Unlocking the Potential of Gifted Students: Innovative Strategies and Best Practices in STEAM Enrichment Programs

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Overview of today's talk

- Self-Introduction
- Motivation of today's talk
- HS student project is not a mimic of Univ.
- Science projects by my students (Examples)
- →Primitive and Super-Analog Tools are the alternative way of ICT or digital gadgets.

Who am I?

- **Earth Science** high-school teacher for over 40 years
- Associate professor and part-time lecturer of **Osaka-Kyoiku University** 2012 - 2022 (now retired)
- Earth Science visiting teacher at **KVIS** since 2017, **PCSHS Mukdahan** in 2019, **PCSHS Loei/NST** 2022
- School seismograph system (at KVIS and PCSHS Mkudahan, PCSHS Loei, PCSHS NST)
- 3D seismicity maps, tsunami simulation using PC etc.
- Polarized microscope unit & Thin-sections in a classroom
- Linux Programming (awk, C, Processing, Arduino IDE, Python, etc.)
- 3D printing (2019-)

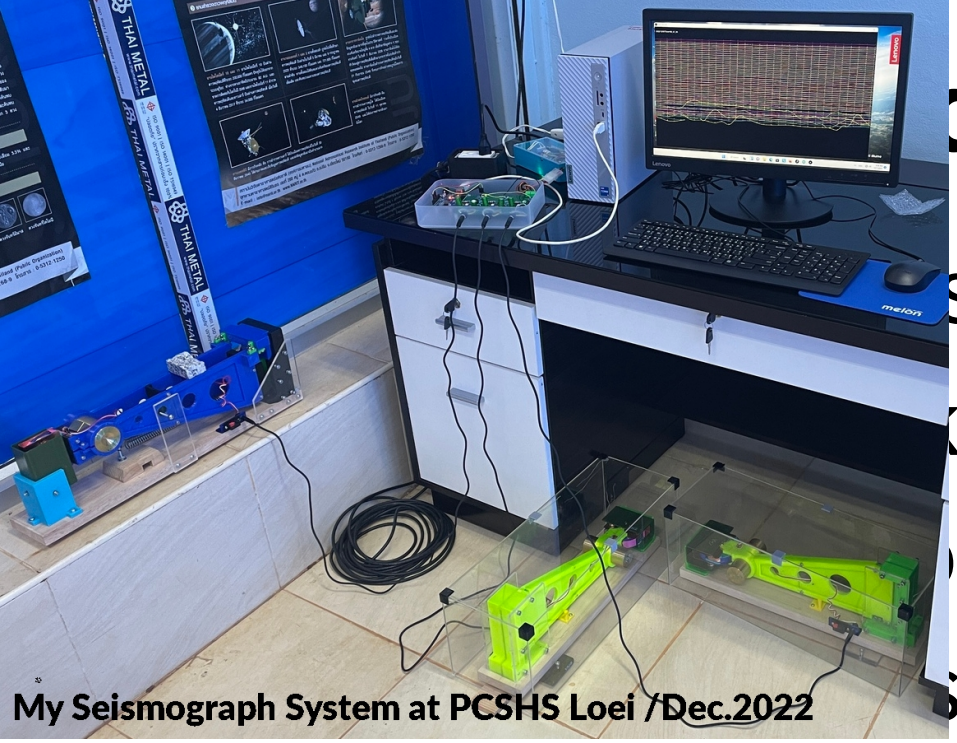
My final stage of teaching
Gifted students
But small size: 4 classes 164 at each grade
Back to BASIC (old-lecture style)

Sister school of Princess Chulabhorn Science High School Pathumthani

A Novel Prize winner of our school graduate

- Shinya Yamanaka 山中伸弥
- The 2012 Nobel Prize for Physiology or Medicine
- for the discovery of “iPS cells”

Nominated as a Super-Science High-school



My Seismograph System at PCSHS Loei /Dec.2022

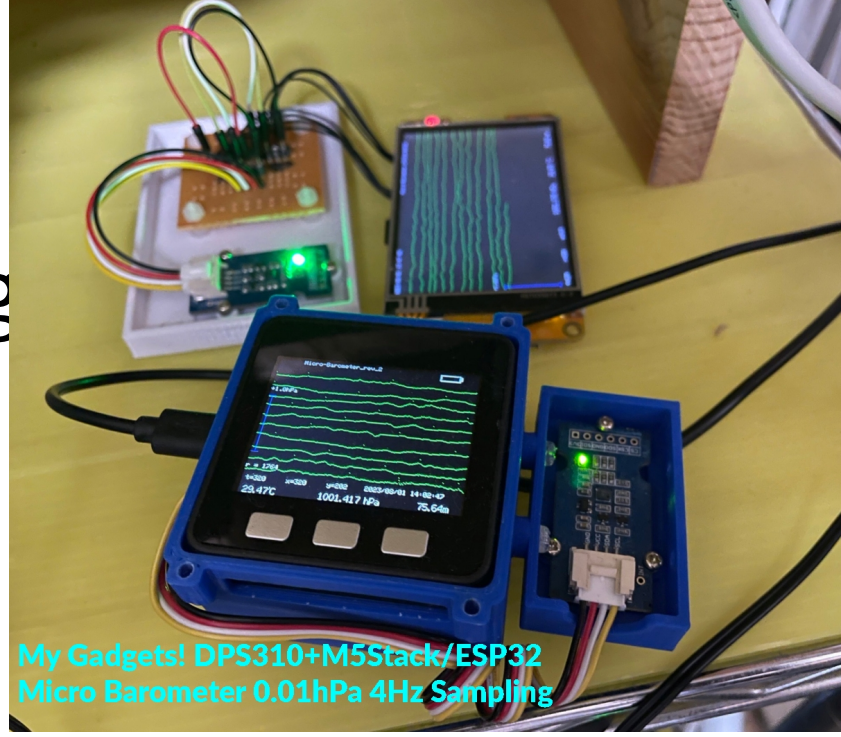
digital

seismog

micro-

of som

unami,



My Gadgets! DPS310+M5Stack/ESP32
Micro Barometer 0.01hPa 4Hz Sampling

- → However, today's talk comes from a completely opposite horizon!!

Motivation

- From 2000 to 2017, I worked at Tennoji HS attached to Osaka-Kyoiku-Univeristy.
- Our science projects start at the same time.
- Many projects had been led and guided by me, so I was proud of our projects.
- In 2011, I was invited as a guest speaker of a branch meeting of "The Science Council of Japan (SCJ)", which is a leading science committee of Japan.

A very tough question from an authority

At this meeting, which is a small session about geo-science education of "The Science Council of Japan (SCJ)"

- I was talking our school/students projects very proudly.
- However, one of the authorities, a famous seismologist in Japan, suddenly asked me -----.
- **"Why do you manage these projects at high school? Is it NOT TO LATE after they become university students?"**
- **“What the meaning of your projects IN HIGHSCHOOL?”**
- He is a highly respected person, and the question came so suddenly that I could not respond quickly enough.

High school students' project is not a mimic of university or graduate school

- This presentation is my answer to the above question.
- Some university researchers may think it is enough to let high school students experience the style or method of researches conducted at university or graduate school.
- But the above ideas completely misunderstand the science project at the high school level.
- The following slides show the difference between the two categories by presenting our project examples.

The difference :

university vs. high school

- Purpose driven
- Socially meaningful
- Get position or degree
- Deadline and Reports
- New discovery is favorite
- Failed experiments are meaningless
- Sophisticated
-

- Interest driven
- Personally meaningful
- Get sense of science
- Loose arrangement
- Nothing is demand
- Failed experiments are welcome
- Primitive and wild
-

Results are required!!

Do what you like!!

How do I manage the students projects?

- I will show you my experience.
- In the beginning, I have no guidelines or philosophy .
- I learned a lot from the struggling practices with my students.
- Through long years of practice and experience, a guiding policy for student projects has finally been established.
- I will show you our student’s projects at first, and then summarize my guiding policy.
- My major is geology/geophysics, so most are related with Earth-Science (Geoscience).

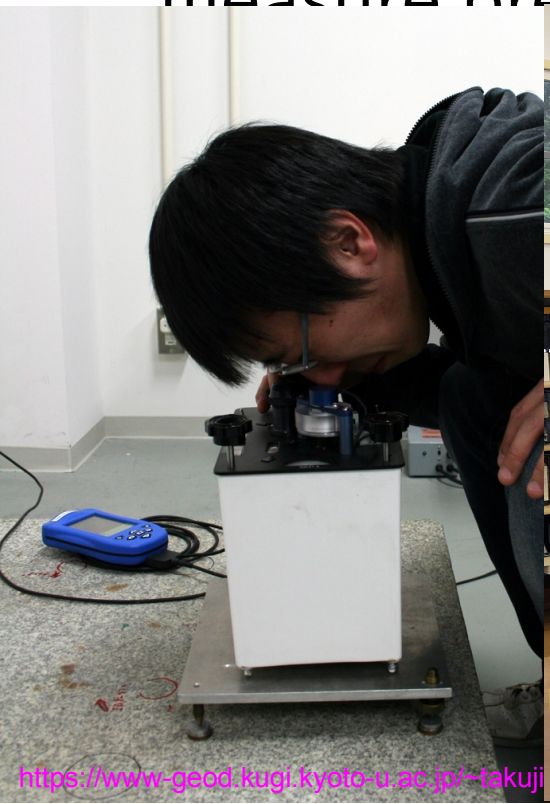
Purpose of Our Projects

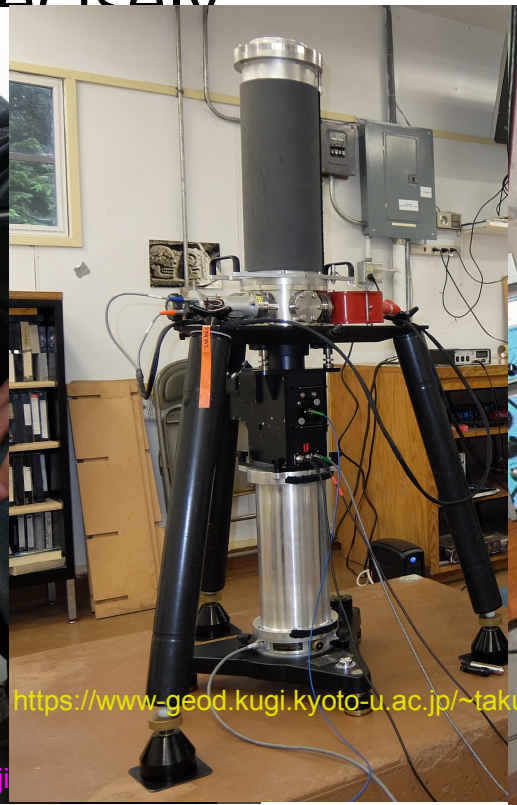
- Cultivate proactivity
- Cultivate creativity
- Learn about super low technique (analogue skills) instead of mastering sophisticated high tech tools (ICT)
- Don't just rely on the knowledge in your brain, but be hands-on by yourselves and create a new idea/items!

Our students’ Projects!

