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CHERNOZEMS (CH)

The Reference Soil Group of the Chernozems accommodates soils with a thick black surface layer that is rich in organic matter. Russian soil scientist Dokuchaev coined the name “Chernozems” in 1883 to denote the typical “zonal” soil of the tall grass steppes in continental Russia. Some international synonyms: ‘Calcareous Black Soils’, ‘Eluviated Black Soils’ (Canada), and (several suborders of) ‘Mollisols’ (USDA Soil Taxonomy).

Definition of Chernozems

Soils having
1 a mollic horizon with a moist chroma of 2 or less if the texture is finer than sandy loam, or less than 3.5 if the texture is sandy loam or coarser, both to a depth of at least 20 cm, or a mollic horizon which has these chromas directly below a plough layer; **and**
2 concentrations of secondary carbonates starting within 200 cm from the soil surface; **and**
3 no petrocalcic horizon between 25 and 100 cm from the soil surface; **and**
4 no secondary gypsum; **and**
5 no uncoated silt and sand grains on structural ped surfaces.

Common soil units:
Chernic, Vertic, Gleyic, Calcic, Luvic, Glossic, Siltic, Vermic, Haplic.

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Summary description of Chernozems

Connotation: black soils rich in organic matter; from R. chern, black, and zemlja, earth or land.

Parent material: mostly eolian and re-washed eolian sediments (loess).

Environment: regions with a continental climate with cold winters and hot summers; in flat to undulating plains with tall-grass vegetation (forest in the northern transitional zone).

Profile development: AhBC-profiles with a dark brown to black mollic surface horizon over a cambic or argic subsurface horizon; commonly with redistribution of calcium carbonate to a calcic horizon or pockets of secondary carbonates in the subsurface soil.

Use: the high natural fertility of Chernozems and their favourable topography permit a wide range of agricultural uses including arable cropping (with supplemental irrigation in dry summers) and cattle ranging.

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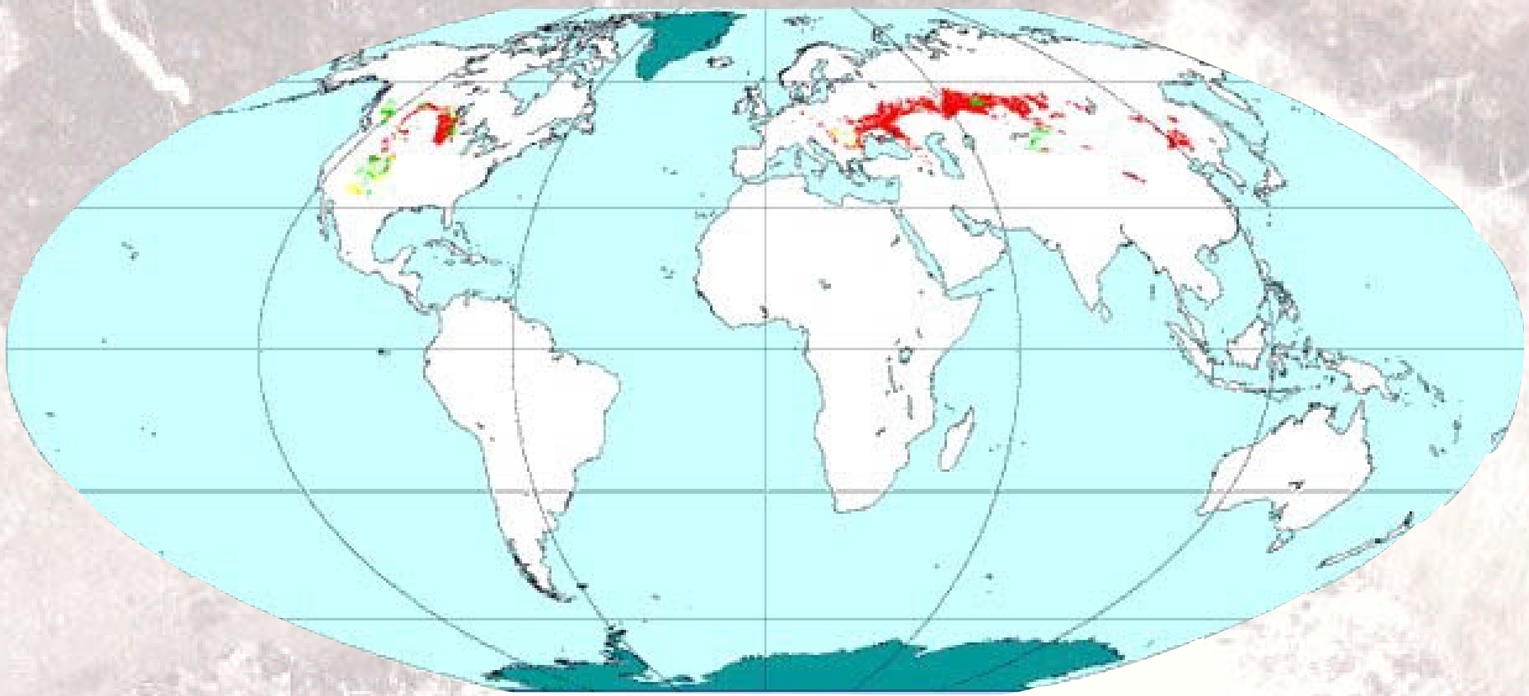
Regional distribution of Chernozems

