

# Soil mineralogy and its ecological consequences at Pasoh Forest Reserve, Malaysia

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## 1. Introduction

Soils in tropical climates are usually heavily weathered and therefore not capable of replenishing lost plant nutrients such as phosphorus, potassium, calcium and magnesium. Therefore they are rich in aluminum and iron oxides, which is responsible for their distinct reddish colour. Yet Pasoh Forest Reserve is one of the most species rich forest ecosystems worldwide. Soils played only a subordinate role in previous studies at Pasoh Forest Reserve. As a consequence, there are still deficits in knowledge of spatial grain size distribution and soil mineralogy, clay mineral composition and the role of river streams in rejuvenescence of soils.

## 2. Methods

Seven soil samples were collected in a homogenized stratum of 30-40cm soil depth (to avoid weathering effects in the topsoil horizons) on different parent materials and proximity to riverbeds. The geology of the entire area consists of igneous rocks (acid granite) in the eastern part and sedimentary rocks (shales and sandstones) in the western part. Soils were classified as Ultisols (Udults) (WRB: Acrisols) and Oxisols (WRB: Ferralsols). Steel sieves were used to fractionate the samples ( $>6300\mu > 2000\mu > 630\mu > 200\mu > 63\mu > 40\mu$ ) and sedimentation analysis (micromeritics Sedigraph 5000ET) for fractions  $<40\mu$ . Bulk mineral and clay mineral analysis (CMA) was performed employing X-ray diffractometry. For the identification of clay minerals (CMA), a range of chemical treatments have to be applied before measuring the samples (see figure 4).

Lab number	Soil type	Riverbed proximity	silt/clay ratio
7576	Oxisol	>100m	0,70
7577	Oxisol	50-100m	0,20
7578	Ultisol	<10m	0,83
7579	Oxisol	<10m	0,51
7580	Ultisol	50-100m	1,77
7581	Ultisol	50-100m	1,34
7582	Ultisol	10-50m	0,52

**Table 1:** Lab number, Soil type, riverbed proximity and silt/clay ratio as an indicator of weathering status are shown.

