Rationale for a 2nd Generation of *Soil Taxonomy*: Differentiation of Dynamic and Pedogenic Steady State Properties

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Discussion topics:

- Basic tenets of *Soil Taxonomy*
- Soil units (Pedon and Polypedon)
- Proposal for addition of 7th categorical level in *Soil Taxonomy*

Pedon

- Soil is continuum- discrete boundaries do not exist
- Pedon is observation or sampling unit
- Pedons are not mutually exclusive
- Pedon is not a practical unit for mapping

Polypedon

- segment of soil continuum not defined by Series limits; “inclusions” are a component of polypedons
- equivalent to mapping unit or landscape component
- most practical natural unit for mapping soils

Proposal:

To propose a new categorical level below the series to accommodate soils that have been significantly altered by soil management.

Soil = *f* (pm, climate, biota, relief, time)

Where time spans centuries to millennia

In human time scale, soils represent steady states

Properties of steady state soils used for classification are also relatively stable

- ✓Kind, thickness, and arrangement of horizons
- ✓Color
- ✓Texture
- ✓Structure
- ✓Chemistry

Dynamic properties are those effected by land use and management

Changes in dynamic properties often occur in time spans of years to decades

Management Practices foster Processes

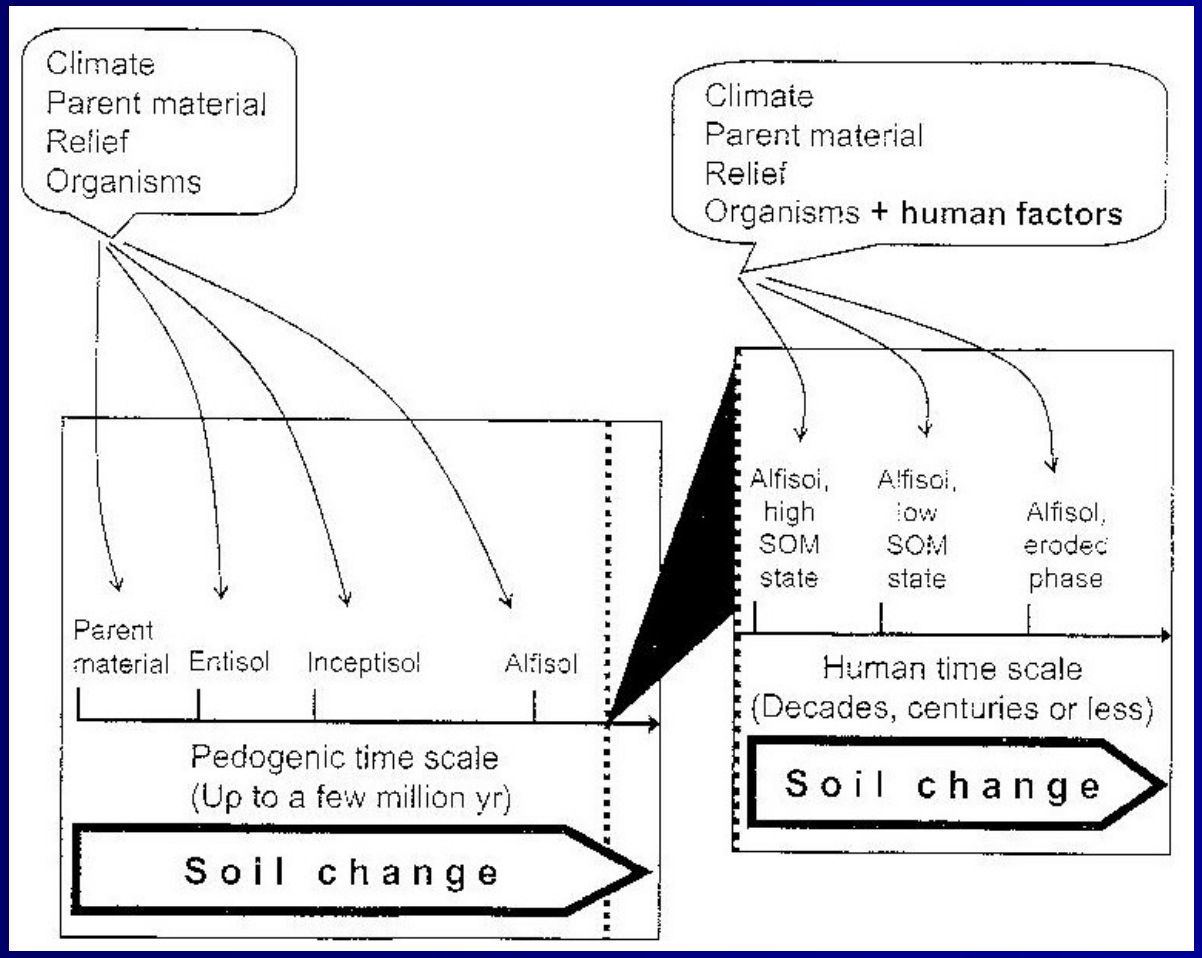
- ✓Tillage
- ✓Drainage
- ✓Intensive grazing
- ✓Clear cutting
- ✓Burning
- ✓Irrigation
- ✓Addition of amendments

