String shot report for KM-8 Stimulation and Microseismic Monitoring via KM7

Revision 1 Nov 14, 2017

Summary

In order to calibrate the geophones in the KM7 well, a string shot was detonated in the KM8 well. The string shot serves two purposes

1) Determination of geophone rotational position within the wellbore
2) Calibration of the velocity model for strata located between the string shot and the geophones

The string shot was successfully detonated, and usable calibration data was obtained.

Details of the string shot

Shot in well	KM-8
Depth within well	4610 ft
Datum	RKB
KB Level	25.5ft above ground level
Time of shot (T0 from timing)	2017-11-13 15:47:07.9423
Length of det cord	15 ft
Det cord used	CRD,DET,80G,OCTOCORD,PT165,HMX,1.1D OTD - DETN,RED®,TOP
Detonator used	FIRE,ELECTRIC,1.14GR

Results

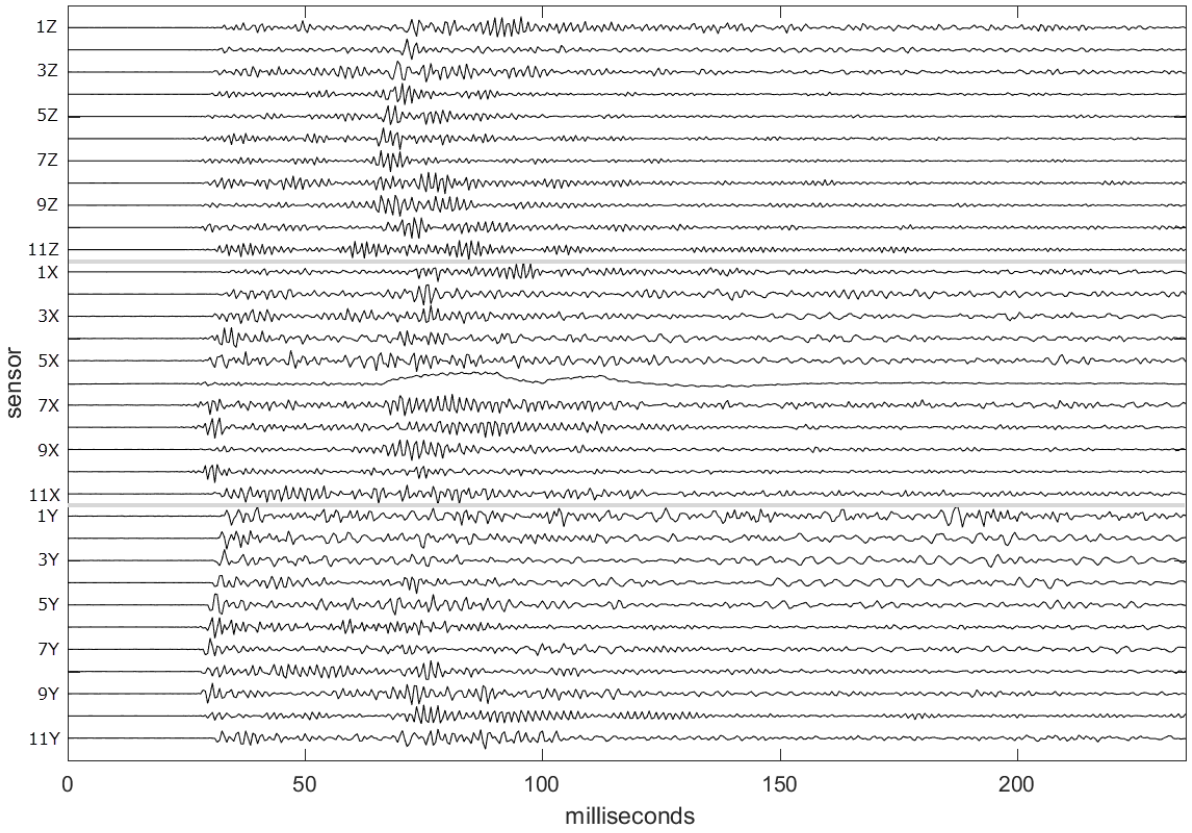

Figure 1. Seismogram showing the string shot. Like components are grouped together. Note: the origin of the time axis is not aligned with T0.

