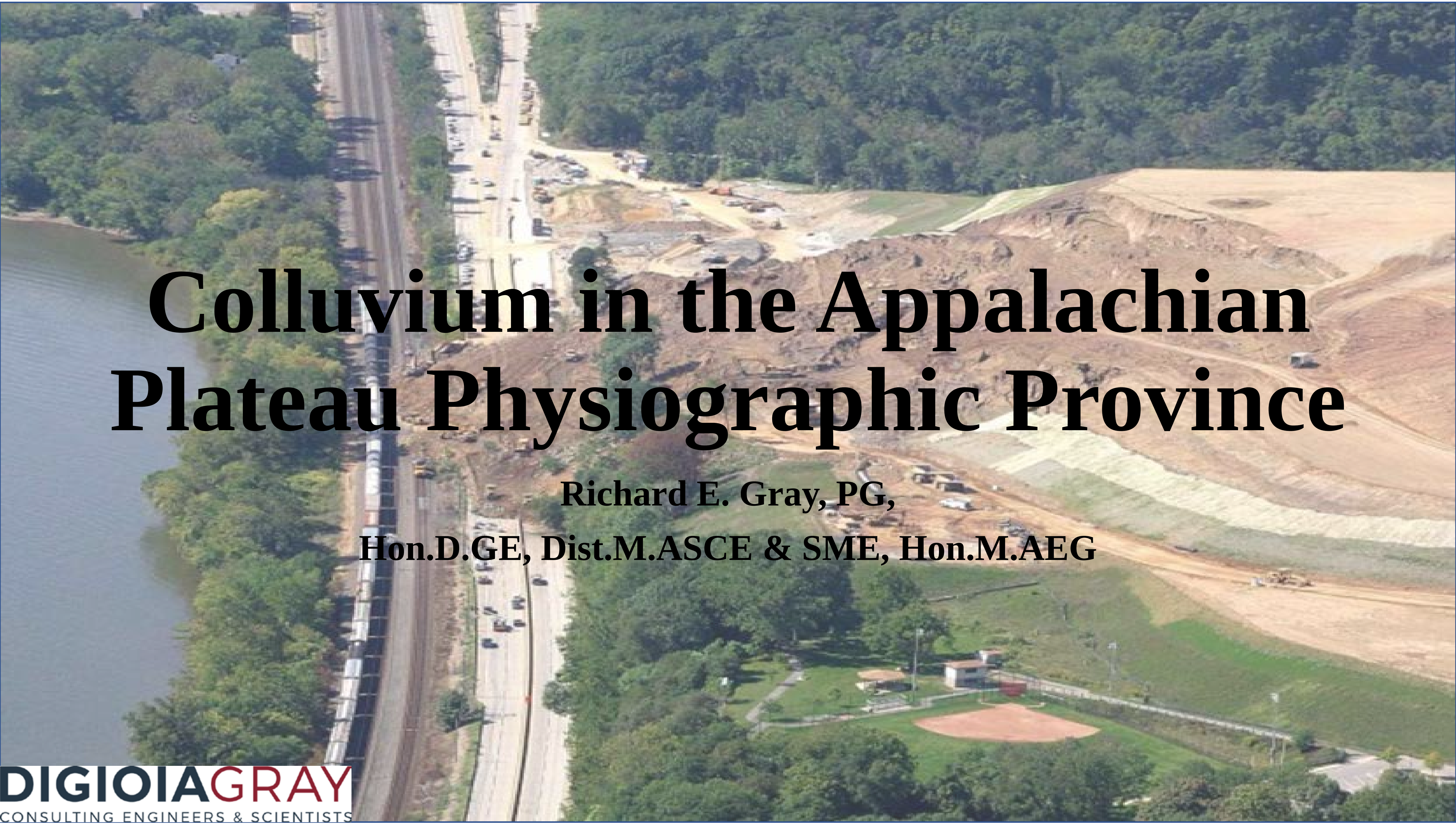
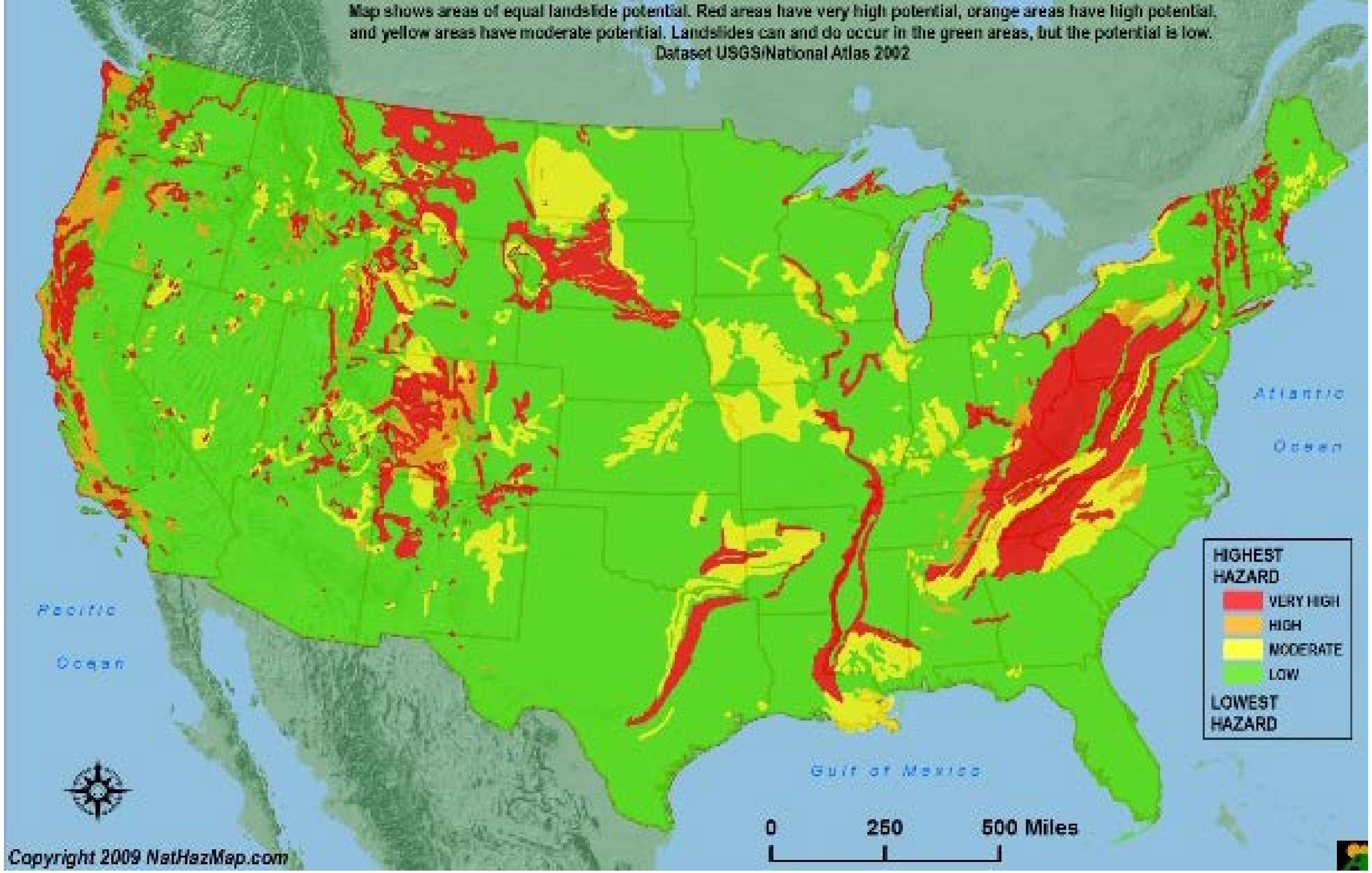


