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SALT OF THE UPPER PERMIAN (ZECHSTEIN-) SALT DIAPIR OF THE ASSE

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ABSTRACT

The Asse salt has many times been used in experiments aimed at a better understanding of the rheological and fluid transport properties of rock salt. In the last decade, it has also repeatedly also been subject of γ -irradiation experiments which have been planned and carried out in order to increase our knowledge of the consequences that radiation and heat will have on the rock salt of prospective radioactive waste repositories. In this frame the Asse rock salt has been used in two different ways, as drilled cores of solid salt, and as mixtures of ground salt of various mineralogical and geochemical composition. This contribution gives a characterization of the salt used in these experiments.

1. GENERAL GEOLOGICAL SITUATION

The Asse salt anticline is part of the subherzynian basin about 30 km north of the Harz mountains. The major rock salt horizon of the Asse is the Staßfurt halite (Na₂) which more or less represents the lowermost part of the entire Upper Permian (Zechstein) salt profile in North Germany. It can largely be considered representative also for other sites in the North German Basin, such as Gorleben. The Zechstein (about 250 to 220 my b.p.) is underlain by the lower permian "Rotliegendes" but overlain by the lower triassic "Buntsandstein".

The Staßfurt Hauptsalz / Main Salt (Na₂ β) generally represents the thickest salt horizon. It consists almost exclusively of anhydritic rock salt (see below), except for its top, and has the more or less same composition and character throughout its entire thickness profile. Fig. 1 shows the stratigraphical sequence at the special position of the HAW-test field in the Asse, which was described in greater detail elsewhere [H. Gies et al., 1994] in the frame

of the HAW-final report. Within the Staßfurt Series the Main Salt is overlain by the Speisesalz (Na₂S) horizon.

