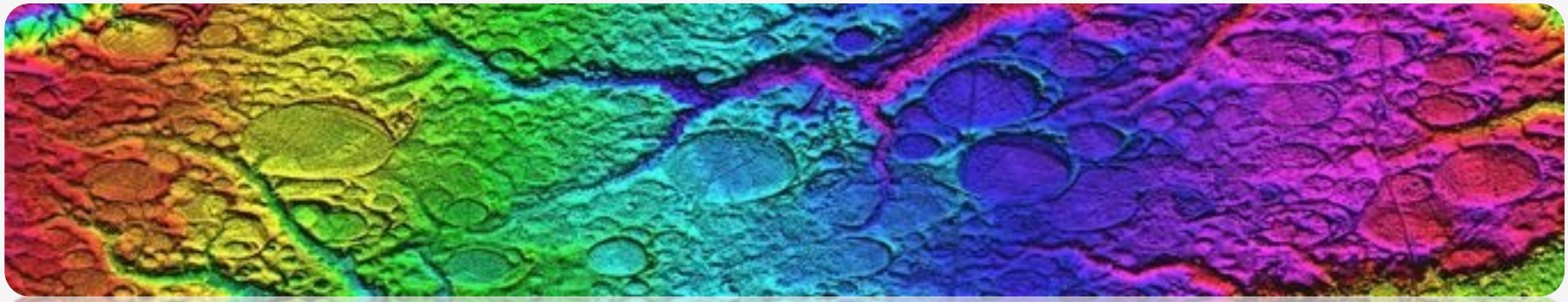
LIDAR DIGITAL ELEVATION MAPS EMPLOYED IN CAROLINA BAY SURVEY

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

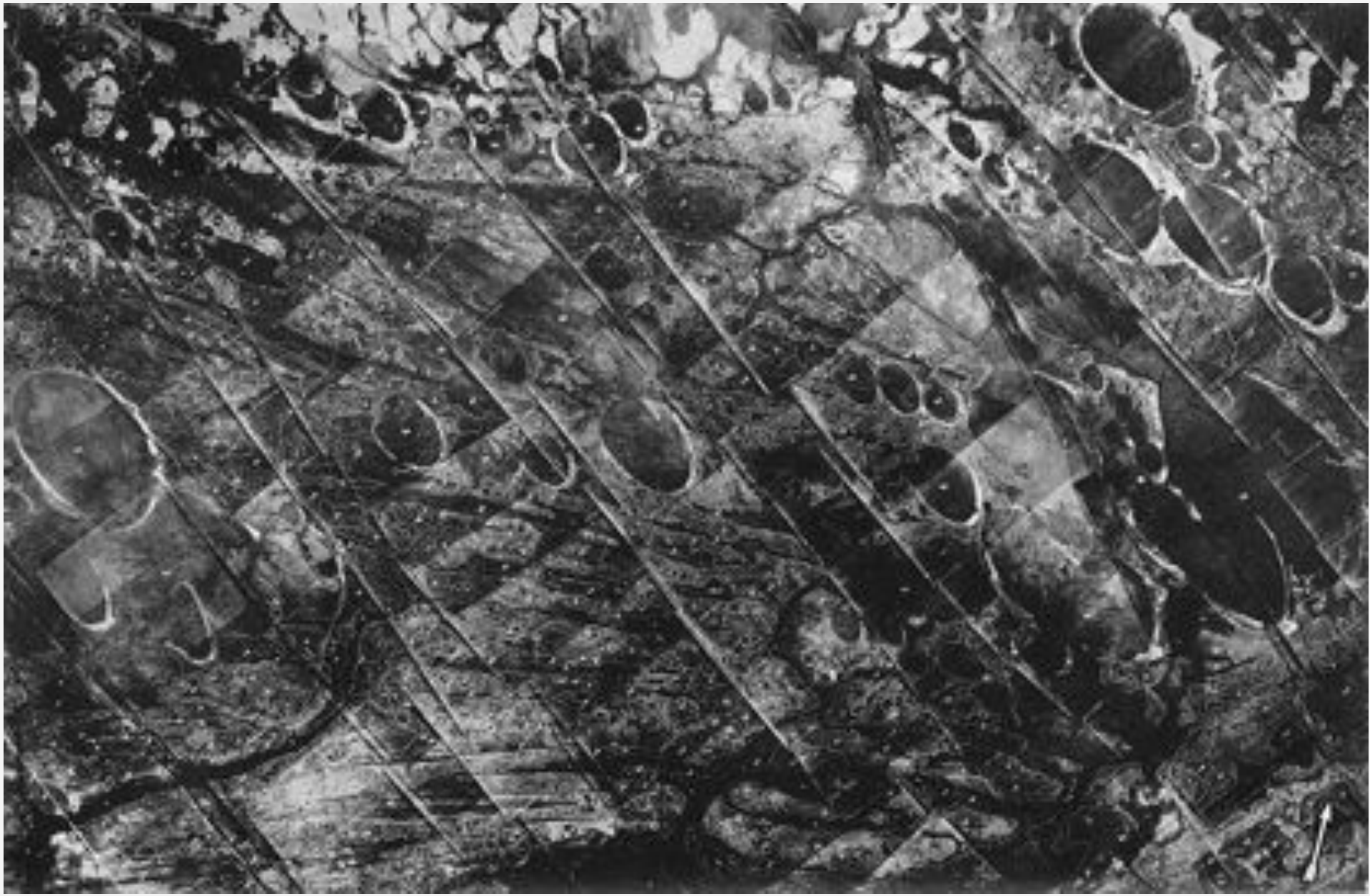
Abstract No: 192576
2011 GSA Meeting:
12 October, 2011
Minneapolis , Minnesota, USA

THE GEOLOGICAL SOCIETY OF AMERICA®

Michael E. Davias
Jeanette L. Gilbride

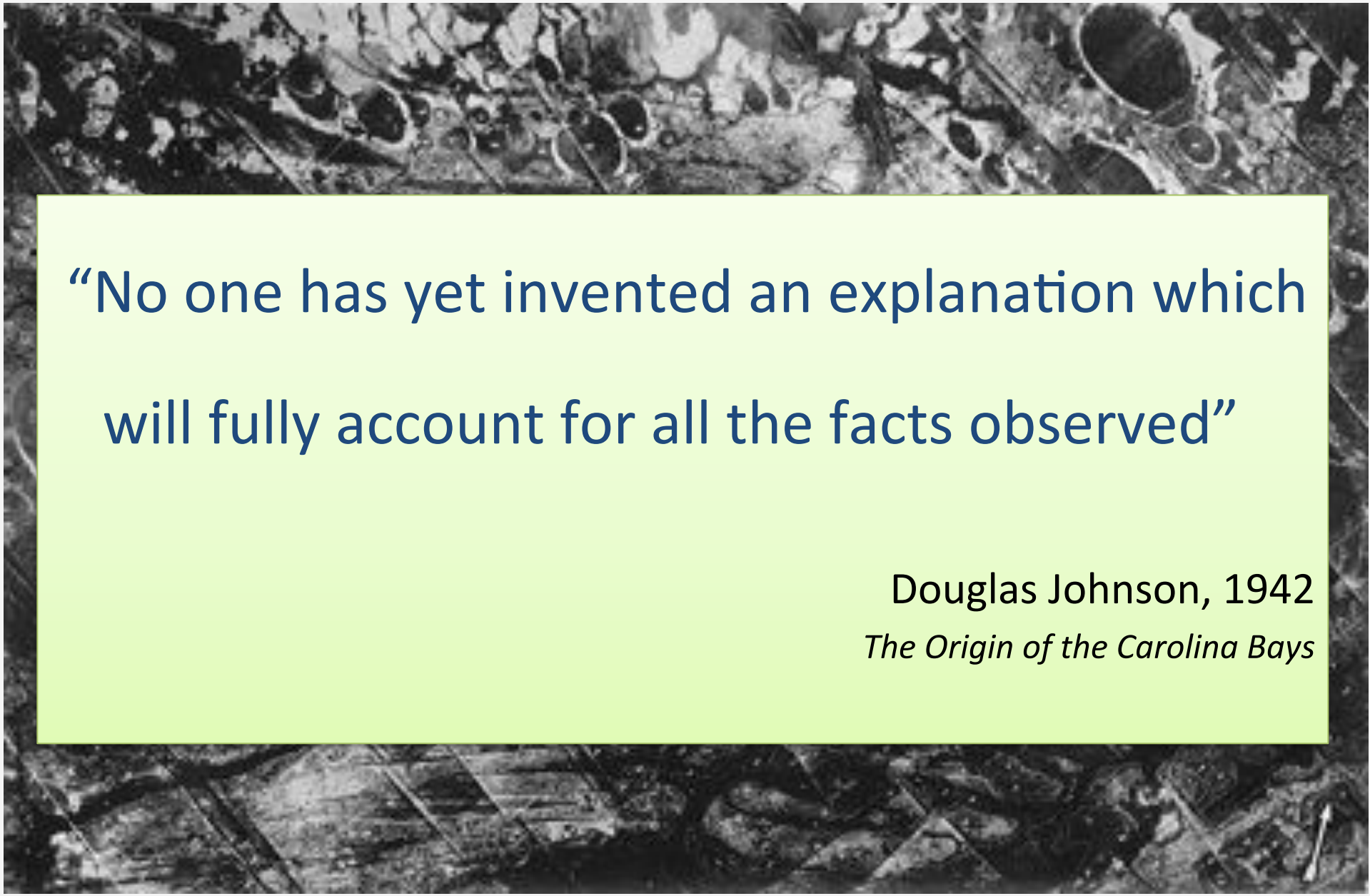


Myrtle Beach, SC



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

Myrtle Beach, SC



"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

©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"

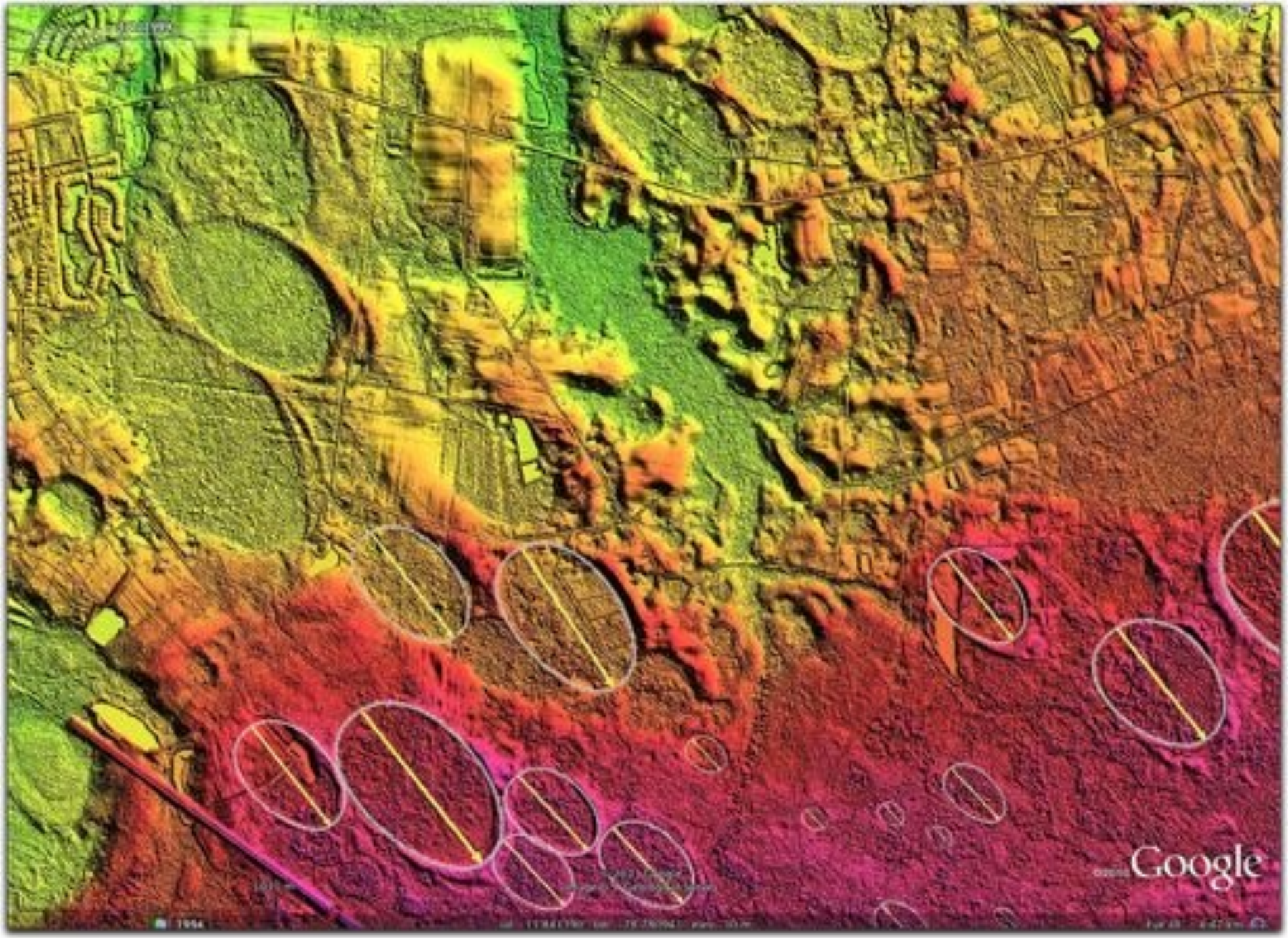
Douglas Johnson, 1942
The Origin of the Carolina Bays

- **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


Google


Google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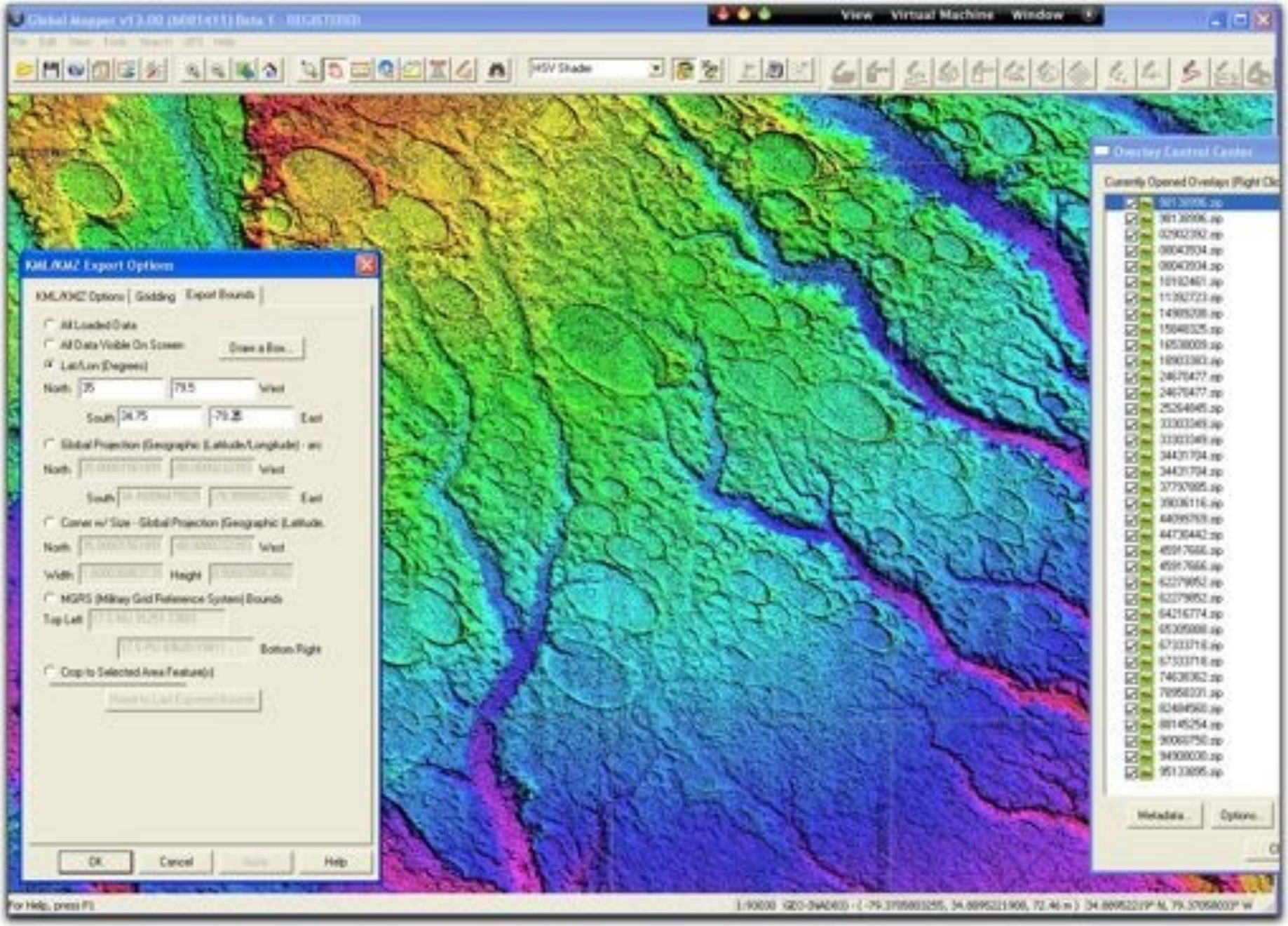
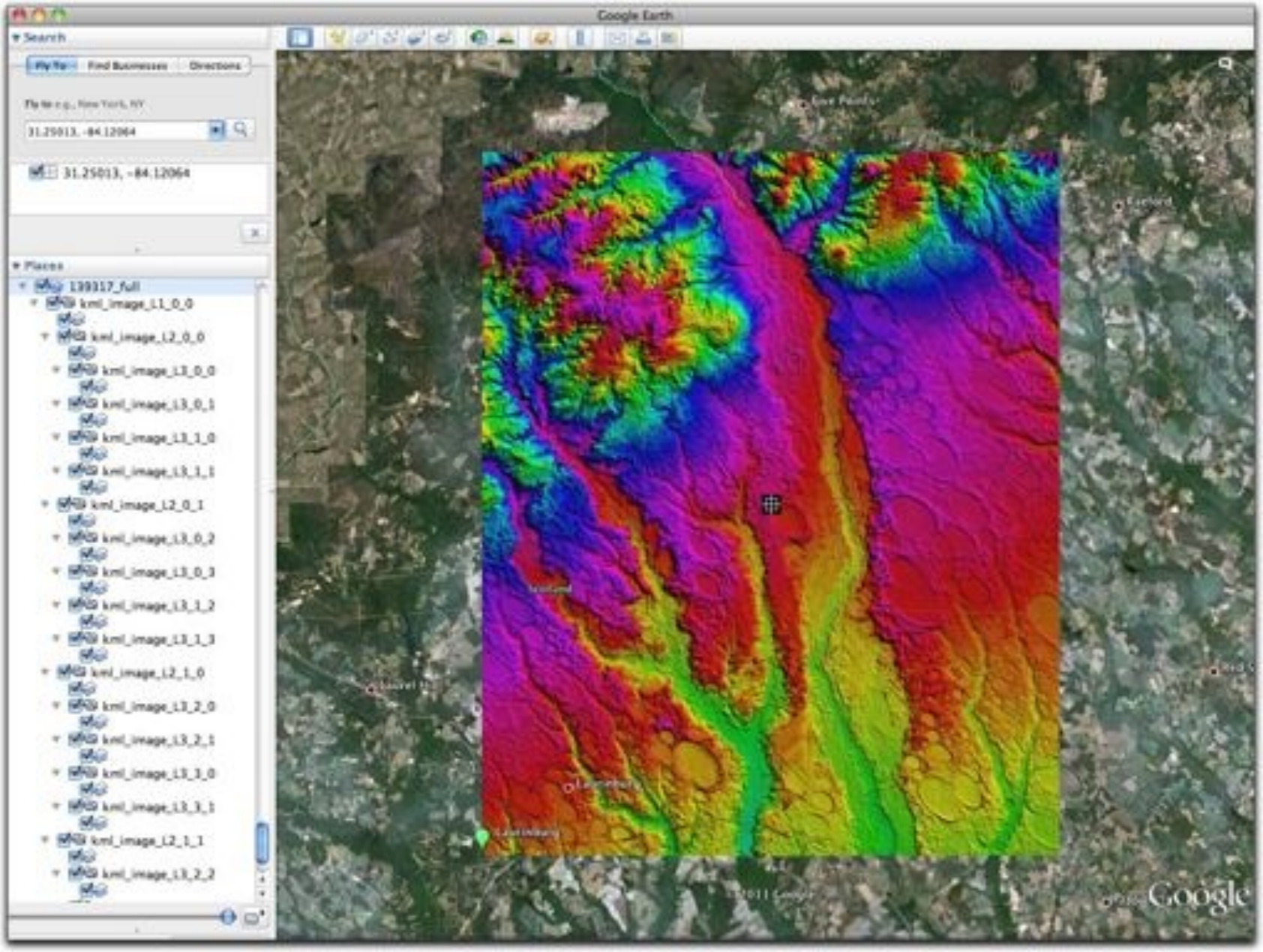
Carolina Bay Survey Tools & Resources

- 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

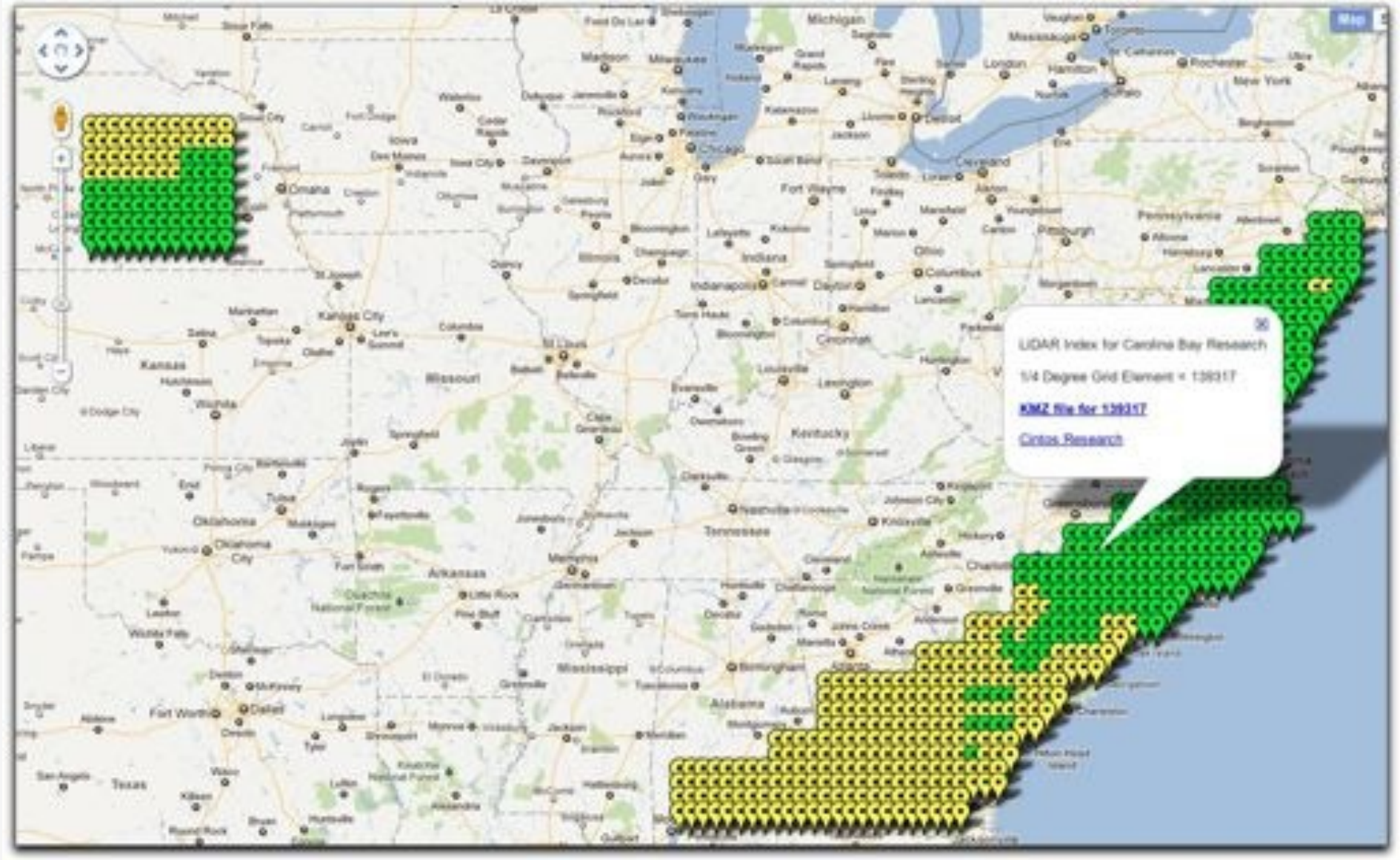
LiDAR Generation Process



LiDAR Tile Set Integration with Google Earth



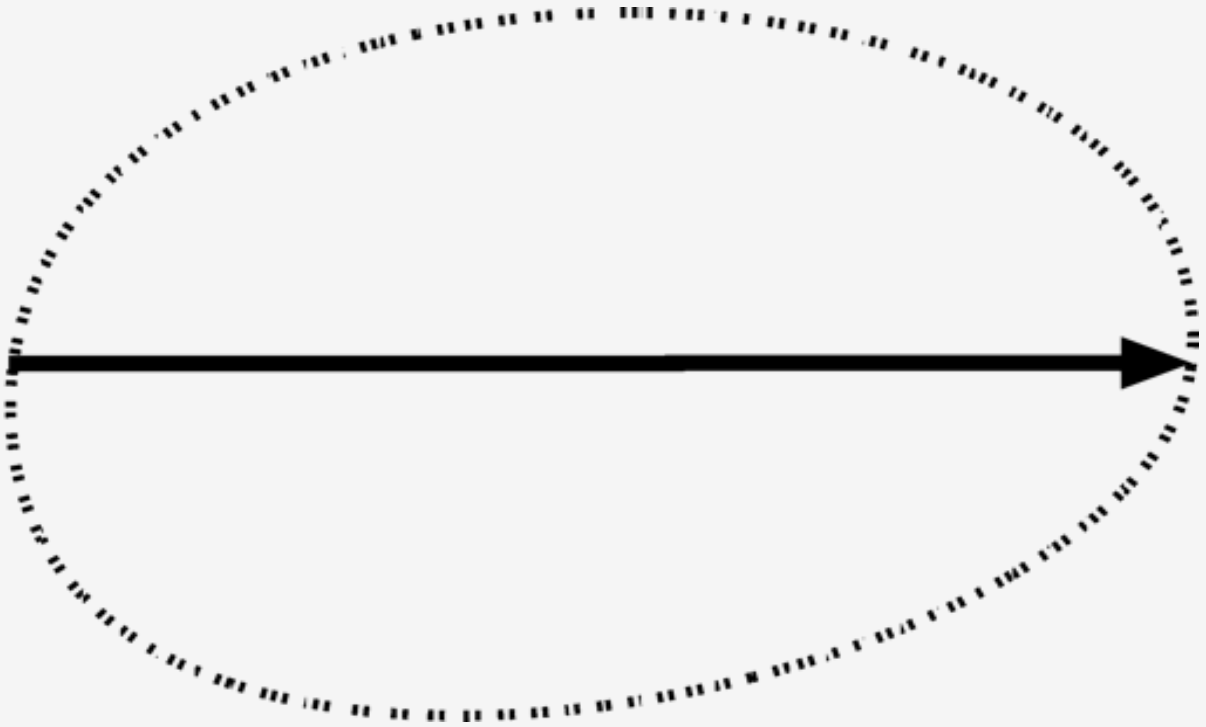
Index Map Of ¼° Octant Grid Geodetic Coding System



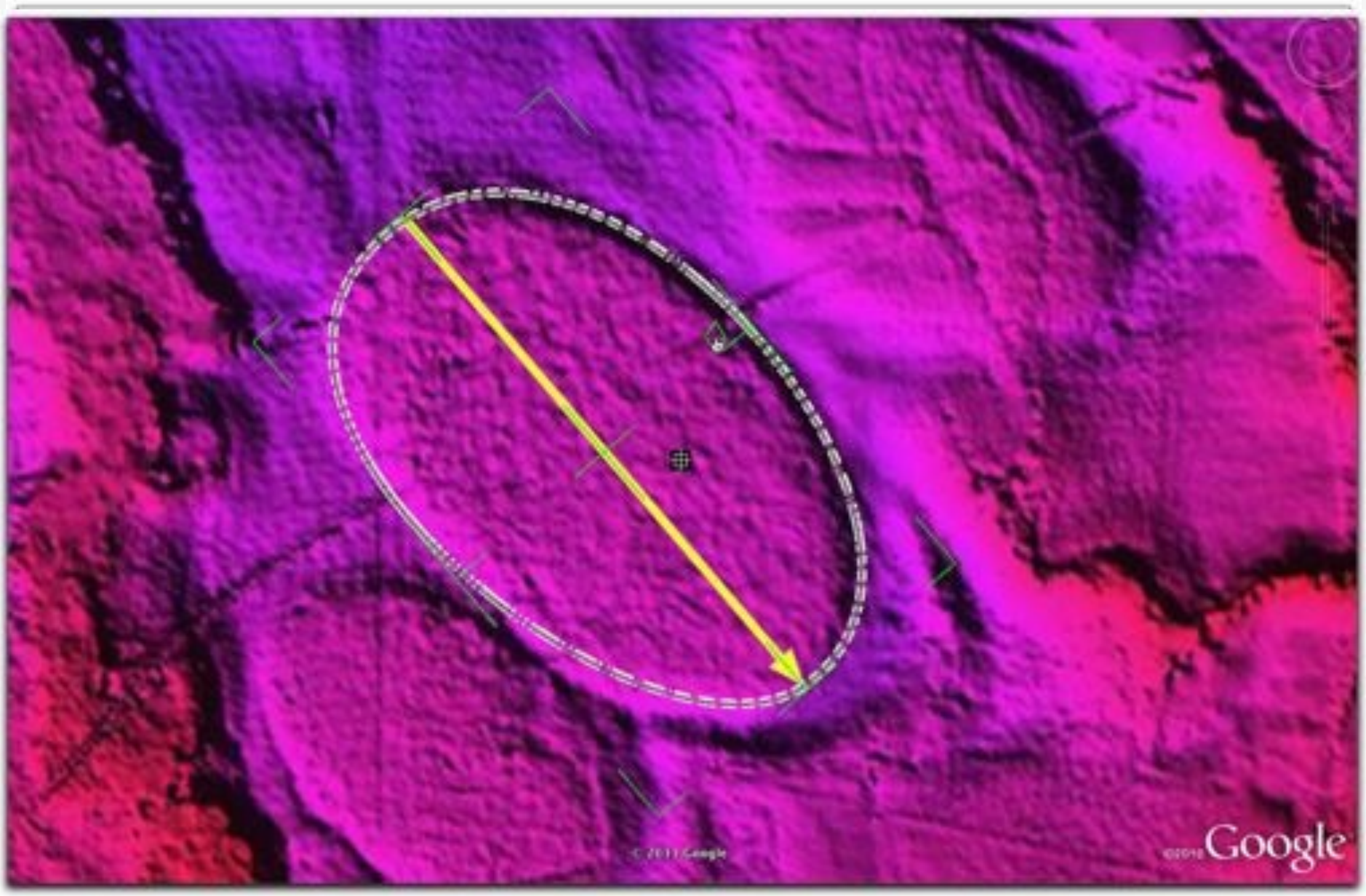
Green Placemark = 1/9 arc-sec LiDAR data

