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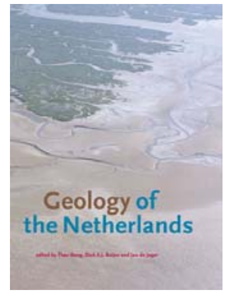

A Preface by main sponsor NAM (Nederlandse Aardolie Maatschappij), a Foreword (by Prof. S. Kroonenberg) and an Introduction (by the editors, Wong, Batjes & De Jager) precede an overview of the geological development of The Netherlands (by De Jager). The Netherlands' flat topography hides 10 km of sediments with a surprisingly varied geology, reflecting Caledonian and Variscan orogenies, Mesozoic rifting and Late Cretaceous to Early Tertiary Alpine inversion. Reactivated basement faults control the structural grain. Thick salt intervals decoupled deep from shallow faulting.

The first part of the book reviews the intervals stratigraphically. The Pre-Silesian interval (dealt with by Geluk, Dusar and De Vos) is reflected in only a few well and seismic sections. Yet, extrapolations from exposures south and east of The Netherlands allow a comprehensive picture to be sketched of the distribution of Middle Devonian to Early Carboniferous siliciclastics and carbonates that unconformably overly the Caledonian basement. The Avalonia plate underneath The Netherlands collided with Baltica and Laurentia. A horst-and-graben topography controlled the distribution of siliciclastics and carbonates that are topped by Silesian coal-bearing molasse.

More than 5500 m of Silesian deposits (dealt with by Van Buggenem & Den Hartog-Jager) occur widespread in the subsurface of The Netherlands and were differently affected by erosion. Marine/lacustrine deltaic sediments and alluvial plains are topped by red beds. Deltaic peats were converted into coal upon burial. It remains the main source of the various gas accumulations in The Netherlands.

Permian deposits (dealt with by Geluk) include the Middle Permian Lower Rotliegend volcanics group that is separated by an unconformity (40–60 Ma) from Silesian deposits. The Middle-Late Permian Upper Rotliegend group of fluvial, eolian and playa lake deposits is conformably overlain by the Middle-Late Permian Zechstein group. This group consists of five cycles of carbonates, anhydrites and salts. The Permian deposits contain some 95% of the natural gas reserves of The Netherlands in addition to exploitable rock salt and potassium-magnesium salts.

The Triassic (by Geluk) includes the Lower and Upper Germanic Trias Formations separated by the Base Solling or Hardegsen Unconformities. The groups are made up of fine-grained lacustrine siliciclastics with fluvial-aeolian sandstone intercalations, both sourced from the southerly Variscan Mountains, and are followed by lacustrine, brackish-water and marine fine-grained siliciclastisc, carbonates and evaporates. The distribution and thickness of both packages of sediments, as well as their depositional basin configuration, were significantly influenced by rifting. The West Netherlands Basin, the Roer Valley and the Dutch Central Graben subsided differentially, while the Fennoscandian shield was uplifted and shedded siliciclastics.

The Jurassic and the lowermost Cretaceous (Rhaetian and Ryazanian) (dealt with by Wong) are made up of four marine siliciclastic groups. Upon a laterally uniform pre-rift sequence other units developed in basins that formed during Middle and Late Kimmerian extension such as; the N-S striking Dutch Central Graben, the E-W striking Lower Saxony Basin and the NW-SE striking Roer Valley Graben – Broad Forteens Basin. The lithostratigraphy of the Late Jurassic to Early Cretaceous has been updated since the stratigraphic compilation by Van Adrichem Boogaert & Van Kouwe (1993).

During the remaining Cretaceous (treated by Herngreen & Wong), regional subsidence triggered sedimentation over the entire Netherlands. Transgressive basal sands and prograding coastal barrier complexes formed, and landwards continental sedimentation took place. By Aptian times, overall deepening occurred and several unconformities formed. Then a fairly uniform succession of marls and limestones was deposited during transgression. It was interrupted by the Laramide inversion. The resulting erosion removed much of the Cretaceous.

