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SAUDI GEOLOGICAL SURVEY

THE ROLE OF ENGINEERING GEOLOGY IN ADVANCING SUSTAINABLE DEVELOPMENT

By the Engineering Geology Programme

The science of geology is the application of geosciences to solve engineering problems. When geosciences are applied to relevant aspects of engineering practice, it is known as Engineering Geology. This discipline involves geologic data, techniques, and principles. It has practical applications in studying rock and soil materials, surface and subsurface fluids, and their environmental interactions. By recognizing and interpreting geologic factors, engineering geology informs decision-making in engineering and related fields, making it a crucial aspect of sustainable development. The International Association for Engineering Geology and the Environment (IAEG) defines it as the science of investigating and solving problems caused by geological hazards and interactions with human activities. As a result, Engineering Geology is a multi-disciplinary subject that intersects with various fields involving interactions with the Earth.

The principles of geology, including those of Engineering Geology, have a significant global impact, providing context for approaches and methodologies that support sustainable development in the Kingdom of Saudi Arabia and worldwide. The importance of population growth underscores the need for the intelligent application of these principles in health, safety, construction, industry, mining, and the welfare of societies across the globe.

The Engineering Geology is one of the essential elements of the foundation for a sustainable and prosperous future. It influences various aspects of life and is a bridge that ties geological science, civil and geotechnical engineering, and the natural and built environments of all times. Sustainable development means meeting the current generation's needs without compromising the ability and needs of future generations. In this context, Engineering Geology is criti-

Figure 1. Photo showing the engineering geological team conducting a field density (FD) test at one of the sites, the NEOM Project.

cal in planning, investigating, designing, constructing, and implementing effective and sustainable solutions. Performing sustainable development is sophisticated, needs solutions to comprehensive issues, and perceives the required exchange.

The role of Engineering Geology begins with creating sustainable and efficient societies. It plays a vital role in applying their experiences, knowledge, and skills and offering their perspectives to help tackle sustainable development challenges. The contribution of Engineering Geology can be expressed in terms of planning and opening of mines, drilling, and exploitation of mineral resources, characterizing geological material properties, discontinuities, earthquakes and liquefaction, ground settlement, problematic soils including swelling and expansive clays, breakdown of disaggregated materials (slaking), changes of groundwater levels, pore water pressure, site investigation of dams; tunnels; roads; airports; bridges and highways, site investigations and landslides and slope stability studies, geohazards, military geology, infrastructure development and protection, material use, renewable energy, and disposal of solid; liquid; chemical; biological and nuclear wastes. Engineering geology also includes the application of geomorphology, hydrogeology, geomechanics, and geochemical characterization (IAEG, 1992). These roles are conducted using the latest theories, studies, and technological innovation to improve the economy, mineral exploitation, mining industry, and infrastructure and make them more efficient and sustainable.

Since strong and efficient infrastructure is the key to achieving sustainable development, the IAEG Congress realized that engineering geologists need to improve how they communicate the value of their contribution to sustainable development (Baynes and others, 2009).

Field investigations in engineering geology are conducted according to the IAEG Commission on Engineering Geological Methods, which describes rocks and soils. Engineering geological and geotechnical characterization of soils and rocks are based on their index and engineering properties. Their classification is based on the standard proposed by the Unified Soil Classification System (USCS), American Association of State Highway and Transportation Officials (AASHTO), International Association of Engineering Geology and Environment (IAEG), the International Society for Rock Mechanics and Rock Engineering (ISRM), the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), and the American Society of Civil Engineers (ASCE). Institution of Civil Engineers (ICE), Saudi Building Code (SBC), and other international systems if required. Soils, rocks, and their experimental parameters are described according to the American Society for Testing Materials (ASTM) and British System (BS), which represents a "Standard Recommended Practice Description of Soils and rocks (Visual-Manual Procedure)." The IAEG standard description of soils supplemented this standard.

