Evaluation of cement integrity using distributed temperature sensing

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Overview

Motivation:

- Cementing: important operation, difficult to control
- Primary objectives: support casing, seal annulus
- Questions: how much cement in place? „Quality“?

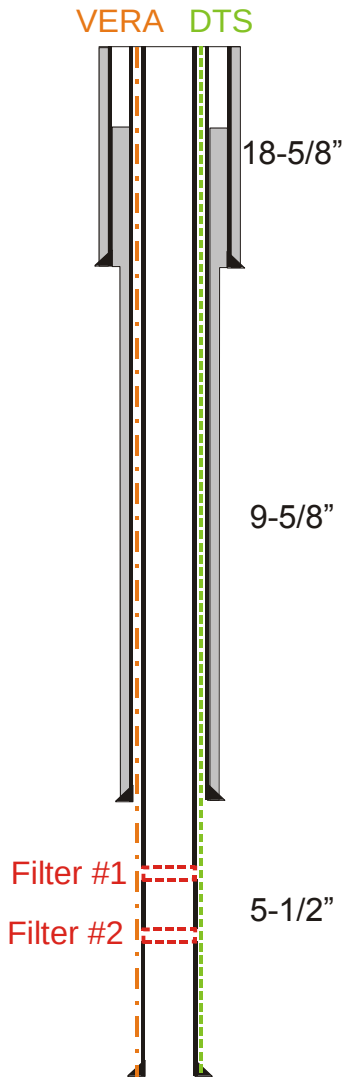
Methods:

- Temperature – heat of hydration during setting of cement
- Acoustic – attenuation, mechanical coupling
- Nuclear – admixture to cement slurry

Case study:

- Permanent monitoring of CO_2 injection and storage (CO2SINK)
- Behind casing sensors: monitoring during operation
- Fiber-optic distributed temperature sensing (DTS) during cementing

Well design



- 18-5/8“ surface casing (cemented)
- 9-5/8“ intermediate casing (cemented)
- 5-1/2“ casing:
  - 8-1/2“ hole
  - two 9m filter screen sections
  - permanent sensor cables behind casing
  - DTS: fiber-optic distributed temperature sensing cable
  - VERA: vertical electrical resistivity array
- stinger cementation
  - below filter screens
  - 2,2 m³ of API Class G cement

Installation of DTS and ERT cables in 1st well (May 5-6, 2007)

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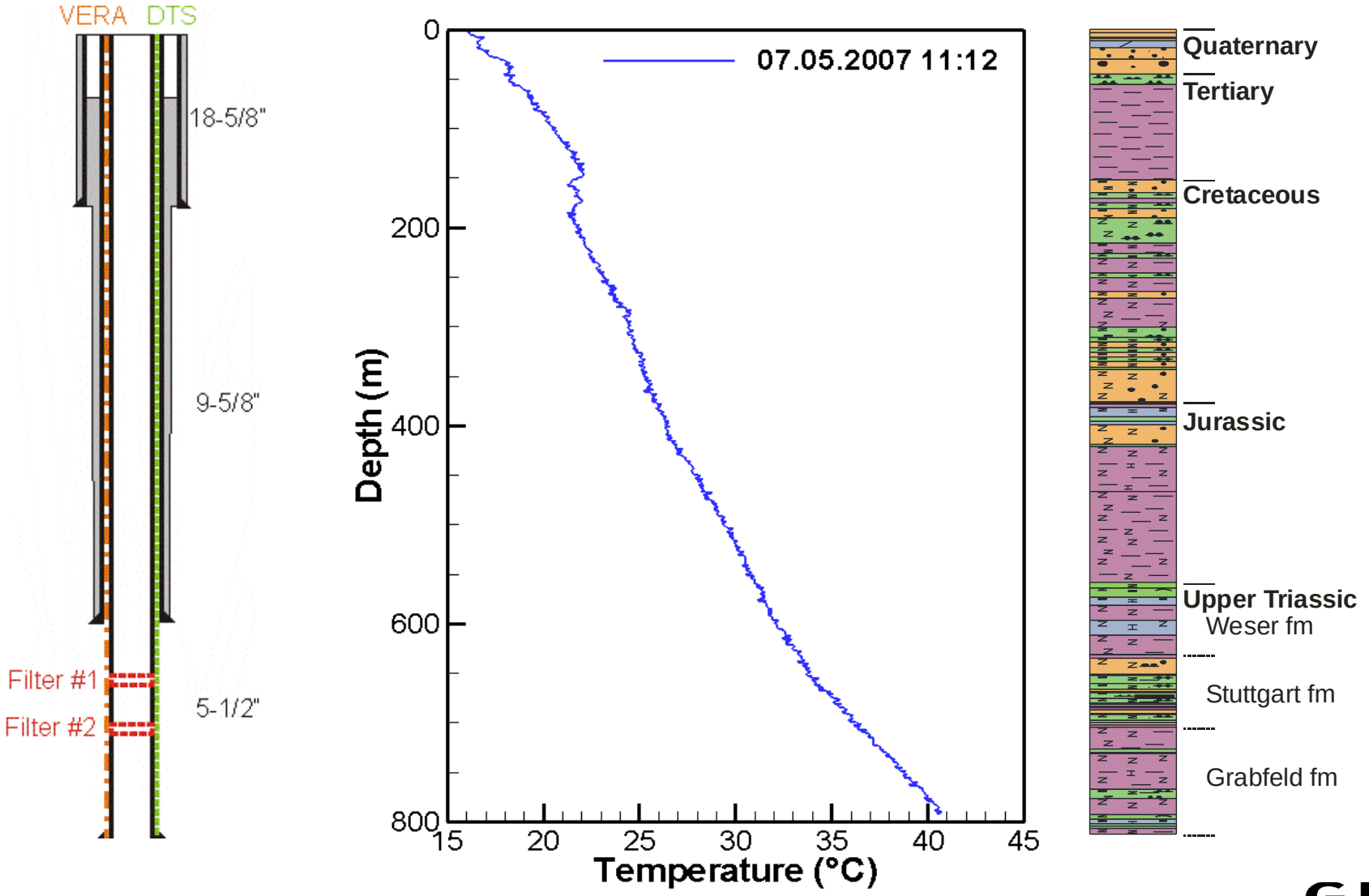
DTS temperature profiles - pumping of cement



