Proposal to Simplify the Mollic Epipedon
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The objective of this proposal is to simplify the definition and the requirements for a mollic epipedon. The proposed changes with comments are in the first part, and the original text from the 12th Ed. of the Keys to Soil Taxonomy are in the second section. The second version uses a different sequence of criteria for thickness from the first version.

**Proposed definition:**

**Mollic Epipedon**

**Required Characteristics**
The mollic epipedon consists of mineral soil material in one or more subhorizons. The top is at the mineral soil surface and the bottom is the base of the deepest subhorizon that meets all requirements in part 1.

1. Subhorizons have the following properties:
   a. Have dominant color\(^1\) with:
      (1) Value 3 or less, moist and 5 or less, dry; and
      (2) Chroma 3 or less moist; and
   b. Have 0.6 percent more organic carbon than the parent material\(^2\); and
   c. Have base saturation by NH\(_4\)OAc of \(> 50\%\); and
   d. Do not occur beneath a subhorizon that is 7.5 cm or more thick has fine stratifications (5 mm or less thick) in 50% or more of the volume; and
   e. Have soil structure (or clods from plowing) in 50% or more of the volume; and
   f. Are not fluid; and
   g. Do not have an aridic soil moisture regime (or they are aridic when not irrigated); and

2. The minimum combined thickness of adjacent\(^4\) subhorizons that meet all of part 1. is 25 cm unless one of the following conditions exists:
   a. 10 cm if:
      (1) The deepest subhorizon directly overlays a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan; and
      (2) The mixed texture class of all subhorizons is finer than loamy fine sand; or
   b. 18-25 cm if any subhorizon has texture class of very fine sand, loamy very fine sand, or finer; and
(1) The thickness is 1/3 or more to the bottom of the deepest part of an argillic, glossic, kandic, natric, spodic, or cambic horizon; or
(2) The thickness is 1/3 or more to the top of the shallowest part of a duripan, identifiable secondary carbonates, or visible secondary gypsum; or
(3) The thickness is 25 cm if the organic carbon decreases irregularly with depth and there are no underlying diagnostic horizon or layers, or
(4) The thickness is 18 cm if the conditions in 2.a. or 2.b. above do not apply.

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1. The colors of the upper 18 cm are estimated as if it were physically mixed into a single plowed layer.
2. Most parent material has zero carbon, but some dark sedimentary or metamorphic rock and transported material from that rock may contain more.
3. As measured by any lab or field test approved by USDA including laboratory analysis or by proximal sensors in the field. In lieu of a measurement that is > 50%, a field estimate of base saturation > 50% can be made by one of the following: The subhorizon contains primary or secondary gypsum, anhydrite, soluble sodium salts, visible secondary carbonates; or the soil matrix is effervescent; or the pedon contains a natric horizon.
4. An albic horizon that has moist chroma of 2 or less, with lower boundary 18 cm or more below the mineral soil surface may be present in between subhorizons that meet all of the requirements for a mollic epipedon. The albic horizon thickness does not count toward the minimum thickness of the epipedon in part 2.

Justification for changes from the version in the 12th Ed. of the Keys:
1. Opening paragraph – The “mixing of the upper 18 cm” sentence is very confusing, and may lead to inconsistent application that encourages people to identify mollic epipedon based on hypothetical plowing to 18 cm. The rule was probably in place to prevent recent depositions on the surface of a mollic from disqualifying the epipedon, or to allow thin, less dark horizons over dark ones. It is more confusing when used to mix a thin dark surface into a less dark subsurface in order to meet the minimum thickness requirement. The 18 cm mixing rule was moved to a footnote for mixing of colors when a light color occurs over a darker color. Also, some people were not sure if rules 1-8 get applied to every horizon or to the whole epipedon. This could lead to circular reasoning errors, so we clarified it. The proposed rule sets color criteria for all subhorizons of the epipedon in Rule 1, and then specifies the depth requirement in Rule 2, explained by footnote 1. The order of the criteria was rearranged to be more logical.
2. Rule 1 - This is an old exception criteria mentioned in the Guy Smith interviews. Rule 1a and 1b used to be connected by “and” instead of “or” I believe. It is almost never applied in the field because if the soil has the right colors and carbon it is almost never massive. However, after the definition of massive was changed to “aggregates with diameter 30 cm or more across”, the exception is no longer used in the Central Valley of California where it was conceptualized in the USA. I could only find one soil series where the rule of massive and hard has been applied. It is the Thurber series in Texas. Thurber meets all other qualities of a mollic epipedon, but the yields are lower than all other Mollisols in the survey areas, so
the hard and massive rules were employed to keep it out of Mollisols. Thurber is classified as an Alfisol. Being hard when dry and massive criteria could be moved to become Subgroup or Series or even “Hard-setting” phase criteria because being hard and massive affects productivity of the soil, but all other properties of the mollic epipedon are still met. That would both simplify the definition and still identify the hard-setting soils on soil maps.

3. Rule 2 – We believed the term “rock structure” was unnecessary and added a bit of confusion, so we replaced it with simpler language. Requiring less than 50% rock structure also does not prevent the soil from being massive, which was not allowed in the older mollic criteria. The 7.5 cm rule is there as an upper thickness limit for recent surface erosion depositions to prevent part of the mollic from being underneath a mantle of new material, as defined in Chapter 1. Were mantle of new material defined in chapter 3, we would have said more simply that subhorizons “Do not occur under a mantle of new material”.

