Teaching with Digital 3D Models of Minerals and Rocks
Graham D.M. Andrews, Gabrielle D. Labishak, Sarah R. Brown, Shelby L. Isom, Holly D. Pettus, Trevor Byers, GSA Today, v. 30, https://doi.org/10.1130/GSATG464GW.1.

Supplemental Material

Methodology

Hardware Set-up

We use a small photography set-up consisting of a 30 cm-across, square, white, plastic Lazy-Susan turntable, a 50 cm-across, cubic, fabric lightbox with three LED ring lights, and an 18.4 MP Sony DSC-HX80 compact digital camera mounted on a simple tripod. We use a matte black background in the lightbox with pastel white filters on the LED lights. The turntable is marked-up with pairs of colored dots in the corners and approximately halfway towards the center; these are used to assist manual registration of images. Samples up to 40 cm-diameter can be accommodated but we generally restrict ourselves to samples less than 25 cm-diameter to enable use of the registration marks on the turntable.

Computer and Software Set-up

Photographs are uploaded to and backed-up on a dedicated Google Drive Team account. We use *Agisoft Metashape Basic* photogrammetry software (https://www.agisoft.com/) on a consumer-grade laptop PC (2.21 GHz, 16 GB, 64 bit) and a research-grade (3.2 GHz, 32 GB, 64 bit) desktop PC, both running Windows 10 and graphics accelerated. We have also run smaller models successfully on a Mac Book Pro 13 (1.4 GHz, 8 GB). There is no appreciable difference in quality; however, processing time correlates with RAM, processor, and GPU speed. A typical model batch processed at high-quality settings takes up to 2 hours machine time.

Metashape Basic is run with GPU acceleration enabled and contemporaneous CPU processing. Images are aligned at high-quality with a key point limit of 250,000 and tie point limit of 100,000 (both significantly higher than the defaults). The aligned images are converted to a dense point cloud at high-quality with mild depth filtering. The mesh is constructed from the dense point cloud with a medium face count. The textured skin is constructed using the imported images and default settings. Completed models are exported as *.glb* files (usually 100 – 200 Mb) to ease uploading to *Sketchfab.com*.

Photo Capture and Processing

A sample is placed on the center of the turntable and illuminated from the front (upper-middle, lower-left, and lower-right). One half of a sample is photographed at a time in three revolutions of the turntable (e.g., Dimitriu and Balan, 2017; Riquelme et al., 2019): sub-horizontal, ~45° from horizontal, and ~80°; for a total of 50 – 100 images. The sample is then turned over and the process repeated. Images for each half are uploaded into separate 'chunks' in *Agisoft Metashape* and processed independently. After extraneous voxels and the model of the turntable are removed by the operator, the two halves are merged together and the seams cleaned-up.

Hosting on *Sketchfab.com*

Completed models are hosted in a dedicated page on *Sketchfab.com* (http://sketchfab.com/WVUpetrology). Models are named, described and assigned keywords to ease online search engines in finding them, under the 'edit properties' control. There we add a logo and make the model downloadable with a Creative Commons license (CC-BY-4.0). We add a doi number generated in *Zenodo* (www.zenodo.org). Models can be processed further for appearance in Sketchfab.com using the 'edit 3D settings' control. We usually display models against a clear background and use the PBR renderer and shadeless settings. Models can be post-processed to maximize visual effect. Annotations are added to points of interest on the model. Each numbered annotation includes a title and an optional body of text that can include URLs and images. Audio recorded separately can be added to the model. Animations of the model generated outside of *Sketchfab.com* can be added. Finally, models can be prepared specially for viewing in virtual reality with controls to preset the scale and viewing angles. After a model is added we share it on social media (Twitter - *@WVURockDoc*) and add it to one of our curated thematic collections of models (https://sketchfab.com/WVUpetrology/collections).

References Cited

Dimitriu, T.-C., Balan, I.V., 2017, 3-D minerals. Auxiliary material for the Physical Geology classes: Analele Stiintifice ale Universitatii "Al. I. Cuza" din Iasi Seria Geologie, v. 63, no. 1–2, p. 25–35. http://geology.uaic.ro/auig/

Riquelme, A., Cano, M., Tomás, R., Jordá, L., Pastor J.L., Benavente, B., 2019, Digital 3D Rocks: A Collaborative Benchmark for Learning Rocks Recognition: Rock Mechanics and Rock Engineering, v. 52, p. 4799-4806, https://doi.org/10.1007/s00603-019-01843-3