

Numerical Modeling of Cenozoic Compressional Events of Northwest Himalayas, Pakistan*

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Abstract

Numerical modeling of Cenozoic compressional events of NW Himalayas, Pakistan is presented. Our goal is to reconstruct stress evolution along major thrusts belonging to the two areas, including metamorphic/igneous and sedimentary regions. Considering the specific geometry of our problem and the available data at hand, a 2-D thin-plate approach was adopted, assuming plane strain conditions. In the model, linear elasticity was used and contact elements were introduced to simulate major faults. Variations in material properties and major thrusts were introduced into the model. For this purpose, we used FEM (ANSYSTM academic license) to simulate stress and fault slip patterns. We assumed N-S directed regional source of stress associated with collision of the Eurasian and Indian plates. The Panjal Thrust and its inferred continuation into the Lesser Himalayan Sedimentary Zone form the major mechanical discontinuity in the model. Our results show that the Panjal Thrust divides the study area into two different stress provinces: the metamorphic/igneous (Higher/Lesser Himalayan Metamorphic Zone), and the sedimentary region (Lesser Himalayan Sedimentary Zone and Sub Himalaya). Compressive structures are observed along all major thrusts including Panjal Thrust, Nathia Gali Thrust, Main Boundary Thrust, and the Salt Range Thrust. The restored stress patterns in NW Himalayas also agree well with the observed present-day stress configuration. Our analyses also suggest significant strike-slip movement along Jhelum Fault (left lateral) and Kalabagh Fault (right lateral) where maximum principle stress (σ_{hmax}) aligned itself along the strike of the faults. The stress pattern associated with strike-slip movement also to be expected to occur along some segments of major thrusts.



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NUMERICAL MODELING OF CENOZOIC COMPRESSIONAL EVENTS OF NW HIMALAYAS, PAKISTAN

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Out Line of Presetation

Phase I

- Intrudction of Study Area
- Regional Geology
- Structural Development

Phase II

- Methedology & Tool
- Results
- Conclusions

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

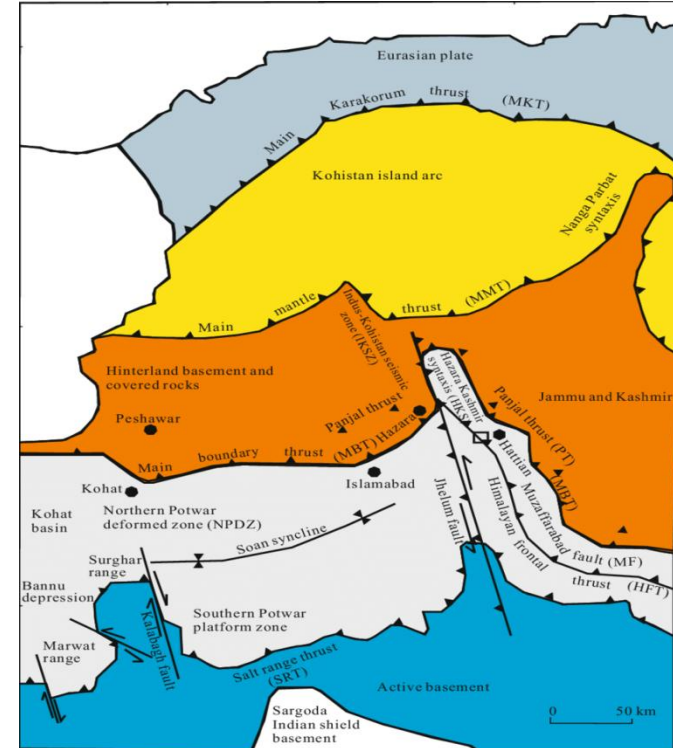
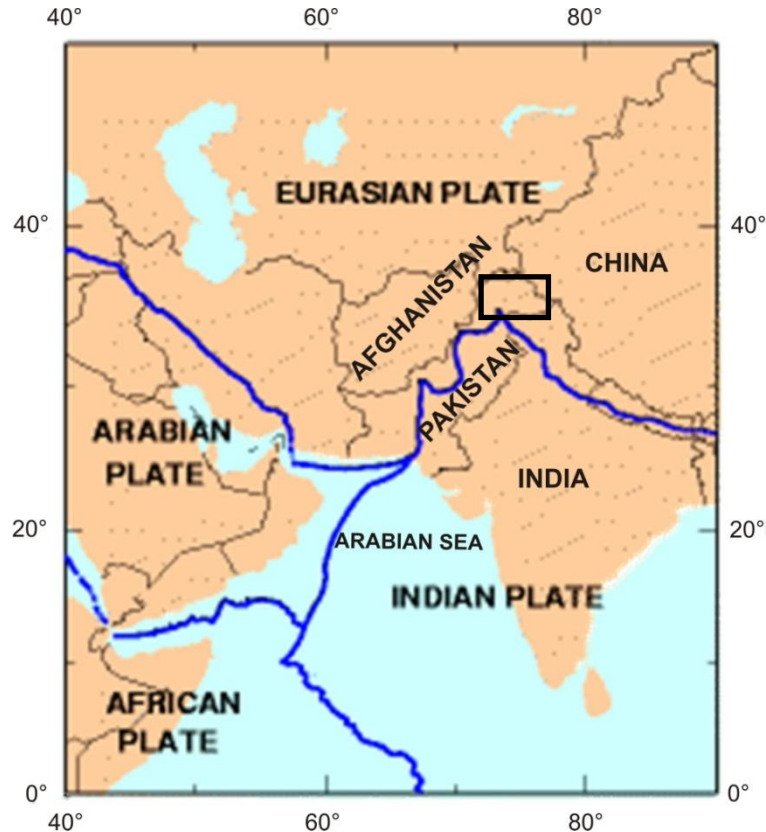
Objectives

