Recent upgrades to the seismic physical modelling system

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PART A. New Water Tank

Older water tanks used in physical modelling of seismic acquisition in marine environments were built of wood and thin acrylic sheets. They were not leak-proof, and also failed when they developed cracks under the long-term water pressure when fully filled . A new, more robust replacement tank with reinforced acrylic sides was designed and built to resolve both issues.

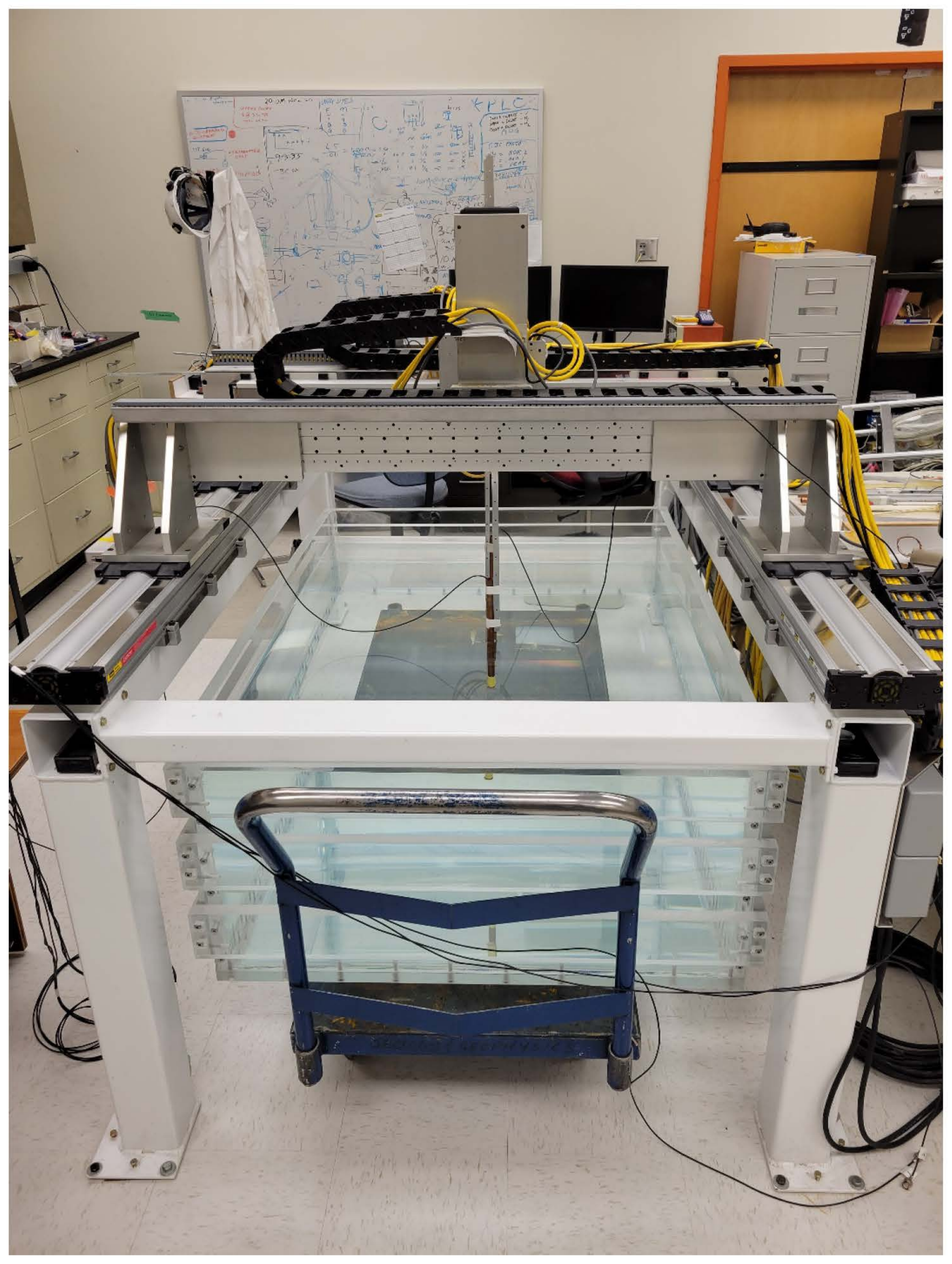

Fig. A1. The new tank filled with water under the gantries of the physical modelling system.

