

Virtual Rocks

Supplementary Document Accompanying the GSAToday Article “Virtual Rocks”

©2016 Declan De Paor and the Geological Society of America.

This document offers technical details of methodologies necessary to create and share virtual rocks. Headers and sub-headers are keyed to the text of the main article.

CREATING VIRTUAL SPECIMENS WITH SKETCHUP

There is a free version of SketchUp called SketchUp Make, however, processing and exporting is easier with SketchUp Pro, which is subsidized for higher education. COLLADA models can be exported from SketchUp as stand-alone DAE (Digital Asset Exchange) files or they can be embedded in KMZ archives. They are imported into Google Earth using the “Add model...” menu or via Keyhole Markup Language (KML) scripts (Wernicke 2009). KMZs are actually zip archives and can be unzipped with standard software, revealing the KML, DAE, and image texture files. DAE files can be examined with a text editor. The main purpose is to change the names or pathnames of files used as textures¹. Textures can also be changed in the associated KML document using the Resource Map element which redirects from a source to a target image.

KML is the most common scripting language used with virtual globes. Nested within the root <kml>...</kml> tags are one or more “Documents” or “Folders” that organize content in the Places sidebar of the Google Earth desktop application, for example. Among elements defined in KML, the most important for our purpose is <Model>...</Model>, a child of the <Placemark>...</Placemark> element. This allows one to insert COLLADA models and see them listed in the Places sidebar. To include a COLLADA model in a Google Earth placemark, one must specify its desired location, orientation, and scale and then use the <Link>...</Link> element to specify a URL of the DAE file containing the COLLADA script. This structure permits a single DAE file to be imported to several placemarks simultaneously. Only one model can be linked to each placemark, however.

Slab-shaped COLLADA Models

A 3D block with rectangular sides was created in SketchUp using the *rectangle* and *push/pull* tools (menu and tool names are italicized in the following discussion). The first photograph was *imported* as a *texture* and placed on the front of the block (Fig. 1a). The narrow sides were *pushed* until they just touched the specimen’s outline. Using the *pencil* tool, lines were drawn on the block’s sides at the specimen-touching points (yellow arrow). This splits a face into two parts that can be *moved* independently.

— — — — —
¹Texture is the term used by modelers for images applied to model surfaces.

Virtual Rocks

Dragging the blue edge changed the block to a trapezoid (Fig. 1b). This process was repeated as new parts of the specimen came to touch the edge until the shape wrapped tightly around the image (Fig. 1c).

