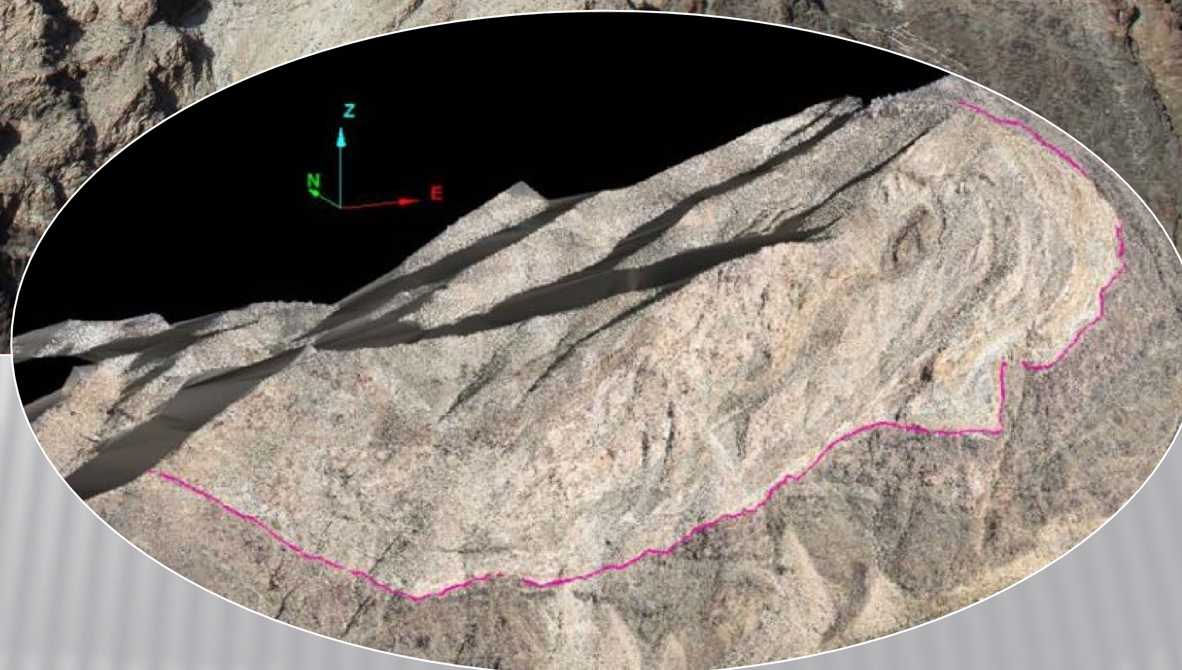
EVALUATING METHODS OF FIELD-BASED 3-D VISUALIZATION AND THEIR APPLICATION TO MAPPING METAMORPHIC TERRANES: AN EXAMPLE FROM THE PANAMINT MOUNTAINS, CALIFORNIA



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The University of Texas at El Paso
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California State University, Fullerton

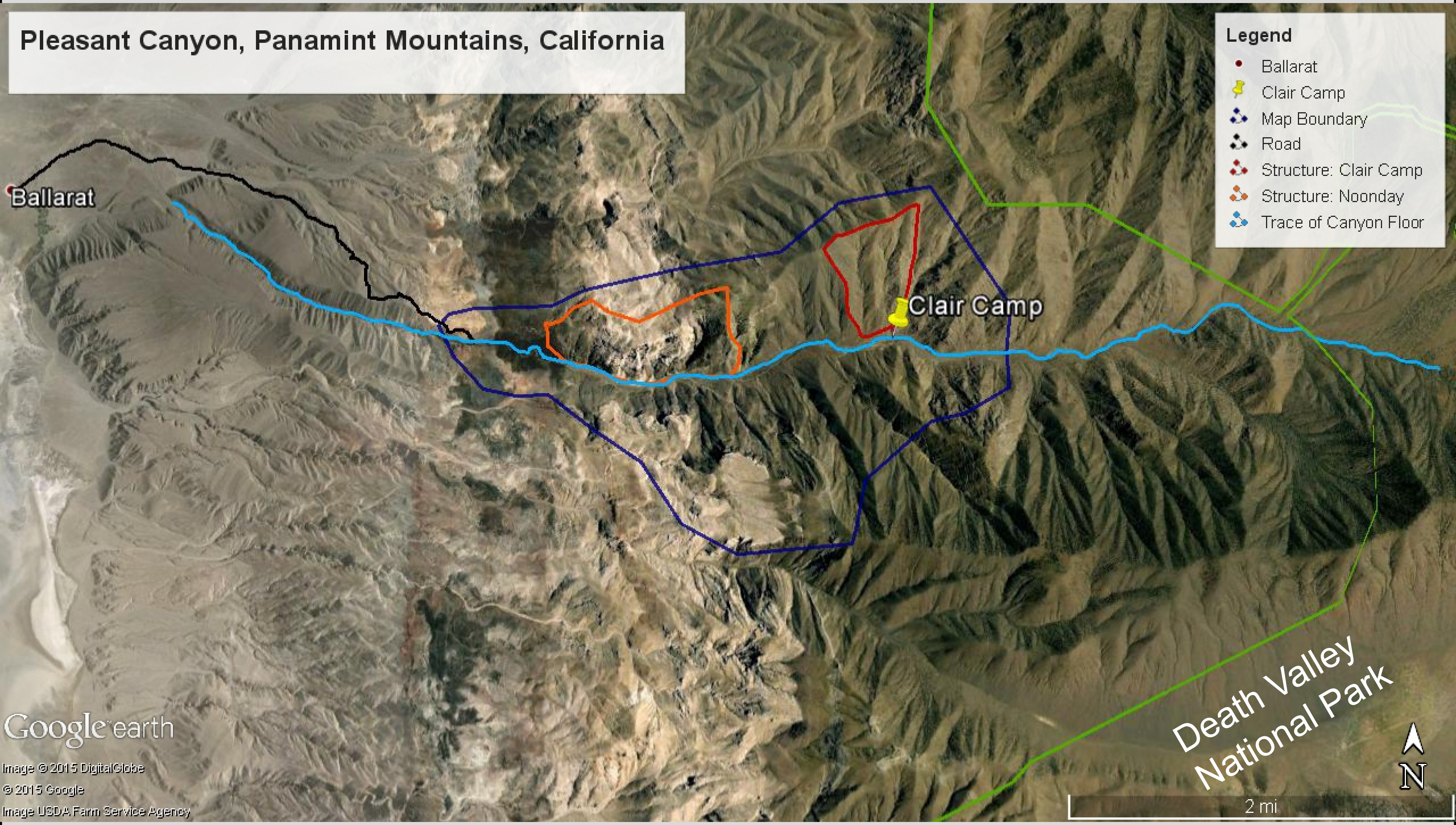
AGENDA

- Rational for 3D Visualizations
- Study Area
- Geologic Background
- Methods
  - Field
  - Computer Lab
- Analysis
- Conclusion

MODERN TECHNOLOGY

- 3D visualizations of Earth's surface
  - Allow for mapping remote, inaccessible locations
  - Obtain orientation data
  - Analyze complex structures
  - Helps optimize field time
- Purpose:
  - Produce 3D visualizations from photogrammetry (SfM) that are comparable to LiDAR
  - How can we increase the spatial accuracy of photogrammetrically-derived models?

STUDY AREA



Pleasant Canyon, Panamint Mountains, California
Legend
Ballarat
Clair Camp
Map Boundary
Road
Structure: Clair Camp
Structure: Noonday
Trace of Canyon Floor
Ballarat
Clair Camp
Death Valley
National Park
N
2 mi
Google earth
Image © 2015 DigitalGlobe
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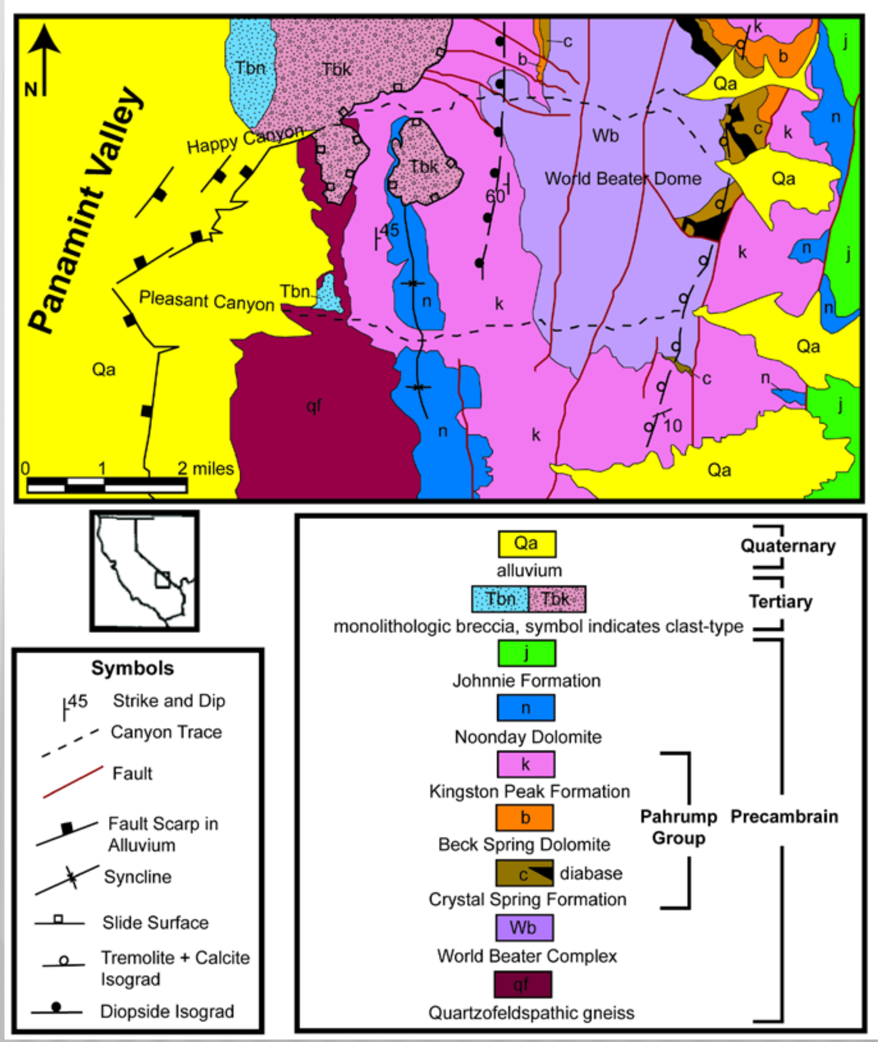
Image USDA Farm Service Agency

