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Stability Of Advanced Breeder Pebbles In Water Containing Purge Gas Atmosphere

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Introduction – Why substitute H_2O for H_2 in the purge gas?

The reference design of the outer tritium fuel cycle uses He with 0.1% of H_2 as purge gas for the generated tritium, that is released as tritiated water besides hydrogen isotopologues.

The separation of tritium from large amounts of hydrogen is challenging and costly. Also, tritium easily permeates through steel. Both issues may be addressed by getting rid of hydrogen isotopologues in the purge gas, using (tritiated) water instead.

If H_2O is added to the He purge gas instead of H_2,…

- …are the current grades of advanced breeder pebbles mechanically or microstructurally degraded?
- …is there an increased vaporization of lithium from the breeder material?

To answer these questions, EU and Japanese breeder pebbles were comparatively annealed under both atmospheres.

Experimental setup and parameters

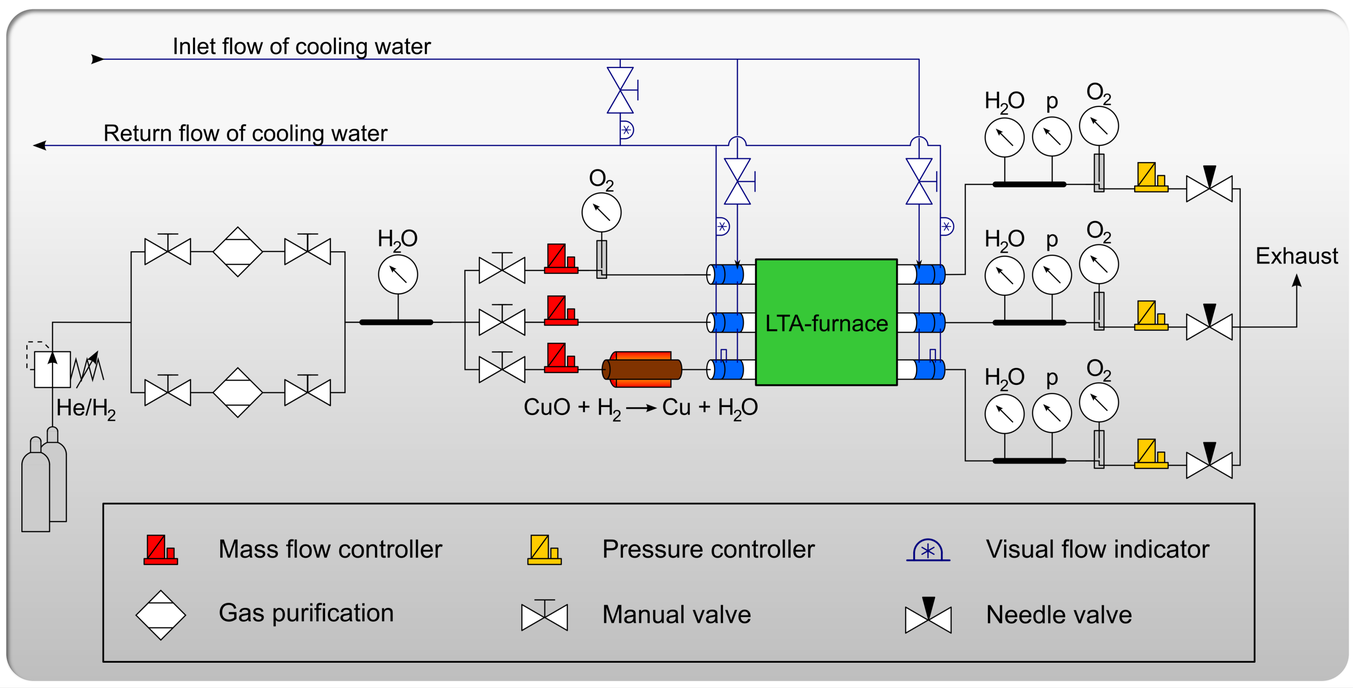
To generate a precise level of H_2O in the gas stream, the H_2 fraction of the inflowing gas is oxidized to H_2O by a CuO-bed.

Annealing parameters

- Temperature: 900 °C
- Pressure & flow: 1200 mbar(a), 1200 ml/h
- Sampling: 4 days, 32 days
- Atmosphere: He/H_2(0.1%), He/H_2O(0.1%)

