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Review Article

A Review on Geological View of Svalbard with its Infrastructure and Strategies

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Abstract

Arctic Region (AR); Its role in global climate change, recently opened commercial sea routes, unexploited industrial resources, unique polar ecosystem, and international geopolitical balance making it a strategic area that attracts the attention of many countries. In this aspect, the Arctic Council carries out various studies and international cooperation, especially interdisciplinary scientific research in AR. Apart from the Council, many institutions, organizations and societies come to the AR to conduct scientific studies. When these studies are examined from a geological point of view, it is been seen that they are classified as glacial science, marine geology, geomorphology, microbial ecology, permafrost, biogeochemistry and geochemistry. Svalbard is geologically salient as well as being the place where most scientific studies are being conducted in the AR. In line with the geological significance of Svalbard, many institutions are engaged in educational research, science strategies, international projects, etc. In this study, the geological structure, geological infrastructure and scientific strategy for geological research of the Svalbard Region are examined. Moreover, projects that can be done within the scope of scientific research of Turkey in AR, are evaluated as a recommendation.

Keywords: Arctic, Svalbard, Geology, Infrastructure, Strategy

Introduction

Svalbard archipelago, which is a part of Norway, was formed as a collection of islands in the Arctic Region (AR). Figure 1, adapted and reproduced from Petrov et al., 2019 shows the location of the archipelago with a general view of tectonic plate boundaries over AR. Svalbard region, located between the Arctic Ocean and the Barents Sea, is one of the focal points of scientific research due to its unique environment. The region has a significant and crucial place in the wildlife care of Svalbard, which is among the protected areas by the Government and the National Assembly of Whom Norway. Researchers in the region are required to be in limited contact with wildlife and not to cause any harm within the area (Cetin and Buyuksagnak, 2021; Larssen, et al., 2008; Korkmaz, et al., 2022).

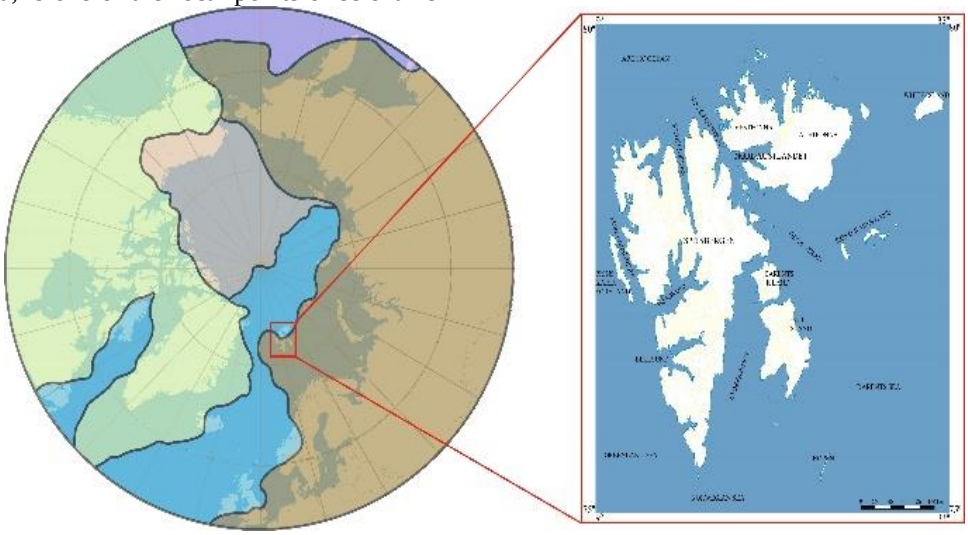

Fig. 1. Location of Svalbard.

Spitsbergen, the largest island of the archipelago, covers 37,673 km^2 area. The center town of the island where the settlements are located is Longyearbyen. There are museum, hospital, primary and secondary schools, university and other places where various social activities are held. Coal mining activities have

diminished over the years in the region where coal mining used to be significant economic sector for the archipelago. The Longyear Power Station in the region is currently being operated with the extracted coal (Midttomme, 2017; Norwegian Ministry of Justice and Police, 2009).

During the first decade of the 20th century, glaciers were increased significantly in and around Svalbard due to the Little Ice Age (Dallmann, et al., 2007). In the region, ice floes formed by tidal water cover more than 1.000 km (Dowdeswell, 1989). Nuth et al. (2013) reported that 57 % of the Svalbard archipelago consists of glaciers. A total of 20 % of the coastline of the major islands in the region is covered with ice. Ice cover lies 92% of the coast of the White Island (Kvitoya) in eastern Svalbard and 41% of the coast of the Big Island (Storoya) (Dowdeswell, 1989). Ice covers are more common in Nordaustlandet, Edge and Barents regions (Ingólfsson, 2004; Harland, et al., 1997). Nordaustlandet has two glaciers known as Vestfonna (2500 m^2) and Austfonna (7800 km^2) and it is the second largest island of Svalbard with 14,443 km^2 area (Moholdt and Kaab, 2012).

