Soil Brief CN 11

PEOPLE'S REPUBLIC OF CHINA

Reference soil of the Changbai Mountains, Jilin Province

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ISSAS

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Number	*Chinese classification*	*FAO-Unesco*	*Soil Taxonomy*
CN 37	Albic Dark Brown Soil	Albic Luvisol	Eutric Glossoboralf

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ABSTRACT

A representative soil from the Changbai mountains (Jilin province) was studied as a contribution to the establishment of a Chinese soil reference collection and pedon database. Description and sampling were carried out in the framework of a European Community supported cooperation programme between the Institute of Soil Science, Academia Sinica, Nanjing, People's Republic of China and the International Soil Reference and Information Centre, Wageningen the Netherlands.

The Changbai mountains are situated in the eastern part of Jilin Province, near the border with the Korean People's Republic. The climatic conditions are those of a typical continental monsoon region strongly modified by altitude: there is a wide range in temperatures during the year, a relatively short frost free period that gets shorter with greater altitude and a climate that is more humid with increasing altitude although summer rains remain dominant. Conditions are unfavourable for agriculture at altitudes over 700 to 900 m: the low temperatures, the short growing season and the long and dry winter present too many limitations for crops.

The soil is a deep, somewhat imperfectly drained, dark brown clay loam formed in loess. It is classified as an Albic Dark Brown Soil (CSTC, 1991), Albic Luvisol (FAO, 1988). It is situated in the Changbai Mountain Natural Reserve under a natural vegetation of mixed broad-leaf/coniferous forest and as such has not been used for agriculture. Preservation of the forest is an ideal form of land use for this soil as the climatic limitations for agricultural use are severe.

At lower elevations, the soil would be moderately well suited for agriculture, but where the soil was sampled the main limiting factors for agriculture are the short summer and poor soil aeration.

摘 要

为建立中国土壤样品参比库和土壤剖面数据库，一个典型土壤剖面采自吉林省长白山地区。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。

长白山位于吉林省东部，毗邻朝鲜人民共和国。气候属于典型大陆型季风气候且受海拔高度的影响：即年温差变异大，相对短的无霜冻期并随海拔高度增加逐渐变短，虽然夏季降水多，但随高度增加，气候更加湿润。由于低温、生长季节短和冬季慢长而干旱，海拔７００－９００ｍ以上的地区不适合农业生产。

所采集的土壤土层深厚，剖面发育于黄土上的暗棕色粘壤土，排水较差。该土壤分类为漂白暗棕壤（ＣＳＴＣ，１９９２）或者漂白淋溶土（ＦＡＯ，１９９０）。该土壤剖面位于长白山自然保护区天然针阔叶混交林下，未被农业利用。森林保护是这类土壤的最好利用形式，由于气候因素限制了农业利用，尽管土壤本身较适合农业生产。

FOREWORD

The objective of a Soil Brief is to provide a description of one or more reference soils in an ecological setting.
It is composed of a text accompanied by a number of data annexes.
The illustrated text includes a description of the ecological setting of the reference soil(s), a description and discussion of the major characteristics of the soil(s), followed by its classification and an evaluation of soil- and land qualities.
The annexes provide data on the soil(s) and the environment, as they became available from the field, the laboratory and the literature.

The Soil Brief is written for both soil-specialists and laymen. For the latter, the comprehensive information in the annexes often is too detailed and therefore requires some textual explanation. For the soil scientist, the textual part is of use since it summarizes important land and soil qualities, relevant aspects of soil management and considerations of soil formation. Furthermore it provides access to additional information that cannot be stored in a computerized database.

This report is one in a series that is the result of a 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. Additional support for field missions was provided by the Royal Dutch Academy of Arts and Sciences.

In 1983, '85, '92 and '93 the Institute of Soil Science of the Academia Sinica (ISSAS), in collaboration with the International Soil Reference and Information Centre (ISRIC) studied, described and sampled 51 reference soils for the National Soil Collection of the People's Republic of China. A duplicate set of soil profiles was collected for ISRIC's world soil collection. These reference soils are chosen to be characteristic of China's major ecological regions.

This Soil Brief considers a representative soil from Changbai Mountains (Jilin Province), an area in northeast China characterized by the presence of vaste natural forests.

Valuable comments on draft versions of this report were received from ISSAS and ISRIC 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 (editing), M.B. Clabaut (text processing) and J.W. Resink (map compilation).

