: A 21/2D AND 3D MODELING STUDY OF JURASSIC SOURCE ROCKS

Compiled PowerPoint* Slides

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U.S. GEOLOGICAL SURVEY

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Preface

The Powerpoint presentation in this report was given at the American Association of Petroleum Geologists International Meeting in Cairo, Egypt, November, 2002. Some diagrams that appeared in the original presentation have been updated in this report. It presents results of a basin modeling study of the Jurassic Petroleum System in Iraq. Basin modeling provides a strategy for optimizing exploration in frontier areas and evaluating new plays within well-explored basins. A 1D, 21/2D, and 3D modeling study of the Jurassic petroleum system in Iraq was undertaken as part of the USGS World Energy Petroleum Resource Assessment Project in order to evaluate source-rock maturity, controls on reservoir filling, and the petroleum generation and migration history. Model simulations were generated using Integrated Exploration System's (IES) multiphase-flow (Petromod) software, a program designed to simulate multiphase fluid-flow in one, two, and three dimensions. Multi-1D simulations were performed to assess the thermal evolution of the region and, in turn, maturation of the source rocks. Potential hyrocarbon migration pathways and timing of reservoir filling were evaluated based on 21/2 D (ray-tracing) simulations. 3D modeling was undertaken to visualize the distribution of reservoir accumulations and directions of hydrocarbon flow since fluid migration and reservoir filling are three-dimensional processes.

Jurassic marine shales and carbonates are the major sources of hydrocarbons produced in the Zagros basin and fold belt. A few studies have been published on the stratigraphy and sedimentology of these source rocks, but information on their burial and temperature histories and regional thermal maturation patterns are generally lacking. The timing and extent of oil generation and secondary migration also have not been adequately addressed. The present study (1) examines source rock maturities using Type II-S kerogen kinetics to describe the kerogen-to-oil transformation process, (2) evaluates the timing of reservoir filling in oil fields, and (3) simulates hydrocarbon migration pathways based on the structural evolution of the basin. A better understanding of the timing and extent of oil generation, formation of traps and seals, and potential migration pathways permits simple risk assessments of areas that have potential (undiscovered) hydrocarbon resources.

