

# Detailed Surficial Geologic Mapping and Terrain Analysis of the Blue Hills Felsenmeer Valley, Rusk County, Wisconsin

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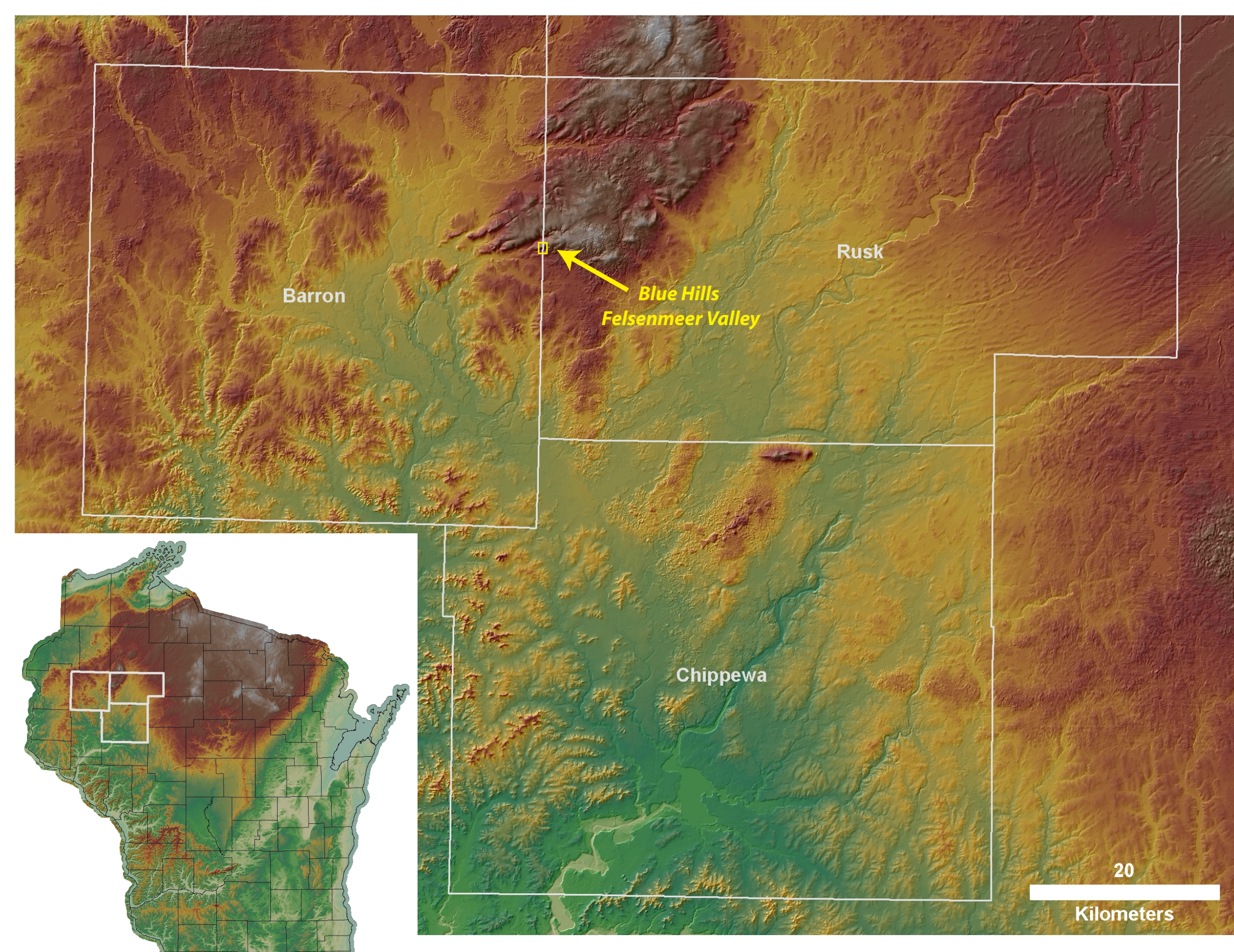
## Abstract

The Paleoproterozoic Barron Quartzite of west-central Wisconsin forms a rolling upland with as much as 180 meters of relief known locally as the Blue Hills. Our study concerns the Blue Hills Felsenmeer State Natural Area in Rusk County, which encompasses a small valley 300 meters long, 100 meters wide, with 25 meters of relief. Underlain by angular quartzite boulders averaging 30 cm long, the valley contains little to no vegetation and contrasts markedly with the surrounding mixed conifer and hardwood forest. Previous studies described the boulder accumulation in this valley as a felsenmeer, which requires in situ frost weathering in a periglacial environment. This work is part of a larger study re-examining the origin of this valley in effort to evaluate if the feature is truly a felsenmeer (rocks frost-shattered in place), and determine if other mechanisms, such as talus accumulation, may account for this feature (Thompson and Syverson, 2006).