In surface and subsurface strata, drilling is conducted in favorable and unfavorable geological conditions to obtain samples, identify the subsurface materials, groundwater level, in-situ tests, correlation of geologic materials, and define the soil and rock subsurface profile. Boring must extend deep into the rock to establish depth to unaltered bedrock. Cone Penetration Tests (CPT), Standard Penetration Tests (SPT), field density testing (sand cone (FD)), and hand augers (HA), which are very suitable for sampling in hard, stiff soils, mixed with fine gravel, both above and below the groundwater level are examples for in-situ testing and sampling (Figs. 1 and 2). Also, Suspension Logging (SL) and Seismic Piezocone Test (SPT) are used to determine the dynamic properties of soil and rock. The Vane Shear Test (VST) measures the undrained shear strength of cohesive soils.

For the rocks, the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation

Figure 2. Auger is a device used to drill soil deposits to obtain shallow subsurface samples, NEOM Project.

(RQD), and Fracture Index (FI) are calculated. Some parameters, such as logging, degree of weathering, and strength, are described, evaluated, and estimated.

Previously, the Engineering Geology Section of the Saudi Geological Survey executed several projects in the vast regions of the Kingdom of Saudi Arabia, and they achieved most of their objectives. The Engineering Geology Program is currently working on many projects related to sustainable development. Among them is the infrastructure protection of engineering projects in the NEOM Area (Sharmah, Al Khuraybah, Qiyal), Tabuk Region. It is one of the main lead projects conducted by the engineering geological teamwork and will be finished next year. This project emphasizes the importance of understanding the geology of the NEOM Area, subsurface investigation, geotechnical evaluation, and engineering geological behavior of soil and rocks, hydrogeology, and hydrology that challenges the infrastructure in the NEOM Area (Fig. 3). It also highlights the continuing expansion in the practice areas of Engineering Geology. It illustrates how this opens new professional frontiers, introducing new knowledge and technology.

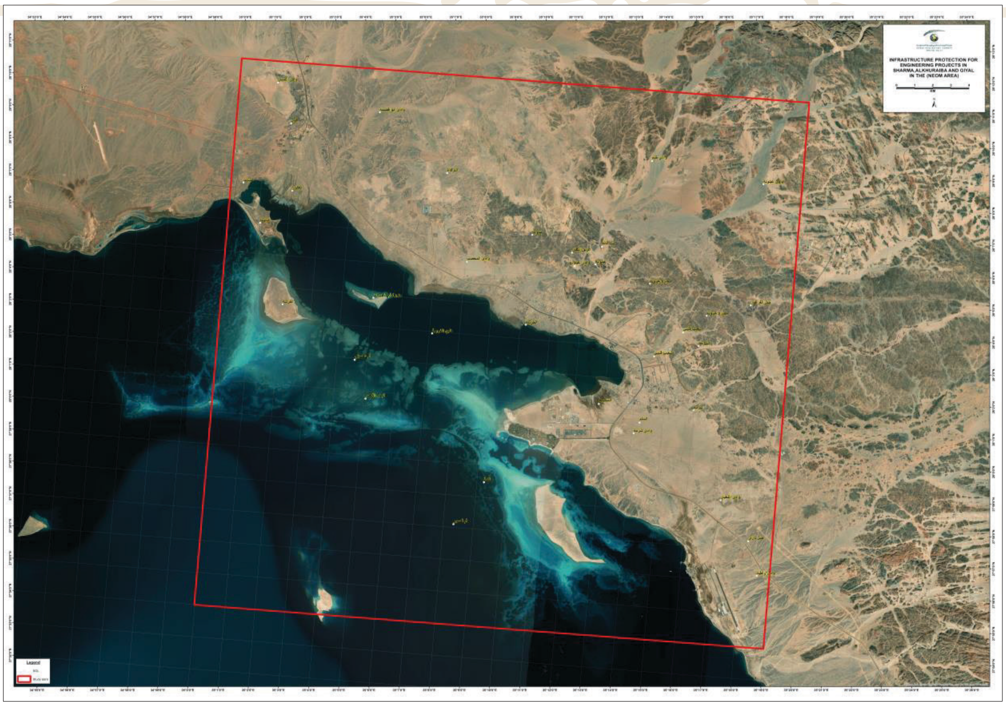

Figure 3. Map showing the borders of the NEOM project executed by the SGS engineering geological team.

