# Documentation Of Lithic Artifacts Using An Inexpensive Reflectance Transformation Imaging System

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# Why is manual illustration (line drawing) still being used to document lithic artifacts?

- Tradition
- Cultural restrictions
- Manual illustration allows archaeologist & illustrator to highlight key man-made features, remove distracting features
- Making a good digital image of a lithic artifact can be really, *really* hard
  - Low relief
  - Low contrast
  - Material coloring/texture non-uniformity
  - Shiny (specular) surfaces

# Digital photographs vs. illustrations
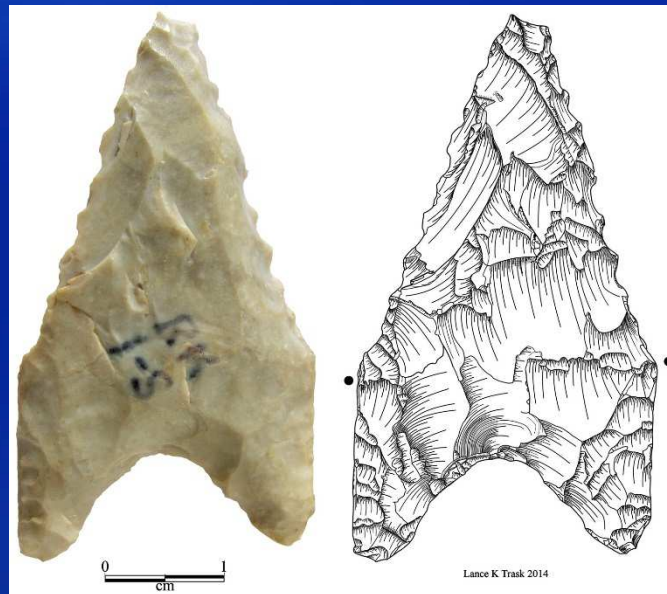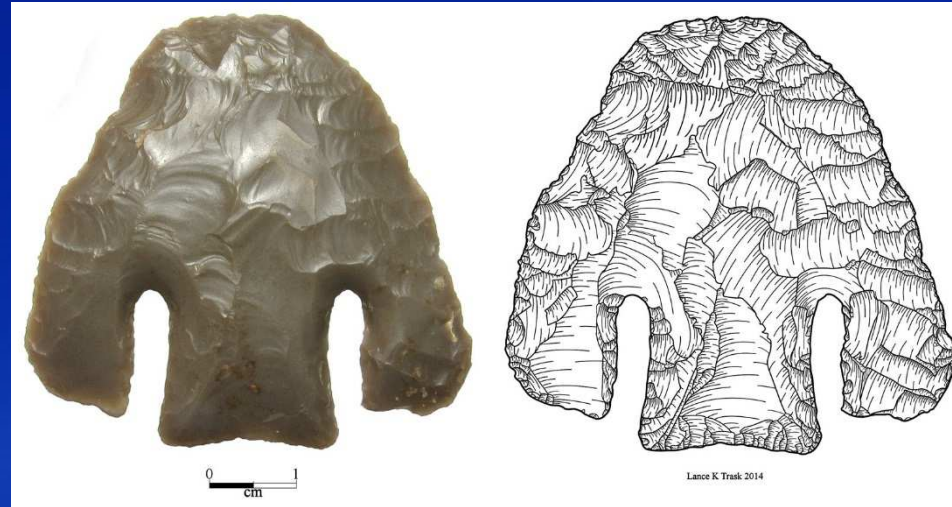


Courtesy Lance K. Trask, http://lktrask-media.com/

# 3D Digital Alternatives To Photography

- ## Micro-Computed Tomography (micro-CT)
  - Digital presentation and dissemination of ancient lithic technology with modern micro-CT. R.L. Abel, S. Parfitt, N. Ashton, S.G. Lewis, B. Scott, C. Stringer, *Computers & Graphics* **35** (2011), pp. 878-884.

- ## 3D Photogrammetry (Structure from Motion)

- ## Laser/Structured White Light Scanning
  - Three-Dimensional Alternatives to Lithic Illustration. M.Magnani, *Advances in Archaeological Practice* **2(4)** (2014), pp. 285-297.

# Reflectance Transformation Imaging (RTI)
## *(aka Polynomial Texture Mapping (PTM))*

- Developed by Tom Malzbender & Dan Gelb, HP Labs, 2001
- Digital photographs taken of an object from a fixed camera position with different lighting angles, constant lighting distance
- Software analyzes photos, fits independent light intensity equation as a function of lighting angle for every image pixel
- => Virtual lighting model of object

# Photos At Multiple Lighting Angles



Standard upper-left lighting



All 48 lighting angles

# Highlight-RTI



Image courtesy Cultural Heritage Imaging

# Dome-RTI

- Lights on interior surface of dome, pointing inwards; camera at top pointing down
- Lights turned on sequentially, camera shutter fired in sync with lights
- Fixed lighting angles and distance
- Can be operated by just one person
- Faster data acquisition and processing times
- Cost??!!



