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Micromorphology of the Diagnostic Horizons of Aridisols of Western Rajasthan

J S Choudhari
Central Arid Zone Research Institute, Jodhpur–342 003 India

Abstract The micromorphology of the diagnostic horizons of the Aridisols of western Rajathan were studied to characterize pedofeatures. The Ochric epipedon do not show any pedofeatures except coatings and mica phantoms. The Cambic horizon in sandy soils showed partially weathered grains of weatherable minerals and channel infillings, whereas moderately fine textured soils showed textural pedofeatures as well as phantoms of mica and feldspars. Argillic horizon showed illuvial clay as specks in voids and as poorly laminated in channel and vughs. The Calcic horizon showed calcitic pedofeatures of varying morphology, as channel infillings, micronodules and pure crystalliitic nodules with and without iron oxide impregnation.

Key words Micromorphology, Cambic horizon, Argillic horizon, Calcic horizon, Aridisols, Pedofeatures

In Aridisols, Nettleton *et al.* (1975), Brewer and Walker (1969) reported the presence of textural B horizon, whereas Goudie (1973), Dan (1984) observed calcic horizon rich in alkaline earth carbonates. West *et al.* (1987) observed grain cutans, ferriargillans in B horizon of sandy soil, having a clay increase in B horizon sufficient to meet the requirement of an argillic horizon in Aridisols of Sahelian desert. Fedoroff and Courty (1987) observed micropans, clay coatings, infillings and intercalations in the horizons of northwest Indian and Sahel desert soils.

Choudhari (1982) observed varying degree of expression of morphological pedofeatures in diagnostic horizons of Aridisols of western Rajasthan formed on different topography, parent material and time. The micromorphological characterization of the diagnostic horizons of arid region soils of western Rajasthan is thus subject of this paper.

Materials and Methods

Peds from different horizons of Aridisols occurring on different landforms and showing varying degree of pedogenic manifestations (Table 1) studied earlier (Choudhari 1982) for their characterization and genesis were collected. Thin sections were prepared (Choudhari 1990) and described following the terminology of Bullock *et al.* (1985).

Table 1 *Site characteristics and degree of pedogenetic manifestation in Aridisols of western Rajasthan*

Characteristics	P1	P2	P3	P4
Landfrom unit	Interdunal plain	Hummocky plain	Accumulative plain	Flat plain
Parent material	Aeolian	Coarse older alluvium	Limestone allluvium	Granite alluvium
Soil classification	Typic Torripsamment	Typic Camborthid	Typic Calciorthid	Typic Haplargid
Diagnostic horizon	No	Cambic, Calcic	Cambic, Calcic	Argillic, Calcic
Degree of manifestations				
Segregation of lime	None	Moderate	Strong	Strong
Pedality	Nil	Weak	Moderate	Moderate
Chroma development	Nil	Weak	Strong	Strong
In situ weathering	Nil	Very weak	Weak	Moderate
Illuviation of clay	Nil	Nil	Nil	Slight

Results and Discussion

Ochric epipedon

Epipedon of dune field and sandy plain soils which is sandy, single grained, loose, and yellowish brown showed loosely arranged fine sand grains with very little fine material in intergrain spaces. Grains are loosely packed and few grains are very thinly coated with yellowish brown clayey mass. Presence of thick epipedons in sandy soils, however, complicates the micromorphological evaluation. The upper part is loose sand, whereas lower part of P2 epipedon have bridged grain structure with few grains partially coated with yellowish brown plasma and calcite crystals. The ochric epipedon of Calciorthid and Haplargid (P3 & P4) which is loam, moderately subangular blocky, brownish showed microstructure with randomly distributed smooth walled channels and few mica phantoms. The lower part of P4 epipedon, showed remnants of grain argillans.