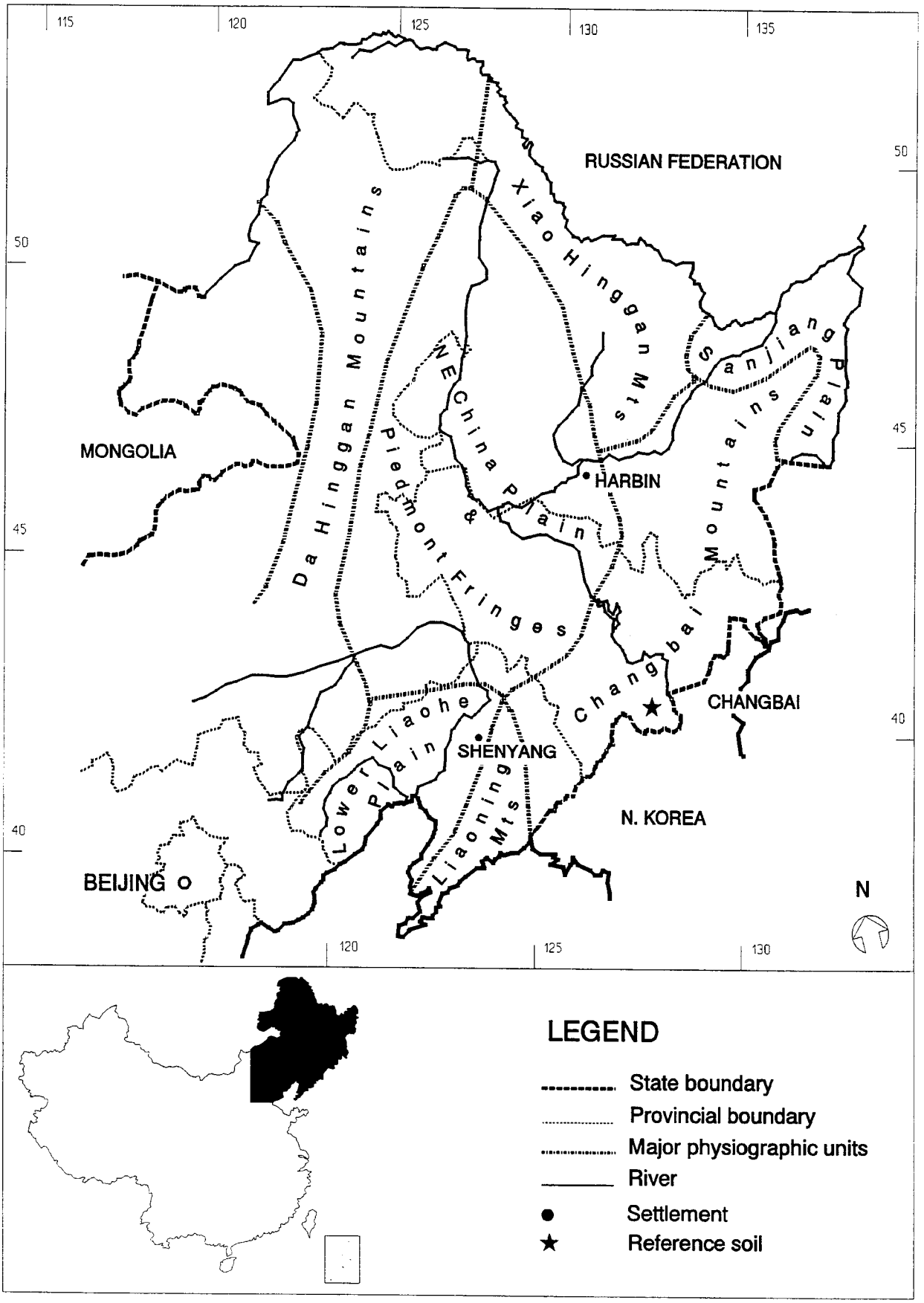

Figure 1 Major physiographical zones of northeast China, location of CN 37 at Changbai.

1 ECOLOGICAL CHARACTERIZATION OF NORTHEAST CHINA

1.1 Introduction

Northeast China comprises the administrative provinces of Heilongjiang, Jilin and Liaoning and the eastern part of the Inner Mongolia Autonomous Region. This Soil Brief is limited to the three provinces. They occupy 1.3 million km^2, of which some 50 percent consists of mountainous areas, about 10 percent has a hilly character and some 40 percent can be described as plains. The mountainous and hilly areas surround the plain of Northeast China and its piedmont fringes on the western, northern and eastern sides (figure 1).

1.2 Climate

The main climatic characteristic of large parts of China is the widespread occurrence of a monsoon climate in combination with a marked continentality. Most of Northeast China is under a temperate monsoon climate, except for the high, northernmost Da Hinggan Mountains that belong to the frigid temperate zone and the Liaodong peninsula which has a warm temperate monsoon climate. The main climatic features of Northeast China can be summarized as follows (Zhao, 1986; Guo *et al.*,1990): mean annual temperatures reach from below 5°C in the north to about 9 °C in the south. The variation between mean summer and winter temperatures is important: in the northern part mean temperatures are about 17 to 20 °C for July and about -28 to -35 °C for January. The south shows a much smaller amplitude: resp. 25 °C and about -4 to -8 °C.

Very cold winters are experienced in the north of Heilongjiang province which has the lowest temperature recorded in China (Mohe, -52 °C). This is illustrated by the soil freezing to a depth of about 2.5 m. Summers may be hot: an absolute maximum of 38 °C has been recorded at Dedu.

Precipitation clearly reflects the monsoon character of the climate. Winters are dry and the maximum amount of precipitation occurs between early summer and autumn. Mean annual amounts of precipitation vary from less than 400 mm yr^{-1} in the north to over 1000 mm yr^{-1} in the south and in mountainous areas. Figures 2 and 3 illustrate the distribution and magnitude of precipitation and temperature for Northeast China. These figures were generated by means of SOLGRAPH (Brunt *et al.*, in prep.)

Winds in Northeast China blow from the northwest in autumn and winter. Summer shows more variable wind directions. Typhoons, common further south, only exceptionally affect northeast China.

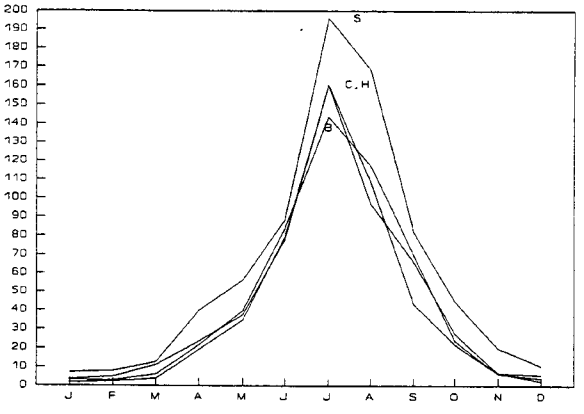

Figure 2 Precipitation in mm for Northeast China.
C: Chaoyang, H: Harbin, B: Beijan, S: Shenyang.

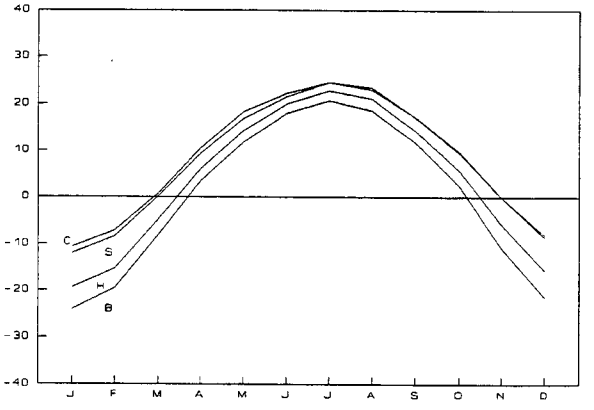

Figure 3 Average temperatures in °C for Northeast China.
C: Chaoyang, H: Harbin, B: Beijan, S: Shenyang.

1.3 Geology and geomorphology

China comprises three major geomorphological divisions: the *Qinghai-Xizang Plateau* ("Roof of the World") with an elevation of 3000 - 5000 m a.s.l., the *Middle China Plateaus and Basins* (1000 - 2000 m base level) and the extensive *Low plains of East China* which continue in the continental shelf beneath the Yellow Sea. Northeast China belongs partly to the Low Plains of East China and partly to the Middle China Plateau (Da Hinggan Mountains).

Two hundred million years ago a large geosyncline occupied this region, in the base of which metamorphism occurred. Subsequent uplift in Hercynian times was accompanied by emplacement of large granitic complexes. Under the influence of the Mesozoic Yanshan orogeny, the central part of NE China subsided to form the NE trending Song-Liao basin. In the eastern and western adjacent zones, large masses of igneous rock were extruded, mainly of basaltic character, but with some granites. Continuing into Recent times, volcanic

activity is present as the Pacific tectonic plate subducts below the Eurasian continent.

Since the beginning of the Cenozoic era, the Song-Liao basin gradually has been infilled with predominantly fluviatile deposits, finally leading to the extensive Dongbei plain. This is made up of two parts, the Liaohe plain in the south and the Songnen plain in the north, separated by a low divide between both plains. The Dongbei plain, which is the largest plain of China, is sandwiched between two mountain ranges: the NNE trending Da Hinggan Mountains in the west and the NE trending Changbai and Quinshan Mountains to the east. Two main tectonic events determine this tripartite division: at depth a major lithosphere fault delimits the eastern boundary of the Da Hinggan Mountains and a crustal fault is the western boundary of the Changbai-Quinshan Mountains (Zhao, 1986; Terman, 1973).

