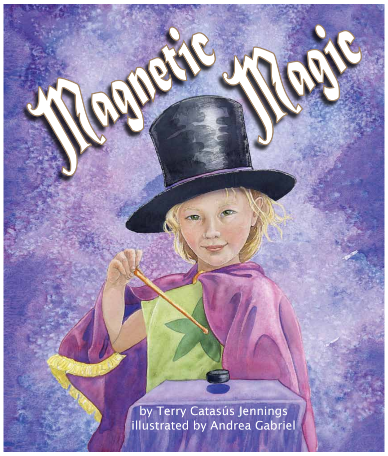
Magnetic Magic

BY TERRY CATASÚS JENNINGS

Discussion and Teacher Guide

ABOUT THE BOOK



Dena loves using magnets to perform magic tricks for the kids at the pool. When Enrique arrives in town, he doesn't like that Dena is fooling the others. He gives her a century-old treasure map and Dena uses her compass and tools to plot the location of the treasure. To her surprise, the treasure is not where it should be! What could cause her compass to lead her off course? When she discovers the answer, will Dena keep fooling the other kids with magic tricks or will she help them learn about magnetism and Earth's shifting magnetic poles?

For core standards to which *Magnetic Magic* is aligned, please visit:

http://www.arbordalepublishing.com/Standards.php

For publisher's teacher guides and activities on magnetism, please visit:

http://arbordalepublishing.com/bookpage.php?id=MagneticMagic

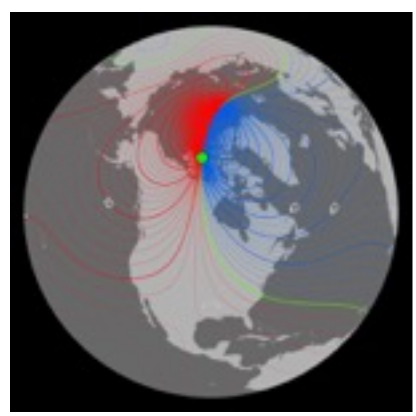
PRE-READING DISCUSSION

Ask students to share what they know about magnetism—how magnets work, for what do we use magnets. Discuss compasses—why we use them, how are they used in navigation. Perhaps students have used compasses for geo-caching. Remind students of the location of the geographic poles of the earth.

DISCUSSION

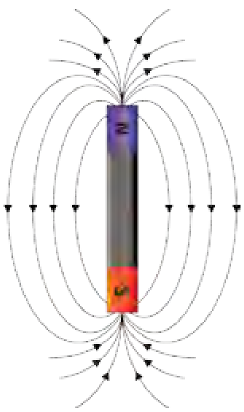
What if you found a hundred-year-old treasure map? Or directions to a geo-cache written fifty years ago?Would you be able to find it? Only if you know the magic number! That number is the declination. It is the difference between true or geographic north, and magnetic north. And it is the number that Dena didn't know in *Magnetic Magic*. That's why she couldn't find the treasure.

Why is that number important? Because the earth's magnetic field changes. It changes slowly, but it changes. The needle of a compass is attracted to magnetic north. So if directions to find a geocache or a treasure were written in 1916, you won't be successful in 2016 unless you know how much magnetic north has moved relative to that area since 1916. Lucky for us, NOAA, the National Atmospheric and Space Administration keeps tabs on the movement of earth's magnetic field. We can use their website to find the value of declination at a specific location at a specific time. Then we can add or subtract that value from the bearings in our directions and *voila!* treasure found.



The map to the right shows the lines of magnetic declination. It shows (in green) the magnetic Equator. In this guide, we will discuss magnetism, it's history and use, declination and its importance, and explore sunspots and the Aurora Borealis. The guide will also explain how the fact that Earth's magnetic field changes help cement the proof for the theories of plate tectonics and continental drift. Links for classroom activities are provided.

WHAT IS MAGNETISM? Magnetism is a force. The ancient people in the town of Magnesia in Asia Minor—now Turkey—found that some rocks attracted and repelled each other, depending on how they faced. The stones also attracted things made of iron. They called these rocks magnets. We now call these rocks lodestones. They are likely formed when a piece of magnetite (a mineral made mostly of iron) is struck by lightning and aligns all the iron particles inside it in the same direction, creating poles. The force these rocks cause, which attracts and repels, is what we call magnetism.

