Hartwick College, NY

10/31/2022

2:00 PM: The Life of a Geologist

5:00 PM: The Geology of Impact Craters, or Impact Crater Tectonics

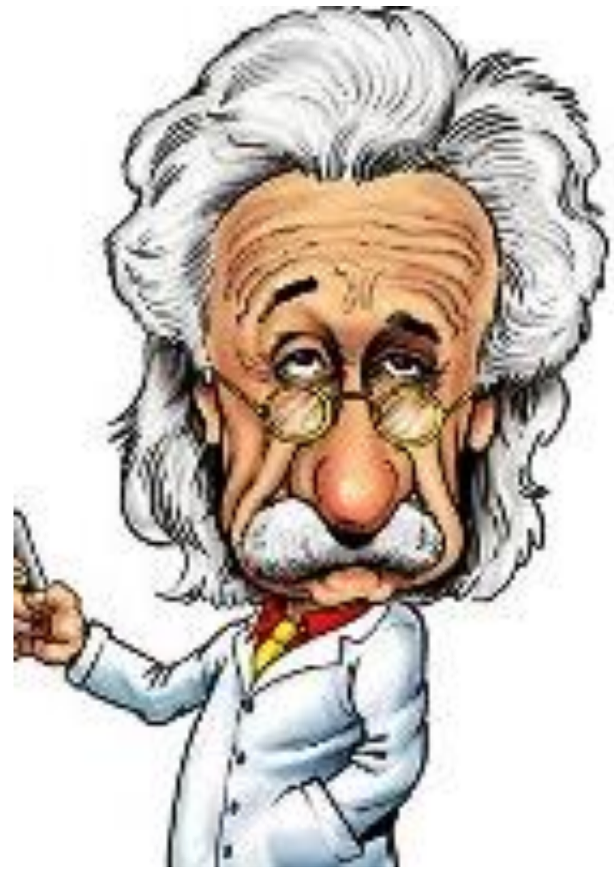
D. Buthman

Message: Alternative hypotheses for the evolution of Earth's structures that is consistent in the universe.

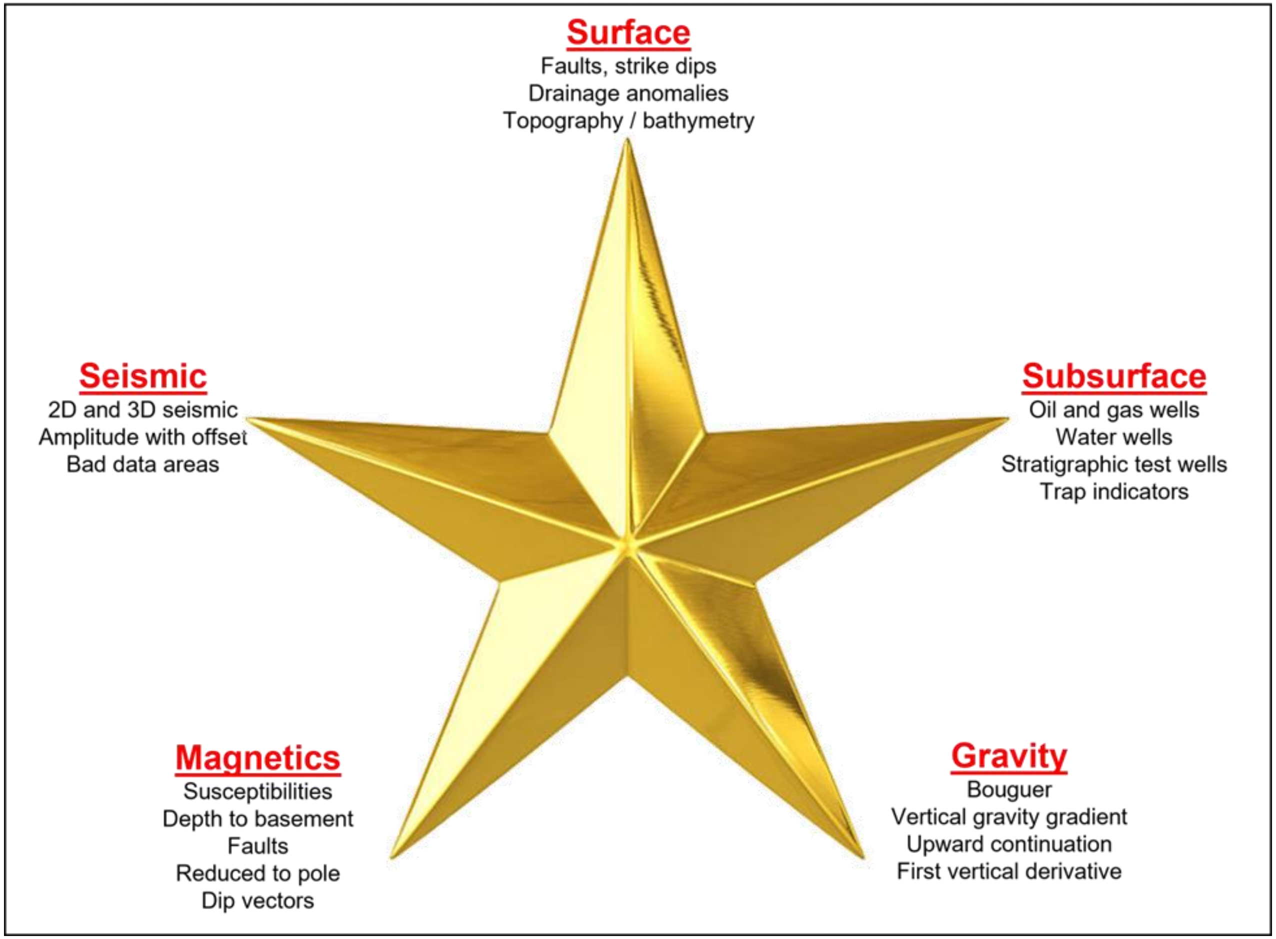
Impact Crater Tectonics AKA The Geology of Large Impact Structures

Scientific Method

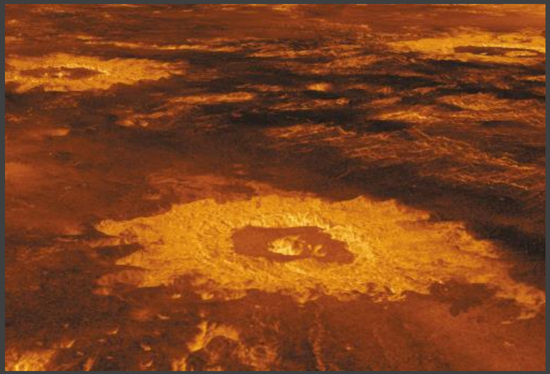
- **State the problem**
  - Where are economic HC fields?
- **Collect observations**
  - Oil seeps, field geology, mapping, potential fields, seismic
- **Formulate hypothesis (Working & Multiple)**
  - Construct structure, isopach, etc. maps
- **Make predictions**
  - Recommend leasing & drilling
- **Test predictions by observing phenomena**
  - Drill & evaluate
- **Accept, modify, or reject the hypothesis**
  - Assess discovery versus dry hole and follow-up



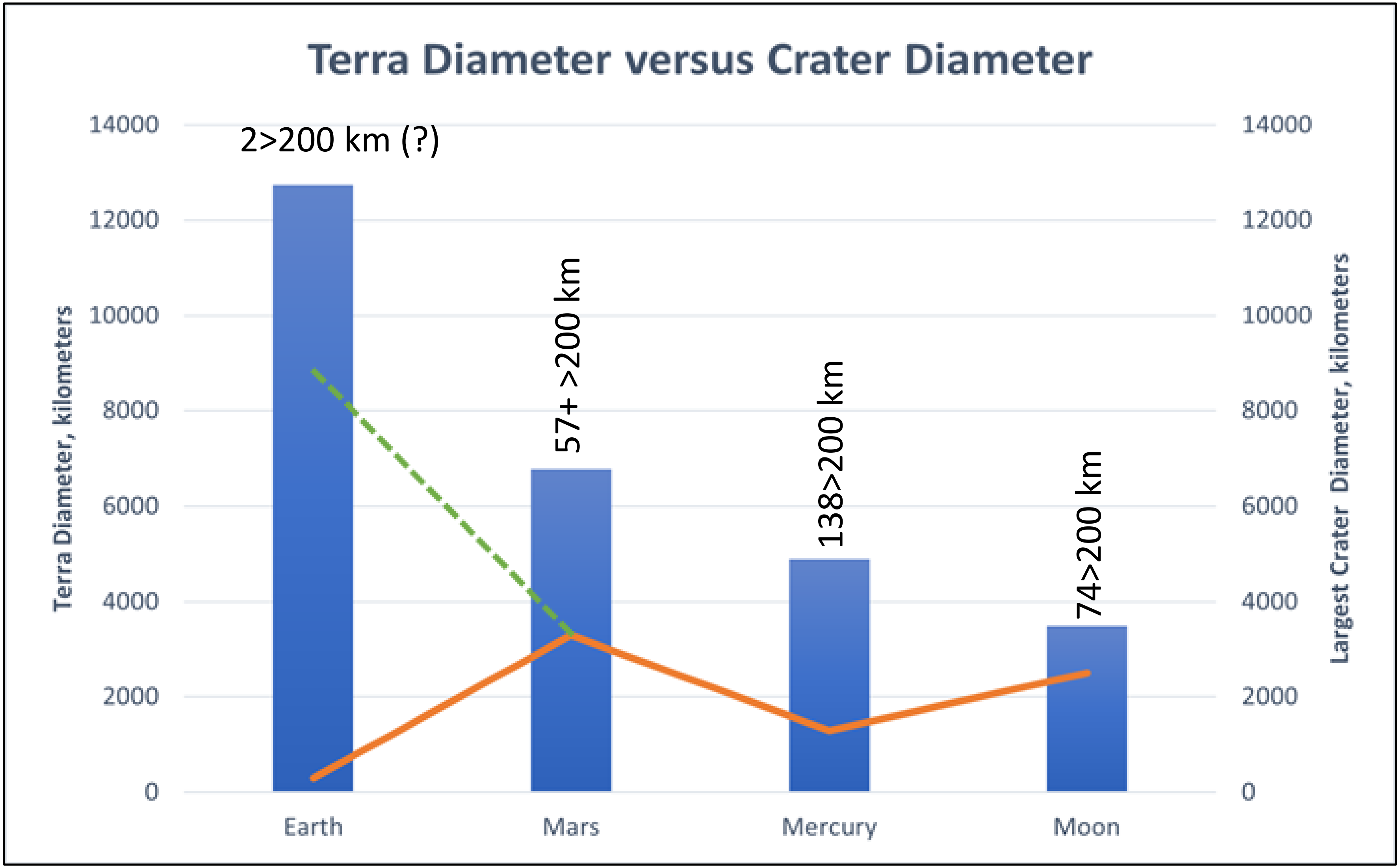
Tools For Detecting the Subsurface



What Do Terrestrial Bodies in our Universe Look Like?

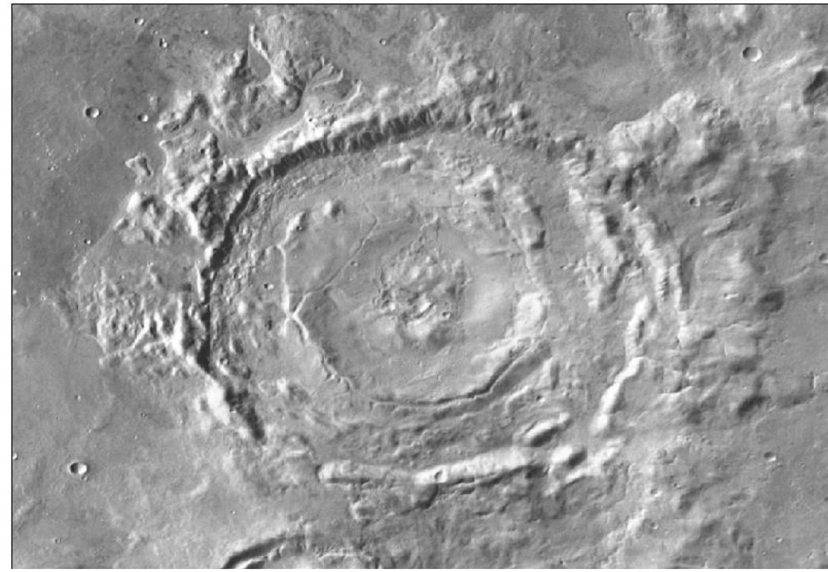


What Are the Large Crater Abundances in Our Universe?

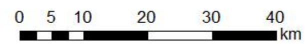


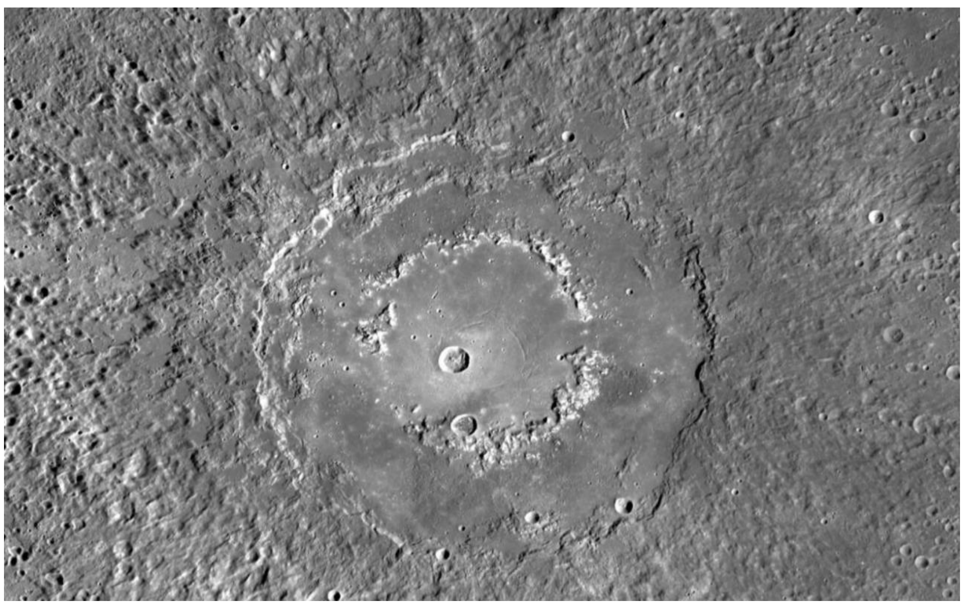
What Types of Impact Craters Exist in our Universe?

