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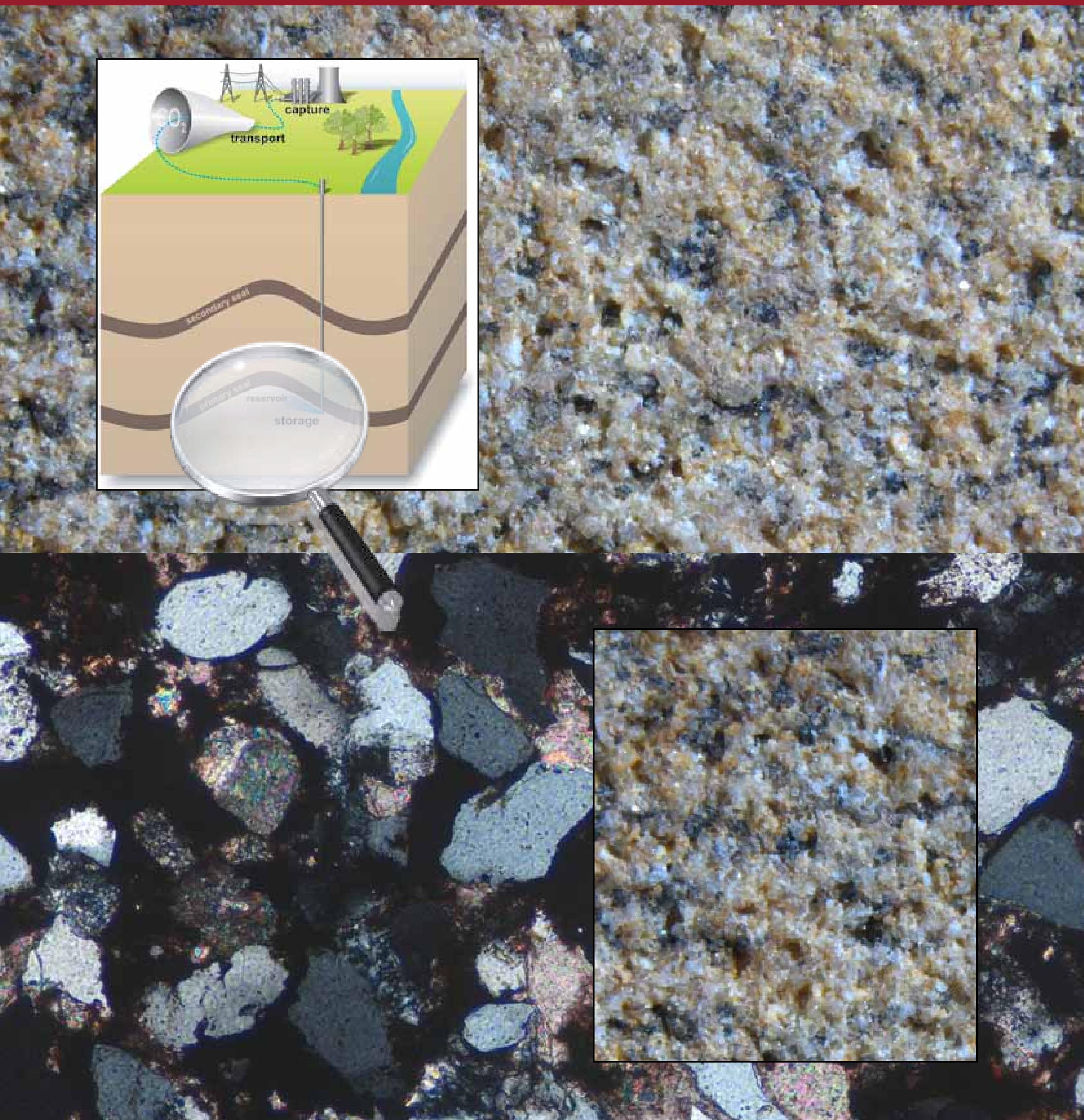
Carbon, capture and storage - potential in Europe and barriers to take up



Introduction by the EFG Panel of Experts on the Geological Storage of CO_2:

Geologists at the centre of CCS research in Europe

*Kris Piessens**

There are no doubt days when we feel inclined to spend a large amount of our professional time proving that geology and geologists are not just important, but actually crucial in our everyday life and economy. This is not always an easy task, and it is good to know that the European Federation of Geologists is out there backing us up. Emphasizing geology is not simply a matter of professional pride, but actually about correctly approaching subjects or projects and keeping focus on the essential aspects. CO_2 Capture and Storage (CCS) is one nice example where about two decades were needed to fully appreciate the importance of geology, and especially the impact of geological uncertainty.

