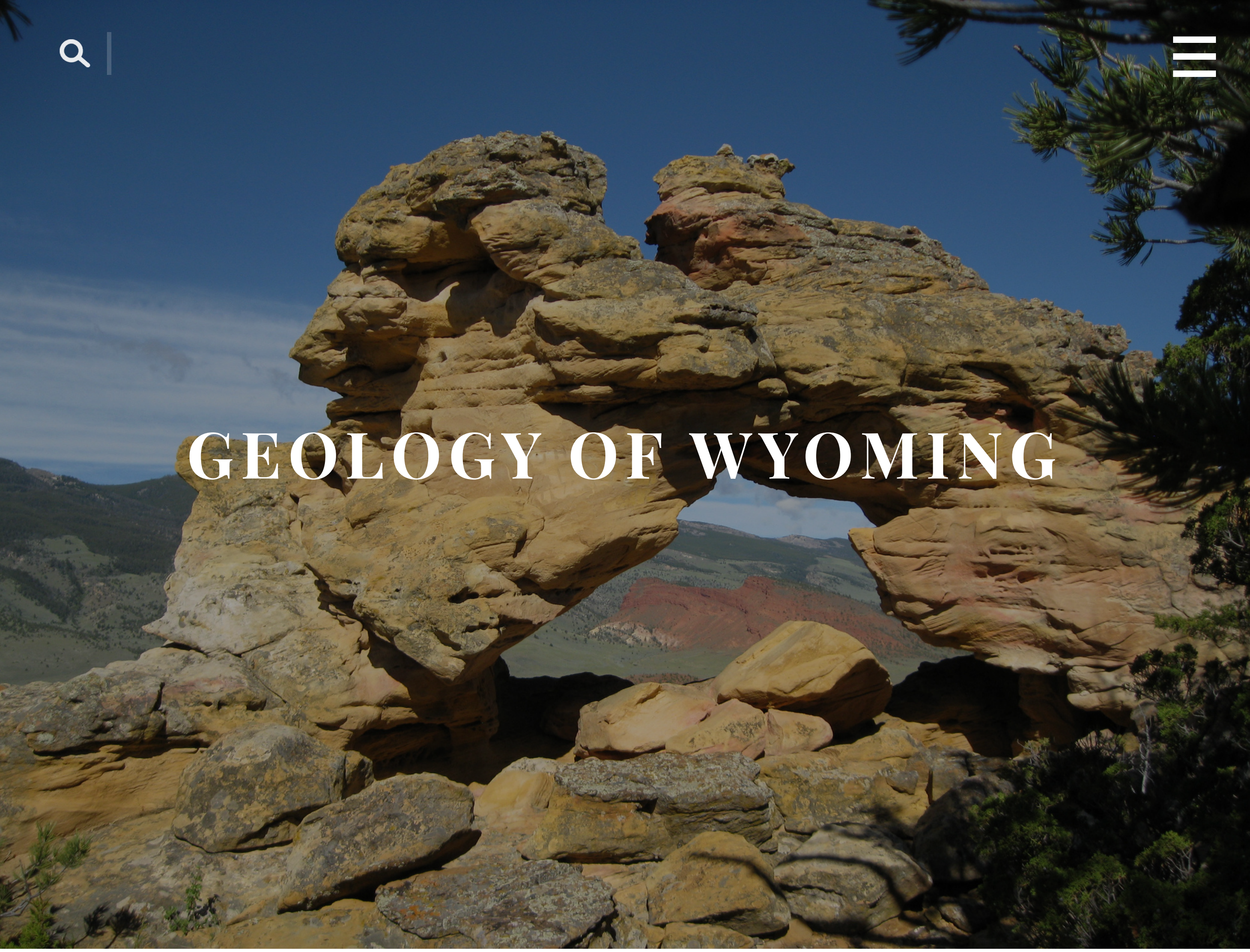


GEOLOGY OF WYOMING

DOUGLAS CRATER FIELD

Douglas Meteor Crater Field, geologists standing on upturned rim of crater
Image by Mark Fisher

Wow Factor *(3 out of 5 stars):*

★★★

Geologist Factor *(3 out of 5 stars):*

★★★

PDF DOUGLAS CRATER FIELD (? MB)

Attraction:

Multiple ancient meteor impact craters preserved in Pennsylvanian Casper Formation Sandstone at Sheep Mountain, central Wyoming. No public access.

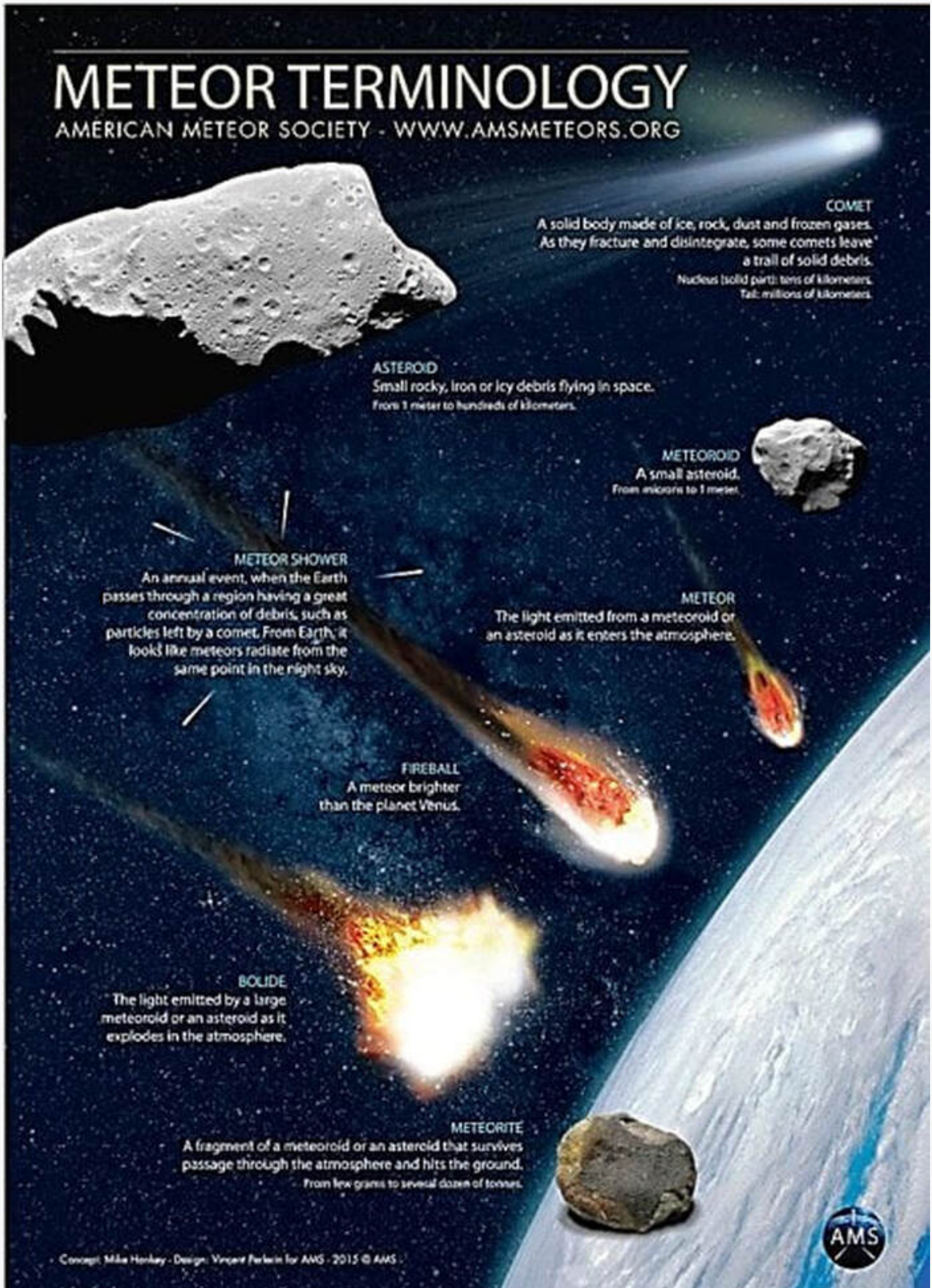
Comets, Meteors, Asteroids and Impact Craters

Modern Perseid meteor shower example, 2016.
Image: https://www.nps.gov/cuga/learn/news/shootingstar.htm.

Interplanetary objects have been orbiting in space since the origin of the solar system. Chunks of ice, rock, or metal traveling in outer space are called comets, meteors, or asteroids. Comets are composed of ice and dust, while meteors and asteroids are made of rock, minerals and/or metal. The latter two objects are differentiated by size, with the smaller being meteors. Asteroids are generally more than ten feet in length (3 m) and orbit around the Sun between Mars and Jupiter.

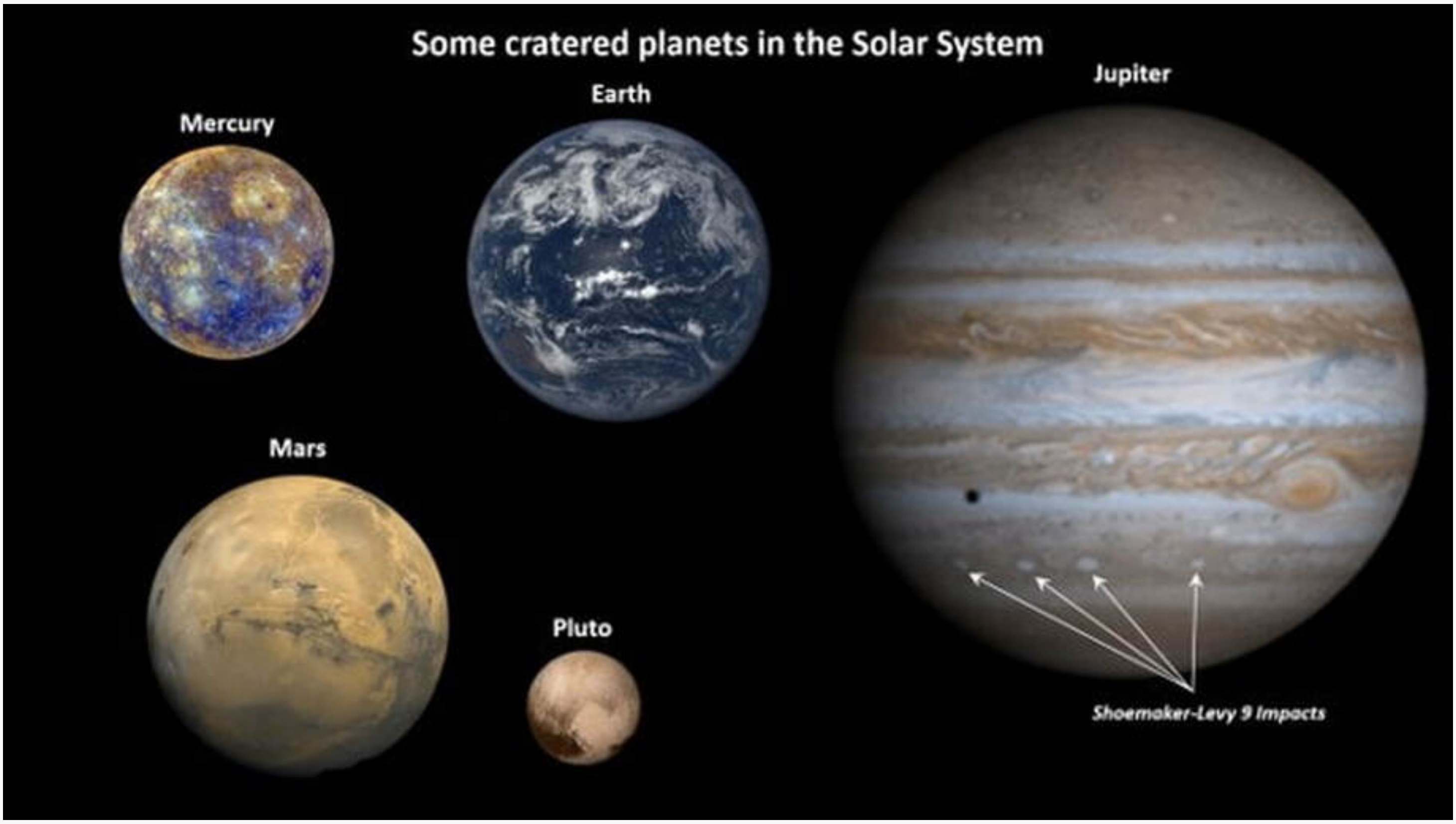
Collisions are common and impact craters are the result. When any of these celestial objects strike a solid planet or satellite, they gouge a hole into the surface. The size of the crater is related to the mass and velocity of the celestial object and the composition of the impacted crust. Evidence of the bombardment is ubiquitous in our solar system.

The period from 4.6 to about 3.8 billion years ago is called the “Late Heavy Bombardment” due to the large quantity of collisions with material left over from the creation of the planets and moons. The Earth’s moon originated in a 4.5-billion-year-old collision event called “The Big Splat” when a Mars-sized object smashed into proto-Earth, ejecting a lot of material into Earth’s orbit. That ejected debris condensed into our moon.