Colluvium in the Appalachian Plateau Physiographic Province

Richard E. Gray, PG,

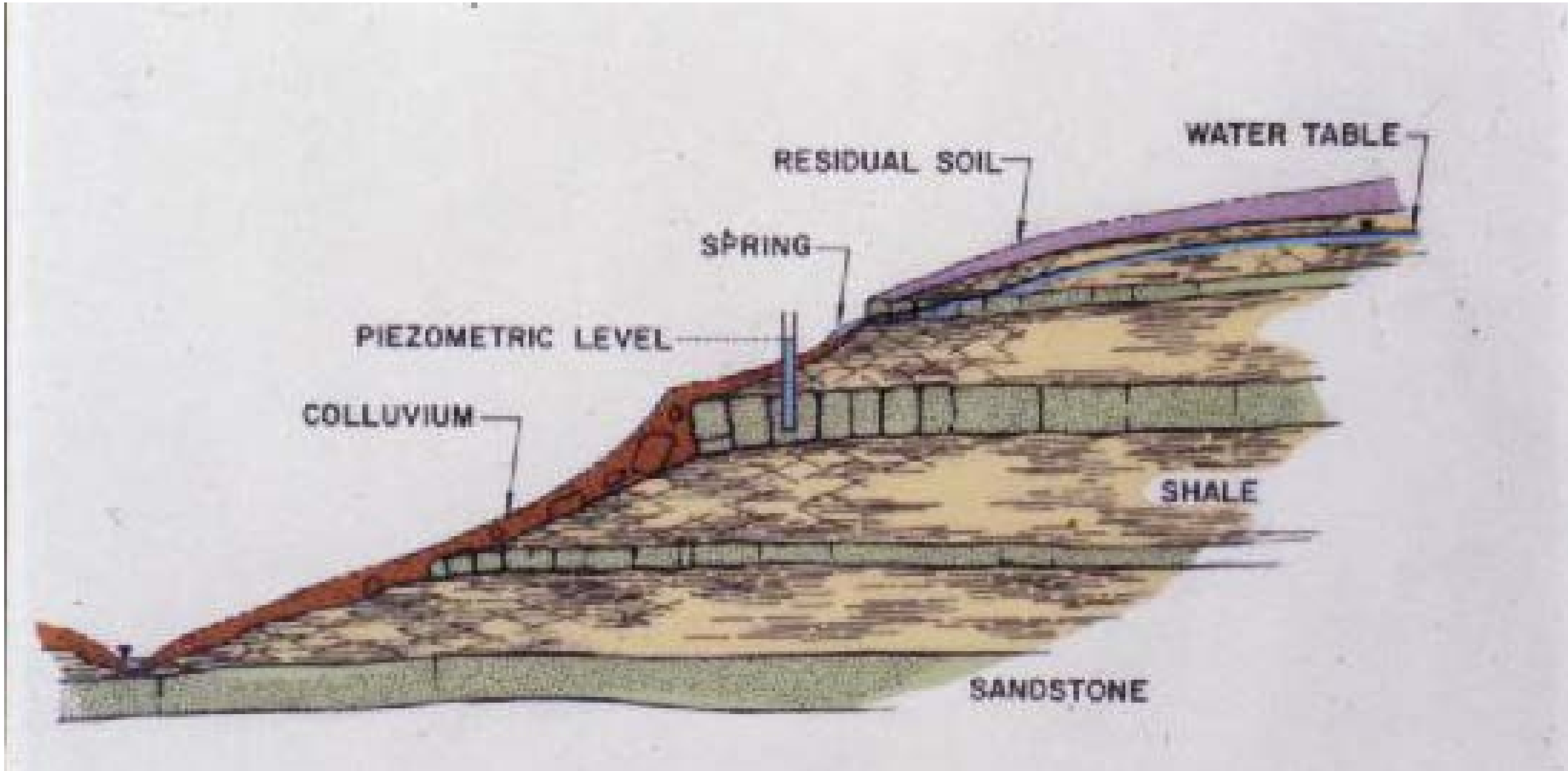
Hon.D.GE, Dist.M.ASCE & SME, Hon.M.AEG

DIGIOIAGRAY
CONSULTING ENGINEERS & SCIENTISTS

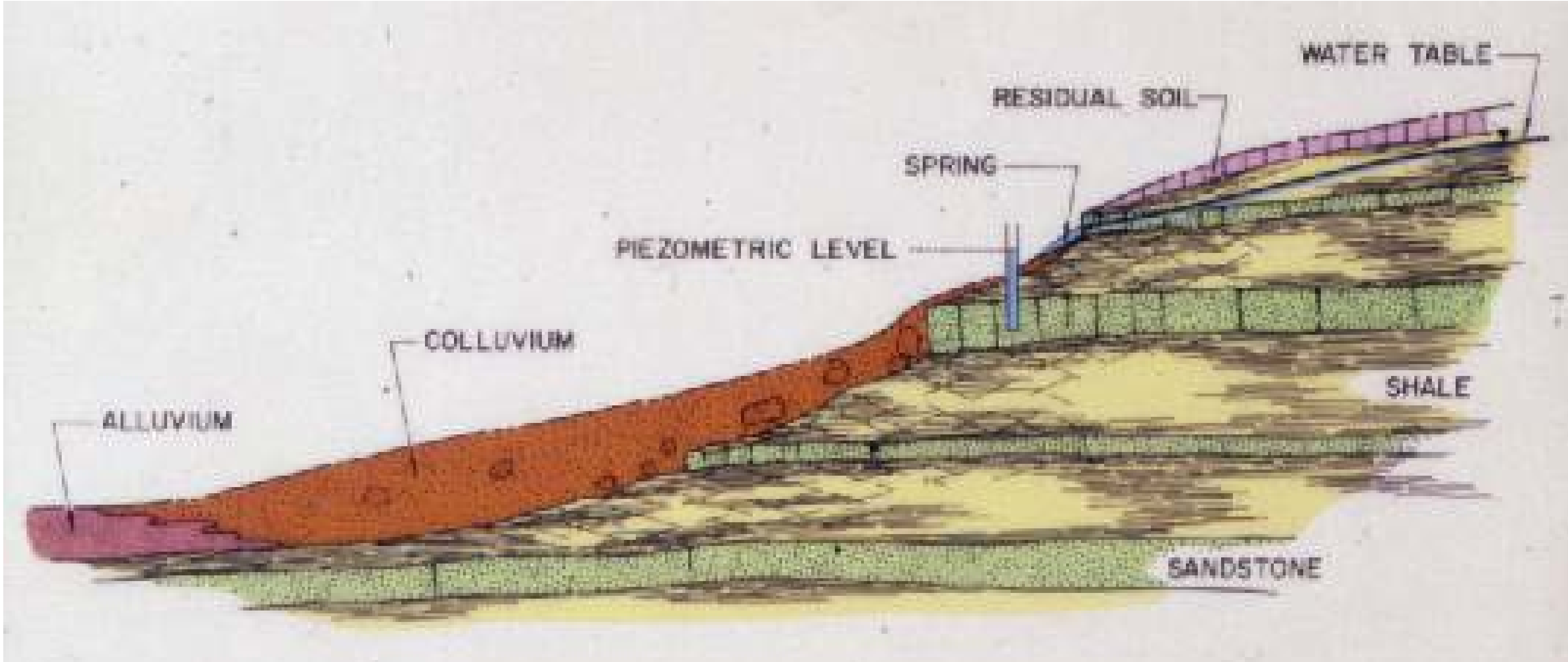


<u>LANDSLIDE RISK</u> – CERTAIN REGIONS TEND TO BE MORE LANDSLIDE PRONE THAN OTHERS. SIMILARITIES OF CLIMATE, SOIL AND ROCK TYPES, VEGETATION, AND TOPOGRAPY WITHIN A GIVEN REGION OFTEN LEAD TO SIMILARITIES IN SLOPE STABILITY CHARACTERISTICS.

