Soils of Saipan

Properties and Diversity

Jonathan Deenik, PhD
Department of Tropical Plant and Soil Sciences
University of Hawaii

Saipan Grazing and Livestock Management Workshop
February 3-5, 2010

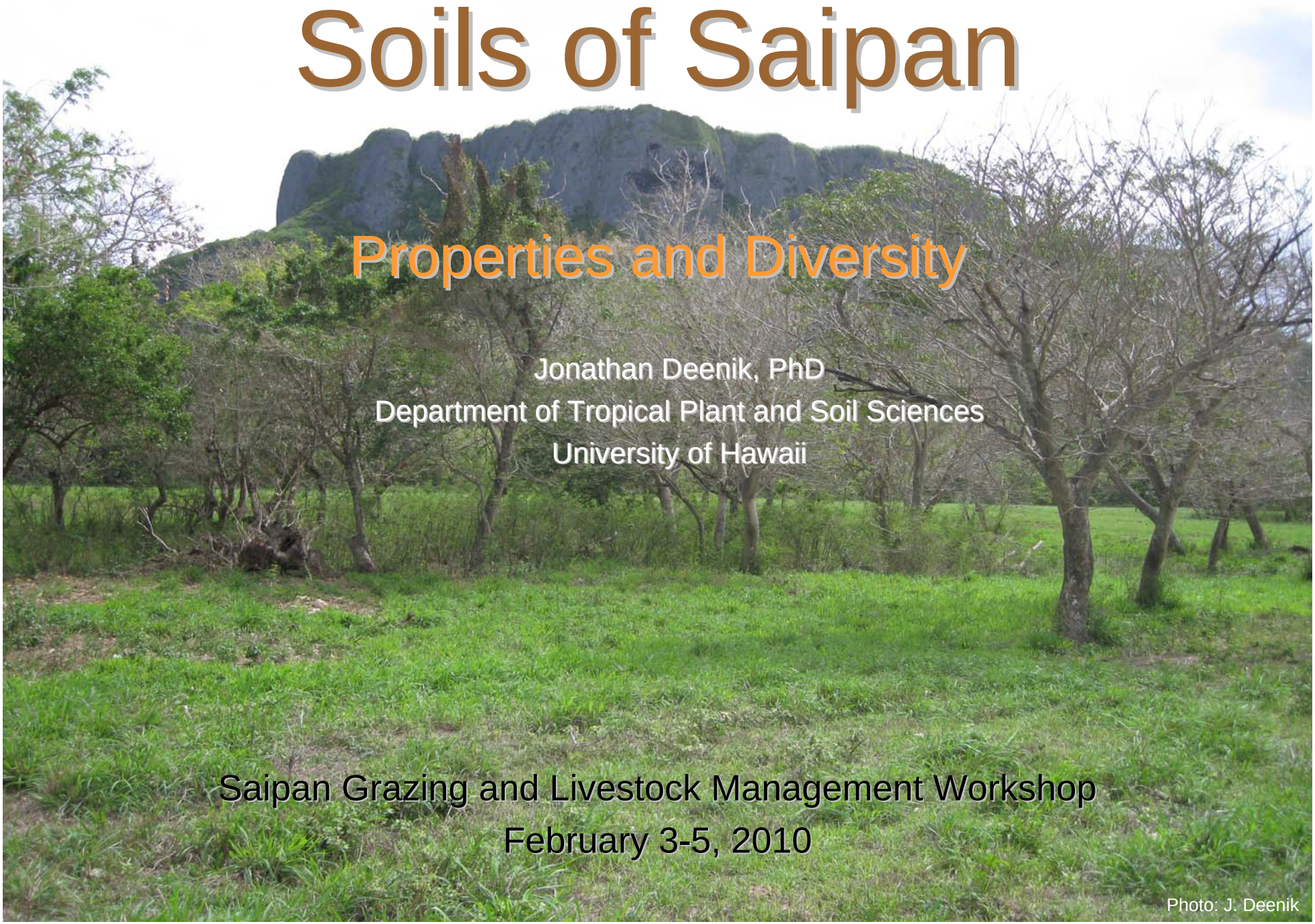


Photo: J. Deenik

Outline

- Soil formation
- Importance of Soil
- Soil Basics
  - Soil composition
  - Texture and clay minerals
  - Soil pH and nutrient availability
  - Soil organic matter
- Soil distribution on Saipan

Soil Formation

Soil = *f*(PM, Cl, O, R, T)

<u>Factors</u>:

PM = parent material (rocks)

Cl = climate (precipitation and temperature)

O = organisms (plants and animals)

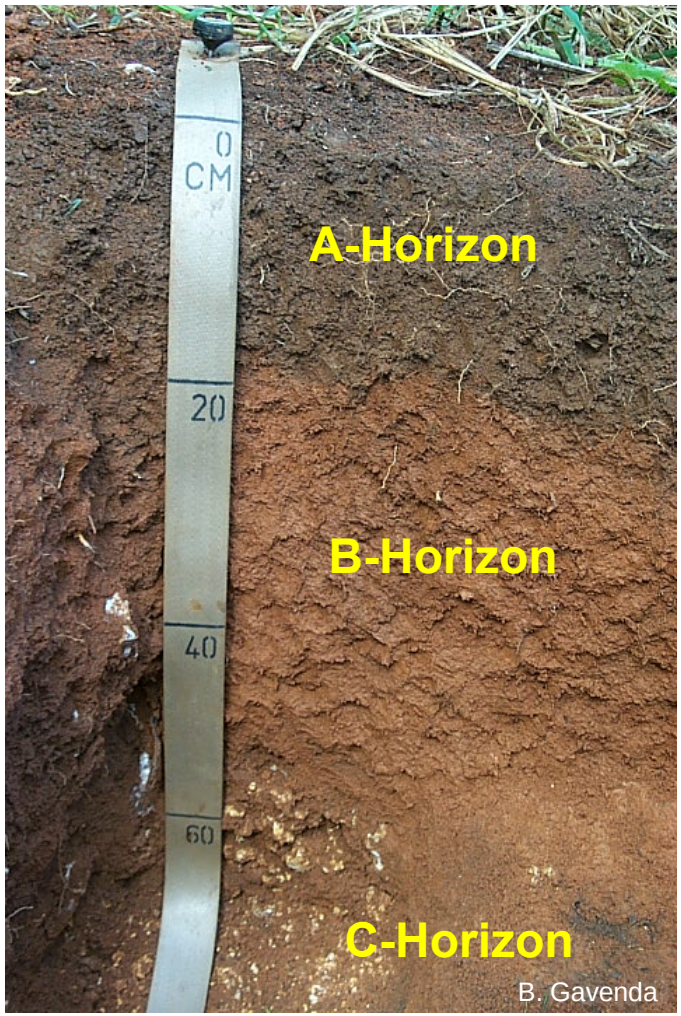
R = relief (topography, drainage)

T = time

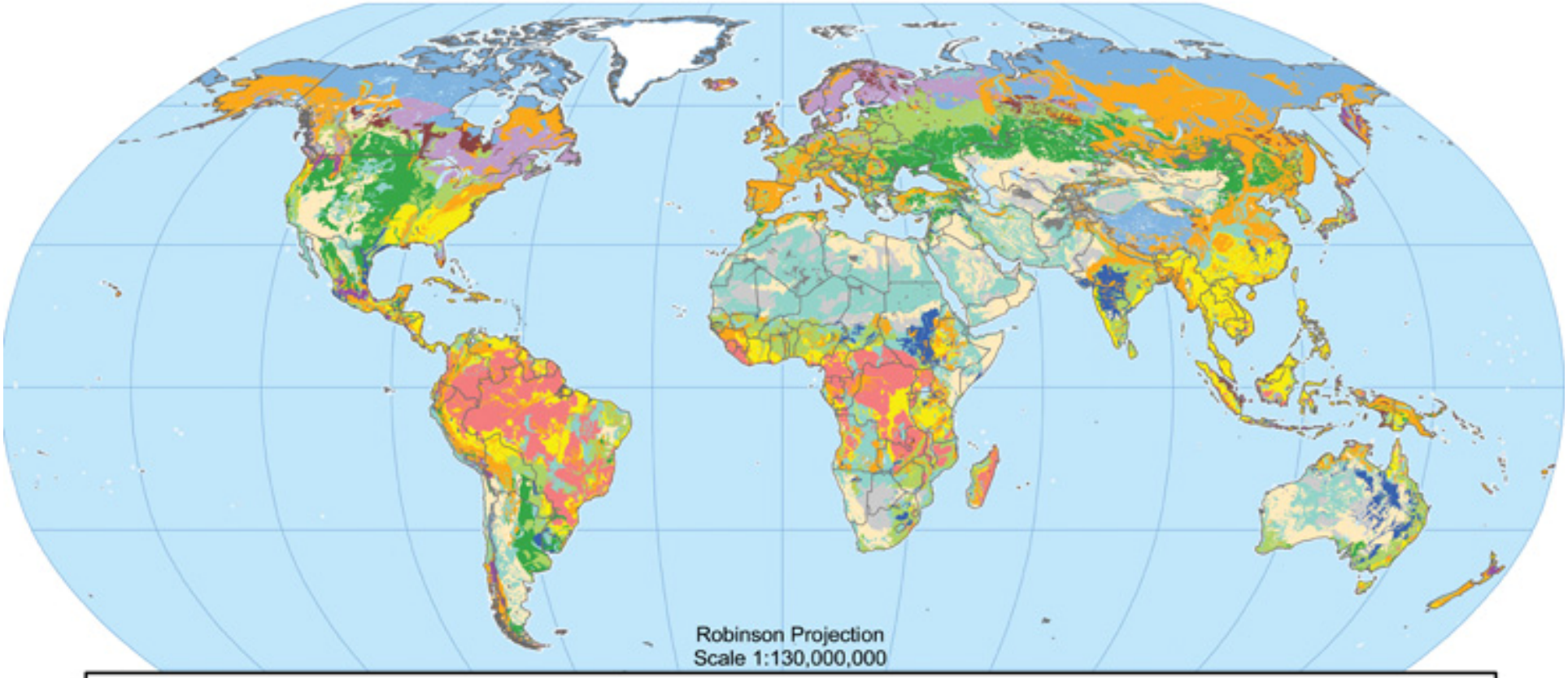
Soil Formation

Processes:

1. Additions
   - Water, organic matter, sediment
2. Losses
   - soluble compounds, erosion
3. Transformations
   - Organic matter to humus
   - Primary minerals to clay minerals
4. Translocations
   - Soluble compounds
   - Clays



Global Soil Regions



Soil Orders

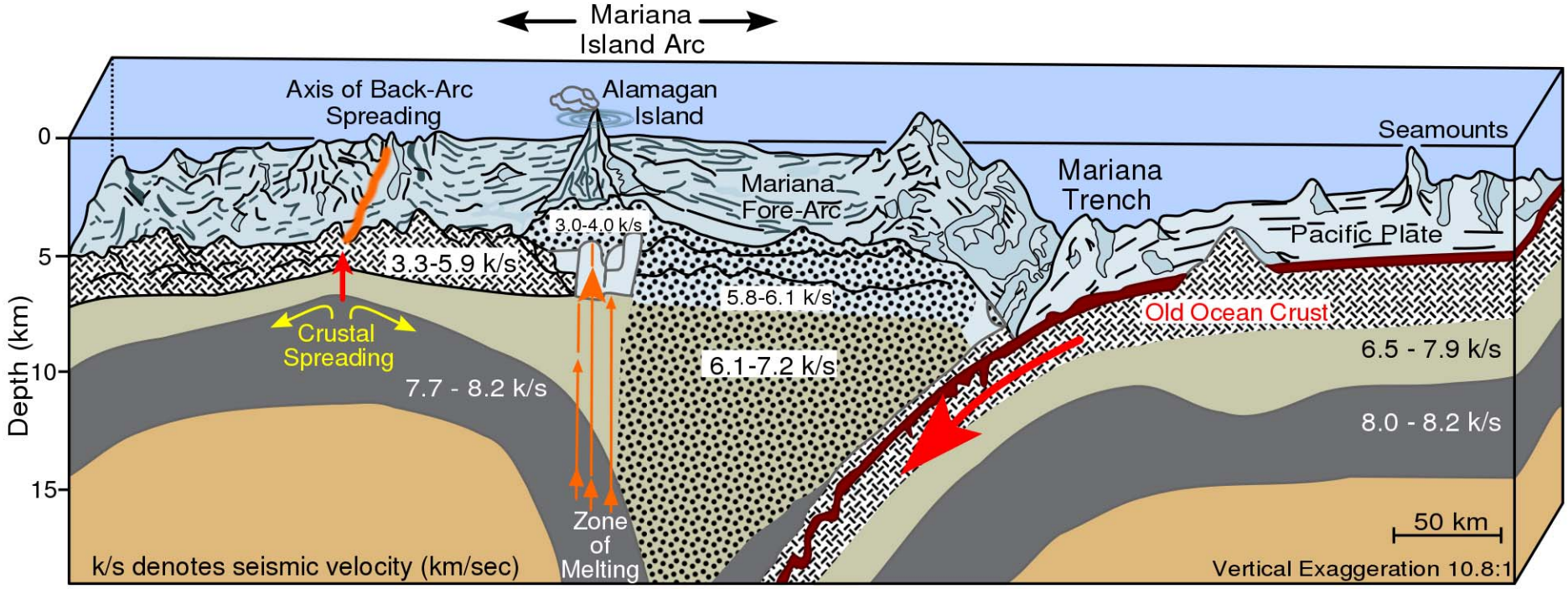
Alfisols	Entisols	Inceptisols	Spodosols	Rocky Land
Andisols	Gelisols	Mollisols	Ultisols	Shifting Sand
Aridisols	Histosols	Oxisols	Vertisols	Ice/Glacier