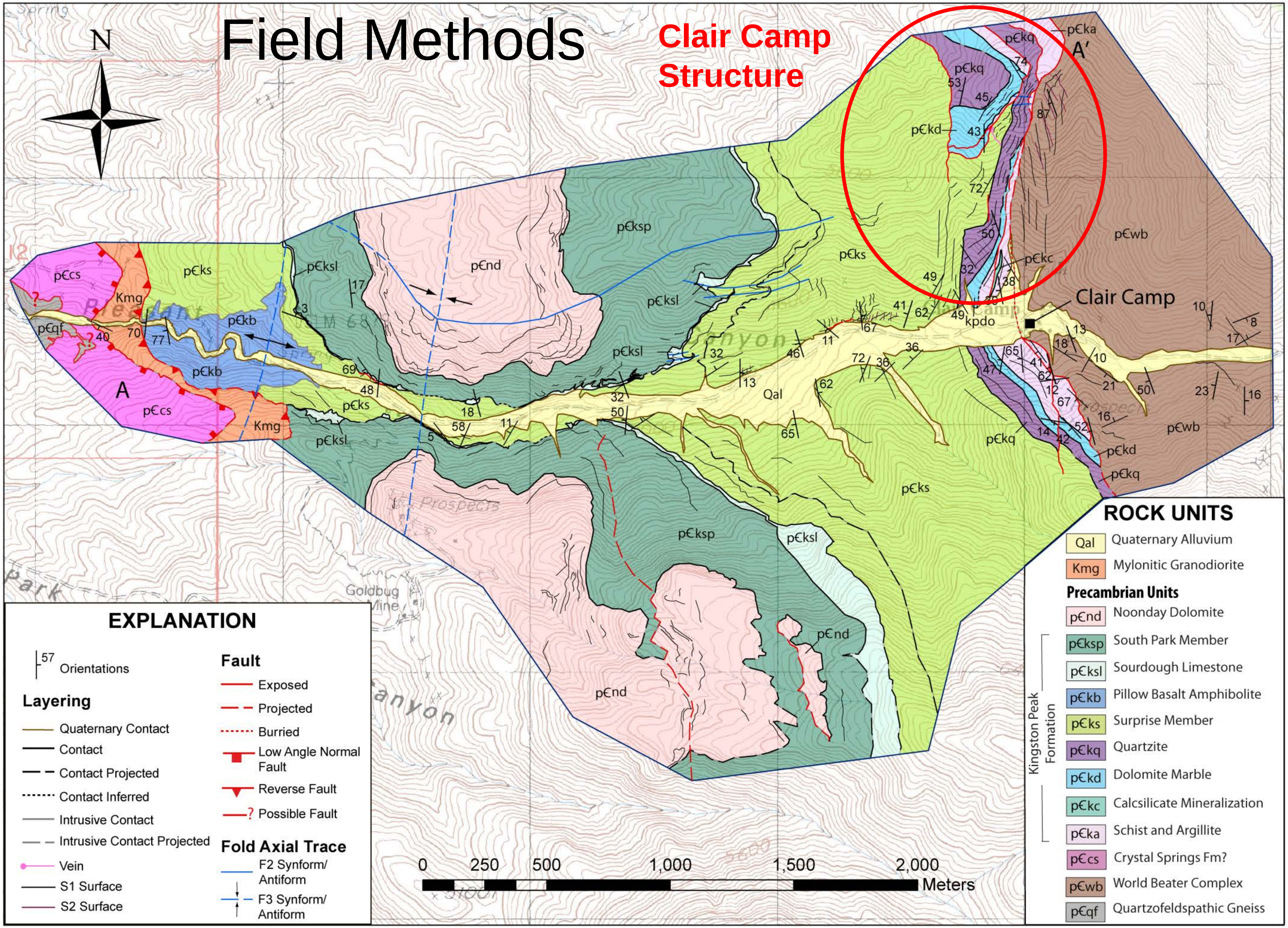
GEOLOGIC BACKGROUND

- Metamorphic complex
- Polyphase metamorphic structure (Mesozoic)
- 3D technology used to visualize complex structure



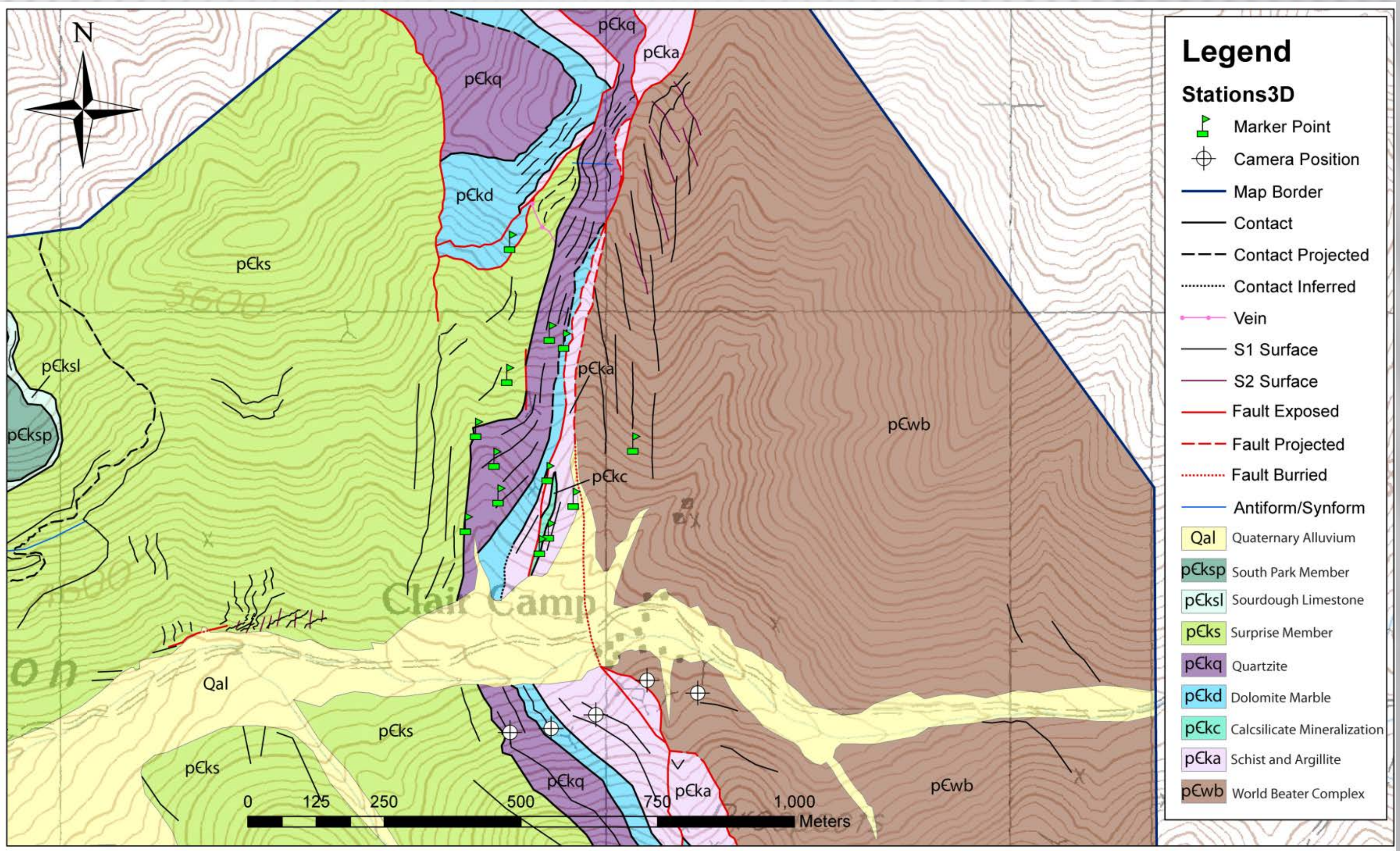
Modified from Labotka et al., 1980

Field Methods



FIELD METHODS: PHOTOGRAMMETRY

- Handheld LaserCraft Contour XLRic laser rangefinder
  - Used to get ground control points (GCPs) up to ~1000 m distance
  - Geolocation limited by GPS (1 – 3 m)
  - Canon Rebel T3i DSLR used to take photographs

