

What is Archaeomagnetism?!

MANGA:
HAYANON+
SCIENCE MANGA STUDIO
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NAGOYA UNIVERSITY



Institute for
Space-Earth
Environmental
Research



TRAN SEHA
Transdisciplinary Network Formation



Scientific Committee on Solar-Terrestrial Physics

The Earth is often described as a “giant magnet”. A compass needle points north because of the force known as the Earth’s magnetic field. Over long periods of time, the direction and intensity of this magnetic field slowly change. Archaeomagnetism is the study that uses these changes in the Earth’s magnetic field to determine when artifacts such as pottery, roof tiles, and burnt soil found at archaeological sites were made. Tiny magnetic minerals inside these materials record the direction and intensity of the Earth’s magnetic field at the moment they were fired. By studying this magnetic record, researchers can learn about past human activities as well as changes in the Earth itself. In this comic, let’s take a look into the world of archaeomagnetism together with Mirubo and Mol-chan.

What is Archaeomagnetism?!

Dr. Chie Kato

Assistant professor,
Advanced Asian
Archaeological Research
Center, Kyushu University.

MOL-chan

She's an energetic elementary schooler who loves science—a bit of a show-off, but always full of curiosity!

MIRUBO

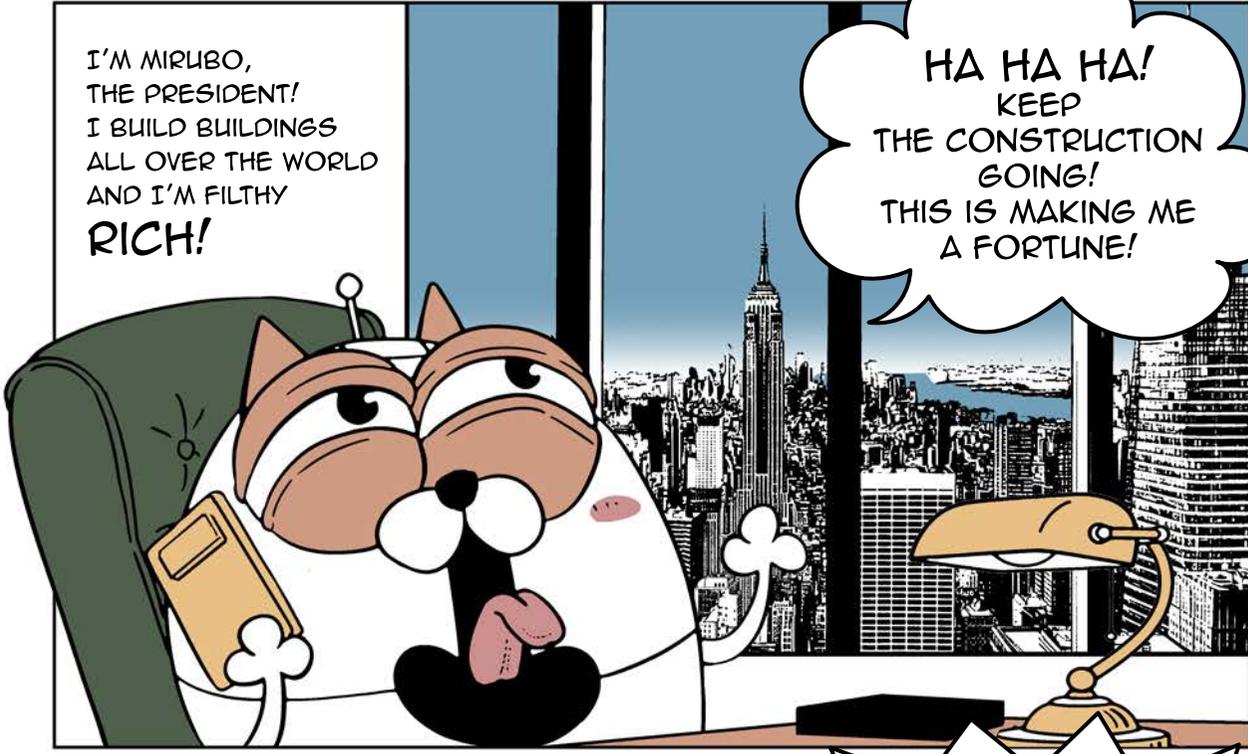
A cutting-edge robot dog!
Totally obsessed with
grilled meat.

Dr. YU KITAHARA

Research Assistant professor,
Advanced Asian Archaeological
Research Center, Kyushu
University.

Dr. TADAIRO HATAKEYAMA

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I'M MIRUBO,
THE PRESIDENT!
I BUILD BUILDINGS
ALL OVER THE WORLD
AND I'M FILTHY
RICH!

HA HA HA!
KEEP
THE CONSTRUCTION
GOING!
THIS IS MAKING ME
A FORTUNE!



PRESIDENT MIRUBO,
WE HAVE A SERIOUS
PROBLEM.

AN ARCHAEOLOGICAL
SITE HAS BEEN FOUND
DURING EXCAVATION.
WE NEED TO STOP
CONSTRUCTION
RIGHT AWAY.



AN
ARCHAEOLOGICAL
SITE?!

WHAT DID YOU
JUST SAY?!
I'LL GO SEE
THE SITE!
MYSELF!



WHAT DO YOU MEAN YOU'RE STOPPING THE CONSTRUCTION?! RESTART IT RIGHT NOW!!!

