IBE&W

When the Ground Stirs

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Extraction of natural resources such as shale gas can disrupt the internal structure of rock, leading to the release of vast amounts of energy in the form of earthquakes. Is the risk of such human-induced quakes high in Poland? Scientists from the PAS Institute of Geophysics are trying to find the answer.

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Anthropogenic seismic activity is the dynamic response of rockmass to human interference in their structure, which disrupts their natural stress field. This leads to a violent release of elastic energy accumulated in rock – the rock cracks, or rock masses shift along an existing fissure. This causes energy to radiate out in the form of seismic waves; the whole process is what we call an earthquake.

When the earth shakes

Apart from tectonic activity, the main causes of earthquakes are underground and opencast excavation of natural resources, the weight of water and water-level changes in artificial reservoirs, traditional and unconventional methods of extracting oil and natural gas, exploitation of geothermal resources and underground detonations of nuclear bombs. Such earthquakes vary in intensity: some are not felt, while others are extremely dynamic and pose a major threat to many people's lives. The original scale measuring earthquake magnitudes, the Richter scale, was introduced in 1935 by Charles F. Richter and Beno Gutenberg. The name persists even though the current version, describing the relationship between the magnitude of ground vibrations with the average amount of slip and the size of the area that slipped, was introduced by Thomas C. Hanks and Hiroo Kanamori in the 1970s. The scale is logarithmic, which means that a magnitude 7 earthquake is ten times more powerful than one of magnitude 6. Events of magnitude 7 and above are very powerful and they can have consequences comparable to those caused by tectonic earthquakes.

The most powerful scientifically-confirmed event caused by industrial activity (conventional extraction of natural gas) was a magnitude 7.3 earthquake which happened in 1976 in the Gazli region in present-day Uzbekistan. Six people were killed and ten thousand were left homeless. In 1967, a 6.5 magnitude earthquake near the artificial Koyna reservoir in India killed 180 people and injured 1500, and 80% of buildings in the nearest town were destroyed. Some scientists claim that the filling of the Zipingpu reservoir in China contributed to the catastrophic 7.9 magnitude quake in 2008, which killed almost 70,000 people. The most powerful earthquake ever registered had the magnitude of 9.5, making it over a hundred times more powerful than the Gazli quake. Fortunately the majority of seismic events caused by human activity aren't as powerful.

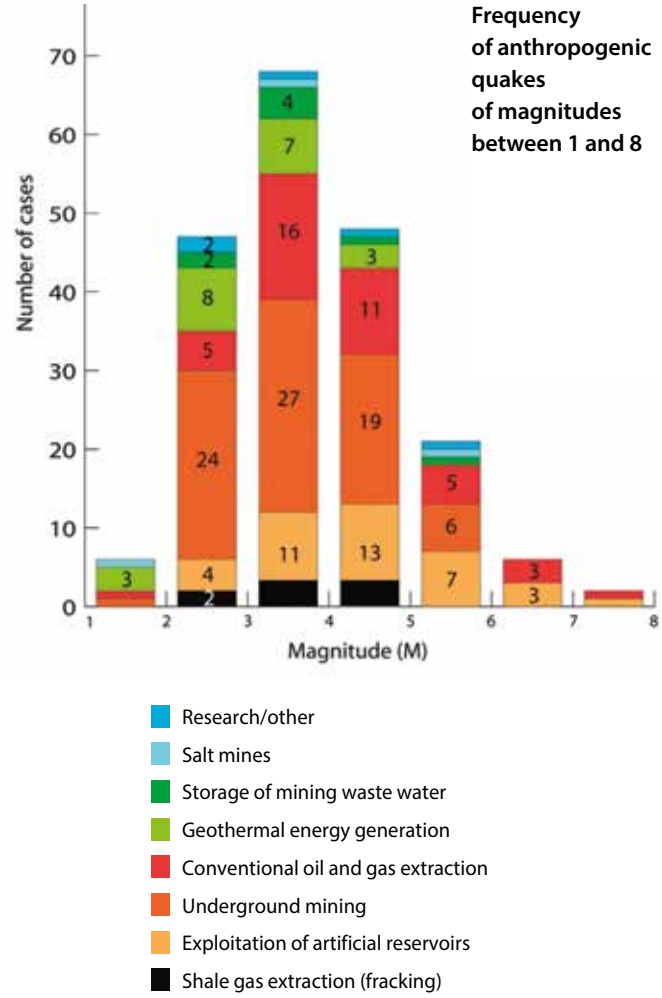
Neither natural nor anthropogenic earthquakes of high magnitudes occur in Poland. According to historical reports, over the course of the last thousand years there have been around 100 natural earthquakes powerful enough to be perceived by people. Nowadays, several quakes are electronically detected every month in the Upper Silesian Coal Basin and the Legnice-Głogów Copper Basin, all directly linked to mining. Seismic events are also detected every few years near the opencast lignite mine in Bełchatów.

