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Investigation on the effect of engine management on the particle emissions

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Co-operation of
- I.C. Engines and Combustion Laboratories (LVV) of ETH Zurich
- Center for Exhaust Gas and Particle Analysis (ZAP) of EMPA Dübendorf

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SAE-Paper 1999-01-3492
Analysis of Factors Influencing Particulate Matter Emissions of a Compression-Ignition Direct-Injection Engine
L.W. Jäger, K. Boulouchos, M. Mohr

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## Schematic Set-up of the Common Rail System
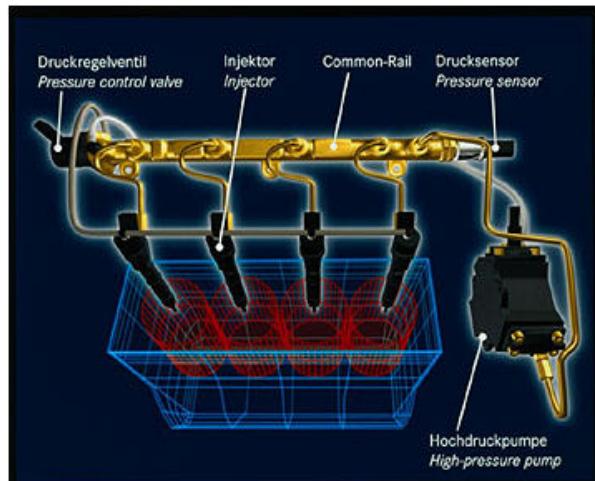
Source: http://www.rastatt.mercedes-benz.com/d/innovation/rd/forschung_cdi8.htm

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What is measured in the experiment

Engine
- 4 Cylinder
- 2.0 l displacement
- Common rail system
- Operation mode
  2 bar bmep, 2000 rpm
- low sulphur fuel (<30 ppm)

Parameters of the Experiment
- Rail pressure (IP)
- Pilot injection (PI)
- Exhaust gas reciculation (EGR)
- Start of injection (SOI)

| Dilution unit | → | Thermo desorber | → | **SMPS** | • Number size distribution w/ & w/o volatiles |

| Dilution unit | → | **Filter sampling** | • Gravimetric analysis • Chemical analysis |

Opacity reading — • Smoke number

Exhaust gas analysers
- NOx
- T.HC
- CO
- CO2

Pressure sensor
- Heat release
- Combustion noise

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Experimental set-up with sampling lines for gravimetric and number analysis of the particulate emissions
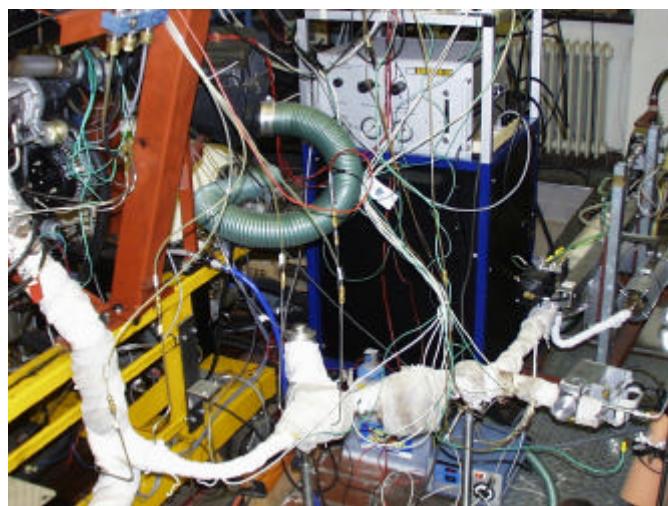
4

