Solos e a Zona Crítica

AGG 0201 Geoquímica de Ambientes Superficiais

Profa. Andréa Teixeira Ustra

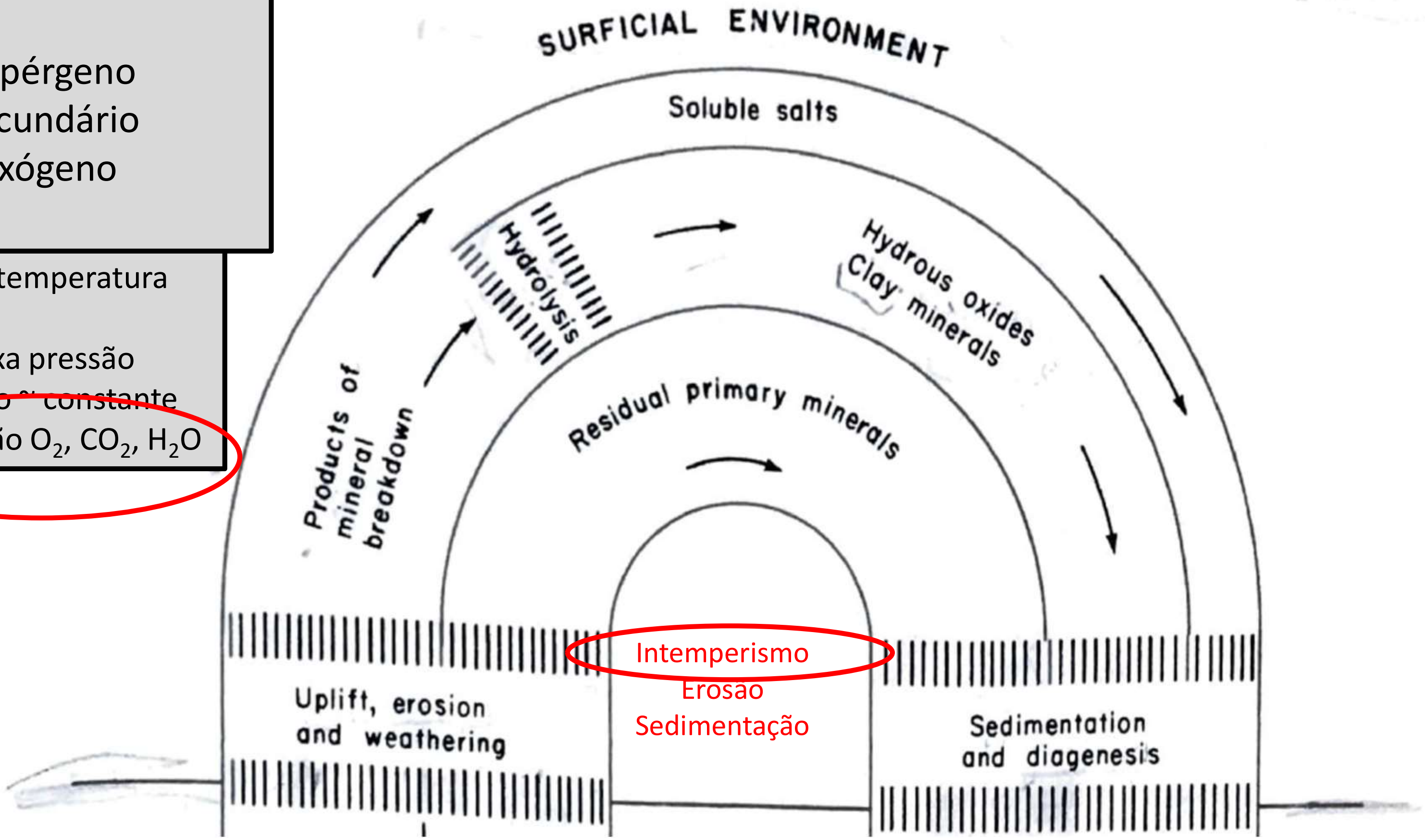
Na aula passada

Ambiente superficial

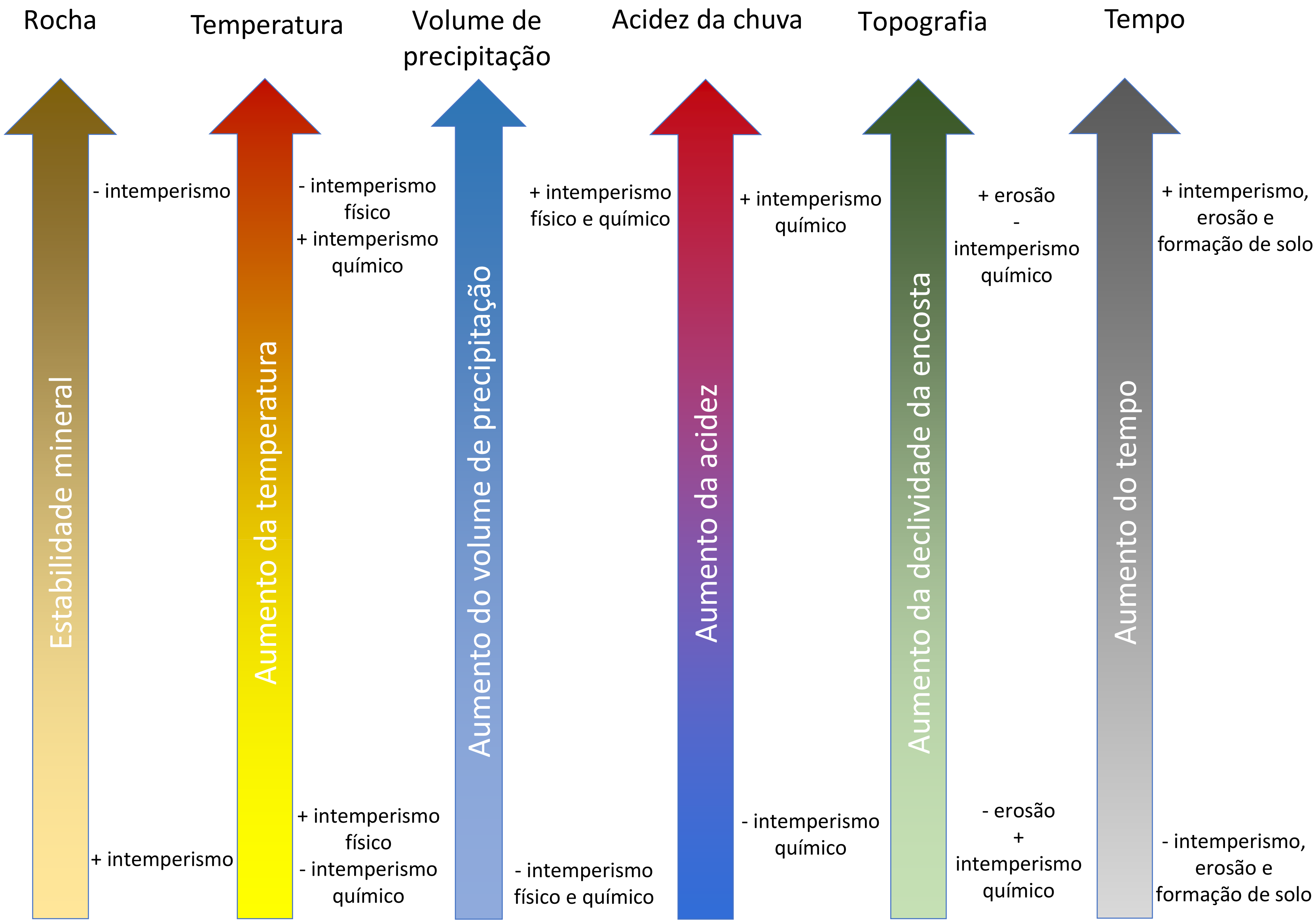
Supérgeno
Secundário
Exógeno

Baixa temperatura

Baixa pressão
Pressão ≈ constante
Circulação O_2, CO_2, H_2O



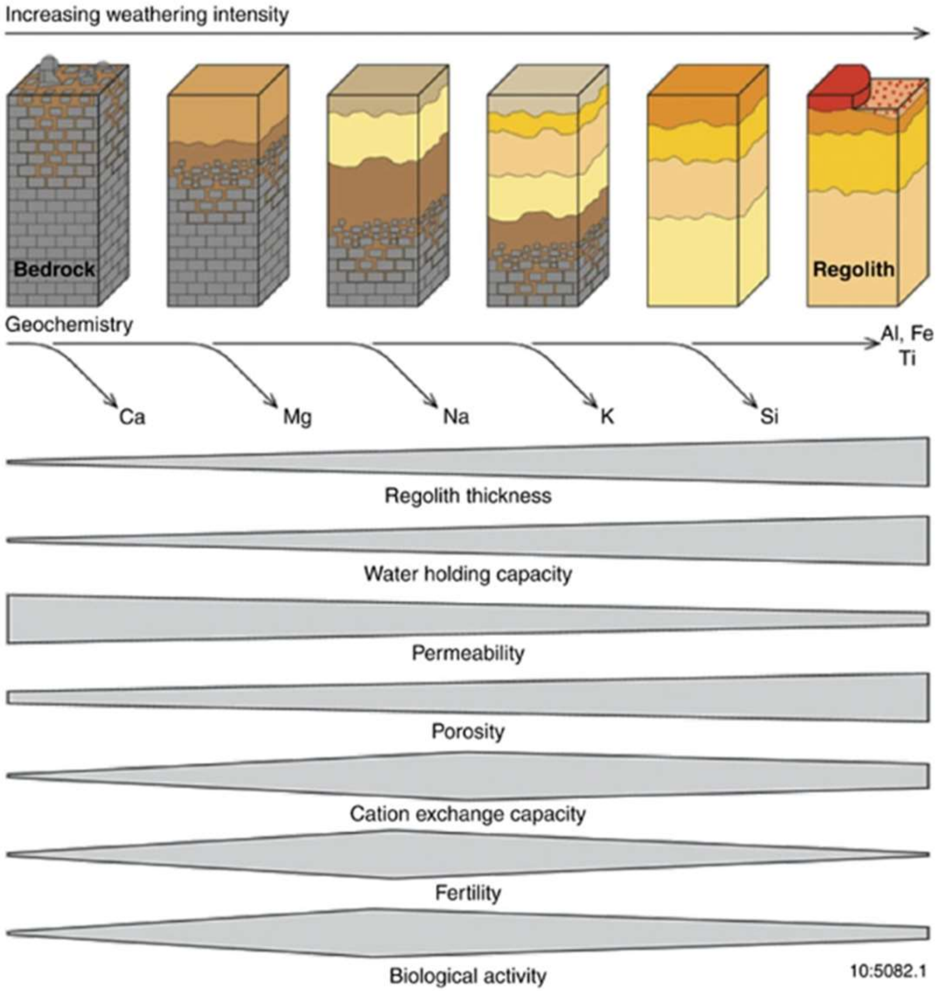
Fatores que influenciam o intemperismo e a erosão



Intemperismo

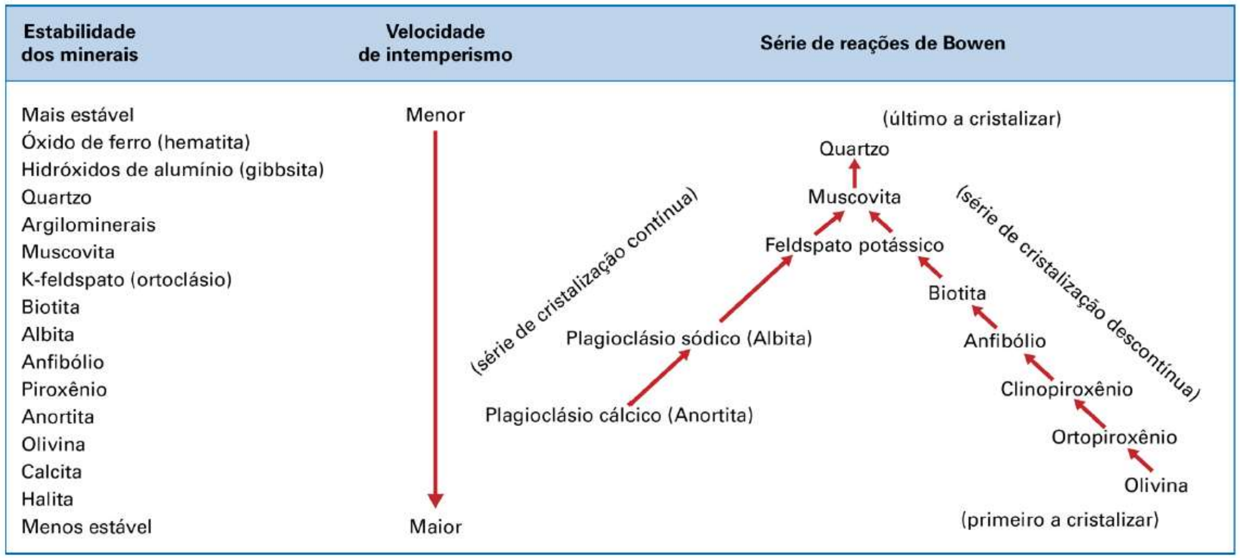
Modifica a crosta Terrestre em resposta as condições atmosféricas, hidrológicas e bióticas

- Formação dos solos
- Qualidade das águas
- Condicionamento de ecosistemas
- Regulador climático e ambiental
- Formador de recursos minerais

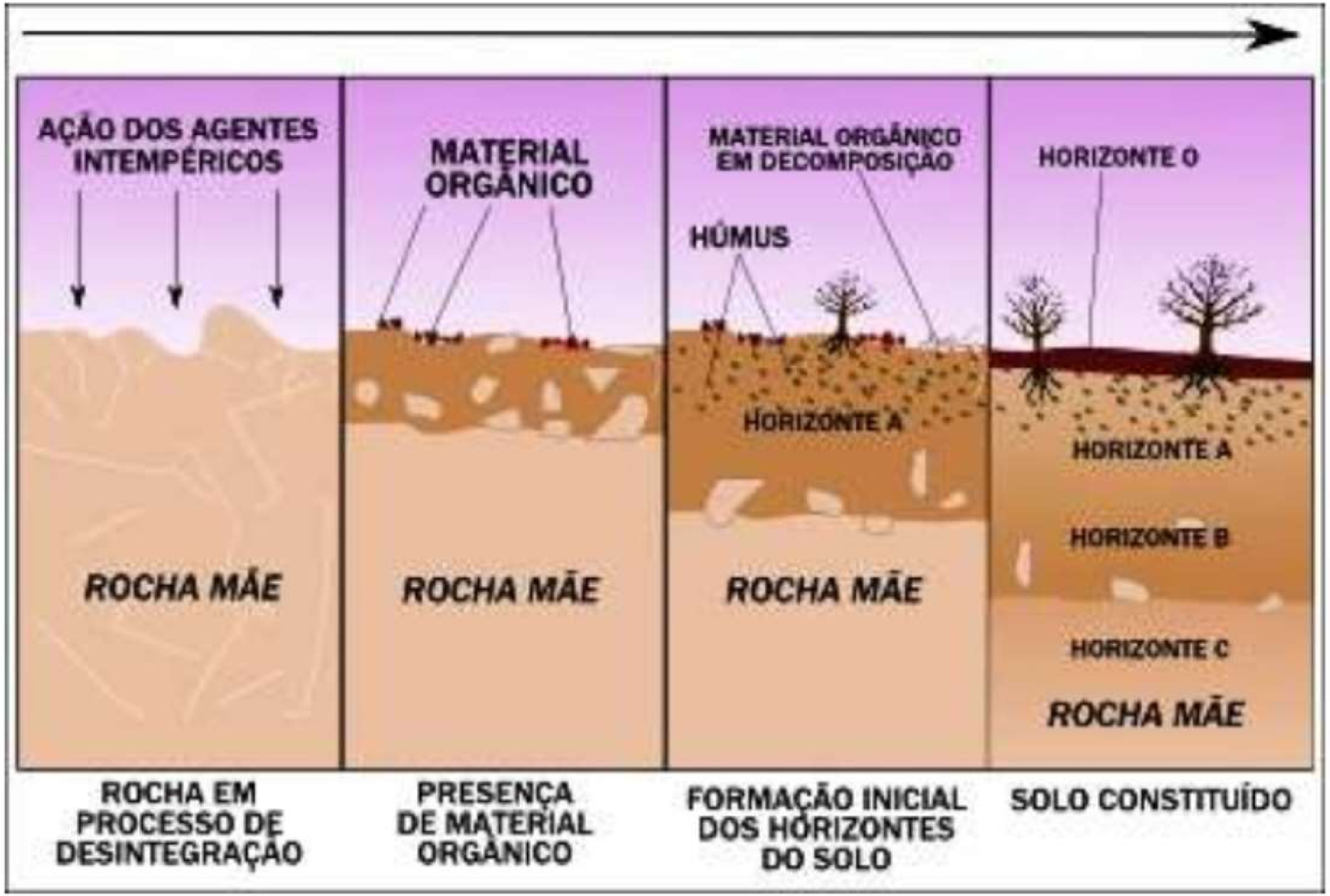


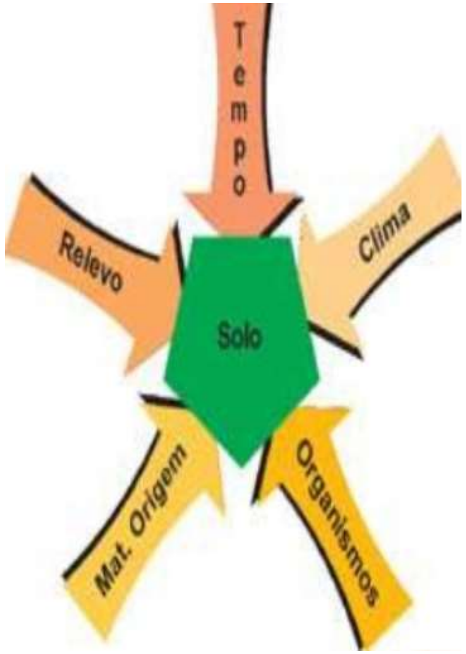
Evolução no tempo

O intemperismo é um processo que progride essencialmente de cima para baixo



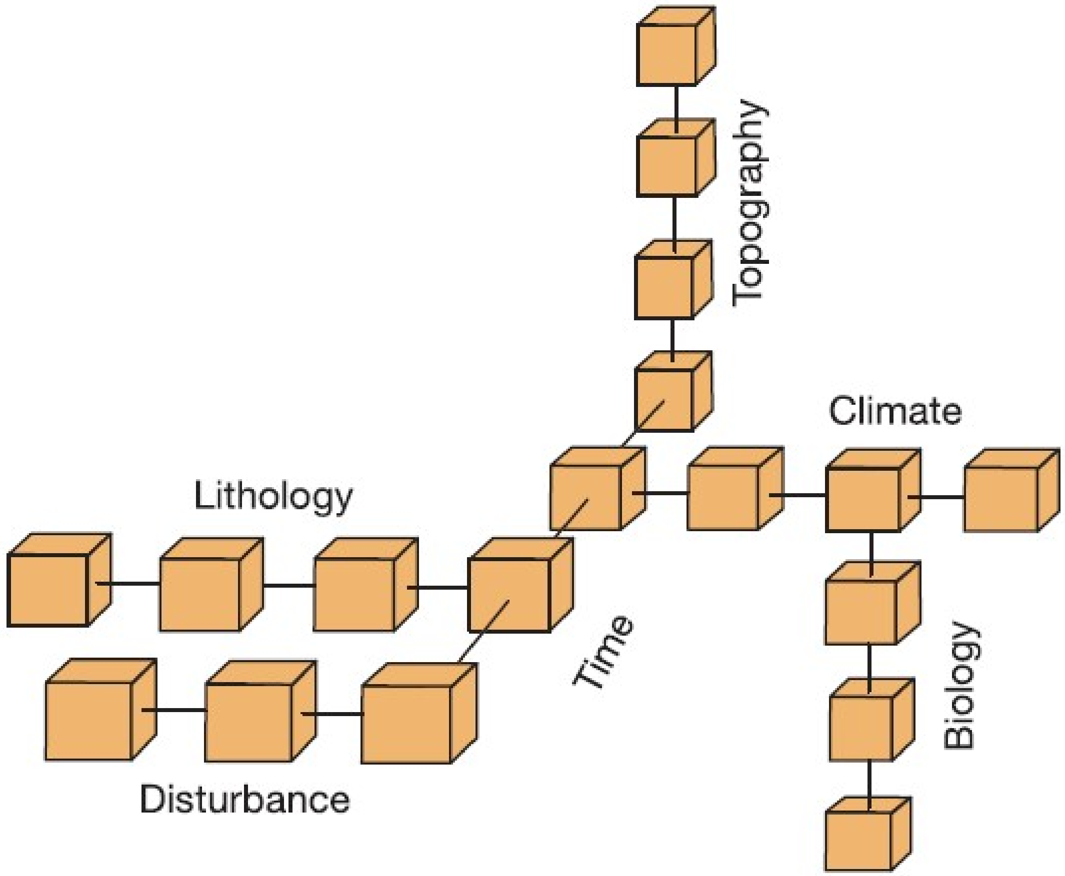
Modelo conceitual do desenvolvimento de solos





