How dust changed the face of the Earth

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In spring 2010, the research icebreaker Polarstern returned from the South Pacific with a scientific treasure - ocean sediments from a previously almost unexplored part of the South Polar Sea. What looks like an inconspicuous sample of mud to a layman is, to geological history researchers, a valuable archive from which they can reconstruct the climatic history of the polar areas over many years of analysis. This, in turn, is of fundamental importance for understanding global climatic development. With the help of the unique sediment cores from the Southern Ocean, it is now possible to provide complete evidence of how dust has had a major influence on the natural exchange between cold and warm periods in the southern hemisphere. An international research team under the management of the Alfred Wegener Institute in Bremerhaven was able to prove that dust infiltrations there were 2 to 3 times higher during all the ice ages in the last million years than in the warm phases in climatic history.

"High large-area dust supply can have an effect on the climate for two major reasons", explained Dr. Frank Lamy, geoscientist at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, about the findings. "Trace substances such as iron, which are essential for life, can be incorporated into the ocean through dust. This stimulates biological production and increases the sea's capacity to bind carbon. The result is that the greenhouse gas carbon dioxide is taken out of the atmosphere. In the atmosphere itself, dust reflects the sun's radiation and purely due to this it reduces the heat input into the Earth's system. Both effects lead to the fact that the Earth cools down." Lamy is the main author of the study which will be published in the renowned *Science* journal on 24th January 2014. Other participants included geochemist Gisela Winckler from the US Lamont-Doherty Earth Observatory and the Bremen Centre for Marine Environmental Sciences MARUM.

The influence of dust supply on the climate changes between ice ages and warm periods has long been suspected. Climatic researchers always found particularly high dust content containing iron when the earth was going through an ice age, both in Antarctic ice cores and in sediment cores from the Atlantic part of the Southern Ocean. However, up to now there was no data available for the Pacific section, which covers 50% of the Southern Ocean. "We can now close this central gap" is how Lamy underlines the importance of the new study. "The result is that we are now finding the same patterns in the South Pacific that we found in cores from the South Atlantic and the Antarctic ice. Therefore, the increased dust input was a phenomenon affecting the southern hemisphere during colder periods. This means that they now have to be considered differently when assessing the complex mechanisms which control natural climate changes."

What sounds almost incidental in Lamy's words is something of considerable relevance for research. This is because up to now many scientists were convinced that dust supply to the Pacific area could not have been higher during the ice ages than during warmer periods of the Earth's climate history. Where could larger dust quantities in this area of the Earth's oceans come from? Up to now, South Patagonia was suspected as a geological dust source since it is the only landmass in the Southern Ocean, intruding into it like a huge finger. However, since the wind predominating in this part of the world comes from the West, any dust particles in the air originating from South America mostly drift towards the Atlantic. For this reason, data from the South Pacific has been on scientists' wishlists for a long time.

However, the Pacific section of the Southern Ocean has remained something of a "terra incognita" for researchers despite modern technology. It is considered to be one of the most remote parts of the world's oceans. "The region is influenced by extreme storms and swells in which wave heights of 10 m or more are not uncommon. The area is also complicated from logistic point of view due to the huge distance between larger harbours" is how AWI scientist Dr. Rainer Gersonde, co-author and at the time leader of the Polarstern expedition, explains the extraordinary challenges faced by the research voyage. The Polarstern made a voyage of 10,000 nautical miles or 18,500 km through this particularly inhospitable part of the Antarctic Ocean in order to obtain high quality and sufficiently long sediment cores.

The question is, however, where did the historic dust freight towards the South Pacific come from, and why did the phases of increased input take place at all? Frank Lamy believes that one of the causes is the relocation or extension of the exceptionally strong wind belts prevalent in this region towards the Equator. The entire Southern Ocean is notorious amongst sailors for its powerful westerly winds - the "Roaring Forties" and the "Furious Fifties". It is considered to be one of the windiest regions in the world. The scientists' theory is that a relocation or extension of this powerful westerly wind belt towards the North could have caused the extended dry areas on the Australian continent to be influenced by stronger wind erosion. The result was higher dust infiltration into the Pacific Ocean - with the consequences described above. On top of this, New Zealand was an additional dust source. The extended glaciation of the mountains there during the ice age provided considerable quantities of fine-grained material which was then blown far out into the South Pacific by the winds.

"Our investigations have now proved without a doubt that colder periods in the southern hemisphere over a period of 1 million years always and almost everywhere coincided, , with lower carbon dioxide content in the atmosphere and higher dust supply from the air. The climatic history of the Earth was, therefore, written in dust."

More information: "Increased Dust Deposition in the Pacific Southern Ocean During Glacial Periods" F. Lamy et al., *Science*, 24 January 2014 DOI: 10.1126/science.1245424

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