USDA NRCS US Department of Agriculture
Natural Resources
Conservation Service

Soil Survey Division
World Soil Resources
soils.usda.gov/use/worldsoils

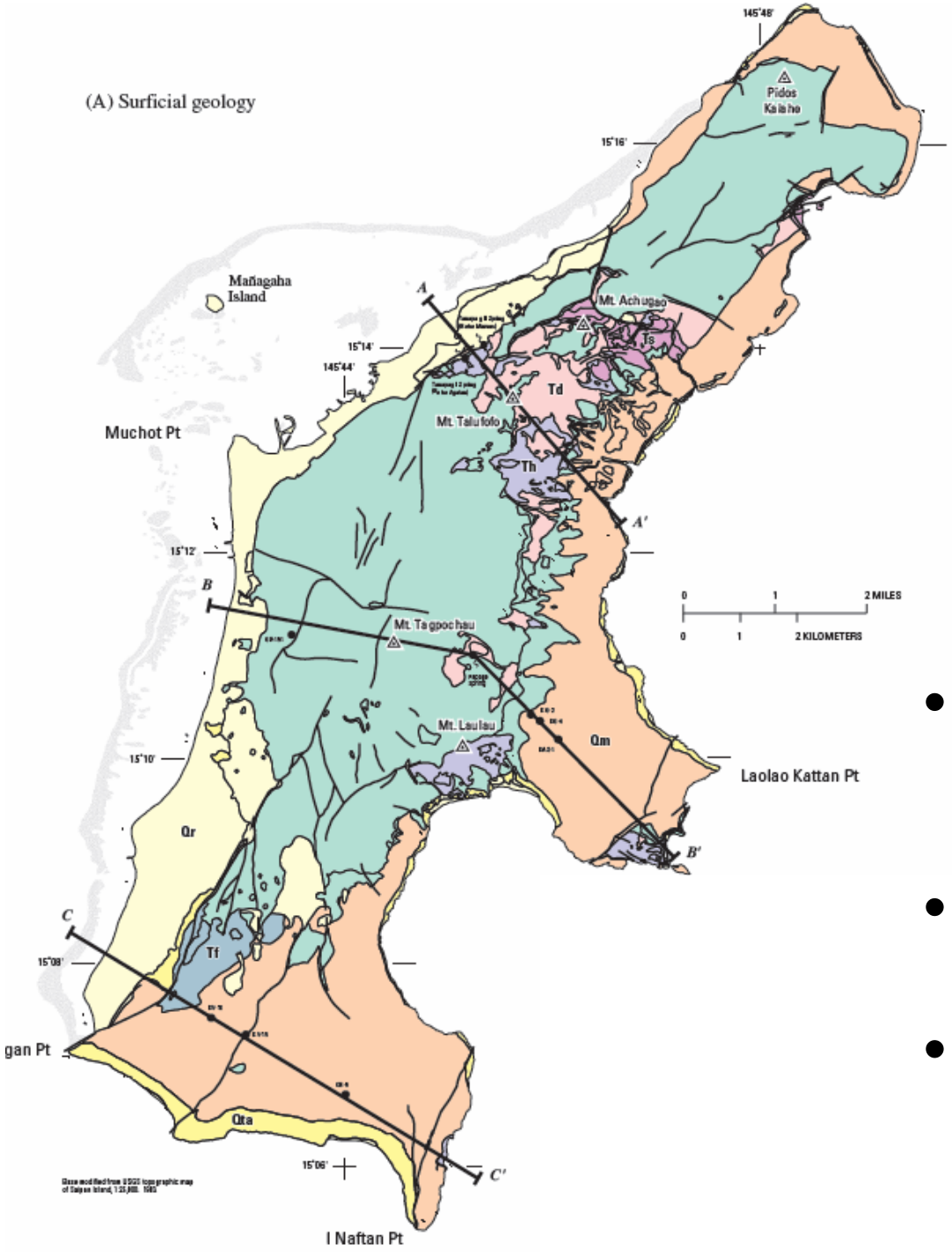
November 2005

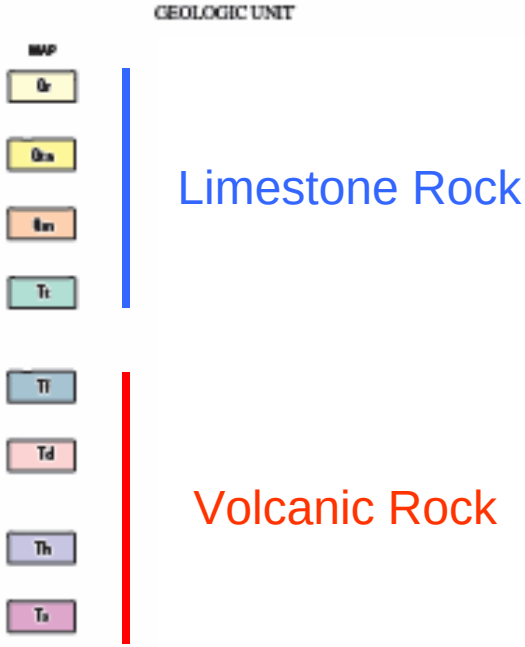
Island Formation



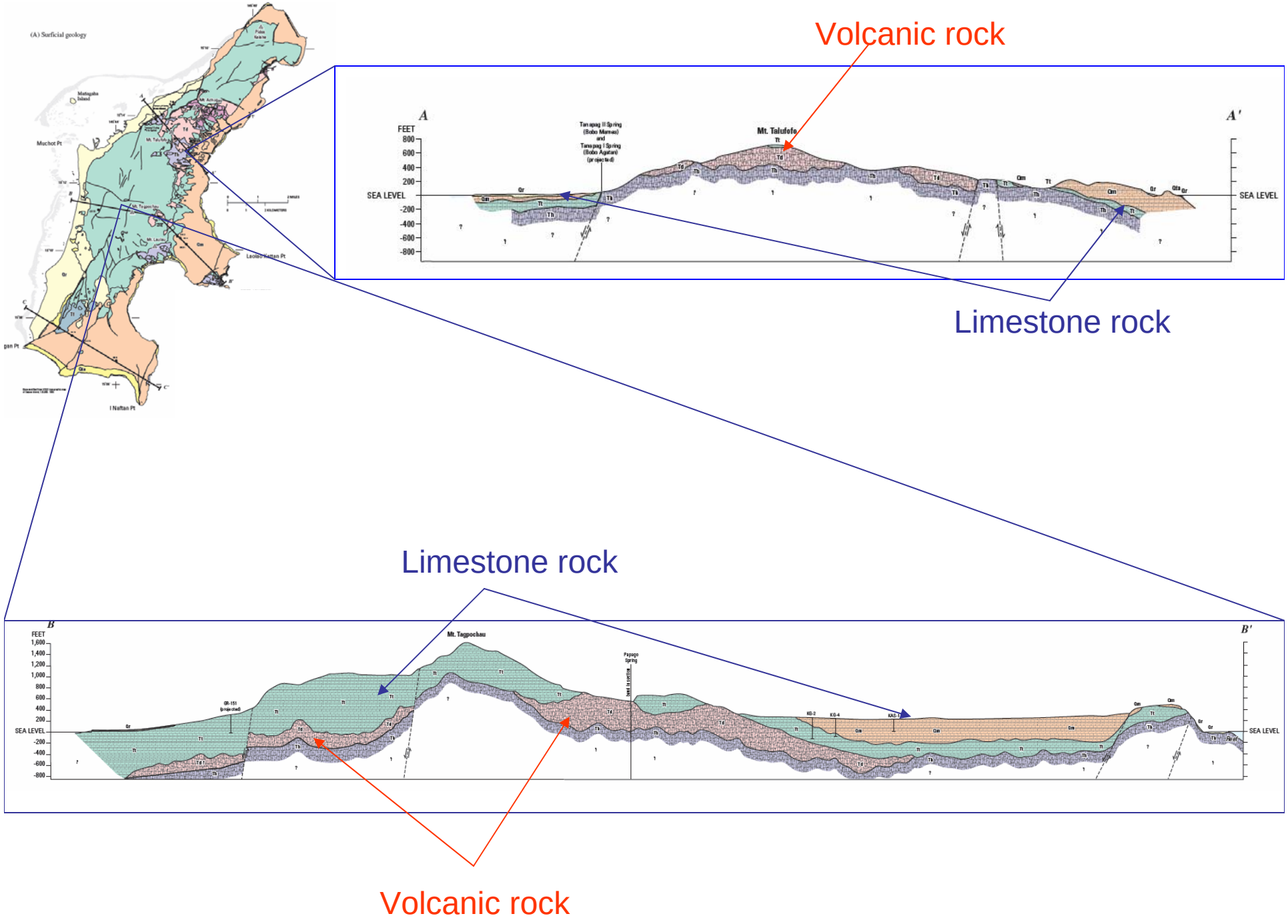
Cross-Section Sketch of Mariana Arc

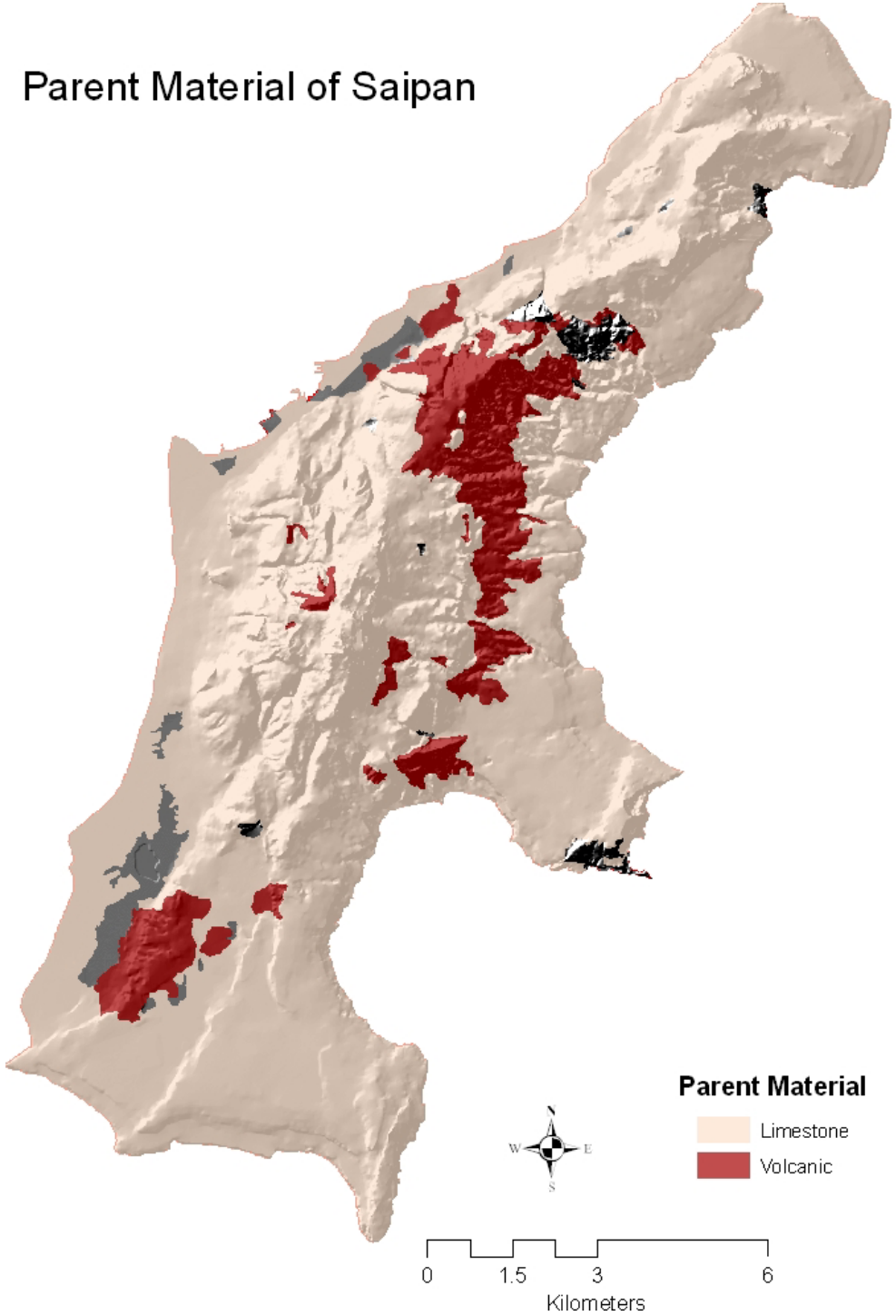
(After Hussong and Fryer, 1981)





- Volcanic base approximately 41 to 13 million years old
- Limestone formed over volcanic base
- Limestone rock covers 90% of the land area


(A) Surficial geology
Matagaha Island
Muchot Pt
Laolao Naftan Pt
I Naftan Pt
A
A'
FEET
800
600
400
200
SEA LEVEL
-200
-400
-600
-800
Tamapag II Spring (Bobo Mamao) and Tamapag I Spring (Bobo Agatan) (projected)
Mt. Talufofo
Tl
Td
Th
Qm
Qr
Qta
SEA LEVEL
Volcanic rock
Limestone rock
Limestone rock
B
B'
FEET
1,600
1,400
1,200
1,000
800
600
400
200
SEA LEVEL