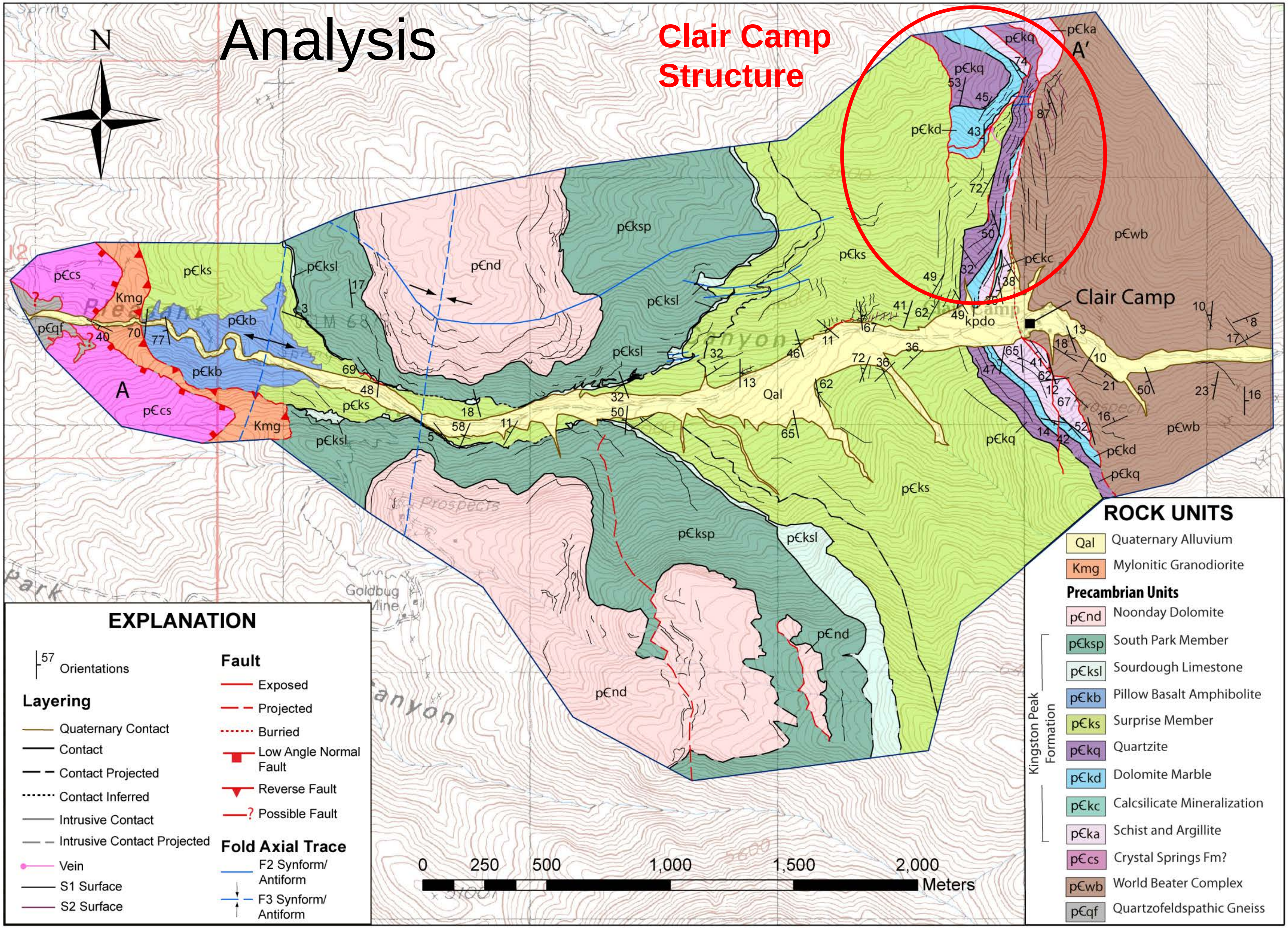


FIELD METHODS: LIDAR

- UNAVCO Riegl LMS-Z620 TLS
  - Nikkon Camera
  - Differential GPS – 3 cm accuracy
  - Laser rangefinder – 10 mm accuracy
  - 2 km maximum range
- 20 scan locations

METHODS: COMPUTER LAB

- Point-cloud processing
  - PhotoScan – make point-clouds using photogrammetry
  - RiScan Pro – Tile LiDAR point-clouds
  - Maptek I-Site – Build 3D surface models from point-clouds



Analysis
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Clair Camp
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pЄkq
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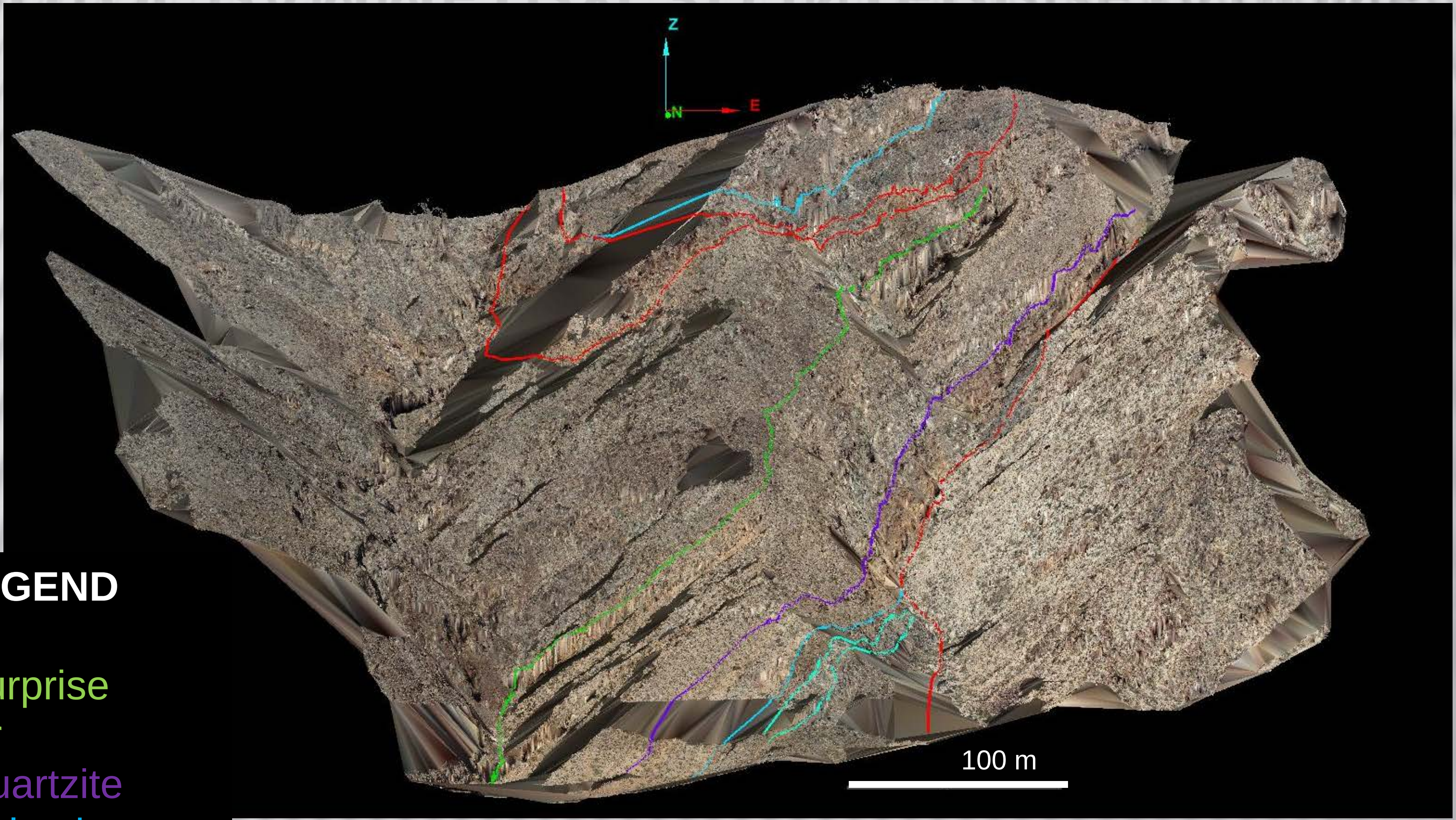
pЄkc
pЄwb
Qal
kpdo
Goldbug
Mine
Prospects
EXPLANATION
57
Orientations
Layering
Quaternary Contact
Contact
Contact Projected
Contact Inferred
Intrusive Contact
Intrusive Contact Projected
Vein
S1 Surface
S2 Surface
Fault
Exposed
Projected
Buried
Low Angle Normal Fault
Reverse Fault
Possible Fault
Fold Axial Trace
F2 Synform/ Antiform
F3 Synform/ Antiform
0
250
500
1,000
1,500
2,000
Meters
ROCK UNITS
Qal Quaternary Alluvium
Kmg Mylonitic Granodiorite
Precambrian Units
pЄnd Noonday Dolomite
Kingston Peak Formation
pЄksp South Park Member
pЄksl Sourdough Limestone
pЄkb Pillow Basalt Amphibolite
pЄks Surprise Member
pЄkq Quartzite
pЄkd Dolomite Marble
pЄkc Calcsilicate Mineralization
pЄka Schist and Argillite
pЄcs Crystal Springs Fm?
pЄwb World Beater Complex
pЄqf Quartzofeldspathic Gneiss

