Soil Brief CN 8

PEOPLE'S REPUBLIC OF CHINA

Reference soils of the Red Basins of Jiangxi Province

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ISSAS

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ISRIC Soil Monoliths:

Number	*FAO (1988)*	*Soil Taxonomy (1992)*
CN 21	Haplic Acrisol	Udic Kandiustult
CN 22	Ferric Alisol	Typic Paleustult
CN 23	Dystric Cambisol	Dystric Ustochrept
CN 24	Ferric Alisol	Anthraquic Hapludalf
CN 25	Haplic Acrisol	Typic Paleustult

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CONTENTS

ABSTRACT

Five representative soils, located on an intermontane plain, forming part of the so-called Red Basins of SE China were studied for the establishment of a Chinese soil reference collection. Four sites are located near the Red Soil Ecological Station at Yingtan and one site is near lake Poyang. Soil description and sampling were carried out within the framework of a cooperation programme supported by the European Community, between the "Institute of Soil Science of the Academia Sinica" and the "International Soil Reference and Information Centre".

A short environmental inventory, comprising a general description of landscape, geology, vegetation and land use, including a study of waterbalances, variability of precipitation and temperature diagrams of meteorological stations, precedes the soil sections.

The climate is characterized by extremes of rainfall, evaporation and temperature. Rainfall is abundant in the spring and early summer months, but in the rest of the year there is a shortage making irrigation essential. Occasionally, an extended period of winter frost causes harm to agricultural production (e.g. citrus).

Field observations regarding the description of landscape, soils, type and degree of erosion and land use of the sites are presented. The soils are derived from Quaternary red clay and sandstone. Major differences between soil types are dependant on erosion degree, soil reaction (pH), texture, available nutrients, exchangeable aluminium and available soil moisture.

The soils most frequently used by farmers are those derived from sandstone, some of which are affected by moderate to severe erosion; the red soils developed on Quaternary clay are less extensively cultivated. Best land use options with either low or high levels of inputs are sweet potato, peanut, maize, cotton, wheet, rape, buck-wheat, citrus, tea and oil-tea, jate bluish dogbean (*Apocynum venetum*), and green manures.

All sites visited showed to some extent different erosion types. The most striking is the heavily gullied bare land, however, such seriously effected land has a limited extent and it is assumed to be of less importance in comparison with the extensive slight to moderate sheet and rill erosion which is insidiously damaging productive land.

It is recommended that special attention should be given to the following problems:

- The formation of a "bio-soil seal" which causes excessive run-off and therefore accelerates erosion. Such a seal is formed especially in red soils, induced by the complete removal of litter which is used for domestic fuel.
- The very high, toxic concentration of exchangeable aluminium in the red soils.
- The need for measurements of available soil moisture, especially for irrigation design purposes.
- The need for updated maps showing distribution/ acreage of land with different types and degrees of soil degradation.

摘 要

为建立中国土壤样品参比库和土壤剖面数据库，五个典型土壤剖面采自中国东南部山间平原即所谓的“红土沉积平原”上，其中四个在江西鹰潭红壤生态实验站附近，另一个在鄱阳湖旁。该项目在欧共体STD2项目资助下，由中国科学院南京土壤所和荷兰国际土壤信息参比中心合作实施。本册中除了提供有详细的土壤描述和分析资料外，还有概略的环境背景材料，包括地形景观，地质，植被和土地利用以及气象站的水分平衡、降雨和温度图示。

气候特征主要表现在降雨、蒸发和气温趋向两个极端。降水量大，但集中在春季和初夏，而其他季节缺水尚需灌溉。东季的冻害甚至影响农业生产（如柑桔）。

野外观察记录了景观，土壤类型，侵蚀状况和土地利用。发育在第四纪红色粘土和红砂岩上的土壤之间的差异表现在侵蚀程度，土壤ｐＨ，质地，有效养分，交换性铝和有效水分。发育于红砂岩上的土壤利用程度很高，但有些具有中度侵蚀；而发育于第四纪红粘土的土壤利用程度相对较低。最佳土地利用的选择是山芋，花生，玉米，棉花，小麦，油菜，柑桔，茶叶，油茶，绿肥等。

该地区都有不同程度的土壤侵蚀现象。最显著的表现为沟蚀光板地，但数量有显。相比之下，广泛分布的轻度和中度面侵蚀对农业生产有更大的影响。

在这一地区对以下的问题应予以充分的注意：

－－为解决燃料，铲除草皮引起的强度径流并加速土壤侵蚀；

－－在红壤中具有非常高的交换性铝，甚至引起毒害；

－－为灌溉之需，应加强土壤有效水分的监测；

－－应编制或更新土壤退化的类型和程度的图件。

FOREWORD

The object of a Soil Brief is to provide a description of one or more reference soils for a specific agro-ecological zone. The Soil Brief consists of a text with data annexes.

The text includes graphical presentations and provides a description and discussion of the major characteristics of the soil, its classification, an evaluation of its qualities, and attention is given to special topics such as erosion, soil formation etc. Comprehensive data available from field, laboratory and office work are presented in annexes.

The Soil Brief is primarily written for soil specialists, agronomists and land use planners. For the latter group, the information in the annexes is often too compressed and therefore requires further explanation in the text. For the soil specialist, the text part can be helpful as it summarizes the important land and soil qualities, relevant aspects of soil management and processes of soil formation which cannot be conveyed by numerical data alone. Furthermore, it provides additional information about research, and discussion papers, details of which are stored in the computerized database, found in the annexes.

This report is result of the joint research programme of ISSAS and ISRIC in the framework of the Science and Technology for Development Programme (STD2) of the European Community, contract No. TS2* -CT91-0336.

The "Establishment of a soil reference collection and pedon-database for the classification and assessment of soil/land" forms part of this project. In 1992 the Institute of Soil Science of the Academia Sinica (ISSAS) and the International Soil Reference and Information Centre (ISRIC) described and sampled five reference soils from the Red Basin area of Jiangxi Province for the establishment of a Chinese soil reference collection and pedon database at ISSAS. Duplicates of these soils were collected for ISRIC's world soil collection. In this Soil Brief the reference soils are presented.

Support for the fieldwork was received from staff of ISSAS Red Soil Experimental Station near Yingtan. Messrs. Zong Hai-hong and Liu Dong-zhen contributed to the laboratory work in the Ecological Experimental Station of Red Soils at Yingtan. The climatic data of meteorological station of Yujiang were provided by Mr. Li Ping-an.

Valuable comments on draft versions were received from ISRIC and ISSAS staff. Soil analytical work was carried out at the soil laboratories of ISSAS and ISRIC. The editing and final lay-out of the document was done at ISRIC with contributions of E.M. Bridges and A.E. Hartemink (editing), W.C.W.A. Bomer (cross-section), M.B. Clabaut (text processing), J.W. Resink (map compilation) and R. Smaal (diagrams).

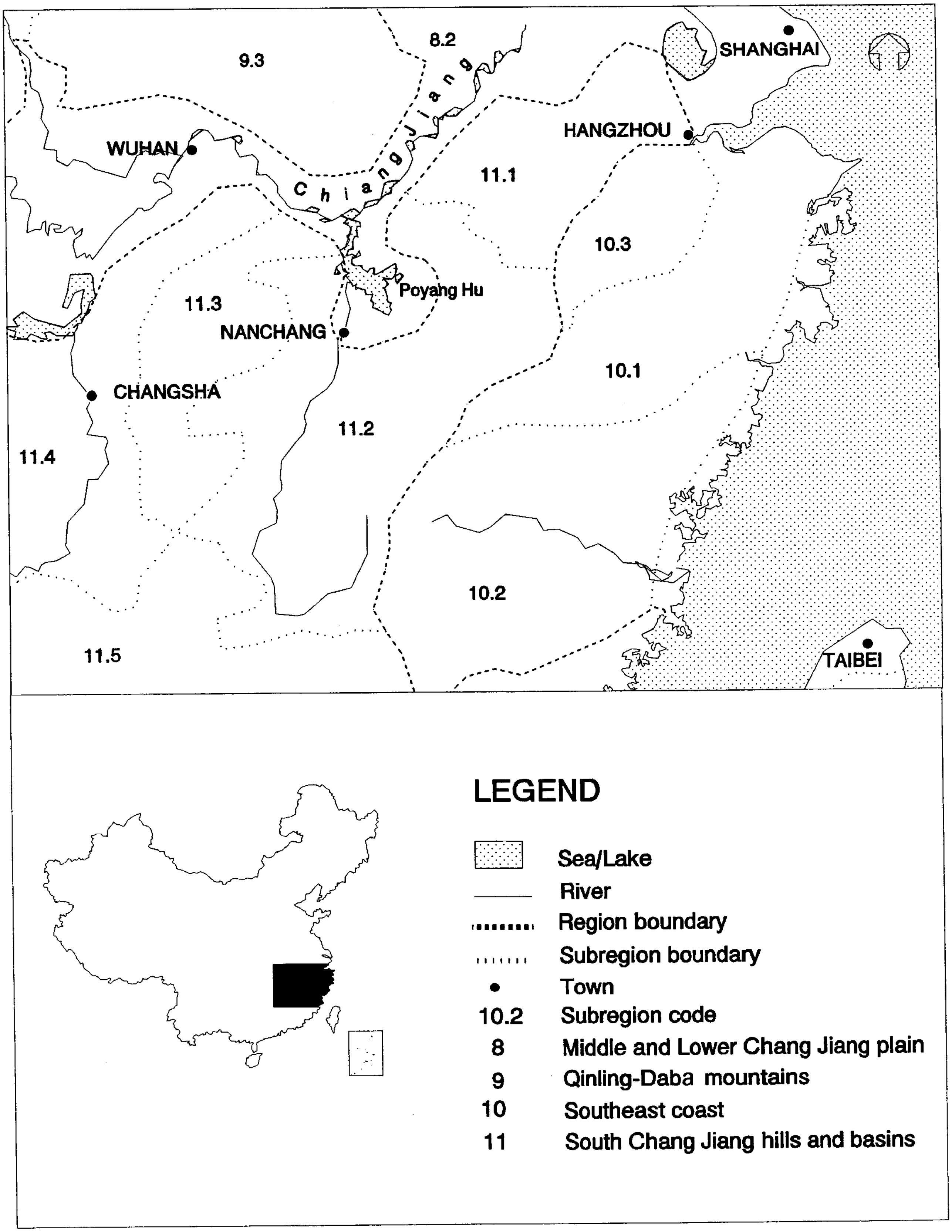


Figure 1 Physiographic map of Jiangxi Province.

1 THE MAJOR ECOLOGICAL REGIONS OF JIANGXI PROVINCE

1.1 Broad ecological setting

The southeastern part of China, including Jiangxi Province forms part of the Subtropical Humid Climatic Division, an ecological zone defined by Zhao Sonqiao (1986). This climatic division is characterized by 'a continental climate with high atmospheric pressure and outflowing northeasterly winds in winter. The winter temperatures are generally colder than in other parts of the world at similar latitudes. During the summer, low atmospheric pressure draws in the maritime southeasterly monsoons, causing high temperatures and heavy rainfall.

Southeastern China has a predominantly montane topography, with broad basins and valleys. According to Zhao Sonqiao (1986), several physiographic regions can be distinguished (see figure 1).

Four reference soils discussed in this paper are situated in the southern Chang Jiang hills and basins. One soil, CN 25 is bordering on the middle and lower Chang Jiang plain. Therefore, only these two regions will be discussed in detail.

1.2 Middle and lower Chang Jiang plain

Leaving the mountains of Central China through a chain of deep gorges, the Chang Jiang river flows slowly through extensive, flat and densely populated plains, with scattered small and large lakes, until it finally flows into the East China Sea near Shanghai.

The middle and lower Chang Jiang alluvial plains are part of the Low Plains of East China and they lie at an elevation of less than 200 m. From the end of the gorges in the west, the river has a very low gradient over a total distance of 1800 km to the sea. At Wuhan in the middle section, its level is already below 25 m. In the lower-middle section the largest lake of China (Poyang Hu) drains, among others, the South Chang Jiang hills and basins.

Climatically the region is characterized by high temperatures and heavy precipitation during the growing season (summer), which makes agriculture very productive. It is possible to practice the highly productive rice-rice-wheat triple cropping system. Precipitation ranges from 900 - 1500 mm with 50 to 60 % concentrated in summer and autumn. Temperatures, although (very) high in summer, can drop below zero in January.

The dominant soils are Paddy soils, and in the somewhat higher areas, so-called Red Earths and Yellow Earths occur. (Zhao Qiguo, 1988).

1.3 South Chang Jiang hills and basins

To the south of the Chang Jiang plains lies an extensive area of hills and basins, surrounded by mountains around 1000 m in elevation, but locally rising to over 2000 m: Huanggang Mountain (2157 m) in the Wuyi Mountains is the highest peak in SE China. Within this larger area a physical subregion covering the greater part of Jiangxi Province and the Poyang lake drainage system can be identified. This is the Central and Southern Jiangxi hills and basins which are discussed in more detail in Chapter 2. This zone has scattered intermontane red basins and strips of level plain along the rivers. The five sites presented in this paper are located in the large intermontane red basin extending eastward of Nanchang.

The low SW-NE trending mountains were formed by Mesozoic tectonic movements resulting in ridges and valleys. They have been heavily dissected by rivers. In Jiangxi Province the drainage density is more that 0.1 km/km^2. (Zhao, 1986). Loose, easily erodable Tertiary and Quaternary red beds deposited in basins and valleys have been dissected into hills with an elevation of less than 500 m.

The climate is characterized by a rainy spring and a hot summer (29-30 °C) with an average annual precipitation of about 1500 mm. Temperatures are somewhat higher than in the middle and lower Chang Jiang plain but January temperatures can still fall below zero, especially at higher elevations.

The soils occurring in this region are Red Earths and Yellow Earths, with Paddy soils on the irrigated floors of the intermontane basins.

Most of the primary vegetation has been removed. Secondary vegetation includes *Pinus massoniana* and oil-tea (*Camellia oleosa*) forests and grassland in the Red Basins with sparse *Pinus massoniana* forest on the low mountains and hills. Small patches of primary bamboo forest and Chinese fir (*Cunninghamia lanceolata*) are found on the highest ranges. As a result of the destruction of the natural vegetation and repeated removal of the topsoil, this area has suffered severe soil erosion.

2 CENTRAL AND SOUTHERN JIANGXI HILLS AND BASINS

2.1 Introduction

Jiangxi Province consists predominantly of low to medium-high mountains which are separated by dissected basins composed of hills, broad valleys and plains. Since ancient times the basins have been used for agriculture and support the greater part of Jiangxi's population. The basins are generally referred to in the literature as Red Basins because of the predominant reddish colour of their soils.

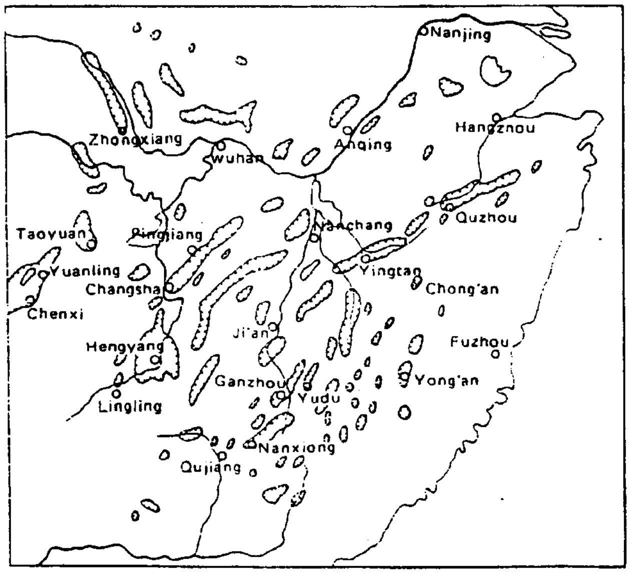


Figure 2 Red Basins in the South Chang Jiang hills and southeast coast regions. (Songqiao, Z., 1986).

2.2 Climate

The climate of southeast China is of a monsoon type. High precipitation and high temperatures occur in summer, low precipitation and low temperatures in winter. It is classified as Cw in the Köppen classification system: a warm temperate climate with dry winters and hot summers. The climate is characterized by extremes of rainfall and temperature. Rainfall is concentrated in the spring and early summer months, leaving the rest of the year with a low and erratic rainfall, making irrigation essential. The occasional long lasting frost causes damage to crops and reduces agricultural production (e.g. citrus).

Yujiang meteorological station, 12 km west of sites CN 21 to CN 24 and Jinxian meteorological station, 20 km south of site CN 25, have been selected as representative for the climate of the Red Basin area. The meteorological data of these stations are given in Annex 1, and the climatic diagrams were generated with SOLGRAPH (Brunt, 1994).

The variability of the annual precipitation in the period 1955-1990 at the meteorological station Yujiang is presented in Figure 3.
The average annual precipitation is 1700 mm with an annual range of about 1400 to 2000 mm. Extreme values include 900 mm in 1963 and 2500 mm in 1975.

The average monthly rainfall and the potential evapotranspiration according to Penman-Monteith (FAO, 1991) is shown in figure 4.

All monthly precipitation data for the period 1955 to 1990 are plotted in a scatter diagram to show the variability of the monthly precipitation (see figure 5). In the same diagram the average monthly precipitation and the potential evapotranspiration from figure 4 are given.

Figures 4 and 5 show that the seasonal distribution of the rainfall is unbalanced. About half of the yearly precipitation is concentrated in the three major monsoon months April, May and June (spring and early summer).

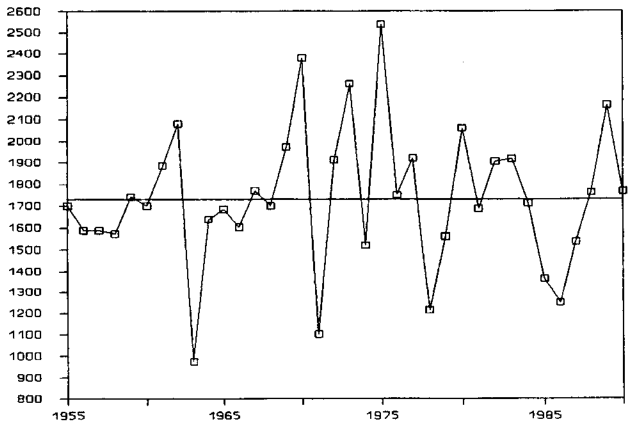


Figure 3 Annual precipitation in mm at Yujiang, for the period 1955-1990.

