SUPPLEMENTARY MATERIAL

to the manuscript

Studying the high frequency seismic signals for enhanced knowledge of the shallow Earth structure and soil investigation

Mohamed A. GAMAL and George MAHER

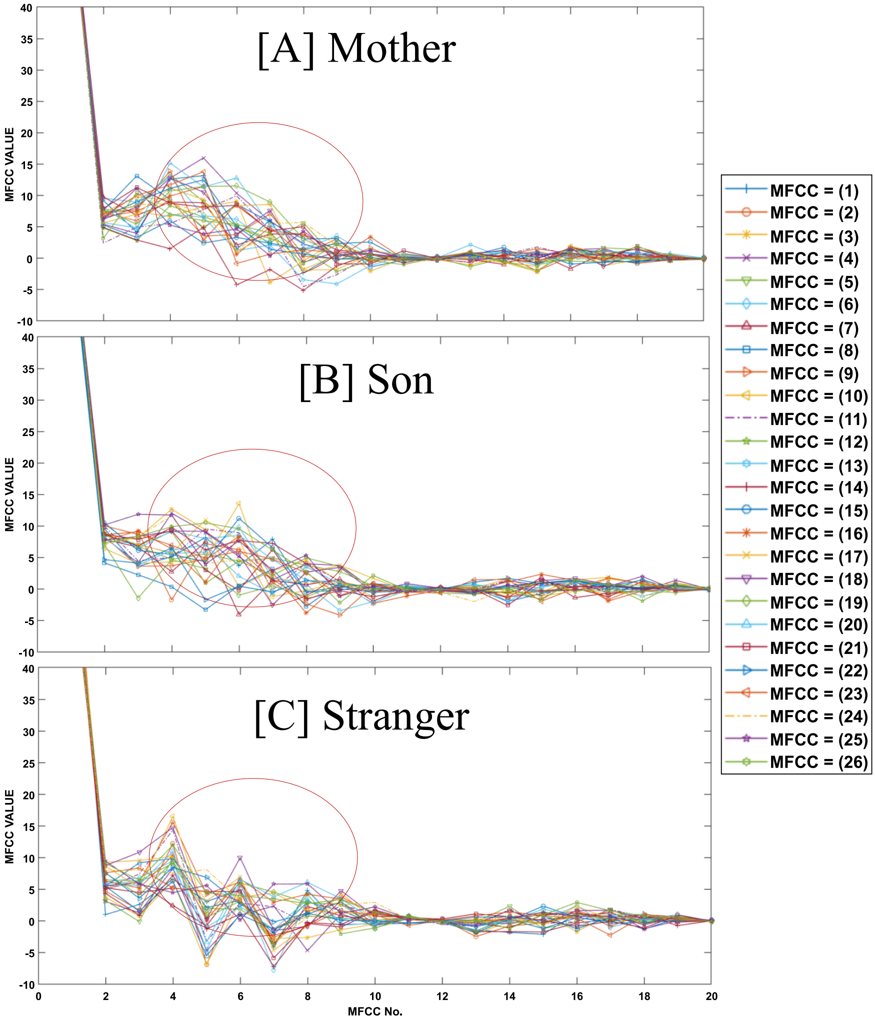

Fig. S1. Similarity between voice properties and MFCC curves of a mother [A] and [B] her son and [C] lack of similarity between them and a strager's voice.

