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Evolution of microseismic activity prior to a salt cavern collapse

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Between 2004 and 2009, the evolution of a salt cavern in operation, located in north-eastern France, was followed until its collapse with a multi-parameter high resolution monitoring system. The latter, designed to characterize the precursor signs of collapse and the collapse itself, included a permanent microseismic monitoring network consisting of nine probes equipped with 40 Hz geophones (five 1D probes and four 3D probes), installed at various depths around and above the cavern.

The monitoring period was marked by two major microseismic episodes:
- in the beginning of spring 2008, the resumption of the dissolution in the cavern resulted in the appearance of repeated surges with several thousand events in a few days;
- in February 2009, the collapse caused by intensive brine pumping in the cavern led to record more than 30,000 events in three days (cons 60,000 over the entire period).

The signature of the events in terms of amplitude and energy provides essential information for operational monitoring and discrimination of these two periods, even though we observe that their variations in average are not significant. Indeed, the evolution of their maxima is much more pronounced: while the latter are quite stable during the 2008 episodes, they significantly increase during the final period indicating the imminence of collapse. A similar trend is obtained while considering the apparent fundamental frequency of the seismograms recorded by the nearest sensors; the farthest did not detect any increase in frequency due to wave attenuation in the medium.
Besides, the spatiotemporal distribution of foci in the overburden highlights the role of a stiff bench, above the cavern, at 120 m depth. Thus, before pumping operations, the microseismicity was concentrated mainly under this stiff bench; ruptures and rockfalls had almost no significant impact on the surface (subsidence <1cm). Then, during pumping operations, the abrupt failure of this bench led to a sharp acceleration in the subsidence and the widespread collapse less than 24 hours later of the layers above it, leaving a crater with very abrupt edges of approximately 150 m diameter.