Significance of Fault Zones

Geotechnical Relevant
Characterization of Brittle Faults

- Faults are elongated complex zones of deformation, ranging from decimeters to kilometers in magnitude
- A significant internal structure of shear and extensional fractures has developed, reflecting the geometry of the strain field and, consequently, the orientation of the principal stresses
- The brittle deformation, such as particle size reduction by crushing of grains and reorientation of grains by shearing, generates the characteristic fine-grained gouge
- Low-temperature solution transfer contributes substantially to the alteration of fault rocks, in particular of gouge, through transformation and neoformation of clay minerals

FROM AEG SHORT COURSE " Tunnels Through Fault Rocks and Tectonic Melanges: A Short Course for Engineering Geologists and Geotechnical Engineers", Oakland, California; June 1, 2002; Instructors: Prof. Gunter Riedmueller and Prof. Wulf Schubert, Technical University of Graz, Austria and Gruppe Geotechnik Graz COPYRIGHT OF 3G - Gruppe Geotechnik Graz www.3-g.at REPRODUCED AND PROVIDED WITH THE PERMISSION OF AEG and 3G CONTACT: Dr. Alfred Fasching, CEO and Managing Director: fasching@3-g.at

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Significance of Fault Zones

Geotechnical Relevant
Characterization of Brittle Faults

- The significant geotechnical feature is a substantial heterogeneity, reflected by the occurrence of more or less undeformed competent blocks which are typically surrounded by a fine-grained matrix consisting of gouge and highly fractured rocks. The matrix appears to be flowing around the blocks in an anastomosing pattern

- The mainly lozenge shaped blocks exhibit a fractal distribution of dimensions, ranging from the microscale to hundreds of meters in length. Fault structures are scale independent

- A considerable heterogeneity of the stress field may exist. Variations in the stress field might be an important cause of segmentary fault zone formation

- Groundwater conditions are also highly variable. Water pressures and flow directions may change dramatically across fault zones. A fault zone acts as aquifer, aquitard and aquiclude

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Fault Morphology

North Anatolian Fault Zone, Turkey
Fault Escarpment of Active Segment, near Bolu Tunnel

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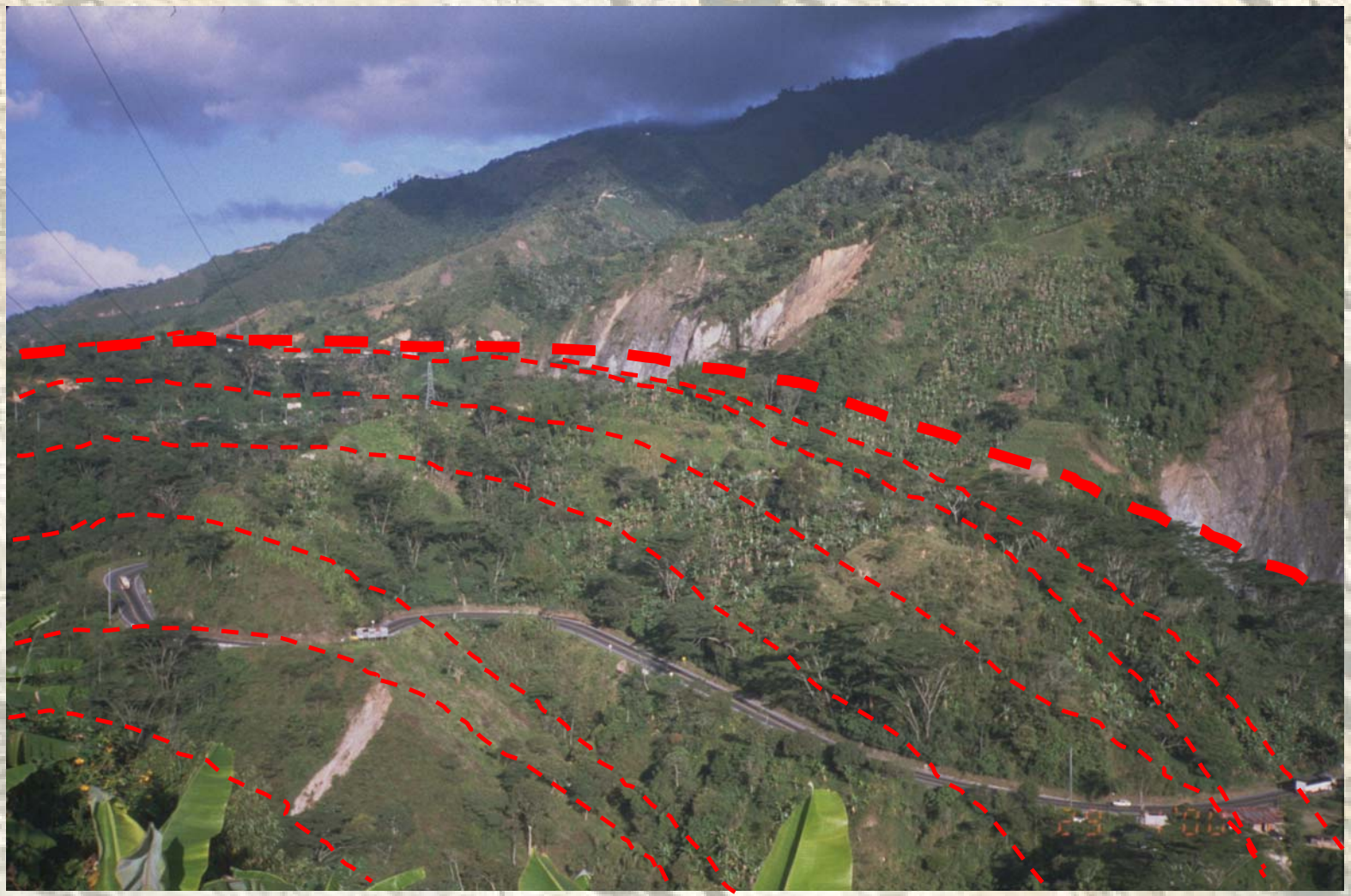
Fault Morphology



