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Micropedological Features of Major Soil Groups in India

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Micropedology or soil micromorphology is the microscopic study of undisturbed soil and regolith materials, without disturbing their natural arrangement and prepared as thin sections (about 25-30 µm thick) of soil which are observed under petrographic microscopes using plane polarized light (PPL) and cross polarized light (XPL).

Micropedological features of soil

1. **Voids:** Voids are air- or water-filled pore spaces between soil particles.
- Control infiltration, aeration, water storage and root growth.
- Indicate soil structure, permeability and biological activity.
2. **Vughs:** Vughs are irregular, unconnected voids with rough walls common in clay-rich soils.
- Formed by aggregation, cementation and shrink-swell processes.
3. **Vesicles:** Vesicles are smooth-walled, rounded and unconnected pores.
- Common in arid and semi-arid soils, especially surface horizons.
- Formed by trapped air during wetting and drying.
4. **Chambers and Channels:** Vesicles connected through channels.
- Formed by roots, earthworms and other soil fauna which improve water/air movement.
5. **Plasma:** Plasma is the fine-grained soil matrix surrounding skeleton grains.
- Mainly contains **clay, OM and iron oxides**. Helps to identify **soil fabric**.
6. **Gypsum Crystals:** Secondary gypsum deposits, common in arid and semi-arid soils.
- Occur as needles, rosettes or lenticular crystals.
- Indicate gypsum accumulation and arid conditions.
7. **Planes:** Elongated voids formed by soil contraction and expansion.
- Common in Vertisols. It has two types like; Joint planes and Craze planes.
8. **Cutans:** Surface coatings deposited on peds, pores, grains, nodules or concretions.
- Formed by clay, carbonate, Fe/Mn deposition and also indicate translocation.
- Types: Argillans, Ferrans, Manganans and Calcitans.
9. **Glaebules:** Discrete pedological bodies distinguishable from the surrounding soil matrix.
- Types: **Orthic** (formed in situ) and **Anorthic** (transported or reworked).
- May contain Fe, Mn, $CaCO_3$, gypsum. Also indicate calcification and ferrugination.
10. **Pedotubules:** Tubular voids or infillings produced by roots, earthworms and soil organisms.
- Provide pathways for water, air and roots. Indicate biological activity and soil mixing.
11. **Crystallaria:** Crystal concentrations formed by precipitation of soluble minerals.
- Indicate salinization and calcification, especially in dry regions.

Major soil groups in India

- USDA Soil Taxonomy has classified **12 Soil Orders**: Aridisols, Vertisols, Alfisols, Gelisols, Andisols, Mollisols, Inceptisols, Histosols, Oxisols, Ultisols, Spodosols, Entisols.

Method of preparation of thin section of soil

Important terminologies

1) Skeleton Grains:

Skeleton grains are coarse mineral particles (>20 µm) that form the framework or "skeleton" of soil and are embedded in fine-grained plasma. They are mainly composed of quartz, feldspars, mica and heavy minerals. They influence soil texture, porosity, drainage and weathering processes and are classified into mineral and organic skeleton grains.

2) S-Matrix (Plasma):

The S-matrix or plasma is the fine-grained material (<20 µm) that surrounds and binds skeleton grains and pores and consists mainly of clay minerals, organic matter, Fe and Al oxides. It controls soil colour, structure and water- and nutrient-holding capacity.

3) Plasmic Fabric in Soil Micromorphology:

Plasmic fabric refers to the arrangement and orientation of the fine soil material, especially clay minerals, as observed under polarized light in a soil thin section. Types:

1. Asepic Fabric - Plasma shows no definite arrangement, particles randomly distributed.
2. Sepic fabric - Plasma is oriented/arranged around grains, pores or peds.
3. Skelsepic fabric - Plasma is oriented around skeleton grains.
4. Masepic Fabric - Plasma is arranged around soil aggregates (peds).
5. Maskelsepic Fabric - Plasma is arranged around both coarse grains and soil aggregates.
6. Mosepic fabric - Weak or partial orientation of plasma.
7. Omnisepic fabric - Strong orientation throughout the plasma.
8. Argillasepic fabric - Orientation caused by illuviated clay.
9. Silasepic fabric - Orientation associated with silt-rich material.

