

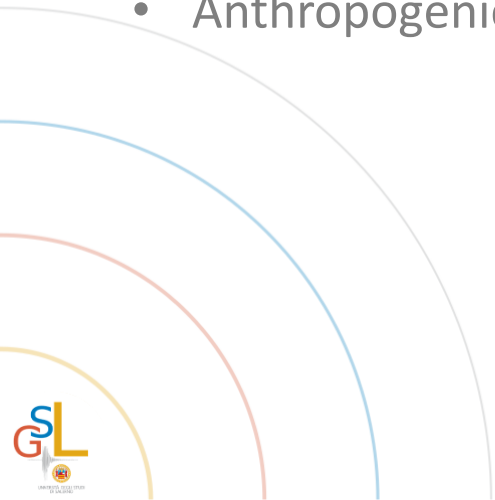
Joint EPS-SIF International School on Energy 2021
*Course 6 – Energy Innovation and Integration for
a Clean Environment*

Exploitation of energy geo-resources
and their impacts on the environment

Elvira Battimelli

Outline

- Risks and geo-resources exploitation
- Multi-hazard/risk assessment
- Anthropogenic seismicity



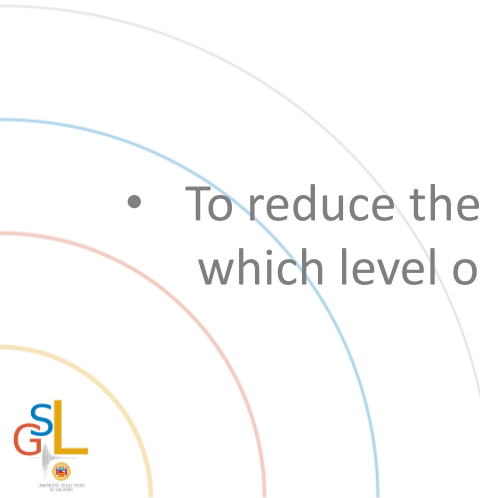
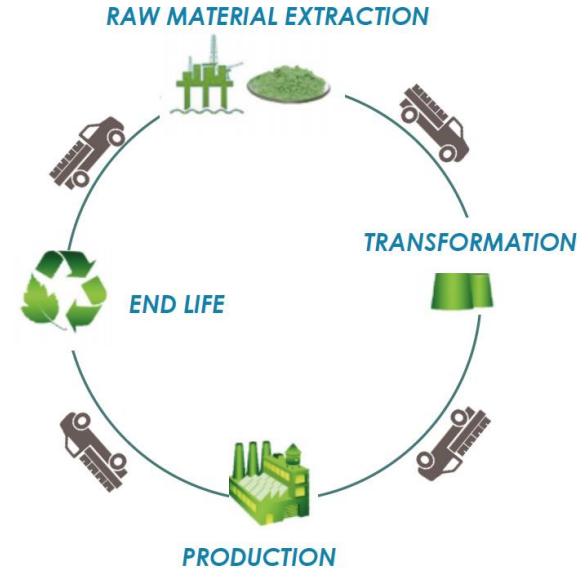
Risks and geo-resources exploitation

- The growth of the world population has led to an increase in energy demand and therefore to a greater exploitation of energy geo-resources;
- The energy sources have positive and negative aspects;



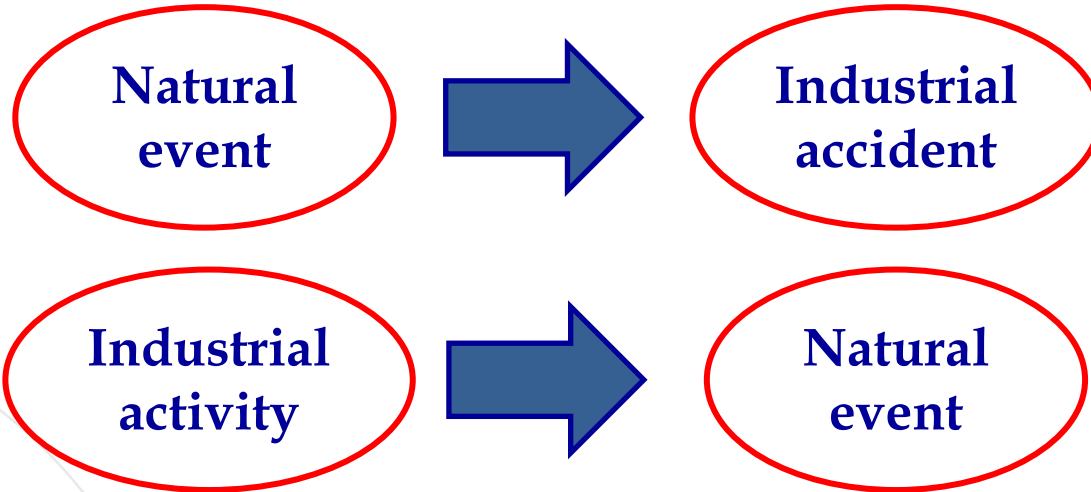
No risk no energy

- To reduce the impacts, it is important to understand which level of risk is considered acceptable.