Cambic horizon

Related distribution (c/f 20) pattern in the B horizon (Cambic) of P2 is gefuric (Fig 3), whereas in P3 it is chittonic. Porosity consists of irregularly shaped vughs about 350-1200 mμ and channels of 100-500mμ in diameter. The skeleton grains are dominantly quartz. Few phantoms of weatherable minerals like plagioclase and biotite were encountered. Comparatively more developed Cambic horizon of P3 showed granular microsturcture and porphyric relative distribution pattern consisting of embeded grains of quartz, cross linearally altered feldspars (Fig.2) and parallel linearly altered mica flakes (Fig.1)

Argillic horizon

Microscopic features of weakly developed agrillic horion (B22t) of P4 showed the textural pedofeatures which are characterized by embeded argillans and illuvial clay coatings associated with channels, pores, vughs and skeleton grains, as specks and optically oriented microlaminations (Fig.4,6). Natric horizon formed in soils occupying low position in coarse textured alluvial plains showed crescentic clay coatings and laminated yellowish brown argillans in biopores and channels (Fig. 4). However, few loose continuous infillings with silt, clay, and calcite in root channels were also observed (Fig.5).

Calcic horizon

Calcic horizon, one of the characteristic horizon in Aridisols, occurs in the lower part of the pedon, generally in the C horizon. The upper part of calcic layer i.e. C horizon, show groundmass fabric similar to B, except calcitic coatings (Fig.7), infillings (Fig. 8) of microsparitic calcite crystals and few fine rounded to subrounded pure microsparitic calcitic nodules. In the lower part of the calcic layer, larger sized lime segregates (concretions and nodules) of crystalline, amiboidal shaped and subrounded predominates, although finer size lime nodules do present in the matrix.

The segregates varied in the microfabric and crystallinity. The segretates of P2 showed porous groundmass (30-40% skeleton grains) with braces of sparitic and larger calcitic crystals partially bridging the interstitial spaces between the coarser particles (Fig.9). Few showed sparitic calcite crystals radially oriented around skeleton grains (Fig. 10). The nodules of P3 and P4 had complex internal fabric comprising an inner very dense part and channels infilled with sparitic calcitic crystals (Fig. 11). The outerpart has more skeleton grains and impregnated with iron oxides.

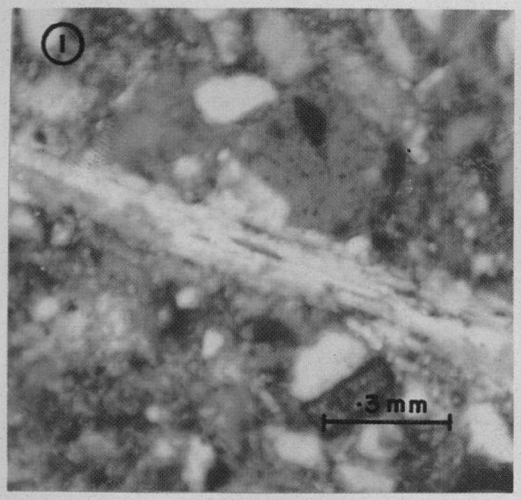
The microsegregates in the calcic horizon of P2 showed a diffuse to gradual boundary with soil matrix, and mineral particles of similar size and mineralogy to that of soil and crystallized calcite around grains and in voids (Fig. 9).

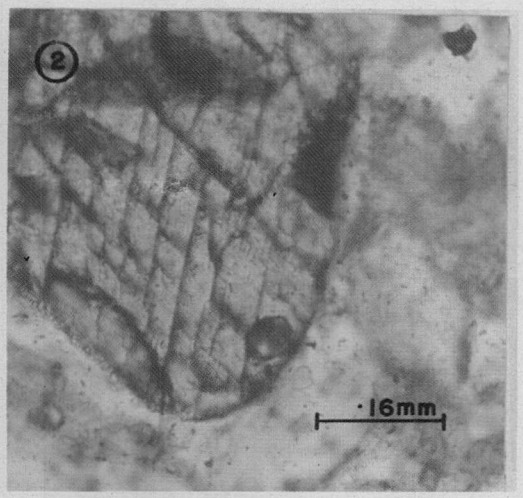
Microsegregates of the waterlogged soils are smaller, dense and have impregnation of oxides (Fig. 12).