4) Related Distribution (Relative Distribution) in Soil Micromorphology:

It refers to the spatial arrangement and relationship between skeleton grains, plasma and voids within the soil groundmass as observed in a thin section. Types:

1. Porphyric - Skeleton grains embedded in a continuous plasma matrix.
2. Enaulic - Skeleton grains surrounded by aggregates of plasma.
3. Gefuric - Skeleton grains connected by bridges of plasma.
4. Chitonic - Plasma forms thin coatings around skeleton grains.
5. Monic - Skeleton grains occur with little or no plasma between them.

1) Diagnostic Micropedological Features of Entisols:

Micropedological Feature	Characteristics of Entisols
Skeleton Grains	Dominated by quartz, feldspars, micas and carbonates
S-Matrix (Plasma)	Sparse and weakly developed; skeleton grains dominate.

Micropedological Feature	Characteristics of Entisols
Related Distribution	Mainly monic-chitonic to gefu-chitonic
Plasmic Fabric	Asepic, skelsepic or maskelsepic fabric common.
Soil Structure	Apedal to weakly pedal structure.
Void System	Abundant vughs, packing voids and root channels.
Sedimentary Features	Stratification and lamination commonly preserved.
Clay Features	Weak or discontinuous argillans and ferri-argillans.
Carbonate Features	Carbonate nodules, calcitans and neocalcitans are common.
Salt Features	Salt crystals may occur in arid Entisols.
Biological Features	Root channels, pedotubules and faunal excrements present.
Pedogenic Development	Very weak; parent material features dominate.

2) Diagnostic Micropedological Features of Inceptisols:

Micropedological Feature	Characteristics of Inceptisols
Skeleton Grains	Quartz, feldspars and micas common.
S-Matrix (Plasma)	More abundant and developed than in Entisols.
Related Distribution	Enaulic, porphyric to chitonic related distribution common.
Plasmic Fabric	Asepic, masepic, skelsepic and insepic fabrics
Soil Structure	Weak to moderate subangular blocky (pedal) structure.
Void System	Vughs, channels, packing voids and planar voids common.
Pedogenic Features	Initial horizon differentiation, moderate pedogenic alteration.
Clay Features	Weak to moderate argillans and ferri-argillans may occur.
Iron Features	Ferrans, ferri-argillans and Fe-Mn nodules present.
Carbonate Features	Carbonate nodules and calcitans may occur in Inceptisols.
Biological Features	Root channels, pedotubules and faunal excrements common.
Weathering Status	Moderate weathering and mineral transformation evident.
Pedogenic Development	Weak-moderate profile development with cambic (Bw) horizon.

3) Diagnostic Micropedological Features of Vertisols:

Micropedological Feature	Characteristics of Vertisols
Skeleton Grains	Dominated by fine clay matrix with quartz and feldspar grains.
S-Matrix (Plasma)	Dense, dark-colored plasma rich in smectitic clay minerals.
Related Distribution	Porphyric to enaulic related distribution commonly observed.
Plasmic Fabric	Predominantly insepic, masepic and vosepic fabric.
Soil Structure	Angular to subangular blocky structure with wedge-shaped peds.
Void System	Planar voids, channels, vughs are abundant.
Pedogenic Features	Strong pedoturbation and self-mulching characteristics.
Clay Features	Argillans generally disrupted by pedoturbation.
Pressure Features	Stress cutans, striated b-fabric and slickensides are diagnostic.
Carbonate Features	Carbonate nodules, calcitans accumulations common.
Biological Features	Root channels, pedotubules and faunal excrements present.
Weathering Status	Moderate weathering, dominance of expanding 2:1 clay mineral.
Pedogenic Development	Strong profile mixing due to shrink-swell activity.

4) Diagnostic Micropedological Features of Alfisols:

Micropedological Feature	Characteristics of Alfisols
Skeleton Grains	Quartz, feldspars and resistant minerals common.
S-Matrix (Plasma)	Brown, reddish-brown or yellowish-brown due to Fe oxides.
Related Distribution	Porphyric, chitonic and gefuric related distribution common.
Plasmic Fabric	Skelsepic, argillasepic, masepic and insepic fabrics.
Soil Structure	Moderate to strong subangular or angular blocky structure.
Void System	Channels, vughs, planar voids and packing voids common.
Pedogenic Features	Well-developed horizon differentiation (prominent Bt horizon).
Clay Features	Abundant argillans on ped surfaces, pores and channels.