Normal Faults, La Linea Tunnel, Colombia

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Case Studies

Project Data

- Rock Fill Dam (Height 120 m)
- Headrace Tunnel (Length 19.5 m, Diameter 3.5 m
- Penstock (Length 2.6 km)
- Gross Head 1.053 m
- Total Capacity 120 MW
- Tailrace Water Canal
- Compensation Reservoir
- Treatment Plant
- Potable Water Conduit
- Irrigation Canals

HPP Misicuni, Bolivia

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Case Studies

Project History

- Construction problems (TBM excavation) of the headrace tunnel due to inadequate geotechnical characterization of fault zones
- The 19.5 km long tunnel penetrates Ordovician quartzitic sandstone and slate. Faults were only identified as individual planar elements
- As a consequence of the inadequate fault model inappropriate equipment was selected which, in combination with insufficient planning and construction shortcomings, caused unforeseen stoppages of the TBM excavation due to tunnel collapse and water inflow
- The total costs for remedial work and effective time of immobilized equipment are US$ 3 million

HPP Misicuni, Bolivia

Case Studies

Strike – Slip Fault, Misicuni Tunnel, Bolivia
Bocatoma Portal, Intermediate Shaft

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Case Studies

HPP Misicuni, Headrace Tunnel, Calio - Portal

HPP Misicuni, Bolivia

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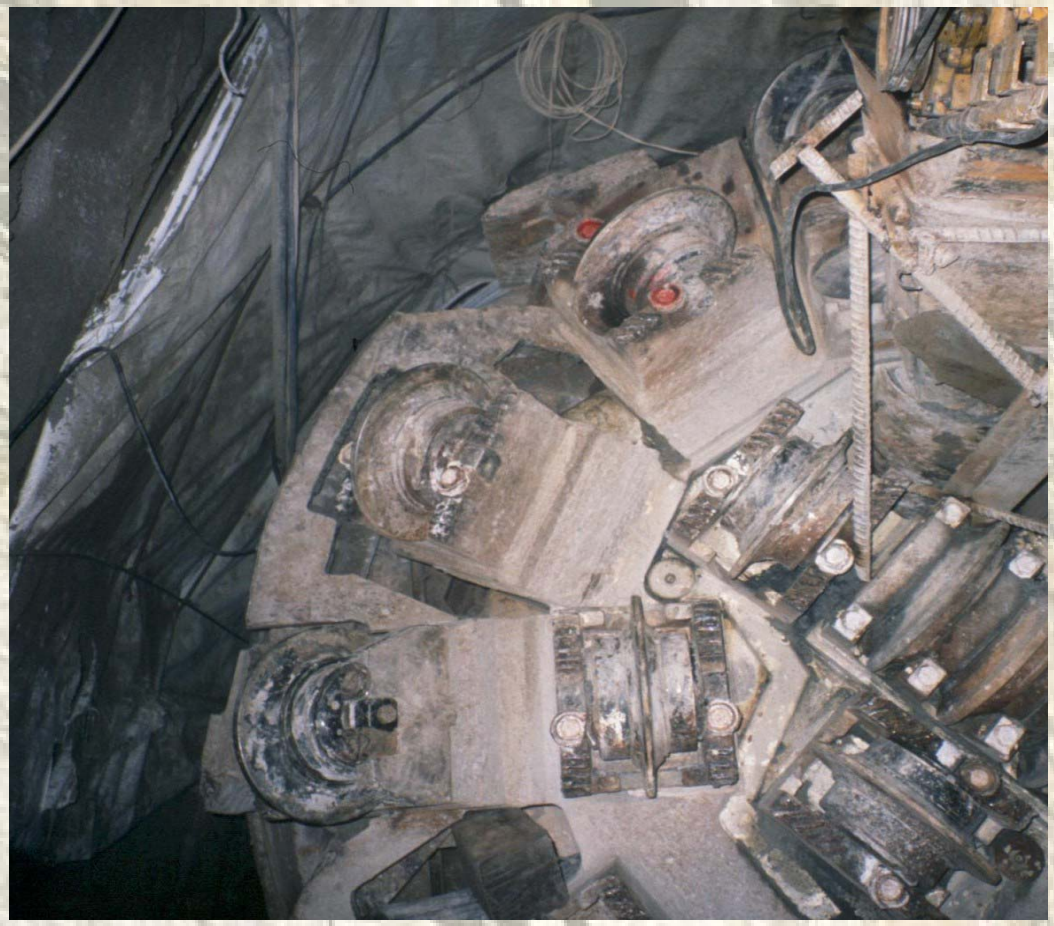
Case Studies

Cutter Head of Buried TBM at km 18 + 513.70
Calio Heading on May 03, 1999



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Characterization

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Case Studies

Excavation Ahead of the TBM Using Marciavantis, Steel Ribs and Shotcrete

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Fault Structures

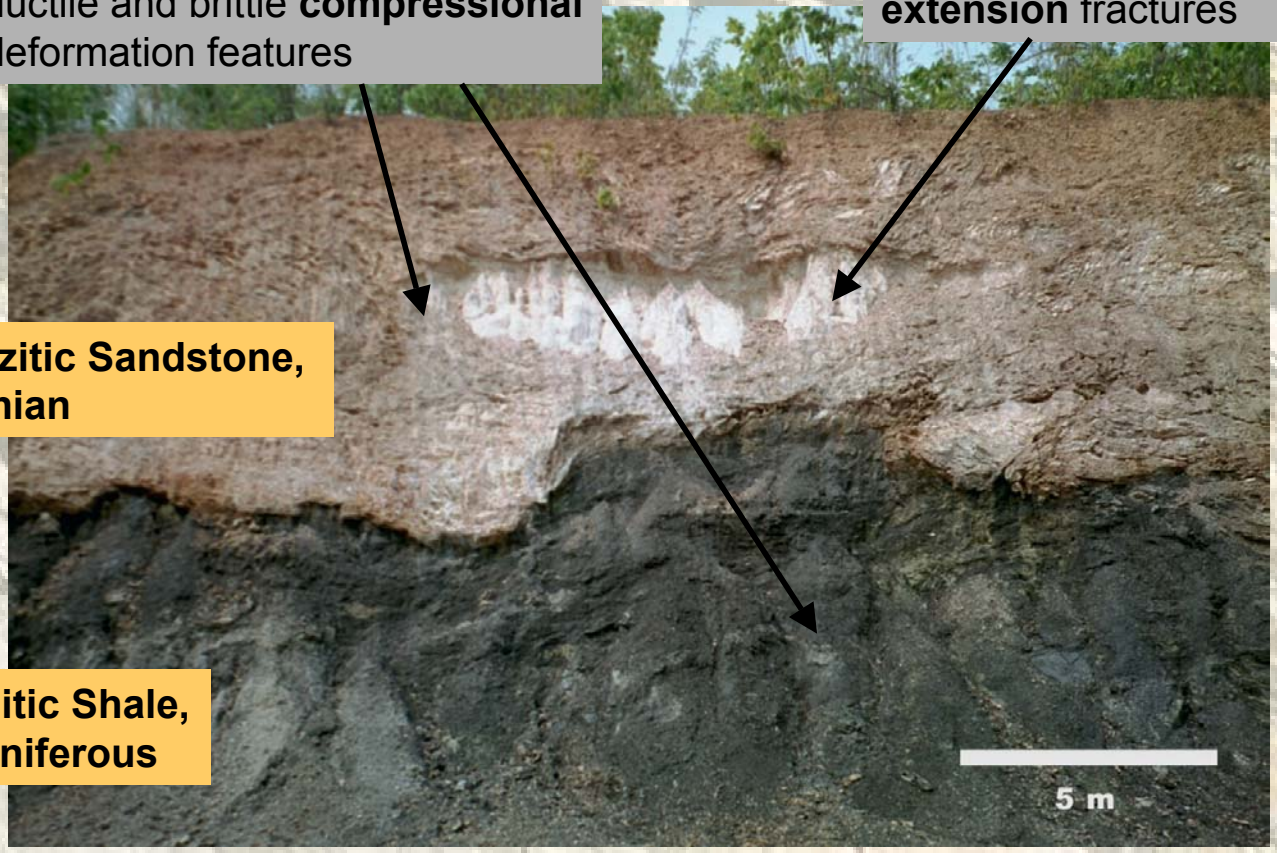
- The analysis of the internal fault structure gives evidence of the displacement field during faulting and indicates the orientation of principal stresses (paleostress analyses)