Large braided river systems that occur in glacial valleys are very common in the region as they form fjords during material transport (Harland, et al., 1997; Choudhary, et al., 2020). Wijdefjorden in northern Svalbard is about 110 km long which makes it the longest fjord in the region (Allaart, 2020).

Svalbard and its surroundings generally have an Arctic climate with long and cold winters along with intense snow falls. The annual average temperature in the region is calculated as -6.9°C which could create suitable conditions to host human population to live (Denstadli, et al., 2014; Hanssen-Bauer, et al., 2019). According to 2021 census data, 2459 people live in the region (Statistics Norway, 2021).

General Geology

Svalbard spreads between 74° - 81° North latitudes and 10° - 35° East longitudes. The region has a tremendously diverse geological history dating back to a very long time. Figure 2 shows the geological map of Svalbard that adapted from the map produced by the Norwegian Polar Institute (NPI).

The Barent shelf is located in the northwest of Svalbard. The rise of the shelf, after Devonian, has led to the formation of archipelagos (Johnsen, 2001). In addition, the 400-million-year-old Caledonian mountain range caused the formation of different rock complexes (Dallmann, et al., 2007; Holtedahl, 1926).

The Svalbard region consists of five important geological sequences. The first is the Hecla Hoek Complex, which consists of Precambrian to Early Silurian metamorphic rocks. These rocks crop out in the northeastern part of Spitsbergen along the west coast and at Nordaustlandet and are the basement (Old Red base). Second, the Devonian Grabens in Northern Spitsbergen are cover rocks. The third is the central basin in the central part of Spitsbergen. This basin covers the center with a distinctive syncline feature and is bounded by the West Spitsbergen fold and thrust belt. The fourth event is the platform areas in the eastern parts of Spitsbergen and in Barents Island and Edge Island. Tertiary fold belt which outcrop on the west coast of Spitsbergen can be considered as the last stage of geological processes in the region (Johnsen, 2001).

The Caledonian Orogeny, which includes faulting, folding, thrusting and metamorphism of Precambrian to Middle Ordovician deposits and magmatic complexes, is very intense and formed the basis of Hecla Hoek. The Hecla Hoek succession consists of Proterozoic and older Paleozoic deposits and was strongly faulted and metamorphosed during the during Caledonian orogeny. The succession is composed of partially garnet, quartzite and less frequently marble schists intercalated. It is followed by quartzite and dolomites, followed by a thick conglomerate or dolomite-limestone series containing tillite, oolite and collenia. Fossils of brachiopods, gastropods and cephalopods identified in the Hornsund region and Paleozoic sequence of the Hecla Hoek series indicate that the sequence is approximately 4500 m thick (Winsnes, 1962; Johnsen, 2001).
The region is mainly composed of igneous and metamorphic rocks of Devonian age formed by the Caledonian Orogeny. Rb-Sr and K-Ar dating also revealed Precambrian aged rocks (Ohta, 1992; Jørgensen, 2021; Burzynski, et al., 2018). Additionally, metamorphic rocks consisted of eclogites and blue schists are described in the region (Labrousse, 2008; Burzynski, et al., 2018).

The sedimentary rocks in the region consists of large-sized sand, gravel and mudstones dating from the Devonian period. The Old Red Sandstones, consisting of conglomerates, sandstones and shales, form the Devonian beds. They contain Caledonian folding and metamorphism, as well as fish and plant fossils. Because of these primitive fish fossils, the period is called 'The Age of Fishes' (Gjelsvik, 1986).

Due to the influence of the Ellesmerian Orogeny, outcrops consisting of quartzites with carbonate-rich laminae and garnet metapelites containing kyanite are observed in the Prince Karls Fornland region. Age determination from garnet metapilites, revealed Late Devonian-Turnesian time period (Majka and Kośmińska, 2017; Burzynski, et al., 2018). In addition, the Old-Red Sandstones after the Caledonian, which were faulted and folded in the Late Devonian, also support the Ellesmerian Orogeny (Majka and Kośmińska, 2017). During the Middle Carboniferous period, evaporites and carbonates were deposited with tectonic movements on land and in shallow marine environments. In the same period, new river systems formed.