1.4 Hydrology

Drainage of large parts of northeast China is towards the Dongbei plain. The northern part of the plain drains to the Heilongjiang and its tributaries; the southern part through the river Liaohe.
In summer, amounts of run-off are large because most precipitation occurs in summer. Run-off is very low in winter, since both soils and rivers are frozen and only small quantities of precipitation occur, mostly as snow. The spring run-off, as a result of melting snow causes floods and amounts to about a quarter of the annual total.
As far as groundwater is concerned, both the Liaohe plain in the south and the Songnen plain in the north of northeast China possess important fresh water aquifers. Locally artesian waters occur.

1.5 Vegetation

The original natural vegetation of northeast China was a warm temperate, mixed needle- and broad-leaved forest, with cool-temperate needle-leaved taiga forest in the northern regions (Zhao, 1986, Zhonghua, 1982). The well-drained, rolling plains, as well as the hilly and mountainous areas of northeast China, once carried these kinds of forests.
Significant parts of Northeast China consist of low-lying areas with moderately high to high levels of groundwater (Liaohe, Songnen and Sanjiang plains). These areas, partly annually flooded, are characterized by various meadow and swamp vegetation types, locally with a salt tolerant character.
A vertical zonality of vegetation is obvious in all mountainous areas and this is especially well developed in the Changbai Mountains.
Today, outside the mountainous areas, most of the natural vegetation has been cleared.

1.6 Agricultural landuse and forestry

Northeast China is a very important agricultural area within the People's Republic of China, and although large parts of Northeast China now are cultivated, many places have a relatively short agricultural tradition.
Some sources claim there are still hundreds of thousands of hectares of virgin lands which could be changed into productive agricultural land (Zhao, 1986). The main problems in developing agriculture in northeast China are spring drought alone or in combination with summer floods, sometimes in combination with low soil fertility and secondary salinization (Xin *et al.*, 1988).
Until relatively recent times, northeast China was not heavily populated and as a consequence agricultural landuse was not intensive. For instance, up to a century ago, large areas in the west of the Liaoning province were covered with (imperial) woods; it was only since then that the trees were felled and the land put into agricultural use. In some places, severe erosion of these lands has resulted as can be seen in the Chaoyang area.
Other areas have been brought into cultivation very gradually since the turn of the century (Heilongjiang province - 710.000 km^2 - had only 25.000 inhabitants and 5.300 ha of cropland in 1897). Considerable extension of the cultivated land took place under duress during the Japanese occupation in the Second World War. Finally, great achievements in the agricultural development of the area have been accomplished since the foundation of the People's Republic of China; a necessity since the population of the area has tripled since 1949. Frequently, this expansion has been at the cost of large areas of natural vegetation which now is limited to the higher, usually inaccessible mountainous country.
China's large needs for timber required the commercial exploitation of these (mainly natural) forests in the northeast of the country; sometimes with important losses from an environmental point of view.

1.7 Human impact

Scarcely populated until recently (4.2 million in the 16th century, 30 million in 1949), today Northeast China has a population of about 100 million, living in both large industrial centres like Shenyang, Harbin, Qiqihar, Daqin, Changchun or Dalian, as well as in numerous towns and villages in the country.
The important industrial potential of the region, results from the presence of natural resources such as gas, oil, coal, iron and non ferrous ores, the easily accessible seaports, and a good infrastructure, as well as the agricultural activities have made this area one of China's busiest regions.

2 THE CHANGBAI MOUNTAINS

2.1 Introduction

The Changbai Natural Reserve is a mountainous area of some 10.000 km^2, with the highest peak Changbai Mountain, a 2691 m volcano rising nearly 2000 m above an extensive basalt plateau. The volcano (Bay Yun) includes a crater lake (Tain Chi) of almost 10 km^2.

2.2 Climate

The climate of the Changbai Mountains varies with altitude but retains a marked monsoonal character. In general it may be characterized as follows: it has mean annual temperatures between -7 °C (at 2600 m) and +5 °C (at 600 m), with mean temperatures for January of -25 to -13 °C and mean temperatures for July of 10 - 24 °C. Mean annual precipitation varies from 650 to 1350 mm.
This leads to a cumulative annual temperature over 10 °C of about 2200 °C, an average frost free period of about 115 days and an aridity coefficient of 0.6; depending on the altitude of the site. Several meteorological stations provide representative data for the reference soil (FAO, 1991.) These data, as well as some other climatic characteristics, are presented in tables included in Annex 1. Correlation between data of the different stations is good (R^2 is 0.94 or more).
Mean annual amounts of precipitation increase from 817 mm for Funsong Donggang situated some 50 km SW of the site to 904 mm for Changbai at 2 km from the site. Both stations show small amounts of precipitation in winter: 138 and 160 mm respectively in 6 months (October through March). Some 55 percent of the annual precipitation occurs in June, July and August. Most of the summer precipitation comes as showers or continuous rains: Changbai has an annual average of less than one day with more than 50 mm precipitation.
Leaching rainfall exists in summer (second half) and autumn. The surplus of precipitation in summer can be stored in the soil easily since the deficit amounts to several hundred millimetres at the end of June.
The calculated potential evapotranspiration (Penman-Monteith, FAO 1991) for Funsong Donggang is 830 mm yr^{-1} with a maximum in May: 127 mm. Although important, evaporation in warm months of July and August is smaller than in May as a consequence of the cloudiness (details in Annex 1).

Air temperatures show a mean annual value of 5 °C for Changbai, with an average summer temperature of 20 °C, and an absolute maximum temperature of 33.2 °C. The average winter temperature (December, January, February) is low: -12 °C; with an absolute minimum of -40.5 °C. For Funsong Donggang average air temperatures are 2 to 2.5 °C lower.
The growing season for Changbai is estimated to be about 100 days and the average number of frost free days is 118 days. The mean annual relative humidity for Changbai is 67 percent.
The annual amount of sunshine is 2503 hrs, which is 56 percent of the theoretical maximum (Zhang, 1980).

Figures 4 and 5 show illustrating average monthly precipitation, evapotranspiration and temperatures for Funsong Donggang (records for Changbai comprise 6 years only).

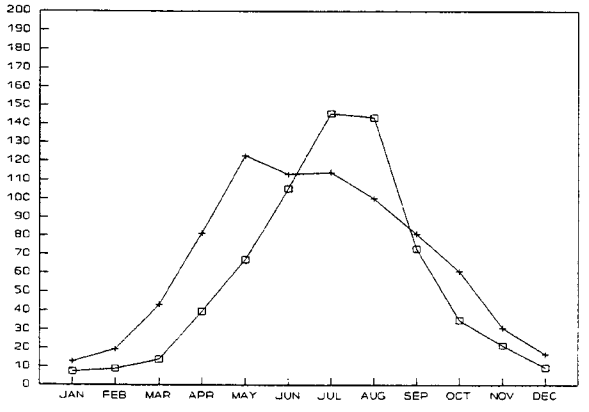

Figure 4 Precipitation (□) and evapotranspiration (+) in mm at Funsong Donggang.

