Keystone (CA-MEN-2200) Revisited with Twenty-First Century Technology

Robert Mark and Evelyn Billo

The Keystone site is a large schist boulder in California's North Coast Range. We previously visited it in 1989 and 1990, with 35mm slide-film cameras in hand, and under part sun/part shade conditions. A subsequent attempt to create a photogrammetric model from the scanned slides was only partially successful. We revisited the site in October 2023, this time with drone, digital cameras, and under overcast skies. The results of this radiance scaling enhanced photogrammetric model are presented here. The images display a dense, complex array of petroglyphs that includes cupules, grids, concentric circles, nested sinuous lines, and other geometric patterns.

In 1989 and 1990 we joined Bay Area Rock Art Research Association (BARARA) field trips to visit a unique petroglyph boulder in the North Coast Range of California (Figures 1 and 2). The boulder had been described in a presentation to the Society for California Archaeology annual meeting in

Figure 1. View of boulder from the road in 2023. Note large branch of tree had been removed (right side). All photographs by the authors.

Robert Mark
Evelyn Billo
Rupestrian CyberServices

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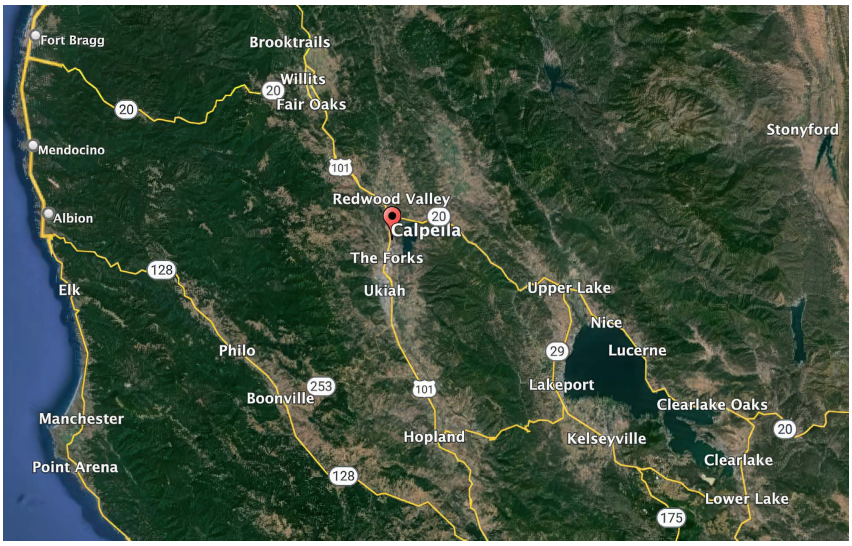

Figure 2. Approximate site location in the North Coast Range of California.

1988 (Gary and McLear-Gary 1988) and in a site form (Gary et al. 1988). It is very complex with thousands of elements (Figure 3). It could not be adequately documented with the then-current technology. John Betts created an excellent and beautiful artistic rendition

8. Prehistoric X Historic _____ Protohistoric _____ 9. Site Description: A large mica chlorite schist boulder covered with pecked and rubbed motifs. The motifs include 700+cupules, 1000+incised lines, 33 small circles with cupules, 5 small circles without cupules, 2 concentric circle motifs, 6 large circles, 5 parallel curvilinear, 4 shields, rows of dots.

10. Area: 2 high 8 diameter m². Method of Determination: measured

Figure 3. Excerpt from site form showing the complexity of the boulder (Gary et al. 1988).

(Figure 4) which gives the viewer an idea of the complex imagery without the distractions of the lichen cover and weather that one experiences when at the site in person.

