A new deformation apparatus to test the physical properties of brittle rocks

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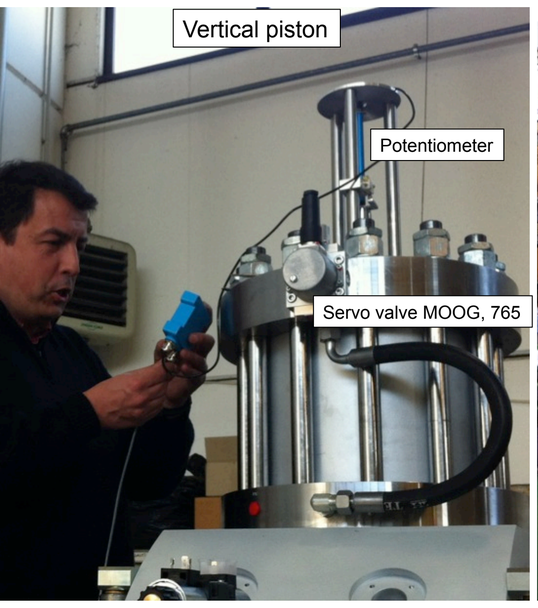
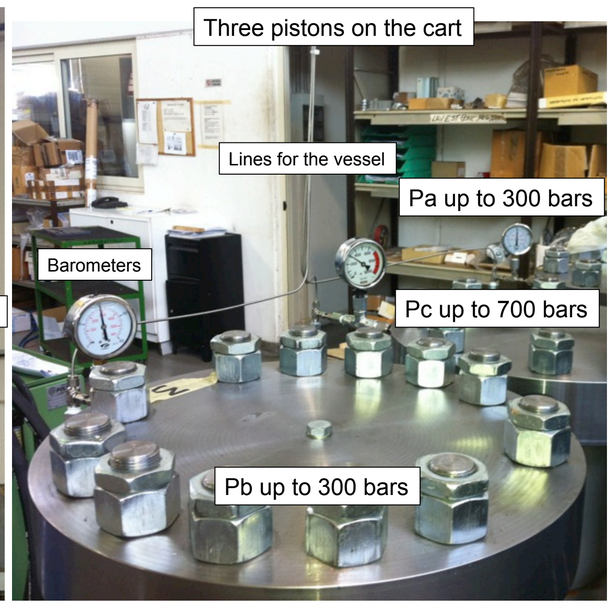
Introduction

A main goal of the European Research Council, Starting Grant, **GLASS**, has been to design, develop, and implement a prototype rock deformation apparatus to examine the physical properties of brittle rocks. We began designing the machine in October 2010 and have recently (March 2012) installed the apparatus in the HP-HT lab at the INGV of Rome. We have concurrently been working to develop a system capable of recording different seismic signals during frictional sliding of large rock samples (up to 20x20 cm) in a fluid-rich environment with the goal of comparing these signals to those recorded in nature.

5 pistons

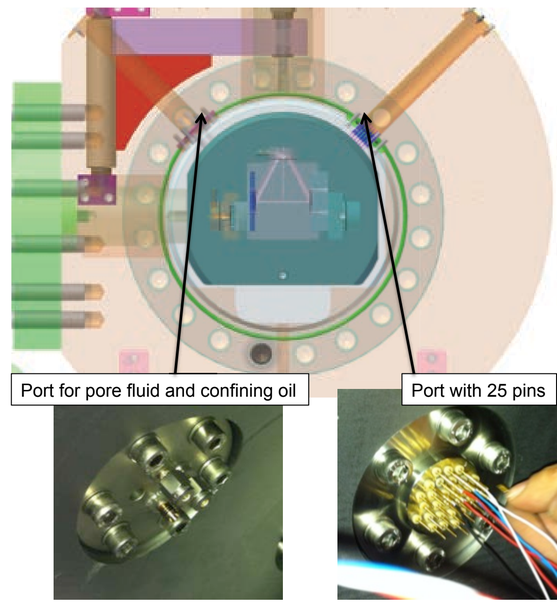
The machine is equipped with 5 pistons, two mounted on the vessel (horizontal, P_H, for normal stress and vertical, P_V, for shear stress) and three positioned on the cart (two for pore fluids Pa and Pb and one for confining oil, Pc). All pistons are controlled by a servo valve and connected to a potentiometer with a resolution of 0.15 microns. Load cells are mounted on the ends of the vertical and horizontal pistons.