A method for detecting a flood on the laboratory floor

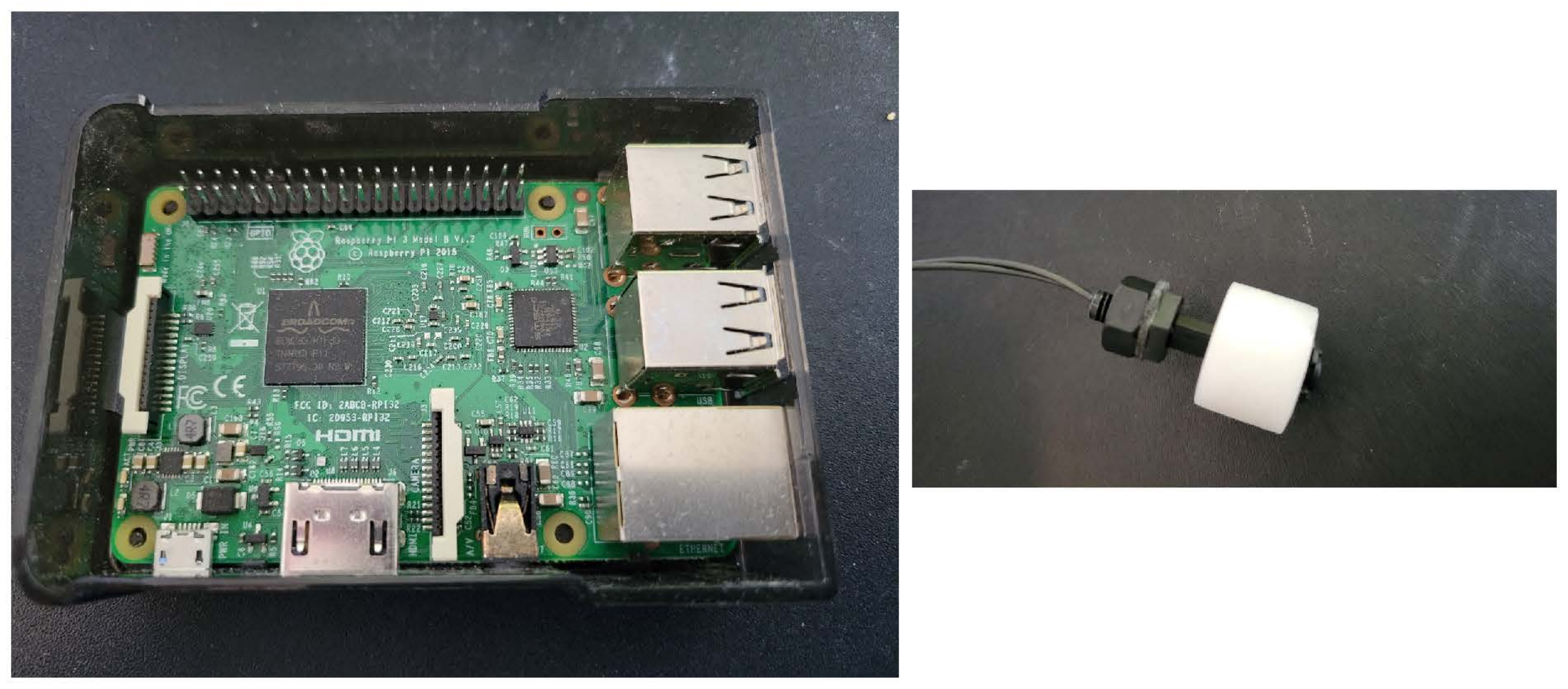

Fig. A2. Key components of a flood detection system. Left: Raspberry Pi microcomputer. Right: Sensor to detect presence of water. Not shown are a berm system on the floor to contain water flooding from a failed tank, and a pump to bail that water.

