



Detecting deep rock weathering

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1. Introduction

The weathering front is the interface between weathered rock and pristine bedrock. In this zone, chemical dis-equilibrium results in intense mineralogical and geochemical transformations.

Its depth is poorly known due to the inaccessible nature deep beneath the Earth's surface. Studies in humid and temperate climate suggest a maximum depth of 20 m in granitoid rocks [1]. In semi-arid climates, the depth of the weathering front is largely unknown.

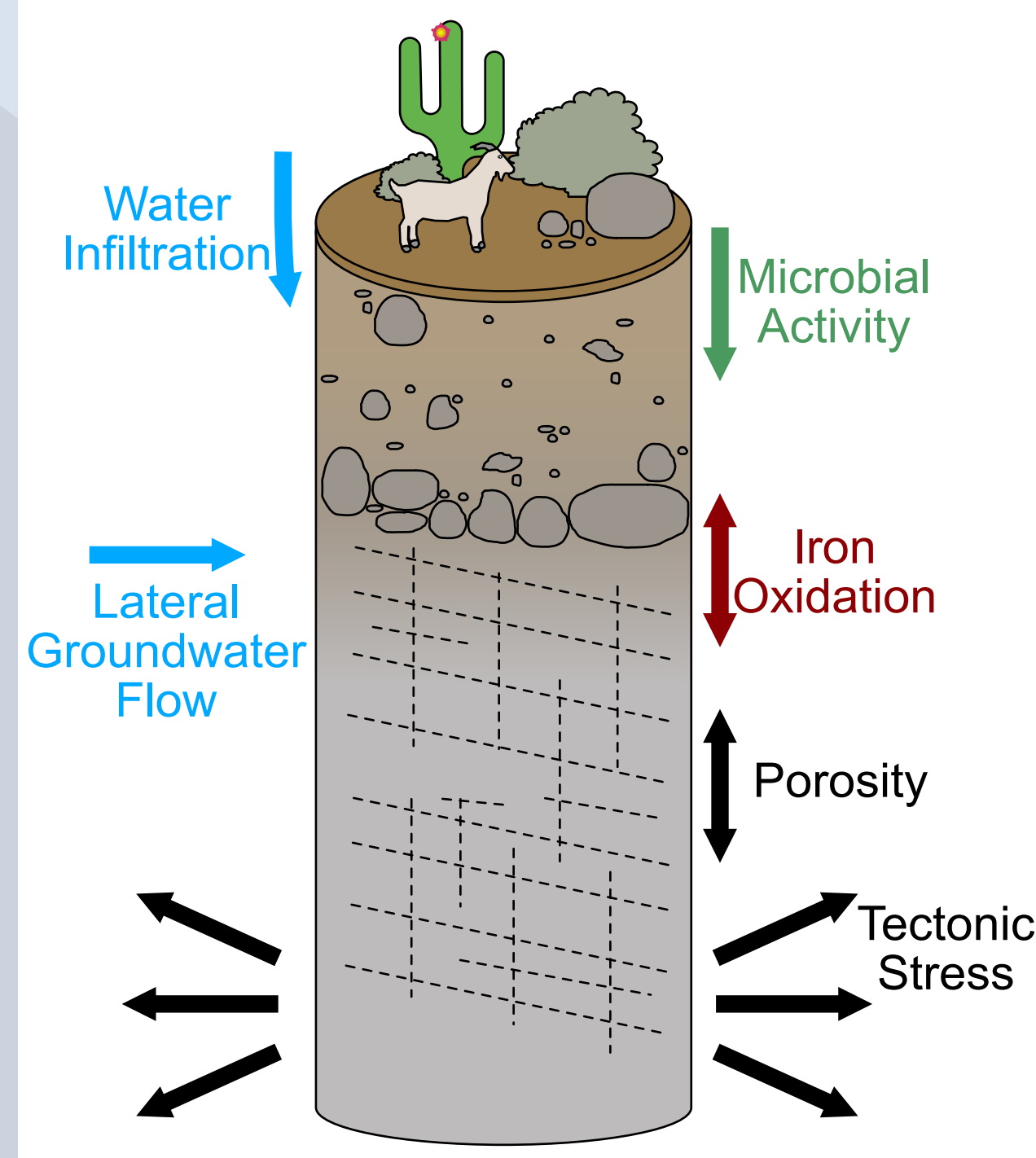
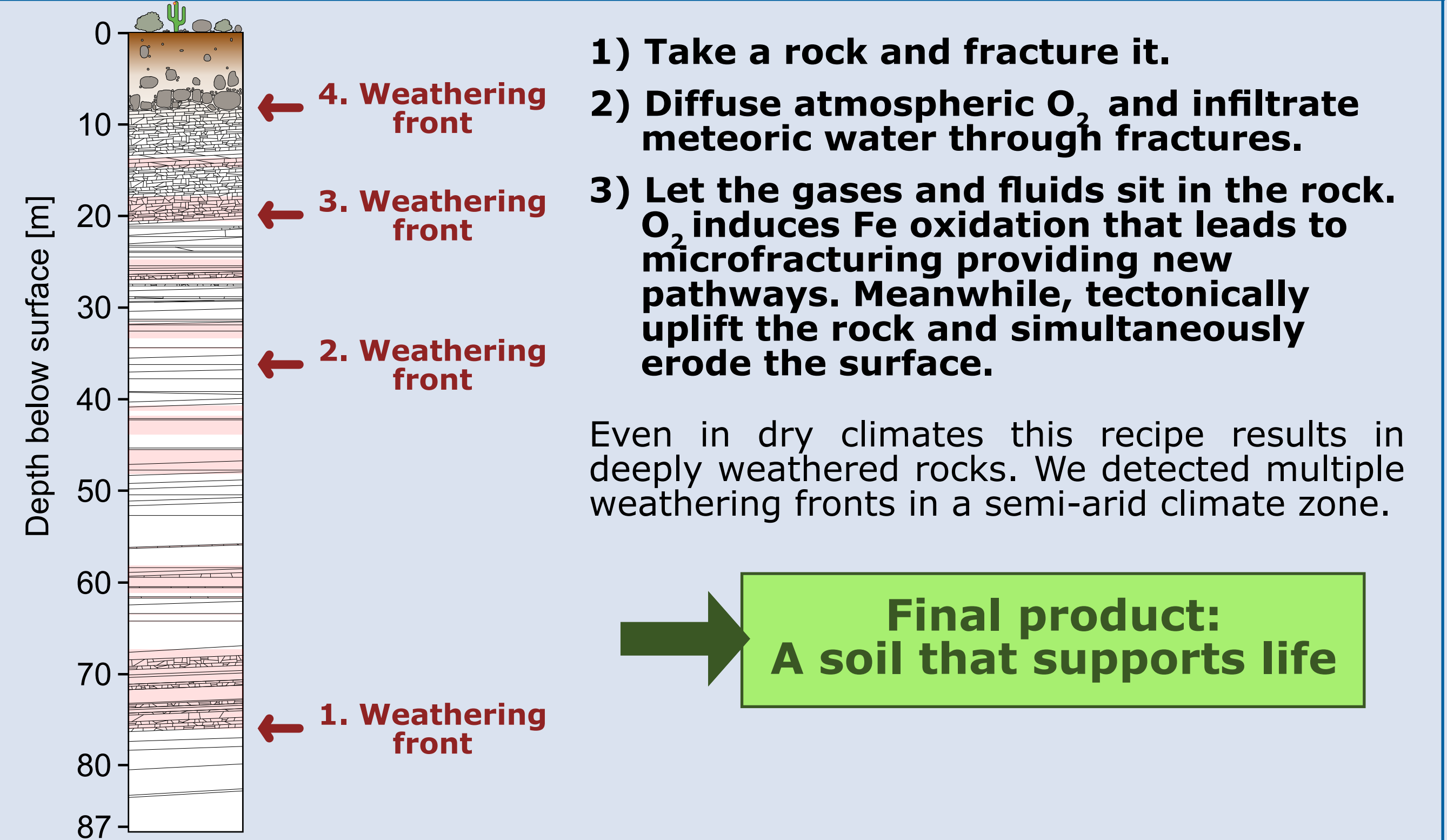


Fig. 1 Processes involved in setting the depth of the weathering front.