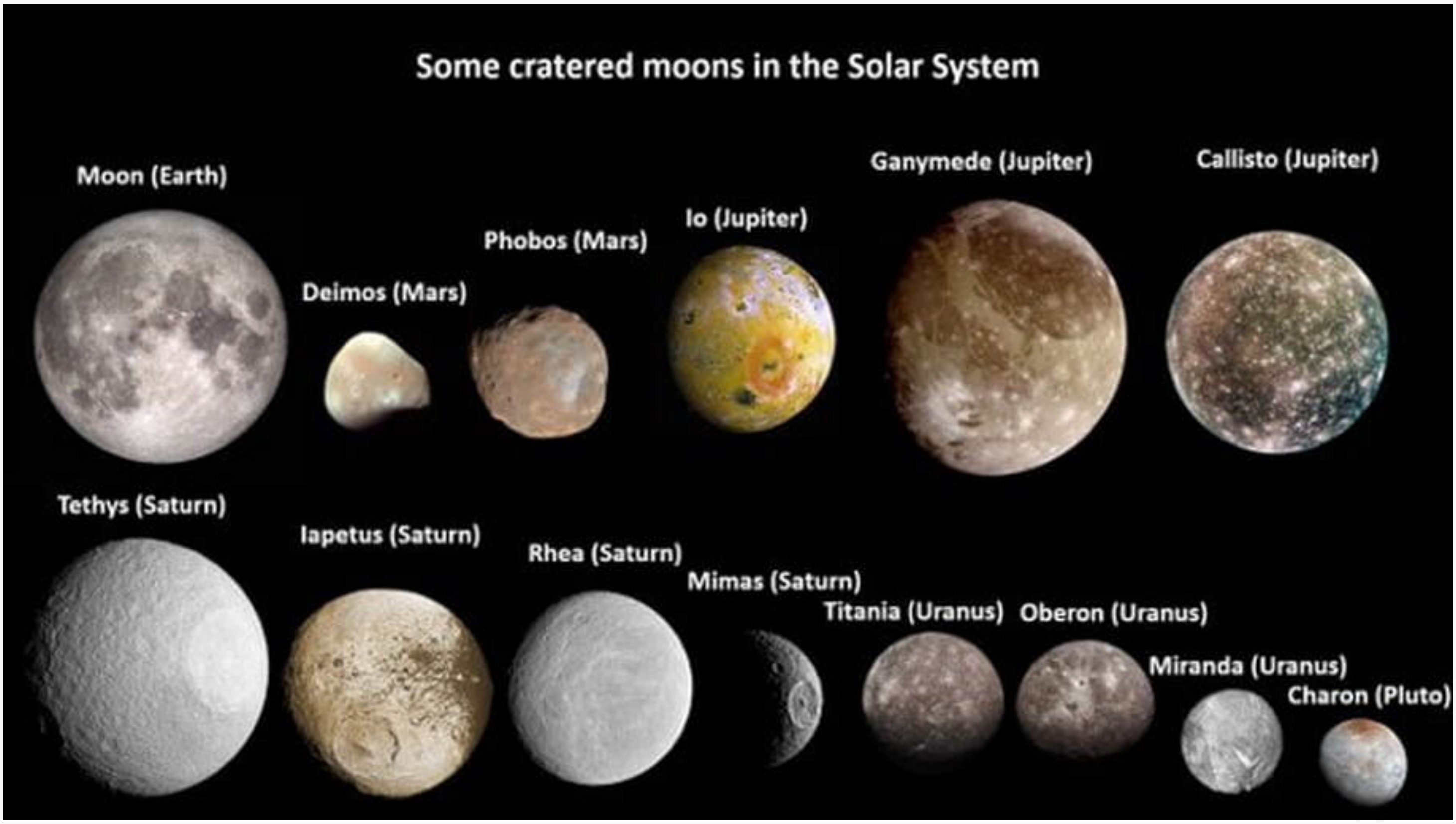


METEOR TERMINOLOGY
AMERICAN METEOR SOCIETY - WWW.AMSMETEORS.ORG
COMET
A solid body made of ice, rock, dust and frozen gases.
As they fracture and disintegrate, some comets leave
a trail of solid debris.
Nucleus (solid part): tens of kilometers.
Tail: millions of kilometers.
ASTEROID
Small rocky, iron or icy debris flying in space.
From 1 meter to hundreds of kilometers.
METEOROID
A small asteroid.
From microns to 1 meter.
METEOR SHOWER
An annual event, when the Earth passes through a region having a great concentration of debris, such as particles left by a comet. From Earth, it looks like meteors radiate from the same point in the night sky.
METEOR
The light emitted from a meteoroid or an asteroid as it enters the atmosphere.
FIREBALL
A meteor brighter than the planet Venus.
BOLIDE
The light emitted by a large meteoroid or an asteroid as it explodes in the atmosphere.
METEORITE
A fragment of a meteoroid or an asteroid that survives passage through the atmosphere and hits the ground.
From few grams to several dozen of tonnes.
AMS
Concept: Mike Hankey - Design: Vincent Perlerin for AMS - 2015 © AMS

Terminology of interplanetary objects.
Image: https://www.amsmeteors.org/wp-content/uploads/2013/09/AMS-TERMINOLOGY-2015-EN-ENGLISH1.pdf.



Some planets with recognizable impact craters. The Earth's impacts have largely been erased due to active geologic processes (Pluto's status was changed from planet to dwarf planet in 2006).
Images: From NASA and JPL at https://www.jpl.nasa.gov/spaceimages/; and https://solarsystem.nasa.gov/moons/.



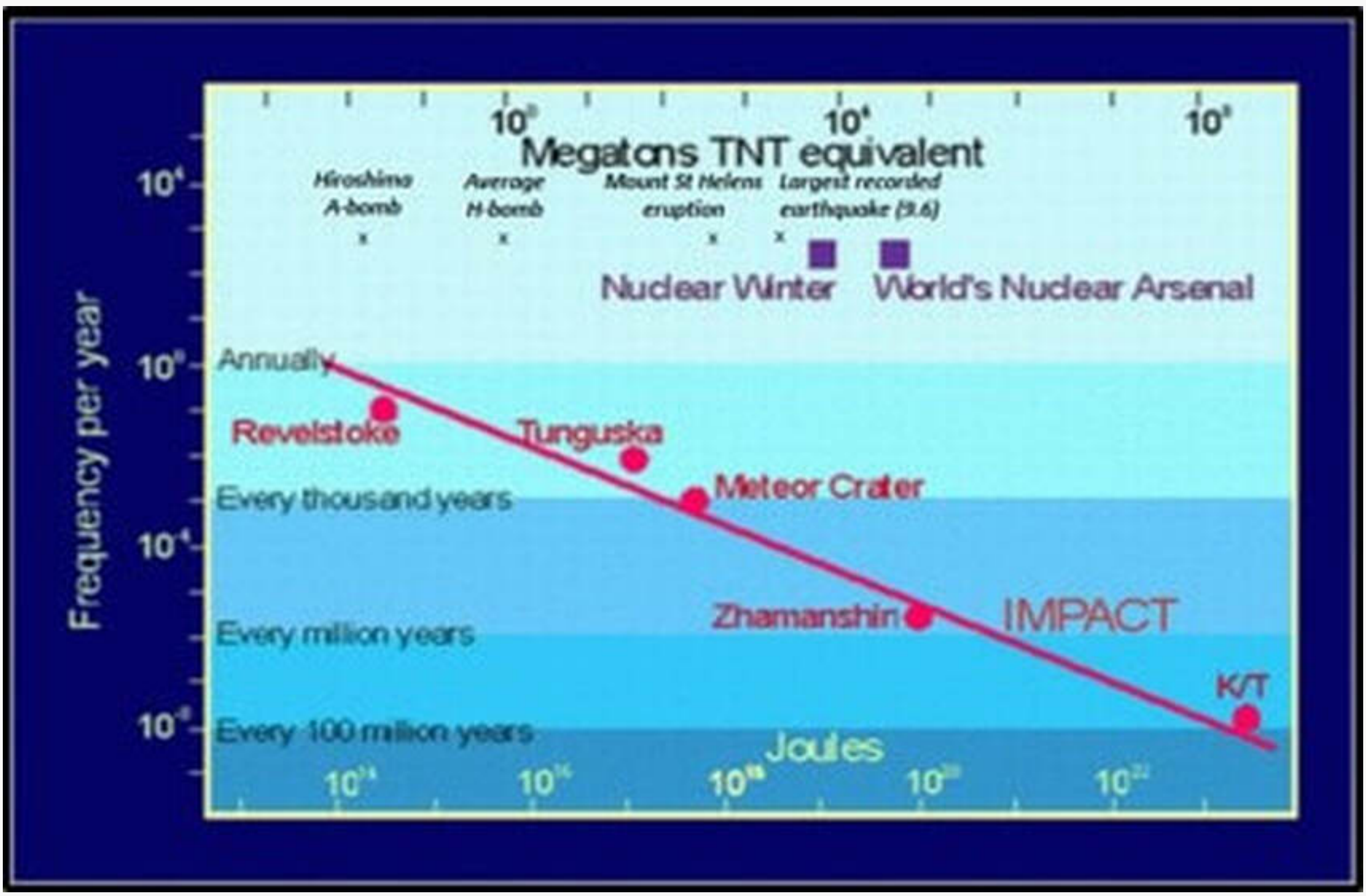
Some moons showing craters from over four billion years of impacts. *Images: From NASA and JPL at https://www.jpl.nasa.gov/spaceimages/; and https://solarsystem.nasa.gov/moons/.*

Artists concept of “The Big Splat.”
Image: NASA/JPL-Caltech, 2009, https://www.nasa.gov/multimedia/imagegallery/image_feature_1454.html.

Pre-scientific understanding of meteors was that they were harbingers of either fortune or doom, or celestial pronouncements of important births. The Magis’ star (Star of Bethlehem) of between 4 to 7 B.C. is a well-known example. Ancient Babylonian astronomers were able to track the movement of planets and objects by the first millennium B.C. In 1908 the atmospheric explosion of a 50-65-foot diameter object leveled over 750 square miles of Russian forest at Tunguska. The 50,000-year-old Barringer Crater (Meteor

Crater) in Arizona was identified as an impact structure in 1920. The potential for meteor strikes to cause global extinctions was recognized in 1980 when the Alvarez team discovered the worldwide iridium layer connected to the impact-extinction of the dinosaurs. The first observation of an extra-planetary impact occurred in 1994 when Comet Shoemaker-Levy 9 collided with Jupiter.

Only about 190 impact craters have been identified on Earth. The Earth's geological processes of weathering, erosion, sedimentation and plate tectonics have largely removed most impact evidence on the planet. Eroded remnants of impact craters are called astroblemes. The two-billion-year-old Vredefort crater (100 to 180 mile diameter) in South Africa was thought to be the oldest crater on Earth until the Maniitsoq structure (62 to 370 mile diameter) was reported in 2009. The structure is the result of a three-billion-year-old asteroid or comet impact that punched a crater into southwestern Greenland. A Canadian mining company had been using an impact model for nickel and platinum exploration in the area since 2011.



