

2004 Return to *Titanic* Expedition

Looking for Clues

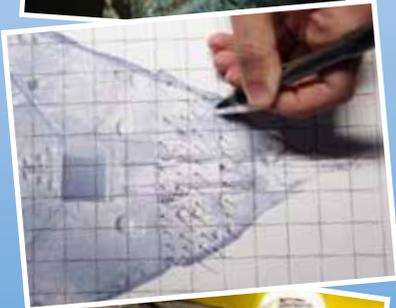


Image captions/credits on Page 2.

lesson plan

Focus

Marine Archaeology of *Titanic*

Grade Level

5-6 (Social Studies)

Focus Question

How can marine archaeologists use historical and archaeological data to draw inferences about shipwrecks?

Learning Objectives

- Students will be able to draw inferences about a shipwreck given information on the location and characteristics of artifacts from the wreck.
- Students will be able to list three processes that contribute to the deterioration of the *Titanic*.

Materials

- Copies of *Inventory of Artifacts Recovered from Three Sites in the Titanic Debris Field*, one copy for each student group
- (Optional; see Learning Procedure, Step 1) One or more copies of *Return to Titanic Mission to Document Wreck's Destruction* by Brian Handwerk (http://news.nationalgeographic.com/news/2004/04/0423_040423_titanicscience.html); and/or *Rusticles Thrive on the Titanic* by Dr. Roy Cullimore (<http://oceanexplorer.noaa.gov/explorations/03titanic/rusticles/rusticles.html>); and/or images of Titanic exterior (<http://oceanexplorer.noaa.gov/gallery/cultural/cultural.html#titanic>)

Audio-Visual Materials

- None

Teaching Time

One 45-minute class periods, plus time for student research

Seating Arrangement

Groups of three to four students

Maximum Number of Students

30

Key Words

Titanic
Debris field
Artifact
Rusticle
Galvanic coupling

Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

At 11:40 pm on April 14, 1912, RMS *Titanic* struck an iceberg off the coast of Newfoundland. Two hours and 40 minutes later, the great liner sank 3,900 meters to the bottom of the North Atlantic Ocean. Thought to be unsinkable, *Titanic* had not survived her maiden voyage. Neither did 1,522 passengers and crew members who also perished on that cold April morning.

In 1985, *Titanic* was seen again by explorers from the Woods Hole Oceanographic Institution and the Institut Français de Recherches pour l'Exploitation des Mers. Using the remotely operated vehicle (ROV) *Argo*, the explorers made dramatic video recordings showing changes brought about by 73 years in the deep ocean. One of the most conspicuous changes is caused by complex communities of bacteria and fungi that produce structures called "rusticles" that superficially resemble icicles or stalactites. Rusticles are built up in ring structures and are highly porous with channels and reservoirs that allow water to flow through. Up to 35% of rusticles' mass consists of iron compounds (iron oxides, iron carbonates, and iron hydroxides). The remainder is biomass of bacteria and fungi. Rusticles grown in laboratories have been found to continuously release a red, powder-like material as well as a yellowish slime. The iron content of these materials is $20 \pm 5\%$ and $8 \pm 3\%$, respectively. These releases total between 0.02% and 0.03% of the rusticles' biomass per day. Based on these observations, it has been estimated that all of the iron in *Titanic*'s bow section could be removed in approximately 280 to 420 years. Experiments are underway at the *Titanic* site to measure the actual rate of iron removal from the ship due to rusticles. Whatever the rate, it is clear that *Titanic* is slowly being recycled back to nature.

Another natural degradation process known as "galvanic exchange" (or "galvanic coupling" or "galvanic corrosion") is also at work on *Titanic*. This process results from different metals in electrical contact with each other in seawater. Metals can be classified into an "Electromotive Series" according to the strength with which they "hold on" to their electrons. Metals lower in the Series tend to give up their electrons

Images from Page 1 top to bottom:

A view of the bow of the RMS *Titanic*. Image copyright Emory Kristof/National Geographic.
http://oceanexplorer.noaa.gov/explorations/04titanic/media/hirez/titanic_bow_hirez.jpg

This mosaic of the *Titanic*'s bow section was originally published in the October 1987 issue of *National Geographic Magazine*. An updated mosaic will be made from images collected by the *Hercules* ROV during this expedition. Image courtesy of Bert Fox © National Geographic Society.

