Supplementary material

Results of rheometry

In total, seventeen aqueous bentonite suspensions, which differ in salt content, were used as model liquids. The suspensions contain bentonite in the fixed ratio to the binary (deionized water and salt) mixture. All suspensions exhibit strong non-Newtonian behavior. The measured values of viscosity are presented in Figure S2. It is seen there that in the measured ranges of shear rates, the significant discrepancy occurs for individual salt types as well as for their concentration within the mixture. All salt suspensions are characterized by the smaller viscosity than the salt-free bentonite mixture which has ~1 - 8 Pa.s within one order of decreased shear rate, and static yield stress 87 ± 4 Pa. The largest difference in the viscosity occurs for increasing concentrations of the Na_2SO_4 (~0.05 - 0.4 Pa.s for the maximum shear rate of 60 s^{-1} and ~0.2 - 4 Pa.s for the minimum shear rate of 10 s^{-1}). The rest of the salts, including the mixtures (Na-based + Mg-based salt), has even smaller viscosities and their difference with increasing concentration is smaller than for the Na_2SO_4. Typical range is ~0.009 - 0.1 Pa.s with shear rate decreasing in range of ~260 - 10 s^{-1}. All the remaining salts also show the non-linear viscosity dependence on concentration with typical viscosity drop with increased concentration, followed by rapid increase for the highest concentration. Typical example is the NaCl which (for the minimum shear rate 10 s^{-1}) exhibits a drop to 0.09 Pa.s for increased salinity to 2.5 wt.% concentration, followed by an increase up to 0.2 Pa.s for the 10 wt.% concentration. Associated parameters of the power-law models are shown in the bottom part of Figure S2. Datasets including the rheometry data are available on request.

Molecular processes - detailed

Nowadays, the anti-freezing of aqueous salt solutions is understood on a molecular level[1]. Even aqueous bentonite suspensions freeze at lower temperatures than water alone and these suspensions display the following trends: a) with a lower water content, there is a lower freezing point, and b) with a lower bentonite density, there is a lower freezing point[2]. Addition of salt rapidly decreases freezing point in coarse-grained frozen soils where higher salt concentration results in higher content of unfrozen water between ice crystals[3]. In our flow experiments, this is one of the effects that supports mud mobility due to increased content of liquid water content with respect to clay and therefore preserves a larger portion of the liquid mud within the flow (see Fig. S4a in *Supplementary material* for liquid fractions). Moreover, pore-confined water freezing either of pure water or NaCl solutions leads to large shift of freezing point (comparing three freezing points in bulk vs in pores of size 6.5 nm for water and 3% NaCl solution: 0 °C vs -14.44°C and -4.39 °C vs -36.96°C respectively)[4]. The eutectic temperature for pore-confined water freezing depends on the salt composition and concentration but it is always lower than that for bulk solution[5]. Therefore, a synergy effect can be supposed in the case of bentonite muds, i.e. decreasing of freezing temperature both due to salt addition and pore-confined water freezing inside the card house structure of bentonite particles (Fig. 5). Rearrangement of acting van der Waals forces in between molecules of clay sheets, ice and salt crystals will progressively change macroscopic bulk properties, leading to the experimentally documented behavior (Fig. 5a,b).

It is also known that salt in an aqueous clay suspension serves as an additive which strongly influences electrochemical interactions between clay particles and therefore stability and flowability of these suspensions. Furthermore, the suspension stability depends on the clay itself (e.g. Na-bentonite is more stable than Ca-bentonite) and this can be either adjusted by various salt content[6]. The absolute value of zeta(electrical)-potential corresponding to the stability of bentonite suspensions increases with the type of salt as follows KCl < LiCl < NaCl < Na_2SO_4[7]. The formation of an electrical double layer which is responsible for electrochemical interactions between bentonite particles and therefore bentonite suspension stability is studied in detail by molecular simulations[8,9]. In our experiments and theoretical calculations, this chain of stability is macroscopically confirmed and thus can explain the increased mobility with certain salt concentrations (Fig. 5a). The flowability is typically adjusted if a salt is added in between the montmorillonite tetrahedrons, forming the diffuse layer. Viscosity of bentonite (montmorillonite) suspensions decreases with increasing concentration either of an acid or its salt up to critical coagulation concentration and then sharply increases with further salt addition[10] (Fig. 5a, Fig. 4d, Fig. S2). Specifically, NaCl addition can reduce viscosity of bentonite suspensions to about 30% for 0.1M NaCl and to 5% for 1M NaCl[10-12]. The same level of viscosity reduction was observed for addition of Na_2SO_4 (see also the measured rheological properties at Fig. 4d, Fig. S2) and even stronger viscosity reduction in the case of KCl, $CaCl_2$ and $BaCl_2$ addition[12]. Our flow experiments then reflect this salt-caused mud viscosity reduction by showing increased mobility and spatially more distributed flows with a more simple morphology of the surfaces (compare Fig. 3f with the Fig. 3h,i). The role of sulfates in cation exchange reactions has recently been investigated within the context of the Martian environment[13], alongside studies on the kinetics of brine formation and its significance in relation to deliquescence periods on Mars[14].

