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Cover photo, front: An impressing boulder from Syros, Greece. Photo by: Mikaela Krona.
Cover photo, back: A signpost from Bergslagen. Photo by: Mikaela Krona.

In this volume

Winter is coming

*Mikaela Krona**

The fall has flown by and here we stand, in the cold and the snow. Despite the darkness, it is a cheerful time of the year when everyone lights up their homes with candles, lights and listens to Christmas music.

During the fall, the Geology club hosted an excursion with Paul Evins, senior geologist at WSP, who guided us through Stockholm geology with an excursion around Brunnsviken. The excursion was a great success with beautiful weather and a large attendance. We hope to take this momentum into next year and offer more excursions. We can already hint that the building stone excursion with Joakim Mansfeld will be held in early spring. More information will come after New years.

If you have ideas or proposals about future excursions or development of Berg & Dalbladet, don't hesitate to contact us. Send us an email or grab us when you see us walking about in the building.

In January, Geologklubben has a tradition to celebrate Robert Burns. He was a Scottish poet which is very famous for his work which includes the poem and song Auld lang syne". In his memory we will celebrate with ceilidh and haggis. Burn's night is The event of the year so keep your eye out for details that will come after the holidays.

Finally, we from the board of Geologklubben would like to thank all of you for celebrating our 130th jubilee with us. Throughout the years, many Earth scientists at Stockholm university has been part of the club. We hope for your continuous support in the future.

The board wishes you all a Merry Christmas and Happy New Year!

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Fig. 1: Winter.

Introducing the board of Geologklubben

Front left to right:
Robert, Elise, Mikaela,
Mattias, Celine,
Sandra.

Window left to right:
Gustaf, Voula,
Vicent, Bella.

A trip back in time: A glimpse into the Cycladic Blueschist Units of Syros in Greece

*Celine Golda**

After a breathtaking journey over the Mediterranean Sea, the Geodynamics Masters class arrived on Syros the 30th of September 2022. Our aim was to understand the metamorphic and tectonic relationships of the Cycladic Blueschist Unit within the Hellenic Subduction System through field mapping along 3 coastal sections guided by Prof. Uwe Ring and Alexandre Peillod. Uwe had advised us not to check in our luggage but I thought it was worth it, considering the number of rocks that I planned to bring home. Once we arrived in Piraeus, we had a few minutes to spare to meet up with the rest of our team and hop onto our ferry to Syros, where we could finally relax in the sea breeze with an astonishing view

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Fig. 1: Admiring the rocks.

of the surrounding Greek archipelago.

The first day in the field was mainly allocated to an introduction by Uwe of the region's tectonic and metamorphic history, and the related lithologies as well as understanding how to describe deformation structures and shear sense indicators. On Syros, the high-pressure metamorphic rocks are linked to subduction of the Cycladic Blueschist Unit in the Hellenic Orogen and represent the most deeply exhumed rocks of the Hellenides.

These metamorphic rocks range from low-grade greenschist- to blueschist- and eclogite facies. Very few of us had seen such well preserved, rich blue and green metamorphic rocks before. Some contained pristine garnets, green omphacite and blue glaucophane, while other rocks showed clear alterations from exhumation, such as chloritized garnets and epidotes with unusual structures. The rocks were characterized by strong tectonic and metamorphic imprints. These features makes the Cycladic Blueschist Unit a perfect study subject in geodynamics.

After the introduction, we were divided into groups of 2 where we carefully mapped the boundaries of the lithologies, taking note of any mineral alterations to determine whether the rocks have undergone any retrograde metamorphism. Moreover, to understand the tectonic history and timing of exhumation of the different rock types, we collected data on various shear sense indicators such as sigma shears in garnets and xenoliths as well as shear fabrics. These give an insight into the evolution of the Hellenic orogen by preserving different deformational imprints, representing different stages of the mountain-building event.