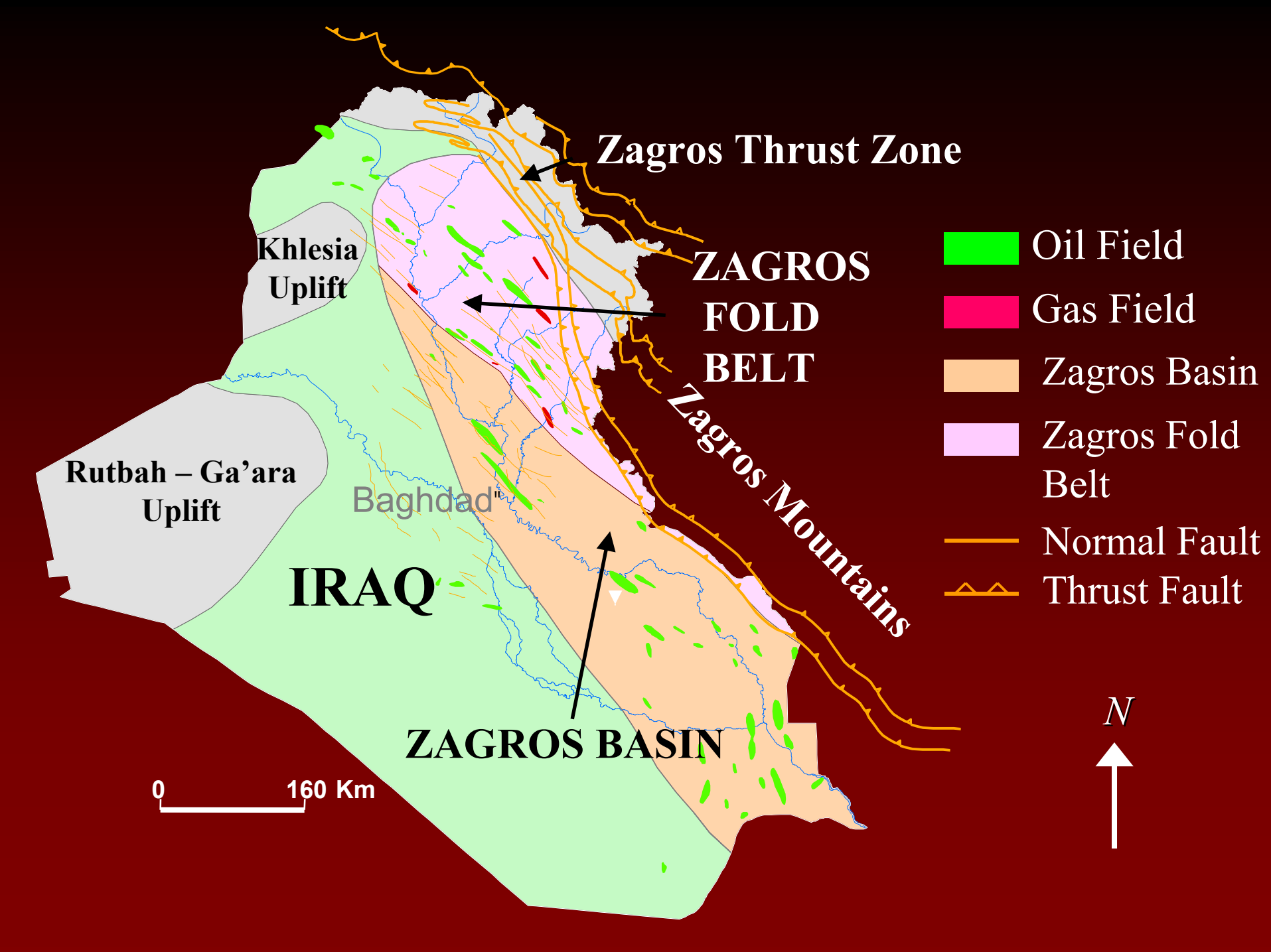
USGS
science for a changing world

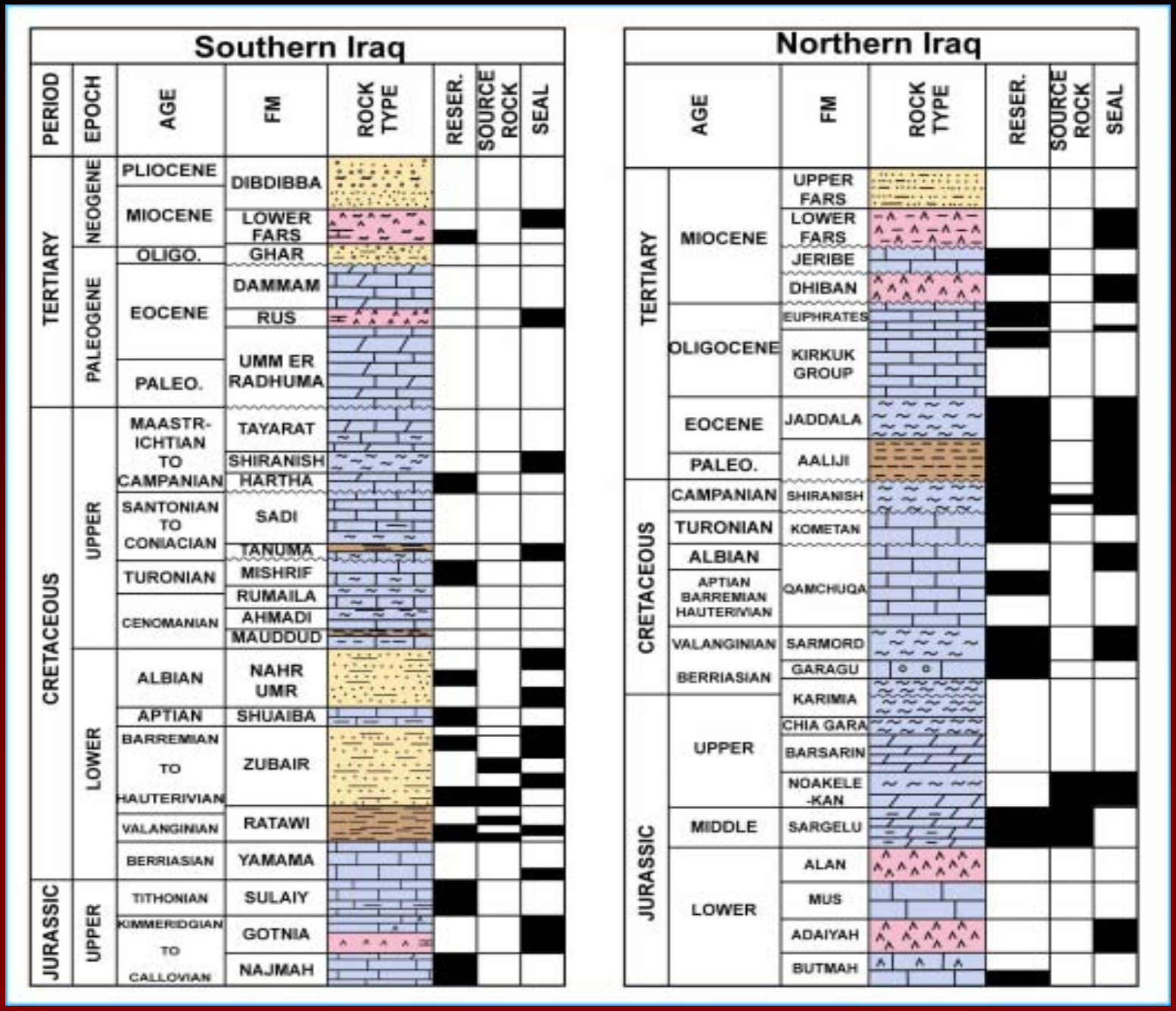
Generation and Migration of Petroleum in Iraq: A 21/2D and 3D Modeling Study of Jurassic Source Rocks

Janet K. Pitman
Douglas W. Steinshouer
Michael D. Lewan

PURPOSE OF STUDY

- Determine Jurassic Source Rock Maturities and Kerogen-to-Oil Transformation Process
- Predict Hydrocarbon Migration Pathways for Source and Reservoir Units Through Time
- Evaluate Timing of Reservoir Filling in Known Fields
- Develop Simple Risk Assessment of Undrilled Areas with Potential Hydrocarbon Resources for U.S.Geological Survey's World Petroleum Assessment 2000 (http://pubs.usgs.gov/bul/b2202-e/; U.S. Geological Survey Bulletin 2202-E)


Zagros Thrust Zone
ZAGROS
FOLD
BELT
Zagros Mountains
Khlesia
Uplift
Rutbah – Ga'ara
Uplift
Baghdad
IRAQ
ZAGROS BASIN
0
160 Km
Oil Field
Gas Field
Zagros Basin
Zagros Fold
Belt
Normal Fault
Thrust Fault
N

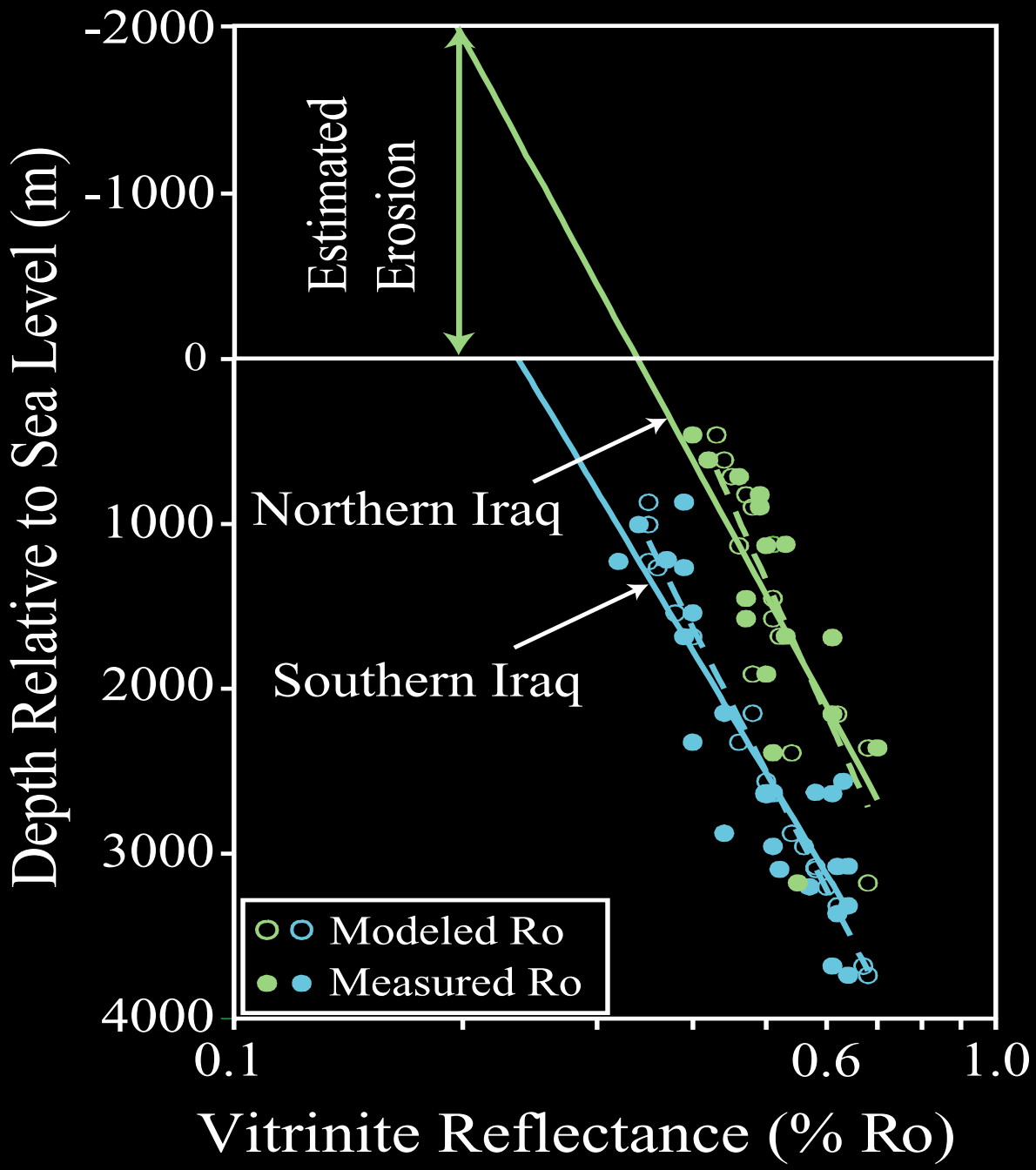


Modified from Alsharhan and Nairn (1997)