Simple crater, Earth, **1200 meter** meter

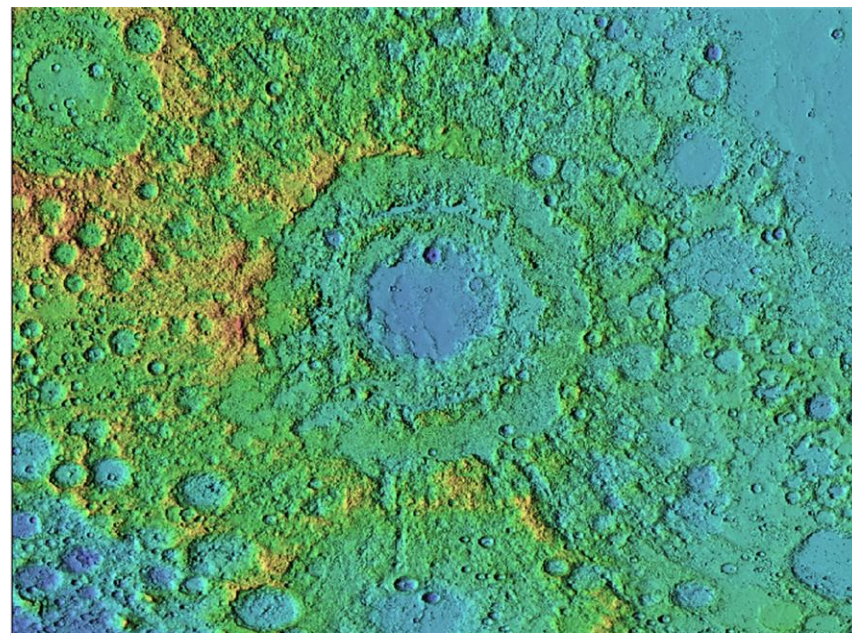


Complex peak ring or multi-ringed crater, Mars, **50 km** meter



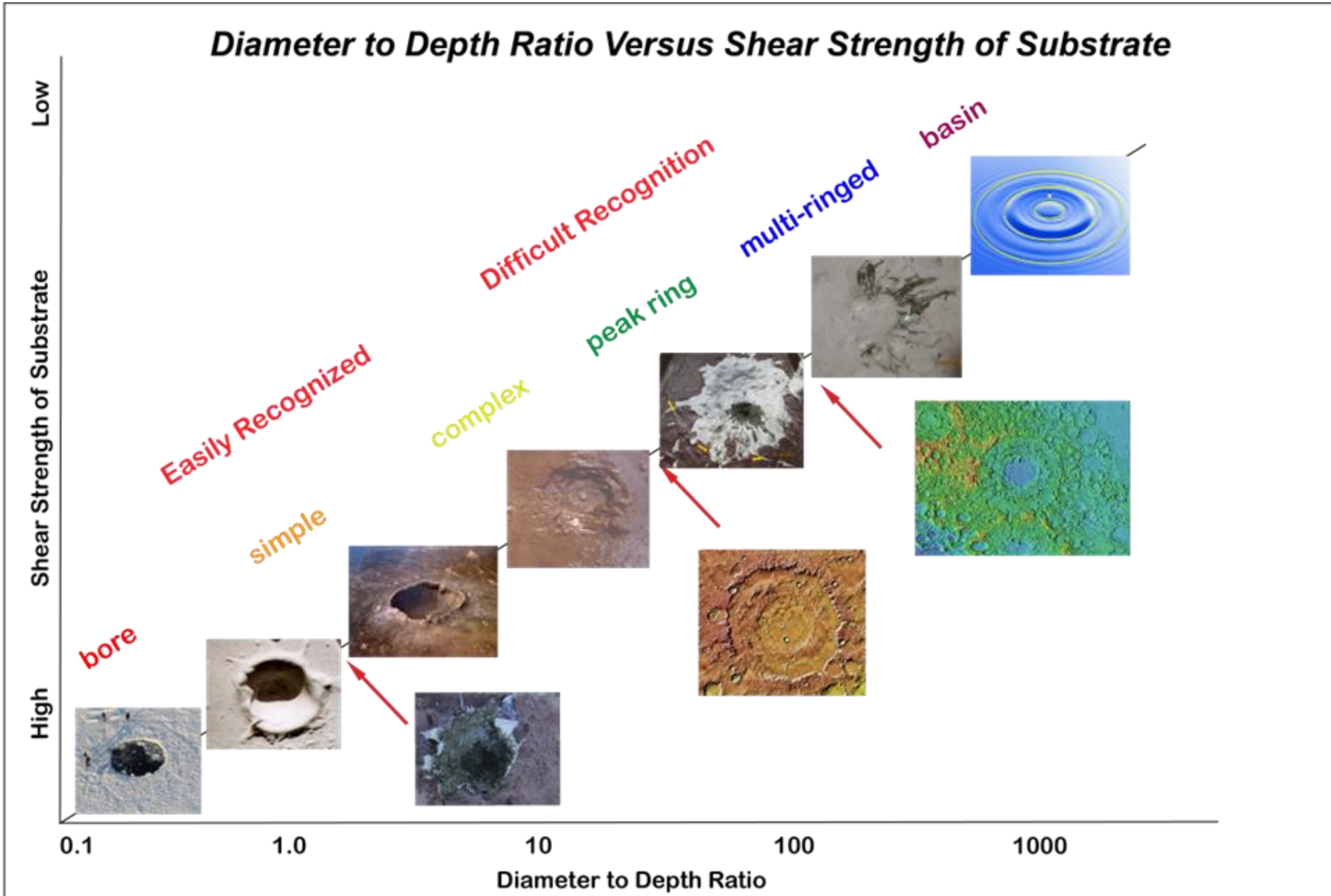


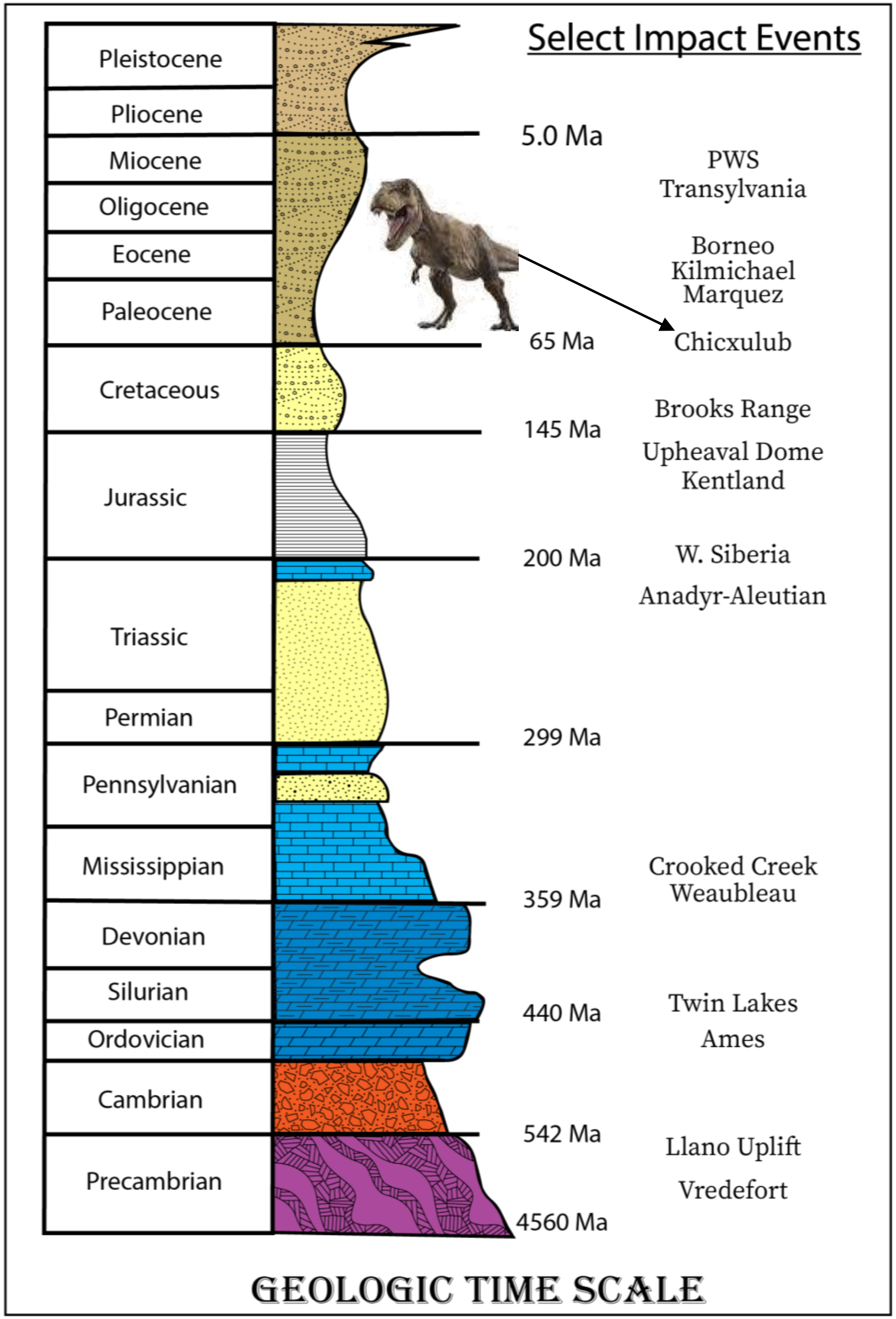
Raditladi peak-ring basin, Mercury. Mercury dual imaging system (MDIS) Crater meter is **258 km**. NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washingston, 4/16/2015.



Mare Orientale multi-ringed crater basin. Innermost ring is 340 km meter, outer rim is **962 km** meter.

Their Geometries Depend on Where They Strike





Prince William Sound (PWS): 750 km meter. Late Miocene, 5.7 Ma.

Avak Astrobleme: 12 km diameter. Cretaceous Turonian (91-94 Ma) age (Banet & Buthman, 2006).

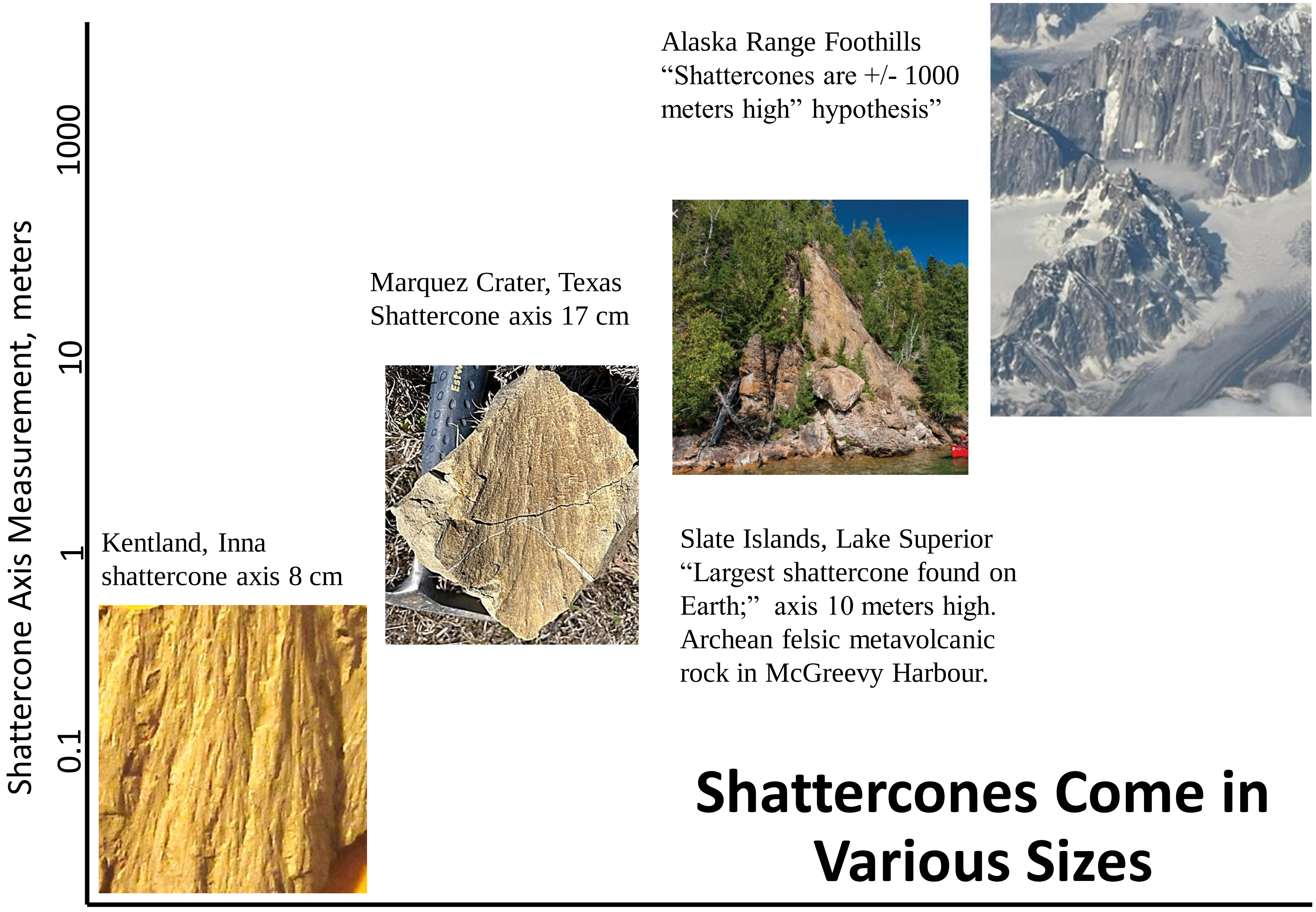
Brooks Range Asteroid Impact: 2550 km meter. Lower Cretaceous Crater structure formed 120 Ma, during the Lower Cretaceous.

Anadyr-Aleutian: 3190 km meter. Upper Triassic

Council Structure: 97 km meter. Structure formed during the Ordovician.

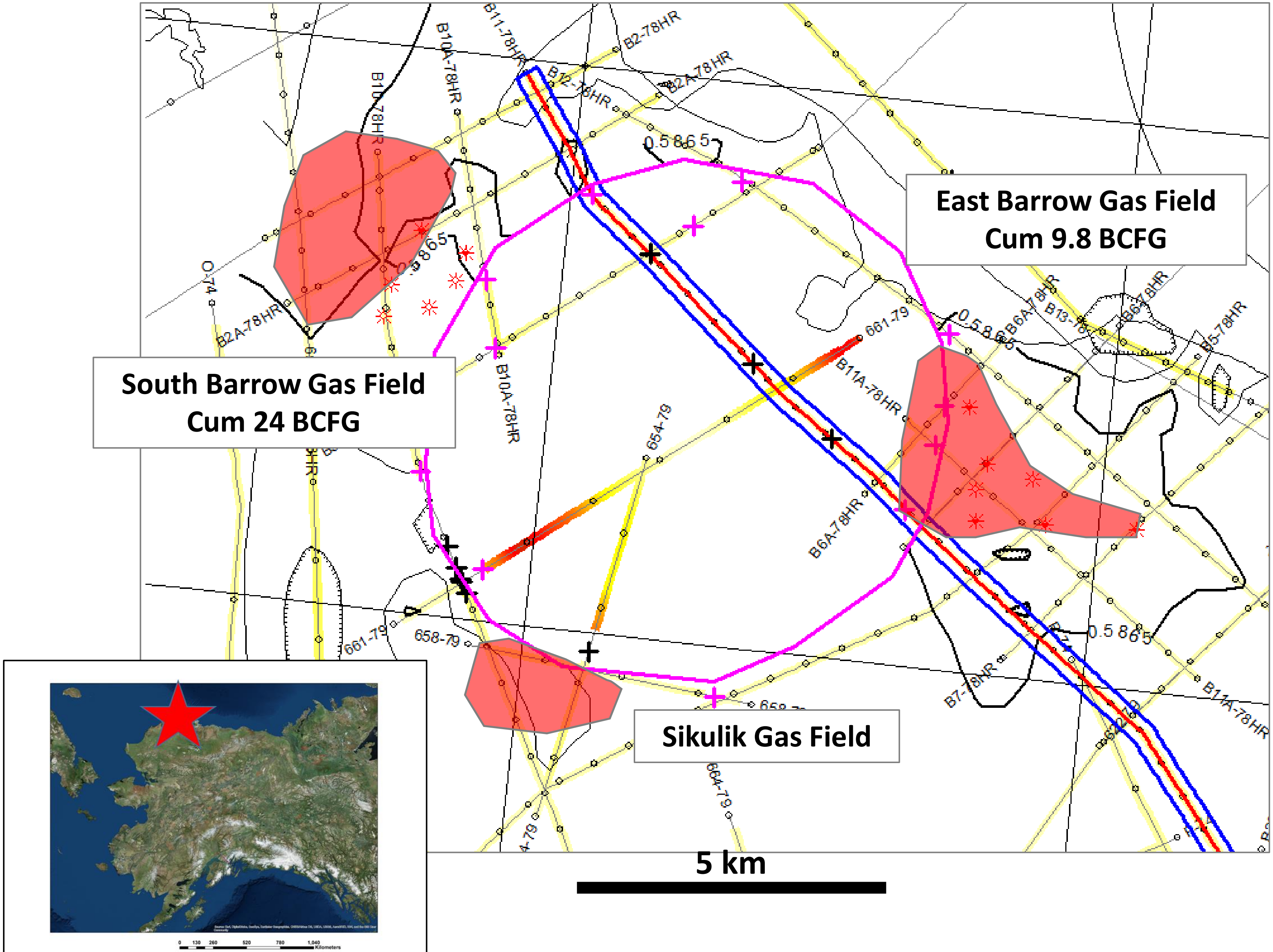
When Did They Occur? Geologic Time Scale & Impact Craters on Earth

What Evidence Proves Impact? Shattercones.

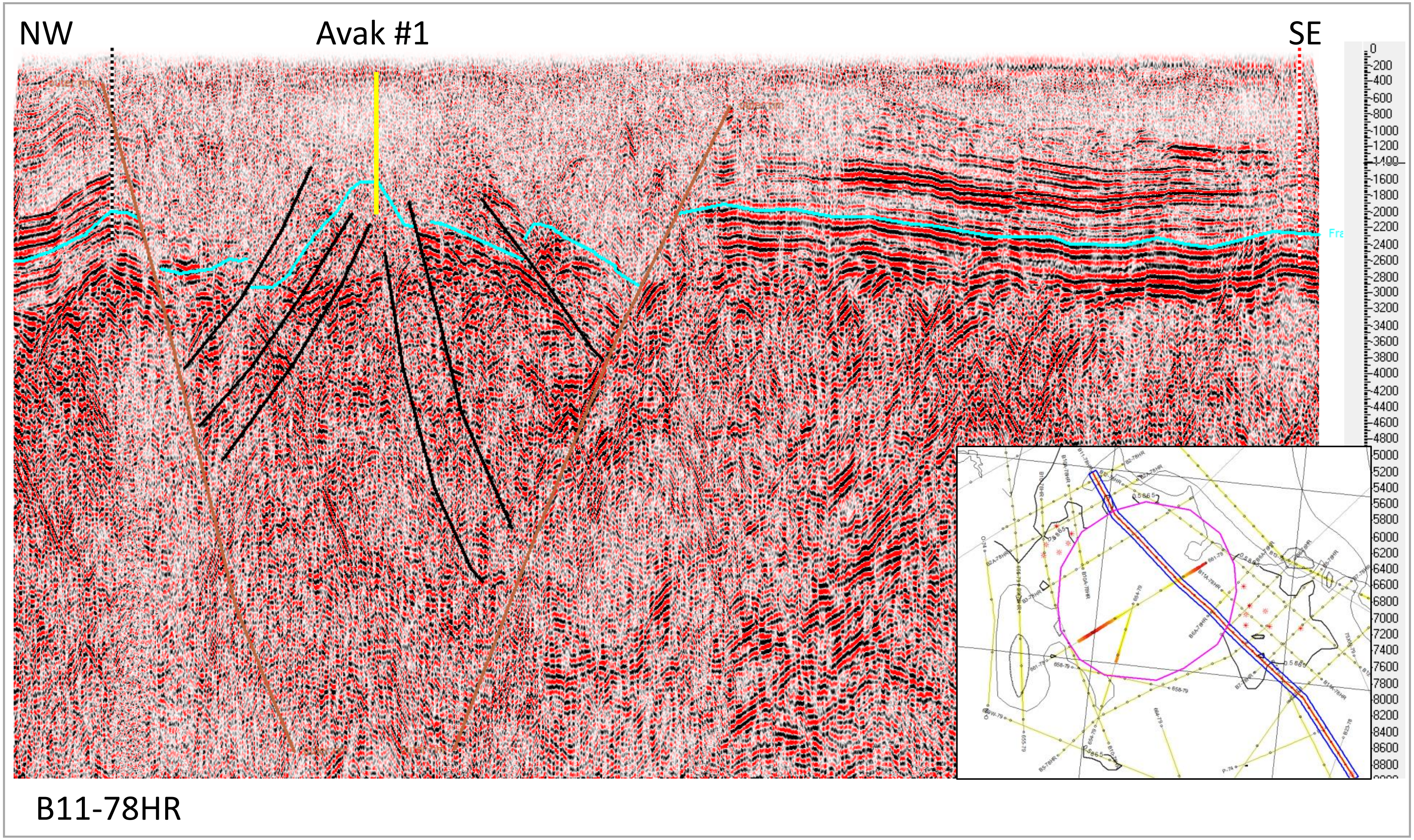


Shattercones Come in Various Sizes
Shattercone Axis Measurement, meters
0.1
1
10
1000
Kentland, Inna
shattercone axis 8 cm
Marquez Crater, Texas
Shattercone axis 17 cm
Slate Islands, Lake Superior
"Largest shattercone found on Earth;" axis 10 meters high. Archean felsic metavolcanic rock in McGreevy Harbour.
Alaska Range Foothills
"Shattercones are +/- 1000 meters high" hypothesis"