7. Recipe for weathered rock



2. Geological setting

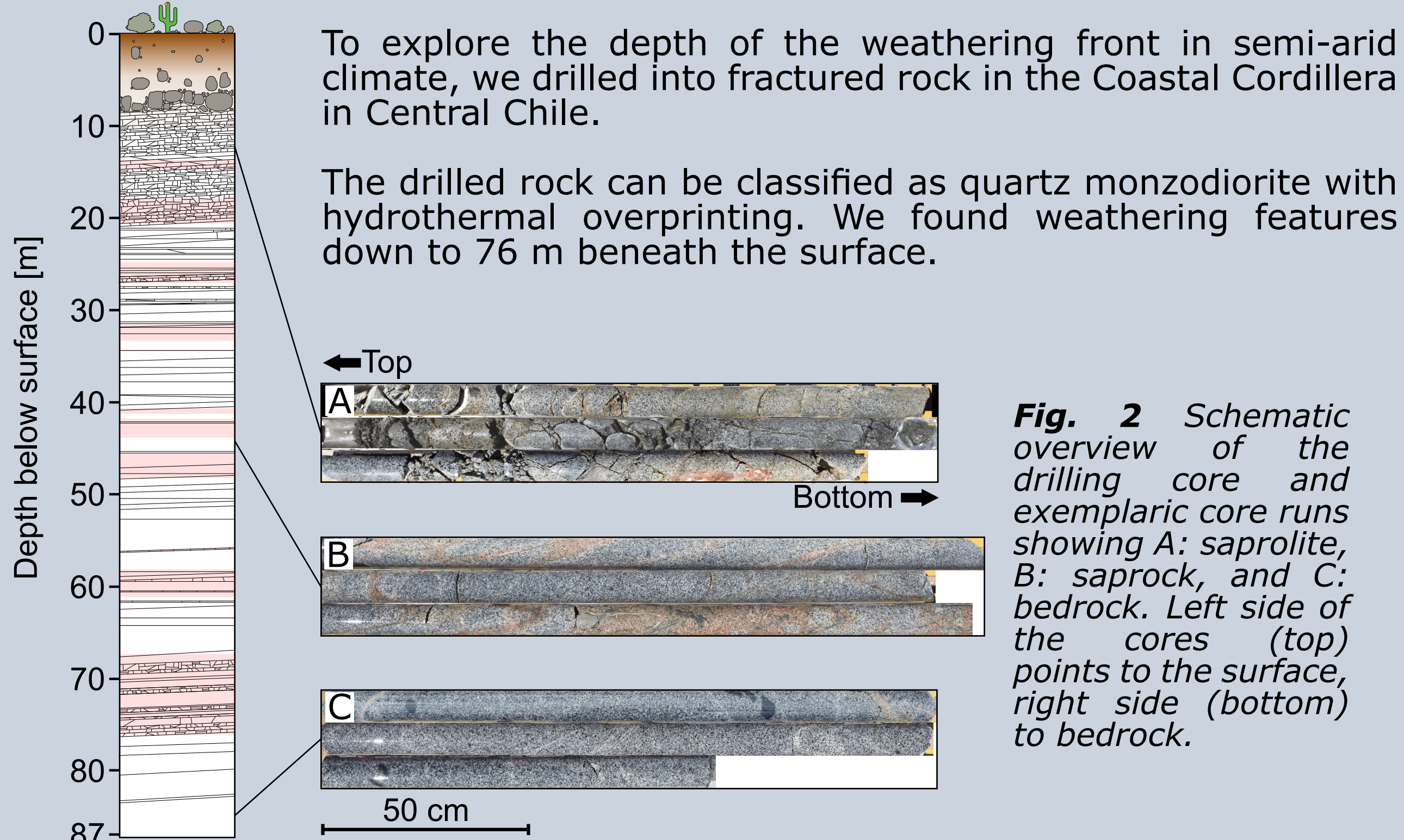


Fig. 2 Schematic overview of the drilling core and exemplaric core runs showing A: saprolite, B: saprock, and C: bedrock. Left side of the cores (top) points to the surface, right side (bottom) to bedrock.