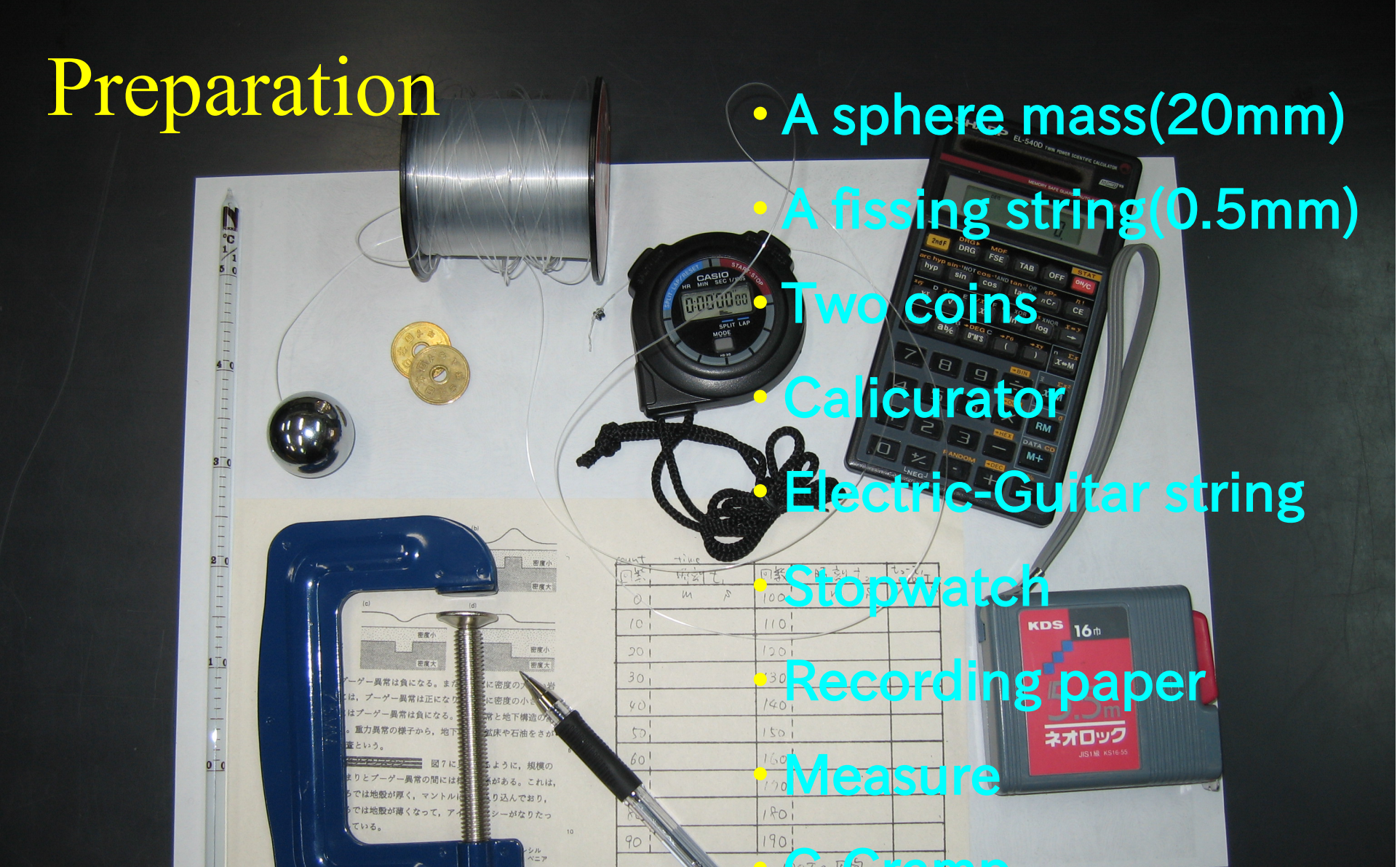
Gravity measurement using a simple pendulum in the school excursion

- Gravity measurement is simple but very difficult to measure precisely

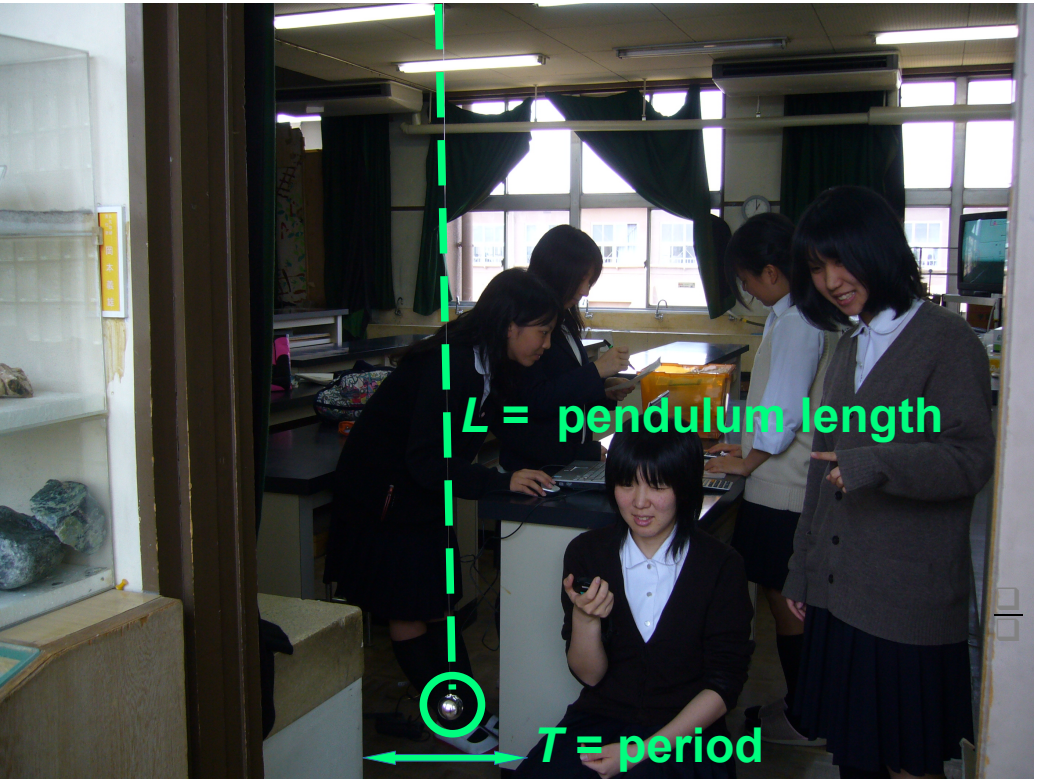




Preparation



- A sphere mass(20mm)
- A fissing string(0.5mm)
- Two coins
- Calicurator
- Electric-Guitar string
- Stopwatch
- Recording paper
- Measure
- C-Cramp

