

LIDAR DIGITAL ELEVATION MAPS EMPLOYED IN CAROLINA BAY SURVEY

Leveraging LiDAR, Google Earth & Fusion Tables for a Network-based Geospatial Database

Abstract No: 192576

2011 GSA Meeting:

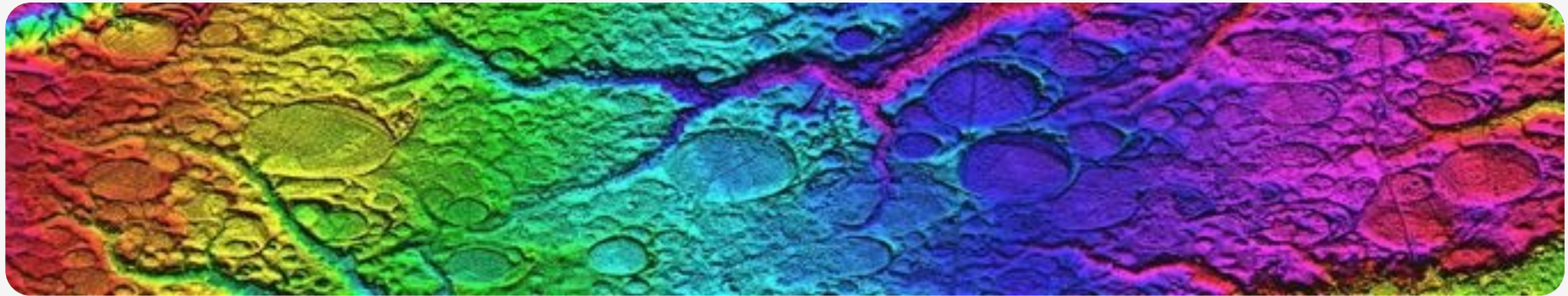
12 October, 2011

Minneapolis , Minnesota, USA

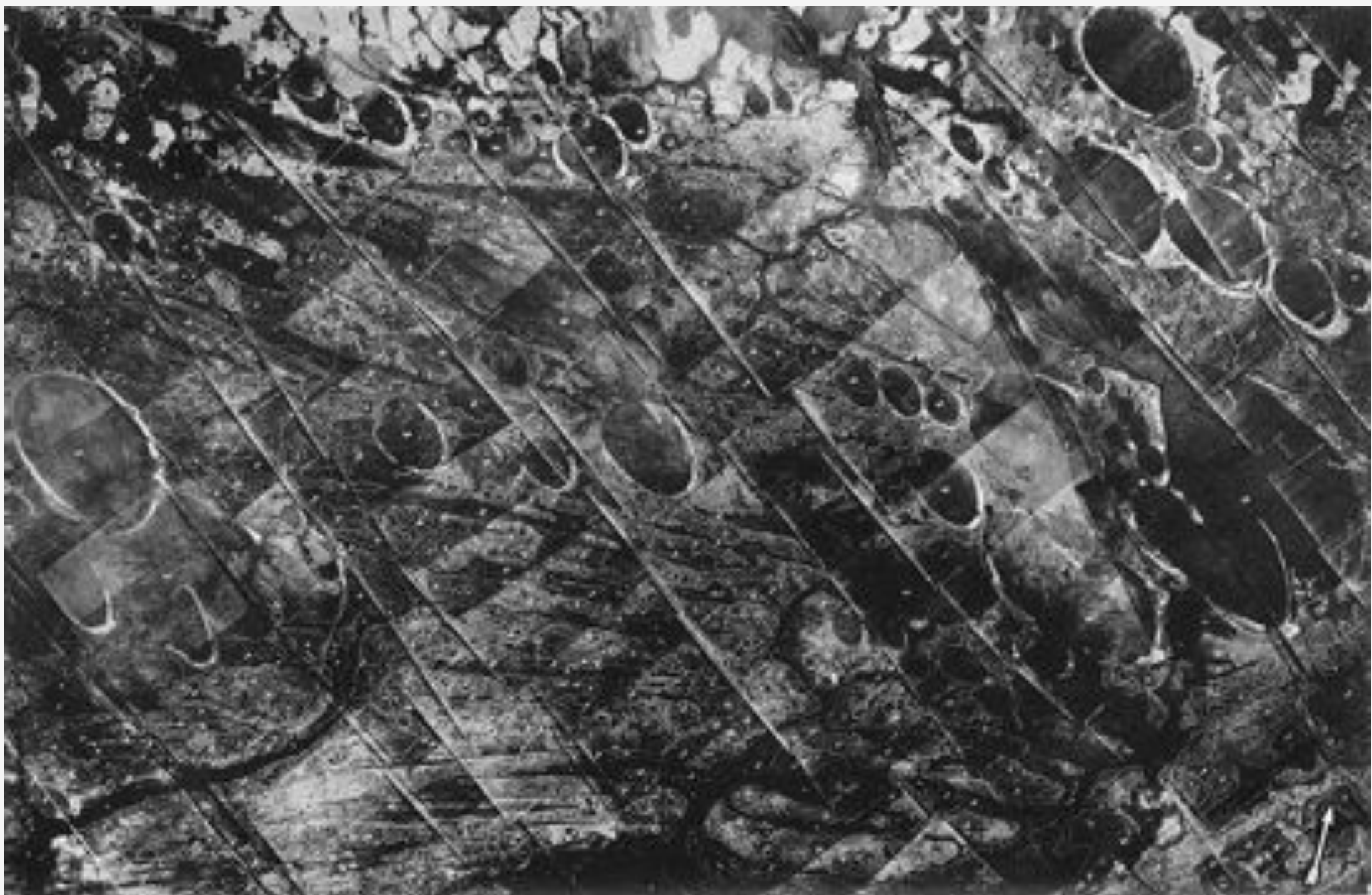


Michael E. Davias

Jeanette L. Gilbride



Myrtle Beach, SC



©Fairchild Aerial Surveys for the Ocean Forest Company: Aerial view taken in 1930 (12x8 km)

“No one has yet invented an explanation which will fully account for all the facts observed”

Douglas Johnson, 1942

The Origin of the Carolina Bays

“No one has yet invented an explanation which will fully account for all the facts observed”

Douglas Johnson, 1942
The Origin of the Carolina Bays

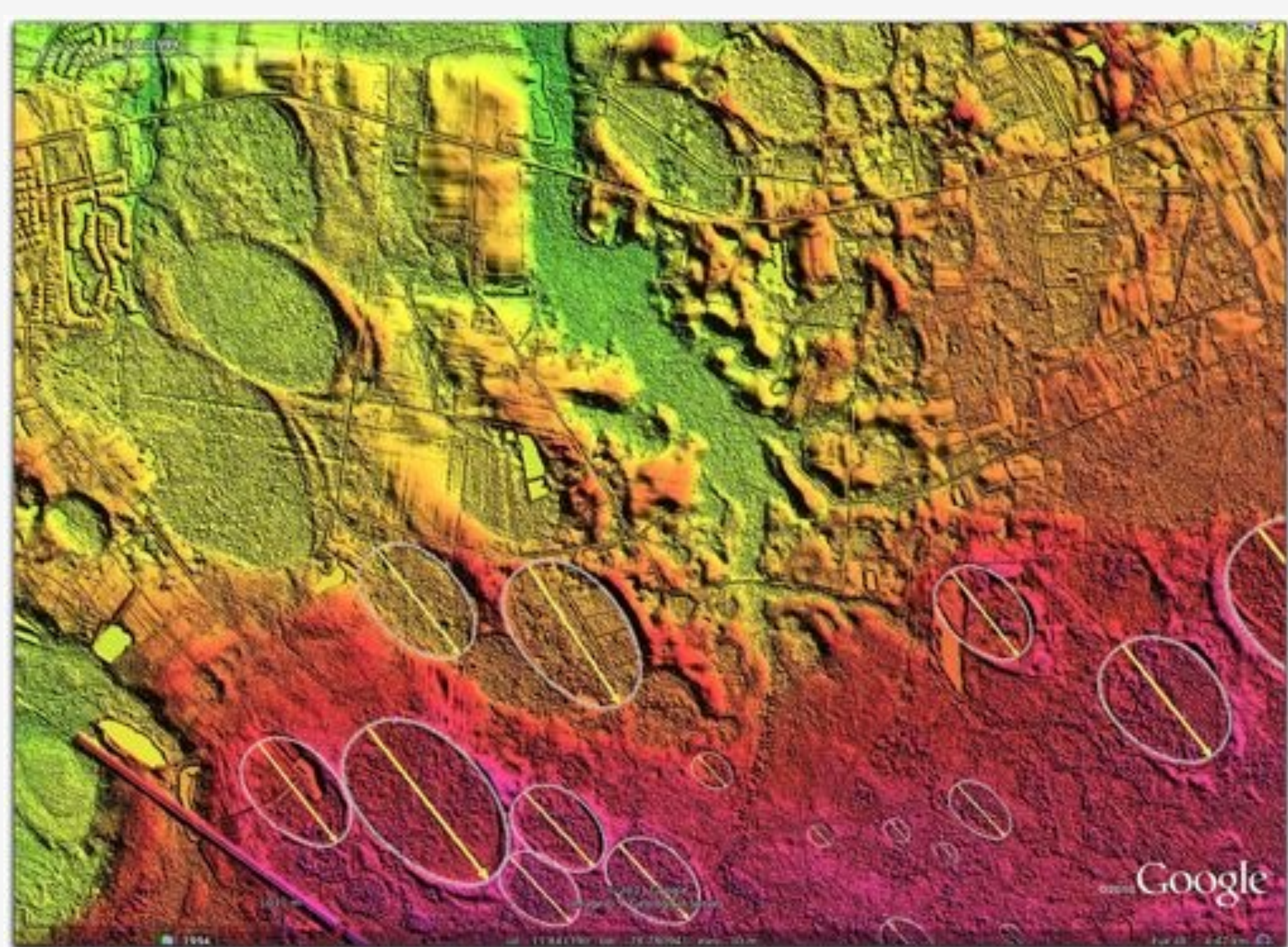
- **Geospatial Survey of Carolina Bay Landforms**
- **LiDAR heavily leveraged for visualization**
- **27,000 Individual bays have been measured & documented**
- **All work product openly available over Internet**

<http://cintos.org/Survey>



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Google

Carolina Bay Survey Tools & Resources

- 1/9 Arc-second Elevation Data
 - USGS Seamless Server
 - NOAA Digital Coast
 - South Carolina DNR
 - Nebraska DNR
 - Virginia's College of William & Mary
- Global Mapper commercial GIS program
 - Visualized as hsv-shaded & high gain
 - Saved as Keyhole Markup language (KML) tiled data files
- Google Earth
 - Google Earth loads Global Mapper KML & aligns on virtual globe
 - Used to capture bay geospatial metrics
- Google Fusion Tables
 - Cloud Based Geospatial Repository
 - Network Linked Data Provider
 - Statistical Data Analysis Source

The screenshot displays the Global Mapper v13.00 interface. The main window shows a 3D terrain model with a bathymetric overlay. The 'KML/KMZ Export Options' dialog is open on the left, and the 'Overlay Control Center' is on the right. The terrain is color-coded by elevation, with blue representing lower elevations and green/yellow representing higher elevations. The bathymetric overlay shows underwater topography in shades of blue and purple.

KML/KMZ Export Options

KML/KMZ Options | Gidding | Export Bounds |

☐ All Loaded Data

☐ All Data Visible On Screen:

☒ Lat/Lon (Degrees)

North: West

South: East

☐ Global Projection (Geographic: Latitude/Longitude) - arc

North: West

South: East

☐ Corner w/ Size - Global Projection (Geographic: Latitude/Longitude)

North: West

Width: Height:

☐ MGRS (Military Grid Reference System) Bounds

Top Left: Bottom Right:

☐ Crops to Selected Area Feature(s)

OK Cancel Help

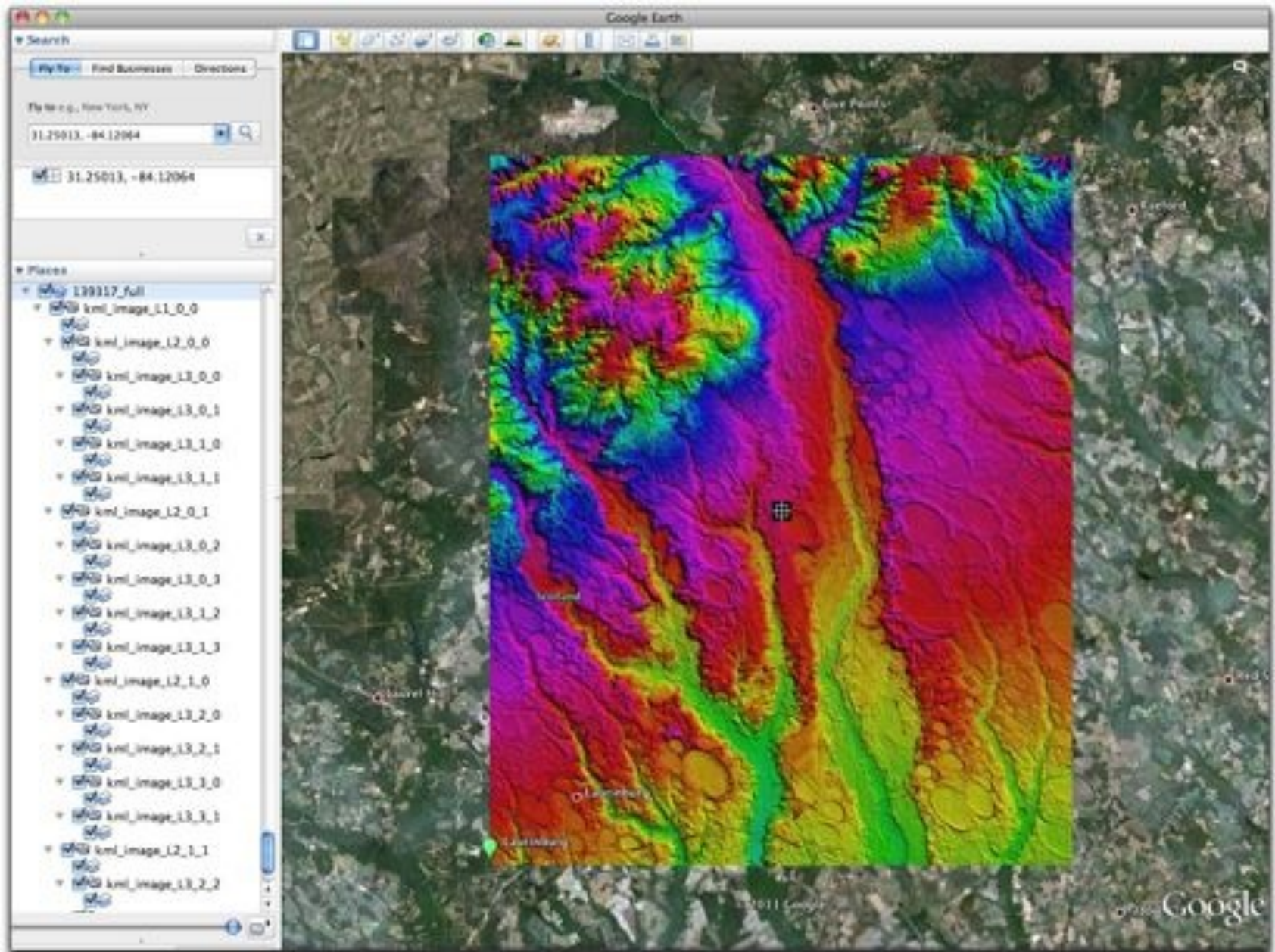
Overlay Control Center

Currently Opened Overlays (Flight Deck)

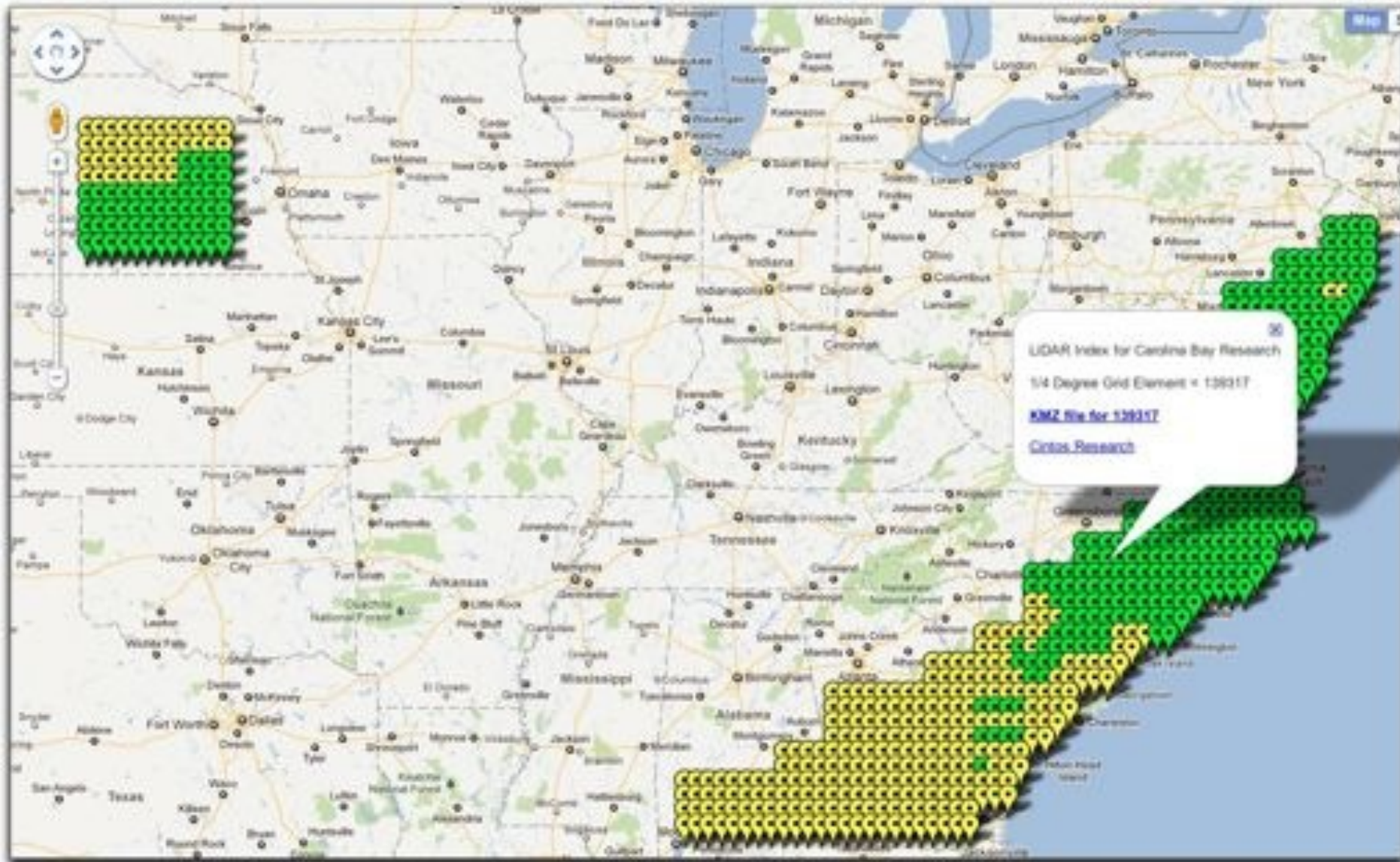
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Metadata... Options...

LiDAR Tile Set Integration with Google Earth



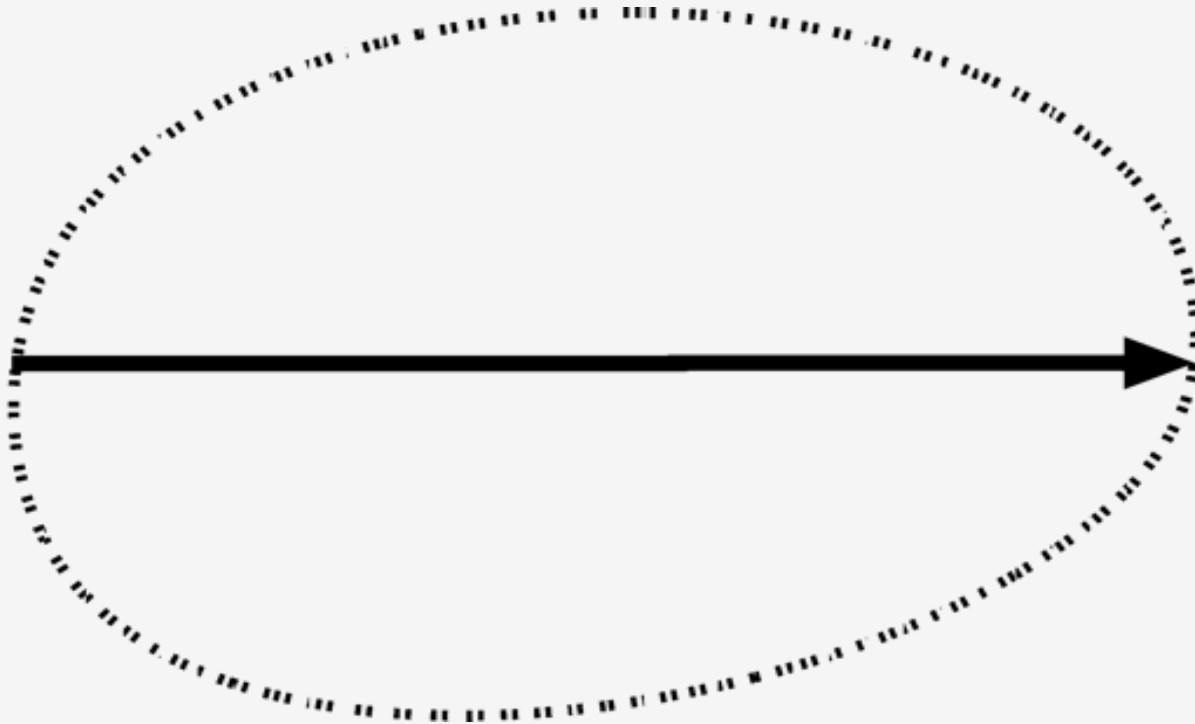
Index Map Of $\frac{1}{4}^\circ$ Octant Grid Geodetic Coding System



Green Placemark = 1/9 arc-sec LiDAR data

Criteria for Identification as a Carolina Bay

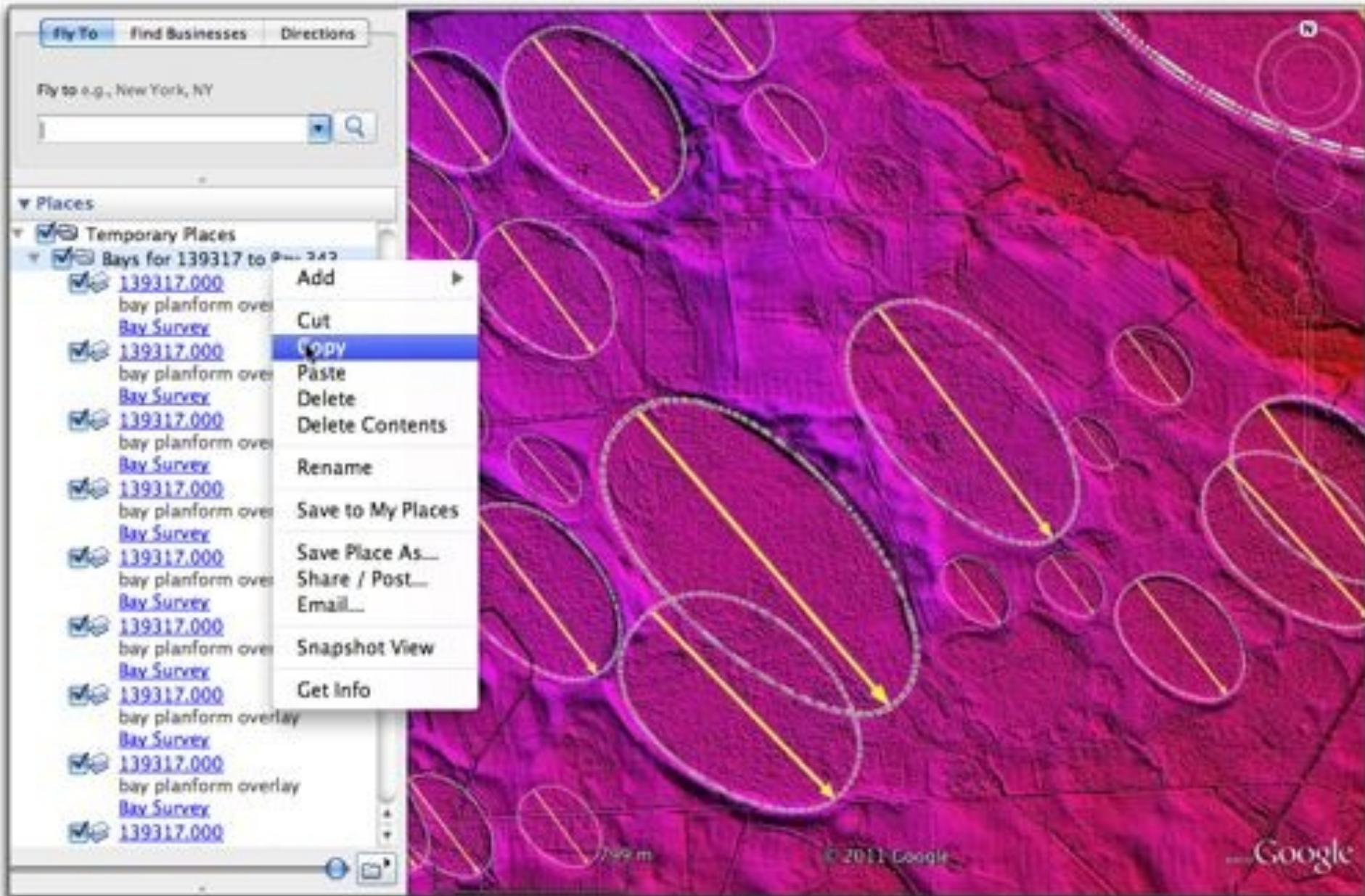
- Found Amongst Collection Of Similar Landforms
- Exhibit A Closed Circumferal Rim
- Satellite Imagery Supported By LiDAR/DEM As A Basin
- Planform Fits Archetype For Locale



Planform – New Image Overlay



Copy Overlays from DOM as Text



KML Meta Data in Overlay

- `<GroundOverlay>`
- `<name>New_Bay</name>`
- `<Icon>`
- `<href>http://cintos.org/bay_prototype.png</href>`
- `</Icon>`
- `<LatLonBox>`
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- `</GroundOverlay>`

Loading Fusion Table

Google fusion tables

Boys

Online

File

View

Edit

Visualize

Merge

Current view: All

Show all data

1 - 100 of 25804 total

Name	Orbit	Location	Latitude	Longitude	Major	Minor	Eccentricity	Area	Bearing	Elevation	Platform	effectiveDiameter
138015_0001	138015	34.75187298054756,-78.87822171824776	34.75187	-78.87822	0.19	0.13	0.729284991	2.14	140.28	42.74	bay_prototype	165.38744
138015_0002	138015	34.75133078881295,-78.883724480721037	34.75133	-78.88372	0.3	0.19	0.773879118	4.58	140.28	42.54	bay_prototype	241.4834
138015_0003	138015	34.750051349333375,-78.89215875049278	34.75005	-78.89215	0.16	0.12	0.681407928	1.88	140.28	42.74	bay_prototype	165.38744
138015_0004	138015											
138015_0071	138015											
138015_0086	138015											
138015_0087	138015											
138015_0101	138015											
138015_0230	138015											
138015_0236	138015											
138015_0262	138015											
138015_0269	138015											
138015_0280	138015											
138015_0336	138015											
138015_0363	138015											
138015_0375	138015											
138015_0379	138015											
138015_0380	138015											
138015_0382	138015											
138015_0384	138015											
138015_0386	138015											
138015_0430	138015											

Import more rows into Boys

Existing columns

	Name	Orbit	Location	Latitude	Longitude	Major	Minor	Eccentricity	Area	Bearing	Elevation	Platform	effectiveDiameter
1	138015_0001	138015	34.75187298054756,-78.87822171824776	34.75187	-78.87822	0.19	0.13	0.729284991	2.14	140.28	42.74	bay_prototype	165.38744
2	138015_0002	138015	34.75133078881295,-78.883724480721037	34.75133	-78.88372	0.3	0.19	0.773879118	4.58	140.28	42.54	bay_prototype	241.4834

Select matching columns in new file

	Name	Orbit	Location	Latitude	Longitude	Major	Minor	Eccentricity	Area	Bearing	Elevation	Platform
1	138026_0010	138026	32.50241958430875,-81.52558568543932	32.50241	-81.52558	0.23	0.2	0.945	3.76	150.68	37.72	bay_south_prototype
2	138026_0104	138026	32.5094448162284,-81.51024428394058	32.50944	-81.51024	0.36	0.25	0.765	8.06	156.28	38.22	bay_south_prototype

Cancel + Back Finish

Fusion Table KML Network Link

Bays Cintos

File View Edit Visualize Merge

Showing Octant = 130326 [hide options](#)

Filter [Aggregate](#) [Create view](#)

Octant

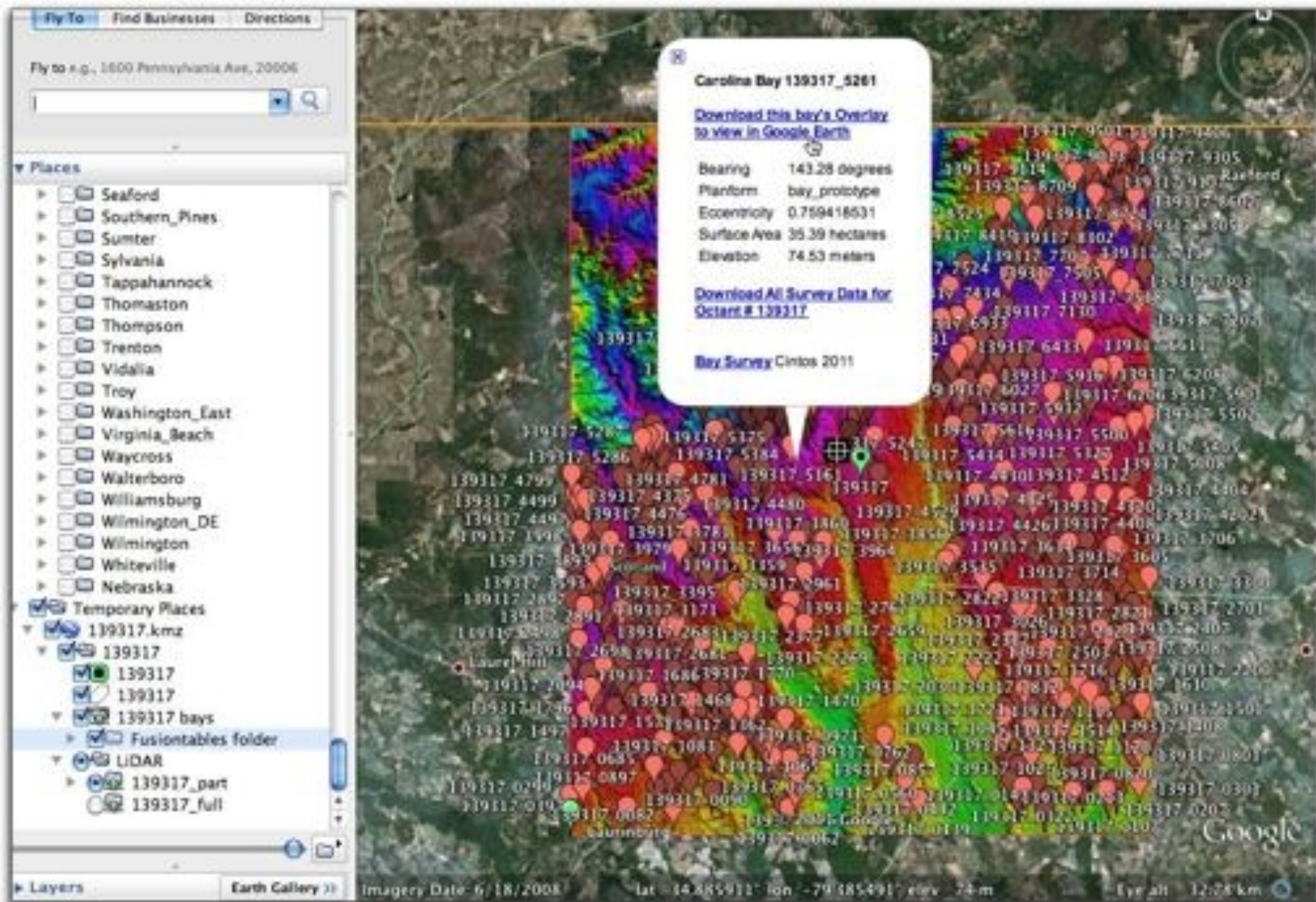
[Add condition](#) ⓘ

Location ☐ Display as heat map [Configure info window](#) [Configure styles](#) [Export to KML](#) [Get KML network link](#) [Get embeddable link](#)

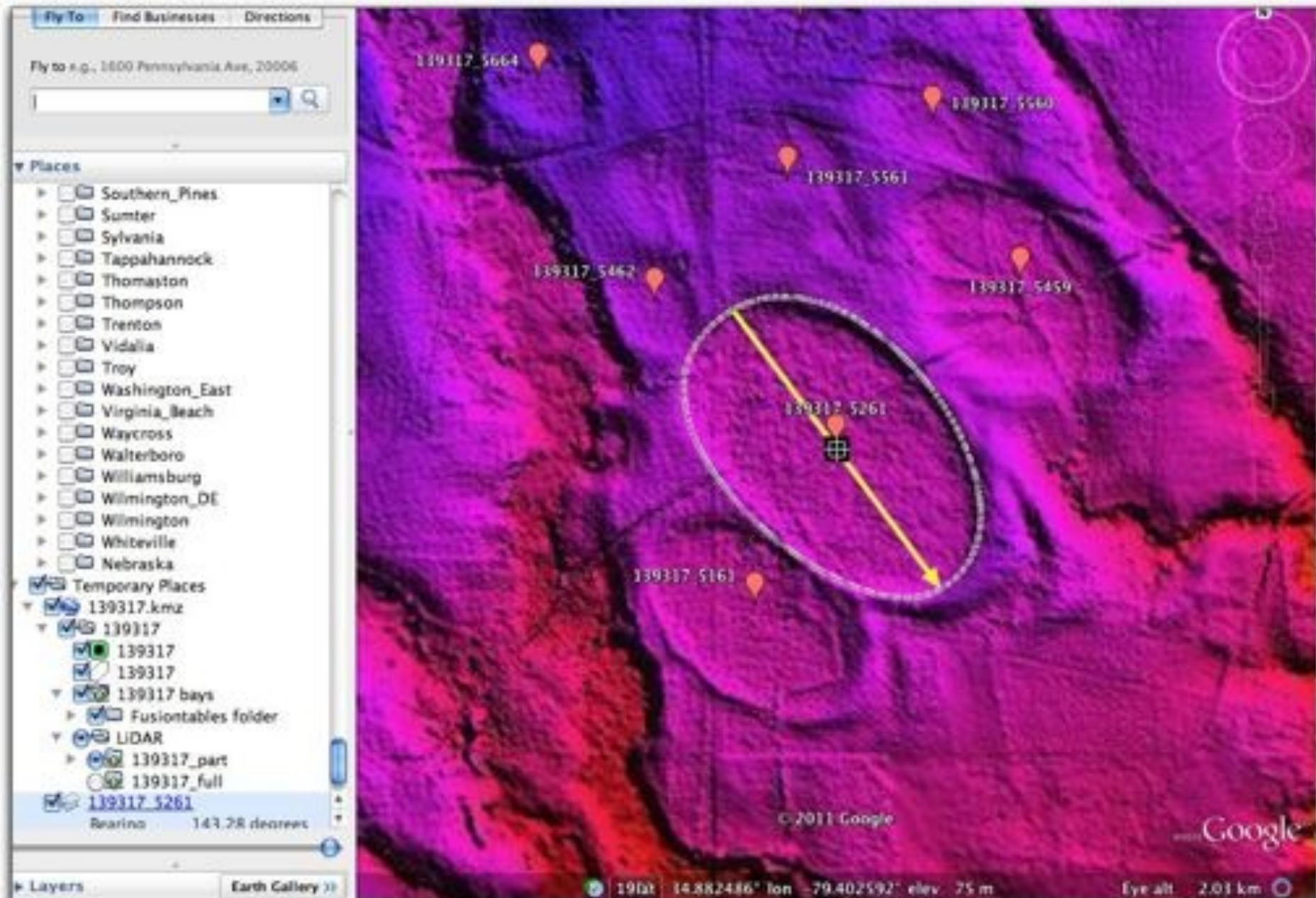
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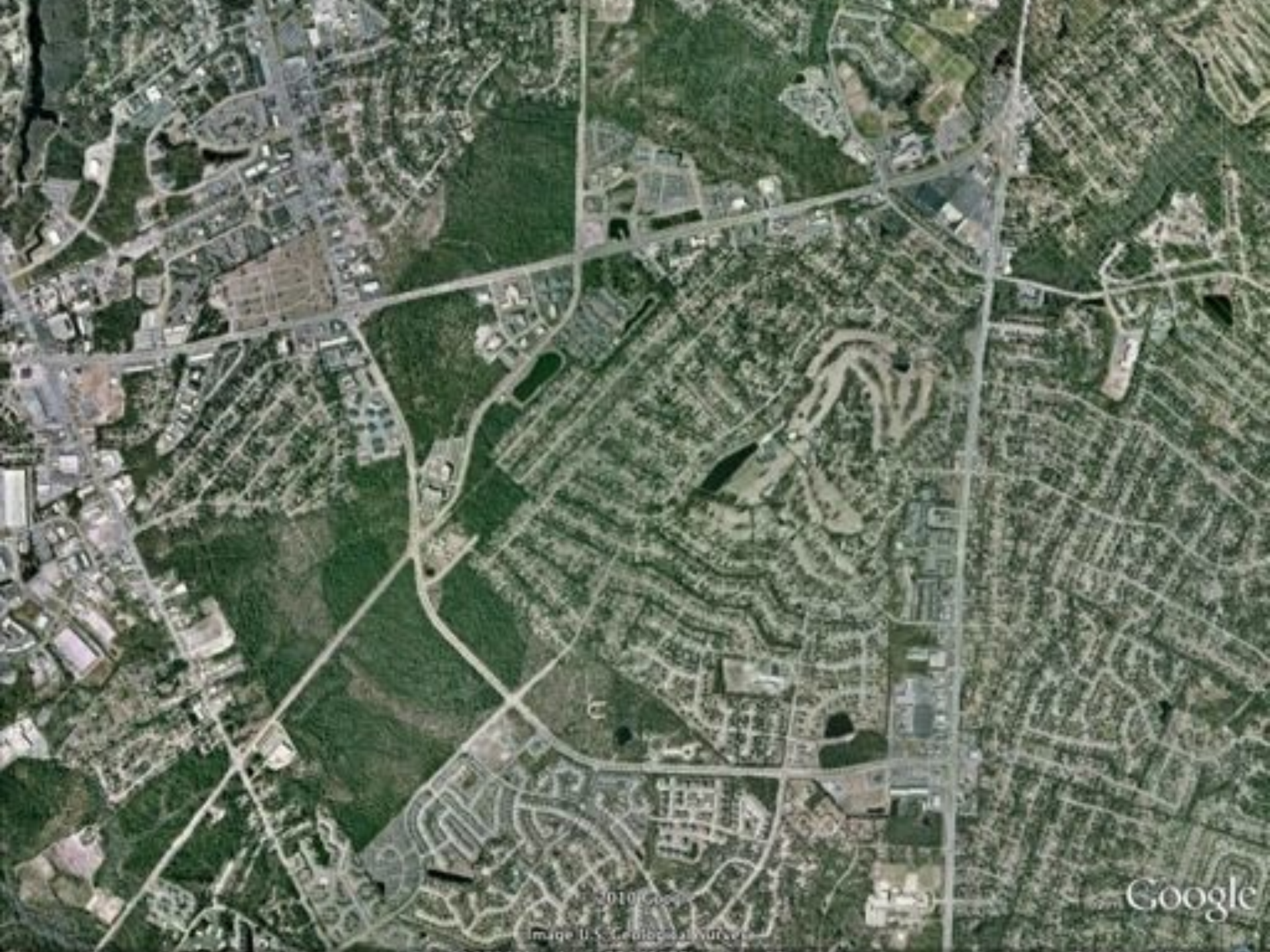