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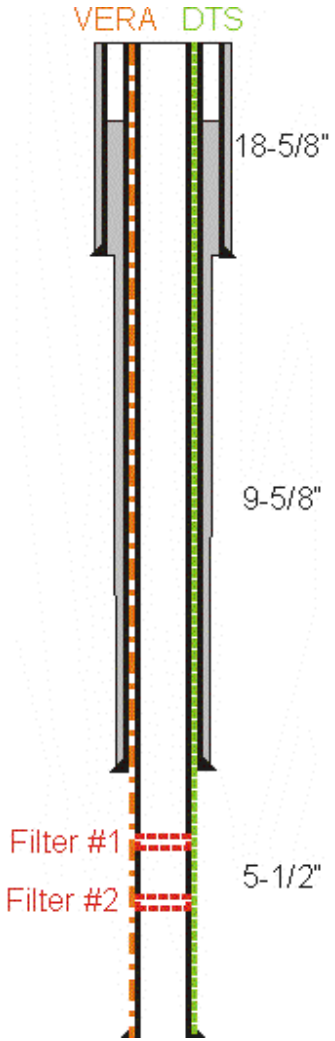
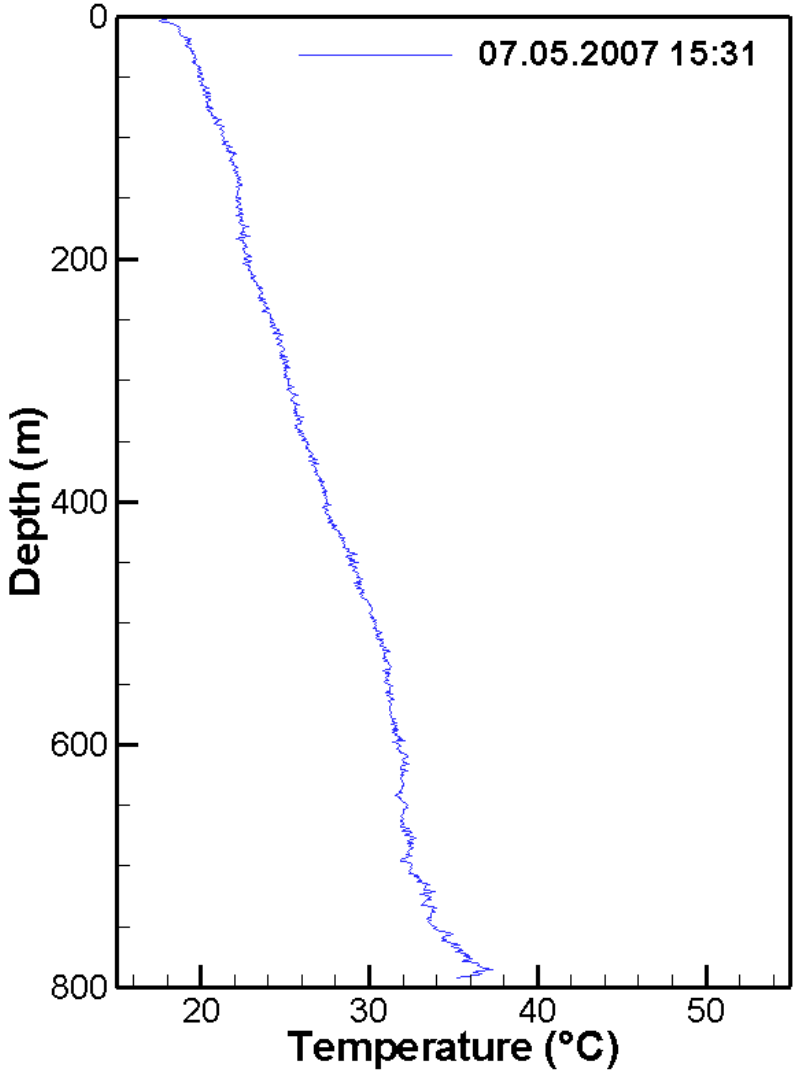
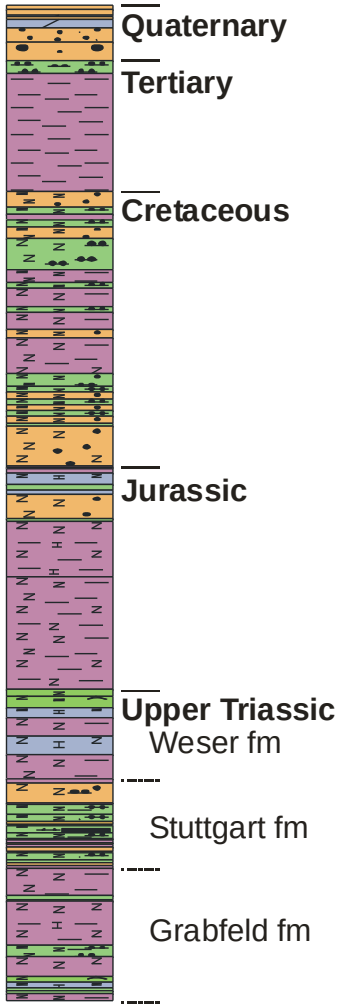
DTS temperature profiles - setting of cement and circulation