<http://oceanexplorer.noaa.gov/explorations/04titanic/slideshows/june02/slideshow.html#>

Institute for Exploration (IFE) engineer Dave Lavalvo (in red) removes a rusticle experiment station from the *Hercules* "bio box" and hands it to microbiologist Dr. Roy Cullimore, who placed it on the *Titanic*'s bow in 1998 for future rusticle analysis. It was retrieved from the depths on June 2, 2004. Image courtesy of Mike Sweeney © National Geographic Society.

<http://oceanexplorer.noaa.gov/explorations/04titanic/slideshows/june03/slideshow.html#>

A view of the steering motor on the bridge of the *Titanic*. Image copyright Emory Kristof/National Geographic.

http://oceanexplorer.noaa.gov/explorations/04titanic/media/hirez/steering_motor_bridge_hirez.jpg

more readily than metals that are higher in the Series. When two metals with different electromotive strengths are electrically connected and submerged in an electrolyte (such as seawater), electrons will flow from the metal lower in the Electromotive Series, causing this metal to form oxides or other compounds in a process we know as corrosion (this is also the process through which batteries produce an electric current). Besides the iron in its hull, *Titanic* contains many other metals such as lead, bronze, copper, and brass that are higher in the Electromotive Series than iron. As a result, the steel in *Titanic*'s hull is degraded as iron is replaced by other compounds formed through galvanic exchange.

It has been suggested that galvanic exchange was the real reason *Titanic* sank in the first place. Since the ship was held together by 3 million rivets made with wrought iron (which is a different material than the hull plates), galvanic exchange could have taken place between the dissimilar metals of the hull and rivets causing the rivets to weaken. In fact, *Titanic* sat in seawater for a year after her hull was launched while the interior was furnished. One of the last photos taken before the ship's maiden voyage shows a pattern that may suggest the rivets were rusting faster than the hull plates. When *Titanic* collided with the iceberg, the weakened rivets could have popped (which would account for a clinking sound reported by some survivors). An opening just an inch wide between the hull plates would have been enough to sink the ship...and video images of the wreckage show a narrow opening in the unburied part of the bow, as well as preferential corrosion of the rivets in some areas. For more information on this theory, visit <http://www.corrosion-doctors.org/Landmarks/titan-sinking.htm>.

Since the initial discovery in 1985, *Titanic* has been visited by numerous other expeditions, many of which have taken away considerably more than video images. At the end of 2002, an estimated 6,000 artifacts had been removed from the *Titanic* wreck site. These activities have stirred controversy, since the *Titanic* shipwreck is unquestionably a gravesite as well. This fact is underscored by video images of paired shoes (for example, at <http://www.titanic-facts.com/titanic-artifacts.html>) lying on the ocean floor in positions that suggest the shoes have not moved since the person wearing them landed on the bottom.

The mission of the 2004 Ocean Exploration Return to *Titanic* Expedition was to assess changes that occurred at the RMS *Titanic* wreck site since 1985, and to investigate natural degradation processes as well as changes caused by human activity.

In this lesson, students will analyze historical and archaeological data to draw inferences about the remains of *Titanic*.

Learning Procedure

To prepare for this lesson, review *Return to Titanic Mission to Document Wreck's Destruction* by Brian Handwerk (http://news.nationalgeographic.com/news/2004/04/0423_040423_titanicscience.html), *Rusticles Thrive on the Titanic* by Dr. Roy Cullimore (<http://oceanexplorer.noaa.gov/explorations/03titanic/rusticles/rusticles.html>), and images of *Titanic* exterior (<http://oceanexplorer.noaa.gov/gallery/cultural/cultural.html#titanic>); decide which of these you want to use as part of Step 1.

1. Briefly review the history of *Titanic*, its sinking, discovery of the shipwreck in 1985, and human activities at the site following this discovery. Show students one or more images of the ship's exterior, and ask what processes might be responsible for the "alarming and possibly increasing rate of deterioration. You may want to assign one or both of the essays referenced above for student reading and reports. Students should recognize that both natural and human-induced processes may be involved with the ship's deterioration, and may distinguish between galvanic action and "rusting." If you have serious *Titanic* fans in your class, they may also know about rusticles. If not, provide a brief summary, highlighting the fact that this is a biologically-mediated oxidation process, in contrast to the more familiar form of "rusting."
2. Tell students that they are going to assume the role of consulting marine archaeologists investigating the wreck of *Titanic*. Their assignment is to analyze artifacts collected from three sites near the ship, and determine their probable location on the ship before *Titanic* sank. These analyses can be used to focus additional explorations on sites in the debris field that are most likely to contain artifacts from areas of the ship that are of particular interest.
3. Provide each student group with copies of *Inventory of Artifacts Recovered from Three Sites in the Titanic Debris Field*. Note that these are actual entries from the inventory of artifacts collected in 2000 by RMST, Inc with the exception of the initials on the leather briefcase (the briefcase is part of the inventory; the initials are fictitious). Students should first group the artifacts according to the site from which they were recovered.