MODEL DEVELOPMENT

Integrated Exploration System (IES)
Multiphase-Flow Software

- 15 Chronostratigraphic Units with Thickness, Age, Facies, and Lithology Assignments
- Erosion/Nondeposition Events
- Temperature and Variable Heat Flow
- Source Rock Parameters
- Fault Assignments

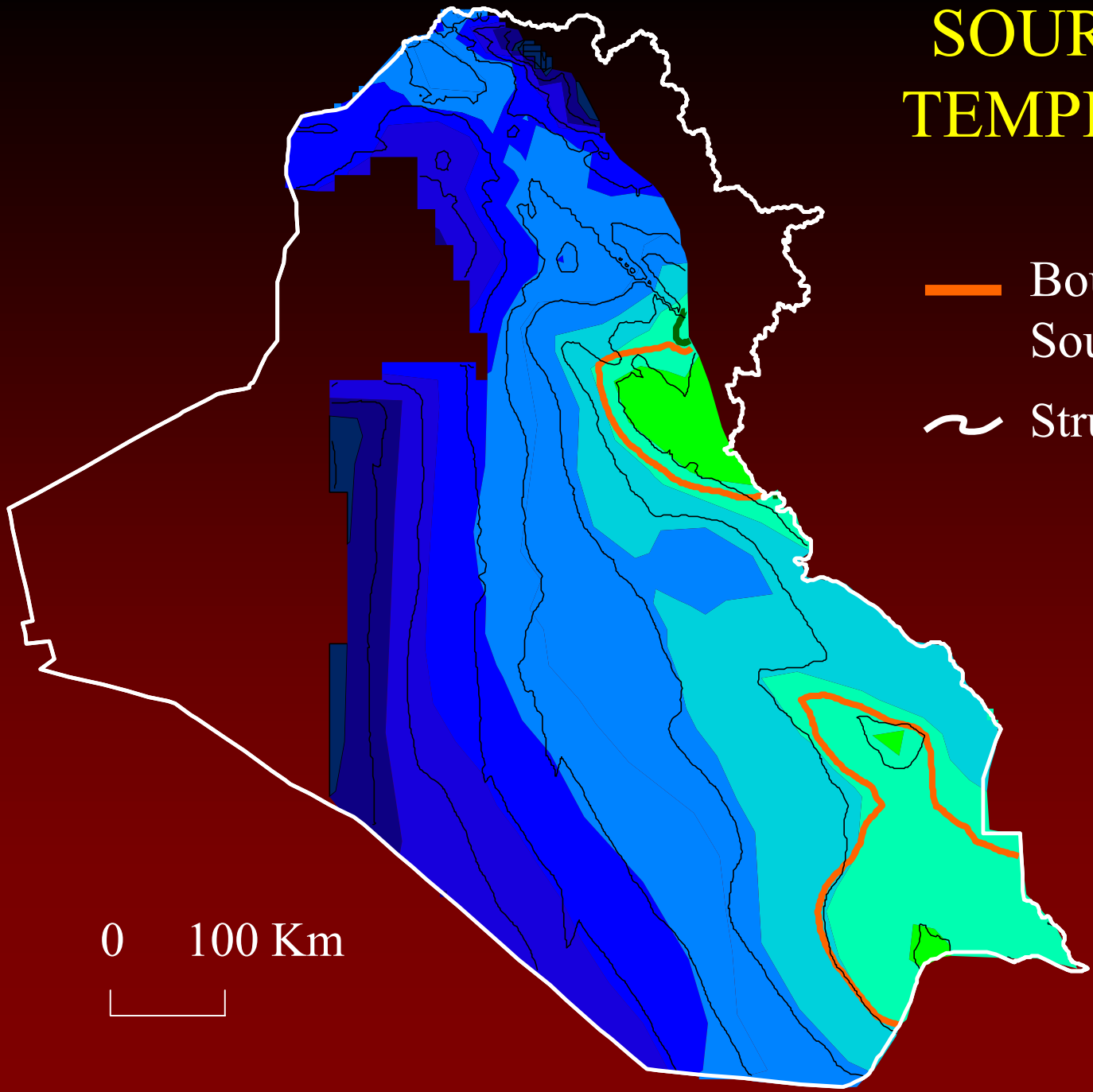

-2000
-1000
0
1000
2000
3000
4000
Depth Relative to Sea Level (m)
Estimated Erosion
Northern Iraq
Southern Iraq
Modeled Ro
Measured Ro
0.1
0.6
1.0
Vitrinite Reflectance (% Ro)

SOURCE ROCK CHARACTERISTICS

- Thickness: 10-80 m (Sargelu-Naokelekan Formations)
- Organic Matter: Type II-S Kerogen
- TOC = 5 wt. % Average (Unpublished Data)
- HI = 568 mg/g TOC (Unpublished Data)
- Kinetic Models: Hydrous Pyrolysis, Rock-Eval

FAULT PROPERTIES

- Fault Age (Fold Belt): Paleogene-Neogene
- Horizontal Direction: Semi-Sealing
- Vertical Direction: Semi-Open
- Major Faults: Absent in Central and Southern Zagros Basin



