Alexander von Humboldt
Stiftung/Foundation

JÜLICH
FORSCHUNGSZENTRUM

Thermodynamics of the Reciprocal $NaCl$-KCl-$NaNO_3$-KNO_3 System

Project:

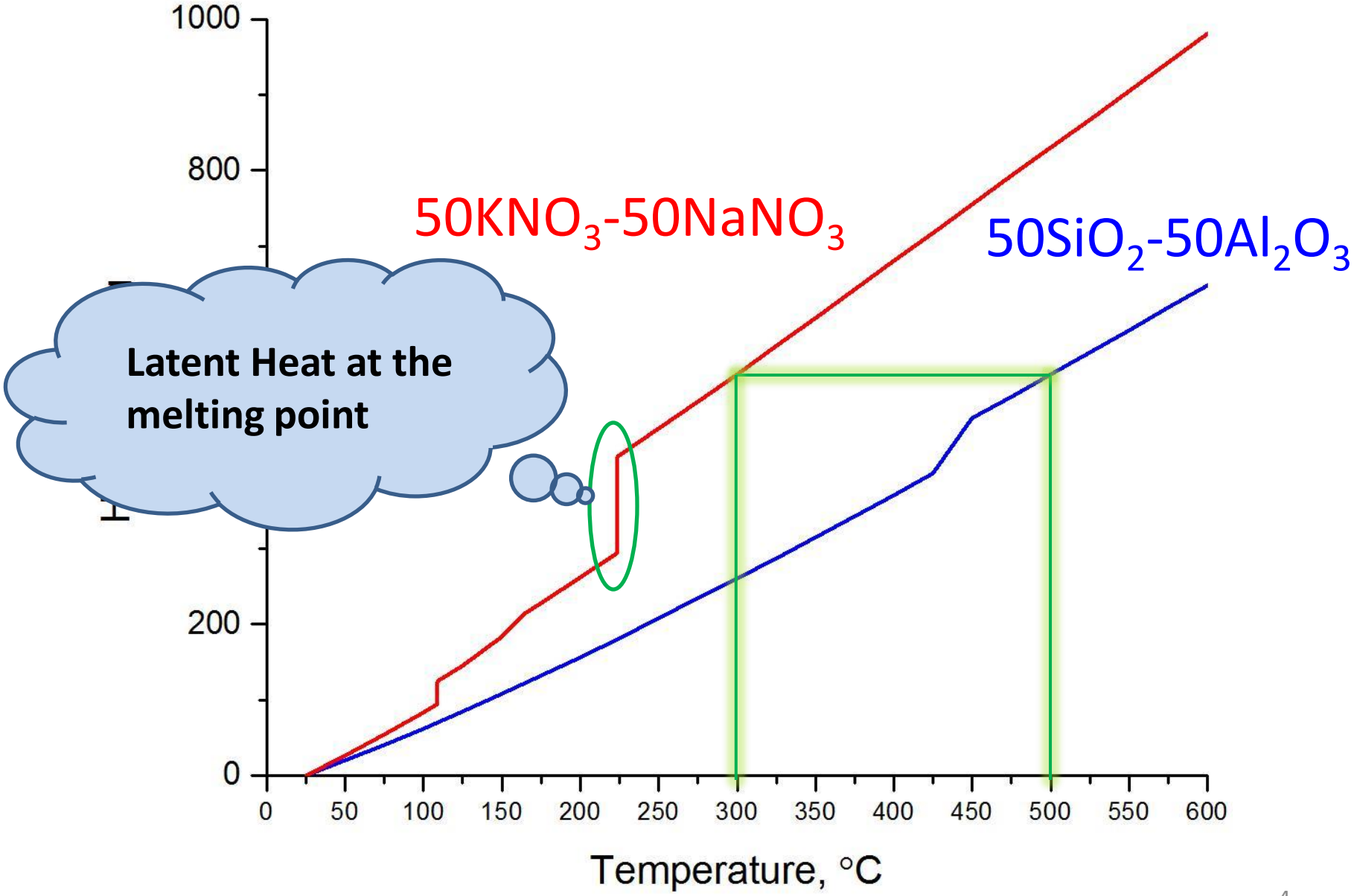
Thermodynamics of Salt Systems for Thermal Energy Storage

Dmitry Sergeev, Elena Yazhenskikh, Nawfel Talukder, Dietmar Kobertz, Michael Müller

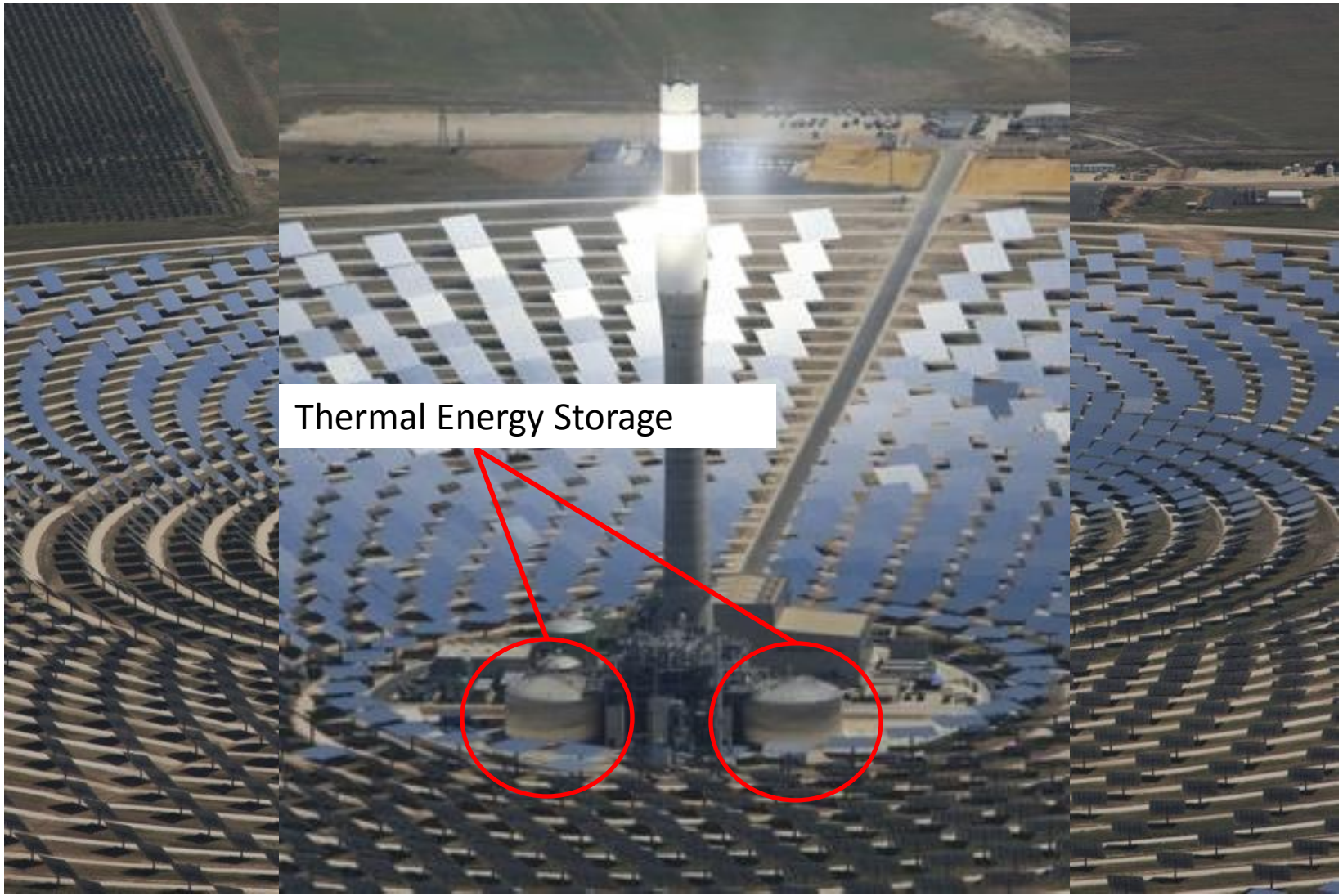
Russian Winter (-30°C)

Sensible Thermal Energy Storage

Heat Increment

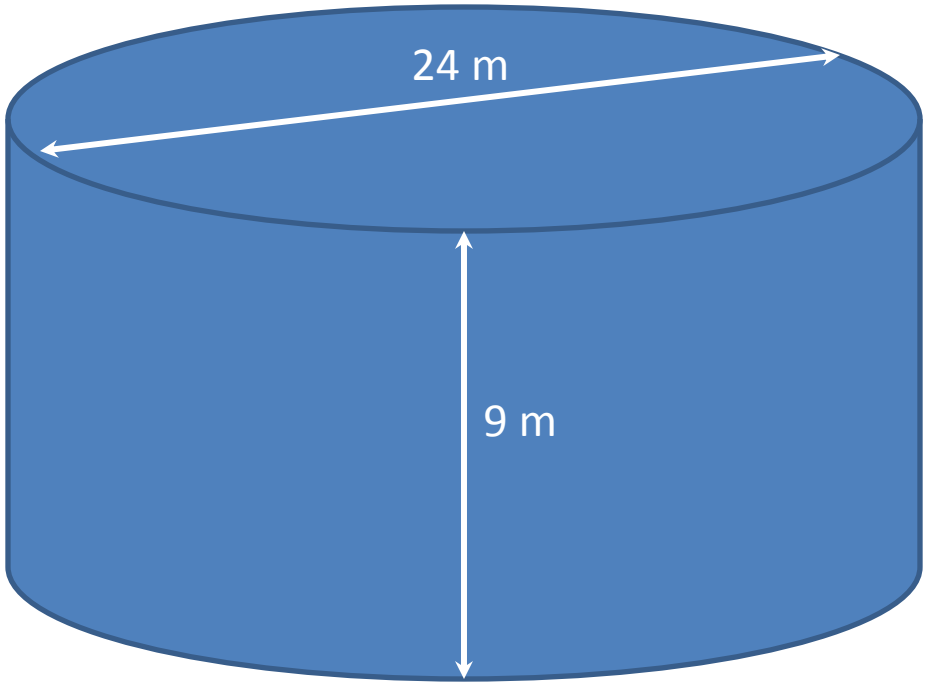


Solar Power Plant



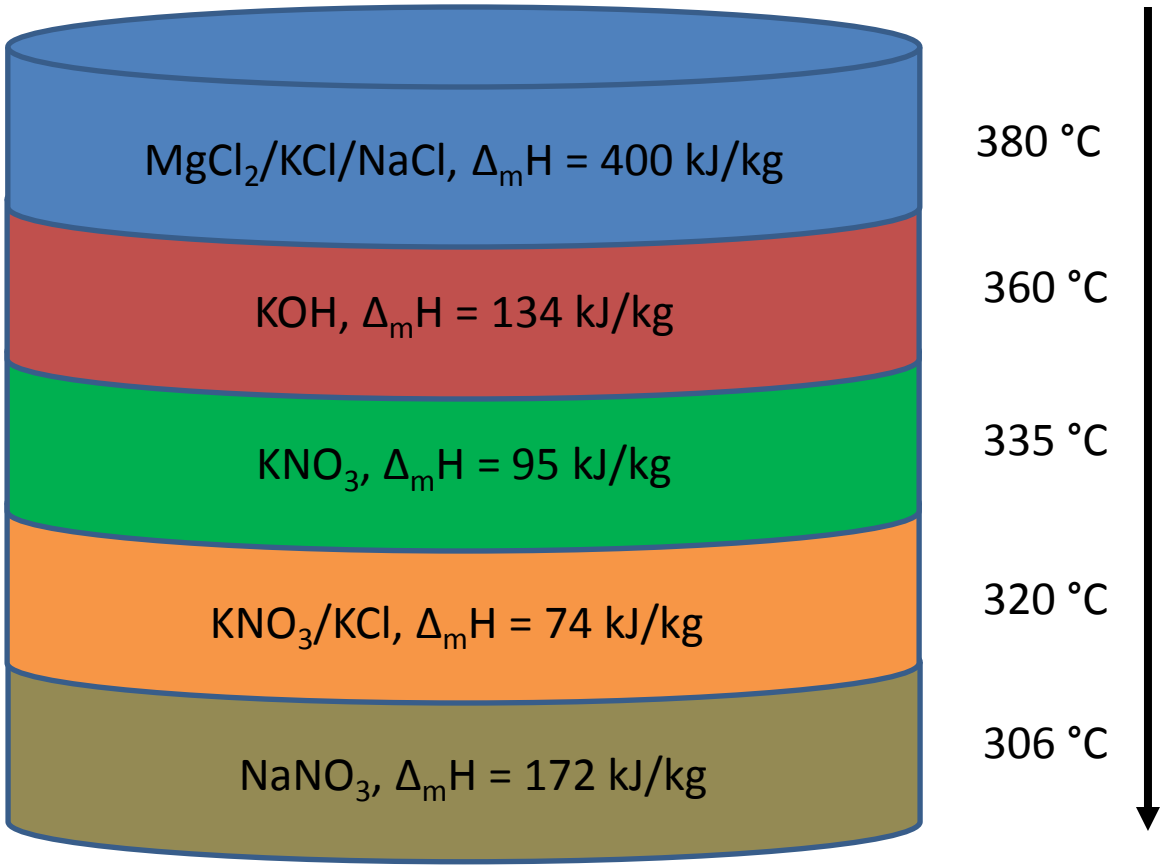
http://www.climatechangebr.org/page25.htm