Mudflow temporal bulk evolution

Our experimental setup cannot provide any information about the internal changes in the composition nor the temperature gradients throughout the flow, however, we speculate that the fast pressure drop can result in non-equilibrium processes. The relative effects of different salts in experimental solutions, on the other hand, are reasonably well predicted by calculated phase equilibria (Fig. 4c). One of the problematic features is the loss of water from the system due to the evaporation from the mixture during the pressure drop. Progressive reduction of the water content through evaporation drives evaporative cooling and affects the bulk composition and hence changes the density-viscosity of the mud. Additionally, once the freezing point is reached and ice forms, salts are rejected into residual brine, creating an ice-brine slurry that varies in its ice content across different salts and salinities (Supplementary Fig. S4). Following the evaporation sequence, this process changes the bulk composition and results in an increased salinity of the whole mixture. Finally, the crystal nucleation process is associated with release of latent heat which can locally contribute to mud temperature (see also local peaks at Figure 4a,b). As the mud (brine) flows, these coupled effects can a) accelerate or slow the cooling and b) influence the mechanical flow properties from the extrusion point and throughout the mud flow. For example, a decreased mud mobility (i.e. velocity) can accelerate the process of the clay-ice crust formation without stalling the flow. In the flows where the lobe-effusion propagation cycles are expected, the internal portions of a “relaxed” liquid mud are immediately exposed to low-pressure again. This mud can then undergo a new cycle with completely different properties that results from all the previous compositional changes. It is also important to note that salt combinations or different clays will impact accordingly on mud cooling and flow properties. For example, different clay-water ratios can lead to mud-lobes inflation as recently proved and quantified by Brož et al.[15]. We can hypothesize that in such cases the process of their depressurization can lead to a completely different thermodynamic cycle and to crystallization of new salts which will influence in multiple ways the flow properties.

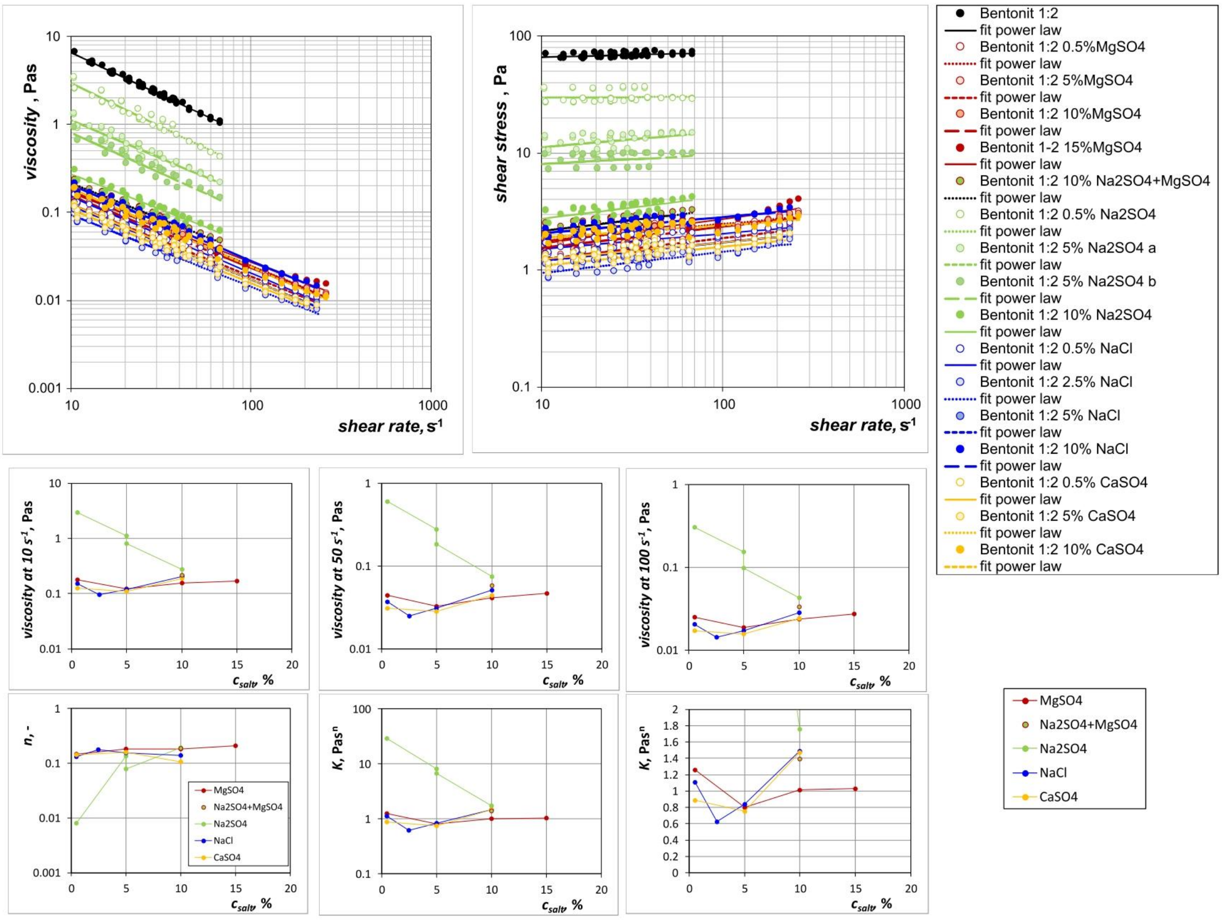

Fig. S2: Results of the rheometry performed on the bentonite suspensions. Multiple rheology parameters, including viscosity and shear rate dependences which are shown in simplified form at figure 4. Further diagrams show measured viscosity-concentration dependence for 3 different tested shear rates (10-100 Pa.s), carrying flow index (n) and coefficient of consistency (K) for various concentrations of tested suspension. Diagrams showing consistency factors are split due to high logarithmic variation. Shown are also salt-combined suspensions.