In the event of a tank failure, the microcomputer is programmed to remotely notify key personnel via email if the water sensor detects water within a berm on the laboratory floor. The sensor also switches on a pump to bail out water on the floor contained within the berm on the floor surrounding the tank.

Part B. Testing New Transducers

Water-filled tanks are used for scale modelling of seismic acquisition in marine environments. We characterized the wavelet shapes and 2D radiation/reception patterns of three types of immersible piezoelectric transducers.

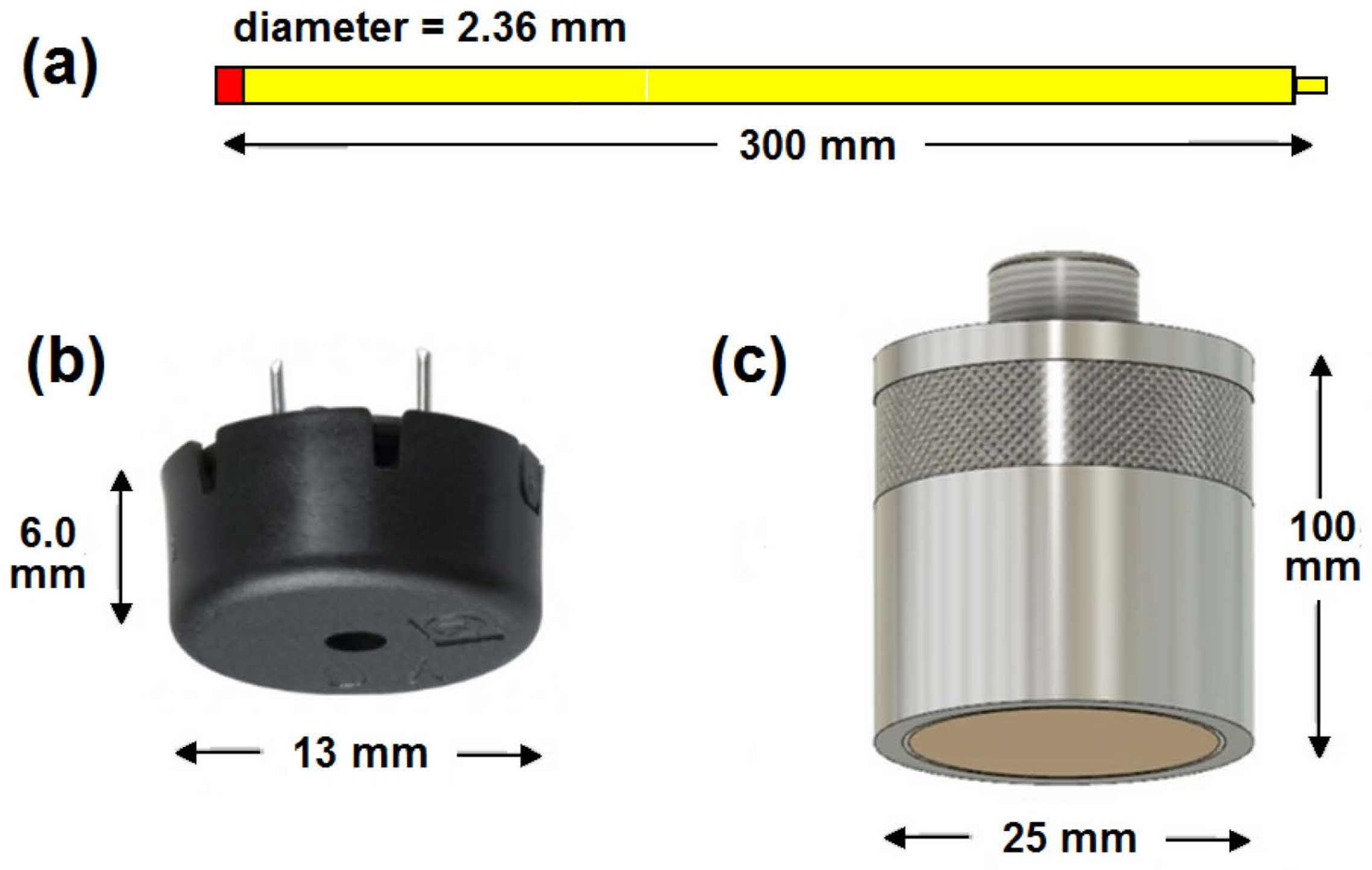

Fig. B1. Piezoelectric transducers used to create ultrasonic data potentially suitable for efficient FWI imaging. (a) Dynasen CA-1136 piezopin. (b) Murata PKM13EPYH4004-B0 buzzer. (c) Ultran GS30-D25 transducer.

