Regolith

What's all that about?

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What is Regolith?

- Regolith is a word derived from:
  - *rhegos* (Gr.) = blanket or cover; and,
  - *lithos* (Gr.) = rock.
- Regolith literally means *"rock blanket"*.

What is Regolith?

- Term introduced by Merrill (1897).
- Redefined in Eggleton (2001):

"The entire unconsolidated or secondarily recemented cover that overlies coherent bedrock, that has been formed by weathering, erosion, transport and/or deposition of older material. The regolith thus includes fractured and weathered basement rocks, saprolites, soils, organic accumulations, volcanic material, glacial deposits, colluvium, alluvium, evaporitic sediments, aeolian deposits and groundwater."

- Or *"Everything between fresh rock and fresh air"!*

What is Regolith?

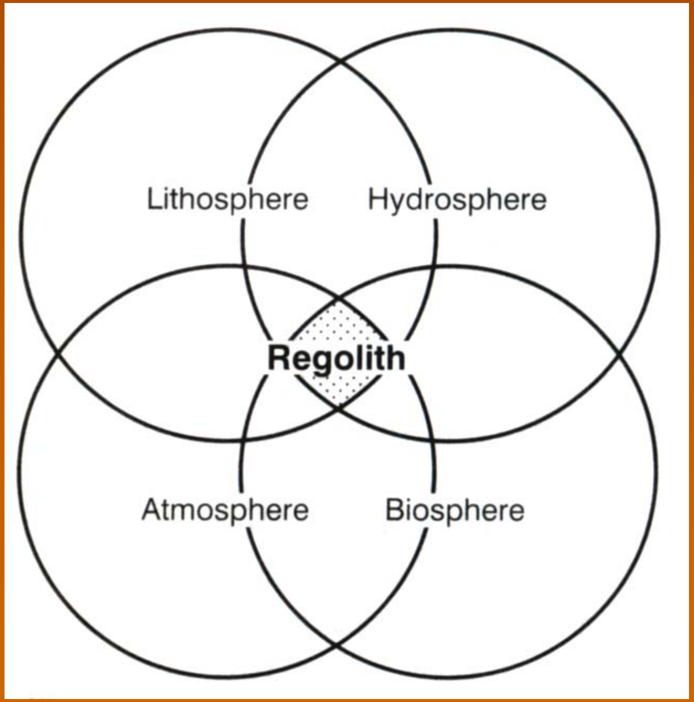
- Rowley Twidale (1990):

"The Regolith is a mass of weathered material that is charged with salts and biota....it is a suppurating mass that gradually consumes any blocks enclosed within it, and is gradually gnawing away at....the bedrock. In general, the regolith is a discontinuous, festering veneer…". In: *Groundwater Geomorphology*. Geological Society of America Special Publication 252.

- Is there an image problem here?

What is Regolith?

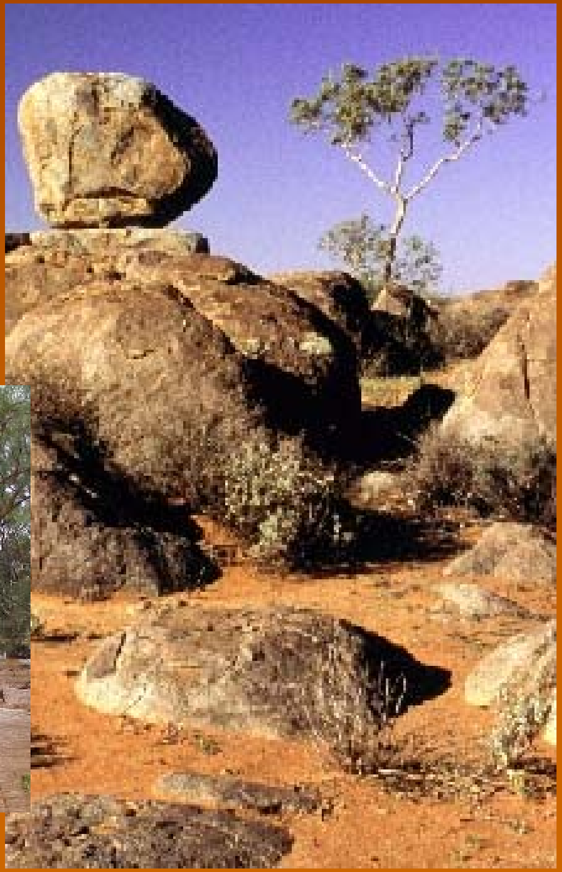
- What is regolith geoscience?
  - The science of the regolith and the landscapes in which it occurs.
  - The study of the inter-relationships between:
    - The Lithosphere;
    - The Hydrosphere;
    - The Atmosphere;
    - The Biosphere



Modified after Taylor & Eggleton 2001

What is Regolith?

- It is everything between fresh rock and fresh air.
- It includes:
  - weathered rock;
  - eruptive volcanic materials;
  - sediments;
  - gasses;
  - water;
  - biota.



Regolith includes:

- Weathered rock:
  - physically weathered rock - fragments of the original;
  - chemically weathered rock - new minerals, solutions and resistate minerals;
  - at the earth's surface;
  - within solid, unweathered rock bodies around fractures and joints within the earth.