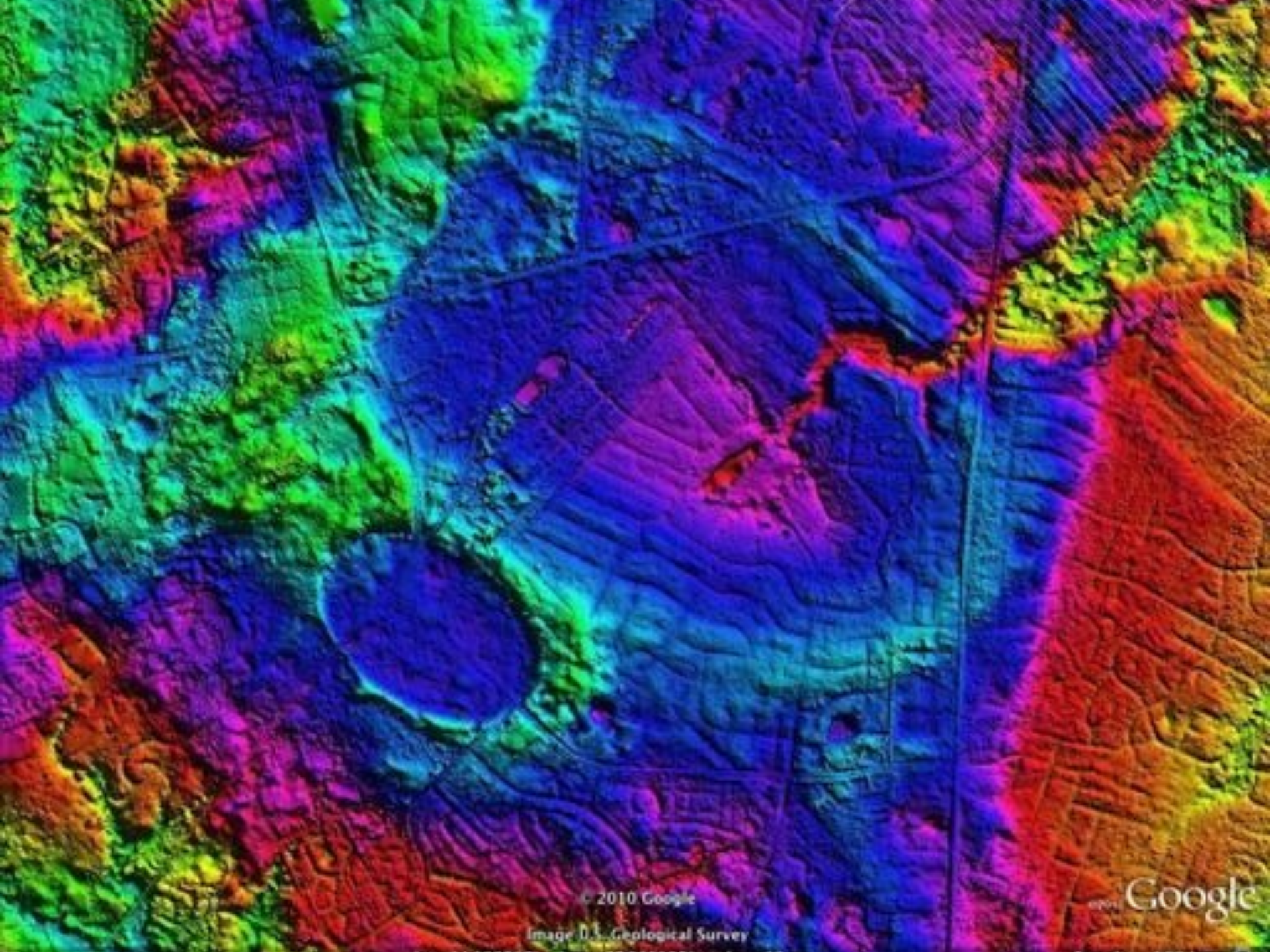
Popup for Bay Placemark



Popup for Bay Placemark





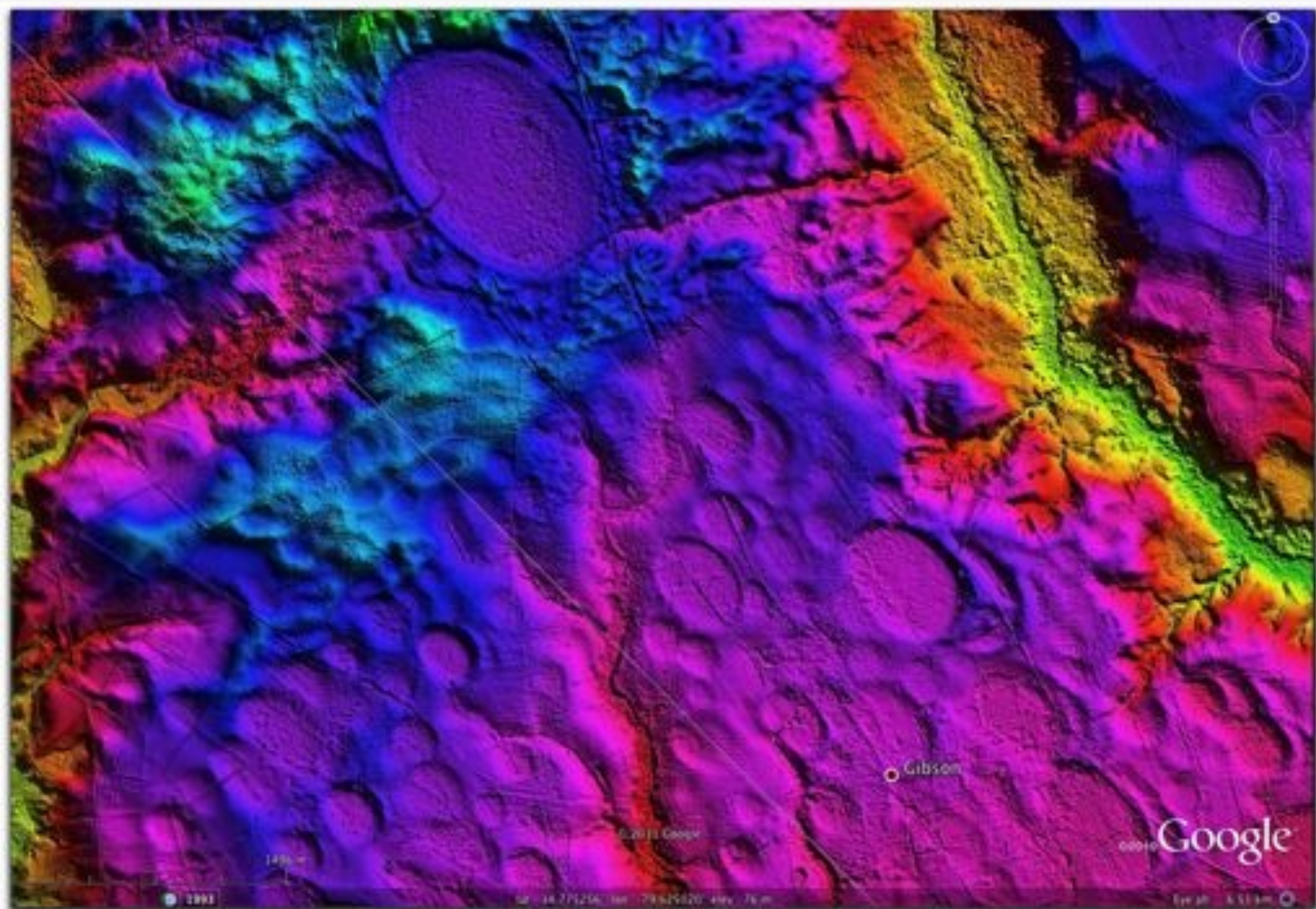


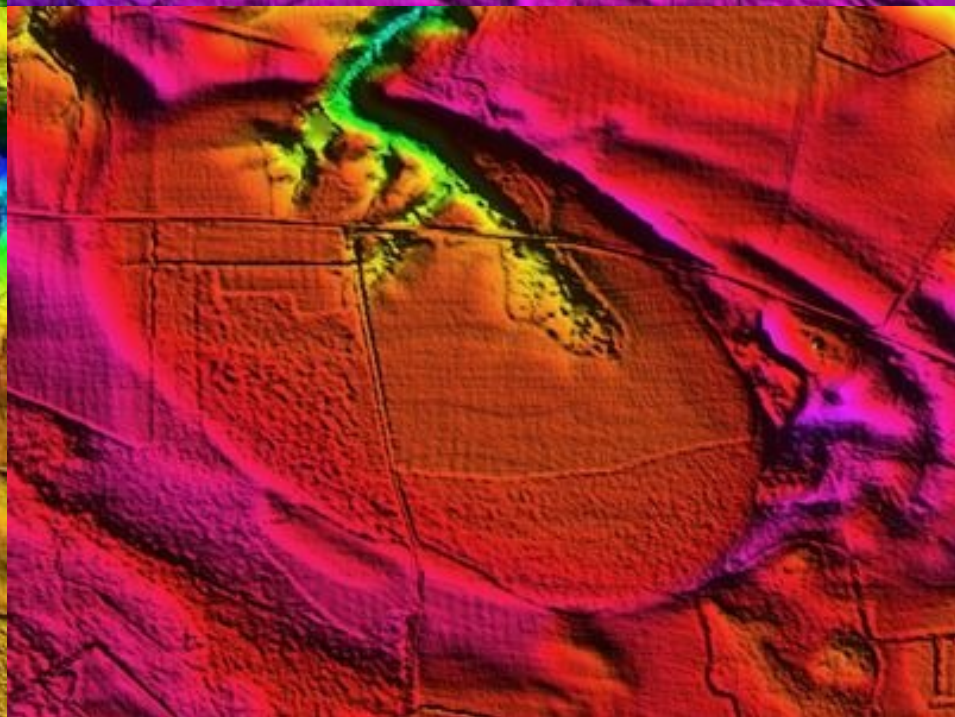
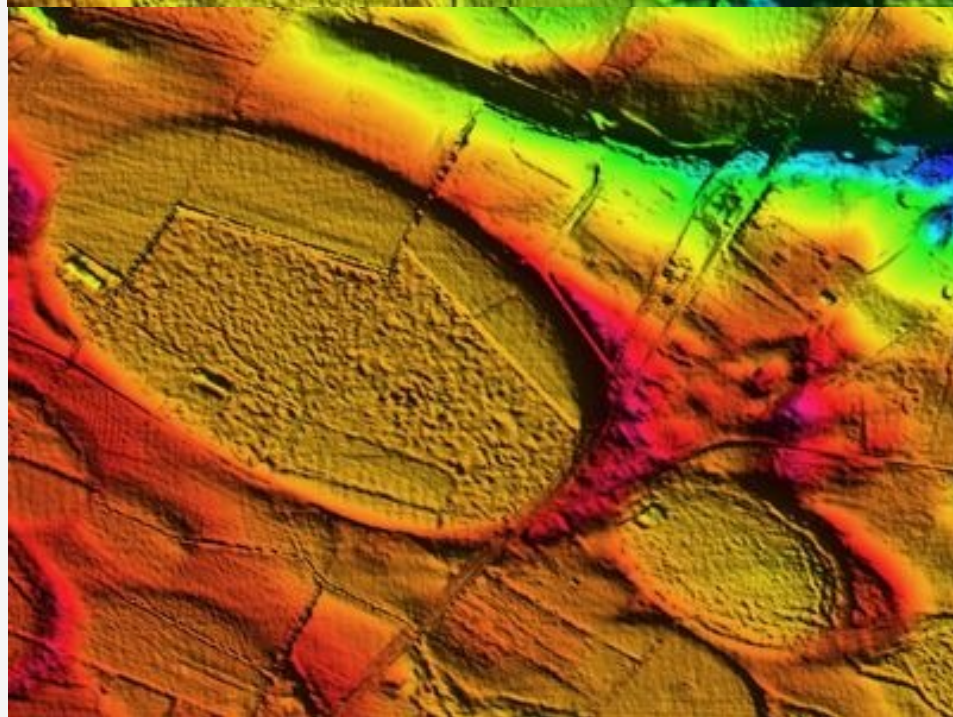
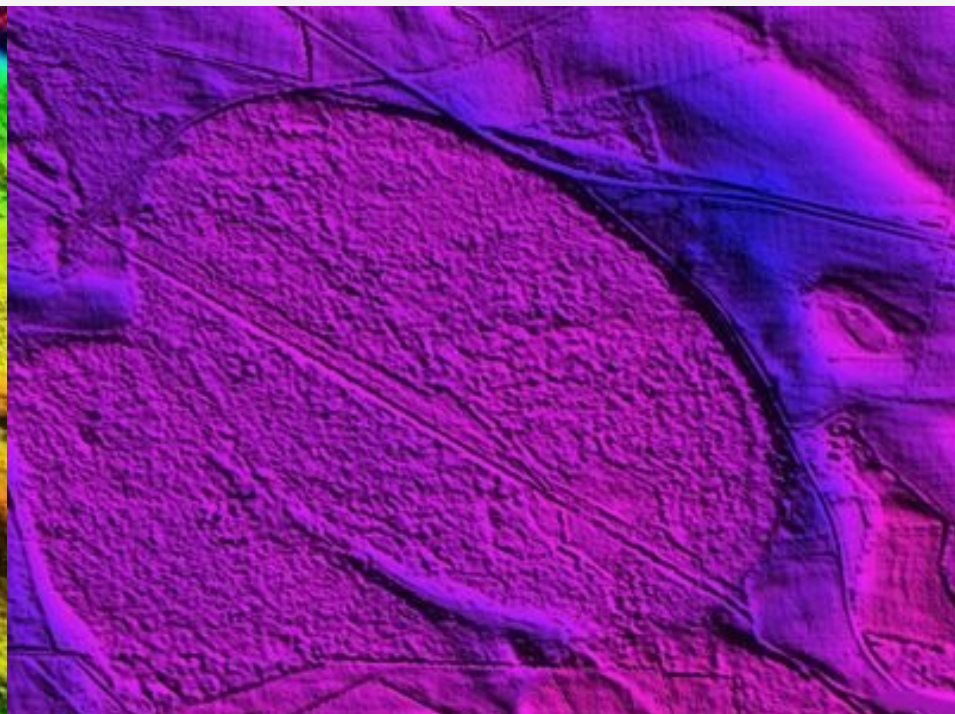
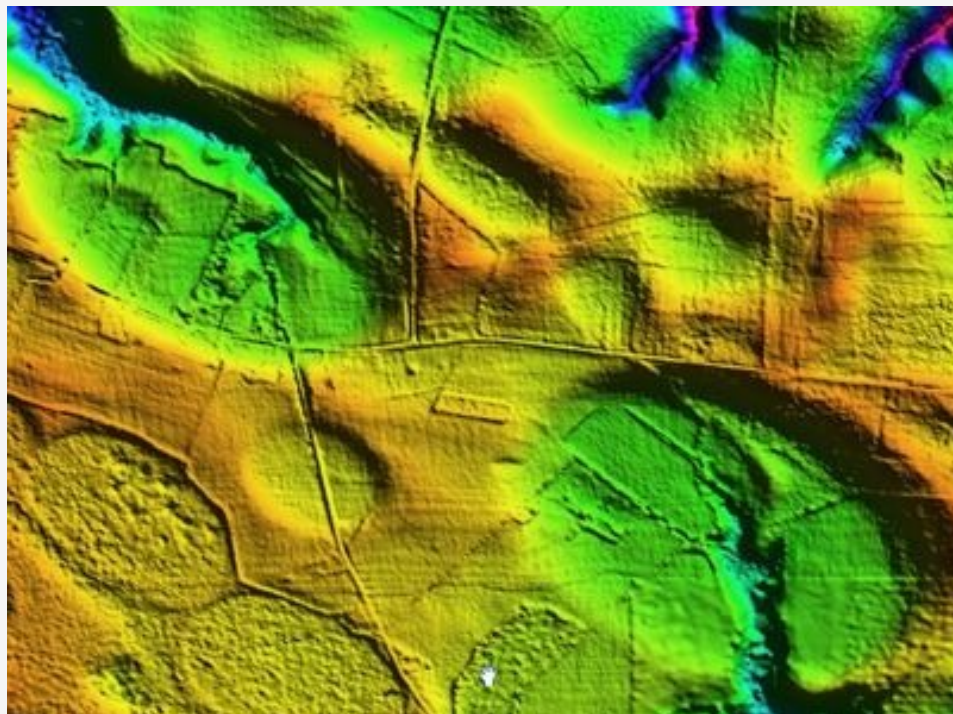
© 2010 Google

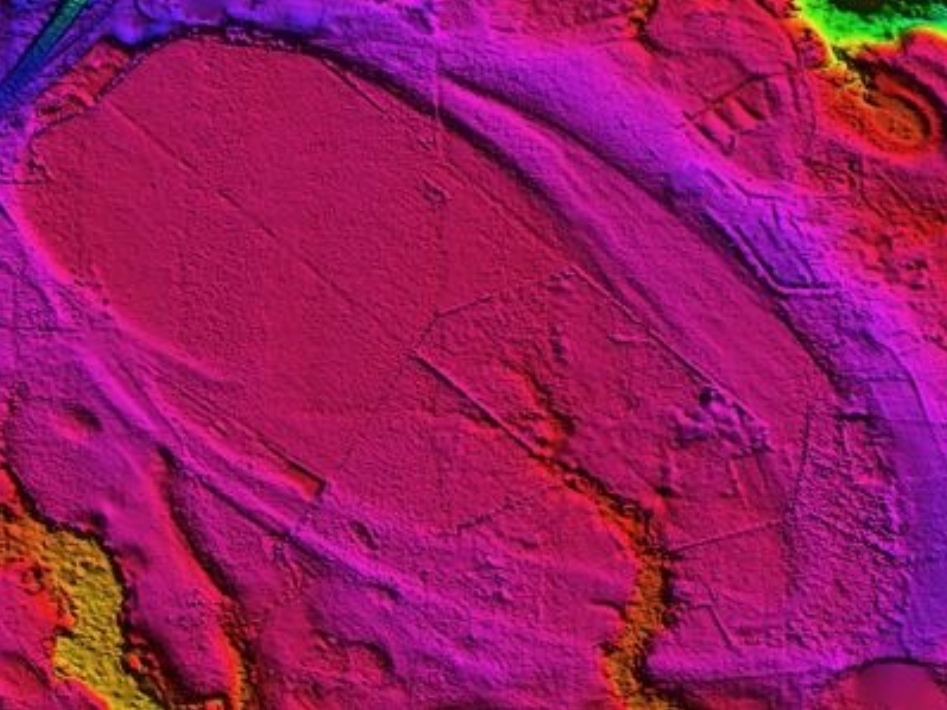
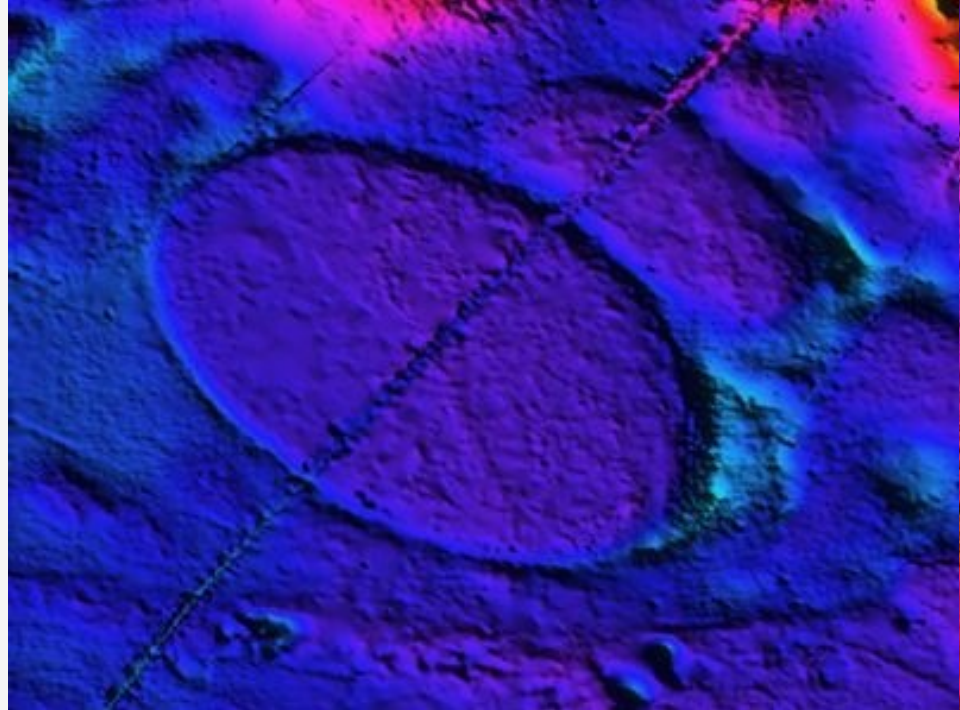
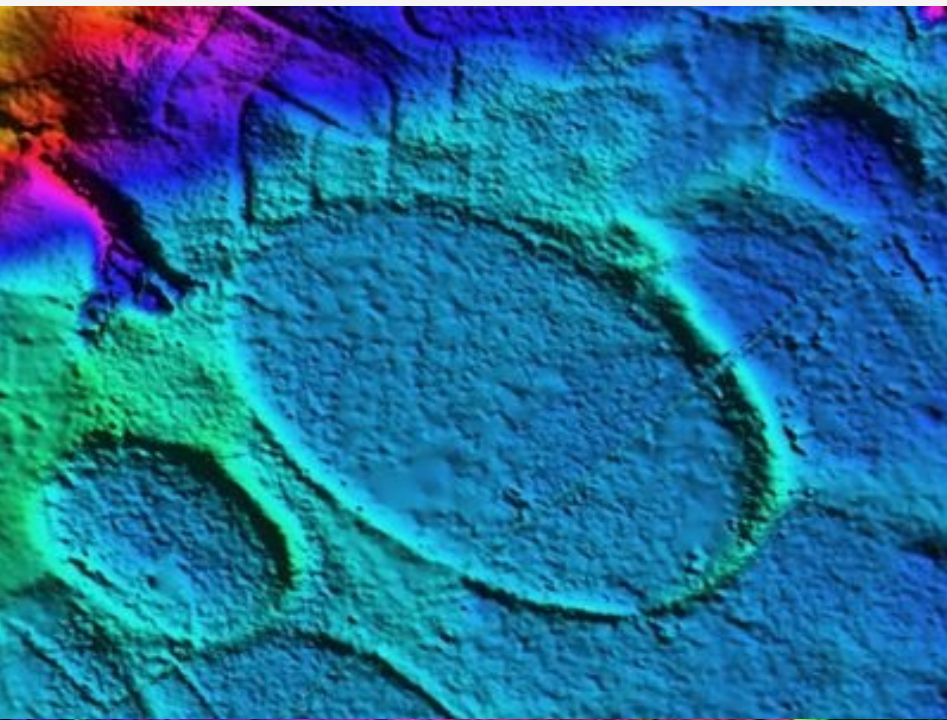
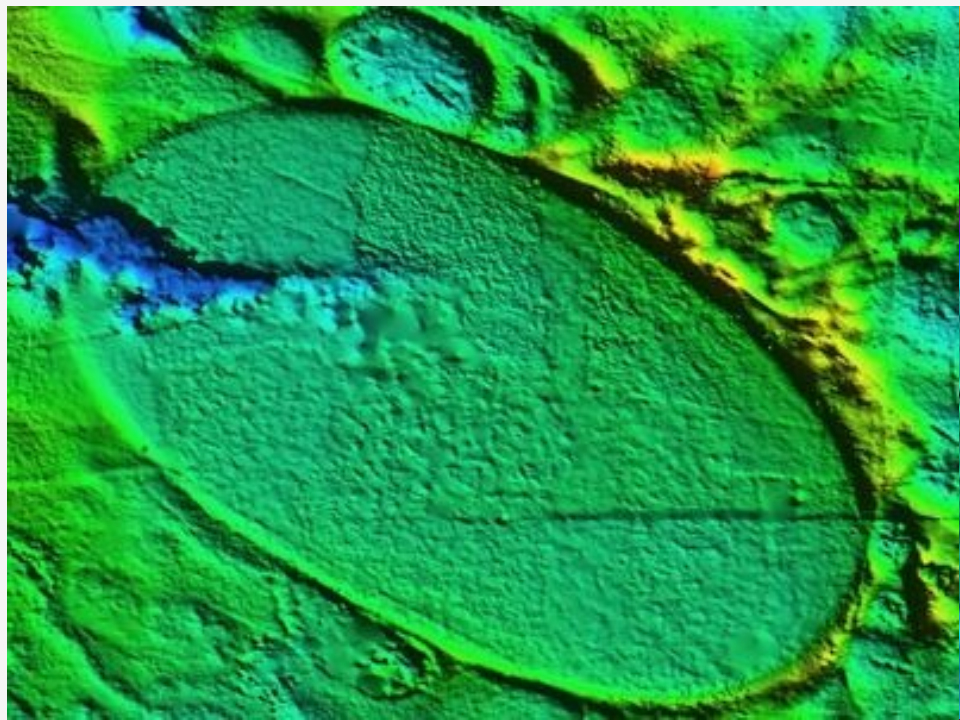
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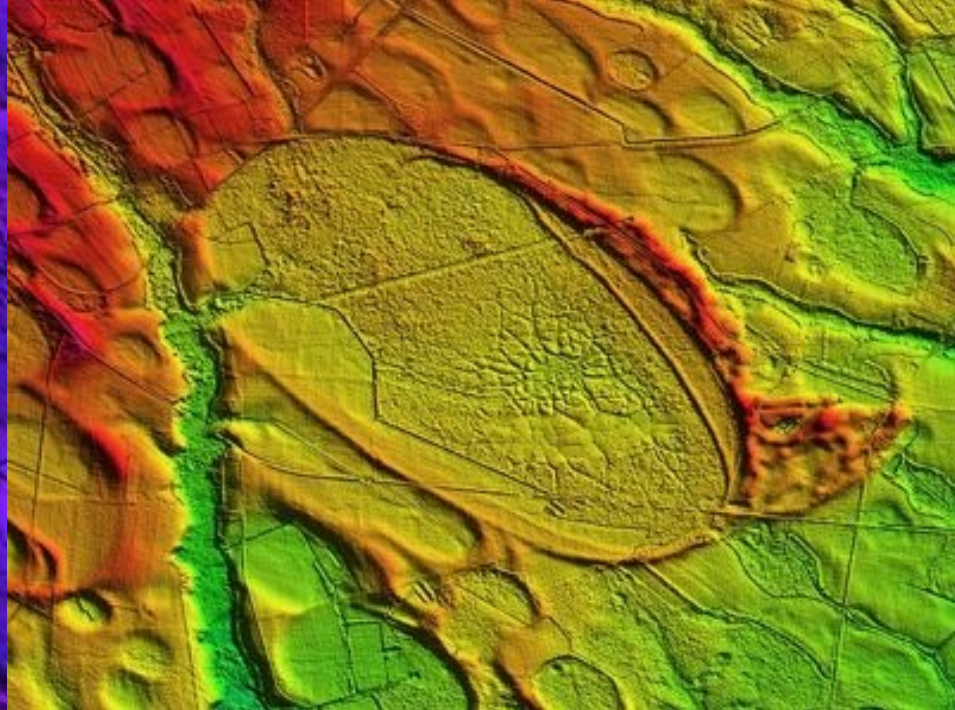
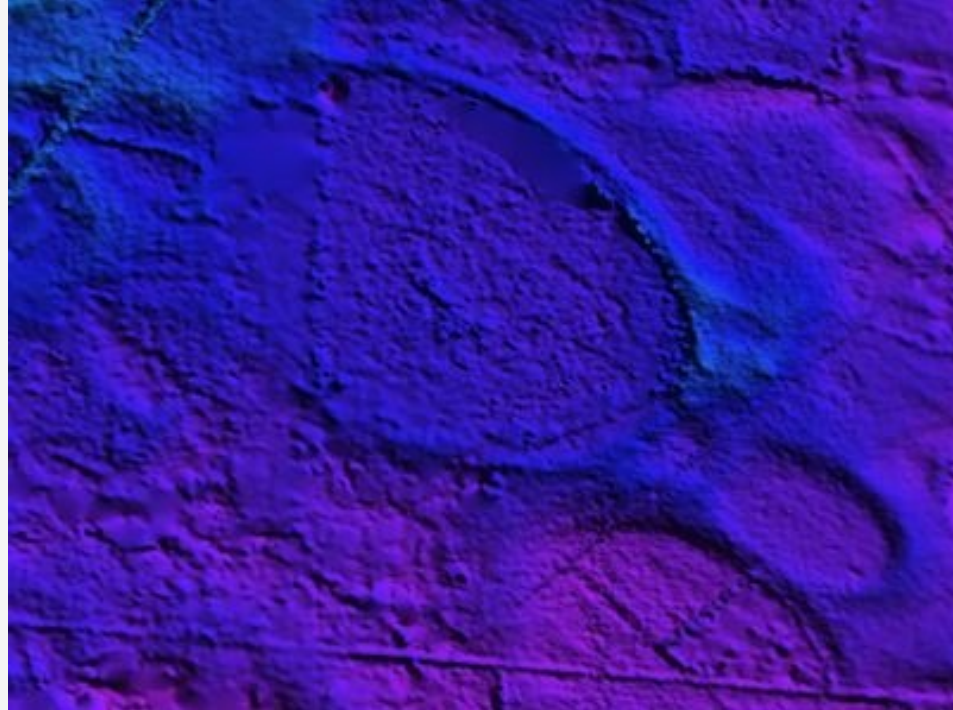
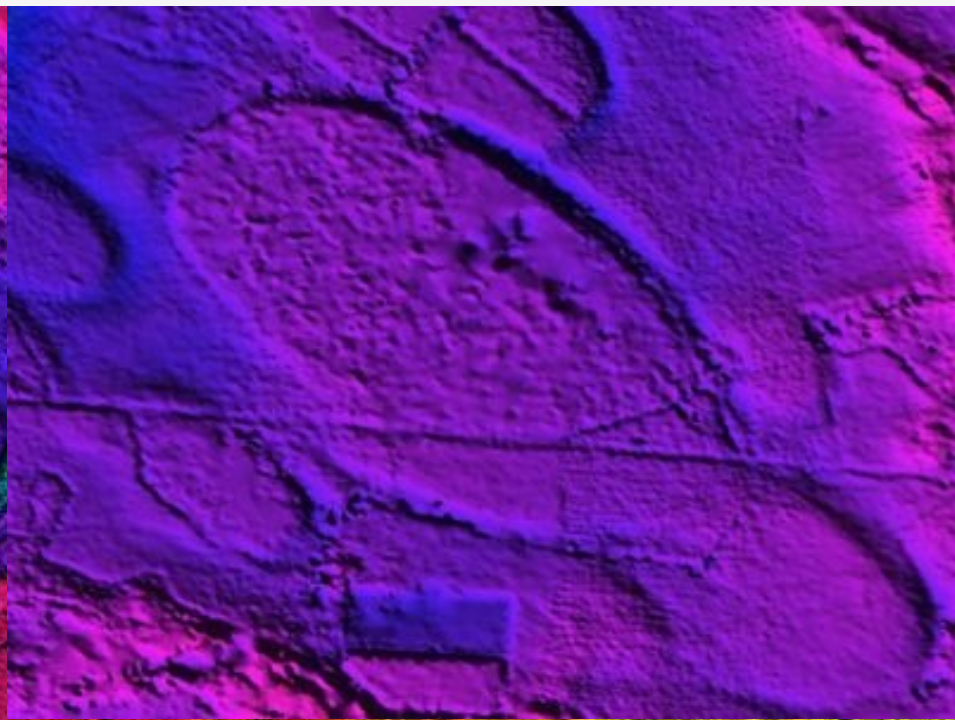
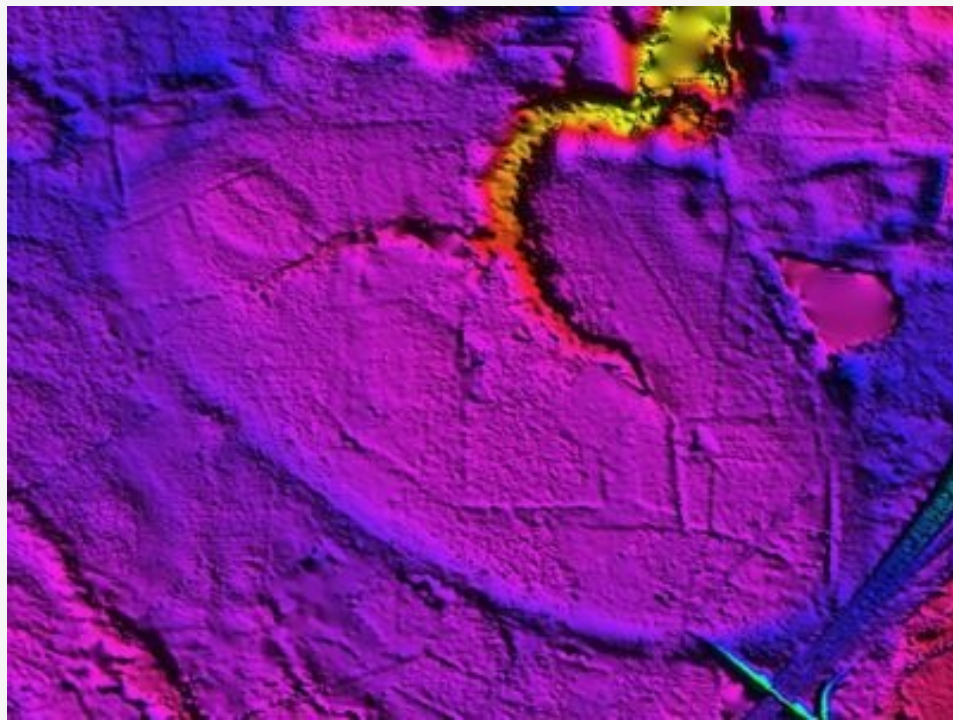
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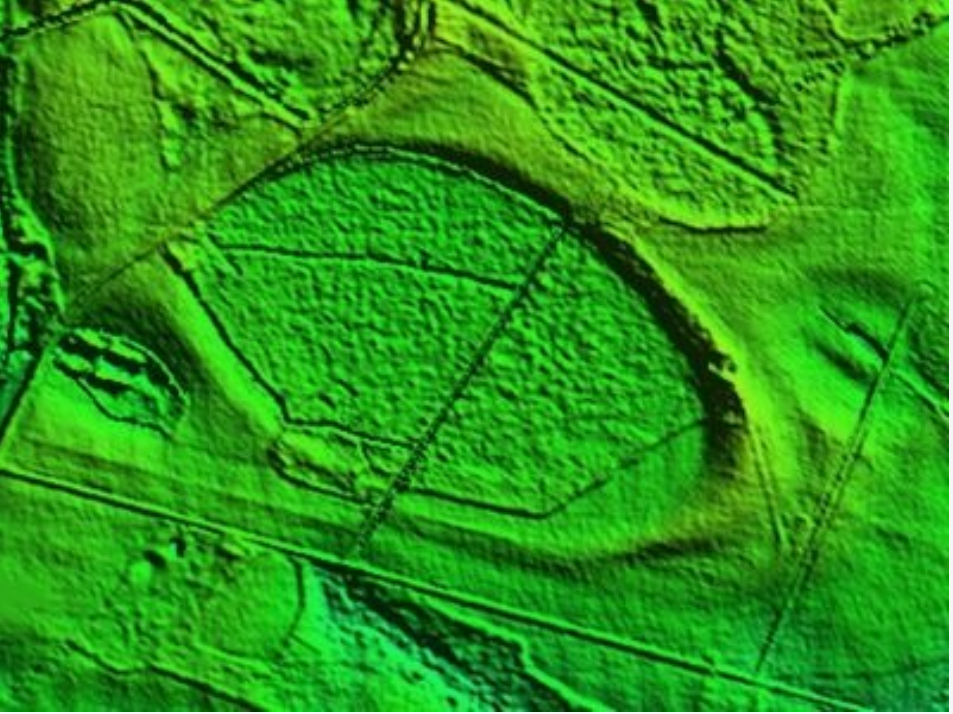
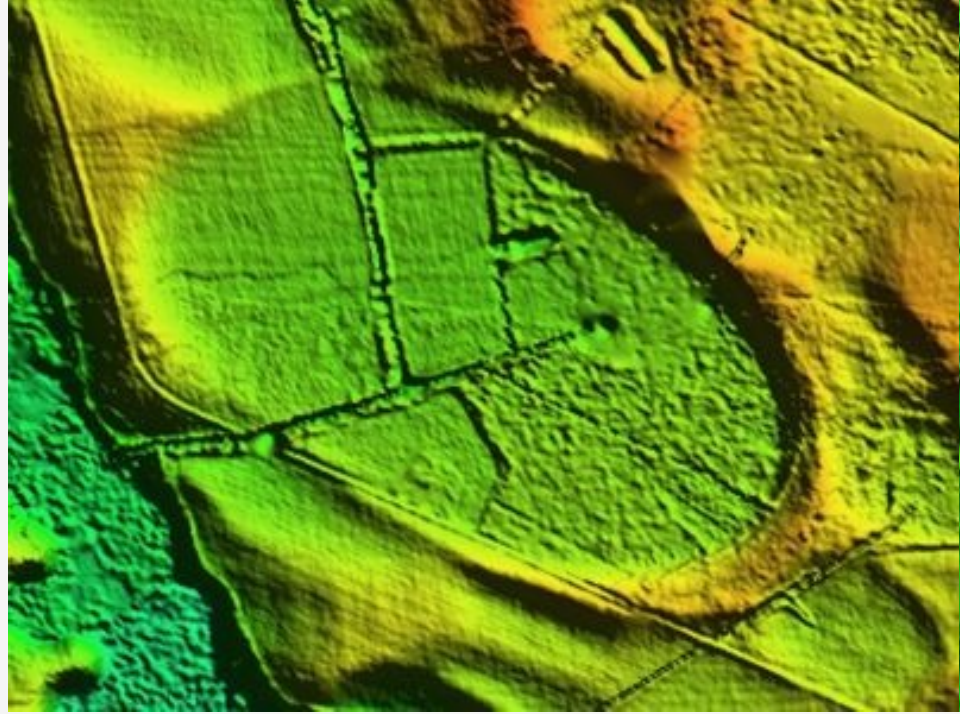
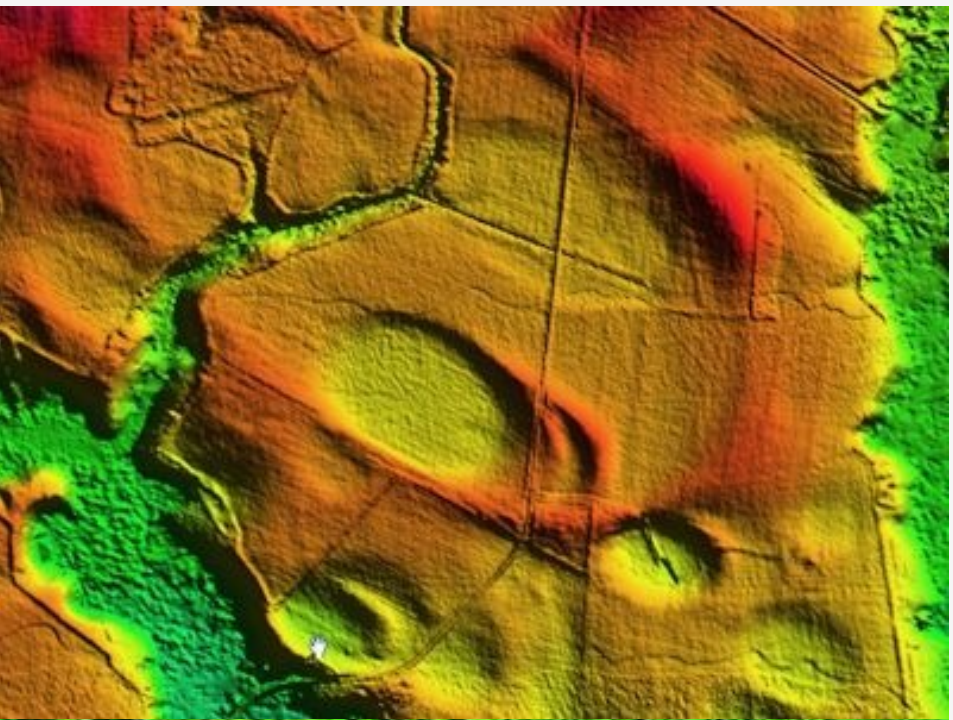
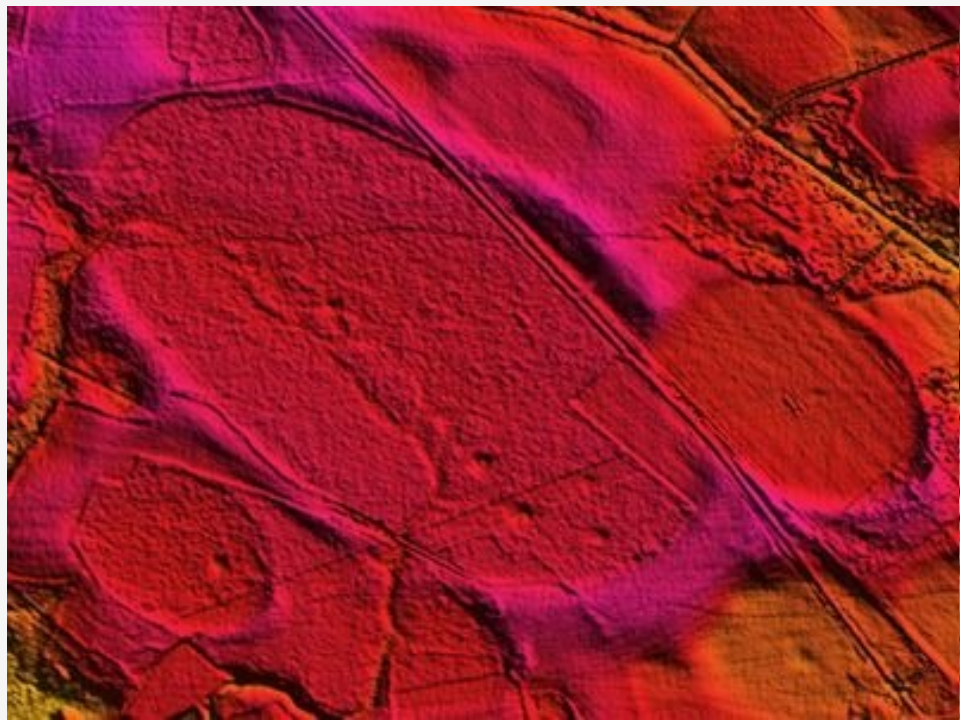