Methods & Tools

Numerical Modeling

Results

Conclusions



Baig 2006

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

Objectives

Methods & Tools

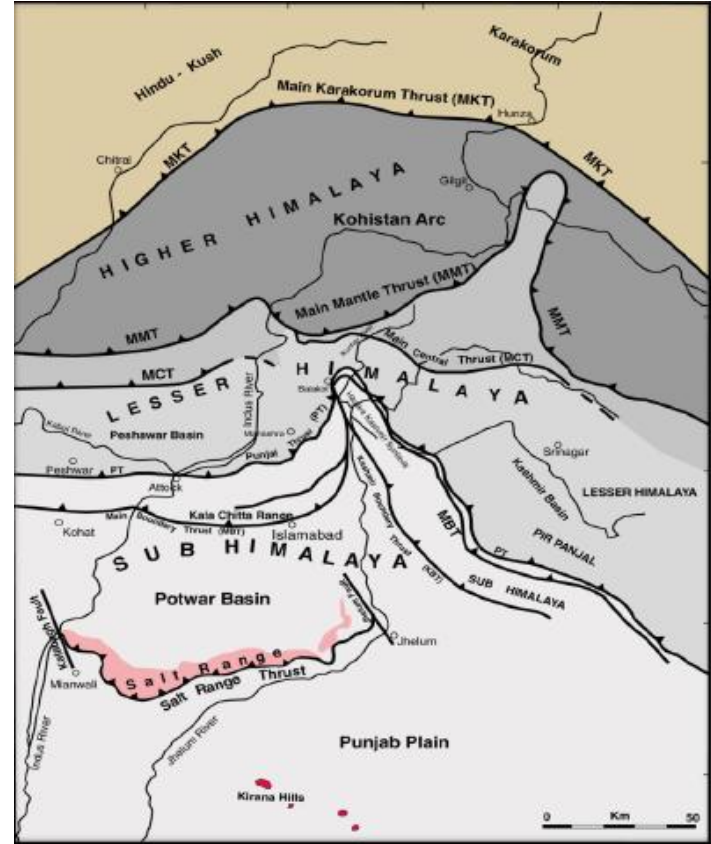
Numerical Modeling

Results

Conclusions

Division of Himalaya

- Higher Himalaya
- Lesser Himalaya
- Sub Himalaya



Main Karakorum Thrust (MKT) – Main Mantle Thrust (MMT)
(Higher Himalaya)