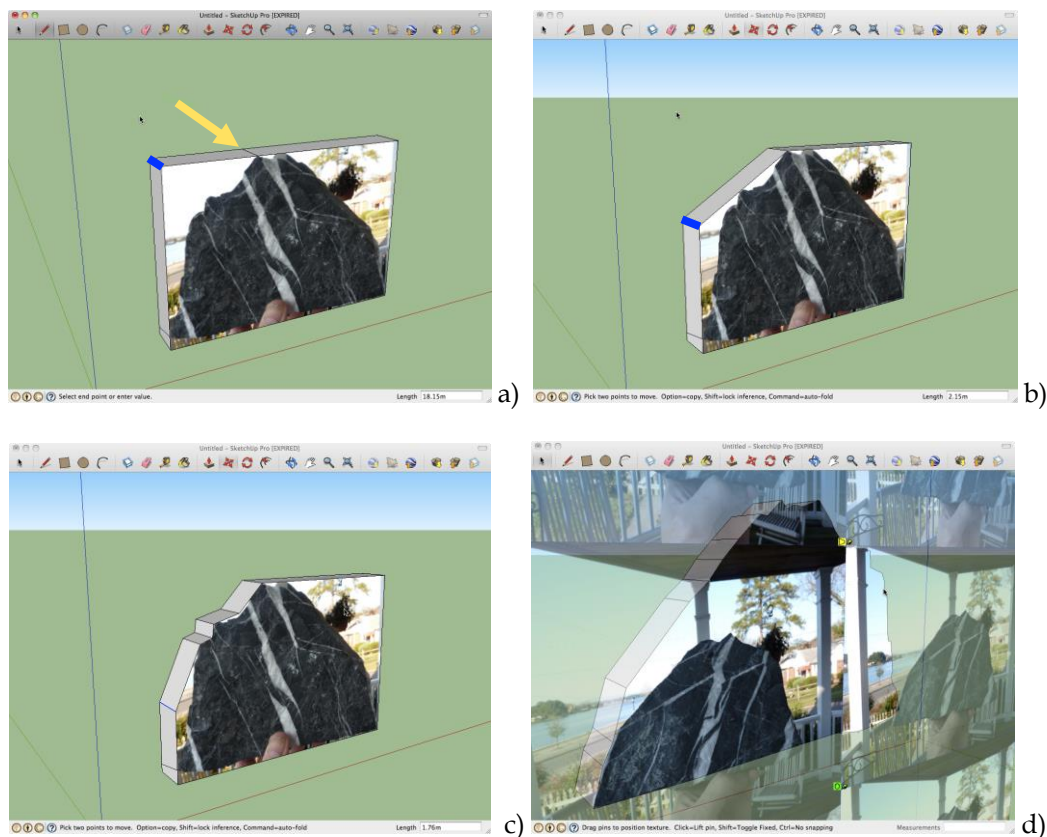


Fig. 1. a) Photo applied to side of block in SketchUp. Sides were pushed until they just touched specimen. Yellow arrow shows line drawn at top point of contact. Blue edge is moved in b). c) shows model after several pushes. d) Applying second image. Texture position menu allows image to be adjusted to fit model.

The model was next *rotated* to reveal the second large face and the second image was applied as a *texture* (Fig. 1d. If only one specimen image is available, it can be flipped to match on opposite faces). The *position texture* tool was used to *align* and *scale* the image to fit the specimen outline as defined by the first image. Since the edges were not of interest, they were colored gray to match the specimen using the *eye dropper* and *paint bucket* tools. One could apply a series of small edge images if desired. A centimeter scale was photoshopped into the two photographs so that students do not have to rotate the model to see the scale. To make features visible in Google Earth, hand specimens may need to be *scaled* up. This can be done directly in SketchUp or by editing the KML file's model <scale> script.

Virtual Rocks

The Google Earth time slider was programmed to make the specimen rotate about a vertical axis by creating a series of KML *Placemarks* each with a different *TimeSpan* and changing the model *heading* tag accordingly. It could alternatively have been elevated or scaled, but unfortunately the Google Earth desktop application permits only one slider control at a time.