The vessel

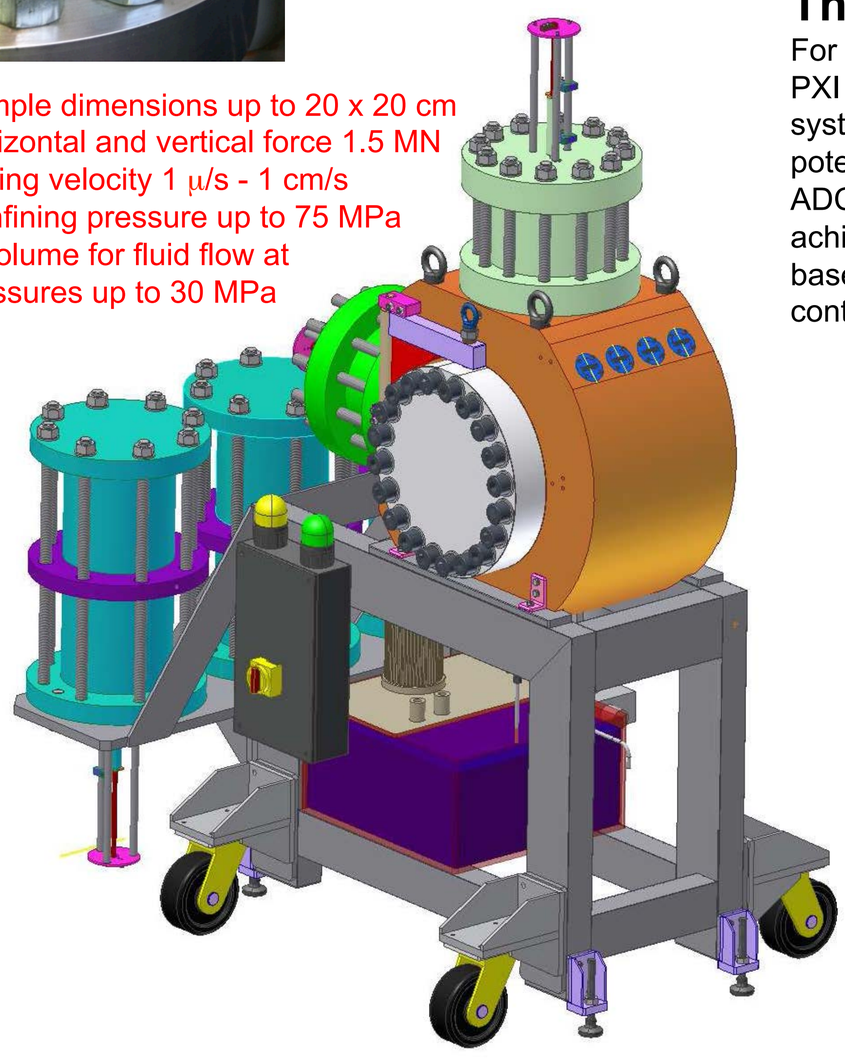
The stainless steel vessel has an internal diameter of 395 mm and is designed to support the vertical and horizontal pistons. Two doors, equipped with 20 M32 bolts, close the vessel. 6 access ports are used for electronics (~100 pins), pore fluids (3 lines) and confining oil.