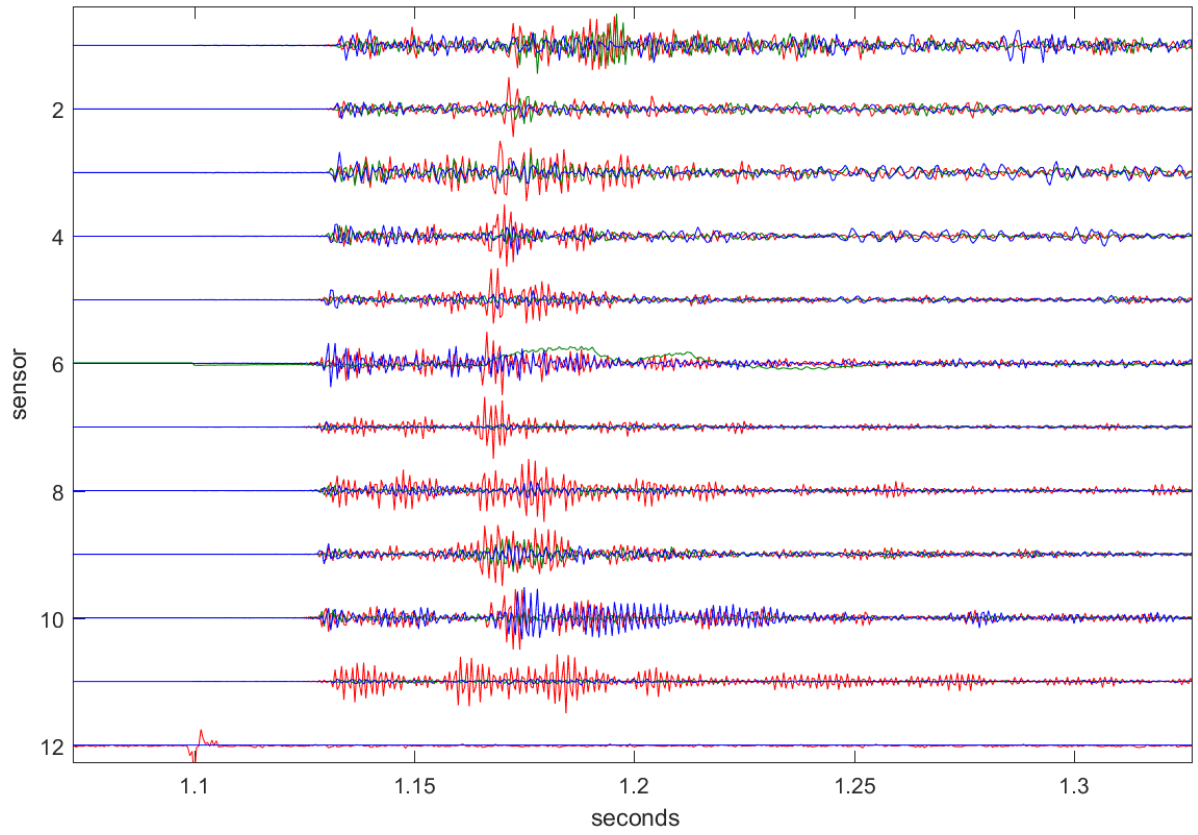

Figure 2. String shot captured on the KM7 microseismic array. Here, components from the same tool are overplotted. Sensor 12 shows the charge initiation time (T0).

Discussion

The string shot was captured with excellent signal-to-noise. This confirms

1) Geophones are operational and sensitive to nearby sources of low-magnitude.
2) Geophones have obtained an adequate clamp within the wellbore

Figure 2 shows the output from the geophones on all levels. All three components are over-plotted with Z component drawn in red, X component drawn in green, and Y component drawn in blue. The within each group of three Z,X,Y channels, the traces are normalized and plotted with the same gain. The 12th sensor is the output of the source-timing system. A pulse indicates the start of the detonation of the string shot.

The seismogram shows a clear P-wave arrival and S-wave arrival. The X component of sensor 6 shows some abnormal behavior. This was noted during in-situ tested. Due to the presence of usable signal on the other two components on level 6, the decision was made to leave the toolstring “as is” rather than risk the replacement of this one tool. The degradation to the monitoring quality will be minimal from this one erroneous channel.

Geophone angle analysis

Geophone angle calibration was performed by combining both the quarry blast data and the string shot. The quarry blast was very beneficial, as it provided a way to resolve the inherent 180 degree ambiguity observed in a downhole microseismic array when there is no dip-component to the raypath.