6. Multiple weathering fronts

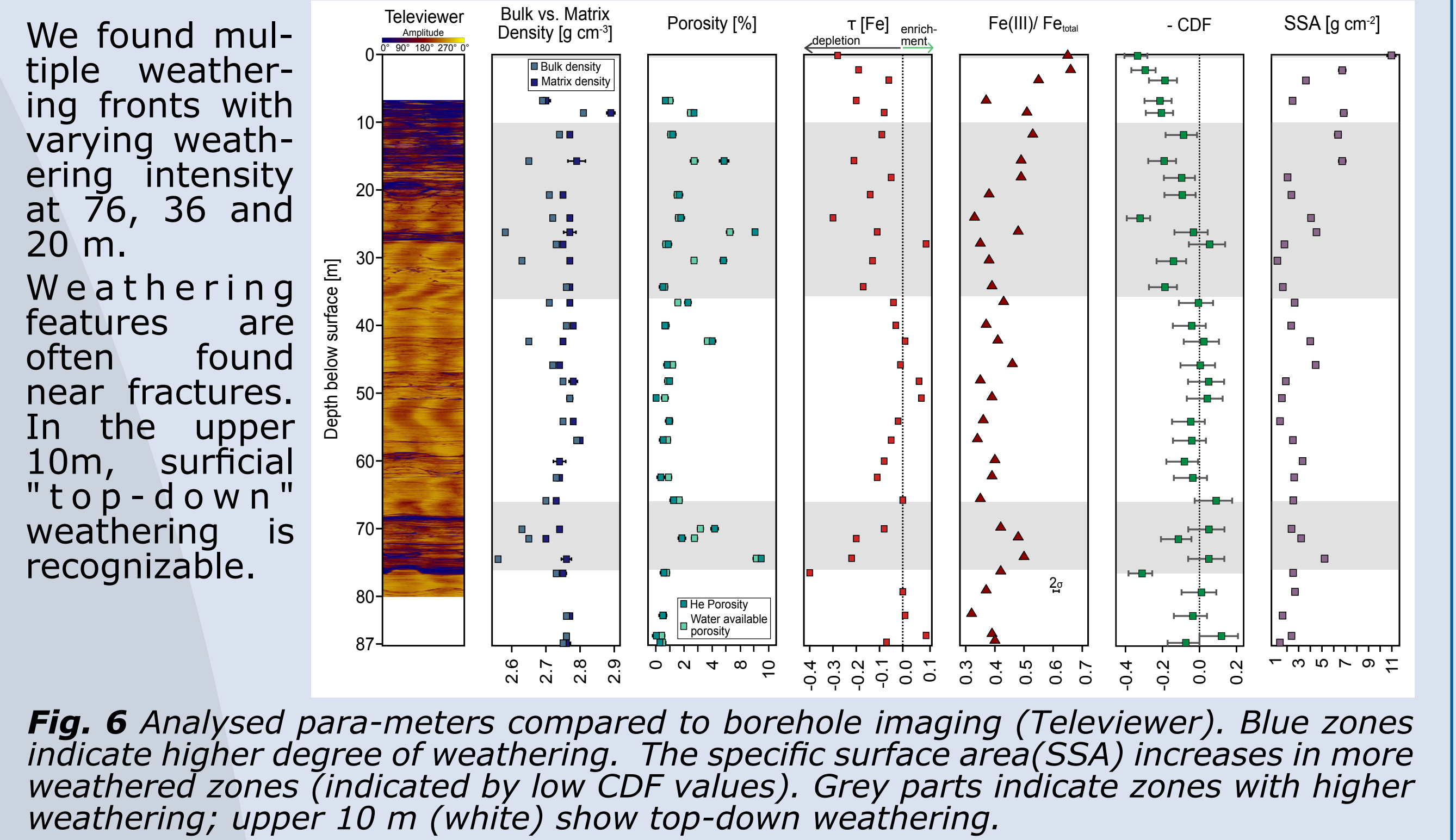


Fig. 6 Analysed parameters compared to borehole imaging (TelevIEWer). Blue zones indicate higher degree of weathering. The specific surface area (SSA) increases in more weathered zones (indicated by low CDF values). Grey parts indicate zones with higher weathering; upper 10 m (white) show top-down weathering.

3. Petrophysics

Density, porosity, and water-available porosity are weathering indicators. Porosity increases due to dissolution of minerals but also decreases due to formation of secondary minerals [2]. Water-available porosity serves as pathways for fluids and gases. Density changes towards the surface are minor because secondary minerals with high density are enriched towards the surface.