The Keystone boulder is situated under dense trees and is, therefore, very difficult to photograph. Figure 5a illustrates a portion of cupules, cup and ring, and incised line glyphs as seen with shadows cast by trees; Figure 5b shows some field trip participants as scale factors to the boulder; Figure 5c includes some of the grids, nested sinuous lines, and unusually shaped pecked curvilinear nucleated elements (PCNs) that are in shade and therefore difficult to discriminate; and Figure 5d shows Evelyn taking photographs while standing on the largest tree and leaning against the trunk-size branch that is no longer there. Although we certainly were not thinking about photogrammetry when we visited with our film cameras, we subsequently attempted to use our scanned slides to create a photogrammetric model[1] illustrated in Figure 6a, which shows a photo of the resulting small area that was modeled, along with large areas that are out of focus and places with gaps where data is missing. Figure 6b is a photo of one view of the model's radiance scaling curvature map's red channel (darker areas are concave) that shows areas of missing data a bit more clearly. Obviously, a return to the site with twenty-first-century technology was needed!

On a rainy afternoon in October of 2023, we were finally able to revisit the boulder and were granted permission by a representative of the property owner to proceed with photography. Some of the tree branches had since been removed, and the cloud cover provided optimal lighting. We were able to carefully fly a small drone (DJI Mini 3 Pro) under the remaining tree branches to acquire about a hundred images. We used our iPhone 15 Pro to acquire another several hundred images that were shot from the ground and from a nearby ladder. The final photogrammetric model (Fig-

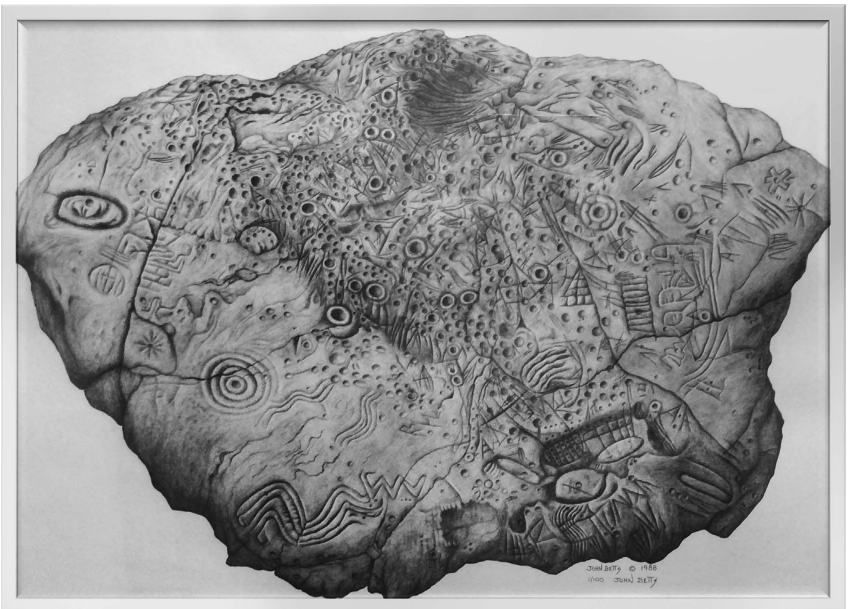

Figure 4. Artistic rendition by John Betts, who asked us to mention that it was not intended as a recording.

Figure 5. Photographs from earlier site visits while on Bay Area Rock Art Research Association field trips. (a) Partial view of boulder top shows cupules, cups and rings, incised lines, and tree branch shadows. (b) Field trip participants indicate size of boulder. (c) Shadows hide rectilinear grids, deep nested sinuous grooves, and unusual examples of pecked curvilinear nucleated glyphs. (d) Evelyn Billo leans on large tree branch (since removed) to shoot her photographs.

ure 7), created with Metashape, used 333 images. It can be viewed with a computer on Sketchfab,[2] where one can also rotate it to see other orientations and zoom in for greater detail.