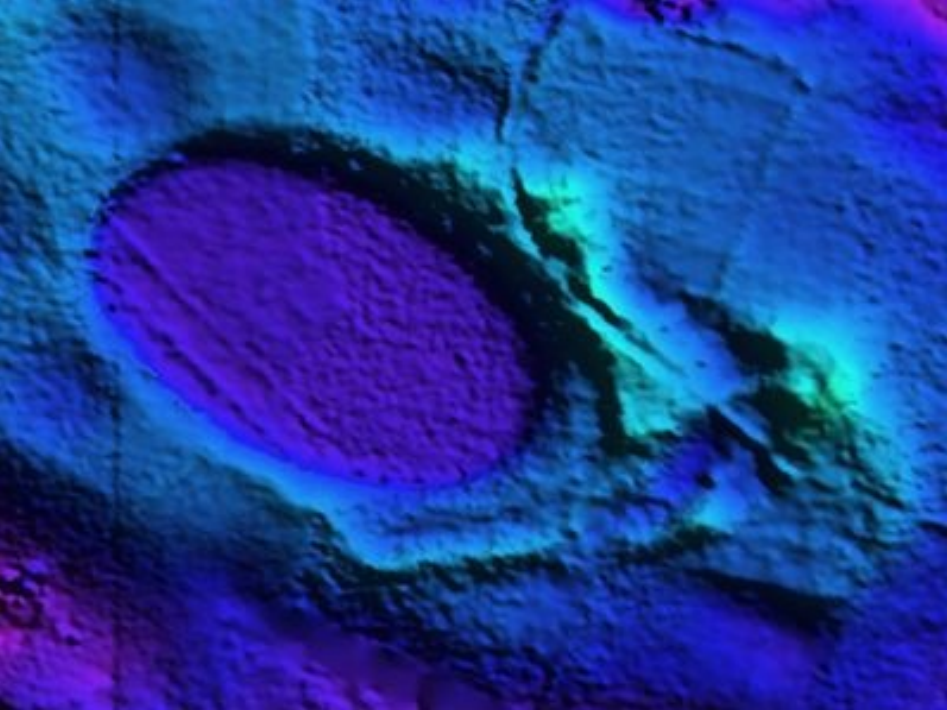
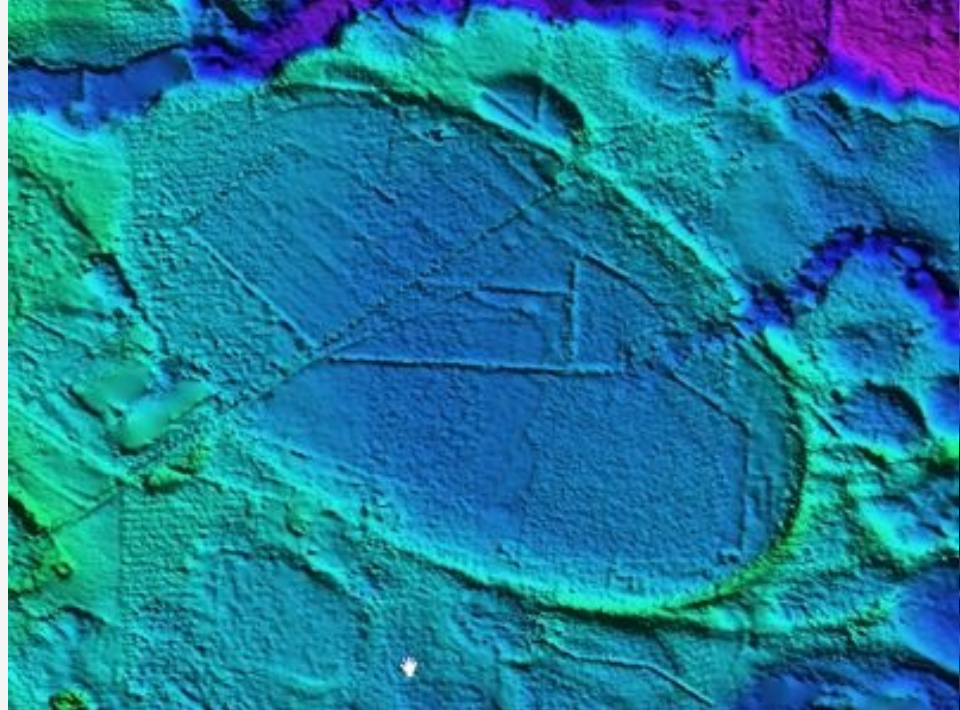
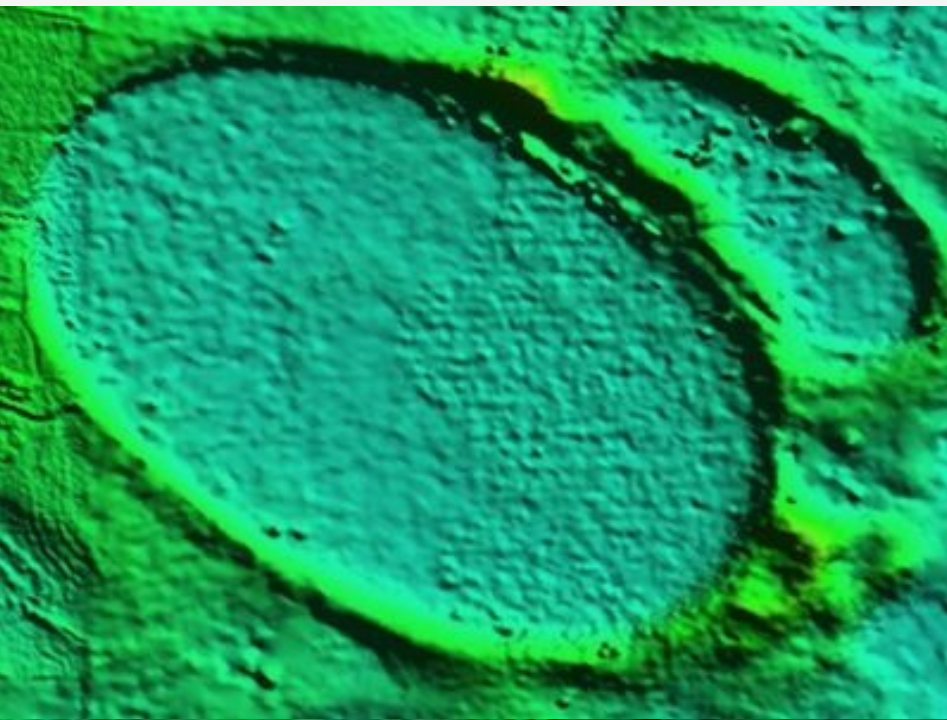
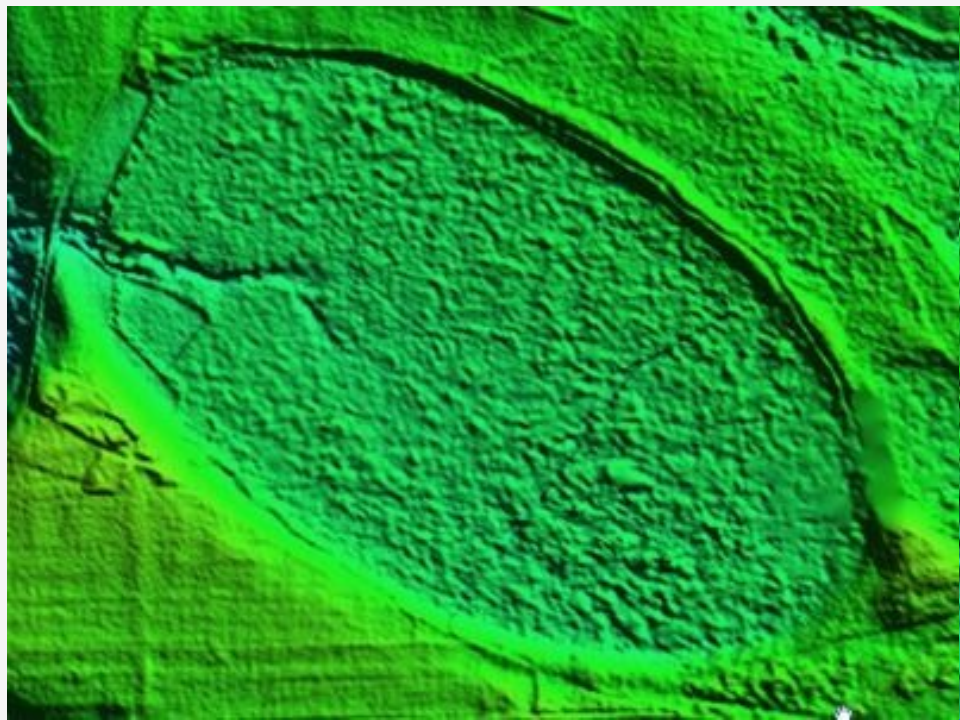


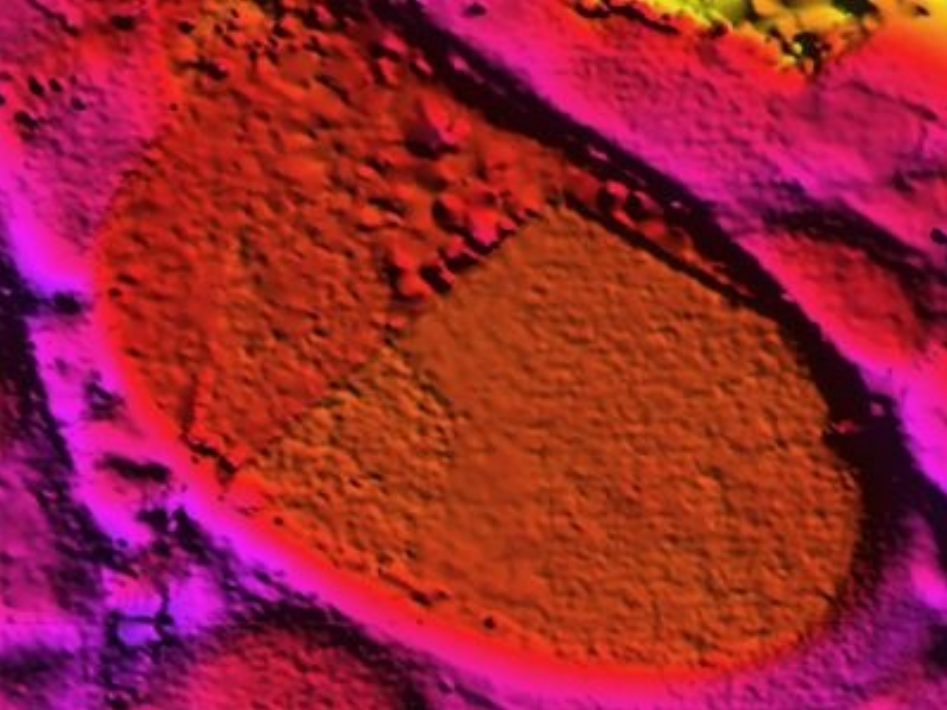
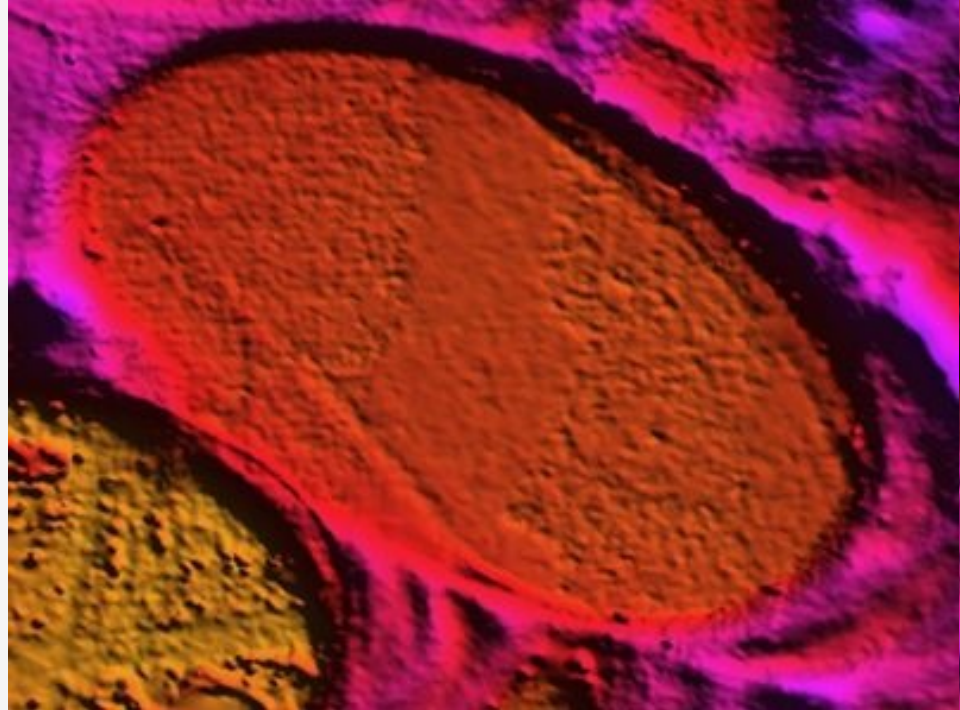
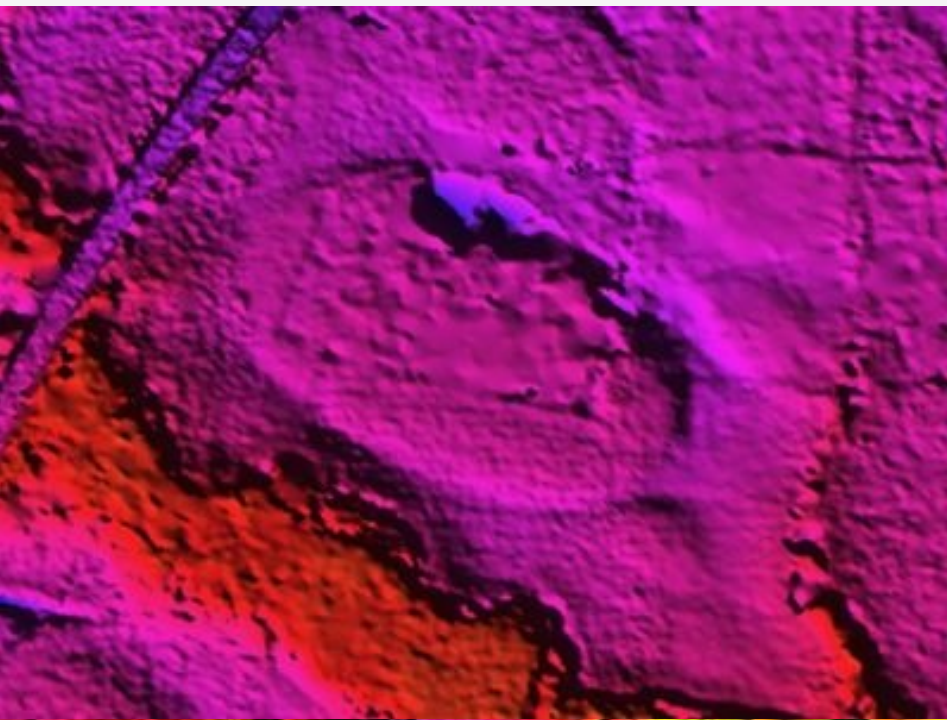
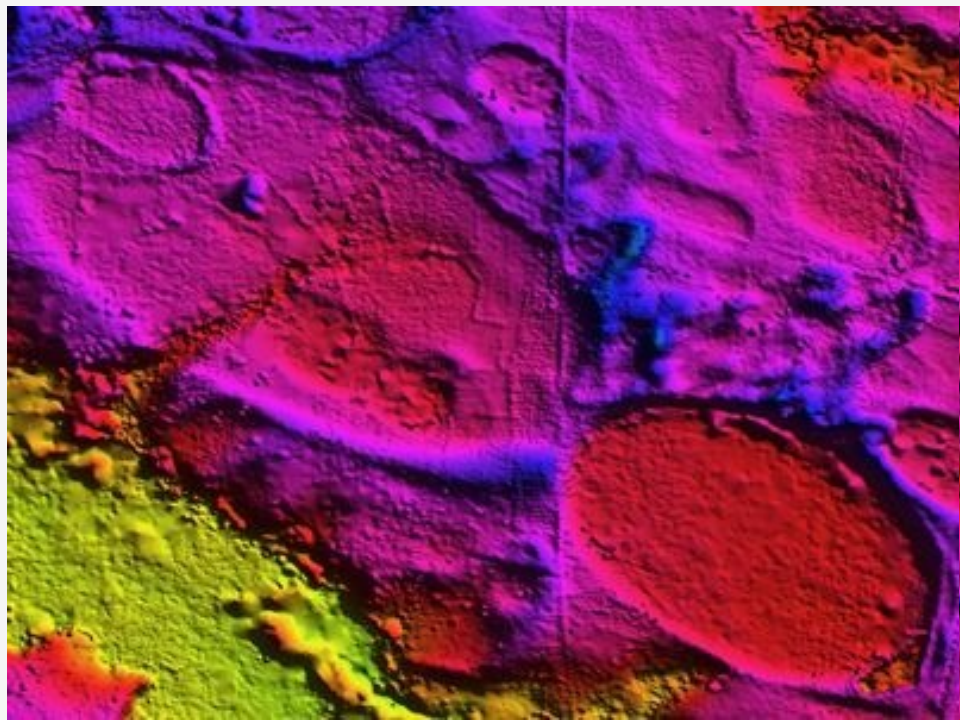


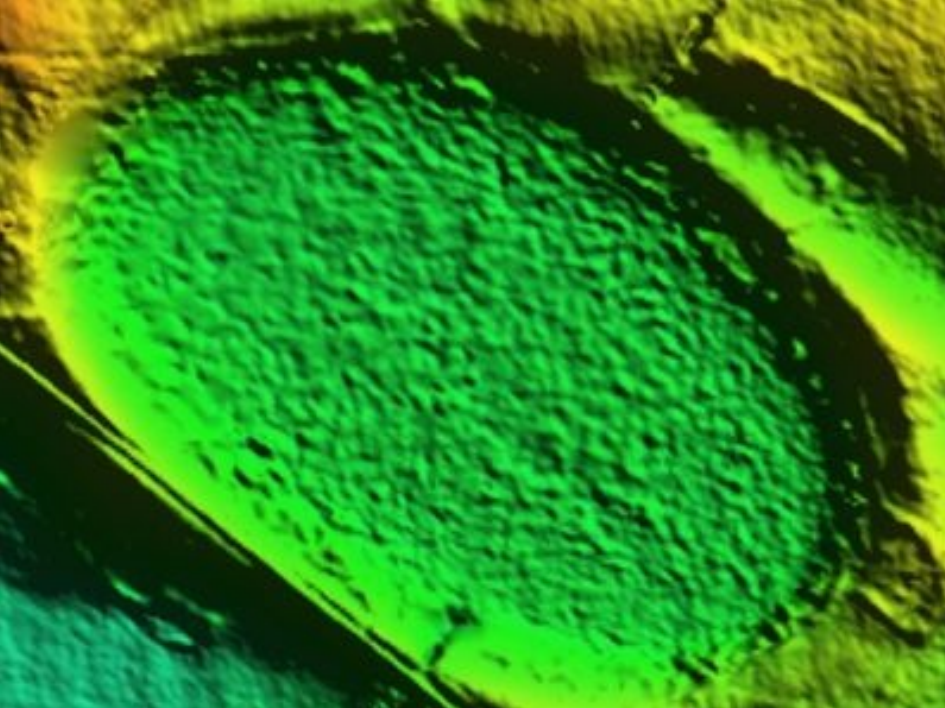
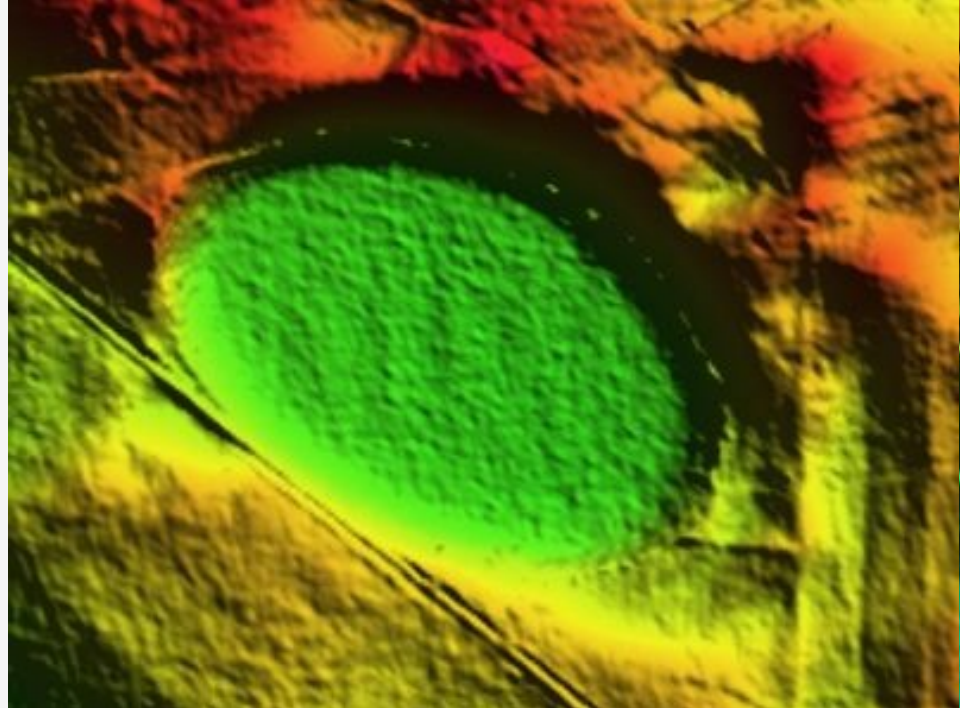
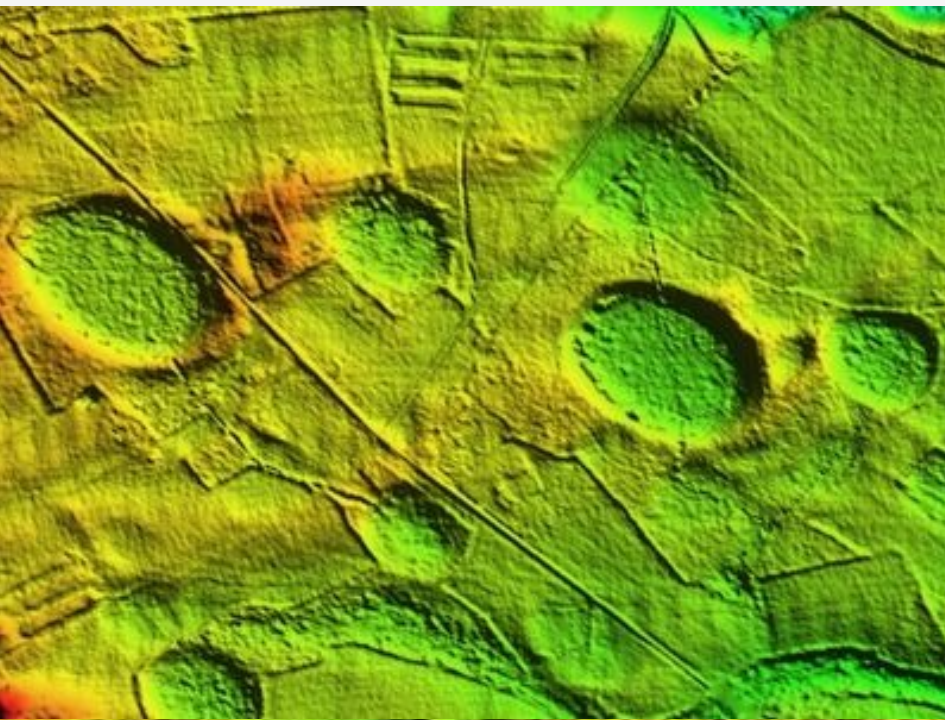
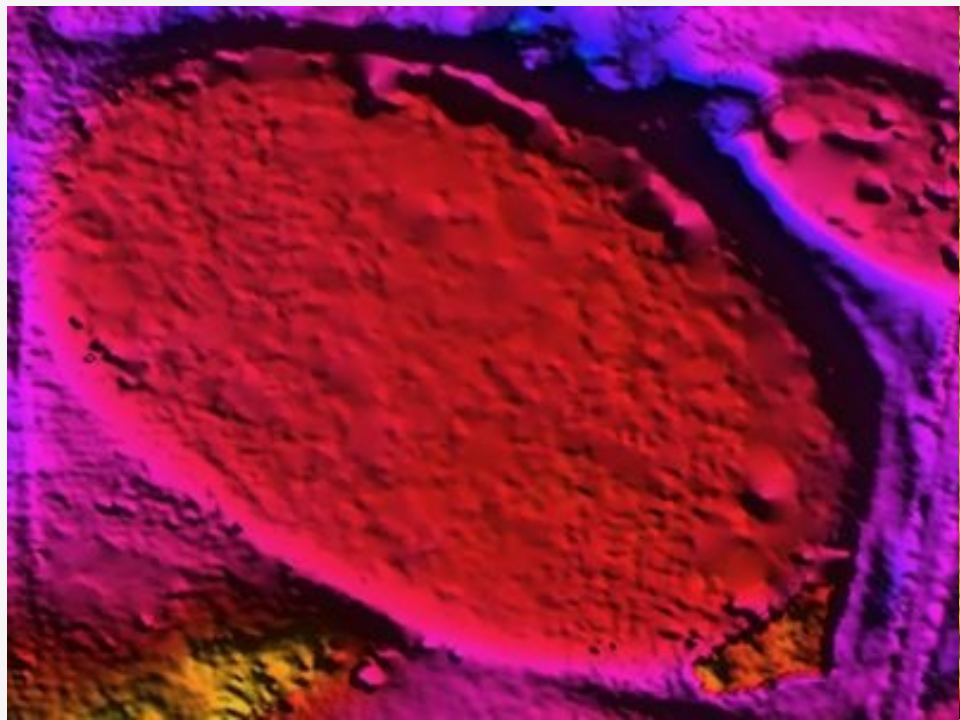


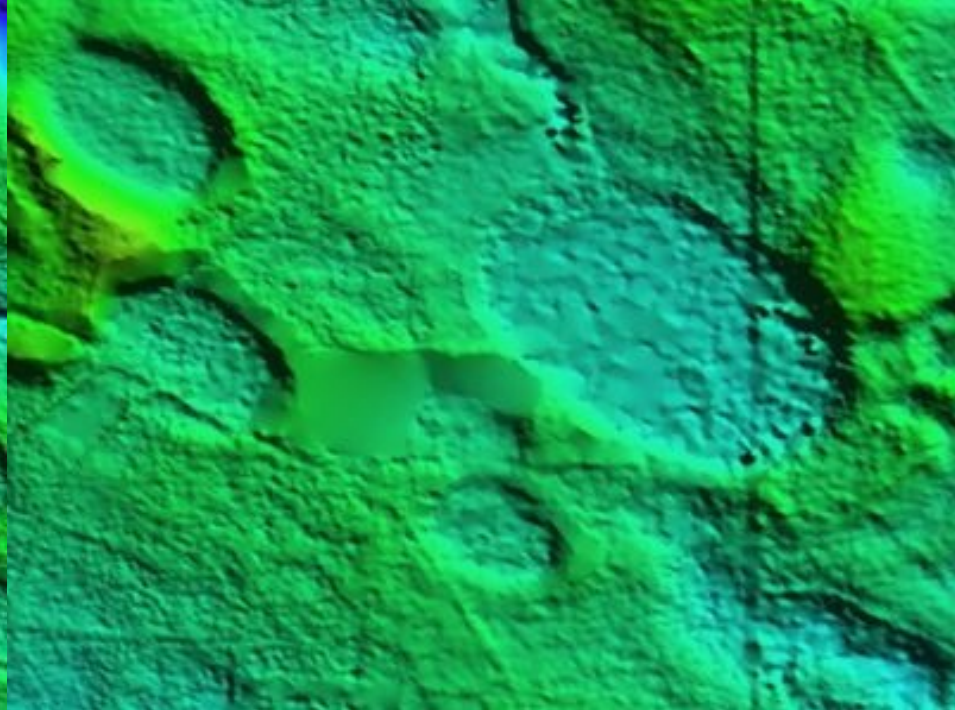
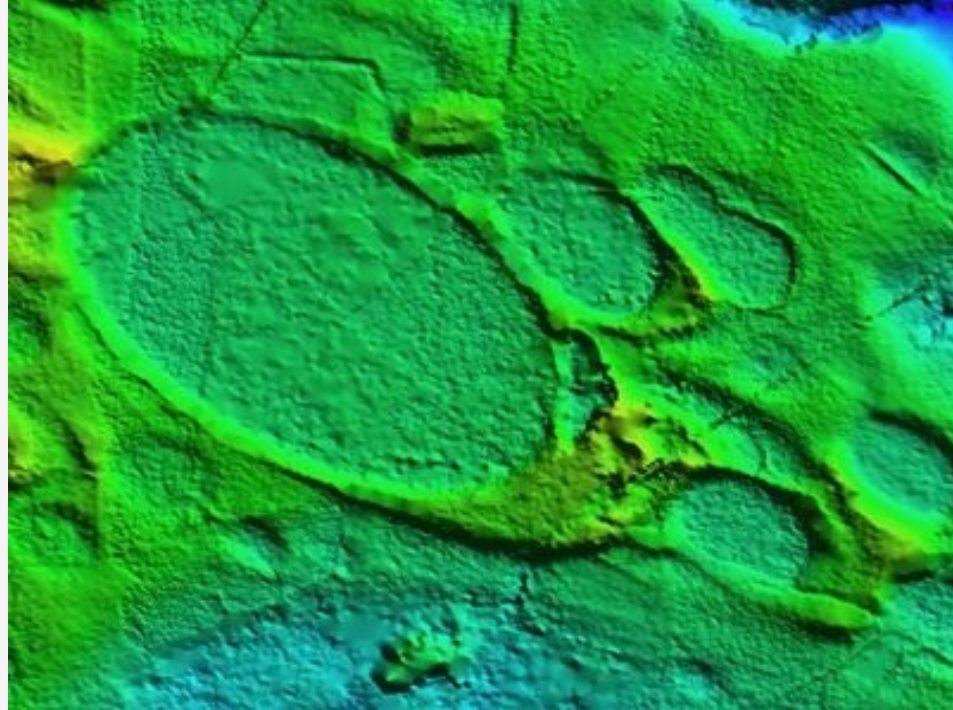
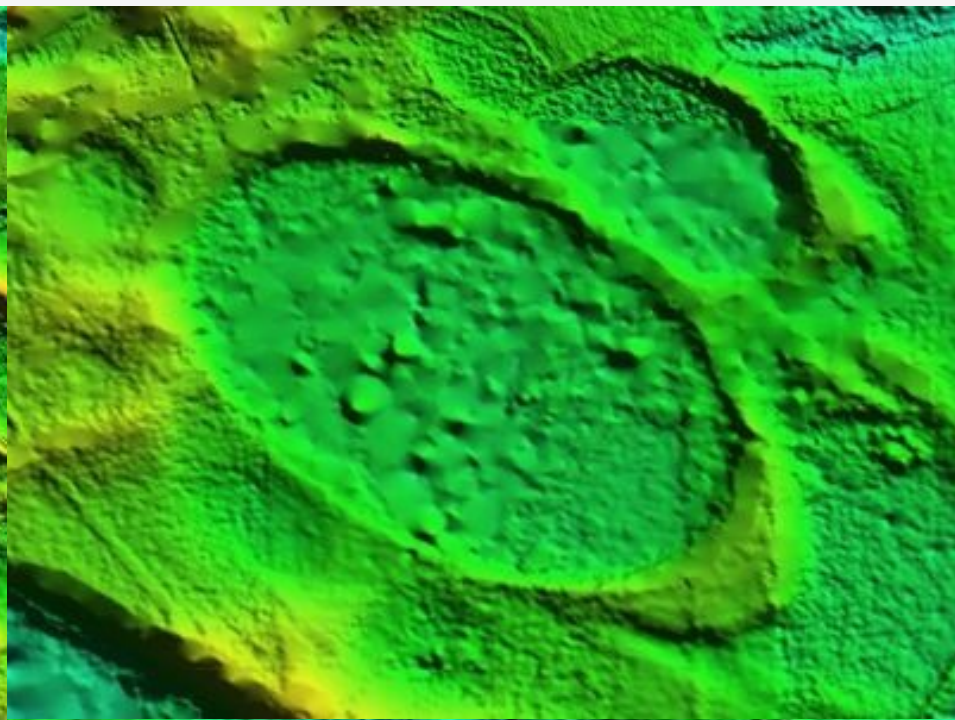
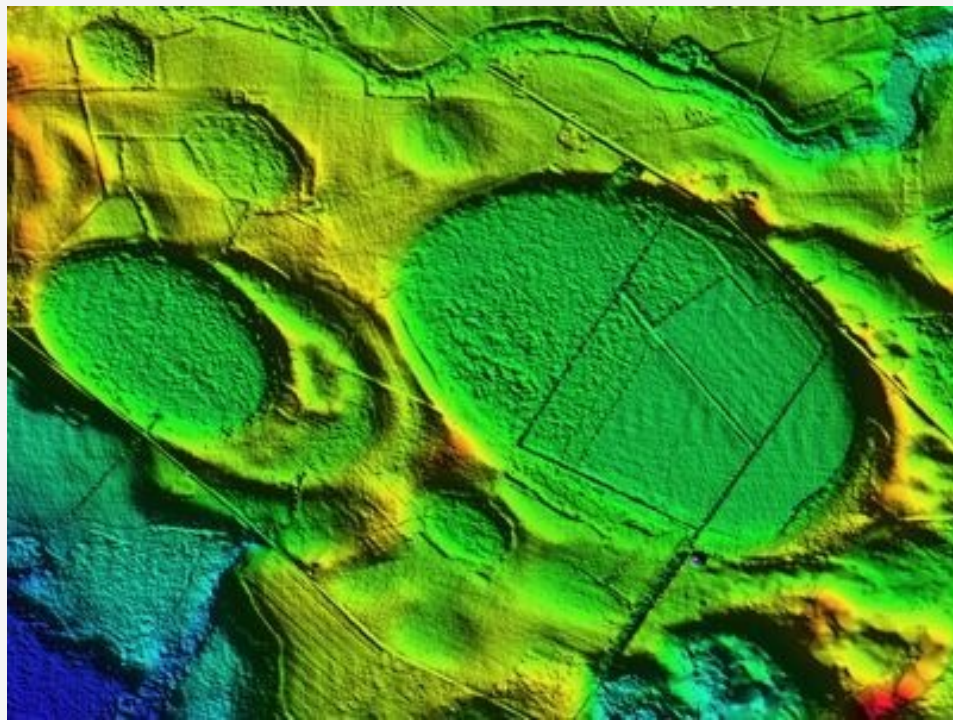