- From the geotechnical point of view the differentiation of extensional and compressional faults is important

Fault Structures

Foliated **soft matrix** showing ductile and brittle **compressional** deformation features

Lenticular **stiff block** showing **extension** fractures



Quartzitic Sandstone, Devonian

Graphitic Shale, Carboniferous

Formation of Melange in an Foreland Basin Overthrust Setting, Main Tunnel, Mae Kuang Irrigation Project, N – Thailand

Characterization

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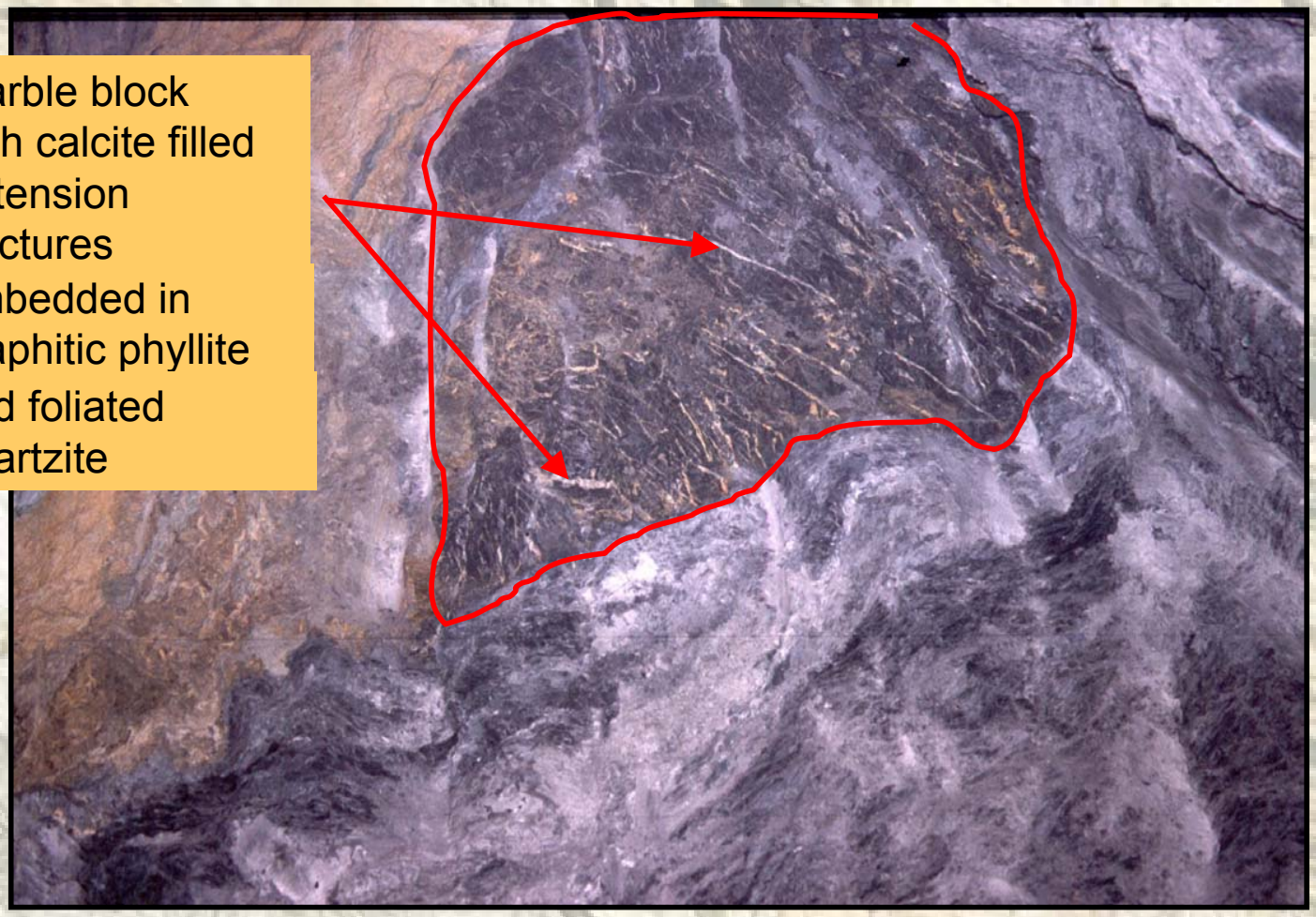
Fault Structures