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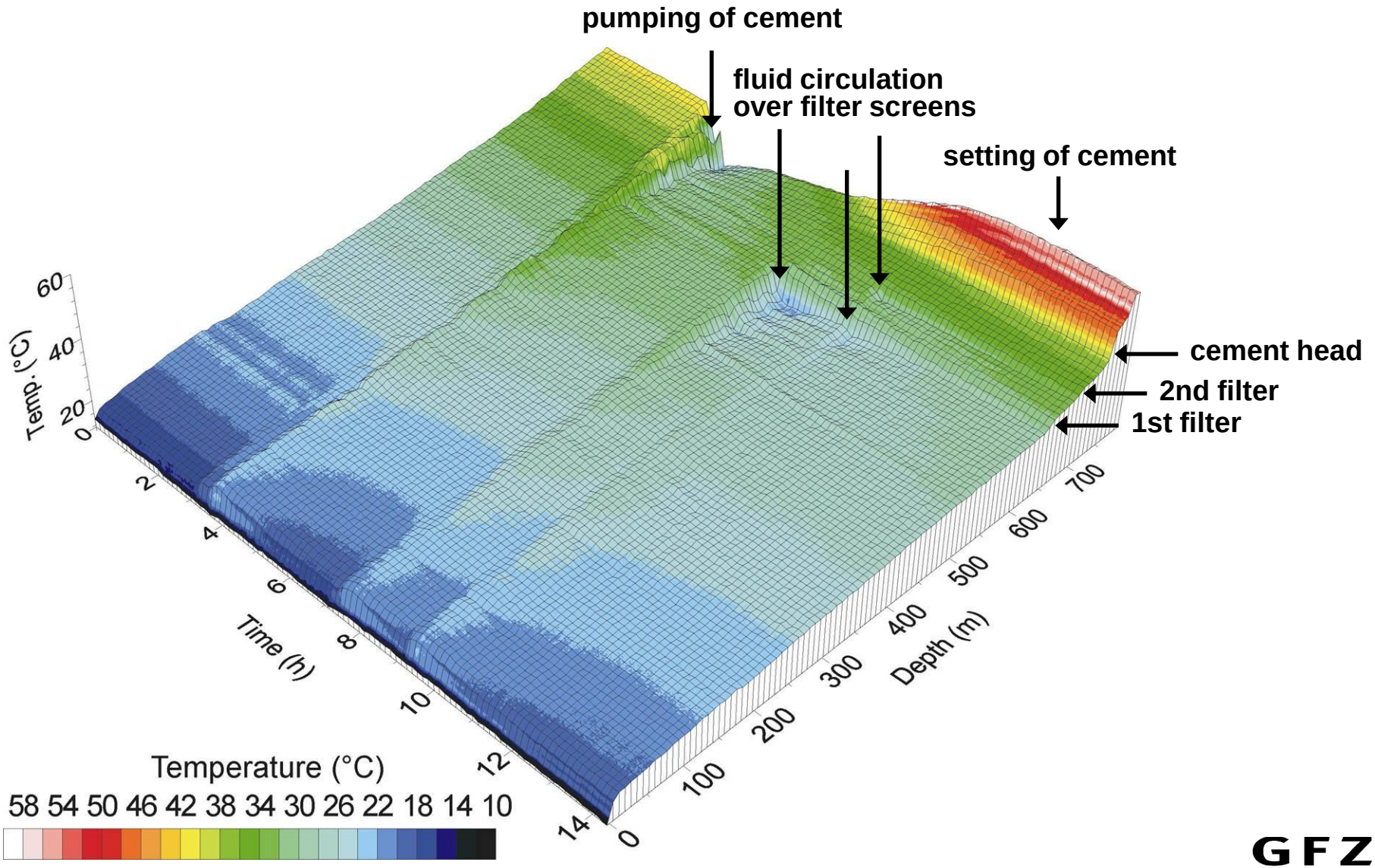
3D-view of DTS temperature data during cementing



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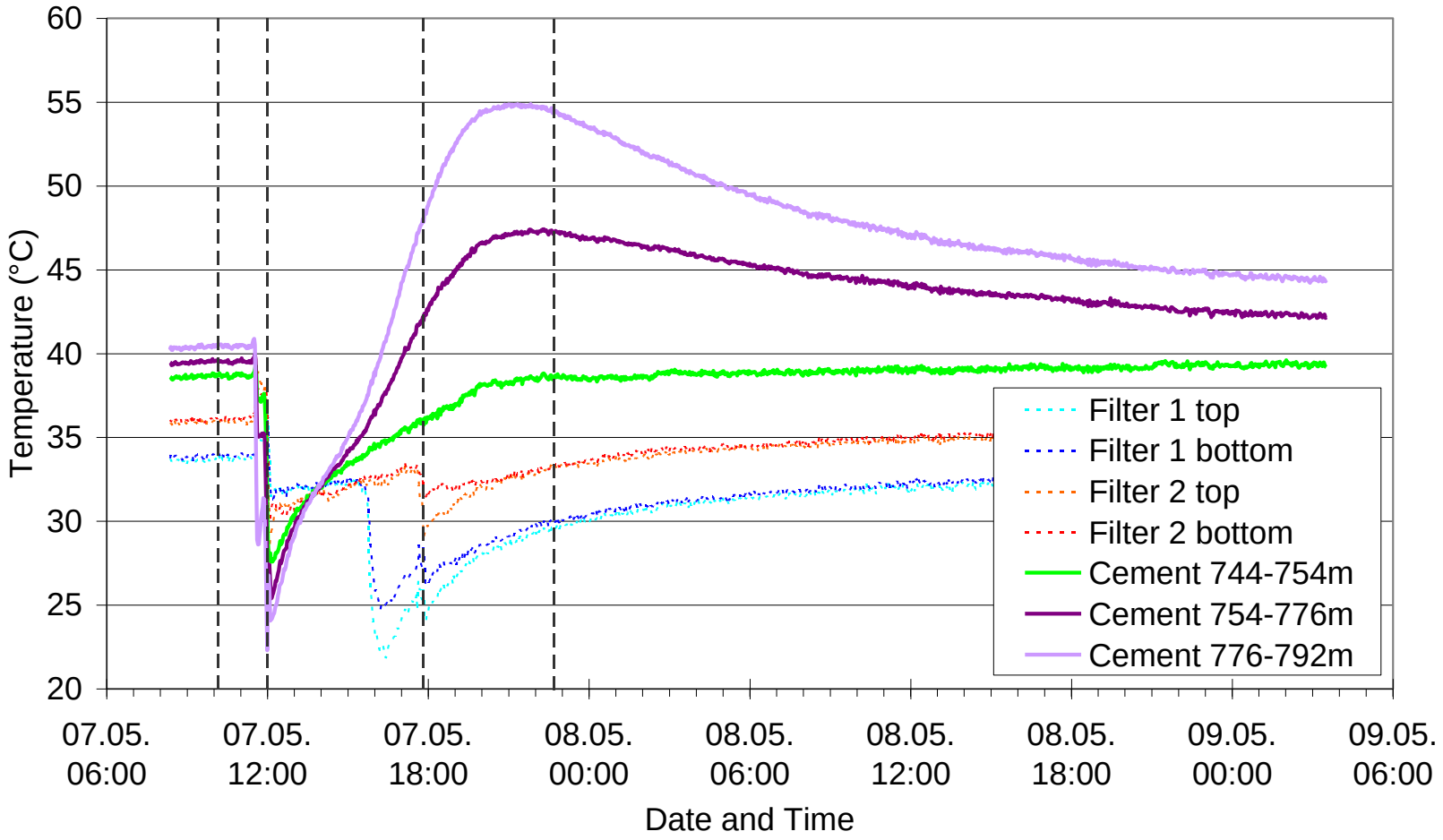
Change of temperature with time