Criteria for Identification as a Carolina Bay

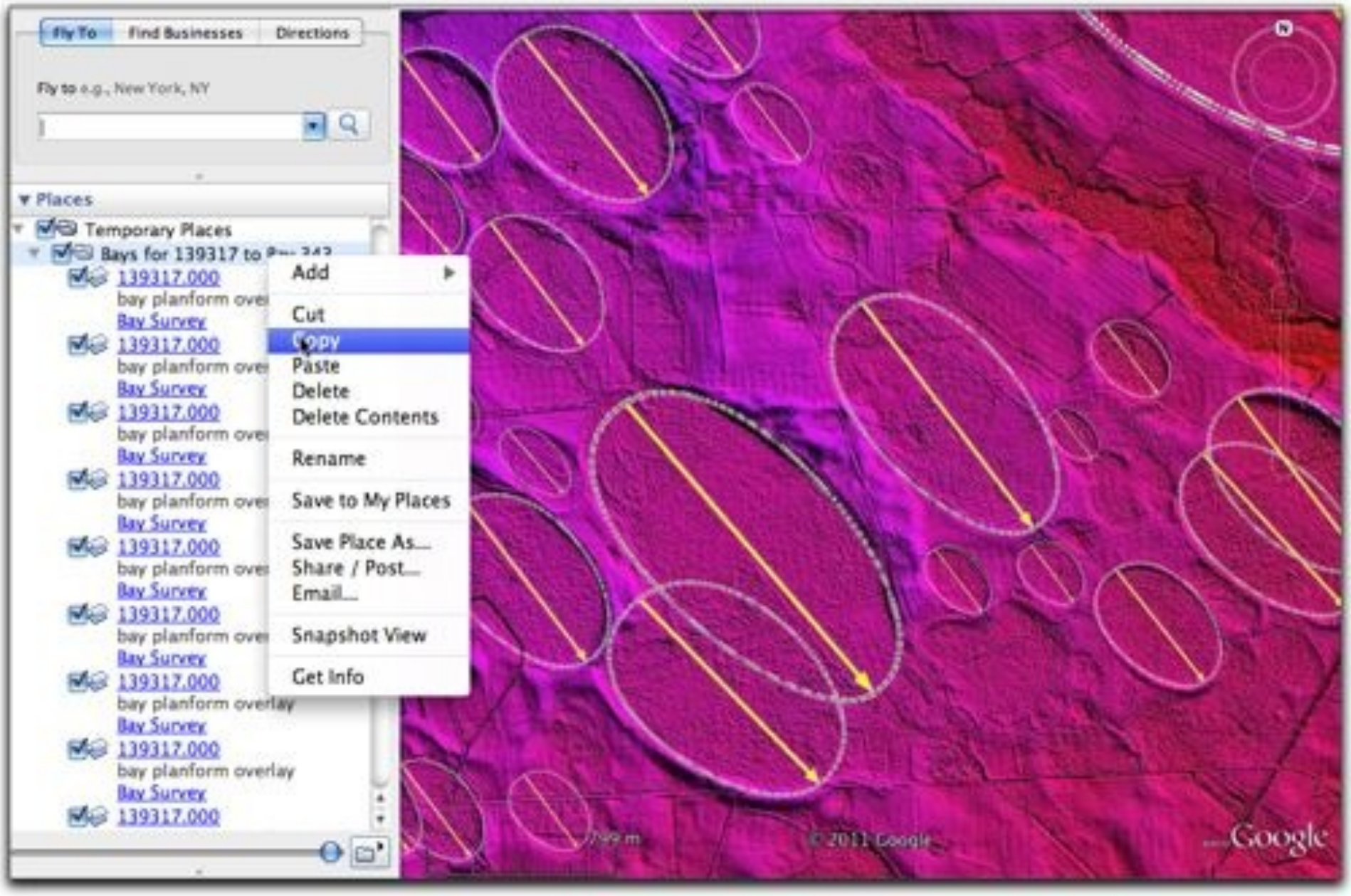
- Found Amongst Collection Of Similar Landforms
- Exhibit A Closed Circumferal Rim
- Satellite Imagery Supported By LiDAR/DEM As A Basin
- Planform Fits Archetype For Locale



Planform – New Image Overlay



Copy Overlays from DOM as Text



KML Meta Data in Overlay

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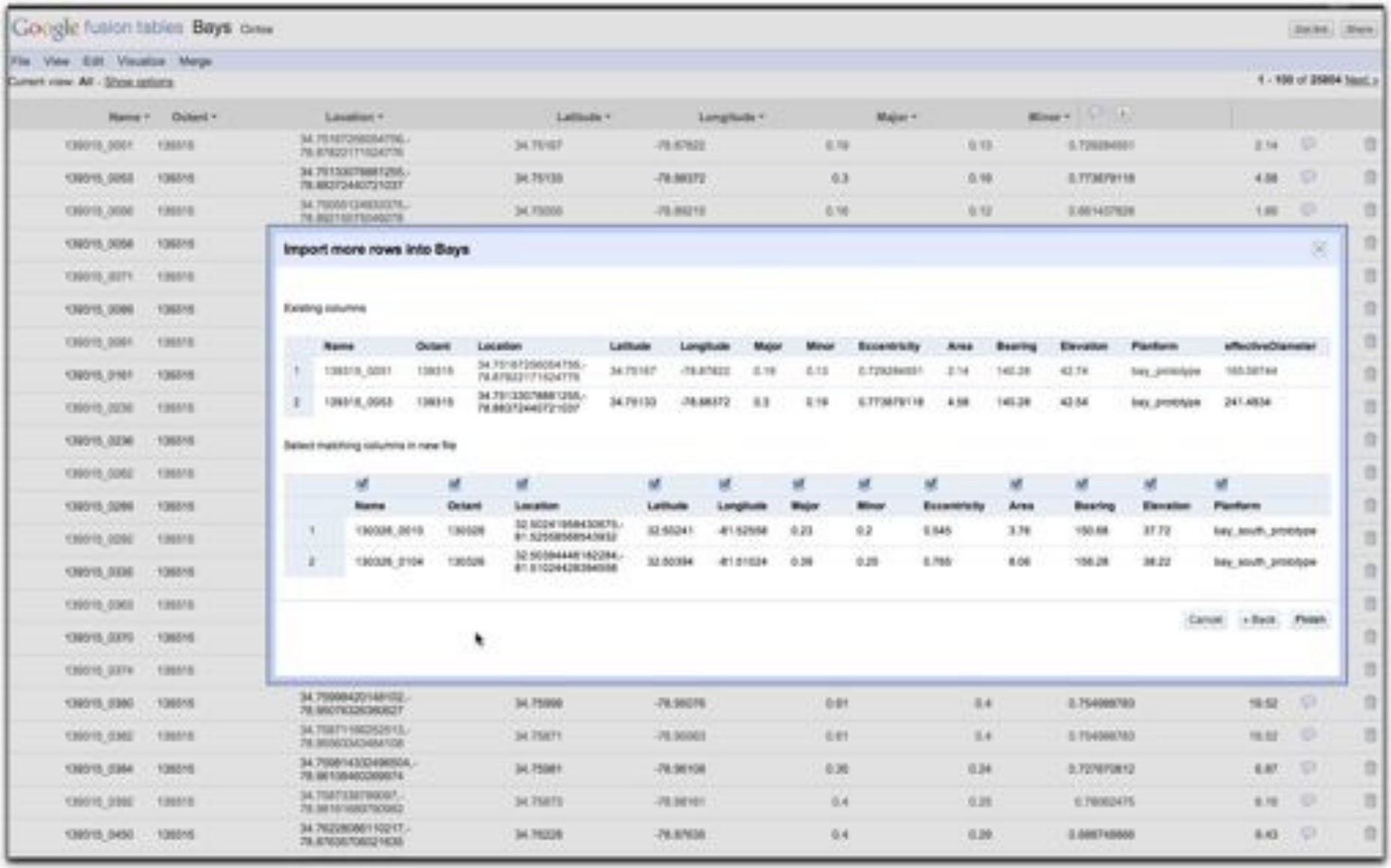

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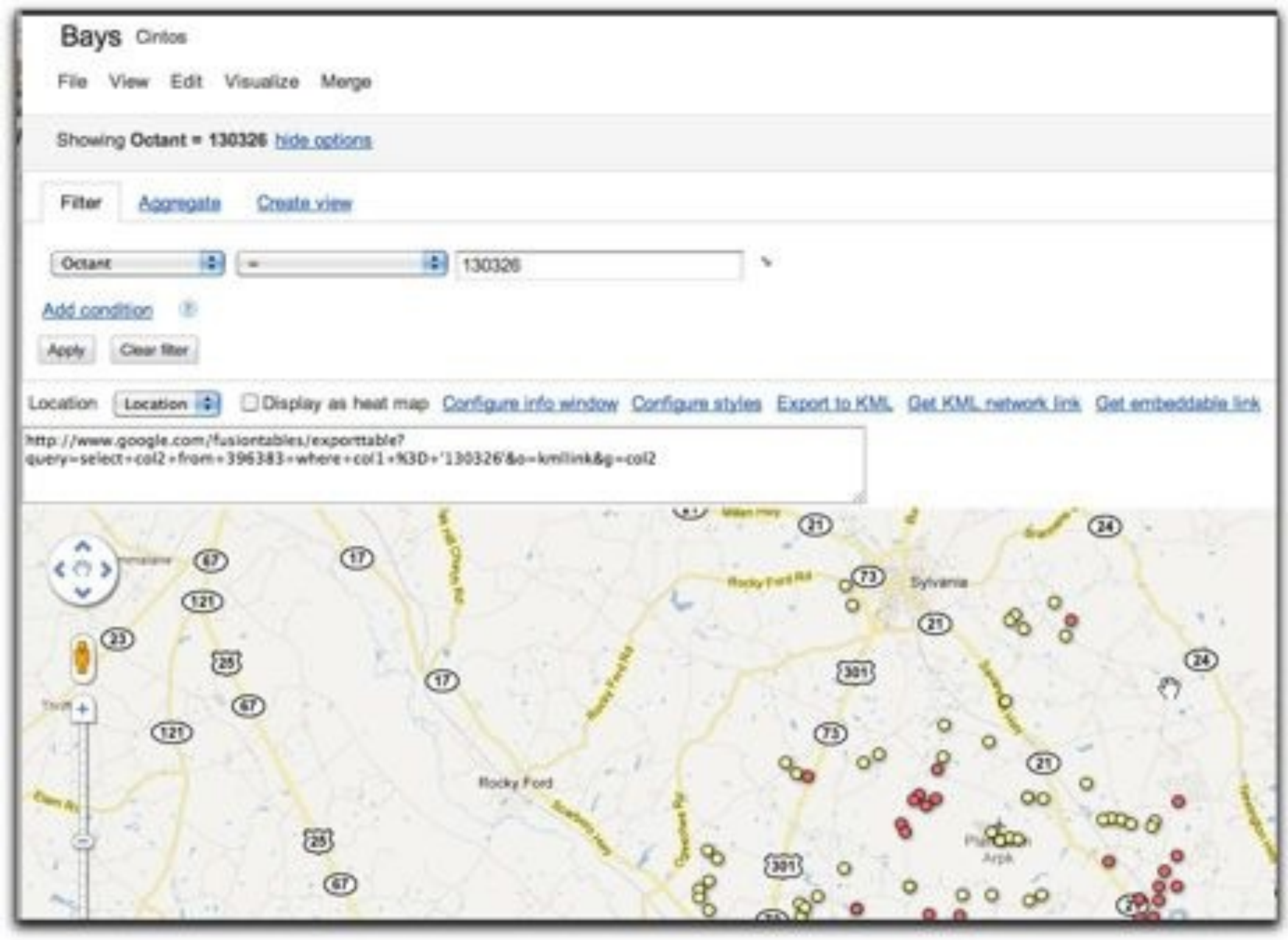
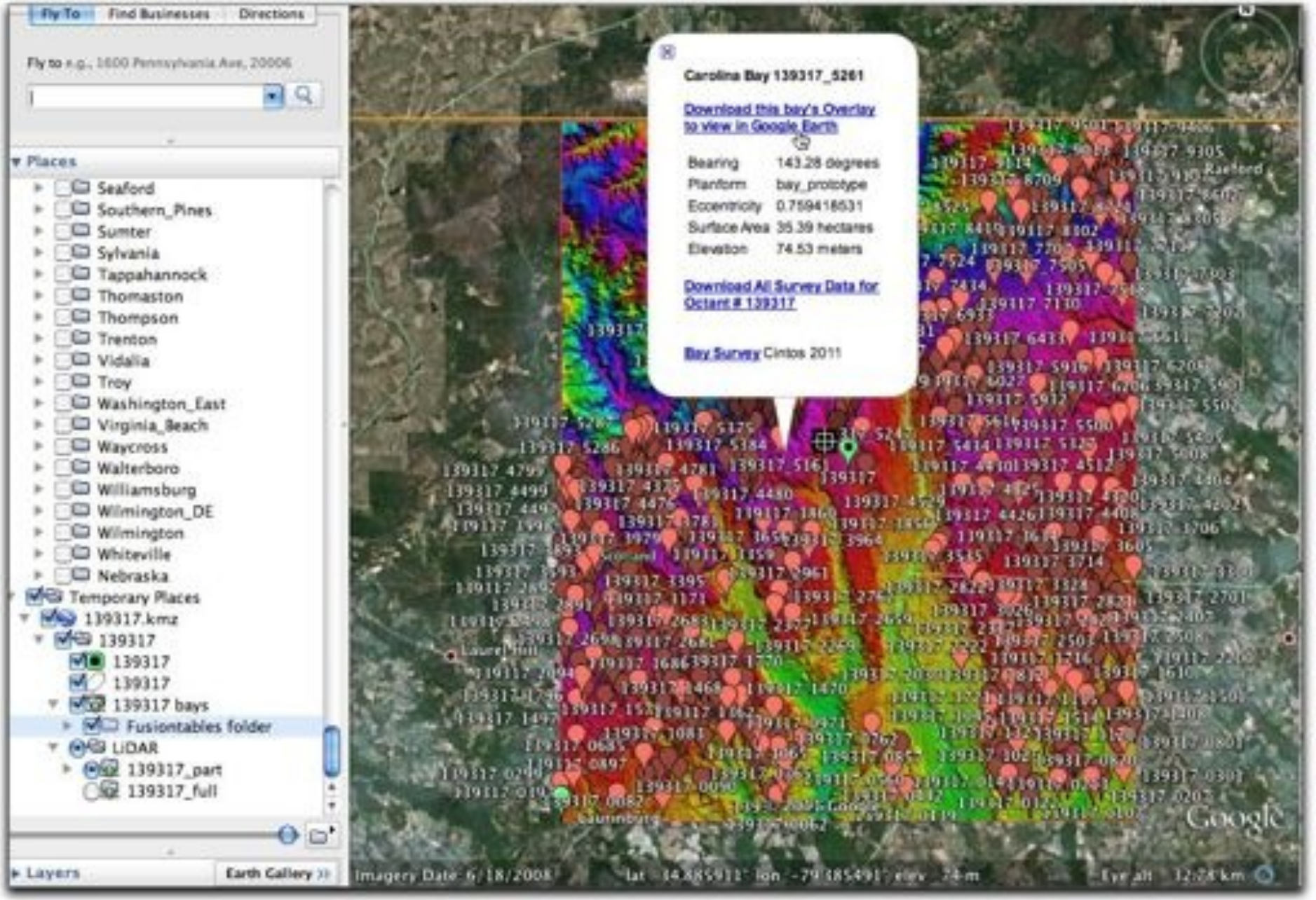


Popup for Bay Placemark



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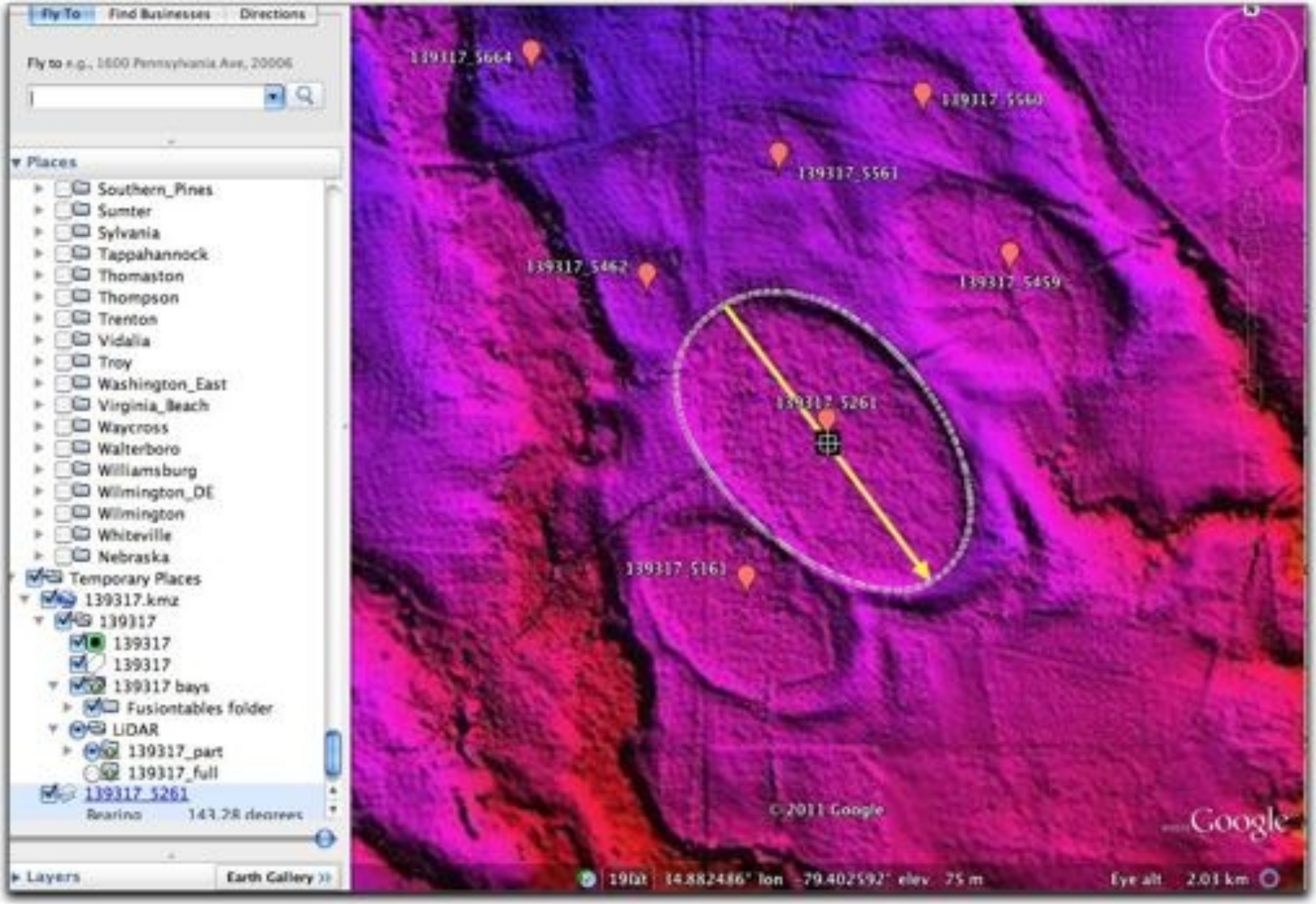