The concept of CCS was first proposed in 1986 in Norway as a technological solution to reduce the emission of CO_2 from large point sources. The concept was easy: at a sufficiently large industrial source, preferably emitting in the range of millions of tonnes of CO_2 per year, CO_2 would be separated from the flue gas (or in later concepts also directly from the fuel), compressed, and then transported to a suitable location to be stored for 'eternity' in sufficiently deep and large geological reservoirs. As such, it would be possible to reduce the emission of greenhouse gases drastically, without the urge to hastily abandon the use of fossil fuels.

But as with any concept, a few blanks needed to be filled in. On the capture side, the efficiency of the capture process has been at the forefront from the beginning. This is the cost-determining part of the CCS chain, and any small improvement makes CCS more economic. It is therefore not surprising that the eyes of the industrial investors have kept turning in this direction.

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Figure 1: At the Sleipner project, natural gas is produced which is too rich in CO_2 to be marketed. Therefore about 1Mt of CO_2 is removed annually. Instead of releasing this CO_2 into the atmosphere, which is the standard practice, it is injected into an aquifer above the natural gas field (Courtesy Statoil).

But they also understood that CCS was going to be a complex chain of technologies, and that any weak link could jeopardize an entire project. Rather quickly, therefore, European projects started to address a general concern: is the capacity of the geological reservoirs large enough for large-scale deployment of CCS, and are they located sufficiently close to industrialized regions? The outcome from these very first studies was very reassuring and was interpreted by the outsider as 'geological storage is not the issue'. After all, the living proof seemed to be out there, with the Sleipner project (***Fig. 1***) pumping a million tonnes of CO_2 into the subsurface each year, and glamorously passing each monitoring test. This high level of confidence reduced the attention to the geological aspects, and caused things to run less smoothly that they could have.

Looking back, there were issues that needed to be addressed urgently. One of them had to do with the nature of geological numbers, which has, in the mean time, been visualized in a comprehensible way by applying the resource pyramid to CO_2 geological storage (***Fig. 2***). This pyramid grasps a well-known geological truth: the longer you look at a resource (or reservoir), the smaller it gets. In other words, the first, often regional, estimates of potential storage capacities tend to be considerable overestimates compared to the actual capacity that can be developed in projects.

Following this logic, storage capacity numbers from initial studies were systematically revised downwards during follow-up projects. This must have surprised policy makers since 'more funding for less capacity' will not have been what they expected. Additionally, some NGOs used this trend of shrinking capacity to question the feasibility of CCS on a large scale.

Experiencing how the capacity numbers were received, or without context used to hastily draw conclusions, geologists across Europe have been emphasizing the need for a European storage atlas. In spite of numerous efforts, it has proven very difficult to put the mapping of geological reservoirs back on the European R&D agenda.

Therefore, in spite of the early start, Europe is now trailing Australia and the US who have published well-elaborated, continent-wide storage atlases.

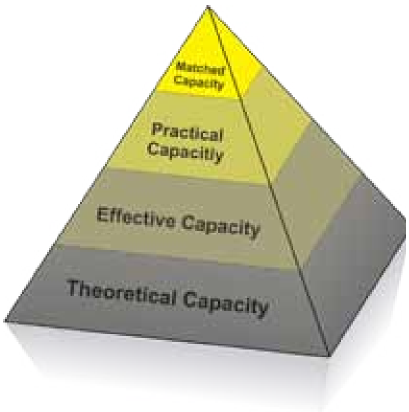

Figure 2: Initial estimates of reservoir capacities are by definition almost always over estimates. Theoretical capacities are regional estimates based on typical parameters of reservoirs rocks (permeability, thickness, etc.), while additional factors, which require more detailed knowledge, usually further restrict these initial numbers (e.g. structural traps, storage efficiency…) until at the level of practical capacity the true number is reached. Matched capacity further takes into account the transport and capture aspects (e.g. the proximity of sources) (After Bachu et al., 2007).