-200
-400
-600
-800
Mt. Tagpochau
Papago Spring
GR-151 (projected)
KG-2
KG-4
KAB-1
Tl
Td
Th
Qm
Qr
SEA LEVEL
Volcanic rock


Parent Material of Saipan
Parent Material
Limestone
Volcanic
W
E
S
0
1.5
3
6
Kilometers


Akina Series
B. Gavenda

Soil Formation on Limestone

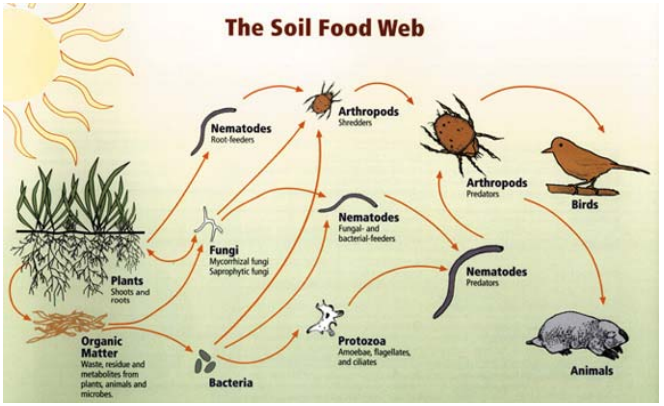
1. Dissolution of $CaCO_3$ limestone, and soil forms from impurities
   - 30-100 ft of limestone to produce 1 ft of soil
2. Deposition of dust blown from Asian deserts, and soils form from weathering of the dust


B. Gavenda

5 Functions of Soil

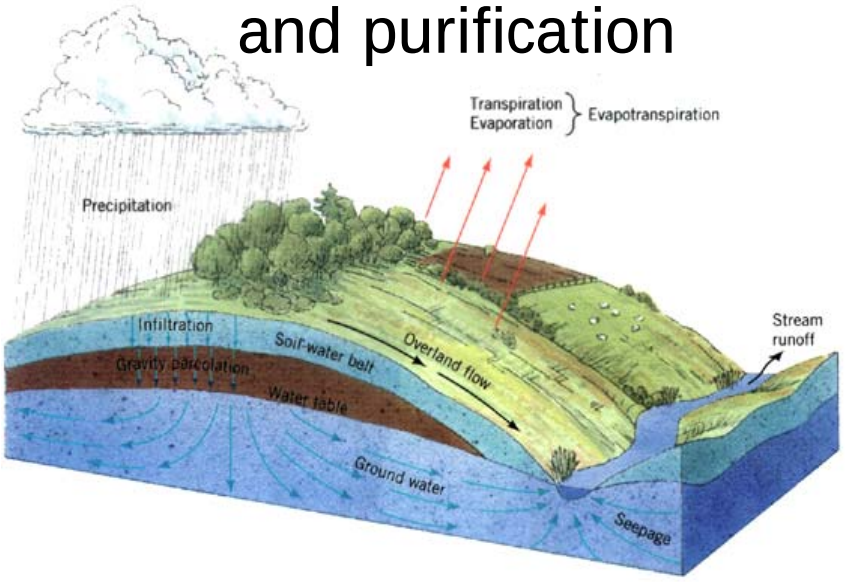
Medium for Plant growth

Habitat for Soil organisms



Recycling system

Water supply and purification

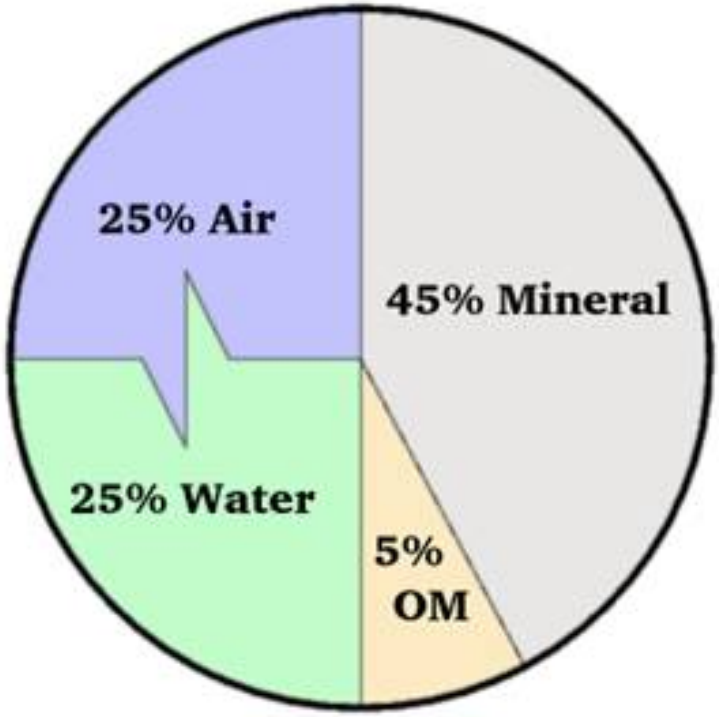


Engineering Medium

- Animal health begins with good nutrition
- Grasses and other plants are the source of nutrients
- Soils supply nutrients and store water for plant growth