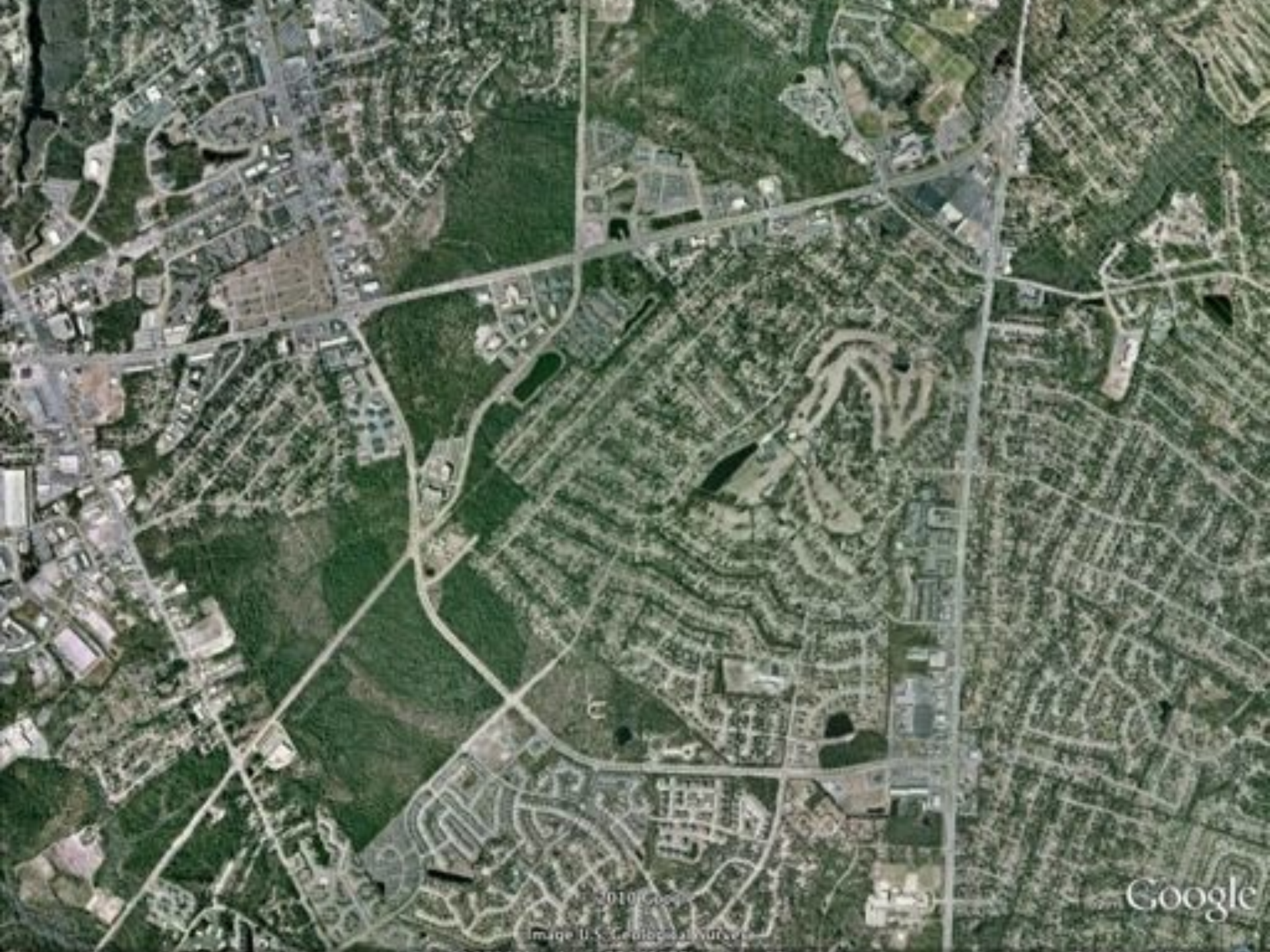
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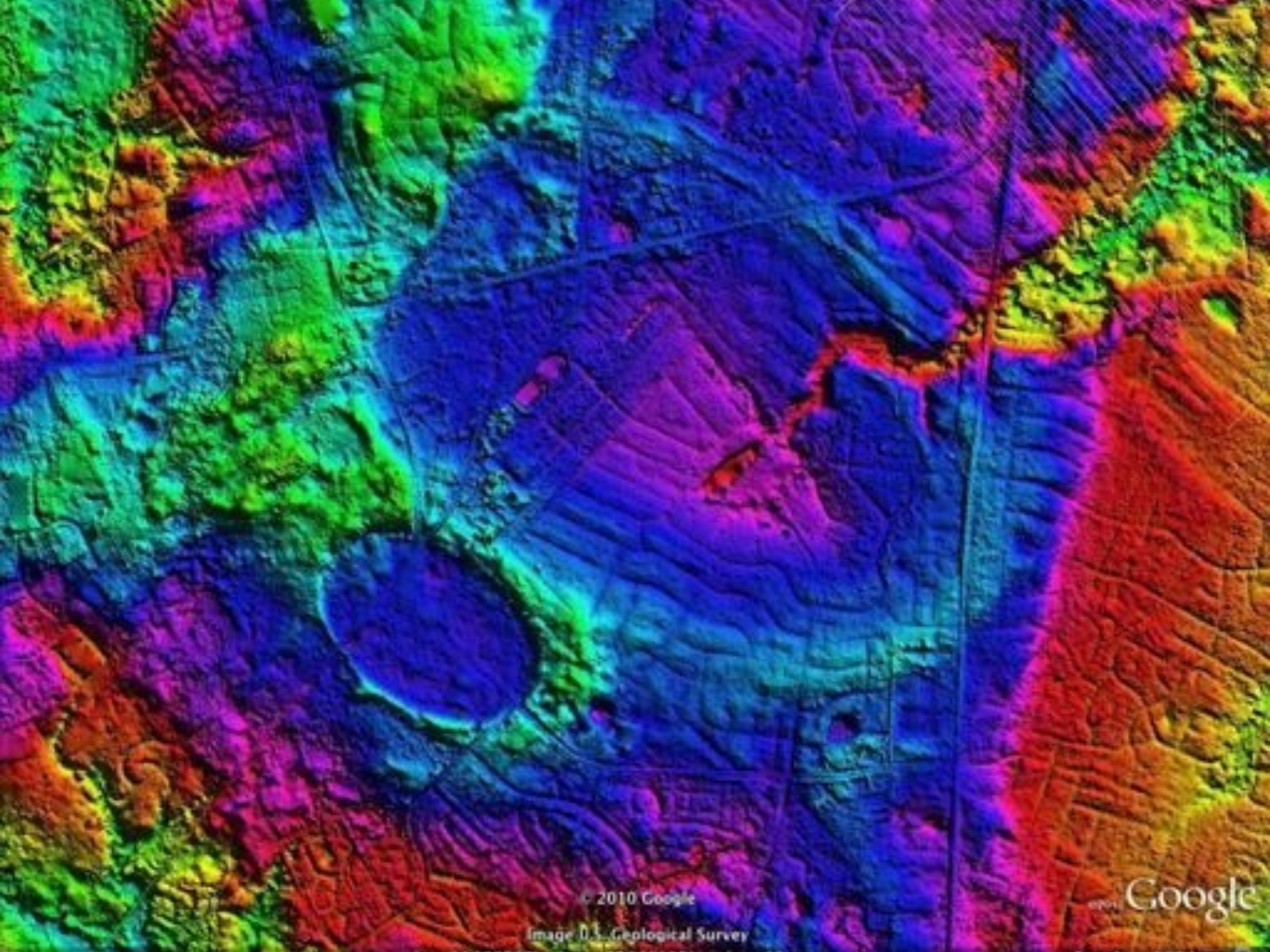
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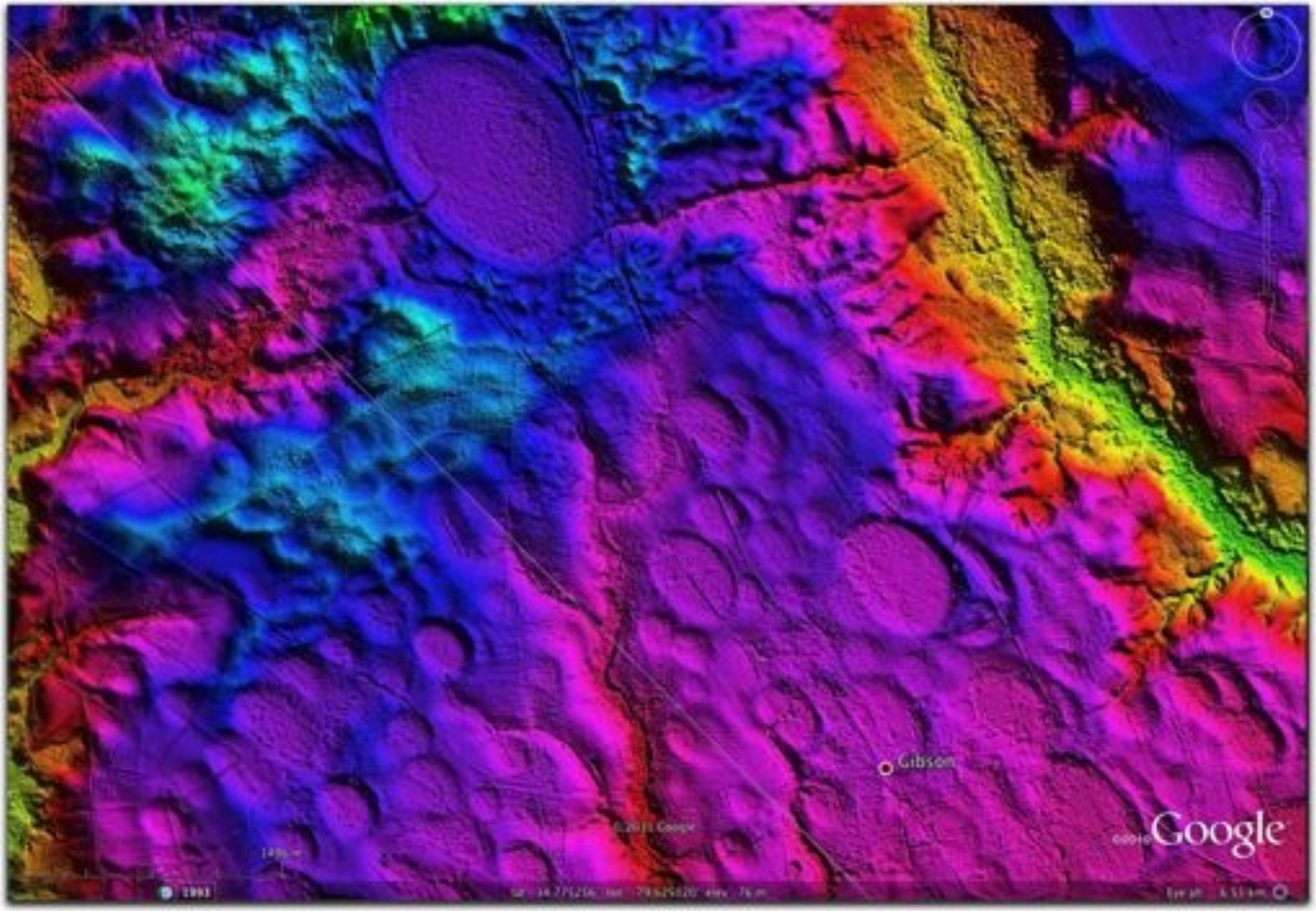
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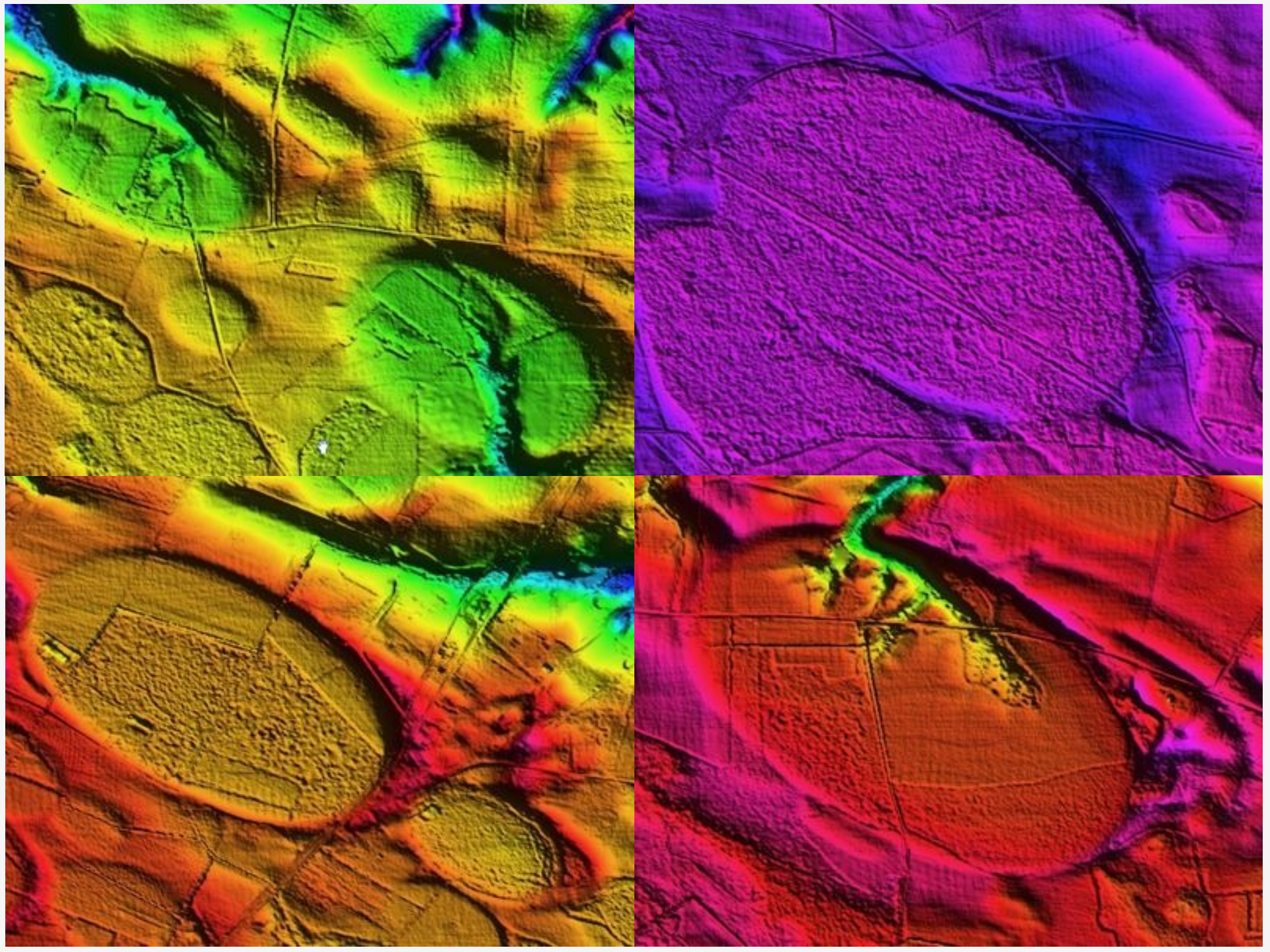
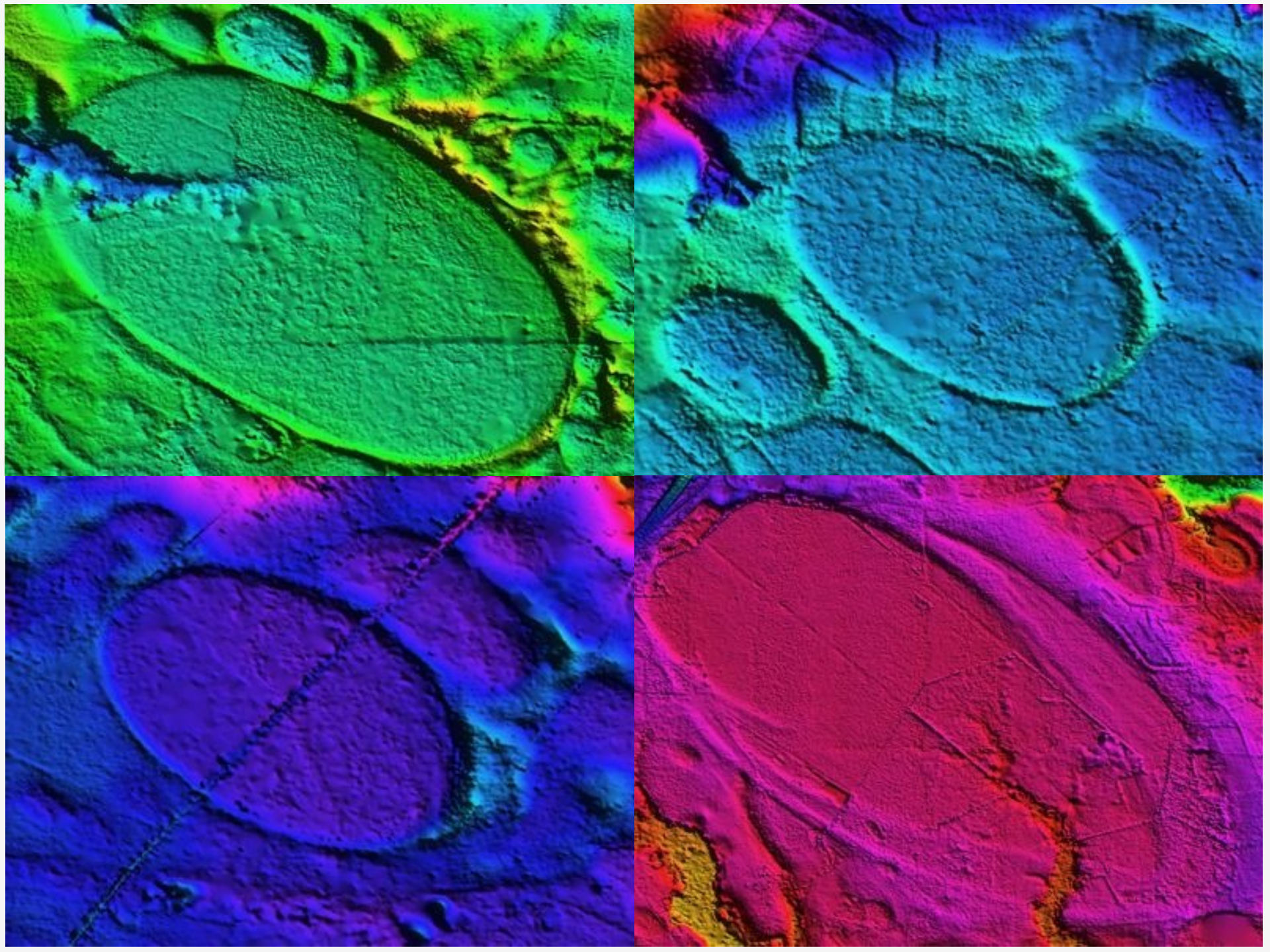
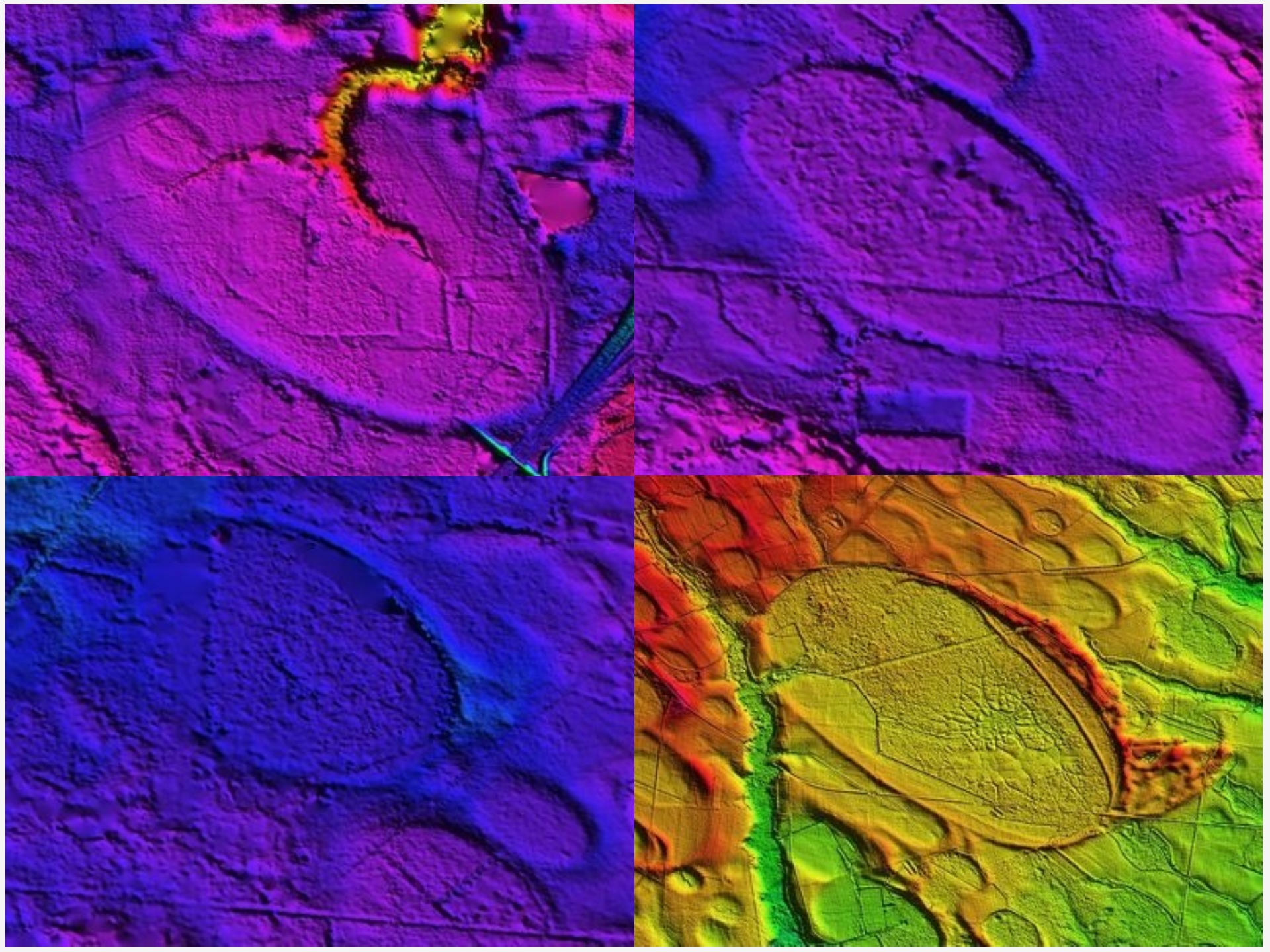
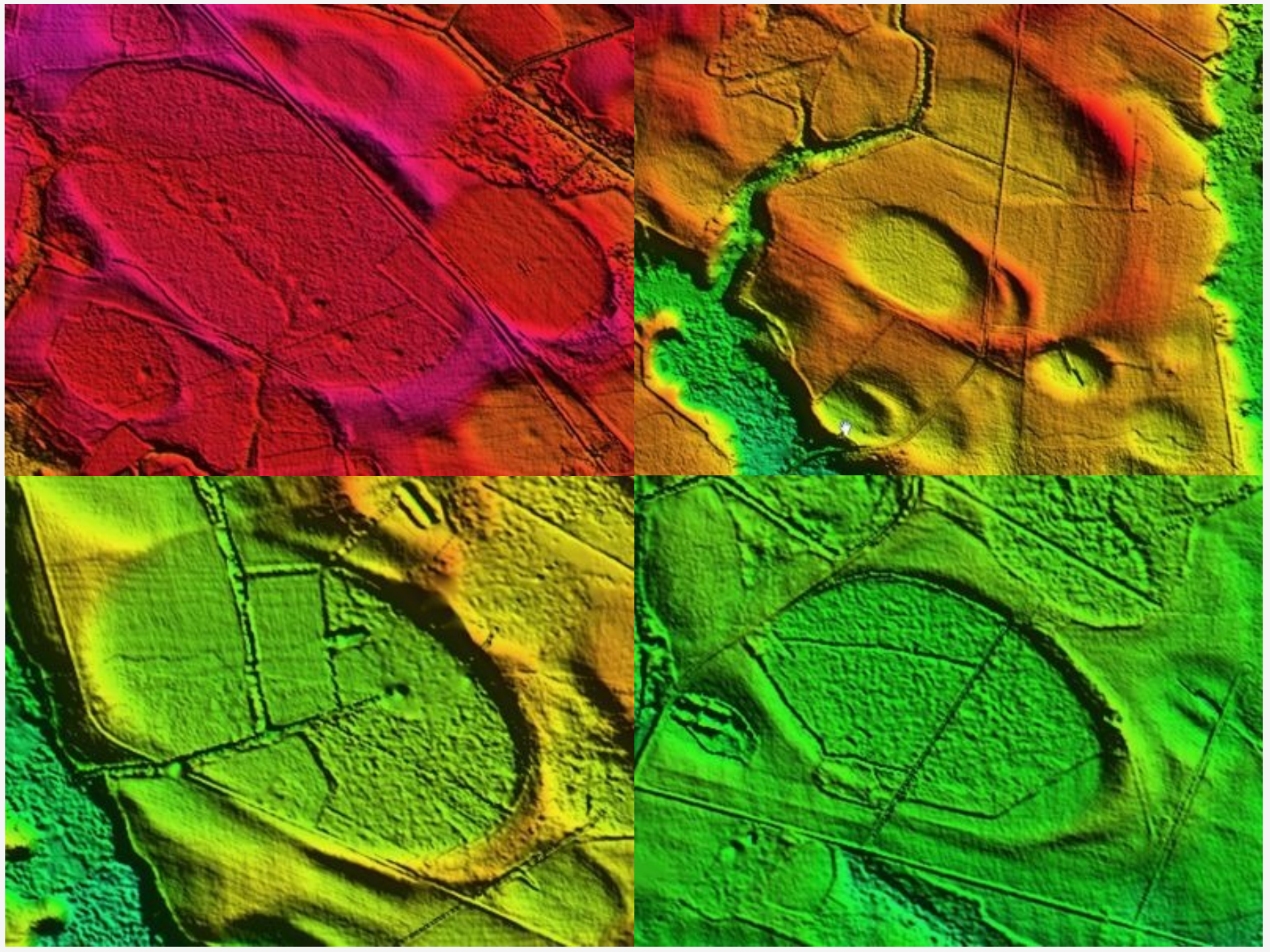
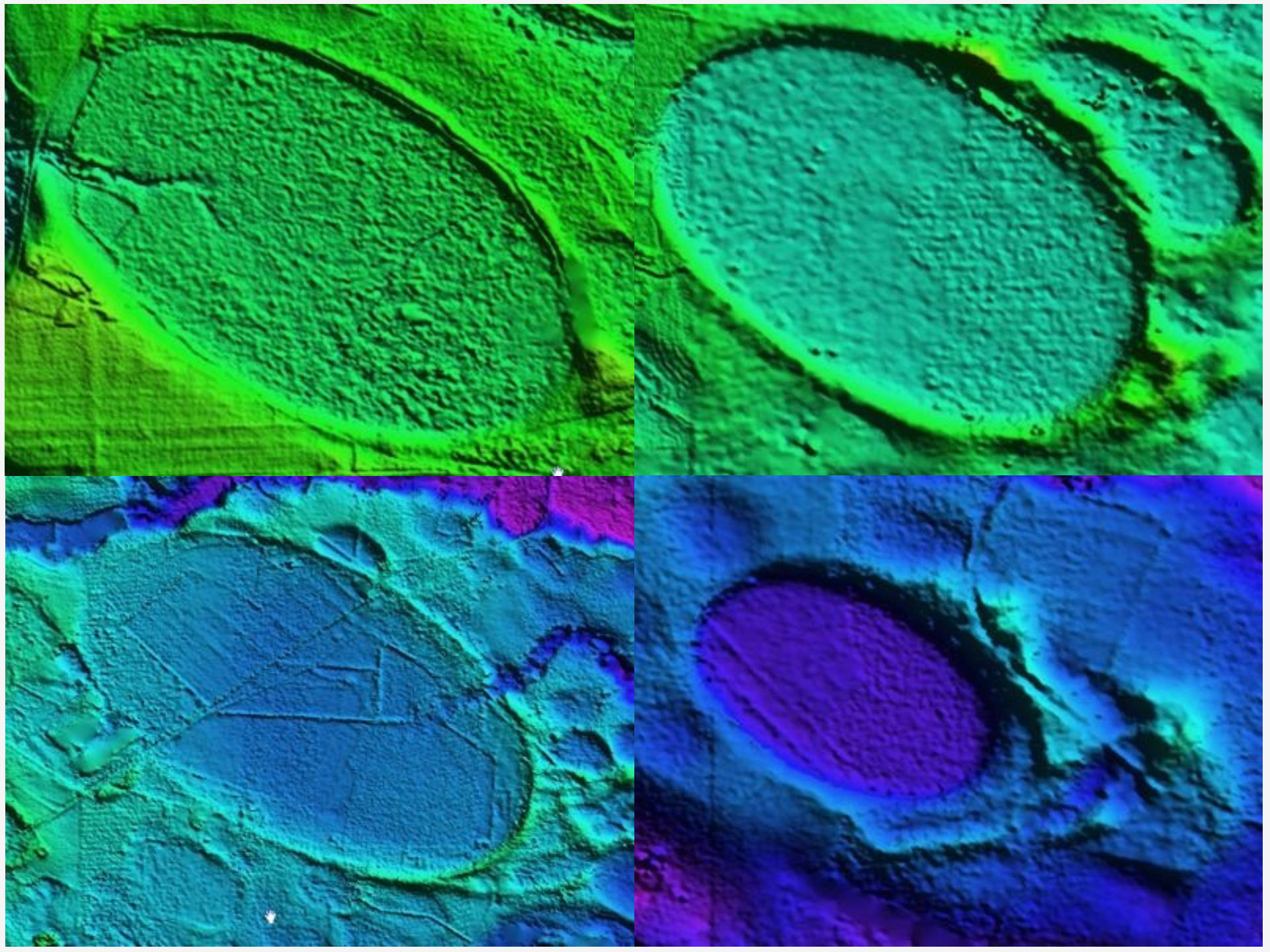
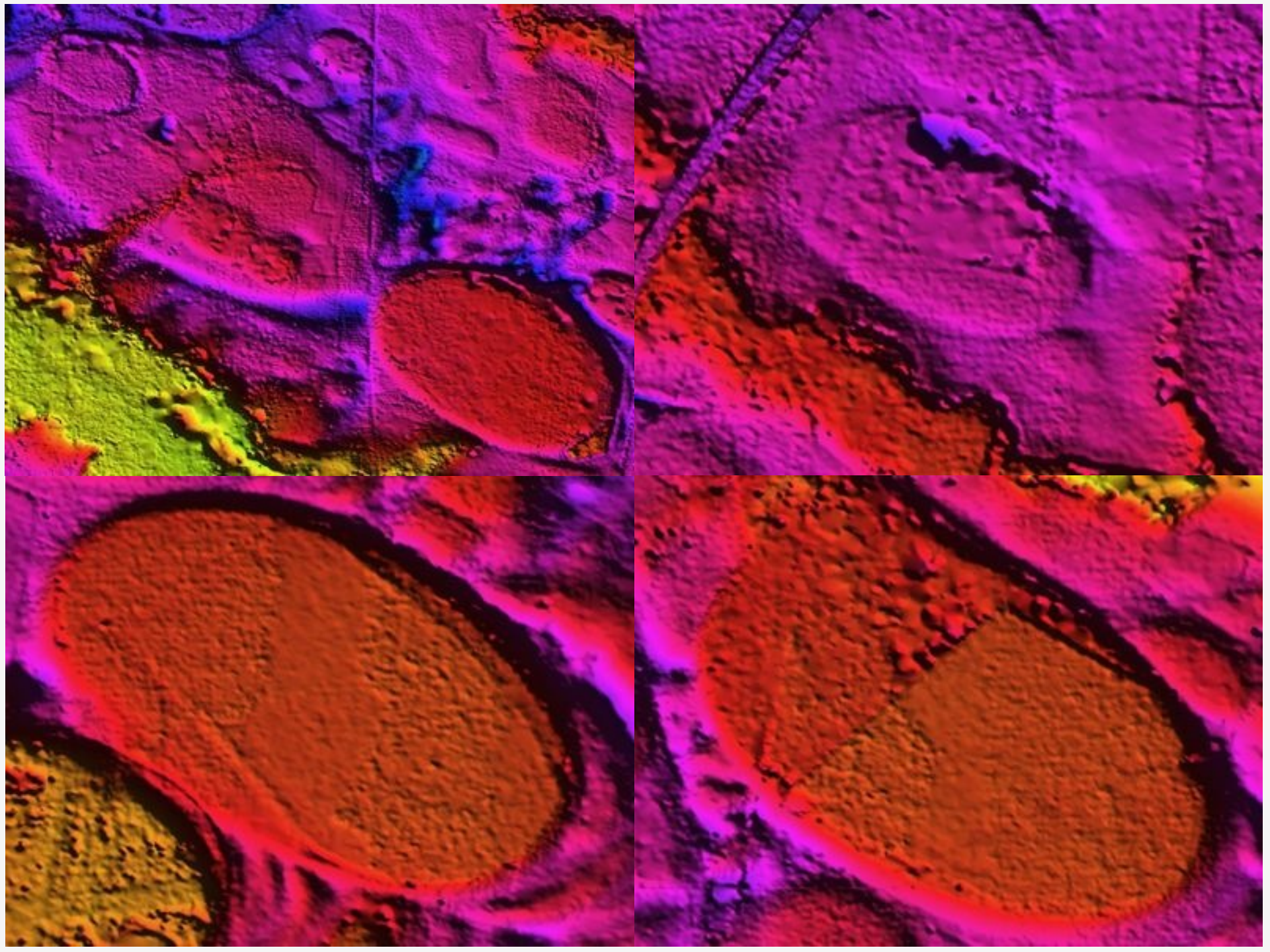