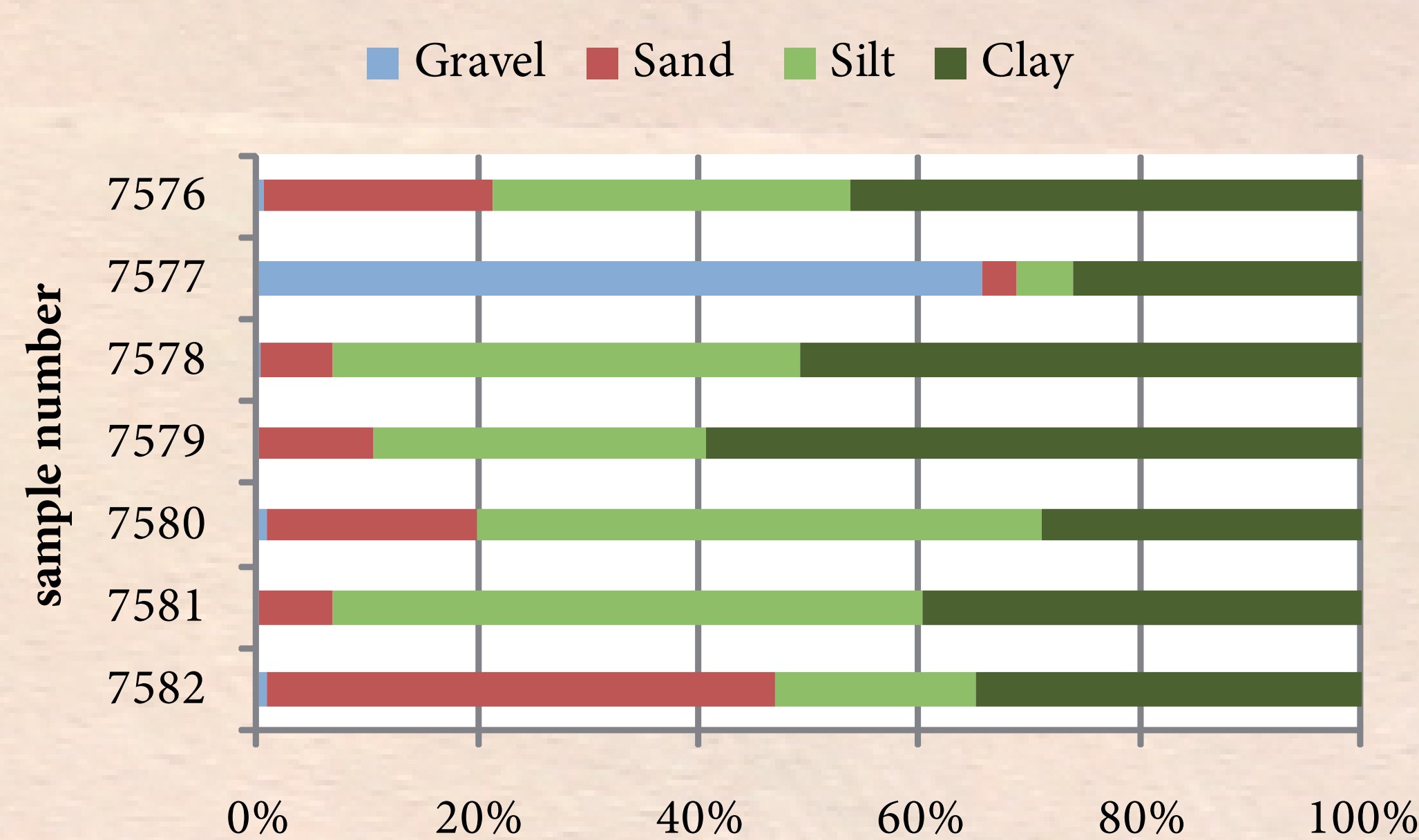


**Figure 1:** Sand fraction (200-630µm) from a sample in the eastern part (left: Ultisol, derived from granite) and western part (right: Oxisol, derived from sandstones). While quartz dominates the left picture, a mixture of quartz, hematite and goethite was found in the Oxisol sample.

