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Ruby Synthesis Experiment Geoscience Background Considered from the Laboratory Experiment of Junior and high School Earth Science Club

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ABSTRACT（要旨）

Currently, although "Earth Science (Geology)" as a high school subject in Japan remains, the number of students who choose earth science is small. In addition, there are very few teachers who teach earth science, and it can be said that there is a crisis in earth science education in Japan. Especially in Shimane prefecture, there are no teachers who teach earth science, and even though there are several geoparks and world heritage sites that are rich in nature, they are not being effectively utilized for education.

We are studying at Kaisei Junior & Senior High School, which is an integrated middle and high school. Also, as a club activity, he belongs to the science club and pursues the joy of science through experiments and observations on our activity.

This time, we will introduce the artificial ruby synthesis experiment that has been repeated at the science club for several years since the GeoSciEd meeting was held in Matsue City. In addition, the science club is discussing geological factors in relation to naturally occurring rubies. This time, we will also introduce the contents of the discussion.

Keywords: Ruby Synthesis Experiment, Science Club, Geoscience Background

RESEARCH HISTORY （研究の歴史）

Raia Sakamoto, first author of this research, is currently in the third greade of the KAISEI HIGH SCHOOL and has been conducting this research since he was in the first year of KAISEI JUNIOR HIGH SCHOOL.

Since he was in the second year of high school, he has taken up this study as a research theme in high school science club. And has been continuing our joint study while repeating friendly rivalry with the members who will present this presentation this time.

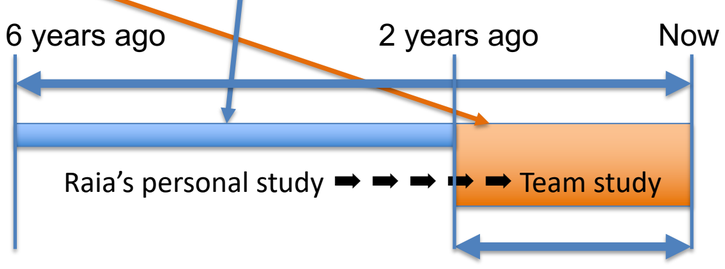
RESERCH BACKGROUND and MOTIVATION （研究の背景と動機）

Raia Sakamoto has been interested in beautiful natural things since he was in kindergarten, and he especially liked stones, minerals, and gems that have a variety of colors and textures. Almost all club member have had similar interests since their elementary school age. And then He entered Kaisei Junior High School, he learned that he could make minerals himself from a science club adviser (teacher), and he wanted to try it himself. After that, many club members also showed interest in ruby synthesis experiments. That was the reason why the Science Club took it up as a research theme.

OBJECTIVES （研究の目的）

A few years ago, anyway, the purpose was to create a ruby (Initial purpose). And then, from two years ago, our goals evolved into something more specific, as shown below.

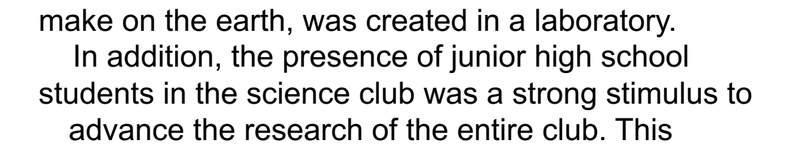
1) We want to increase the success rate in each experiment.
2) We want to make a lot (number) of crystals in one experiment
3) We want to make a large crystal
4) We want to make beautiful minerals that are highly transparent and sellable (however, we do not sell them).
5) What is the difficulty and ingenuity in the process of making we wanted to know.



We wanted to know what it feels like to have a gem (ruby), which normally takes a long time to make on the earth, was created in a laboratory.

In addition, the presence of junior high school students in the science club was a strong stimulus to advance the research of the entire club. This was because the juniors, while they had little experience, easily repeated successful ruby synthesizing experiments.

In other words, the research environment It is formed by the club members' good sense of competition, which motivates our research.



METHODS（研究手法）

【MATRIALS and TOOLS】

The following items were prepared for the experiment.

Reagents: Chromium Oxide (Cr_2O_3),
Aluminum Oxide (Al_2O_3)
Instruments: microwave oven, electronic balance, mortar, pestle, crucible, tripod, wire mesh, crucible scissors Aluminum foil, medicine scoop, medicine wrapping paper, mechanical pencil lead (HB, 2B, 4B), copper wire

【 METHODS（ basic and common method ）】

★ Refer to the academic paper, the ratio of aluminum Oxide powder (5.00g) and chromium oxide powder (0.05g) is 100:1 to mix. ・Mix the mixed powder evenly with a pestle.