PHOTOGRAMMETRY: 3D INTERPRETATIONS



LEGEND

Faults

Base Surprise Member

Base Quartzite

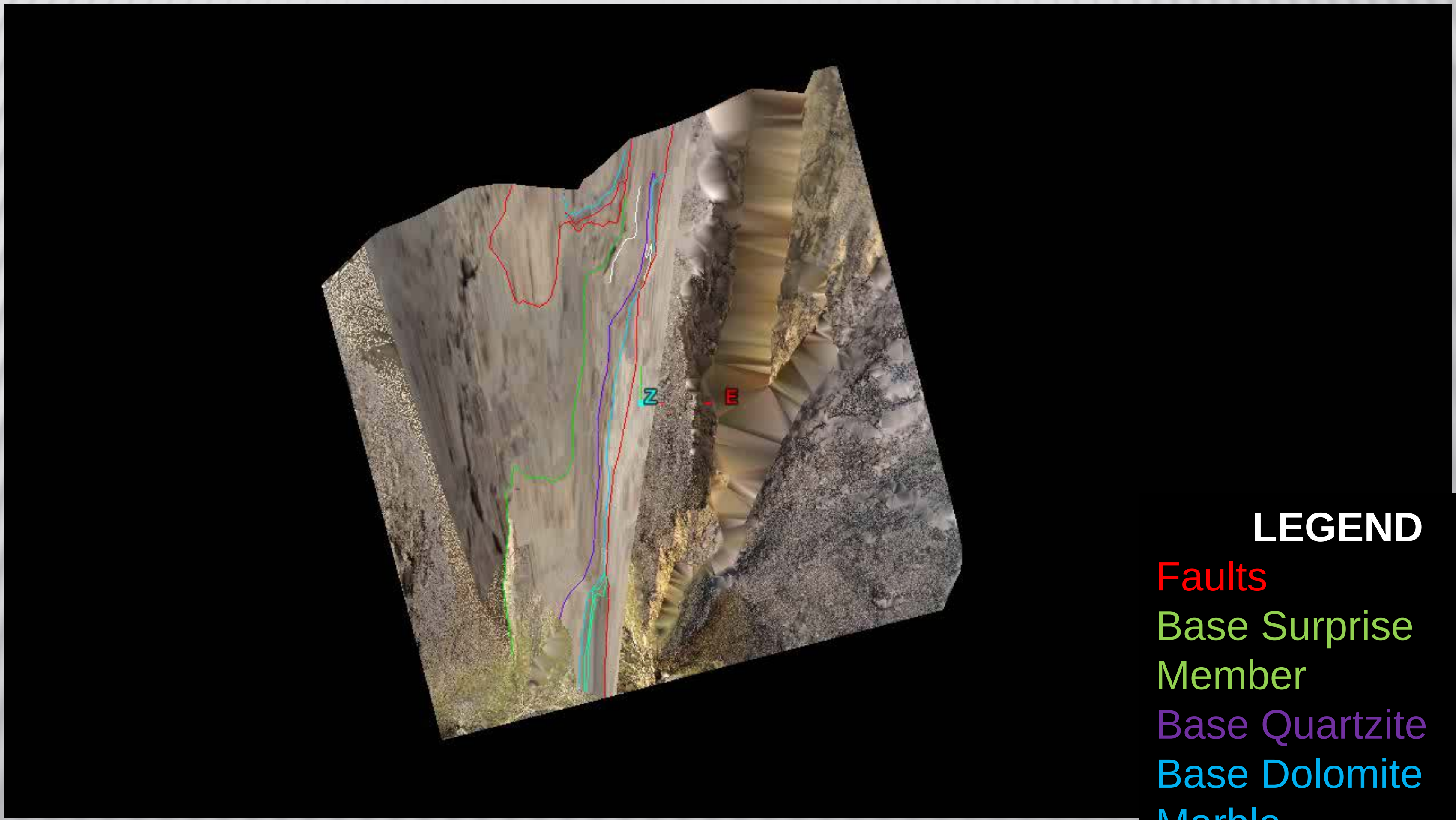
Base Dolomite

Marble

CalcSilicate

Mineralization

LIDAR: 3D INTERPRETATIONS



LEGEND

Faults

Base Surprise Member

Base Quartzite

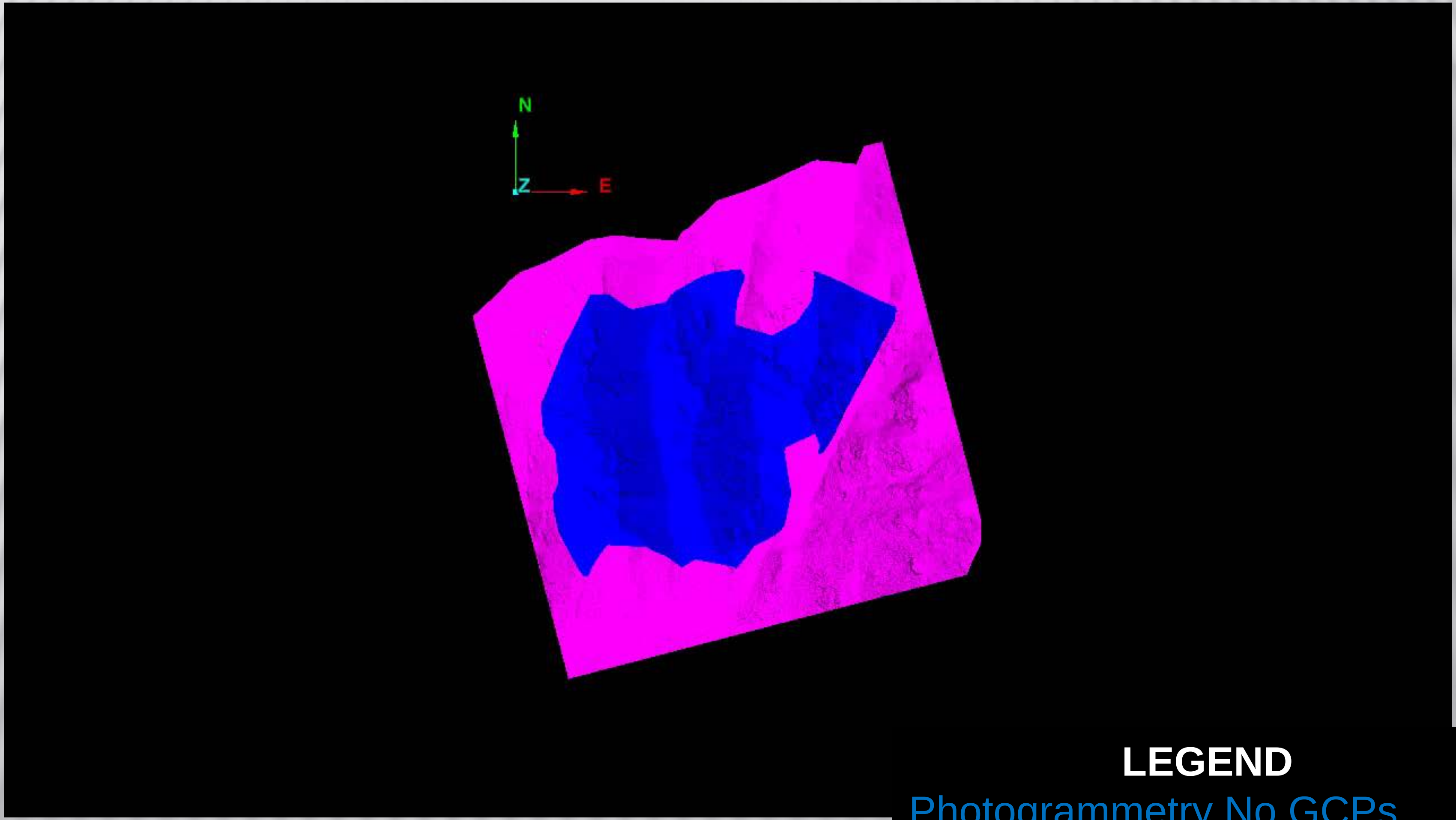
Base Dolomite Marble

CalcSilicate Mineralization

SPATIAL ACCURACY FOR PHOTOGRAMMETRY

- Vertical imagery—moderately well tested
- Little data on oblique imagery only
- Examined several sites—compare LiDAR to Photogrammetry

