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Induced and triggered seismicity from Nov 2019 to Dec 2020 below the city of Strasbourg, France

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Since Nov 2019, a series of seismic events were felt by the population of the city of Strasbourg, France. The first main event (M13.0) on Nov 12, 2019 was part of a seismic swarm that has been initiated a few days before, lasted four months and was located by the BCSF-RéNaSS (EOST) in the northwestern part of the town (Robertsau area) at a depth of 5 km. Its location in the vicinity of the deep geothermal wells (GEOVEN), the temporal correlation with the injection activity on site, the similarity of the depth between the bottom of the wells and the hypocenter of the event, the lack of local seismicity before the event occurrence, the known geological structures including crustal faults in the area, all strongly support the possible triggering of the events by the deep geothermal activities despite the relatively large distance (4-5km). Template matching has been applied and allowed for a significant improvement of the detections. Double-difference relocations evidenced a complex fault zone in the swarm area that extends over 800m. Focal mechanisms of the two main events are consistent with the known orientation of the fault zone. The regional stress field in combination with the fault orientation and a Coulomb failure criterion, shows that the swarm location is in an unstable domain if the cohesion of the fault is weak, particularly sensitive to stress perturbations. Since Oct 2020, hydraulic tests were initiated and a second cluster of seismic events with more felt earthquakes developed closer to the geothermal wells. It includes the largest event (M13.6) that was induced on Dec 4, 2020 and caused the definitive arrest of the project. A preliminary analysis shows that most of the largest events happened along the same fault zone as in Nov 2019 but very close to the injection well, where a significant over-pressure has been maintained over time.

This presentation is dedicated to the memory of Prof. François Cornet.