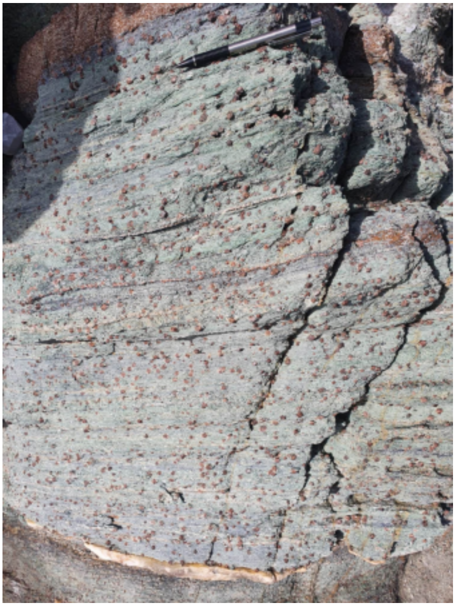

Fig. 2: The layered blueschist/eclogite unit.

We would occasionally cool off with a swim in the Mediterranean to view the geological structures from afar. After the long mapping days, we would all get together to explore the old town in Syros, enjoying traditional music performances, wild cats fishing for food, and the authentic Greek cuisine awaiting the sunset.

Is white Norrland our green future?

*Robert Dunst**

The green future of Sweden and Europe lies in the white forests of Norrland, at least if we believe the representatives of the mining and energy industry in northern Sweden. During a PhD workshop organised by the Swedish Mining Innovation, I had the opportunity to talk to investors and visionaries and to see the gigantic construction site where one of the world's largest battery factories is thrown up in the forest. When we arrived at the Northvolt Ett site in a bus with our group of international PhD students, the sun was just rising and the forest was covered in snow, but what we were looking for was the clearing, which is about 71 football fields in size. The construction site is far too big to see from the ground, but you get a feel for it when you drive past huge halls and endless car parks for several minutes.

According to Markus Gustafsson, co-founder and CEO of MindDig, the recent industrial boom in northern Sweden that led to this facility started with a pissing contest between some influential men in the industry and public sector fighting for the lead in the new green industry, and this facility feels exactly like the result of such a game. Northvolt's statements are bold, they want to produce 60GWh in this factory in Skellefteå, enough to supply large European car manufacturers with lithium-ion batteries for their new electric vehicles. However, it is not the only very ambitious project in this region of Sweden, which has been marked by emigration and brain drain for decades. Another project is H2 Green Steel, which is currently building a large-scale production facility for steel with a very low carbon footprint in Boden. This is expected to produce five million tonnes of steel by 2030[1] (compared to 4.7 million tonnes produced across Sweden in 2021[2]).

One of the main reasons why these large investments are being made in northern Sweden is the abundance of cheap hydroelectric power. But the relative proximity of mining and metal industries is also attractive for these industrial projects. Northern Sweden is now one of Europe's largest metal producers, with large mines such as the Kiruna iron mine and the Aitik copper mine, but also steel and copper production facilities (e.g. SSAB Luleå & Boliden Rönnskär). Therefore, from a technical point of view, it makes sense to build large industrial plants here that can produce in an environmentally and economically sustainable way on a large scale.

However, the biggest challenge for these development plans is not infrastructure, financing or environmental issues, but the people. To run these industries here, tens of thousands will have to move in over the next few years. Maybe even 100,000 in

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Fig. 1: Sign at the Northvolt Ett battery factory showing numbers and plans of the green future which is being built here.

the next ten years, as MindDig puts it as a target (MindDig is a company that promotes and arranges jobs in northern Sweden). These numbers are enormous, especially when you consider that by far the largest city in this region has 50,000 inhabitants (Luleå). The really critical question is therefore: Can this be done in a socially sustainable way?

Proponents of these projects point to Norrland's history where large groups of workers already moved to new cities a century ago and that this should be seen as an opportunity for the region. But the social impact of such large population moves cannot be engineered. And to change societies in such a drastic way commonly leads to resistance and protests. The engineers see it as a problem that the people here are not welcoming enough and want to get them to change and anegage in the development. That may or may not work, but one reason for the scepticism is the history of the local population, which has created a deep mistrust of people from southern Sweden. On of the reasons for that is what happened in the 20th century when the Swedish state tried to assimilate the indigenous population in northern Sweden and resettle them in the south[3]. This scepticism towards new developments emanating from the southern Swedish population is evident not least in the movements against mines and wind power in northern Sweden. But we will see how it all develops.