THIS IS THE REMAINS OF AN OLD KILN THAT PEOPLE USED LONG AGO. PLEASE WAIT UNTIL OUR INVESTIGATION IS FINISHED.

WHAT?! IT JUST LOOKS LIKE ORDINARY GROUND TO ME!!

KILN REMAINS, AND THE POTTERY FOUND THERE, GIVE US IMPORTANT CLUES ABOUT HOW PEOPLE LIVED IN THE PAST.

IT MIGHT EVEN TURN OUT TO BE A HISTORICALLY SIGNIFICANT TREASURE.



WHAT?! A TREASURE?!

A TREASURE, YOU SAY...? I WANT TO HEAR MORE ABOUT THIS!

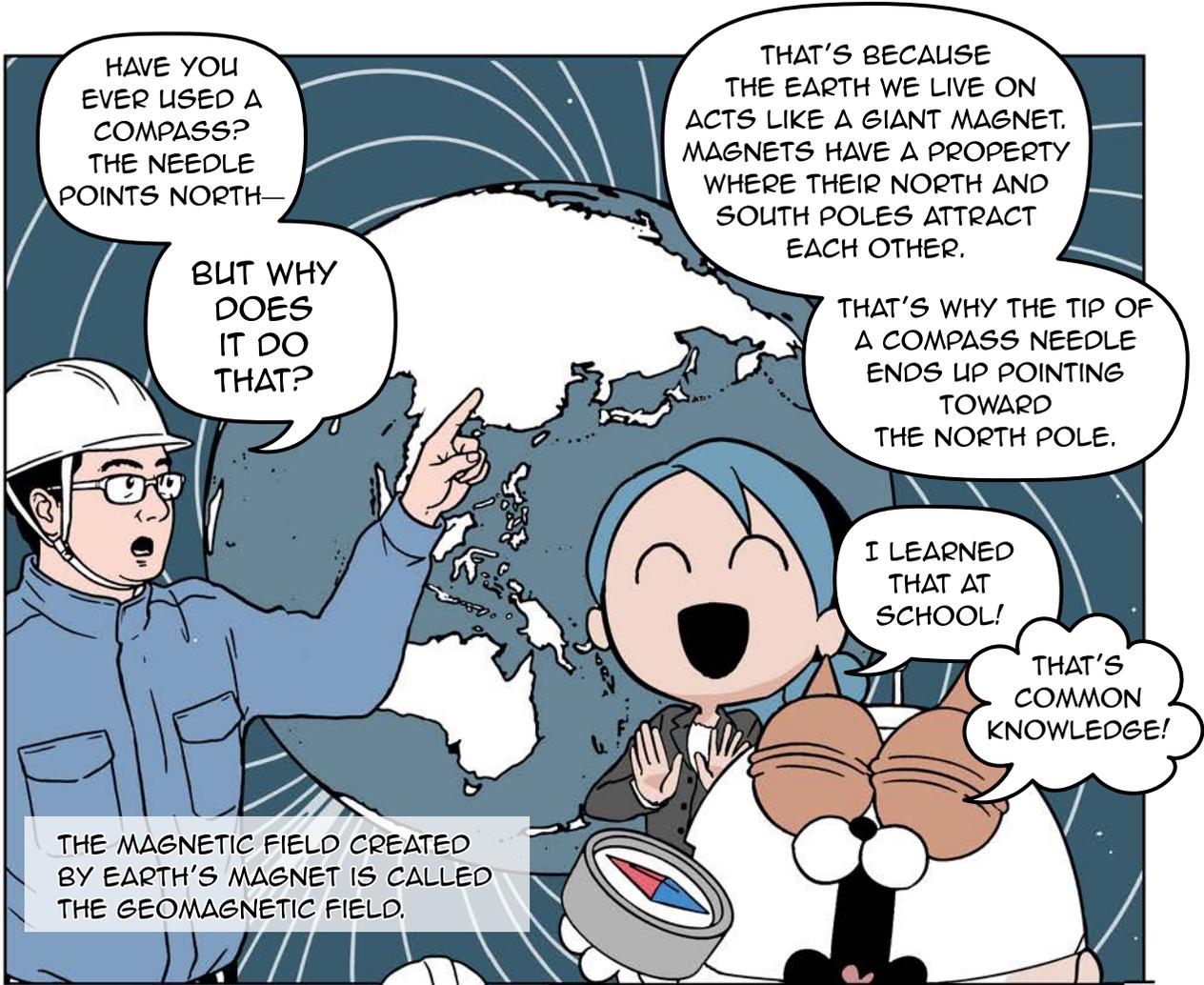
WHAT A SUDDEN CHANGE IN ATTITUDE!



WE ARE RESEARCHERS IN A FIELD CALLED ARCHAEOMAGNETISM, WHICH STUDIES THE MAGNETIC SIGNALS PRESERVED IN KILN REMAINS AND POTTERY.

USING MAGNETISM, WE SEARCH FOR "TREASURES" OF THE PAST.





HAVE YOU EVER USED A COMPASS? THE NEEDLE POINTS NORTH—

BUT WHY DOES IT DO THAT?

THAT'S BECAUSE THE EARTH WE LIVE ON ACTS LIKE A GIANT MAGNET. MAGNETS HAVE A PROPERTY WHERE THEIR NORTH AND SOUTH POLES ATTRACT EACH OTHER.