Micropedological Feature	Characteristics of Alfisols
Iron Features	Ferri-argillans, ferrans and Fe-Mn nodules commonly present.
Carbonate Features	Usually absent in upper horizons; may occur in lower horizons.
Biological Features	Root channels, pedotubules and faunal excrements common.
Weathering Status	Moderate weathering with active clay translocation.
Pedogenic Development	Well-developed profile showing significant illuviation.

5) Diagnostic Micropedological Features of Ultisols:

Micropedological Feature	Characteristics of Ultisols
Skeleton Grains	Dominated by resistant minerals: Quartz, Zircon, Tourmaline, Rutile. Feldspars and micas are highly weathered or absent.
S-Matrix (Plasma)	Abundant, plasma rich in kaolinitic clay and sesquioxides.
Related Distribution	Predominantly porphyric, chitonic and gefuric related distribution.
Plasmic Fabric	Argillasepic, skelsepic, masepic and insepic fabrics common.
Soil Structure	Moderate to strong subangular and angular blocky structure.
Void System	Channels, vughs, planar voids and compound packing voids.
Pedogenic Features	Strong horizon differentiation, well-developed kandic horizon.
Clay Features	Abundant argillans, ferri-argillans along ped faces and channels.
Iron Features	Ferrans, Fe-Mn nodules and sesquioxide accumulations common.
Carbonate Features	Generally absent due to extensive leaching.
Biological Features	Root channels, pedotubules and faunal excrements present.
Weathering Status	Highly weathered with depletion of weatherable minerals.
Pedogenic Development	Strongly developed profile with intense eluviation and illuviation.

6) Diagnostic Micropedological Features of Aridisols:

Micropedological Feature	Characteristics of Aridisols
Skeleton Grains	Dominated by quartz, feldspars and other primary minerals.
S-Matrix (Plasma)	Weakly developed plasma due to limited pedogenic activity.
Related Distribution	Chitonic and enaulic distributions dominate. Porphyric distribution occurs in clay-enriched natric horizons.
Plasmic Fabric	Asepic, skelsepic and masepic fabrics commonly observed.
Soil Structure	Apedal to weakly developed subangular blocky structure.
Void System	Packing voids between sand grains. Vughs common in calcic and gypsic horizons. Vesicular pores often develop near the soil surface under desert conditions.
Pedogenic Features	Accumulation of carbonates, gypsum and soluble salts.
Clay Features	Weak argillans (clay coatings) may occur in older Aridisols; clay illuviation generally limited.
Carbonate Features	Abundant calcitans, neocalcitans, carbonate nodules and petrocalcic horizons.
Gypsum Features	Gypsans, gypsum crystals and petrogypsic horizons present.
Salt Features	Halite and other soluble salt crystals frequently occur.
Biological Features	Root channels and pedotubules present but generally less abundant than humid-region.
Weathering Status	Weakly weathered due to low rainfall and limited leaching.
Pedogenic Development	Calcification, gypsification and salinization processes dominant.

7) Diagnostic Micropedological Features of Mollisols

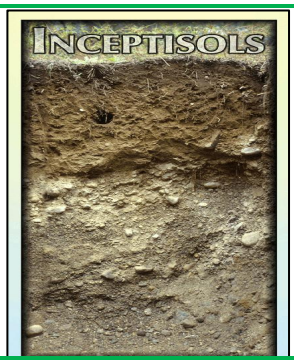
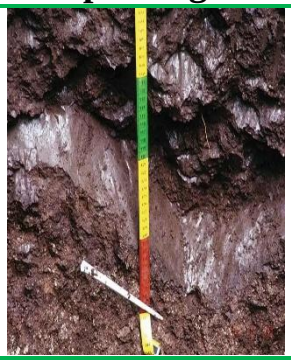
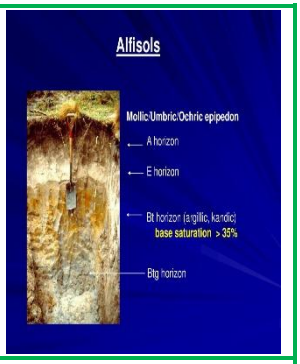
Micropedological Feature	Characteristics of Mollisols
Skeleton Grains	Quartz, feldspars and resistant minerals common.
S-Matrix (Plasma)	Dark-colored plasma enriched with humified organic matter. Also consists of clay minerals, iron oxides, calcium-rich compounds.