Keny (1941) –
Definição de solos

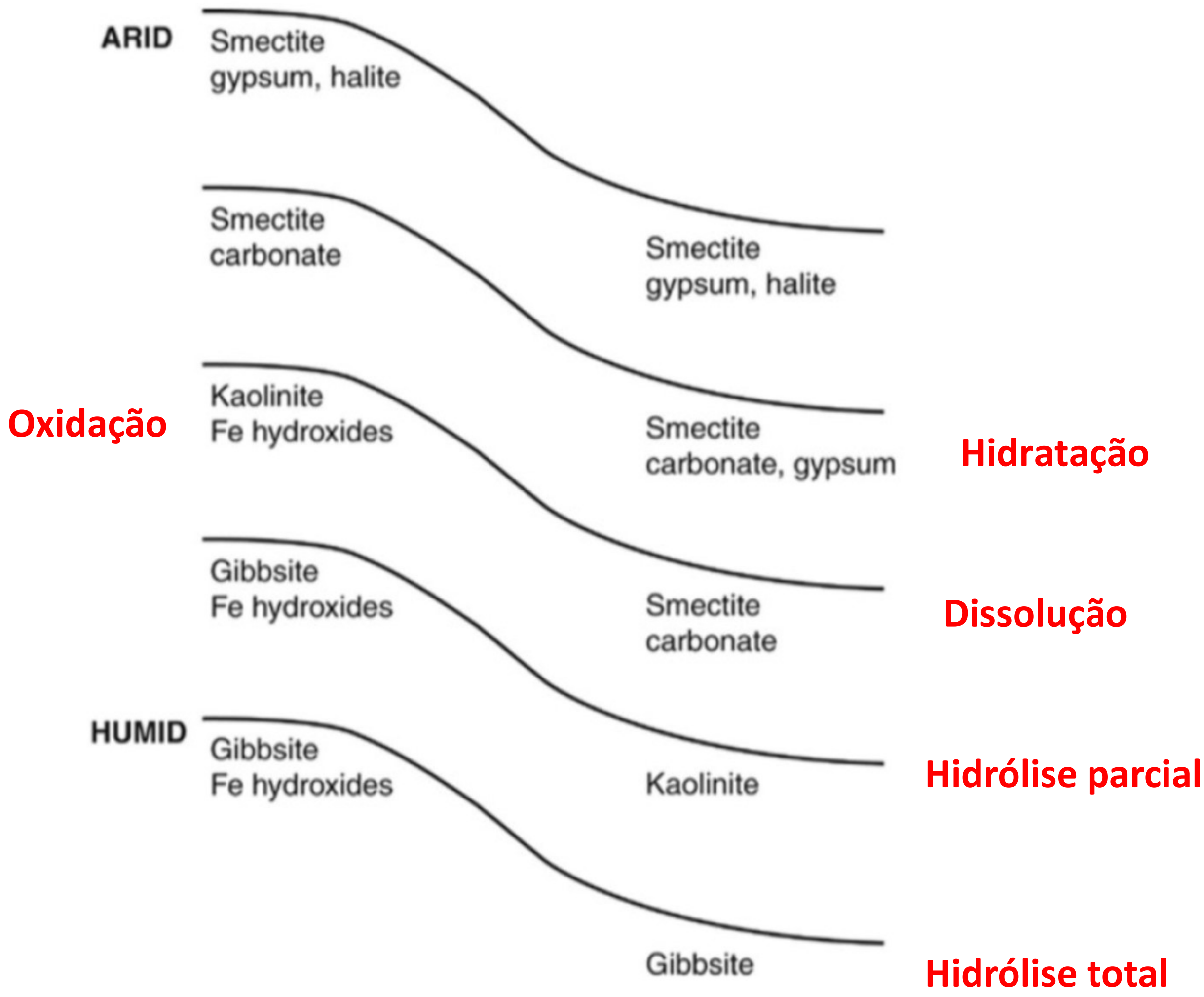
“Sistemas que trocam massa e energia com o entorno”



Solos/ecosistemas = *f* (estado inicial do sistema, ambiente local, tempo) Fatores

= *f* (clima, organismos, topografia, material parental, tempo…) Processos

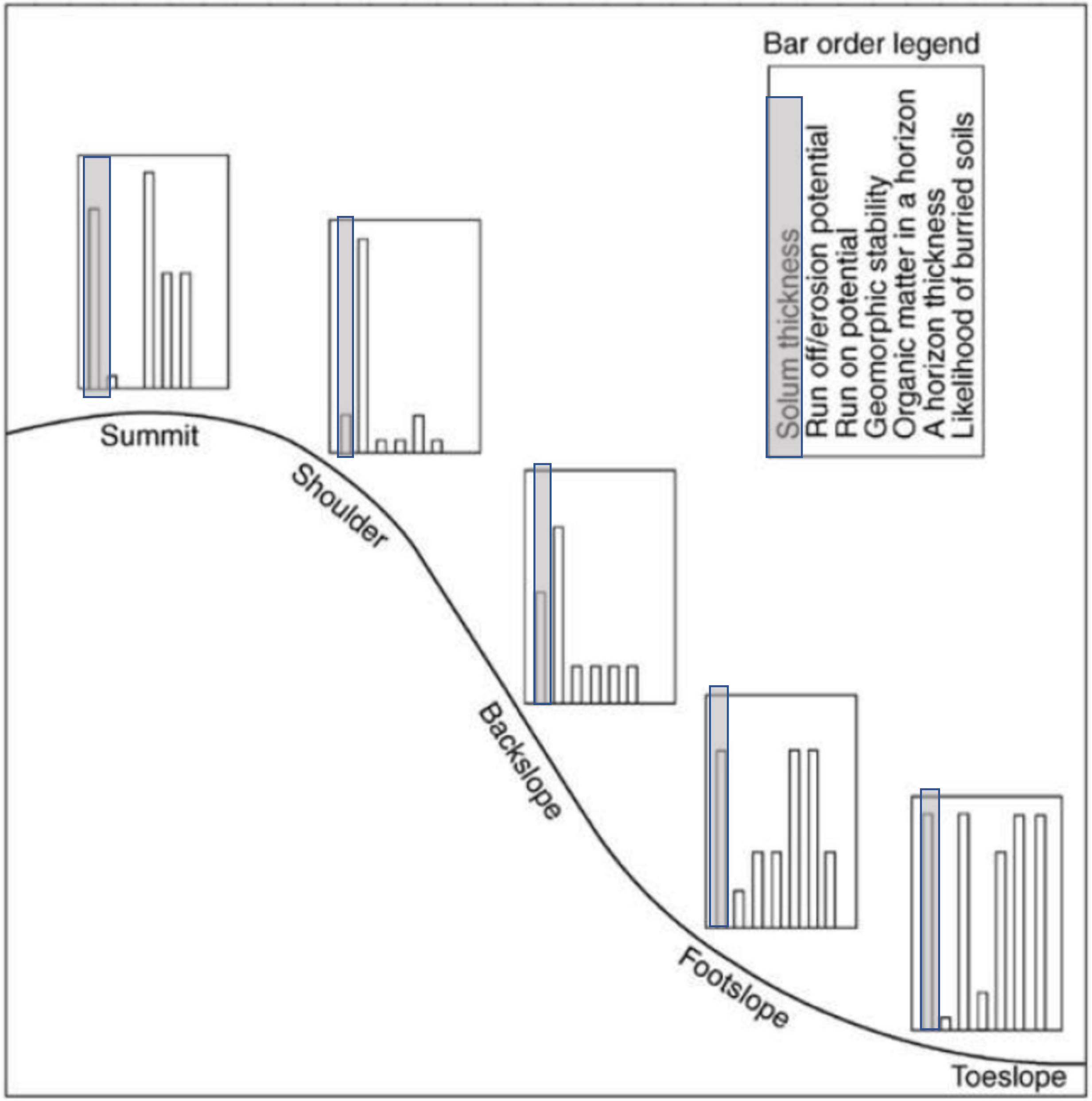
Clima e topografia



Topografia

Catena

Clima húmido



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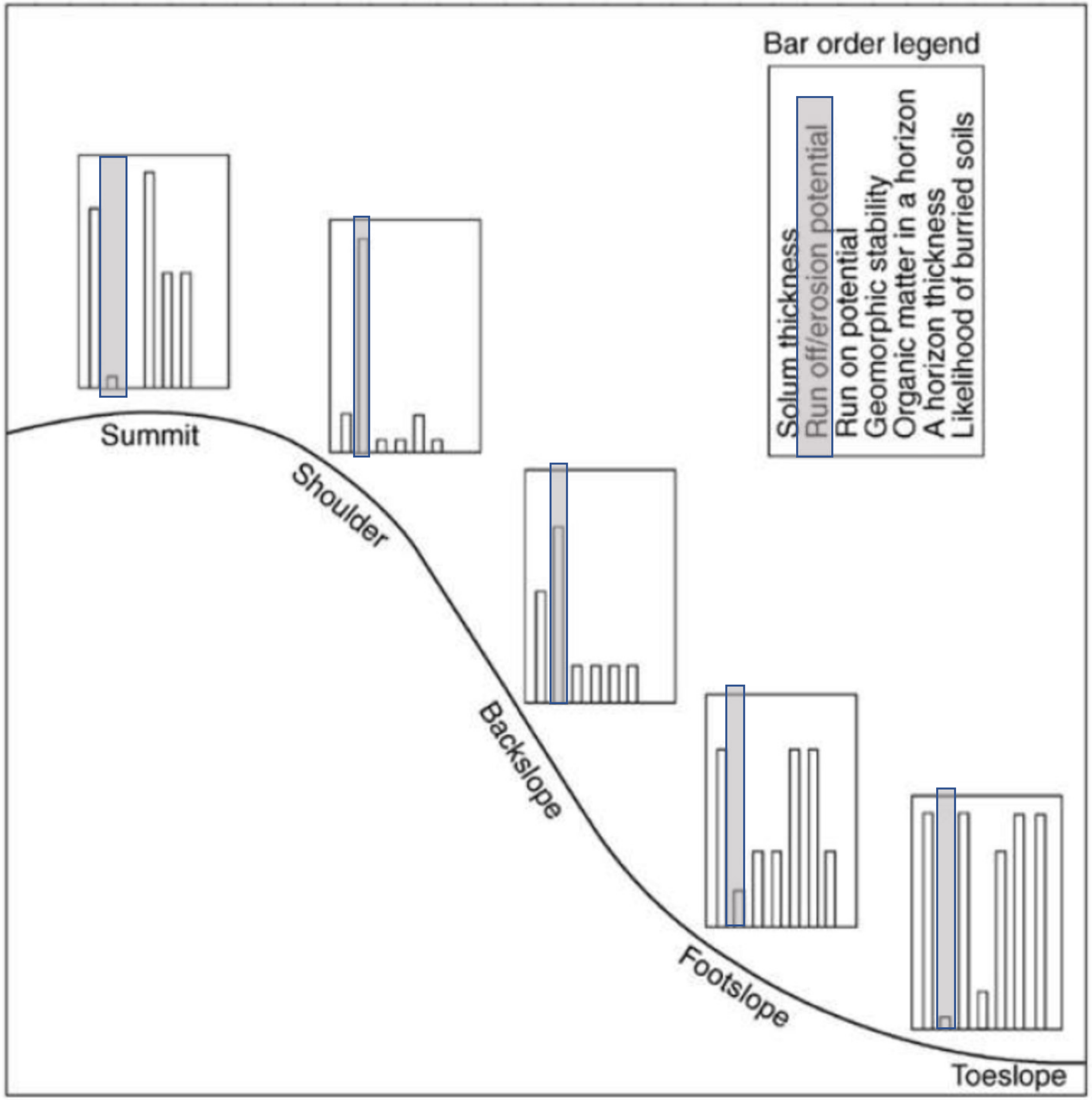

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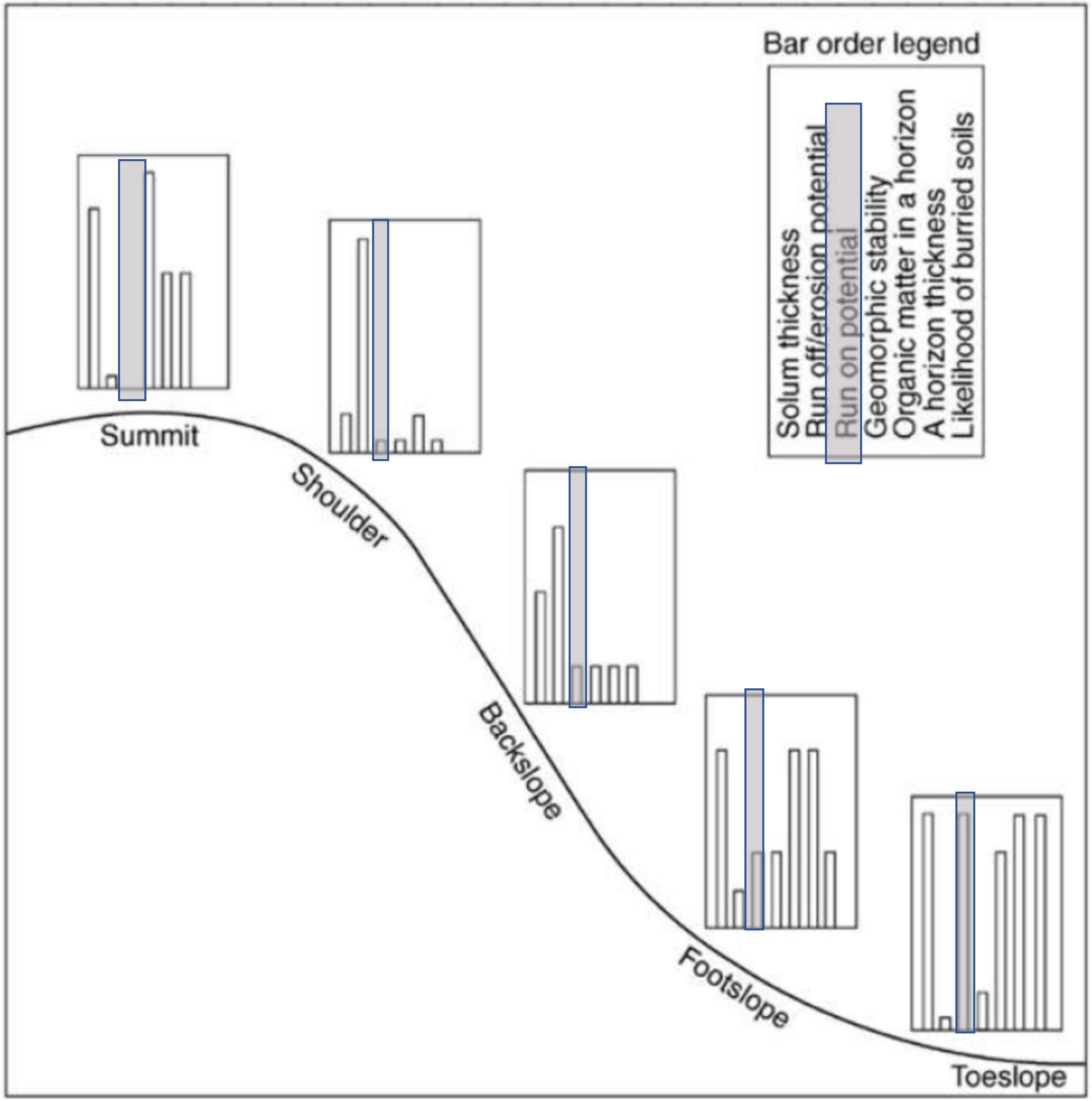

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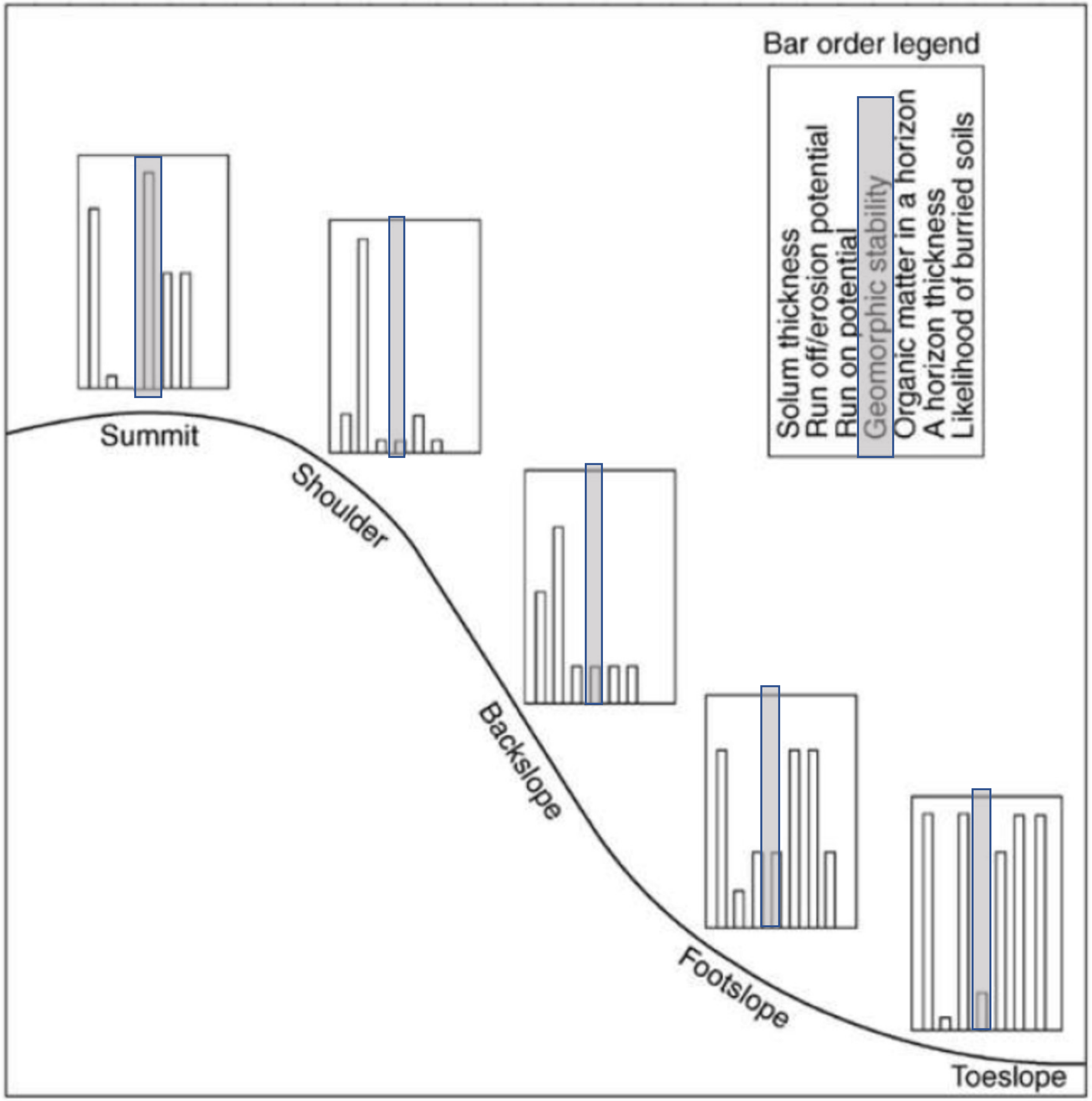

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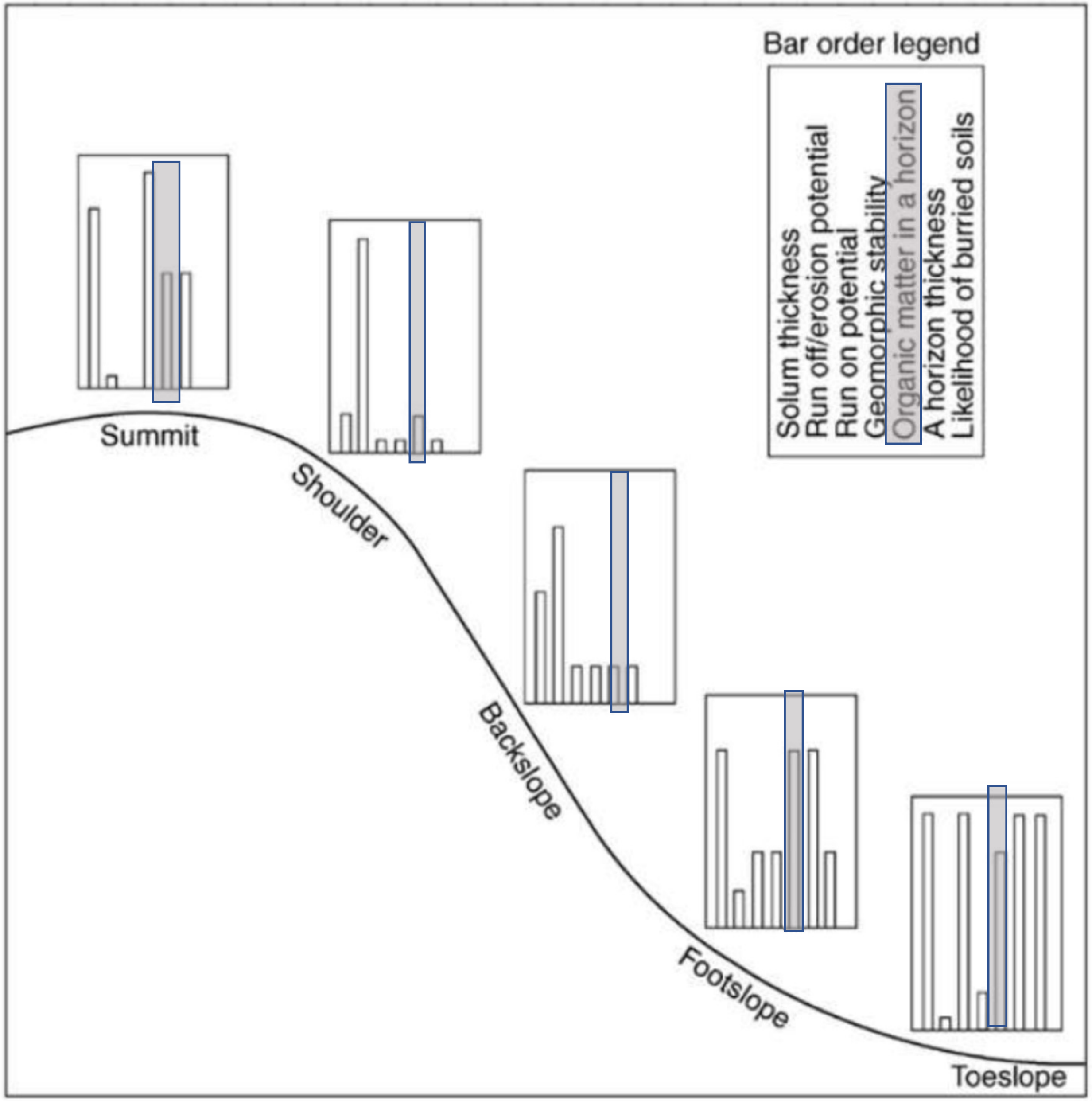