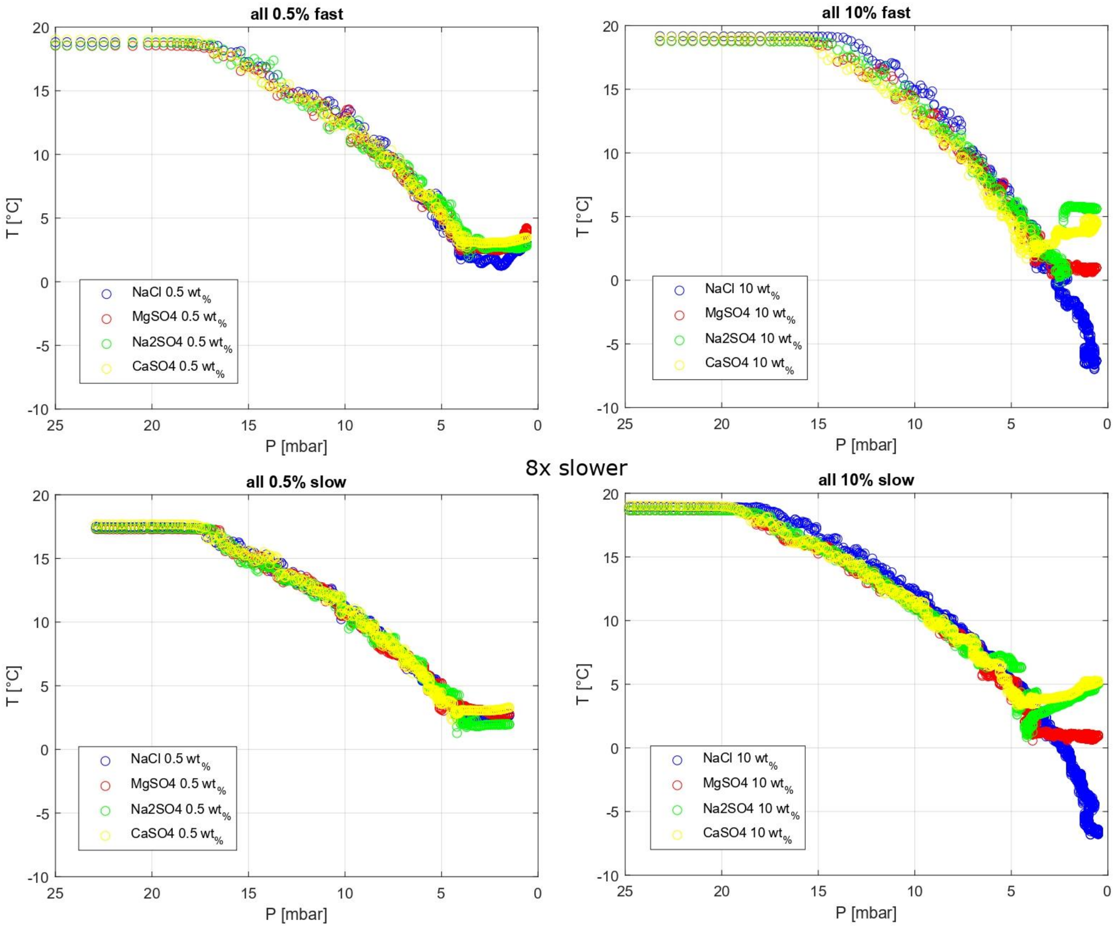

Fig. S3: Comparison of the p-T paths from the fast and slow experiments - for the low concentration (exp11 and exp26) and for the high concentration (exp10 and exp20). Well visible are the increased discrepancies and more perturbed trends for the fast pressure drop while the slow pressure drop is characterized by more stable paths. Boiling point occurs at ~5-7 mbar lower pressures for the increased concentrations, with respect to slow and fast rate of the pressure drop. The terminal temperatures, associated with freezing in the upper level of a column, are lower for the higher concentrations and slow depressurization.