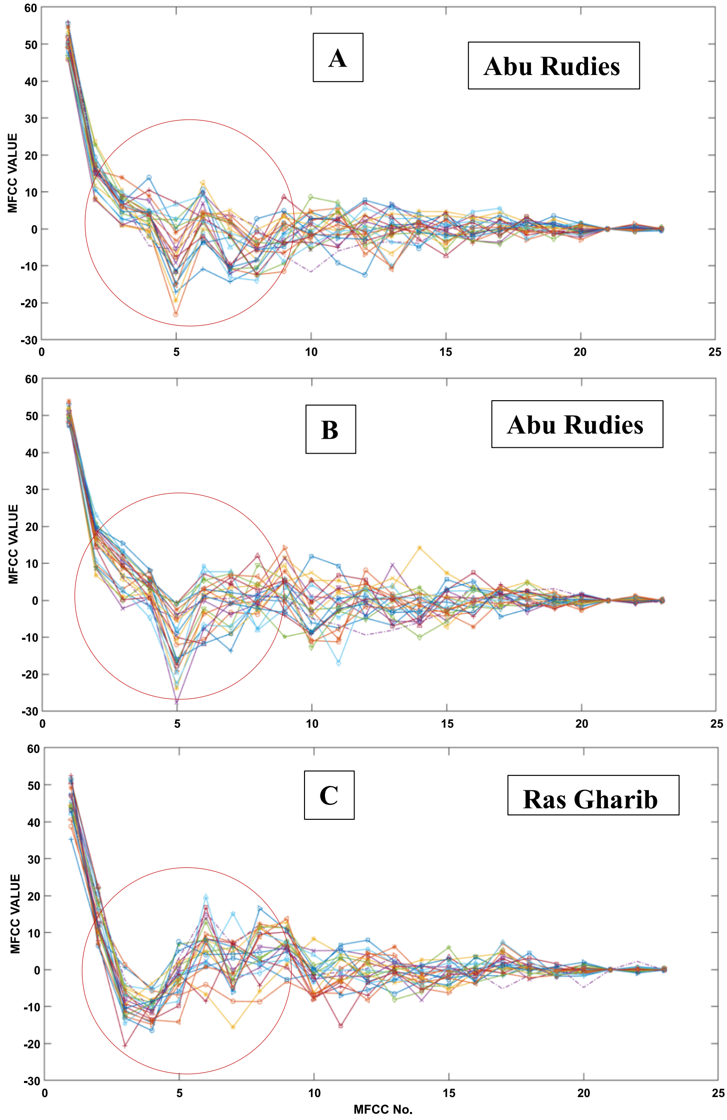

Fig. S2. Similarity in Earth HFSS voice or voice properties (MFCC curves) for two samples taken in the Abu Rudies area, separated by only 20 m [A], [B], and lack of similarity between them and a the soil sample taken in the Ras Gharib area, located 60 km from Abu Rudies. Note the better similarty in Earth HFSS voice, compared to human voices.

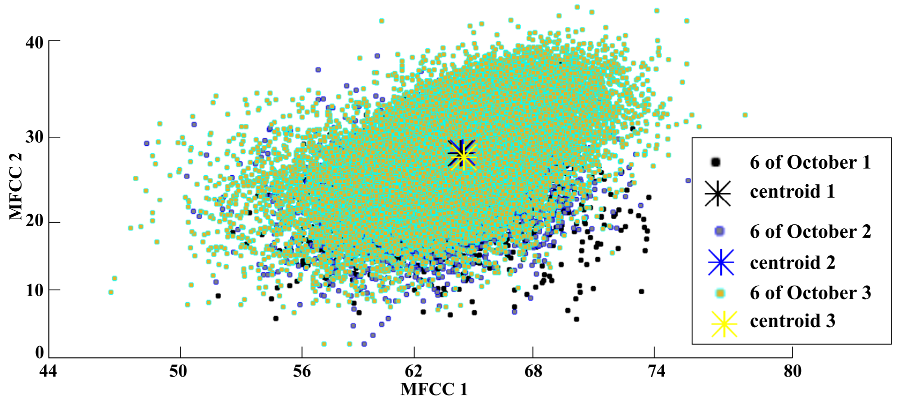

Fig. S3. Sound HFSS voice print of three soil samples taken in 6^{th} of October, separated by 5 m, using MFCC1 versus MFCC2. Note the same NE–SW trend for the three sites and the coincidence of the three centroids determined using k-means method.

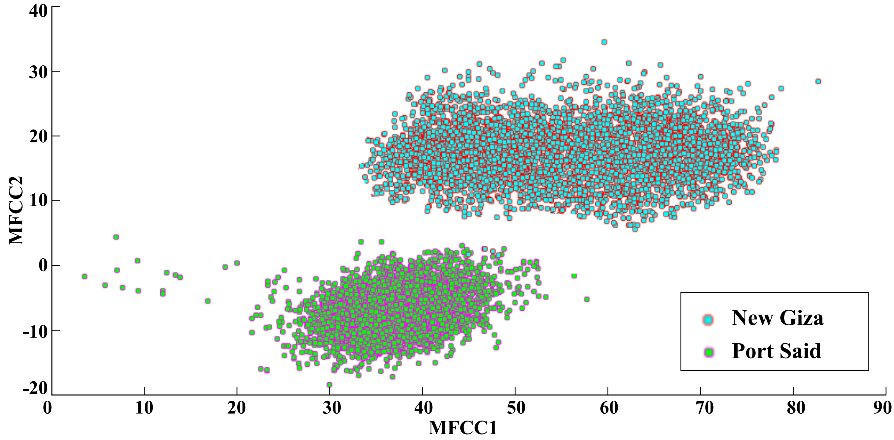

Fig. S4. A plot of two different soil HFSS voice prints showing the strength soil in New Giza separated from the weaker soil of Port Said by a distance. Note the migration of New Giza soil's HFSS voice print into the N–E direction.

