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Summary: The report describes the contents and purposes of the applied mineralogy exhibition at the Geological Survey of Norway (NGU) in Trondheim. The exhibition comprises 446 objects currently exhibited in the common room of the Mineral Resources Division of the Geological Survey. The exhibition is structured according to economic commodity classes: metal ores and minerals, industrial minerals, and energy minerals. The metal ores and minerals are subdivided into precious metals (Au and Ag), base metals (Fe, Pb, Cu, Mn, Zn, Co, Ni), and rare metals (Sn, W, Sc, Li, Cs, and Be). The exhibited industrial minerals include quartz, feldspars, graphite, olivine, kyanite, micas, apatite, diamond, garnet, calcite, dolomite, kaolinite, montmorillonite, sulphur, and Ti minerals (Ti minerals, such as ilmenite and rutile, are considered as industrial minerals even Ti is a metal). The energy minerals include U-Th minerals. In addition, crude oil and heavy water are exhibited together with the energy minerals.

The purposes of the exhibition are, firstly, to display representative samples mainly from Norwegian but also from some international metal and industrial mineral deposits and, secondly, to illustrate how minerals are processed and in which products they are used. To demonstrate the value chain from mineral mining to final products, mineral concentrates and mineral products are displayed for some commodities. The target groups are visitors of the Geological Survey of Norway, such as politicians, researchers, school classes and public visitors.

In addition, the report provides chemical analysis of daily-life items, such as smartphones, compact cameras, toothpaste, deodorants and eye shadows to illustrate their complex chemistry and the diversity of minerals required for their production. The discussed examples of daily life items and the establishment of the applied mineralogy collection at NGU aim to raise awareness about the complexity of sourcing mineral raw materials and the need of mining.

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1. INTRODUCTION

In 2009 the idea arose to establish an exhibition of ore and industrial minerals and their industrial applications at the Geological Survey of Norway (NGU) in Trondheim. The exhibition has two major purposes, firstly, to display representative samples mainly from Norwegian but also from some international metal and industrial mineral deposits and, secondly, to illustrate how minerals are processed and in which products they are used. To demonstrate the value chain from mineral mining to final products, mineral concentrates and mineral products are displayed for some commodities. The target groups are visitors of the Geological Survey of Norway, such as politicians, researchers, school classes and public visitors. The exhibition is dynamic, meaning it undergoes continuous updating. By the end of 2015, the collection comprised 446 specimen and items (Appendix 1).

Besides documenting the collection content and purpose, this report includes chemical analysis of daily-life products, such as smartphones, compact cameras, toothpaste, deodorants, and eye shadows to illustrate their complex chemistry and diversity of minerals required for their production. The data provided is complementary to the exhibition.

2. STRUCTURE AND PURPOSE OF THE EXHIBITION

Most of the 446 objects of the collection are currently exhibited in glass cabinets in the meeting room of the Section for Mineral Resources at the Geological Survey of Norway. Some of the larger specimens (>1 kg) are kept in the storage room of the section. The exhibition is structured according to economic commodity classes: metal ores and minerals, industrial minerals, and energy minerals. The metal ores and minerals are subdivided into precious metals (Au and Ag), base metals (Fe, Pb, Cu, Mn, Zn, Co, Ni), and rare metals (Sn, W, Sc, Li, Cs, and Be). The exhibited industrial minerals include quartz, feldspars, graphite, olivine, kyanite, micas, apatite, diamond, garnet, calcite, dolomite, kaolinite, montmorillonite, sulphur, and Ti minerals (Ti minerals, such as ilmenite and rutile, are considered as industrial minerals even Ti is a metal). The energy minerals include U-Th minerals. In addition, crude oil and heavy water are exhibited together with the energy minerals.

The focus is on Norwegian deposits, but the exhibition does not aim to show examples of every Norwegian deposit. For commodities which have not been mined in Norway, examples from other countries are shown. Most of the rock and mineral specimens have fist size and are relative compact and not so easily breakable, so that visitors and users of the exhibition are allowed to take specimen in their hands to inspect them. For several ores and minerals, processed mineral concentrates and daily life products are exhibited. Examples of the exhibited objects are shown in Figures 1 to 4. The collection and exhibition are dynamic, meaning that specimens can be added, and the exhibition themes changed.

In the following, chemical analyses of some daily life items are provided to illustrate which minerals and in which amounts are needed for their production. This aims to demonstrate the use and need of minerals in industrial production, and to raise societal awareness and acceptance of mineral exploration and mining.

Figure 1. Exhibition display showing the industrial minerals olivine and kyanite, their processed concentrates (in glasses) and one application (olivine refractory brick used for smelter paneling). Source: NGU.

Figure 2. Exhibition display showing the base metal minerals cassiterite (SnO2), three examples of Sn concentrates (glasses to the left) and one application (tin cup). Source: NGU.

Figure 3. Exhibition display showing the industrial minerals calcite (limestone, marble) and kaolinite (glasses), one processing product (Hydrocarb paper filler) and one application (paper). Source: NGU.

Figure 4. Exhibition display showing Fe minerals and ores, processed iron pellets from the Kiruna mine in Sweden (small glass) and two Fe products comprising Fe-oxide pigment "Falun Red" (in glass) and a large steel bolt. Source: NGU.

3. METHODS APPLIED FOR THE CHEMICAL ANALYSIS OF DAILY-LIFE ITEMS

3.1 Comminution of compact cameras and smartphone

Three compact digital cameras (models: Fujifilm Finepix JZ, Canon IXUS 400, and Nikon Coolpix 7900) and one smartphone (LG Optimus L7 on the market since 2012) were analysed for bulk composition to reveal their chemical complexity and the diversity of minerals needed to manufacture these devices (Figures 5 and 6). Chemical analysis requires that the devices are crushed and milled ideally to a particle size <200 µm.

However, comminution of individual, small electronic devices into a homogenous, equigranular powder for high precision chemical analysis is still a technical challenge. In a previous study, Müller (2013) comminuted mobile phones by electrical fragmentation (Selfrag, 2015). The high-voltage, pulsepower fragmentation of mobile phones, which was performed in a liquid, resulted in a wide range of particle sizes ranging from powder (~20 µm) to nearly undestroyed metal and plastic parts up to 10 cm in size. Multiple composed components of the mobile phones such as printed circuit boards and micro-processors were well fragmented and partially powdered. Large single-material components, such as the plastic body and supporting metal frame were hardly damaged. This is because electronic fragmentation weakens the object primarily along particle and component boundaries. Thus, single-material components without internal boundaries are hardly affected by electronic fragmentation. Components >1 cm were therefore cut manually down to <1 cm. Because electronic fragmentation was performed in a liquid, the powdered material was suspended and had to be filtered. The process resulted in a weight loss of 7-10 wt.% of the material adding to the uncertainties of the chemical results.

Figure 5. Compact cameras which were crushed and analysed in the frame of this study. Source: NGU.

Figure 6. Smartphone (type LG Optimus L7) which was crushed and analysed in the frame of this study. Source: NGU.

Figure 7. Compact cameras set in liquid nitrogen for 30 minutes prior to crushing. Source: NGU.

In this study, comminution of compact cameras and the smartphone was carried using conventional, laboratory-scale crushes and shredders at the Mineral Processing Laboratory at NTNU in Trondheim, Norway. The workflow included several steps. First, prior to crushing, compact cameras and the smartphone were set into liquid nitrogen for about 30 minutes to increase their fragmentarily (Figure 7). In the next step, the electronic devises were crushed with an 8A Hazemag Impact Crusher type D-4400 (Figure 8A). Results of the crushed devises are shown in Figures 9A to 9D. The final steps involved cutting of the crushed material by a Retsch SM 2000 shredder using bottom sieves with 8 mm mesh size (Figure 9E) and 2.5 mm mesh size (Figure 9F). Micro magnets from speaker, receivers, vibration mode motor, tactile feedback motor, and camera autofocus mechanism of the smartphone sticked to the inside walls of the used machines and were collected with a strong magnet. Because of the complex comminution, loss of material could not be avoided. The weight of lost material was considered when evaluating the precision of element concentrations determined by the following chemical analysis (Table 1).

Table 1. Original weight and weight loss during crushing and shredding of electronic devices.

Company and model of analysed device	Original weight [g]	Weight after crushing and shredding [g]	Weight loss [g]	Relative error adding to the precision of chemical analysis [%]
Canon IXUS 400	187.0	179.0	8.0	4
Nikon Coolpix 7900	153.3	140.5	12.8	8
Fujifilm Finepix JZ	116.5	109.6	6.9	6
LG Optimus L7	93.4	84.2	9.2	10

Figure 8. Crushers used for crushing compact cameras and mobile phones. A - Hazemag Impact Crusher for dry material 0-100 kg/h. B - Retsch SM 2000 Shredder. Source: NGU.

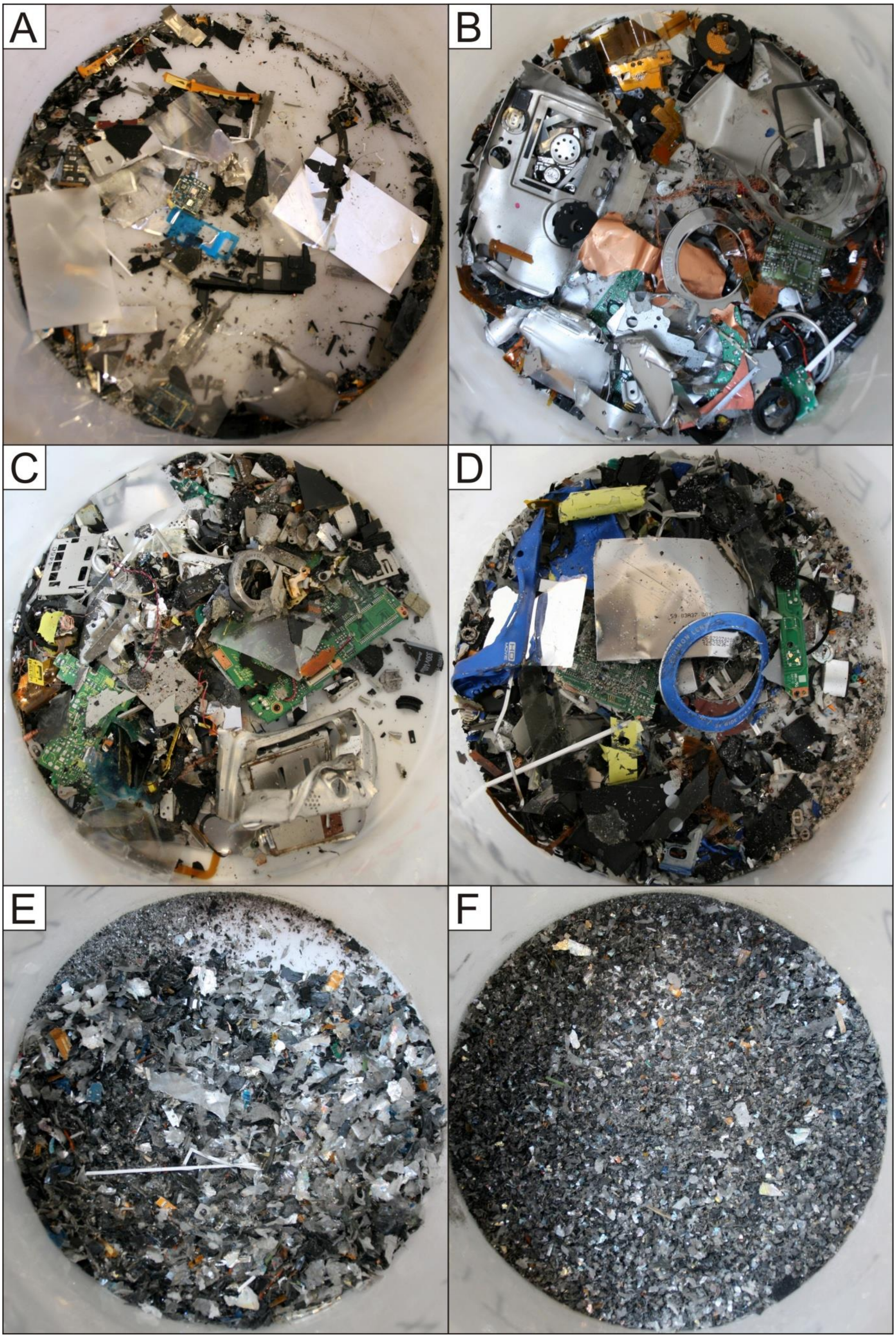

Figure 9. Smartphone (A) and compact cameras (B, C, D) after crushing with the Hazemag Impact crusher. The crushed compact camera shown in D after grinding with the Retsch SM 2000 shredder using first a bottom sieve with 8 mm mesh size (E) and afterwards a bottom sieve with 2.5 mm mesh size (F). Source: NGU.

3.2 Chemical analysis of compact cameras, smartphone, eye shadows, and deodorants

The chemical analyses of compact cameras, smartphone, eye shadows, and deodorants were performed at Activation Laboratories Ltd. in Ancaster, Ontario, Canada (Actlabs, 2015). A combination of several methods was applied to get an almost complete list of analysed chemical elements. The methods included instrumental neutron activation analysis (INAA) for the elements Ag, Br, Cl, Ir, Lu, Sc, Yb, Zn, and Cr, infrared spectroscopy for C and S, inductively coupled plasma optical emission spectroscopy (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) for the remaining major and trace elements. In the case of deodorants, element concentrations were determined by solution ICP-MS and ion chromatography (Cl, Br, F, N, S, P). The used instrumentations and methodologies are summarized in Table 2. The relative analytical error of the determined element concentration is 5%. Elements not included in the analytical package are Na, F, N, H, noble gases, Po, At, Fr, Ra, Ru, Rh, Tc, Re, Os, Ac, Pa, and O.

Table 2. Methodologies applied for chemical analysis of compact cameras, smartphone, eye shadows, and deodorants by Actlabs (2015).

Method	Description of used instrumentation and methodology
Instrumental neutron activation analysis (INAA) for Ag, Br, Cl, Ir, Lu, Sc, Yb, Zn, Cr	A 1 g sample aliquot is encapsulated in a polyethylene vial and irradiated with flux wires at a thermal neutron flux of 7 x 10^{12} n cm^{-2} s^{-1}. After a 7-day decay to allow Na-24 to decay, the samples are counted on a high purity Ge detector with resolution of better than 1.7 keV for the 1332 keV Co-60 photopeak. Using the flux wires, the decay-corrected activities are compared to a calibration developed from multiple certified reference materials. The standard present is only a check on accuracy and is not used for calibration purposes. 10-30% of the samples are checked by re-measurement.
Infrared spectrometry (IRSpec) for C and S	The analysis of C and S is performed with an Eltra CS-2000 infrared spectrometer. The CS-2000 is equipped with an induction furnace for sample oxidation and can provide temperatures up to 2500 °C. The inductive elements of the sample and accelerator couple with the high frequency field of the induction furnace. Sulfur is measured as sulfur dioxide in the first IR cell. Carbon is measured as carbon dioxide in the IR cell as gases flow through the IR cells.
Inductively Coupled Plasma Mass Spectrometry (ICP-MS)	The majority of elements are analyzed by ICP-MS using a Perkin Elmer Sciex ELAN 6000, 6100 or 9000 ICP-MS. Samples were prepared as tablets by sodium peroxide fusion or, in the case of deodorants, as diluted solutions.
Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)	Aluminium, Ca, Fe, K, Mg, P, Si, and Ti are analyzed by ICP-OES using a Varian 735 ES. The samples are analyzed with a minimum of 10 certified reference materials for the required analytes.
Ion Chromatography	Chlorine, Br, F, N, S, P ion contents of deodorants are analyzed using the DIONEX DX-120 Ion Chromatography System. This analysis is applicable to concentrations less than 75 mg/l for Cl, NO_2 and NO_3; less than 50 mg/l for F; less than 125 mg/l for PO_4; less than 250 mg/l for Br and less than 375 mg/L for SO_4. Samples exceeding this range are diluted to avoid over-saturation. Measurement uncertainty is evaluated and controlled by an appropriate quality assurance program.

3.3 Ion chromatography for the analysis of F in toothpaste

Fluorine (F- ion) content in toothpaste was determined using the chromatographic system Dionex ICS-1100 connected to a Dionex AS-DV auto sampler and a Chromeleon 7.1 workstation at the Geological Survey of Norway (NGU) in Trondheim. Details about the analytical system used are provided in Table 3. The standard solutions listed in Table 4 were diluted with water type 1 (18.2 MΩ.cm) to the appropriate level to calibrate the system to measure fluoride, chloride, nitrite, bromide, nitrate, phosphate, and sulphate. Approximately 0.7 g toothpaste was dissolved in 45 ml water type 1 (18.2 MΩ.cm), and an ultrasonic bath was used to complete the dissolution. 1 ml of this suspension was further diluted up to 5 ml with water type 1 in a 5 ml sample tube with 20 µm filter cap prior analysis, with a total dilution factor between 2800 and 3200.

Table 3. Instrument conditions of the chromatographic system Dionex ICS-1100.

Unit	Description
Column	Ion Pac AS 14 A 4x250 mm P/N 56904
Guard column	Ion Pac AG 14 A 4x250 mm P/N 56897
Suppressor	ASRS 300 4-mm P/N 064554
Injection loop	25 µl
Temperature	30°C
Ovn	ICS-1100 Column Heater
Eluent	0.8 M Na_2CO_3 + 0.1 M $NaHCO_3$
Sample tube	5 ml Poly Vials with 20 µm filter caps P/N 038141

Table 4. Standard solutions for Dionex ICS-1100 instrument calibration.

Standard ID m.m.	Anion	mg/l	P/N
Dionex Fluoride Standard	F^-	1000	37158
Dionex Chloride Standard	Cl^-	1000	37159
SPEX Sulfat Standard	SO_4^{2-}	1000	SPC AS-SO49-2Y
Spectrascan	Br^-	1000	SS-11BR
Spectrascan	NO_3^-	1000	SS-11NO3
Spectrascan	PO_4^{3-}	1000	SS-11PO4
Spectrascan	NO_2^-	1000	SS-11NO2

4. Results

4.1 Chemistry of compact digital cameras and smartphones

Compact digital cameras are small and lightweight, making them easy to carry around for everyday photography. Even if the use of compact digital cameras has strongly declined because of the increasing quality of in-built cameras in smartphones, compact cameras are still preferred by many costumers due to the higher image quality (because of larger sensors and more advanced optics), optical zoom lenses that can physically zoom in on subjects (smartphones typically rely on digital zoom, which compromises image quality), more manual control options allowing photographers to have greater creative control over their images, and better device handling and ergonomics. The construction of compact digital cameras includes a metal frame, built-in lens, built-in flash, sensor that captures light and converts it into digital information, processor for image processing, built-in storage, electronics to connect to external devices, battery and viewing screen for framing and reviewing photos. Each of these parts consists of many components consisting of different materials (Figure 10).

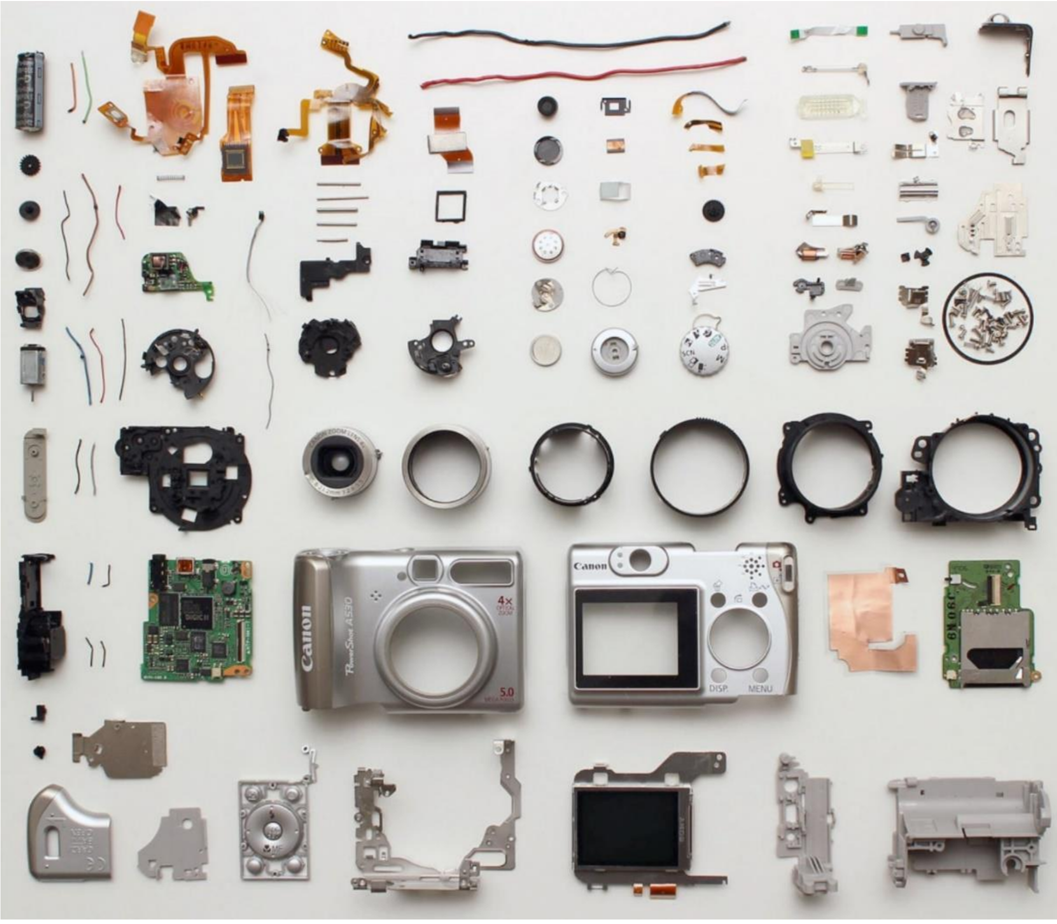

Figure 10. Example of a disassembled compact digital camera in this case a Canon PowerShot A530 camera. Source: Wikimedia.

Today smartphones are some of the most used electronic devices. The in-built camera, flash, processor etc. in smartphones have much smaller dimensions than in compact cameras. In addition, smartphones have a large liquid crystal display (LCD), circuit board, antenna, microphone, speaker and a relatively large battery. These parts are made of many individual components of complex chemical composition. In all, they contain 75 % metals and 25 % plastics. However, looking in detail, the chemistry of smartphones is rather complex. For the casing, alloys of Fe, Al, Mg and Ni are used. Nickel is used as well in the microphone diaphragm, electrical connections, capacitors and battery. Beside Ni, C, Co, Li and Br are constituents of the battery. Ag, Au, and Cu are the major metals in microelectronic components. Tantalum is the major component of micro capacitors. Indium is part of the LCD display where it is used as Sn-doped In_2O_3. Iron alloys containing Nd, Pr and Gd are used in the magnets contained in the speaker, microphone, vibrator and micro motors. Figure 11 illustrates the complex chemical composition of just one component: the vibrator. The vibrator alone is made up of parts made of 10 different metals: Fe, Ni, Cu, Cr, Au, Ag, W, Pd, Nd and Pr. However, complete and precise chemical bulk analyses of individual smartphones are not readily available. Several sources provide information on the major and some trace element compositions of smartphones. One of the few comprehensive studies which provided an almost complete list of elements in mobile phones was done by Müller et al. (2013).

