

A bathymetric map of the sea floor of the Arctic Ocean reveals the Lomonosov ridge running between Greenland (lower left) and Russia (upper right).

The next land rush

As countries race to file claims to areas of the sea floor before a United Nations deadline, geologists and geophysicists are getting caught up in the frenzy. **Daniel Cressey** reports.

Russia's twin Mir submersibles are perhaps the most-photographed explorers of the deep sea. Because they are manned, and can dive together to depths of 6,000 metres, film producers love sending them down for unprecedented footage. The 20-year-old Mirs have starred in a number of Hollywood adventures, including director James Cameron's exploration of the wreck of the *Titanic*.

So it is fitting that it was the flashy Mir-1 that planted a Russian flag on the sea floor at the North Pole last August, as part of a high-profile race to claim the riches of the Arctic Ocean. The stunt was, of course, purely symbolic — Russia does not own the sea floor at the North Pole, at least not yet. But the flag-planting reignited nationalistic debate about who has rights to what in the Arctic. And scientists play a crucial part in resolving those debates.

The latest area of interest is the Lomonosov ridge, a submerged rise about 1,800 kilometres long that runs from offshore Russia to offshore

Greenland, crossing the geographic North Pole in the process. The ridge is also key to the ambitions of Russia, Denmark and Canada to lay claim to swaths of Arctic sea floor. The validity of their claims will be decided by a United Nations body, in accordance with the 1982 UN Convention on the Law of the Sea (UNCLOS). Under Article 76 of this treaty, a state can assert rights over the sea floor and its accompanying oil, gas and mineral wealth — beyond the standard 'exclusive economic zone' that extends to 200 nautical miles off the coast. For this to

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happen, the country must prove that the claimed area is a "natural prolongation" of its continental shelf (see 'How to split up the sea floor', overleaf).

Russia and Denmark both sent expeditions to the Lomonosov ridge last summer, but they are far from alone. A deadline of 2009 is approaching for some nations to stake claims under UNCLOS, and experts are poised for a rush of new applications worldwide. Most agree that the international body will eventually accept some of the claims. "There's no doubt in my

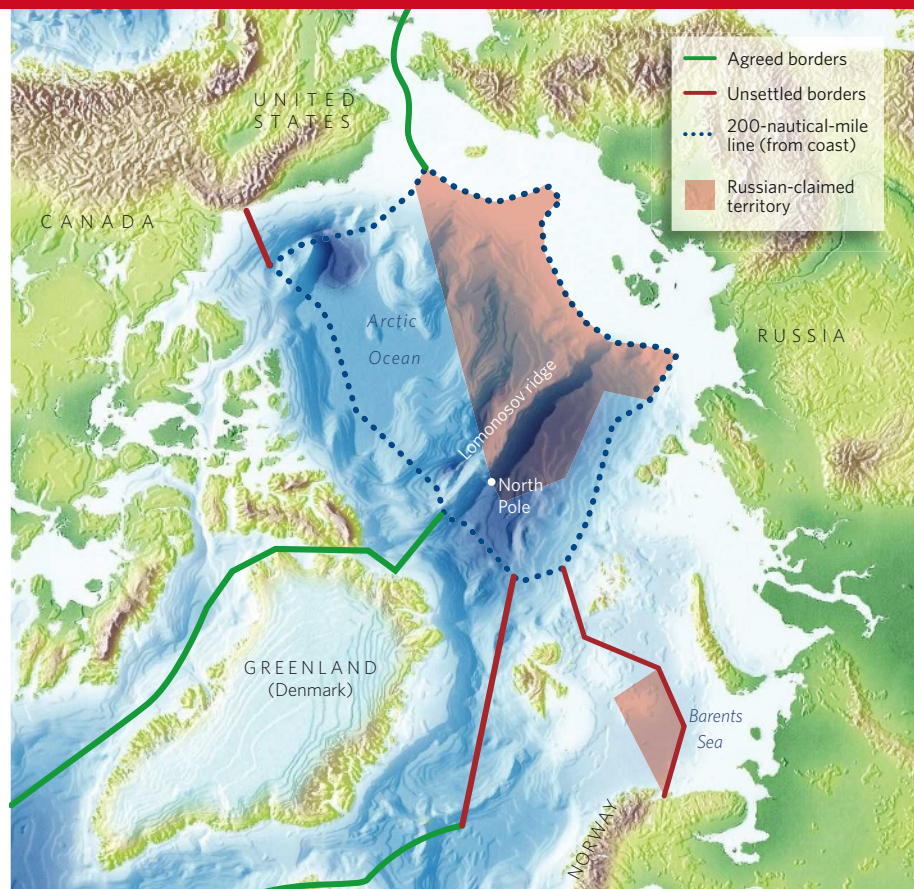
mind the map of the Arctic will change as a result of these actions," says Ronald Macnab, a marine geophysicist formerly of the Geological Survey of Canada who now works as a consultant to those submitting claims.