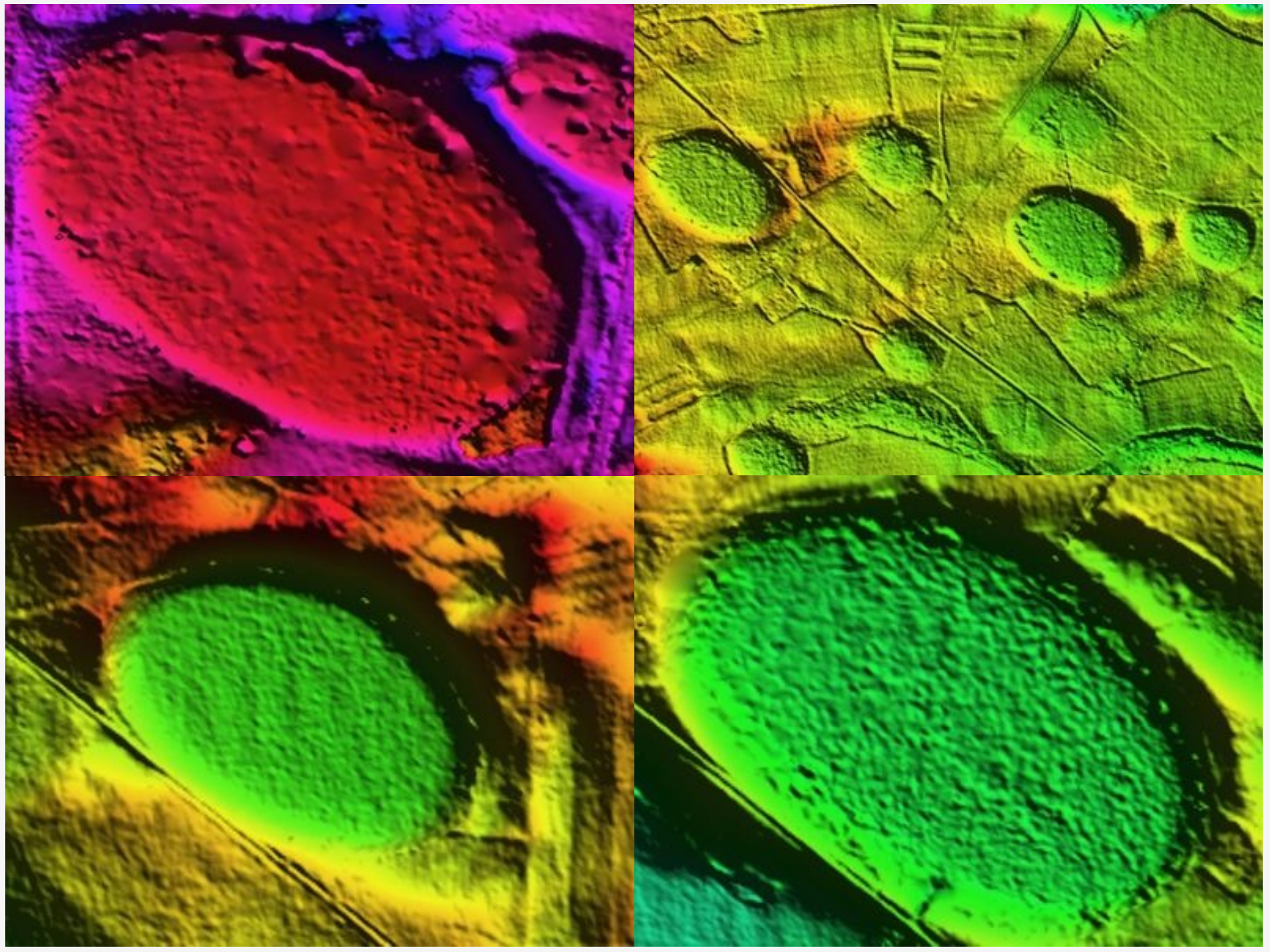


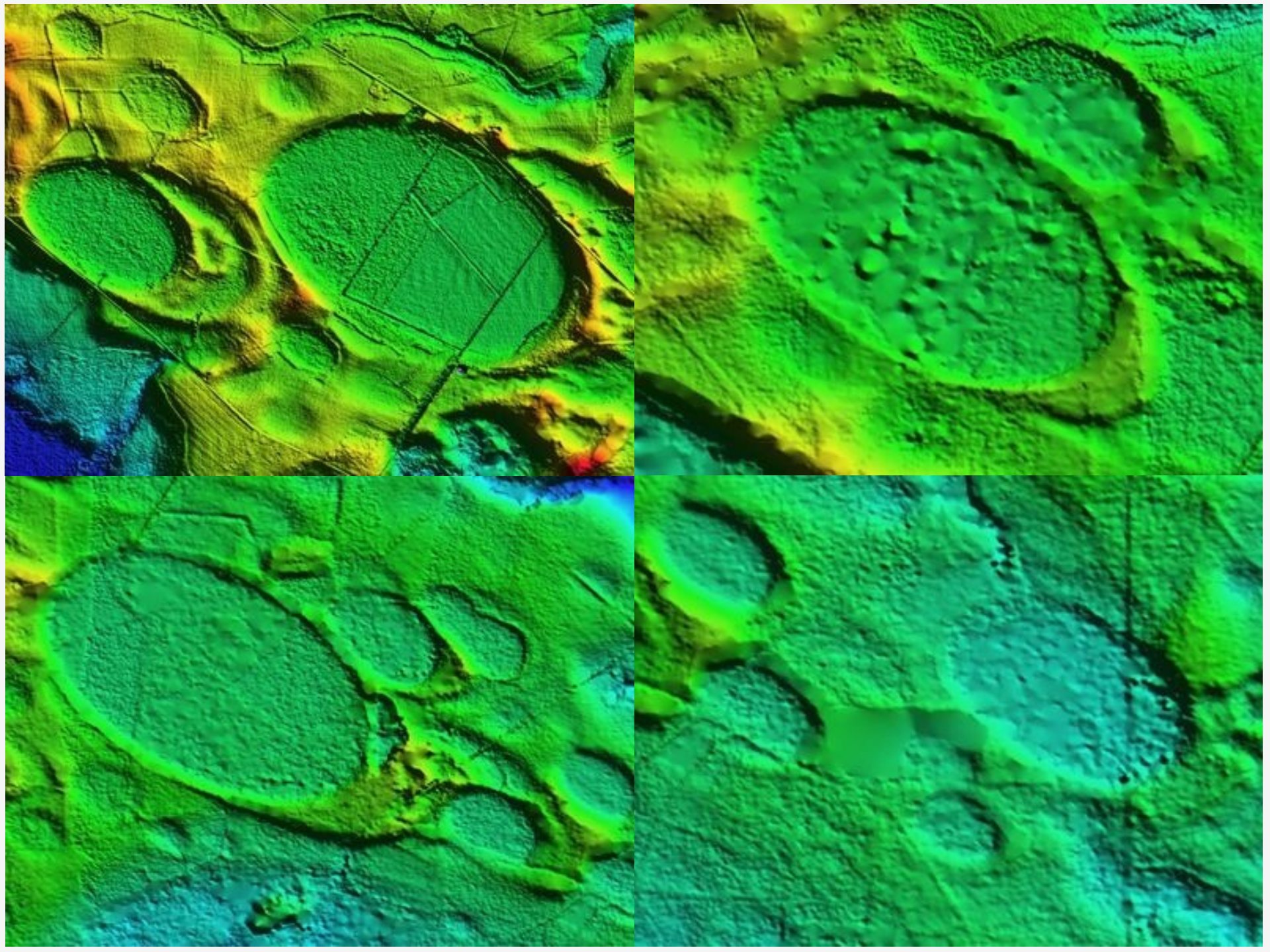


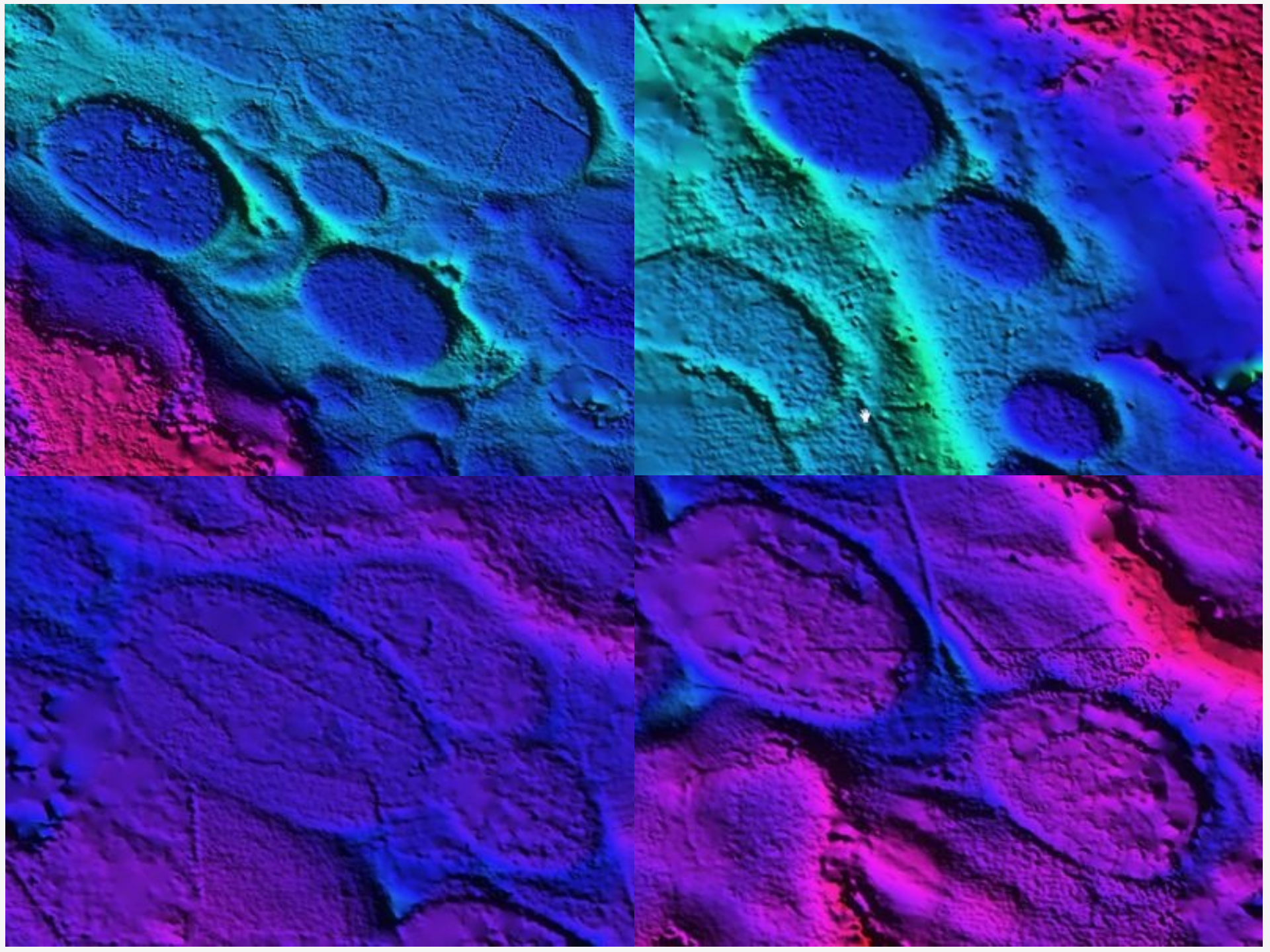


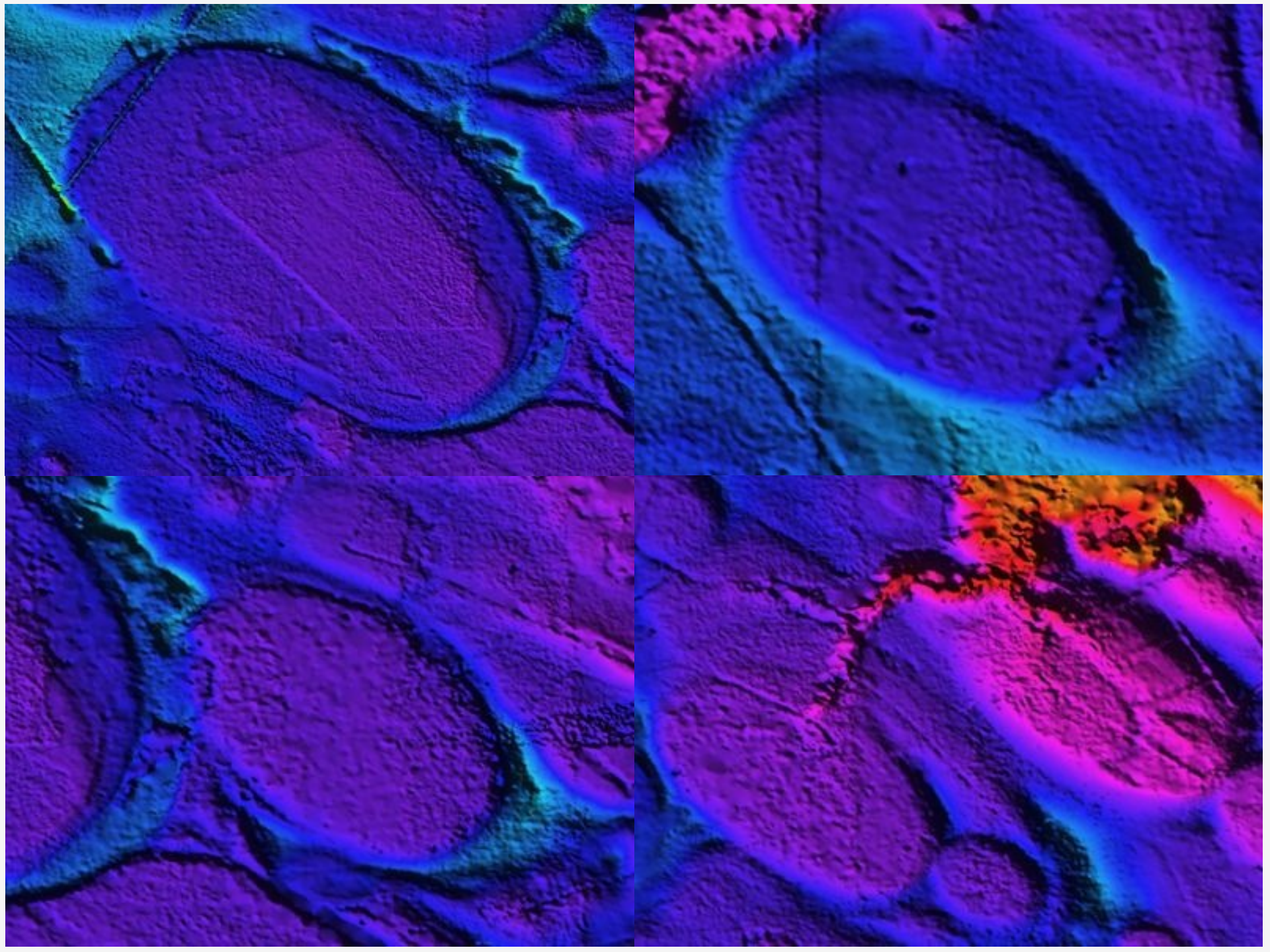


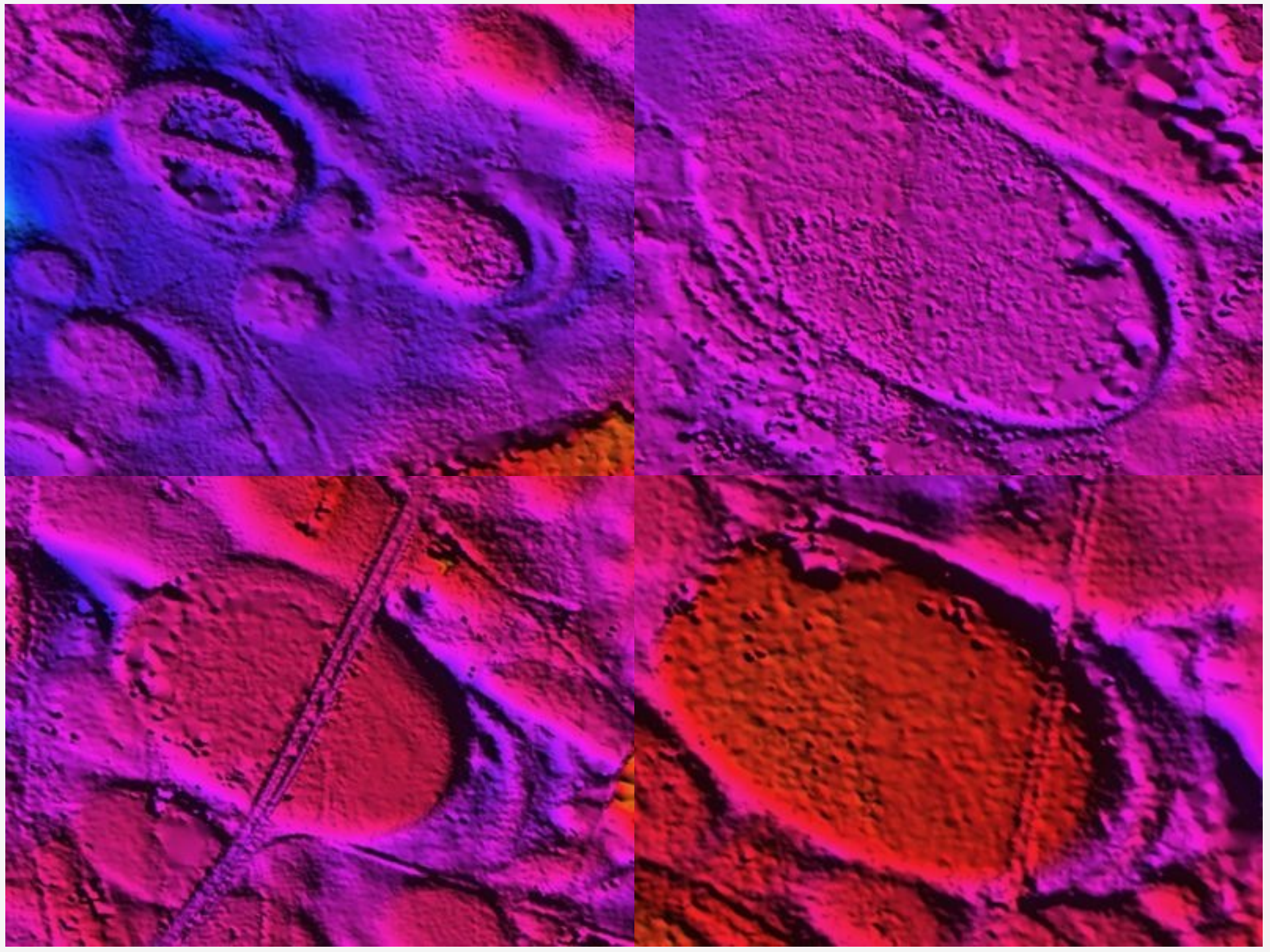


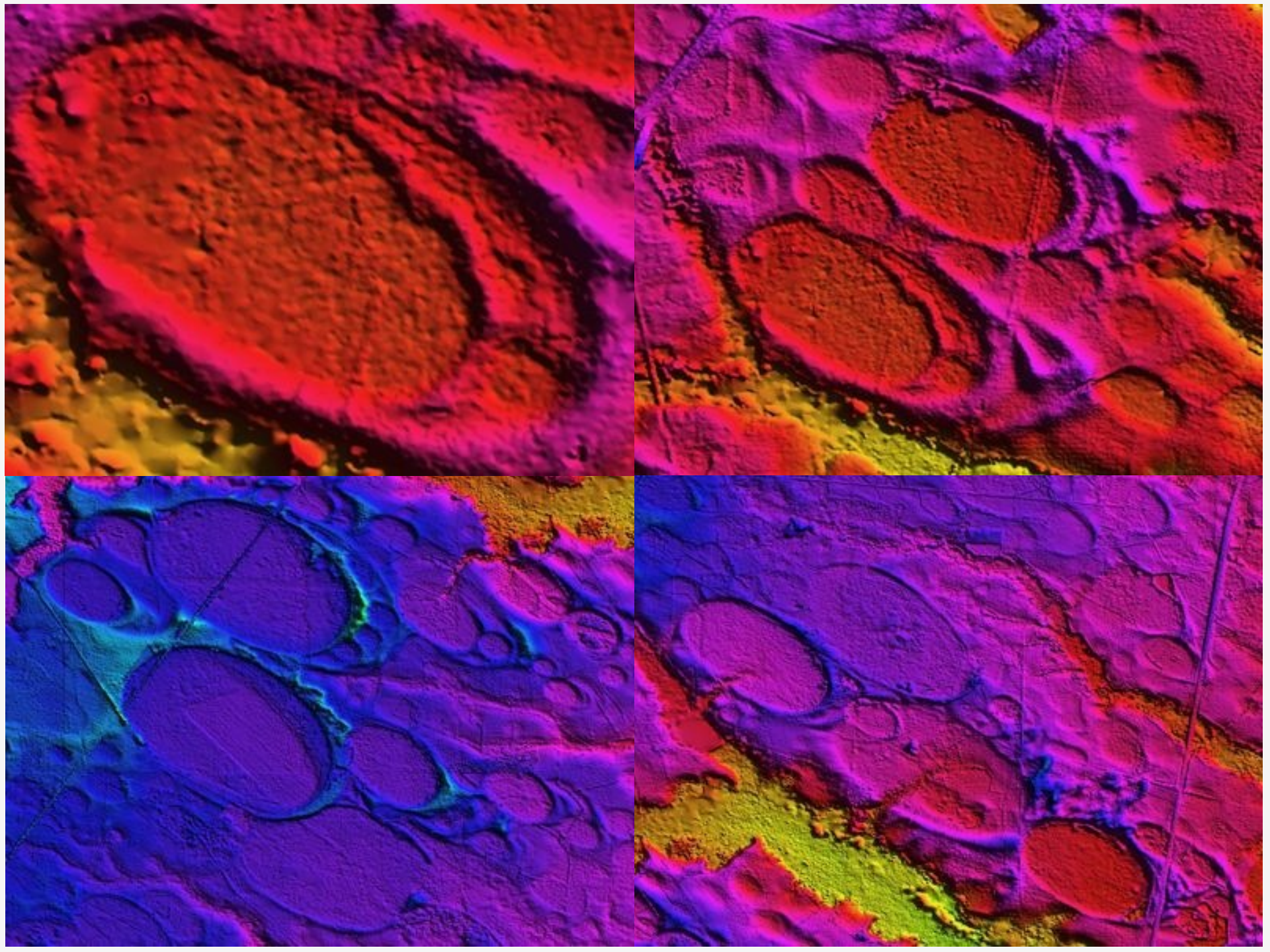


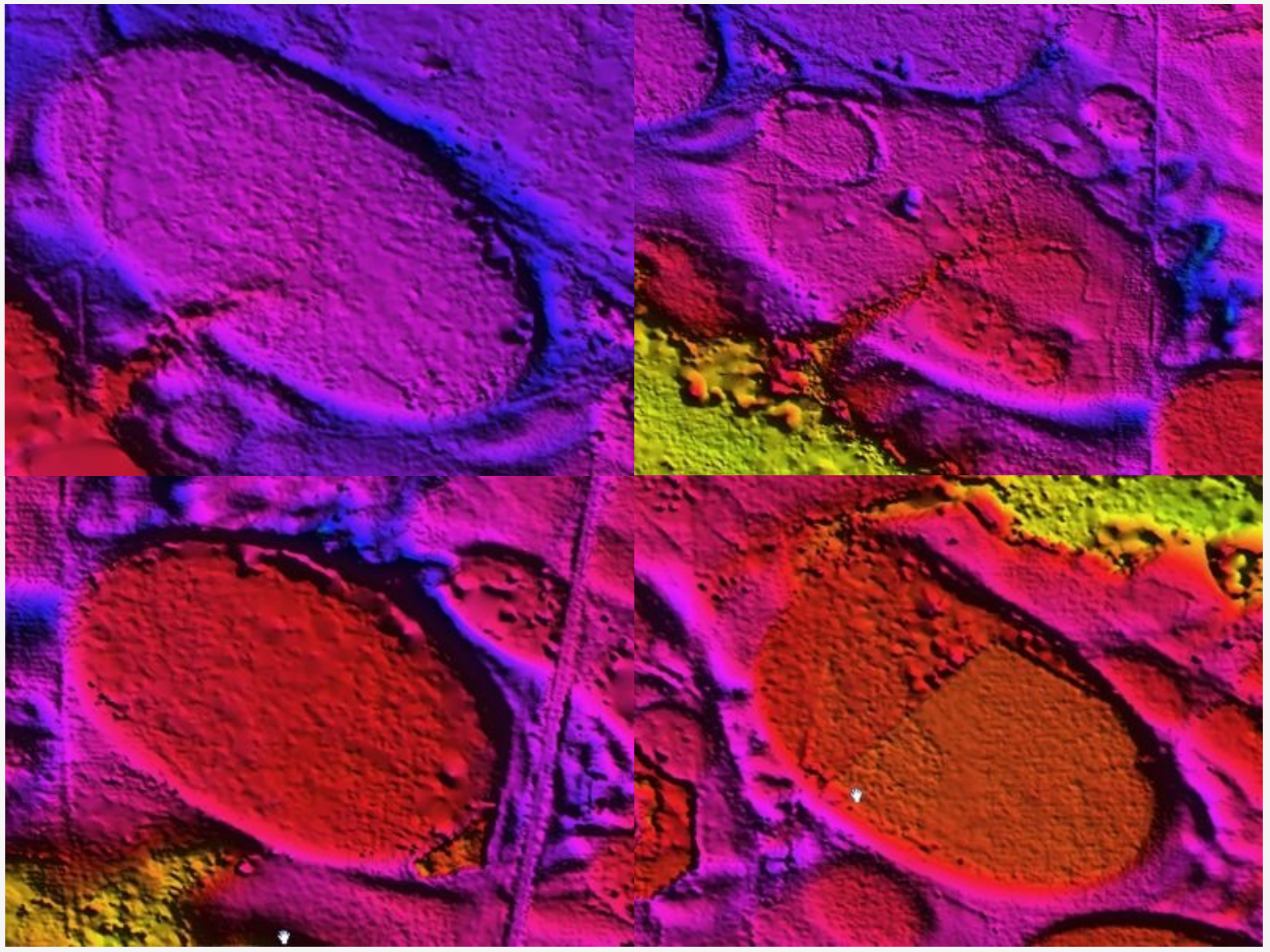


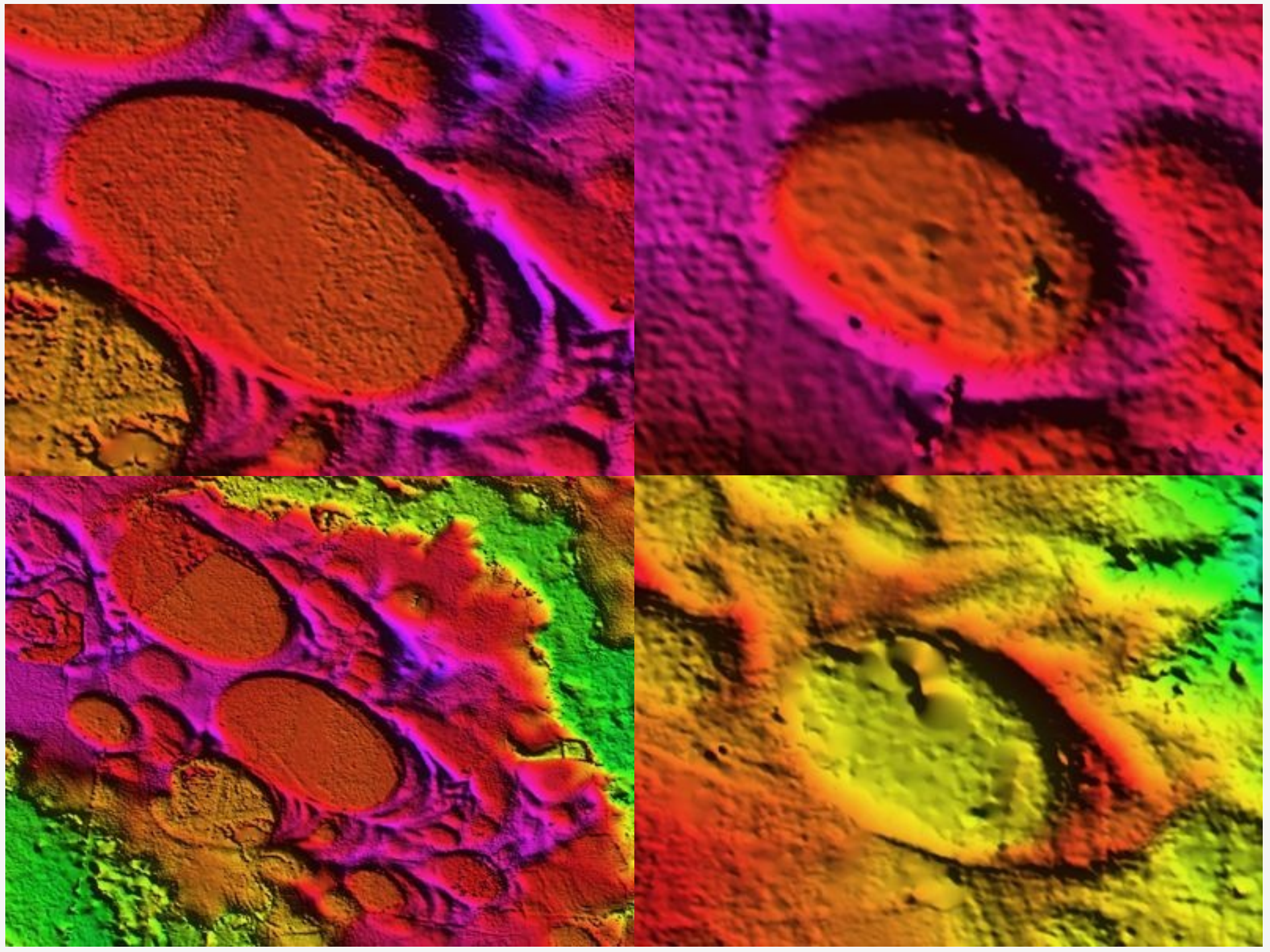


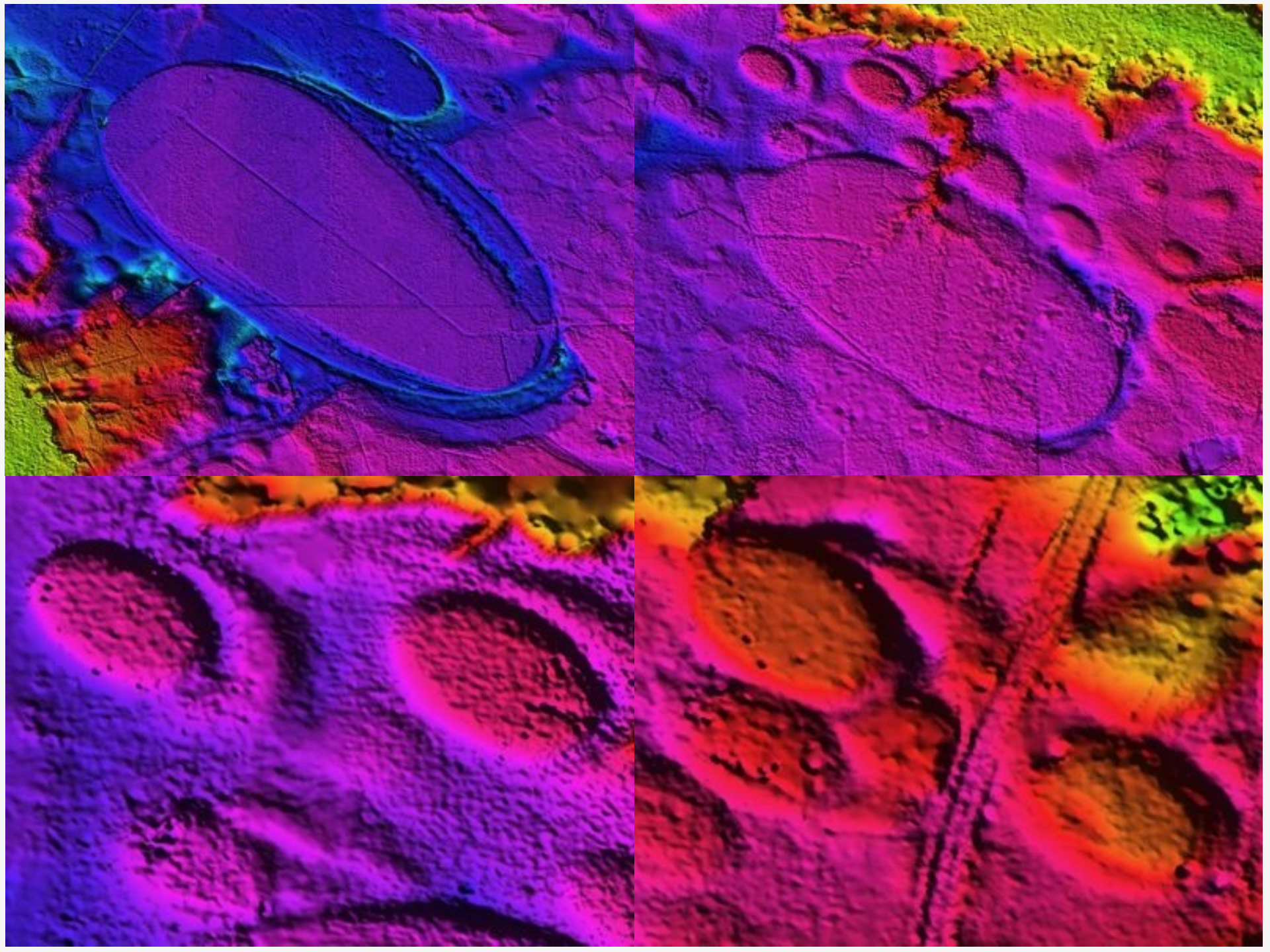


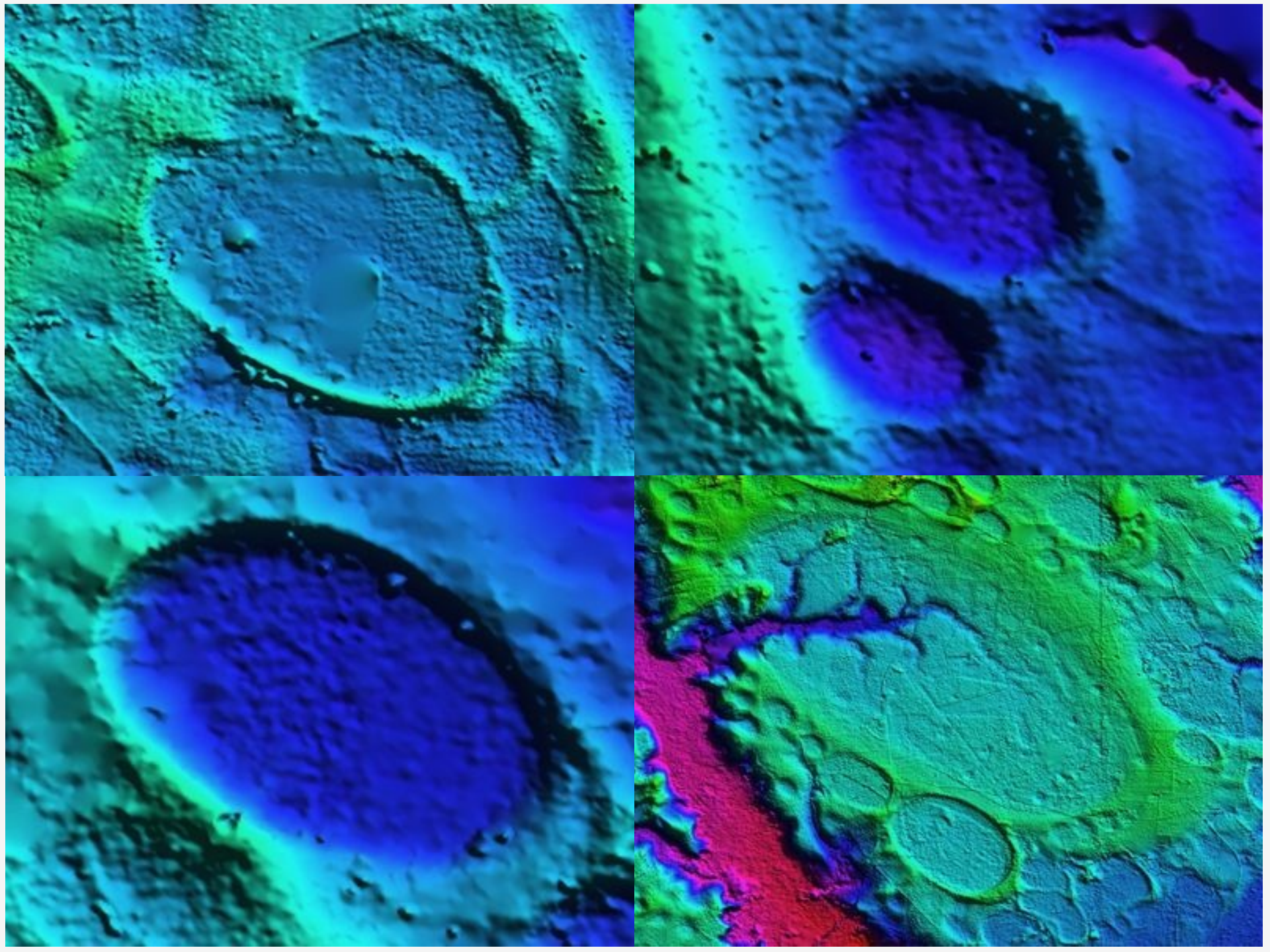


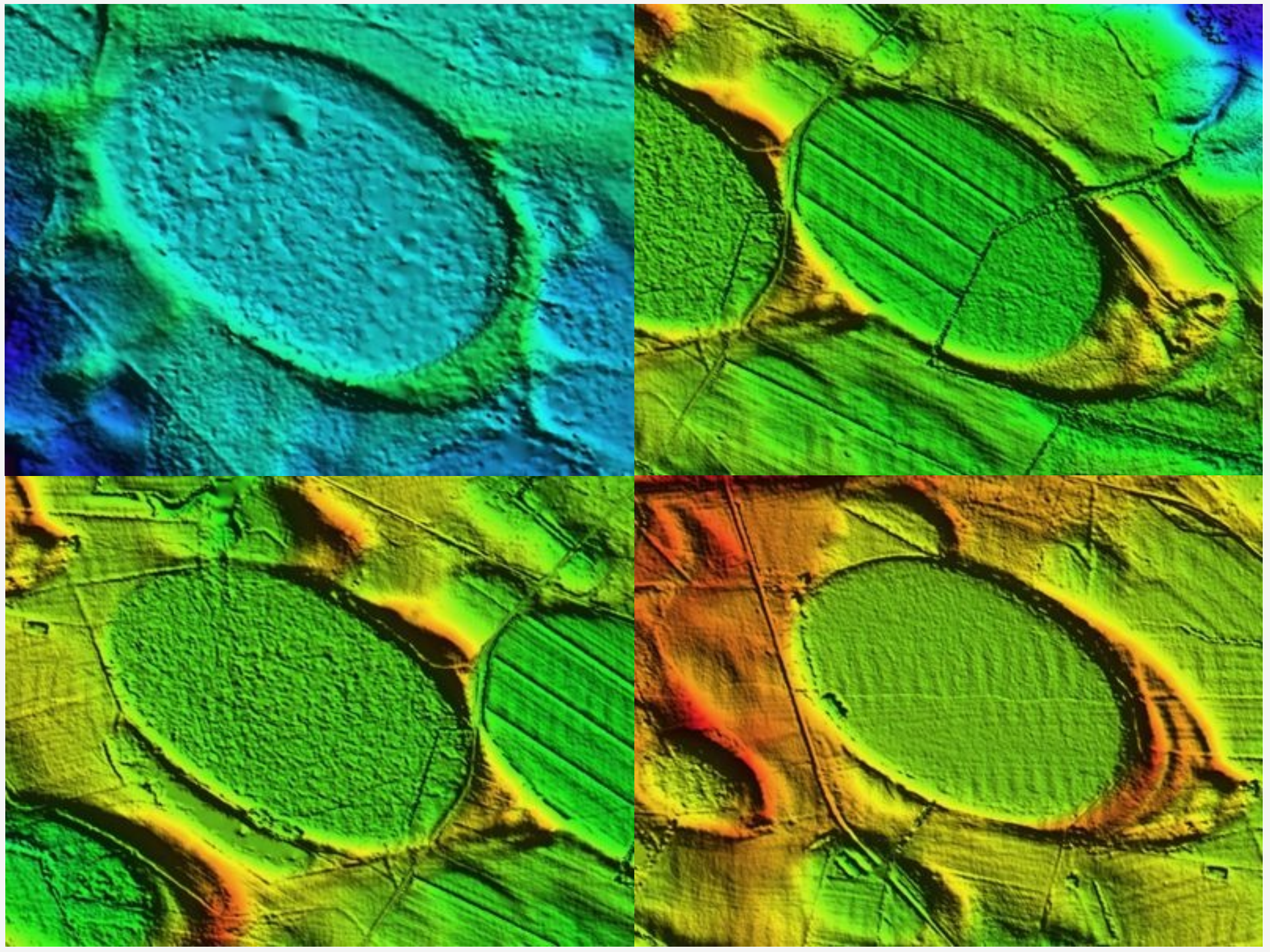


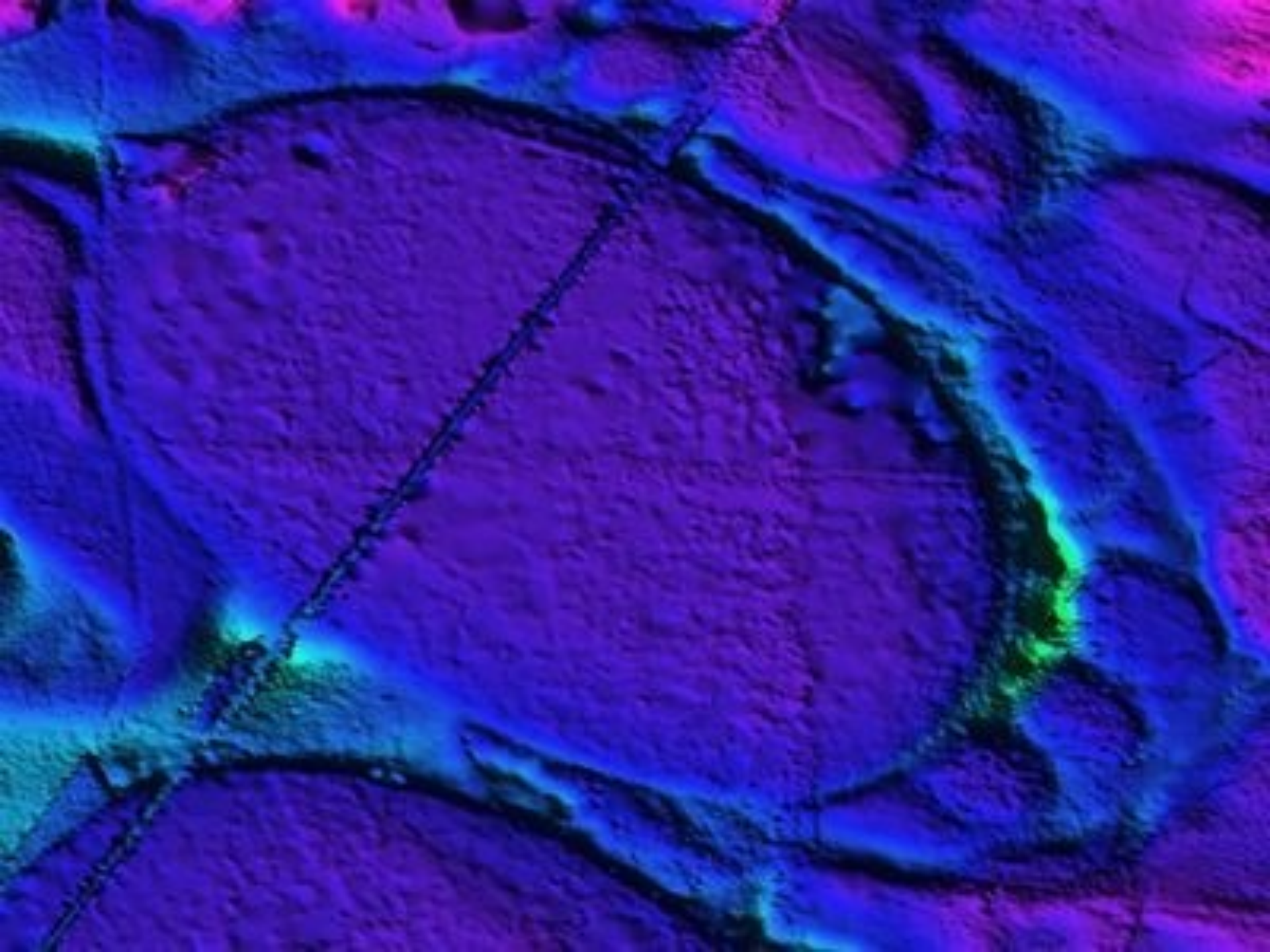












Variations of bay Planforms

