Competition of Growing Crystals –

terra mineralia Freiberg/Germany

on the Occasion of the European Science Day for Youth 2014

2014 is the International Year of Crystallography. On this occasion LJBW developed a project with a duration of 90 minutes in cooperation with the exhibition terra mineralia - a mineralogical collection (http://www.terra-mineralia.de/english/startpage). The project is linked to a competition of growing crystals.

Participants learn about crystallography, growing crystals and making them especially attractive. The submitted crystals will be exhibited in the entrance area of the museum from 29th May 2014. They will be judged according to size, form and creativity.

Start: from 13th March 2014

Deadline: 26th May 2014

In Exhibition: from 29th May 2014

Prize: The winners receive a guided tour through terra mineralia including a visit of the custody.

Crystals should be sent to:

TU Bergakademie Freiberg
Ausstellung terra mineralia
Schloss Freudenstein
Schloßplatz 4
09599 Freiberg
Germany

What is EDSY and why is it happening on 13th March 2014?

The European Science Day for Youth (ESDY) has been one of the annual projects of the international organisation MILSET Europe for 10 years. The member organisations of MILSET Europe are responsible for the coordination in their countries/regions. LJBW is one of those and has been coordinating the German/Saxonian activities on this day from 2005 onwards.

The main principle of ESDY is, that everywhere in Europe

- on the same day
- during the same time
- a mutual activity

happens in the framework of a scientifical topic that has been set before.

After "Water for Thought" 2013 and "Astronomy and Time" 2012 the topic of 2014 is Crystallography. In the International Year of Crystallography (UNO) kids can learn about the structure, existence and characteristics of crystals.

All participating organisations upload pictures of their projects on ESDY on the official website: http://esdy.milset.org

Who can participate?

All schools and institutions of youth work can participate. Please give a short statement of interest if you plan to come to terra mineralia. Participating in ESDY does not oblige in participating in the competition. Both projects are free of charge.

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LJBW

Landesverband Sächsischer Jugendbildungswerke e.V.

Concept for a Project of Crystallography - ESDY

Overview about the single topics:

(1) What is a crystal?
(2) What is crystallography?
(3) How does a crystal grow?
(4) The ideal conditions for growing
(5) Colours – the mistakes of crystals
(6) Instruction for growing
(7) Forms of crystals – the seven systems

(1) What is a crystal?

Task:

- What is a crystal to you? Where do you see crystals in daily life?

Information:

- „Crystal" is coming from Greek language: „krystallos" and means „ice". It was assumed that rock crystals freeze during extreme cold and cannot be melted anymore. But actually, ice is as well a mineral and consists of crystals – snowflakes.
- Crystals are hard and have a certain chemical structure. There the atoms are fixed regularly in a three-dimensional lattice.
- In nature, minerals are making crystals. But there are also organic substances that can make crystals, e.g. rock sugar.
- Crystals can also be made artificially, e.g. mono-crystals out of silicium that are needed for the production of chips.
- More than 98% of hard earth is crystalline.

Material: rock crystal, snowflake, salt, rock sugar

(2)What is crystallography?

Task:

- Why is 2014 the International Year of Crystallography?

Information:

- Crystallography is the science of crystals. This includes researching their structure, their formation/production and their characteristics and possibilities of use.
- Crystallography is a combination of different sciences. Mineralogists, chemists, biologists, pharmacists, physicians, mathematicians, material scientists – all of them can become scientists of crystallography.
- Crystallography was born exactly 100 years ago. In 1914, the German physician Max von Laue received the Nobel Prize. He provided evidence for the regular and lattice-like structure of crystals.
- For the research on crystals, more than 45 Nobel prizes have been awarded so far. The last one was the Nobel Prize of Chemistry in 2011 for the Israelian researcher Daniel Shechtman. He discovered the quasicrystals.
- Crystallography is playing an important role in the development of new material such as memory cards, flat screens, cars and planes. The scientists of crystallography not only study the structure of material. They can also use this knowledge to change structures and to provide material with new characteristics.

The use of crystallography

Example 1: Chocolate

- Cocoa butter, the most important ingredient of chocolate, crystallizes in six different forms. Just one of theme is melting enjoyably in the mouth and is bright and crisp.
- When chocolate is lying untouched for some time, the form of crystal is changing. It is detectable in the murky, whitish surface and the softer consistence. The chocolate is melting much slower in the mouth. It feels coarse-grained and sandy.
- Producers of chocolate have to use sophisticated processes of crystallisation to get the right form.