For a review of the radiance scaling technique, see Mark and Billo (2021). Basically, it uses a curvature map derived from the photogrammetric model using Meshlab. Channels (red or blue) are then blended with the model image in Photoshop. Figure 6b shows the result for the model with 1989–1990 data and Figure 8 shows the 2023 data enhancement for the top of the boulder, using both the red (Figure 8a) and the blue (Figure 8b) channels for blending. This model provides much more detail in many of the wide variety of petroglyphs at CA-MEN-2200, such as the large concentric circle, several PCNs, and curvilinear and zigzag ele-

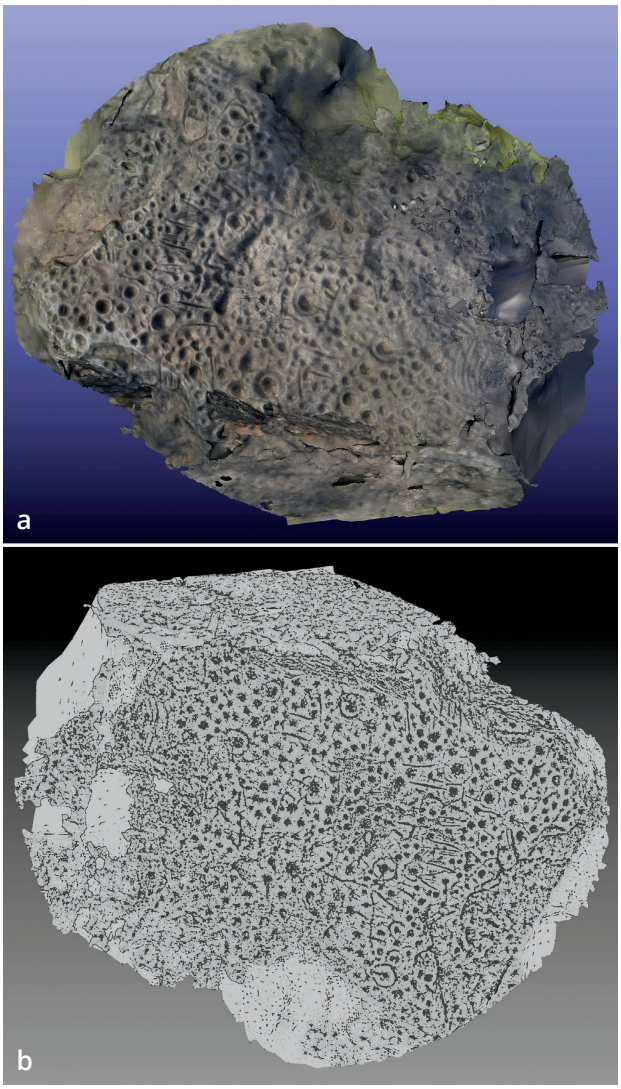

Figure 6. Photogrammetric model from 1989–1990 scanned slides. (a) View from model. (b) Radiance scaling enhancement.

ments. Figure 9 shows the 2023 model's red-channel results for the back side of the boulder, where the rectilinear grid patterns with central dots show clearly, along with the plethora of cupules and incised lines. Images like this simply could not be obtained without modern technology. These model images have been submitted to the California Historical Resources Information System repository for addition to the site form.

The drone images also permitted a partial generation of a georeferenced orthophoto and digital elevation model with Maps Made Easy. Figure 10a shows one-meter contour lines in red and Figure 10b is the georeferenced orthophoto. With QGIS, an estimate of the boulder dimensions was calculated to about 3 meters high and 7 meters long.

Acknowledgments. Thanks go to John Betts, the very talented artist who created the illustration shown in Figure 4 and gave us permission to use it. We thank the site's property owner and manager, who gave us permission to photograph and who continue to appreciate and protect this unique boulder. Thanks also to the recorders who introduced us to CA-MEN-2200 34 years ago; current ARARA friends Chris Gralapp and Leigh Marymor, who encouraged us; and the unknown indigenous people who pecked, carved, and incised this boulder. Their marks from the past have been modeled with state-of-the-art non-invasive techniques that hopefully will be of use to future researchers.