Chernozems cover an estimated 230 million hectares worldwide, mainly in the middle latitude steppes of Eurasia and North America, north of a zone with Kastanozems. Figure 1 presents an overview of their main areas of occurrence.



🟥 Dominant 🟩 Associated 🟨 Inclusions 🟦 Miscellaneous lands

Figure 1. Chernozems worldwide.

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Associations with other Reference Soil Groups

Chernozems in Russia (north of the Ural range) and in North America are associated with Luvisols, Albeluvisols and Greyic Phaeozems towards the cool northern border of the steppe zone and grade into Kastanozems towards the warm and dry south. Where the Chernozem belt borders on warm, humid regions, Chernozems grade into Phaeozems.

Genesis of Chernozems

The ‘typical’ Chernozem formed in uniformly textured, silty parent material (loess), under tall-grass vegetation with vigorous growth. The above ground biomass amounts to some 1 to 1.5 tons of dry matter per hectare; the corresponding root mass, already incorporated in the soil, weighs 4 to 6 tons/hectare. The main concentration of roots is in the upper 60 cm of soil, with 80 percent of all roots concentrated in the top 30 to 40 cm.

Deep, humus-rich Chernozems occur in the central part of the steppe zone where the annual precipitation sum is approximately equal to the evaporation sum. Such soils contain 10 to 16 percent organic matter in their surface layers, are neutral in reaction (pH 7.0, and around 7.5 in the subsoil), and highly saturated with bases. Soil fauna is very active in Chernozems, in wet periods predominantly in the upper 50-cm layer but the animals move to deeper strata at the onset of the dry period. Vermic Chernozems consist for the greater part of worm casts, a stable mixture of mineral and organic soil material. Burrowing small vertebrates contribute significantly to intense homogenization (‘*bioturbation*’) of the soil. Animal burrows that became filled-in with humus-rich surface soil stand out as black ‘krotovinas’ (from R. krot, a Eurasian mole, *Talpa europaea*) against the typically cinnamon coloured deeper soil matrix.

The high porosity and favourable structure of the deep, homogenized Ah-horizon explain why deep percolation of rainwater during wet spells is sufficient to flush virtually all readily soluble salt from the soil. There may be some accumulation of gypsum at a depth of 2 to 3 meters from the soil surface (1.5 to 2.5 m in southern Chernozems), and accumulation of lime at a shallower depth, say at about 1 metre from the soil surface. A '*dead dry horizon*' may exist at a depth of about 4 metres, deeper in the north of the Chernozem belt and closer to the surface in the south. This soil layer receives neither percolation water from above nor capillary rise from below. The dead dry horizon needs not to be continuous; its thickness varies and it can even be absent altogether.

Migration of clay has resulted in slightly increased clay contents between 50 to 200 cm from the surface in many Chernozems in the central steppe zone. This also suggests that central Chernozems are exposed to moderately strong leaching during wet periods.

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Towards the northern fringe of the Chernozem belt, the surface horizon becomes shallower, more acid (pH 6-6.5) and more greyish until signs of podzolization such as an ash-grey eluvial subsurface horizon and/or horizontal lamellae in the subsoil become evident. In northern Chernozems, the horizon with carbonate accumula-tion is normally separated from the humus-rich surface layer by a carbonate-free layer of appreciable thickness.

Towards the southern fringe of the steppe zone, the water regime becomes more and more intermittent, with increasingly longer dry periods. Consequently, plants with a long vegetative period disappear and xerophytes and ephemeral grasses move in. Also, the soil's humus undergoes more intense mineralization and there is an increase in the content of readily soluble salts in the surface soil.

Note that the colour of the surface soil has diagnostic value: where the chroma of the upper 20 cm of soil has become more than 2, this is seen as a sign that aridity is so severe that the soils are no longer true Chernozems. They are then classified as Kastanozems.