NaTech and TechNa events

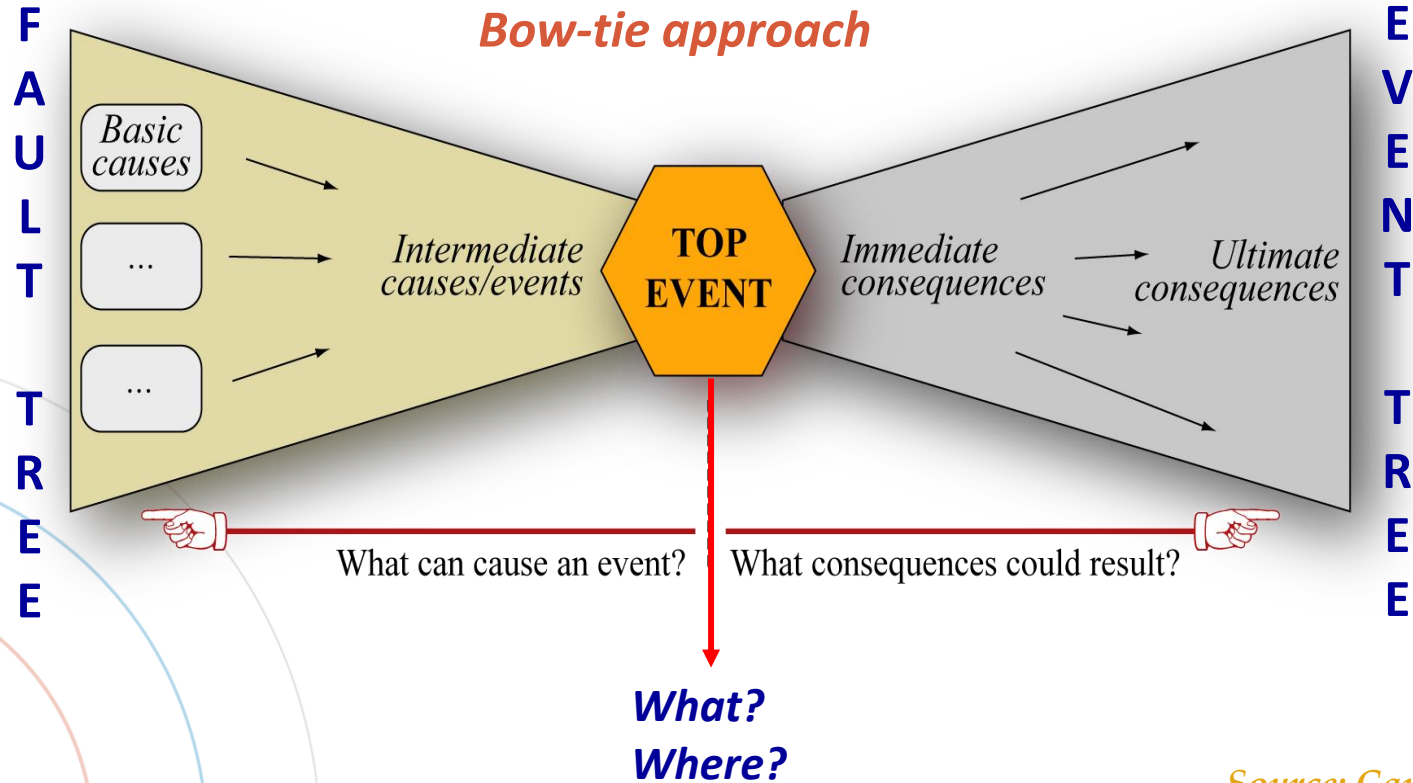
Natural Hazard Triggering Technological Disasters (NaTech event)



Technological Hazard Triggering Natural Disasters (TechNa event)