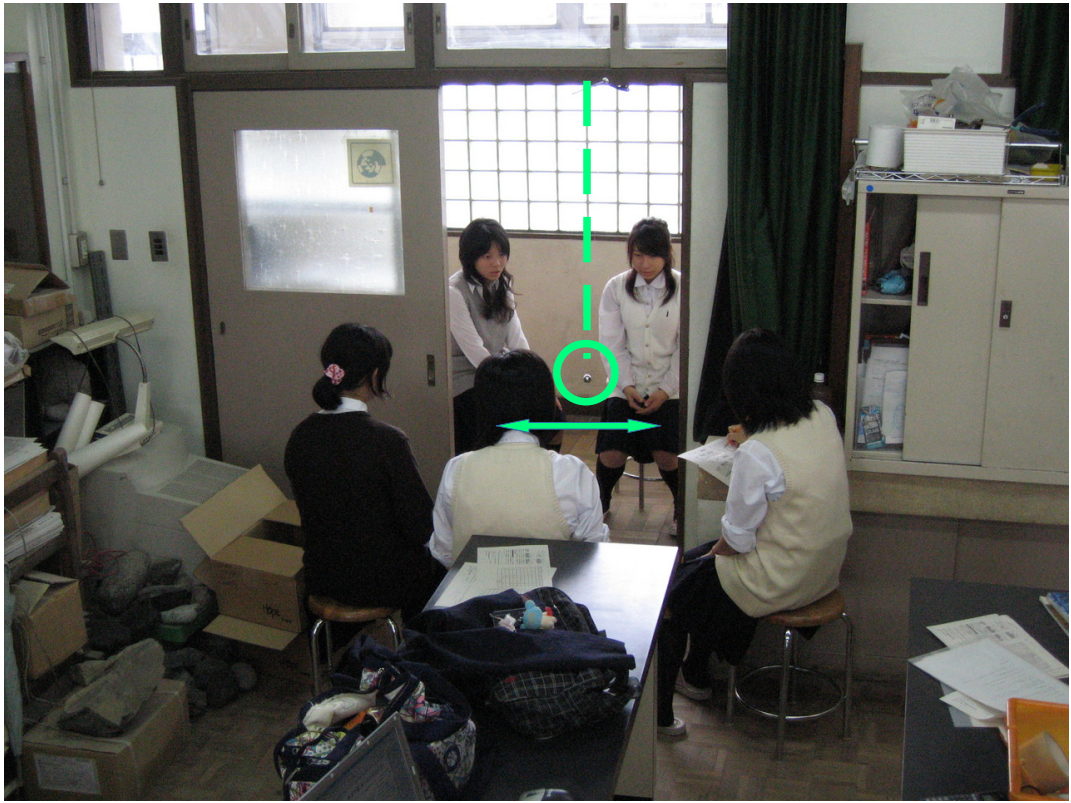


Measuring at

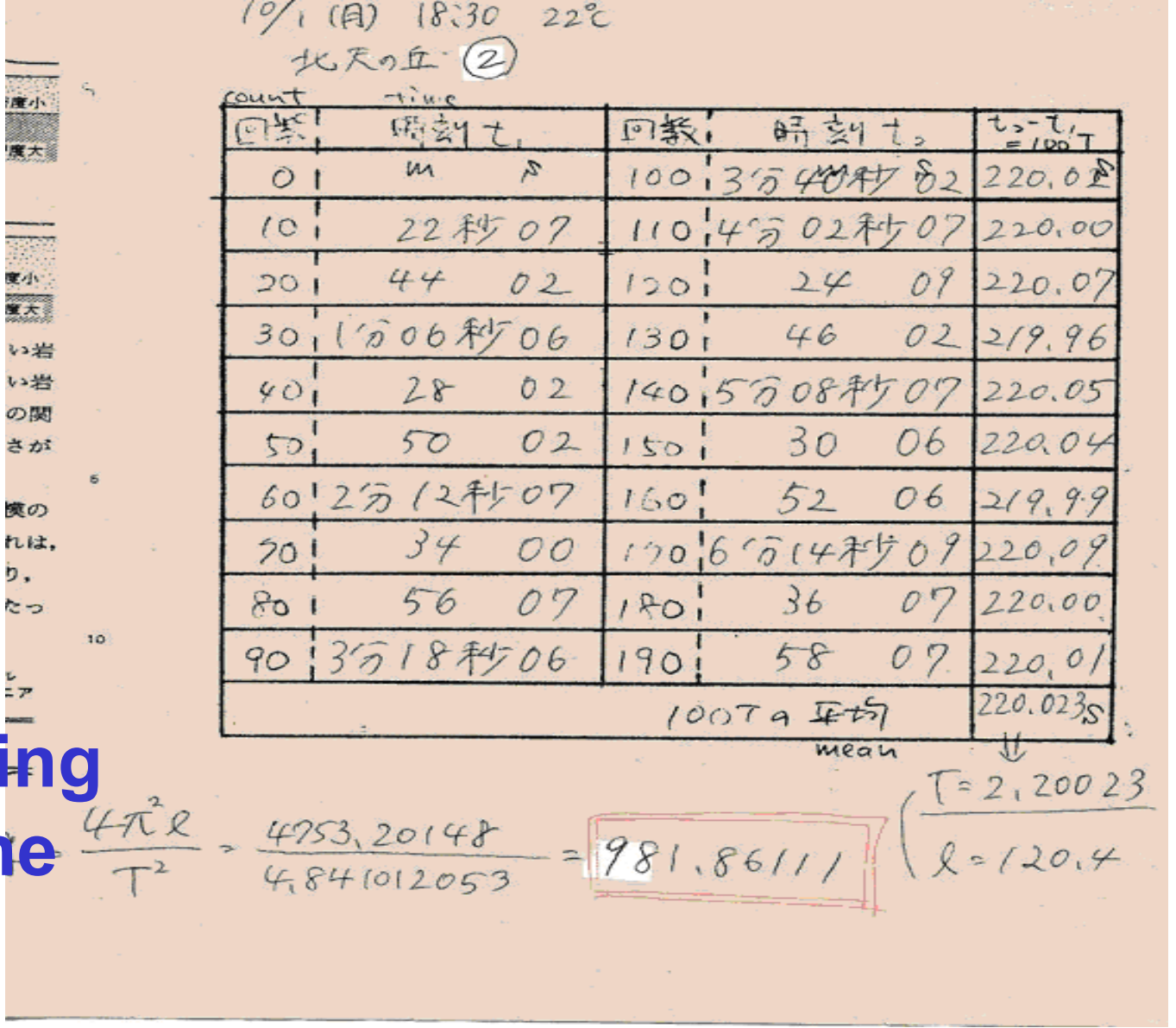
Our geoscience room

$$T = 2\pi\sqrt{\frac{L}{g}}$$

T = period
π = pi
L = pendulum length
g = acceleration due to gravity



Calculating moving averages from the measuring data



10/1 (月) 18:30 22℃

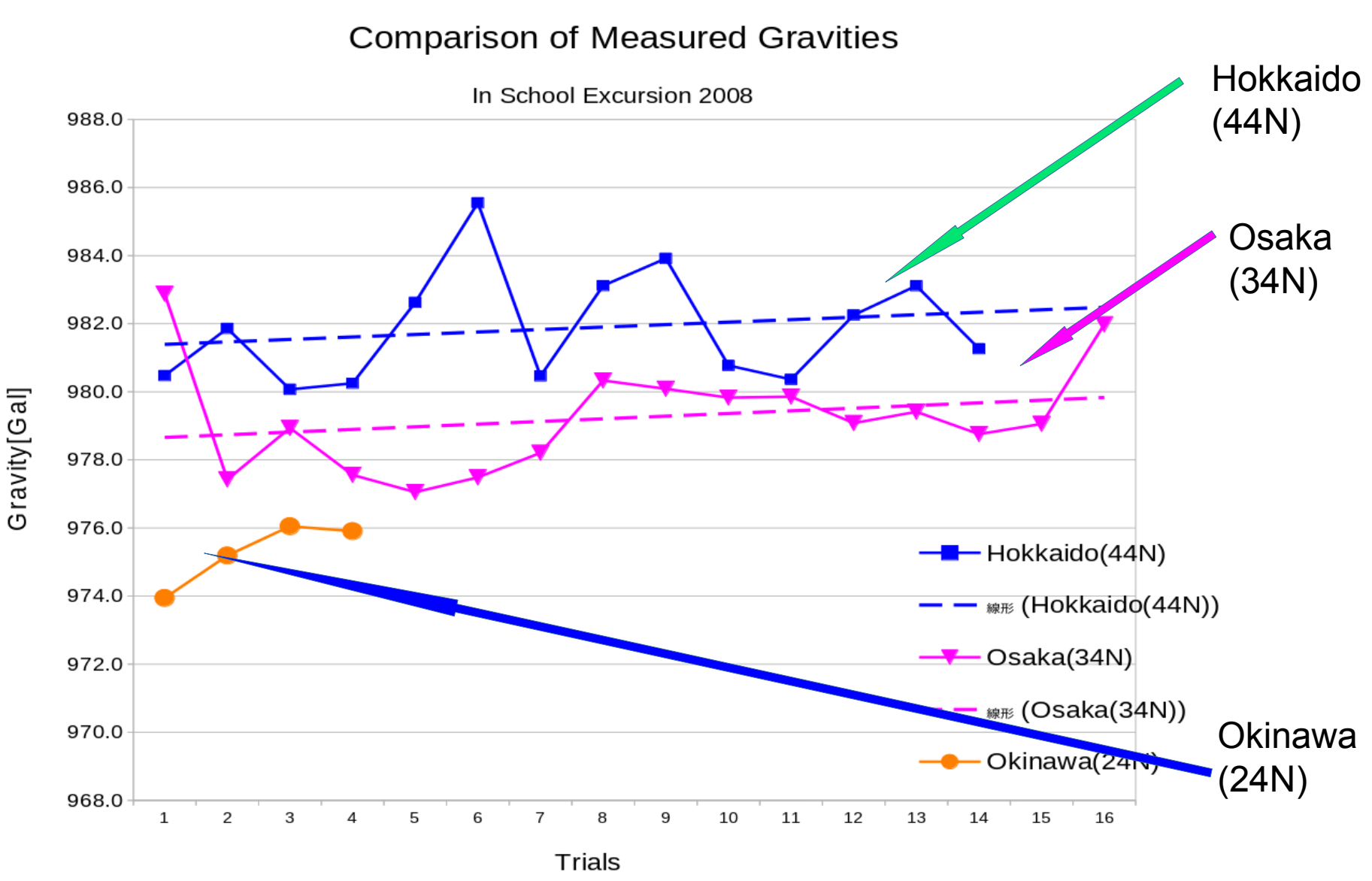
北天の丘 ②

回数 count	時刻 time	回数	時刻 time	もっても 100T
0	m s	100	3分40秒82	220.02
10	22秒07	110	4分02秒07	220.00
20	44 02	120	24 09	220.07
30	1分06秒06	130	46 02	219.96
40	28 02	140	5分08秒07	220.05
50	50 02	150	30 06	220.04
60	2分12秒07	160	52 06	219.99
70	34 00	170	6分14秒09	220.09
80	56 07	180	36 07	220.00
90	3分18秒06	190	58 07	220.01
			100Tの平均 mean	220.0235

$\frac{4\pi^2 \ell}{T^2} = \frac{4753.20148}{4.841012053} = 981.86111$

$T = 2.20023$

$\ell = 120.4$


Comparison of Measured Gravities
In School Excursion 2008
Gravity[Gal]
988.0
986.0
984.0
982.0
980.0
978.0
976.0
974.0
972.0
970.0
968.0
1
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11
12
13
14
15
16
Trials
Hokkaido(44N)
線形 (Hokkaido(44N))
Osaka(34N)
線形 (Osaka(34N))
Okinawa(24N)
Hokkaido
(44N)
Osaka
(34N)
Okinawa
(24N)

Hard-earned data set!

This measurements is shown on the text book
But any HS students try it practically ever!
So their work is one of the pioneering attempt in Japan.
They got an exellent award at JpGU2008

Of course, They were enjoying their school trip!

Breaks!

”Kitchen Geoscience” by our students

- “Model experiments” related with Geosciences
- Our unique study at GeoSciEd2006 and JpGU2007
- “Kitchen Geoscience” trend around 2000 to 2010
- It is popular again for Geo Park Outreaches in Japan
- 1) Primitive method:
- 2) Daily materials:
- 3) Quantitative analysis: → **measuring and graph plot**
- 4) This is not a science magic or science show!

http://seagull.stars.ne.jp/Old_Conferences/2007_rengo_5.pdf
http://seagull.stars.ne.jp/2006_Germany/model-based777.pdf

Examples_1 *Using sugar sweets!*

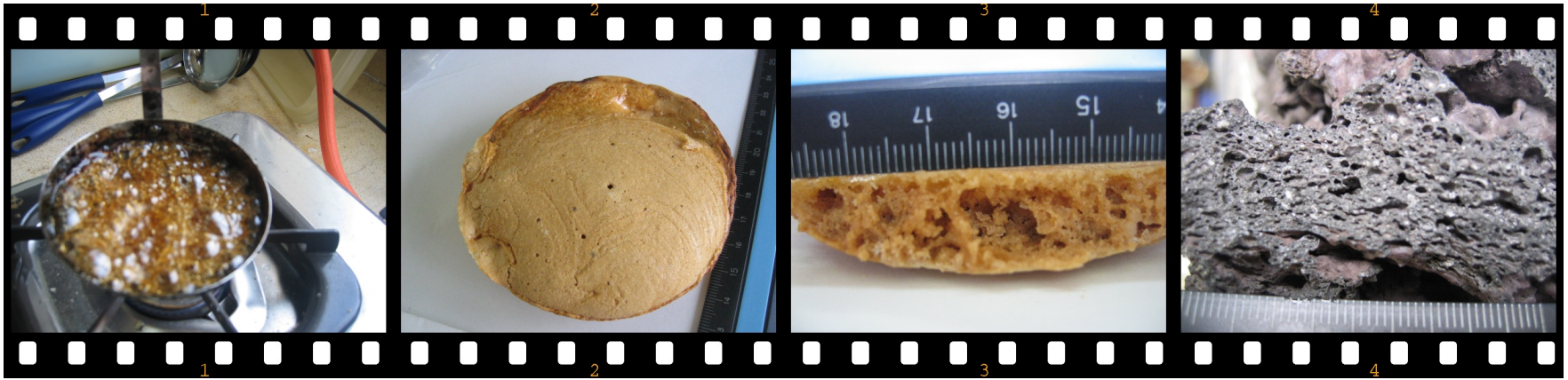


Fig1. "Sugar Calmera" as a mimic of basalt lava

Fig2. Sugar candy models cool joints of lava flow

Examples_2 *Karst related*

Fig3. Stalactite using Sodium thio-sulphate($Na_2S_2O_3$) aqua.

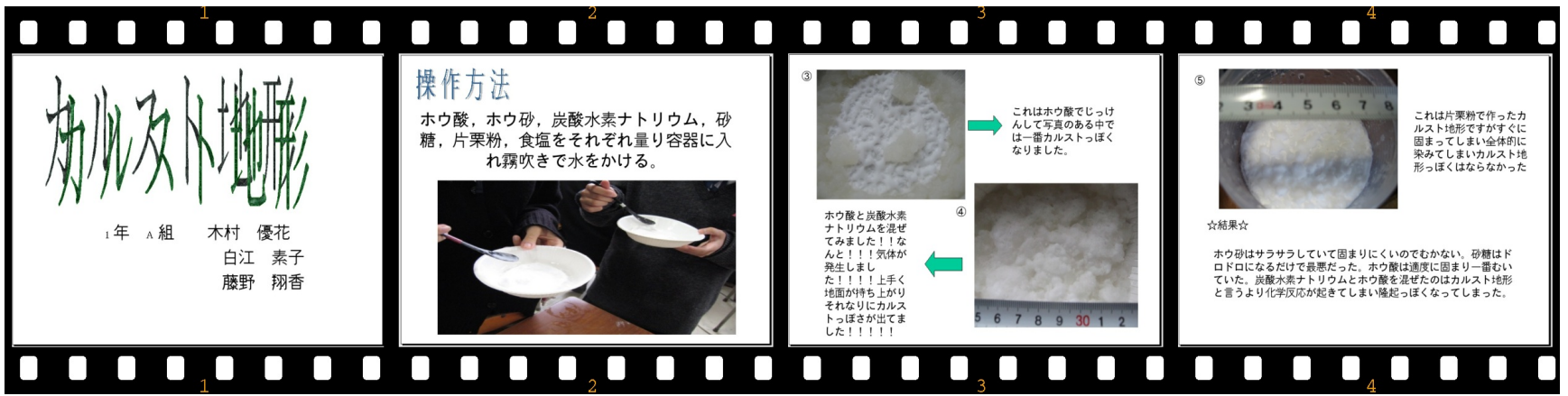


Fig4. Doline like surface using powder and spray.

Example_3 *'Air mirage' is examined---*

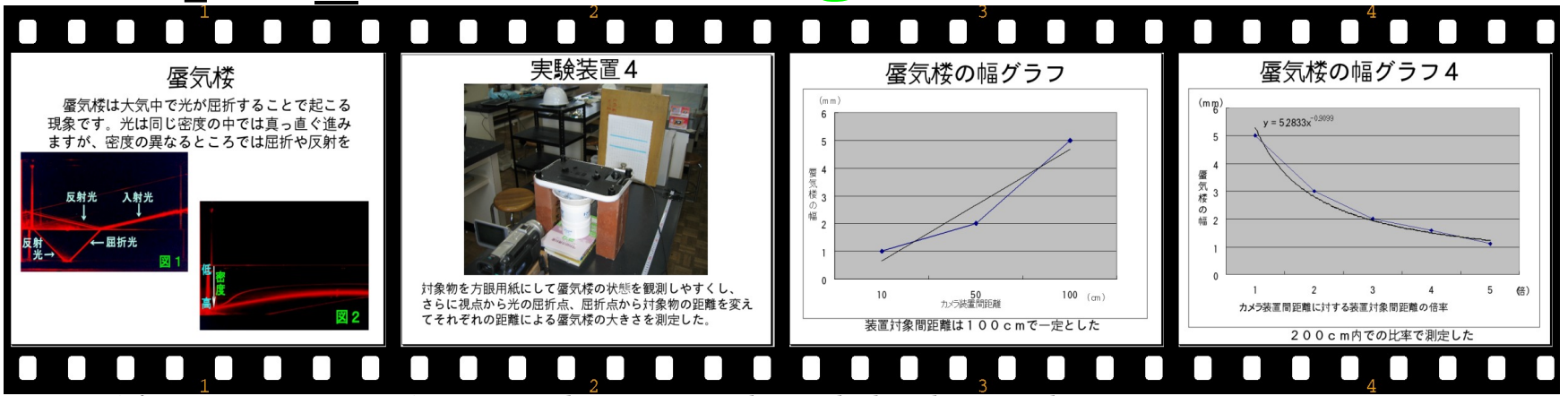


Fig17. 'Air mirage' in a hot and cold chamber .

Fig18. An example showing inverse layer and failed examples.

Example 4 *Plate tectonics*

Fig7. Plates collision (Himalayan orogen model with flour).

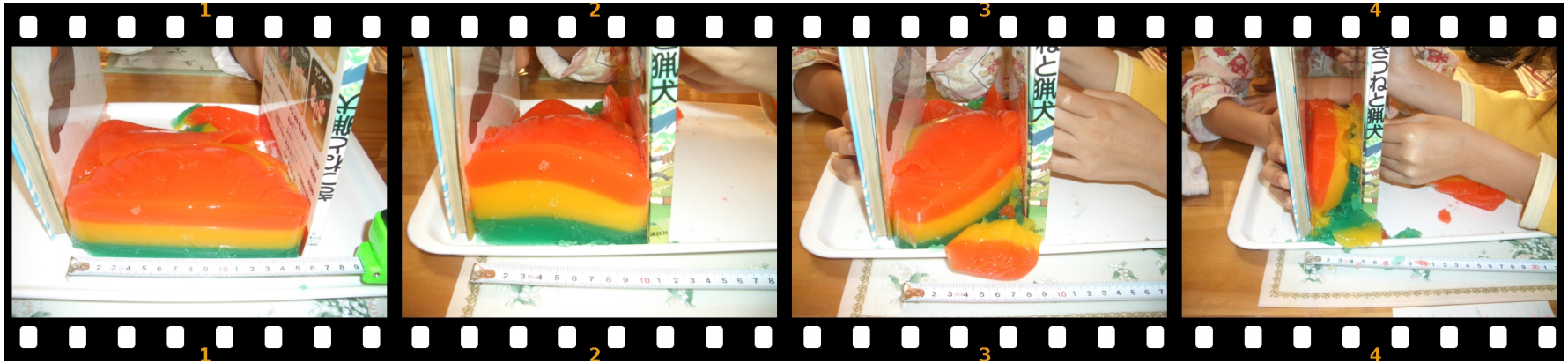


Fig8. A gelatin reverse fault failed.

