Muhammad Armaghan Faisal Miraj¹, Naveed Ahsan¹, and Muhammad Wajid Manzoor¹

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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 (ohmax) 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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¹University of the Punjab, Lahore, Pakistan (armghan.geo@pu.edu.pk)





NUMERICAL MODELING OF CENOZOIC COMPRESSIONAL EVENTS OF NW HIMALAYAS, PAKISTAN

Muhammad Armaghan Faisal Miraj, Naveed Ahsan, Muhammad Wajid Manzoor Institute of Geology, University of the Punjab, Lahore, Pakistan.

armghan.geo@pu.edu.pk

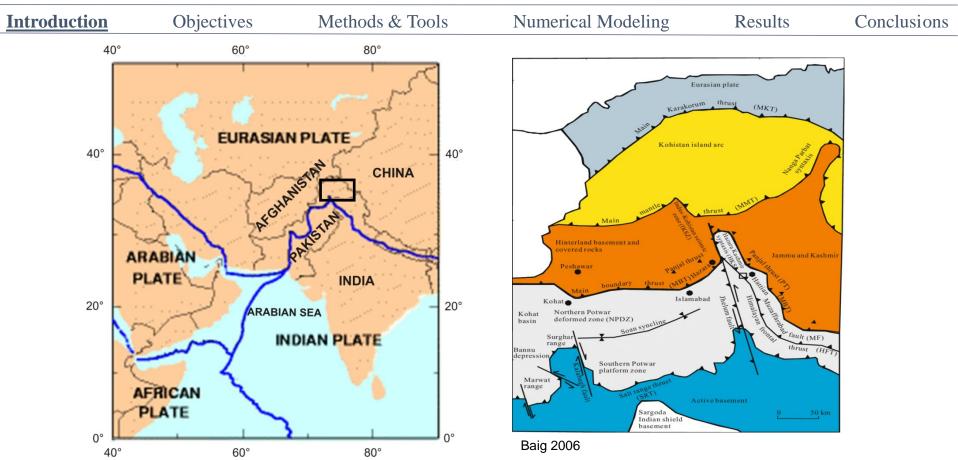
Out Line of Presetation

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. uction Objectives Methods & Tools Numerical Modeling Results Conclusions

Objectives	Methods & Tools	Numerical Modeling	Results	Conc
Late Cretaceous (80 Ma)	Cretaceous-Tertiary Boundary (65 Ma)	(a)	Present 20 Ma 40 Ma	N 30° 15° 0° 15°
Palaeocene (60 Ma)	Early Eocene (55 Ma)			
ASTA ASTA ASTA ASTA ASTA ASTA ASTA ASTA	Rorets Sa INDIA S	(b) (b) 150 100	75° 90° 105	20 15 [, L\(\text{\text{wo}}\) 10 5
pai 2016	U	Yoshida and Santosh 2	2018	
	Late Cretaceous (80 Ma) A Palaeocene (60 Ma) A C C	Late Cretaceous (80 Ma) Cretaceous-Tertiary Boundary (65 Ma) Palaeocene (60 Ma) Early Eocene (55 Ma) C D	Late Cretaceous (80 Ma) Cretaceous-Tertiary Boundary (65 Ma) B Palaeocene (60 Ma) Early Eocene (55 Ma) (a) (b) (b) (b) (c) D (a)	Late Cretaceous (80 Ma) Cretaceous-Tertiary Boundary (65 Ma) A B Early Eccene (55 Ma) E 30' 45' 60' 75' 90' 105' (b) (c) (d) Present 20 Ma 40 Ma 40 Ma 200 Ma 100 Ma 200 Ma 20

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan. Introduction Objectives Methods & Tools Numerical Modeling Results Conclusion

Division of Himalaya

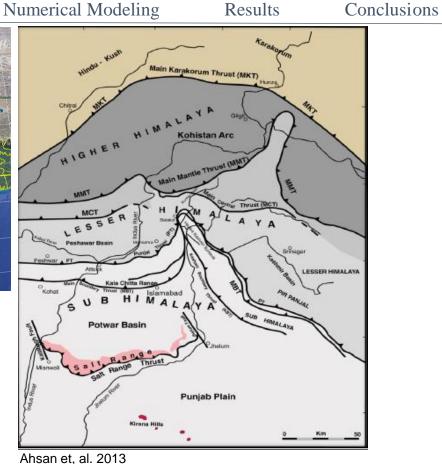
- Higher Himalaya
- Lesser Himalaya
- Sub Himalaya



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)



Pakistan. Introduction Objectives Methods & Tools Numerical Modeling Results Conclusions

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas,

- 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

Pakistan. Introduction Numerical Modeling Conclusions Objectives **Methods & Tools** Results

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas,

Numerical Modelling Approach

•With the purpose of calculating horizontal stress patterns in the study

generated using the ANSYS Workbench.

