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THE NEED for a soil map of Malaya has become increasingly apparent in recent years, especially in view of the major projects envisaged under the First and Second Five Year Plans for the development of new areas and the improvement of existing rural lands. The accompanying soil map of the Federation of Malaya is the first to be published. It is based largely on a limited number of soil surveys, supplemented by information from published geological and topographical maps. It represents only a transitional stage in the cataloguing of the national soil resources, and is therefore not a completely accurate record, but it is hoped that this map will stimulate further pedological work in Malaya.

Studies on the classification of Malayan soils can be traced to the early years of this century. The published works of Akhurst and Haines (1), Barrowcliff (2), Belgrave (3), Dennett (4, 5, 6, 7), Grantham (8, 9, 10), Greenstreet (11), Hamilton (12), and Savage and Wilshaw (13) show how much attention this subject received between the First and Second World Wars. A notable advance was made in 1951, when Owen published a provisional classification of Malayan soils, in which he proposed names for a number of soil types then known to exist in the peninsula (14). In all these studies the importance of parent material was recognized and repeatedly stressed, and frequent reference was made to existing geological maps. However, apart from a map of the Rubber Research Institute's Experiment Station at Sungei Buloh (1), no true soil maps were published, and the only systematic surveys known to have been made of extensive areas were those commissioned by certain large planting companies for their own properties. The unpublished works of Tommerup and Cole were excellent pioneer efforts in this sphere.

Later, in the nineteen-fifties, Coulter and others carried out a number of soil surveys of some of the major swamp areas along the west coast of Malaya (15, 16, 17). These surveys were designed primarily to determine the suitability of the soil for padi before planning drainage and irrigation facilities. They sampled soils at regular intervals along specially cut traverse lines, or *rentis*; these samples were mechanically and chemically analysed, and soil maps showing the principal textural groups were produced. During the same period, a number of detailed maps of both sedentary and alluvial soil types were prepared for a few areas of developed land in several regions of the country, using profile characteristics as the basis of the classification. In the mid-fifties, reconnaissance soil surveys of some extensive padi areas were undertaken, and a schematic-reconnaissance soil survey programme for the whole country was also started. In view of the limited staff available, it was decided that the schematic-reconnaissance mapping programme should be carried out on a State basis, commencing with the north-east coast States, and to date soil maps on a scale of 1:500,000 with accompanying reports have been published for the States of Trengganu and Kelantan (18, 19). Field work in Kedah and Perak has been completed, and soil maps and reports for these States will soon be available. In addition, a large number of *ad hoc* surveys have been carried out in various parts of the country, and the information provided by such work, as well as from other sources of a less direct nature, has been used in compiling the present map (20, 21, 22, 23).

Surveys are now in progress in Pahang and Johore, and in a number of large alluvial areas in other parts of the country. Within the next few years the results should allow the preparation of a more detailed soil map. In addition to this official programme, certain private organizations have undertaken soil surveys, mainly of oil palm estates, to help with agronomic studies. Close liaison has been maintained with these organizations, which have mostly adopted the soil classification of the Malayan Department of Agriculture, which in turn is based on Owen's original scheme.

At present, priority is given to reconnaissance surveys of the less developed areas of the country to assess their development potentials and soil patterns. The value of these surveys for the official Rural Development Plan is well appreciated, as shown by the priority allocated to such surveys in recent years.

It may be appropriate to mention some details about soil survey methods in Malaya, a country noted for its thick, luxuriant vegetation and difficult topography, especially that formed by large areas of steep and broken mountains and extensive swamps. These features present considerable difficulties to soil surveyors in undeveloped areas, where, in the absence of tracks, work is often confined to *rentis* lines specially cut to provide access and to locate soil pits and soil boundaries. Aircraft, cross-country vehicles, boats, rafts, bicycles and the human foot are all used frequently, and a not inconsiderable athletic prowess is almost as important as professional ability to the surveyor working in the jungle. Aerial photographs are not as useful as might be expected, owing to the limited variations in the forest cover that might indicate soil differences. On the other hand, local soil surveyors are well served by the one inch to one mile topographic maps of the Malayan Survey Department, which cover the whole country.

The classification of soils in the field is based essentially on the United States Department of Agriculture system, and mapping is carried out at series or at association level, depending on the detail required. The larger groupings shown on the accompanying soil map are based on the Great Soil Groups of Marbut, as revised by Baldwin, Kellogg and Thorp (24), with subdivisions according to parent materials wherever possible. The latosol and laterite groups conform to the definitions given by Kellogg and Davol (25). An outline of the characteristics of the great soil groups that occur in Malaya is given below.