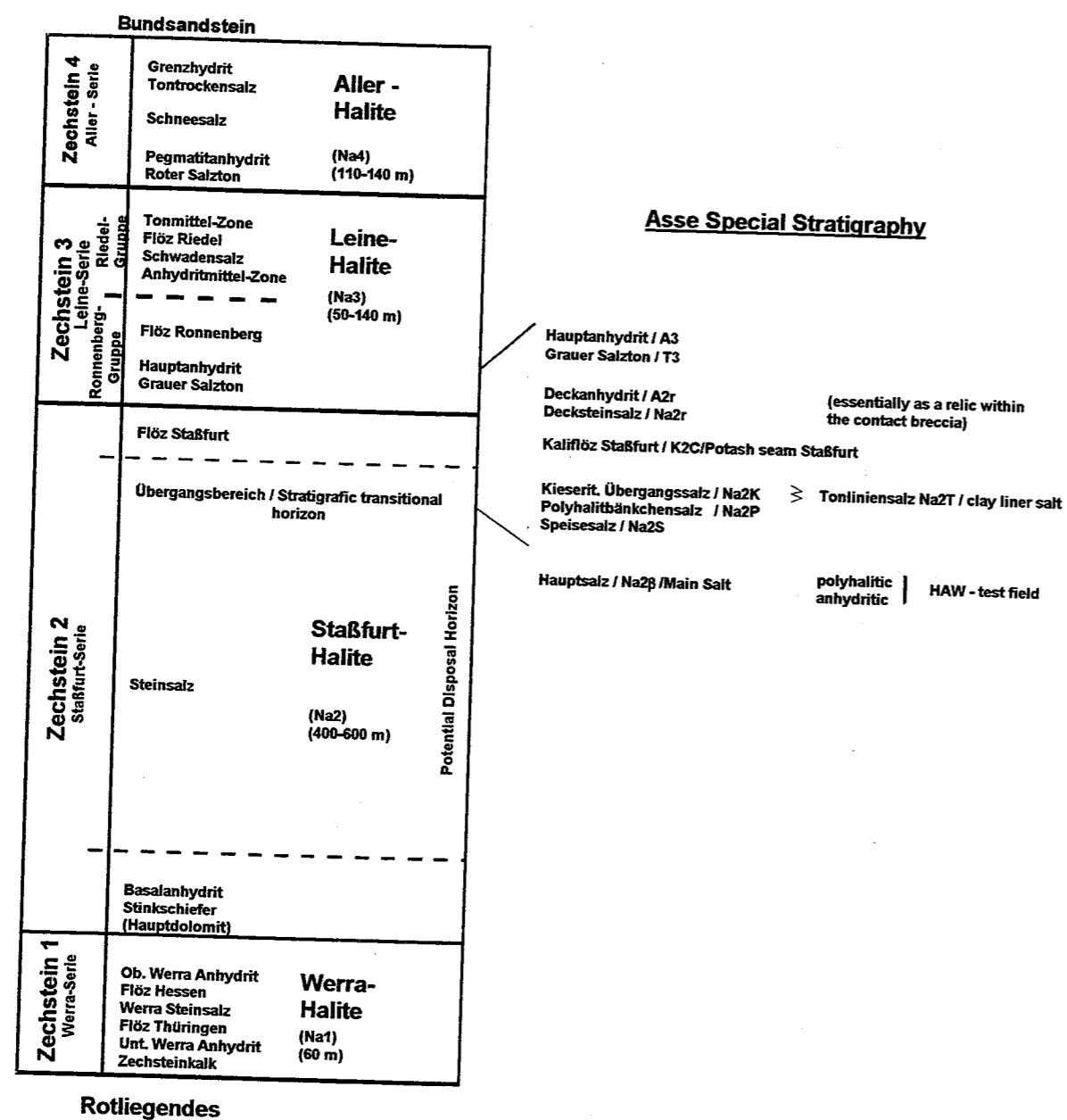


Figure 1: General stratigraphy of the Upper Permian (Zechstein) in North Germany with special stratigraphy of the uppermost Staßfurt halite/lower Leine series at the Asse

2. MINERALOGICAL AND GEOCHEMICAL CHARACTERIZATION

The Main salt (Na₂β) can be divided into the most abundant (400 to 600 m thick) anhydritic main salt (Na₂β_a) and the less abundant (~ 15 m thick) polyhalitic main salt (Na₂β_p). Salt samples from these two sub-horizons have been used in the laboratory irradiation experiments, either as mixtures of broken salt for radiolytic gas research [Jockwer et al., 1995 (article nr. 13, this volume), Gaudez et al., 1995 (article nr. 14, this volume)], and determination of radiation damage formation [Mönig et al., 1995, article nr. 16, this volume] or as drilling cores of solid salt. In some of the papers in this volume, however, a different sample designation was used [Donker and Garcia Celma, 1995, articles nr. 17 and 18, this volume, Garcia Celma and Donker, 1994], where they were called Borehole anhydritic (Bha) and Borehole polyhalitic (Bhp) salt, respectively.

The mean mineralogical composition of the two sub-horizons was given by Pahl [Pahl, 1988]:

Table 1: Mean mineralogical composition of the anhydritic Staßfurt main salt and its polyhalitic top

	anhydritic main salt (Na ₂ β _a) [% by weight]	polyhalitic main salt (Na ₂ β _p) [% by weight]
halite	94.6	96.3
anhydrite	4.3	0.8
polyhalite	0.4	2.8
water	0.04	0.18

The quantities of water given here represent the total water comprising the polyhalite crystal water (5.98 % by weight of the polyhalite present) and the interstitial water of the pore spaces. Since all components were determined analytically the difference to 100 % reflects the analytical accuracy. Various clay minerals and magnesite are usually found as trace minerals, mostly around or below their detection limits. Kieserite and sylvite occur, if at all, only in the uppermost Na₂ above the Polyhalitbänkchensalz Na₂P, closer to the Staßfurt potash seam.

3. MICROSTRUCTURAL CHARACTERIZATION

A direct microstructural characterization of the salt mixtures used in the German irradiation programme was not performed. Previous investigations [Urai et al., 1987] showed that the Asse salt reveals very little internal dislocation structure and indicate low dislocation densities. High internal strain features such as slip bands and kinks band (indicative of dislocation glide mechanisms) are almost entirely absent. But these results were gained on Asse Speisesalz, Na₂S, a salt that is much more recrystallized due to its high purity than the main salt itself [Spiers et al., 1986, 1988, Peach et al., 1987, Peach, 1991]. This is also expressed by a larger volume of salt showing grain shape fabrics [Gies et al., 1994]. The general applicability of those results seems, therefore, to be limited.

4. PREPARATION AND CHARACTERIZATION OF BROKEN SALT MIXTURE

The salt samples were prepared by mixing salt from two different horizons, in order to have both accessory sulfate minerals present in the salt samples. The final mixture had grain sizes of between 1 and 3 mm. It was split into a large number of subsamples using a sample splitter. In order to confirm that the subsamples had identical compositions five subsamples were chemically analyzed. The compositions found are listed in Table 2.

