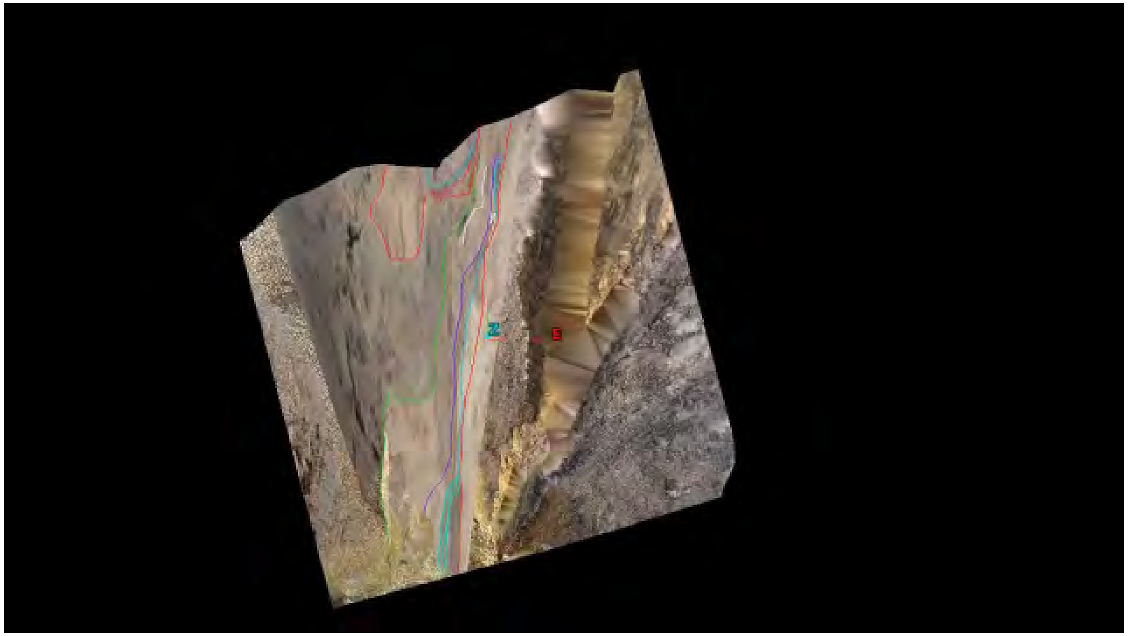
Camp site, where we recognize deviation in interpretations of the TLS-derived terrain model relative to map-based orthophoto interpretations that appears to result from stretching of the draped photograph on the TLS model (Animation 5). This arises because the photographs were taken from near the canyon floor, leading to a view that is highly oblique to the target surface, generating pixel smear and distortions analogous to pixel smear and image distortions in the 2.5-D method where vertical imagery is draped onto an elevation model in steep terrain. That is, because of look angle, this method remains a 2.5-D method, despite the high-resolution terrain model. Thus, in this case, line positions mapped on the nadir-looking orthophoto are probably as well constrained, or better constrained, than line positions based on the image drape to the TLS terrain model.

Because image drape errors appear to be the major issue in both TLS and the conventional 2.5-D methods with vertical imagery, our limited data set suggests strongly that direct mapping on an MVS point cloud is a superior method for 3-D mapping, provided the MVS model is accurately georeferenced. This conclusion is relatively obvious from the basic distinction between any model that requires a photographic drape (e.g., TLS or the 2.5-D method) versus MVS. In any colored terrain model where the imagery is draped on the model, the image drape is subject to look-angle distortions, whereas in MVS, every point in the point cloud is in its true position and has the proper color for its position because it is made from the same photographs that were used to generate the model. In essence, this means that in a MVS point cloud each point is a 3-D pixel that is not subject to pixel smear. Its spatial position may be misplaced due to model errors, but it will always be the proper color for its relative position.

Based on these observations, we suggest that different methods should be considered based on local terrain. Where terrain is relatively subdued (slopes generally <45°) and steeper escarpments are smaller than the scale of geologic features being analyzed, 2.5-D methods are preferred due to their simplicity and their tie to well-established methods. As terrain becomes steep, particularly where features to be analyzed are smaller than the scale of escarpments, a true 3-D mapping approach is needed. MVS modeling provides the simplest and generally superior method for generating the terrain model base, provided good spatial referencing can assure an accurate terrain model.

Remote Sensing of Orientations

The similarities in orientations obtained from analyzing points on the TLS terrain model relative to field measurements suggest that these digital techniques show great promise in analyzing orientations in inaccessible sites. Nonetheless, the model-based measurements versus the field measurements (Fig. 10) show different types of scatter. Some of this scatter may be real, but



Animation 5. Visualization of the terrestrial laser scanner–derived terrain model of the Clair Camp structure along with three-dimensional interpretations. In order to make these interpretations, it was necessary to drape a field photograph onto the terrain model. However, when the model is rotated outside the field of view of the photograph, pixel smear is evident, making it difficult to make interpretations. White lines—S1 foliation traces; red lines—faults; green lines—base of the Surprise Member of the Kingston Peak Formation; purple lines—base of the quartzite unit within the Kingston Peak Formation; blue lines—base of the dolomite marble unit within the Kingston Peak Formation; teal lines—enclosed calc-silicate mineralization. Refer to Figure 3A for scale. This video was made using I-Site Studio software. If reading the full-text version of this paper, please download article PDF to view Animation 5 in Adobe Acrobat or Adobe Reader. It is also available by visiting http://doi.org/10.1130/GES01691.a5 or the full-text article on www.gsapubs.org.

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