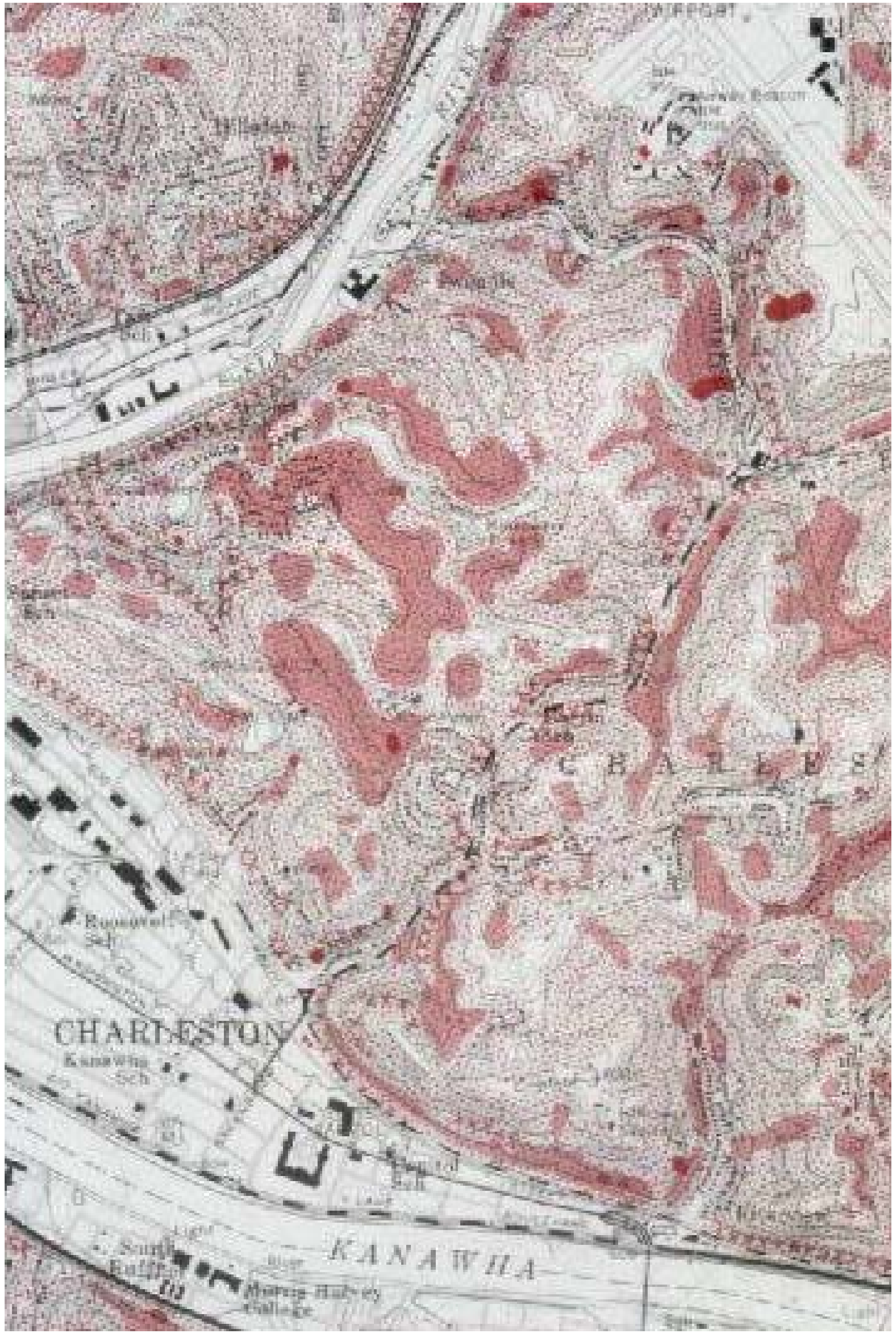
WELCOME FOR THE NEXT FEW MINUTES TO THE LARGEST RED AREA ON THE U.S. LANDSLIDE HAZARD MAP



THIN COLLUVIAL COVER – MOST LANDSLIDES OCCUR IN CLAYEY, COLLUVIAL SOIL DEVELOPED ON SLOPES UNDERLAIN BY RELATIVELY FLAT LYING SEDIMENTARY ROCK STRATA. WITH ACTIVE EROSION, THERE IS LITTLE ACCUMULATION OF COLLUVIUM AT THE TOES OF SLOPES.