During the Tertiary (dealt with by Wong, De Lugt, Kuhlman & Overeem), The Netherlands was part of the southern North Sea Basin. After initial calcareous deposition, siliciclastics dominated and—together with the Quaternary—the Lower Middle and Upper North Sea Groups formed. They are separated from each other by unconformities. The variable thicknesses of the lithological units reflect deposition and erosion in different areas due to sea-level changes and tectonics.

The stratigraphic part of the book concludes with the Quaternary, to which almost all surface rocks of The Netherlands belong. The sediments in the westernmost part of the country form a Holocene barriers system crossed by estuaries and tidal inlets, a coastal plain and an intertidal area that is more inland cut by the present-day rivers. Further east and south, low sandy flat areas with exposed Pleistocene occur. Alternating glacials and interglacials left their marks with erratic blocks, push-moraine ridges and lacustrine, eolean and fluviatile facies. Peat formed abundantly and was removed by human influence that increased through the ages, causing fundamental changes in depositional environments and landscapes from today's Netherlands.

The second part of this book deals with miscellaneous features. The "Discussion of Magmatism in the Netherlands: expression of the north-west European rifting history" (by Van Bergen & Sissingh) is based on material from approx. 60 wells penetrating igneous rocks, mainly of an intrusive nature and almost all emplaced in Carboniferous and younger intervals. The Zuidwal volcano under the Wadden Sea is a prominent extrusive rock. Radiometeric dating places these rocks within the Late Paleozoic to Mesozoic pattern of igneous activity associated with rifting phases during the Early Permian, the Mid Jurassic and the Early Cretaceous. The rocks are usually mafic and have a high alkali content.

Natural and induced seimicity are dealt with by Dost & Haak. Natural seimicity is mainly confined to normal faulting in the Roer Valley rift, with normal faults that have a small strike-slip component. Historical seismic analysis shows a maximum magnitude of 6.3 to be expected for future earthquakes. Higher magnitudes may occasionally arise from large strike-slip and thrust-fault movements along the Brabant Massif. Since 1986, induced seismicity has been recorded in the north of The Netherlands; it is associated with gas production. These are shallow events with a maximum expected magnitude of 3.8.

"Petroleum Geology" (by De Jager & Geluk) presents a wide variety of proven hydrocarbon plays and trap styles. The giant Groningen gasfield within the Rotliegend reservoir rock is ideally situated between the Westphalian source rocks and the Zechstein evaporatic caprocks. Other gas reserves occur in Zechstein carbonates. Triassic plays are second in importance with respect to proven gas reserves, as are gas reserves in Jurassic and Cretaceous sandstones, Late Cretaceous chalk and shallow, unconsolidated Tertiary and Quaternary sands. The Mesozoic is oil- and gas-prone, and producable oil has been found in Late Juarassic and EarlyCretaceous rift basins in several sandstone reservoirs and traps. Exploration in The Netherlands is in a mature stage, but new discoveries continue to be made and significant volumes of gas are yet to be found.

Peat, coal and coalbed methane (by Van Bergen, Pagnier & Van Tongeren) are traditional fuels on which The Netherlands has relied for centuries. They occur in several stratigraphic intervals: peat in the Holocene, brown coal in the Miocene, and bituminous coal and anthracite in the Upper Carboniferous. Production of these energy sources ceased in the 20th century, but substantial amounts of exploitable coal remains above a depth of 1500m. Since 1990, interest in such coals has increased as a source of coalbed methane. Currently such production is economically not feasible but theoretically recoverable amounts of such gas are large. Coalbed-methane production may become economically feasible in combination with subsurface storage of CO_2 which also helps in fulfilling the 1997 Kyoto protocol. Therefore coal may still play a role in the future.