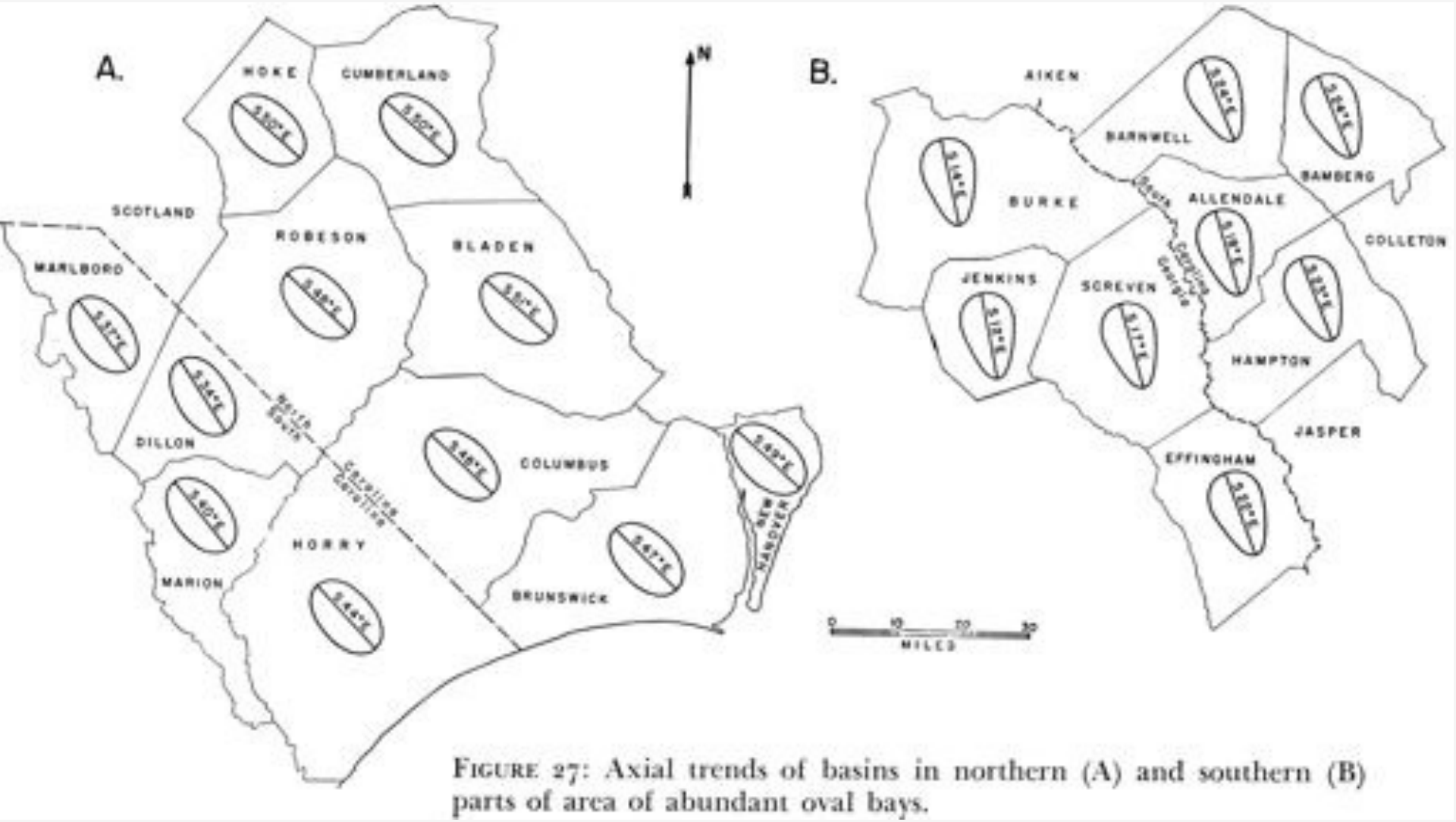
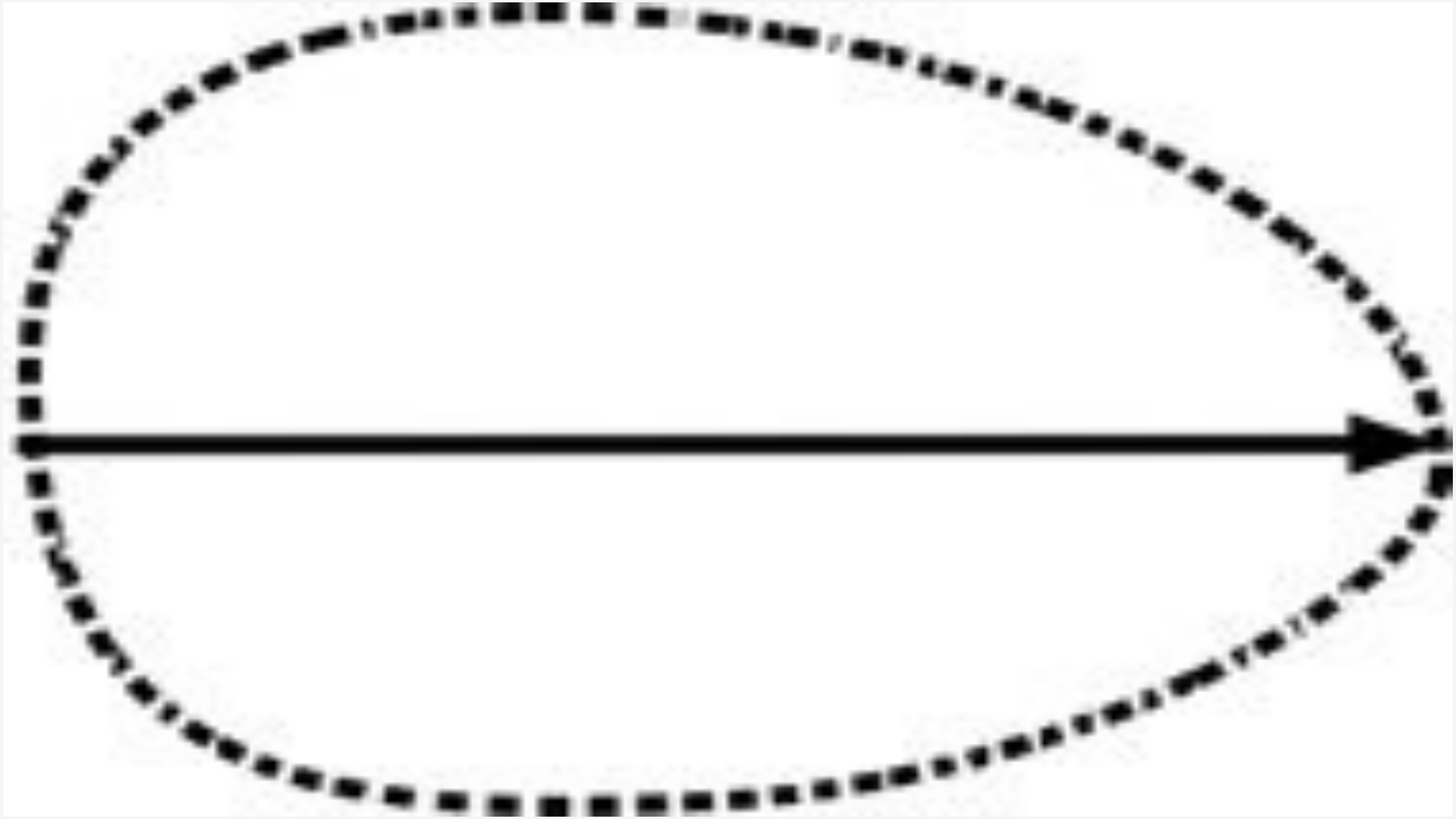


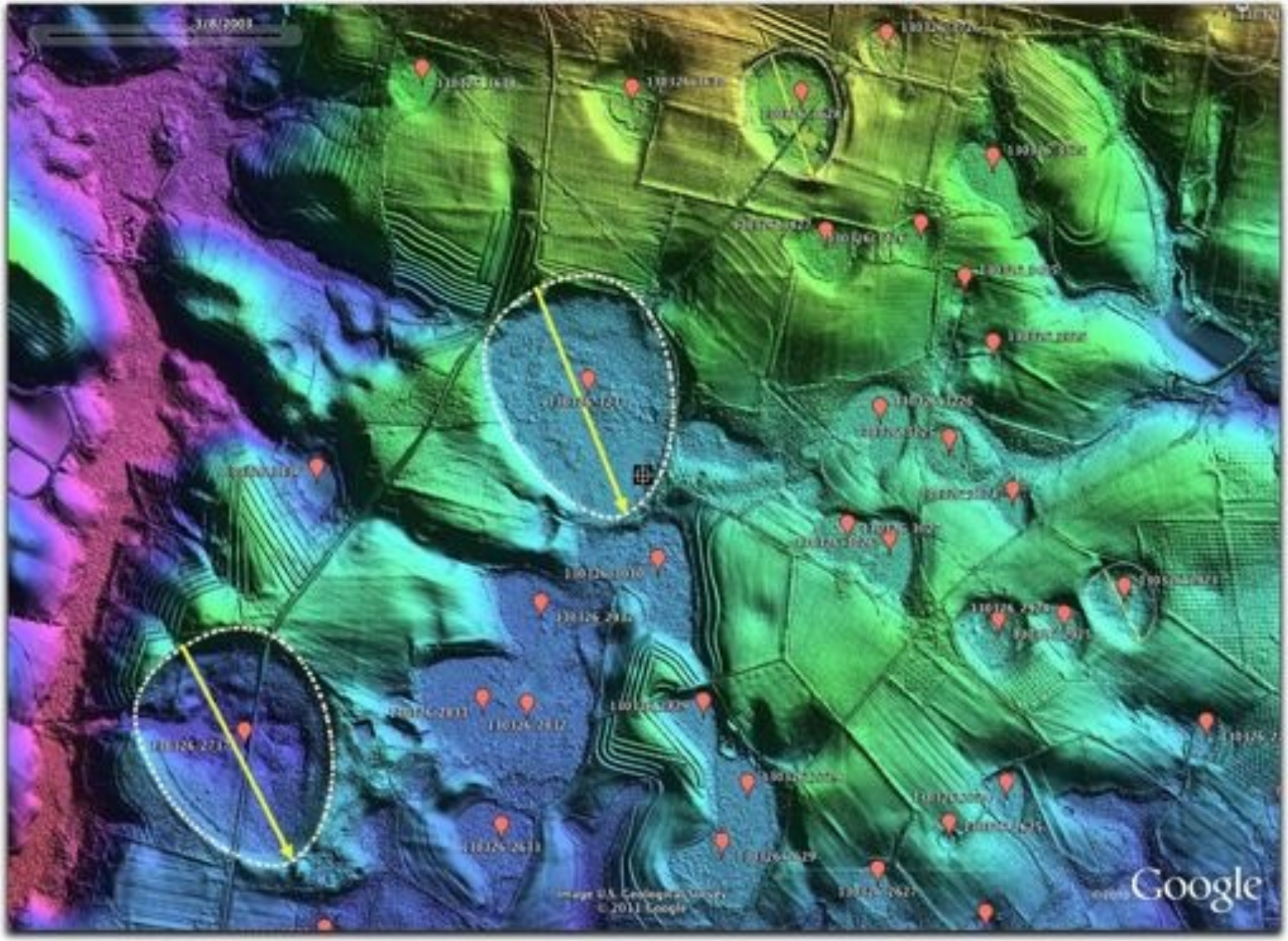
FIGURE 27: Axial trends of basins in northern (A) and southern (B) parts of area of abundant oval bays.

D. Johnson, 1942

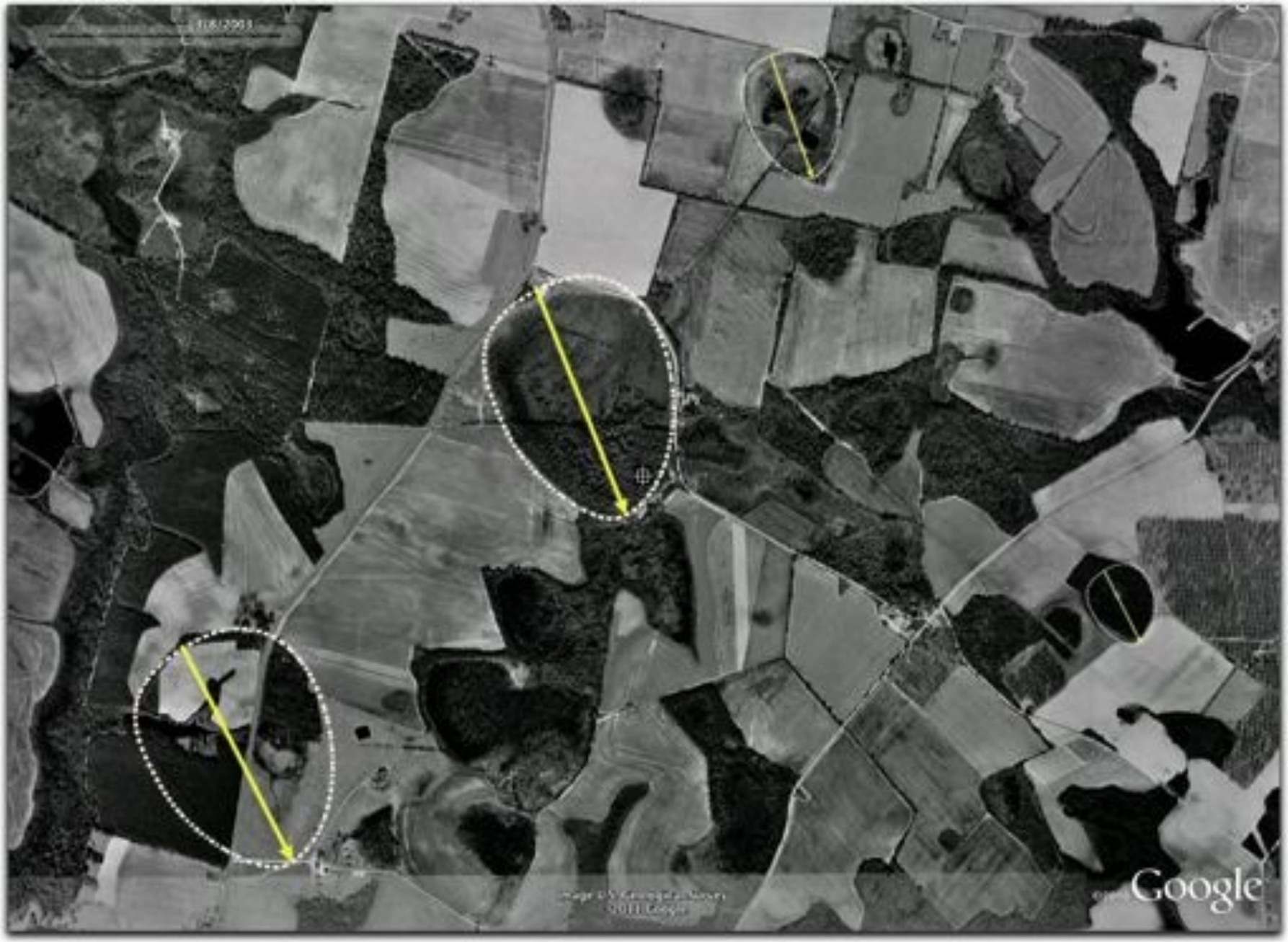
Variations of bay Planforms



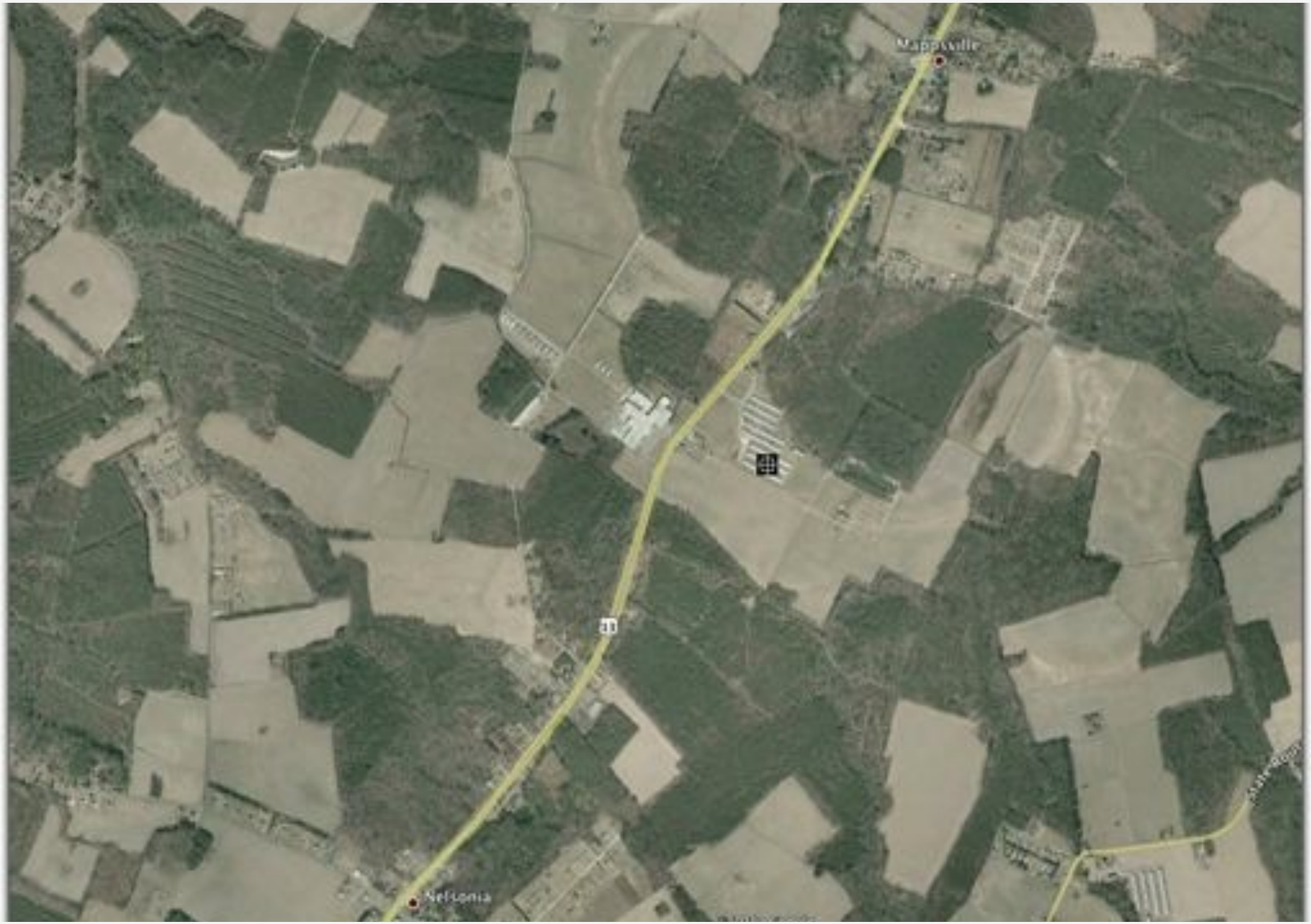
Bay South Prototype Example



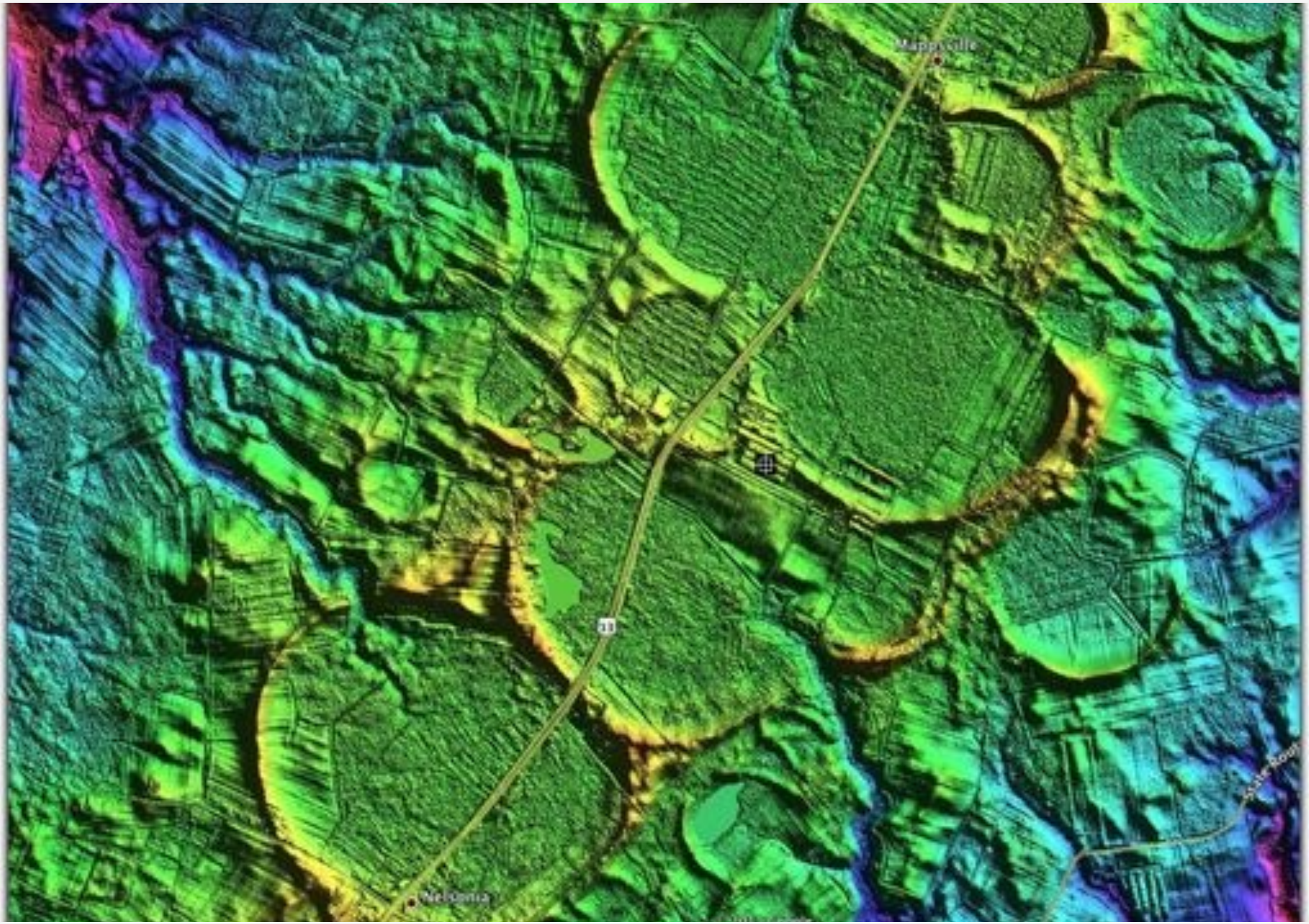
Bay South Prototype Example



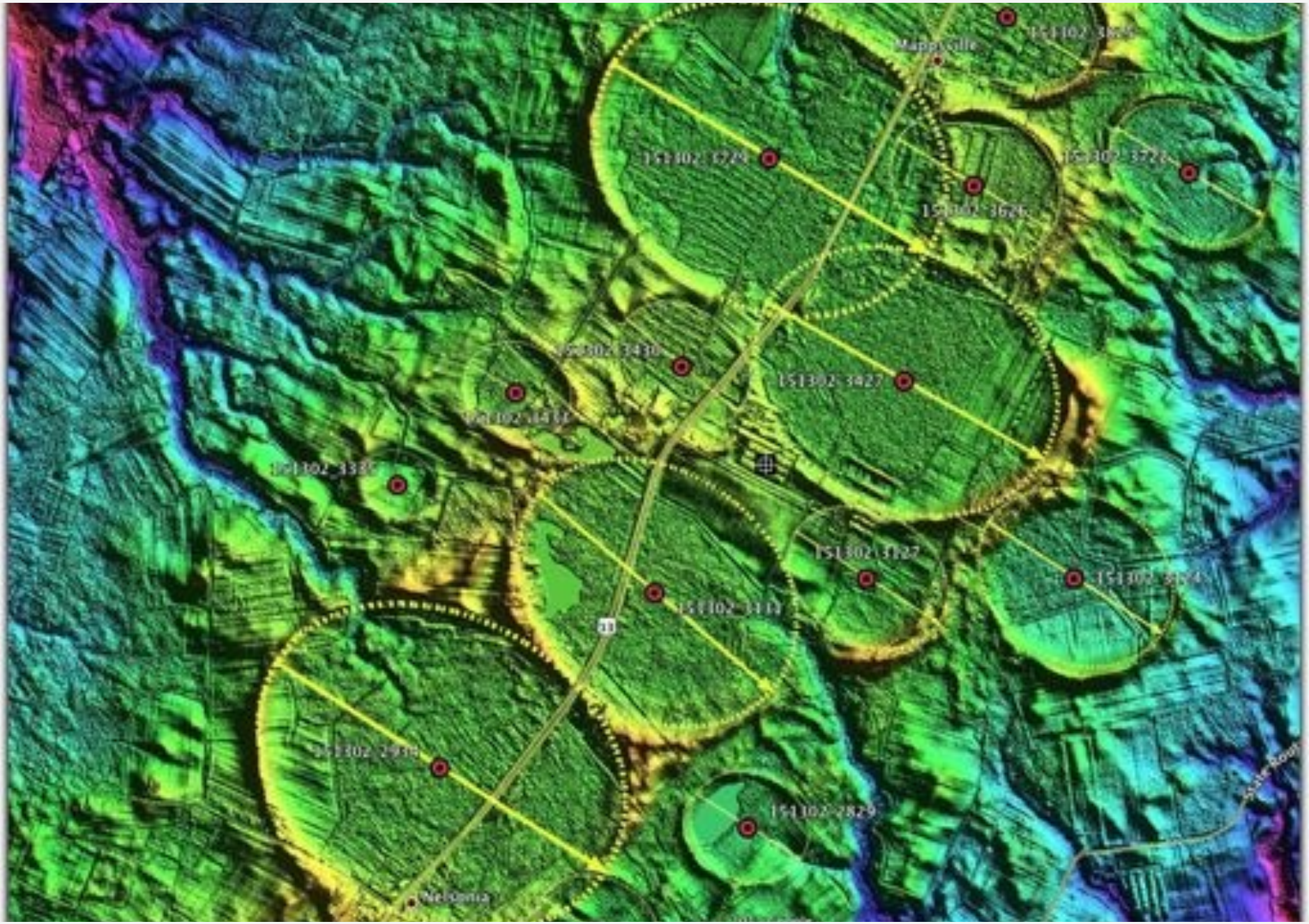
Oval Planform: Virginia Eastern Shore – Mappsville