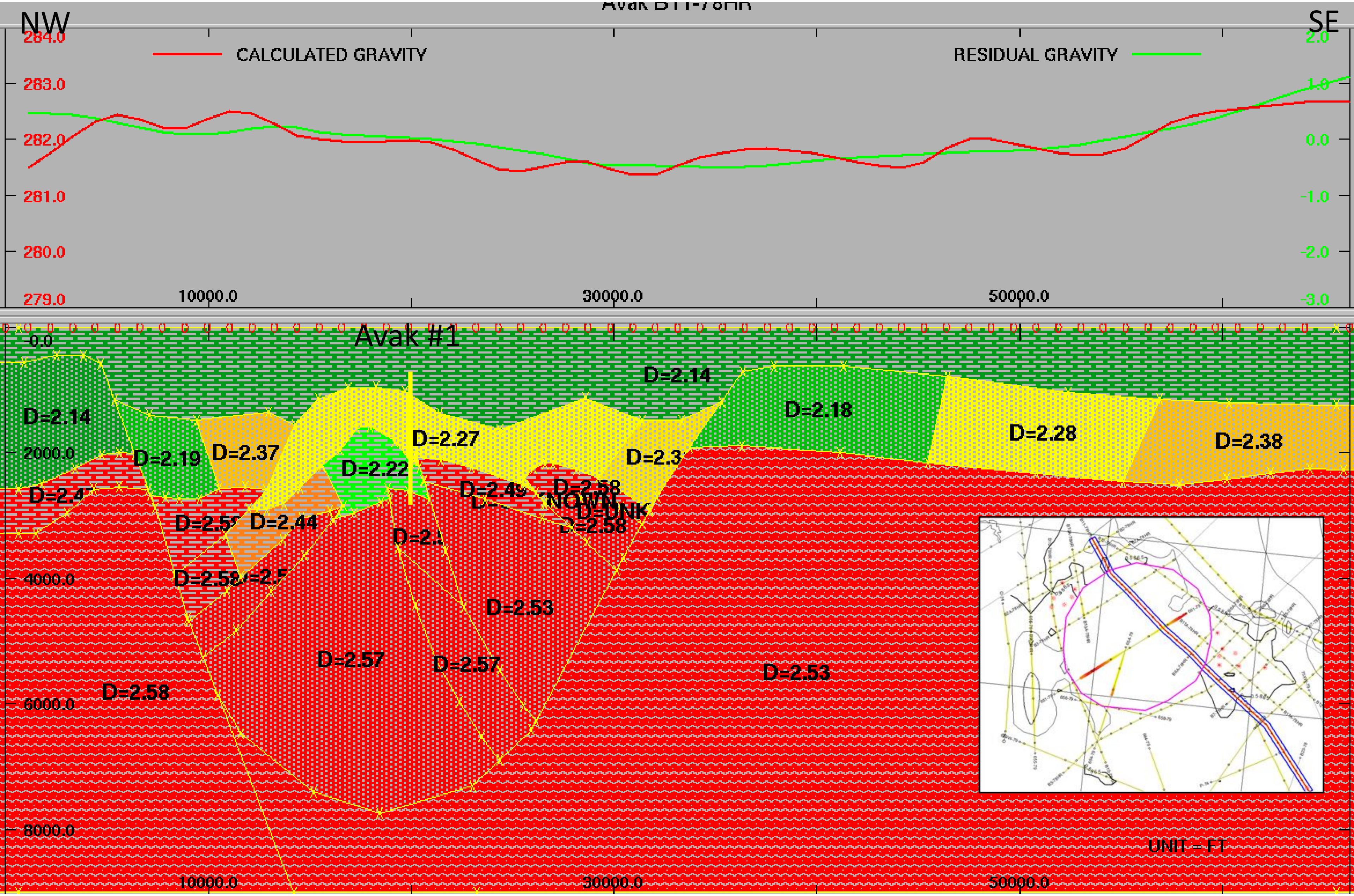
Example: Avak Astrobleme, Alaska



2D Seismic Profile Across The Avak Astrobleme, Alaska



Gravity-Seismic Model of Avak Astrobleme



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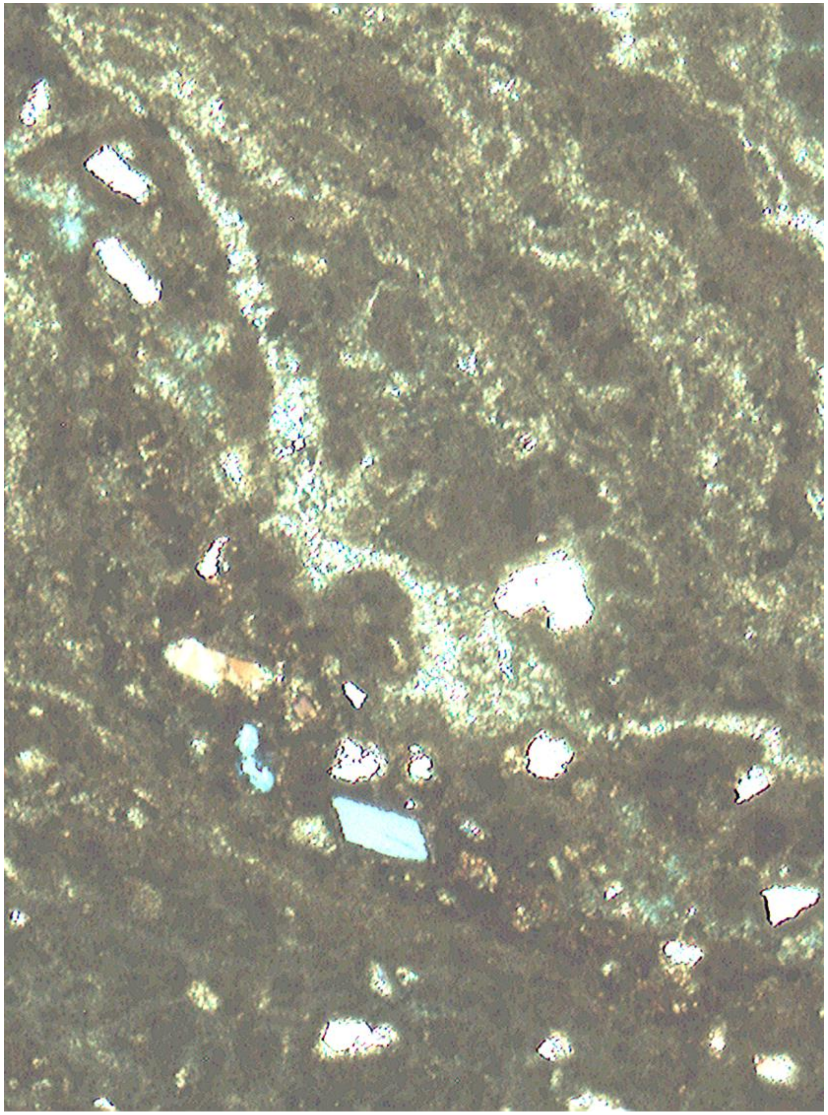
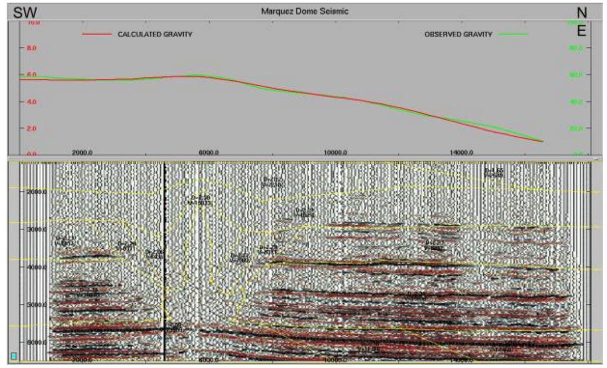
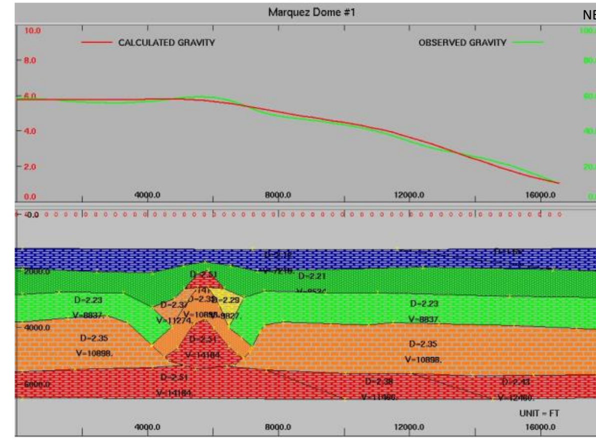
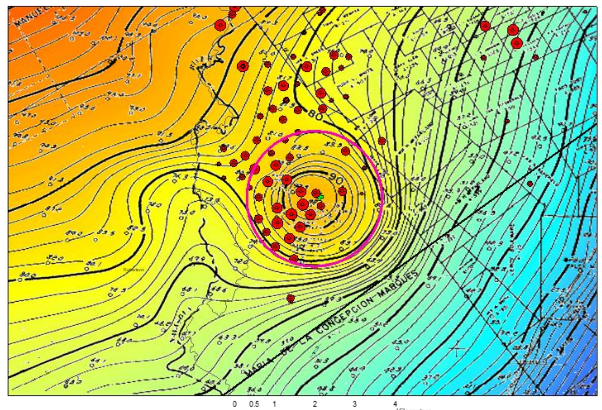
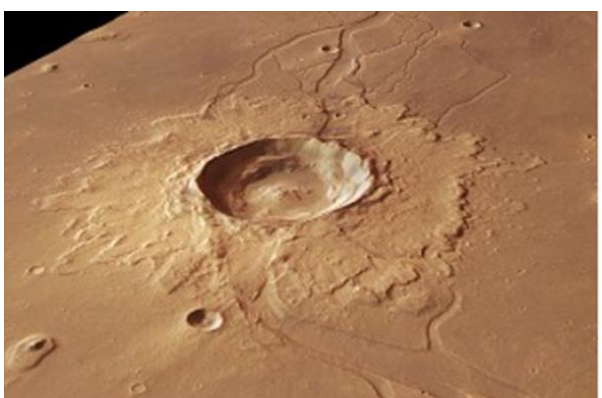
Flow Structures Meteor Crater (L) and Avak (R)





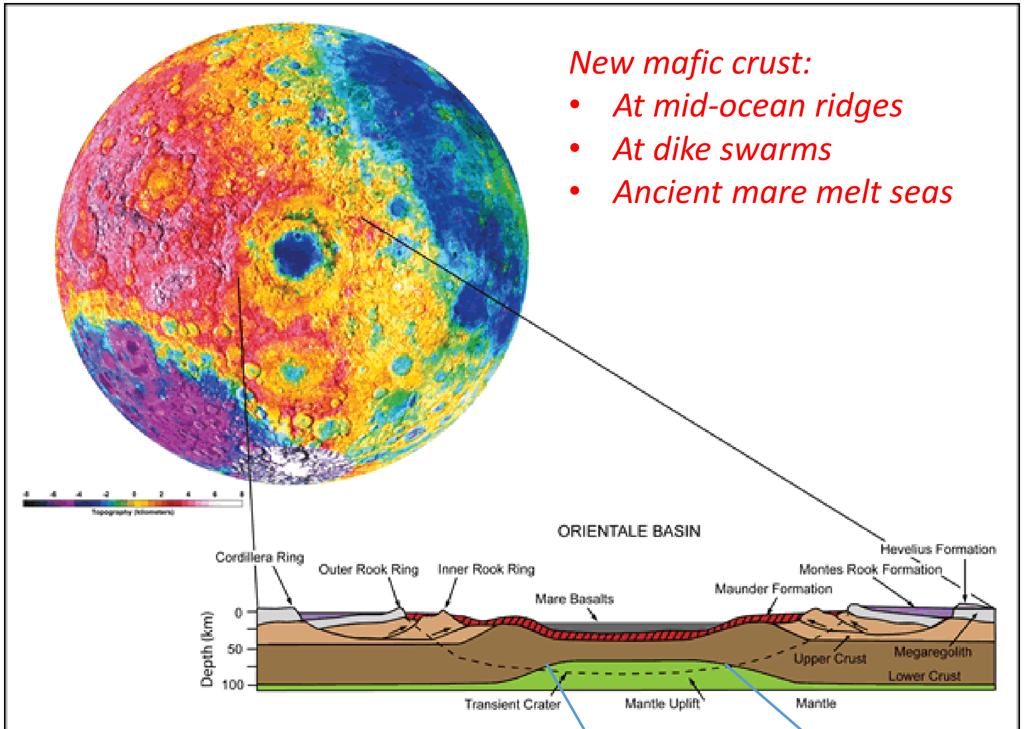






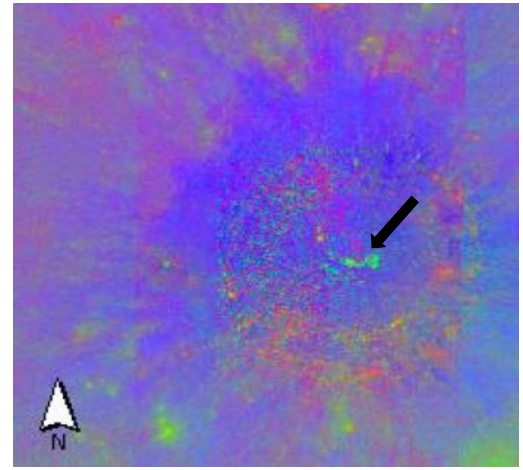
Marquez Crater, Texas

Large Impact Tectonics Theories

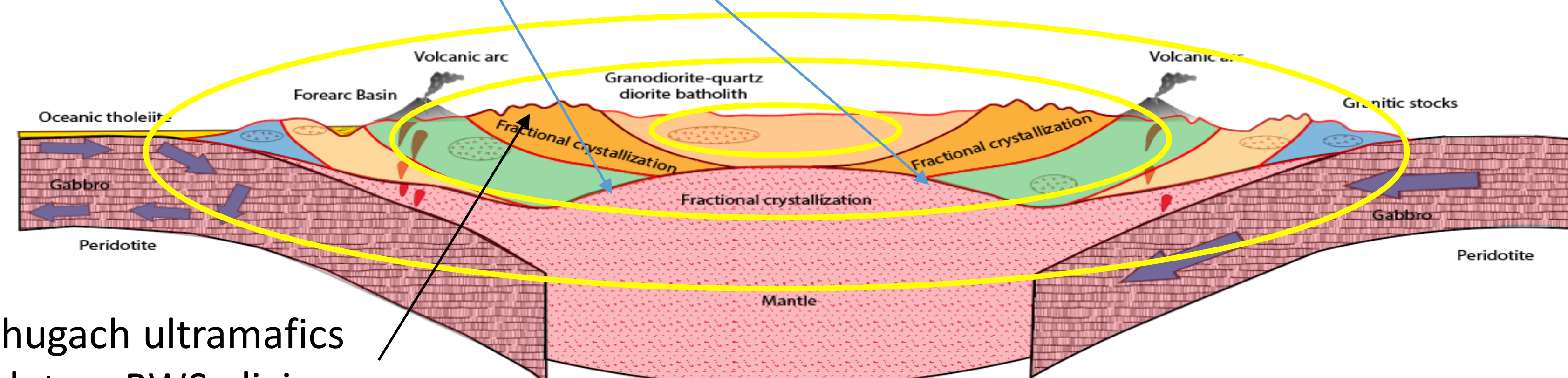


New mafic crust:

- *At mid-ocean ridges*
- *At dike swarms*
- *Ancient mare melt seas*

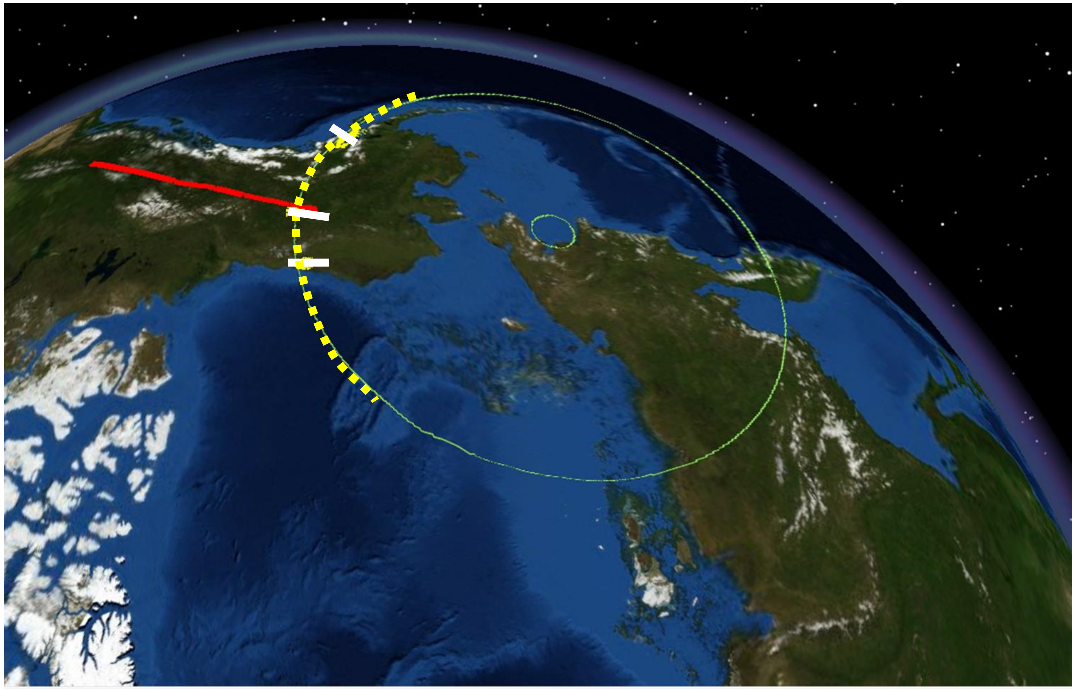


Uplifted mantle / crustal thinning and mantle overturn, arrow indicating olivine troctolite in the central dome of this 93-km meter crater, Clementine mission (Cohen, 2001).

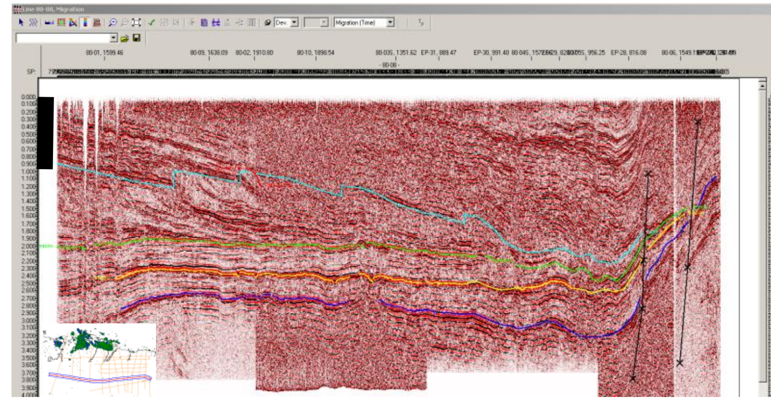


Chugach ultramafics
Eklutna, PWS olivines

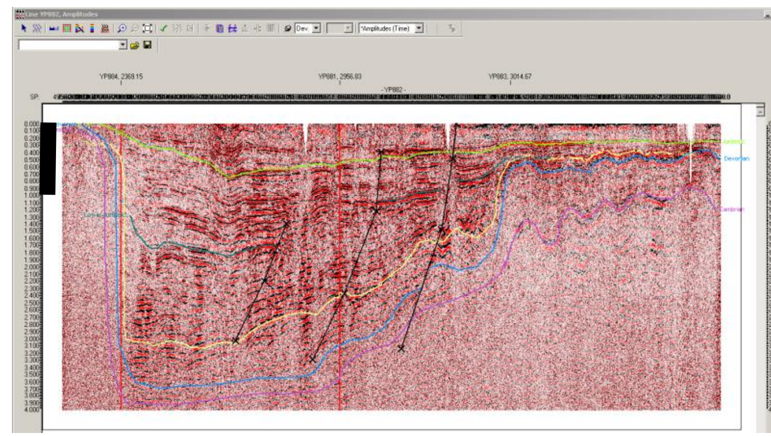
Large Impacts:Anadyr-Aleutian Structure 2D Seismic



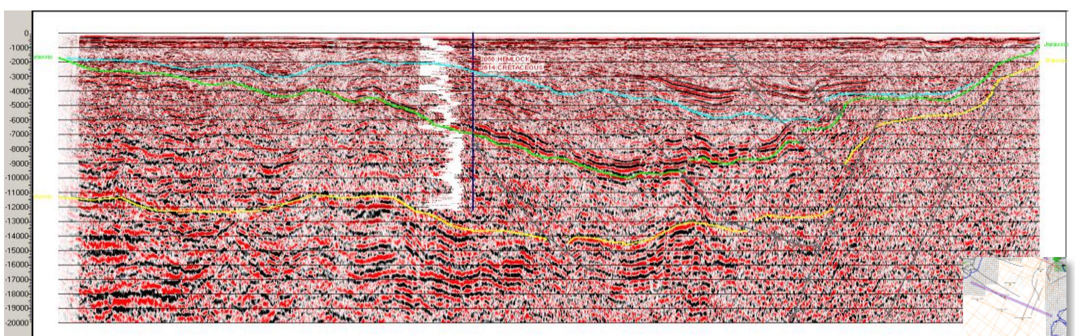
Global perspective view towards the south of the Anadyr-Aleutian multi-ringed basin.