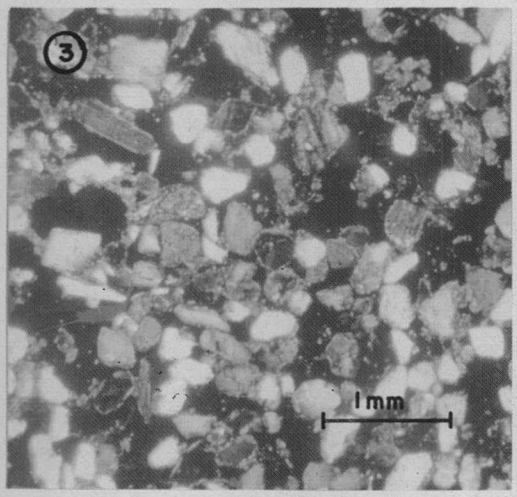
Weathering of primary minerals

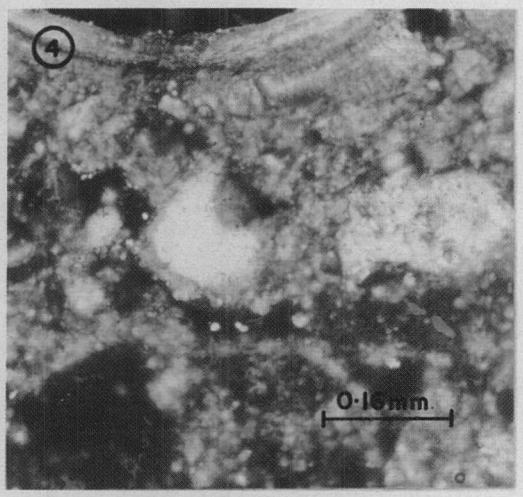
From the C to B horizon the degree of the weatherable primary minerals increase quite markedly. Micromorphological observations suggest that many of the phantoms and clay nodules in the B12 horizon are weathered remnants of biotite and feldspar grains. Biotite on weathering frequently appears to alter via parallel linear alteration in the C and B horizons (Stoops *et al.* 1979) to form strong continuously oriented phantoms in the lower B horizon.

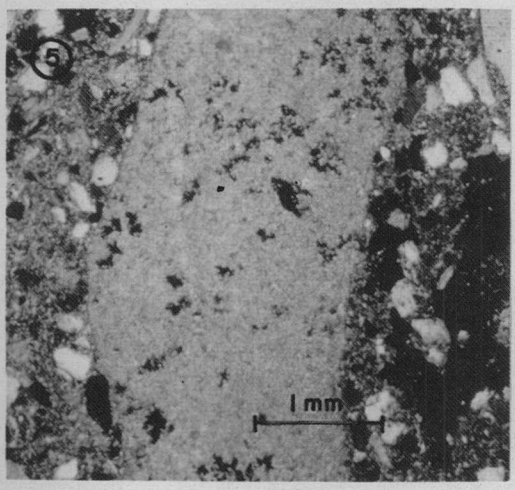
The void argillans observed in the B horizon, indicate that some illuviation of clay from A to B horizon has occured. The increased fine clay in the