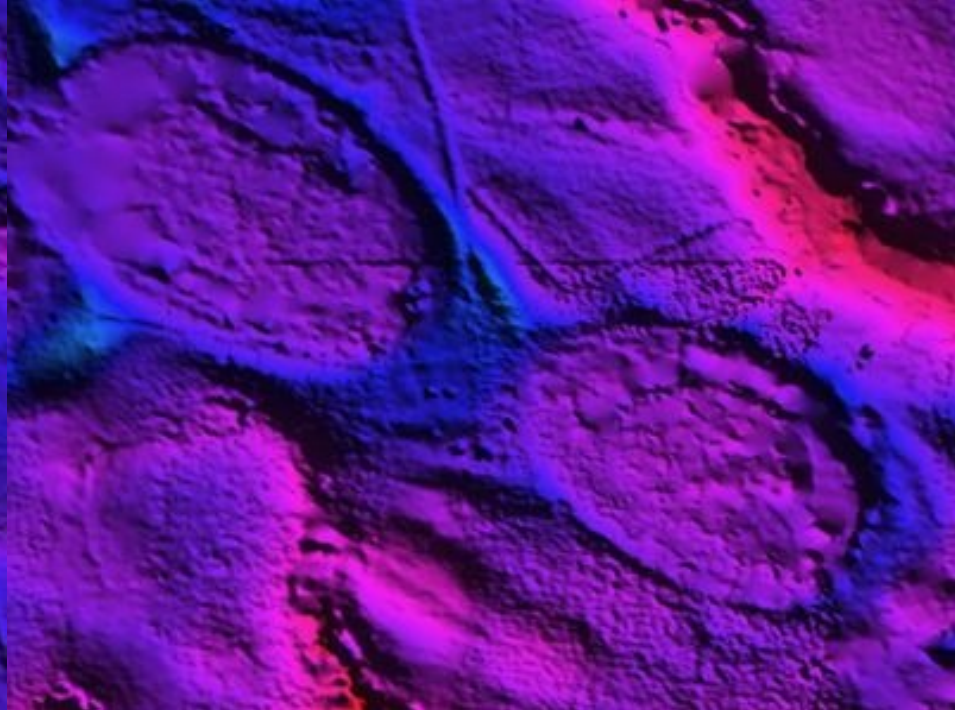
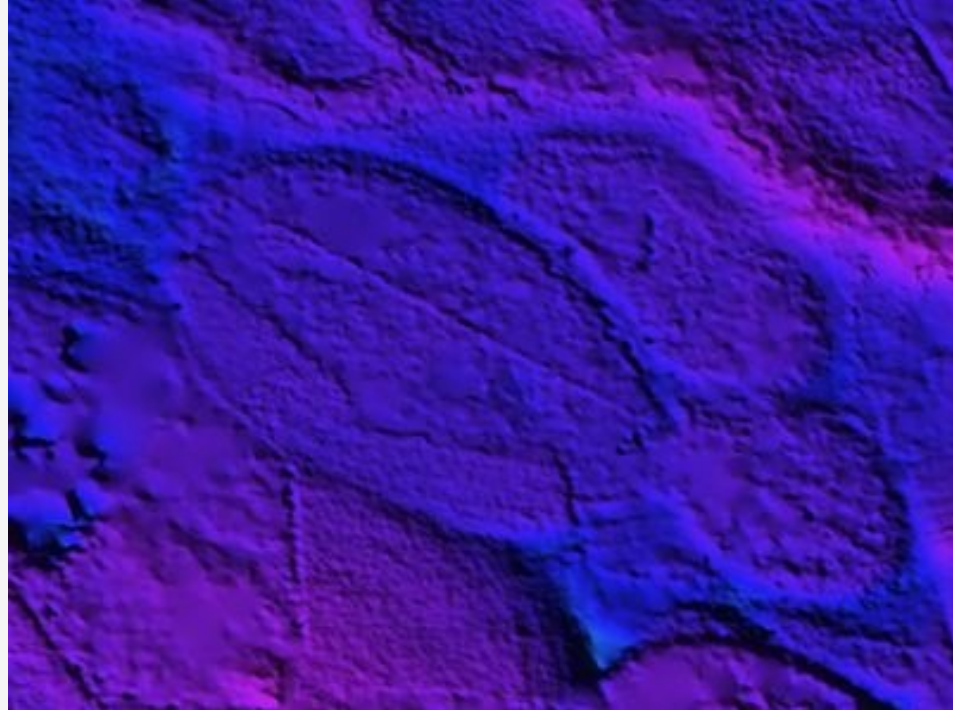
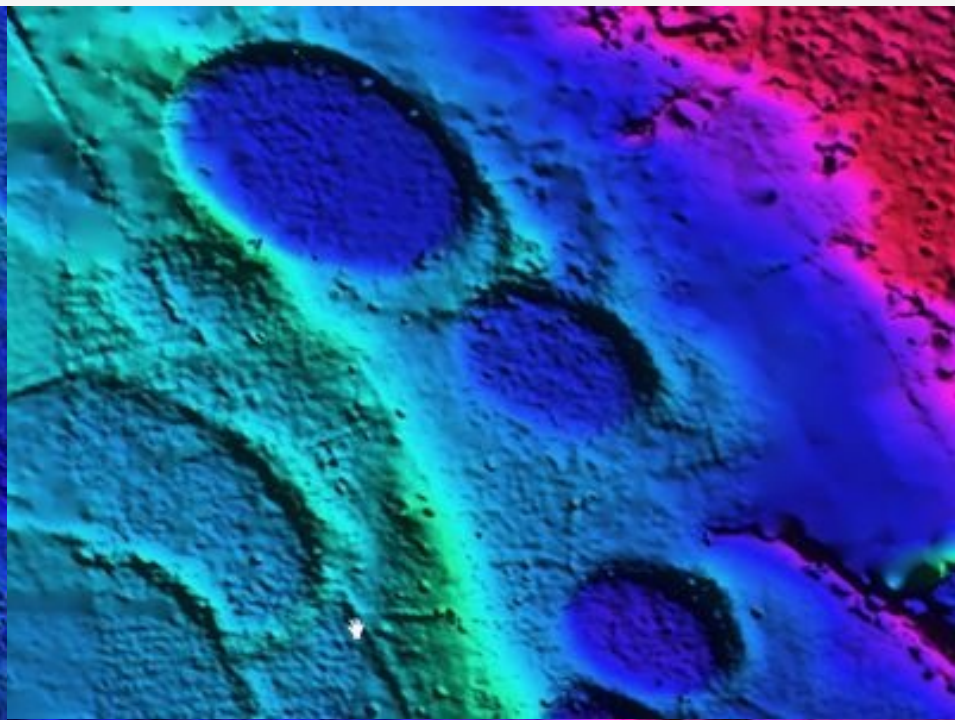
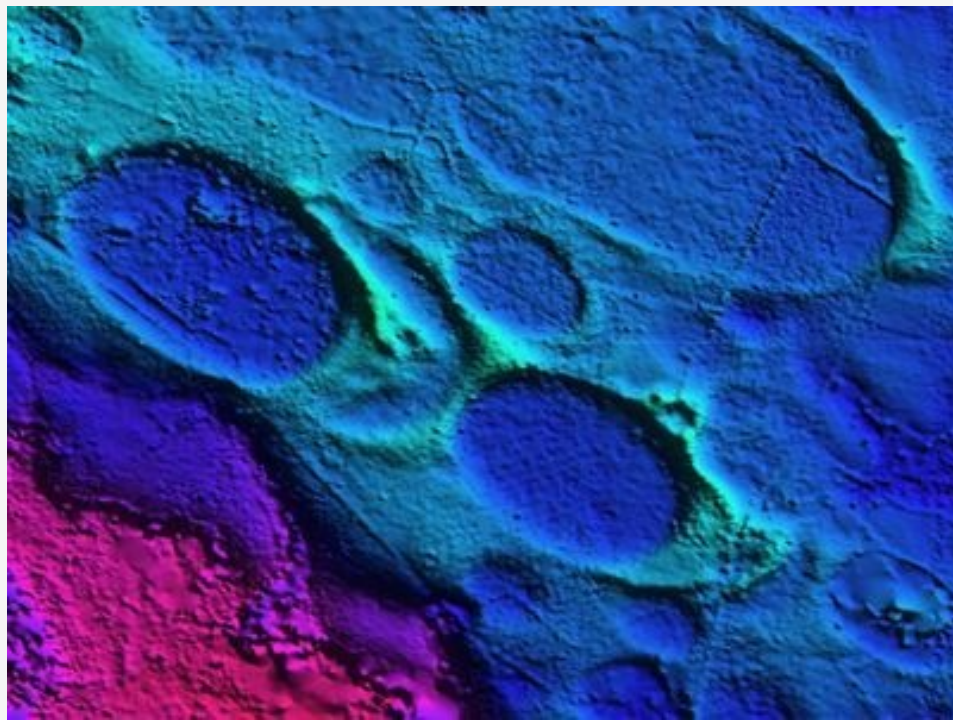


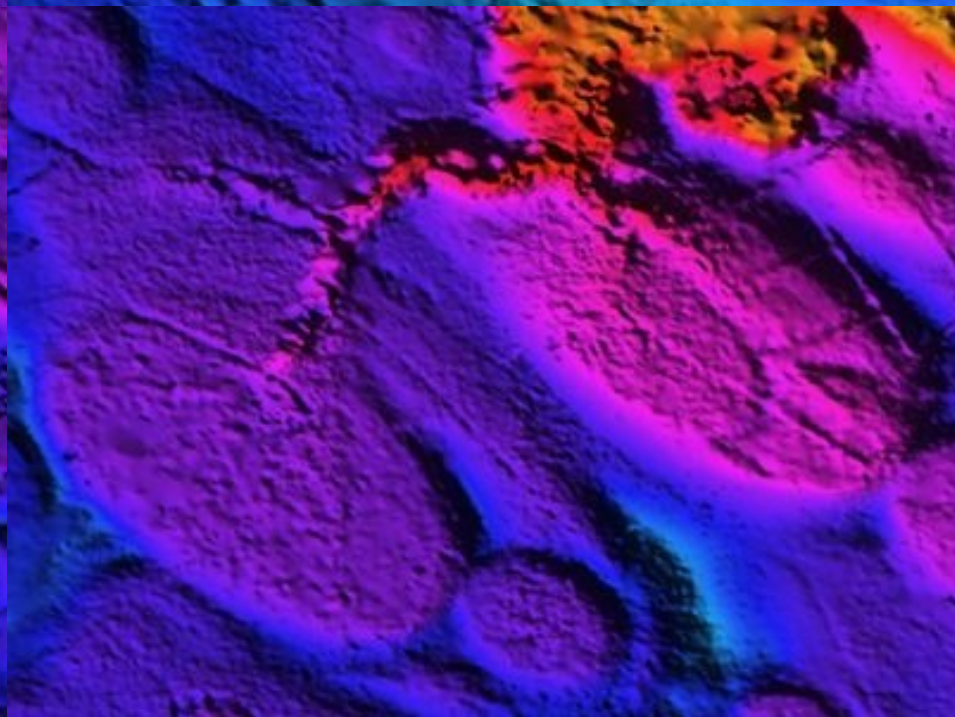
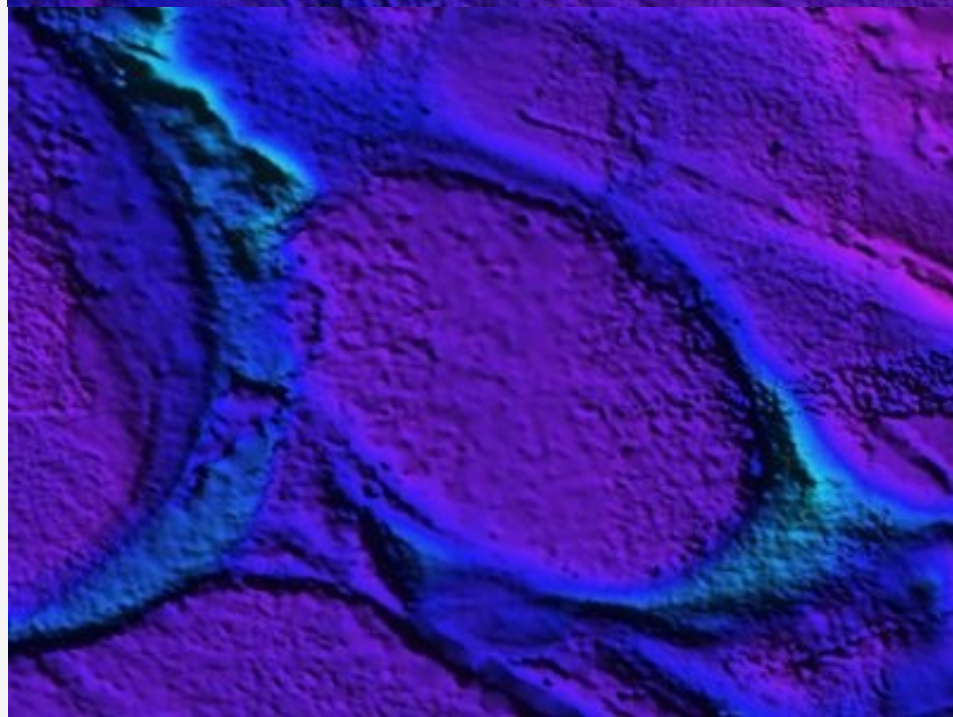
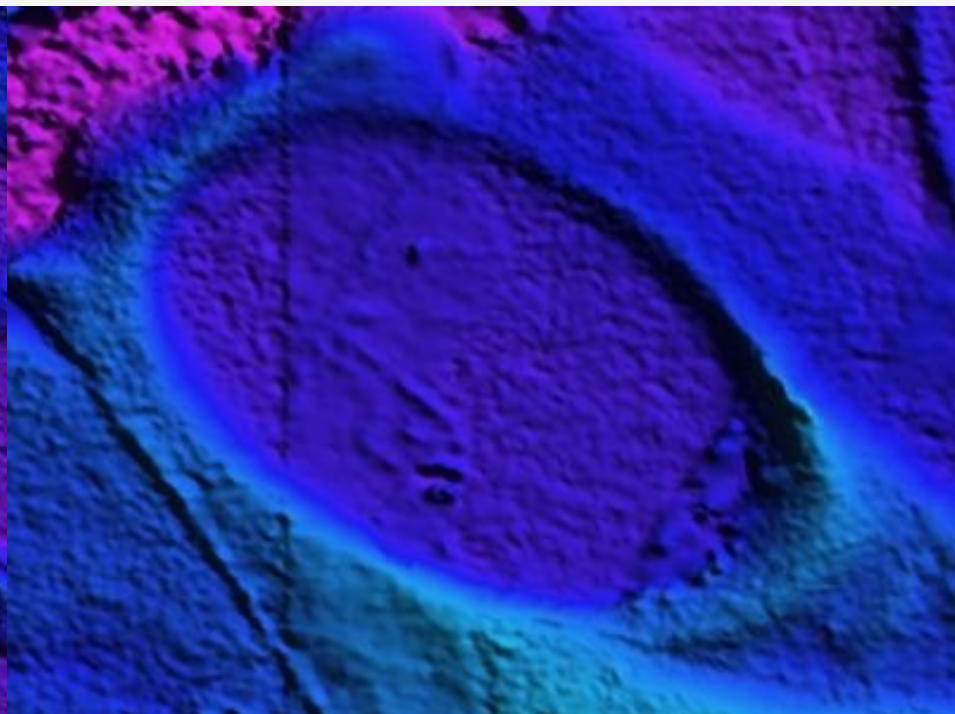
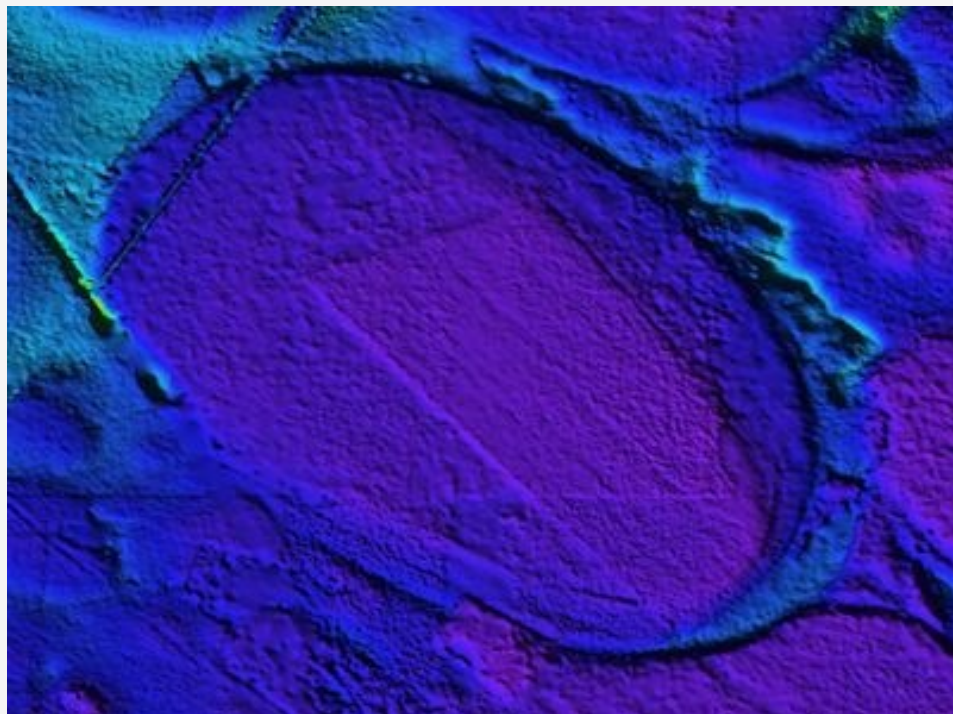


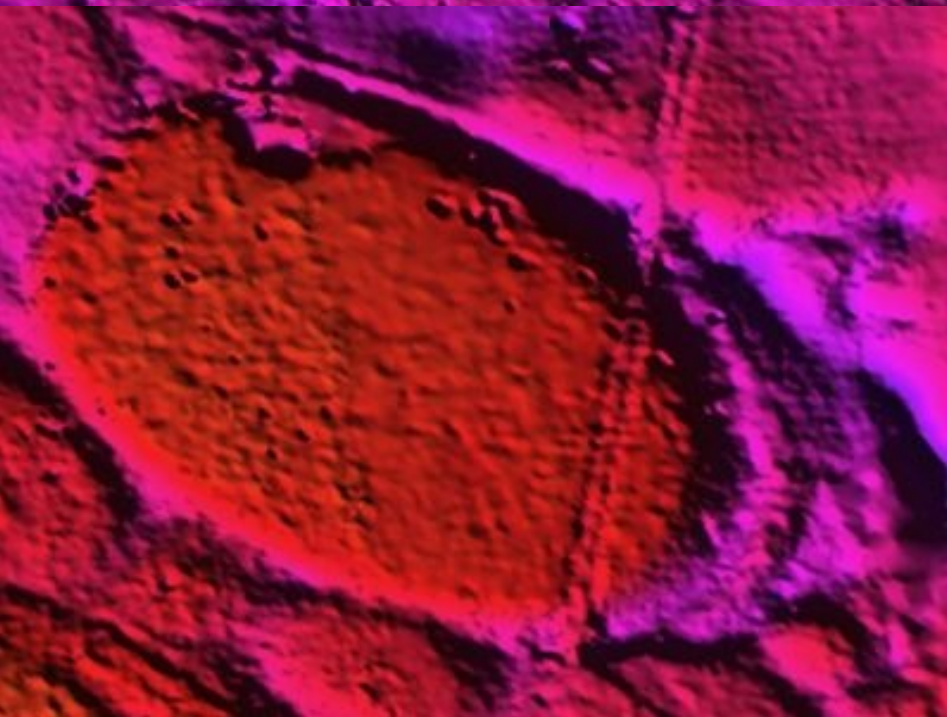
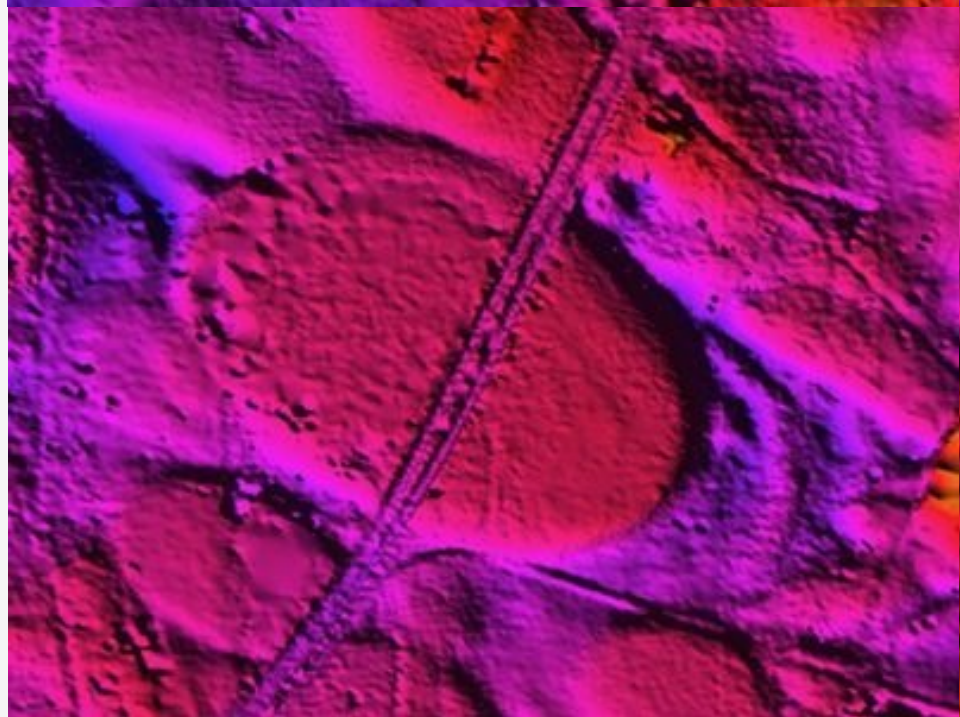
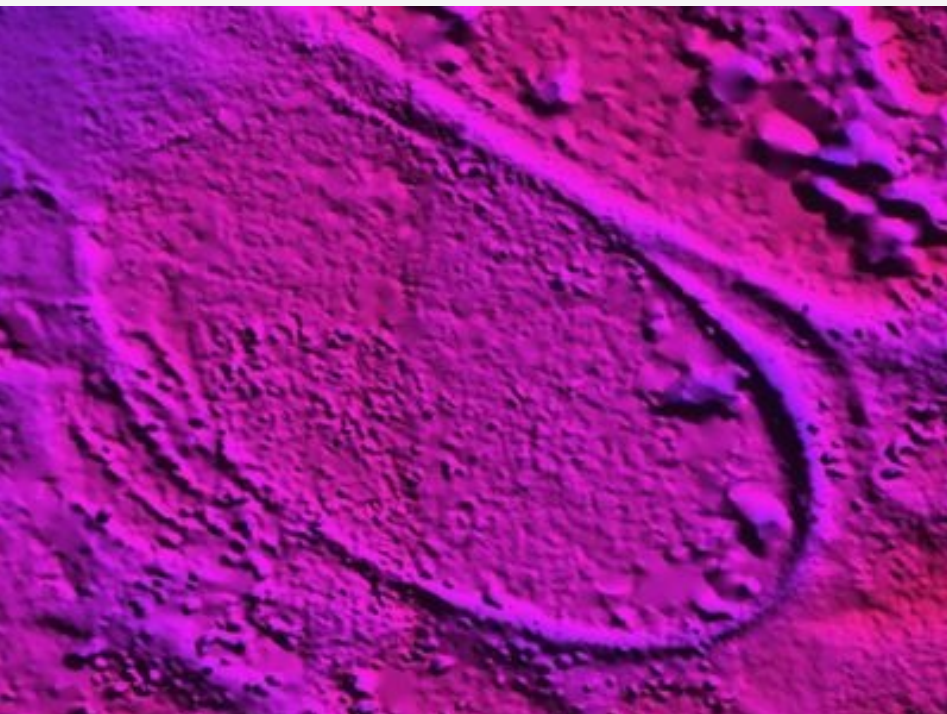
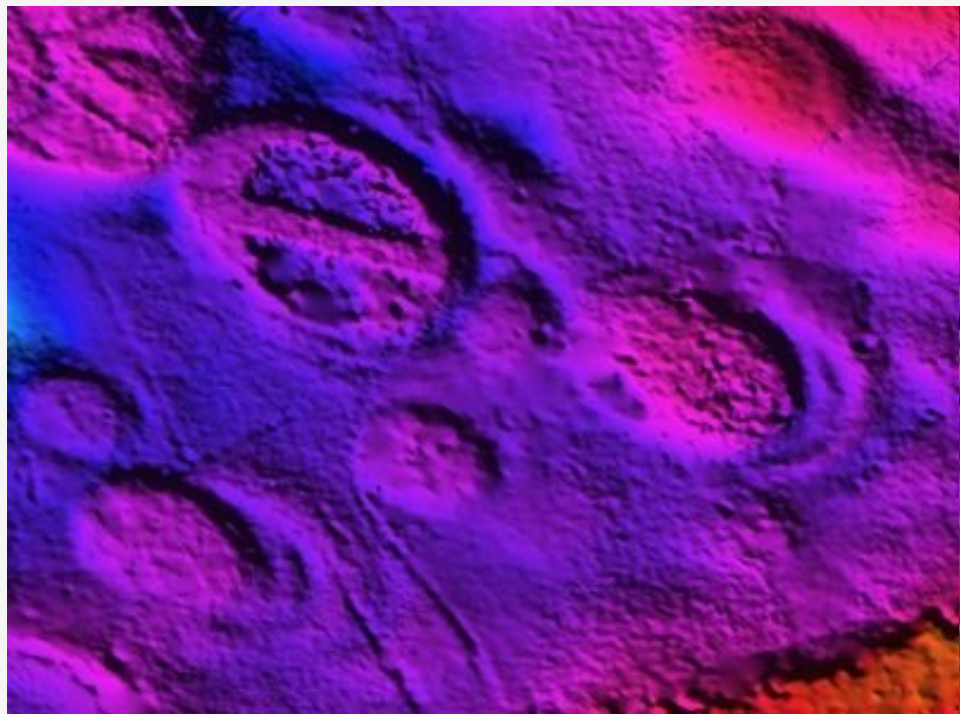


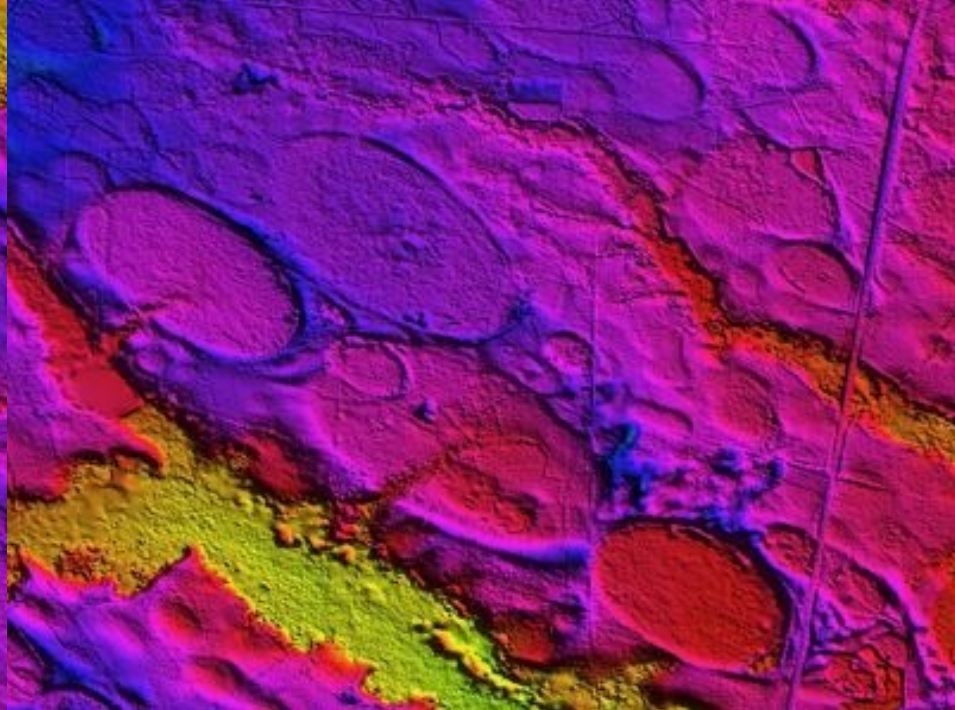
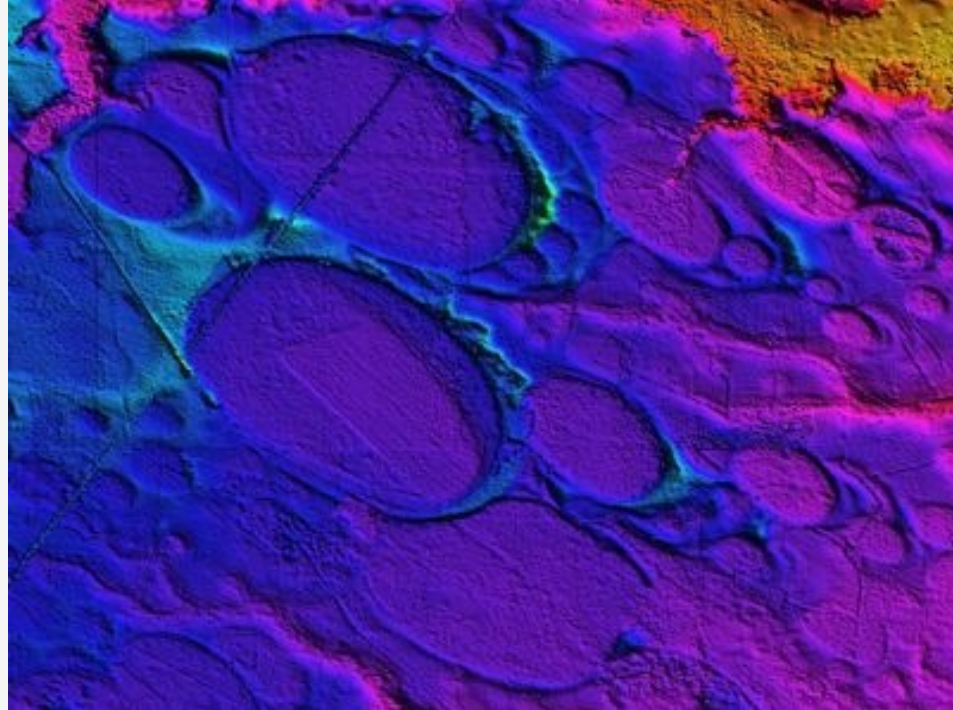
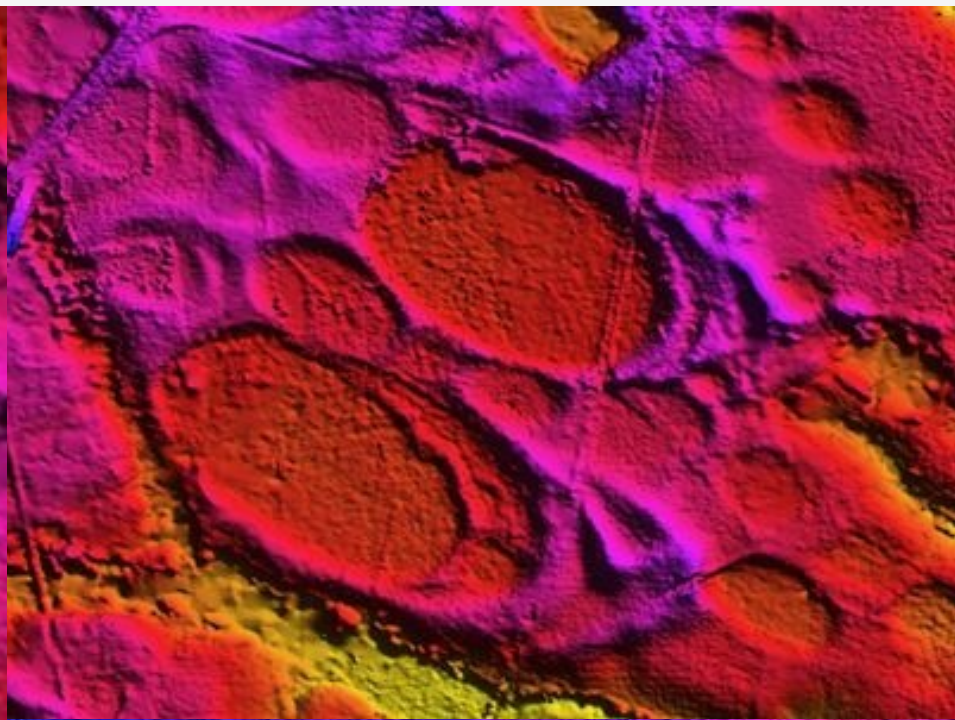
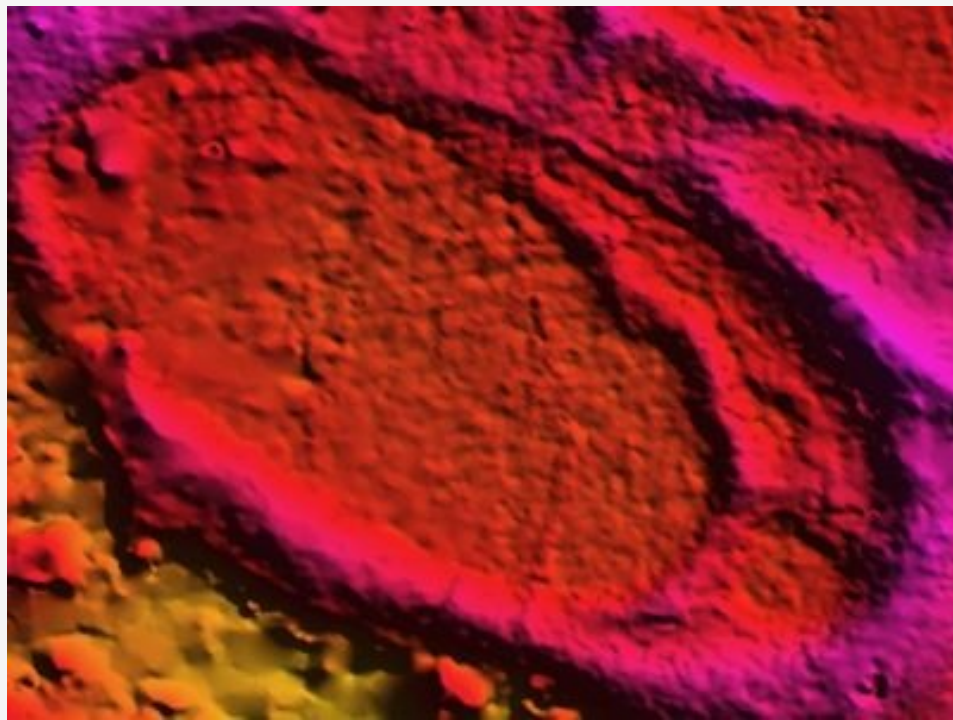