[1] https://www.h2greensteel.com/our-locations

[2] https://www.jernkontoret.se/en/the-steel-industry/industry-facts-and-statistics/production/

[3] Daniel Fjellborg, personal communication, November 10, 2022

Neogloboquadrina pachyderma - A true polar extremist

Tirza Weitkamp *

I'm Tirza, a second year PhD student in Marine Geology at IGV and I was asked to write about the project I'm working on at the moment! My PhD projects focus on planktonic foraminifera fossils and little did I know when starting my PhD how invested I'd become in a single species. Planktonic foraminifera fossils are tiny (50-500µm) calcite shells made by unicellular marine protists and accumulate on the seafloor throughout time, their fossil record goes all the way back to the Jurassic (ca. 180 million years ago). Because of their widespread distribution and long fossil record, planktonic foraminifera are extremely useful in reconstructing past climates and oceanographic conditions (palaeoceanography).

About 50 species live in the oceans nowadays, from the tropics to the poles. Modern planktonic foraminifera assemblages in the high latitudes are dominated by only one species, Neogloboquadrina pachyderma. N. pachyderma is considered to be a polar extremist and the only true polar planktonic foraminifera that can tolerate intensive sea ice conditions and cold waters reaching near-freezing temperatures, with abundances exceeding 90% in many high southern and high northern latitude regions. A great example of how specialised this species is, is seen in Antarctic N. pachyderma that can feed and grow whilst overwintering in sea ice brine channels. This behaviour has not yet been seen in their Arctic counterpart.

N. pachyderma evolved from Paragloborotalia continuosa in the late Miocene, about 9.37 million years ago. However, it has not always been a polar extremist. One of the questions regarding this species is when it became a polar extremist and when it invaded the polar regions. The climate during the Miocene (23 – 5 million years ago) was relatively warm compared to nowadays. Towards the end of the Miocene global cooling led to the Pleistocene glacial-interglacial cycles, accompanied by big ice sheet formation in the Arctic and Antarctic regions. One hypothesis is that N. pachyderma became a true Arctic specialist during the last 1.3 million years when glacial periods became more intense in the Northern Hemisphere.

So, one goal of my PhD is to answer the question when N. pachyderma invaded the Arctic Ocean. I'm currently working on deep sea sediments collected from Deep Sea Drilling Project (DSDP) Site 407, located near southwest Iceland, to track the evolution of this species and its ancestor throughout roughly the past 20 million years. The youngest sample is from the Quaterna-

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ry and was collected at 0.57 meters below seafloor, whereas the oldest sample is from the late Oligocene (ca. 24 million years) and was collected at a depth of 329.5 meters below the seafloor.

Another exciting aspect of N. pachyderma is its wide range in morphologies. For example, modern Arctic specimens have 5 different morphotypes, whereas this variability becomes less throughout the Pliocene and Miocene as can be seen in Figure 1. Tracking these different morphotypes is also a goal of my PhD, such as figuring out when the 5 modern morphotypes evolved and how much they differ from their older counterparts. Answering these questions is important since palaeoceanographic reconstructions in high latitudes are based on this single species, so it's crucial to understand how and when N. pachyderma began to occupy the polar environment. Stay tuned to learn more about the evolution of this interesting polar specialist!