- ✓Accelerated erosion
- ✓Oxidation
- ✓Compaction
- ✓Mixing of horizons
- ✓Changes in
  - -pH
  - -Nutrient status
  - -Base saturation
  - -Salinity

Changes in dynamic soil properties affect:

- ✓Pedogenic steady states
- ✓Soil quality
- ✓Soil capacity to function

Soil Change on Pedogenic and Human Time scales



(Tugel et al., 2005, SSSAJ)

Soil Classification Changes due to Soil Management

Pedogenic Steady State		After Dynamic Change
Argiudoll	Erosion of mollic/argillic →	**Udalf / Udept**
Alfisol	Erosion of argillic/cambic →	**Inceptisol / Entisol**
Spodosol	Destruction of spodic by tillage →	**Entisol**
Ultisol	Long-term lime application →	**Alfisol**

Basic Attributes of *Soil Taxonomy* (1999, p. 16)

3rd - "taxa represent real bodies of soil that are known to occupy geographic areas"

4th - "differentiae are soil properties"

6th - "differentiae keep an undisturbed soil and its cultivated or otherwise human-modified equivalents in same taxon insofar as possible"

Spatial concurrence between Soil Orders and Ecosystems

Order	Ecosystem
Gelisols	Tundra
Mollisols	Prairies
Alfisols	Humid, deciduous forests
Spodosols	Cool, humid, coniferous forests
Ultisols	Warm, humid climates
Oxisols	Tropical/subtropic climates
Aridisols	Deserts

Genetic Thread in *Soil Taxonomy*

Diagnostic Horizon or Feature	Order
Mollic epipedon	Mollisols
Argillic horizon	Alfisols
Spodic horizon	Spodosols
Argillic/Kandic horizon	Ultisols
Oxic horizon	Oxisols
Slickensides	Vertisols
Cambic horizon	Inceptisols
Gelic materials	Gelisols
Andic materials	Andisols

Differentiae keep undisturbed soils and human-modified equivalents in same taxa

Solution: "use subsurface horizons for definitions of higher categories" (Smith, 1986, p. 17)

Except for Mollisols: "the use of the Mollic epipedon to group the grassland soils of the Great Plains was unavoidable with the knowledge that we had of those soils at the time we developed *Soil Taxonomy"* (Smith, 1986, p. 197)

Possible solution for eroded Mollisols (Smith, 1986, p. 197):

"In classifying these soils as Mollisols, when the Mollic epipedon has been removed in places, perhaps most places even, it might be possible to write definitions such that when applied to a polypedon, the presence of these less eroded areas would be considered justification for putting the soil in the Mollisol Order."