Soil Composition

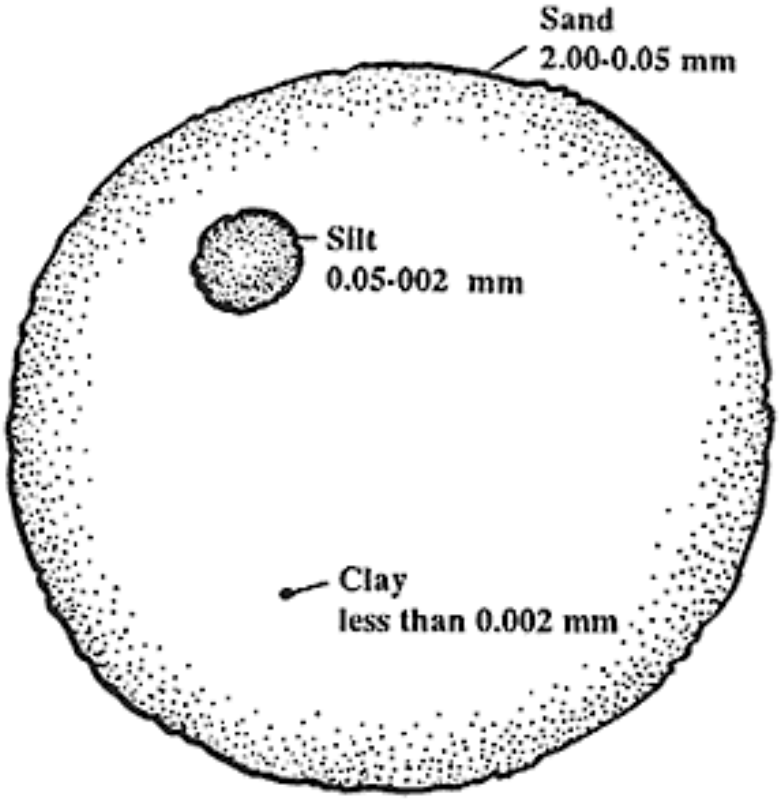

Inarajan soil

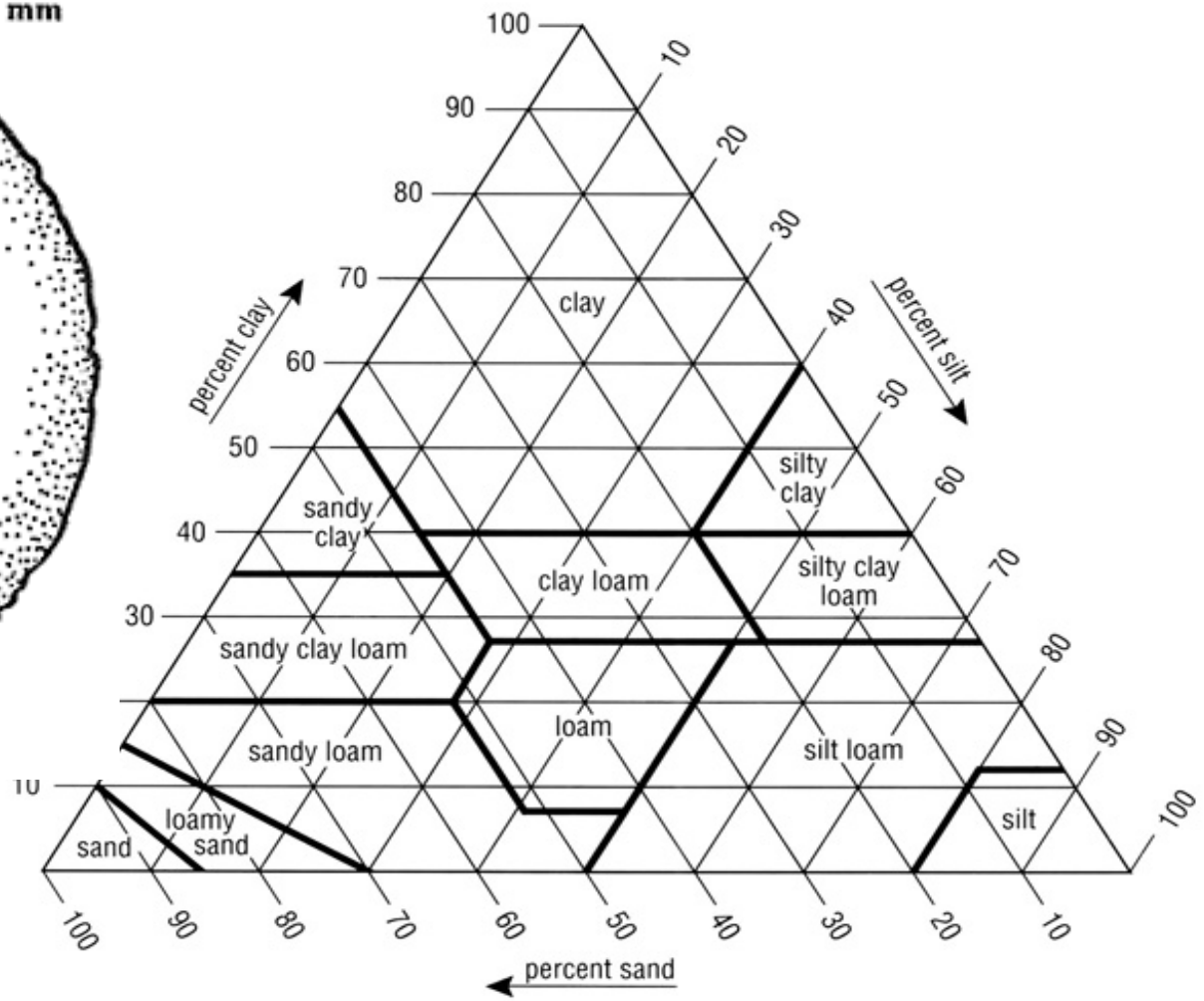



Akina soil

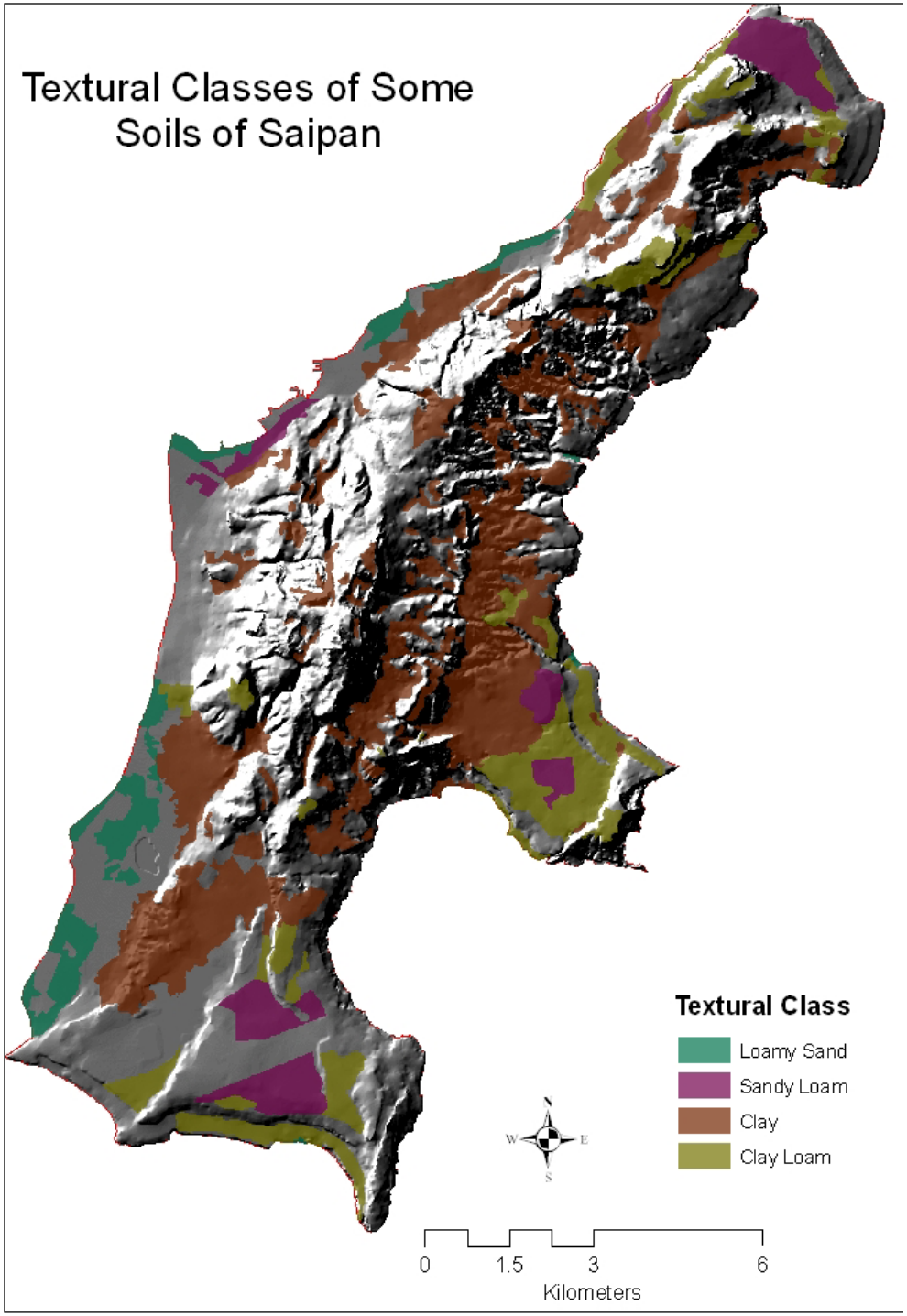
Photos: B. Gavenda

Soil Texture



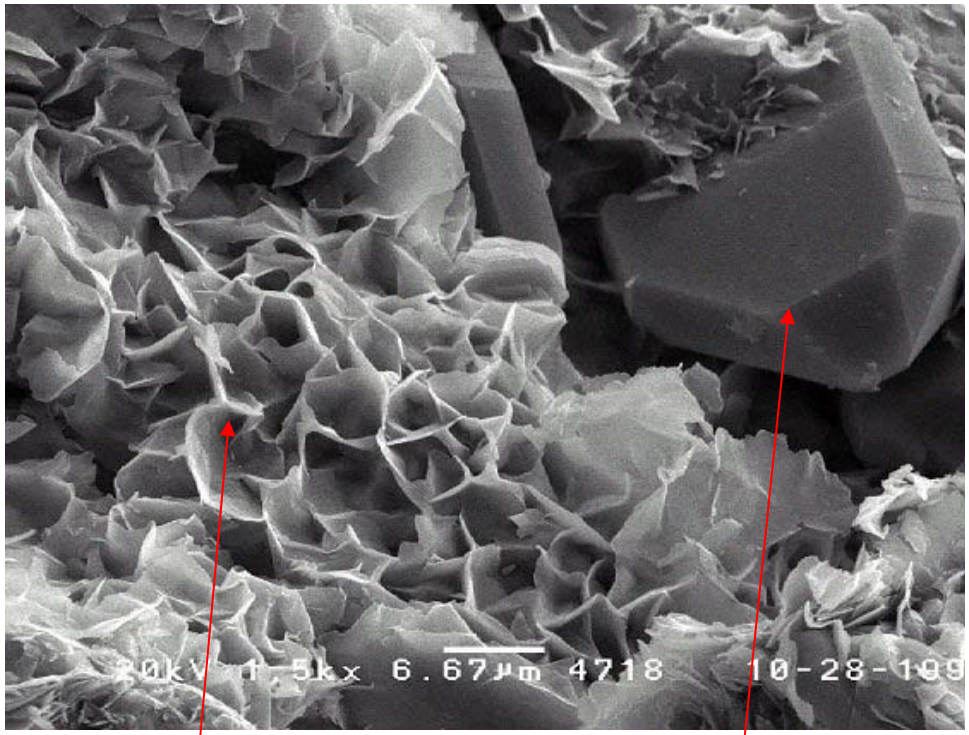


Soil Series	Textural Class
Banaderu	Clay Loam
Chacha	Clay
Chinen	Clay Loam
Chinen	Sandy Loam
Inarajan	Clay
Kagman	Clay
Laolao	Clay
Saipan	Clay
Shioya	Loamy Sand



Properties and Importance of Clay

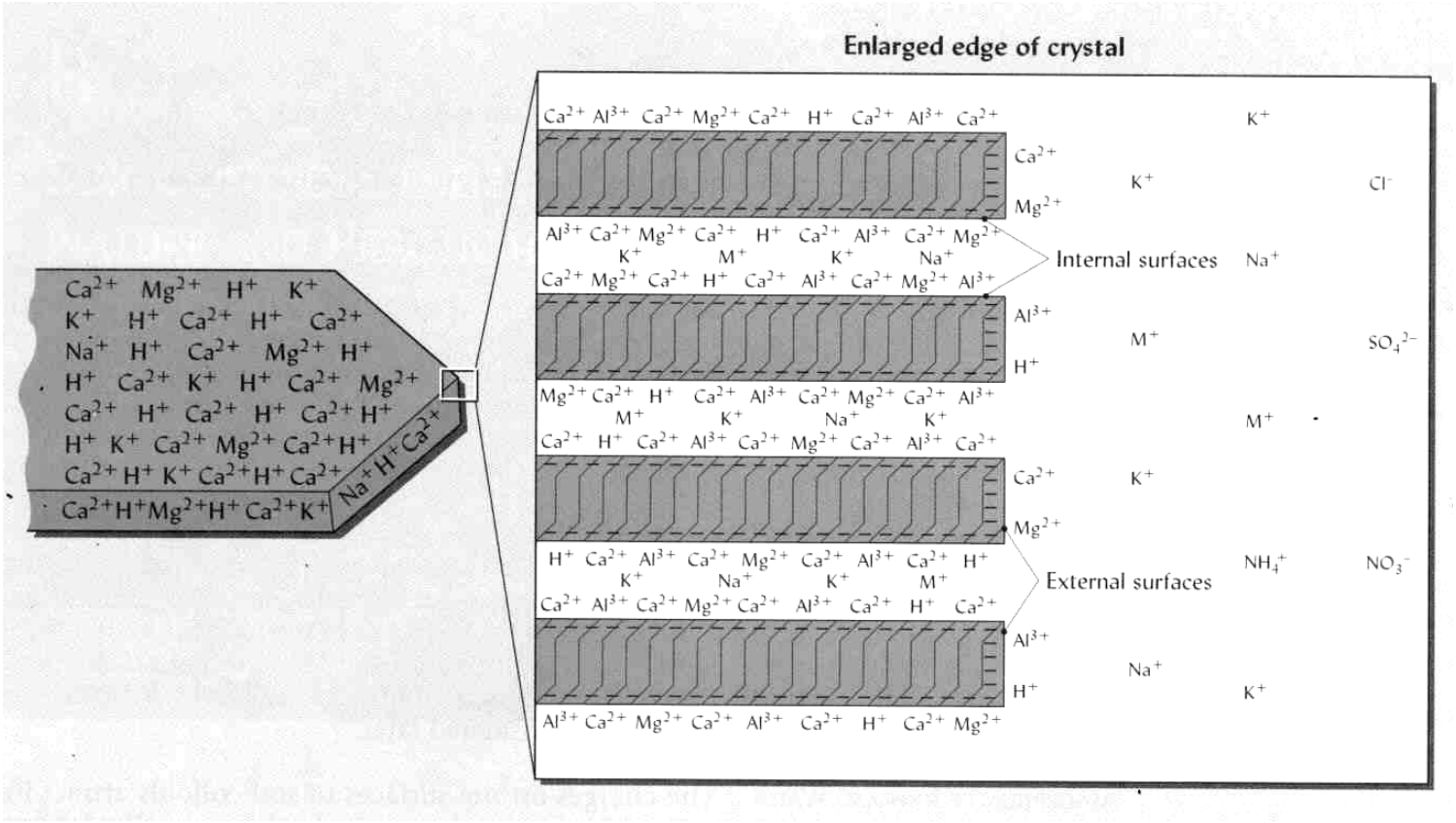
- Properties
  - High surface area
    - 1 gram = 10 to 800 m^2
  - Charged surfaces
    - Usually negatively charged, but highly weathered oxide clays can have + charge
- Importance
  - High water holding capacity
  - High nutrient retention capacity (cation exchange capacity, CEC)