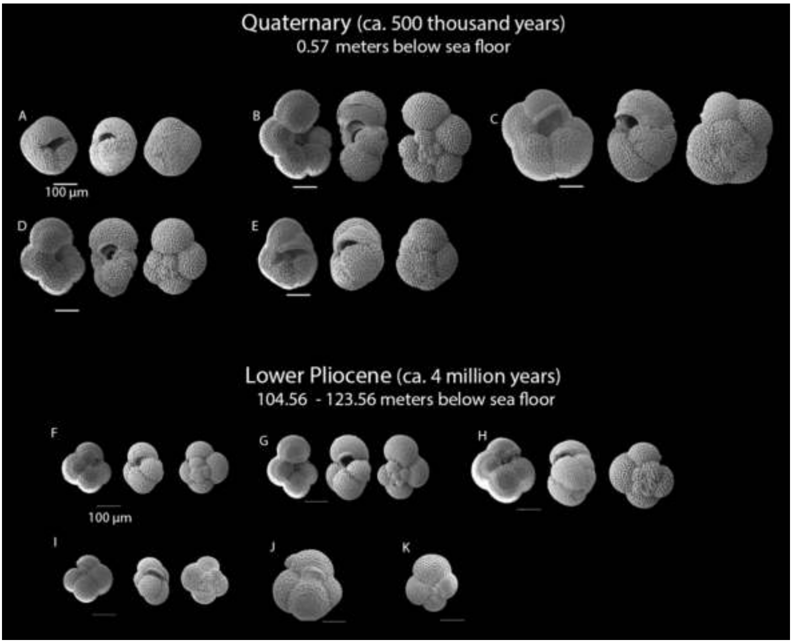

Fig. 1: Scanning electron microscope images of Quaternary (A-E) and lower Pliocene (F-K) N. pachyderma showing the range in morphology throughout time. Scale bars are 100µm.

Stockholm geology in Brunnsviken

Robert Dunst *

On 12 November we went on an excursion to Lake Brunnsviken with the Geology Club. We were lucky to have Paul Evins as our guide, who gave us an understanding of Stockholm's geology and sparked our interest in structural- and applied- geology.

Paul Evins is a geological consultant at WSP in Stockholm and until this year was a lecturer for two very popular master courses in applied geology at SU. His background is in structural geology in North America, but he has also worked in Australia, mapping bedrock for the geological survay, among other things. For the last 10 years he has been involved in geotechnical planning and monitoring of structures in the Stockholm bedrock and is now one of the most knowledgeable experts on Stockholm's geology.

On this very sunny and exceptionally warm Saturday, more than 30 members of the Geology Club gathered. Paul Evins started the excursion with a fast run through Sweden's, Bergslagen's and Stockholm's geological history. He started with plate tectonics 2 billion years ago, which formed the basis for the formation of the crust that gave rise to Stockholm's sedimentary, volcanic and igneous rocks, and ended with a very practical definition of the different types of gneiss using hand samples.

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After this very interesting and dense introduction, there was some time for discussion and Joakim Mansfeld, another great expert of Stockholm geology, helped to explain some concepts to people who were new to the area. We started our walk in the Japanese Garden, where we looked at an orthogneiss, then we walked west along the coast, looking at joints, fracture zones and changes in the rock. On the Italian terrace we looked at the very typical and perhaps boring Stockholm granite.

Further along the way, Paul Evins pointed out some glacial landforms (Roche moutonnée) and we entered an area dominated by sedimentary gneiss. In these sedimentary gneisses nicely exposed at shore and illuminated by the evening sun we looked at the gradation from meta- to diatexitic gneisses. We also saw some examples of beautiful cauliflower texture feldspars in a diatexitic gneiss. At Lilla Frescati beach we found some large (>2cm) pink garnets in the sedimentary gneiss, from where we drove back to the university.

At Roslagsbanan Bridge Paul showed us some typical amphibolites and explained that when taking out rocks close to sensitive constructions (such as roads or buildings), the rocks are often drilled instead of blasted. A very educative stroll around Brunnsviken, to say the least!

Fig. 1: Pictures from the excursion which was held by Paul Evins.

Deep continental subduction in the Western Alps

*Mattias Barkelius**

The metamorphic history of a rock unit is most often described by the pressure and temperature conditions the rock experienced during metamorphism. As the rock gets buried, pressure and temperature increase, which causes reactions to take place in the rock, lower grade minerals being successively replaced by higher grade minerals. The assemblage of minerals that form when the rock reaches its maximum burial depth is called the peak assemblage, and it is characteristic for the pressure and temperature it formed at. When the rock is exhumed (returned towards the surface), the reversed mineral reactions can take place if the rock is supplied with fluids like water and CO_2.

The Alpine belt is a classical high-pressure orogen characterized by metamorphism under blueschist- and eclogite facies conditions. The Dora-Maira Massif of the Western Alps is home to some of the highest-pressure rocks known in the Alps, including coesite-bearing rocks of the Brosasco Isasca Unit. Coesite is the ultra-high-pressure polymorph of quartz and the reaction between the two minerals defines the transition into ultra-high-pressure metamorphism. For my bachelor project, I was tasked with estimating the peak pressure and temperature conditions of the Muret Unit of the Dora-Maira Massif, Western Alps, since there was no previous estimate. I got to study a garnet-chloritoid bearing mica-schist, a mineral assemblage indicative of high-pressure metamorphism of a sedimentary protolith, but just how high?