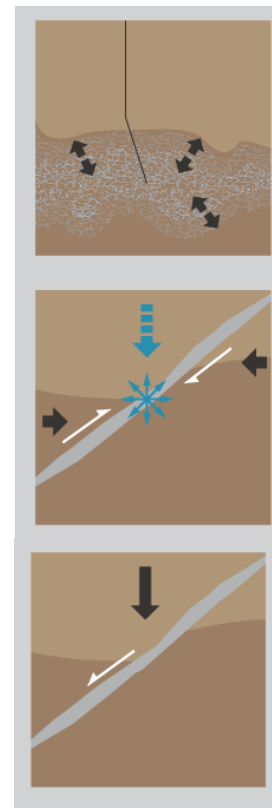
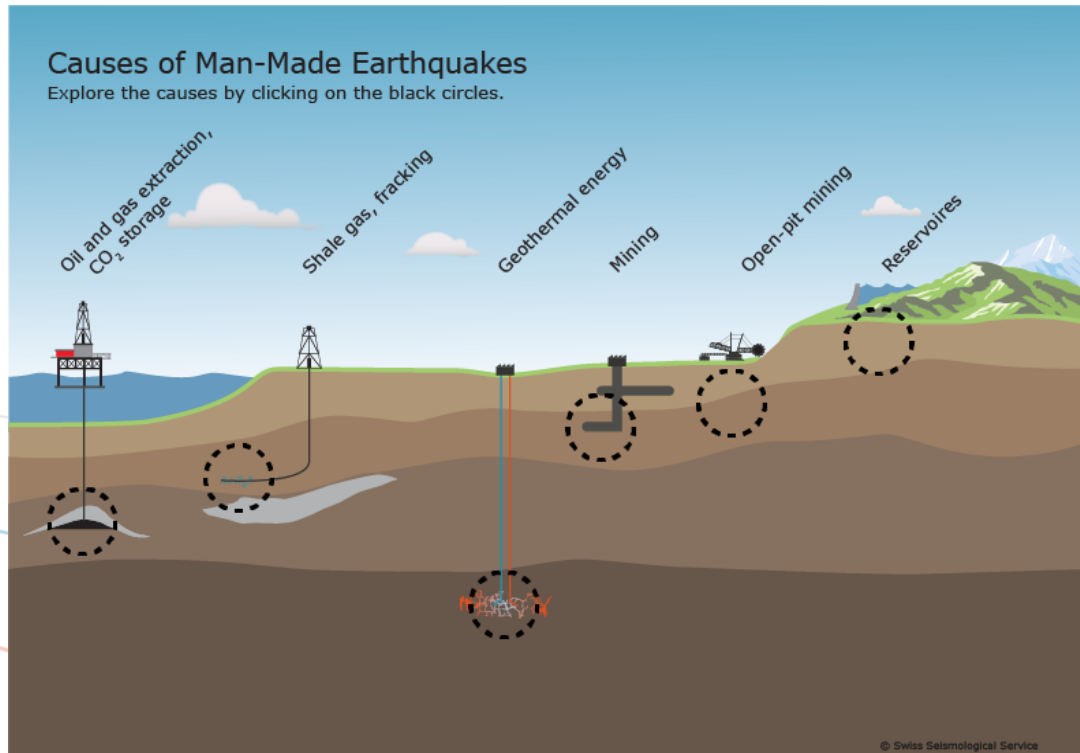
Risk assessment is important to develop new strategies to prevent and mitigate accidents.