Frequency of impact plotted against energy, either in Joules or Megatons

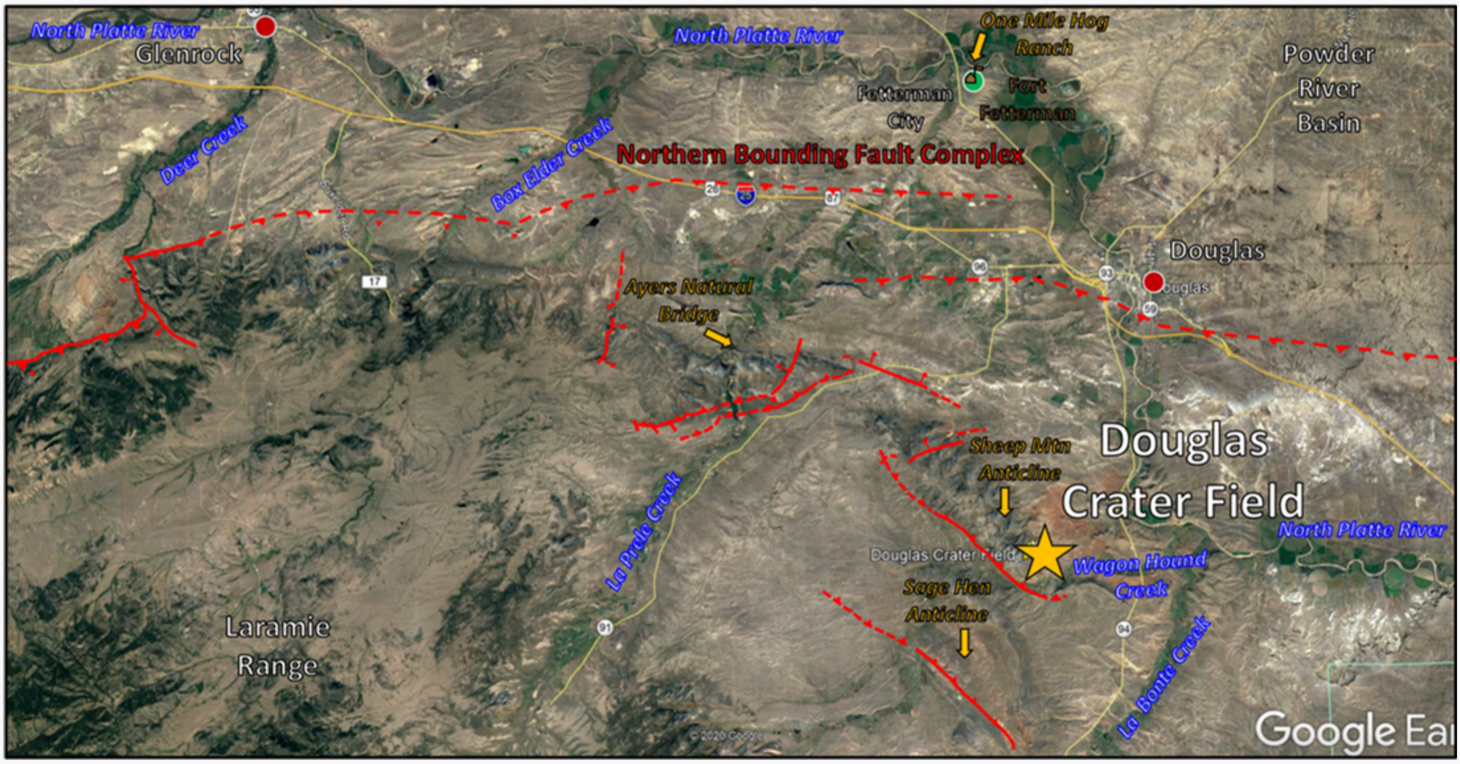
TNT equivalent. Also indicated are a number of impact events. Note an impact event with energy greater than the world's nuclear arsenal occurs on a time-scale of less than a million years.
Image: Planetary and Space Sciences Centre (PASSC), 2018, Earth Impact Database, accessed 12/3/2019; http://www.passc.net/EarthImpactDatabase/New%20website_05-2018/IntrotoImpacts.html.

As objects pass through the Earth's atmosphere, they begin to melt and vaporize creating a burning, glowing tail. The glow they emit inspired the names shooting star, falling star, and fireball depending on the size and brightness. In late 1833, a spectacular shower of Leonid meteors occurred. It had an estimated rate of a thousand meteors a minute. James P. Beckwourth, a black mountain man and adopted Crow medicine chief observed the event in Wyoming and recorded it in his journal:

"On our way to Little Box Elder . . . we observed a remarkable meteoric shower, which filled us all (more particularly my followers) with wonder and admiration . . . Although my warriors were ready to face death in any form, this singular phenomenon appalled them. It was the wrath of the Great Spirit showered visibly upon them."

Douglas Meteor Impact Craters

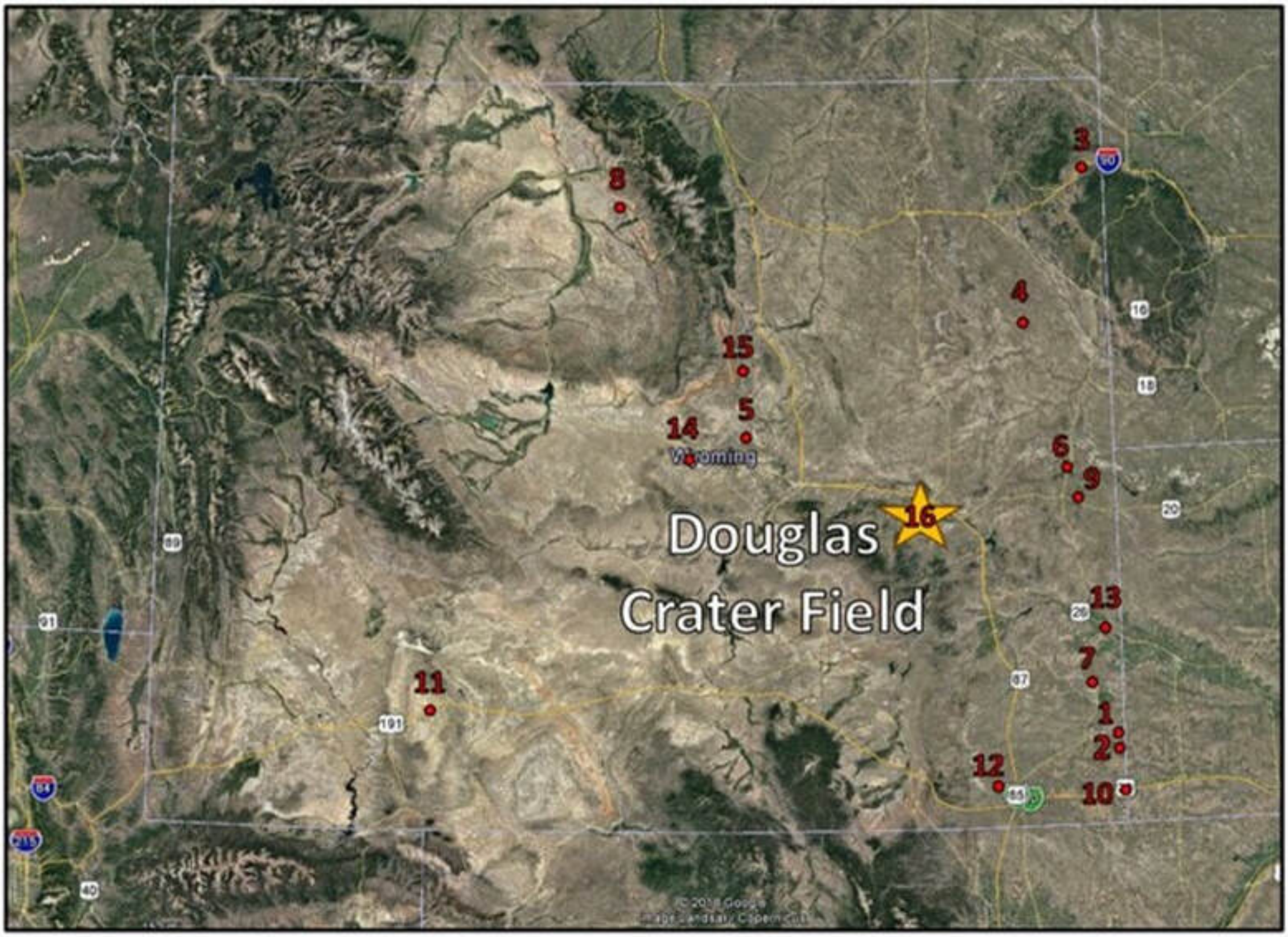
Sometimes multiple objects enter the atmosphere or large meteors break apart creating a crater swarm on the surface they strike. Such an impact field was recently reported near Douglas, Wyoming at Sheep Mountain and Sage Hen Anticline (Kastning and Huntoon, 1996; Kenkmann, T., Sundell, K.A., and Cook, D., 2018).



The Douglas meteor swarm impact field is shown with a dashed line. Long axis of ellipse is aligned with inferred impactor travel direction.
Image: Google Earth

The Douglas impact field is the most recently recognized crater site (there are 16 impact sites recognized in Wyoming). Craters were first reported in the Douglas area in a 1959 Master's thesis but without discussion of their possible origin (Spelman, A.R., 1959, Geology of the area between Bed Tick Creek and the west fork of LaBonte Creek, Converse County, Wyoming: M.A. Thesis University of Wyoming, 81 p).

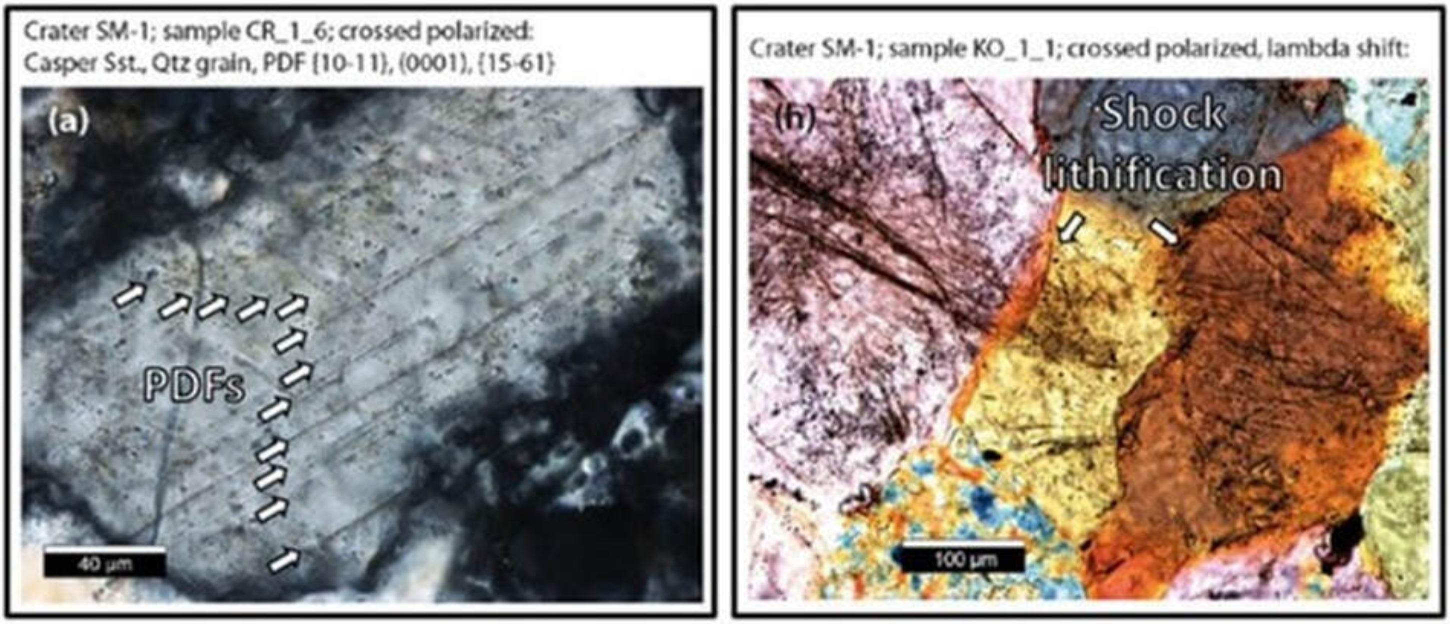
To date, over eighty circular and ellipsoid features are identified as possible meteor craters in the Douglas swarm area (Kenkmann, et. al., 2018). The craters range from 50 to 260 foot diameter. The impact field lies within an elliptical area eight miles long (12.8 km) and four and a quarter miles wide (6.9 km). In addition to crater morphology, rock samples show deformation that supports the interpretation of meteorite impact. These include planar deformation features, impact glass, and shock lithification of mineral grains.