Source: Centre for Heritage Imaging and Collection Care Manchester

Dome Mark 1aaa

# Dome-RTI



**Mark 2 Dome**

- 48 high-power (3W) LED lights on inside of dome pointing inwards at object
- Synchronized electronic control of LEDs and camera (high-end Canon Point-And-Shoot here, but will work with most modern DSLRs)
- Data acquisition time 1-3 minutes; data processing time 1-3 minutes
- One-person operation
- < $800 with camera (vs $10-30K for custom systems)
- 12" dome diameter / 13.5" x 13.5" with stand
- Plug-in DC power supply or battery pack
- Weighs less than 4 kg

# Operational Modes





Basic configuration fits into standard backpack, < 5kg total



USB Microscope (or DSLR with macro lens)



Upright mode for larger objects

# "Yeah, that's all great, but I can't put an RTI digital file in my next paper."

- Even with RTI's ability to set any arbitrary lighting angle, there's no guarantee you'll find a single lighting angle that shows every important detail in a single screen capture.
- What to do?

# RTI Normals Mode

- Lighting angle for peak light intensity of a pixel corresponds to the "normal" (perpendicular) direction to the surface at that point

- RTI normals mode color-codes the pixels based on that normal direction
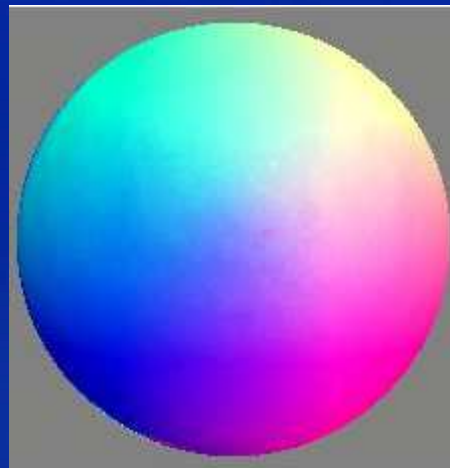
# Molina Spring Clovis

- Light, mottled, glossy chert; worn flake scars difficult to see even by eye
- Normals mode makes them visible
- Standard/custom digital photo enhancement improves visibility
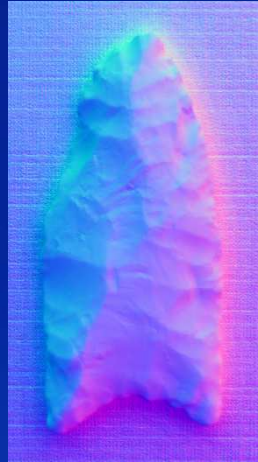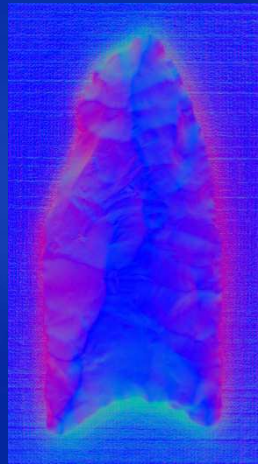


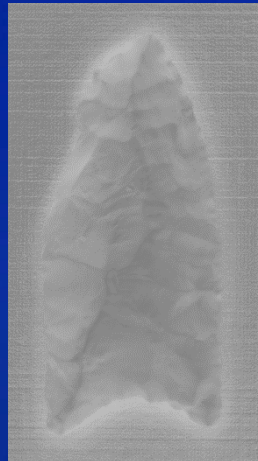Original photo
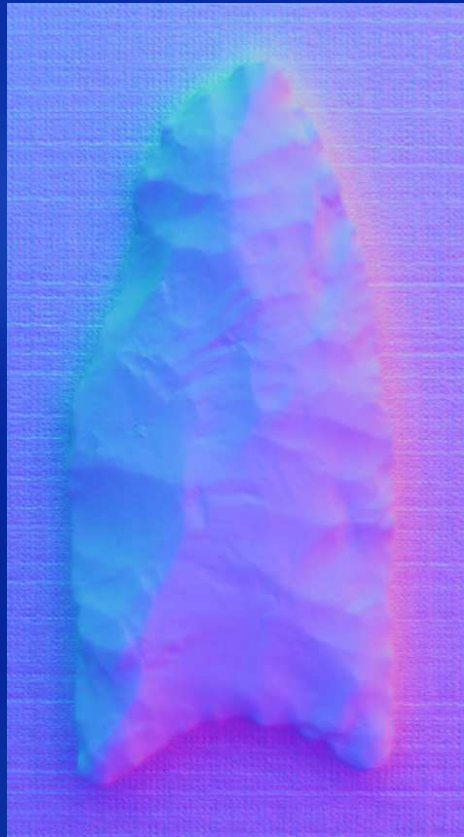