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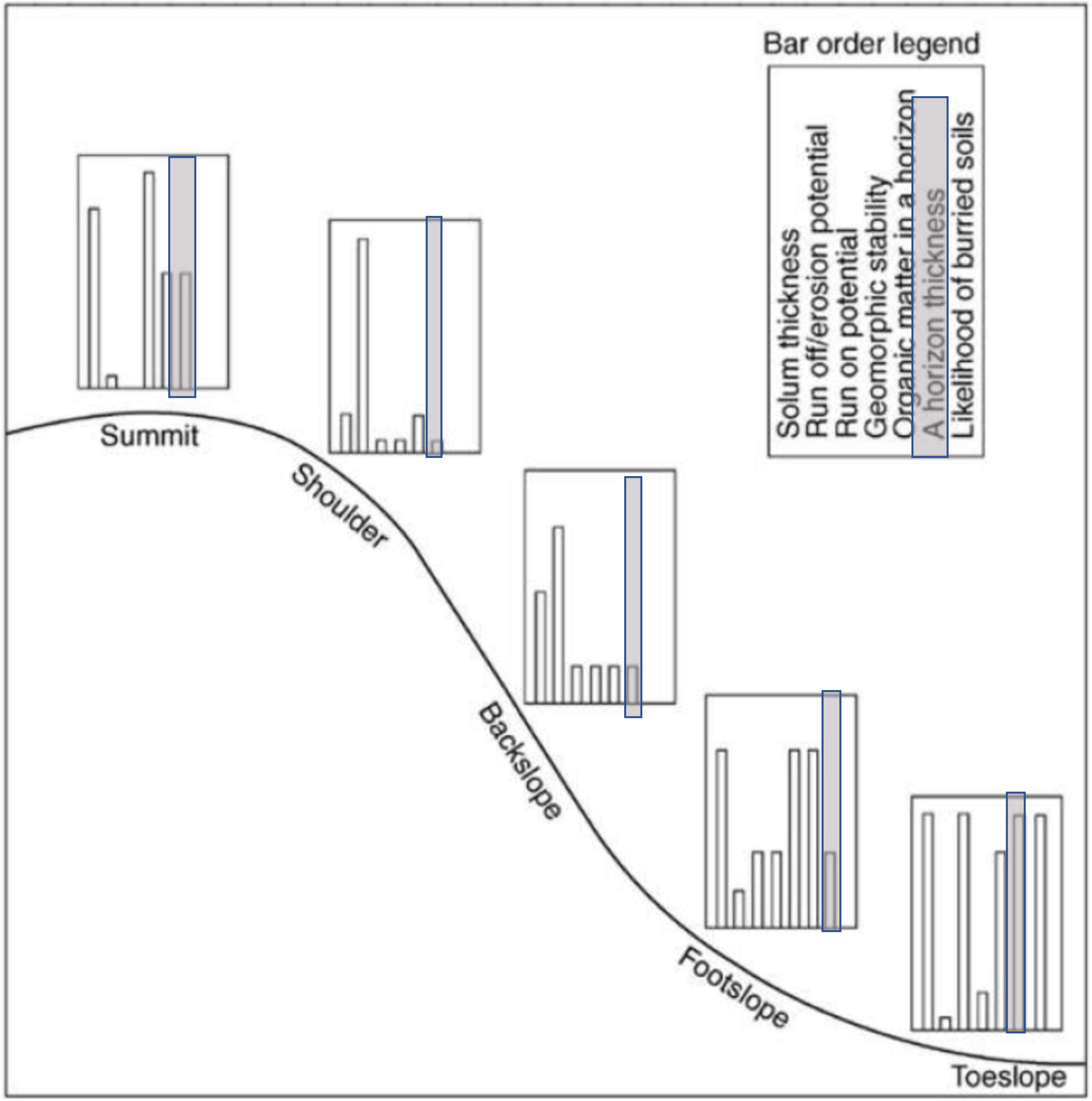

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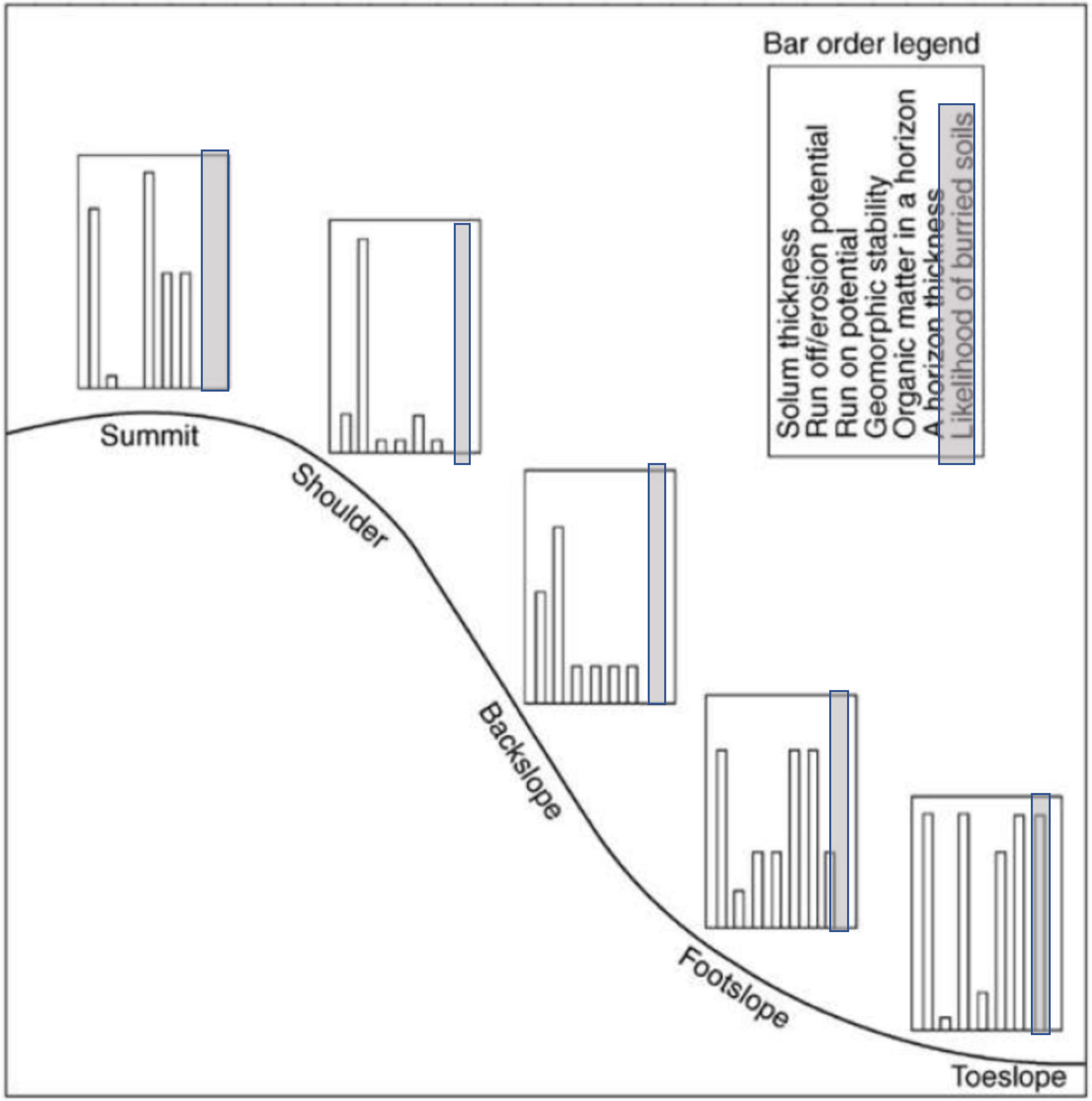

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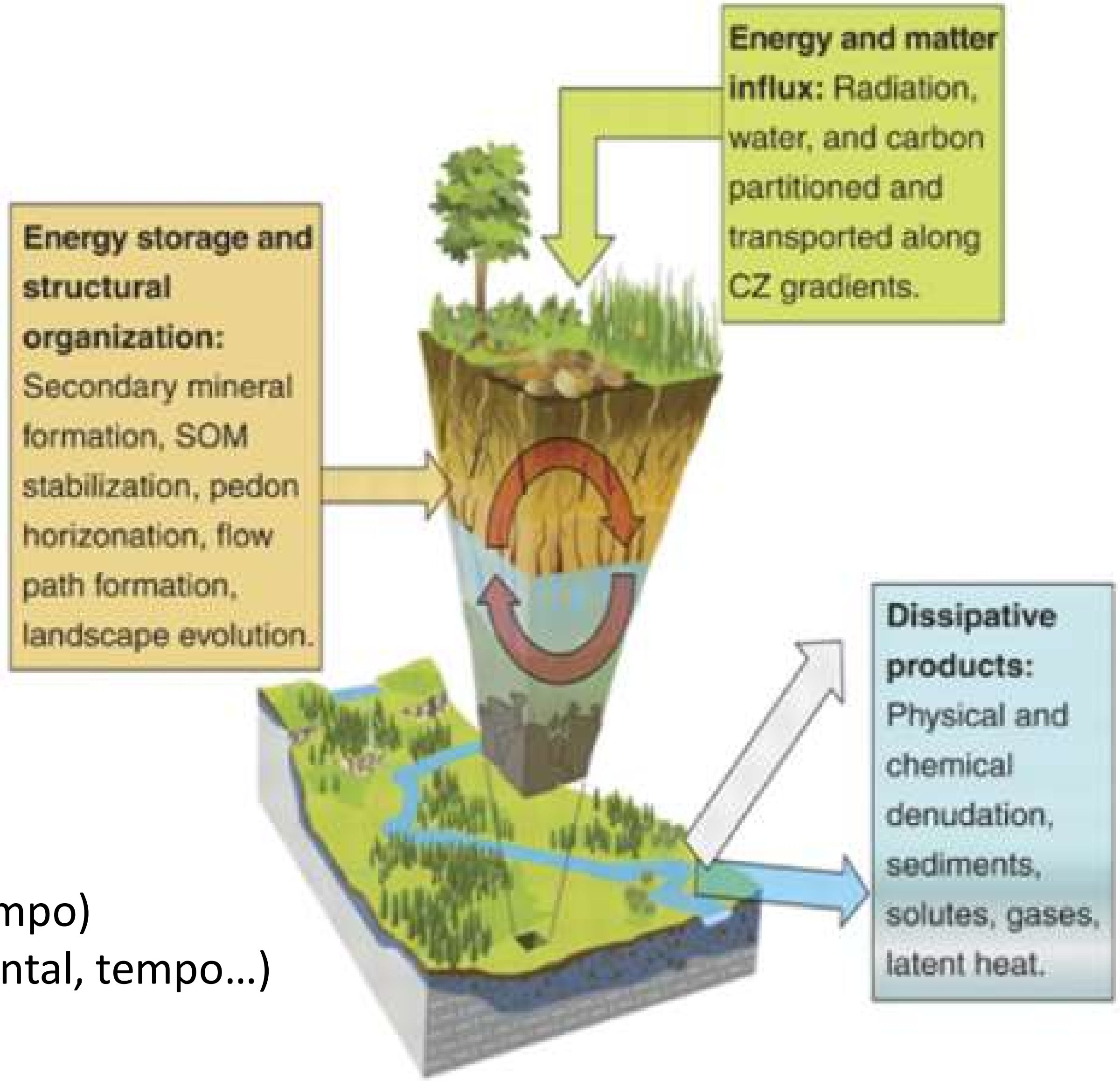

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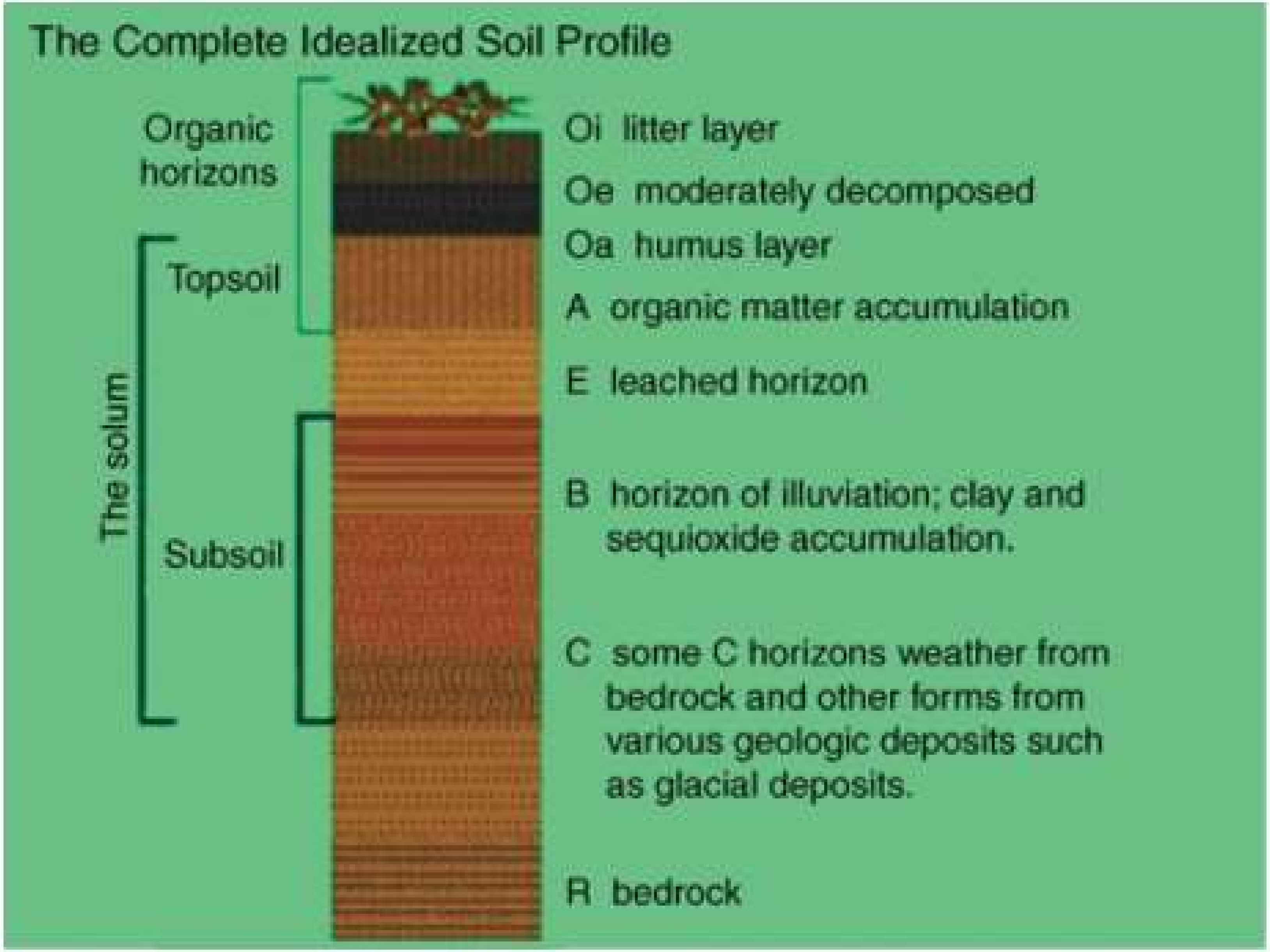
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Topsoil
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Oi litter layer
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Oa humus layer
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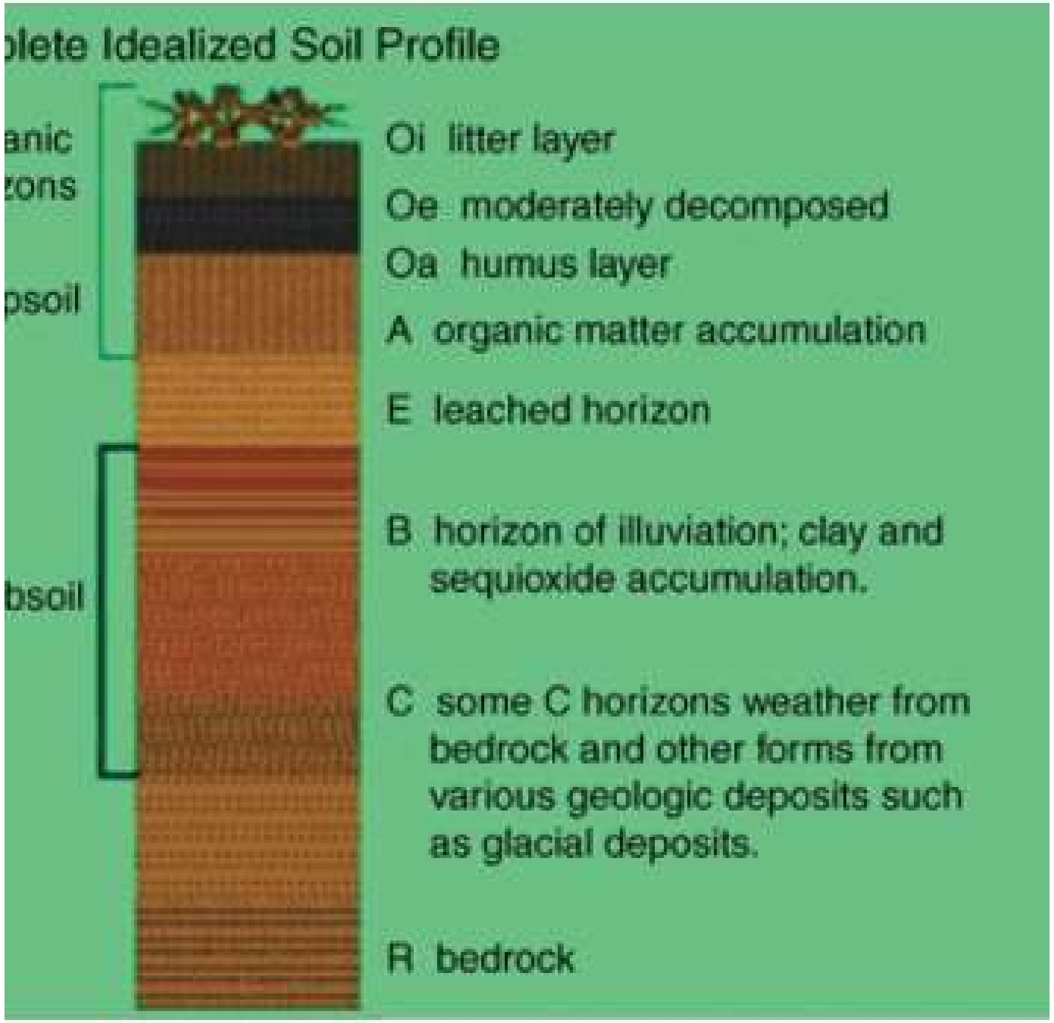
R bedrock