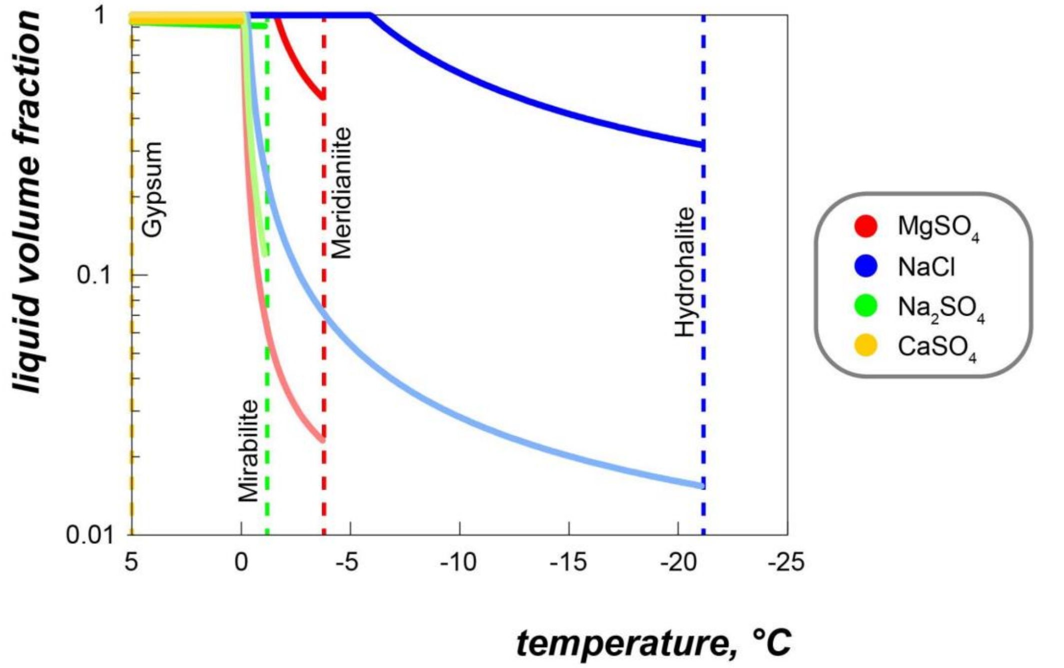

Fig. S4: Temperature-dependent volume fraction of individual salts provided by thermodynamic calculations. The color saturation corresponds to salt concentration (light - 0.5 wt%, dark - 10 wt%). The NaCl solution represents a system with the highest liquid volume portion kept for the lowest temperatures. Crystallization terminal (eutectic) temperatures where solid phase assemblages being formed are marked by dashed lines. Individual salts are hydrohalite ($NaCl.2H_2O$), meridianiite ($MgSO_4.11H_2O$), mirabilite ($Na_2SO_4.10H_2O$) and gypsum ($CaSO_4.2H_2O$) for NaCl, $MgSO_4$, Na_2SO_4 and $CaSO_4$ solutions, respectively. Dilute solutions (0.5 wt%) show negligible predicted deviations from pure H_2O, with freezing point depressions of <1 °C and decrease in saturation vapor pressure of <0.07 mbar at 20 °C (Tab, S3). The greatest influence on phase equilibria is exerted by 10 wt.% for NaCl, $MgSO_4$ and Na_2SO_4, with freezing point depressions of -5.9, -1.7 and -1.7 °C and saturation vapor pressure decreases relative to pure H_2O of 1.36, 0.36 and 0.58 mbar at 20 °C, respectively.

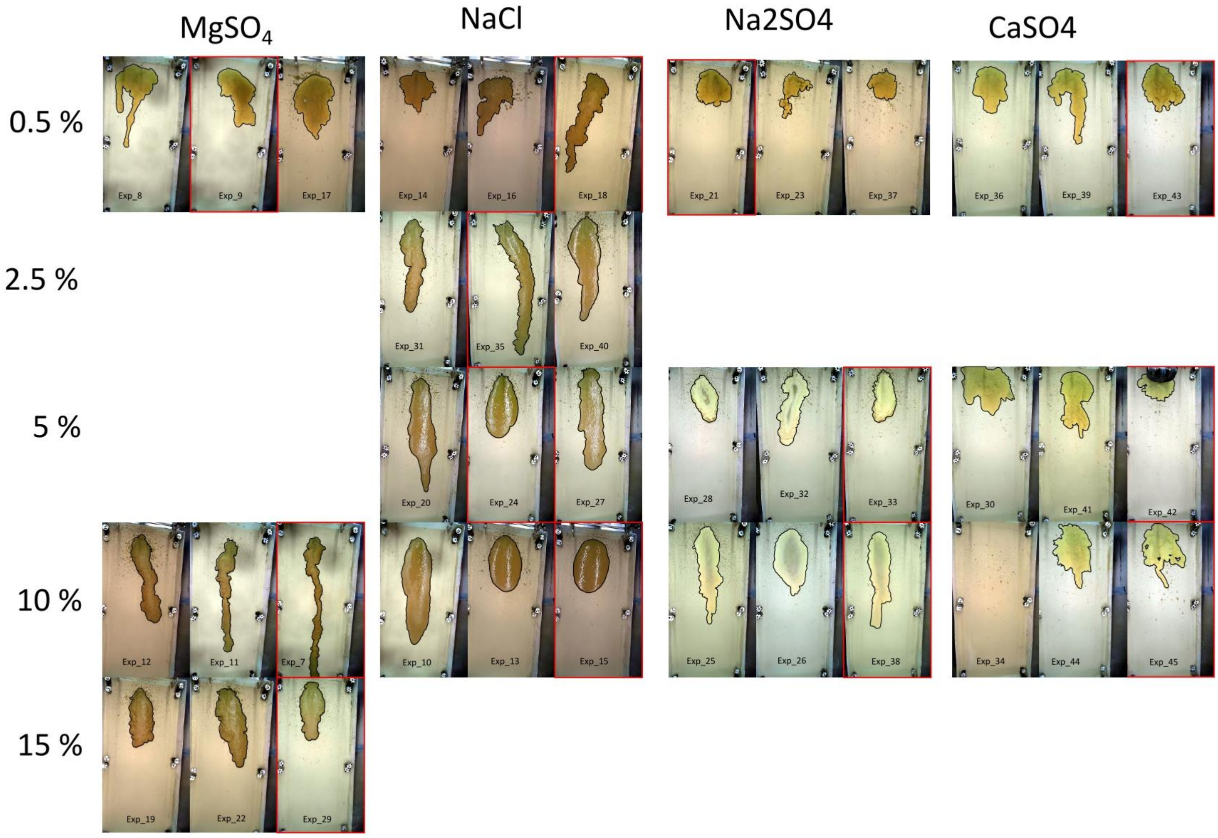

Fig. S5: Resultant shapes of all flow experiments (excluding salt mixtures), shown in the grid of salts and their concentrations.