★ Transfer the mixed powder to aluminum foil or a crucible and put it in the microwave oven (this step is the experimental version different depending on the application: various contents were implemented with ingenuity)

★ The microwave heating time varies depending on the version of the experiment.

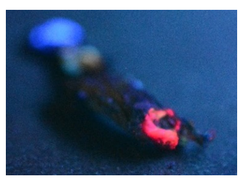
★ We checked whether the ruby was formed by illuminating it with a black light and showing the fluorescence.

★ Changes in experimental methods during the research.

RESULTS ⭐ 12 Experiments （研究結果）

[Experiment 1: Put mixed powder on aluminum foil and microwave it] ・Wrap the mixed powder in aluminum foil ・Put it in the microwave for about 15 seconds. ※It was difficult to make a spark, so I took it out and checked it when I could.

[Results] ・It was rarely successful (It would be nice if I could do it once a day. The success rate is about 1 time in 100 times). ・Only a few rubies could be made. There were no sparks. [Consideration of Experiment 1] ・If sparks cannot be seen with the naked eye in a microwave oven, ruby crystals cannot be formed. ・It was found from literature that the sparks found in the microwave oven were plasma.



[Experiment 2 Improving Experiment 1] Experiment adding mechanical pencil lead to aluminum foil ・I put the core of a mechanical pencil in the aluminum foil tube from experiment 1 and put it in the microwave.

[Results] ・There was no effect on the success rate. ・It wasn't easy for sparks to form. [Consideration of Experiment 2] ・It was found that there was no change in the success rate between Experiment 1 and Experiment 2.

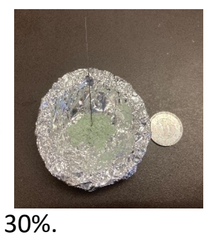
[Experiment 3 Improvement of Experiment 2] The experiment was conducted with the lead of the mechanical pencil sticking out of the aluminum foil.

[Results] ・Sparks came out well (progress). However, there was no effect on the success rate. [Discussion] Ease of generating sparks has been greatly improved. However, it was confirmed that the spark did not hit the sample directly, so I thought it was necessary to devise a way to hit it directly.

[Experiment 4 :Improvement of Experiment 3] We decided to conduct an experiment using a crucible. The sample was placed in the crucible and one lead of a mechanical pencil was pierced.

[Results] ・Sparks don't fly much. ・Even if the core of the mechanical pencil catches fire, it immediately collapses. [Discussion] ・From the comparison with Experiment 3, it is possible that the aluminum foil affects the ease with which the lead of the mechanical pencil catches fire. ・It was no longer successful without aluminum foil.

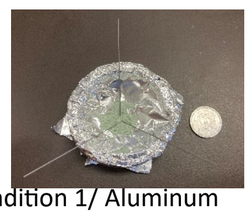
[Experiment 5 :Improving Experiment 4 Using aluminum foil again] ・Aluminum foil was spread over the crucible, the sample was placed on the crucible, and the core of a mechanical pencil was set up.



[Results] ・The percentage of blue sparks increased. The ruby generation rate has increased to about 30%.

[Discussion] ・The success rate seemed to be high when blue sparks were formed. ・If the sparks do not fall on the sample efficiently, it will not turn into a ruby.

[Experiment 6: Improving Experiments 4 and 5] Finding the optimal conditions. Comparative experiments were conducted by changing the way the aluminum foil was laid, the number of mechanical pencil cores, and how the mechanical pencil cores were placed. Condition 1/ Aluminum foil and sample were layered. Condition 2/ We tried 1 to 3 mechanical pencil leads. Condition 3: Changed the way the lead of the mechanical pencil is placed. Conditions 1 to 3 were changed one by one, and ruby generation was performed about 10 times for each to confirm the success rate.



[result] As a result of changing conditions 1 to 3, the success rate increased to about 80% under the following conditions. ・The aluminum foil and the sample were alternately stacked in two stages ・There are 3 mechanical pencil cores ・The lead of the mechanical pencil was laid down on the sample in the crucible in three directions.

[Discussion] · I did a literature survey, but I didn't understand why this condition was optimal. ・The success rate was close to 100% when a blue flame was created in the lead of the mechanical pencil.

[Experiment 7] · Changed to 4B, which has a high carbon content in the shear core. · Extend the experiment time until blue fire occurs. 2-3 minutes.

[Results] ・Dramatically improved success rate almost 100%. However, a large amount of small crystals can be formed (granular ruby)

[Discussion] ・When the success rate reached 100%, the goal was changed to "create a large crystal that actually exists."