In the frame of this study, three compact cameras including a Fujifilm Finepix JZ, Canon IXUS 400 and a Nikon Coolpix 7900 were grinded and analysed to reveal their chemical complexity. The results of the chemical analysis are shown in Table 5. The relative analytical errors of the determined concentrations are ±9% for Canon, ±13% for Nikon, ±11% for Fujifilm, and ±15% for LG. About 49 elements out of 68 determined elements occur with concentration >1 mg/kg in the analysed devices.

In the diagrams in Figures 12 and 13, elements are ordered according to their abundance in the Canon camera. The most abundant, major (>0.4 wt.%/ >4000 mg/kg) elements in these devices are (from higher to lower contents) C (24-30 wt.%), Cu (7-16 wt.%), Fe (12-16 wt.%), Al (3.7-11.8 wt.%), Ni (0.4 to 6.1 wt.%), Cr (3.4-6.2 wt.%), Si (2.3-5.5 wt.%), Ca (0.4-1.6 wt.%), Zn (0.29-0.77 wt.%), Mn (0.05-0.52 wt.%), and Sn (0.18-0.56 wt.%). Carbon as the most abundant element is bound in polymers of the plastic parts and used as elementary carbon in the batteries. Overall, the compositions of the three cameras and the smartphone are relatively similar. There are, however, device-specific differences (see element concentrations marked in red in Table 5). The Canon camera is significantly richer in Mo (3150 mg/kg), Ni (6.1 wt.%), Pb (1850 mg/kg), S (1590 mg/kg), Sc (10 mg/kg), Ta (355 mg/kg), V (420 mg/kg) and W (412 mg/kg) and contains lower Y (4.5 mg/kg) and Mg (<100 mg/kg). The Nikon camera has high Al (11.8 wt.%) and Ba (5410 mg/kg) and the Fujifilm camera high Bi (107 mg/kg), Sb (798 mg/kg), Nd (1590 mg/kg) and Pr (424 mg/kg), and low in Mn (502 mg/kg). The smartphone is higher in Ni (5.4 wt.%) and has low Br (17 mg/kg), La (97 mg/kg) and Gd (12 mg/kg). The low Br in the smartphone is due to the different battery type used in the phone.

When compared to the average composition of the upper continental crust (UCC; Figures 14 to 16), the part of the Earth from where minerals are sourced, Au (51-153 mg/kg) is about 100,000 times enriched in the devices. The average concentration of Au in the UCC is 0.0015 mg/kg. Silver (259-428 mg/kg), Cu (8.5-16.2 wt.%) and Pd (2-5 mg/kg) are about 10,000 times enriched. Other elements which are considerably enriched and not named above include W (18-412 mg/kg), Mo (24-3150 mg/kg), Sb (21-798 mg/kg), Ta (60-355 mg/kg), Se (10-495 mg/kg), In (4-21 mg/kg) and the REEs La (97-1480 mg/kg), Gd (12-262 mg/kg), Pr (3-424 mg/kg) and Dy (3-33 mg/kg).

Table 5 also lists the minerals from which the different elements are sourced through mining and mineral processing. The major producers of these minerals in 2015 are listed in Table 5 as well. Even though most minerals are mined in China, there is a great diversity of countries from which the individual ore minerals origin. The list of countries illustrates the complexity of the product supply chains considering only the raw material sources for compact cameras and smartphones. This is one reason why the device producers have little or no control or knowledge about the raw material sources.

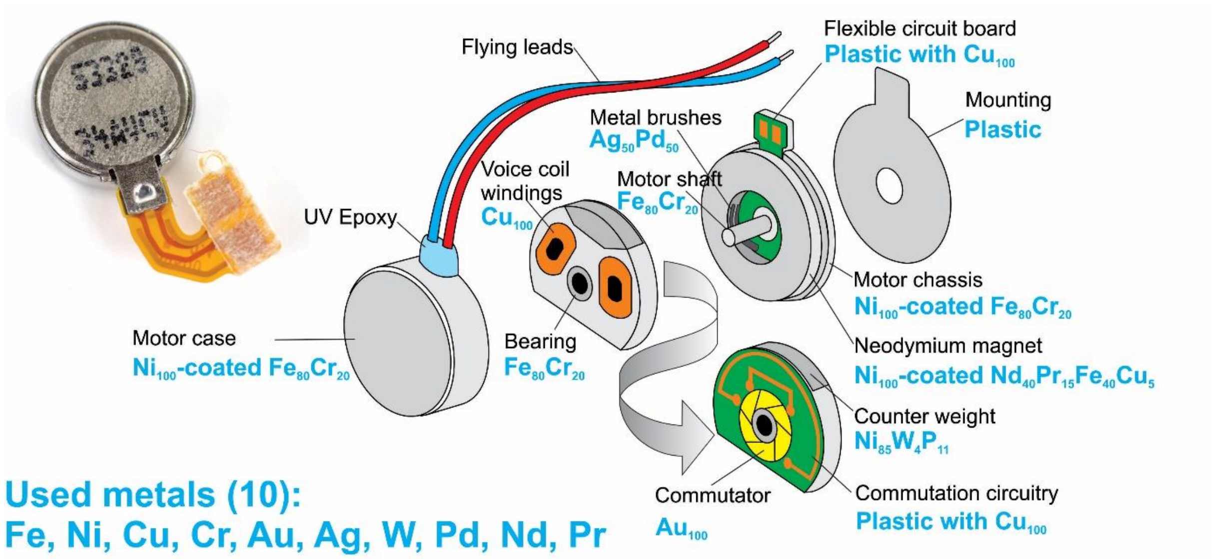

Figure 11. Example of a construction of a vibrator found in smartphones. The motor is 10 mm in diameter. The lower-case numbers next to the element abbreviations are concentrations in wt.% with an analytical error of 5 wt.%. Ten different metals, including Fe, Ni, Cu, Cr, Au, Ag, W, Pd, Nd and Pr are beside plastic required to manufacture the vibrator. Modified from Müller (2014).

Table 5. Results of chemical analysis of compact cameras (Canon, Nikon, Fujifilm) and smartphone (LG). Element concentrations are provided in mg/kg. Relative analytical errors of the determined concentrations are ±9% for Canon, ±13% for Nikon, ±11% for Fujifilm, and ±15% for LG. Numbers in red mark concentrations which very are different to the other analysed devices. Major ore minerals are provided for elements only, which have considerable concentrations in the analysed devices. UCC – Average concentration of the element in the upper continental crust according to Rudnick and Gao (2014). n.p. – not provided; DL – Detection limit.

Analyte symbol	DL [mg/kg]	Analysis method	Canon	Nikon	Fujifilm	LG	UCC	Major ore mineral	Formula of mineral	Major producer of mineral in 2015
Ag	0.5	INAA	259	638	271	428	0.053	Argentite	Ag_2S	Mexico
Al	100	ICP-OES	38500	118000	83300	37300	81504	Bauxite	$AlOH_3$, AlO(OH)	China
As	5	ICP-MS	24	99	<5	15	4.8	Arsenopyrite	FeAsS	China
Au	0.01	FA-ICP	153	140	51.2	108	0.0015	Gold	Au	China
B	10	ICP-MS	1560	2760	4030	2870	17	Borax	$Na_2(B_4O_5)(OH)_4 \cdot 8H_2O$	Chile
Ba	3	ICP-MS	1770	5410	754	1540	628	Baryte	$BaSO_4$	China
Be	4	ICP-MS	<4	<4	<4	<4	2.1	-	-	-
Bi	2	ICP-MS	6	5	107	4	0.16	Bismuthinite	Bi_2S_3	China
Br	0.5	INAA	2800	4280	1300	16.8	1.6	(sourced from Br-rich brines not from mineral)	-	-
C	100	IRSpec	256000	244000	302000	263000	n.p.	C in battery is sourced from graphite	C	China
Ca	100	ICP-OES	4500	15000	16500	14000	25658	Calcite	$CaCO_3$	China
Cd	0.5	ICP-MS	<0.5	<0.5	0.6	<0.5	0.09	-	-	-
Ce	0.8	ICP-MS	<0.8	3	6	40	63	Bastnäsite	$(Ce/Nd/Y/REE)(CO_3)F$	China
Cl	100	INAA	1200	700	500	1100	370	Halite	NaCl	China
Co	0.2	ICP-MS	743	135	115	348	17.3	Cobaltite	CoAsS	Congo
Cr	0.5	INAA	62200	33600	42000	52400	92	Chromite	$FeCr_2O_4$	South Africa
Cs	0.1	ICP-MS	<0.1	<0.1	2	<0.1	4.9	-	-	-
Cu	50	ICP-OES	162000	158000	70900	85200	28	Chalcopyrite	$CuFeS_2$	Chile
Dy	0.3	ICP-MS	3.5	33	7	5	3.9	Bastnäsite	$(Ce/Nd/Y/REE)(CO_3)F$	China
Er	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1	2.3	-	-	-
Eu	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1	1	-	-	-
Fe	500	ICP-OES	159000	156000	124000	136000	39176	Magnetite	Fe_2O_3	Australia
Ga	0.2	ICP-MS	20.5	28	12	17	17.5	Bauxite	$AlOH_3$, AlO(OH), AlO(OH)	China
Gd	0.1	ICP-MS	224	262	119	12	4	Bastnäsite	$(Ce/Nd/Y/REE)(CO_3)F$	China
Ge	0.7	ICP-MS	9.5	4	3	4	1.4	Ge-rich Sphalerite	ZnS	China
Hf	10	ICP-MS	<10	<10	<10	<10	5.3	-	-	-
Hg	0.005	ICP-MS	0.027	<0.005	0.033	0.005	0.05	-	-	-
Ho	0.2	ICP-MS	1.3	<0.2	<0.2	1	0.83	-	-	-
In	0.2	ICP-MS	4.5	5	15	21	0.056	In-rich sphalerite	ZnS	China
Ir	0.001	INAA	<0.001	<0.001	<0.001	<0.001	0.000022	-	-	-
K	1000	ICP-OES	<1000	1000	1000	2000	23244	Sylvite	KCl	Canada
La	0.4	ICP-MS	1480	843	2550	97	31	Bastnäsite	$(Ce/Nd/Y/REE)(CO_3)F$	China
Li	3	ICP-MS	236	65	14	6	24	Spodumene	$LiAlSi_2O_6$	China
Lu	0.01	INAA	<0.01	<0.01	<0.01	<0.01	0.31	-	-	-

Analyte symbol	DL [mg/kg]	Analysis method	Canon	Nikon	Fujifilm	LG	UCC	Major ore mineral	Formula of mineral	Major producer of mineral in 2015
Mg	100	ICP-OES	<100	2000	4700	2100	14955	Magnesite	$MgCO_3$	China
Mn	3	ICP-MS	5230	4880	502	2090	774	Pyrolusite	MnO_2	South Africa
Mo	1	ICP-MS	3150	66	24	321	1.1	Molybdenite	MoS_2	China
Nb	2.4	ICP-MS	294.5	95	324	17	12	Columbite	$(Fe,Mn)(Nb,Ta)_2O_6$	Brazil
Nd	0.4	ICP-MS	49.5	22	1590	101	27	Bastnäsite	$(Ce/Nd/Y/REE)(CO_3)F$	China
Ni	50	ICP-OES	61400	4270	7060	53600	47	Pentlandite	$(Ni,Fe)_9S_8$	Philippines
P	50	ICP-OES	1440	980	1320	1290	655	Apatite	$Ca_5(PO_4)_3(F,Cl,OH)$	China
Pb	0.8	ICP-MS	1850	456	19	34	17	Galena	PbS	China
Pd	0.03	ICP-MS	3.89	2.04	2.38	4.56	<0.03	Palladium arsenide	$PdAs_2$	South Africa
Pr	0.1	ICP-MS	8.5	3	424	19	7.1	Bastnäsite	$(Ce/Nd/Y/REE)(CO_3)F$	China
Pt	0.03	FA-ICP	<0.03	0.12	0.19	0.2	<0.03	-	-	-
Rb	0.4	ICP-MS	2.5	1	1	2	84	Rb-rich pollucite	$(Cs,Na)_2(Al_2Si_4O_{12}) \cdot 2H_2O$	Canada
S	10	IRSpec	1590	260	380	140	621	Pyrite	FeS	USA
Sb	2	ICP-MS	118	189	798	21	0.4	Stibnite	Sb_2S_3	China
Sc	0.01	INAA	10.4	0.96	1.13	2.21	14	Sc-rich amphiboles		China
Se	0.8	ICP-MS	49.5	21	26	10	0.09	Se-rich sulfides		Japan
Si	100	ICP-OES	22900	32500	42300	54400	311315	Quartz	SiO_2	China (silicon metal)
Sm	0.1	ICP-MS	<0.1	<0.1	1	2	4.7	-	-	-
Sn	0.5	ICP-MS	3800	5580	4900	1800	2.1	Cassiterite	SnO_2	China
Sr	3	ICP-MS	2210	2540	3320	1790	320	Celestite	$SrSO_4$	China
Ta	0.2	ICP-MS	355	68	112	60	0.9	Tantalite	$(Mn,Fe)(Ta,Nb)_2O_6$	Brazil
Tb	0.1	ICP-MS	<0.1	1	<0.1	<0.1	0.7	-	-	-
Te	6	ICP-MS	<6	<6	<6	<6	n.p.	-	-	-
Th	0.1	ICP-MS	<0.1	1	1	2	10.5	-	-	-
Ti	100	ICP-OES	600	4200	2700	300	3837	Rutile	TiO_2	South Africa
Tl	0.1	ICP-MS	<0.1	< 0.1	<0.1	<0.1	0.9	-	-	-
Tm	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1	0.3	-	-	-
U	0.1	ICP-MS	<0.1	<0.1	<0.1	7	2.7	-	-	-
V	5	ICP-MS	420	35	59	159	97	V-rich magnetite	Fe_2O_3	China
W	0.7	ICP-MS	412	21	18	48	1.9	Wolframite	$(Fe,Mn)WO_4$	China
Y	0.1	ICP-MS	4.5	208	127	34	21	Xenotime	$Y(PO_4)$	China
Yb	0.05	INAA	<0.05	<0.05	<0.05	<0.05	1.96	-	-	-
Zn	1	INAA	4120	4650	7670	2890	67	Sphalerite	ZnS	China
Zr	2	ICP-MS	1346	863	4943	4803	193	Zircon	$Zr(SiO_4)$	Australia
Total [wt.%]			**80.41**	**80.49**	**73.29**	**72.26**	**50.40**	**42 minerals**		**10 countries**

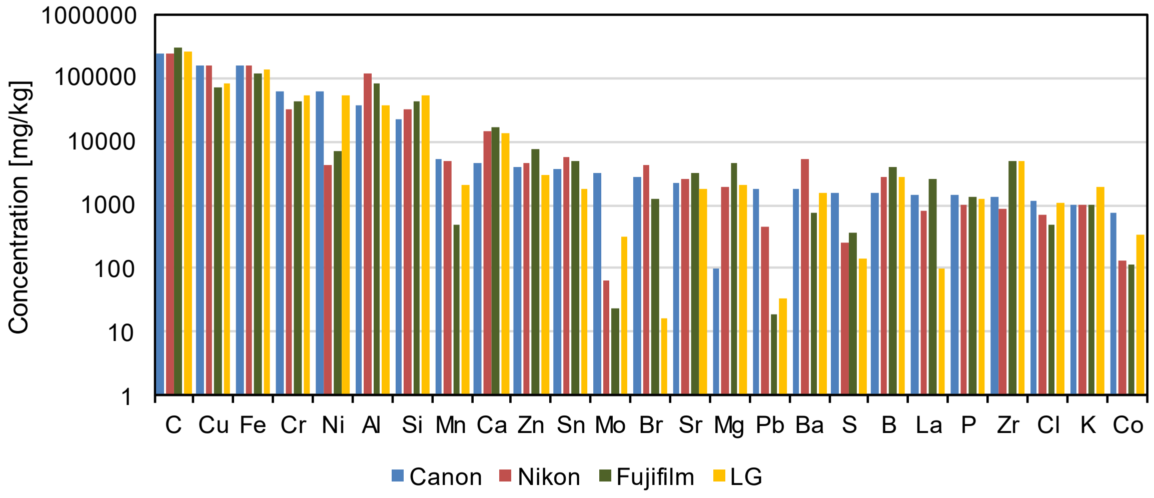

Figure 12. Column chart of the 25 most abundant elements in compact cameras and smartphone. Elements are ordered according to their abundance in the Canon camera.

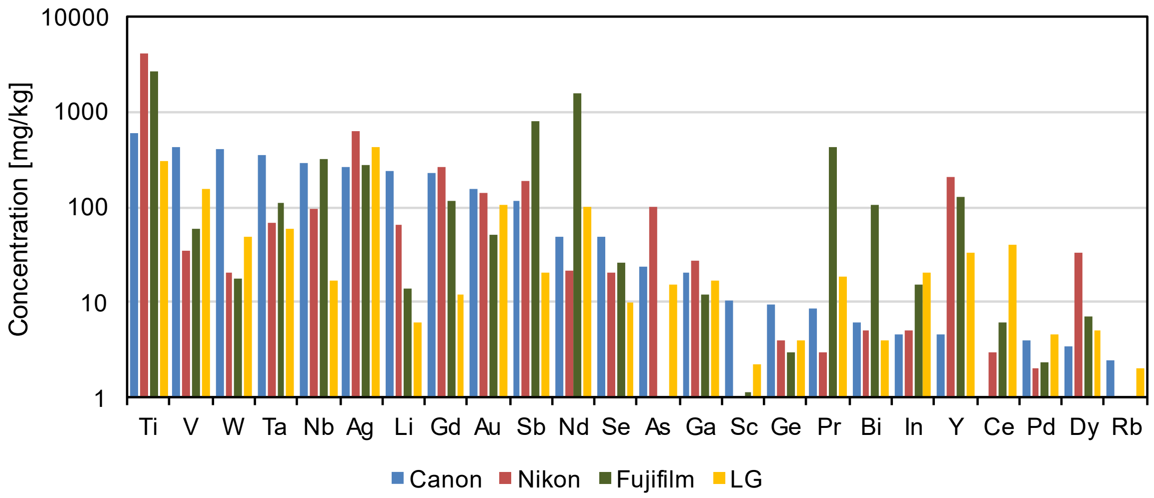

Figure 13. Column chart of less abundant elements in compact cameras and smartphone. Elements are ordered according to their abundance in the Canon camera.

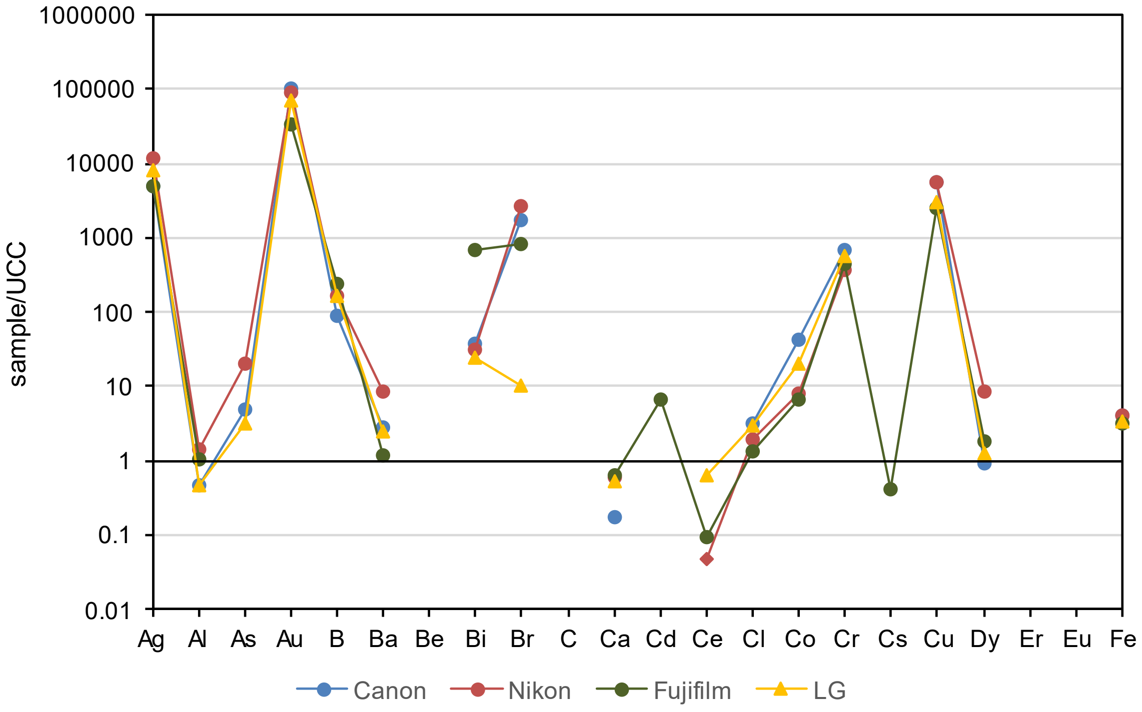

Figure 14. Element concentrations of smartphones normalised to the average composition of the Earth's upper crust according to Rudnick and Gao (2014). The diagram illustrates how elements in smartphones are enriched (>1) by natural processes (in the mineral deposit which was mined) and by industrial processing (rock crushing, mineral separation, metallurgy) or depleted (<1) compared to the UCC.

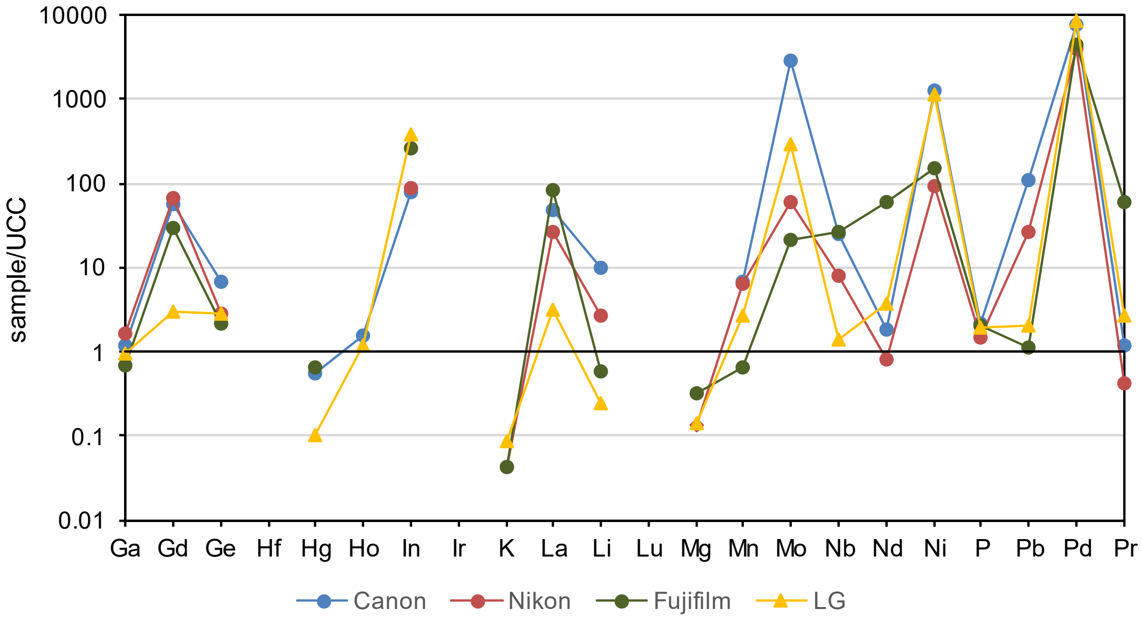

Figure 15. Column chart of less abundant elements in compact cameras and smartphone. Elements are ordered according to their abundance in the Canon camera.