Clay Type is Important

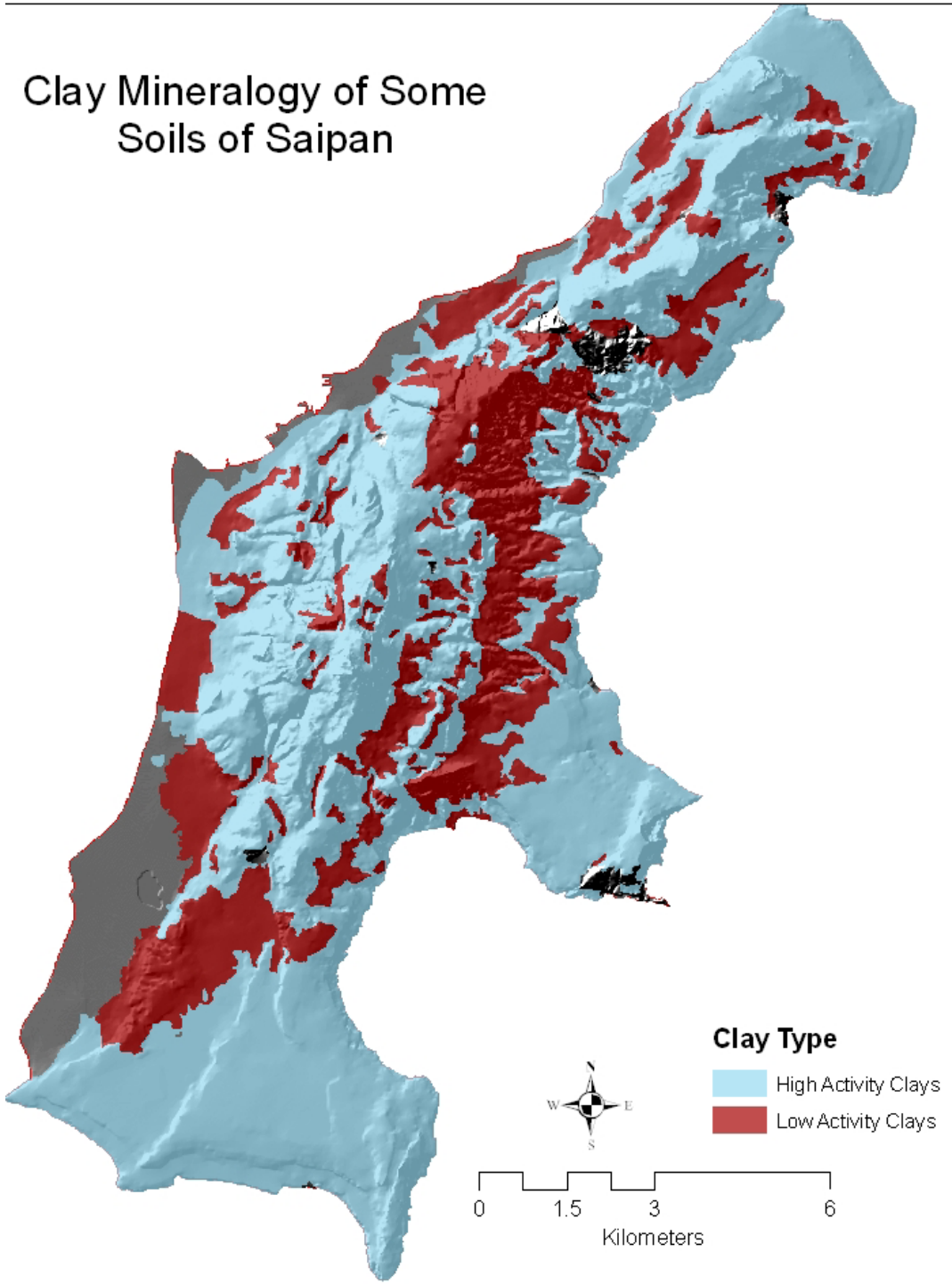
- Montmorillonite (high activity clay)
  - Shrink-swell clay (unstable)
  - High fertility clay (high cation exchange capacity)
- Kaolinite (low activity clay)
  - Non-expanding clay (stable)
  - Low fertility clay (low cation exchange capacity)
- Fe & Al oxides (low activity clay)
  - Goethite, gibbsite
  - Non-expanding clay (stable)
  - Very low fertility (no cation exchange capacity)

Cation Exchange Capacity (CEC)



Negatively charged sites that adsorb cations:

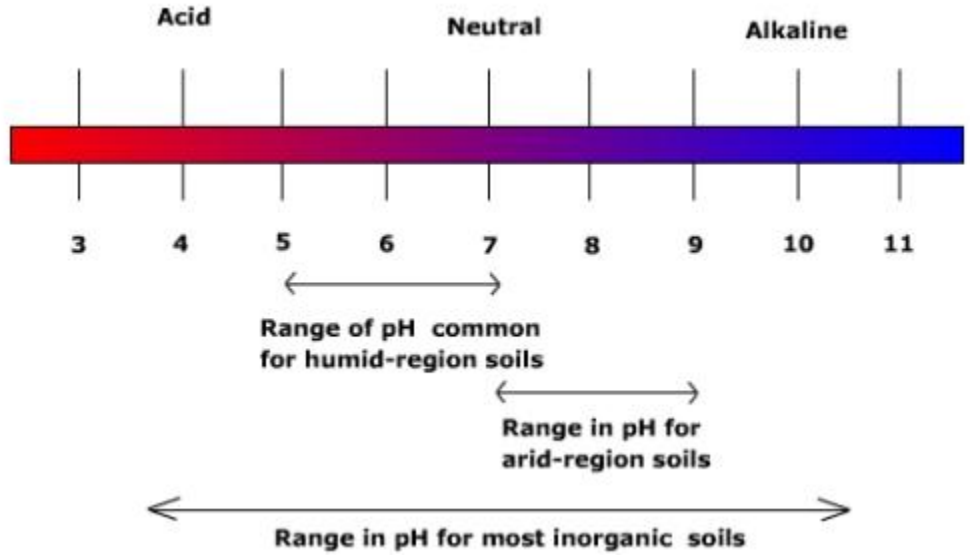
Ca^{2+}, Mg^{2+}, K^{+}, NH^{4+}



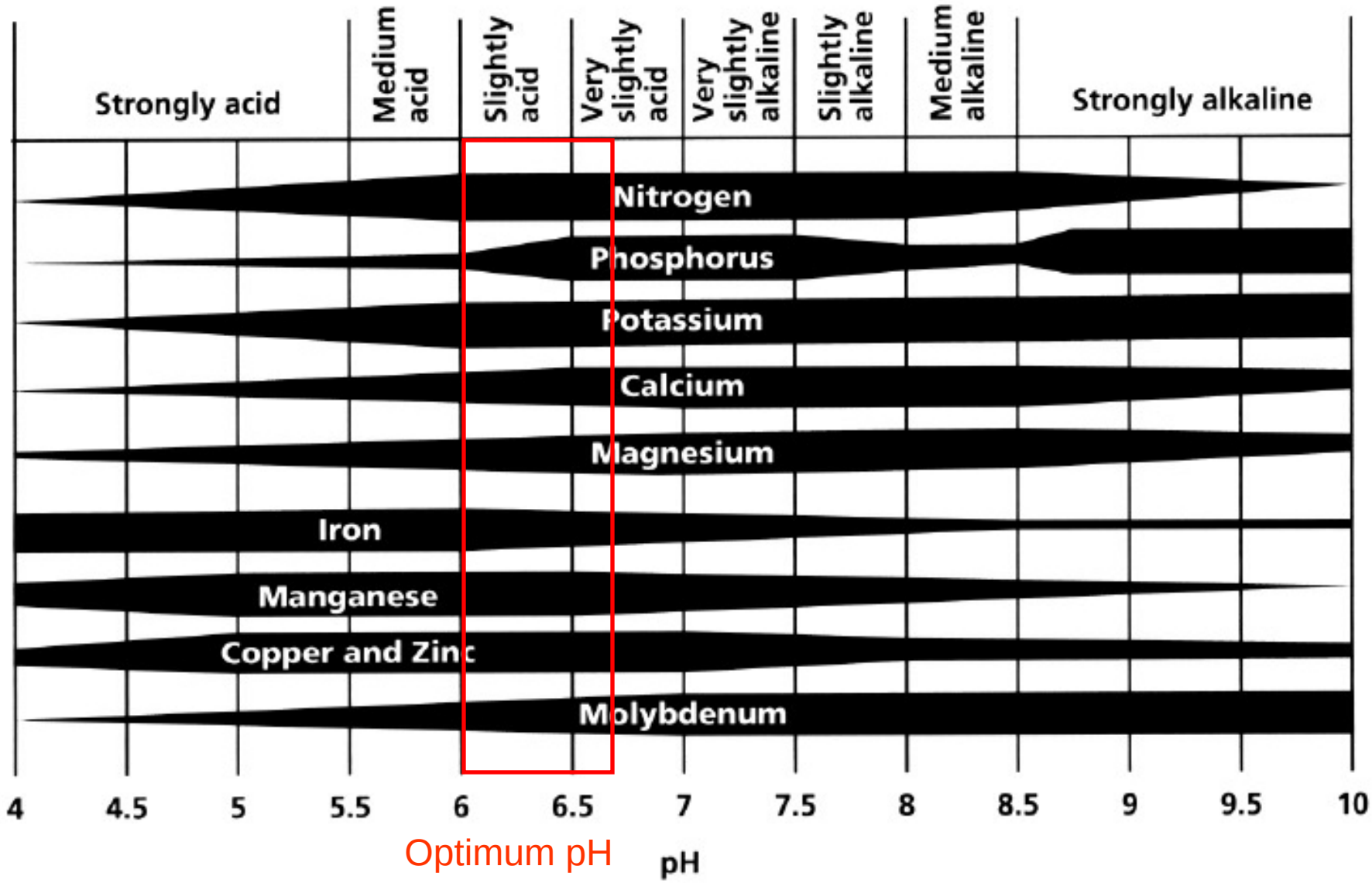
- High activity clay soils are usually rich in base cations (Ca, Mg, K)
- Low activity clay soils are often deficient in base cations and P