Weight of TES



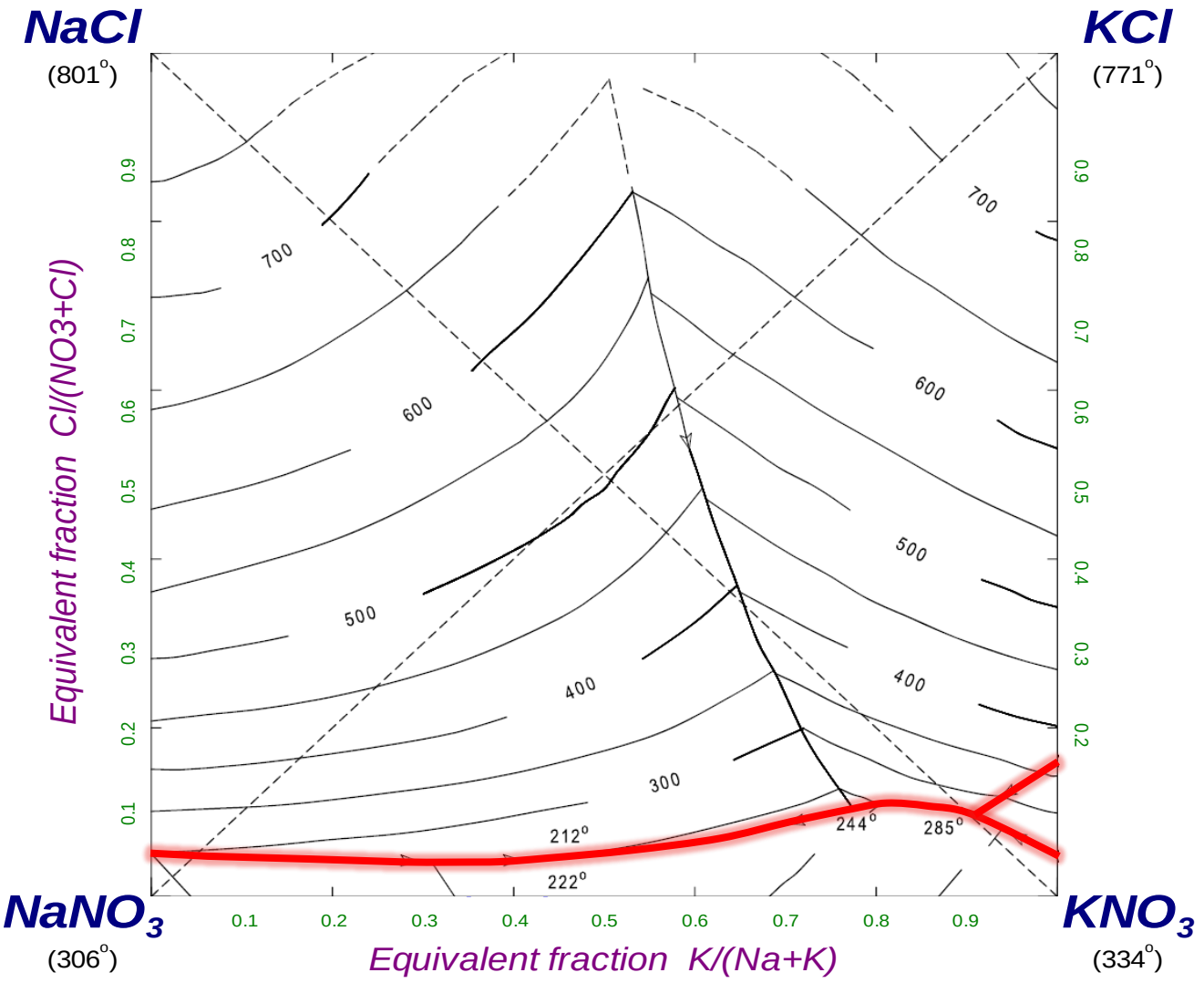
m=10 000 kg

Cascaded Latent Heat Storage



Dinter F., Geyer M., Tamme R., "Thermal Energy Storage for Commercial Applications" Berlin, Heidelberg, New York, usw.: Springer-Verlag; 1991.

Phase Diagram of the NaCl-KCl-$NaNO_3$-KNO_3 system



R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

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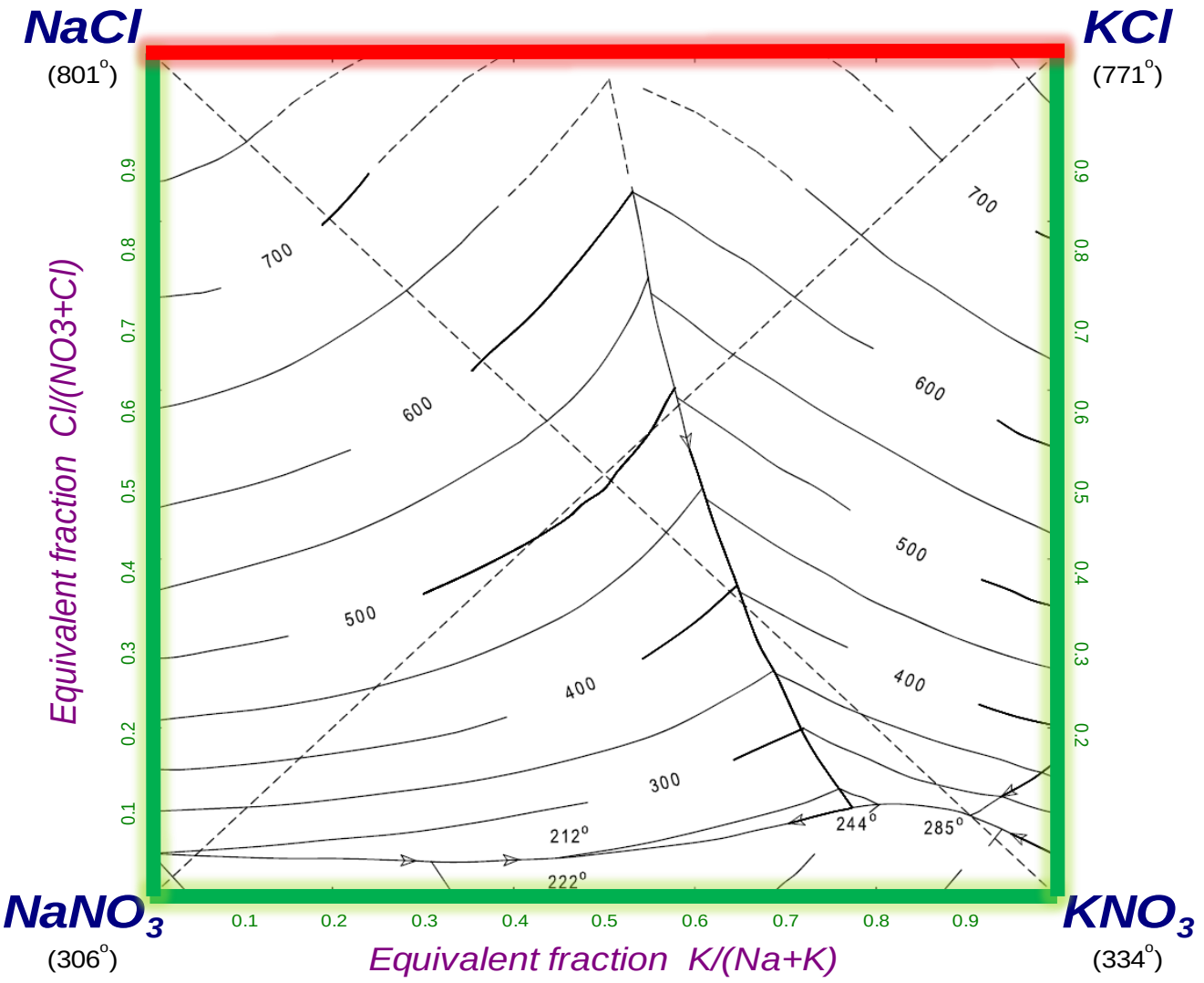
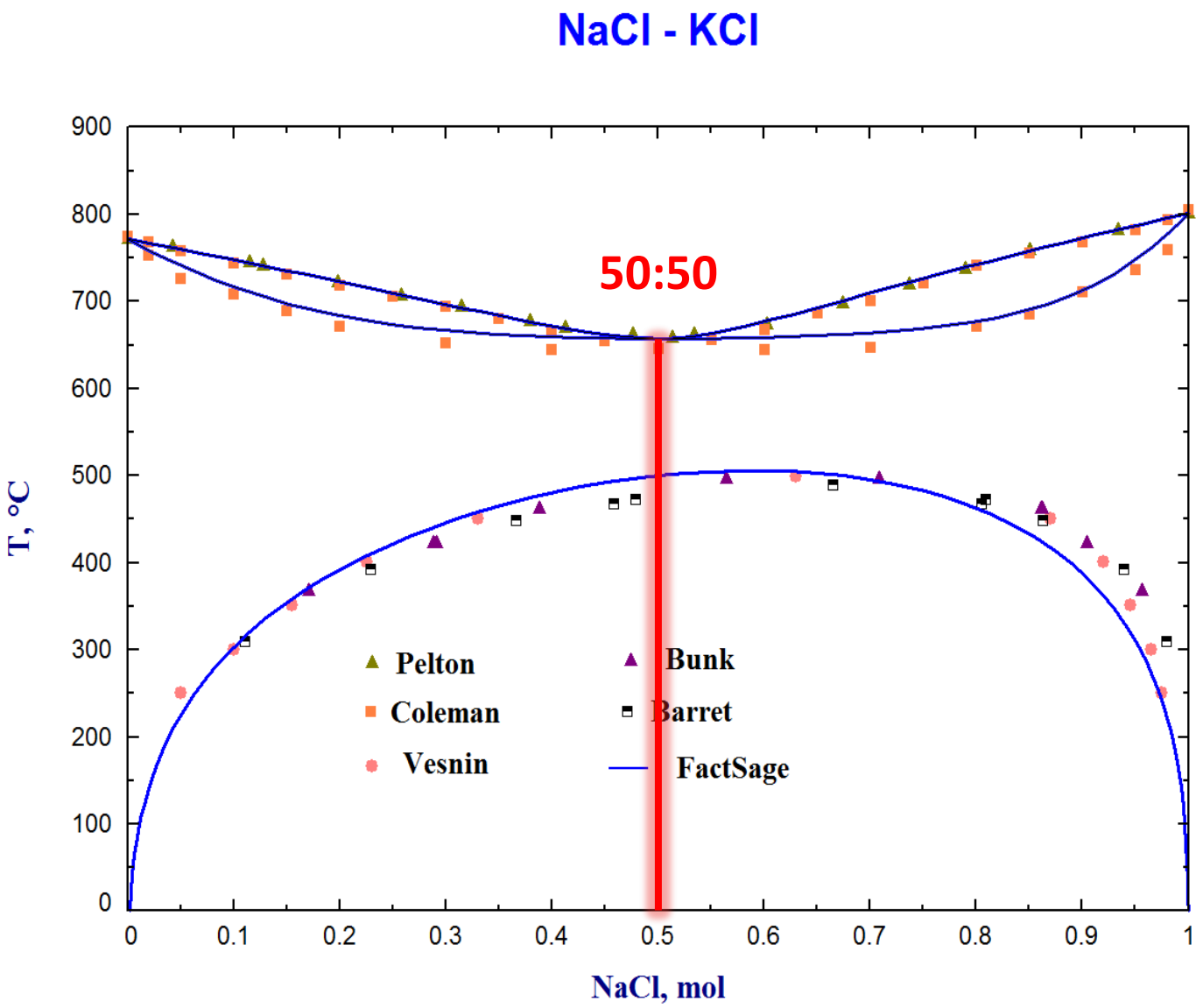


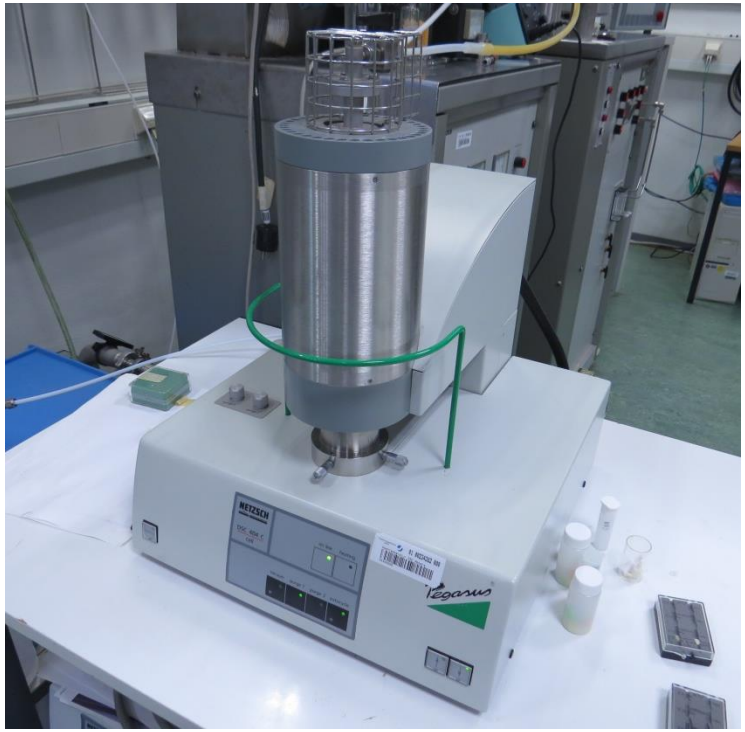
R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