The main objectives of the NEOM project are to identify, delineate, and correlate the geological materials, geological features, and hydrogeological conditions in the NEOM Area to construct facilities and infrastructure in a more efficient, safe, and sustainable environment. Evaluate the engineering geological aspects of the project area and provide information on the geotechnical properties of soils and rocks for support, design, construction, and economic and developmental significance to avoid the areas of fragile geological environments, potential hazards, and damage. Determine the most suitable sites for construction and development depending on the stratigraphic sequence and their subsurface vertical and lateral extensions. Ensure the safety and stability of structures in their natural settings. They are reducing economic, property, and life losses by protecting facilities, infrastructure, and sensitive areas from geological, engineering, and seismic hazards since the liquefaction of the soil is possible. To produce comprehensive engineering geological maps. Finally, the level of safety can be raised by controlling risks and potential damage to engineering facilities and infrastructure in the area, as the study helps increase the quality of life consistent with the Kingdom's Vision 2030.

Figure 4. A photo showing a shallow excavated wall trending E-W representing the beginning work of the Line project, which is situated within the project area.

The eastern part of the Line project, which is set to provide a revolution in urban living that creates a new urban sustainability model, is located within the study area (Fig. 4).

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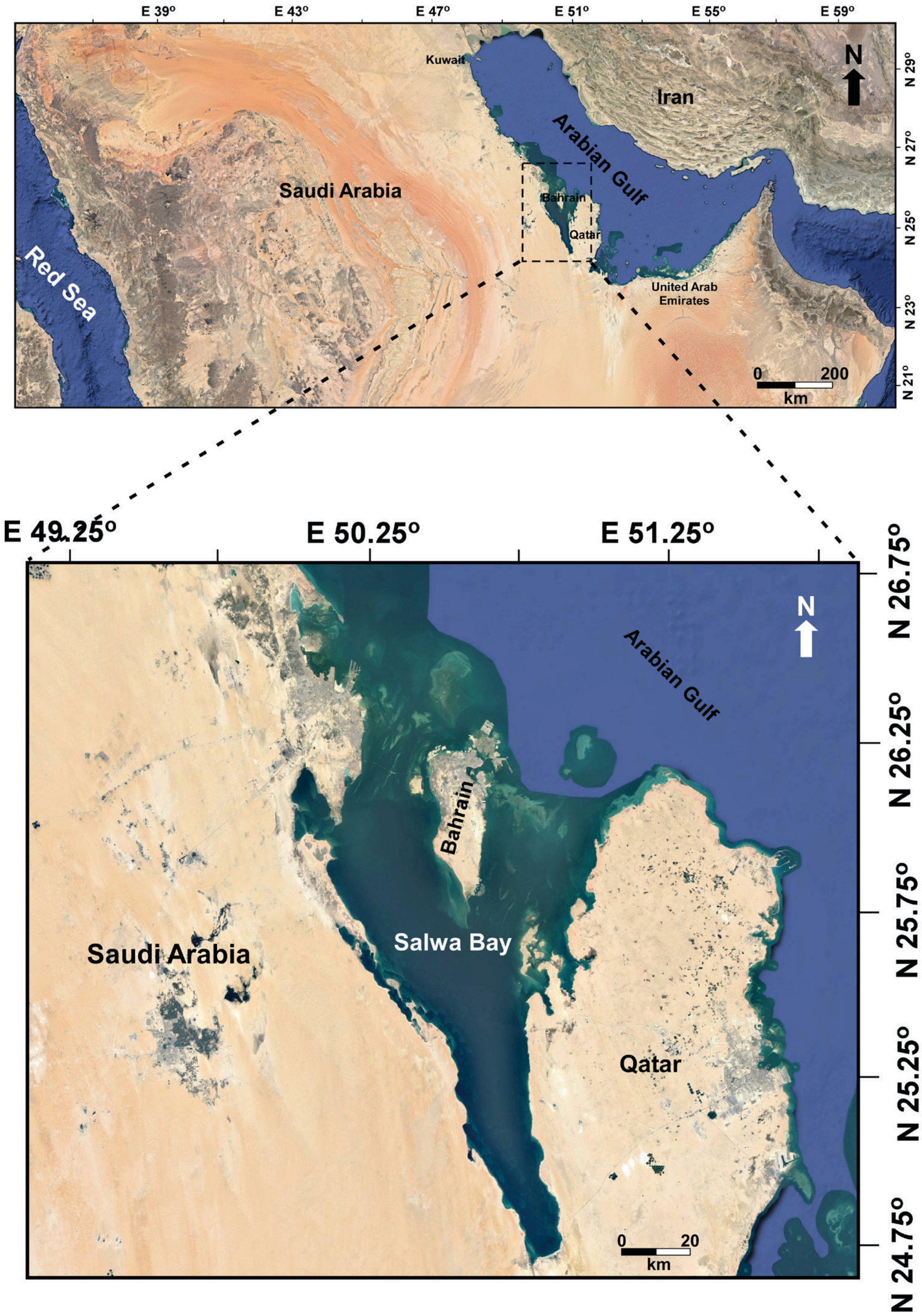
SEABED MORPHOLOGY, SEDIMENT CHARACTERISTICS, AND ENVIRONMENTAL ASPECTS OF SALWA BAY IN THE SAUDI ARABIAN PART OF THE ARABIAN GULF