[Experiment 8] I thought that by creating a large spark, a large amount of material would melt and become a large ruby. I tried various ideas.

・A flat plate was used to make it easier for sparks to fall on the sample.
・Copper wire was inserted to create a large amount of sparks
・I thought there was water in the actual crust, so I added Water
・The material was heated in advance with a burner in order to have a high temperature from the beginning.

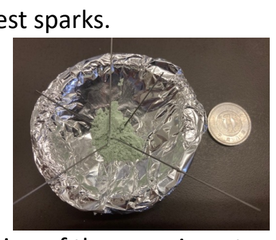
[result] All failed (ruby could not be made or there was no change in size)

[Discussion] Instead of increasing the size of the blue sparks, it is necessary to increase the number of times they occur, the time they occur, and the probability that the flames hit the sample.

[Experiment 9] ・Break the shear wick short to increase the area where the blue flame is generated.

[result] No sparks at 10mm size. The wick burns out quickly with the 20 mm size. The 30 mm size is good for "spark generation rate", "experiment duration time", and "probability of blue flame hitting the sample" 60mm normal size.

[Discussion]
・Sparks didn't fly with mechanical pencil lead that was too short.
・ Ruby crystals could not be formed with a length that burned out immediately even if sparks flew.
・ A length of about 30 mm produces the bluest sparks.



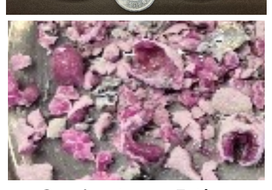
[Experiment 10] Two types of mechanical pencil cores, 60mm and 30mm, were used to lengthen the time in the microwave. The 30mm wick burns first, then the 60mm wick shortens to create a blue flame.

[result] ・The success rate is 100% ・The duration of the experiment was extended to about 5 minutes. It ends when the core of the mechanical pencil burns out. ・The size of the ruby can now be made a little larger. [Discussion] ・I felt that the number of blue sparks generated increased as the temperature in the range rose.

[Experiment 11] Accident during the continuation of Experiment 10 ・ The temperature sensor was broken, so I canceled

[result] ・As a result, the frequency of blue light generation increased dramatically because the microwave oven did not stop irradiating microwaves. Increased duration of blue sparks. [Discussion] · Until now, when the temperature inside the microwave oven rose, there was a time when the microwave oven stopped irradiating microwaves. With it gone, it became even easier to make rubies. ・ The temperature inside the microwave oven has risen, and the completed ruby crystal can now be taken out while still at a high temperature. ・When you observe the finished ruby, it is not red (close to white) immediately after taking it out of the microwave. I noticed it turned red as it cooled.

[Experiment 12] ・I came to imagine what is actually happening on the earth. Various factors such as "temperature", "pressure" and "time" in the earth must be intertwined. ・Without lowering the temperature of the ruby, the "sample" and "mechanical pencil core" were added and the experiment was conducted continuously. · Overheat several times in a row. 3 minutes x 5 times. Heat quickly before the crystals cool down. ・Replenish the shear core that causes sparks each time. ・Replenish materials that will be the source of the crystals → Just cover the existing crystals thinly 【result】・I was able to extend the experiment time to 15 minutes. (It is judged that the temperature of the microwave oven rises above this and is dangerous.) ・The crystals grew larger with each overheating. ・The largest crystal ever made has become possible.



[Discussion] ・When I started experimenting with an awareness of the flow of time on the earth, various ideas came to my mind. ・I think that we can be even more creative if we think from the perspective of reproducing the changes inside the earth in a few minutes in the laboratory.

DISCUSSION （議論）

When we (especially Raia) think back to when my experiments dramatically improved, they were always accompanied by failures. Rather than thinking about the reasons for success, thinking about the reasons why things didn't go well and repeating improvements improved the probability of ruby generation and the size of the finished ruby.

★ When changing to a crucible → Sparks reach the sample more easily
★ When changing to a shear core → Sparks are more likely to occur
★ When the shear core was changed to 4B → the percentage of blue sparks increased
★ Continued to devise the arrangement and length of the shear core → There is an optimal place for the microwave oven
★ The temperature sensor was canceled → The range continued to emit microwaves regardless of the temperature within the range.
★ Two microwave ovens → Continuous experiments became possible.

Through trial and error, I gradually gained knowledge. Experiments became even more fun when we considered the relationship between the obtained knowledge and the actual movement of the earth.

ACKNOWLEDGMENTS （謝辞）

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