Main Mantle Thrust (MMT) – Main Boundary Thrust (MBT)
(Lesser Himalaya)

Main Boundary Thrust (MBT) – Salt Range Thrust (SRT)
(Sub Himalaya)

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction	<u>Objectives</u>	Methods & Tools	Numerical Modeling	Results	Conclusions
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- Verification and prediction of stress pattern along major thrusts
- To determined the total deformation
- To understand resulting stress and strain patterns on thrust related geometries

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction	Objectives	<u>Methods & Tools</u>	Numerical Modeling	Results	Conclusions
--------------	------------	----------------------------	--------------------	---------	-------------

Numerical Modelling Approach

- With the purpose of calculating horizontal stress patterns in the study area, 2D linear elastic models involving contact elements were generated using the **ANSYS Workbench**.

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

Objectives

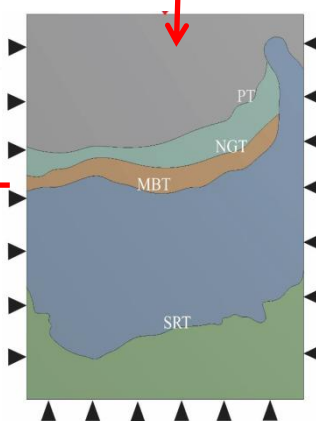
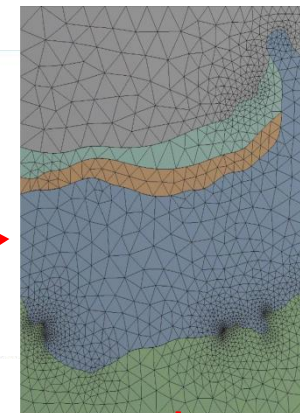
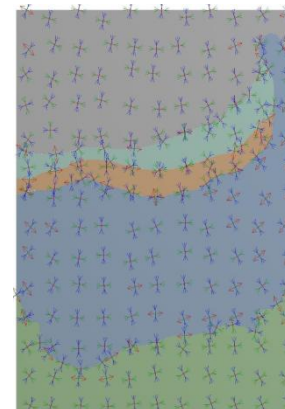
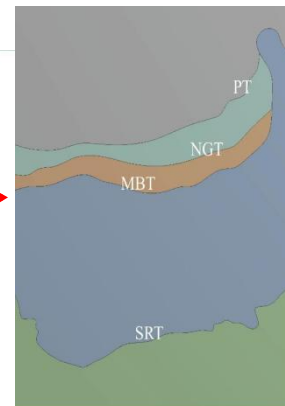
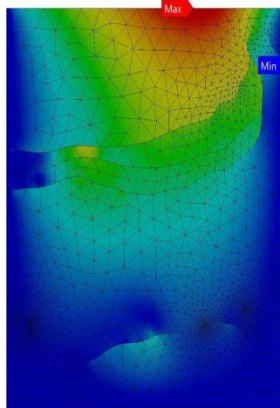
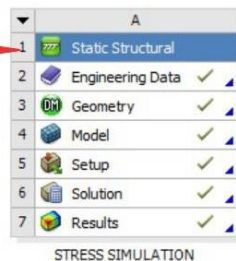
Methods & Tools

Numerical Modeling

Results

Conclusions

- Static Structural
- Engineering Data
- Geometry
- Meshing
- Model Setup
- Results



Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

Objectives

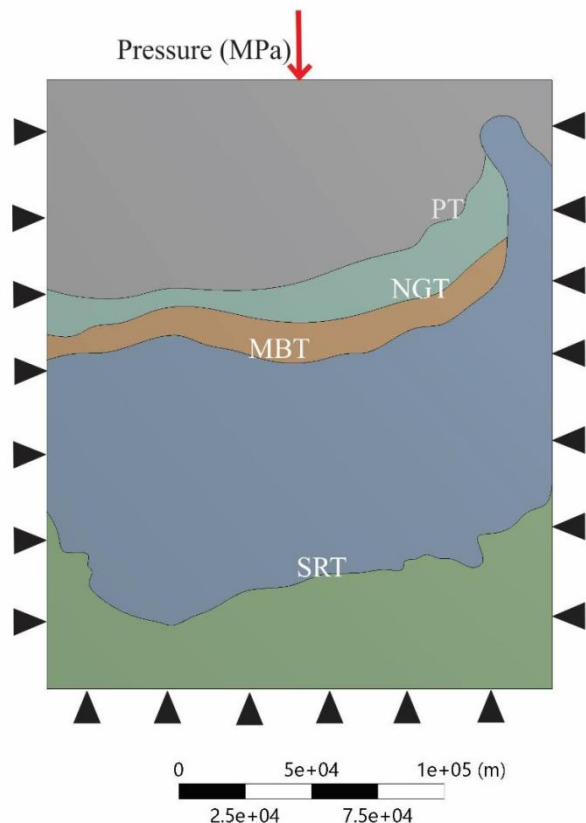
Methods & Tools

Numerical Modeling

Results

Conclusions

Boundary Conditions



Material Properties

Rock type	Density (ρ) (g/cm ³)	Young's Modulus (E) (GPa)	Poisson's Ratio ν	Bulk Modulus (Pa)	Shear Modulus (Pa)
Sedimentary Portion	2.6	70	0.25	4.667×10^{10}	2.4×10^7
Metamorphic Portion	2.75	100	0.25	6.667×10^{10}	2.8×10^{10}

Pascal and Gabrielsen 2001

PT (Punjal Thrust)

NGT (Nathia Gali Thrust)

MBT (Main Boundary Thrust)

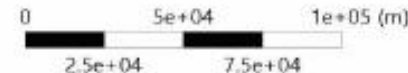
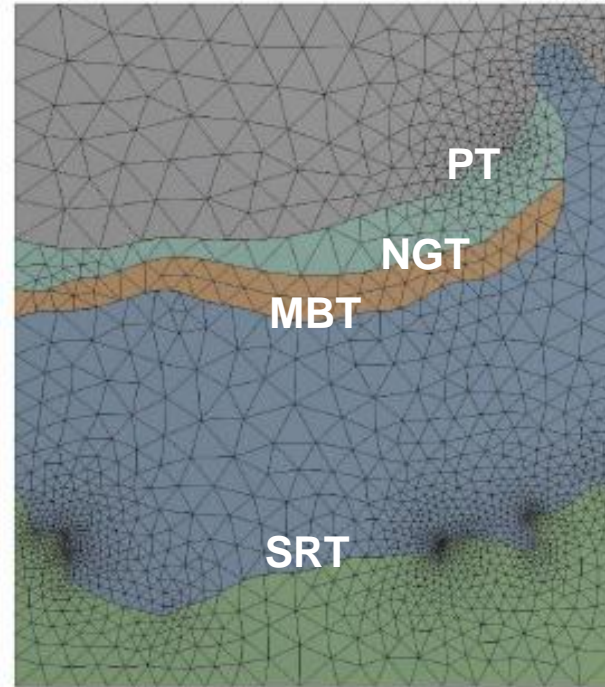
SRT (Salt Range Thrust)

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction	Objectives	Methods & Tools	<u>Numerical Modeling</u>	Results	Conclusions
--------------	------------	-----------------	---------------------------	---------	-------------

Meshing

Models mesh with refinement along the faults with ~8000 mid-nodes and approximately ~3600 contact elements.



Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

Objectives

Methods & Tools

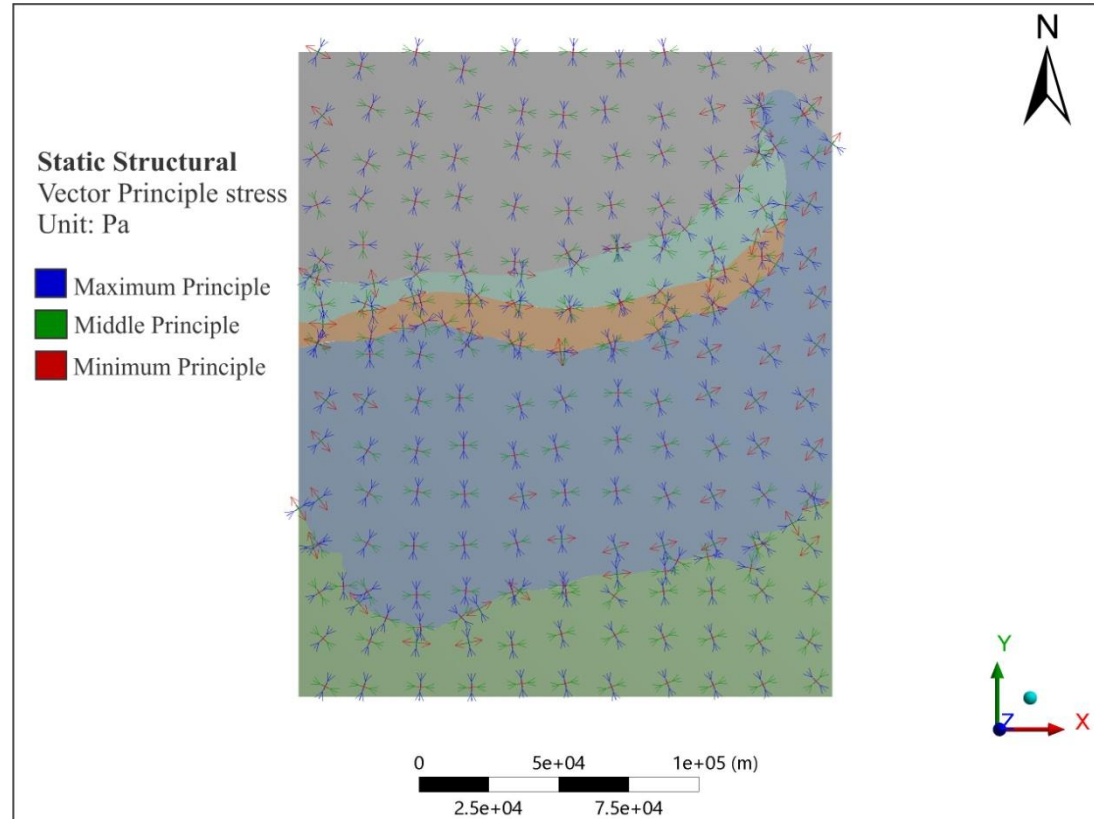
Numerical Modeling

Results

Conclusions

Results

Vector Principal Stress



Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

Objectives

Methods & Tools

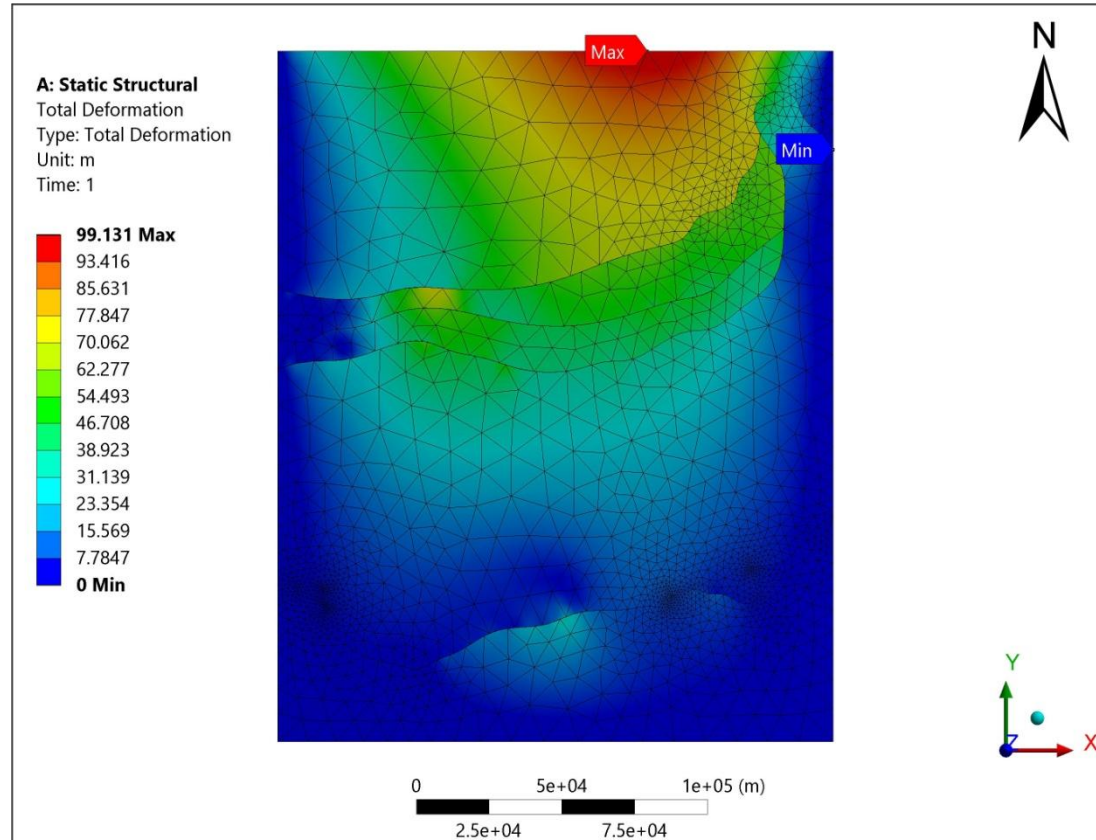
Numerical Modeling

Results

Conclusions

Results

Total Deformation



Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction

Objectives

Methods & Tools

