DEFINING AND DELINEATING ANCIENT LANDSLIDE DEPOSITS DURING HAZARD MAPPING IN VIRGINIA

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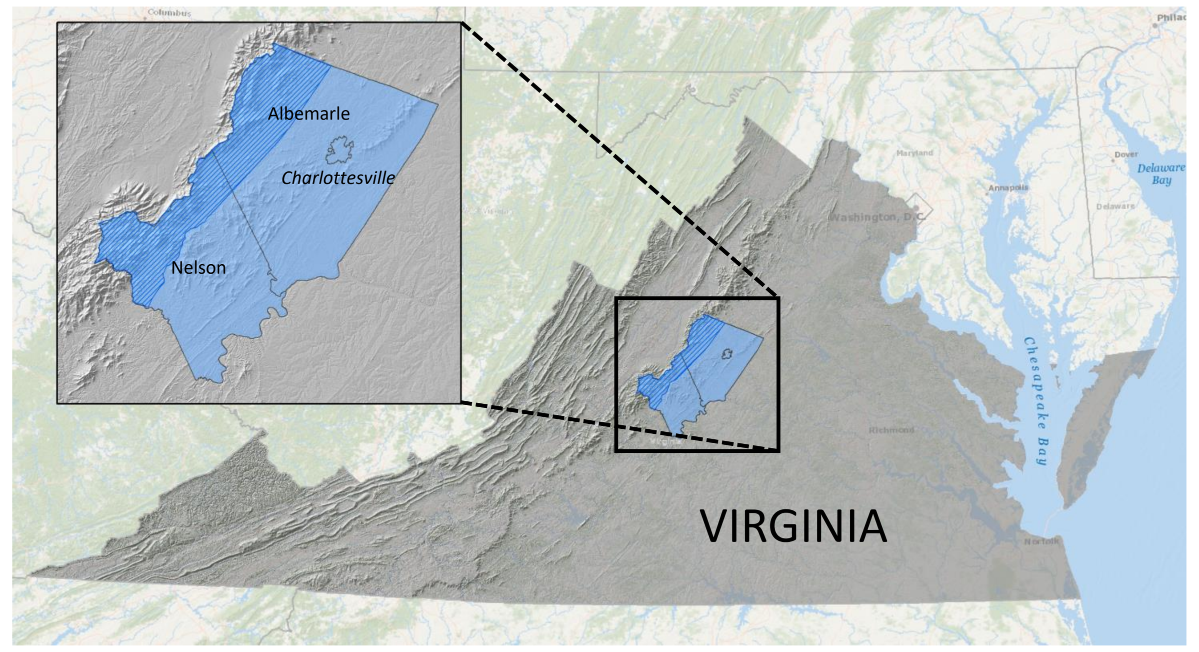
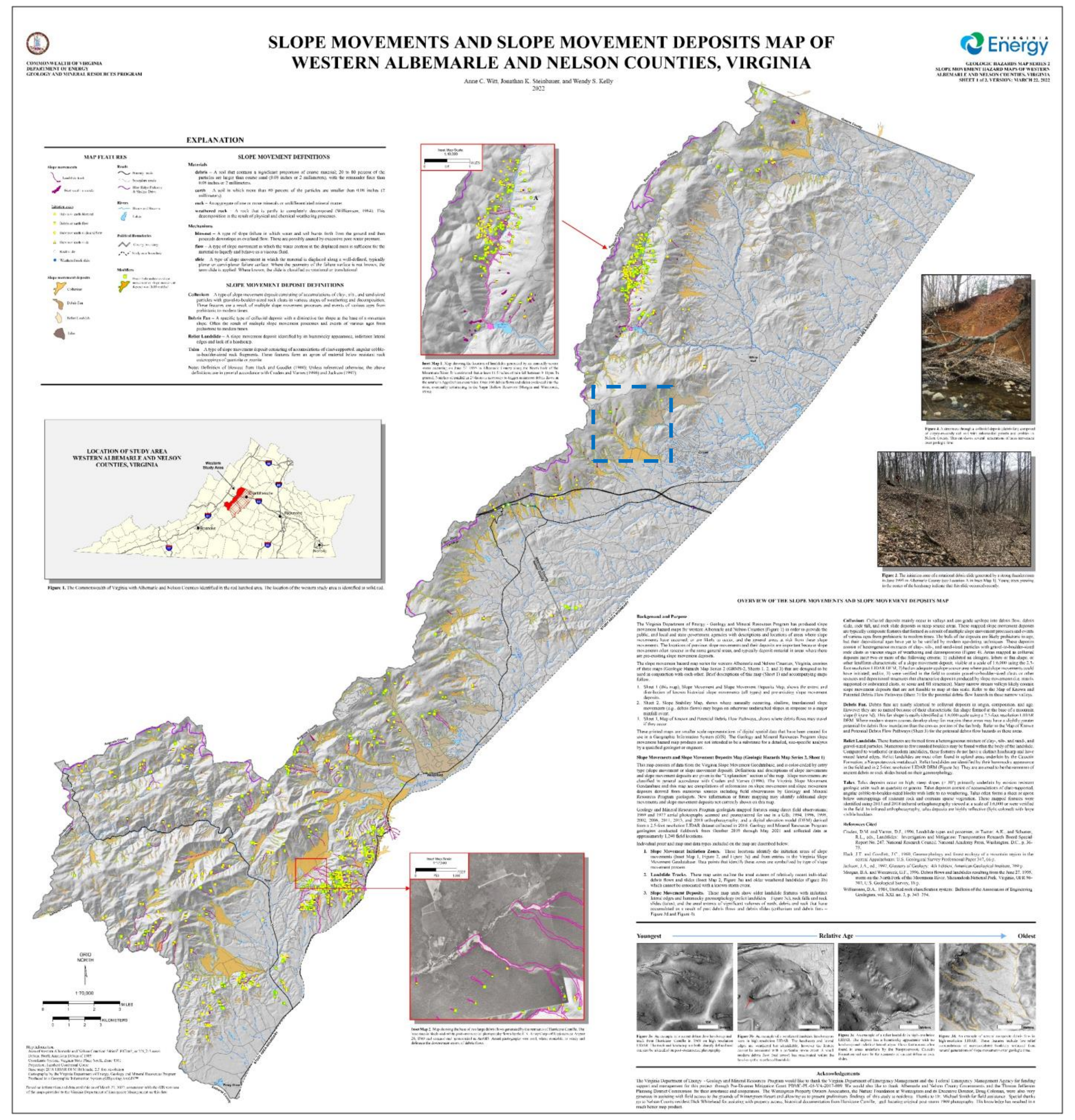
In 2018, the Virginia Department Energy – Geology and Mineral Resources Program (GMR), received a 3-year Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation (PDM) grant to conduct landslide hazard mapping in the western portions of Nelson and Albemarle Counties in central Virginia. Located along the eastern slopes of the Blue Ridge Mountains, these counties suffered severe landslide damage due to Hurricane Camille in 1969 and a strong rainstorm in 1995. There are also numerous areas of unconsolidated colluvial deposits.