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Characteristics of Chernozems

Morphological characteristics

Virgin Chernozems have a thin leafy litter layer on top of a dark grey to black, crumb, ‘vermic’ Ah-horizon. The surface horizon can be only 20 cm thick but extends down to a depth of more than 2 metres in well-developed Chernozems. Worm casts and krotovinas testify of intense faunal activity. Calcium carbonate accumulation is common in the lower part of the surface soil, evident from pseudomycelium and/or nodules of secondary carbonates in a brownish grey to cinnamon subsoil. The subsurface horizon has a blocky or weakly prismatic structure.

The grass vegetation grades into deciduous forest towards the north of the Chernozem belt where the Ah-horizon can overly an argic B-horizon (Luvic Chernozems) or may even penetrate the B-horizon with tongues that are deeper than wide (Glossic Chernozems). There, Chernozems grade into Luvisols or Albeluvisols. Many Chernozems in wet areas develop signs of hydromorphy (Gleyic Chernozems, known as ‘Meadow Chernozems’ in Russia and most of Eastern Europe).

Mineralogical characteristics

The mineral composition of Chernozems is rather uniform throughout the profile, in line with the high rate of homogenization of the soil material. The SiO_2/R_2O-ratio is high, at about 2.0.

Hydrological characteristics

Although it is widely accepted that Chernozems formed under conditions of good drainage, there are also (Russian) soil scientists who maintain that certain Chernozems passed through a boggy phase of soil formation. Today’s Chernozems are well drained, apart from soils in depressions with occasional shallow groundwater. By and large, there is approximate equity between the annual precipitation sum and evaporation, with a slight precipitation surplus in the north of the steppe zone and a slight deficit in the south. Table 1 presents an overview of the occurrence of Eurasian steppe soils in relation with the annual precipitation sum and the type of vegetation.

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Table 1. Typical Reference Soil Groups in the Eurasian steppe zone.

Temperature	Precipitation	Vegetation	Reference Soil Group / Unit
increase V	> 550 mm	deciduous forest	Luvisols, Albeluvisols, Phaeozems
	500 mm	**steppe and forest**	**Luvic Chernozems**
	500 mm	**tall grass steppe**	**Haplic Chernozems**
	450 mm	**tall grass steppe**	**Calcic Chernozems**
	200-400 mm	medium height grass steppe	Kastanozems
	< 200 mm	open vegetation	Calcisols

Physical characteristics

Chernozems possess favourable physical properties. The total pore volume of the Ah-horizon amounts to 55 to 60 volume percent and lies between 45 and 55 percent in the subsoil. The soils have good moisture holding properties; reported soil moisture contents of some 33 percent at *field capacity* and 13 percent at *permanent wilting point* suggest an 'available water capacity’ of some 20 volume percent. The stable micro-aggregate structure (‘crumb’) of the humus-rich Ah-horizons ensures a favourable combination of capillary and non-capillary porosity and makes these soils suitable for irrigated farming.

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Chemical characteristics

Chernozem surface soils contain between 5 and 15 percent of 'mild' humus with a high proportion of humic acids and a C/N-ratio that is typically around 10. The surface horizon is neutral in reaction (pH 6.5-7.5) but the pH may reach a value of 7.5-8.5 in the subsoil, particularly where there is accumulation of lime. Chernozems have good natural fertility; the surface soil contains 0.2-0.5 percent nitrogen and 0.1 to >0.2 percent phosphorus. This phosphorus is only partly 'available'; crops on Chernozems tend to respond favourably to application of P-fertilizers. In southern Chernozems, the humus contents are lower (4-5 percent) and consequently also the cation exchange capacity: 20-35 cmol(+)/kg dry soil, versus 40-55 cmol(+) per kg in central Chernozems. Normally, the base saturation percentage is close to 95 percent with Ca^{2+} and Mg^{2+} as the main adsorbed cations but sodium adsorption may be high in southern Chernozems.

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Management and use of Chernozems

Russian soil scientists rank the deep, central Chernozems among the best soils in the world. With less than half of all Chernozems in Eurasia being used for arable cropping, these soils constitute a formidable resource for the future.

Preservation of the favourable soil structure through timely cultivation and careful irrigation at low watering rates prevents ablation and erosion. Application of P-fertilizers is required for high yields. Wheat, barley and maize are the principal crops grown, alongside other food crops and vegetables. Part of the Chernozem area is used for livestock rearing. In the northern temperate climatic belt, the possible growing period is short and principal crops grown are wheat and barley, in places in rotation with vegetables. Maize is widely grown in the warm temperate belt. Maize production tends to stagnate in drier years unless the crop is adequately irrigated.