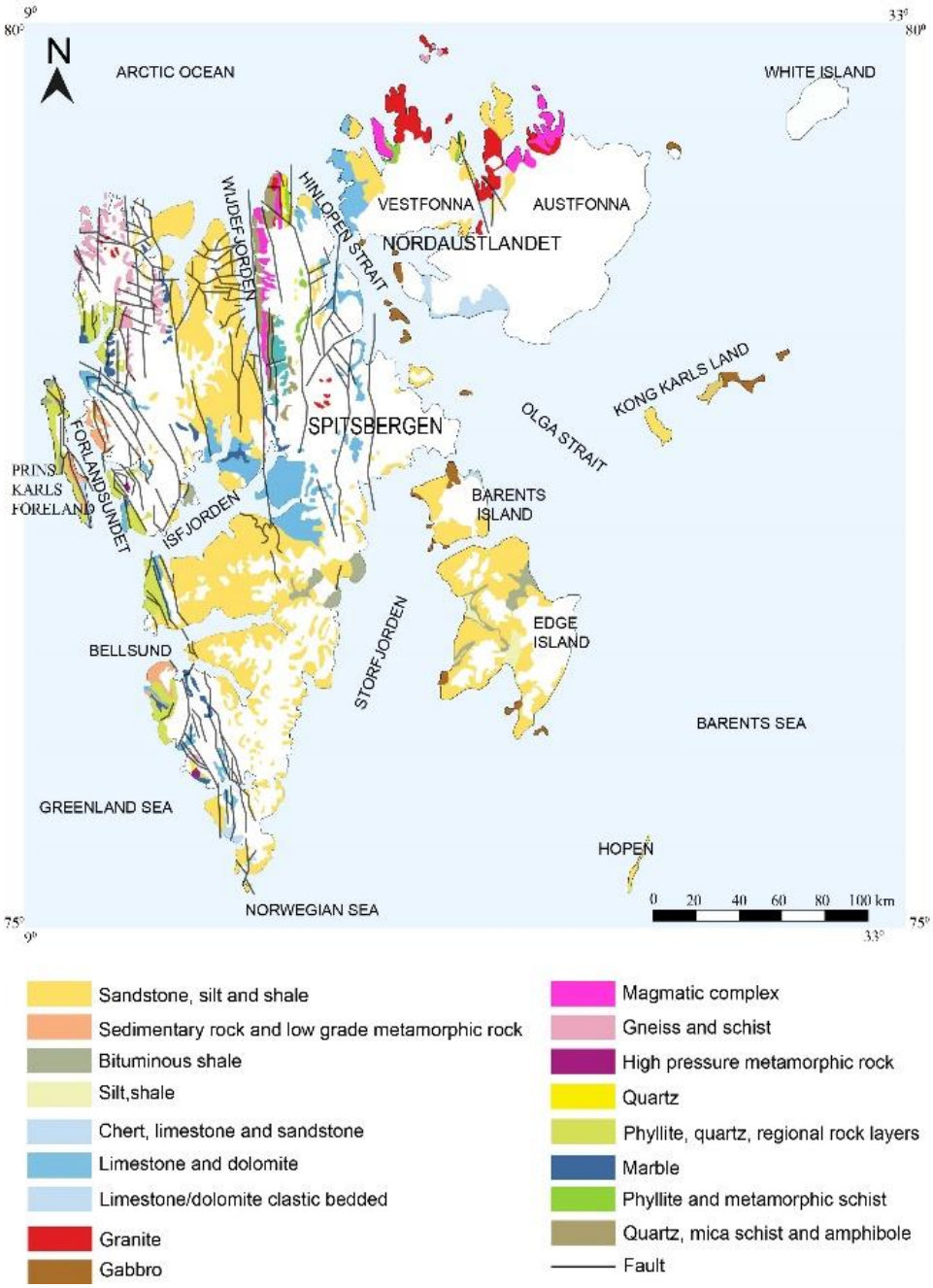

Fig. 2. Svalbard geological map.

Accordingly, accumulation and deposition occurred in delta deposits, evaporites, carbonates, and red alluvial fan deltas. As a result of the periodic flooding of the region, it became rich in organic matter and coal seams from the Tertiary period were identified (Friend, 1961; Piepjohn and Dallmann, 2014; Dallmann, et al., 2007; Gjelsvik, 1986).

Between the Cretaceous and Tertiary, Svalbard collided with Greenland, causing folds in the western part of Svalbard and a depression basin in the eastern part where sedimentation took place. As plate pressure began to decrease in the second part of the Tertiary, Svalbard was exposed to intense faulting and volcanism. The Eurekan deformation represents the formation of different systems of regional fold and thrust belts, different thrust zones and strike-slip fault zones (Piepjohn, et al., 2015). The structures in the Svalbard region are Cenozoic in age and Eurekan deformation is observed in the Northern Greenland and Queen Elizabeth Islands region (Piepjohn, et al., 2015; 2016).