Next, have students review deck plans of *Titanic* at <http://www.encyclopedia-titanica.org/deckplan/index/> and <http://www.copperas.com/titanic/> (the latter site also has a link to a detailed description of *Titanic* published in the May 26, 1911 issue of the British journal *Engineering*). Students should study the artifacts found at each of the three sites, and develop inferences about the areas on the ship from which these artifacts originated. Have each

student group prepare a short report on their analyses, stating which areas of the ship are represented in each site, and evidence to support their conclusions.

4. Lead a discussion of students' results. Many of the artifacts from Site 00-12 appear to be associated with dining areas, and seem to include a mixture of items from First, Second, and Third Class areas. Examination of deck plans shows that although the First and Second Class dining saloons, galleys, and pantries on C-Deck were separate from the Third Class dining facilities on F-Deck, they were all near the center of the ship. Damage to the hull in this area could reasonably be expected to result in the mixture of artifacts found at this site.

Artifacts from Site 00-23 include items that might have belonged to wealthy passengers as well as items that might have been associated with the ship's navigation (speaking tube, binoculars, etc.). The briefcase with initials "JCS" is a valuable clue, since the location of many First Class passengers' cabins is known. If students search the A-Deck cabins on <http://www.encyclopedia-titanica.org/deckplan/index/>, they will find the cabin assigned to James Clinch Smith near the forward end of the ship on the starboard side. This cabin is relatively close to the wheelhouse on the deck above which was damaged when the foremast collapsed. These observations support the inference that these artifacts originated from this general area.

A great deal of clothing is mingled with mechanical artifacts at Site 00-27. The staircase portion and pieces of reciprocating engine suggest that many artifacts at this site may have originated from areas of the ship beneath the First Class Lounge (A-Deck). A reciprocating engine room was located on the Orlop deck in this area, as well as many Third Class cabins on E-Deck.

Ask students to speculate about why clothing and personal items are scattered throughout all of the collections. Based on their examination of deck plans, students should realize that passenger and crew accommodations were distributed over almost the entire length of the ship on multiple decks. Since the collections probably include artifacts from several decks, some of these artifacts are likely to have originated in accommodation areas.

The BRIDGE Connection

www.vims.edu/bridge/ – In the Navigation toolbar, click on "Ocean Science Topics," then "Human Activities," then "Heritage," then "Archeology". Also, search keyword "*Titanic*" in the "Search" box for more locations on the BRIDGE site dealing with *Titanic* topics.

The “Me” Connection

Have students write a brief essay describing why investigations of wrecks such as that of *Titanic* are (or are not) worth the time, money, and risk involved, and how such investigations might affect their lives personally.

Connections to Other Subjects

English/Language Arts

Assessment

Student analyses and report prepared in Step 3 offer opportunities for assessment.

Extensions

1. Have students visit <http://oceanexplorer.noaa.gov/explorations/04titanic/welcome.html> to find out more about the 2004 Return to *Titanic* Expedition.
2. Have students investigate the controversy surrounding recovery of artifacts from *Titanic*. You may want to have student groups debate both sides of the argument, or write an essay supporting one view or analyzing both views. The Encyclopedia *Titanica* web site is a useful starting point for this activity.
3. Have students investigate one or more persons who were aboard *Titanic* when the ship sank, and prepare a report on their activities on April 14 and 15, 1912.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page’s publication, but the linking sites may become outdated or non-operational over time.