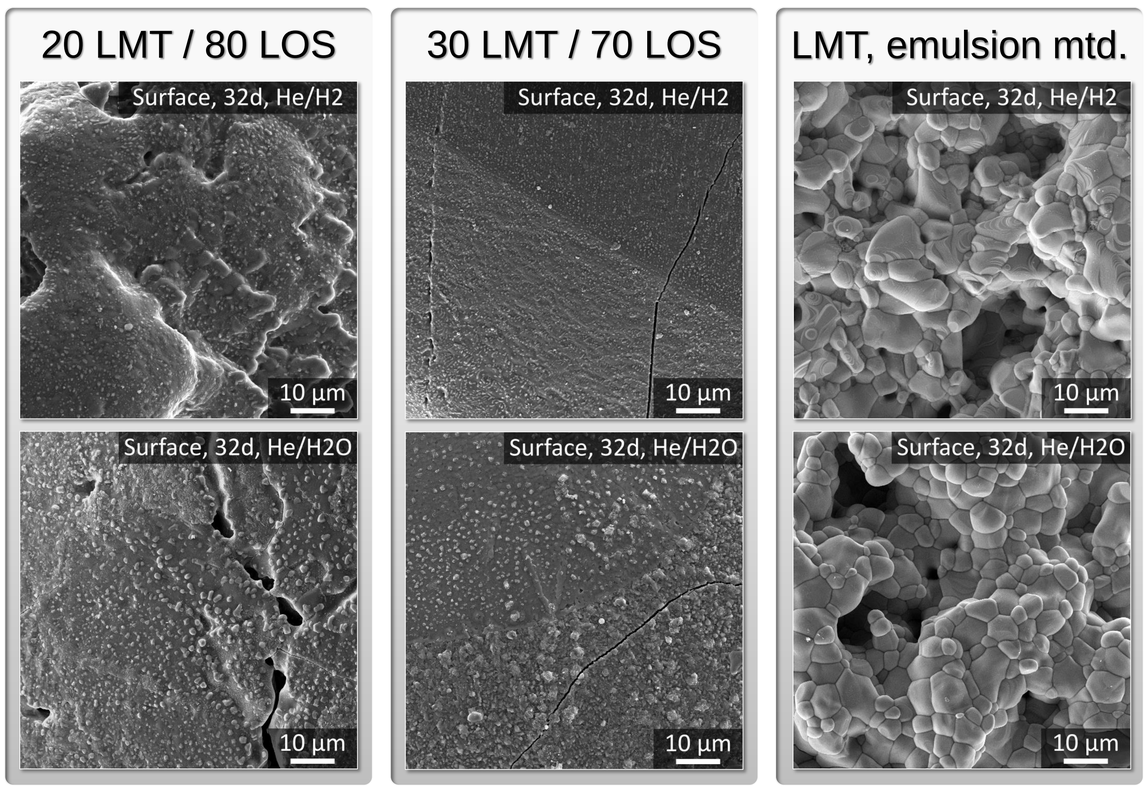
Samples

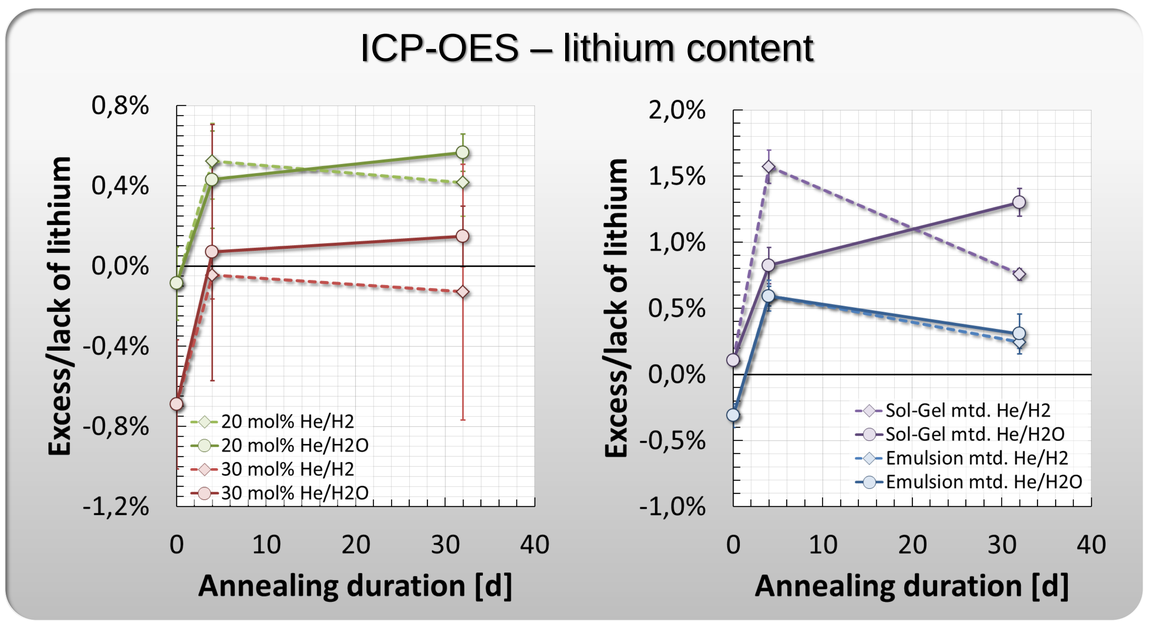
- 20 mol% Li_2TiO_3 (LMT) in Li_4SiO_4 (LOS)
- 30 mol% Li_2TiO_3 (LMT) in Li_4SiO_4 (LOS)
- $Li_{2.16}TiO_{3.08}$ (emulsion method)
- $Li_{2.11}TiO_{3.055}$ (sol-gel method)