THAT'S WHY THE TIP OF A COMPASS NEEDLE ENDS UP POINTING TOWARD THE NORTH POLE.

I LEARNED THAT AT SCHOOL!

THAT'S COMMON KNOWLEDGE!

THE MAGNETIC FIELD CREATED BY EARTH'S MAGNET IS CALLED THE GEOMAGNETIC FIELD.



HOWEVER, IN REALITY, A COMPASS DOES NOT POINT EXACTLY TO TRUE NORTH.

WHAT?!



MAGNETIC NORTH DIFFERS FROM TRUE NORTH. AND THIS DIFFERENCE VARIES BY LOCATION.

AND IT ALSO CHANGES OVER TIME.

WHAT?! THE NORTH AND SOUTH THAT A MAGNET POINTS TO CAN ACTUALLY CHANGE?!

HAVE YOU EVER PLAYED WITH A MAGNET AND IRON SAND?

THOSE TINY BLACK GRAINS THAT STICK TO A MAGNET!

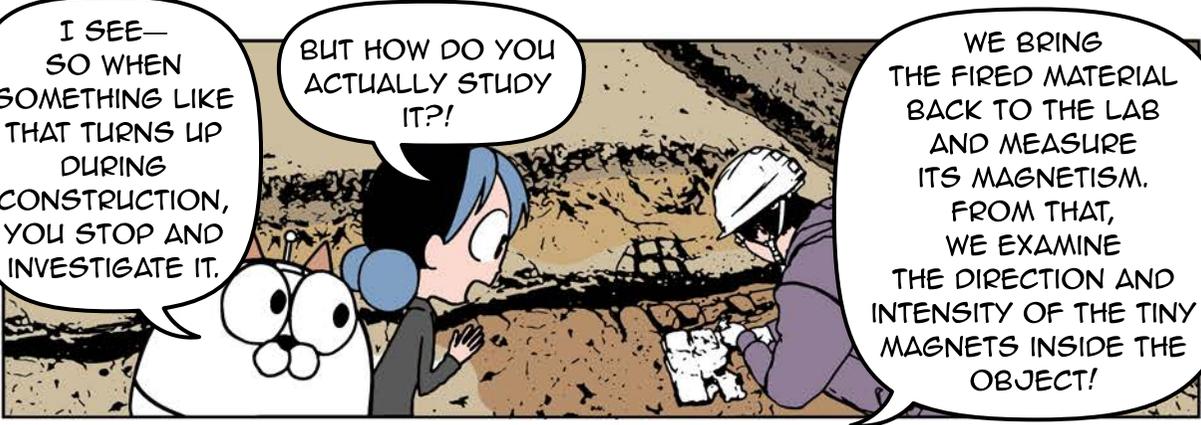
THE POTTERY AND KILN REMAINS WE STUDY HERE— INCLUDING THE BURNT SOIL— ALSO CONTAIN EXTREMELY SMALL PARTICLES, MUCH LIKE IRON SAND.

THESE TINY GRAINS ARE ALSO **MAGNETS.**

A MAGNET POINTS TOWARD **MAGNETIC NORTH!**

SO WHEN POTTERY OR SOIL IS HEATED TO HIGH TEMPERATURES, THE TINY MAGNETIC GRAINS INSIDE RECORD THE EARTH'S MAGNETIC FIELD AT THAT TIME— ITS DIRECTION AND ITS INTENSITY!

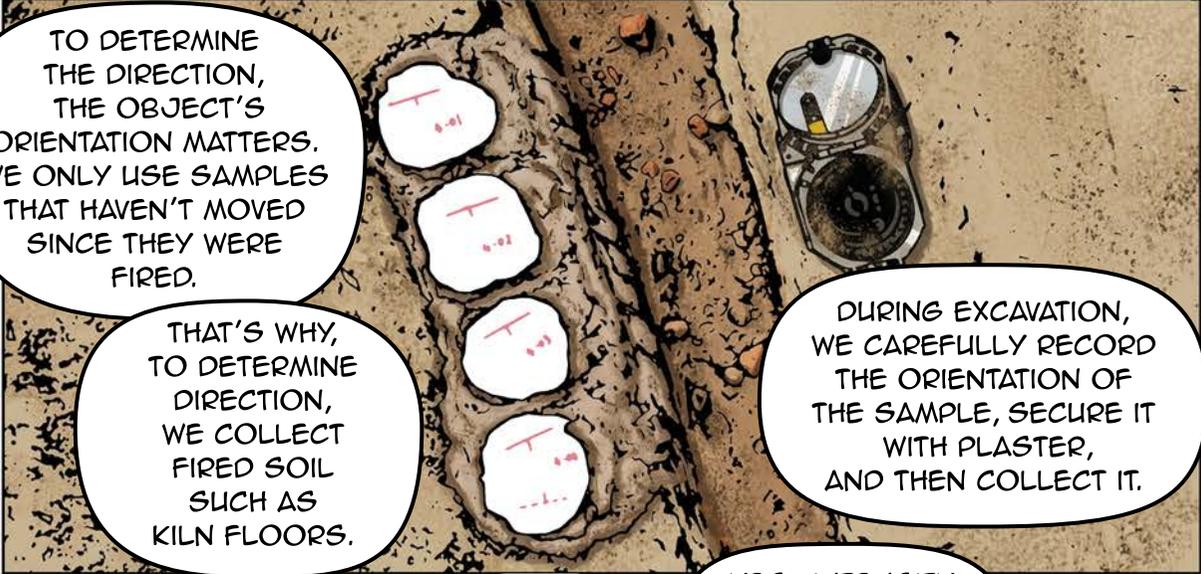
BY ANALYZING THIS MAGNETIC RECORD IN DETAIL, WE CAN ESTIMATE WHEN THE POTTERY OR KILN WAS FIRED.