<http://www.corrosion-doctors.org/> – A web site about corrosion causes and solutions, with modules designed for training in corrosion science and engineering

<http://www.encyclopedia-titanica.org/> – Encyclopedia *Titanica* web site with biographies, research articles and ongoing discussions about the *Titanic*

<http://www.titanic-nautical.com/RMS-Titanic.html> – Titanic Web page from the Titanic and Nautical Resource Center

<http://score.rims.k12.ca.us/activity/bubbles/> – Marine archaeology activity guide based on investigations of the wreck of a Spanish

galleon; from the Schools of California Online Resources for Education website

<http://www.titanic1.org/> – *Titanic* Historical Society

<http://www.titanicinquiry.org/> – *Titanic* Inquiry Project

<http://www.skarr.com/titanic/> – The *Titanic* Information Site

<http://www.titanicscience.com/TSci-ActivityGuideFinal.pdf> – Maryland Science Center’s *Titanic* Science Teacher Activity Guide

<http://www.encyclopedia-titanica.org/deckplan/index/> – Deck plans for *Titanic*

also <http://www.copperas.com/titanic/> – Deck plans for *Titanic*, as well as a link to a detailed description of *Titanic* published in the May 26, 1911 issue of the British journal “Engineering”

Archbold, R. and D. McCauley. 1997. *Last Dinner on the Titanic*. Madison Press. Toronto.

Ballard, R. D. with R. Archbold. 1995. *The Discovery of the Titanic*. Warner Books. New York.

Ballard, R. D. 1985. *How we found Titanic*. National Geographic Magazine 168(6):696-719

Ballard, R. D., with M. Sweeney. 2004. *Return to Titanic*. National Geographic. Washington, DC.

Macaulay, D. 1993. *Ship*. Houghton Mifflin Company. Boston.

Lord, W. 1986. *The Night Lives On*. William Morrow and Company, Inc. New York.

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Properties and changes of properties in matter

Send Us Your Feedback

In addition to consultation with expedition scientists, the development of lesson plans and other education products is guided by comments and suggestions from educators and others who use these materials. Please send questions and comments about these materials to:

oceanexeducation@noaa.gov.

For More Information

Paula Keener, Director, Education Programs
NOAA Office of Ocean Exploration and Research
Hollings Marine Laboratory
331 Fort Johnson Road, Charleston SC 29412
843.762.8818
843.762.8737 (fax)
paula.keener-chavis@noaa.gov

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Credit

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Inventory of Artifacts Recovered from Three Sites in the *Titanic* Debris Field

| Item | Material | Site |
|--|------------------------|-------|
| pair of wool socks | textile (wool) | 00-27 |
| pair of wool socks | textile (wool) | 00-27 |
| pair of wool socks | textile (wool) | 00-27 |
| pair of wool socks | textile (wool) | 00-27 |
| pair of wool socks | textile (wool) | 00-27 |
| five linen handkerchiefs | textile (linen) | 00-23 |
| silk necktie | textile (silk) | 00-23 |
| pair of silk socks | textile (silk) | 00-23 |
| cravat | textile (silk) | 00-23 |
| four London omnibus tickets | paper | 00-27 |
| polka dotted handkerchief | textile (silk) | 00-12 |
| red box containing a dropper and a pen | paper, glass, metal | 00-27 |
| red box containing a dropper and a pen | paper, glass, metal | 00-27 |
| two cotton rags | textile (cotton) | 00-12 |
| long john pants | textile (cotton) | 00-12 |
| cambray blue work shirt | textile (cotton) | 00-27 |
| white cotton work shirt | textile (cotton) | 00-27 |
| dress bibb | textile (cotton) | 00-23 |
| white cotton long sleeve work shirt | textile (cotton) | 00-27 |
| white cotton work shirt with red stripes | textile (cotton) | 00-27 |
| man's shirt collar | textile (cotton) | 00-23 |
| man's shirt collar | textile (cotton) | 00-12 |
| man's shirt collar | textile (cotton) | 00-12 |
| three man's shirt collar | textile (cotton) | 00-23 |
| man's shirt cuff | textile (cotton) | 00-23 |
| four leather suspender brace ends | leather | 00-12 |
| silver match box | metal (silver) | 00-23 |
| folding pocket knife | metal (brass), wood | 00-12 |
| eraser | rubber | 00-23 |
| miniature imitation pistol | metal (brass) | 00-23 |
| milk warmer with White Star Line logo | metal (brass, copper) | 00-23 |
| swivel loupe | leather, glass, metal | 00-27 |
| pencil | graphite | 00-12 |
| First Class silver plated tureen | metal (copper, silver) | 00-12 |
| Second Class soup tureen | metal (copper, silver) | 00-12 |
| Second Class blue and white plate | ceramic (earthen ware) | 00-12 |
| sink splash with decanter holder | metal (silver), stone | 00-23 |
| Third Class sink with drain plug | metal (brass), ceramic | 00-27 |
| brown ceramic jug | ceramic (earthen ware) | 00-12 |
| brown ceramic jug | ceramic (earthen ware) | 00-12 |
| screw down window | metal (bronze), glass | 00-23 |
| coal | coal | 00-27 |
| lavatory slate | stone | 00-12 |