VISUAL 3D SURFACE COMPARISON

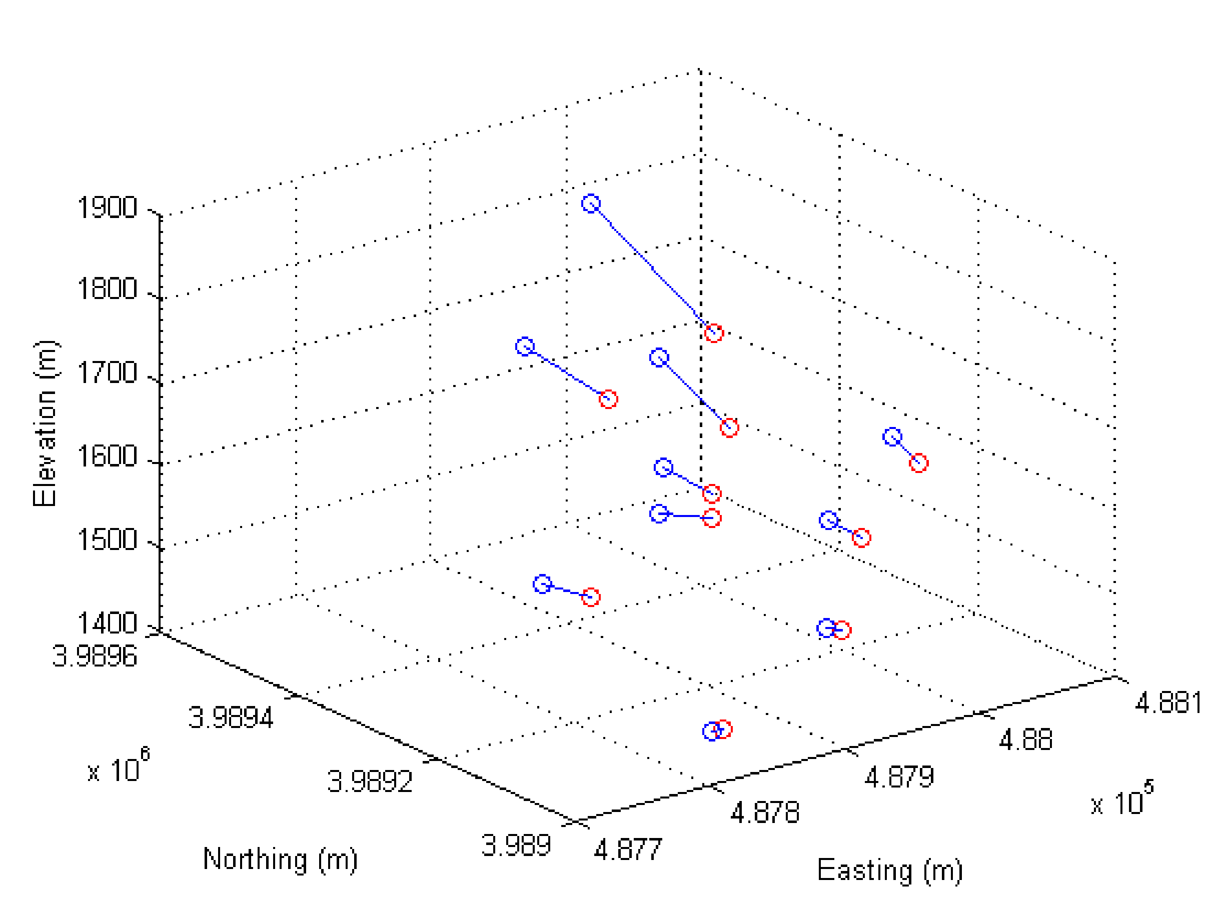


LEGEND

Photogrammetry No GCPs
LiDAR
Photogrammetry With GCPs

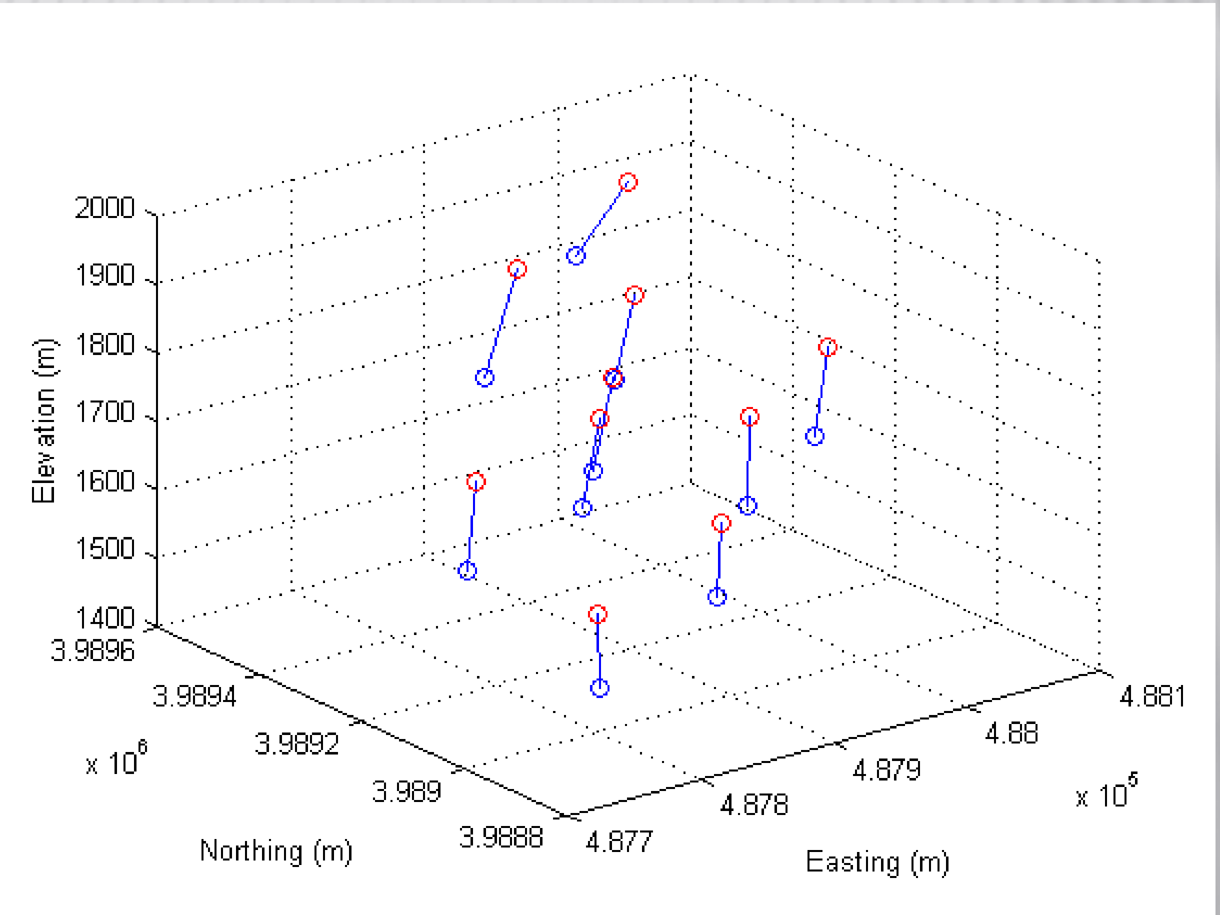
QUANTIFIED 3D OFFSET OF SURFACE MODELS

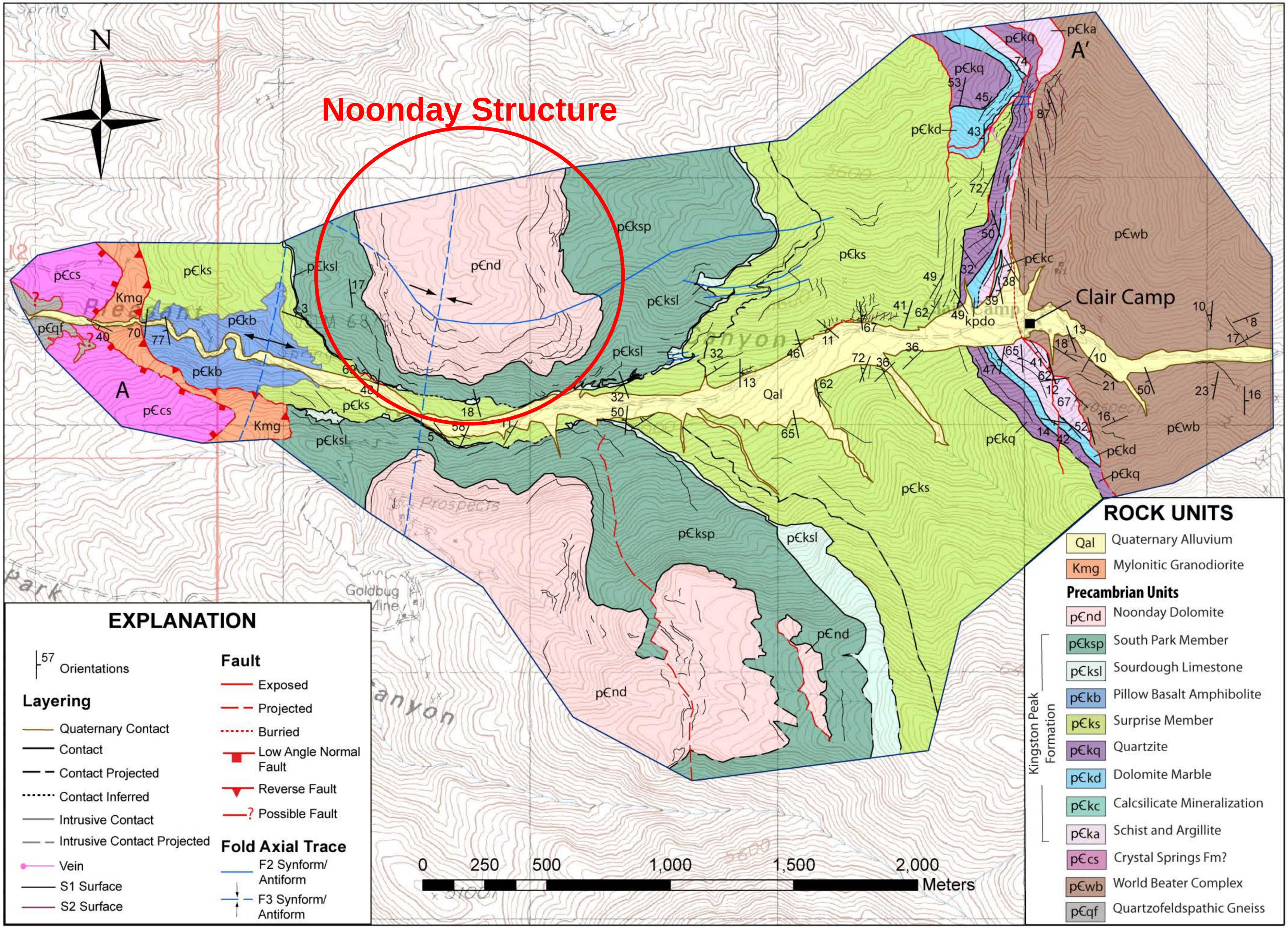
- Photogrammetry (with GCPs) v. LiDAR
  - Max offset 200 m
  - Average 64 m



QUANTIFIED 3D OFFSET OF SURFACE MODELS

- Photogrammetry (without GCPs) v. LiDAR
  - Max offset 252 m
  - Average offset 186 m





Noonday Structure
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Clair Camp
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Qal
p€cs
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Goldbug Mine