Quakes in Upper Silesia rarely reach dangerous magnitudes, that is those exceeding 4.0. The highest numbers of such incidents occurred during the 1980s, with the most recent registered in April 2015 (data from the National Mining Institute, www.grss.gig.eu). In the Upper Silesian Coal Basin, around 20 events exceed magnitude 3.0 every year of the total of around registered 1000 in the country. The events registered in the Legnica-Głogów Copper Basin are generally more powerful; the most powerful, of magnitude 4.5, occurred in 1977 in the Lubin mine. Three events of a similar magnitude have been noted until 2015, with the most recent in March 2013 (data from the PAS Institute of Geophysics). A few hundred seismic events are registered every year in the Legnica-Głogów Copper Basin in the Lubin, Polkowice-Sieroszo and Rudna mines. In the Bełchatów lignite mine, earthquakes are rare but they are relatively powerful, with

Photo:
Debate continues on whether the exploitation of the Zipingpu reservoir in China contributed to the catastrophic 7.9 magnitude quake in 2008, which killed 70,000 people

Polish scientists on the EPOS project

Polish scientists have many years of experience in research into anthropogenic seismic activities, leading to the formation of a working group as part of the European Plate Observing System. Solutions created during the preparatory phase, held between 2010 and 2014, will be implemented by 2019. The PAS Institute of Geophysics currently leads the working group which aims to integrate data and data processing methods for research into anthropogenic hazards. In 2015, the PAS Institute of Geophysics and the Cyfronet IT Centre at the AGH University of Science and Technology, the National Mining Institute and the coal company Kompania Węglowa prepared a prototype network as a free platform https://tcs.ah-epos.eu/ (IS-EPOS project financed by the Innovative Economy Operational Programme 2013–2015). The platform presents six seismic, geological and production datasets from anthropogenic seismicity. They are complete sets of geophysical, geodesic and technical data correlated by time and space, describing seismic events caused by specific technologies used to exploit natural resources at given locations. The information originates from Poland, Germany and Vietnam and covers underground mining, exploitation of artificial reservoirs and geothermal energy generation. In the future, the platform aims to include at least twenty episodes of all types of anthropogenic seismic events.



Frequency of anthropogenic quakes of magnitudes between 1 and 8

five exceeding magnitude 4.0. The most recent M4 event was registered in November 2014 (data from the European-Mediterranean Seismological Centre, www.emsc-csem.org and the PAS Institute of Geophysics).

Dynamic shale

Unconventional extraction methods of oil or gas, in particular shale gas extraction by hydraulic fracturing (known as "fracking"), have been subject to extensive investigation in recent years due to their potential risks. The technology involves high-pressure injection of water containing sand and chemicals into shale; this fractures the rock, releasing the trapped gas. The fractures are known as microseismic events, imperceptible to people. They can be detected with specialist equipment, although the extraction areas do often experience more powerful seismic events. These latter are driven by two factors: the regions are home to geologically-active faults, and excavation causes major change of stress field in the rockmass. Several such events have been registered so far. The most powerful, recorded in Canada in 2015, had a magnitude of 4.6, with weaker events noted in the US (2.8) and the UK (2.3). Quakes with magnitudes up to 5.3 and increased seismic activity have also been noted in the US not due to fracking but from injecting high volumes of water left over after gas and oil extraction into cavities designed to store such waste. The cavities are deeper than those used for fracking, and the water can originate from several excavation sites. The practice is banned in the EU, although geothermal energy is obtained by pumping water into rocks at a higher temperature. The seismic events this causes are less powerful; the most pronounced was the 3.4 magnitude quake near Basel in 2008, which caused major economic losses – the total insurance claims came to around six million euro. Societal pressure and the investor's analysis of future risks, suggesting a high probability of future seismic events of a similar magnitude, resulted in the closure of the project, valued at over 40 million euro.

Assessing risk

Fracking and its impact on the environment are being investigated by representatives of the European Commission and the European Parliament, as shown in topics suggested as part of the Horizon 2020 Programme. The PAS Institute of Geophysics is one of the eight international scientific institutions responsible for implementing the SHEER project (Shale Gas Exploration and Exploitation Induced Risks). Its aim is to assess risks to humans and the environment due to fracking. The consortium uses state-of-the-art technologies for direct measurement of ground vibrations and the quality of air and surface and ground water at fracking sites and around them. The PAS Institute of Geophysics is conducting measurements in the Liniewo commune in the Pomeranian Voivodship, which is being prepared for excavation and testing of fracking effectiveness. The data will be compared against similar information from fracking sites in Poland and the UK, as well as data on conventional gas extraction from the UK and the Netherlands and generation of geothermal energy in Germany and the US. The aim of the project is to develop Best Practice standards for monitoring and estimating industrial risk of fracking.

All major industrial activities pose a certain degree of risk to humans and the environment. This applies to technologies used to extract natural resources and generate energy, with new technologies generally being regarded with suspicion and concerns about their effects. However, the existence of risk should not itself be a reason for abandoning certain activities. Any decisions on commencing new activities and ways of implementing them should be based on objective scientific assessment of potential negative impact on humans and the environment.

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Further reading:

http://www.igf.edu.pl/materialy-edukacyjne.php

http://www.eduscience.pl

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