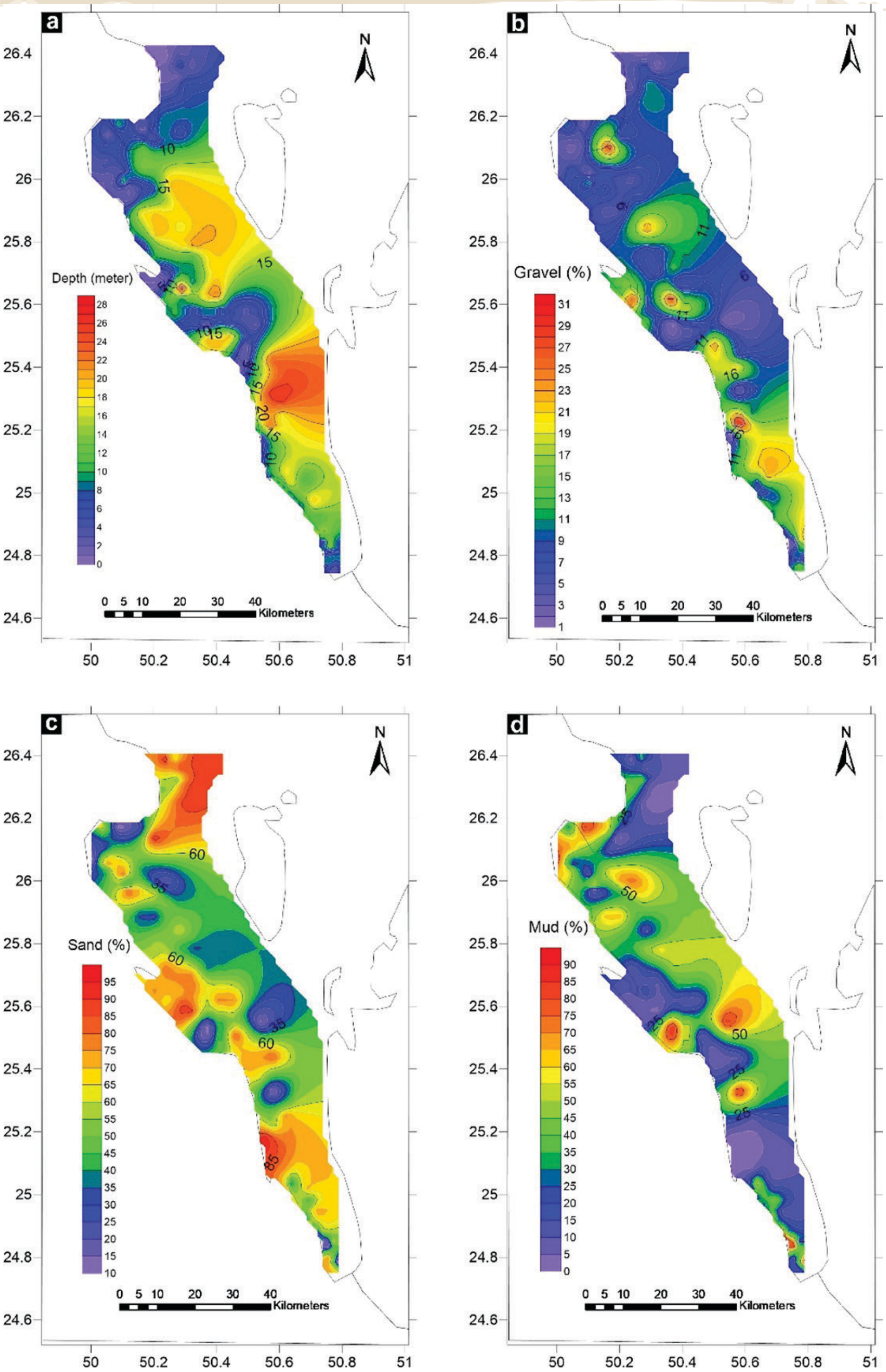
By Ali A. Al-Tharowi, Nawaf A. Widinly, and Mustafa M. Khorsheed

