

# 3D PRINTING AS A TOOL FOR TEACHING CRYSTALLOGRAPHY (and SOME OTHER STUFF)

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## Abstract

## Teaching Crystallography

## (Geologic) maps

## (and SOME OTHER STUFF)

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### The assignment

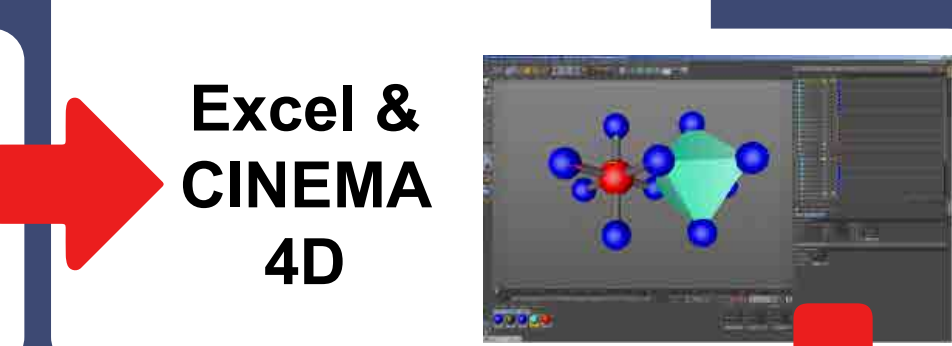
- STEP 1** pick a mineral
- STEP 2** identify the cations present in your mineral and their respective coordination
- STEP 3** use scaled spheres to represent ions, cylinders for bonds, and platonic objects (tetrahedra, octahedra, or cubes) for coordination polyhedra
- STEP 4** build a coordination polyhedron and for your cations
- STEP 5** copy, paste, and translate your coordinated elements to build a unit cell
- STEP 6** copy and translate the unit cell into a large enough structure that an observer can get a feel for the symmetry/repetition
- STEP 7** include some ions that are full sized and some that are shrunk to reveal the bonds, at least one of each coordination polyhedron, indication of one unit cell
- STEP 8** make sure that the mineral is (structurally) printable
- STEP 9** pre-print digital clean-up
- STEP 10** actual printing (.wrl export)
- STEP 11** post-printing (depowdering, dipping)
- STEP 12** (stereographic) in class-presentations

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### Inputs



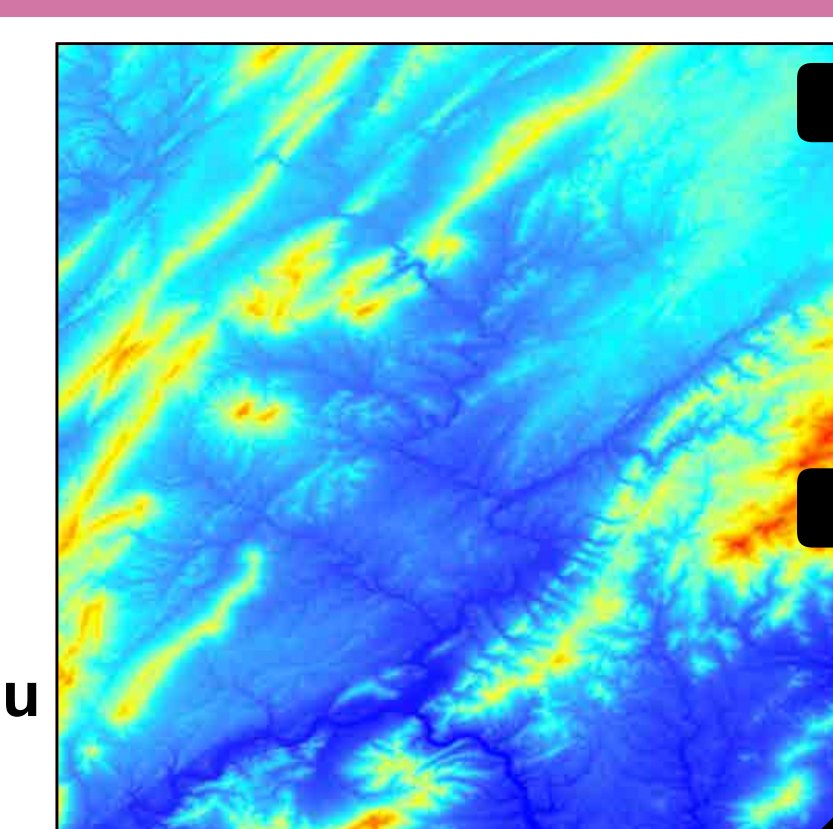
### Workspace



### ArcMap

Start with a rectified, projected geologic map and a DEM that covers (exceeds) your area of interest, and that everything is projected using the same coordinate system.

1. Export the scanned map to Illustrator (or the projected shapefiles if you have them). Other shapefiles (geo-political boundaries, watersheds, etc.) can be exported as well (see below).
2. Export the DEM as a geotiff (better for larger areas) -or-
3. Extract the elevation data from the DEM and export as a text file
4. The geologic map (or any image (see below)) can be exported as a .tif and mapped in CINEMA 4D.



### Photoshop

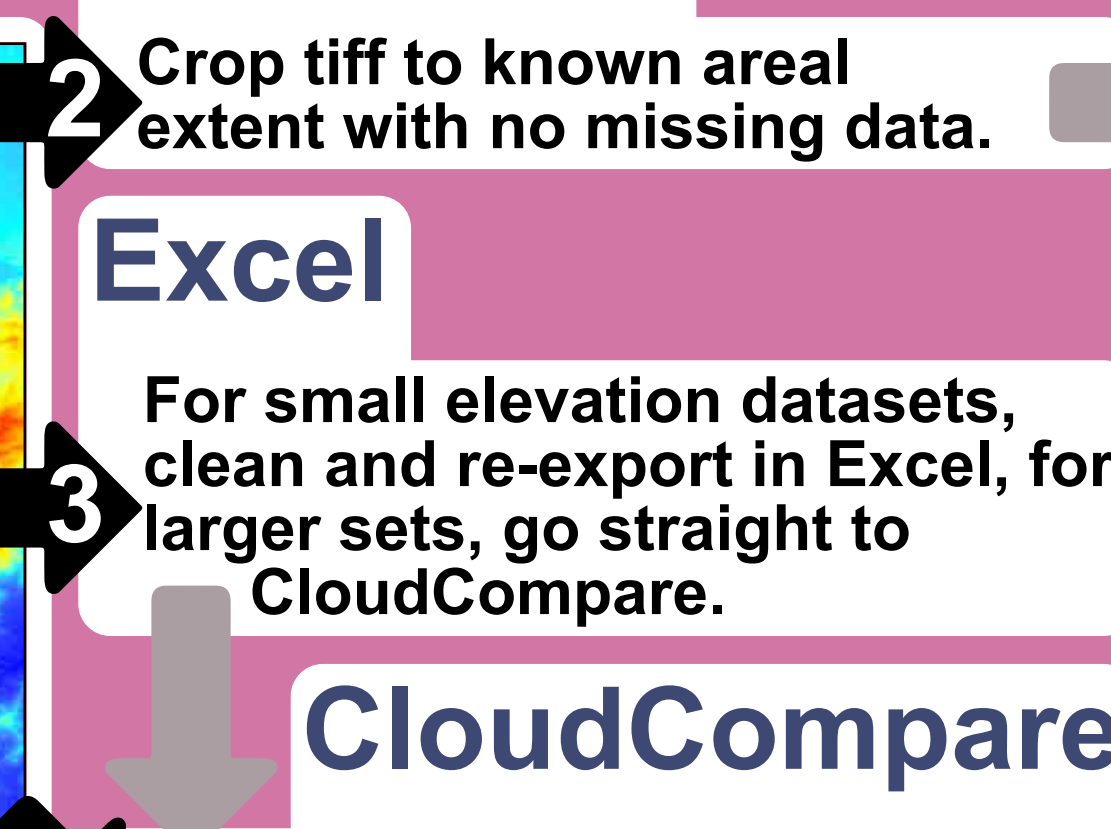
- 2 Crop tiff to known areal extent with no missing data.