SOURCE ROCK TEMPERATURES 10 Ma

Boundary of Mature Source Rock

Structure Contour

20 C

40 C

60 C

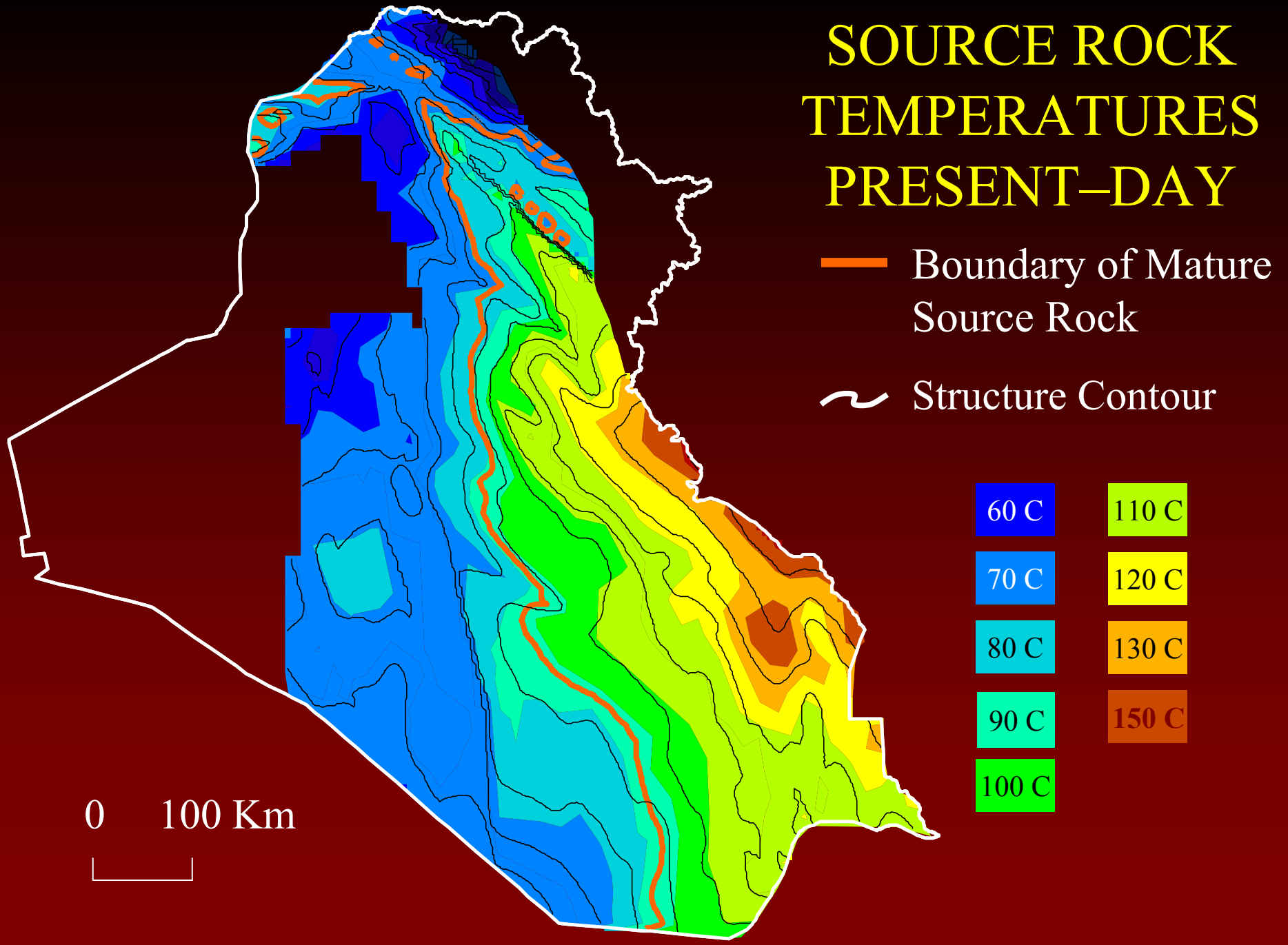
70 C

80 C

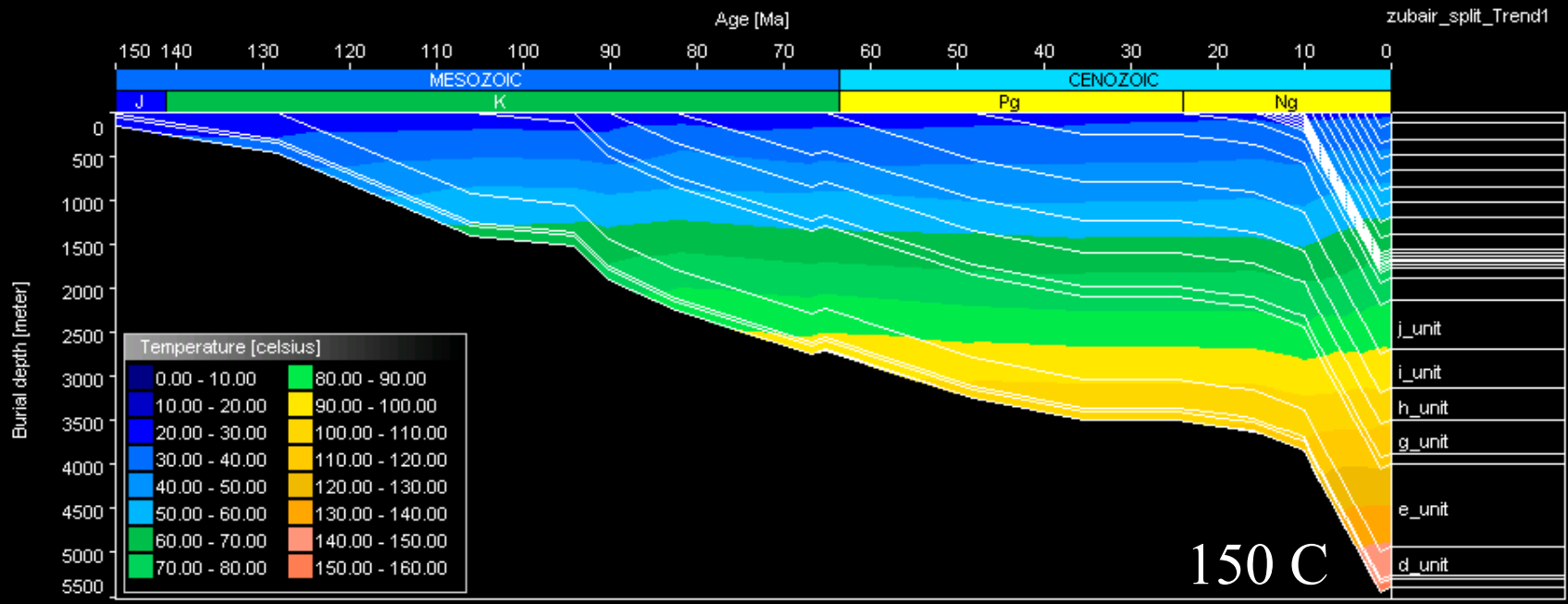
90 C

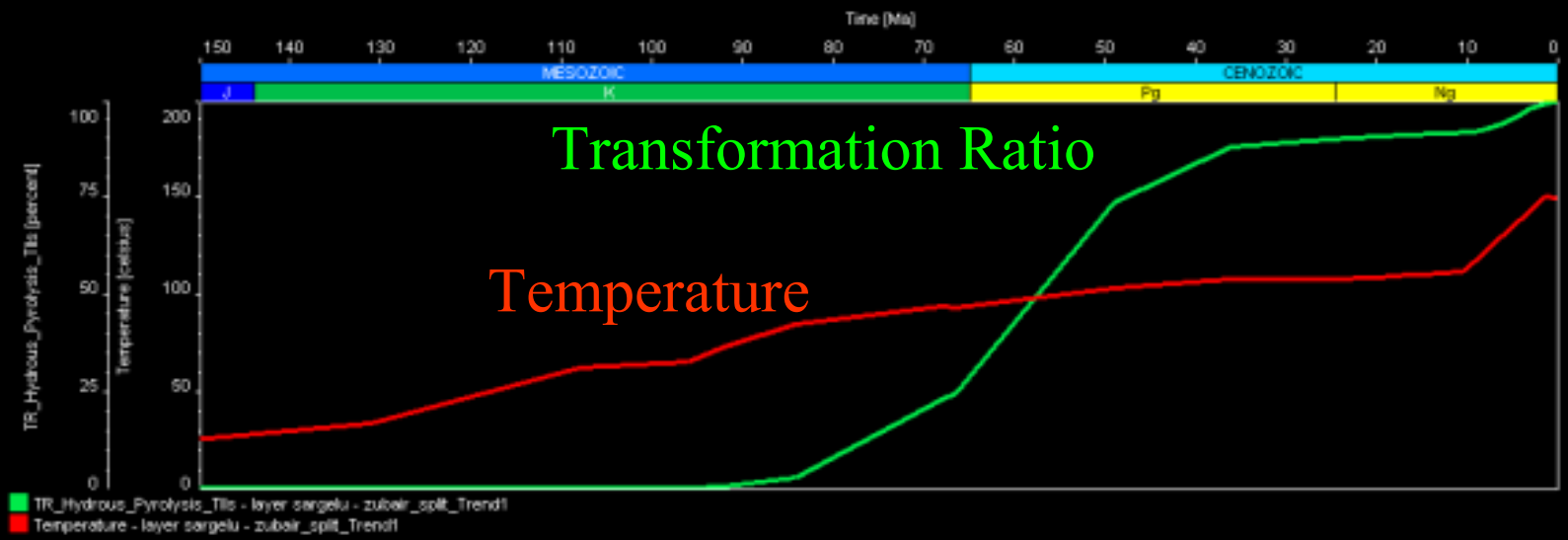
100 C

0 100 Km