Regolith includes:

- Sediments - mainly unconsolidated:
  - various environments - *fluvial, slope deposits, lacustrine, marine, aeolian, glacial;*
  - may be physico-chemical:
    - Those derived by processes associated with:
      - Eh (electron potential) or redox reactions;
      - pH (hydrogen potential, or acid-base) changes;
      - saturation (evaporation).
    - biochemical.
  - may be detrital:
    - distribution controlled by hydraulics of water, air and ice.

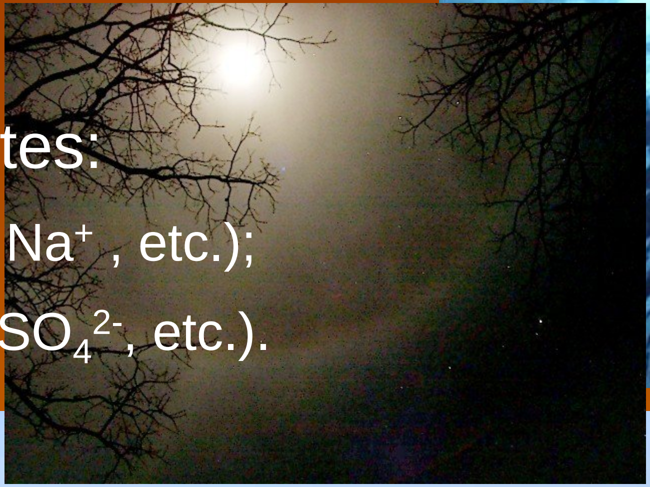
Regolith includes:

- Volcanic materials - fresh or weathered:
  - loose ash;
  - welded ash (ignimbrite);
  - lava;
  - hyaloclastite (explosively disrupted lava formed in water bodies).

Regolith includes:

- Gasses:
  - most soil and regolith gasses are different in composition to surface air:
    - < O_2;
    - > N_2, CH_4, H_2O.

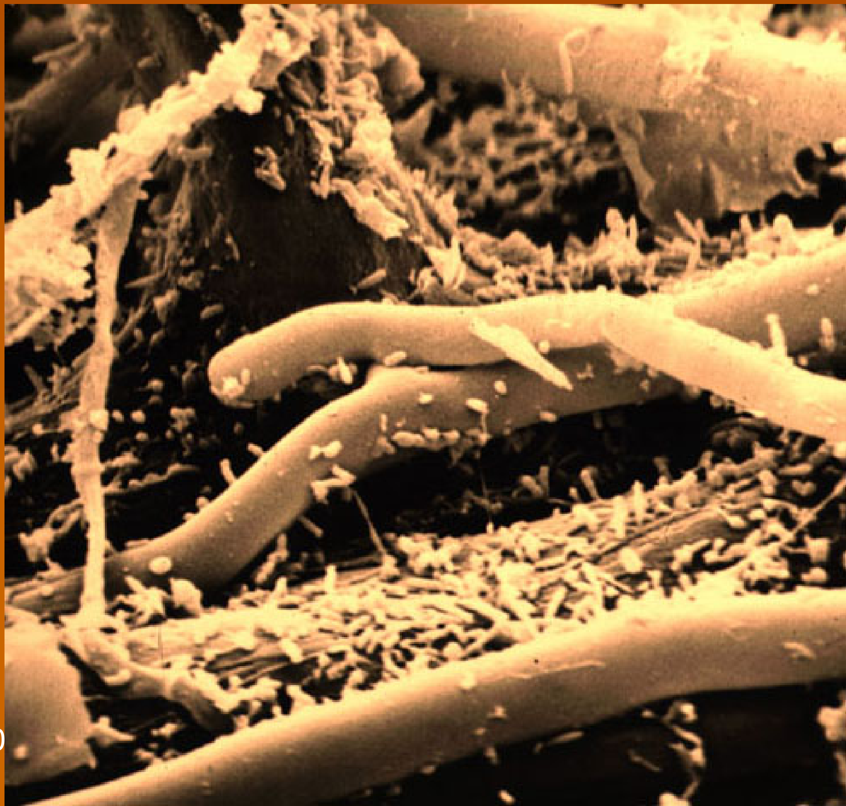
Regolith includes:



- Water:
  - contains many solutes:
    - cations (Fe^{2+}, Ca^{2+}, Na^{+} , etc.);
    - anions (Cl^{-}, HCO^{3-}, SO_4^{2-}, etc.).
  - aerosols.