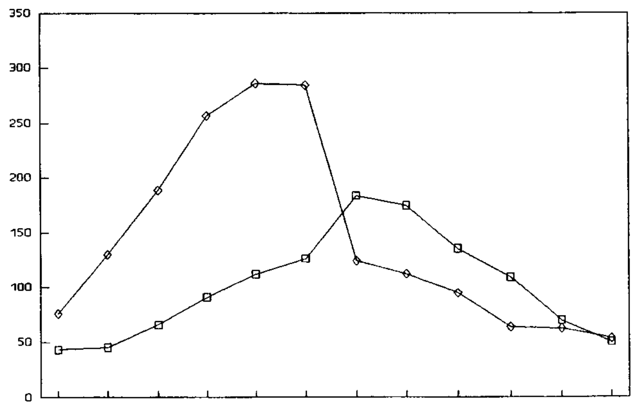


Figure 4 Precipitation (◊) and evapotranspiration (□) in mm at Yujiang.

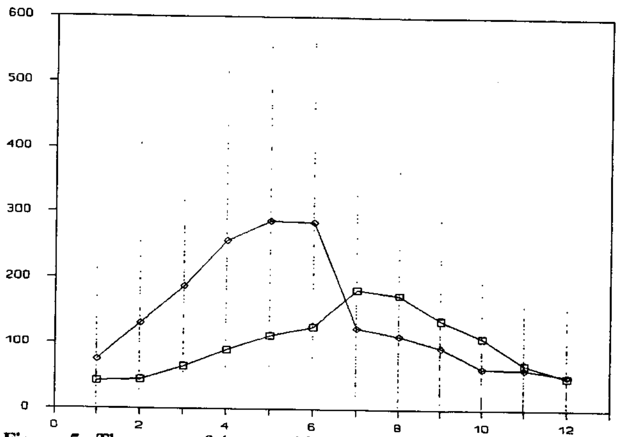


Figure 5 The range of the monthly precipitation (.) at Yujiang in the period 1955 to 1990. Average precipitation (◊) and evapotranspiration (□) are taken from figure 4)

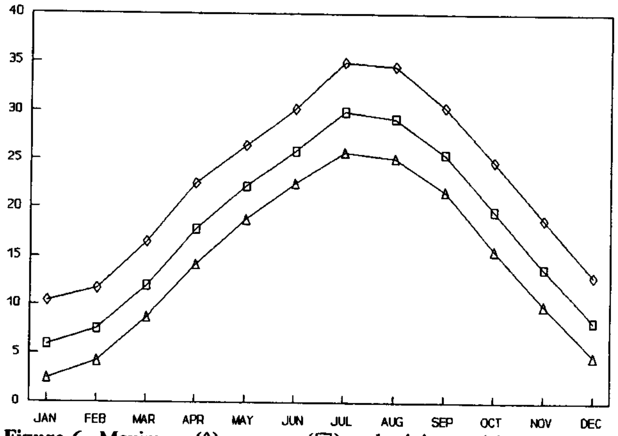


Figure 6 Maximum (◊), average (□) and minimum (△) temperature in °C at Yujiang.

These months have a surplus of rainfall over evapotranspiration. The total Leaching Rainfall (LR) or surplus of rainfall percolating through the soil, is about 800 mm per year.

Droughts occur during the growing season, between July and October, and these are caused by the high potential evapotranspiration and an erratic low rainfall. On average, this period has a moisture deficit for crop growth. The period of water deficit (July-August) coincides with the highest temperatures. Therefore, crop failures occur regularly on non-irrigated lands. The waterbalance also shows a deficit during the winter period from November to February. Generally the monsoon rains start in March.

Temperature

The temperature regime is characterized by cool winters and hot summers. Lowest average temperatures in January are about 2 to 4 °C. Figure 6 shows mean maximum, average and mean minimum temperatures at Yujiang meteorological station. The figure clearly shows the large variation in temperature, but the average minimum temperature data do not show the risk of frost. However, temperatures below 0 °C do occur. The absolute minimum temperature is -6 °C in normal years, but reached -15 °C in 1991. This heavy frost lasted several days and as a result, many citrus trees died.

Spring and autumn are characterized by rapidly changing temperatures. The summer period is hot and average maximum temperatures of the months of July and August reach 33 °C. Absolute maximum temperatures are about 40 °C. The area ranks as one of the hottest areas in China.

Growing period

Figures 4 to 6 show the availability of moisture and the temperature regimes recorded by the meteorological station at Yujiang. The contrasting seasonal distribution of precipitation and temperature allows the cultivation of both sub-tropical and temperate crops. The water balance indicates the necessity of supplementary irrigation during July and August. Supplementary irrigation may also be required to overcome dry spells in other months.
A general crop calendar of summer and winter crops is presented below.

	Winter	Summer
Paddy field	Green manure	Rice-Rice
	Rape	Rice-Rice
Upland	Green Manure	Peanut
	Rape	Sweat-potato

Other climatic characteristics which affect agricultural potential are hailstorms, typhoons and flooding.

2.3 Landscape and Soils

The zonal soil distribution of China is discussed in Li and Sun (1990), who placed the southeast of the country in the area of red or lateritic soils. An internationally accepted classification of the soils can be found on the 1:5 M FAO-Unesco Soil Map of the World (FAO, 1977). The dominant soils in the hilly and mountainous region of southeast China, including the inter-montane basins, have been classified as various types of Acrisols, reddish soils with clay illuviation and a low base saturation.

The distribution of major soils of the Jiangxi Province is well known. A number of soil surveys have taken place by staff of ISSAS and the Provincial Red Soil Institution in the period 1980-1985 (Zhao, 1988), and by the Soil Survey Office at Jiangxi (1991).

The results of these surveys are summarized on the 1:148,000 soil map of Jiangxi Province (Zhao, 1988).

The soils of Jiangxi Province are derived from the following parent materials: shales/slates, limestone, purplish shales, Quaternary red clay and sandstone. These parent materials occur in the inter-montane Red Basins on rolling hills, terraces and broad valley plains. The area is drained by a network of rivers, the largest of which is the Ganjiang river.

The climax vegetation is an evergreen, broad-leaved forest, and the original soil is a thick, mostly clayey, acid red soil. However, severe soil erosion has taken place in historic times, and recently again in the early sixties during the Big Leap Forward campaign, so that today many soils are not so deep and exhibit signs of moderate to severe erosion.

Red soils are the dominant soil type of Sub-tropical Humid China. According to the Chinese soil classification system of 1978, these include the following soil taxa: Red earth, Yellow red earth, Limestone soil and Purplish soils (ISSAS, 1990). Here, the term 'red soils' will be used, because it is in common usage. Over large areas the original soil profile has been eroded so badly that only the soil parent material remains. The soil maps consulted, made no distinction between uneroded (deep soil) and seriously eroded (very shallow) soils. There is a great need for current maps showing the distribution of land with different types and degrees of soil degradation.

Brief, general descriptions of the major soils of Jiangxi Province are given here. Detailed information based on field studies of soils derived from Quaternary red clay and sandstone are given in Chapter 3.

Soils developed from Quaternary red clay

The higher hills and mountains of Jiangxi Province consist of pre-Devonian metamorphic rocks and granites. The scattered intermontane Red Basins are filled with continental deposits of Cretaceous-Tertiary age and these have been mostly eroded into hills and terraces, with an elevation of less than 200 m. Intensive tropical weathering continued well into the Quaternary forming deposits which are called 'Quaternary red clay'. The soils derived from the Quaternary red clay are commonly found at low altitudes. The degree of erosion of these soils ranges from slight to severe.

Uneroded soils

Where uneroded or only slightly eroded, soils on the Quaternary red clay are very deep, well drained dark red clays. A strongly mottled clay subsoil starts at a depth of about 1.5 to 2 m. The soil is well structured and porous, and offers potentially good rooting possibilities. However, the strong acidity and low fertility pose constraints to rooting. Lime and fertilizer are required for these soils to become productive.

Eroded soils

Moderately and severely eroded, strongly mottled clay soils (unprotected by vegetation) occur on severely eroded land. The thick horizons of red clay have been washed away and the strongly mottled subsoil is near or at the surface. Such soils have a poor internal drainage, low permeability, and the natural fertility is lower than that of the uneroded red clay soil. Consequently the agricultural potential is very low. Semi-natural regrowth of a protective grass/herb cover is needed to protect the land from further degradation.

The infiltration capacity of a red clay soil, when covered with grass/herbs or mulch, is good. However, when left bare the soil will form a surface crust which impedes infiltration, causing run-off and erosion.

Further information on these soils is given in Chapter 3 (profiles CN 21 and 25).

Soils developed from Granite

Granite covers large areas in the mountains and hills. The soils derived from granite are shallow to moderately deep, yellow to red coloured with a sandy clay texture. The colour and the depth of the soil varies considerably depending on the altitude and the slope.

Further information on the soils of the mountainous areas of Jiangxi Province is given in Soil Brief CN 5 (Van Engelen *et al.*, 1994).

Soils developed from Sandstone

Soils derived from sandstone cover large areas in Jiangxi Province. The deep red soils derived from this parent material are comparable to the Quaternary red clay soils. However, the soils derived from sandstone have a coarser texture and less clay. Their fertility is lower and the drainage is slightly better than in the red clay. Erosion hazards are more serious, but provided the soil remains covered by vegetation, the more gentle sloping areas can be cultivated in spite of the sheet erosion currently occurring.

Further information on this soil is given in Chapter 3 (profiles CN 22 to 24).

Paddy soils

Paddy soils are widely distributed in the relatively flat lowland regions occupying about 15% of the total area of Jiangxi Province.

Soils derived from Purplish Shale

Purplish shales cover about 3% of Jianxi Province. The moderately deep to deep soils are productive. However, erosion has been extensive resulting in very shallow soils. Consequently, the area of moderate to deep soils is restricted.

The soft nature of the calcareous purplish shales enables this soil parent material to be turned into a new man-made soil by digging manually or using explosives to shatter the rock. Generally, such a newly man-made soil will have a depth of about 50 to 60 cm and can support non-irrigated, drought resistant trees.

Soils derived from Shale and Slate

The soils derived from shale and slate cover only 2% of the province. They are soils of low potential with moderately deep or shallow profiles, depending on the degree of erosion and nature of the parent material which determines the resistance to weathering.

Soils derived from Limestone

Limestone parent materials cover 2% of the province, concentrated in middle and low hills. Generally, the soil distribution shows an irregular pattern of (very)shallow dark brown clay soils (Rendzinas), and moderately deep reddish brown clay soils (Red soils), both directly overlying hard limestone rock. These soils erode easily and only the hard limestone remains, leaving the land without further land use options.

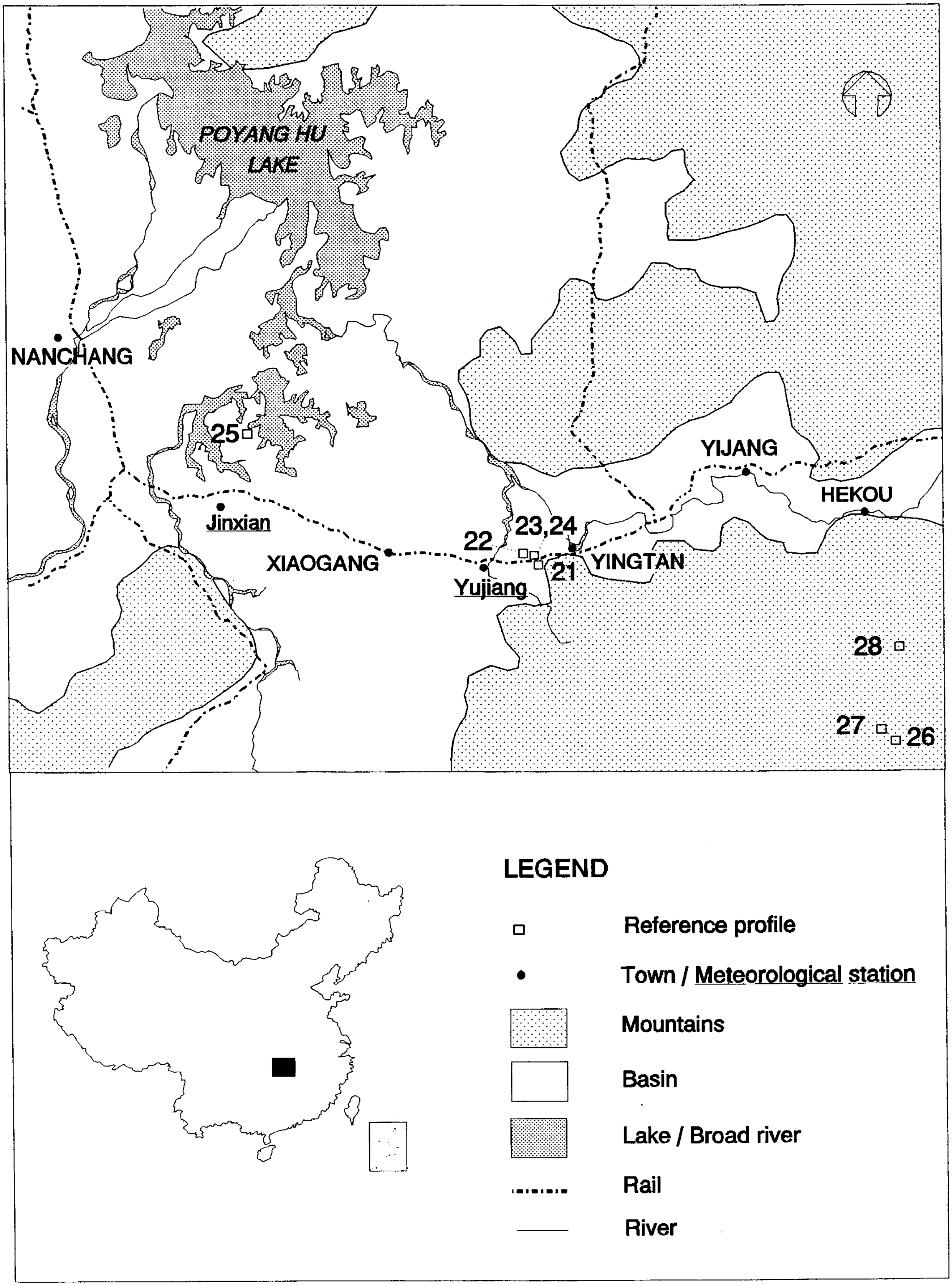


Figure 7 Major landscapes and location of the reference soils.

3 REFERENCE SOILS OF THE RED BASIN AREAS OF JIANGXI PROVINCE

In this chapter, a selection of data and research information about reference soils CN 21, 22, 23, 24 and 25 is discussed. Comprehensive field and laboratory data are given in Annex 1 - Soil and environmental datasheet, which was made using the ISRIC Soil Information System (ISIS).

3.1 Location

The five reference soils are located in the intermontane Red Basin of Jiangxi Province. Two soils, derived from Quaternary red clay, are situated near Yingtan (CN 21) and one near Nanchang (CN 25). Three soils derived from sandstone parent materials are from near Yingtan (CN 22, 23 and 24). See figure 7 for their location.

Quaternary red clay deposits are restricted to the lowlands. In Jiangxi Province these soil parent materials are widely spread in the counties around the Poyang Hu lake and in the scattered intermontane Red Basins with low altitudinal range in the rest of Jiangxi Province.

Soil derived from sandstone cover large areas in Jiangxi Province, especially in the counties of Yu Jiang, Dong Xiang and Guixi.

3.2 Landscape, geology, vegetation and land use

The area around Lake Poyang is part of a large intermontane basin of more than 15000 km^2. The basin is surrounded on all sides by mountains of low to medium height. Within this basin, two major physiographic units are present: in the central northern part lies the lake surrounded by a low fringe several kilometers wide which is submerged for more than 6 months during the year. It consists of recent to very recent alluvial and lake deposits in which soil development has been minimal.

The rest of the basin has a somewhat higher elevation and consists of so called Red Beds or Quaternary red clay, continental deposits with a clayey to sandy clay texture. Slight incision by the major rivers has formed a gently undulating plain with valleys that are a few meters deep and have steeply sloping sides.

The parent material of soils in the Red Basins scattered throughout the rest of Jiangxi Province consists of various materials with sandstone and Quaternary red clay being dominant. The intermontane basins are large, e.g. the width at Yingtan is about 30 km, with the appearance of a nearly level to undulating upland plain and broad, nearly level, valleys.

The areas not regularly submerged by the Lake Poyang are intensively cultivated. Most are terraced and mostly used for paddy cultivation. Only the higher parts of the basin, where there is insufficient irrigation water, are used for other crops like fruit trees and cotton.

In the scattered Red Basins areas, the valleys are used for paddy cultivation. Since 1950 many dams have been constructed and a part of the uplands is now terraced and used for paddy. Rainfed land use of the Red Basins is limited by the unreliable rains in late summer. On rainfed land, fruit trees, cotton, peanuts, tea and flax are grown. This Soil Brief deals mainly with soils from the rainfed upland areas, where there is a potential for expansion of agricultural land.
Information on Paddy soils of the lowlands is given in Soil Brief CN 14 (Spaargaren, in prep.).

The climax vegetation in the Red Basins was removed centuries ago. Except for the Quaternary red clay soils, the area is densely populated and the major part of the land is used for agriculture. The soils on Red Quaternary clay are less favoured by the farmers and are generally covered by a degraded open woodland.
Figure 8 presents a cross-section summarizing the pattern of landform and land use. Note that the cross-section is generalized and that in practice these sites are not located along any one section line (see also location map, Fig.7).

3.3 Soil characterization

Detailed description of soil horizons to a minimal depth of 150 cm, according to the *Guidelines for Soil Profile Description* (FAO, 1990), is given in Annex 1.
Soil samples were analyzed at ISRIC's soil laboratory according to the procedures described by Van Reeuwijk (1993).
In this section field and analytical information are summarized and special attention is given to selected key properties.