Example 2: Water softening with zeolites

- Each detergent of today contains besides soap crystals of a mineralogical family – zeolites. They help to soften water.
- Water hardness measures the lime content in tap water. It contains very small lime particles that are dispensed in water. If water is too hard/the lime content too high, it needs much soap to foam. With soft water just a bit of soap is needed to make foam. This is obviously positive for the environment, because in the wastewater treatment plant less dirty soap has to be cleansed.
- But how does water softening work? Zeolites are built like a sponge. Their crystals have small channels and excavations inside. When you put all these hollows together in mind, the surface is enormous. Some zeolites therefore have a surface of 1000 m² when weighing only 1 g. The small dispensed lime particles of the tap water get into the zeolites‛ hollows while washing and are kept there. The water hardness in the washing drum decreases. Zeolites work similar to a filter.
- A further positive advantage is the increased softness of laundry after washing with decalcified water and drying

(3)How does a crystal grow?

Material:

- bricks or modelling clay
- anhydrites or salt (no cooking salt, NaCl or salt for dishwasher), water
- object slides
- pipette
- beakers
- overhead projector

Information:

A dissolution is needed.

- Theory:
    - Before a crystal can emerge, its elements must be present, but dispensed.

- Experiment:
    - Anhydrit or salt should be dispensed in water – which makes a saturated dissolution.
    - The bricks can be used to show on the overhead projector what is happening with the atoms. All the bricks are lying loosely.

A germ is needed to make the crystal start growing.

- Theory:
    - If the dissolution is saturated, the atoms come together spontaneously and make small crystals. Often, a germ (e.g. dust particle or branch) is the starting point of crystal growth. Sometimes, small crystals can work as germs (seed crystals). They are used in industrial crystal growing.
- Experiment:
    - You should put the object slide on the overhead projector with one drop of the saturated dissolution. You might be able to see a dust particle in the drop.
    - Build the first bricks around the small germ.

It's getting started. The crystal can grow.

- Theory:
    - Now, all of the dispensed atoms start to out themselves in a certain pattern around the germ. This is similar to holding each other's hands.
    - The pattern is shaped according to the elements. This is how the crystal looks differently in the end.
- Experiment:
    - Many small crystals fall out of the dissolution. They grow slowly. You can watch this under a microscope.
    - Using the bricks, you can build a nice crystal, e.g. a cube that shows the lattice of salt. Some bricks should be left over.

Slowly!

- Theory:
    - To get really beautiful, the crystal needs a lot of time for growing.
- Experiment:
    - You can show the crystal in the dissolution.
    - You can build the bricks symbolically very slowly around.

Done! The dissolution is gone, here comes the crystal!

- Theory:
  - If the water is evaporated, the crystals are left over. Show them.
- Experiment:
  - The object slide should stay on the overhead projector as long as the water is evaporated and only salt or gypsum crystals are left.
  - You can finish the crystal (in cubic shape) by using the last bricks.

(4)The ideal conditions for growing

Task:

- Which conditions are needed to make crystals grow?
- Develop your own ideas!

Information:

- In nature, crystals often are not perfect. They can come with enclaves, cracks, bubbles, distorted surfaces or murky colours.
- A crystal consists of many billions of atoms. The bigger it is, the more particles are in it. If the conditions of growth are not ideal, the particles may structure themselves in the wrong way. Mistakes occur that can be seen.
- Important: The bigger a crystal becomes, the higher is the probability of arising mistakes.
- Nevertheless, rare examples of ideal crystals might be found in nature. They have perfect surfaces and colours. They are geometrically perfect and mostly small. When you measure their side lengths, angles and surfaces – it's all the same value. That is why they are called ideal crystals.
- If you want to grow a crystal, you should create ideal conditions for growing to make it as perfect as possible. You need:
  - a calm place without vibrations
  - clean glass containers
  - a lot of time

(5)Colours – the mistakes of crystals

Task:

- Are mistakes of crystals bad?

Information:

- Mistakes in the growing process of crystals can create interesting intergrowth such as twin formations.
- Defects in the crystal lattice can conclude in the enclaving of foreign atoms or ions or other minerals in the crystal. This is a reason for the colouring of some minerals.

Quartz and its varieties

pure quartz (rock crystal) → see picture below

- Quartz without any pollution is colourless and transparent such as window glass/ a rock crystal.

amethyst → see picture below

- The violet colour is created by enclaved Fe3+-ions, that are changed in Fe4+-ions, e.g. by radioactive radiation.

iron pebble → see picture below

- The red colour is created by very subtle enclavings or another mineral - hematite/iron oxide.

cairngorm → see picture below

- The brown-black colouring is generated by defects in the structure of crystals because of natural radioactive radiation during the formation.

prasem → see picture below

- The green colouring is generated by the enclaving of a green mineral - aktinolite.

Material:

- pictures in the attachment

(6)Instruction for growing

Task:

- Make your own crystal grow and send the results to terra mineralia until 26th May 2014.
- All results are going to be exhibited and the best crystals are awarded. There are three categories: size, form and creativity
- The creators of the best crystals receive a guided tour through terra mineralia including a visit of the custody.

