Twenty-five Years of Mine Waste Characterisation in Western Australia:

Overview of Testwork Approaches

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Outline

A. Static Testing

- S Forms
- Bulk-ANC, CO3-ANC, pH-buffering
- NAG
- mineralogy

B. Kinetic Testing

- columns (cf. humidity-cells)
- oxygen-consumption cells

Generics

- Presciptive (?) Compendia for Geochem Testing
  - MEND (2009) (= "Bill's Tome"!) ✓
  - GARD Guide, AMIRA (2002), and others
  - originators may not intend these to be prescriptive, but can easily be perceived as prescriptive by regulators, consultants, etc.
- **But,** in undertaking a characterisation programme:
  - always "horses for courses"
  - personal preferences of individual practitioners
  - professional judgement

Static-testing (1)

- **S Forms**
  - Total-S (Leco)
  - SO4-S-[Na2CO3]
  - Cr(II)-Reducible-S when needed
  - mineralogy selective samples
- **ANC (= NP)**
  - Bulk-ANC
    - use -2mm (nominal) crushings (cf. pulps, AMIRA [2002])
  - CO3-C
  - pH-buffering curves selective samples
    - autotitrations and pH5-soak tests

Static-testing (2)

- **NAG**
  - Single-addition
  - Multiple-addition when needed

- (in)consistency between NAPP and NAG values
  - useful prompt for things being not what thought to be initially (?)
  - rarely strive for accurately "matching" NAPP and NAG values

➔ any "mismatch" generally enough in itself to "corrected" direction for valid interpretation

Kinetic-testing (1): Weathering-Columns

- **AMIRA (2002)**
- setup similar to AMIRA (2002), but modified operating protocol:
  - control of sample-bed temperature, and higher V/M ratio
- used for estimating:
  - rates of sulphide-oxidation, acid-consumption, and and solute-elution
- suited to both coarse- and fine-textured materials, due to **aggressive drying conditions** (i.e. rates limited by high relative-saturations rare even for tailings)