Unconsolidated deposits of Quarternary age are observed, generally as moraines, fluvial deposits and coastal deposits. Active volcanism is still observed in the northwest of the region where these sediments are located. During the first decade of the 20th century, glaciation increased significantly by through the Little Ice Age (Goncharov, et al., 2015; Cianfarra and Salvini, 2013; Dallmann, et al., 2007).

Geological Research Infrastructure

Scientists conduct their research at scientific research stations, science camps, scientific research ships, universities etc. at temporary infrastructures of various countries in the Svalbard Region (Svalbard Science Forum, 2021; Norwegian Polar Institute, 2021). Research stations where scientific studies are carried out are located in Ny-Ålesund, Pyramiden and Longyearbyen regions on Spitsbergen Island. Infrastructure services such as electricity, water, food facilities, accommodation, air and sea transportation to Ny-Alesund stations are provided by the Kings Bay company (Bryhn, 2016). Researchers from twenty different countries can carry out their studies at the scientific research stations of 12 countries in the region. Figure 3 shows these stations' locations with the names of operating countries. While there are 150-180 scientist in the region in June and August, this number drops down to 40-60 people in the spring and winter months (INTER-ACT, 2017).

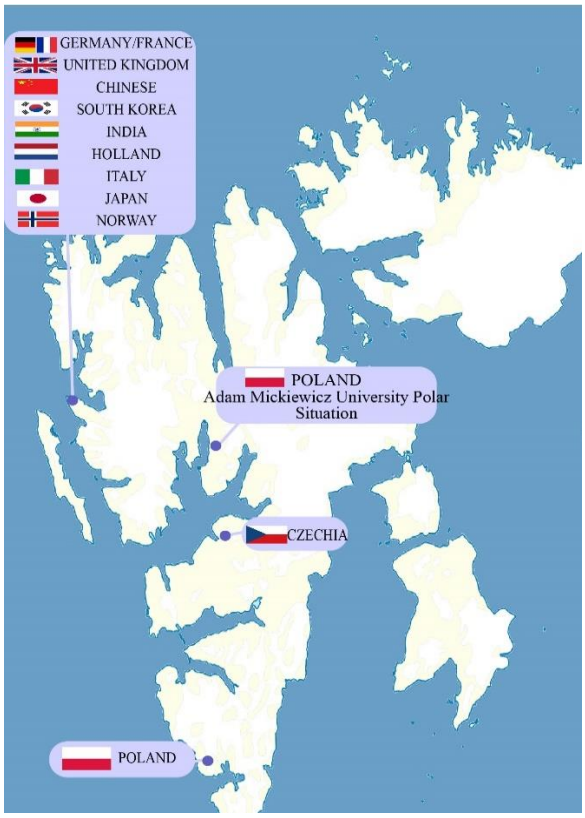

Fig. 3. Research Stations in Svalbard Archipelago.

Scientific Research Stations

List of scientific research stations belonging to 12 different countries in the Svalbard Region are listed below and Figure 4 shows the chronological list of the scientific research stations that established in Spitsbergen.

- AWIPEV Arctic Research Station,
- CNR Arctic Station "Dirigibile Italia",
- Ny-Alesund Research Station- NPI Sverdrup,
- UK Arctic Research Station,
- Netherland's Arctic Station,
- AMUPS Perunabukta,
- Czech Arctic Research Station,
- Hornsund Poland Station,
- South Korea Dasan,
- Japan National Institute of Polar Studies,
- India Himadri
- China Yellow River Station

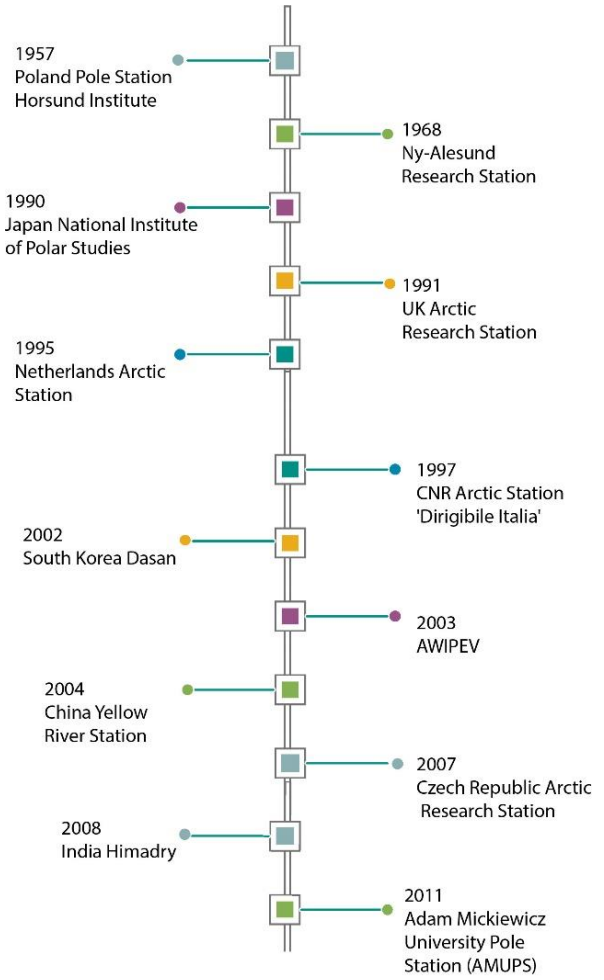

Fig. 3. Time sequence of stations.