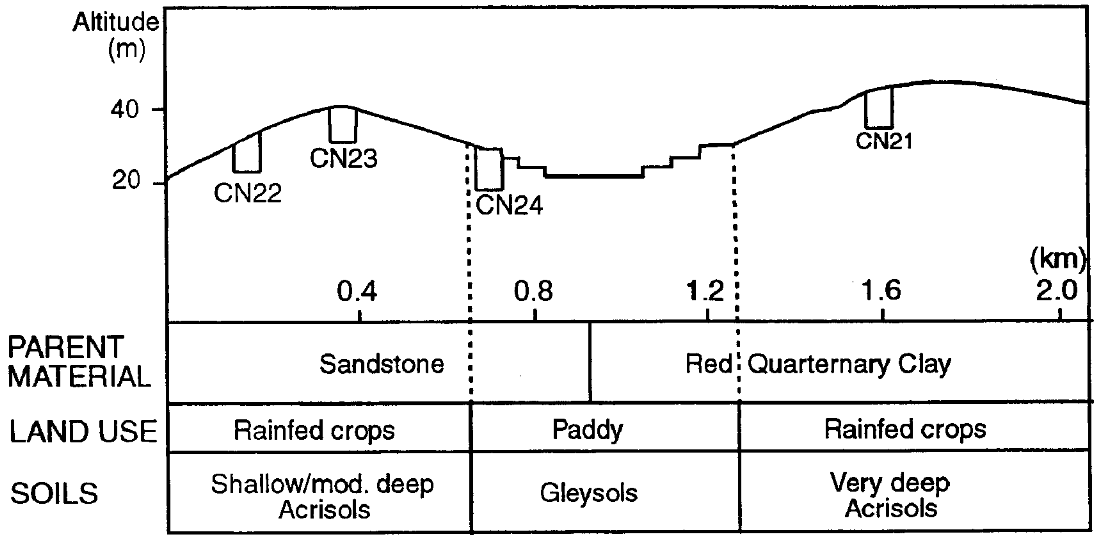


Figure 8 Cross-section of the landscape of sites CN 21 to 24 near Yingtan.

3.3.1 Brief field descriptions

Profile CN 21

Uneroded or slightly eroded soils

Very deep, well drained, red clay derived from Quaternary red clay, strongly mottled in the deeper subsoil. The bare soil surface is smooth and has a thin seal. On eroded bare soil surfaces a bio-seal may be formed (see section 3.5). The topsoil is nearly structureless. The subsoil has a subangular blocky structure and the strongly mottled deeper subsoil is angular blocky. The subsoil is compact, there are mainly micro pores and very few fine pores. The permeability is therefore probably limited, especially in the strongly mottled subsoil, where ped surfaces are covered by clay cutans.

Severely eroded soil

In severely eroded areas, the uniform red clay horizons are eroded and frequently the mottled subsoil of low permeability is near or at the soil surface. The subsoil is poorly structured and the mottles are indicative of water saturation because of low permeability.

Profile CN 22

Deep, imperfectly drained, red, sandy clay loam derived from sandstone. The topsoil is very weakly developed showing very light colour, without structure, and it slakes easily to form a thin crust/seal. The subsoil has a weak, massive blocky structure (inherited from the sandstone). The deeper horizons are strongly mottled, a sign of stagnating water in the massive structured subsoil.

Profile CN 23

Shallow to moderately deep, well drained, brownish yellow, sandy loam derived from sandstone. The subsoil consists of fragmented weathered sandstone and consolidated sandstone starts at about 1 m depth. The sandstone can be relatively easily cut in blocks, which are used as building material. Many sandstone quarries are found in the area.

Profile CN 24

Deep, imperfectly to poorly drained, greyish sandy loam derived from sandstone. The profile is strongly influenced by human activities as its site is one of the upper rice terraces on the middle slope. Irrigation water is brought through canals to the land and the soil is saturated for a prolonged period in the year.

Profile CN 25

Very deep, well drained, dark red clay soil derived from Quaternary red clay with a strong blocky structure and a strongly mottled subsoil. The soil is comparable to profile CN 21, but without the upper half meter present in CN 21, which was removed by erosion and terracing.

Colour pictures of the landscape and soil profiles are provided on photo-pages.

3.3.2 Brief analytical characterisation

A summary of selected analytical properties, taken from Annex 1, is presented in Table 1.

Table 1 Key properties of soils CN 21, CN 22, CN 23, CN 24 and CN 25

PROPERTIES	Profile CN 21	Profile CN 25	Profile CN 22	Profile CN 23	Profile CN 24
Clay	clay increases with depth (from 30 to 52%) in the upper 60 cm; silt content is high (40%) throughout	clay increases with depth (from 26 to 53%) in the upper 20 cm; silt content is high (44%) throughout	clay increases (29 to 39%) in upper 40 cm, fine sand content (45%) throughout)	soil consists of 60 to 80% of fine sand, clay increases slightly with depth	clay increases (from 10 to 44%) in the upper 55 cm
Organic Carbon	very low (0.3%) in the topsoil	low (0.8%) in the topsoil	very low (0.2%) throughout	very low (0.2-0.6%) throughout	very low (<0.3%) throughout
pH-H_2O	strongly acid (4.2 - 4.5) throughout	moderately acid (5.4) in the topsoil, very acid in the subsoil	strongly acid (4.3 to 4.5) throughout	strongly acid (4.4 to 4.5) throughout	strongly acid to acid (4.8 to 5.4) throughout
Sum of bases [$cmol_c\ kg^{-1}$ soil]	low (1.2 - 1.9) throughout	medium (7.0 - 4.2) throughout	low (1.0 to 1.4) throughout	low (1.0-1.4) throughout	low to medium (2 to 7) throughout
Cation exch. cap. [$cmol_c\ kg^{-1}$ soil]	low (6.0 - 10) throughout	low (<10) throughout	topsoil low (6) and medium (11 to 17) in subsoil	low (6) in topsoil, medium (11) in subsoil	low (7 to 9) throughout
Exchang. Aluminium	high (>50%) in the first 150 cm	nil in the topsoil, low (25%) in the subsoil	very high (40 to 60%) in topsoil, medium (40%) in subsoil	high (50-75%) in first 75 cm, very high (75-100%) below 75 cm	nil in the first 70 cm, high (40%) in the subsoil
Clay mineralogy	kaolinite dominant, mixed with some mica, vermiculite and smectite	kaolinite dominant, mixed with some mica and vermiculite	kaolinite and chlorite dominant	equal mixture of kaolinite, vermiculite and smectite	kaolinite dominant mixed with some mica, chlorite and smectite
Air capacity ϕ(pF0-pF2.0)	medium (11%) in the topsoil, very low (3-5%) in the subsoil	medium (12%) in the topsoil, very low (2 to 7%) in the subsoil	low (7 to 9%) in the topsoil, very low (4%) in the deeper subsoil	low (8%) in the topsoil, very low (5%) in the subsoil	medium (11%) in topsoil, very low (4%) in subsoil
Available moisture ϕ(pF2.0-pF4.2)	medium (12-14%) in the topsoil, low (6%) in the subsoil	medium in the topsoil, low in the subsoil	medium (10%) throughout	low to medium (8-14%) throughout	medium (11%) throughout

The textural composition of the soils CN 21 to 25 is given in Figure 9. The soils developed from Quaternary red clay form a separate cluster in the textural triangle diagram because of the high clay, high silt and very low fine sand content. Despite the large geographic distance between CN 21 and 25, the textural composition has great similarity. This, and the lack of fine sand, points to the lacustrine origin of these intermontane basin sediments. The soils derived from sandstone have less than 40% clay and a sand content ranging between 40 to 80%.

The particle size distribution of the sand, silt and clay fractions with depth of the five reference profiles is given in graphical form in Figures 10 to 14.

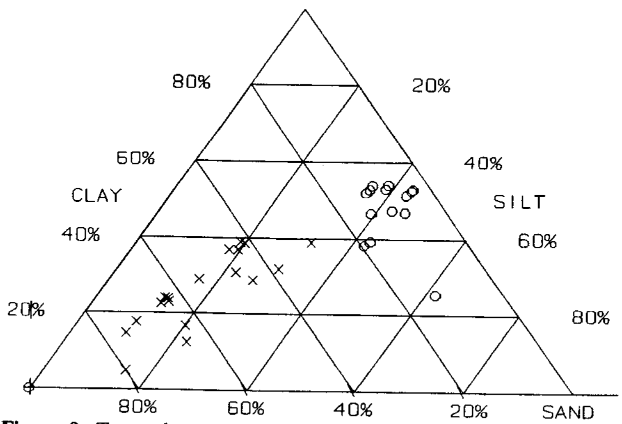


Figure 9 Textural composition of the soils CN 21 to CN 25. o = CN 21 and 25; x = CN 22, 23 and 24.

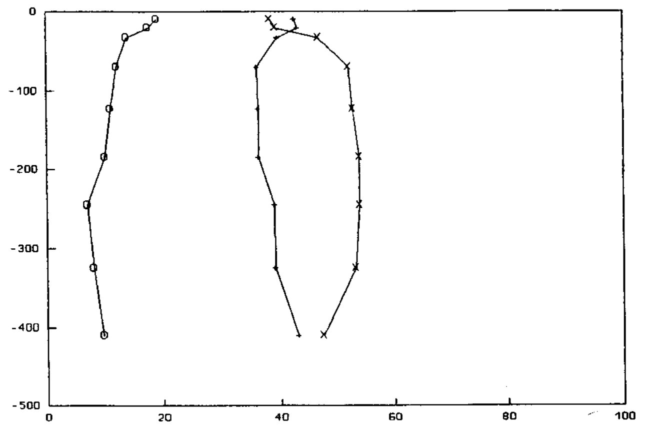


Figure 10 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CN 21.

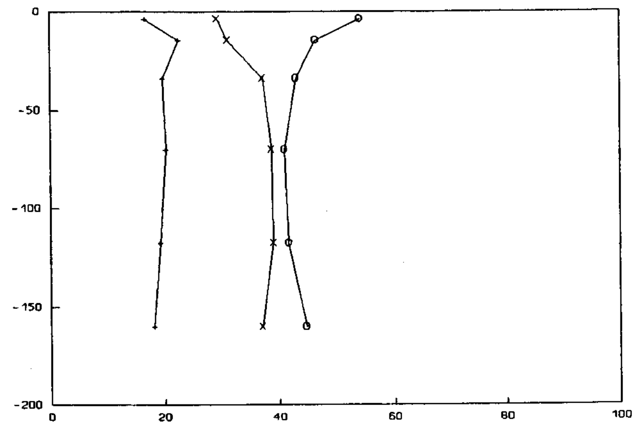


Figure 11 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CN 22.

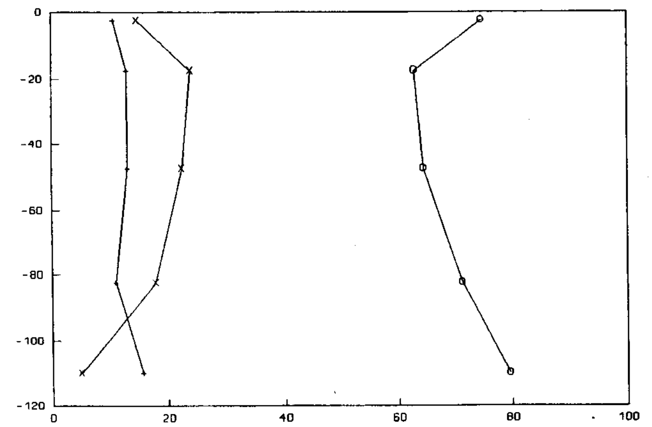


Figure 12 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CN 23.

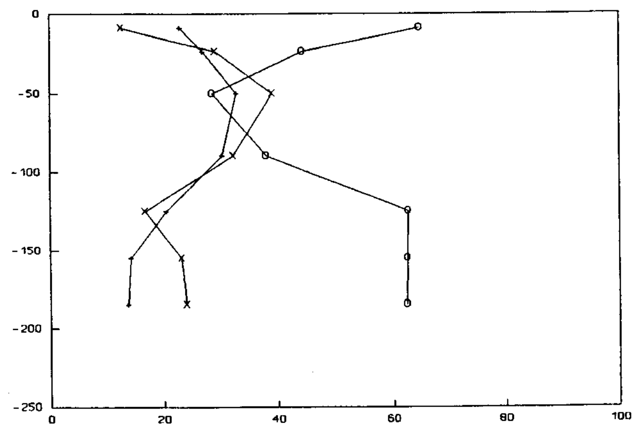


Figure 13 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CN 24.

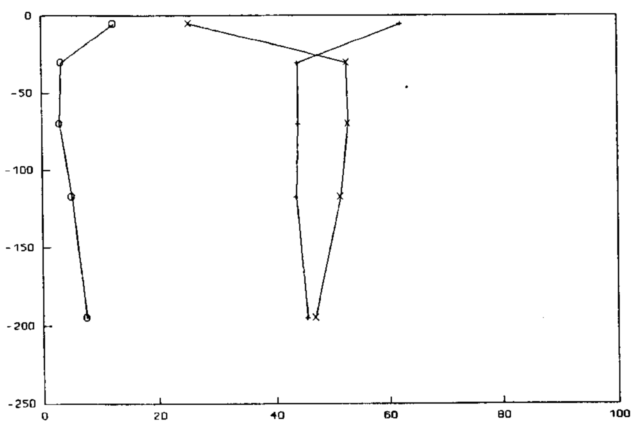


Figure 14 Percentages clay (x), silt (+) and sand (o) versus depth (cm) in profile CN 25.

The similarity of particle size distribution with depth of the soils on the Quaternary red clay is striking (CN 21 and 25). The only difference is the clay increase in the topsoil, which is more abrupt in the first 20 cm of profile CN 25, resulting from loss of topsoil through erosion and terracing.

The soils derived from sandstone are much more heterogenous and show substantial differences when comparing profiles CN 22, 23 and 24. Texture depends on sandstone type, but also on the position of the soil in the landscape. The shallow soil CN 23, the upper member of the catena, has the highest sand content (60 to 80%) and uniform distribution of silt and clay. CN 24, the lowest profile in the catena, has the lowest sand content.

The amount of water dispersable clay is very low in the soils developed from Quaternary red clay (see Annex 1). It was observed during fieldwork that a mixture of soil in water settled within minutes. The main cause of this phenomenon is the high exchangeable aluminium which induces rapid flocculation. In general, a low water dispersable clay percentage is indicative for a less erodible soil. However, in practice, all soils have a high intrinsic erodability. This is further discussed in section 3.5.

The percentage of organic carbon, sum of bases, pH-H_2O & pH-KCl with depth of all four profiles are presented in Figures 15 to 19.
A comparison of organic carbon content in figures 15 to 19 shows that all soils, irrespective of parent material, have a very low organic carbon content (less than 0.5%).

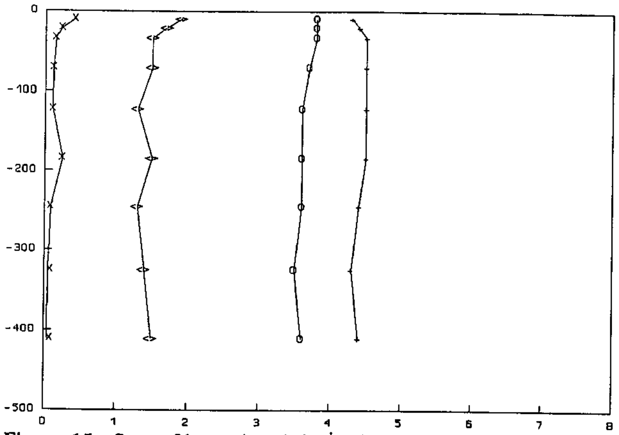


Figure 15 Sum of bases ($cmol_c\ kg^{-1}$ soil) (◇), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile CN 21.

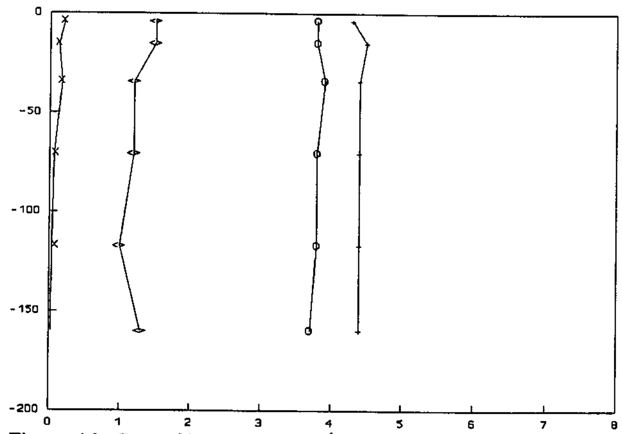


Figure 16 Sum of bases ($cmol_c\ kg^{-1}$ soil) (◇), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile CN 22.

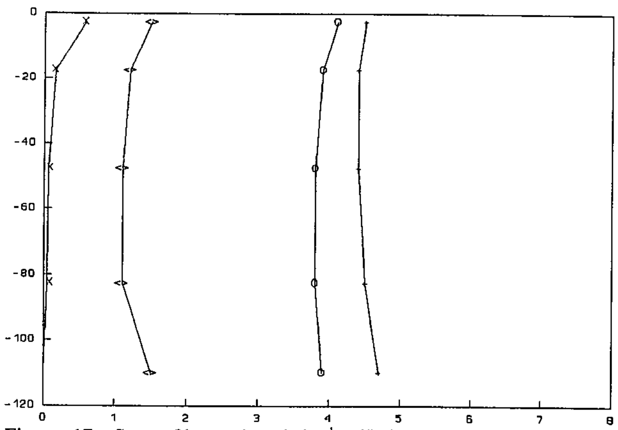


Figure 17 Sum of bases ($cmol_c\ kg^{-1}$ soil) (◇), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile CN 23.

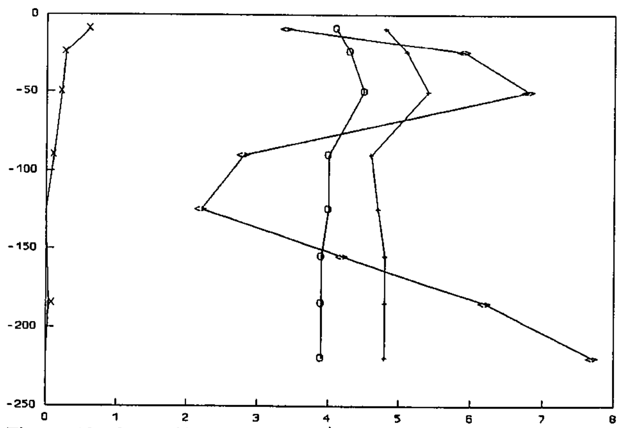


Figure 18 Sum of bases ($cmol_c\ kg^{-1}$ soil) (◇), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile CN 24.