I SEE—
SO WHEN
SOMETHING LIKE
THAT TURNS UP
DURING
CONSTRUCTION,
YOU STOP AND
INVESTIGATE IT.

BUT HOW DO YOU
ACTUALLY STUDY
IT?!

WE BRING
THE FIRED MATERIAL
BACK TO THE LAB
AND MEASURE
ITS MAGNETISM.
FROM THAT,
WE EXAMINE
THE DIRECTION AND
INTENSITY OF THE TINY
MAGNETS INSIDE THE
OBJECT!



TO DETERMINE
THE DIRECTION,
THE OBJECT'S
ORIENTATION MATTERS.
WE ONLY USE SAMPLES
THAT HAVEN'T MOVED
SINCE THEY WERE
FIRED.

THAT'S WHY,
TO DETERMINE
DIRECTION,
WE COLLECT
FIRED SOIL
SUCH AS
KILN FLOORS.

DURING EXCAVATION,
WE CAREFULLY RECORD
THE ORIENTATION OF
THE SAMPLE, SECURE IT
WITH PLASTER,
AND THEN COLLECT IT.



CAN YOU STUDY
POTTERY TOO?

YES—INTENSITY
CAN BE MEASURED
EVEN FROM
POTTERY
FRAGMENTS.

INTENSITY
DOESN'T DEPEND ON
ORIENTATION,
SO EVEN MOVED OBJECTS
CAN BE USED.



OH, I GET IT!
YOU STOPPED
THE CONSTRUCTION
TO INVESTIGATE
ON SITE
SO YOU COULD
FIND OUT THE
DIRECTION!

EXACTLY.

AT CONSTRUCTION
SITES,
IT'S DIFFICULT TO STOP
WORK FOR LONG,
SO WE HAVE TO CARRY
OUT THE INVESTIGATION
QUICKLY.

ONCE WE COLLECT THE SAMPLES AND BRING THEM BACK TO THE LABORATORY, WE USE MAGNETOMETERS TO MEASURE THEIR MAGNETIZATION.

MAGNETIZATION IS A MATERIAL'S MAGNETIC "DIRECTION" AND "INTENSITY".



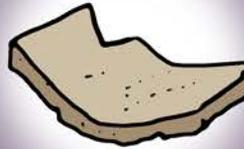
VOLCANIC ROCKS.

SEDIMENTS OR SINGLE MINERAL CRYSTALS.

IF THE MAGNETIZATION IS STRONG, WE USE A SPINNER MAGNETOMETER.

IF THE MAGNETIZATION IS EXTREMELY WEAK, WE USE A SUPERCONDUCTING MAGNETOMETER, ALSO KNOWN AS A SQUID MAGNETOMETER.

HOWEVER, TO STUDY THE ANCIENT EARTH'S MAGNETIC FIELD—ITS DIRECTION AND INTENSITY—WE CANNOT SIMPLY MEASURE THE MAGNETIZATION AS IT IS.



THAT'S BECAUSE THE SAMPLE MAY HAVE GAINED ITS ORIGINAL MAGNETIZATION WHEN IT WAS FIRED, AND LATER ACQUIRED ADDITIONAL MAGNETIZATION THROUGH REHEATING OR CHEMICAL CHANGES.

TO REMOVE THESE LATER EFFECTS, WE APPLY A PROCESS CALLED DEMAGNETIZATION, WHICH ACTS AS A KIND OF MAGNETIC CLEANING.



FINALLY, WE COMPARE THE DIRECTION AND INTENSITY OF THE RECOVERED MAGNETIZATION WITH RECORDS OF GEOMAGNETIC VARIATION.

THIS ALLOWS US TO ESTIMATE WHEN THE SAMPLE WAS FIRED.

BY STUDYING MATERIALS THIS WAY, WHAT ELSE CAN WE LEARN?

RESEARCH IN ARCHAEOMAGNETISM REVEALS HOW THE EARTH'S MAGNETIC FIELD HAS CHANGED OVER TIME— WHEN IT CHANGED, IN WHICH DIRECTION, AND BY HOW MUCH.