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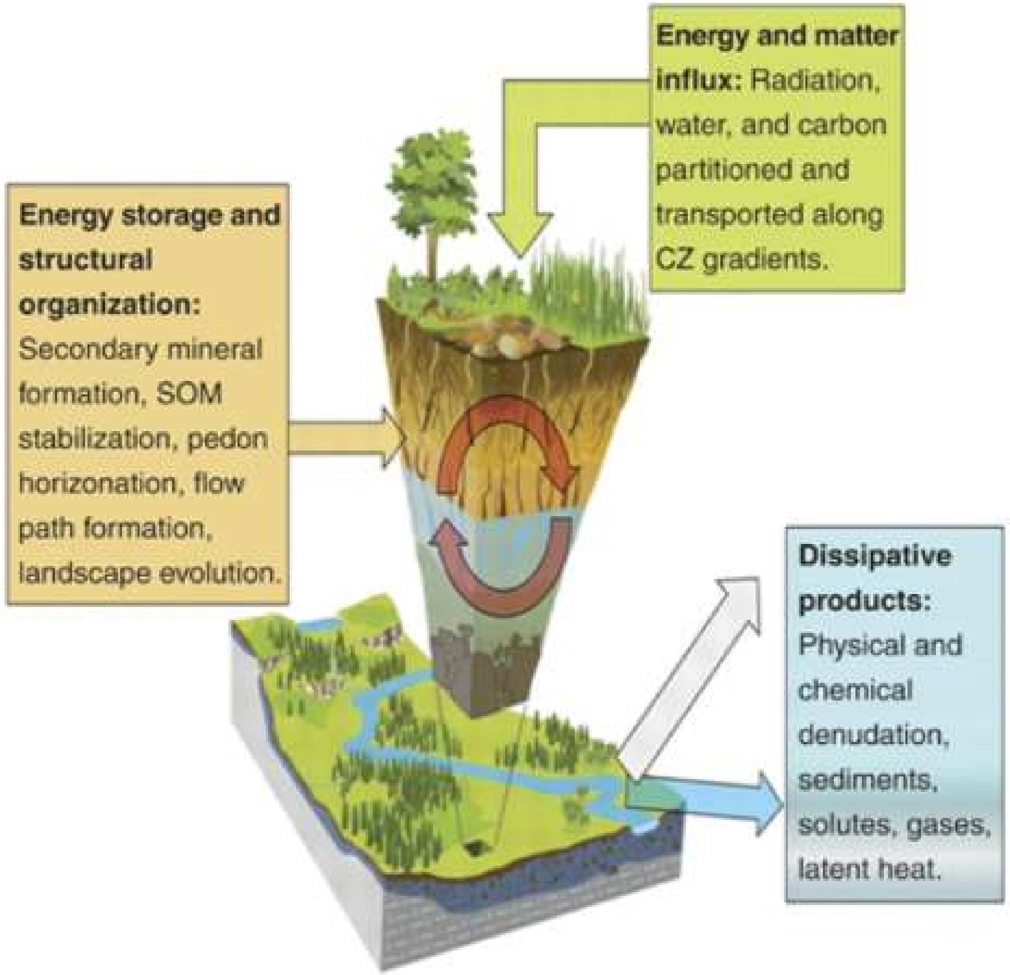
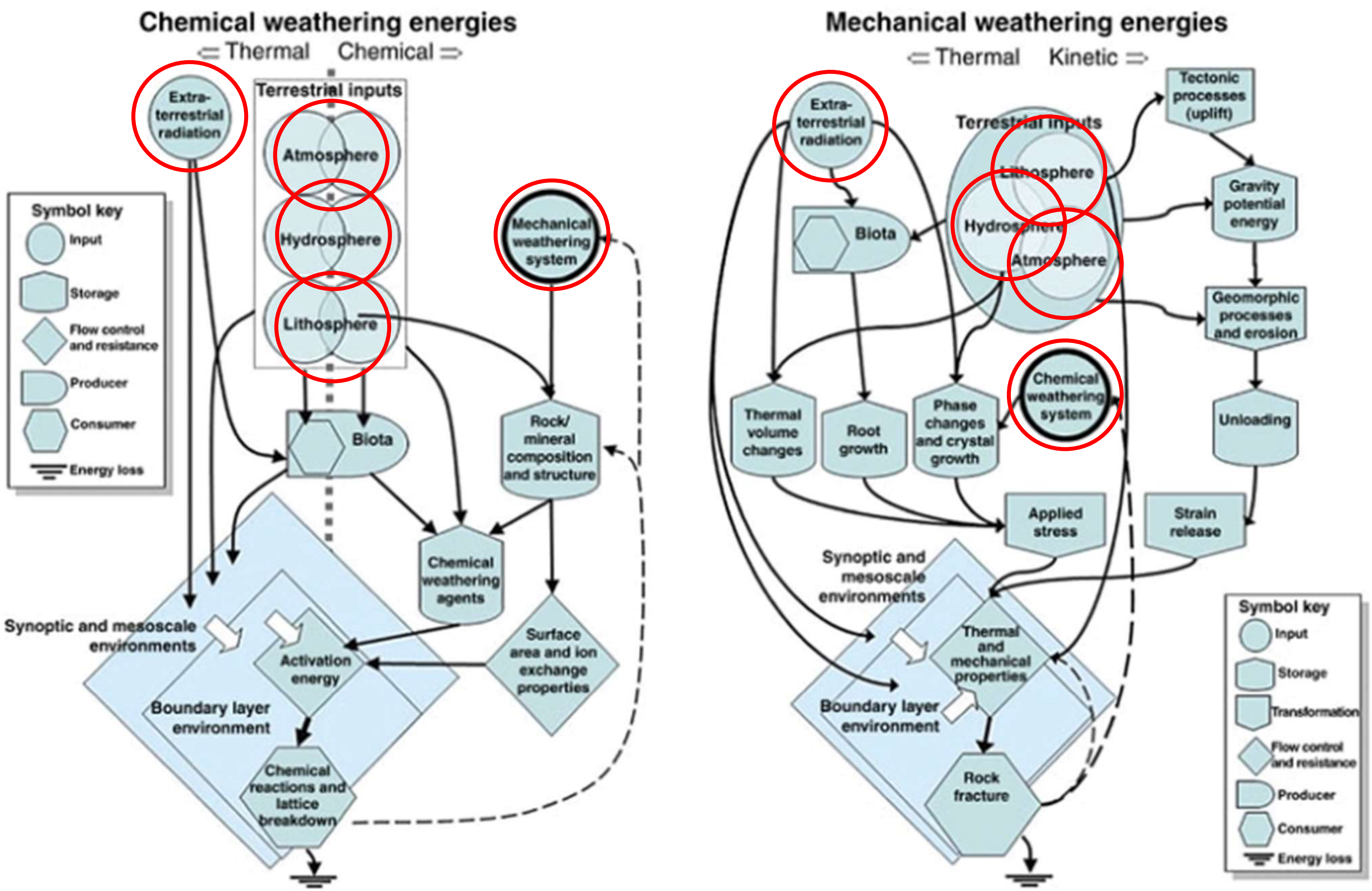


Energy and matter influx: Radiation, water, and carbon partitioned and transported along CZ gradients.
Energy storage and structural organization: Secondary mineral formation, SOM stabilization, pedon horizonation, flow path formation, landscape evolution.
Dissipative products: Physical and chemical denudation, sediments, solutes, gases, latent heat.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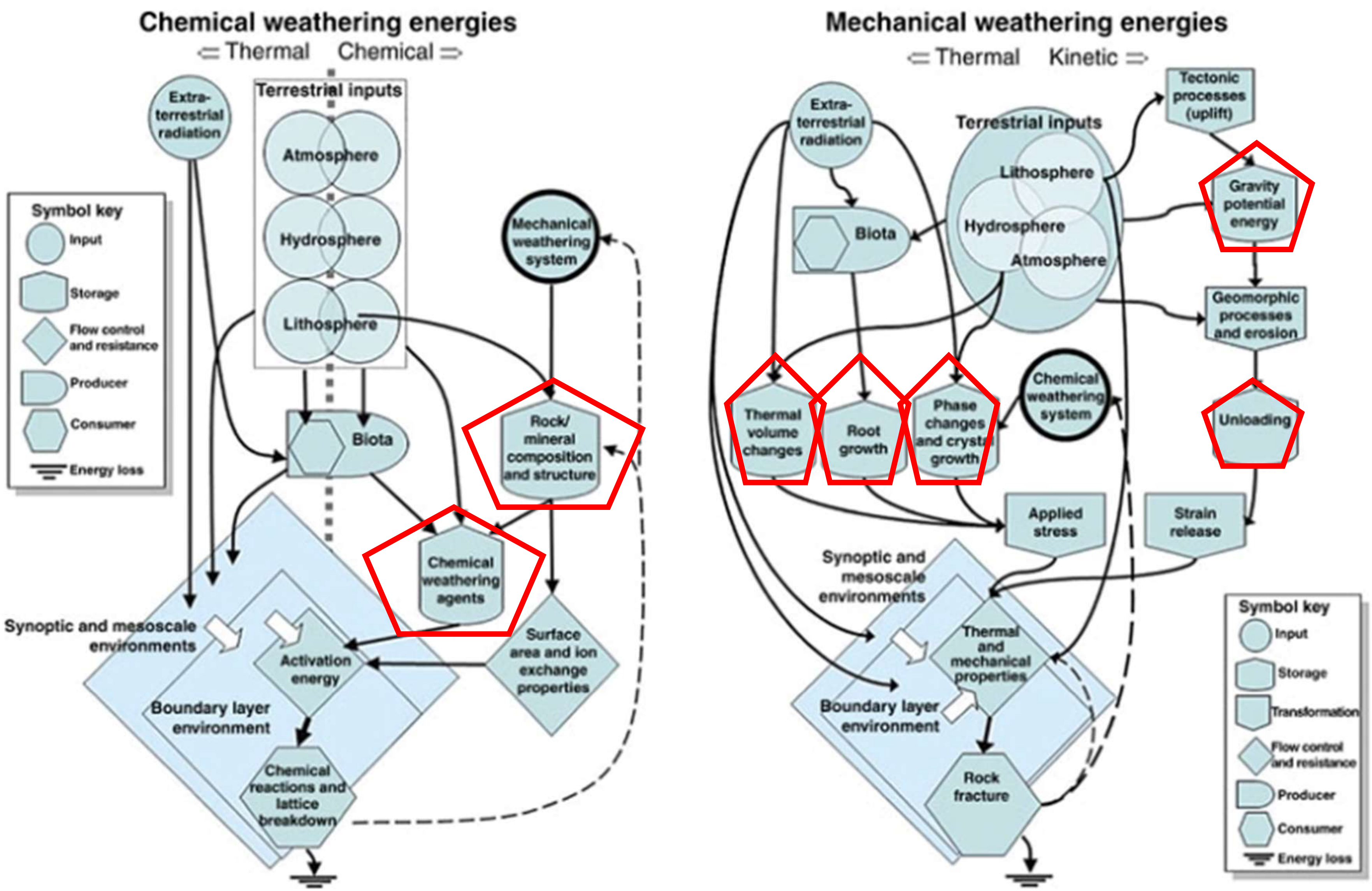

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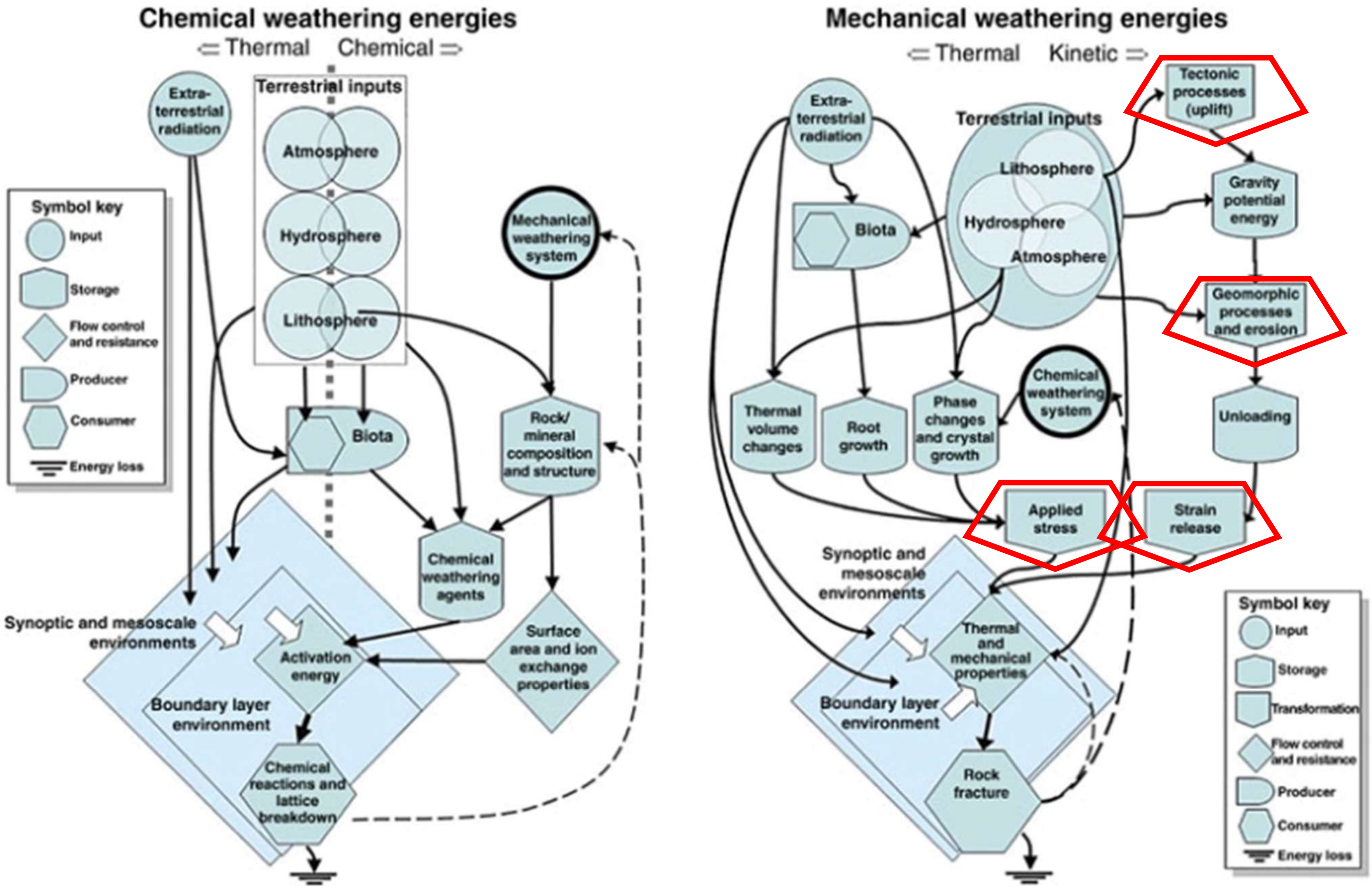

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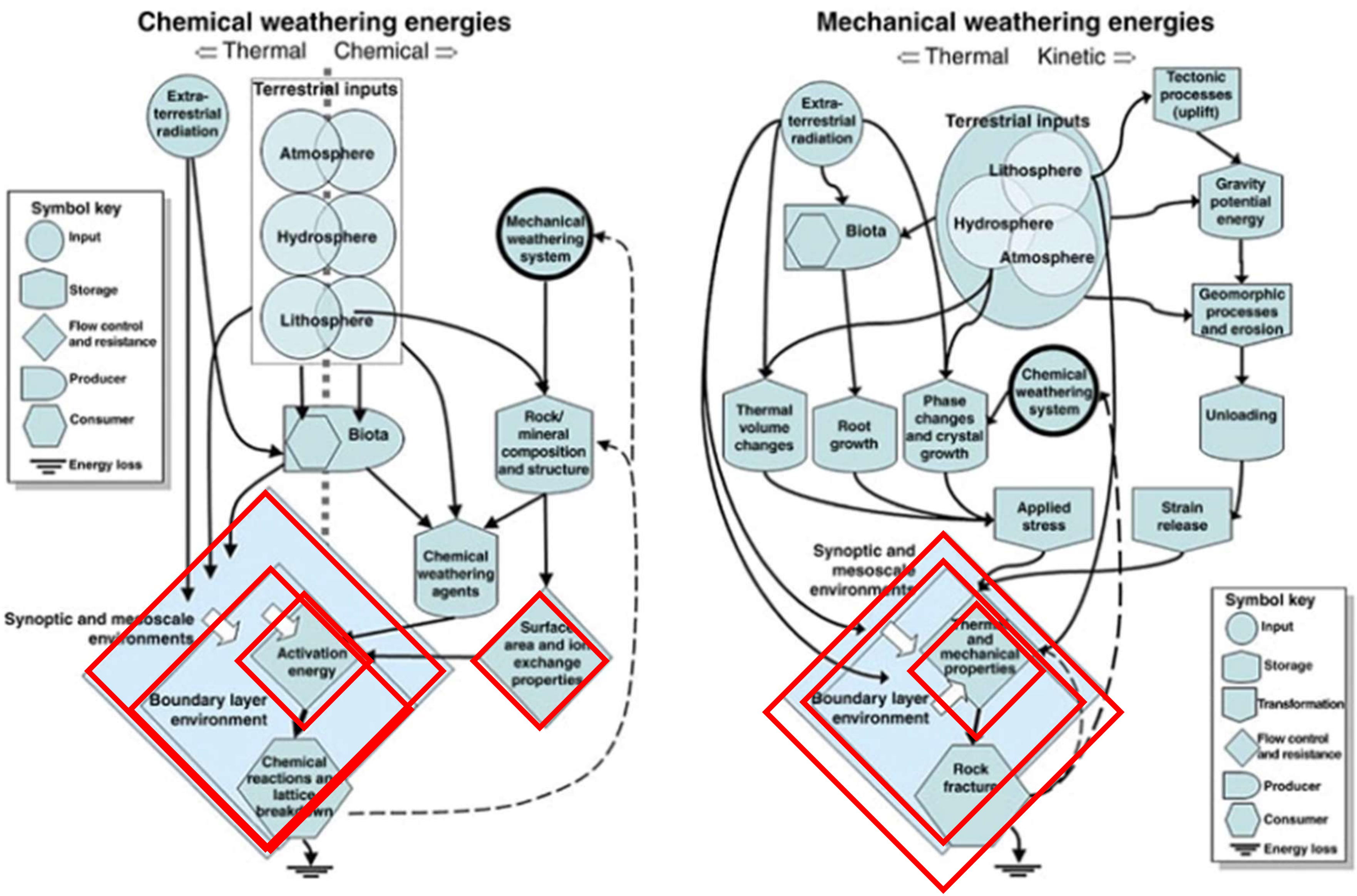