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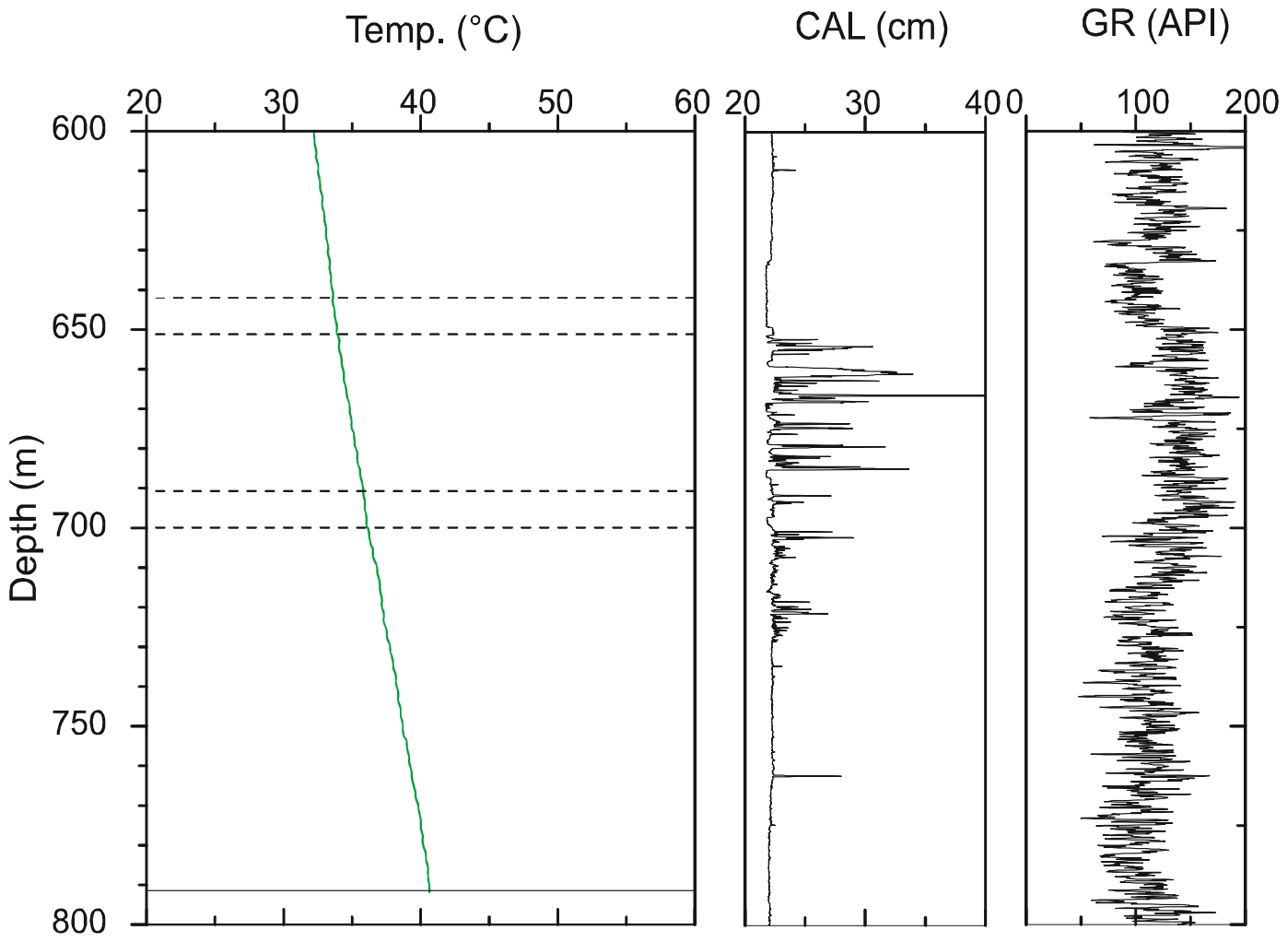
Temperature profiles – initial condition