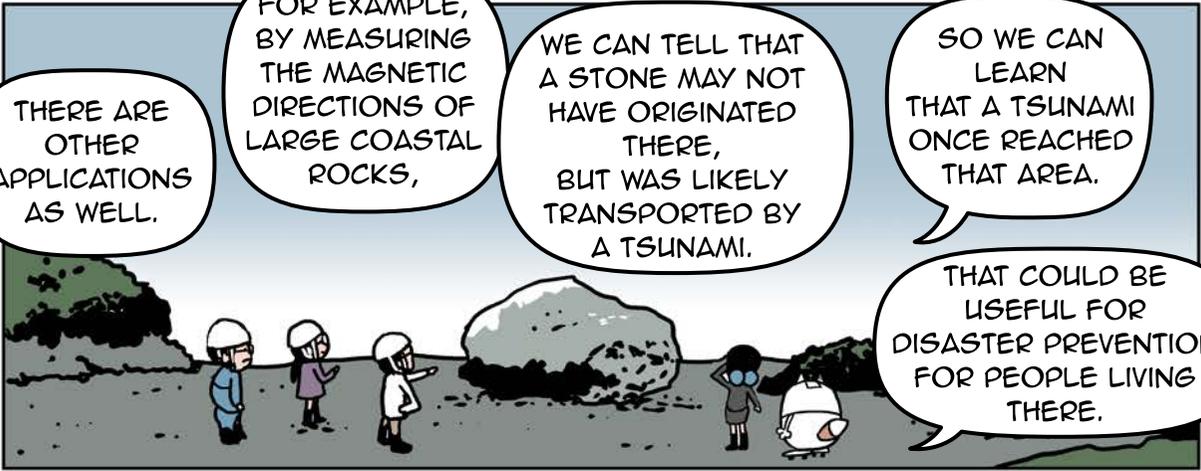
BY STUDYING ROCKS AND SEDIMENTS,

WE CAN TRACE GEOMAGNETIC CHANGES FURTHER BACK IN TIME DEEPENING OUR UNDERSTANDING OF HOW EARTH'S CORE GENERATES THE MAGNETIC FIELD,

AND HOW CONTINENTS HAVE MOVED OVER LONG PERIODS OF TIME.

IN ADDITION, BY STUDYING THE MAGNETIC SIGNALS RECORDED IN LAYERS OF ROCK AND SEDIMENTS, WE CAN OBTAIN CLUES ABOUT WHEN THOSE LAYERS WERE FORMED.

SO IT'S NOT JUST ABOUT ARCHAEOLOGY— IT HELPS US UNDERSTAND THE EARTH ITSELF!



THERE ARE OTHER APPLICATIONS AS WELL.

FOR EXAMPLE, BY MEASURING THE MAGNETIC DIRECTIONS OF LARGE COASTAL ROCKS,

WE CAN TELL THAT A STONE MAY NOT HAVE ORIGINATED THERE, BUT WAS LIKELY TRANSPORTED BY A TSUNAMI.

SO WE CAN LEARN THAT A TSUNAMI ONCE REACHED THAT AREA.

THAT COULD BE USEFUL FOR DISASTER PREVENTION FOR PEOPLE LIVING THERE.



IN ADDITION, BY STUDYING THE BRICKS OR STONE MATERIALS OF HISTORICAL BUILDINGS, WE CAN SOMETIMES DETERMINE THAT THEY WERE REBUILT OR REPAIRED IN THE PAST.

HUMAN HISTORY AND CHANGES IN NATURE...

THE EARTH'S MAGNETIC FIELD GIVES US CLUES TO UNDERSTANDING MANY THINGS.

THAT WOULD BE HELPFUL FOR ARCHAEOLOGISTS STUDYING WHAT MAY HAVE HAPPENED AT A PARTICULAR TIME.

BESIDES
ARCHAEOMAGNETIC DATING,
RADIOCARBON DATING
(CARBON-14 DATING)
IS ALSO COMMONLY
USED TO DETERMINE
A SAMPLE'S AGE.

RADIOCARBON DATING
IS A METHOD
THAT DETERMINES AGE BY USING
THE FACT THAT CARBON-14, WHICH
LIVING ORGANISMS SUCH AS WOOD,
CHARCOAL, BONES, AND SHELLS
TAKE IN WHILE THEY ARE ALIVE,
GRADUALLY DECREASES
AFTER DEATH.

YOU CAN READ
A COMIC CALLED
"WHAT IS
CARBON-14?!"
CHECK IT OUT!



Dr. MASAYO MINAMI
Professor,
Office for the Promotion of Transdisciplinary
Network / Division for Chronological Research,
ISEE, Nagoya University.

ARCHAEOMAGNETIC
DATING ESTIMATES AGE
BY ANALYZING
THE DIRECTION AND
INTENSITY
OF MAGNETIZATION
RECORDED IN FIRED
MATERIALS
SUCH AS KILNS AND
POTTERY,
AS WELL AS
ROCKS.