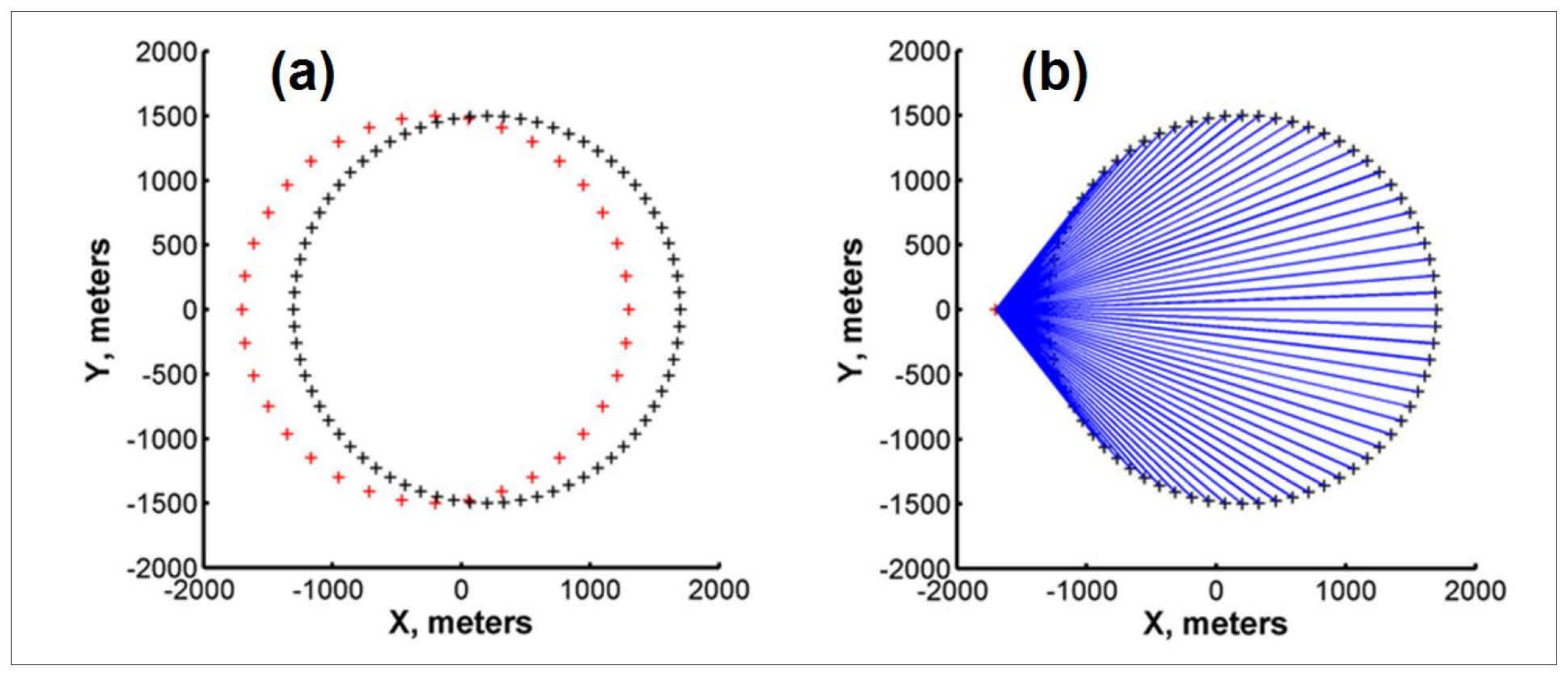

Fig. B2. (a) Source (red) and receiver (black) locations. (b) Raypaths for acquiring all the sample seismic data shown below. The dimensions have been scaled up from laboratory values.