Example_5 *Volcanic eruption*

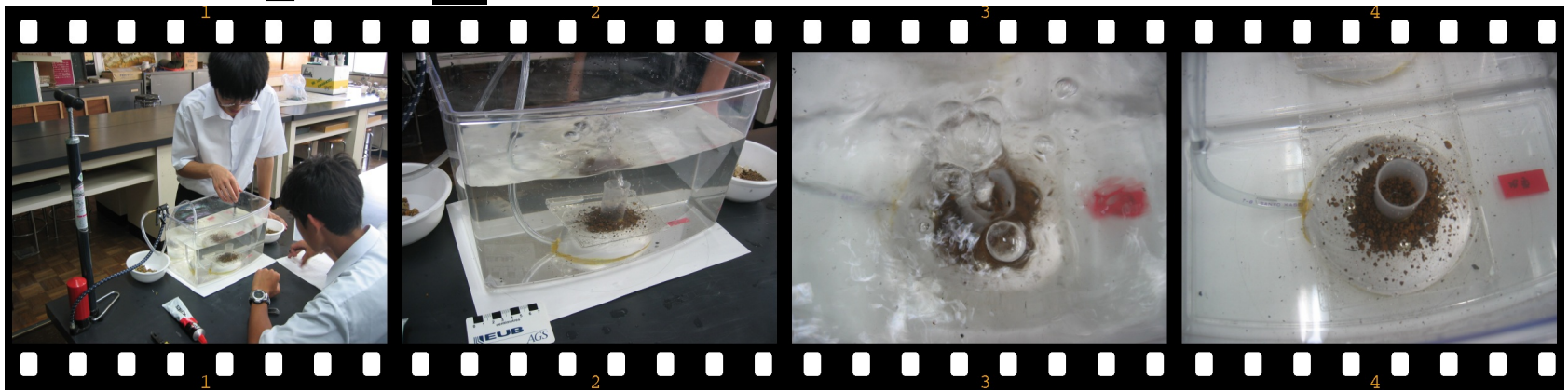


Fig9. Water bottom volcano showing inverse distribution of pumice.

Fig10. A Video capture of a bath sparkler and hot water volcano.

Example_6 *Pyroclastic flow in a water tank*

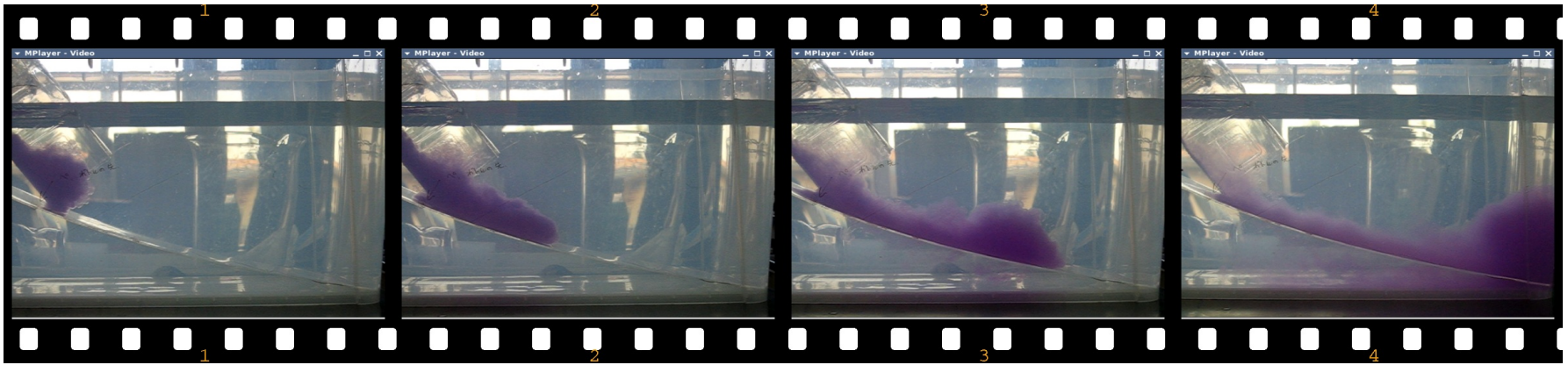


Fig11. A coloured sugar water flow mimics a Pyroclastic flow.

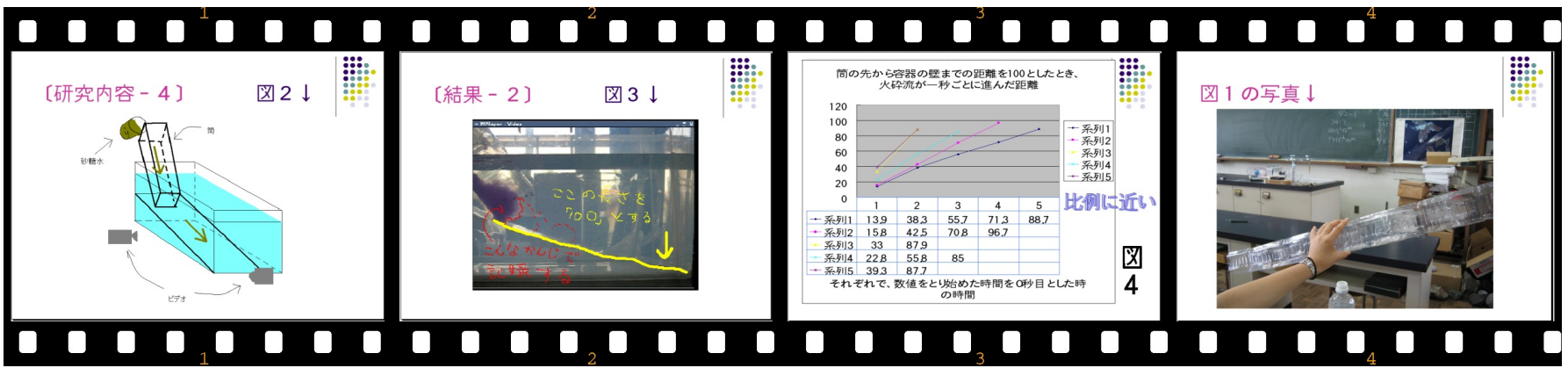


Fig12. An analysis about "Sugar water pyroclastic flow".

Example_7 *Liquidization and sand_dune*

Fig13. Mixture of plastic balls with vibrate-motor mimic ground liquidizing.

Fig14. A sand dune model using polyethylenes balls.

Example_8 The 'Japan Island' is sinking---

Fig15. 'Japan island' sinks into the pacific plate! After ice cream melting.

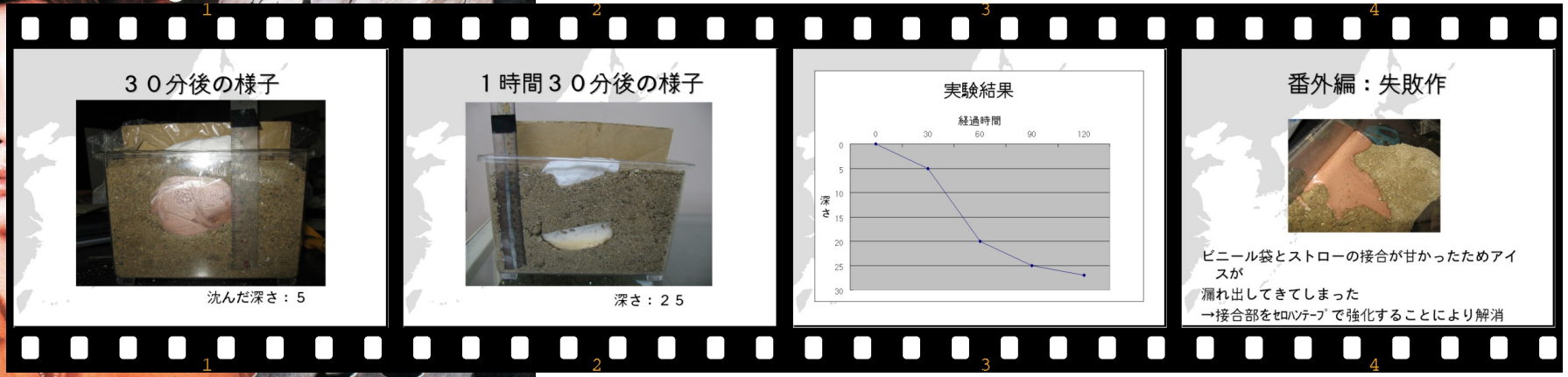


Fig16. Clips, an analysis and a failed example .

https://www.imdb.com/title/tt0473064/mediaviewer/rm4073767169/?ref_=tt_ov_i

Example_10 *K/T asteroid impact!!!*

Fig20. Baby powder in a 'Fish tank' and a Japanese food 'Fu' .

Fig21. Volt-meter shows a depletion of sun ray with an impact.

Failed experiments:

Fig19. Shake the bottle but not stand. And shake---, succeed!

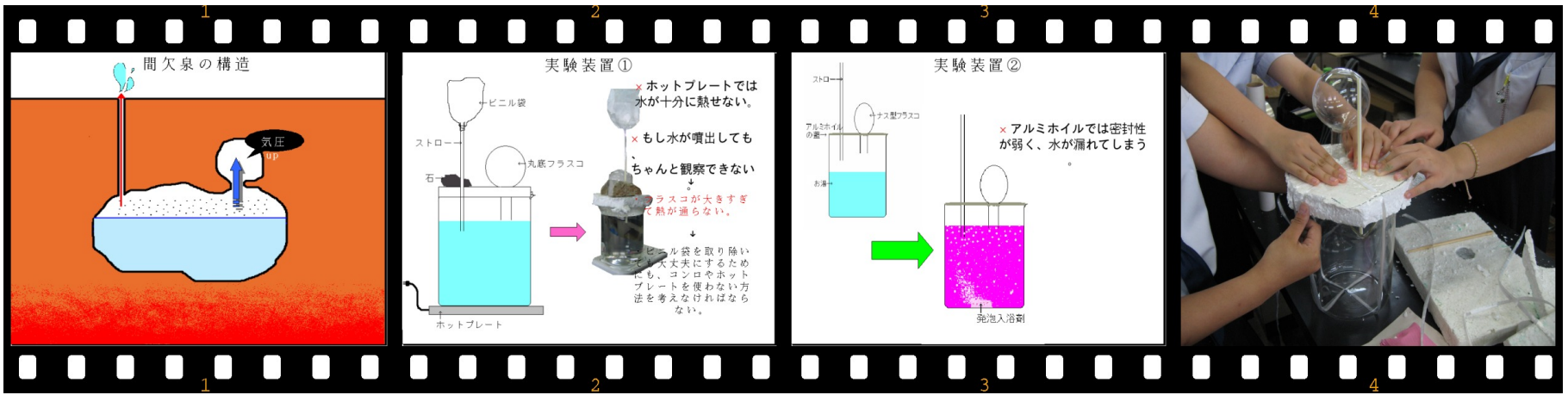


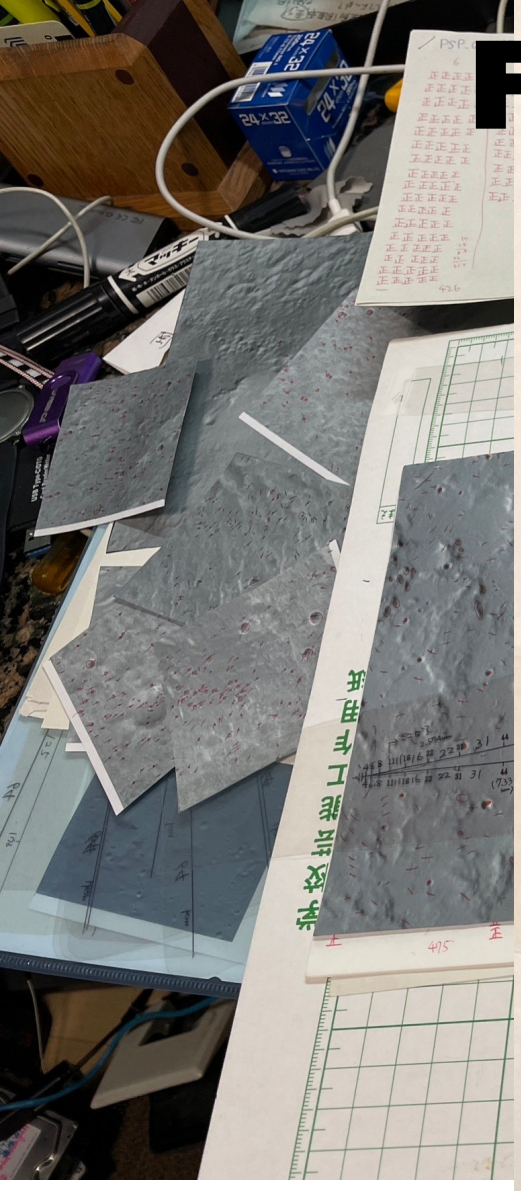
Fig6. A geyser model using a beaker and a flask.