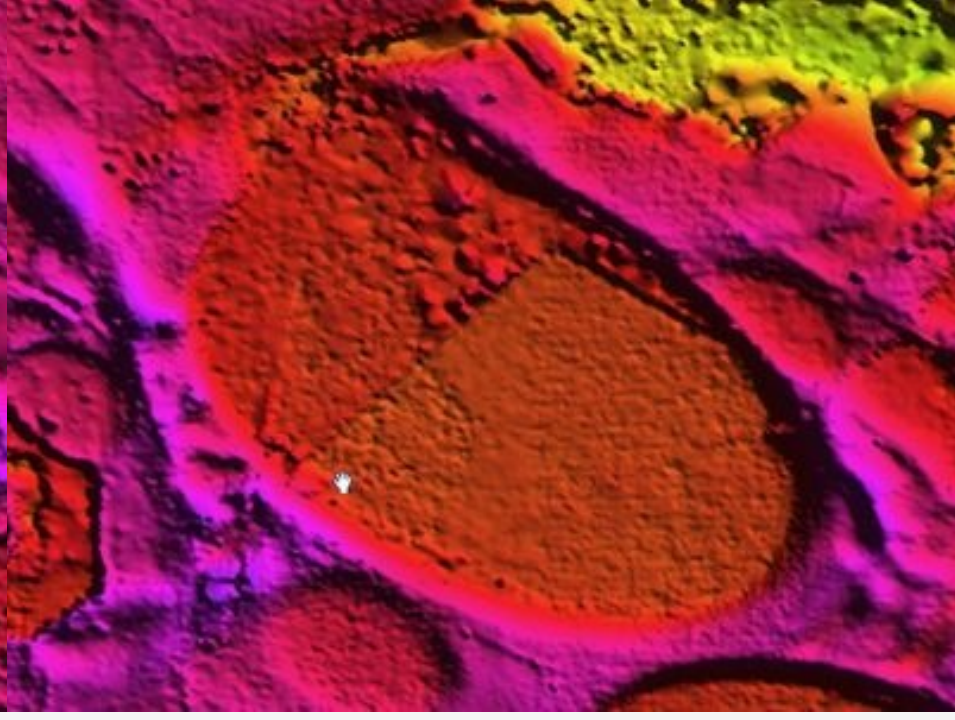
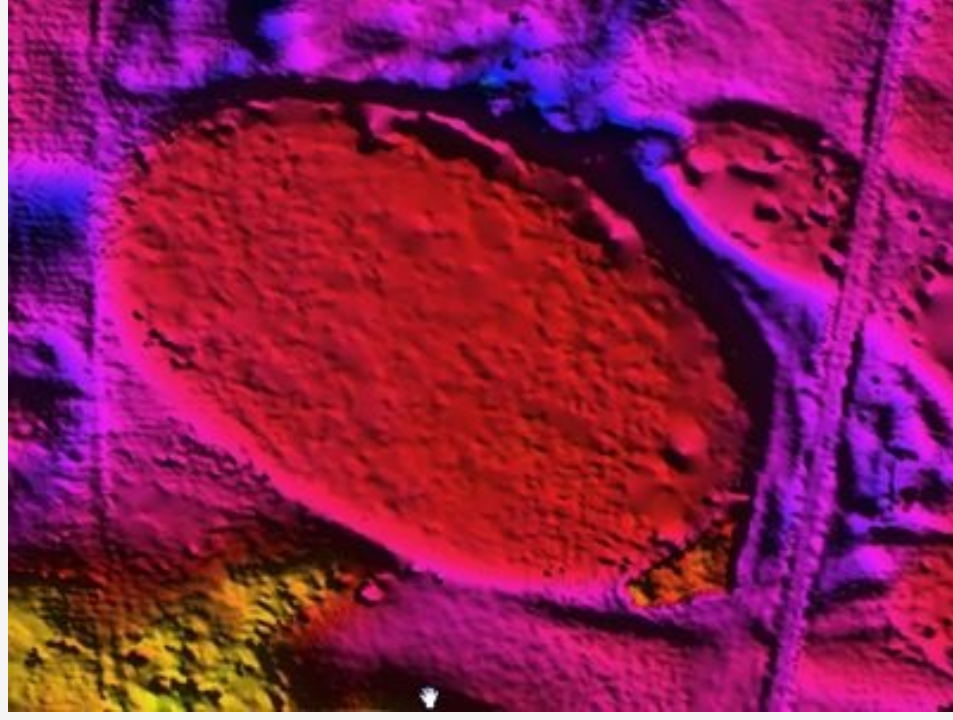
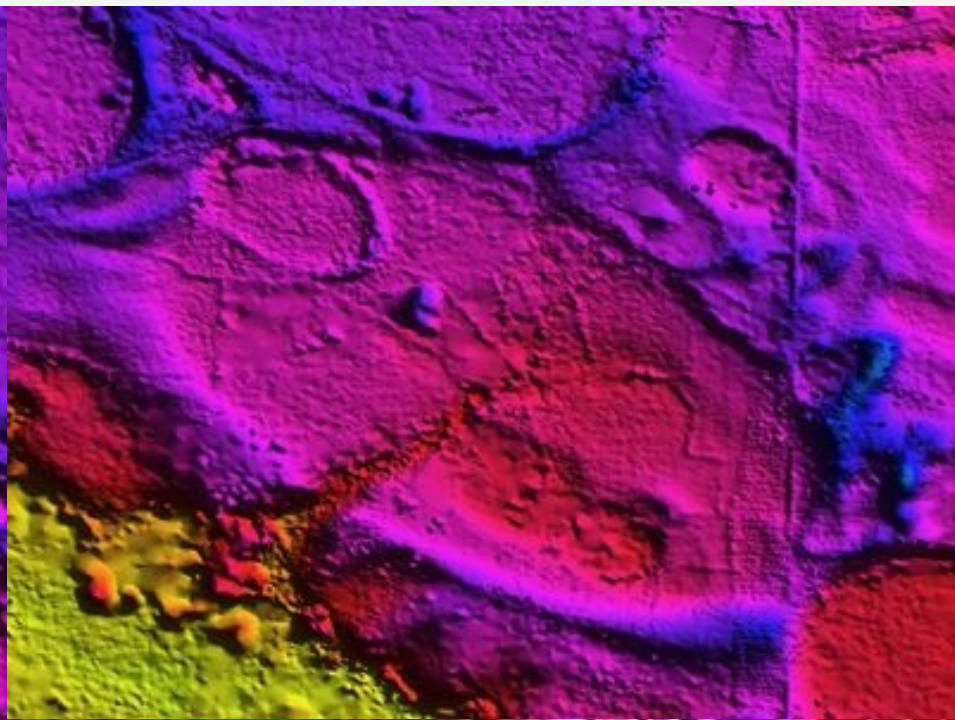
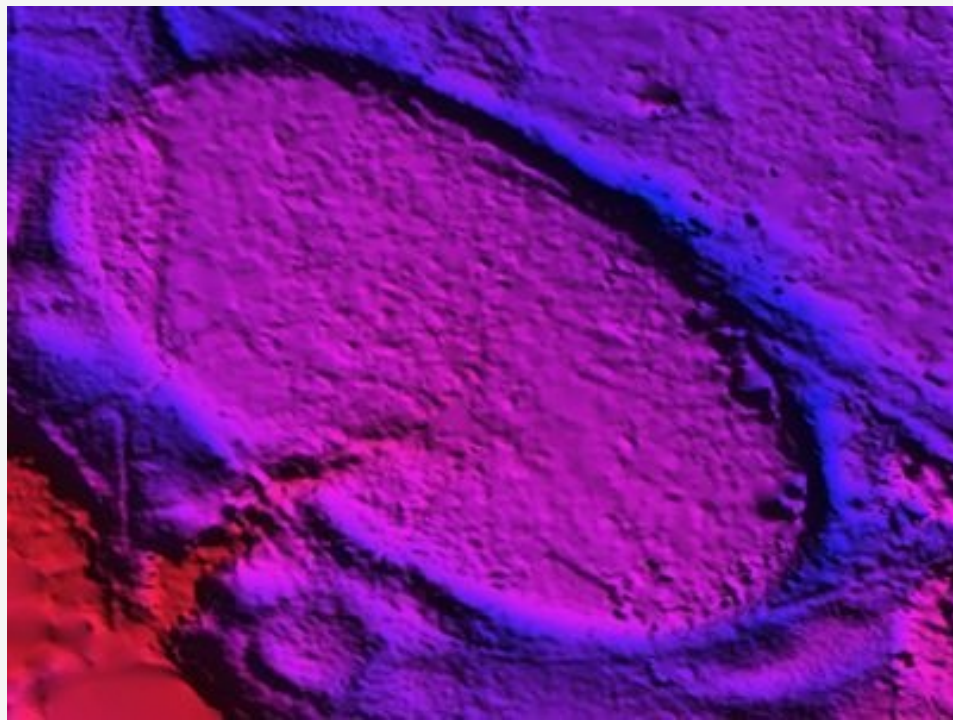


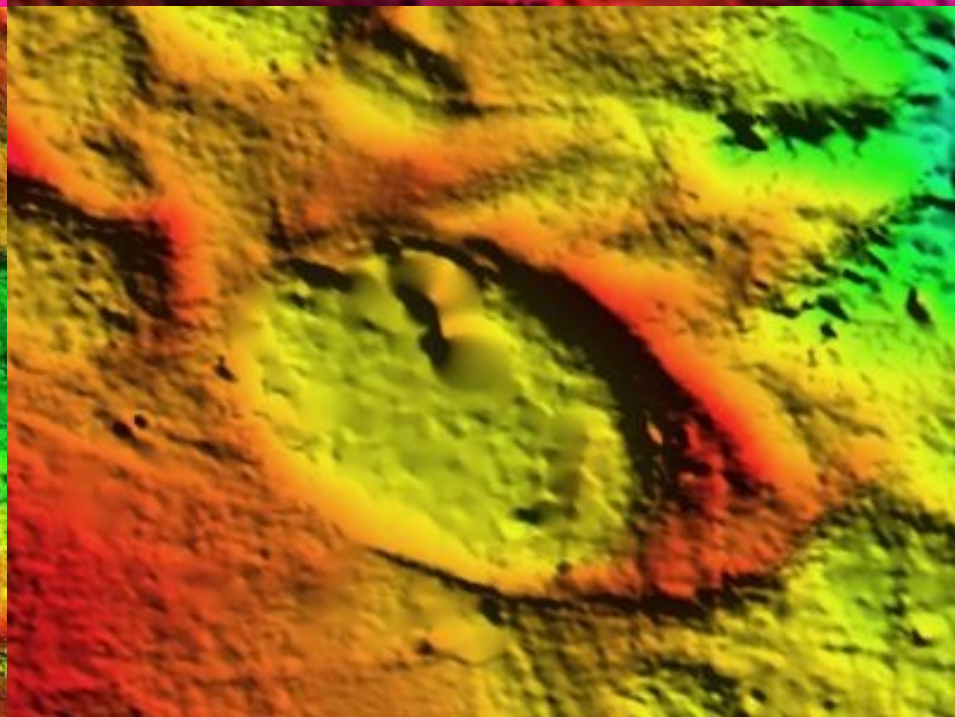
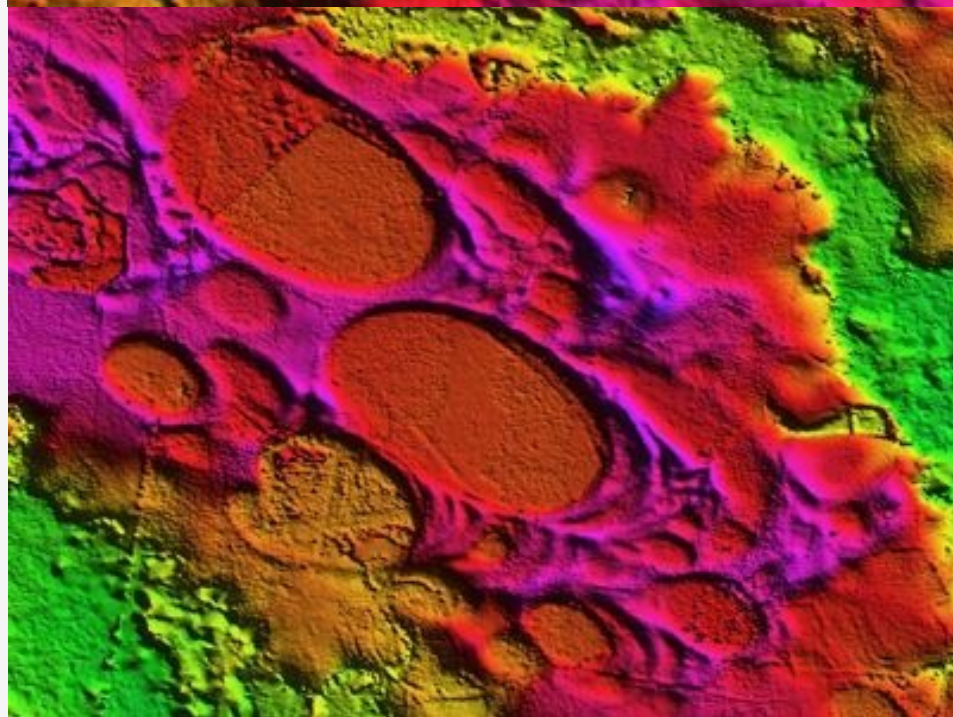
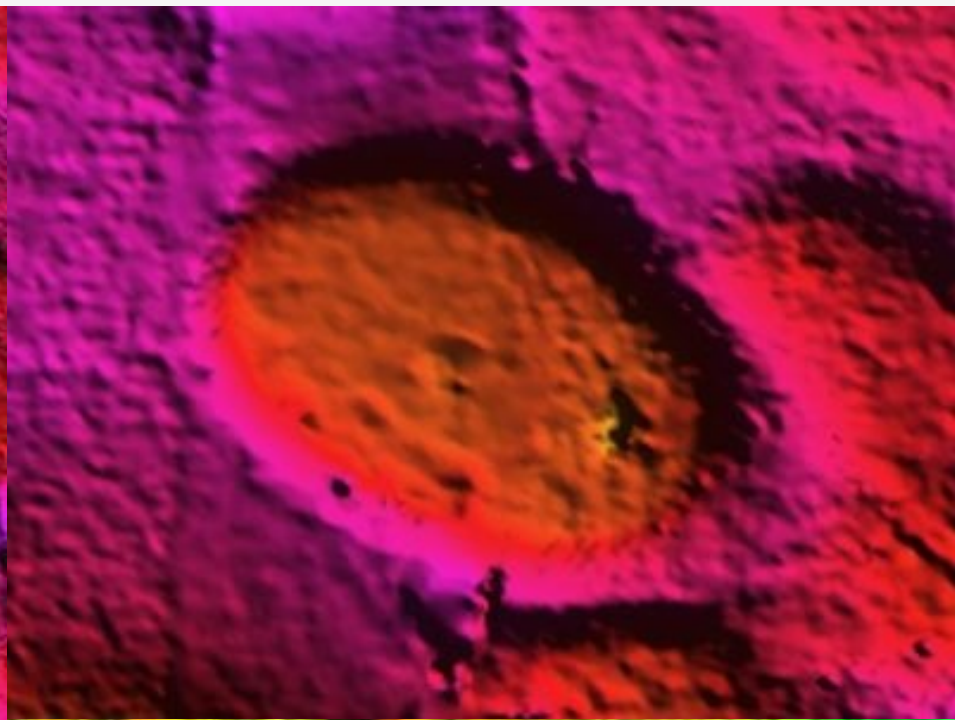
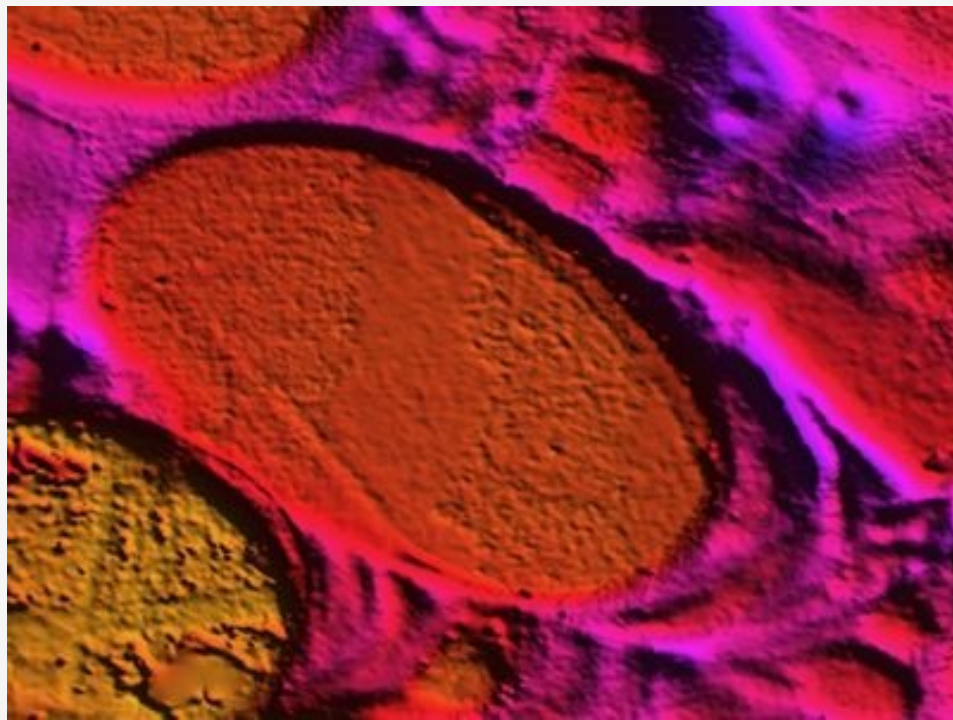


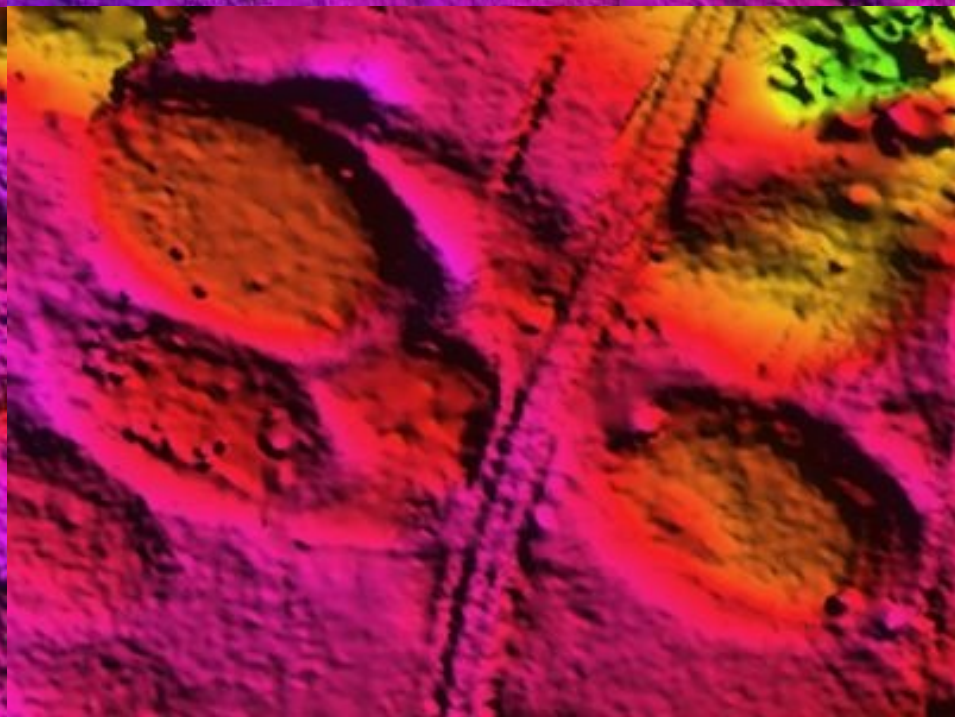
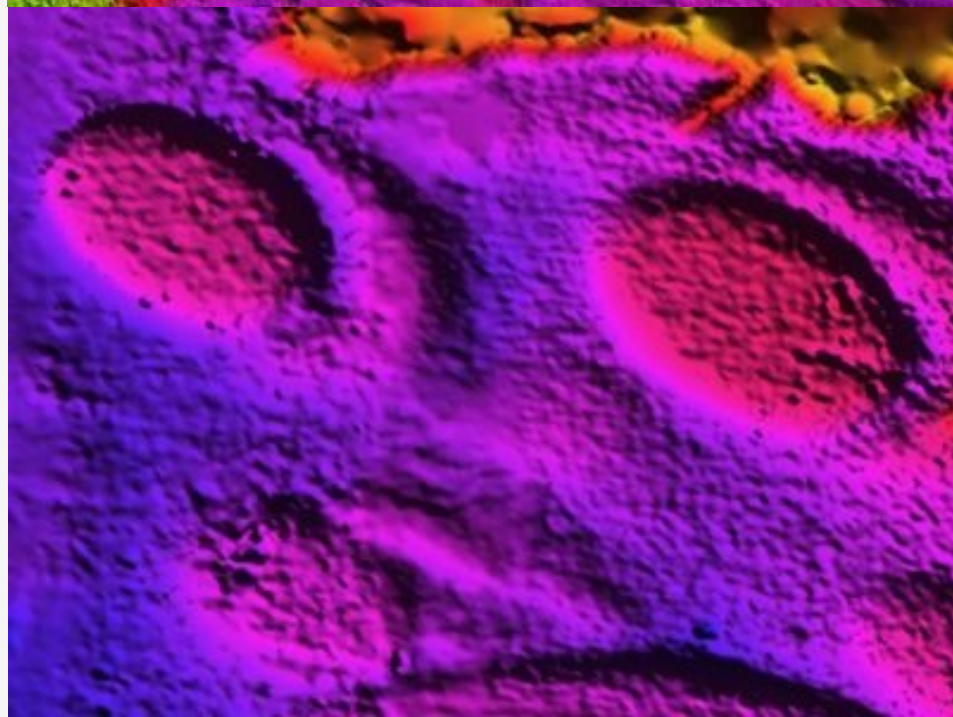
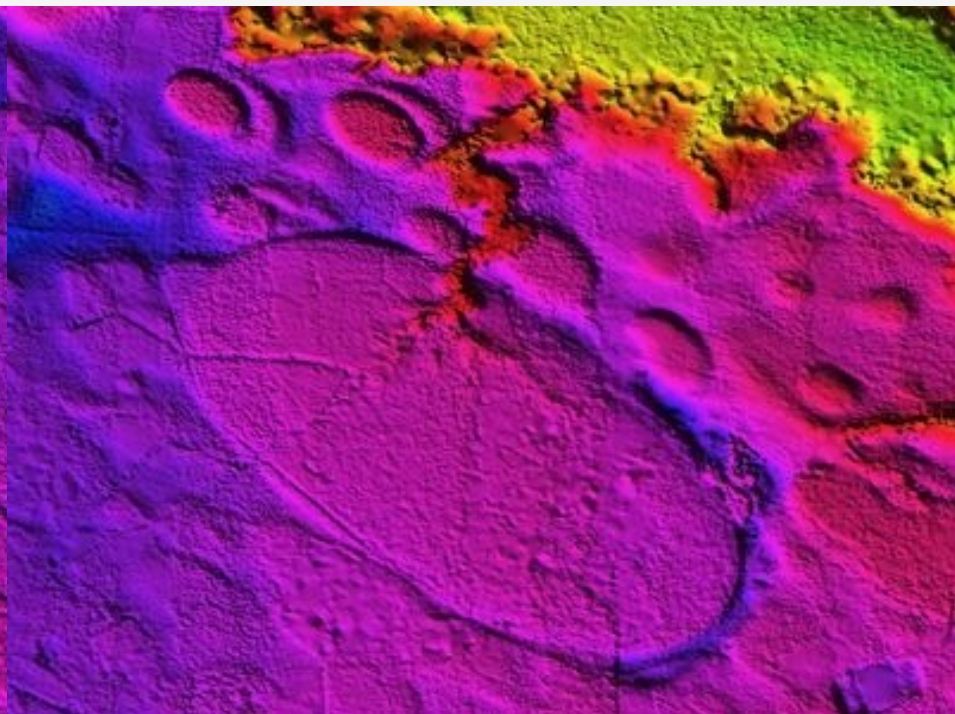
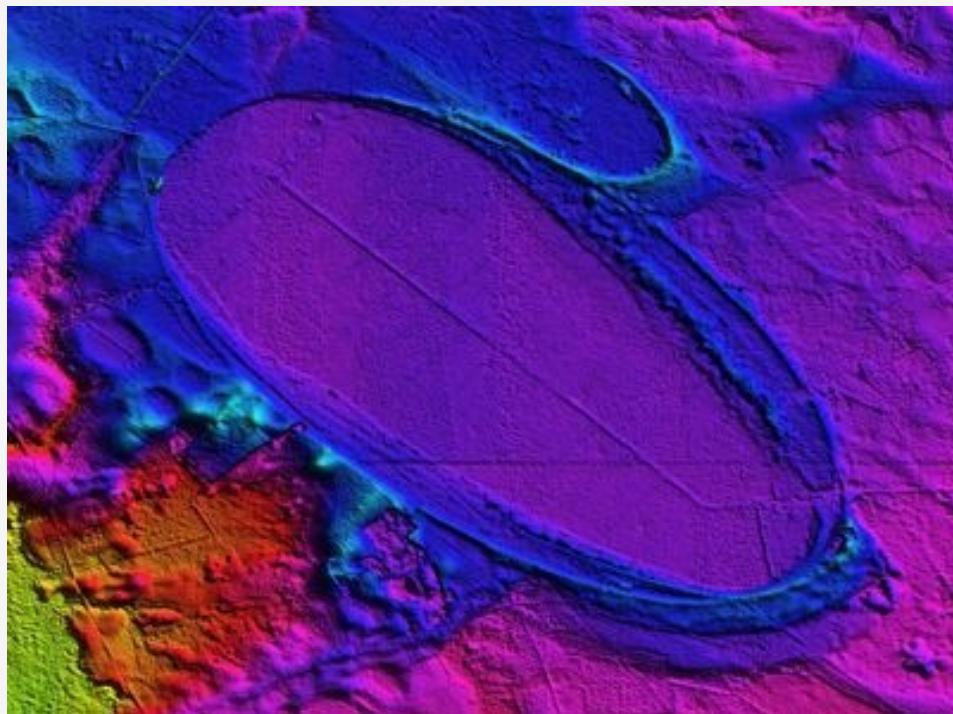


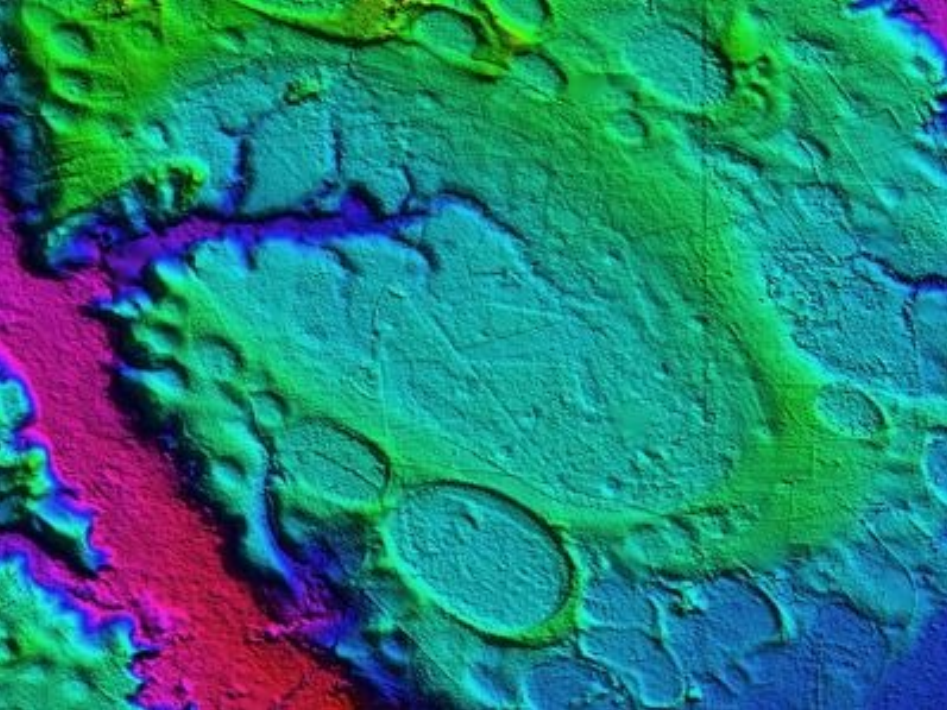
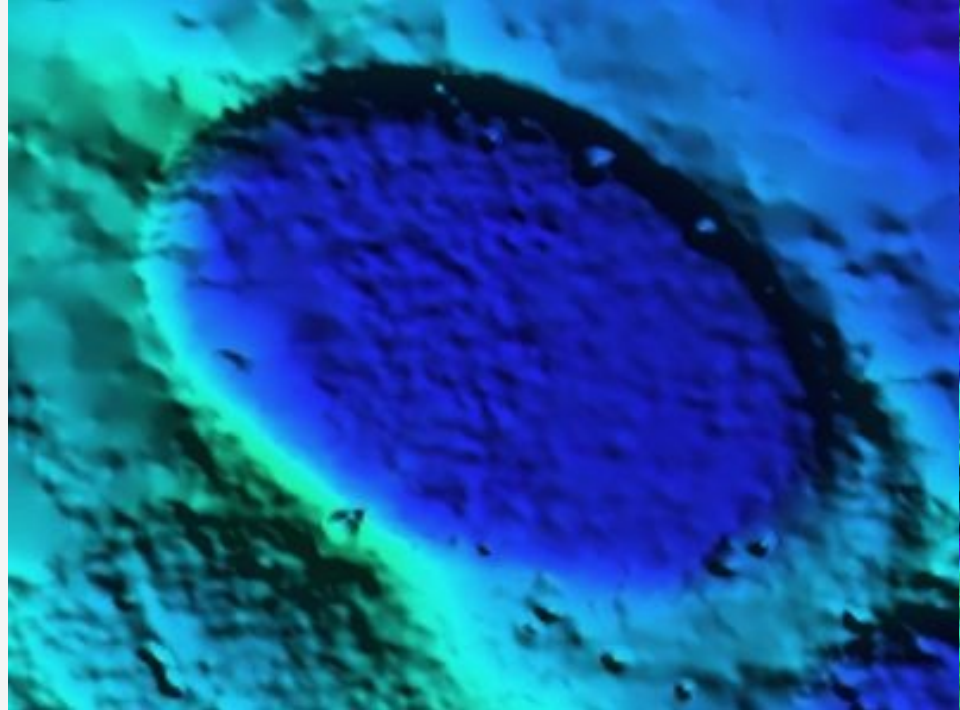
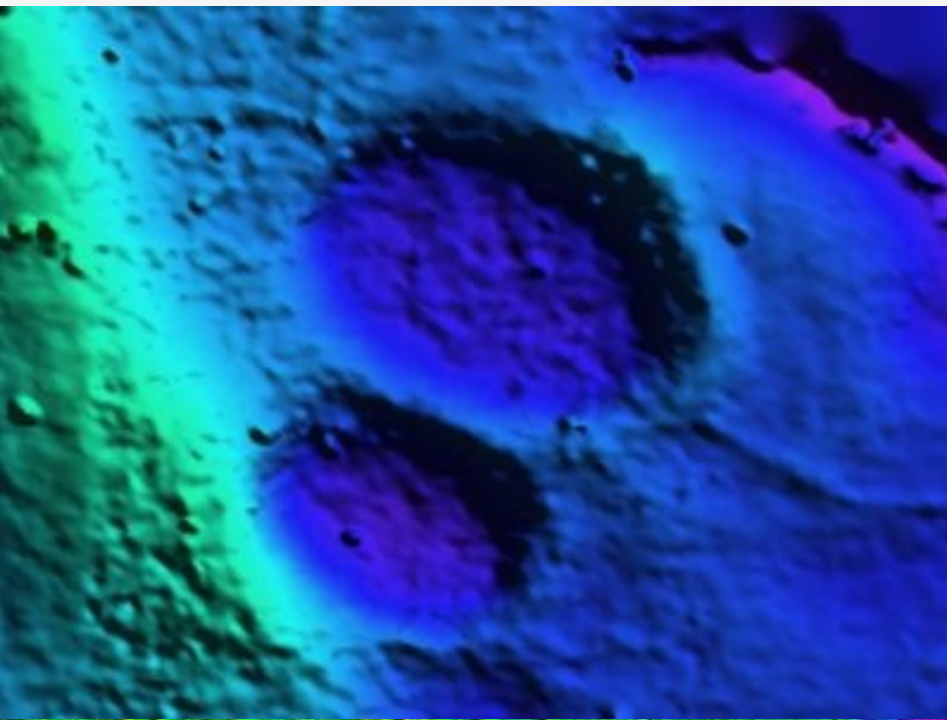
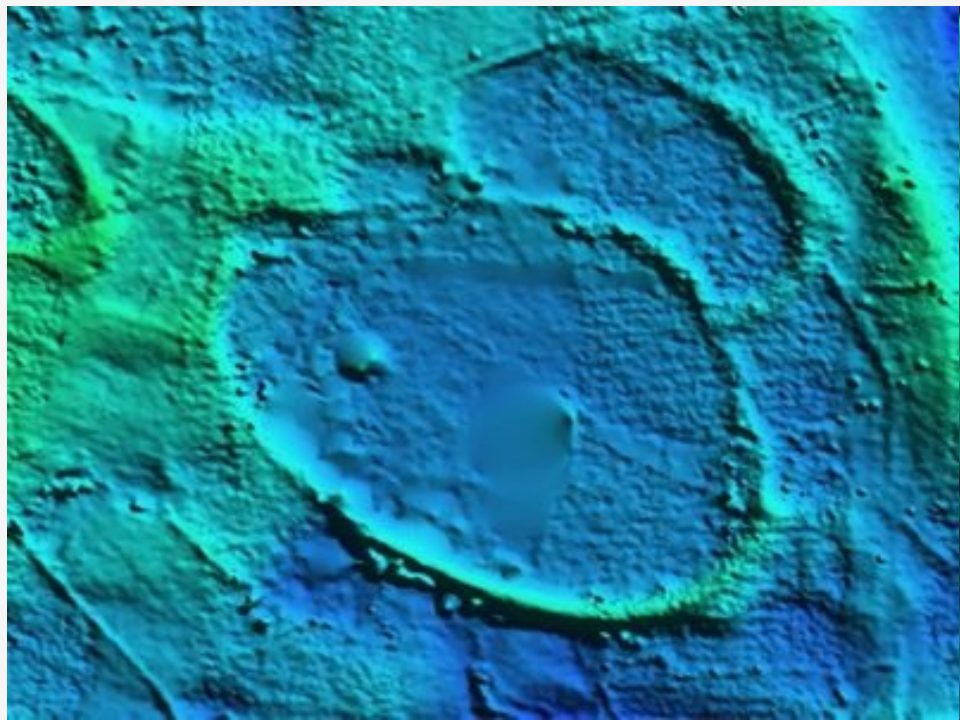


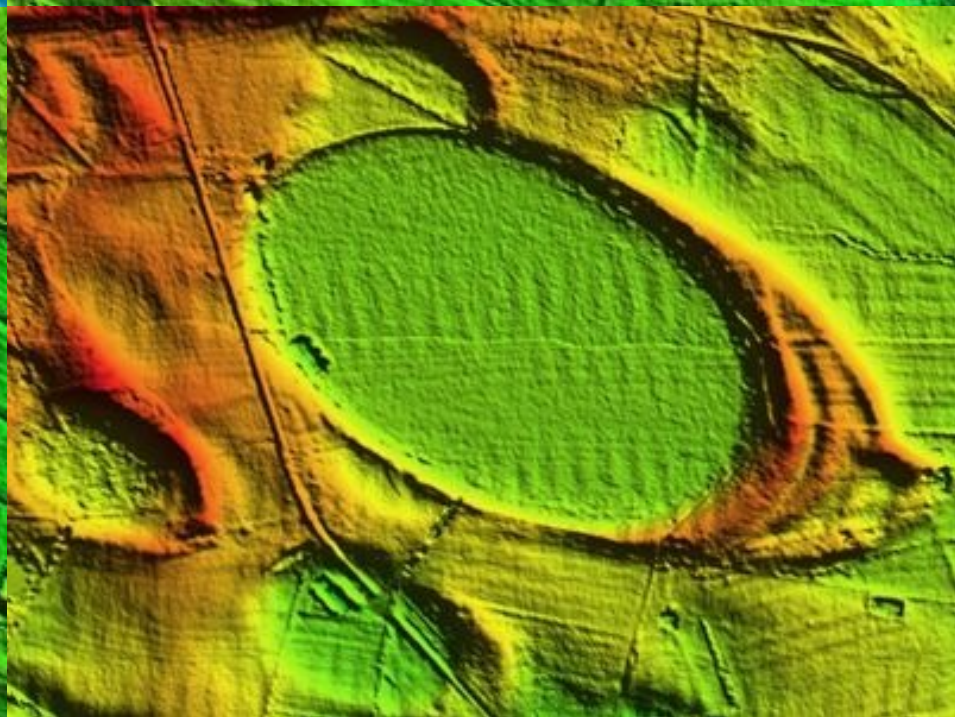
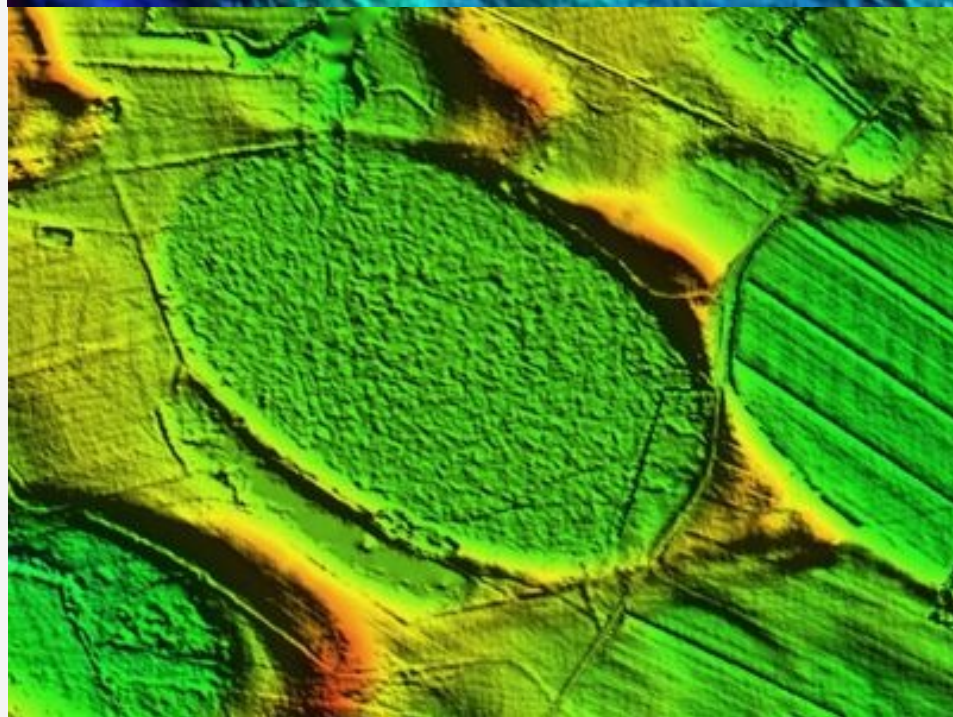
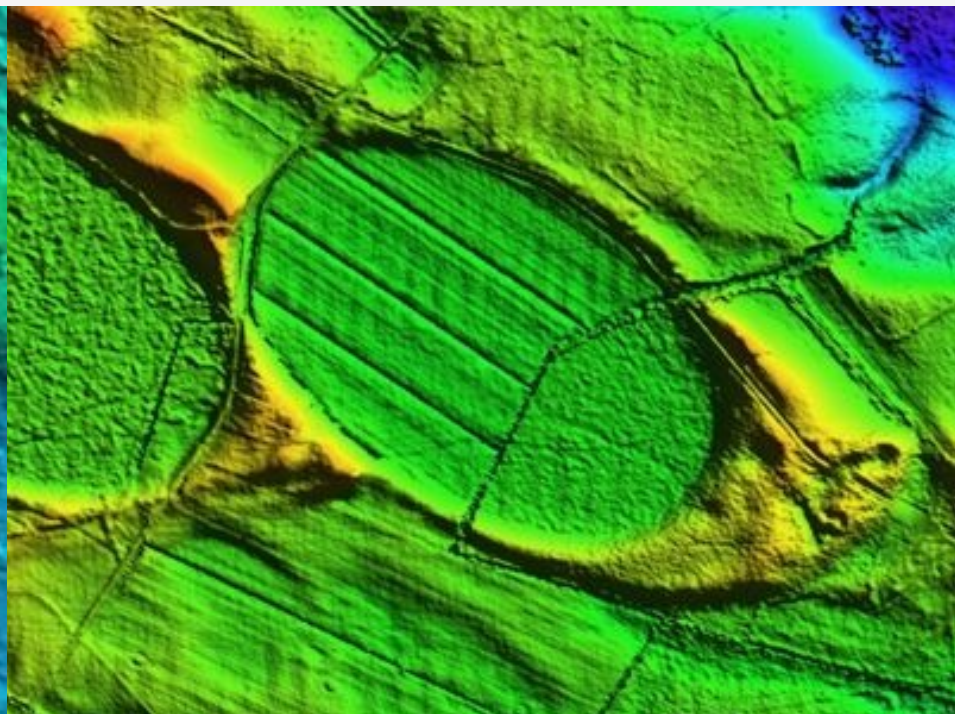
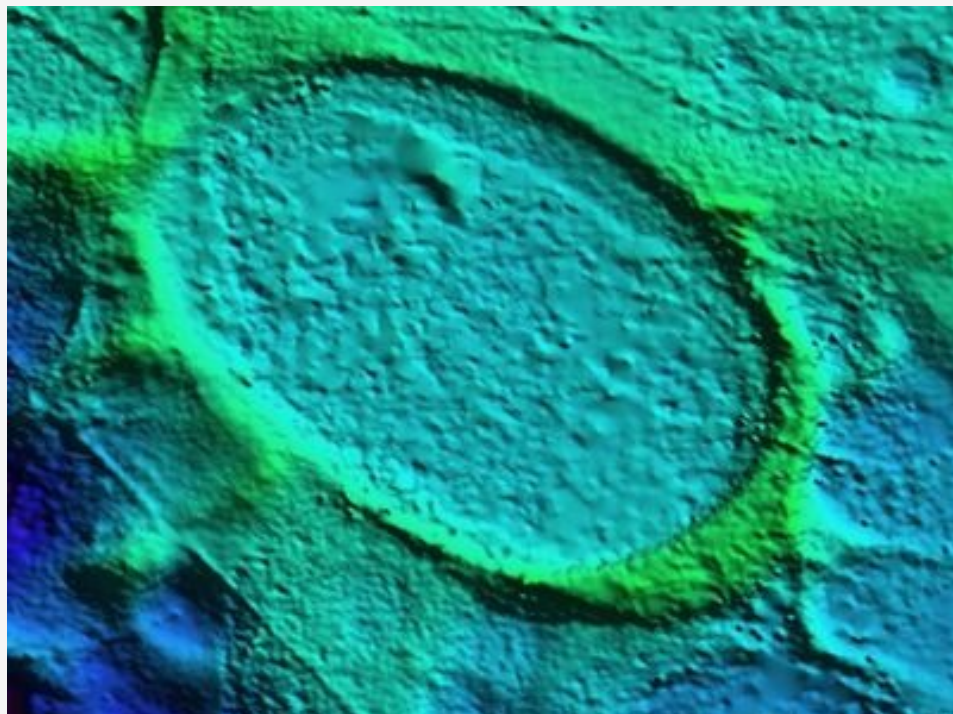