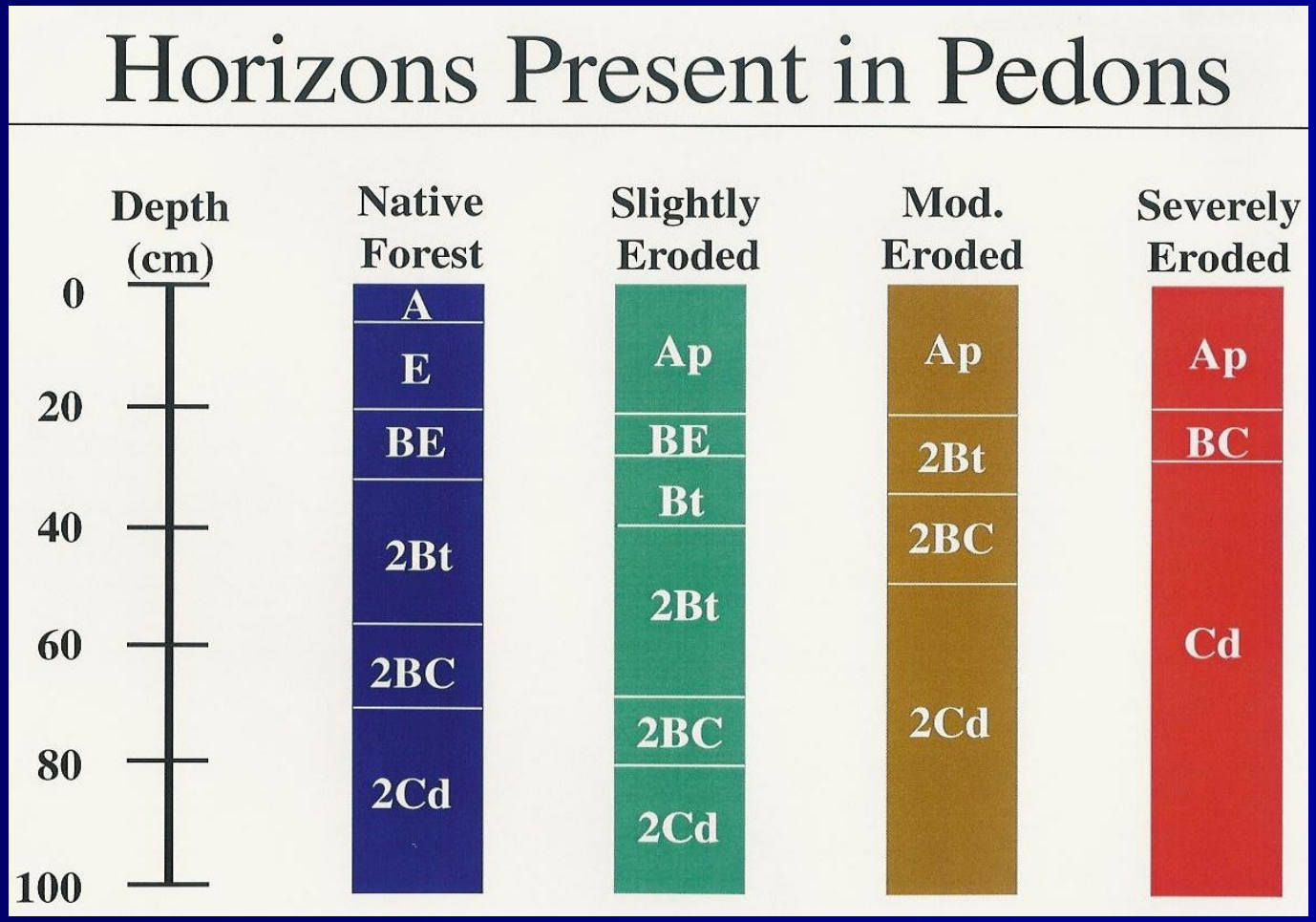
Points to note:

1) **Smith recognized need to keep eroded soils in same Order as uneroded soils**
2) **Smith suggested <u>selection</u> of steady state (unmodified) pedons for classification of polypedon**