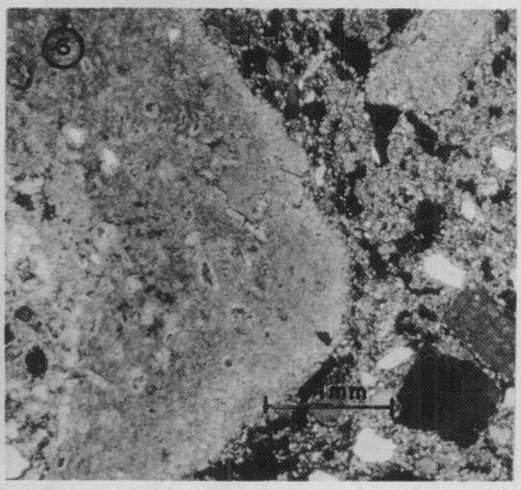


Fig 1 Partially weathered elongated mica showing parallel linear alteration pattern in Cambic horizon of P3. XP, X63. **Fig 2** Cross linear alteration pattern on plagioclase mineral coated with yellowish brown plasma in Cambic horizon of P3. XP, X125. **Fig 3** Gefuric related distribution pattern in Cambic horizon of sandy soil (P2) with fresh as well as partially weathered mica grains. XP, X20. **Fig 4** Laminated argillans in a biopore in the Natric horizon. XP, X125. **Fig 5** Loose continous infilling of microagregates consists of silt, clay and calcite crystals in the root chennel of Playa soil. XP, X20. **Fig 6** Speckled fine materials in Argillic horizon of P4. (Brownish). XP, X20.