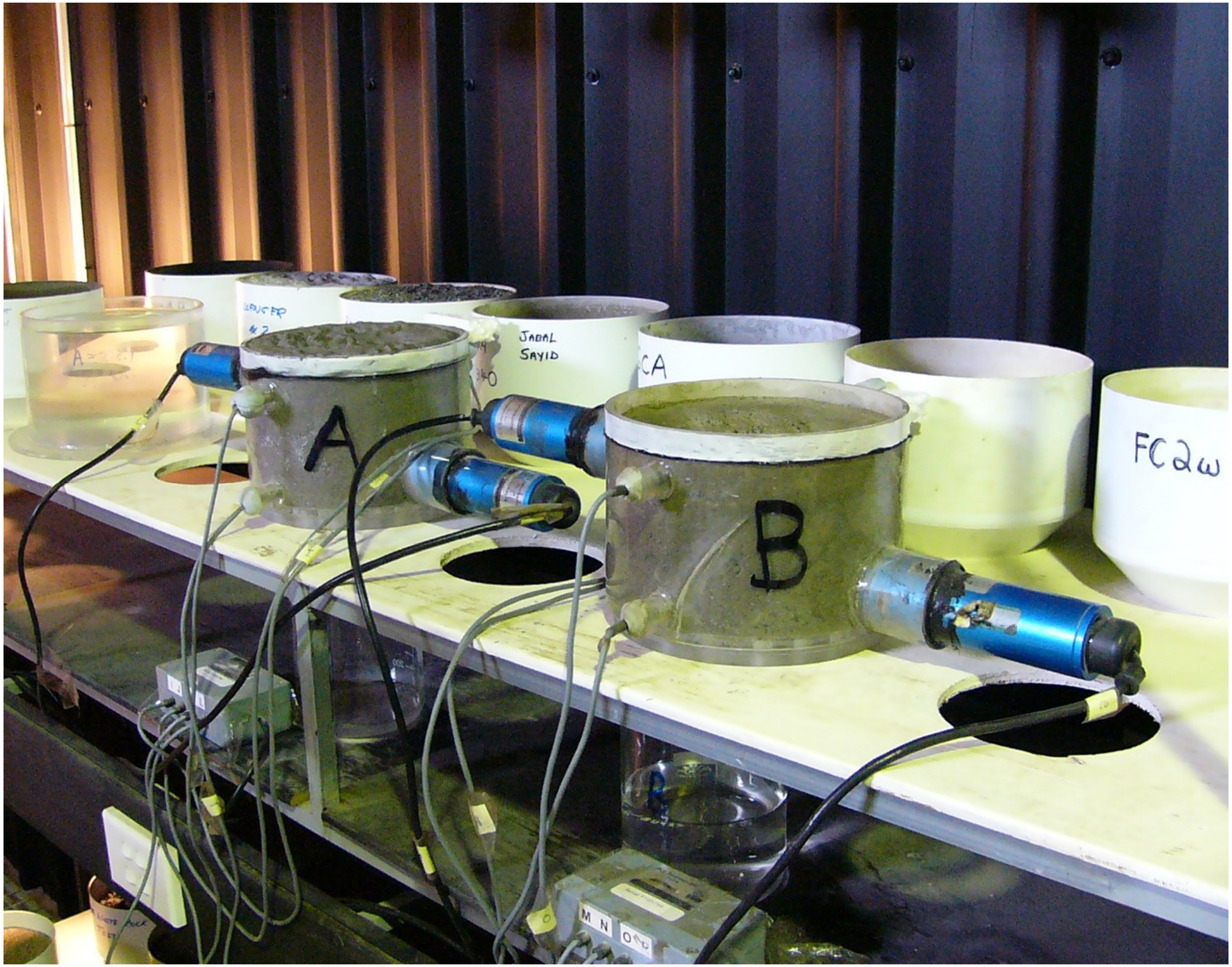
But:

- variation in seasonal-T can confound interpretation
- drying to residual-moistures, and remaining at these for days, is at variance with moisture/suction regimes *in situ*