Multi hazard-risk assessment



Source: Capuano et al., 2017

TechNa event: Anthropogenic seismicity



Volume changes

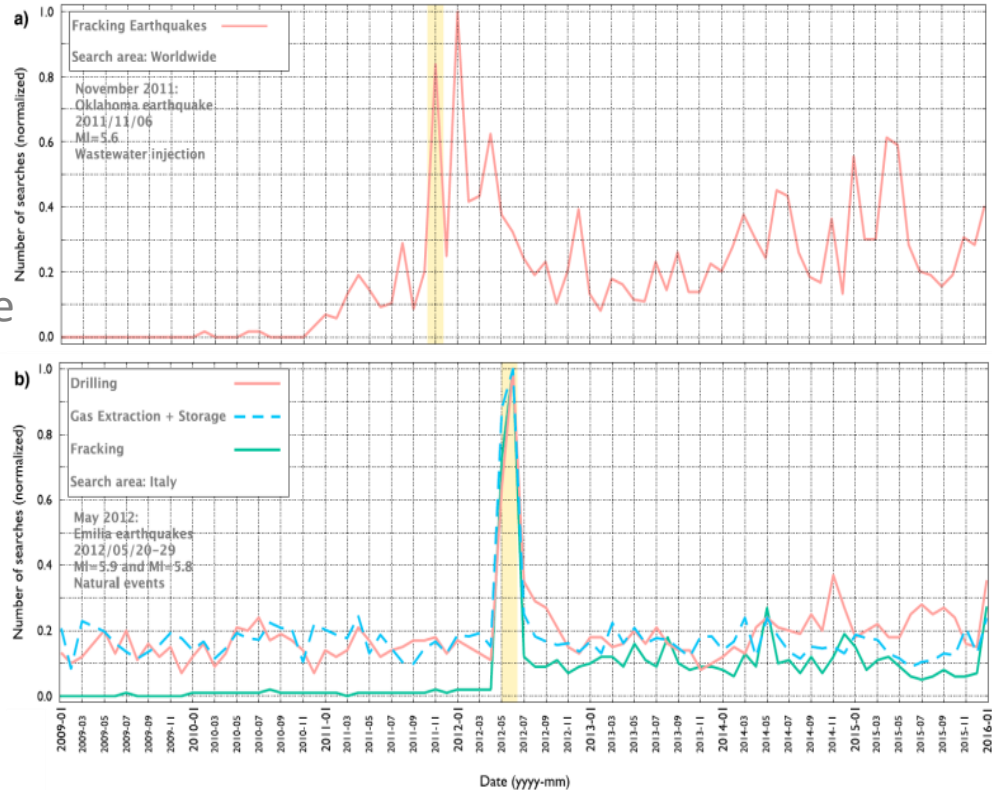
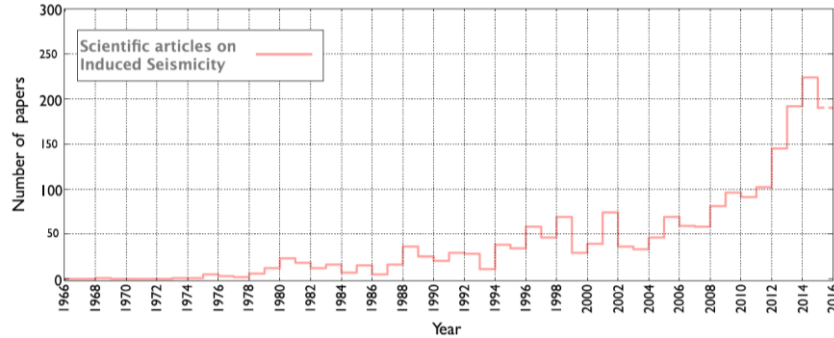
Increase in pore pressure

Load changes

Source: Swiss Seismological Service (SED) ETH Zurich
(<http://www.seismo.ethz.ch>)

Interest on induced seismicity

- First case of induced seismicity in the early decades of the 1900s;
- The interest in this topic has grown in recent years in the scientific community, politics and society due to the damage that these events can generate