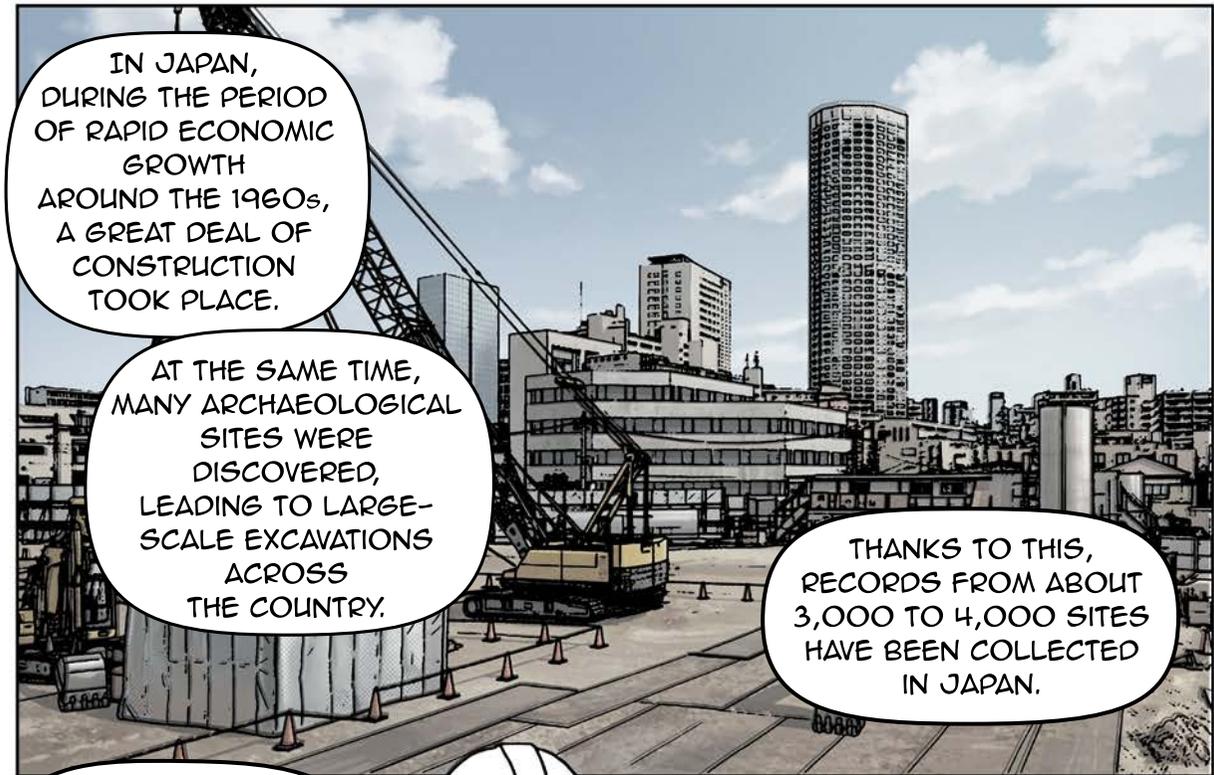
DOES THE MATERIAL
CONTAIN CARBON?
OR DOES IT
CARRY MAGNETIC
INFORMATION?

IF ONE METHOD
DOESN'T WORK,
WE USE THE OTHER.
BY COMPLEMENTING
EACH OTHER,
THESE METHODS
HELP US DETERMINE
MORE
RELIABLE AGES.

THIS WAY,
WE CAN TEST
WHETHER ARCHAEOLOGICAL
HYPOTHESES AND EVEN
HISTORICAL ACCOUNTS
FOUND IN ANCIENT
DOCUMENTS
ARE ACTUALLY TRUE.

WRITTEN RECORDS
AND
DATING OBJECTS,
HUH...!

PEOPLE
INVESTIGATE
THE PAST
IN MANY
DIFFERENT
WAYS.



IN JAPAN, DURING THE PERIOD OF RAPID ECONOMIC GROWTH AROUND THE 1960s, A GREAT DEAL OF CONSTRUCTION TOOK PLACE.

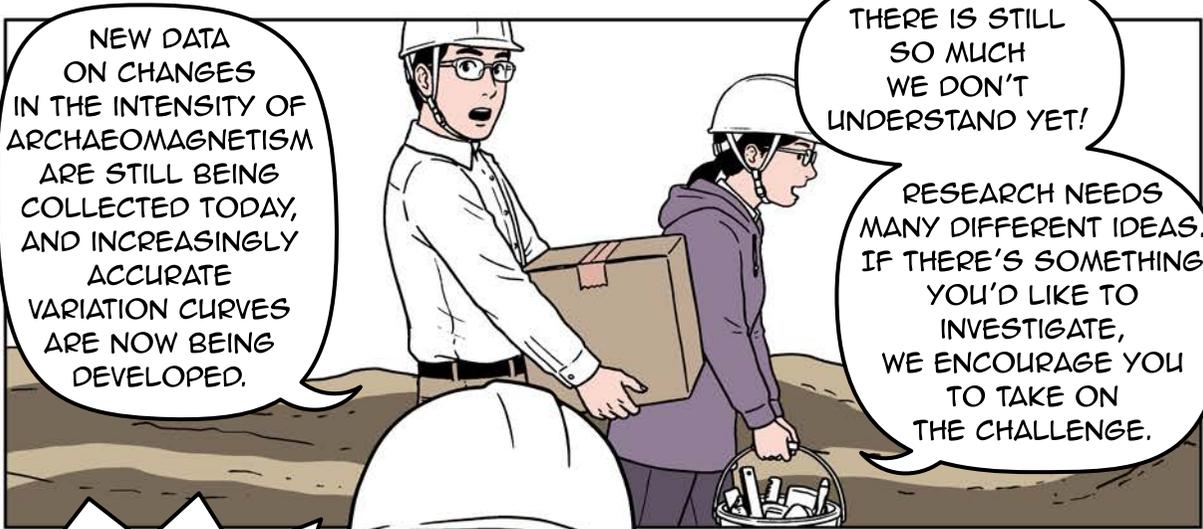
AT THE SAME TIME, MANY ARCHAEOLOGICAL SITES WERE DISCOVERED, LEADING TO LARGE-SCALE EXCAVATIONS ACROSS THE COUNTRY.

THANKS TO THIS, RECORDS FROM ABOUT 3,000 TO 4,000 SITES HAVE BEEN COLLECTED IN JAPAN.



WE'RE ORGANIZING THESE RESULTS INTO A DATABASE THAT CAN BE USED BY RESEARCHERS IN ARCHAEOLOGY AND EARTH SCIENCE, AND WE'RE MAKING IT PUBLICLY AVAILABLE.