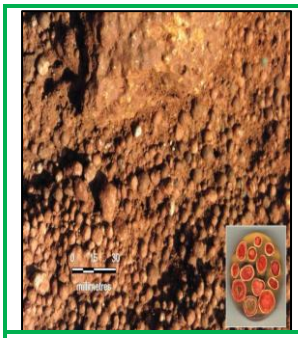
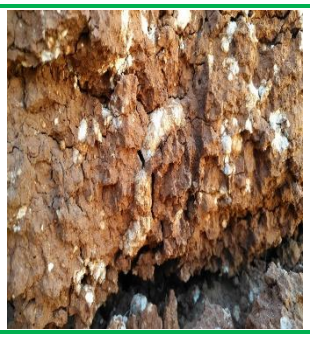
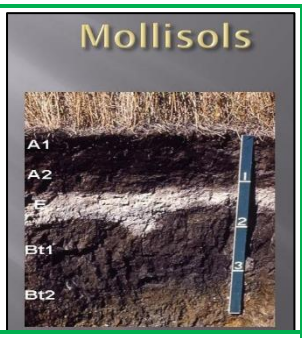
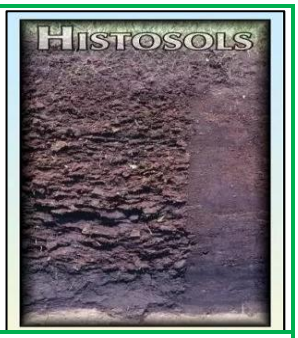
Micropedological Feature	Characteristics of Mollisols
Related Distribution	Enaulic and porphyric distributions are common.
Plasmic Fabric	Masepic, insepic and skelsepic fabrics commonly observed.
Soil Structure	Moderate to strong granular, crumby and subangular blocky structure.
Void System	Abundant channels and chambers created by roots and earthworms. Vughs, biological pores and interconnected pores produce high porosity and aeration.
Pedogenic Features	Thick, dark mollic epipedon with strong biological activity.
Clay Features	Weak to moderate argillans may occur in Bt horizons.
OM Features	High humus content; organic coatings and dark plasma common.
Carbonate Features	Carbonate nodules and calcitans often present in subsoil.
Biological Features	Root channels, pedotubules and faunal excrements abundant.
Weathering Status	Moderately weathered with active nutrient cycling.
Pedogenic Development	Strong melanization and biological mixing dominant.

8) Diagnostic Micropedological Features of Histosols:

Micropedological Feature	Characteristics of Histosols
Organic Constituents	Dominated by partially to highly decomposed plant residues and organic matter.
S-Matrix (Plasma)	Organic plasma predominates over mineral material.
Skeleton Grains	Mineral grains are few and generally consist of quartz and resistant minerals.
Related Distribution	Enaulic and porphyric related distribution common where mineral material occurs. Transition from fibric to sapric material reflects increasing decomposition.
Plasmic Fabric	Omnisepic, masepic and insepic organic fabrics
Soil Structure	Massive, granular or weakly developed pedal structure.
Void System	Abundant channels, chambers, vughs and compound packing voids. Very high total porosity and water-holding capacity.
Pedogenic Features	Accumulation of organic residues due to slow decomposition.
Organic Features	Fibric, hemic and sapric materials commonly present.
Redox Features	Grey and bluish-grey matrix colour and iron mottles may occur under waterlogged condition. Localized ferrans and mangan nodules around root channels.
Biological Features	Root channels, faunal excrements and decomposed plant tissues abundant.
Weathering Status	Mineral weathering is limited; O.M. transformation dominates.
Pedogenic Development	Profile development controlled mainly by organic matter accumulation and decomposition.

Soil Orders and Their Characteristic Micropedological Features

			
Image of a young **Entisol** with minimal pedogenic features	Weakly developed subsurface (**cambic**) horizon	Slickensides in Black Soil (**Vertisol**)	**Alfisol** Bt horizons with evidence of clay illuviation.

			
lateritic concretions formed in a **Ultisols**	Calcic nodules in **Aridisols**	**Mollisol** Soil Profile	**Histosols** Soil Profile

Minor Soil Orders of India and Their Micropedological Features:

Soil Order	Key Micropedological Features	Occurrence in India
Oxisols	Ferrans, Fe-Al rich plasma	Very rare (<0.1%)
Spodosols	Organic-Fe-Al coatings, spodic horizon	Extremely rare (<0.1%)
Andisols	Volcanic glass, allophane, porous fabric, low B.D.	Very limited (<0.1%)
Gelisols	Cryoturbation features, frost cracks, ice lenses	High Himalayas (<0.1%)

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