Instruction for growing crystals:

- The basic material (three different kinds of salt) has been selected based on easy purchase.
- The chosen salt (kinds below) has to be dispensed according to instruction.
- The mixture can be slightly heated. It should be left alone for some hours. The sediments are not dispensed. The mixture can be stirred once in a while.
- After cooling down, the dissolution should be saturated. That means at room temperature, there shouldn't be additional salt dispensable. The dissolutions is filtered and filled in a clean beaker or jar. The sediments can be thrown away.
- In this way, the most beautiful crystals can be grown, but the conditions have to remain constant.
- If the temperature (and air pressure) is not constant, a partly or complete cancellation of the crystal may occur. Too high temperature may destroy the work of several weeks, but may also generate bizarre crystals in the shape of a hemisphere. If the temperature of the dissolution sinks, the balance is delaid and too much salt is falling too quickly out of the dissolution. Disturbances of the monocrystal or the formation of further crystals occur.

Example 1: potash alun (potassium aluminum sulfate)

Material

- 25g potash alun
- 150ml distilled water
  → rate: 25 g : 150 g = 1 : 6 (potash alun : water)
- containers: jars or beakers (200 ml)

Example 2: vitriol (copper(II)sulfate)

Material

- 75 g coppersulfate on 150 ml water (1:2) → approach to quick growth
- 20 g coppersulfate on 150 ml water (1:7,5) → approach to slow growth

Example 3: red blood alkalisalt (potassiumhexacyanoferrate(III))

- ***more difficult to purchase!***

Material:

- You should heat 150 ml of water on 40°C and add red blood alkalisalt as long as soil grains are built during cooling.

Hints for successful crystal growing

- Duration:
  - A beautiful or large crystal is not grown within three days. Patience as well as weekly controlling of the dissolution is necessary to make a good result.
  - Because experiments can go wrong, it is advisable to have more than one dissolution for growing crystals.
- Seed Crystals:
  - The saturated dissolution should be decanted and left for one week. After that you can choose a regular grown crystal from the ones on the bottom and use it as seed crystal.
  - Attach the seed crystal to a fine thread with glue. Then you should hang everything on a small rod. Put the crystal in a cold, really saturated, filtered dissolution of the salt in question.
  - Attention: Watch the streaks. If the dissolution is not saturated, the streaks flow downwards from the crystal because it is dissolving. If the dissolution is saturated and the crystal growing, the streaks are moving to the top. You can see them best above the crystal.
- In case the dissolution is kept in a place with constant temperature, the seed crystal is growing regularly and without enclavings to get a natural, perfect form. If too much solvent has evaporated or crystals are built on the bottom of the container, you should renew the dissolution.

- If you are experimenting with differently shaped containers, changes can happen. The bigger the hole, the quicker water evaporates and therefore the quicker spare salt can be refined from the seed crystal. You can accelerate the growth also by a higher temperature or constant stirring (e.g. with a magnetic mixer). But if the solvent evaporates too quickly, disturbances in the growth can occur. Irregular growth, enclavings or cracks might follow. If additional crystals grow on the bottom, you can remove them by filtering.
- The crystal should be kept without vibrations and in constant temperature. Therefore a fridge is quite suitable.
- You can avoid twin formation by removing the deposits that have grown on the main crystal with a sharp tool.
- How to rinse the final crystal? Do not use distilled water. It works better with ethanol or denatured alcohol (not when you used red blood alkalisalt (potassiumhexacyanoferrate(III)).

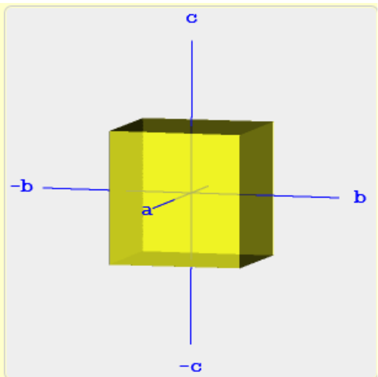
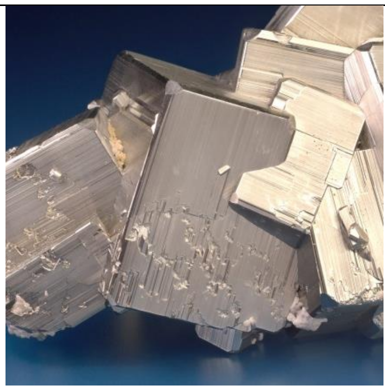
(7)Forms of crystals – the seven systems