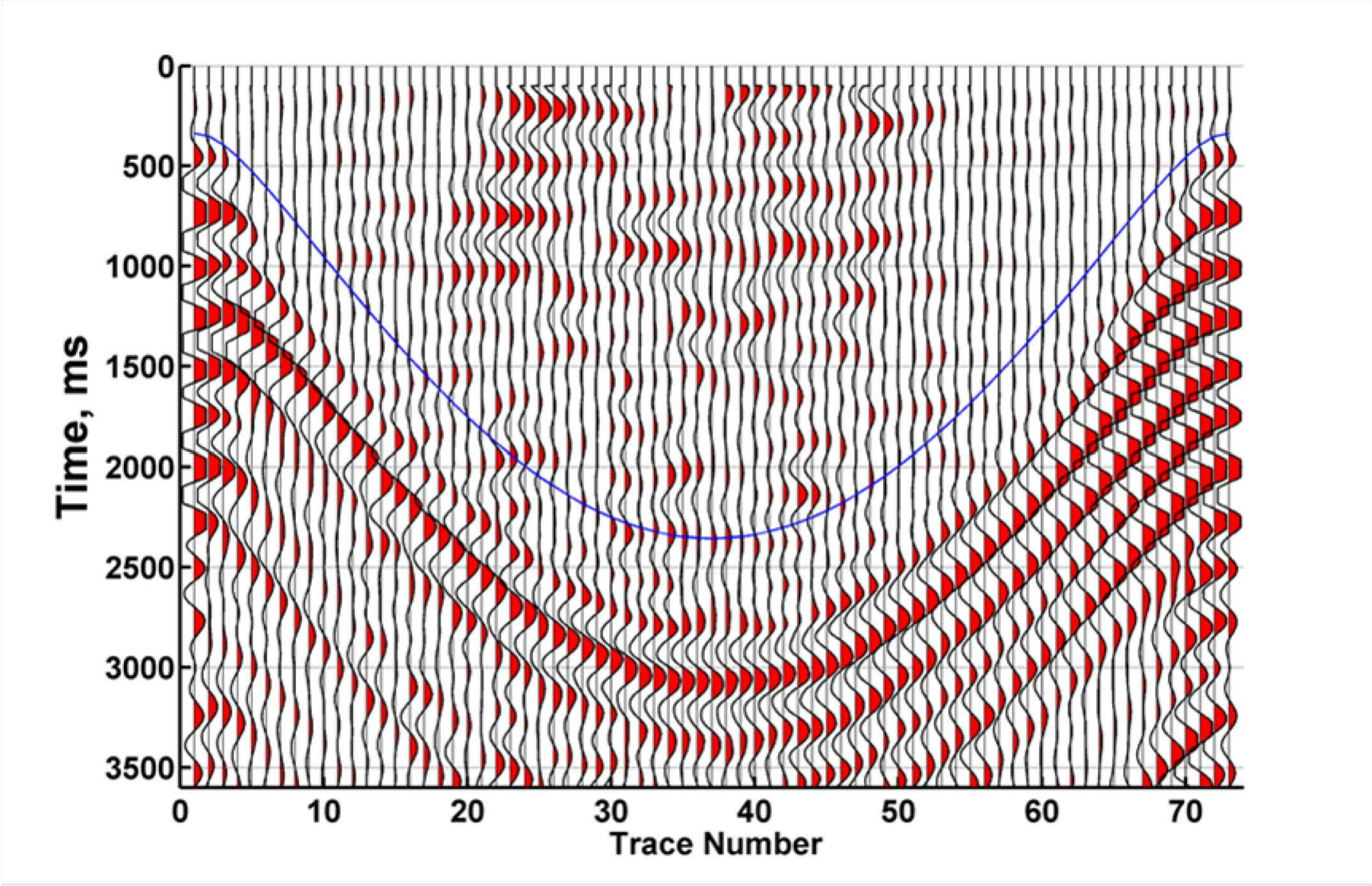

Fig. B3. Trace-normalized raw seismograms acquired with Ultran transducers. Dominant frequency is about 3Hz (30kHz unscaled). The traces are too noisy, wavelets are too inconsistent, the coda too long for Ultran data to be used for physical modelling.