## Instrumental set-up for number size distribution measurements
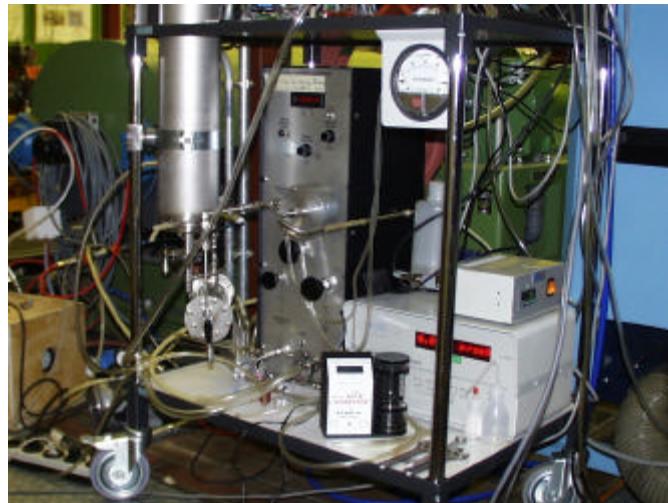
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Parameters

Injection pressure **IP**	Pilot injection **PI**	Exhaust gas recirculation **EGR**	Start of injection **SOI**
40 MPa **L**	Yes **Y**	$\lambda = 2.1$ (33%) **L**	-6°CA **E**
120 MPa **H**	No **N**	M	middle **M**
		$\lambda = 2.5$ (25%) **H**	+6°CA **L**

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Experiment with 24 different sets of parameters
Number size distributions
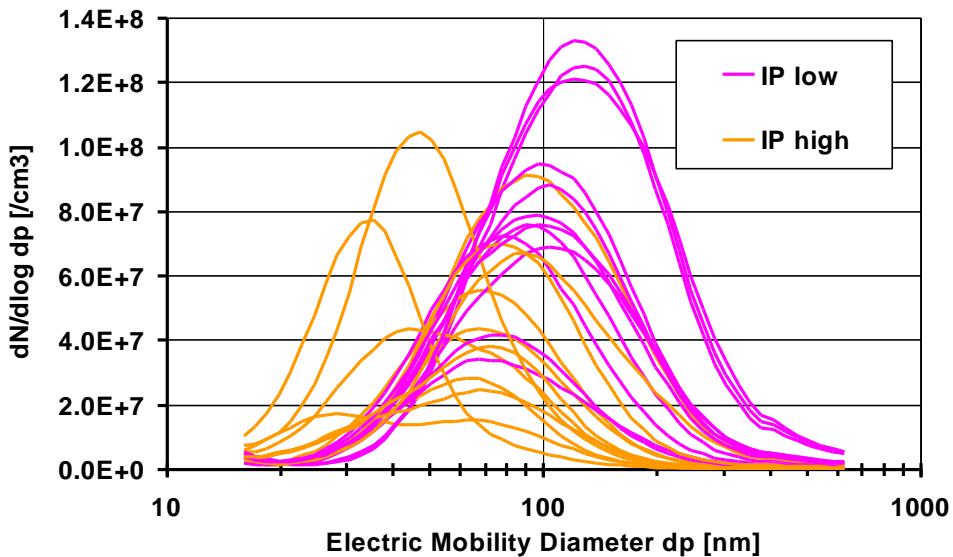
Effect of pilot injection & SOI
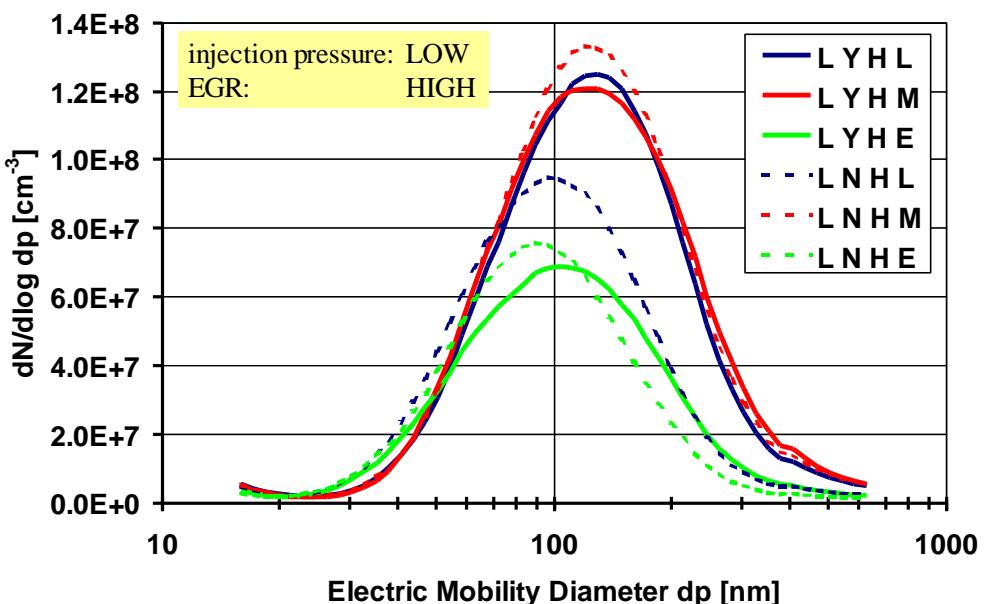
injection pressure: LOW
EGR: HIGH

