Akina
Guam State Soil

Soil Science Society of America

Introduction

Many states have a designated state bird, flower, fish, tree, rock, etc. And, many states also have a state soil – one that has significance or is important to the state. The **Akina** is the official state soil of **Guam**. Let's explore how the **Akina** is important to **Guam**.

History

The Akina soil was established as an official soil series in the Territory of Guam in July 1985. The Akina soil series is found in Southern Guam, predominately in steep areas underlain by volcanic rock. The USDA Natural Resources Conservation Service unofficially designated the soil in 2007.

What is Akina Soil?

The Akina soils are well drained and moderately deep, 50 to 100 centimeters (20 to 40 inches). They occur on volcanic hillslopes and formed in place, from *tuff* (a type of rock made from volcanic ash that is ejected from a volcano) and tuff *breccia* (a rock made up of rock fragments and cemented together by volcanic ash). Slopes range from 0 to 99 percent, but typical slopes are steep (greater than 20 percent).

Every soil can be separated into three separate size fractions called *sand*, *silt*, and *clay*, which makes up the *soil texture*. They are present in all soils in different proportions and say a lot about the character of the soil.

The Akina soil (**Figure 1**) is a dark reddish brown silty clay throughout the topsoil, or A horizon. This horizon can be 3 to 15 centimeters (1 to 6 inches) thick and has an average of 40 percent clay. The subsoil, or B horizon(s), is dark red clay. The red colors indicate high iron content in the soil, which promotes strong aggregation (mass or grouping) of soil particles so that the soil does not behave as though it has a high clay content. Below the bottom of the B horizons, around 61 centimeters (24 inches), the soil becomes mixed with highly weathered tuffaceous saprolite (*volcanic bedrock broken down by chemicals)* that is dense and massive. The depth to hard *bedrock* is greater than 152 centimeters (60 inches).

Photo Soil Monolith: Chip Clark/Smithsonian Institution

Fig. 1 Akina series in south central Guam. The subsoil (behind the soil knife handle) has high soluble aluminum and few nutrients. The *saprolite* (chemically weathered bedrock) (soil knife blade is sticking into it) can be a physical barrier to roots. Plowing can mix relatively good topsoil with subsoil that has undesirable chemical properties (low carbon content, very low fertility, high levels of soluble aluminum). Credit: Bob Gavenda

Fig. 2. Distribution of Akina soil in Guam. Credit: Smithsonian Institution Forces of Change

Where to dig Akina

Yes, you can dig a soil. It is called a soil pit and it shows you the *soil profile*. The different horizontal layers of the soil are called *soil horizons.* Akina soils are found predominately on the volcanic landscapes in the southern part of Guam, including the villages of Agat, Asan, Inarajan, Merizo, Santa Rita, Talofofo, and Umatac, as well in a small area near the northern village of Yigo. Akina covers approximately 19,000 acres of land in Guam, or about 14 percent of Guam's land area (**Figure 2**). In these areas, the Akina soil is the most common, but other types of soil also exist across the landscape. In all, there are a total of 15 named soils (series) in Guam. The type location, or place that represents a typical soil profile of Akina, is located at the University of Guam Ija Experiment Station near the village of Inarajan.

Importance

What makes the Akina soil so important is its use and prevalence in Guam. The Akina series is one of the prominent soils in the volcanic highlands of Southern Guam (**Figure 3**). It is a fragile soil that readily degrades once the topsoil is removed by erosion or direct human activities. It is not a fertile soil, so agriculture needs careful management of soil organic matter. The Ugum River watershed, which is comprised predominately of Akina soils, provides drinking water to several Southern Guam communities. Maintaining soil quality in this watershed is necessary for producing and delivering clean water.