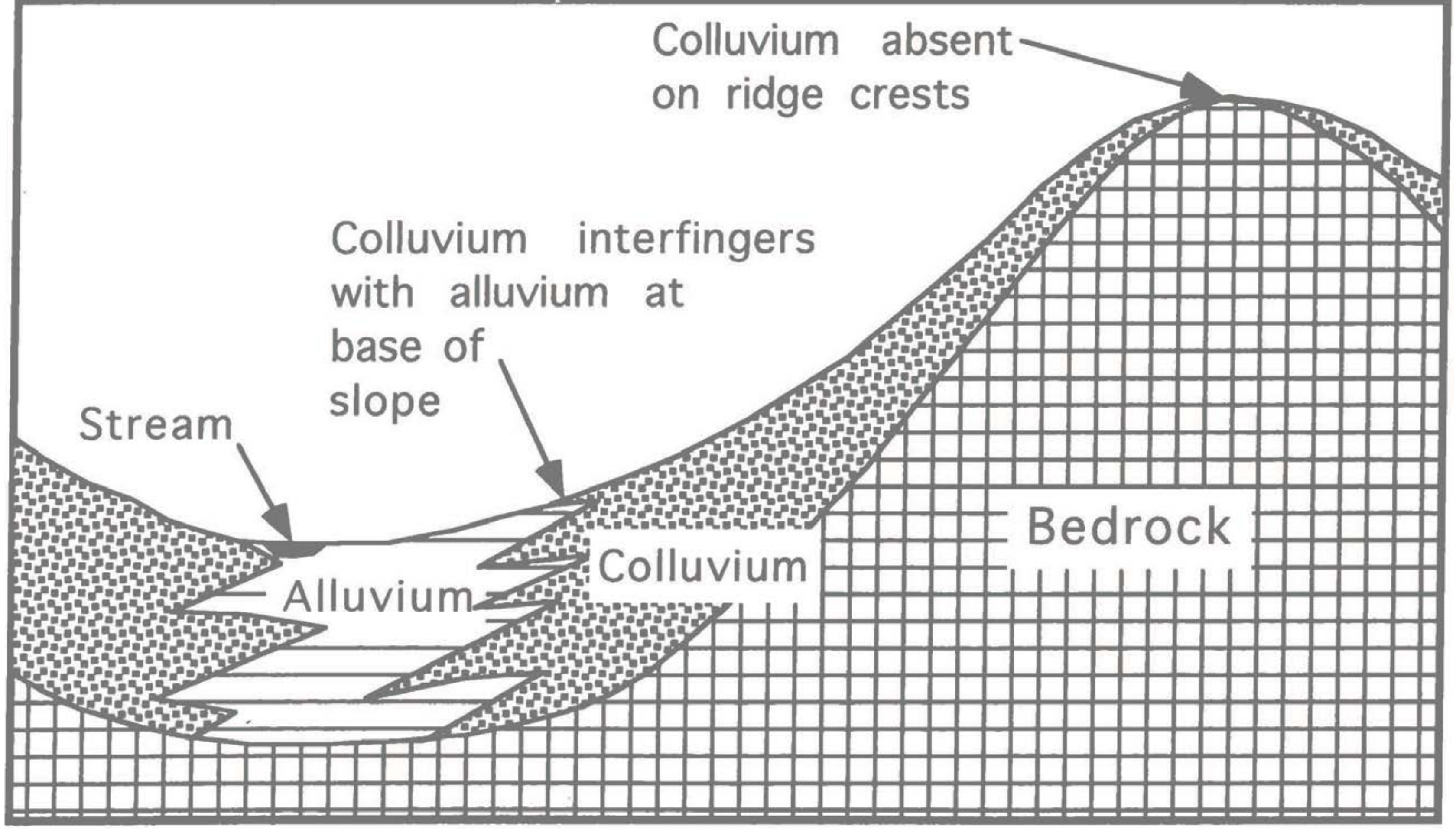


<u>THICK COLLUVIAL COVER</u> - COLLUVIAL MASSES DEVELOP HAVING VOLUMES OF SEVERAL MILLION M^3 AND THICKNESS OF UP TO 30 m. MATURE COLLUVIAL SLOPES MAY EXHIBIT ANGLES AS FLAT AS 7 – 10°. MANY LARGE COLLUVIAL MASSES INTERFINGER WITH GLACIAL OUTWASH AND RADIOCARBON DATING INDICATES THEY MAY HAVE FORMED UNDER PERIGLACIAL CONDITIONS.



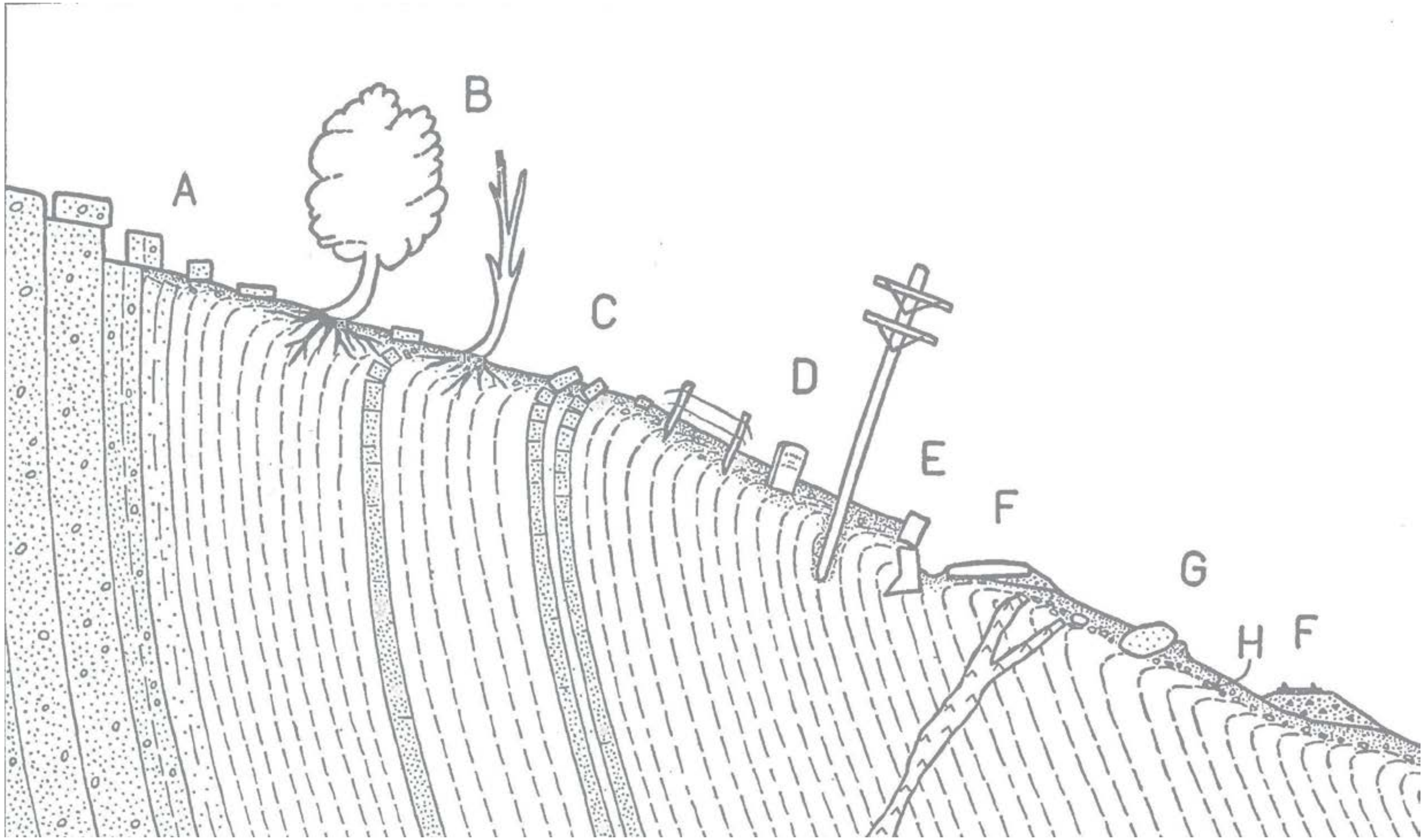
PORTION OF CHARLESTON EAST QUADRANGLE, WEST VIRGINIA, SHOWING LANDSLIDE (COLLUVIAL) MASSES AND SLIDE PRONE AREAS: ACTIVE – OLD AND POTENTIAL.