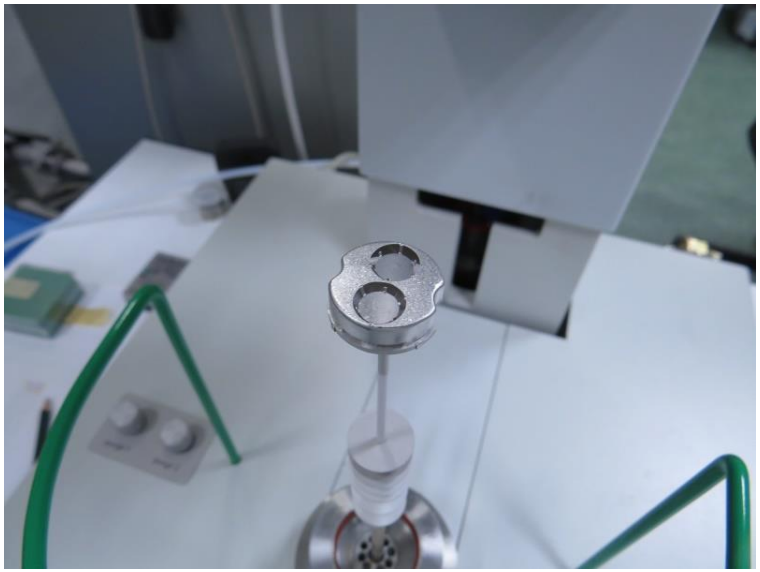
Phase Diagrams of the NaCl-KCl System



Differential Scanning Calorimetry

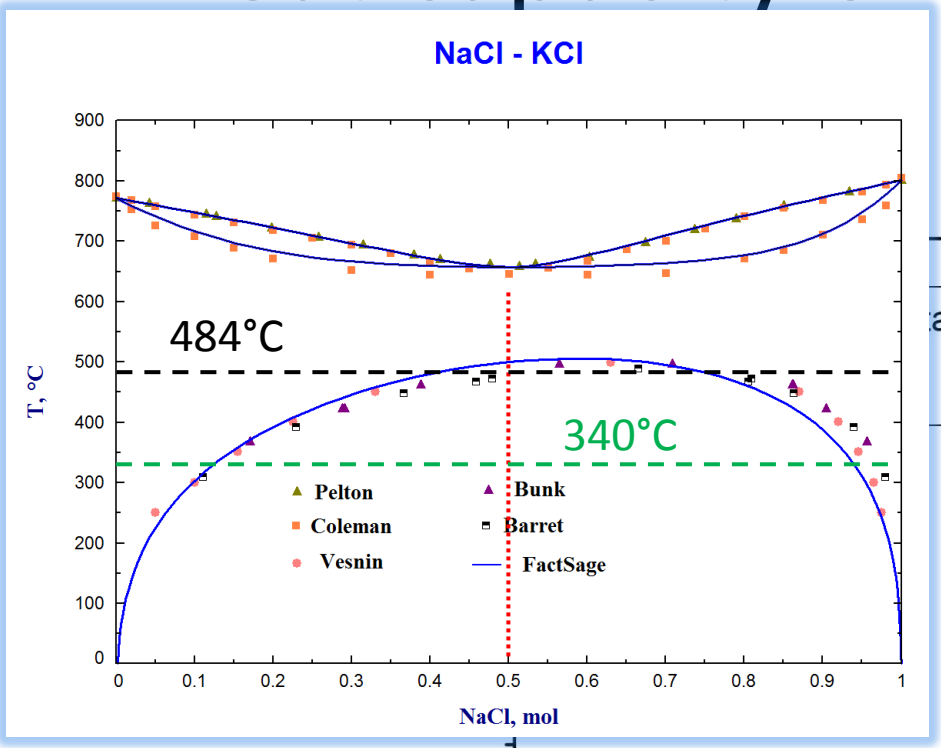
DSC 404C Netzsch

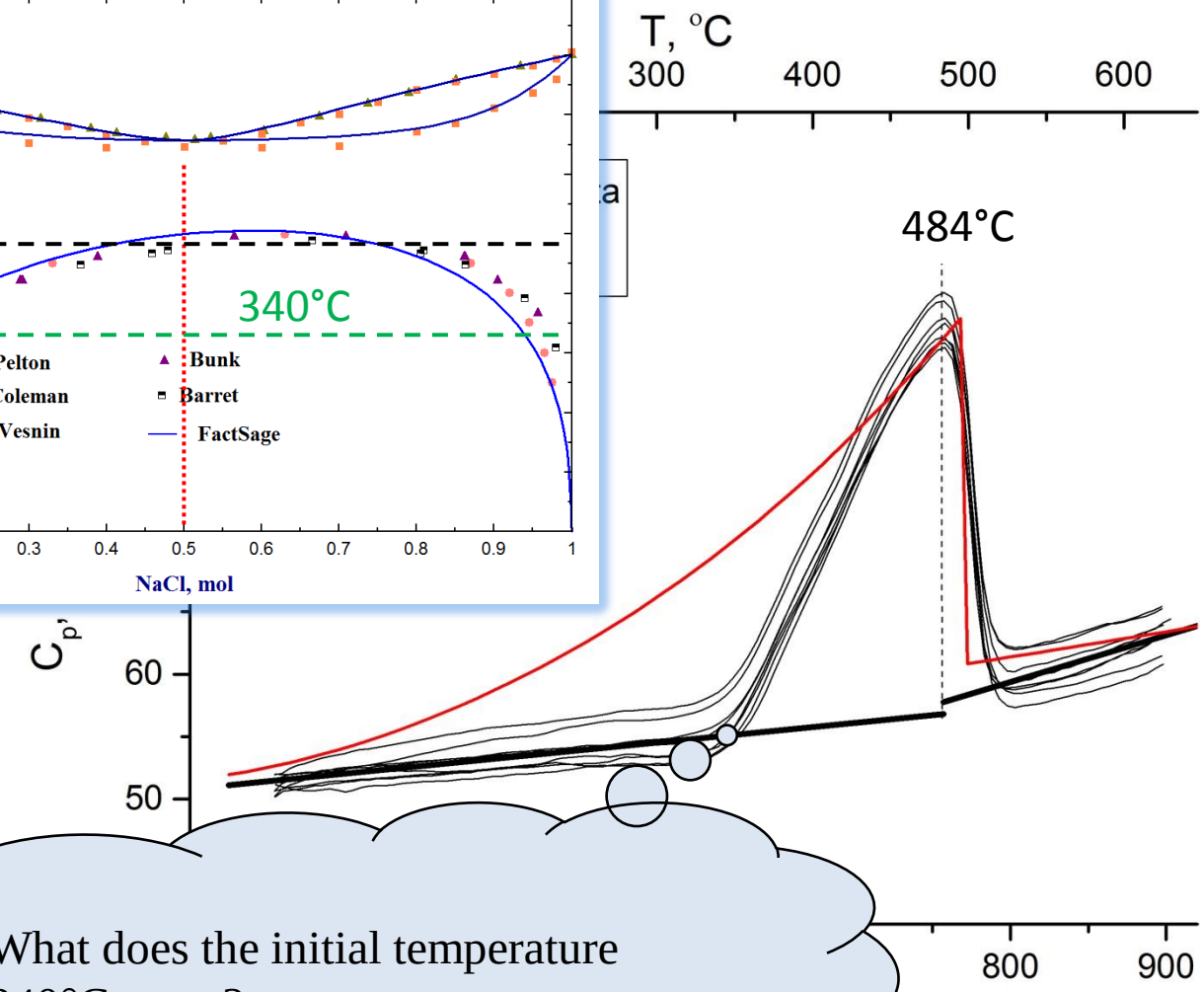




Sample holder

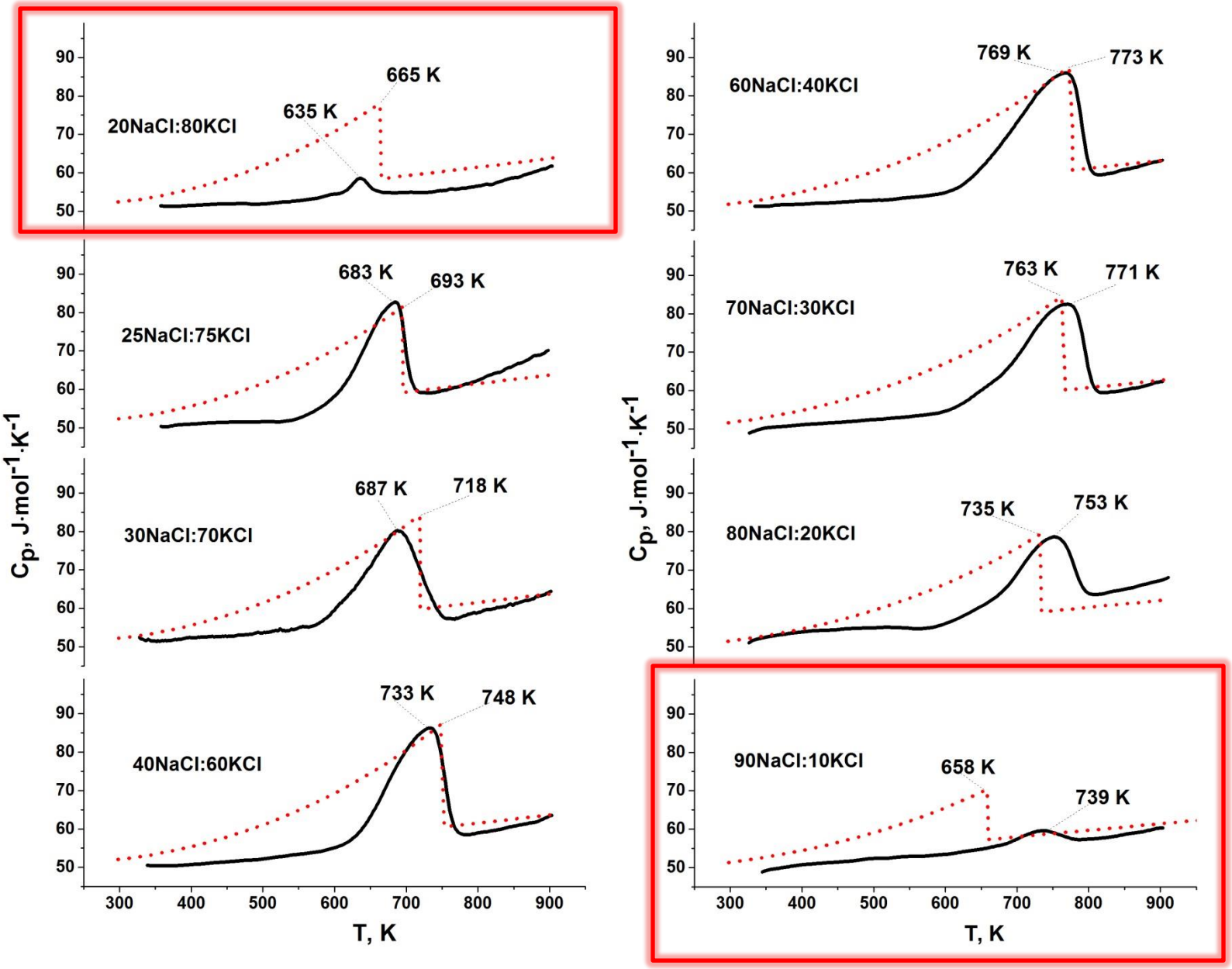
Heat capacity of the 50NaCl-50KCl



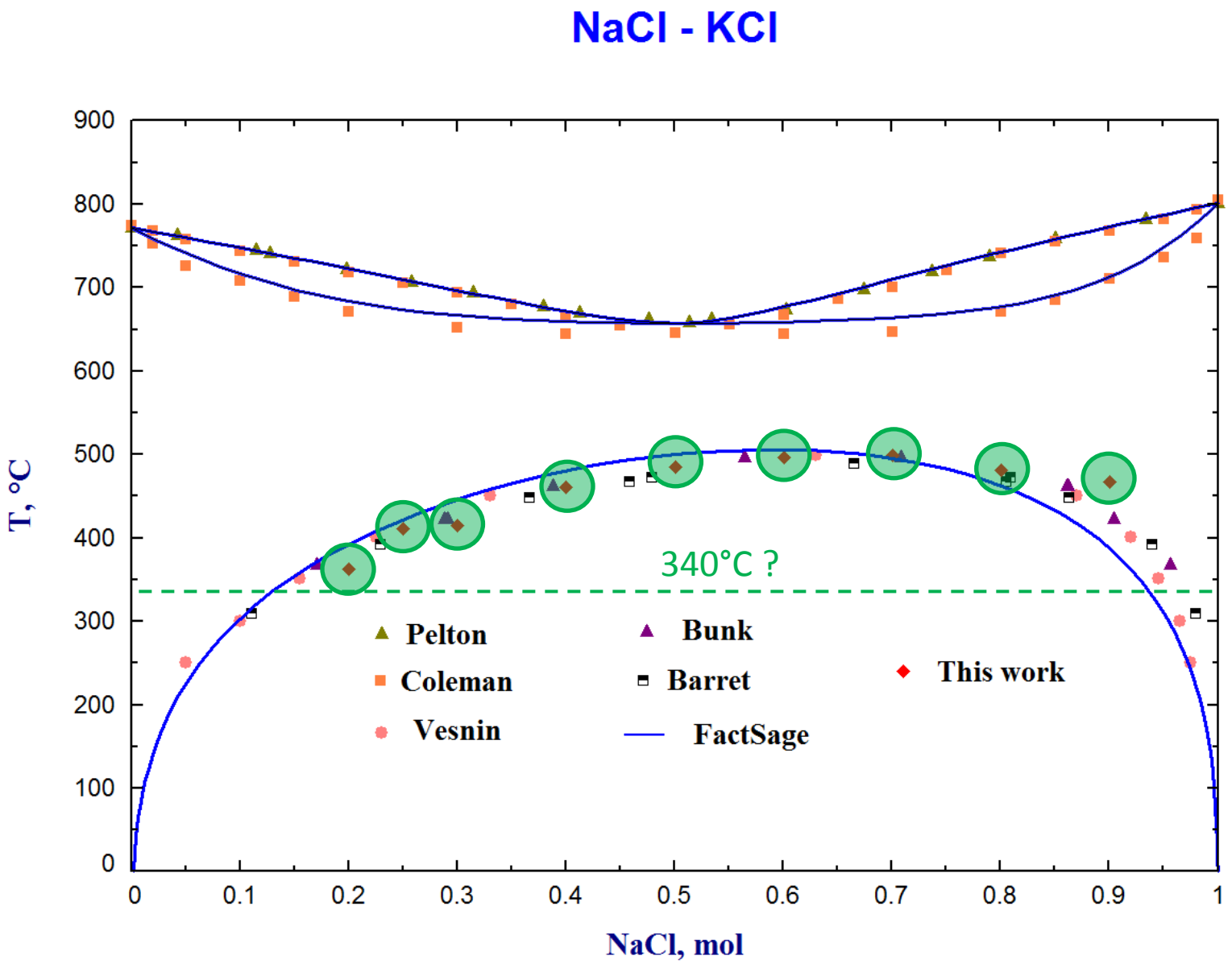


What does the initial temperature 340°C mean?