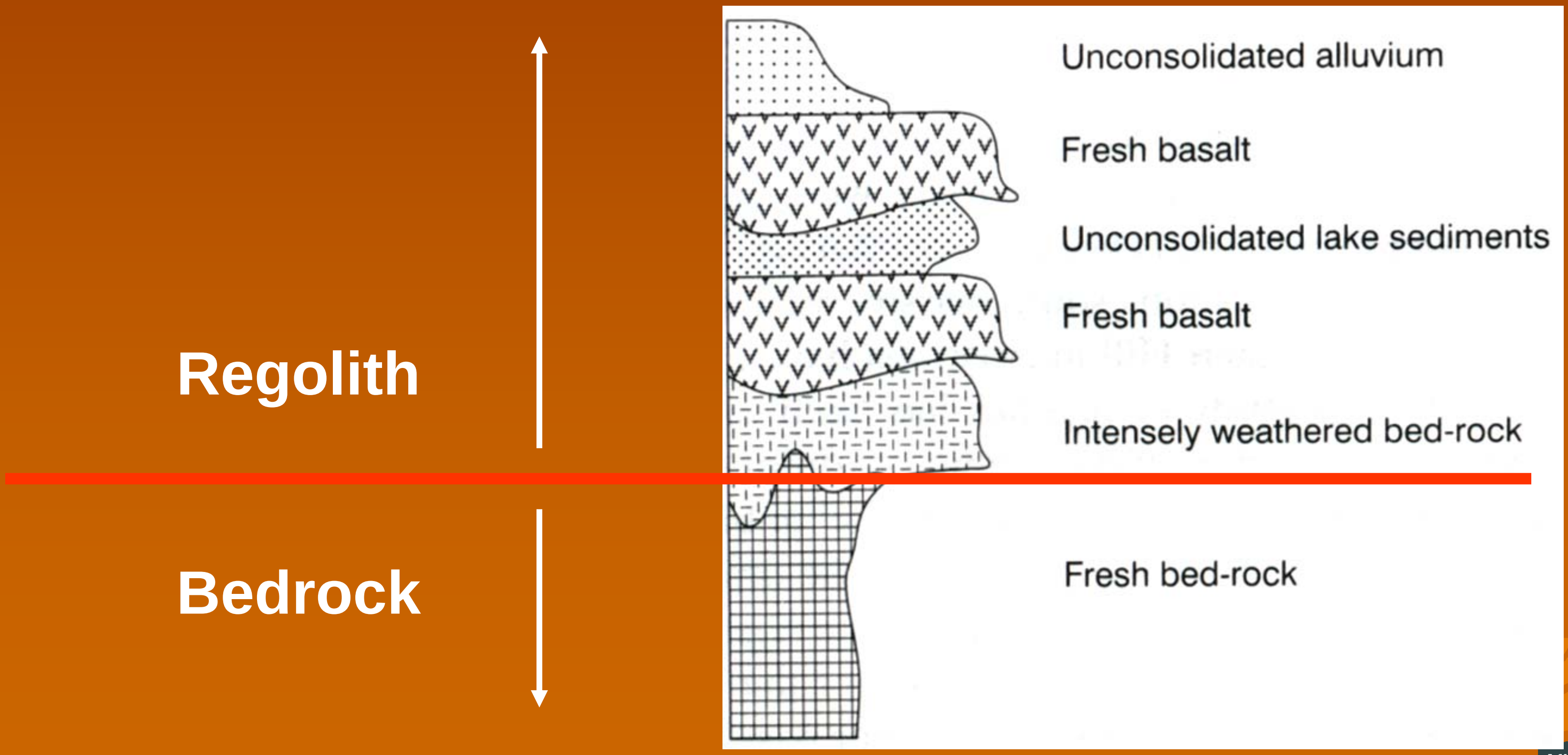
Regolith includes:

- Biota—an important and major part of the regolith.
- A wide variety of both "bugs" and plants occur including:
    - plant roots;
    - invertebrates (termites, worms, ants, etc.);
    - micro-organisms (diatoms, bacteria, fungi, etc);
    - occasional vertebrates (wombats, rabbits, etc.).
- Biota both physically and chemically affect the regolith.