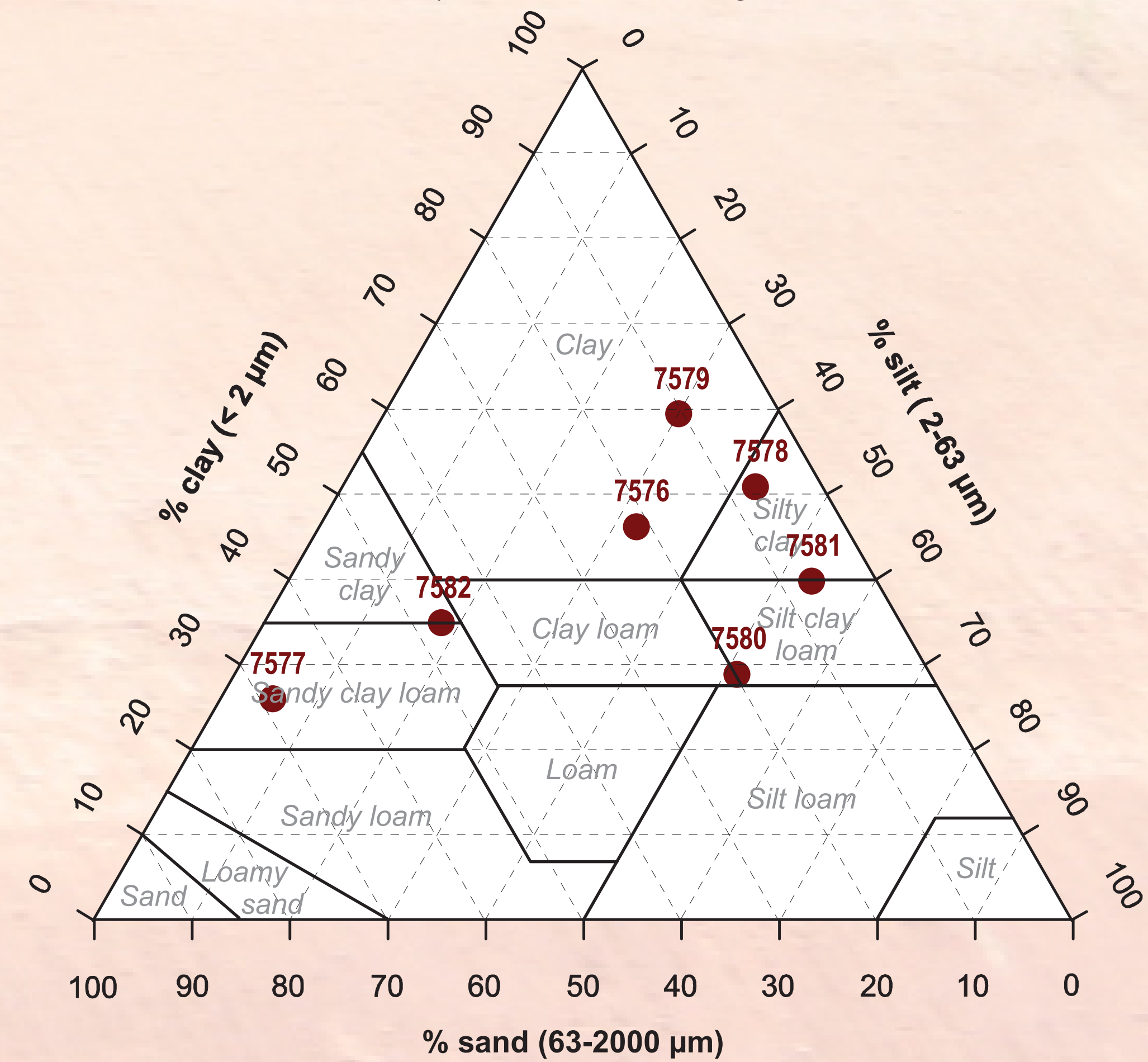
## 3. Results

### Grain size distribution

Fine fractions (clay, silt) were generally dominating with a mean value of 40,9% and 33,2% respectively. Only one sample (#7577, Oxisol) showed a considerable amount of gravel ( $>6300\mu$ ; figure 2). Generally low silt/clay ratios were observed (table 1).



**Figure 2:** Grain size distribution of the seven samples. Gravel in sample #7577 consists mainly of hematite and goethite.



**Figure 3:** Samples classified under the United States Department of Agriculture (USDA) soil texture triangle.

Two samples were classified as sandy clay loam / sandy clay with a considerable amount of sand (figure 3). The remaining samples mainly consist of silt and clay.

### Bulk mineral analysis (BMA)

BMA revealed that quartz ( $\text{SiO}_2$ ) was by far the dominating mineral, followed by layer silicates (sum of clay minerals). Kaolinite ( $\text{Al}_2(\text{Si}_2\text{O}_5)(\text{OH})_4$ ) could be identified, suggesting considerable amounts.  $\Sigma$  of layer silicates represents clay minerals (table 3).

### Clay mineral analysis (CMA)

As expected from the results of BMA, kaolinite is by far ( $\geq 95\%$ ) the dominating clay mineral, with quite even shares of well and poor ordered amounts.