We present a detailed surficial geologic map of the valley generated through collection of differential GPS data in the field and supplemented by aerial photo interpretation. The map is plotted on a LiDAR (Light Detection and Ranging) base with a two-foot contour interval provided by courtesy of the Barron County Soil and Water Conservation Office. Mapping targets include areas of boulder accumulation with no vegetation, areas of boulder accumulation with some vegetation, bedrock outcrops, and possible meltwater features.

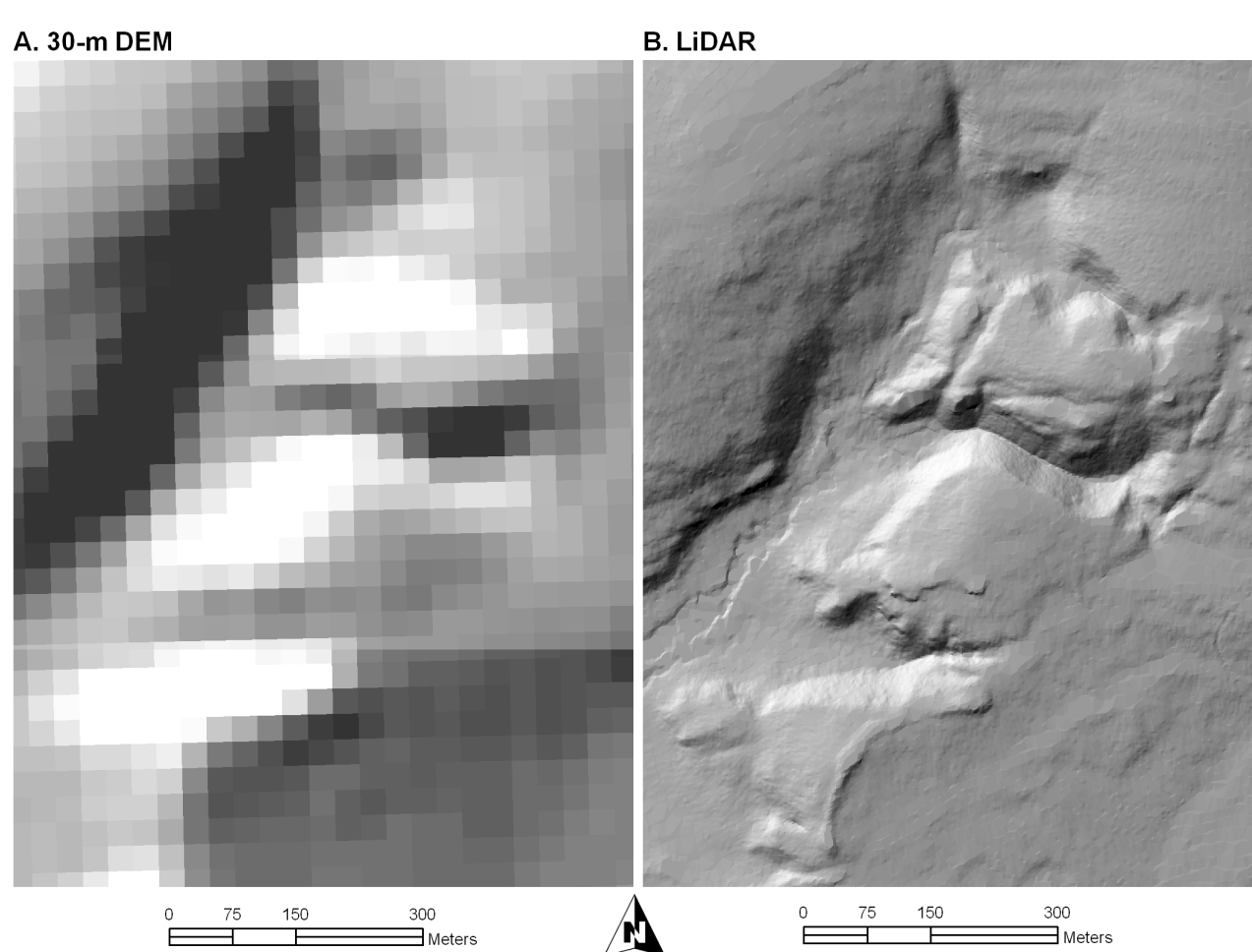
LiDAR data were also employed to generate digital elevation models, which can be used to create shaded-relief maps and conduct terrain analysis. Parameters obtained from digital terrain analysis—including slope angle and aspect angle—may provide additional insight regarding the mechanism of landscape development by comparing locations of boulder accumulation with slope angle and aspect values using GIS. Areas of boulder accumulation with slopes near the angle of repose would be more suggestive of talus than felsenmeer origin, while areas of boulder accumulation with low slopes may be more suggestive of a felsenmeer origin.