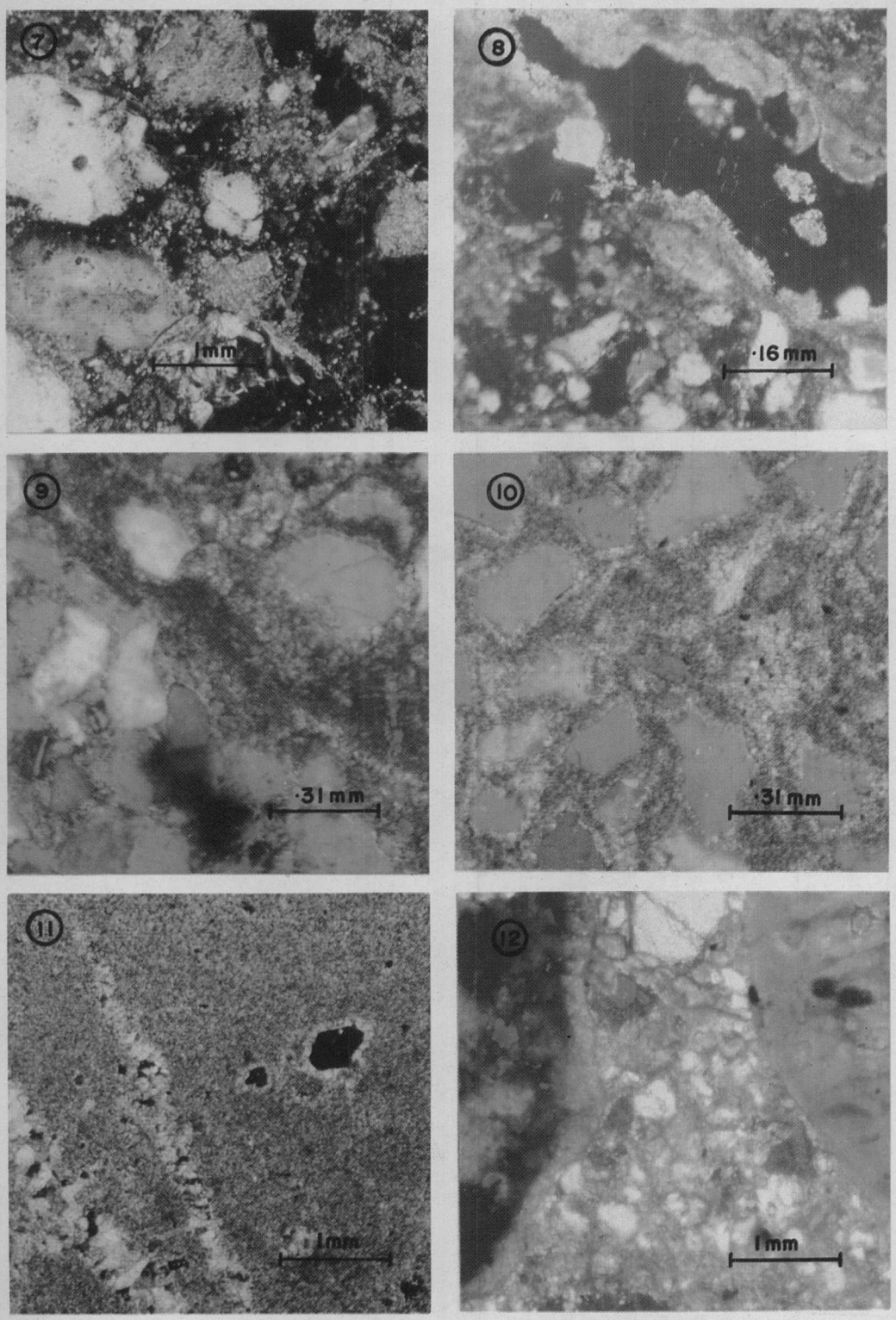


Fig 7 Calcite fabric consisting of sparitic calcite randomly dispersed and around skeleton grains in upper part of C horizon of P2. XP, X20. **Fig 8** Microsparitish calcite crystals as hypocoatings and coatings in channles of C horizon of P2. XP, X25. **Fig 9** Secondary $CaCO_3$ impregnated crystallitic pedofeatures having detrital grains in C horizon of P2 XP, X63. **Fig 10** Simple internal porous fabric of a soft lime nodule consisting of randomly packed micritic crystals radially crystallized around skeleton grains in lower part of C horizon of P2. XP, X63. **Fig 11** Internal fabric of a hard nodule of P3 with sparitic and larger crystals in voids and channel. XP, X20. **Fig 12** Crystallitic calcitic nodules with and without Fe impregnations in lower $CaCO_3$ horizon of P2. XP, X20.

Table 2 *Some important morphological and physico- chemical characteristics of the diagnostic horizons of soils*

Pedon No.	Horizon	Depth cm	Colour	Texture	Structure	Reaction	Silt %	Clay % Coarse	Clay % Fine	pH	EC dSm^{-1}	CEC cmol (p) kg^{-1}
P1	AP	0–30	YB	s	sg	+	5.3	2.4	1.3	8.3	0.16	3.9
	C2	66–120	PB	s	sg	+	5.9	2.9	1.5	8.4	0.13	5.7
	C3	120–50	PB	s	sg	+	7.1	3.0	2.1	8.7	0.23	6.2
P2	AP	0–10	DB	fs	sg	–	5.4	2.2	1.4	8.4	0.12	5.4
	B21	35–68	DYB	fsl	F_{lsbk}	+	10.7	6.9	1.8	8.4	0.18	5.3
	B22	68–95	B	fsl	M_{lsbk}	+	8.8	8.3	2.0	8.2	0.31	5.1
	C2ca	135–200	PB	fsl	Massive	++	9.5	8.6	2.0	8.4	0.26	6.0
P3	AP	0–20	DYB	l	$M_{2}sbk$	+	20.3	7.5	10.1	8.1	0.31	13.1
	B22	20–46	B	Cl	$C_{2}sbk$	++	16.4	13.6	19.4	8.3	0.22	16.8
	B22ca	46–78	B	Cl	M_{lsbk}	++	16.1	11.8	17.6	8.2	0.35	15.9
	C1ca	78–110	YR	Cl	massive	+++	20.8	17.8	16.2	8.2	0.35	13.8
P4	AP	0–20	B	sil	M2 sbk	–	38.6	18.5	10.4	8.1	1.02	18.3
	B22t	20–35	DB	sicl	M2 sbk	++	37.2	22.3	20.4	8.0	0.71	23.0
	B23t	35–50	DG	sicl	C2 sbk	++	30.9	21.4	11.2	8.0	0.81	20.6
	C1ca	50–80	B	g sicl	Massive	+++	–	–	–	8.0	–	–

B 22t horizon (Table 2) of P4 further support clay translocation.

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