Tab. S1: Overview of the (mud flow) experimental data.

Exp #	Pressure range [mbar]	Salt *	Concentration [% w/w] **	Mud temperature [°C] ***	Surface Temperature [°C]	Release time [s] ****	Included in main analysis	Cooling exp. counterpart *5	Flow type stream/length/surface/speed
7	4.5 (6.0) - 5.9 (7.4)	$MgSO_4$	10	18.85/-1.15	-23	56	yes	yes	narrow/long/ropy/slow
8	4.6 (6.1) - 5.7 (7.2)	$MgSO_4$	0.5	18.90/-0.15	-26	40	yes	yes	multiple/short/lobes/very slow
9	4.7 (6.2) - 5.6 (7.1)	$MgSO_4$	0.5	19.85/-0.16	-17	41	yes	yes	multiple/short/lobes/very slow
10	4.5 (6.0) - 5.8 (7.3)	NaCl	10	18.80/0.85	-25	37	yes	yes	wide/average/flat/medium
11	4.8 (6.3) - 5.9 (7.4)	$MgSO_4$	10	17.80/-0.10	-23	47	yes	yes	narrow/long/ropy/slow
12	4.6 (6.1) - 5.8 (7.4)	$MgSO_4$	10	19.80/-1.15	-22	37	yes	yes	narrow/average/ropy/slow
13	4.3 (5.8) - 5.7 (7.1)	NaCl	10	18.85/-1.17	-27	40	yes	yes	very wide/short/flat/very slow
14	4.6 (6.1) - 5.8 (7.4)	NaCl	0.5	19.90/-0.10	-29	27	yes	yes	wide/very short/lobe/very slow
15	4.6 (6.1) - 5.8 (7.4)	NaCl	10	20.65/2.65	-16	44	yes	yes	circular/short/flat/very slow
16	4.5 (6.0) - 5.8 (7.3)	NaCl	0.5	20.60/-1.15	-23	36	yes	yes	multiple/short/lobes/slow
17	4.5 (6.0) - 5.8 (7.3)	$MgSO_4$	0.5	20.75/0.05	-23	41	yes	yes	multiple/short/lobes/slow
18	4.6 (6.1) - 5.8 (7.4)	NaCl	0.5	19.85/-0.15	-12	40	yes	yes	narrow/average/lobes/slow
19	4.3 (5.8) - 5.7 (7.1)	$MgSO_4$	15	19.90/-1.05	-23	35	yes	no	short/wide/flat/very slow
20	4.7 (6.2) - 5.8 (7.3)	NaCl	5	19.80/-1.20	-22	42	yes	yes	long/wide/flat/fast
21	4.6 (6.1) - 5.8 (7.4)	Na_2SO_4	0.5	19.85/0.85	-18	20	yes	yes	circular/very short/lobe/very slow
22	4.5 (6.0) - 5.8 (7.3)	$MgSO_4$	15	19.85/-1.10	-26	34	yes	no	wide/average/flat/slow
23	4.6 (6.1) - 5.8 (7.4)	Na_2SO_4	0.5	19.80/1.80	-19	25	yes	yes	multiple/very short/lobes/very slow
24	4.5 (6.0) - 5.8 (7.3)	NaCl	5	19.90/1.85	-20	39	yes	yes	wide/average/flat/medium
25	4.6 (6.1) - 5.8 (7.3)	Na_2SO_4	10	19.90/3.80	-21	35	yes	yes	wide/average/flat/medium
26	4.5 (6.0) - 5.9 (7.4)	Na_2SO_4	10	18.90/3.90	-23	28	yes	yes	wide/short/flat/medium
27	4.5 (6.0) - 5.8 (7.3)	NaCl	5	19.85/-1.35	-31	37	yes	yes	wide/avarage/flat/medium
28	4.5 (6.0) - 5.8 (7.3)	Na_2SO_4	5	20.55/-1.15	-19	30	yes	yes	circular/short/flat/very slow
29	4.5 (6.0) - 5.8 (7.3)	Na_2SO_4	15	20.85/1.90	-23	28	yes	no	wide/short/flat/slow
30	4.6 (6.1) - 5.8 (7.3)	$CaSO_4$	5	20.75/0.60	-26	25	yes	yes	multiple/very short/lobes/very slow
31	4.6 (6.1) - 5.8 (7.3)	NaCl	2.5	20.50/-2.15	-24	37	yes	yes	narrow/long/ropy/medium
32	4.5 (6.0) - 5.9 (7.4)	Na_2SO_4	5	20.90/1.75	-22	30	yes	yes	wide/average/ropy/medium
33	4.5 (6.0) - 5.8 (7.3)	Na_2SO_4	5	20.85/-0.20	-24	38	yes	yes	circular/short/ropy/slow
34	4.4 (5.9) - 5.0 (6.5)	$CaSO_4$	10	20.85/1.05	-23	failed exp.	no	yes	N/A
35	4.5 (6.0) - 5.8 (7.3)	NaCl	2.5	20.65/1.00	-19	55	yes	yes	average/very long/ropy/fast
36	4.4 (5.9) - 5.8 (7.3)	$CaSO_4$	0.5	19.90/0.95	-25	20	yes	yes	multiple/very short/lobes/very slow
37	4.5 (6.0) - 5.8 (7.3)	Na_2SO_4	0.5	19.90/-0.20	-22	26	yes	yes	circular/very short/lobe/very slow
38	4.5 (6.0) - 5.8 (7.3)	Na_2SO_4	10	20.50/-1.30	-19	40	yes	yes	average/long/flat/medium
39	4.4 (5.9) - 5.9 (7.4)	$CaSO_4$	0.5	20.50/-0.15	-33	25	yes	yes	multiple/short/lobes/slow
40	4.5 (6.0) - 5.8 (7.3)	NaCl	2.5	20.50/0.95	-28	40	yes	yes	wide/average/flat/medium
41	4.6 (6.1) - 5.8 (7.3)	$CaSO_4$	5	20.85/0.80	-21	25	yes	yes	multpile/short/lobes/slow
42	4.5 (6.0) - 5.8 (7.3)	$CaSO_4$	5	20.75/0.80	-22	26	yes	yes	multiple/very short/lobes/very slow
43	4.5 (6.0) - 5.8 (7.3)	$CaSO_4$	0.5	19.80/-0.15	-22	30	yes	yes	multiple/very short/lobes/very slow
44	4.6 (6.1) - 5.8 (7.3)	$CaSO_4$	10	19.85/0.75	-26	25	yes	yes	multiple/short/lobes/very slow
45	4.6 (6.1) - 5.8 (7.3)	$CaSO_4$	10	19.85/0.80	-27	24	yes	yes	multiple/short/lobes/very slow
46	4.4 (5.9) - 5.8 (7.3)	Na_2SO_4	15	20.80/-0.20	-26	23	no	no	wide/short/flat/slow
47	4.5 (6.0) - 5.8 (7.3)	$MgSO_4$	15	19.95/0.85	-24	43	no	no	narrow/long/ropy/medium
48	4.5 (6.0) - 5.8 (7.3)	$CaSO_4$	10	20.45/0.80	-16	30	no	yes	multiple/short/lobes/slow
49	4.4 (5.9) - 5.9 (7.4)	$MgSO_4$ + Na_2SO_4	5	19.50/-0.35	-29	27	no	yes	average/average/ropy/medium
50	4.5 (6.0) - 5.8 (7.3)	$CaSO_4$	10	19.65/0.65	-30	18	yes	yes	multiple/short/lobes/slow
51	4.5 (6.0) - 5.8 (7.3)	$MgSO_4$ + Na_2SO_4	10	19.60/-0.20	-27	30	no	yes	wide/long/flat/fast
52	4.4 (5.9) - 5.8 (7.3)	NaCl + Na_2SO_4	5	18.75/-0.15	-25	42	no	yes	narrow/very long/ropy/fast
53	4.5 (6.0) - 5.8 (7.3)	$MgSO_4$	5	20.25/-1.20	-25	40	yes	yes	narrow/very long/lobes/fast
54	4.5 (6.0) - 5.8 (7.3)	$MgSO_4$	5	20.35/0.95	-23	35	yes	yes	multpile/very long/lobes/fast
55	4.3 (5.8) - 5.8 (7.3)	$MgSO_4$	5	19.70/1.00	-21	32	yes	yes	narrow/long/lobes/fast