The PDM project area is indicated by the dark blue hatching. In 2020, GMR received additional grant funding to complete the remainder of the counties.

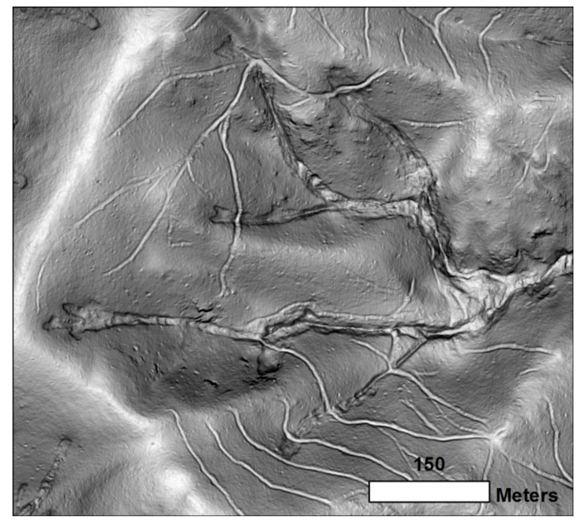


The deliverables to FEMA included a set of three maps (Geologic Hazards Map Series 2, Sheets 1, 2, and 3) designed to be used in conjunction with each other. Sheet 1 shows an inventory of modern landslides and prehistoric landslide deposits (above), Sheet 2 shows where shallow landslides like debris flows are likely to start during a heavy rainfall event, and Sheet 3 shows where debris flows are likely to inundate if they occur. GMR also provided a "how-to" guide for landowners to assist them with interpreting the maps.