Marble block with calcite filled extension fractures embedded in graphitic phyllite and foliated quartzite

Tectonic Melange in an Alpine Thrust Setting
Semmering Motorway, Tunnel Steinhaus, Austria

Characterization

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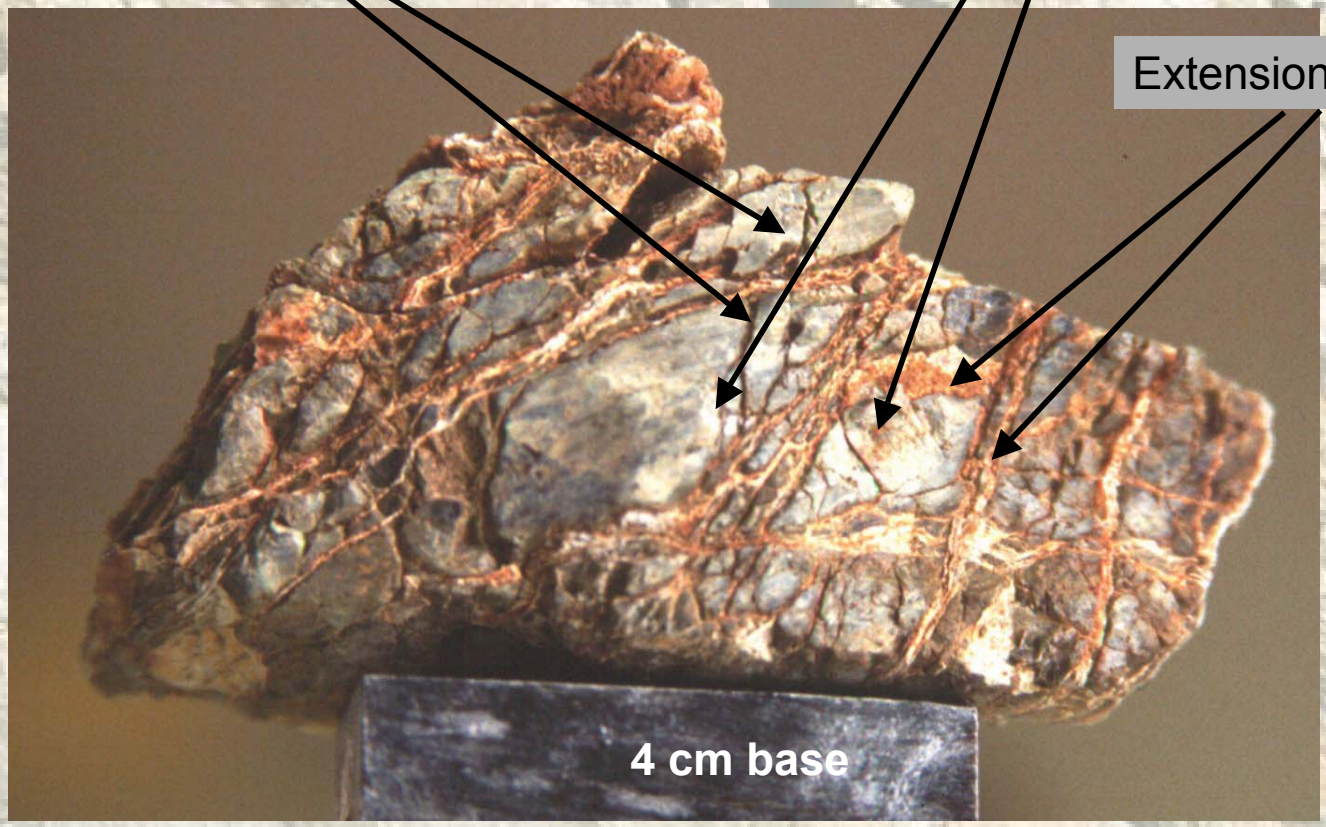
Fault Structures