* Salt combinations werere prepared in the ratio 1:1 (w/w)

** Exp #46-#48 were prepared with using of a same volume of the pre-prepared salt binars instead of weight fraction (to test the effect of a different water content)

*** Approximate temperature within the container before/after the pressure drop (at a moment of release)

**** Time period of the mud release from the container

*5 Existence of the cooling experiment with the same salt-water concentration

*6 Exps. marked by italic have stored movies in the supplemenetary materials (corresponding to images on Figure 2 and 3)

Tab. S2: Overview of the (tube cooling) experimental data.

Exp #	Type*	Rate	Pressure limit [mbar]	Salt *	Concentration [% w/w]	Initial temperature averaged [°C]	Initial temperature difference [°C] **	Boiling time (a, b, c, d) [s] ***	Freezing time [s] ****	Pressure boiling [mbar] *5	Pressure freezing [mbar] *5	Finite temperature 3 cm above the bottom [°C] *6	Included in main analysis	Internal features (main observations)
1	salt	fast	2.2	NaCl	0.5 - 10	19.22	0.2	140, 143, 145 149	340, 500, 710, 1310	-	-	4.35, -0.15, -2.75, -4.95	yes	a,b,d thin ice lids, c column freezing
2	salt	fast	1.2	$MgSO_4$	0.5 - 10	19.7	0.4	138, 139, 139, 140	300, 298, 315, 337	-	-	3.95, 2.75, 2.05, 0.05	yes	ice lids, gradually increased thickness
3	salt	fast	2.3	$MgSO_4$	0.5 - 10	19.5	0.3	140, 141, 142, 140	297, 309, 327, 315	-	-	4.35, 3.25, 2.35, 0.15	yes	ice lids, gradually increased thickness
4	salt	fast	2.2	NaCl	0.5 - 10	19.35	0.4	138, 140, 142, 145	326, 390, 480, 650	-	-	2.65, 0.95, -2.05, -5.25	yes	ice lids, gradually increased thickness
5	salt	fast	2.1	NaCl	0.5 - 10	20.2	0.2	136, 138, 141, 144	328, 360, 440, 700	-	-	3.15, -0.55, -2.85, -5.95	yes	ice lids, gradually increased thickness
6	salt	fast	1.7	$MgSO_4$	0.5 - 10	18.5	0.6	140, 141, 140, 142	327, 330, 340, 345	-	-	3.25, 2.35, 1.25, 0.95	yes	ice lids, gradually increased thickness
7	salt	fast	1.9	Na_2SO_4	0.5 - 10	19.2	0.6	142, 142, 143, 147	298, 385, 380, 345	-	-	4.25, 1.45, 2.15, 2.55	yes	mirabilite precipitation in d
8	salt	fast	0.7	Na_2SO_4	0.5 - 10	18.35	0.4	140, 141, 144, 150	325, 326, 395, 420	-	-	3.37, 1.55, 1.05, 7.15	yes	mirabilite precipitation in d
9	salt	fast	1.7	Na_2SO_4	0.5 - 10	18.05	0.3	140, 140, 141, 144	310, 337, 338, 340	-	-	3.55, 1.45, 3.45, 4.35	yes	mirabilite precipitation in d
10	***all***	***fast***	***0.6***	***all***	***10***	***18.65***	***1***	***138, 145, 140, 136***	***347, 849, 426, 240***	***26.1, 18.1, 20.9, 20.4***	***3.7, 1.8, 2.6, 3.7***	***0.65, -6.55, 5.55, 4.65***	***yes***	***c,d frozen whole volume***
11	***all***	***fast***	***1.7***	***all***	***0.5***	***18.95***	***0.4***	***142, 143, 143, 144***	***333, 351, 347, 318***	***21.4, 21, 21, 19***	***3.7, 3.7, 3.9, 4.1***	***3.95, 2.95, 3.25, 3.85***	***yes***	***similar times, similar lid thickness***
12	salt	fast	1.7	$CaSO_4$	0.5 - 10	19.65	0.2	146, 147, 147, 146	318, 337, 353, 350	-	-	4.05, 3.55, 2.35, 5.35	yes	increased thickness for d
13	salt	fast	0.7	$CaSO_4$	0.5 - 10	19.05	0.7	141, 142, 143, 143	325, 335, 337, 363	-	-	2.95, 2.25, 2.15, 3.95	yes	similar freezing time and lid thickness
14	***all***	***fast***	***0.5***	***all***	***10***	***18.75***	***0.2***	***141, 146, 143, 138***	***316, 709, 462, 310***	***27.5, 17.7, 22.6, 19.8***	***5.1, 1, 2, 4.5***	***1.45, -6.65, 7.25, 5.05***	***yes***	***c,d frozen whole volume***