Youngest

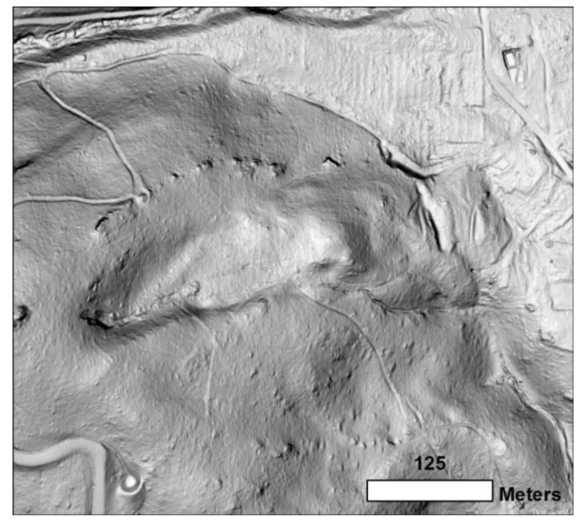
Relative Age

Oldest



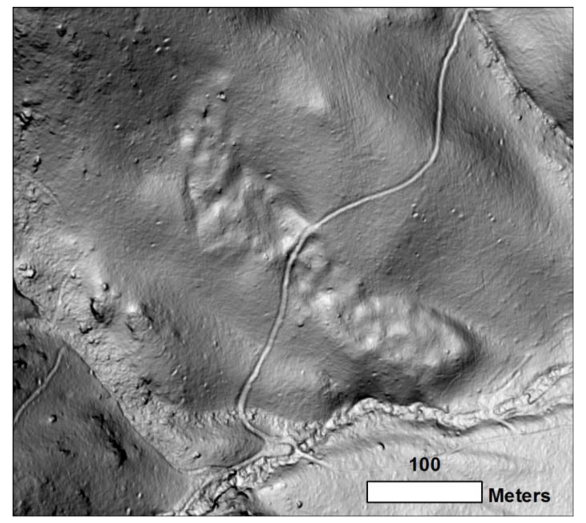
Modern Landslide: track and headscarp sharply defined in LIDAR, can be identified on post-storm aerial photography

Photograph: 1995 headscarp cutting sharply into the slope. Modern tracks are often scoured and may contain young tree growth. Toes contain piles of angular boulders, coarse debris, and sometimes the remnants of trees.



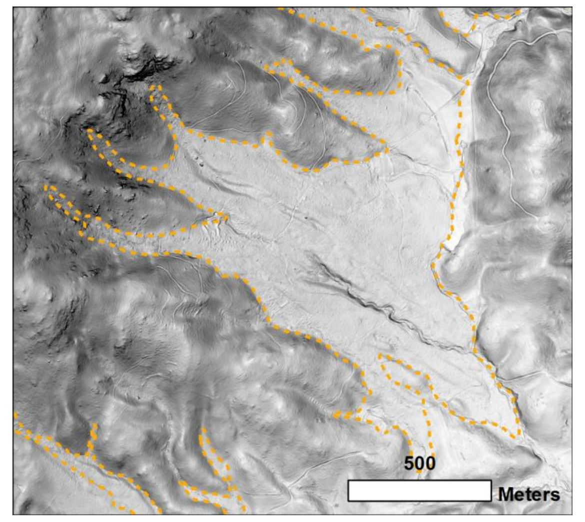
Weathered Landslide: headscarp and lateral edges weathered but identifiable in LIDAR; cannot be associated with storm event

Photograph: weathered concave headscarp with piles of subangular-to-angular bouldery debris. These features are often found within colluvial hollows or along linear tracks.



Relict Landslide: hummocky appearance in LIDAR, indistinct lateral edges and no headscarp.