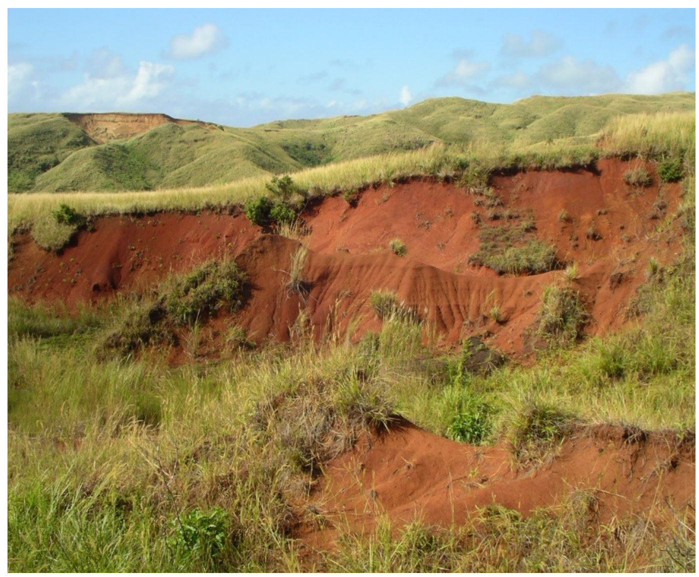

Fig. 3. Akina soil series landscape in Southern Guam. It is likely that this landscape was forested before millennia of human-caused fires destroyed the forest. Once subsoil is exposed it is difficult for vegetation to become established on the bare red soil because of active erosion, very low inherent soil fertility, and elevated levels of soluble aluminum that are toxic to many plants. Credit: Bob Gavenda

Uses

In general, soils can be used for agriculture (growing foods, raising animals, stables); engineering (roads, buildings, tunnels); ecology (wildlife habitat, wetlands), recreation (ball fields, playground, camp areas) and more. Akina soils are mainly used for wildlife habitat for introduced deer and pigs and as a watershed. Due to the steep landscapes and difficulty accessing some areas there is little urban development on Akina soils. Some areas on

Fig. 4 (Above) A view of a variety of landscapes where Akina soils occur in Southern Guam. Note the patches of red, exposed soil.

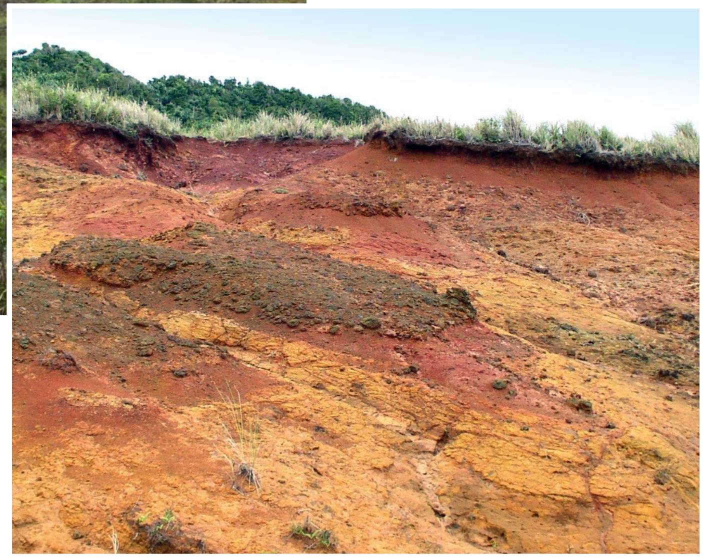

Fig. 5 (Right) Once the topsoil is removed, erosion can become uncontrollable for all practical purposes. The exposed subsoil easily erodes down to the dense weathered rock (saprolite) after the protective topsoil is removed. Active erosion occurs primarily in the red subsoil that overlies saprolite. Credit: Bob Gavenda

gentle slopes are farmed with truck crops such as watermelon and pineapple. Some areas are planted in hardwood tree species; however, vegetation in most areas is dominated by savannah grassland (**Figure 4**). The area covered by the Akina and other volcanic soils were likely originally forested prior to human arrival on the island at least 4500 years ago[1]. Fire removed the original forest and repeated burning of grasslands prevents forest re-establishment and promotes land degradation.

Limitations

When a soil cannot be used for one or more of the described functions, it is referred to as a limitation. Soil experts, called *Soil Scientists*, studied Akina soil and have found limitations. Intense weathering has resulted in Akina soils being very acidic (pH values of 4.9 to 5.3). The weathering has *leached* out many nutrients required for plant growth, including calcium and magnesium. Aluminum toxicity results from acidic soil conditions and is a problem for most plants, preventing plant growth. Almost all plant nutrients are in the topsoil but repeated burning of the land has resulted in topsoil erosion and for all practical purposes permanent degradation of the soil (**Figure 5**).

