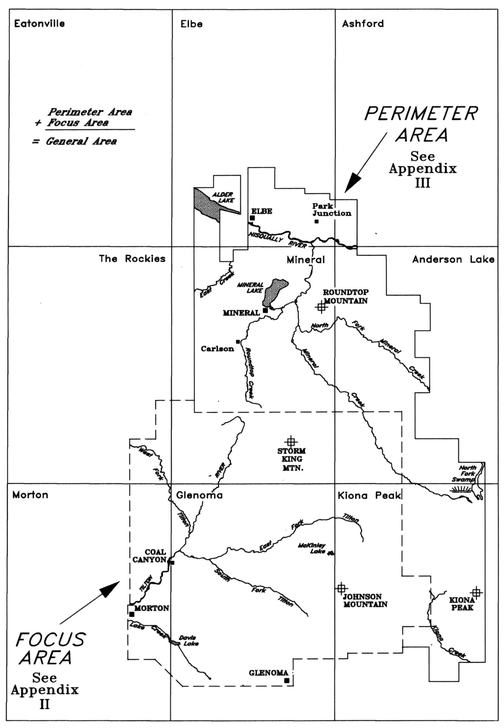
WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
Raymond Lasmanis, State Geologist

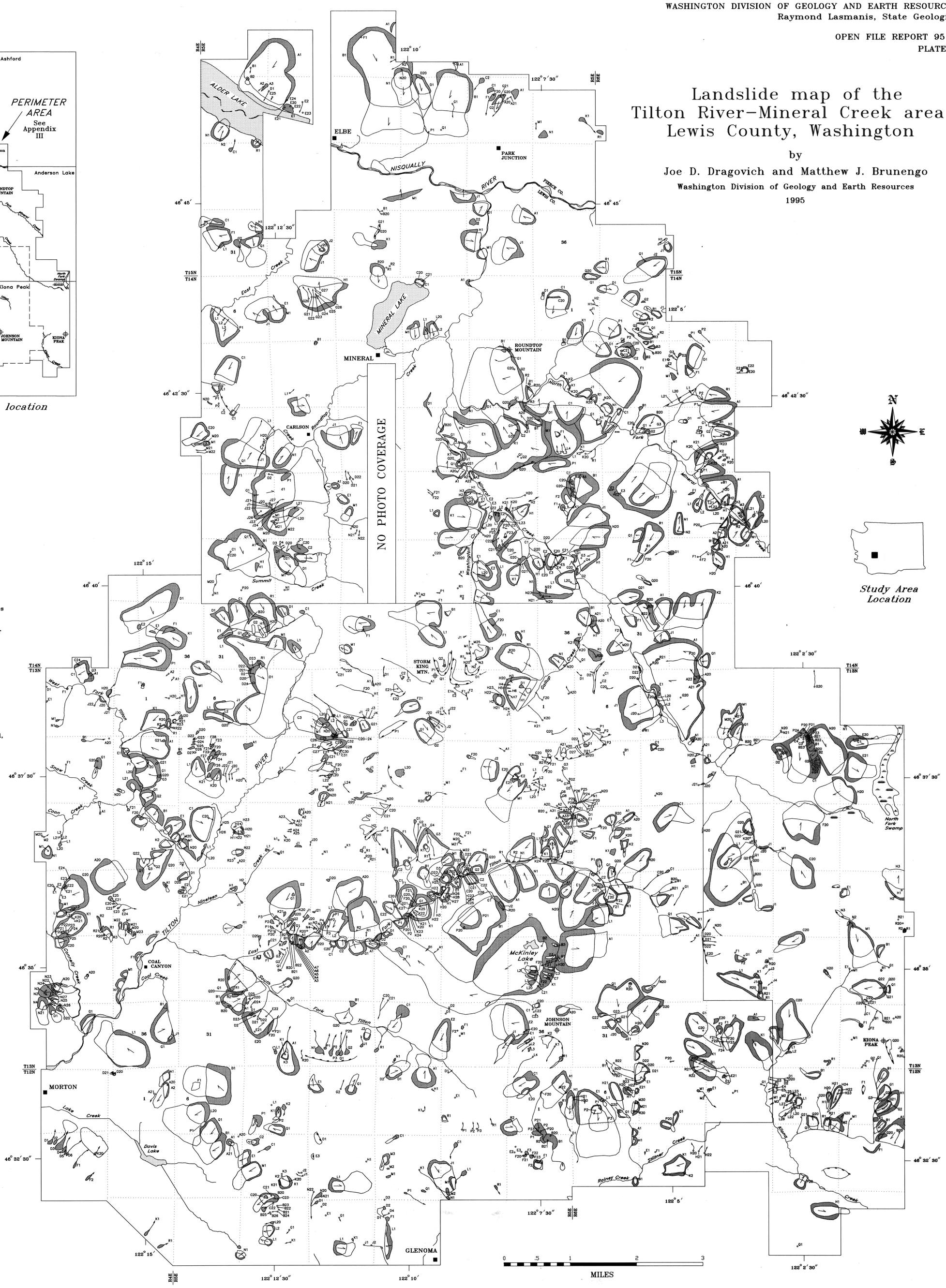
OPEN FILE REPORT 95-1
PLATE 1

Landslide map of the Tilton River–Mineral Creek area, Lewis County, Washington

by
Joe D. Dragovich and Matthew J. Brunengo
Washington Division of Geology and Earth Resources
1995



7.5-Minute quadrangle location



Study Area Location

EXPLANATION

Deep-seated landslides: large rock slumps, debris slumps and slump-earthflows.

1. Headscarp
2. Main body
3. Foot

1&2 = Area of depletion
2&3 = Area of accumulation or landslide deposit

Arrow denotes direction of movement.

Shallow landslides: debris slides, avalanches and torrents.

Polygon reresents area of depletion. Arrow represents landslide run-out (longer arrows are debris torrents).

Mappable large shallow landslide, small deep-seated landslide.

Shallow landslides, not mapped to scale; arrow shows run-out (where significant).

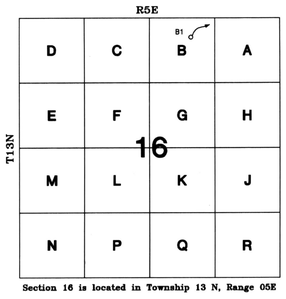
Talus

Exposed rock face

Major exposed cliffs susceptible to rockfall, topple, and slide.

See the landslide inventories for the focus study area (Appendix II) or the perimeter study area (Appendix III) for data (e.g., landslide type, dimensions, features, forest practices, aspect, slope, elevation, certainty, activity, or effects).

Landslide identification numbers were assigned using U.S. Geological Survey water-well location system. For example, 13/05E-16B1 is located on this grid system as follows:



Section 16 is located in Township 13 N, Range 05E

Cartography by Jeanne Demorest, Carl F. T. Harris, and Nancy Eberle

(DOMINANT) TYPE OF MOVEMENT	TYPE OF MATERIAL (BEFORE MOVEMENT)**		
	BEDROCK	ENGINEERING SOILS: PREDOMINANTLY COARSE DEBRIS	ENGINEERING SOILS: EARTH — PREDOMINANTLY FINE
I. FALLS Mass in motion travels most of the distance through the air. Includes free fall, movement by leaps and bounds, and rolling of fragments of bedrock or soil.	(2.1a) ROCK FALL, extremely rapid — a — * I a	b — DEBRIS FALL	c — EARTH FALL
II. TOPPLES Movement due to forces that cause an overturning moment about a pivot point below the center of gravity of the unit. If unchecked, will result in a fall or slide.	(2.1d1) ROCK TOPPLE (de Freitas and Watters, 2.37). * II d1; (2.1d2) * II d2 — d	(2.1e) DEBRIS TOPPLE — e	f — EARTH TOPPLE
III. SLIDES Movement involves shear displacement along one or several surfaces, or within a relatively narrow zone, which are visible or may reasonably be inferred. — **A. ROTATIONAL** Movement due to forces that cause a turning moment about a point above the center of gravity of the unit. Surface of rupture concaves upward.	(2.1g) ROCK SLUMP, extremely slow to moderate — g — * III Ag	h — * III Ah — DEBRIS SLUMP	(2.1i) EARTH SLUMP — i
B. TRANSLATIONAL Movement predominantly along more or less planar or gently undulatory surfaces. Movement frequently is structurally controlled by surfaces of weakness, such as faults, joints, bedding planes, and variations in shear strength between layers of bedded deposits, or by the contact between firm bedrock and overlying detritus.	(2.1j1) (Nemčok, 2.115, after Beck, 2.5); (2.1j2) ROCK BLOCK SLIDE; (2.1j3) ROCK SLIDE — j	(2.1k) DEBRIS SLIDE, very slow to rapid — k — * III Bk	(2.1l) EARTH BLOCK SLIDE (Hansen, 2.57) — l
IV. LATERAL SPREADS Distributed lateral extension movements in a fractured mass. A. Without a well-defined controlling basal shear surface or zone of plastic flow (predominantly in bedrock). B. In which extension of rock or soil results from liquefaction or plastic flow of subjacent material.	(2.1m2) (Záruba and Mencl, 2.193); (2.1m1) (Jahn, 2.73); (2.1m3) (Ostaficzuk, 2.119) — m	n	(2.1o) EARTH LATERAL SPREAD, very rapid — o
V. FLOWS A. IN BEDROCK Includes spatially continuous deformation and surficial as well as deep creep. Involves extremely slow and generally nonaccelerating differential movements among relatively intact units. Movements may 1. Be along many shear surfaces that are apparently not connected; 2. Result in folding, bending, or bulging; or 3. Roughly simulate those of viscous fluids in distribution of velocities. B. IN SOIL Movement within displaced mass such that the form taken by moving material or the apparent distribution of velocities and displacements resemble those of viscous fluids. Slip surfaces within moving material are usually not visible or are short-lived. Boundary between moving mass and material in place may be a sharp surface of differential movement or a zone of distributed shear. Movement ranges from extremely rapid to extremely slow.	A (2.1p1) (Nemcok, Pašek, and Rybář, 2.116); (2.1p3) (Zischinsky, 2.194); (2.1p4) (Rybář and Dobr, 2.137); (2.1p2) (Zischinsky, 2.194) — p. Gravity downslope movement of clayey rocks and coal on the margin of a sedimentary basin. Note: Sackung or gravitational sagging is illustrated by p1, p2, and p3.	B (2.1q1) DEBRIS FLOW, very rapid — q — * V bqf; * V bqt (debris torrent); (2.1q2) SOLIFLUCTION; (2.1q3) DEBRIS AVALANCHE, very rapid to extremely rapid — * V Bq3; (2.1q4) SOIL CREEP, extremely slow; (2.1q5) BLOCK STREAM. Note: Drawings in q2, q4, and q5 courtesy of G. M. Richmond, from Colluvium, an unpublished chart.	WET FLOWS: (2.1r1) WET SAND OR SILT FLOW, rapid to very rapid; (2.1r2) RAPID EARTH FLOW (QUICK CLAY FLOW), very rapid (Sharpe, 2.146); (2.1r3) EARTH FLOW, very slow to rapid (Záruba and Mencl, 2.193); MUD FLOW — r. DRY FLOWS: (2.1r4) DRY SAND FLOW, rapid to very rapid; (2.1r5) LOESS FLOW (dry, caused by earthquakes), extremely rapid. Also moist or wet
VI. COMPLEX Movement is by a combination of one or more of the five principal types of movement described above. Many landslides are complex, although one type of movement generally dominates over the others at certain areas within a slide or at a particular time.	EXAMPLES: (2.1s1) ROCK FALL–DEBRIS FLOW (ROCK-FALL AVALANCHE), Extremely rapid (After Heim, 2.58, Elm, Switzerland, 1881); (2.1s2) SLUMP AND TOPPLE (Záruba, 2.192); (2.1s3) ROCK SLIDE–ROCK FALL (Nemčok, Pašek, Rybář, 2.116); (2.1s4) CAMBERING AND VALLEY BULGING	(2.1s5) SLUMP–EARTH FLOW — * VI s5	S — Note: Most, if not all slow earth flows in cohesive materials are complex in that finite shear occurs along the flanks and basal surface, although the distribution of velocities within the displaced material may indicate plastic flow.