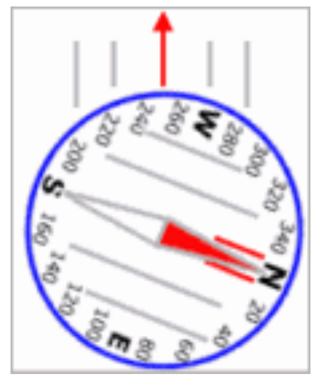


WHAT IS A MAGNET? A magnet is a piece of iron in which all the atoms point in the same direction. All north seeking atoms point one way (North seeking pole or N) and all the south seeking atoms point in the opposite direction (South seeking pole or S). A magnet attracts anything made of iron. And if a piece of iron is attached to a magnet, it also becomes magnetic—it attracts other pieces of iron. The N poles of magnets pull toward—attract—the S pole of other magnets. The N poles of magnets push away—repel—the N poles of other magnets. The S poles of magnets also repel the S poles of other magnets. An easy way to think of this is to say that like poles repel and unlike or opposite poles attract.

MAGNETIC HISTORY In the 1100s, The Chinese discovered that when lodestones or magnets were allowed to float in a bowl of water, the lodestone or magnet would align itself along the earth's north-south axis.

The Chinese began using these needles as compasses in the 11th century.

In the early 1820s, scientists found that currents of electricity also create magnetic fields. Two wires in which the current is flowing in the same direction will repel. Two wires in which the current is flowing in opposite directions will attract. Currents are formed by negatively charged particles and positively charged particles. Negatively charged particles repel each other. Positively particles repel each other. Negatively charged particles and positively charged particles attract each other. Just like in, well, a magnet. An electric current, like lightning, can make magnets. Now we make magnets by passing a piece of iron through an electric field. The electric field aligns all the iron atoms in the same direction.

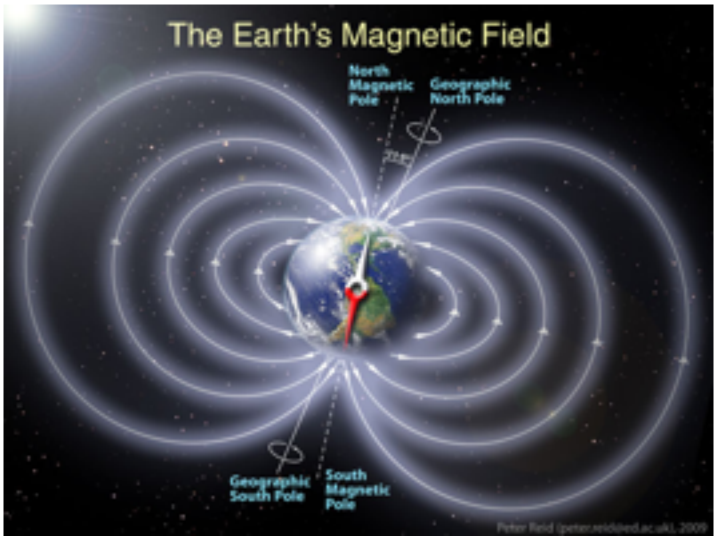


USES OF MAGNETS We use magnetism in compasses to find our way. Imagine the Age of Exploration when Columbus set out across an unknown ocean without a compass. They could use the sun and the stars for navigation, that's true, but what if it was cloudy for days? They would waste precious time and with limited provisions, time was something that could not be wasted.

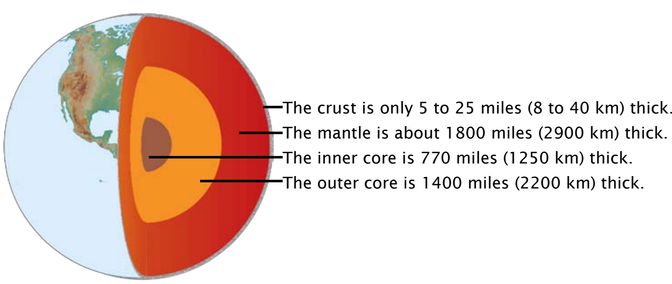
And we're not the only ones who use magnetism to navigate. Birds and whales may use magnetism to orient themselves during migration.