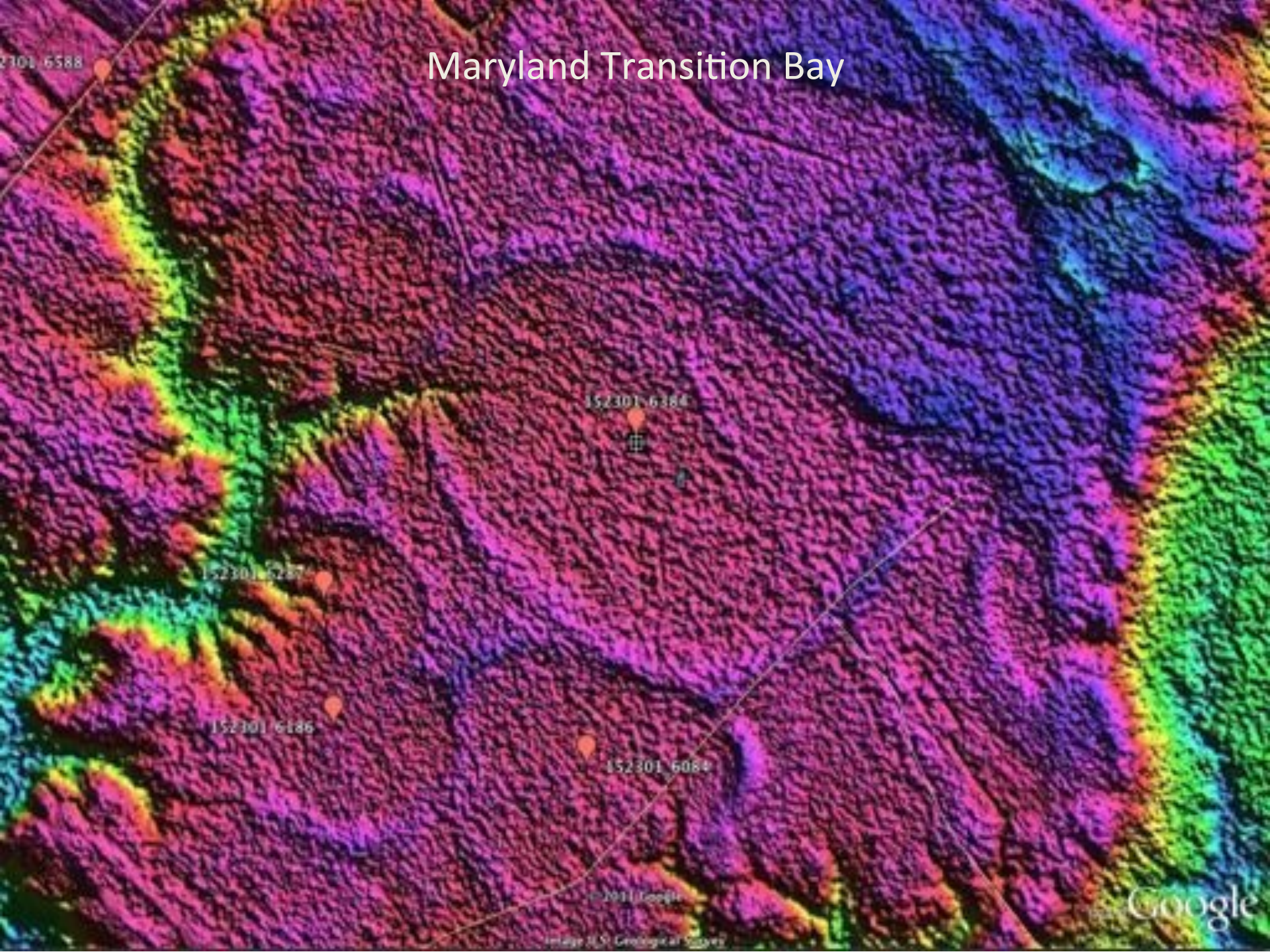


Virginia Eastern Shore – Mappsville



Virginia Eastern Shore – Mappsville




Maryland Transition Bay
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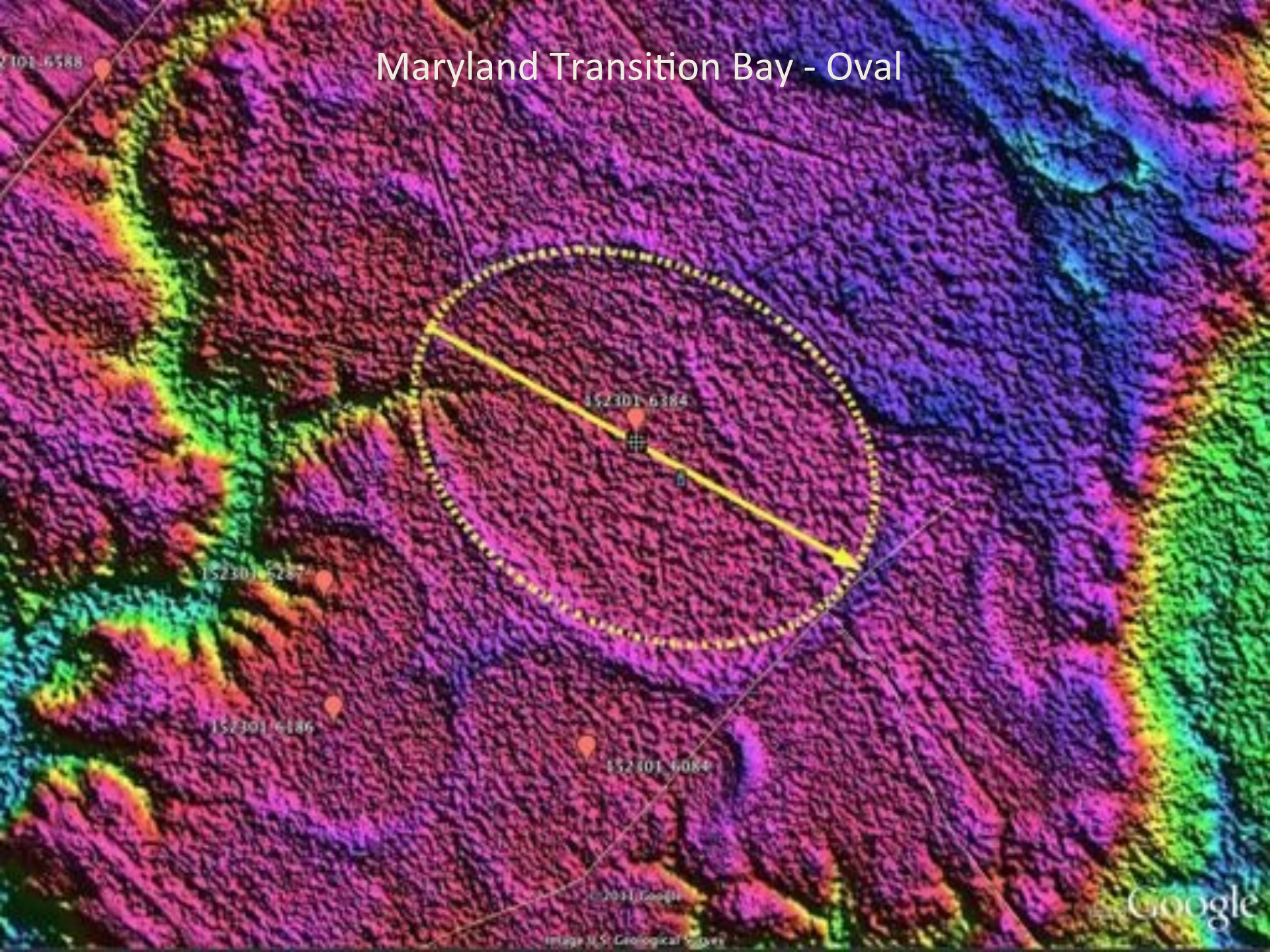
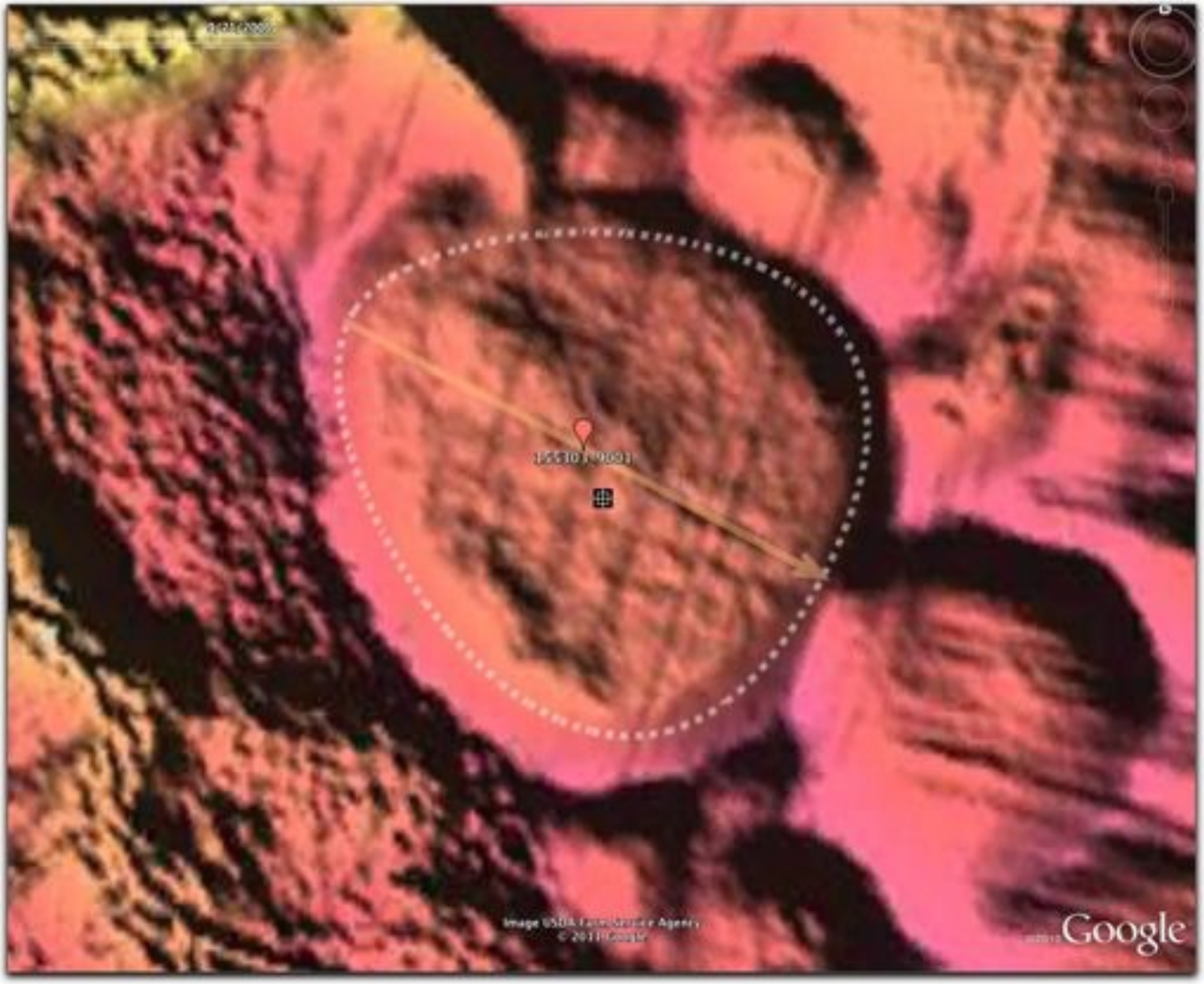
Google

Maryland Transition Bay - Oval



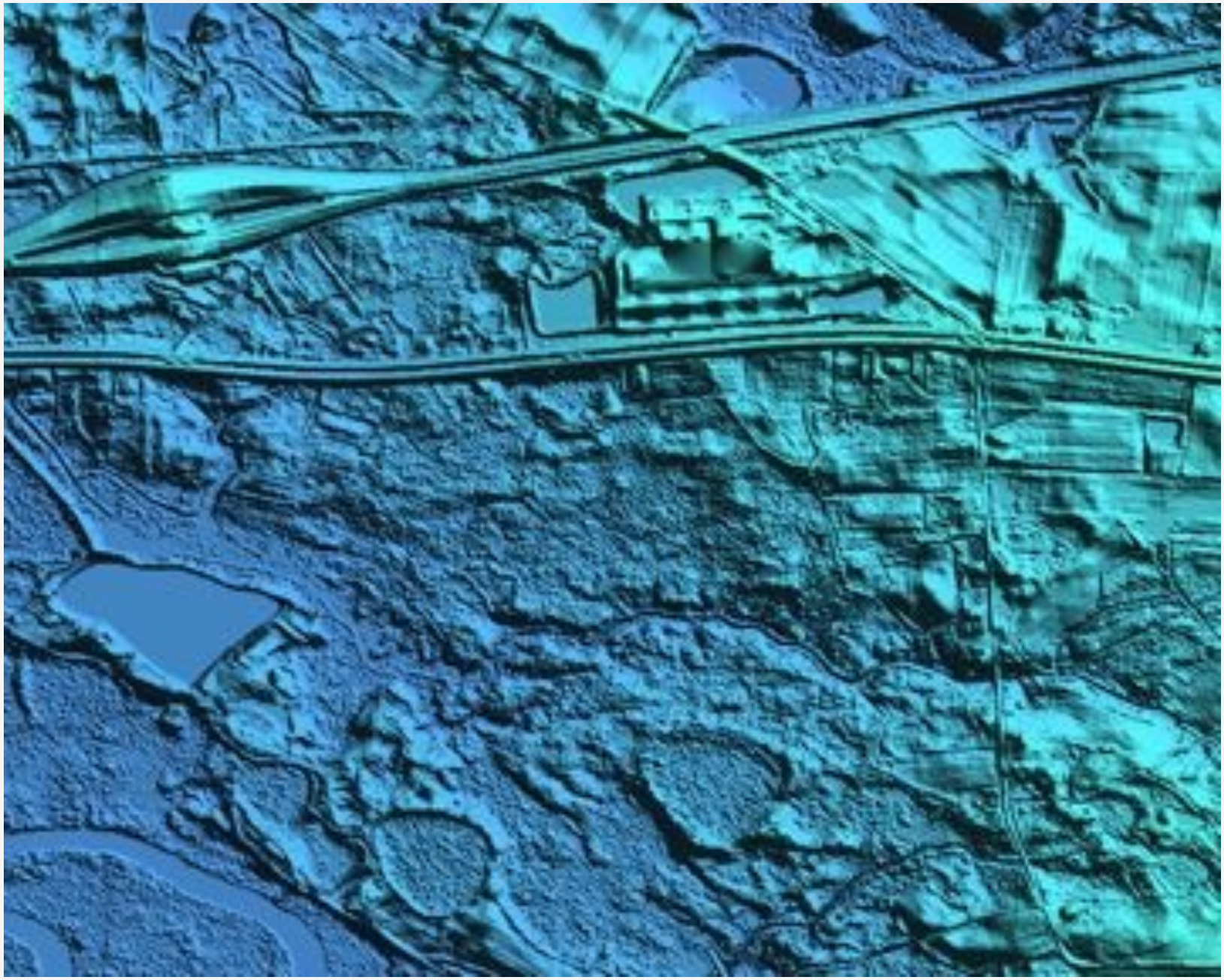
Maryland Transition Bay - Bell

Bell-Shaped bays – MD, DE, NJ

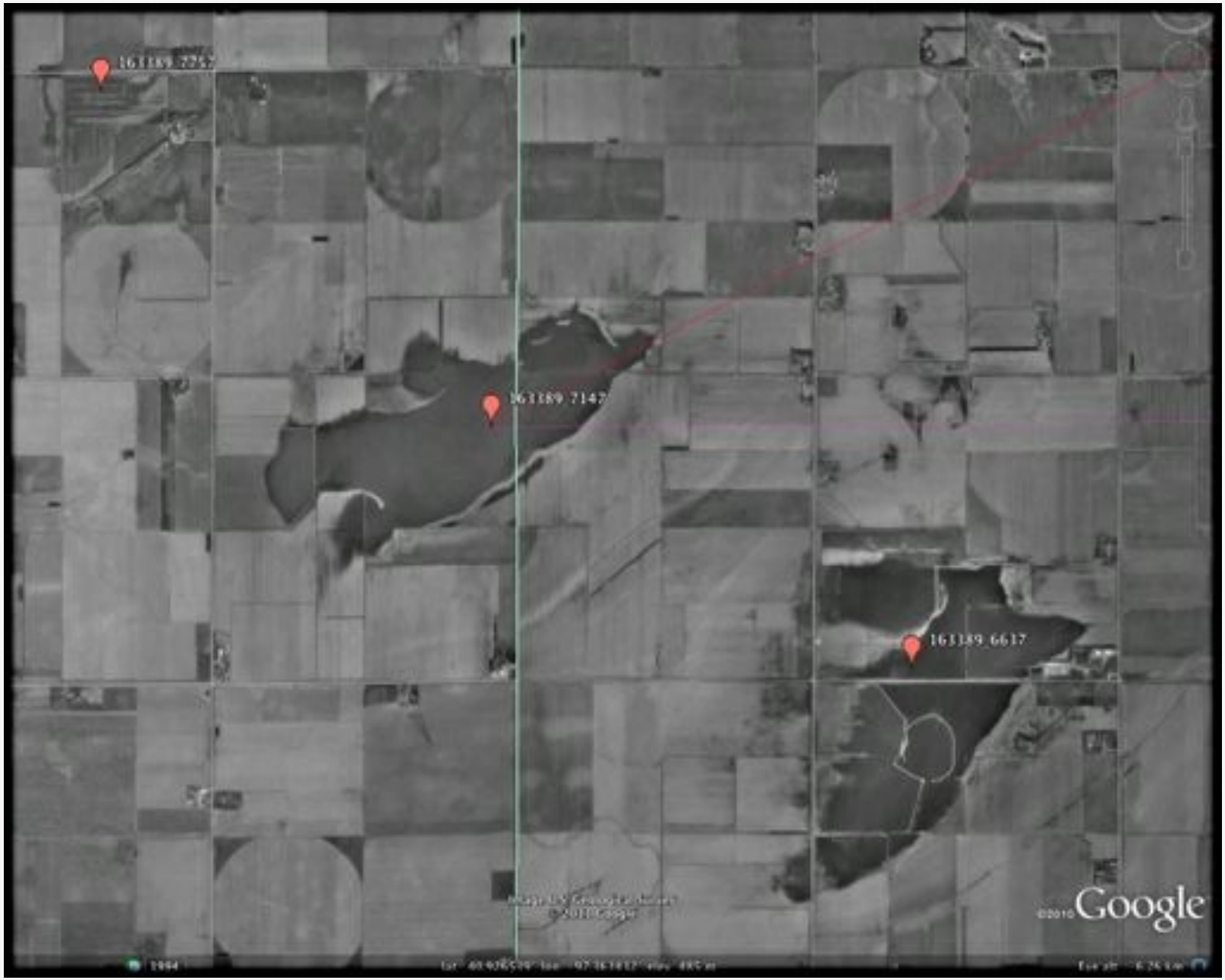


Bell-Shaped bays – MD, DE, NJ

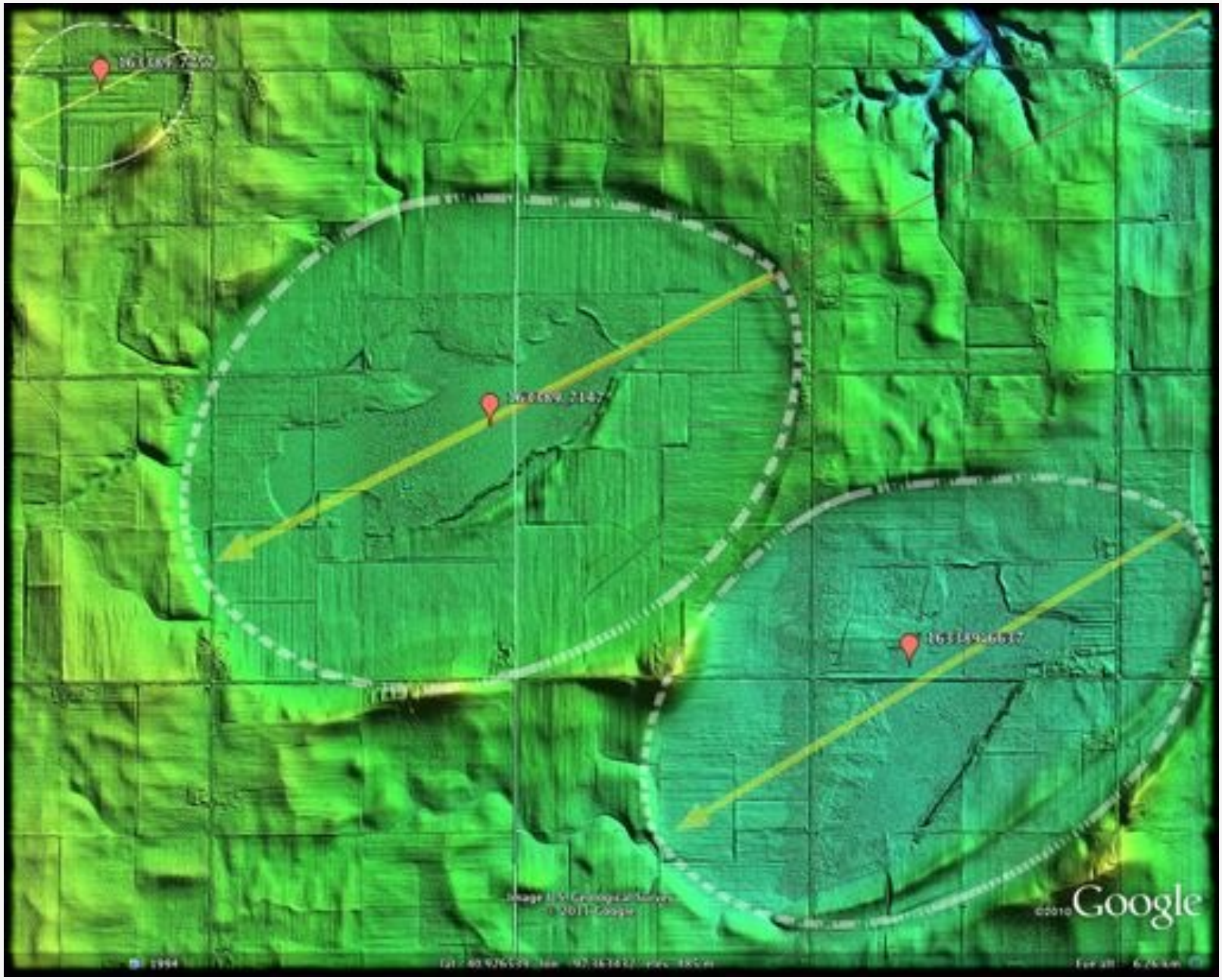
Bell-Shaped bays – MD, DE, NJ



Nebraska “Rainwater Basins”



Nebraska Bay Archetype



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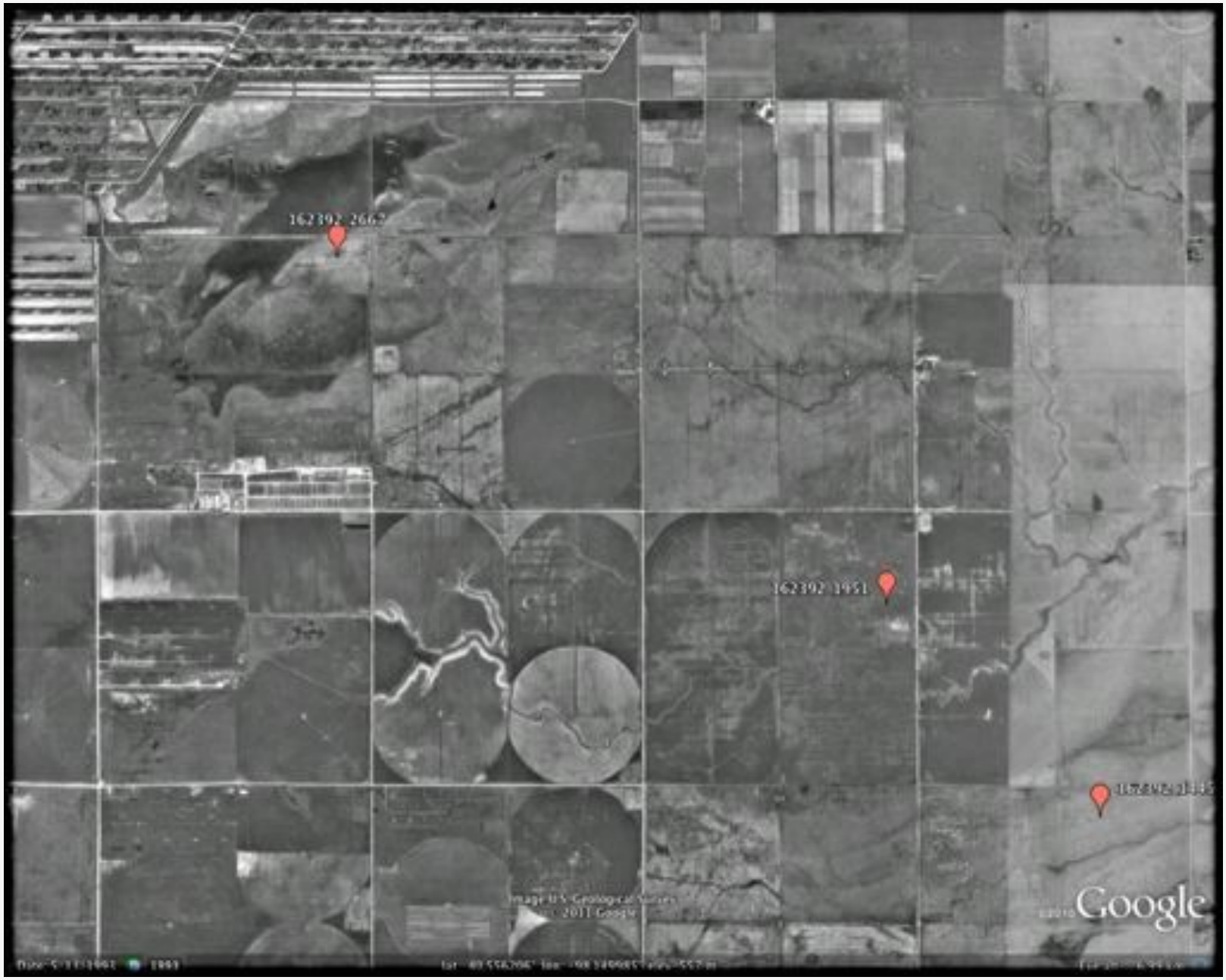
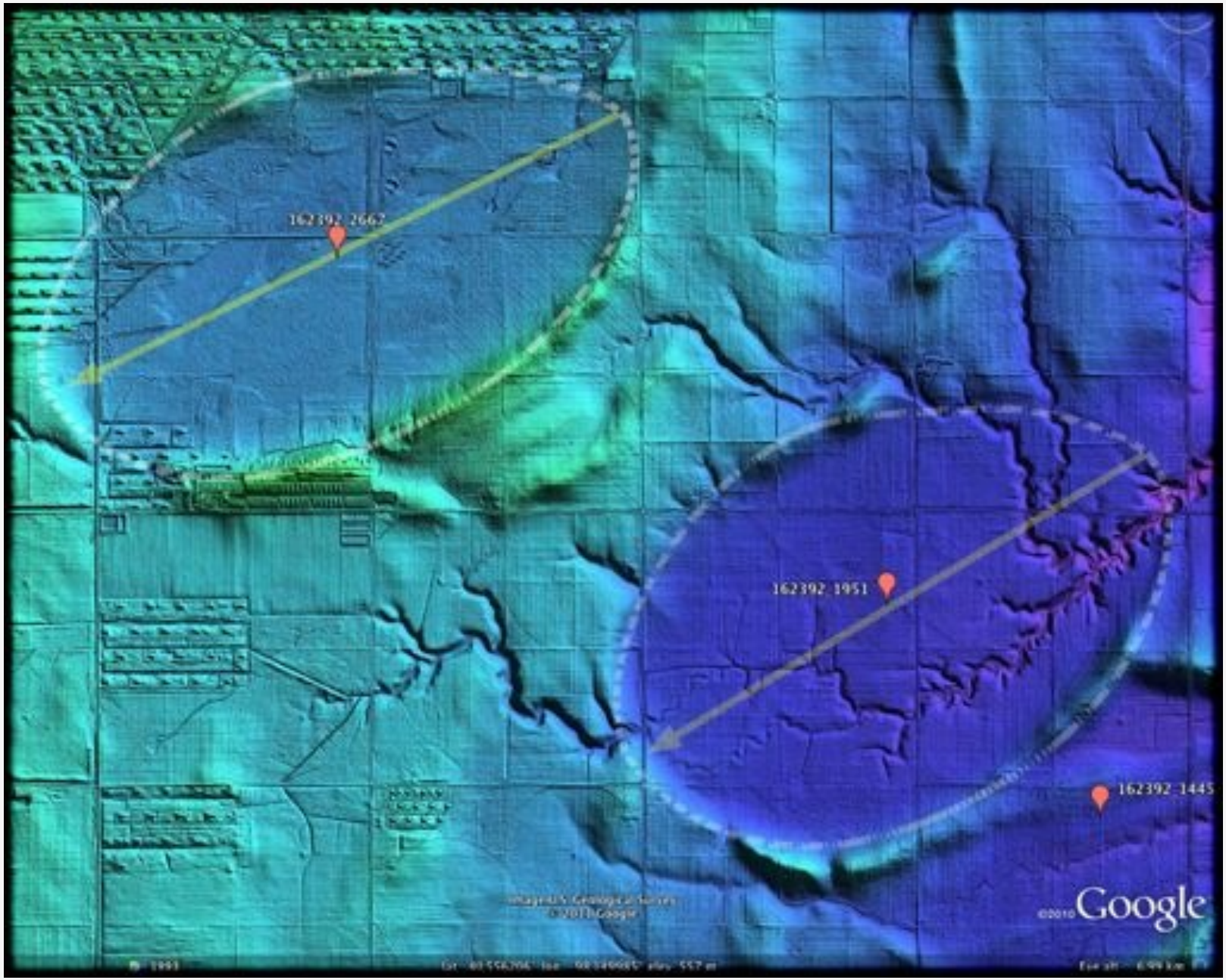
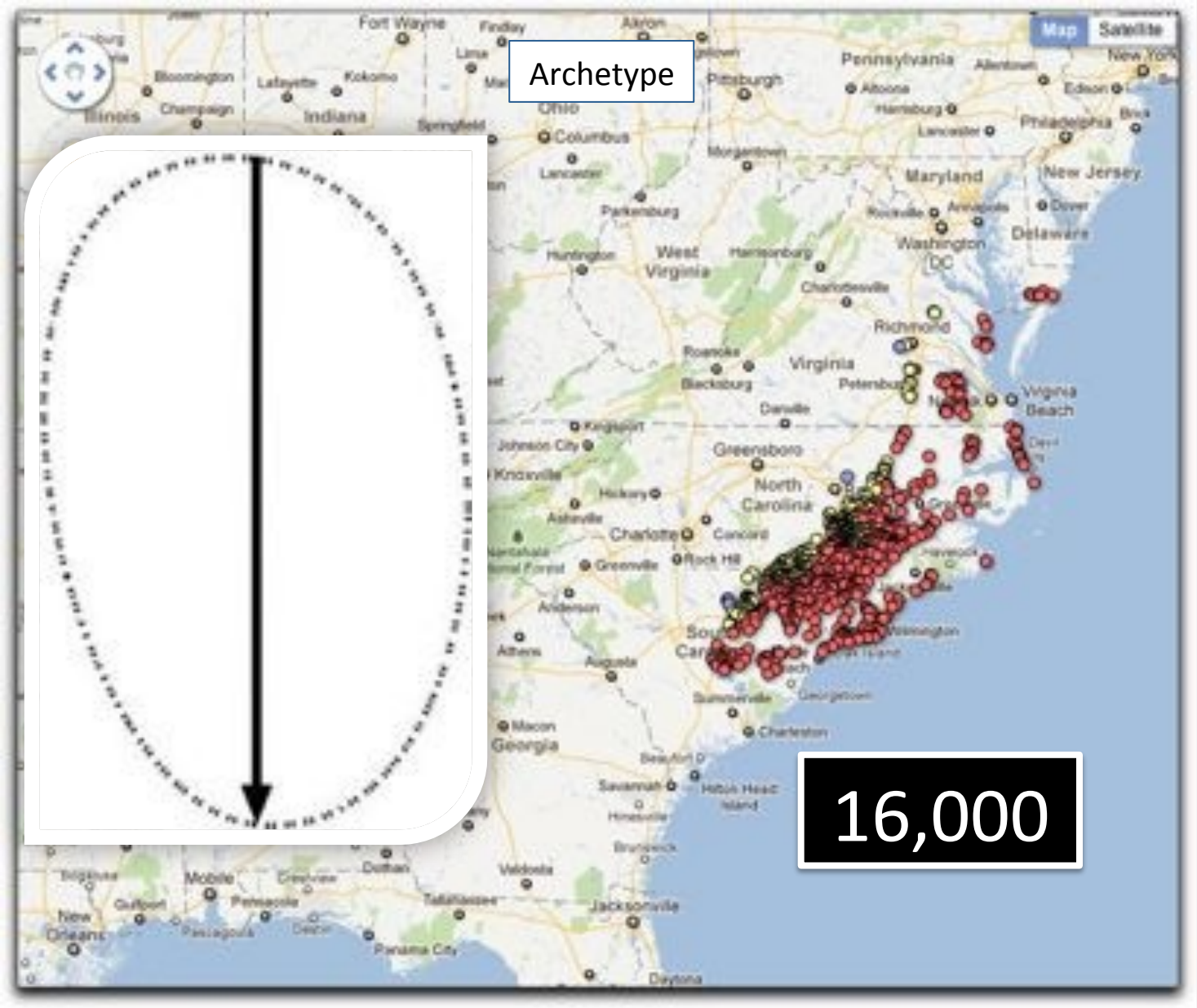


