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Scientific Essay

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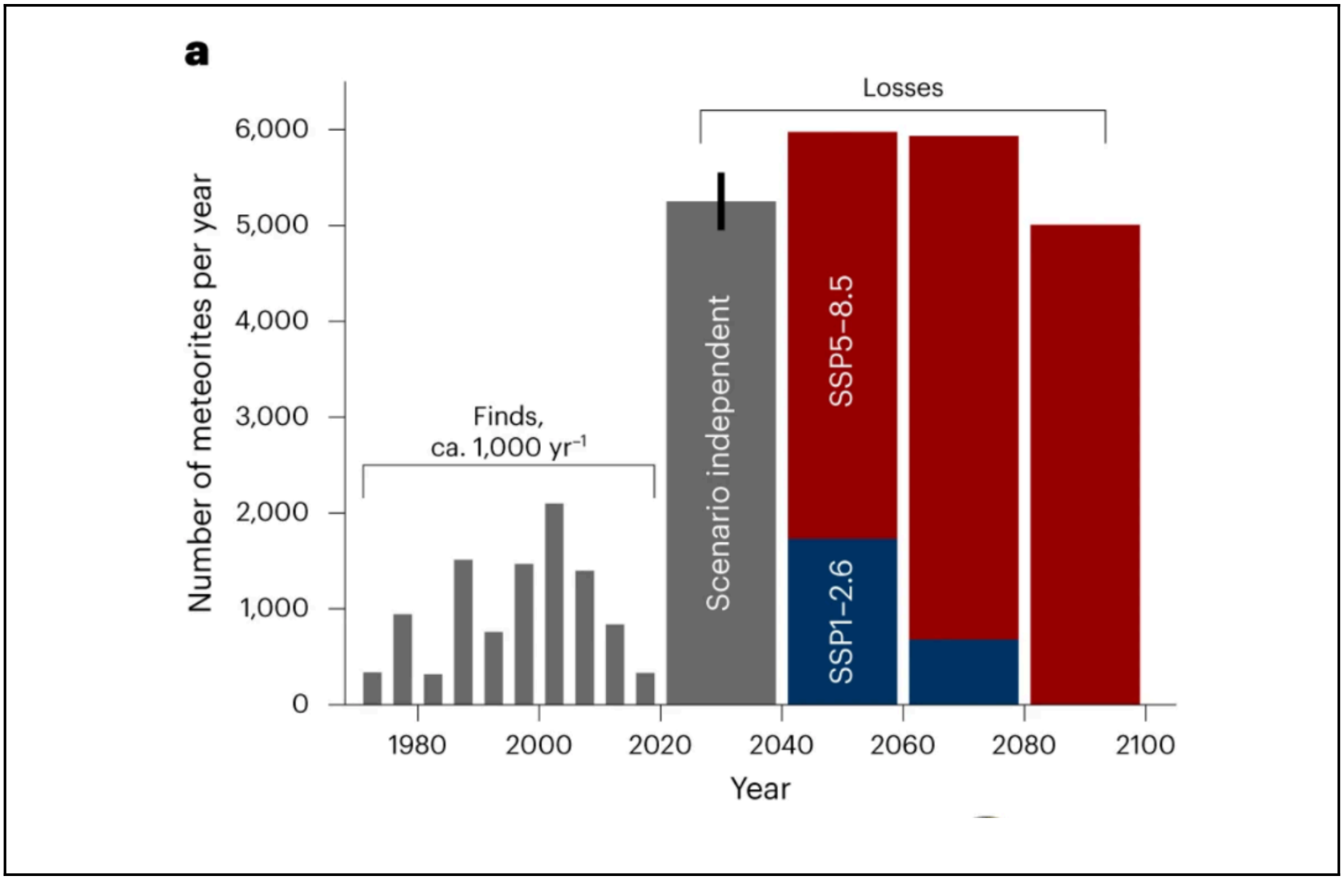
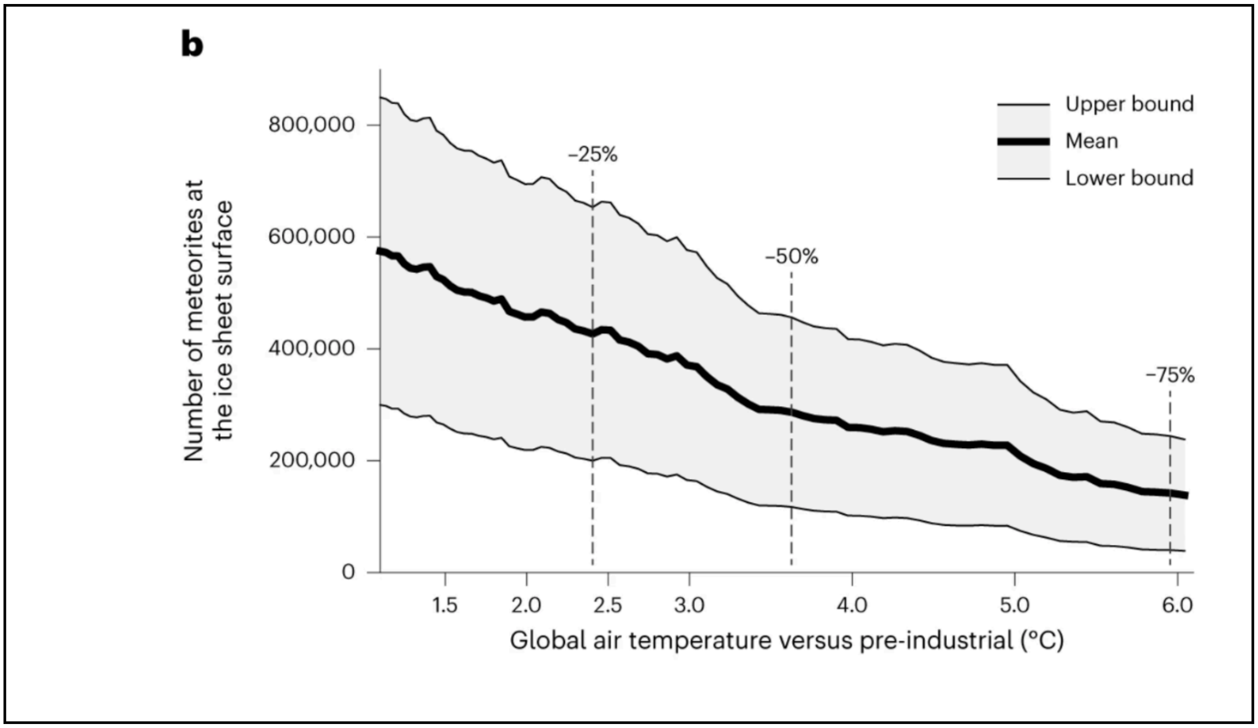
Meteorites have been a significant part of Antarctic exploration since shortly after the time of Roald Amundsen and Captain Scott. Although neither of their expeditions yielded meteorite discoveries, as it wasn't something they were aiming to discover, meteorites became synonymous with the continent in 1912, when a member of Sir Douglas Mawson's voyage discovered the Adelie Land Meteorite (Anderson et al., 2004). In modern times, nearly 60% of all meteors found on Earth have been located in Antarctica; that's close to 50,000 of the nearly 80,000 total meteorites identified (Tollenaar et al., 2024). Although they do exist -and have been found- in other regions of the world, it is clear that a significant portion of meteorites are found in the vast blue ice areas of Antarctica. With this being true, scientists have long traveled to the continent to recover and study meteorite fragments. Much of what we know about these extraterrestrial masses is only possible because of Antarctic research. The characteristics of the landscape and the potential effects of climate change on this landscape, and in turn on the ability to recover meteorites, are of increasing interest as climate change has become a more pressing issue. Determining what makes this region ideal for meteorite collection, as well as how this may be changed as the poles warm, is a crucial part of Antarctic research.