Perf timing summary (Well: KM-7)					String shot		Quarry Blast	
Level	Sensor Angle	Ave Az	StDev	RzHodo	Az	RzHodo	Az	RzHodo
1	-7.26	-7.26	9.9	0	-4	-1.13504	-38	-1.07884
2	-26.3	-26.3	6.42	0	-29	0.21989	-11	-0.50597
3	-172.38	-172.38	7.83	0	-171	-1.94348	138	1.6975
4	153.52	153.52	2.88	0	154	-1.46517	136	0.73484
5	175.48	175.48	2.63	0	175	-1.43004	-170	-0.13032
6	8.35	8.35	10.8	0	2	-1.64503	152	-0.88891
7	152.08	152.08	3.87	0	151	-1.65074	166	-1.0354
8	120.29	120.29	5.68	0	119	1.16908	146	-0.45307
9	176.05	176.05	5.59	0	175	0.29191	-153	-0.22093
10	90.17	90.17	16.01	0	85	-0.20248	145	2.40489
11	177.11	177.11	3.14	0	178	0.81428	166	0.84419

Figure 3. Summary geophone angle (hodogram analysis) for the two sources of calibration

The target standard deviation for multiple calibration sources is 10 degrees. In the Figure 3 we can see that level 10 had a standard deviation greater than 10. With 10 of 11 tools falling within tolerance, we're confident that the geophone angles are chosen correctly, and that the 180 degree ambiguities have been resolved.

Event location using computed angles

Without any velocity model calibration our microseismic location software positions the event at a reasonable location. Calibration will move the event closer to the actual string shot position, but it is premature to optimise the velocity model using this single calibration position. As more calibration data become available, we will optimise the velocity model to obtain a better match between calibration points and their re-located positions.

Event magnitude

The magnitude of the string shot was computed. Downhole microseismic magnitudes are not considered valid for TLS decisions and are only to be used to aid in event interpretation. The string shot was analysed and a magnitude of -3.0 was computed. This shows that the system is quite sensitive to very small microseisms as they approach the toolstring. This should provide a level of assurance that very low-magnitude microseismic events, at depths around 4600ft, should be readily detectable by the downhole microseismic array.