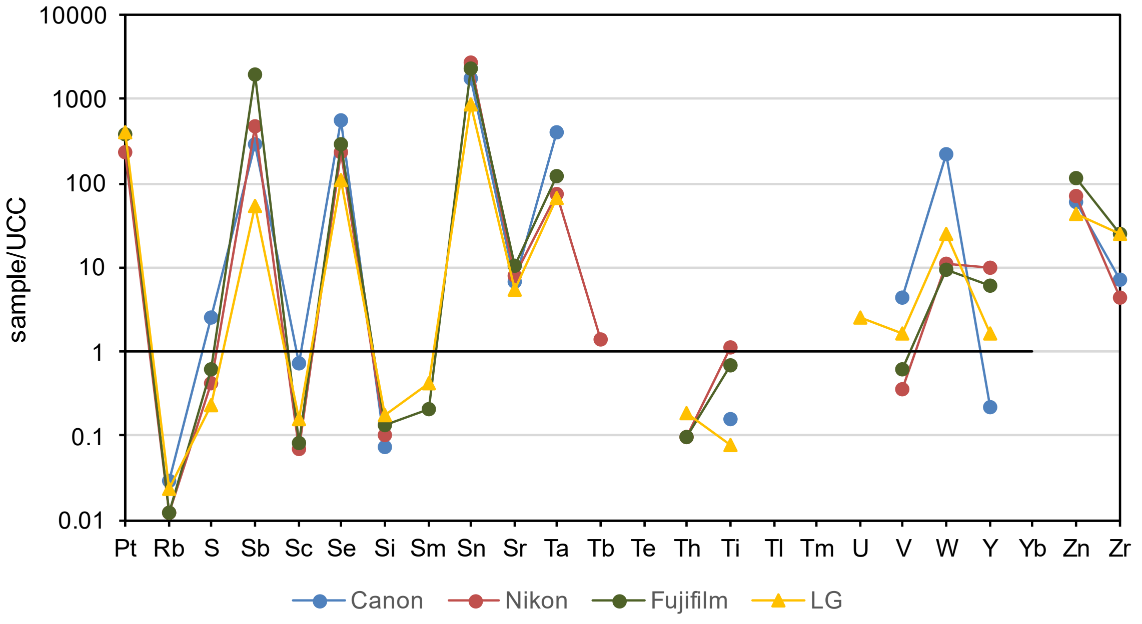

Figure 16. Column chart of less abundant elements in compact cameras and smartphone. Elements are ordered according to their abundance in the Canon camera.

4.2 The chemistry of decorative cosmetics: Example eye shadow

Eye shadow is a decorative cosmetic applied to the eyelids to attract attention. The manufacturing and use of eye shadows dates back to predynastic Egypt about 5000-4000 BCE (Lucas, 1930; Kreston, 2012). Today, eye shadow or eye makeup is chemically and mineralogical rather complex. Eye shadows typically consist of five ingredient types: base fillers, binders, slip, color pigments and preservatives. Base fillers are usually minerals such as mica, talc or kaolin, which add bulk and texture to eye shadow. Mica absorbs moisture, gives the eye shadow shine and luster, and makes it opaque. Binders help eye shadow adhere and stay attached to skin. Zinc and magnesium, which are both white powders, are commonly used as dry binders. Silicone, paraffin wax, mineral oil or vegetable oils may be used as liquid binders. Slip allows eye shadow to glide across the skin smoothly. Products may use silica or nylon, which are fine, colorless powders. Other types of slip include dimethicone, boron nitride or bismuth oxychloride. The list of color pigments used can be long depending on the color to be achieved. Preservatives help products stay bacteria free and extend their lifespan. Common preservatives in eye shadow are glycol and tocopherol.

In Table 6 an example of list of ingredients in the eye shadow “01 Scooby blue - 4 trendige Farben” produced by the German brand Rival de Loop Young is provided (Figure 17). The 28 ingredients are made of 21 different chemical elements. Eighteen of the elements are sourced from 18 different minerals, which are shown in Table 6 together with the major mining country of these minerals. Because the actual mining country of a particular mineral is difficult to trace, the major producing country is provided in Table 6 to show the complexity of the raw material supply. Carbon (±H) is sourced from crude oil or plant- or animal-based raw materials, and N and O from air. Bromine is extracted from Br-rich brines.

Half of the ingredients are color pigments. The color pigments used for this product, as provided by the producer, are bismuth oxychloride (BiOCl), tin oxide (SnO_2), titanium oxide (TiO_2), ultramarine (lapis lazuli rock), chromium oxide greens (Cr_2O3), ferric ferrocyanide ($C_{18}Fe_7N_{18}$), two variants of iron oxide (Fe_2O_3), manganese violet ($NH_4MnP_2O_7$), tartrazine ($C_{16}H_9N_4Na_3O_9S_2$), lithol rubin ($C_{18}H_{12}CaN_2O_6S$), acid red ($C_{20}H_2Br_4Cl_4Na_2O_5$), and allura red ($C_{18}H_{14}N_2Na_2O_8S_2$) (Table 6). For the production of these pigments alone, 13 different minerals are needed. Additionally, mica and kaolin may be considered color pigments, because mica causes the glitter effect and kaolin improves the opaqueness.

Table 7 lists element concentrations analysed in four eye shadows (“White”, “Bright blue”, “Steel blue bright”, “Steel blue dark”) with different color from the Rival de Loop Young company (see also Figure 17). In the diagrams in Figures 18 and 19, elements are ordered according to their abundance in the eye shadow “White”. In general, the determined element concentrations are relative similar for all four eye shadows. The most abundant elements (beside O and H) are Si (16.9-20.2 wt.%), C (8.8-15.3 wt.%), Ti (4.6-13.0 wt.%), Mg (7.4-9.6 wt.%), Al (4.4-5.8 wt.%), K (1.8-2.4 wt.%), Fe (0.7-1.8 wt.%), Ca (786-2666 mg/kg), F (2300-2800 mg/kg), and Bi (1->2000 mg/kg). The Bi content in the eye shadow “White” is higher than the upper detection limit of the applied ICP-MS methodology. However, the other three eye shadows have much lower Bi contents between 1 and 9 mg/kg. Other major differences in chemistries among the investigated eye shadows are high Cr (105 mg/kg) and low Ti (46282 mg/kg) in “Steel blue bright”, high Sn (1544 mg/kg) in “Steel blue dark”, low Cr (<5 mg/kg) in “White”, and low V (<8 mg/kg) in “Bright blue”. These differences are caused by differences in the use color pigments and their mixtures. Other elements with concentrations between 2000 and 10 mg/kg are Na, Cl, Rb, P, Ba, Sn, Mn, Nb, W, Cr, Ga, Cs, V, and Zr (Table 7).

Barium, Cs, F, Ga, Nb, Rb, W, V and Zr are elements which were determined with considerable concentrations (>10 mg/kg) but are not listed in the ingredients list provided by the producer (compare Tables 6 and 7). The reasons for that are mainly the used minerals, because natural minerals incorporate not only the major elements they are made of, but also traces of other elements which are considered natural impurities or contaminations. Cesium (16-28 mg/kg), F (2300-2800 mg/kg) and Rb (197-354 mg/kg) are most likely trace elements in the used mica. Gallium (16-29 mg/kg) is a trace constituent of kaolin, W (20-33 mg/kg) and Nb (23-57 mg/kg) of cassiterite, V (<8-23 mg/kg) of chromite, and Zr (5-22 mg/kg) of rutile.

Figure 17. Eye shadow powders of the product "Colour Palette" of German brand Rival de Loop Young. For analysis, the four eye shadows of "01 Scooby blue" palette shown in the upper left were chosen. Source: NGU.

Table 6. Ingredients in the eye shadow "Scooby blue - 4 trendige Farben" produced by the German brand Rival de Loop Young. Minerals, which are needed to produce the ingredients, are listed and the major mining country as well. Mineral-based color pigments are shown in red.

Ingredient	Chemical formula of ingredient	Major ore mineral	Formula of mineral	Major producer of mineral in 2015
Talc	$Mg_3Si_4O_{10}(OH)_2$	Talc	$Mg_3Si_4O_{10}(OH)_2$	China
Mica	$KAl_2(AlSi_3O_{10})(F,OH)_2$	Muskovite	$KAl_2(AlSi_3O_{10})(F,OH)_2$	China
Silica	SiO_2	Quartz	SiO_2	China
Octyldodecanol	$C_{20}H_{42}O$	-	-	-
Magnesium Stearate	$C_{36}H_{70} \cdot MgO_4$	Magnesite for Mg	$MgCO_3$	China
Kaolin	$Al_2(Si_2O_5)(OH)_4$	Kaolin	$Al_2(Si_2O_5)(OH)_4$	USA
Sorbiton Sesquioleate	$C_{66}H_{126}O_{16}$	-	-	-
Bis-Diglyceryl Polyacyladipate-1	Adipic Acid (q.v.) diester of a mixed diglyceryl ester ofcaprylic, capric, hydroxystearic and isostearic acids	-	-	-
Phenoxyethanol	$C_8H_{10}O_2$	-	-	-
Caprylyl Glycol	$C_8H_{18}O_2$	-	-	-
Chlorphenesin	$C_9H_{11}ClO_3$	Halite for Cl	$NaCl$	China
Hydrolyzed Silk	Natural protein obtained from natural silk noils (fibers, fibroin) from the cocoon of the silk worm (bombyx mori)	-	-	-
Maltodextrin	$C_{6n}H_{(10n+2)}O_{(5n+1)}$	-	-	-
Tocopheryl Acetate	$C_{31}H_{52}O_3$	-	-	-
Bismuth Oxichloride (white)	**$BiOCl$**	Bismuthinite for Bi Halite for Cl	Bi_2S_3 $NaCl$	China China
Calcium Aluminum Borosilicate (creamy-white)	**$Al_2B_2CaMgO_{10}Si$**	Bauxite for Al Borax for B Calcite for Ca Magnesite for Mg	$AlOH_3$, $AlO(OH)$ $Na_2(B_4O_5)(OH)_4 \cdot 8H_2O$ $CaCO_3$ $MgCO_3$	China Chile China China
Tin Oxide (white)	**SnO_2**	Cassiterite for Sn	SnO_2	China
Titanium Oxide (CI 77891) (white)	**TiO_2**	Rutile	TiO_2	South Africa
Ultramarine (CI 77007)	**Lapis lazuli rock**	Lazurite	$Na_7Ca(Al_6Si_6O_{24})(SO_4)(S_3) \cdot H_2O$	Afghanistan
Chromium oxide greens (CI 77288)	**Cr_2O_3**	Chromite for Cr	$FeCr_2O_4$	South Africa
Ferric Ferrocyanide (CI 77510) (dark blue)	**$C_{18}Fe_7N_{18}$**	Magnetite for Fe	Fe_3O_4	Australia
Iron oxide (CI 77491) (deep red)	**Fe_2O_3**	Magnetite	Fe_3O_4	Australia
Iron oxide (CI 77499) (black)	**Fe_3O_4**	Magnetite	Fe_3O_4	Australia
Manganese violet (CI 77742) (reddish purple)	**$NH_4MnP_2O_7$**	Pyrolusite for Mn Apatite for P	MnO_2 $Ca_5(PO_4)_3(OH,Cl,F)$	South Africa China
Tartrazine (CI 19140) (yellow)	**$C_{16}H_9N_4Na_3O_9S_2$**	Halite for Na Sulfur	$NaCl$ S	China USA
Lithol rubin (CI 15850) (red)	**$C_{18}H_{12}CaN_2O_6S$**	Calcite for Ca Sulfur	$CaCO_3$ S	China USA
Acid red (CI 45410) (red to dark reddish brown)	**$C_{20}H_2Br_4Cl_4Na_2O_5$**	Halite for Na and Cl Br-rich brines for Br	$NaCl$ Br	China Israel
Allura red (CI 16035) (red)	**$C_{18}H_{14}N_2Na_2O_8S_2$**	Halite for Na Sulfur	$NaCl$ S	China USA
28 ingredients	**21 elements**	**18 minerals**		**7 countries**

Table 7. Analytical results of four eye shadows of "Scooby blue - 4 trendige Farben" produced by the German brand Rival de Loop Young. Numbers in red mark concentrations which very are different to the other analysed eye shadows.

Analyte symbol	Detection limit [mg/kg]	Analysis method	White (108160)	Bright blue (108161)	Steel blue bright (108162)	Steel blue dark (108163)
Ag	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1
Al	100	XRF	57688	43928	52925	52502
As	0.5	ICP-MS	<0.5	<0.5	<0.5	<0.5
Au	0.5	ICP-MS	<0.5	<0.5	<0.5	<0.5
Ba	1	ICP-MS	195	107	152	128
Be	1	ICP-MS	4	3	2	5
Bi	0.1	ICP-MS	>2000.0	8.7	2.6	1.2
C	200	IRSpec	87600	100300	153200	118400
Ca	100	XRF	2666	1772	1001	786
Cd	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1
Ce	0.1	ICP-MS	1.8	1.3	1.4	1.5
Cl	200	INAA	740	790	730	710
Co	0.2	ICP-MS	0.9	1	1.5	1.1
Cr	5	ICP-MS	<5	27.7	105	9.4
Cs	0.1	ICP-MS	28.3	17.9	16	17
Cu	0.1	ICP-MS	1	0.6	0.4	0.3
Dy	0.05	ICP-MS	0.12	0.07	0.09	0.07
Er	0.03	ICP-MS	0.09	0.05	0.07	<0.03
Eu	0.02	ICP-MS	0.09	0.04	0.04	0.04
F	500	INAA	2300	2300	2800	2300
Fe	200	XRF	6708	10701	18185	15038
Ga	0.5	ICP-MS	29.3	16.2	19.8	21
Gd	0.05	ICP-MS	0.14	0.11	0.09	0.11
Hf	0.1	ICP-MS	1.1	1.4	0.2	0.2
Hg	0.01	ICP-MS	<0.01	<0.01	<0.01	<0.01
Ho	0.02	ICP-MS	0.02	0.02	<0.02	<0.02
K	100	XRF	23659	17682	22082	22082
La	0.1	ICP-MS	1.4	0.9	1.2	1.2
Lu	0.01	ICP-MS	0.02	0.01	0.01	0.01
Mg	100	XRF	96486	85028	94677	74776
Mn	100	XRF	<50	85	124	93
Mo	0.1	ICP-MS	<0.1	0.1	<0.1	<0.1
Na	200	XRF	1558	1261	1632	1780
Nb	0.1	ICP-MS	57.2	54.5	22.8	22.8
Nd	0.3	ICP-MS	0.9	0.5	0.5	0.7
Ni	0.1	ICP-MS	1.5	1.5	0.5	1.3
P	50	XRF	253	367	105	96
Pb	0.1	ICP-MS	4.6	1.4	0.8	5
Pr	0.02	ICP-MS	0.18	0.11	0.11	0.14
Rb	0.1	ICP-MS	353.9	196.8	229.1	232.6
S	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1
Sb	0.1	ICP-MS	0.2	<0.1	<0.1	<0.1
Sc	1	ICP-MS	8	4	6	6
Se	0.5	ICP-MS	<0.5	<0.5	<0.5	<0.5
Si	100	XRF	202401	173420	197259	169213
Sm	0.05	ICP-MS	0.1	0.08	0.13	0.11
Sn	1	ICP-MS	72	45	135	1544
Sr	0.5	ICP-MS	9.1	5.4	5.3	4.9
Ta	0.1	ICP-MS	7.4	5.7	3.6	3.8
Tb	0.01	ICP-MS	0.03	0.01	0.02	0.01
Th	0.2	ICP-MS	0.5	0.4	0.4	0.6
Ti	100	XRF	71941	130093	46282	112108
Tl	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1
Tm	0.01	ICP-MS	0.02	<0.01	<0.01	<0.01
U	0.1	ICP-MS	0.4	0.4	0.4	0.3
V	8	ICP-MS	23	<8	12	11
W	0.5	ICP-MS	33.3	20.4	23.4	24.3
Y	0.1	ICP-MS	1	0.6	0.5	0.4
Yb	0.05	ICP-MS	0.08	0.09	0.05	0.07
Zn	1	ICP-MS	3	3	3	4
Zr	0.1	ICP-MS	22.5	31	6.6	5
Total [wt.%]			**55.69**	**56.83**	**59.18**	**57.19**

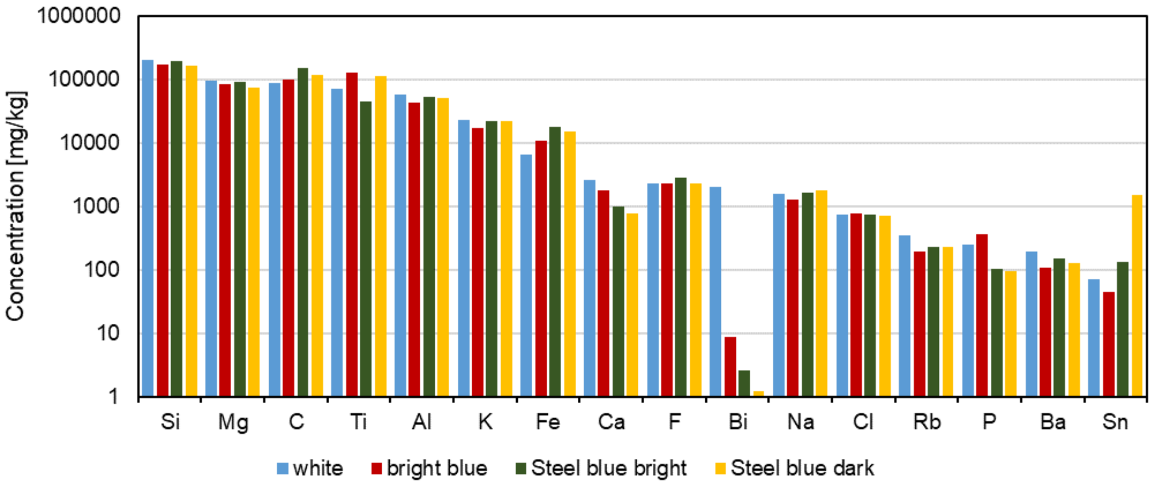

Figure 18. Column chart of the 16 most abundant elements in eye shadows. Elements are ordered according to their abundance in eye shadow "white", which is richer in Bi than the other analysed eye shadows.

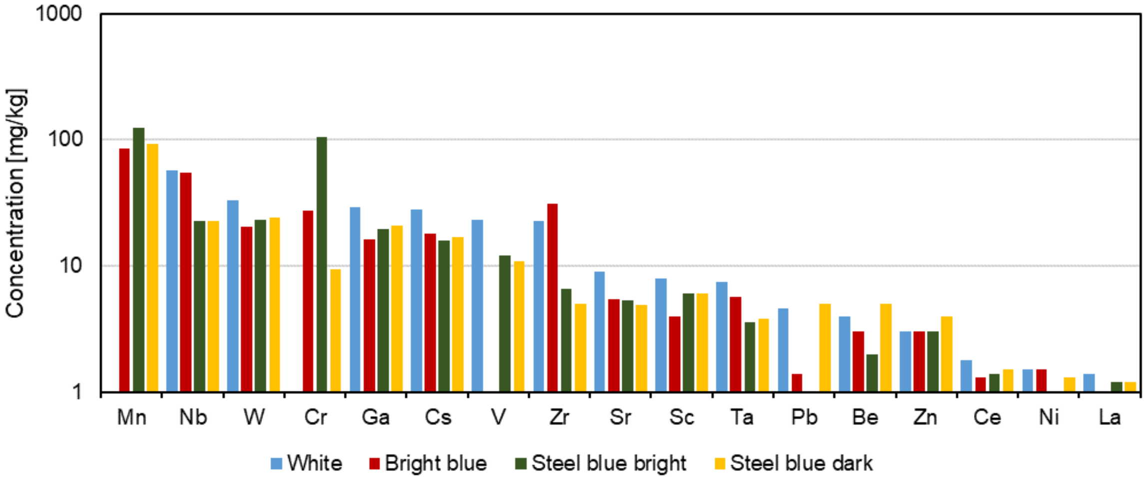

Figure 19. Column chart of the 16 most abundant elements in eye shadows. Elements are ordered according to their abundance in eye shadow "white".

4.3 The chemistry of deodorants

Deodorants are a mixture of antiperspirants, antibacterial ingredients, fixatives, moisturizer, emollients, emulsifier, stabilisers, humectants, propellants, additives for pH control, perfumes and preservatives (e.g., Shen and Nardello-Rataj, 2009). The functional most important ingredients are antiperspirants, which inhibit perspiring and sweating, and antibacterial ingredients which kill bacteria and neutralise smell. Antiperspirants are commonly aluminium compounds such as aluminium chloride, aluminium chlorohydrate, aluminium hydroxybromid, and aluminium zirconium trichlorohydrate glycine. The aluminium ions released from these compounds form a temporary blockage in the sweat ducts, stopping the flow of sweat to the skin's surface (e.g., Laden, 1999). Common antibacterial ingredients are alcohol, triclosan, ethylhexylglycerin, polyglyceryl-2 caprate, chlorhexidine, polyhexamethylene, aluminium salts, zinc salts or zinc oxide. Deodorants are available as spray, roll-on or sticks. The concentration of ingredients increases from spray, to roll-on and stick. Table 8 provides an example of ingredients of the Sterilan ‘Men Extra Cool’ roll-on deodorant are listed as provided by the producer. The 25 ingredients are composed of ten different chemical elements. Five of the ten elements, Al, Si, Cl, Zr and Na, are sourced from four different minerals. In addition, the minerals quartz and talc are directly used in powdered form.

In the frame of this study, two deodorants sprays, Dior ‘Homme Sport’ and Old Spice ‘Pure Sport’, and two roll-on deodorants, Sterilan ‘Men Extra Cool’ and Palmolive ‘Men Pure Arctic’, have been analysed (Figure 20). The aim was to determine the absolute concentrations of the elements in these deodorants. The results of the chemical analyses are given in Table 9. Elements which were detected in the deodorants including (from high to low concentrations): Cl, Al, Zr. Hf, S, N, F, Zn, Ti, Na, Fe, Cd, Sc, Ga, V, and Te (Figure 21). Both roll-ons, Sterilan and Palmolive, have the highest concentrations of most of these elements, except F which is highest in Dior, and Zn which is highest in Old Spice.