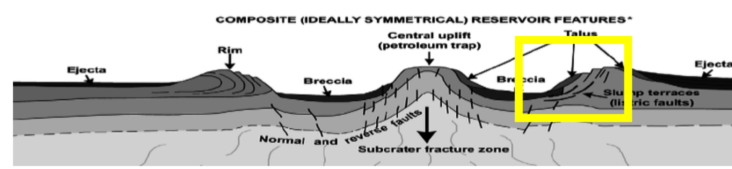
North Slope Regional 2D seismic.



Yukon Flats Basin 2D seismic.



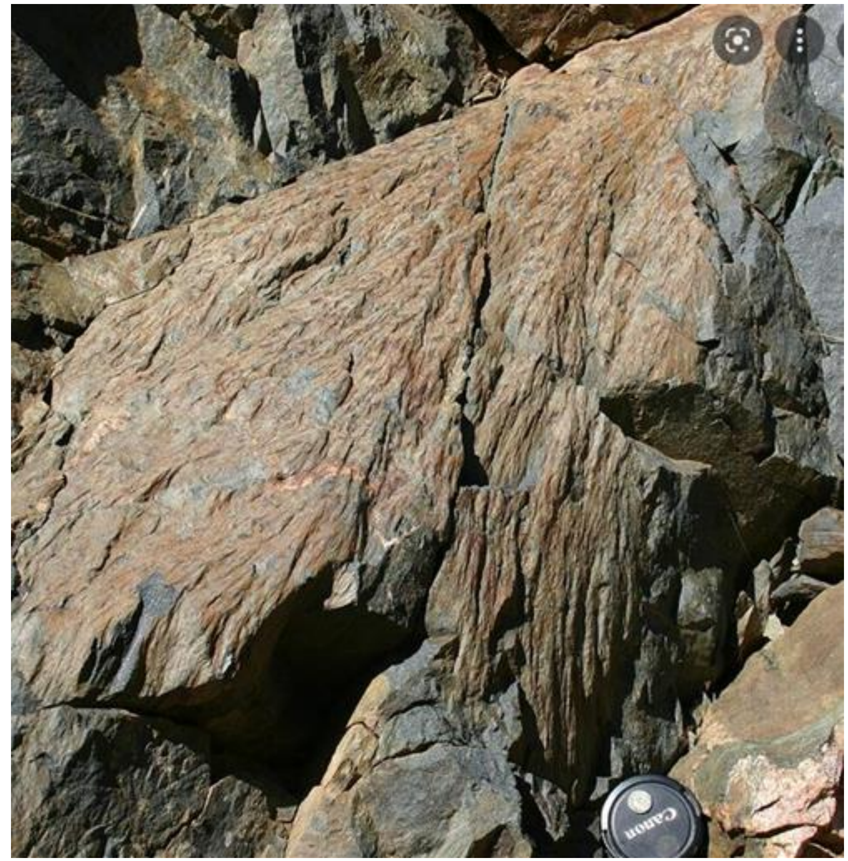
Cook Inlet regional 2D seismic.



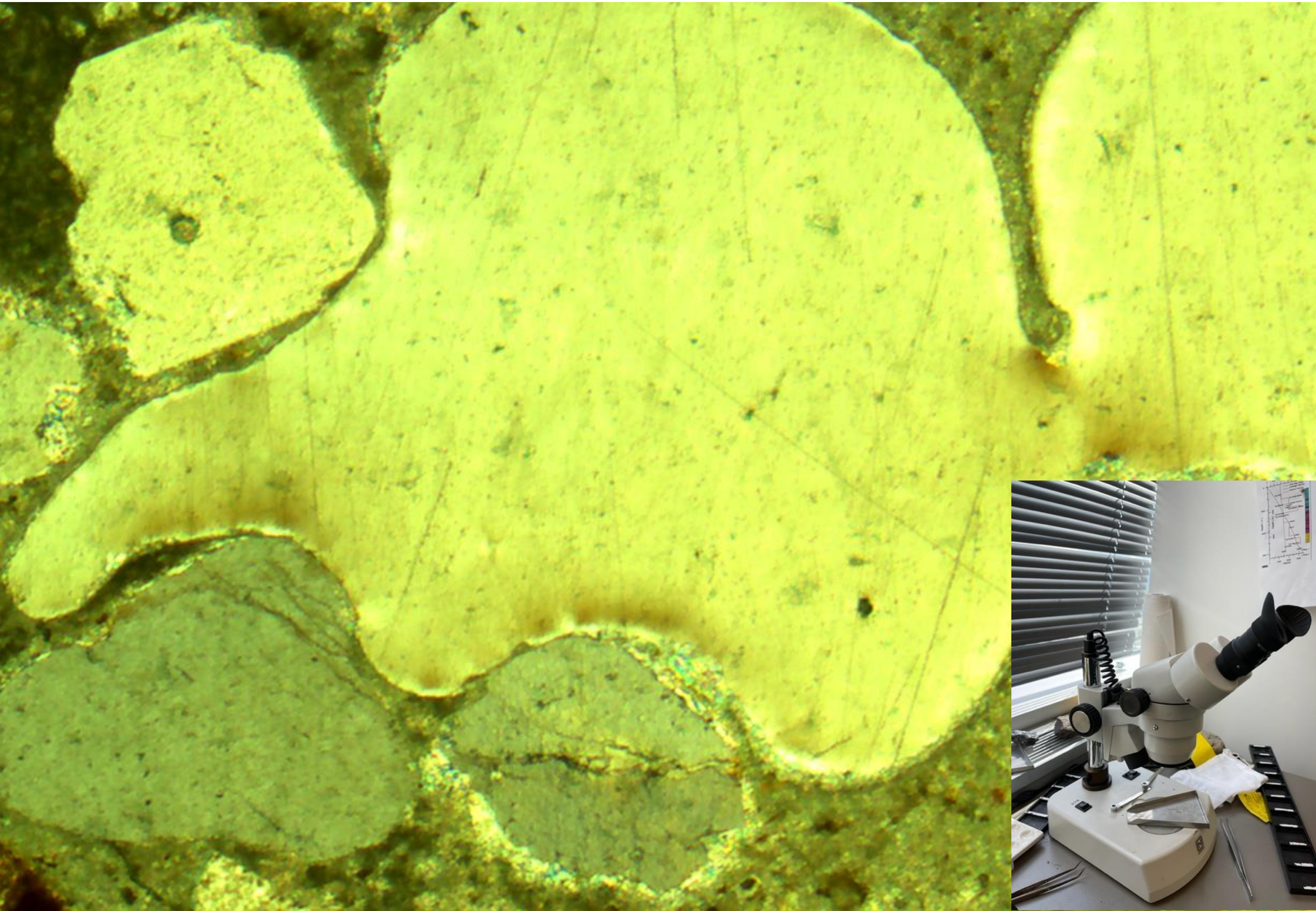
Petroleum reservoir parameters exhibited in large multi-ringed craters.

D. Buthman 8/23/2018

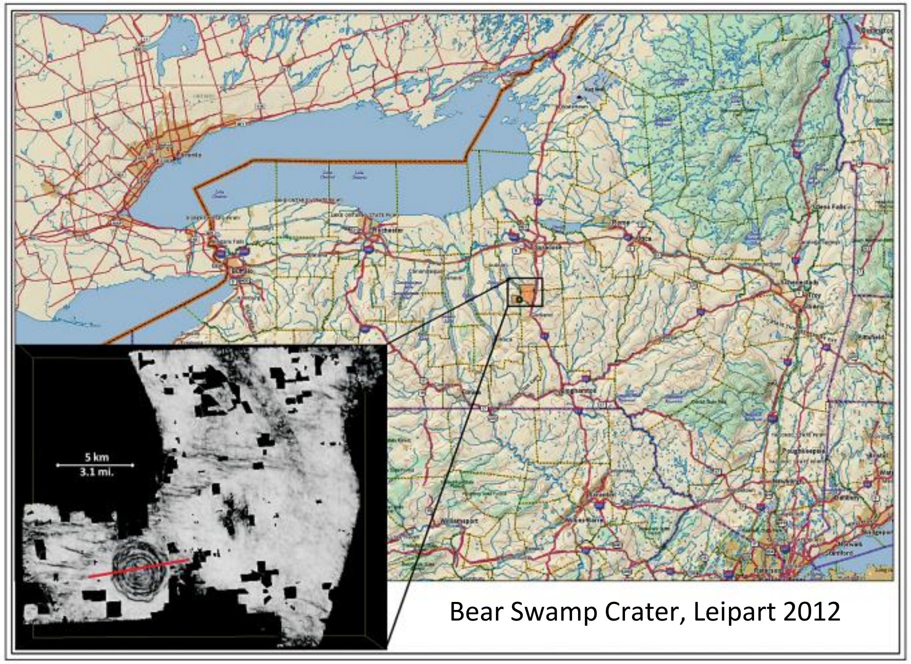
Shattercone Brooks Range



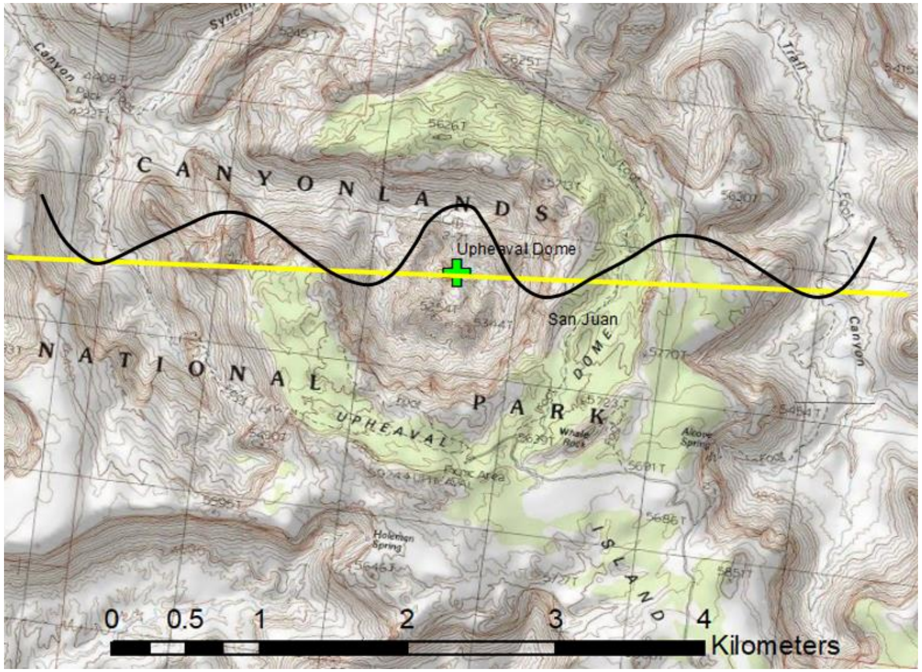
At Decaturville, The Impact Has Melted the Rock!

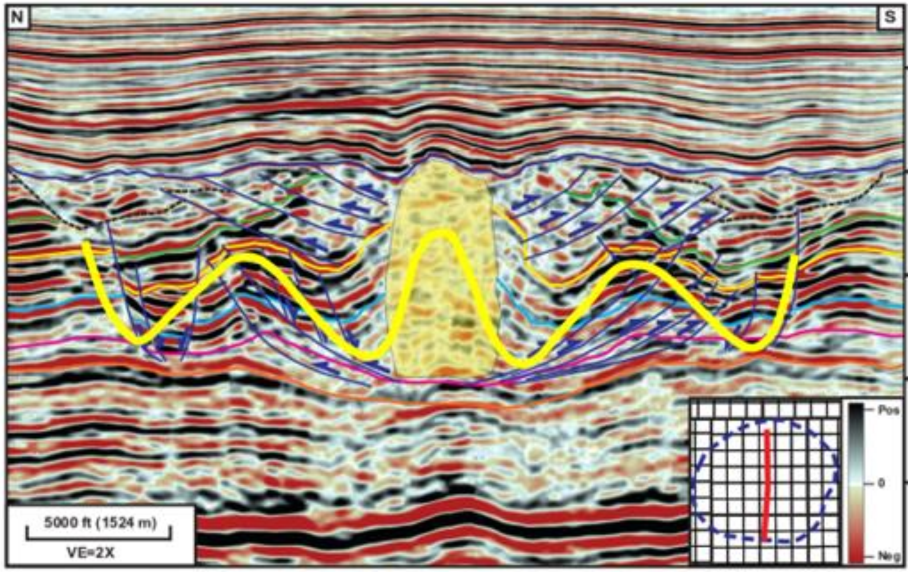


Multi-Ringed Basin Upheaval Dome, Utah

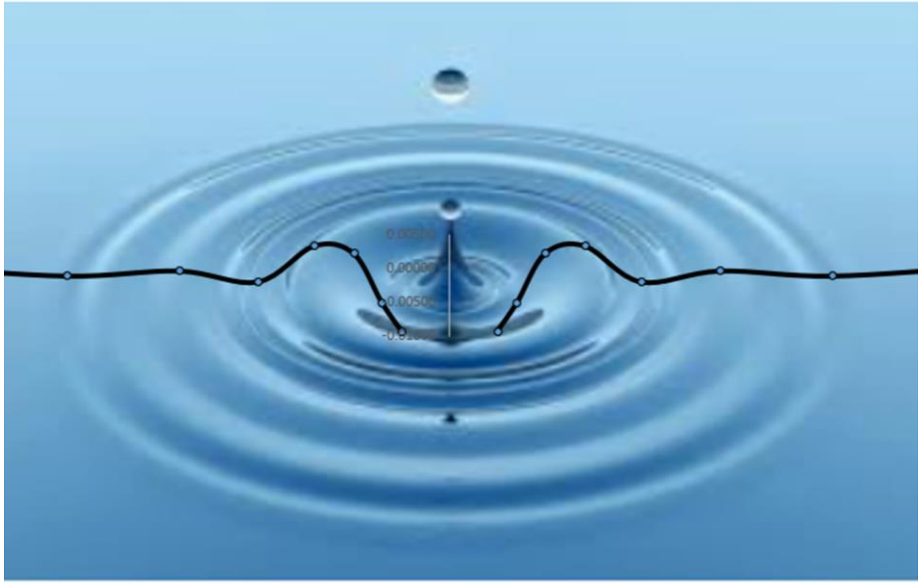


Bear Swamp Crater, Leipart 2012

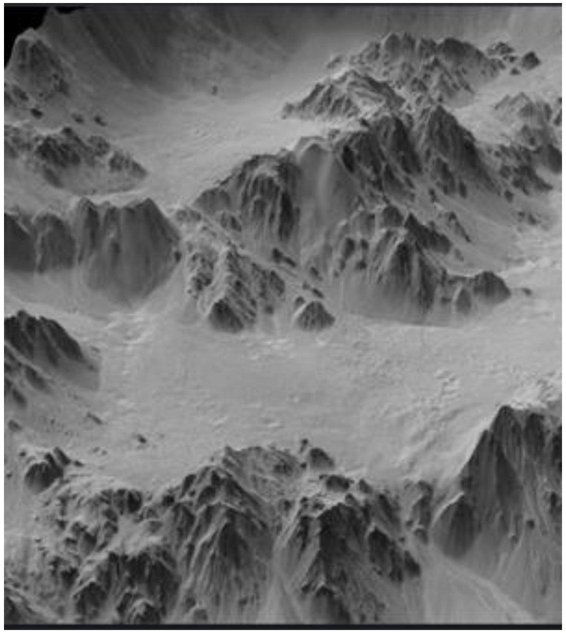




Redwing Creek Oil Field,
Herber, 2010



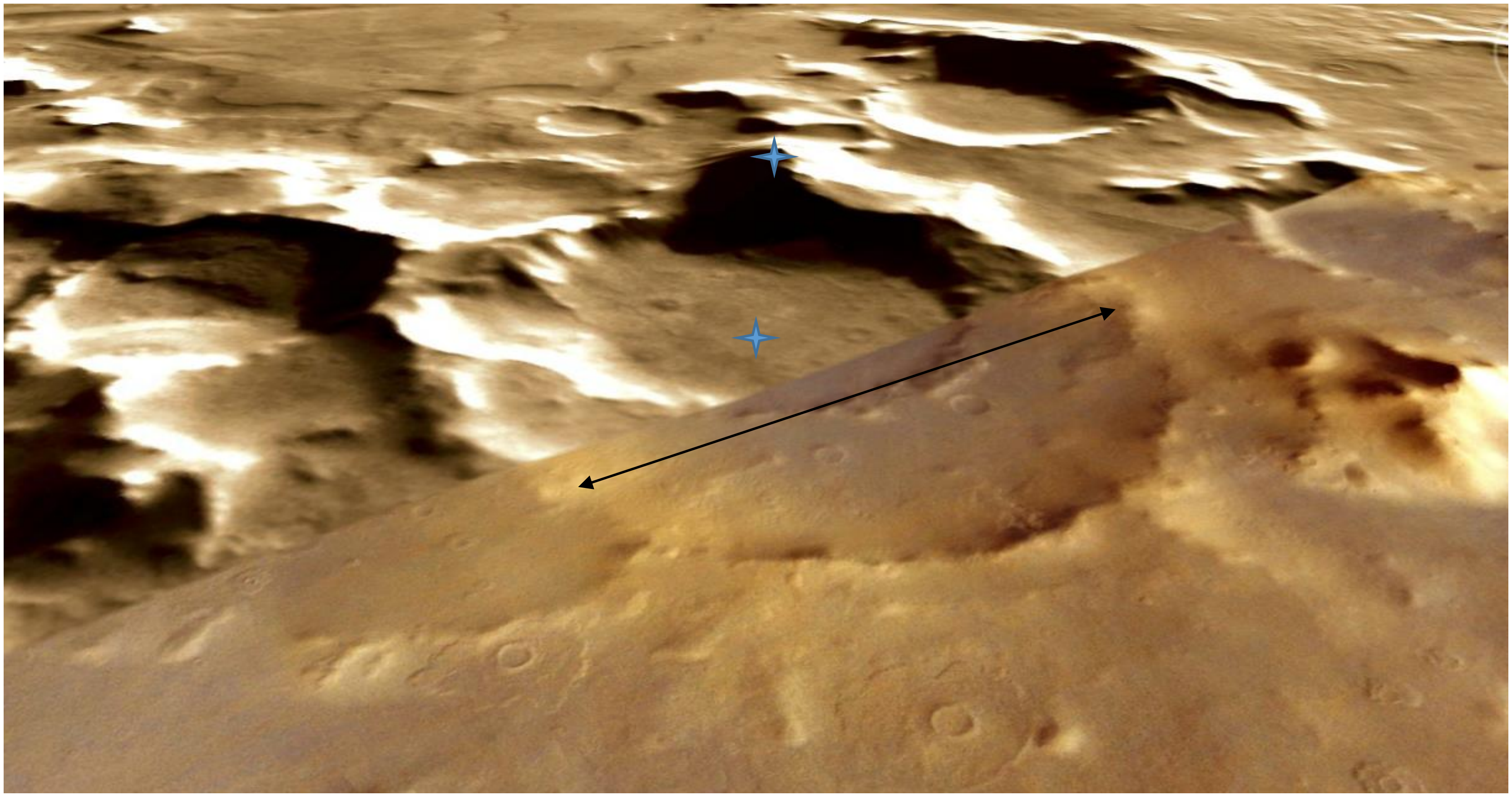
Multi-ringed Impact Basins

Universal Observation:

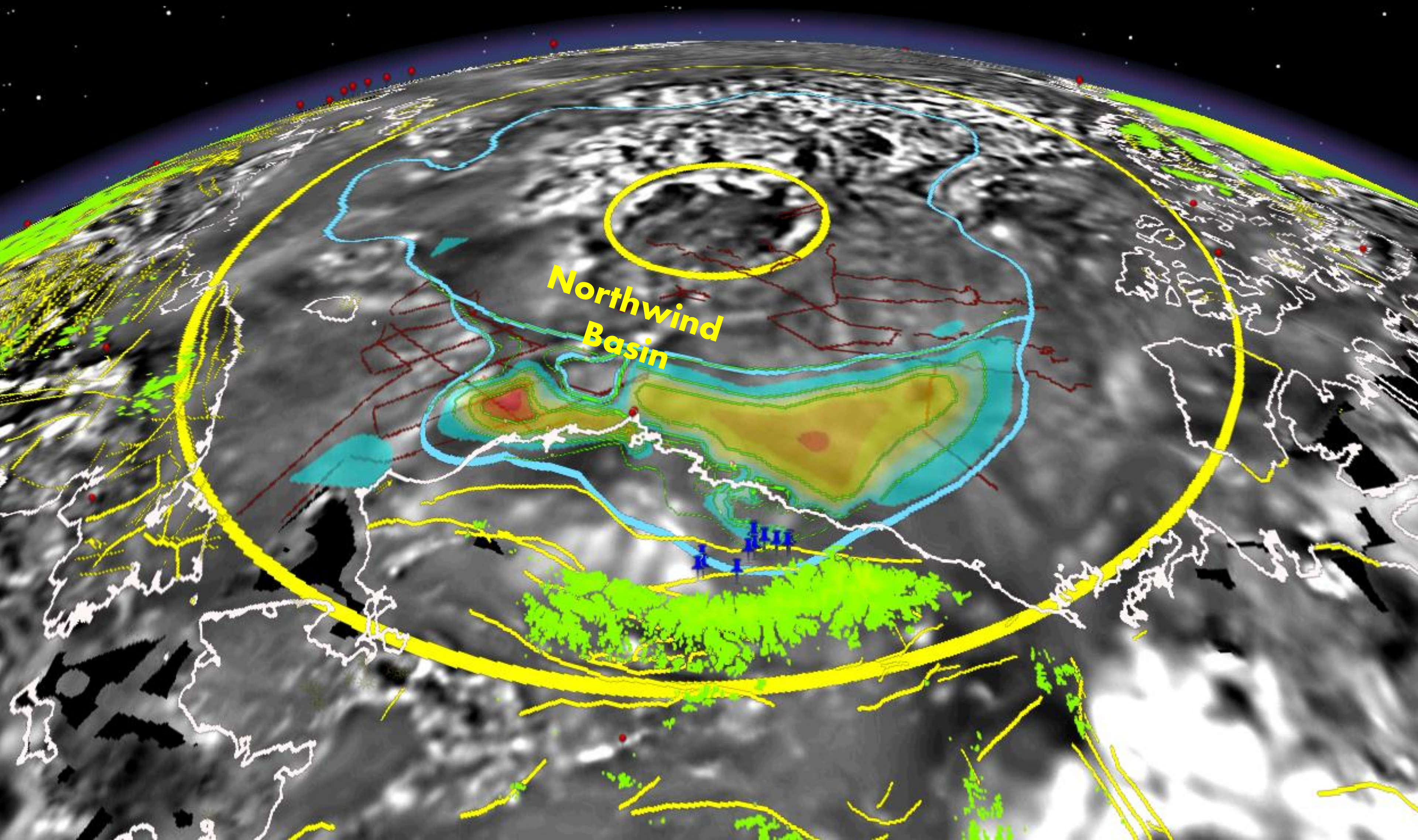
Virtually all arcuate mountain ranges in our Solar System are rims of large impact basins.

Martian Multi-Ringed Crater

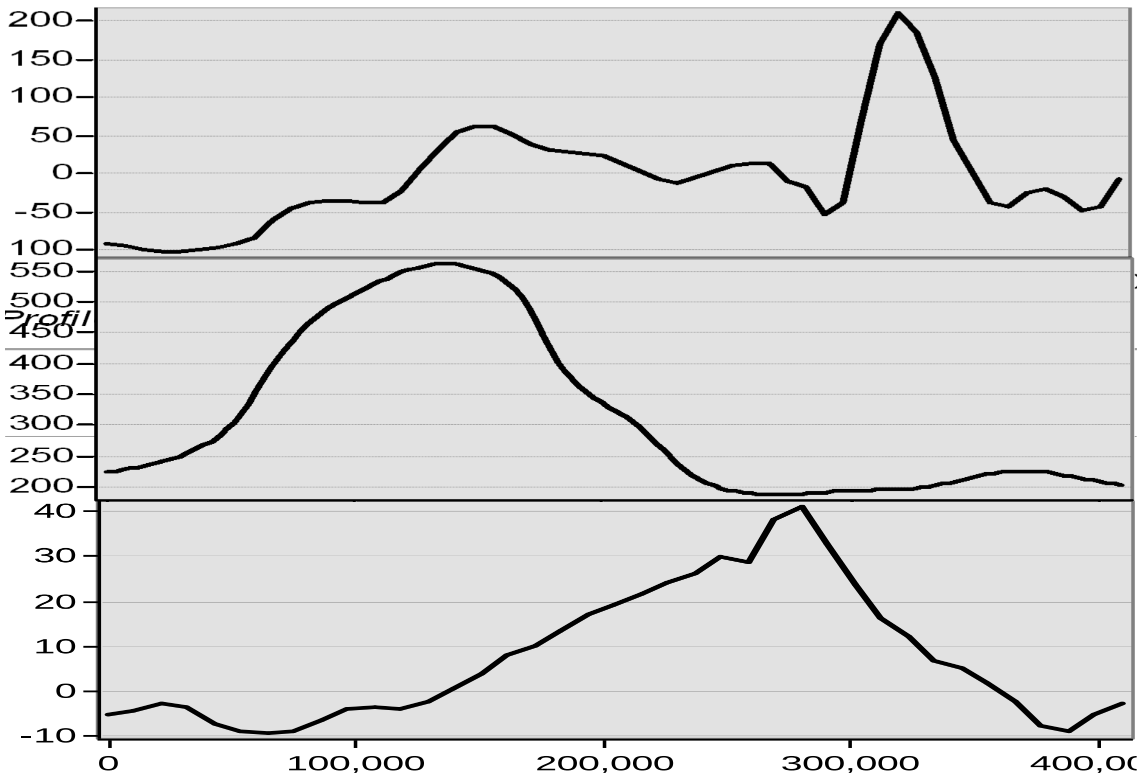


Outer ring diameter is 56 km; center of multi-ringed crater at 55 deg 25' S / 80 deg 20' E, Mars; relief from center of crater to high peak = -6926 to +3240 feet, or 10,166 feet relief.

Brooks Range ICS Emag-3. Pebble Shale Isopach, extrapolating circum-polarly.

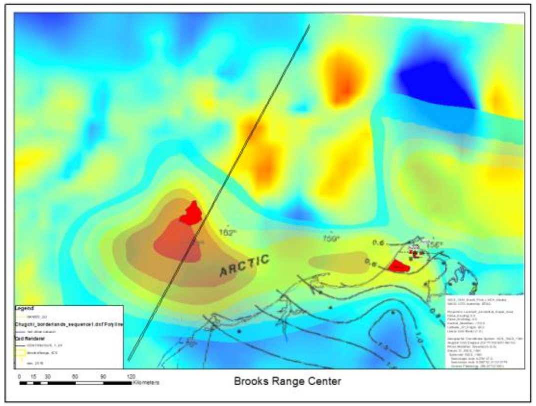


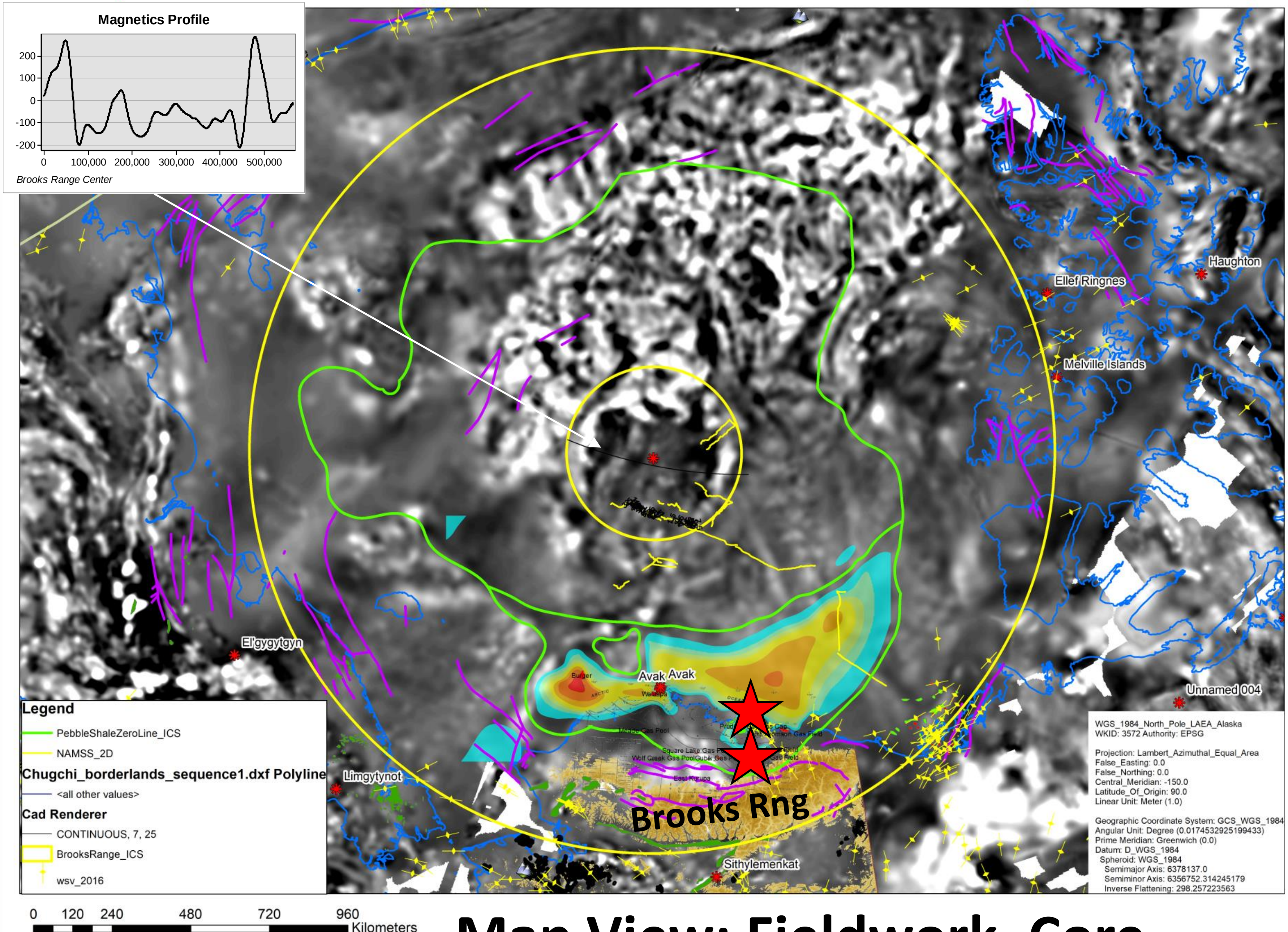
Relationship Between Petroleum Source Rock Thickness and Gravity



Top: Total magnetic intensity; middle: Pebble Shale isopach; bottom: Isostatic gravity anomaly profile, milligals. Note that where we have subsurface control, the gravity highs have thin Pebble Shale, and that the gravity lows have thick Pebble Shale.

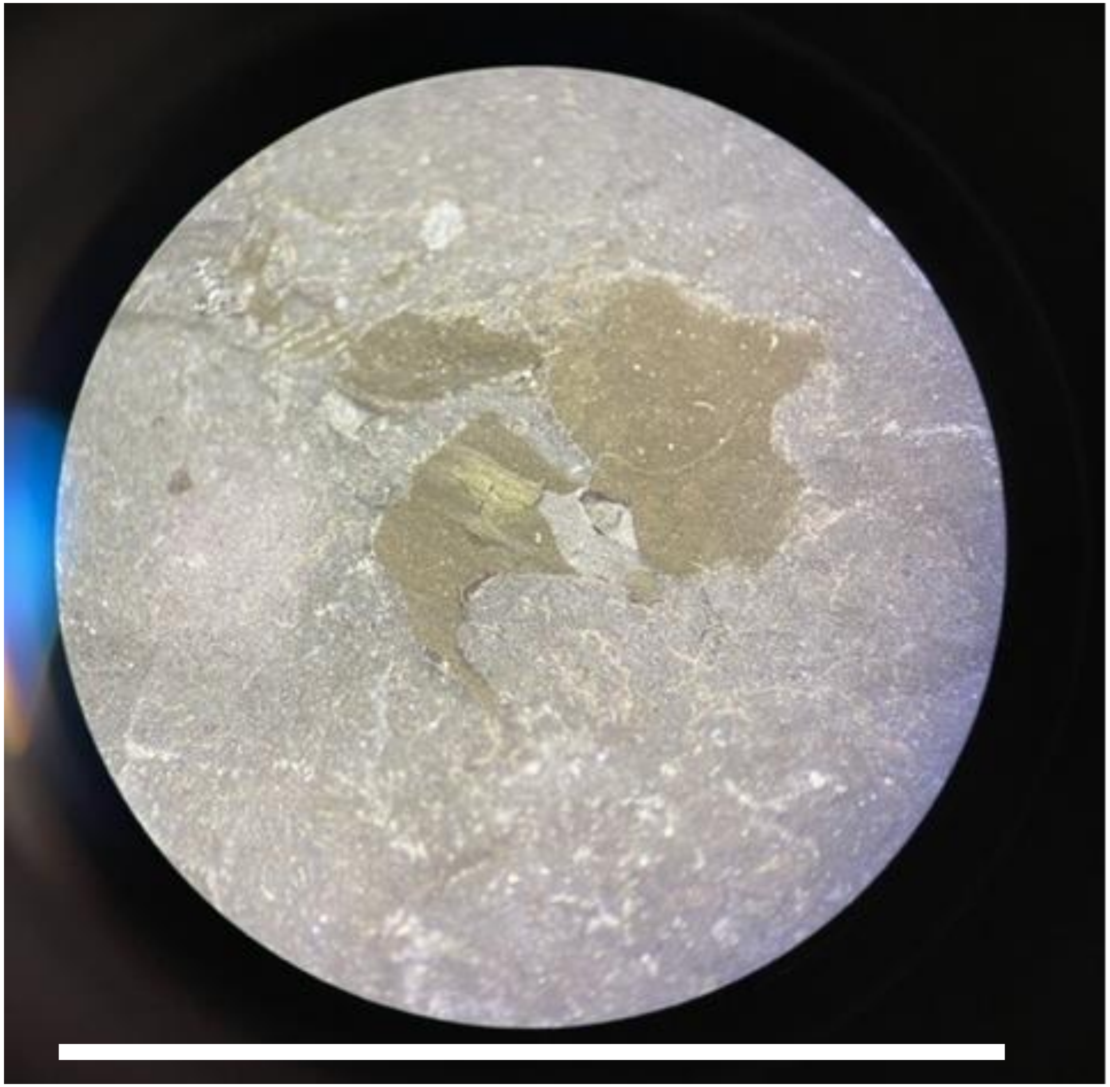
In areas of good control for wells, seismic, and potential fields data, thick Lower Cretaceous Pebble Shale correlates with gravity minima, and vice versa. Given this observation, the correlation is extended across the arctic regions.