Site Number	Name	Age	Discovered	Coordinates	Type	Mass
1	Albin (pallasite)		1915	41° 30'N, 104° 6'W	Pallasite, PMG	37.6 kg (82.7 lb)
2	Albin (stone)		1949	41° 25'N, 104° 6'W	L	15.4 kg (33 lb)
3	Bear Lodge		1931	44° 30' N, 104° 12' W	Iron, IIIAB	48.5 kg (106.7 lb)
4	Clareton		1931	43° 42'N, 104° 42'W	L6	1050 g (2.3 lb)
5	Cloud Creek	190 + 20 Ma	1985	43° 7'N, 106° 45'W	Impact Crater	
6	Hat Creek		1939	42° 55'N, 104° 25'W	H4	8.9 kg (19.6 lb)
7	Hawk Springs		1935	41° 47'N, 104° 17'W	H5	367 g (12.85 lb)
8	Hyattville		2008	44° 20' 18"N, 107° 40' 27"W	L6	8.91 kg (19.6 lb)
9	Lusk		1940	42° 46'N, 104° 21'W	Iron	46 g (1.6 oz)
10	Pine Bluffs		1935	41° 11'N, 104° 4'W	H	2.7 kg (5.9 lb)
11	Rock Springs		2003	41° 39' 0"N, 109° 1' 30"W	L6	52.7 g (1.8 oz)
12	Silver Crown		1887	41° 14' N, 104° 59'W	Iron, IAB-MG	11.6 kg (25.52 lb)
13	Torrington		1944	42° 4'N, 104° 10'W	H6	259 g (9.07 oz)
14	Waltman		1948	43° 0'N, 107° 10'W	L4	23.41 kg (51.5 lb)
15	Willow Creek		1914	43° 28'N, 106° 46'W	Iron, IIIE	51 kg (112.2 lb)
16	Douglas (impact field)	280 Ma	2018	42°40'38"N, 105°28'00"W	Impact Craters	

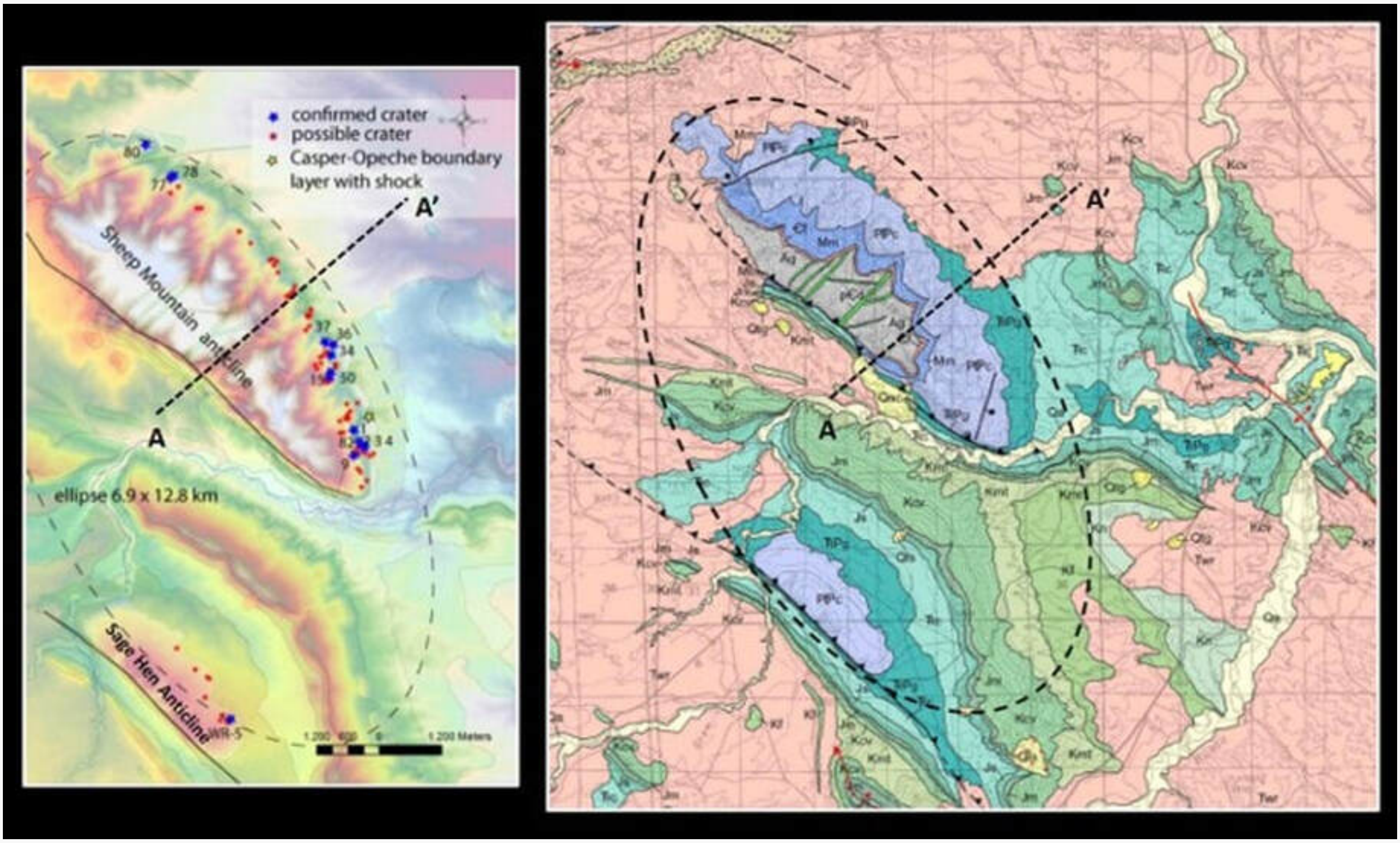
Recognized impact crater sites in Wyoming map and table. Douglas site (16) shown by gold star. The 2018 discovery date for the Douglas field

represents when definitive evidence of impact origin was found.
Image: Google Earth; Data: After http://worldwidemeteoritemaps.blogspot.com/2013/07/wyoming-meteorites-map.html.



Deformation features from Sheep Mountain Crater number 1: (A) Cross-cutting and fluid-decorated planar deformation features (PDFs) in quartz grain, spacing is 3.5 micrometers on average: (H) Shock-lithification of quarts grains at indentation and interlocking sites.
Image: Kenkmann, T., Sundell, K.A., and Cook, D., 2018, Evidence for a large Paleozoic Impact Crater Strewn Field in the Rocky Mountains: Scientific Reports 8, Fig. 5A & 5H, p. 8; https://www.nature.com/articles/s41598-018-31655-4

The craters are exposed on the northeast flanks of Sheep Mountain and Sage Hen Anticline. Both anticlines were formed during the Laramide Orogeny that occurred about 70 million years ago. The craters occur in the uppermost Pennsylvanian Casper Formation at the contact with the overlying Opeche Shale Member, Goose Egg Formation. This gives an approximate age of 280 million years ago for the impact.



Quaternary surficial deposits

Qa — **Alluvial deposits (Holocene)**—Unconsolidated and poorly consolidated clay, silt, sand, and gravel, mainly in channel or meander belt of creeks and rivers. Includes lowest level terrace deposits in many of the stream valleys

Qac — **Mixed alluvium and colluvium (Holocene/Pleistocene)**—Sand, silt, clay, and gravel deposited mainly along intermittent streams and rivers; includes slope wash and smaller alluvial fan deposits that coalesce with alluvium and youngest low-level terrace deposits

Qls — **Landslide deposits (Holocene/Pleistocene)**—Blocks of bedrock, surficial materials, or loose slope debris that have fallen, slumped, or flowed down moderate to steep slopes, especially those weakened by water and undercutting

Qsw — **Slope wash (Holocene/Pleistocene)**—Pebbles, cobble, and gravels amidst a variegated matrix. Result of mass wasting on steep slopes

Qtg — **Terrace deposits (Holocene/Pleistocene)**—Unconsolidated (partially consolidated locally) beds of pebble and cobble gravels and lenses of silt and sand. Consist of uncorrelated terraces which occur along present drainages, a few feet (0.6 m) to over 100 feet (30 m) above modern flood plain

Qs — **Windblown sand (Holocene/Pleistocene)**—Primarily gray quartz sand; includes active and inactive (stabilized) sand dunes trending southwest to northeast, mainly in the area northeast of Douglas

Tertiary sedimentary rocks

To — **Ogallala Formation (upper Miocene)**—Fine- to coarse-grained, light- to greenish-, yellowish-, and orange-gray sandstone interbedded and interfingered in the upper part with conglomerate, claystone, and freshwater limestone; white to dark-gray vitric tuff beds near the top. Lower part has hard "pipy" calcareous sandtone concretions. Thickness 0 to 400 feet (0 to 122 m)

Ta — **Arikaree Formation (lower Miocene/Oligocene)**—Light-colored (tan to gray to white), poorly to well cemented, variably tuffaceous siltstone and sandstone interbedded with thin claystone and conglomerate. The formation also contains local limestone and volcanic ash beds. Thickness 0 to 705 feet (0 to 215 m). Only present in the Denver Basin

Tmoc — **Miocene and Oligocene conglomerate**—Mostly light-gray conglomerate and gray channel sandstone interbedded with blocky brown and gray claystone and orange-gray siltstone. Claystone is like that underlying White River Formation (Twr). Clasts in the conglomerate are Paleozoic and Precambrian rocks, mostly in a gray calcareous sandstone matrix. Thickness 0 to 490 feet (0 to 150 m)

Twr — **White River Group (Oligocene and upper Eocene)**— White to pale-pink blocky tuffaceous, bentonitic claystone and lenticular arkosic conglomerate with lenses of thin gray sandstone. Thickness 0 to 1,150 feet (0 to 350 m). Individual formations (Chadron and Brule) that compose the group elsewhere in eastern Wyoming were not identified or distinguished on this quadrangle. Age of lower part re-assigned to the Eocene based on redefinition of the Oligocene-Eocene boundary (Lillegraven, 1993)

Tw — **Wasatch Formation (lower Eocene)**—Lenticular interbeds of gray to light-brown, fine- to coarse-grained, locally conglomeratic, feldspathic to arkosic, cross-bedded sandstone dark- to light-gray or brown or greenish-gray shale, claystone, and siltstone. Subbituminous coal beds, lignite beds, and carbonaceous shales occur locally. Thicknesses of over 2,400 feet (730 m) in the Powder River Basin, but only the lowermost part exposed on this quadrangle (description based on Kohout, 1957)

Fort Union Formation (Paleocene)

Tftl — **Tongue River and Lebo Members undivided**—Yellowish-gray sandstone and siltstone; coal beds and carbonaceous shales; and, locally, thin lenses of conglomerate. Thickness ranges from approximately 1,725 to 2,825 feet (525 to 861 m) (Denson and others, 1995)

Tft — **Tullock Member**—Distinguished from the conformably overlying Lebo Member by its drab appearance and massive sandstone units. Interbedded tan to buff sandstone, siltstone, dark brown and gray carbonaceous shale, and thin coal beds. Thickness 750 to 1,850 feet (229 to 564 m) (description and thicknesses from Denson and others, 1995)

Upper Cretaceous sedimentary rocks

Kl — **Lance Formation**—Gray shale and drab brown, massive lenticular, concretionary sandstone; thin coal beds in lower half. Thickness 1,000 to 2,500 feet (300 to 760 m) (description and thickness modified from Love and others, 1979)

Kfh — **Fox Hills Sandstone**—Brownish gray to yellow-brown sandstone interbedded with siltstone and dark sandy shale containing marine fossils. The sandstone is characterized as a coarsening upward sequence. Thickness approximately 150 to 200 feet (45 to 60 m) (description and thickness modified from Love and others, 1979)

Kmv — **Mesaverde Formation**—Teapot Sandstone Member, white, at top; underlain by unnamed gray sandstone, shale, and coal member; nonmarine gray Parkman Sandstone Member at base. Parkman Sandstone commonly contains brown-weathering calcareous concretions. Thickness approximately 600 to 1,200 feet (180 to 365 m) (description and thickness from Love and others, 1979)

Kc — **Cody Shale**—Dark-gray calcareous, fossiliferous marine shale interbedded with light-gray fine-grained sandstone, with numerous bentonite beds in the upper two-thirds of the formation. Septarian concretions common throughout the shale units. An upper, glauconitic, fine-grained shaly sandstone (Shannon Sandstone Member) occurs about 1,000 feet (300 m) below the top of the formation. The Sussex Sandstone Member occurs approximately 400 feet (120 m) above the Shannon. Thickness approximately 3,000 to 4,500 feet (915 to 1,370 m) (description and thickness from Love and others, 1979)

Kn — **Niobrara Formation**—Dark-gray to yellowish-buff marine shale and chalky, soft, white limestone; highly seleniferous. Equivalent to the lower Cody Shale and used in the area 9 miles (km) south of Douglas. Thickness about 700 feet (205 m) (description and thickness modified from Love and others, 1979)

Kf — **Frontier Formation**—Dark-gray and black shales with thin concretionary sandstone. Wall Creek Sandstone Member at top. Thickness 590 to 705 feet (180 to 215 m) (description and thickness from Love and others, 1980)

Upper and Lower Cretaceous sedimentary rocks

Kmt — **Mowry Shale, Muddy Sandstone, and Thermopolis Shale undivided**

Mowry Shale (Upper Cretaceous)—Hard, dark-gray, siliceous shale that weathers silver gray and contains thin bentonite beds and abundant fish scales. Lower unit is dark-gray to black nonresistant shale with thin interbedded white fine-grained ledge-forming sandstone near the base, grading into the underlying Muddy Sandstone. Contact with overlying Frontier Formation is at the base of the persistent "Clay Spur Bentonite." Thickness approximately 350 feet (107 m) (description and thickness modified from Ver Ploeg, 2004)

Muddy Sandstone (Lower Cretaceous)—Tan to gray, fine- to medium-grained, friable to well-lithified sandstone that is 5 to 30 feet (1.5 to 9 m) thick. Easily identified by its drab color and grains of black minerals (description and thickness modified from Ver Ploeg, 2004)