Photograph: Piles of subangular to subrounded boulder- to cobble-size debris scattered across a hummocky slope. May represent weathered rockfall when found downslope from outcrop ledges.



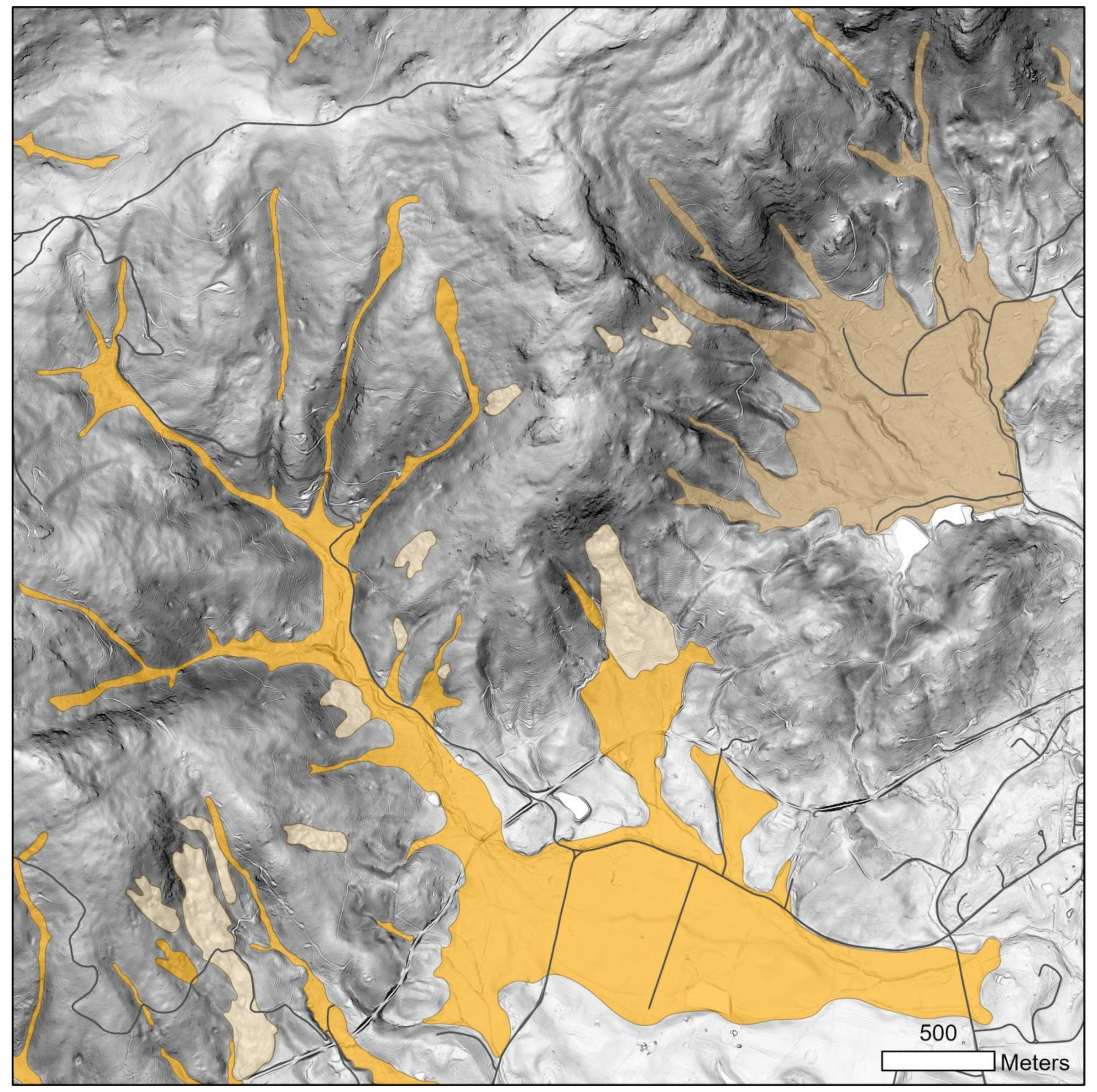
Colluvium undifferentiated: low-relief accumulations of unconsolidated bouldery sediment. Result from multiple debris flows and slides over geologic time.

