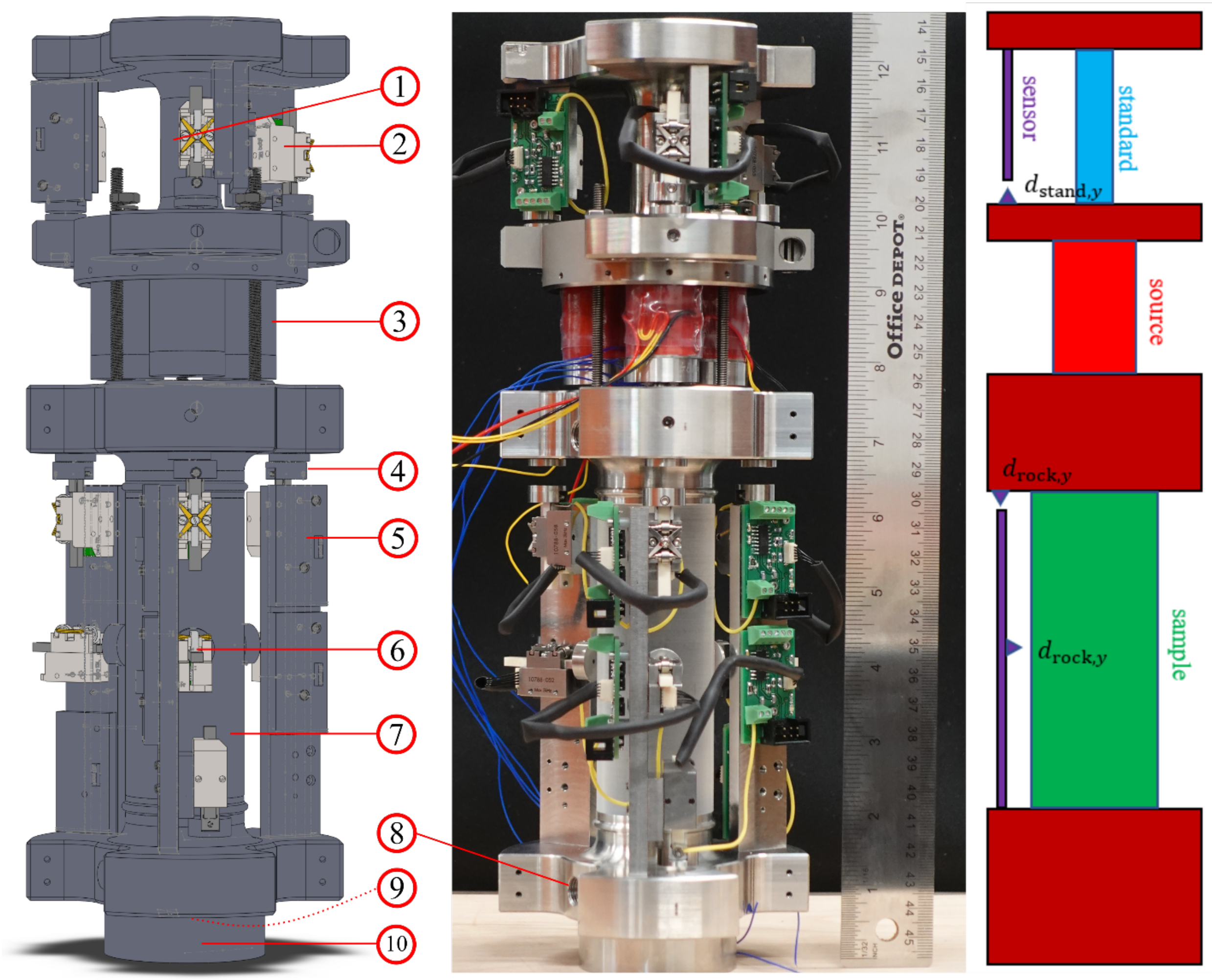
LABORATORY EXPERIMENTS OF LOW-FREQUENCY ATTENUATION IN FRACTURED BEREA SANDSTONE PART 1: LOW-FREQUENCY MODULE

Ken Ikeda, Eric Goldfarb, and Nicola Tisato

Department of Geological Sciences
The University of Texas at Austin

ABSTRACT

Fractures are important in defining the transport and elastic properties of rocks. Determining fracture characteristics of subsurface formations, such as fracture orientation and distribution, using the elastic response of rocks is challenging. Previous studies have shown that the non-elastic interaction between rocks and seismic waves, which is typically quantified with the coefficient of attenuation ($1/Q$), is more effective in sensing rock fractures. Models suggest that attenuation is even more enhanced when materials are partially saturated. At low-frequencies and in partially saturated rocks, the primary attenuation mechanism is known as wave-induced fluid flow (WIFF). As seismic waves propagate through a medium, part of the wave energy dissipates by mobilizing the pore fluid, resulting in the loss of carried energy. Numerical studies of WIFF in fractured media show a strong correlation between attenuation and fracture geometries. Nevertheless, insufficient experimental evidence leaves the topic under debate. Here, we present a state-of-the-art laboratory apparatus to measure the attenuation of rocks at seismic frequencies (0.1 – 100 Hz): the Low-Frequency module (LFM). LFM can be used to measure attenuation based on the sub-resonance method, where deformations of an elastic standard and a viscoelastic sample are used to estimate attenuation. This manuscript will focus on the design limitations of the LFM. In future studies, the apparatus will be used to verify WIFF theories for fractured media.



A schematic diagram of the LFM (left) along with the cross-section of the module (middle) and the simplified diagram indicating four main components (right). The number labels are: 1) standard titanium part, 2) piezo LEGS® Linear 6N and capacitive sensors [vertical standard], 3) PICA™ (Power Dynamics Piezo Actuators) actuator, 4) piezo LEGS® Linear 6N and capacitive sensors [vertical sample], 5) PCB boards, 6) piezo LEGS® Linear 6N and capacitive sensors [horizontal sample], 7) rock sample, 8) fluid inlet channel, 9) piezoelectric crystal chamber, and 10) spacer.