Sterilan and Palmolive are particularly enriched in Cl (19000 and 31400 mg/l respectively), Al (about 4000 mg/l), but very different in the Zr content (1660 and 0.03 mg/l, respectively). The difference in Zr is because Sterilan contains aluminium zirconium tetrachlorohydrex glycine and Palmolive aluminium hydrochlorohydrate as antiperspirant. Because the mineral zircon is the source of Zr in the Sterilan antiperspirant, relatively high Hf concentrations of 40.7 mg/l were detected. Hafnium is a common trace element in natural zircon and, thus, has been inherited in the antiperspirant from the original raw material. The same inheritance process applies for Ga found Sterilan and Palmolive. The elevated Ga content of about 0.3 ml/g in the roll-ons is due to the use of bauxite as raw material for the production of the antiperspirant. Clay minerals in bauxite are naturally enriched in Ga compared to other minerals and, thus, Ga in the antiperspirant is inherited (without purpose) from the raw material. The high S content in Sterilan is unexpected, because according to the ingredient list provided by the producer, there is no S-bearing ingredient. Also, there is no straightforward explanation for the elevated concentrations of Cd, Sc, V, and Te in Sterilan. One explanation could be, that chemical catalysts containing these elements, were used for ingredient production. The Old Spice deodorant is particularly enriched in Zn (8.6 mg/l). This is because of the use of zinc phenolsulfonate $(Zn(C_6H_5O_4S)_2$ as antibacterial ingredient. Dior has the lowest concentrations of all elements compared to the other investigated deodorants, except for F (12.5 mg/l). Dior is the only analysed deodorant which contains traces of F. However, none of the ingredients on the list provided by the producer, contains F.

Figure 20. Deodorants analysed in the frame of this study. Source: NGU.

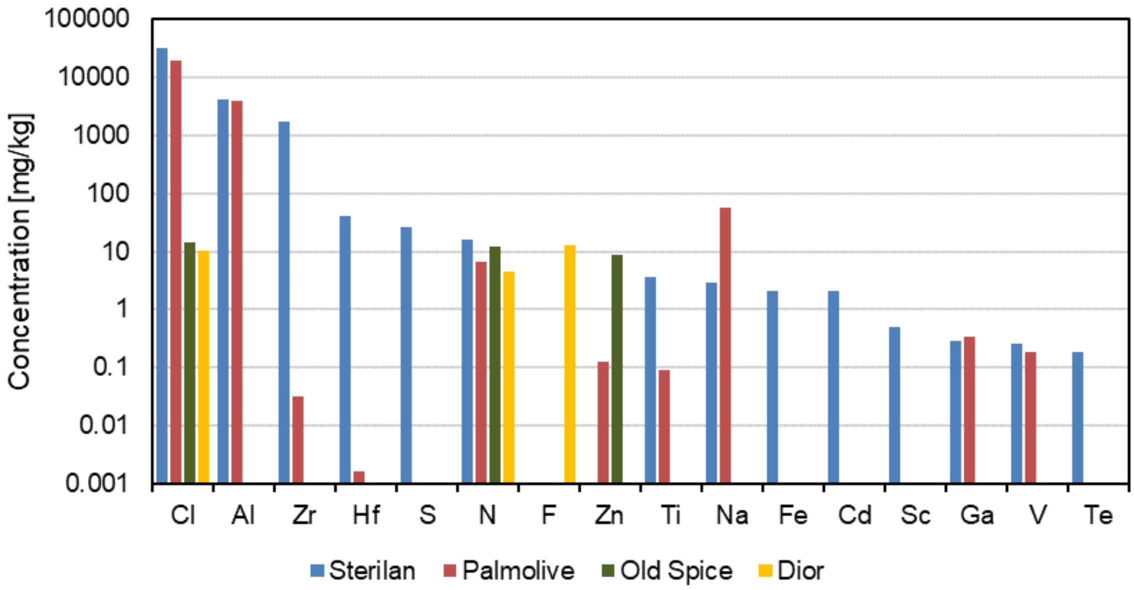

Figure 21. Column chart of the 16 detectable (above detection limits of the applied methods) elements in deodorants. Elements are ordered according to their abundance in deodorant Sterilan 'Men Extra Cool', which is most enriched in most of the detected elements.

Table 8. Ingredients in the deodorant Sterilan 'Men Extra Cool' as provided by the producer. Minerals, which are needed to produce the ingredients, are listed and the major mining country as well. Mineral-sourced elements and mineral ingredients are shown in red.

Ingredient	Chemical formula of ingredient	Major ore mineral	Formula of mineral	Major producer of mineral in 2015
Cyclopentasiloxane	$C_{10}H_{30}O_5\mathbf{Si}_5$	Quartz for Si	SiO_2	China
Aluminium zirconium tetrachlorohydrex glycine	$C_2H_8\mathbf{AlCl}NO_4\mathbf{Zr}^{+5}$	Bauxite for Al Halite for Cl Zircon for Zr	$Al(OH)_3$, $AlO(OH)$ NaCl $Zr(SiO_4)$	China China Australia
Polypropylene (PPG-14) butyl ether	$C_4H_9(OC_3H_6)_nOH$ where n= 2 - 53	-	-	-
1-Octadecanol (stearyl alcohol)	$C_{18}H_{38}O$	-	-	-
Hydrogenated castor oil	$C_{57}H_{110}O_9$	-	-	-
Parfum (denatured ethanol, essence or fragrance, fixative, propylene glycol, water)	C_2H_6O, $C_{10}H_{20}O$, $C_3H_8O_2$, H_20	-	-	-
PEG-8 distearate	$C_{40}H_{78}O_5$	-	-	-
Talc	$\mathbf{Mg_3Si_4O_{10}(OH)_2}$	Talc	$Mg_3Si_4O_{10}(OH)_2$	China
Butylhydroxytoluol (BHT)	$C_{15}H_{24}O$	-	-	-
Caprylic/Capric triglyceride	$C_{24}H_{48}O_8$	-	-	-
Gelatin crosspolymer	Gelatin is a mixture of tasteless animal proteins. The main component is denatured or hydrolyzed collagen: $C_4H_6N_2O_3R_2\cdot(C_7H_9N_2O_2R)_n$	-	-	-
Cellulose gum	$C_8H_{15}\mathbf{Na}O_8$	Halite for Na	NaCl	China
Sodium benzoate	$C_7H_5\mathbf{Na}O_2$	Halite for Na	NaCl	China
Hydrated silica	$H_{10}O_3\mathbf{Si}$	Quartz for Si	SiO_2	China
Aqua	H_2O	-	-	-
Sodium starch octenylsuccinate	$C_{39}H_{66}O_{23}$	-	-	-
Maltodextrin	$[(C_6H_{10}O_5)_nH_2O]$	-	-	-
Hydrolysed corn starch	$(C_6H_{10}O_5)_n$	-	-	-
Silica	$\mathbf{SiO_2}$	Quartz	SiO_2	China
Butylphenyl methylpropional	$C_{14}H_{20}O$	-	-	-
Citral	$C_{10}H_{16}O$	-	-	-
Citronellol	$C_{10}H_{20}O$	-	-	-
Hexyl cinnamal	$C_{15}H_{20}O$	-	-	-
Limonene	$C_{10}H_{16}$	-	-	-
Linalool	$C_{10}H_{18}O$	-	-	-
25 ingredients	**10 different elements**	**5 minerals**		**2 countries**

Table 9. Chemical analysis of deodorants. Elements with elevated concentrations are highlighted in red. Concentrations are given in mg/l.

Analyte Symbol	Unit Symbol	Detection Limit	Analysis Method	Sterlian Roll-on	Palmolive Roll-on	Old Spice Spray	Dior Spray
Ag	mg/l	0.04	ICP-MS	<0.04	<0.04	<0.04	<0.04
Al	mg/l	0.4	ICP-MS	**4030**	**3820**	<0.4	<0.4
As	mg/l	0.006	ICP-MS	<0.006	<0.006	<0.006	<0.006
Ba	mg/l	0.02	ICP-MS	<0.02	<0.02	<0.02	<0.02
Be	mg/l	0.02	ICP-MS	<0.02	<0.02	<0.02	<0.02
Bi	mg/l	0.06	ICP-MS	<0.06	<0.06	<0.06	<0.06
Br	mg/l	3	IC	<3	<3	<3	<3
Ca	mg/l	100	ICP-MS	<100	<100	<100	<100
Cd	mg/l	0.002	ICP-MS	**2.04**	<0.002	<0.002	<0.002
Ce	mg/l	0.0002	ICP-MS	0.0020	0.0022	<0.0002	<0.0002
Cl	mg/l	0.03	IC	**31400**	**19000**	**14**	**10**
Co	mg/l	0.001	ICP-MS	0.00114	<0.001	<0.001	<0.001
Cr	mg/l	0.1	ICP-MS	<0.1	<0.1	<0.1	<0.1
Cs	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
Cu	mg/l	0.04	ICP-MS	<0.04	<0.04	<0.04	<0.04
Dy	mg/l	0.0002	ICP-MS	0.0004	<0.0002	<0.0002	<0.0002
Er	mg/l	0.0002	ICP-MS	0.0006	<0.0002	<0.0002	<0.0002
Eu	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
F	mg/l	1	IC	<1	<1	<1	**12.5**
Fe	mg/l	2	ICP-MS	**2.05**	<2	<2	<2
Ga	mg/l	0.002	ICP-MS	**0.292**	**0.342**	<0.002	<0.002
Gd	mg/l	0.0002	ICP-MS	0.0002	<0.0002	<0.0002	<0.0002
Ge	mg/l	0.002	ICP-MS	<0.002	<0.002	<0.002	<0.002
Hf	mg/l	0.0002	ICP-MS	**40.7**	0.00168	<0.0002	<0.0002
Hg	mg/l	0.04	ICP-MS	<0.04	<0.04	<0.04	<0.04
Ho	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
In	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
K	mg/l	6	ICP-MS	<6	<6	<6	<6
La	mg/l	0.0002	ICP-MS	0.0036	0.0036	<0.0002	0.0002
Li	mg/l	0.2	ICP-MS	<0.2	<0.2	<0.2	<0.2
Lu	mg/l	0.0002	ICP-MS	0.0002	<0.0002	<0.0002	<0.0002
Mg	mg/l	0.4	ICP-MS	<0.4	<0.4	<0.4	<0.4
Mn	mg/l	0.02	ICP-MS	0.030	0.045	<0.02	<0.02
Mo	mg/l	0.02	ICP-MS	<0.02	<0.02	<0.02	<0.02
Na	mg/l	1	ICP-MS	2.97	**56.4**	<1	<1
Nb	mg/l	0.001	ICP-MS	0.0132	<0.001	<0.001	<0.001
Nd	mg/l	0.0002	ICP-MS	0.0006	0.0004	<0.0002	<0.0002
Ni	mg/l	0.06	ICP-MS	<0.06	<0.06	<0.06	<0.06
N	mg/l	0.01	IC	**16.1**	**6.7**	**12.2**	**4.4**
Pb	mg/l	0.01	ICP-MS	0.008	0.004	0.002	0.002
Pr	mg/l	0.001	ICP-MS	0.0002	<0.0002	<0.0002	<0.0002
P	mg/l	2	IC	<2	<2	<2	<2
Rb	mg/l	0.001	ICP-MS	<0.001	<0.001	<0.001	<0.001
Sb	mg/l	0.002	ICP-MS	<0.002	<0.002	<0.002	<0.002
Sc	mg/l	0.2	ICP-MS	0.5	<0.2	<0.2	<0.2
Se	mg/l	0.04	ICP-MS	<0.04	<0.04	<0.04	<0.04
Si	mg/l	40	ICP-MS	<40	<40	<40	<40
Sn	mg/l	0.02	ICP-MS	0.02	<0.02	<0.02	<0.02
Sm	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
S	mg/l	3	IC	**26.1**	<3	<3	<3
Sr	mg/l	0.008	ICP-MS	<0.008	<0.008	<0.008	<0.008
Ta	mg/l	0.0002	ICP-MS	0.002	<0.0002	<0.0002	<0.0002
Tb	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
Te	mg/l	0.02	ICP-MS	0.182	<0.02	<0.02	<0.02
Th	mg/l	0.002	ICP-MS	0.0070	<0.0002	<0.0002	<0.0002
Ti	mg/l	0.02	ICP-MS	**3.66**	0.09	<0.02	<0.02
Tl	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
Tm	mg/l	0.0002	ICP-MS	<0.0002	<0.0002	<0.0002	<0.0002
U	mg/l	0.0002	ICP-MS	0.0026	0.0014	<0.0002	<0.0002
V	mg/l	0.02	ICP-MS	**0.26**	**0.18**	<0.02	<0.02
W	mg/l	0.004	ICP-MS	<0.004	<0.004	<0.004	<0.004
Y	mg/l	0.0006	ICP-MS	0.0129	<0.0006	<0.0006	<0.0006
Zn	mg/l	0.1	ICP-MS	<0.1	0.126	**8.55**	<0.1
Zr	mg/l	0.002	ICP-MS	**1660**	0.032	<0.002	<0.002
Yb	mg/l	0.0002	ICP-MS	0.001	<0.0002	<0.0002	<0.0002

4.4 Minerals in toothpaste

Toothpaste is a paste or gel of complex composition used with a toothbrush to clean and maintain teeth. Beside foaming agents and odorants, toothpaste contains a number of mineral-based ingredients for abrasion, preventing tooth decay and to colour the paste. Table 10 shows the ingredient list of the toothpaste Colgate 'Karies Kontroll' as provided by the producer Colgate-Palmolive Norge AS. This toothpaste has 18 ingredients consisting of 13 different chemical elements. These 13 elements represent 14% of the element diversity of our universe. Nine of these 13 elements are sourced from nine different minerals, which are mined in different parts of the world. In addition, the minerals quartz and mica are directly used in powdered form.

Fluorine-bearing substances in toothpaste are mineralogically the most interesting. The use of fluoridated toothpastes was first introduced in the 1970s. Today, over 90% of the toothpastes produced worldwide contain F-bearing substances. Fluorine in these substances is sourced from the mineral fluorite (CaF_2). Fluorine substances promote the formation of dental enamel to prevent or reducing the incidence of dental caries and dental erosion. The strengthening of dental enamel by F is based on a simple chemical reaction. Dental enamel consists of the mineral hydroxylapatite ($Ca_5(PO_4)_3(OH)$). When reactive F- ions come into contact with the enamel tooth surface, OH- of hydroxylapatite is partially replaced by F- ions forming fluorapatite ($Ca_5(PO_4)_3(F)$). Because fluorapatite is more resistant to acid than hydroxylapatite, the modified enamel provides better protection against caries and other forms of damage. Fluorine is added to toothpaste typically at levels of 1000 to 1500 mg/kg. Concentrations below 1000 mg/kg are not likely to be preventive, and the preventive effect increases with concentration (Walsh et al., 2010).

In the frame of this study, three different toothpastes, Colgate 'Karies Kontroll', Solidox 'Total beskyttelse', and Elmex 'Kariesschutz', were analysed for F using ion chromatography. In addition to F, nitrate, phosphate or sulphate were detected (Table 11). Different F-bearing substances are used in these pastes. Elmex contains amine fluoride, Solidox sodium fluoride, and Colgate sodium fluoride and sodium monofluorophosphate (Table 11). For the Elmex toothpaste, the determined F of 1302 mg/kg is a bit lower than the content provided by the producer (1400 mg/kg). The Solidox toothpaste contains the highest F content with 1446 mg/kg. The F content detected by ion chromatography in the Colgate toothpaste of 402 mg/kg is much lower than the concentration given by the producer. That is because only F bound in the ingredient sodium fluoride was detected (Table 11). The applied method was not able to detect F in sodium monofluorophosphate. The Cl, N, and S contents of the investigated toothpastes are highly variable. Solidox and Elmex are high in Cl 1342 and 1029 mg/kg, respectively) whereas Colgate has low Cl of 154 mg/kg. Also, S and N is low in the Colgate paste compared to the Solidox and Elmex pastes. Solidox contains sodium lauryl sulfate ($NaC_{12}H_{25}SO_4$) and sodium saccharin ($C_7H_5NNaO_3S^+$) which explains the high S and N.

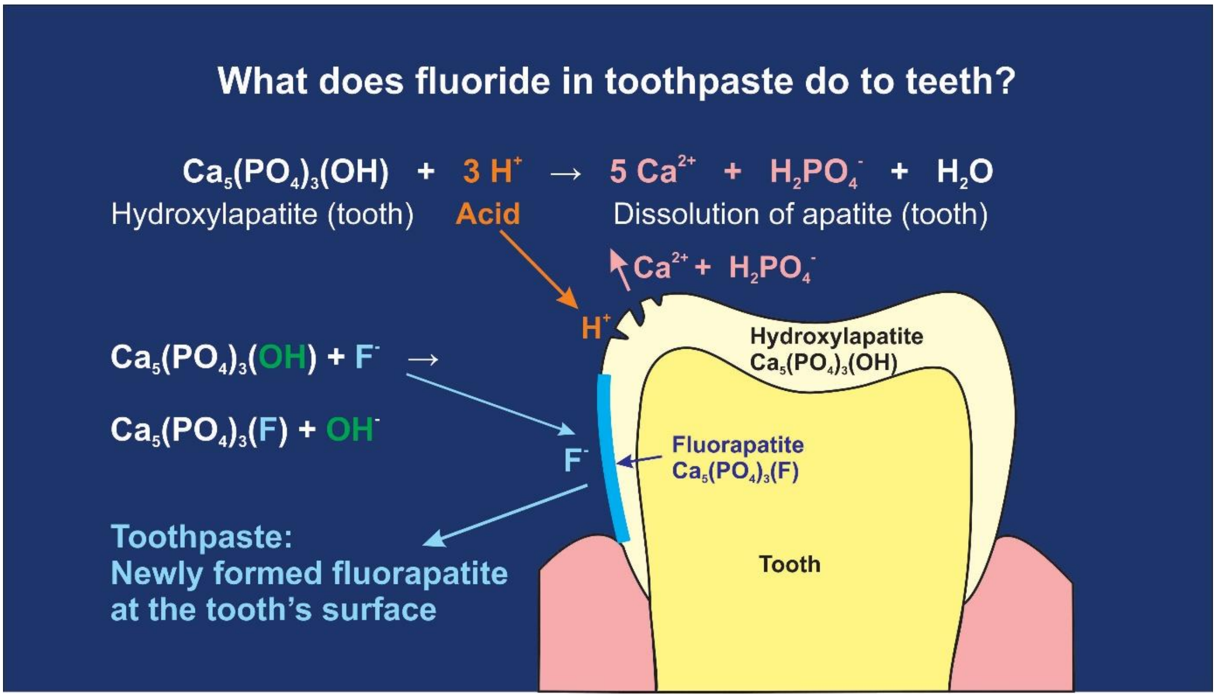

Figure 22. Sketch illustrating the dissolution of dental enamel (hydroxylapatite) by acids, and the substitution of OH^- ions by F^- ions released from the toothpaste to form fluorapatite at the enamel's surface. Source: NGU.

Table 10. The left column lists the ingredients of toothpaste Colgate as indicated on the product. Columns 3 and 4 provide the minerals and their chemical formulas required to produce ingredients. Mineral-sourced elements and mineral ingredients are shown in red. Carbon and H are sourced from organic chemicals.

Ingredient	Chemical composition of the ingredient	Mineral needed to source elements for ingredient	Mineral formular	Major producer of mineral in 2015
Aqua	H_2O	-	-	-
Hydrated silica	$\mathbf{SiO_2} \cdot nH_2O$	Quartz for Si	SiO_2	China
Sorbitol	$C_6H_{14}O_6$	-	-	-
Glycerin	$C_3H_8O_3$	-	-	-
PEG-12 (Polyethylene glycol)	$C_{2n}H_{4n+2}O_{n+1}$	-	-	-
Tetrapotassium Pyrophosphate	$\mathbf{K}_4O_7\mathbf{P}_2$	Sylvin for K, Apatite for P	KCl $Ca_5(PO_4)_3(OH,F,Cl)$	Canada China
Zinc Citrate	$C_{12}H_{10}O_{14}\mathbf{Zn}_3$	Sphalerite for Zn	ZnS	China
Sodium Lauryl Sulfate	$\mathbf{Na}C_{12}H_{25}\mathbf{S}O_4$	Halite for Na Sulfur	NaCl S	China USA
PVM/MA Copolymer	$C_7H_8O_4$	-	-	-
Aroma (Menthol)	$C_{10}H_{20}O$	-	-	-
Sodium Monofluorophosphate	$\mathbf{Na}_2\mathbf{P}O_3\mathbf{F}$	Fluorite for F Halite for Na Apatite for P	CaF_2 NaCl $Ca_5(PO_4)_3(OH,F,Cl)$	China China China
Sodium Hydroxide	NaOH	Halite for Na	NaCl	China
Cellulose Gum	CH_2CO_2H	-	-	-
Sodium Saccharin	$C_7H_5NO_3S$	-	-	-
Xanthan Gum	$C_{35}H_{49}O_{29}$	-	-	-
Mica	$\mathbf{KAl_2(AlSi_3O_{10})(F,OH)_2}$	Muskovite	$KAl_2(AlSi_3O_{10})(F,OH)_2$	China
Limonene	$C_{10}H_{16}$	-	-	-
CI 77891 (Titanoxid)	$\mathbf{TiO_2}$	Rutile	TiO_2	South Africa
Total: 18 ingredients	**13 elements**	**9 minerals**	**-**	**4 countries**

Table 11. Fluorine contents in three toothpastes as provided by the producer and analysed with ion chromatography in the frame of this study. n.a. – not analysed, n.p. – not provided by the producer. Concentrations are given as mg/kg.

Toothpaste type	Colgate 'Karies Kontroll'	Solidox 'Total beskyttelse'	Elmex 'Kariesschutz'
F-bearing ingredient as provided by producer	Sodium monofluorophosphate (1000 mg/kg F) and sodium fluoride (450 mg/kg F)	Sodium fluoride	Amine fluoride
F content as provided by producer	1450	n.p.	1400
F content determined by ion chromatography	402	1446	1302
Cl	154	1342	1029
N bound as nitrate	691	30956	1196
P	38878	n.a.	n.a.
S	201	3227	633

5. CONCLUSIONS AND OUTLOOK

Analyses of daily life items performed in the frame of this study, including compact cameras, smartphone, eye shadows, deodorants, and toothpastes, illustrate their complex chemistry. The production of components and ingredients of these consumer goods requires a wide range of mineral-based raw materials (i.e. minerals), as well as plant-, animal-, and crude-oil-based raw materials. The minerals have to be mined in different countries around the world. Table 12 summarizes how many minerals are needed for the production of the items mentioned above and the number of mining countries. Small amounts of certain mineral-based raw materials, such as Fe, Au, Ag, Al, Pb, and Cu, may have been sourced from recycled waste. Mineral processing may occur in the same country where the mineral is mined, but this is not always the case. The next step in the production cycle, the manufacture of chemical ingredients and components, commonly takes place in different countries. Consequently, the production cycle from mining through mineral processing, manufacture of ingredients and components to final product assembly, and transport, logistics and trading is very complex.

The main aim of this study and the establishment of the collection at NGU is to raise awareness about the complexity of sourcing mineral raw materials, the need for mining and the need to address associated environmental and social impacts. The increasing societal demand for better living conditions, combined with a steadily growing global population, drives the need for higher production. Mining of minerals will remain essential, even as waste recycling becomes more prevalent. However, recycling of deodorants and toothpaste, for example, is not technological feasible. Additionally, the invention of new technologies, such as smartphones, requires the use of new raw materials which have not been in the production cycle previously. Thus, the production cycle must be continually supplied with new raw materials, which need to be mined.

Table 12. Number of minerals and mining countries required for the production of daily life items analysed in this study.