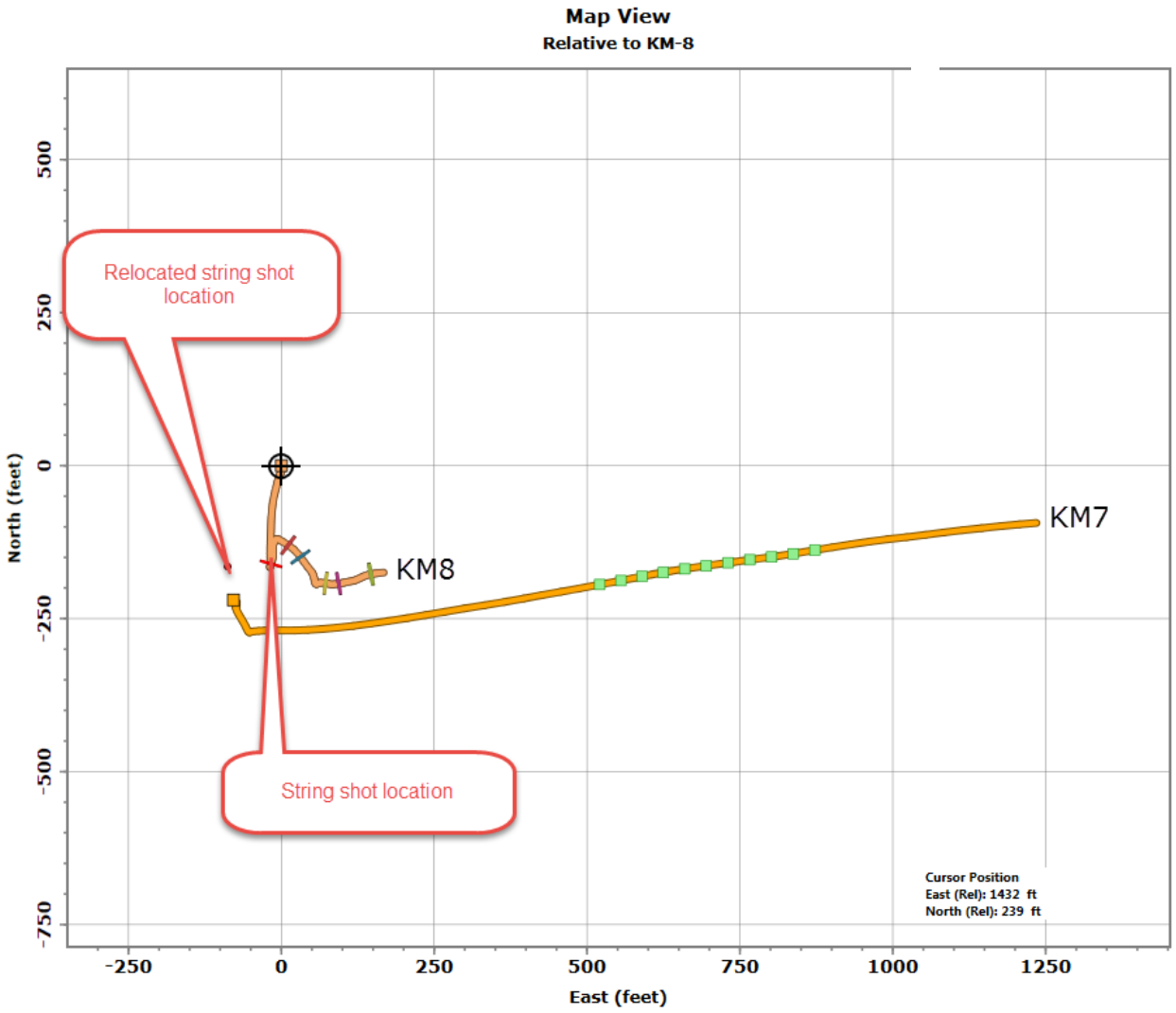

Figure 4. Top view of the KM7 and KM8 wells showing the string shot location and the preliminary relocated string shot location. Lateral units are in feet.