Antarctica is ideal for meteorite detection and collection for a variety of reasons. Although these extraterrestrial rocks have been found in other regions, particularly in flat, arid deserts like the Sahara, Antarctic meteorites tend to be better preserved and easier to spot. As asteroids travel into Earth's atmosphere, they heat up and gain energy, turning into meteorites as they make contact with the Earth (*Hall of Meteorites*). In Antarctica, the meteorites land and absorb solar radiation, warming their dark exterior and causing them to melt the ice beneath them. They then sink into the ice and are quickly covered by newly formed snow and ice above them (Tollenaar et al., 2024). As this process has been occurring for as long as the Earth has existed, ancient meteorites are residing on the planet, many of which are found buried under layers of snow and ice in the Antarctic continent, where they have been preserved and protected against the elements. In other areas where they have been found, such as the Sahara Desert, the rocks have been subjected to erosion by sand and winds as well as discolored by the sun. This is less than ideal, as it chips away and alters parts of these celestial rocks, which impacts what information can be gathered from them; a pristine, unaltered meteorite is preferred for studying. This is not an issue in Antarctica, where they are encased in ice and there is no sand to erode them. Thus, they are kept relatively the same as they are when they land on Earth. Antarctica also lacks the variations in landscape that other regions have, which makes it difficult to find meteorites. Even in deserts like the Sahara, where meteorites have been found, the landscape makes them easily obscured. Dunes, rocks, and other formations can hide the meteorites from view. Additionally, spotting meteorites through feet of sand is significantly more difficult than spotting them through layers of ice, as sand does not offer the same level of transparency as ice does. It is possible and likely that there are meteorites to find in other areas of the world, such as forests, oceans, and jungles, but identifying them would prove extremely difficult as obstructions to view would make it nearly impossible to locate them; finding a meteorite in a forest or ocean is akin to finding a needle in a haystack. Therefore, Antarctica is somewhat of a perfect location for this kind of research. Fallen meteorites are preserved in snow and ice, preventing degradation and erosion, while still allowing them to be easily viewed and recovered. Knowing what we do about climate change and its impact on snow and ice packs, however, the fate of this meteorite utopia is increasingly at risk as temperatures rise.