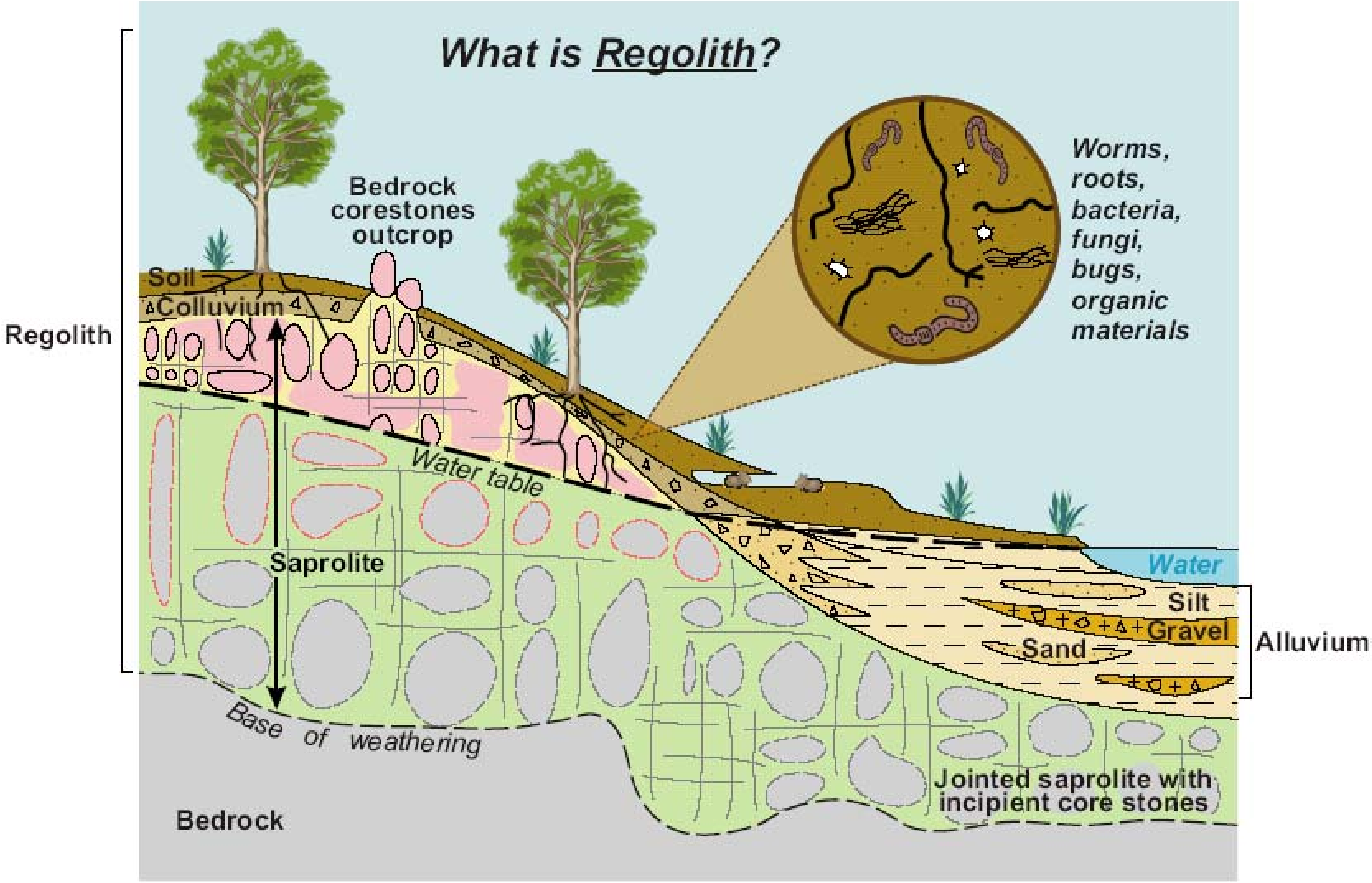


What is Regolith?

- Having said that, which is the regolith here...?

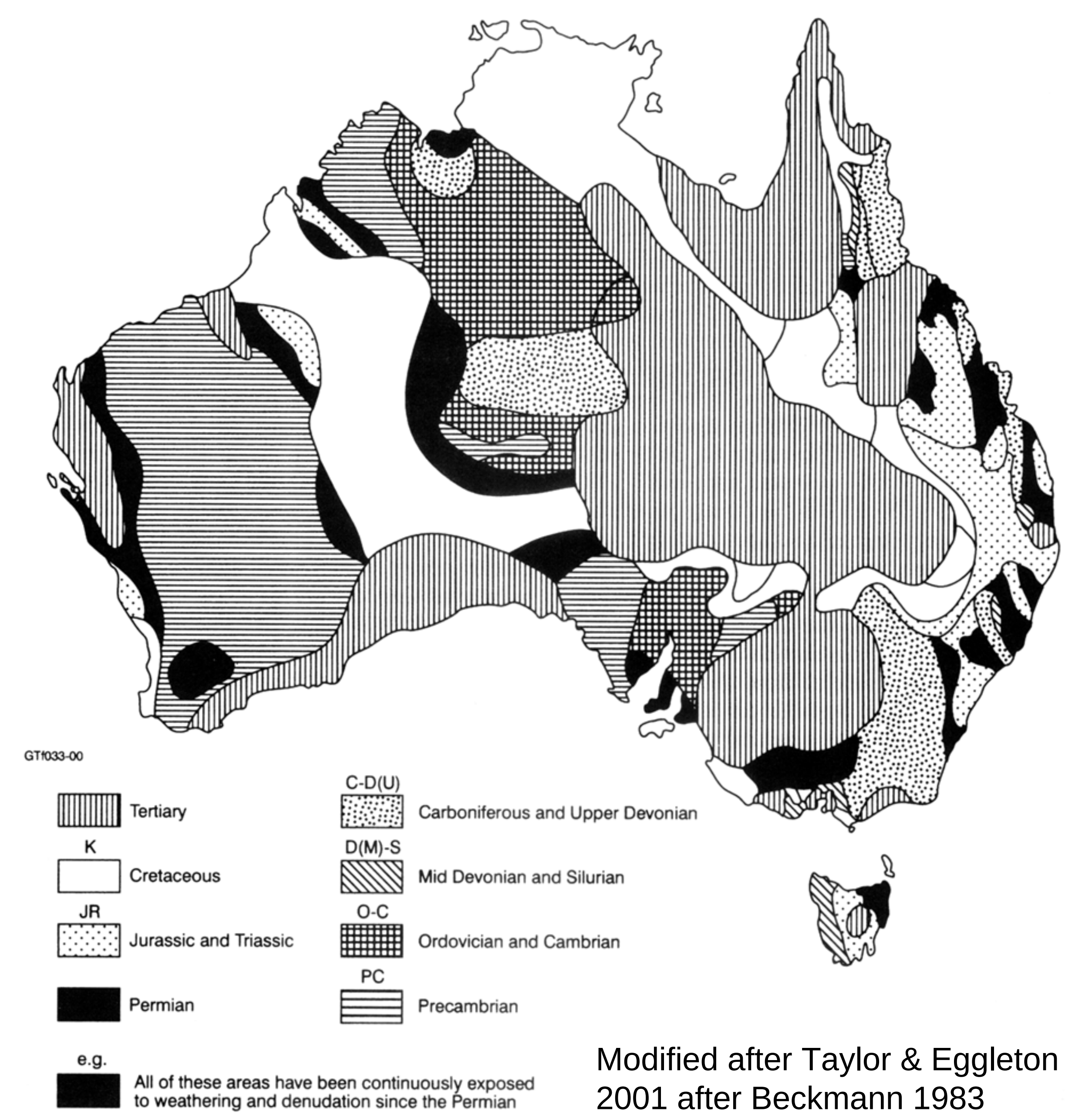


 Modified after Taylor & Eggleton 2001


What is Regolith?
Regolith
Bedrock corestones outcrop
Worms, roots, bacteria, fungi, bugs, organic materials
Soil
Colluvium
Water table
Saprolite
Water
Silt
Gravel
Sand
Alluvium
Base of weathering
Bedrock
Jointed saprolite with incipient core stones