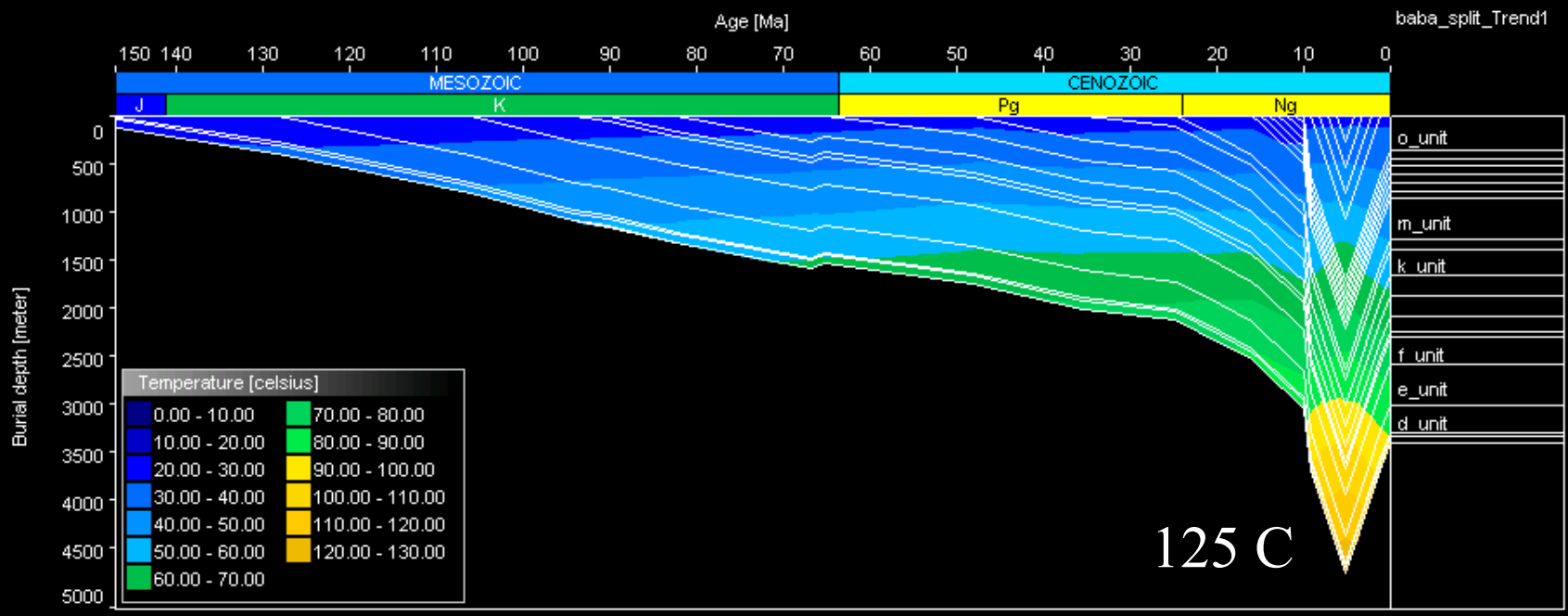

SOURCE ROCK
TEMPERATURES
PRESENT–DAY
Boundary of Mature
Source Rock
Structure Contour
60 C
70 C
80 C
90 C
100 C
110 C
120 C
130 C
150 C
0
100 Km

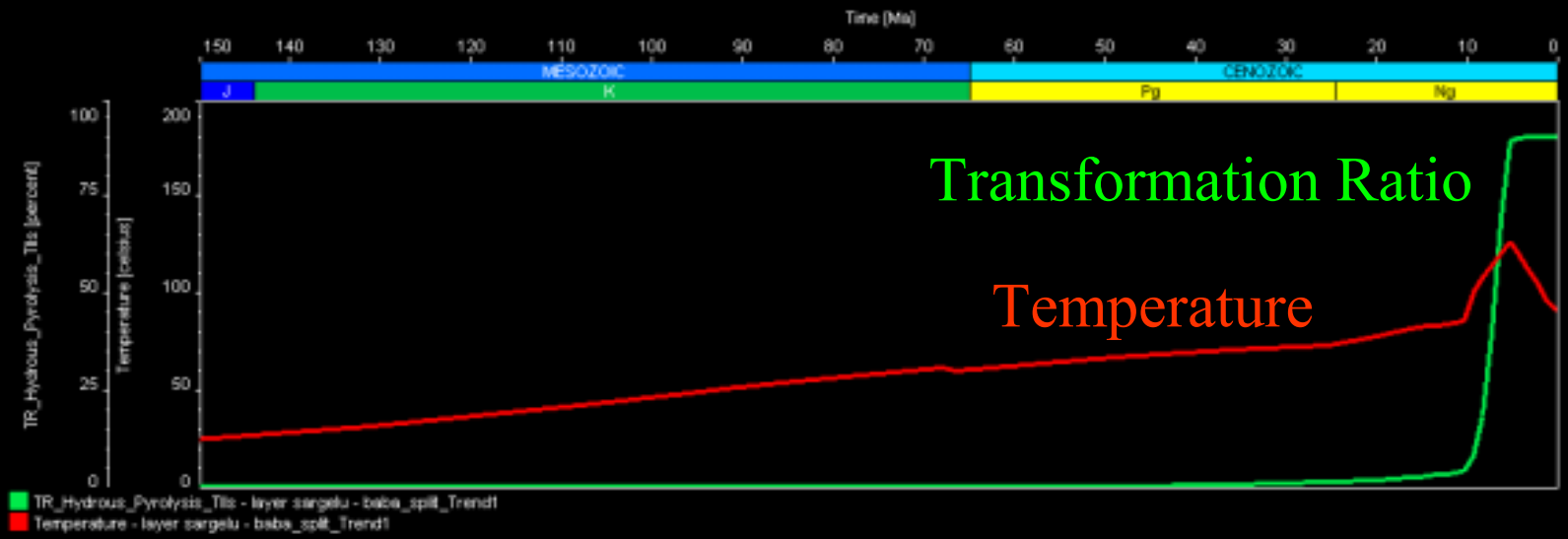
ZAGROS BASIN (ZUBAIR ANTICLINE)