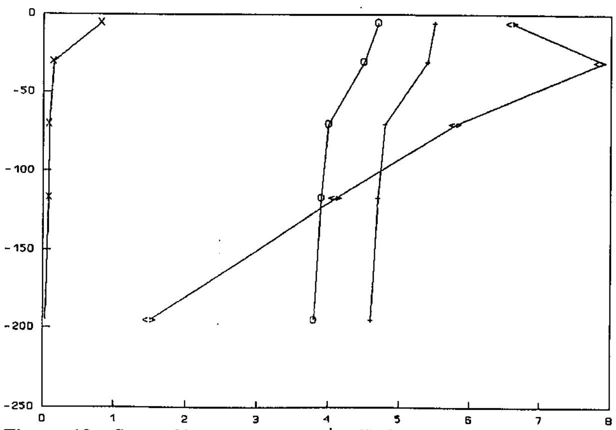


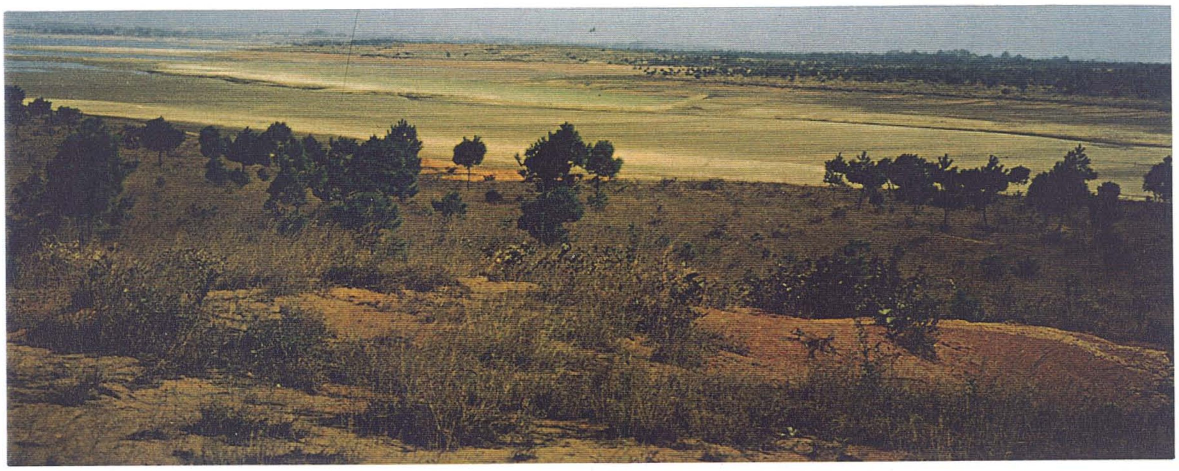
Figure 19 Sum of bases ($cmol_c\ kg^{-1}$ soil) (◇), pH-H_2O (+), pH-KCl (o) and organic carbon (x) versus depth (cm) in profile CN 25.

This is one of the key factors contributing to the high erodibility and low fertility of the soils.

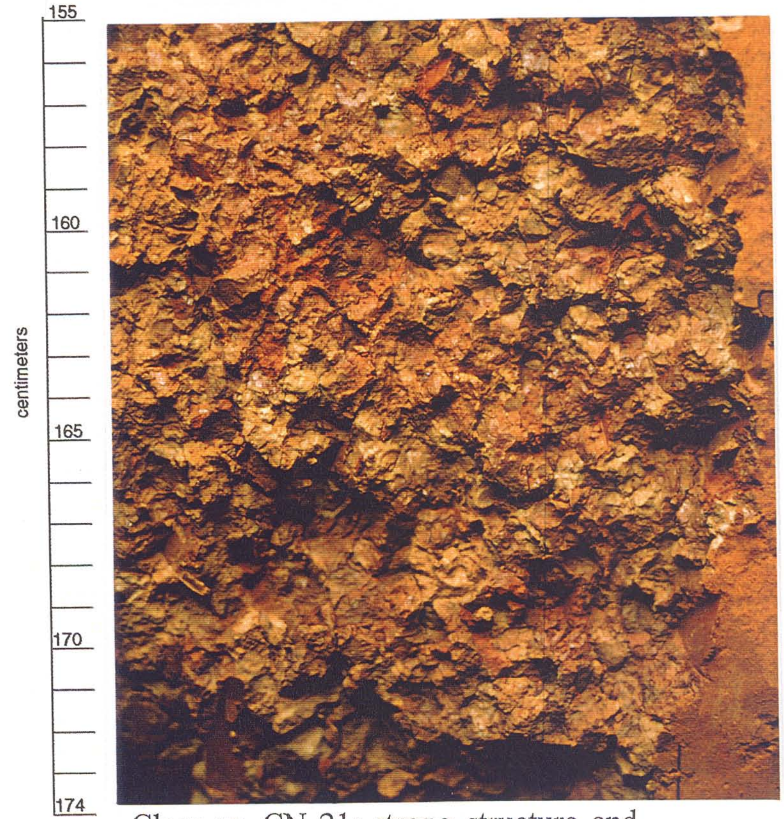
An examination of the sum of bases in figures 15 to 19 shows that except for the paddy soil (CN 24) and Quaternary red clay (CN 25), all other soils have a (very) low level of the sum of bases throughout the profile. There is no clear difference between topsoil and subsoil. The distinctly higher amount of exchangeable bases in the upper part of the paddy soils (CN 24 and CN 25) may be caused by the fertilization of the paddy fields over a long period. This low nutrient content will be further discussed in section 3.5.

A comparison of the acidity, pH-H_2O & pH-KCl, in figures 15 to 19 shows that all soils have a similar pattern. The soils are (very) acid throughout and have about one pH unit difference between pH-H_2O & pH-KCl.

ECOLOGICAL EXPERIMENTAL STATION OF RED SOIL - ACADEMIA SINICA

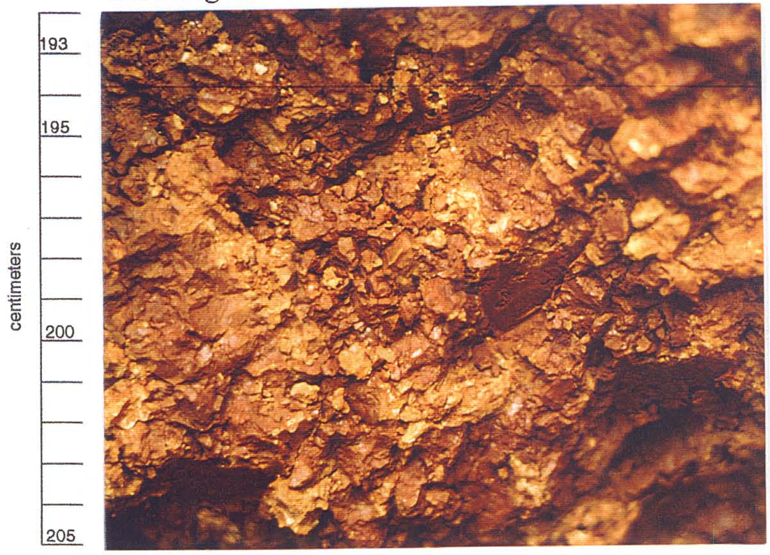


Landscape of CN 21



Close-up CN 21: strong structure and mottling at 155-174 cm

Soil surface, undergrowth and profile CN 21



Close-up CN 21: strong mottling at 193-205 cm

The moisture retention curves of CN 21, 22, 23, 24 and 25 are given in Figures 20 to 24.

The pF curves of the five reference soils show comparable patterns for clay soils, with a gradual release of moisture with increasing soil tension. In general the form of pF curves of tropical clay soils having a high content of kaolinitic clay is comparable to curves characteristic for sandy soils (i.e. a more abrupt release of soil moisture at lower suction ranges). This is mainly due to the cementation of clay particles into stable sand-sized aggregates. However, this is not the case for the Jiangxi soils, probably because of the presence of other clay minerals.

Air capacity, defined as the amount of pore space in the soil tension range of pF0-pF2.0, for all soils is rather low amounting to less than 10 % in the topsoil and below 5% in the subsoil. It is an indication of a reduced capacity of the subsoil to transmit water, hence water stagnation and mottling.

The available moisture content, defined as the amount of moisture retained by the soil in the soil moisture tension range of pF2.0-pF4.2, is medium to low in all soils.

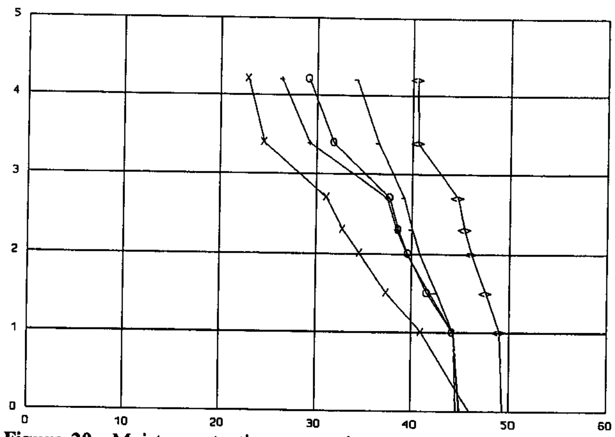


Figure 20 Moisture retention curves (water content in vol % versus suction) at depth 7-22 cm (x), 45-95 cm (+), 95-150 cm (o), 150-220 cm (-) and 220-270 cm (◇) in profile CN 21.

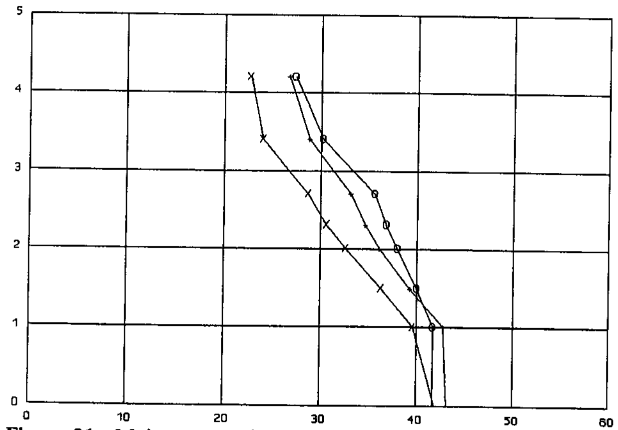


Figure 21 Moisture retention curves (water content in vol % versus suction) at depth 8-22 cm (x), 46-95 cm (+) and 95-140 cm (o) in CN profile 22.

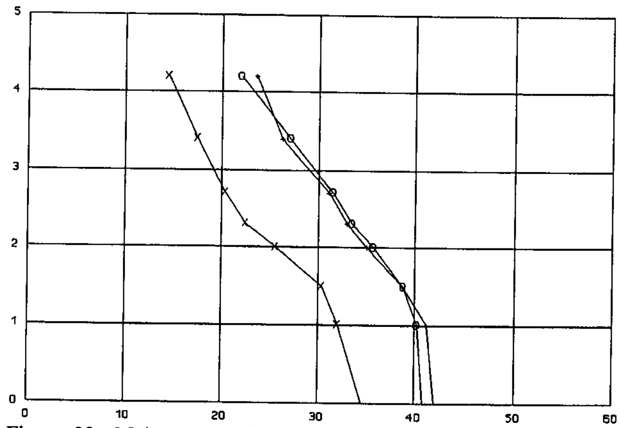


Figure 22 Moisture retention curves (water content in vol % versus suction) at depth 5-30 cm (x), 30-65 cm (+) and 65-100 cm (o) in profile CN 23.

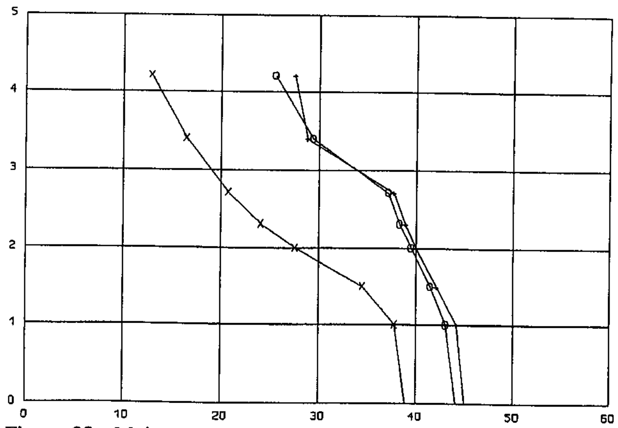


Figure 23 Moisture retention curves (water content in vol % versus suction) at depth 0-18 cm (x), 30-70 cm (+) and 70-110 cm (o) in profile CN 24.

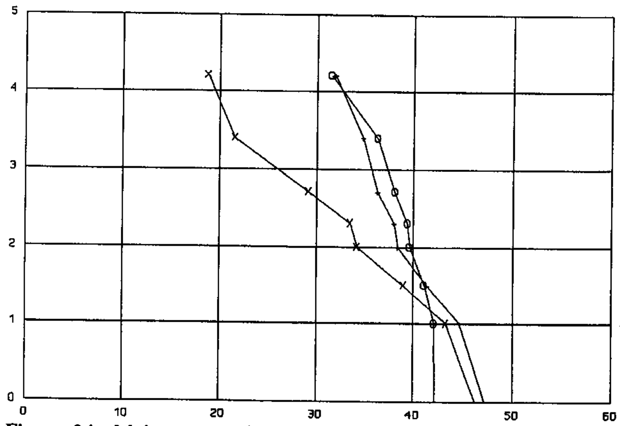
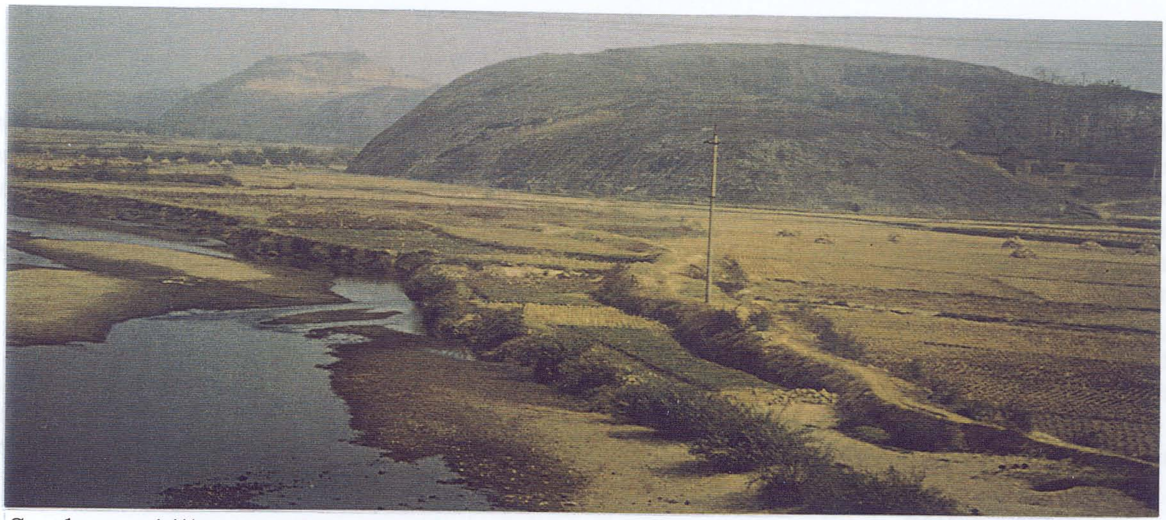


Figure 24 Moisture retention curves (water content in vol % versus suction) at depth 0-11 cm (x), 11-50 cm (+) and 90-145 cm (o) in profile CN 25.

Landscape of CN 22

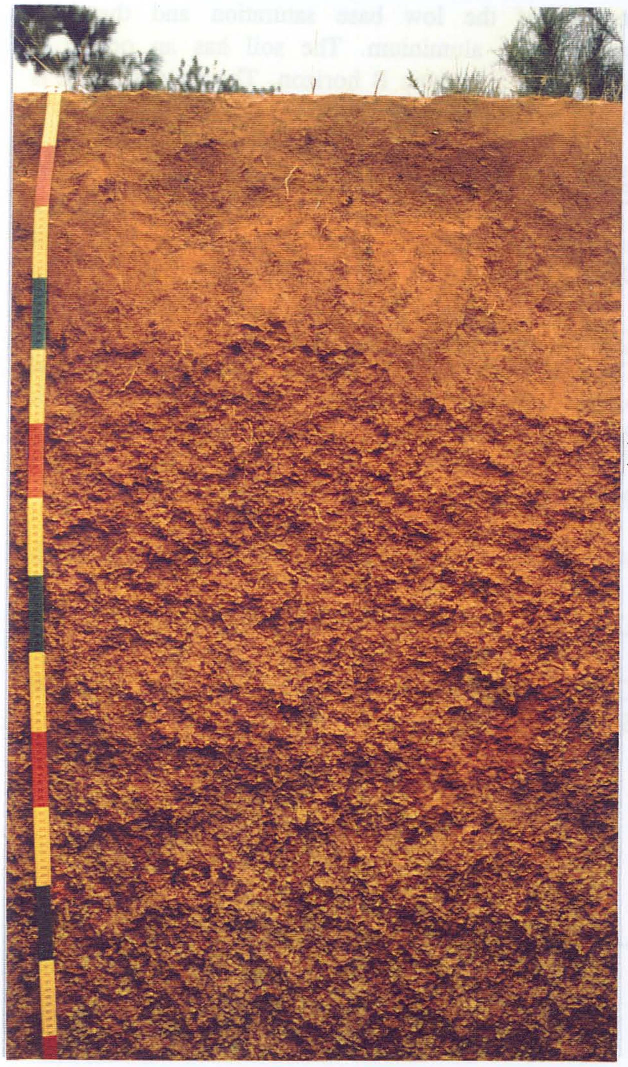
Profile CN 22

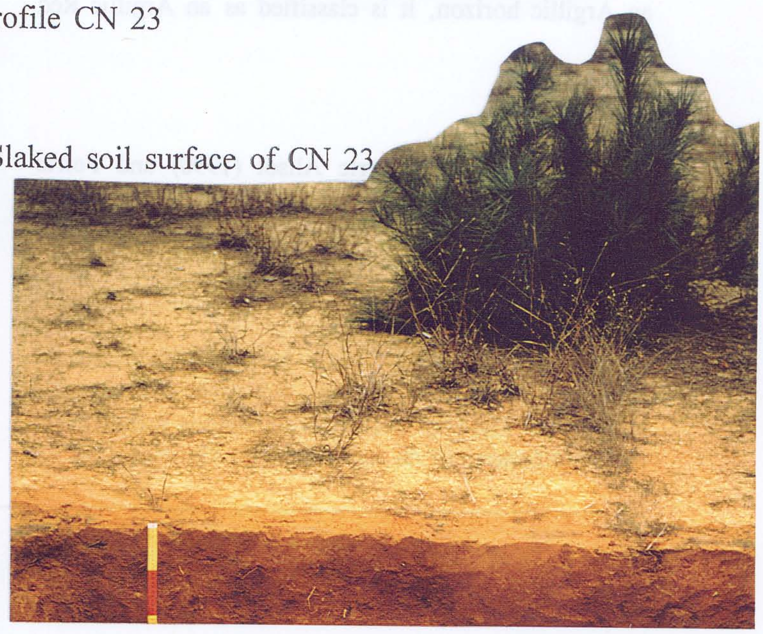
Collecting litter for kitchen fuel,
one of the causes of enhanced run-off/erosion


Sandstone hills near sites CN 22 and CN 23


Land use near CN 22 (buck-wheat, background tea)


Close-up buck-wheat


Profile CN 23


Slaked soil surface of CN 23

Based on the data obtained from the five reference soils, it can be concluded that the soil physical properties, as expressed in the air capacity and available moisture content, are sub-optimal. So far, this conclusion is not confirmed by other analytical data, because the soil reports of provincial agricultural institutions consulted during the fieldwork, lack pF curves or other water retention data. In view of necessity of supplementary irrigation, and the limited amount of irrigation water from dams, measured water retention information will be necessary to design efficient water management schemes.