This question was answered by first, using optical microscopy to describe thin sections, which included identifying minerals, rock textures and evidence of mineral reactions (fig. 1). Secondly, by measuring chemical compositions using X-ray fluorescence and electron microprobe analysis. Thirdly, by calculating pressure and temperature conditions during metamorphism, using the measured chemical data and thermodynamic modelling.

Peak pressure and temperature conditions were constrained by observed mineral assemblage, garnet end-member compositions and silica content of muscovite, to 510-530 °C and 22-26 kbar. These data suggest that the Muret Unit almost reached ultra-high-pressure conditions (quartz/coesite reaction at 28 kbar) and a calculated maximum burial depth of 66-78 km. Future work involving dating of metamorphic stages will allow for the calculation of exhumation rates, a requirement for the establishment of a geodynamic model explaining continental subduction and exhumation in the Muret Unit.

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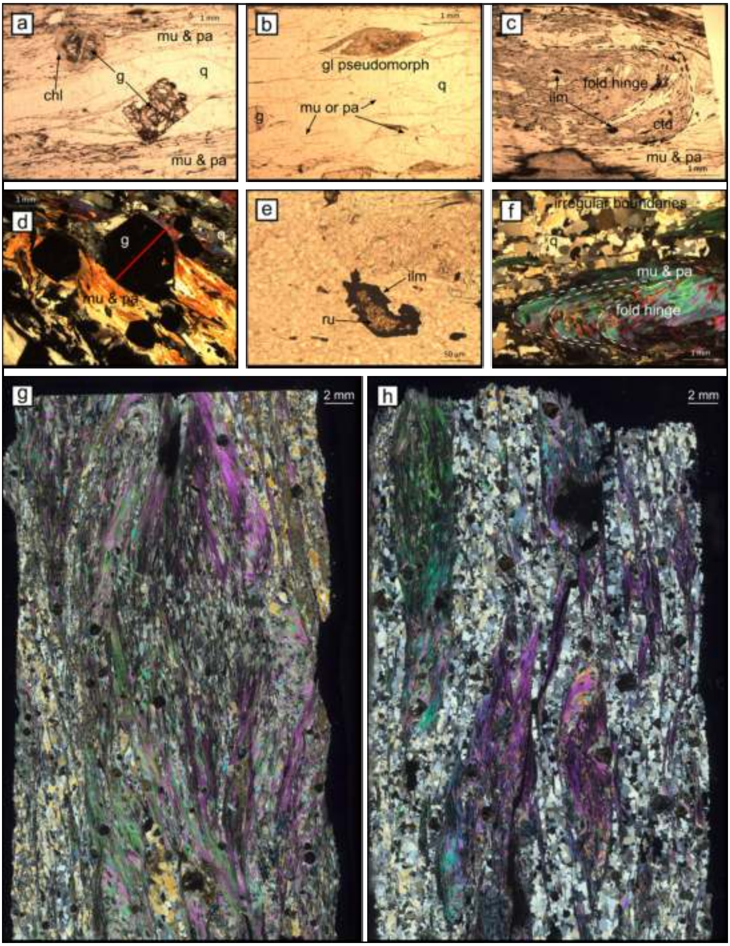

Fig. 1: Photomicrographs of thin sections, a, b, c and e are in plane polarized light while d, f, g and h are in cross polarized light. (a) Subhedral to anhedral garnet porphyroblasts replaced to a varying degree by chlorite. (b) Pseudomorphed glaucophane porphyroblast. (c) Chloritoid and white mica oriented along a fold hinge. (d) Euhedral garnet porphyroblasts with almost no inclusions. White mica wraps around the garnet. (e) Rutile being replaced by ilmenite. (f) Quartz-quartz interlobate boundaries in quartz band. White mica oriented along a fold hinge in mica band. (g-h) Scan of thin sections, showing fold hinges defined by white mica and chloritoid (g) and alternating bands of quartz and white mica(h).