But redrawing maps will take time. "There aren't going to be any easy claims under Article 76," says Lindsay Parson, an oceanographer at the University of Southampton, UK. In the process, geology and geophysics will have a significant role — as is already happening not only at the Lomonosov, but also in claims regarding the Bay of Biscay off France and Spain, the sea floor off New Zealand, and elsewhere.

Surveying the deep

The Lomonosov ridge, named after the eighteenth-century Russian scientist and writer Mikhail Lomonosov, is ground zero for the hottest claims. It may seem strange that the sea floor in the middle of the Arctic Ocean, miles from any land, can be considered a "natural extension" of Europe, Asia or North America. But the ridge's unique geology is behind this.

In the early 1960s, sea-floor mappers Bruce Heezen and Maurice Ewing recognized that



Up for grabs: Russia will not be the only nation to claim a share of the potential riches under the Arctic.

the mid-Atlantic ridge — the chain of underwater mountains that runs up the centre of the Atlantic Ocean, marking where new sea floor is born — extended into the Arctic, where it is known as the Gakkel ridge¹. And in 1963, Canadian geologist J. Tuzo Wilson published a paper showing how the basin on the Siberian side of the Arctic Ocean could have opened up as the Gakkel produced new sea floor. That would have moved the Lomonosov ridge, which once formed a sliver along the edge of the Eurasian continent, over to run between Greenland and Russia². In other words, the ridge was once part of Eurasia.

In 1991, researchers aboard the German icebreaker *Polarstern* and the Swedish icebreaker *Oden* set out to test this idea. Geologist Yngve Kristoffersen, of the University of Bergen, Norway, was part of the research team. “When we saw the first seismic survey I almost went through the roof,” he remembers. “It was all there, just like a textbook.” On the Eurasian side of the ridge lay half-grabens, features formed by fault rifting as the ridge pulled away from the continent. On the other side lay deep sediments. Kristoffersen and his colleagues estimated that the ridge subsided below sea level between 64 million and 56 million years ago³.

In 2004, the first cores were drilled from the Lomonosov ridge, providing the first ‘ground truth’ for its geology and the history of the Arctic⁴. “Basically the bedrock is the same

material from the Eurasian margin,” says Kate Moran, an oceanographer at the University of Rhode Island, Kingston, who co-led the Arctic Coring Expedition. “There’s full agreement that the ridge used to be connected to the Eurasian margin.”

With the origin of the ridge not in doubt, the Russians must stake their claim on an inter-

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pretation of the brief passage in the UN rules, and must prove where exactly, if anywhere, the ridge is attached. “That is the difficult part,” says Larry Mayer, director of the Center for Coastal and Ocean Mapping at the University of New Hampshire, Durham. “The issue is this demonstration of a natural prolongation of the land mass.”