We also use the magnetic property of attraction to lift weights, close doors. Spinning magnets inside wire coils generates electricity—to light homes, to roll up the windows in the car or operate the radio. They make motors run. Magnets are used to search for oil, detecting metal and mines, finding sunken ships under water and for looking inside our bodies. MRI's are *Magnetic* Resonance Imaging.

EARTH IS A MAGNET The earth itself is a magnet, with a north magnetic pole and a south magnetic pole. It has a magnetic field around it. But, as Dena found out in *Magnetic Magic*, the north magnetic pole is not the same as the north geographic pole. The north and south magnetic poles move. The north magnetic pole has been in Antartica before.



Earth's magnetism is created in it's outer core, inside the crust of the earth. The outer core is a liquid ocean of iron with a little bit of nickel and an even smaller amount of an unknown mineral. It surrounds the solid inner core which is made of iron.



The outer core, the orange part in the graphic above, moves like an ocean, but slowly. It churns. The atoms in that ocean move and create an electrical current. That electrical current inside the earth creates its magnetic field. Since the liquid in the outer core moves slowly, the magnetic field moves as well. It's poles move. The rock record shows that the earth's magnetic field has reversed it self many times in the last three billion years. The last time it reversed was 780 years ago.

Earth's magnetic field moves, but it moves slowly, very slowly. See the map to the right, it shows how magnetic north moved from 1905 to 2016.

HOW WE USE MAGNETIC DECLINATION

Magnetic declination has different values at different locations in the same year. It also varies from year to year. The NOAA websites for calculating and viewing magnetic declination are listed in the resource section below. Before setting out on an adventure, hikers and treasure seekers need to check the date of our map and use the NOAA tools to find out the declination.

Sailors use a nemonic to decide whether to add or subtract declination to the bearing on a map:
CMDVT AE - Can Dead Men Vote Twice At Elections (add east)
When correcting from the compass bearing to geographic bearing, add any east variation and subtract west variation.
CADET is another way of remembering: Compass Add East True

Some compass roses on maps show both true/geographic north and magnetic north. And there are compasses that allow you to adjust for magnetic declination. In the picture of the compass in the prior page, there are two red lines. This is the 'shed.' Adjust the face of the compass so that the shed accounts for the declination and place the North seeking needle in the shed.

PLATE TECTONICS AND CONTINENTAL DRIFT

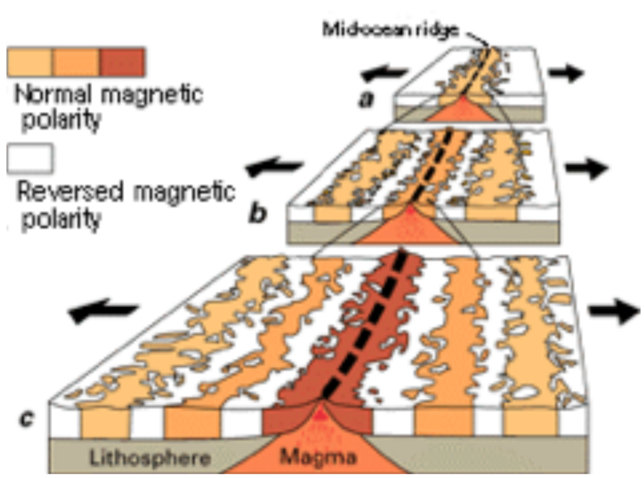
Earth's shifting magnetic poles are evidence for the theories of continental drift and plate tectonics.

A scientist named Alfred Wegener saw that Africa and South America looked like adjoining pieces of the same puzzle. The fossil of an ancient reptile had been found both in Africa and South America, but the reptile couldn't swim. Putting together Europe and North America, the Appalachians and the Caledonide mountains look like one continuous mountain range.

Wegener proposed that the continents of the earth were once together and they had moved apart. Other scientists didn't agree with him.