Photograph: Boulder levee within larger accumulation of subrounded gravel- to boulder-sized debris. Boulder streams and levees transition to broad flat surfaces downslope with few boulders. First order streams often occur along the margins or within colluvial deposits.

Identifying and defining ancient landslide deposits for hazard susceptibility is not as straightforward as "traditional" surficial geologic mapping.

Accurately delineating modern landslides (those from 1969 to the present) is straightforward as headscarps and tracks are sharply defined in 1-meter LIDAR-derived hillshades and slopeshades. Modern landslide types were identified using the Cruden and Varnes (1996) classification system for material and movement. Older landslide features (relict and weathered landslides) are categorized by the degree of weathering or major geomorphic features (e.g., the headscarp, lateral edges, or landslide body).

Traditional geologic mapping often captures all surficial geologic material in an area, including those formed by alluvial and gradual colluvial processes. As this project only focused on potential hazards from various types of landslides, deposits resulting from these processes were omitted from the mapping. Older, extremely weathered deposits, generally mapped as high elevation debris fans on 1:24,000-scale geologic maps, were also excluded.



Colluvium: A type of slope movement deposit consisting of accumulations of clay-, silt-, and sand-sized particles with gravel-to-boulder-sized rock clasts in various stages of weathering and decomposition. These features are a result of multiple slope movement processes and events of various ages from prehistoric to modern times.

Debris fan: A specific type of colluvial deposit with a distinctive fan shape at the base of a mountain slope. Often the result of multiple slope movement processes and events of various ages from prehistoric to modern times.

Relict landslide: A slope movement deposit identified by its hummocky appearance, indistinct lateral edges and lack of a headscarp.

Map area corresponds to the blue dashed box on map to the far lower left.

Debris deposits are low-relief accumulations of unconsolidated bouldery material representing many landslide events over geologic time. They form at the base of steep mountain slopes and have an obvious uphill source. LIDAR derived 10-foot (3-meter) topographic contours are straight and broad along the base of the deposits. Deposit polygons were ended uphill in colluvial hollows where material accumulation ends (or is unmappable at the map scale) and where contours become tightly curved. Deposits are considered a moderate hazard for development as oversteepened cuts and embankments in unconsolidated sediment may be more prone to failure. First and second order streams along, and within, the margins of these deposits are likely locations for future debris flows.

REFERENCES

Bailey, C.M., Lamoreaux, M.H., Olney J., Nicholls, O.G., and Tadlock, J.E., 2009, Geologic Map of the Browns Cove quadrangle, Virginia, 1:24,000 scale map.

Carter, M.W. and Heller, M.J., 2015, Geologic map of the Big Levels quadrangle, Virginia: Virginia Division of Geology and Mineral Resources Open-file Report 2015-1, 1:24,000-scale map.

Cruden, D.M. and Varnes, D.J., 1996, Landslide types and processes, *in* Turner, A.K., and Schuster, R.L., eds., Landslides: Investigation and Mitigation: Transportation Research Board Special Report No. 247, National Research Council, National Academy Press, Washington, D.C., p. 36-75.