VII. Anthroprogenic causes: Movement initiated from or caused by manmade structures (for example, logging roads).

(2.1t) SLUMP-EARTH FLOW

NOMENCLATURE

MAIN SCARP—A steep surface on the undisturbed ground around the periphery of the slide, caused by the movement of slide material away from undisturbed ground. The projection of the scarp surface under the displaced material becomes the surface of rupture.

MINOR SCARP—A steep surface on the displaced material produced by differential movements within the sliding mass.

HEAD—The upper parts of the slide material along the contact between the displaced material and the main scarp.

TOP—The highest point of contact between the displaced material and the main scarp.

TOE OF SURFACE OF RUPTURE—The intersection (sometimes buried) between the lower part of the surface of rupture and the original ground surface.

TOE—The margin of displaced material most distant from the main scarp.

TIP—The point on the toe most distant from the top of the slide.

FOOT—That portion of the displaced material that lies downslope from the toe of the surface of rupture.

MAIN BODY—That part of the displaced material that overlies the surface of rupture between the main scarp and toe of the surface of rupture.

FLANK—The side of the landslide.

CROWN—The material that is still in place, practically undisplaced and adjacent to the highest parts of the main scarp.

ORIGINAL GROUND SURFACE—The slope that existed before the movement which is being considered took place. If this is the surface of an older landslide, that fact should be stated.

LEFT AND RIGHT—Compass directions are preferable in describing a slide, but if right and left are used they refer to the slide as viewed from the crown.

SURFACE OF SEPARATION—The surface separating displaced material from stable material but not known to have been a surface on which failure occurred.

DISPLACED MATERIAL—The material that has moved away from its original position on the slope. It may be in a deformed or undeformed state.

ZONE OF DEPLETION—The area within which the displaced material lies below the original ground surface.

ZONE OF ACCUMULATION—The area within which the displaced material lies above the original ground surface.

(2.1u) RATE OF MOVEMENT SCALE

Approximate ranges of rates of movement are according to the scale below

ft/sec		
10^{2}		extremely rapid
10	10 ft/s - 3 m/s	
1		very rapid
10^{-1}		
10^{-2}	1 ft/min - 0.3 m/min	
10^{-3}		rapid
10^{-4}	5 ft/d - 1.5 m/d	
10^{-5}		moderate
10^{-6}	5 ft/mo - 1.5 m/mo	
10^{-7}		slow
10^{-8}	5 ft/yr - 1.5 m/yr	
10^{-9}		very slow
10^{-10}	1 ft/5 yr - 0.06 m/yr	
10^{-11}		extremely slow

**The type of material involved is classified according to its state prior to initial movement or, if the type of movement changes, according to its state at the time of the change in movement. Thus, the Elm slide began as a rock slide and rock fall in bedrock, but at the time a flowing type of movement started the material was an unconsolidated mass of extremely rapidly moving rock fragments.

VARNES' LANDSLIDE CLASSIFICATION SYSTEM

This chart is modified from figure 2.1, Types of slope movement, *of* D.J. Varnes, 1978, Slope movement and types and processes, in Landslides–Analysis and control: National Academy of Sciences Transportation Research Board Special Report 176, Chap. 2. Used with permission of the Transportation Research Board, National Research Council, Washington D.C.