Kinetic-testing (2): Weathering-Columns

Kinetic-testing (3): Weathering-Columns

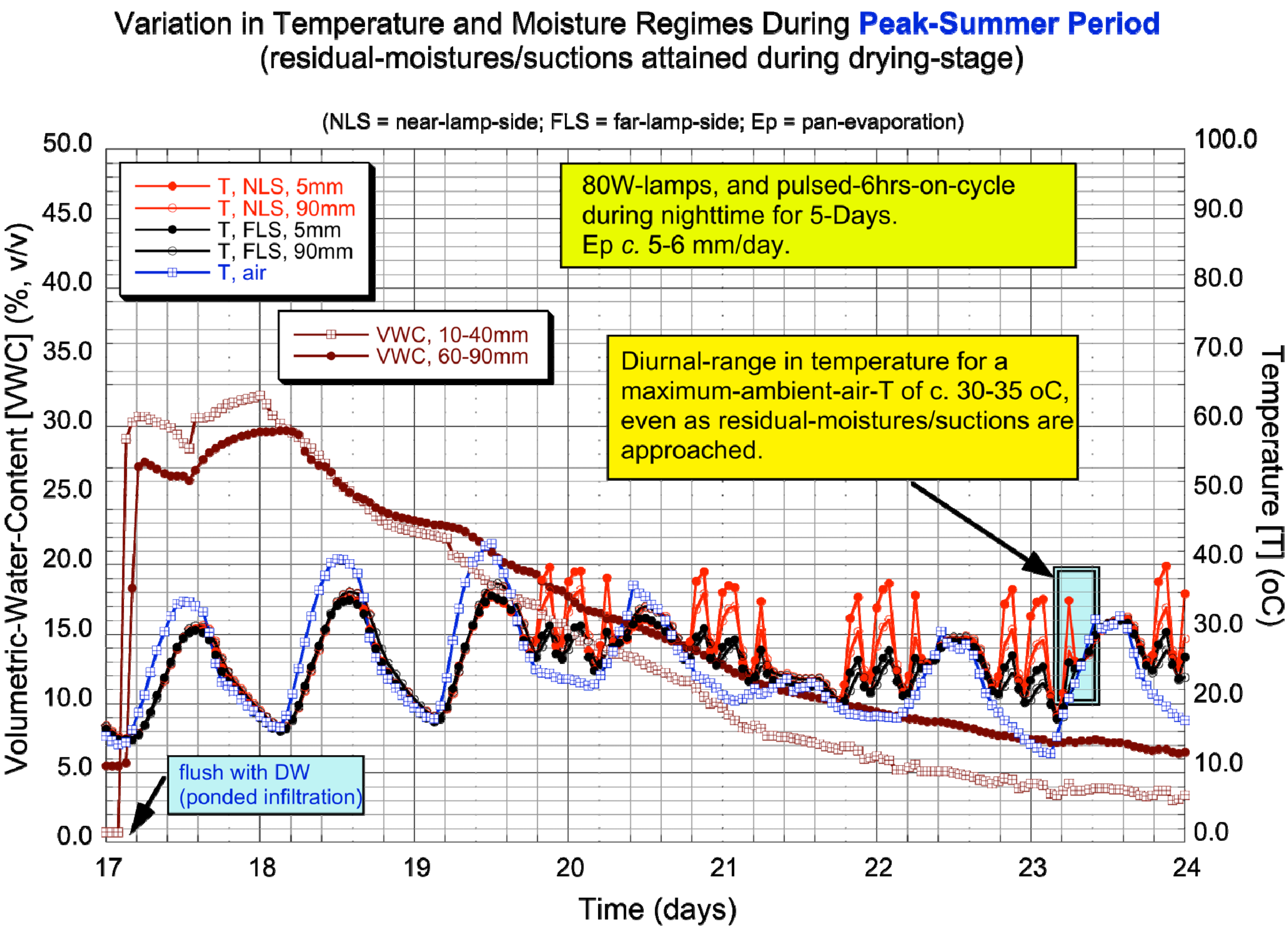
(defining thermal "boundary conditions" for kinetic testing)



