The role of soil minerals in red and black Vertisol in Jeneponto Regency

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Abstract. Vertisol is one type of soil that is found with various colour variations. Various factors that influence these colour variations are topography, parent rock, organic matter and iron oxide and manganese. The research was conducted in the Jeneponto Regency by purposive sampling based on the colour of the soil to be investigated. The results of this study indicate that clay minerals are quite influential in the colour of the soil. Iron oxide minerals such as Goethite, Hematite and Halloysite are often found in red soils, indicating that the soil has undergone further weathering. However, Vertisol can not be said to have experienced weathering further, because it is still found perishable minerals such as Calcite and Sanidin, so Vertisol with color variations is indicated to have experienced early development. The red colour on Vertisol was influenced by iron oxide minerals such as Goethite, Hematite and Halloysite and the slopes ranging from 8-15% so that washing is indicated which makes montmorillonite unstable and turn into other minerals. While the black colour on Vertisol was indicated by a flat slope so that intensive washing does not occur.

1. Introduction
The soil has a variety of colours ranging from white, brown, grey, yellow to red. The colour variations are caused by various factors such as topography, parent rock, organic matter and iron oxide and manganese. One type of soil that has colour variations in Vertisol. Vertisol is a soil formed in areas with annual rainfall >1400 mm / year.

One of the factors that cause various colour variations on Vertisol is the parent rock. Black Vertisol was caused by apparent deviations that occur in coastal, river and delta deposits in wet tropical regions. At the same time, Vertisol in grey to brown and brownish red colour develops from new alluvial material [1]. Variations in black and red Vertisol was caused by topography and parent material, i.e. black Vertisol is generally found on a flat topography with carbonate sediment parent material. In contrast, in Red Vertisol, it is usually was influenced by a slightly tilted topography with sediment parent material [2].

Colour variations in Vertisol also cause differences in soil fertility. Agusman [3]conducted a study on the transition of the colour of the soil above the karst formation in Gunung Kidul Regency. From the results of the study, it was found that black Vertisol has high base saturation and cation exchange capacity. In contrast, red Vertisol has low base saturation and cation exchange capacity and the discovery of mixed minerals, namely Montmorillonite and Kaolinite.
Clay minerals are one of the essential components of soil because basically, clay minerals can determine the physical and chemical properties of the soil and as a central reaction in the process of ion exchange in the soil. Although clay minerals have a very small size, there are minerals which have the ability to expand shrinking, and cation exchange capacity (CEC) varies. The consistency of the soil was influenced by clay minerals [4]. One type of clay mineral found in Vertisol is Montmorillonite. The presence of the Montmorillonite mineral makes this type of soil expand when wet and shrink when dry causing slickenside to form. The existence of Vertisol both black and red often were found in Jeneponto Regency which is an area with a dry climate and dominant clay texture, so it is interesting to see the role of soil minerals in Vertisol color variation

2. Materials and methods
The materials were used in the research is disturbed soil samples obtained from soil profiles and basic maps such as administrative, geological and topographic. The stages of this research are 1) Conducted a preliminary survey to determine the observation points of the profile based on the colour of the soil namely red and black colours and overlapping colours, 2) Conducted profile observations, 3) Analysis of soil mineralogical properties using X-Ray Diffraction (XRD). XRD is a tool was used in analyzing sand and clay fractions from random samples (Unoriented samples). To see peak data clearly, the software was used is Qualx.

3. Results and discussion
A map of the slopes of the Jeneponto Regency can be seen in figure 1. The results of observing the soil profile can be seen in table 1 and figure 2, while the results of the analysis of mineral sand and clay can be seen in table 2 and figure 3.