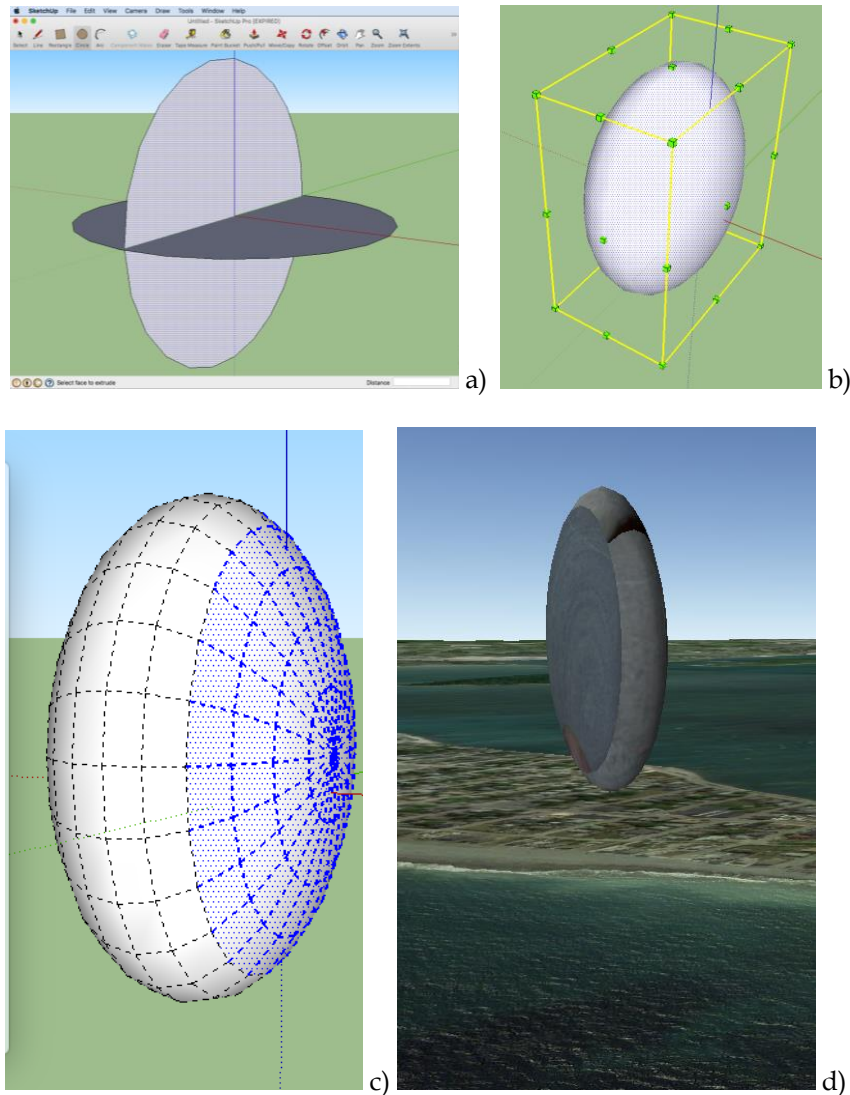


Fig. 2. a) Creating a sphere from two circles and the *FollowMe* tool. b) Stretching the sphere into an ellipsoid. c) After showing hidden geometry, part of web frame is selected to receive one photo. d) Final virtual pebble. Nantasket Beach MA in background. ©Google, Image Landsat.

SKETCHUP MODELS OF OVOID AND CYLINDRICAL SPECIMENS

SketchUp can also be used to make models of near-ovoid objects such as well-rounded pebbles. Three pairs of mutually orthogonal photos are required. The *FollowMe* tool is used to extrude a circle into a sphere (Fig. 2a) and the *scale* tool changes that into

Virtual Rocks

an ellipsoid (Fig. 2b). The *show hidden geometry* menu reveals the ellipsoid's wireframe mesh, and the *match new photo* menu option drapes the appropriate texture on the selected parts of the mesh (blue). No attempt was made to blend the images in Fig. 2d so that the photo stitching would be obvious. Photoshop could be used to disguise the seams for a more engaging teaching specimen. For added realism, two halves of an ellipsoid may be stretched by different amounts, creating an non-centro-symmetric form.

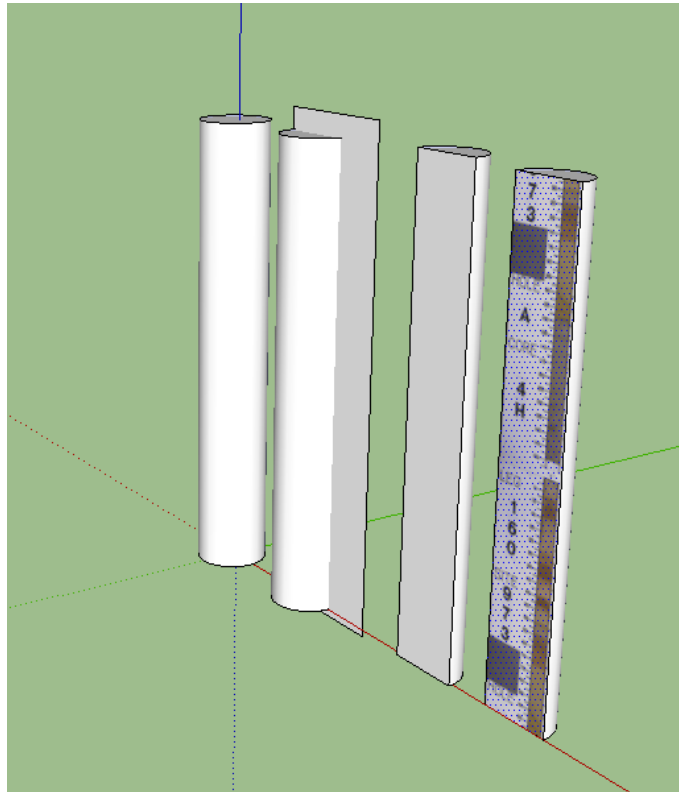


Fig. 3. Creating a split drill core. Image source: <http://iodp.tamu.edu/database/coreimages.html>.

Cylindrical specimens are created with the *circle* and *push/pull* tools. Cylinders may be sliced by *intersecting* with a plane and drill core images may be applied as textures to the flat and/or curved slices (Fig. 3).