The AWIPEV scientific research station in the partnership of Germany / France has been operating in Ny-Ålesun since 2003. Marine, land and glacial science and permafrost are studying in terms of geology at the station. There is no permanent activity at the station (Stolpmann, et al., 2021; Wunder, et al., 2021; Schlager, et al., 2021).

CNR Arctic Station named 'Dirigibile Italia', which belongs to Italy, has been carrying out various studies in the Ny-Ålesund region since 1997. In terms of geology, permafrost, biogeochemistry, remote sensing and climate issues are focused at the station in terms of geology. (Doveri et al.; Cianfarra, Salvini, 2016).
Norwegian station, "Ny-Ålesund Research Station – NPI Sverdrup" since 1968, marine, land and glacial science and environmental observation of the region have been carried out as geological studies in Ny-Ålesund (INTERACT, 2020).

The UK-owned Arctic Research Station has been located in the Ny-Ålesund region since 1991. The

geological topics at the station are geomorphology, hydrology and glacial/periglacial studies (Arctic Office, 2021).

The Netherlands' Arctic Station has been located in Ny-Ålesund since 1995. They mostly work on the food chain, the harm of herbivores-predators to the environment, social and humanity sciences (INTERACT, 2020).

Polar Station of Adam Mickiewicz University (AMUPS) "Petuniabukta", which belongs to Poland, has been operating in the Pyramiden region since 2011. In terms of geology, it deals with permafrost, ice science, hydrology, geomorphology and geochemistry (Bednorz and Kolendowicz, 2010; Dragon and Marciniak, 2010; Gibas, et al., 2005).
Another Polish Polar Station has been operated by the Hornsund Institute since 1957 and is located in the Hornsund region to the southern side of the island of Spitsbergen. As geology; glacial science, geophysical monitoring, permofrost, geomorphology, geomagnetism, marine and land geophysics are studied (Hornsund Polska Stacja Polaarna, 2014).

Czech Republic's Arctic Research Station has been located in the Longyearbyen region since 2007. Geology study topics include geomorphology, hydrology, interdisciplinary bioclimatology and ecology (Centre for Polar Ecology, 2013).

Consisting of archipelagos, Svalbard has made a great contribution to the literature in numerous geological studies carried out so far. In general, glacial science, marine geology, geomorphology, microbial ecology, permafrost, biogeochemistry and geochemistry are the main scientific areas (INTERACT, 2020; Ny-Alesund Science Managers Committee).

Science Town: Ny-Ålesund

Ny-Ålesund, considered to be the northernmost science town in the world, is a settlement built entirely for scientific purposes. Ny-Ålesund was primarily a coal mining town from 1916 to 1962. After 1962, coal-mining activities almost ended and the region turned into a research center. Infrastructure in the region is provided by Kings Bay Company and active scientific studies continue. 25% of research activities in the Svalbard archipelago are conducted here (Ny-Ålesund Research Station, 2019).

Ny-Ålesund is a radio silent area with a long-term goal to further reduce emissions of electromagnetic pollution. Some important sensing devices, such as the VLBI radio telescopes at Norway's geodetic laboratory, need radio silence to function optimally. For this reason, an application must be made to the National Communications Authority for the technology used between 2 GHz-32 GHz frequencies within a radius of 20 km from Ny-Ålesund (Ny-Ålesund Research Station, 2019).

Furthermore, there are laboratories open to common sharing in the region. These are: marine laboratory, Airship observatory, climate change tower, Vaskeri laboratory, MS Teisten (scientific research vessel), terrestrial laboratory (Veksthuset) and photosensitive cabin. Geology, marine geology and biogeochemistry are also studied in the laboratories.

UNIS: The University

Svalbard University Center (UNIS), located in Longyearbyen, opened in 2006. Next to the 12,000 m^2 center there is also the Svalbard Museum, the Norwegian Polar Institute's Svalbard office, the SIOS (Svalbard Integrated Arctic Earth Observation System) and the Svalbard Science Forum. Svalbard University Center provides undergraduate and postgraduate education. According to UNIS 2021, the center conducts studies in the fields of Arctic Biology, Arctic Geology, Arctic Geophysics and Arctic Technology with additional various course opportunities.