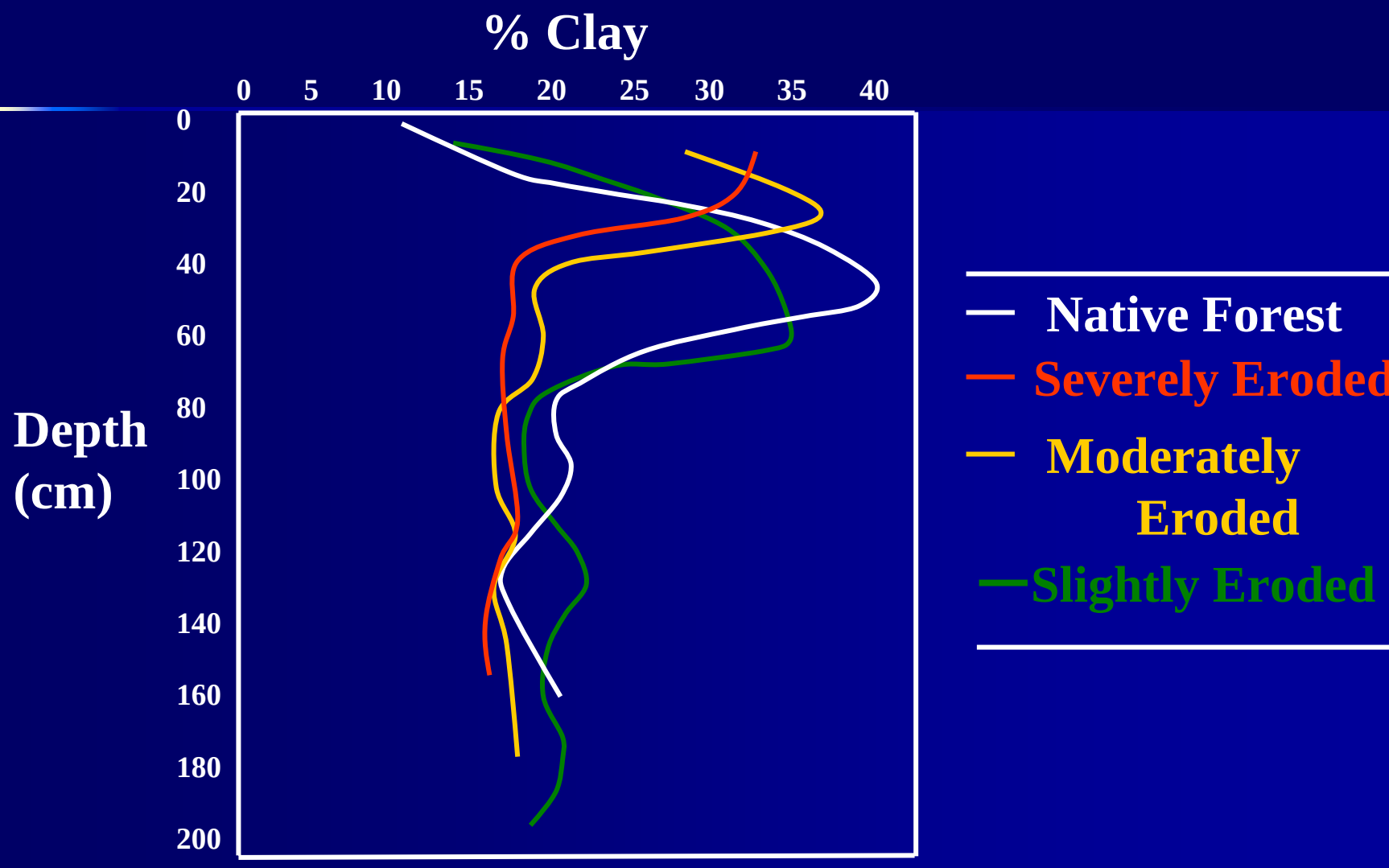
Essential information:

- Soil surveys should not ignore nor obscure the influence of soil management on soil properties that affect soil function, quality, or sustainability
- Classification of steady state soils and human modified soils in a given landscape should aid elucidation of human impact responsible for differences in such soils