Legend:
- L Y H L
- L Y H M
- L Y H E
- L N H L
- L N H M
- L N H E

Effect of EGR & SOI

injection pressure: LOW
pilot injection: NO

Legend: L N H L, L N H M, L N H E, L N L L, L N L M, L N L E

y-axis: dN/dlog dp [/cm3]
x-axis: Electric Mobility Diameter dp [nm]

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Effect of EGR & SOI

injection pressure: HIGH
pilot injection: NO

Legend: H N H L, H N H M, H N H E, H N L L, H N L M, H N L E

y-axis: dN/dlog dp [/cm3]
x-axis: Electric Mobility Diameter dp [nm]

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Filters samples for gravimetric analysis after collection

12
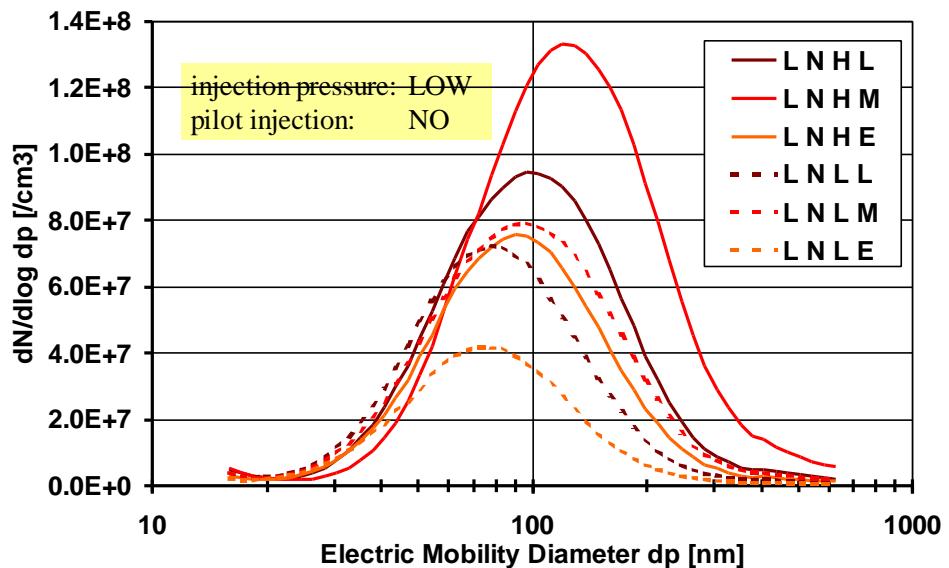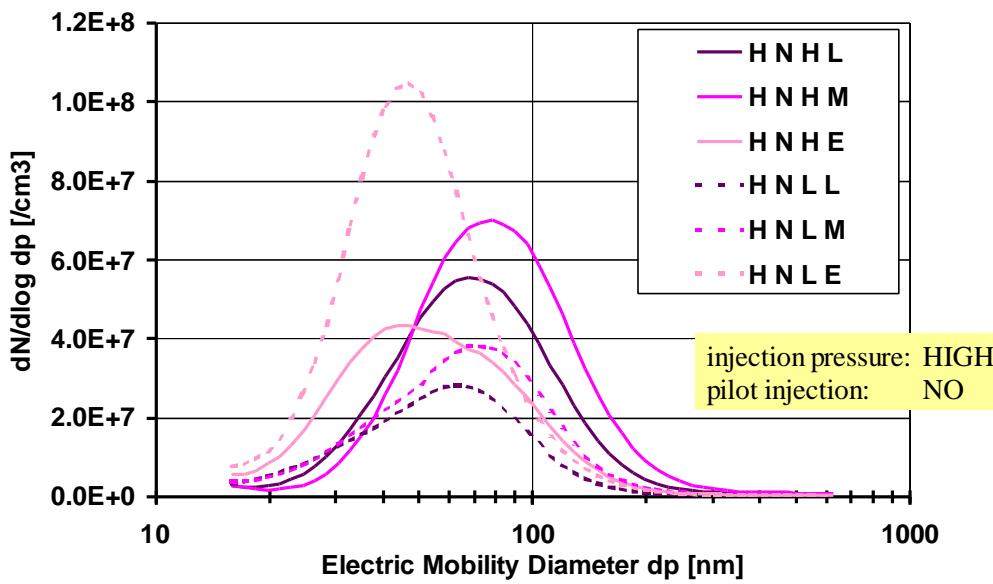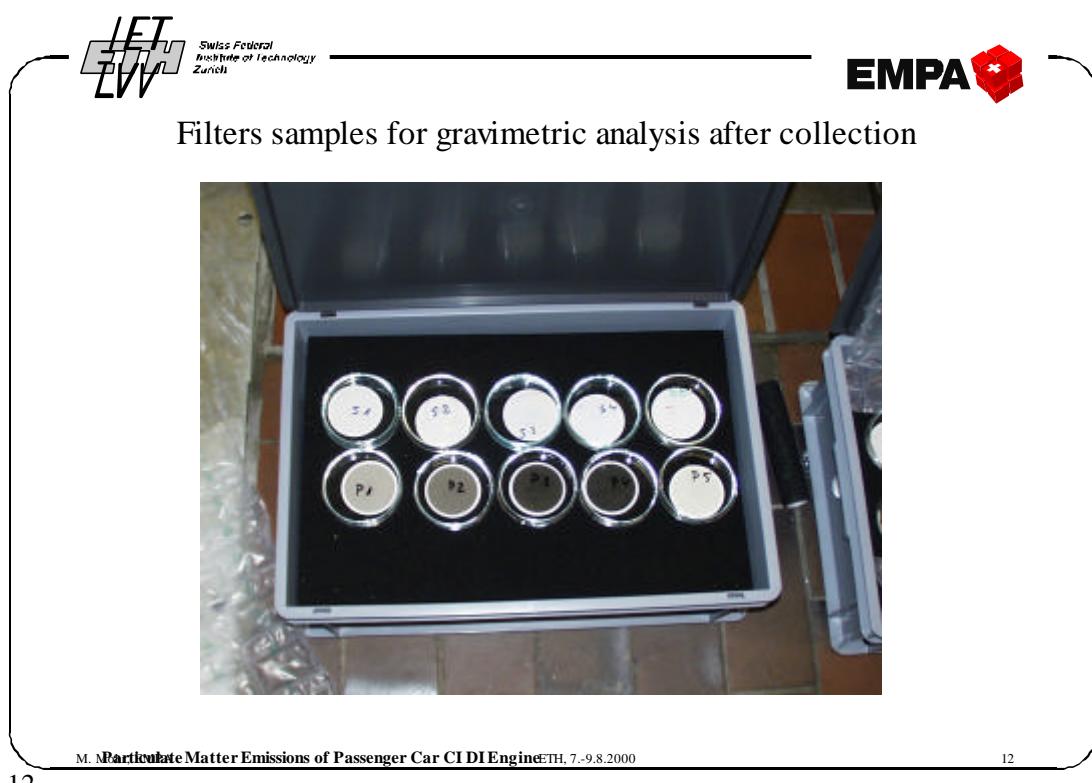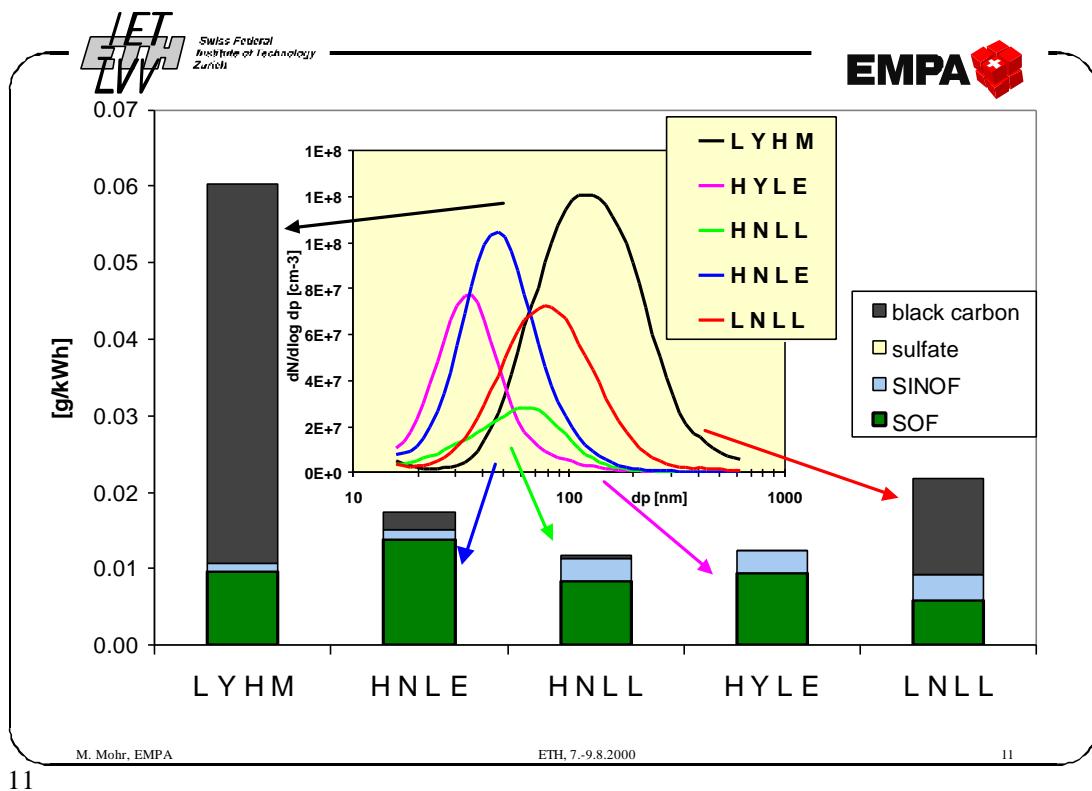
Particle number versus NPVP