Prospects
EXPLANATION
Orientations
Layering
Quaternary Contact
Contact
Contact Projected
Contact Inferred
Intrusive Contact
Intrusive Contact Projected
Vein
S1 Surface
S2 Surface
Fault
Exposed
Projected
Buried
Low Angle Normal Fault
Reverse Fault
Possible Fault
Fold Axial Trace
F2 Synform/ Antiform
F3 Synform/ Antiform
0 250 500 1,000 1,500 2,000
Meters
ROCK UNITS
Qal Quaternary Alluvium
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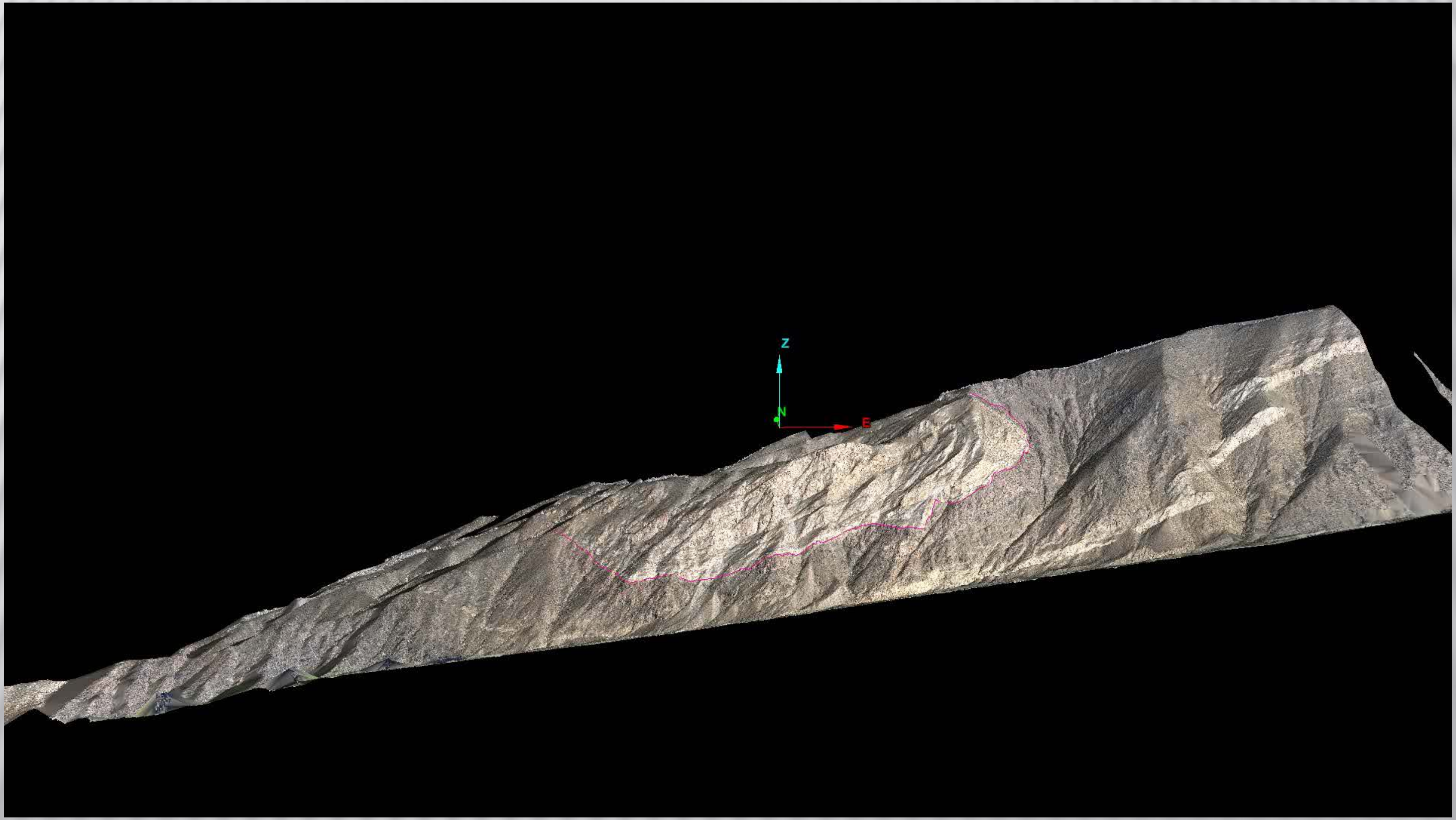
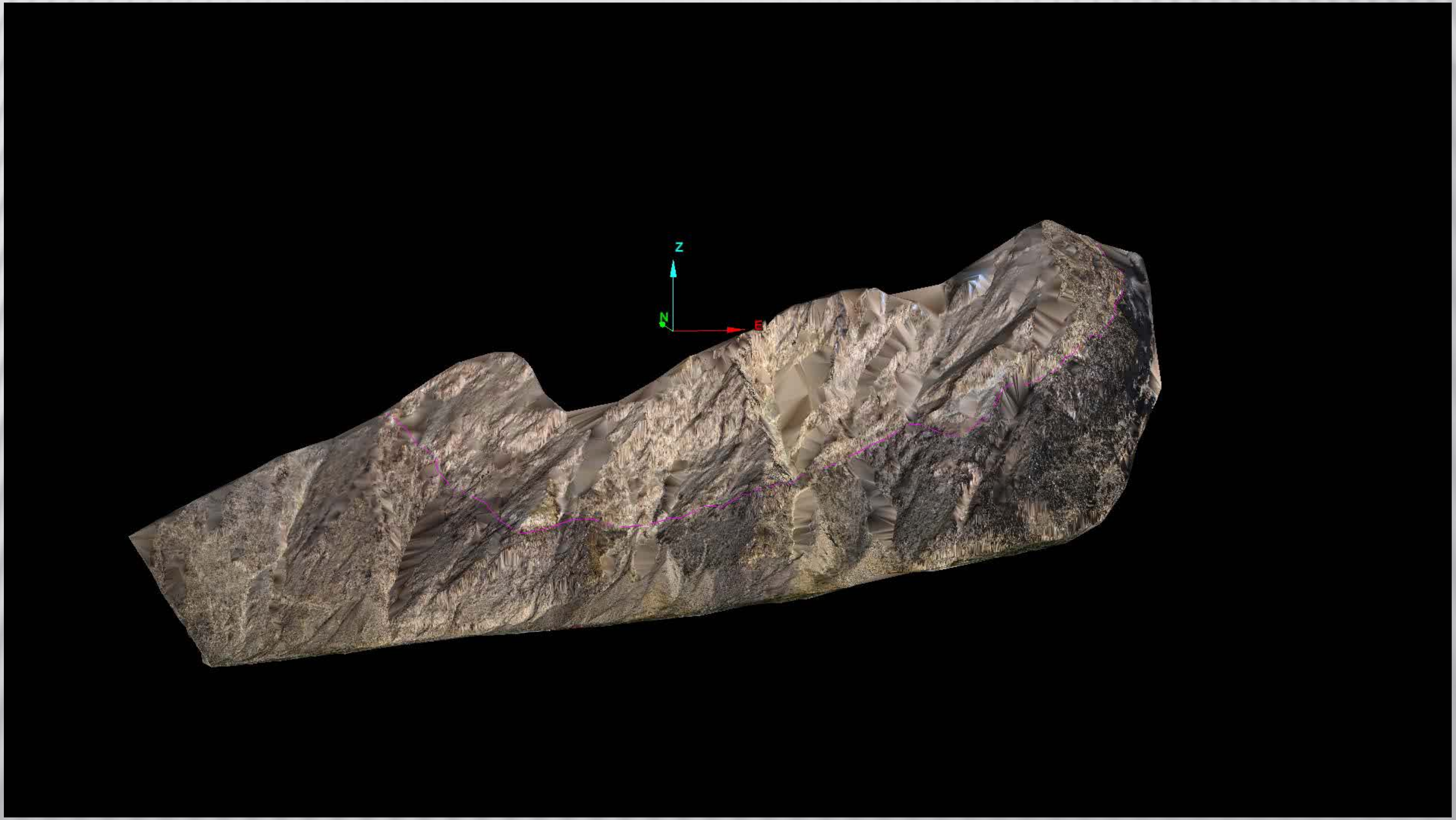
p€kc Calcsilicate Mineralization
p€ka Schist and Argillite
p€cs Crystal Springs Fm?
p€wb World Beater Complex
p€qf Quartzofeldspathic Gneiss