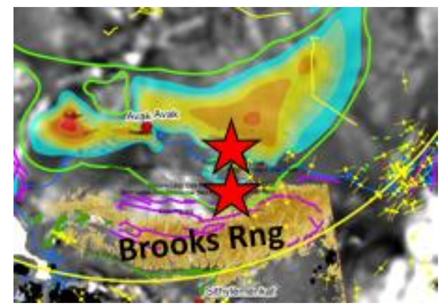




Map View: Fieldwork, Core

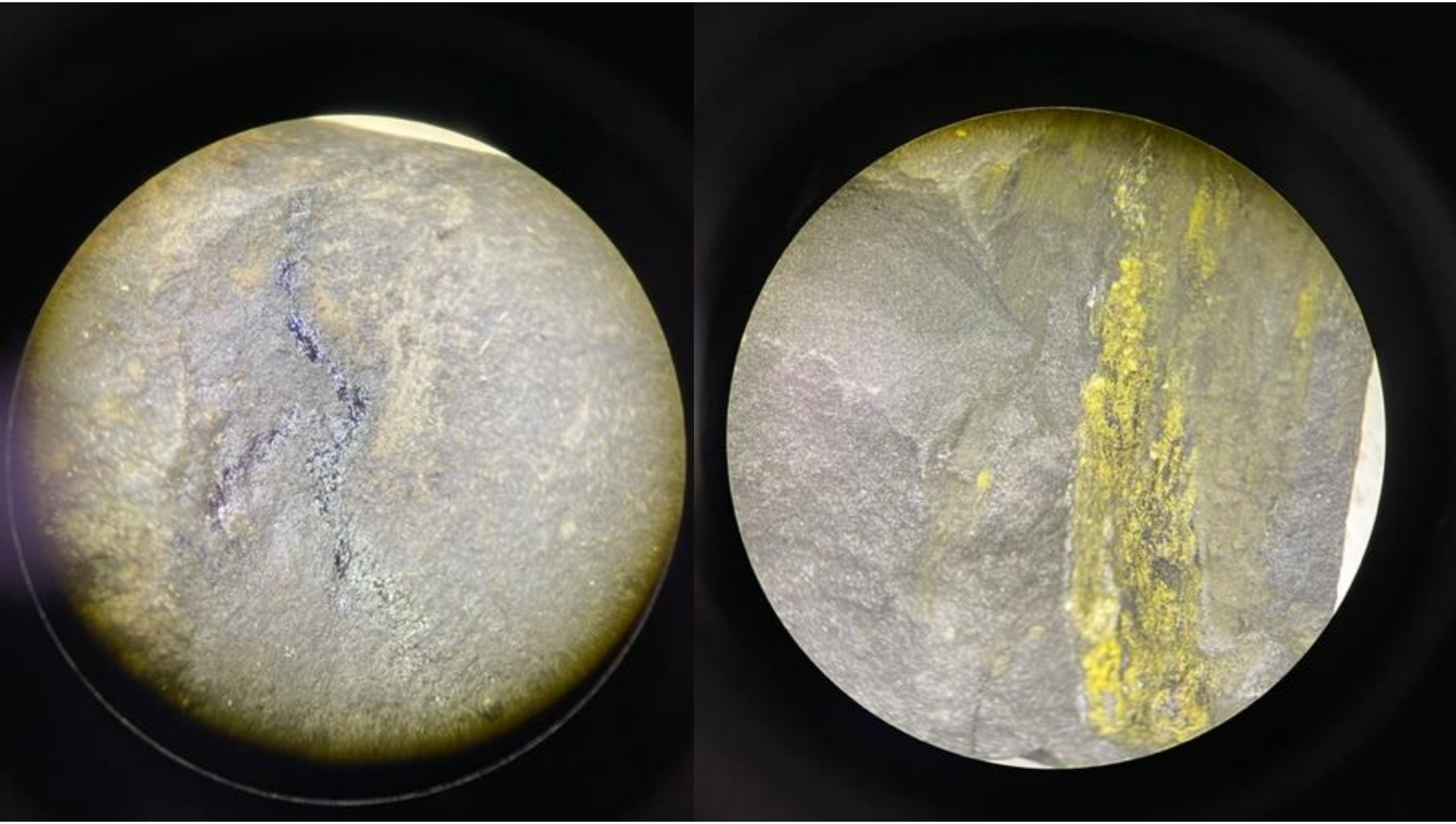
Angular breccia petroliferous source rocks of the Lower Cretaceous Pebble Shale.



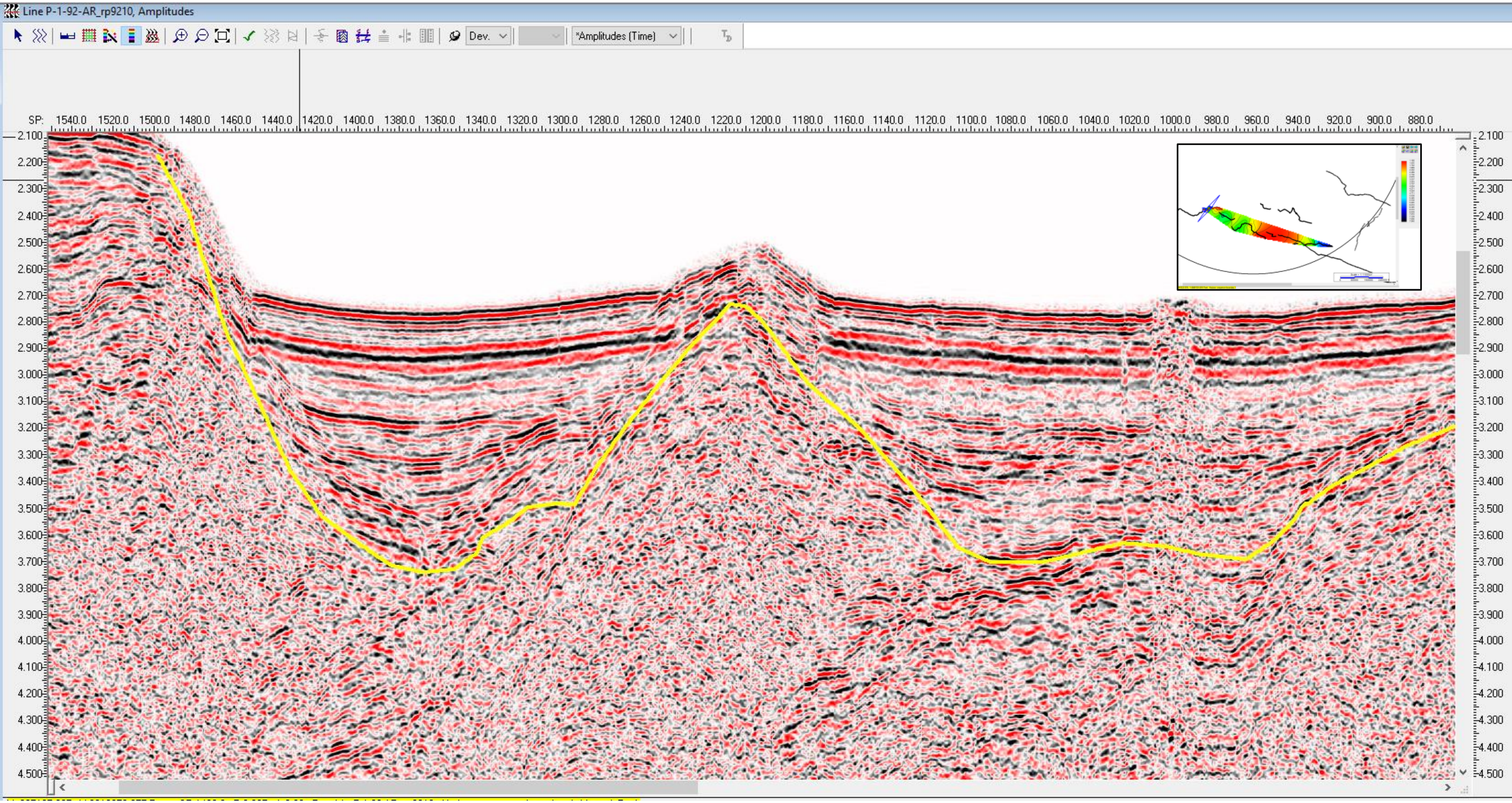


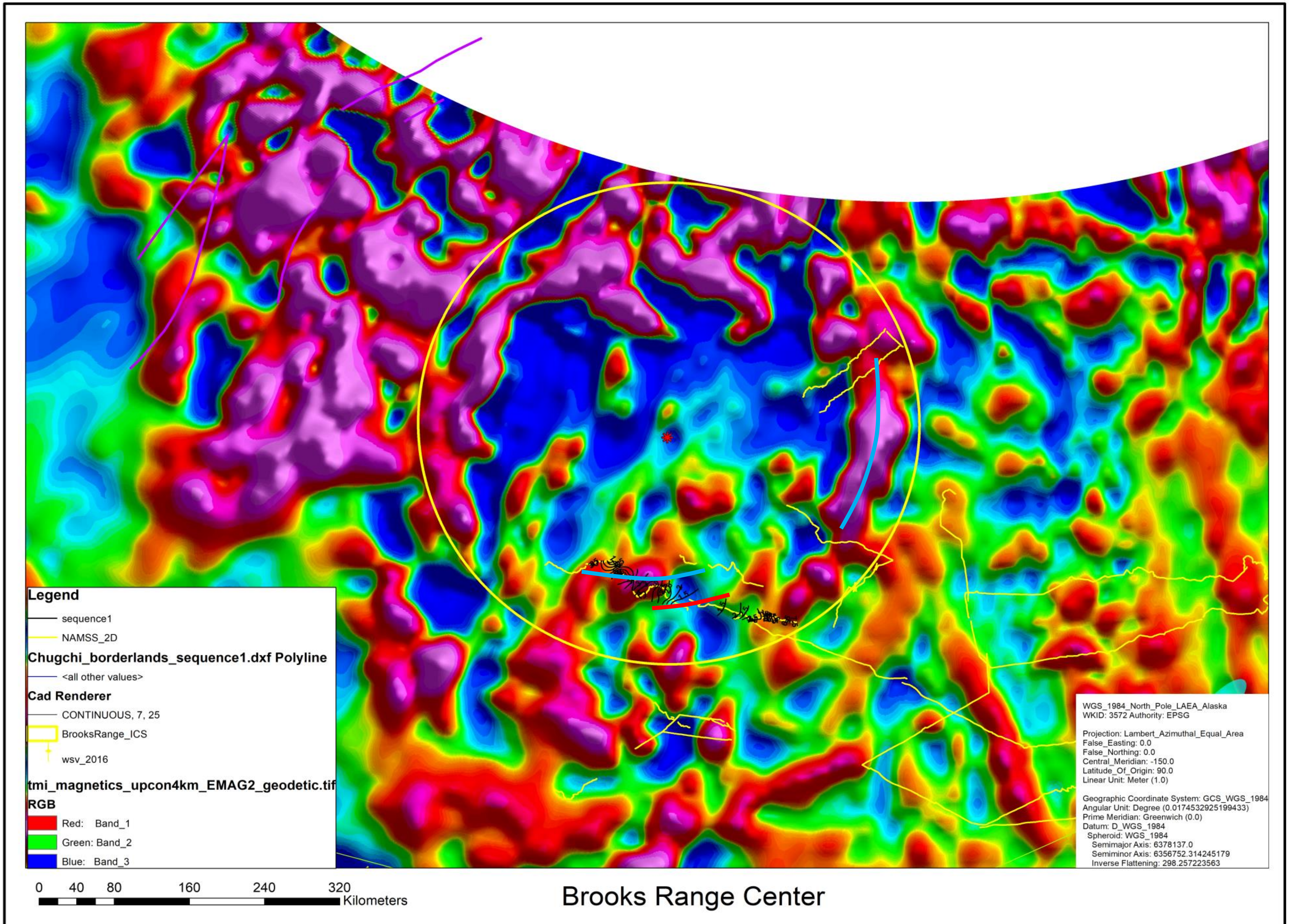
Core chip from 11629-30’ in the Mikkelsen Bay State #1 well. Lower Cretaceous Pebble Shale:
Dark grey silty shale with angular olive shale clasts and abundant petroleum. Angular breccia and petroliferous source rocks. Scale bar is 25 mm.