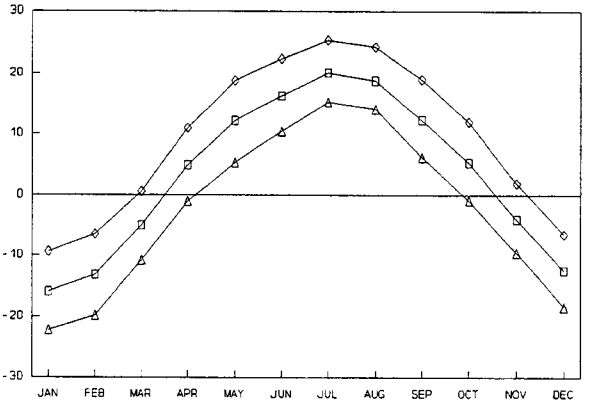

Figure 5 Maximum (◊), average (□) and minimum (△) temperatures in °C at Funsong Donggang.

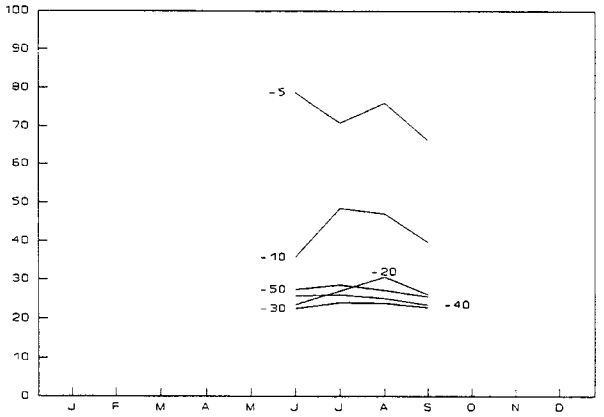

Figure 6 Soil moisture conditions (vol %) at depths of 5, 10, 20, 30 40 and 50 cm at Changbai, 1982- 1983.

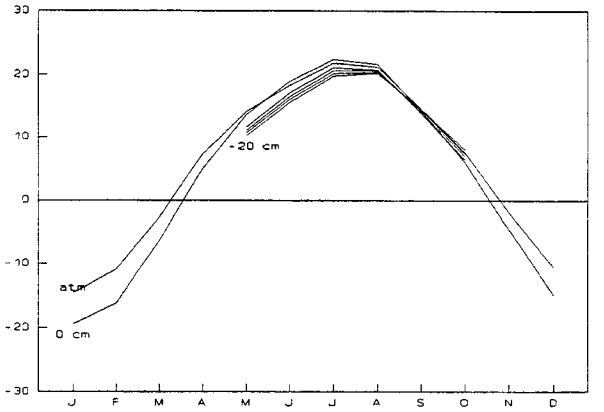

Figure 7 Atmospheric temperature (atm) and soil temperatures in °C at depths of 0, 5, 10, 15 and 20 cm at Changbai, 1982-1983.

2.2.1 Soil climate

The intensive research undertaken at the Changbai Mountain Research Station for Forest Ecology of the Academia Sinica (CMRSFEAS) provides some details on soil climate. These are presented in figures 6 and 7. Data have been taken from Zhang *et al.* (1980) and Zhang (1985). Soil temperatures were not recorded for November - April since the station is not manned during this period.

Soil moisture data indicate that precipitation reaches the upper decimeter of the soil only. The vegetation takes up infiltrating rainwater close to the soil surface as is confirmed by the root distribution pattern (see detailed profile description). Any significant influence of lateral (sub)surface flow can be excluded in this wooded area with 100 percent vegetation cover.

2.3 Parent materials and hydrology

In many places, the soil parent materials in the Changbai Mountains consist of basaltic materials of Quaternary age covered by Pleistocene loesses. The loesses vary from less than one metre to several metres in thickness. The reference soil has developed in a loess deposit of several metres thickness.

Drainage of the northern slopes of the Changbai Mountains is by the headwaters of the Di'er Songhua Jiang, towards the Songnen Plain, where it joins the Nen Jiang river and continues towards the Heilong Jiang which finally reaches the Pacific Ocean.

At several places around the volcano of Changbai Mountain volcano hot sulphuric springs occur, where bathing takes place and health resorts have developed.

2.4 Vegetation, agriculture and forestry

A large part of the Changbai Mountains consists of a national park of 190.000 ha covered by virgin forests.

On the northern slopes, vegetation shows a marked vertical zonation:

Up to 500 m above sea level a deciduous forest occurs.

From about 500 - 1100 m above sea level a mixed forest has developed, including following major tree species: *Abies holophylla,* red or Korean pine *(Pinus koraiensis),* Amur maackia (*Tilia amurensis*), Mandshurain linden (*Tilia mandshurica*), painted mono maple (*Acer mono*), several other maple species, Manchurian ash (*Fraxinus mandshurica*), white elm (*Ulmus sp.*), *Carpinus cordata, Betula costata* and Manchurian walnut (*Juglans mandshurica*). Locally some poplar (*Populus davidiana*), larch (*Larix olgensis*), and a few fir (*Abies holophylla*) occur as a secondary regrowth. Mongolian oak (*Quercus mongolica*), Asian white birch (*Betula platyphylla*) and sometimes pine (*Pinus sylvestris*) also occur. The reference soil is situated in this zone.

From 1100 to 1700 m above sea level a coniferous forest is present, characterized by larch and pine (main species *Pinus koraiensis*).

The zone from 1700 - 2000 m consists of a birch forest (*Betula ermanii),* which is well adapted to snow and cold.

Finally the zone over 2000 m above sea level is an alpine tundra with several Rhododendron species and *Dryas octopetala.*

Most of the Changbai Mountain area is considered to be a humid environment (section 2.3) where the annual amount of precipitation would allow agricultural landuse (Zhao, 1986). However the growing season is short and the topography is unfavourable. Apart from some small scale horticulture (medical plants like ginseng), no agriculture is practised.

The Changbai Mountain National Park itself is not used for forest exploitation. However, the areas surrounding the Park are commercially exploited and re-afforestation of such areas outside the park is common practice.

3 REFERENCE SOIL CN 37

3.1 Introduction

The first nationwide soil survey of China started in 1958, so the distribution of soils in the area is well known. The results of this survey provided knowledge of the broad distribution of soils and lead to the soil map of China at a scale of 1:10.000.000 (Nanking Institute of Soil Science, 1980); followed by a translation in Japanese (1983) and an English version in combination with the book *Soils of China* (ISSAS, 1990), and the Chinese contribution to the *FAO-Unesco Soil Map of the World 1:5.000.000* (FAO, 1978).