## Study Area



## Methods

LiDAR topographic data are collected using aircraft-mounted laser altimeters and spatially referenced using GPS (Global Positioning System) technology (Figure 1; Haugerud et al. 2003). LiDAR data have a vertical resolution of less than one foot and horizontal resolution of 2-5 feet, allowing for production of topographic maps of large areas at a detail that has not been previously available. Figure 2 demonstrates the sharp improvement in resolution between traditional 30-m digital elevation model data and LiDAR data.



LiDAR data of the study area were provided by the Barron County Conservation office in two formats: tagged-vector two-foot contours, and raw XYZ datapoints (Figure 3). In order to perform surface analysis, each dataset was converted to a raster DEM (digital elevation model) format following a similar procedure. XYZ data were imported into an ArcGIS point file using the ASCII 3D to Feature tool in the 3D Analyst Extension. Using 3D Analyst, this point file was then converted to a TIN (Triangular Irregular Network)—a 3D surface composed of nodes connected to their closest neighbors using triangles. Finally, a 0.5-m DEM was generated using the TIN to raster tool. Tagged-vector contours were also used to generate a TIN and raster DEM using the process outlined above. DEMs generated using the contour data were sufficient for general display purposes, but a slight increase in resolution was afforded by converting raw XYZ data to a DEM.

DEM data were subsequently used to generate hillshade maps (315 azimuth and 45 degree sun angle) using the Spatial Analyst extension of ArcMap, and perform terrain analysis using the 3D Analyst extension of ArcMap.

Differential GPS was used in the field to assist in accurately locating features of interest.