Table 2: *Mineralogical composition of five rock salt samples to be irradiated and measured (% by weight.)*

	1	2	3	4	5
halite	97,72	97,40	97,66	97,58	98,09
anhydrite	1,80	2,16	1,87	1,94	1,45
polyhalite	0,48	0,44	0,47	0,48	0,46
water	0,042	0,038	0,040	0,037	0,038

The above compositions are considered to be satisfactorily representative for the individual samples that were filled into the ampoules. In total, 160 ampoules each having 300 g of rock salt were prepared, sealed and irradiated in the HFR at Petten (for results see Jockwer et al. [article nr. 13, this volume] and Mönig et al. [article nr. 16, this volume]). As everytime the entire subsample participates in the production of radiolytical gases

The situation, however, is very different when partial samples are being taken for the calorimetric determination of stored energy. In that case, the single sample to be measured weighs only ~ 0.3 g.

The microscopic picture shows very clearly an intergrowth of the halite and sulfate components too close as to allow for a mechanical separation of the minerals (Fig. 2). Likewise, no method is available to take a single specimen having the representative bulk composition.



Figure 2a: *Polyhalite and anhydrite crystals in halite (black). (The grain sizes shown here are the coarser ones; a lot of the sulfate portion of the rock salt is represented by very fine grained particles of a few microns). long edge = 1 mm; Nicols +*

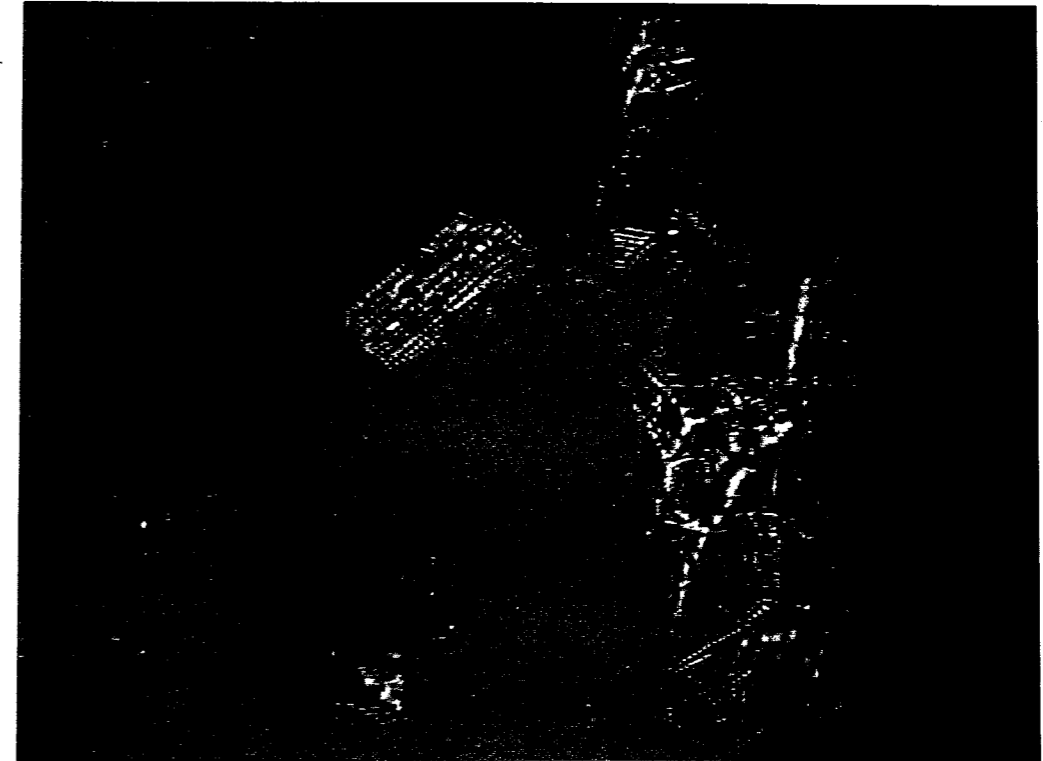


Figure 2b: *Anhydrite and polyhalite crystals in or adjacent to halite turned black (colloidal sodium) by the irradiation. Long edge = 0.2 mm; Nicols //*

The only way to obtain reliable information as to the amount of energy stored in the halite portion of the rock salt seemed to be to perform calorimetric measurements, be it on simple subsamples or on a halite concentrate separated by hand-picking under the microscope. Important in both cases is, that the calorimetric specimens have to be analyzed once more after they were measured, as the originally chosen composition can no longer be expected.

For a general information and evaluation of the potential role of trace elements both in the halite and the sulfate minerals of the rock salt an extensive description was given in the final report on 'Material inventory and petrophysics of the HAW-test field in the Asse' [Gies et al., 1994].

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