area, 2D linear elastic models involving contact elements

1 akistan.							
Introduction	Objectives	Methods & Tools	Numerical Modeling	Results	Conclusions		
Static Struct	tural Analysis Syste Design Assi Eigenvalue!	essment Suckling	A Structural				
 Engineering 	Fluid Flow (CFX) 3 (iii) Geome	ering Data 🗸 – MBT				
 Geometry 	Harmonic Ar Harmonic Ri L' IC Engine (F	esponse 5 🙀 Setup	· · · · · · · · · · · · · · · · · · ·				
Meshing	Magnetosta Modal Modal Modal Acou	stress s	SRT SRT				
 Model Setul 	Response S Rigid Dynar B Static Acous	pectrum nics ttics	** * * * * * * * * * * * * * * * * * *	* +			
• Results	Static Struct Steady-Stat Thermal-Ele Topology O Transient Ti Transient Ti ComponentS ComponentS Custom Syste Design Explo	e Thermal ctric ptimization ructural nermal nery Fluid Flow ystems ms	**************************************	*** *** *** *** ***	NGT NGT SRT		

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan. Introduction Objectives Methods & Tools **Numerical Modeling** Conclusions Results

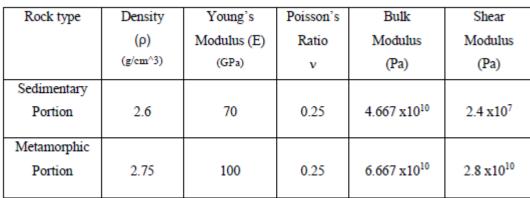
Boundary Conditions Pressure (MPa)

2.5e + 04

NGT

1e+05 (m)

Material Properties



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 Conclusions

Numerical Modeling

Results

1e+05 (m)

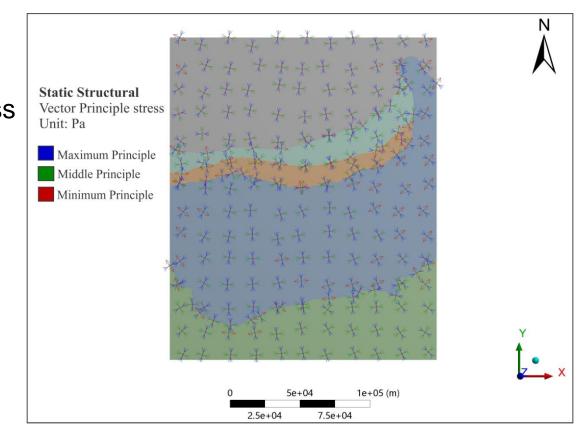
Meshing	
Models mesh with refinement	NGT
along the faults with ~8000 mid-	MBT
nodes and approximately ~3600	
contact elements.	SRT

Methods & Tools

Introduction Objectives Methods & Tools Numerical Modeling Results Conclusions

Results

Vector Principal Stress



Results

A: Static Structural
Total Deformation

A: Static Structural
Time: 1

A: Static Structural
Time: 1

A: Static Structural
Time: 1

A: Static Structural
Total Deformation
Time: 1

Total Deformation 99.131 Max 93.416 85.631 77.847 70.062 62.277 54.493 46.708 38.923 31.139 23.354 15.569 7.7847 0 Min 1e+05 (m) 5e+04 2.5e + 047.5e + 04

Numerical Modeling of Cenozoic Compressional Events of NW Himalayas, Pakistan. Introduction Objectives Methods & Tools Numerical Modeling Results Conclusions

2.5e+04

1e+05 (m)

7.5e+04

Results A: Static Structural Total Deformation Type: Total Deformation Unit: m **Total Deformation** Time: 1 99.131 Max 93.416 85.631 77.847 70.062 62.277 54.493 46.708 38.923 31.139 23.354 15.569 7.7847 0 Min

Methods & Tools

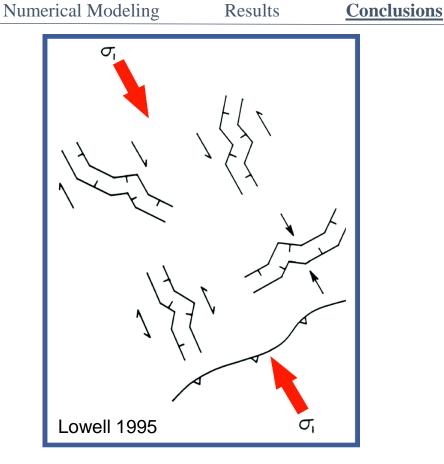
 Head 	on	comp	ression

Objectives

- Thrust fault
- Strike-slip

Introduction

- Dextral
- Sinistral



Introduction	Objectives	Methods & Tools	Numerical Modeling	Results	Conclusions

Pakistan.

• Major stress rotation occurred between Lesser Himalayas and Sub Himalayas due

• Model shows pronounced stress rotations along major thrusts in NW Himalayas,

• Significant strike-slip movement also observed along different segments of major thrusts.

to change in material property.