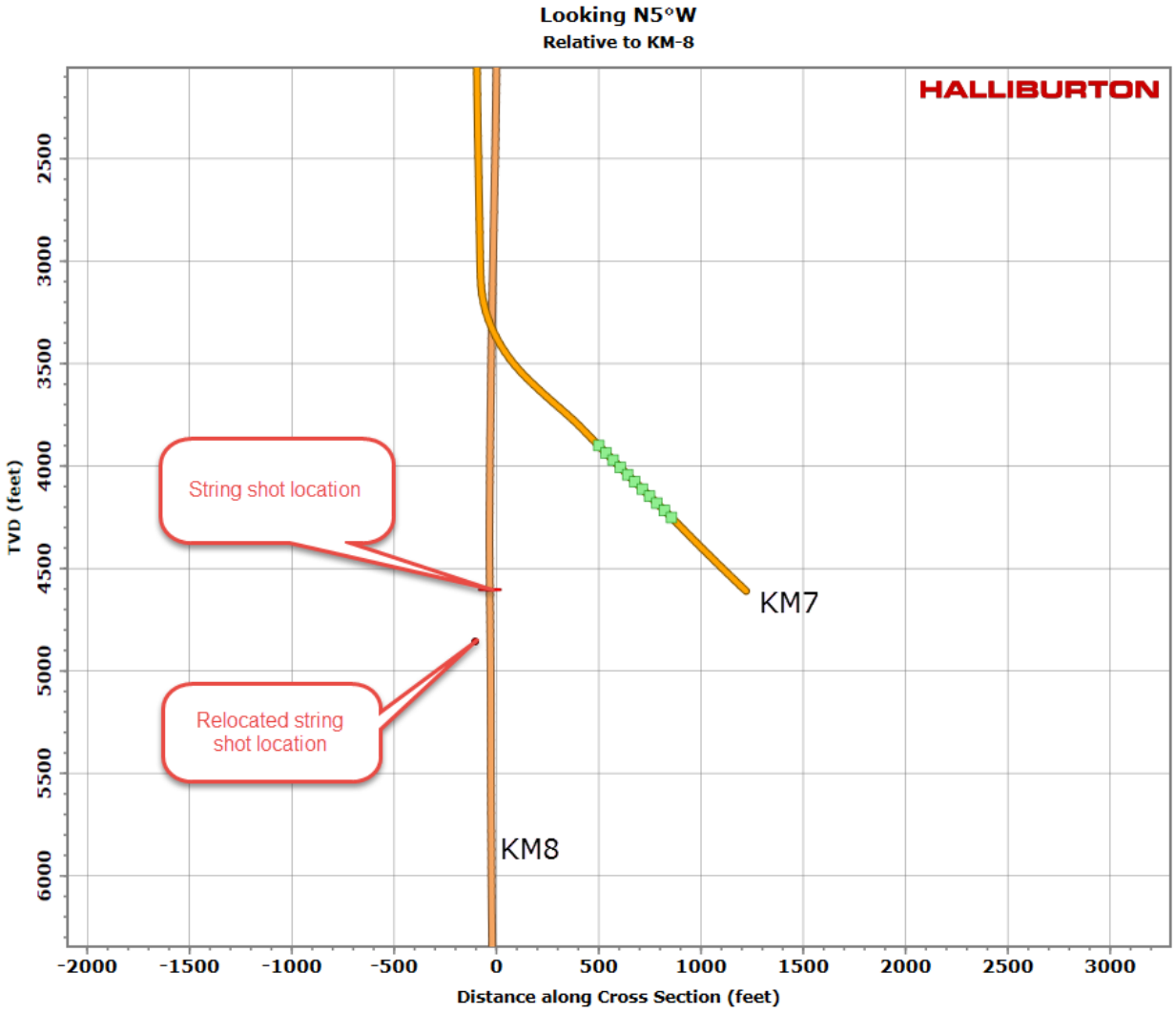

Figure 5. Map view of the KM8 and KM7 wells showing the string shot location and the preliminary relocated string shot location. Lateral and depth units are in feet.

TLS System

A thorough review of the TLS data turned-up no sign of the string shot on the TLS array. The string shot is well beneath the detection-threshold of the TLS array, so it is not surprising that no event was detected. At the time of the string shot, all 12 TLS stations were fully operable.

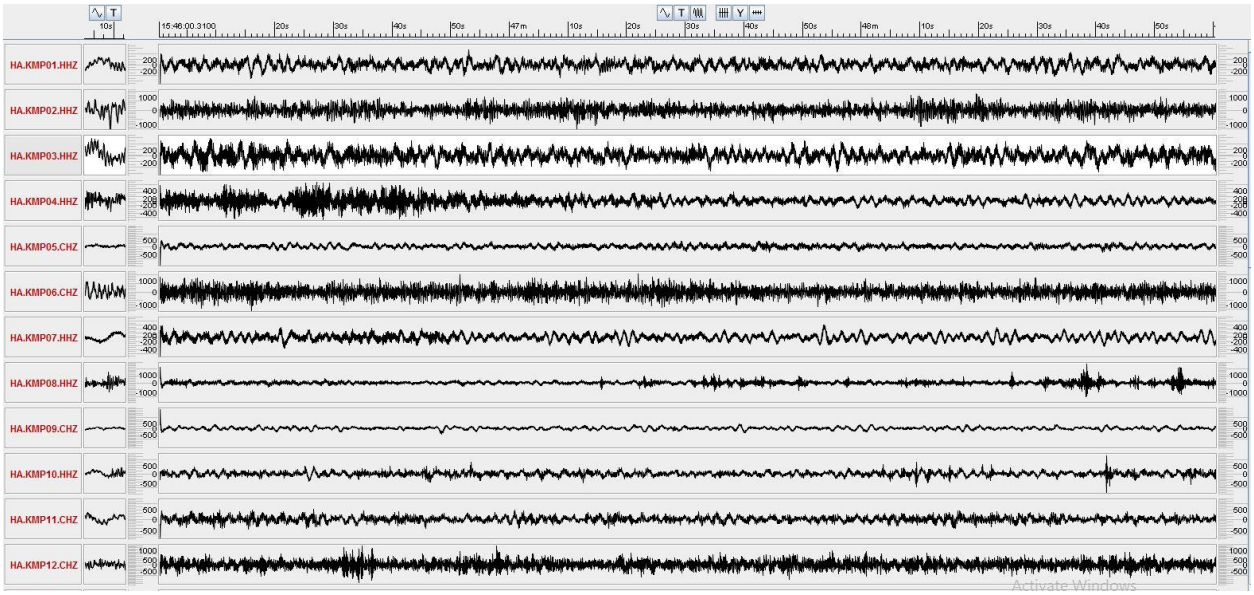

Figure 6. TLS system response during the string shot.

Conclusion

The string shot was executed and recorded successfully. The geophone orientations were determined by combining the string shot data and the quarry blast data. Application of the geophone orientation angles to the observed data place the string shot at a reasonable location. Once additional calibration shots are acquired the velocity model will be optimized further to allow for more precise location of downhole microseismic events. The event magnitude was estimated at -3.0, giving an assurance that the downhole microseismic system is adequately sensitive to shallow events. Finally, the TLS system did not detect the string shot, but this is to be expected due to its very small magnitude.

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