The oil-dynamic circuit

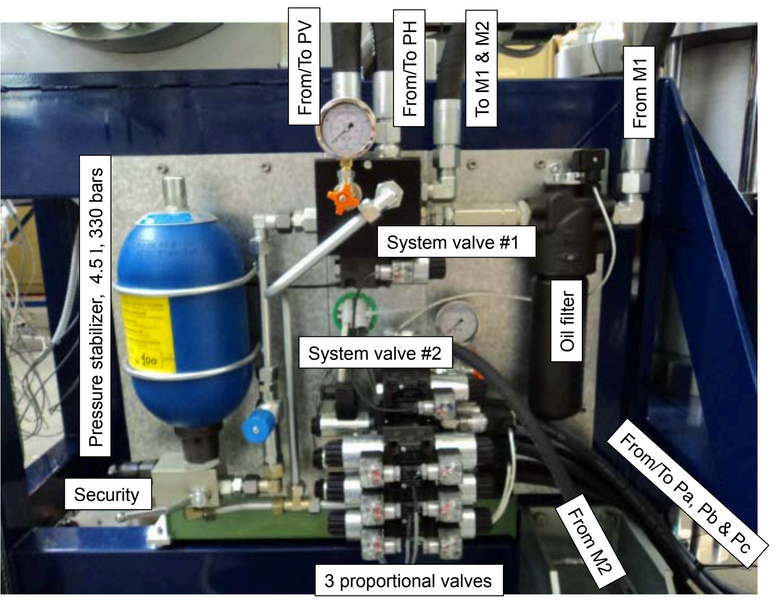
Two ON/OFF system valves enable oil pressure to: a) P_H and P_V and b) Pa, Pc & Pb. Three distribution valves with three proportional valves are used to operate Pa, Pc & Pb. The distribution valves allow for changes in piston direction while the proportional valves modulate pressure and sliding velocity.

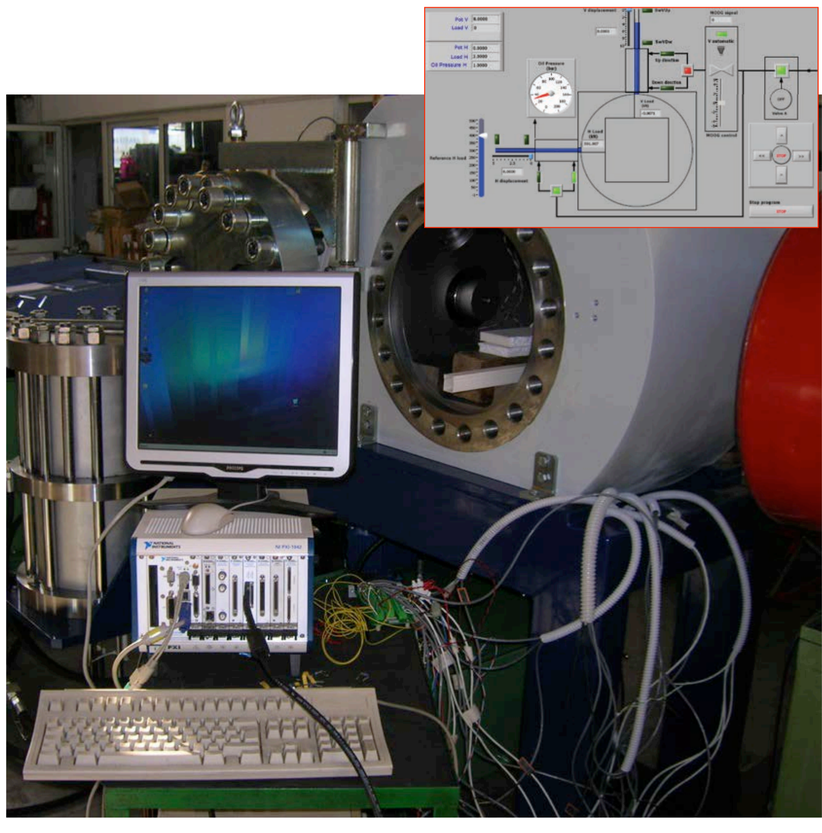
Sample dimensions up to 20 x 20 cm
Horizontal and vertical force 1.5 MN
Sliding velocity 1 μ/s - 1 cm/s
Confining pressure up to 75 MPa
8l volume for fluid flow at pressures up to 30 MPa



