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Effect of Soil Mineral Variability on Soil Use and Management

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Soil mineralogical variability arises from two factors. The mineralogical composition of the parent material and the degree to which the original composition has been modified by external soil forming factors and internal soil building processes during the course of weathering. Different stages of soil weathering are represented by different mineralogical compositions and therefore a different combination of physical and chemical properties. Some soil scientists have divided these weathering stages into fresh, juvenile, virile, senile, and lateritic. The ability of soil to provide nutrients to plants reaches a maximum at the beginning of the virile stage and then declines rapidly with further weathering. Most of the soils in Kentucky have passed the middle of the virile stage, and therefore, exhibit a declining availability for plant nutrients. At this stage, plant nutrient deficiencies due to advanced stage of weathering should be offset by the application of commercial fertilizers. However, because soil in each small segment of a weathering stage contains a wide range of mineralogical compositions, a variety of management practices may be required to compensate for this variability.

Some of the mineralogical variability we encounter in soils is consistent with changes in the landform, geomorphology, soil forming factors and/or soil management. In these soils, certain patterns or combinations of these elements are associated with similar mineralogical compositions. We take advantage of these repeated patterns to establish concepts from which soil mapping units are defined. Other times, however, this variability is unpredictable and very difficult to assess due to random variations in the parent material, intensity of weathering, erosional patterns, drainage etc. Random variation due to these factors is difficult to cope with in soil use and management interpretations because it is unpredictable. For example, two soils with very similar physical and chemical properties and mapped as being alike may have different mineralogical compositions.

This is very common in some central Kentucky soils developed on thinly interbedded limestone-shale parent materials. Because some of the bedrock formations are slightly tilted there are situations where some soils have developed primarily on limestone material immediately adjacent to others on shaly material. Morphologically, physically and chemically there are no noticeable differences in these two soils. However, the shaly soil will have more expanding minerals and mica and less kaolinite and quartz. Assuming that both soils have a pH of about 5.0, more lime will be required to reach a desired pH value in the shaly than in the limestone soil. Furthermore, since most of these soils have been considerably leached of nutrients, K-fertilizer applications to the shaly soil may have to be higher than those on the adjoining limestone soil to compensate for the increased K-fixation capacity of the expanding minerals. Several examples of K underfertilization have been reported in central Kentucky soils forming on such interstratified parent materials. Although soil testing can indicate the amount of lime needed to adjust acidity in most of these soils, fertilizer application recommendations are usually lower than needed because they do not account for the K-fixation capacity of the present minerals.

In addition, some serious engineering problems may be encountered in such soils because the soil morphological, classification, and characterization data on which site evaluation and interpretations are based on do not account for the variable mineralogical composition. Specific examples of how the mineralogical composition can vary within some common soil series due to random variation are given in Tables 1 and 2. It is obvious from these examples that even soils with the same mineralogy classification may exhibit considerable variability in mineralogical composition. For example within the Eden soil series (Table 1) which has mixed mineralogy, data from 5 Eden soils suggest that the amount of expanding minerals can range from 30 to about 50%. This same range in three Lowell soils is 25 to 40%. Therefore, in these and other similar cases the term "mixed mineralogy" is not very helpful in determining the best management for each individual soil with respect to fertilizer needs, lime requirements and workability by mechanical implements and tools.

Another factor that may cause mineralogical variability and consequently modify soil use and management interpretations is uncontrolled erosion. Since most Kentucky soils, especially those with a thin loess mantle have increasing amounts of expanding minerals with depth, removal of that thin loess cap by erosion will result in incorporation of more expanding minerals into the plowed layer. Depending on the type of the soil, agricultural and engineering management practices in these eroded mapping units should be modified to compensate for these mineralogical changes. This is especially important where soil use and management recommendations are based primarily on uneroded soils. Striking examples of this situation are eroded Lowell and Shrouts soils in the outer Bluegrass area whose exposed clayey subsoil exhibits considerable shrink swell potential and significant cracking in dry periods.

Although soil survey reports provide valuable information on soil use and management, an assessment of soil variability by on site evaluations may be necessary in many cases to optimize agricultural and engineering management practices. This will help farmers to improve land use efficiency, help builders identify better housing sites, help engineers find the most suitable locations for highways, air fields and other structures and help developers and planners avoid problem areas for septic tank drainage fields, underground pipelines and basements.

Table 1. Clay mineralogical variability in the surface 20-inch layer of some major soils in Kentucky.†

Soil Series	Number of soils	Expanding†† minerals	Mica	Kaolinite	HIV†††	Quartz
		- - - - -	- - - -	- - % - -	- - -	- - -
Maury	6	15-30	15-25	15-35	15-25	5-15
Eden	5	30-50	35-65	5-15	0-10	5-10
Lowell	3	25-40	20-30	15-20	15-25	5-10
Crider	7	15-25	15-30	30-35	20-25	10-15
Frederick	9	15-30	15-35	20-35	10-30	5-15
Baxter	6	10-30	20-30	20-35	15-25	5-20

† includes A and B horizons.
†† expanding minerals include montmorillonite and vermiculite.
††† HIV = hydroxy-interlayered vermiculite.

Table 2. Clay mineralogical variability with depth within the same soil profile

Soil Series	Horizon	Depth	Mineralogy†
		-in-	
Beasley	Ap	0-7	mixed
	Bt1	7-12	mixed
	Bt2	12-17	montmorillonitic
Bledsoe	Ap	0-4	mixed
	Bt1	4-10	mixed
	Bt2	10-18	montmorillonitic
Eden	Ap	0-7	mixed
	Bt1	7-16	illitic
	Bt2	16-24	mixed
Shrouts	Ap	0-4	mixed
	Bt1	4-10	montmorillonitic
	Bt2	10-17	illitic
Vertrees	Ap	0-8	mixed
	Bt1	8-16	kaolinitic

† family mineralogy classification according to Soil Taxonomy.

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