Dr Iain Pitcairn

Associate Professor in Ore Geology

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What is your research area?
I work on the formation of ore deposits with specific focus on identifying where the metals and fluids that form ore deposits come from. Many people work on the deposits themselves but few people work on the processes that produce the metal-rich ore forming fluids. I have spent a lot of time working on gold deposits that form in orogenic belts but I also work on other ore deposit types including Fe-oxide ore, REE bearing deposits. Working on ore deposits is excellent as one needs to understand many aspects of geology such as geochemistry, sedimentary, metamorphic, igneous petrology, volcanic processes, structural geology.

What made you choose geology?
I was always interested in mountains and have been a keen mountaineer and rock climber since I was about 11. At first I wanted to study geography but then luckily I learned that geology wasn't all about mud and oil and that if I wanted to study mountains then I should be a geologist. After an undergraduate degree in Edinburgh I did an MSc in Geochemistry in Leeds and it was here I got interested in the geochemistry of ore deposits and how metals get transported in hydrothermal fluids.

What courses do you teach?
I teach Ore geology Msc course, Ore forming processes BSc distance course, Field studies (Geological Mapping) MSc course and contribute to various other courses. I'm also in the process of writing an introductory level course on mineral resources and the green energy transition".

What are you working on right now?
I working on a project trying to identify the minerals that host gold in some Archean aged sedimentary rocks from Canada. We have found gold in the sulfide minerals which was expected but also found gold on mineral grain boundaries as micro or nano gold particles.

Tell us a non-geology fact about you!
I'm a rock climber.

What do you look forward to in 2023?
So many things! Continuing my research, doing field work, climbing, taking my kids to Scotland, kayaking. Life is good.

Fig. 1: Dr Iain Pitcairn.

Dr Carl-Magnus Mörth

Professor in Environmental geochemistry

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What is your research area?
Geochemistry and isotope geochemistry.

What made you choose geochemistry?
I was very interested in the environment and saw all the large scale environmental changes that the society did in the name of a ‘better’ world (and no worries about the future). These changes were regulating rivers, acid rain and contamination of the environment from mining and paper mills just to mention a few things.

What courses do you teach?
Isotope geology and geochemical modelling.

What are you working on right now?
Research wise for the moment I mostly work with carbon and DIC in aquatic systems and a little bit on sulfur isotopes (Icelandic rivers) and so called natural acidification in Jämtland. Climate change has increased the decay of organic matter and this has resulted in more ‘brown’ water which is acting as weak acid.

Tell us a non-geology fact about you!
I liked to fly fish for Atlantic salmon in Norway but do not that so much anymore. The salmon populations are declining and then it’s not so fun anymore. Now I stand up for migratory fish.

Fig. 1: The new mass spectrometer which can measure clumped isotopes.

What do you look forward to in 2023?
That we will find a way to take decisions that are environmental sustainable for a long period of time (not 4 years, i.e., the next election but over 100 years).

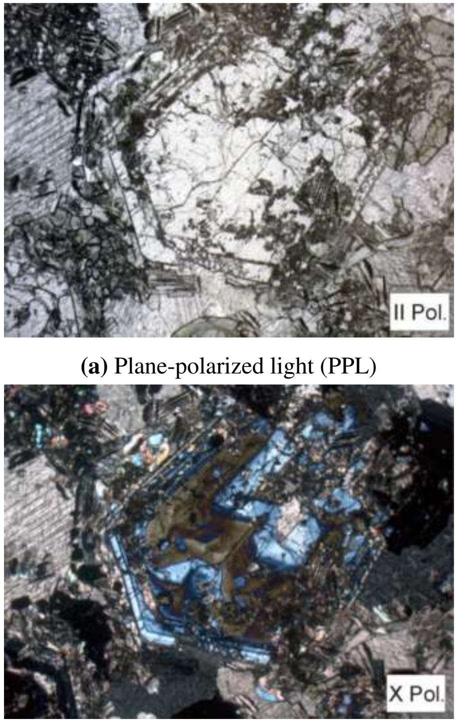
Featuring: Vesuvianite

$(Ca, Na)_{19}(Al, Mg, Fe)_{13}(SiO_4)_{10}(Si_2O_7)_4(OH, F, O)_{10}$

Named after Mount Vesuvius by the famous geologist Abraham Gottlob Werner in 1795, Vesuvianite is a accessory mineral commonly rich in calcium. It tends to form during contact metamorphism and hydrothermal alteration of carbonate rocks and can be found in rocks such as limestone, marble and skarn. Vesuvianite can either form massive clusters or occur as partial replacement of the country rock. It's often associatated with garnet, wollastonite (Ca-pyroxene) and diopside (Ca-Mg pyroxene).