	Compact camera and smartphone	Eye shadow	Deodorant	Toothpaste
Number of minerals required to produce the ingredients and components	42	18	5	9
Approximate number of countries in which the minerals are mined	10	7	2	4

This study has several direct outcomes. The first outcome includes two posters illustrating and explaining minerals used in daily life items. These posters are available for purchase online:

(1) the NGU poster "Nyttige mineraler og grunnstoffer (Useful minerals and elements)" utilizing minerals of the NGU collection for photographs (https://openarchive.ngu.no/ngu-xmlui/handle/11250/2675461?locale-attribute=en) (Figure 23),

(2) the poster of the Natural History Museum (NHM) of Oslo “Mineraler i hverdagen (Minerals in the daily life)” (https://webshop-uio-naturhistorisk-museum.trmed.no/produkt/2787/mineraler_i_hverdagen_a2) (Figure 24). The latter was prepared by the Mineralogy Team NORMIN with photographs by Øivind Thoresen, using minerals of the NHM collection.

The second outcome is the establishment of the Minerals-of-the-daily-life theme for the new geological NHM exhibition at Tøyen in Oslo. Results of smartphone and toothpaste analysis of this study were integrated in the content and design of the exhibition (Figure 25 and Figure 26).

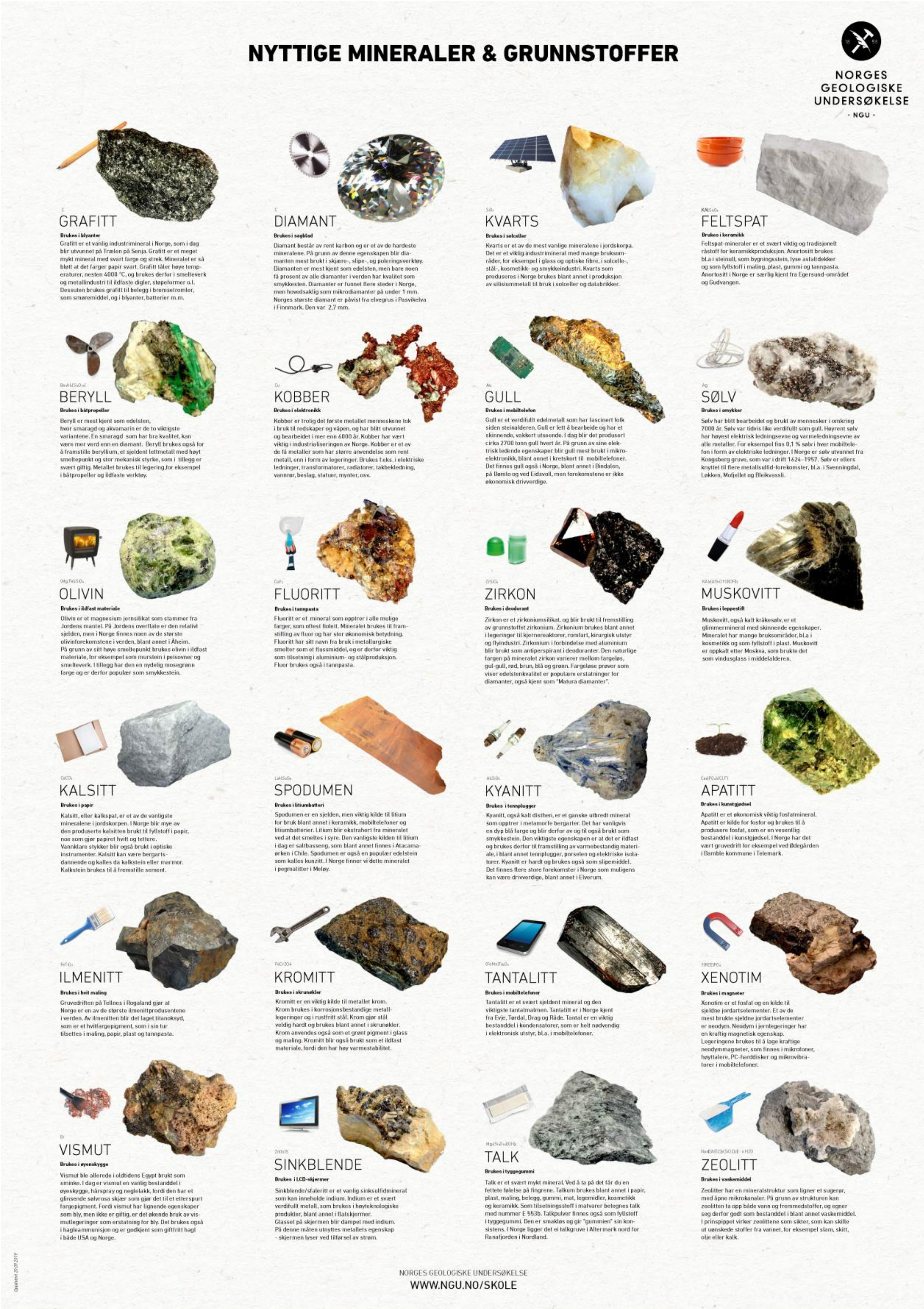

Figure 23. NGU poster "Nyttige mineraler og grunnstoffer (Useful minerals and elements)".

Figure 24. NHM poster "Mineraler i hverdagen (Minerals in the daily life)".

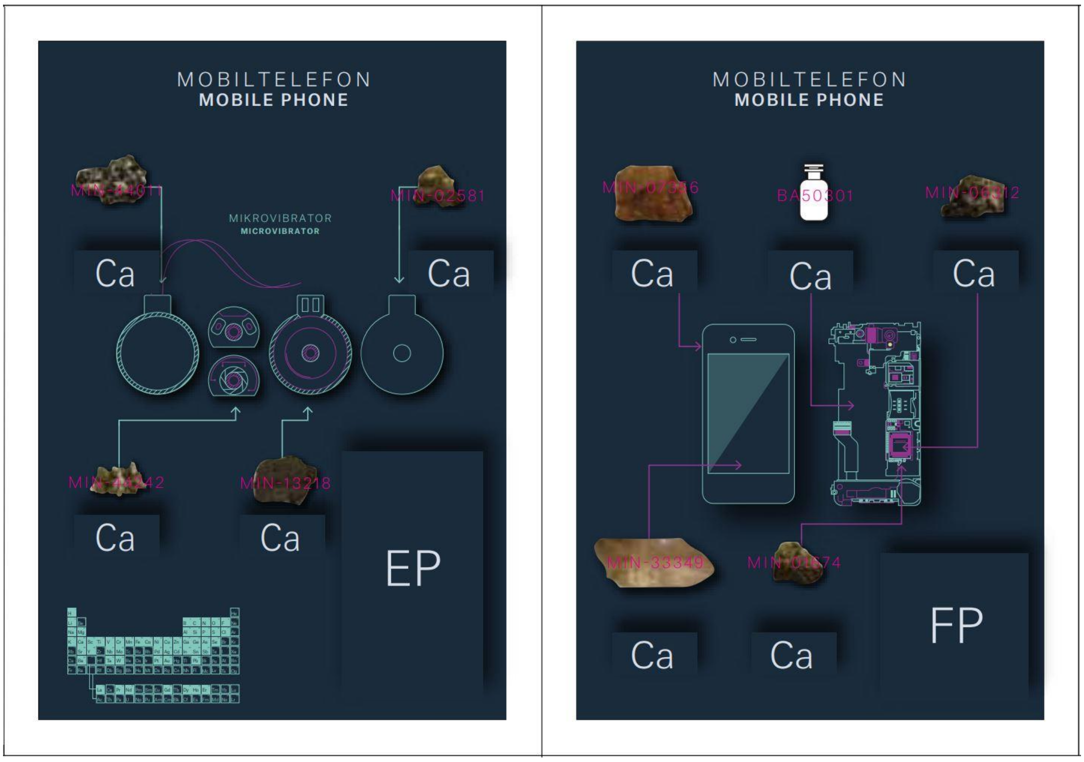

Figure 25. Design draft of "minerals in smartphones" for the geological NHM exhibition at Tøyen, Oslo, by Atelier Brückner GmbH. On the left, minerals are shown which are needed for the manufacture of micro vibrators in smartphones, which is based on the Figure 11. On the right, are minerals exhibited which are used for the production of other parts of smartphones. The abbreviations Ca, EP, and FP refer to label text types.

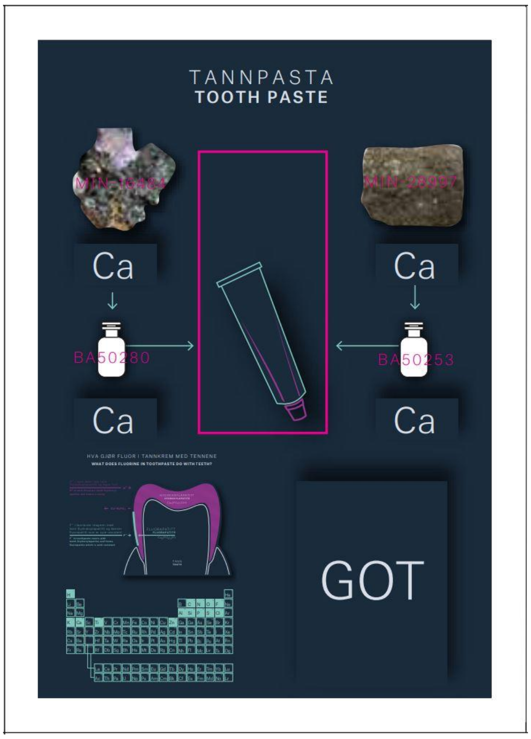

Figure 26. Design draft of "minerals in smartphones" for the geological NHM exhibition at Tøyen, Oslo, by Atelier Brückner GmbH. It illustrates the minerals used in toothpaste. The sketch on the lower left is based on Figure 22.

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APPENDIX 1: List of specimens of the applied mineralogy exhibition at NGU.

Sample number	Sample description	Locality	Municipality/area	County/ region	Country	Sample category	Exhibition theme	Collector/ donator	Property status	Collecting/ purchase date	Sample size	Exhibition/ storage place
1	chalcopyrite, pyrite	Rieppe	Nordreisa	Troms	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	26x15x1.5 cm	meeting room Foslie
2	beryl, single crystal	Li 6	Evje	Vest Agder	Norway	ore mineral	Be deposits	Axel Müller	donation	4 July 2009	7x5x4 cm	meeting room Foslie
3	baryte, white and green fluorite, 6x3x2.5 cm	Heskestad	Farsund	Rogaland	Norway	industrial mineral	industrial minerals	Frank Kaiser	donation	May 2013	6x3x2.5 cm	meeting room Foslie
4	magnetite, single crystal	Tutten	Iveland	Vest Agder	Norway	ore mineral	Fe deposits	Axel Müller	donation	2 October 2013	4x3x2.5 cm	meeting room Foslie
5	pit coal	Sveagruva	Spitzbergen	Spitzbergen	Norway	energy mineral	energy minerals	Morten Often	donation	2013	26x19x15 cm	meeting room Foslie
6a	natrolite	Hammerunterwiesenthal	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	1992	16x9x7 cm	meeting room Foslie
6b	natrolite, calcite	Hammerunterwiesenthal	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	1992	15x10x7 cm	meeting room Foslie
7	wolframite, cassiterite	St. Michael's Mount	Penzance	Cornwall	United Kingdom	ore mineral	Sn-W deposits	Axel Müller	donation	2003	21x20x4 cm	meeting room Foslie
8	almandine, single crystal	unknown	x	x	x	industrial mineral	industrial minerals	Axel Müller	donation	unknown	3.5x2.5x3 cm	meeting room Foslie
9	pyrrhotite, arsenopyrite, magnetite, 3 g/t Au	Svartliden	Skellefte	Västerbottom	Sweden	ore mineral	Au deposits	Håvard Gautneb	donation	unknown	19x13x5 cm	archive Lab-bygg 1.
10	chalocopyrite, sphalerite	Birtavarre	Kåfjord	Troms	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	24x13x4 cm	archive Lab-bygg 1.
11	bornite, chalcopyrite, covellite	Ulveryggen	Repparfjord	Troms	Norway	ore mineral	Cu deposits	Espen Torgensen	donation	2014	14x10x5 cm	meeting room Foslie
12	smoky pegmatite quartz	Slobrekka	Evje	Vest Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2009	16x12x7 cm	archive Lab-bygg 1.
13	amazonite crystal	Vassend	Evje	Vest Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	18 September 2010	16x13x9 cm	archive Lab-bygg 1.
14	fluorite, quartz	Hundholmen	Tysfjord	Nordland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2010	19x13x12 cm	archive Lab-bygg 1.
15	galena, quartz	Quarry Bösenbrunn	Erzgebirge	Vogtland	Germany	ore mineral	Pb-Zn deposits	Axel Müller	donation	historical Sample	14x9x2 cm	meeting room Foslie
16	quartz-zinnwaldite vein	Bünaustollen	Zinnwald	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	2010	9x8x6 cm	meeting room Foslie
17	galena	Nasafjell Sølvgruve	Nasafjället	Norrbottom	Sweden	ore mineral	Pb-Zn deposits	Axel Müller	donation	10 July 2006	12x8x6 cm	meeting room Foslie
18	sphalerite	unknown	x	x	x	ore mineral	Pb-Zn deposits	Nigel Cook	NGU	unknown	7x6x3 cm	meeting room Foslie
19	tetrahedrite, pyrite, calcite, rhodochrosite	unknown	x	x	x	ore mineral	Cu deposits	Nigel Cook	NGU	unknown	11x7x3 cm	meeting room Foslie
20	chalcopyrite	Mănăila	Iacobeni	Buzău	Romania	ore mineral	Cu deposits	Axel Müller	donation	18 September 2010	8x8x4 cm	meeting room Foslie

Sample number	Sample description	Locality	Municipality/area	County/ region	Country	Sample category	Exhibition theme	Collector/ donator	Property status	Collecting/ purchase date	Sample size	Exhibition/ storage place
21	pyrolusite, psilomelane	Ulm Quarry	Vanatori	Neamt	Romania	ore mineral	Mn deposits	Axel Müller	donation	18 September 2010	9x6x4 cm	meeting room Foslie
22	chalcopyrite, bornite	Rudna Mine	Wrozlaw	Wrozlaw	Poland	ore mineral	Cu deposits	Axel Müller	donation	2010	10x5x3 cm	meeting room Foslie
23	chalcopyrite, pentlandite	Pechenga	Murmansk	Kola	Russia	ore mineral	Ni deposits	Rongvald Boyd	donation	unknown	12x11x5 cm	meeting room Foslie
24	eclogite with rutile	Orkheia	Hyllestad	Sogn og Fjordane	Norway	industrial mineral	industrial minerals	Are Korneliussen	donation	unknown	23x13x5 cm	meeting room Foslie
25	Th-rich søvite with hematite	Søve gruver	Fensfeltet	Telemark	Norway	energy mineral	energy minerals	Axel Müller	donation	2005	8x6x4 cm	meeting room Foslie
26	limonite	Belo Horizonte	Belo Horizonte	Belo Horizonte	Brazil	ore mineral	Fe deposits	Axel Müller	donation	2000	10x7x6 cm	meeting room Foslie
27	fluorite, baryte	Niederschlag	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	November 2014	12x7x6 cm	meeting room Foslie
28	massive fluorite	Niederschlag	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	November 2014	10x9x7 cm	meeting room Foslie
29	fluorite crystals	Niederschlag	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	November 2015	15x8x5 cm	meeting room Foslie
30	fluorite bowl	unknown	x	x	China	product	industrial minerals	Axel Müller	donation	unknown	5.5x5.5x3.5 cm	meeting room Foslie
31	pyrite megacrystal in pegmatite quartz	Storsynken	Evje	Vest Agder	Norway	ore mineral	Fe deposits	Axel Müller	donation	November 2013	25x22x18 cm	archive Lab-bygg 1.
32	quartz wolframite vein	Hemerdon mine	Dartmoor	Devon	United Kingdom	ore mineral	Sn-W deposits	Axel Müller	donation	13 July 2014	10x9x6 cm	meeting room Foslie
33	quartz-cassiterite greisen vein	Cligga Head	St. Agnes	Cornwall	United Kingdom	ore mineral	Sn-W deposits	Axel Müller	donation	17 July 2014	8x8x3 cm	meeting room Foslie
34	garnet, plagioclase, quartz, muscovite	Bjortjern	Froland	Aust-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2005	22x17x6 cm	archive Lab-bygg 1.
35	citrine, presumably heat-treated single crystal amethyst	unknown	x	x	Brazil	industrial mineral	industrial minerals	Axel Müller	donation	unknown	12x12x10 cm	meeting room Foslie
36	yttria-stabilized zirconia (YSZ), mill stone	x	x	x	x	product	industrial minerals	Bjørn Willemoes-Wissing	donation	2013	1.2x1x1 cm	meeting room Foslie
37	synthetic corundum, grindstone	x	x	x	x	product	industrial minerals	Axel Müller	donation	2014	9x2x1 cm	meeting room Foslie
38	rock salt crystal	Wieliczka	Krakow	Poland	Poland	industrial mineral	industrial minerals	Axel Müller	donation	2010	5x4x3.5 cm	meeting room Foslie
39	hematite (Banded Fe ore)	Njuovcut	Hammerfest	Finnmark	Norway	ore mineral	Fe deposits	Morten Often	donation	unknown	11x2.2x1 cm	meeting room Foslie
40	magnetite (banded Fe ore)	Bjørnvatnet	Kirkenes	Finnmark	Norway	ore mineral	Fe deposits	Jan Sverre Sandstad	donation	2012	12x10x4 cm	meeting room Foslie
41	crude oil	Heidrun Nord Statoil	Haltenbanken	Norwegian Sea	Norway	energy mineral	energy minerals	NGU	NGU	1990	glass bottle	meeting room Foslie

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42	fossil wood (Miocene)	Bischofsheim	Rhön-Grabfeld	Bavaria	Germany	energy mineral	energy minerals	Axel Müller	donation	1991	24x9x5 cm	meeting room Foslie
43	coal	Luiza coal mine	Zabrze	Silesia	Poland	energy mineral	energy minerals	Lars Petter Nilsson	donation	2010	16x13x9 cm	meeting room Foslie
44	lignite (Miocene)	Bischofsheim	Rhön-Grabfeld	Bavaria	Germany	energy mineral	energy minerals	Axel Müller	donation	1992	14x13x8 cm	meeting room Foslie
45	Fuchsite-bearing quartzite	Masi	Kautokeino	Finnmark	Norway	ore mineral	Cr deposits	Ingvar Lindahl	donation	unknown	16x8x6 cm	meeting room Foslie
46	bornite, malachite, magnetite, chalcopyrite (epdite-garnet skarn)	Lillebotn, Storjord	Tysfjord	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	15x11x5 cm	meeting room Foslie
47	synthetic silicon carbide, large crystals	Silicon carbide	Freiberg	Saxony	Germany	intermediate product	industrial minerals	Axel Müller	bought for NGU	23 January 2015	7x5x4 cm	meeting room Foslie
48	pentlandite, pyrite, magnetite, chalcopyrite	Flåt	Evje	Aust-Agder	Norway	ore mineral	Ni deposits	Ben Snook	donation	28 July 2014	10x8x1 cm	meeting room Foslie
49	pentlandite, pyrite, magnetite, chalcopyrite	Flåt	Evje	Aust-Agder	Norway	ore mineral	Ni deposits	Morten Often	donation	June 2004	11x8x4 cm	archive Lab-bygg 1.
50	pyrite, chalcopyrite	Sulitjelma	Sulitjelma	Nordland	Norway	ore mineral	Cu deposits	Axel Müller	donation	2007	14x12x3 cm	archive Lab-bygg 1.
51	phlogopite megacryst	Kovdov	Murmansk	Kola	Russia	industrial mineral	industrial minerals	Morten Often	donation	unknown	60x42x2 cm	archive Lab-bygg 1.
52	sodalite	Orotumba	Swartbooisdrif	Namibia	Namibia	gemstone	gemstone	Nigel Cook	NGU	unknown	20x17x10 cm	archive Lab-bygg 1.
53	sodalite in nepheline syenite	Stjernøy	Alta	Finnmark	Norway	gemstone	gemstone	Håvard Gautneb	donation	unknown	17x7x5 cm	archive Lab-bygg 1.
54	sodalite	Princess Mine	Bancroft	Ontario	Canada	gemstone	gemstone	Arne Bjørlykke	donation	unknown	18x14x3 cm	archive Lab-bygg 1.
55	Ordovician oil shale	Narva quarry	Mustanina	Ida-Viru	Estonia	energy mineral	energy minerals	Ola Magne Sæther	donation	19 February 2015	7x5.5x3.5 cm	meeting room Foslie
56	bismuth shotgun shells, Bi-Sn alloy	x	x	x	United Kingdom	product	Bi deposits	Pål Gundersen	donation	10 February 2015	10x10x6 cm	meeting room Foslie
57	baryte concentrate	Heskestad	Farsund	Rogaland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	10 February 2015	x	meeting room Foslie
58	cassiterite concentrate	Geevor mine	St. Just	Cornwall	United Kingdom	ore mineral	Sn-W deposits	Axel Müller	donation	17 July 2014	x	meeting room Foslie
59	corundum	Rio Muthicana	Odinepa	Nampula	Mozambique	industrial mineral	industrial minerals	Jan Sverre Sandstad	donation	31 January 2015	10x9x1.5 cm	meeting room Foslie
60	corundum	Rio Muthicana	Odinepa	Nampula	Mozambique	industrial mineral	industrial minerals	Jan Sverre Sandstad	donation	31 January 2015	9x7x2.5 cm	meeting room Foslie
61	halite crystals	Iquique	Tarapacá	Atacama	Chile	industrial mineral	industrial minerals	Axel Müller	donation	December 2000	6.5x5x1.5 cm	meeting room Foslie

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62	muscovite megacryst, 2 sheets	Bjortjenn	Froland	Arendal	Norway	industrial mineral	industrial minerals	Axel Müller	donation	August 2009	25x20x0.3 cm	meeting room Foslie
63	muscovite megacryst	Bjortjenn	Froland	Arendal	Norway	industrial mineral	industrial minerals	Axel Müller	donation	August 2009	44x29x1 cm	archive Lab-bygg 1.
64	biotite megacryst	Hellheia midtre	Froland	Arendal	Norway	industrial mineral	industrial minerals	Axel Müller	donation	July 2004	35x28x6 cm	archive Lab-bygg 1.
65	høgtuva crystal in granite gneiss	Høgtuva	Mo i Rana	Nordland	Norway	ore mineral	Be deposits	Axel Müller	donation	September 2011	35x35x8 cm	archive Lab-bygg 1.
66	høgtuva crystal in granite gneiss	Høgtuva	Mo i Rana	Nordland	Norway	ore mineral	Be deposits	Axel Müller	donation	September 2011	13x13x6 cm	meeting room Foslie
67	biotite megacrysts on quartz	Hellheia midtre	Froland	Arendal	Norway	industrial mineral	industrial minerals	Axel Müller	donation	July 2004	32x20x15 cm	archive Lab-bygg 1.
68	pegmatitic granite	Sønnristjern	Froland	Arendal	Norway	industrial mineral	industrial minerals	Axel Müller	donation	July 2004	30x22x6 cm	archive Lab-bygg 1.
69	anthropogene sulphur, realgar	Freiberg, smelter heaps	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	February 1993	14x10x7 cm	meeting room Foslie
70	anthropogene realgar, sulphur	Freiberg, smelter heaps	Erzgebirge	Saxony	Germany	industrial mineral	industrial minerals	Axel Müller	donation	February 1993	6x6x3 cm	meeting room Foslie
71	K-feldspar	Pine Mountain	Spruce Pine	North Carolina	USA	industrial mineral	industrial minerals	Axel Müller	donation	9 November 2011	9x9x8 cm	archive Lab-bygg 1.
72	K-feldspar	Evje	Evje	Vest Agder	Norway	industrial mineral	industrial minerals	Leif Furuhaug	donation	unknown	12x12x12 cm	archive Lab-bygg 1.
73	quartz, K-feldspar	Solås	Evje	Vest Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2009	18x16x6 cm	archive Lab-bygg 1.
74	quartz crystals	Lierne	Lierne	Nordland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	July 2012	22x15x11 cm	meeting room Foslie
75	dolomite	Hekkelstrand	Ballangen	Nordland	Norway	industrial mineral	industrial minerals	Are Korneliussen	donation	2009	19x16x14 cm	archive Lab-bygg 1.
76	hematite crystals (large)	Jouvvacorru	Skjomen	Nordland	Norway	ore mineral	Fe deposits	Axel Müller	donation	2007	16x12x5 cm	archive Lab-bygg 1.
77	pyrite, chalcopyrite, Au	Photo Lake Mine	Snow Lake	Manitoba	Canada	ore mineral	Cu, Au deposits	Terje Bjerkgård	donation	unknown	14x8x6 cm	archive Lab-bygg 1.
78	pyrite, chalcopyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	22x18x1.5 cm	archive Lab-bygg 1.
79	bornite in Weissliegendes	Rudna Mine	Wrozlaw	Wrozlaw	Poland	ore mineral	Cu deposits	Axel Müller	donation	2009	28x12x5 cm	archive Lab-bygg 1.
80	pyrite, chalcopyrite, sphalerite	New Brunswick Nr. 12 mine	Bathurst	New Brunswick	Canada	ore mineral	Cu deposits	Terje Bjerkgård	donation	unknown	10x8x1 cm	archive Lab-bygg 1.
81	staurolite in amphibolite schist	unknown	x	x	Norway	industrial mineral	industrial minerals	historical sample	NGU	unknown	23x14x4 cm	archive Lab-bygg 1.
82	andradite-hematite skarn	Gjellebekk	Drammen	Buskerud	Norway	ore mineral	Fe deposits	Peter M. Ihlen	donation	unknown	14x12x10 cm	archive Lab-bygg 1.
83	slag from Cu melting, 18th century	Berget	Gaula valley	Sør-Trøndelag	Norway	smelter slag	Cu deposits	Axel Müller	donation	2010	14x13x3 cm	archive Lab-bygg 1.