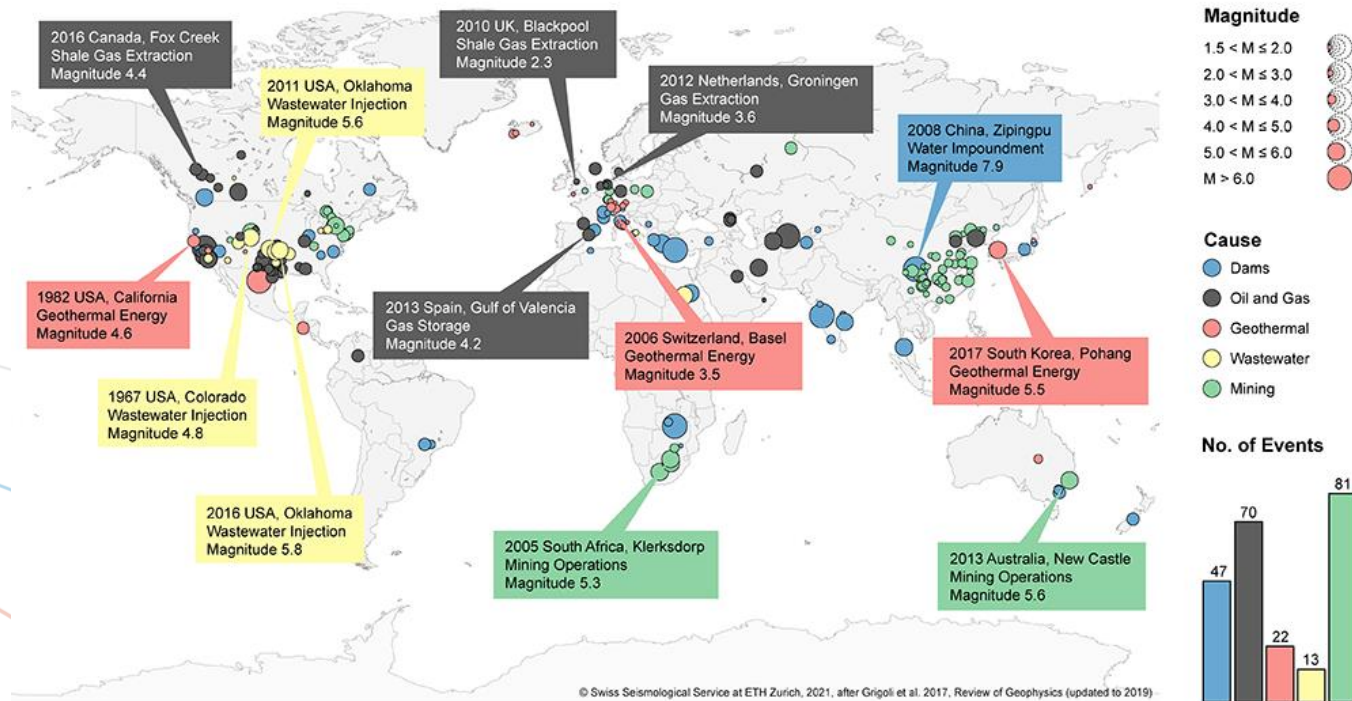


Source: Grigoli et al., 2017

Cases of induced seismicity in the world

Induced Earthquakes around the World

Published data from 1930 to 2019

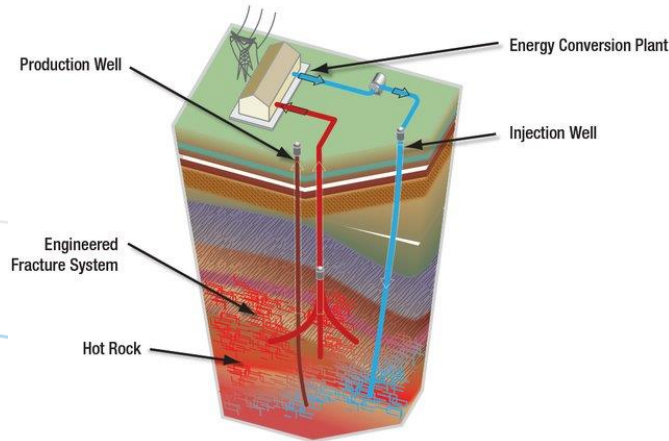


Source: Swiss Seismological Service (SED) ETH Zurich
(<http://www.seismo.ethz.ch>)

Examples of induced seismicity

Enhanced Geothermal Systems (EGS)

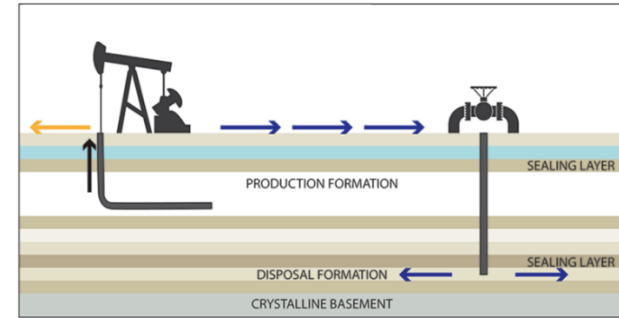
- Basel (Switzerland, M_L 3.4 in 2006)
- Cooper Basin (Australia, M_w 3.1, 2012)



Source: Thiel, 2017

Wastewater re-injection

- Colorado (M 5.3 in 2011)
- Oklahoma (M 5.6 in 2011)



Source: Rubisten & Mahani, 2015

Oil and gas extraction

- Gazli (Uzbekistan, M 7 in 1976 and 1984)
- Groningen (Netherlands, M_L 3.6, 2012)

Study of induced seismicity

- The study of induced seismicity requires not only seismological but also industrial data (e.g., volume and pressure of oil and gas extracted, volume and pressure of water injected).
- Industrial data are often inaccessible to researchers because they are only available for energy companies.
- It is important to overcome this barrier by cooperation between scientists and energy companies.



Conclusions

- There is no risk no energy, so it is important to keep in mind this aspect in any phase of an industrial project;
- The study of environmental risks associated with the exploitation of energy geo-resources requires multidisciplinary knowledge;
- It is important to conduct these studies to develop strategies to mitigate and prevent economic, social and environmental impacts;



Thank you for the attention

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