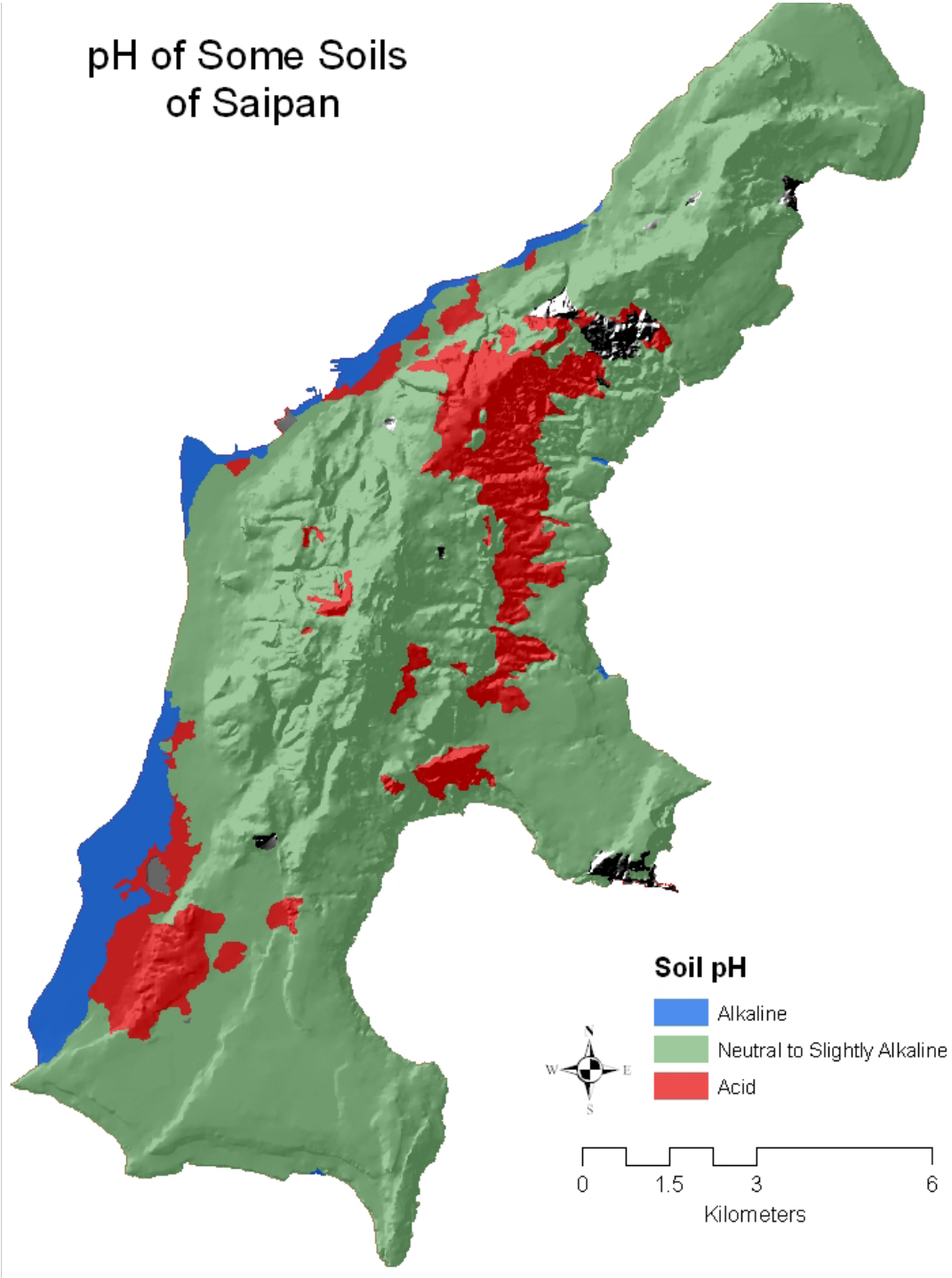
The pH Scale


Hydrochloric acid
Lemon
Apple
Banana
Water
Baking soda
Ammonia
Drain cleaner
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Most acidic
Most basic
Vinegar
Tomato
Milk
Blood
Soap

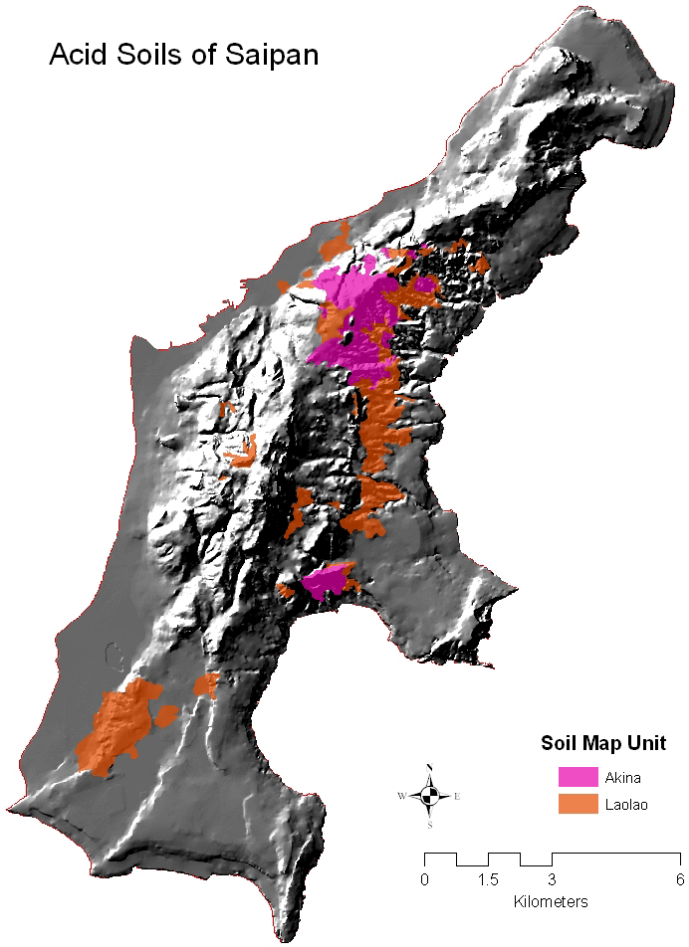

Acid
Neutral
Alkaline
3
4
5
6
7
8
9
10
11
Range of pH common for humid-region soils
Range in pH for arid-region soils
Range in pH for most inorganic soils

Soil Acidity and Nutrient Availability





- Soils developed on limestone parent material are neutral to alkaline
- Soils developed on volcanic parent material are acid

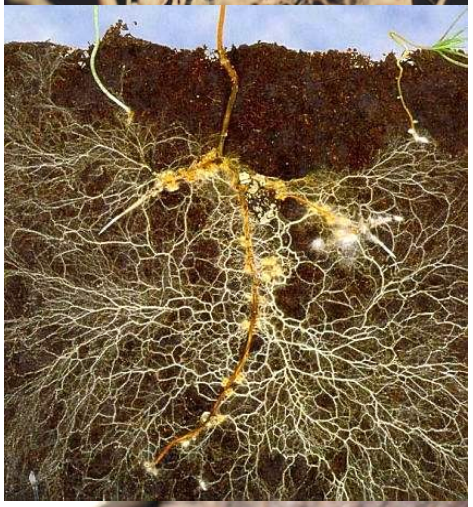


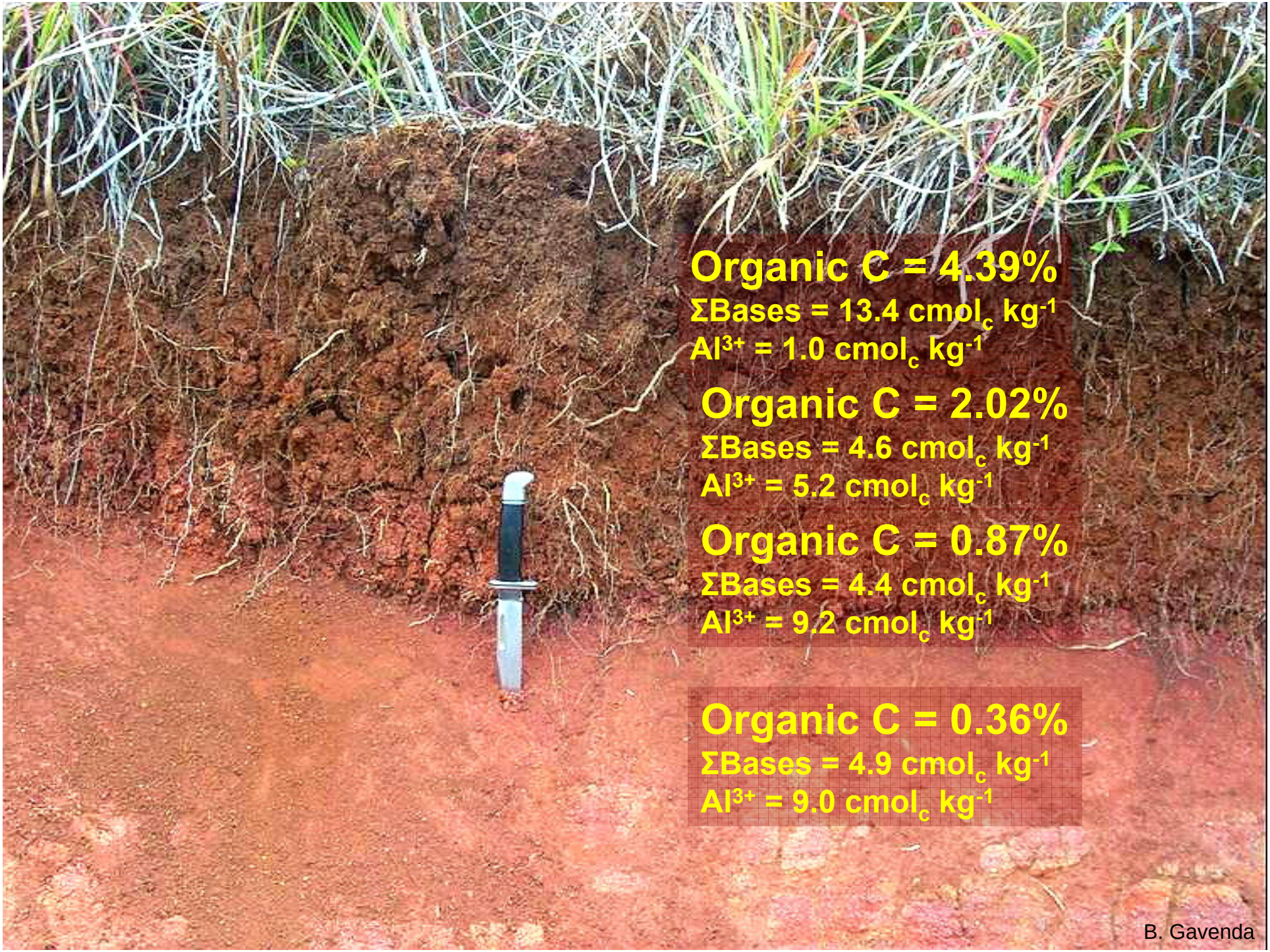
Some chemical properties of the Akina series

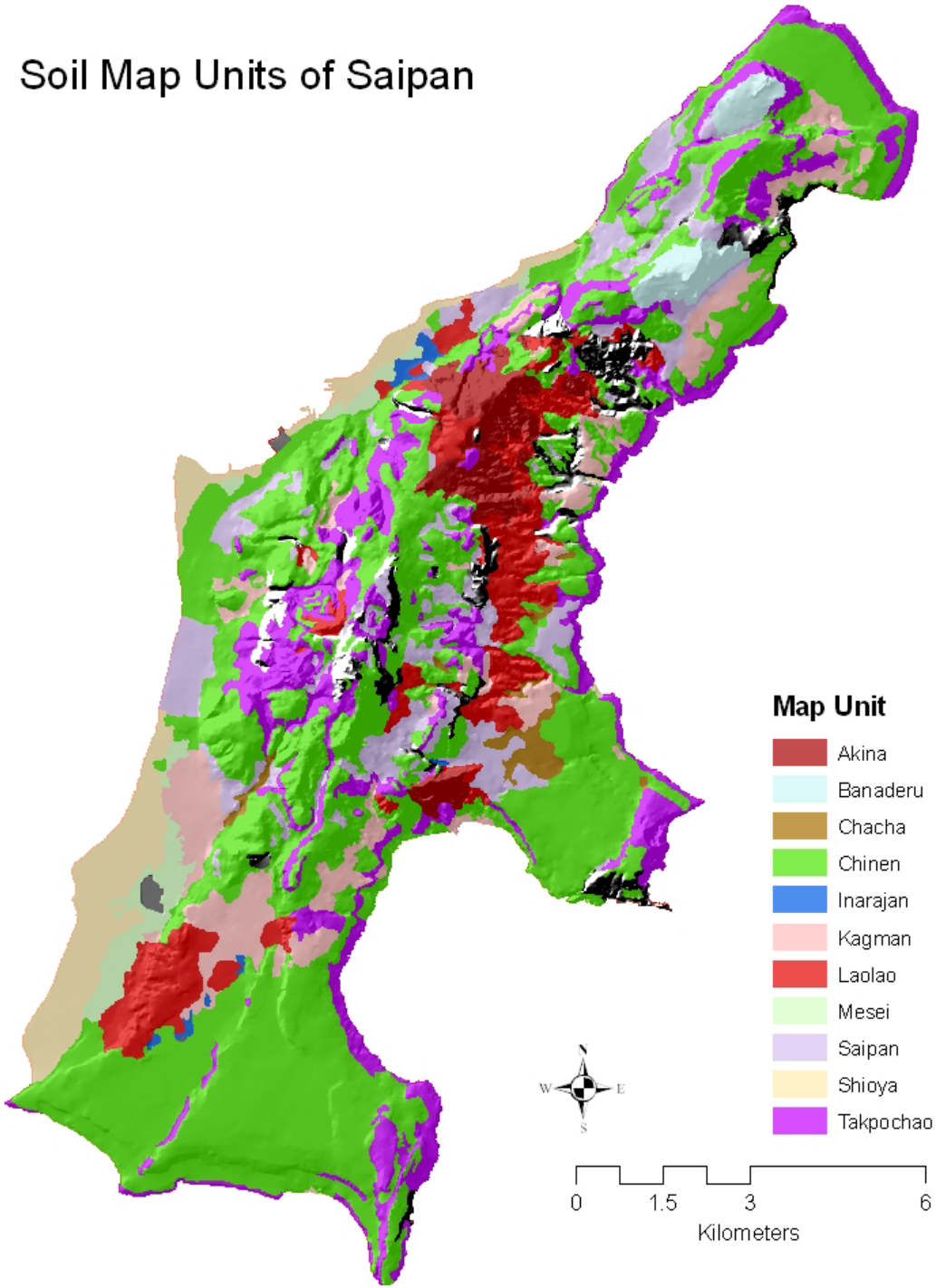
Depth (cm)	OM	pH	CEC	$Base_{sat}$	Al_{sat}
	%		$cmol_c\ kg^{-1}$	%	
0-10	5	5.0	12.4	85	15
20-10	2.8	4.9	8.4	49	51