Def. (by D. Kittelson): NPVP = Number particles / Volume particles
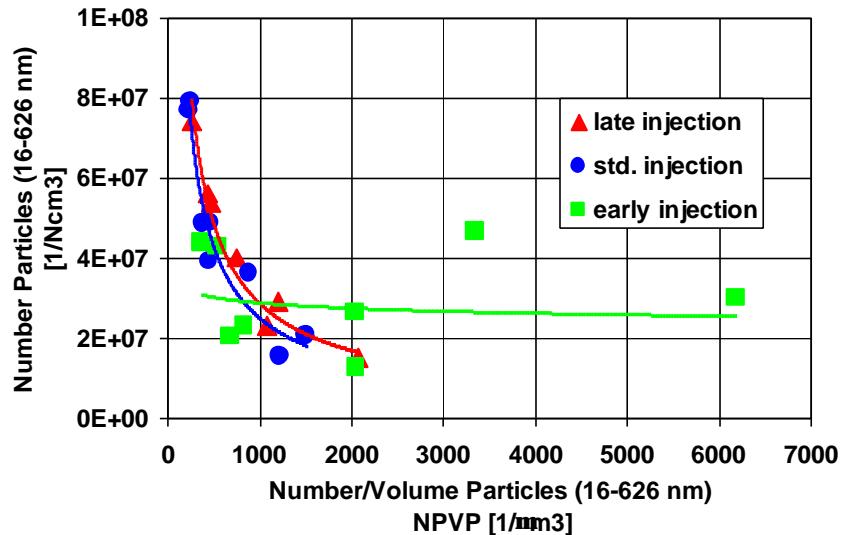
NOx versus particle number