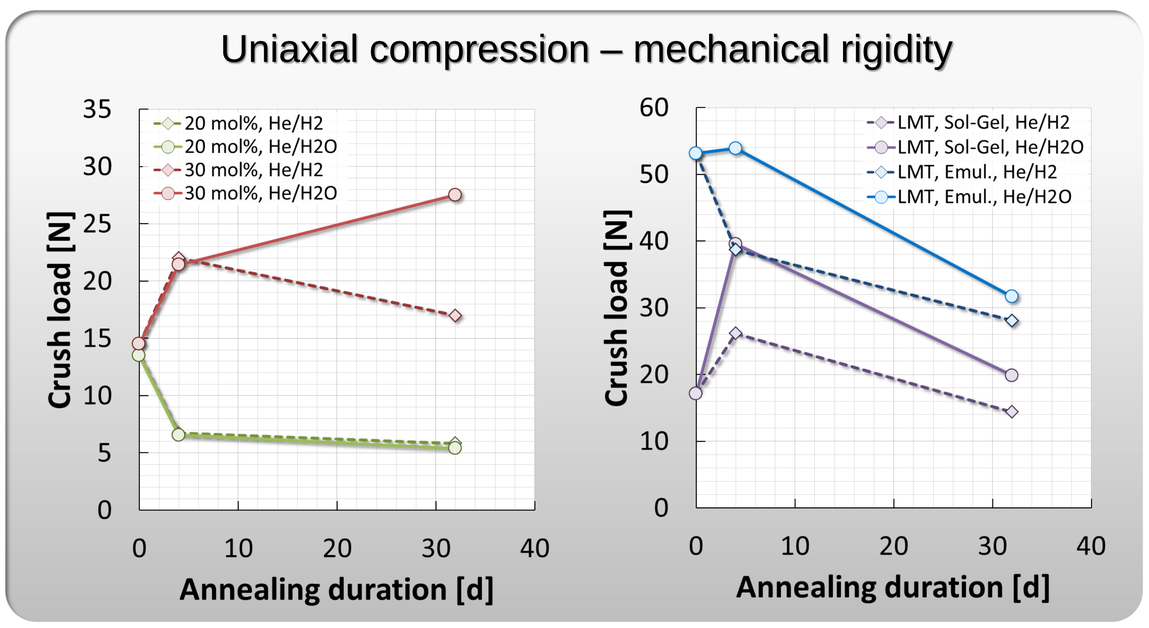


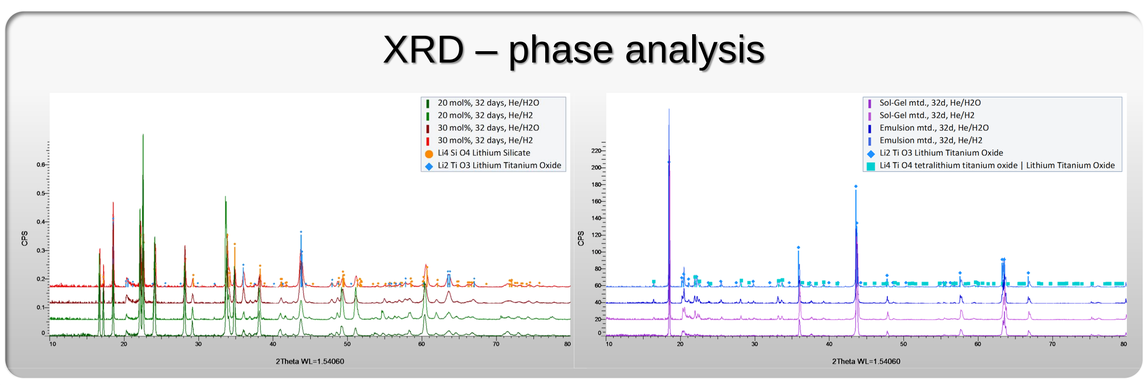
Results & conclusions

- The pebble surface changes significantly during annealing. Yet, there are no significant changes resulting from annealing in the two different atmospheres.
- The XRD histograms show no formation of impurity phases.
- The lithium content is not affected by annealing in He/H_2O.
- The crush loads rather increase by annealing in He/H_2O.









The critical pebble properties do not degrade during annealing in He/H_2O atmosphere, regardless of the pebble composition. Actually some properties are enhanced during annealing in a H_2O containing atmosphere. Therefore, the use of the tested breeder pebbles in this environment is unproblematic.