Pedons in 5 ha Landscape in Ohio



Clay Distribution



Classification of Eroded Phases in a Landscape

Pedon	Family Classification	Series
Forest	Fine-loamy, mixed, active, mesic Oxyaquic Hapludalf	Miami
Slightly eroded	Fine-loamy, mixed, active, mesic Oxyaquic Hapludalf	Miami
Moderately eroded	Loamy, mixed, active, mesic, shallow Oxyaquic Hapludalf	Wapahani
Severely eroded	Loamy, mixed, superactive, mesic, shallow Oxyaquic Hapludalf	Thrifton

Important Points:

- ✓ **Human activity can affect the classification of pedogenetically similar soils at any categorical level**
- ✓ ***Soil* Taxonomy should differentiate between soils that are primarily pedogenic and those significantly altered by anthropogenic processes**

Proposal: create a 7th categorical level in *Soil Taxonomy*

<u>Anthropogenic Deviant</u> – a subclass of the series for inclusion of soils that do not fit series criteria or criteria for a higher categorical level as a result of change in dynamic soil properties induced by anthropogenic activity.

Terminology

Anthropogenic Deviant – implies a deviation from an accepted norm as a result of human impact on nature

(paraphrased from Webster's Dictionary)

Potential Anthropogenic Deviants

Series	Anthropogenic Deviant	Subgroup
Tama		Typic Argiudoll
	Tama Severely Eroded	Mollic Hapludalf
Miami		Oxyaquic Hapludalf
	Miami Severely Eroded	Typic Udorthent
Caribou		Typic Haplorthod
	Caribou Tilled/Eroded	Typic Udorthent
Cecil		Typic Kanhapludult
	Cecil Limed	Typic Kanhapludalf

Incorporation of Anthropogenic Deviants

- New Heading Following Range of Characteristics in Official Series Description
- Each Anthropogenic Deviant would include:
  - ✓Anthropogenic activity responsible
  - ✓How properties differ from those of the series
  - ✓Classification at family level

Question?

How to establish that pedons classifying as Anthropogenic Deviants and Series were similar prior to human induced modification?