The machine controlling system and test

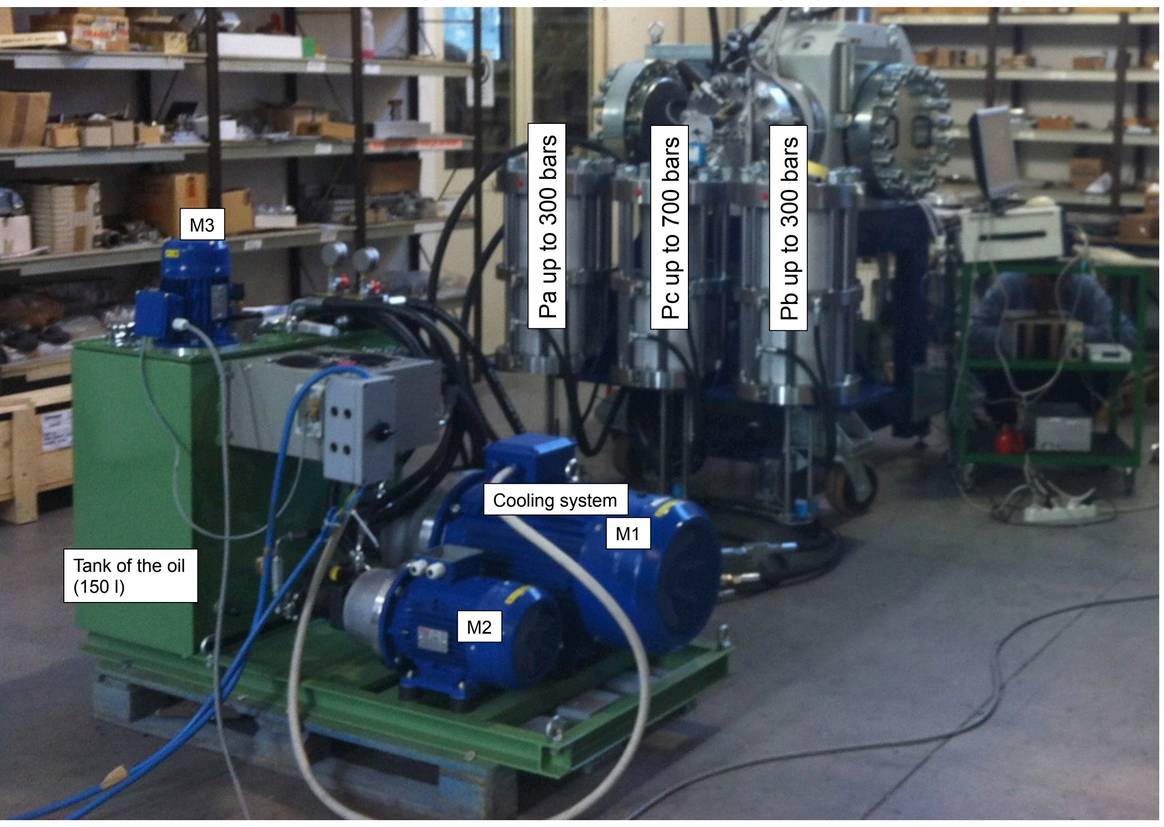
For initial tests of the machine, it was controlled by an industrial PXI based PC with a generic data acquisition board (DAC). The system acquires signals from apparatus components (load cells, potentiometers, pressure transducers, etc.) using a high quality ADC board and regulates the current of the five servo-valves to achieve the targeted experimental conditions. We use LabView based software with a synoptic user interface for real-time machine control.





Hydraulic power supply

The machine is powered by two motors M1 controlling P_H & P_v and M2 controlling Pa, Pb and Pc. M1 is electric motor 18 KW-4P-240-415 V/50Hz connected to a pump with a variable flow rate up to 42 l/min. M2 is a 4 KW-4P-240-415V/50Hz motor connected to a pump with a flow rate up to 10 l/min. Motor M3, located above the oil tank, is used to cycle oil through the cooling system.



Early results

We sheared two 5 mm thick layers of powered carbonates at constant sliding velocity (0.179 mm/s) and a nearly constant normal stress of 20MPa. We measured a friction coefficient of 0.66.