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84	bornite in Weissliegendes	Rudna Mine	Wrozlaw	Wrozlaw	Poland	ore mineral	Cu deposits	Axel Müller	donation	2009	13x6x3 cm	archive Lab-bygg 1.
85	bornite in Weissliegendes	Rudna Mine	Wrozlaw	Wrozlaw	Poland	ore mineral	Cu deposits	Axel Müller	donation	2009	16x11x3 cm	archive Lab-bygg 1.
86	pyrite, chalcopyrite, sphalerite	Mofjell gruver	Mo i Rana	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	20x13x4 cm	archive Lab-bygg 1.
87	chalcopyrite, pyrite, Au	Bidjovagge	Kautokeino	Finnmark	Norway	ore mineral	Cu, Au deposits	historical sample	NGU	unknown	9x8x5 cm	archive Lab-bygg 1.
88	arsenopyrite with Au at gneiss-marble contact	Gautelis	Skjomen	Nordland	Norway	ore mineral	Au deposits	Axel Müller	donation	2007	16x8x4 cm	archive Lab-bygg 1.
89	arsenopyrite with Au	Gautelis	Skjomen	Nordland	Norway	ore mineral	Au deposits	Axel Müller	donation	2007	17x7x6 cm	archive Lab-bygg 1.
90	chalcopyrite	Chuquicamata	Antofagasta	Atacama	Chile	ore mineral	Cu deposits	Axel Müller	donation	2002	10x7x4 cm	archive Lab-bygg 1.
91	chalcopyrite	Hilfe Gottes Mine	Bad Grund	Harz	Germany	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	9x4x4 cm	archive Lab-bygg 1.
92	sphalerite (Au)	Svartliden	Skellefte	Västerbottom	Sweden	ore mineral	Zn (Au) deposits	Håvard Gautneb	donation	unknown	18x17x9 cm	archive Lab-bygg 1.
93	pyrite, chalcopyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	19x15x3 cm	archive Lab-bygg 1.
94	pyrite, chalcopyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	22x14x5 cm	archive Lab-bygg 1.
95	chalcopyrite, pyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	14x10x4 cm	archive Lab-bygg 1.
96	sphalerite, (chalcopyrite)	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	9x12x4 cm	archive Lab-bygg 1.
97	bornite in Weissliegendes	Rudna Mine	Wrozlaw	Wrozlaw	Poland	ore mineral	Cu deposits	Axel Müller	donation	2009	12x9x2 cm	archive Lab-bygg 1.
98	chalcopyrite, pyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	17x8x3 cm	archive Lab-bygg 1.
99	pyrite, chalcopyrite	Vaddas	Nordreisa	Troms	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	24x14x6 cm	archive Lab-bygg 1.
100	magnetite (banded Fe ore)	Bjørnvatnet	Kirkenes	Finnmark	Norway	ore mineral	Fe deposits	historical sample	NGU	unknown	10x8x4 cm	archive Lab-bygg 1.
101	pyrite, chalcopyrite	Joma gruver	Rørvik	Nordland	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	8x6x4 cm	archive Lab-bygg 1.
102	pyrite, chalcopyrite, magnetite	Tverrfjellet	Dovre	Oppland	Norway	ore mineral	Cu deposits	Morten Often	donation	unknown	30x16x10 cm	archive Lab-bygg 1.
103	Ordovician marble with karst surface	Marmorgrotta Rørvik	Rørvik	Nordland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2005	53x17x18 cm	archive Lab-bygg 1.
104	chalcopyrite, pyrite	Olavsgruva	Røros	Sør-Trøndelag	Norway	ore mineral	Cu deposits	Axel Müller	donation	2004	19x12x5 cm	archive Lab-bygg 1.
105	chalcopyrite, pyrite	Olavsgruva	Røros	Sør-Trøndelag	Norway	ore mineral	Cu deposits	Axel Müller	donation	2004	20x12x11 cm	archive Lab-bygg 1.
106	Cr-diopside, tremolite, brucite	Granåsen	Mosjøen	Nordland	Norway	ore mineral	Cr deposits	Ingvar Lindahl	donation	unknown	36x16x10 cm	archive Lab-bygg 1.

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107	Cr-rich tremolite	Hatten	Hattfjelldal	Nordland	Norway	ore mineral	Cr deposits	Ingvar Lindahl	donation	unknown	16x10x2 cm	archive Lab-bygg 1.
108	barite, fluorite	Heskestad	Farsund	Rogaland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2012	12x11x10 cm	archive Lab-bygg 1.
109	barite, fluorite	Heskestad	Farsund	Rogaland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2012	13x12x10 cm	archive Lab-bygg 1.
110	arsenopyrite, Au	Kolsvika	Bindal	Nordland	Norway	ore mineral	Au deposits	Peter M. Ihlen	donation	unknown	18x15x3 cm	archive Lab-bygg 1.
111	fluorite	Okuruso	Otjiwarongo	Otjozondjupa	Namibia	industrial mineral	industrial minerals	Axel Müller	donation	2002	12x10x8 cm	archive Lab-bygg 1.
112	chalcopyrite, pyrite	Mina de Feitais	Aljustrel	Beja	Portugal	ore mineral	Zn, Cu deposits	Axel Müller	donation	2012	9x9x3 cm	archive Lab-bygg 1.
113	pyrite, sphalerite	Neves Corvo mine	Castro de Verde	Alentejo	Portugal	ore mineral	Zn, Cu deposits	Axel Müller	donation	2012	14x9x4 cm	archive Lab-bygg 1.
114	staurolite-kyanite quartzite	Keivy	Murmansk	Kola	Russia	industrial mineral	industrial minerals	Morten Often	donation	unknown	26x22x9 cm	archive Lab-bygg 1.
115	megacrystic garnet in schist	Buviknakken	Sørfold	Nordland	Norway	industrial mineral	industrial minerals	Ingvar Lindahl	donation	unknown	24x18x5 cm	archive Lab-bygg 1.
116	calcite on Ordovician limestone	Dalen-Kjørholt mines	Heistad	Porsgrunn	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2005	24x20x15 cm	archive Lab-bygg 1.
117	chalcopyrite, magnetite	Staws skjerp	Karasjok	Finnmark	Norway	ore mineral	Cu deposits	Morten Often	donation	unknown	24x17x11 cm	archive Lab-bygg 1.
118	chalcopyrite	Neves Corvo mine	Castro de Verde	Alentejo	Portugal	ore mineral	Cu, Zn deposits	Axel Müller	donation	2012	12x8x5 cm	archive Lab-bygg 1.
119	pyrite, chalcopyrite	Flintheia	Leksvik	Nord-Trøndelag	Norway	ore mineral	Cu (Au) deposits	Axel Müller	donation	2009	14x11x6 cm	archive Lab-bygg 1.
120	sphalerite, pyrite	Huaraz	Huaraz	Anacash	Peru	ore mineral	Zn, Pb deposits	Axel Müller	donation	2010	12x9x3.5 cm	archive Lab-bygg 1.
121	chalcopyrite, pyrite	Mina de Feitais	Aljustrel	Beja	Portugal	ore mineral	Zn, Cu deposits	Axel Müller	donation	2012	13x8x5 cm	archive Lab-bygg 1.
122	pyrite, galena, Au 3.3 g/t	Sanshandao Mine	Yantai	Jiaodong	China	ore mineral	Au deposits	Axel Müller	donation	2007	12x8x2 cm	archive Lab-bygg 1.
123	pyrite in carbonate-altered amphibolite	Bieskenjarg	SW Karasjok	Finnmark	Norway	ore mineral	Cu deposits	Morten Often	donation	unknown	32x22x7 cmj	archive Lab-bygg 1.
124	chaolcopyrite, sphalerite in pillow lava	Rieppe	Nordreisa	Troms	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	28x19x5 cm	archive Lab-bygg 1.
125	pyrite in Carboniferous schist	Gaulfossen	Melhus	Sør-Trøndelag	Norway	ore mineral	Fe deposits	Axel Müller	donation	2007	14x12x3 cm	archive Lab-bygg 1.
126	hematite, bornite, chalcocite	Lakselv	Karasjok	Finnmark	Norway	ore mineral	Cu deposits	Morten Often	donation	unknown	18x15x3 cm	archive Lab-bygg 1.
127	bornite, malachite in Weissliegendes	Rudna Mine	Wrozlaw		Poland	ore mineral	Cu deposits	Axel Müller	donation	2009	33x14x4 cm	archive Lab-bygg 1.
128	kyanite in eclogite	Roan	Fosen	Nord-Trøndelag	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2012	24x18x7 cm	archive Lab-bygg 1.

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129	miner shoes made of straw used for marble mining in 2000	Yunnan	Yunnan	Yunnan	China	mining equipment	mining equipment	Axel Müller	donation	2000	x	meeting room Foslie
130	heavy water (deuterium oxide 2H2O)	Rjukan	Rjukan	Telemark	Norway	energy mineral	energy minerals	Håvard Gautneb	donation	unknown	x	meeting room Foslie
131	thorite, allanite, zircon	Einerkilen	Evje	Vest-Agder	Norway	energy mineral	energy minerals	Axel Müller	donation	September 2010	16x14x6 cm	meeting room Foslie
132	autunite	Bergen	Vogtland	Saxony	Germany	energy mineral	energy minerals	Axel Müller	donation	historical sample	5x3x3 cm	meeting room Foslie
133	uraninite in muscovite	Vegårdshei	Evje	Agder	Norway	energy mineral	energy minerals	Nigel Cook	NGU	unknown	9x4x3 cm	meeting room Foslie
134	torbernite	Chalk Mountain	Spruce Pine	North Carolina	USA	energy mineral	energy minerals	Axel Müller	donation	2010	14x8x2 cm	meeting room Foslie
135	uranophan	Chalk Mountain	Spruce Pine	North Carolina	USA	energy mineral	energy minerals	Axel Müller	donation	2010	9x5x3 cm	meeting room Foslie
136	torbernite	Guarda	Guarda	Guarda	Portugal	energy mineral	energy minerals	Axel Müller	donation	2012	6x4x4 cm	meeting room Foslie
137	polycrase	Tutten	Iveland	Vest-Agder	Norway	energy mineral	energy minerals	Axel Müller	donation	October 2013	12x5x4 cm	meeting room Foslie
138	samarskite-(Y), single crystal	Tjeldøya	Tjeldsund	Lofoten	Norway	energy mineral	energy minerals	Ingvar Lindahl	donation	unknown	3x2x2 cm	meeting room Foslie
139	fergusonite	Knipane, Apatittbrudd	Iveland	Vest-Agder	Norway	energy mineral	energy minerals	Axel Müller	donation	October 2013	8x7x4 cm	meeting room Foslie
140	samarskite-(Y)	Bjortjørn	Froland	Bamble	Norway	energy mineral	energy minerals	Axel Müller	donation	September 2011	4x3x2 cm	meeting room Foslie
141	thalenite	Rossås	Iveland	Vest-Agder	Norway	energy mineral	energy minerals	Axel Müller	donation	2010	9x4x3 cm	meeting room Foslie
142	alaskite with uraninite	Rössing Mine	Arandis	Guanikontes	Nambia	energy mineral	energy minerals	Axel Müller	donation	September 2014	10x7x6 cm	meeting room Foslie
143	thorite-bearing Rødbergite	Rødberg	Fensfeltet	Telemark	Norway	energy mineral	energy minerals	Axel Müller	donation	September 2004	7x7x5 cm	meeting room Foslie
144	pyroxenite with 6% apatite	Misværdal	Bodø	Nordland	Norway	industrial mineral	industrial minerals	Peter M. Ihlen	donation	2010	9x5.5x1 cm	meeting room Foslie
145	pyroxenite with 6% apatite	Misværdal	Bodø	Nordland	Norway	industrial mineral	industrial minerals	Peter M. Ihlen	donation	2010	10x9x5 cm	meeting room Foslie
146	pyroxenite with 15% apatite	Kodal	Andebu	Vestfold	Norway	industrial mineral	industrial minerals	Ben Snook	donation	2014	10x7x4 cm	meeting room Foslie
147	pyroxenite with apatite	Lillebukt	Seiland	Finnmark	Norway	industrial mineral	industrial minerals	Håvard Gautneb	donation	unknown	12x9x4 cm	meeting room Foslie
148	blue apatite, single crystal	Brazil	x	x	Brazil	industrial mineral	industrial minerals	Axel Müller	donation	2014	4.5x2x2 cm	meeting room Foslie
149	garden fertilizer YaraMila with 4% P	Norway	x	x	Norway	product	industrial minerals	Axel Müller	donation	2014	x	meeting room Foslie
150	Shimmer sugar with muscovite	USA	x	x	USA	product	industrial minerals	Axel Müller	donation	2010	x	meeting room Foslie
151	lipstick with muscovite	x	x	x	x	product	industrial minerals	Axel Müller	donation	2012	8x2x2 cm	meeting room Foslie

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152	muscovite, single crystal	Birkeland 4	Iveland	Vest-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2010	12x9x4 cm	meeting room Foslie
153	muscovite concentrate	Rendalsvik	Holandsfjord	Nordland	Norway	mineral concentrate	industrial minerals	Håvard Gautneb	donation	unknown	x	meeting room Foslie
154	phlogopite concentrate	Ødegård verk	Bamble	Telemark	Norway	mineral concentrate	industrial minerals	Håvard Gautneb	donation	unknown	x	meeting room Foslie
155	muscovite concentrate	Spruce Pine	Mitchell	North Carolina	Norway	mineral concentrate	industrial minerals	Axel Müller	donation	2010	x	meeting room Foslie
156	talk	Granåsen	Mosjøen	Nordland	Norway	industrial mineral	industrial minerals	Ingvar Lindahl	donation	unknown	32x19x7 cm	archive Lab-bygg 1.
157	fine-grained galena in sandstone	Laisvall	Arjeplog	Norrbotten	Sweden	ore mineral	Pb deposits	Nigel Cook	NGU	unknown	35x30x8 cm	archive Lab-bygg 1.
158	tourmaline in muscovite (single crystal)	Rånkeipen	Råna Massiv	Nordland	Norway	industrial mineral	industrial minerals	Ingvar Lindahl	donation	unknown	8x6x1 cm	meeting room Foslie
159	kyanite	Brazil	x	x	Brazil	industrial mineral	industrial minerals	Axel Müller	donation	2012	10x9x5 cm	meeting room Foslie
160	kyanite concentrate	Tverrådalen	Surnadal	Møre og Romsdal	Norway	mineral concentrate	industrial minerals	Axel Müller	donation	2005	x	meeting room Foslie
161	olivine	Åheim	Vanylven	Møre og Romsdal	Norway	industrial mineral	industrial minerals	Axel Müller	bought for NGU	2011	11x10x6 cm	meeting room Foslie
162	olivine sand	Åheim	Vanylven	Møre og Romsdal	Norway	mineral concentrate	industrial minerals	Axel Müller	donation	2011	x	meeting room Foslie
163	olivine in basalt	Wilcza Gora	Gmina Przystajń	Lower Silesia	Poland	industrial mineral	industrial minerals	Krzysztof Szopa	donation	2010	7x5x5 cm	meeting room Foslie
164	talc powder "Penaten"	Germany	x	x	Germany	product	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
165	chewing gum with talc	x	x	x	x	product	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
166	talc (soapstone)	Bårstad	Oppdal	Sør-Trøndelag	Norway	industrial mineral	industrial minerals	Lars Petter Nilsson	donation	unknown	17x14x2 cm	meeting room Foslie
167	talc (edel talc)	Sotkamo	Sotkamo	Kainuu	Finland	industrial mineral	industrial minerals	Håvard Gautneb	donation	unknown	10x9x3 cm	meeting room Foslie
168	chrysotile asbestos	Norway	x	x	Norway	industrial mineral	industrial minerals	historical sample	NGU	unknown	13x3x2 cm	meeting room Foslie
169	kyanite	Grasvatnet	Rana	Nordland	Norway	industrial mineral	industrial minerals	Terje Bjerkgård	donation	unknown	14x11x6 cm	meeting room Foslie
170	staurolite-kyanite quartzite	Keivy	Murmansk	Kola	Russia	industrial mineral	industrial minerals	Morten Often	donation	unknown	12x8x4 cm	meeting room Foslie
171	kyanite quartzite	Halsjöberget	Torsby	Värmland	Sweden	industrial mineral	industrial minerals	Axel Müller	donation	2005	21x13x6 cm	meeting room Foslie
172	kyanite in garnet schist	Herjangen	Narvik	Nordland	Norway	industrial mineral	industrial minerals	Steinar Foslie (historical sample)	NGU	27 August 1911	20x115 cm	meeting room Foslie
173	olivine (harzburgite)	Åheim	Vanylven	Møre og Romsdal	Norway	industrial mineral	industrial minerals	Håvard Gautneb	donation	unknown	10x8x5 cm	meeting room Foslie
174	talc (soapstone)	Göpfersgrün	Wunsiedel	Bavaria	Germany	industrial mineral	industrial minerals	historical sample	NGU	c. 1970	7x6x3 cm	meeting room Foslie

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175	talc (soapstone)	United Arab Emirates	x	x	United Arab Emirates	industrial mineral	industrial minerals	historical sample	NGU	c. 1970	11x6.5x4 cm	meeting room Foslie
176	talc (soapstone)	Kalpana	Kalpana	Andhra Pradesh	India	industrial mineral	industrial minerals	historical sample	NGU	c. 1970	9x6x5 cm	meeting room Foslie
177	olivine brick: olivine, hematite, kaolin	Åheim	Sunnmøre	Møre og Romsdal	Norway	product	industrial minerals	Axel Müller	donation	2014	11x11x4 cm	meeting room Foslie
178	garnet concentrate	Spruce Pine	Mitchell	North Carolina	USA	mineral concentrate	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
179	kimberlite, diamant-bearing	Ontario	Ontario	Ontario	Canada	gemstone	industrial minerals	Morten Often	donation	unknown	14x11x3 cm	meeting room Foslie
180	garnet schist	Rondane	Rondane	Innlandet	Norway	industrial mineral	industrial minerals	Axel Müller	donation	1993	15x12x1.5 cm	meeting room Foslie
181	saw blade with micro diamonds	x	x	x	x	product	industrial minerals	Axel Müller	donation	2013	diameter 9 cm	meeting room Foslie
182	cut glass "diamond"	x	x	x	x	product	industrial minerals	Axel Müller	donation	2011	diameter 8 cm	meeting room Foslie
183	corundum-bearing rock	Mutsuna		Naxos	Greece	industrial mineral	industrial minerals	Lars Petter Nilsson	donation	unknown	6x5x5 cm	meeting room Foslie
184	corundum-bearing gneiss	Kleggåsen quarry	Froland	Aust-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	unknown	6x5x2 cm	meeting room Foslie
185	cut-off wheel made of synthetic corundum	x	x	x	x	product	industrial minerals	Axel Müller	donation	2013	diameter 11.4 cm	meeting room Foslie
186	silicon carbide powder	x	x	x	x	product	industrial minerals	Axel Müller	donation	2013	x	meeting room Foslie
187	forsterite abrasive sand "Star Grit"	x	x	x	x	product	industrial minerals	Axel Müller	donation	2013	x	meeting room Foslie
188	corudum (sapphire) in basalt	Ölberg	Siebengebirge	Nordrhein-Westfalen	Germany	industrial mineral	industrial minerals	historical sample	NGU	unknown	7x6x2 cm	meeting room Foslie
189	crystalline silicon carbide	x	x	x	x	intermediate product	industrial minerals	Axel Müller	donation	2012	13x6x4 cm	meeting room Foslie
190	quartz crystal(s) with calcite inclusions	Thailand	x	x	Thailand	industrial mineral	industrial minerals	Axel Müller	donation	2001	8x5x4 cm	meeting room Foslie
191	green fluorite crystal	China	x	x	China	industrial mineral	industrial minerals	Axel Müller	donation	2013	4x4x4 cm	meeting room Foslie
192	fluorite concentrate	Niederschlag	Erzgebirge	Saxony	Germany	mineral concentrate	industrial minerals	Axel Müller	donation	2014	x	meeting room Foslie
193	toothpast with fluorine	x	x	x	x	product	industrial minerals	Axel Müller	donation	2010	x	meeting room Foslie
194	fluorite coated with pyrite	El Hammam mine			Marocco	industrial mineral	industrial minerals	Axel Müller	donation	2013	18x10x6 cm	meeting room Foslie
195	granite breccia healed with fluorite	Heskestad	Farsund	Vest-Agder	Norway	industrial mineral	industrial minerals	Frank Kaiser	donation	2012	13x11x6 cm	meeting room Foslie