Typical Structure of Ophiolitic Melange in Mesoscale

Egnatia Motorway, N-Greece

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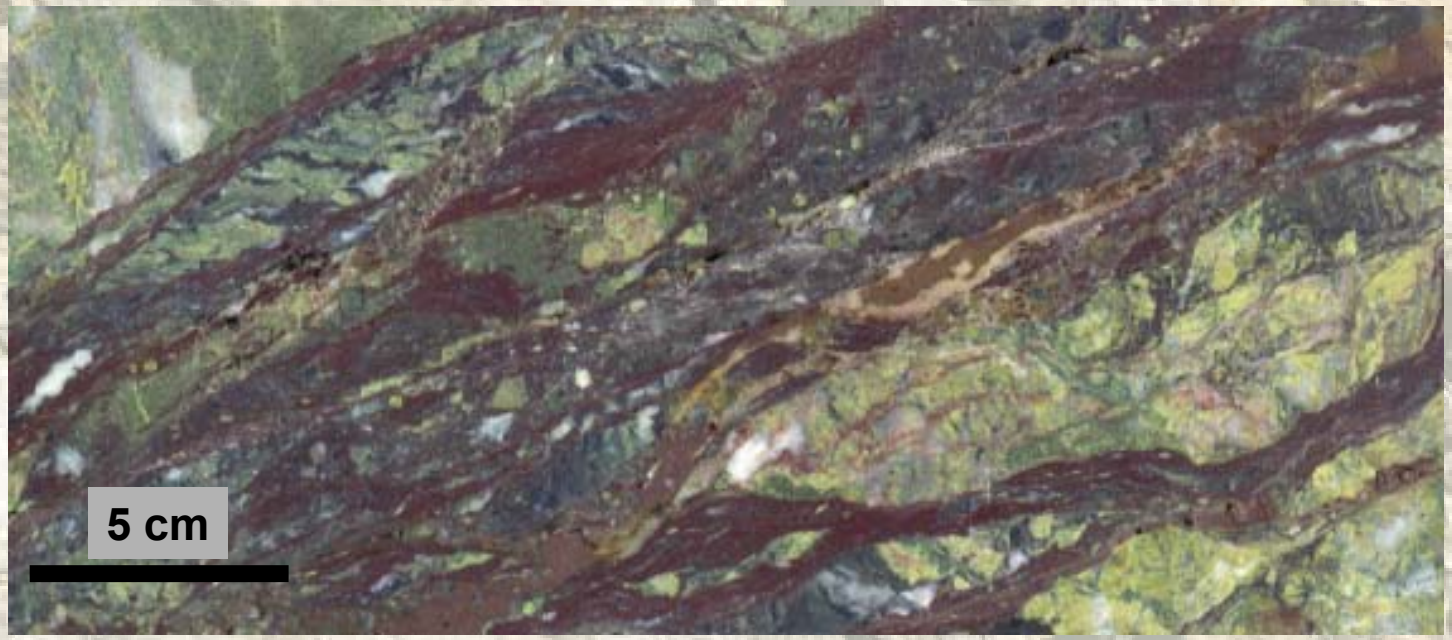
Fault Structures