Moran says that some theories suggest that the ridge might have ‘sheared’ at the Russian end, meaning it is not really attached in the traditional sense. But such questions are difficult to answer without more data — hence the recent Russian and Danish expeditions.

A 2001 Russian claim to UNCLOS for more Arctic territory was sent back with a request for more

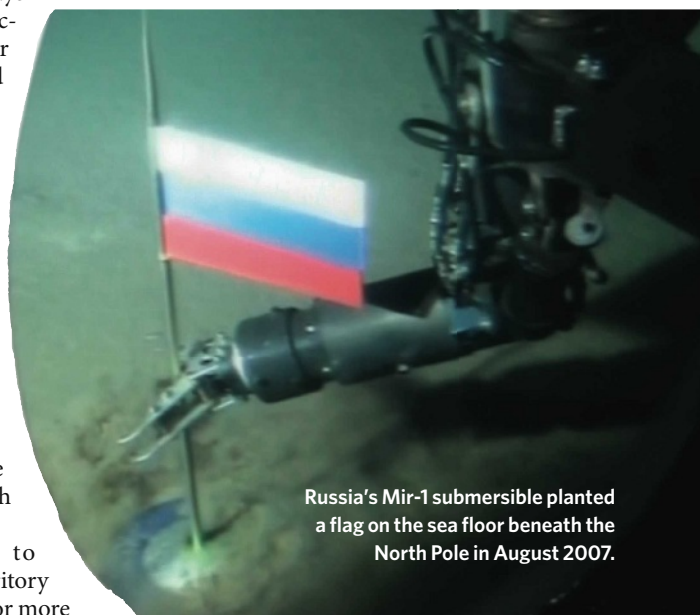
information. Exactly what was requested is not known, but this year’s expedition included not only the Mir submersibles, which gathered water and sediment samples, but also aircraft running tests that included gravity surveys. Russian scientists are currently studying the data.

For their part, Denmark and Sweden sent two icebreakers as part of the Lomonosov Ridge off Greenland (LOMROG) 2007 expedition. The project ran into extraordinarily thick ice at the southern end of the ridge, but managed to undertake geological coring and oceanographic sampling, among other studies.

“We wanted to see change in composition going from the shelf onto the ridge,” says Christian Marcussen, a senior adviser at the Geological Survey of Denmark and a principal investigator on the cruise. “What we’re looking for is some kind of crustal continuation from the continent to the ridge.”

But that may not necessarily hold sway with the UN committee deciding on the question of natural prolongation. “The geochemical affinity of rocks is not a defining factor in whether rocks are part of a nation’s landmass,” says Vaughan Stagpoole, a geologist at the Institute of Geological & Nuclear Sciences in Lower Hutt, New Zealand. “The key is in distinguishing such rocks from *in situ* ‘deep ocean floor with its oceanic ridges,’ which does not form part of the natural prolongation of a state,” he and his colleagues say in a statement to *Nature*.

Many of the LOMROG findings have not yet become public, as they are being prepared for publication in peer-review journals



Russia’s Mir-1 submersible planted a flag on the sea floor beneath the North Pole in August 2007.

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or for submission to the UN commission. But a few details emerged last month at a meeting of the American Geophysical Union, in which co-investigator Martin Jakobsson, from Stockholm University in Sweden, reported features such as ice scours on the ridge, probably caused by giant icebergs dragging across the ridge surface. The Danish part of the team, led by Marcussen, is still working on data from their underwater surveys, which aimed to delineate the foot of the continental slope to better inform any claim Denmark may make under UNCLOS.

Small country, big claim

For its part, New Zealand submitted a claim in 2006 that encompasses roughly 1.7 million square kilometres surrounding its islands. The claim is based on a host of complex features, including plateaux, ridges, seamounts and trenches, and also involves the first claim of a major active subduction margin. Some of the areas in the claim may overlap with other countries' entitlements (see map opposite), and New Zealand is in ongoing negotiations with Fiji and Tonga regarding this.