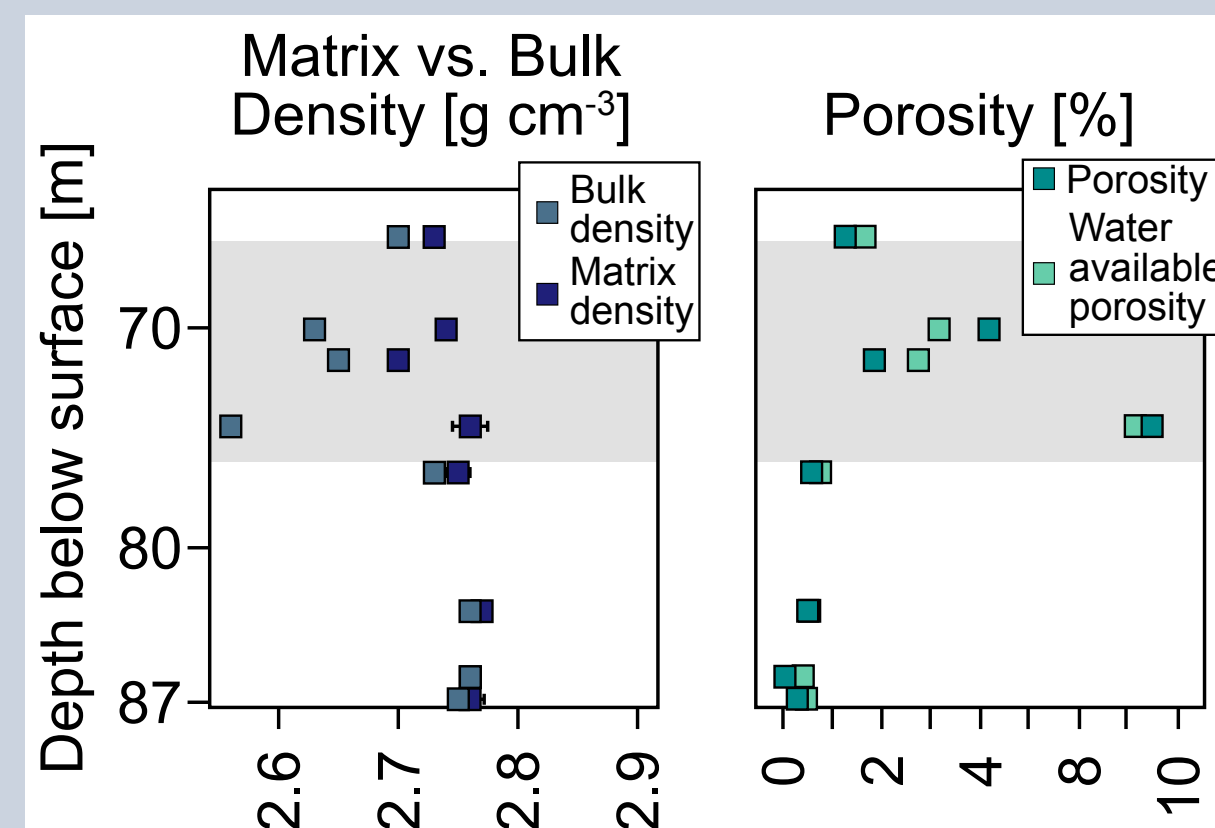


Fig. 3 Density and porosity at deepest weathering front. Grey area shows strongly weathered zone.

4. CDF

The chemical depletion fraction (CDF) shows bulk elemental loss relative to bedrock composition. It is calculated using the immobile element zirconium (Zr):

$$CDF = 1 - \frac{[X_{Zr}]_{bedrock}}{[X_{Zr}]_{weathered}}$$

The CDF decreases towards the surface. Close to fractures and in fracture zones, the CDF is also lower compared to less weathered rock.