Later data helped prove Wegener's idea. When lava is deposited by a volcanic eruption, or when igneous rock is formed (cools from magma into rock) the iron particles within the lava or the rock align with the earth's magnetic field at the time the rock cooled. Geologists analyzed lava laid down by eruptions of the same volcano many years apart. They found the orientation of the lava from each eruption to be different. They performed this experiment with many volcanoes and found the same to be true. There are two ways this could have happened—the continent moved, or the magnetic pole moved. At the time these experiments took place, scientists already knew that the pole moved. But the data they found in the lava was not consistent with pole movement being the only reason.

In the 1950s and 60s, paleomagnetologists, scientists who study the behavior of the magnetic field in ancient times, towed magnetometers behind ships along the Atlantic Ocean. They found variations in the magnetic field when the reached the area of the Mid Atlantic Rift. They found that the ocean floor in that area was like zebra stripes. There were stripes with normal polarity (pointing roughly to geographic north) and stripes with reversed polarity. The stripes on each side of the rift, had the same orientation and the rocks in corresponding stripes on both sides were of the same age.



This showed scientists that magma was flowing up through the Mid Atlantic Rift—a place where the plates on the crust of the earth spread away from each other, or diverge. When the magma cooled, it created new crust. This explained the theory of plate tectonics. Now scientists could say that crust was formed by volcanic activity at the divergent boundaries of tectonic plates and it was consumed at the convergent boundaries of plates. The system was in equilibrium. These findings explained not only continental drift and plate tectonics, but with that knowledge, then the data found at subsequent layers of volcanoes was totally consistent and made sense. And it all happened because of that pesky wandering of the earth's magnetic pole.

SUN SPOTS AND THE AURORA BOREALIS

Magnetism in space also affect Earth's magnetic field. Sunspots are areas in the sun where there is an intense magnetic field. The magnetic field creates a cool spot on the surface of the sun by keeping the heat inside the sun from reaching it's surface. This shows up as a dark spot in the sun. Sun spot activity in the sun cycles every 11 years. The intense magnetism of sun spots give off radiation which is so powerful that it can interfere with radio signals.

The Aurora Borealis, spectacular light which can be seen near the north and south pole, clusters around the North and South *magnetic* Poles. They are caused by electrons that crash into Earth's upper atmosphere. The electrons are attracted by Earth's magnetic field to the poles and they release their energy as light—like neon light.

QUESTIONS TO PONDER:

- How would you make your own magnet?
- How would you explain magnetism without using the word magnet?
- Would the Age of Exploration have taken place if there had been no compasses?
- What would you do if you had a theory but other scientists didn't believe it was right?
- How would you perform a magic trick? What's important in fooling your audience?
- Why do you think some animals use magnetism to guide them on migrations?
- Why do scientists not know what the third, mystery, element is in the outer core of the earth?
- Did you know that magnets and magnetism had so many applications?
- Can you think of a use for magnets that we haven't discussed?
- How would you perform a magic show with magnets?

MORE INFORMATION:

From Arbordale Publishers:

For Creative Minds:

http://www.arbordalepublishing.com/ForCreativeMinds/MagneticMagic_FCM.pdf

Teaching Activities Guide:

http://www.arbordalepublishing.com/documents/TeachingActivities/MagneticMagic_TA.pdf

Quizzes:

http://www.arbordalepublishing.com/quize.php?title_id=243&q_type=1;

http://www.arbordalepublishing.com/quize.php?title_id=243&q_type=2

http://www.arbordalepublishing.com/quize.php?title_id=243&q_type=3

Resources:

Magnetic Declination Calculator: **http://www.ngdc.noaa.gov/geomag-web/**

Declination Map Viewer: https://maps.ngdc.noaa.gov/viewers/historical_declination

Author's Website:

http://www.terrycjennings.com/Teacher-Resources-Sounds.html,

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http://maps.ngdc.noaa.gov/viewers/historical_declination/ NAOO National Geophysical Data Center, Historical Magnetic Declination. Used this to determine change in declination from 1905 to 2015 using the map.

http://mta.maryland.gov/sites/default/files/DowntownBaltimoreVisitorsMap.pdf Visitors' Map of Baltimore. Used to determine that 10° on a map.

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“From Continental Drift to Plate Tectonics.” Columbia University. http://www.columbia.edu/~vjd1/devel_pl_tect.htm

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