### Excel

For small elevation datasets, clean and re-export in Excel, for larger sets, go straight to CloudCompare.

### CloudCompare

Use CloudCompare (or some other mesh-triangulating software) to create a mesh from x,y,z, point cloud extracted from in ArcMap. Export as a .obj file.



### CINEMA 4D (&printing)

Apply a DEM (tif) as a texture for a relief surface (as in this example) or open a .obj file (or other compatible triangulated mesh file) in c4d.

Import traced 2d lines as a spline from Illustrator, position, scale, and orient.

Extrude the spline so that it penetrates the relief surface.

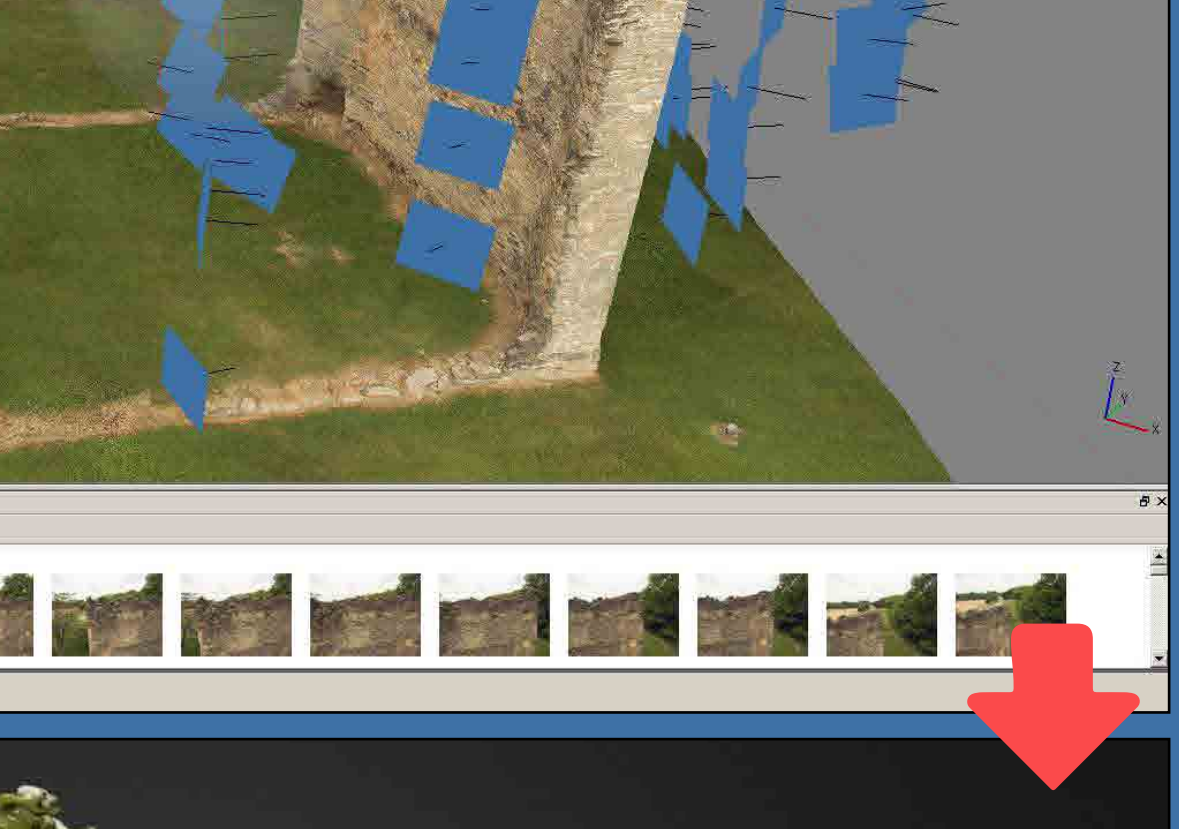
