Deltares

Living Lab for Mud

Phase D: 1DV ripening model development

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EcoShape

building with nature

Deliverables for Phase D

- High-level presentation (this document)
  - Brief overview of how model development relates to overall goals of Living Lab for Mud (LLM) project
  - Rationale for developing **1**-**D**imensional **V**ertical (1DV) ripening model
  - Overview of model developments

- Technical memo on 1DV ripening model
  - Outlines equations to be solved
  - Numerical details and solving procedure

Project goals and focus

- EcoShape project, goal is to: *'connect and build upon the different pilots in the EcoShape Living Lab for Mud, to boost development of applied knowledge'*

- Specific focus: develop practical knowledge on consolidation and ripening
  - Combine expertise of physical processes with numerical modelling and experience from large-scale pilots

- Large-scale pilots that are considered in this scope:
  - Kleirijperij
  - KIMA (Marker Wadden)

Project phases

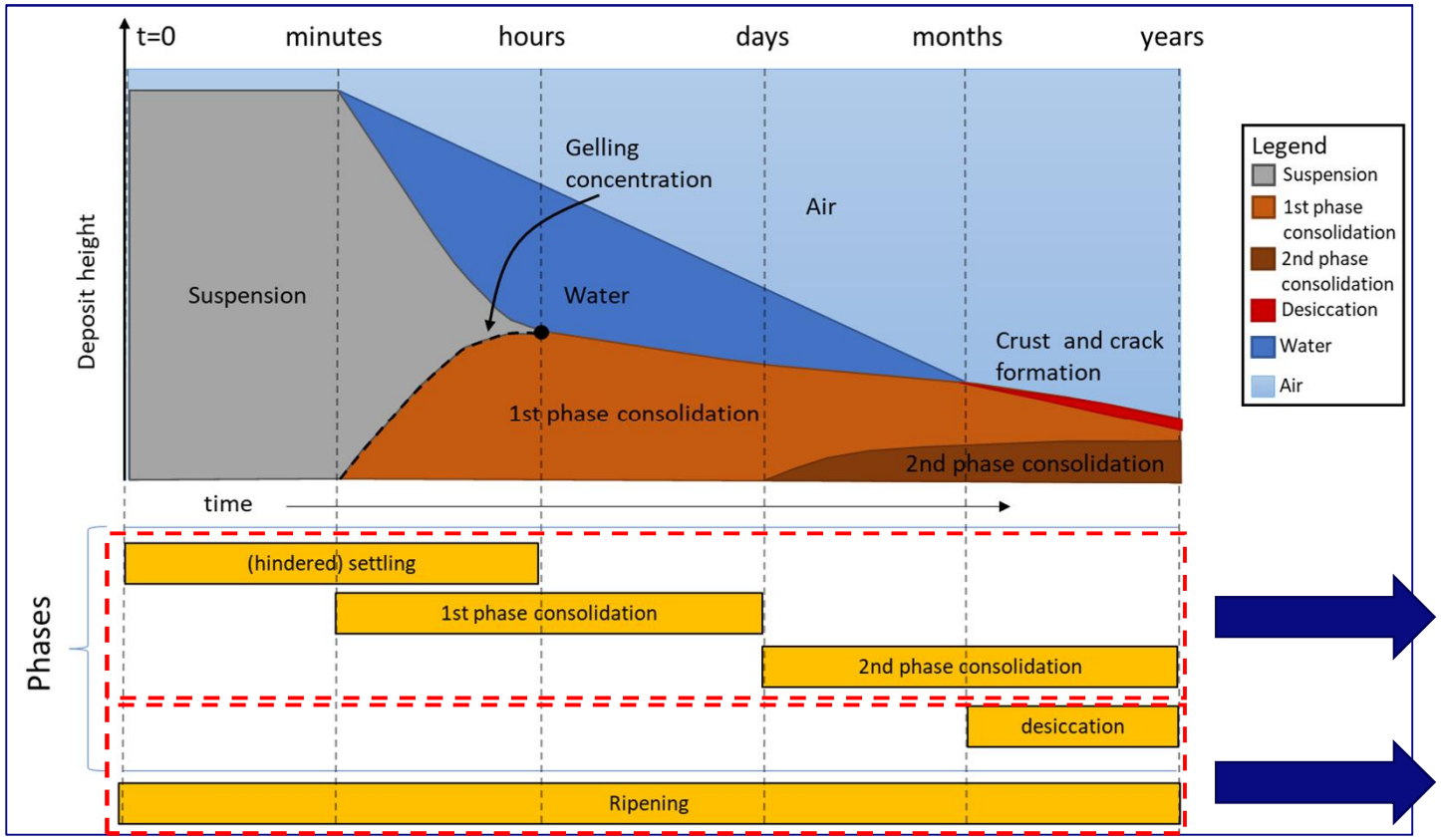
Phase A-D: Knowledge collection and development