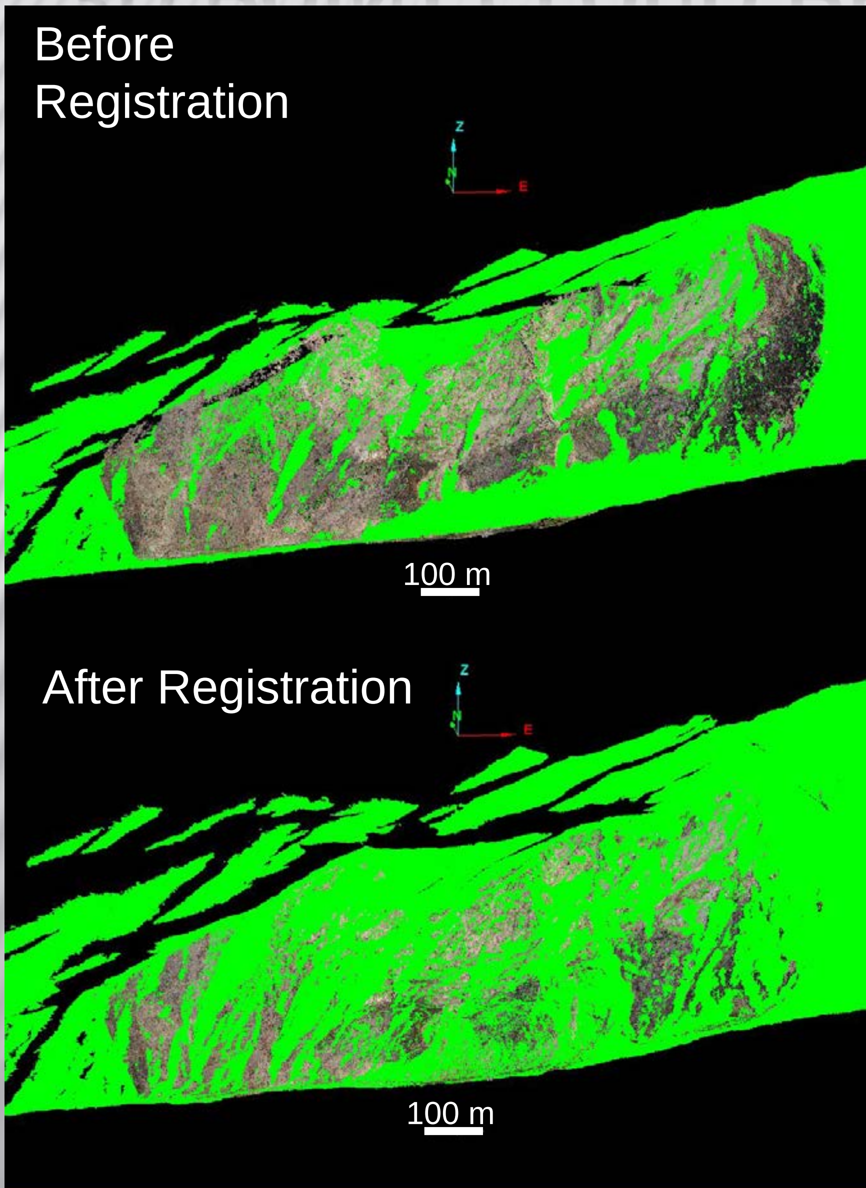
PHOTOGRAMMETRY 3D SURFACE MODEL

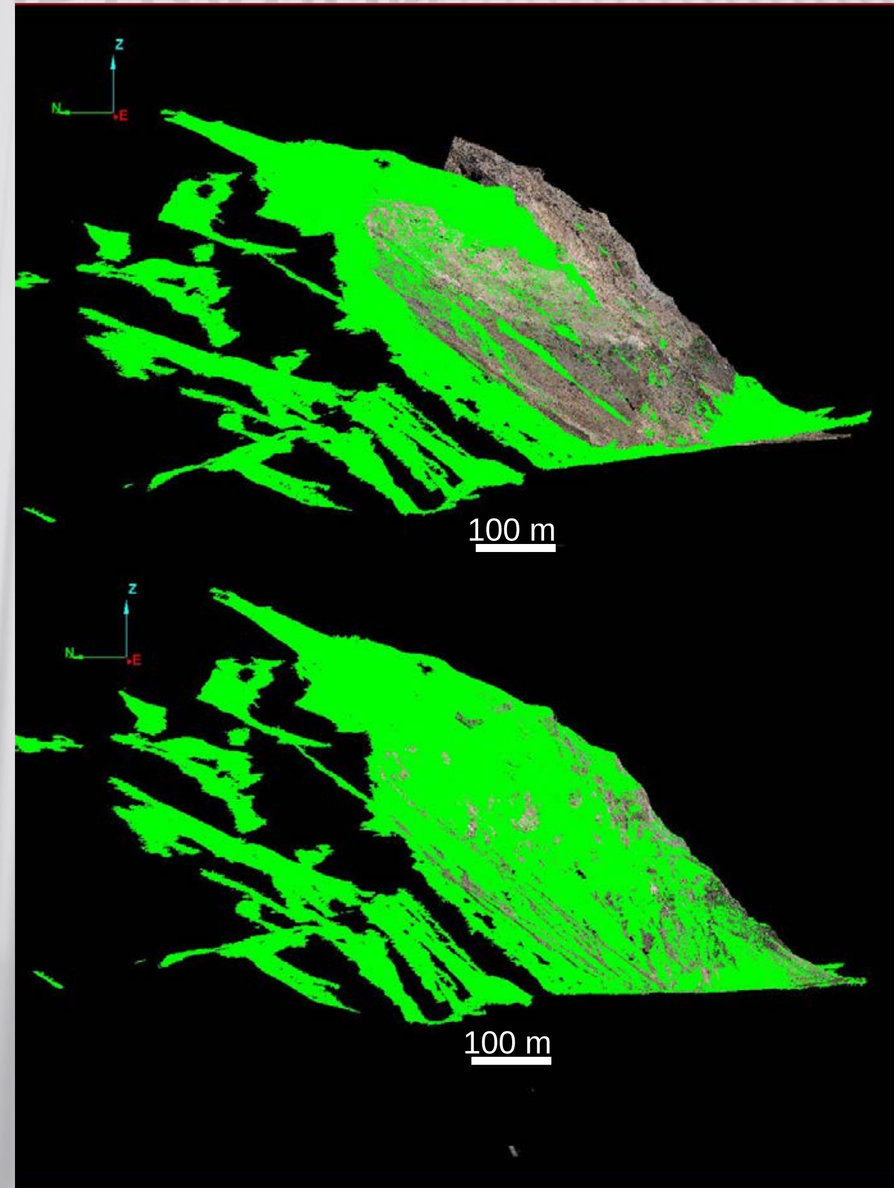


LIDAR 3D SURFACE MODEL



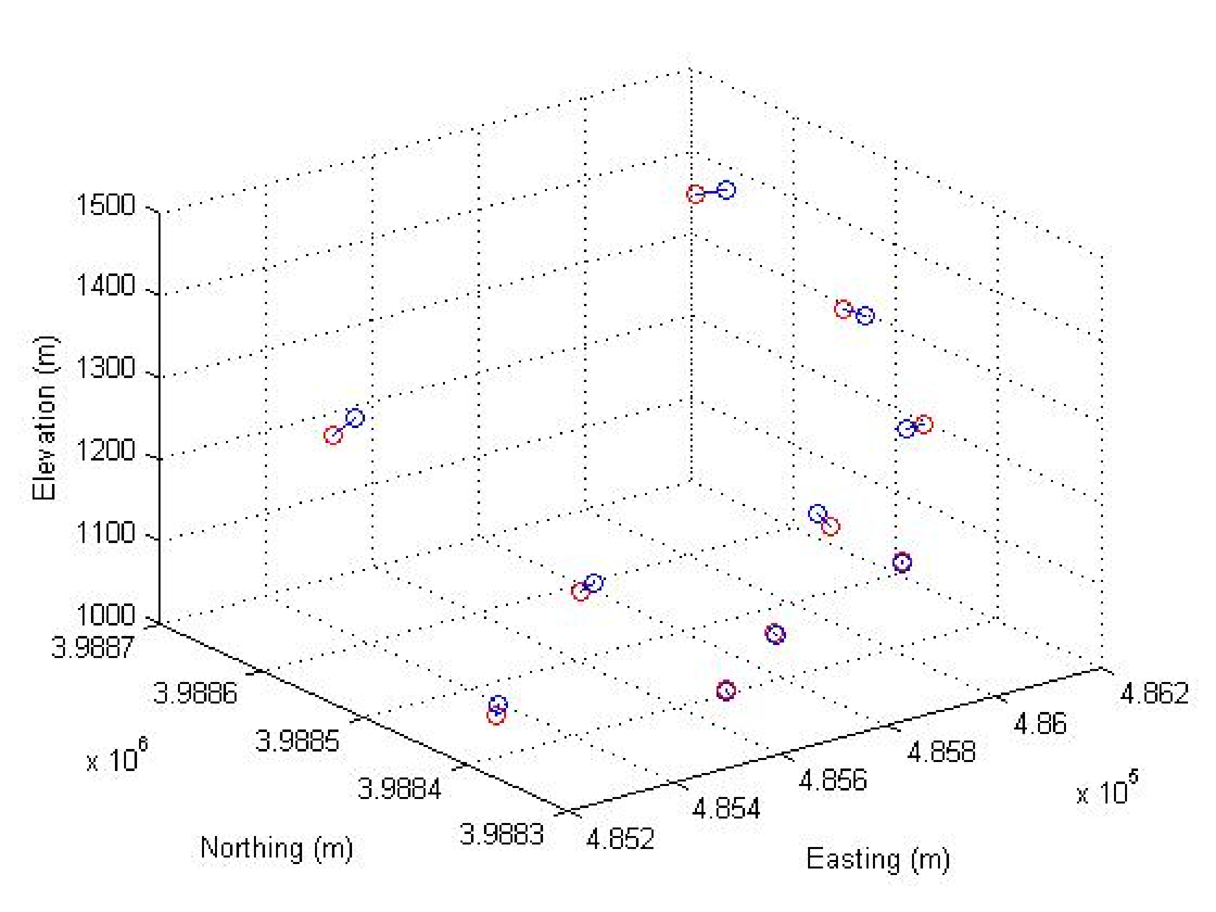
3D POINT-CLOUD REGISTRATION





QUANTIFIED 3D OFFSET OF SURFACE MODELS

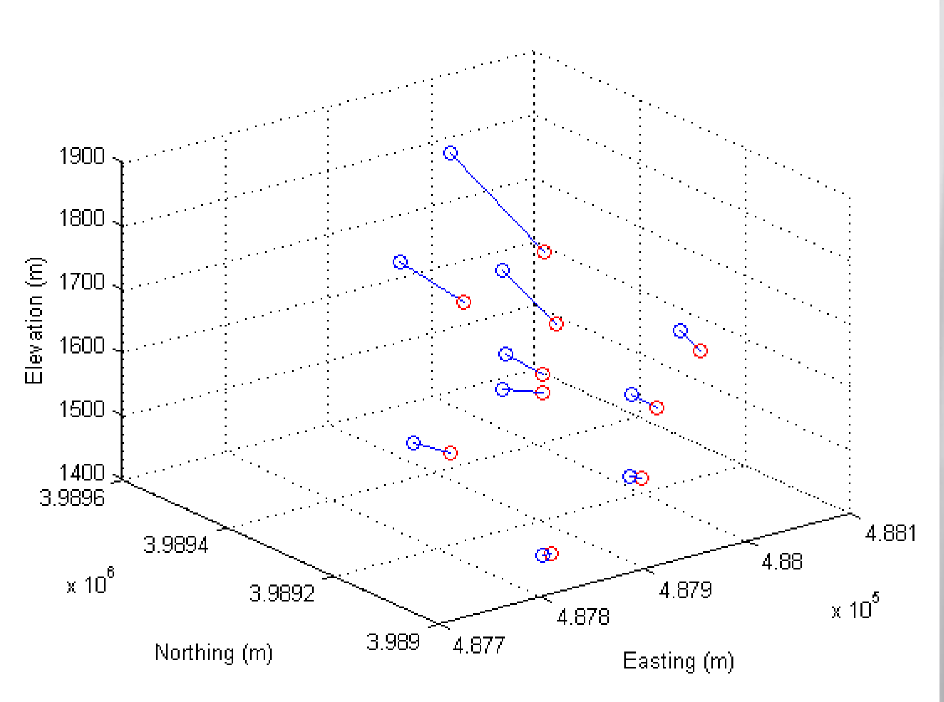
- Photogrammetry v. LiDAR
  - Max offset 45 m
  - Average offset 22 m