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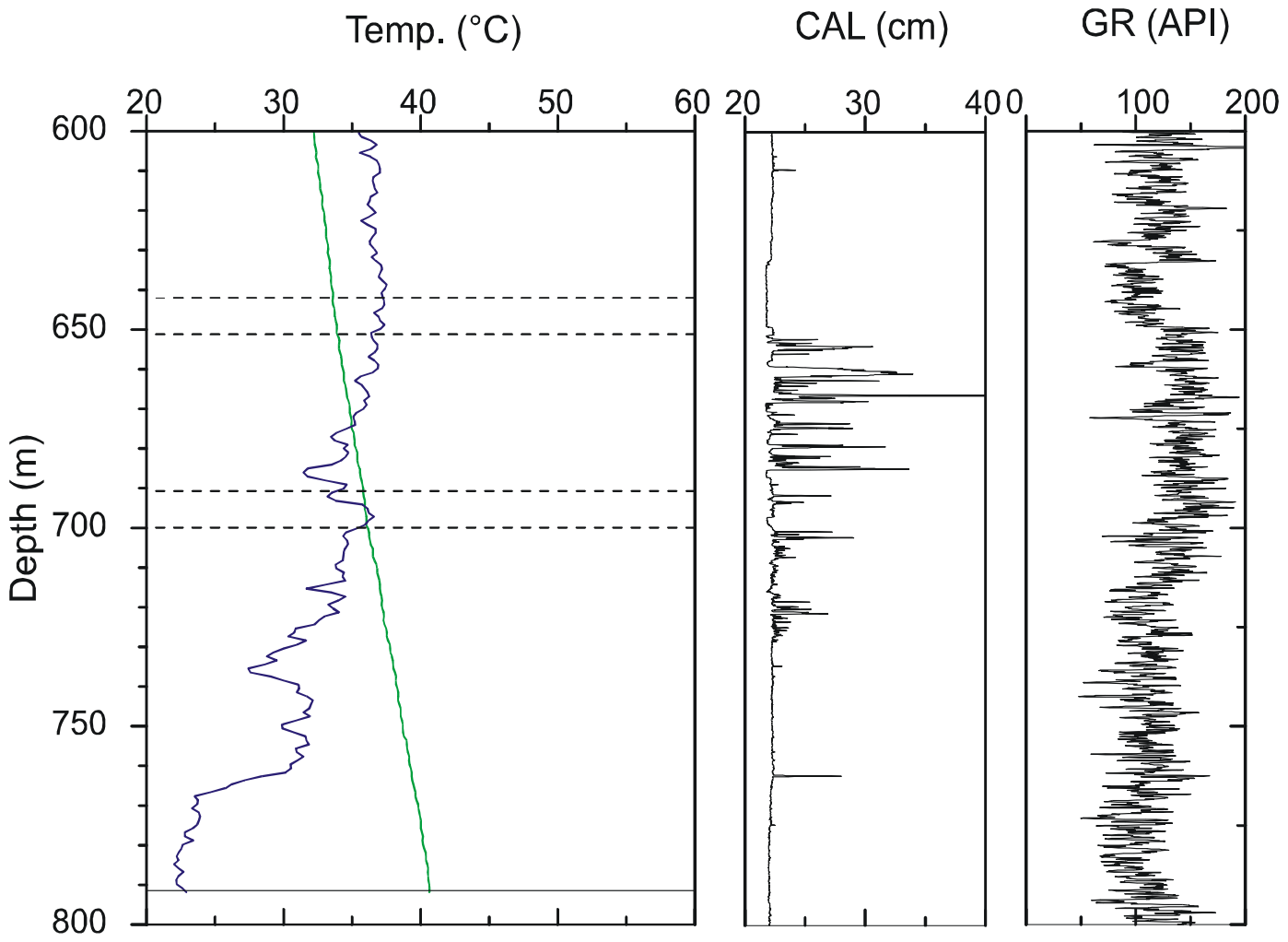
Temperature profiles – pumping of cement



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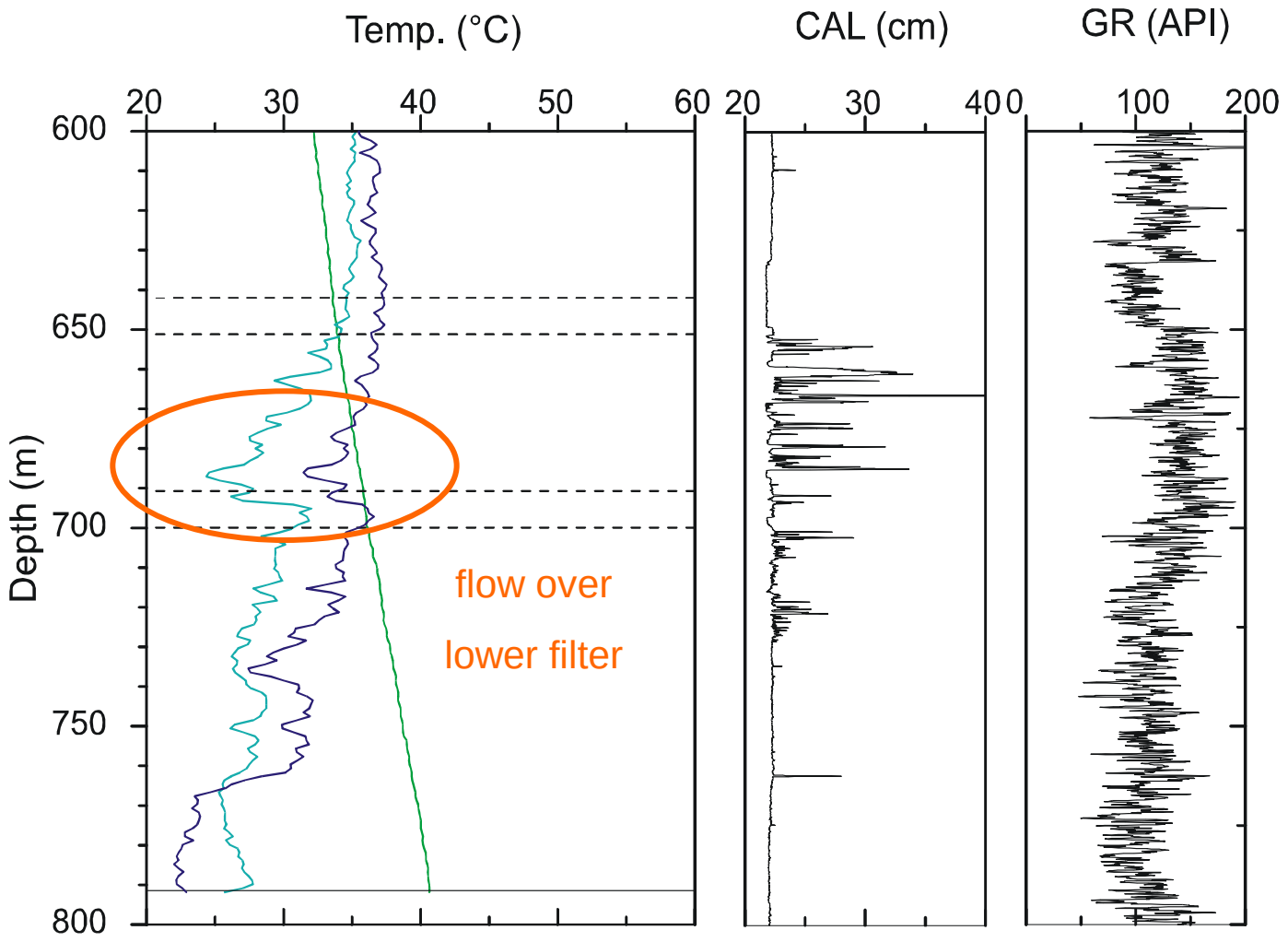
Temperature profiles - pumping of cement