NAEW - Coshocton

Western Allegheny Plateau

Erosion Assessments of NAEW

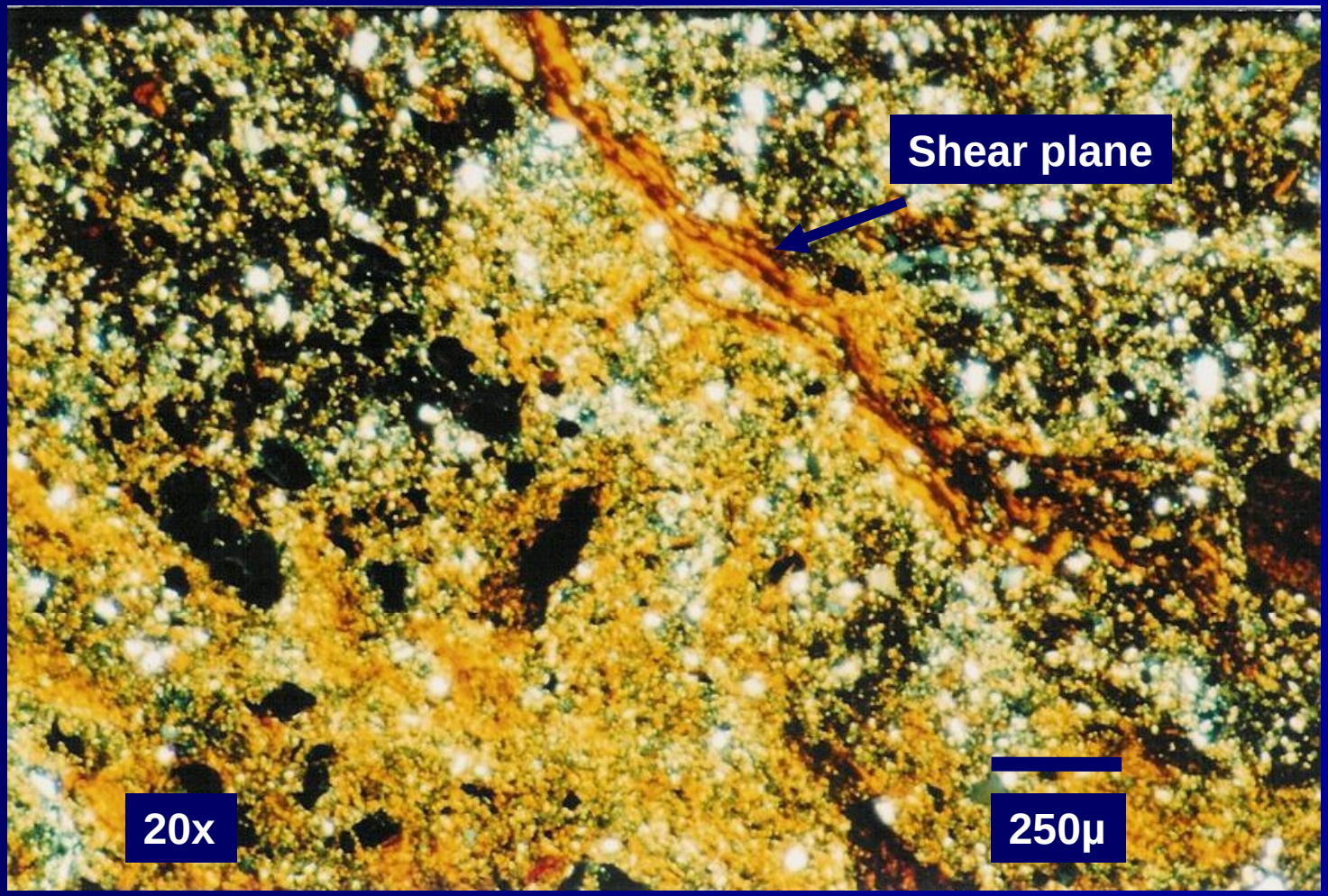
1935- Severe sheet erosion with occasional gullies

1969- 77% moderately eroded and 1% severely eroded

2002- 10% classified as “eroded”

Macromorphological evidence for incorporation of Bt horizon into Ap horizon.