<u>THICK COLLUVIUM</u> – KEYSTONE PROJECT. COLLUVIAL SOILS ARE GENERALLY STIFF TO HARD AND INDIVIDUAL SAMPLES HAVE RELATIVELY HIGH SHEAR STRENGTHS



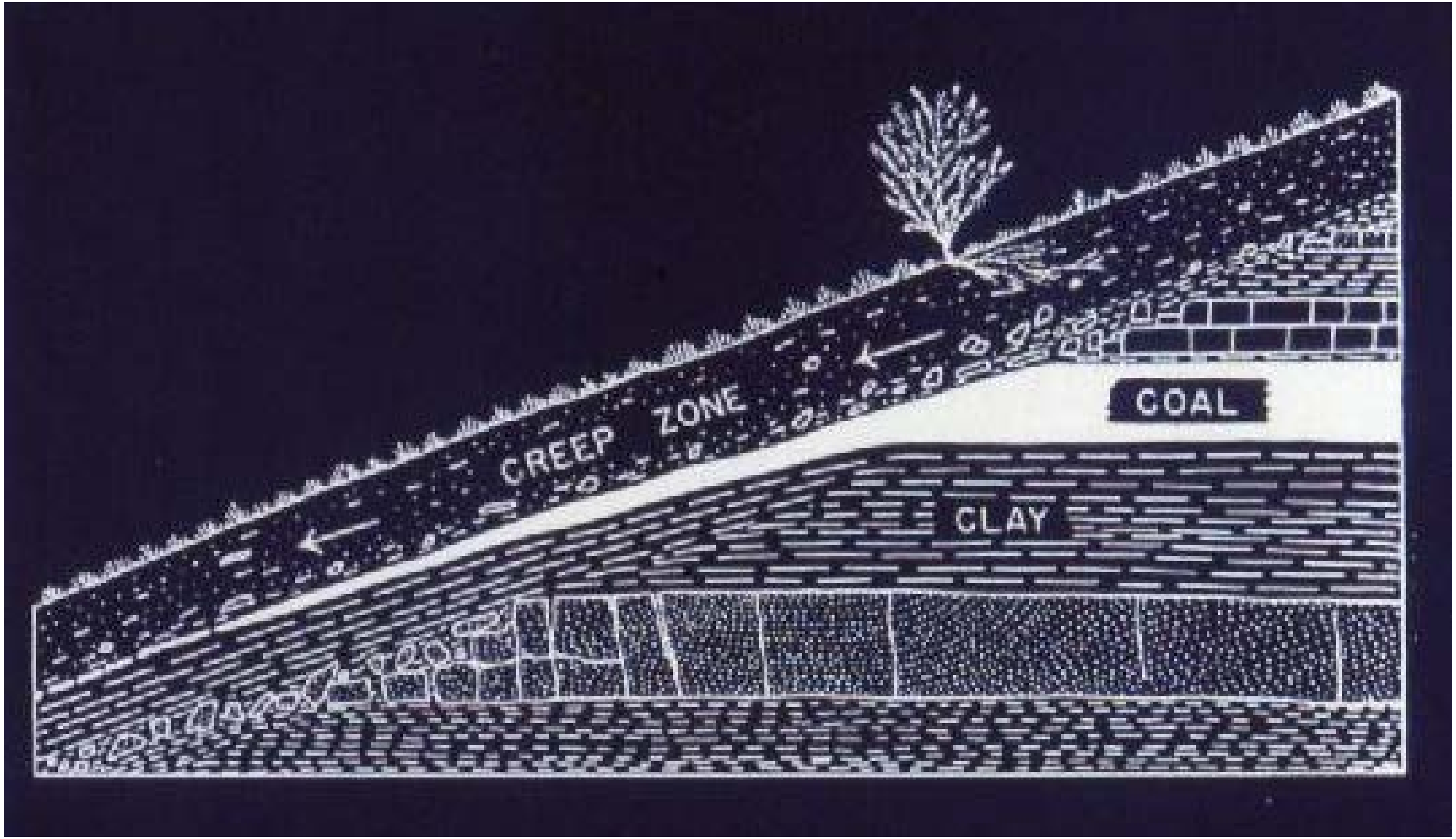
A. Keith Turner, TRB Special Report 247, A.K. Turner & R.L. Schuster, 1996

TYPICALLY, COLLUVIUM IS A POORLY SORTED MIXTURE OF ANGULAR ROCK FRAGMENTS AND FINE-GRAINED MATERIALS. THESE DEPOSITS ARE USUALLY THINNEST NEAR THE CREST AND THICKEST NEAR THE TOE OF EACH SLOPE. COSTA AND BAKER (1981) REPORTED ESTIMATES THAT COLLUVIUM COVERS MORE THAN 95 PERCENT OF THE GROUND SURFACE IN HUMID TEMPERATE REGIONS. DEERE AND PATTON (1971) INDICATE WHERE SLOPE GEOHYDROLOGY KEEPS THE COLLUVIUM SATURATED THE FAILURE SURFACE OF SLIDES GENERALLY OCCURS ALONG THE COLLUVIUM – ROCK CONTACT.



CFS Sharpe (1938) "Landslides and Related Phenomena" Columbia University Press
Prior to Dr. Sharpe's book , Physical Geology Text Books did not contain a section on Mass Wasting.

COMMON EVIDENCES OF CREEP. (A) MOVED JOINT BLOCKS; (B) TREES WITH CURVED TRUNKS CONCAVE UPSLOPE; (C) DOWNSLOPE BENDING AND DRAG OF BEDDED ROCK, (D) DISPLACED POSTS, POLES, AND MONUMENTS; (E) BROKEN OR DISPLACED RETAINING WALLS AND FOUNDATIONS; (F) ROADS AND RAILROADS MOVED OUT OF ALIGNMENT; (G) TURF ROLLS DOWNSLOPE FROM CREEPING BOULDERS; (H) STONE-LINE AT APPROXIMATE BASE OF CREEPING SOIL. RATE OF CREEP ON A HILLSIDE DEPENDS NOT ONLY ON CLIMATIC CONDITIONS AND ANGLE OF SLOPE BUT ON TYPE OF SOIL, PARENT MATERIAL, AND MANY OTHER FACTORS.



<u>SOIL CREEP</u> – CREEP AND OTHER FORMS OF MASS WASTING PRODUCE THE COLLUVIAL SOIL WHICH BLANKETS SLOPES. SLOW DOWN SLOPE MOVEMENT, A FEW CM/YR, IS USUALLY IMPERCEPTIBLE EXCEPT TO OBSERVATIONS OF LONG DURATION. THIS MOVEMENT FORMS SLICKENSIDES.