15	***all***	***fast***	***0.5***	***all***	***10***	***18.35***	***0.4***	***145, 151, 146, 144***	***393, 721, 481, 386***	***24.8, 17, 18.7, 18.7***	***3, 1.3, 2.6, 3.2***	***-0.15, -5.55, 0.75, 4.85***	***yes***	***c,d frozen whole volume***
16	salt	fast	0.7	$CaSO_4$	0.5 - 10	18.65	0.2	142, 142, 142, 144	395, 330, 350, 397	-	-	3.15, 1.75, 1.65, 3.85	yes	similar lid thickness
17	salt	fast	0.6	$CaSO_4$	0.5 - 10	18.75	0.3	144, 144, 144, 145	335, 323, 318, 393	-	-	2.75, 2.95, 2.45, 3.25	no	freezing does not occur gradually
18	***all***	***fast***	***0.8***	***all***	***0.5***	***17.95***	***0.3***	***145, 147, 147, 146***	***313, 312, 311, 323***	***21.2, 20.1, 23, 23.5***	***4.3, 4.3, 4.3, 4***	***2.05, 2.15, 1.75, 1.95***	***yes***	***similar freezing time and lid thickness***
19	***all***	***fast***	***0.5***	***all***	***0.5***	***18.75***	***0.6***	***148, 149, 149, 148***	***305, 308, 293, 296***	***19.1, 18.7, 18.6, 19.1***	***4.2, 4.2, 4.5, 4.3***	***2.45, 2.35, 3.15, 3.15***	***yes***	***similar boiling and freezing times, thickness***
20	***all***	***slow***	***0.5***	***all***	***10***	***19.15***	***0.3***	***1765, 1771, 1770, 1763***	***2471, 3653, 2476, 2354***	***18.4, 18, 18.1, 18.7***	***3.7, 1.2, 3.9, 4.6***	***0.95, -7.15, 5.15, 5.35***	***no***	***strongly different boiling and freezing times***
21	***D.I. water***	***fast***	***1.1***	-	-	***17.45***	***0.15***	***140, 141, 140, 140***	***309, 310, 308, 312***	***17, 16.6, 17, 17***	***3.9, 4, 4, 3.9***	***3.05, 2.85, 2.85, 3.25***	***yes***	***reference experiment, similar trends of a-d***
22	***D.I. water***	***slow***	***1.1***	-	-	***15.85***	***0.2***	***1355, 1357, 1351, 1352***	***1638, 1639, 1632, 1624***	***13.7, 13.6, 14, 14***	***3.1, 3.1, 3.2, 3.6***	***2.75, 2.85, 2.95, 1.65***	***no***	***reference experiment, similar trends of a-d***
23	D.I. water	fast	1.5	-	-	16.05	0.3	141, 139, 142, 142	305, 303, 306, 304	16.3, 17.1, 16, 16	4.1, 4.2, 4, 4.1	2.85, 2.15, 2.15, 2.65	yes	reference experiment, similar trends of a-d
24	D.I. water	fast	1.2	-	-	10.85, 16.95, 34.85	-	169, 145, 99	334, 310, 268	12.6, 17.9, 60.5	2.6, 3.7, 4.9	2.35, 2.95, 5.25	yes	tested various T of water
25	D.I. water	slow	0.9	-	-	2.85, 17.35, 27.25	-	1440, 1292, 1098	1636, 1615, 1572	6.7, 16.3, 37.4	2.5, 3, 4.3	1.95, 3.25, 5.15	no	tested various T of water
26	***all***	***slow***	***2.3***	***all***	***0.5***	***18.15***	***0.4***	***1863, 1852, 1859, 1849***	***2292, 2297, 2301, 2256***	***16.5, 17.5, 16.8, 17.7***	***3.3, 3.7, 3.4, 3.9***	***2.45, 3.05, 1.95, 2.95***	***no***	***similar trends, lid thickness***
27	all	slow	1.7	all	0.5	17.95	0.7	1386, 1366, 1387, 1364	1725, 1722, 1710, 1715	16, 12.4, 16, 17.4	3.5, 2.7, 3.2, 2.7	2.25, 2.35, 2.65, 2.55	no	similar trends, lid thickness
28	all	slow	0.7	all	0.5	17.85	1	1578, 1563, 1559, 1556	1807, 1832, 1818, 1804	16.1, 16.9, 17.2, 17.4	3.7, 3.6, 3.8, 3.8	1.85, 2.45, 1.65, 3.45	no	similar trends, lid thickness
29	all	slow	0.8	all	10	19.15	0.4	1491, 1515, 1500, 1495	1751, 2255, 1802, 1730	18.2, 16.4, 17.5, 17.9	3.4, 1, 3.5, 3.8	1.55, -13.35, 1.75, 4.85	yes	strongly different boiling and freezing times
30	all	slow	0.5	all	10	18.65	0.4	1374, 1386, 1378, 1368	1686, 1976, 1659, 1590	17.5, 15.9, 16.9, 18.4	3.7, 1.1, 3.7, 3.8	-0.05, -6.45, 3.25, 2.75	no	strongly different trends and precipitations
31	mixture	fast	1.1	$MgSO_4$ + Na_2SO_4/NaCl	2.5:2.5/ 5:5/ 2.5:7.5/2.5:2.5	18.15	0.3	137, 139, 139, 141	430, 478, 537, 477	19.5, 17.5, 17.5, 16.8	3.4, 3.2, 3, 3.2	1.35, -0.55, -2.05, -	no	various freezing and thickness