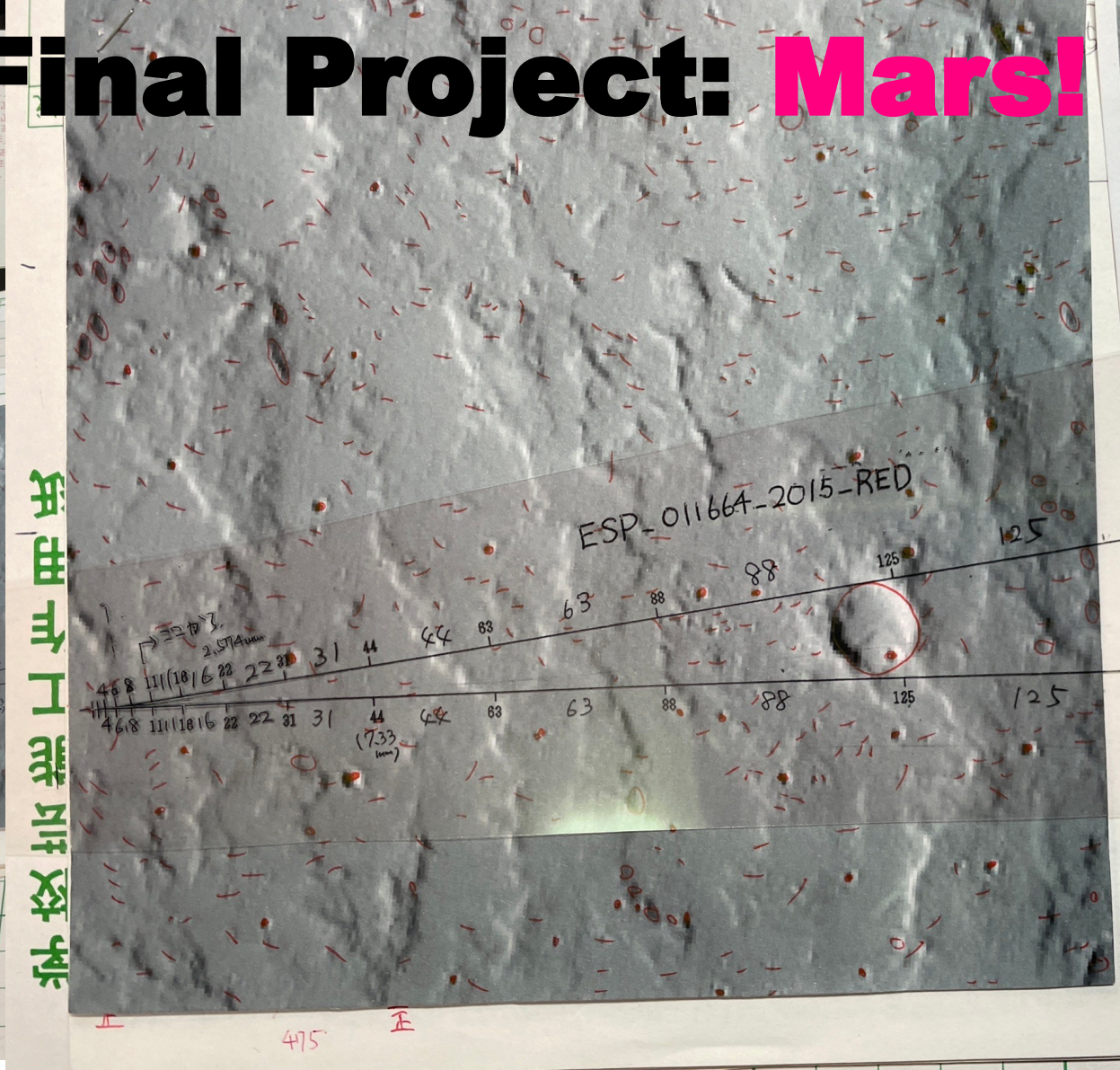
Let's cook!

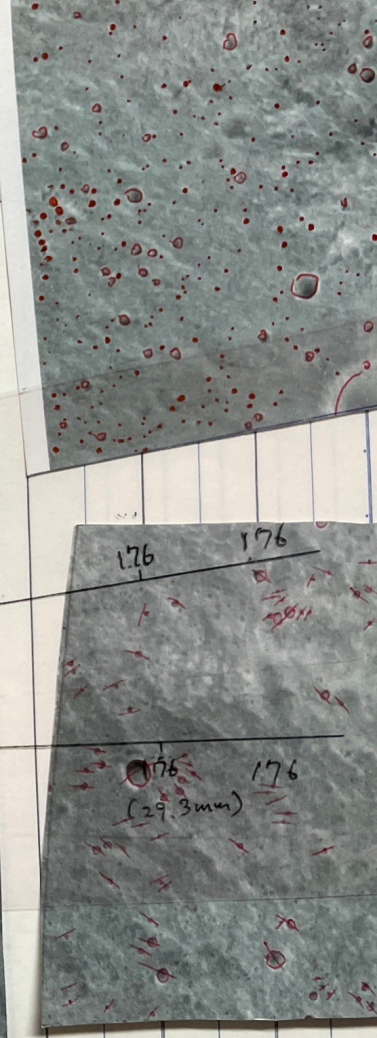
Fig20. Making chocolate fan??? Too sweet!!!!!

Fig21. Various food materials and items for experiments.

Final Project: Mars!







Martian Surface Ages using "Crater Chronology"

- Mars is a next target of our exploration.
- Because the planet has a possibilit
- There are a lot of study method to
- My students was interested in a pr
  estimate the Martian surface ages.
- Dr. William Hartmann who is a pior
  Chronology" and is famous his "Gi
  for the origin of Moon.
- My students used his technique to
  surface.

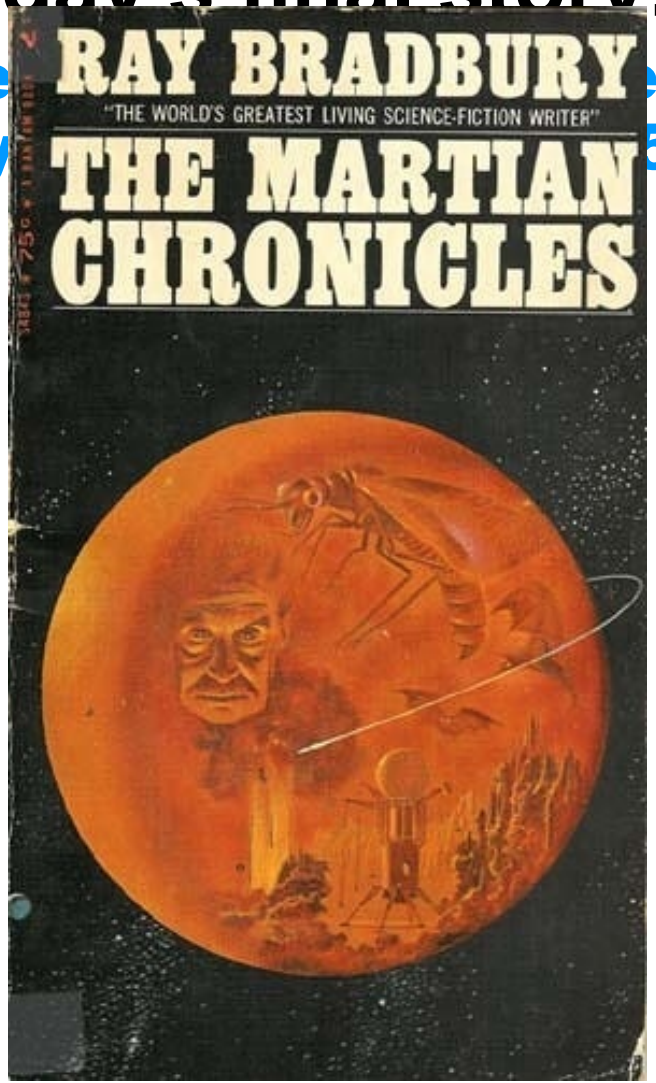
Dr. W.K.Hartmann at PSI 2011 (my photo)

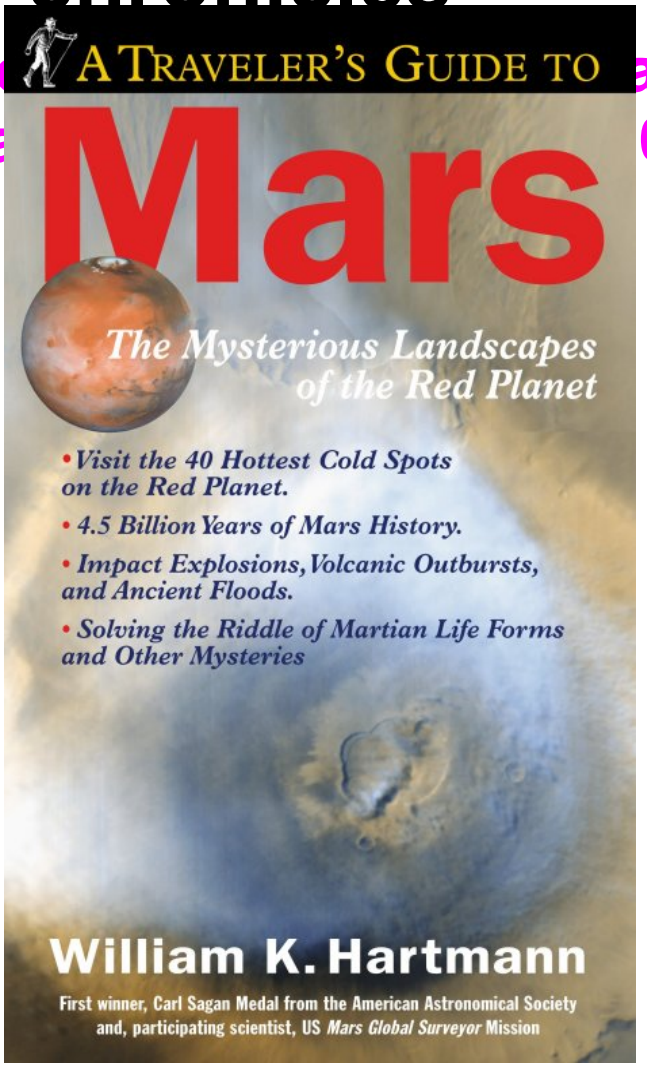
https://www.lpl.arizona.edu/news/2013/fall/2013-shoemaker-award-bill-hartmann

Today's final story: A Martian chronicles

"The es" "A Trav ars"