Since 1958, much detailed information on soil distribution and soil characteristics has become available. In many counties and districts in northeast China (semi-) detailed soil surveys have been carried out within the framework of the second national survey of China, usually resulting in county or district soil survey reports. In most cases, these reports, enriched with additional information, have lead to provincial monographs. Some of these detailed reports have been included in the list of references. All materials contribute to the elaboration of a new version of the soil map of China, now prepared by the Institute of Soil Science of the Academia Sinica at Nanjing, foreseen to be published in a few years.

The distribution of soils in the Changbai Mountains has been studied in detail since the creation of the Research Station in the 1980's (Cheng *et al.*, 1981; Fu *et al.*, 1983; Zhang, F., 1985; Zhang, H. *et al.*, 1980, 1984). The soils of the Changbai Mountains form a clear altitudinal sequence. The most representative profiles are classified according to the FAO-Unesco nomenclature, Soil Taxonomy and two Chinese classification systems and are presented in table 1.

The reference soil is situated 200 m SE of the barrier and the fire tower at the town limits of Baihe on the road to Tianchi.

3.2 Landscape and soils

The reference soil presented in this paper has a close relationship and occurs in association with other soil units. In several places the Albic Luvisol is associated with Haplic Luvisols (no albic E), in other places a close association with Stagnic Luvisols occurs (stagnic features). It is seldom associated with the Chromic Luvisols ("red Bt") or with the major soil grouping of Greyzems (rare cases where the A horizon qualifies as mollic; but it is usually too thin).

Brief description of CN37
The reference soil considered here is an Albic Luvisol. It is a deep, somewhat imperfectly drained, dark brown clay loam; weakly structured and influenced by stagnating surface water. It is characteristic of those soils on the northern slopes of the Changbai Mountains between 600 and 1100 m above sea level that are developed in a thick cover of loess or loess-like materials.

A detailed description of this soil and its horizons, according to FAO guidelines (FAO *et al.*, 1990) is given as an ISIS database presentation sheet in Annex 1.

3.3 Brief analytical characterization of CN 37

Soil samples have been analyzed at ISRIC's soil laboratory according to the procedure as described by Van Reeuwijk (1993). A full account of analytical data is given in Annex 1; a number of characteristics is given below and illustrated in figures 8 - 10. Data on a comparable profile are presented by Cheng *et al.*, (1981).

Table 1 Major soils of the Changbai Mountains, partly after Zhao (1986) and ISSAS (1990).

FAO-Unesco (1988) 1974	1988	Chinese soil classification 1984 (ISSAS, 1990)	Chinese Soil Taxonomic Classification (1991)	USDA Soil Taxonomy (1992)
Stagnic, Gleyic Luvisols		Luvic soils - Dark brown forest soils	Udic siallisols - Gleyed dark brown forest soils	Alfisols
Lg	LVj, LVg			
Albic Luvisols		Semi-aquic soils - Albic soils	Udic siallisols - Albic dark brown forest soils	Glossudalfs, Glossaqualfs
La	LVa			
Lithic, Mollic, Eutric Leptosols		Alpine soils - Subalpine meadow and alpine frozen soils	Lithic primarosols - Haplic, Umbrihumic leptisols	Orthents
I, U	LPq, LPm, LPe			
Bare rock				

N.B. Correlation of soils is approximate.

2

4

5

1

3

1. Changbai: Bai Yun volcano and Tian Chi Lake, 2691 m
2. Reference soil CN 37
3. Mixed coniferous deciduous forest at 750 m
4. *Betula ermannii* forest at 1900 m
5. Larch and pine forest at 1200 m

Table 2 Physical and chemical characteristics

	CN 37
Texture	silt loam over silty clay loam
Organic carbon %	topsoil very high (11)
Acidity	acid
Sum of bases $cmol_c\ kg^{-1}$ soil	medium to very high
CEC $cmol_c\ kg^{-1}$ soil	high to very high
Phosphorus	medium in topsoil over low to medium at depth
Total N %	1
Clay mineralogy	mixed
Air capacity %	very low (4)
Available moisture %	high (20) decreasing to low (8) in the subsoil
Bulk density Mgm^{-3}	high (1.42)

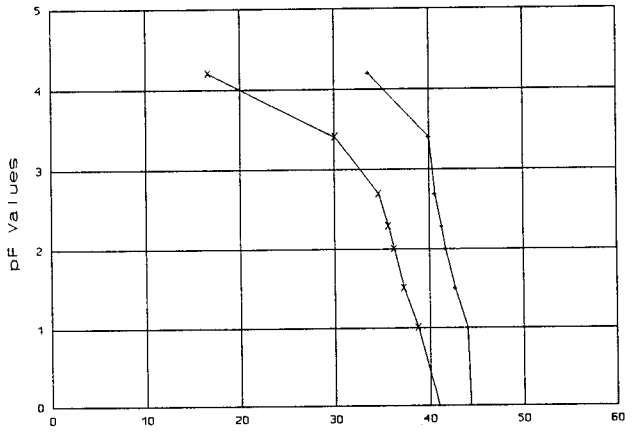

Figure 8 Soil moisture retention curves (water content in vol % versus suction (pF)) at depths of 18-30 cm (x), 45-80 cm (+), of CN 37.

The soil moisture retention capacity is presented in figure 8. The available moisture content amounts 120 mm/100 cm, of which only 65 mm within the range of effective soil depth. Particle size distribution, as well as sum of exchangeable bases, pH and organic carbon content are presented in figures 9 and 10 respectively.

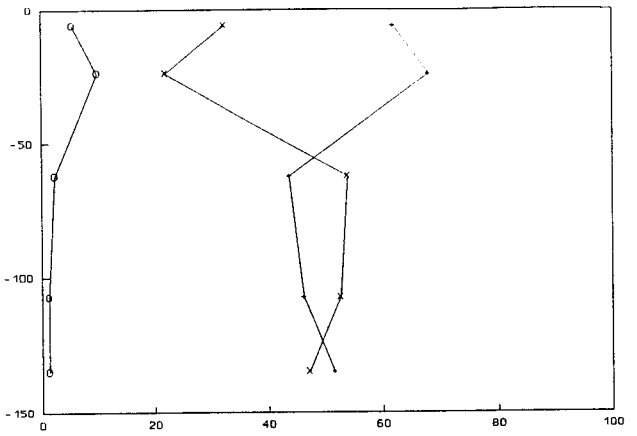

Figure 9 Percentages clay (x), silt (+) and sand (o) versus depth (cm) of CN 37.