Heat capacity of the NaCl-KCl system



Phase Diagramm

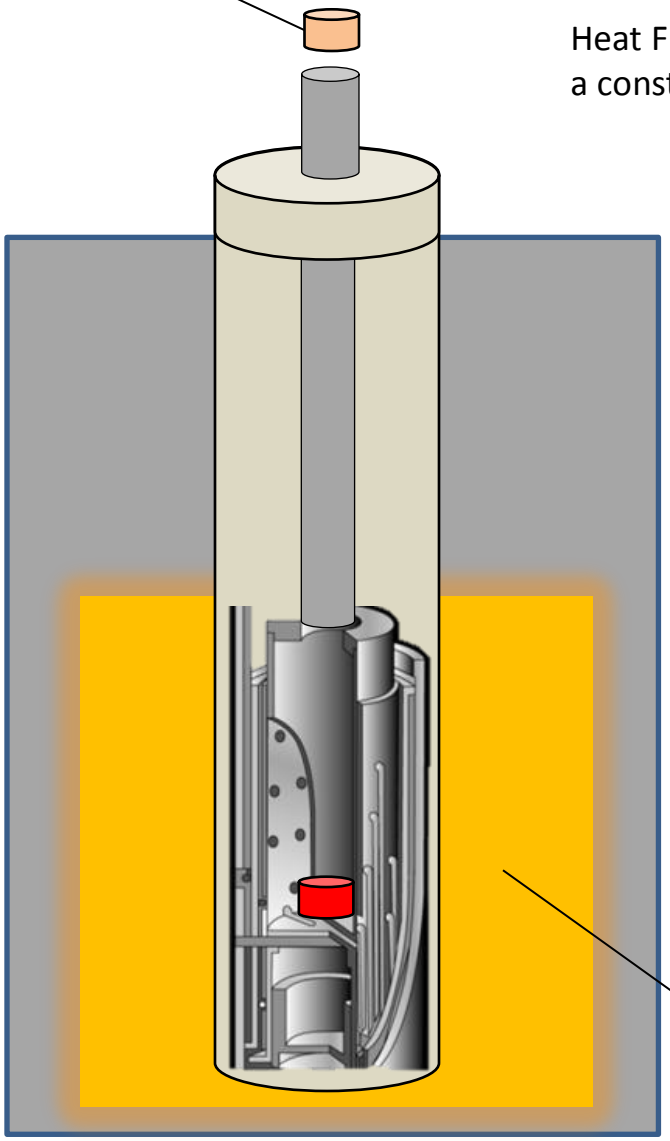


Drop Calorimeter

mHTC 96 Seteram

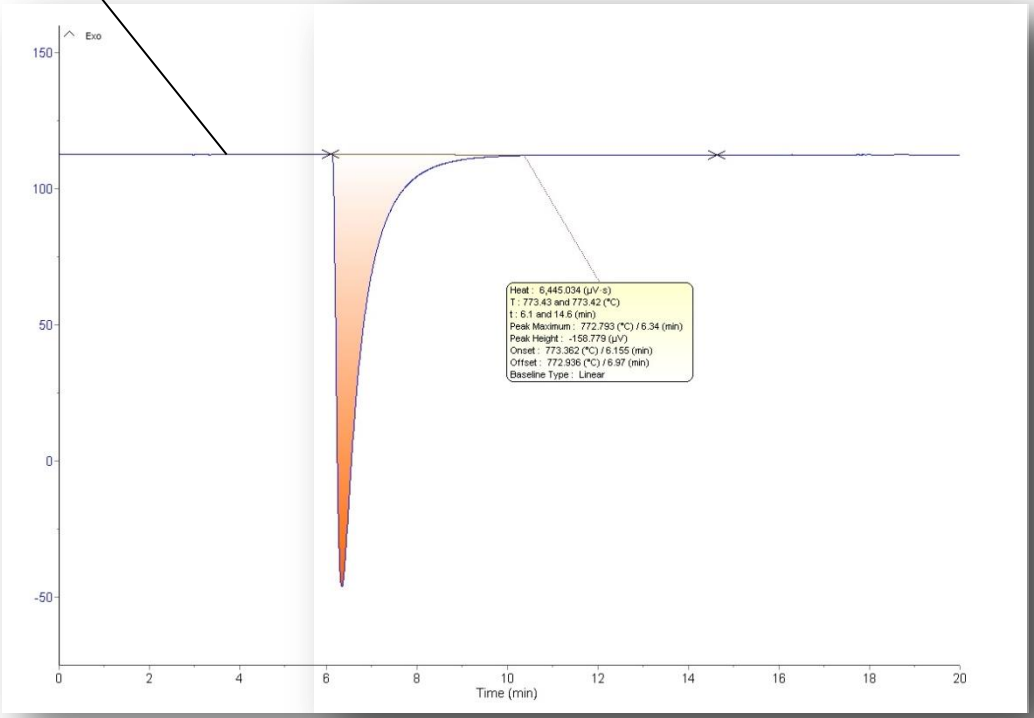
Drop Calorimetry

Sample (10-100mg)
at room temperature



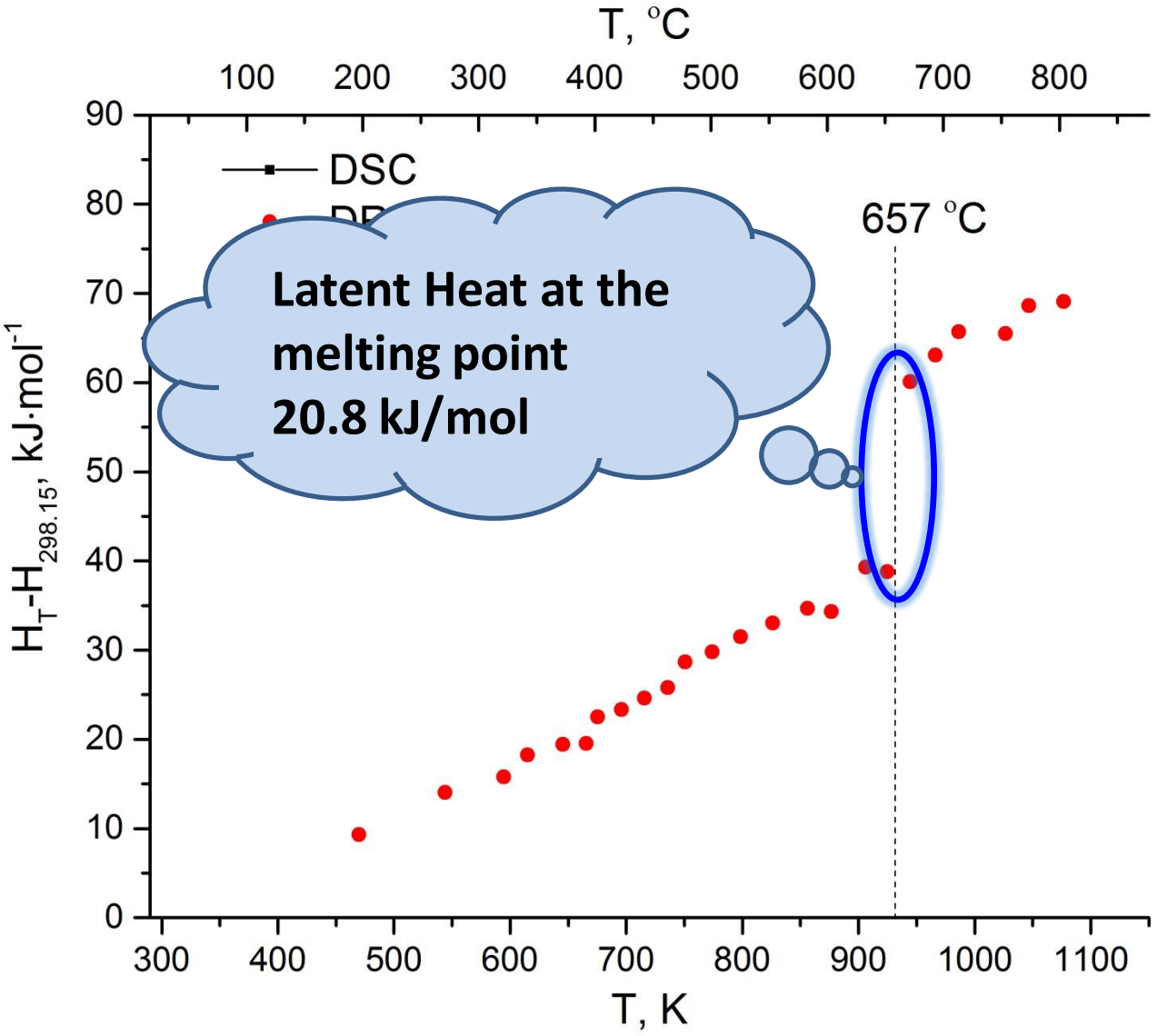
Heat Flow (µV) at
a constant *T*

Experimental data

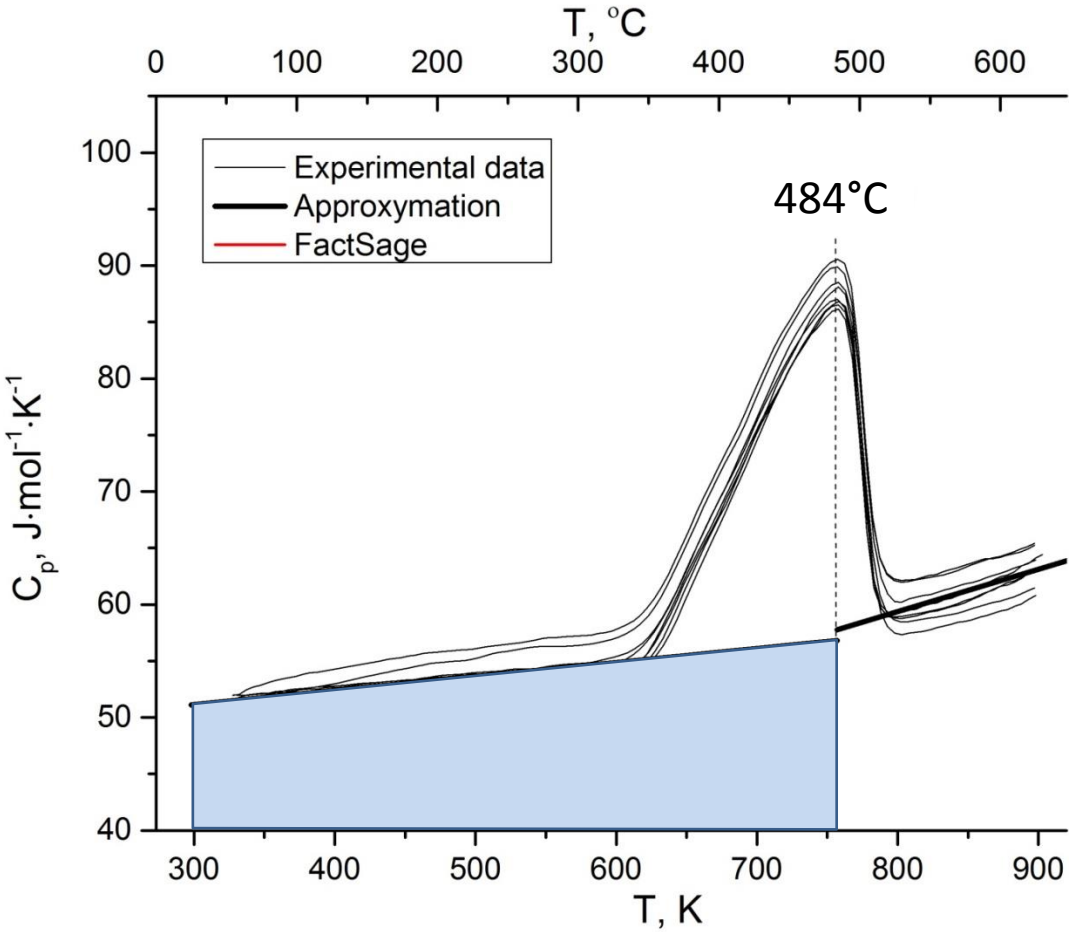


Hot zone,
constant temperature T