Management

Akina soils are highly infertile especially when the subsoil is exposed as a result of slumping or *erosion*. These soils may have calcium deficiency and aluminum toxicity, which can be corrected by applying lime in small, managed areas. Conservation or soil management practices promote building up topsoil and protecting the soil from erosion are recommended. Revegetation efforts are difficult, but have been attempted in some areas (**Figure 6**).

Fig. 6 This photo shows grass plantings on a military land restoration project. Grass will offer greater protection from erosion than will trees in these soils. Note the soil remnant indicating that at least about 2 meters (6 feet) of soil has been removed from this landscape. Also note the recent burned area in the midground of the photo. Credit: Bob Gavenda

Fig. 7 Active erosion on the soils of Guam. Credit: USDA-NRCS

Akina Formation

Before there was soil there were rocks and in between, CLORPT. Without CLORPT, there will be no soil. So, what is CLORPT? It is the five major factors that are responsible for forming a soil like the Downer series. It stands for **CL**imate, **O**rganisms, **R**elief, **P**arent material and **T**ime. CLORPT is responsible for the development of soil profiles and chemical properties that differentiate soils. So, the characteristics of **Akina** (and all other soils) are determined by the influence of CLORPT. Weathering takes place when environmental processes such as rainfall, freezing and thawing act on rocks causing them to dissolve or fracture and break into pieces. CLORPT then acts on rock pieces, marine sediments and vegetative materials to form soils.

Climate – Temperature and precipitation influence the rate at which parent materials weather and dead plants and animals decompose. They affect the chemical, physical and biological relationships in the soil. High temperatures and precipitation on Guam have resulted in highly weathered soils that have been leached of most of their nutrients. The high rainfall and seasonal dryness results in clay accumulation in the subsoil. Mean annual precipitation is 2159 to 2921 millimeters (85 to 115 inches), with most rainfall occurring between July and November. The dry season lasts from January through April and brings trade winds that blow from the east or northeast. Typhoons can bring heavy rains and violent wind any month of the year but occur more frequently during the rainy season.

Organisms – This refers to plants and animal life. In the soil, plant roots spread, animals burrow in, and bacteria break down plant and animal tissue. These and other soil organisms speed up the breakdown of large soil particles into smaller ones. Plants and animals also influence the formation and differentiation of soil horizons. Plants determine the kinds and amounts of *organic matter* that are added to a soil under normal conditions. Animals breakdown complex compounds into small ones and in so doing add organic matter to soil. Akina soils have relatively high organic matter content in the topsoil, but the subsoil has almost no organic matter. Thus plant life is dependent on the topsoil to provide most of its nutrients. Although there are some forested areas, primarily in ravines, Akina landscapes are mostly covered by grasslands.

Relief – Landform position or relief describes the shape of the land (hills and valleys), and the direction it faces which makes a difference in how much sunlight the soil gets and how much water it keeps. Deeper soils form at the bottom of the hill rather than at the top because gravity and water move soil particles downhill. Akina soils formed on volcanic tuff saprolite that has been deeply weathered to form clay. Down cutting of streams has formed steep side slopes that are prone to slumping during periods of prolonged heavy rain. This leaves subsoil exposed at the surface that is then prone to erosion from rain and stream water (**Figure 7**), forming areas of *badlands* where vegetation cannot grow. Elevation ranges from sea level to 329 meters (0 to 1,080 feet).

Parent material (C horizon) – Just like people inherit characteristics from their parents, every soil inherits some traits from the material from which it forms. Some parent materials are transported and deposited by glaciers, wind, water, or gravity. Akina soils formed in *residuum*, or in place on the landscape, derived from volcanic tuff and tuff breccia. Over time, the volcanic tuff weathered into clay when exposed to high temperatures and rainfall.

Time – All the factors act together over a very long period of time to produce soils. As a result, soils vary in age. The length of time that soil material has been exposed to the soil-forming processes makes older soils different from younger soils. Generally, older soils have better defined horizons than younger soils. Less time is needed for a soil profile to develop in a humid and warm area with dense vegetative cover than in a cold dry area with sparse plant cover. More time is required for the formation of a well-defined soil profile in soils with fine textured material than in soils with coarse-textured soil material. Akina soils are very highly weathered and leached, as is characteristic of very old soils that have been forming over millions of years. The volcanic parent materials date from Lower Miocene to Upper Eocene[2] (23 to 38 million years ago) although the soils and landscapes are younger.