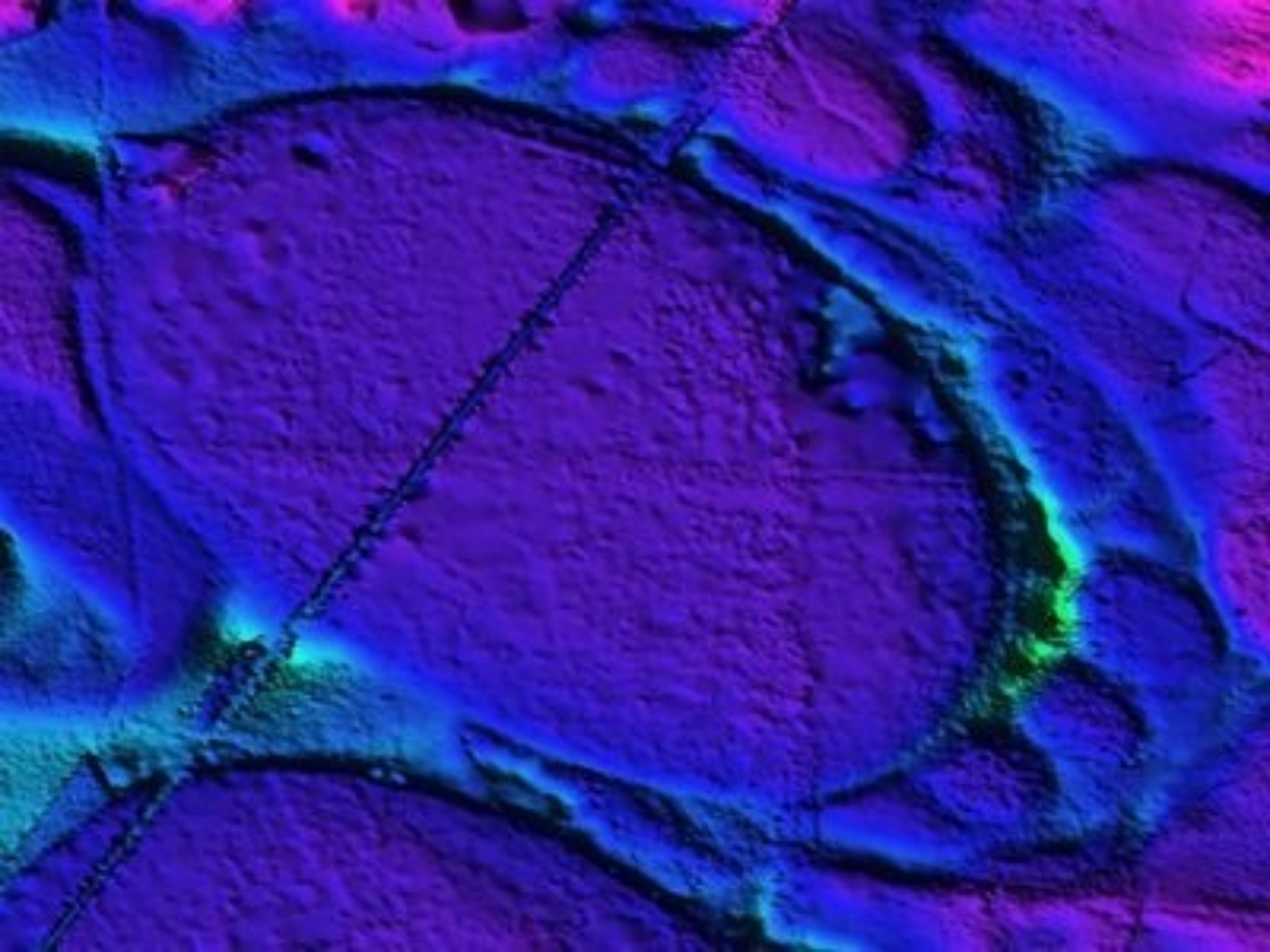




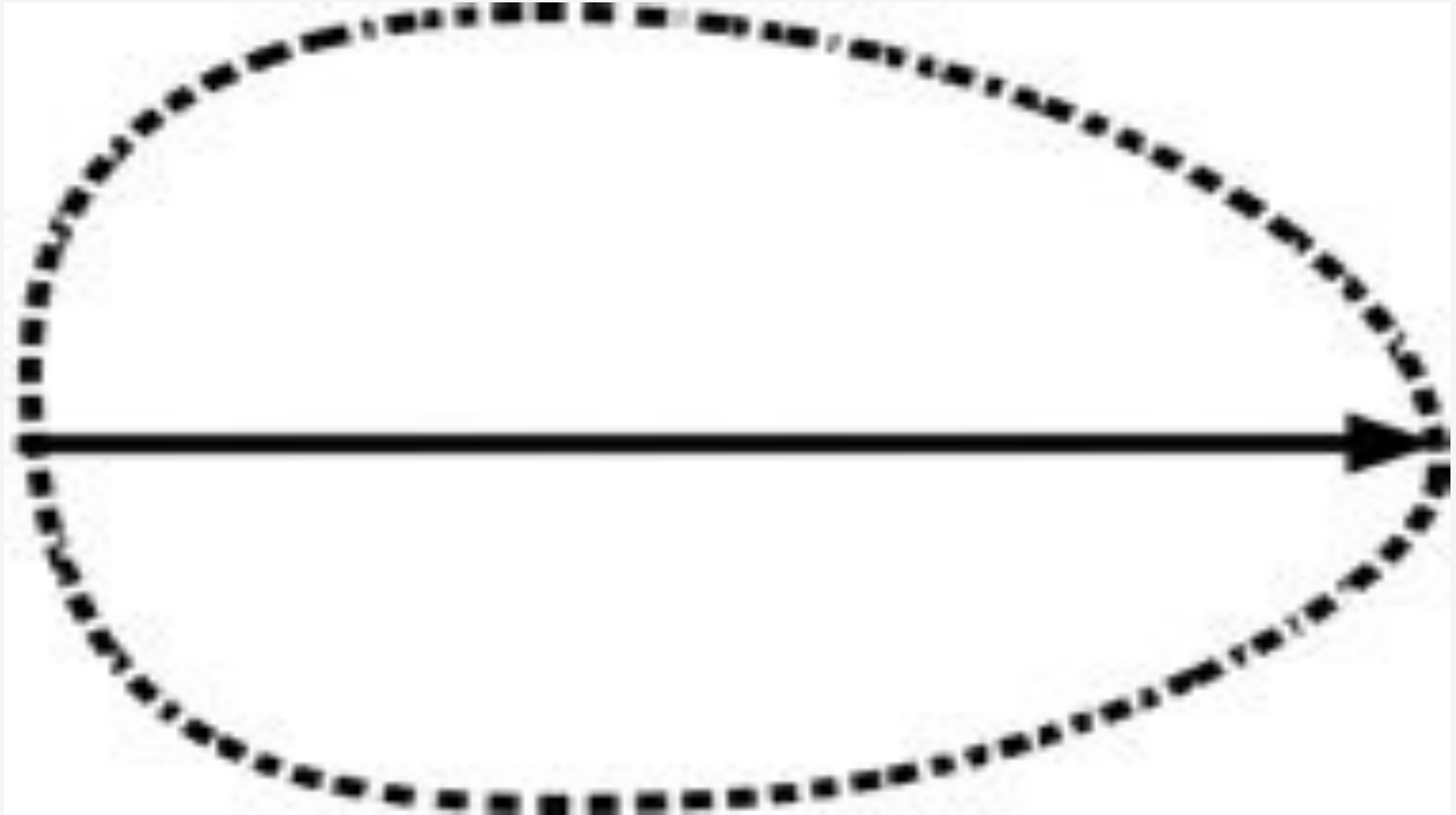




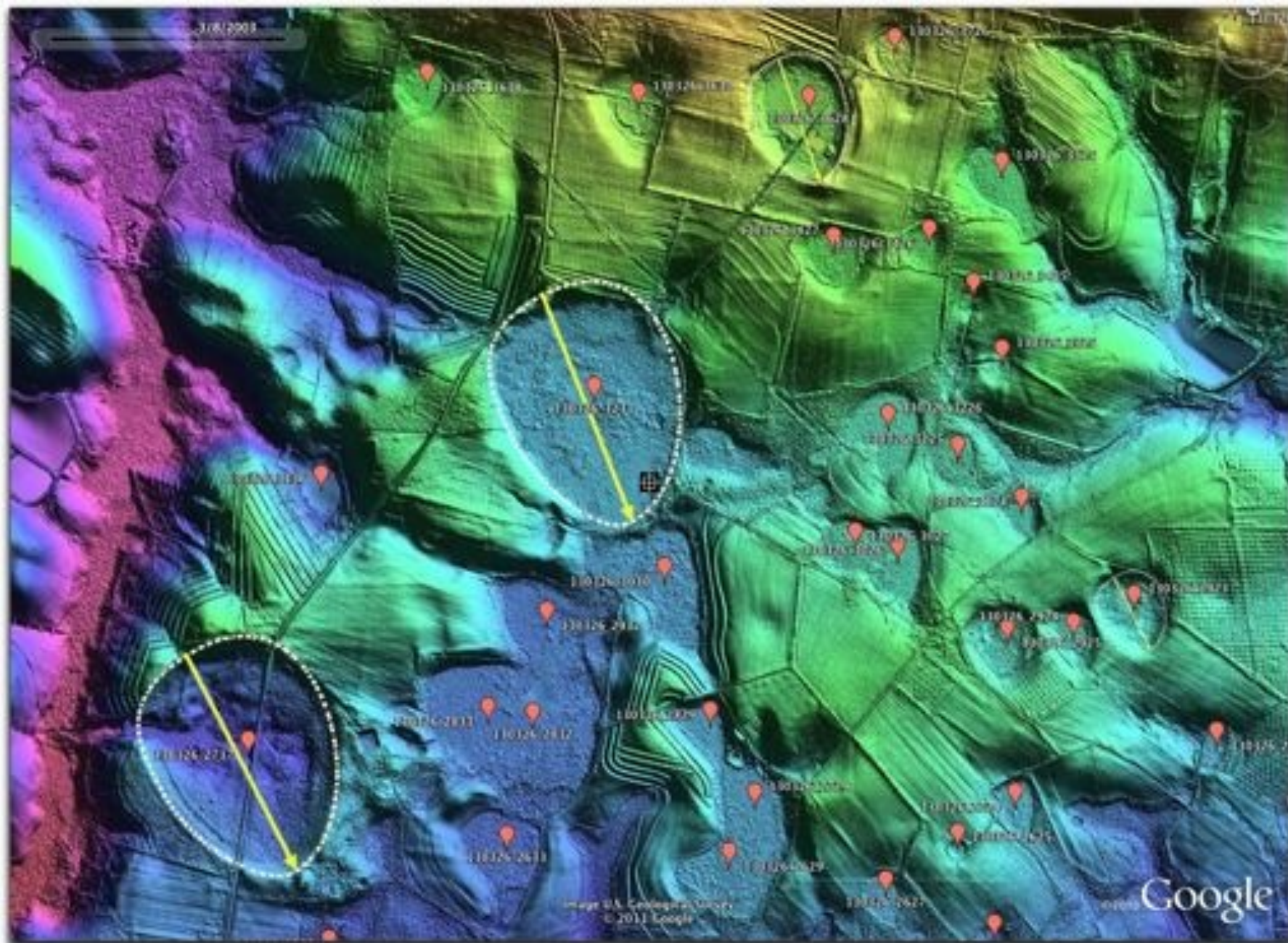




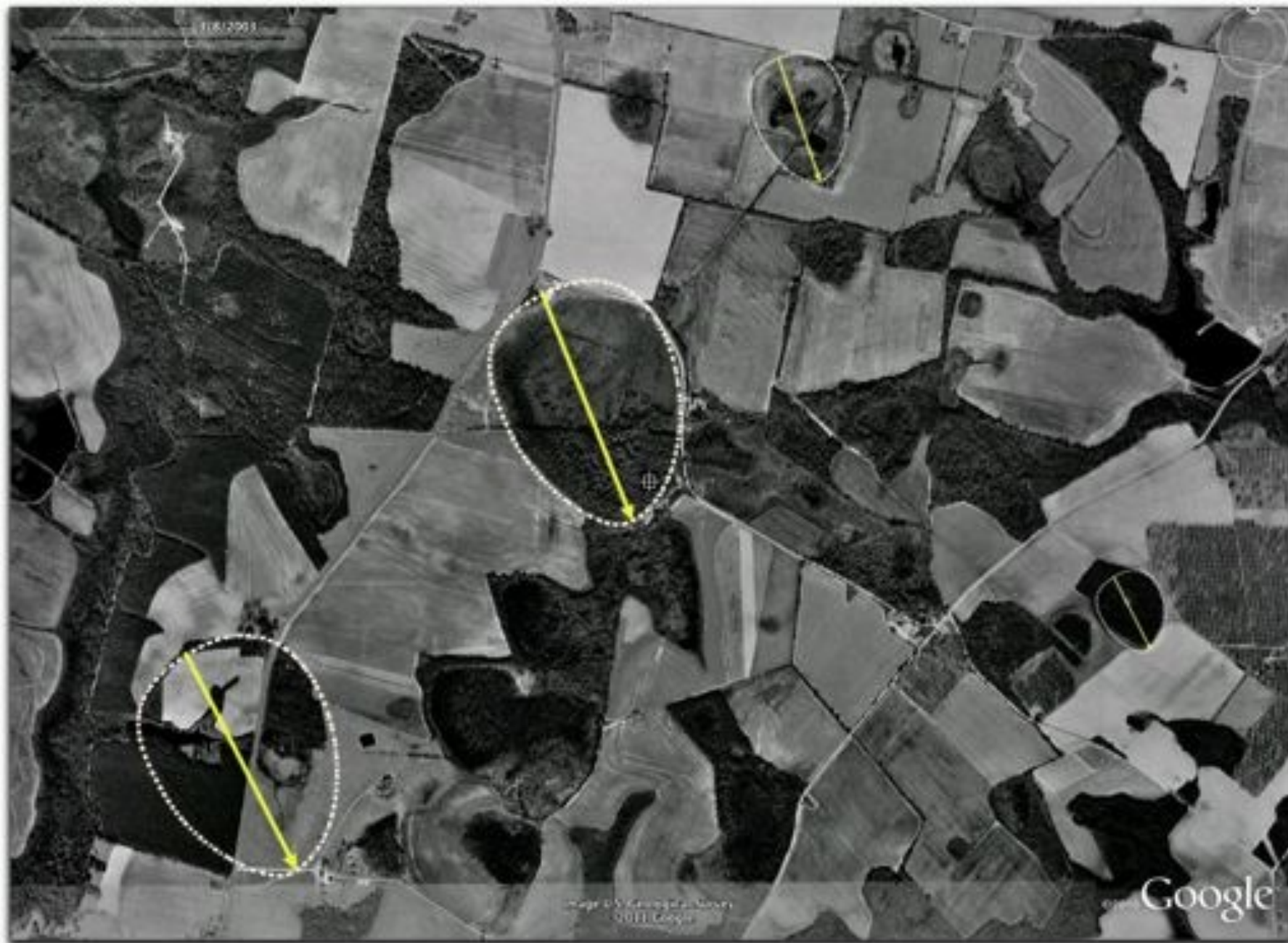
Variations of bay Planforms



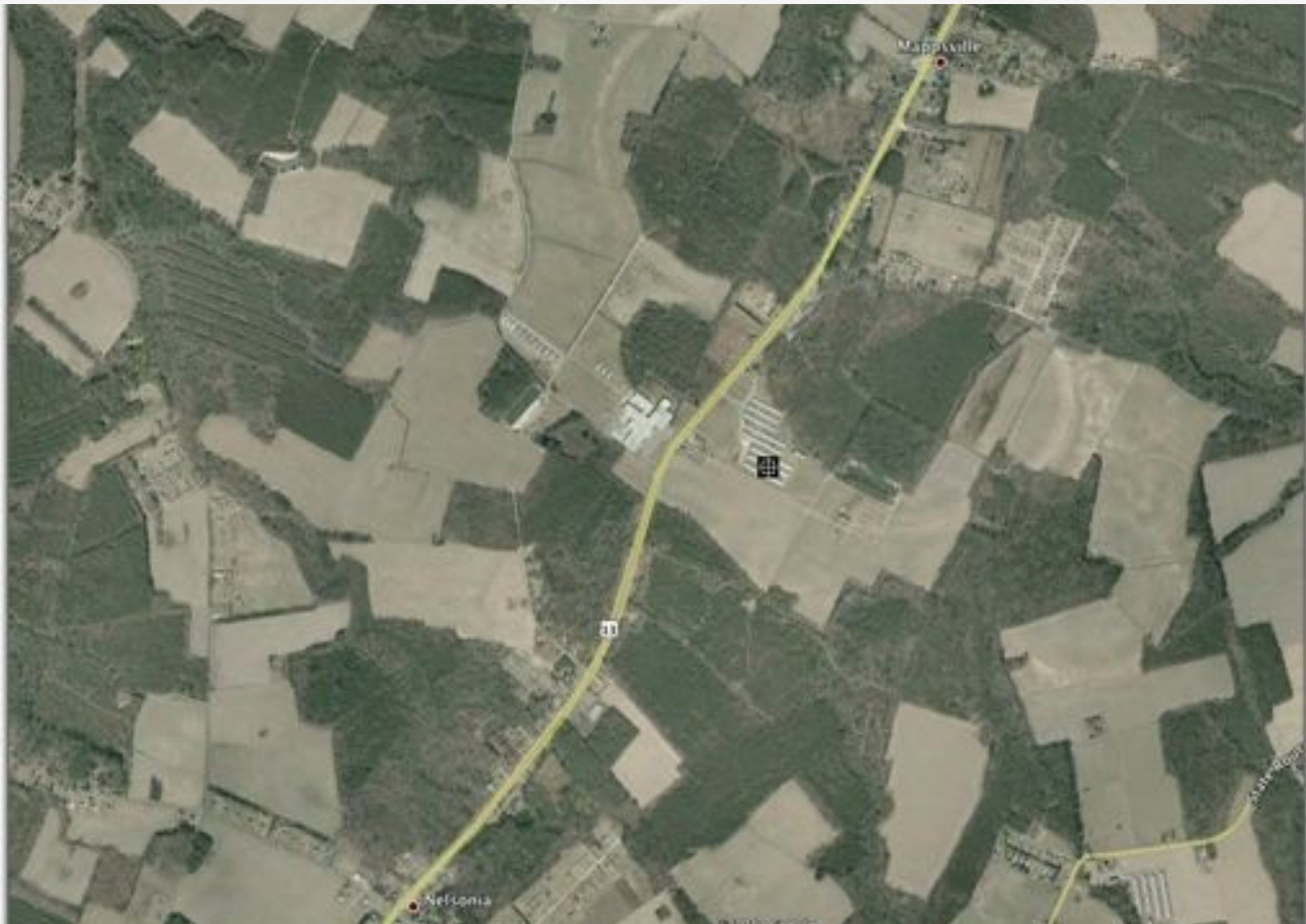
Bay South Prototype Example



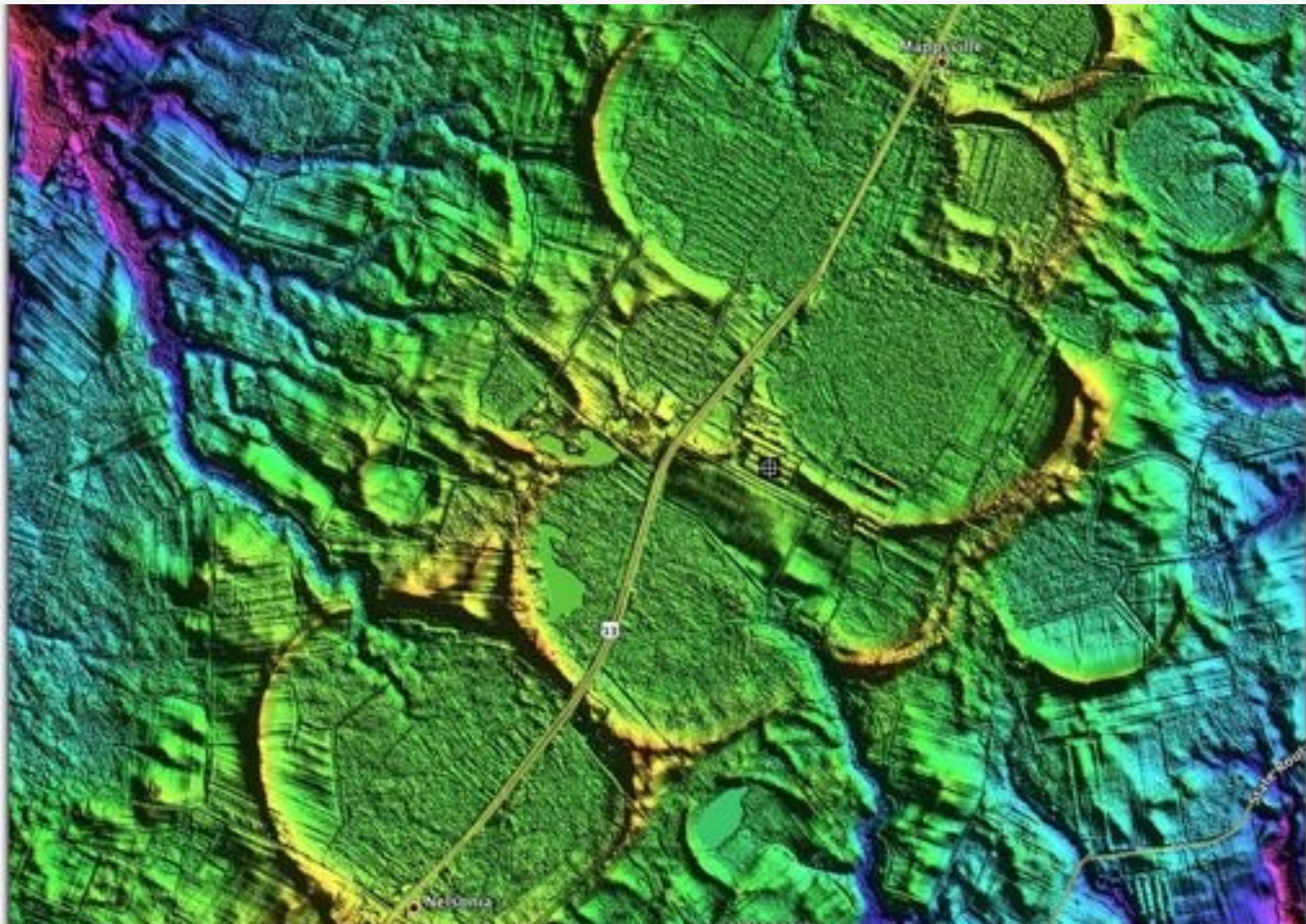
Bay South Prototype Example



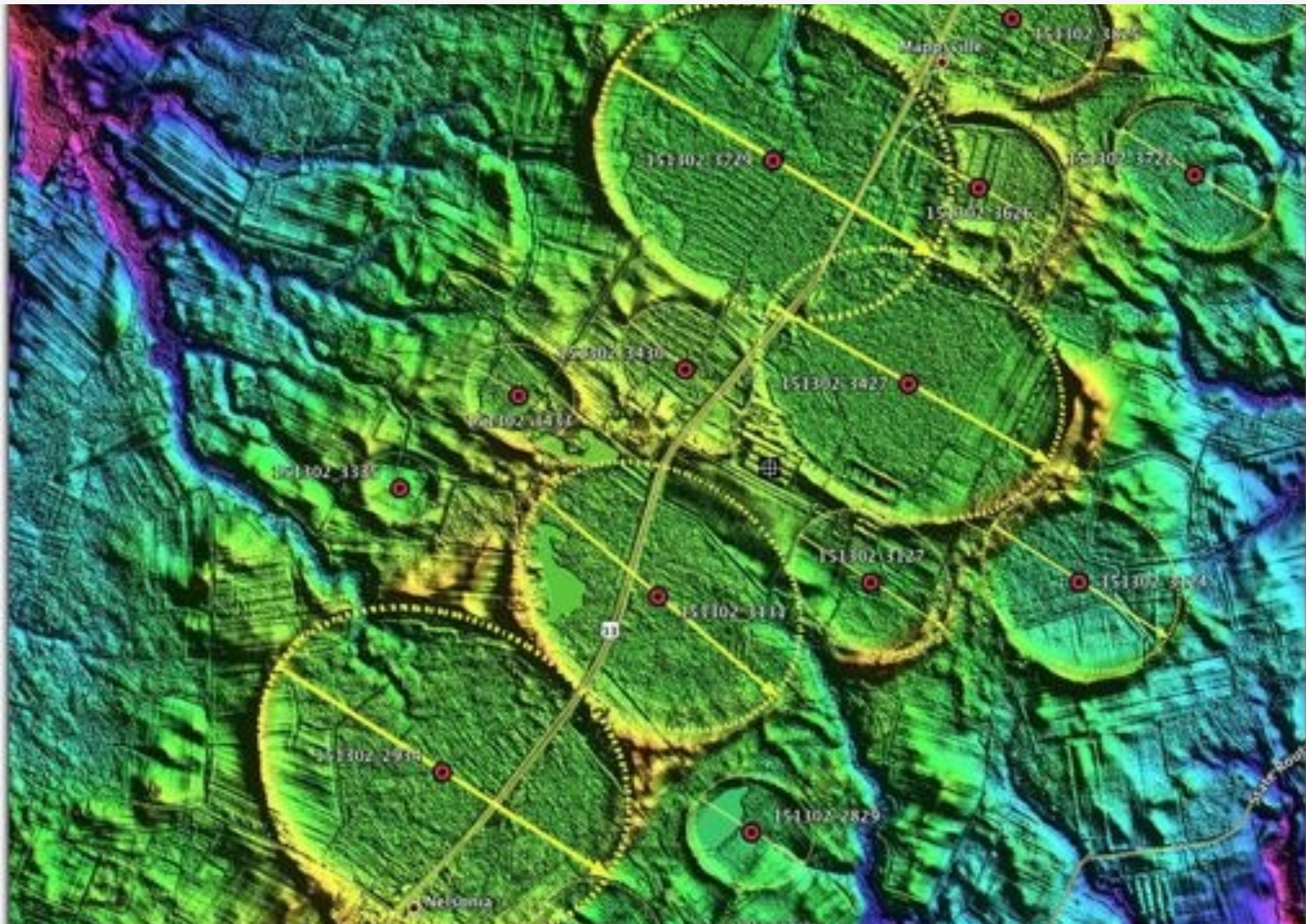
Oval Planform: Virginia Eastern Shore – Mappsville