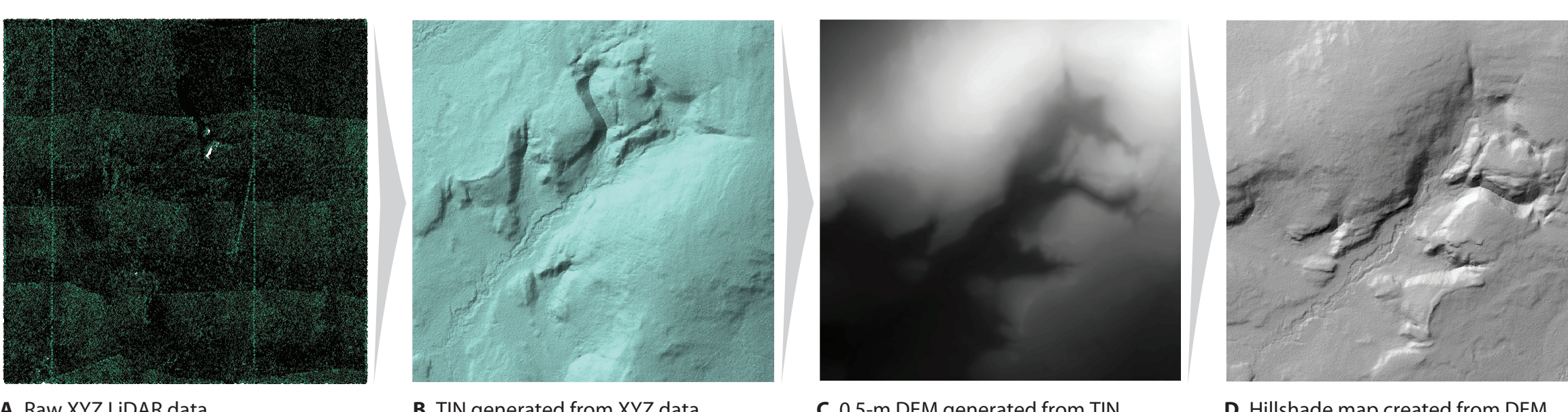
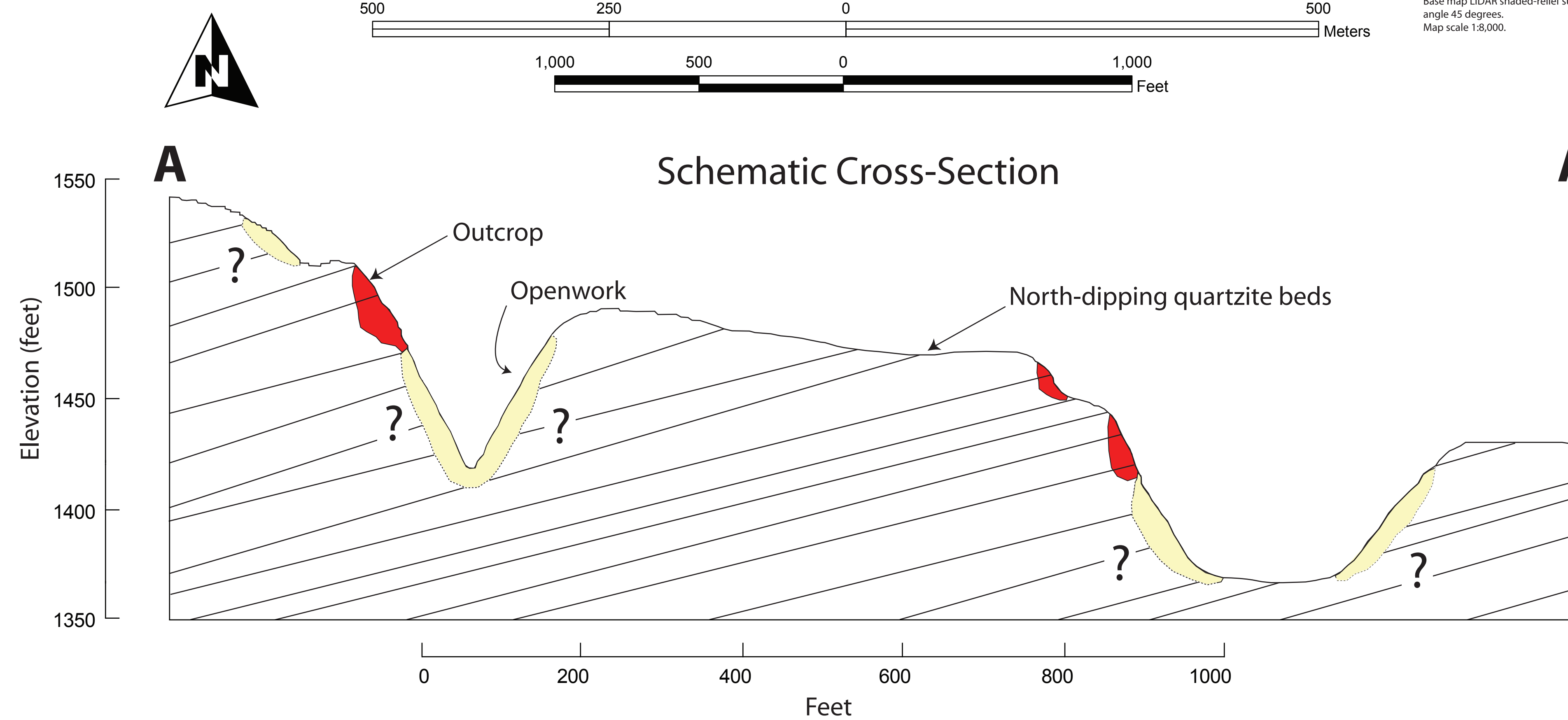