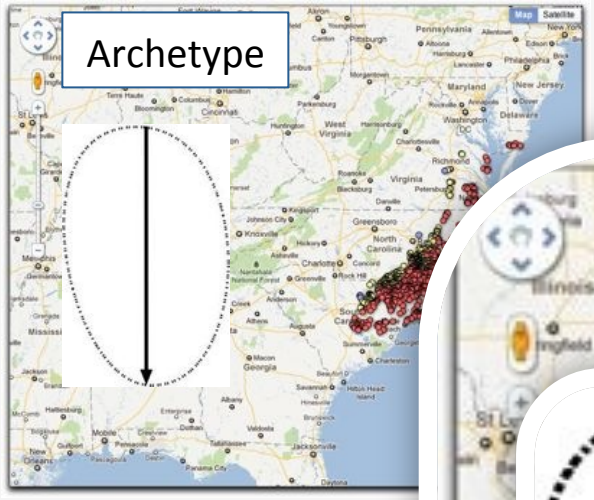
Nebraska Bay Archetype

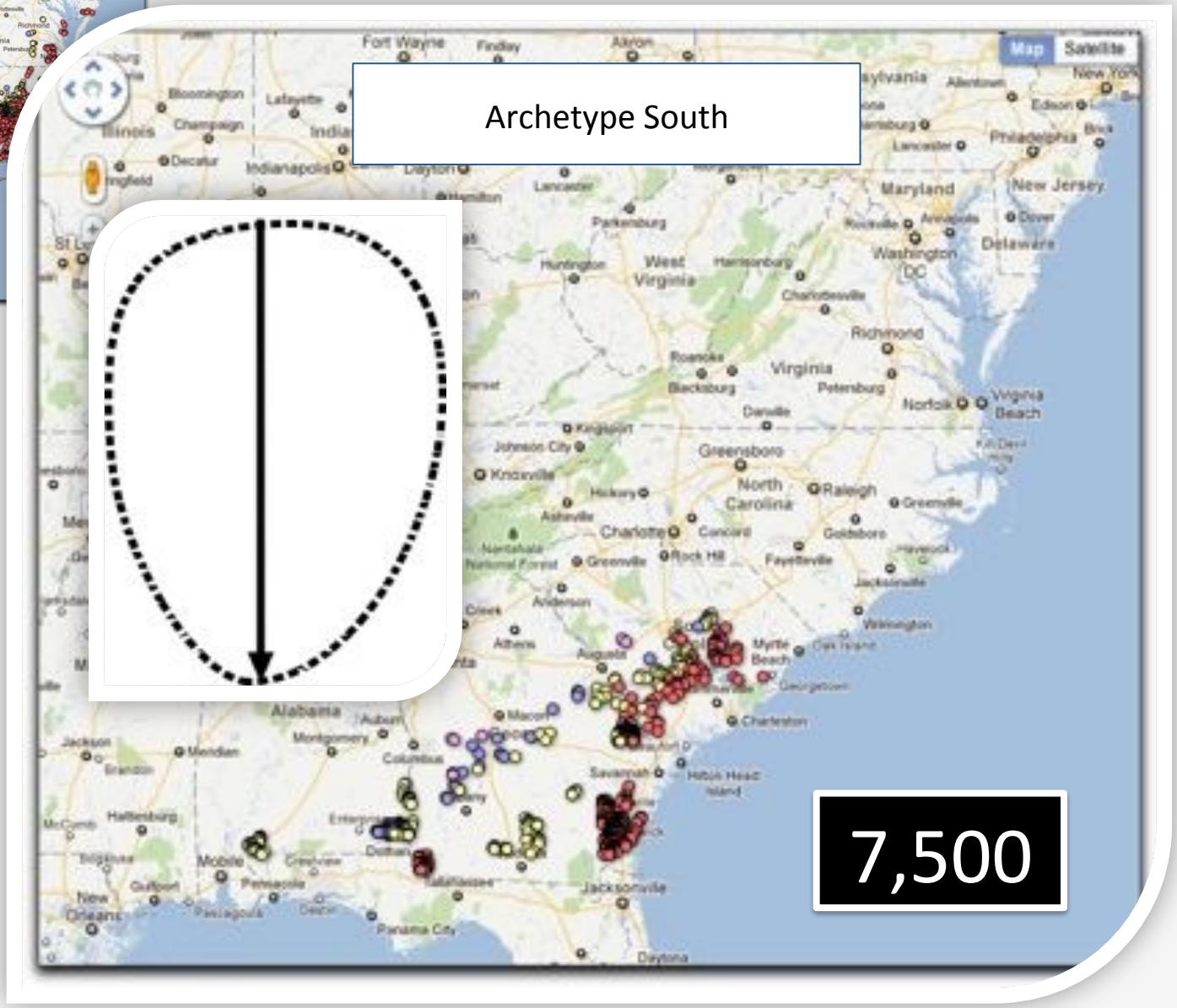


Extent of Archetype Locales

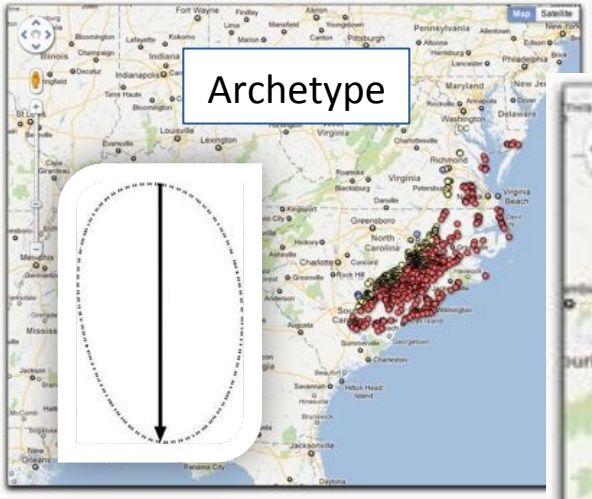


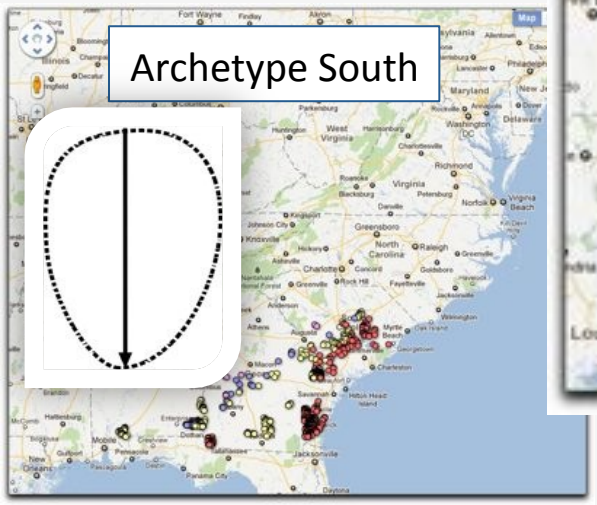
Extent of Archetype Locales

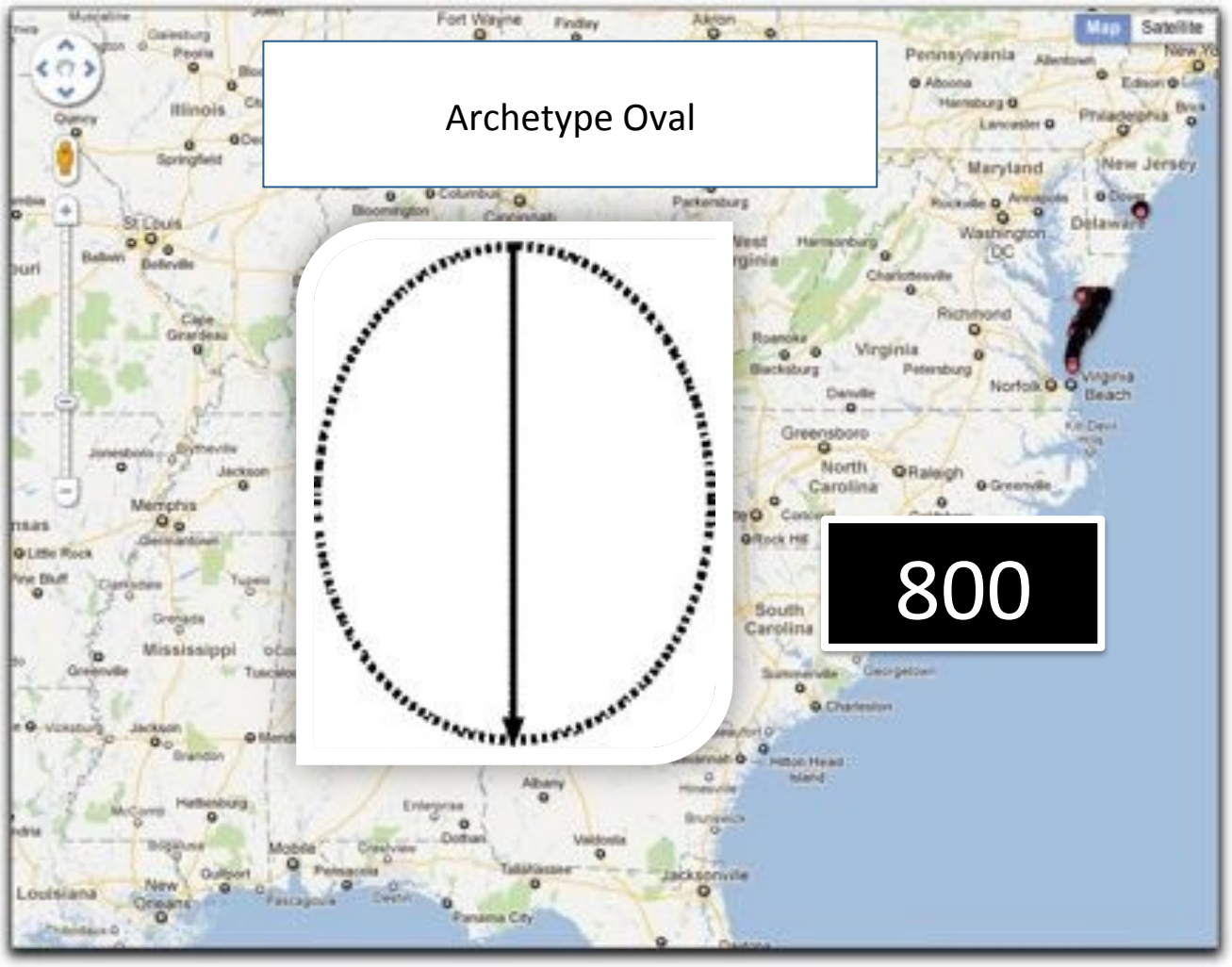




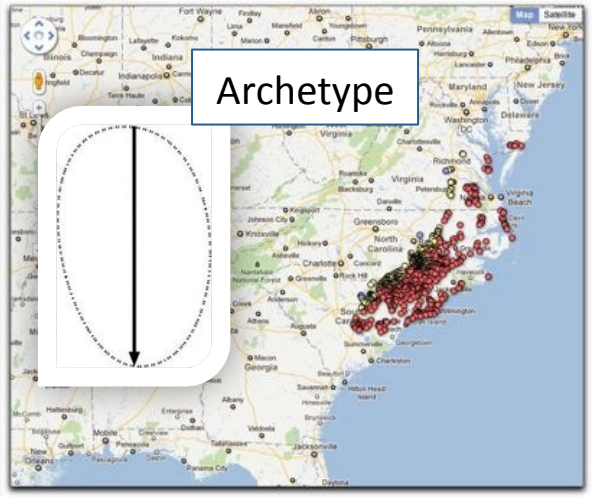
Extent of Archetype Locales

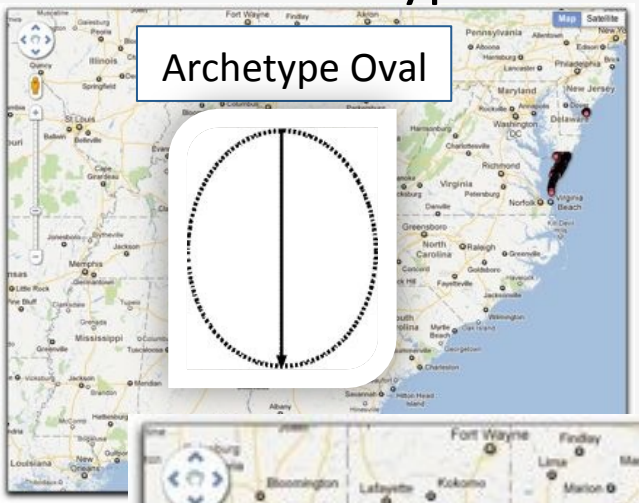


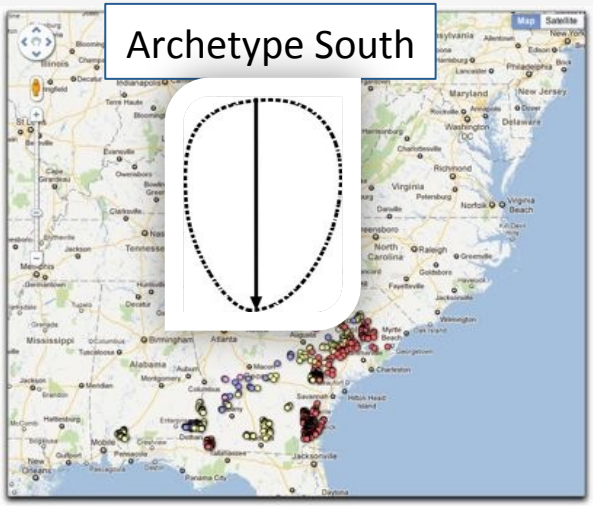


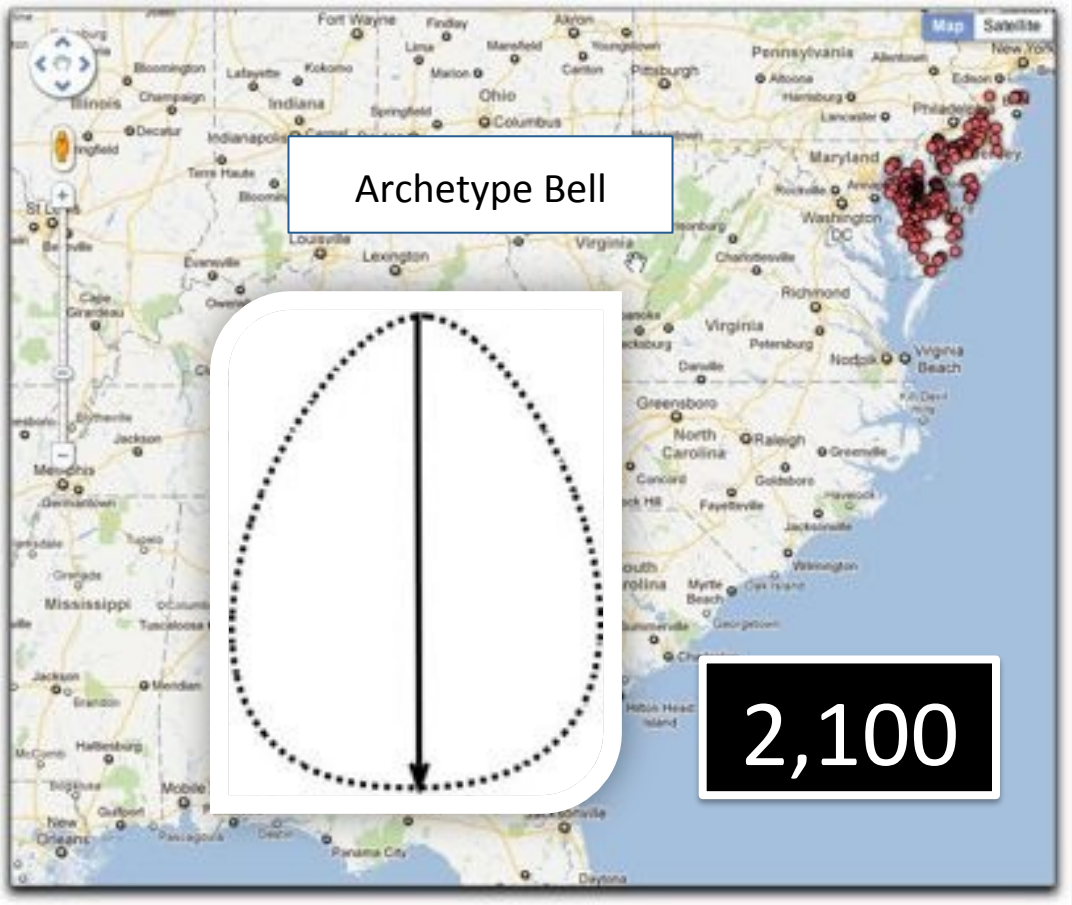


Extent of Archetype Locales

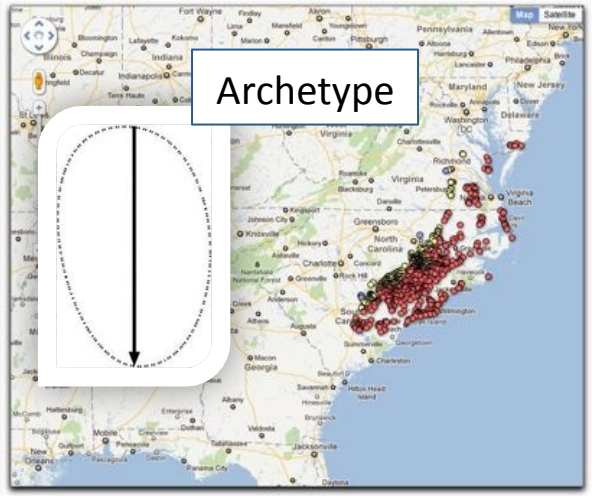


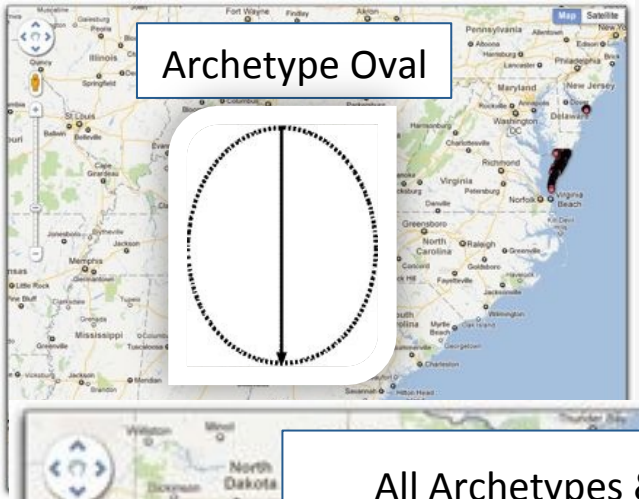


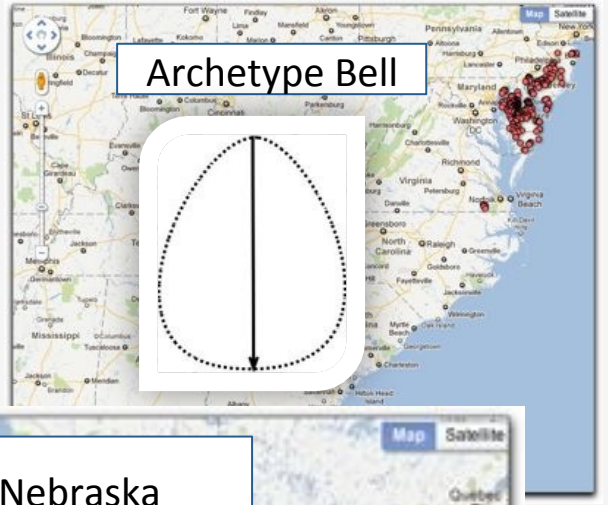


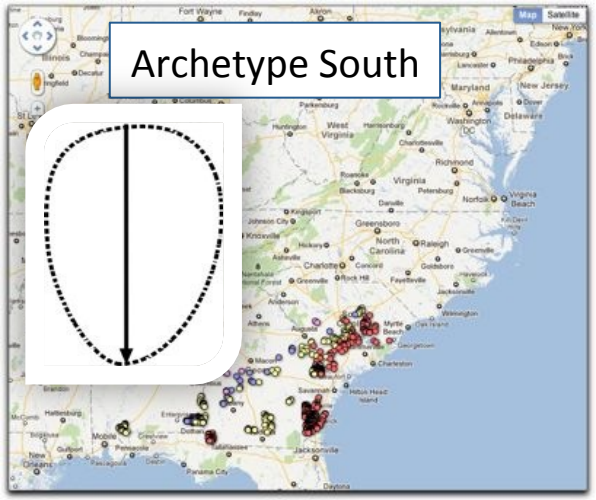


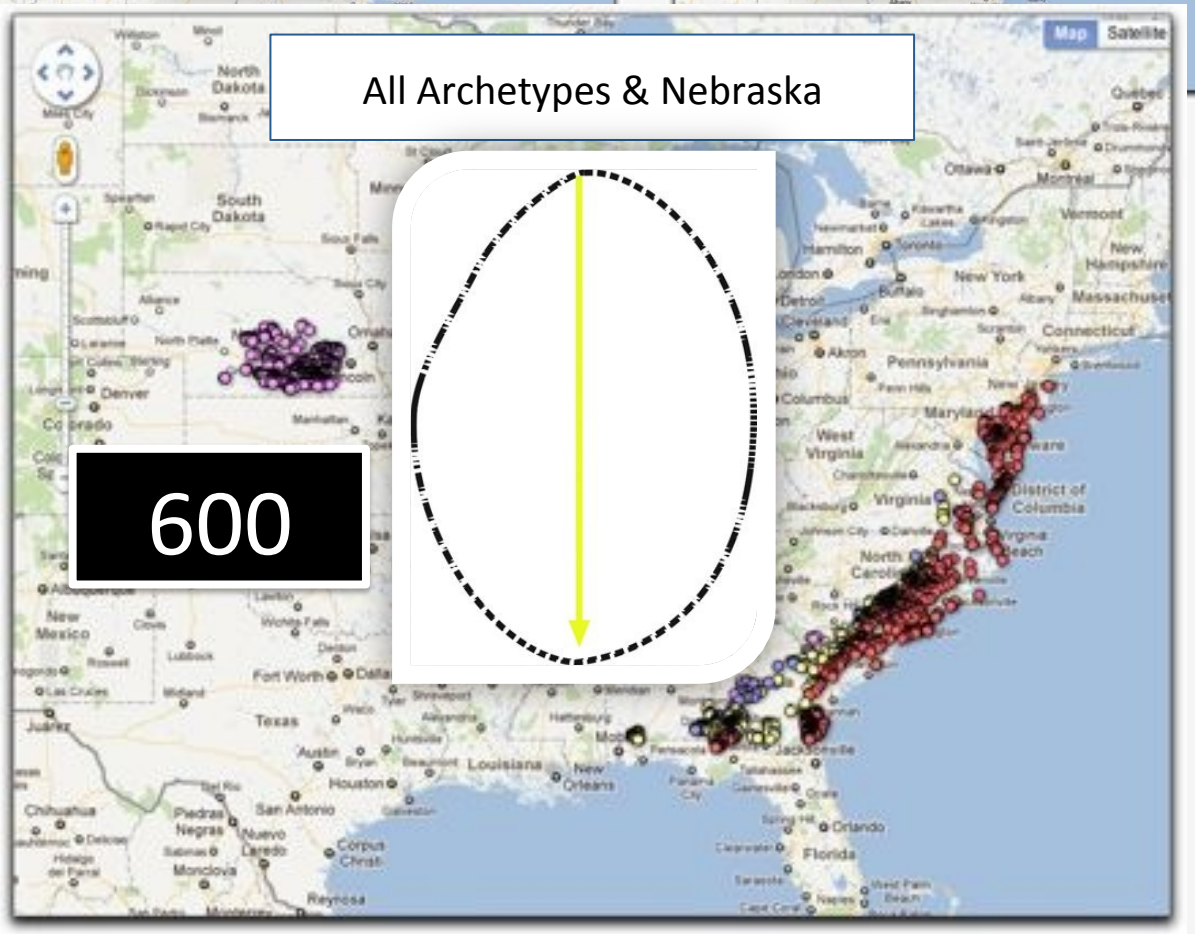
Extent of Archetype Locales











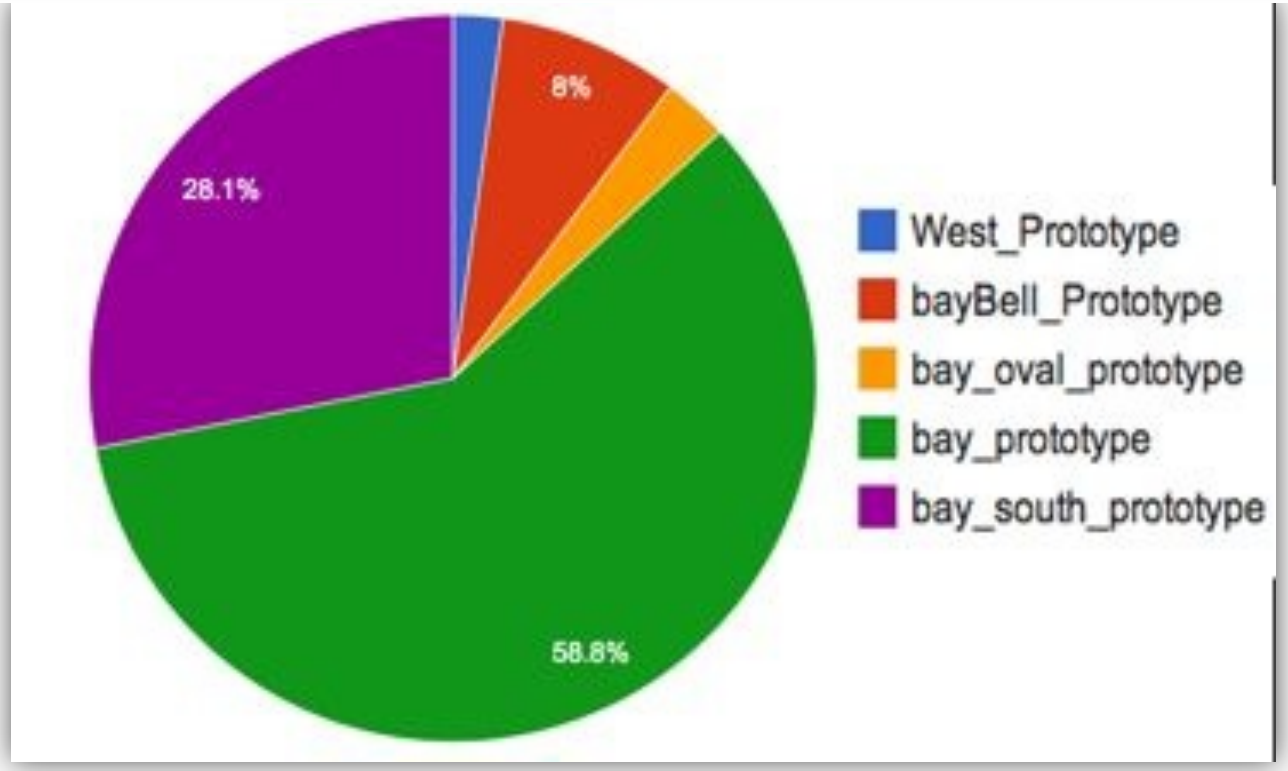
Fusion Tables: Metrics by Archetype

Bays Cintos

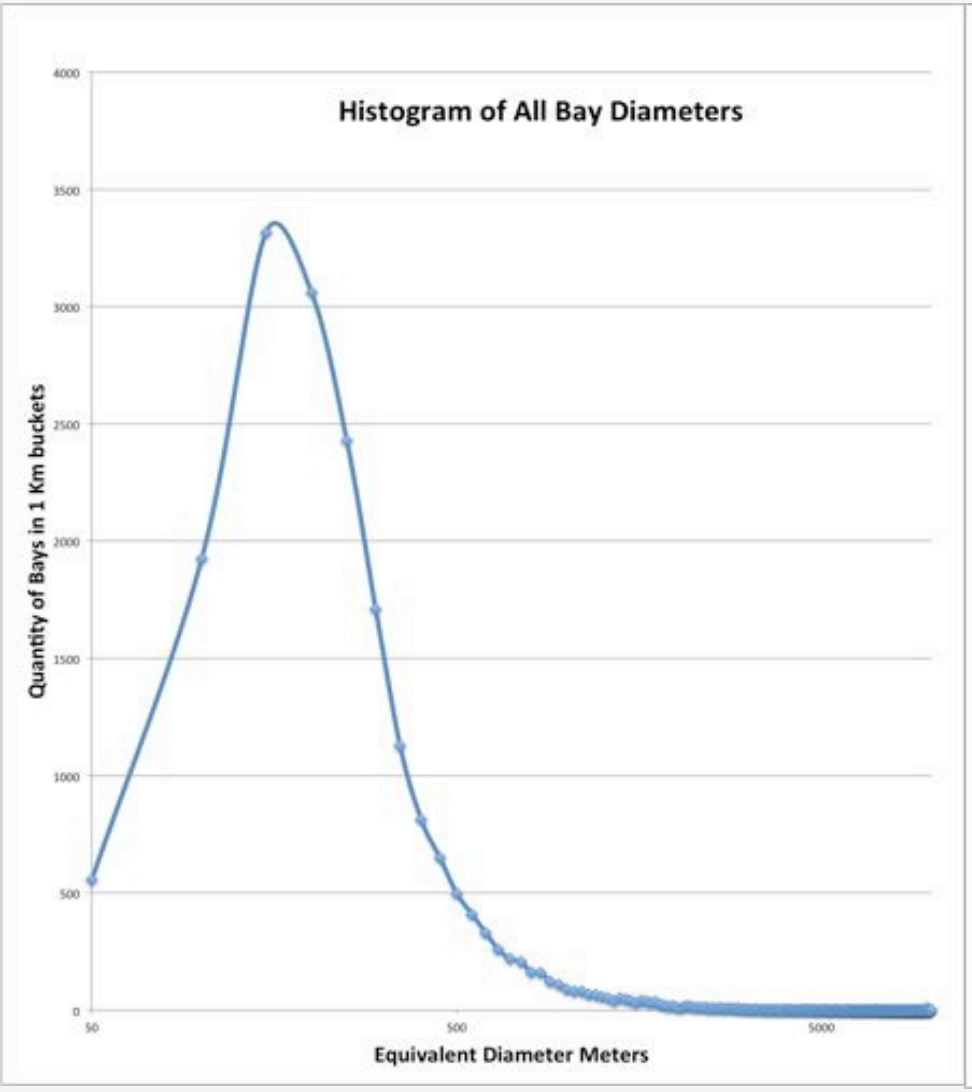
File View Edit Visualize Merge

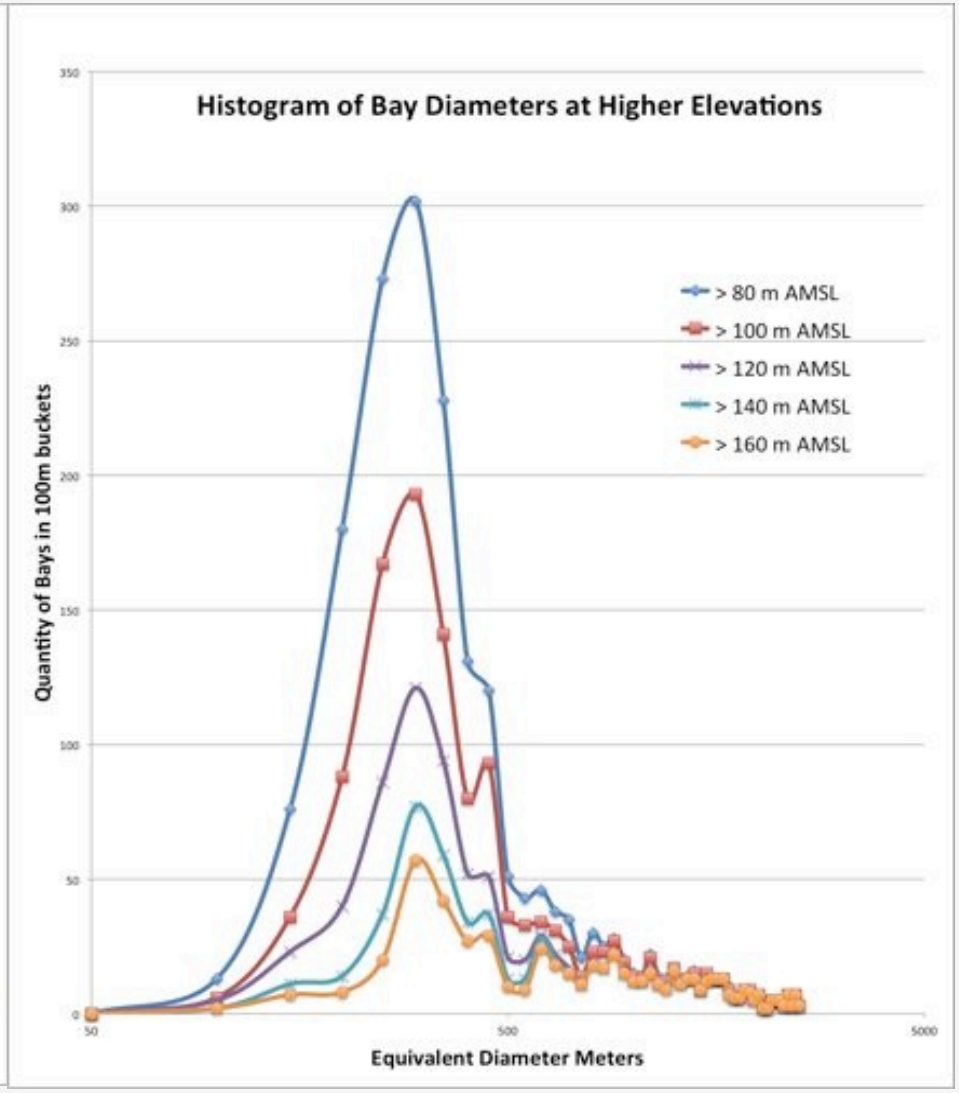
Showing **aggregate AVERAGE(Eccentricity), AVERAGE(Bearing) by Planform** options