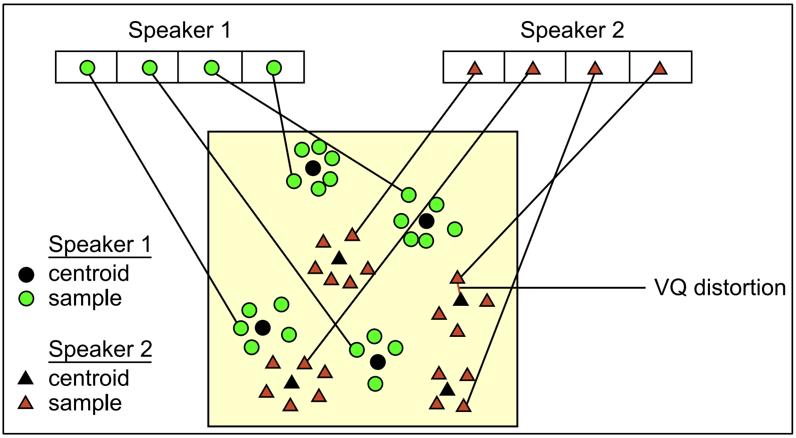

Fig. S5. Speaker recognition process using vector quantisation method and centroids of data to differentiate between speakers (*Bharti and Bansal, 2015; Kamale and Kawitkar, 2013*).

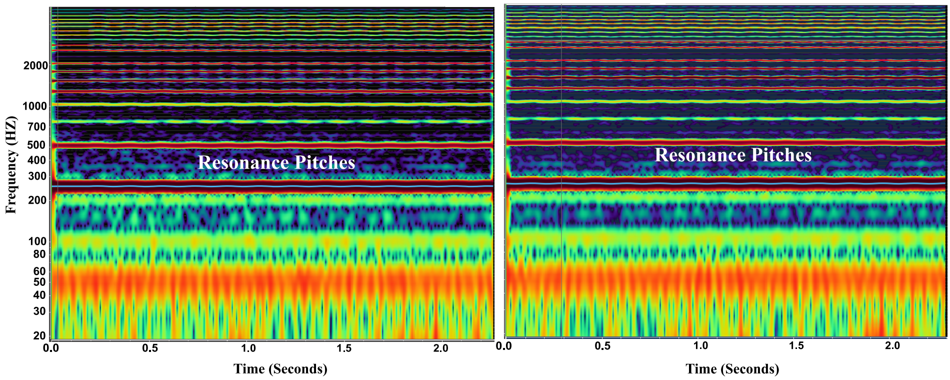

Fig. S6. Two samples of the same pure tone C4 (C4–1 and C4–2) showing identical resonance pitches occurring at 50 Hz, 100 Hz, 250 Hz, 500 Hz to 2000 Hz.

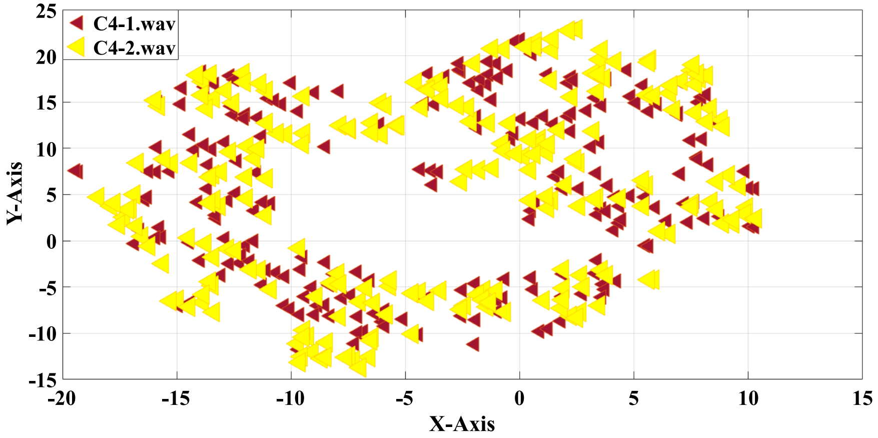

Fig. S7. Similarity between the two pure violin tones C4–1 and C4–2, as shown in Fig. S6, for two-second recorded signals using 25 MFCCs and multidimension reduction by t-SNE method (*Van der Matten and Hinton, 2008*).