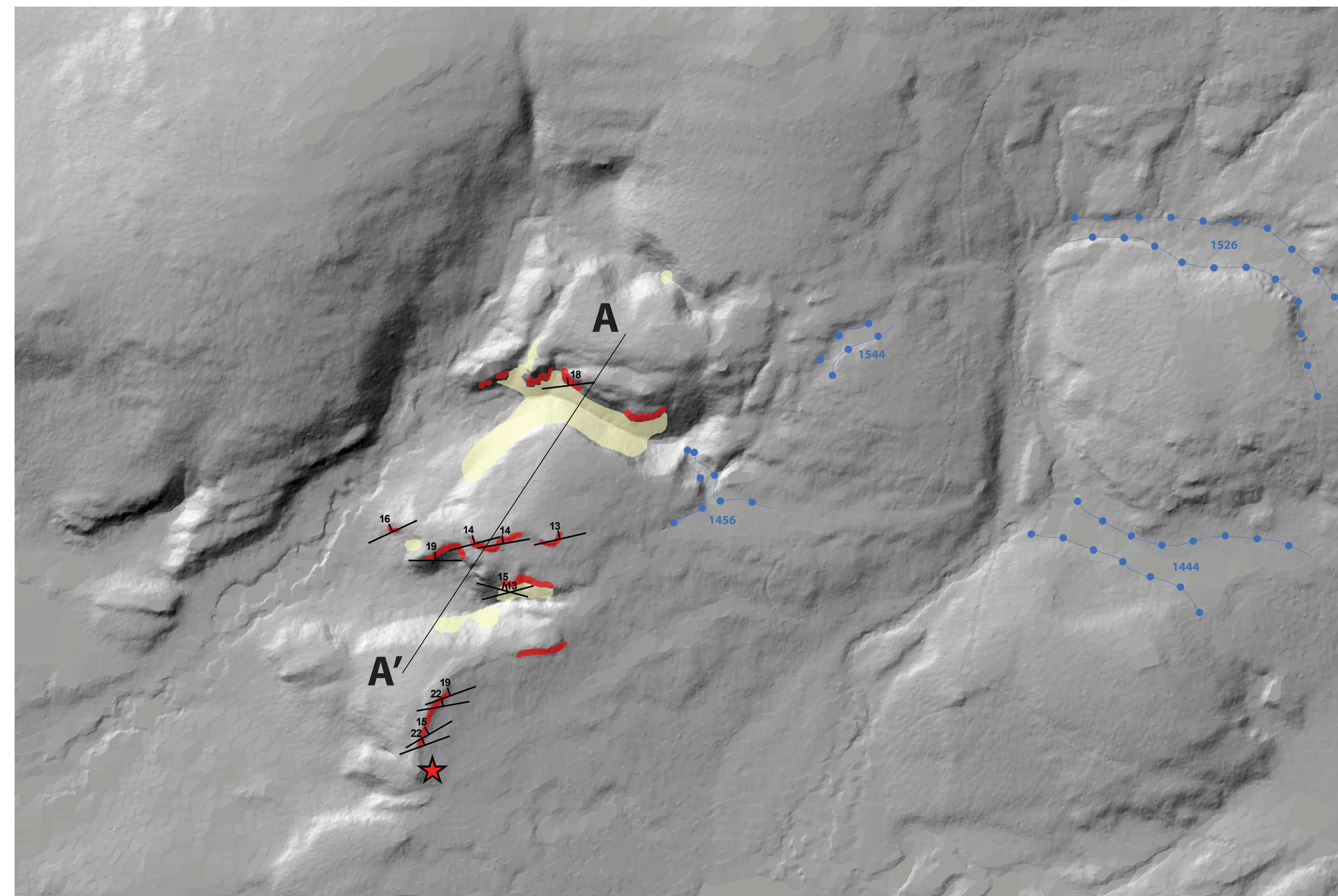