Notes

1. The model from original incomplete data can be viewed on Sketchfab at https://skfb.ly/RsrL.

2. The new model from our current research can be viewed on Sketchfab at https://skfb.ly/oMPXG.

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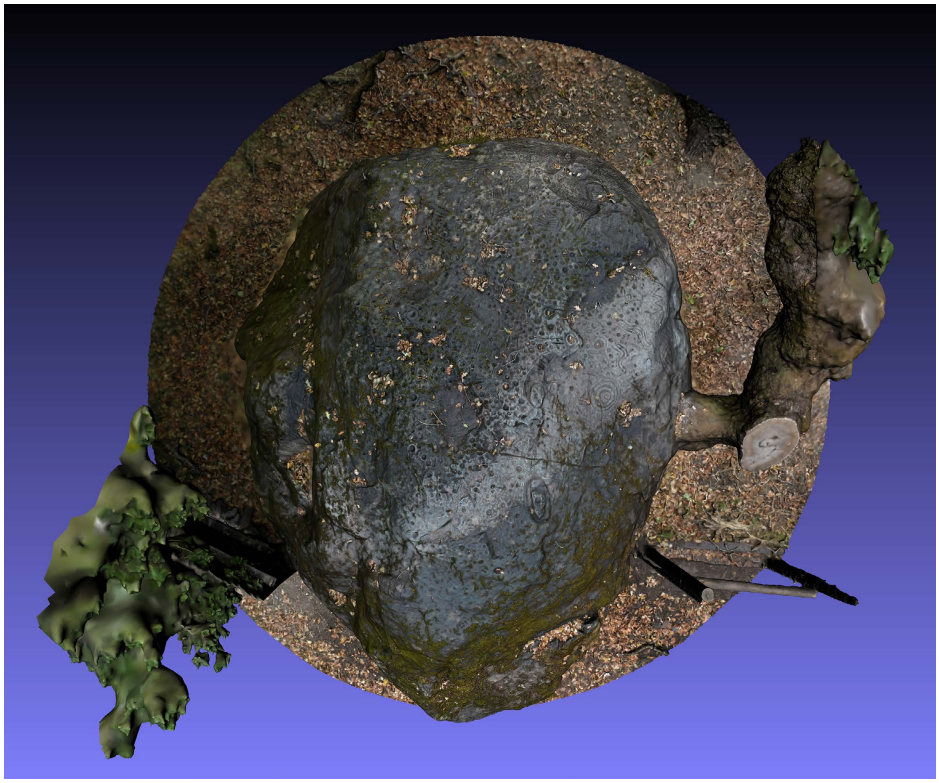

Figure 7. Top view from new 2023 model. Note cross-section stump remaining from removal of the large tree branch on right.