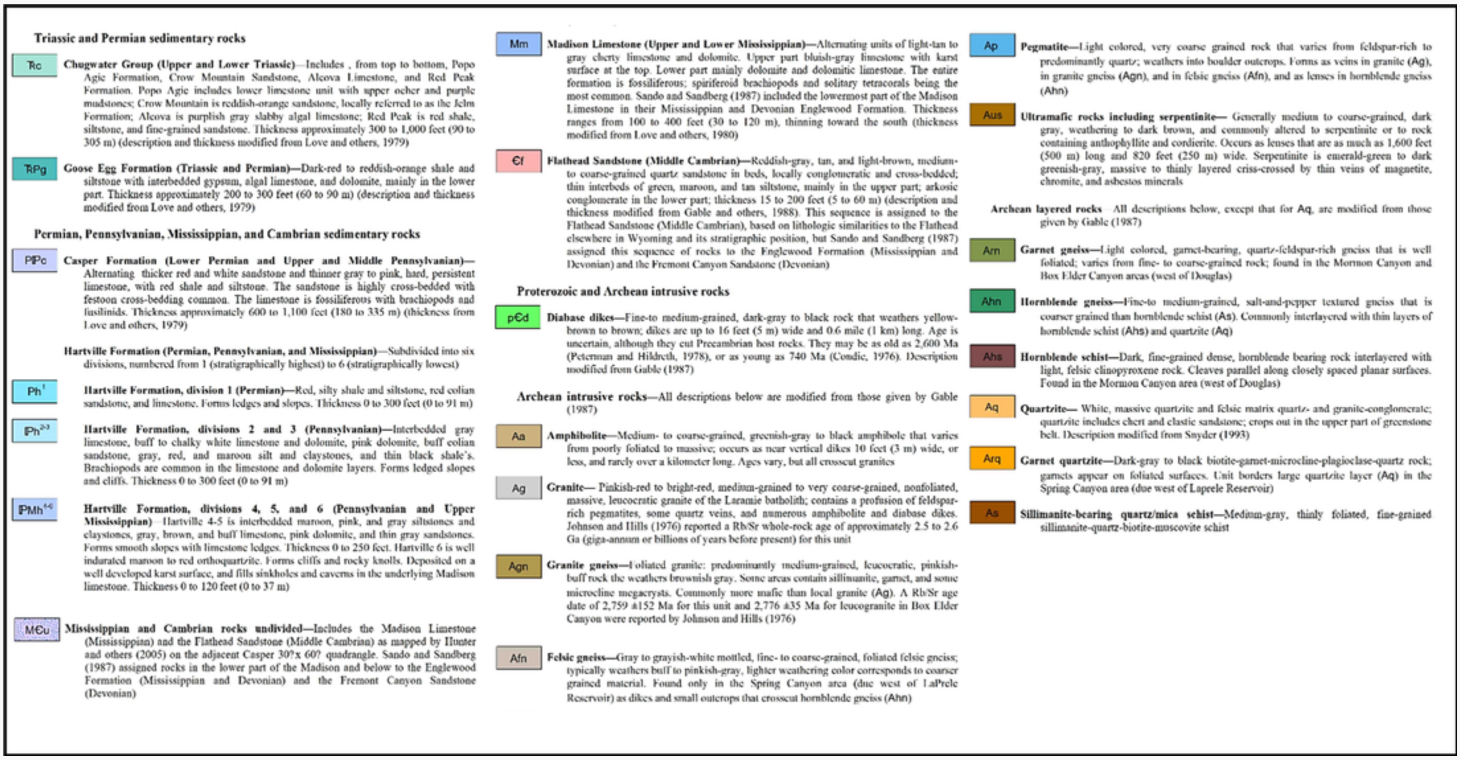
Thermopolis Shale (Lower Cretaceous)—Dark-gray to black soft fissile shale with some interbedded bentonite layers. Ironstone concretions appear in the lower portion of the formation. Thickness 160 to 200 feet (49 to 60 m) (description and thickness modified from Ver Ploeg, 2004)

Kcv — **Cloverly Formation (Lower Cretaceous)**— A tripartite unit consisting of an upper gray to buff to brown, fine- to coarse-grained, resistant slabby sandstone and siltstone, locally referred to as the "Rusty Beds;" variegated buff and purple claystones interbedded with thin black shale beds in the middle; and a basal tan to white, coarse-grained sandstone and chert pebble conglomerate, locally cross-bedded. Thickness approximately 100 to 300 feet (30 to 90 m) (description and thickness modified from Love and others, 1979)

Jurassic sedimentary rocks

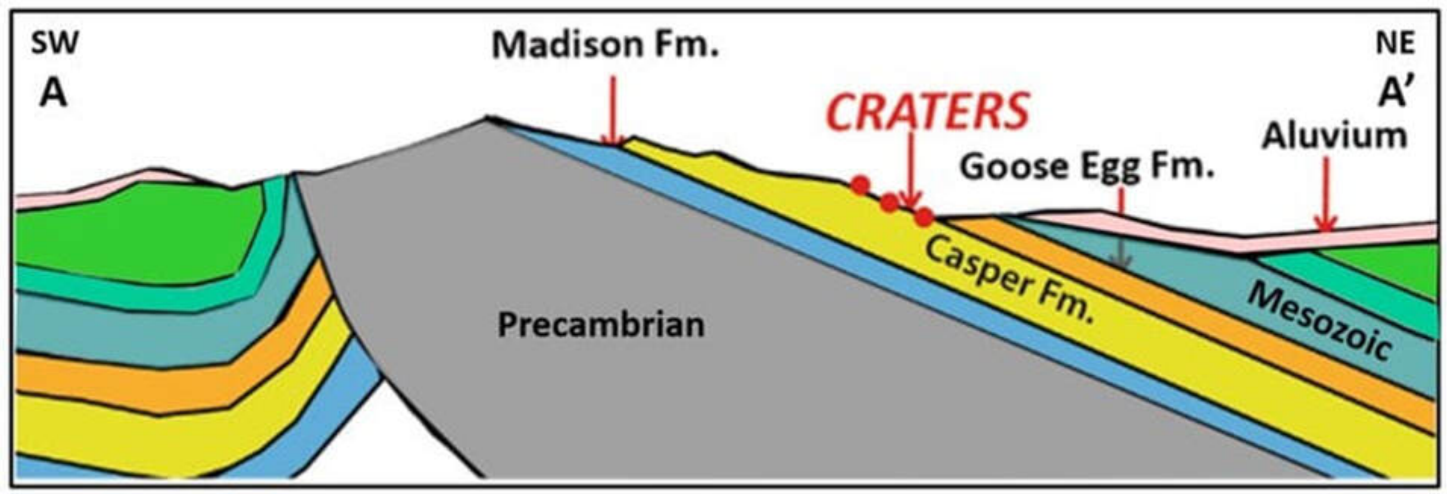
Jm — **Morrison Formation (Upper Jurassic)**—Pale-green, olive-green, blue-green to maroon and chalky, white, variegated calcareous and bentonitic claystones interbedded with light-gray, fine-grained, friable, cross-bedded silty sandstones. Dinosaur bones and bone fragments are common in the upper part of the section. Thickness approximately 100 to 300 feet (30 to 90 m) (description and thickness modified from Love and others, 1979)

Js — **Sundance Formation (Upper and Middle Jurassic)**—Upper part is gray to greenish-gray glauconitic shale with an upper layer consisting of slabby shale and calcareous sandstone that weathers brown and is slightly glauconitic. Middle part is red and gray nonglauconitic sandstone and shale and thin gypsum and limestone beds. Lower part is thick-bedded gray to pink sandstone. Thickness approximately 550 feet (170 m) (description and thickness modified from Love and others, 1979)



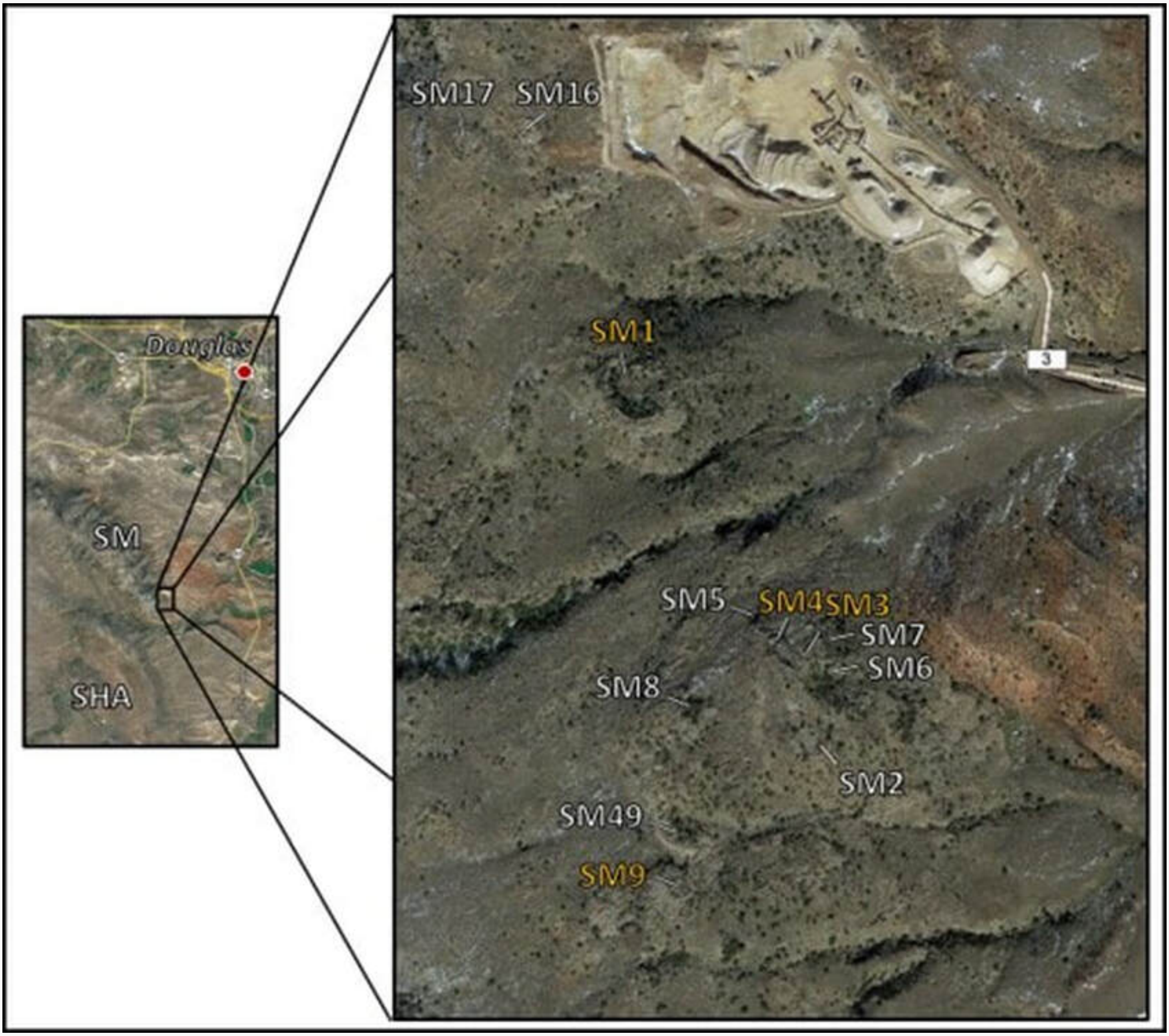
Douglas Impact Swarm (dashed line ellipse) elevation map on left and geologic map on right. Impact craters are restricted to the uppermost Casper Formation.

Image: Left: After Schulze, T., Kenkmann, T., Poelchau, M.H., Sundell, K.A., and Cook, D., 2019, Douglas Impact Crater Strewn Field, WY, USA: A Progress Report: Large Meteorite Impacts VI 2019 (LPI Contrib. No. 2136) 5036.pdf, Fig. 1, p. 206; https://www.hou.usra.edu/meetings/lmi2019/pdf/5036.pdf; Image Right: After McLaughlin, J.F., and Ver Ploeg, A.J., 2008, Geologic map of the Douglas 30' x 60' quadrangle, Converse and Platte counties, Wyoming: Wyoming State Geological Survey Map Series 83, scale 1:100,000; McLaughlin, J.F., and Ver Ploeg, A.J., 2008, Geologic map of the Douglas 30' x 60' quadrangle, Converse and Platte counties, Wyoming: Wyoming State Geological Survey Map Series 83, scale 1:100,000; https://www.wsgs.wyo.gov/products/wsgs-2008-ms-83.pdf.