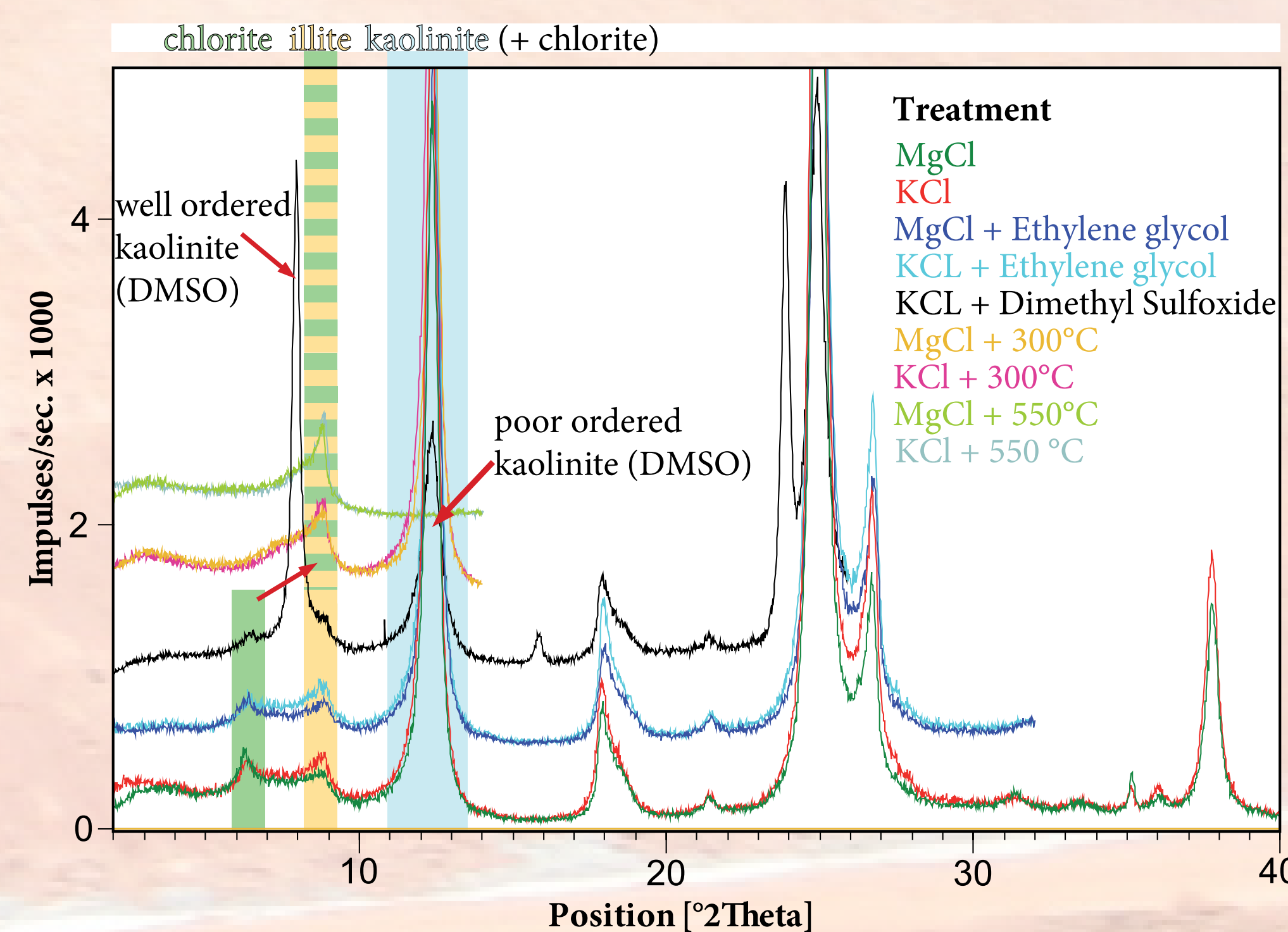
Lab number	Mica	Kaolinite	$\Sigma$ of layer silicates	Quartz	Alkali Feldspar	Plagio-clase	Goethite	Hematite
7576	o	•	••	•••			o	
7577		•	•	•			•	•
7578		•	••	•••			•	
7579		•	••	•••	o	?	•	
7580	o	•	••	•••			•	
7581		•	••	•••			•	
7582		•	••	•••	o		o	

**Table 2:** Bulk mineral composition. Symbols: o= traces, •= low, ••= medium, •••= high, ?= questionable, indirect detection.

Table 3 highlights the dominance of kaolinite. Some illite and secondary chlorite was found in three samples.

Lab number	Kaolinite (>95%)		Other clay minerals (<5%)			
	crystallization level		Vermiculite (14Å)	Illite	Mixed layer	Chlorite (secondary)
	well	poor				
7576	••	••	o	o	o	
7577	••	••	o	o	o	
7578	••	••	o	o	o	
7579	••	••	o	•	o	•
7580	•••	•	o	•	o	o
7581	•	•••	o	•	o	•
7582	••	••	o	o	o	o

**Table 3:** Clay mineral composition. Symbols: o= traces, •= low, ••= medium, •••= high.



**Figure 4:** X-ray diffractogram of sample #7579. The kaolinite peak (001) at  $12,5^\circ 2\theta$  (blue background) is dominant.

## 4. Conclusions

Soils at Pasoh Forest Reserve are heavy weathered. As a consequence, resistant and chemically inert minerals are dominating (quartz). The high kaolinite content is consistent with the intense weathering conditions experienced by these soils in the humid tropics. Kaolinite is only marginally able to exchange central Si- or Al-ions and therefore has a low CEC. Phosphate fixation by kaolinite was reported in many studies, contributing to elevated P scarcity. Proximity to riverbeds tends to influence mineral composition towards less weathered compartments. Streams at Pasoh Forest Reserve actively translocate younger sediments and contribute to soil rejuvenescence. Transforming these lowland rain forests into plantations ultimately leads to nutrient depletion and subsequent fertilizer application will be necessary.