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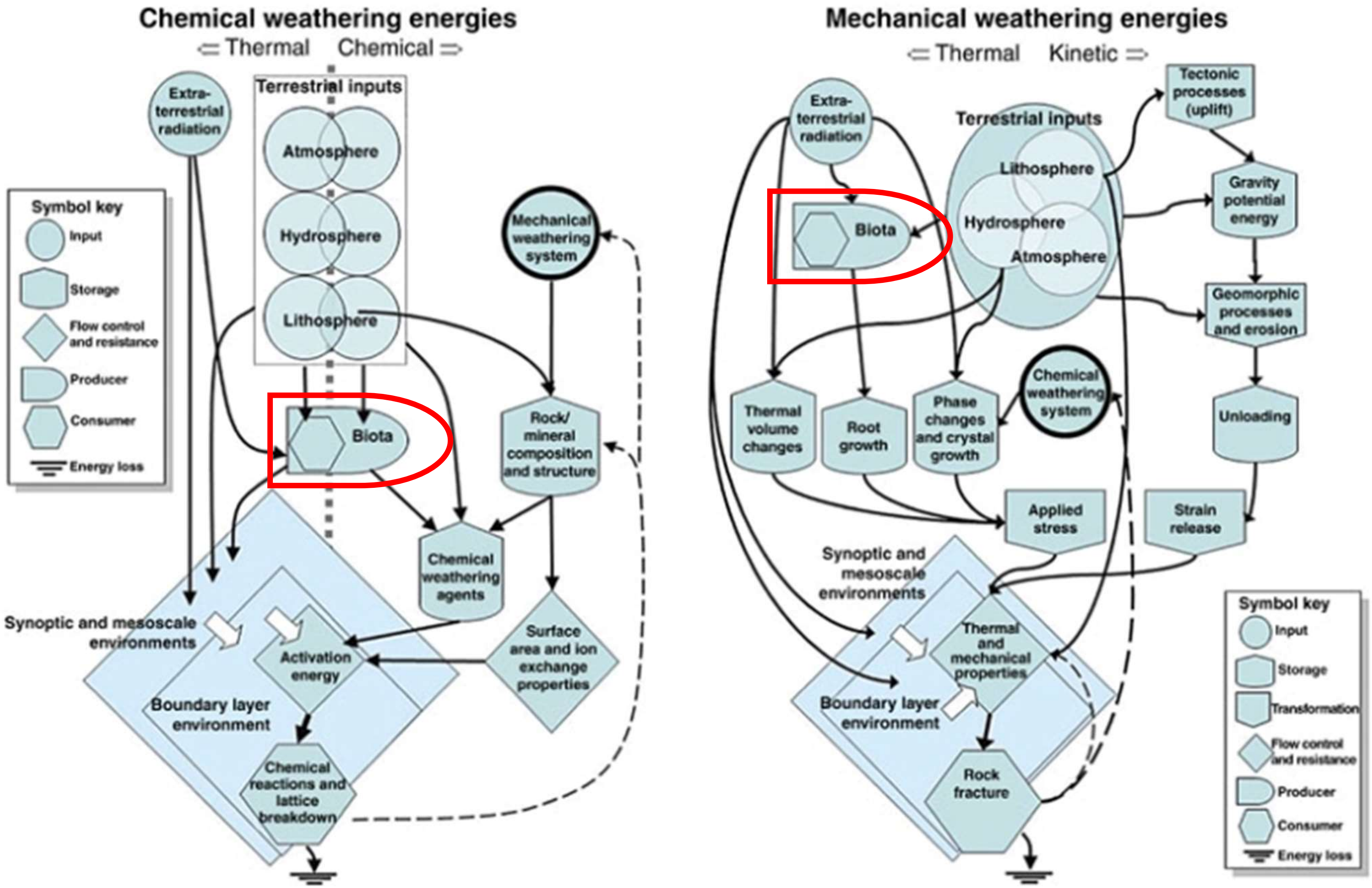
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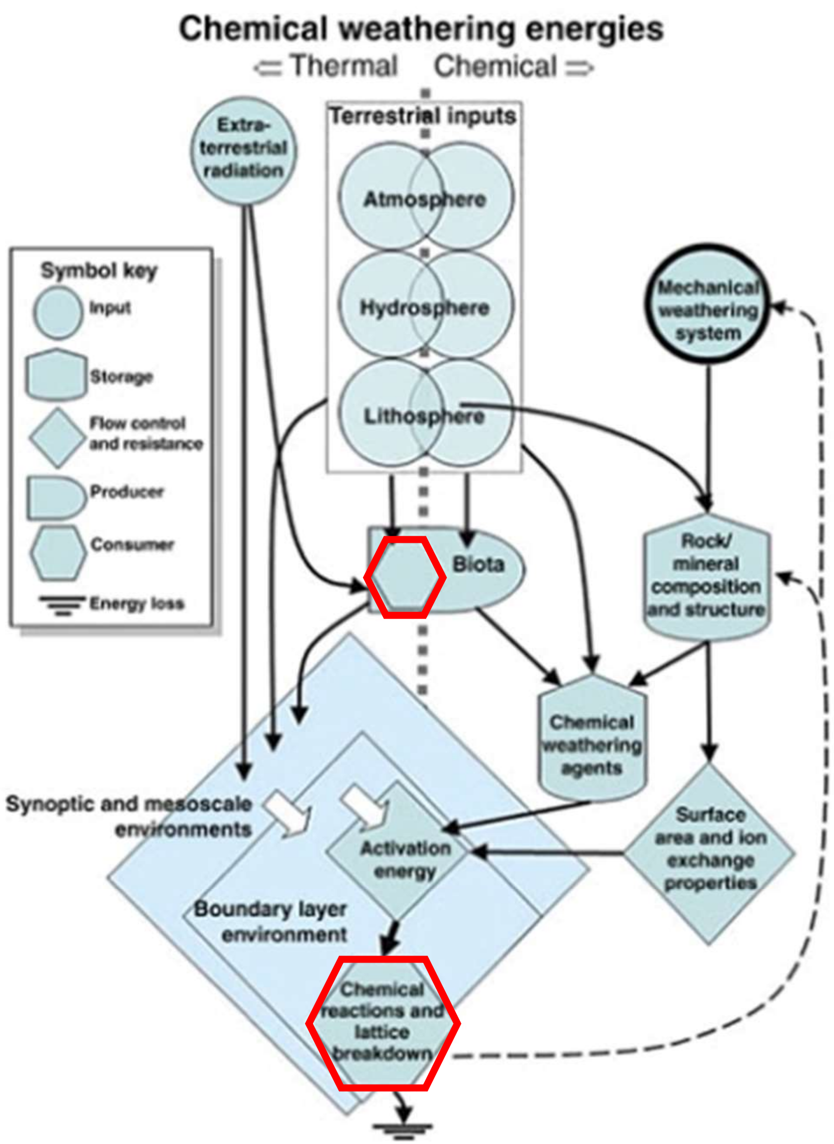
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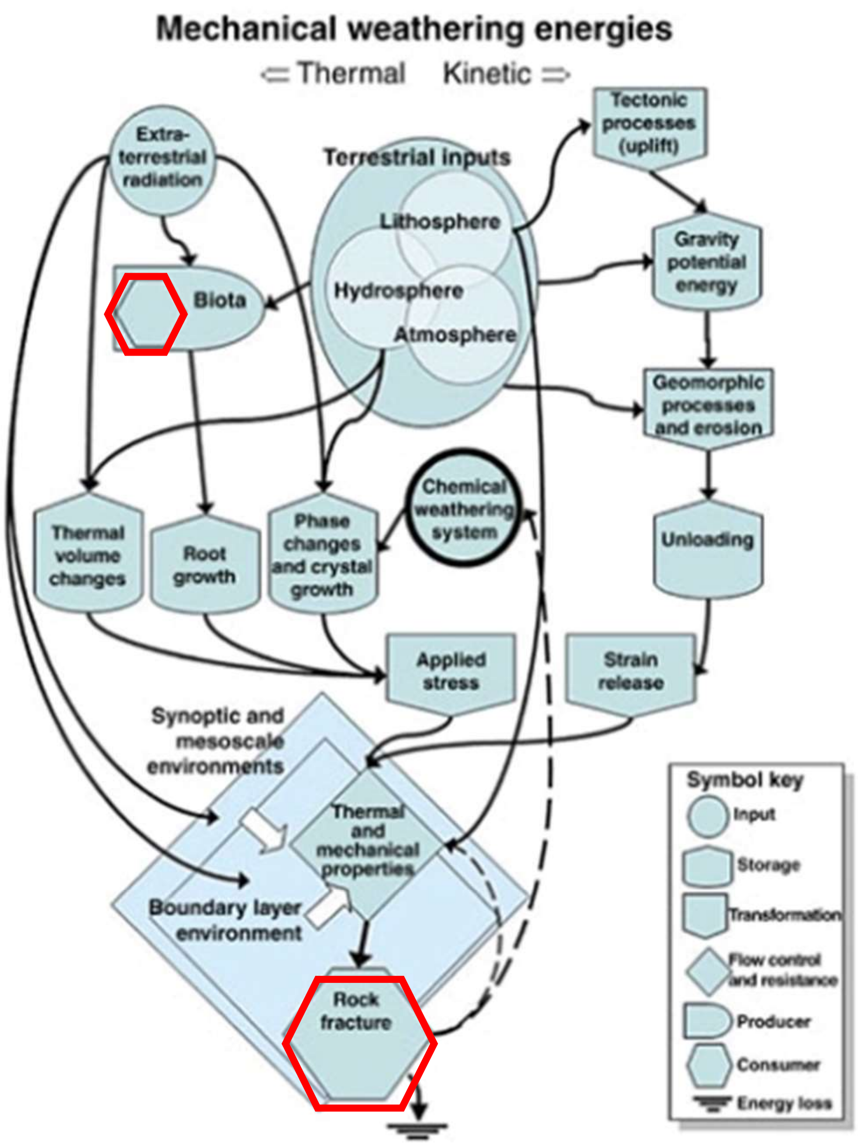
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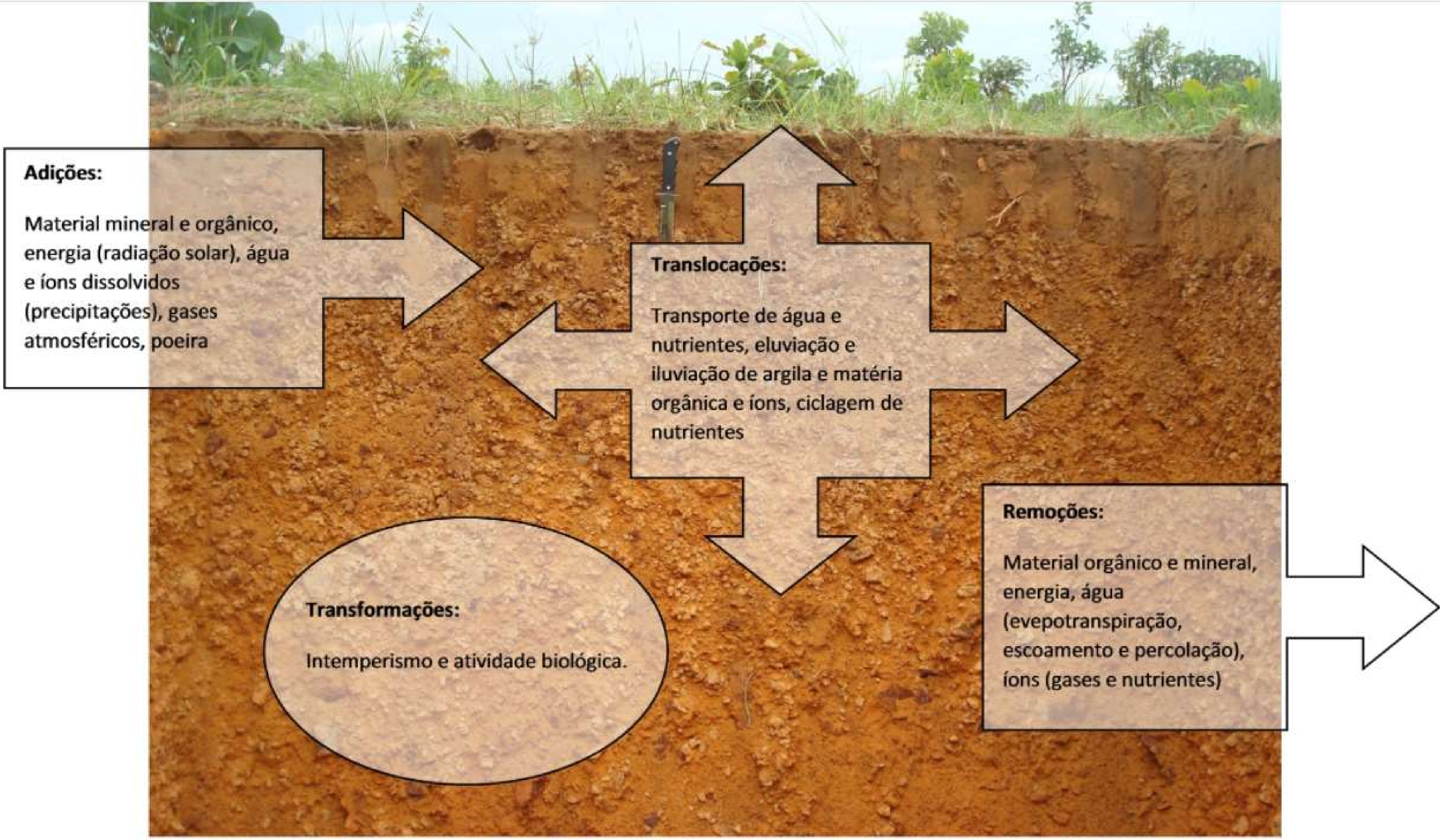
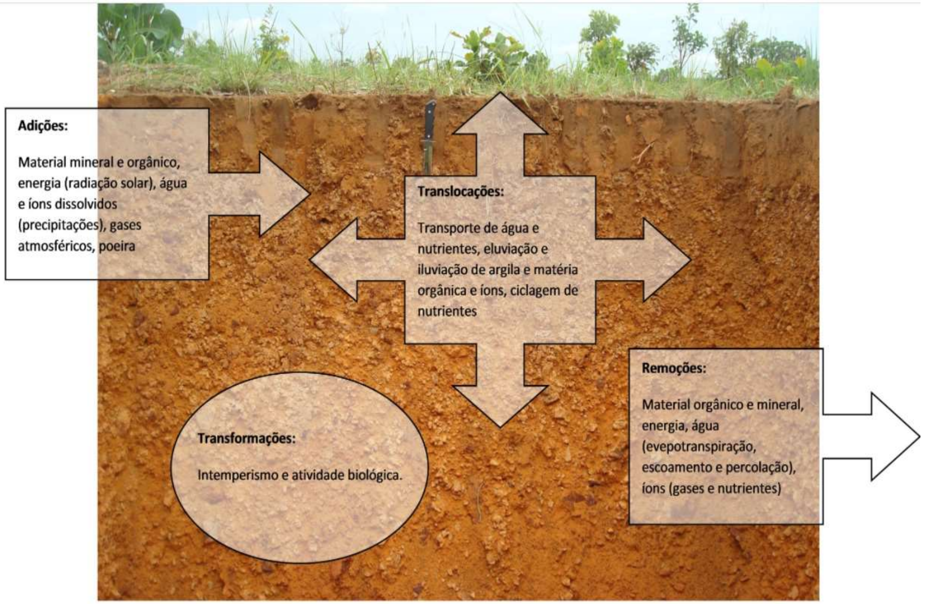
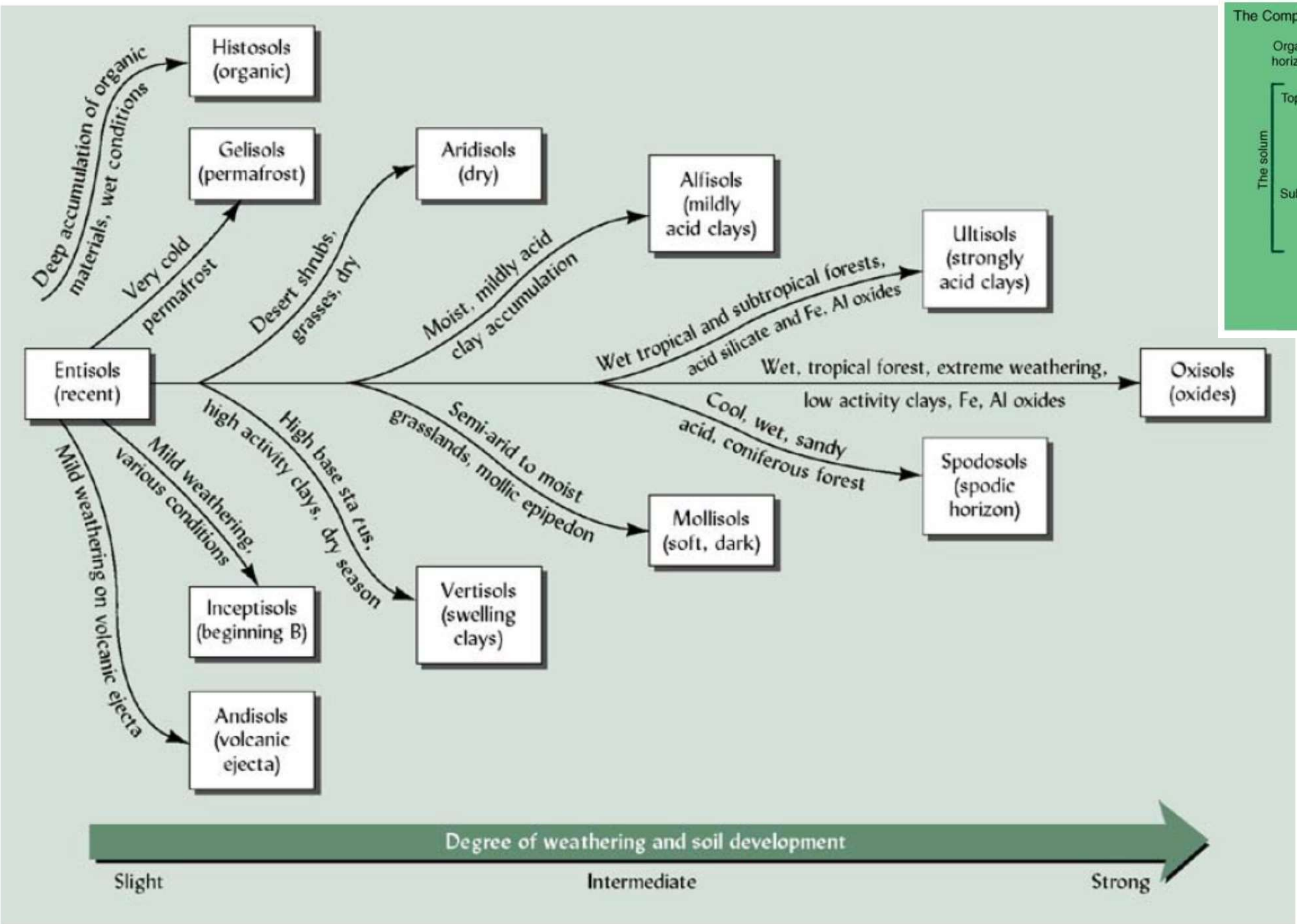

Adições:
Material mineral e orgânico, energia (radiação solar), água e íons dissolvidos (precipitações), gases atmosféricos, poeira
Translocações:
Transporte de água e nutrientes, eluviação e iluviação de argila e matéria orgânica e íons, ciclagem de nutrientes
Remoções:
Material orgânico e mineral, energia, água (evepotranspiração, escoamento e percolação), íons (gases e nutrientes)
Transformações:
Intemperismo e atividade biológica.

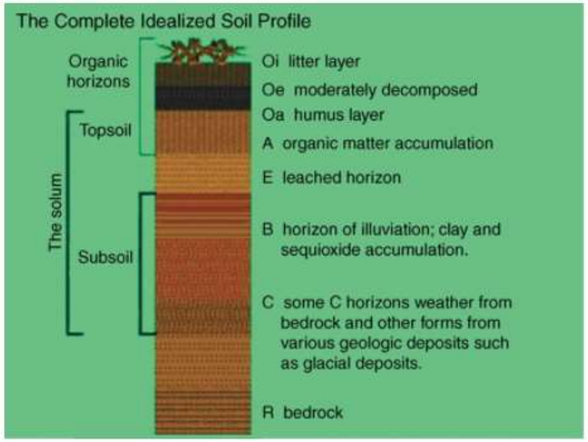


Processos pedogenéticos

Processos pedogenéticos específicos	Processos múltiplos	Descrição resumida do processo	Exemplo de ocorrência
Ferralitização	Remoção, transformação e translocação	Remoção de sílica e concentração de óxidos de Fe e Al.	Latossolos, Nitossolos, caráter ácrico
Silicificação	Transformação e translocação	Migração e acúmulo de sílica cimentando estruturas ou a matriz do solo	Latossolos e Argissolos Amarelos coesos
Plintitização e laterização	Transformação e translocação	Redução e translocação de Fe e oxidação e precipitação originando mosqueados, plintita ou petroplintita	Plintossolos
Lessivagem ou argiluviação	Translocação	Migração vertical de argila no solo	Argissolos, Luvissolos, horizontes E, lamelas
Podzolização	Transformação e translocação	Migração de complexos de Fe, Al e matéria orgânica no solo com acúmulo em horizonte iluvial, com ou sem sílica	Espodossolos, Ortstein
Gleização	Remoção, transformação e translocação	Redução de Fe em condições anaeróbias e translocação formando horizontes acinzentados com ou sem mosqueados	Gleissolos, Planossolos
Calcificação ou carbonatação	Translocação	Acumulação de $CaCO_3$ com nódulos ou horizonte endurecido	Luvissolos, Chernossolos Rêndzicos
Ferrólise	Remoção, transformação e translocação	Destruição de argila com formação de horizonte B textural	Planossolos, Argissolos
Salinização	Translocação	Acumulação de sais por evaporação no horizonte superficial ou na superfície do solo	Gleissolos sálicos
Sulfurização ou tiomorfismo	Transformação e translocação	Acidificação do solo causada pela oxidação de compostos de enxofre	Gleissolos Tiomórficos

Adaptado de Kämpf & Curi (2012).


Histosols (organic)
Gelisols (permafrost)
Aridisols (dry)
Alfisols (mildly acid clays)
Ultisols (strongly acid clays)
Entisols (recent)
Oxisols (oxides)
Spodosols (spodic horizon)
Mollisols (soft, dark)
Vertisols (swelling clays)
Inceptisols (beginning B)
Andisols (volcanic ejecta)
Deep accumulation of organic materials, wet conditions
Very cold permafrost
Desert shrubs, grasses, dry
Moist, mildly acid clay accumulation
Wet tropical and subtropical forests, acid silicate and Fe, Al oxides
Wet, tropical forest, extreme weathering, low activity clays, Fe, Al oxides
Cool, wet, sandy acid, coniferous forest
Semi-arid to moist grasslands, mollic epipedon
High base sta rus, high activity clays, dry season
Mild weathering, various conditions
Mild weathering on volcanic ejecta
Degree of weathering and soil development
Slight
Intermediate
Strong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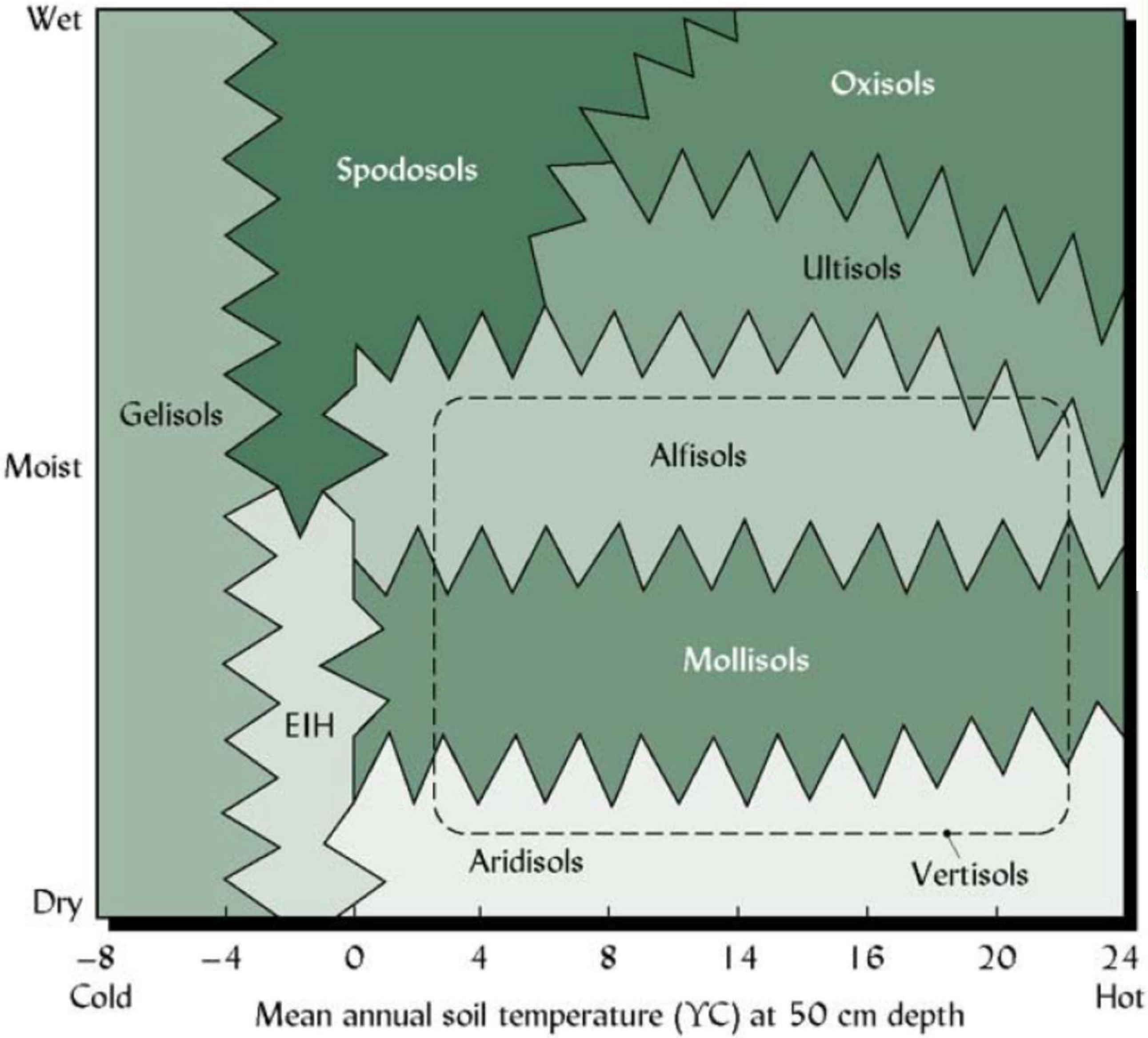
Wet
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Dry
Oxisols
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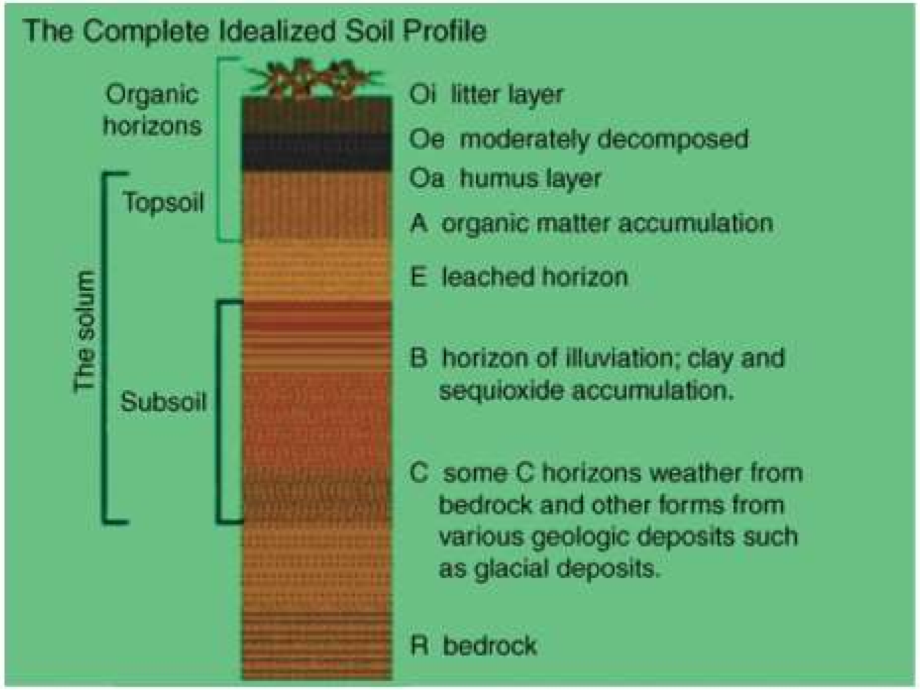
Gelisols
Alfisols
Mollisols
EIH
Aridisols
Vertisols
−8
−4
0
4
8
14
16
20
24
Cold
Hot
Mean annual soil temperature (ΥC) at 50 cm depth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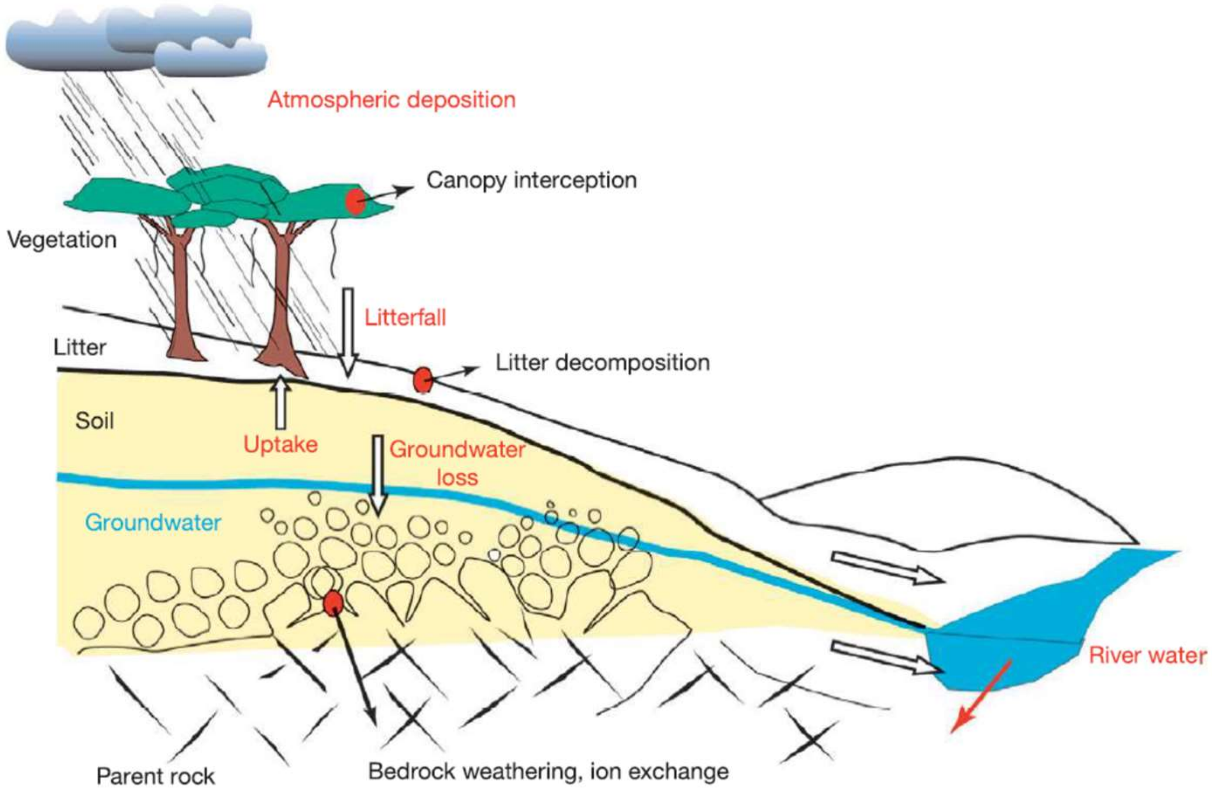
Solos brasileiros