- Phase A: Brief literature survey, compile knowledge on ripening, based on Kleirijperij inputs and internal Deltares research
- Phase B: Conceptual model, derive ballpark numbers for final volume and relevant timescales
- Phase C: hindcast modelling of Kleirijperij using existing numerical model (TUD – Vardon), focusing on different ripening strategies and treatment options
- **Phase D: Adjust 1DV consolidation model (Deltares) to make it suitable for desiccation**

Phase E-F: Apply knowledge through practical design rules and guidelines

- Phase E: Use theoretical understanding and lessons learned from projects to devise design rules and guidelines for adaptive management
- Phase F: Summarize findings in final report and guidelines to be published on Ecoshape website

Ripening concept – relation to 1DV model



To fully model the ripening process, the following phases should be modelled:

- (hindered) settling
- Consolidation (1st and 2nd phase)
- Desiccation

The 1DV consolidation model by XX et al includes settling and consolidation

To make it suitable for ripening, we include **desiccation** in this model

Governing processes and driving forces

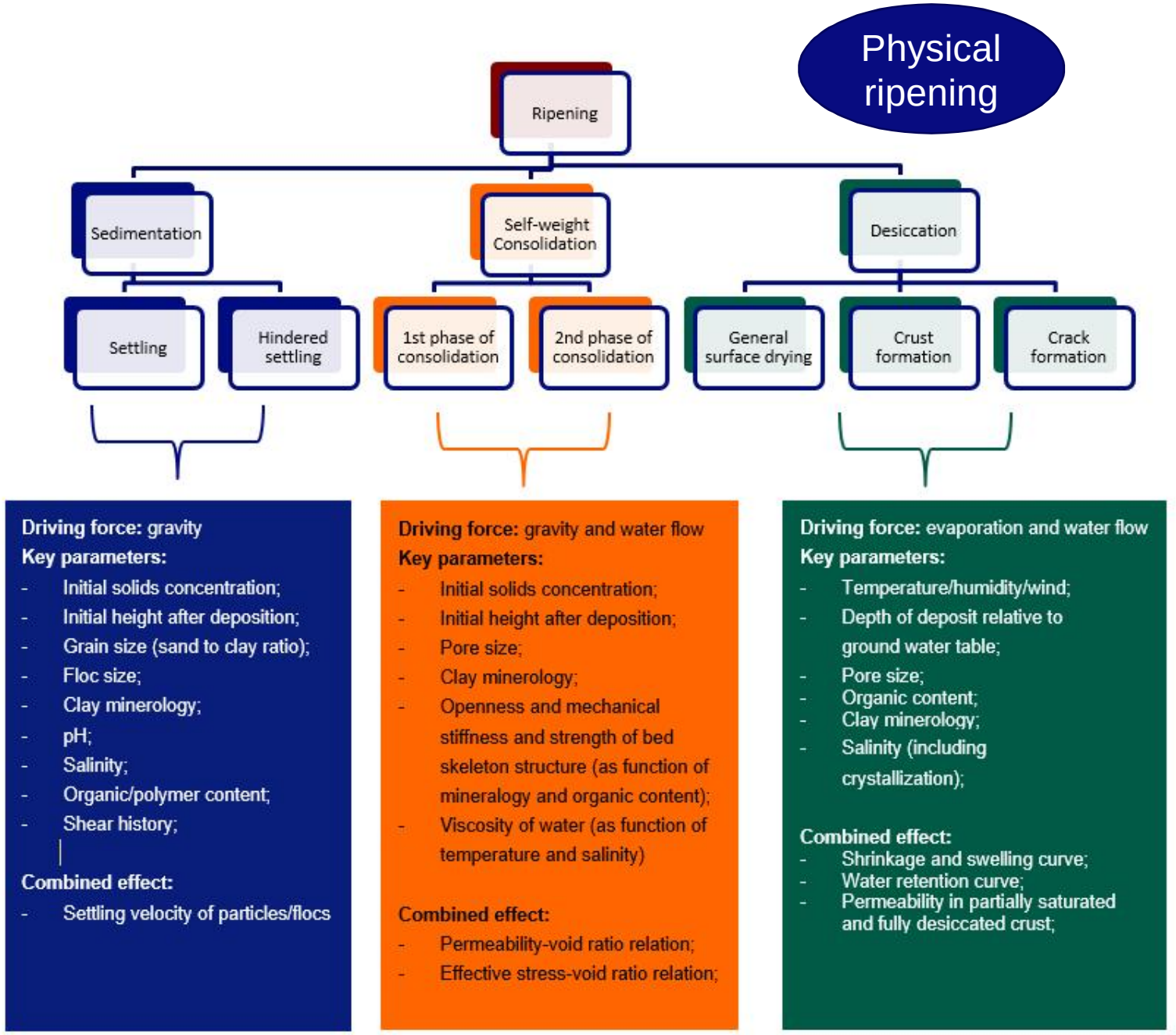
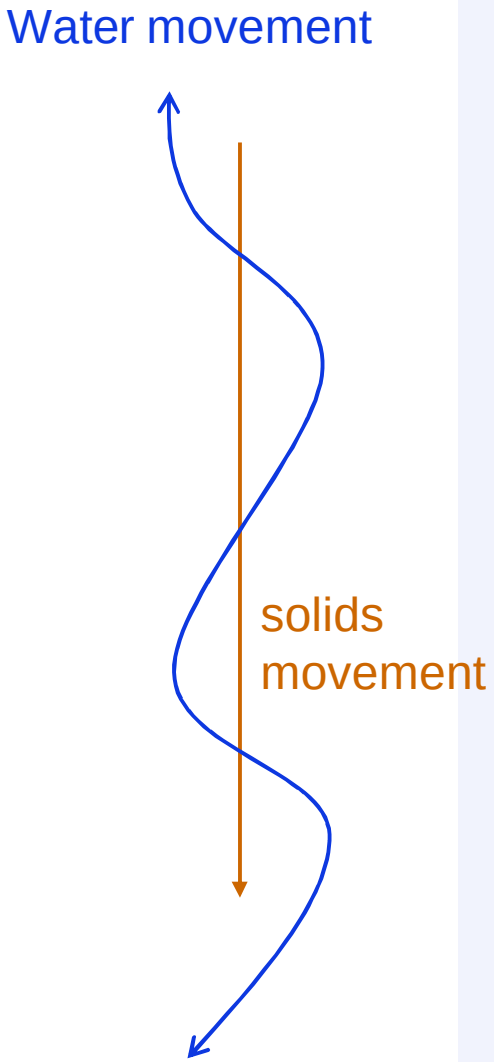


Figure 3: A summary of governing processes during ripening process (Meshkati et al., 2021).



Deltares

Adjusting the 1DV consolidation model so it becomes a 1DV ripening model

- The new 1DV model covers settling, consolidation and with new adjustments **desiccation**

- Hereby, it covers all the main governing physical processes a fresh mud may undergo during the ripening process

- Model capabilities:
  - Process-based numerical model
  - stacks of layers with different soil properties are allowed;
  - different types of bottom drainage can be defined i.e. sink, natural drainage, etc.
  - this model includes accurate physical descriptions of the involved processes, e.g. by taking into account both the relation between suction and saturation degree in the main equations.

Numerical model features

- The model is written in an implicit method which offers a more stable calculation and allows the possibility of defining larger time steps

- a nonlinear Multigrid approach is used as a solver to improve the computational efficiency

- the model allows for three-phase flow
  - It not only solves for movement of water and solids but also the penetration and movement of air by which an accurate estimation of Matric suction in the pores can be achieved;
  - this provides more accurate modeling of desiccation and offers possibilities for calculation of e.g. organic content oxidation (decay) in the soil.

Preliminary results from 1DV model & follow-up steps

- Settling and consolidation is fully validated;
- Bottom drainage and upper boundary conditions (i.e. evaporation and infiltration) are implemented/validated;
- Desiccation related components in the model are already implemented and the final validation is ongoing (in December 2021);
- Preliminary results will be provided early next year (2022).
- in a separate NWO project (awarded in October 2021) biochemical processes will be added to this model as well.