According to UNIS 2021 data 50% Norwegian and 50% international staff work at the university center. Currently, 48 professors, 15 associate professors and nearly 160 guest lecturers are actively working on Arctic subjects. In addition, according to 2019 data, nearly 750 students from 43 countries participated in the courses at the center.

Geological research at the center is divided into three main branches: Arctic Basins, Quaternary and Cryosphere. The rich geological history of the Svalbard region makes it possible to study many diverse subjects. For instance, geology, structural geology, geomorphology, sedimentology, geochemistry and geobiochemistry to name a few. In addition, the location of the center provides unique opportunities to monitor to global climate change. Researches on marine and terrestrial current sediments also provide opportunities for issues such as sea level, glaciation and climate. There is also the opportunity to work in oil exploration fields in the region (Kalinowska, et al., 2020; Hodson, et al., 2020; Marchenko, 2014).

Geological Science Strategies

Svalbard, the northernmost piece of land in the Arctic Ocean, where the most scientific studies are carried out, even the science town is located, is an important region in terms of geology. Consisting of archipelagos, Svalbard came under the sovereignty of Norway with the Treaty of Svalbard signed on February 9, 1920, and opened the door to scientific research to other countries. The region is open to studies in almost all fields, especially mining in terms of geology.
Strategy is the policies determined in line with the main objectives (Sağbansua and Biskek, 2006). As Sun Tzu states in his book The Art of War, mentioned that a person could achieve success with good strategy and different policies. These policies include geopolitical, tourism, industrial, environmental, technological and scientific studies (Pedersen, 2021). The Polar Regions are important for the strategic ambitions of many

different countries. In this direction, various studies and collaborations, especially scientific research, are carried out by the member states of the Arctic Council in the North Pole region and the Antarctic Treaty in the South Pole Region (Arctic Council; Antarctic Treaty). States such as the USA and Russia, which are important powers, recently have been making strategic plans in this region (Shubin, 2020; Calik, 2021). Ostreng, in his 2010 study, summarized the six most important geopolitical features of the AR as the location of the AR, its role in global climate change, sea routes, industrial resources, ecosystem and compliance with international conventions. In addition, new sea routes opened as a result of melting sea ice under the effects of global climate change increase the geopolitical importance of the AR (Squire and Dodds, 2020; Canturk and Atvur, 2021). Apart from military and political strategies, scientific studies also have an important place for the Arctic (IASC, 2018).

There are many institutions, organizations and communities in the AR that are interested in scientific polar research and planning long-term strategies. According to data retrieved from Arctic Portal, some of these were the Arctic Council, APECS (Society of polar early career scientists), the Arctic Energy Summit, Edu-Arctic (Arctic research of STEM education to include students through), IASC (International Arctic Science Council) inter-act (International Arctic Terrestrial research and monitoring network), ARTICLE (Svalbard Integrated Arctic Earth Observing System), UNIS (University Centre in Svalbard) and the UArctic (University of the Arctic).

The European Union (EU) operates research especially in the AR in terms of studying global climate change. Considering the geological plans of the EU, it has a detailed investigation of the permafrost event and its environmental degradation. Geospatial analyzes are carried out with the EU Satellite Center (SatCen). In line with these analyzes, data on subjects such as environment, weather, ice, biology and maritime can be obtained. In addition to these issues, thanks to the Copernicus Emergency Management Service of the EU, it provides early warning and mapping opportunities by detecting disasters in the region beforehand. The EU is currently engaged in mining activities in the AR. In addition, it supports policies for the safe use, recycling, disposal and recovery of raw materials from mining and operational wastes and other secondary sources (European Commission, 2021).

Turkey, on the other hand, carried out the first National Arctic Scientific Expedition (TASE-I), which started in the Svalbard Region in 2019 and extended to 81°North latitude in the Arctic Ocean, under the coordination of Istanbul Technical University Polar Research Center. During the expedition, 15 different projects were completed, from marine sciences, atmospheric studies to social sciences and environmental sciences. As part of the expedition, scientific research stations of countries such as Norway, South Korea, Poland, and India were visited, and it was also aimed to develop bilateral cooperation in scientific terms for the future field operations (Bilim Teknik, 2019).

Fig. 4. Arctic Council member states and observers.