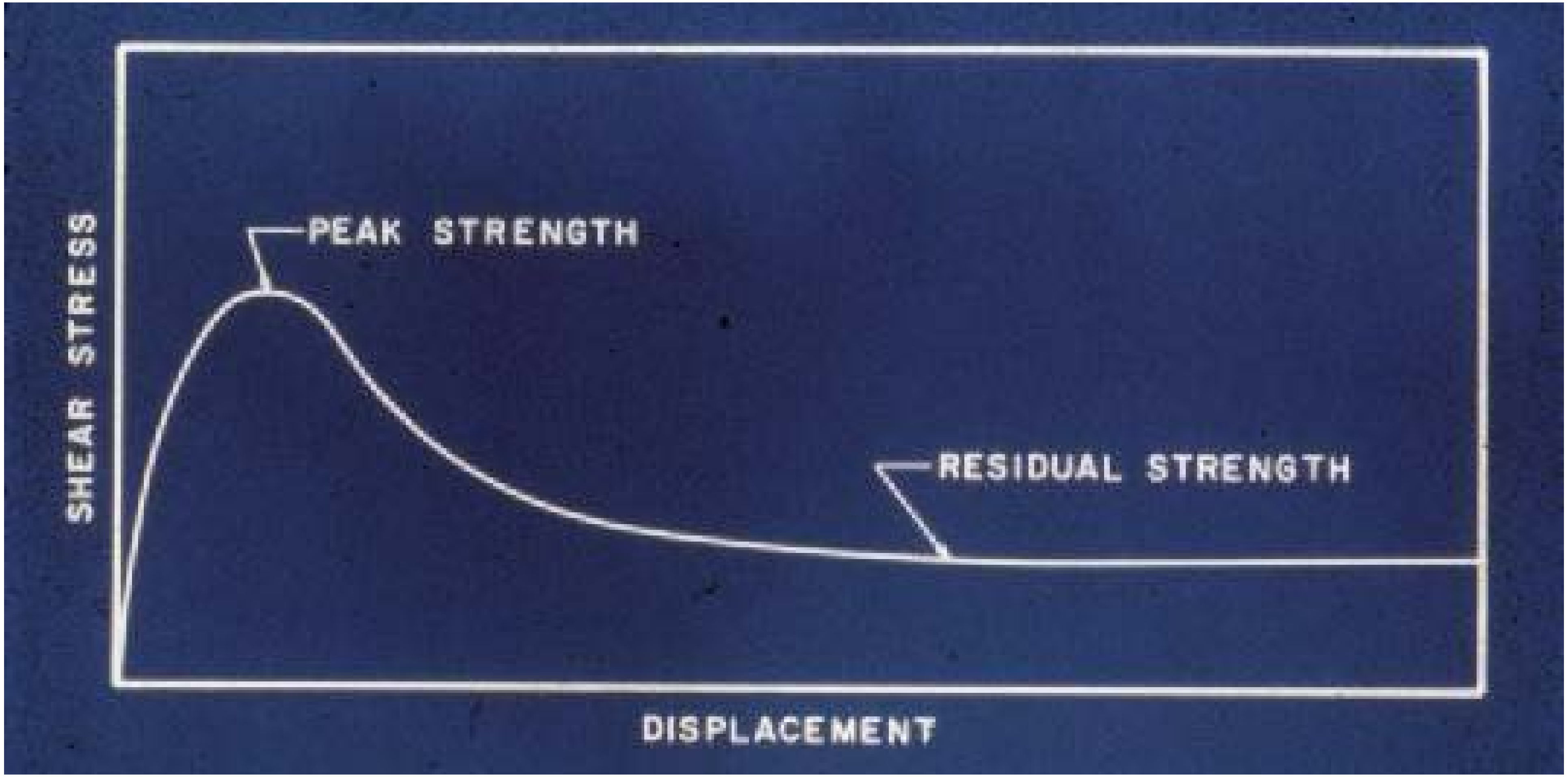
SHALES AND OTHER ROCKS GENERALLY PRODUCE FINE-GRAINED COLLUVIUM, OFTEN CONTAINING SIGNIFICANT PROPORTIONS OF CLAY. THE SLOW DOWNSLOPE CREEP OF COLLUVIUM RESULTS IN A PROGRESSIVE ALIGNMENT OF MINERAL GRAINS AND THE CREATION OF NUMEROUS MICROSCOPIC SHEAR SURFACES. THESE SURFACES GREATLY REDUCE THE NORMALLY EXPECTED SHEAR STRENGTH OF COLLUVIAL MATERIALS, AND YET THE SURFACES ARE HARD TO IDENTIFY OR RETAIN IN SAMPLES. INTENSE RAINFALL IS CITED AS THE MOST COMMON TRIGGERING MECHANISM FOR LANDSLIDES INVOLVING COLLUVIUM.

A. Keith Turner, TRB Special Report 247, A.K. Turner & R.L. Schuster, 1996

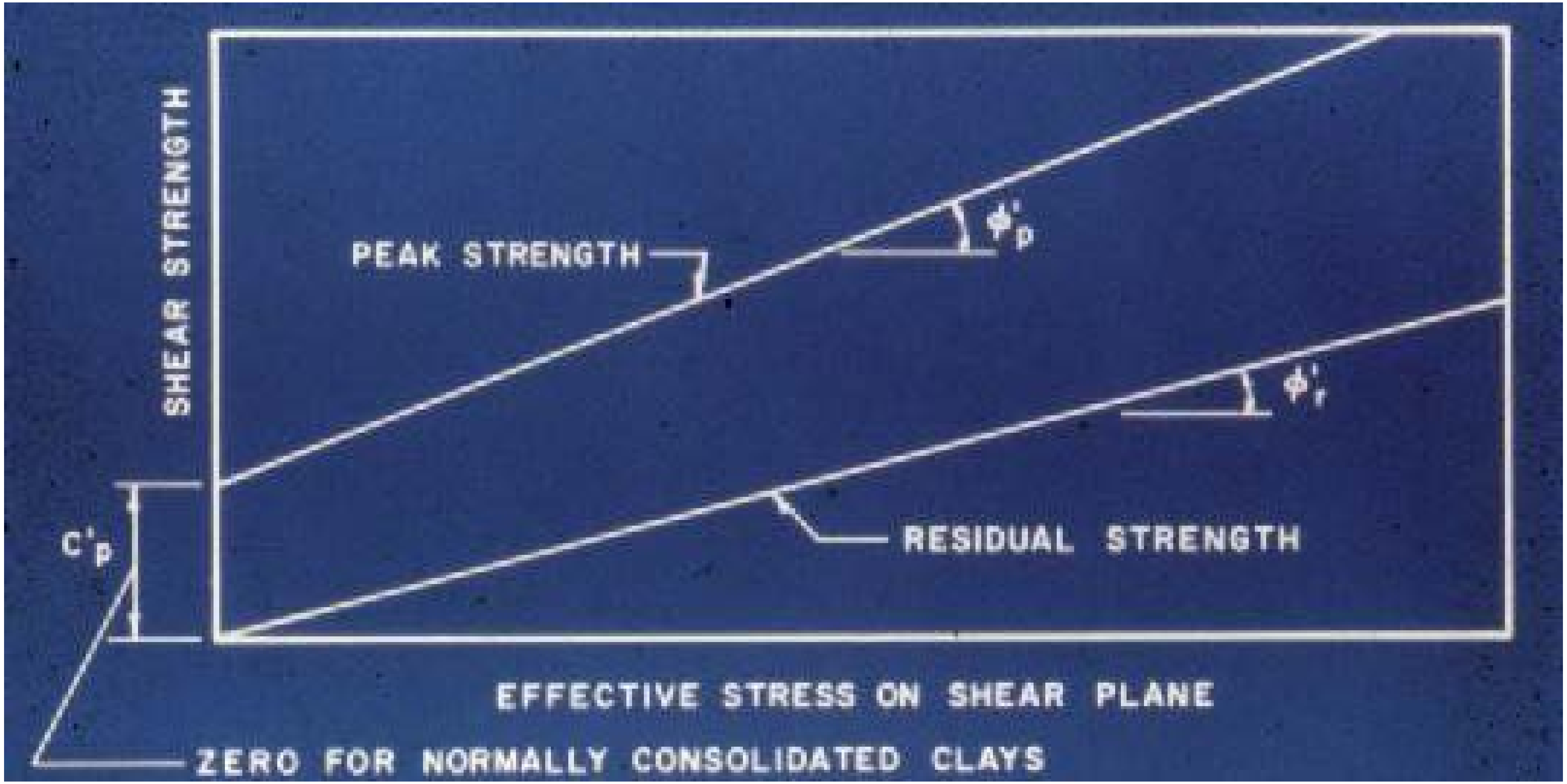
SLICKENSIDED FAILURE SURFACE IN SOUTH EASTERN OHIO

EXPOSED MOVEMENT SURFACE IN A COLLUVIAL SOIL
WEIRTON, W. VA

EXPOSED MOVEMENT (SLICKENSIDED) SURFACE
WEIRTON, W. VA.