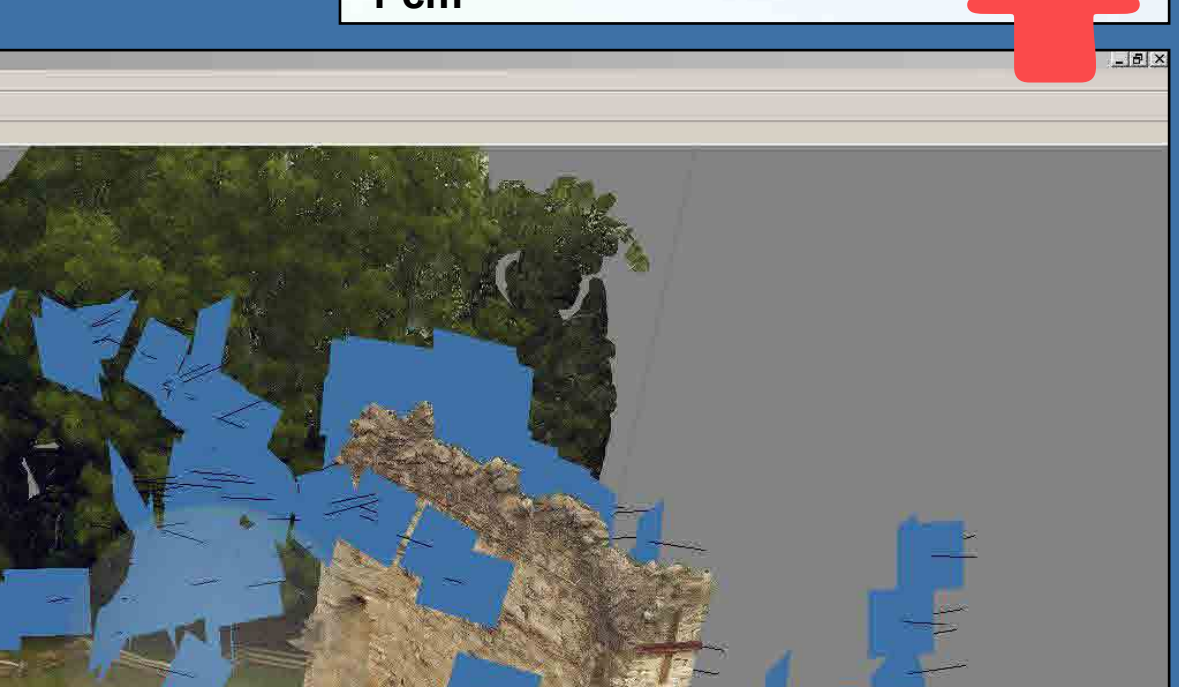
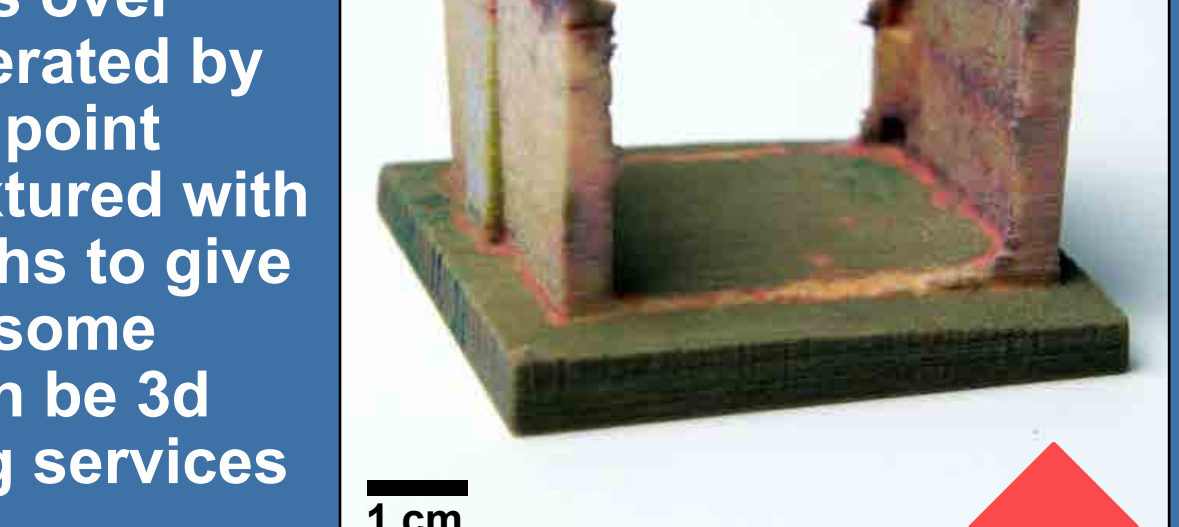
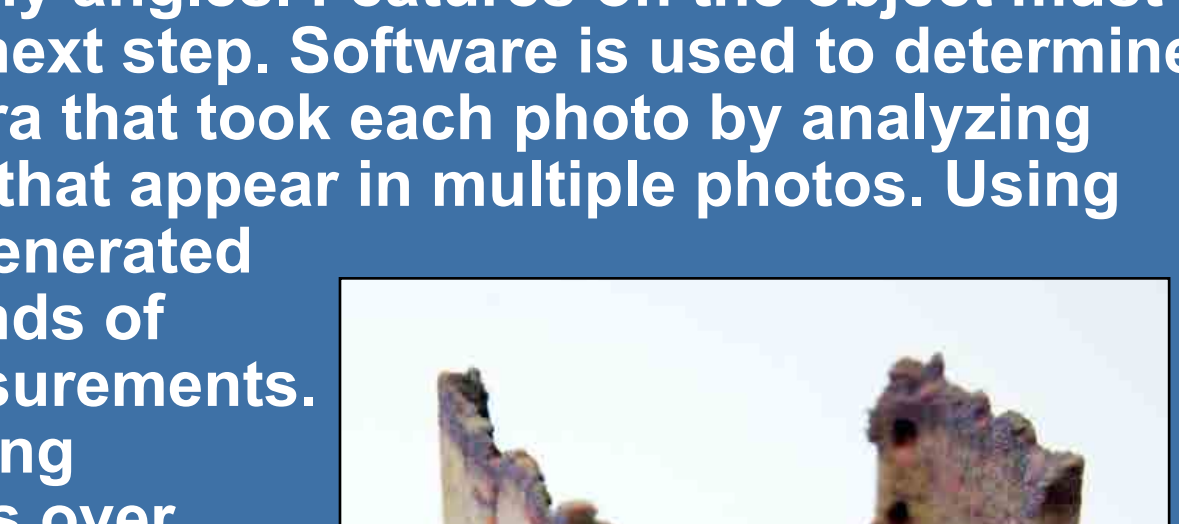
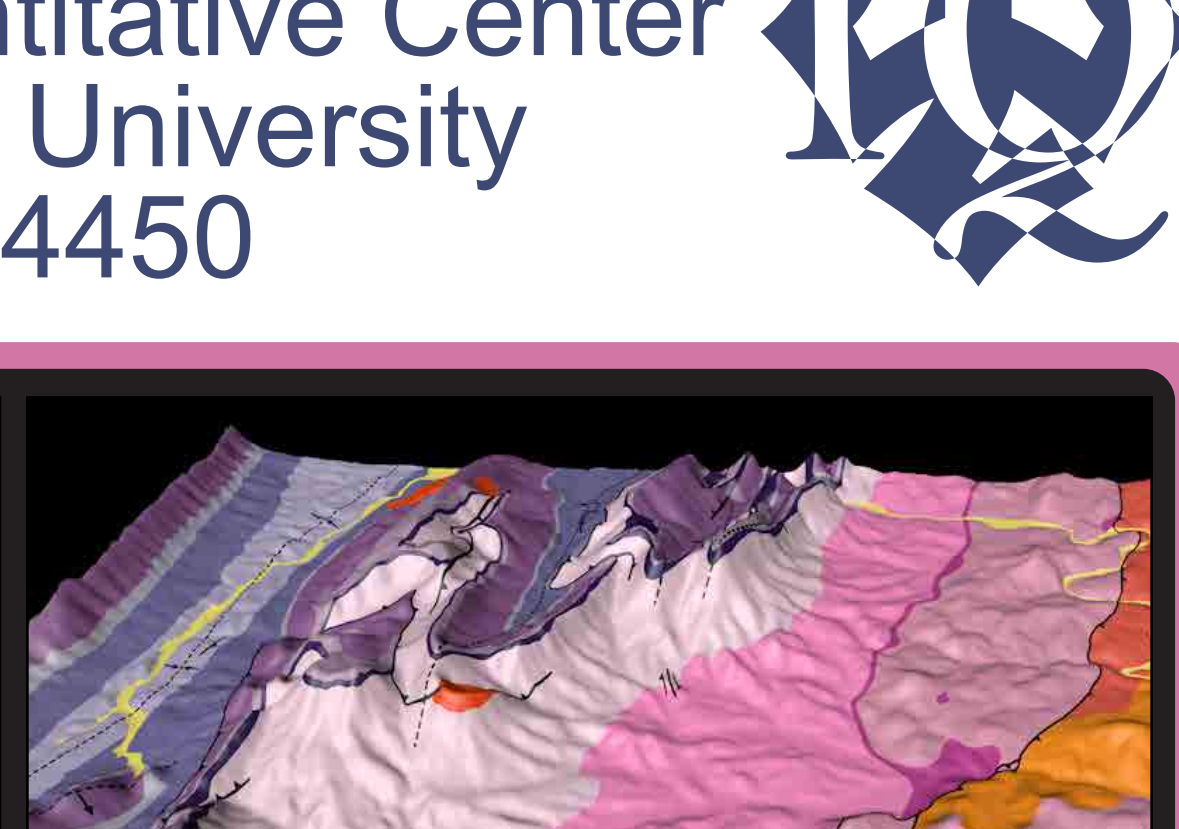
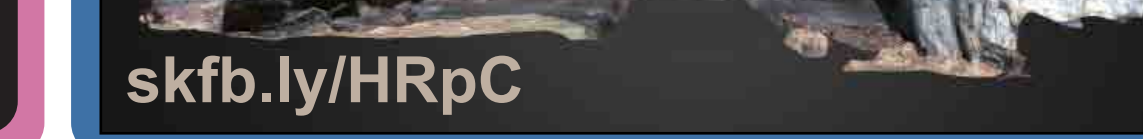
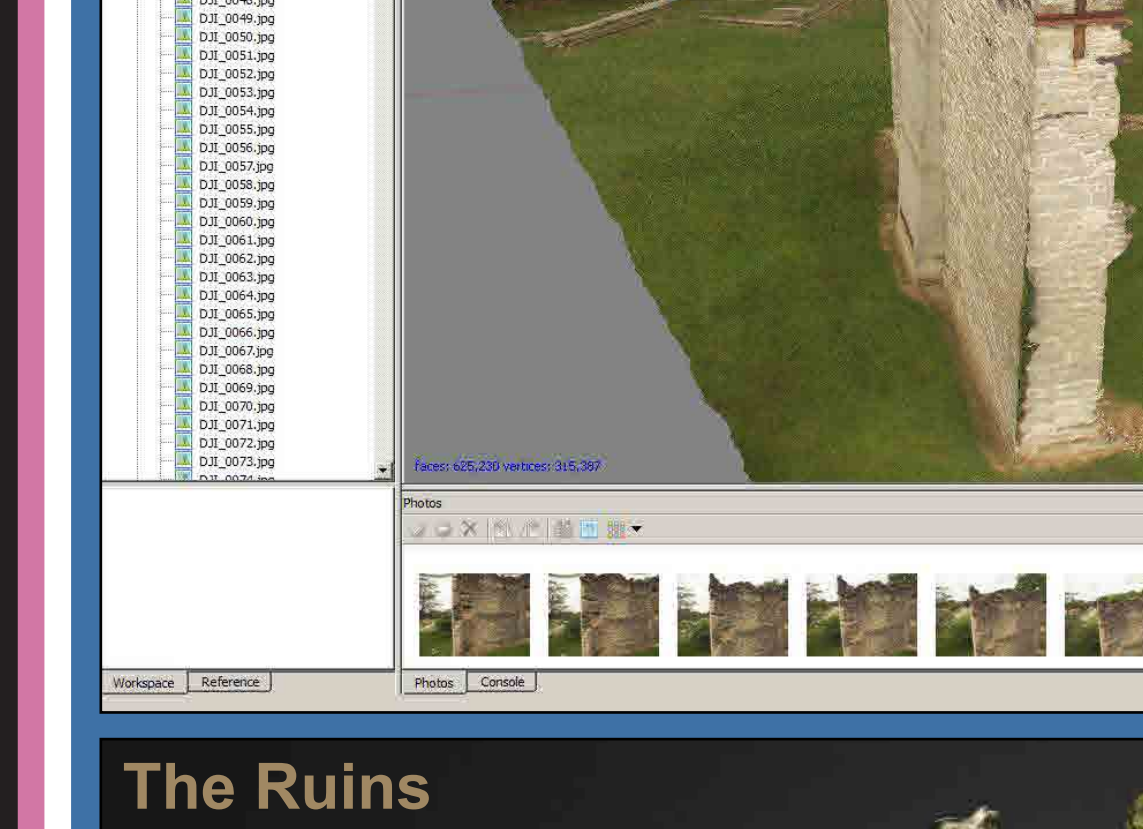
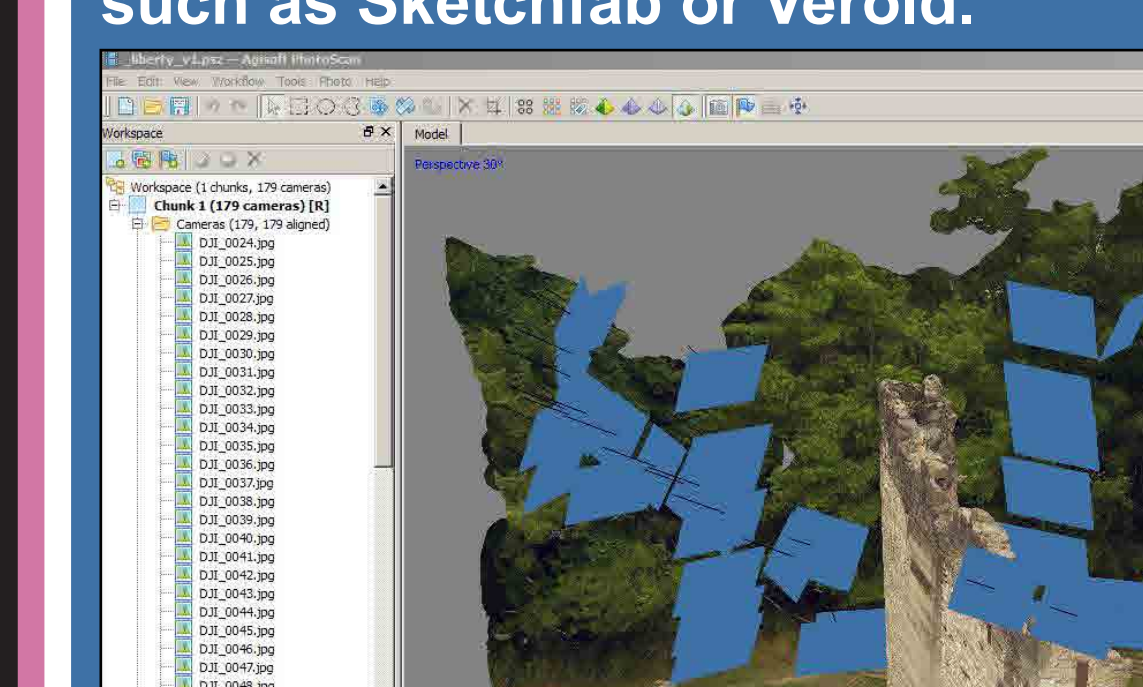
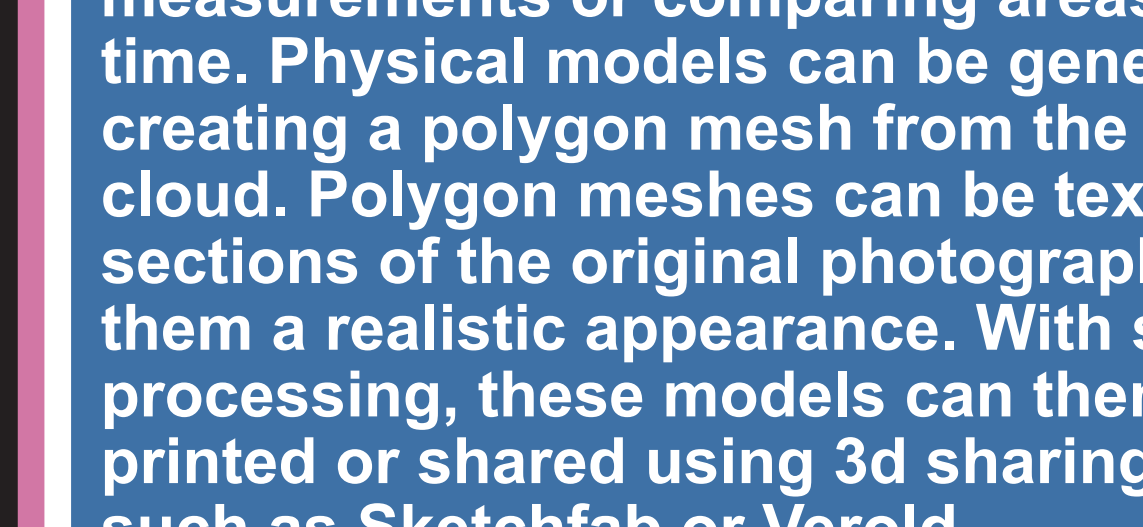