4. Rule 3 – Subparts 3b and 3c are exceptions to the color that could not be verified if used in any existing soil series. Their removal should not affect any existing soil series and no soil mapping. In the pedon database, there were 3309 horizons that were part of a mollic epipedon. 321 subhorizons have 15-40% CaCO₃ and are 3/3 or darker moist and have enough OC. Of those, only 2 of 321 (0.6%) would be eliminated from being part of a mollic if rule 3.b. is removed. There are 100 mollic subhorizons that have > 40% CaCO₃ and that are value 5 or darker moist and have enough OC. Of those, only 4 of (4%) that are in 3 pedons (3%) would be eliminated from being part of a mollic if rule 3.c. is removed.

5. Rule 4 – We felt that we should provide some surrogate measurements for a base saturation of 50% or more to allow field determination of that property, and did so in a footnote. We think that other surrogates should be investigated for addition since lab measurement of base saturation is seldom available and since so few soil labs are still in operation.

6. Rule 5 – the rule was complicated by rare exceptions that were probably only used for black, high carbon parent materials. In 5a, the 2.5% OC value is aligned with rule 3c for soils with 40% or more CaCO₃. We could not find any soil series that employ rule 3c or 5a. In 5b, we looked at the 0.6% threshold and almost all mollic epipedons in the part of the Eastern USA that have dark shales typically have more than 0.6% more OC than the C horizon. Rule 5a and 5b are cross-listed with color requirements and that becomes complicated.

7. Rule 6 – The language was simplified and reorganized from the original rule 6. Glossic and kandic horizon were added to the list of subsoils that could logically have a mollic epipedon above. Oxic was removed because there are no soil series or lab data pedons with an oxic and a mollic, and the combination is illogical. Fragipan was removed because only 1 soil series was found with both fragipan and mollic, and the minimum thickness of mollic is set at 25 to 50 cm, so the fragipan would never enter into the classification criteria. We added visible secondary gypsum to the list of features along with visible carbonates.

8. Rule 7 – The irrigation rule is very conceptually challenging, and difficult to apply in the field. The question is why it is needed at all, because there are relict mollic epipedons in aridic SMR. If Aridisols were allowed to have a mollic epipedon along with ochric and anthropic, the rule would not be needed. However, the rule was kept in and simplified.

9. Rule 8 – the n value rule is suggested to be replaced with the more practically-measured fluidity rating. There is a question of whether it is needed at all, since mollic epiepdons are
not found in soils that are fluid. In fact, soils that are fluid do not have structure, so if we require soil structure, we should not need to require soils to be non-fluid.

**Mollic Epipedon**

**Required Characteristics**

The mollic epipedon consists of mineral soil material and, after mixing of the upper 18 cm of the mineral soil or of the whole mineral soil if its depth to a dentic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan (all defined below) is less than 18 cm, has the following properties:

1. When dry, *either or both*:
   a. Structural units with a diameter of 30 cm or less or secondary structure with a diameter of 30 cm or less; *or*
   b. A moderately hard or softer rupture-resistance class; *and*

2. Rock structure, including fine stratifications (5 mm or less thick), in less than one-half of the volume of all parts; *and*

3. *One* of the following:
   a. *Both* of the following:
      (1) Dominant color* with a value of 3 or less, moist, and of 5 or less, dry; *and*
      (2) Dominant color with chroma of 3 or less, moist; *or*
   b. A fine-earth fraction that has a calcium carbonate equivalent of 15 to 40 percent and colors with a value and chroma of 3 or less, moist; *or*
   c. A fine-earth fraction that has a calcium carbonate equivalent of 40 percent or more and a color value of 5 or less, moist; *and*

4. A base saturation (by NH₄OAc) of 50 percent or more throughout; *and*

5. An organic-carbon content of:
   a. 2.5 percent or more if the epipedon has a color value of 4 or 5, moist; *or*
   b. 0.6 percent (absolute) more than that of the C horizon (if one occurs) if the mollic epipedon has a color value less than 1 unit lower or chroma less than 2 units lower (both moist and dry) than the C horizon; *or*
   c. 0.6 percent or more and the epipedon does not meet the qualifications in 5-a or 5-b above; *and*

6. The minimum thickness of the epipedon is as follows:
   a. 25 cm if:
      (1) The texture class of the epipedon is loamy fine sand or coarser throughout; *or*
      (2) There are no underlying diagnostic horizons (defined below) and the organic-carbon content of the underlying materials decreases irregularly with increasing depth; *or*
      (3) *Any* of the following, if present, are 75 cm or more below the mineral soil surface:
         (a) The upper boundary of the shallowest of any
identifiable secondary carbonates or a calcic horizon, petrocalcic horizon, duripan, or fragipan (defined below): and/or

(b) The lower boundary of the deepest of an argillic, cambic, natric, oxic, or spodic horizon; or

b. 10 cm if the epipedon has a texture class finer than loamy fine sand (when mixed) and it is directly above a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan; or

c. 18 to 25 cm and the thickness is one-third or more of the total thickness between the mineral soil surface and:

(1) The upper boundary of the shallowest of any identifiable secondary carbonates or a calcic horizon, petrocalcic horizon, duripan, or fragipan; and/or

(2) The lower boundary of the deepest of an argillic, cambic, natric, oxic, or spodic horizon; or

d. 18 cm if none of the above conditions apply; and

7. Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm below the soil surface is 5°C or higher, if the soil is not irrigated; and

8. The n value (defined below) is less than 0.7.