Kinetic-testing (4): Weathering-Columns

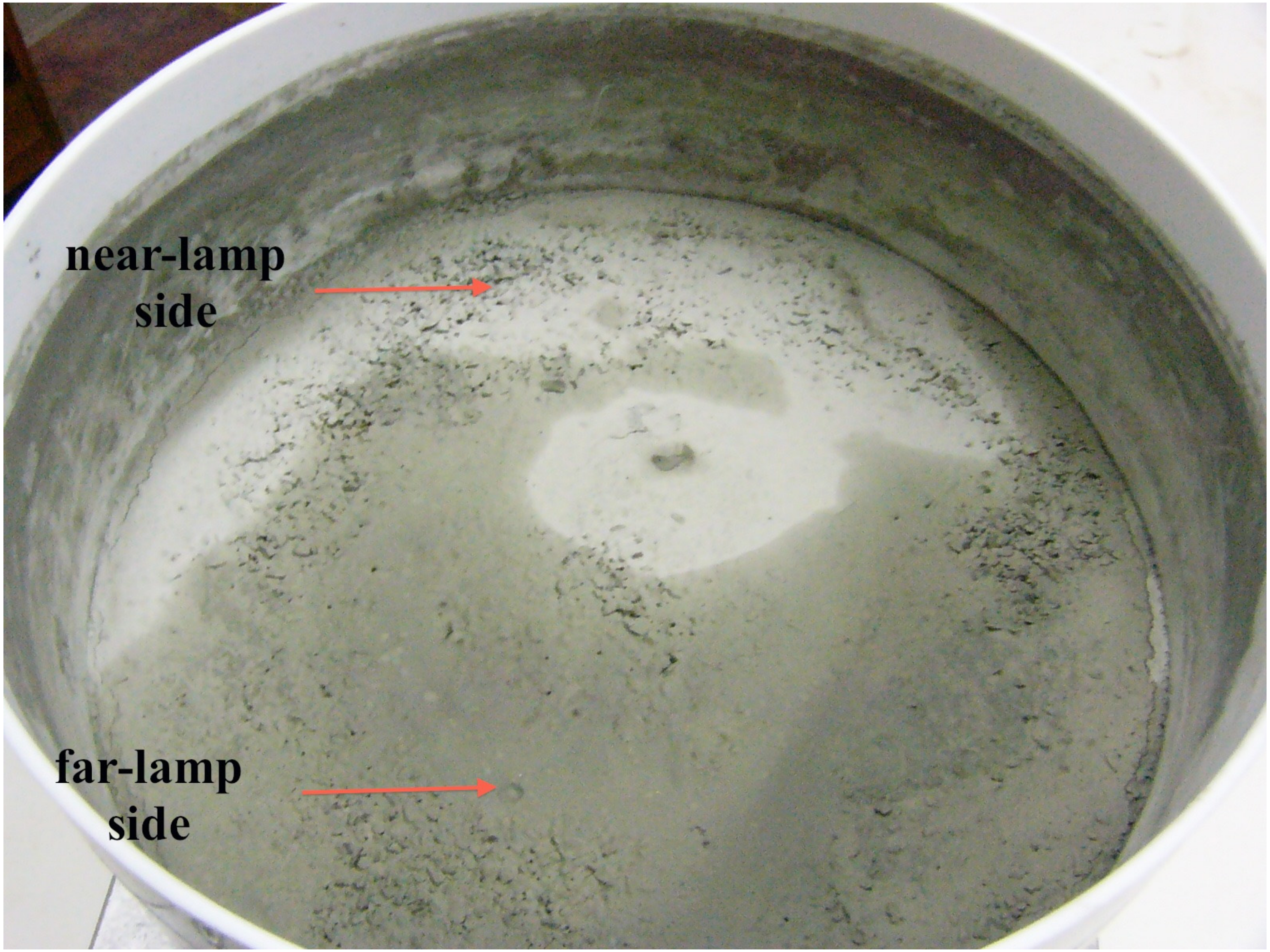
Intermittent (cf. Continuous) Operation of Flood-Lamps

Kinetic-testing (5): Weathering-Columns



Kinetic-testing (6): Weathering-Columns

geometry of applied heat loads ➔ lateral variation in drying



Kinetic-testing (7): Weathering-Columns

Flushing under ponded conditions of infiltration.
Formation of "surface-clay-skin" ➔ limitation of oxidation by O_2 diffusion (i.e. limiting relative-saturation)