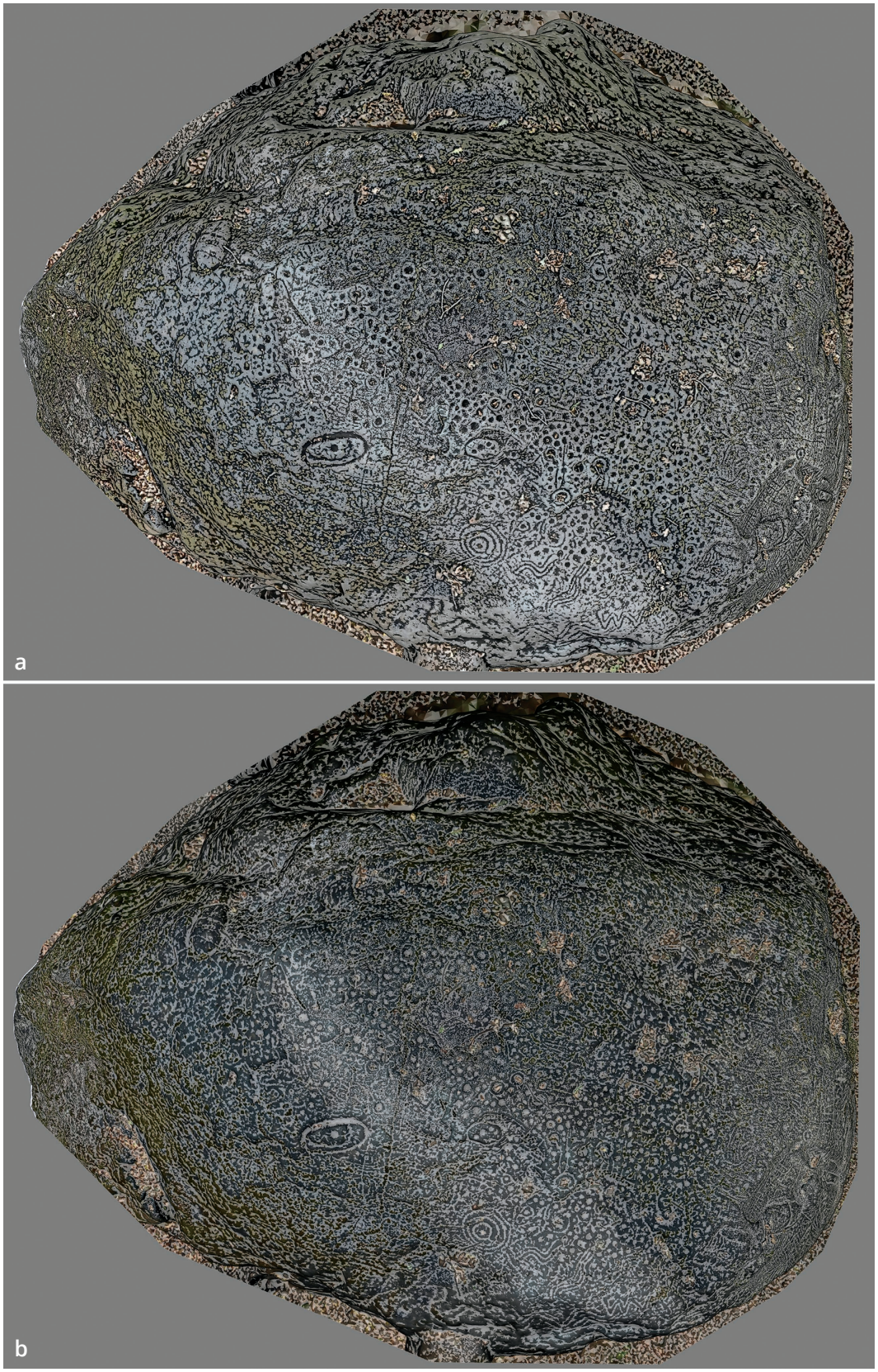

Figure 8. Enhanced top view. (a) Using red channel from curvature map. (b) Using blue channel from curvature map.