SketchUp *saves* COLLADA models in SKP files that can only be *opened* in SketchUp, however models can also be *exported* as DAE files or embedded in KMZs. DAE files may be viewed in Apple Preview, GLC Player, PhotoShop, AutoCAD, Blender, or HTML5 canvas elements, as well as Google Earth.

Virtual Rocks

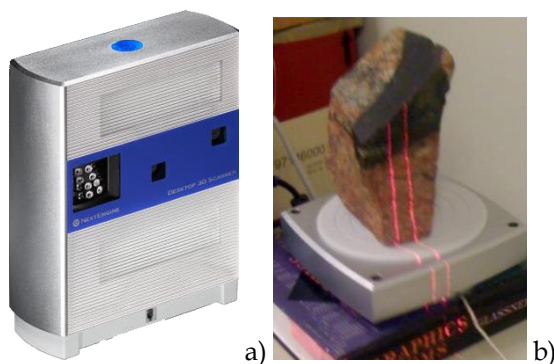


Fig. 4. a) The NextEngine 3D scanner. b) Stereo lasers scan a specimen.

Complex Specimens and 3D Scanners

A NextEngine™ 3D scanner was used to create complex virtual specimens (Fig. 4). Rocks were placed on the turntable and scanned with stereo laser beams. Bundled ScanStudio™ software was used to stitch the specimen parts — a very tedious process.

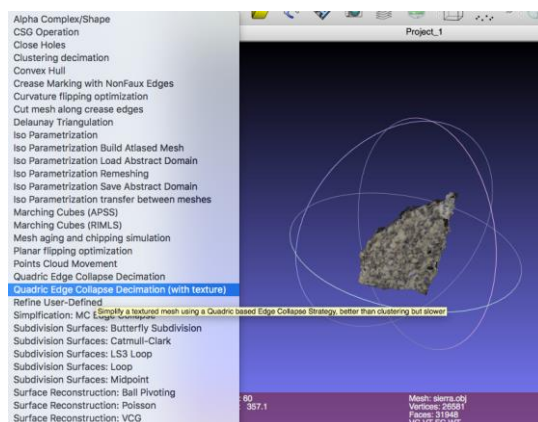


Fig. 5. Model of Sierra Nevada Granodiorite imported into MeshLab for clean up, vertex reduction, and export in COLLADA format. The highlighted menu option is *Quadric Edge Collapse Decimation [with texture]*.

3D scanners create very large file sizes and the output file types — STL, OBJ, VRML, XYZ, and PLY — cannot be viewed directly in Google Earth. Models have holes that need to be filled, for example where they sat on the turntable. To reduce the file size, fill holes, and convert to COLLADA format, OBJ files were imported into MeshLab (a free open source app) for post-processing (Fig. 5). Several vertex reduction algorithms are available in MeshLab but the only one that worked and preserved shapes well was *Quadric Edge Collapse Decimation*. zBrush is an expensive alternative to MeshLab.

Virtual Rocks

Multi-View Stereo and Structure from Motion

Structure from Motion models were created with the 123D Catch app. Again the file formats—STL, 3DP, and OBJ—must be changed to DAE in MeshLab, where mesh size can also be reduced if necessary. Tests suggest that 40 to 60 images are optimal. Camera quality is not critical. Models made by a student with the mobile app on an iPhone 4 were indistinguishable from ones created by a professional photographer using a top-of-the-range Nikon DSLR camera. Evidently the extra resolution of the professional camera is lost in the point cloud and stitching processes.

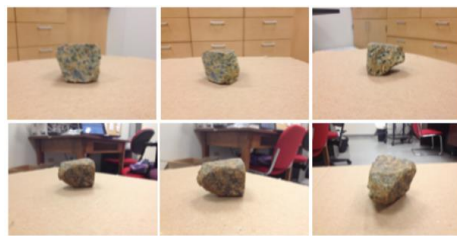


Fig. 6. Part of a set of 30 views used to create a 123D Catch model. Busy background is an advantage. See Fig. 3 in the main paper for resultant COLLADA model.

Because the software uses background parallax for depth perception, a busy background is good (Fig. 6). The background is almost all cut out of the final model, however there are usually artifacts to be cropped and a hole where the specimen rested on the table. The hole can be filled with a gray or beige facet so that viewers do not see into the model's interior which can be confusing. Alternatively, the hole can be oriented close to the Google Earth terrain so it is never seen from below.