Enthalpy increment in the 50NaCl – 50KCl mixture

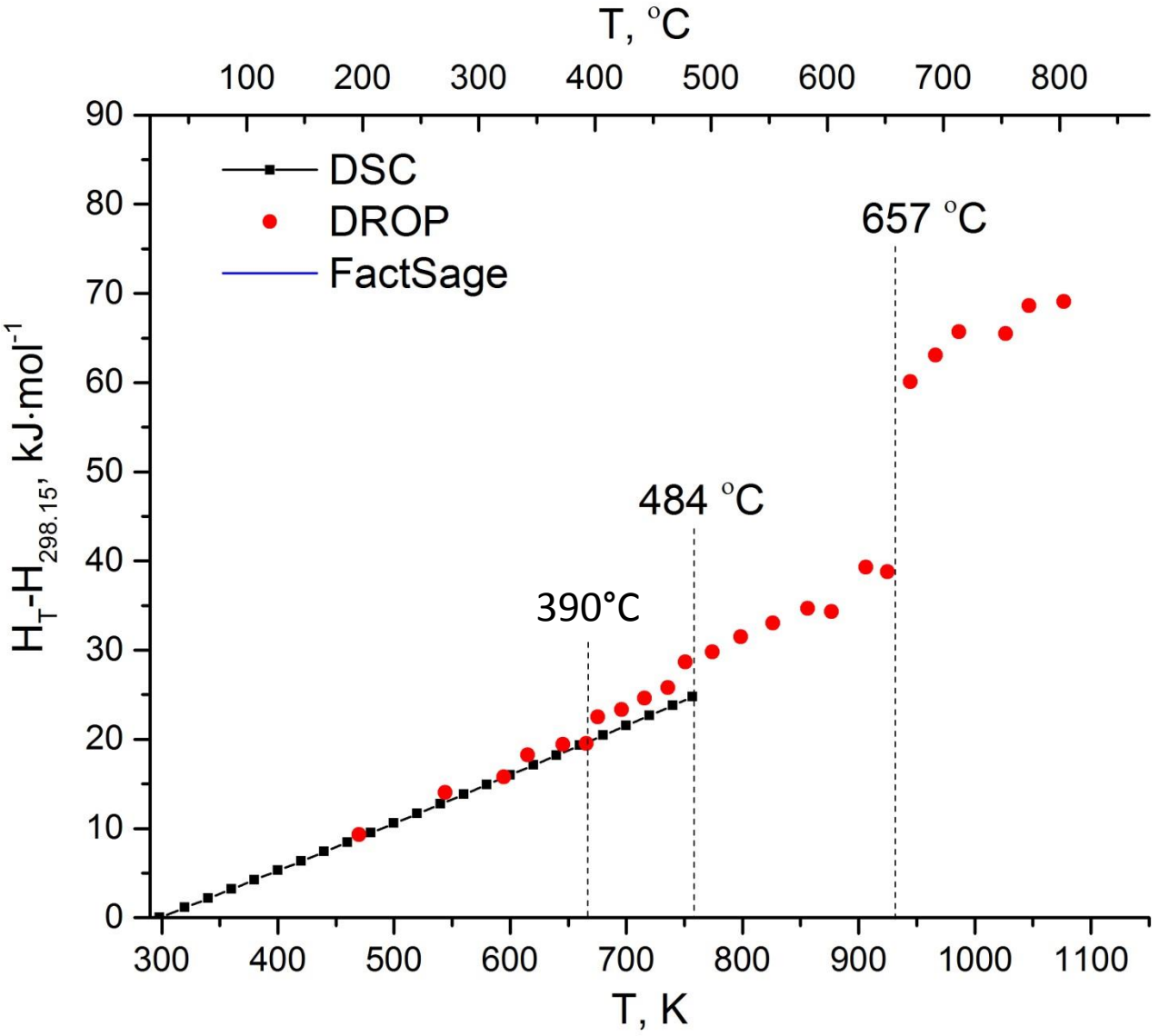


Heat capacity of the 50NaCl-50KCl



$$H_T^\circ - H_{298.15}^\circ = \int_{298.15}^{T} C_p^\circ(T)\,dT$$

Enthalpy increment in the 50NaCl – 50KCl mixture



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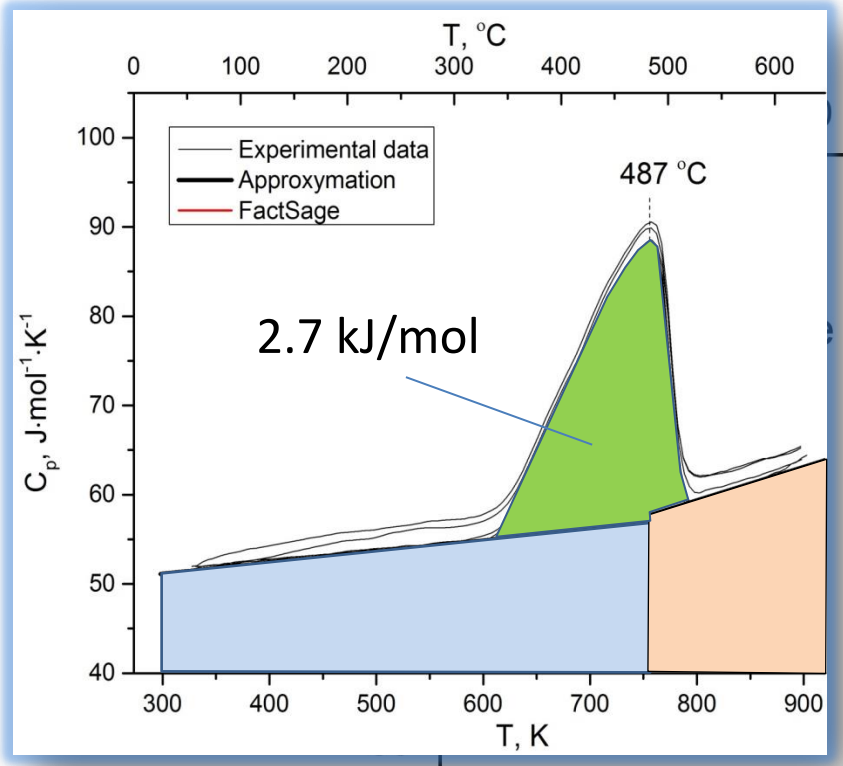
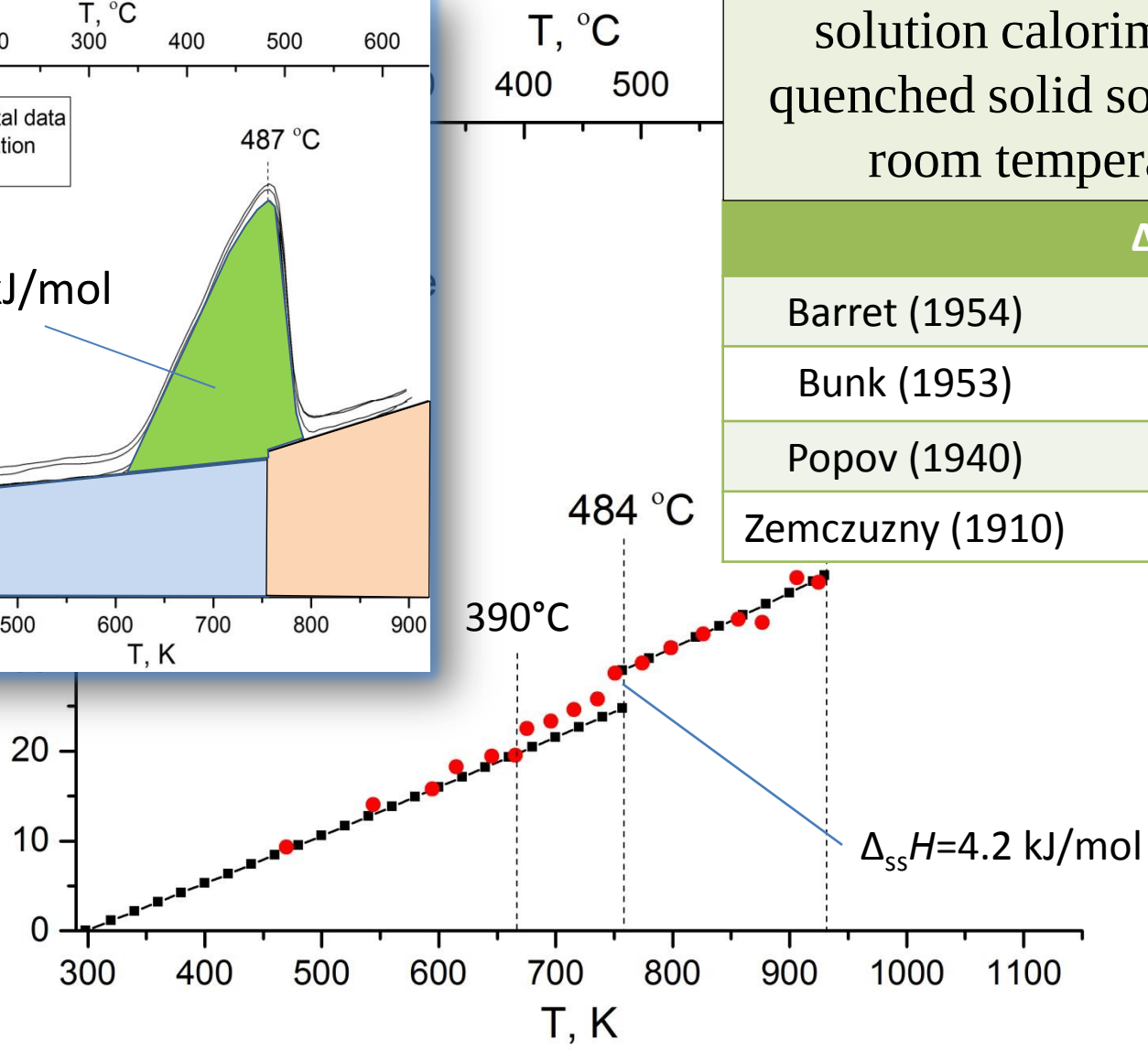
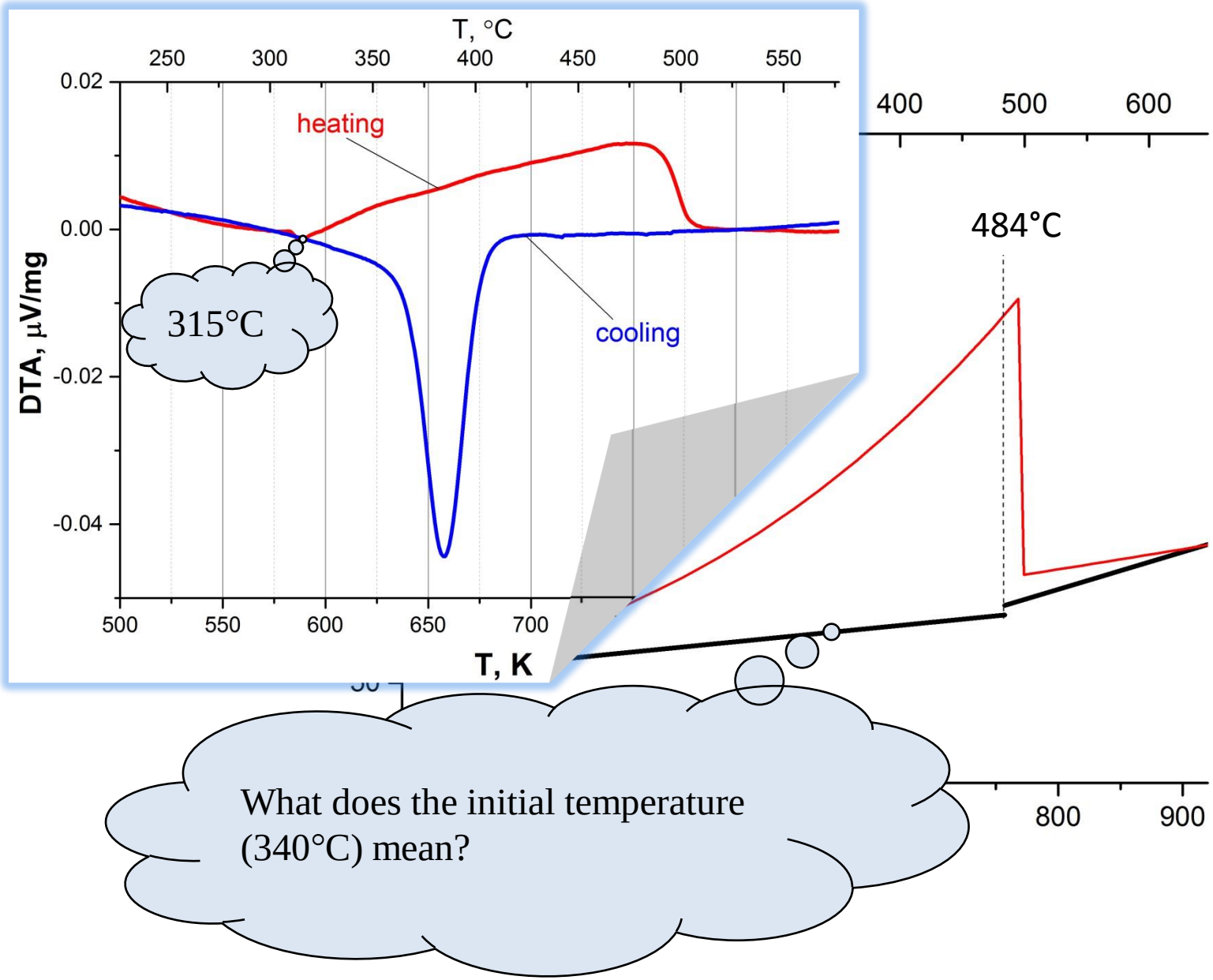