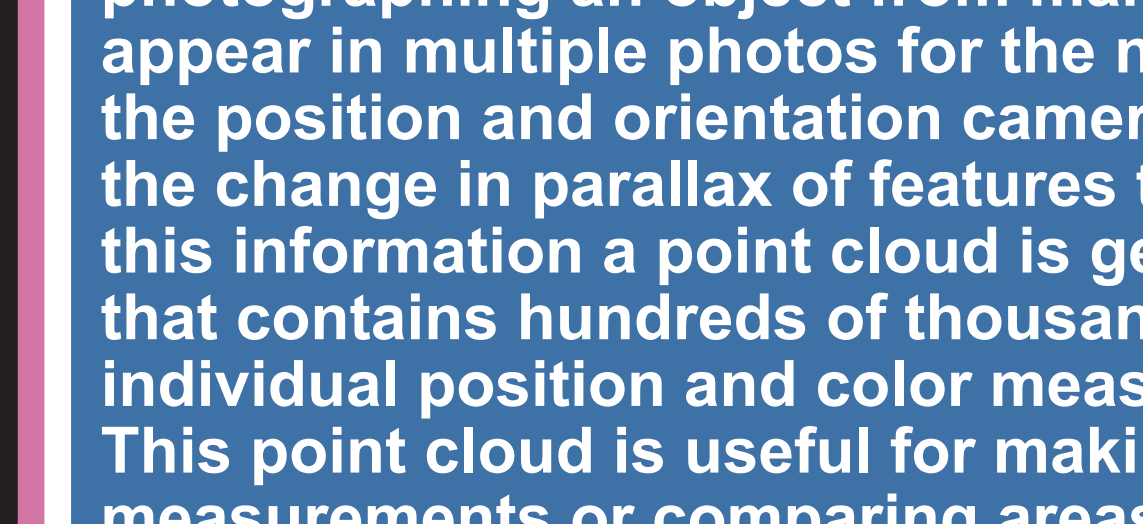
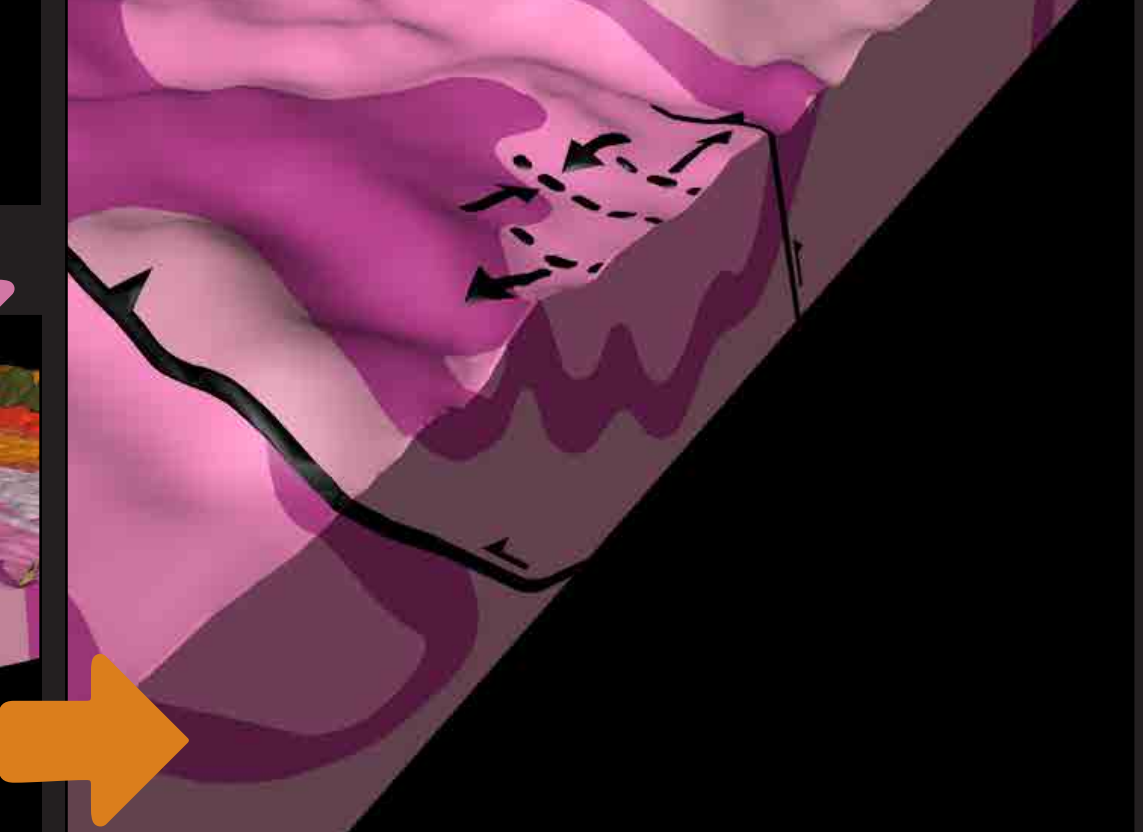
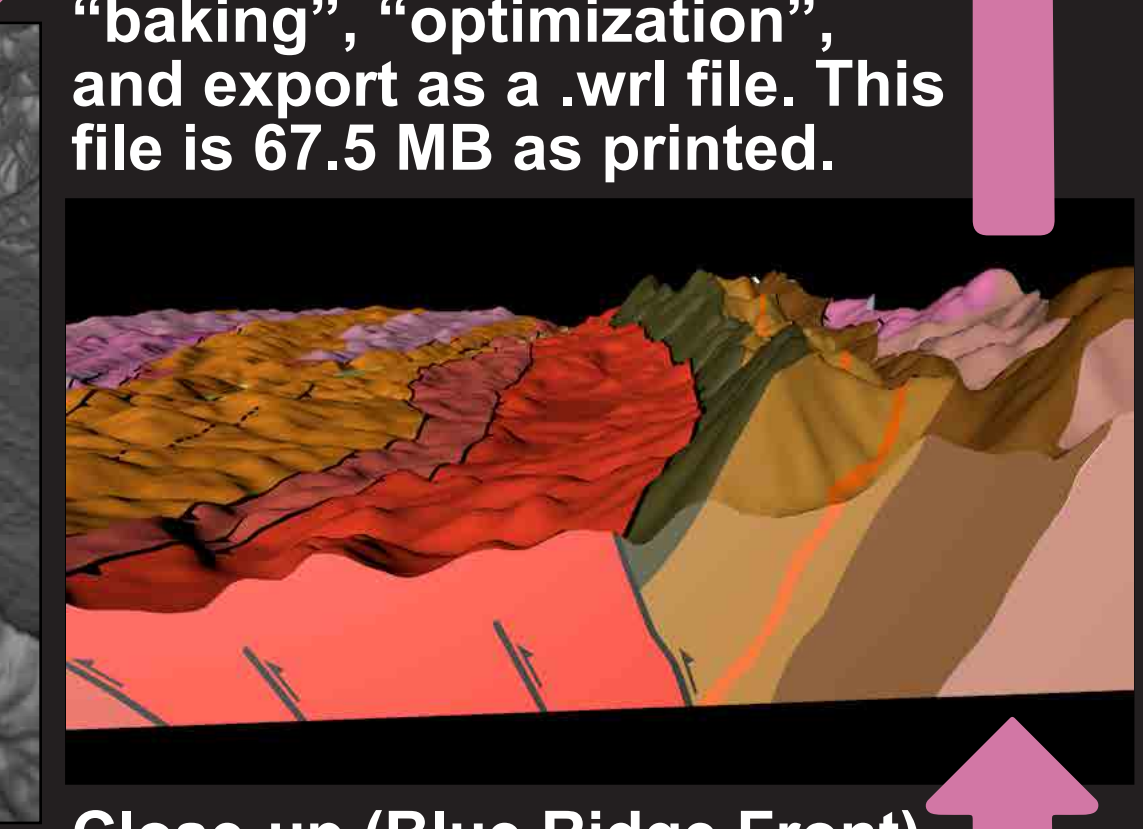
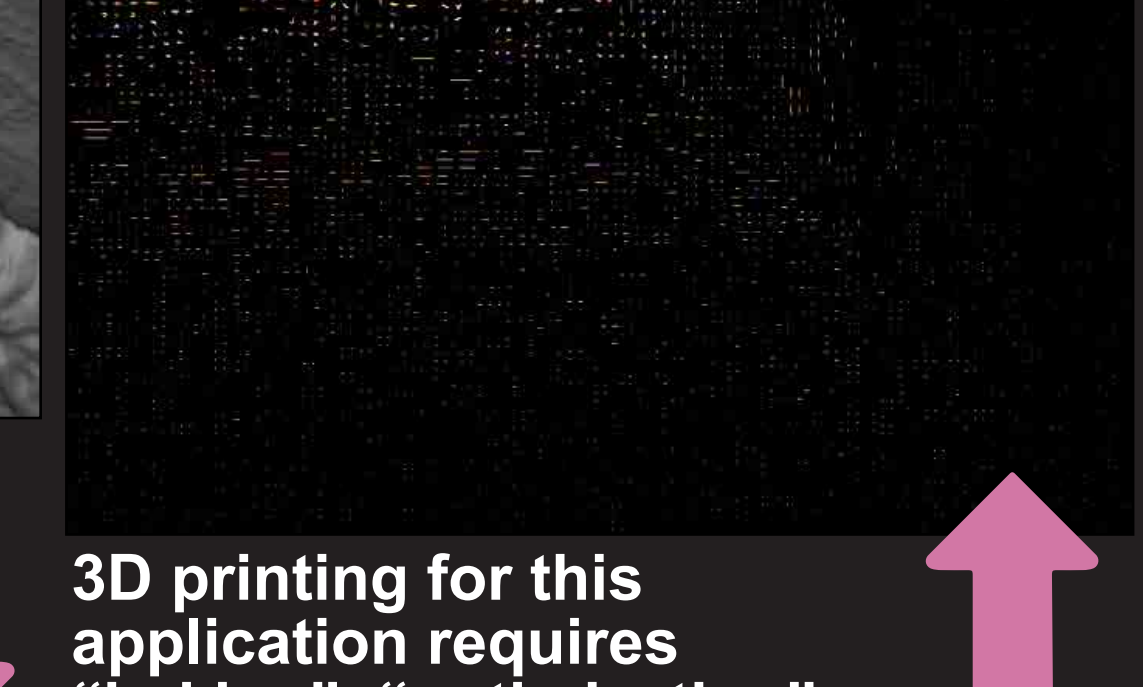
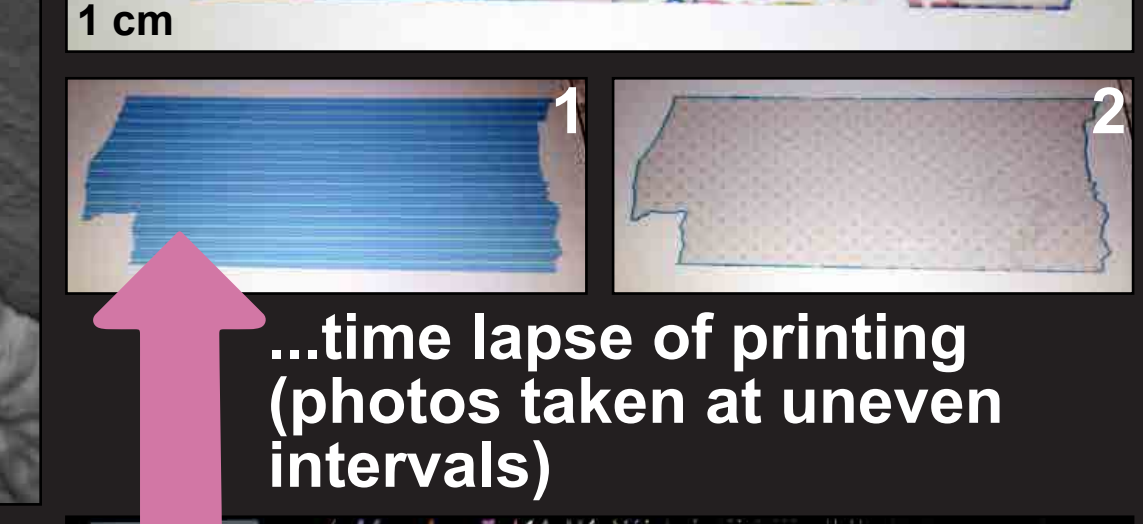
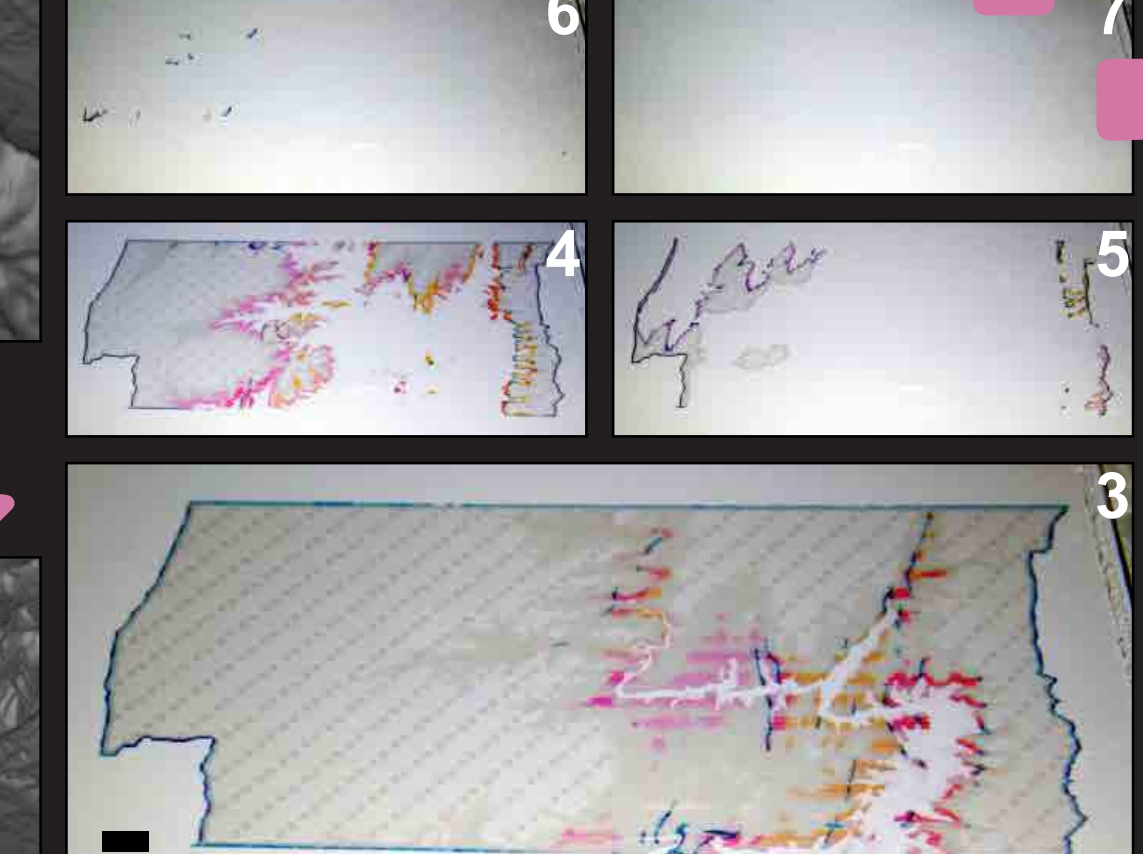
Cut the relief surface with the polygon developed from the extruded spline using a boolean intersect.