Significantly Anisotropic Melange (Mesoscale)
Diverse Elongate Blocks (Phacoids) in Foliated Matrix

Characterization

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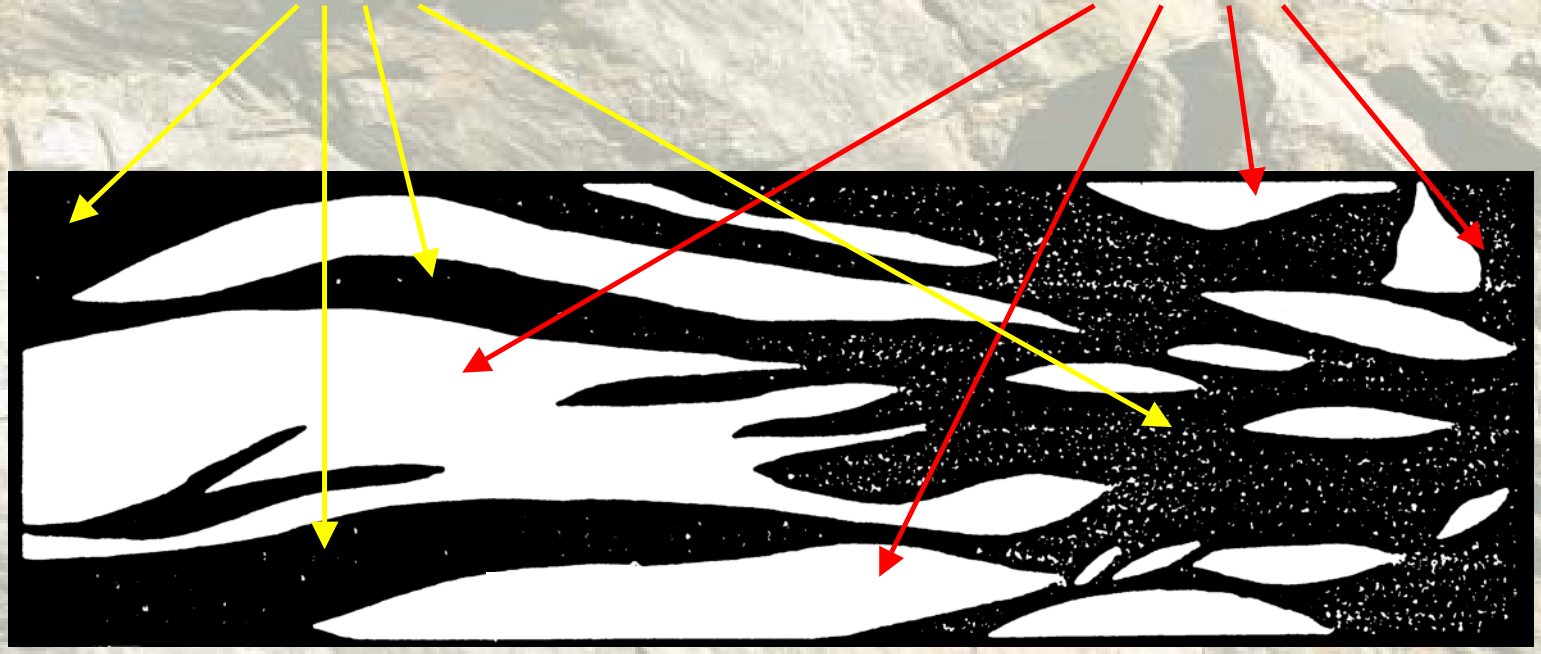
Fault Structures

FINE - GRAINED INTENSELY SHEARED GOUGE

LOZENGE - SHAPED BLOCKS OF NO DEFORMATION



Fault Zone Model, Blocks Show Fractal Dimensions, from the Micro – to the Megascale

Characterization

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Fault Structures

RESEARCH ON "BIMROCKS"

- **Lindquist (1994):**
  The strength and deformation properties of melange.
  PhD dissertation, Univ. Calif. Berkeley

- **Medley (1994):**
  The engineering characterization of melanges and similar Block-in-Matrix Rocks (Bimrocks).
  PhD dissertation, Univ. Calif. Berkeley

Fault Structures

RESEARCH ON “BIMROCKS“
presented by ED MEDLEY

Characterization

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