In hand sample it is often green with a vitreous luster. However, since the composition of Vesuvianite is highly variable there are many color varieties. On the Mohs scale it has a hardness of 6-7, similar to quartz and it has a tetragonal crystal structure.

Fig. 1: Vesuvianite in hand sample.



(a) Plane-polarized light (PPL)

(b) Cross-polarized light (XPL)

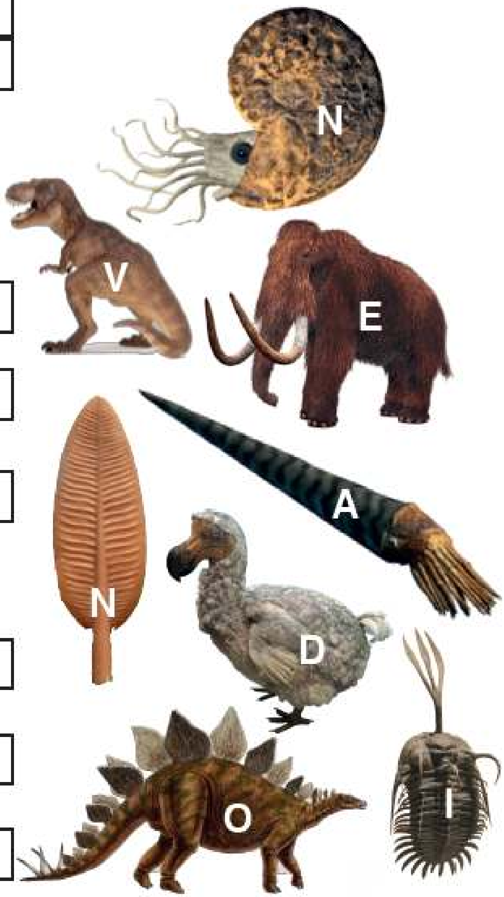
Fig. 2: Vesuvianite observed in an optical microscope.

Optical properties: Vesuvianite tend to form euhedral tetragonal crystals and has a high relief. In PPL it is colorless or green with slight pleochroism. In XPL, it shows first order interference colors with anomalous blue tones.

The fossils are lost!

Difficulty level: Aspiring paleontologist

Era	Ma	PERIOD	Match the species with the periods!
CENOZOIC	2.6	Quarternary	
	23	Neogene	
	66	Paleogene	
MESOZOIC	145	Cretaceous	
	201	Jurassic	
	252	Triassic	
PALEOZOIC	299	Permian	
	359	Carboniferous	
	419	Devonian	
	444	Silurian	
	485	Ordovician	
	538	Cambrian	
4‘600		Precambrian	



Get involved!

Submitting article to Berg & Dalbladet

Are you interested in submitting an article for the next volume of Berg & Dalbladet?

We accept all types of articles, as long as they are somehow related to Earth sciences. Your article may inform of new research findings, your abstract from your thesis, an anecdote from an excursion or about your own experience as a student, enthusiast or researcher. The article may be in English or Swedish and will be published in the language the author has submitted. Send your article to geologklubben@gmail.com and assign Berg & Dalbladetas subject.

We look forward to reading your submitted article!

Fig. 1: Geovetenskapens hus.

Join Geologklubben

An annual membership in Geologklubben costs 100SEK and by being a member you get four copies of Berg & Dalbladet per year emailed to you and free entrance to our excursions.

You can pay the membership fee via Swish to 0737043030 (Mikaela) or via Plusgiro: 40 29 33 - 6 (Geologklubben).

Alternatively, you can pay by cash to one of the board members.

Become a boardmember

Are you interested in joining the board of Geologklubben? We are always looking for new boardmembers! Geologklubben arranges excursions and activities for our members on a monthly basis. It does not matter if you are a geographer, petrologist, geomorphologist or a hydrologist, Geologklubben is open to anyone part of the Earth science community.

Contact the board

If you want to come into contact with the board, send us an email or a DM on Facebook or Instagram. You can also talk to us if you see us running around the building.

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List of figures

Finally, Geologklubben would like to thank all authors who have contributed with articles to this issue.

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