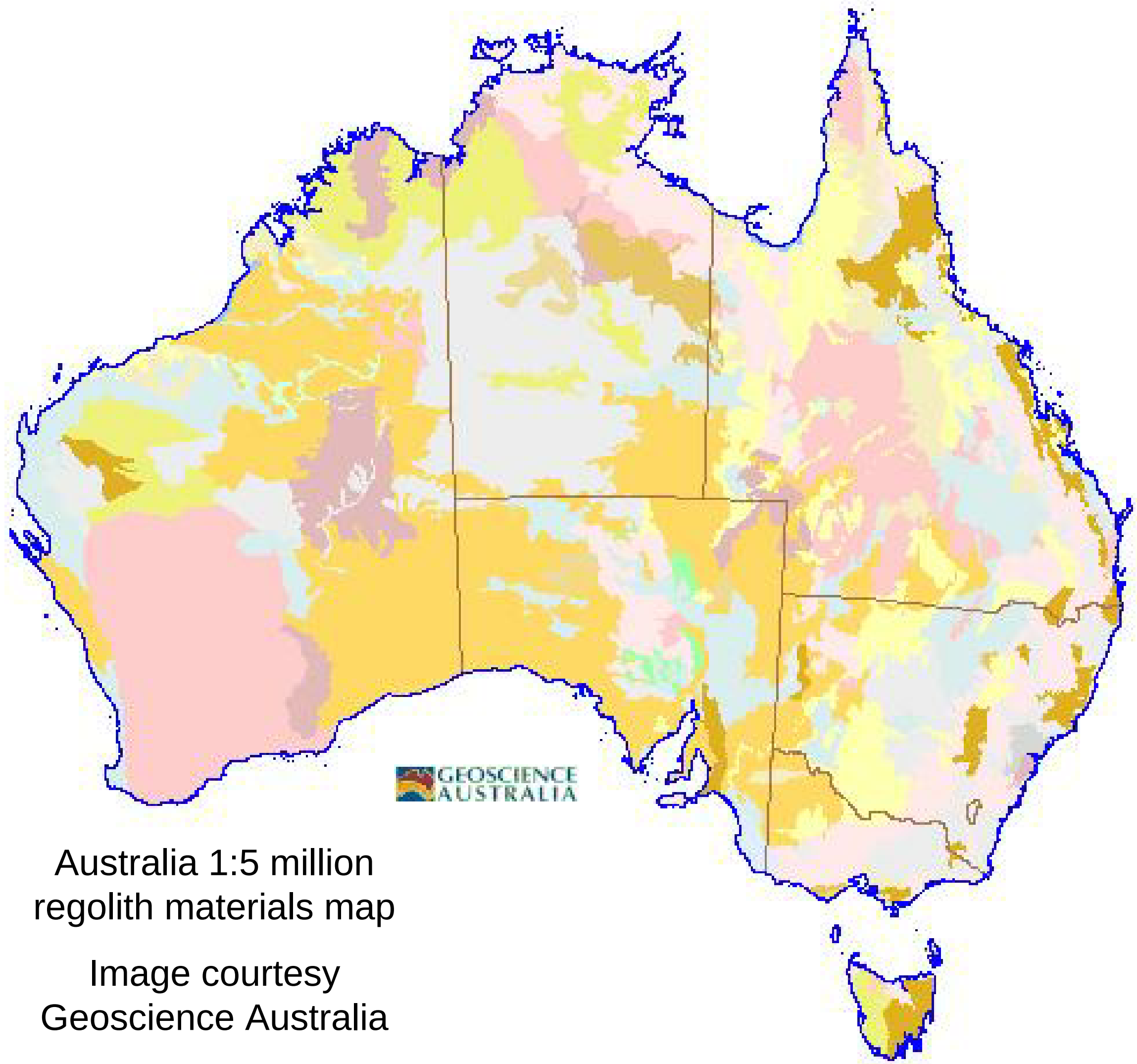
Where is Regolith?

- No easy answer.
- In Australia, regolith is *everywhere.*
- All of Australia has been exposed to weathering since the Tertiary, but some may be *much* older.



