In light of these prior attempts, there is a need for a system and method for characterizing non-linear properties in a remote region from a borehole.

SUMMARY

An aspect of the present invention~~disclosure is to~~ provides a method for investigating rock formations outside a borehole. The method includes generating a first compressional acoustic wave at a first frequency by a first acoustic source; and generating a second compressional acoustic wave at a second frequency by a second acoustic source. The first and the second acoustic sources are arranged within a localized area of the borehole. The first and the second acoustic waves intersect in an intersection volume outside the borehole. The method further includes receiving a third shear acoustic wave at a third frequency, the third shear acoustic wave returning to the borehole due to a non-linear mixing process in a non-linear mixing zone within the intersection volume at a receiver arranged in the borehole. The third frequency is equal to a difference between the first frequency and the second frequency.

Another aspect of the present invention~~disclosure is to~~ provides a system for investigating rock formations outside a borehole. The system includes a first acoustic source configured to generate a first acoustic compressional wave at a first frequency; and a second acoustic source configured to generate a second acoustic compressional wave at a second frequency. The first and the second acoustic sources are arranged within a localized area of the borehole. The first and the second acoustic waves intersect in an intersection volume outside the borehole. The system further includes a receiver arranged in the borehole and configured to receive a third shear acoustic wave at a third frequency, the third shear acoustic wave returning to the borehole due to a non-linear mixing process in a non-linear mixing zone within the intersection volume. The third frequency is equal to a difference between the first frequency and the second frequency.

In some aspects of the present disclosure, the first acoustic wave and the second acoustic wave include coded acoustic signals. In other aspects of the present disclosure, the first and second acoustic sources are configured to generate conical broadcast acoustic signals. In yet further aspects of the present disclosure, there is provided a system and method for imaging non-linear properties of the rock formation, or determining a compressional velocity, determining a shear velocity, or