Figure 1. Map of the slopes of The Jeneponto Regency
### Tabel 1. Soil profile description

| Profile | Parent material formation | Slope (%) | Elevation (masl) | Soil color |
|---------|--------------------------|-----------|-----------------|------------|
| VH1     | Carbonate sediment       | 3-5       | 53              | 10 YR      |
| VH2     | Carbonate sediment       | 5-8       | 35              | 10 YR      |
| VM      | Carbonate sediment       | 8-15      | 53              | 2.5 YR     |
| VMH     | Sediment                 | 8-15      | 35              | 5 YR       |

![Image of soil profile](image1.jpg)

**Figure 2.** The soil profile of VH1, VH2, VM and VMH

### Tabel 2. The results of the analysis of mineral sand and clay

| Profile | Sand minerals           | Clay minerals                        |
|---------|-------------------------|--------------------------------------|
| VH 1    | quartz, calcite         | Illite, montmorillonite              |
| VH 2    | quartz, calcite         | Montmorillonite                      |
| VM      | quartz, calcite, sanidin| Montmorillonite, halloysite          |
| VMH     | quartz, magnetite, sanidin | Illite, montmorillonite, goethite, hematite |
Based on table 2 and figure 2, it can be seen that quartz was found on all profiles both in black, red Vertisol and in overlapping red and black colours. The difference in the presence of clay minerals found in Vertisol is seen from the mineral halloysite, Goethite and hematite. Halloysite, Goethite and hematite are the most common iron oxide mineral. These three types of minerals were found in red soils.

In black Vertisol which develops from carbonate sediment parent material. Illite and montmorillonite clay minerals, quartz sand and calcite minerals are commonly found. This shows that the soil has not undergone further weathering due to the presence of calcite minerals in the profile and is in line with Prasetyo [5] who states that limestone is carbonate rocks which in new mineral conditions will be dominated by calcite and dolomite. After the weathering process of rock and soil formation occurs, both calcite and dolomite minerals will wear out, so that when the weathering level of the soil is advanced, all that remains are weathered resistant minerals such as quartz and opaque. The presence of quartz and opaque minerals in the soil made from limestone parent material also
occurs at the time of formation of limestone, so the process is a geogenic process rather than pedogenic, and this process also contributes to the colour of the soil on the profile.

The Halloysite mineral was found in red Vertisol, which is indicated that the mineral plays a role in the soil colour profile. Halloysite minerals are often found in red soils with advanced weathering. However, in the VM profile, it cannot be said to be weathered entirely further because there are still perishable minerals (calcite and sanidin) and montmorillonite minerals. It is possible that smectites and vermiculites in red soil are formed through weathering sequences of Mica-Illite-(if acidic pH)-Vermiculite-Kaolinite, or Mika-Illite- (if base pH) -smectite-Kaolinite [5]. Besides that the VM profile is on a slope of 8-15% which is quite steep, it is indicated that there has been leaching resulting from weathering montmorillonite which makes the montmorillonite unstable and turns into minerals such as kaolinite, Halloysite and Goethite. This is consistent with the opinion of Wilson and Cradwick [6] which states that the condition of organic matter is low and a slightly acidic environment can cause smectite (montmorillonite) to become unstable and transform into kaolinite and iron oxide minerals.

On the VMH Profile, the soil colour was influenced by the presence of Goethite and hematite minerals. Previous researchers have agreed that the presence of hematite and goethite minerals in the soil can cause reddish and reddish yellow soil, which hue with 10 R to 5 YR containing hematite and soils with hue between 2.5 YR to 7.5 YR containing Goethite [7]. This is in accordance with the colour of the soil in the profile that has been observed, i.e. the VMH profile has a hue colour of 5 YR. Hematite can cause red colour in the soil, while goethite can cause yellowish colour [8]. The presence of goethite and hematite minerals shows that an increase in the rate of development of the soil becomes oxic which causes the free iron content to reach its maximum level and form crystalline iron oxides such as goethite and hematite. In addition to goethite and hematite, in the VMH profile also found montmorillonite minerals formed through weathering sequences of Mica-Illite (if acidic pH) -Vermiculite- Kaolinite, or Mica-Illite- (if base pH) -Smectite-Kaolinite [5].

4. Conclusions

Iron oxide minerals such as Goethite, Hematite and Halloysite are often found in red soils, indicating that the soil has undergone further weathering. However, Vertisol can not be said to have experienced weathering further, because it is still found perishable minerals such as Calcite and Sanidin, so Vertisol with color variations was indicated to have experienced early development. The red colour on Vertisol was influenced by iron oxide minerals such as Goethite, Hematite and Halloysite and the slopes ranging from 8-15% so that washing is indicated which makes montmorillonite unstable and turn into other minerals, while the black colour on Vertisol was indicated by a flat slope so that intensive washing does not occur.

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