3.4 Soil classification

Profile CN 21

FAO-Unesco: Alumi-Haplic Acrisol (1988) and Orthic Acrisol (1974)
USDA Soil Taxonomy: Udic Kandiustult (1992) and Paleustult (1975)
Chinese classification: Argillic Red soil

FAO-Unesco (1988)
The clay increase with depth is sufficient for an argic horizon. The soil is classified as Haplic Acrisol because of the low CEC and the low base saturation. The strong reddish mottles in the subsoil (ferric properties) occur too deep for a Ferric Acrisol. The soil has nearly all properties of a Ferralic horizon except for the high silt content (silt/clay ratio is > 0.2). Because of the high exchangeable aluminium % it is classified at the third level as Alumi (FAO, 1994)

USDA Soil Taxonomy (1992)
The clay increase with depth and the low CEC meet the criteria for a kandic horizon. The soil is classified as Udic Kandiustult.

Chinese soil classification (1991)
The soil meets all requirements for Ferrallisols, and based on the udic soil regime (although some people consider it as ustic soil regime), it can be classified as a Red Soil according to its ratio of ECE/clay. Because of an Argillic horizon, it is classified as an Argillic Red Soil.

Profile CN 22

FAO-Unesco: Alumi-Ferric Alisol (1990) and Ferric Acrisol (1974)
USDA Soil Taxonomy: Typic Paleustult (1992 and 1975)
Chinese classification: Argillic Red Soils

FAO-Unesco (1988)
The soil is classified as Ferric Acrisol, with Alumi for the third level, because of the high exchangeable aluminium. The clay increase with depth is sufficient for the identification of an argic horizon. The high CEC of the clay fraction and the low base saturation means it is classified as an Alisol. It is assumed that the strong mottled subsoil is not plinthite because there is not enough evidence that the mottled layers will harden upon repeated wetting and drying. The mottled horizons qualify as having ferric properties.

USDA Soil Taxonomy (1992)
This soil is classified as a Paleustult because the clay % does not decrease, or only slightly decreases, in the deeper subsoil. The clay increase with depth and the high CEC qualify as an argillic horizon.

Chinese classification (1991)
The soil meets all requirements for Ferrallisols, and based on the ustic soil moisture regime, it is classified as a Red Soil according to its ratio of ECE/clay. Because of an Argillic horizon, it is classified as an Argillic Red Soil.

Profile CN 23

FAO-Unesco: Alumi-Dystric Cambisol (1988) and Dystric Cambisol (1974)
USDA Soil Taxonomy: Dystric Ustochrept (1992 and 1975)
Chinese classification: Haplic Para Red soil

FAO-Unesco (1988)
This soil is classified as an Alumi-Dystric Cambisol because of the low base saturation and the high exchangeable aluminium. The soil has an ochric A horizon and a cambic B horizon. The clay increase is insufficient for an argic horizon.

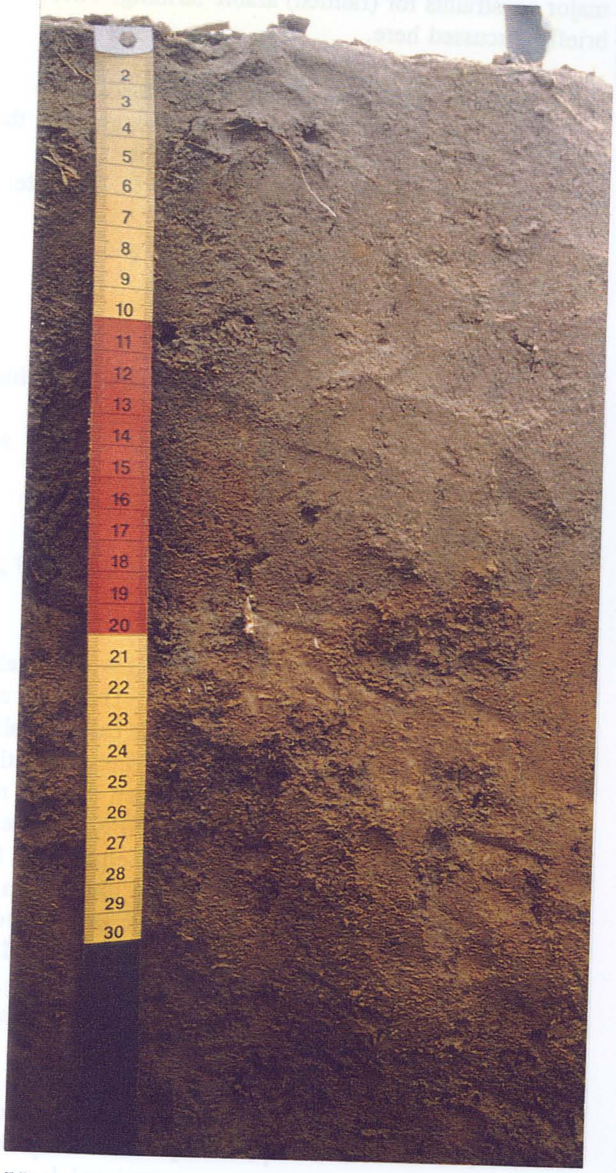
USDA Soil Taxonomy (1992)
The soil has an ochric epipedon, a cambic horizon and a ustic moisture regime. Therefore, it is classified as a Dystric Ustochrept.

Chinese soil classification (1991)
The soil meets all requirements for Fersiallisols, and based on the ustic soil regime, it is classified as a Haplic Para-Red Soil according to its ratio of ECE/clay.

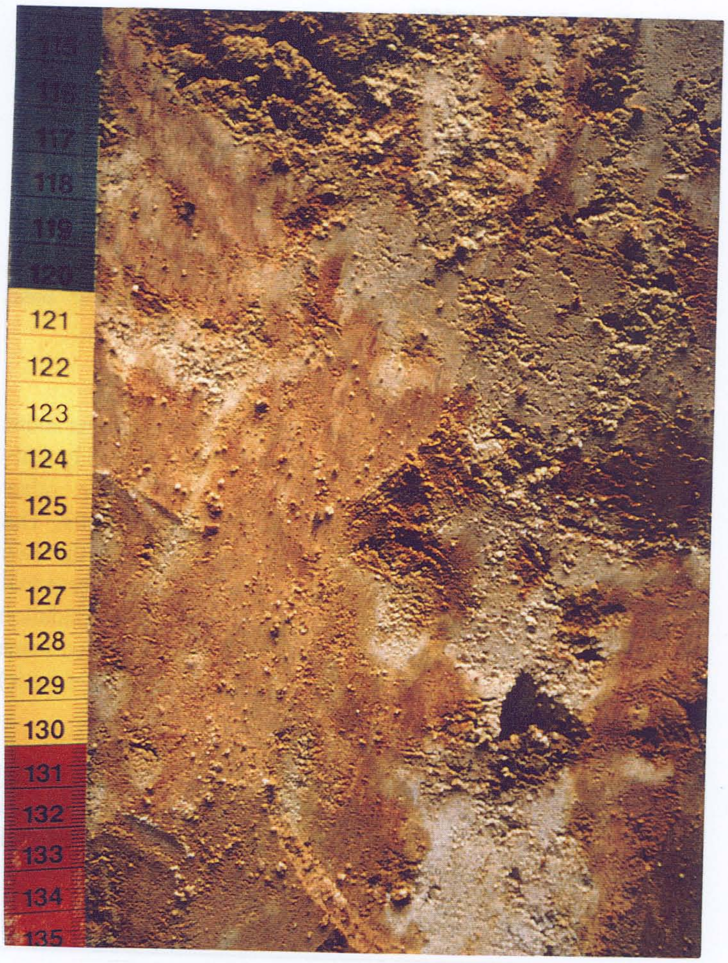
Profile CN 24

FAO-Unesco: Orthi-Ferric Alisol (1988) and Ferric Acrisol (1974)
USDA Soil Taxonomy: Antraquic Hapludalf (1992) and Typic Hapludalf (1975)
Chinese classification: Aquic Red Soils/Aquic Para-Red Soils

Land use: terraced rice fields near site CN 24



Upper part of profile CN 24



Close-up profile CN 24: strong mottling at 115-135 cm depth

FAO-Unesco (1988)

The presence of an argic B horizon, the high CEC and the low base saturation in a part of the B-horizon means the soil is classified as a Ferric Alisol.

USDA Soil Taxonomy (1992)
The soil is classified as an Alfisol, because of the presence of an argillic horizon and the high base saturation in the subsoil. Irrigation, resulting in prolonged saturation of the soil, and a udic soil moisture regime, means the soil is classified as an Anthraquic Hapludalf.

Chinese soil classification (1991)
The properties of this soil fall on the boundary between the requirements for Ferrallisols and Fersiallisols. Based on the udic soil regime (although some people consider it as ustic soil regime) it can be classified as a Red Soil or a Para-Red Soil according to its ratio of ECE/clay. The presence of redoxic features requires that it is called an Aquic Red Soil or an Aquic Para-Red Soil.

Profile CN 25

FAO-Unesco: Niti-Haplic Acrisol (1988) and Ferric Acrisol (1974)
USDA Soil Taxonomy: Typic Paleudult (1992 and 1975)
Chinese classification: Haplic Red soil

FAO-Unesco (1988)
This soil is classified as a Haplic Acrisol, because of the low CEC and the low base saturation in the subsoil. The clay increase meets the criteria for an argic B horizon. The strong blocky structure and thick cutans mean it qualifies for Niti at the third level.

USDA Soil Taxonomy (1992)
The soil is classified as an Ultisol, because of the presence of an argillic horizon and the low base saturation in the deeper subsoil.

Chinese soil classification (1991)
In the national classification there are two opinions about paddy soils (Li and Sun, 1990). One regards paddy soils as an individual great soil group while the other considers paddy soils as subgroups of other soils. The monolith discussed here has characteristics of the Red Earths which have been modified by seasonal submergence through irrigation. Alternation of oxidation and reduction conditions in the profile has changed some characteristics. This soil belongs to the submergic (oxic) paddy soils.

In the Chinese Soil Taxonomic System (CSTC, 1991) this soil classifies as a Haplic Red soil (subgroup of udic Ferrallisols). In the CSTC system the "Udic" soil moisture is defined according to the degree of dryness ($D<1$).

3.5 Soil/land suitability

3.5.1 Major constraints for agriculture

For the purpose of highlighting major soil/land constraints, an assessment of relevant land qualities was made with STRESS (ISRIC, in prep.), a PC programme based on ALES (Rossiter, 1993) and the *Framework for Land Evaluation* (FAO, 1983).

The evaluation was made for a generalized, deep rooting, high nutrient demanding annual crop (e.g. maize). The results for the five reference soils are presented in Annex 2 with 22 climate, soil and land management qualities. The lay-out of the table is such that it directly reveals the major constraints for (rainfed) arable farming. These are briefly discussed here.

Major climatic constraints for all reference soils:
- shortage of rainfall and risk of drought in the summer/autumn months of July to October
- risk of prolonged temperatures below 0 °C in winter

Major soil constraints (mainly CN 21, 22 and 23)
- (very) low availability of plant nutrients
- (very) low capacity of nutrient retention
- strong soil acidity
- moderate to high level of toxic exchangeable aluminium

Major land management related constraint for all reference soils:
- moderate to high risk of soil erosion

Soils with Quaternary red clay parent materials (CN 21 and 25)

The nutrient availability of these soils is low, especially for nitrogen, magnesium and potassium. The soils are strongly acid and have a high level of toxic exchangeable aluminium (with highest value in the deeper mottled subsoil). The soil fertility status of the well drained red clay soil can be improved by liming and NPK fertilizers. An application of 1.6 ton ha^{-1} of $CaCO_3$ equivalent for every 1 $cmol_c$ kg^{-1} soil of exchangeable aluminium is often used as a measure of the lime requirement for very acid tropical soils (Landon, 1991). The higher plant nutrient level and the somewhat lower acidity in the upper layers of soil CN 25 is probably caused by such soil amelioration.

The soil moisture retention capacity is moderate to low. However, as the soil is deep, a deep rooted crop (e.g. trees) should be able to overcome occasional long dry periods. However, the high level of exchangeable aluminium may strongly restrict the effective rooting depth. For annual crops, supplementary irrigation is needed in the months of July to September.

For the eroded soil on Quaternary red clay, having the mottled soil layer at or near the soil surface, the limitations imposed by lack of available nutrients, presence of exchangeable aluminium and low available moisture are more severe.

Soils on Quaternary red clay are highly erodible caused by high silt and low organic matter content. The soil coherence is weak and therefore the soil slakes easily when wetted (irrigation or precipitation). Infiltration is limited and surface run-off is very high on bare soil surfaces.

Sandstone soils (CN 22, 23 and 24)
Soils derived from sandstone parent materials have constraints comparable to Quaternary red clay soils, such as low natural fertility, moderate to low moisture availability and a highly toxic concentration of exchangeable aluminium. However, these soils are preferred by the farmers. The main reason for this preference is probably that the soils derived from sandstone are more sandy and therefore more easily cultivated. In the past, with no mechanization and limited animal traction, the soils on Quaternary red clay were difficult to till in both dry and wet conditions. Field trials should indicate which soil is superior in terms of production, when used with optimal inputs and some mechanisation.

3.5.2 Risk of land degradation

Erosion
The soil developed in the Quaternary red clay parent material is always very deep. However, considerable areas are affected by moderate to severe erosion. Slight and/or moderate erosion is found mainly on land devoted to tea-oil, while severe rill and gully erosion is restricted to sparsely covered and bare soil areas. The bare, severely eroded land is very spectacular but in terms of total erosion in Jiangxi Province, the much larger area of low to moderately eroded land probably constitutes a far more serious problem.
The infiltration capacity of a red clay soil, when covered with grass/herbs or mulch, is good. When bare, the soil will form a surface crust or seal. The lack of a protective vegetative cover is induced by grass sods and litter removal in the past period when chemical fertilizers where not or limited available. The technique of bringing sods and litter to the paddy fields is no longer practised. However, the collection of litter (leaves and branches) for kitchen fuel still commonly occurs. Consequently the organic matter content is very low. This, combined with a high content of silt, creates an unstable soil structure. Rain impact on bare soil surface creates a smooth soil surface, which is sometimes sealed by a 'bio-seal', i.e. a slimy film composed of algae, mosses and soil particles which develops at the soil surface. Such a bio-seal impedes rainfall infiltration causing run-off. As the run-off concentrates, depending on slope length and slope gradient, rill and gully erosion may occur.
Although this process may be slow, in the long term it may result in seriously degraded land. From field observations it is clear that tree planting alone does not protect the soil because of the litter removal for fuelwood. The vicious circle may be broken by giving the farmer access to fuelwood and by planting trees on the uplands.
Even on land with contour ditches or bench terraces with furrows, soil erosion occurs when the farmers collect the litter. Although ditch and bench terracing slow down the erosion rate, rill and gully erosion was observed in several parcels of land having tall pine trees and a bare soil surface.

The high erodibility makes soil and water conservation techniques essential for this soil type. A permanent protective vegetative cover such as forest with herb/grass undergrowth will be the most effective. The following soil and water conservation techniques were observed where the soil was cultivated:
- to avoid a bare soil surface, green manures, crop residues and mulch were left on the soil surface.
- to reduce the erosive action of the run-off mechanical protection was implemented, such as a sloping bench terraces with careful attention to the storm drain channel for discharging the excess water. The bench terrace-bunds are or will be planted with Vetiver grass.
- several cropping practices, such as very deep land preparation, more or less parallel to the contour, and fertility improvement have been adopted.

The intrinsic high erodibility of the soil cannot easily be overcome. Although a higher organic matter content will create a more stable soil, a substantial increase is not easy to accomplish and requires a long time. When annual crops are considered, adoption of a variety of techniques, such as described previously, will be required.

Leaching of nutrients
Because of the very low cation exchange capacity the soil behaves as a sandy soil. The soils have therefore a high risk of nutrient leaching (cations and anions) from inputs such as fertilizers and lime. From the viewpoint of nutrient balance, the area has a high risk of nutrient depletion. Nutrient output factors are high: erosion, leaching of nutrients to the deeper subsoil, removal by the (multiple) crops. Input factors are low e.g. restoration period (fallow), manure and limited fertilizer use.

3.6 Soil formation

According to Jenny (1941), the factors responsible for soil formation are climate, plant and animal organisms, relief, parent material and time. Others consider that factors such as mankind, hydrology and the history of the landscape are important. For the Red Basins of Jiangxi, the factors for soil formation are:

Climate
The greater part of Jiangxi Province has a sub-humid sub-tropical climate with a surplus of rainfall over evapotranspiration. Climate is characterized by extremes, a wet spring and early summer, a very hot, partly dry summer and a dry cool winter.

Vegetation
The climax vegetation of Jiangxi Province is an evergreen, broad-leaved forest, but it has been mostly cleared. In the Red Basins, secondary vegetation includes pine tree and oil tea forests. Small patches of primary forest still remain on the high mountains.