Kinetic-testing (8): Weathering-Columns

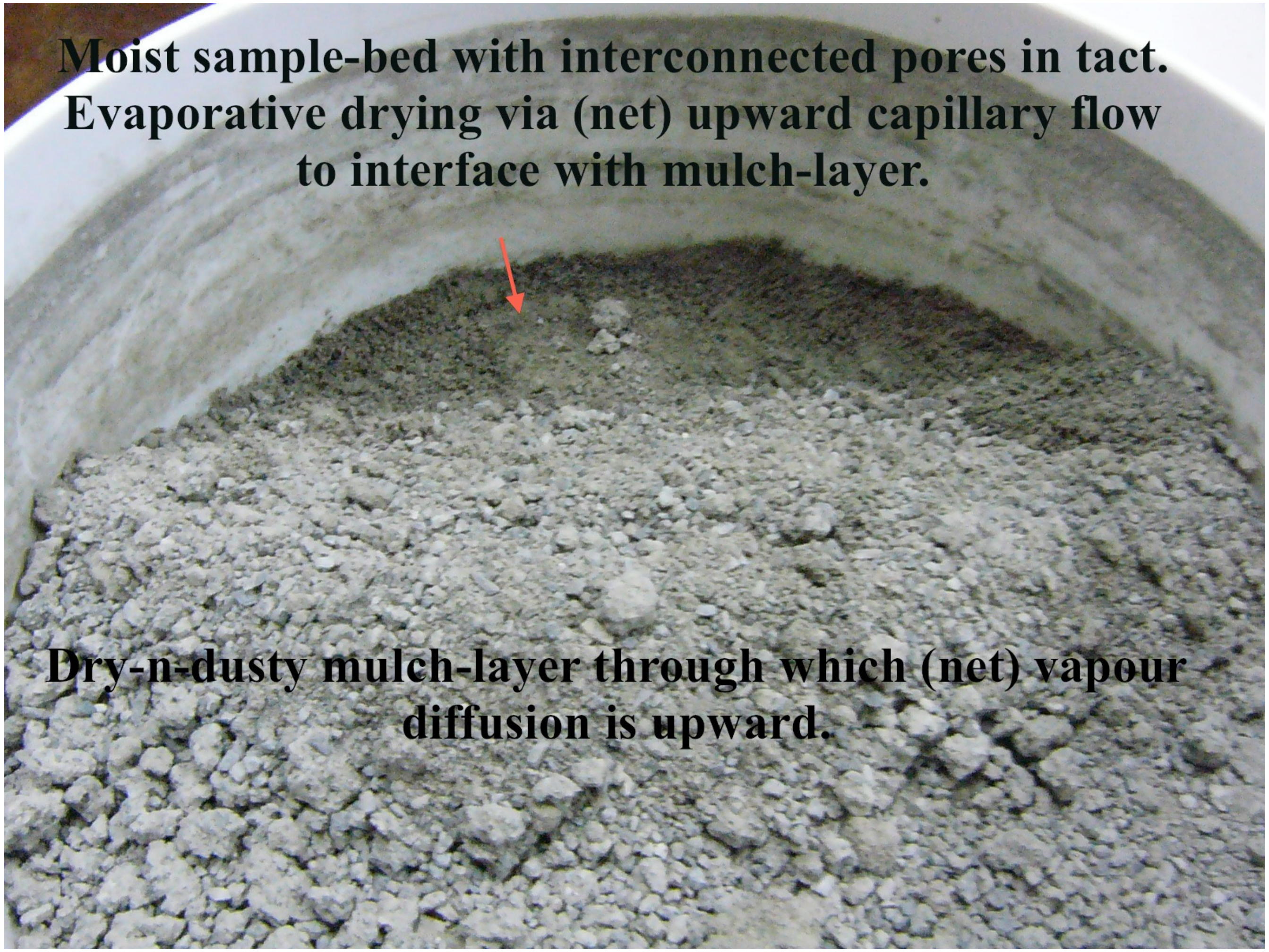
Breakup "surface-clay-skin" by chipping when not too sticky

Kinetic-testing (9): Weathering-Columns

chipping breaks connectivity of capillary-pores to surface
➔ formation of "mulch-layer"