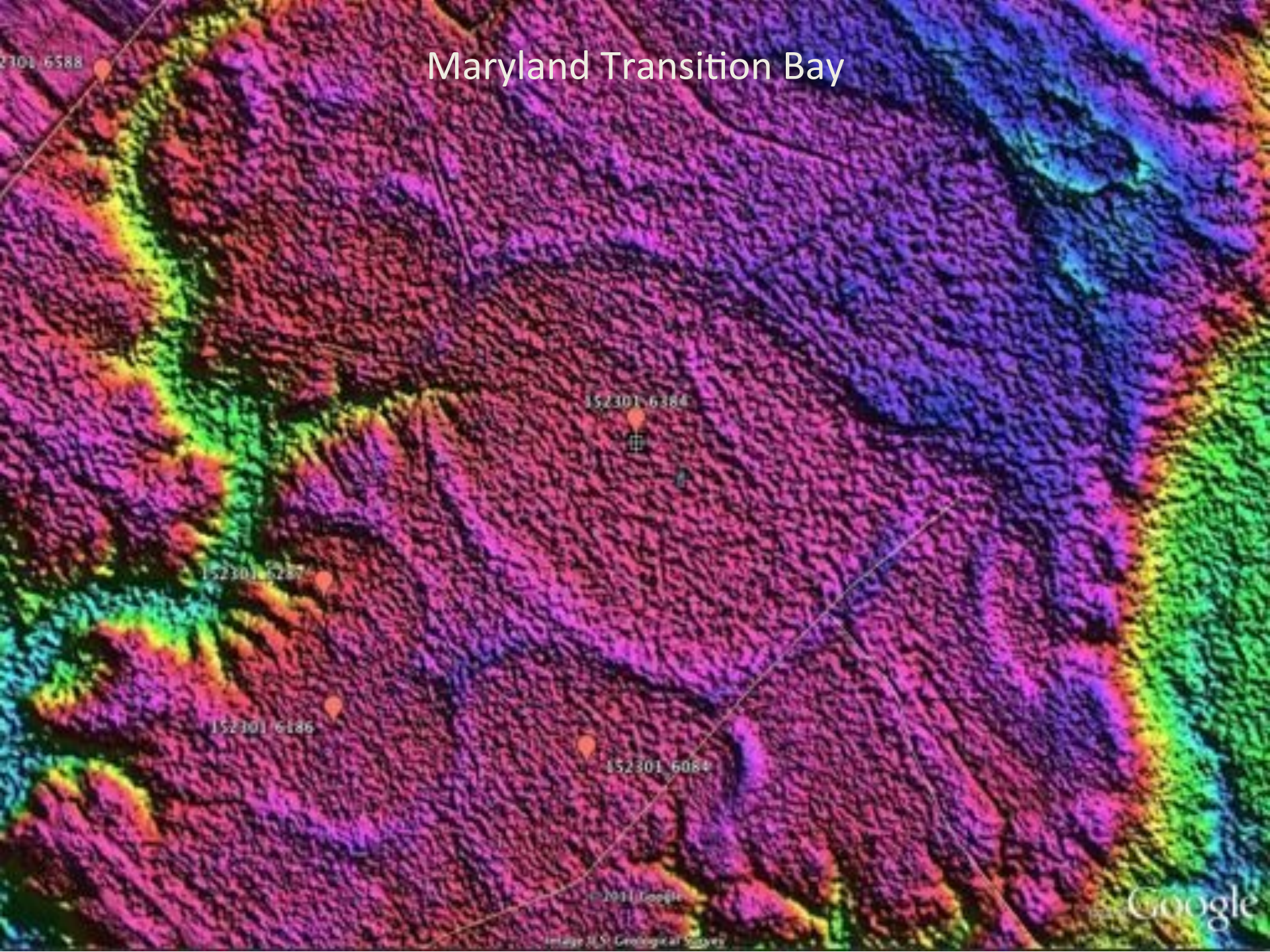
Virginia Eastern Shore – Mappsville



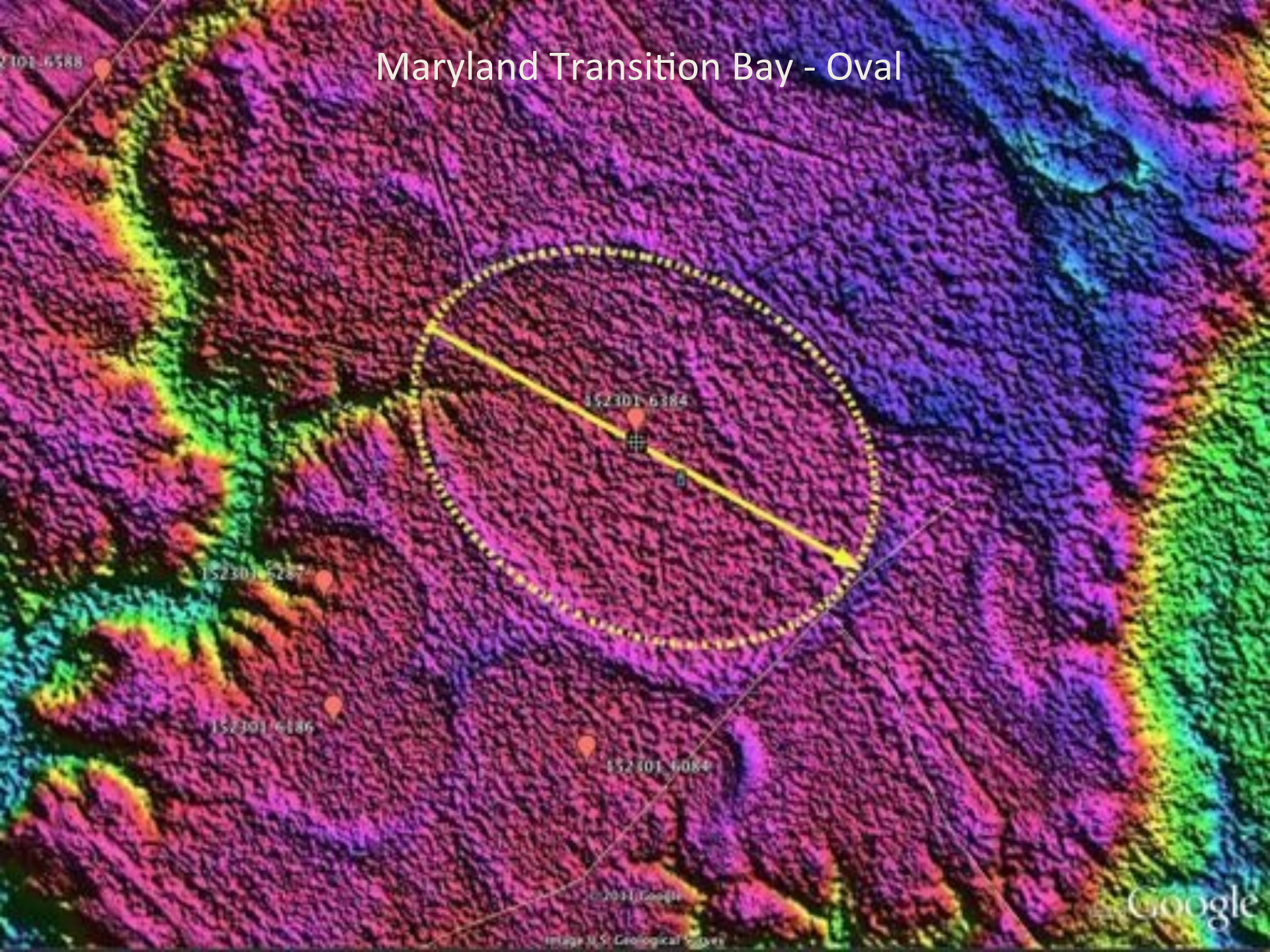
Virginia Eastern Shore – Mappsville



Maryland Transition Bay



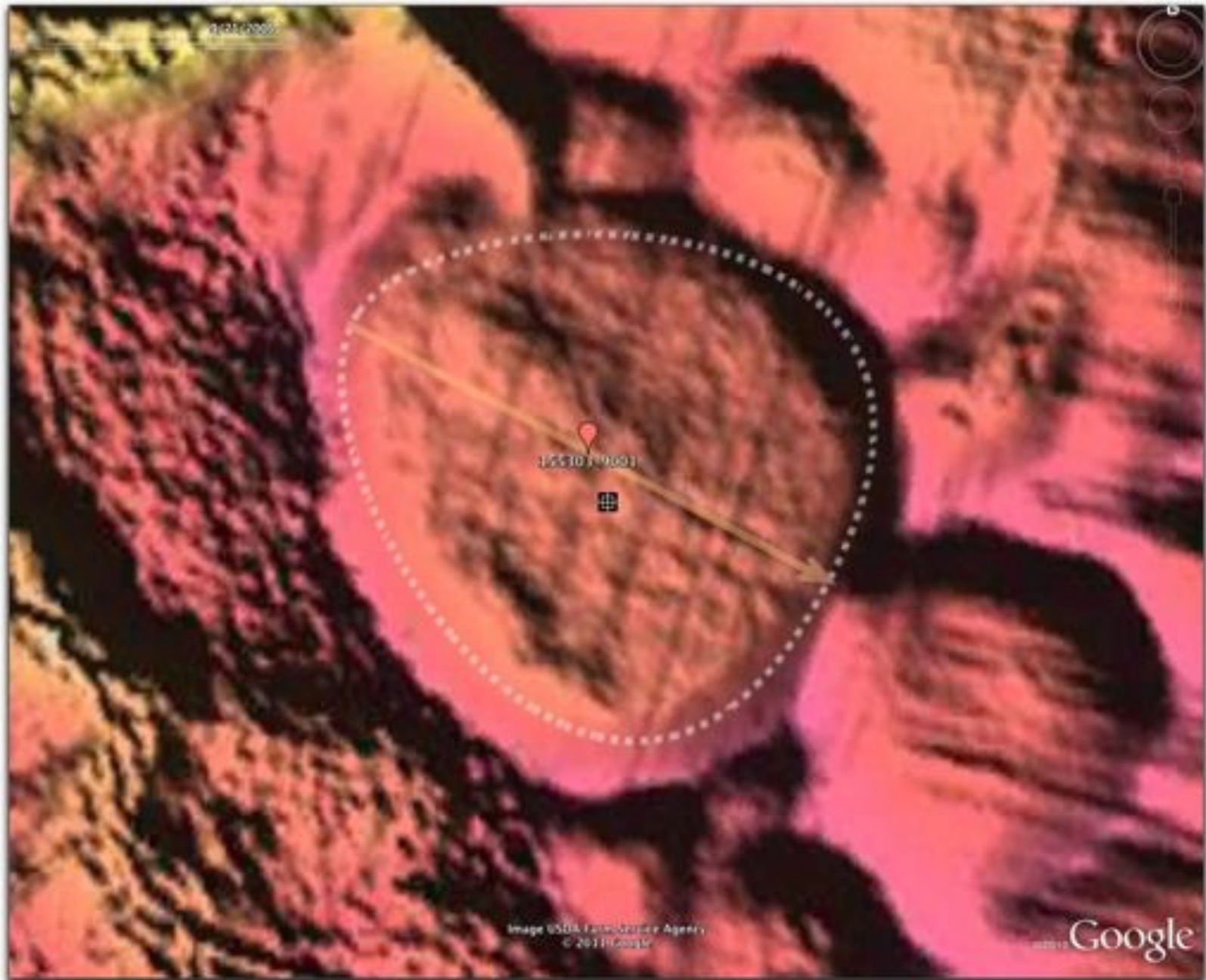
Maryland Transition Bay - Oval



Maryland Transition Bay - Bell



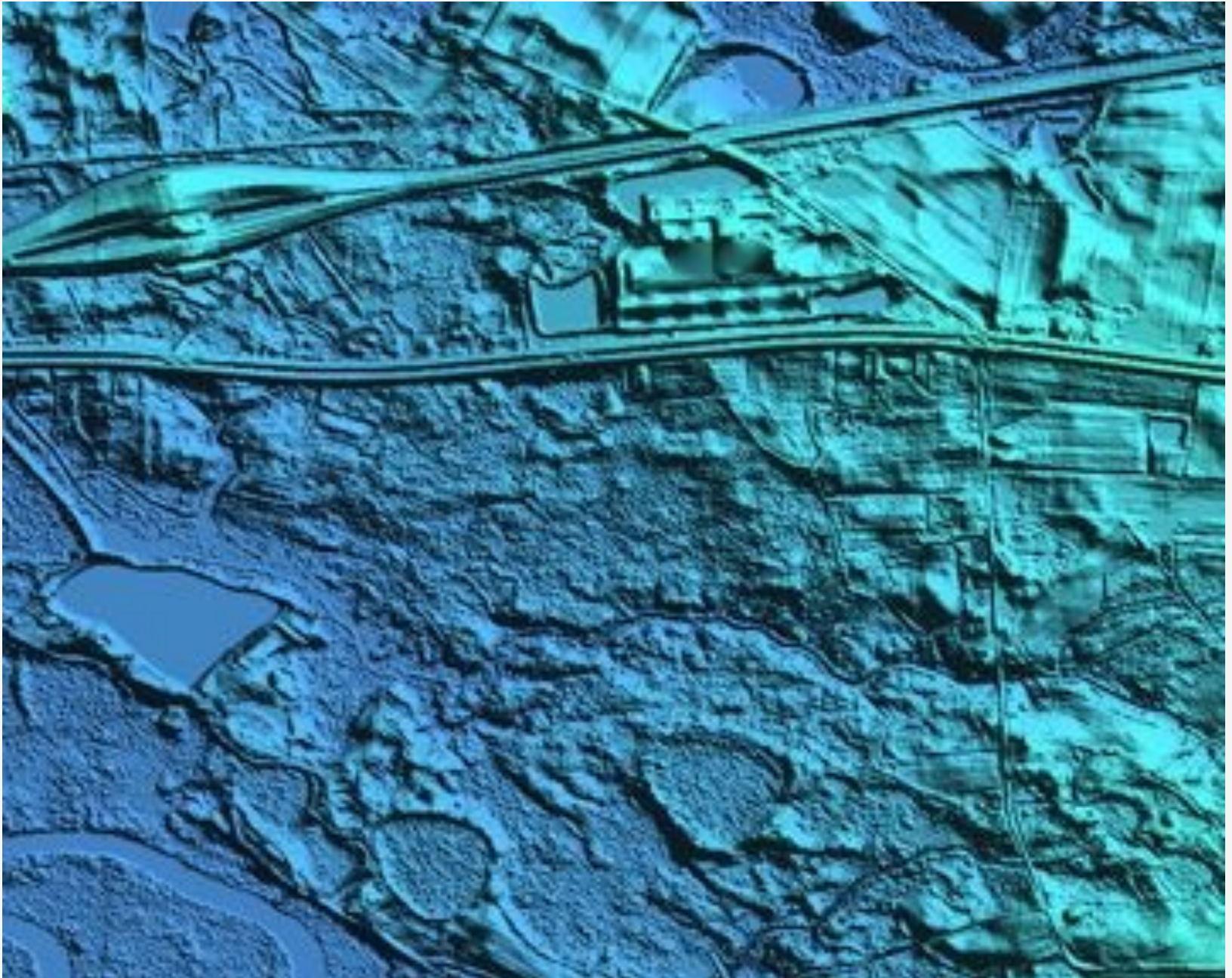
Bell-Shaped bays – MD, DE, NJ



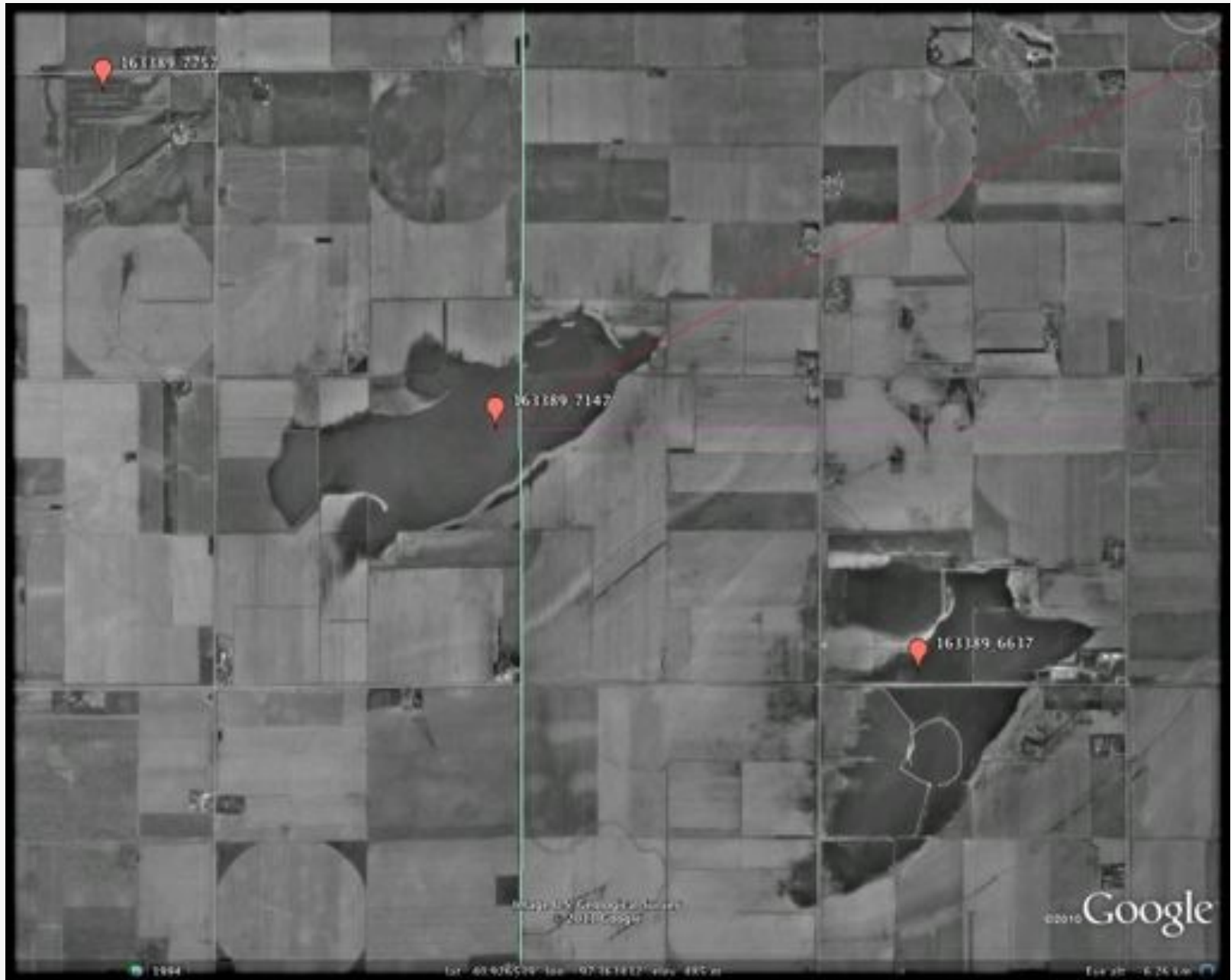
Bell-Shaped bays – MD, DE, NJ



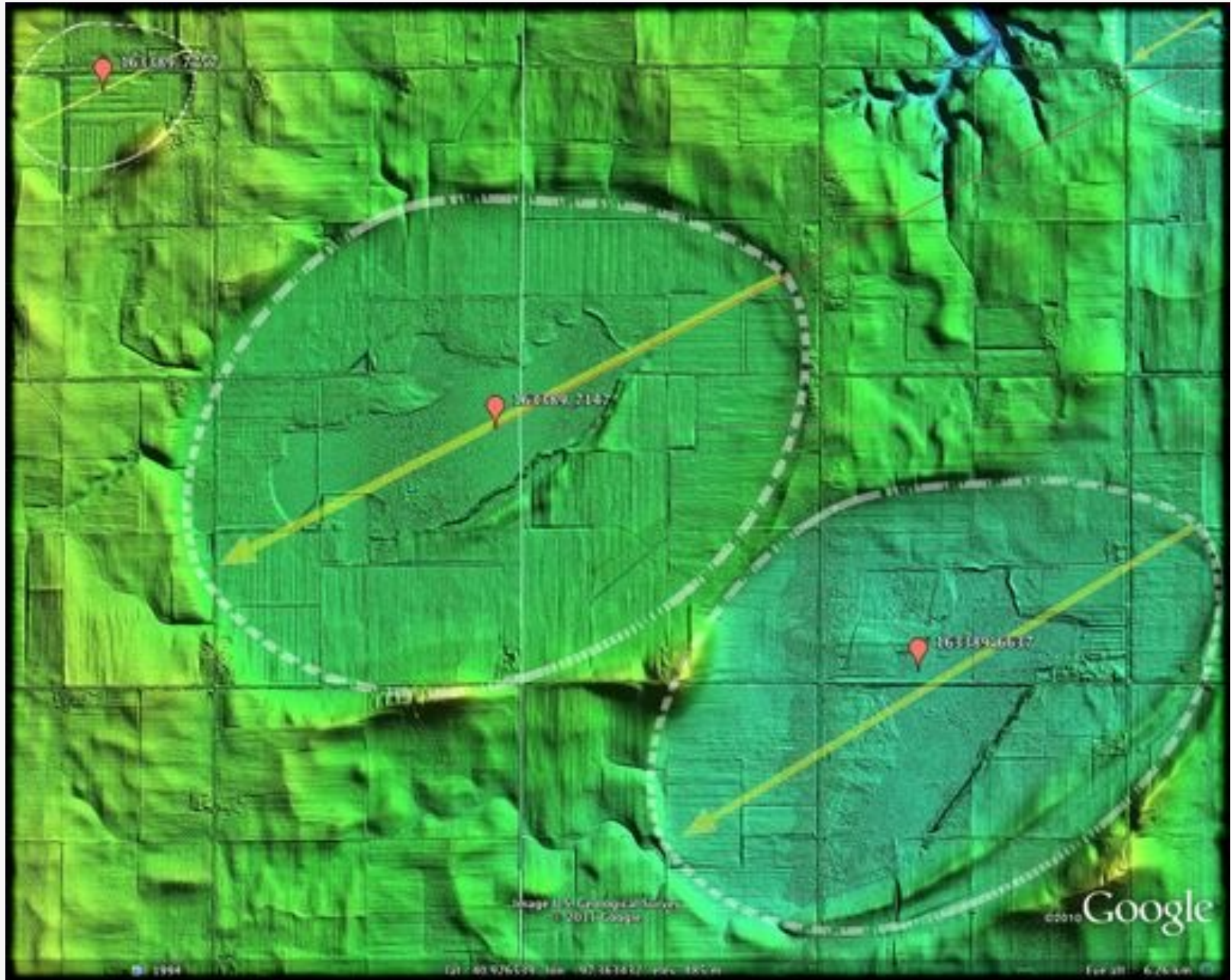
Bell-Shaped bays – MD, DE, NJ



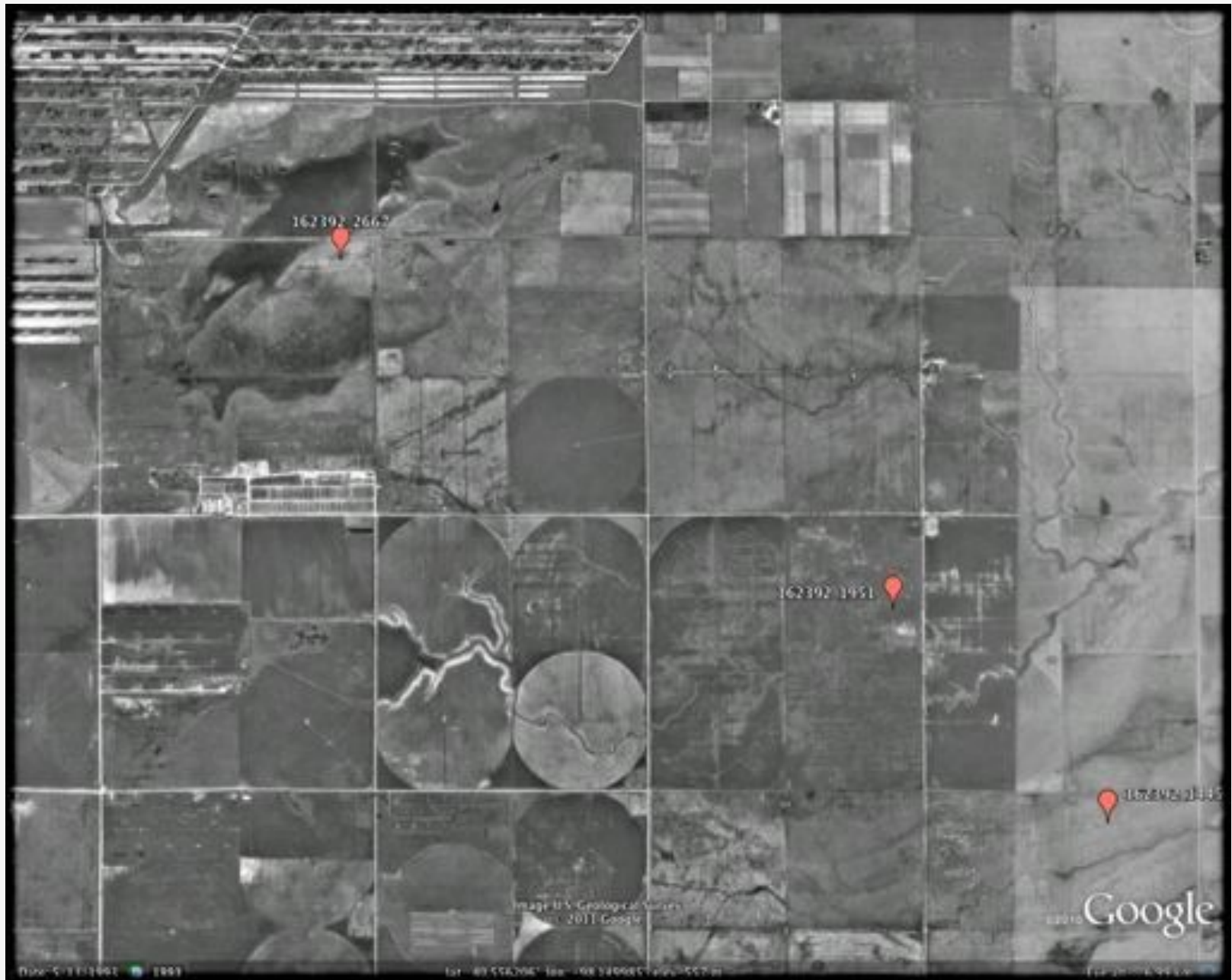
Nebraska “Rainwater Basins”



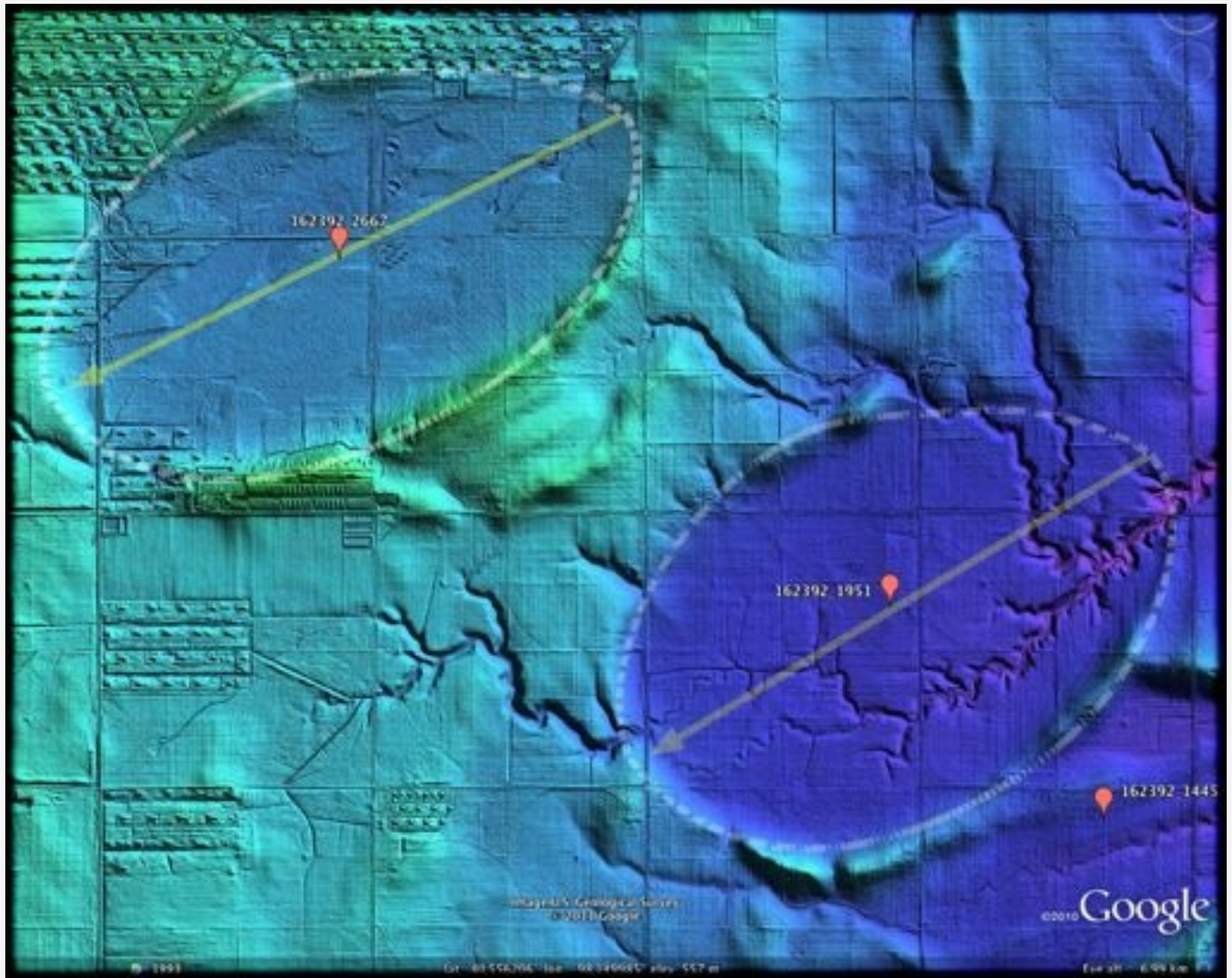
Nebraska Bay Archetype



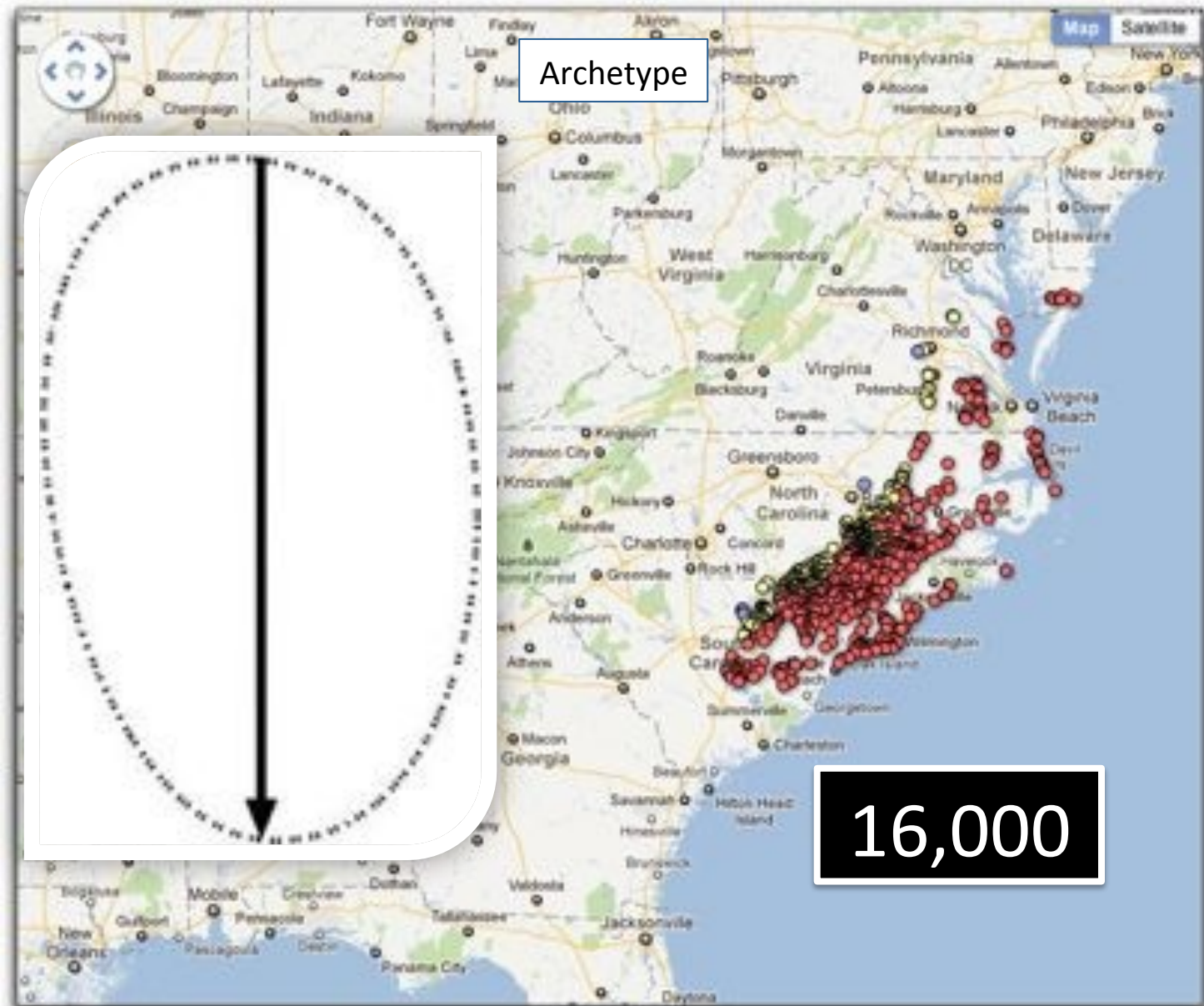
Nebraska "Rainwater Basins"



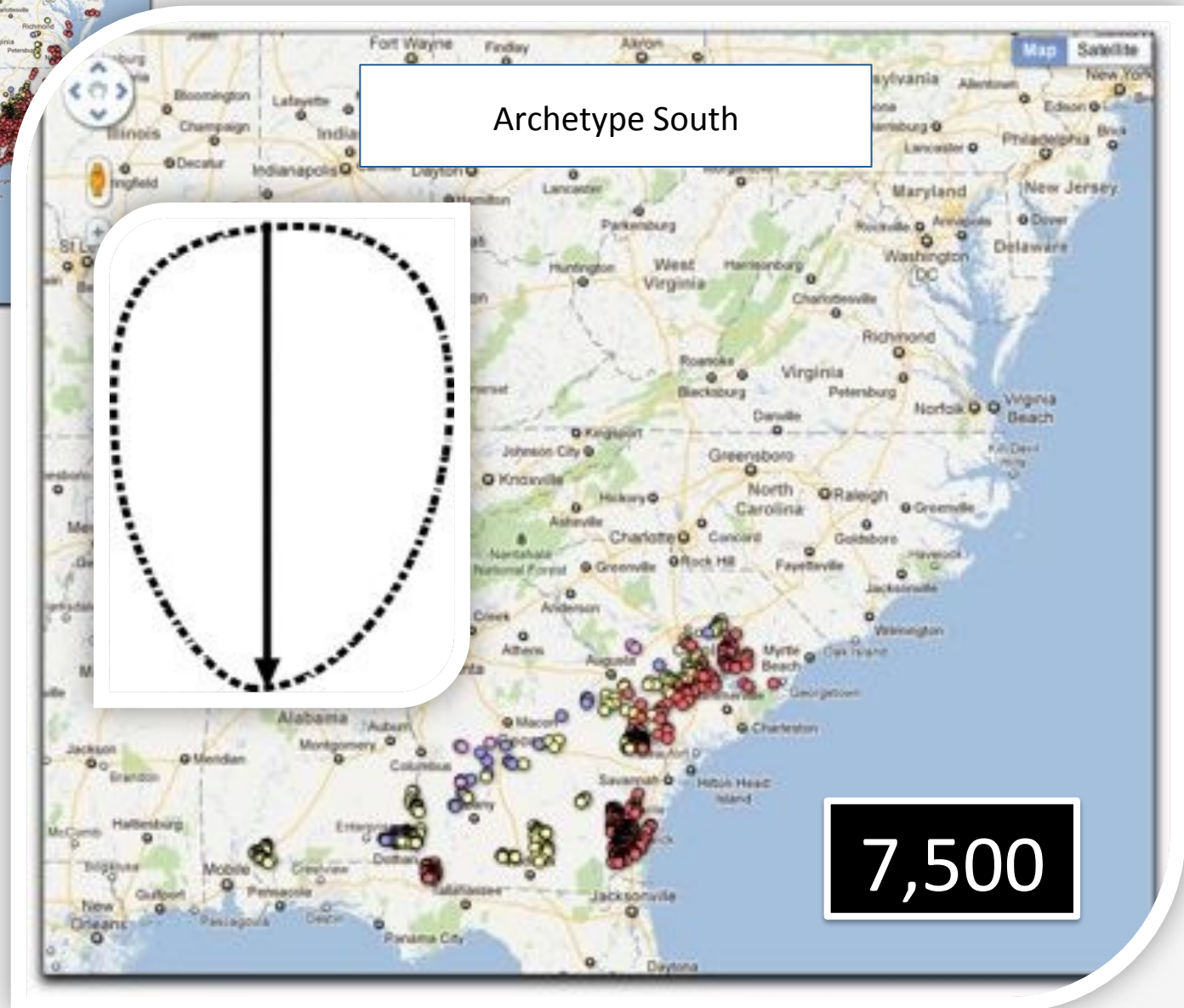
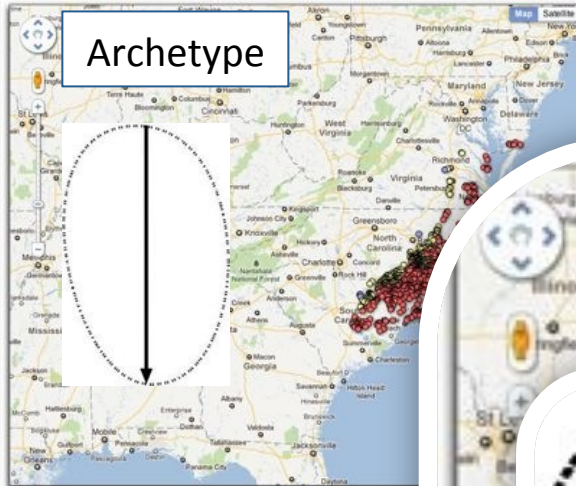
Nebraska Bay Archetype