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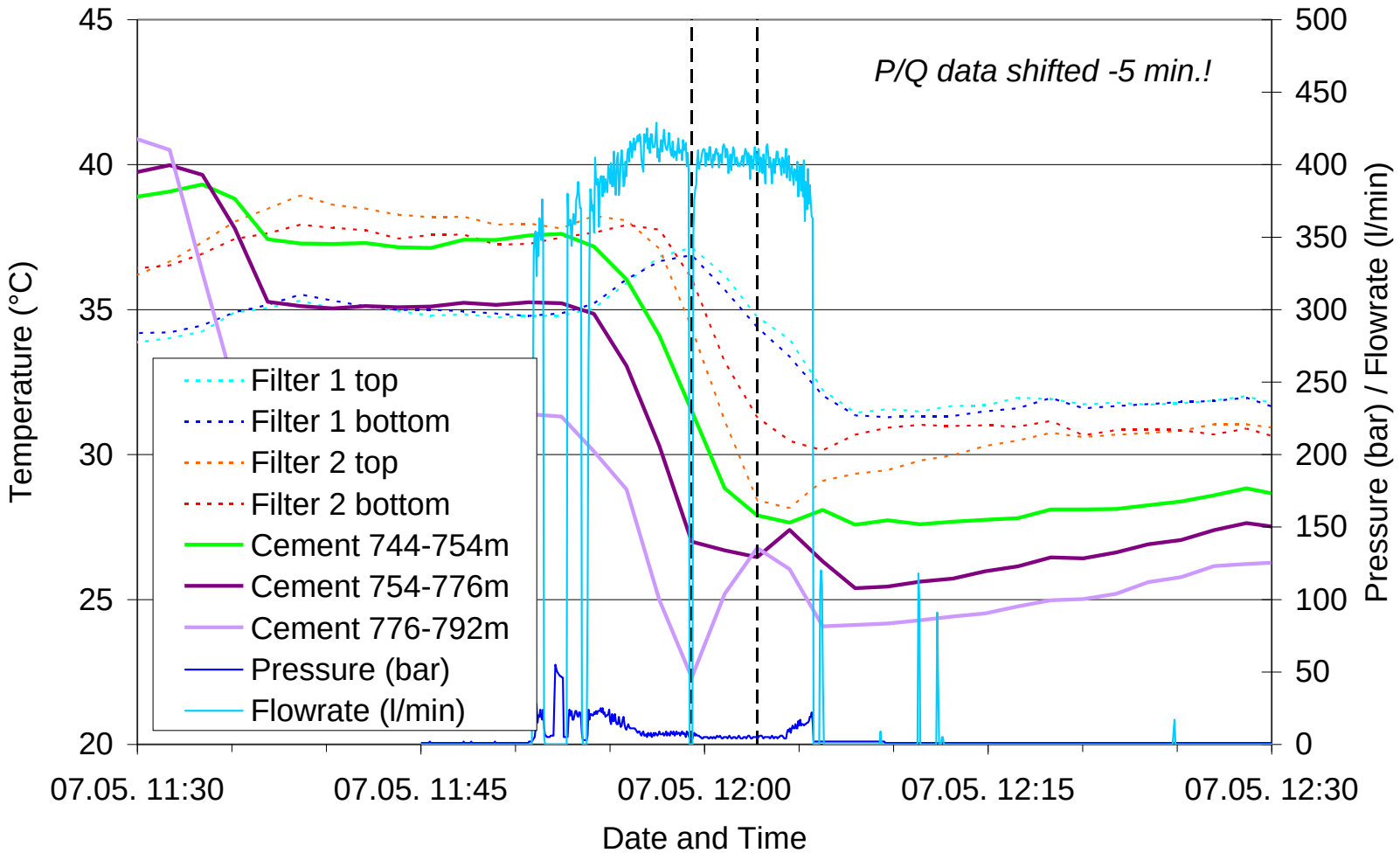
Change of temperature with time and hydraulic data