- Composição mineralógica ~quartzo, caulinita, oxi-hidróxidos de Fe e Al
- Grandes espessuras
- Horizontes amarelo/laranja/vermelho/castanho
- Solos tropicais são mais empobrecidos em relação aos climas temperados (ricos em argilominerais capazes de reter nutrientes)
- Latossolos, vertosolos e outros

- Keny (1941) – Definição de solos

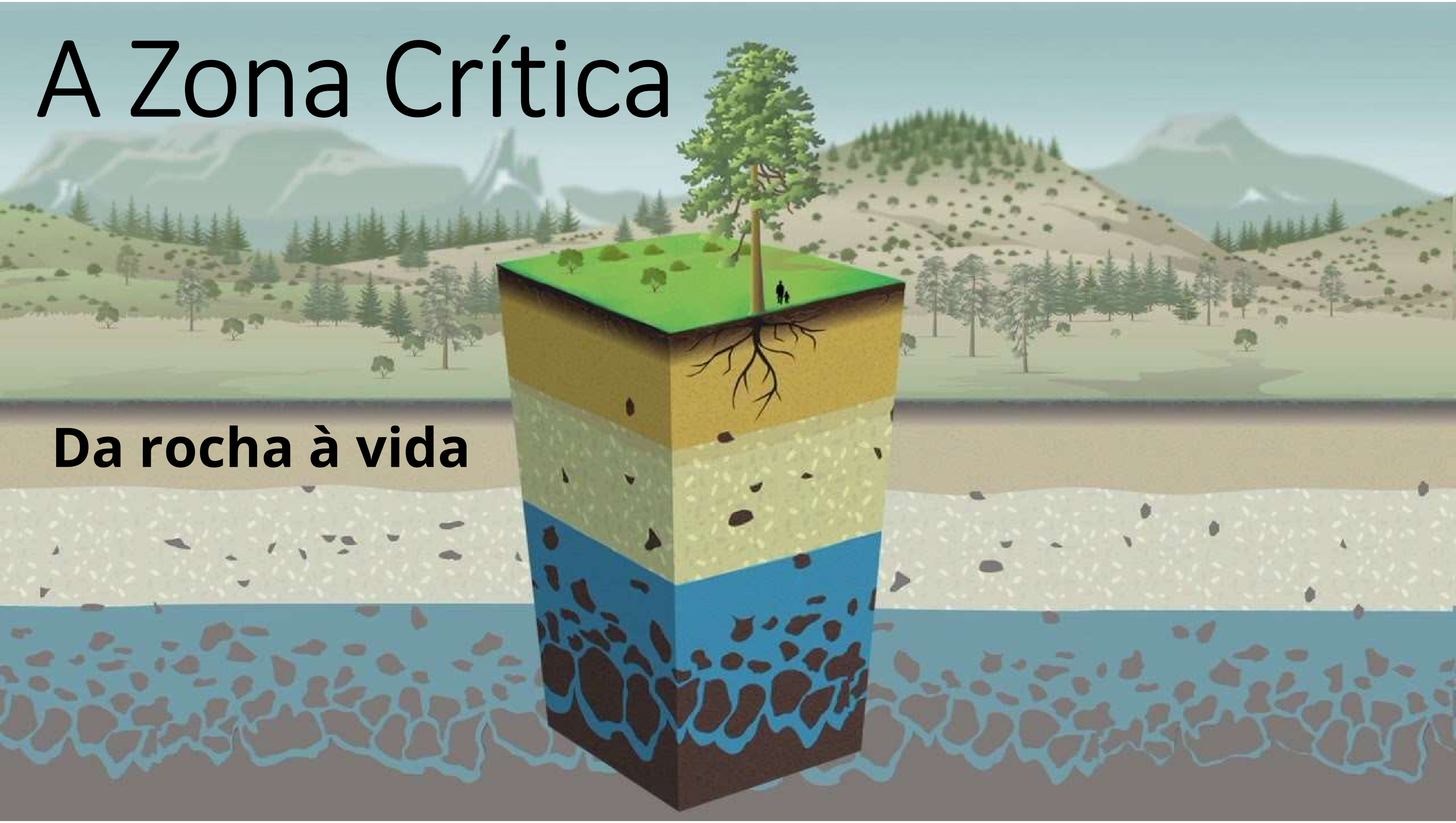
- “Sistemas que trocam massa e energia com o entorno”

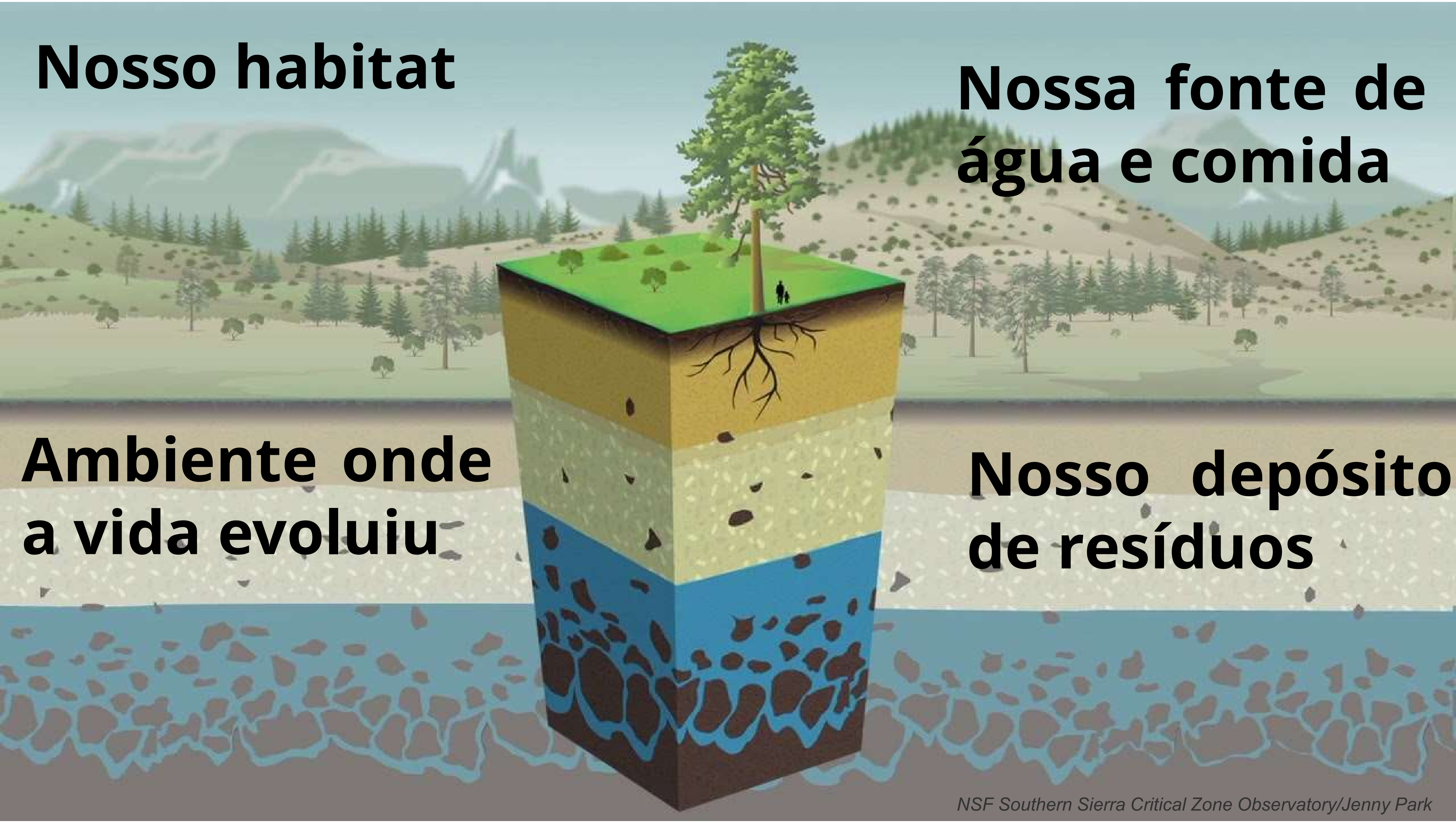


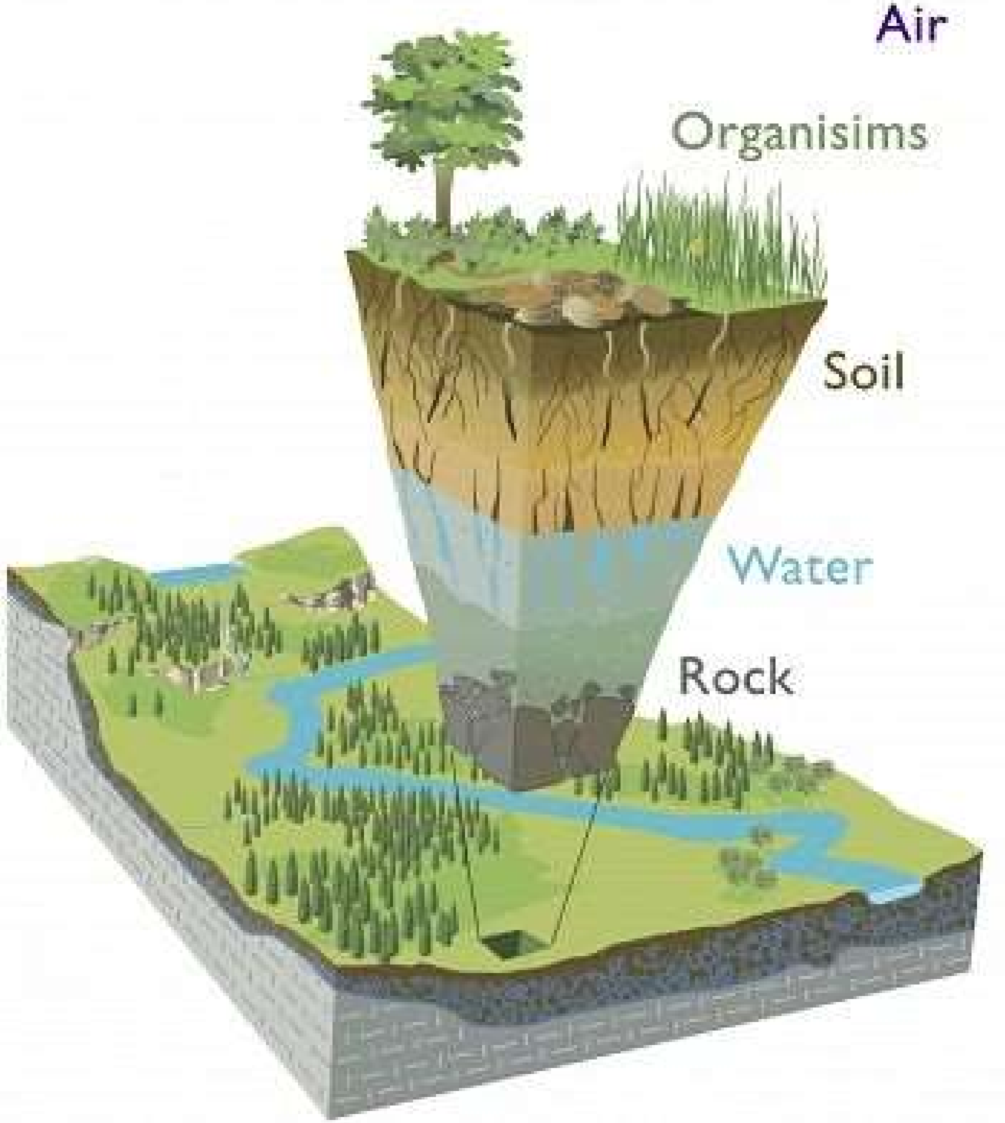
Biogeochemical cycling of elements within the different reservoirs (i.e., soil–rock system, vegetation, and atmosphere) of a watershed.

A Zona Crítica

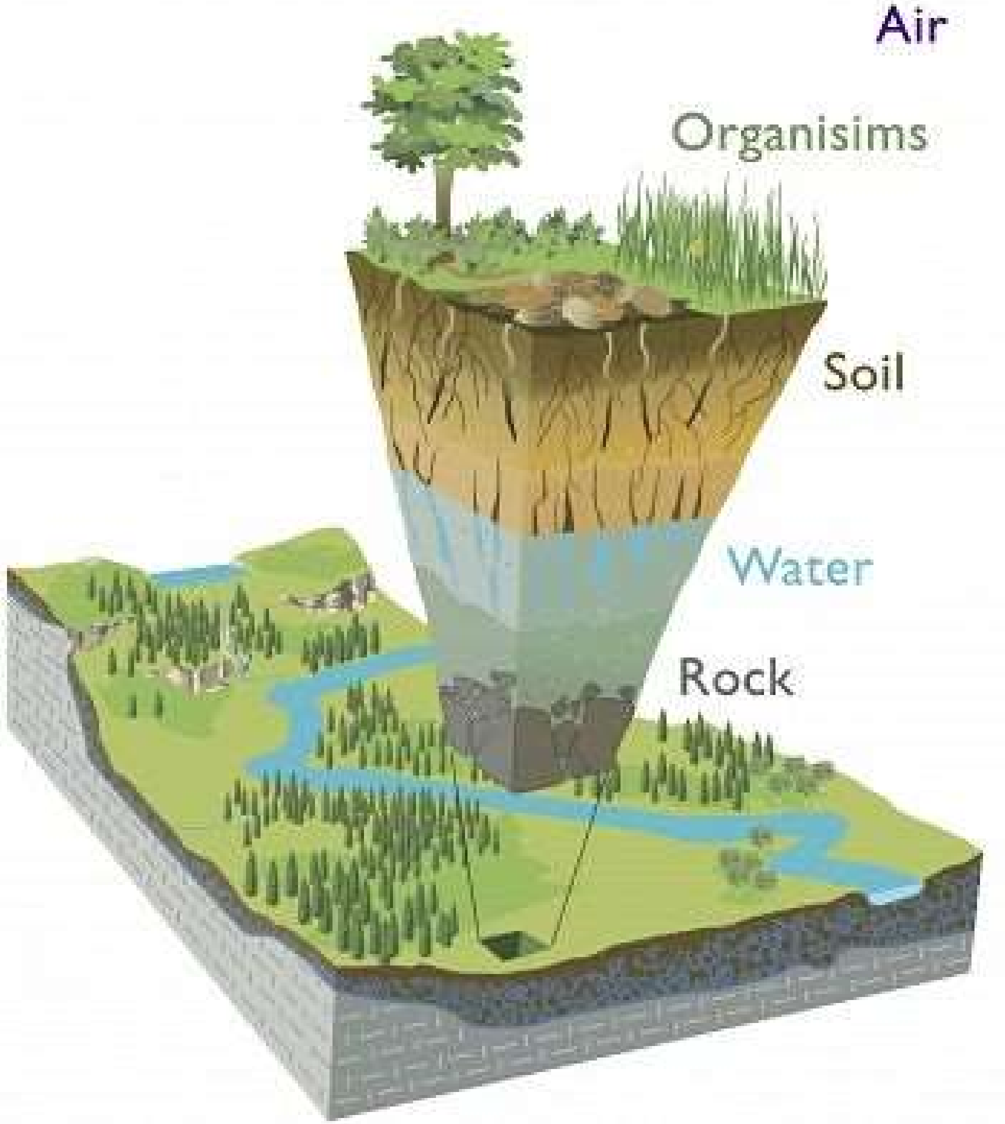
Da rocha à vida



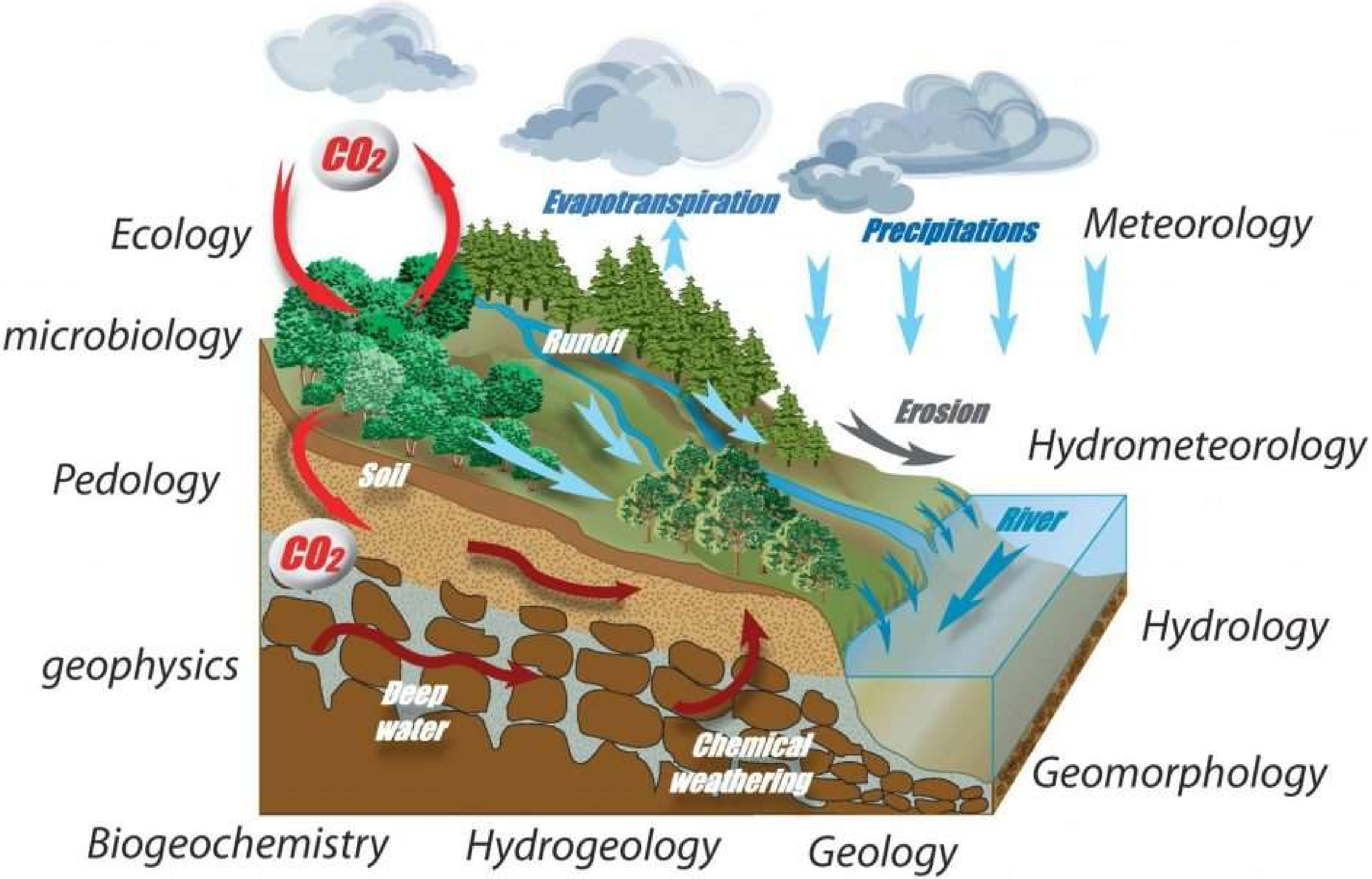

Nosso habitat
Nossa fonte de água e comida
Ambiente onde a vida evoluiu
Nosso depósito de resíduos
NSF Southern Sierra Critical Zone Observatory/Jenny Park



