Dynamic Triggering of Microseismicity in a Mine Setting

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Summary

Seismicity is correlated in space and time with mining activities. We initially expected blasting operations to trigger events. However, no seismicity is detected during the two to three hours after each blast. One possibility is that seismicity is triggered due to subsidence, assuming a compacting earth. Surprisingly, the seismicity occurs during certain times during the day. Therefore, it is likely that the seismic activity has been triggered by the transportation of the debris along the shaft and main tunnels. This analysis can enhance our understanding of activation processes and factors that can severely impact the safety and productivity of the mine.

Introduction

Over the last several years, microseismic monitoring has been used extensively for monitoring mine infrastructure and ground control (Pandey et al., 1995; Richardson and Jordan, 2002). The most common cause of seismicity in a mine is blasting operations (Adushkin, 2013). Other studies associate seismicity to hydrocarbon field deformation, mainly above and below compacting reservoirs (Grasso and Wittlinger, 1989). Therefore, a similar process could occur in mines when tunnels are excavated if we assume a compacting earth.

In this work we describe spatial and temporal variations of detected seismicity in an underground mine. A multiplet analysis is performed. Also, we analyze possible correlations in time of the seismicity with blasting operations, schedule of debris transportation and among multiplets to better understand their possible causes.

Background Data

A microseismic system was installed to monitor zones of potential instabilities and possible water inflows. Seven boreholes containing four three-component geophones each which surround the mine workings are deployed (Figure 1).

Located seismicity

Multiplet groups 1, 3 and 4 comprise most doublets in the dataset and are shown in Figure 1. The located seismicity likely relates to activities carried out in the main levels. Unfortunately, field reports do not provide information on where miners crew were working.