Thin Section of Ap



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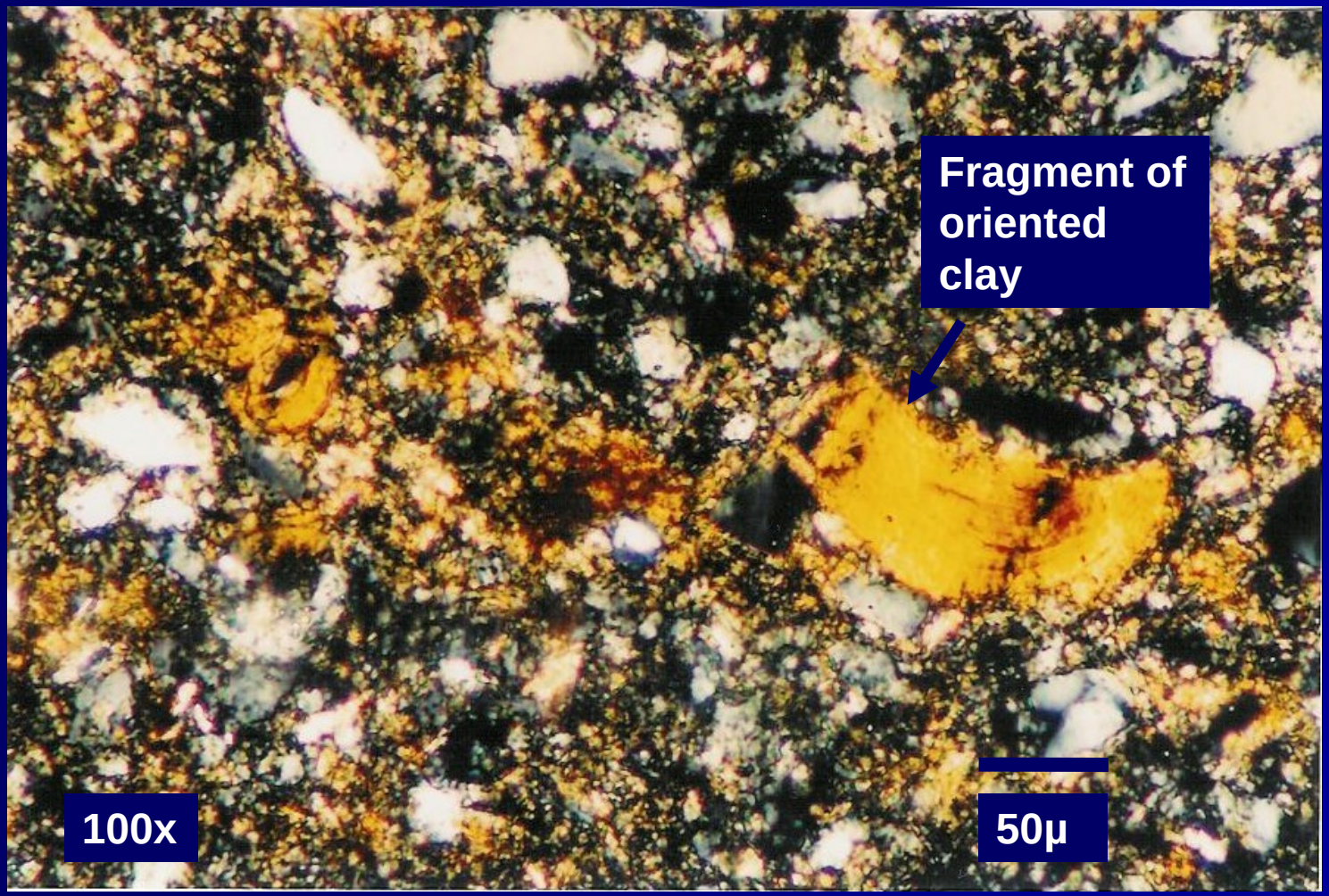

Soil Organic Carbon and Clay Contents in Upper 30 cm of Soils in Watershed 118 at North Appalachian Experimental Watershed

Loess Depth (cm)	Vegetation	SOC (kgm^{-2})	Clay (kgm^{-2})
68	Forest	14.7	40.6
38	Meadow	6.2	70.4
25	Prevailing rotation/ no-till corn-soybeans	5.8	68.6

How to Establish Linkage between Series and associated Anthropogenic Deviants?

- Examine soil properties in landscape components that extend across boundaries between managed and native areas
- Extend information from such studies to areas where such opportunities do not exist

Database of pedons in undisturbed natural settings

Westmoreland Series

57% slope

Sampling of Pristine Ohio Forest

Pedon (series)	Slope (%)	Thickness A and E horizons (cm)
Elba	18	38
Westmoreland	34	47
Westmoreland	57	48

Series- maximum thickness of Ap = 25 cm

Conclusion: In cultivated pedons, combined thickness of A, E and BE horizons has declined by <u>at least</u> 34 to 48 %

Soil Taxonomy should foster differentiation between:

- Pedogenic steady state and anthropogenically modified soils
- Inherent soil quality and anthropogenically influenced soil quality

Proposed revision will:

1) Facilitate correlation between distributions of regional and global ecosystems and Orders to Great Groups identified at Series level

2) Identify pedogenic relationships between Series and Anthropogenic Deviants

3) Provide information regarding human impact on soil properties by comparison of Series and associated Anthropogenic Deviants

Continued

Proposed revision will:

4) **Facilitate assessment of inherent differences in soil quality among steady state soils**

5) **Facilitate evaluation of dynamic change in soil quality induced by human activity**