* Slope movement types given in bold large lettering are those Varnes landslide types shown in the landslide inventory table.

"This figure is part of Selected Text 1: LANDSLIDES: ANALYSIS AND CONTROL of Compendium 13: SLOPES, ANALYSIS AND STABILIZATION, Transportation Technology Support for Developing Countries, prepared under contract AID/OTR-C-1591."

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Plate 3

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Jennifer M. Belcher · Commissioner of Public Lands
Kaleen Cottingham · Supervisor

WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
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PLATE 2

Geologic map of the Tilton River–Mineral Creek area, Lewis County, Washington

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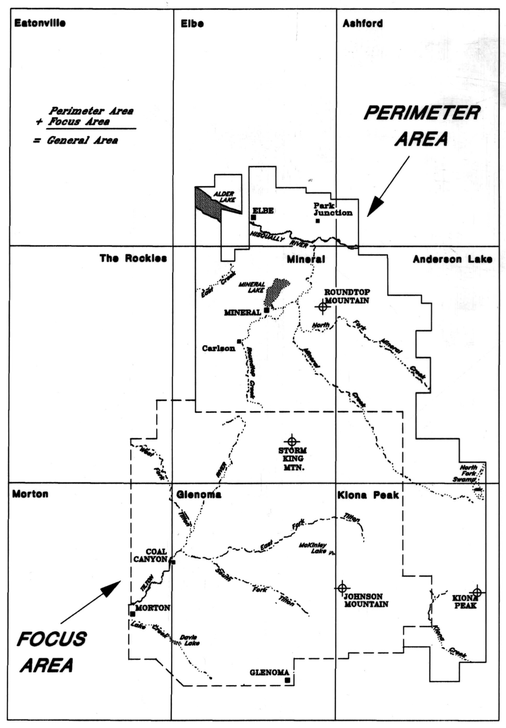


7.5–Minute Quadrangle Location Map

MAP EXPLANATION

CONTACT, known and approximate locations.

ANTICLINE, showing plunge; dashed where existence and/or location inferred; dotted where concealed.

SYNCLINE, showing plunge; dashed where existence and/or location inferred; dotted where concealed.

U/D FAULT, showing sense of displacement; dashed where existence and/or location inferred; dotted where concealed.

STRIKE AND DIP of beds

HORIZONTAL BEDS

GEOLOGIC UNITS

QUATERNARY UNCONSOLIDATED UNITS

- **Qal** Alluvium
- **Qls** Landslide debris
- **Qdet** Evans Creek Drift, till deposits
- **Qdem** Evans Creek Drift, moraine deposits
- **Qoe** Evans Creek Drift, outwash deposits
- **Qdh** Hayden Creek Drift, undifferentiated
- **Qdht** Hayden Creek Drift, till deposits
- **Qoh** Hayden Creek Drift, outwash deposits
- **Qdw** Wingate Hill Drift, undifferentiated

TERTIARY STRATIFIED ROCKS

Lower Miocene

- **Tva_3** basaltic andesite and andesite flows
- **Tvb_3** basalt flows

Oligocene

- **Tva_2** andesite flows
- **Toh** Ohanapecosh Formation

Oligocene – Eocene

- **Tva** basaltic andesite and andesite flows
- **Tvc** volcaniclastic rocks

Eocene

- **Tno** Northcraft Formation
- **Tva_0** andesite and basaltic andesite flows
- **Tpg** rocks of the Puget Group