Literature data obtained by solution calorimetry of quenched solid solutions at room temperature

	$\Delta_{ss}H$, kJ/mol
Barret (1954)	4.4
Bunk (1953)	4.5
Popov (1940)	4.4
Zemczuzny (1910)	4.4

Heat capacity of the 50NaCl-50KCl



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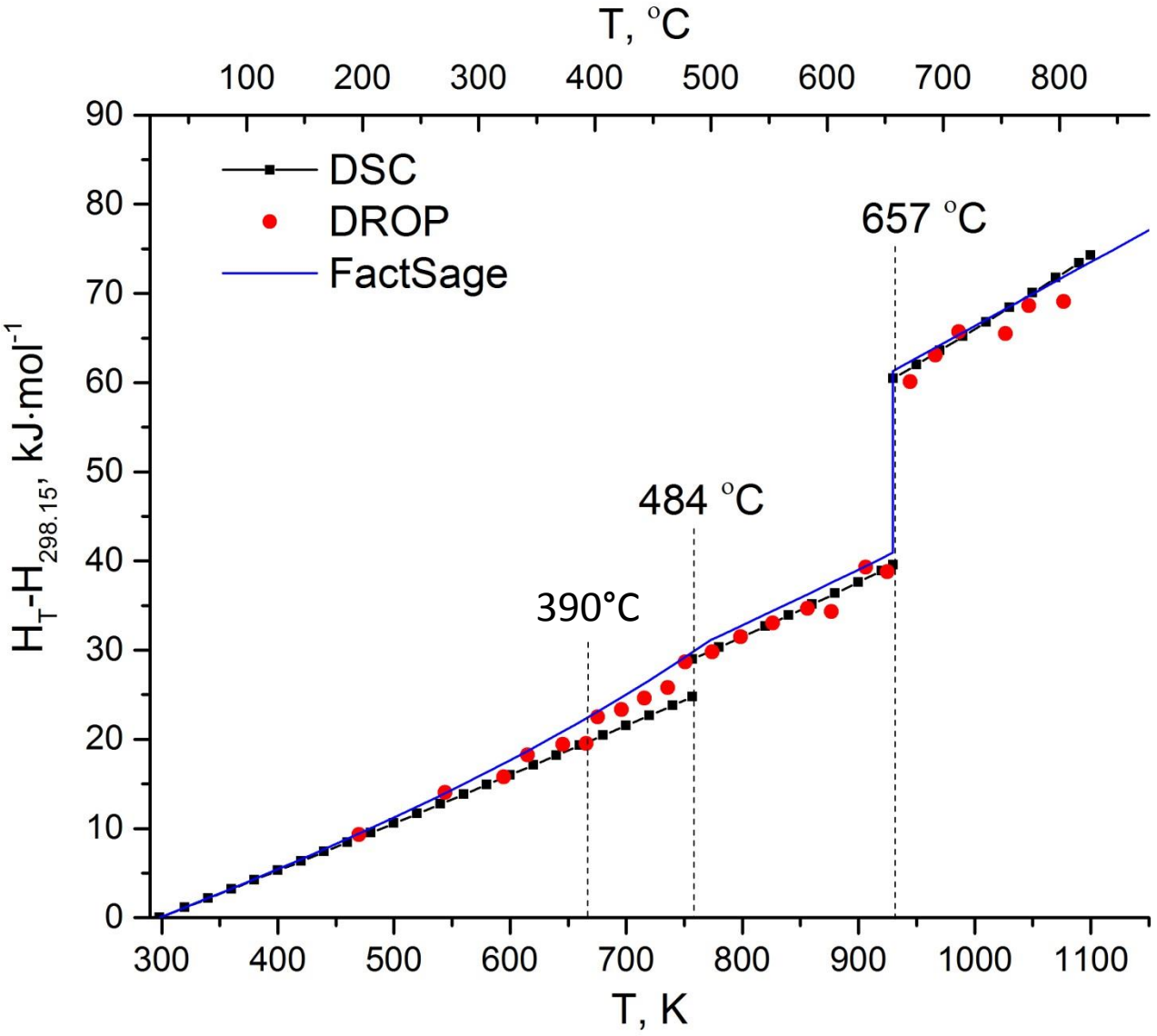
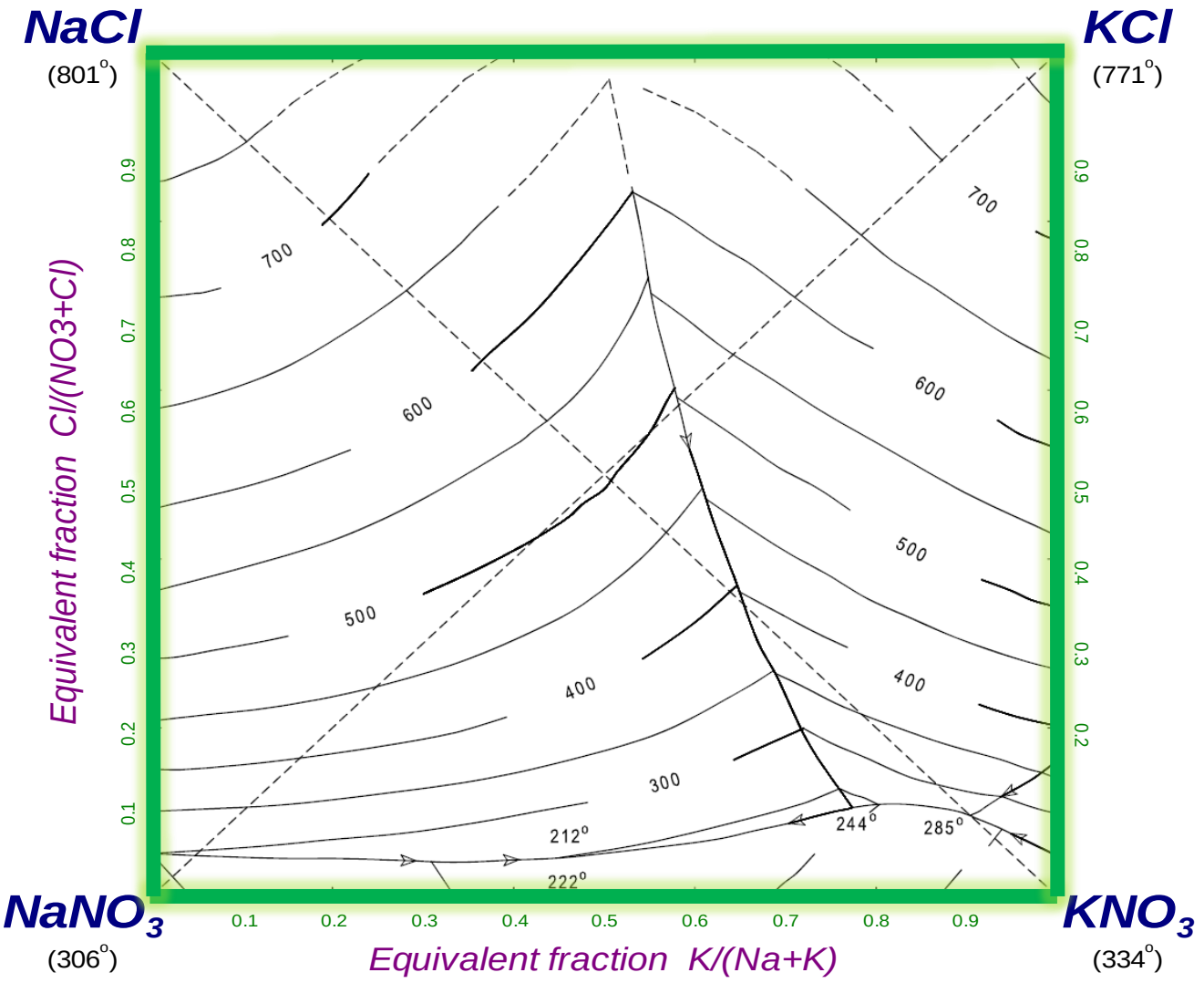
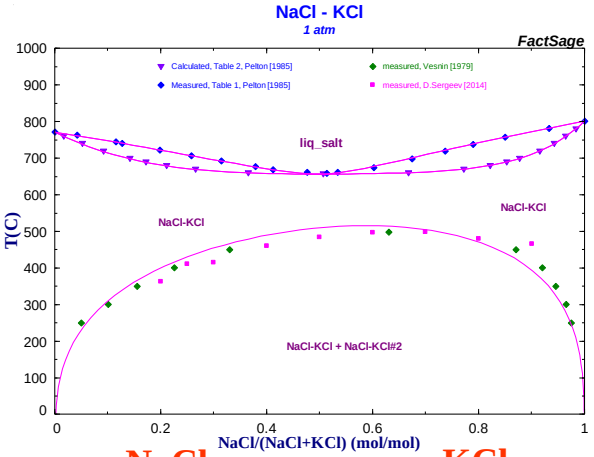


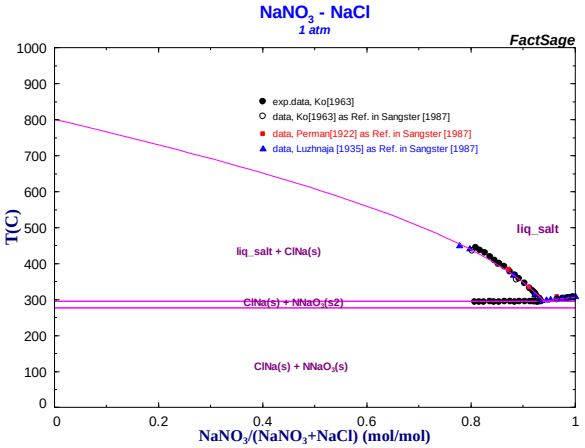
Reciprocal NaCl-KCl-$NaNO_3$-KNO_3 system

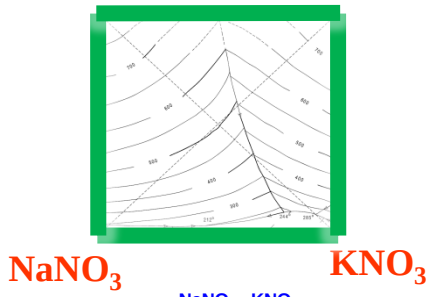


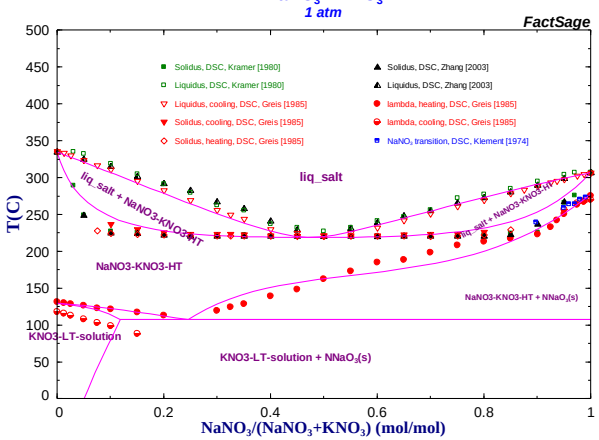
R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

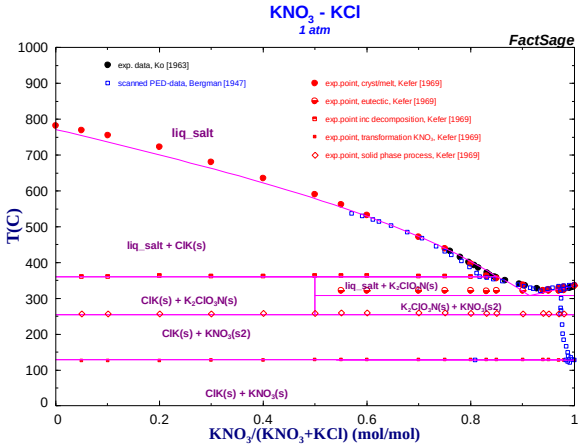
Modelling results of the binary salt systems