by 50. by Willia 003

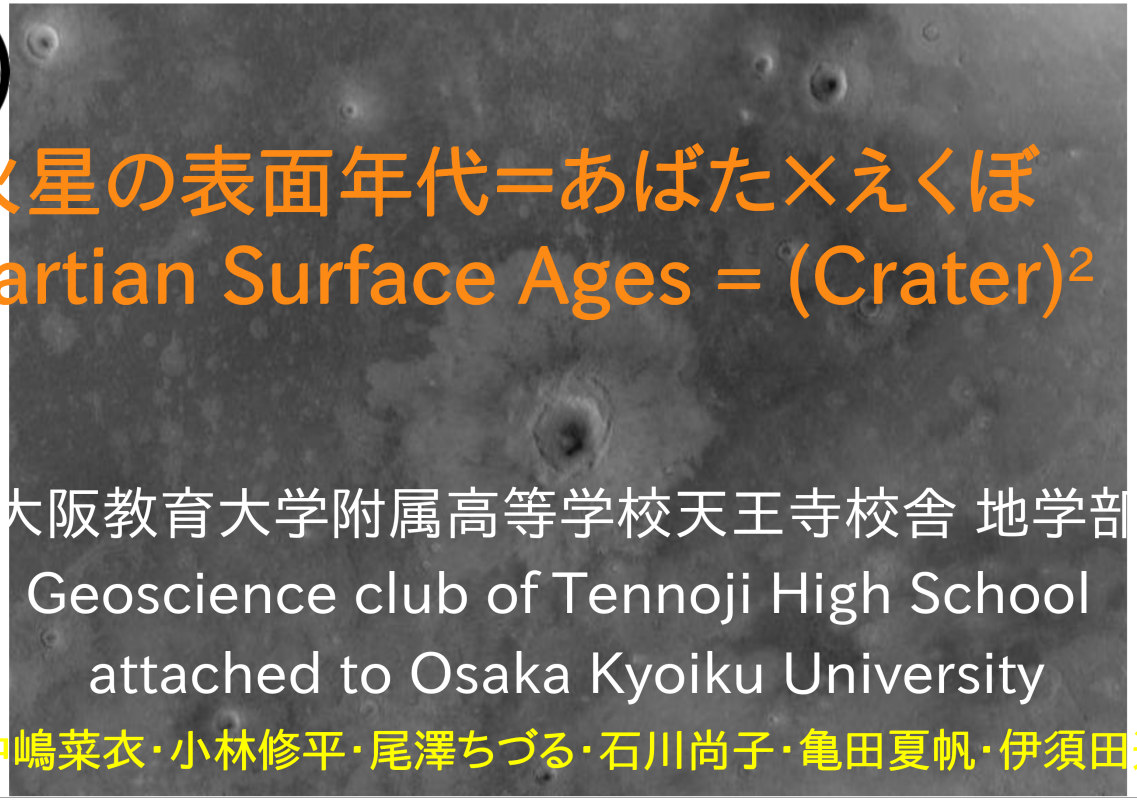




From here, we introduce our project quoting from the student’ PPT

Super Science Highschool(SSH) competition At 2011 Kobe

Slightly modified

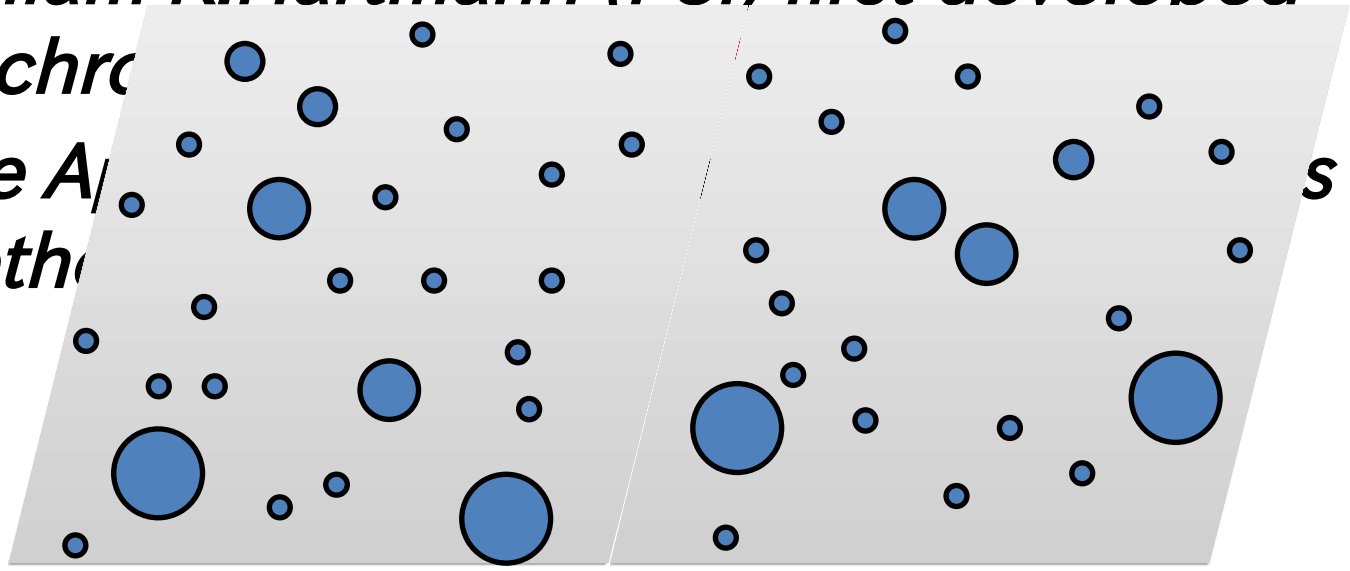


Motivation　研究動機

- *We are interested in “Crater-Chronology”.*
- *Dr. William Hartmann , founder of “Crater-Chronology”*
- *It is generally believed*
  “Mars has died” or “Mars has dried up”
- *However, is it true?*
- *How do we study using simple method?*

What is Crater-Chronology?

- *William K.Hartmann (PSI) first developed isochro*
  - *The A s and meth*



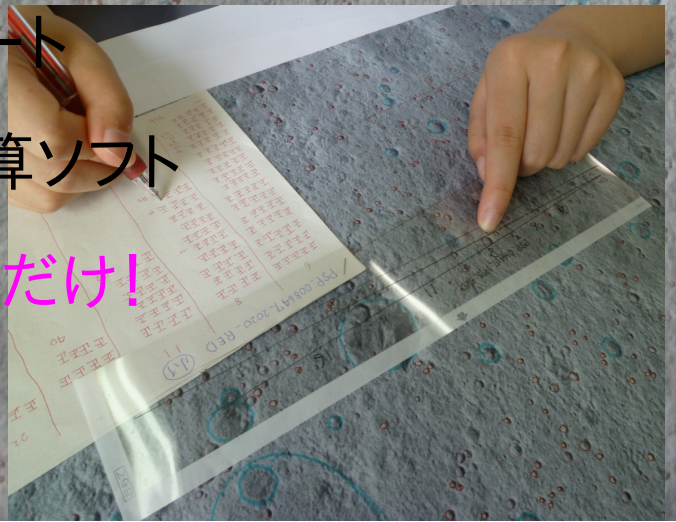
Many → **Old**

Few → **Young**

Our low-tech tools!!

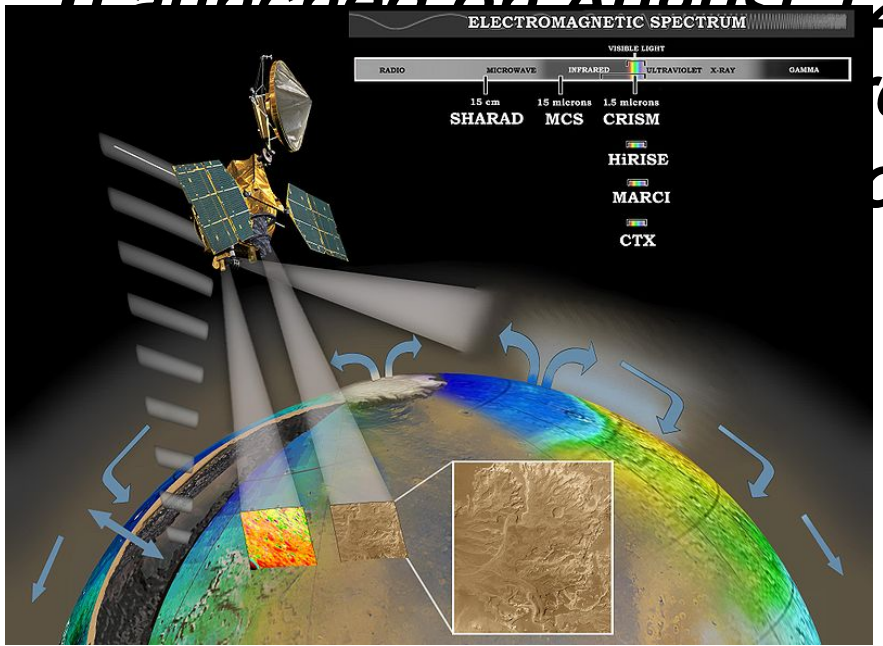
- *Printed image* 印刷した画像
- *Color pens* カラーペン
- *Handmade ruler* 自作のものさし
- *Data sheet* データシート
- *Excel on PC* 表計算ソフト

That's all! たったこれだけ！



We focus on the most recent Mars images

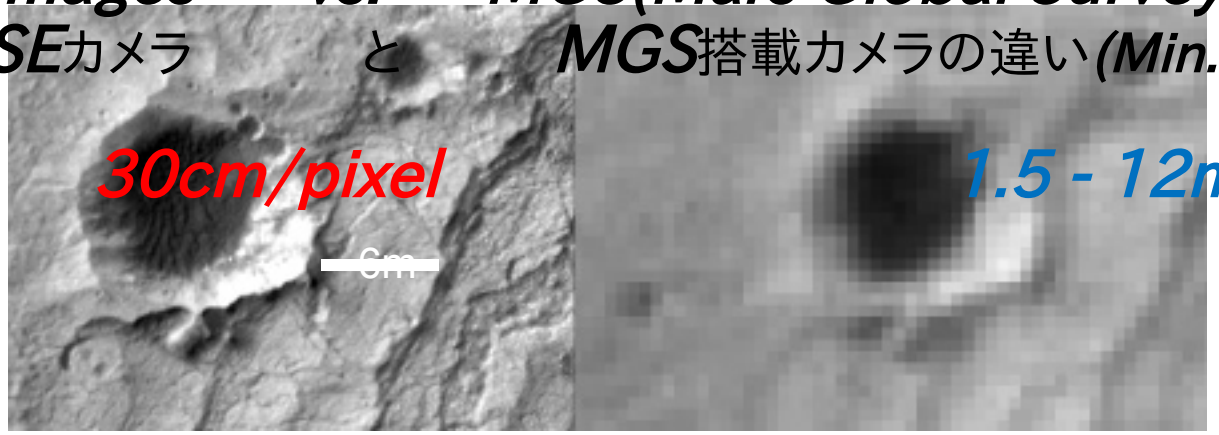
- Mars Reconnaissance Orbiter (MRO) carries the HiRISE camera.　MRO衛星はハイライズカメラを搭載
- Launched on August 12, 2005　打ち上げ
- ch 10,
- ct. 200



HiRISE camera
ハイライズカメラ
50cm reflector
反射鏡

Comparison of Satellite Images 衛星画像の比較

- *HiRISE images vs. MGS(Mars Global Surveyor) images*
  *HiRISE*カメラ と *MGS*搭載カメラの違い*(Min. Resolution* 解像度*)*



From HiRISE Website

*HiRISE images are quite suitable for small crater counting. HiRISE*画像は小クレータのカウントに最適である.

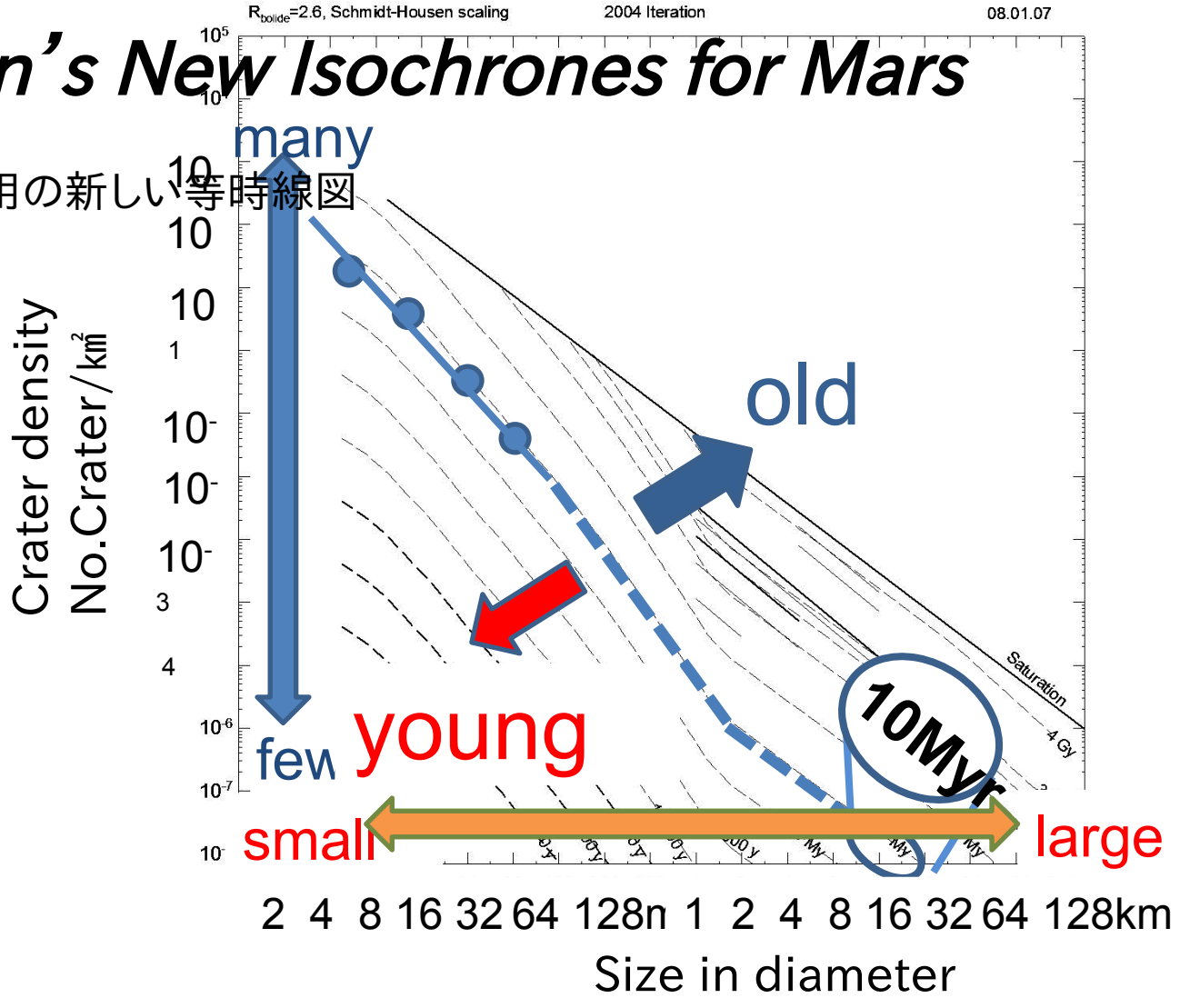
Studies using HiRISE images are quite few yet.
HiRISE 画像を用いた研究は現在のところまだ極めて少ない.