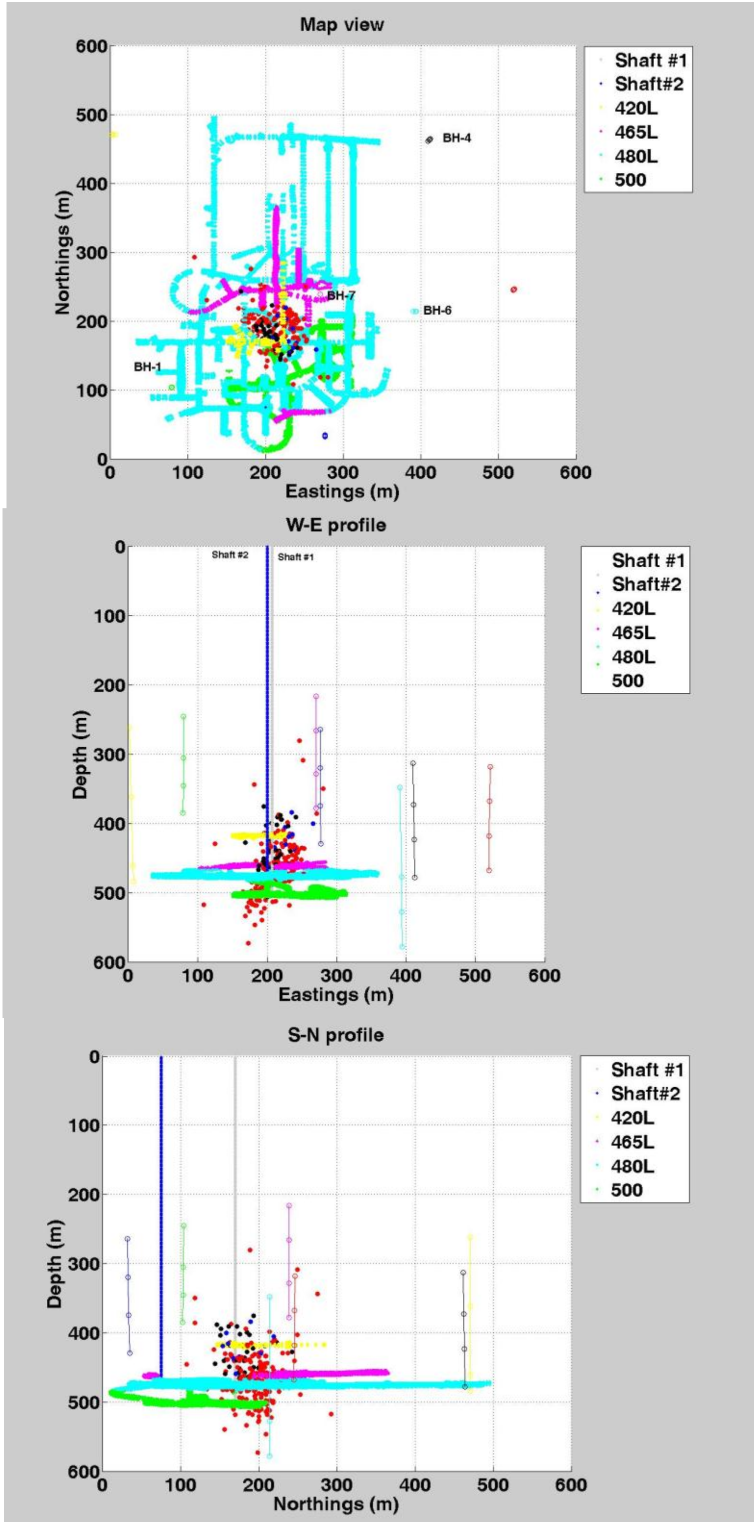

Figure 1 3-D view of multiplet groups #1 (179 events in red), #3 (38 events in black) and #4 (10 events in blue) in red, black and blue dots, respectively. Top: Map view. Middle: West-East cross-section. Bottom: South-North cross-section. The seismicity is clustered 20 m North to the shaft 1. Open colored circles: Receiver stations. Colors of tunnels: 420 m (yellow), 465 m (pink), 480 m (blue) and 500 m (red).

Pattern of multiplet occurrence over time

Figure 2 is a Gantt chart showing the occurrence of the 21 multiplet groups found during January 2011. In general, multiplet groups 1, 3 and 4 largely dominate the seismicity, especially during the first and third week, while during the second week the seismicity is quieter. It is suggested to evaluate if causal links exist between detected seismicity and anthropogenic activities, such as blasting or other scheduled mining operations.

Blasting activities

What triggers the seismicity within the mine? The first thought is the possibility that blasts induce seismicity, which represents a major concern during mining operations (Young et al., 1992). Figure 3 shows that after the blasting activities occur there are no immediate triggered files.