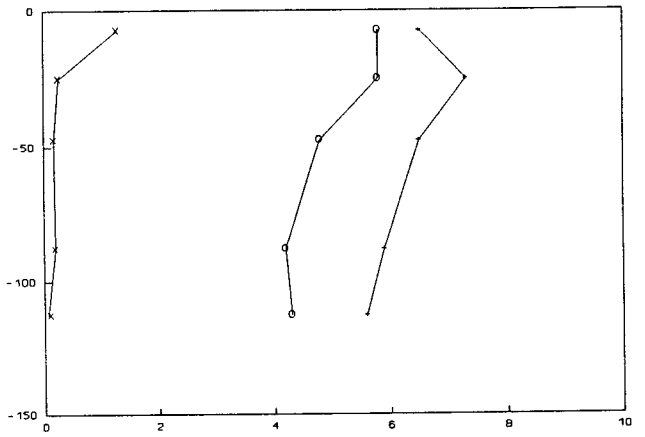

Figure 10 Sum of bases ($cmol_c\ kg^{-1}$ soil) (◇), pH-H_2O (+), pH-KCl (o) and organic carbon content (%) (×) versus depth (cm) in CN 37.

3.4 Soil classification

According to FAO-Unesco (1988) the soil is classified as an Albic Luvisol. It has following diagnostic features which are used for identification: an argic B horizon (a subsurface horizon which has a distinctly higher clay content than the overlying horizon), and an albic E horizon (a horizon from which clay and free iron have been removed or re-arranged to such extent that it has a colour determined by the uncoated sand and silt particles). As a third diagnostic criterion, the cation exchange capacity (over 24 $cmol^{(+)}kg^{-1}$ clay) and the base saturation (over 50 percent) of the argic B horizon must be considered.

The soil lacks an abrupt textural change between top soil and subsurface horizons, it also lacks diagnostic stagnic properties and a mollic A horizon (too thin).

According to the Chinese Soil Taxonomic Classification System (1991) the soil is classified as an Albic Dark Brown soil. It has an ochrihumic (a surface horizon with a moderately low organic matter content) or a umbrihumic epipedon (a dark surface horizons with a moderately high organic matter content and a base saturation of less than 50 percent); possesses an albic horizon (a pale horizon low in clay and iron) and an argillic horizon (a subsurface horizon that has a distinctly higher clay content than the overlying horizon); and has

a udic soil moisture regime and a frigid soil temperature regime. This means it qualifies as a Siallisol.
Within the order of Siallisols it belongs to the Udic Siallisols; the frigid soil temperature regime places it in the group of Dark Brown Soils; whereas the albic horizon in the absence of gleyic or stagnic evidence leads to the subgroup of Albic Dark Brown soils.

Its place in Soil Taxonomy (Soil Survey Staff, 1992) is determined by a series of diagnostic features: an argillic horizon (the ratio of clay in the illuvial horizon to that in the eluvial horizon is more than 1.2), a base saturation of more than 35 % and a frigid soil temperature regime in combination with the absence of both a xeric soil moisture regime and diagnostic redoximorphic features related to surface water stagnation, leads to a place in the subgroup of Boralfs. Its designation as a Glossoboralf is because of the presence of interfingering of albic (bleached) material into the argillic horizon (interfingering without being diagnostic for a glossic horizon) in the absence of a fragipan, a natric horizon or periodically dry soil moisture control section. Finally, its deep character, the absence of andic characteristics or aquic conditions in the upper part of the argillic horizon gives the soil its name at subgroup level: Eutric Glossoboralf. As a consequence of the almost saturated conditions of the soil when it was described, a taxonomic place close to the Oxyaquic Glossoboralfs must be considered.

3.5 Soil and land suitability

A qualitative evaluation of the relevant land qualities according to the *Guidelines for Rainfed Agriculture* (FAO, 1983) has been done and is presented in Annex 2. No particular crop was chosen for this exercise since the reference soil is situated under forest vegetation in a natural reserve.
From this evaluation a number of constraints for agricultural landuse are obvious: apart from the serious climatic limitations, the moderate oxygen availability and the moderate germination conditions, as well as the available soil moisture potential (120 mm/100 cm) present limitations. Measures like mulch farming (Ma, 1988) would not sufficiently diminish the limitations imposed by the climate.

Considering the actual landuse, there is no question of any constraint: the forest vegetation of the Changbai Natural Reserve is in perfect equilibrium with the land and soil qualities.

3.6 Soil genesis

Given the ubiquitous presence of loess and loess-like parent materials and the presence of a low to moderate relief on the northern slopes of the Changbai Mountains, soil genesis is governed mainly by climatic conditions, relief and drainage. In the area, hard rock may occur at a variable but usually considerable depth. The well drained soils reflect the influence of the monsoon climate as a soil forming processes in a limited way as is illustrated below.
The production of organic matter starts in late spring when the temperature rises quickly and precipitation increases. The warm, humid summer leads to both a high production and a rapid turnover of organic matter. Consequently, when the cold season starts in October, a relatively small amount of organic matter has been incorporated in the soil by the activity of the soil fauna. The soil is frozen for several months to a depth of about 0.5 to 1 meter. This generalized account of soil evolution is modified by the amount of rainfall and evapotranspiration. The effect of the precipitation, in combination with a nearly equal amount of evapotranspiration during late summer, will lead to a leaching of carbonates from the soil. This is then followed by eluviation of clay and the development of Luvisols.

The spring and summer rains frequently have some difficulties in percolating through the soil (at first a still frozen subsoil, and secondly the argic B horizon) hence reduction phenomena occur in the upper part of the profile leading to the depletion of iron compounds and a development of the E horizon (albic E horizon).
A characteristic feature of these Luvisols is the (unexpected) occurrence of thin and or broken cutans of organic carbon, or simply very dark brownish clay cutans, giving them a distinctly different appearance from the classical European and American Luvisols. This is the consequence of the high production of organic matter and breakdown followed by complexation just before and during the time eluviation of clay is assumed to be active. The high amount of organic matter in the Ah horizon is illustrative in this respect.

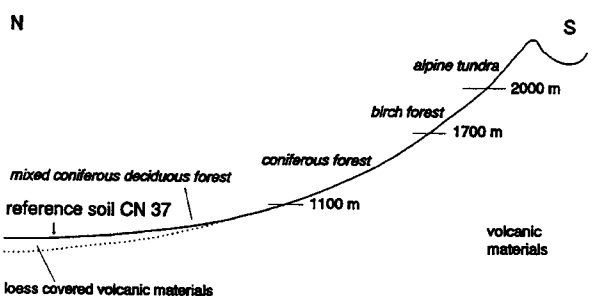

Figure 11 Reference soil CN 37, situated on the northern slope of the Changbai Bay Yun volcano. Indication of the soil and vegetation zones on the northern slope

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Annex 1 ISIS Data Sheet CN 37

ISIS 4.0 data sheet of reference soil CN 37 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 19/12/94

FAO/UNESCO (1988) : Hypoglossi-Albic Luvisol (Siltic) (1974 : Albic Luvisol)
USDA/SCS SOIL TAXONOMY (1992) : Ultic Glossobralf, fine, mixed, frigid (1975 : Ultic Glossoboralf)
CSTC (1991) : Haplic dark brown soil