Comparing seismic data acquired with piezopins and buzzers

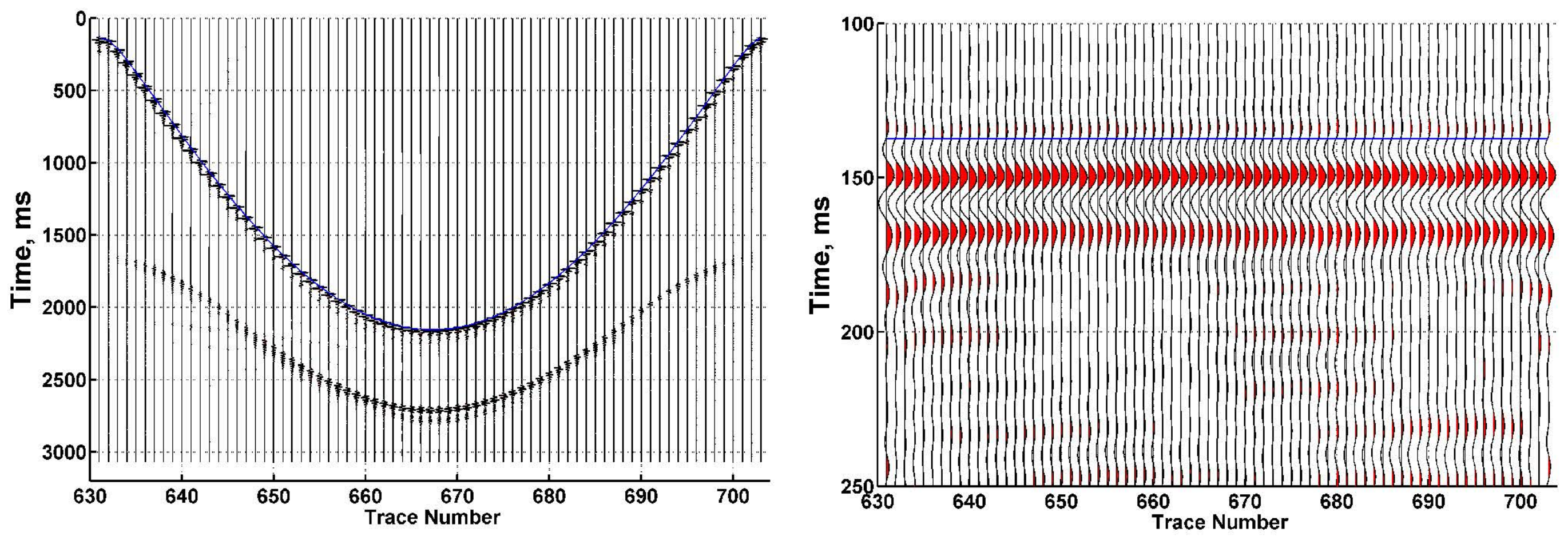

Fig. B.4. Normalized piezopin-acquired seismograms. Left: Raw traces. Right: Pre-processed and aligned traces. Dominant frequency is about 50Hz. The wavelet coda is repeatable; duration is less than 50ms.

