Phreatic explosion apparatus

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A new setup was developed for the rapid decompression apparatus at the FragLab of LMU München, tailored especially towards the investigation of phreatic and hydrothermal explosions. This new setup allows the pressurization and rapid decompression of dry and partially to fully water-saturated samples.

The phreatic explosion apparatus consists of:

1) High-pressure, high-temperature autoclave (0.1-25 MPa & 20-400 °C)
2) Pressurization and Diaphragm system
3) Particle collection tank at ambient conditions
4) P-T- monitoring and DAQ- System including high-speed camera

A cylindrical large low-pressure tank (3m height, 0.4m diameter) is separated by a set of 1-3 diaphragms (rupture discs) from the autoclave. The large tank is held at ambient conditions and allows recovering all particles ejected during an experiment. The diaphragm system with 2-3 rupture discs enables precise and repeatable P&T conditions of the experiments at varying equilibration times (time waited after reaching final experimental conditions). The autoclave is built of Nimonic90, a corrosive resistant alloy geared towards high-temperature, high-pressure applications. The autoclave can be heated by a vertical split-tube furnace. The sample is positioned in the middle of the autoclave to assure homogeneous heating of the sample resulting in a very small (negligible) temperature gradient across the sample. The pressurization of the autoclave can be reached by (1) Argon gas only, (2) the development of water vapor in closed autoclave system during heating, or (3) a combination of both.

Dynamic high-temperature pressure sensors, based on $GaPO_4$-crystals, are installed directly below the sample and at the upper section of the autoclave to monitor the pressure evolution in the autoclave and across the sample during fragmentation. The temperature of the sample is monitored with a thermocouple beneath it, next to the pressure sensor. All signals are recorded with a DAQ system from Yokogawa (WE7000). The pressure signals can be recorded at up to 1MS/s capturing dynamics signals i.e. of explosions, simultaneously the pressure signals can also be recorded at very low sampling rates (1- 10 S/s) to track the pressure evolution over the entire experiments. Temperature data are recorded in concert with the slow pressure recording only. A transparent section made of acrylic glass is inserted at the bottom of the low-pressure tank to observe the ejection of gas, vapor and particles. The ejection can be monitored with a high-speed camera at frame rates from 1.000 – 60.000 fps; the recording of high-speed videos and pressure signals at high frame rate is synchronized.

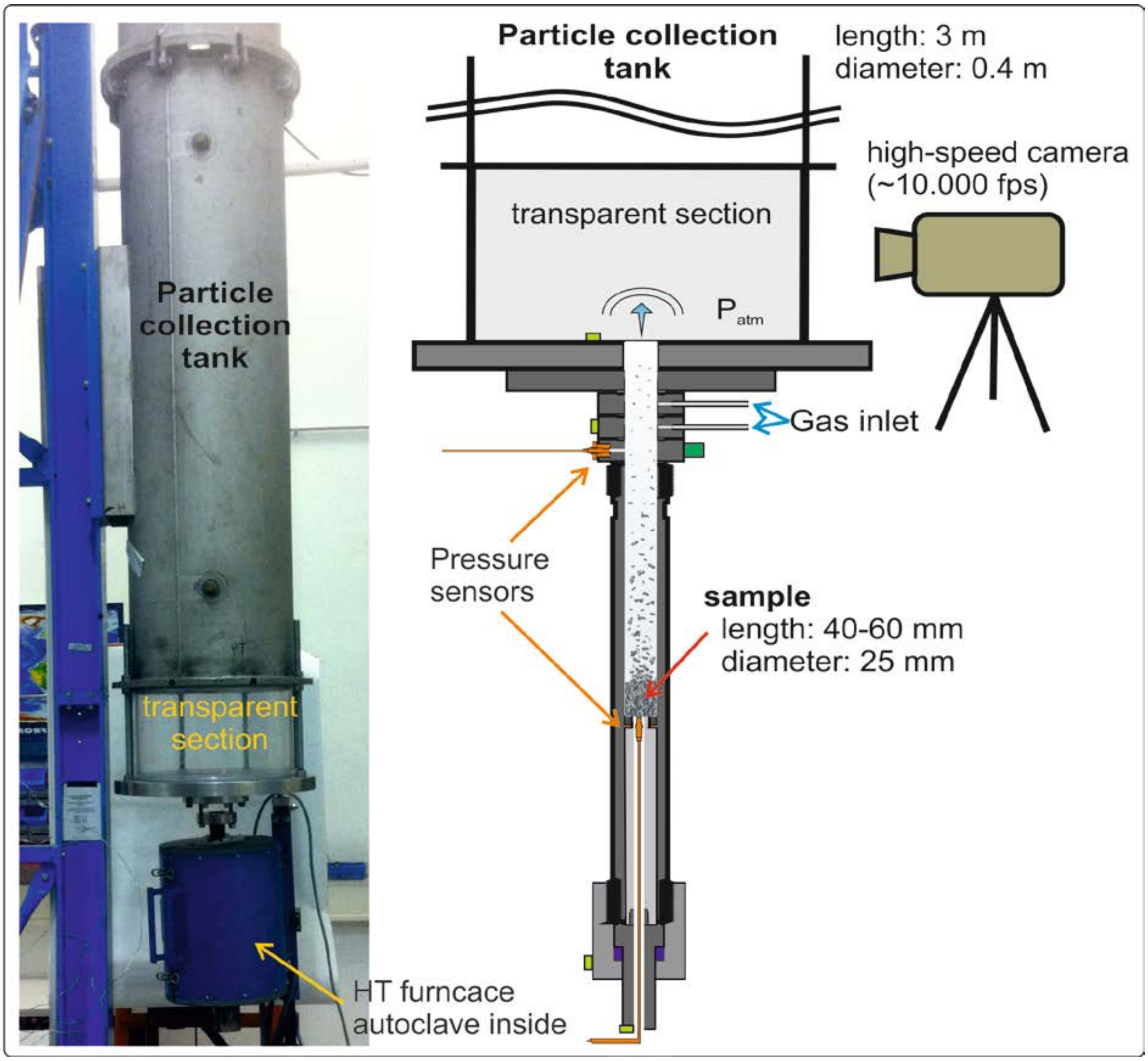

Photo and schematic drawing of the phreatic explosion apparatus showing the autoclave (high-pressure section), the diaphragm system with the gas inlet and particle collection tank (atmospheric pressure).<u>NOTE:</u> The autoclave sits entirely in a split tube furnace (see photo left side).