Core Photograph of Pebble Shale Oil Source Rocks

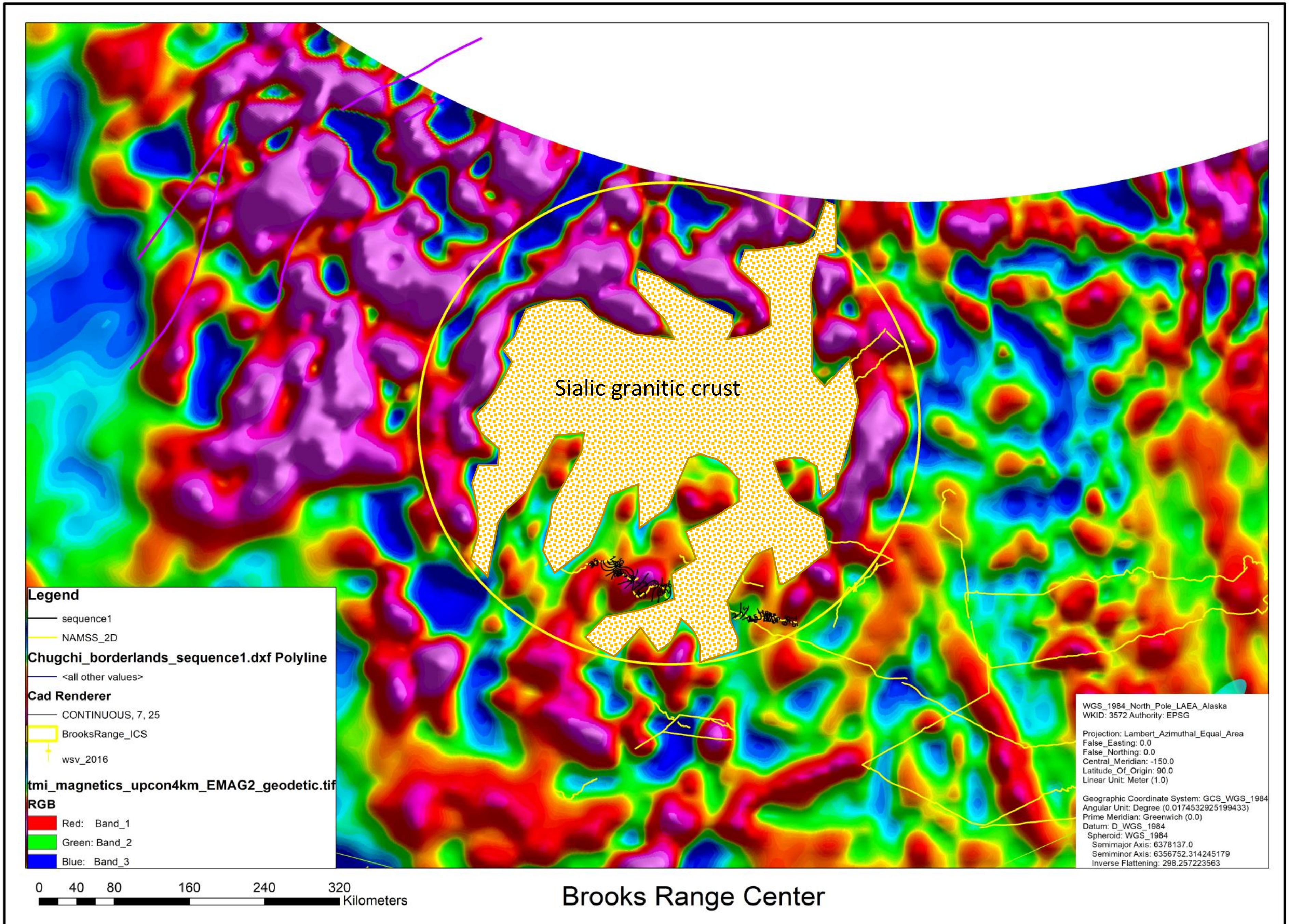


Seismic Definition of the Brooks Range Impact Crater Center



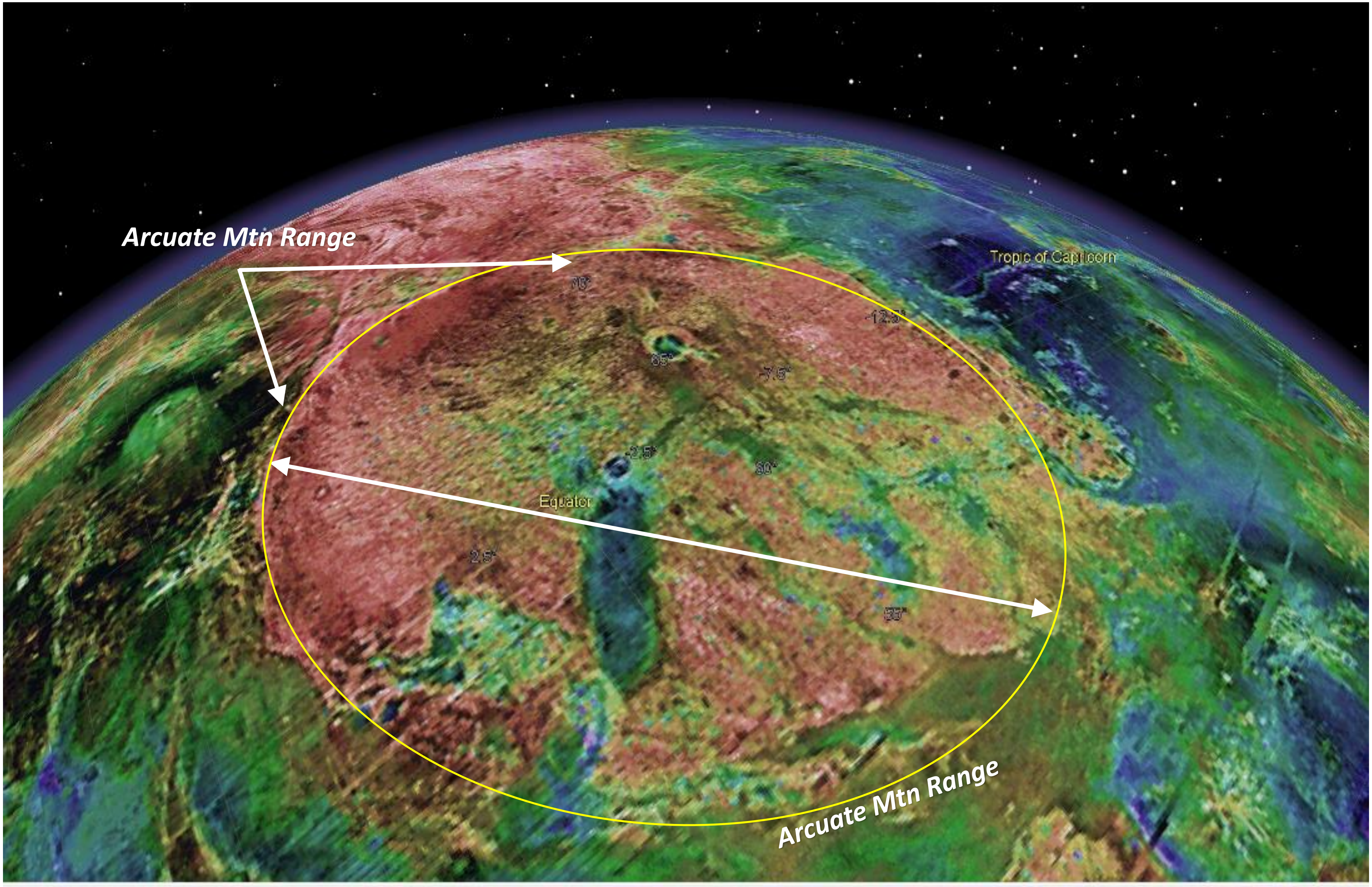


Brooks Range Center

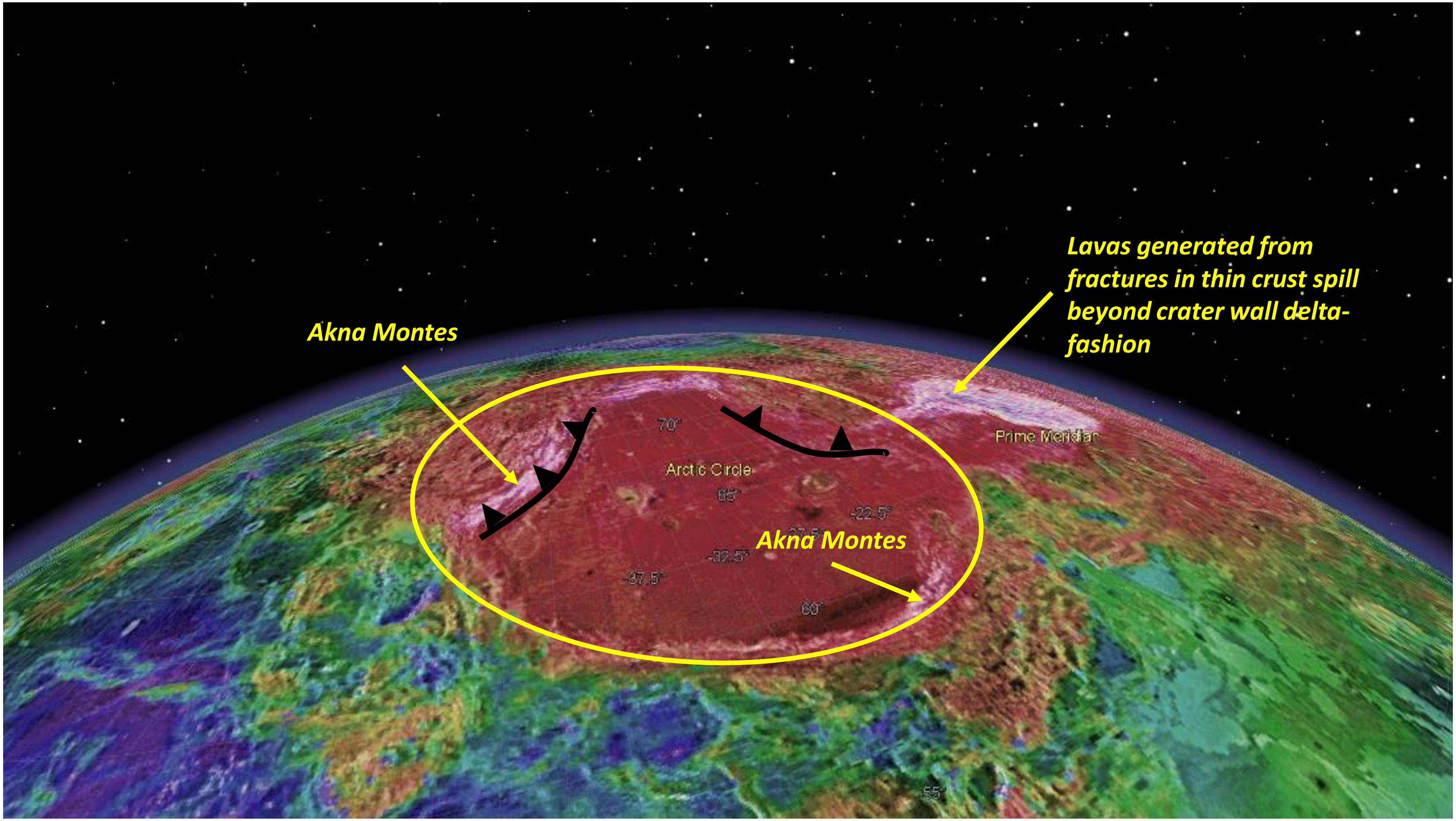


Brooks Range Center

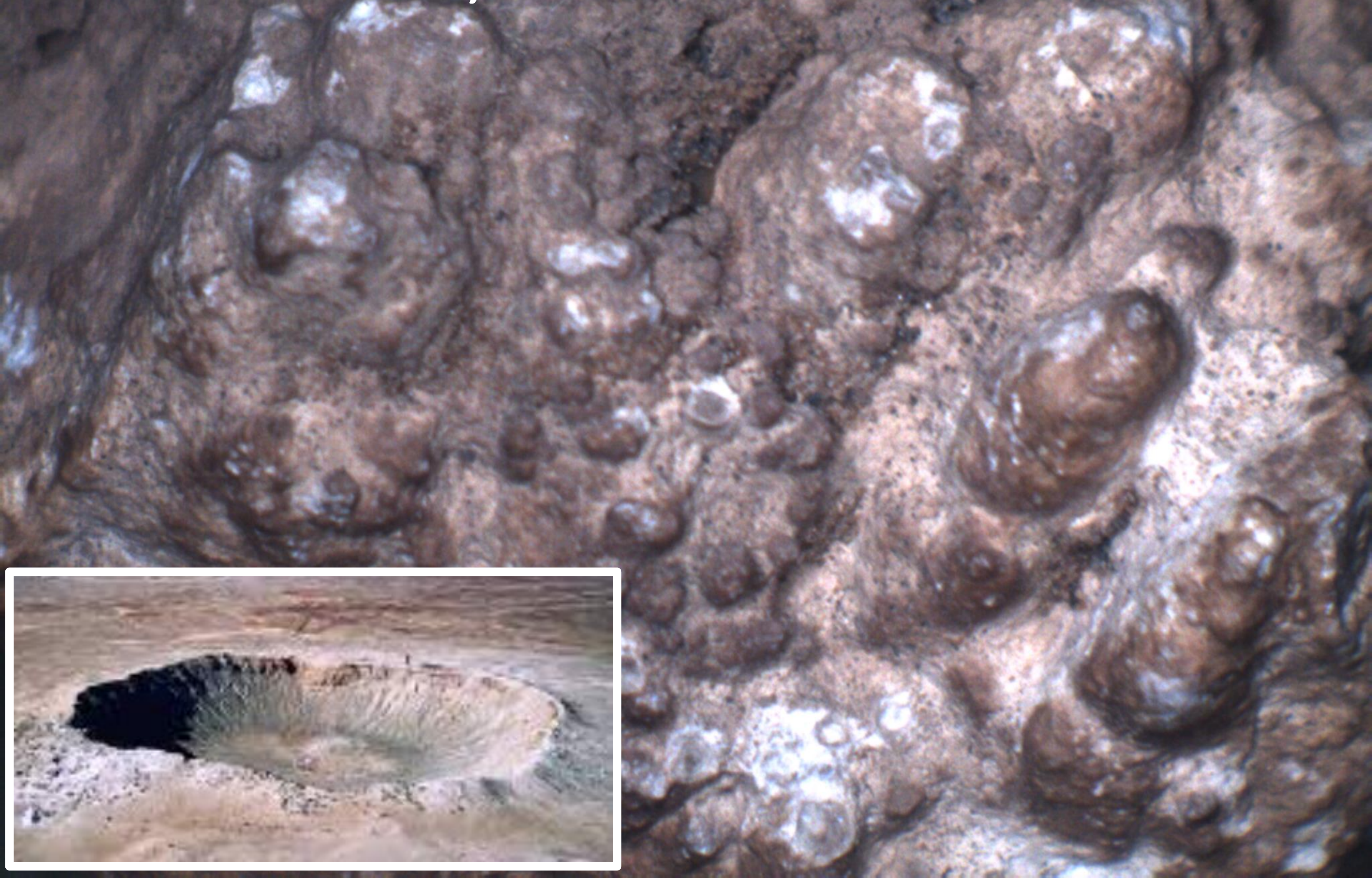
Model for Earth from Large Crater on Venus



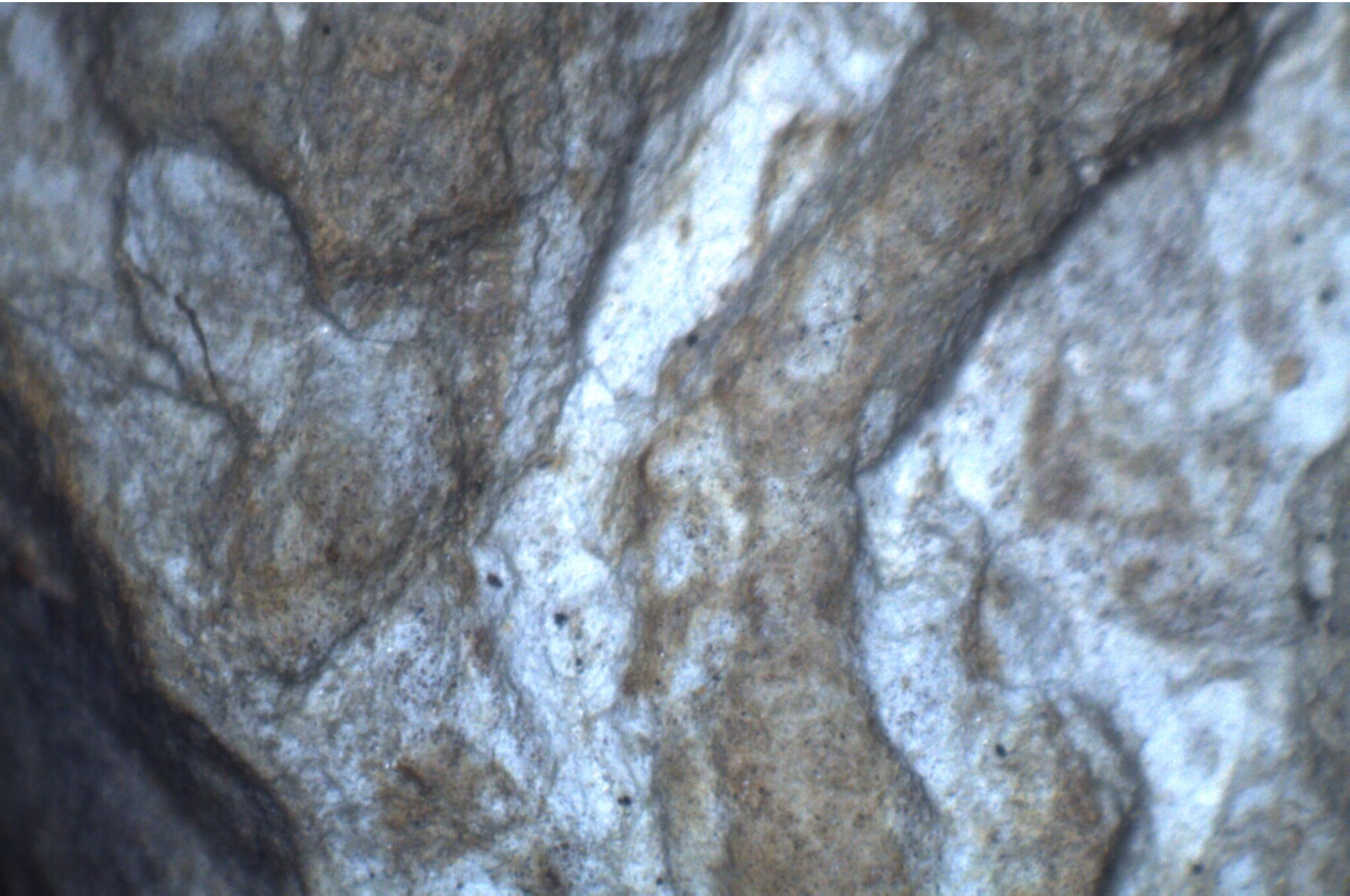
Akna Montes, Venus, Arcuate Range, 2000 km



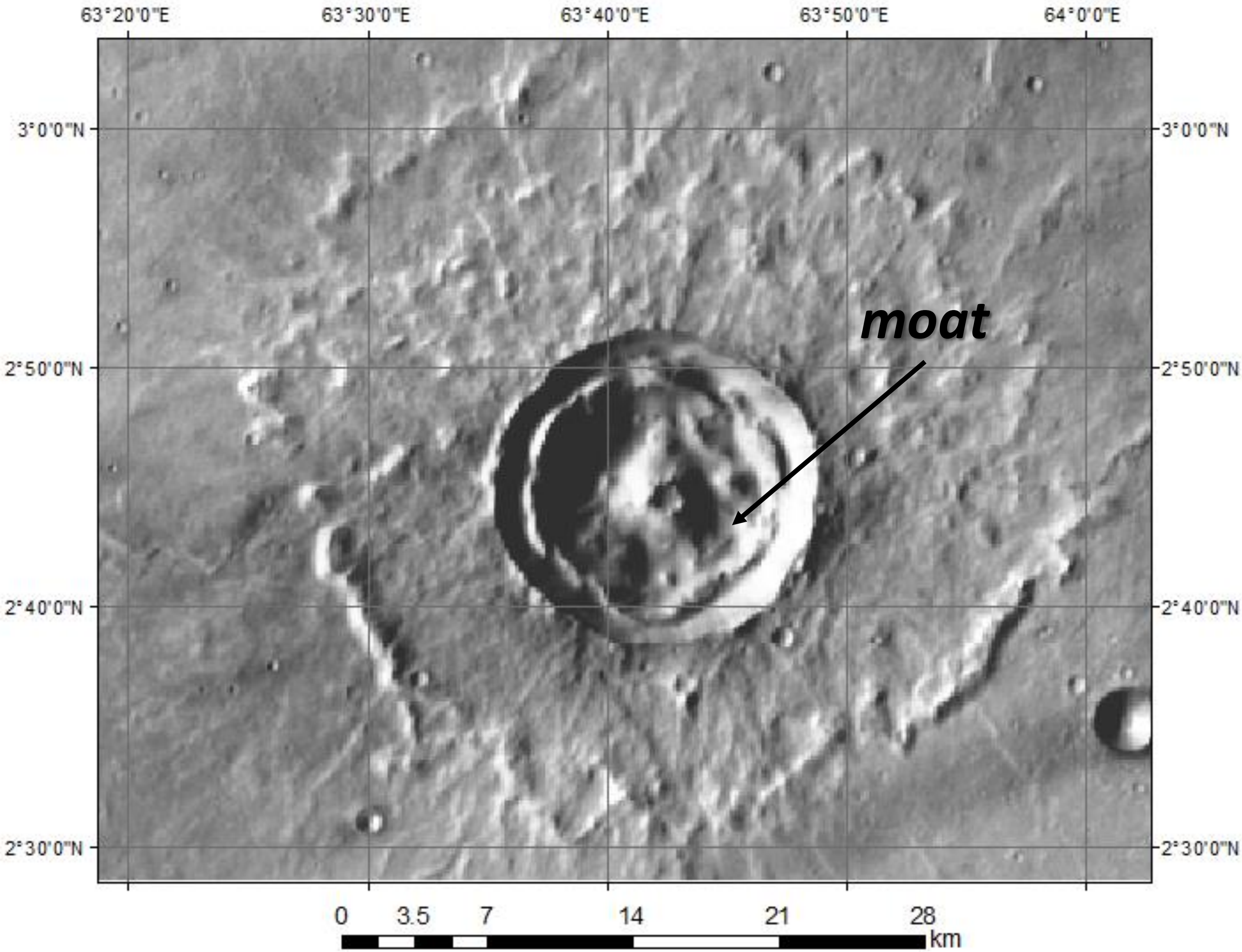
Met-R: Meteor Crater Rose-colored, meltrock from the airblast, 14x



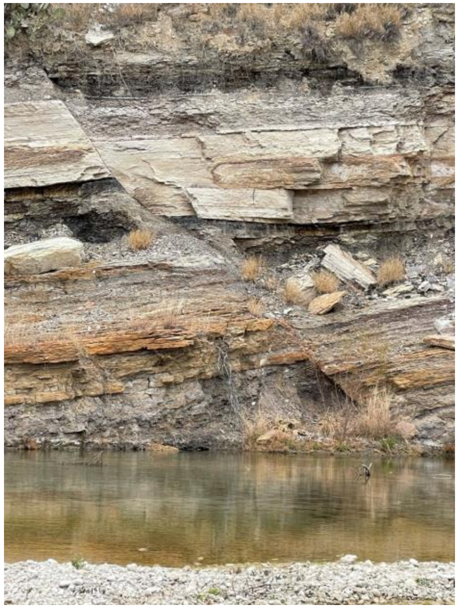
Rock Elm Shale Moat Deposition Worm Trails



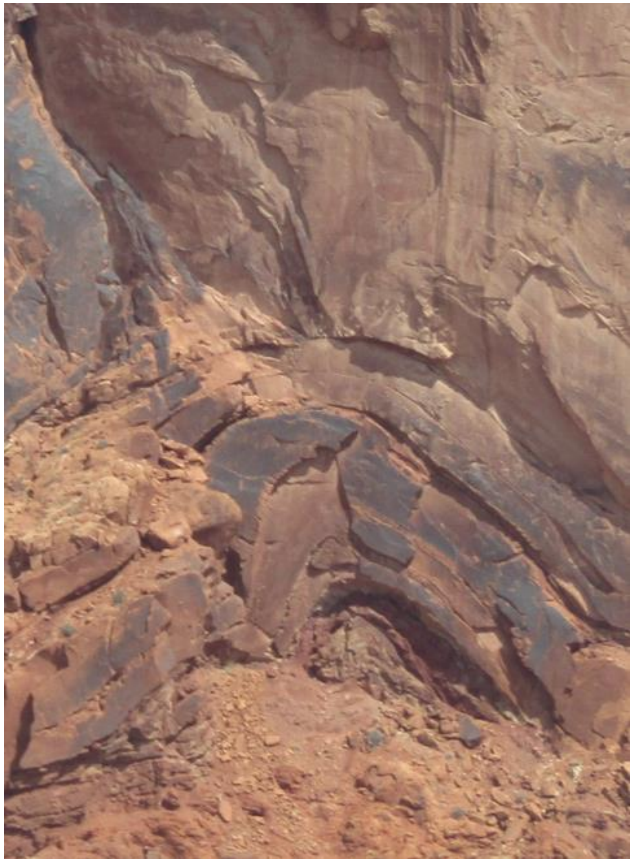
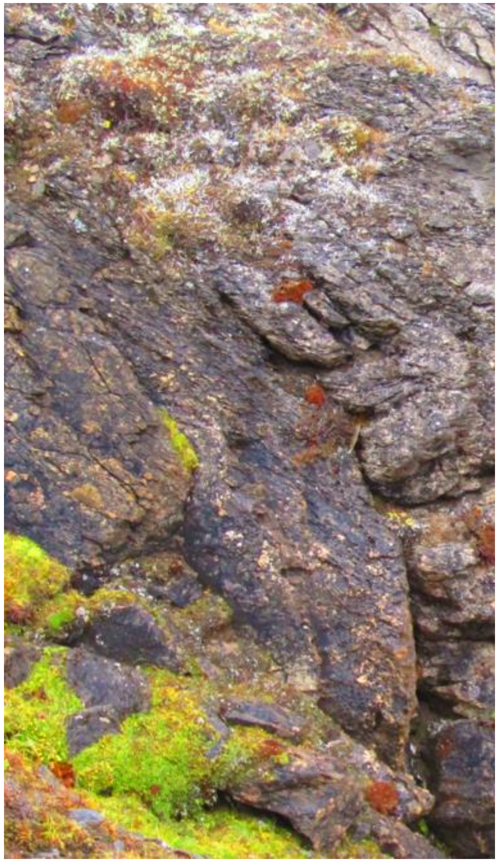
Mars Splotch Crater