Figure 3: LiDAR surface conversion thumbnails. 3D surfaces were generated from LiDAR data using two data sources. A-D: Conversion from raw XYZ data. A. Raw XYZ LiDAR data imported to ArcGIS point feature. B. TIN generated from XYZ points. C. 0.5-m DEM generated from XYZ TIN. XYZ data were provided in a proprietary coordinate system, which required the DEM to be rotated and flipped using Raster Tools in Arc GIS. D. Hillshade generated from 0.5-m DEM. E and F: Conversion from 2-foot tagged-vector contours. E. Raw 2-foot contour data provided as ArcGIS shapefile. F. TIN surface created from contour data.



## Surficial Geologic Map of the Blue Hills Felsenmeer Valley, Rusk County, Wisconsin

### DESCRIPTION OF MAP UNITS

**Qob** **Openwork boulders (Quaternary)**—Clast-supported angular quartzite boulders. Clast size averages 30 cm, but reaches as long as 175 cm. Soil development is absent, and vegetation is generally absent with the exception of rare small trees. Size sorting of boulders is evident on some slopes. Thickness unknown



Photo A. Openwork deposit in Felsenmeer valley. Quartzite outcrop in background. View to west-northwest.

**Bedrock outcrop**—Paleoproterozoic Barron Quartzite, deposited between 1750 and 1650 Ma (Holm et al. 1998). Well-lithified ortho-quartzite with well preserved primary sedimentary textures and structures. Generally well-sorted and rounded medium to fine-grained quartz sands with decimeter-scale bedding planes displaying trough and tabular cross bedding. Outcrops average 2-meters high and predominantly south facing. Bedding displays consistent west-southwest strike and 14-18 degree dip to north-northwest



Photo B. Outcrop of Barron Quartzite displaying decimeter-scale bedding.

**Strike and dip**—of quartzite bedding (dip angle in degrees)

**Meltwater Channel**—Suspected meltwater channels mapped by morphology. LiDAR-derived elevation for head of channel (in feet)