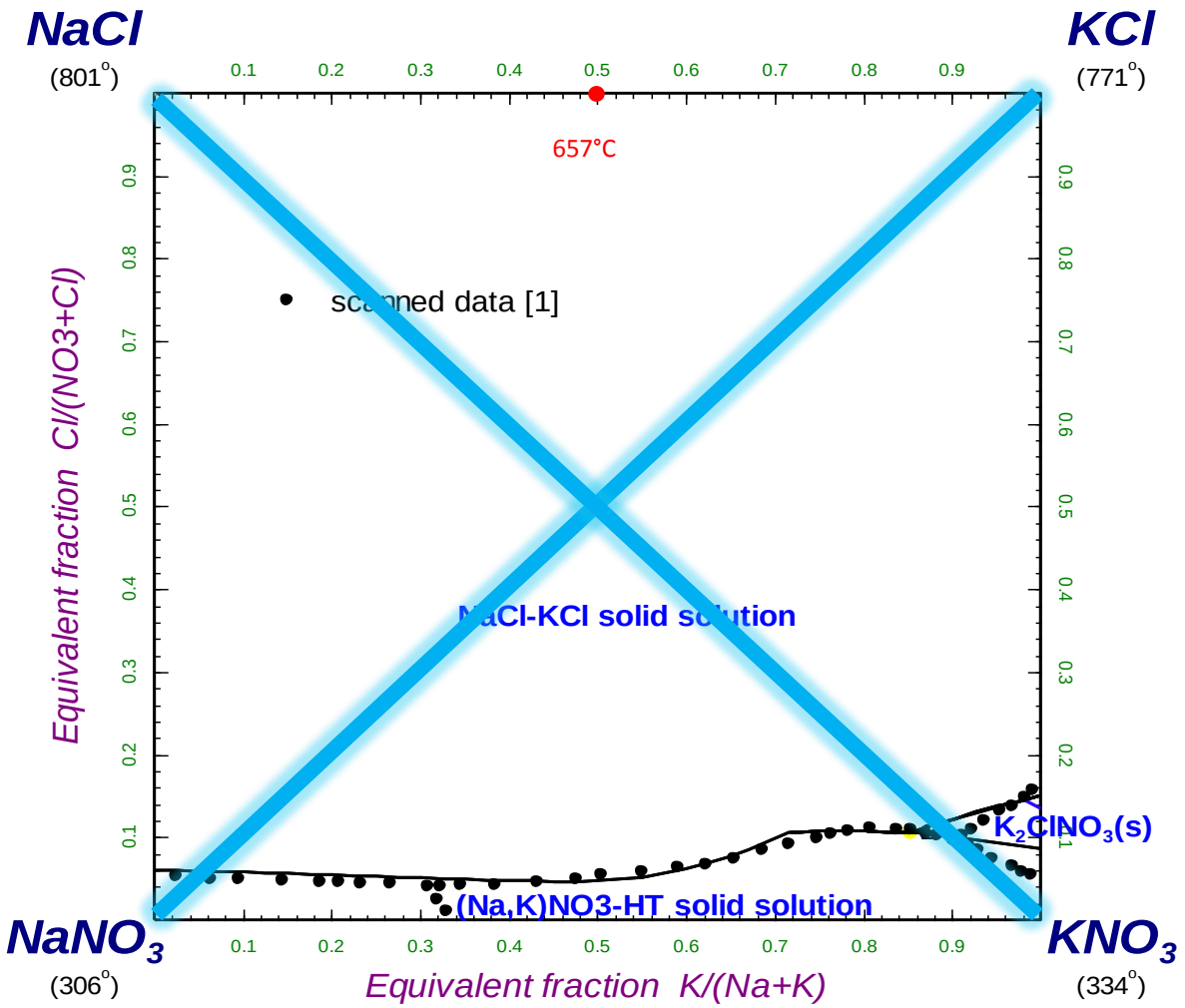






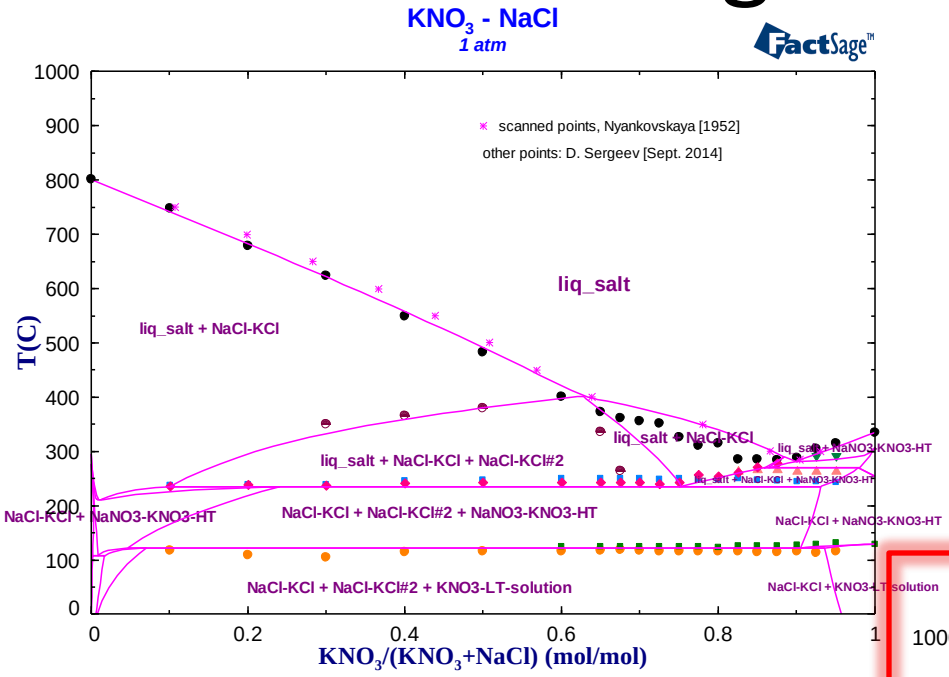


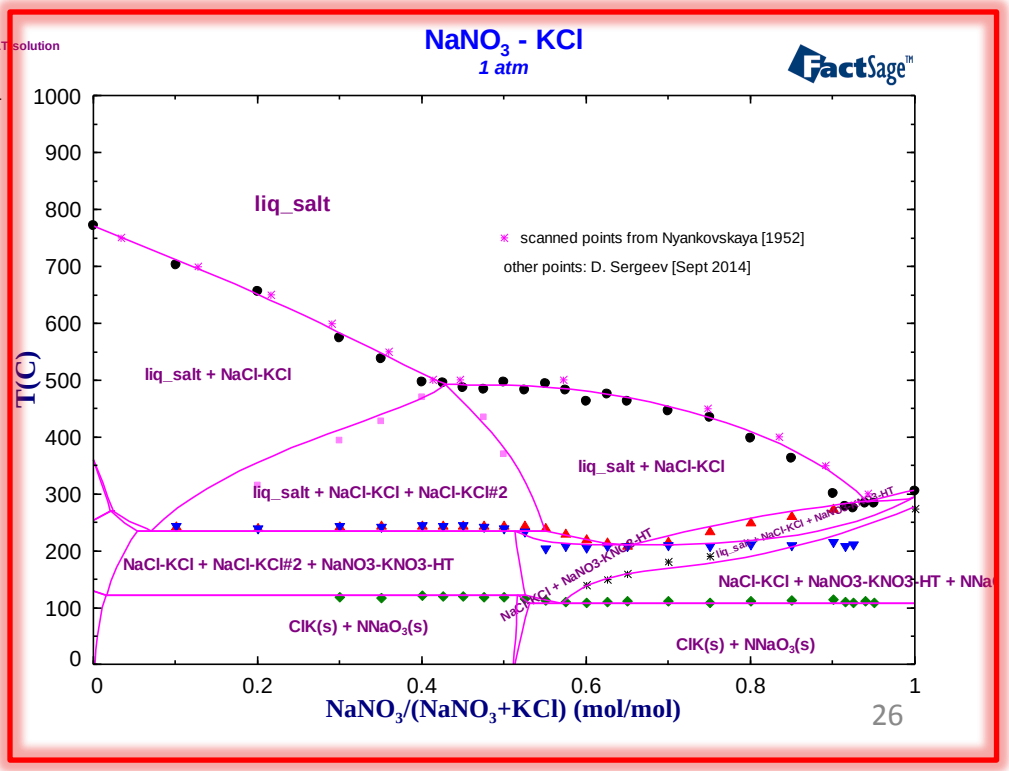
Univariant line of the NaCl-KCl-$NaNO_3$-KNO_3 system



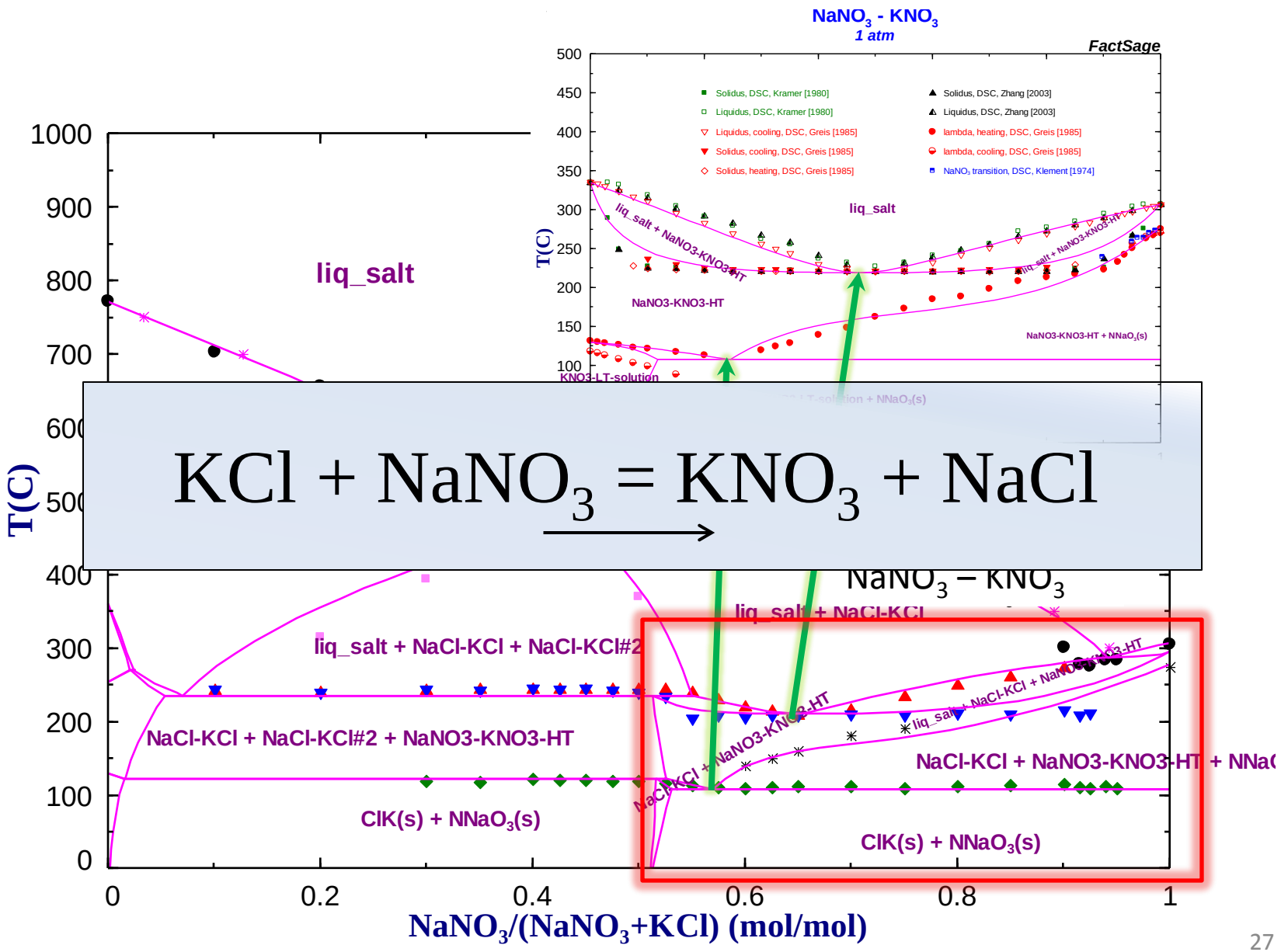
[1] R.N. Nyankovskaya, *Izv. Sekt. Fiz.-Khim. Anal.*, 21 (1952) 259-270.