All regions around the globe have been impacted by climate change, and will continue to be impacted so long as mitigation remains poor. Especially vulnerable areas include coastal and arctic regions, which are predicted to be directly impacted by warming global temperatures that lead to increased ice melt and rises in sea level (Climate Change Impacts). Antarctica is facing these same realities, however. A warming temperature of around 3℃ (5℉) in the summer months has been recorded on the continent, which shrinks ice shelves and causes rising sea levels (Antarctic Ice and Rising Sea Levels). Additionally, the ocean surrounding the continent is warming as a result of carbon dioxide uptake and heat capture, which has severe implications for the health of species that reside in and around the continent. This reality also has an impact on the ability to recover meteorites. As the temperature warms, ice becomes less reliable for year-round cover, which means that meteorites can sink further into the ice and become unrecoverable. An estimated 5,000 meteorites are expected to be lost per year as the ice sheet warms and melts. This is reflected in the two graphs below (Tollenaar et al., 2024). In graph a, the estimated meteorite losses per year are displayed, beginning in 2020 and extending out to 2100, as compared to meteorites found between 1980 and 2020. The losses are considered for three different climate change plans; the grey bar represents losses when no action is taken, the blue bars represent low emission scenarios, and the red bars represent high emission scenarios. The graph shows a shift from recovering a maximum of 2,000 meteorites per year to losing up to 6,000 if high emission behavior continues. This has serious and lasting consequences for the ability of continued meteoritics, or the study of meteorites. Graph b displays this loss as the relationship between the rise in temperature and the number of meteorites accessible on the ice sheet surface. It shows up to a 75% decrease in meteorites accessible on the surface as the temperature rises 6℃ from pre-industrial levels. Though Antarctica has only seen up to a 5℃ rise in temperature in the summer months, this still puts the risk of meteorite loss higher than ideal. Thus, although Antarctica is the ideal place for meteoritics, it may not be for long if climate change remains unmitigated.





While the majority of meteorites discovered in Antarctica have originated from the asteroid belt, a small minority have been traced to the Moon and Mars. This provides researchers with insight into these bodies that we otherwise wouldn't have access to, as exploration of these areas is still very limited today. Parts of these meteorites contain minerals that reveal the composition of other planets and stars, while the iron cores of some meteorites have also been studied to help better understand the origin of the universe (Malsbury, 2021). In Antarctica, the ANSMET, or the Antarctic Search for Meteorites, has worked since the 1970s to find meteorites, which they use to gain information about extraterrestrial material. They can collect data from meteorites from all over the universe and of all different ages, which enables scientists to gain a better understanding of the composition of the universe (ANSMET). Without this program, meteorites would likely be understudied and largely misunderstood. ANSMET allows scientists to better grapple with the unknowns of the universe while finding answers to some of the questions we have surrounding it. Over 20,000 meteorites have been collected and stored by

ANSMET, but they continue their search for more even now; there remain many unanswered questions about space that meteorite compositions may shed some light on. Through this project, researchers have been able to identify water content and element availability in other regions of the universe, which is important for understanding if our neighbors in the solar system were ever habitable or inhabited by some kind of beings, whether they be complex life forms, like humans, or simple single celled organisms. Solar system evolution, which is the process by which clouds of gas and dust are pulled together to form planets and stars, can also be studied through meteorites. The contents of meteorites reveal what elements were in abundance when the meteor was formed, which helps scientists gain a better understanding of what the solar system was like long ago. This is a complex topic that is still being refined and is of extreme importance in understanding the universe as a whole, and it would be made even more difficult if Antarctic exploration had not opened the continent up for research.