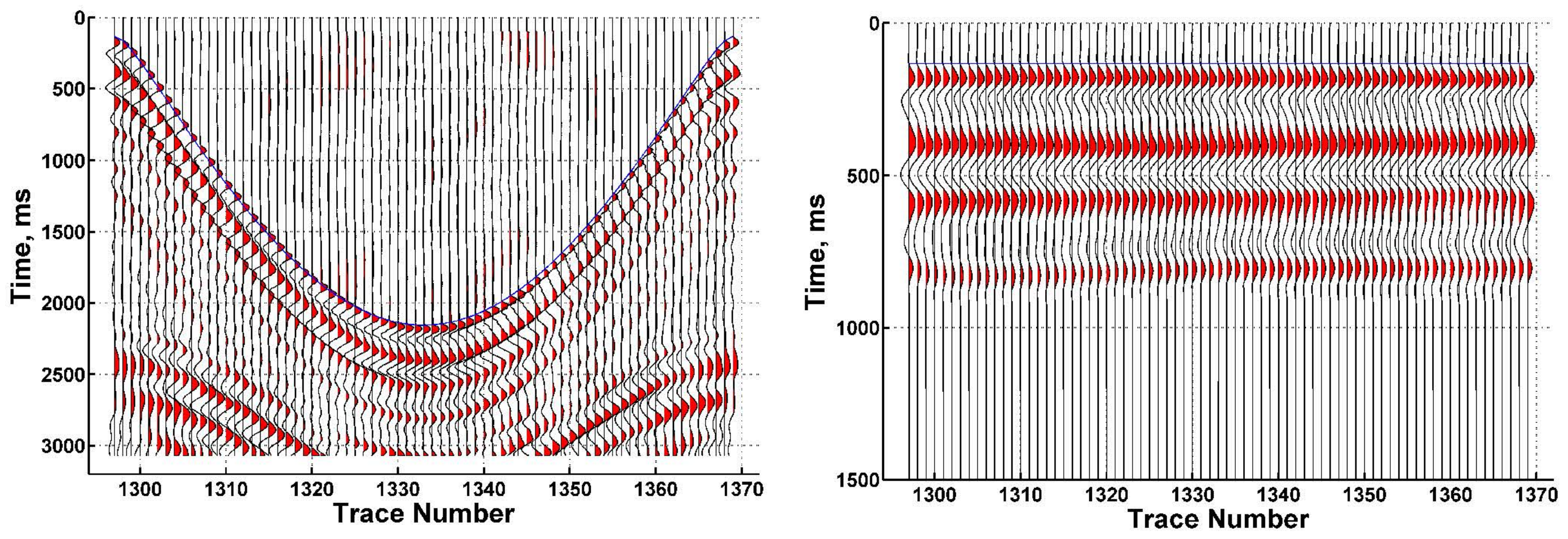

Fig. B5. Normalized buzzer-acquired seismic traces. Left: Raw traces. Right: Pre-processed traces, flattened and showing repeatable wavelet shapes. Wavelet duration is about 700ms.

PART C: Arbitrary Waveform generator (AWG)

The ability to produce controlled source-waveforms increases the types of seismic physical-modeling experiments. Piezoelectric transducers driven by controlled waveforms can be used in simulations of real-world seismic sources such as swept-frequency vibrators, impulsive sources with controlled delay times, and complex SWD signals produced by drill-bits interacting with subsurface rocks. For this purpose, we have designed and built a prototype Arbitrary Waveform Generator (AWG). The heart of the AWG is a Raspberry Pi 4B microcomputer driving an R2R resistor ladder for digital-to-analogue conversion.