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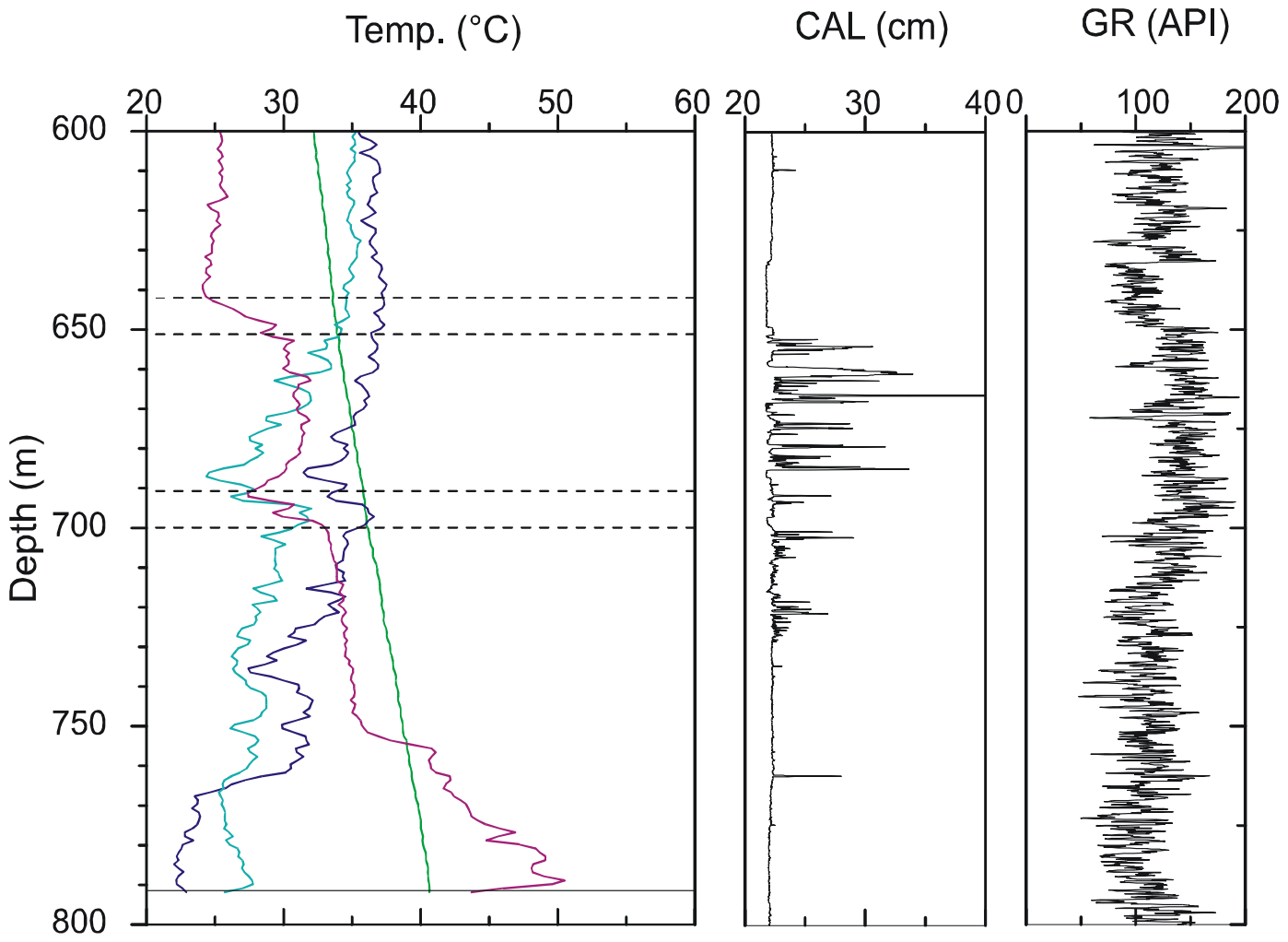
Temperature profiles – circulation of KCl pill



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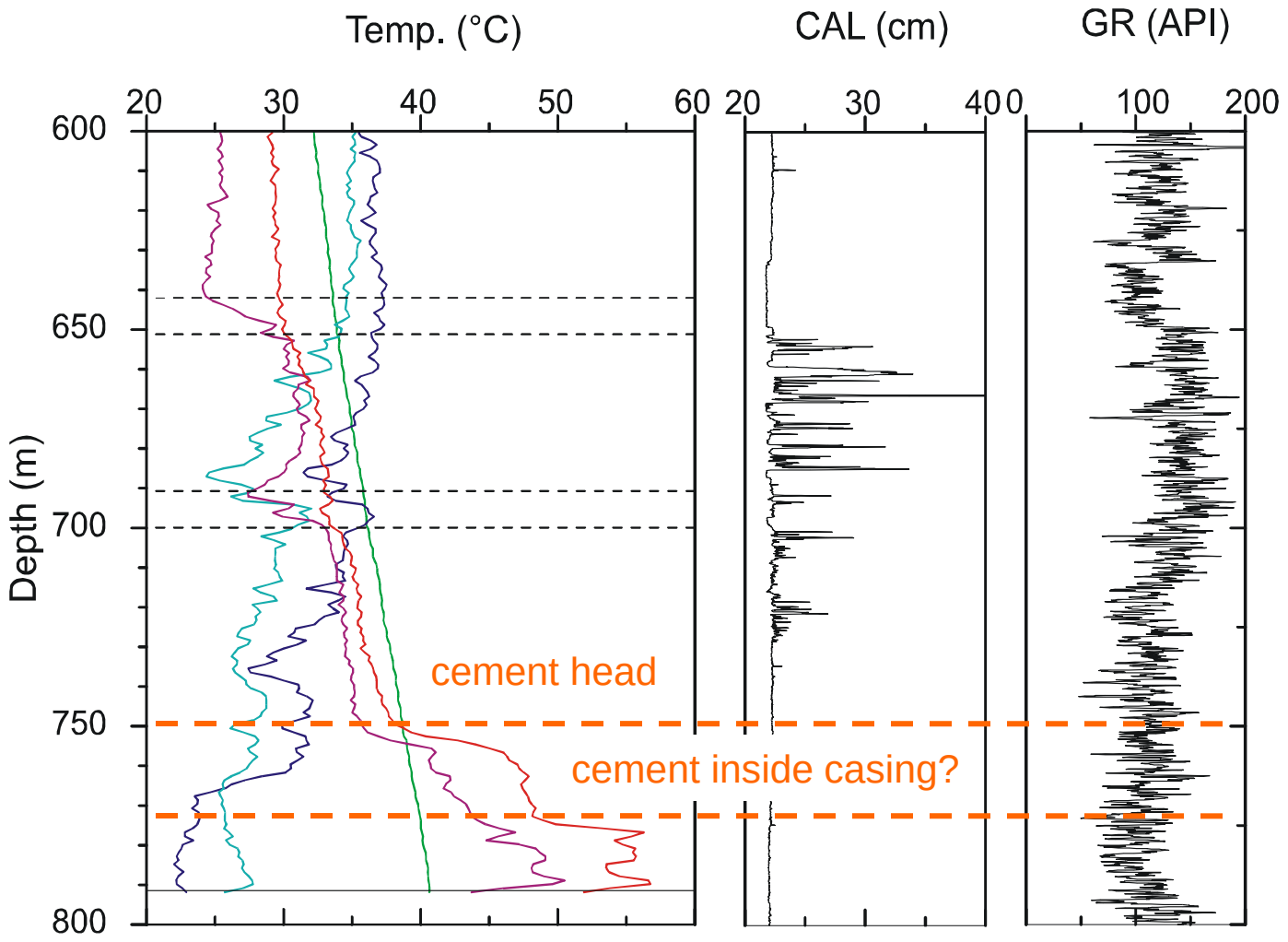
Temperature profiles – setting of cement