Salt (dealt with by Geluk, Paar & Fokker) occurs within the Permian and Triassic. Late Permian salt reaches significant thicknesses and was mobilised during geologic history in the northern half of The Netherlands and the adjacent offshore. Thus salt pillows and diapers originated, which strongly influenced the structural style in the subsurface. Salt is produced by solution mining in the east and north of The Netherlands. Exploitation takes place at depth between 300 and 3000m. The salt is mainly used for the manufacturing of chlorine and for magnesium oxide.

Groundwater (by De Vries) occurs in regional aquifers of Plio-Pleistocene fluvial sands of 25-250 m thickness that outcrop at the surface in the east, and that dip underneath lagoonal clays and peat in the western coastal area. Most of the western half of The Netherlands is below sea level, and is a patchwork of polders, each with its own artificially controlled level of surface and groundwater. Relatively elevated polders are infiltrated and deep polders suffer from diffuse upward leaking of fresh and brackish water. In the eastern half of The Netherlands, shallow aquifers in level areas are seasonally drained, and deeper aquifers in more elevate areas are virtually without surface drainage and a groundwater table that reacts on annual variations in rainfall. Annually 1700 m^3 of fresh groundwater is extracted of which 60% is used for public water supply.

Surface mineral resources (Van der Meulen et al.) from Quaternary and Tertiary deposits include sand, gravel and clay. These are mainly exploited for construction works and the building industry. Surface Cretaceous chalk and Triassic limestone and dolomite are resources mainly used for cement production. Import of aggregate material surpasses that of exportation. Sustainability policy stimulates the use of recycleable waste material and industrial by-products as alternatives for natural material.

“Underground storage and sequestration” is dealt with by Bos. Currently, underground storage of natural gas is the only operational storage project. It serves to meet peak demands for gas when the gradually depleting Groningen gas field cannot deliver the required volume. A potential new form of underground energy storage is that of compressed air from the planned large-scale offshore wind-energy plant. It may help to meet fluctuations in electricity demand. Underground sequestration of CO_2 is needed to reduce emission in the atmosphere. One field test is currently ongoing. Future possibilities include sequestration in coal seams that stimulate the recovery of methane adsorbed to the coal, and CO_2 flooding of oil and gas reservoirs enhancing hydrocarbon recovery. Disposal of toxic and radioactive solid wastes have been investigated but are not yet carried out.

A chapter on geothermal energy (by Lokhorst & Wong) concludes the book. The shallow subsurface has already been successfully used for some time for extraction and storage of heat; for the deep subsurface, a number of evaluation studies showed the feasibility in some cases, but have not yet led to actual exploitation of such energy. Potential interesting aquifers are of Permian, Early Triassic, Early Cretaceous and Tertiary age, and substantial amounts of Heat in Place (HIP) may be present. Successful production strongly depends on reservoir properties and the world energy demand and pricing.

The preparation of this book has taken several years, and some early contributions were overtaken by newly published data and released information that necessitated updating. The book contains many detailed seismic sections, well logs and paleogeographical maps. It thus supplements other recent publications in Dutch and English on the geology of The Netherlands that cover the subsurface with only limited subsurface data, or in a popular fashion for a general public. The present book arrives timely and is likely to serve professional geologists and others as an authorative source of information on the geology of The Netherlands for years to come. It is comprehensive, yet complete, and includes next to a stratigraphic treatment of the various intervals also a range of contributions of a more general nature with emphasis on the economic application of rocks.

One critical commentary should be made with regard to small but occasional also sizable changes in stratigraphic nomenclature with respect to the Stratigraphic Nomenclature as defined in 1993 by the then State Geological Survey. Not always the full references are given, so that the need for the changes is not always fully spelled out. The book is bound in a hardcover, and good quality paper has been used. The page layout is pleasant and the illustrations are usually of good quality. No significant typos or mistakes have been found. The price is reasonable and the book is wholeheartedly recommended.

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