#### 1. LITHOSOLS AND SHALLOW YELLOW LATOSOLS ON STEEP MOUNTAINOUS AND HILLY LAND

This group, which covers some 40 per cent of the total area of Malaya, is one of the least studied of local soil groups, as it is considered to be of very low agricultural potential, due to unfavourable topography rather than to inherent infertility. These soils have not been examined in much detail during reconnaissance surveys, and in practice delineation of their downhill boundaries is all that is necessary. In unsurveyed areas this boundary can be inferred from relief patterns shown on topographic maps or aerial photographs. That shown on the accompanying Soil Map is normally very apparent on the ground, being marked by a pronounced change of slope separating moderately undulating land, with average slopes under 20°, from rising land with slopes exceeding 25°. The break occurs at different altitudes in different parts of the country. It corresponds with the 150-foot contour over a large part of Kedah State, and with the 750-foot contour in the region around Kuala Lipis in north Pahang; in the rest of the country the boundary lies between these two extremes.

These soils are generally thinner and younger phases of the latosolic soils that occupy most of the gentler slopes in adjoining lowlands. At very high altitudes they may consist of thick fibrous root mats and very little else. Their parent material is usually granite, which forms the core of nearly every mountain range in Malaya, but quartzites, conglomerates and shales, which outcrop over large areas of steep land in the eastern half of the country, also produce similar soils.

#### 2. RED AND YELLOW LATOSOLS AND RED AND YELLOW PODZOLIC SOILS DERIVED FROM ACID IGNEOUS ROCKS

These form a relatively uniform group of medium-textured soils characterized by deep, free-draining profiles. They are usually yellow or reddish-yellow in colour, and are uniform throughout their profiles except in some areas where a textural B horizon can be distinguished close to the surface, indicating a slight development of podzol characteristics. They are mature soils which have undergone considerable leaching under existing high rainfall conditions, and are moderately acid, with pH values ranging between 4.5 and 5.5. They have very low reserves of exchangeable bases, but in spite of this apparent paucity of available plant nutrients they are of good average fertility; in part this is due to their good subsoil structure and considerable soil volume in which the roots of perennial crops can ramify. The gradual release of further nutrients resulting from mineral decay in the lower horizons may explain the anomaly between analytical and yield data.

The parent material of the group is most commonly of granodioritic composition rather than true granite. Differences in grain size, porphyritic structure and the relative proportions of constituent minerals in the parent rock, as well as topographic variations, give rise to a number of series in the group. The most extensive is the Rengam series, originally established by Owen and now recognized in nearly every State in the country.

#### 3. RED AND YELLOW LATOSOLS AND RED AND YELLOW PODZOLIC SOILS DERIVED FROM VARIOUS SEDIMENTARY ROCKS

These soils show considerable variation in profile character and many series have been established, although much detailed survey work is required to determine their distributional patterns. Large areas remain unsurveyed, even by exploratory methods, especially in Pahang and Johore, and the present grouping is likely to become more complex as further work is undertaken.

All profiles developed over such widely varying parent materials show comparatively uniform development of deep A<sub>2</sub> horizons displaying various yellow and reddish-yellow colours and other latosolic features. But in field diagnoses, an almost infinite number of differences in texture, structure, colour and subsoil drainage may arise from variations of topography and parent material. In gently sloping or low-lying sites, or with iron-rich, heavy-textured parent materials, thin laterite horizons or discrete ferric oxide concretions may develop, emphasising the strong relationship between the latosol and laterite groups. The Serdang series is a typical yellow latosol derived from quartzites (20) and is of widespread occurrence in the west coast States.

#### 4. RED AND YELLOW LATOSOLS AND RED AND YELLOW PODZOLIC SOILS DERIVED FROM OLDER AND SUB-RECENT ALLUVIUM

In recent years, reconnaissance soil surveys and detailed geological studies in two separate areas of Malaya have indicated the existence of a variable group

of soils developed on dissected terraces and platforms lying at 20 to 230 feet above sea level. These topographic features were formed in unconsolidated shallow-water deposits of Pleistocene age known as Older Alluvium (26, 27). The resulting soils are similar in general appearance to the yellow latosols derived from sedimentary rocks (groups 2 and 3), although some, especially those at lower elevations, are rather looser structured and more freely drained. They are grouped separately on the basis of their lower fertility and, in most cases, marked deficiencies in major and minor elements. Their low nutrient status appears to be a result of (i) the two-fold cycle of weathering to which their parent materials have been subjected, (ii) the lack of profile rejuvenation through erosion, due to the relatively flat topography on which they have evolved, and (iii) their lower content of clay as compared with other latosols. The practical implications of their low nutrient status make further work on these soils a matter of urgency.

#### 5. REDDISH-BROWN LATOSOLS DERIVED FROM BASIC AND INTERMEDIATE IGNEOUS ROCKS

The reddish-brown latosols have a much more restricted distribution than the red and yellow latosols, being confined to areas where dark igneous rocks, largely of andesitic or basaltic composition, occur. They have been found mainly in Pahang State and sizeable acreages have been located in Kelantan and Johore. It is likely that other outcrops of this fertile soils occur in the unsurveyed parts of Pahang. These soils, which are of above-average fertility, possess very deep and uniform profiles with unusually well developed crumb structures. Their marked reddish colour distinguishes them from the less intense chromas of latosols. The two main series forming the group correspond to soils evolved from basaltic and andesitic parent materials, thus simplifying the field classification.