"I called it the critical zone because it's critical for life…Also, it's critical to know more about it because of the potential for damaging it" (Gail Ashley, 1998)



"We should be looking at the Earth's surface as one thing and bringing all those subdisciplines together" (Susan Brantley, 2000)



CO_2
Evapotranspiration
Precipitations
Meteorology
Ecology
microbiology
Runoff
Erosion
Hydrometeorology
Pedology
Soil
River
CO_2
Hydrology
geophysics
Deep water
Chemical weathering
Geomorphology
Biogeochemistry
Hydrogeology
Geology

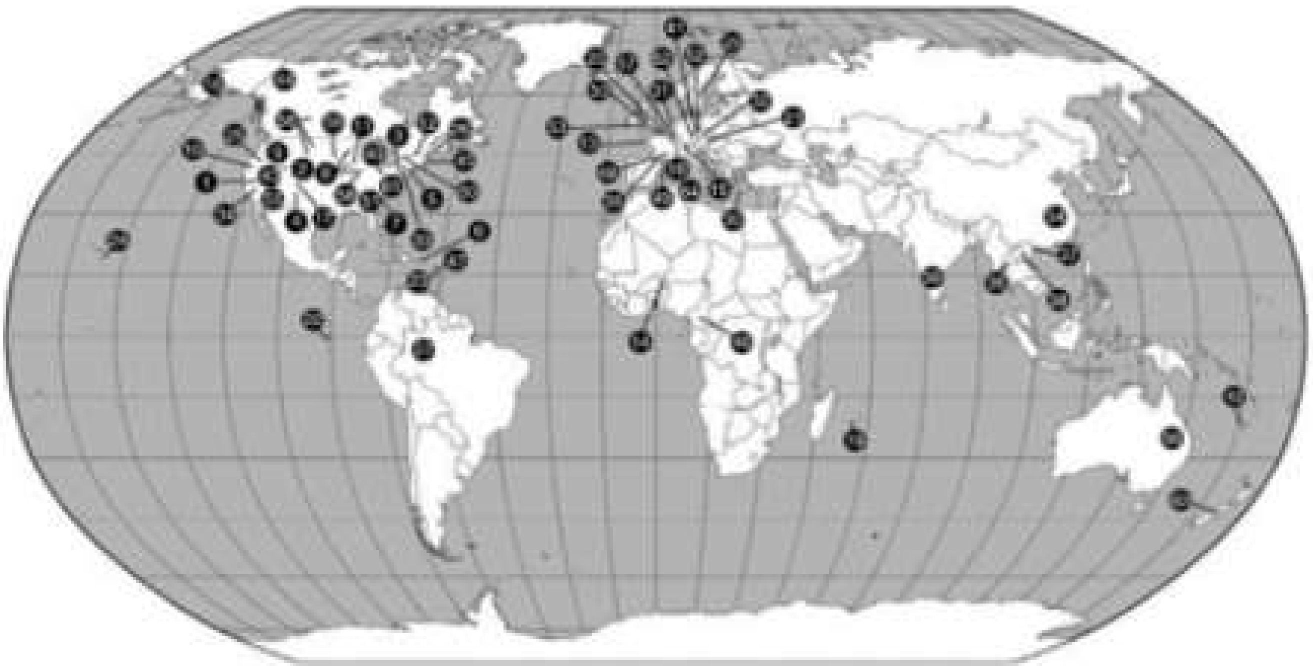
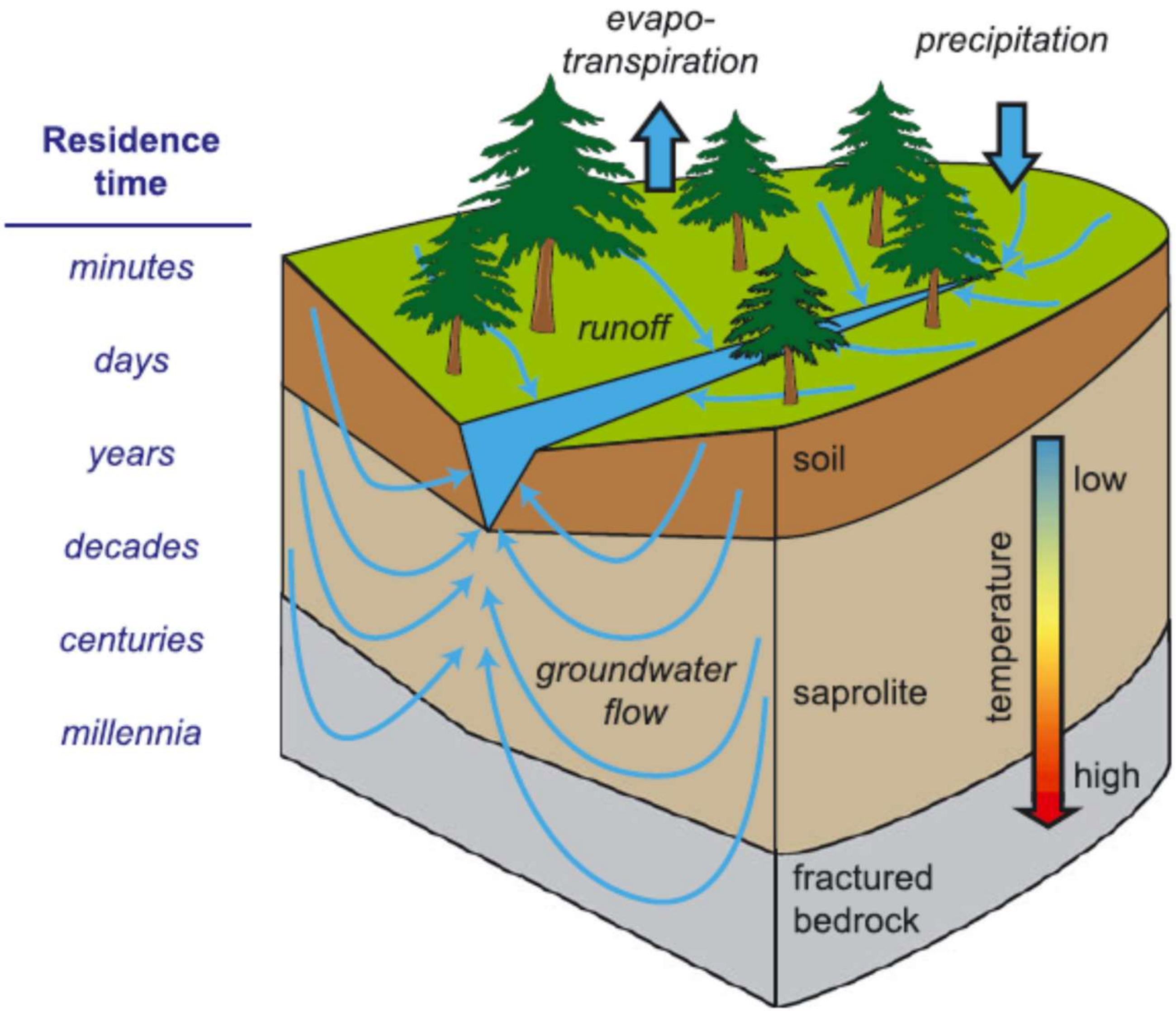


FIGURE 1.2 Locations of Critical Zone sites located around the world.
The number in the marker corresponds to the Critical Zone site listed in the table. Map compiled from Banwart et al. (2013) and NRC (2001).

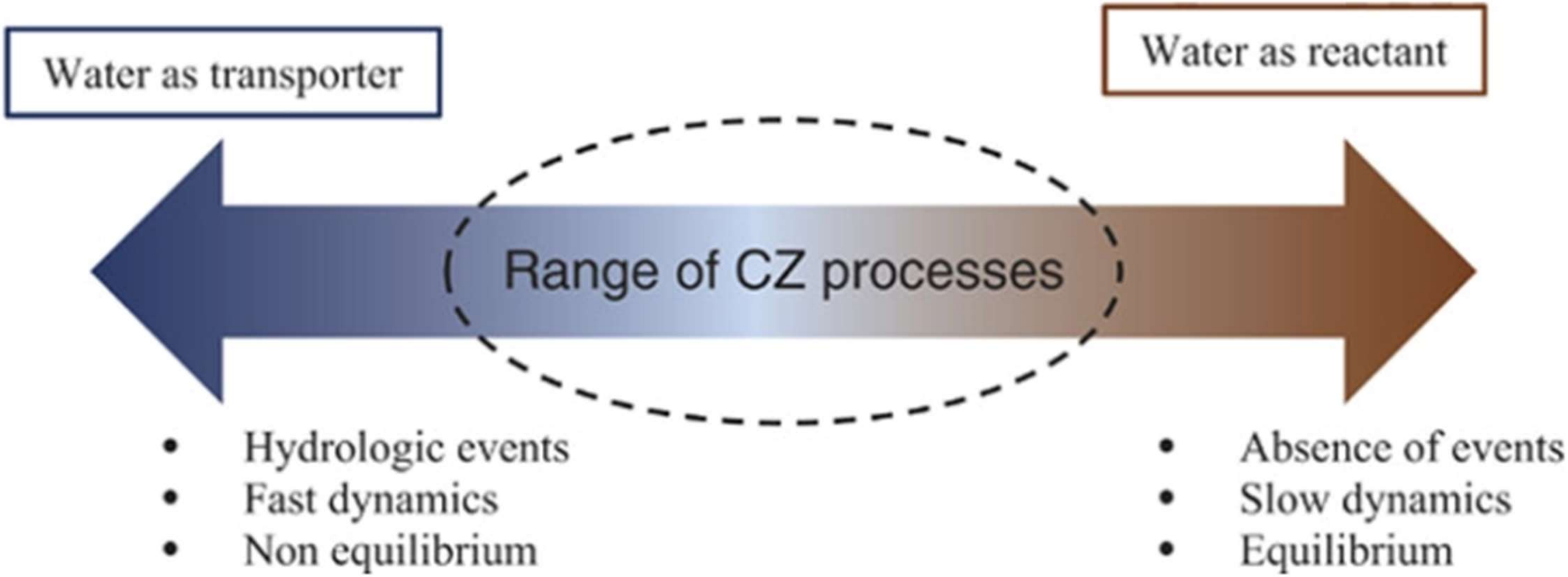
TABLE 2.1 Categories of Instrumentation and Measurements Made at the United States CZOs.

1. Land-atmosphere
   a. LiDAR datasets
   b. Eddy flux for momentum, heat, water vapor, CO_2
   c. Wind speed and direction sensors
   d. Solar radiation and temperature sensors
   e. Precipitation and through-fall samplers
   f. Wet and dry deposition samplers
2. Vegetation and associated microbiota
   a. Above- and below-ground vegetative and microbial composition
   b. Relations between ET and species composition and structure
   c. Soil/plant respiration, net ecosystem exchange
3. Soil (vadose zone)
   a. Solid phase (campaign sampling for spatial characterization)
   b. Elemental composition and mineralogy
   c. Texture and physical characterization
   d. Organic-matter content
   e. Stable and radiogenic isotope composition
   f. Fluid phase (sensors and samplers for time series)
   g. Soil moisture (sensors)
   h. Soil temperature (sensors)
   i. Soil-solution chemistry (samplers)
   j. Soil-gas chemistry (samplers/sensors)
   k. Rates of infiltration and groundwater flow
4. Saprolite and bedrock (saturated zone)
   a. Solid phase (campaign sampling for spatial characterization)
   b. Petrology and mineralogy
   c. Elemental-composition and organic-matter content
   d. Texture and other physical and architectural traits
   e. Fluid phase (sensors and samplers for time series)
   f. Potentiometric head and temperature (sensors)
   g. Groundwater chemistry (samplers/sensors)
   h. Gas chemistry (samplers/sensors)
5. Surface water
   a. Discrete and instantaneous discharge (flumes, weirs, with water quality sensors)
   b. Channel morphology
   c. Stream-water chemistry, dissolved and suspended (samplers/sensors)
   d. Sediment and biota (samplers/sensors)

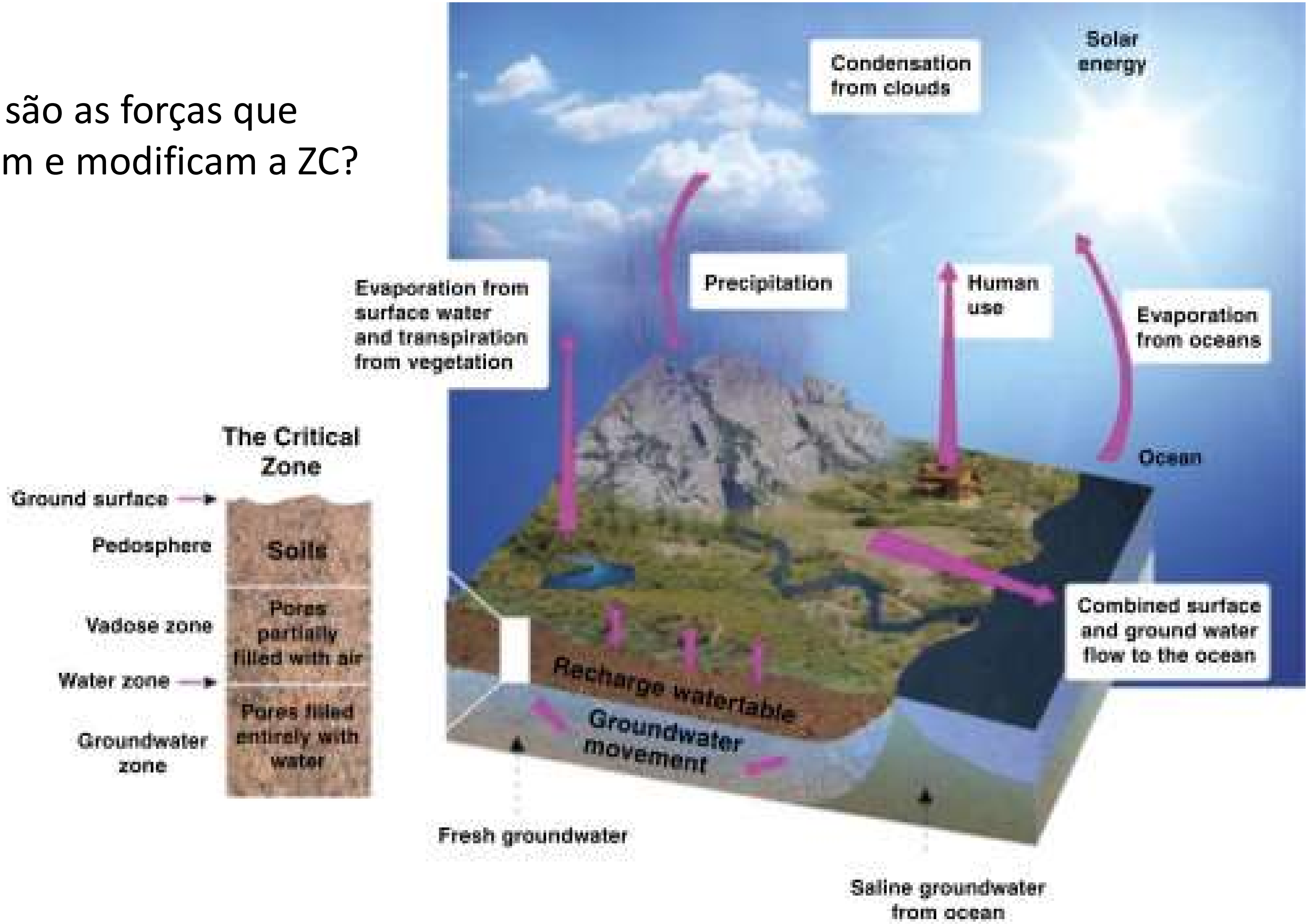


Processos locais e globais, na ampla escala do tempo

O papel da água nos processos biogeoquímicos nos solos

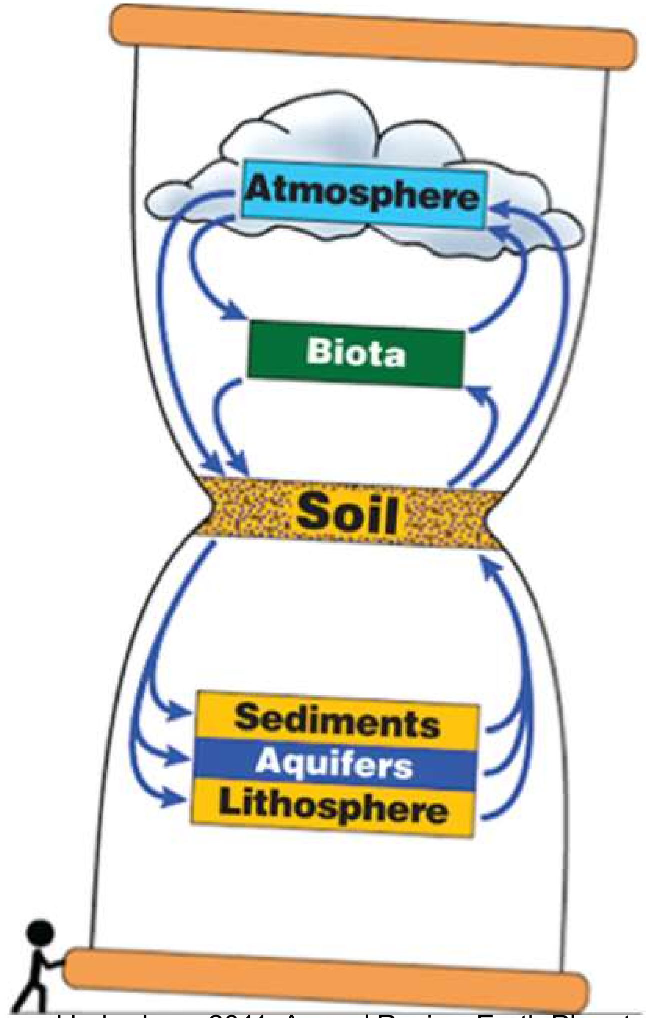


Quais são as forças que formam e modificam a ZC?

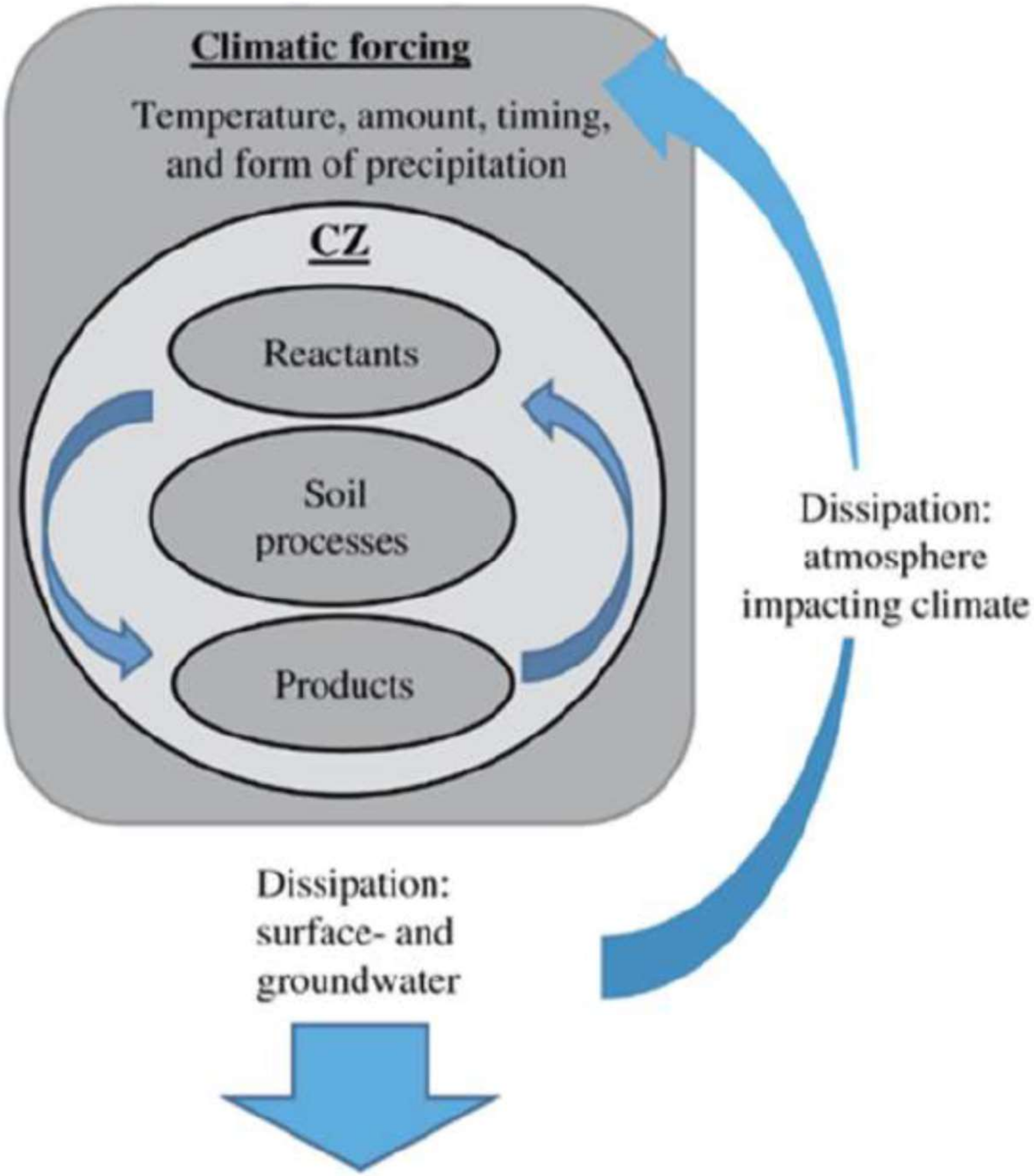


Somos inclusive uma “força geológica”

Quão rápido e como responde a forças antropogênicas, climáticas ou tectônicas, e como as escalas de tempo se ajustam?