Repeat for the x-sections.

Close-up (Blue Ridge Front)

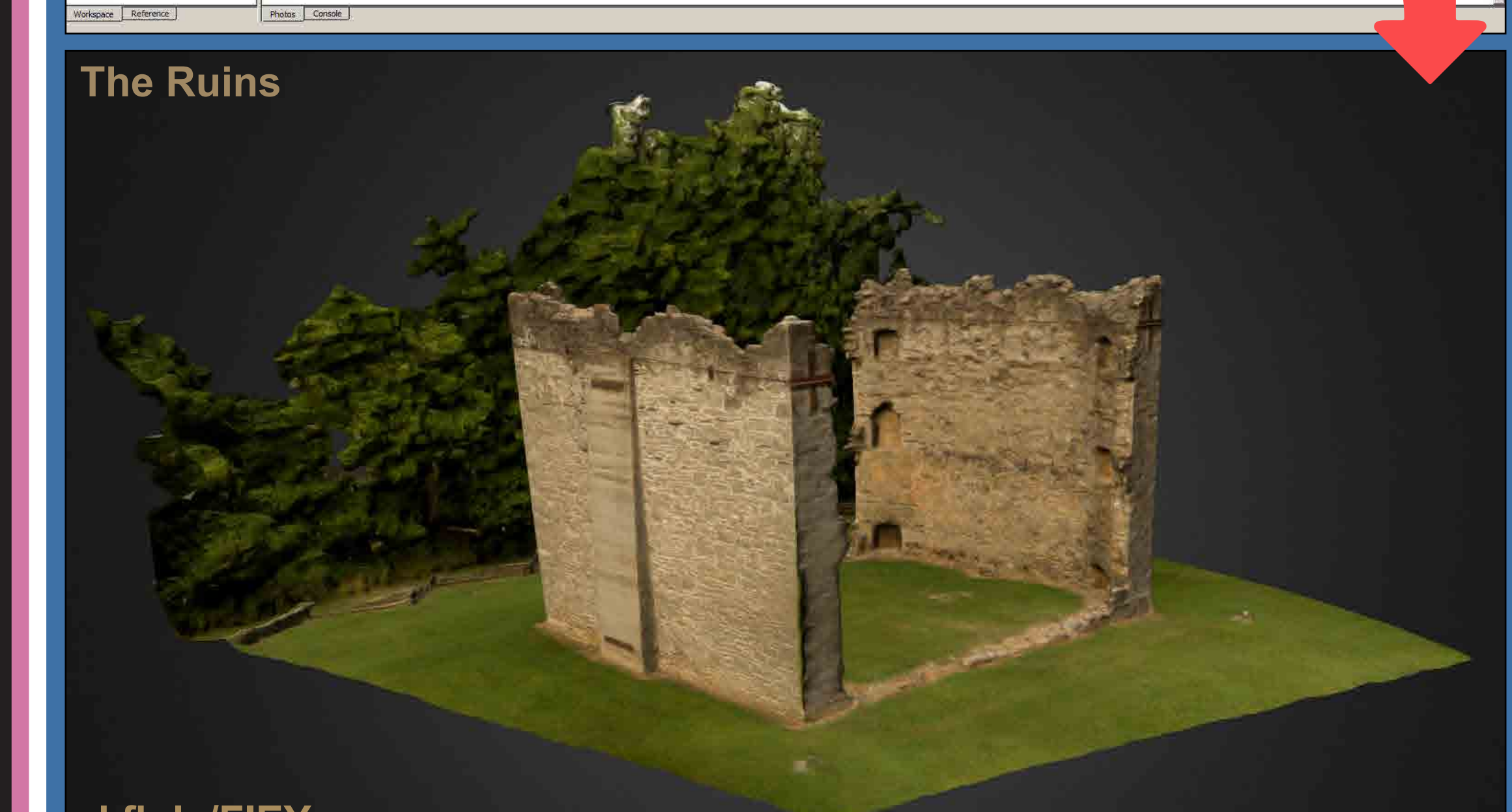
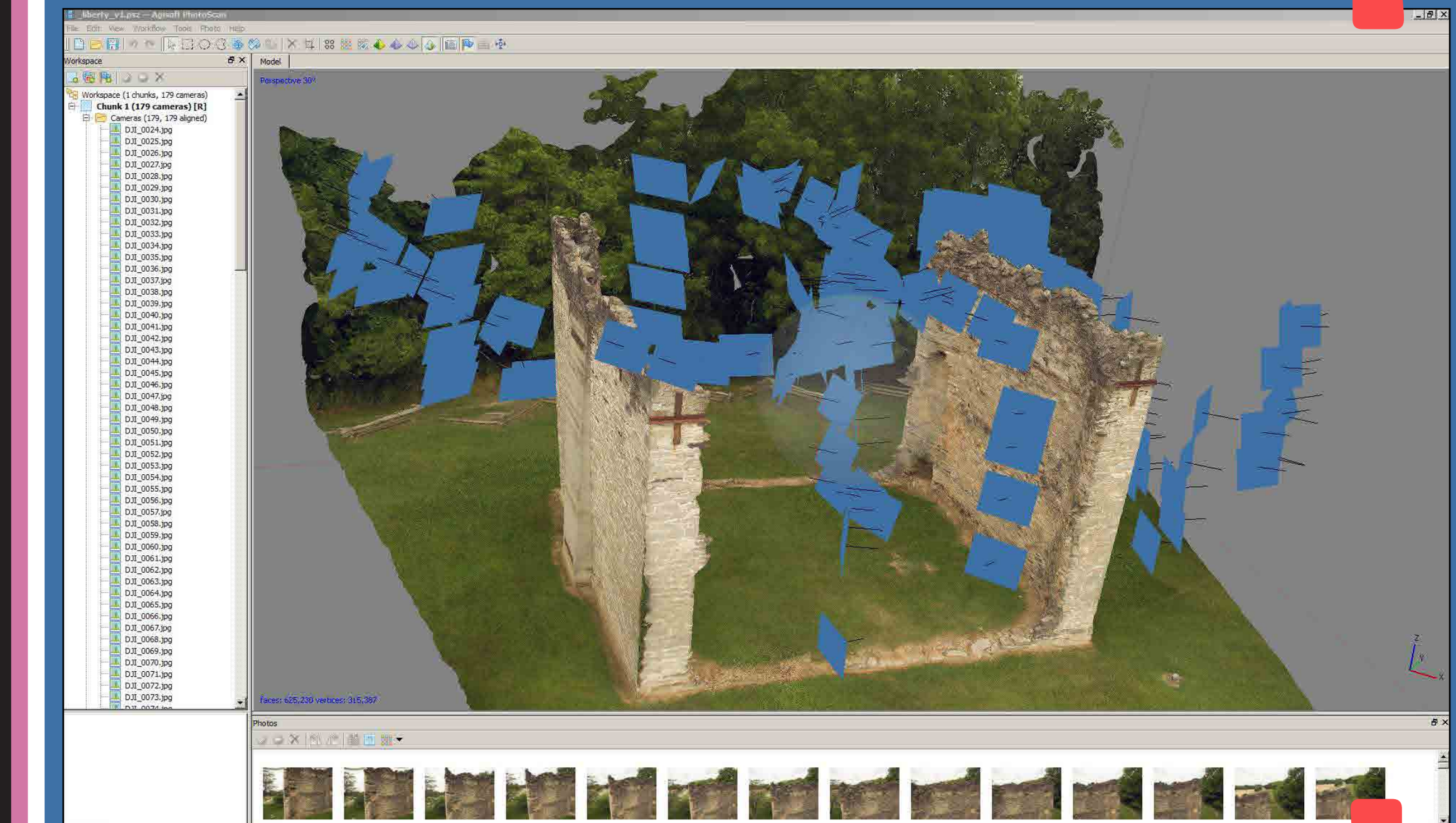
Close-up (Goshen Pass)