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196	dacite from the 1902 eruption	Mt Pelee	Martinique	Martinique	Martinique	igneous rock	igneous rocks	Guillet (historical sample)	NGU	1903	8x7x6 cm	meeting room Foslie
197	barite with fluorite	Heskestad	Farsund	Vest-Agder	Norway	industrial mineral	industrial minerals	Frank Kaiser	donation	2013	12x10x10 cm	meeting room Foslie
198	deodorant with the antiperspirant aluminium zirconium tetrachlorohydrex gly (AZG)	x	x	x	x	product	industrial minerals	Axel Müller	donation	2010	x	meeting room Foslie
199	zircon, single crystal	Peixe alkaline complex	Tocantins	Tocantins	Brazil	industrial mineral	industrial minerals	Axel Müller	donation	unknown	2x1.5x1 cm	meeting room Foslie
200	barite, single cystal	Woodfjorden	Svalbard	Svalbard	Norway	industrial mineral	industrial minerals	Peter M. Ihlen	donation	unknown	10x8x7 cm	meeting room Foslie
201	needle tremolite	Voslabeni quarry	Gheorgheni	Harghita	Romania	industrial mineral	industrial minerals	Axel Müller	donation	August 2009	9x6x5 cm	meeting room Foslie
202	platy tremolite	Voslabeni quarry	Gheorgheni	Harghita	Romania	industrial mineral	industrial minerals	Axel Müller	donation	August 2009	11x6x5 cm	meeting room Foslie
203	wasing powder with >30% zeolite	x	x	x	x	product	industrial minerals	Axel Müller	donation	unknown	x	meeting room Foslie
204	rock salt crystal	Vienenburg	Goslar	Niedersachsen	Germany	industrial mineral	industrial minerals	historical sample	NGU	unknown	3.5x3x2 cm	meeting room Foslie
205	sylvite	Asse mine	Wolfenbüttel	Niedersachsen	Germany	industrial mineral	industrial minerals	Ingvar Lindahl	donation	unknown	8x4x2 cm	meeting room Foslie
206	"Himalayan" rock salt	Khewra salt mines	Khewra	Jhelum	Pakistan	product	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
207	sylvite	Vienenburg	Goslar	Niedersachsen	Germany	industrial mineral	industrial minerals	historical sample	donation	unknown	9x5x4 cm	meeting room Foslie
208	sulfide concentrate "eksportkis 1957" (sulfur ore)	Orkla gruve	Løkken	Sør-Trøndelag	Norway	mineral concentrate	industrial minerals	historical sample	donation	1957	x	meeting room Foslie
209	matchbox "Cook's matches"	x	x	x	x	product	industrial minerals	Axel Müller	donation	2009	x	meeting room Foslie
210	pyrite (sulfur ore)	unknwon	x	x	x	ore mineral	industrial minerals	Nigel Cook	NGU	unknown	12x8x5 cm	meeting room Foslie
211	synthetic sulfur	Netherland	x	x	Netherland	intermediate product	industrial minerals	Maarten Broekmans	donation	unknown	11x7x5 cm	meeting room Foslie
212	rock salt	Wieliczka	Krakow	Silesia	Poland	industrial mineral	industrial minerals	Lars Petter Nilsson	donation	2009	8x6x5 cm	meeting room Foslie
213	"Hydrocarb" paper filler, calcite suspension	Hustadmarmor AS	x	x	Norway	intermediate product	industrial minerals	Axel Müller	donation	unknown	x	meeting room Foslie
214	calcite megacrysts	Heskestad	Farsund	Aust-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2013	21x8x6 cm	meeting room Foslie
215	paper containing calcite and kaolinite	x	x	x	x	product	industrial minerals	Axel Müller	donation	2012	10x10x1.5 cm	meeting room Foslie

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216	calcite on siderite, quartz, galena, chalcopyrite	Cavnic	Cavnic	Maramureș	Romania	industrial mineral	industrial minerals	Nigel Cook	NGU	unknown	9x7x6 cm	meeting room Foslie
217	marble with graphite specks	Akselberg	Brønnøy	Helgeland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2010	10x9x7 cm	meeting room Foslie
218	limestone mined by Norcem	Kjøpsvik	Tysfjord	Nordland	Norway	industrial mineral	industrial minerals	Lars Petter Nilsson	donation	unknown	16x9x8 cm	meeting room Foslie
219	dolomite (white) with carbon-bearing carbonate layers (grey)	Hekkelstrand	Ballangen	Nordland	Norway	industrial mineral	industrial minerals	Are Korneliussen	donation	unknown	17x13x7 cm	meeting room Foslie
220	kaolinized Beauvoir granite	Beauvoir granite	Massif Central	Auvergne-Rhône-Alpes	France	industrial mineral	industrial minerals	Axel Müller	donation	October 2014	9x8x5 cm	meeting room Foslie
221	gypsum "Gipsrose"	Schraplau	Weida	Sachsen-Anhalt	Germany	industrial mineral	industrial minerals	Axel Müller	donation	c. 1970	5x5x4 cm	meeting room Foslie
222	halloysite ore	Matauri Bay	Northland	Northland	New Zealand	industrial mineral	industrial minerals	Axel Müller	donation	2013	x	meeting room Foslie
223	gypsum, single crystal	Sorbas	Almería	Andalusia	Spain	industrial mineral	industrial minerals	Jan Sverre Sandstad	donation	2014	10x4x2 cm	meeting room Foslie
224	magnesite, climbing "chalk" "White Gold"	x	x	x	x	product	industrial minerals	Axel Müller	donation	unknown	x	meeting room Foslie
225	kaolinite concentrate	Spruce Pine	Mitchell	North Carolina	USA	mineral concentrate	industrial minerals	Axel Müller	donation	2013	x	meeting room Foslie
226	kaolinite concentrate	Beauvoir mine	Massif Central	Auvergne-Rhône-Alpes	France	mineral concentrate	industrial minerals	Axel Müller	donation	2014	x	meeting room Foslie
227	calcite	Estremoz marble mine	Estremoz	Évora	Portugal	industrial mineral	industrial minerals	Axel Müller	donation	October 2012	10x8x6 cm	meeting room Foslie
228	magnesite	Turkey	x	x	Turkey	industrial mineral	industrial minerals	Axel Müller	donation	c. 1970	13x7x4 cm	meeting room Foslie
229	cassiterite concentrate (45% Sn)	Renison Bell mine	Tasmania	Tasmania	Australia	ore mineral	Sn-W deposits	Axel Müller	donation	August 2012	x	meeting room Foslie
230	wolframite, siderite, quartz	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	ore mineral	Sn-W deposits	Axel Müller	donation	October 2012	12x8x6 cm	meeting room Foslie
231	cassiterite concentrate	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	mineral concentrate	Sn-W deposits	Axel Müller	donation	October 2012	x	meeting room Foslie
232	cassiterite, quartz, zinnwaldite	Militär shaft	Zinnwald	Saxony	Germany	ore mineral	Sn-W deposits	Axel Müller	donation	July 2011	x	meeting room Foslie
233	tin cup "Barthel zinn"	Freiberg	Freiberg	Saxony	Germany	product	Sn-W deposits	Axel Müller	donation	December 2014	x	meeting room Foslie
234	wolframite	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	ore mineral	Sn-W deposits	Axel Müller	donation	October 2012	7x4x3 cm	meeting room Foslie
235	pyrrhotite, cassiterite	Renison Bell mine	Tasmania	Tasmania	Australia	ore mineral	Sn-W deposits	Axel Müller	donation	August 2012	8x8x4 cm	meeting room Foslie
236	garnet-diopside skarn with scheelite	Målvika	Bindal	Helgeland	Norway	ore mineral	Sn-W deposits	Axel Müller	donation	2007	9x6x5 cm	meeting room Foslie

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237	wolframite, single crystal	Ørsdalen	Bjerkreim	Rogaland	Norway	ore mineral	Sn-W deposits	historical sample	NGU	unknown	4x1x1 cm	meeting room Foslie
238	light bulb with tungsten wire	x	x	x	x	product	Sn-W deposits	Axel Müller	donation	unknown	x	meeting room Foslie
239	fine-grained wolframite concentrate	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	mineral concentrate	Sn-W deposits	Axel Müller	donation	October 2012	x	meeting room Foslie
240	coarse-grained wolframite concentrate	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	mineral concentrate	Sn-W deposits	Axel Müller	donation	October 2012	x	meeting room Foslie
241	bog iron, Fe ore of the Vikings	Norway	x	x	Norway	ore mineral	Fe deposits	historical sample	NGU	unknown	6x5x4 cm	meeting room Foslie
242	pyrite, single crystal	unknown	x	x	unknown	ore mineral	Fe deposits	Axel Müller	donation	unknown	2.5x2.5x2 cm	meeting room Foslie
243	Fe ore pellets	Kiruna	Kiruna	Norrbotten	Sweden	intermediate product	Fe deposits	Axel Müller	donation	unknown	x	meeting room Foslie
244	hematite skarn	Hundmulen	Hamarøy	Nordland	Norway	ore mineral	Fe deposits	Axel Müller	donation	27 September 2010	12x12x7 cm	meeting room Foslie
245	hematite, magnetite	Rana Gruver	Mo i Rana	Nordland	Norway	ore mineral	Fe deposits	Jan Sverre Sandstad	donation	unknown	11x11x7 cm	meeting room Foslie
246	hematite, magnetite	Rana Gruver	Mo i Rana	Nordland	Norway	ore mineral	Fe deposits	historical sample	NGU	unknown	14x6x3 cm	meeting room Foslie
247	hematite, magnetite	Håfjellsmulden	Ofoten	Nordland	Norway	ore mineral	Fe deposits	Ingvar Lindahl	donation	unknown	10x9x5 cm	meeting room Foslie
248	hematite, magnetite, pyrite	Fosdalen	Steinkjer	Trøndelag	Norway	ore mineral	Fe deposits	historical sample	NGU	unknown	12x10x3 cm	meeting room Foslie
249	pyrite, magnetite	Njuovcut	Hammerfest	Finnmark	Norway	ore mineral	Fe deposits	Morten Often	donation	unknown	11x7x3 cm	meeting room Foslie
250	steel screw	x	x	x	x	product	Fe deposits	Axel Müller	donation	unknown	13x5x5 cm	meeting room Foslie
251	hematite pigment "Falun red"	Falun	Falun	Dalarna	Sweden	product	Fe deposits	Axel Müller	donation	unknown	x	meeting room Foslie
252	banded iron ore	Ukraine	x	x	Ukraine	ore mineral	Fe deposits	Agnes Raaness	donation	unknown	9x8x0.5 cm	meeting room Foslie
253	hematite skarn	Hundmulen	Hamarøy	Nordland	Norway	ore mineral	Fe deposits	Axel Müller	donation	27 September 2010	15x10x5 cm	meeting room Foslie
254	pollucite, K-feldspar	Vasim Myl'k	Kola	Kola	Russia	ore mineral	Cs deposits	Håvard Gautneb	donation	unknown	7.5x5x2 cm	meeting room Foslie
255	lithium battery	x	x	x	x	product	Li deposits	Axel Müller	donation	unknown	x	meeting room Foslie
256	spodumen (kunzite), single crystal	Nuristan	x	Nuristan	Afghanistan	ore mineral	Li deposits	Axel Müller	bought for NGU	unknown	11x4x2 cm	meeting room Foslie
257	synthetic bismuth crystal	x	x	x	x	ore mineral	Bi deposits	Axel Müller	donation	2014	4x3.5x2.5 cm	meeting room Foslie
258	native bismuth	Hartenstein		Erzgebirge	Germany	ore mineral	Bi deposits	Axel Müller	bought for NGU	unknown	7x6x5 cm	meeting room Foslie
259	shadow tint for eyes	x	x	x	x	product	Bi deposits	Axel Müller	donation	unknown	x	meeting room Foslie

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260	cobalt glass	Norway	x	x	Norway	product	Co deposits	Axel Müller	donation	unknown	diameter 7 cm	meeting room Foslie
261	cobalt pigment	x	x	x	x	intermediate product	Co deposits	Axel Müller	donation	unknown	x	meeting room Foslie
262	Li-ion battery containing c. 20% cobalt	x	x	x	x	product	Co deposits	Axel Müller	donation	unknown	x	meeting room Foslie
263	Mo-W porphyry	Myszkow	Krakow		Poland	ore mineral	Mo deposits	Axel Müller	donation	unknown	17x7x3.5 cm	meeting room Foslie
264	arsenopyrite, pyrite with Co	Modum Blåfarveverk	Modum	Buskerud	Norway	ore mineral	Co deposits	historical sample	NGU	unknown	11x7x2.5 cm	meeting room Foslie
265	Mo porphyry	Climax	Lake County	Colorado	USA	ore mineral	Mo deposits	Jan Sverre Sandstad	donation	unknown	16x10x4 cm	meeting room Foslie
266	molybdenite in gneiss	Knaben II mine	Kvinesdal	Vest-Agder	Norway	ore mineral	Mo deposits	Axel Müller	donation	24 September 2011	16x10x5 cm	meeting room Foslie
267	massive molybdenite	Hovland	Bjerkreim	Rogaland	Norway	ore mineral	Mo deposits	historical sample	NGU	unknown	9x6x3 cm	meeting room Foslie
268	molybdenite in pegmatite	Birtavarre	Kåfjord	Troms	Norway	ore mineral	Mo deposits	Axel Müller	donation	20 August 2008	14x6x5 cm	meeting room Foslie
269	molybdenite concentrate	Knaben II mine	Kvinesdal	Vest-Agder	Norway	mineral concentrate	Mo deposits	Trond Slagstad	donation	September 2013	x	meeting room Foslie
270	bornite-quartz vein in sandstone	Repparfjord	Kvalsund	Finnmark	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	19x16x6 cm	meeting room Foslie
271	bornite in Weissliegendes	Rudna Mine	Wrozlaw	Wrozlaw	Poland	ore mineral	Cu deposits	Axel Müller	donation	2010	16x9x2 cm	meeting room Foslie
272	pyrite, chalcopyrite	Kvikne	Kvikne	Innlandet	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	12x9x4 cm	meeting room Foslie
273	pyrite, chalcopyrite	Løkkenverk	Løkken	Trøndelag	Norway	ore mineral	Cu deposits	Axel Müller	donation	2007	11x10x4 cm	meeting room Foslie
274	chalcopyrite, pyrite	Vigsnes	Karmøy	Rogaland	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	10x9x3 cm	meeting room Foslie
275	pyrite, chalcopyrite	Gjersvik min	Rørvik	Nord-Trøndelag	Norway	ore mineral	Cu deposits	Axel Müller	donation	2005	10x7x2 cm	meeting room Foslie
276	pyrite, chalcopyrite, galena	Mofjell	Mo i Rana	Nordland	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	11x9x3 cm	meeting room Foslie
277	pyrite, sphalerite, magnetite, galena	Bleikvassli	Hemnes	Nordland	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	13x10x5 cm	meeting room Foslie
278	pyrite, chalcopyrite, sphalerite	Killingdal	Håltalen	Sør-Trøndelag	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	11x7x3 cm	meeting room Foslie
279	dioptas on quartz	unknown	x	x	x	ore mineral	Cu deposits	Nigel Cook	NGU	unknown	8x8x5 cm	meeting room Foslie
280	pyrite, chalcopyrite	Joma gruver	Rørvik	Nordland	Norway	ore mineral	Cu deposits	Axel Müller	donation	2005	14x8x2 cm	meeting room Foslie
281	pyrite, chalcopyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	15x9x2 cm	meeting room Foslie
282	pyrite, chalcopyrite,	Løkkenverk	Løkken	Sør-Trøndelag	Norway	ore mineral	Cu deposits	Tor Grenne	donation	unknown	22x18x2 cm	meeting room Foslie

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	feeder zone breccia											
283	pyrite, chalcopyrite	Sulitjelma	Sulitjelma	Nordland	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	12x6x6 xm	meeting room Foslie
284	pyrite, chalcopyrite	Skorovos	Namskogan	Nord-Trøndelag	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	10x8x4 cm	meeting room Foslie
285	chalcopyrite, pyrite, Au vein in graphite schist	Bidjovagge	Kautokeino	Finnmark	Norway	ore mineral	Cu, Au deposits	historical sample	NGU	unknown	10x8x7 cm	meeting room Foslie
286	chromite, dunite	Ørnstolen	Selsøyvik	Nordland	Norway	ore mineral	Cr deposits	Johann Vogt	NGU	unknown	10x6x4 cm	meeting room Foslie
287	chromite	Skarvgruva	Feragen	Sør-Trøndelag	Norway	ore mineral	Cr deposits	Axel Müller	bought for NGU	unknown	9x8x5 cm	meeting room Foslie
288	pentlandite, chalcopyrite (nickel ore)	Norilsk	Taymyr		Russia	ore mineral	Ni deposits	Ingvar Lindahl	donation	unknown	12x10x1.5 cm	meeting room Foslie
289	chromite in serpentinite	Feragen	Feragen	Sør-Trøndelag	Norway	ore mineral	Cr deposits	historical sample	NGU	unknown	11x11x3.5 cm	meeting room Foslie
290	chromite ore	Kemi	Kemi	Lappland	Finland	ore mineral	Cr deposits	Jan Sverre Sandstad	donation	unknown	9x6x5 cm	meeting room Foslie
291	fuchsite schist	Gabelhorn	Zermatt	Wallis	Switzerland	ore mineral	Cr deposits	Axel Müller	donation	1995	10x6x2.5 cm	meeting room Foslie
292	wrench made of Cr-V steel (Fe, C)	x	x	x	x	product	Cr deposits	Axel Müller	donation	unknown	x	meeting room Foslie
293	pentlandite, pyrite	Flåt	Evje	Vest-Agder	Norway	ore mineral	Ni deposits	Lars Petter Nilsson	donation	unknown	6x5x3 cm	meeting room Foslie
294	pentlandite, chalcopyrite (nickel ore)	Norilsk	Taymyr	Taymyr	Russia	ore mineral	Ni deposits	Morten Often	donation	unknown	9x3.5x3.5 cm	meeting room Foslie
295	pyrolusite, psilomelane	Braunsteinhaus	Ilfeld	Sachsen-Anhalt	Germany	ore mineral	Mn deposits	Axel Müller	donation	1992	13x7x3 cm	meeting room Foslie
296	jaspis with hematite	Elbingerode	Harz	Sachsen-Anhalt	Germany	ore mineral	Fe deposits	Axel Müller	donation	1992	10x9x4 cm	meeting room Foslie
297	magnetite in serpentinite	Savage River Mine	Tasmania	Tasmania	Australia	ore mineral	Fe deposits	Axel Müller	donation	12 August 2012	7x7x3 cm	meeting room Foslie
298	thuringite va. Chamosite	Wittmannsgereuth	Saalfeld	Thuringia	Germany	ore mineral	Fe deposits	Axel Müller	donation	1992	10x6x3 cm	meeting room Foslie
299	chamosite (minette), Ordovician oolitic ironstone	Wittmannsgereuth	Saalfeld	Thuringia	Germany	ore mineral	Fe deposits	Axel Müller	donation	1995	11x8x2 cm	meeting room Foslie
300	tullite	Leksvik	Fosen	Sør-Trøndelag	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2007	11x5x2 cm	meeting room Foslie
301	magnetite, apatite	Kiruna	Kiruna	Norrbotten	Sweden	ore mineral	Fe deposits	Are Korneliussen	donation	unknown	13x19x9 cm	meeting room Foslie
302	limonite	unknown	x	x	unknown	ore mineral	Fe deposits	Nigel Cook	donation	unknown	13x8x5 cm	meeting room Foslie
303	magnetite	Malmberget	Malmberget	Norrbotten	Sweden	ore mineral	Fe deposits	Axel Müller	donation	1993	4x4x3 cm	meeting room Foslie
304	bauxite	Brazil	x	x	Brazil	ore mineral	Al deposits	Håvard Gautneb	donation	unknown	x	meeting room Foslie

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305	aluminiumoxide powder	Brazil	x	x	Brazil	intermediate product	Al deposits	Håvard Gautneb	donation	unknown	x	meeting room Foslie
306	arsenopyrite	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	ore mineral	As deposits	Axel Müller	donation	2012	5x4x3 cm	meeting room Foslie
307	orpigment	Getchell mine	Humboldt county	Nevada	USA	ore mineral	As deposits	Axel Müller	donation	unknown	4x4x3 cm	meeting room Foslie
308	native mercury	unknown	x	x	unknown	mineral concentrate	Hg deposits	Bjørn Willemoes-Wissing	donation	unknown	x	meeting room Foslie
309	native mercury in schist	Idrija mine	Idrija	Idrija	Slowenia	ore mineral	Hg deposits	Axel Müller	donation	1995	x	meeting room Foslie
310	stibnite	Baia Sprie	Baia Sprie	Maramureș	Romania	ore mineral	Sb deposits	Axel Müller	donation	17 August 2010	9x7x3 cm	meeting room Foslie
311	stibnite	Neumühle	Greiz	Vogtland	Germany	ore mineral	Sb deposits	Axel Müller	donation	unknown	9x6x3 cm	meeting room Foslie
312	galena, chalcopyrite	unknown	x	x	unknown	ore mineral	Pb-Zn deposits	Nigel Cook	donation	unknown	10x10x6 cm	meeting room Foslie
313	sphalerite, galena, chalcopyrite	Hilfe Gottes Mine	Bad Grund	Harz	Germany	ore mineral	Pb-Zn deposits	Ingvar Lindahl	donation	unknown	6x4x4 cm	meeting room Foslie
314	galena, sphalerite, chalcopyrite	Hellyer Mine	Tasmania	Tasmania	Australia	ore mineral	Pb-Zn deposits	Axel Müller	donation	12 August 2012	8x8x3 cm	meeting room Foslie
315	siderite, calcite, sphalerite concretion in Jurassic clay	Gnaszyn	Czestochowa	Czestochowa	Poland	ore mineral	Pb-Zn deposits	Axel Müller	donation	unknown	20x17x9 cm	meeting room Foslie
316	galena	unknown	x	x	unknown	ore mineral	Pb-Zn deposits	Nigel Cook	donation	unknown	10x8x5 cm	meeting room Foslie
317	galena	unknown	x	x	unknown	ore mineral	Pb-Zn deposits	Nigel Cook	donation	unknown	10x7x4 cm	meeting room Foslie
318	galena, pyrite	unknown	x	x	unknown	ore mineral	Pb-Zn deposits	Nigel Cook	donation	unknown	15x12x10 cm	meeting room Foslie
319	Zn concentrate	Folldal Verk	Folldal	Innlandet	Norway	mineral concentrate	Pb-Zn deposits	historical sample	NGU	unknown	x	meeting room Foslie
320	sphalerite, chalcopyrite	Rosebery Mine	Tasmania	Tasmania	Australia	ore mineral	Pb-Zn deposits	Axel Müller	donation	13 August 2012	12x9x2 cm	meeting room Foslie
321	sphalerite, quartz	Baia Sprie	Baia Sprie	Maramureș	Romania	ore mineral	Pb-Zn deposits	Axel Müller	donation	17 August 2010	17x8x7 cm	meeting room Foslie
322	sphalerite	Hilfe Gottes Mine	Bad Grund	Lower Saxony	Germany	ore mineral	Pb-Zn deposits	Ingvar Lindahl	donation	unknown	9x4x3 cm	meeting room Foslie
323	sphalerite	Pomorzany	Bytom	Silesia	Poland	ore mineral	Pb-Zn deposits	Axel Müller	donation	2010	11x8x1 cm	meeting room Foslie
324	galena, single crystal	Alte Elisabeth	Freiberg	Saxony	Germany	ore mineral	Pb-Zn deposits	Axel Müller	donation	1991	2x1.5x1 cm	meeting room Foslie
325	sphalerite	Bleikvassli	Hemnes	Nordland	Norway	ore mineral	Pb-Zn deposits	historical sample	NGU	unknown	8x6x4 cm	meeting room Foslie
326	sphalerite concentrate	Neves Corvo mine	Castro Verde	Beja	Portugal	mineral concentrate	Pb-Zn deposits	Axel Müller	donation	2012	x	meeting room Foslie
327	silicon metal produced by	Freiberg	Freiberg	Saxony	Germany	intermediate product	industrial minerals	Axel Müller	bought for NGU	2013	10x8x6 cm	meeting room Foslie