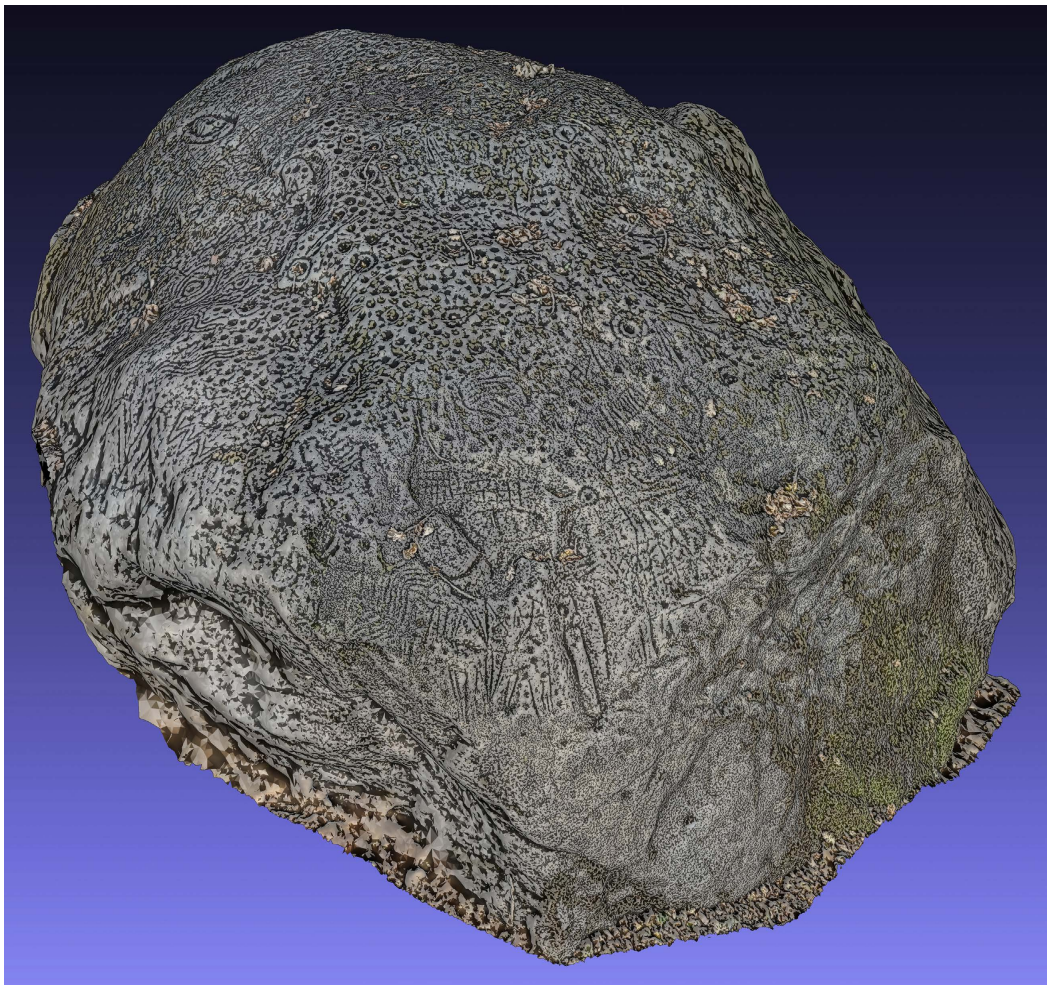

Figure 9. Enhanced rear view, using red channel of 2023 model. Note rectilinear grids with central dots, deep nested sinuous grooves, zigzags, and concentric circles.

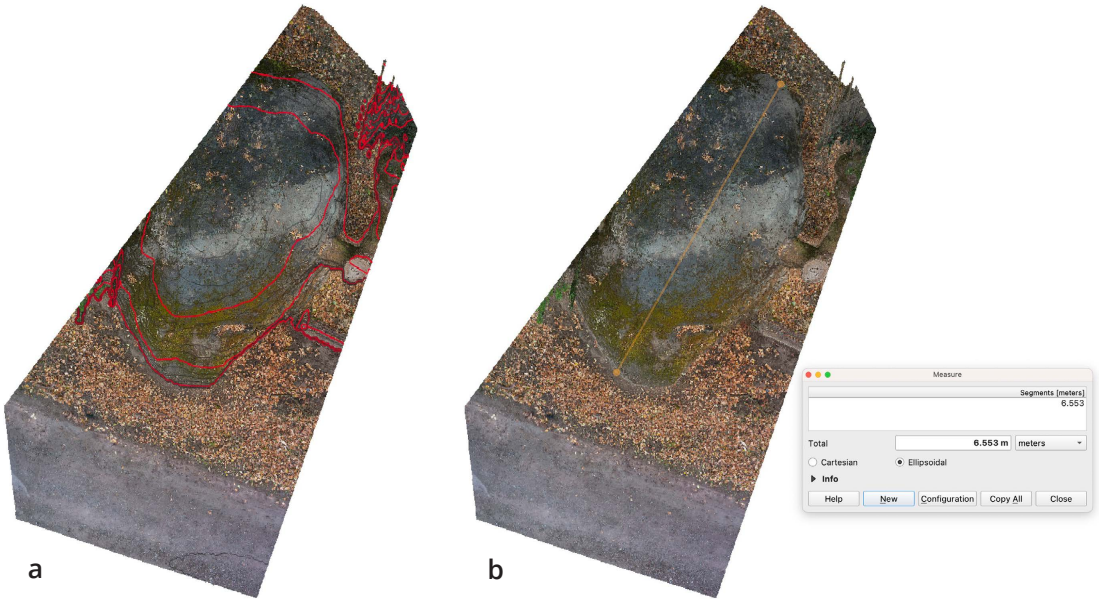

Figure 10. Maps Made Easy orthophoto and digital elevation products, displayed using QGIS. (a) Orthophoto with red 1-meter contour lines. (b) Orthophoto with yellow measurement line.