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



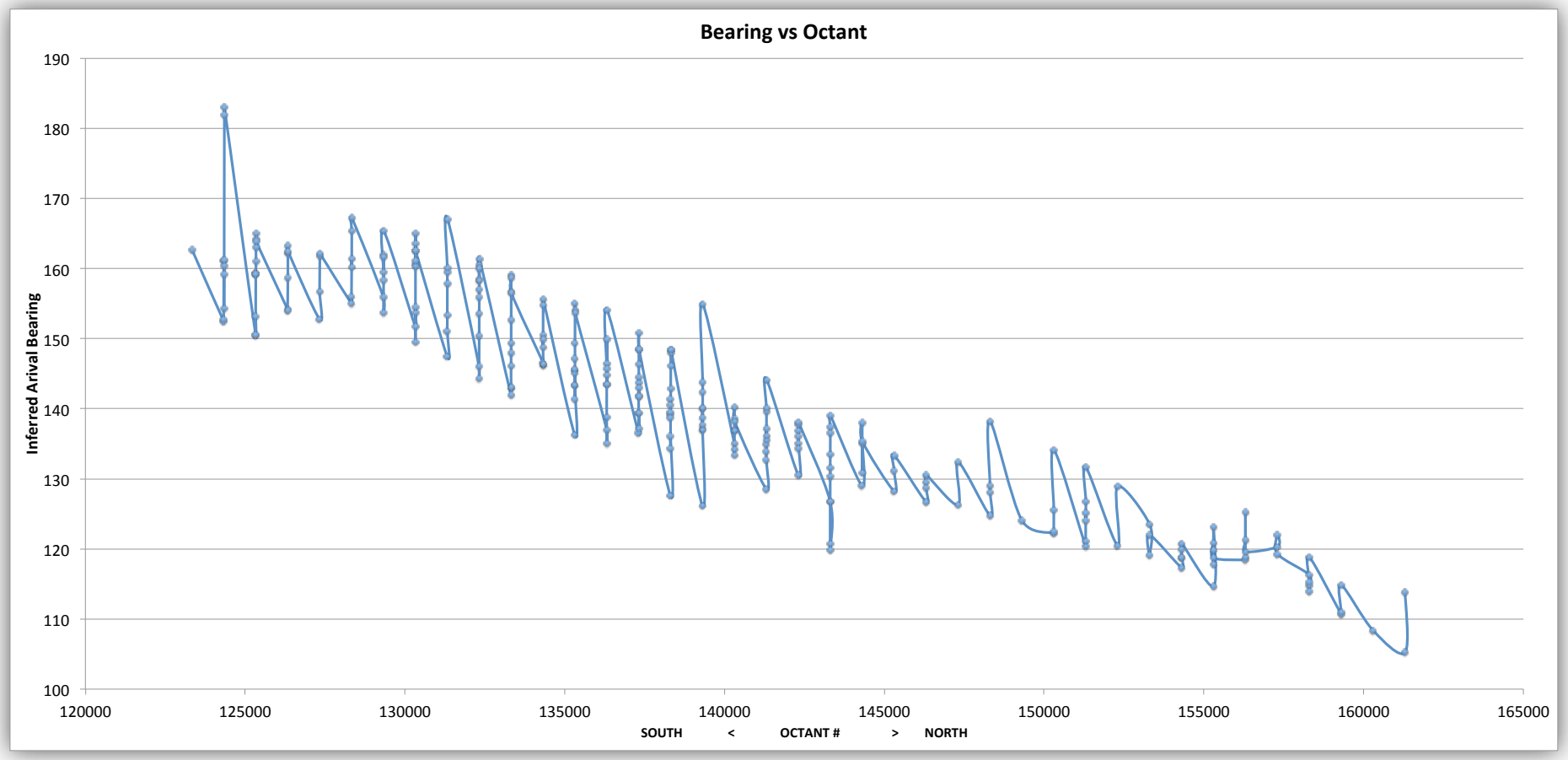
Bay Sizes Exhibit Log-Normal Distribution





Eastern Bay Orientations

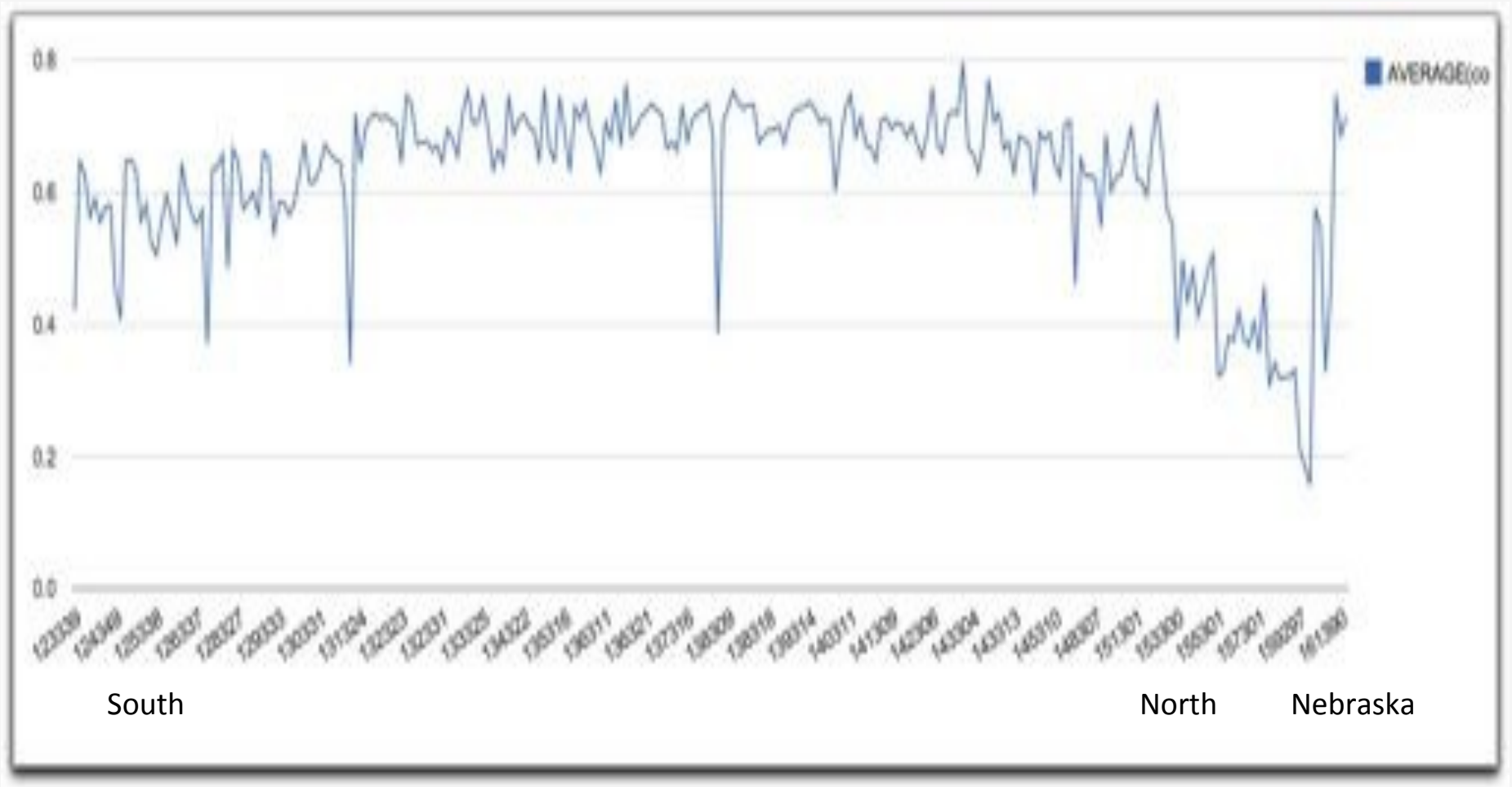
Showing **Longitude > -88; aggregate AVERAGE(Bearing) by Octant**



South

North

Fusion Tables: Average Bay Eccentricity by Octant



Fusion Tables: Bay Eccentricity in Octant 150303

Summary

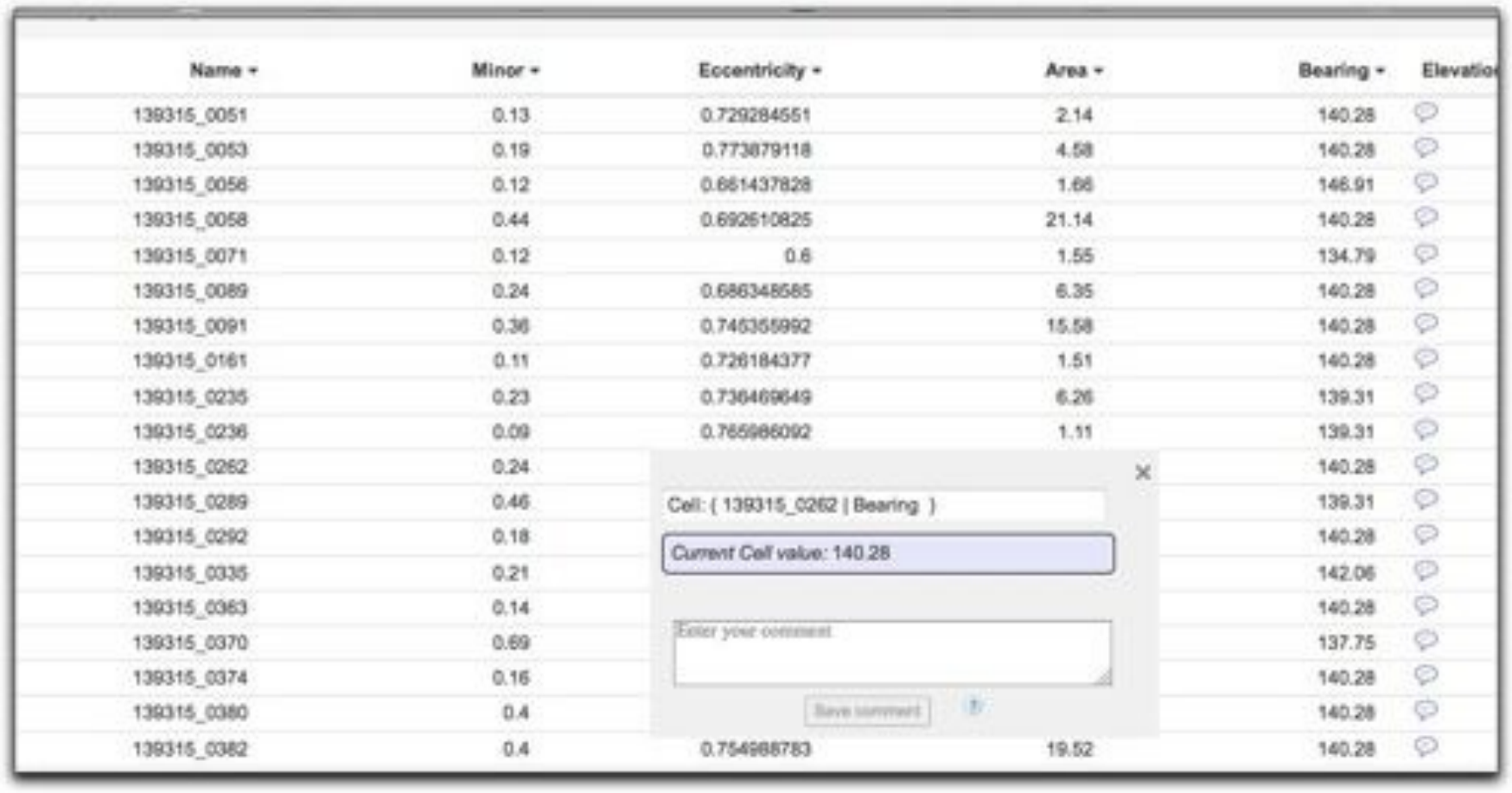
- Integrated thousands of LiDAR DEM images into Google Earth
- Identified and Documented ~ 27,000 Individual Bays
- Captured Individual bay Metrics
  - Location
  - Major & Minor Axis: yields Area & Eccentricity
  - Orientation
- Integrated data into Google Fusion Tables
  - Feeds Google Earth visualizations
- 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



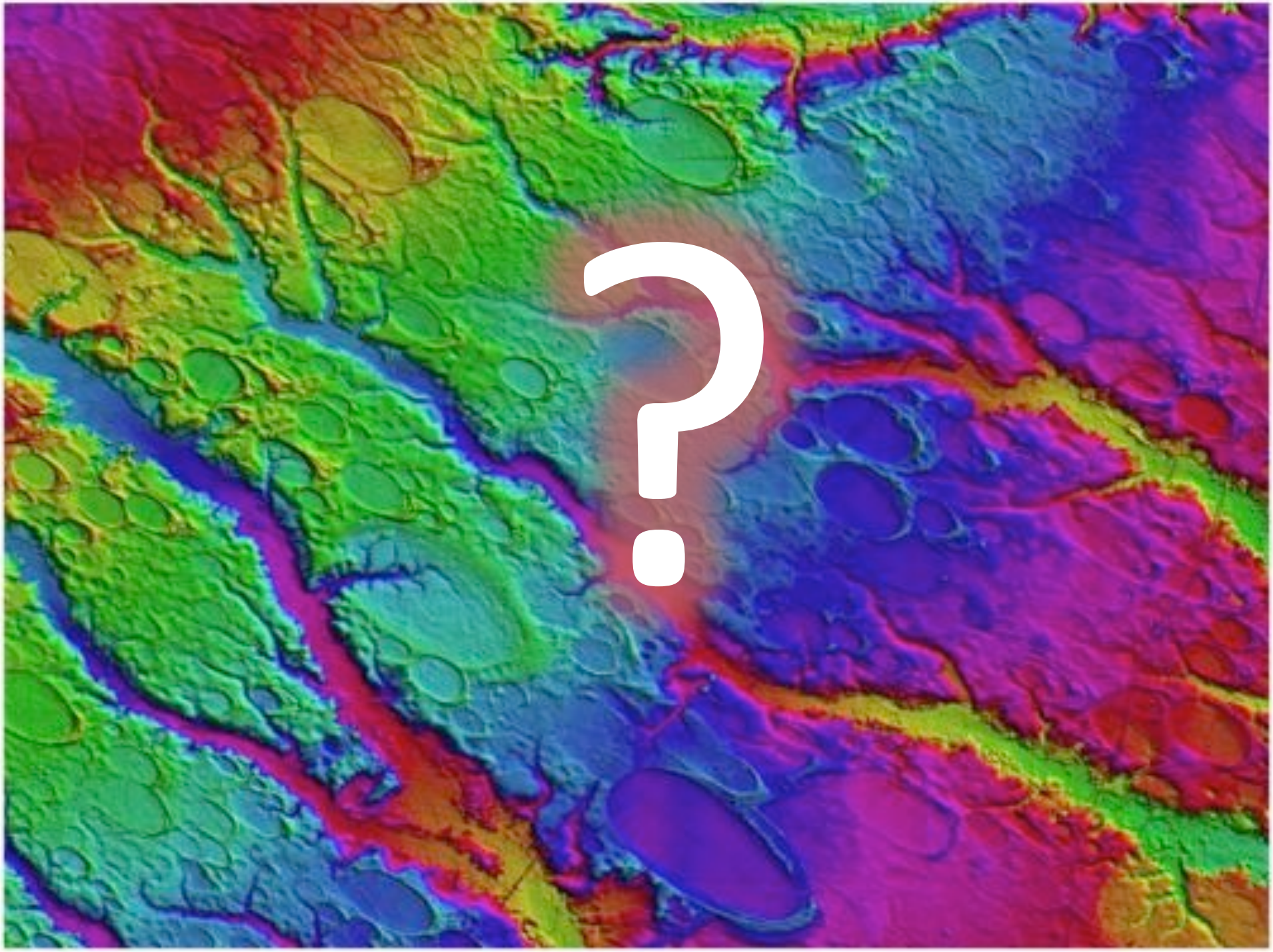
Name	Minor	Eccentricity	Area	Bearing	Elevatio
139315_0051	0.13	0.729284551	2.14	140.28	
139315_0053	0.19	0.773879118	4.58	140.28	
139315_0056	0.12	0.661437828	1.66	146.91	
139315_0058	0.44	0.692610825	21.14	140.28	
139315_0071	0.12	0.6	1.55	134.79	
139315_0089	0.24	0.686348585	6.35	140.28	
139315_0091	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	0.765986092	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	0.754966783	19.52	140.28	

Cell: (139315_0262 | Bearing)

Current Cell value: 140.28

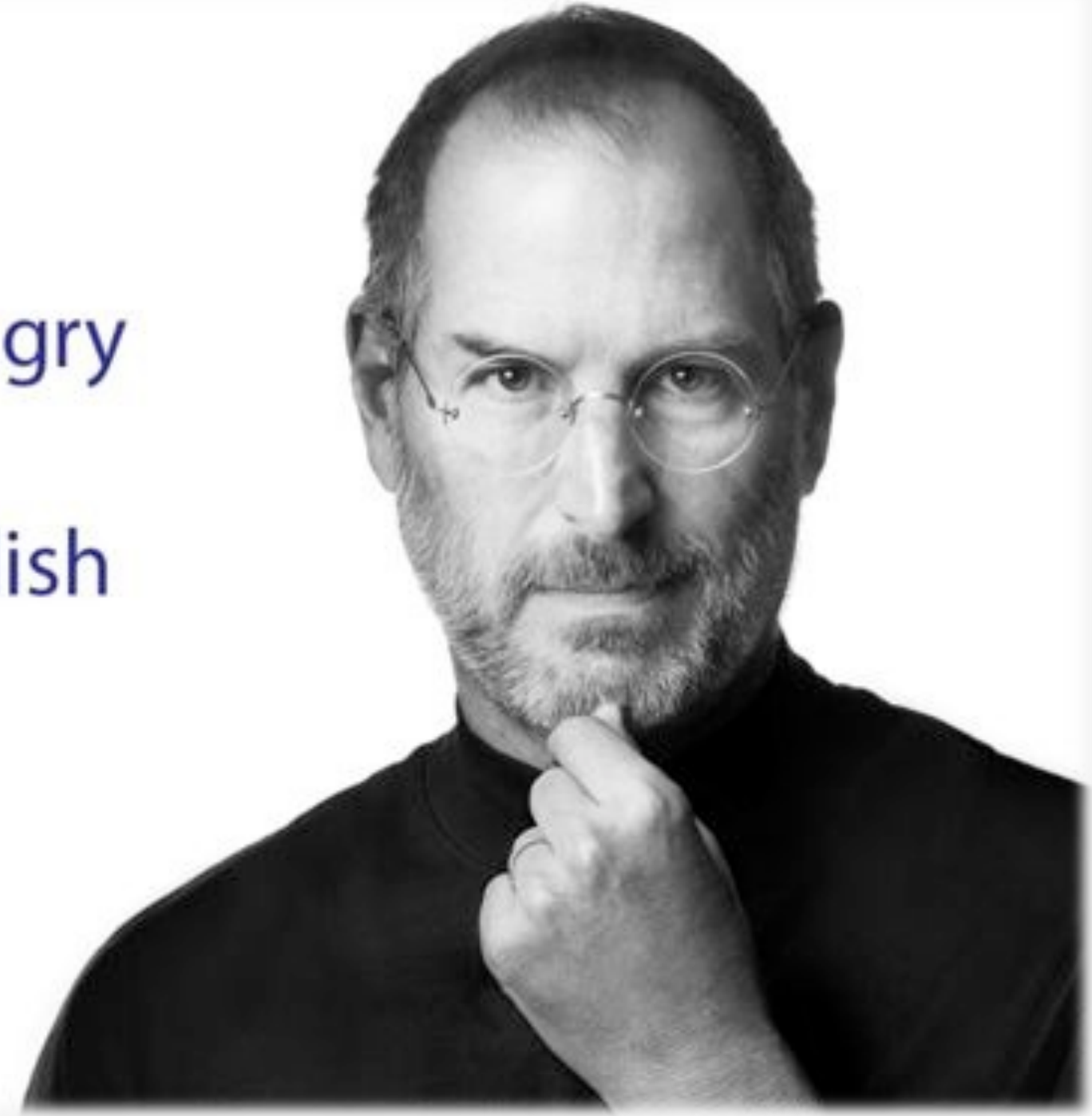
Enter your comment

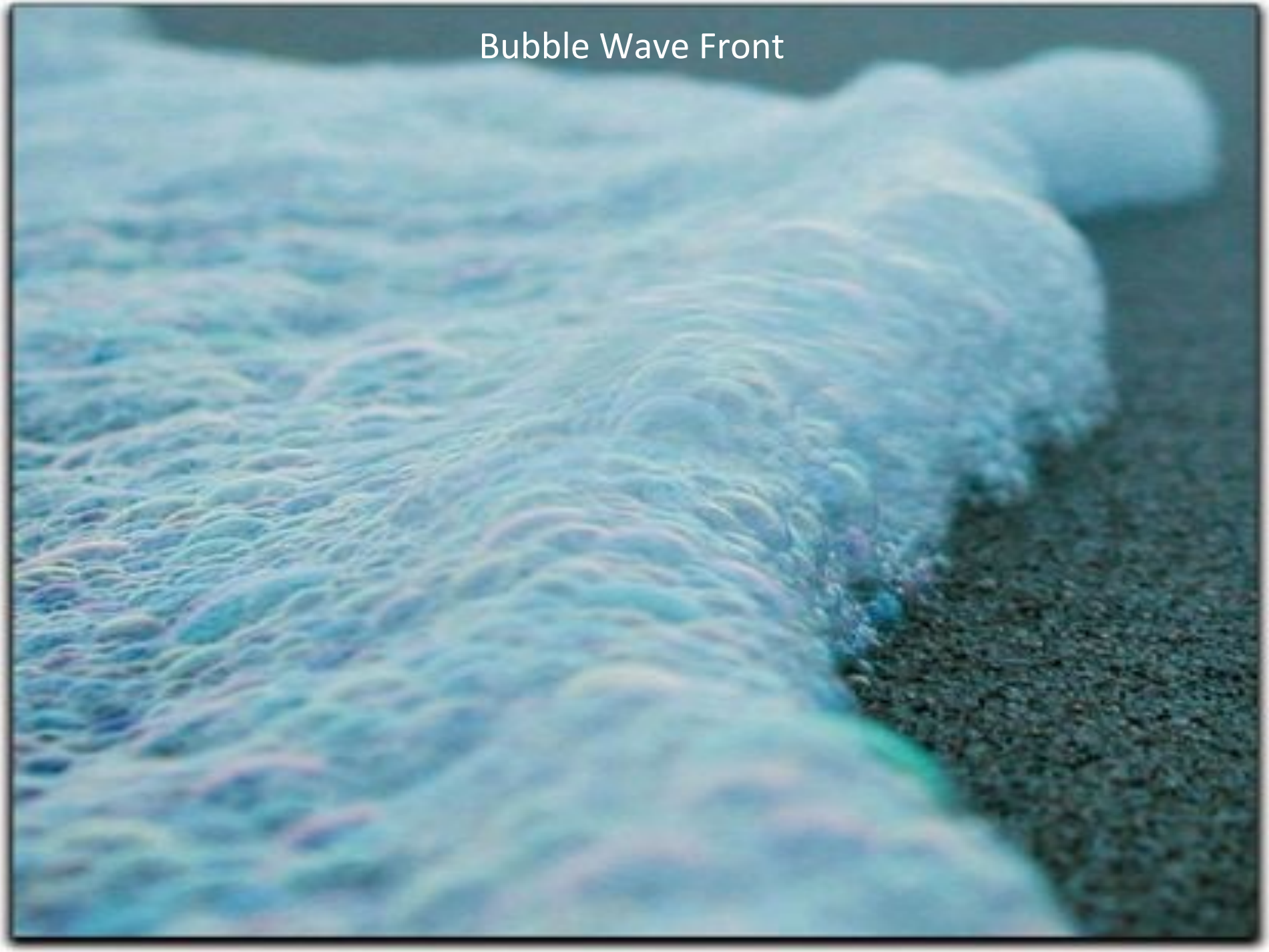
Save comment

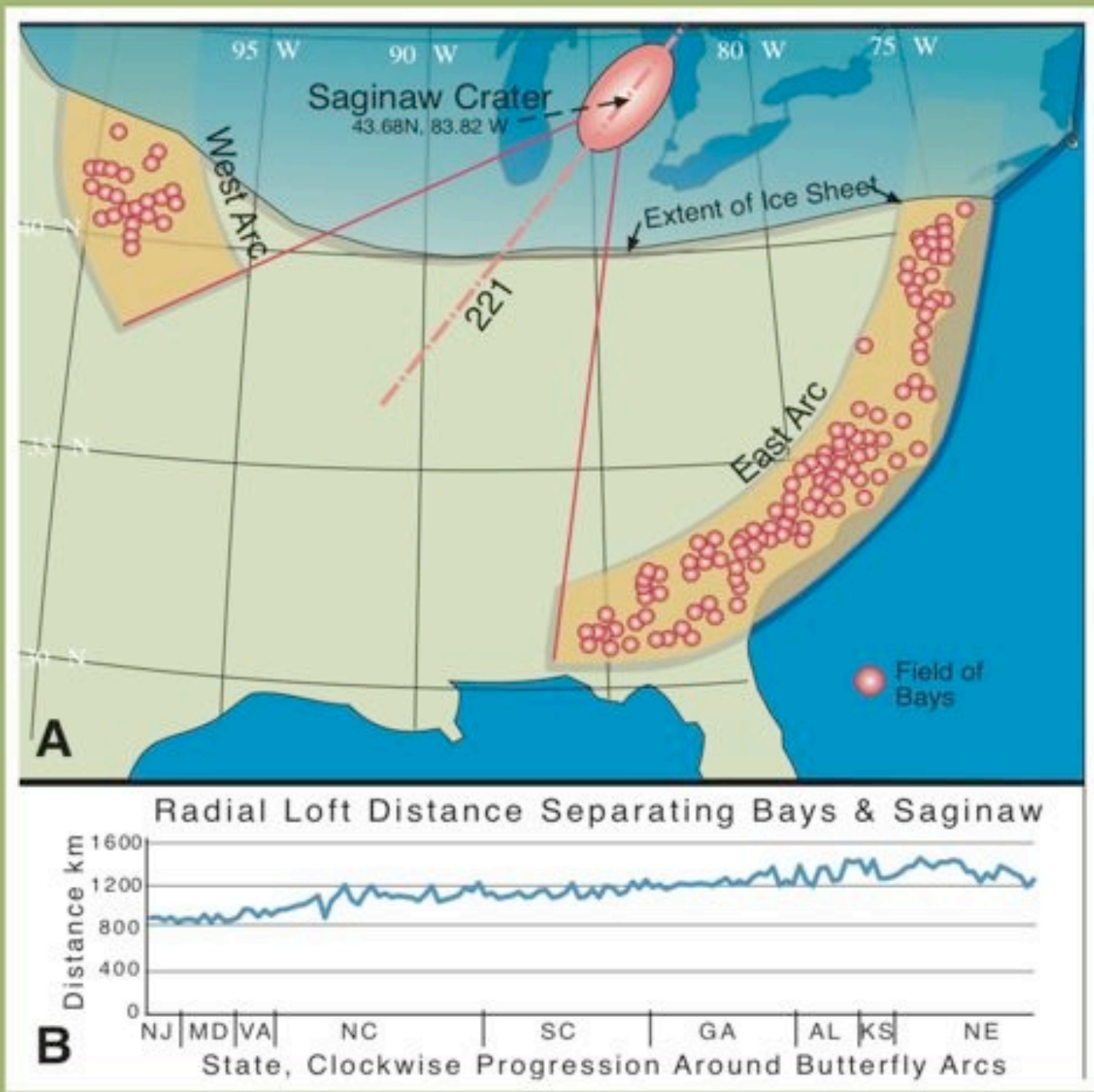


Stay Hungry

Stay Foolish




Bubble Wave Front


95 W
90 W
80 W
75 W
Saginaw Crater
43.68N, 83.82 W
West Arc
Extent of Ice Sheet
221
East Arc
Field of Bays
A
Radial Loft Distance Separating Bays & Saginaw
Distance km
1600
1200
800
400
0
NJ
MD
VA
NC
SC
GA
AL
KS
NE
B
State, Clockwise Progression Around Butterfly Arcs

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 km^2 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 ~700 ¼º x ¼º 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