DIAGNOSTIC CRITERIA FAO (1988) : ochric A, albic E, argic B horizon; interfingering
USDA/SCS (1992) : ochric epipedon, albic horizon, argillic horizon; interfingering of albic materials
Soil moisture regime : ustic
Soil temperature regime : frigid

LOCATION : Jilin Province, Antu County, Changbaishan Forest
Latitude : 42°24′ N Longitude : 128° 6′ E Altitude : 750 m a.s.l.
AUTHOR(S) : Boerma, J.A.K. Date (mm/yy) : 6/93

GENERAL LANDFORM : plateau Topography : rolling
PHYSIOGRAPHIC UNIT : gently sloping foot of volcano
SLOPE Gradient : 3% Aspect : N Form : straight
POSITION OF SITE : middle slope
MICRO RELIEF Kind :
SURFACE CHAR. Rock outcrop : nil Stoniness : nil
Cracking : nil Slaking/crusting : nil
Salt : nil Alkali : nil
SLOPE PROCESSES Soil erosion : nil Aggradation : nil
Slope stability : stable

PARENT MATERIAL : loamy loess

EFFECTIVE SOIL DEPTH : 110 cm

WATER TABLE : no watertable observed
DRAINAGE : imperfect-moderately well
PERMEABILITY : slow; slowly permeable layer at 33 cm depth
FLOODING Frequency :
MOISTURE CONDITIONS PROFILE : 0 - 150 cm wet

LAND USE : (semi-)natural vegetation
VEGETATION Type : closed forest Status : primary
Land use/vegetation remarks : mixed broad-leaf/coniferous forest (Korea pine / broad-leaved species mixed forest: main species Korean pine (*Pinus koreaensis*), Amur linden (*Tilia amuriensis*), painted mono maple (*Acer mono*), Manchurian ash, white elm (*Ulmus* sp.) and Mongolian wallnut, with locally birch (*Betula* sp.) and Mongolian oak (*Quercus mongolica*).

ADDITIONAL REMARKS :
PARENT MATERIAL: below the parent material (loess) basaltic material is present at several m depth. MOISTURE CONDITIONS: as a consequence of rains the profile was nearly saturated with water at the moment of description and sampling. CSTC (1991) CLASSIFICATION: the soil belongs to the Udic Siallisols, Dark brown soils (frigid STR, eutric umbrihumic epipedon, eutric brown B horizon and pH 5-7). The subgroup of Haplic dark brown soils lacks an albic horizon with a discontinuous wavy or gradual boundary, gleyic evidence in the surface horizon and redoxic features between 50 and 100 cm depth. As the lower boundary of the albic horizon present in this soil is gradual and smooth, the soil does not fit the concept of "Albic dark brown soil". Therefore the soil has been retained as "Haplic dark brown soil".

CLIMATE : Köppen: Dbw
Station: CHANGBAI 42 24 N/128 06 E 750 m a.s.l. 2 km W of site Relevance: very good
FUNSONG DONGGANG 42 6 N/127 34 E 774 m a.s.l.

		No. years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
CHANGBAI															
precipitation	mm	6	21	21	35	79	89	116	169	191	97	32	41	13	904
T mean	°C	6	-14.6	-10.9	-2.6	7.3	14.2	18.3	21.8	21.2	14.6	7.5	-1.8	-10.6	5.4
FUNSONG DONGGANG															
ETo (PenMon)	mm	24	17	20	42	82	127	118	119	106	86	63	32	18	830
pan evaporation	mm	24	19	30	63	136	215	177	168	139	117	90	42	21	1216
precipitation	mm	24	11	12	21	53	77	116	186	167	83	47	32	14	817
no. of raindays		24	12	10	13	12	14	17	19	17	14	11	12	12	163
T mean	°C	24	-16.0	-13.2	-5.0	4.9	12.2	16.3	20.1	18.8	12.3	5.3	-4.0	-12.5	3.3
T max	°C	24	-9.4	-6.5	0.6	10.9	18.8	22.4	25.4	24.3	19.0	12.0	1.9	-6.5	9.4
T min	°C	24	-22.2	-19.8	-10.8	-1.0	5.3	10.4	15.3	14.1	6.2	-0.9	-9.6	-18.4	-2.6
relative humidity	%	24	66	62	59	55	56	73	79	82	75	64	66	67	67
windspeed(at 2m)	m/s	24	2.0	2.2	2.6	3.0	2.9	2.1	1.8	1.7	1.8	2.2	2.3	2.2	2.2
bright sunshine	h/d	24	5.9	6.8	7.3	7.5	8.2	7.6	7.0	6.6	7.2	6.6	5.6	5.2	6.8

Remarks: extensive climatic data are also available in ISIS for ANTU (SONGJIANG) (42 32 N/128 15 E, 591 m a.s.l., about 19 km NE of site, relevance good).

ISIS 4.0 data sheet of reference soil CN 37 Country : PEOPLE'S REPUBLIC OF CHINA Print date (dd/mm/yy) : 19/12/94

PROFILE DESCRIPTION :
Very deep, imperfectly to moderately well drained, brown to light yellowish brown clay loam derived from loess. The soil shows, apart from the obvious clay-sesquioxide cutans in the Bt1 (and to a lesser extent in the Bt2), important whitish quartz silt coatings on pedfaces, especially visible when the soil is dry. The Bt2 and Btg horizons show distinct pressure faces/slickensides. Very few earthworms occur down to 75 cm. Organic carbon content is very high and the soil reaction is acid throughout.

O	2 - 0 cm	Leaves, slightly decomposed; abrupt smooth boundary to
Ah	0 - 15 cm	Dark brown (7.5YR 2/1, moist) silt loam; weak to moderate medium to coarse crumb structure; slightly sticky, slightly plastic, friable; many very fine interstitial pores; common very fine to coarse roots throughout; non calcareous (10% HCl); abrupt smooth boundary to
E	15 - 33 cm	Pale brown (10YR 6/3, moist) silt loam; moderately coherent porous massive structure; slightly sticky, slightly plastic, firm; few coarse distinct diffuse yellowish red (5YR 5/8) mottles; many very fine and few fine tubular pores; few fine and medium roots; non calcareous (10% HCl); gradual smooth boundary to
Bt1	33 - 85 cm	Brown (7.5YR 5/4, moist) clay loam; weak very coarse prismatic parting to moderate to strong coarse angular blocky structure; non sticky, non plastic, firm; many coarse distinct clear light yellowish brown (10YR 6/4) and few coarse distinct diffuse yellowish red (5YR 5/8) mottles; continuous thick clay and sesquioxide cutans throughout; common very fine inped tubular pores and few fine tubular pores; few very fine and fine roots; non calcareous (10% HCl); diffuse smooth boundary to
Bt2	85 - 110 cm	Light yellowish brown (10YR 6/4, moist) clay loam; weak very coarse prismatic parting to moderate to strong coarse angular blocky structure; non sticky, non plastic, firm; common coarse distinct clear light yellowish brown (10YR 6/4) mottles; continuous thick clay and sesquioxide cutans throughout; common very fine inped tubular pores; few very fine roots; non calcareous (10% HCl); gradual broken boundary to
Btg	110 - 150 cm	Dark brown (7.5YR 3/4, moist) clay; strong coarse angular blocky structure; non sticky, non plastic, very firm; common medium distinct clear yellowish red (5YR 5/8) mottles; continuous thick clay and sesquioxide cutans throughout; many very fine inped tubular pores; no roots; non calcareous (10% HCl)