* two major sets of experiments: 1) salt with 4 different w/w concentrations (0.5%, 2.5%, 5% and 10%); 2) Four tested salts ($MgSO_4$, NaCl, Na_2SO_4, $CaSO_4$) with the same concentrtion

** Maximum difference between the initial temperatures

*** Approximate time when solution starts to boiling after (captured times of initial rapid T drop in solutions) ; indexes a-d in the brackets represent type of the salt ($MgSO_4$, NaCl, Na_2SO_4, $CaSO_4$) or current conentrations (0.5 %, 2.5 %, 5 %, 10 %)

**** Approximate time when solution starts to freeze (form an ice lid)

*5 For selected and deeply analyzed experiments; Pressure value corresponds to position in the middle of the chamber (secondary P logger counts value +1.5 mbar)

*6 Temperature at the final moment before pressurization

*7 D.I. water reference experiment used the same cylinders in the same positions; a-d are denoted samples from left to right)same order as for salts)

Tab. S3: Results of thermodynamic simulations of freezing of salt solutions. In all cases, only a single secondary salt phase was predicted to form during freezing. Temperatures are reported to the nearest 0.1 °C. Eutectic temperatures correspond to salt formation temperatures for all solutions with the exception of $CaSO_4$ solutions, wherein gypsum was supersaturated at room temperature. In this latter case, the eutectic temperature corresponds to the ice formation temperature.

Initial salt	Concentration, wt%	Ice formation temp., °C	Secondary salt phase[a]	Salt formation temp., °C	Eutectic temp., °C
NaCl	0.5	-0.4	Hydrohalite	-21.2	-21.2
	10	-6.0	Hydrohalite	-21.2	-21.2
$MgSO_4$	0.5	-0.2	Meridianiite	-3.8	-3.8
	10	-1.7	Meridianiite	-3.8	-3.8
Na_2SO_4	0.5	-0.2	Mirabilite	-1.2	-1.2
	10	-1.2	Mirabilite	-1.2	-1.2
$CaSO_4$	0.5	-0.1	Gypsum	20.0	-0.1
	10	-0.1	Gypsum	20.0	-0.1

[a]Hydrohalite: $NaCl\cdot 2H_2O$; Meridianiite: $MgSO_4\cdot 11H_2O$; Mirabilite: $Na_2SO_4\cdot 10H_2O$; Gypsum: $CaSO_4\cdot 2H_2O$

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