Thrust & Normal Faults, Decaturville & Bee Bluff, TX



Vergent Recumbent Folds Filling Transient Craters

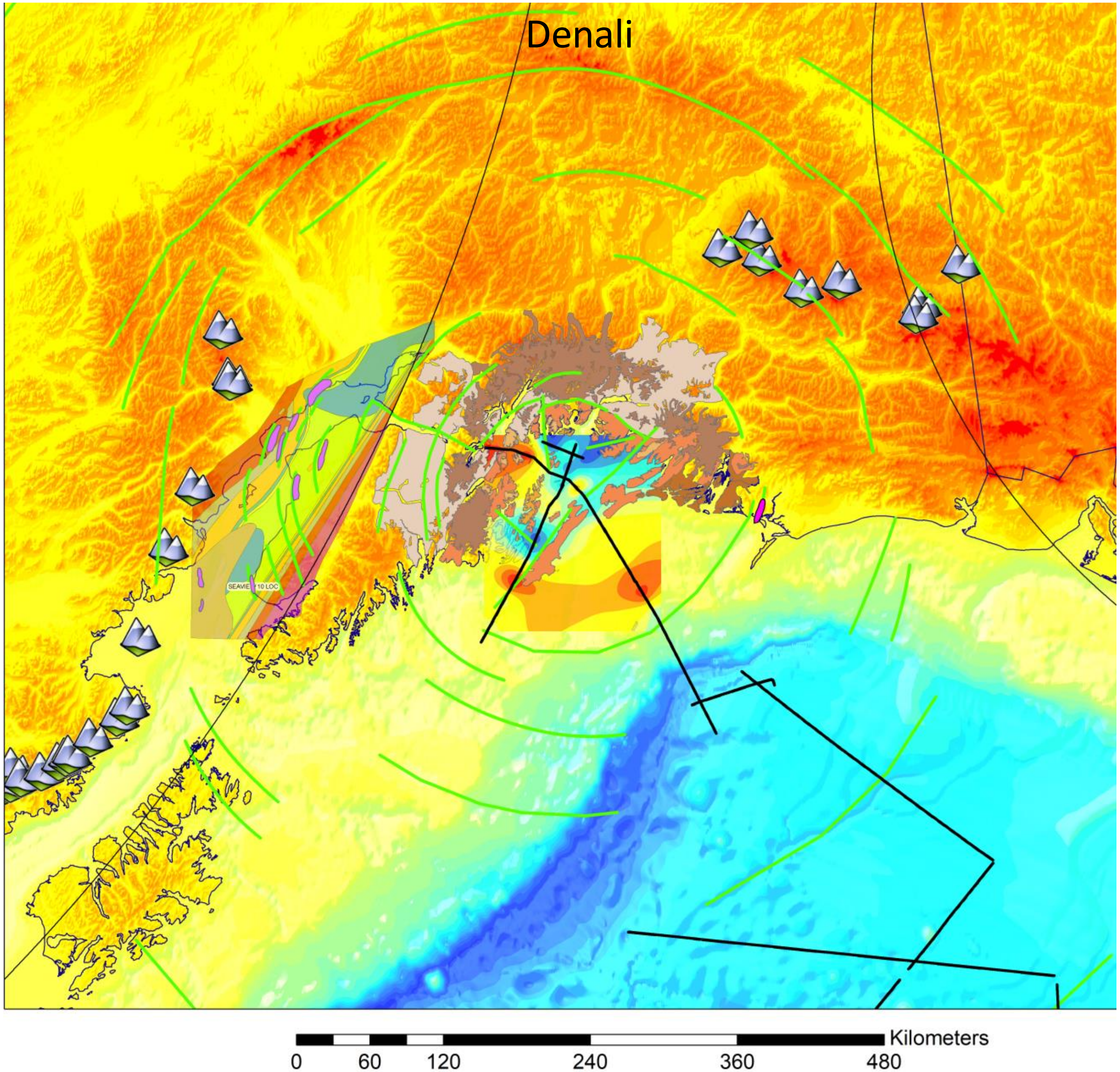




Recumbent and Thrust Folds Filling Transient Craters

Known Associations of Oil & Gas Deposits and Impact Structures

Name, Location	Diameter, Km	Comments
Viewfield, Saskatchewan	2.4	oil
Newporte, N. Dakota	3.2	oil
Lyles Ranch, TX	4	
Johnsonville, Illinois	4	oil
Avak, Alaska	8	gas
Red Wing Creek, N. Dakota	9	oil & gas
Hartney, Manitoba	11.2	
Steen River, Alberta	12.8	oil
Marquez, TX	13	gas
Sierra Madera, TX	13	gas
Calvin-28, MI	13.6	oil
Ames Astrobleme, OK	14	oil & gas
Haswell Hole, Colorado	35	
Cantarell, Bay of Campeche	300	2nd Largest Conventional Oil Field

Large Impact Basin: Volcanoes, Topo, Seismic



Alaska Range to Prince William Sound

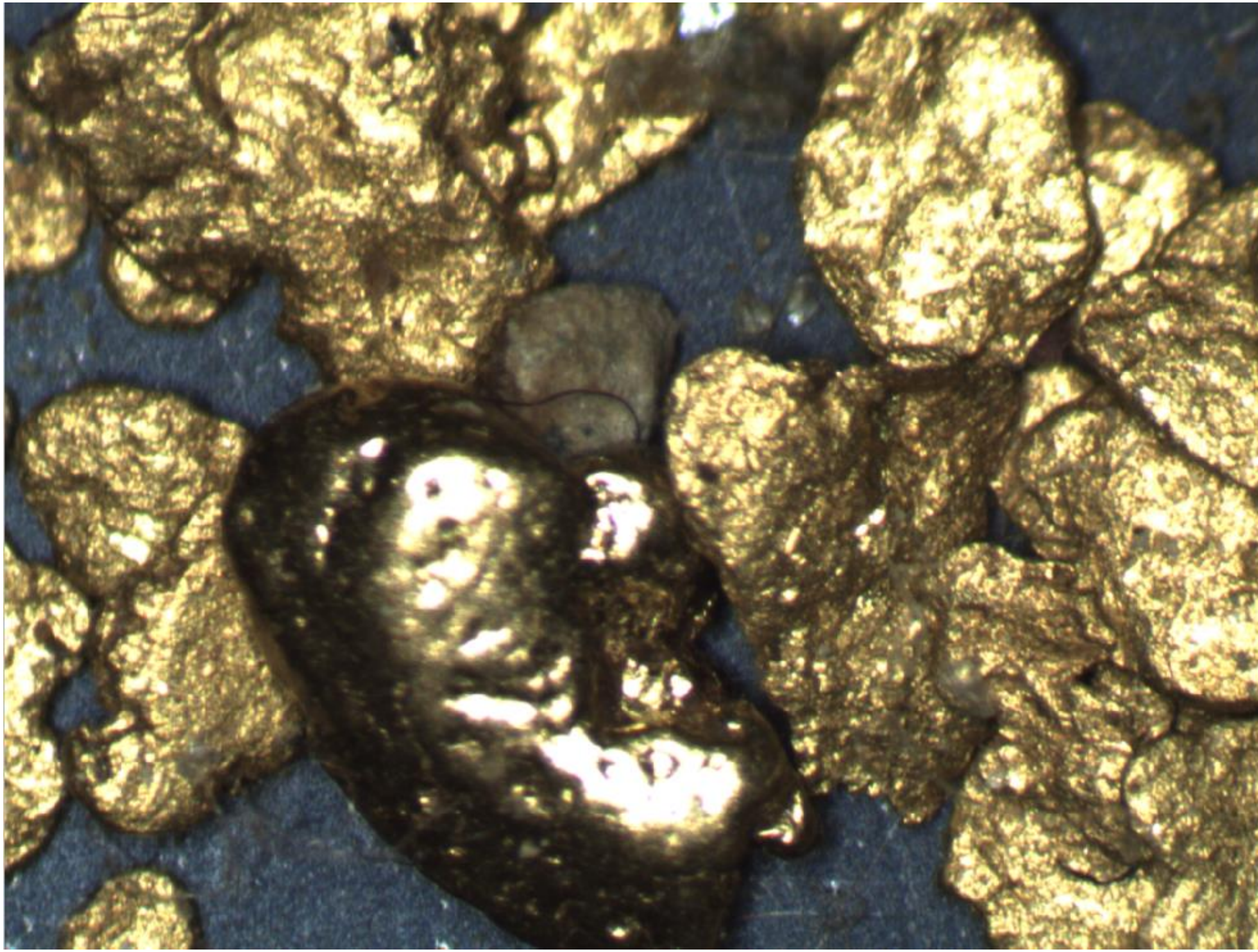
Interrupted Volcano Chains

Seismic Mapped

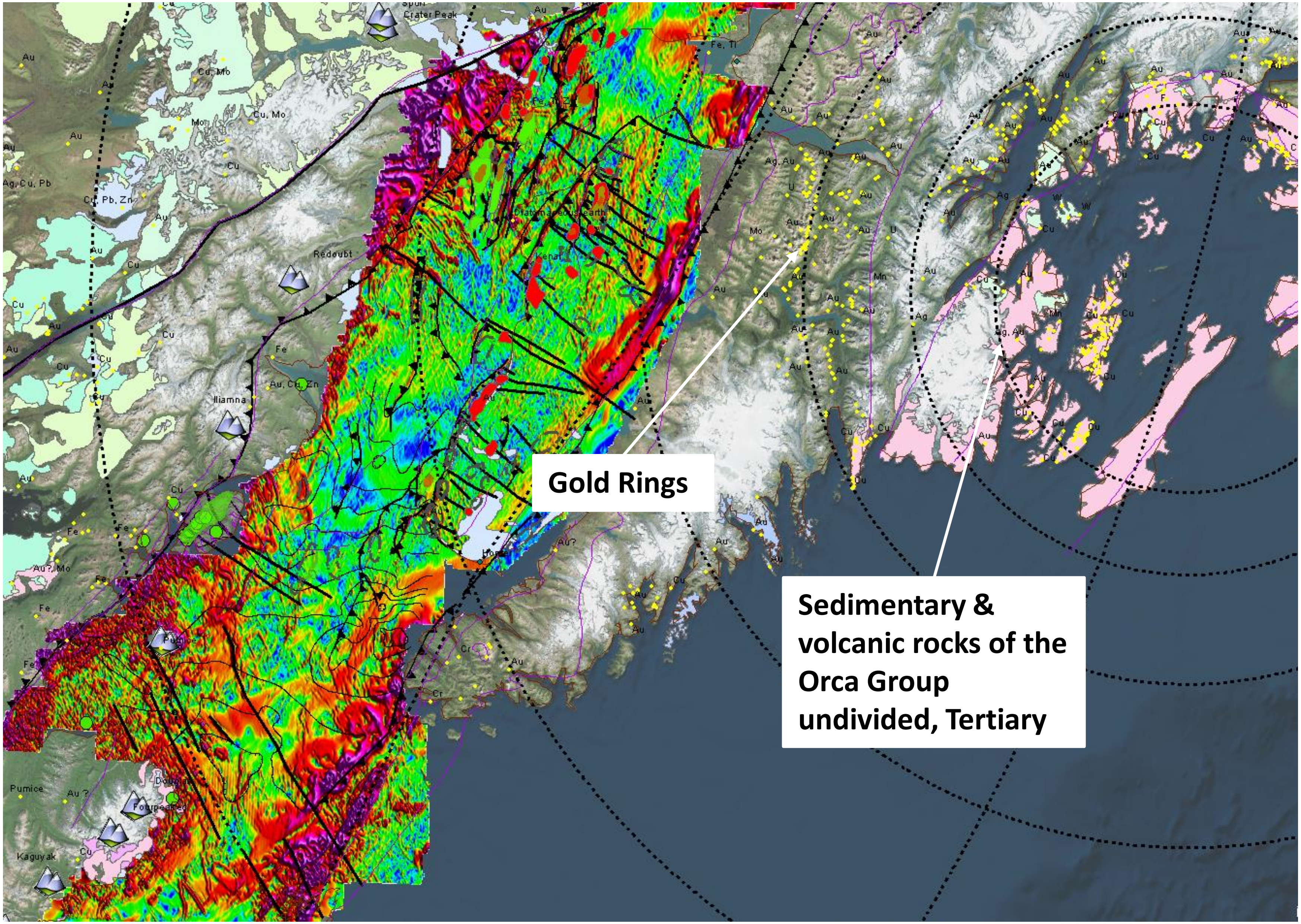
Magmatic Rocks in PWS

Surface Lineations

Economics: Au



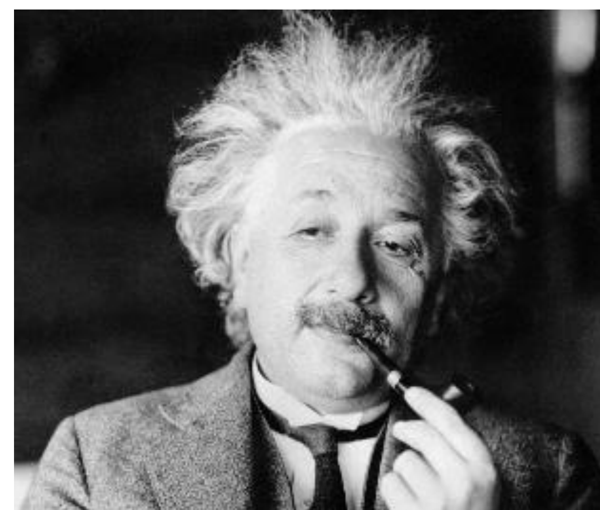
Economics: Ring Alignment of Gold Deposits



Petroleum Geologists' Greatest Fears

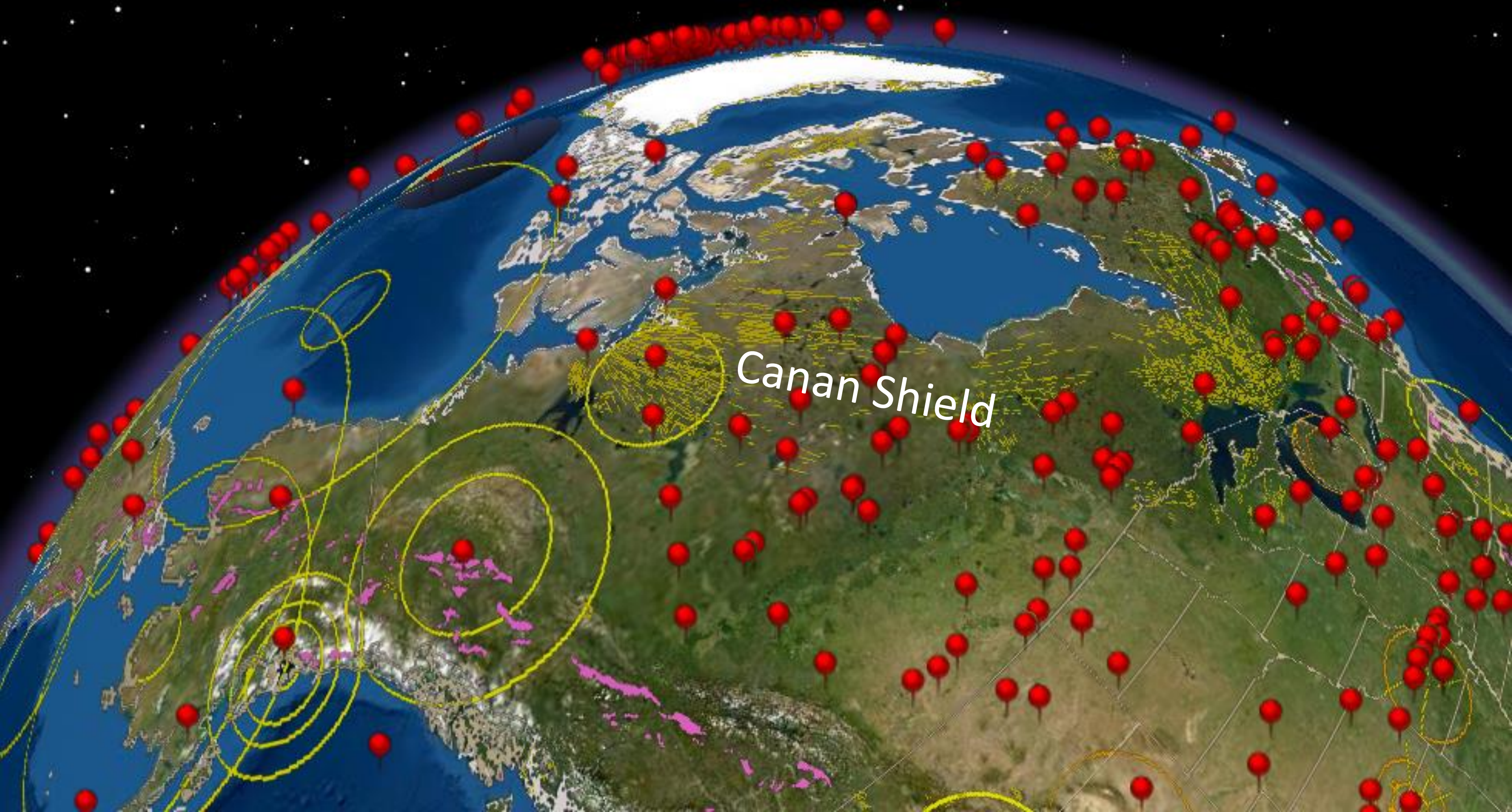
- Stopping drilling a well just above the main pay zone
- Drilling through the main pay zone and not recognizing it
- Condemning a prospect and it comes in
- Getting close but not close enough

"The important thing is to not stop questioning. Curiosity has its own reason for existing."



It’s a Whole New World

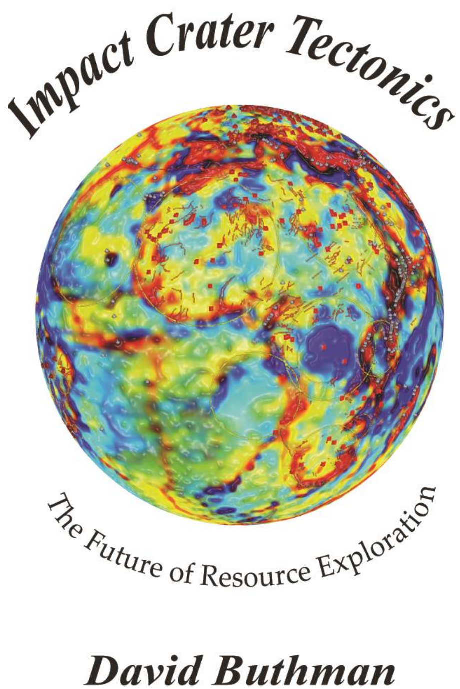
Impacts Seeded Crust--Continental Accretion



The Future

- Geologic processes are similar throughout the terrestrial universe
- Crater Tectonics offers an alternative to Plate Tectonics
- Collect data and craft your own hypotheses to explain what you observe, then test these hypotheses.
- Innovate, adapt, and progress quickly. Recognize your drivers (money, fame, altruism)
- Avoid “groupthink,” biases, and paradigms

Oh No…Plate Tectonics is Dead!



Impact Crater Tectonics provides a universal geologic framework for the prediction of Earth's mineral resources. Based on sound scientific, mathematic, and geologic principles, the demonstrated relationships between impact craters and mineral resources consecrates an imminent paradigm shift for interpreting the tectonic evolution of Earth, particularly for Alaska.

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