

# SUBSIDENCE: A SLOW-MOTION PROBLEM



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The Netherlands is subsiding faster than the sea level is rising. In large parts of the Netherlands, human intervention is causing increased subsidence, in part because of a reduction in groundwater levels. The Geological Survey of the Netherlands (GDN), part of TNO, investigates all aspects of subsidence in collaboration with other institutes. This is done through measuring and understanding, but also through predicting. Municipalities, provinces and the government use this data and knowledge as an integral part of decision-making. TNO researchers Peter Fokker and Kay Koster, and head of geomodelling Michiel van der Meulen answer a number of questions about subsidence.

## WHAT IS SUBSIDENCE?

‘Subsidence is a process in which the ground sinks or settles downwards, and human action may induce or accelerate the process. The local effects are seen when roads, bridges, dykes or houses sink. But we also see it in an increased risk of flooding in low-lying areas. If, in a few hundred years, we want land on which we can live, we have to stop this process. The two most important processes that cause subsidence are peat oxidation and the shrinking of clay in the shallow subsurface,’ says Koster.

‘On a more local scale, subsidence is exacerbated by the extraction of gas, salt and oil reserves in the deep subsurface,’ adds Fokker.

## WHAT ARE THE EFFECTS OF WATER MANAGEMENT AND RECLAMATION?

‘Subsidence is especially a problem in parts of the Netherlands where there is a lot of clay and peat, where we keep the

groundwater level artificially low. We do this to keep our feet dry and to keep the land suitable for agriculture. But these low levels cause groundwater to disappear from the pores, and the layers to become more compact. The organic matter that is present oxidises and disappears into the air as CO<sub>2</sub>. TNO research in Flevoland shows that, since the reclamation of land in 1968, the clay shrinking and peat oxidation have caused local subsidence of more than one-and-a-half metres. Parts of Flevoland have gone from 3 to 4.5 metres below sea level in those 50 years. At the time, the extent and duration of the subsidence was underestimated,’ explains Koster.

## WHAT ABOUT MINING?

‘People associate subsidence in the north of the Netherlands mainly with gas production in Groningen, but subsidence also results from the extraction of salt from salt caverns. We see the effects of mining in this region in two situations: in the Wadden Sea, where natural sedimentation

can compensate for it, and on the land, where this doesn't apply,' says Fokker. Government policy regulates the pace of gas production in order to protect the vulnerable Wadden Sea, especially in view of the expected sea level rise. Fokker: 'We monitor this closely. Gas production in Groningen also creates extra stresses in the subsurface, as the reservoir becomes more compact. That affects seismicity and can induce earthquakes.'

#### WHAT IS SPECIAL ABOUT THE GDN'S EXPERTISE?

'We have expertise in both deep and shallow geological processes, which is unique. We try to examine everything in conjunction, to tie it together and thereby unravel the subsidence. We have a lot of data and knowledge at our disposal about the structure and processes of the subsurface. That makes us *the* geoscientific institute of the Netherlands. In the coming years, we want to expand our research by regularly measuring subsidence via satellite observations. This measuring, monitoring and modelling will allow us to predict subsidence better and better. Where other parties often only focus on one, specific aspect, we cover the entire field,' Fokker emphasises.

'We can also measure greenhouse gases released by peat oxidation,' adds Koster.

#### HOW MUCH CO<sub>2</sub> IS RELEASED BY PEAT OXIDATION?

'It is difficult to estimate how much peat oxidises each year and how much CO<sub>2</sub> is emitted. Still, the Netherlands must report this to the UN annually. We currently estimate that peat oxidation accounts for more than 2% of total national CO<sub>2</sub> emissions, but this figure is rather uncertain, so we are now busy developing models that can better determine this form of CO<sub>2</sub> emission,' explains Koster.

#### HOW CAN SUBSIDENCE BE LIMITED?

'In view of the consequences, we need to take a critical look at what we are doing in the Dutch subsurface. With the help of our knowledge and data, we can show where—and how much—subsidence is occurring. This allows us to analyse and balance the opportunities and risks. Policies and regulations can be geared to minimise the consequences of subsidence. Because responsibility for controlling subsidence



does not lie with one party, but is linked to everything—infrastructure, economy, regional water authorities, nature, etc.—tackling it is difficult,' says Fokker.

'Our knowledge is also highly relevant internationally. Land reclamation and gas production happen elsewhere, of course. Moreover, subsidence is occurring much faster in many other countries than it is here,' concludes Koster.

'The most apt description of subsidence I've ever heard, at a congress, is "subsidence is a slow-motion disaster". In the Netherlands, the highest rates of subsidence are caused by human intervention. Although the causes are known, even to the general public, we are regularly asked to predict subsidence as if it were an autonomous process. There is still a lot to learn and measure, but the ultimate problem does not lie in the physical and chemical processes. The biggest difficulty is predicting what humans are going to do,' says van der Meulen, head of geomodelling.

'In doing so, it is important to take into account the various causes discussed. Subsidence due to water management has been going on for centuries. Subsidence due to gas extraction has been taking place for decades. Even if these happen at similar speeds, the total subsidence effect of gas production is much lower and more predictable than that of water management.'

*Typical Dutch river landscape with high water levels because of spring tide and stormy weather in February, town of 'Wijk en Aalburg', provincie 'Noord-Brabant', the Netherlands.*

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#### MORE INFORMATION

**Geological Survey of the Netherlands**

Dr. Peter A. Fokker

E peter.fokker@tno.nl