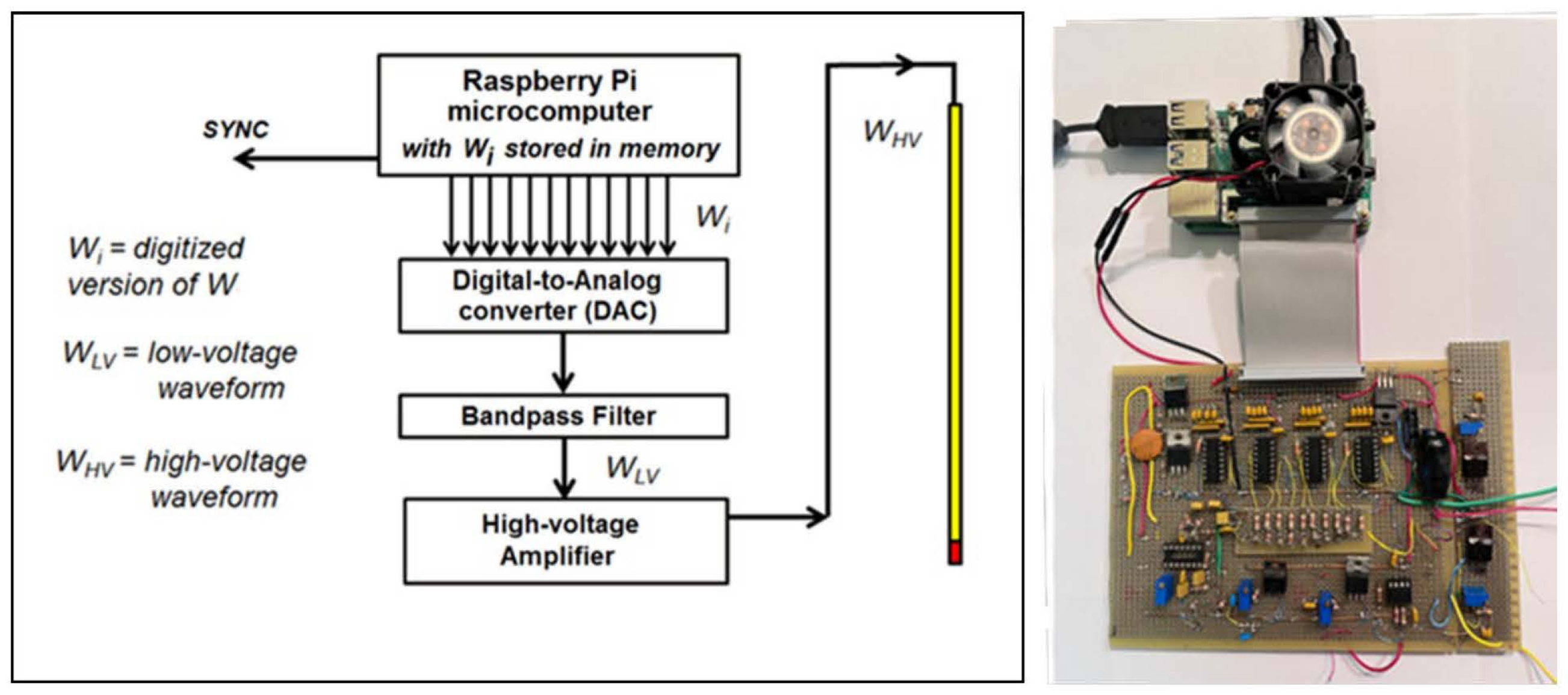

Fig. C1: Arbitrary waveform generator (AWG) for driving piezoelectric transducers. Left: Functional block diagram. W_i is the desired waveform that is stored in the Raspberry Pi as digital numbers; both W_{LV} and W_{HV} are analog signals. Right: Raspberry PI Model 4B connected to prototype AWG support circuit board.

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