ACKNOWLEDGEMENTS

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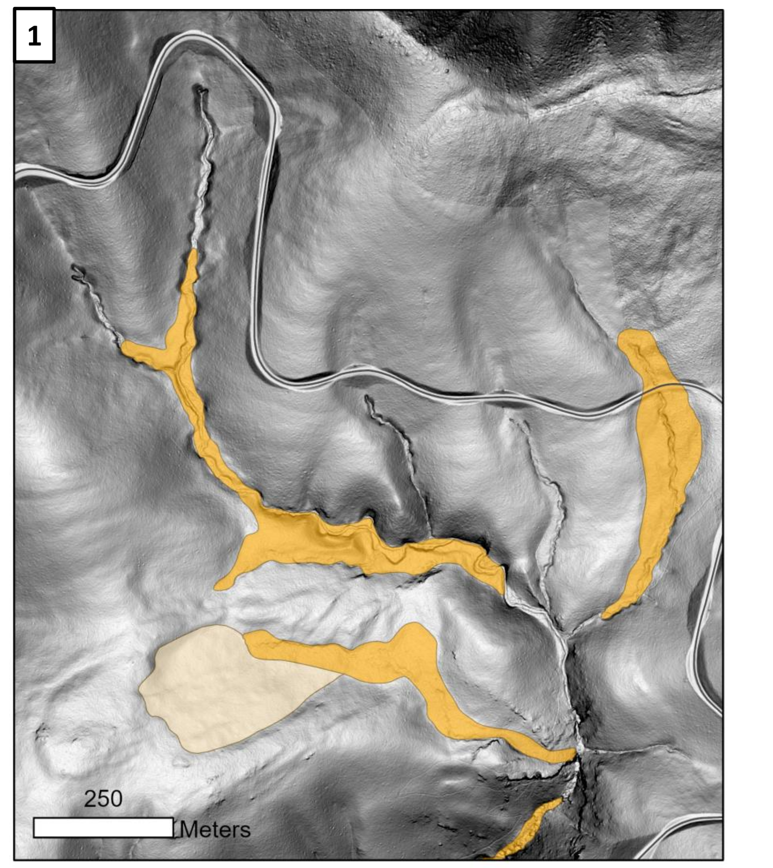
Surficial deposits mapped in Nelson County in 2022 (Figure 1) were compared with those mapped in 2015 (Figure 2) within the Big Levels 7.5 minute quadrangle (Carter and Heller, 2015). Mapping of colluvium within the drainages is similar. The Big Levels geologic map includes more detail since mapping occurred at the 7.5 minute quadrangle scale, rather than the county scale. Colluvium is extended into the highest reaches of streams and includes areas of talus. However, mapping in Big Levels was completed before 1-meter LIDAR was available for the area. Surficial mapping was reliant on topographic contours, 10-meter resolution DTM data, and field checking. Areas identified as relict landslide in the 2022 mapping are virtually invisible without LIDAR data. *Note: The geologic map of the Big Levels 7.5 minute quadrangle has since been updated using 1-meter LIDAR and is currently in review.*



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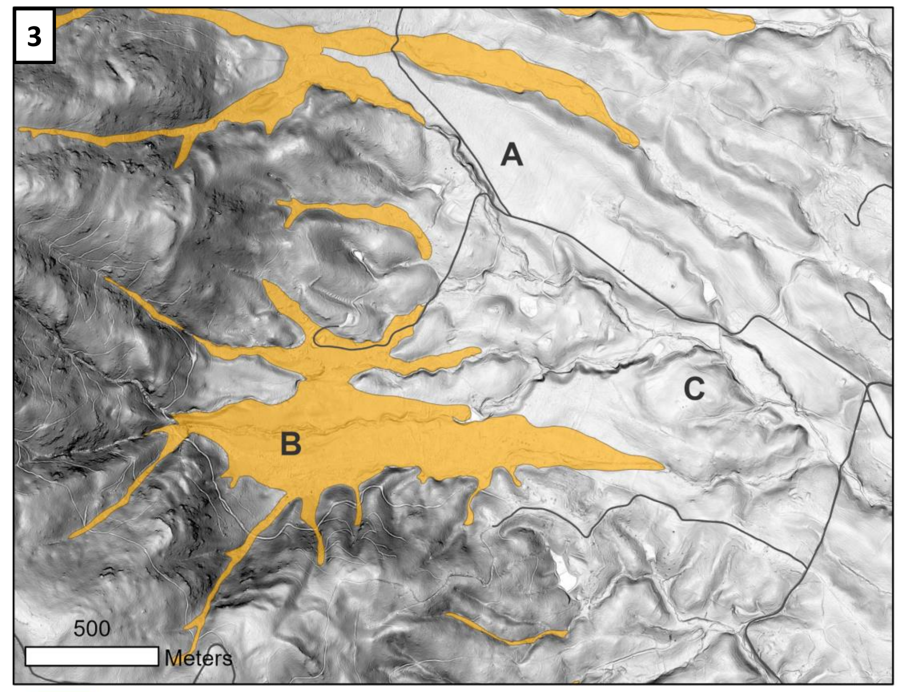
Relict landslide: A slope movement deposit identified by its hummocky appearance, indistinct lateral edges and lack of a headscarp.