Landform
Although dissected by rivers, the interfluvial areas of the Red Basins have a rather flat to weakly undulating landscape. The mountainous regions have very steep slope gradients.

Parent material
The soils of Jiangxi Province are derived from several parent materials, granite being the dominant one in the mountainous area. In the intermontane Red Basin areas, soils are derived from sandstone and Quaternary red clay deposits.

Hydrology
Most upland soils are imperfectly or poorly drained, the deeper subsoil showing strong mottling, indicative of water stagnation, caused by insufficient permeability in the deep subsoil and weathered rock to transmit the percolating excess of rainfall.

Time
A very long period of time is available for *in situ* soil formation.

Human influences
Human beings influence soil development in many ways: by exchanging the natural vegetation for crops and grassland, by liming, adding fertilizers, draining and terracing. Such activities may cause disruption of the soil horizons and can induce soil erosion.

History of the landscape
The landscape has been formed from continental sediments, the so-called 'red clays' which were deposited in intermontane basins during the Tertiary and Quaternary. Subsequent dissection of these sediments transformed the original horizontal surface into an undulating landscape. The red clays now form an extensive undulating plain with relief increasing towards the surrounding mountains where some isolated hills can be found. Relief decreases towards the central part of the basin. The transition to the lake deposits of Poyang Hu is marked by a clear step in the topography.

The original dense forest vegetation, the sub-tropical climate and a long period of time are major factors in the formation of the deep, strongly weathered soils. It is suggested that the sediments originating from the mountains were already (strongly) weathered. The balance between rainfall and evapotranspiration results in a surplus of precipitation, which in spring and early summer, causes a downward movement of water in the soil. The textural differentiation between topsoil and subsoil can be attributed to clay eluviation into the deeper subsoil. This process has translocated clay to the lower part of the profile where illuvial clay skins (cutans) are found on many ped surfaces in the B horizon.

The presence of mica/illite and vermiculite clay minerals indicates that soils are not completely weathered as e.g. under humid tropical conditions.

The original broad leaved forest of the Red Basins has been cleared long ago. The upland soils have been stripped of turf and topsoils to fertilize the paddy fields in the valleys. Since the introduction of artificial fertilizers this technique has been abandoned, but removal of litter for domestic fuel still takes place. This is probably one of the main causes for the very low organic matter content of all reference soils studied.

The genesis of the strongly mottled subsoils is not well understood. The first thought is to compare them with plinthite, however, there is not enough evidence to confirm these mottled subsoils as plinthite. Possibly, the material could be pseudo-plinthite, or result from the gley process. It is not clear whether the mottling is the result of water stagnation in a past period with different climatic conditions or whether the process is still taking place. Groundwater observations throughout the year are required to verify the assumed stagnation of water in the mottled deeper subsoil, caused by excess of rainwater which percolates to the subsoil. Insufficient permeability of the strongly mottled subsoil and/or of the (weathered) sandstone is probably the major determining physical factor of soil formation.

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Annex 1A ISIS data sheet CN 21

ISIS 4.0 data sheet of monolith CN 21 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 21/11/94

FAO/UNESCO (1988) : Alumi-Haplic Acrisol (Pachic and Chromic) (1974 : Orthic Acrisol)
USDA/SCS SOIL TAXONOMY (1992) : Udic Kandiustult, clayey, kaolinitic, thermic (1975 : Oxic Paleustult)
CSTC (1991) : Haplic red soil

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, argic B horizon
USDA/SCS (1992) : ochric epipedon, kandic horizon
Soil moisture regime : ustic

Remarks : < 10% weatherable minerals in the 20-200 micron fraction is assumed based on the lack of bases on the exchange complex and the dominance of kaolinite in the clay fraction down to 150 cm

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LOCATION : Jiangxi, Yujiang, Red Soil Ecological Station of ISSAS
Latitude : 28°13' N Longitude : 116°55' E Altitude : 45 m a.s.l.
AUTHOR(S) : Kauffman, J.H. Date (mm/yy) : 11/92

GENERAL LANDFORM : intermontane basin Topography : undulating
PHYSIOGRAPHIC UNIT : low, broad, interfluve
SLOPE Gradient : 3% Form : convex
POSITION OF SITE : crest
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : slaked
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : moderate sheet and severe gully

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PARENT MATERIAL : residual material derived from the Red Quarternary clay formation (1)

EFFECTIVE SOIL DEPTH : > 150 cm

WATER TABLE : no watertable observed
DRAINAGE : well
PERMEABILITY : slow Slowly permeable layer from : 150 to 500 cm
FLOODING Frequency : nil Run off : rapid
MOISTURE CONDITIONS PROFILE : 0 - 200 cm dry 200 - 400 cm moist

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LAND USE : fallow
Remarks : Red Quaternary Clay soils are not cultivated (2)

ADDITIONAL REMARKS :
(1) The intermontane basins in S. China are known as 'Red Basins'. At Yingtan the width of the basin is about 30 km. The basin has a plain appearance and consists of nearly level to undulating interfluves (low broad hills) with broad nearly level valleys.
(2) The Red Quaternary Clay soils of the interfluves are not used for cultivation by the farmer. Present vegetation is sparse grass cover and Masson Pine planted about 15 years ago. Growth is slow (height about 4 meters and diameter 8 cm).

The Red Quaternary Clay soil interfluves (hills) are affected by erosion. This is caused by the high run-off, resulting in sheet erosion. On middle and lower slopes, run-off water concentrates and severe gully erosion may occur. Erosion is man-induced, because the original broad-leaved forest has been cleared long ago. Before the use of inorganic fertilizers, the grass/herb vegetation with some topsoil was removed for the fertilization of the paddy fields in the valley. At present this practice is not anymore done, however, the litter is still frequently collected by farmers for kitchen fuel. This will still reduce the vegetation cover, incorporation of organic matter in the topsoil, lowering bio-activity and therefore still enhance the run-off and erosion.
The soil has all properties for a ferralic B horizon except for the high silt content (silt/clay >> 0.2).

CLIMATE : Köppen: Cwa
Station: YUJIANG 12 km W of site Relevance: very good

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
relative humidity %	27	77	79	80	80	80	80	71	72	74	72	74	76	76
PET (P.-M.) mm	26	43	45	65	90	112	126	183	174	135	109	69	50	1200
precipitation mm	37	75	130	188	257	286	284	124	112	94	63	62	53	1729
no. of raindays	28	12	15	19	18	19	17	10	11	10	9	9	11	161
T mean °C	28	5.9	7.5	12.0	17.8	22.2	25.9	30.0	29.3	25.6	19.7	13.8	8.3	18.2
T max °C	28	10.4	11.7	16.5	22.5	26.5	30.3	35.0	34.6	30.5	24.8	18.8	13.0	22.9
T min °C	28	2.5	4.3	8.7	14.2	18.8	22.5	25.8	25.2	21.7	15.7	10.0	4.8	14.5
windspeed(at 2m) m/s	26	2.1	2.4	2.5	2.4	2.4	2.1	2.2	2.1	2.3	2.4	2.1	2.0	2.2
bright sunshine h/d	27	3.7	3.4	3.3	4.2	4.5	5.6	9.0	8.5	7.1	6.0	5.0	4.4	5.4
bright sunshine %	27	35	30	28	33	33	40	65	65	58	53	49	42	45

PROFILE DESCRIPTION :

Very deep, well drained, reddish brown to red clay derived from Quaternary clay. The topsoil is nearly structureless. The subsoil has a subangular blocky structure and the deep subsoil an angular blocky structure, being strongly mottled. The soil is compact, there are mainly micropores and few very fine to fine pores. The soil permeability is therefore judged to be reduced, especially in the strongly mottled deeper subsoil, where ped surfaces are covered by clay cutans and show very few pores.

The soil surface is smooth and has a thin seal. Especially on eroded bare soil surfaces a bio-seal may be formed, reducing even more the infitration capacity of the topsoil for rain.

A	0 - 22 cm	Yellowish red (5YR 5/8, moist), reddish yellow (7.5YR 6/8, dry) sandy clay; weakly coherent porous massive to fine to weak medium subangular blocky structure; sticky, slightly plastic, firm, very hard; many micro pores and common very fine pores; many fine roots throughout; clear smooth boundary to
AB	22 - 45 cm	Red (2.5YR 4/8 moist), yellowish red (5YR 5/8, dry) clay; weak fine to medium subangular blocky structure; sticky, slightly plastic, very friable, hard; many micropores and common very fine pores; common fine roots throughout; gradual smooth boundary to
Bw1	45 - 95 cm	Red (1.0YR 4/6, moist, 2.5YR 4/8, dry) clay; weak to moderate fine to medium subangular blocky structure; sticky, slightly plastic, very friable, hard; continuous moderately thick clay cutans; many micropores and common very fine pores; few fine roots throughout; gradual smooth boundary to
Bw2	95 - 150 cm	Red (2.5YR 4/6 moist) clay; moderate fine to medium subangular blocky to moderate fine to medium angular blocky structure; sticky, slightly plastic, friable; continuous moderately thick clay cutans; common very fine pores; few fine roots throughout; diffuse smooth boundary to
Bg1	150 - 250 cm	Dark red (2.5YR 3/6, moist) clay; strong medium angular blocky structure; sticky, slightly plastic, firm; many medium distinct strong brown (7.5YR 5/6) mottles; clay cutans on pedfaces; few very fine pores; diffuse smooth boundary to
Bg2	220 - 450 cm	Dark red (2.5YR 3/6, moist) clay; strong medium angular blocky structure; sticky, slightly plastic, firm; many coarse prominent light yellowish brown (10YR 6/4) mottles; continuous moderately thick clay cutans on pedfaces

ANALYTICAL DATA :

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 µm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 7	-	0	1	2	7	9	19	13	30	43	38	1.7	-	-	-	-	-	-	-	-	-
2	7 - 22	-	0	1	2	7	7	17	12	31	43	39	1.4	1.35	46	41	37	35	33	31	25	23
3	22 - 45	-	0	1	2	5	6	14	13	26	40	47	0.0	-	-	-	-	-	-	-	-	-
4	45 - 95	-	0	1	2	5	5	12	11	26	36	52	2.0	1.20	45	44	42	40	38	37	29	26
5	95 - 150	-	0	0	1	4	6	11	11	25	36	53	1.4	1.27	45	44	42	40	39	38	32	29
6	150 - 220	-	0	0	1	3	6	10	12	25	36	54	5.0	1.46	45	44	43	41	40	39	37	34
7	220 - 270	-	0	0	0	2	5	7	13	26	39	54	-	1.36	49	49	48	46	45	45	41	41
8	300 - 350	-	0	0	0	1	6	8	15	24	39	53	-	-	-	-	-	-	-	-	-	-
9	370 - 450	-	0	0	0	1	9	10	13	30	43	47	-	-	-	-	-	-	-	-	-	-

Hor. no.	Top - Bot	pH- H2O	KCl	CaCO3 %	ORG- C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS cm^{-1}
							cmol$_c$ kg^{-1}													
1	0 - 7	4.3	3.8	-	0.42	0.05	1.8	0.0	0.1	0.0	1.9	3.4	3.2	6.2	16	1.5	5.3	31	52	0.04
2	7 - 22	4.4	3.8	-	0.24	0.04	1.6	0.0	0.0	0.0	1.6	3.7	3.4	6.2	16	0.8	5.3	26	55	0.02
3	22 - 45	4.5	3.8	-	0.15	0.04	1.4	0.0	0.0	0.0	1.4	4.5	4.1	7.6	16	0.5	5.9	18	54	0.01
4	45 - 95	4.5	3.7	-	0.12	0.04	1.4	0.0	0.0	0.0	1.4	5.3	5.0	9.2	18	0.4	6.7	15	54	0.01
5	95 - 150	4.5	3.6	-	0.11	0.04	1.2	0.0	0.0	0.0	1.2	6.2	5.9	9.9	19	0.4	7.4	12	60	0.01
6	150 - 220	4.5	3.6	-	0.25	0.04	1.4	0.0	0.0	0.0	1.4	8.1	7.8	15.8	29	0.9	9.5	9	49	0.01
7	220 - 270	4.4	3.6	-	0.09	0.04	1.2	0.0	0.1	0.0	1.3	10.0	9.6	13.4	25	0.3	11.3	10	72	0.01
8	300 - 350	4.3	3.5	-	0.05	0.04	1.2	0.0	0.2	0.0	1.4	11.7	11.0	17.6	33	0.2	13.1	8	63	0.02
9	370 - 450	4.4	3.6	-	0.04	0.03	1.2	0.0	0.3	0.0	1.5	13.2	12.8	22.2	47	0.1	14.7	7	58	0.02

CLAY MINERALOGY (1 very weak, ..., 8 very strong) / EXTRACTABLE Fe & Al by Na DITHIONITE / AVAIL. P (Bray)

Hor. no.	Top - Bot	MICA /ILL	VERM	SMEC	KAOL	MIX	QUAR	GOET	Fe	Al	AVAIL. P (Bray) mg kg^{-1}
1	0 - 7	2	2	2	5	3	4	1	2.1	0.3	0.0
2	7 - 22	2	2	2	5	3	3	1	2.1	0.3	0.0
3	22 - 45	2	2	2	5	3	3	2	2.7	0.3	0.0
4	45 - 95	2	2	2	5	3	2	1	3.2	0.4	0.0
5	95 - 150	3	2	2	6	3	2	2	3.4	0.3	0.0
6	150 - 220	3	2	2	6	3	1	2	4.3	0.4	0.0
7	220 - 270	3	2	2	6	3	-	2	6.7	0.5	0.1
8	300 - 350	4	3	3	6	3	-	2	5.6	0.4	0.0
9	370 - 450	4	3	3	4	3	-	1	4.0	0.3	0.0

Annex 1B ISIS data sheet CN 22

ISIS 4.0 data sheet of monolith CN 22 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 21/11/94

FAO/UNESCO (1988) : Alumi-Ferric Alisol (Pachic and Chromic) (1974 : Ferric Acrisol)
USDA/SCS SOIL TAXONOMY (1992) : Typic Paleustult, clayey, mixed, thermic (1975 : Typic Paleustult)
CSTC (1991) :

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, albic E, argic B horizon; ferric properties
USDA/SCS (1992) : ochric epipedon, argillic horizon
Soil moisture regime : ustic

LOCATION : Jiangxi, Yujiang
Latitude : 28°13' N Longitude : 116°55' E Altitude : 40 m a.s.l.
AUTHOR(S) : Kauffman, J.H. / Wang Minzhu Date (mm/yy) : 11/92

GENERAL LANDFORM : intermontane basin Topography : undulating
PHYSIOGRAPHIC UNIT : low, broad, interfluve
SLOPE Gradient : 2% Form : convex
POSITION OF SITE : crest
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : slaked
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : moderate sheet

PARENT MATERIAL : residual material derived from fine sandstone

EFFECTIVE SOIL DEPTH : 100 cm

WATER TABLE : no watertable observed
DRAINAGE : moderately well to well
PERMEABILITY : slow Slowly permeable layer from : 100 to 200 cm
FLOODING Frequency : nil Run off : rapid
MOISTURE CONDITIONS PROFILE : 0 - 100 cm dry 100 - 200 cm moist

LAND USE : fallow
Landuse/vegetation remarks : Near site arable farming; crops: tea, buck-wheat, tunip, peanuts, millet.

ADDITIONAL REMARKS :
The strongly mottled subsoil is considered to be pseudo-plinthite, because it does not harden upon wetting and drying. It is not clear whether the mottling results from a past period with different climatic conditions or is caused by actual processes. Groundwater observations throughout the year are necessary to verify the assumed stagnation of water in the deeper subsoil. Possibly the sandstone and the strongly mottled deeper subsoil are having insufficient permeability to transmit vertically and/or laterally the excess precipitation during the rainy season.

CLIMATE : Köppen: Cwa
Station: YUJIANG 12 km W of site Relevance: very good

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
relative humidity %	27	77	79	80	80	80	80	71	72	74	72	74	76	76
PET (P.-M.) mm	26	43	45	65	90	112	126	183	174	135	109	69	50	1200
precipitation mm	37	75	130	188	257	286	284	124	112	94	63	62	53	1729
no. of raindays	28	12	15	19	18	19	17	10	11	10	9	9	11	161
T mean °C	28	5.9	7.5	12.0	17.8	22.2	25.9	30.0	29.3	25.6	19.7	13.8	8.3	18.2
T max °C	28	10.4	11.7	16.5	22.5	26.5	30.3	35.0	34.6	30.5	24.8	18.8	13.0	22.9
T min °C	28	2.5	4.3	8.7	14.2	18.8	22.5	25.8	25.2	21.7	15.7	10.0	4.8	14.5
windspeed(at 2m) m/s	26	2.1	2.4	2.5	2.4	2.4	2.1	2.2	2.1	2.3	2.4	2.1	2.0	2.2
bright sunshine h/d	27	3.7	3.4	3.3	4.2	4.5	5.6	9.0	8.5	7.1	6.0	5.0	4.4	5.4
bright sunshine %	27	35	30	28	33	33	40	65	65	58	53	49	42	45

PROFILE DESCRIPTION :

Deep, imperfectly drained red sandy clay loam derived from sandstone. The topsoil is very weakly developed (light colour and no structure). The subsoil is strongly mottled.