order of symbol size:
low IP, PI;
low IP, no PI;
high IP, PI;
high PI, no PI
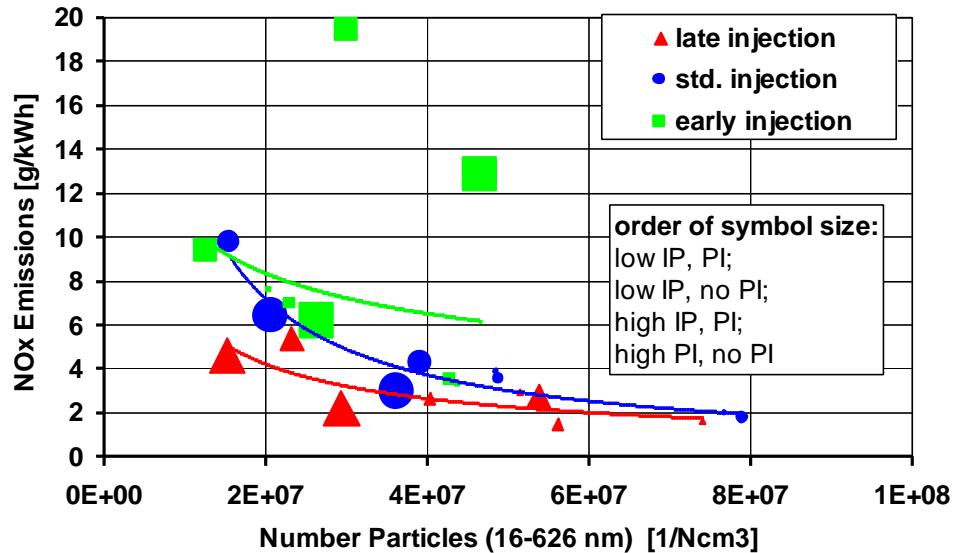
Fuel consumption versus particle number
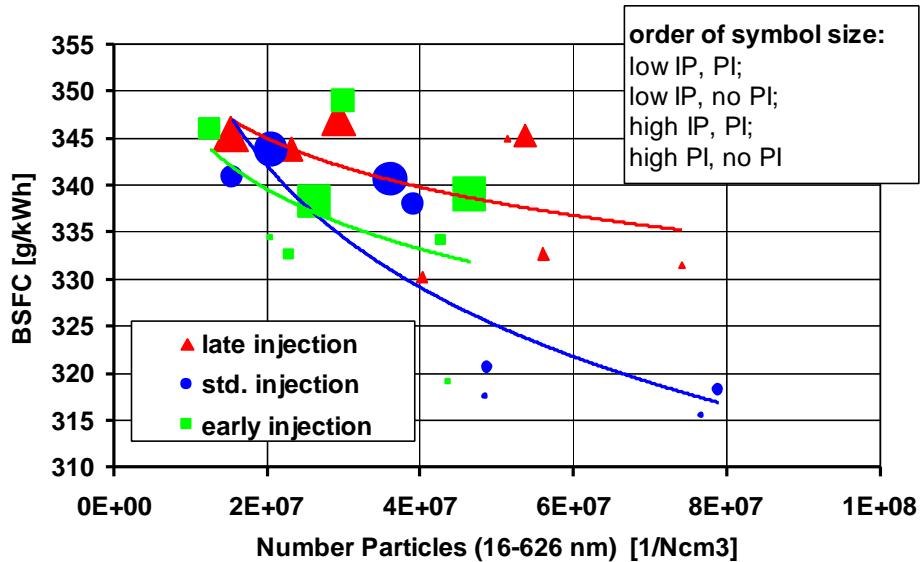
Summary

- Particle emission could be reduced by
  IP ↑   PI ↗↘   EGR ↓   SOI ←
       => higher premixed combustion portion

- Mainly the solid fraction of the particle mass was affected by the measures

- "Very clean" parameter setting → formation of a new mode
       => nucleation due to limited surface available

- Results of gravimetric and SMPS analysis in good agreement as long as no new formation takes place.