Modified after Taylor & Eggleton 2001 after Beckmann 1983

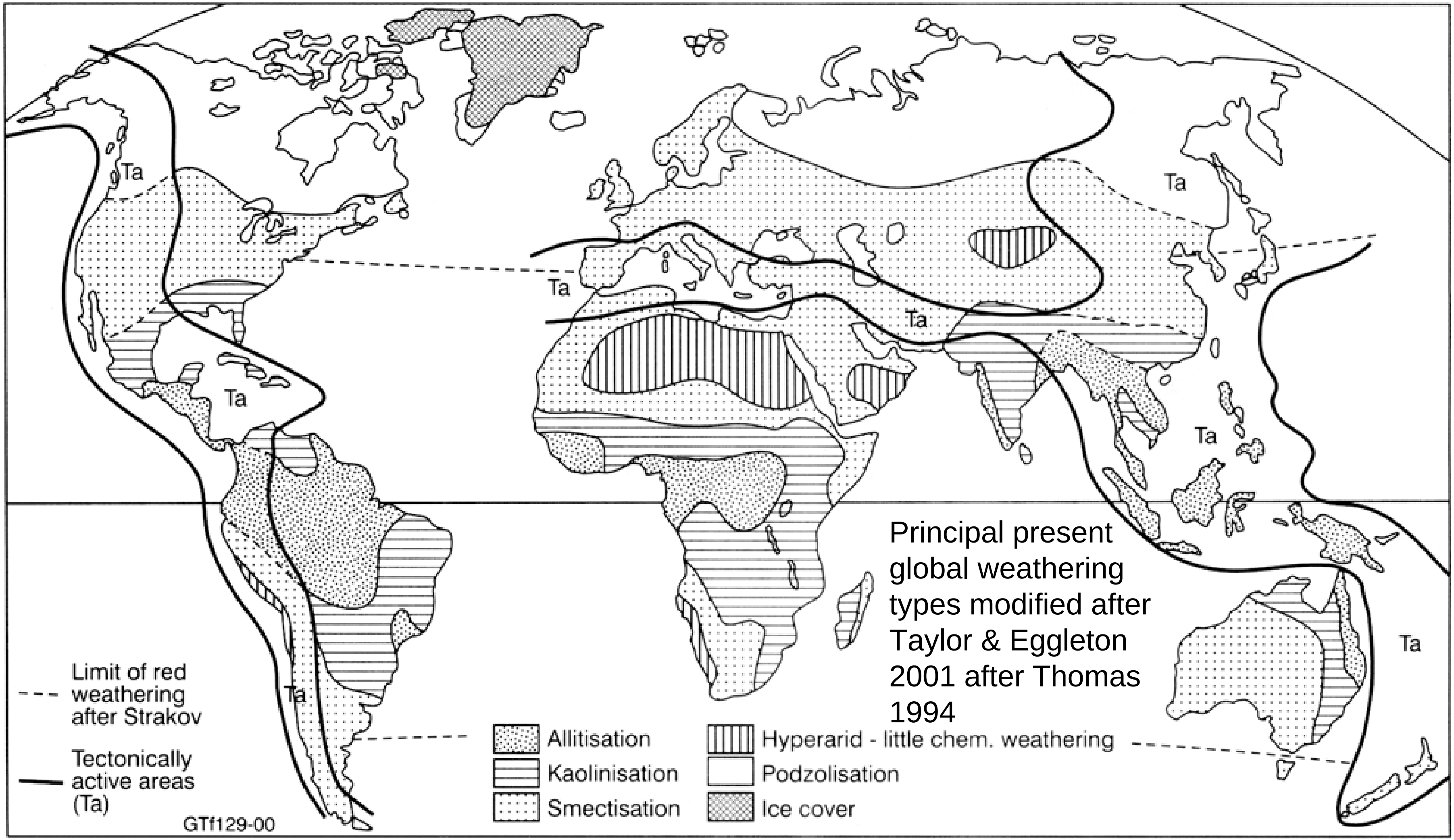
Where is Regolith?



Australia 1:5 million regolith materials map

Image courtesy Geoscience Australia

Where is Regolith?



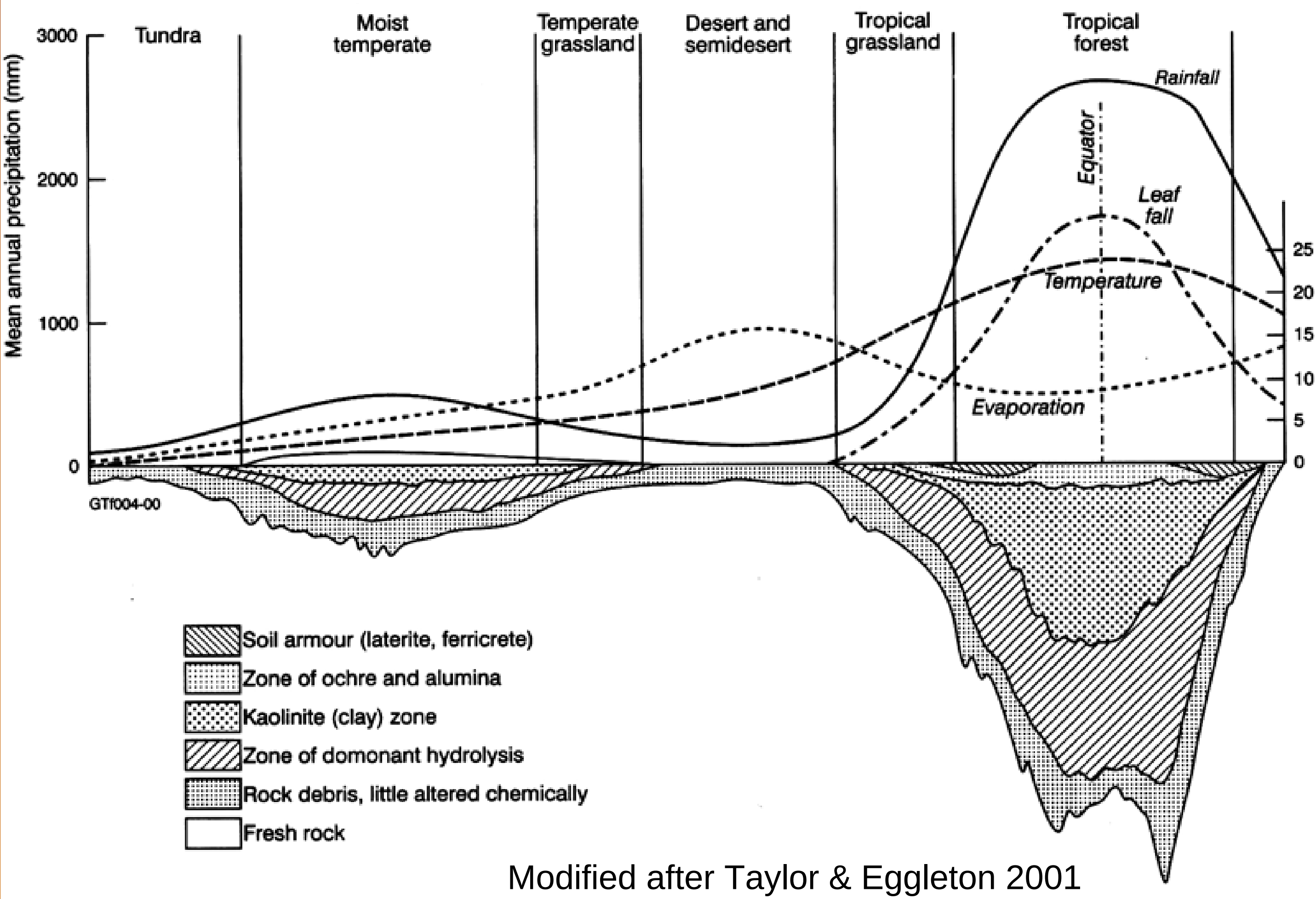
Principal present global weathering types modified after Taylor & Eggleton 2001 after Thomas 1994