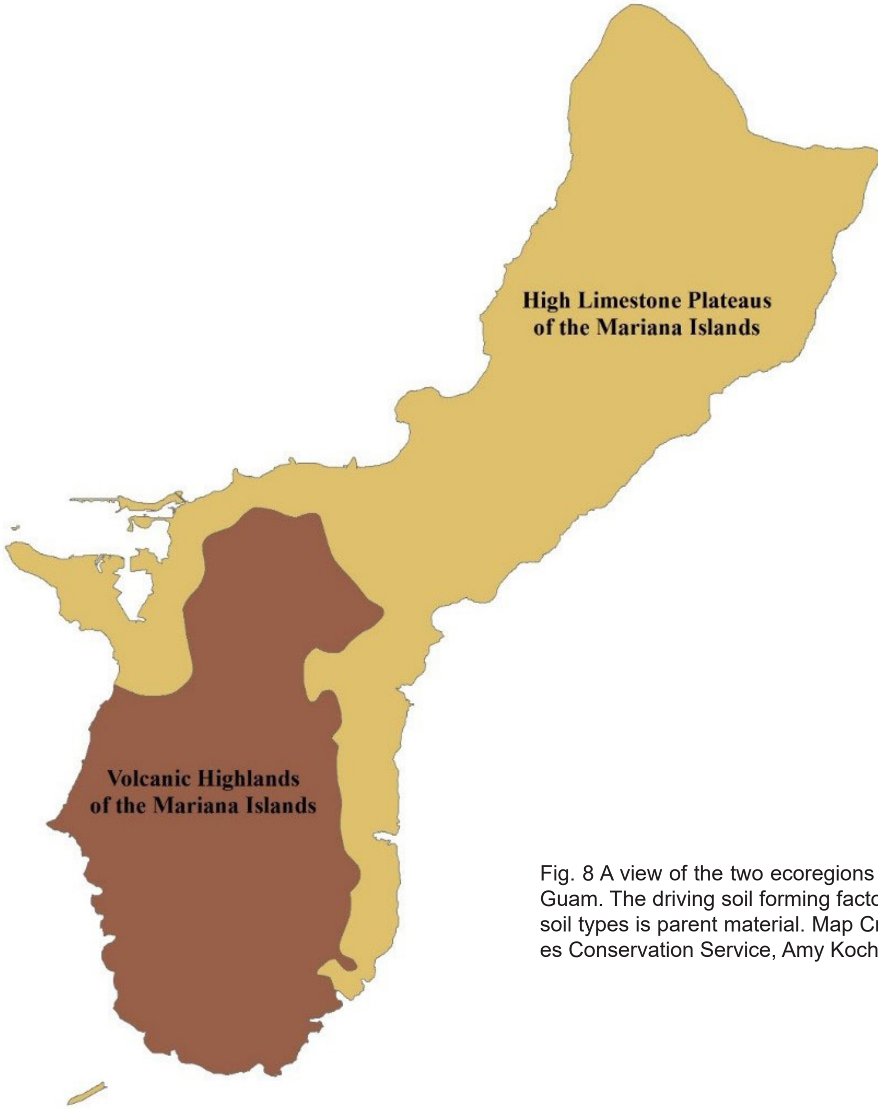

Fig. 8 A view of the two ecoregions found on the Island of Guam. The driving soil forming factor that creates different soil types is parent material. Map Credit: Natural Resources Conservation Service, Amy Koch

Ecoregions, Soils and Land Use in Guam

The Territory of Guam is the largest and southernmost island of the Mariana Islands. The island has two distinct physiographic areas or *ecoregions* distinguished by the type of rock from which the soil formed. The northern part of the island consists of limestone plateaus with shallow soils; whereas the southern part of the island is dominated by volcanic geology with deep, iron rich, yet infertile, soils (**Figure 8**).