Diagonal Systems





Diagonal System



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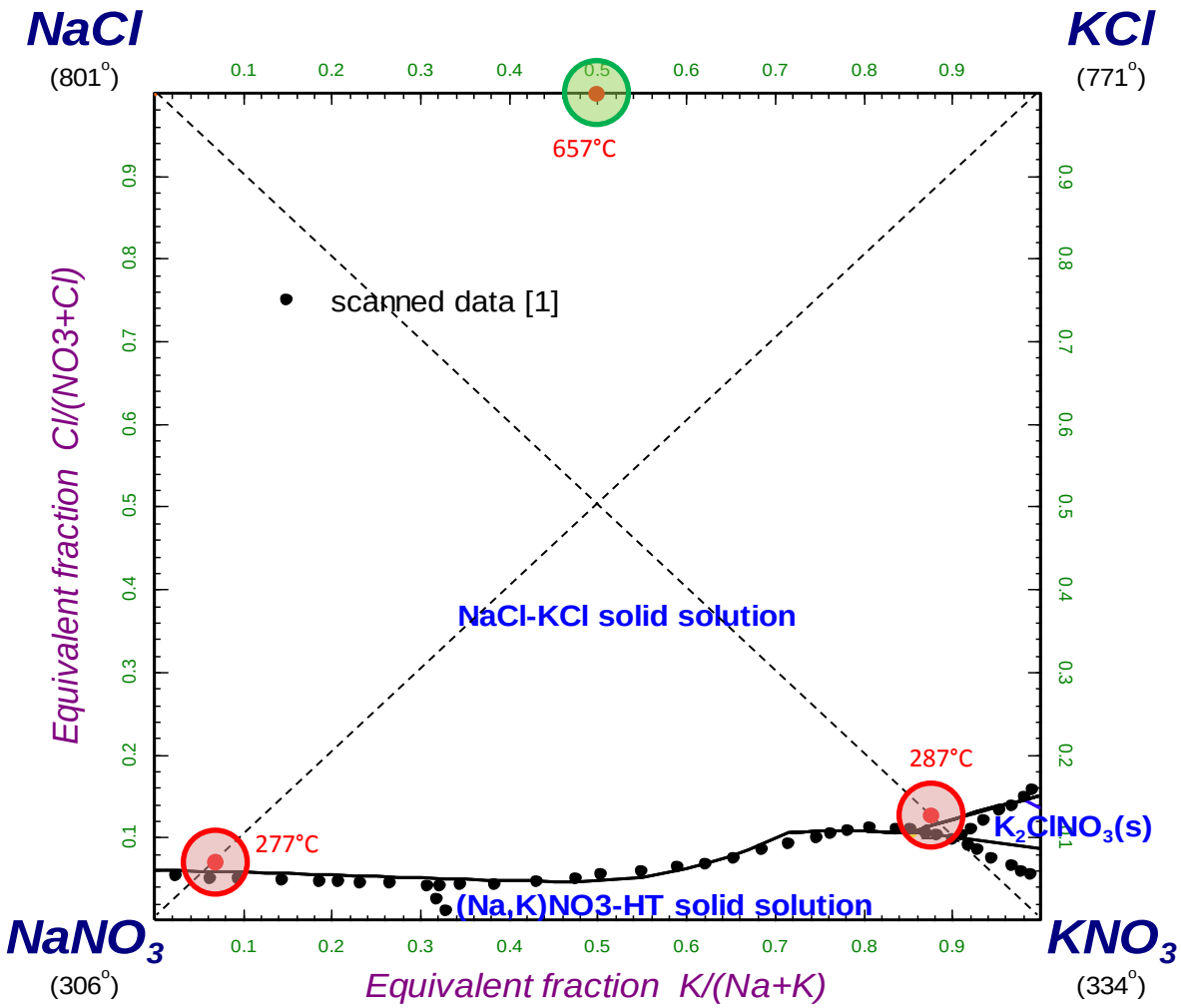
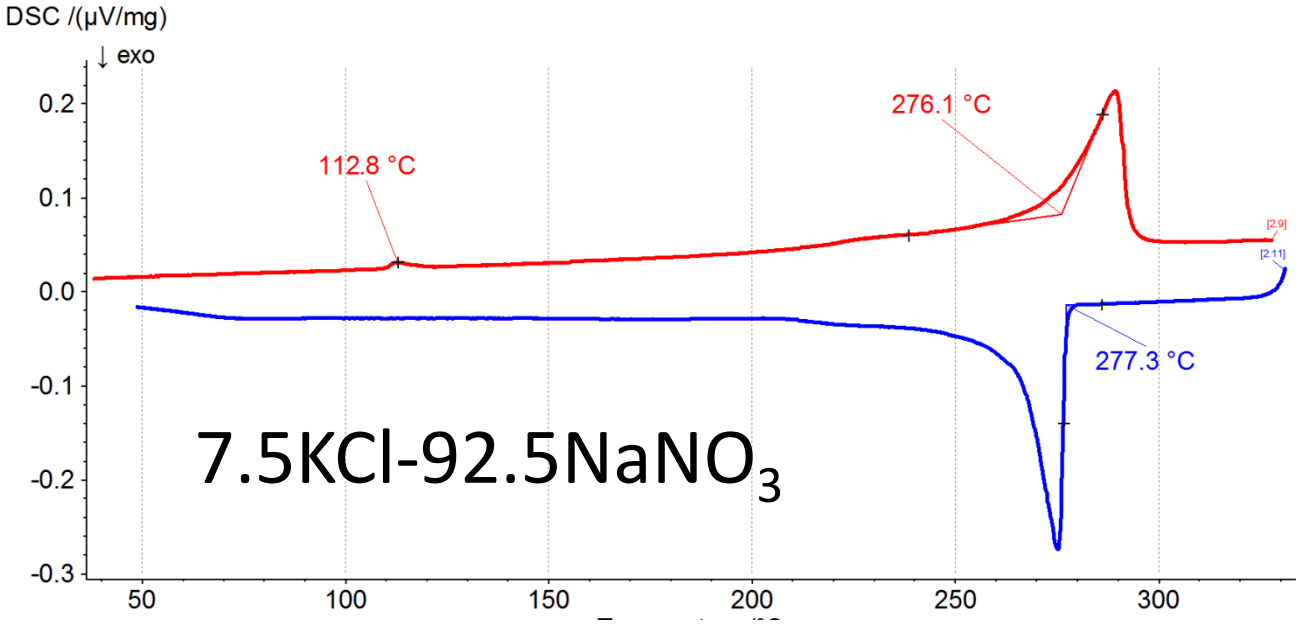
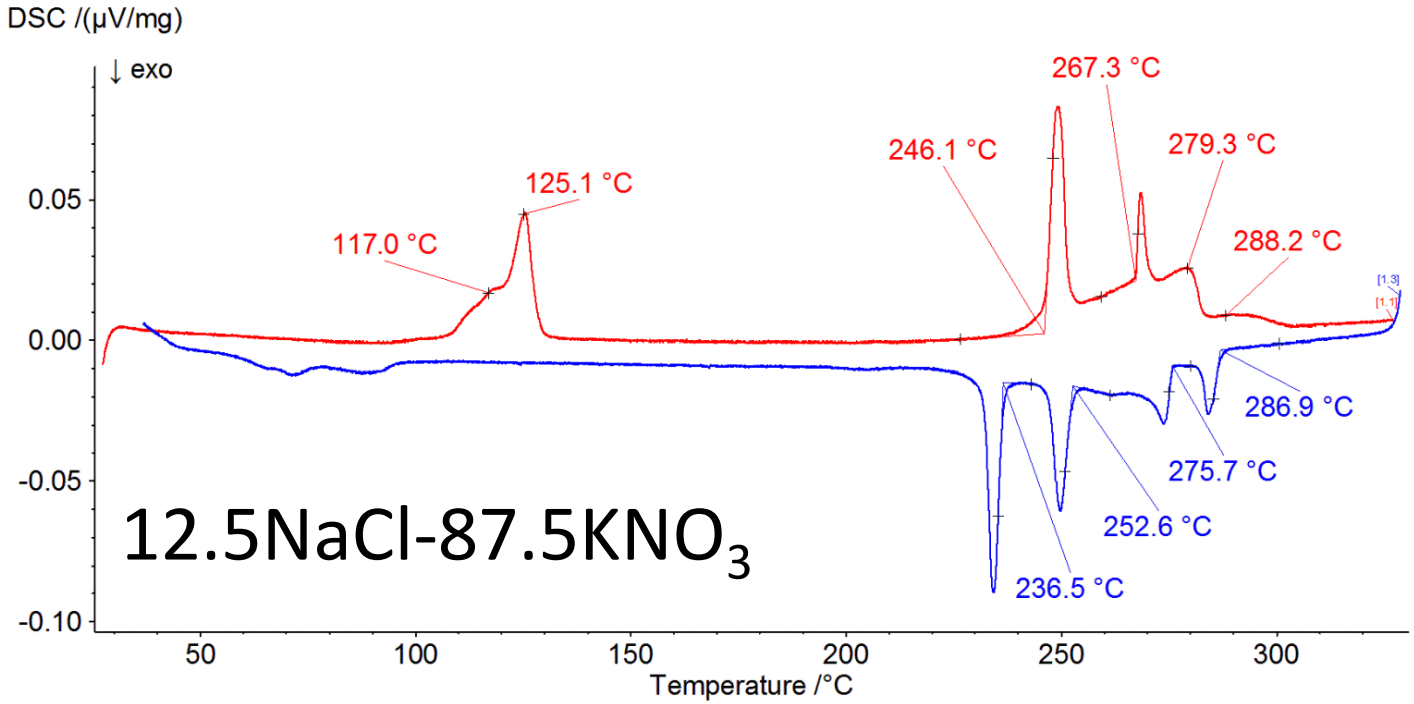
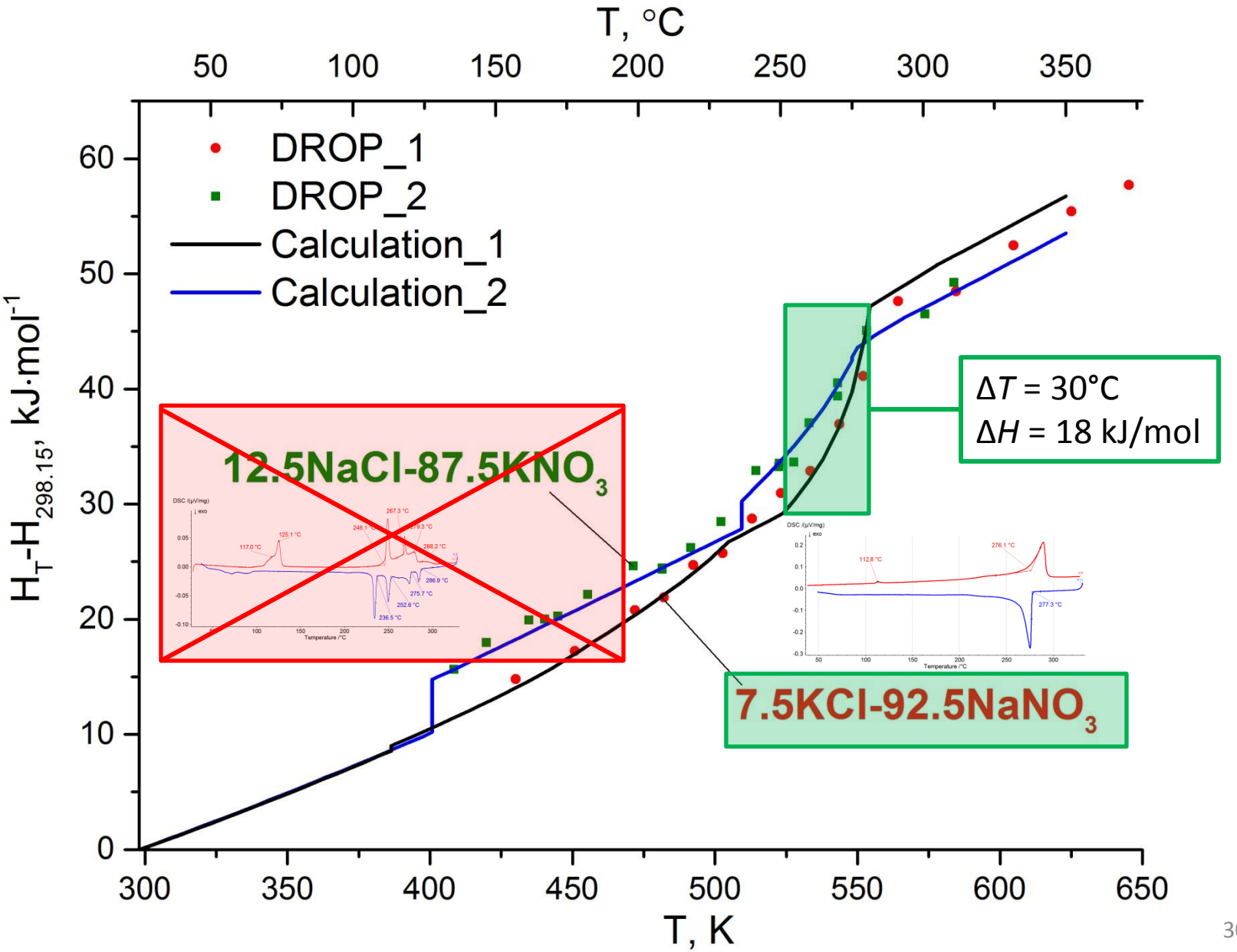



DSC /(µV/mg)
↓ exo
0.2
0.1
0.0
-0.1
-0.2
-0.3
50
100
150
200
250
300
112.8 °C
276.1 °C
277.3 °C
7.5KCl-92.5NaNO3


DSC /(µV/mg)
↓ exo
0.05
0.00
-0.05
-0.10
50
100
150
200
250
300
Temperature /°C
117.0 °C
125.1 °C
246.1 °C
267.3 °C
279.3 °C
288.2 °C
286.9 °C
275.7 °C
252.6 °C
236.5 °C
12.5NaCl-87.5KNO3

Heat Increment



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Energy Saving Technologies

Thank you for your kind attention!