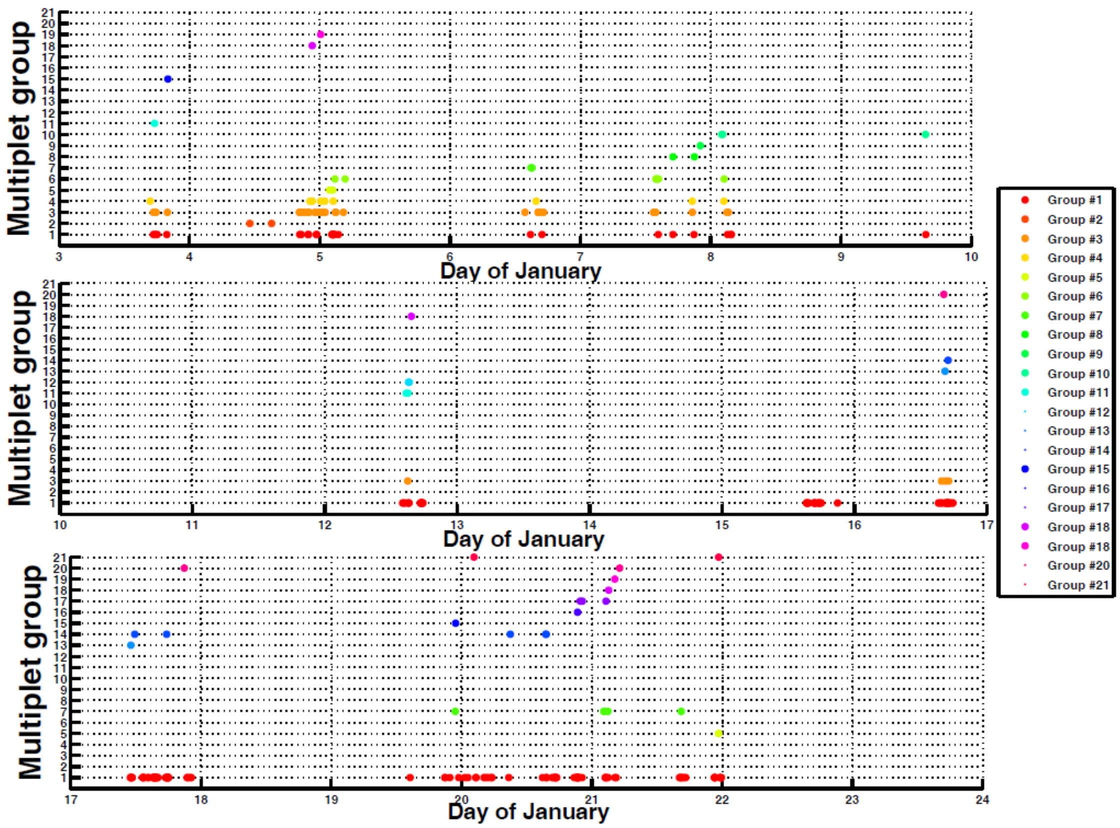

Figure 2 Gantt chart showing multiplets occurrence during January 2011. Each multiplet group (21 in total) is shown with a different color. Most events from the largest multiplet group (red) occur during the third week of January.

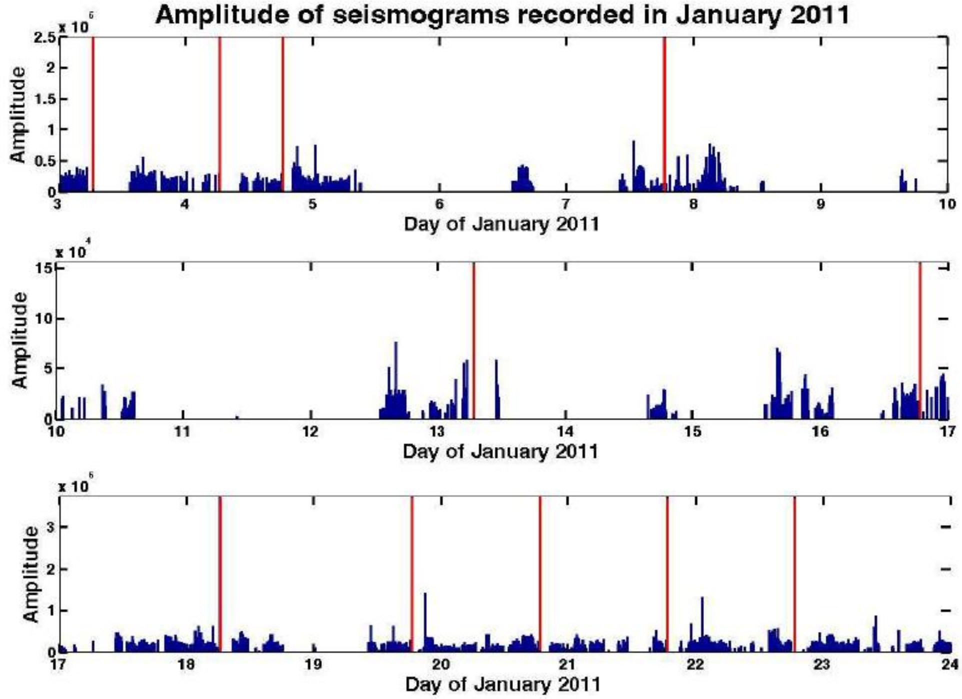

Figure 3. Triggered files during January 2011. Top: January 3rd to 9th. Middle: January 10th to the 16th. Bottom: January 17th to 23rd. The vertical red lines represent the times of the blasting activities.

Removed rock volume vs seismicity

When comparing Table 1 with Figures 2 and 3, there seems to be a correlation between removed rock mass and triggering events and multiplet activity, especially in the first and third week of January, thus, it is likely that transportation of the excavated rock mass via the main tunnel, instead of the actual blasts, is triggering the recorded seismicity.

Day	Depth(m)	Time	Rock volume(m3)
1	480-a	7:00	112
2	500-a	19:00	77
3	480-b	7:00	95
4	500-a	7:00	77
4	480-d	19:00	70
7	480-a	19:00	30
13	480-a	7:00	174
16	480-b	7:00	86
18	480-c	7:00	114
19	500-b	19:00	36
20	480-d	19:00	74
21	480-b	19:00	102
22	480-a	19:00	174
24	500-c	7:00	111
25	480-c	7:00	99
26	480-d	7:00	112

Table 1 Master advance of blasting activities.

Conclusions

In this work, a set of microseismic events in an underground mine is investigated. We have learned that microseismic events are likely to have occurred as a result of routine mining activities, evidenced by observed temporal/spatial patterns. The improved locations of the main clusters are associated to mining activities, especially along the main levels. Unexpectedly, the blasting activities do not induce seismic activity. Given the microseismic locations and temporal pattern, it is likely that these have been triggered by the transportation of the debris.

Acknowledgements

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References

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