Where is Regolith?

- Regolith is *everywhere.*
- Modern regolith processes are principally climate-controlled (except in areas with strongly active tectonics), thus similar weathering processes are occurring at similar latitudes, e.g., Australia, Southern Africa and South America, North America, Europe and Russia.
- Regolith may be modified by geologically recent events such as large-scale glaciation (North America, Europe, Russia) or desertification (North Africa, Middle East).

Regolith and climate

- Strakhov (1967) described distribution & depth of weathering on a global scale. This is a reasonable 1st approximation of global regolith distribution.



Modified after Taylor & Eggleton 2001

Figure 1.4 *Weathering mantles and climate. The effects of climatic change are ignored in this summary (after Strakhov 1967)*

Regolith and climate

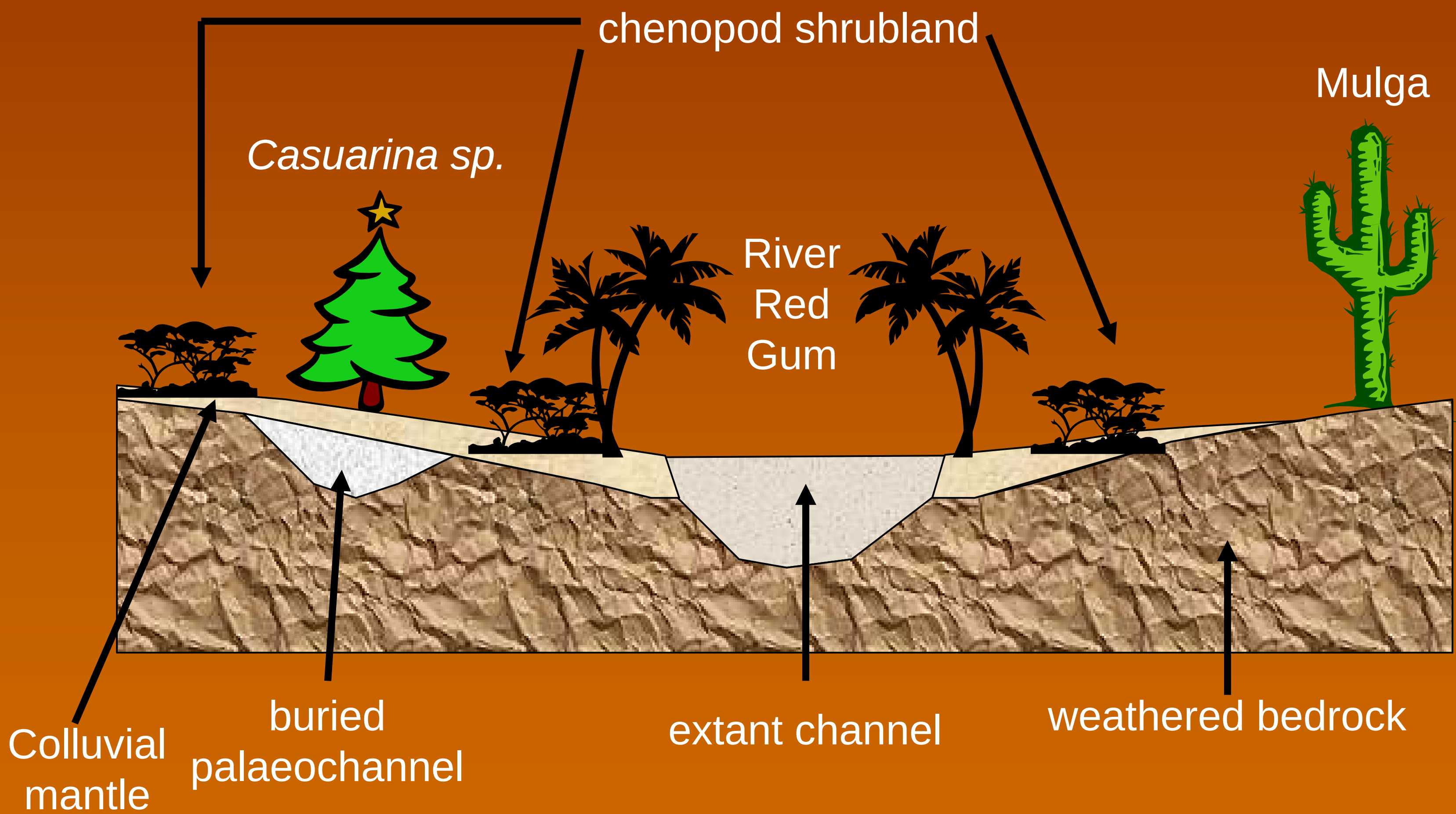
- Most studies of global regolith distribution are climate-based; this is a major shortcoming.
- You will see that much of the regolith preserved in Australia is relict—it is not related to the current climate.
- Strakhov assumed tectonic stability and that regolith was thicker where climates are warmer and wetter.
- Reality tells us that regolith preservation is controlled largely by (neo)tectonics and that the present is not necessarily the key to the past!