Images are freely downloadable from the HiRISE web site. 画像は*HiRISE*のウェブサイトから誰でも自由にダウンロードできる.

The Hartmann's New Isochrones for Mars

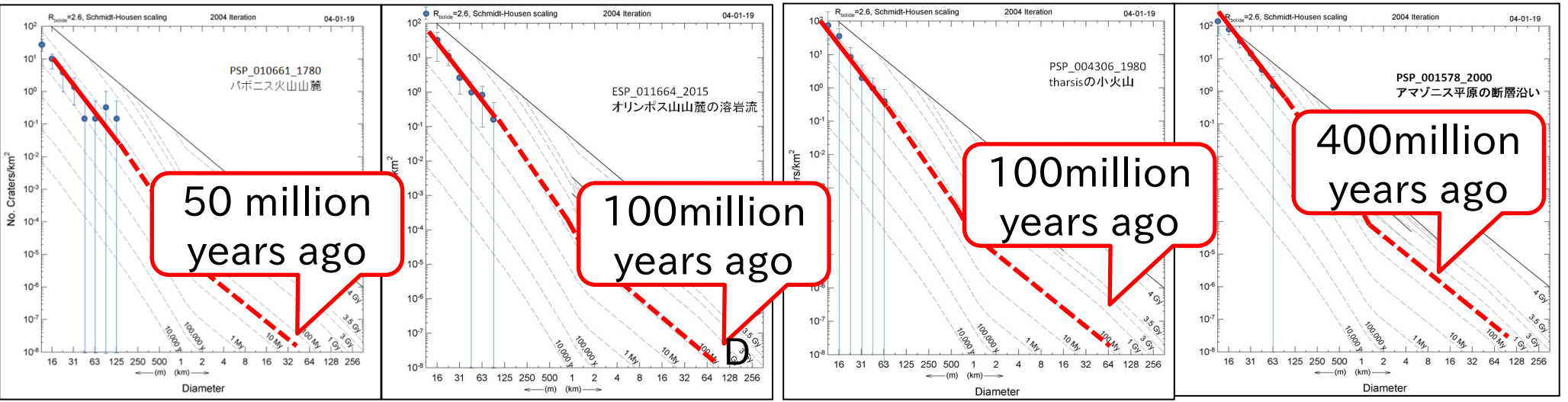
ハートマン先生から頂いた火星用の新しい等時線図

Erosion or resurfacing makes isochrones complicated.



Previous Study　昨年度までの研究

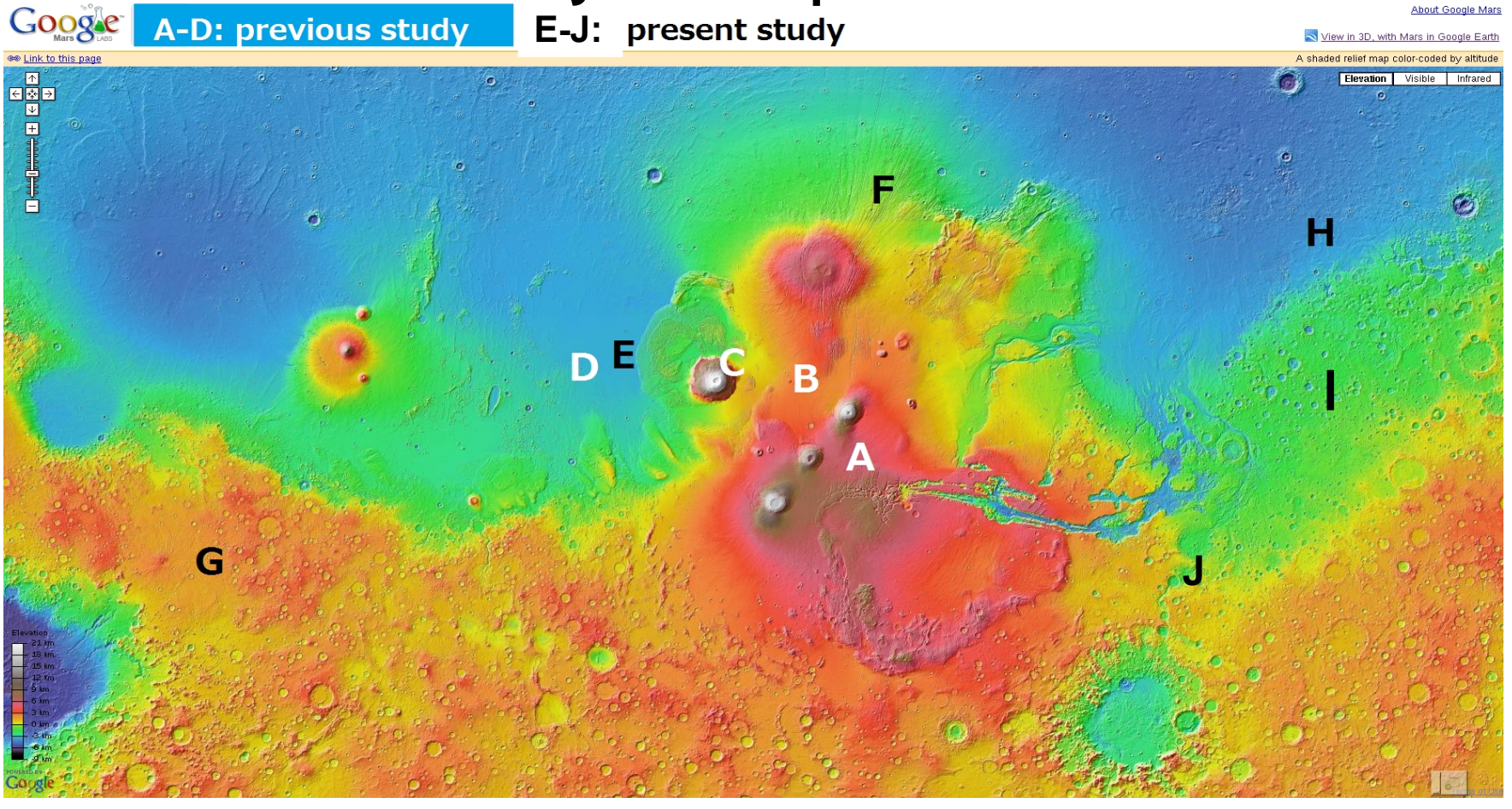
We estimated young lava flows as 50-400Myr;
Good agreement with recent studies (Hartmann, 2011, personal comm.).
若い溶岩流の年代を5000万年から4億年と推定した. これは最近の研究とよい一致を示す（ハートマン2011私信）



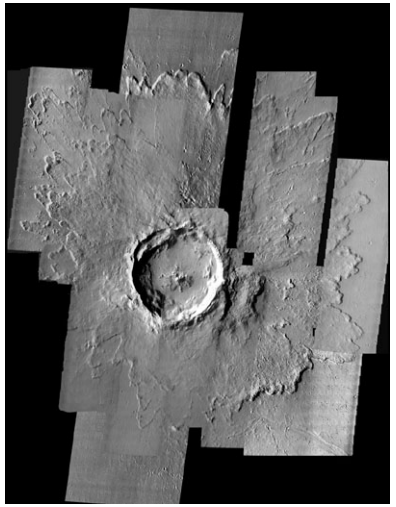
A　B　C　D

Previous Study: young lava flows A-D

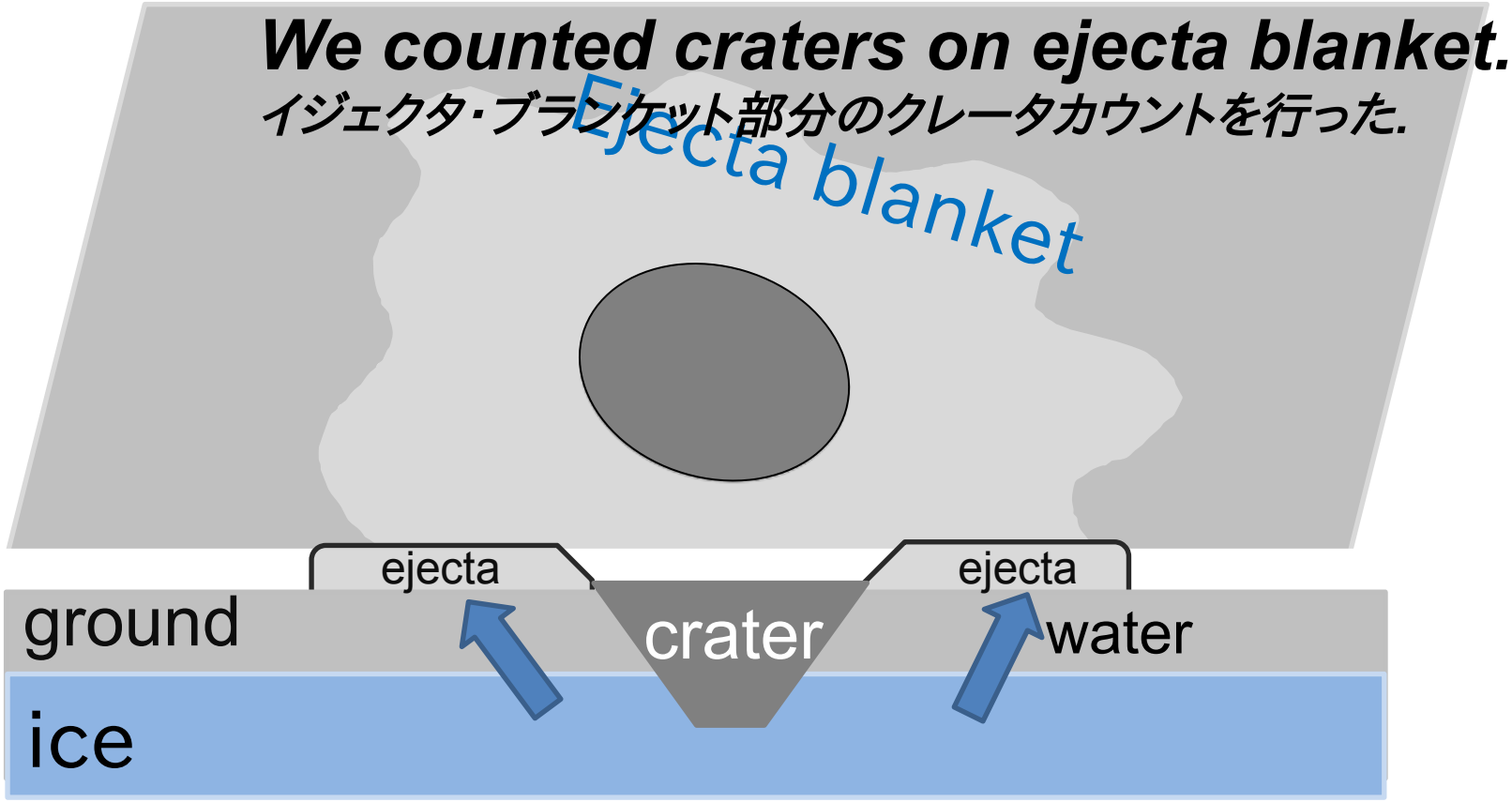
Present Study: rampart craters E-J



Rampart Crater having ejecta blanket
イジェクタ・ブランケットを持つランパート・クレータ



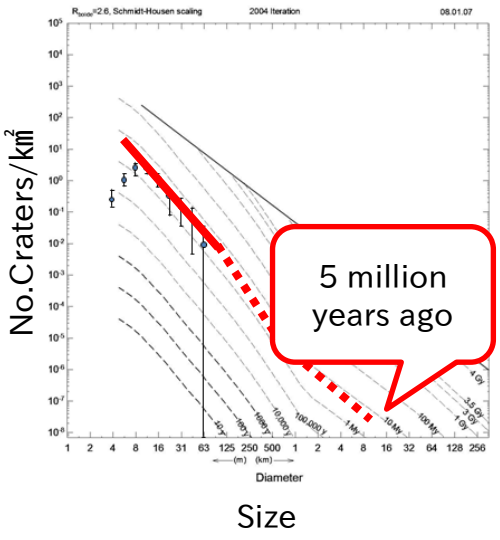
We counted craters on ejecta blanket.
イジェクタ・ブランケット部分のクレータカウントを行った.