Fig. 7. Alan Pitts, Robin Rohrback, and Callan Bentley collaborated on this 3D model of Reynolds Limestone filled with gastropods. Geolocation: 39.234042 N, -79.185402 E on Google Earth. ©2016 Google. Image Landsat.

This was done with the Reynolds Limestone sample downloaded from Alan Pitts's SketchFab page: <https://skfb.ly/KNAA> (Fig. 7)—a collaboration with Robin Rohrback and Callan Bentley.

As with 3D scanner output, 123D Catch output file types must be converted to COLLADA for Google Earth and file sizes usually must be shrunk well below 64,000

Virtual Rocks

vertices using quadric edge collapse decimation. Note that Autodesk Remake is destined to replace 123D Catch.

VIEWING VIRTUAL SPECIMENS IN WEB BROWSERS

Google is reportedly developing a plug-in-free Google Earth API. Meanwhile, one can use the plug-in-free Cesium virtual globe (Cesium, 2016). Cesium loads 3D models using the OpenGL Transfer Format (glTF). It is faster and renders better than COLLADA and seems destined to replace that format. A tool on the Cesium web site converts COLLADA models to glTF automatically. See the sample here: geode.net/cesium_glTF.html (Chrome browser recommended).

Direct viewing with HTML5 and JavaScript

COLLADA models may be embedded directly in web pages using HTML5 and JavaScript available from GitHub (2016). (see Fig. 8 and the cover art of the main article)

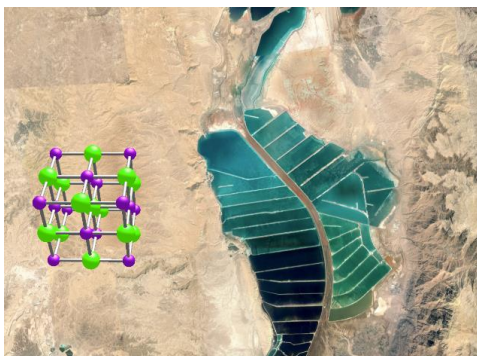


Fig. 8. Model of Halite lattice viewed against salt pans south of the Dead Sea. Image NASA. See GSAToday cover art associated with the main paper.

The following examples can be viewed online:

[Ammonites 1](#) (Gryphaea specimen from Brain, 2016)

[Ammonites 2](#) (Semington specimen from Brain, 2016)

[Halite](#) (for fast computers only)

[Halite \(small\)](#) (for slow computers and mobile devices)

[Mantle Xenolith](#) (from Hawaii)

[Rheems](#)

[Vredefort](#)

Virtual Rocks

To make your own HTML-hosted COLLADA models, the simplest approach is to modify one of these HTML files. For example, in `halite.html`, search for the line:

```
“loader.load('Halite.dae', function(collada) {“
```

and replace the `Halite.dae` model with a COLLADA model of your choice. It may be necessary to change the model scale, position, or distance to lighting source, depending on the size of the substituted model. Note that some servers block untrusted file types. Talk to your IT help desk if models are not correctly served.

KMZ equivalents are available for download:

[Acasta.kmz](#)

[Ammonites_1.kmz](#)

[Ammonites_2.kmz](#)

[Apatite_GEv6.0_or_Earlier.kmz](#) (use only with Google Earth version 6.0 or earlier)

[Halite.kmz](#)

[Hawaii.kmz](#) (this is a mantle xenolith)

[Hull_Pebble.kmz](#)

[Reynolds_Limestone.kmz](#)

[Reynolds_Limestone.pdf](#) (3D PDF: View with Acrobat Reader only. User will need to extract PDF from .zip file before viewing).

[Vredefort.kmz](#)

References Cited

Brain, A, 2013: <http://www.123dapp.com/MyCorner/AdrianBrain-20378945/models> (last accessed 4 Mar. 2016).

Cesium, 2016: <http://cesiumjs.org> (last accessed 4 Mar. 2016)

GitHub, 2016:

https://github.com/mrdoob/three.js/blob/master/examples/webgl_performance_static.html (last accessed 4 Mar. 2016).

Wernicke, J., 2009, *The KML Handbook: Geographic Visualization for the Web*: Pearson Education Inc. ISBN-13: 978-0321525598.