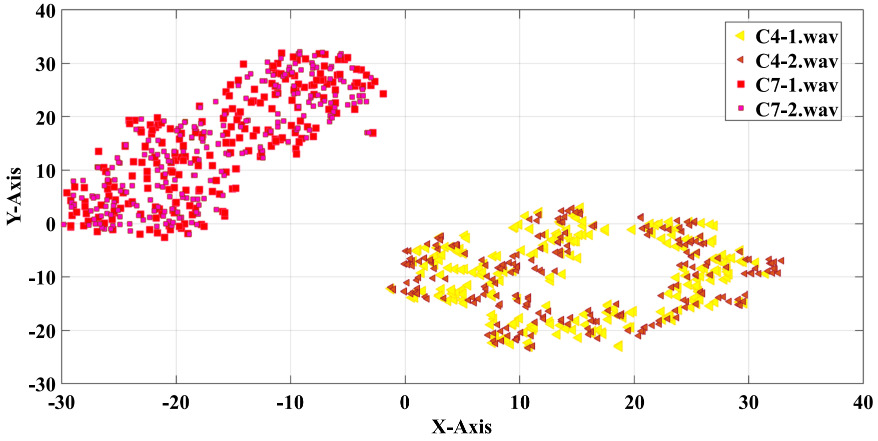

Fig. S8. Similarity between the same pure violin tones C4–2 and C4–2 and dissimilarity between them and two other pure tones of C7–1 and C7–2. Two-second recordings of the violin tones were used to exclude the 25 MFCC sound properties and the t-SNE multidimension reduction method (*Van der Matten and Hinton, 2008*).

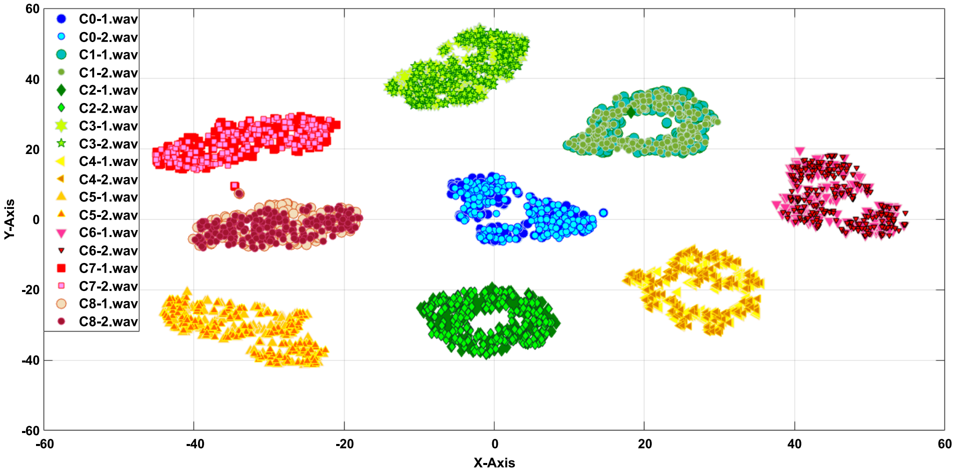

Fig. S9. Similarity between the same tones (e.g. c0–1 and c0–2, c1–1 and c1–2, etc.) and dissimilarity between other tones (e.g. C1 to C8) while using 25 MFCC sound properties and t-SNE multidimensional reduction of data method (Van der Matten and Hinton, 2008). Note the unique geometrical shape for each pure tonetakes a specific direction and can be considered as the unique voice print for this tone.