**Erratic**—location of crystalline mafic (gabbro?) boulder

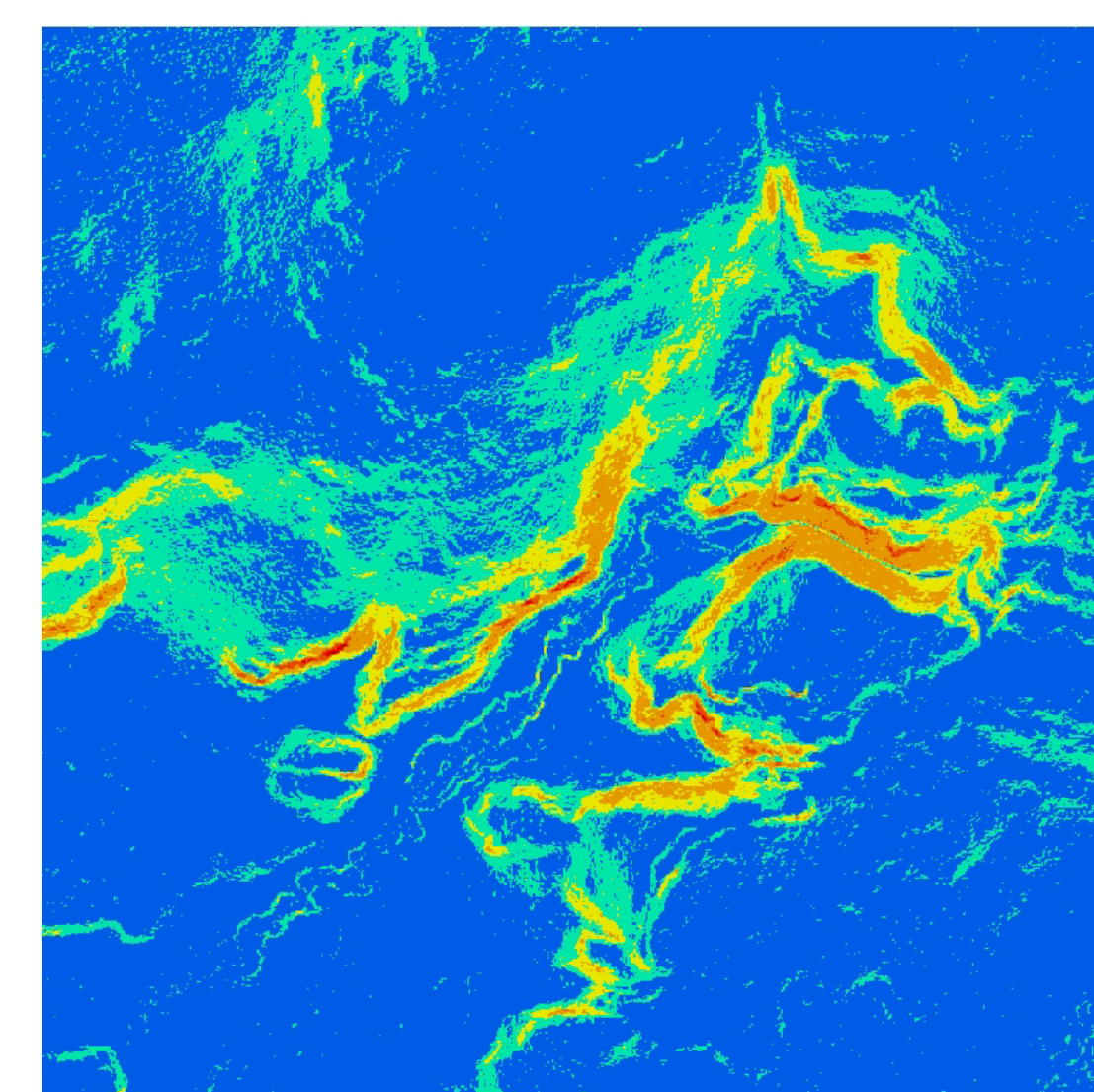
### Cross-Section

Schematic cross-section along A-A' through the Felsenmeer Valley and a smaller valley to the south. Surface profile extracted from LiDAR DEM; vertical exaggeration 4.5. Colored areas show generalized locations of outcrop and openwork deposits.

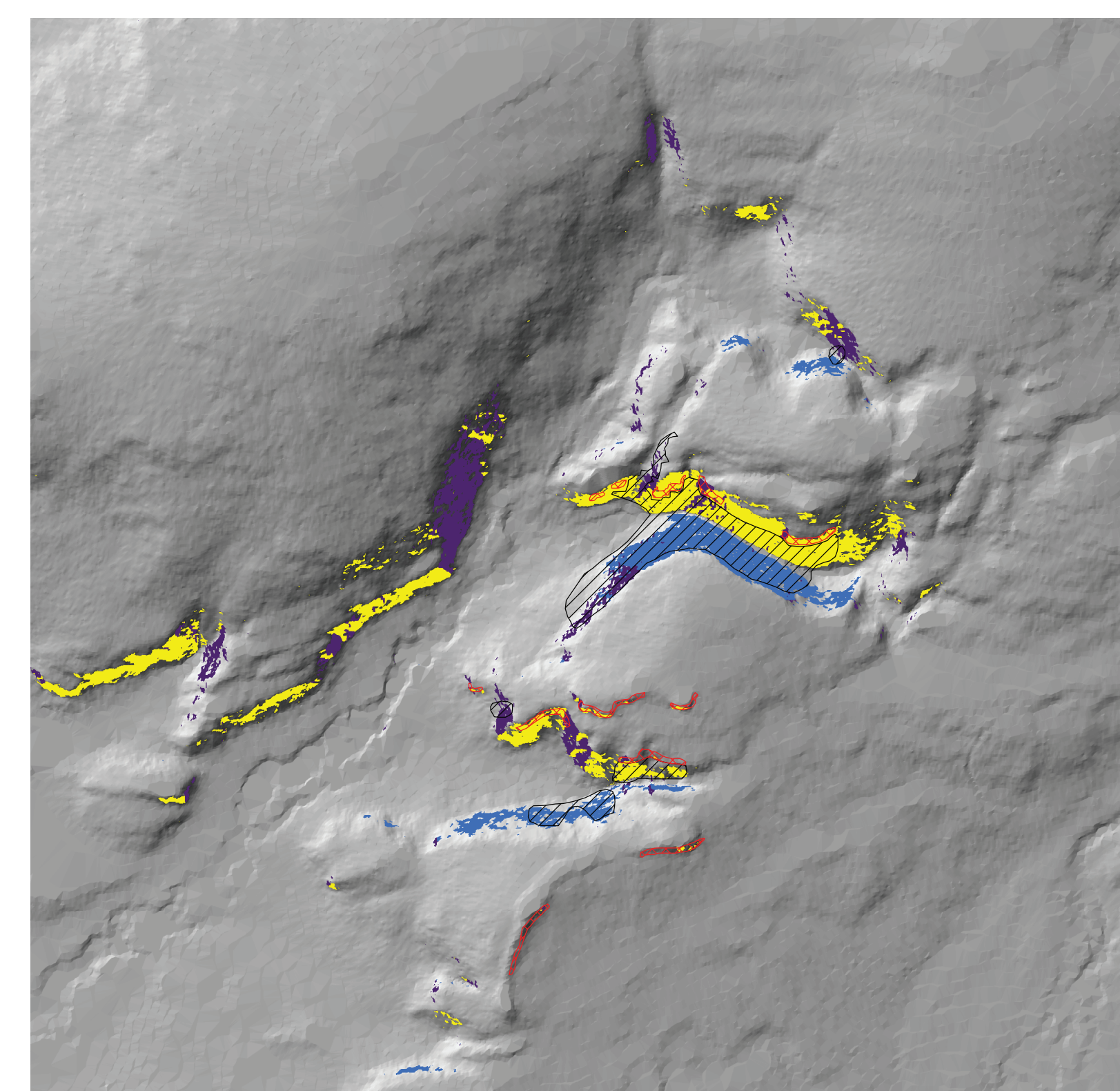
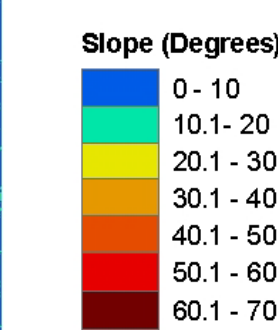
Outcrops are restricted to south-facing slopes because of a uniform dip of quartzite beds to the north-northwest at 14-18°; north-facing slopes lack outcrop due to a dip-slope effect. The exact depth to bedrock beneath the openwork is unknown and is the subject of ongoing research (Teige et al., 2007). Isolated openwork deposits occur in the valley south of the Felsenmeer Valley, but do not predominate the valley floor. The narrowness of the Felsenmeer Valley likely drives the unusual accumulation of openwork that covers the entire valley floor.