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	Siltronic, Freiberg											
328	silicon metal (single crystal) produced by Siltronic, Freiberg	Freiberg	Freiberg	Saxony	Germany	intermediate product	industrial minerals	Axel Müller	bought for NGU	2013	diameter 7 cm, 13 cm high	meeting room Foslie
329	high purity quartz sand NC4, 100-300 µm, QuartzCorp	Drag	Tysfjord	Nordland	Norway	mineral concentrate	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
330	rose quartz	Quintos Mine	Borborema	São Paulo	Brazil	industrial mineral	industrial minerals	Axel Müller	donation	2009	6x6x5 cm	meeting room Foslie
331	silica sinter	Meillers Mine	Meillers	Massif Central	France	intermediate product	industrial minerals	Axel Müller	donation	2014	13x6x4 cm	meeting room Foslie
332	quartz glass crucible, Labor Pilz	Germany	x	x	Germany	product	industrial minerals	Axel Müller	bought for NGU	2013	diameter 7 cm	meeting room Foslie
333	network inderface controller (NIC) with silicon microchips	x	x	x	x	product	industrial minerals	Axel Müller	donation	2011	10x8x1.5 cm	meeting room Foslie
334	silica (alumina) gel	x	x	x	x	product	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
335	halogen lamp made of high purity quartz glass	x	x	x	x	product	industrial minerals	Axel Müller	donation	2010	8x5x5 cm	meeting room Foslie
336	"optical" quartz	Minas Gerais	Minas Gerais	Minas Gerais	Brazil	industrial mineral	industrial minerals	Jens Götze	donation	unknown	5x3.5x2.5 cm	meeting room Foslie
337	"poly" silicon (microcrystalline), raw material for coarse-crystalline silicon	x	x	x	Norway	intermediate product	industrial minerals	Axel Müller	donation	2009	7x2.5x2.5 cm	meeting room Foslie
338	high purity pegmatite quartz	Nedre Øyvollen	Drag	Nordland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2009	9x7x5 cm	meeting room Foslie
339	fused spherical silica, Teco-sphere, 2-40 µm, C-E Minerals	Greeneville	Greene	Tennessee	USA	intermediate product	industrial minerals	Axel Müller	donation	2011	x	meeting room Foslie
340	silica gel	x	x	x	x	product	industrial minerals	Axel Müller	donation	2012	x	meeting room Foslie
341	pocket calculator with solar cells	x	x	x	x	product	industrial minerals	Axel Müller	donation	2009	8x5x0.3 cm	meeting room Foslie
342	fused silica, C-E Minerals, TECO plant	Greeneville		Tennessee	USA	intermediate product	industrial minerals	Axel Müller	donation	2011	12x8x5 cm	meeting room Foslie
343	"alaskite" (leucogranite),	Pine Mountain Mine	Spruce Pine	North Carolina	USA	industrial mineral	industrial minerals	Axel Müller	donation	10 May 2011	10x10x2 cm	meeting room Foslie

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	source of high purity quartz											
344	optical fiber, application of high purity quartz	x	x	x	x	product	industrial minerals	Axel Müller	donation	2009	23x1x1 cm	meeting room Foslie
345	crystalline silicon, untreated solar cell panel, 180 µm thick, REC Porsgrunn	Porsgrunn	Porsgrunn	Telemark	Norway	intermediate product	industrial minerals	Axel Müller	donation	2009	15x15x0.018 cm	meeting room Foslie
346	graphite schist mined by Skaland Graphite AS	Trælen	Senja	Troms	Norway	industrial mineral	industrial minerals	Jan Sverre Sandstad	donation	unknown	17x9x6 cm	meeting room Foslie
347	"medical" shungite with 30% carbon	Onega Lake		Karelia	Russia	industrial mineral	industrial minerals	Håvard Gautneb	donation	2014	x	meeting room Foslie
348	shungite with >90% carbon	Onega Lake		Karelia	Russia	industrial mineral	industrial minerals	Jan Sverre Sandstad	donation	2014	9x7x6 cm	meeting room Foslie
349	shungite "tiger"	Onega Lake		Karelia	Russia	industrial mineral	industrial minerals	Håvard Gautneb	donation	2014	3.5x3x2.5 cm	meeting room Foslie
350	shungite, drill core	Onega Lake		Karelia	Russia	industrial mineral	industrial minerals	Jan Sverre Sandstad	donation	2014	6.5x3x3 cm	meeting room Foslie
351	pencil clay, Late Oligocene	Kärlich	Mayen-Koblenz	Rheinlandpfalz	Germany	industrial mineral	industrial minerals	Axel Müller	donation	2013	10x9x4 cm	meeting room Foslie
352	graphite spray	x	x	x	x	product	industrial minerals	Axel Müller	donation	2013	15x4.5x4.5 cm	meeting room Foslie
353	flake graphite "Silvershine"	Skaland Mine	Senja	Troms	Norway	mineral concentrate	industrial minerals	Håvard Gautneb	donation	2012	x	meeting room Foslie
354	graphite schist	Jennestad	Vesterålen	Nordland	Norway	industrial mineral	industrial minerals	Håvard Gautneb	donation	2012	10x8x6 cm	meeting room Foslie
355	graphite schist, drill core	Jennestad	Vesterålen	Nordland	Norway	industrial mineral	industrial minerals	Håvard Gautneb	donation	2012	9x3.5x1.5 cm	meeting room Foslie
356	pencil containing a mixture of graphite and pencil clay	x	x	x	x	product	industrial minerals	Axel Müller	donation	2012	17.5x1x1 cm	meeting room Foslie
357	graphite "Technocraft"	Kahatagaha Mines	Maduragoda	Kurunegala	Sri Lanka	mineral concentrate	industrial minerals	Håvard Gautneb	donation	2012	x	meeting room Foslie
358	graphite powder	Kropfmühl	Bayerischer Wald	Bavaria	Germany	mineral concentrate	industrial minerals	Håvard Gautneb	donation	2012	x	meeting room Foslie
359	HREE-enriched carbonatite with xenotime and magnetite	Lofdal	Khorixas	Kunene	Namibia	ore mineral	REE deposits	Axel Müller	donation	2002	11x6x5 cm	meeting room Foslie
360	allanite	Gloserhei	Froland	Agder	Norway	ore mineral	REE deposits	Axel Müller	donation	17 September 2011	11x9x4 cm	meeting room Foslie
361	aeschynite-(Y)	Kåbuland	Evje	Agder	Norway	ore mineral	REE deposits	historical sample	NGU	unknown	7x7x4 cm	meeting room Foslie

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362	thortveitite	Kåbuland	Evje	Agder	Norway	ore mineral	Sc deposits	Axel Müller	donation	2009	3x2x1 cm	meeting room Foslie
363	eudialyte	Lovozero Massif	Murmansk	Kola	Russia	ore mineral	REE deposits	Peter M. Ihlen	donation	unknown	9x7x5 cm	meeting room Foslie
364	REE-rich fluorite	Ak-Tyuz REE mine	Talas	Talas	Kirgizstan	ore mineral	REE deposits	Axel Müller	donation	2002	10x9x2 cm	meeting room Foslie
365	altered søvite, Nb-ore	Søver Gruver	Fensfeltet	Telemark	Norway	ore mineral	REE deposits	historical sample	NGU	unknown	7x5x2.5 cm	meeting room Foslie
366	light-emitting diodes (LED) coated with rare earth phosphors	x	x	x	x	product	REE deposits	Axel Müller	donation	2012	9x5x5 cm	meeting room Foslie
367	euxenite-(Y)	Kåbuland 8	Evje	Vest-Agder	Norway	ore mineral	REE deposits	Axel Müller	donation	13 September 2010	3x1.5x1 cm	meeting room Foslie
368	laser lamp with Nd-doped Y3Al5O12 crystals (Nd:YAG)	x	x	x	x	product	REE deposits	Bjørn Willemoes-Wissing	donation	2009	15x6x3 cm	meeting room Foslie
369	monazite	Brattekleiv	Evje	Vest-Agder	Norway	ore mineral	REE deposits	Axel Müller	donation	2012	3x2x2 cm	meeting room Foslie
370	gadolinite	Slobrekka	Evje	Vest-Agder	Norway	ore mineral	REE deposits	Axel Müller	donation	2012	4x2x2 cm	meeting room Foslie
371	xenotime	Knipane	Evje	Vest-Agder	Norway	ore mineral	REE deposits	Axel Müller	donation	2012	4x3x2 cm	meeting room Foslie
372	neodymium magnets Nd2Fe14B	x	x	x	x	product	REE deposits	Axel Müller	donation	2011	6x1x1 cm	meeting room Foslie
373	tantalite-(Y)	Dillingøy	Råde	Østfold	Norway	ore mineral	Nb-Ta deposits	historical sample	NGU	unknown	2.5x1.5x0.5 cm	meeting room Foslie
374	columbite	Steli	Iveland	Vest-Agder	Norway	ore mineral	Nb-Ta deposits	historical sample	NGU	unknown	5x4x4 cm	meeting room Foslie
375	mobile phone enriched in Ag, Au, Cu, Sn, In, Ta, Ni	x	x	x	x	product	Nb-Ta, Au deposits	NGU	2011	10x4.5x 1 cm	meeting room Foslie	
376	tantalum capacitors, anode consists of tantalum powder coated with Ta2O5	x	x	x	x	product	Nb-Ta deposits	Axel Müller	donation	2011	x	meeting room Foslie
377	feldspar sand	Spruce Pine	Mitchell	North Carolina	USA	mineral concentrate	industrial minerals	Axel Müller	donation	2011	x	meeting room Foslie
378	K-feldspar	Birketveit 1	Iveland	Vest-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2009	11x8x3 cm	meeting room Foslie
379	Saint-Gobain Emmaboda glass, test glass in cruicible	Emmabodda glass	x	x	Sweden	intermediate product	industrial minerals	Rune Larsen	donation	unknown	10x7x5.5 cm	meeting room Foslie

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380	nepheline syenite	Stjernøy	Stjernøy	Finnmark	Norway	industrial mineral	industrial minerals	Håvard Gautneb	donation	unknown	11x8x4 cm	meeting room Foslie
381	K-feldspar ceramic melting tests (3 pieces)	La Toma AS	San Luis	San Luis	Argentina	intermediate product	industrial minerals	Axel Müller	donation	2011	6x2.5x2.5 cm	meeting room Foslie
382	spectrolite (labradorite)	Hidra (Hitterø)	Hidra (Hitterø)	Rogaland	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2009	6x4x3 cm	meeting room Foslie
383	anorthosite	Jordalsnuten	Indre Sogn		Norway	industrial mineral	industrial minerals	Lars Petter Nilsson	donation	unknown	16x10x4 cm	meeting room Foslie
384	Rockwool produced from anorhtosite and basalt	Trondheim	Trondheim	Sør-Trøndelag	Norway	product	industrial minerals	Jan Egil Wanvik	donation	2010	9x5x5 cm	meeting room Foslie
385	anorthosite	Kinsedal	Luster	Sogn og FJordane	Norway	industrial mineral	industrial minerals	historical sample	NGU	unknown	9x6x5 cm	meeting room Foslie
386	K-feldspar	Håkonhals	Hamarøy	Nordland	Norway	industrial mineral	industrial minerals	historical sample	NGU	c. 1970	10x7x4 cm	meeting room Foslie
387	albite	Bulgaria	x	x	Bulgaria	industrial mineral	industrial minerals	historical sample	NGU	c. 1970	9x9x6 cm	meeting room Foslie
388	water glass (sodium silicate)	REC Glomfjord	Meløy	Nordland	Norway	intermediate product	industrial minerals	Peter M. Ihlen	donation	unknown	5x5x3 cm	meeting room Foslie
389	Bon Ami feldspar cleaning powder	North Carolina	x	North Carolina	USA	product	industrial minerals	Axel Müller	donation	2011	15x7.5x7.5 cm	meeting room Foslie
390	"cleavelandite", platy albite	Solås	Evje	Vest-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2010	10x8x8 cm	meeting room Foslie
391	"amazonite", green K-feldspar	Jennyhaugen	Drag	Nordland	Norway	industrial mineral	industrial minerals	historical sample	NGU	c. 1970	14x10x5 cm	meeting room Foslie
392	graphic granite	Sønnristjern	Froland	Aust-Agder	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2007	15x13x3 cm	meeting room Foslie
393	beryl, single crystal	Tjeldøya	Tjeldsund	Lofoten	Norway	ore mineral	Be deposits	Leif Furuhaug	donation	unknown	9x5.5x5 cm	meeting room Foslie
394	replica of a miner's lamp "Frosch" from the Harz Mts., Germany, from 1834	Harz	Harz	Lower Saxony	Germany	mining equipment	mining equipment	Axel Müller	donation	1992	12x10x7 cm	meeting room Foslie
395	replica of a miner's lamp "Linsenlampe" from the Saarland, Germany, from c. 1870	Saarland	x	Saarland	Germany	mining equipment	mining equipment	Axel Müller	donation	1995	22x14x12 cm	meeting room Foslie
396	donators, Dyno Industrier ASA, c. 1970's	x	x	x	Norway	mining equipment	mining equipment	Axel Müller	donation	c. 1970's	7.5x6x5 cm	meeting room Foslie
397	miner's hammer, c. 1970's	Drag	Tysfjord	Nordland	Norway	mining equipment	mining equipment	Axel Müller	donation	c. 1970's	32x12x4 cm	meeting room Foslie
398	drill bit, c. 1940's	Knaben II mine	Kvinesdal	Vest-Agder	Norway	mining equipment	mining equipment	Axel Müller	donation	c. 1940's	18x5x5 cm	meeting room Foslie

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399	rhyolitic tuff with bertrandite, fluorite	Spor Mt.	Juab	Utah	USA	ore mineral	Be deposits	Ingvar Lindahl	donation	unknown	11x11x7 cm	meeting room Foslie
400	beryl, blue	Snøfjell	Høgtuva	Nordland	Norway	ore mineral	Be deposits	Ingvar Lindahl	donation	unknown	9x6x4 cm	meeting room Foslie
401	massive beryl	Birkeland 4	Evje	Agder	Norway	ore mineral	Be deposits	Axel Müller	donation	22 September 2011	11x10x8 cm	meeting room Foslie
402	beryl	Li 6 mine	Evje	Agder	Norway	ore mineral	Be deposits	Axel Müller	donation	7 July 2009	11x10x6 cm	meeting room Foslie
403	boat propeller, Be-Cu-Ti alloy	x	x	x	x	product	Be deposits	Axel Müller	bought for NGU	2014	6.5x3x3 cm	meeting room Foslie
404	arsenopyrite with Au in marble	Gautelis	Skjomen	Nordland	Norway	ore mineral	Au deposits	Axel Müller	donation	2007	13x10x3 cm	meeting room Foslie
405	beat gold	Brazil	x	x	Brazil	intermediate product	Au deposits	Axel Müller	donation	2011	x	meeting room Foslie
406	gold chloride	x	x	x	x	intermediate product	Au deposits	Rolf Lynum	donation	unknown	x	meeting room Foslie
407	native gold, arsenopyrite	Korsvika	Bindal	Nordland	Norway	ore mineral	Au deposits	Peter M. Ihlen	donation	unknown	10x4x0.5 cm	meeting room Foslie
408	epithermal high-grade Au ore	Baia Sprie	Baia Sprie	Maramureș	Romania	ore mineral	Au deposits	Axel Müller	donation	17 August 2010	10x8x3 cm	meeting room Foslie
409	native silver	Kongsberg	Kongsberg	Buskerud	Norway	ore mineral	Ag deposits	Terje Bjerkgård	donation	2012	10x5x4 cm	meeting room Foslie
410	native silver	Kongsberg	Kongsberg	Buskerud	Norway	ore mineral	Ag deposits	Axel Müller	bought for NGU	2012	4.5x2x1.5 cm	meeting room Foslie
411	silver wool	x	x	x		product	Ag deposits	Ana Banica	donation	2012	x	meeting room Foslie
412	chalcopyrite, Cu-Au porphyry	Almalyk	Almalyk	Tashkent	Uzbekistan	ore mineral	Au deposits	Jan Sverre Sandstad	donation	2014	6x6x4 cm	meeting room Foslie
413	tourmaline-quartz "brain" (UST) rock, Au-bearing	Bayan Uul	Mörön Soum	Gobi	Mongolia	ore mineral	Au deposits	Axel Müller	donation	2004	19x8x3 cm	meeting room Foslie
414	arsenopyrite, Au-bearing	Suurikuusikko	Kittilä	Lapland	Finland	ore mineral	Au deposits	Morten Often	donation	unknown	10x6.5x3 cm	meeting room Foslie
415	Au ore with 47.6 g/t Au	Kumtor	Issyk Kul	Issyk Kul	Kyrgyzstan	ore mineral	Au deposits	Axel Müller	donation	2004	7x5x2 cm	meeting room Foslie
416	arsenopyrite, native Au	Kolsvika	Bindal	Nordland	Norway	ore mineral	Au deposits	Peter M. Ihlen	donation	unknown	14x11x3 cm	meeting room Foslie
417	Au ore with 3.8 g/t Au	Changshang Mine	Jiaodong peninsula	East China	China	ore mineral	Au deposits	Axel Müller	donation	2009	13x9x4.5 cm	meeting room Foslie
418	gold, silver and platinum acid testing kid	x	x	x	x	mining equipment	Au deposits	Håvard Gautneb	donation	unknown	x	meeting room Foslie
419	gold ingot made of sheet metal	x	x	x	x	intermediate product	Au deposits		NGU	2013	x	meeting room Foslie
420	pyrite, chalcopyrite in jaspis	Løkkenverk	Løkken	Sør-Trøndelag	Norway	ore mineral	Cu deposits	Tor Grenne	donation	unknown	17x17x0.5 cm	meeting room Foslie
421	chalcopyrite, pyrite, pyrrothite	Olavsgruva	Røros	Sør-Trøndelag	Norway	ore mineral	Cu deposits	Axel Müller	donation	2004	19x12x5 cm	meeting room Foslie

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422	chalcopyrite concentrate	Neves Corvo mine	Castro Verde	Beja	Portugal	mineral concentrate	Cu deposits	Axel Müller	donation	2012	x	meeting room Foslie
423	pyrite concentrate (sulfur concentrate)	Stordø	Litlabø	Hordaland	Norway	mineral concentrate	industrial minerals	historical sample	NGU	1966	x	meeting room Foslie
424	chalcopyrite, pyrite	Vigsnes	Karmøy	Rogaland	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	12x8x1.5 cm	meeting room Foslie
425	Statue of Liberty made of copper ore from Vigsnes?	x	x	x	x	product	Cu deposits	Axel Müller	donation	2012	14x3x3 cm	meeting room Foslie
426	chalcopyrite, pyrite	Bidjovagge		Finnmark	Norway	ore mineral	Cu deposits	historical sample	NGU	unknown	drill core, diameter 8.5 cm	meeting room Foslie
427	copper ingot	Olavsgruva	Røros	Sør-Trøndelag	Norway	intermediate product	Cu deposits	Axel Müller	donation	2009	7x2.5x2 cm	meeting room Foslie
428	slag from Cu melting, 19th century	Dragås	Gaula valley	Sør-Trøndelag	Norway	smelter slag	Cu deposits	Axel Müller	donation	2011	12x5x2.5 cm	meeting room Foslie
429	chalcopyrite concentrate	Panasqueira mine	São Jorge da Beira	Covilhã	Portugal	mineral concentrate	Cu deposits	Axel Müller	donation	2012	x	meeting room Foslie
430	native copper	Keewenaw Co.	Whitehorse	Yukon	Canada	ore mineral	Cu deposits	Axel Müller	bought for NGU	2013	6x6x2 cm	meeting room Foslie
431	copper nail from Åfjord boat	Trøndelag	x	Trøndelag	Norway	product	Cu deposits	Axel Müller	donation	2007	5x2x2 cm	meeting room Foslie
432	50 øre coin deprecated on 1 May 2012	Norway	x	x	Norway	product	Cu deposits	Axel Müller	donation	2012	diameter 1.6 cm	meeting room Foslie
433	ilmenite concentrate	Tellnes	Sokndal	Rogaland	Norway	mineral concentrate	Ti deposits	Titania AS	donation	2014	x	meeting room Foslie
434	titanium white (TiO2 pigment)	x	x	x	x	product	Ti deposits	Bjørn Willemoes-Wissing	donation	2014	x	meeting room Foslie
435	ilmenite-bearing norite	Tellnes	Sokndal	Rogaland	Norway	industrial mineral	Ti deposits	historical sample	NGU	unknown	13x9x3.5 cm	meeting room Foslie
436	rutile in eclogite	Engebøfjellet	Naustdal	Sogn og Fjordane	Norway	industrial mineral	Ti deposits	Øyvind Skår	donation	unknown	7x5x3 cm	meeting room Foslie
437	ilmenite, megacrystals	Mølland 15	Evje	Vest-Agder	Norway	industrial mineral	Ti deposits	Axel Müller	donation	1 August 2010	8x7x5 cm	meeting room Foslie
438	rutile, single crystal	Graves Mt.	Lincoln	Georgia	USA	industrial mineral	Ti deposits	Axel Müller	bought for NGU	2013	6x5.5x5 cm	meeting room Foslie
439	rutile, ilmenite, titanite in eclogite	Engebøfjellet	Naustdal	Sogn og Fjordane	Norway	industrial mineral	Ti deposits	Mona Schanche	donation	2014	10x7x4 cm	meeting room Foslie
440	rutile, ilmenite, titanite in eclogite	Engebøfjellet	Naustdal	Sogn og Fjordane	Norway	industrial mineral	Ti deposits	Are Korneliussen	donation	April 1989	12x3.5x2 cm	meeting room Foslie
441	rutile	Rekevik	Flekkefjord	Vest-Agder	Norway	industrial mineral	Ti deposits	historical sample	NGU	unknown	10x7x1 cm	meeting room Foslie
442	actinolite in dolomite	Selåsvatn	Gjerstad	Aust-Agder	Norway	industrial mineral	industrial minerals	Peter M. Ihlen	donation	unknown	18x12x10 cm	meeting room Foslie

Sample number	Sample description	Locality	Municipality/area	County/ region	Country	Sample category	Exhibition theme	Collector/ donator	Property status	Collecting/ purchase date	Sample size	Exhibition/ storage place
443	pyrite, chalcopyrite	Melkedal	Ballangen	Nordland	Norway	ore mineral	Cu deposits	Ingvar Lindahl	donation	unknown	23x12x2 cm	meeting room Foslie
444	albitized granite	Ringsjø	Kragerø	Telemark	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2005	25x8x11 cm	meeting room Foslie
445	actinolite	Allalinhorn	Zermatt	Wallis	Switzerland	industrial mineral	industrial minerals	Axel Müller	donation	1995	20x12x6 cm	meeting room Foslie
446	lepidolite	Øvre Høydalen, Tørdal	Drangedal	Telemark	Norway	industrial mineral	industrial minerals	Axel Müller	donation	2015	12x6x5 cm	meeting room Foslie

GEOLOGICAL
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