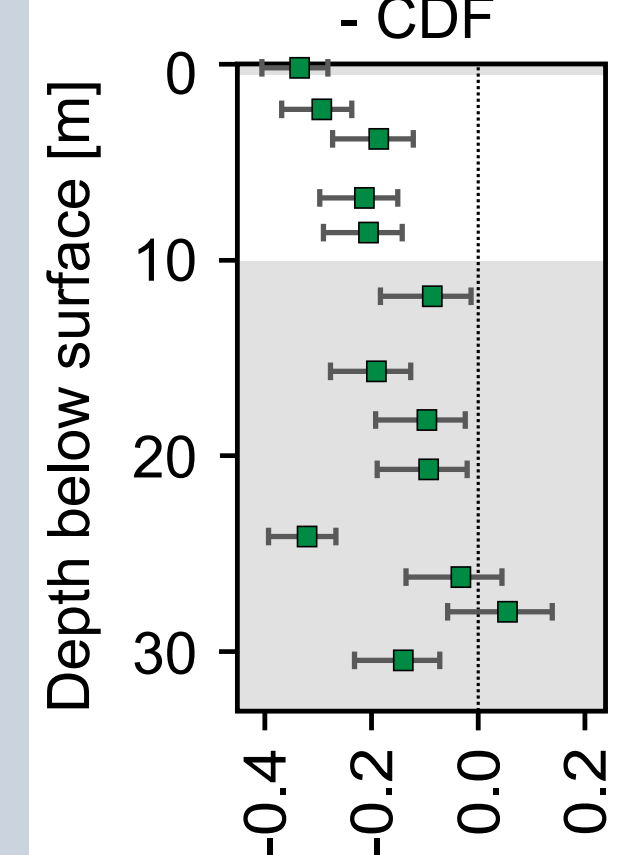


Fig. 4 Mass loss relative to bedrock given as negative CDF. Negative values indicate relative depletion.

5. Fe oxidation

Fe(III)/Fe_{total} ratios indicate the state of iron (Fe) oxidation. The measured ratio increases towards the surface.

τ values indicate the loss of an element relative to bedrock concentration. τ[Fe] values show depletion towards the surface and close to fractures.