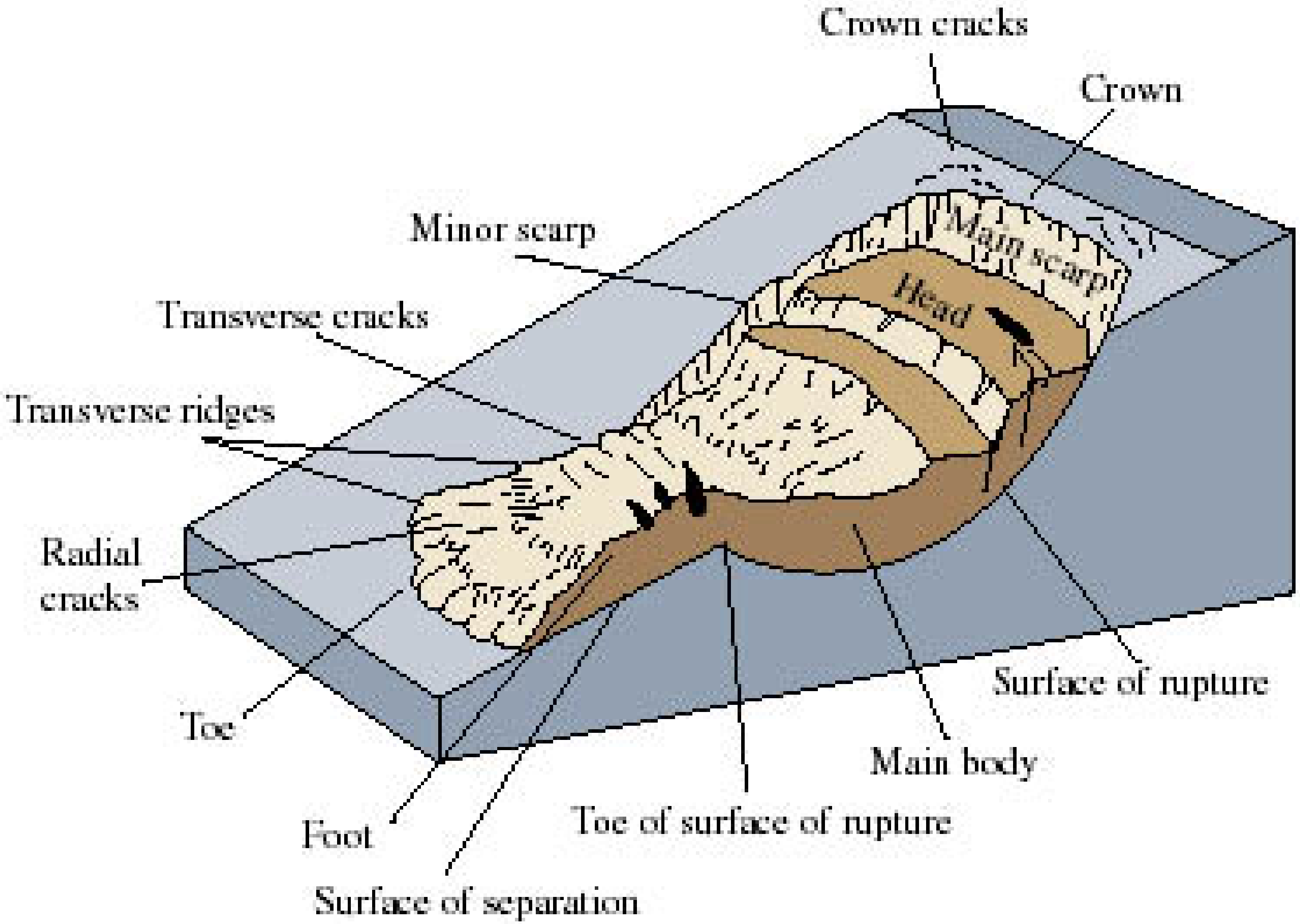


TYPICAL SHEAR STRESS - DISPLACEMENT RELATIONSHIP

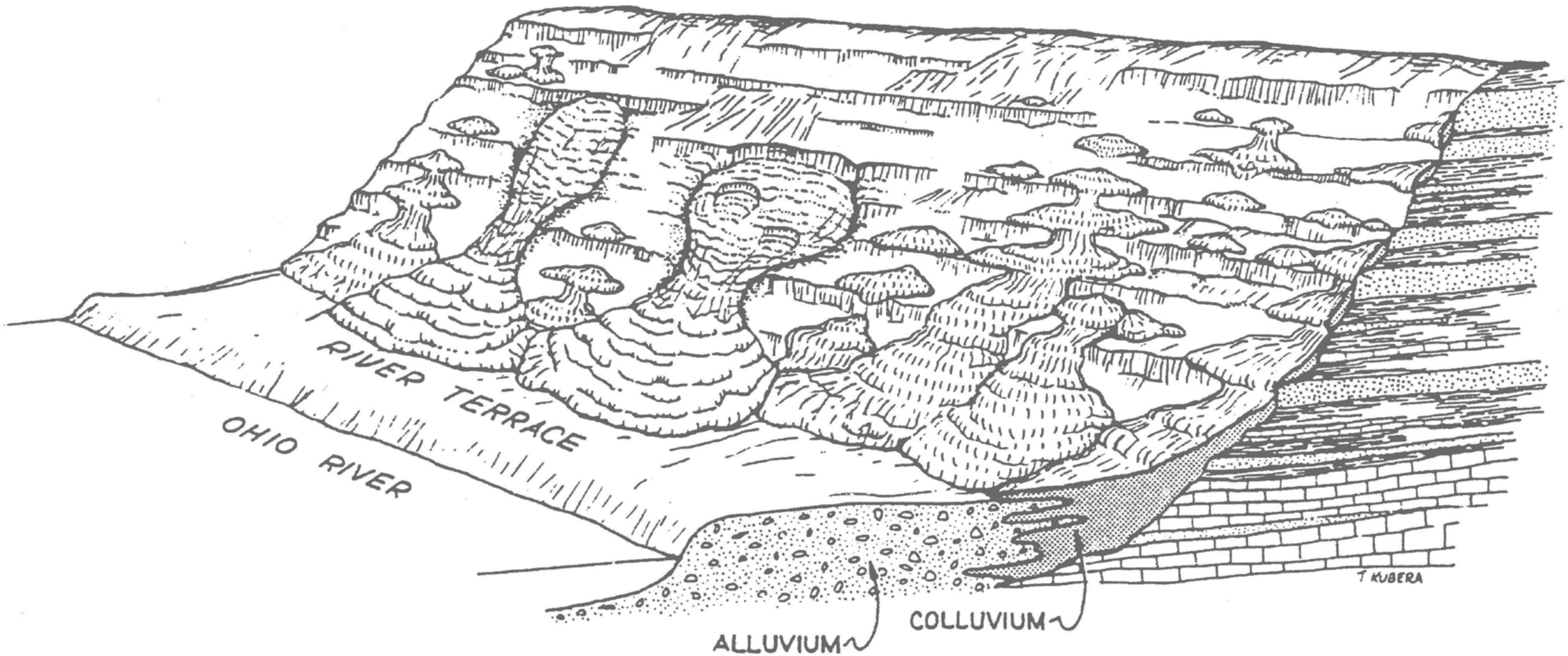


TYPICAL SHEAR STRENGTH - (EFFECTIVE STRESS RELATIONSHIP)