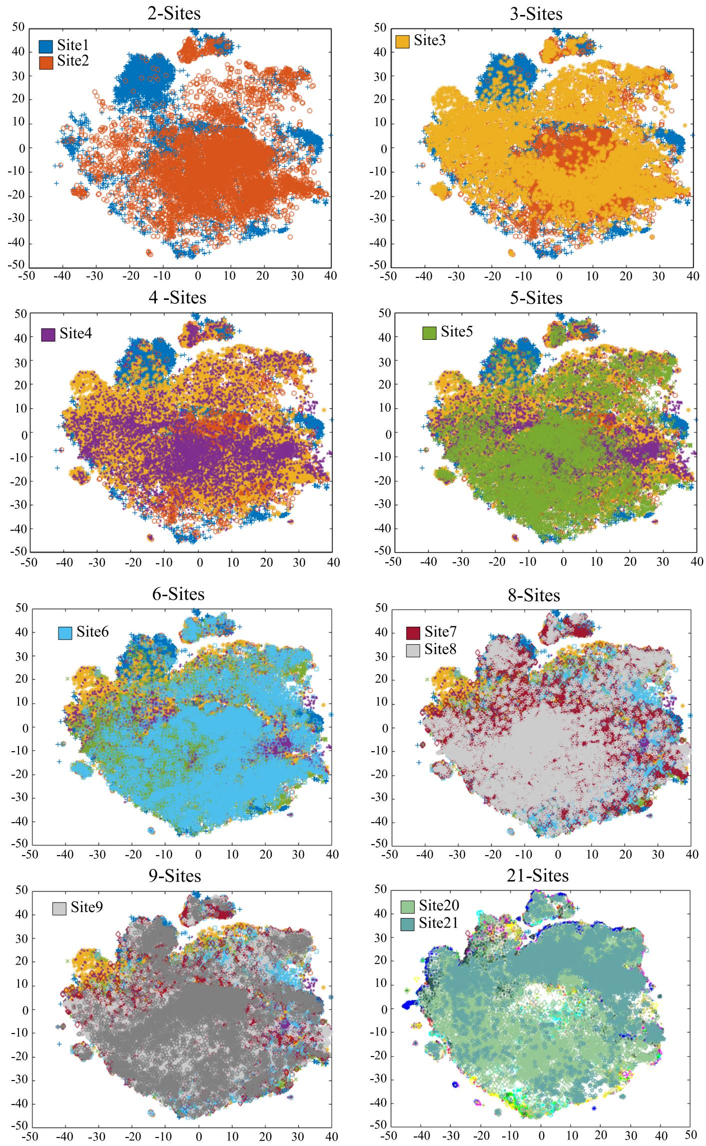

Fig. S10. Overlay of 21 HFSS using 25 MFCCs and t-SNE method (*Van der Matten and Hinton, 2008*) for Ras Gharib Site. 2 second records were collected using 21 site stations separated by v5 m in a collinear line. Note that all HFSS had nearly the same geometrical features, with few differences, most probably due to the similarity of soil composition in this distance.

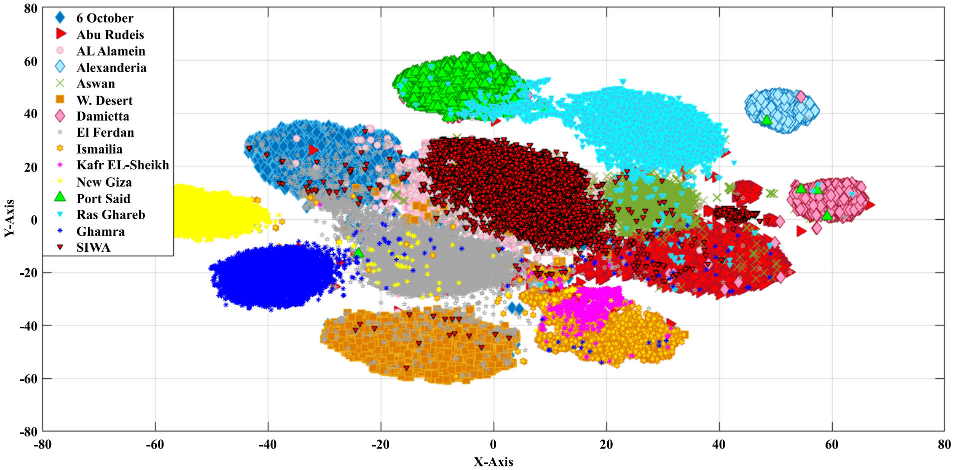

Fig. S11. "Earth HFSS Voiceprint map" produced using 15 different geological environments from all over Egypt using 25 MFCC sound properties and t-SNE method (*Van der Matten and Hinton, 2008*). Note that some geological environments share some areas most probably due to the similarity in soil composition such as Siwa and Al Alamein sites which are composed mainly of saline saturated sand and limestone rock.