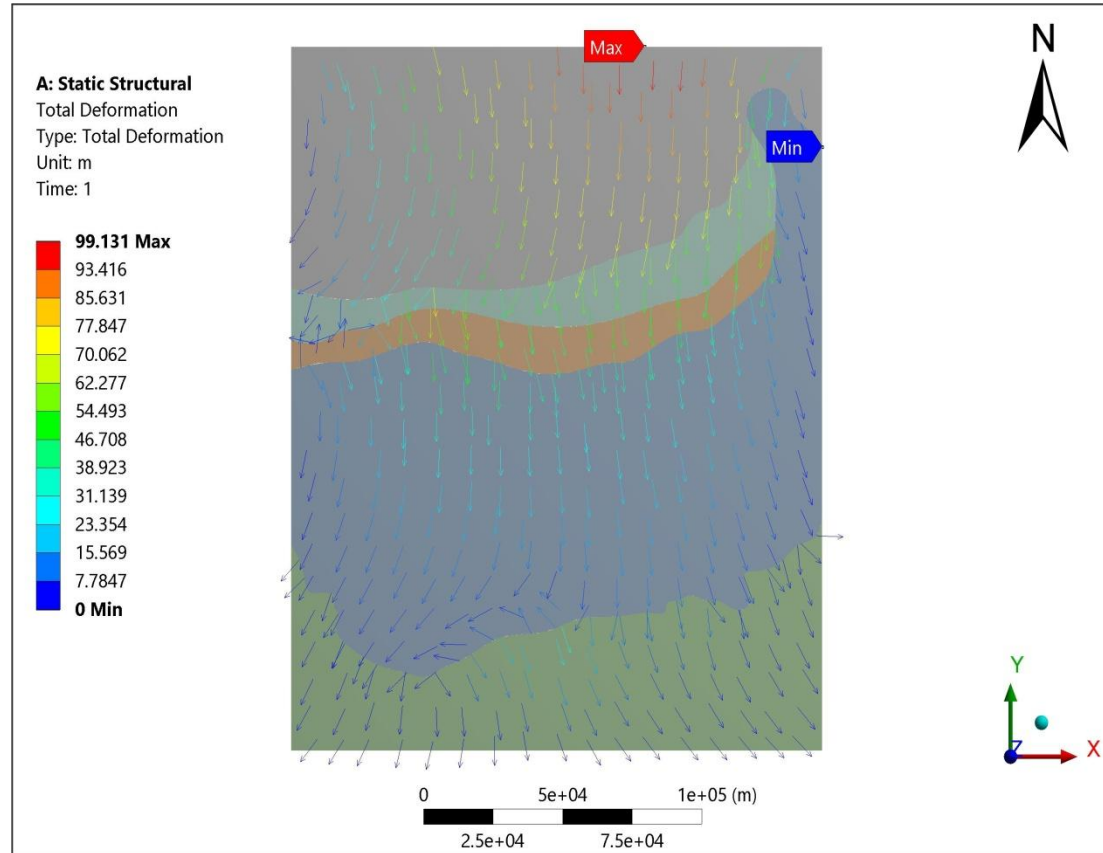
Numerical Modeling

Results

Conclusions

Results

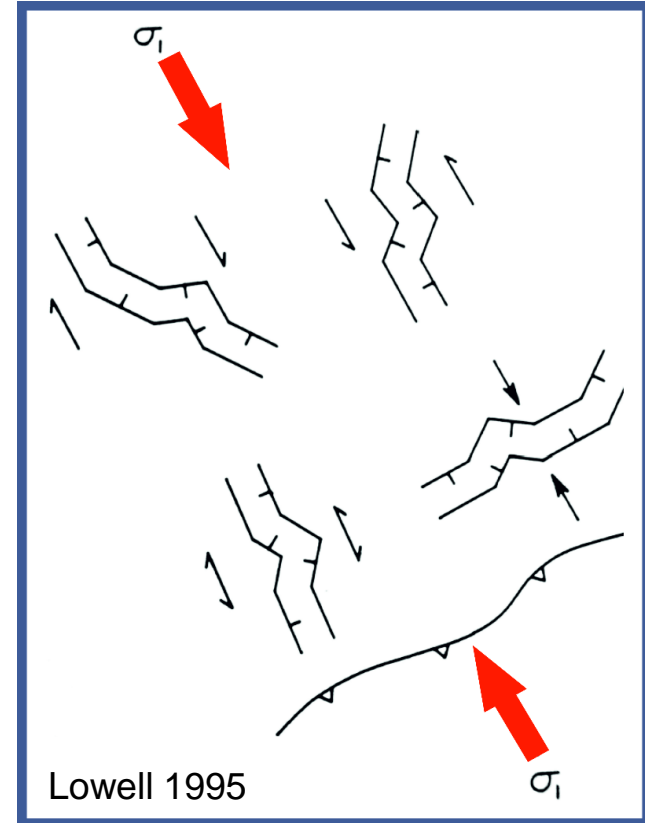
Total Deformation



Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction	Objectives	Methods & Tools	Numerical Modeling	Results	<u>Conclusions</u>
--------------	------------	-----------------	--------------------	---------	--------------------

- Head on compression
 - Thrust fault
- Strike-slip
 - Dextral
 - Sinistral



Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan.

Introduction	Objectives	Methods & Tools	Numerical Modeling	Results	<u>Conclusions</u>
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- Model shows pronounced stress rotations along major thrusts in NW Himalayas, Pakistan.
- Major stress rotation occurred between Lesser Himalayas and Sub Himalayas due to change in material property.
- Significant strike-slip movement also observed along different segments of major thrusts.