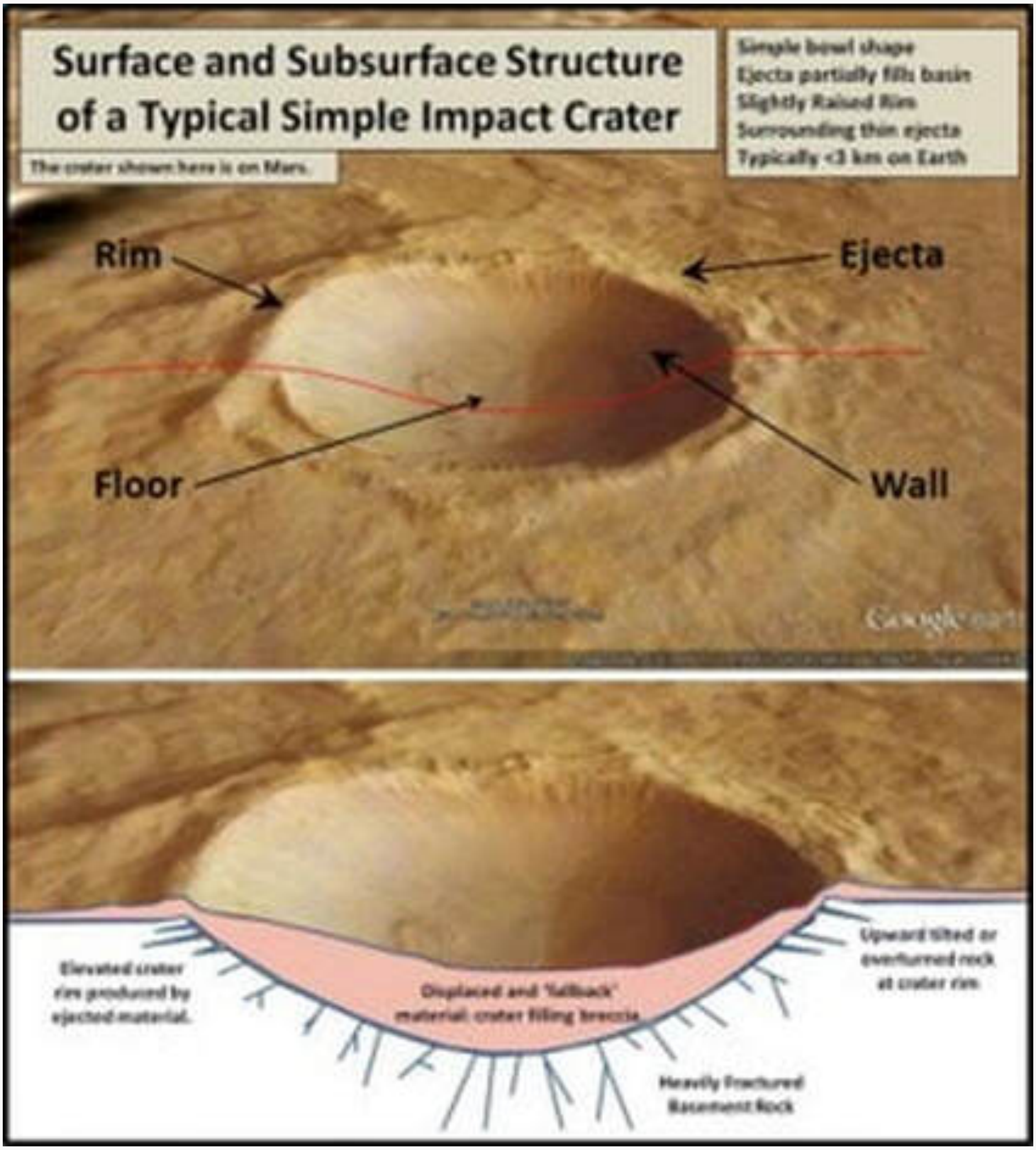
Sheep Mountain cross section AA' showing impact site and the asymmetric structure of the Laramide anticline.

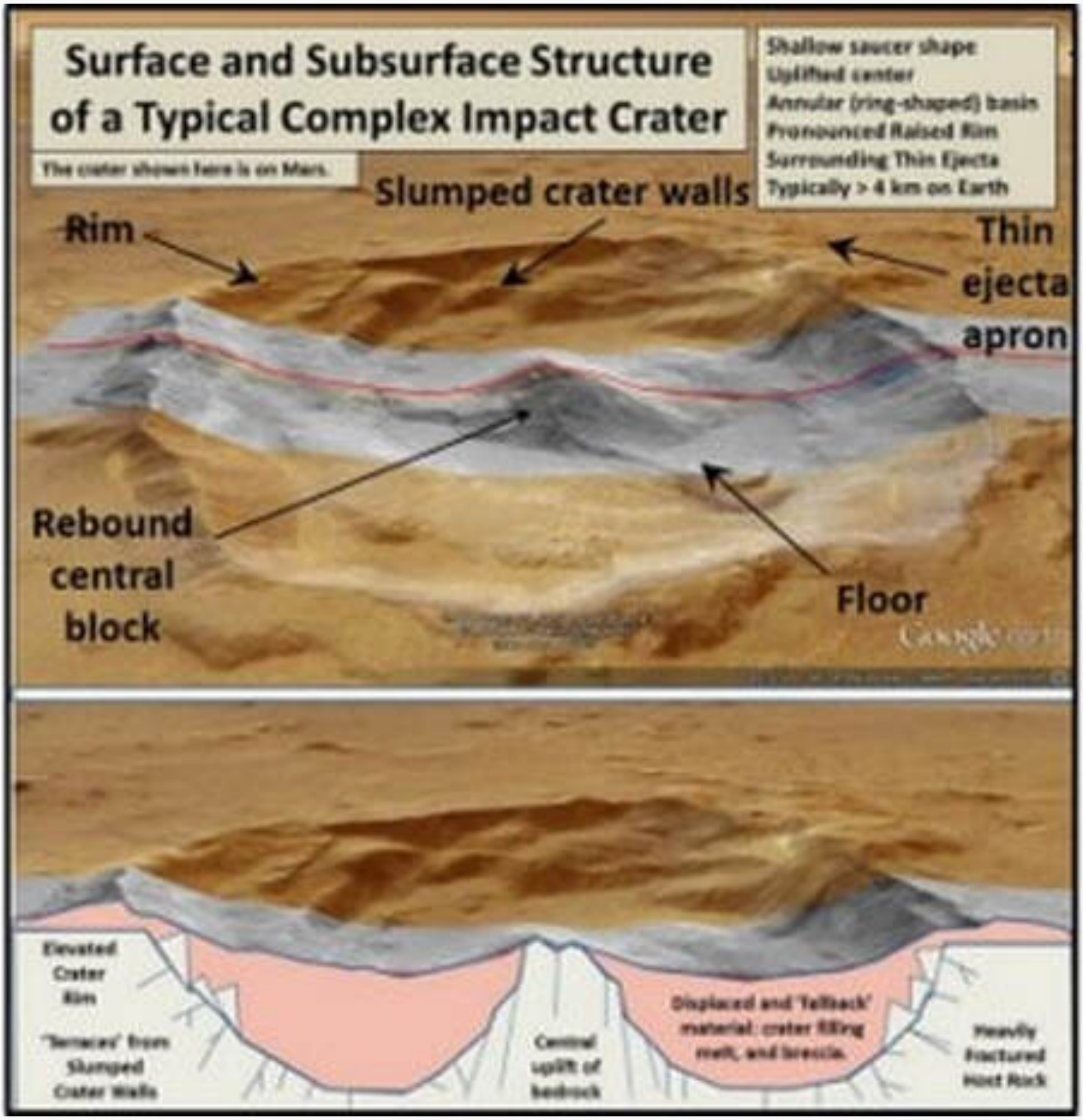
Image: After ***Kenkmann, T., Sundell, K.A., and Cook, D., 2018, Evidence for a large Paleozoic Impact*** *Crater Strewn Field in the Rocky Mountains: Scientific Reports 8, Fig. 1, p. 3; https://www.nature.com/articles/s41598-018-31655-4.*



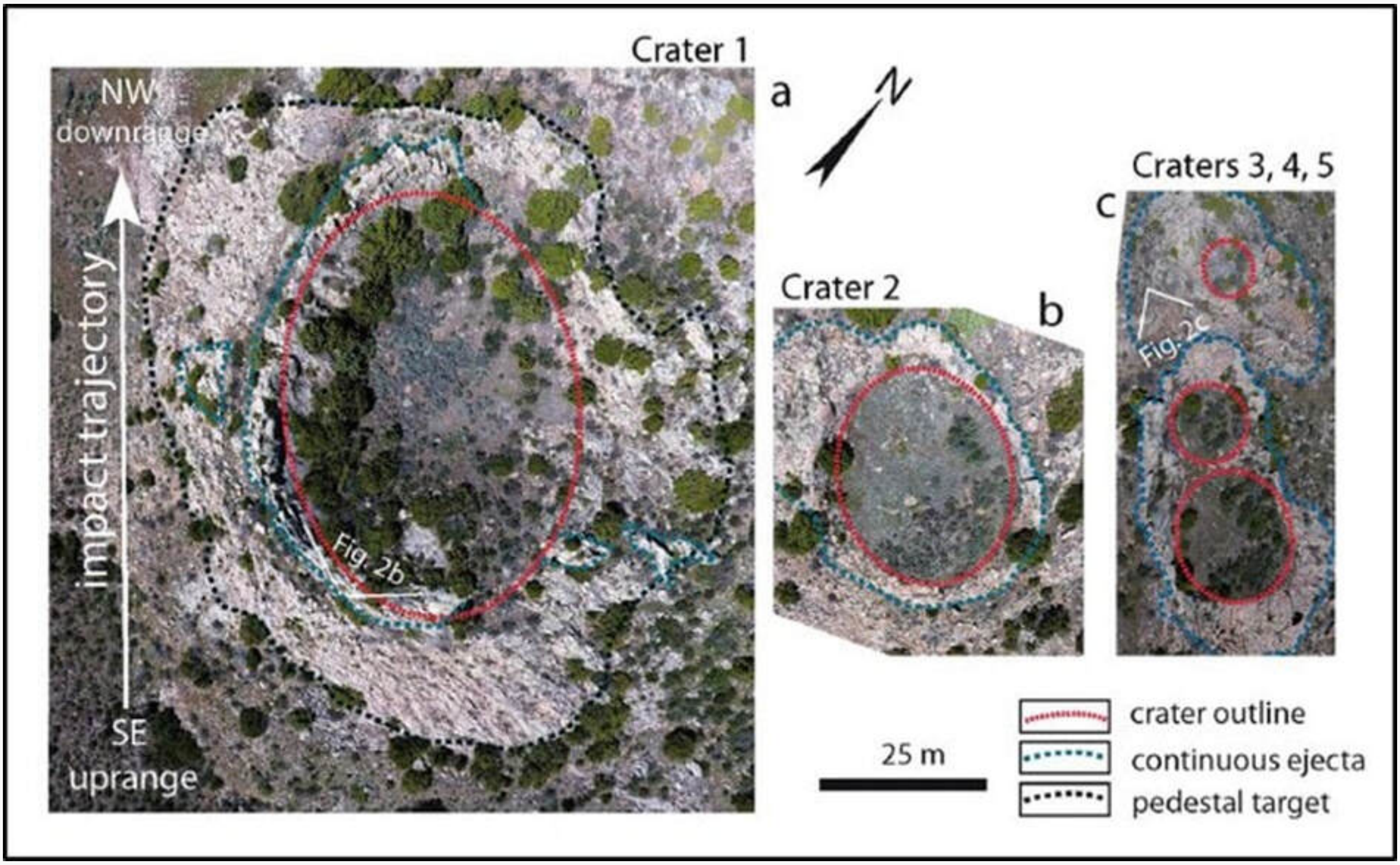
Crater field along southeast flank Sheep Mountain. Gold colored sites are proven meteorite impacts. There is a quarry in the upper center of the image (Pinnacle Materials Inc, Douglas quarry). Abbreviations: SHA = Sage Hen Anticline; SM = Sheep Mountain.
Image: After Kenkmann, T., Sundell, K.A., and Cook, D., 2018, Evidence for a large Paleozoic Impact Crater Strewn Field in the Rocky Mountains: Scientific Reports 8, Fig. 3, p. 5; https://www.nature.com/articles/s41598-018-31655-4

Meteoroids strike the Earth at high velocity between 25,000 mph (11 km/s) and 150,000 mph (70 km/s), or about 4 to 23 times the speed of sound. Two kinds of impact craters are recognized: simple and complex. The Douglas impact site exhibits generally simple crater morphology. The crater field is tilted about 15 degrees east-northeast due to Laramide uplift of Sheep Mountain and Sage Hen Anticline.