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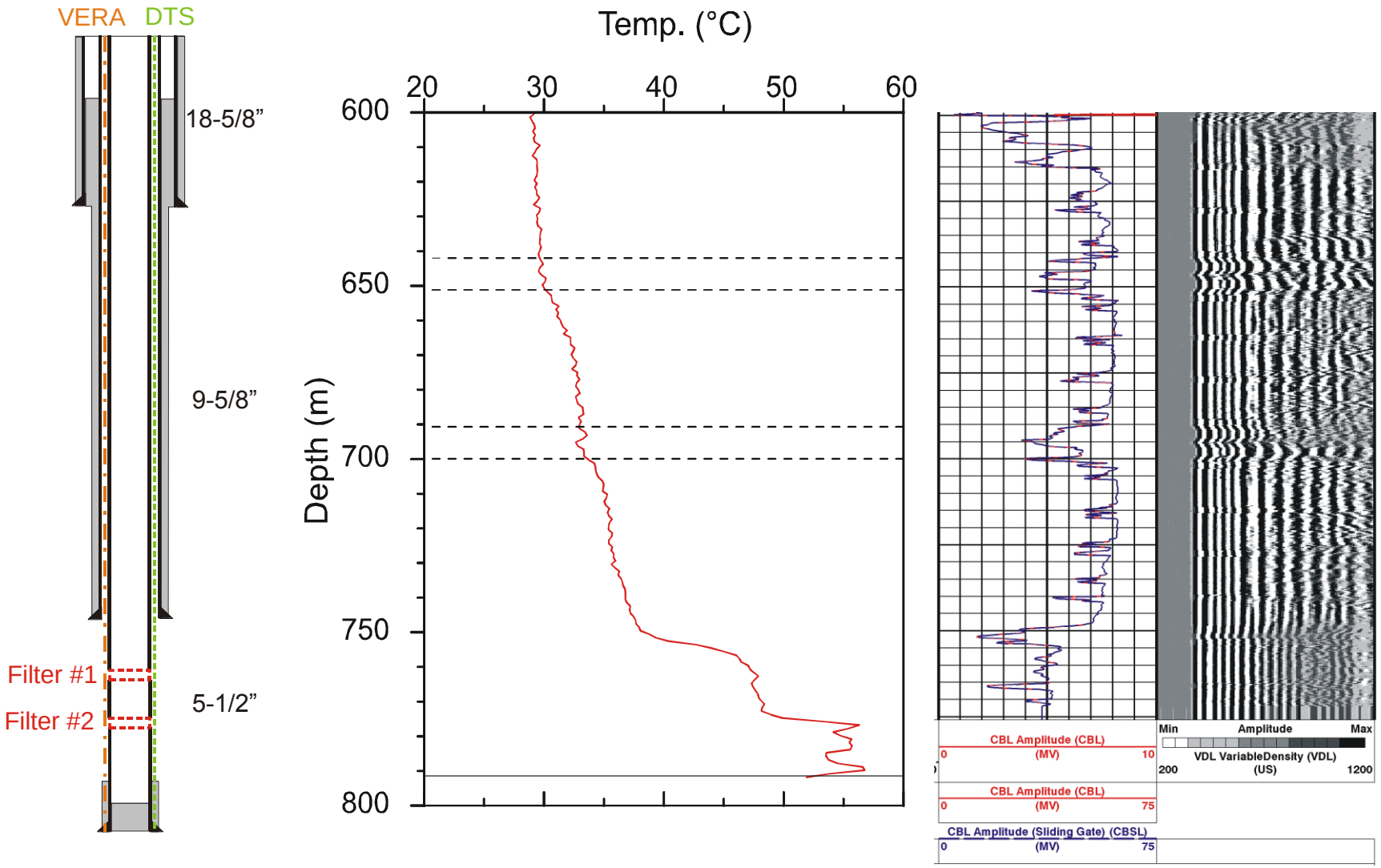
Temperature profiles and cement bond log



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Summary and Outlook

- Successful installation of permanent sensor cables behind casing
- Continuous temperature monitoring:
  - Location of cement head
  - Amount of cement in place
  - On-line information during operation
- Evaluation of sealing, zonal isolation: other methods (CBL, etc.)
- Advanced thermal modeling: thickness of cement sheath?