⇒Existence of underground ice!

Rampart crater ages ランパート･クレータの年代

E ESP_013089_2040_RED



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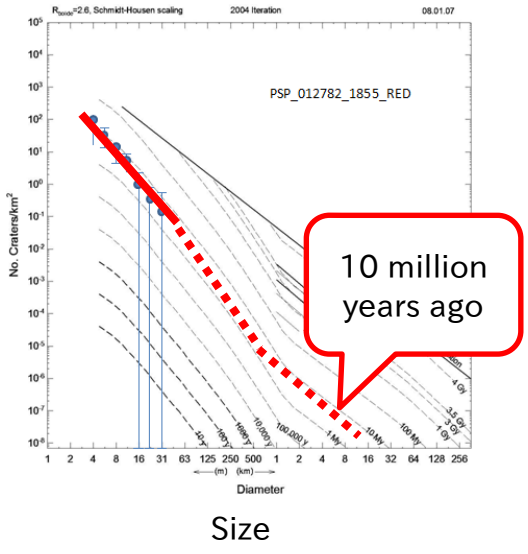
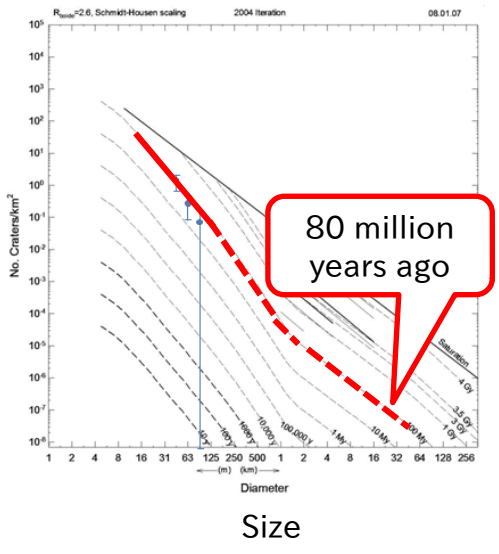
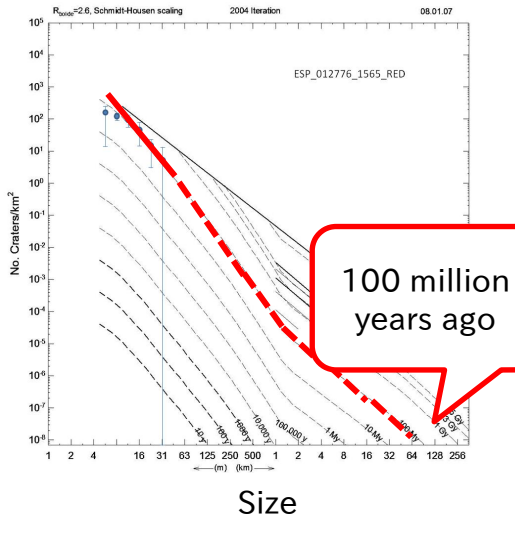


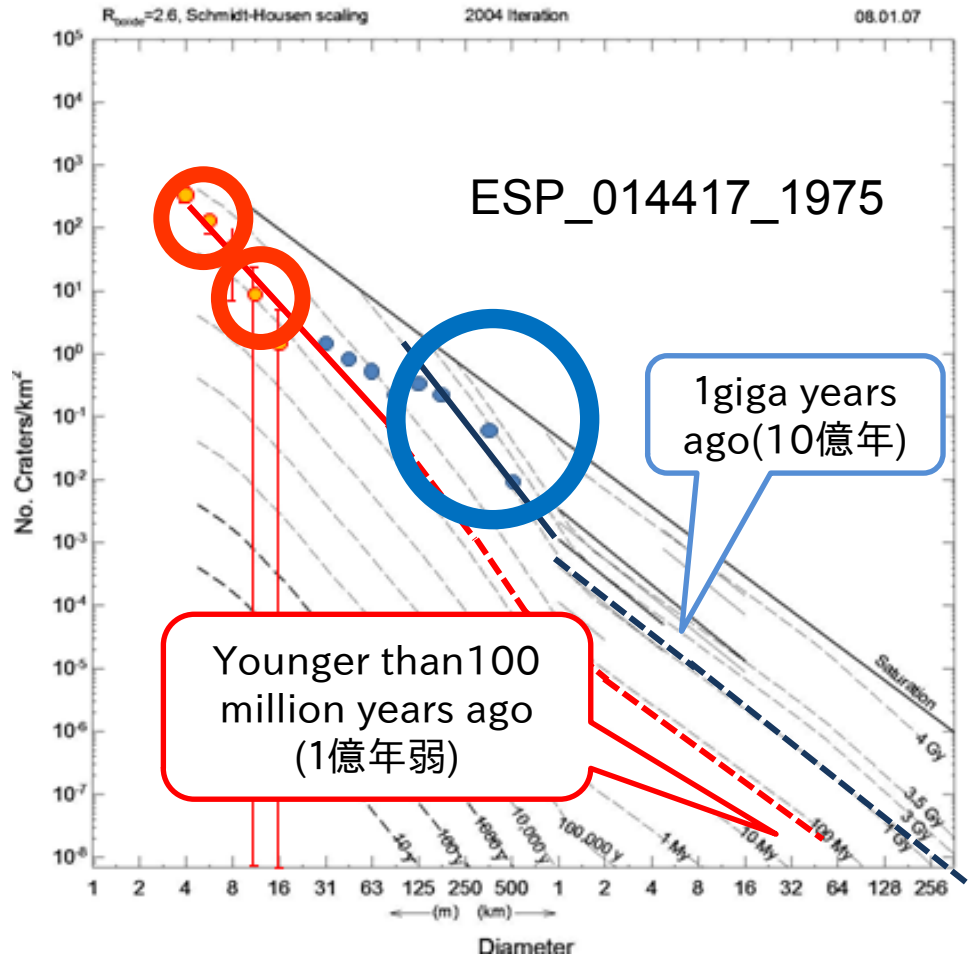
G ESP_001747_2330_RED



H ESP_001776_1565_RED



Interesting results　興味深い結果



- Orange: small craters with sharp edges
  オレンジ色：ふちがくっきりした小クレータ
- Blue: mid to large craters with degraded edges
  青色：ふちがぼんやりした中大クレータ
- **Mysterious isochrones**
  不可思議な等時線！
- Reiss et. al.,(2006) suggest older ages 1.5-3.6 Gyr, conflicting with our resu
  Reissら(2006)は我々の結果と は異なる15-36億年の古い年代を示唆している

Okonomiyaki Hypothesis　お好み焼き仮説

Blu

Discussion 考察

- Estimated ages of young lava flows span **from 50 to 400Myr. -> in good agreement with recent analysis.**
- Ejecta ages of rampart craters obtained from counting of small craters range **from 5Myr to 1Gyr**.
- Counting areas must be chosen less resurfaced or degraded.
- Some rampart craters show **mysterious isochrones** ages.
- Our proposal is one of the solutions.

Conclusions

- Ejecta of rampart craters: some isochrones indicate complicated process of their origin and evolution.
- HiRISE images and **our low-tech exercises** are quite useful for **“Crater chronology” on Mars.**
- Our **“quite simple but painstaking approach”** reveals Mars’ mystery, especially “young lava flows” and unique “rampart craters”.

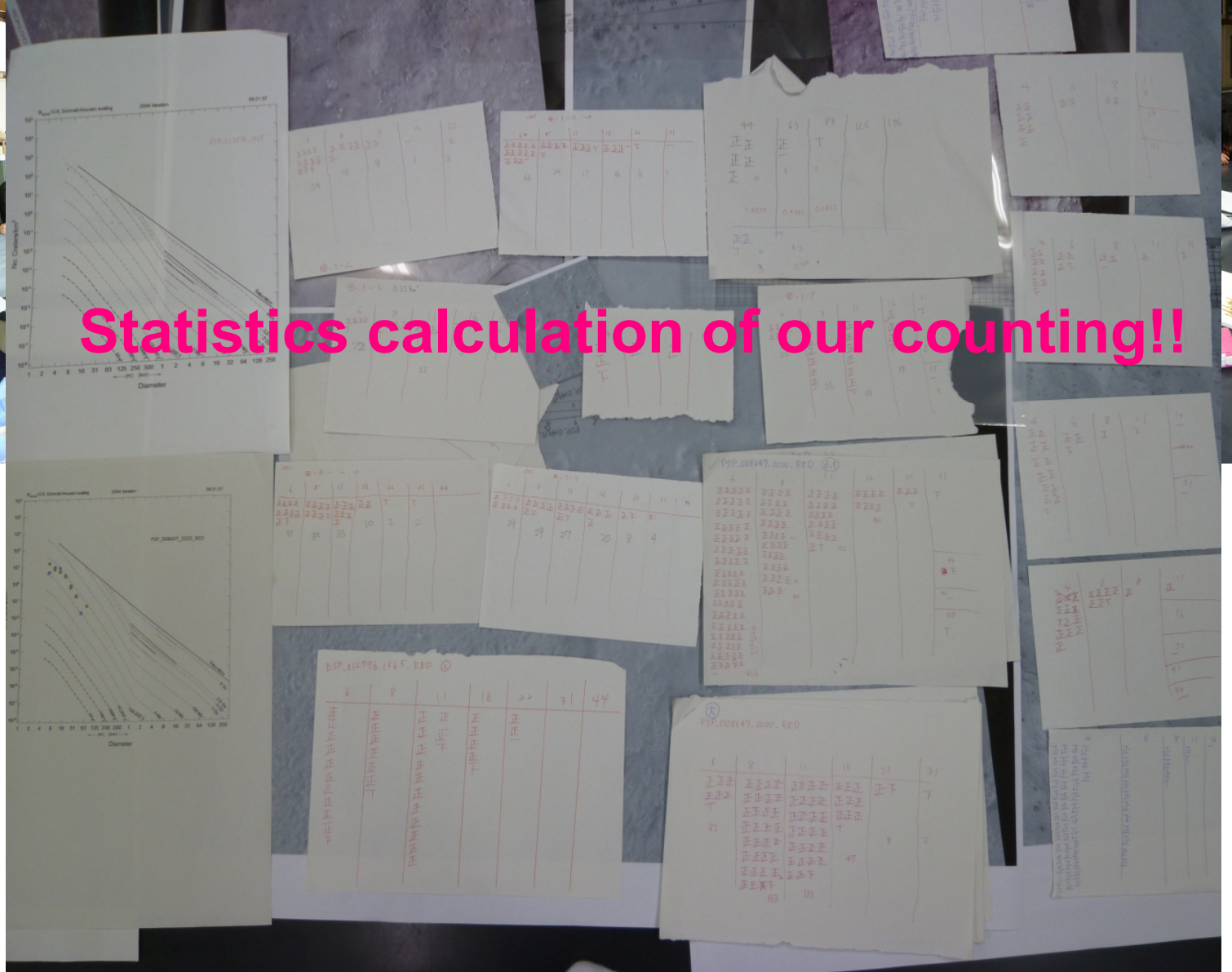
Epilogue

- Mars has not died out

  but still Alive!! Active!!
- Martian water has not dried up

  but remains as ground ice!!
- Our results will be confirmed in 2030's by the future piloted space missions toward Mars!
- We, **"crater boys and girls"**, are looking forward to hear **The Big News confirming our hypothesis!!**

Members of Martian Crater Project



Statistics calculation of our counting!!

Very frustrating!

Finally, Our team got the silver medal at the SSH competition at Kobe in 2011 summer.

Conclusions: as an answer to the first authority's question;

"Why do you treat these projects at high school? Is it not too late after they become university students?"

Policy of Our Projects

- Learn about scientific method through their practices.
- To make tools and data by themselves.
- The methods how to acquisition the real data.
- Trials and errors are main driver.
- Enjoying their process is important.
- Evaluation or discussion methods are testing in situ.
- Learn how to facilitate is a teacher-side goal too.

Not too much teach or suggest!

Conclusions

- High school science project is **NOT** a mimic of university's.
- No goal, or no duty, and allows to fail or not completed.
- However, of course, we try to complete the project.
- Unique ideas/methods are sourced by fresh HS students.
- **Not too much teach or suggest by teachers.**
- **Super analog/low-tech or primitive method, that I told, are never used or supposed at university.**
- **So, my proposal is to use such methods becomes a new cutting edge of the STEAM projects.**

References and Acknowledgments

- My students who joined our projects, provided us fruitful studies and results.
- This report relies heavily on their efforts.
- Our modeling experiments owe much to the “Kitchen Earth Science Movement” in 1990s Japan.
- Dr. Isao Iizawa (a geoscience teacher of Horikawa HS at Kyoto)’s lecture is very informative.
- Dr.Thanit Pewnim read my article and provide me useful comments. I am much appreciated his kind help.

Not too much teach or suggest!


Thank you very much for your listening!!