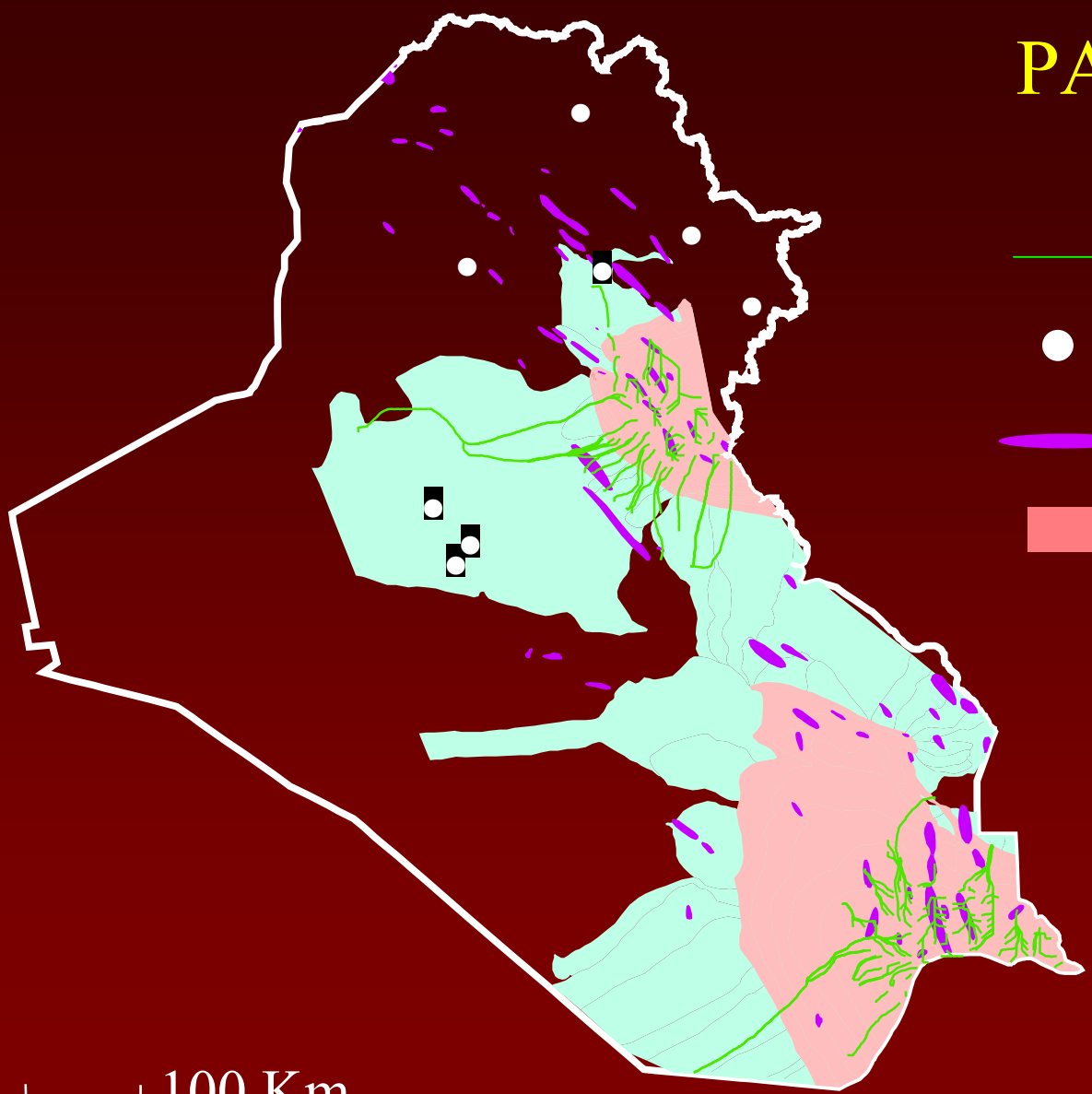


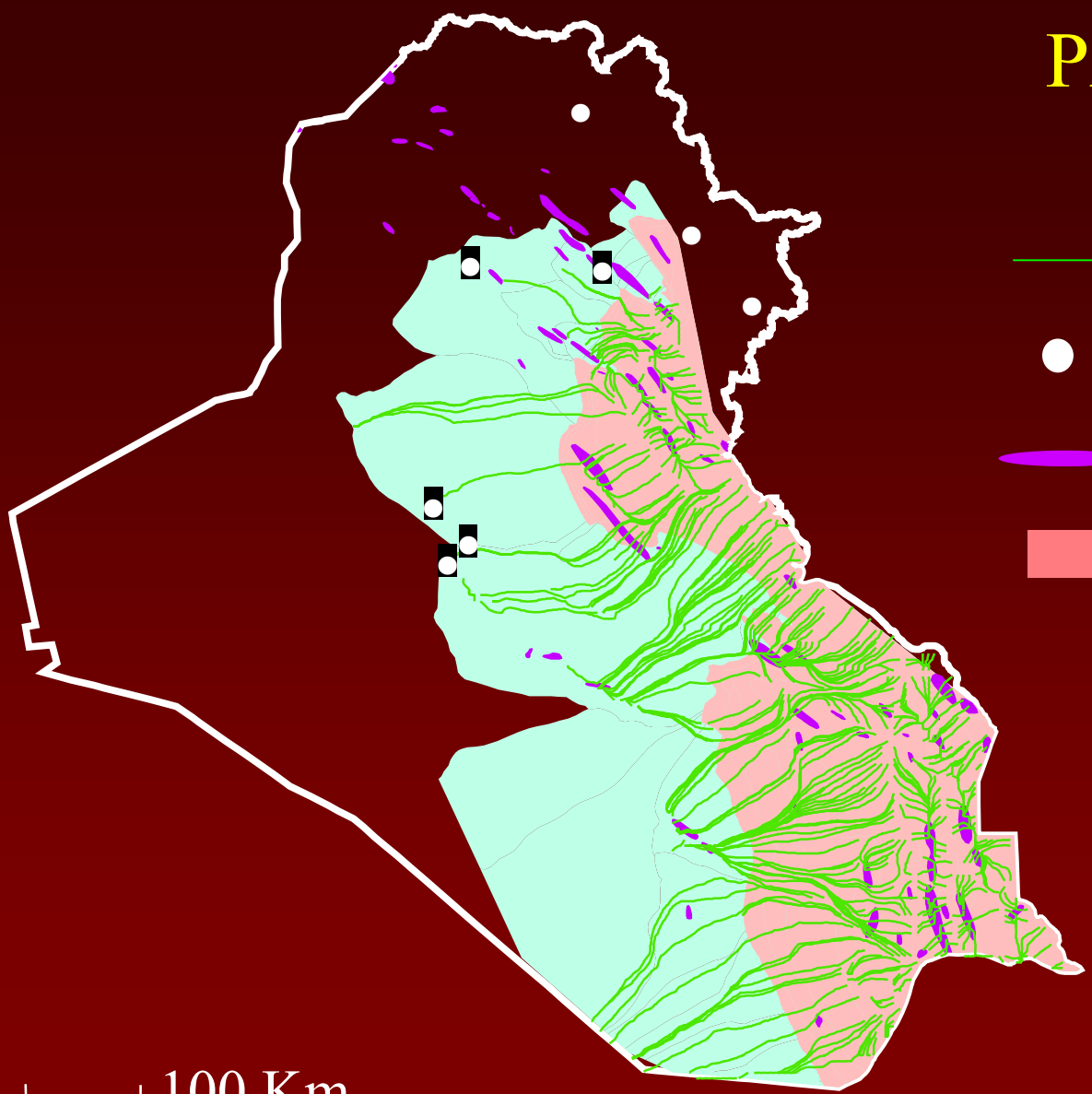


FOLD BELT (KIRKUK ANTICLINE)