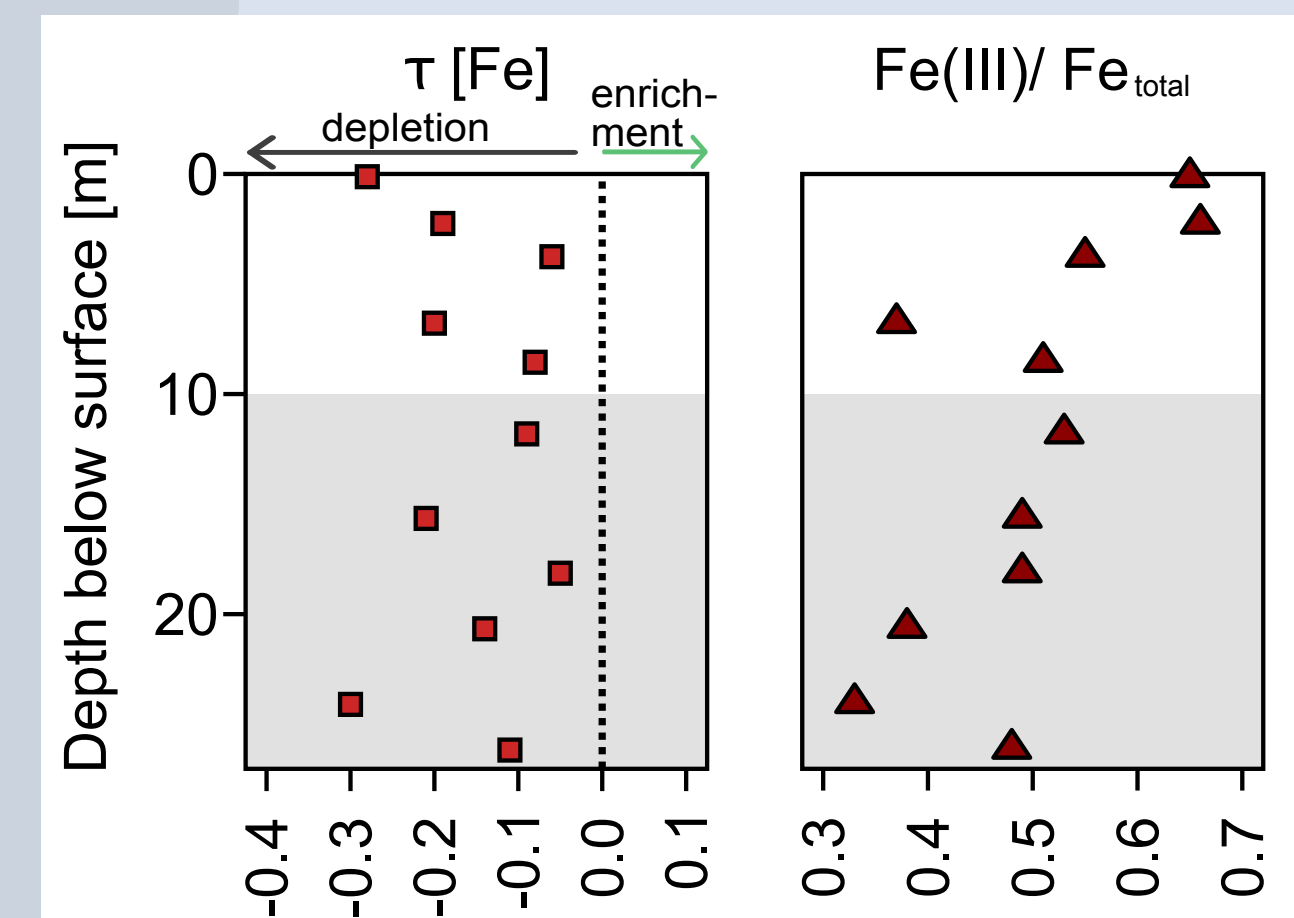


Fig. 5 Elemental loss of Fe (τ[Fe]) and Fe(III)/Fe_{total} ratios in saprolite (white) and saprock (grey). Dashed line indicates zero loss.

Questions?



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References:

- [1] Hayes, N.R., Buss H.L., Moore, O.W., Krám, P. and Pancost, R.D. (2020): Controls on granitic weathering fronts in contrasting climates. *Chemical Geology*, 535, 119450.
[2] Buss H.L., Sak, P.B., Webb, S.M. and Brantley, S.L. (2008): Weathering of the Rio Blanco quartz diorite, Luquillo Mountains, Puerto Rico: Coupling oxidation, dissolution, and fracturing. *Geochimica et Cosmochimica Acta*, 72 (18), 4488-4507.