Kinetic-testing (10): Weathering-Columns

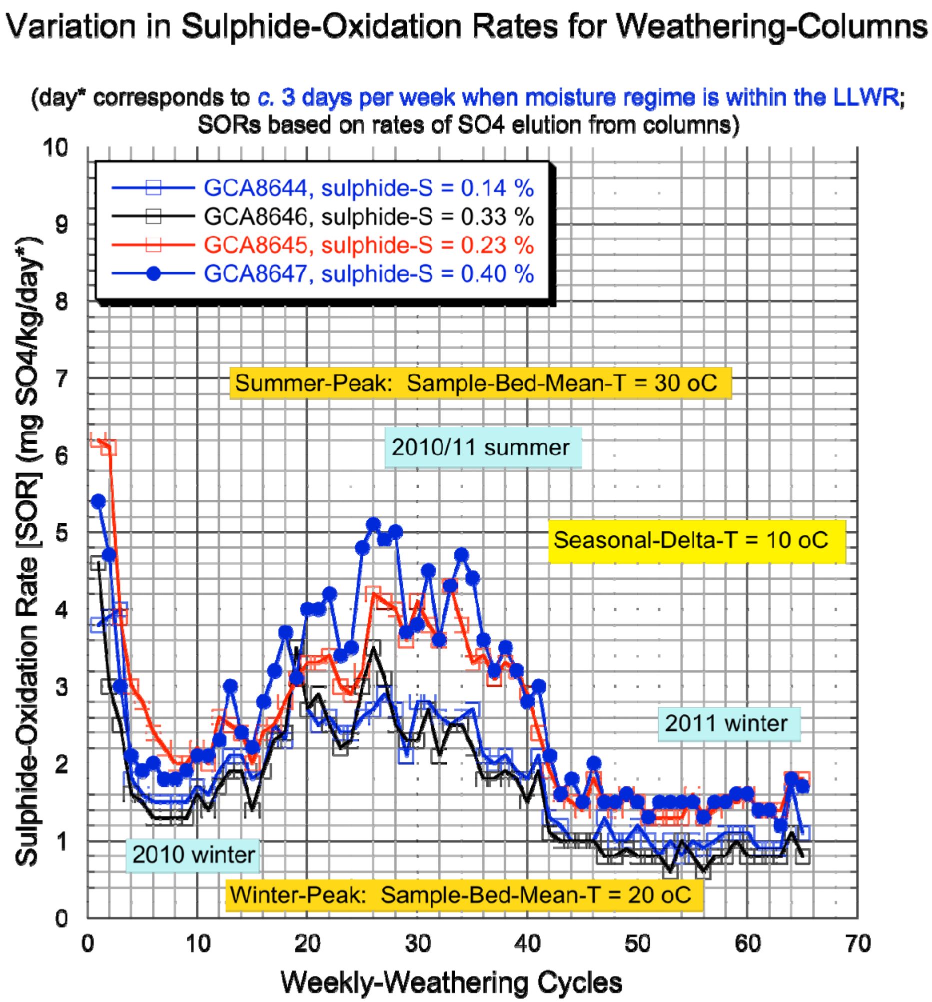
evaporative-drying continues via capillary-flow below, and
vapour diffusion through mulch-layer:
all acting under transient diurnal-T gradients



Kinetic-testing (11): Weathering-Columns

Desiccated state prior to flushing ➔ marked **matric-suction gradients** initially (= sorptivity phase of infiltration into dry soil).

Kinetic-testing (12): Weathering-Columns



See Lapakko (2003) for related Seasonal-T swings for SORs in humidity-cell testing

Kinetic-testing (12): Oxygen-consumption Cells

use weathering-columns to measure OCR directly

Kinetic-testing (13): Hybrid Approach

use flood-lamps to dewater "sludge" immediately after flushing to a "middling-moisture", then keep in an incubator

Kinetic-testing (14)

- AMIRA (2002) weathering-columns corresponds to dewatering under non-isothermal conditions

  - need to define thermal boundary conditions to assist interpretation

    e.g. seasonal-T trends masking intrinsic-weathering trends

  - are effects associated with drying to residual-moistures/ suctions important practically, or inconsequential?