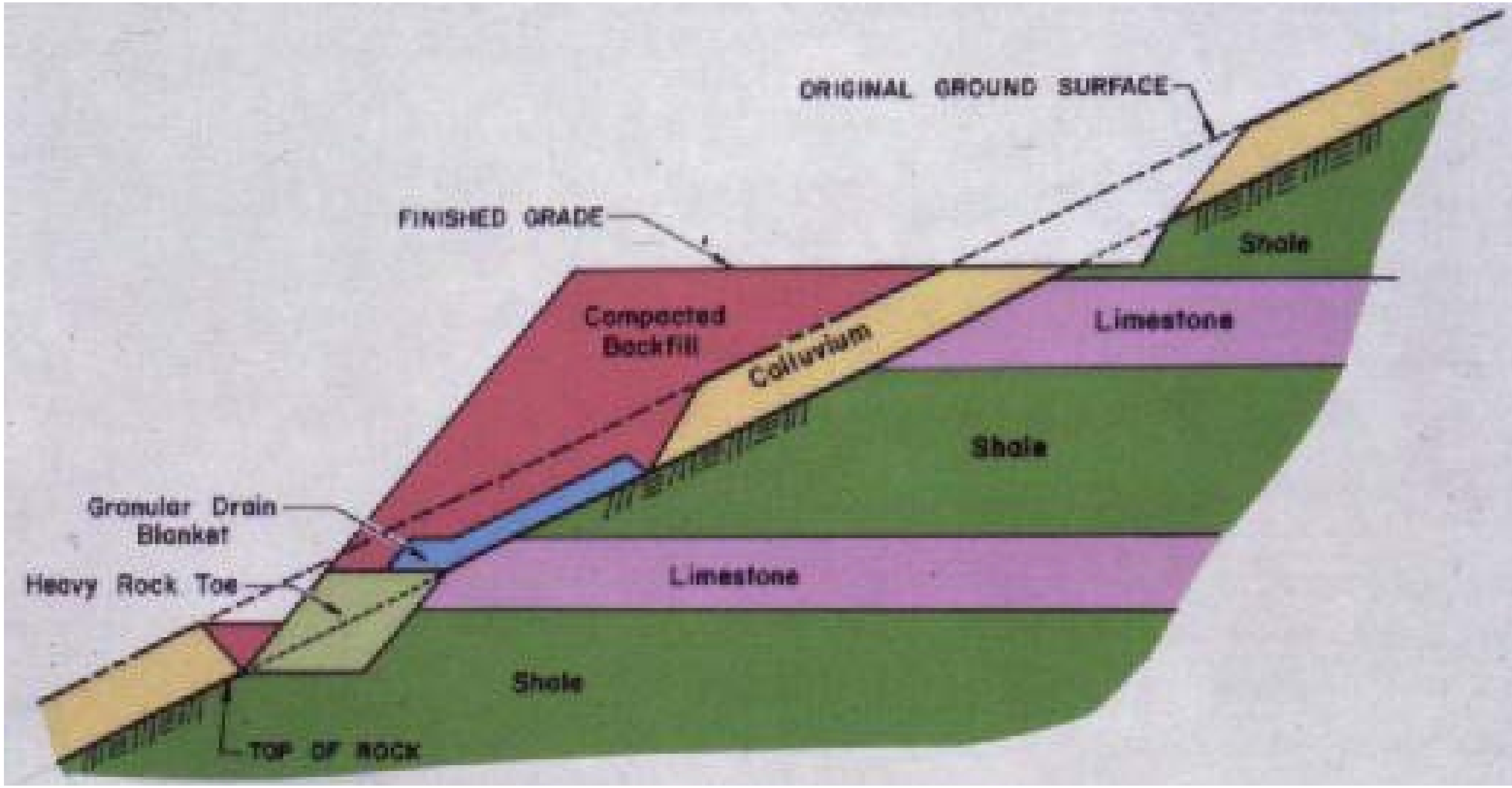
PEAK & RESIDUAL SHEAR STRENGTHS – THE PEAK STRENGTH OF CLAYSTONE DERIVED COLLUVIUM IS CHARACTERIZED BY COHESION INTERCEPTS OF 1 TO 5 psi AND FRICTION ANGLES OF 20 TO 25°, WHILE THE RESIDUAL STRENGTH IS CHARACTERIZED BY NEGLIGIBLE COHESION INTERCEPTS AND FRICTION ANGLES OF 8°TO 16°.



Skempton and DeLory, 1957, and Skempton, 1964, indicate that a relationship exists between piezometric level, residual angle of internal friction and the natural slope angle when the shear surfaces are parallel to the natural slope. For such planar slide masses, the natural slope angle is approximately one half the residual angle of internal friction when the piezometric level is at the ground surface. Saturated natural slopes will generally fall within the limits of ½ φ′ and ½ φ′r.



DEERE AND PATTON (1971) HAVE SUGGESTED THAT THERE ARE NO STABLE NATURAL SLOPES IN THE APPALACHIAN PLATEAU WHERE THE INCLINATION EXCEEDS 12-14°. MOVEMENTS HAVE BEEN REPORTED ON SLOPES AS FLAT AS 10° BY TERZAGHI AND PECK (1948, P.357), WHEREAS GRAY AND DONOVAN (1971) DEMONSTRATED THAT SEVERAL MATURE COLLUVIAL SLOPES, WITH EVIDENCE OF PRE-EXISTING FAILURE SURFACES, HAD SLOPE ANGLES RANGING FROM 7° TO 10°.



SCHEMATIC CROSS-SECTION

<u>EXCAVATION AND REPLACEMENT WITH COMPACTED MATERIAL –</u> THE BEST SOLUTION FOR SMALL SLIDE MASSES OR SLIDES IN CRITICAL AREAS MAY BE REMOVAL OF UNSTABLE MATERIAL AND REPLACEMENT WITH SELECT COMPACTED MATERIAL WHICH HAS SUFFICIENT SUBSURFACE DRAINAGE TO ENSURE A STABLE SLOPE. THIS PROCEDURE IS MOST APPLICABLE TO SLIDES LOCATED BELOW GRADE LEVEL.

GEOTECHNICAL ENGINEERS HAVE UNDERSTOOD THE FORMATION OF COLLUVIUM AND ITS RESULTING LOW SHEAR STRENGTH SINCE THE LATE 1960'S. THESE SPECIALISTS HAVE GENEROUSLY SHARED THEIR KNOWLEDGE THROUGH TECHNICAL PAPERS, WORKSHOPS AND FIELD TRIPS. YET NUMEROUS SLIDES OCCUR BECAUSE SOME GEOLOGISTS AND GEOTECHNICAL ENGINEERS DO NOT RECOGNIZE THE UNIQUE PROPERTIES OF COLLUVIUM.

THIS FAILURE OF AN ACCESS ROAD TO A WELL PAD IN SOUTHEASTERN OHIO IS THE RESULT OF BELIEVING THE SOILS BENEATH THE ROAD WERE RESIDUAL.

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