Close-up.

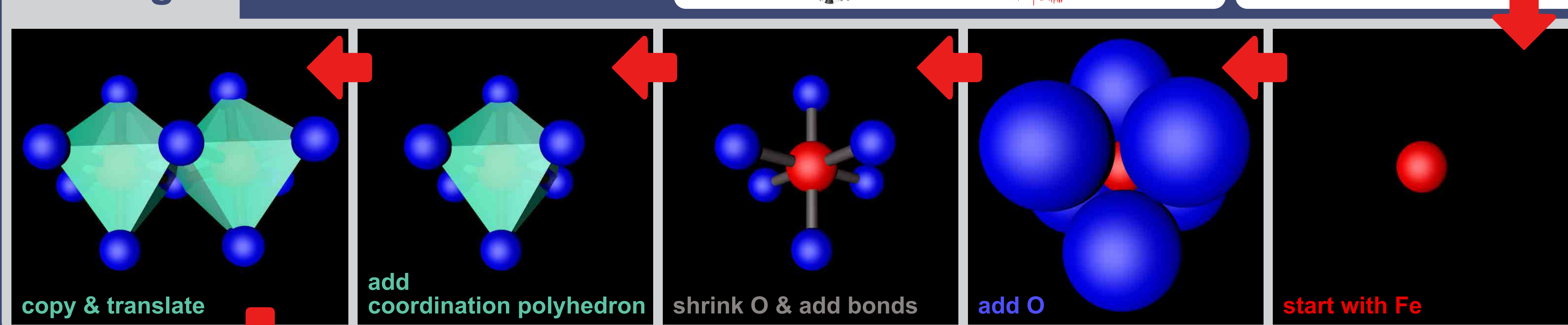


## Photogrammetry

Photogrammetry, also known as structure from motion, uses standard digital photos to create accurate 3d models. The process starts by photographing an object from many angles. Features on the object must appear in multiple photos for the next step. Software is used to determine the position and orientation camera that took each photo by analyzing the change in parallax of features that appear in multiple photos. Using this information a point cloud is generated that contains hundreds of thousands of individual position and color measurements. This point cloud is useful for making measurements or comparing areas over time. Physical models can be generated by creating a polygon mesh from the point cloud. Polygon meshes can be textured with sections of the original photographs to give them a realistic appearance. With some processing, these models can then be 3d printed or shared using 3d sharing services such as Sketchfab or Verold.

