Acoustic Emission Processes Occurring During High-Pressure Sand Compaction

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Introduction

Granular materials submitted to uniaxial compression suffer a pore space reduction due to mechanisms such as particle rearrangement and grain crushing. These changes in the internal structure of the material release energy in the form of elastic waves that can be detected by sensors sensitive to acoustic emission. The purpose of this study is to identify the different phenomena produced during high-pressure sand compaction by analyzing the acoustic signals generated along the process. Particle movement, grain failure, friction between grains and the surface of the compression container as well as intergranular friction were studied. Decrepitation of fluid inclusions was also evaluated to temperatures up to 100 °C.

Methods

A broadband acoustic emission sensor (BOTEG UTS400BNC) connected to a high-speed data acquisition system and control software (AeWIN for PCI12.10) has been attached to a steel ram and used to monitor the different processes occurring during the oedometric compaction of uniform (0.5-2.5 mm) quartz sand up to an axial load of about 120 MPa and constant temperature. Load was stepwise applied using a servocontrolled hydraulic press acting at a constant loading rate. Axial strain was simultaneously measured with the aid of a LDT device. Counts, energy, event duration, rise time and amplitude were recorded along each experiment and after completion selected waveforms were transformed from the time to the frequency domain via FFT transform. Additional simplified tests were performed in order to isolate the frequency characteristics of the dominant processes occurring during sand compaction.

Results and discussion

From simplified tests, frequencies for each phenomena were obtained. Average values associated with grain crushing are higher (~150 kHz) than those of the rest of processes considered in this study (~110-120 kHz), with the exception of particle movement (~190 kHz).

During compression tests, a different behaviour is found for different temperatures. While frequencies are almost invariable at room temperature, an upward trend can be detected at 100 °C, especially at pressures higher than 8 MPa. The process of grain crushing would be partially overlapped by the other ones but it can be identified in the range of 150-170 kHz.
Figure 1: Power vs frequency graphs for each of the different processes considered in this study.

Figure 2: AE frequency and applied load at room (blue) and 100°C (red) temperature tests.

Conclusions

Our results show that, from simple tests, it is possible to determine process-dependent frequency components. When considering more complex experiments, many of the studied processes overlap but it is still possible to identify when a particular one dominates as well as the likely onset of crushing.

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References