The New Zealand claim team had a budget of NZ\$44 million (about US\$30 million), underscoring the interest governments have in sea-floor claims. Under UNCLOS, nations get rights to exploit the oil, gas and mineral wealth in sea-floor areas awarded to them. The team, however, says its survey was motivated by the desire to know what might be claimable under Article 76, as opposed to what might lie within that potential claim.

Other claims also seem to fall under the 'grab-it-now' mentality. Under UNCLOS, countries lose their rights to stake a claim once their deadline has passed. UNCLOS stipulates that countries have 10 years from the date they ratified the treaty to submit claims, with none coming before 2009. This gives deadlines of 2009 for Russia, 2013 for Canada and 2014 for Denmark — not a huge amount of time considering that the Arctic, for instance, is accessible to researchers for only a few months each summer.

In 2006, France, Spain, the United Kingdom and Ireland submitted a joint claim to a small area in the Bay of Biscay. The claim is based



The Union Jack flew above Rockall in 1955, but claims to the sea floor around the rock in the North Atlantic Ocean must come from geological proof.

on a series of relatively small ridges that run out into the Atlantic, remnants from the period when the Iberian peninsula moved away from what is now France, creating the Bay of Biscay. "The process of ocean basin formation is not always a clean break," explains Parson, who is heavily involved in the UK claims. "Very often there's a lot of stretching and twisting that goes on. You can think of it as similar to breaking a biscuit — there are crumbs left over."

The Bay of Biscay claim is one of the less controversial under the UNCLOS process. "It's relatively small but the total area is about the same as the land area of Ireland — on that sort of scale it is significant," says Peter Croker, head of the team for Ireland's submission. "As submissions go it is relatively

straightforward," says Croker, who also serves as a member of the UN Law of the Sea commission on the limits of the continental shelf. Subgroups within the commission decide on the merits of each claim, and they do not include any members who might have a stake in the claim being discussed.

More likely to be controversial are the expected claims around the hotly disputed

'island' of Rockall farther north in the Atlantic. The tiny, uninhabited outcrop that forms Rockall is frequently entirely swamped by waves and can itself support no claims; under UNCLOS, rocks that "cannot sustain human habitation or economic life of their own" cannot be used to claim the sea floor around them. But the sea floor surrounding Rockall could potentially be claimed as an extension of Ireland, the United Kingdom, Iceland or Denmark's Faroe Islands under the UNCLOS process.

The four countries have clashed before over Rockall. Ireland and the United Kingdom have agreed how to divide the continental shelf within their exclusive economic zones. But Iceland and the Faroes may also eventually claim part of the sea floor around Rockall — and the disputes are likely to rule out any previously-agreed joint submission as in the Bay of Biscay.

Other disputes may flare up farther south. The United Kingdom is expected to file a claim to the sea floor around what it calls the Falkland Islands — over which it fought a war in the early 1980s

with Argentina, which claims the land as the Malvinas. Britain is also preparing a claim for sea bed off the coast of Antarctica, contiguous with its designated Antarctic territory on land. Australia and New Zealand have submitted similar claims off their Antarctic territories.

Flying blind

Controversies over claims are not helped by the secrecy of the UNCLOS process. Only summaries of submissions are published, and these need only contain a list of coordinates for the territory being claimed. "The commission operates under pretty serious rules of confidentiality," says Macnab. "We don't know how it has dealt with other submissions that may have similar circumstances. The states are flying blind."

The insistence on confidentiality is written into UNCLOS. "In an ideal world the whole process would be open," admits Croker. "The whole process is not transparent to the outside world. I understand why there's some frustration about it."

Inevitably, the criteria can lead to overlapping claims. For instance, Russia's Arctic claim in 2001 extended to, but not past, the North Pole, taking in the half of the Lomonosov

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ridge that extends from the pole towards Russia. Claims are expected from Denmark and Canada regarding the part of the Lomonosov on their side of the pole; the countries would have to resolve between them where to put a boundary between their claims.