WHAT RESEARCHERS DISCOVER IS SHARED LIKE THIS, SO THAT EVERYONE CAN USE IT.



NEW DATA ON CHANGES IN THE INTENSITY OF ARCHAEOMAGNETISM ARE STILL BEING COLLECTED TODAY, AND INCREASINGLY ACCURATE VARIATION CURVES ARE NOW BEING DEVELOPED.

THERE IS STILL SO MUCH WE DON'T UNDERSTAND YET!

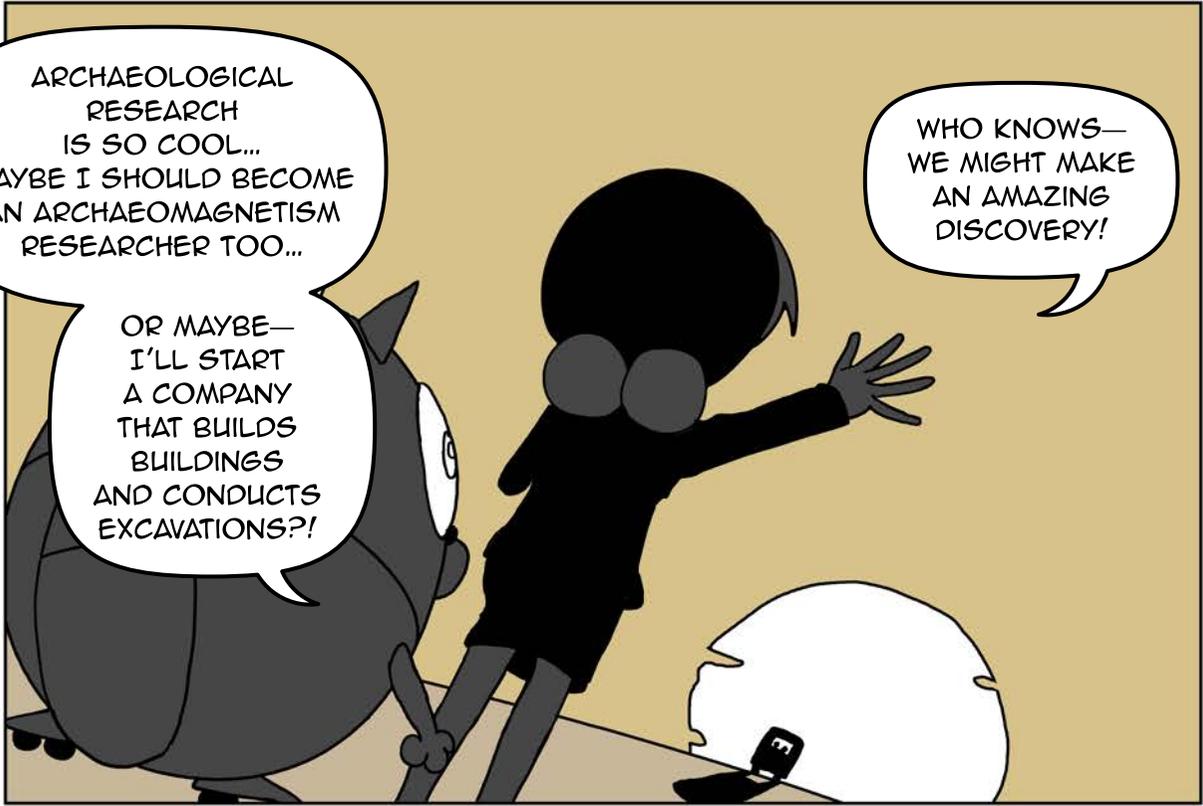
RESEARCH NEEDS MANY DIFFERENT IDEAS. IF THERE'S SOMETHING YOU'D LIKE TO INVESTIGATE, WE ENCOURAGE YOU TO TAKE ON THE CHALLENGE.



ALL RIGHT—SAMPLE COLLECTION COMPLETE!!



LET'S HEAD BACK TO THE LAB AND START THE MEASUREMENTS!



ARCHAEOLOGICAL RESEARCH IS SO COOL... MAYBE I SHOULD BECOME AN ARCHAEOMAGNETISM RESEARCHER TOO...

WHO KNOWS—WE MIGHT MAKE AN AMAZING DISCOVERY!

OR MAYBE—I'LL START A COMPANY THAT BUILDS BUILDINGS AND CONDUCTS EXCAVATIONS?!

What is Archaeomagnetism?!



So archaeomagnetism can tell us when something was made—like its age?



Yeah, you use it for dating things. Got it. I totally get it now!



Dating is just one of the entry points. Archaeomagnetism can also help us infer what actually happened at a site.



Burnt soil and clay products record the Earth's magnetic field at the moment they were heated. Now, what do you think happens if there's another major fire later on?



Wait—So you can tell whether it was fired just once—or fired a second time later?!



Exactly. And that means we can test whether famous historical fires or battles really happened the way they're described.

For example, Sakamoto Castle, built in the late 16th century in Japan, associated with the warlord Akechi Mitsuhide, is said to have been destroyed by a great fire when it fell. But was it really?

When researchers examined roof tiles from the site, they found that the magnetization had changed at around 400 degrees Celsius.



400 degrees, that wouldn't happen under normal conditions. It strongly suggests an intentional, human-caused fire.



So archaeomagnetism can actually check whether historical accounts are true.



That's amazing! What else can it tell us?



Apparently, it can even help answer the question: When did magnets arrive in Japan?