Volcanic Highlands of the Mariana Islands: The majority of Akina soils formed in southern Guam in the ecoregion dominated by volcanic parent materials. Much of this ecoregion has steep mountains that are dissected by streams and rivers. The geology of this area consists mostly of highly weathered volcanic rock from an uplifted submarine volcano. The uplift occurs at the interface where the Pacific Plate is subducting under the Philippine Plate. The volcanic materials are mostly *andesite* and *basalt* reworked as tuff, tuff breccia, and other tuffaceous rocks. The climate is warm and humid throughout the year with little seasonal variation in temperature and humidity. However, there are two notable seasons, the dry season (January through April), and the rainy season (July through November). Native forest vegetation has largely been replaced by savannah grassland due to repeated burning. Much of the area is used as a watershed for drinking water supply and wildlife habitat for introduced deer, pigs, and goats. Farming is limited due to the steep terrain and poor *soil fertility*. The major resource concern in this ecoregion is soil erosion from high rainfall and stream flow. The excessive erosion coupled with poor soil fertility has led to the formation of badlands that are extremely difficult to revegetate. Excessive runoff and soil erosion can shut down water delivery to surrounding communities during the rainy season. Coral reefs in the near shore waters surrounding the island are also adversely affected when sediment runoff causes siltation and poor water quality.

Additional Resources

Soil! Get the Inside Scoop. David Lindbo and others. Soil Science Society of America, Madison, WI.

Know Soil, Know Life. David L. Lindbo, Deb A. Kozlowski, and Clay Robinson, editors. Soil Science Society of America, Madison, WI.

Web Resources

Soils for Teachers—www.soils4teachers.org

Soils for Kids—http://www.soils4kids.org/

Have Questions? Ask a Soil Scientist—https://www.soils.org/ask

Soil Science Society of America—https://www.soils.org/

Smithsonian Soils Exhibit – http://forces.si.edu/soils/

References

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[2]**Tracey, J.I., Jr., S.O. Schlanger, J.T. Stark, D.B. Doan and H.G. May. 1964.** General geology of Guam. U.S. Geological Survey Professional Paper 403-A.

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United States Department of Agriculture, Natural Resources Conservation Service. 2009. Geomorphic Description System, Version 4.12.

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Glossary

Andesite: Fine-grained, extrusive volcanic rock of intermediate silica content.

Badland: Moderately steep to very steep barren land dissected by many intermittent drainage channels. Potential runoff is very high and erosion is active.

Basalt: Fine-grained extrusive volcanic rock of low silica content.

Bedrock: A general term for the solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Breccia: Course-grained clastic rock composed of large, angular, and broken rock fragments that are cemented together in a fine-grained matrix.

Clay: A soil particle that is less than 0.002 mm in diameter. Clay particles are so fine they have more surface area for reaction. They hold a lot of nutrients and water in the soil. A clay soil is a soil that has more than 40% clay, less than 45% sand and less than 40% silt.

Ecoregion: Represents areas with similar biotic and abiotic characteristics which determine the resource potential and likely responses to natural and man-made disturbances. Characteristics such as climate, topography, geology, soils, and natural vegetation define an ecoregion. They determine the type of land cover that can exist and influence the range of land use practices that are possible.

Erosion: The wearing away of the land surface by water, wind, ice, or other geologic agents.

Fertility (soil): The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specific plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Horizon: see Soil horizons

Leaching: The removal of soluble material from soil or other material by percolating water.

Organic matter: Material derived from the decay of plants and animals. Always contains compounds of carbon and hydrogen.

Parent material: The unconsolidated organic and mineral material in which soil forms.

Residuum: Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Sand: A soil particle between 0.05 and 2.0 mm in diameter. Sand is also used to describe soil texture according to the soil textural triangle, for example, loamy sand.

Saprolite: Unconsolidated, weathered, or partly weathered residual material underlying the soil and grading to hard bedrock below.

Silt: A soil particle between 0.002 and 0.05 mm diameter. It is also used to describe a soil textural class.

Soil Horizon: A layer of soil with properties that differ from the layers above or below it.

Soil Management: The sum total of how we prepare and nurture soil, select type of crops that suitable for a type of soil, tend the crop and the soil together, and determine fertilizer types and other materials to be added to soil to maintain productivity and preserve soil.

Soil Profile: The sequence of natural layers, or horizons, in a soil. It extends from the surface downward to unconsolidated material. Most soils have three major horizons, called the surface horizon, the subsoil, and the substratum.

Soil Scientist: A soil scientist studies the upper few meters of the Earth's crust in terms of its physical and chemical properties; distribution, genesis and morphology; and biological components. A soil scientist needs a strong background in the physical and biological sciences and mathematics.

Soil Texture: The relative proportion of sand, slit, and clay particles that make up a soil. Sand particles are the largest and clay particles the smallest. Learn more about soil texture at www.soils4teachers.org/physical-properties

Tuff: A compacted deposit that is 50 percent or more volcanic ash and dust.