Arctic Council

The Arctic Council consists of Arctic states, permanent participants, observers and working groups (Arctic Portal, 2021). Eight states bordering the Arctic Ocean: Canada, the Kingdom of Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden and the United States. In addition to these states, there are 13 countries in observer status: Germany, United Kingdom, Netherlands, Poland, France, Spain, China, South Korea, India, Italy, Japan, Singapore, Switzerland (Arctic Council, 2021). Both Arctic States and observers showed in Figure 5. According to the

2021-2030 Arctic Council Strategic plan, it is aimed to be united as a global power for the Arctic climate, to reduce greenhouse gases and pollutants (Arctic Council Strategic Plan 2021-2030, 2021). In this direction, they planned to prevent global climate change by reducing the amount of emissions. In addition, it maintains the current status of Arctic ecosystems and promotes the conservation of biodiversity in a sustainable way. It enables cooperation to prevent marine pollution by protecting the Arctic Ocean and its environment (Arctic Council, 2021).

Its six permanent members are: Arctic Athabaskan Council, Aleutian International Union, Greenwich International Council, Inuit Environmental Council, North Russian Arctic Indigenous Peoples and Saami Council. There are also observers: non-Arctic states, intergovernmental and inter-parliamentary organizations. Working groups of the Arctic Council: Arctic Pollutants Action Programme, Arctic Monitoring and Evaluation Program, Conservation of Arctic Flora and Fauna, Emergency Prevention – Preparedness – Combat, Arctic Marine Environment Protection and Sustainable Development Working Group. These working groups also study topics such as interdisciplinary geobiology, pollution sources and climate change (Arctic Council, 2021).

Since the region is rich in energy resources, geological activities are also carried out in the council countries under the name of the energy sector. Among these activities, mining activities are at the forefront. With the extraction of various metals, oil exploration studies are carried out in the ocean and on land (Kurt, 2021; Stauffer, 2009). The amount of oil is 1732,4 thousand barrels in the world in 2020 (Bp, 2021). According to studies, 41% of the oil resources in the AR belong to Russia, 28% to Alaska, 18% to Greenland, 9% to Canada and 4% to Norway (Lindholt and Glomsrød, 2011). The potential of the region is also high in terms of renewable energy sources. Moreover, hydroelectric and geothermal energy enables geological studies (Energy Portlet).

International Arctic Science Council (IASC)

The International Arctic Science Council (IASC) was established in 1990 by representatives of eight Arctic countries. It has regularly taken its place as an international science organization in the AR. Today, it conducts research in the AR with at least 23 countries (The International Arctic Science Committee, 2015). It includes research in many different branches of science that has the potential to be done in the AR. The main themes of these researches in scientific studies were brought together under five headings: Atmosphere, cryosphere, marine, terrestrial and social-humanity. It has been observed that many geological surveys have been carried out in the study groups under these five headings. From a geological perspective, the marine studies focus on the understanding of geochemical processes in the Arctic Ocean and Sub-arctic Seas, and the development and improvement of access to the paleo record of the Arctic Ocean through scientific drilling technique. When looking at terrestrial studies, those following are studied; examining the current state of Arctic terrestrial geosystems and ecosystems at multiple spatial scales, investigating past changes in Arctic geobiological diversity, measuring current change and predicting future changes, using high spatial resolution models of terrestrial geosystem and ecosystem change and adaptation strategies and naturalization strategies by Arctic stakeholders. The development of other tools that can be used for the sustainable management of resources and ecosystem services, and the study of the functioning of Arctic terrestrial systems, including the connections within the Arctic-global system, are discussed in geological perspective. In addition, interdisciplinary studies are being conducted on how the decreasing ice cover will affect the carbon cycle in the Arctic and what are the consequences it might cause, and how changes in the hydrological cycle will affect various components of the Arctic system (IASC, 2021). Also, the IASC is dedicated to scientists, young career researchers, technicians, etc. for the Arctic climate system. It provides a communication network among science stakeholders. A MOSAiC (Multidisciplinary Observatory for the Study of Arctic Climate) training program established for young researchers, providing extensive environmental research opportunities in many branches of science and especially in geology (IASC, 2021).

Norway

The NPI, founded on March 7, 1928, is now an institution under the Ministry of Climate and Environment. Its main research area is both Arctic and Antarctic Regions. The institute conducts research on biodiversity, geological mapping, climate, pollutants, etc. especially for Arctic. With the Svalbard Treaty, especially geological and topographical researches in and around Svalbard gained importance (Norwegian Polar Institute, 2021). At its stations located in Svalbard in the North, geological mapping, glacial science, atmospheric science, marine geology and bedrock geology were studied in particular. The institute continuous its geological research projects (NPI, 2021).