Antarctica is a very unique and important landscape, which is valued both for its pristine, untouched glaciers and its association with scientific exploration. It is ideal for a variety of scientific endeavors, including neutrino detection, species adaptation, and meteoritics, as it offers an undisturbed, largely unpolluted workspace. While other scientific fields may be more closely associated with the continent, meteoritics has been closely related to it since it first became a beacon for European exploration in the 1800s. One of the first notable explorers who made contact with Antarctica did so following a trip to Tahiti, where astronomers had travelled to conduct astronomical calculations based on the transit of Venus. This explorer was Captain James Cook, and he was the first of many who braved the continent for the sake of exploration. Later, both Roald Amundsen and Robert Falcon Scott rushed to reach the true south pole first, both using astronomical calculations to guide their expeditions once the magnetic field rendered their compasses useless. Through this, astronomical sciences have been closely entwined with Antarctica from the beginning. In more modern times, this relationship has been refined further; now, scientists travel to the Antarctic in search of fallen extraterrestrial rocks, or meteorites, which provide a glimpse into the makeup of the universe. This is the ideal location for finding meteorites, as it is essentially a desert, but the blue ice fields have an added benefit; their blue coloring provides a stark contrast to the grey-black coloring of the rocks. This allows researchers to definitively identify meteorites and gather them for study. Though this work is still ongoing, boosted by a desire to better understand the origins of the universe, connections between ancient meteorites found in the blue ice fields of Antarctica and the Moon and Mars have been made; fragments of rocks from the Moon and Mars have been found in Antarctica. These fragments allow scientists to better understand the composition of these bodies in a way that couldn't be done through physical exploration of them, due to technological and physical restraints. Thus, being able to find this resource housed on Earth, well preserved and buried beneath just a few layers of ice, is a valuable asset. Climate change threatens the longevity of this asset, however. As the planet's temperature and oceans warm, the blue ice sheet melts. This results in the loss of valuable meteorites, making the collection and examination of them increasingly difficult. It is estimated that up to 75% of all previously accessible meteorites will be made inaccessible if the global temperature rises by the predicted 6℃ from pre-industrial temperatures. This would mean that 75% of our glimpse into the origins of the universe would be lost as well, leaving many questions unanswered. Special care must be taken to preserve the blue ice sheet, as this is an irreplaceable location within which a valuable field of study operates.

<u>Works Cited</u>

Anderson, J. B., Cassidy, W. A., Denton, G. H., Drummond, J. D., Fredriksson, K., Gooding, J., Grady, M. M., Huss, G. R., Koeberl, C., Lipschutz, M. E., McCoy, T. J., Mittlefehldt, D. W., Allen, C., Anderson, R. S., Anderson, D. R., Annexstadt, J. O., Ashley, J. W., Azevedo, I. S., Barabesi, L., … Dodd, R. T. (2004, November 2). *The origin and significance of Antarctic meteorites*. Geochemistry. https://www.sciencedirect.com/science/article/pii/S0009281904700215?casa_token=n07OLjRrdgkAAAAA%3A5GAAhvB8erx8ON9qhkI1vDZc-QwWDhLNe2MkX5UUYn-sr8BfxHwe3oQhGY8QPD6uNzyrx1J7o5jy

Antarctic Ice and Rising Sea Levels. Antarctic and Southern Ocean Coalition. (n.d.). https://www.asoc.org/learn/antarctic-ice-and-rising-sea-levels/

Climate change impacts | National Oceanic and Atmospheric Administration. (n.d.). https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts

Hall of Meteorites | American Museum of Natural History. American Museum of Natural History. (n.d.). https://www.amnh.org/exhibitions/permanent/meteorites

Malsbury, E. (2021, January 12). *What Antarctic meteorites tell us about Earth's origins*. Smithsonian.com. https://www.smithsonianmag.com/blogs/national-museum-of-natural-history/2021/01/12/what-antarctic-meteorites-tell-us-about-earths-origins/

Tollenaar, V., Zekollari, H., Kittel, C., Farinotti, D., Lhermitte, S., Debaille, V., Goderis, S., Claeys, P., Joy, K. H., & Pattyn, F. (2024, April 8). *Antarctic meteorites threatened by climate warming*. Nature News. https://www.nature.com/articles/s41558-024-01954-y

What is ANSMET?. ANSMET The Antarctic Search for Meteorites. (n.d.). https://caslabs.case.edu/ansmet/faqs/