Simple and complex crater morphology. Red line on images shows line of cross section.*Image: After Beauford, R., 2018, United States Meteorite Impact Craters Website, Chapter 7: Crater morphology - simple and complex craters; https://impactcraters.us/crater_identification/chapter_7.*



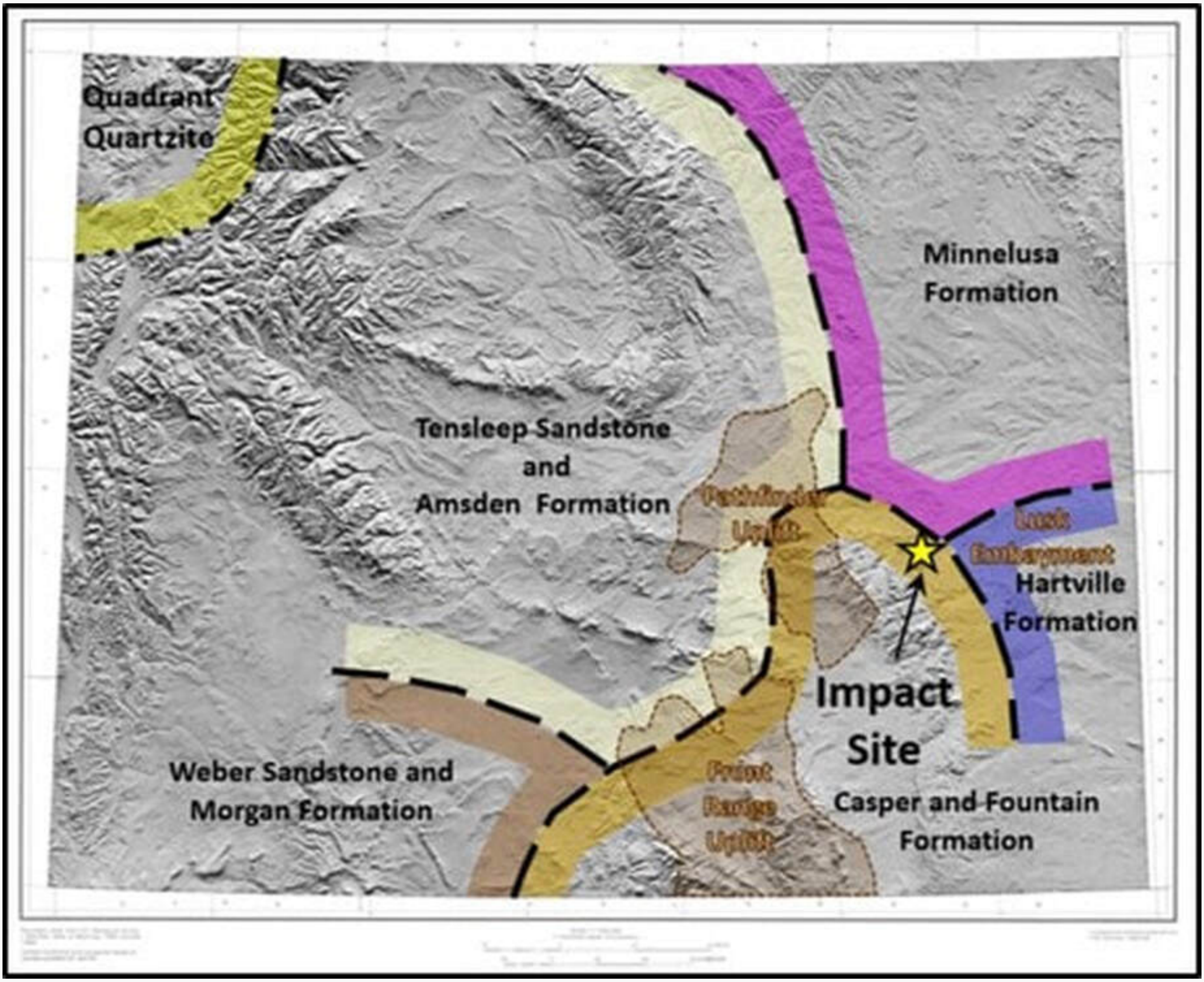
Drone images of Sheep Mountain craters SM1 to SM5 (a) Crater 1 is 60 m in diameter along the NW-SE trajectory. Its NE flank is eroded. Crater 1 samples have shocked quartz grains. (b) Crater 2 has a 31 m long axis and ovoid shape. The apparent overturned flap is well-preserved downrange. (c) Craters 3, 4 and 5 interfere with each other and together form a highly elliptical cavity in NW-SE direction. Crater 5 possibly formed by ricochet of the projectile. Dotted red and blue lines outline the crater cavities and the preserved ejecta blankets, respectively.

Image: Kenkmann, T., Sundell, K.A., and Cook, D., 2018, Evidence for a large Paleozoic Impact Crater Strewn Field in the Rocky Mountains: Scientific Reports 8, Fig. 4, p. 7; https://www.nature.com/articles/s41598-018-31655-4

Dr. Kent Sundell on vertical sandstone rim of crater and pointing toward the center of the crater.
Image by Mark Fisher

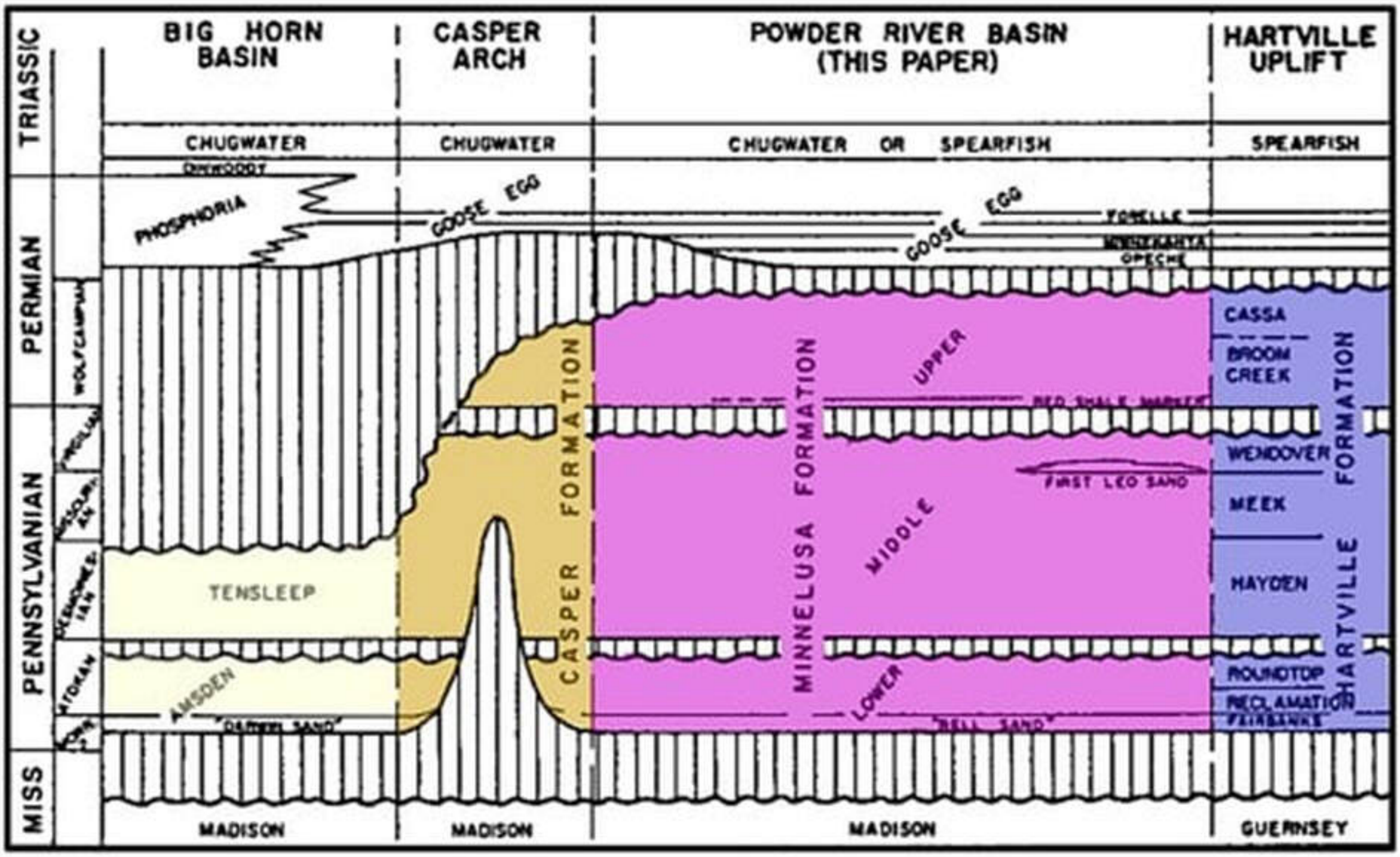
The Casper Formation is one of the units in the Pennsylvanian system located on the Wyoming shelf. This region (Wyoming Straits) was periodically flooded by a shallow arm of the Panthalassic Ocean that connected to the Midcontinent Sea. It is comprised of a mixed clastic and carbonate sequence deposited on the shelf along the east flank of the Pathfinder Uplift (Ancestral Rockies) and west of the Lusk Embayment. The uppermost Casper Formation at the impact site exhibits eolian dune deposition on the Wyoming shelf.

The continental collision and suturing between Gondwana and Laurentia was nearing completion by the close of the Pennsylvanian system when the Douglas meteor swarm collided with paleo-Wyoming. For 70 million years Earth would have a single supercontinent called Pangea (“all earth”) that was surrounded by the Panthalassic Ocean. Pangea would begin to breakup about 200 million years ago at the beginning of the Jurassic Period.



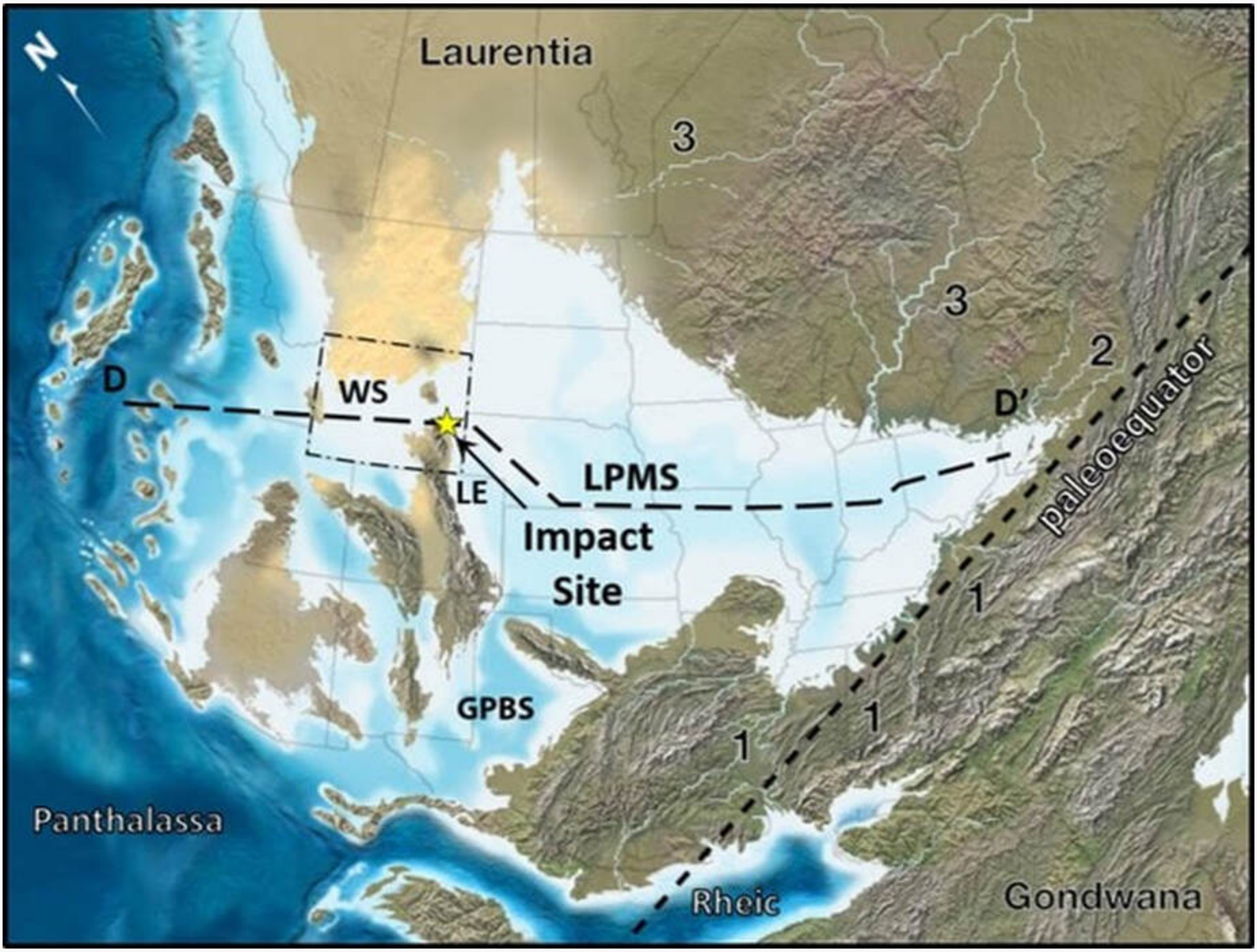
Areal extent of Pennsylvanian formations in Wyoming (colored long black dash areas) on shaded relief map of present-day Wyoming topography. Boundaries are approximate. Position of the Pennsylvanian-age Ancestral Rocky Mountains relative to existing ranges and basins in Wyoming is shown (brown shaded region). Douglas meteorite crater field shown by yellow star on the southeast flank of Pathfinder Uplift, west of the Hartville Formation depocenter in the Lusk Embayment.

Image: After Base: Kathleen Edwards, K. and Batson, R.M., 1990, Experimental digital shaded-relief maps of Wyoming: U.S. Geological Survey IMAP 1846, Plate 2; https://pubs.usgs.gov/imap/1846/plate-2.pdf; Data: Mallory, W.W., 1967, Pennsylvanian and Associated Rocks in Wyoming: U.S. Geological Survey Professional Paper 554-G, Fig.2, p. G4 and Fig. 4, p. G5; https://pubs.usgs.gov/pp/0554g/report.pdf.