#### 6. LATERITE SOILS

Although soils with indurated concretionary B horizons occur in localized patches throughout the main latosolic groups, those with thick continuous bands of accumulated sesquioxides, known locally as laterite or *batu merab* (Malay for 'red stone'), are largely confined to the three main areas indicated on the Soil Map. These soils have a distinct subsoil zone of limonitic, sometimes bauxitic, pebbles of irregular shape which may be cemented together to form massive blocks. The indurated zone has sharp boundaries, and usually runs roughly parallel to the surface under a uniformly coloured and textured A horizon varying in thickness from six inches to ten feet. The laterite horizon is only exposed following local soil movements of recent occurrence such as sheet erosion and soil creep; occasionally the roots of a falling tree may drag parts of the concretionary layers to the surface leaving a small mound of laterite pebbles after the roots have rotted away. The location and distribution of the horizon is entirely consistent with a contemporary age for its formation, and no pedologist with local experience could fail to appreciate the dynamism of the laterite-forming process in the country at the present day (28).

Under existing climatic and topographic conditions, shales and phyllites appear to be the most common parent materials of laterite soils. The resulting heavy-textured soils of low permeability often develop a pallid zone of reddish mottles or streaks in a pale grey or white matrix in the subsoil below the laterite horizon, suggesting a possible relationship with the groundwater laterites of Marbut (29).

## 7. LOW HUMIC GLEY SOILS

The main coastal plains of western Malaya and the lower valleys and flood-plains of the larger east coast rivers contain a variety of grey or brown clays mottled with red and with obvious gleyed horizons developed close to their surfaces. These soils vary widely in fertility. Some are highly acid and present considerable problems in cropping, while others are only moderately acid, possessing abnormally high nutrient reserves by Malayan standards and produce excellent yields of certain crops with adequate drainage. A large number of series have been recognized through detailed mapping of most of the main padi-growing districts; only a limited acreage of the group still remains under natural forest.

## 8. AZONAL ESTUARINE AND COASTAL SOILS

Large tidal swamps, colonized by dense stands of mangroves (mainly *Avicennia* spp.), occur along the west coast and in smaller areas along the estuaries of east coast streams. The soils in this environment are immature featureless muds or sandy clays with varying amounts of decaying roots and occasional bands of sea shells. Little or no profile differentiation is seen, and in many places the coastal margins of the swamps are advancing seawards rapidly. The high cost of bunding, and subsequent difficulties of draining such areas have limited their agricultural utilization, but they provide valuable timber when well managed by a silvicultural programme of rotational extraction.

## 9. PODZOLS

Podzols are found on the east coast of Malaya, where they evolve from the coarse sands of low beach ridges which run parallel to the coast and rise to about twenty feet above sea level. The ridges are often separated by lagoonal swamps in which peats or highly sulphurous clays occur. The podzolic soils are very free draining and loose, and have very low reserves of plant nutrients. Their reddish- or yellowish-brown B horizon normally occurs at a depth of four to five feet, and is set within a pale, structureless subsoil; darker-coloured humus horizons are also common. The natural forest cover has in most cases been replaced by a poor open scrub or by low-yielding coconuts.

## 10. ORGANIC SOILS

Large peat and muck swamps are common in the poorly drained parts of the coastal plains of Malaya, and less extensively in a few inland areas. The muck soils, with 35 to 65 per cent of organic matter, are normally quite shallow, and are usually underlain by clayey mineral horizons at depths of less than twenty-four inches containing varying amounts of sulphur compounds. Malayan peats, or soils with over 65 per cent of organic matter, normally exceed three feet in depth, except for a narrow transitional fringe along the swamp boundaries, and peat depths as great as fifteen or even twenty feet are not uncommon.

In recent years, the muck soils and many of the shallow peats have been extensively cleared and cropped, but with only limited success. Their acidity, the coarse woody texture of the organic matter, and difficult drainage pose problems that are not yet satisfactorily resolved. However, some of the deeper peats, such as those in south-west Johore, have proved suitable for pineapples. Good stands of natural forest often appear in the peat swamps, and their preservation seems to be the best use for such land, at least for the immediate future.

## 11. DISTURBED LAND

Disturbed soils occupy about 2 per cent of the total area of Malaya, mostly held on mining leases. The white sandy wastes, dotted with mining pools, mark the sites of present or abandoned tin mines which are especially common in western Malaya. They have little or no agricultural potential, but attempts at reforestation are showing considerable promise. These skeletal soils have received very little attention, but they are sufficiently widespread to warrant mapping as a separate group.

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