ANALYTICAL DATA :

Hor.	Top - Bot	PARTICLE SIZE DISTRIBUTION (PSD) >2 mm	2000 1000	1000 500	500 250	250 100	100 50 µm	TOT SAND	50 20	20 2	TOT SILT	<2	DISP CLAY %	BULK DENS	pF 0.0	1.0	1.5	2.0	2.3	2.7	3.4	4.2
Ah	0 - 15	-	0	1	2	1	1	6	14	48	62	32	9.2	-	-	-	-	-	-	-	-	-
E	15 - 33	-	0	3	4	2	1	10	12	56	68	22	12.5	1.43	41	39	37	36	36	35	30	17
Bt1	33 - 85	-	0	0	1	1	1	2	8	36	44	54	29.0	1.42	44	44	43	42	41	41	40	34
Bt2	85 - 110	-	0	0	0	1	0	1	6	40	46	53	25.6	-	-	-	-	-	-	-	-	-
Btg	110 - 150	-	0	0	0	1	0	1	9	43	52	47	23.0	-	-	-	-	-	-	-	-	-

Hor.	pH H2O	pH KCl	CaCO3 %	ORG MAT C %	ORG MAT N %	EXCHANGEABLE BASES Ca	Mg	K	Na	sum	EXCH AC H+Al cmol$_c$ kg^{-1}	EXCH AC Al	CEC soil	CEC clay	OrgC	ECEC	BASE SAT %	Al SAT %	EC 2.5 mS cm^{-1}
Ah	5.6	4.9	-	11.31	0.99	29.7	5.2	1.2	0.2	36.3	-	-	51.0	157	39.6	36.3	71	-	0.26
E	5.3	3.8	-	0.42	0.07	3.7	1.4	0.0	0.1	5.2	2.4	2.1	10.7	49	1.5	7.6	49	20	0.02
Bt1	4.9	3.4	-	0.24	0.04	11.1	5.7	0.2	0.4	17.4	11.4	10.7	29.6	55	0.8	28.8	59	36	0.02
Bt2	5.0	3.5	-	0.17	0.05	13.3	6.8	0.3	0.3	20.7	7.9	7.0	27.9	53	0.6	28.6	74	25	0.03
Btg	5.2	3.5	-	0.96	0.09	13.4	6.0	0.2	0.4	20.0	5.1	4.6	30.8	65	3.4	25.1	65	15	0.03

CLAY MINERALOGY (1 very weak → 8 very strong)

Hor.	MICA /ILL	VERM	SMEC	KAOL	QUAR	AVAILABLE P mg kg^{-1}
Ah	3	3	4	3	2	9.6
E	2	4	3	3	2	1.2
Bt1	3	3	5	3	2	3.5
Bt2	4	3	8	3	2	10.3
Btg	3	3	6	3	2	16.9

PSD: weight %. BULK DENS: Mg/m^3. pF: vol. %. $CaCO_3$, org. C, tot. N: weight %. Exch. bases, CEC: NH_4OAc pH 7. Exch. ac.: 1 *M* KCl. Clay mineralogy: MICA/ILL mica/illite, VERM vermiculite, SMEC smectite, KAOL kaolinite, QUAR quartz. Available P (Olsen): mg/kg.

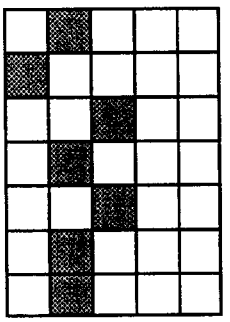
Annex 2 Evaluation of Land Qualities of CN 37

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

vh	very high	n	not present
h	high	w	weak
m	moderate	m	moderate
l	low	s	serious
vl	very low	vs	very serious

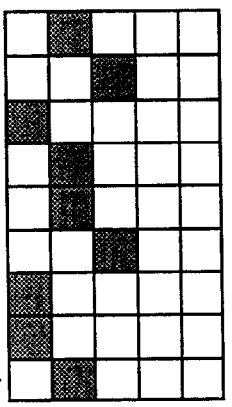
CLIMATE

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



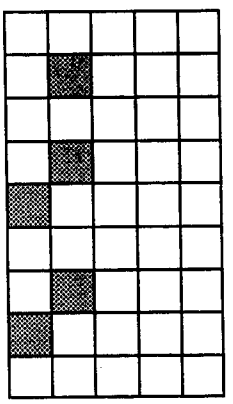
SOIL

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



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: $1/1000^{th}$ 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

(ISSN: 1381-6950)

No.	Title	No. of soils*
CN 1	Red reference soils of the subtropical Yunnan Province	3
CN 2	Reference soil ("Latosol") of tropical southern Yunnan Province	1
CN 3	Yellow/brown reference soils of subtropical Guizhou Province	3
CN 4	Purple upland and lowland reference soils of subtropical Sichuan Province	2
CN 5	Reference soils of the subtropical mountains of Jiangxi Province	3
CN 6	Reference soils of the subtropical mountains of Guangdong Province	3
CN 7	Reference soils of tropical China (Hainan Island)	4
CN 8	Reference soils of the Red Basins of Jiangxi Province	5
CN 9	Reference soil of Chaoyang County, typical of the formerly wooded hilly areas in the SW of Liaoning Province	1
CN 10	Reference soils of the Liaohe plain, Liaoning Province	2
CN 11	Reference soil of the Changbai Mountains, Jilin Province	1
CN 12	Reference soils of the Songnen plain, Heilongjiang Province	4
CN 13	Reference soil of the Wudalianchi volcanic area, Heilongjiang Province	1
CN 14	Reference paddy soils of the eastern alluvial lowlands of China (in prep.)	3

Country Reports

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1	Cuba	22	15	Gabon	6
2	P.R. of China	51	16	Ghana	in prep.
3	Turkey	15	17	Philippines	6
4	Côte d'Ivoire	7	18	Zimbabwe	13
5	Thailand	13	19	Spain	20
6	Colombia	18	20	Italy	17
7	Indonesia	48	21	Greece	in prep.
8	Ecuador	in prep.	22	India	in prep.
9	Brazil	28	23	Kenya	in prep.
10	Peru	21	24	Mali	in prep.
11	Nicaragua	11	25	Nigeria	in prep.
12	Costa Rica	12	26	Mozambique	in prep.
13	Zambia	11	27	Botswana	in prep.
14	Uruguay	10			

* State of reference collections as of January 1995