c **colluvium:** talus, block slope, and related coarse colluivial deposits on very steep slopes, and debris-flow deposits in steep, higher-order stream channels; slope deposits consist of angular blocks of locally derived rock, with little or no matrix, whereas debris-flow deposits typically contain finer-grained sand to silt matrix that entrains coarser-grained sub-rounded to angular blocks of locally derived rock. Talus typically consists of Angular blocks of Antietam or Harpers orthoquartzite and quartz sandstone, and is best developed on south-facing and outcrop slopes, and slopes where bedding is nearly horizontal. Bedrock is exposed in some slope breaks and stream cuts.

Surficial deposits mapped in Albemarle County in 2022 (Figure 3) were compared to those mapped in 2009 (Figure 4) within the Browns Cove 7.5 minute quadrangle (Bailey et al., 2009). In some cases, the 2022 mapping captured more detail in the high reaches of colluvial hollows and narrow drainages, primarily due to the availability of high resolution 1-meter LIDAR. However, the 2022 mapping eliminates low-relief areas of weathered debris fan that extend well away from steep areas (locations A and C). These areas are composed of boulders-to-cobbles in a fine-grained matrix with few, if any, boulders visible on the ground surface. They are not generally considered a high hazard for landslide susceptibility. The 2022 mapping includes areas of high-relief along and below steep mountainous areas, generally with boulder-to-cobble sized rocks on the ground surface and within drainages (location B in Figures 3 and 4).



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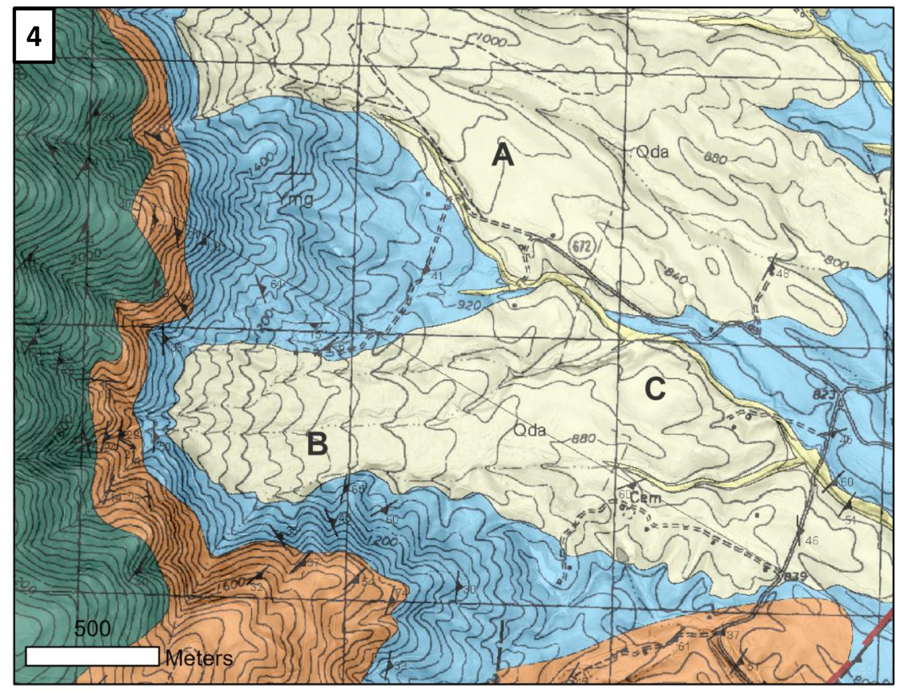

Qa **Alluvium:** clay, silt, sand, and rounded cobbles of vein quartz, greenstone, charnockite, gneiss granitoid, and quartz sandstone. 3 to 16 feet (1 to 5 m) thick.

Qda **Debris Fans/Alluvial aprons:** Poorly sorted cobbles and boulders of greenstone and megacrystic granitoid (greenstone>granitoid) in a red silty and sandy matrix. Deposits grade from very coarse bouldery debris fans along the steep mountain slopes and grade into surfaces of cobbles extending outward from mountain front. 5 to 25 feet (2 to 7 m) thick.