Indeed, the commission cannot even consider submissions on disputed areas without the permission of those involved in the dispute. Hence the joint submission for the Bay of Biscay, which involved researchers from all four countries on the survey team. If the claim is approved, the countries involved can then divide the land among themselves.

Redrawing the maps

Even so, scientists working in the area reject media and public statements that such claims amount to a selfish 'land grab'. "There is order in the oceans and that order is provided by the Law of the Sea," says Croker. "Terms such as 'land grab' are unfortunate to say the least."

But some researchers continue to stoke nationalistic fervour. Artur Chilingarov, who led the Russian expedition that planted the underwater flag, has been quoted as saying: "The Arctic is Russian. We must prove the North Pole is an extension of the Russian coastal shelf." Danish and Canadian politicians have made similar, if not quite so strident, statements.

In the end, though, the decisions that are made by UNCLOS will massively redraw sea-floor maps. Article 76 holds that the commission's recommendations will be "final and binding". Still, questions

How to split up the sea floor

In 1973 the Third United Nations Conference on the Law of the Sea was convened, in an attempt to bring some order to increasing unilateral declarations of 'rights' over the oceans and the inevitable conflict that ensued. When the conference ended nine years later, it gave birth to the UN Convention on the Law of the Sea. It has now been ratified by 155 countries, with a notable exception being the United States, which is caught up in congressional debates about national sovereignty.

The convention gave nations the rights over the continental shelf out to the limit of their exclusive economic zone, 200 nautical miles from shore. But if nations can prove other geological criteria, they can claim to either 350 miles from territorial waters, or 100 miles from the 2,500-metre depth.

Article 76 itself, which lays out these criteria, is just 600 words long — leading to much confusion, particularly on the issue of what

constitutes a claimable 'natural prolongation' of a continental shelf. "Here the commission has to sort out some guidelines that people can follow," says Wilfried Jokat, a geophysicist at the Alfred Wegener Institute for Polar and Marine Research in Potsdam, Germany. "The article is too general about this."

Decisions on claims are made by a subcommittee of the 21-member commission on the limits of the continental shelf, staffed by scientific experts in the field. To date eight claims have been submitted:

- Russian Federation: 2001
- Brazil: 2004
- Australia: 2004
- Ireland: 2005
- New Zealand: 2006
- Joint submission by France, Ireland, Spain and the United Kingdom: 2006
- Norway: 2006
- France: 2007

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are being raised as to what exactly that means. "I've been at several meetings where people have questioned what it means, this 'final and binding,'" says Macnab. "The legal people themselves aren't quite sure what the terms mean."

"The Arctic is Russian. We must prove the North Pole is an extension of the Russian coastal shelf."

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So all the sea-floor wrangling may end up not even being permanent. "Although most countries have ratified the Law of the Sea," says Macnab, "there's nothing to say you wouldn't have some rogue government

saying it didn't agree with some past decision and they were going to do things differently. It wouldn't surprise me to see states say 'we want to reopen.'" In which case it is back to the drawing board.

Daniel Cressey is a reporter in Nature's London offices.

1. Heezen, B. C. & Ewing, M. in *Geology of the Arctic* (ed. Raasch, G.) 622-642 (Univ. Toronto Press, Toronto, 1961).
2. Wilson, J. T. *Nature* **198**, 925-929 (1963).
3. Jokat, W., Uenzelmann-Neben, G., Kristoffersen, Y. & Rasmussen, T. M. *Geology* **20**, 887-890 (1992).
4. Moran, K. et al. *Nature* **441**, 601-605 (2006).

The Bay of Biscay (left-hand picture) has been subject to a joint extended-shelf claim by France, Spain, the United Kingdom and Ireland.



New Zealand (right-hand picture) covers only about 270,000 square kilometres, but its claim on areas beyond its exclusive economic zone could see it have access to 6 million square kilometres of sea floor.