Role of Organic Matter in Soil

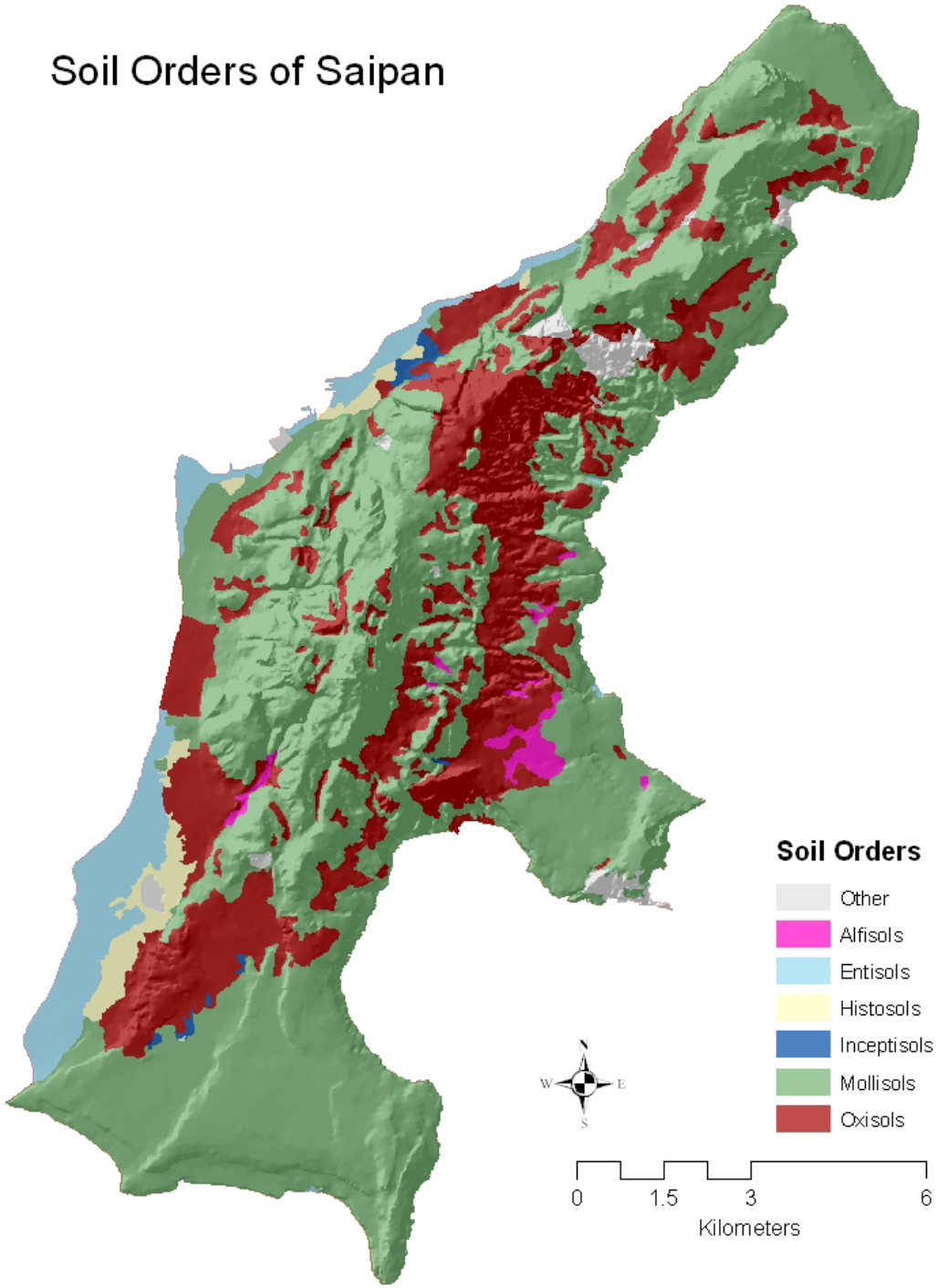
- **Physical**
  - Improves soil structure
  - Increases water retention
- **Chemical**
  - Increases nutrient availability (N & P cycling, solubility)
  - Increases nutrient retention (CEC)
  - Detoxifies Al
- **Biological**
  - Increases microbial diversity
  - N fixation (rhizobia), P availability (myccorhiza)
  - Increases pathogen suppression

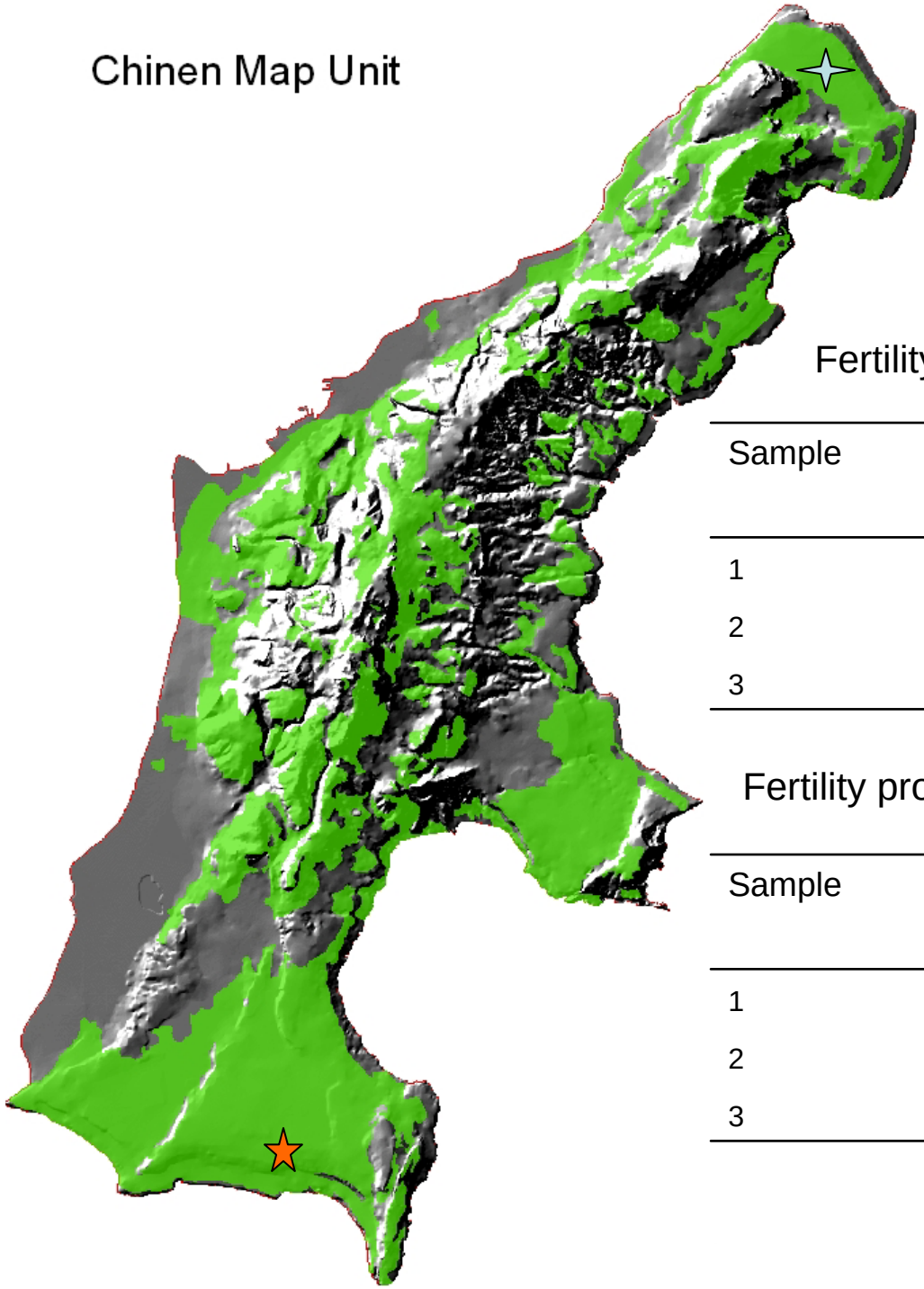



Organic C = 4.39%
ΣBases = 13.4 $cmol_c$ kg^{-1}
Al^{3+} = 1.0 $cmol_c$ kg^{-1}
Organic C = 2.02%
ΣBases = 4.6 $cmol_c$ kg^{-1}
Al^{3+} = 5.2 $cmol_c$ kg^{-1}
Organic C = 0.87%
ΣBases = 4.4 $cmol_c$ kg^{-1}
Al^{3+} = 9.2 $cmol_c$ kg^{-1}
Organic C = 0.36%
ΣBases = 4.9 $cmol_c$ kg^{-1}
Al^{3+} = 9.0 $cmol_c$ kg^{-1}
B. Gavenda



- 35 map units on the soil survey
- Map unit name provides no information on soil properties
- Soil Taxonomy is a classification system used to group soils based on measurable properties


Soil Orders of Saipan
Soil Orders
Other
Alfisols
Entisols
Histosols
Inceptisols
Mollisols
Oxisols
W
E
S
0
1.5
3
6
Kilometers

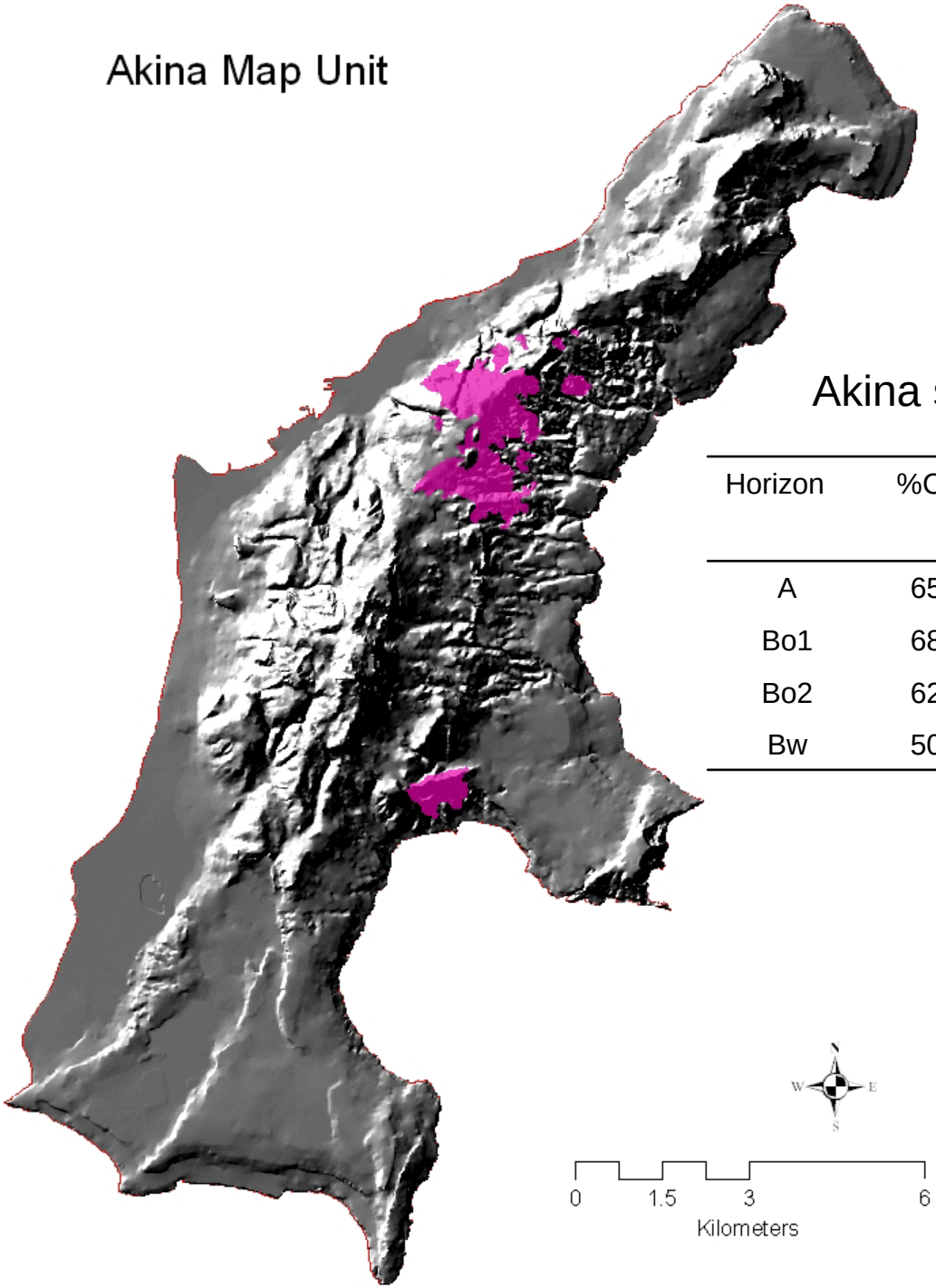


Fertility properties of surface soils at Banaderu (☆)