The Kingdom of Saudi Arabia is bordered by two ecologically and economically significant waterbodies: the Red Sea to the west and the Arabian Gulf to the east. The Red Sea is famous for its unique type of biodiversity and its bottom sediments particularly the hot brines, which host voluminous, economically important marine mineral resources. The Arabian Gulf, on the other hand, is a semi-enclosed basin with extremely high surface water salinity and temperatures, as well as limited water circulation. The Gulf is the most extensive stretch of hypersaline shelf on Earth. It is a unique environment for endemic flora and fauna that have adapted to high levels of salinity and temperature (Murray, 1991; Naser, 2011). It is, therefore, characterized by a special type of bio-communities that are capable of overcoming these harsh ecological stresses. The thermal regime of the Arabian Gulf has been selected as a model for projected tropical seas in 2090–2099 (Solomon and others, 2007; Riegl, 2012; Amao and others, 2018).

The Salwa Bay is a semi-enclosed coastal waterbody between Saudi Arabia and Qatar. The bay is an ecologically important coastal waterbody, as it hosts a special type of opportunistic coral reefs that persist in high salinity water and provide important fishing grounds. The bay has a history of oil spills, dredging, and various anthropogenic impacts, which have negative impacts on the ecosystem. The area is a priority in the integrated management plan for the Arabian Gulf because of the possibility of increased human activities, e.g., urbanization, fishing, and oil industries in this area, which may negatively impact on its vulnerable marine ecosystems. The water of the bay is the most saline extension of the Arabian Gulf.



Google Earth map, showing the location of the study area.



Showing contour maps and the spatial variation in the water depth (a), gravel percentage (b), sand percentage (c), and mud percentage (d) in the bottom sediments of Salwa Bay.

The primary objective of this work is to gather a broad background information about the bottom sediments and the seabed morphology of the Salwa Bay.

This work presents the grain size characteristics of the seabed sediments and the bathymetric maps of the hypersaline Salwa Bay, Arabian Gulf. This bay is generally shallow, with a maximum water depth of 30 m. The water depths in other areas of the bay are less than 26 m. The bottom sediments of the bay consist mainly of biogenic remains of low diversity benthic fauna, dominated by corals, bivalves, gastropods, benthic foraminiferas, and ostracods. The grain size distribution maps of 101 seabed sediment samples were acquired in 131 sampling stations using a grab sampler. The grain size maps show that 65 percent of the samples are sand-dominated, whereas 35 percent of the total samples are mud-dominated. Both groups of sediments contain relatively low gravel contents. The sediments are composed of poorly sorted to moderately well-sorted, very coarse-to-fine sands. Grain size shows no remarkable trend in the bay, reflecting the dominantly low energy of the depositional hydrodynamic conditions. The relatively high sand contents of the sediments cannot be interpreted relative to the depositional energy, because the sediments are dominantly of biogenic remains, which exhibit angular to sub-angular shapes, suggesting their limited transport. The sediments were mainly formed by the disintegration of shells and coral skeletons by bio-erosion rather than by wave and current action. The colors of the sediments reflect their biogenic composition, i.e., white to gray, and to a lesser extent, the encrustation with algae and other organic matter, i.e., dark gray to black. Some black-tarnished sediments may indicate stagnant bottom conditions. This study recommends to extend the work to cover the mineralogical and geochemical analyses of the bottom sediments to determine the environmental conditions and the possible anthropogenic controls on sediment composition. (SGS-OF-2023-7)

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