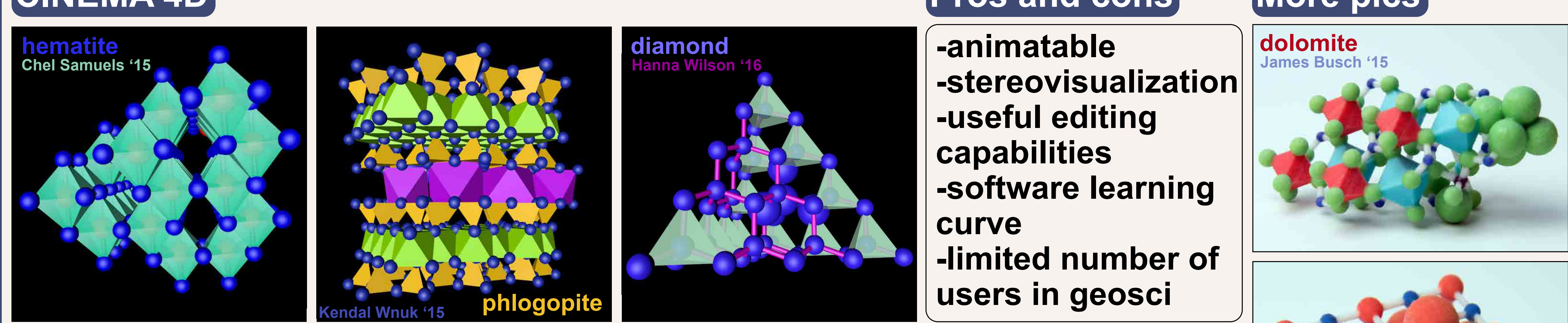


## Building

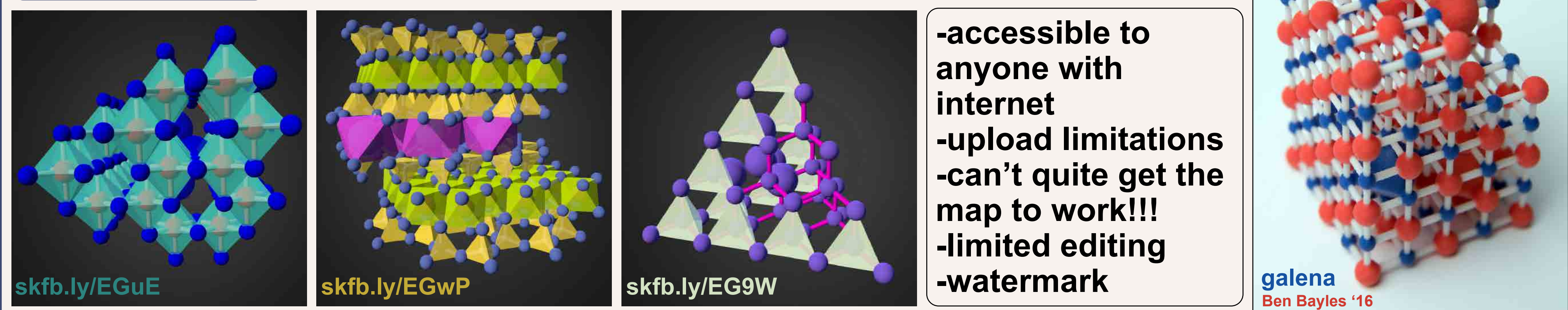


## Exporting

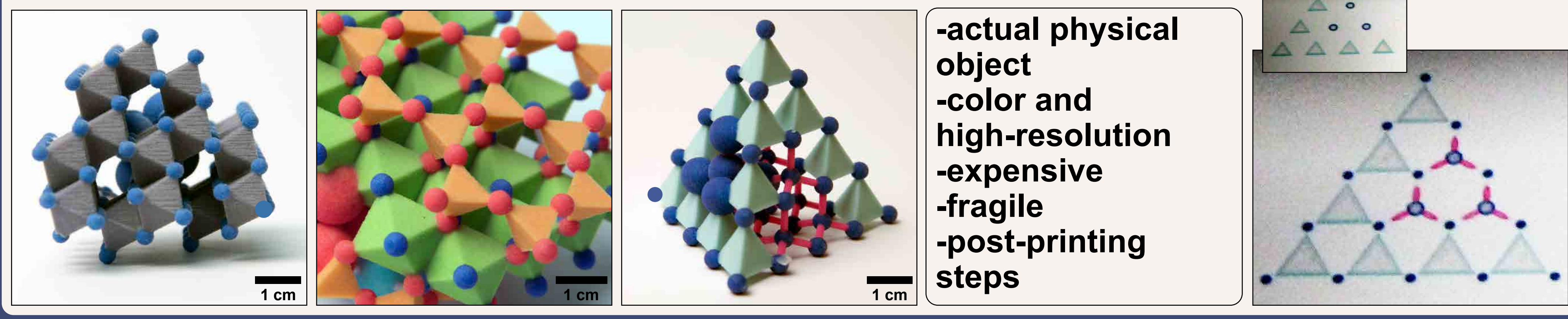
### CINEMA 4D



### sketchfab.com



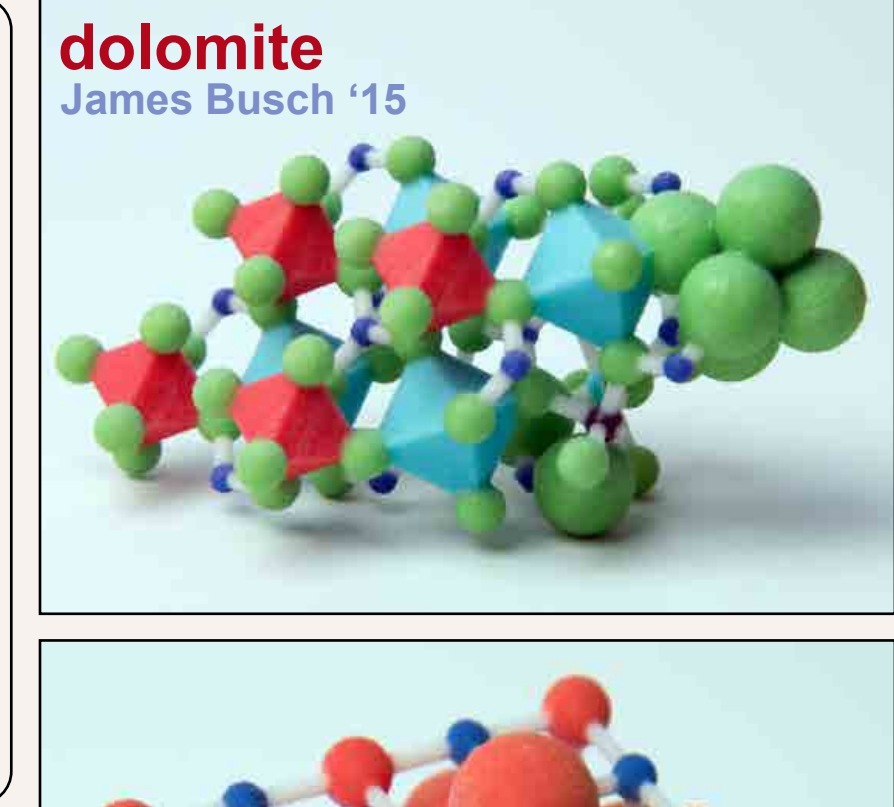
### 3D systems ProJet 260C



### Pros and cons

- animatable
- stereovisualization
- useful editing capabilities
- software learning curve
- limited number of users in geosci

### More pics



### accessible to anyone with internet

- upload limitations
- can't quite get the map to work!!!
- limited editing
- watermark

### -actual physical object

- color and high-resolution
- expensive
- fragile
- post-printing steps