Diagrammatic correlation of Permian-Pennsylvanian rocks central and eastern Wyoming. The Casper consists of fine- to medium-grained, massive to thin cross-bedded, well cemented sandstones, calcareous sandstones, and limestones that interfinger with the arkose of the Fountain Formation adjacent to the Pathfinder and Front Range Uplifts, Ancestral Rocky Mountains.

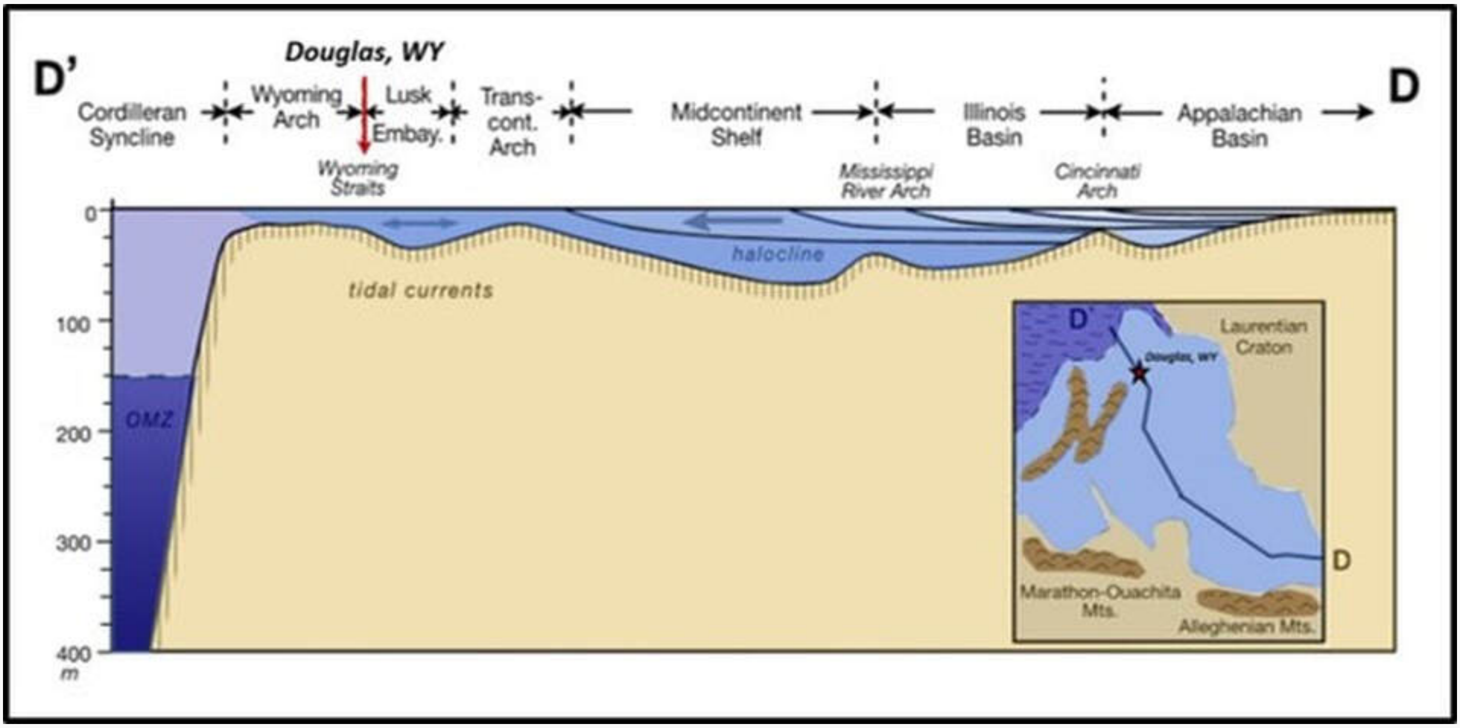
Image: After Foster, D.I., 1958, Summary of the Stratigraphy of the Minnelusa Formation, Powder River Basin, Wyoming: Wyoming Geological Association Powder River Basin of Wyoming; 13th Annual Field Conference Guidebook, Fig. 1, p. 39.



Regional paleogeography of North America during Late Pennsylvanian high sea level events about 280 million years ago when the Douglas meteor swarm slammed into paleo-Wyoming. Major drainage systems: 1 = orogenic, 2= foreland basin, and 3 = cratonic. Note connections to the global ocean through (1) an elongate, serpentine corridor in the Greater Permian Basin region, and (2) a broad, shallow and only intermittently open strait across the Wyoming Shelf. Abbreviations: GPBS = Greater Permian Basin Seaway; LE = Lusk Embayment; LPMS = Late Pennsylvanian Midcontinent Sea; WS = Wyoming Straits. N arrow represents paleonorth. Wyoming outline by black dot-dashed line. Cross section DD' shown by black long dashed line. The Late Pennsylvanian paleoequator shown by black short dashed line. Douglas Meteorite impact site shown by yellow star.

Image: After Algeo, T.J., Heckel, P.H., Maynard, J.B., Blakey, R.C., and Rowe, H., 2008, Modern and Ancient Epeiric Seas and the Super-estuarine

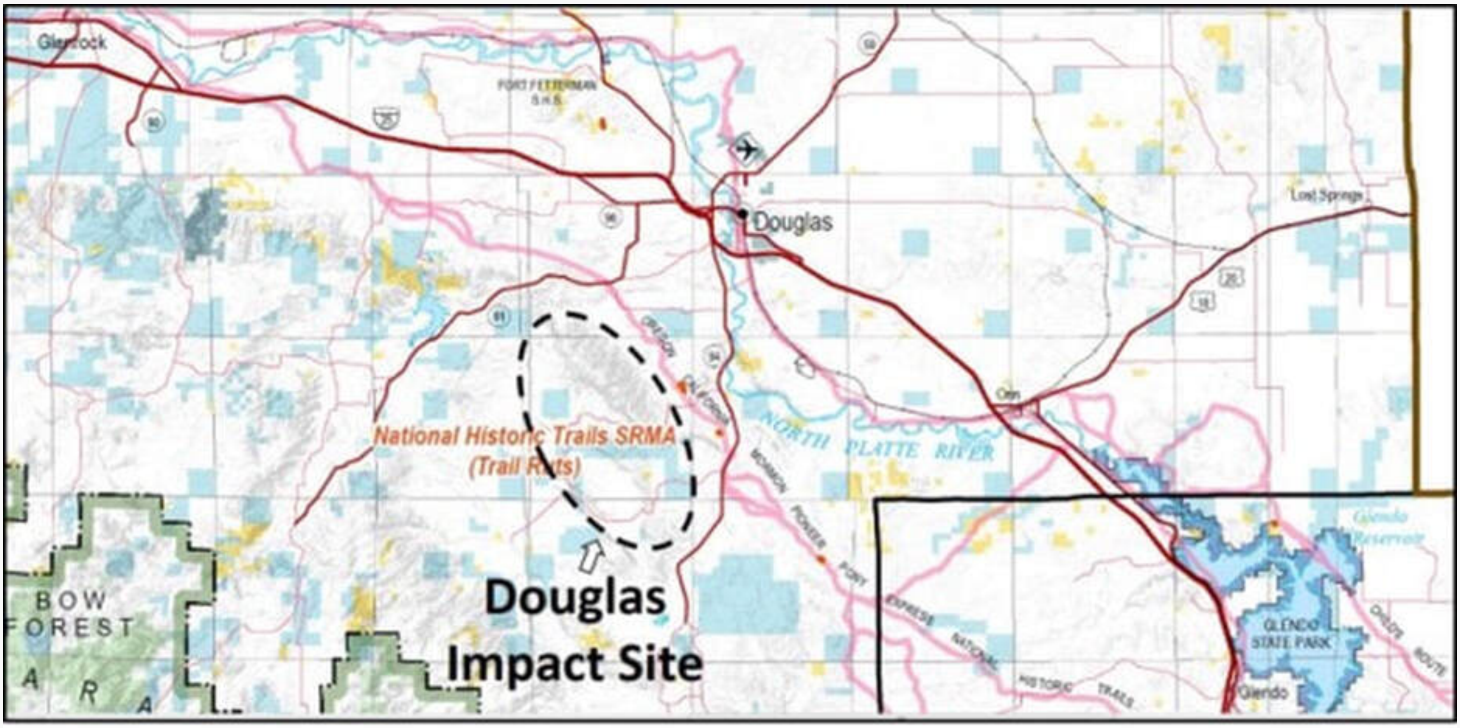
Circulation Model of Marine Anoxia, in Pratt, B.R. and Holmden, B., Editors, 2008, Geological Association of Canada Special Paper 48: Dynamics of Epeiric Seas, Fig. 4, p. 16; http://homepages.uc.edu/~algeot/Algeo-etal-GAC-2008-off.pdf.

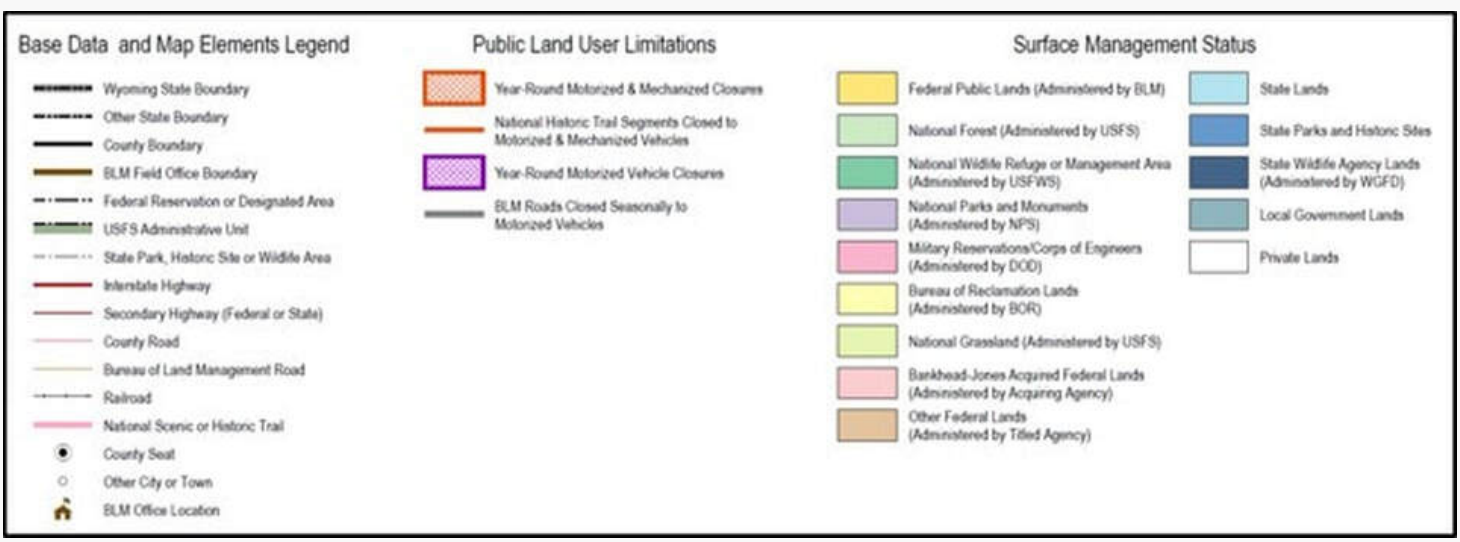


Schematic cross section DD' of the Late Pennsylvanian Mid-continent Sea from the eastern interior region (Appalachian Basin) through the Wyoming Straits passage to the global ocean (Panthalassa). Inferred watermass circulation patterns are shown by arrows. Note: Douglas crater location between the Wyoming Arch shelf and the Lusk Embayment is shown at maximum transgression (high sea level). Vertical scale is highly exaggerated to show ocean features

Image: After Algeo, T.J., Heckel, P.H., Maynard, J.B., Blakey, R.C., and Rowe, H., 2008, Modern and Ancient Epeiric Seas and the Super-estuarine Circulation Model of Marine Anoxia, in Pratt, B.R. and Holmden, B., Editors, 2008, Geological Association of Canada Special Paper 48: Dynamics of Epeiric Seas, Fig. 6, p. 20; http://homepages.uc.edu/~algeot/Algeo-etal-GAC-2008-off.pdf.

Note: The Douglas Impact swarm lies on private property and there is no access at this time. There are occasional geology field trips to visit these craters. Dr Kent Sundell at Casper College, co-author of the paper on this site is the best contact about upcoming field trips. The landowners have graciously allowed scientists to study these craters, please do not trespass.





Surface land map in the Douglas area. White is private land, blue is state,

yellow is BLM, and light green is Forest Service.
After BLM Casper Field Office, 2019, Seasonal & Year-Round BLM Public Land User Limitations Georeferenced Map; https://www.blm.gov/sites/blm.gov/files/Casper_FO_PublicLandUserLimitations.pdf.

Whoopie ti yi yo, git along little dogies

You know that Wyoming will be your new home