Sample	pH	%N	% C	P	Ca	Mg	K
				----------ppm----------			
1	7.7	0.56	16.2	50	7714	332	190
2	7.8	0.74	17.2	54	8482	334	188
3	7.8	0.57	15.7	64	7726	284	78

Fertility properties of surface soils at I Fadang (★)

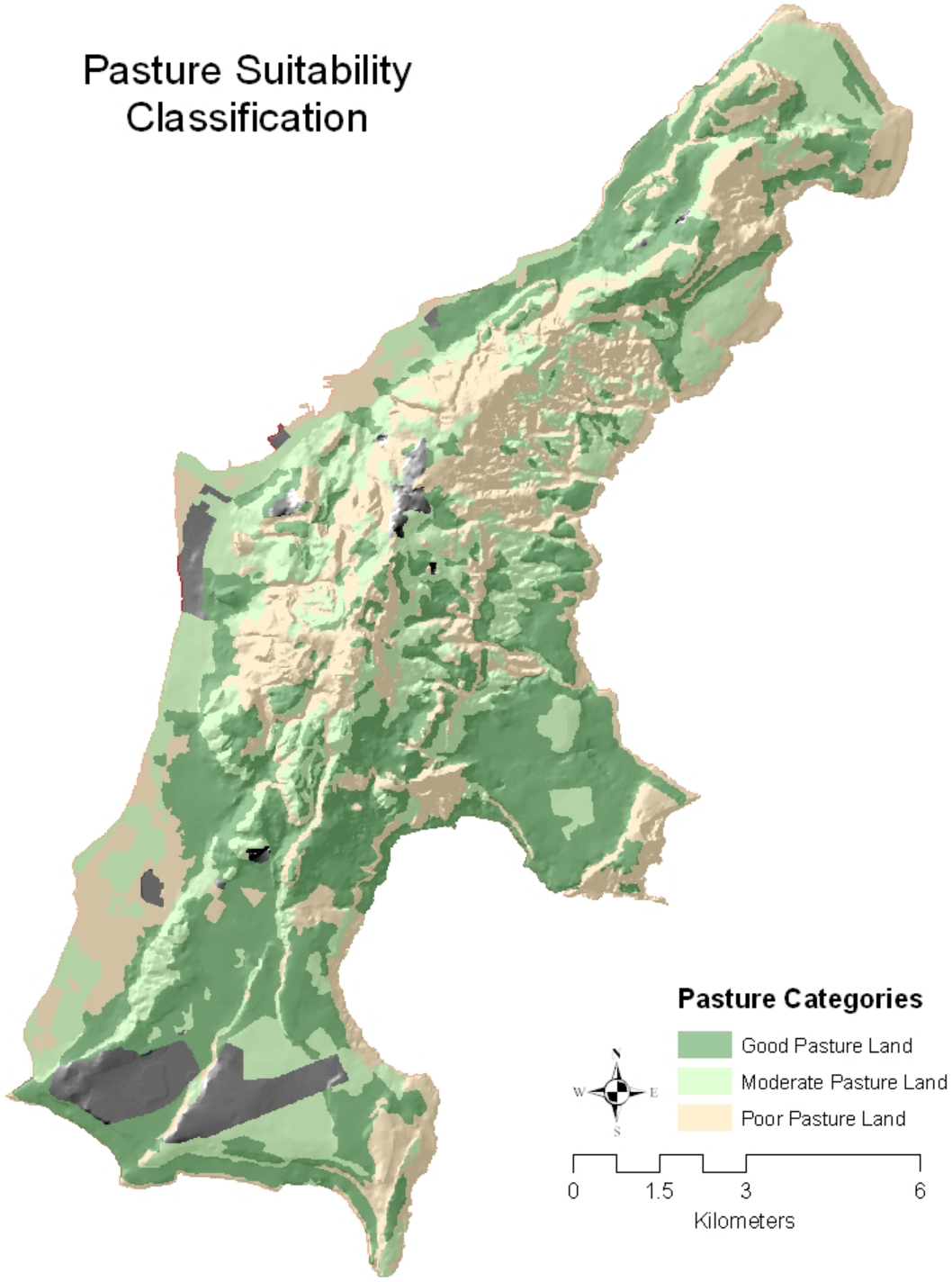
Sample	pH	%N	% C	P	Ca	Mg	K
				----------ppm----------			
1	7.7	0.84	13.8	56	10944	344	130
2	7.1	0.55	5.4	50	7026	596	646
3	7.4	0.56	5.8	40	6750	628	228

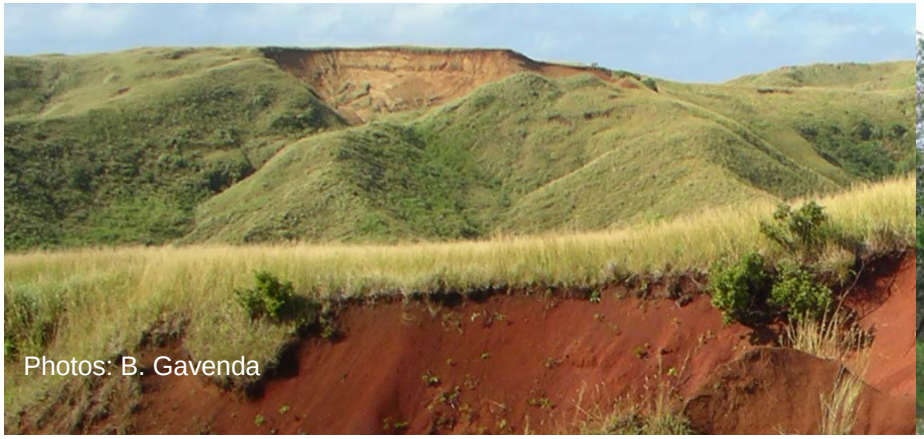


Akina series (Oxisol)

Horizon	%Clay	pH	% C	Ca	Mg	Na	K
					$cmol_c\ kg^{-1}$		
A	65.5	5.0	5.04	3.4	6.6	tr	0.5
Bo1	68.9	4.9	2.81	1.4	2.7	tr	tr
Bo2	62.1	5.0	1.53	1.1	2.6	tr	--
Bw	50.5	5.1	0.63	1.0	2.8	tr	--

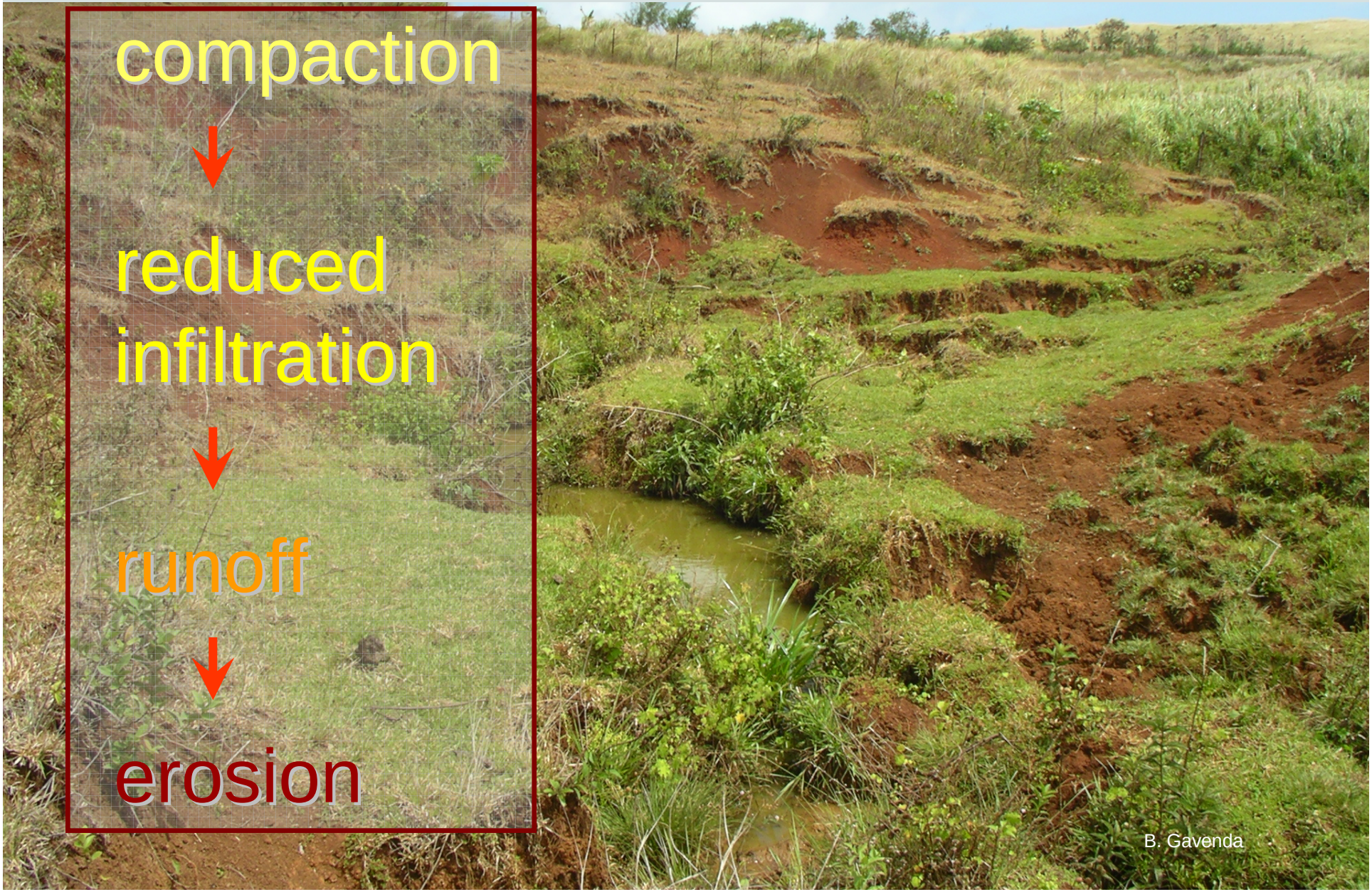
Pasture Suitability Classification





Suitability Class	Soil Series	Limitations
Good	Banaderu, Chacha, Kagman, Laolao, Saipan	steepness of slope, erosion hazard, compaction
Moderate	Chinen, Inarajan, Shioya	droughtiness on shallow soils, steepness of slope, compaction,
Poor	Akina, Takpochao, Mesei	Erosion hazard, low fertility, high water table, flooding, soil compaction

Grazing Management and Soil Quality



Grazing Management and Soil Quality


Soils are non-renewable!