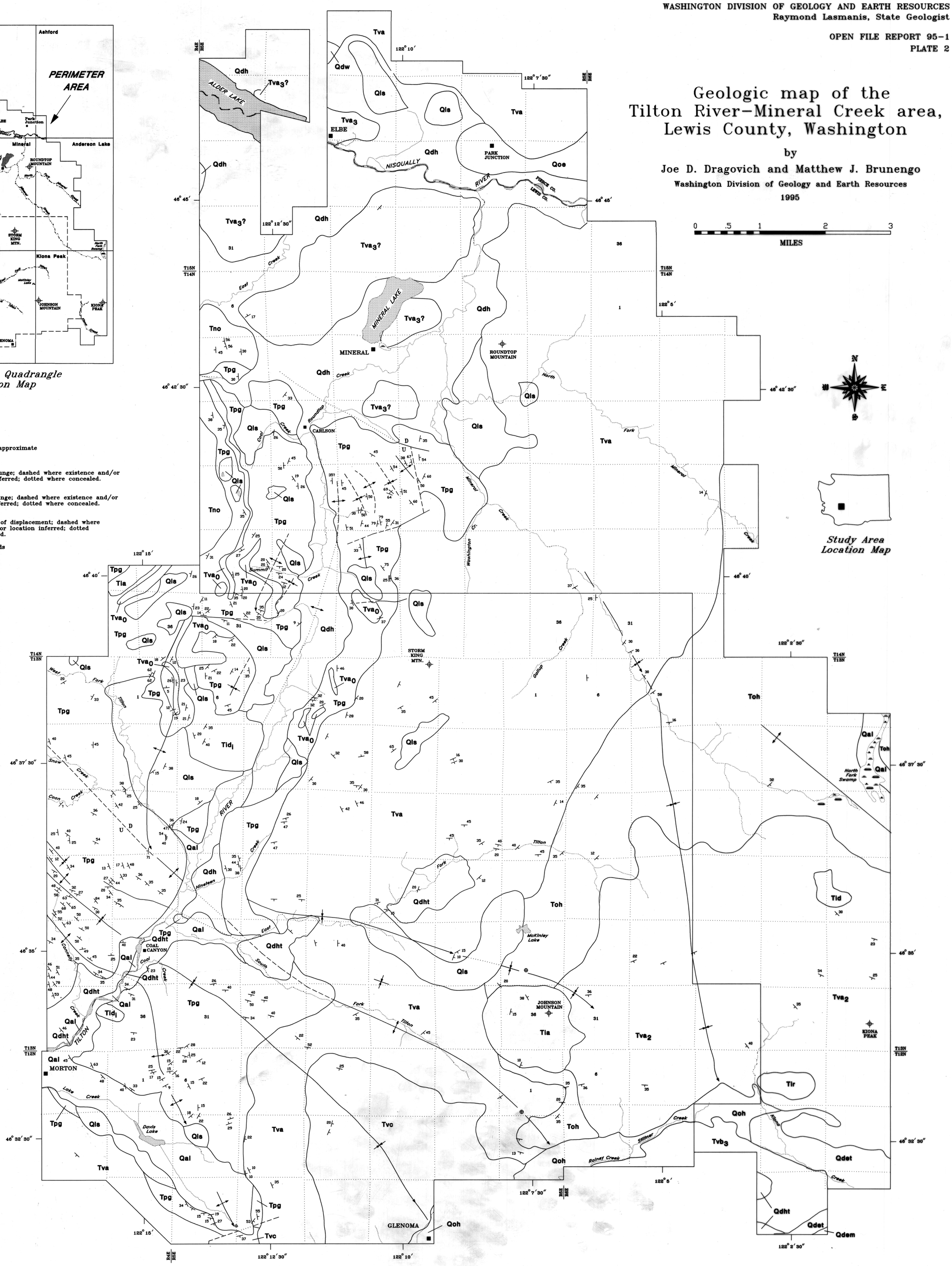
TERTIARY INTRUSIVE ROCKS

Miocene

- **Tir** rhyolite dike

Miocene – Oligocene

- **Tid_i** diorite dikes, sills, or plugs
- **Tid** dacite dikes, sills, or plugs
- **Tia** andesite and andesite porphyry dikes, sills, or plugs



Modified from "Geologic Map of the Centralia Quadrangle, Washington"
Compiled by H. W. Schasse, Washington Div. of Geol and Earth Res.
Open File Report 87–11.
Cartography by Carl F. T. Harris