The Treaty of Svalbard was signed in Paris on February 9, 1920, between the countries; Norway, the United States, Denmark, France, Italy, Japan, the Netherlands, Great Britain, Ireland, and the British Overseas Dominions and Sweden. According to Article 1 of the Treaty, Bear Island and North Spitsbergen Island, Northeast Land Island, Barents Island, Edge Island, Wiche Islands, Hope Island and Prince Charles Foreland Island along with other smaller islands in the Spitsbergen Archipelago are under the sovereignty of Norway. In line with the framework of the treaty, scientific studies are carried out on these islands within the rules determined by various institutions of Norway.
The Norwegian Research Council is the funding agency for scientific research, was established in 1993 (The Research Council of Norway, 2021). The Svalbard Integrated Arctic Earth Observation System

(SIOS) was launched in 2008 to establish the SIOS Information Center funded by the Norwegian Research Council. The SIOS Remote Sensing Service (RSS) provides researchers with satellite data for Svalbard. This opportunity provides a great contribution to geology. It provides the opportunity to work remotely on topics such as geological mapping, oil exploration, geochemical factors (Svalbard Integrated Arctic Earth Observing System, 2021).

The Svalbard Science Forum (SSF), coordinated by the Norwegian Research Council, organizes research activities in the Svalbard region, providing cooperation between both institutions and researchers (Svalbard Science Forum, 2021). The Svalbard Strategic Grant (SSG) program runs workshop funded by the Norwegian Research Council (RCN) and affiliated with the SSF. Scientific studies are actively supported by these platforms at stations located in Ny-Ålesund, Hornsund, Longyearbyen and Barentsburg. In terms of geology, glaciology, seismology, environment etc. topics are main working themes. It has also been being operating in Barentsburg since 1962 with the Polar Marine Geological Survey Expedition (PMGRE) (Svalbard Science Forum, 2021).

The Svalbard Research Database (RIS) is an international platform by Norway for building research infrastructures in Svalbard. It allows researchers to work interdisciplinary and encourages the study of geology subjects with other disciplines (Research in Svalbard Database, 2021).

Suggestions and Outcomes

The aim of the presented study here is to review geological studies, scientific infrastructures and the interest of various international organizations, which have been studied in Svalbard since the 1900s. It is important that Turkey should take a leading role, particularly in scientific research including and prioritizing earth sciences in the Svalbard archipelago by developing bilateral cooperation with Norway within the scope of polar research studies. Some suggestions within the context are presented below:

- To develop and applicate the National Polar Science Program in AR, especially the geological research in Svalbard should be added.
- Focusing on underrepresented research areas of Svalbard that Turkey will carry out in the AR,
- Encouraging the participation of Turkish scientists and university students to educational programs in the Svalbard Region.
- Establishing bilateral cooperation with the countries of the region in order to take part in new studies that can be completed in the AR, since the increasing glacier meltdowns provide opportunities to access to unexplored regions.
- Facilitating scientific research and access to the region for Turkish researchers by ensuring that Turkey becomes a party to the Svalbard Treaty.
- Creating a scientific memory about the region by conducting scientific studies at points of geopolitical importance, as countries are eyeing the polar regions due to the increasing energy needs and decreasing natural resources in the world.
- Polar Research Institute in Turkey should develop close relations with other institute such as NPI to work bilateral projects on the island.

Conclusion

AR; Its role in global climate change, newly opened maritime sea routes, unexploited industrial resources, unique polar ecosystem and international geopolitical balance is a strategic area that attracts the attention of many countries. Especially countries such as America, Russia and England are making significant investments to this region. In this direction, especially in the AR, the Arctic Council carries out various studies and international cooperation, particularly interdisciplinary scientific research. Apart from the council, many institutions, organizations and societies also come to the AR to conduct scientific studies. When these studies are examined from a geological point of view, it is seen that they are classified as glacial science, marine geology, geomorphology, microbial ecology, permafrost, biogeochemistry and geochemistry.

As sum up from the geological view of Svalbard showed that the archipelago was formed by the combination of different rock complexes under the influence of the 400-million-year-old Caledonian mountain range. The main rock of the region was formed by the alteration of the mountains formed by the Caledonian Orogeny and Devonian aged magmatic and metamorphic rocks. Its sedimentary structure consists of coarse sand, pebbles and mudstones from the Devonian period. Quaternary aged unconsolidated sediments, moraines, fluvial deposits and coastal deposits are also observed. Active volcanism are still monitored in the northwestern part of Svalbard, where glaciers are located.

In line with the geological importance of Svalbard, many institutions present scientific infrastructures such as educational studies, science strategies, international projects. Svalbard University Center (UNIS), educational institutions like many universities of northern countries, accepts students and researchers from different countries and makes a great contribution to the geological research of Svalbard. Educational institutions accept students and researchers from different countries and contribute greatly to the geological research of Svalbard. In addition, important organizations such as the Arctic Council also provide many different funds for these scientific studies.
The geological structure, geological infrastructure and science strategy of geological researches of the Svalbard Region are presented here. It is vital that

Turkey should join geological studies for the future researches in the archipelago with bilateral collaborations.

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