A second issue is that utility companies and industry are not used to dealing with geological uncertainty. It is indeed fundamental to see the difference with financial uncertainties, security of supply, performance issues, etc. All of these can usually be resolved by waiting, taking a strategic action, or investing in development. Geological uncertainty is different in two ways: it can only be resolved by exploration and it is site-specific (exploration elsewhere will not resolve your problem).

During the planning of a CCS project, from a geologist's point of view it is prudent to verify early on if the targeted geological reservoir is reliable and sufficiently large. However, from the perspective of the project planners it is sensible to first worry about the economics (costs) of a project, and then deal with the practical and planning issues, such as geology. Someone familiar with geological uncertainty knows that this is a huge risk, especially if you realize that the time line for geological exploration easily expands to more than five years before conclusive results can be presented, and should not overlap with the construction of a major coal-fired power plant which takes around seven years. Fortunately, this now seems to be better understood, and demonstration projects, which need to be realized in a limited timeframe rely on proven reservoirs that were for other reasons already well explored. However, when further developing CCS, the lack of regional or targeted exploration may become a crucial bottleneck.

A final issue is that of public perception of CCS. Right from the beginning it was realized that the concept and necessity of CCS would need to be explained to the wider public. Most CCS researchers expected that first of all the lack of sustainability would need to be justified, because CCS is a technology that can prolong the use of fossil fuels. Explaining that CCS is needed, in addition to the portfolio of renewable energy, energy efficiency and consumer behaviour, is indeed challenging and of relevance at the level of policy makers. The public however has proven to be much more sensitive to the 'fear of the unknown': geological storage.

As geologists it is important to continuously remind ourselves how abstract the deep subsurface is to almost everyone else. Personally, I always keep a core of reservoir and one of a cap rock (***Fig. 3***) at hand during interviews to throw a casual question like 'a reservoir, you do know what I'm talking about?' at the journalist. Time and time again you can watch his or her expression change from a self-confident 'I've done my bit of background reading', to a highly confused 'and the CO_2 goes where?' when being confronted with a slab of Bunter sandstone.Taking into account that a science journalist is usually well informed, it will come as no surprise that the average man in the street has no clue as to what underground storage of CO_2 encompasses. He will therefore be easily scared by vague or incorrect facts. This unfortunately seems to be well understood by the opponents of CCS, because most public campaigns against CCS are based on raising fear of the unknown.

In summary, CCS is certainly a topic with many different aspects. As geologists, we should trust the engineers with optimizing the capture side to shrink the costly head of CCS. Danger however lies in the uncertain tail, and the geological uncertainties should be properly addressed in CCS projects. On a national or basin scale it is important to address the potential overestimation of the storage capacity, and ensure that for each project exploration is quickly initiated since the go/no-go decision will depend on the availability of storage. Equally challenging is to weigh up the communication strategy which, especially for onshore storage, will inevitably need to deal with the 'dangers' of geological storage.

But the bottom line is that geology has proven to be of crucial importance for CCS, and that is a source of joy for our professional hearts.

Figure 3: The result of a small test with water as an analogue to the behaviour of CO_2 at large depths. Water infiltrates rapidly into the porous sandstone (reservoir) on the left, but not into the impermeable siltstone on the right (reservoir seal).

The European Federation of Geologists, engaged with the responsible use of natural resources, as well as environmental protection and sustainability, aims to promote geological activity in this area.

Reference

Bachu, S., Bonijoly, D., Bradshaw, J., Burruss, R., Holloway, S., Christensen, N.P., Maathiassen, O.M. 2007. CO_2 storage capacity estimation: methodology and gaps. Int. J. *Greenhouse Gas Control 1 (4)*, 430–443.