A	0 - 22 cm	Yellowish red (6YR 5/8, moist) sandy loam; weakly coherent porous massive structure; slightly sticky, slightly plastic, very friable, hard; common medium distinct brownish yellow (10YR 6/8) mottles; common very fine tubular pores; common fine roots throughout; clear smooth boundary to
AB	22 - 46 cm	Yellowish red (5YR 5/8, moist) sandy loam; weak fine subangular blocky structure; slightly sticky, slightly plastic, very friable, hard; common medium distinct brownish yellow (10YR 6/8) mottles; many micro pores and few very fine tubular pores; common fine roots throughout; gradual smooth boundary to
Bg1	46 - 95 cm	Red (2.5YR 4/6, moist) sandy clay loam; moderate fine to medium subangular blocky structure; slightly sticky, slightly plastic, friable; many medium distinct yellowish red (5YR 5/6) mottles; patchy moderately thick clay cutans; few very fine pores; few fine roots throughout; diffuse smooth boundary to
Bg2	95 - 180 cm	Red (2.5YR 4/8, moist) sandy clay loam; weak medium subangular blocky structure; slightly sticky, slightly plastic, friable; many coarse prominent reddish yellow (7.5YR 6/6) and pinkish gray (7.5YR 7/3) mottles

ANALYTICAL DATA :

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 μm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 8	-	0	1	3	23	27	54	1	16	17	29	0.9	-	-	-	-	-	-	-	-	-
2	8 - 22	-	0	1	3	14	29	47	7	15	23	31	1.5	1.45	42	40	36	33	31	29	24	23
3	22 - 46	-	0	1	3	21	19	43	6	14	20	37	1.5	-	-	-	-	-	-	-	-	-
4	46 - 95	-	0	1	2	14	25	41	7	13	20	39	1.5	1.38	43	43	39	36	35	33	29	27
5	95 - 140	-	0	1	3	19	20	42	7	13	19	39	1.9	1.45	42	42	40	38	37	36	30	27
6	140 - 180	-	0	0	2	14	28	45	5	13	18	37	22.3	-	-	-	-	-	-	-	-	-

Hor. no.	Top - Bot	pH- H2O	KCl	CaCO3 %	ORG- C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS cm^{-1}
							$cmol_c\ kg^{-1}$													
1	0 - 8	4.3	3.8	-	0.21	0.03	1.4	0.0	0.1	0.0	1.5	3.2	2.9	4.2	14	0.7	4.7	36	69	0.03
2	8 - 22	4.5	3.8	-	0.13	0.02	1.4	0.0	0.1	0.0	1.5	3.8	3.4	8.7	28	0.5	5.3	17	39	0.02
3	22 - 46	4.4	3.9	-	0.17	0.02	1.2	0.0	0.0	0.0	1.2	4.2	4.1	14.7	40	0.6	5.4	8	28	0.01
4	46 - 95	4.4	3.8	-	0.07	0.02	1.2	0.0	0.0	0.0	1.2	4.8	4.5	11.9	31	0.2	6.0	10	38	0.02
5	95 - 140	4.4	3.8	-	0.04	0.02	1.0	0.0	0.0	0.0	1.0	6.0	5.4	13.1	34	0.1	7.0	8	41	0.01
6	140 - 180	4.4	3.7	-	0.03	0.01	1.2	0.0	0.0	0.0	1.2	6.5	5.7	17.9	48	0.1	7.7	7	32	0.01

CLAY MINERALOGY (1 very weak, ..., 8 very strong) — EXTRACTABLE Fe & Al by Na DITHIONITE — AVAIL. P (Bray)

Hor. no.	Top - Bot	MICA /ILL	CHLO	KAOL	MIX	QUAR	GOET	Fe	Al	AVAIL. P (Bray) mg kg^{-1}
1	0 - 8	1	4	5	3	2	3	1.4	0.4	0.3
2	8 - 22	1	4	5	3	2	3	1.8	0.4	0.0
3	22 - 46	1	4	6	4	1	3	2.1	0.5	0.0
4	46 - 95	1	4	6	4	-	3	2.6	0.4	0.0
5	95 - 140	1	4	5	3	-	3	2.6	0.4	0.0
6	140 - 180	1	4	5	3	-	3	2.5	0.4	0.0

Annex 1C   ISIS data sheet CN 23

ISIS 4.0 data sheet of monolith CN 23   Country : PEOPLE'S REPUBLIC OF CHINA   Print date (dd/mm/yy) : 21/11/9[illegible]

FAO/UNESCO (1988)	: Alumi-Dystric Cambisol (Xanthic)	(1974 : Dystric Cambisol)
USDA/SCS SOIL TAXONOMY (1992)	: Dystric Ustochrept, fine-loamy, mixed, thermic	(1975 : Dystric Ustochrept)
CSTC (1991)	:	

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, cambic B horizon
USDA/SCS (1992) : ochric epipedon, cambic horizon
Soil moisture regime : ustic

LOCATION : Jiangxi, Yujiang, Lijia farm
Latitude : 28°13' N   Longitude : 116°55' E   Altitude : 50 m a.s.l.
AUTHOR(S) : Kauffman, J.H. / Wang / Zhang Gan   Date (mm/yy) : 11/92

GENERAL LANDFORM : plain   Topography : undulating
PHYSIOGRAPHIC UNIT : low broad interfluve
SLOPE Gradient : 2%   Form : convex
POSITION OF SITE : crest
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil   Stoniness : nil
Cracking : nil   Slaking/crusting : slaked
Salt : nil   Alkali : nil
SLOPE PROCESSES Soil erosion : moderate sheet

PARENT MATERIAL : residual material derived from fine red sandstone
Weathering degree : high

EFFECTIVE SOIL DEPTH : 100 cm

WATER TABLE : no watertable observed
DRAINAGE : moderately well to well
PERMEABILITY : no slowly permeable layer(s)
FLOODING Frequency : nil   Run off : rapid
MOISTURE CONDITIONS PROFILE : 0 - 50 cm dry   50 - 125 cm moist

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LAND USE : fallow
Remarks : the hard sandstone can be relatively easily cut in blocks and is frequently used for house building. Many quarries are observed in the area.

CLIMATE : Köppen: Cwa
Station: YUJIANG 12 km W of site   Relevance: very good

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
relative humidity %	27	77	79	80	80	80	80	71	72	74	72	74	76	7[illegible]
PET (P.-M.) mm	26	43	45	65	90	112	126	183	174	135	109	69	50	120[illegible]
precipitation mm	37	75	130	188	257	286	284	124	112	94	63	62	53	172[illegible]
no. of raindays	28	12	15	19	18	19	17	10	11	10	9	9	11	16[illegible]
T mean °C	28	5.9	7.5	12.0	17.8	22.2	25.9	30.0	29.3	25.6	19.7	13.8	8.3	18.2
T max °C	28	10.4	11.7	16.5	22.5	26.5	30.3	35.0	34.6	30.5	24.8	18.8	13.0	22.9
T min °C	28	2.5	4.3	8.7	14.2	18.8	22.5	25.8	25.2	21.7	15.7	10.0	4.8	14.5
windspeed(at 2m) m/s	26	2.1	2.4	2.5	2.4	2.4	2.1	2.2	2.1	2.3	2.4	2.1	2.0	2.2
bright sunshine h/d	27	3.7	3.4	3.3	4.2	4.5	5.6	9.0	8.5	7.1	6.0	5.0	4.4	5.4
bright sunshine %	27	35	30	28	33	33	40	65	65	58	53	49	42	4[illegible]

PROFILE DESCRIPTION :
Shallow to moderately deep yellow sandy loam derived from sandstone. The shallow soil overlays a weathered sandstone, the hard sandstone starts at about 100 cm.

A	0 - 5 cm	Dark brown (10YR 3/3, moist) to yellowish brown (10YR 5/8, dry) sandy loam; weakly coherent porous massive structure; slightly sticky, slightly plastic, friable, hard; many fine roots throughout; gradual smooth boundary to
B	5 - 30 cm	Brownish yellow (10YR 6/8, moist) sandy clay loam; weakly coherent porous massive to weak medium subangular blocky structure; slightly sticky, slightly plastic, friable; few fine tubular pores; common fine roots throughout; gradual smooth boundary to
BC	30 - 65 cm	Yellow (10YR 7/8, moist) loam; weakly coherent porous massive to weak medium subangular blocky structure; slightly sticky, slightly plastic, friable; few medium faint orange (2.5YR 7/8) mottles; few fine tubular pores; few fine roots throughout; few medium soft ferrigenous nodules; clear wavy boundary to
C	65 - 100 cm	Sandy loam; weakly coherent porous massive structure; slightly sticky, slightly plastic, very friable; common fine tubular pores; abrupt smooth boundary to
R	100 - 120 cm	Sand; non sticky, non plastic

ANALYTICAL DATA :

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 µm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 5	-	1	2	13	35	25	75	6	4	11	15	5.5	-	-	-	-	-	-	-	-	-
2	5 - 30	-	0	1	18	24	20	63	4	9	13	24	2.0	1.65	35	32	30	26	23	20	18	15
3	30 - 65	-	0	1	25	29	10	65	4	9	13	23	5.5	1.45	42	41	39	35	33	31	26	24
4	65 - 100	-	0	0	24	30	17	71	4	7	11	18	5.9	1.54	41	40	39	36	34	32	27	22
5	100 - 120	-	0	0	20	46	13	80	6	10	16	5	-	-	-	-	-	-	-	-	-	-

Hor. no.	Top - Bot	pH- H2O	KCl	CaCO3 %	ORG- C %	MAT. N %	EXCH CAT. Ca (cmol$_c$ kg^{-1})	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS cm^{-1}
1	0 - 5	4.5	4.1	-	0.58	0.04	1.4	0.0	0.1	0.0	1.5	2.4	2.2	4.0	27	2.0	3.9	38	55	0.03
2	5 - 30	4.4	3.9	-	0.16	0.02	1.2	0.0	0.0	0.0	1.2	7.0	6.4	8.7	36	0.6	8.2	14	74	0.02
3	30 - 65	4.4	3.8	-	0.06	0.01	1.0	0.0	0.1	0.0	1.1	9.1	8.8	11.2	50	0.2	10.2	10	79	0.02
4	65 - 100	4.5	3.8	-	0.04	0.01	1.0	0.0	0.1	0.0	1.1	9.3	8.8	9.0	51	0.1	10.4	12	98	0.02
5	100 - 120	4.7	3.9	-	0.00	0.01	1.4	0.0	0.1	0.0	1.5	8.8	8.4	9.8	196	0.0	10.3	15	86	0.01

CLAY MINERALOGY (1 very weak, ..., 8 very strong) — EXTRACTABLE Fe & Al by Na DITHIONITE — AVAIL. P (Bray) mg kg^{-1}

Hor. no.	Top - Bot	CHLO	SMEC	KAOL	GOET	Fe	Al	AVAIL. P (Bray) mg kg^{-1}
1	0 - 5	4	3	4	4	0.9	0.2	1.1
2	5 - 30	4	3	4	4	1.2	0.3	0.0
3	30 - 65	4	3	4	4	0.9	0.3	0.0
4	65 - 100	3	4	4	4	0.7	0.2	0.0
5	100 - 120	3	5	3	-	0.2	0.1	3.7

Annex 1D ISIS data sheet CN 24

ISIS 4.0 data sheet of monolith CN 24 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 21/11/94

FAO/UNESCO (1988) : Orthi-Ferric Alisol, anthraquic phase (1974 : Ferric Acrisol, phreatric phase)
USDA/SCS SOIL TAXONOMY (1992) : Anthraquic Hapludalf, fine, mixed, thermic (1975 : Typic Hapludalf)
CSTC (1991) : Hydragric paddy soil

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, argic B horizon; ferric properties
USDA/SCS (1992) : ochric epipedon, argillic horizon; anthraquic conditions
Soil moisture regime : udic

LOCATION : Jiangxi, Jujiang, Liujia farm, Zhongshan Liujia
Latitude : 28°13' N Longitude : 116°55' E Altitude : 40 m a.s.l.
AUTHOR(S) : Kauffman, J.H. / Luo Guobao / Z. Ganlin Date (mm/yy) : 11/92

GENERAL LANDFORM : plain Topography : undulating
PHYSIOGRAPHIC UNIT : low, broad, smooth interfluve
SLOPE Gradient : 5% Form : straight
POSITION OF SITE : middle slope
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : slaked
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : not observed

PARENT MATERIAL : residual material derived from sandstone

EFFECTIVE SOIL DEPTH : 140 cm

WATER TABLE Depth : 160 cm Kind : groundwater table
Estimated highest level : 0 cm Estimated lowest level : 200 cm
DRAINAGE : imperfect-moderately well
PERMEABILITY : no slowly permeable layer(s)
FLOODING Frequency : not known Run off : ponded
MOISTURE CONDITIONS PROFILE : 0 - 10 cm dry 10 - 140 cm moist 140 - 210 cm wet

LAND USE : arable farming
Landuse/vegetation remarks : terraced paddy field

ADDITIONAL REMARKS :
The valley and lower hill slopes are cultivated already for centuries. The middle slopes are terraced and brought under cultivation since the construction of large reservoirs in the area (about 1950 till present).
The soil is derived from sandstone. Although mainly formed in situ some colluvial material has contributed to the soil.
CN 24 forms the middle catena-member and is related to CN 23 which is located on top of the interfluve at a distance of about 100 to 150 meter.
Both soils are situated in a 'Red Basin' (intermontane basin). At Yingtan the width of the basin is about 30km.

CLIMATE : Köppen: Cwa
Station: YUJIANG 12 km W of site Relevance: very good

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
relative humidity	%	27	77	79	80	80	80	80	71	72	74	72	74	76	76
PET (P.-M.)	mm	26	43	45	65	90	112	126	183	174	135	109	69	50	1200
precipitation	mm	37	75	130	188	257	286	284	124	112	94	63	62	53	1729
no. of rain days		28	12	15	19	18	19	17	10	11	10	9	9	11	161
T mean	°C	28	5.9	7.5	12.0	17.8	22.2	25.9	30.0	29.3	25.6	19.7	13.8	8.3	18.2
T max	°C	28	10.4	11.7	16.5	22.5	26.5	30.3	35.0	34.6	30.5	24.8	18.8	13.0	22.9
T min	°C	28	2.5	4.3	8.7	14.2	18.8	22.5	25.8	25.2	21.7	15.7	10.0	4.8	14.5
windspeed(at 2m)	m/s	26	2.1	2.4	2.5	2.4	2.4	2.1	2.2	2.1	2.3	2.4	2.1	2.0	2.2
bright sunshine	h/d	27	3.7	3.4	3.3	4.2	4.5	5.6	9.0	8.5	7.1	6.0	5.0	4.4	5.4
bright sunshine	%	27	35	30	28	33	33	40	65	65	58	53	49	42	45

PROFILE DESCRIPTION :

Deep, moderately well drained, mottled, brown to light yellowish brown loam derived from sandstone. At the site weathered sandstone occurs at a depth of 2 meter. The dark yellowish brown topsoil is low in organic carbon. The soil is porous massive and weakly coherent, apart from some weakly developed subangular blocky structures between 30 and 70 cm depth. The general soil reaction is stongly acid except between the bottom of the plough layer and 70 cm depth which is acid in reaction possibly due to colluvial influences or caused by fertilization, or both.

Ap	0 - 18 cm	Dark yellowish brown (10YR 4/4, moist) loam; weakly coherent porous massive; slightly sticky, slightly plastic, friable; common fine distinct strong brown (7.5YR 5/8) mottles; many fine roots throughout; abrupt wavy boundary to
AB	18 - 30 cm	Brown (10YR 4/6, moist) loam; weakly coherent porous massive; slightly sticky, slightly plastic, friable; many fine distinct strong brown (7.5YR 5/8) mottles; common fine roots throughout; gradual smooth boundary to
Bw	30 - 70 cm	Brown (7.5YR 4/6, moist) loam; weakly coherent porous massive to weak medium subangular blocky structure; slightly sticky, slightly plastic, very friable; many medium distinct yellowish brown (10YR 5/6) mottles; few fine roots throughout; gradual smooth boundary to
Bg1	70 - 110 cm	Light yellowish brown (10YR 6/4, moist) loam; weakly coherent porous massive; slightly sticky, slightly plastic, very friable; many coarse prominent yellowish brown (10YR 5/6) mottles; gradual smooth boundary to
Bg2	110 - 140 cm	Very pale brown (10YR 7/3, moist) sandy loam; weakly coherent porous massive; slightly sticky, slightly plastic, very friable; many coarse prominent yellowish brown (10YR 5/8) mottles; clear smooth boundary to
Bg3	140 - 200 cm	White (10YR 8/2, moist) loamy sand; many medium prominent brownish yellow (10YR 6/8) mottles; abrupt smooth boundary to
C/R	200 - 210 cm	Sand with sandstone fragments

ANALYTICAL DATA :

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 µm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 18	-	0	3	9	24	28	65	8	15	23	13	-	1.45	39	38	35	28	24	21	17	13
2	18 - 30	-	0	3	7	21	14	44	7	20	27	29	-	-	-	-	-	-	-	-	-	-
3	30 - 70	-	0	2	5	13	9	28	7	26	33	39	-	1.41	45	44	42	40	39	38	29	28
4	70 - 110	-	0	2	7	15	14	38	7	23	30	32	-	1.43	44	43	42	40	38	37	29	26
5	110 - 140	-	0	3	9	34	16	63	8	13	21	17	-	-	-	-	-	-	-	-	-	-
6	140 - 170	-	0	3	10	25	25	63	5	9	14	23	-	-	-	-	-	-	-	-	-	-
7	170 - 200	-	0	2	12	34	14	63	5	8	14	24	-	-	-	-	-	-	-	-	-	-
8	200 - 240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Hor. no.	Top - Bot	pH H2O	pH KCl	CaCO3 %	ORG. C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS cm^{-1}
							cmol$_c$ kg^{-1}													
1	0 - 18	4.8	4.1	-	0.61	0.07	2.6	0.7	0.1	0.0	3.4	1.0	0.9	4.0	32	2.1	4.4	85	22	0.04
2	18 - 30	5.1	4.3	-	0.27	0.05	4.7	1.0	0.1	0.1	5.9	0.5	0.2	7.3	25	0.9	6.4	81	3	0.03
3	30 - 70	5.4	4.5	-	0.22	0.05	5.6	1.0	0.1	0.1	6.8	0.2	0.0	9.5	24	0.8	7.0	72	0	0.02
4	70 - 110	4.6	4.0	-	0.11	0.03	2.4	0.3	0.1	0.0	2.8	2.9	2.7	7.1	22	0.4	5.7	39	38	0.03
5	110 - 140	4.7	4.0	-	0.00	0.01	1.8	0.3	0.1	0.0	2.2	1.6	1.4	3.0	18	0.0	3.8	73	47	0.02
6	140 - 170	4.8	3.9	-	0.02	0.02	3.4	0.7	0.1	0.0	4.2	2.2	2.0	7.0	30	0.1	6.4	60	29	0.02
7	170 - 200	4.8	3.9	-	0.04	0.01	5.3	0.7	0.1	0.1	6.2	3.1	3.0	9.8	41	0.1	9.3	63	31	0.03
8	200 - 240	4.8	3.9	-	0.00	0.00	6.1	1.0	0.1	0.1	7.3	3.9	3.4	-	-	0.0	11.2	-	-	0.03

CLAY MINERALOGY (1 very weak, ..., 8 very strong)

Hor. no.	Top - Bot	MICA /ILL	CHLO	SMEC	KAOL	MIX	QUAR	GOET	EXTRACTABLE Fe & Al by Na DITHIONITE Fe	Al	AVAIL. P (Bray) mg kg^{-1}
1	0 - 18	1	2	2	4	3	3	1	0.6	0.1	20.8
2	18 - 30	2	2	2	4	3	3	2	1.6	0.4	0.3
3	30 - 70	2	2	2	4	3	3	2	1.6	0.5	0.2
4	70 - 110	2	2	2	4	3	3	2	1.5	0.4	0.3
5	110 - 140	2	2	2	4	3	3	3	0.8	0.2	3.8
6	140 - 170	2	2	2	4	4	2	5	1.9	0.3	6.2
7	170 - 200	2	2	4	3	4	2	5	1.8	0.3	0.2
8	200 - 240	1	-	4	3	4	1	-	0.1	0.1	0.5

Annex 1E ISIS data sheet CN 25

ISIS 4.0 data sheet of monolith CN 25 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 01/06/94

FAO/UNESCO (1988) : Niti-Haplic Acrisol (Pachic and Chromic) (1974 : Ferric Acrisol)
USDA/SCS SOIL TAXONOMY (1992) : Typic Paleudult, clayey, mixed, thermic (1975 : Typic Hapludult)
CSTC (1991) : Haplic red soil

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, argic B horizon
USDA/SCS (1992) : ochric epipedon, argillic horizon; weatherable minerals
Soil moisture regime : udic

LOCATION : Jinxian, Zhaobu, Beian, km 24.8 on road Jinxian-Sanyang
Latitude : 28°29′ 0′′ N Longitude : 116°16′ 0′′ E Altitude : 30 m a.s.l.
AUTHOR(S) : Luo/ Van Engelen, V./ Zhang Date (mm/yy) : 11/92

GENERAL LANDFORM : plain Topography : undulating
PHYSIOGRAPHIC UNIT : summit of broad interfluve
SLOPE Gradient : 2% Aspect : S Form : convex
POSITION OF SITE : crest
MICRO RELIEF Kind : level
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : partly slaked
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : nil Aggradation : nil
Slope stability : stable

PARENT MATERIAL : unconsolidated Quaternary red clay

EFFECTIVE SOIL DEPTH : 200 cm

WATER TABLE : no watertable observed
DRAINAGE : moderately well
PERMEABILITY : moderate; no slowly permeable layer(s)
FLOODING Frequency : nil Run off : medium
MOISTURE CONDITIONS PROFILE : 0 - 11 cm wet; 11 - 146 cm moist

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LAND USE : low level arable farming; crops : cotton; seasonal irrigation (not sufficient water for paddy rice); rotation : continuous crop rotation; improvements : terracing, dating back 20 years.