Why study Regolith?

- Now, having been through all of that…

  What possible advantage would a knowledge of regolith have for you?

Ecology and biodiversity



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National Parks

- Most national, etc., parks depend on scenery and/or ecological niches for their existence:
  - Wilsons Promontory - dissected Cretaceous ? weathering profiles with younger weathering and materials;
  - Kosciuszko - dissected planated and uplifted Mesozoic? land surface;
  - Uluru - desert landscapes, monoliths;
  - Kakadu - Quaternary and Proterozoic landscapes and ecology;
  - Yosemite - glacial landscapes with active uplift due to hotspot volcanism;
  - Stonehenge - regolith materials (sarsen stones or silcrete).

Natural Resource Management

- Recent regolith work in Central western NSW:
    - salts shown to be largely aeolian, minor rock weathering;
    - salts stored in weathered rock (regolith);
    - salt released by rising groundwaters;
    - groundwater flow controlled by buried landscapes.
- Understanding salinity depends on
    - weathering history;
    - landscape evolution;
    - climate past and present;
    - realization that Australia has always been salty.

Greenhouse

- As rocks weather they consume CO_2:
  - they tend to become carbonated at Earth's surface, especially under arid conditions.
- Additional CO_2 creates additional carbonic acid, creating more weathering.
- Weathering buffers greenhouse in the long term.

Engineering

- 2:1 lattice clays and self-mulching clay soils expand when wetted (smectite 9.6 Å dry - 15.5 Å wet), strong pressures are developed during wetting/drying.
- Optical fibre cable laying is a problem; cables can be progressively strained and snapped in swelling soils.
- Building foundations in swelling ground must be specially treated.
- Road pavement stabilization a problem in areas with swelling ground.
- Aggregate from regolith materials for road/rail base (silcrete, calcrete, ferricrete). Each with own problems.

Agriculture

- All agriculture occurs within the regolith
- What about hydroponics?
  – *Where do they get their fertilisers from?*
- Agriculture strongly relies on the upper part of the regolith, *soil*.
- Regolith studies are crucial for soil management:
    - Stability/erodability;
    - Salinity issues;
    - Plant health (soil nutrient deficiencies/overabundances).

Mineral exploration

- Positive effects of regolith processes:
  - larger target halo;
  - Useful sampling media:
    - Regolith carbonates and Au;
    - Ferruginous regolith and base metals/Au/PGE;
    - Biota and base metals/Au/PGE
- Negative effects of regolith processes:
  - deposits hidden by transported regolith.
- Need to first understand regolith structure and landscape relationships, then choose appropriate sampling media and exploration strategies.

Resources

- Regolith-derived natural resources:

Commodity	Reserves	Production (t)	Export Value ($M)
Bauxite	5.7x10^{9}[a]	56.6x10^{6}[a]	$126[a]
Alumina	na	16.7x10^{6}[c]	$4,110[c]
Gold[+]	5,589t[a]	258[c]	$5,551[c]
Iron ore	14.6x10^{9}t[a]	234x10^{6}[c]	$8,101[c]
Magnesite	930x10^{6}[a]	3.83x10^{6}[a]	na
Manganese	133x10^{6}[a]	3.4x10^{6}[c]	$399[c]
Diamond	59x10^{6}c[a]	20.6x10^{6}c[c]	$456.1[c]
Clays	na	59.7x10^{3}[c]	$12.4[c]
Gypsum	na	3.94x10^{6}[b]	$15.1[c]
Opal	na	na	$47.28[c]
Alluvial sapphires	na	na	$1.08[c]
Ilmenite	217x10^{6}t[a]	1.93x10^{6}[c]	$77.0[c]
Rutile	20.2x10^{6}t[a]	163x10^{3}[c]	$98.2[c]
Zircon	30x10^{6}t[a]	441x10^{3}[c]	$285[c]
Salt	na	11.2x10^{6}[c]	$194.6[c]
			$19,473.76

[a]GA 2005 mineral resources figures, [b]ABARE 2003, [c]ABARE 2006, otherwise 1996 BRS extractable resources figures [+]includes supergene ores.

So there you have it...

- Life on earth evolves around the evolving regolith.
- We rely on the regolith to maintain our daily needs.
- In weathered terrains we need to explore within and underneath the regolith for mineral deposits.

- We need to understand the regolith to sustainably manage our natural resources.

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