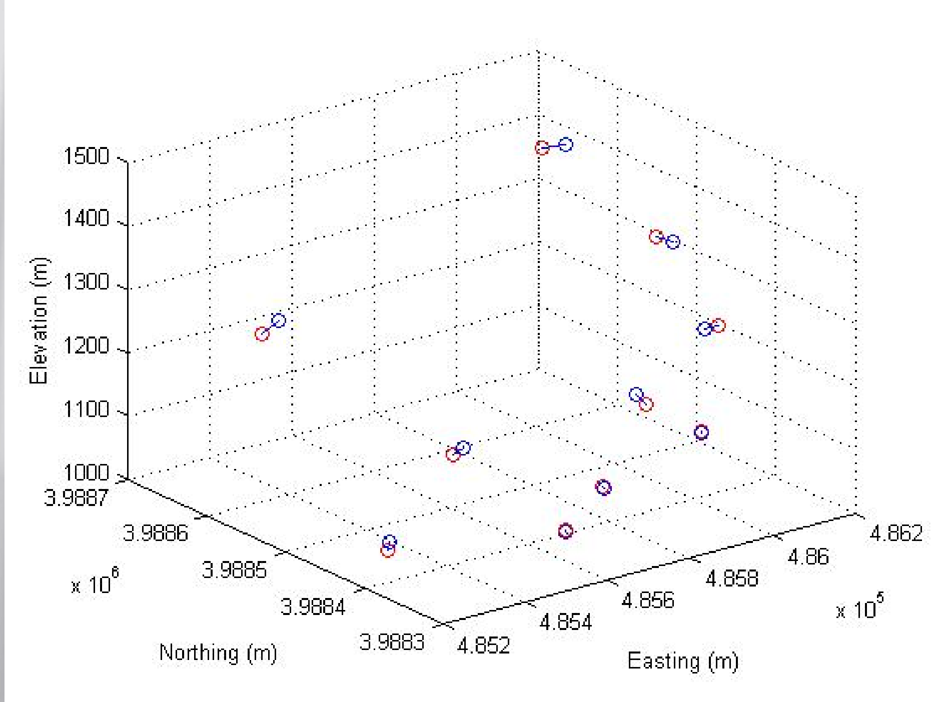
OBSERVATIONS

- Clair Camp Structure has more error, why?
- Baseline v. distance to feature

Clair Camp Structure

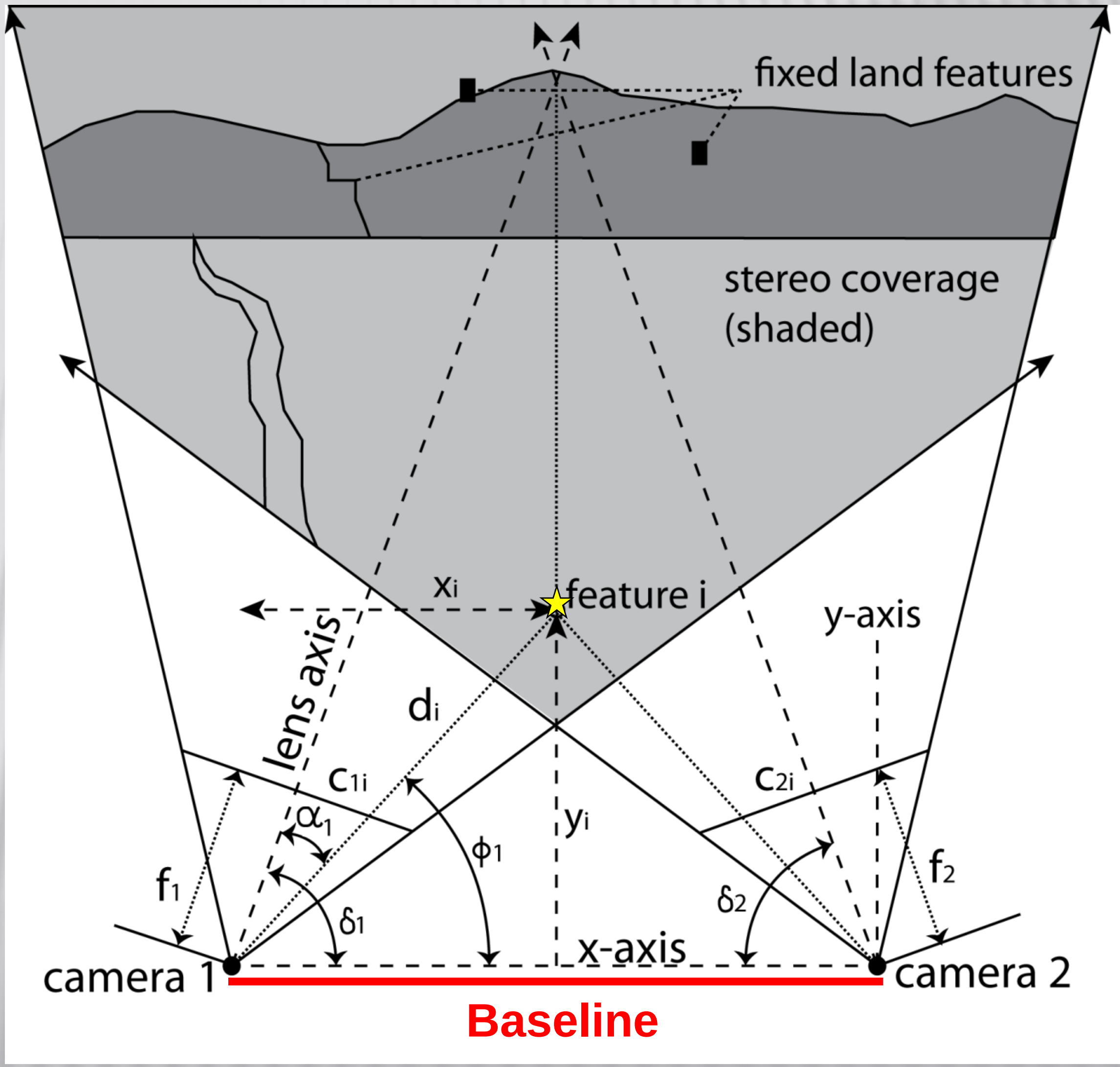


Noonday Structure

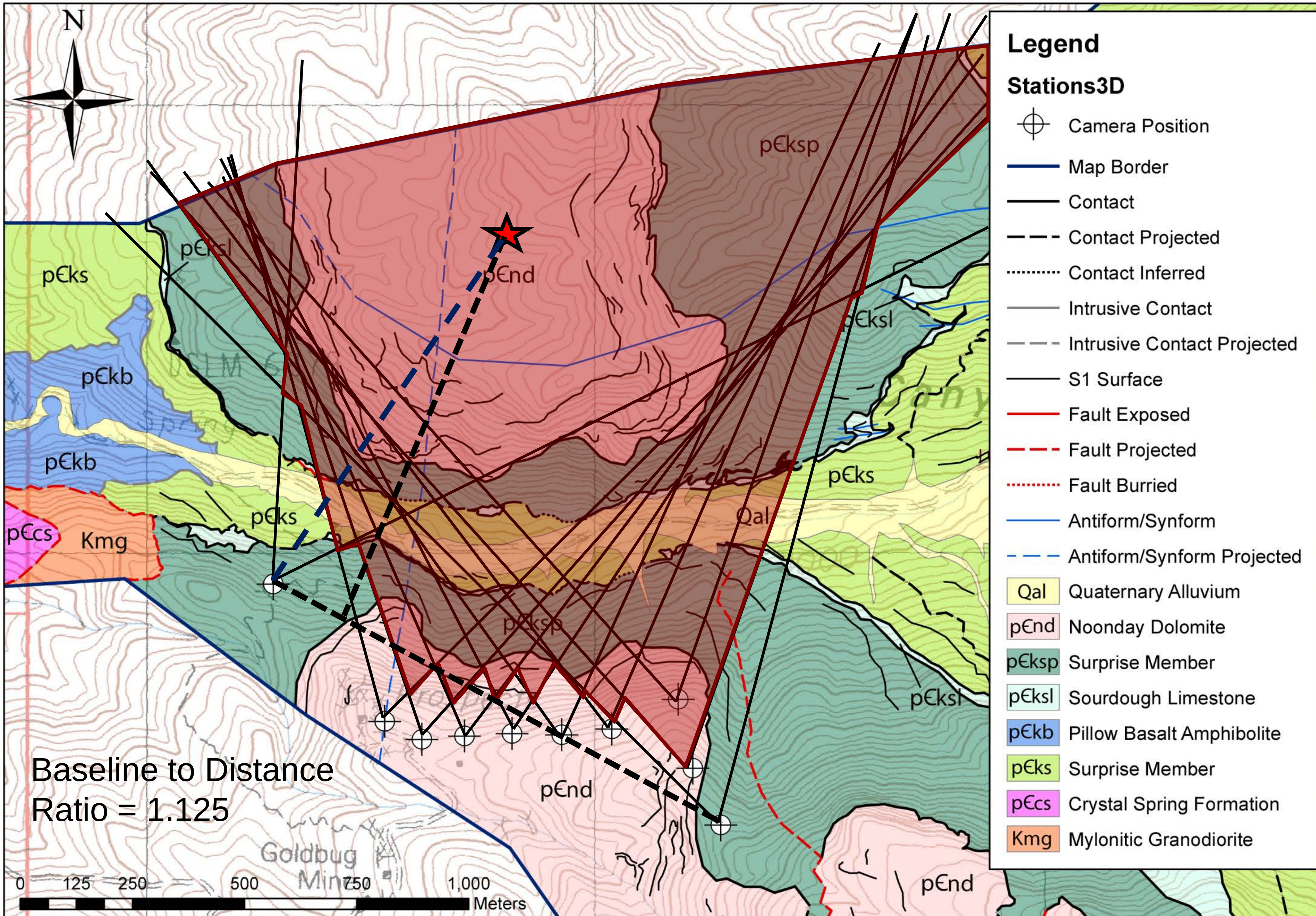


HYPOTHESIS: BASELINE-DISTANCE RATIO

- Baseline v. distance to feature (star) should be 2:1
- The larger the baseline the greater the distance that can be calculated



Modified from
http://polarmet.osu.edu/jbox/icecams/Greenland/project.htm. Based on Wolf, 1983


N
Legend
Stations3D
Camera Position
Map Border
Contact
Contact Projected
Contact Inferred
Intrusive Contact
Intrusive Contact Projected
S1 Surface
Fault Exposed
Fault Projected
Fault Burried
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Kmg
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Qal
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Baseline to Distance
Ratio = 1.125
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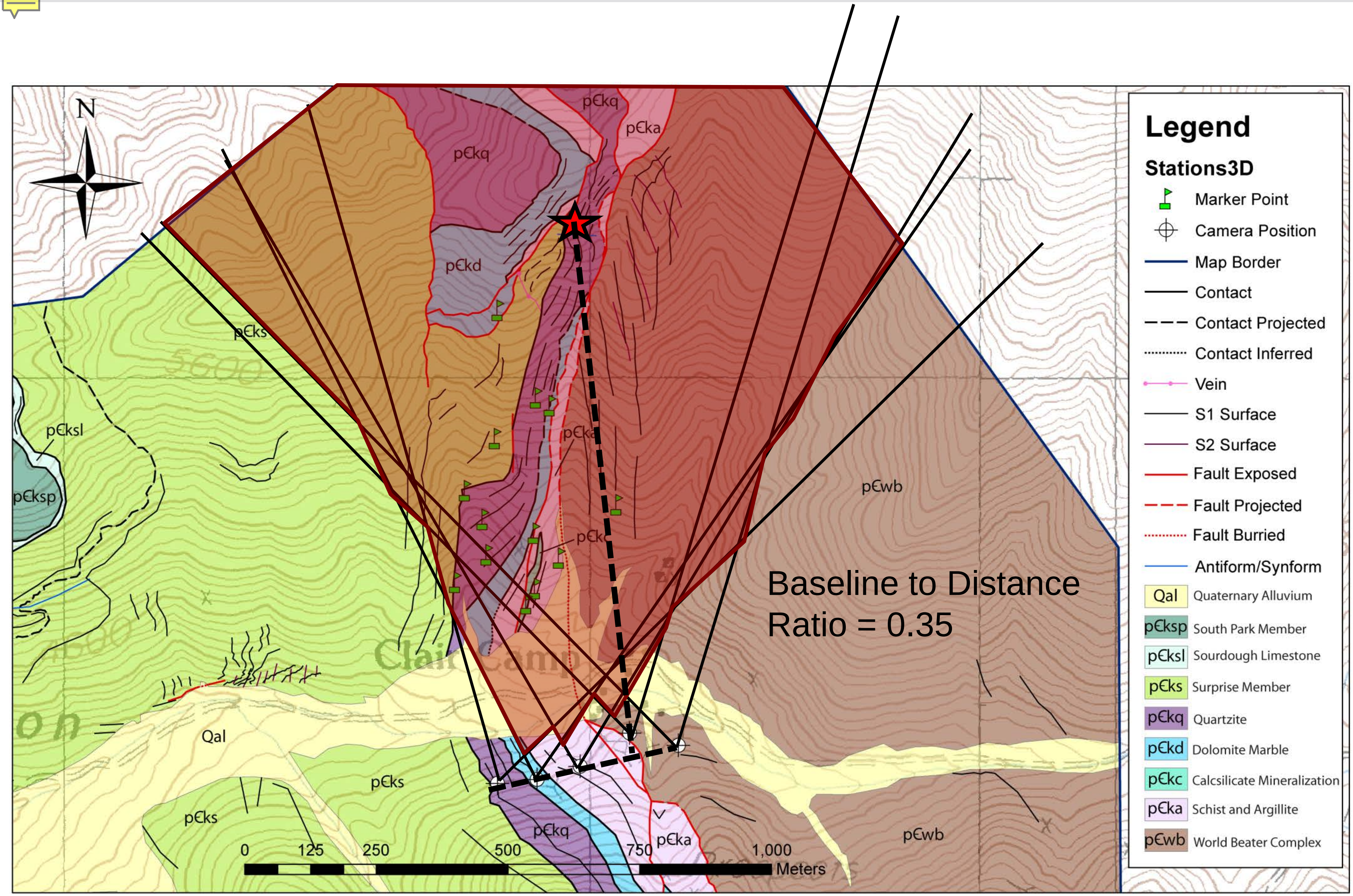
0 125 250 500 750 1,000
Meters



N
Legend
Stations3D
Marker Point
Camera Position
Map Border
Contact
Contact Projected
Contact Inferred
Vein
S1 Surface
S2 Surface
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Fault Projected
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p€kd Dolomite Marble
p€kc Calcsilicate Mineralization
p€ka Schist and Argillite
p€wb World Beater Complex
Baseline to Distance
Ratio = 0.35
p€kq
p€ka
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p€ksl
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p€wb
p€kc
Qal
Clair Camp
0 125 250 500 750 1,000
Meters

CONCLUSION

- Baseline-Distance Ratio
- Important: In a real field study can't always control this
- Use of ground control
- Vertical angle issue
  - SfM – oblique photogrammetry
  - Requires further evaluation

THANK YOU

Questions?

UNAVCO

NSF

MAPTEK™

UTEP™

REFERENCES

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