ADDITIONAL REMARKS :
The Bt horizon is now only 11 cm from the surface because of the terracing.

Slide nos. of the ISRIC collection: 13891-13896 (landscape, profile, profile details).

CLIMATE : Köppen: Cwa
Station: JINXIAN 28 23 N/116 17 E 30 m a.s.l. 20 km S of site Relevance: very good

	No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
pan evaporation mm	12	43	43	67	103	165	183	290	239	146	111	82	66	1539
relative humidity %	12	83	85	85	83	80	81	72	77	81	80	79	76	80
precipitation mm	12	80	113	181	205	205	267	130	128	84	71	50	25	1525
no. of raindays	12	15	17	20	18	16	15	11	10	10	10	9	7	158
tot.glob.rad. MJ/m2	12	6.6	6.5	8.4	10.3	13.6	15.0	19.1	18.2	13.7	11.1	8.9	8.6	11.7
T mean °C	12	5.3	6.2	10.6	16.9	22.6	26.1	29.9	29.0	24.5	19.2	13.4	7.1	17.6
T max °C	12	8.6	9.5	14.3	21.0	26.8	30.1	34.5	33.4	28.3	23.3	17.6	11.7	21.6
T min °C	12	2.6	4.1	8.1	14.0	19.1	23.0	26.2	25.5	21.5	16.0	10.0	4.2	14.5
windspeed(at 2m) m/s	12	1.7	1.8	1.8	1.6	1.7	1.7	1.8	1.6	1.8	1.7	1.7	1.5	1.7
bright sunshine h/d	12	2.7	2.2	2.3	3.2	4.8	5.3	8.0	7.8	5.8	4.6	4.4	4.7	4.7

PROFILE DESCRIPTION :

Very deep, moderately well drained, dark red to red clay derived from Quaternary red clayey deposits. The topsoil is only 11 cm thick and consists of reworked B material. Organic carbon content is low. The subsoil has very strongly developed angular blocky structures. Soil reaction is acid in the surface layers and strongly acid in the subsoil below 50 cm depth.

Ap	0 - 11 cm	Dark yellowish brown (10YR 4/6, moist) clay loam; weak to moderate medium to coarse subangular blocky structure; sticky, plastic, firm; few fine continuous exped-inped tubular pores; slightly porous; many fine and medium roots throughout; few pedotubules; clear smooth boundary to
Bt1	11 - 90 cm	Dark red (2.5YR 3/6, moist), dark reddish brown (5YR 3/6, dry) clay; very strong fine angular blocky structure; very sticky, very plastic, very hard; continuous moderately thick clay cutans on pedfaces; few fine discontinuous exped-inped tubular pores; slightly porous; few medium roots between peds and few fine roots throughout; very few small spherical hard manganiferous concretions; no biological activity; gradual smooth boundary to
Bt2	90 - 146 cm	Red (2.5YR 4/8, moist), yellowish red (5YR 4/8, dry) clay; very strong fine angular blocky structure; very sticky, very plastic, very hard; few medium prominent clear strong brown (7.5YR 5/8) mottles; continuous moderately thick clay cutans on pedfaces; few fine discontinuous exped-inped tubular pores; slightly porous; no roots; few medium spherical hard manganiferous concretions; no biological activity
	146 - 200 cm	Red (2.5YR 4/8, moist) clay

ANALYTICAL DATA :

Hor. no.	Top - Bot	>2 mm	2000 1000	1000 500	500 250	250 100	100 50	TOT SAND	50 20	20 2	TOT SILT	<2 µm	DISP	BULK DENS	pF- 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
1	0 - 11	-	1	1	2	4	4	12	20	42	62	26	10.3	1.23	46	43	39	34	34	29	22	19
2	11 - 50	-	0	0	0	1	2	3	10	34	44	53	1.0	1.30	47	45	41	38	38	36	35	32
3	50 - 90	-	0	0	0	1	2	3	10	34	44	53	2.3	-	-	-	-	-	-	-	-	-
4	90 - 145	-	0	1	1	1	3	5	11	33	44	51	1.5	1.49	42	42	41	40	39	38	36	32
5	190 - 200	-	0	1	1	1	5	8	13	32	46	47	-	-	-	-	-	-	-	-	-	-

Hor. no.	Top - Bot	pH- H2O	KCl	CaCO3 %	ORG-C %	MAT. N %	EXCH CAT. Ca	Mg	K	Na	sum	EXCH AC. H+Al	Al	CEC soil	clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS cm⁻¹
							cmol$_c$ kg^{-1}													
1	0 - 11	5.5	4.7	-	0.82	0.10	5.0	1.3	0.5	0.1	6.9	0.1	0.0	8.6	34	2.9	7.0	80	0	0.08
2	11 - 50	5.4	4.5	-	0.15	0.05	6.2	1.4	0.2	0.0	7.8	0.0	0.0	10.4	20	0.5	7.8	75	0	0.04
3	50 - 90	4.8	4.0	-	0.09	0.05	4.1	1.4	0.3	0.0	5.8	1.5	1.1	10.0	19	0.3	7.3	58	11	0.03
4	90 - 145	4.7	3.9	-	0.08	0.05	2.6	1.3	0.3	0.0	4.2	2.7	2.3	9.2	18	0.3	6.9	46	25	0.03
5	190 - 200	4.6	3.8	-	0.03	0.04	0.4	0.7	0.2	0.0	1.3	4.2	3.9	8.3	18	0.1	5.5	16	47	0.02

CLAY MINERALOGY (1 very weak, ..., 8 very strong) / EXTRACTABLE Fe Al (by AMM. Na DITHIONITE) / AVAIL. P

Hor. no.	Top - Bot	MICA /ILL	VERM	KAOL	MIX	QUAR	GOET	Fe	Al	(Bray) mg kg^{-1}
1	0 - 11	4	3	4	3	2	1	2.0	0.2	2.4
2	11 - 50	4	3	5	3	1	2	3.2	0.4	1.0
3	50 - 90	4	3	5	3	1	2	3.3	0.4	1.2
4	90 - 145	4	3	5	3	1	1	3.3	0.4	0.5
5	190 - 200	4	3	6	3	1	2	3.5	0.3	0.2

Annex 2A Evaluation of Soil/Land Qualities of soils CN 22, 23 and 24

LAND QUALITY

Availability (1) | vh | h | m | l | vl |

vh = very high h = high m = moderate l = low vl = very low

Hazard/Limitation (2) | n | w | m | s | vs |

n = not present w = weak m = moderate s = serious vs = very serious

Land quality		Type	CN 22	CN 23	CN 24
CLIMATE					
Radiation regime	- total radiation	1			
	- day length	1			
Temperature regime		1			
Climatic hazards (hailstorm, wind, frost)		2			
Conditions for ripening		1			
Length growing season		1	h	h	h
Drought hazard during growing season *)		2	m	m	m
SOIL					
Potential total soil moisture		1	m	m	h
Oxygen availability		1	h	h	m
Nutrient availability		1	vl	vl	l
Nutrient retention capacity		1	l	m	l
Rooting conditions		1	h	h	vh
Conditions affecting germination		1	vh	vh	vh
Excess of salts	- salinity	2	n	n	n
	- sodicity	2	n	n	n
Soil toxicities (e.g. high Al sat.)		2	m	s	w
LAND MANAGEMENT					
Initial land preparation		2			
Workability		1	h	h	h
Potential for mechanization		1	vh	vh	h
Accessibility	- existing	1			
	- potential	1			
Erosion hazard	- wind	2			
	- water	2	w	w	m
Flood hazard		2	n	n	m
Pests and diseases		2			

COMMENTS

*) droughts occurring during a part of the growing season, i.e July to October.

Annex 2B Evaluation of Soil/Land Qualities of soils CN 21 and 25

LAND QUALITY	Availability	(1)	vh	h	m	l	vl
	Hazard/Limitation	(2)	n	w	m	s	vs

vh = very high h = high m = moderate l = low vl = very low

n = not present w = weak m = moderate s = serious vs = very serious

			CN 21					**CN 25**				
CLIMATE												
Radiation regime	- total radiation	1										
	- day length	1										
Temperature regime		1										
Climatic hazards (hailstorm, wind, frost)		2										
Conditions for ripening		1										
Length growing season		1	■					■				
Drought hazard during growing season *)		2			■					■		
SOIL												
Potential total soil moisture		1		■					■			
Oxygen availability		1	■						■			
Nutrient availability		1					■				■	
Nutrient retention capacity		1				■					■	
Rooting conditions		1	■					■				
Conditions affecting germination		1						■				
Excess of salts	- salinity	2	■					■				
	- sodicity	2	■					■				
Soil toxicities (e.g. high Al sat.)		2			■				■			
LAND MANAGEMENT												
Initial land preparation		2										
Workability		1			■					■		
Potential for mechanization		1		■				■				
Accessibility	- existing	1										
	- potential	1										
Erosion hazard	- wind	2										
	- water	2			■			■				
Flood hazard		2	■					■				
Pests and diseases		2										

COMMENTS

*) droughts occurring during a part of the growing season, i.e July to October.

Annex 3 Units, Glossary, Classes and Acronyms

UNITS

Chinese weights and measures	SI equivalent
1 mu	0.067 ha
1 jin	0.5 kg
1 jin/mu	0.133 kg ha^{-1}

Other units

$cmol_c\ kg^{-1}$	centimol charge per kilogram (formerly meq/100 g; 1 meq/100 g = 1 $cmol_c\ kg^{-1}$)
μm	micro-metre: 1/1000th of a millimetre.
mg kg^{-1}	milligram per kilogram (formerly parts per million (ppm))
mS cm^{-1}	milliSiemens per cm at 25°C (formerly mmho cm^{-1})
MJ	Megajoules (formerly kcal; 1 MJ = 4186.8 kcal)

GLOSSARY

Air capacity	Amount of pore space filled with air 2 or 3 days after soil has been wetted. It is calculated from the difference between amount of water under almost saturated conditions (pF 0.0) and moisture retained at "field capacity" (pF 2.0), and expressed as volume percentage.
Al saturation	Ratio of exchangeable aluminium to the CEC, expressed as percentage.
Available soil moisture	Amount of moisture retained between "field capacity" (pF 2.0) and "wilting point" (pF 4.2), expressed as volume percentage (also called "available water capacity"). It is indicative of the amount of moisture available for plant growth.
Base saturation	Ratio of the sum of bases to the CEC, expressed as percentage.
Bulk density	Weight of an undisturbed soil sample divided by its volume.
CEC	Cation exchange capacity, indicative of the potential nutrient retention capacity of the soil.
Clay mineralogy	Type of clay-sized (< 2μm) particles.
kaolinite	Clay mineral with a low nutrient retention capacity, common in soils from (sub)tropical regions.
smectite	Silica-rich clay mineral with a high nutrient retention capacity and the ability to absorb water, resulting in swelling of the clay particles.
illite	Potassium-rich clay mineral with a moderately high nutrient retention capacity, common in soils from temperate regions and in alluvial soils.
vermiculite	Clay mineral with a high nutrient retention capacity and strong potassium-fixation.
chlorite	Aluminium-rich clay mineral with a moderately high nutrient retention capacity, occurring in variable quantities in soils rich in aluminium.
halloysite	Clay mineral with a moderately high nutrient retention capacity, common in soils derived from volcanic ashes.
quartz	Residual silica, resistant to weathering.
feldspar	Residual primary mineral, unstable in soil environments and, if present, indicative of a slight to moderate degree of weathering.
hematite	Reddish coloured iron oxide, common in well drained soils of tropical regions.
goethite	Yellowish coloured hydrated iron oxide, common in soils of temperate regions.
gibbsite	Aluminium hydroxide, indicative of a high degree of weathering.
Consistence	Refers to the degree and kind of cohesion and adhesion of the soil material, or to the resistance to deformation or rupture.
ECEC	Effective cation exchange capacity. It is calculated by addition of the sum of bases and exchangeable acidity, and reflects the actual nutrient retention capacity of the soil.
ESP	Exchangeable sodium percentage, ratio of exchangeable sodium to the CEC, expressed as percentage.
Exchangeable acidity	Sum of exchangeable hydrogen and aluminium.
Fine earth fraction	Part of the soil material with a particle-size of 2 mm or less (nearly all analyses are carried out on this soil fraction).
Horizon	Layer of soil or soil material approximately parallel to the earth's surface.
Land characteristic	Measurable property of land (e.g. texture).
Land quality	Set of interacting land characteristics which has a distinct influence on land suitability for a specified use (e.g. erosion hazard, which is a.o. influenced by slope, rainfall intensity, soil cover, infiltration rate, soil surface characteristics, texture).
Leaching	Downward or lateral movement of soil materials in solution or suspension.
Mottle	Spot or blotch differing in colour from its surroundings, usually indicative of poor soil drainage.
Organic carbon	Content of organic carbon as determined in the laboratory (% org. C x 1.72 = % org. matter)
Parent material	The unconsolidated mineral or organic material from which the soil is presumed to have been developed by pedogenetic processes.

pF value	Measure for soil moisture tension.
SAR	Sodium adsorption ratio of the soil solution, indicative of sodication hazard.
Soil reaction (pH)	Expression of the degree of acidity or alkalinity of the soil.
Soil structure	Aggregates of primary soil particles (sand, silt, clay) called peds, described according to grade, size and type.
Sum of bases	Total of exchangeable calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^{+}) and sodium (Na^{+}).
Texture	Refers to the particle-size distribution in a soil mass. The field description gives an estimate of the textural class (e.g. sandy loam, silty clay loam, clay); the analytical data represent the percentages sand, silt and clay measured in the laboratory.
Water soluble salts	Salts more soluble in water than gypsum.

CLASSES OF SOME ANALYTICAL SOIL PROPERTIES

Organic Carbon - C (%)

< 0.3	very low
0.3 - 1.0	low
1.0 - 2.0	medium
2.0 - 5.0	high
> 5.0	very high

Acidity pH-H_2O

< 4.0	extremely acid
4.0 - 5.0	strongly acid
5.0 - 5.5	acid
5.5 - 6.0	slightly acid
6.0 - 7.5	neutral
7.5 - 8.0	slightly alkaline
8.0 - 9.0	alkaline
> 9.0	strongly alkaline

Available phosphorus (mg kg^{-1})	**Olsen**	**Bray**
low	< 5	< 15
medium	5 - 15	15 - 50
high	> 15	> 50

CEC [pH7] ($cmol_c$ kg^{-1} soil)

< 4	very low
04 - 10	low
10 - 20	medium
20 - 40	high
> 40	very high

Sum of bases ($cmol_c$ kg^{-1} soil)

< 1	very low
1 - 4	low
4 - 8	medium
08 - 16	high
> 16	very high

Base saturation - BS [CEC pH7] (%)

< 10	very low
10 - 20	low
20 - 50	medium
50 - 80	high
> 80	very high

Aluminium saturation (%)

< 5	very low
05 - 30	low
30 - 60	moderate
60 - 85	high
> 85	very high

Exchangeable sodium percentage - ESP (%)

Soil structure		*Crops*
< 5	very low	< 2
05 - 10	low	02 - 20
10 - 15	medium	20 - 40
15 - 25	high	40 - 60
> 25	very high	> 60

Bulk density (kg dm^{-3})

< 0.9	very low
0.9 - 1.1	low
1.1 - 1.5	medium
1.5 - 1.7	high
> 1.7	very high

ACRONYMS

FAO	Food and Agricultural Organization of the United Nations
ISIS	ISRIC Soil Information System
ISRIC	International Soil Reference and Information Centre
ISSAS	Institute of Soil Science - Academia Sinica
SCS	Soil Conservation Service
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture

Soil Briefs of China

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CN 8	Reference soils of the Red Basins of Jiangxi Province	5
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CN 10	Reference soils of the Liaohe plain, Liaoning Province	2
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15	Gabon	6
16	Ghana	in prep.
17	Philippines	6
18	Zimbabwe	13
19	Spain	20
20	Italy	17
21	Greece	in prep.
22	India	in prep.
23	Kenya	in prep.
24	Mali	in prep.
25	Nigeria	in prep.
26	Mozambique	in prep.
27	Botswana	in prep.

* State of reference collections as of January 1995