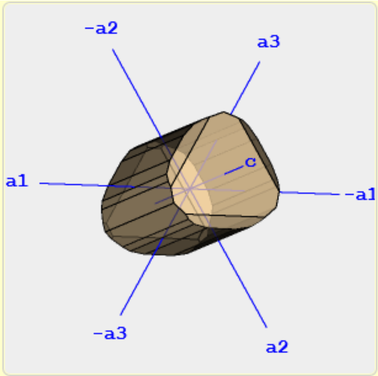
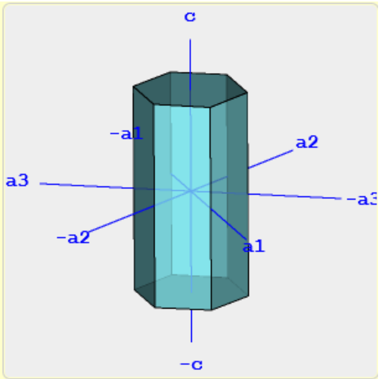
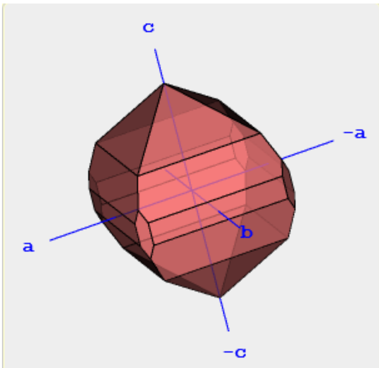
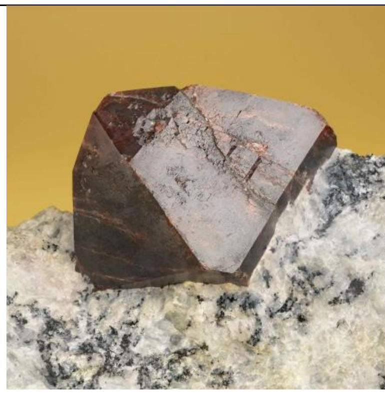
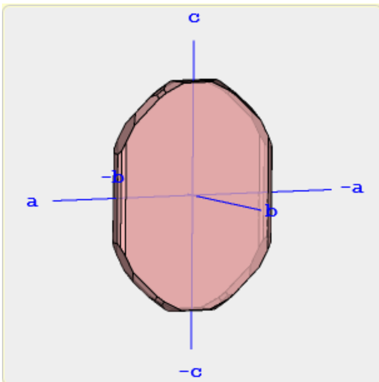
Task:

- Which form of crystals can I get by growing?
- You should use the pattern and assign your crystal to the according system.
-

Information:

- There are hundreds of different forms of crystals, all of them geometrical figures such as cubes or tetrahedra as known from maths.
- Scientists of crystallography assign all forms of crystals to seven systems of crystals.

system of crystals	geometrical figure	mineral
cubic • three equal axes at right angles $a=b=c$, $\alpha=\beta=\gamma=90°$		 pyrite

trigonal • two equal axes at 120°, third axe at right angle • a=b≠c, α=β=90°, γ=120°		 schorl rock
hexagonal • two equal axes at 120°, third ax at right angle • a=b≠c, α=β=90°, γ=60°		 aquamarine
tetragonal • three axes at right angle, two of those equal • a=b≠c, α=β=γ=90°		 zircon
rhombidal • three nonequal axes at right angle • a≠b≠c, α=β=γ=90°		 brookite

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three nonequal axes, an angle ≠90°
a≠b≠c, α=γ=90°≠β

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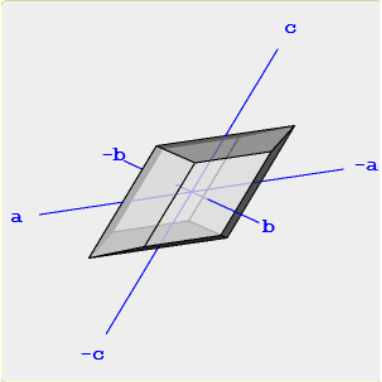
<td>

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gypsum</td>
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three nonequal axes and angles ≠ 90°
a≠b≠c, α≠β≠γ≠90°

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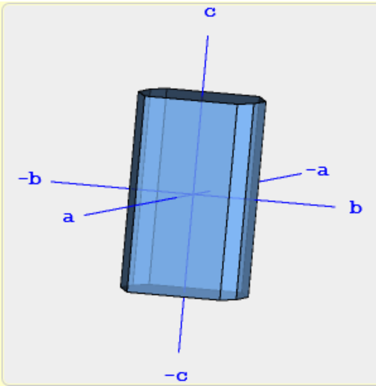
<td>

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disthene (cyanite)</td>
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Rock Crystal

Amethyst

Iron Pebble

Cairngorm

Prasem