Inventory of Artifacts Recovered from Three Sites in the *Titanic* Debris Field - page 2

| Item | Material | Site |
|--|---------------------------|-------|
| oval port hole with glass | metal (brass), glass | 00-12 |
| ventilating port hole | metal (cast iron, bronze) | 00-23 |
| ventilating port hole | metal (cast iron, bronze) | 00-23 |
| leather travel bag | leather, paper | 00-23 |
| dome metal object | metal | 00-12 |
| turnbuckle | metal (brass) | 00-23 |
| table base | metal (cast iron, brass) | 00-12 |
| leather bag | leather, paper | 00-23 |
| deck bench armrest | metal (bronze) | 00-12 |
| deck bench end | metal (cast iron) | 00-12 |
| boiler access plate | metal (bronze) | 00-27 |
| bearing liner | metal (babbet metal) | 00-27 |
| water boiler | metal (brass, copper) | 00-27 |
| large wrench | metal (wrought steel) | 00-27 |
| over port hole frame | metal (brass) | 00-12 |
| bearing liner | metal (babbet metal) | 00-27 |
| watertight shaft | metal (bronze, steel) | 00-27 |
| deck light | metal (brass), glass | 00-23 |
| glass bottle with contents | glass, paper, cork | 00-12 |
| floor tile | textile (linoleum) | 00-12 |
| floor tile | textile (linoleum) | 00-12 |
| door knob with eschutcheon & hardware | metal (brass) | 00-12 |
| floor drain | metal (cast iron) | 00-12 |
| lead crystal bead | glass | 00-12 |
| gong | metal (brass) | 00-12 |
| spigot from folding lavatory tilt sink | metal (brass) | 00-12 |
| toilet | ceramic, metal (iron) | 00-23 |
| window from officers quarters | metal (brass), glass | 00-23 |
| taffeta bag with contents | textile | 00-23 |
| leather satchel with initials "JCS" | leather | 00-23 |
| pair of leather work boots | leather, metal | 00-27 |
| wool jacket | textile (wool) | 00-27 |
| wool vest | textile (wool) | 00-27 |
| wool suit pants with suspenders | textile (wool) | 00-27 |
| white cotton dress shirt | textile (cotton) | 00-23 |
| short sleeve wool smock | textile (wool) | 00-12 |
| man's left shoe | leather | 00-12 |
| gold plated cylindrical tin | metal | 00-23 |
| speaking tube | metal | 00-23 |
| two large ceramic fuse holders | ceramic, metal (copper) | 00-27 |
| large pieces of wood | wood | 00-27 |
| glass dish with White Star Line logo | glass | 00-23 |
| steering wheel stand | metal (bronze, iron) | 00-23 |

Inventory of Artifacts Recovered from Three Sites in the *Titanic* Debris Field - page 3

| Item | Material | Site |
|---|-----------------------|-------------|
| beveled gear with shaft | metal (bronze, steel) | 00-23 |
| crystal candy dish with White Star Line logo | glass | 00-12 |
| Third Class cup with White Star Line logo | ceramic | 00-12 |
| Third Class mug with White Star Line logo | ceramic | 00-12 |
| bronze base for First Class staircase | metal (bronze) | 00-27 |
| wash basin | ceramic | 00-12 |
| mustard bottle | glass, cork | 00-12 |
| First Class demitasse cup | ceramic | 00-12 |
| binoculars | metal, glass | 00-23 |
| Second Glass soap dish | ceramic | 00-27 |
| Third Class soup bowl with White Star Line logo | ceramic | 00-27 |
| cherry toothpaste jar with lid | ceramic | 00-12 |
| three silver plated porrigers | metal | 00-12 |
| spittoon | metal (copper) | 00-12 |
| bath tub hot and cold water fixture | metal (brass) | 00-12 |
| small hot and hold water fixture | metal (brass) | 00-23 |
| three First Class chamber pots | ceramic | 00-23 |