Extent of Archetype Locales

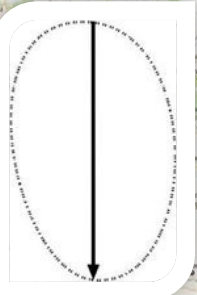


Extent of Archetype Locales

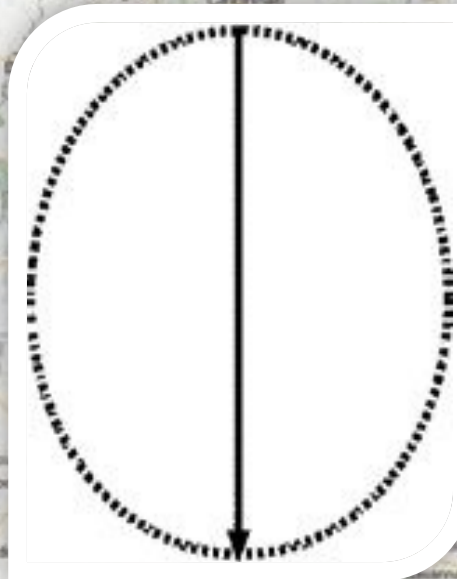


Extent of Archetype Locales

Archetype

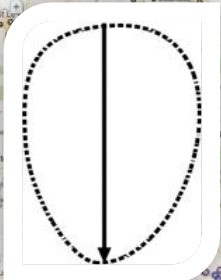


Archetype Oval



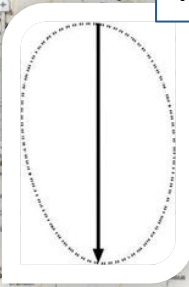
800

Archetype South

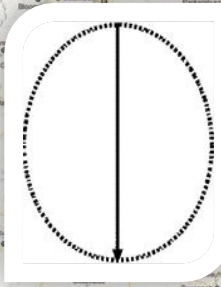


Extent of Archetype Locales

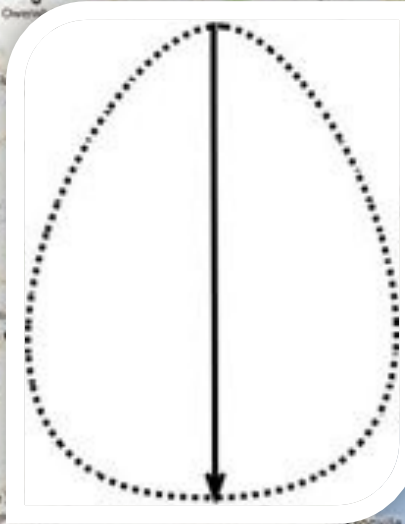
Archetype



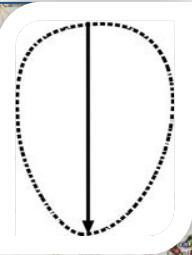
Archetype Oval



Archetype Bell



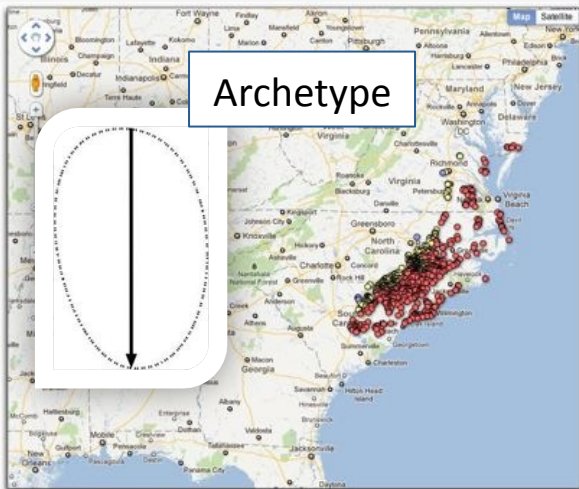
Archetype South



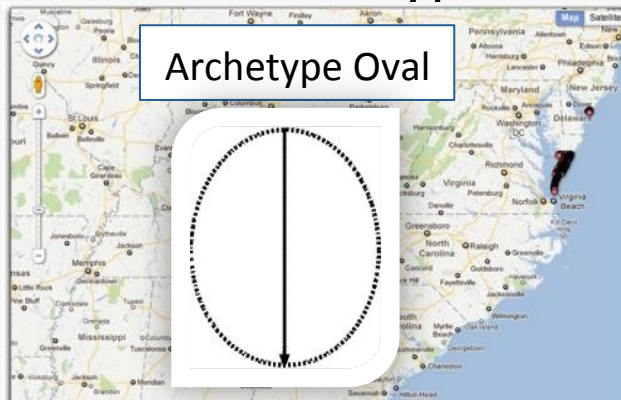
2,100

Extent of Archetype Locales

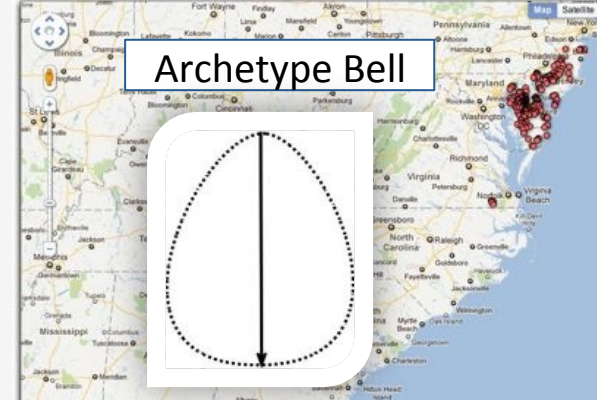
Archetype



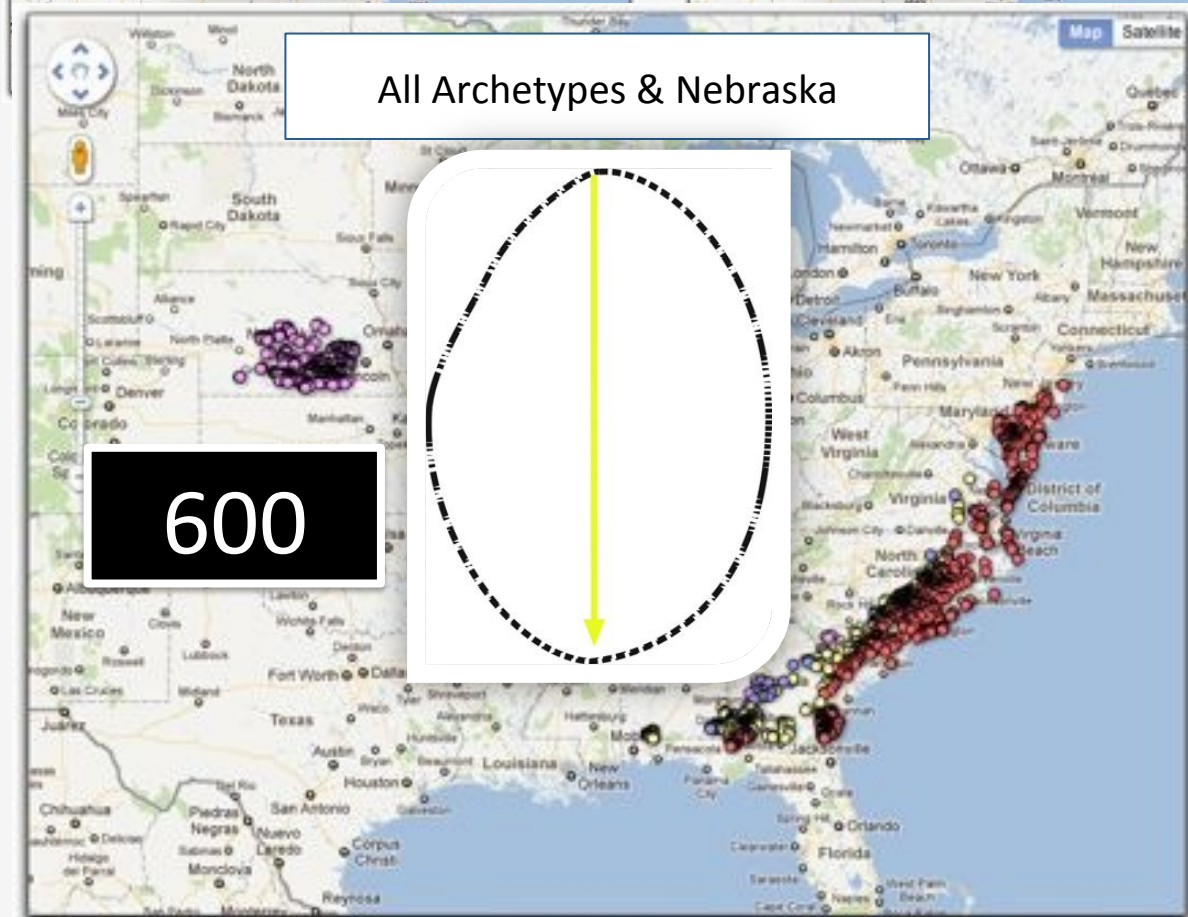
Archetype Oval



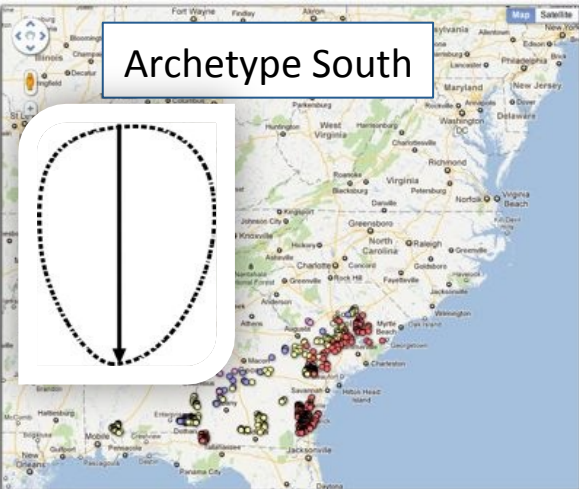
Archetype Bell



All Archetypes & Nebraska



Archetype South



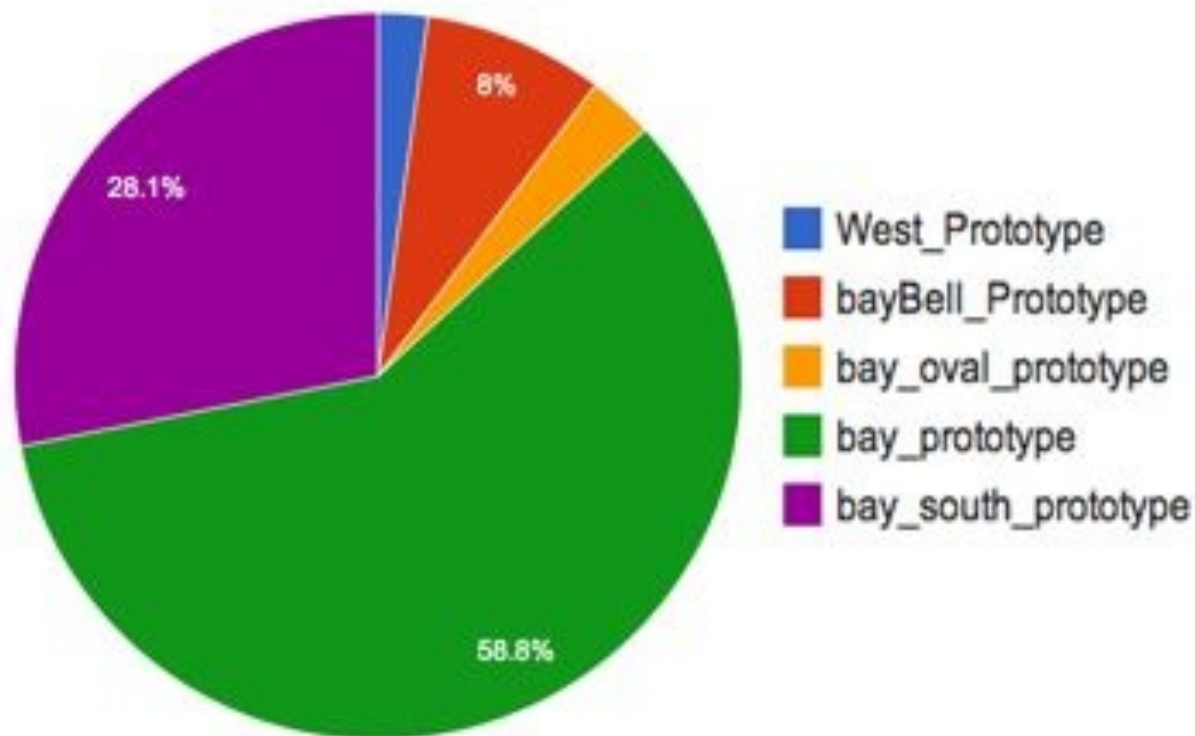
600

Fusion Tables: Metrics by Archetype

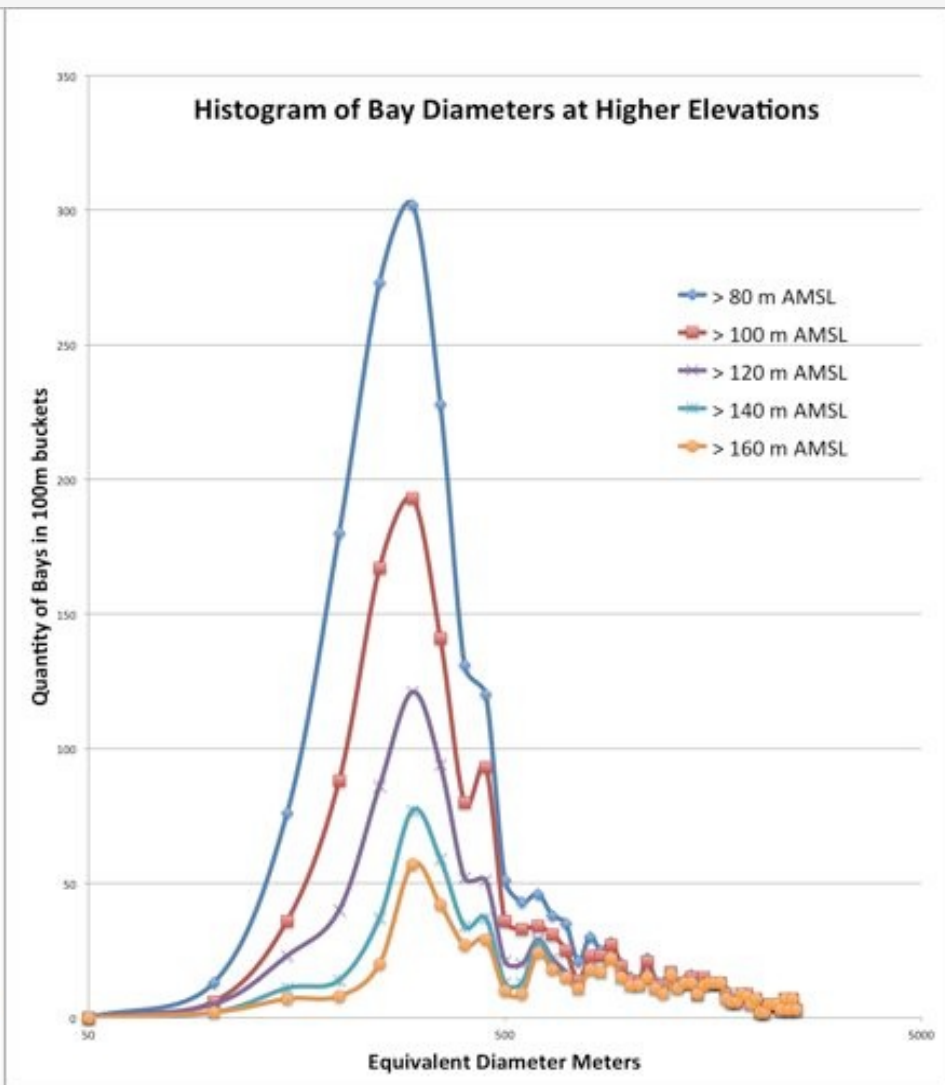
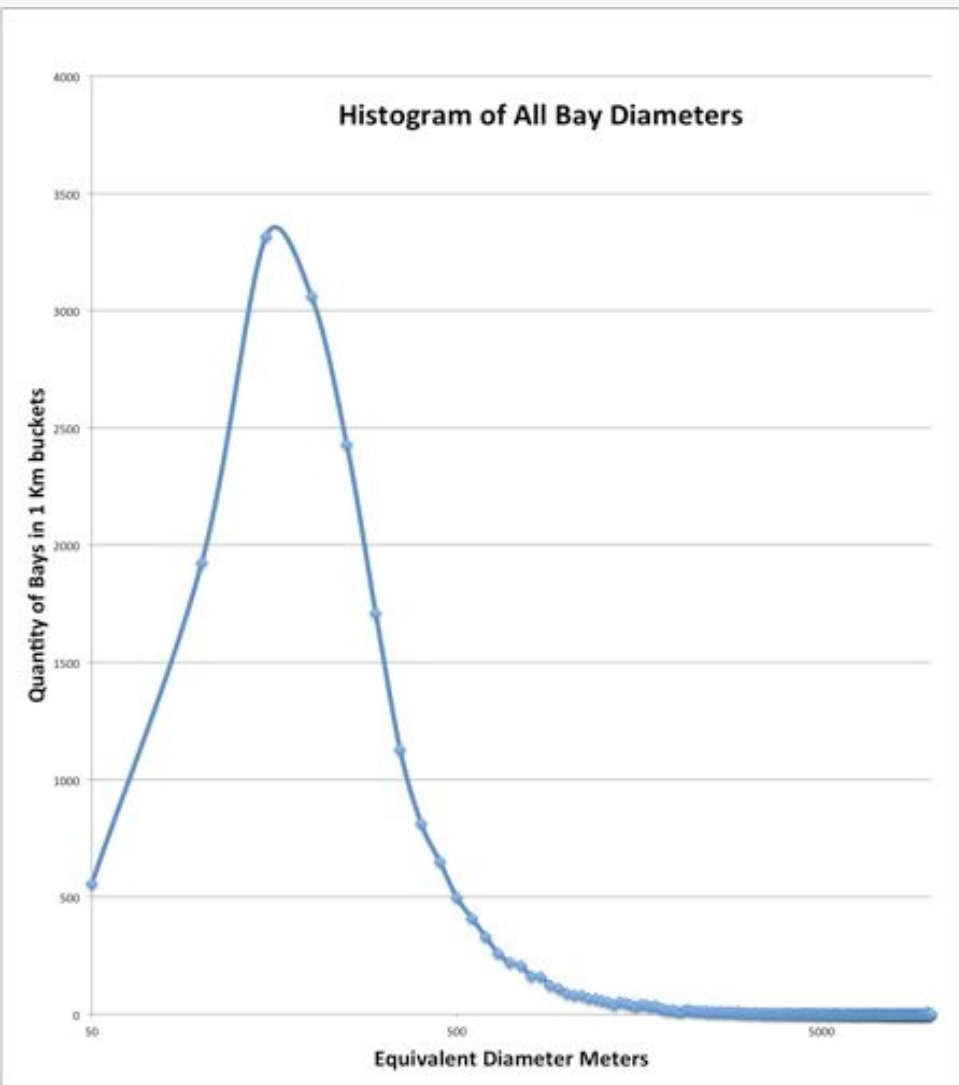
File View Edit Visualize Merge

Showing aggregate AVERAGE(Eccentricity), AVERAGE(Bearing) by Planform [options](#)

Planform ▾	Eccentricity AVERAGE ▾	Bearing AVERAGE ▾	Count ▾
bayBell_Prototype	0.36869	119.08299	2,099
bay_oval_prototype	0.61059	122.25139	768
bay_prototype	0.69814	141.86584	15,411
bay_south_prototype	0.65919	153.0453	7,364
West_Prototype	0.68209	240.63126	579

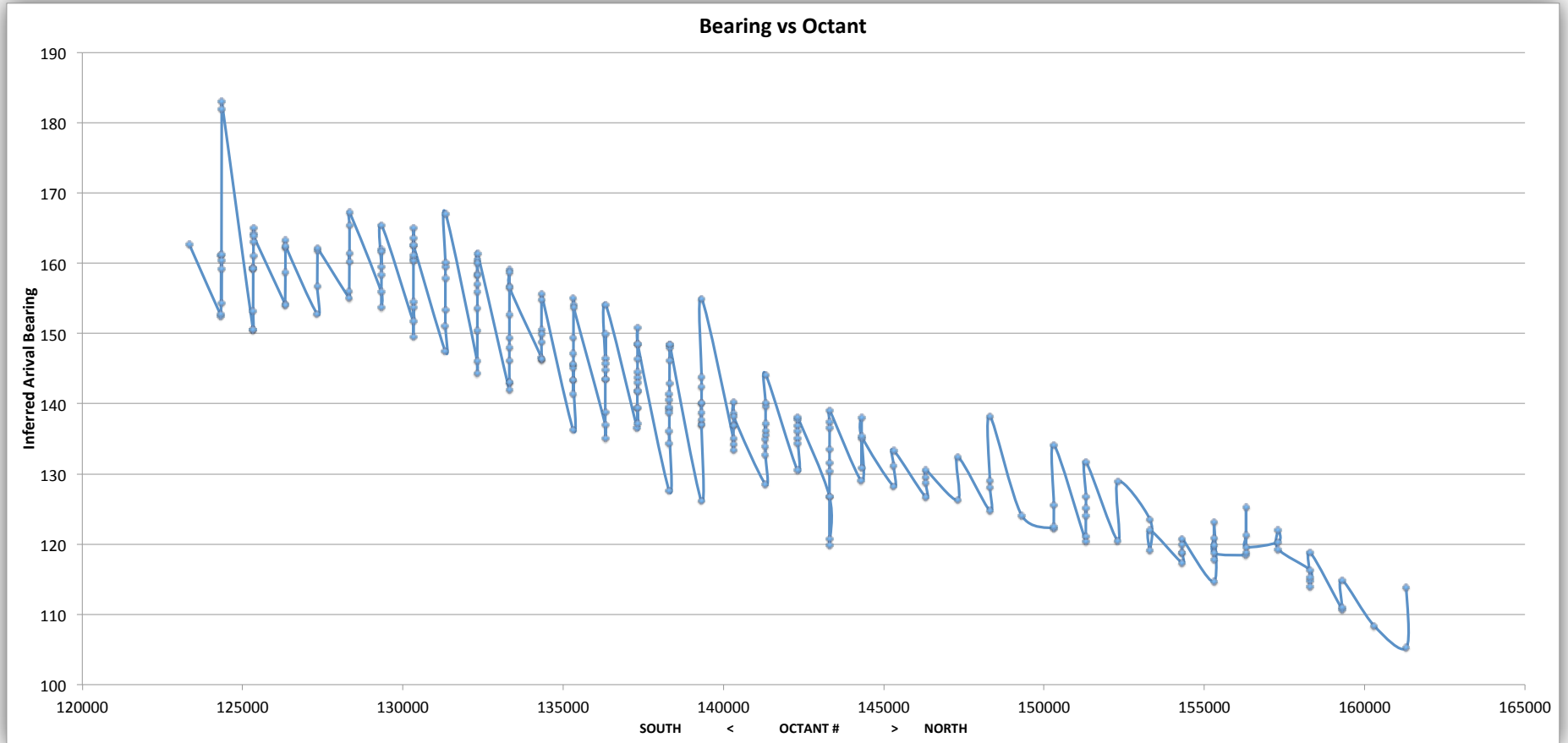


Bay Sizes Exhibit Log-Normal Distribution



Eastern Bay Orientations

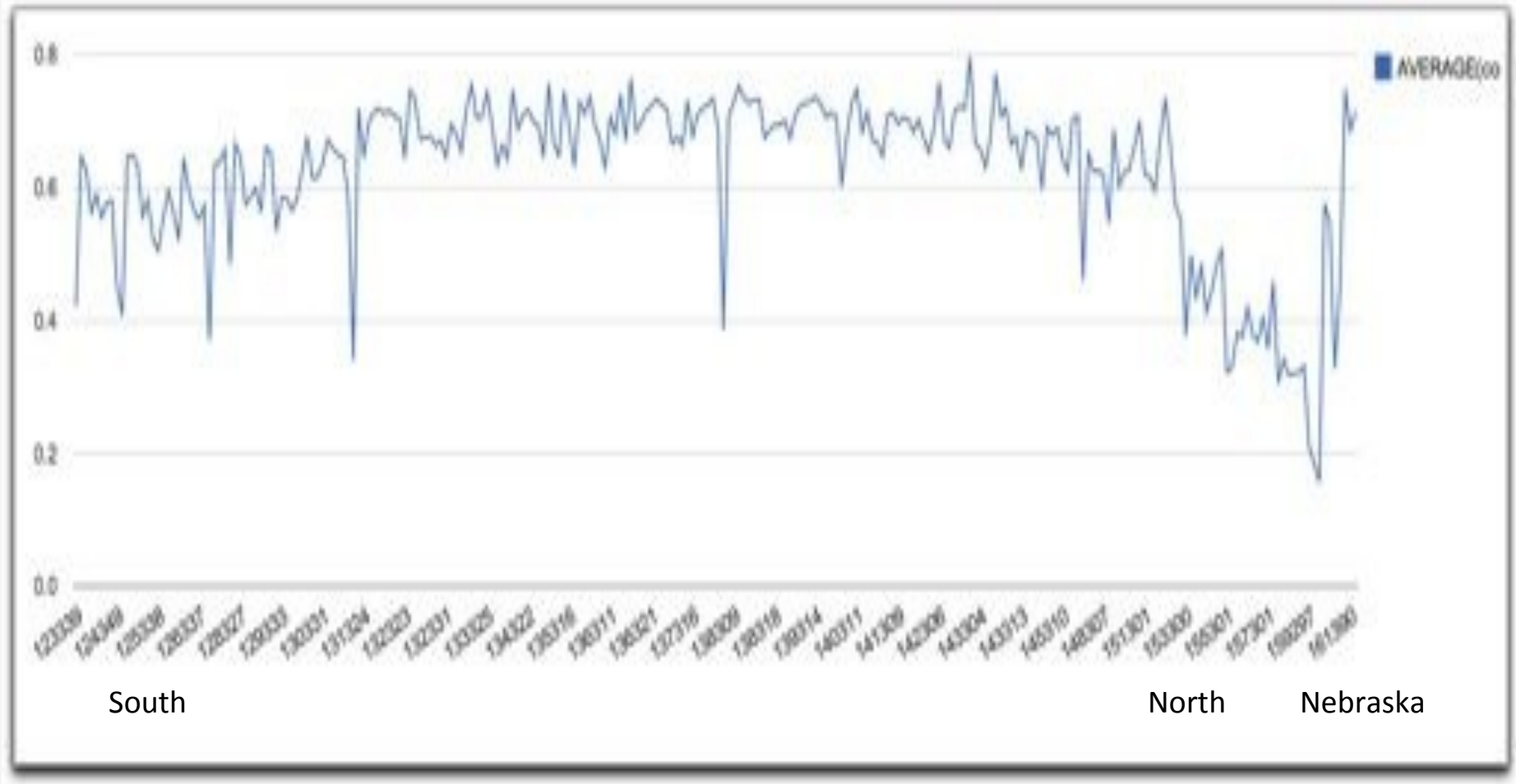
Showing **Longitude > -88**; aggregate **AVERAGE(Bearing)** by Octant



South

North

Fusion Tables: Average Bay Eccentricity by Octant



[illegible]

Summary

- Integrated thousands of LiDAR DEM images into Google Earth
- Identified and Documented ~ 27,000 Individual Bays
- Captured Individual bay Metrics
 - Location
 - Major & Minor Axis: yields Area & Eccentricity
 - Orientation
- Integrated data into Google Fusion Tables
 - Feeds Google Earth visualizations
- Observations
 - Bays exhibit tightly constrained planform shapes
 - Bays exhibit log-normal size distribution
- Survey is Remote Sensing Based Only
 - Ground-proofing efforts are non-existent

Open Questions

- How many bays exist? ... 50,000?
- How were the bays were created?
 - ... but we do speculate....
- Relationship between the various Archetypes
 - due to similar mechanisms?
- Do the orientations suggest a triangulation network focus?

What You Can Do

- Access the Bays Survey, export a copy from cintos.org/bays
- Review individual bay planforms for voracity of identification
- Comment on quality of measurement based on your own observations
- Do statistical analysis on the orientations with a triangulation in mind

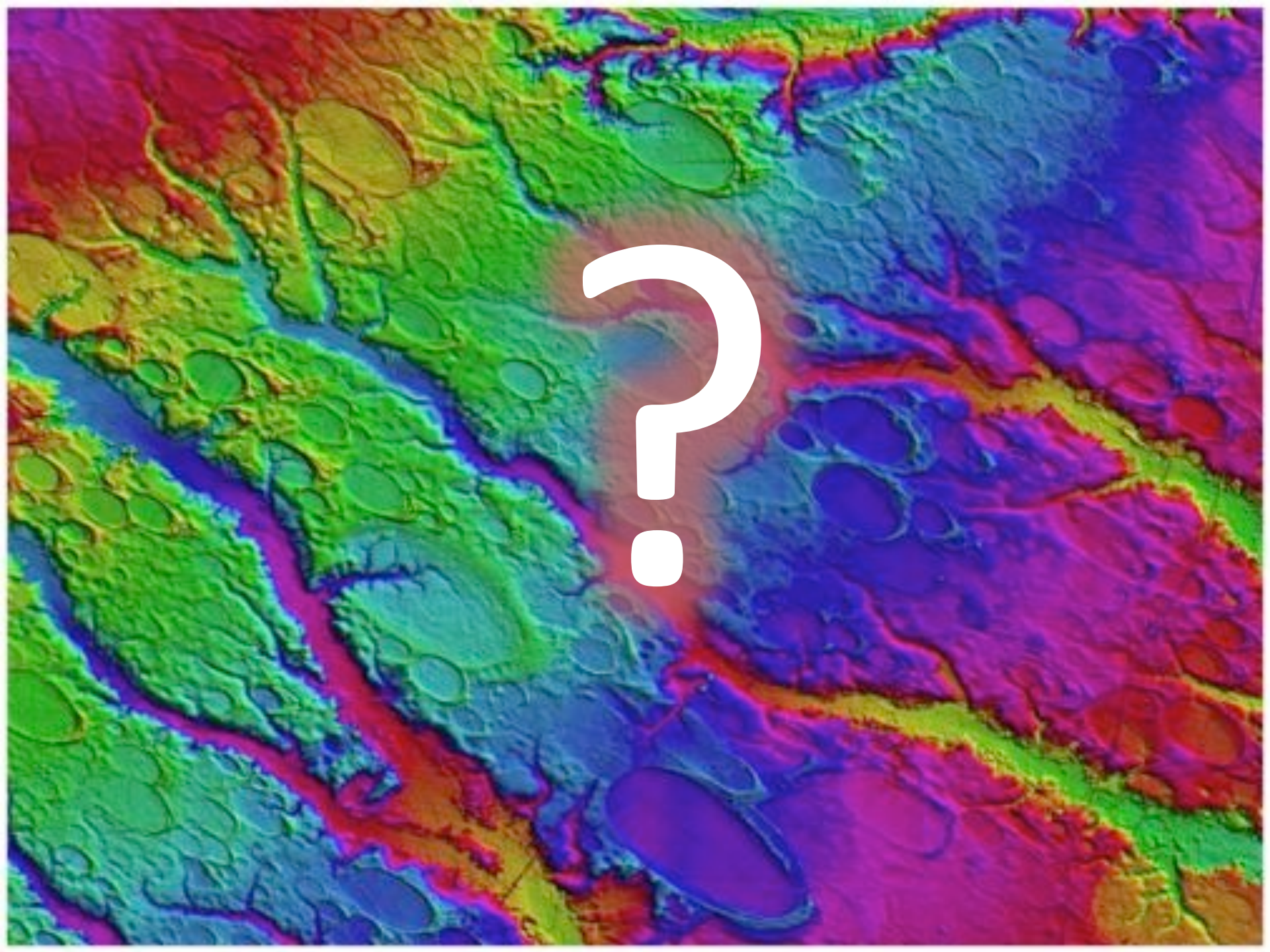
Name +	Minor +	Eccentricity +	Area +	Bearing +	Elevation
139315_0051	0.13	0.729284551	2.14	140.28	
139315_0053	0.19	0.773879118	4.58	140.28	
139315_0056	0.12	0.661437828	1.66	146.91	
139315_0058	0.44	0.692510825	21.14	140.28	
139315_0071	0.12	0.6	1.55	134.79	
139315_0089	0.24	0.686348585	6.35	140.28	
139315_0091	0.36	0.746355992	15.58	140.28	
139315_0161	0.11	0.726184377	1.51	140.28	
139315_0235	0.23	0.736469649	6.26	139.31	
139315_0236	0.09	0.765985092	1.11	139.31	
139315_0262	0.24			140.28	
139315_0289	0.46			139.31	
139315_0292	0.18			140.28	
139315_0335	0.21			142.06	
139315_0363	0.14			140.28	
139315_0370	0.69			137.75	
139315_0374	0.16			140.28	
139315_0380	0.4			140.28	
139315_0382	0.4	0.754985783	19.52	140.28	

Cell: (139315_0262 | Bearing)

Current Cell value: 140.28

Enter your comment

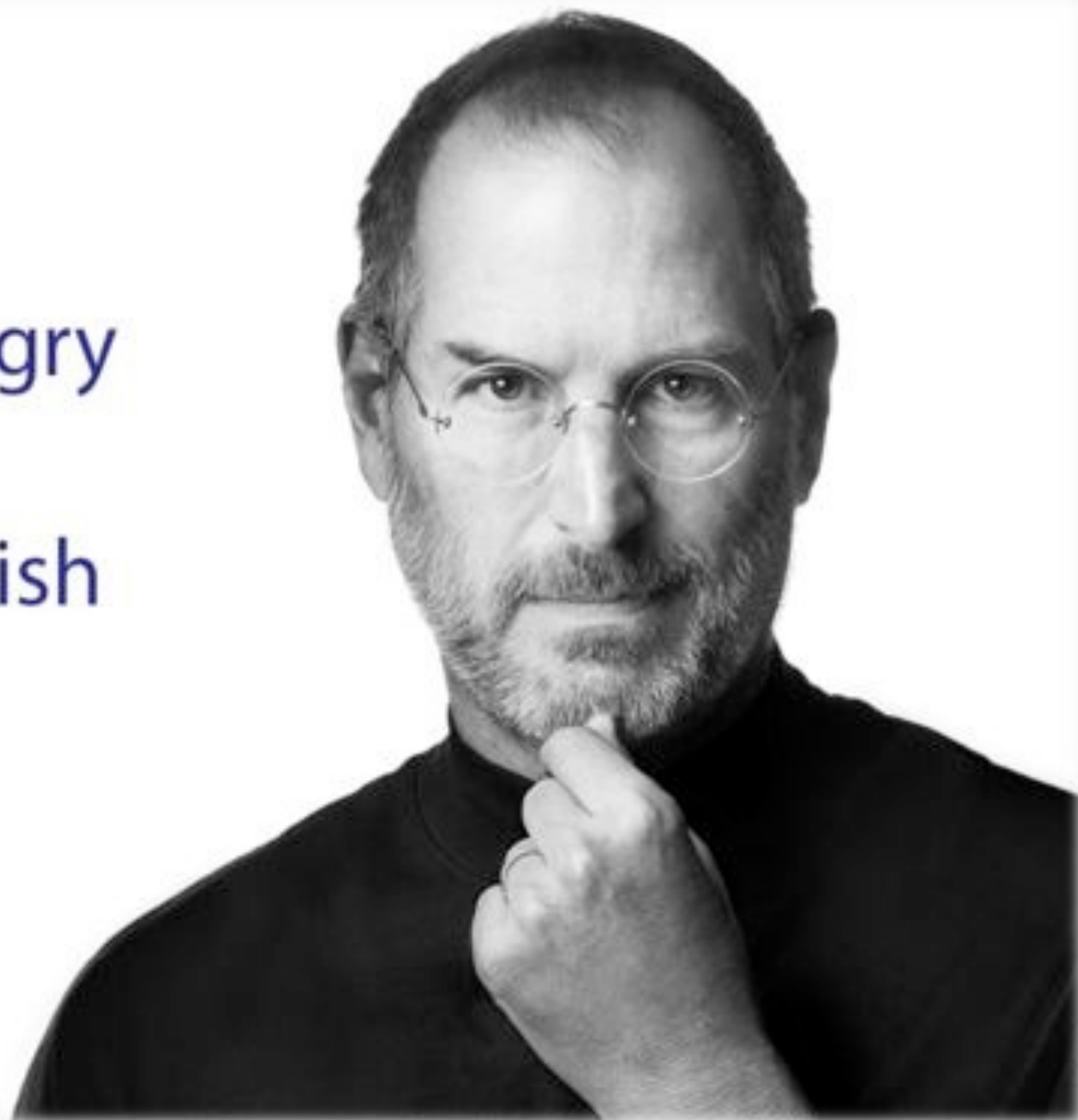
Save comment

The background is a complex, multi-colored texture. It features a mix of vibrant colors including red, orange, yellow, green, blue, and purple. The texture appears to be composed of many small, irregular shapes and patterns, giving it a marbled or cellular appearance. A large, white, stylized question mark is centered in the image, standing out prominently against the colorful background.

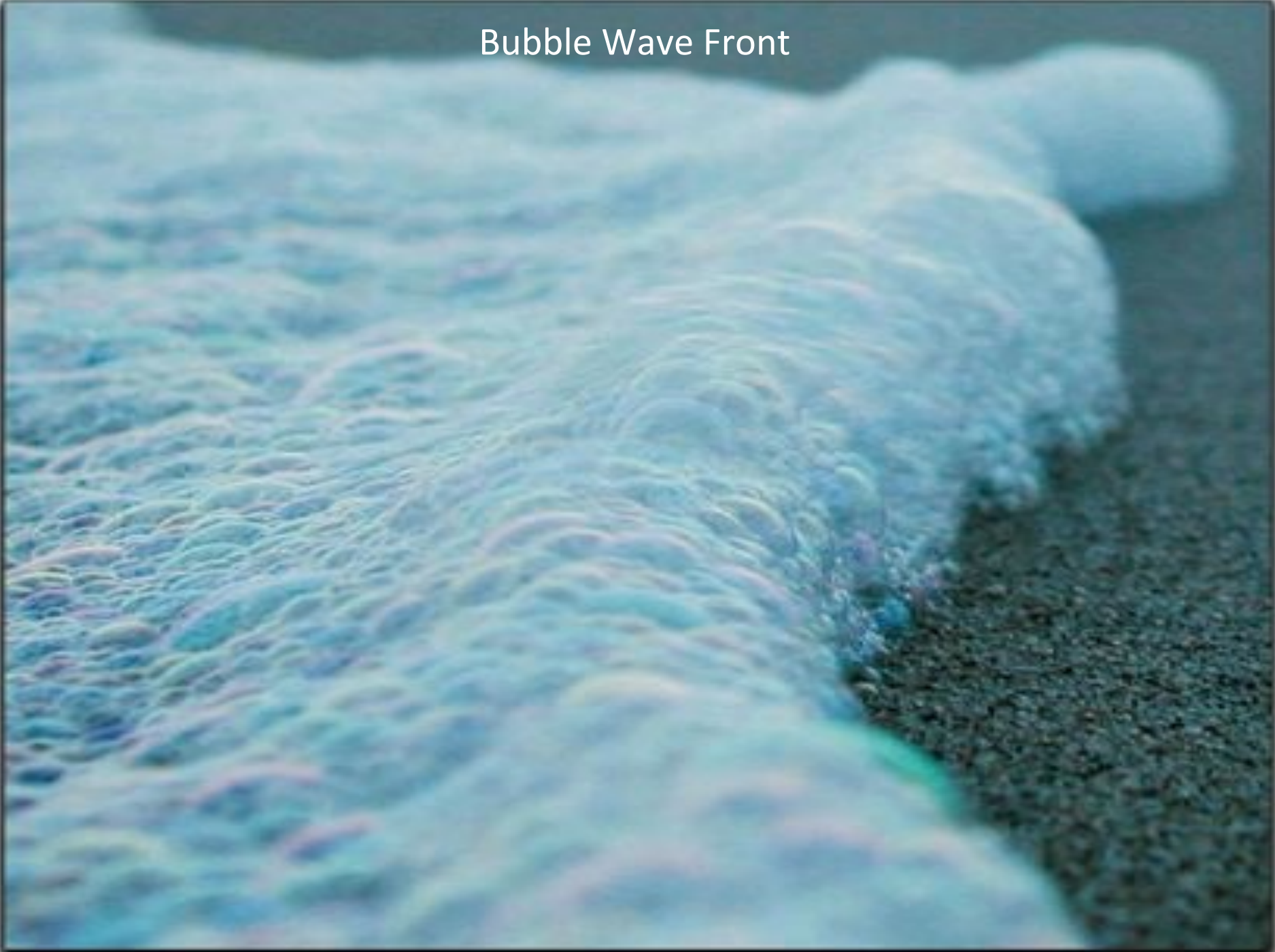
?

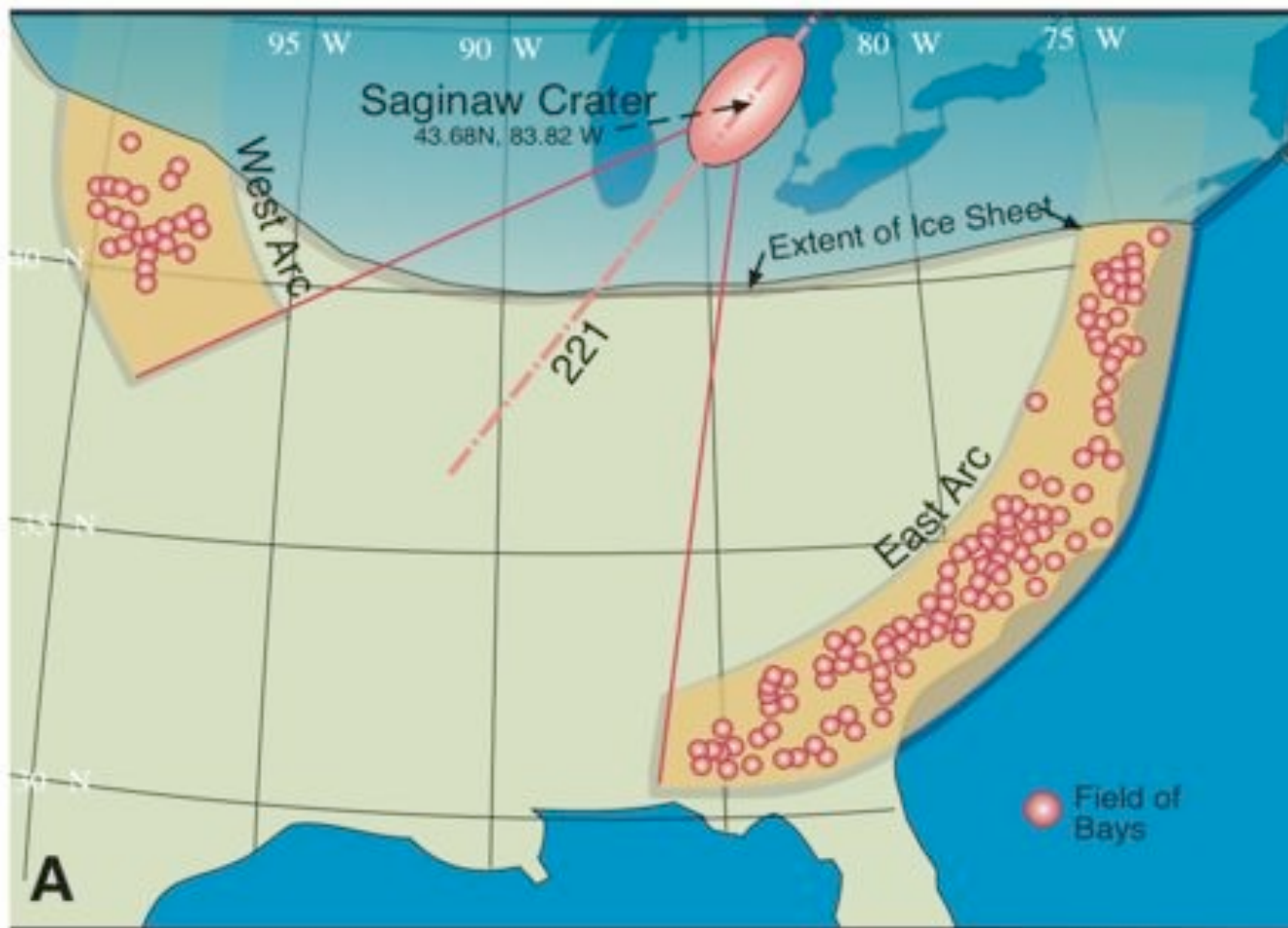
Stay Hungry

Stay Foolish



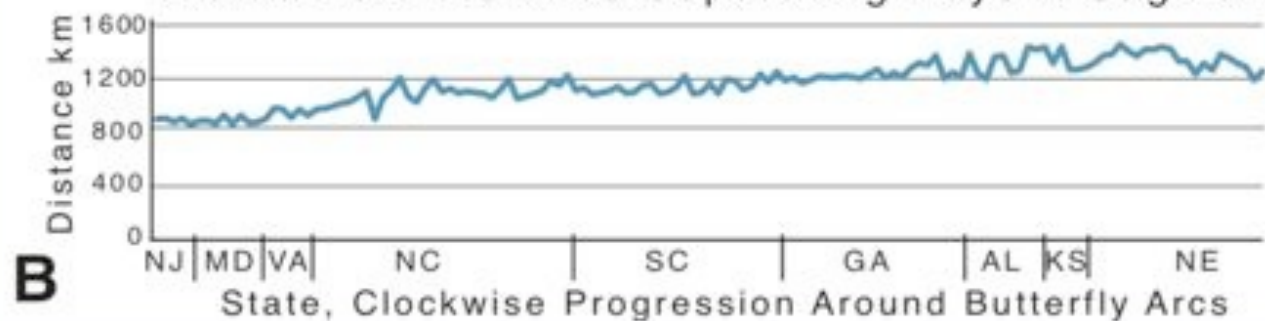
Bubble Wave Front





A

Radial Loft Distance Separating Bays & Saginaw



B

Abstract

LIDAR DIGITAL ELEVATION MAPS EMPLOYED IN CAROLINA BAY SURVEY

DAVIAS, Michael, Stamford, CT 06907, michael@cintos.org

and GILBRIDE, Jeanette L., North Carolina State University, Raleigh, NC 27695

Aerial photographs of Carolina bays taken in the 1930's sparked research into their geomorphology, but revealed only part of their unique planforms. Digital Elevation Maps (DEMs), using LiDAR-derived data, accentuate the visual presentation of these shallow basins. To support a geospatial survey of Carolina bay landforms in the continental US, 400,000 km² of hsv-shaded DEMs were created as KML-JPEG tile sets for visualization on a virtual globe. A majority of these DEMs were generated with LiDAR data, while the remainder represents USGS 1/3 arc second data. We demonstrate the tile generation process and their integration into Google Earth for open public access over the Internet. While the generic Carolina bay planform is considered oval, we document regional variations. Using a small set of empirically derived planform shapes, we created Google Earth overlay elements to support the manual capture of individual Carolina bay shapes and orientations. The resulting overlay data element for each measured bay is extracted from Google Earth and programmatically processed to generate metrics such as geographic location, elevation, surface area and inferred orientation. When visualized in LiDAR, we document the robustness of a single planform shape across hundreds or thousands of basins within geographically large areas. We maintain that utilizing a virtual globe facility for data captures and extraction results in more reliable data sets compared to processes that reference flat map projections. This is especially true when capturing the geospatial shape and orientation of the bays, which can be skewed and distorted in the projection process. Using the process described, we have measured over 25,000 distinct Carolina bays, and have assembled their individual characteristics into a geographic information database. We examine the Google Fusion geospatial visualization facility, through which the database has been made publically accessible. Preliminary findings from the survey are briefly discussed, such as how bay surface area, eccentricity and orientation vary within and across $\sim 700 \frac{1}{4}^{\circ} \times \frac{1}{4}^{\circ}$ grid elements.

Session No. 165 - Seeing the True Shape of Earth: Quantitative and Qualitative Applications of Airborne LiDAR
Minneapolis Convention Center: Room 101DE, 8:00 AM-12:00 PM, Tuesday, 11 October 2011