Brantley and Lebedeva, 2011. Annual Review Earth Planetary Science



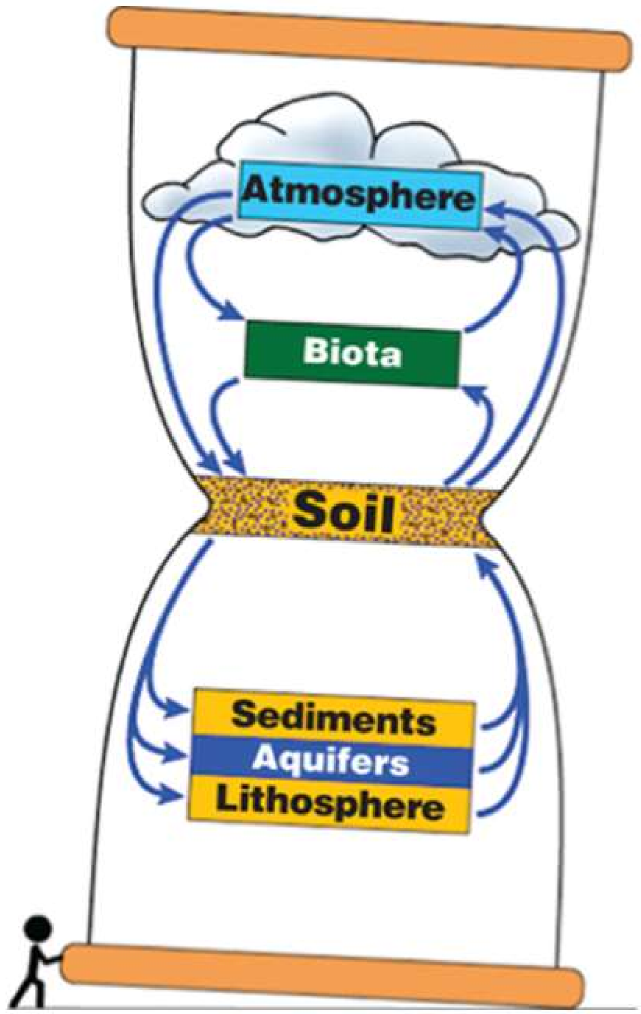
O clima afeta os processos biogeoquímicos do solo, que por sua vez afetam a composição da atmosfera, águas superficiais e subterrâneas

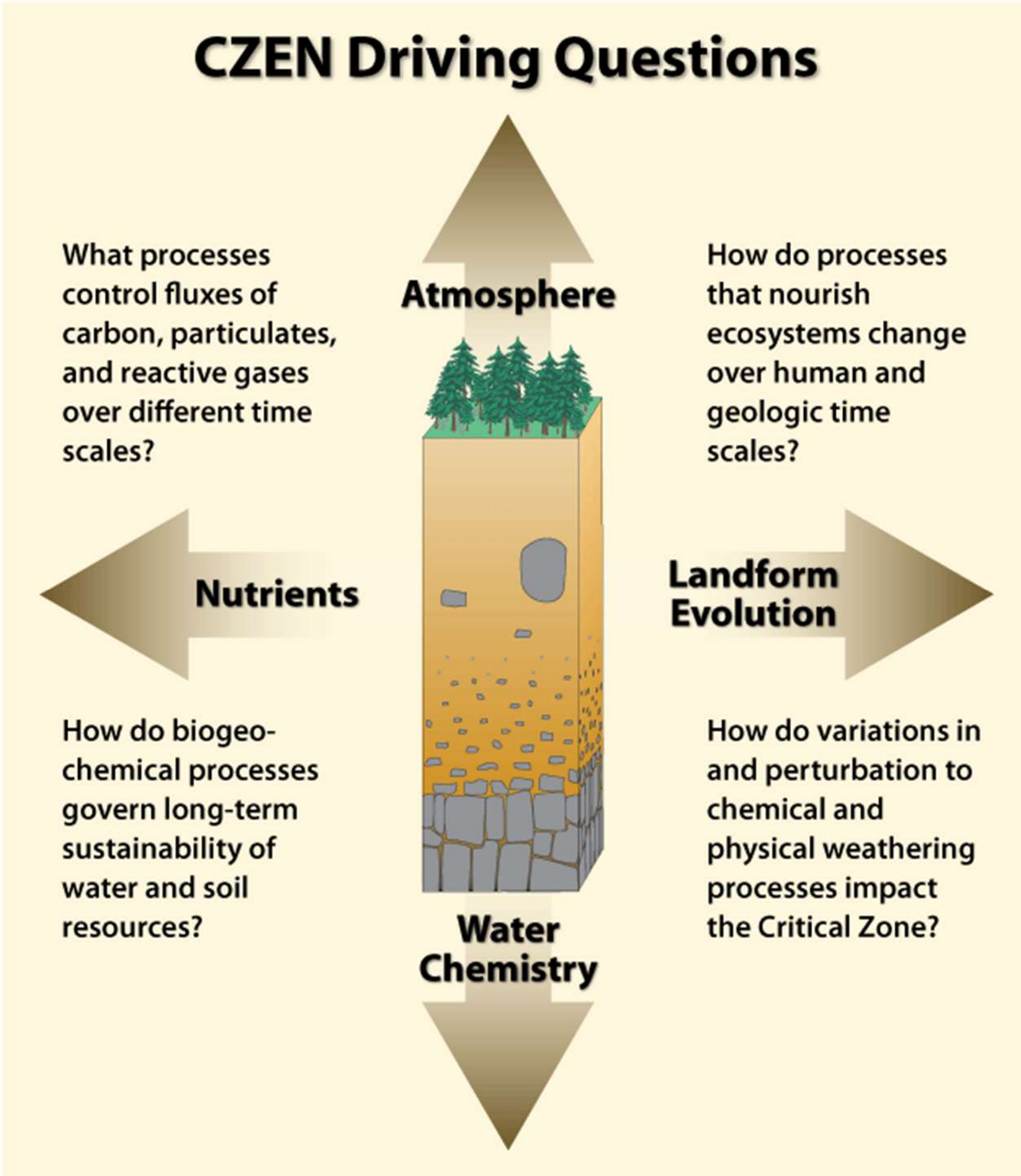
Mudanças na atmosfera afetam o clima

Questões fundamentais

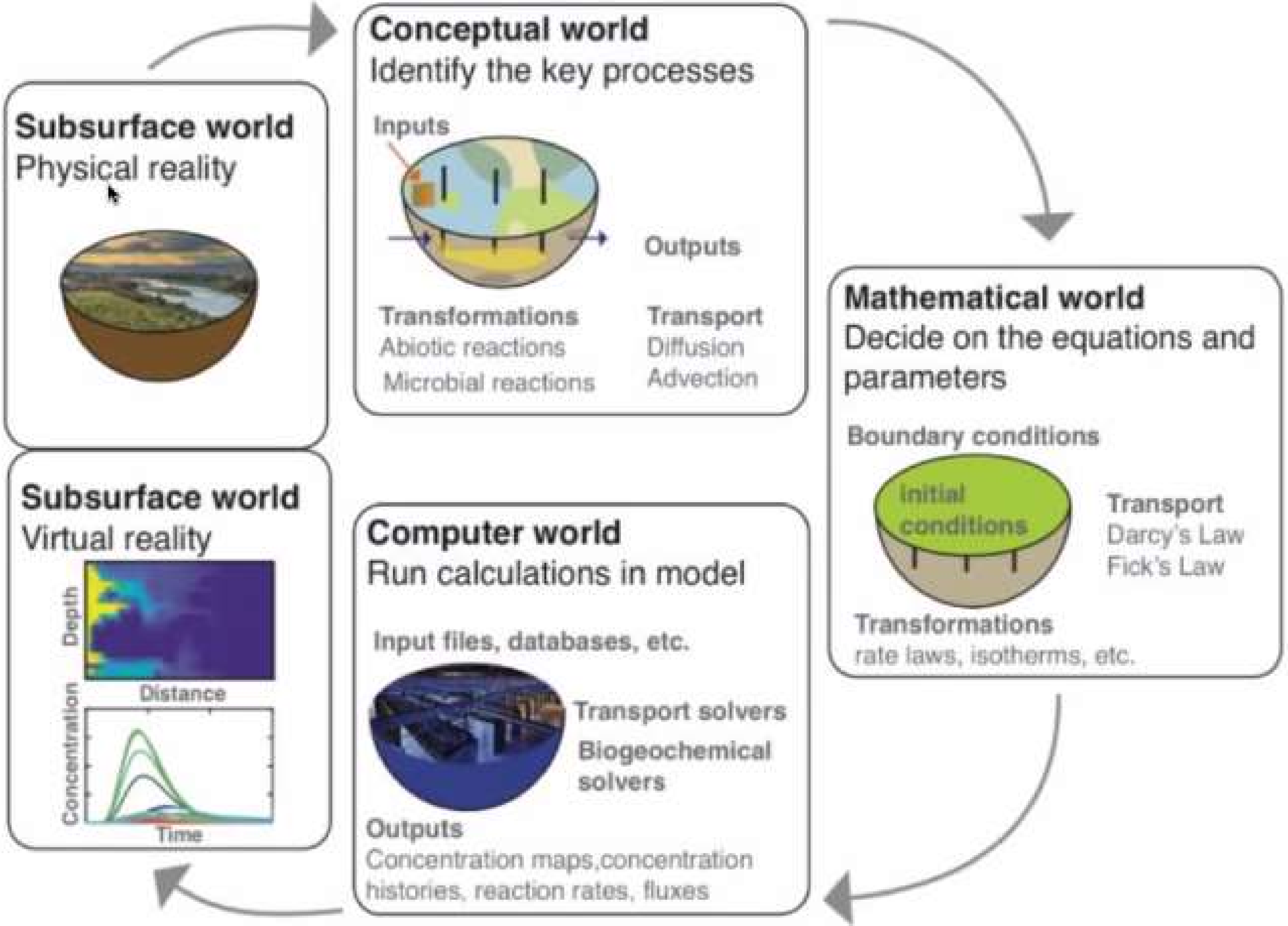
- ▶Como a ZC se forma?
- ▶Como a ZC opera?
- ▶Como a ZC evolui?

▶Como será que a ZC responderá as mudanças climáticas e outros impactos?



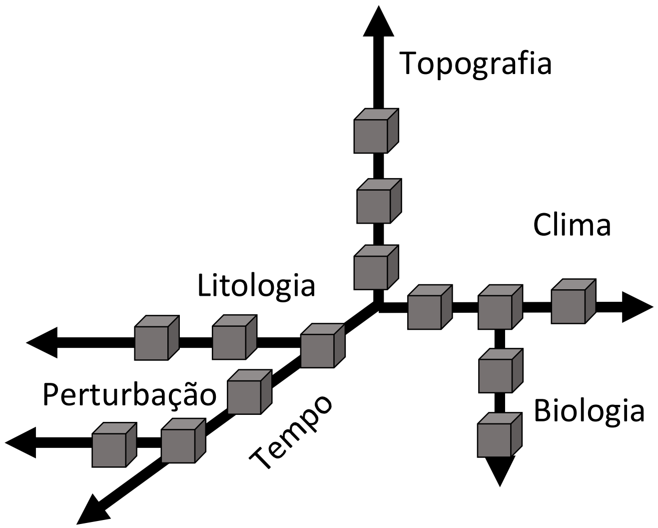

CZEN Driving Questions
What processes control fluxes of carbon, particulates, and reactive gases over different time scales?
Atmosphere
How do processes that nourish ecosystems change over human and geologic time scales?
Nutrients
Landform Evolution
How do biogeo-chemical processes govern long-term sustainability of water and soil resources?
Water Chemistry
How do variations in and perturbation to chemical and physical weathering processes impact the Critical Zone?

Será possível usar todas essas observações para desenvolver modelos e explorar como a ZC vai responder as forças antropogênicas, climáticas e tectônicas?

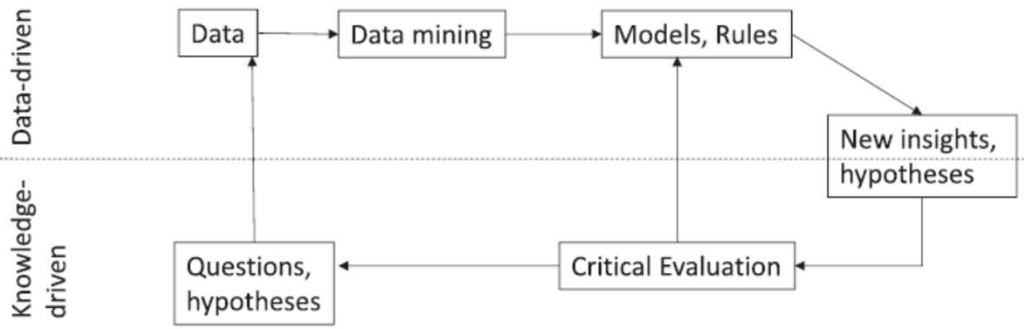


Desafio: os diferentes processos ocorrem em diferentes escalas espaciais e temporais

Redes de observação



Modificado de Brantley et al., 2007. Crossing disciplines to understand the critical zone



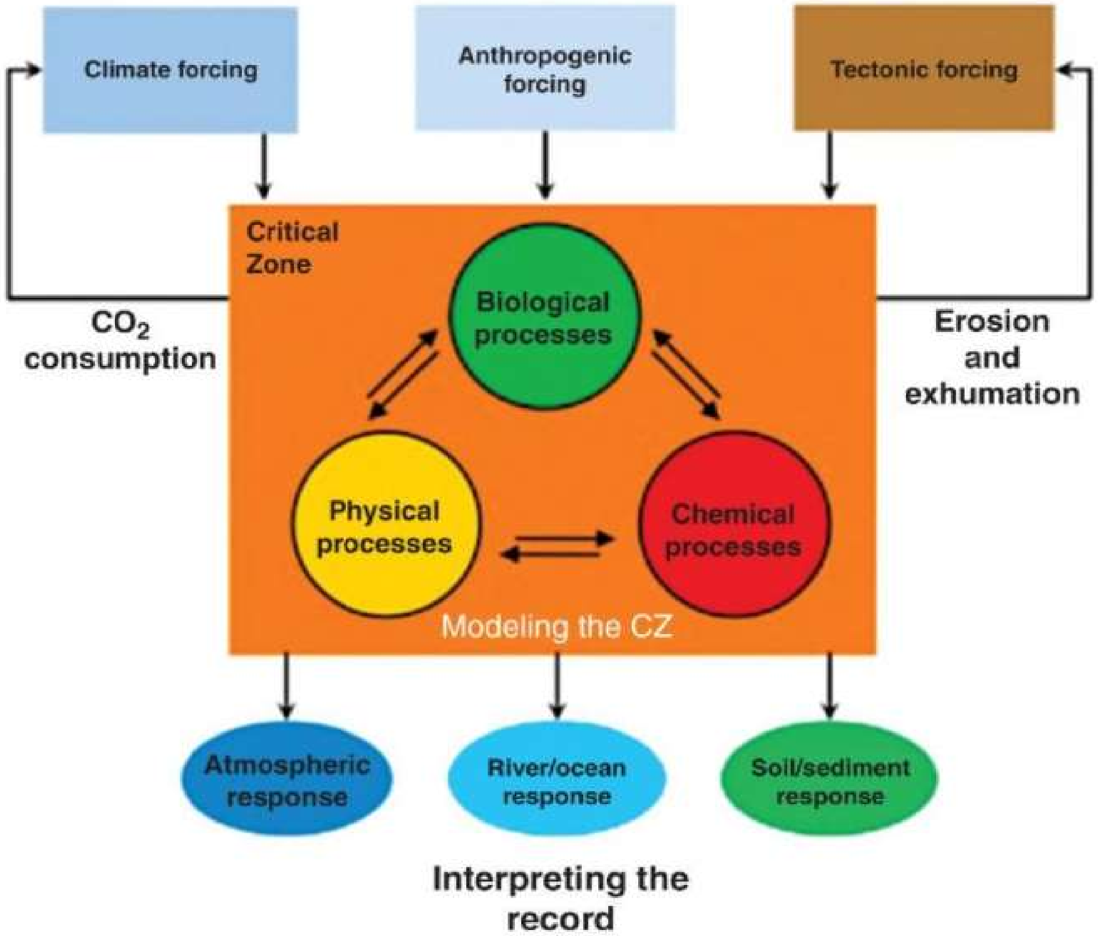
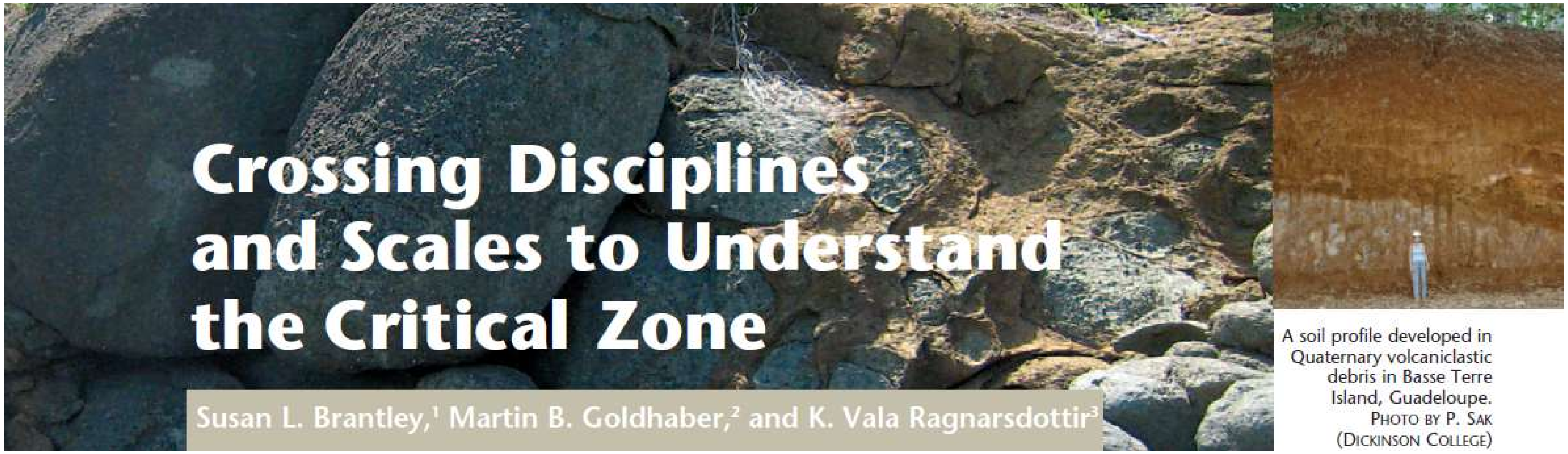


FIGURE 2.1 Physical, chemical, and biological processes in the Critical Zone (CZ) are subjected to climate, tectonic, and anthropogenic forcing that lead to responses in the atmosphere, biosphere, hydrosphere, lithosphere, and pedosphere. The challenge of CZ science is to interpret CZ processes over both short and long timescales: for example, CZ scientists attempt to understand sediment and soil records for comparison to changes in the CZ associated with ongoing climate and land-use change. *(From Brantley et al. (2007).)*

Discussão em grupos 2

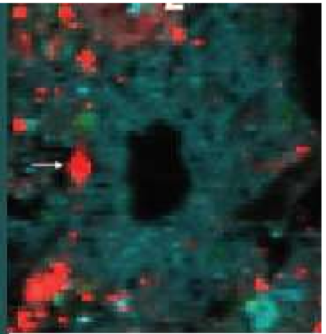


The challenge to cross disciplines and scales in understanding the CZ is a growing focus for scientists from geology, soil science, hydrology, environmental engineering, chemistry, and ecology.

By way of introduction to the CZ, we discuss in this paper the geochemical story written in the regolith, defined here as the weathered rock material overlying pristine bedrock, as documented by chemical gradients at the pedon scale.

We then describe the flux of materials through the CZ, and we conclude with a discussion of issues that transect disciplines and scales of time and space, as we think about CZ sustainability.

Soil Biogeochemical Processes within the Critical Zone



Jon Chorover,[1] Ruben Kretzschmar,[2] Ferran Garcia-Pichel,[3] and Donald L. Sparks[4]

In this paper, we emphasize the importance of soil *biogeochemical interfaces to internal CZ function* and focus on their effect on environmental pollutants.

Reactions that occur at the boundary between multicomponent solid, liquid, and gas phases in weathering systems are indeed critical to the capacity of the Earth's surface to sustain water and soil quality.

Removal of pollutants, sustainable provision of clean water, and support of productive ecosystems are all inextricably linked to the diversity and reactivity of natural interfaces formed by interaction of biota and water with lithogenic materials in the CZ.

Soil is central to food production, the regulation of greenhouse gases, recreational areas such as parks and sports fields and the creation of an environment pleasing to the eye. But soil is fragile and easily damaged by uninformed management or accidents.

One type of damage is contamination by chemicals that provide the lifestyles to which the developed world has become accustomed.

Traditional soil “clean-up” has entailed either simple disposal or isolation of contaminated soil. Clearly this is not sustainable.

Modern remedial techniques apply mineralogical and geochemical knowledge to clean up contaminated soil and make it good for reuse, rather than simply discarding this precious and finite resource.

Organic Amendments for Remediation: Putting Waste to Good Use

David L. Jones and John R. Healey*

Using organic wastes as a sustainable remediation option not only helps divert another waste stream from landfill but also provides a simple remediation technology that has the potential for widespread adoption.

We review the main types of organic waste currently available, the range of contaminants they can treat and their practicality.

As the long-term success of any remediation strategy depends on more than just technical factors, we also assess the environmental,

economic, social and cultural sustainability of organic wastes in land restoration.

Last, we look to the future and speculate on what lies ahead, in particular, the translation of research into industry practice.