RTI normals mode
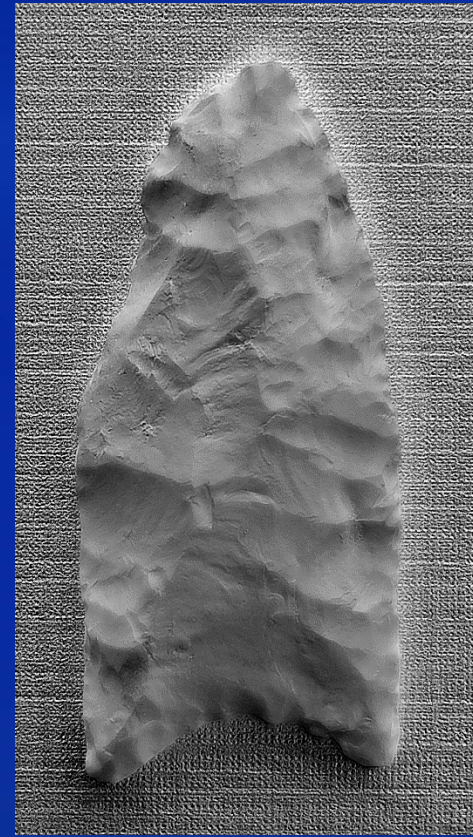

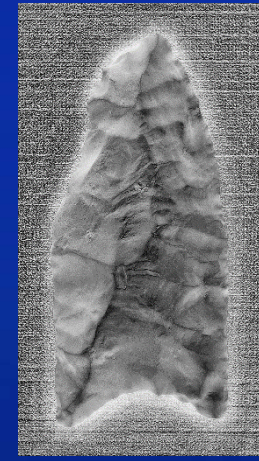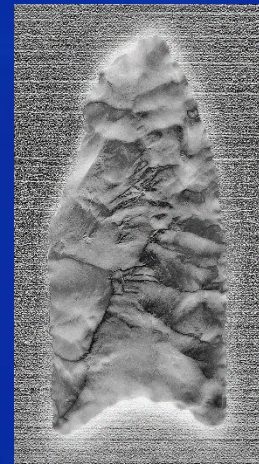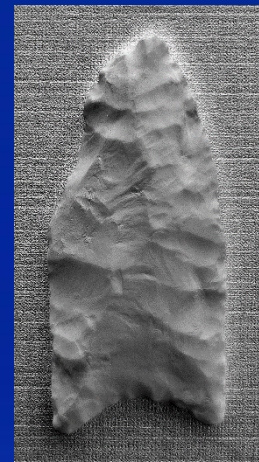
Enhanced normals

Standard
normals

Multiply:
Enhanced color
gradient

Symmetric:
Mirrored color
gradient

Slope: Enhanced
based on overall
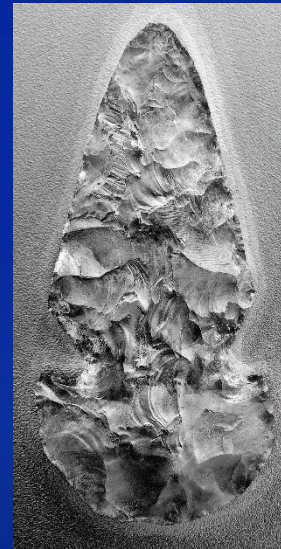surface slope
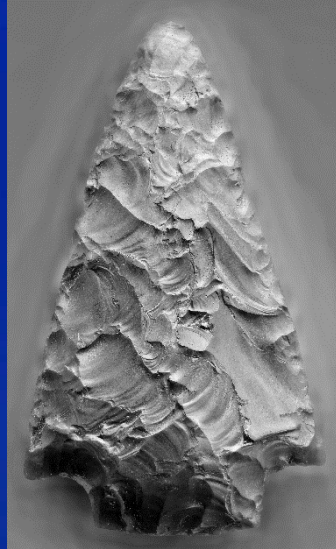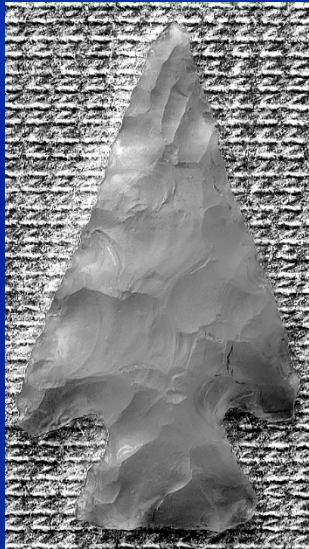
# Some more tough tests...



Chalcedony

Specular obsidian

Specular & transparent obsidian

# RTI and 3D

- Can't create a full 3D model; only sees one side
- 3D surface information for that one side can be derived from normals data
- Just got this working a few days ago – still bugs, quirks and inaccuracies – work continues on resolving these

# More information on RTI

- Cultural Heritage Imaging ([culturalheritageimaging.org](culturalheritageimaging.org))

- Your pal Google: "reflectance transformation imaging" or "polynomial texture mapping" (including image search)

- My site – rtimage.us
  - PDF of slides for this talk
  - Extended video version of this talk (coming soon)
  - Links to sites/docs with RTI information
  - RTI lithics data files to download and play with
  - 3D model views
  - Info on how to build your own RTI system (coming soon, I hope)

# Acknowledgements

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