A thin soil layer covers the remainder of the area but is not shown.

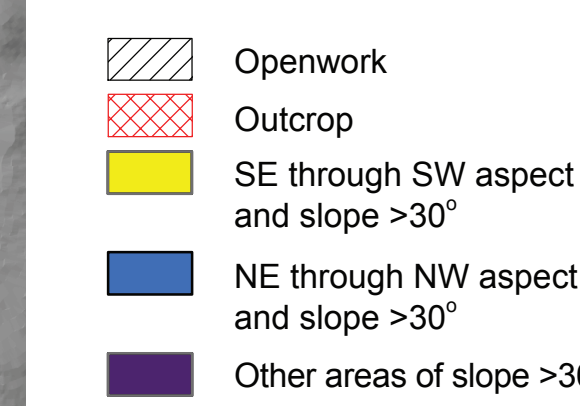
## Terrain Analysis



Map A. LiDAR DEM-derived slope



Map C. Comparison of high-slope areas with openwork and bedrock



Left: Maps of slope and aspect generated from LiDAR-derived DEMs using the 3D Analyst extension of ArcGIS. Map A. Surface slopes of study area. Note the continuous field of >30 degree slopes in the main portion of the Felsenmeer Valley. Map B. Surface aspect of study area.

Above (Map C): Synthesis generated using the Raster Calculator function in Spatial Analyst. This map highlights areas with southeast through southwest aspects and slopes greater than 30 degrees, and areas with northeast through northwest aspects and slopes greater than 30 degrees. Areas of openwork and bedrock determined from field mapping are overlaid.

The majority of openwork deposits occur in highlighted areas, with the exception of one small openwork body that occurs in a west-facing aspect with a high slope. The strong correlation between slopes at above the angle of repose and the location openwork accumulations suggests a gravity-fall origin for the deposits.

## Conclusions and Future Work

1. Small, isolated openwork deposits occur in areas adjacent to the Felsenmeer Valley.
2. All openwork deposits, including those in the Felsenmeer Valley, occur on slopes >30 degrees. This relationship strongly suggests a gravity-fall (talus) origin for the openwork deposits.
3. Quartzite outcrops only occur on south-facing walls of the Felsenmeer Valley as a result of bedding which dips uniformly to the north-northwest and creates a subtle cuesta (dip slope) effect on north-facing slopes.
4. Deviations from the consistent strike and dip of quartzite bedding may provide indication of Quaternary slumping or glacial deformation of bedrock. Collection of additional strike and dip and joint orientations are needed to differentiate between potential primary bedrock structures and Quaternary deformation.
5. A suspected ice-marginal ridge to the south of the Felsenmeer Valley is largely underlain by in-place quartzite bedrock. Boulder accumulation at the southern tip of the ridge and anomalous strikes in southern-most outcrops may be evidence of glacial deformation.
6. Additional mapping is needed to locate other openwork deposits and document their slope and aspect environment. Mapping of areas quartzite boulders with a soil matrix may further our understanding of landform generation in this area.

## References Cited

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