MIGRATION
PATHWAYS
25 Ma
Pathways
Seep
Oil Field
Mature Source
Rock
100 Km



MIGRATION PATHWAYS 8 Ma

Pathways

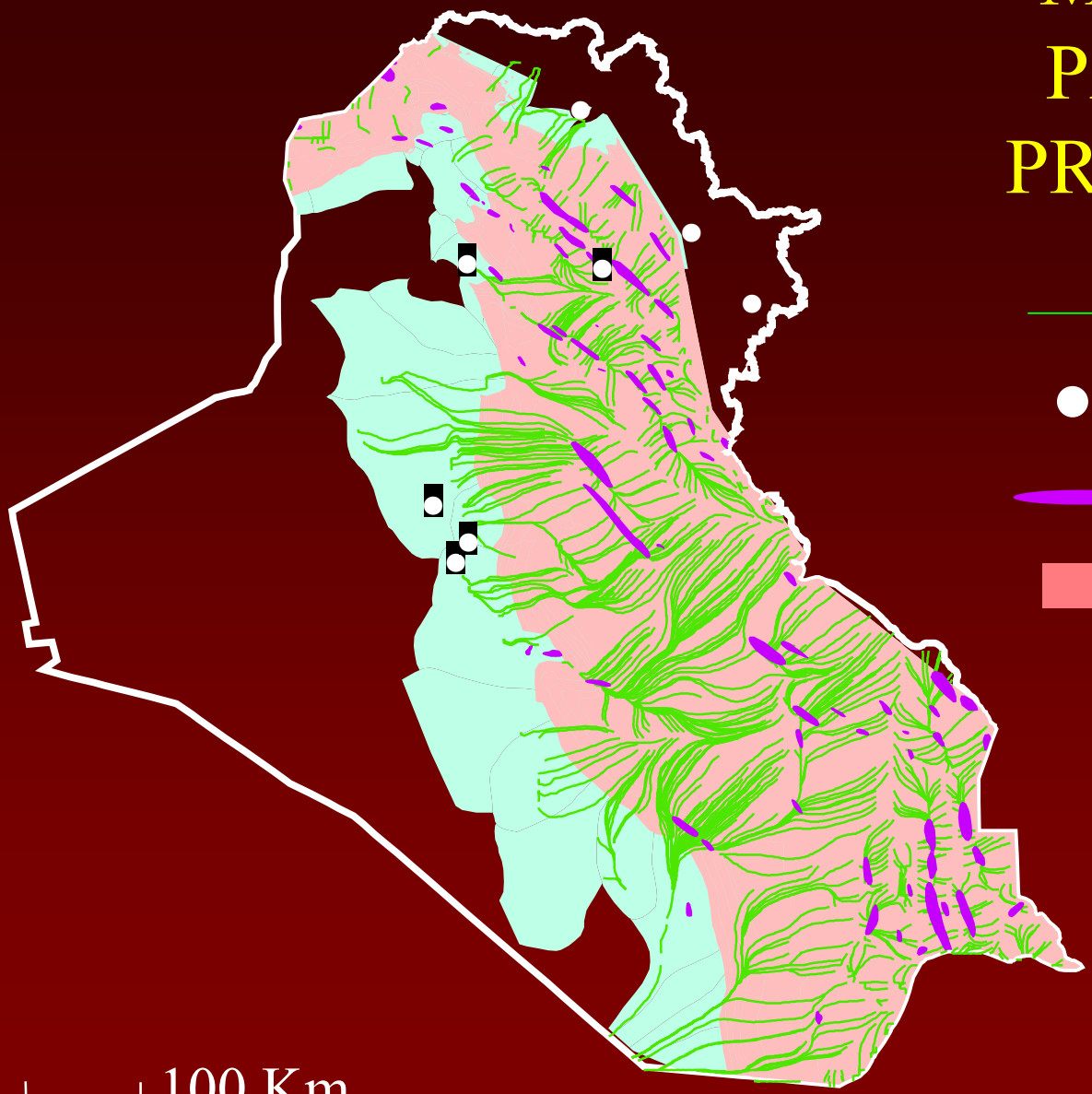
Seep

Oil Field

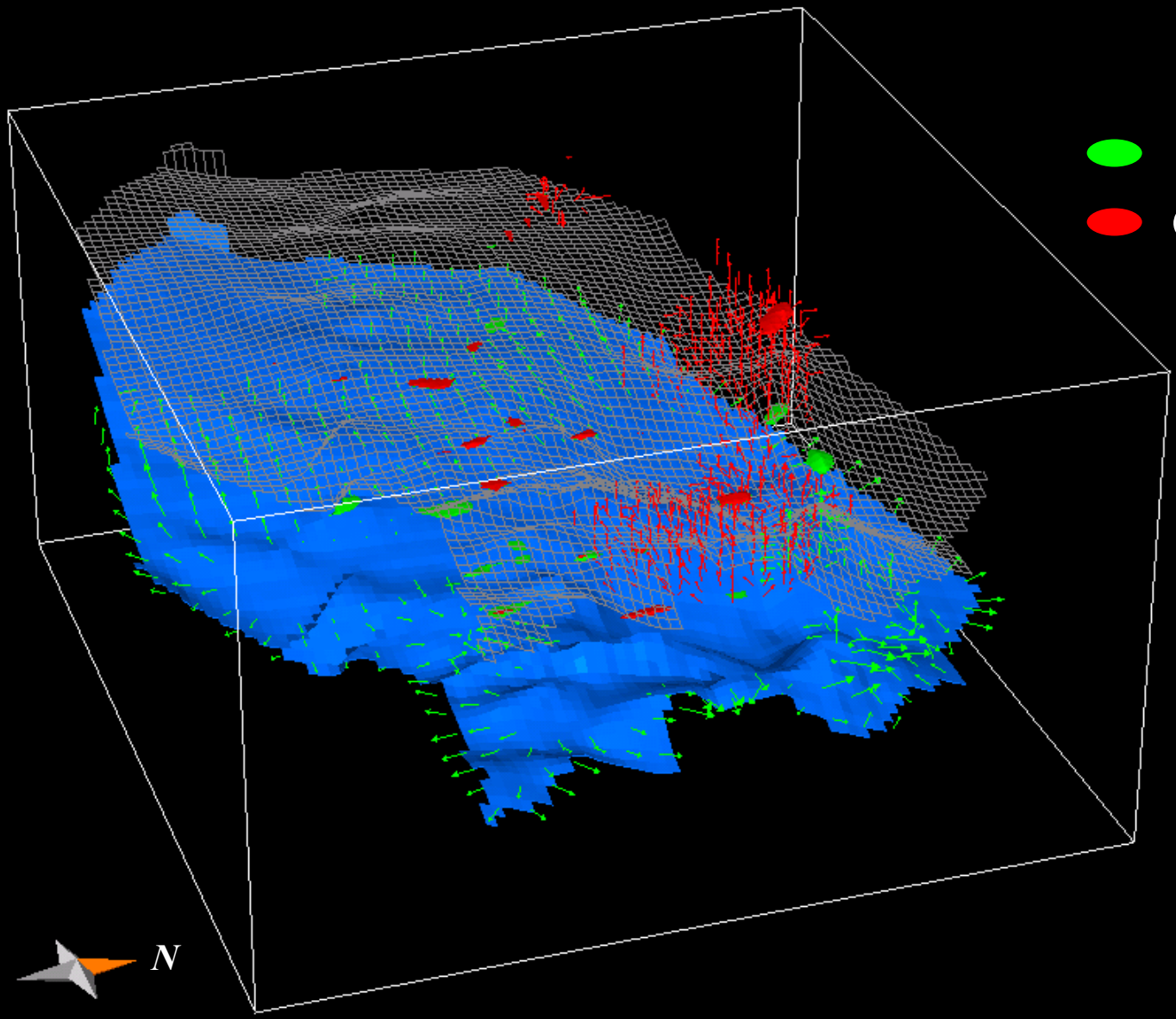
Mature Source Rock

100 Km

MIGRATION PATHWAYS PRESENT-DAY



3D SIMULATION-SOUTHERN ZAGROS BASIN



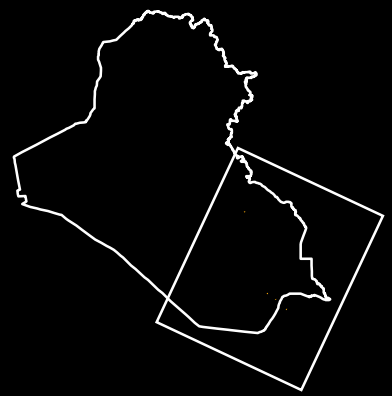
Oil Accumulation

Gas Accumulation

Source Rock

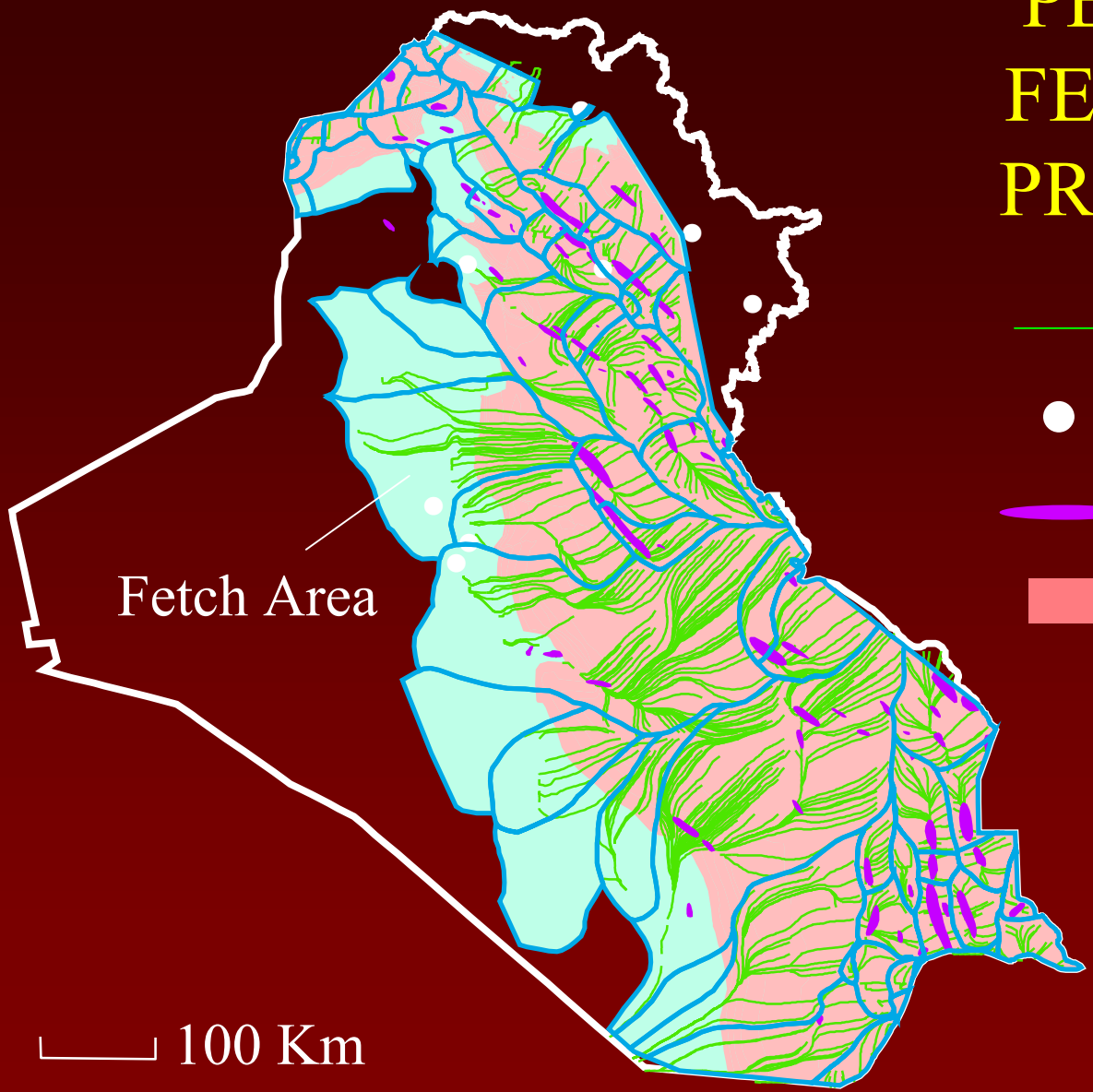
Oil Vector

Gas Vector



3D Area

PETROLEUM FETCH AREAS PRESENT-DAY



Pathways

Seep

Oil Field

Mature Source Rock

CONCLUSIONS

- Petroleum generation and migration commenced in the Late Cretaceous in the southern Zagros Basin following major trap development
- Generation and migration in the Zagros Fold Belt began during late Paleogene/Neogene folding and faulting which resulted in large hydrocarbon loss
- Modeled migration pathways predict all known petroleum accumulations in the Basin
- Model was used to assess prospective areas for U.S. Geological Survey's World Petroleum Assessment 2000