- Above rendered redundant where use incubators after dewatering to relative-saturations less than 80-85 % (nominal)

  ➔ remain within **Least-Limiting-Water Range (LLWR)**

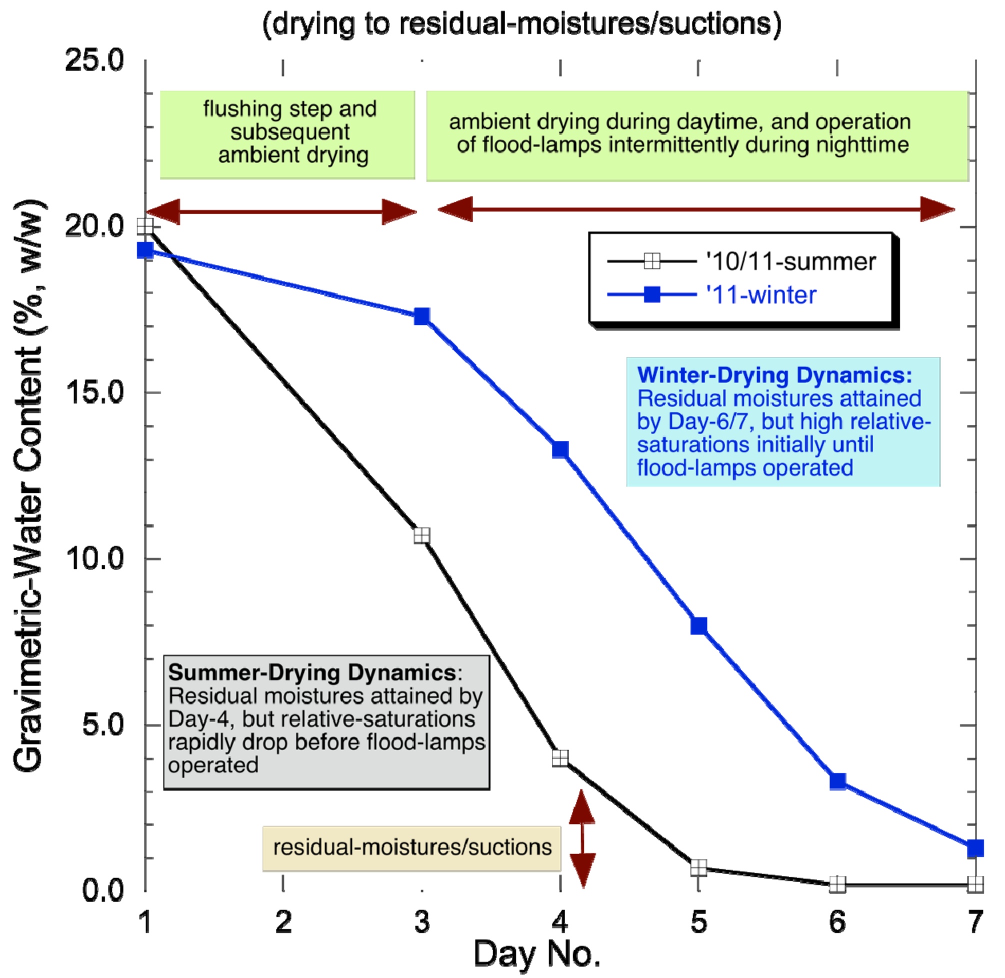
Sulphide-Oxidation within
Least-Limiting-Water Range (LLWR)
(Arid-Zone Weathering)

- Long-held concept in soil-science and agronomy

- Moisture limits on **plant-growth**:
  - "wet-end": θ_v > 80-90 % of ϕ ⇒ O_2-limited
  - **"middling"**: ⇒ **optimal** √
  - "dry-end": Ψ_t > 10-20 bars (nominal) ⇒ H_2O-limited

- Moisture limits on **sulphide-oxidation**:
  - **"wet-end"**: θ_v > 80-90 % of ϕ ⇒ **O_2-limited** √
  - "middling": ⇒ optimal
  - **"dry-end"**: Ψ_t > 10+ bars (nominal) ⇒ **H_2O-limited** √

Seasonal Variations in Desaturation and Unsaturated-Flow Dynamics
During Weekly-Weathering-Cycles (GCA8644)



period that sample-beds are within LLWR is taken as 3 days for each weathering-cycle irrespective of time of year

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