Really? How does that work? I want to know!



We know from eighth-century documents that magnets existed in Japan by the Nara period. But before that, written records are unclear. So instead of texts, we looked at the orientation of buildings.



Wait—how can you tell that from the Earth's magnetic field?!



Yes. The layout of temple complexes changes subtly over time. When we compare their orientations with the geomagnetic declination of each period, some seventh-century temples appear to reflect the magnetic field of their time.



If those orientations were chosen deliberately, it suggests that people already had knowledge of magnetic direction—possibly using magnets.



Even without old documents, the Earth's magnetic field can tell us the truth.
—If words can't answer it, ask the ground—
Natural science is so cool!



Exactly. And when we combine methods—like radiocarbon dating and archaeomagnetism—we start to see a much clearer picture of the past.



Archaeomagnetism sounds fascinating. Do you think I could become a researcher too?

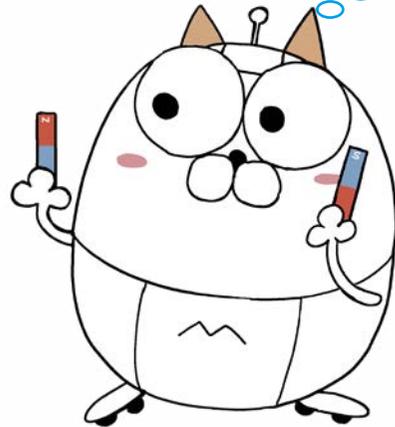


Absolutely. In fact, there aren't many archaeomagnetism researchers. In Japan, only about five or six core research groups are active. Which means many mysteries still remain unresolved.



Heh heh heh... Exactly. Archaeomagnetism is far from a "finished" science. It's a field where new researchers will keep asking new questions—and making new discoveries.

Magnets are something we see all the time, but we didn't know they could help us learn about the past! Now we really want to know more, so maybe we'll try reading a book about the Earth's magnetic field!





NAGOYA UNIVERSITY



Institute for Space–Earth Environmental Research (ISEE), Nagoya University



The Institute for Space–Earth Environmental Research (ISEE), Nagoya University, studies the Earth, the Sun, and space as an integrated system, promoting interdisciplinary research that bridges space science and Earth science through international collaboration.

<https://www.isee.nagoya-u.ac.jp/>



MEXT Promotion of Development of a Joint Usage/Research System Project: Coalition of Universities for Research Excellence Program (CURE)

Transdisciplinary Network linking Space–Earth Environmental Science, History, and Archaeology (TranSEHA)

In September 2024, ISEE launched the Transdisciplinary Network linking Space–Earth Environmental Science, History, and Archaeology (TranSEHA) program in collaboration with five partner institutions: the National Museum of Japanese History; the Center for Accelerator Mass Spectrometry, Yamagata University; the Advanced Asian Archaeological Research Center, Kyushu University; the Joint Support-Center for Data Science Research; and the Center for Digital Humanities and Social Sciences, Nagoya University. Centered on four research groups—archaeomagnetic research group, cataclysmic disasters and dating group, solar–terrestrial environmental history group, and interdisciplinary database research and development group—the program aims to establish a new transdisciplinary network integrating space–Earth environmental science, history, and archaeology.

<https://transeha.isee.nagoya-u.ac.jp/en>

Research Institute of Frontier Science and Technology, Okayama University of Science

By integrating theory and technology, this institute advances cross-disciplinary research to explore new scientific frontiers, aiming to create academic and societal value through research and international collaboration.

<https://ifst.ous.ac.jp/>

Advanced Asian Archaeological Research Center, Kyushu University.

A research center that leverages Kyushu University's archaeological materials as academic resources, serving as an international interdisciplinary hub for the study and utilization of Asian cultural heritage.

<https://isgs.kyushu-u.ac.jp/~qa3rc/>

Japanese Archaeomagnetism Database

A searchable database of archaeomagnetic records accumulated in Japan over the past 50+ years, providing directional and intensity data along with past geomagnetic field variations for research and educational use.

<https://mag.ifst.ous.ac.jp/>



Hayanon

Science manga artist, born in 1975. Graduated from the Department of Physics, Faculty of Science, University of the Ryukyus, with a B.A. (Science). Completed M.A. (Education) in English Education from the Graduate, Graduate School of Education, Chiba University. Her representative works include "GoGo! MIRUBO", "Fantastic R&D", "Lerning Earth Science with MIRUBO" (NASA), and "International Science Olympiad Manga" (Japan Science and Technology Agency). She is a representative of Science Manga Studio Co., Ltd., a PR for research business.

Science Manga Studio, Japan

is a company that produces science communication manga featuring academic research, along with journal cover illustrations, research diagrams, and explanatory visuals. It works across a wide range of disciplines in both the sciences and humanities, and also supports the development of early-career science illustrators through its production work.

Illustrators and Designers in the production

Hayanon, Akiba, Ms.Shell, Hakushi Jaco, Omidu and Ikuto, all from Science Manga Studio Co., Ltd.

What Is...?! Series

This is a research introduction Manga series started in 2002.

You can learn about the study of the Sun and Earth with Sensei, Mirubo, and Mol.



<https://www.isee.nagoya-u.ac.jp/en/outreach.html>

ISEE MIRUBO

SEARCH

PDFs are distributed free of charge. In addition to the English version, Japanese and other language versions are also available.